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A Natural Resource Condition Assessment for Sequoia and Kings Canyon National Parks, Appendix 16 - Bats

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Natural Resource Stewardship and Science

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Natural Resource Report NPS/SEKI/ NRR—2013/665.16

ON THE COVER
Giant Forest, Sequoia National Park
Photography by: Brent Paull

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Contents

Page

Figures and Tables

Page

Scope of analysis

North American bats are highly unique animals that have historically been overlooked by land managers and misunderstood by the public. Bats are unique as the only true flying mammals and due to their exceptionally long lives (5-15 years) and unusually low reproductive rates (typically one young per year) for their small size. Most North American bat species are insectivorous, serve as the primary predators of nocturnal insects, and can consume up to one-third of their weight in insects per night. Thus, bats play a role in regulating insect populations, insect-related ecological processes, and nutrient redistribution and cycling (Ross 1967) and are integral to the function and integrity of many ecosystems. Through this role, bats also provide tangible economic benefits. For example, Mexican free-tailed bats (*Tadarida brasiliensis*) consume significant quantities of several moth species whose larvae are known agricultural pests (e.g. corn earworm, *Helicoverpa zea*) and provide significant economic value in pest control services to the agriculture industry (Cleveland et al. 2009).

Because of their small size, the energetic demands of flight, a limited ability to store fat, and the seasonal abundance of their prey, bats have an annual energy budget that is difficult to balance (McNab 1982). Many species rely on hibernation as a critical strategy to survive the winter. In the fall, these bats accumulate up to 30% of their body weight in fat to prepare for the winter hibernation. During hibernation, bats lower their body temperature to 1-2 degrees above ambient, reduce their heart rate and respiration, and thus minimize their basal metabolic energy requirements. Bats emerge in the spring with depleted energy stores, and adult females may be pregnant from fall matings. During spring and summer, female bats feed heavily to replenish their energy reserves, gestate fetuses that grow to 10-15% of the female’s weight, and provide rich milk for growing pups. In the fall, adults and young-of-the-year forage heavily in preparation for the winter. Because of their tight energy budgets, bats require roosts with appropriate microclimates to minimize thermoregulatory energy requirements (Kunz 1982, Hill and Smith 1984). As such, reproductive success and overwinter survival of individuals and populations may largely depend on the availability of suitable roosts (Humphrey 1975). Not only do they minimize thermoregulatory requirements, suitable roosts also facilitate gestation in pregnant females and maximize growth rates of young pups. Many species often congregate into winter hibernacula or summer maternity colonies to reap thermoregulatory and other communal benefits. This colony roosting behavior also makes bats susceptible in large numbers to impacts such as disturbance, vandalism, cave and mine closures, destruction of roosts, disease, etc. The overall distribution and abundance of suitable roost sites (summer and winter) may ultimately determine the distribution and abundance of many bat species (Humphrey 1975).

Based on physiological adaptations to water conservation of lack thereof, bats must find roosts and foraging areas that have water within an economical flight distance. Nonetheless, roost and foraging habitat may still be separated by significant distances (Pierson 1998, Chambers et al. 2006). Food availability also determines bat species distribution and habitat use. Although insects appear to be so abundant as to preclude competition between bat species (Ross 1967, Humphrey 1975), dietary partitioning among insectivorous bat species is evident from their wide range of sizes, flight styles, echolocating abilities, and the partitioning of vertical and horizontal space during foraging (Black 1974). Nonetheless, our understanding of the food habits and dietary preferences of different bat species is extremely limited.

Data sources

Information on distribution and abundance of different bat species comes from netting records, museum specimens, general observations, roost studies, and acoustical surveys (in the last 20 years). However, records are not complete throughout each species' geographic range, not all habitat types have been sampled equitably, and all sampling techniques have different biases.

As part of the NPS Inventory & Monitoring program, inventory goals of the Sierra Nevada Network (SIEN) were to 1) document through existing, verifiable data and targeted field investigations, the occurrence of at least 90 percent of the vertebrate species and vascular plants currently estimated to occur in the parks and 2) describe the distribution and abundance of species of special management concern, such as listed Threatened and Endangered species and invasive species. The SIEN Biological Inventory Plan identified bats as a high priority for inventory at DEPO and SEKI because many bat species have special management status within various agencies and at regional, state, and national levels. Thus, SIEN sponsored a review of the literature and examination of museum records that revealed that very few bat records exist for portions of the Sierra Nevada that encompass Sequoia and Kings Canyon National Parks (SEKI) and Devils Postpile National Monument. While Grinnell's extensive vertebrate survey of the 1920's addressed Yosemite and Lassen National Parks, his efforts did not include the southern Sierra Nevada that encompasses SEKI (Grinnell and Storer 1924, Grinnell et al. 1937). Modern day survey tools (e.g., mist nets, bat detectors, night vision devices) were not available to those conducting faunal surveys in the early to mid 1900's, and thus bat surveys and museum collections were limited to specimens collected at dusk by shotgun.

After determining that little information exists on bats within SEKI, SIEN sponsored an inventory to examine bat distribution and relative abundance within SEKI and provide information on the potential impacts of management actions. This inventory project conducted field surveys from 2001 to 2006 for bats around water features (ponds, streams, meadows, & other associated habitat) at different elevations within 5 major drainages in SEKI (Kern, Kaweah, South Fork San Joaquin, Middle Fork Kings, and South Fork Kings Rivers) and synthesized the results with information from previous surveys conducted by the principal investigators in SEKI and the previously conducted literature and museum record search. The resulting inventory report (Pierson and Rainey 2009) is the basis for this chapter on bats and to date, is the best compilation of bat-related information for the park.

Pierson and Rainey (2009) surveyed 39 museum collections bats from Fresno & Tulare counties (Table 1). Both the literature and museum record search revealed relatively few records for SEKI. The review of museum collections yielded a total of 48 specimens (9 specimens for KICA and 39 specimens for SEQU) which were housed within 7 institutions. Results of the literature search yielded the following relevant records:

- Allen 1919
- Barbour and Davis 1969
- Elliot 1904 & 1907

- Grinnell, H. W. 1916 &1918
- Grinnell, J. 1933
- Miller and Allen 1928
- Sumner and Dixon 1953

Table 1. List of museum collections reviewed for bat records from Sequoia and Kings Canyon National Parks.

Acronym	Museum Name
AMNH	American Museum of Natural History
CAS	California Academy of Sciences
CM	Carnegie Museum of Natural History, Pittsburgh
CPSU	California Polytechnic State University, San Luis Obispo
CPSUP	California Polytechnic State University, Pomona
CSUC	California State University, Chico
CSUF	California State University, Fresno
CSUH	California State University, Humboldt
CSULB	California State University, Long Beach
CSUN	California State University, Northridge
CU	Cornell University, Ithaca, NY
DEVA	Death Valley National Monument
FMNH	Field Museum of Natural History, Chicago
KU	University of Kansas
LACM	Los Angeles County Museum
LSUMZ	Louisiana State University Museum of Zoology
MCZ	Museum of Comparative Zoology, Harvard
MLZ	Moore Laboratory of Zoology, Occidental College
MSB	University of New Mexico
MSU	Michigan State University, East Lansing
MVZ	Museum of Vertebrate Zoology, University of California, Berkeley
PSM	University of Puget Sound
ROM	Royal Ontario Museum, Toronto
SBMNH	Santa Barbara Museum of Natural History
SDNHM	San Diego Natural History Museum
SDSU	San Diego State University
SEQNP	Sequoia National Park
TCWC	Texas A & M
TTU	Texas Tech University
UA	University of Arizona
UCLA	University of California, Los Angeles
UCSB	University of California, Santa Barbara
UIMNH	University of Illinois Museum of Natural History
UM	University of Michigan

Pierson and Rainey (2009) used mist-net capture and acoustical surveys in their study to maximize the number of species detected. Sampling was distributed subjectively along an elevational gradient in 5 river drainages and was focused around water features (e.g., tributaries, ponds, flooded meadows) because bats are easiest to observe or capture near water (Grindal et al. 1999, Pierson et al. 2001). Sampling was limited to accessible areas within each river drainage, and priority was given to areas that had not been previously surveyed. Field work typically occurred in the months of July and August from 2001 to 2006, but in some years occurred as early as late June and as late as late September.

Biases of Study Methods and Data Limitations

Bats are difficult to observe and study because they are nocturnal, volant, and essentially silent to the human ear. Mist-net capture and acoustical monitoring are two common methods for studying the distribution and relative abundance of bats, and both have biases. Individual bats can be captured by strategically placing mist-nets over water sources and across flyways, and captured bats can be examined in hand to identify species, age, sex, and reproductive status. Individual bats can be 'heard' with strategically placed acoustic detection devices that record ultrasonic echolocation calls, and call recordings (or sonograms) can be analyzed to determine species. Unfortunately, neither method provides complete and unbiased data. Only a small subset of individuals are captured in mist-nets, some species are easier or difficult to capture depending on flight style and foraging behavior, and capture rates are affected by environmental conditions, moon phase, time of year, net placement, and many other factors. Thus mist-netting does not capture all species in an area. Acoustical monitoring is biased because results are affected by device placement (location, orientation, height, etc.), not all individuals present will be recorded, identification of species from sonograms is often subjective and dependent on observer skill, and not all species are easily identified by their sonograms. Even when recorded, individuals of certain species are not easily identified. Due to these and other biases, the types of survey techniques used and sampling design should always be considered when evaluating the geographic presence or absence, habitat associations, and habitat requirements of different bat species. Using both methods simultaneously can improve the number species detected.

While capture and acoustic methods are excellent for determining the presence of bats, it is difficult to estimate abundance. In combination with other techniques, reporting methods (e.g. using capture rates instead of absolute numbers), and standardization of field conditions, data from these methods may be used to estimate and compare relative abundance. But the conditions under which such data were collected should always be evaluated, and such estimates should be taken with a grain of salt because numerous uncontrollable factors influence capture rates and acoustical detection. Ultimately we do not have adequate methods to reliably and accurately estimate abundance except through direct physical counts of colonial species within their roosts or during evening emergence from roosts under standardized conditions.

Reference conditions

Twenty-five bat species are found in California, and 17 were expected to occur in SEKI. Of these 17, sixteen species were found in each of the parks (Pierson and Rainey 2009). Fifteen species were common to both parks, and one species was documented in each park that was not documented in the other (Table 2). Bats were documented at elevations as low as 500 m (the lowest survey location) to elevations above 3500 m, and the lowest and highest elevation at which each species was detected are illustrated in Figure 1. While 10 species were captured at very high elevations, it should be noted that captures at these elevations were much less frequent, and most captures occurred at elevations below 3,000 m. Capture data from this study generally supported hypotheses that reproductive females (pregnant, lactating, postlactating) prefer lower elevations (i.e. warmer microclimates) than nonreproductive females or males (Cryan et al. 2000, Pierson and Rainey 2009). Nonetheless, these data demonstrate that bat foraging habitat spans from low elevations to some of the highest elevations in the park during the summer.

Table 2. Bat species documented to occur in Sequoia National Park (SEQU) or Kings Canyon National Park (KICA) and their current federal, state, or organizational status. CDFG-SSC = California Dept. of Fish and Game-Species of Special concern, BLM-Sens = Bureau of Land Management-Sensitive, USFS-Sens = U.S. Forest Service- Sensitive, and WBWG-H = Western Bat Working Group- High risk of imperilment. C= captured in mistnets, and A = acoustic detection.

Species Name	Common Name	Status				Documented?	
		CDFG- SSC	BLM Sens	USFS-Sens	WBWG-H	KICA	SEQU
Antrozous pallidus	Pallid bat	X	X	X	X	C, A	C, A
Corynorhinus townsendii	Townsend's big-eared bat	X	X	X	X		C
Eptesicus fuscus	Big brown bat					C	C
Euderma maculatum	Spotted bat	X	X		X	A	C, A
Eumops perotis	Western mastiff bat	X	X		X	A	A
Lasionycteris noctivagans	Silver-haired bat					C	
Lasiurus blossevillii	Western red bat	X		X	X	C, A	C, A
Lasiurus cinereus	Hoary bat					C	C
Myotis californicus	California myotis					C	C
Myotis ciliolabrum	Small-footed myotis		X			C	C
Myotis evotis	Long-eared myotis		X			C	C
Myotis lucifugus	Little brown myotis					C, A	C, A
Myotis thysanodes	Fringed myotis		X		X	C	C
Myotis volans	Long-legged myotis				X	C	C
Myotis yumanensis	Yuma myotis		X			C	C
Parastrellus hesperus	Western pipistrelle					C	C
Tadarida brasiliensis	Mexican free-tailed bat					C	C
	Total # Species Detected					**16**	**16**

Nine of the species observed in SEKI are considered Sensitive by the U.S. Forest Service (USFS) or Bureau of Land Management (BLM), five are California Department of Fish and Game (CDFG) Species of Special Concern (SSC), and five are considered at high risk of imperilment by the Western Bat Working Group (WBWG), a professional association of scientists, land managers, and individuals interested in bat research, management, and conservation (Table 2). General information on each species' geographic range, roost preferences, and foraging behaviors may be found in Pierson and Rainey (2009). Based on the inventory results, the report also includes park-specific information on each species, such as habitat associations within SEKI, locations where detected or captured, relative frequencies of detection or capture, and potential management issues. Specific locations at which each species was observed are found in Pierson and Rainey (2009) and are illustrated with maps in Appendix A of this chapter.

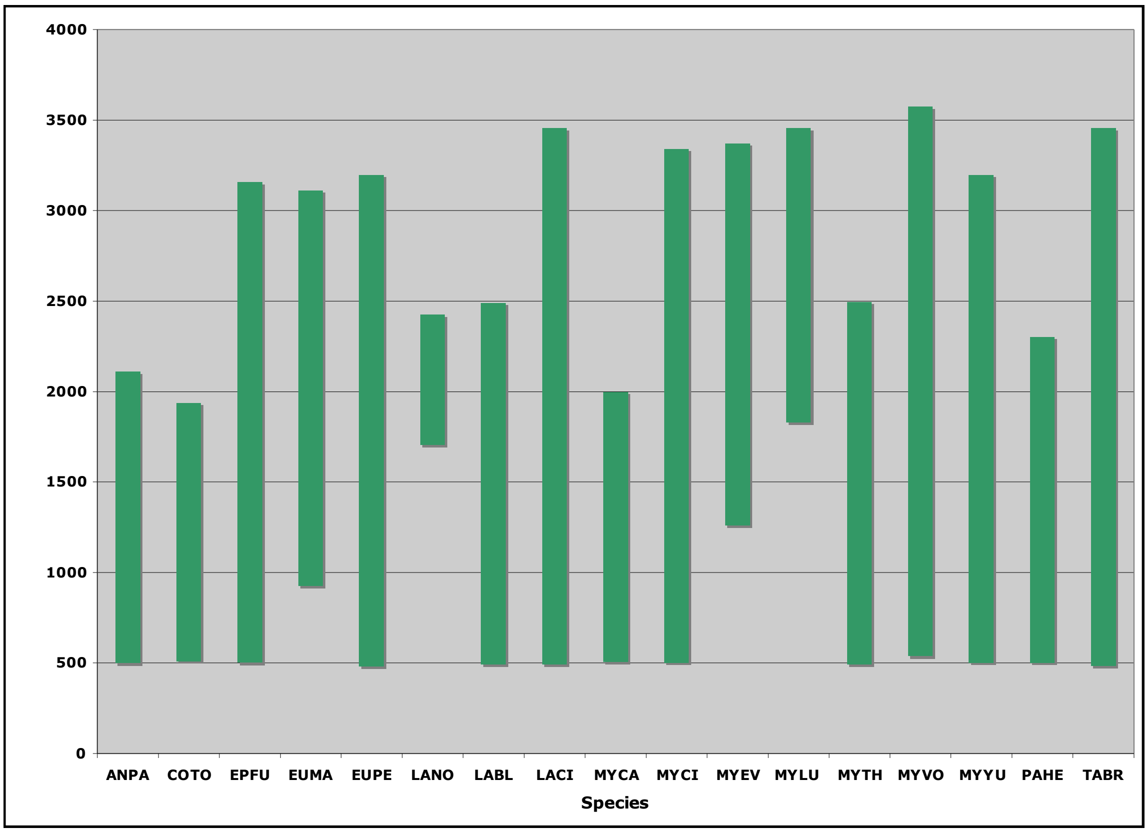

Figure 1. Range of elevations (m) at which each bat species was documented at SEKI (Pierson and Rainey 2009). Individual bars span from the lowest to the highest documented elevation, but do not reflect relative abundance at different elevations.

Roosts

Ensuring the availability of suitable summer and winter roosts is key to ensuring reproductive success and overwinter survival in bat species. Since many bat species aggregate into colonies, management can be particularly effective when efforts are made to protect known colony roosts. Not only should physical roost structures be conserved, but measures should be taken to protect these roosts from disturbance during critical periods. Pregnant females and their young in maternity roosts are particularly vulnerable in the spring and summer when the young have not yet learned to fly, and hibernating bats are vulnerable to disturbance that causes unnecessary arousals or that introduces the fungus *Geomyces destructans* which causes white note syndrome. Because we rarely know the locations of most solitary or colony roosts, it is important to protect general types of structures known to be used by bats and areas known to provide suitable foraging habitat.

Types of Roost Structures

This section presents information on the different types of structures used by bats for summer and winter roosts. While individual species exhibit tendencies towards specific roost behaviors (e.g. colony or solitary) or roost preferences (caves/mines vs. trees), many species also demonstrate significant plasticity within a locale that may be based on the specific region within their geographic range, vegetation type, roost availability, and other factors. For each category of roost below, the species found using these roost types in SEKI are listed. It should be recognized that these records are mostly incidental observations and not the result of a significant or methodical effort to identify roosts, and thus may not accurately represent patterns and preferences of each species in the park.

Cave and mines are often used as summer or winter roosts by many species of bats, particularly colonial species. Caves roosts may range from talus caves and large rock shelters to large limestone caverns. At SEKI, seven species have been documented using caves, including *A. pallidus*, *C. townsendii*, *E. fuscus*, *M. evotis*, *M. thysanodes*, *M. volans*, and *M. yumanensis* (Pierson and Rainey 2009). In particular, *C. townsendii* is a colonial cave and mine specialist that is known to form large hibernating colonies in California (Kunz and Martin 1982, Pierson et al. 1999). Specific caves where bats have been observed or collected include Clough Cave, Crystal Cave, and Soldier's Cave (Pierson and Rainey 2009).

Many bat species are also known to roost in narrow crevices found in large cliff faces (or rock outcrops) to small crevices in boulders on the ground. In general, large colonies are more likely to be found in the larger crevices such as cliff faces, whereas solitary bats or a few individuals are more likely to be found in small crevices found amongst or within boulders. At SEKI, two bat species (*E. perotis* and *P. hesperus*) have been found using cliff and rock roosts (Pierson and Rainey 2009). Specifically, *E. perotis* colonies were observed emerging from cliff face roosts at Moro Rock, near the entrance station on Mineral King Road, and from cliffs just east of Shepherds Saddle (Pierson and Rainey 2009).

Much of the early information about bats originated from studies of bats in man-made structures because this is where bats are often encountered and are easily observed and studied. Colonies of bats can be found roosting in large and small buildings of various materials, bridges, towers, culverts, and other structures. At SEKI, three species (*A. pallidus*, *M. evotis*, and *M. thysanodes*) were documented to use man-made structures (Pierson and Rainey 2009). Some documented structures include the bridge over Lewis Creek in Cedar Grove, an abandoned mine building in the foothills (colony roost), and the Southern Sierra Research Center (night roost).

Trees are also an important roost resource to many species of bats, which exploit the crevices and cavities in live and dead trees of a variety of species. Roosts are found tree cavities such as fire-scarred basal hollows, woodpecker holes, and holes created by other processes. Individuals and small colonies may also be found roosting under loose bark, in cracks through the trunk caused by lightning or wind, or in the deep furrows of bark. In the southwest, bats were commonly found roosting only 1-2 meters off the ground in pinyon snags (*Pinus edulis*) and live junipers (*Juniperus monosperma* and *J. deppeana*; Chung-MacCoubrey 2005). While most tree-roosting bats use crevices and cavities in or on the tree trunk or in large branches, the lasiurines (*Lasiurus* spp.) and *Lasionycteris* species often roost amongst the foliage and branches in the tree canopy. At SEKI, seven species have been found in tree roosts, including *A. pallidus*, *E. fuscus*, *M. californicus*, *M. evotis*, *M. thysanodes*, *M. volans*, and *M. yumanensis* (Pierson and Rainey 2009). Through limited radiotracking and incidental observations, tree roosts were located under loose bark of large sugar pine and ponderosa pine snags, bark crevices of giant sequoias, and in the Log Cabin- a hollow fallen giant sequoia in Redwood Mountain Grove (Pierson and Rainey 2009).

Stressors

Roosts with suitable thermoregulatory properties enable bats to meet their very specific energy requirements during different seasons, and this ability is critical to their overwinter survival and reproductive success. For these reasons, the distribution and abundance of suitable summer and winter roosts can determine the distribution and abundance of bat species across the landscape. Thus, this section largely focuses on anthropogenic stressors that affect roost availability, abundance, and suitability. Nonetheless, we also discuss white-nose syndrome as a disease that could affect the distribution, abundance, and survival of several species in the near future.

Land use/fragmentation

Human land use may affect bats as it affects the availability and suitability of roosts and as it may cause disturbance to roosting bats. While bats are not affected by landscape fragmentation in the same manner as animals that cannot fly, fragmentation can still have negative impacts. Recreational caving and climbing, cave tours, hazard tree removal, recreational trails and the associated foot traffic, and highway or construction projects can disturb, displace, or kill cave, cliff, and tree-roosting bats and their young. Fragmentation can increase exposure to predation or increase the energetic costs of commuting between foraging and roost areas, thus affecting daily energy balances.

Climate change

Many species are expected to shift their latitudinal and elevation distribution as a result of climate change (Humphries et al. 2004). Bats will be affected by climate change as changes in ambient temperatures alter summer or winter roost microclimates (temperature and humidity), forcing bats to find new roost locations or endure suboptimal conditions and suffer effects on reproduction and survival. Colonial bats may be challenged to find new roosts with a suitable configuration, microclimate, space requirements, and protection from predators. If suitable foraging and roost habitat become available at increasingly higher elevations, bat species may expand their range upward in elevation within the Sierra. For these same reasons, thermal regimes, foraging habitat, and roosts may become less suitable at lower elevations, and the lower elevational limit for these species may shift upward. While many species may be poised to shift their elevational distribution upward, the exception may be *Myotis lucifigus*. In the Sierra, this species is already found primarily at higher elevations (above 5,000 ft; Pierson and Rainey 2009). Thus suitable habitat for hibernating and breeding *M. lucifugus* in the southern Sierra may decrease with climate change.

Altered fire regimes

Fire and fire management activities can affect bats directly and indirectly through their effects on foraging and roost habitat. Historic fire suppression activities have undoubtedly resulted in changes in forest distribution, species composition, age structure, and density, which in turn have likely affected foraging and roost habitat for bats. As for many taxa, these changes may enhance or detract from habitat quality, depending on the individual species. When forests become denser and more cluttered below the canopy, foraging habitat would decrease for fast-flying, less maneuverable species, but increase for slower, more maneuverable, gleaning species. Changes in forest species composition, structure, and density also likely translate to changes in insect communities and thus prey availability for different species of bats. When fire creates or forest management activities remove snags or trees with defects (loose bark, cavities, cracks), desirable habitat for tree-roosting bats may be created or removed. While adult bats generally can escape direct injury due to fire, young pups and non-volant juveniles may perish in maternity tree roosts or rock roosts due to smoke and/or heat during spring and summer forest fires. In addition, the *Lasiurus* and *Lasionycteris* species have been found to hibernate in leaf litter of riparian forests (Sanborn 1953, Saugey et al. 1998, Hein et al. 2007), and thus individuals of these species may disturbed or killed by fires while hibernating in these locations.

New disease paradigms

The disease called white-nose syndrome (WNS) emerged in bats in 2007 in upstate New York, has since spread over 1,000 mi (1,600km), and is now found throughout much of the eastern U.S. and as far west as Oklahoma. The disease is caused by a cold-loving fungus (*Geomyces destructans*) that thrives at temperatures below 20 degrees Celsius and in high humidity, both of which are common environmental conditions in bat hibernacula. The fungus infects the skin and membranes of bats, likely causing death by increasing the frequency of arousal during hibernation, damaging wing membranes, and disrupting critical physiological functions (Blehert et al. 2011). During hibernation, bats rouse periodically to drink, urinate, defecate, or forage, and these natural arousals usually consume most of their fat stores by the end of winter. White-nose syndrome is suspected of increasing the frequency of arousal, thus causing bats to prematurely deplete their fat stores and starve before winter's end. It is also suspected that damage to wing membranes by the fungus disrupts blood circulation, water balance, thermoregulation, cutaneous respiration, and ultimately increases the susceptibility to mortality (Cryan et al. 2010).

Over one million bats are estimated to have died from this syndrome, and one of the most common North American species, the little brown bat (*Myotis lucifugus*) is projected to disappear from the eastern region within 16 years (Blehert et al. 2011). This disease, with its rapid spread and high rate of infection and mortality, has the potential to devastate populations of all hibernating species (over half of the species in North America), and through their role as insect predators, have cascading effects on ecosystem function, agriculture, and the global economy.

There is little information on types and locations of winter hibernacula used by California bats. Of the 17 bat species documented in SEKI, 12 species are known to hibernate. Six species are currently known to be affected by WNS (USFWS 2011), and 2 of these species, *M. lucifugus* and *Eptesicus fuscus*, are found at SEKI. Leading bat researchers recently prepared a status review of *M. lucifugus* to advocate for an endangered status listing under the Federal Endangered Species Act (Kunz and Reichard 2011). Although WNS has not yet been detected in *Corynorhinus townsendii*, this species specializes in cave use for both summer and winter roosts and could be highly vulnerable to WNS. Little is known about winter hibernacula for bats in California, and thus far, *C. townsendii* is the only species known to form relatively large hibernating colonies in California (Pearson et al. 1952, Pierson 1988). Should this disease reach California, the park is not well equipped to manage or mitigate its impacts because we know little about the locations of important cave hibernacula, nor the numbers and bat species of bats that use them.

Information Gaps and Research Recommendations

To facilitate management of bat habitat, information is needed on the types and locations of roosts used by bats in SEKI. Park managers could likely use information regarding: What types of structures in SEKI are used for summer maternity roosts? For hibernacula? Where are the important hibernacula and maternity roosts, particularly for large colonies? While conservation of all species is important, colonies are effective management units because protection of a single roost benefits a large number of individuals. In addition, efforts should be focused on protecting summer maternity roosts (i.e. reproductive females) to ensure successful reproduction in these slow-reproducing species (typically a single young per year) and winter roosts to ensure overwinter survival of large aggregations of hibernating bats. Other important questions include: How will climate change affect suitability of these locations for hibernation and rearing of young? What are the effects of climate change on cave microclimate for bats? Are there alternate locations for hibernacula that provide suitable microclimate & protection if current locations are no longer suitable? (It will be critical to implement measures to prevent spread and contamination of caves with the white nose fungus). Which man-made structures (buildings, warehouses, etc.) are currently used by colonies during the summer? What types of trees are used for maternity roosts, by which species of bats, and in what numbers?

Although it would not answer the above roost-related questions, acoustic monitoring of bat activity could be a cost-effective method for detecting changes in relative abundance of bats (as an index of population trends in a particular time and place) or for detecting changes associated with particular events (e.g. catastrophic fire), management actions (e.g. prescribed fire), or other anthropogenic activities (e.g. effects of meadow usage on foraging activity).

National parks encompass significant quantities of valuable bat habitat (e.g. cave and mine roosts, untrammeled wilderness) and the National Park Service is well positioned to support bat conservation, particularly in light of the devastating new disease ravaging bat populations in the east. Even if WNS does not directly affect bats within SEKI, resident bat populations within these parks may play an important role in recovery from the impacts of this disease.

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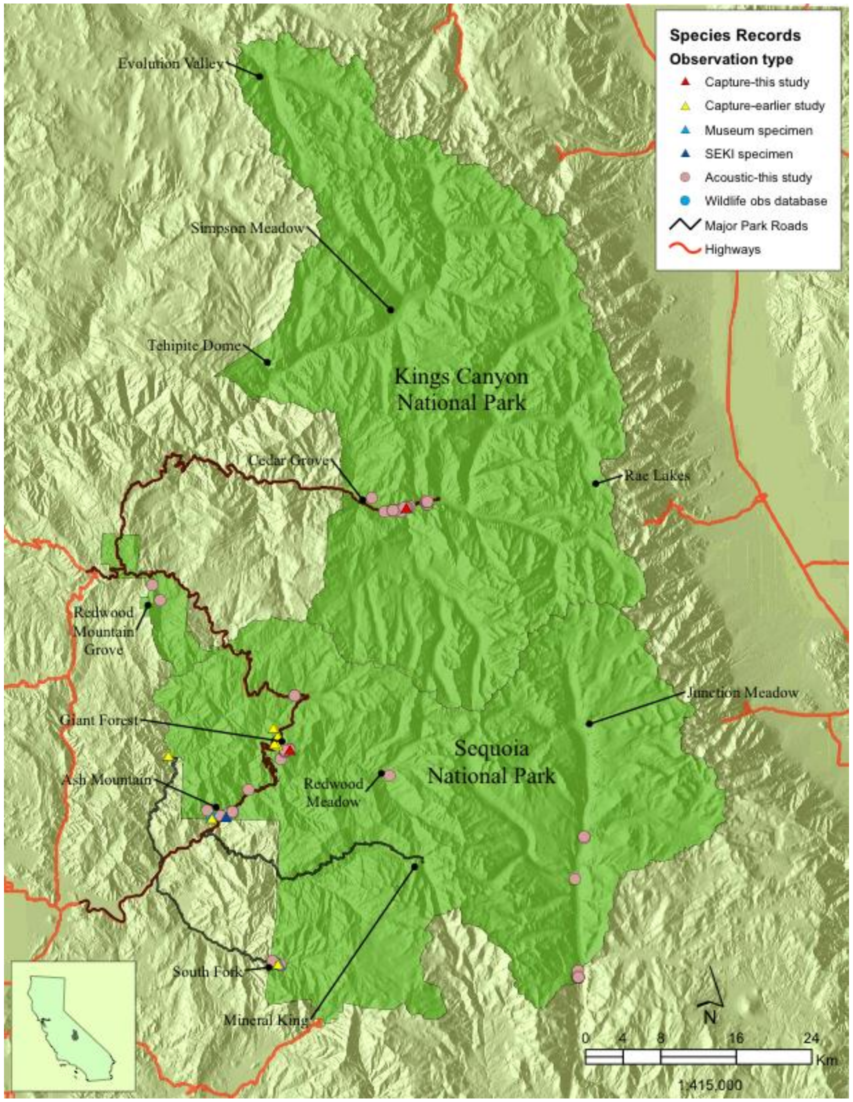
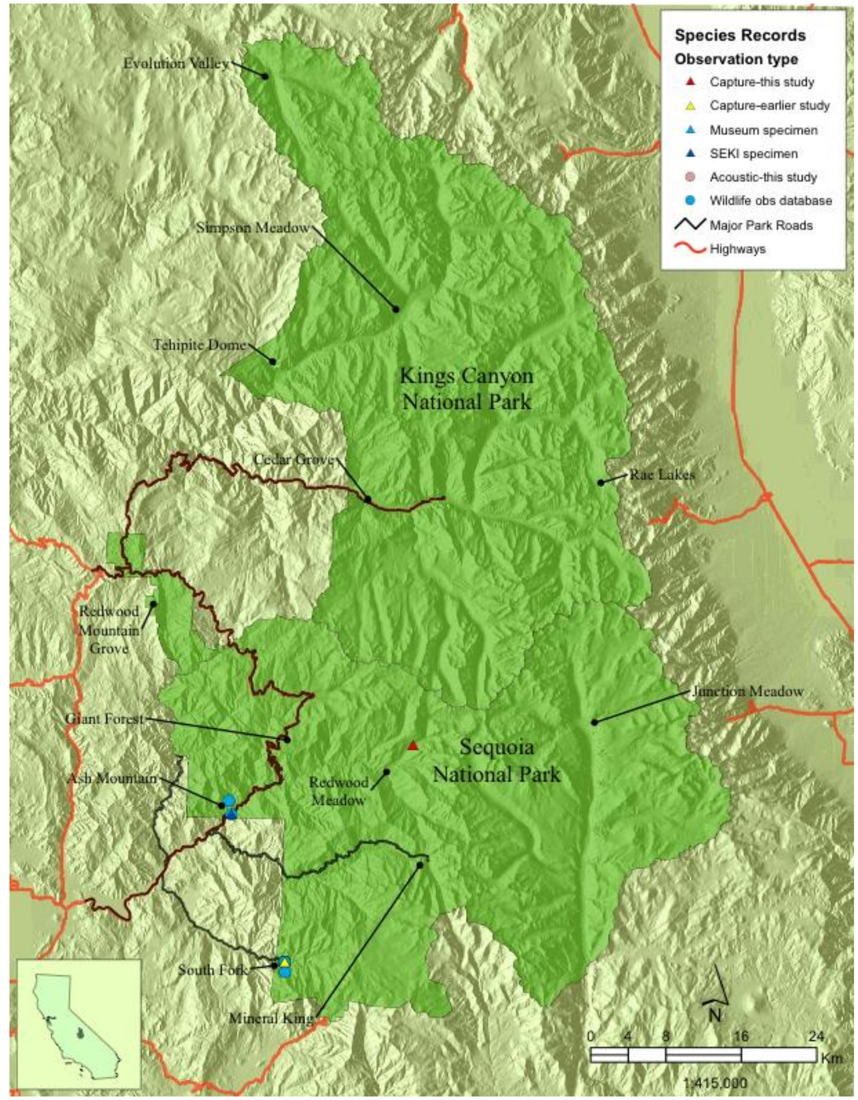
Appendix A.

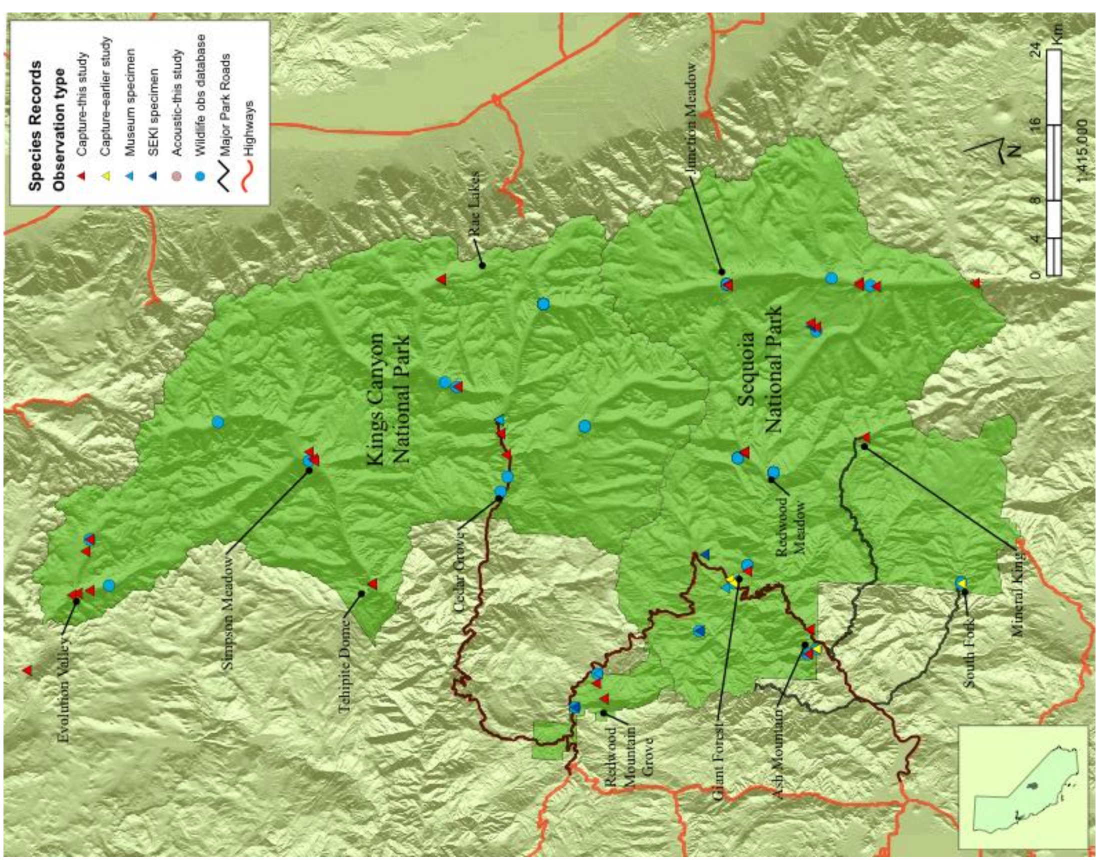
Maps illustrating locations at which bat species were observed at Sequoia and Kings Canyon National Parks. From Pierson and Rainey (2009). The legend indicates the observation type. Observation types include the following:
‘Capture-this study’ indicates the species was captured during the recent SEKI bat inventory (Pierson and Rainey 2009)
‘Capture-earlier study’ indicates the species was captured by Pierson and Rainey during previous inventories at SEKI.
‘Museum specimen’ indicates that an individual was collected for a museum collection.
‘SEKI specimen’ indicates that an individual was collected and resides in the SEKI museum collection.
‘Acoustic-this study’ indicates that acoustic evidence was collected for this species at this location.
‘Wildlife obs database’ indicates observations in the park database supported by museum specimens or recorded by credible sources (e.g. experienced bat researchers)



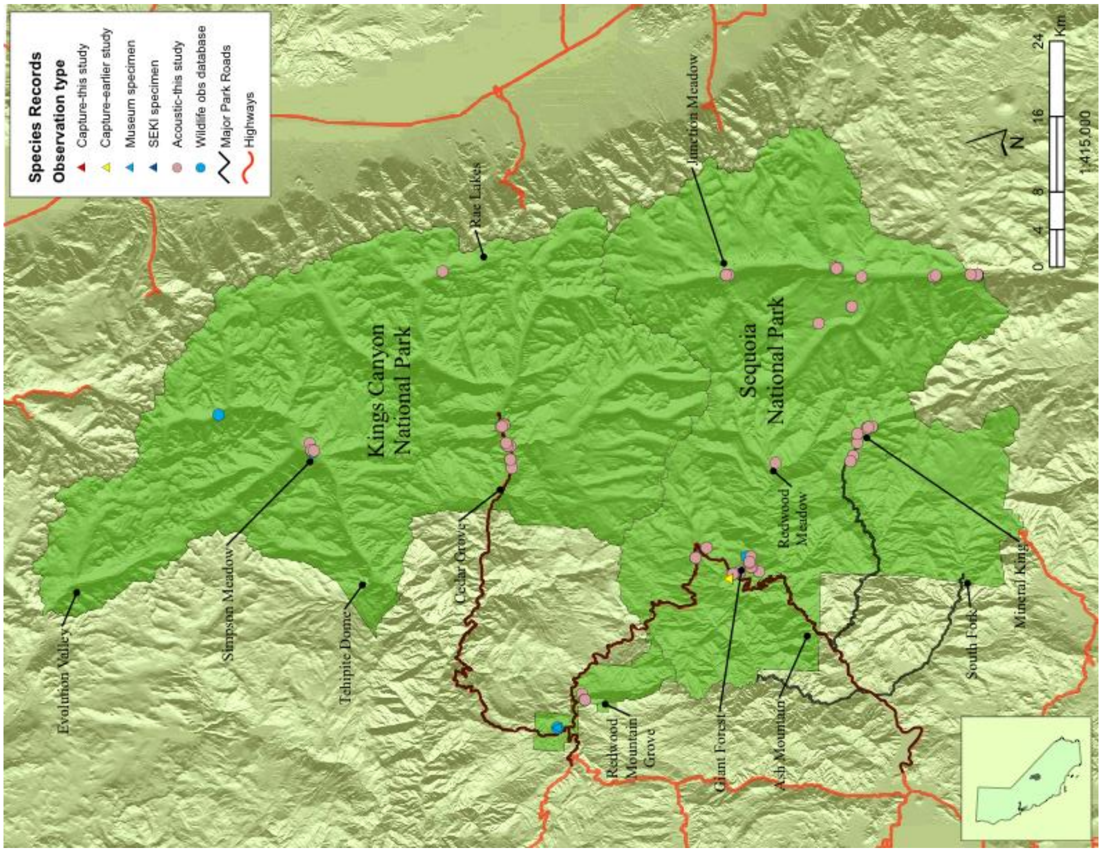
Antrozous pallidus. Pallid bat.



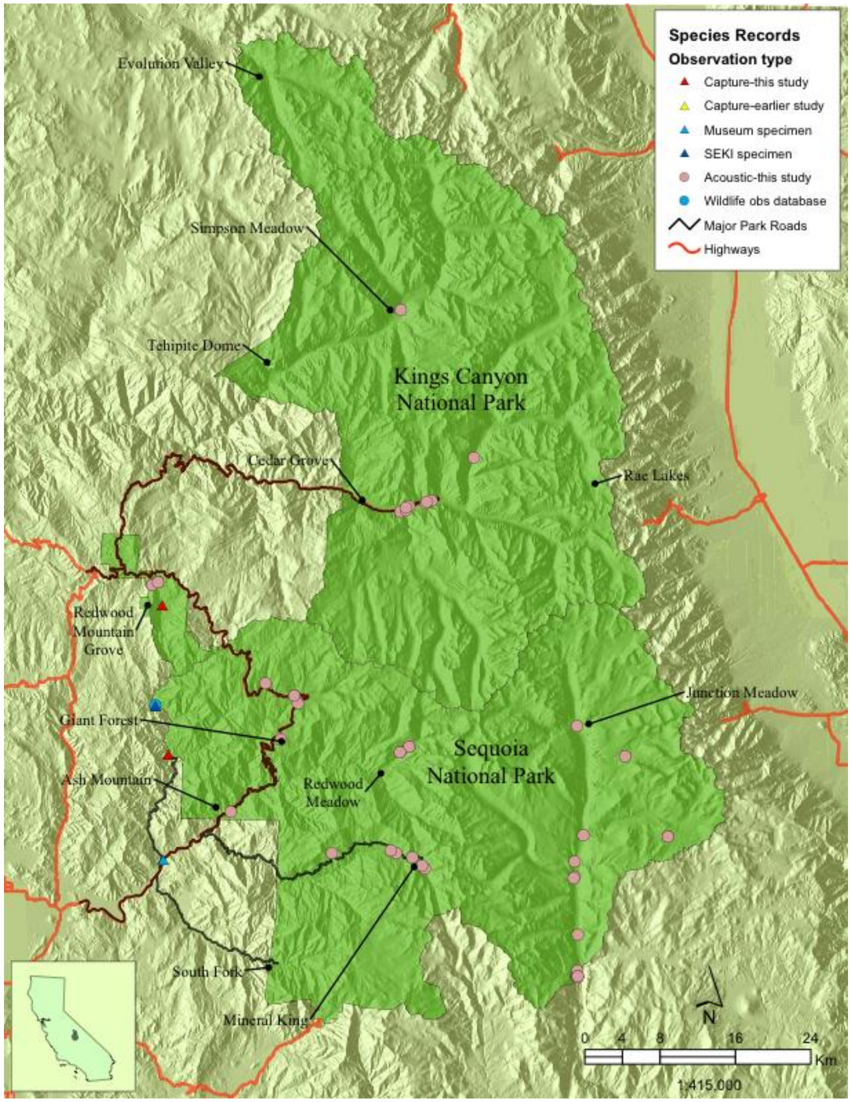
Corynorhinus townsendii. Townsend's big-eared bat.



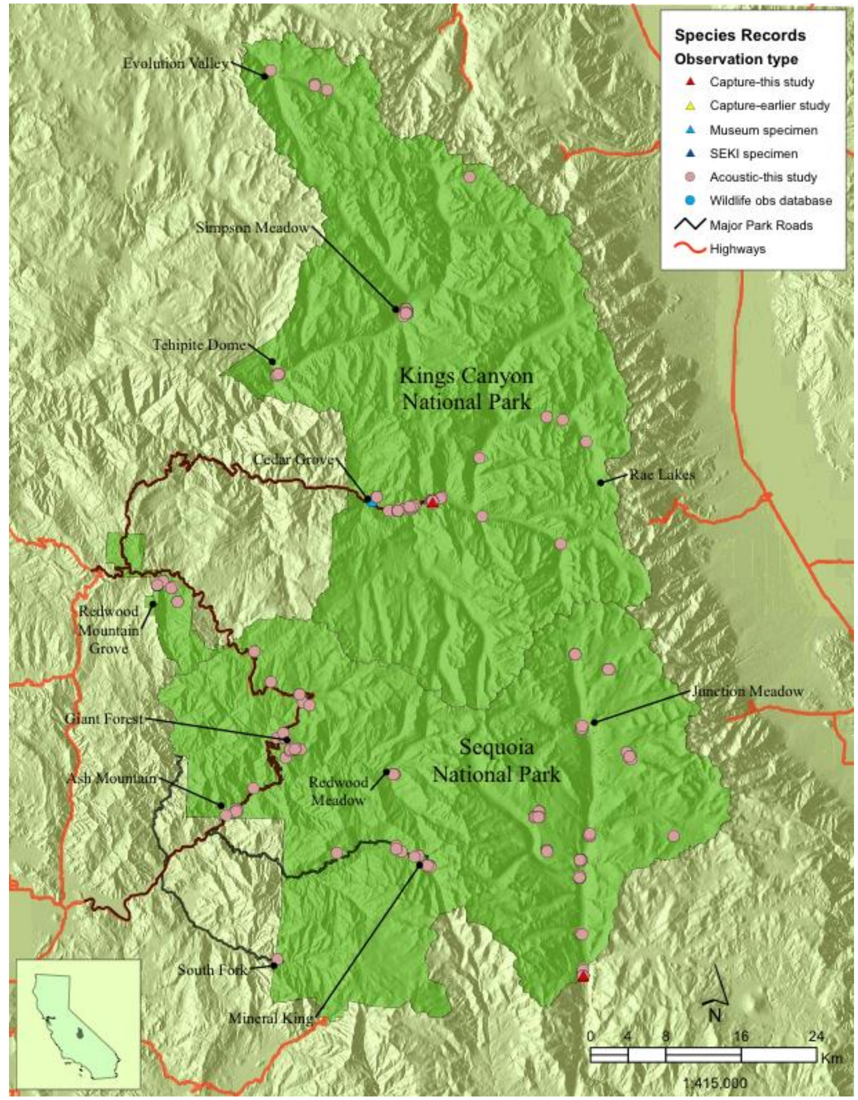
Eptesicus fuscus. Big brown bat



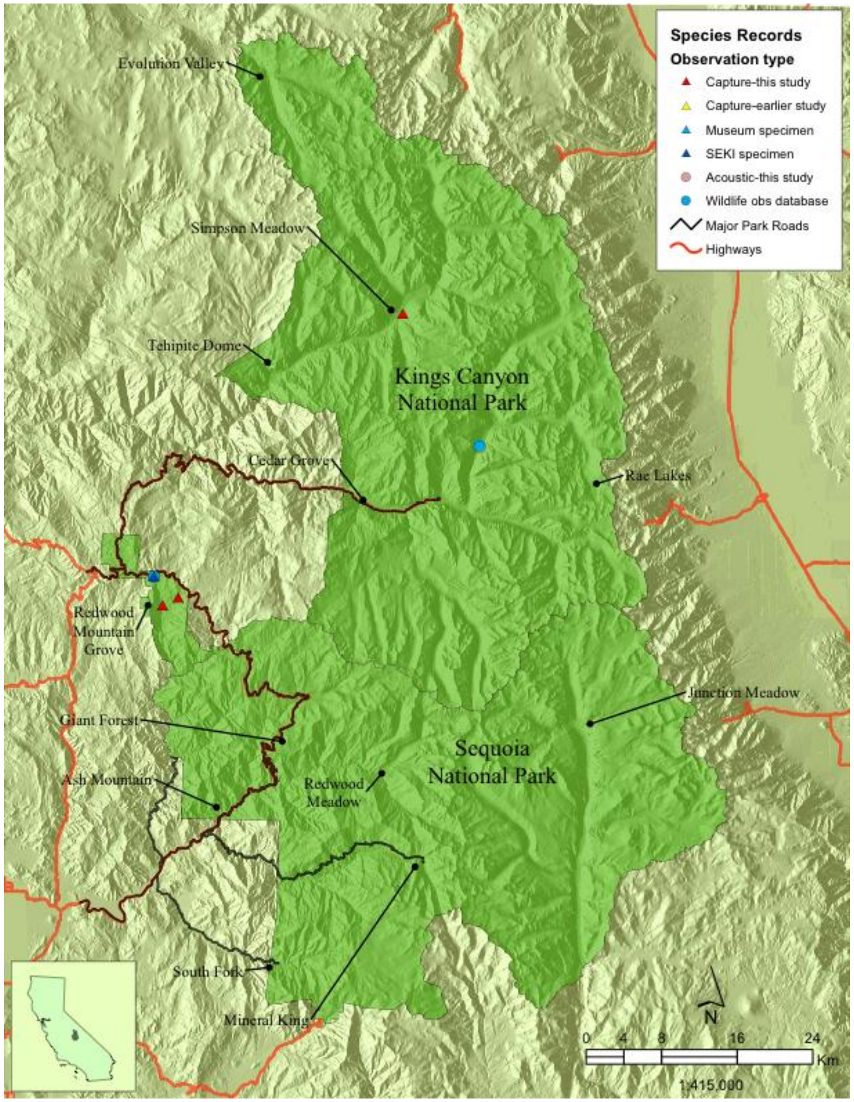
Euderma maculatum. Spotted bat



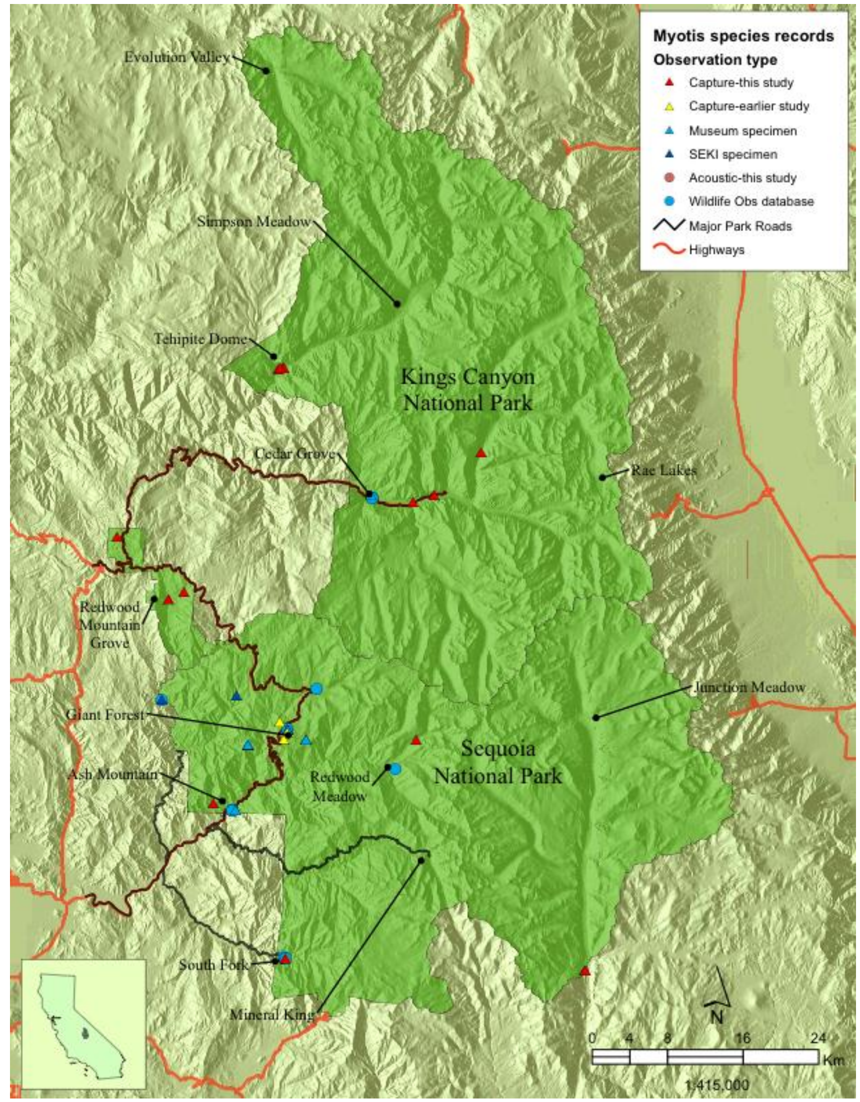
Lasiurus blossevillii. Western red bat



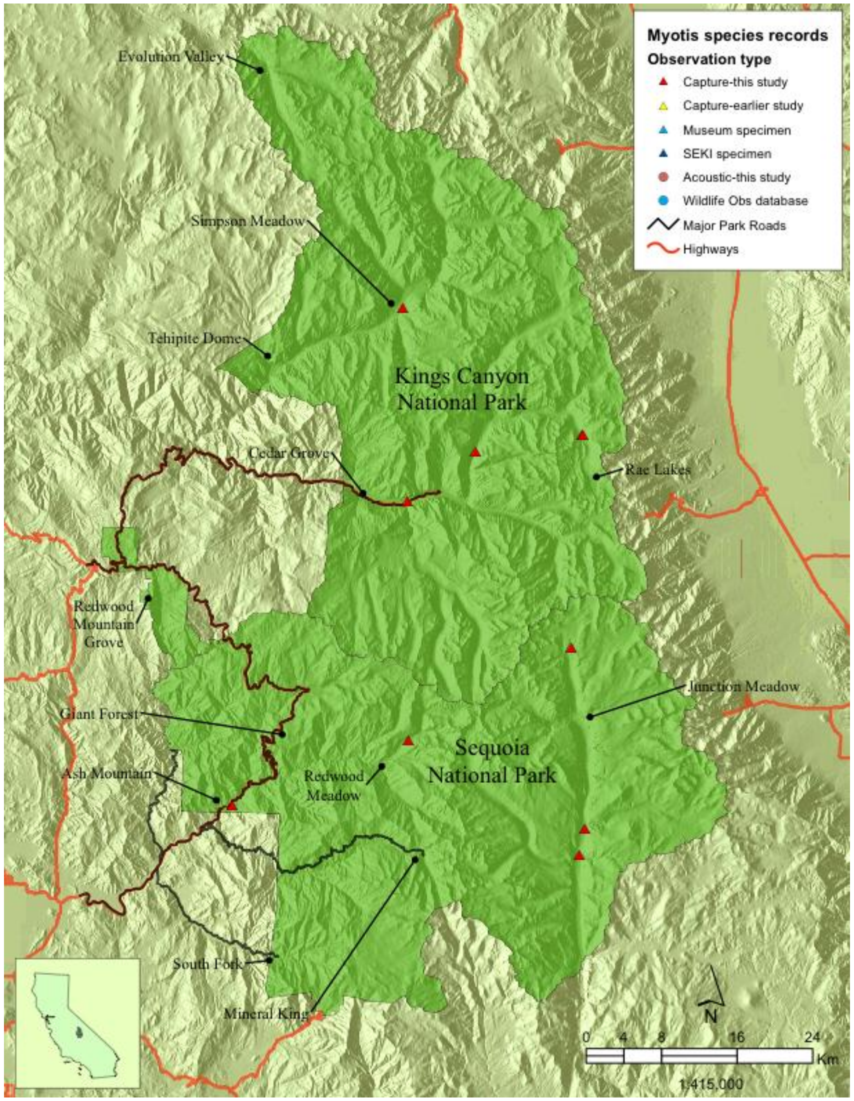
Lasiurus cinereus. Hoary bat.



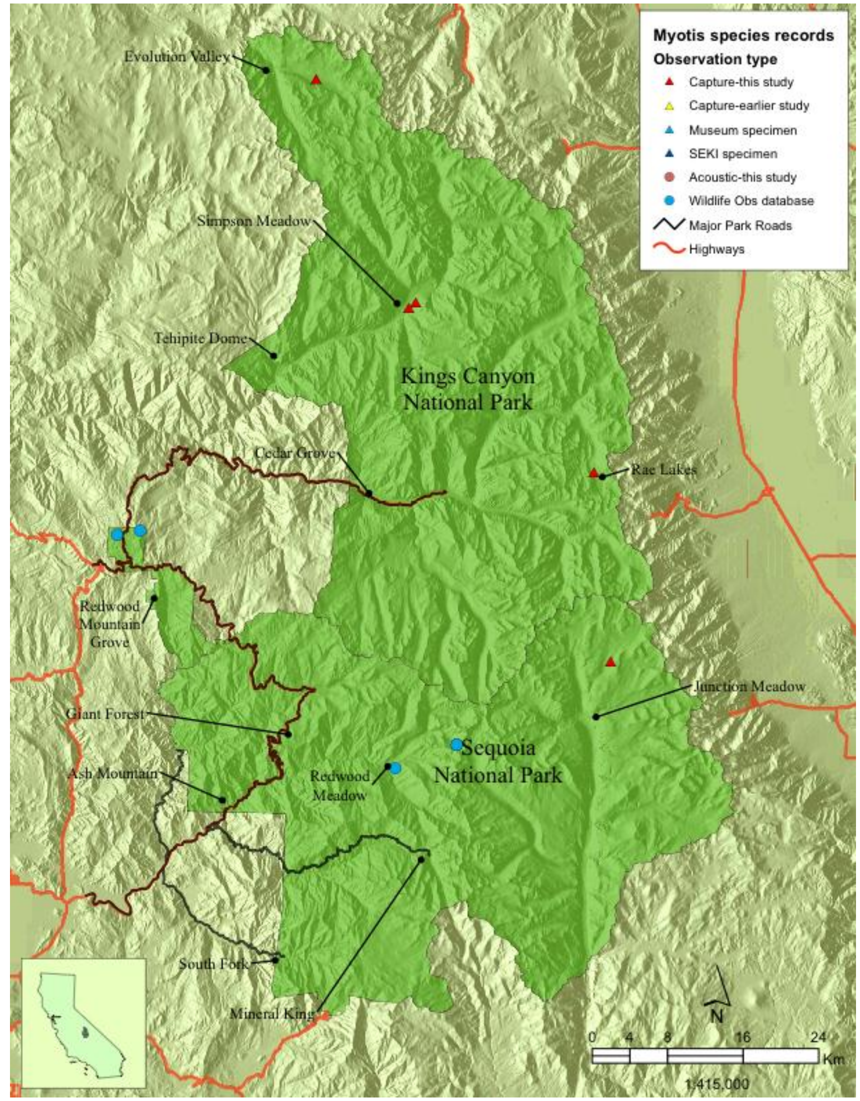
Lasionycteris noctivagans. Silver-haired bat



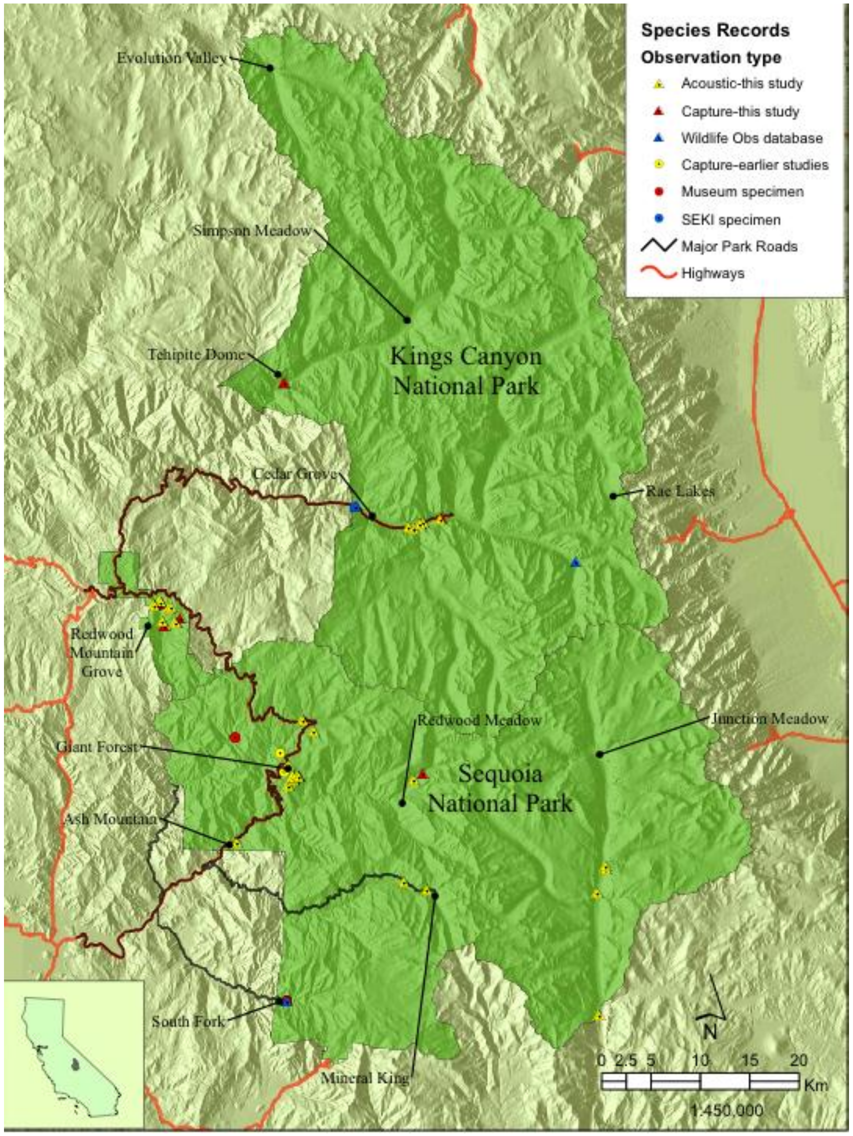
Myotis californicus. California myotis



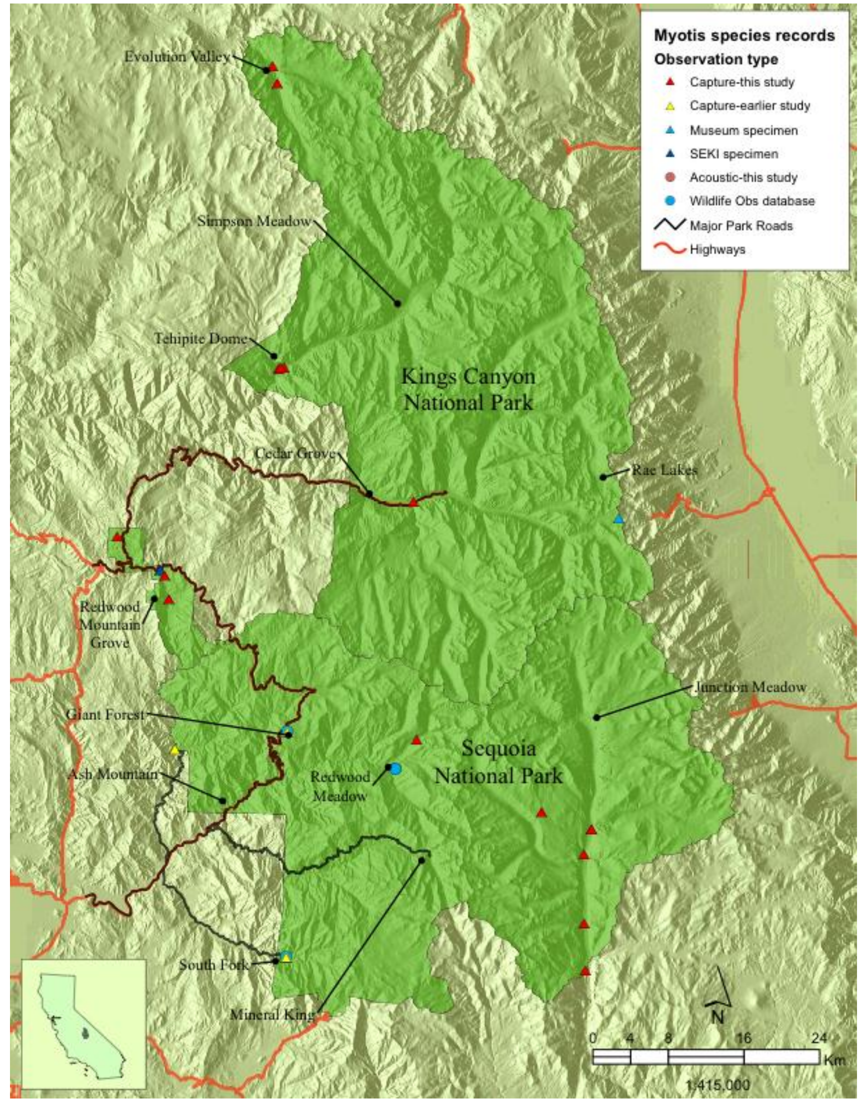
Myotis ciliolabrum. Small-footed myotis.



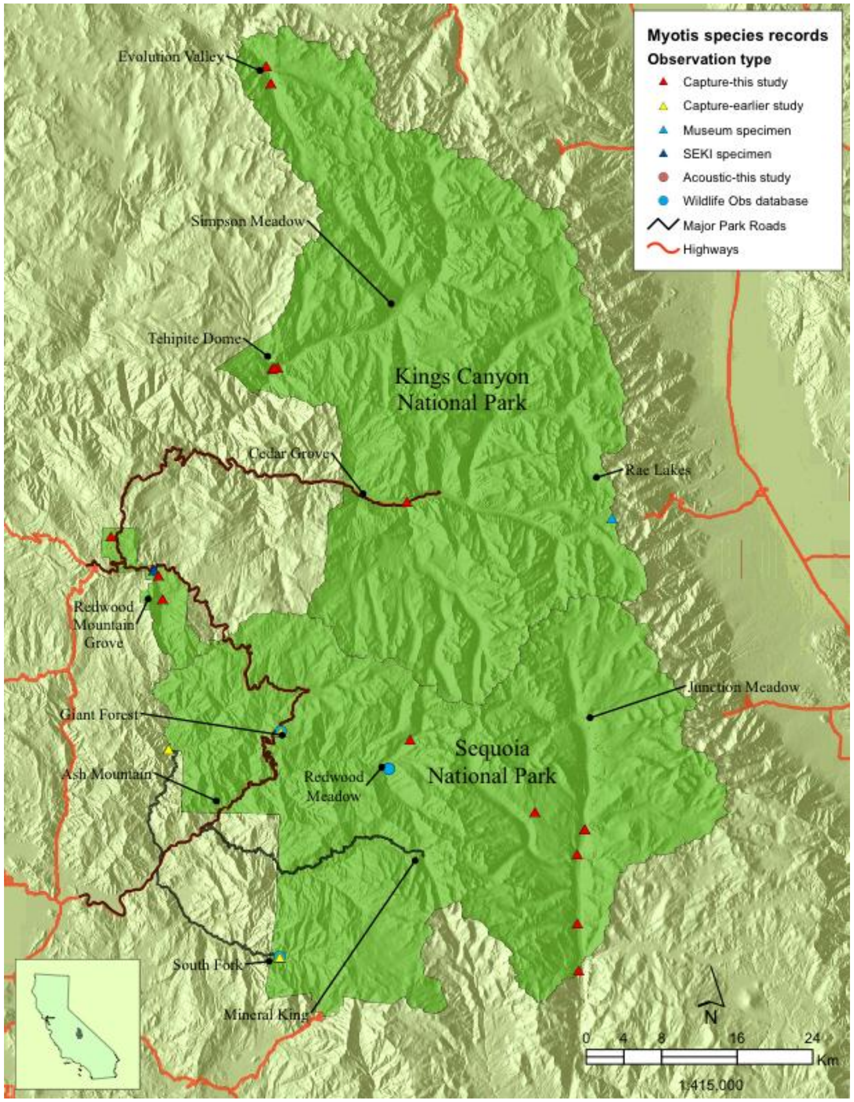
Myotis lucifugus. Little brown bat.



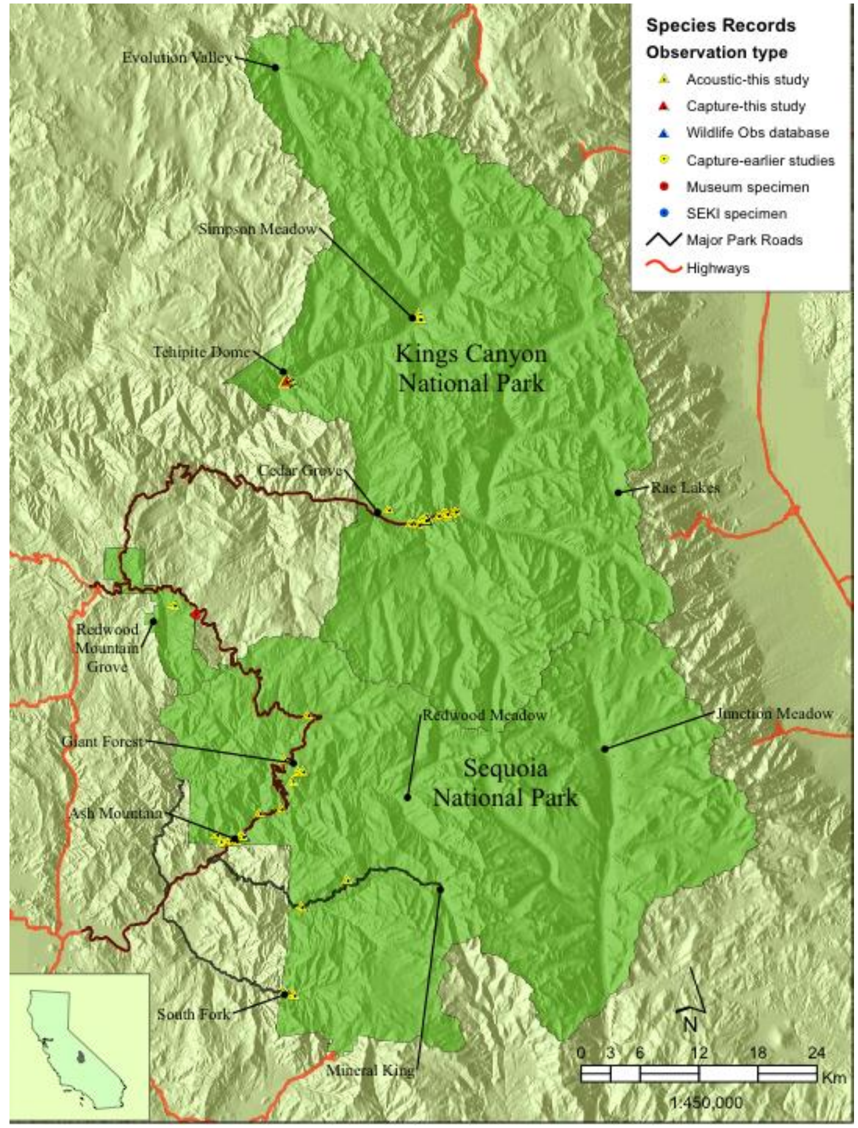
Myotis thysanodes. Fringed myotis.



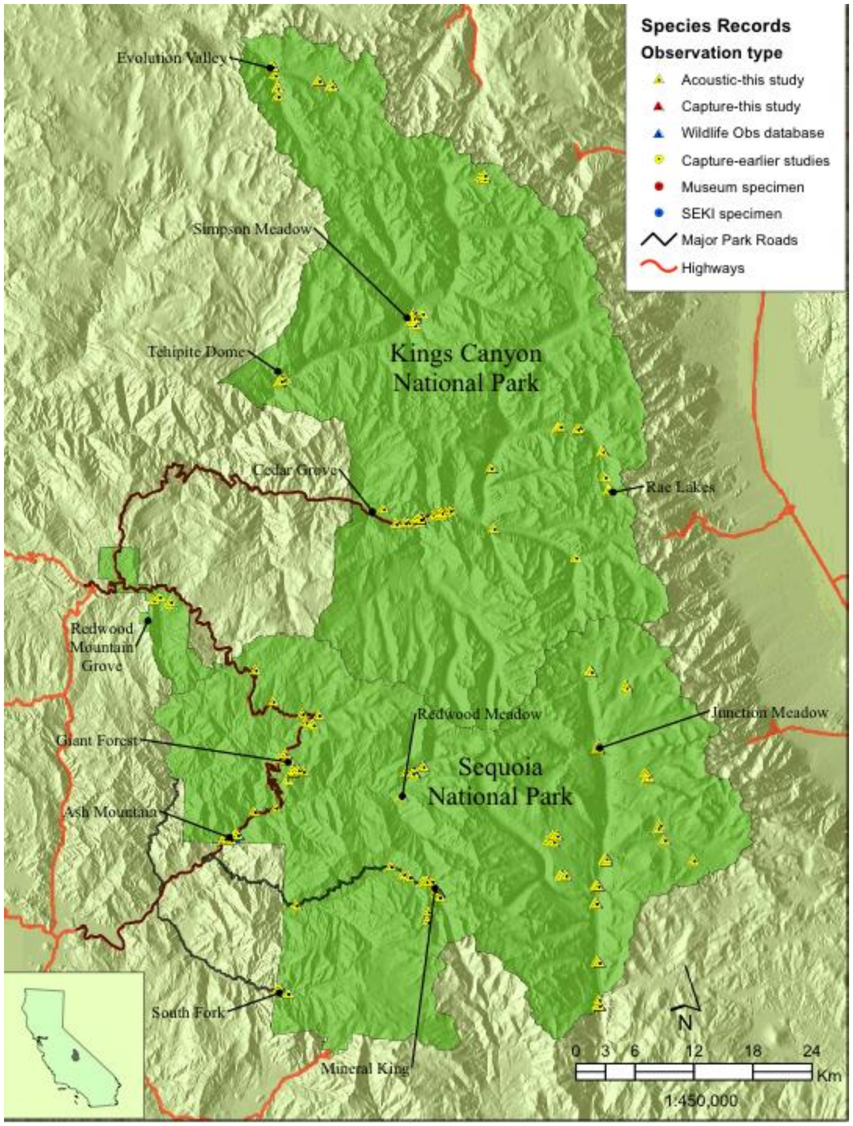
Myotis volans. Long-leggedmyotis



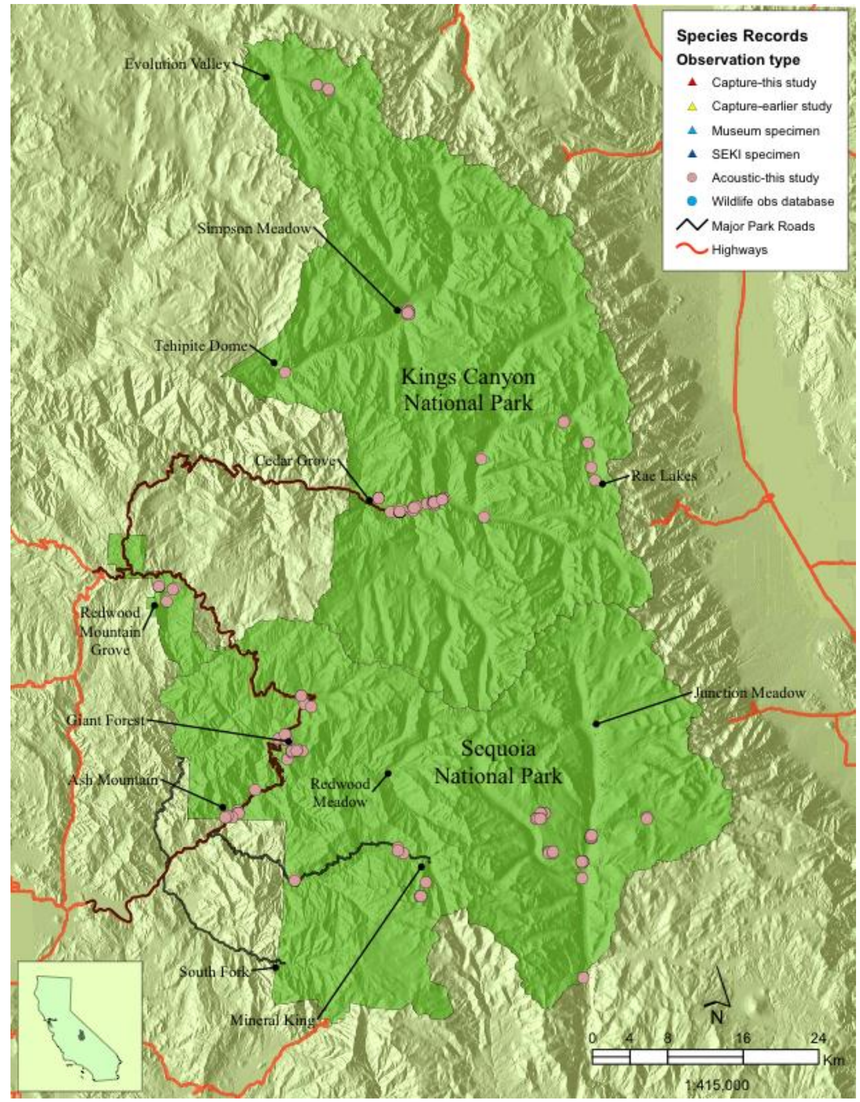
Myotis yumanensis. Yuma myotis.



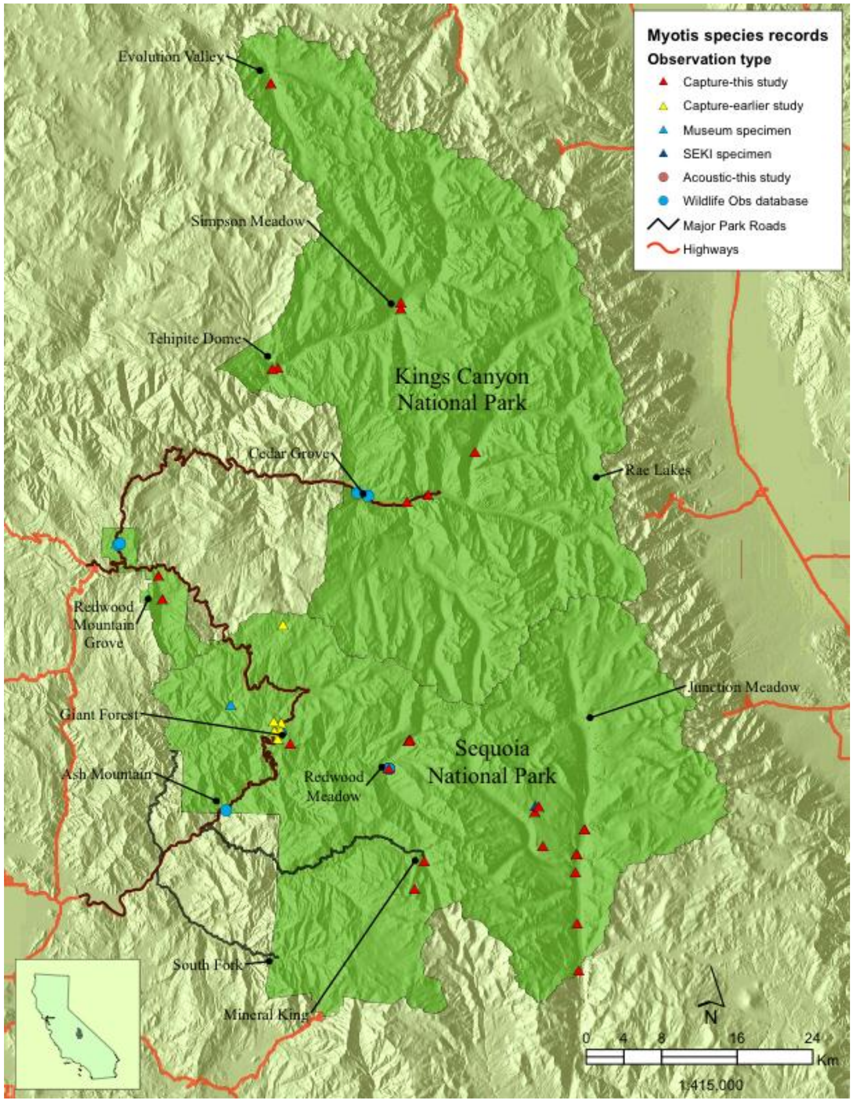
Parastrellus hesperus. Western pipistrelle.



Tadarida brasiliensis. Mexican free-tailed bat.



Eumops perotis. Western mastiff bat.



Myotis evotis. Long-eared myotis.

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