

State of California  
The Resources Agency  
DEPARTMENT OF FISH AND GAME

**DISTRIBUTION, STATUS, AND MANAGEMENT OF TOWNSEND'S  
BIG-EARED BAT (*Corynorhinus townsendii* IN CALIFORNIA**

by

**Elizabeth D. Pierson, Ph.D.  
William E. Rainey, Ph.D.**

**Wildland Resources Center  
1323 Academic Surge  
University of California  
Davis, California 95616**

submitted November 1994 to

**WILDLIFE MANAGEMENT DIVISION  
BIRD AND MAMMAL CONSERVATION PROGRAM  
FINAL REPORT FOR CONTRACT NO. FG7129  
updated and finalized May 1998**

**BMCP Technical Report Number 96-7**

## ABSTRACT

A four year survey (1987-1991) investigating the status of Townsend's big-eared bat, *Corynorhinus townsendii*, in California shows marked population declines over the past 40 years: a 52% loss in the number of maternity colonies, a 44% decline in the number of available roosts, a 55% decline in the total number of animals (primarily adult females), and a 32% decrease in the average size of remaining colonies. The data indicate that *C. townsendii* is roost limited, and the primary cause for the observed declines has been human disturbance of roosting sites. The 37 known colonies have a total population of approximately 4,250 adult females. Only three of these colonies have adequately protected roost sites. Declines are also indicated at four important hibernating sites for which past population data are available.

## INTRODUCTION

Townsend's big-eared bat, *Corynorhinus townsendii*, ranges throughout western North America from British Columbia to the central Mexican highlands, with isolated populations reaching east in the United States to the Ozarks and Appalachia. It is divided into five subspecies (Hall, 1981), two found in the western United States (*C.t. townsendii* and *C. t. pallescens*), two in the central and eastern United States (*C. t. ingens* and *C. t. virginianus*), and one exclusively in Mexico (*C. t. australis*).

Recent information suggests that, regardless of subspecies, *C. townsendii* appears to be declining throughout the west. In Arizona, there are currently only 13 verified maternity roosts, representing 10 separate colonies, with a total population of about 1,000 adult females. Two historically known populations, both in caves, are now gone; another population declined by 50% in 2 years after its cave roost was commercialized; another population, which historically had several hundred adult females, now numbers fewer than 100 (V. Dalton, pers. comm.). In Colorado, a hibernating site which contained more than 500 in December 1968 (S. Altenbach, pers. comm.), apparently is reduced to only a few animals (P. Brown, pers. comm.). Only four maternity sites have been documented in Colorado since 1970, and the largest has only ca. 80 adult females (K. Navo, pers. comm.). In New Mexico, in October 1992, S. Altenbach (pers. comm.) located >10,000 *C. townsendii* hibernating in a timber-lined 100 m deep mine shaft. When he revisited this site in February 1993, the shaft had been burned in an act of vandalism. Several hundred dead animals could be seen still hanging from the walls, and thousands more were presumed dead. Recent surveys of four known hibernating sites by the Bureau of Land Management in Idaho indicate a 60% population decline since 1987 (L. Lewis, pers. comm.). Intensive surveys, conducted over the past ten years, of 96,000 km<sup>2</sup> of northeastern Nevada have revealed only two small *Corynorhinus* maternity sites (P. Bradley, pers. comm.). Severe population declines for both summer and winter populations of *C. townsendii* in Oregon and Washington have been well documented in recent years (Cross *et al.*, 1976; Perkins, 1982, 1983, 1984, 1985a,b & c, 1986, 1987, 1990; Senger & Crawford, 1984). Perkins (1990) estimated in 1990 that known *C. townsendii* sites in Oregon and Washington contained ca. 2,700 and 800 adult females respectively.

Prior to these surveys, very little information was available on the status of *C. townsendii* in California, although Graham (1966) expressed concern for the species in the 1960s, and more recent information suggested declines as well. An article in "American Caves" (Anon., 1986) reported that recent visits to previously reported *C. townsendii* sites in northern California by Bruce Marcot, a U.S. Forest Service employee, failed to locate any populations. Williams (1986) commented that *C. townsendii* was common in central California in the 1960s, but has rarely been seen since the early 1970s. D. Constantine (pers. comm.) noted a decline in recent years in the number of specimens submitted to public health facilities for rabies testing.

Threats to *C. townsendii* populations have been acknowledged to some degree by various state and federal agencies. The two eastern subspecies were placed on the Federal Endangered Species List in 1979. One of the western subspecies, *C. t. townsendii*, was a former Category 2 Federal Candidate for listing. *C. townsendii* is on the list of threatened species in Washington (Anon., 1986; M. Perkins, pers. comm.), and on the "sensitive" species list for Region Six of the U.S. Forest Service and the Oregon Department of Fish and Wildlife. In 1986, it was designated a Species of Special Concern in California (Williams, 1986).

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The purpose of this study was to identify those areas in California, known historically to have substantial concentrations of *C. townsendii*, and to assess the current status of populations in those areas.

### **Taxonomy and Distribution of *C. t. townsendii* and *C. t. pallescens* in California**

California has two subspecies of *Corynorhinus townsendii* (*C. t. townsendii* and *C. t. pallescens*), as defined in the last taxonomic revision of the species (Handley, 1959). Although there are areas where only one or the other of the two western subspecies apparently occurs, throughout much of their range in California, Nevada, Idaho, Oregon and Washington there are extensive zones of intergradation (Handley, 1959). In California, this zone of overlap covers all areas west of 118° west longitude. To confound the issue, throughout the zone of intergradation it is frequently impossible to assign individuals to one subspecies or the other. Although Handley makes the distinction between the two subspecies based on size and color characteristics, he also claims that one can observe a full spectrum of characteristics for both subspecies within a single population. To quote Handley (1959): "Within this zone of intergradation there is considerable individual variation in dorsal coloration. . . Tone is very variable throughout the zone, the range in some samples almost bridging the gap between the pale and dark extremes of the northwestern coast and the pallid belt (p. 192). . . Similarly, there is intergradation between the pale-colored and dark-colored populations in cranial characteristics. This is best seen in the relative stoutness of the rostrum (normally stout in dark-colored northwestern coast populations, normally less stout in pale-colored interior populations). Within the zone of intergradation, stoutness of the rostrum can not be correlated with coloration: some pale-colored individuals have the rostrum very stout; some dark-colored individuals have the rostrum rather frail (p. 193). . . Allocation of specimens, especially in inadequate series, from much of this [zone of inter-gradation] to one race or the other is largely a matter of personal opinion. As a result, various authors have disagreed on just where the artificial boundary between the ranges of *townsendii* and *pallescens* should be set (p. 199)." The results of preliminary DNA studies, using PCR techniques, have also failed to distinguish between the subspecies (W.E. Rainey, pers. comm.).

Given the difficulties in distinguishing between these two subspecies, and the fact that California Department of Fish and Game considers the entire species to be a Species of Special Concern, for the purposes of this study, the two subspecies are considered as a single taxonomic unit.

The taxon now known as *Corynorhinus*, and originally described by that name (Hall, 1981), was known as *Plecotus* for nearly forty years based on a revision by Handley (1959). In his revision, he subsumed three lineages in *Plecotus*:

1. the Palearctic taxa previously known as *Plecotus*,
2. the North American taxa previously known as *Corynorhinus*,
3. the monotypic western North American lineage now known as *Idionycteris*.

He retained these former genera as subgenera. *Idionycteris* was subsequently reevaluated and restored to generic status (Williams *et al.*, 1970), a change which has been generally accepted (e.g., Koopman, 1993). More recently, two phylogenetic studies have reviewed relationships among plecotine genera (Frost and Timm, 1992; Tumlison and Douglas, 1992). They derive significantly different relationships among the genera and differ in some taxonomic recommendations (e.g., one proposes synonymizing *Idionycteris* with *Euderma*), but are consistent in recognizing *Corynorhinus* (= North American *Plecotus*) as distinct at the generic level

from Palearctic *Plecotus*. These suggested revisions post-date the closing publication date for Koopman (1993), and Koopman (in litt.) subsequently agreed that *Corynorhinus* should now be recognized as a separate genus.

### **Roosting Ecology and Population Biology**

*C. townsendii* is a colonial species. Females aggregate in the spring at nursery sites and give birth to one young in late spring or early summer. These nursery colonies, comprised of adult females and their young, remain intact until the young are independent in late summer or early fall. Banding studies (Pearson *et al.*, 1952) have shown that these groups are stable, with individuals showing fidelity to both their group and chosen roost sites. If undisturbed, *C. townsendii* colonies will use the same roosts indefinitely. The loyalty of this species to given roosts is most dramatically illustrated by the "guano bowls" found in some limestone and travertine caves (Graham, 1966). At these known *C. townsendii* sites, which must have been used for centuries, continuing guano deposition has slowly dissolved the rock, generating remarkable bowl-like depressions (Graham, 1966).

In the absence of human disturbance, the size of *C. townsendii* nursery colonies tend to remain stable over time. The same individuals can be found together year after year, and may live more than 16 years (Kunz and Martin, 1982). Mortality is fairly high among juveniles, but those females that return to their natal roost after their first winter (38-46%) have about a 75% chance of survival in each succeeding year, with the average age of animals in a population being 5 years (Pearson *et al.*, 1952). Whereas young males disperse after their first summer, many, and perhaps all, surviving females return in the spring to their natal group (Pearson *et al.*, 1952). Thus, nursery colonies appear to be multi-generational, matrilineal groups. Although colonies comprised only of adult males are known in the East (C. Stihler, pers. comm.), no such aggregations have ever been found in the West. Thus all summer aggregations of *C. townsendii* in California are presumed to be nursery colonies comprised only of adult females and their young. During the summer months, adult males are generally found roosting alone.

Although *C. townsendii* is generally viewed as a cave dwelling species (all known nursery sites for the two eastern subspecies are caves), the two western subspecies are also found in human-made structures (e.g. old mine workings and buildings). *C. townsendii* is especially likely to be found in buildings along the coast. Unlike many species which take refuge in crevices, *C. townsendii* only roosts in the open, hanging from walls and ceilings, where it is relatively easily detected and particularly vulnerable to disturbance.

*C. townsendii* populations appear to be quite sedentary, with marked animals (all females) not known to move more than a few kilometers from their natal roost. Banding (Pearson *et al.*, 1952; Humphrey and Kunz, 1976), light-tagging and radiotracking studies suggest that movement in the nursery season, either for foraging or shifting to an alternate roost, is confined to within 15 km of the primary roost (Brown *et al.*, 1994; D. Dalton, pers. comm.; V. Dalton, pers. comm.; G. Fellers, pers. comm.; E.D. Pierson and W.E. Rainey, unpubl. data). Seasonal movements also appear to be limited. In the fall, when colonies disband, and the animals move to hibernacula, banded individuals have never been recorded more than 43 km from the banding site (O.P. Pearson, pers. comm.).

## METHODS

Key *C. townsendii* localities (maternity roosts and hibernacula) were identified by review of the literature, unpublished museum records, field notes and personal recollections of earlier workers. We relied particularly on the work of Koford (1945-1950), A.K. Pearson (1949-1966), O.P. Pearson (19448-1950), Pearson *et al.* (1952), Dalquest (1947), Graham (1966 & pers. comm.), Krutzsch (1948), and K. Stager (pers. comm.). Records were gathered from many North American museums (i.e., the American Museum of Natural History in New York (AMNH), the U.S. National Museum of Natural History in Washington (USNM), the Field Museum in Chicago (FMNH), the Museum at the University of Michigan in Ann Arbor (UMNH)), including a number of California museums (i.e., the California Academy of Sciences (CAS), Los Angeles County Museum of Natural History (LACM), the Museum of Vertebrate Zoology at Berkeley (MVZ), and collections of some state universities).

Surveys were conducted between June 1987 and January 1991. Although a few hibernating sites were surveyed, the focus was on maternity roosts, because more records were available, and these populations tend to be more stable year to year (Pearson, *et al.*, 1952; Humphrey & Kunz, 1976). The hibernating period is November through February, and the maternity period, April through mid-September. All surveys of hibernating sites were conducted in January and February, and surveys of maternity sites between June and early September.

Surveys focused on species status in nine areas known to have substantial populations of *C. townsendii* in the past:

- 1) the northern coast and inner coast ranges (Del Norte, western Siskiyou, Trinity, Humboldt, Mendocino, Sonoma, Lake, Colusa, Yolo, Napa, and Marin counties);
- 2) the central coast, including the inner coast ranges (Contra Costa, Alameda, San Mateo, Santa Clara, Santa Cruz, Monterey, San Benito, San Luis Obispo and Santa Barbara counties);
- 3) northeastern California (Lassen, Shasta, and eastern Siskiyou counties);
- 4) the western Sierra (Calaveras, Alpine, Tuolumne, Mariposa, eastern Fresno, Tulare, and the Sierra portions of Kern counties);
- 5) the Owens Valley and areas east of the Sierra Nevada Range (Mono, Inyo, northeastern Kern, and northwestern San Bernardino counties);
- 6) the Providence Mountains (San Bernardino County);
- 7) the low desert along the Colorado River (eastern San Bernardino, eastern Riverside, and eastern Imperial counties);
- 8) San Diego County;
- 9) Santa Cruz Island in the Channel Islands.

All known significant maternity colonies (>30 animals) for *C. townsendii* within the state were

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included in the survey. Because such roosts were relatively few and geographically concentrated, some additional sites, for which records were more limited, were also included. The survey also covered a selection of known hibernating sites.

The survey technique involved locating, when possible, the original roost site to determine if it was still being used by *C. townsendii*, and searching for additional or alternate roosts within a 15 km radius of the original site. Because *C. townsendii* is so sedentary (Pearson *et al.*, 1952; Humphrey and Kunz, 1976), it seemed reasonable to expect that a previously known population, if still extant, would be found at or close to the documented site.

The survey was conducted by examining potentially suitable and accessible caves, tunnels (e.g., old mine workings, water diversion tunnels, and abandoned railroad tunnels), buildings, and bridges in the survey area. Any mine working that was open, and not considered too hazardous, was surveyed by day; others were monitored with night vision equipment at night. Buildings were considered "potentially suitable" if they appeared abandoned or little used, and not so degraded that all possible refuges were brightly illuminated. Since many modern bridges (e.g., concrete box beam or steel I-beam) offer no refuge, the survey was limited to a selection of older (pre- 1960) bridges.

Censuses were conducted at occupied roosts by: 1) a direct count of animals in the roost using night vision equipment, 2) an estimate based on area covered by the cluster (a 30 X 30 cm cluster = ca. 150 *C. townsendii* [V.Dalton, pers. comm.]), or 3) a direct count at evening emergence using night vision equipment and a QMC S-200 bat detector. Early in the season all emerging animals were assumed to be adult females. After the young were volant (the timing of which varies with latitude), one half were counted as adult females.

Status in the survey area was assessed by comparing the number of previously known and current colonies, the number of previously known and current roost sites, and past and current colony size. It was necessary to separate number of colonies from number of roosts, since some colonies used more than one roost. In some cases multiple roosts were documented. In other cases, when records were separated in time, two roosts were assumed to belong to a single colony if the roost site for the earlier record was no longer occupied, and the two roosts were within 15 km of each other.

## RESULTS

### Maternity Colonies

#### Number and Distribution of Colonies

Figure 1 illustrates the past and present distribution of known *C. townsendii* colonies within California. Of the 46 maternity colonies known prior to 1980 (with most records dating from the late 1940s to the 1960s), 24 could no longer be found either at the original roost site, nor within a 15 km radius. This suggests a 52% decline in the number of *C. townsendii* colonies in the state in the past 40 to 50 years. Twenty-one (and possibly 22) of the historically known colonies still exist. An additional 18-21 colonies were identified, either in the course of this survey or as post-1980 records. Thus a total of 39 colonies are known to exist currently, with indications (i.e.,

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unconfirmed, but reliable reports) of four others. The identity and current status of each of these colonies is given by area in Appendix I, and summarized in Table 1.

The majority of currently extant *C. townsendii* colonies are found in four regions of the state (Fig. 1; Table 1): the lava flow area of the northeast (Area 3); the limestone caves and old mines of the Mother Lode and western Sierra (Area 4); the abandoned mine workings in the Eastern Sierra and Western White Mountain foothills (Area 5); and at various sites in the northern coastal areas and inner coast range (Area 1). Declines in colony numbers are greatest in three areas: the eastern and southern San Francisco Bay area (Area 2), the lower Colorado desert along the Colorado River (Area 7), and San Diego County (Area 8).

**Table 1.** Numbers of historically known and recently discovered *C. townsendii* maternity colonies in California by area

Area	Colonies Located Prior to 1980		Colonies Located After 1980		Current Colonies
	No Longer Extant	Extant	No Longer Extant	Extant	
1. N. Coast	4	7(8) <sup>1</sup>		2	9(10) <sup>1</sup>
2. C. Coast	7			1	
3. Northeastern	1	3		3(4) <sup>2</sup>	6(7) <sup>2</sup>
4. W. Sierra	4(5) <sup>3</sup>	4		2(3) <sup>4</sup>	6(7) <sup>4</sup>
5. E. of Sierra	0	3	1	8	12
6. High Desert	1	1		(1) <sup>5</sup>	2
7. Colorado Riv.	2	1			1
8. San Diego	4	0		0(1) <sup>6</sup>	0(1) <sup>6</sup>
9. Channel Is.	0	1		0	1
Totals	23(24)	21(22)	1	17(20)	39(43)

<sup>1</sup> Reliable reports (several cavers); site not successfully located.

<sup>2</sup> Reliable report (D. Cowan, pers. comm.); site on private land; access not available.

<sup>3</sup> Reliable reports of colony in area (B. Rogers, pers. comm.); not located in two survey attempts.

<sup>4</sup> Reliable report (J. de Spain, pers. comm.); large guano deposit located.

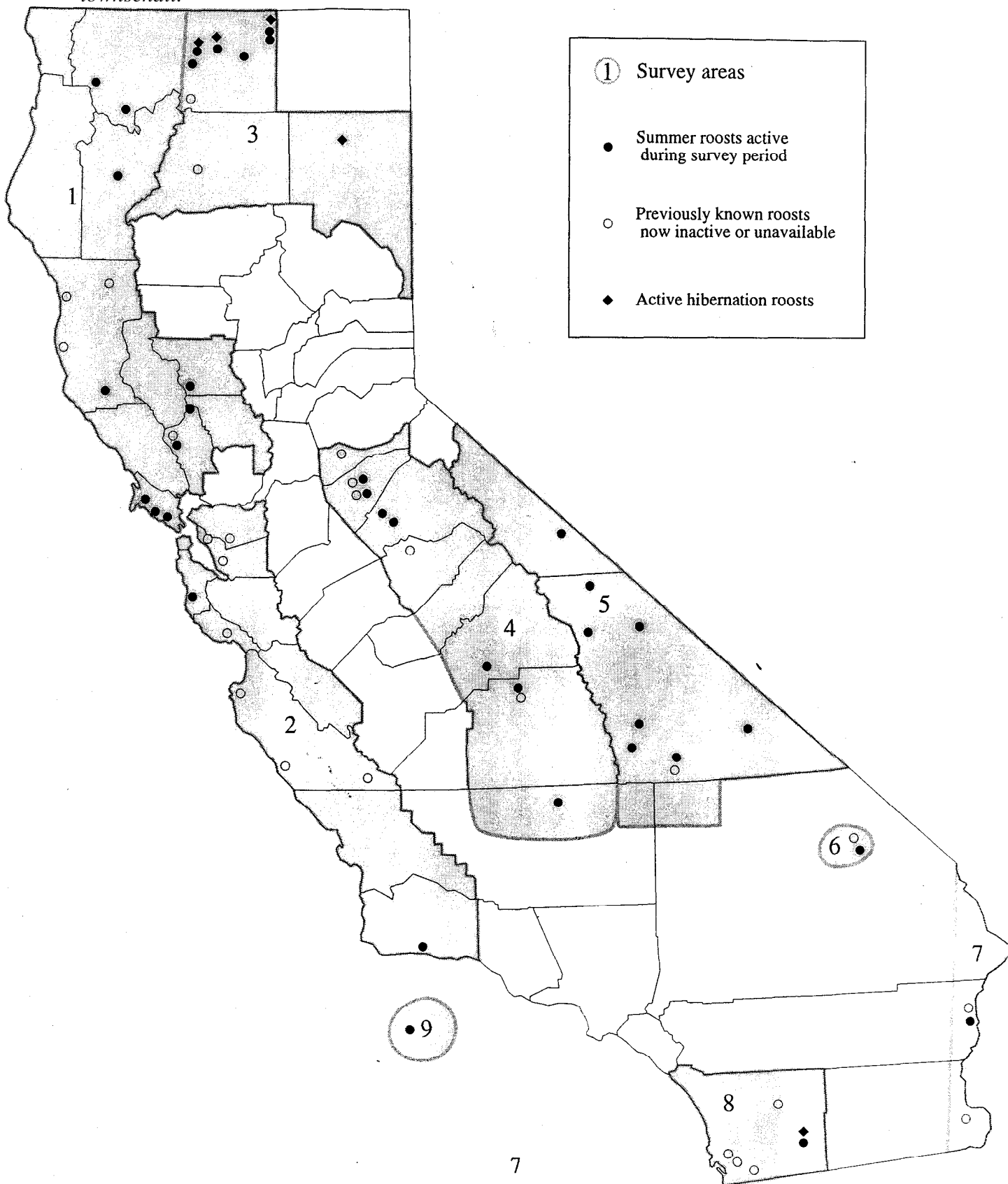
<sup>5</sup> Reproductive females in mine complex; actual roost site not yet located (P. Brown, pers. comm.).

<sup>6</sup> Fall roost (K. Miner, pers. comm.) and hibernaculum located; summer maternity site not located



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Figure 1. Map of California, identifying nine survey areas, and showing the distribution of past maternity sites, current maternity sites, and currently significant hibernating sites for *Corynorhinus townsendii*.



## Current Status of Populations

A comparison of former and current population estimates for the 18 historic colonies (Table 2) suggests a 55% decline in the number of adult female *C. townsendii* over the past 20-40 years. Six nursery colonies (33.3%) appear to be extirpated. Five others (27.8%) have decreased in size. Four (22.2%) have remained approximately stable, and three (16.7%), all within national parks (Lava Beds National Monument and Point Reyes National Seashore), have increased. Colonies were considered to have increased or decreased in size if the change exceeded 20%.

**Table 2.** Population trends for *C. townsendii* in California: comparison of former and current maternity roost populations. (All current population estimates derived from this survey).

Colony	Original Date	Original Population Size (No. Adult Females)	Current Population Size (No. Adult Females)	Ref.
Albion	May 2, 1947	200	0	M. Ramage, MVZ Notes
Fremont	May, 1943	75	0	Dalquest, 1947
Sulfur Creek	1966-1967	200	145	P. Leitner, pers. comm.
Knoxville	April 27, 1950	140	105	O.P. Pearson, MVZ Notes
Inverness	July 10, 1947	78	93	O.P. Pearson, MVZ Notes
Olema	May 30, 1974	75	160	P. Myers, MVZ Notes
Bolinas	June 18, 1959	65	230	R. Bandar, pers. comm.
Aetna Springs	April 28, 1949	50	0	A. Pearson, MVZ Notes
Calistoga	August 24, 1945	100 <sup>1</sup>	15	M. Ramage, MVZ Notes
Lava Beds #1	June 22, 1961	100 <sup>2</sup>	175	Park records
Lava Beds #2	July 23, 1970	220	240	Park records
Music Hall	August 17, 1963	16	12	R. Graham, pers. comm.
Moss	Sept. 3, 1961	200 <sup>3</sup>	0	R. Graham, pers. comm.
Macedonia	June 17, 1970	85	75	P. Brown, pers. comm.
Alice Mine	July, 1935	1000	0	K. Stager, pers. comm.
Mountaineer Mine	June, 1968	50	50	D. Constantine, pers. comm.
Senator Mine	May, 1918	200	0	Howell, 1920
Santa Cruz Island	August 11, 1949	150	65	O.P. Pearson, MVZ Field Notes
TOTALS		3,004	1,365	

<sup>1</sup> Another colony was identified in Calistoga on August 18, 1949, with 35 adult females

<sup>2</sup> This same colony was also estimated at 200 on July 20, 1978

<sup>3</sup> Cavers reported a large colony in the area in 1992, but several surveys failed to confirm its continued existence.

Decline in number of adult females = 54.6%

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A comparison of colony size for historically and currently known colonies indicates mean colony size has decreased by 31.9%, from 164.4 (n = 18) to 111.9 (n = 38). The 38 colonies for which population estimates could be obtained **totalled** approximately 4,250 adult females (Appendix I).

Table 3 gives the mean colony size and total population size, by region, of currently known populations in the state. The largest concentrations of *C. townsendii* are found in the lava flow and limestone regions of the northeast (Area 3), the mines and caves east of the Sierra (Area 5), and the northern coast and inner coast ranges (Area 1). The largest colonies are found in the northeast (Area 3) and along the central coast (Area 2), and the smallest in the Western Sierra foothills (Area 4) and the low desert (Area 7).

**Table 3.** Estimated population *size* for *known* maternity colonies of *C. townsendii* in California, by area.

Area	# Colonies	Total # Adult Females	Mean Colony Size
1. North Coast	9	963	107.0
2. Central Coast	2	325	162.5
3. Northeast	6	1142	190.3
4. W. Sierra	7	326	46.61
5. E. Sierra	11	1306	118.7
6. High Desert	1	75	--
7. Low Desert	1	50	--
8. San Diego	1 <sup>2</sup>	Unk.	--
9. Santa Cruz Island	1	65	--
Total	39	4,252	111.9

<sup>1</sup> This number includes the colony in Sequoia National Park, which was estimated by park personnel at 200, but has not been observed by us.

<sup>2</sup> Fall and winter aggregations located. Maternity colony not located. This colony excluded from calculation of mean colony size.

## Maternity Roost Sites

### Number of Maternity Roost Sites

For most colonies a single roost was identified, but for some, alternate roosts were also found. It was possible, using available records, to identify 58 roost sites used by the 46 colonies known prior to 1980. Thirty-six new roost sites were identified, making a total of 94 roost sites known to have been used by these colonies over their documented history. Forty-one of these roosts have

been destroyed or are no longer used, suggesting a 43.6% decline in available roosting habitat for these colonies.

For the 39 currently known colonies, 55 actively used roost sites have been identified.

### **Fate of Formerly Occupied Roosts**

Table 4 depicts the structural distribution and current status of pre- 1980 nursery roost sites. Of the 58 roost sites known to be used by *C. townsendii* prior to 1980, 23 (39.6%) have been destroyed or made unavailable to bats, 15 others (25.9%) appear suitable, but are unoccupied, and only 20 (34.5%) are still being used. In many of these, disturbance levels are sufficiently high that occupation is not predictable. Attrition has been highest for building roosts, with 88.2% destroyed or unavailable to bats. Fifty percent of the original cave roosts, and 57.1% of the mine roosts, are no longer being used. Even though caves are inherently the most stable structurally, and thus might be expected to provide the most consistently available habitat, four have become unavailable to bats through human intervention: two by inappropriate gating, one by flooding for a reservoir, and another by quarrying for highway rip-rap. The fifteen roosts that are structurally suitable but unoccupied (1 building, 7 caves, 6 mines, and one flume) all are subject to moderate to high levels of human disturbance.

**Table 4.** Distribution and status of pre-1980 *C. townsendii* nursery roosts.

=====					
STRUCTURE					
STATUS	Building	Cave	Mine	Other	Total
Occupied	1	12	6	1	20
Available, unoccupied	1	7	6	1	15
Burned	4	0	0	0	4
Entrance closed	1	3	1	1	6
Demolished	6	2	1	0	9
Renovated	4	0	0	0	4
-----					
Total	17	24	14	3	58
=====					

Of the 23 roosts that are no longer available to bats, 9 (mostly buildings) have been demolished, 4 (all buildings) have burned, 4 (all buildings) have been renovated in such a way that bats were excluded, and 6 (including buildings, caves, mines, and a water diversion tunnel) have had the entrance closed. Additionally, three roosts discovered since 1980 have been lost -- two have been

demolished, and another abandoned following a vandalism incident in 1988, in which a number of juvenile bats died.

### Roost Structures

Figure 2 shows the distribution of the 54 currently occupied *C. townsendii* maternity roosts in caves, mines, buildings and other anthropogenic structures : 23 (42.6%) in caves, 21 (38.9%) in mines, 8 (14.8%) in buildings, and 2 (3.7%) in other structures (i.e., an abandoned bridge and a diversion tunnel).

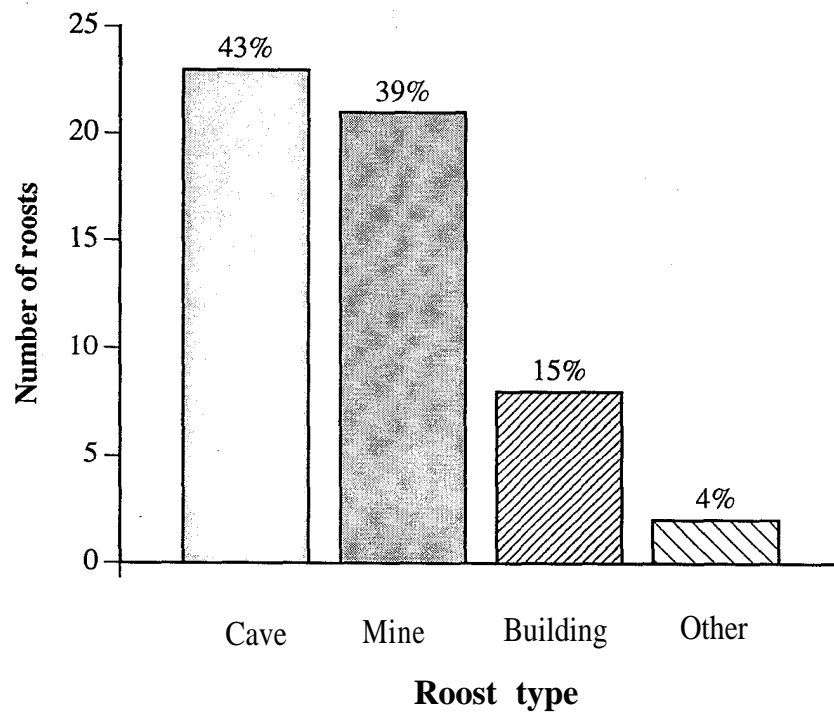
### Roost Criteria

Once investigated, a structure was deemed a “suitable” nursery site for *C. townsendii* if it met certain semi-quantitative criteria (Table 5), which were established by evaluating features of known roosts. All *C. townsendii* roosts could be classified structurally as cave analogues. The animals seem to require a relatively large, but enclosed space with a fairly substantial opening. All roost entrances, except one, are at least 15 cm high and 31 cm wide (the smallest being 15 cm high x 46 cm wide), and most are considerably larger (e.g., ungated mine entrances, broken windows or open doors). One notable exception is a mine roost in which the opening, above a closed door, is about 10 cm high x 60 cm wide. The animals, however, may have been forced into this roost by a vandalism event at an alternate site where an arranged pile of dead babies was found (P. Brown, pers. comm.). The smallest known entrance to a cave roost is 25 cm high and 45 cm wide. All roosting sites are at least 1 m, and generally 2.5-5.0 m, off the ground. This compares with a minimum roost height of 1.7 m for *C. t. virginianus* (Lacki *et al.*, 1994). The area is always large enough to permit extended flight within the roost, but also somewhat enclosed (e.g., a two story barn, with no second floor, is generally too open). All roosts are in semi-dark to dark settings.

**Table 5.** Criteria used to evaluate suitability of roosts as nursery sites for *C. townsendii*.

Roost Entrance	Minimum 15 cm high X 31 cm wide
Roost Height	Minimum 1.0 m, generally 2.5-5.0 m
Roost Area	Large enough for flying forays
Light Quality	Semi-dark to dark
Temperature	18°-30°C
Humidity	19-93% R.H.
Distance to Water	Within 100 m for coastal populations; up to 8 km for other populations

Fig. 2. Distribution by structural category of currently occupied *C. townsendii* maternity roost sites.



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Early in pregnancy animals will often roost in cooler, darker areas, but, if undisturbed, will move once the young are born to the considerably warmer “twilight zone” (Graham, 1966; Pierson *et al.*, 1991; V. Dalton, pers. comm.). In disturbed roosts colonies are often found in zones of total darkness (e.g., the areas of long mines most distant from the entrance). Although most cave and mine roosts have a depth of at least 25 m, colonies and/or large guano deposits are occasionally found in more shallow settings. Along the coast and in the inner coast ranges, most known roosts are within 100 m of a stream or riparian habitat, but inland and desert roosts are frequently a number kilometers from the nearest water. Isolated males are sometimes found in roosts with less height and considerably smaller entrances.

The mean temperature of maternity roosts (24.1°C, n=24) was slightly, but not significantly higher than that of roosts which housed single individuals or small groups (22.2°C, n=16). However, both kinds of occupied roosts had significantly higher mean temperatures than unoccupied roosts (17.9°C, n=27, df=2, F=73.84, p=.0001) (see Fig. 3). Although early in the maternity season aggregations can be found at sites with temperatures as low as 14°C, the more typical temperature range in later pregnancy and lactation is between 18° and 30°C. Building roosts, which are thermally more variable than caves or mines, often show dramatic seasonal and diurnal temperature fluctuations. At one site monitored in detail, between March 14 and 31, diurnal temperatures ranged from 7.9°C (0700-0800) to 26.1° (1400-1500); between July 8 and 27, from 15.0° (0700-0800) to 32.3° C (1600-1700) (G. Fellers, pers. comm.). The mean mid-day temperatures at three building roosts in late June-early July was 32.3° C. These roost temperatures are higher than the range reported by Lacki *et al.* (1994) for *C. t. virginianus* in Kentucky, and the same subspecies in Virginia (V. Dalton, pers. comm.).

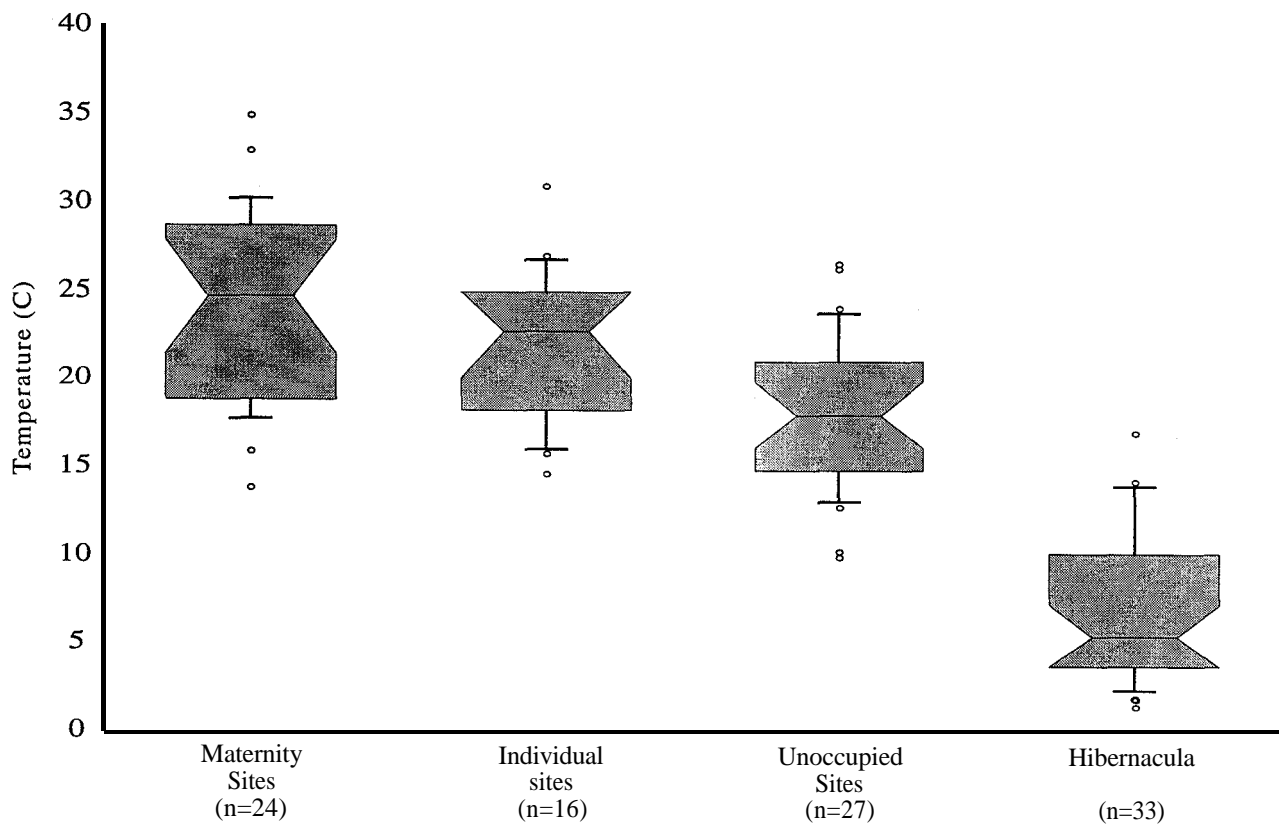
Relative humidity appears to be a less significant factor in roost selection than temperature. Relative humidity values for 10 maternity sites varied from 19 to 93%. Most, however, tended to be fairly dry, with a mean relative humidity value of 33.2% (n=10). Only one roost, in Macedonia Canyon (San Bernardino County), had standing water, and this colony had been driven by disturbance from its preferred site.

### **Status and Future Security of Currently Occupied Roost Sites**

The status of all 54 currently known maternity roost sites was evaluated using four criteria: the structural integrity of the roost, the risk of human disturbance, the prospects for future protection, and the availability of alternate roosts (see Appendix II). Only four roosts (7.4%) were deemed to be secure. For three roosts (5.6%) the risk was assessed to be very high, for 23 (42.6%) moderately high, and for 24 others (44.4%) moderate.

Although some of the known roosts are more secure than others, many have a history of disturbance, and none are likely to survive long-term without active maintenance and/or protection. Building roosts, because they are often abandoned structures in poor repair, are frequently at high risk -- prone to destruction by vandalism, fire and/or disintegration. Cave roosts, while generally secure structurally, are often at high risk of disturbance from recreational activities. Old mines vary in their structural integrity, and often experience high recreational use. Mine entrances have a tendency to slump closed over time, and are particularly vulnerable to collapse during winter rains. Renewed mining operations are often located in old mining districts, and many old mine workings have been destroyed by current, open pit mining practices. Additionally, old mines are frequently perceived as a safety hazard, and mine closure programs, particularly on public lands, are common.

Fig. 3. Boxplot of temperatures in occupied and unoccupied California roost sites of *C. townsendii*.





## Other *Corynorhinus townsendii* Records

Records were also kept of individual *C. townsendii* sightings. One or more (up to 12) *C. townsendii* were found in 73 different sites (excluding nursery roosts) during the course of the summer surveys (Appendix III). Although the roosts in which these animals were found often did not seem suitable as nursery sites, the presence of the animals indicated the existence of a population somewhere in the vicinity. These records were particularly valuable when historic colonies could not be found. The absence of animals in the vicinity of historically important, unoccupied roosts, provided further indication that these colonies had been extirpated.

## Hibernating Sites

### Locality Records

Although very large hibernating aggregations (up to 6,000) are known for *C. townsendii* in the East (V. Dalton and C. Stihler, pers. comm.), and in New Mexico (S. Altenbach, pers. comm.), no such sites are known for California. The most significant hibernating aggregations (200-600) occur in the most northern parts of the state, particularly Siskiyou County. In other areas, particularly the desert, smaller aggregations of 5-20 individuals are more typical. Based on available records, limited surveys were conducted in Areas 1,3,4 and 8. Records for all hibernating animals that were located are given in Appendix IV. Four caves, identified by B. Marcot in 1979 (Marcot, 1984) as containing hibernating *C. townsendii* were not checked during this survey, and one in particular, which contained 40-50 animals, may be a significant site.

### Current Status of Populations

It is more difficult to assess hibernating than maternity populations because animals appear to move among sites during a hibernating season (Pearson *et al.*, 1952; Humphrey & Kunz, 1976). Nevertheless, four hibernating sites studied by Pearson *et al.* (1952), in Napa, Lake and Shasta counties, have shown declines of between 69 and 94% (Table 6). While it is possible that animals are utilizing alternate hibernating sites, members of the Shasta Area Grotto, who are well acquainted with caves in Shasta County, know of no other caves in that area containing wintering bats. Additionally, Bower Cave in Mariposa County, identified by Graham (1966) as a significant hibernating site, currently has no hibernating population due to high recreational use. Individual *C. townsendii*, located hibernating in nearby mines (Appendix IV), indicate the species does still exist in the area.

In Siskiyou County, comparable numbers of hibernating animals were found in the same caves in Lava Beds National Monument in January 1949 and January 1988 (Table 6). Additionally, the largest known hibernating aggregations of *C. townsendii* occur in Siskiyou County (Appendix IV). The largest known population, within Lava Beds National Monument, had 134 animals when first discovered in November 1988, and over 600 in early March 1994 (B. Stoffel, pers. comm.). This site is being monitored and protected by the Monument. Other populations are less secure. The population identified in Pluots's Lava Flow #1 in January 1988 was significantly reduced when the site was vandalized in a few years later by young people who removed a number of bats and released them in a local store. A nearby site, Pluto's Lava Flow #4, confirmed as a significant hibernating site in February 1994 (with about 250 animals) (R. Miller, pers. comm.), receives heavy recreational traffic. Preliminary survey results indicate that population numbers within this cave are unpredictable, and may fluctuate in response to human disturbance.

No large hibernating colonies have ever been found in the desert regions of California (Appendix IV). This may be explained, however, by the fact that deep mine shafts, found to harbor very large aggregations of hibernating *C. townsendii* in New Mexico (Altenbach and Milford, 1991), have not been extensively explored in California. P. Brown and R. Berry (pers. comm.) report finding at least 20 hibernating *C. townsendii* in a shaft in January 1994 on the China Lake Naval Weapons Center. Two other significant hibernating populations have been found in mine adits, one in Death Valley National Monument and the other in Noble Canyon, San Diego County. At the Death Valley site, the population increased, once a protective gate was installed, from 17 on 5 March 1992 to 54 on March 5, 1993. The discovery of 21 *C. townsendii* hibernating in a mine in Noble Canyon on 24 January 1991 suggests there is a breeding population in this valley, whose summer roost has yet to be located. This was also indicated by the discovery of 25 animals in a different mine in this valley in October 1990. Although this population appears small, it is currently the only one known for San Diego County.

**Table 6.** Numbers of hibernating *C. townsendii* -- historic and current Records.

Locality	Historic Records (Largest No. individuals)	This Survey (No. individuals)	Percent Decline
<b>Lake County</b>			
Bartlett Mountain	55	17	69.1
<b>Napa County</b>			
Knoxville	166	27	83.7
<b>Shasta County</b>			
Subway Cave	72	4	94.4
Parrish Cave	177	11	93.8
<b>Siskiyou County</b>			
Lava Beds National Monument (Sentinel & Labyrinth)	27	30	

### Hibernating Roost Characteristics

Hibernating sites, like nursery roosts, are either caves or cave analogues. They differ from maternity sites in that they are often L-shaped, with vertical and horizontal entrances -- a structure

that generates a “cold sink” with significant air flow (Tuttle and Stevenson, 1978; Pierson *et al.*, 1991). One site has been found in a timber covered shaft, requiring the bats to crawl through small slits between timbers for entry (P. Brown, pers. comm.). *C. townsendii* appears to seek the coldest non-freezing temperatures available. In the colder northern areas of Shasta, Siskiyou and Lassen counties, the mean hibernating roost temperature is 4.3°C (n = 20), and animals likely hibernate for prolonged periods of time. In the warmer sections of coastal and southern California, animals apparently arouse and feed periodically. Nevertheless, the mean hibernating temperature for known sites throughout the state is 7.1°C (n=33), and preferred hibernating temperatures are always below 10°C. Although individuals are occasionally found in very warm roosts (>25°C), no hibernating aggregations of more than ten animals have been found in roosts above 11°C (Pierson *et al.*, 1991).

One of the most important characteristics of a suitable hibernating site is that it be free of human disturbance. Human intrusion into a roost can cause animals to arouse from hibernation, thereby using up critical fat stores needed to survive the winter. Also, the animals often roost well within human reach, and are defenseless in their hibernating state.

## DISCUSSION

### Maternity Colonies

#### Past and Current Distribution

Although historic and current records for *C. townsendii* in California indicate the species occurs in a wide variety of habitats (from desert scrub to chaparral, oak woodland, and conifer forest) and in several life zones (particularly Lower and Upper Sonoran and Transition), its distribution appears to be constrained primarily by two factors: availability of suitable roosting sites and degree of human disturbance at roosts.

The primary centers of distribution for *C. townsendii* in California in the past 30-70 years are found in areas that offer caves or cave analogues (such as old mine workings). Thus populations have been concentrated in the limestone formations of the Sierra Nevada and Trinity mountain ranges, the volcanic formations in the northern part of the state, and a number of mining districts (most significantly those in the desert regions east and southeast of the Sierra Nevada, the Mother Lode country, and the inner coast range north of San Francisco). Although the majority of *C. townsendii* colonies are still found in cave and mining districts, there have been notable declines in either number of colonies or population levels in the Mother Lode country of the Western Sierra foothills, and in the mining district along the Colorado River, two areas that experience heavy recreational use. Both historically and currently, there have also been significant coastal populations located in buildings or other human-made structures (e.g., bridges or water tunnels). These have declined most notably in San Francisco Bay area counties, where native habitat and rural land have undergone conversion for agriculture (i.e., wine production) or suburban/urban development.

## Population Trends

The results of this survey suggest there have been marked population declines for *C. townsendii* in California in the past 40-60 years -- a 52% loss in the number of maternity colonies (Appendix I), a 44% decline in the number of roosts, a 55% decline in the total number of animals (Table 2), and a 32% decrease in the average size of remaining colonies in the state. The most notable declines have occurred in the Mother Lode country, along the Colorado River, in San Diego County, in the San Francisco Bay area, and along the northern coast. The only areas where populations appear to be stable are at Lava Beds National Monument and at Point Reyes National Seashore. Although there are currently relatively high densities of *C. townsendii* in the mining districts of Inyo County, lack of historic distribution records precludes assessment of population trends, and several of these populations are under threat from renewed mining operations.

The first consideration is whether observed discrepancies between current and historic records are indicative of a long-term trend, or fall within the expected variation for populations sampled at two points in time. This survey plus available information on the population biology of *C. townsendii* point to a long-term trend. Because bats are long-lived animals with a low reproductive rate (for *C. townsendii*, one young per year), and tend to show great loyalty to chosen roosts, their populations do not show the interannual fluctuations in numbers and distribution characteristic of some mammalian taxa. Pearson et al. (1952) predicted that, with a 38-46% survival rate in the first year, and 75% chance of survival thereafter, population size at maternity sites should remain relatively stable year to year. Studies on two species of *Plecotus* in Britain (Stebbing, 1966b), and populations of *C. townsendii* in Virginia (V. Dalton, pers. comm.) revealed that undisturbed populations maintained constant numbers over time. Although a precipitous decline due to a catastrophic event would not be surprising for any one colony, the pattern, observed in this survey, of a number of colonies, sampled over a broad geographic area, showing serious declines is alarming, and argues for a general decline in California *C. townsendii* populations. Available evidence suggests that human activity has been the primary cause.

## Factors Contributing to Population Declines

### Loss or Damage of Roosting Habitat

The combination of restrictive roost requirements and sedentary behavior would suggest that *C. townsendii* is roost limited, and that roost loss, through disturbance or destruction, has been primarily responsible for population declines in most areas. Although fire, winter storms, or general deterioration are sometimes responsible, in all but two of 38 cases, roost loss could be directly linked to human activity (e.g., demolition, renewed mining, entrance closure, human-induced fire, renovation, or roost disturbance). Population declines are most highly correlated with roost destruction in the San Francisco Bay area, along the northern coast, and in San Diego County, and with roost disturbance in the Mother Lode country and along the Colorado River.

### Human Activity at Roosts

Human intrusion into a roost can be very damaging to a population, particularly during the maternity season when females are aggregated and rearing defenseless young. The intense recreational use of caves and mines in California provides the most likely explanation for why otherwise suitable, historically significant roosts are currently unoccupied. It is well documented that *C. townsendii* is so sensitive to human disturbance, that simple entry into a maternity roost can

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cause a colony to abandon or move to an alternate roost (Pearson *et al.*, 1952; Graham, 1966; Stebbings, 1966a; Mohr, 1972; Humphrey & Kunz, 1976).

Recreational activity provides the most likely explanation for the loss of traditional cave roosts in the Mother Lode country. Here, a number of historically known roost sites, which are structurally unchanged, have been abandoned or are occupied unpredictably. Whereas colonies in excess of 200 animals were known historically, the current mean colony size is 47 (vs. a statewide mean of 112, and an historical mean of 167). Work in Canada (Brigham and Fenton, 1986) has shown that reproductive success was significantly reduced in colonies of *Eptesicus fuscus* which were temporarily excluded from their primary roost. Although not documented at this point, it seems possible that human activity at *C. townsendii* maternity roosts has reduced reproductive success and contributed to the downward trend in colony size,

Whereas many species will dwell in the roofs or attics of inhabited buildings, *C. townsendii* selectively seeks unused sites. In this survey, all but four building roosts were abandoned at the time *C. townsendii* was using them. In the four that were used by humans, the roost was either separate from the utilized space or in a protected setting in which the animals had not been harassed and visitation by humans was restricted.

The expanding human population along the California coast, in the greater San Francisco Bay area, and San Diego County has made it increasingly difficult for *C. townsendii* to find roosts that are free from human disturbance. There was evidence of some human traffic at or near all the currently occupied roosts. Recreational vandalism is also common at bat roosts (Klimack, 1987). In two roosts (Bodfish Cave in Kern County, and Wilson Canyon Mine in Inyo County), the presence of dead bats (obviously killed by humans) documented recent vandalism events. The Wilson Canyon roost, monitored since 1988, has not been reoccupied since the vandalism event (P. Brown, pers. comm.).

Eliminating bats is a lucrative business for pest control companies (Tuttle and Kern, 1981), and remains a threat wherever bats roost close to people and a fear of rabies is prevalent. In this study, population declines were observed in two Napa County roosts (Aetna Springs Resort and Old Bale Grist Mill) after spraying with pesticides. Although the use of pesticides against bats is prohibited under EPA rules and current California law, it does still occur (D. Constantine, pers. comm.).

Another local problem historically may have been excessive collection for scientific purposes. One Marin County colony (Olema Inn) was almost entirely eliminated in one collecting effort in the 1970s. A sequence of collections for scientific purposes on Santa Cruz Island may have contributed to declines in this isolated population. Additionally, there are large single site series of *C. townsendii* (>75 animals) at several museums (e.g., California Academy of Sciences, Los Angeles County Museum, the Museum of Vertebrate Zoology). In most cases the long term effects of these collections are not known, but given the low reproductive potential of *C. townsendii*, they are likely to be damaging, particularly in those cases where colonies have been subjected to repeated collections or where the series represent a significant proportion (>20%) of a local population.

### The Significance of Old Mines as Roosting Habitat

*C. townsendii* is one of several cavern-dwelling, western bat species that relies very heavily on old mine workings for roosting habitat (Pierson *et al.*, 1991). This raises several significant

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conservation issues regarding this species (Riddle, 1995). First, safety considerations have led to extensive mine closure programs in western states, often without consideration for the biological values of old mines. If closures are done at the wrong time of year, or without prior biological survey, they can result in the entrapment, and thus elimination of entire bat colonies.

Second, the resurgence of gold mining in the west potentially threatens cavern-dwelling bat species (Brown and Berry, 1991; Pierson *et al.*, 1991; Brown *et al.*, 1993). Since open pits, created by current mining practices, are often located in historic mining districts, old mine workings are frequently demolished as part of the ore extraction process. Known *C. townsendii* roosts have been destroyed or are scheduled for demolition at four known mining sites in the state, and have been displaced at others. While effective mitigation is possible (Pierson, 1989; Pierson *et al.*, 1991), there is currently no legal mandate requiring that existing populations be protected.

Third, the use of cyanide in the ore extraction process has caused wildlife deaths at a number of mine sites in the West. Although bats comprise 33.7% of documented wildlife fatalities (Clark and Hothem, 1991), they frequently are not considered in assessment of cyanide risks (Nevada Mining Assoc. *et al.*, 1990).

### Loss of Foraging Habitat

It is also possible that destruction or damage of foraging habitat is contributing to the declines in *C. townsendii* populations in some areas. This appears most likely in urbanized regions and along the Colorado River. Although recreational use of mines along the Colorado River is high, a number of the more remote mine workings receive little human visitation (particularly in the hotter summer months). Furthermore, parallel population declines for a number of other bat species since the 1940s (including those, like *Myotis velifer*, that appear more tolerant of roost disturbance), suggest that agricultural conversion of the Colorado River basin and decimation of the cottonwood riparian zone along the river, may be partially responsible (K. Stager, pers. comm.).

The potential impact of logging on *C. townsendii* foraging habitat has not been examined, and warrants investigation. Logging recently occurred in Siskiyou County, close to the largest known *C. townsendii* roost, and a timber cut, covering several sections, is proposed in the Modoc National Forest, within a few km by air of the Lava Bed National Monument populations. Since no bat species in California are considered sensitive (PETS) by the Forest Service, there is no mandate other than the provisions of the National Forest Management Act and NEPA for the Forest Service to consider the impacts of their activities on bat populations. These provisions have not been adequate.

While loss of foraging habitat may be a significant factor in some areas, *C. townsendii* appears to be fairly adaptable regarding its foraging requirements. Although a moth specialist (Kunz and Martin, 1982; Dalton *et al.*, 1986), it feeds on a wide variety of lepidopterans. Light tagging studies indicate the animals are opportunistic, feeding in a range of habitats, from open agricultural fields to dense forest (data from V. Dalton and V. Brack; pers. obs.). In California, the species occurs in rural settings from the inland deserts to the cool, moist coastal redwood forests, in oak woodlands of the inner coast ranges and Sierra foothills, and lower to mid-elevation mixed coniferous-deciduous forests (up to 1,800 m in California, and > 2,000 m in Nevada [MVZ records]).

### Inadequate Management Policies on Public Lands

Of the 20 largest currently known colonies, 13 are on public lands (see Appendix V). The National Park Service has jurisdiction over six sites, the USFS over four, the BLM over one, and the Department of Defense over two. Although not all these sites have been brought to the attention of the responsible agency, the National Park Service has made the most substantial commitment to managing known sites for the animals (e.g., Death Valley National Monument has installed protective bat gates on several mines; Pt. Reyes National Seashore has done structural modifications to secure two building roosts against human intrusion; Lava Beds National Monument and Sequoia National Park have made roost caves off limits to the public by closing areas or keeping localities confidential. Additionally, the California Department of Parks and Recreation has been responsive regarding cave management. An historically important population of *C. townsendii* was excluded from Mitchell Caverns by an improper gate installation in the early 1970s. This gate was replaced with a “bat friendly gate” in the summer of 1993, and within days *C. townsendii* began to reoccupy the site. The Forest Service has been far more reluctant to recognize the biological significance of caves and mines. The decision makers within this agency continue, often against the advice of their own biologists, to give first priority to recreational interests, despite the documented incompatibility between recreational caving and cave roosting bat populations. Although the National Forest Management Act mandates the Forest Service maintain viable populations of native wildlife and the 1988 Cave Resources Protection Act directs the Secretaries of Interior and Agriculture to identify, protect and maintain significant caves, two of the historically most significant, and now apparently extirpated, populations of *C. townsendii* (the hibernating colony in Subway Cave, and the maternity roost at Samwell Cave) occupied caves promoted by the Forest Service as tourist caves. Although an inappropriate gate at Samwell Cave has been replaced by a “bat friendly” design, tourists are still granted access to the cave upon request. The only active attempt to protect *C. townsendii* roosting sites through a gating program was initiated on Sequoia National Forest in response to the an appeal being filed (Pierson and Brown, 1992). BLM biologists, concerned for the status of *C. townsendii* populations located in mines or caves on their land, frequently report they are unable to obtain support from superiors for site protection.

### **Assessment of Current Risk**

*C. townsendii* populations have declined at a disturbing rate in the past 40-50 years, and despite isolated conservation measures, remain at high risk throughout most of their range in California. A comparison of past and present population size at 18 colonies reveals stable or increasing populations only at Lava Beds National Monument and Point Reyes National Seashore, where active protective measures and monitoring programs have been instituted in response to the preliminary findings of this survey. Protective gates have also been installed for the Knoxville, Sulfur Creek, Death Valley National Monument colonies (Pierson *et al.*, 1991; P. Brown, pers. comm.), and at Mitchell Caverns in Providence Mountains State Park (K. Miner, pers. comm.). Populations, although still below historic levels, have increased at all these sites. While these measures are essential for the persistence of particular colonies, they are not adequate to protect the species in California, nor to ensure the reversal of declining population trends. Intense roost disturbance persists in many areas, particularly the Mother Lode country, and other roosts are currently at risk from renewed mining. None of the populations are likely to persist without management intervention.

## **Status of *C. townsendii* by Area**

Because the risk factors vary somewhat geographically within the state, each area (as defined in Appendix II) is treated separately below.

### Area 1 (Northern Coast and Inner Coast Ranges)

Of the twelve colonies previously known from this area, seven (and possibly eight) still exist, and two new roosts were identified. This area contains four colonies currently receiving some protection and monitoring -- two at Point Reyes National Seashore (Olema and Bolinas) and two on Homestake Mining Company land (Knoxville and Sulfur Creek). The future for others, particularly the Calistoga colony, is uncertain. Currently the greatest risk to colonies in this area is roost disturbance at unprotected sites and deterioration of poorly maintained building roosts. Two of the currently unprotected sites (Butter Creek and Cecilville Caves) are in the Shasta Trinity National Forest, and should be managed by the Forest Service to exclude the public during the maternity season.

### Area 2 (Central Coast)

Out of eight *C. townsendii* colonies that were known in the past along the coast from the San Francisco Bay area to Santa Barbara only one remains, and only one new roost was found. *C. townsendii* appears to be extirpated from the heavily suburbanized communities of the East Bay and the Peninsula. Individual animals were located in more rural areas around Livermore and Calaveras Reservoir, but the size of resident populations in these areas is unknown. The two currently extant maternity colonies, one near Pescadero in San Mateo County, and one near Santa Inez in Santa Barbara County, are fairly large (>150), but their roosts occur on private land (one in a structurally unsound building), and their future is very uncertain. The greatest risk to populations in this area appears to be loss of roosting sites, and secondarily, foraging habitat to development.

### Area 3 (Northeastern)

Of the four colonies that were previously known in this area, three still remain, and colony size appears to have remained stable in two. Also, three (and possibly four) substantial new colonies were identified. The largest colonies (ca. 27% of total known population) of *C. townsendii* occur in this area. Four of the six known colonies, all caves, occur on public land (two at Lava Beds National Monument, one on the Shasta-Trinity National Forest, and one on the Klamath National Forest). Lava Beds National Monument has taken significant steps toward restricting human access to roosts. A comparable management policy is needed for the two caves on Forest Service land. A bat friendly gate has been installed at the Shasta-Trinity cave, but no monitoring program or management plan have been implemented. One of the most important historic roosts for this species, Samwell Cave, under the jurisdiction of Shasta-Trinity National Forest, long unavailable to the animals because an inappropriate gate (now replaced) covered the entrance, continues to receive heavy tourist visitation. Another roost, an abandoned railroad tunnel near Dunsmuir, discovered in 1991, was destroyed by Southern Pacific Railroad shortly thereafter for hazard abatement. The greatest threat to colonies in this area is, however, disturbance due to recreational caving.



#### Area 4 (Western Sierra)

Although *C. townsendii* is still relatively frequently encountered in caves in the western Sierra foothills, the species is no longer found in many of its traditional maternity sites, and populations appear to be seriously reduced. The six currently used roosts that could be monitored have a total population of only 125 animals.

Five out of nine (55.5%) of the roosts used in the past are no longer occupied. Three of these are now commercial tourist caves. One of these, privately owned Moss Cave, once contained the largest known colony in the Mother Lode. Although cavers report occasional sightings of a colony in the area, several attempts to locate this colony have been unsuccessful. Characteristic ceiling stains at old roosting locations in Bower Cave indicate that this site also once contained a very significant (multiple hundreds) *C. townsendii* population. Although recently acquired by the Stanislaus National Forest, which is developing a management plan, the cave is currently being heavily used for recreation by local residents. Attempts to date by the Forest Service to control access appear to have been unsuccessful. Occasional accumulations of *C. townsendii* guano indicate a population is still trying to use this cave.

Those roosts that are still occupied have small, highly disturbed populations. For example, the Murphys population appears to move with disturbance among three known caves, and another yet to be identified locality. An attempt by a landowner and one group of recreational cavers to gate one of these caves at first met with intense resistance from other recreational cavers, and the gate was breached a number of times. The Boyden Cave population roosts near the gated entrance of a tourist cave. Although the guides are sensitive to the bats, groups pass below the cluster a number of times each day, and colony size is much smaller than it once was (S. Fairchild, pers. comm.). The Bodfish Cave population, the only one known in the Lake Isabella area, had been vandalized (i.e., 10 dead, smashed, animals were found) when visited in August 1988, and was threatened again in the spring of 1992 by the proposed closure of numerous mine workings in the area by Sequoia National Forest (Pierson and Brown, 1992). Semi-fossilized guano formations within this cave suggested a very large colony had existed here at one time, although the colony is now relatively small (about 33 adults).

A reactivation of mining in the Mother Lode country also poses a potential threat to *C. townsendii*. One small colony is located in an old mine near Jamestown, which, until recent suspension of mining activities, was scheduled for demolition as part of a current mining operation. The extent to which *C. townsendii* is using old mines in the Mother Lode area has not been fully explored.

In 1991 staff at Sequoia National Park located a well protected cave within park boundaries that had a large (0.3 x 0.6 m) cluster of *C. townsendii* in April 1991, suggesting a colony size >200. Although the colony was not occupying the cave in July 1991, a large *C. townsendii* guano deposit confirmed the presence of a colony in the area. The Park has expressed a commitment to protecting this colony.

#### Area 5 (Eastern Sierra)

This area supports some of the largest populations of *C. townsendii* in the state. There are 12 known roosting sites, with about 31% of the total population for the state. Eleven of the 12 known roosts occur in mines, primarily on public lands. Most of these colonies are at risk for disturbance from recreational use, mine closure for hazard abatement, or reactivation of old mining claims. The

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roost at Wilson Canyon on the Naval Weapons Center was vandalized in 1988 and has not been reoccupied since. Since numbers increased at the nearby Mountain Springs Mine, some animals from Wilson Canyon may have moved there. Other mines, like the Poleta, Snowflake, and Yaney all had evidence of extensive recreational use. The Briggs mines are scheduled for demolition as part of an active mining operation. The only colony with assurance of future protection is located in Death Valley National Monument. Yet despite efforts by the Park to protect this site through gating, it was vandalized in 1993, and the number of animals occupying the site in the summer of 1993 was greatly reduced.

#### Area 6 (Providence Mountains)

Two roosts were known historically from this area, one in Mitchell Caverns, now a state park, and the other in mine workings in Macedonia Canyon. The Mitchell Caverns colony was excluded in about 1970, when the cave entrance was redesigned and a bat-proof gate installed. The occasional occurrence of individual *C. townsendii* in the caverns or nearby mine workings indicates a population still exists in the area. Within days of replacing the gate in the summer of 1993, *C. townsendii* began to reoccupy the cave (K. Miner, pers. comm.). Reactivation of a private mining claim in Macedonia Canyon has excluded the *C. townsendii* colony from its historical roost, but the colony has relocated to another mine in the area. Another population of *C. townsendii* was identified to the east of the Providence Mountains, in the Castle Mountain range, by the capture of a lactating female. The primary roost site has not been located, but is likely in the Hart Mine complex (P. Brown, pers. comm.).

#### Area 7 (Colorado River Basin, Eastern Mojave Desert)

The Colorado River Basin once supported large bat populations (K. Stager, pers. comm.). This survey and work conducted by P. Brown and P. Leitner since the 1960s have documented *alarming* declines for most species. *C. townsendii* was once found in many mines along the Colorado River (K. Stager, pers. comm.); three maternity sites were known; and the Alice Mine housed the largest colony (>1000 adults) known in California. Extensive surveys by P. Brown and E. Pierson in 1990, and further surveys by P. Brown in 1991 and 1992 have revealed only one relatively small maternity roost in the Mountaineer Mine (present in 1991, but not in 1992), and one isolated individual. Recreational use of abandoned mines is high along the Colorado, and may account for much of the observed decline. A number of surveyed mines, however, which had no evidence of disturbance and offered suitable roosting conditions, also had no bats. Extensive agricultural conversion of the lower Colorado flood plain over the past sixty years has likely reduced available foraging habitat, and contributed to the observed declines (although this species is known to feed over alfalfa and corn fields in the East [V. Dalton, pers. comm.]). Pesticides, which are heavily used in this area, also may have had a negative effect.

#### Area 8 (San Diego County)

Although *C. townsendii* was not one of the most common species in San Diego County even in the 1930s (Kruttsch, 1948), it was widely distributed and frequently encountered. None of the four colonies identified in the past still exist. Evidence from fall and winter records suggests a small population exists in Noble Canyon in Cleveland National Forest, but this colony has not been located during the maternity season. The primary cause for decline in western San Diego County is likely rapid suburbanization.

### Area 9 (Santa Cruz Island)

Although there are isolated records for *C. townsendii* on four of the Channel Islands (Brown, 1980), the only maternity colony that has been identified occurs on Santa Cruz Island. It has been disturbed a number of times over the years both by displacement from roosts and collection for scientific purposes. A colony, relocated in 1991, in a building at the east end of the island (P. Brown *et al.*, 1994), is less than half its former size. It is currently roosting in an area under negotiation for purchase by the National Park Service.

### **Priorities for Roost Protection**

It is apparent from this study and others that one of the primary factors contributing to declines in *C. townsendii* populations is disturbance or loss of roosting sites. Protection of roost sites, primarily by gating, has been effective in protecting populations in the East (Stihler and Hall, 1993; V. Dalton, pers. comm.). In California, four populations have been protected since the initiation of this survey: two at the McLaughlin (= Knoxville) Mine in 1988, by gating old mine workings (Pierson, 1989; Pierson *et al.*, 1991) and the others at Point Reyes National Seashore, by securing buildings against vandalism. The three that have been monitored closely have increased in size.

Existing *C. townsendii* colonies have been assigned priorities for protection throughout the state based on three criteria: colony size, geographic significance, and historic importance (Appendix V). The twenty colonies with 100 or more animals were selected on size criteria alone, and assigned Priority #1. Priority #2 was given to roost sites that were once large and historically significant (e.g., Samwell, Moss and Bower Caves, Mitchell Caverns), and/or represented isolated populations (e.g., Santa Cruz Island, Noble Canyon, and Murphys). Since it has been shown for other bat species that sites long abandoned due to disturbance will be reoccupied once the disturbance factor is removed (Tuttle, 1979), it is reasonable to expect that with appropriate protection, historically important roosts would be reoccupied if populations have not been totally extirpated. Priority #3 was assigned to remaining colonies of 50 or more, and Priority #4 to smaller colonies (or colonies of unknown size) of historic or geographic importance. These priorities (especially #4) would be expected to change for some colonies as more information is available.

## **Hibernating Roosts**

### **Population Declines**

Information on hibernating populations is limited and difficult to evaluate. Declines have been precipitous at four known hibernacula, and appear to be stable only at Lava Beds National Monument. There are two possibilities: 1) that the populations have dropped to the levels indicated, or 2) that the known sites have become unsuitable, forcing the animals to alternate roosts. While there is little question from the maternity roost data that populations of *C. townsendii* have been declining, it is unlikely to be at the rate indicated by this limited census of hibernacula, since the numbers at the temporally more stable maternity sites should provide a better indicator of current status. Nevertheless, the paucity of animals at historically preferred sites is alarming. If, as is possible, the animals have been forced to select less suitable sites with suboptimal temperature regimes, the short- and long-term consequences for these populations could be serious.

## Loss of Hibernating Sites

Although individual animals can be found hibernating in a number of places (buildings, caves, mines), most of the known group hibernating sites are in structurally stable caves. In these situations, the greatest risk to the animals is repeated human disturbance. Population declines associated with human disturbance at hibernacula have been documented for a number of species, including European *Plecotus* (Mohr, 1953; Stebbings, 1966a; Humphrey, 1978). Human presence in a hibernaculum can cause animals to arouse from torpor, thereby using up valuable fat stores that may be required to survive the winter. Three of the formerly known hibernating sites, Parrish, Subway and Bartlett Mountain caves all experience a substantial amount of human traffic.

Recent data collected by S. Altenbach and H. Milford (1991) in New Mexico has highlighted the extreme importance of old mines, and particularly shafts, as hibernating habitat for bats. Since shafts are often hazardous and difficult to survey, closure programs rarely consider wildlife. The largest known *C. townsendii* hibernaculum (up to 10,000 animals), located in a deep shaft in New Mexico, was destroyed by vandals, who set fire to the timbered walls, in the winter of 1992 (S. Altenbach, pers. comm.). The Knoxville hibernating site, the largest known mine roost (166 animals) in California, was demolished by renewed mining in the area in the early 1980s.

Given that *C. townsendii* populations travel relatively short distances to find hibernating sites, and seem to have fairly restrictive roost requirements (especially regarding temperature regimes), the supply of suitable hibernating sites for any one colony is almost certainly limited in most areas.

## Assessment of Current Risk

Although very little is known about the hibernating behavior of *C. townsendii* in California, it is well documented that the hibernating period is a critical time for temperate zone bat species. Accumulating enough fat stores in the autumn to survive the periods of low to zero food availability is a challenging physiological task, leading to high mortality rates, particularly for the young (Mohr, 1953 & 1972; Humphrey, 1978; Tuttle and Stevenson, 1982). Having suitable, disturbance free, hibernating sites is probably essential for the long term survival of this species. It is impossible, based on this study, to estimate how much, if any, of the decline observed at maternity sites is attributable to losses at the hibernacula. This could only be determined with a more complete survey of wintering sites. It would, however, be possible to initiate protection of known roosts.

## RECOMMENDATIONS

### Proposed Management/Conservation Measures

1. The highest priority should be to seek state and federal protection for *C. townsendii*. Given observed population declines, precarious status for most known roosts, pressures on populations from mining, logging, recreational caving, and development, it seems clear that threatened or endangered status is warranted.
2. Immediate steps should be taken to protect key maternity sites, particularly on public lands. In many cases adequate protection could be accomplished by gating the roost entrance, using a gate design that excludes people but allows bats to pass through (Pierson *et al.*, 1991), or by securing a

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building roost against vandalism (as has been done at Point Reyes National Seashore). Although appropriate gate design is essential, it is not sufficient. Gates must also be maintained, and human traffic prohibited during the critical maternity or hibernating seasons. Those sites that issue keys to visitors upon request (e.g., Samwell Cave in Shasta-Trinity National Forest) need to alter their management practices if historical *C. townsendii* populations are to be reestablished.

3. Key populations (based on both size and geographic distribution) should be monitored on an annual or biannual basis to document current population trends. Counts should be conducted, as they were in this study, by counting animals upon emergence from the roost, using night vision equipment.

4. Regulatory agencies need to be informed of the extreme importance of both caves and anthropogenic structures, such as mines, as roosting habitat for *C. townsendii* and other bat species. Too often the biological significance of these habitat features is overlooked in the environmental assessment process.

5. An appropriate survey protocol needs to be established for *C. townsendii*. Since this species is rarely caught in nets or identified with an acoustic detector, it often escapes detection using standard bat survey techniques. Because roost surveys offer the only viable survey method, and roost disturbance is such a critical issue, guidelines need to be established for survey methods which do not require roost entry (e.g., electronic monitoring devices and night vision equipment), or which set standards for roost entry in those cases where access to the roost is necessary.

6. Baseline foraging studies should be required of any private or public party proposing a project (e.g., mining, logging, suburban/urban development) which has the potential to alter foraging habitat for *C. townsendii*. So little information is available on the foraging requirements of this species there is currently no way to assess potential impacts from various types of habitat alteration.

7. In light of the findings of S. Altenbach in New Mexico (pers. comm.; Altenbach and Milford, 1991), a policy to regulate destruction of potential hibernating sites should be instituted. For example, no mines or caves should be closed or destroyed in the winter months without prior surveys for hibernating bats. Since there appears to be some movement in and out of hibernating sites throughout the winter in most parts of California, monitoring inaccessible portions of potential hibernating sites without entry is possible. At present, however, the only cost-effective way to evaluate large numbers of sites is entry.

### **Research Goals**

1. Although in the course of this survey we were able to identify certain roost requirements for *C. townsendii*, and show that roosts are abandoned in response to disturbance, there is much more to be learned about the specific effects of roost disturbance, most importantly the impacts on colony composition and reproductive success. This is particularly critical in the Mother Lode country.

2. Information gathered in recent years on the roosting and foraging requirements of *C. townsendii* (Dalton *et al.*, 1986; Pierson *et al.*, 1991; Fellers, 1993; Lacki *et al.*, 1993 & 1994; Brown *et al.*, 1994) suggests the need for longitudinal studies covering a variety of habitats during different phases of the reproductive cycle.

3. Additional surveys are needed to explore the limits of distribution for *C. townsendii* in California. Certain areas, like some of the mining districts, were overlooked altogether, and other areas, like the north coast and inner coast ranges, warrant further investigation.

### **Education Programs**

Much of the disturbance and habitat destruction could be alleviated through education. In our experience, it takes relatively little effort for people to become sensitive to the needs of these animals. There are a number of ways the State of California could facilitate a bat education program:

1. California, with its extensive state park system and high bat diversity, would provide an excellent laboratory for developing model education programs. We know from contacts made during this survey, and workshops we have conducted, that many park rangers are eager to incorporate bat education into their natural history programs, but they lack the basic knowledge and necessary educational materials. Many materials, both books (i.e., Barbour and Davis, 1969; Fenton, 1983 & 1992; Tuttle, 1988) and slide shows ("Bats of America" and "Bats: Myth and Reality") are available from Bat Conservation International in Austin, Texas.
2. Produce an educational guide to the bats of California, following the example of several states, Canadian provinces, and the National Park Service (i.e., Alberta Fish and Wildlife, no date; Colorado Division of Wildlife, 1984; French *et al.*, 1986; Harvey 1986; Geluso *et al.*, 1987).
3. Develop an educational poster on the bats of California.

### **ACKNOWLEDGEMENTS**

We would like to thank the California Department of Fish and Game for its support of this project, and in particular, Caryla Larsen for her interest and encouragement. We are deeply indebted to A.K. and O.P. Pearson, without whose past work and current assistance, this project would not have been possible, and to P.E. Brown who has assisted in the field, generously shared her extensive knowledge of bat populations in southern California, and supplied much of the data for southern California populations. Also, R. Miller of the Shasta Area Grotto has volunteered many hours to identifying and monitoring populations in northern California.

We are especially grateful to the McLaughlin Mine, Point Reyes National Seashore, and Lava Beds National Monument. All have contributed resources to the project, and made a commendable commitment to protect *C. townsendii* roosts. Particular assistance has come from R. Krauss, D. Koontz, N. Lehrman and D. Enderling at McLaughlin Mine; G. Fellers and A. Quintero at Point Reyes National Seashore; D. Omundson, G. Hathaway, P. Toops, B. Stoffel, S. Underwood, C. Sydoriak, and student interns at Lava Beds National Monument. Also, special thanks to B. Rogers of the USGS; D. Cowan of California Lands and Survey; R. Berry of the China Lake Naval Weapons Center; T. Russi of BLM; R. Woychak and C. Boyd of the Cleveland National Forest; P. Leitner of St. Mary's College; and the numerous members of the California caving community who have assisted in this project and are working to promote bat conservation -- especially L. Wolfe of the Mt. Shasta Area Grotto, L. Woodward, R. Squire, and other members of the Columbia Grotto; and J. Sowers of the Diablo Grotto. All these people have contributed time in the field, and supplied invaluable information regarding *C. townsendii* habitat in California. I am

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also grateful to the support for appropriate bat management by S. Botts, Environmental Manager of the Jamestown Mine, J. White, Environmental Manager of the Hayden Hill Mine, and C. Morgan of Stanislaus National Forest. C. Hills of the Boggs Mountain Reserve provided much appreciated support and accommodations.

Numerous other people contributed assistance in the field -- S. Benson of Inverness, A. Brooke of the University of Tennessee, K. Miner of California Department of Parks and Recreation, T. Jeffreys of Sequoia National Park, M. Faull of Red Rock Canyon State Park, R. Darby of the Cleary Preserve, W. Gummer of the Old Bale Grist Mill State Park, M. Schuler and B. Pochodowicz of San Diego Bat Conservation, C. Mushet-Rogers of the Banner Queen Ranch, J. Livermore of Middletown, D. Reasor of Sunol Regional Park, M. Schwartz and R. Peterson of Audubon Canyon Ranch.

I also appreciate the cooperation of various landowners, administrators, and/or caretakers who have granted us permission to survey their lands. Critical roost information was supplied by R. Bandar, J.C. von Bloeker, D. Constantine, J. Evens, D. Hemphill, H.B. Leech, D. Livingston, J. Musci, and R.T. Orr. The staff of many museums supplied bat records, in particular the Museum of Vertebrate Zoology at Berkeley, the California Academy of Sciences, the Los Angeles County Museum of Natural History, the National Museum of Natural History, the Field Museum in Chicago, the American Museum on New York, the Santa Barbara Museum of Natural History, and the Museum at the University of Michigan.

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