

Research Article

The “Night Wings” (Bats) of Southern Alameda County - East Bay Regional Park District

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Abstract

Bats perform substantial ecological services, including insect consumption, pollination, seed dispersal, and nutrient cycling. Their low reproductive rates and sensitivity to human disturbance makes bats vulnerable to a variety of threats including habitat loss and fragmentation through weather disasters, pesticides, toxic wastewater, wind farm development, and the fungal white-nose syndrome. With the help of the “Bat Brigade” wildlife volunteer group, the East Bay Regional Park District (EBRPD) conducted a 9-year study (2017 to 2025) of bat distribution, abundance, and calls per hour at three locations in southern Alameda County. A total of 58 bat exit, and acoustic surveys were conducted periodically between April and July at Sunol Wilderness Regional Preserve, Lake Del Valle Regional Park, and Camp Arroyo Regional Recreation Area. The study confirmed the presence of 7 genera and 10 species of bats, including three California Species of Special Concern: The Pallid Bat (*Antrozous pallidus*), Townsend’s Big-Eared Bat (*Corynorhinus townsendii*), and the Western Red Bat (*Lasiurus blossevillei*). Additionally, the acoustic sampling detected the following species in order of abundance: Yuma Myotis (*Myotis yumanensis*), Mexican Free-Tailed Bat (*Tadarida brasiliensis*), and California Myotis (*Myotis californicus*). Lastly, more than 1,000 volunteers contributed over 5,000 hours of supervised service annually, and this effort demonstrates the tremendous energy that community scientists can bring to a wildlife conservation program.

Keywords

Bat Distribution and Abundance, Listed Species, Volunteer Contributions

1. Introduction

Because of their longevity and sensitivity to disturbances, bats both indicate the health of the environment [1, 2] and provide substantial ecological services [3]. Two such services are seed dispersal and nutrient cycling via bat guano and urine [4]. Also, insect-eating bats save American farmers more than \$20 billion each year in reduced pesticide usage [5]. In southwestern California, Nevada, and Arizona, bat species that feed on pollen and nectar are responsible for pollinating cacti and

tropical fruits [6]. Bats worldwide face a multitude of threats, including pesticides, habitat loss, wind farm development, heat stress, human harassment, and invasive species [7]. For example, researchers in Germany showed that for old, poorly-placed wind farms, bat mortality was estimated at 70 casualties/wind turbine in a two-month period [8]. Another major concern is bat fatalities from the white-nose syndrome, a disease caused by the fungus *Pseudogymnoascus destructans*.

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The *P. destructans* fungus attacks a bat's hairless skin and causes the bat to be abnormally active during hibernation periods. This in turn leads the bat to expend fat deposits needed for the winter and ultimately causes malnutrition and death. Since its introduction to North America, white-nose syndrome is estimated to have killed more than six million bats, and for some bat species like the Little Brown Bat (*Myotis lucifugus*), *P. destructans* has led to 95% kill rates [9].

With the death toll that the white-nose syndrome has caused, farmers are now using 31% more pesticide on their crops, which is linked to an 8% rise in human infant mortality [10]. Increased pesticide use is concerning for both humans and bats; bats exposed to pesticides endure bioaccumulation in their brains and organ tissues, which negatively affects their echolocation and foraging [11]. Moreover, toxic substances from urban wastewater (toxic metals) are consumed by foraging insects and are passed along to insectivorous bats, which then experience damage to their DNA, liver, and kidneys [12].

The fact that bats consume significant quantities of aquatic insects in agricultural areas means that the presence of bats directly leads to reduced pesticide use and increased crop and monetary yields [13]. For example, the Mexican Free-Tailed bat (*Tadarida brasiliensis*) is the most common bat species in California's agriculturally-rich Central Valley [14]. Research is showing that Mexican Free-Tailed bats spend more time over crops where insect populations are high, particularly over high-valued crops like rice, thus providing positive biological control measures and improved agricultural export and profits [14].

To our knowledge, this is the first long-term study of its kind involving volunteer community scientists and staff in an effort to systematically document for nearly a decade the distribution and abundance of the bat species in three parklands in California's southern Alameda County where only limited data was previously available. The objectives of the study were to: (1) identify bat species' presence, (2) document the yearly trends in bat populations, (3) establish a baseline density of bat community structure for comparison purposes, and (4) develop adaptive management recommendations for the conservation and enhancement of bat populations in the region.

2. Methods

2.1. Study Area

The lake at Del Valle Regional Park, located 10 miles south of Livermore in Alameda County, California (37.59838, -121.721992) has been surveyed since 2017. Lake Del Valle is situated within a valley in a rural area at Del Valle Regional Park. The Arroyo del Valle tributary extends southeast from the lake and the surrounding area is covered mostly by oaks, pines, and various types of grasses and shrubs.

Sunol Wilderness Regional Preserve, located 6 miles southeast of Sunol in Alameda County, California (37.51575, -121.83141) has been surveyed since 2017. Alameda Creek

comprises one of the largest watersheds in the South San Francisco Bay. The creek flows through the area, providing refuge to a number of special status species, including an array of Neotropical migrant birds. There is a mixture of native trees and shrubs as well as native and non-native annual and perennial herbaceous plants at this site. The predominant habitat types are annual grassland and valley foothill riparian.

Camp Arroyo Regional Recreation Area, located 5 miles south of Livermore in Alameda County, California (37.61826, -121.75315) has been surveyed since 2020. This location is ringed by agriculture, urban, and suburban development, with the Arroyo del Valle tributary on its eastern boundary. The predominant habitat types are annual grassland and valley foothill riparian.

2.2. Bat Species in Study Areas

2.2.1. Pallid Bat (*Antrozous pallidus*)

The Pallid Bat has a 91-135mm body length, 380-406mm wingspan, and lives in xeric, rocky habitats, hunting scorpions and other hard-shelled insects [15, 16]. The Pallid Bat is the State Bat of California and is listed as a California Species of Special Concern [17, 15].

2.2.2. Western Red Bat (*Lasiurus blossevillei*)

The Western Red Bat has a 90-115mm body length, 280-330mm wingspan, is mostly solitary except in nursing colonies, roosts in trees, near streams, and in fields or urban areas, and prefers flying ants and beetles among other insects [18, 19]. The Western Red Bat is a California Species of Special Concern [20].

2.2.3. Townsend's Big-Eared Bat (*Corynorhinus townsendii*)

The Townsend's Big-Eared Bat has a 89-117mm body length, 305-335mm wingspan, lives in mesic wet habitats, prefers moths, flies, and beetles, hibernates in large groups, is very sensitive to human disturbances, and is listed as a California Species of Special Concern [21, 22].

2.2.4. Yuma Myotis (*Myotis yumanensis*)

The Yuma Myotis bat has a 76-89mm body length, 230-254mm wingspan, can exist in large colonies in both urban and forested areas, has a strong preference for foraging over aquatic environments for moths, midges, and crane flies, among other insects, and has a Global Conservation Status of Least Concern [23, 24].

2.2.5. Mexican Free-Tailed Bat (*Tadarida brasiliensis*)

The Mexican Free-Tailed Bat has a 86-109mm body length and 305-356mm wingspan, lives in a variety of habitats in-

cluding woodlands, grasslands, and urban environments, appears after dusk and forages high above the ground to capture moths, and has a Global Conservation Status of Least Concern [25-27].

2.2.6. California Myotis (*Myotis californicus*)

The California Myotis has a 71-94mm body length, 280-330mm wingspan, hibernates and roosts alone or in small groups, lives in desert and forest habitats, captures moths and flies while flying over the vegetation, and has a Global Conservation Status of Least Concern [28, 29].

2.2.7. Hoary Bat (*Lasiurus cinereus*)

The Hoary Bat has a 130-150mm body length, 330-406mm wingspan, forages on moths, mosquitoes, and other insects, is a solitary tree species for most of year, with the exception of the fall breeding season, and has as Global Conservation Status of Least Concern [30, 31].

2.2.8. Big Brown Bat (*Eptesicus fuscus*)

The Big Brown Bat has a 86-137mm body length, 330-406mm wingspan, consumes insect pests that would otherwise target agricultural crops like corn, apples, cotton, and cereals, roosts in urban and wooded environments, and has a Global Conservation Status of Least Concern [32, 33].

2.2.9. Silver-Haired Bat (*Lasionycteris noctivagans*)

The Silver-Haired Bat has a 91-117mm body length, 280-330mm wingspan, lives in forested areas and hibernates in conifer tree hollows and bark, consumes moths, termites, and other insects, and has a Global Conservation Status of Least Concern [34, 35].

2.2.10. Canyon Bat (*Parastrellus hesperus*)

The Canyon Bat is the smallest bat of North America, has a 61-86mm body length, 178-229mm wingspan, lives in deserts and grasslands, appears 45 minutes before sunset and is most active 1-2 hours after sunset, consumes flies, wasps, and mosquitoes, and has a Global Conservation Status of Least Concern [36, 37].

2.3. Survey Methods

All locations were monitored for bats using two consistent survey protocols. For bat roost exit surveys, we used the Wisconsin Summer Bat Colony Monitoring Program guidelines, which rely on data and reporting from citizen scientists data collection and reporting [38]. In this method, observers usually count all bats leaving a roost site at sunset for approximately one hour, thus providing a numerical index, during a single night event, of total individuals emerging from the day roost location. The roost exit surveys, depending on the size of the area, usually involved 5 to 25 trained "Bat Brigade" volunteer observers.

The acoustic sampling for bats was conducted using SonoBat® software and Pettersson M500-384 ultrasound microphones following the Plan for North American Bat Monitoring Program (NABat). In this method, with survey seasonal restrictions between the months of April through July, the SonoBat® software records, processes, and analyzes high frequency bat sounds by evaluating call types and sequence of calls within a known regional context and provides output for determining whether to accept or reject identified bat echolocation call sequences, which contributes to decision-making on bat species' presence or absence, followed by a final manual vetting of all call types by an expert to reduce the likelihood of species misclassification. Bat echolocation call sequences are defined as a series of two or more consecutive echolocation clicks produced by a bat as it flies within range of the detector [39-41].

The output from SonoBat® was used to count the number of bat passes per hour, as a relative measure of bat activity, similar to methods used by Seidman and Zabel [42]. Because research shows that bat activity is greatest during the first three hours following sunset [43-45], we used the number of bat passes per hour to compare the relative amount of bat activity between locations, not as an absolute count of the bats using any particular site. Like Seidman and Zabel, we assumed that bat-detection biases were similar for all locations. SonoBat® software is tailored to the specific region for the most accurate classification, and to date, SonoBat® has been used to detect and monitor endangered bat species in Texas and to classify echolocation pulses of bat species in Louisiana [46, 47]. In this study, all acoustic monitoring sessions were done using the California classifiers (North of Big Sur or Central Valley) for a minimum of 2 hours following sunset (typically between 20:30 and 22:30) and annually corresponding with the summer solstice (around June 20-22).

3. Results

Bat roost exit surveys for Lake Del Valle and Sunol Wilderness Regional Preserve showed a general increasing trend from 2017 to 2021, followed by an overall decline in 2022 and 2023, with modest increases starting in 2024 (Figure 1). The Camp Arroyo Regional Recreation Area bat roost exit surveys over the five years (2021 to 2025) showed an increase (Figure 1). The highest, single-event maximum, roost survey counts of existing individual bats were recorded at Lake Del Valle (1,163 bats in 2022), Camp Arroyo (563 bats in 2025), and Sunol Wilderness Regional Preserve (426 bats in 2020) (Figure 1).

Acoustic sampling revealed the following: 9 species of bats frequent the night sky of Sunol Wilderness Regional Preserve; 7 bat species are found at Camp Arroyo Regional Recreation Area; and 7 bat species are found at Lake Del Valle (Figure 2). Further acoustic sampling and analysis revealed that three species of bats dominate the night at all locations in decreasing

order of abundance: Yuma Myotis (*Myotis yumanensis*), Mexican-Free Tailed Bat (*Tadarida brasiliensis*), and California Myotis (*Myotis californicus*) (Figure 2). The Pallid Bat (*Antrozous pallidus*), a California Species of Special Concern, is found at all three locations while the Western Red Bat (*Lasiurus blossevillei*) was only detected at the Sunol Wilderness Regional Preserve and Camp Arroyo Regional Recreation Area, and the Townsend’s Big-Eared Bat (*Corynorhinus townsendii*) was only detected at Camp Arroyo Regional Recreation Area (Table 1).

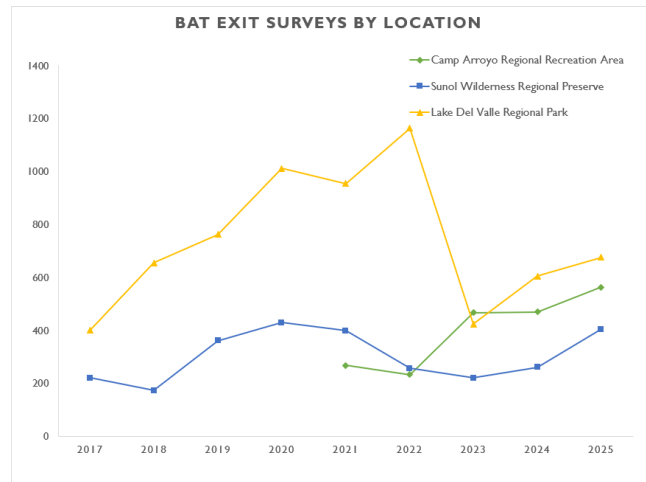


Figure 1. Bat exit surveys by location (Sunol Wilderness Regional Preserve, Lake Del Valle Regional Park, and Camp Arroyo Regional Recreation Area).

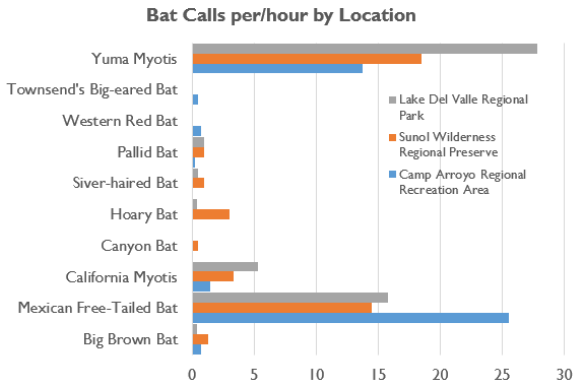


Figure 2. Bat calls per hour by Location (Lake Del Valle Regional Park, Sunol Wilderness Regional Preserve, and Camp Arroyo Regional Recreation Area).



Figure 3. District staff and volunteers (“Bat Brigade”) will continue monitoring bat distribution and abundance within the EBRPD land holding, including continued long-term monitoring of all known bat colonies and bat houses as a measure of ecological health, with special attention given to the three special status species.

Table 1. Special Status Bat Species by Location (Lake Del Valle Regional Park, Sunol Wilderness Regional Preserve, and Camp Arroyo Regional Recreation Area).

Locations	Bat Species		
	Pallid Bat (<i>Antrozous pallidus</i>)	Western Red Bat (<i>Lasiurus blossevillei</i>)	Townsend’s Big-Eared Bat (<i>Corynorhinus townsendii</i>)
Lake Del Valle Regional Park	Detected		
Sunol Wilderness Regional Preserve	Detected	Detected	
Camp Arroyo Regional Recreation Area	Detected	Detected	Detected

4. Discussion

The global biological diversity situation identifies de-faunation as a significant threat to ecosystem stability, wildlife populations, and human health [48]. Current analyses imply

that 56% of the mammalian species assessed are declining [48]. We know from the literature [15, 49, 50] that mammalian species like bats play critical ecological roles and substantial ecosystem services, including insect suppression, seed dispersal, and pollination. While native wildlife species face many stressors including habitat fragmentation and environmental change [51], this new research conducted on public lands in

southern Alameda County informs data gaps, thereby improving our understanding about local bat species distribution, abundance, and trend, which will be critical for measuring the overall ecological health of the region in the future.

From the literature we know that riparian areas are important foraging habitats for bats [52-55]. Barclay reported that greater abundances of insects are found over water as compared to forest paths [56]. The high abundance of bats we observed at our three survey locations, adjacent to riparian habitats, is a likely reflection of these past research conclusions. Additionally, Thomas reported that *Myotis* species' foraging activity is ten-times greater over water than within the forest interior in the Pacific Northwest [57]. Our research is consistent within the above-mentioned, in that our acoustic sampling detected the Yuma Myotis (*Myotis yumanensis*) as the most plentiful bat species, the Mexican Free-Tailed Bat (*Tadarida brasiliensis*) as the second most abundant, and the California Myotis (*Myotis californicus*) as the third most abundant. Bats use riparian areas not only for foraging but also for drinking. Because they drink from water holes while flying, the pool size needed varies with each bat species' specific flight behavior. For example, the highly maneuverable *Myotis* species can drink from a pool a few centimeters in diameter, whereas the less maneuverable but fast-flying Mexican Free-Tailed Bat (*Tadarida brasiliensis*) requires large pools [58].

Bat species split potential foraging space, based on their wing size and shape, which determines their flight speed and maneuverability [59]. Additionally, bat echolocation call sequences are ecologically related to their prey size [60]. For example, the Yuma Myotis feeds largely on emergent aquatic insects by skimming near the surface of lacustrine ecosystems (e.g., lakes or ponds with still water) or slow-moving waters [61] using its characteristic call frequency of 50kHz [62], and the Yuma Myotis can forage in a much smaller space than the Mexican Free-Tailed Bat. In contrast, the Mexican Free-Tailed Bat has long narrow wings, emits call sequences at 25 kHz [63], and is an open-air forager, typically flying at greater heights and foraging on moths at much faster speeds than the Yuma Myotis [63].

Our analysis is consistent with previous studies of bats foraging over aquatic ecosystems in that the Yuma Myotis, which are known to concentrate on emergent aquatic prey [64, 65], is the most abundant species detected in all of our sites. The Mexican Free-Tailed Bat, which typically forages in wide open spaces, usually well above the landscape [66], was the second most abundant species detected. Moreover, this species is a generalist with a broad diet, although it too will take advantage of large swarms of aquatic insects and large, terrestrial prey [67, 68]. The California Myotis, which normally does not forage over aquatic areas [62], was not prevalent and was the third most-detected bat species.

Temperature and time of the year have been found to influence bat activity [69, 70]. Bat activity is greater in the later summer months [40] because of higher temperature, foraging

young-of-the-year bats, and greater prey abundance due to maximum-productivity temperate-zone insects [40, 71, 72]. Although bat activity can be highly variable within a single night, like the findings of Seidman and Zabel [42] showed, it probably had limited effects on the results we are reporting and was likely consistent across all of our sites.

The Mexican Free-Tailed bat and Yuma Myotis form large colonies of several hundred to many thousands of individuals in bridges [73]. Johnston reported that bridges over waterways where insect prey is typically plentiful is likely responsible for the increasing population of Mexican Free-Tailed bat and Yuma Myotis [41]. Bat colonies form for hibernation during the winter, whereas maternity colonies, made up of adult females and their young, occur from spring through early fall [74]. Bat maternity colonies are often matrilineal, with females returning to their natal roost throughout their lives [75]. This high fidelity to their chosen roost sites, particularly our protected sites, might explain the trends we are reporting, namely a confirmed presence of 7 genera and 10 species of bats in southern Alameda County, including three California Species of Special Concern.

By recruiting everyday people and giving them the training tools and inspiration, we have mobilized hundreds of volunteer community scientists who are committed to wildlife preservation, management, and research [76]. As part of our "Bat Brigade," participants contribute over 5,000 hours of supervised service annually, demonstrating the tremendous energy that community scientists can bring to a wildlife conservation program, while improving public perception of these uniquely important animals (Figure 3). In addition, other bat conservation programs are encouraging bat-friendly communities through stewardship education and habitat protection strategies, such as removing objects near bat roosts that may cause entrapment (i.e. open pails, old tires, coils of barbed wire, ornamental and exotic plants that are spiny or adhesive) that can be applied by all [77].

In closing, we know that bats depend on crepuscular swarms of insects, largely following bimodal activity patterns, with a peak at dusk and a second peak at dawn [40, 69]. Our results along with those of other scientists Seidman and Zabel suggest that short-term sampling durations may not yield accurate information regarding bat relative abundance and habitat use patterns [42]. Therefore, the continuing research recommendation for these sites might focus on long-term comparison of the local bat species' foraging behavior, bimodal activity pattern, diets, and population dynamics before and after the addition of protected bat roosting structures.

Abbreviations

kHz kilohertz

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Author Contributions

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Fendi De Amicis: Data curation, Investigation, Writing – original draft, Writing – review & editing

Conflicts of Interest

The authors declare no conflict of interest.

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