Townsend's big-eared bat, *Corynorhinus townsendii pallescens* and *C. t. townsendii*

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Description: *Corynorhinus townsendii* is a medium sized (10-12 g) vespertilionid, with an adult forearm of 39-48 mm and ears of 30-39 mm. It shows some geographical variation in color, but generally has buffy brown dorsal fur with somewhat paler underparts (Barbour and Davis 1969, Kunz and Martin 1982). *C. townsendii* can be distinguished from all other western bat species by the combination of a two-pronged, horseshoe-shaped lump on the rostrum, and large, rabbit-like ears. Although other California species have long ears (e.g., the pallid bat, *Antrozous pallidus*, the spotted bat, *Euderma maculatum*, the California leaf-nosed bat, *Macrotus californicus*, and the long-eared myotis, *Myotis evotis*), none of these have the two-pronged nose lump, and most can be distinguished by other features (Pierson et al. 1991).

Although the ears on *C. townsendii* are obvious (erect and facing forward) when animals are alert, they can be difficult to see (curled tightly against the top of the head in the shape of a ram's horn) when animals are in torpor or hibernation. At such times, the tragus (a narrow prominence on the frontal, external opening to the ear, which is enlarged in many microchiropteran species), remains erect, and can be mistaken for short, sharply pointed ears, leading to misidentification of the species.

Taxonomic Remarks: *C. townsendii* is in the Family Vespertilionidae. There are five currently recognized subspecies of *C. townsendii* in the United States (Handley 1959); two (*C. t. townsendii* and *C. t. pallescens*) in the western U.S., two (*C. t. ingens* and *C. t. virginianus*) in the eastern part of the country, and one (*C. t. australis*) with a primarily Mexican distribution, which overlaps with *C. t. pallescens* in western Texas. Only the two western subspecies are found in California.

For most of its taxonomic history, the recognized generic name for this North American species was *Corynorhinus*. Beginning, however, with a taxonomic revision by Handley (Handley 1959) it became known as *Plecotus*. Two recent phylogenetic studies have reviewed relationships among plecotine genera (Frost and Timm 1992, Tumlison and Douglas 1992), and have recommended resurrecting the generic name of *Corynorhinus* to distinguish the North American from the Palearctic forms. Because of publication timing, these conclusions are not addressed in the most recent compilation of mammalian species (Wilson and Reeder 1993), but K. Koopman, who prepared the bat section of this volume, indicates that the name for the genus should revert to *Corynorhinus* (K. Koopman in litt.).

Distribution: *C. t. townsendii* occurs in California, Oregon, Washington, Nevada, Idaho, and possibly southwestern Montana and northwestern Utah. *C. t. pallescens* occurs in all the same states as *C. t. townsendii*, plus Arizona, Colorado, New Mexico, Texas, and Wyoming (Handley 1959). Throughout much of their range in California, Idaho, Nevada, Oregon and Washington there are extensive zones of intergradation for the two subspecies. Throughout the zone of intergradation it is frequently impossible to assign individuals to one subspecies or the other. Handley distinguishes the two subspecies based on size and color characteristics, but he also notes that the full spectrum of characteristics for both subspecies can be found within a single population. The results of preliminary mitochondrial DNA studies, using PCR techniques, failed to distinguish between these two subspecies, but this may reflect the relatively conservative region sequenced (cytochrome b) (W. Rainey). For the purposes of this document, we make no distinction between these subspecies.

In California, *C. townsendii* is found throughout most of the state, with populations concentrated in areas offering caves (commonly limestone or basaltic lava) or mines as roosting habitat. The species is found from sea level along the coast to 1,820 m in the Sierra Nevada (Dalquest 1947, Pearson et al. 1952, Pierson and Rainey 1996a). Outside California it has been found to 2,400 m (Jones 1965, Jones and Suttkus 1972) and 2,900 m (Findley and Negus 1953).

Life History: *C. townsendii* is a colonial species, with maternity colonies in California varying in size from a dozen to several hundred animals. Maternity colonies are seasonal, and form in the spring, although the timing varies with latitude. For example, colonies begin to form in March in the desert and central coastal California, and not until June in interior northern California (G. Fellers pers. comm., E. Pierson unpubl. data). A single young is born sometime between May and July (Easterla 1973, Pearson et al. 1952, Twente 1955). *C. townsendii* pups average 2.4 g at birth, nearly 25% of the mother's postpartum mass (Kunz and Martin 1982). Young bats are capable of flight at 2.5 to 3 weeks of age and are fully weaned at 6 weeks (Pearson et al. 1952). Nursery colonies start to disperse in August about the time the young are weaned, and break up altogether in September and October (Pearson et al. 1952, Tipton 1983).

Following the typical pattern for temperate zone vespertilionids, mating generally takes place in the hibernaculum between October and February, with the females storing sperm in the uterine lining until spring, when ovulation and fertilization occur. Females are generally reproductive in their first year, whereas males do not reach sexual maturity until their second year. Gestation length varies with climatic conditions, but generally lasts from 56 to 100 days (Pearson et al. 1952).

Pearson et al. (1952) estimated annual survivorship at about 50% for young, and about 80% for adults. Band recoveries have yielded longevity records of 16 years, 5 months (Paradiso and Greenhall 1967) and 21 years, 2 months (Perkins 1995).

C. townsendii is a relatively sedentary species, for which no long-distance migrations have been reported (Barbour and Davis 1969, Humphrey and Kunz 1976, Pearson et al. 1952). The longest movement known for this species in California is 32.2 km (Pearson et al. 1952).

Although diet has not been examined in detail for any California populations, it is likely that C. *townsendii* here, as elsewhere, is a lepidopteran specialist, feeding primarily (>90% of the diet) on medium sized (6-12 mm) moths (Dalton et al. 1986, Ross 1967, Sample and Whitmore 1993, Whitaker et al. 1977, 1981). Shoemaker and Lacki (1993) determined that *P. t. virginianus* differentially selected noctuid moths, with geometrids, notodontids and sphingids also making up a significant portion of the diet. Representatives of the family Arctiidae constituted 37.5% of the available moth prey items, but were not consumed. Sample and Whitmore (1993) identified moth species from wing fragments collected at maternity caves. Of the 28 moth taxa identified, 15 were noctuids. Twenty-one species were forest dwelling, and six were associated with open, field habitats.

In addition to lepidopterans, small quantities of other insects have been detected in the diet of *C. townsendii*, particularly Coleoptera and Diptera (Dalton et al. 1986, Ross 1967, Sample and Whitmore 1993). Hemiptera, Hymenoptera, Homoptera, Neuroptera, Trichoptera, and Plecoptera have also been found sporadically (Dalton et al. 1986, Whitaker et al. 1977).

Habitat: *C. townsendii* occurs primarily in rural settings from the inland deserts to the cool, moist coastal redwood forests, in oak woodlands of the inner coast ranges and Sierra Nevada foothills, and lower to mid-elevation mixed coniferous-deciduous forests. Its distribution, however, tends to be geomorphically determined, and is strongly correlated with the availability of caves or cave-like roosting habitat. Population concentrations occur in areas with substantial surface exposures of cavity-forming rock (e.g., limestone, sandstone, gypsum or volcanic), and in old mining districts (Genter 1986, Graham 1966, Humphrey and Kunz 1976, Kunz and Martin 1982, Perkins et al. 1994, Pierson and Rainey 1996a).

C. townsendii is primarily a cave-dwelling species, but also roosts in cave analogues, especially old mine workings (Barbour and Davis 1969, Graham 1966, Humphrey and Kunz 1976). In some areas, particularly along the Pacific coast, it has been found in old, mostly abandoned, buildings with darkened, enclosed cave-like attics and in other anthropogenic structures (e.g., water diversion tunnels and bridges)(Barbour and Davis 1969, Dalquest 1947, Howell 1920b, Kunz and Martin 1982, Pearson et al. 1952, Perkins and Levesque 1987, Brown et al. 1994, Pierson and Rainey 1996a).

This species appears to have fairly restrictive roost requirements (Humphrey and Kunz 1976, Perkins et al. 1994, Pierson et al. 1991). Roost temperature appears to be critical (Lacki et al. 1994, Pearson et al. 1952, Pierson and Rainey 1996a), and varies in maternity roosts throughout California from 19°C in the cooler regions to 30°C in the warmer southern regions (Pierson et al. 1991). Some colonies are known to change roosts during the maternity season, using cooler roosts earlier in the year (Pierson et al. 1991, P. Brown pers. comm., V. Dalton pers. comm.). Roost dimensions are also important. The majority of the roosts examined in California are fairly spacious, at least 30 m in length, with the roosting area located at least 2 m above the ground, and a roost opening at least 15 cm by 62 cm (Pierson et al. 1991). Maternity clusters are always situated on open surfaces, often in roof pockets or along the walls just inside the roost entrance, within the twilight zone.

Hibernation sites are generally caves or mines (Pearson et al. 1952, Barbour and Davis 1969), although animals are occasionally found in buildings (Dalquest 1947, E. Pierson pers. obs.). Deep mine shafts, known to provide significant hibernating sites in New Mexico (Altenbach and Milford 1991), may also be important in California (P. Brown pers. comm.). Winter roosting behavior varies with latitude. In areas with prolonged periods of non-freezing temperatures, *C. townsendii* tends to form relatively small hibernating aggregations of single to several dozen individuals (Barbour and Davis 1969, Pierson et al. 1991, Pierson and Rainey 1996a). Larger aggregations (75-460) are confined to areas which experience prolonged periods of freezing temperatures (Pierson and Rainey 1996a).

Studies in the western U.S. have shown that *C. townsendii* selects winter roosts with stable, cold temperatures, and moderate air flow (Humphrey and Kunz 1976, Kunz and Martin 1982). Individuals roost on walls or ceilings, often near entrances (Humphrey and Kunz 1976, Twente 1955). If undisturbed, individuals will frequently roost < 3 m off the ground (Perkins et al. 1994), and have been found in air pockets under boulders on cave floors (E. Pierson pers. obs.). Temperature appears to be a limiting factor in roost selection. Recorded temperatures in *C. townsendii* hibernacula range from -2.0°C to 13.0°C (Humphrey and Kunz 1976, Genter 1986, Pearson et al. 1952, Pierson et al. 1991, Twente 1955), with temperatures below 10°C being preferred (Perkins et al. 1994, Pierson and Rainey 1996a).

Recent radiotracking and light-tagging studies have found *C. townsendii* foraging in a variety of habitats. Brown et al. (1994) showed that *C. townsendii* on Santa Cruz Island in California avoided the lush introduced vegetation near their day roost, and traveled up to 5 km to feed in native oak and ironwood forest. P. Brown (pers. comm.) also documented *Corynorhinus* foraging in desert canyons with water on the west slopes of the Panamint Mountains in Inyo County. Radiotracking and light-tagging studies in northern California have found *C. townsendii* foraging within forested habitat (Rainey and Pierson 1996), within the canopy of oaks (E. Pierson and W. Rainey unpubl. data), and along heavily vegetated stream corridors, avoiding open, grazed pasture land (G. Fellers pers. comm.). In Oklahoma, *C. t. ingens* preferred edge habitats (along intermittent streams) and open areas (pastures, crops, native grass) over wooded habitat (Clark et al. 1993). Light-tagging studies in West Virginia (V. Dalton pers. comm.) showed a bimodal foraging pattern for *C. t. virginianus*, with animals foraging over hayfields during the first part of the night, and within the forest later in the night, traveling up to 13 km from the day roost.

Status: Class I. Recent surveys conducted by Pierson and Rainey (1996a) for the Department show marked population declines for both subspecies in California, and suggest this species should be recommended for Threatened status in the state. Over the past 40 years, there has been a 52% loss in the number of maternity colonies, a 45% decline in the number of available roosts, a 54% decline in the total number of animals, and a 33% decrease in the average size of remaining colonies for the species as a whole statewide. The status of particular populations is correlated with amount of disturbance to or loss of suitable roosting sites. The populations that have shown the most marked declines are along the coast, in the Mother Lode country of the western Sierra Nevada foothills, and along the Colorado River.

A comparison of former and current population estimates for 18 historically known maternity colonies shows that six colonies (33%) appear to be extirpated; six others (33%) have decreased in size; one (6%) has remained stable; and five (28%) (four of which are protected within national parks) have increased.

A comparison of colony size for historically and currently known colonies, indicates that mean colony size has decreased from 165 (n = 18) to 111 (n = 34). The median colony size has decreased from 100 to 75. There are currently 38 known maternity colonies, occupying 55 known roost sites, with an estimated total population of about 4,300 individuals. Only three of these colonies have adequately protected roost sites.

Hibernating *C. townsendii* have been found historically or during a recent survey (Pierson and Rainey 1996a) at 44 sites (24 in mines, 19 in caves, one in a building). Most of these sites contain fewer than 20 individuals. Only three hibernating colonies number more than 100. The most significant aggregations (all those with >100) occur in the most northern part of the state, particularly Siskiyou County. In other areas, particularly the desert, smaller aggregations (5-20) are more typical, although mine shafts, found by Altenbach and Milford (1991) to house the largest aggregations, remain essentially unexplored in California. Four additional hibernating sites, not visited by Pierson and Rainey (1994) were located in 1979 (Marcot 1984), one of which contained 40-50 individuals.

Threats to *C. townsendii* include the following:

The species is roost limited. 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 documented cases, roost loss in California can 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. Population declines along the Colorado River are also attributable to foraging habitat loss due to agricultural expansion.

Human Activity at Roosts. The intense recreational use of caves and mines in California provides the most likely explanation for why most 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 cause a colony to abandon or move to an alternate roost (Pearson et al. 1952; Graham 1966; Stebbings 1966; Mohr 1972; Humphrey & Kunz 1976; Stihler and Hall 1993; P. Brown pers. comm.). Inappropriate behavior on the part of well-intentioned researchers and others (i.e., entry into maternity roosts, capture of animals in roosts) could also contribute to population declines. Mark recapture studies are not without risk, since at least one wing band design causes serious injuries to *C. townsendii* (Pierson and Fellers 1994). Scientific collecting likely resulted in the extirpation of a population at Prisoner's Harbor on Santa Cruz Island (Brown et al. 1994).

Closure of Old Mines. Old mines are significant roosting habitat for a number of bat species, particularly *C. townsendii* (Altenbach and Pierson 1995, Pierson and Rainey 1991, P. Brown pers. comm.). Liability and safety concerns have led to extensive mine closure programs in western states, particularly on public lands, 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 (Altenbach 1995, Navo 1995, Rainey 1995), they can result in the entrapment, and thus elimination of entire bat colonies.

Renewed Mining in Historic Mining Districts. The resurgence of gold mining in the West potentially threatens cave dwelling bat species (Brown and Berry 1991, Brown et al. 1993, Brown 1995). 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. While effective mitigation is possible (Pierson 1989, Pierson et al. 1991), there is currently no legal mandate requiring that existing populations be protected. Renewed mining is known to account for the loss of one substantial colony in the California desert (P. Brown pers. comm.).

Additionally, process water containing cyanide has caused substantial wildlife mortality at a number of mine sites in the West. Although one study found that bats constitute 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). A *Corynorhinus* maternity colony in a mine on the west slope of the Inyo Mountains disappeared after an open cyanide pond was constructed within 2 km of the roost (P. Brown pers. comm.). Similarly, process residues in open oil sumps are another significant source of wildlife mortality (Flickinger and Bunck 1987, Esmoil and Anderson 1995).

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, e.g., in urbanized regions, and along the Colorado River, where the native floodplain community has been subjected to extensive agricultural conversion. Also, forest management activities, particularly timber harvest and spraying that kills non-target lepidopteran species may alter the prey base for *C. townsendii*. Perkins and Schommer (1991) suggest that *Bacillus thuringiensis* sprays may suppress Tussock moth and spruce budworm reproduction enough to suppress reproduction in resident *C. townsendii*. Although the effects of grazing have not been specifically addressed for this species, a radiotracking study at Point Reyes National Seashore indicated that telemetered bats avoided grazed pastureland (E. Pierson pers. obs.). Roosting areas adjacent to water sources may be essential for desert populations of *C. townsendii* (P. Brown pers. comm.).

Inadequate Management Policies on Public Lands. Of the 20 largest currently known colonies in California, 13 are on public lands. While the National Park Service and California Department of

Parks and Recreation have made substantial commitments to protecting known roosts, other agencies have been less willing to recognize the biological significance of cave and mine roosts, often against the advice of their own biologists.

<u>Behavioral Ecology/ Population Biology</u>. The tendency for *C. townsendii* to roost in highly visible clusters on open surfaces, near roost entrances, makes them highly vulnerable to disturbance. Additionally, low reproductive potential and high roost fidelity increase the risks for the species.

Management Recommendations: Given the documented population declines, the precarious status of most known roosts, the pressures on populations from mining, logging, recreational caving, and development, Threatened status under CESA may be warranted.

Steps should be taken to protect key maternity sites, particularly on public lands. In many cases adequate protection could be accomplished by excluding people from the roost site. For caves and mines this generally means gating the roost entrance, using a gate design that excludes people and allows the bats to pass through (Dalton and Dalton 1995, Pierson et al. 1991, Pierson and Brown 1992).

Key populations (based on both size and geographic distribution) should be monitored on an annual or bi-annual basis to document current population trends. Counts should be conducted early in the maternity season (before young are volant) by counting animals upon emergence from the roost, using night vision equipment.

Regulatory agencies need to be informed of the 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 environmental assessment processes.

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) (e.g., Navo 1995, Rainey 1995), or which set standards for roost entry in those cases where access to the roost is necessary.

In light of the findings of Altenbach and Milford (1991) in New Mexico, a policy to regulate destruction of potential hibernating sites should be instituted. For example, no mines or other structures, 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 accurate and cost effective way to evaluate large numbers of sites is entry (Altenbach 1995, Navo 1995).

Additional surveys are needed to explore the limits of distribution for *C. townsendii* in California. Although the surveys conducted in 1992-1994 (Pierson and Rainey 1996a) focused on areas of known historical importance, some likely important areas (e.g., some old mining districts) were not investigated at all, and other areas, like the north coast and inner coast ranges, warrant further investigation.

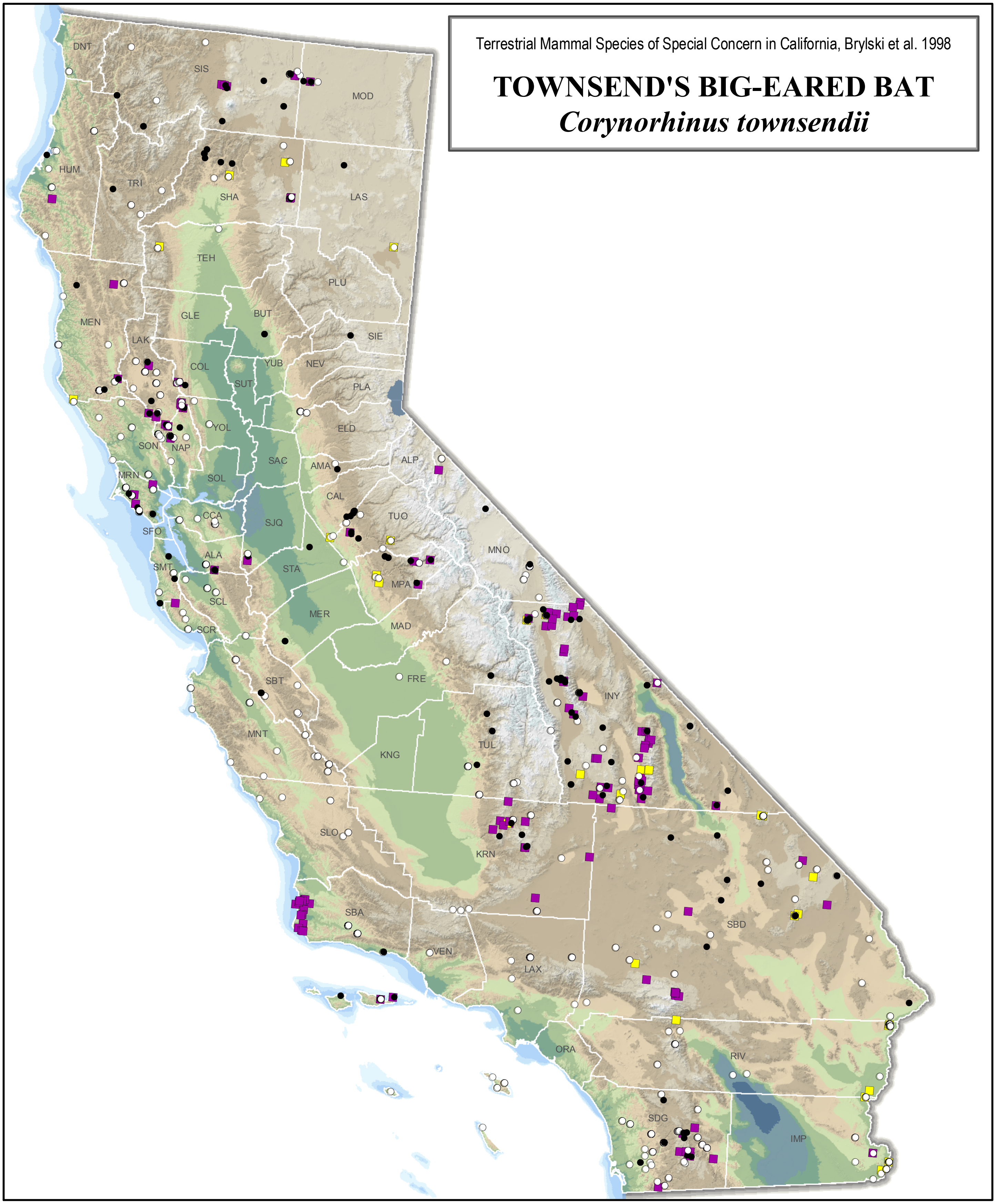
Studies are needed to evaluate the specific effects of roost disturbance, most importantly the impacts on colony composition and reproductive success. This is particularly critical in the Mother Lode country.

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

Terrestrial Mammal Species of Special Concern in California, Brylski et al. 1998

TOWNSEND'S BIG-EARED BAT

Corynorhinus townsendii



RESOURCES AGENCY CALIFORNIA DEPARTMENT FISH & GAME

Locations verified by authors
(captures, observations, museum records)

- ● Post - 1978
- ○ 1978 and before
- ■ CNDDB 1979 - 1998
- ■ CNDDB 1978 and before

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Wildlife Branch:KFien12109