Bats in the South Coast Ecoregion: Status, Conservation Issues, and Research Needs[1]

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Abstract

California's bat fauna is one of the most diverse in the United States. Of the 25 species of bats in the state, 24 have been detected in the south coast ecoregion. Many of these species appear to have experienced population declines in the ecoregion, and 16 are officially recognized as sensitive (including one endangered) by wildlife regulatory agencies. Data from recent field survey work conducted by bat researchers were compiled in order to provide a tentative assessment of the current status of bats within the south coast ecoregion. These data suggest that the pallid bat (*Antrozous pallidus*), Townsend's big-eared bat (*Corynorhinus townsendii*), and California leaf-nosed bat (*Macrotus californicus*) have experienced population declines and could be seriously threatened, particularly at lower elevations. This may also be true for some of the region's other bat species, such as the western red bat (*Lasiurus blossevillii*), but additional research is needed. The Yuma myotis (*Myotis yumanensis*), Mexican free-tailed bat (*Tadarida brasiliensis*), and big brown bat (*Eptesicus fuscus*) were frequently encountered in both Krutzsch's (1948) and recent field inventories, so they appear to remain relatively common at this time. The major threat to bats in the ecoregion is the loss of habitat (especially riparian and oak woodland habitats) due to urban expansion as well as extermination or disturbance of bat colonies. Characterization of species-specific distribution and seasonal habitat use patterns is needed so that land managers can address both foraging and roosting habitat requirements from a landscape perspective. Research is also needed regarding the effects of urbanization, insect control, tree/snag management, bat exclusions, mine closures, and recreational activities, specifically rock-climbing, on bat populations.

Key words: bat conservation, Chiroptera, habitat loss, population status, species diversity

Introduction

California has the fourth highest diversity of bat species in the United States, following Arizona, New Mexico, and Texas, with 25 species representing three families. Twenty-four of these species occur in the south coast ecoregion of the state, indicating the importance of the region to bat diversity. Over two-thirds of the region's bat species are officially recognized as sensitive by the California Department of Fish and Game, U.S. Fish and Wildlife Service, and/or Federal land management agencies at this time (*table 1*). The California Department of Fish and Game (B. Bolster pers. comm.) reports that four additional species have been proposed to become *California Species of Special Concern* in the latest draft of "Mammal Species of Special Concern in California" (CSC* in *table 1*).

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Table 1—*Bats of California and their legal status. All except* Myotis occultus *have been previously documented in the south coast ecoregion.*

Family/ Scientific name[1]	Common name	Legal status[2]
Phyllostomatidae	**American leaf-nosed bats**	
Macrotus californicus	California leaf-nosed bat	CSC, FSS, BLM
Choeronycteris mexicana	Mexican long-tongued bat	CSC
Leptonycteris curasoae yerbabuenae	Lesser long-nosed bat	FE[3]
Vespertilionidae	**Mouse-eared bats**	
Myotis lucifugus	Little brown bat	none
Myotis occultus	Arizona myotis	CSC, BLM
Myotis yumanensis	Yuma myotis	FSC, BLM
Myotis velifer	Cave myotis	CSC, BLM[3]
Myotis evotis	Long-eared myotis	FSC, BLM
Myotis thysanodes	Fringed myotis	FSC, CSC*, BLM
Myotis volans	Long-legged myotis	FSC, CSC*, BLM
Myotis californicus	California myotis	none
Myotis ciliolabrum	Small-footed myotis	FSC, BLM
Lasionycteris noctivagans	Silver-haired bat	none
Pipistrellus hesperus	Western pipistrelle	none
Eptesicus fuscus	Big brown bat	none
Lasiurus blossevillii	Red bat	CSC*, FSS
Lasiurus xanthinus	Western yellow bat	CSC*
Lasiurus cinereus	Hoary bat	none
Euderma maculatum	Spotted bat	CSC, FSC, BLM
Corynorhinus townsendii	Townsend's big-eared bat	CSC, FSC, FSS, BLM
Antrozous pallidus	Pallid bat	CSC, FSS, BLM
Molossidae	**Free-tailed bats**	
Tadarida brasiliensis	Mexican free-tailed bat	none
Nyctinomops femorosaccus	Pocketed free-tailed bat	CSC
Nyctinomops macrotis	Big free-tailed bat	CSC
Eumops perotis californicus	Western mastiff bat	CSC, FSC, BLM

[1] Scientific names after Koopman (1993), with the exception of *Corynorhinus townsendii* (Frost and Timm 1992, Tumlison and Douglas 1992), *Lasiurus blossevillii*, and *L. xanthinus* (Baker and others 1988, Morales and Bickham 1995).

[2] Legal status categories include Federal Endangered (FE), Federal Species of Concern (FSC), California Species of Special Concern (CSC), Forest Service Sensitive (FSS), and Bureau of Land Management Sensitive (BLM). Source: Calif. Dept. of Fish and Game, Special Animals List of July 2002 and species proposed to become California Species of Special Concern (CSC*, DFG—B. Bolster pers. comm.)

[3] Currently known in the state from only two or three recent public health records from urban areas in the ecoregion (Constantine 1998).

Despite the high diversity and sensitivity of bats in the south coast ecoregion, this group of mammals has been largely ignored during environmental review of proposed projects and in recent multi-species planning efforts. This is primarily due to the lack of information on the distribution, seasonal habitat associations, and population status of bat fauna. The purpose of this paper is to bring together recent bat inventories, in order to attempt a preliminary assessment of population status and research needs for this ecologically important group of mammals in the south coast ecoregion of California.

Historic and Recent Field Studies

Early studies of bats covering portions of the south coast ecoregion of California include Grinnell (1918), *A Synopsis of the Bats of California*; Krutzsch (1948), *Ecological Study of the Bats of San Diego County, California*; and Vaughan (1954), *Mammals of the San Gabriel Mountains of California*. While all three studies presented species records for the region, only Krutzsch (1948) attempted to assign estimates of relative abundance of species with respect to environmental factors, such as gross climatic zones, topography, life zones, and plant associations (*table 2*). In addition, 18 of the 24 species in the ecoregion are represented in Krutzsch's study. This allows us some measure by which to compare and contrast historic and current information regarding bat species richness and diversity within the ecoregion.

Table 2—*Relative abundance of bats in San Diego County (A-abundant, C-common, R-rare) by topographic areas during the 1930s and '40s, after Krutzsch (1948). Scientific names as in table 1.*

Species	Coastal plain	Inland valley	Western foothills	Mountains	Eastern foothills	Desert
Ma. californicus		R	R			C
C. mexicana	R	R				
M. yumanensis	C	A	A	C		
M. evotis			C	C		
M. thysanodes			C	C	R	
M. volans			R	R		
My. californicus	C	C	A	A	C	C
M. ciliolabrum		R	C	C	C	C
P. hesperus		C	C		A	A
E. fuscus	C	A	A	A	C	
L. blossevillii	C	C	C			
L. cinereus	C	C	C			
C. townsendii	C	A	A	A	C	C
A. pallidus	A	A	A	R	C	C
T. brasiliensis	A	A	A	C	C	
N. femorosaccus			R		R	
N. macrotis	R					
E. perotis	R	R	C		R	

The only recent published literature on bat distribution in the region is a review of public health records by Constantine (1998), in which he focused on range extensions of ten rare or uncommon species. However, government agencies and private individuals have conducted inventories of bat fauna at various locations throughout the ecoregion in recent years. Written reports or data for some of these efforts have been obtained to develop a picture of the current status of bats in the ecoregion. These studies vary in duration, intensity, and area covered, but all used at least two of the three primary detection methods for bats: mist-net capture, acoustic detection, and roost searches. The most extensive of the studies is the 3-year study by the USDA Forest Service on bat habitat associations within the four southern California national forests (Simons and others 2000), conducted for the Southern California Mountains and Foothills Assessment (Stephenson and Calcarone 1999). Results from this study have been divided according to national forest boundaries to provide a more geographic representation of the data. The most intensive of the studies presented are those for Orange County (Remington 2000) and Marine Corp Air Station at Miramar

(MCAS Miramar) in San Diego County (Hunsaker 2001), for which the total nights of effort were 68 and 73, respectively, with multiple visits to most, if not all, of the sites sampled. Data from the collection of unpublished studies have been summarized and grouped into two general topographic categories: studies conducted in the coastal plain or inland valley areas, with the majority of sampling sites located under 300 meters elevation, and studies conducted in the foothills or mountain areas with the majority of sampling sites above 300 meters (*table 3*). This division roughly corresponds to the topographic divisions in *table 2* (after Krutzsch 1948), as well as the current location of the expanding edge of urbanization. The general study areas are mapped in *figure 1*.

There are several caveats to keep in mind when comparing results of these studies. Selection of sample sites among studies was subjective, and the distributions of the sites are not likely representative of habitats present within the study area. Bat researchers typically select sites near water or suspected roosts where the probability of detecting and capturing bats is higher. The seasonal distribution of sampling effort also varied among studies with most, if not all, of the effort focused on the summer season. Within the region, some species are more commonly detected during migration (for example, silver-haired bat, *Lasionycteris noctivagans*) or in winter months (Mexican long-tongued bat, *Choeronycteris mexicana*, and hoary bat, *Lasiurus cinereus*). The studies also differ in the relative emphasis of the survey methods employed. Some species are not readily detected acoustically due to either low call amplitude or inconsistent use of echolocation (Townsend's big-eared bat, *Corynorhinus townsendii*, and Mexican long-tongued bat), while others are not readily captured in mist nets (western mastiff bat, *Eumops perotis*). In addition, species identification based solely on limited acoustic data can be problematic, as with *Myotis* species. In consideration of the above, we recognize that the lack of species detection within any one study does not necessarily mean that a species is absent from the study area. However, together these studies do provide some indication of the frequency at which species are detected during field investigations across the ecoregion.

Both Krutzsch (1948) and recent field studies (*table 3*) detected 18 species. However, Krutzsch's list included the Mexican long-tongued bat, while recent studies include the spotted bat (*Euderma maculatum*). In general, both historic and recent studies indicate that species diversity is higher in the foothills and mountains than the coastal plain and inland valleys in terms of the relative frequency of detection, particularly for the genus *Myotis*.

Other Records

Five other species occurring in the ecoregion, unaccounted for in the above studies, include the little brown bat (*Myotis lucifugus*), cave myotis (*Myotis velifer*), western yellow bat (*Lasiurus xanthinus*), silver-haired bat, and the federally-listed endangered lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*). These species are reported in the ecoregion based on a few individual specimens and/or public encounters in urban settings only (Bond 1977, Constantine 1998). Additional information on bat distributions can be obtained through investigation of encounters reported by the public (Remington 2000, KLM and DCS pers. obs.) These records compliment recent field studies by providing information for the coastal plain/inland valley

Table 3—*Summary of recent bat inventory studies in the south coast ecoregion showing the number and percent (shown in italics) of sites at which each bat species was detected. The studies are grouped into two general topographic categories: coastal plain and inland valleys (A-F) and foothill and mountains (G-N).*

	Study[1]													
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
	Effort (nights/sites)													
	68	30	12	73	16	36	33	3	11	14	21	26	33	35
Species	6	26	9	23	7	24	21	7	8	12	17	14	21	19
Ma.						1								
californicus						*4*								
M.	6	19		15	6	13	15	7	5	5	3	3	7	4
yumanensis	*100*	*73*		*65*	*86*	*54*	*71*	*100*	*63*	*42*	*18*	*21*	*33*	*21*
M.						3			1	7	2	3	7	3
evotis						*13*			*13*	*58*	*12*	*21*	*33*	*16*
M.										1	2	2	1	5
thysanodes										*8*	*12*	*14*	*5*	*26*
M.											2	3	3	4
volans											*12*	*21*	*14*	*21*
My.	3				2	7	8		6	7	9	7	9	12
californicus	*50*				*29*	*29*	*38*		*75*	*58*	*53*	*50*	*43*	*63*
M.					4	10	12	4	6	10	4	4	6	10
ciliolabrum					*57*	*42*	*57*	*57*	*75*	*83*	*24*	*29*	*29*	*53*
P.		2		1	7	9	8	3	3	10	9	8	3	3
hesperus		*8*		*4*	*100*	*38*	*38*	*43*	*38*	*83*	*53*	*57*	*14*	*16*
E.	4	17		3	6	12	17	4	7	10	9	9	18	14
fuscus	*67*	*65*		*13*	*86*	*50*	*81*	*57*	*88*	*83*	*53*	*64*	*86*	*74*
L.	1		1	2	4	2	1		4	1	1		1	5
blossevillii	*17*		*11*	*9*	*57*	*8*	*5*		*50*	*8*	*6*		*5*	*26*
L.				1	2	4			4	1		1	2	3
cinereus				*4*	*29*	*17*			*50*	*8*		*7*	*10*	*16*
C.					1	3		1	2	4			1	5
townsendii					*14*	*13*		*14*	*25*	*33*			*5*	*26*
E.											1			1
maculatum											*6*			*5*
A.	3	7				3	1	2	2		4	3		
pallidus	*50*	*27*				*13*	*5*	*29*	*25*		*24*	*21*		
T.	6	18	1	11	7	16	11	2	6	8	3		3	5
brasiliensis	*100*	*69*	*11*	*48*	*100*	*67*	*52*	*29*	*75*	*67*	*18*		*14*	*26*
N. femoro-	2	5		9	7	13	10		6	9			2	7
saccus	*33*	*19*		*39*	*100*	*54*	*48*		*75*	*75*			*10*	*37*
N.			1		1	3			2	1				
macrotis			*11*		*14*	*13*			*25*	*8*				
E.	6	12		10	7	12	13	2	8	10	6	1	7	11
perotis	*100*	*46*		*43*	*100*	*52*	*62*	*29*	*100*	*83*	*35*	*7*	*33*	*58*

[1] A) Orange County, Remington 2000; B) Camp Pendleton Marine Corp Base, Brown and Berry 1999; C) Pt Loma, USGS 2002 unpublished data D) Marine Corp Air Station, Miramar, Hunsaker 2001; E) San Diego National Wildlife Refuge, Stokes unpublished data; F) San Diego County MSCP area, USGS 2002 unpublished data; G) Southern Santa Ana Mountains, Fisher & Crooks 2000; H) Potrero Creek, Riverside County, Stokes unpublished data; I) Ysabel Ranch Preserve, USGS 2002 unpublished data; J) Cleveland National Forest, Descanso District, USGS 2002 unpublished data; K) Los Padres National Forest, L) Angeles National Forest, M) San Bernardino National Forest, and N) Cleveland National Forest, Simons and others 2000.

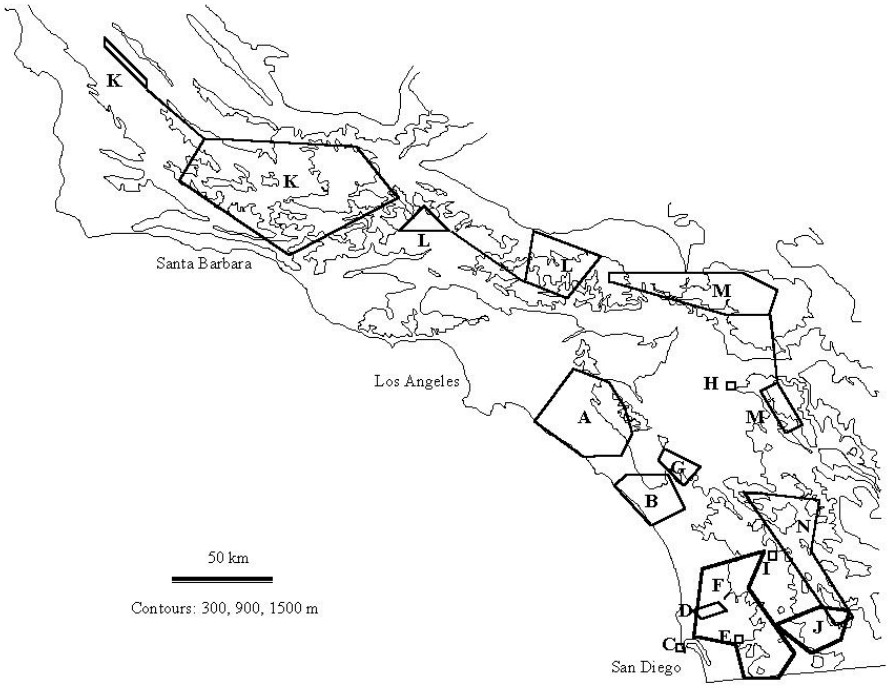

Figure 1—Locations and general area covered by recent bat inventories conducted within the south coast ecoregion. Letters correspond to studies as in *table 3*.

topographic regions, which are more urbanized now than during Krutzsch's study and, therefore, under-represented in recent fieldwork conducted in wildlands.

Current Population Status

Declining Populations

Inferences regarding the population status of bats in the south coast ecoregion can be made from the information presented above. There is reasonably strong evidence of population declines within the ecoregion for three species: the pallid bat (*Antrozous pallidus*), Townsend's big-eared bat, and California leaf-nosed bat (*Macrotus californicus*).

The pallid bat is a large-bodied species that typically roosts in a variety of crevice-like situations and feeds primarily on large arthropods, including several terrestrial species (Barbour and Davis 1969). It appears to have undergone a serious decline within the ecoregion, particularly in the low-lying areas. Krutzsch (1948) described the coastal race as being abundant from sea level through the western foothills, occurring in riparian, chaparral, oak savannah, and cultivated areas. All of the roosts located by Krutzsch were in man-made structures, often in association with other common species such as the Yuma myotis (*Myotis yumanensis*), big brown bat (*Eptesicus fuscus*), and Mexican free-tailed bat (*Tadarida brasiliensis*). Vaughan (1954) referred to this species as "probably the most common and characteristic bat of the citrus belt" at the Pacific base of the San Gabriel Mountains. However, by the 1970s only one of twelve roosts previously described by Krutzsch as having been

consistently occupied for a decade in San Diego County was still extant (P. Brown pers. comm.). In recent years, the pallid bat has been detected in the Transverse Range (Simons and others 2000), sycamore-oak riparian areas in and around the Santa Ana Mountains (Brown and Berry 1999, Fisher and Crooks 2000, Remington 2000), and a few inland valley sites in southern San Diego County (USGS 2002[4]). During the last decade in San Diego County we have observed numerous colonies occupied by the three common bat species listed by Krutzsch as pallid bat associates; however, very few pallid bat colonies have been documented. Although this species can be found in rural settings, it appears to be intolerant of urban development (E. Pierson pers. comm., Remington 2000). Populations will likely continue to decline as urban expansion encroaches into the foothills of the region.

The Townsend's big-eared bat occurs in a variety of habitats, including desert scrub, sagebrush, chaparral, and deciduous and coniferous forests, where it feeds primarily on moths (Barbour and Davis 1969). However, its distribution is strongly correlated with the availability of roosting habitat such as caves or cave-like structures including mines, tunnels, abandoned buildings, and bridges (Pierson and Rainey 1998a). According to Krutzsch (1948), the Townsend's big-eared bat was "widely and commonly distributed from the seacoast to the desert." He described it as common on the coastal plain and abundant in the inland valleys, foothills, and mountains (*table 2*). Now it appears that within the south coast ecoregion the species is relatively rare and limited primarily to the foothill and mountain areas (*table 3*). Pierson and Rainey (1998a) reported that the cismontane maternity colonies described by Krutzsch in San Diego County were no longer extant. This species was often encountered during recent mine surveys conducted above 850 m within the ecoregion, but few maternity colonies were confirmed (Miner and others 2000, Simons and others 2000). The Townsend's big-eared bat is not readily detected in mist net or acoustic surveys; roost searches are the most efficient survey method for this species. However, roost surveys must be undertaken with caution because disturbance at the roost can result in abandonment by this species. The loss of or disturbance to both maternity and hibernation roost sites has been recognized as the primary threat to the Townsend's big-eared bat throughout the western United States (Pierson and others 1999). There are few known extant maternity colonies within the ecoregion, and none can be considered adequately protected. Due to the species' vulnerability to human disturbance at roost sites, further declines might be expected as the human population increases within the region.

The California leaf-nosed bat is a tropical, insectivorous species that ranges north into the lower Sonoran life zone of southern California, Arizona, and New Mexico. It is an obligate cave or mine roosting species and requires roost temperatures in excess of 26°C year-round to survive because it lacks the ability to hibernate (Bradshaw 1962 in Anderson 1969). Historically, the California leaf-nosed bat was known from a few caves, tunnels, or mines in the inland valleys of the south coast ecoregion (Bond 1977, P. Brown pers. comm., Constantine 1998, Grinnell 1918, Krutzsch 1948). Live individuals of this species have not been observed at the Los Angeles/Ventura County sites since the late 1940s or early 1950s (Constantine 1998), nor have they been seen at the northern San Diego County sites since the early 1900s (P. Brown pers. comm.). However, one extant small colony (less than a dozen bats) continues to persist in a tunnel at an inland valley site in southern San Diego

[4] Unpublished data on file, U.S. Geological Survey, Western Ecological Research Center, San Diego, CA.

County (P. Brown pers. comm., USGS 2002[5]). While the California leaf-nosed bat can still be found in the California deserts, this species appears to have been all but extirpated from the south coast ecoregion.

Stable Common Populations

Based on the information provided by the various bat inventories (*table 3*) and the authors' experience investigating calls received by San Diego Bat Conservation (SDBC), it is clear that three species—Yuma myotis, Mexican free-tailed bat, and big brown bat—are relatively common within the south coast ecoregion and appear to be relatively urban-adapted. All three readily roost in man-made structures. The Yuma myotis forages primarily over open water, although it will forage in other habitats, and often roosts near available water sources. The Mexican free-tailed bat covers large areas while foraging over a variety of habitats. This, along with its generalized roosting requirements (caves, rock crevices, buildings, and bridges), makes it probably the most adaptable species in urban landscapes. The big brown bat is typically found in association with wooded areas, whether natural or planted. Although fairly common in both field studies and SDBC public contacts, evidence suggests that this species might not persist in small isolated habitat fragments or highly urbanized areas (Remington 2000.)

Stable Uncommon and Rare Populations

There are several uncommon-to-rare species that appear to have relatively stable populations within the ecoregion. These include the western pipistrelle (*Pipestrellus hesperus*), small-footed myotis (*Myotis ciliolabrum*), long-eared myotis (*Myotis evotis*), fringed myotis (*Myotis thysanodes*), long-legged myotis (*Myotis volans*), and Mexican long-tongued bat. While the desert population of western pipistrelle is abundant in rocky areas, the coastal population apparently always has been less abundant (Krutzsch 1948). This species appears to still be present in rocky canyon habitat of the inland valleys, foothills, and mountains. The small-footed myotis occupies the same topographic regions as the western pipistrelle but seems to be associated more with riparian and wooded habitats. While still regularly encountered, both of these species may be experiencing habitat loss in the lower elevations of their range within the ecoregion.

The long-eared myotis, fringed myotis, and long-legged myotis occur primarily in forested habitat in the mid- to upper elevations of the region. Based on limited historic collections, they likely have never been particularly common, especially the latter two species (Grinnell 1918, Krutzsch 1948, Vaughan 1954). Recent field studies in the upper elevations of the ecoregion detected these species at a few sites within each study area, indicating that they are patchily distributed throughout the forests. These species have been documented roosting in snags or trees in other portions of their range (Barclay and Brigham 1996). However, during the USDA Forest Service's southern California forest bat study, individual bats of these species were radio-tracked to rock crevices and building roosts (Miner and Brown 1996). The only maternity colony documented during the study was a building roost of long-eared myotis (~ 30 individuals). Timber harvest is the major threat to these species in other portions of their range (Barclay and Brigham 1996). While currently this is not a serious threat within the ecoregion, there is concern that the removal of snags or

[5] Unpublished data on file, U.S. Geological Survey, Western Ecological Research Center, San Diego, CA.

trees, such as is done for hazard abatement, fire suppression, and forest pest management, may seriously impact *Myotis* species. Of particular concern is the lack of known extant maternity colonies for the fringed myotis and long-legged myotis (B. Bolster pers. comm.).

The Mexican long-tongued bat feeds on pollen and nectar, specializing in the flowers of agaves and columnar cactus. It will also visit hummingbird feeders and other nectar-rich plants (Arroyo-Cabrales and others 1987, W. Peachey pers. comm.), possibly even farmed avocado plants in the ecoregion (public contact investigations). The southern part of the ecoregion represents the northwestern extreme margin of the otherwise subtropical distribution of the Mexican-long-tongued bat. It roosts in shallow caves and mines throughout most of its range. However, in California the species has yet to be documented in the wildlands and instead is found in residential areas, roosting in garages, sheds, porches, and under houses built on stilts. The Mexican long-tongued bat was first recorded in San Diego County in the late 1940s in developed areas along the coast and inland valleys (Olson 1947). Since then, individuals have been turned in to public health departments in Los Angeles, Orange, and Ventura counties (Constantine 1998). While the Mexican long-tongued bat is regularly seen during fall and winter in San Diego residential areas, it is as yet undocumented that it remains during the maternity season, and it is presumed not to breed in California.

Increasing Populations

The western yellow bat is another primarily subtropical species. It is known to roost among the fronds of palm trees and was first recorded in palm habitat of the California desert in the 1940s (Constantine 1946). Now it is regularly encountered year-round in urban areas throughout the region, primarily in association with planted palm trees (Constantine 1998, D. Simons pers. comm., KLM and DCS pers. obs.), and it is assumed to breed within the ecoregion (P. Brown, pers. comm.). This apparent expansion into the ecoregion may be in response to exotic landscape plantings and possibly to global warming (Constantine 1998).

Status Unknown

It is not possible to determine the population status for the 11 remaining species within the ecoregion based on available information. This is due to either the seasonal or elevational bias of the field studies or the lack of comparable historical data. The survey effort for most of the field studies presented above (*table 3*) was concentrated during the summer months. Therefore, tree-roosting species such as the silver-haired bat and hoary bat that occur in the ecoregion primarily during migration or winter are less frequently encountered. Most hoary bat records within the ecoregion are between late September and May (Vaughan and Krutzsch 1954, authors' public contact investigations). However, some individuals remain all summer in the higher elevations of the mountains (KLM and DCS pers. obs., Simons and others 2000, Vaughan and Krutzsch 1954). The higher detection frequency of hoary bats in the most recent field studies in San Diego County (studies E and F in *table 3*) is due to spring survey effort, when hoary bats are migrating. The silver-haired bat is a migratory species associated primarily with coniferous forests and is not known to breed in southern California (Barbour and Davis 1969). It is only represented within

the ecoregion from public contact records (Constantine 1998), presumably encountered during migration.

Urbanization in the south coast ecoregion has removed habitat primarily at lower elevations. For bat species that rely on the impacted habitat types, population status would be predicted to decline. Such appears to be the case for the western red bat and California myotis (*Myotis californicus*). However, surveys focused on these habitat types, as well as urban landscaped areas, are needed before conclusions can be drawn. The western red bat (*Lasiurus blossevillii*) is a solitary, migratory species that roosts in the foliage of trees and shrubs (Shump and Shump 1982). It has a strong association with riparian woodlands, especially in the lowlands of the Central Valley and southern California (Pierson and others 2000). It has also been observed to roost in orchards (Constantine 1959, Grinnell 1918, Krutzsch 1948, Vaughan 1954). According to Grinnell (1918), the sexes segregate during late spring and summer, with females remaining in the lowlands and males moving to higher elevations. However, Krutzsch (1948) found both sexes of this species to be common year-round from the coast up into the western foothills. After reviewing location records for the species, E. Pierson (pers. comm.) postulated that coastal southern California could provide very important wintering as well as summering habitat for the western red bat. Additional studies are needed at lower elevations during both winter and summer to determine whether this species, like riparian birds, has indeed suffered critical habitat loss from agricultural conversion, reservoir construction, and urban expansion. The California myotis has generally been considered to be common to abundant throughout all topographic regions of the ecoregion (Krutzsch 1948), particularly in oak woodland canyons (DCS pers. obs., Vaughan 1954). However, current data suggest that local declines may be occurring in the more developed portions of the coastal plains and inland valleys.

Bat surveys in urban settings in coastal plain and inland valley areas could help determine the status of other bat species in the ecoregion as well. Constantine (1998) documented the first and only two specimens of the federally listed, endangered lesser long-nosed bat for the state from southern California public health records. This species is similar in habit to the Mexican long-tongued bat in that it is migratory, forages on pollen and nectar, and roosts openly in cave-like situations. Like the Mexican long-tongued bat, it appears to be found within the ecoregion during the fall and winter in association with exotic landscaping in urbanized areas. Another species that is only known in the ecoregion from a few public health records is the cave myotis, which previously was only known in the state along the Colorado River (Constantine 1998). While these records may represent vagrants or inadvertently transported individuals, it is possible that these species, like the Mexican long-tongued bat and western yellow bat, may be expanding their range into the ecoregion.

It is difficult to determine current population status relative to historic occurrence information for several species of bats, including the western mastiff bat, big free-tailed bat (*Nyctinomops macrotis*), pocketed free-tailed bat (*Nyctinomops femorosaccus*), and spotted bat. This is due primarily to the fact that acoustic detection is now used more frequently as a survey method, greatly increasing the detectability of these species. Historically, the greatest concentration of western mastiff bat roosts documented in the state was in southern California (Pierson and Rainey 1998b). Many of these roosts were located near the base of the Transverse Range in the Los Angeles basin, often in buildings. Natural roosts for this species are located primarily in rock crevices on cliffs and large rock outcrops. The western mastiff bat

was detected in all but the USGS Point Loma study represented in *table 3*, and it was previously detected at Point Loma as well (P. Brown pers. comm.). This does not necessarily mean that it is abundant within the ecoregion. The detection rate of the mastiff bat is greater relative to other species because it has an echolocation call falling within the human range of hearing that can be heard at distances up to 300 meters. Because of this, its relative abundance can be overestimated. Of particular concern is the apparent decline of this species in the northern portion of the Los Angeles basin. In their statewide review of the western mastiff bat, Pierson and Rainey (1998b) were unable to detect this species in areas that had provided numerous historic records. The western mastiff bat was also recorded only from one site in the Angeles National Forest (*table 3*), providing further evidence for a possible decline in that area. This species typically forages over wide-open spaces of various habitats (Pierson and Rainey 1998b). It is likely that urban development of the coastal plain has greatly reduced foraging habitat for this species in the ecoregion.

As with the western mastiff bat, pocketed and big free-tailed bats appear to be more frequently detected now than historically, both in field studies (*table 3*) and public health records (Constantine 1998). This could be due to increases in their populations within the region or to improved survey methods and increased public contact with these species. Both of these species roost in rock crevices on cliff faces and have been found to use abandoned rock quarries in San Diego County (KLM and DCS pers. obs.). The pocketed free-tailed bat is detected throughout the southern portion of the south coast ecoregion and east through the deserts. The big free-tailed bat is much rarer and found further north along the coast than the pocketed free-tailed bat (Constantine 1998).

The spotted bat always has been represented in the region by few records and is probably so rare as to be easily missed without committing to focused searches. Likewise, the Transverse Ranges forming the northern border of the ecoregion may represent the most southern limit of the little brown bat in the state, explaining the rarity of records for this species.

Conservation Issues

Although specific information from the south coast ecoregion is lacking, the basic ecology of bats and information from focused studies conducted elsewhere provide indications of relevant conservation issues. Bats have specific seasonal roosting requirements that may or may not be met within a given roost, area, or region. Most bats will change roosts several times over their annual cycle, through longitudinal or altitudinal migration or local movements (Barbour and Davis 1969). Recent research has shown that many tree roosting species will switch roosts every few days (Barclay and Brigham 1996). This means that multiple roosts of varying temperature regimes need to be available within appropriate habitat and flight distance of the species for a population to remain viable. Bats also need adequate foraging habitat within the nightly commute distance from a given roost. Commute distances vary among species (Pierson 1998) and seasonally within a given species (Brown and others 1995). Therefore, spatial distribution of roosts and foraging habitat may be critical for sustainable bat populations. This necessitates that a landscape-level approach be taken when considering bat conservation, especially in a region experiencing large-scale urban development and increased habitat fragmentation such as the south coast ecoregion.

Another important conservation issue with respect to bats is the wanton destruction of or disturbance to bat colonies. Many species of bats aggregate into colonies during at least a portion of their annual cycle, making them vulnerable to catastrophic events. This is particularly true for colonies that find the microclimatic conditions of man-made structures favorable, placing them in close proximity to humans. Irrational fears and misconceptions regarding health risks have led to the needless destruction of numerous bat colonies. In addition, several species of bats, most notably the Townsend's big-eared bat (Pierson and others 1999), will abandon roosts if frequently disturbed. Due to low fecundity (typically one pup per year, Barbour and Davis 1969), longevity (individuals may live for over a decade, Hill and Smith 1984), and the fact that colonial bats typically exhibit high site fidelity from year to year (Lewis 1995), recovery or recolonization is slow if it occurs at all. While public education can help dispel myths about bats, and humane exclusions can spare the lives of bats, physical protection of occupied roosts is crucial for bat conservation, particularly for the rarer species.

Even though there is a wide range of threats to bats (Pierson 1998), the greatest threat in the south coast ecoregion is urban/suburban expansion and its associated impacts to roosts and foraging habitat. Loss or conversion of habitat at the lower elevations, particularly of riparian and oak woodlands, has likely had significant impacts on regional bat fauna. Moreover, once bats take up residence in suitable anthropogenic roosts and are discovered, they are often driven out or exterminated. Even tree trimming activities (for example, palm skinning) can impact bats that attempt to roost in landscape plantings. The effects of urbanization reach beyond the immediate developed areas. These edge effects include recreational activities, which increase disturbance to nearby natural roosts and mines, and increased predation from human commensal animals, particularly domestic cats. Thus, the urban-wildland interface may act as a sort of population "sink," where bats appear to be common at first (possibly even attracted to man-made structures) but then decrease in abundance or richness with time and further development of the area (Remington 2000). As the urban landscape continues to encroach into the foothills, the number and relative abundance of bats in the ecoregion is likely to decline.

Other relevant threats to bats in the south coast ecoregion include water projects or the development of transportation routes, in which riparian habitat is reduced or geomorphic roosting habitat (cliffs and mines) is blasted or inundated. Several historic roosts appear to have been lost in this fashion (Pierson pers. comm.). However, dams and highway bridges do provide roosting habitat for some species of bats. Many of the dams and bridges within the region currently house bat colonies, primarily of Yuma myotis and Mexican free-tailed bats. Bridge replacement or alteration has the potential to eliminate resident colonies, but California Department of Transportation and other jurisdictions are now considering impacts to bats by their bridge projects and ways to avoid them.

Closure of mines for hazard abatement or renewed mining activities can greatly impact many species of bats, including several threatened species, such as the Townsend's big-eared bat (Brown 1995, Riddle 1995, Tuttle and Taylor 1994). The USDA Forest Service and Bureau of Land Management are making an effort to conduct bat surveys for such projects and address potential impacts.

Recreational activities such as cave or mine exploration and rock climbing can disturb bats, potentially affecting reproductive success and survival or causing roost abandonment. While impacts from cave and mine entry are well documented (Hill

and Smith 1984, McCracken 1989, Tuttle 1979), impacts to bats from rock climbing need to be investigated. Once important mine roosts are discovered, protection measures (for example, gating) should be implemented following established guidelines for the species involved.

Prescribed burns and wildfires can create snags and cavities favored by several species of bats for roosting (Barclay and Brigham 1996), but these snags also may be destroyed in a fire or even selectively removed afterwards to reduce perceived hazards. Another concern stems from the observation that some lasiurine bats will roost under leaf litter during winter (Moorman and others 1999, Saugey and others 1998) and, thus, could be killed when fires (for example, prescribed burns) occur during winter months. Smoke inhalation also can kill roosting bats if the fire or smoke enters the mines or caves.

Because most of our bats are insectivorous, the application of pesticides is a threat to bats. Not only is there a potential for reduction of the prey base, but bats also may be directly poisoned, either through consumption of tainted prey or by being sprayed while roosting in trees or orchards. Although chlorinated hydrocarbons, which were documented to impact bats (Clark 1981), are now banned in the United States, the effects of the now popular organophosphates on bats and other wildlife have not been fully investigated. Even application of Bt (*Bacillus thuringiensis*) may significantly reduce the prey base, especially moths, which form the majority of the diet for many species of bats (Ross 1967). For further discussion of conservation issues and threats to bats, see Pierson (1998).

Research Needs

Bats need to be recognized as ecologically important members of natural communities that warrant greater research effort within the ecoregion. Due to the lack of current information, until now bats have been excluded from regional habitat conservation planning efforts. General bat inventories need to be conducted across the ecoregion during all seasons. Priority should be given to the coastal plains and inland valleys where habitat loss is proceeding rapidly and species appear to be on the decline. These areas also appear to be important to wintering bats and as foraging areas for far-ranging species that roost in the foothills, such as the free-tailed bats.

Focused, systematic surveys need to be conducted to determine the status and distributions of species that appear to have suffered population declines and are vulnerable to extirpation. These species include the California leaf-nosed bat, Townsend's big-eared bat, pallid bat, and western red bat, followed by the western mastiff bat, hoary bat, and possibly the California myotis. The availability of suitable roost sites is a major limiting factor for many species, and roosting aggregations are extremely vulnerable to disturbance or destruction by humans. Therefore, roost sites, particularly for the rarer species, need to be located and given the highest level of protection. However, it is also important to determine and protect the foraging habitat associated with those roosts if the colony is to remain viable. To this end, research into species-specific home-range size and attributes, including juxtaposition of roosting and foraging habitat, would be valuable. This is particularly true with respect to preserve design and management. Land managers also would benefit from information on the effects of recreational activities, such as rock-climbing, and the effects of prescribed fire.

Given that the bats of the region are almost exclusively insectivorous, research also is needed on factors affecting insect distribution and abundance, including the effects of pesticides, exotic vegetation, and artificial lights.

The south coast ecoregion, with its rapidly increasing human population and associated urban expansion, provides an ideal opportunity to study patterns of urban landscape use by bats and the effects of habitat loss and fragmentation on bat species diversity and reproductive success (Remington 2000).

Other potential research topics relevant to the ecoregion include the response of bats to riparian habitat restoration, the effectiveness of artificial roosts used as mitigation, the effects of climatic change on bat distribution, and the value of bats as indicators of healthy ecosystems.

While in the past bat research has been logistically difficult, recent technological advancements provide valuable tools to aid ecological investigations. We hope that current and future efforts will greatly expand our knowledge of this fascinating and ecologically important group of animals and provide the information necessary for their conservation within the ecoregion and elsewhere.

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References

Anderson, S. 1969. ***Macrotus waterhousii.*** American Society of Mammologists, Mammalian Species No. 1; 4 p.

Arroyo-Cabrales, J.R.; Hollander, R.; Jones, J.K., Jr. 1987. ***Choeronycteris mexicana*.** American Society of Mammologists, Mammalian Species No. 291; 5 p.

Baker, R.J.; Patton, J.C.; Genoways, H.H.; Bickham, J.W. 1988. **Genetic studies of *Lasiurus* (Chiroptera: Vespertilionidae).** Occasional Papers, the Museum, Texas Tech. University 117: 1-15.

Barbour, R.W.; Davis, W.H. 1969. **Bats of America.** Lexington, KY: University of Kentucky Press; 286 p.

Barclay, Robert M.R.; Brigham, R. Mark, editors. 1996. **Bats and forests symposium**; 1995 October 19-21; Victoria, British Columbia, Canada. Work Paper. 23/1996. Victoria, B.C.: Research Branch, British Columbia Ministry of Forests; 292 p.

Bond, S.I. 1977. **An annotated list of the mammals of San Diego County, California.** San Diego Society of Natural History Transactions 18: 229-248.

Bradshaw, G. van R. 1962. **Reproductive cycle of the California leaf-nosed bat, *Macrotus californicus*.** Science 136: 645-646.

Brown, P.E. 1995. **Closure of historic mines and mitigation for impacts on bat populations.** In: Proceedings of conference on mine closure: Creating productive public and private assets; 287-288.

Brown, P.E.; Berry, R. 1999. **Bat survey at the Marine Corps Base, Camp Pendleton, California, 1995-1997.** Bishop, CA: Brown-Berry Biological. 24 p. Available from U.S. Marine Corps, Camp Pendleton. Oceanside, CA; Contract M00681-94-C-0041.

Brown, P.E.; Berry, R.; Brown, C. 1995. **The California leaf-nosed bat (*Macrotus californicus*) and American Girl Mining Joint Venture—impacts and solutions.** In: Proceedings VI: Issues and technology in the management of impacted wildlife; 1994 April 4-6; Thorne Ecological Institute, Glenwood Springs, CO; 54-56

Clark, D.R. 1981. **Bats and environmental contaminants: A review.** Special Scientific Report No. 1. Washington, DC: Fish and Wildlife Service, U.S. Department of the Interior; 27 p.

Constantine, D.G. 1946. **A record of *Dasypterus ega xanthinus* from Palm Springs, California.** Bulletin, Southern California Academy of Sciences 45: 107.

Constantine, D.G. 1959. **Ecological observations of lasiurine bats in the North Bay area of California.** Journal of Mammology 40: 13-15.

Constantine, D.G. 1998. **Range extensions of ten species of bats in California.** Bulletin, Southern California Academy of Sciences 97: 49-75.

Frost, D.R.; Timm, R.M. 1992. **Phylogeny of plecotine bats (Chiroptera: Vespertiliondae): Summary of the evidence and proposal of a logically consistent taxonomy.** American Museum Novitates 3034: 1-16.

Grinnell, H.W. 1918. **A synopsis of the bats of California.** University of California Publications in Zoology 17: 223-404.

Hill, J.E.; Smith, J.D. 1984. **Bats: a natural history.** Austin, TX: University of Texas Press. 339 p.

Hunsaker, D., II. 2001. **Habitat use and relative density of bats at Marine Corp Air Station at Miramar.** La Mesa, CA: The Environmental Trust. 183 p. Available from Marine Corp Air Station Miramar, San Diego, CA.

Koopman, K.F. 1993. **Order Chiroptera.** In: Wilson, D.E.; Reeder, D.M., editors. Mammal species of the world. Washington, DC: Smithsonian Institute Press; 137-241.

Krutzsch, P.H. 1948. **Ecological study of the bats of San Diego County, California.** Berkeley, University of California; 184 p. M.A. thesis.

Lewis, S.E. 1995. **Roost fidelity of bats: A review.** Journal of Mammology 76: 481-496.

McCracken, G.F. 1989. **Cave conservation: Special problems of bats.** National Speleological Society 51: 47-51.

Miner, K.L.; Brown, P.E. 1996. **A report on the southern California forest bat survey and radio-telemetry study of 1996.** Bishop, CA: Brown Berry Biological. 13 p. Available from San Diego, CA: Cleveland National Forest, Forest Service, U.S. Department of Agriculture.

Miner, K.L.; Stokes, D.S.; Dooley, C.; Henshaw, M.; Le Duc, R.; O'Corry-Crowe, G. 2000. **Bats and mines survey of Bureau of Land Management lands in San Diego County, with special emphasis on the protection of important roost sites.** San Diego, CA: San Diego Bat Conservation 42 p. Available from El Centro Office, Bureau of Land Management, U.S. Department of the Interior.

Moorman, C.E.; Russell, K.R.; Menzel, M.A.; Lohr, S.M.; Ellenberger, G.E.; Van Lear, D.H. 1999. **Bats roosting in deciduous leaf litter.** Bat Research News 40(3): 74-75.

Morales, J.C.; Bickham, J.W. 1995. **Molecular systematics of the genus *Lasiurus* (Chiroptera: Vespertilionidae) based on restriction-site maps of the mitochondrial ribosomal genes.** Journal of Mammology 76: 730-749.

Olson, A.C. 1947. **First record of *Choeronycteris mexicana* in California.** Journal of Mammology 28: 183-184.

Pierson, E.D. 1998. **Tall trees, deep holes, and scarred landscapes: Conservation biology of North American bats.** In: Kunz, T.H.; Racey, P.A., editors. Bat biology and conservation. Washington, DC: Smithsonian Institution Press; 309-325.

Pierson, E.D.; Rainey, W.E. 1998a. **Distribution, status, and management of Townsend's big-eared bat (*Corynorhinus townsendii*) in California.** Tech. Rept. 96-7. Sacramento, CA: Bird and Mammal Conservation Program, California Department of Fish and Game; 34 p.

Pierson, E.D.; Rainey, W.E. 1998b. **Distribution, habitat associations, status, and survey methodologies for three Molossid bat species (*Eumops perotis, Nyctinomops femorosaccus, Nyctinomops macrotis*) and the Vespertilionid (*Euderma maculatum*).** Berkeley, CA: Pierson and Rainey; 61 p. Available from Wildlife Management Division, California Department of Fish and Game, Sacramento, CA; Contract #FG2328WM.

Pierson, E.D.; Rainey, W.E.; Corben, C. 2000**. Distribution and status of red bats (*Lasiurus blossevillii*) in California.** Berkeley, CA: Pierson and Rainey; 37 p. Available from Species Conservation and Recovery Program, Habitat Conservation Planning Branch, California Department of Fish and Game, Sacramento, CA.

Pierson, E.D.; Wackenhut, M.C.; Altenbach, J.S.; Bradley, P.; Call, P.; Genter, D.L.; Harris, C.E.; Keller, B.L.; Lengus, B.; Lewis, L.; Luce, B.; Navo, K.W.; Perkins, J.M.; Smith, S.; Welch, L. 1999. **Species conservation assessment and strategy for Townsend's big-eared bat (*Corynorhinus townsendii townsendii* and *Corynorhinus townsendii pallescens*).** Boise, ID: Idaho Conservation Effort, Idaho Dept. of Fish and Game; 42 p.

Remington, S. 2000. **The distribution and diversity of bats in Orange County, California.** Pomona, CA: California State Polytechnic University; 114 p. M.S. thesis.

Riddle, B.R., editor. 1995. **Inactive mines as bat habitat: Guidelines for research, survey, monitoring and mine management in Nevada.** Reno: Biological Resources Research Center, University of Nevada; 148 p.

Ross, A. 1967. **Ecological aspects of the food habits of insectivorous bats.** Proceedings, Western Foundation of Vertebrate Zoology 1: 205-264.

Saugey, D.A.; Vaughn, R.L.; Crump, B.G.; Heidt, G.A. 1998. **Notes on the natural history of *Lasiurus borealis* in Arkansas.** Journal of the Arkansas Academy of Science 52: 92-98.

Shump, K.A.; Shump, A.U. 1982. ***Lasiurus borealis*.** American Society of Mammologists, Mammalian Species No. 183: 1-6.

Simons, D.; Stephenson, J.; Stokes, D.; Miner, K.; Brown, P.; Underwood, L. 2000. **Distribution and habitat associations of bat species in the mountains of southern California.** Unpublished paper provided by author.

Stephenson, J.R.; Calcarone, G.M. 1999. **Southern California mountains and foothills assessment: Habitat and species conservation issues.** Gen. Tech. Rep. PSW-GTR-172. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 402 p.

Tumlison, R.; Douglas, M.E. 1992. **Parsimony analysis and the phylogeny of the plecotine bats (Chiroptera: Vespertilionidae).** Journal of Mammology 73: 276-285.

Tuttle, M.D. 1979. **Status, cause of decline, and management of endangered gray bats.** Journal of Wildlife Management 43: 1-17.

Tuttle, M.D.; Taylor, D.A.R. 1994. **Bats and mines.** Resource Publication No. 3, Austin, TX: Bat Conservation International; 42 p.

Vaughan, T.A. 1954. **Mammals of the San Gabriel Mountains of California.** University of Kansas Museum of Natural History Publications 7: 513-582.

Vaughan, T.A.; Krutzsch, P.H. 1954. **Seasonal distribution of the hoary bat in southern California.** Journal of Mammology 35: 432-432.