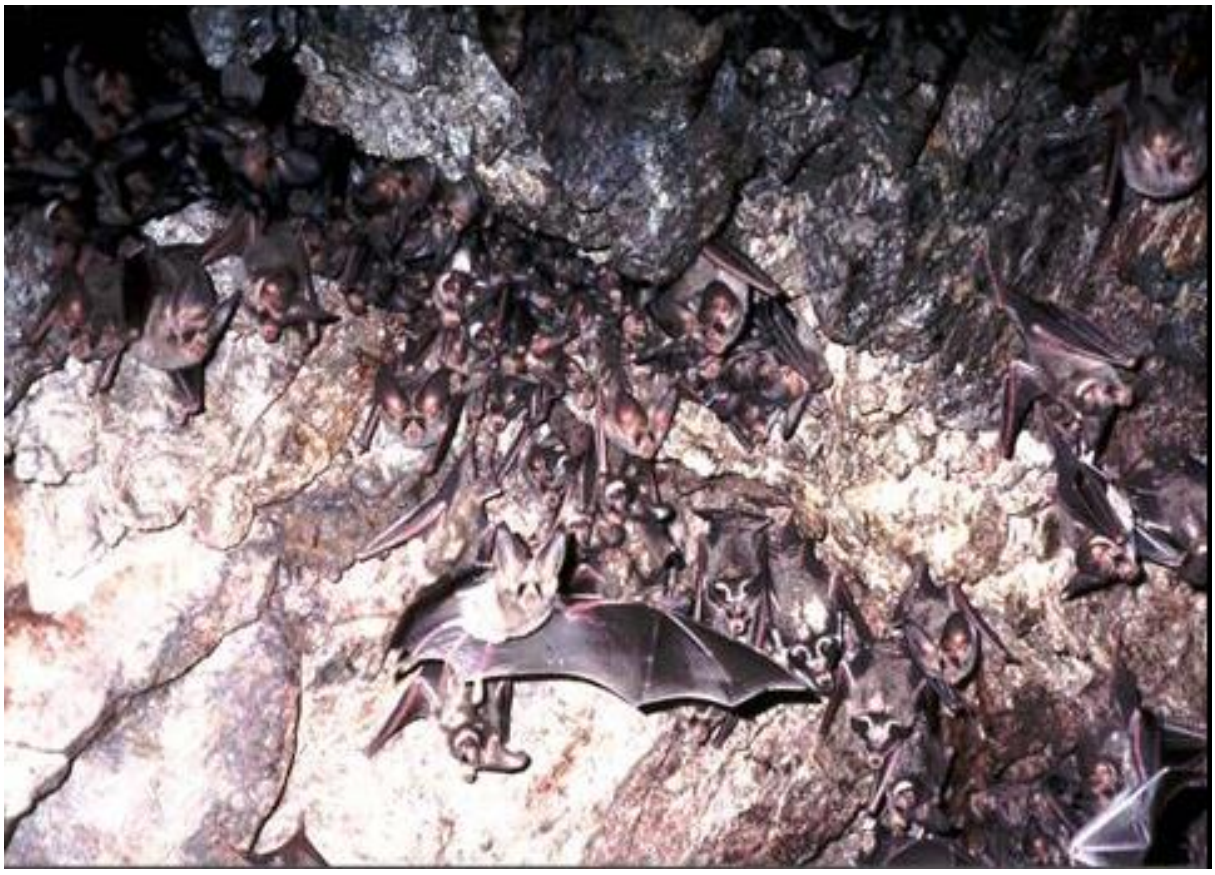
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Roost Surveys and Monitoring for Lower Colorado River Bat Species

2013 Annual Report



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September 2013

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Lower Colorado River
Multi-Species Conservation Program

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Lower Colorado River
Multi-Species Conservation Program
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ACRONYMS AND ABBREVIATIONS

AGFD	Arizona Game and Fish Department
BLM	Bureau of Land Management
Cibola NWR	Cibola National Wildlife Refuge
Havasu NWR	Havasu National Wildlife Refuge
Imperial NWR	Imperial National Wildlife Refuge
km	kilometer(s)
Lake Mead NRA	Lake Mead National Recreation Area
LCR	Lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
m	meter(s)
Reclamation	Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service

Symbols

°C	degrees Celsius
°F	degrees Fahrenheit
>	greater than

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ABSTRACT

The Lower Colorado River Multi-Species Conservation Program, implemented in 2005, included two bat species as covered: the western red bat (*Lasiurus blossevillii*) and the western yellow bat (*Lasiurus xanthinus*), while the Townsend's big-eared bat (*Corynorhinus townsendii*) and California leaf-nosed bat (*Macrotus californicus*) were added as evaluation species. The latter two species are colonial and roost in mines adjacent to the flood plain of the lower Colorado River (LCR). Over the past 60 years, declines have been observed in some bat species, such as the cave myotis (*Myotis velifer*) and Townsend's big-eared bat, which were at one time relatively abundant along the LCR. Colonial bats offer the opportunity to directly monitor numbers of bats through roost exit counts and thereby determine population trends. Since 2000, biannual censuses have been conducted of eight winter and summer mine roosts along the LCR from near Davis Dam to near Laguna Dam. Since 2011, three more mines have been added to the census (Roosevelt, Senator, and Rio Vista) as well as mines near Planet Ranch along the Bill Williams River. The main objective of this project is to monitor population trends of colonial roosting bats using outflight counts. Both manual finger tally and video counts were used to estimate the annual number of bats. The Eureka Mine appears to be the only roost that has had a noticeable decline since 2008. Some other roosts showed variability between years but not a specific upward or downward trend.

INTRODUCTION

The Lower Colorado River (LCR) historically sustained a diverse bat assemblage of at least 14 species (Allen 1864; J. Grinnell 1914; H.W.Grinnell 1918; Barbour and Davis 1969; Stager 1939; Constantine 1998; Vaughan 1959; Cockrum et al. 1996; Brown and Berry 2003), with another 6 species potentially occurring (table 1). A total of 25 bat species have been reported from the State of California and 29 from the State of Arizona. Some bats roost in trees along the LCR, others in mines and caves, while others (such as Mexican free-tailed and western mastiff bats) may commute nightly over 40 kilometers (km) from cliff roosts to forage over the LCR. All can be construed to be dependent on the LCR for their survival. Colonies of several thousand bats have been documented roosting in mines in the Riverside Mountains, Riverside County, California, in the 1930s (Stager 1939). As described by Dr. Ken Stager, "these rugged, volcanic mountains are bordered on the east by the almost impenetrable, broad, lower valley of the Colorado River which separates California from Arizona. From them, one obtains a view of countless square kilometers of the broad river valley, cloaked in a covering of luxuriant vegetation. This mass of green, consisting mainly of cottonwood (*Populus*) and arrowweed (*Pluchea*), extends to the foot of the mountains where it is suddenly replaced by the more typical desert plants, such as smoke tree (*Dalea*), palo verde (*Cercidium*), iron wood (*Olneya*), and creosote bush (*Larrea*). From this blanket of vegetation over the river valley, rise countless millions of insects, which provide food for bats." When I visit the mines in the Riverside Mountains now, I witness a blanket of agricultural fields bordered by *Tamarisk* spp. and interspersed with river camps. Times have indeed changed along the LCR and so has the biota. However, this trend is being reversed to some extent by the restoration activities led by the Bureau of Reclamation (Reclamation) for the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) (Reclamation 2004). Two bat species are covered under the habitat conservation plan, the western red bat (*Lasiurus blossevillii*) and the western yellow bat (*Lasiurus xanthinus*), while the Townsend's big-eared bat (*Corynorhinus townsendii*) and California leaf-nosed bat (*Macrotus californicus*) are included as evaluation species.

Over the past 60 years, some bat species appear to have declined in numbers, such as the cave myotis (*Myotis velifer*) and Townsend's big-eared bat, which were at one time relatively abundant along the Colorado River. Large deposits of the distinctive guano of these colonial species are found in abandoned mines that border the LCR where the bats are now absent or are present in relatively small numbers. Only three maternity colonies of cave myotis are now known along the Colorado River south of Lake Mead, and one is imperiled by closure of the mine from wash debris (Brown and Berry 2003). Colonies of the Arizona myotis (*Myotis occultus*) appeared to have disappeared from the LCR (Stager 1943), with the last museum specimen collected by Constantine in 1945. The type locality for this bat species was Ft. Mojave north of Needles, California (Grinnell 1918). However, recently Arizona myotis have been captured in a habitat creation area in

Table 1.—Status[1] of bats potentially occurring along the LCR
(Bold = Bats that roosted in mines along the LCR during the current survey.)

Species name	USFWS	CDFW	BLM	AGFD	WBWG	IUCN
Phyllostomidae						
Choeronycteris mexicana	SC	SSC	Sensitive	Threatened	High	LR:nt
Leptonycteris curasoae	Endangered		Endangered	Endangered	High	VU:A1c
Macrotus californicus	SC	SSC	Sensitive	Candidate	High	VU:A2c
Vespertilionidae						
Myotis yumanensis	SC	–	–	–	Low	LR:lc
Myotis velifer	SC	SSC	Sensitive	–	Medium	LR:lc
Myotis occultus	SC	SSC	Sensitive	–	Medium	LR:lc
Myotis californicus	–	–	–	–	Low	LR:lc
Parastrellus hesperus	–	–	–	–	Low	LR:lc
Eptesicus fuscus	–	–	–	–	Low	LR:lc
Lasiurus blossevillii	–	SSC	–	Candidate	High	LR:lc
Lasiurus xanthinus	–	–	–	Candidate	High	LR:lc
Lasiurus cinereus	–	–	–	–	Medium	LR:lc
Euderma maculatum	SC	SSC	Sensitive	Candidate	Medium	LR:lc
Idionycteris phyllotis	SC	N/A	Sensitive	–	High	LR:lc
Corynorhinus townsendii	SC	Candidate for CESA[2]	–	–	High	VU:A2c
Antrozous pallidus	–	SSC	–	–	Low	LR:lc
Molossidae						
Tadarida brasiliensis	–	–	–	–	Low	LR:nt
Nyctinomops femorosaccus	–	SSC	Sensitive	–	Medium	LR:lc
Nyctinomops macrotis	SC	SSC	Sensitive	–	Medium	LR:lc
Eumops perotis	SC	SSC	–	–	Medium	LR:lc

[1] Sources for status determination are as follows:

USFWS = U.S. Fish and Wildlife Service's Endangered Species Act listing. SC refers to species of concern. These are currently all former Category 2 species. These are species whose conservation status may be of concern to the USFWS but do not have official status.

CDFW = California Department of Fish and Wildlife species of special management concern. SSC refers to species of special concern. Corynorhinus townsendii is currently a candidate for threatened or endangered status.

BLM = Bureau of Land Management's sensitive species list (October 2000).

AGFD = Arizona Game and Fish Department – wildlife of special concern in Arizona. AGFD publication. Phoenix, Arizona. 32 p.

WBWG = Western Bat Working Group's *The Western Bat Species: Regional Priority Matrix*. High priority species may be imperiled or at risk of imperilment; medium priority indicates a level of concern, but information regarding the species and perceived threats is lacking; and low priority indicates that most of the existing data suggest species' populations are stable, and the potential for major changes in status is considered unlikely.

IUCN = The World Conservation Union conservation status: LR:nt = lower risk, near threatened; VU = vulnerable; and LR:lc = lower risk, least concern. Red list (VU) subcategories include: A = threshold levels of population reduction either in the past (1) or predicted for the future (2), and c = reduction based on decline in area of occupancy, extent of occurrence, or quality of habitat (Hutson et al. 2001).

[2] CESA = California Endangered Species Act.

the ʻAhakhav Tribal Preserve south of Parker, Arizona, as well as the Cibola Valley Conservation Area north of Cibola, Arizona (Calvert 2009a, 2010, 2012b). A single telemetered female was tracked to a maternity colony of over 200 bats roosting in the skirt of a palm tree next to a house on Colorado River Indian Tribe land (Diamond et al. 2013).

One hypothesis for the decline of some bat species is the removal and replacement of native flood plain vegetation that supported the insect diets of these bats. Another is the heavy pesticide spraying in agricultural areas (conducted principally at night) that would directly reduce the prey base and poison the bats. A third possible cause is the disturbance of roosts by the increased resident and recreational human populations along the Colorado River.

Although some historic data exist on the distribution and relative abundance of bats along the LCR, many areas had never been surveyed for bats. Traditional methods of collecting bats (shooting and mist netting) would sample only those bats flying at low altitude. Capturing bats in mines and caves would overlook those species roosting in trees and cliffs. In 2001–02, Brown and Berry (2003) were funded to conduct baseline surveys and to develop a monitoring protocol for LCR bat species. One goal of the surveys was to determine if the apparent reduction in numbers and species of some bats, such as cave and Arizona myotis, was the result of sampling bias or if these species had in fact disappeared or declined along the LCR. The survey employed relatively new methods of acoustic monitoring (O'Farrell and Gannon 1999) as well as roost surveys and some mist netting to give a more complete picture of the bat species present along the LCR.

The goals stated in the original 2001 bat proposal to the LCR MSCP committee were fourfold:

1) To provide a better understanding of the past versus current bat assemblage along the LCR

2) To establish a long-term monitoring protocol for bats utilizing current technology

3) To identify potential species-specific threats to bats

4) To assist in the protection of critical roosts

In 2005, the LCR MSCP was implemented. The most visible effects of this program have been the revegetation of parcels of previous agricultural land with native cottonwood, willow, and mesquite. The tree-roosting western red and yellow bats covered by the program are being monitored through mist netting and acoustic surveys by Reclamation and Arizona Game and Fish Department (AGFD) biologists (Calvert 2009a, 2009b, 2010; Vizcarra and Piest 2010;

Diamond et al. 2013) and appear to be increasing in numbers as the program proceeds due to the increase in detections at LCR MSCP habitat creation areas.

The two evaluation species, California leaf-nosed bats and Townsend's big-eared bats, emit low-intensity echolocation signals and are therefore more difficult to monitor. They do, however, roost in mines along the LCR, and their populations can be monitored through roost exit surveys. The cave myotis is considered to be an indicator species of good cottonwood riparian habitat, and the remaining LCR colonies were included in the roost surveys to provide another measure of the success of the revegetation projects. Additionally, all of the remaining cave myotis roosts are shared by California leaf-nosed bats. The main objective of the current project is to monitor these three colonial roosting bats using outflight counts to monitor population trends in order to monitor these species at a system-wide scale across the LCR.

METHODS

The field surveys for the current LCR MSCP funded project were conducted along the LCR from mines near Lake Mojave in Lake Mead National Recreation Area (Lake Mead NRA) to Laguna Dam (figure 1) for 278 days and/or nights between October 6, 2002, and May 20, 2013, primarily on land administered by the National Park Service, U.S. Fish and Wildlife Service (USFWS), and the Bureau of Land Management (BLM). All survey areas (acoustic, mist netting, and roost) were documented and located using Magellan or Garmin Global Positioning Systems. An additional 19 days per night were devoted to surveys at the Planet Mines between August 27, 2011, and May 15, 2013.

Roost Surveys

Roost surveys were conducted at mines along the LCR both during the day and at night for evidence of bats and guano. Occasionally, bats were captured in hand nets inside the roost or in mist nets or a harp trap erected at the portal in order to obtain information on sex and reproductive status.

Several factors were involved in the selection of mines for long-term monitoring. Some had prior baseline population data gathered by Stager (1939), Vaughan (1959) or Brown and Berry (personal observation; Brown and Berry 1998, 2003, 2004). The 10 major mine complexes selected occurred in different geographic sections of the LCR and were within 8 km of the flood plain. The winter surveys focused on mines with large populations of California leaf-nosed bats. This species concentrates in relatively few mines in winter. The spring or summer monitoring sites included the only known maternity colony of Townsend's big-eared bat along the LCR and the larger maternity colonies of California

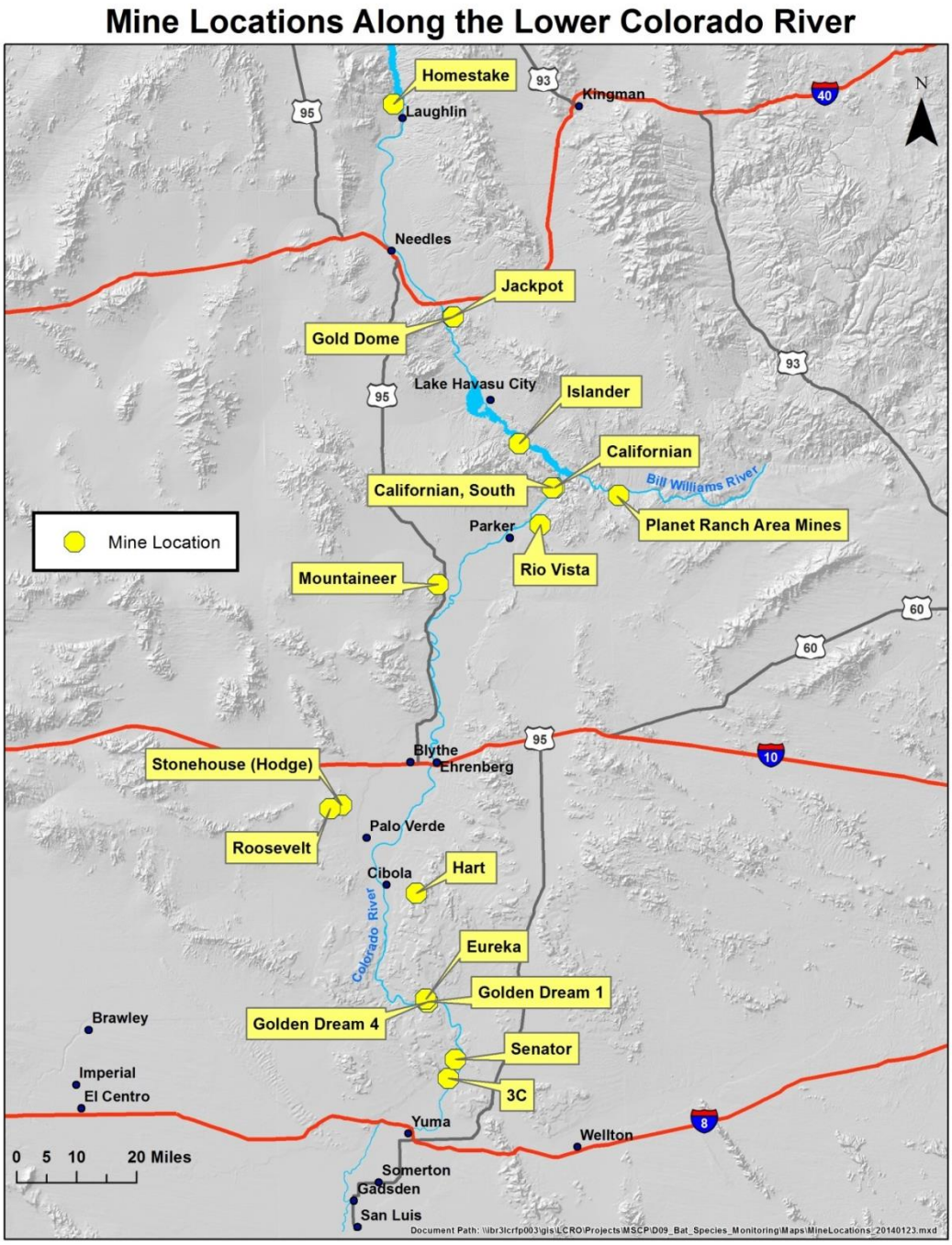

Figure 1.—Map of mine survey sites.

leaf-nosed bats. Some large colonies of Yuma and cave myotis were included as indicator species where they shared roosts with California leaf-nosed bats.

Winter surveys were conducted in January or February, a time when the winter California leaf-nosed bat colonies are at their greatest size and when they are usually the only species present in the mine. The spring surveys are usually conducted between mid-April and mid-May in an attempt to count the maternity colony before any of the juveniles became volant. Sometimes the *Myotis* sp. give birth in early April, before all of the California leaf-nosed bat females have arrived in the mine. California leaf-nosed bats usually deliver their pups from the middle to the latter part of May.

Weather data were recorded at the time of the surveys, and exit counts were not attempted if the windspeed was greater than 20 km per hour or if it was raining. In January 2003, we became aware that moon phase was recognized as a significant variable in determining population size by exit counts for California leaf-nosed bats when paired counts were conducted during the week before and after the full moon on selected mines in southeastern California. There was a several fold increase in the number of bats exiting the mine in the hour after dark in the absence of moonlight (Brown and Berry 2003, 2004; figure 21 this report). For example, the absolute numbers of bats were greater in the 3C Mine exit counts in January 2003 (1,515 with the moon and 2,491 the following week). Since past exit counts over the last 20 years prior to 2003 did not factor in the moon phase variable, we are now attempting to do the California leaf-nosed bats census when no appreciable moonlight is available (and avoid the week before the full moon).

To obtain accurate exit counts, occupied mines are monitored at dusk by surveyors with night vision equipment (augmented with infrared light sources) and two finger tally counters: one for bats exiting and one for those entering a mine. The counts continue for at least 60–90 minutes after the first bat exits or until more bats began to enter than exit the mine. For mines where the bats exit very rapidly in great numbers, several people might watch the same portal and their net exit counts averaged. Some of the mines (Hart, Californian, and Jackpot) can be safely entered after the exodus dwindles to visually estimate the number of bats still remaining. Sony "Nightshot" video cameras with auxiliary infrared lights are used to remotely monitor mines and to obtain permanent records of exiting bats (even for some mines that are watched by people real time). This is especially important in those mines in which hundreds of bats might exit within 5 minutes. The tapes are reviewed to count bats later at half speed. Depending on the number of bats, the speed of their exodus, and the experience of the observers, real time counts could be either greater or lesser than the video-taped record. At times, mist nets or harp traps are also placed across portals of the Mountaineer, 3C, Californian, Homestake, and Stonehouse Mines to ascertain if maternity colonies are still using them.

RESULTS

Roosts

Between 2002 and 2010, 10 mine areas along the LCR were regularly monitored for bats, and several more were surveyed. Beginning in 2011 or 2012, three more mines close to the LCR were added – Roosevelt, Senator, and Rio Vista – as well as mines near Planet Ranch along the Bill Williams River. Six of the original mines had baseline data spanning two decades or more. Most of the mines sheltered California leaf-nosed bats at some season, and some also had maternity colonies of *Myotis* sp. Nine bat species were discovered using these mines as day or night roosts (see table 1). The mines described below were selected for monitoring because they represented roost areas along different sections of the LCR, starting north and heading down river, as well as sheltering large colonies of target species at some time of the year. Both real time observer counts and video data are presented in the figures for comparison. The raw counts will not be presented in this report but are available upon request from Reclamation.

Homestake Mine (a.k.a. Jackass Flat)

This mine complex is the furthest north of the monitored mines and is located in the Newberry Mountains, Clark County, Nevada, within the Lake Mead NRA northwest of Davis Dam. This is the "lost" Jackass Flats Mine surveyed by Musgrove in 1961–62 (Cockrum et al. 1996), although the geographic location given in the paper is inaccurate. This mine shelters the only known colony of cave myotis in Nevada (Cockrum and Musgrove 1964). From the summer banding records of Musgrove, the colony contained approximately 70 male and female cave myotis and was probably a maternity site. Other species present at the time included over 200 male and female California leaf-nosed bats, over 100 male and female Yuma myotis, and a small number of male and female Townsend's big-eared bats. Since the mine was "rediscovered" in May 1999, we have observed fewer bats (individuals and species) than were reported in 1961. The main adit entrance has collapsed, and the mine is now entered through three shafts. An adit on the wash leads into stopes only accessible to bats. Large piles of old cave myotis guano remain in the mine, but only about 12 cave myotis were seen in May 2001, including 2 males that were captured. Only male cave myotis and California leaf-nosed bats have been captured in the spring or summer surveys, and the mine is probably not a maternity roost. Both sexes of California leaf-nosed bats have been captured in winter. Bryan Moore (Lake Mead NRA) gated the lower wash adit in 2002 and installed cupolas (vertical angle iron bars on three sides and expanded metal on the top) on the shafts in 2009. The resident bat populations reached the peak census in winter 2009, with over 500 bats emerging from all openings; since that time, the numbers have declined

to an average winter population of 150 California leaf-nosed bats (figure 2). The spring population fluctuates more, with a low count of 32 in May 2012 and a high of 197 in 2011, and is predominantly California leaf-nosed bats with a few cave and Yuma myotis.

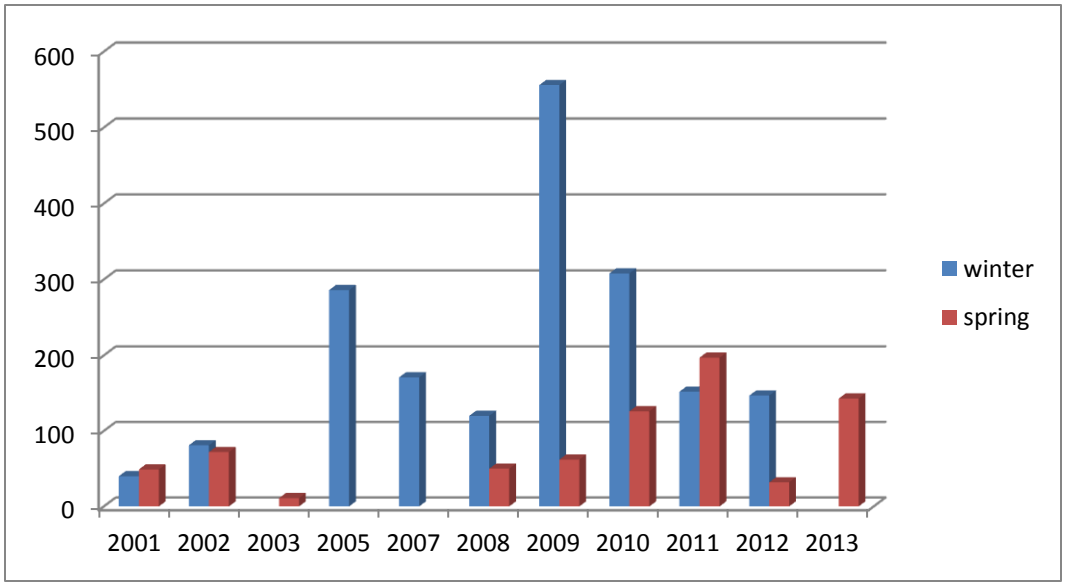

Figure 2.—Homestake Mine winter and spring exit counts of California leaf-nosed bats.

Jackpot Mine

This mine (Mojave County) is the only known active maternity colony for cave myotis along the LCR on the Arizona side of the river. This mine is located 2 km from the LCR in the Mojave Mountains within designated wilderness on the Havasu National Wildlife Refuge (Havasu NWR). Because the main workings of the mine are not properly sited on the topographic map, this mine does not appear to have been previously surveyed by Musgrove (Cockrum et al. 1996). The main Jackpot Mine adit (approximately 200 meters [m] long) is almost sealed by dirt washed down from above, leaving a 2-foot-diameter hole from which the bats emerge. When the mine was first visited in January 2002, almost 500 California leaf-nosed bats exited after dark. A post-outflight exploration of the mine revealed large piles of guano that smelled like that of cave myotis. This was confirmed when we returned on May 8, 2002, and watched about 950 cave myotis and approximately 30 California leaf-nosed bats exiting from the mine. The Jackpot Mine can be entered after the outflight has ended to estimate how many bats remain in the mine. A quick internal survey confirmed the presence of a maternity roost when clusters of newborn cave myotis were discovered in the mine. The cave myotis maternity colony outflights fluctuate between 600 and 1,000 bats; however, in May 2005, over 2,000 bats were recorded on video exiting the mine, predominantly cave myotis and some California leaf-nosed bats.

In May 2005, there were still female cave myotis with juveniles observed inside during the post-exit internal survey. During the May census, only male California leaf-nosed bats were captured in the mine after dark, and these appeared to enter to "night" roost. The winter California leaf-nosed bat population varies between 500 to 800 bats of both sexes. On several occasions, active cave myotis have been captured in the mine in winter. Overall, except for the increase in bats during the winter and spring 2005 counts, the population of both species has fluctuated relatively little between 2002 and 2013 (figures 3 and 4).

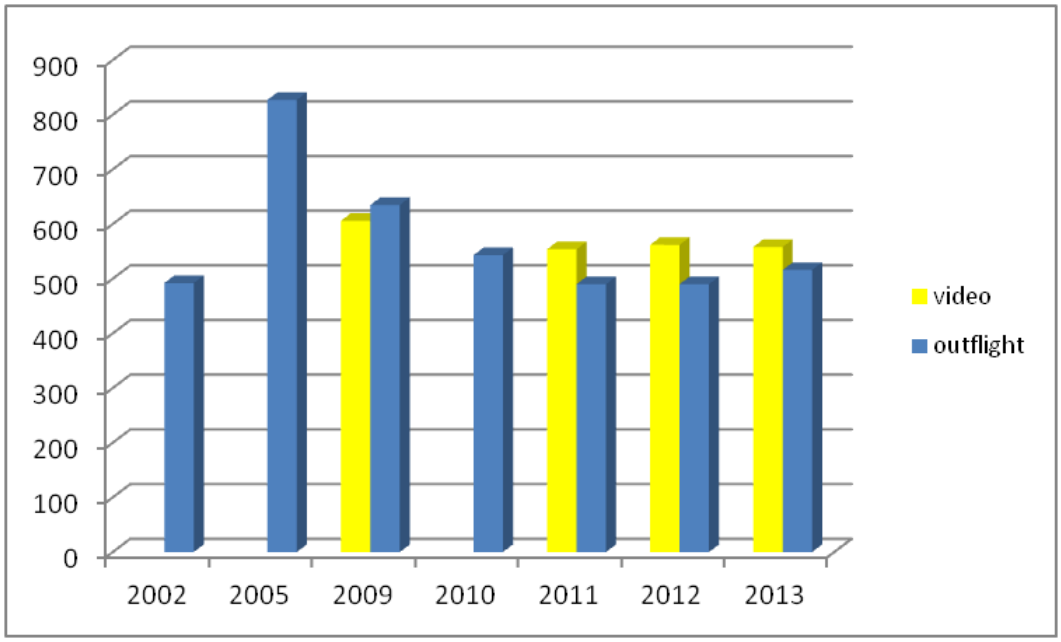

Figure 3.—Jackpot Mine exit counts of winter California leaf-nosed bats.

In addition to the main adit (Jackpot 1), two shorter workings (Jackpot 2 and 3) in the next drainage are used as night roosts by California leaf-nosed bats and several *Myotis* sp. During the day in May, Jackpot 2 shelters between 3 and 17 male California leaf-nosed bats, and in October, the number increases to about 30. The mine appears to function as a reproductive display or "lek" location for displaying males. Jackpot 3 sometimes contains small numbers of male California leaf-nosed bats and Yuma, California (*Myotis californicus*), and cave myotis during the day. A male Townsend's big-eared bat was captured here in October 2003. None of the Jackpot workings appear to have much human visitation, probably due to the hidden location in a Wilderness area, and bat gates are not recommended at this time. A water diversion channel above the portal of Jackpot 1 is helping to prevent rock and debris from washing down and sealing the mine. The catchment area above the mine is relatively small.

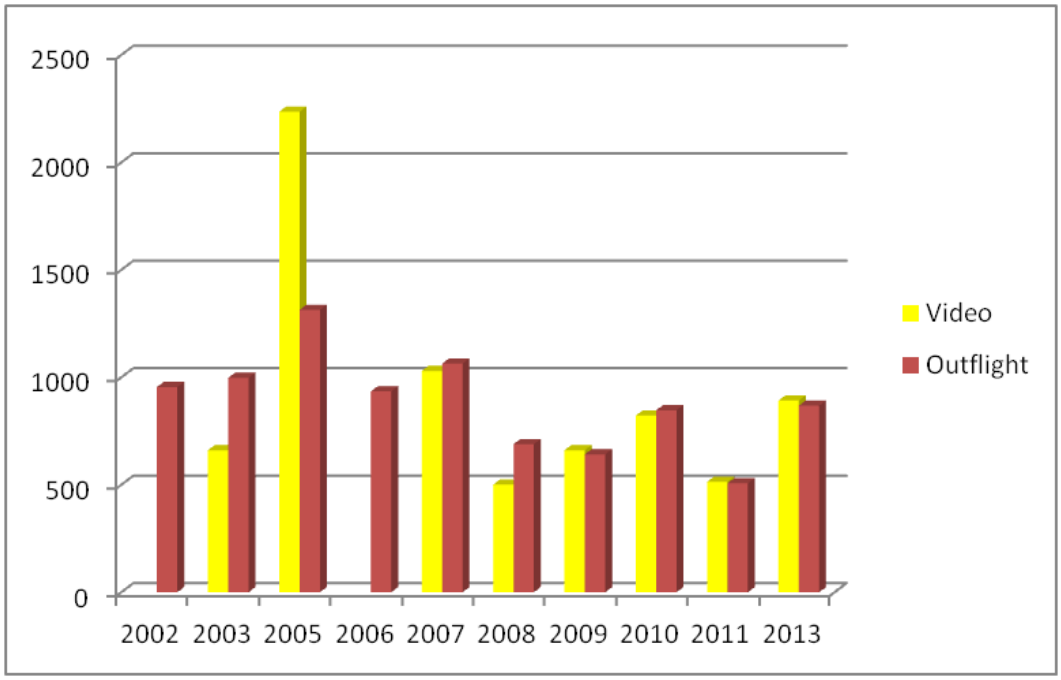

Figure 4.—Jackpot Mine spring exit counts of cave myotis and California leaf-nosed bats.

Gold Dome Mine

This mine is located about 1 km (as the bat flies) south of the Jackpot Mine just below the Needles formation, but it takes about an hour to hike there from the Jackpot Mine. The mine was visited by Musgrove (Cockrum et al. 1996) in January 1962 when he captured and banded 109 female and male California leaf-nosed bats (out of an estimated 150 bats present). In April 1962, he captured 7 male California leaf-nosed bats, 2 male Yuma myotis, and 19 male and 5 female cave myotis. In July 1990, Mitch Ellis (then Assistant Manager at the Havasu NWR) mist netted 62 male Yuma myotis, 20 male cave myotis, and a male canyon bat (*Parastrellus hesperus*) at the mine portal. When we first visited the mine in January 2002, we counted 81 California leaf-nosed bats exiting after dark. In May 2002, 5 male Yuma myotis and a male cave myotis were caught in the mine during the day, and 47 *Myotis* spp. and California leaf-nosed bats (combined) emerged after dusk. There is no evidence that this mine is used by female bats, and male use is primarily in the warmer months. The spring exit counts for all species have ranged between a low of 55 in May 2002 to a high of 840 in 2003 (a year with a lower census in Jackpot 1) (figure 5). Few bats are present in winter, with none observed in February 2009 and 2010.

In his notes, Musgrove referred to two adits in the vicinity containing 200 pounds of guano. The topographic map indicated another adit above the Gold Dome Mine.

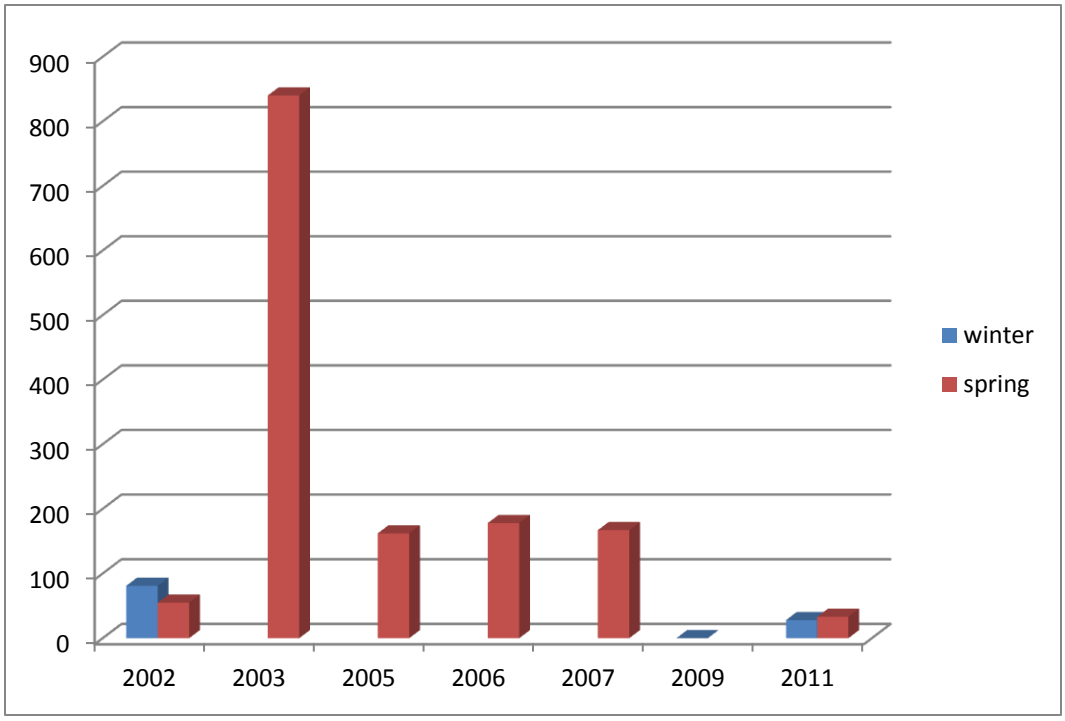

Figure 5.—Lower Gold Dome Mine spring and winter exit counts for California leaf-nosed bats and Yuma and cave myotis.

Access to this mine was not achieved until October 2003 due to a shear wall that raises above the lower mine and no apparent trail. Finally, in October 2003, using a rope, we succeeded in reaching the Upper Gold Dome Mine adit, which contained a colony of about 30 California leaf-nosed bats. It is possible that the Upper Gold Dome Mine is a California leaf-nosed bat maternity site, but it is too inaccessible to be regularly monitored. The two features may be connected internally via a raise in the lower adit. The Lower Gold Dome Mine will continue to be monitored sporadically in spring in conjunction with the Jackpot Mine, even though it does not appear to be a maternity site for any bat species.

Islander Mine

This mine complex is located about 1 km west of Lake Havasu between Black Meadow Landing and Havasu Palms in the Whipple Mountains, San Bernardino County, California. It was one of the most exciting discoveries of a survey conducted for the BLM Lake Havasu Field Office of mines in the Parker Strip (Brown and Berry 2005). The easiest access is by boat; however, in some years (especially winter), the water level of Lake Havasu has been too low in the

cove downstream from the mine to land. The largest working mine (Islander 1) has three entrances: a lower east-facing adit, a stope above that, and a shaft on the ridge above that is almost plugged with timbers. The stoped area is used by a small maternity colony of California leaf-nosed bats in the warm season during some years. Some Yuma myotis also roost in Islander 1, although the main colony is in Islander 2. Islander 1 is too cool in winter for California leaf-nosed bats; however, a Townsend's big-eared bat was hibernating here in January 2005. Islander 2, across the wash, is a relatively short, warm adit with enormous bat use. The mine shelters a colony of less than 50 California leaf-nosed bats year round. In spring, a maternity colony of between 900 and 5,500 Yuma myotis use this adit. A few Yuma myotis are present in the mine even in winter. This adit has great fluctuations between years in spring (figure 6), with the peak in 2003, and fewer bats in 2007–13. The 2010 spring count is about 1,000 bats less than in 2003, but the lowest count of 780 bats occurred in May 2013 following the installation of a bat gate on the mine in March 2013.

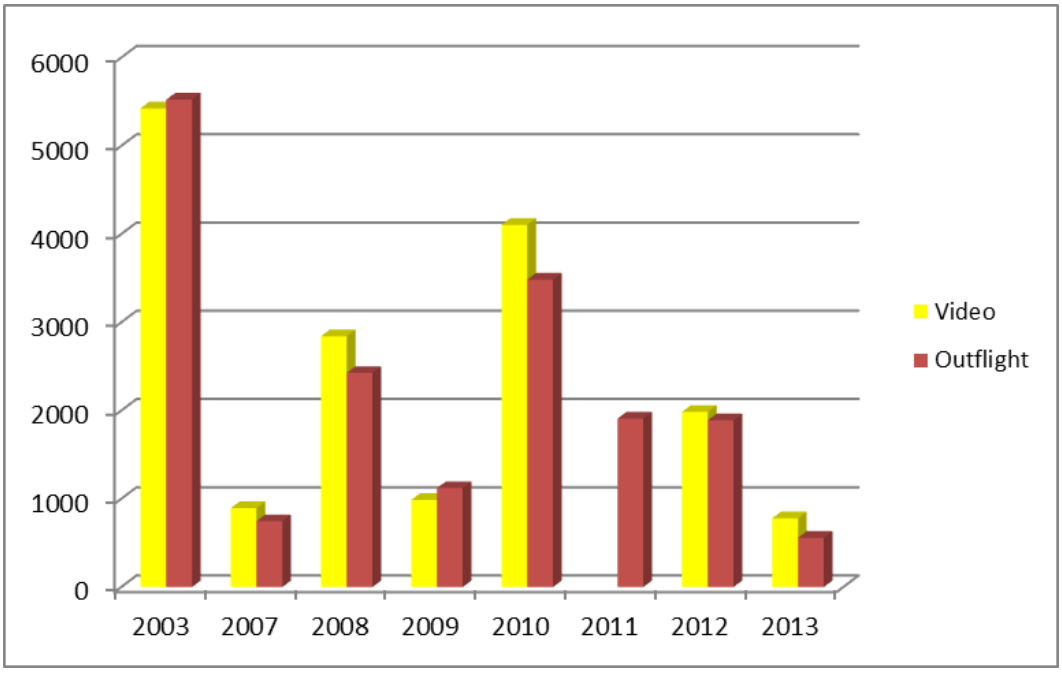

Figure 6.—Islander Mine spring exit counts of Yuma myotis and California leaf-nosed bats.

However, the most amazing event was observed starting at dusk on January 26, 2003, when over 6,000 Mexican free-tailed bats (*Tadarida brasiliensis*) poured into the mine in an hour (and they were still coming when we stopped counting). When we entered the mine, the ceiling was covered with bats. This is the mating

time for this species, and the mine is probably a key site for breeding bats (the Lake Havasu "singles bar"). When we visited the mine again on February 5, 2003, to video tape this mass entry, only about 300 Mexican free-tailed bats were present. Instead, Yuma myotis were entering the mine to night roost. We returned on January 31, 2004, and January 28 and 30, 2005, to document the Mexican free-tailed bat inflight, but less than a net of 100 bats entered the mine. On January 24, 2009, 24 California leaf-nosed bats exited the mine, and no Mexican free-tailed bats entered. However, each spring, large piles of fresh Mexican free-tailed bat guano attest to the continued use by this species for winter mating. Mexican free-tailed bats are known not to fly through bat gates, and so this unique use of Islander 2 may be eliminated by the installation of a bat gate. Islander 3 is up the wash on the right side and is a chamber with some California leaf-nosed bat guano, although no bats have been found day roosting in the mines. It may be used in the fall as a "lek" site or for night roosting. Islander 4, located across the wash from Islander 3, is a tunnel that has little evidence of bat use.

Californian Mine

This adit in the Whipple Mountains south of Parker Dam on the California side (BLM Lake Havasu land) was named by Patricia Brown in August 1968 at the time of her first visit to the mine, as it was near the "Californian" River Camp. A local youth referred to it as the "bat mine," and the mine contained thousands of cave myotis. In winter, several hundred California leaf-nosed bats replace the cave myotis. Beginning in 1969, this mine was selected by Patricia Brown for long-term banding of California leaf-nosed bats for longevity and home range studies. Visits were made every winter through 1981 to band bats, and then on an average of every fourth year to the present. The winter population fluctuated between 300 and 650 California leaf-nosed bats, as indicated by banding captures (all bats in the mine were caught), until 2010, when 810 bats were banded. There was a jump in winter 2008 when over 1,200 bats were counted. The average California leaf-nosed bat population has been stable overall between 2002 and 2013 (figure 7). In some years, a few cave myotis (both male and female) were also present in the mine during winter—the first winter records for cave myotis in California. This is a mine that can be entered in winter after the exodus is over to check for any remaining bats. On January 13, 2013, the weather was unusually cold, and many bats remained in the mine after the exit count of 350 bats was completed. When this mine was recounted on February 5, 2013, twice (almost 700) the number of bats emerged.

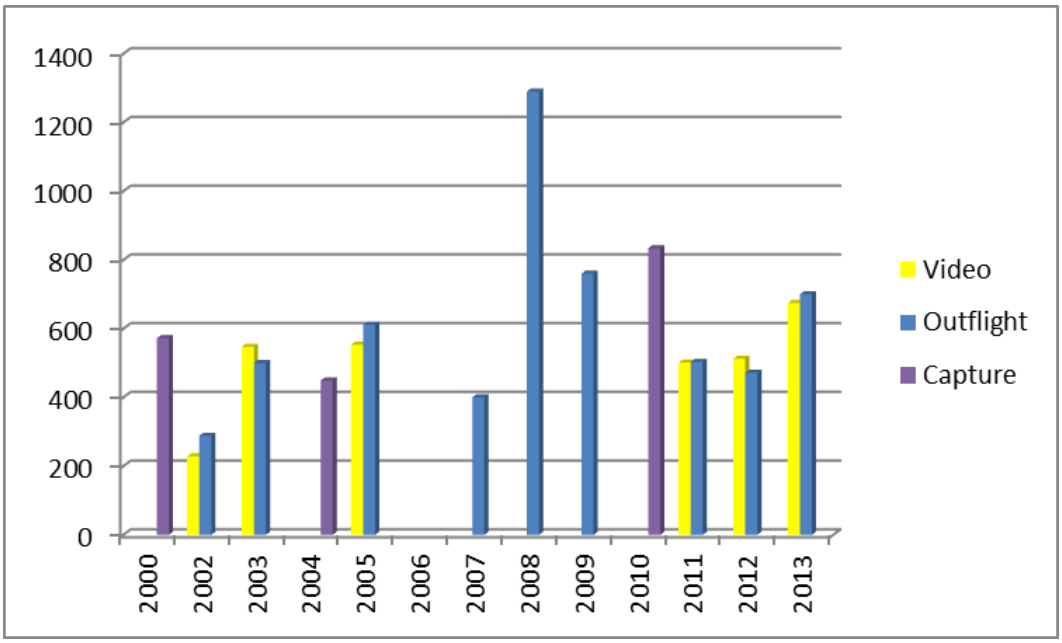

Figure 7.—Californian Mine winter exits counts of California leaf-nosed bats.

The mine is not entered in spring when a maternity colony of between 3,500 and 6,000 cave myotis move in (along with several rattlesnakes). This is the largest cave myotis colony along the LCR, and is a long-term bat monitoring site, with a peak population of over 5,500 bats in 2005 (the same year as the Jackpot Mine peak). However, by 2010, the count had declined by about 2,000 bats and then to an all-time low of less than 1,000 bats in 2011 (figure 8). In 2012 and 2013, the numbers have again approached 5,000 bats. Less than 100 male California leaf-nosed bats use the mine in the warm months. The bats are not disturbed by human entry due to its location in a small drainage with no road leading to it. The overpowering odor of ammonia from the cave myotis guano makes warm season entry unpleasant. At this time, a bat gate is not recommended due to the small opening and the large number of bats exiting. There is also evidence that large maternity colonies of cave myotis do not accept gates. The portal dimensions have been reduced twofold in the past 30 years due to wash debris. A gabian or other diversion is necessary to deflect water and mud from flowing into the mine during flood events and potentially sealing the portal, and some attempts to hand dig a channel away from the portal have been successful to this point. However, a greater effort should be made to protect this important roost.

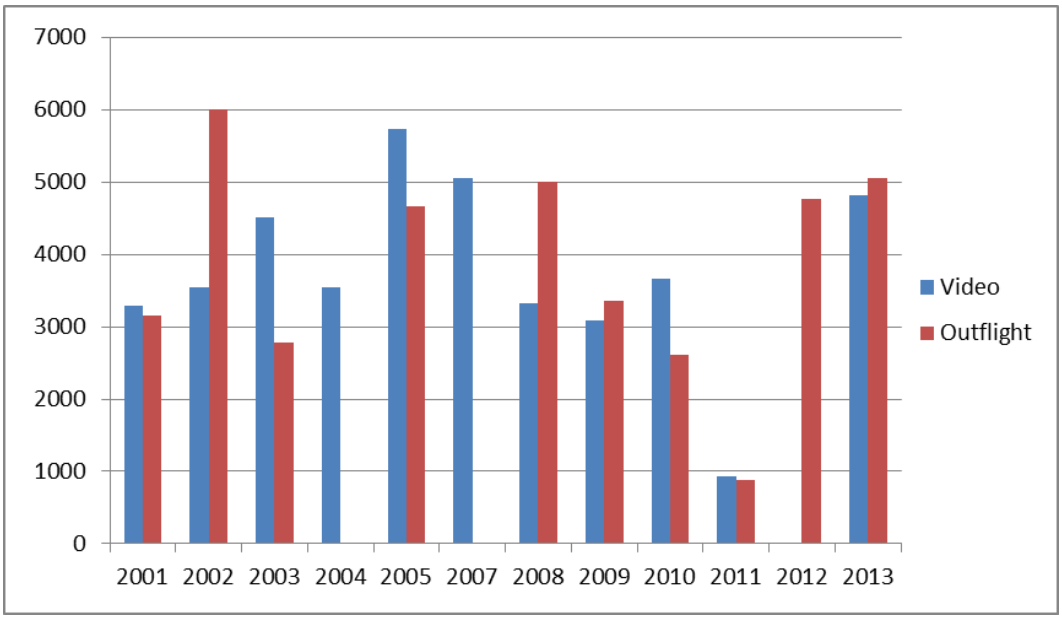

Figure 8.—Californian Mine spring exit counts of primarily cave myotis and some male California leaf-nosed bats.

South Californian

Located in the next drainage west of the Californian Mine, this adit (with an intersecting shaft from the surface) has always been the alternate roost for California leaf-nosed bats disturbed by banding activities of bats captured in the Californian Mine. Some of the bats will move here the night after the banding, but no studies have been conducted on how long they remain before returning to the preferred roost in the Californian Mine. The banding that occurs here around every 4 years is not part of the funding from Reclamation, but the data are provided to Reclamation with the hope that it can be utilized to better understand population dynamics within a roost in the future. Without disturbance in the Californian Mine, the mine has a winter colony of between 5 and 86 California leaf-nosed bats. In the warm season, a maternity colony of about 30 California leaf-nosed bats, plus male Yuma and cave myotis, roost in the mine (figure 9). In May 2002, we observed clusters of about 200 cave myotis in the adit, possibly in response to the recent protection of this mine by gate installation as a result of a human injury that occurred in the mine several years ago. This gate was subsequently vandalized and then repaired in 2007. The spring population increased to over 350 bats following this protection, although the winter population was not affected. Since 2007, the spring exit count has been between 100–150 bats of all species. This mine is monitored to provide baseline data in case a disturbance occurs at the main Californian Mine adit.

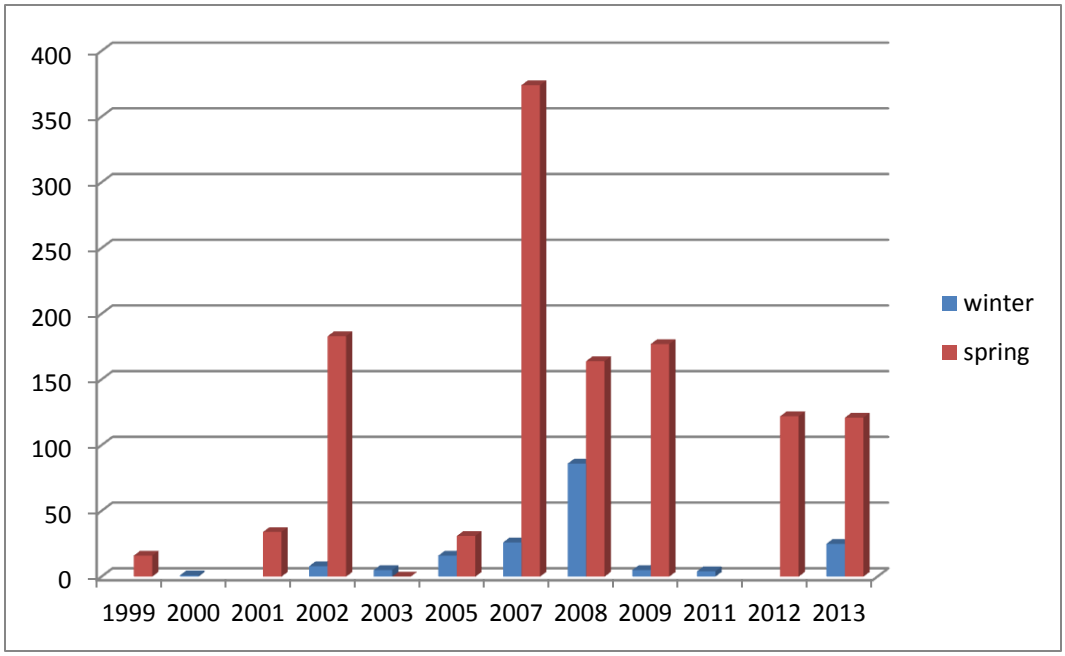

Figure 9.—South Californian Mine winter and spring exit counts of California leaf-nosed bats and Yuma and cave myotis.

Mountaineer Mine

This Riverside Mountains mine on BLM (Palm Springs) land was a collection site for Dr. Stager in the 1930s. Patricia Brown has been monitoring the bat population since 1968. The mine has over three levels, accessed by a winze (internal shaft), with multiple stopes and warm roosting sites for the bats. It has the greatest diversity of bats of any mine in the California desert and is the last known maternity roost for Townsend's big-eared bats along the main stem of the LCR. The lowest level crosses under the wash and can be accessed from the surface by a declined shaft on the opposite side of the wash. Most of the bats exit via the adit portal rather than the shaft, although since 2006, an increasing number of bats are exiting via the shaft in the warm season (and this may be in response to our trapping at the adit portal). The winter population of between 300 and 800 California leaf-nosed bats exit via the adit. In the past, this mine sheltered maternity colonies of California leaf-nosed bats, cave myotis, big brown bats (*Eptesicus fuscus*), Townsend's big-eared bats, and pallid bats (*Antrozous pallidus*), with males of Mexican free-tailed bats and Yuma and California myotis also being captured. With so many species using this mine, the only way to document reproductive behavior is by capture of exiting bats at the main portal with a mist net or harp trap. In May 2002, reproductive females (pregnant or lactating) of the first five species listed above were captured. However, by monitoring what side of the net that the bats were captured in subsequent years (July 2003 and May 2006, 2007, 2009, and 2010), the only reproductive female bats captured exiting the main adit were Townsend's big-eared bats, pallid bats, and big brown bats. The cave myotis maternity colony now appears to be located near the shaft entrance, and the California leaf-nosed bat maternity colony is in

the Morningstar Mine about 0.5 km to the west. The females of those two species are captured entering the adit after dark on most years. Spring exit counts when there is no capture at the adit portal document an average of about 300 bats exiting (see figure 11). We now count and record bats one night in spring and then capture bats on a subsequent night. In winter, approximately 500–600 California leaf-nosed bats roost in the mine (see figure 12). Since this is the only Townsend's big-eared bat colony monitored along the LCR, it would be desirable to know how many of this species are present. However, since six species (and three with large ears) roost in the mine, this is impossible to do from exit observations, even with video taping. In addition, the orientation of the Mountaineer Mine portal makes accurate outflight observations or recordings difficult without disturbing the bats. It is typical that observer counts are higher than video counts because the view of bats re-entering the mine is often obscured.

Between 1969 until the 1980s, the Mountaineer Mine was one of Dr. Patricia Brown's long-term winter banding sites for California leaf-nosed bats. We have witnessed increased all-terrain vehicle use visitation over the years that has created disturbance problems for the bats in the mines. Vandals have burned the hoist over the shaft, and graffiti and shotgun shells are apparent throughout the adit. In late fall 2012, the BLM installed a standard bat gate on the adit and a very high cupola on the shaft that was designed to allow for maximum circling of the bats prior to exiting. The January 2013 exit count was very unusual in that more than one-half of the bats emerged from the shaft (figures 10 and 12), and about one-half of the normal number of bats used the adit gate. By May 2013, the bats appeared to have accepted the adit gate, and the numbers were approaching "normal" counts (figure 11).

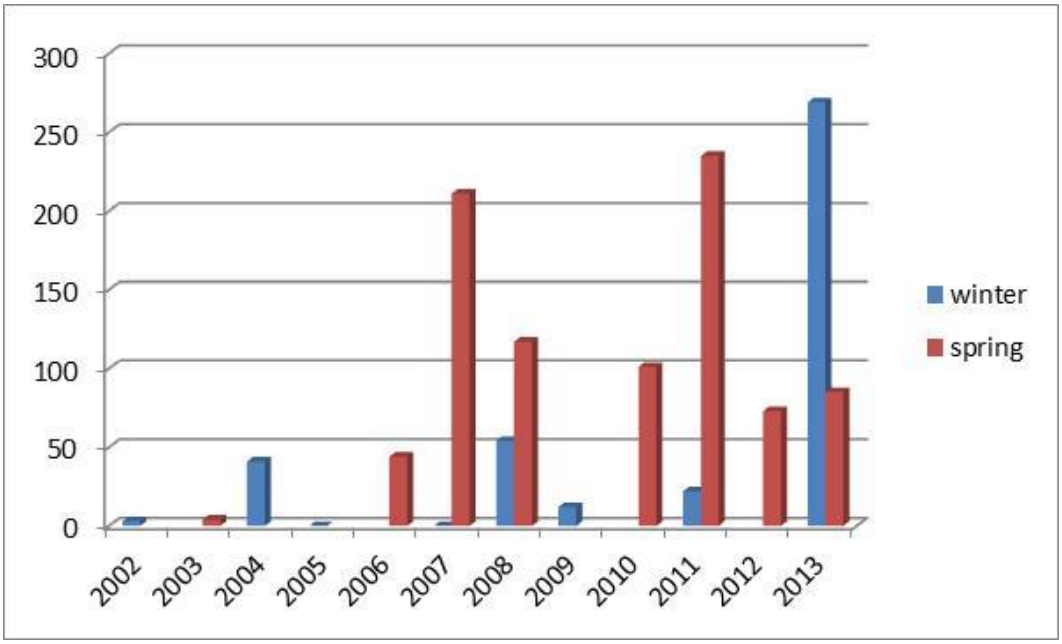

Figure 10.—Mountaineer Mine shaft exit counts of all species.

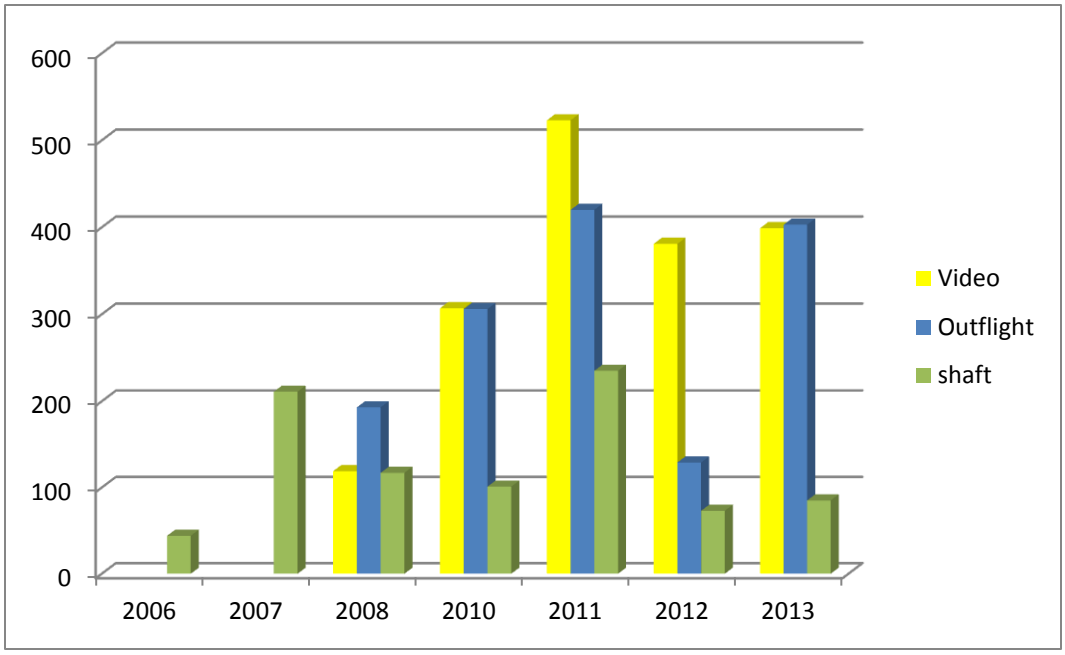

Figure 11.—Mountaineer Mine spring exit count of all species.

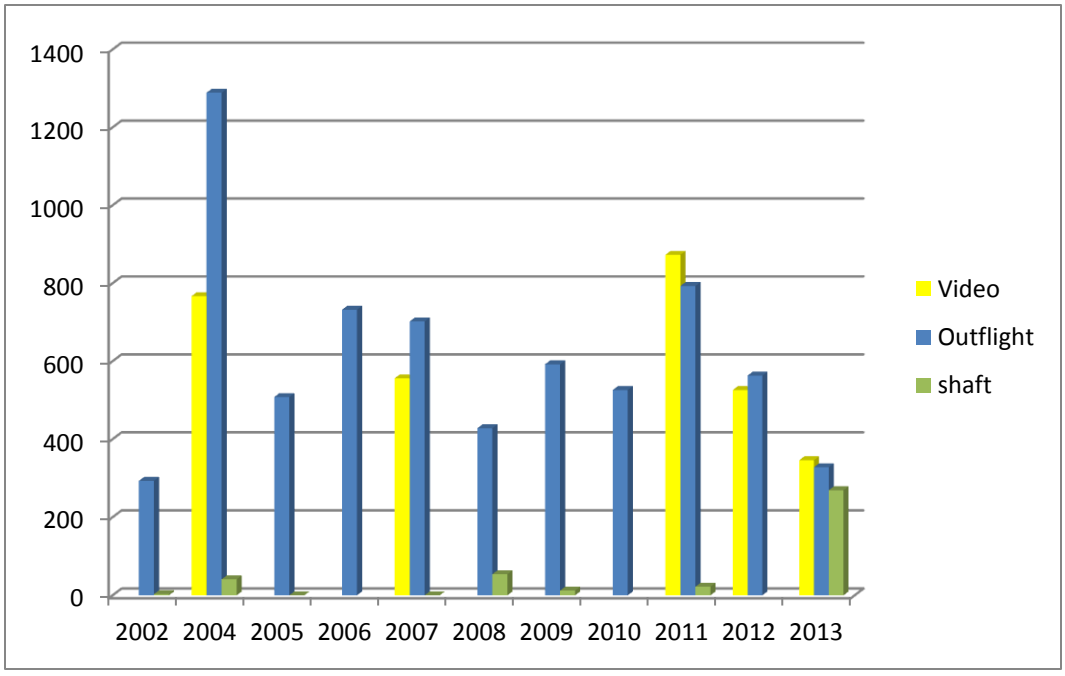

Figure 12.—Mountaineer Mine winter exit count of California leaf-nosed bats.

Stonehouse Mine (a.k.a. Hodge Mine)

This mine complex is located in the Mule Mountains, Riverside County, California, southwest of Blythe on BLM land (Palm Springs). I was directed to the mine in 1976 by locals in Blythe who referred to it as the "bat cave" or "Stonehouse" due to the stone building ruins on the road to the mine, although the name of the topographic map is the Hodge Mine. Through the 1980s, this was another banding site for California leaf-nosed bats in winter, with several thousand bats present. Capturing bats was always difficult due to large stope areas and hazardous winzes. Until 2002, only the two adits (lower and upper) were monitored for bats. An upper shaft complex with three openings was first surveyed in January 2002, and another 1,400 California leaf-nosed bats emerged from there in addition to the over 2,700 bats from the lower adits. The Stonehouse complex, with a total exit count of 3,000–4,000 bats (5,000 in 2005), is the largest known winter colony of California leaf-nosed bats in the United States (figures 13 and 14). In spring, the total complex houses about 3,000 bats, with a colony of about 1,500 male California leaf-nosed bats and cave myotis (maternity colony and males) in the upper adit, while the upper shafts shelter a large California leaf-nosed bat maternity colony. The lowest adit is used by an increasing number of bats since it was gated in 2006 (California leaf-nosed bats, pallid bats, and cave myotis) but is still primarily a night roost. The gating of the upper adit in 2006 was very important for preventing human accidents since it is very hazardous due to an internal winze near the portal. Since the upper three shaft openings are difficult to reach, and do not appear to receive human visitation, no closure action is recommended.

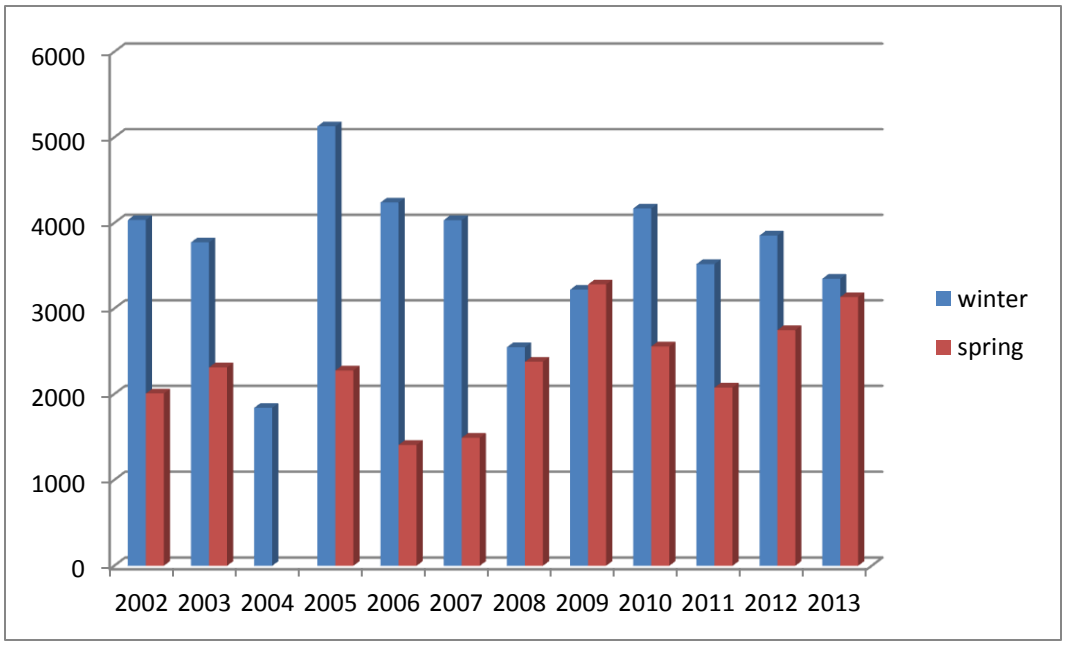

Figure 13.—Stonehouse Mine winter and spring exit counts of California leaf-nosed bats.

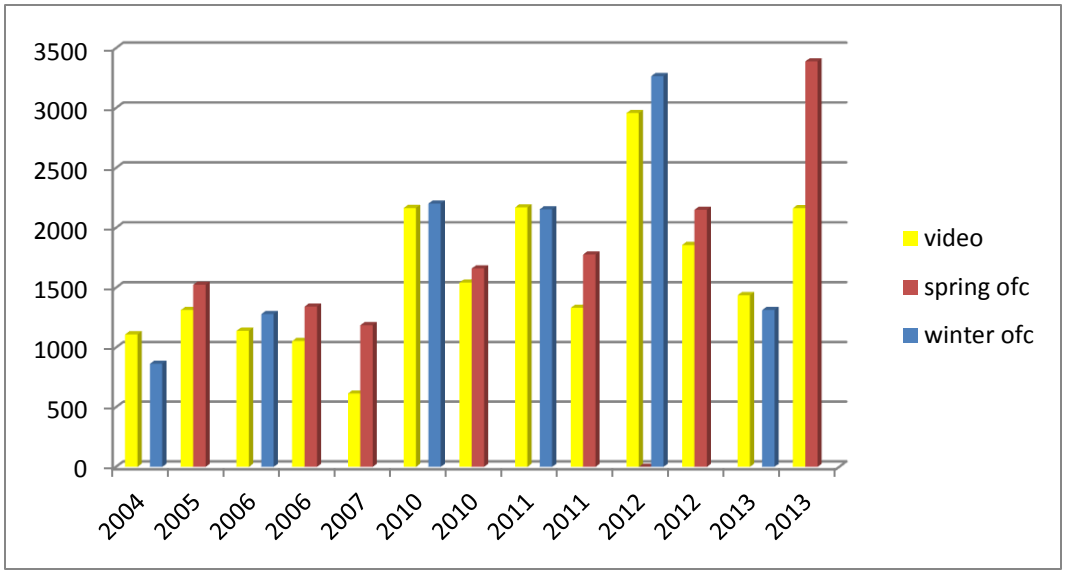

Figure 14.—Comparison of video and observer counts for the Stonehouse Mine upper adit.

Hart Mine

When California leaf-nosed bats were discovered night roosting and engaging in courtship displays under the Island Unit bridge on the Cibola National Wildlife Refuge (Cibola NWR), we searched for the closest mine roost to the bridge. The Hart Mine is located about 12 km from the bridge up Hart Mine Wash in the Trigo Mountains of Arizona (Yuma BLM). In February 2002, over 3,500 California leaf-nosed bats emerged from the mine's single portal, although since that time, most exit counts have ranged between 1,500 and 2,000 bats (figure 15). Both sexes occupy the mine in winter; however, between 100–500 males are present in spring and summer (figure 15). In fall, the mine is a "lek" site, and males display at the portal. The mine was gated in 2007 using funds from a Bat Conservation International grant. Lin Piest (AGFD) has added this mine to the list of AGFD's long-term bat monitoring sites.

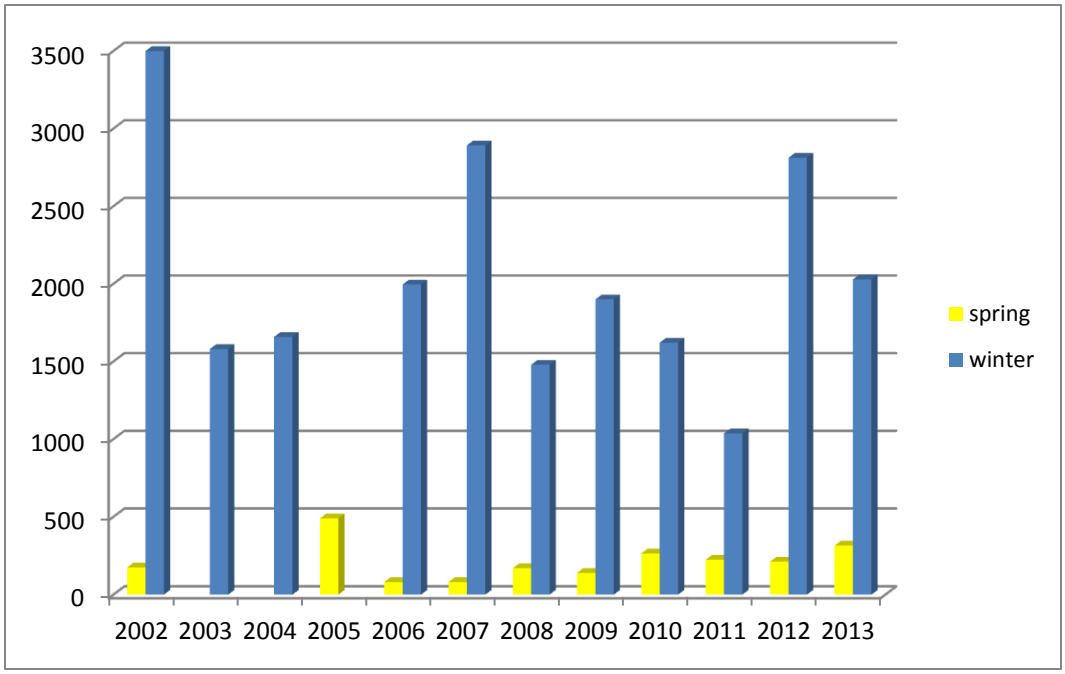

Figure 15.—Hart Mine winter and spring exit counts of California leaf-nosed bats.

Eureka Mine

This mine complex is located in the Chocolate Mountains on the Arizona side of the LCR within wilderness on the Imperial National Wildlife Refuge (Imperial NWR). The mine is a historic locality for a maternity colony of several thousand Yuma myotis. The mine is located close to a popular landing for boaters on the LCR and receives considerable visitation. In 1995, the two lower adits were gated, followed by cupolas on the two upper shafts in 2006. AGFD and Imperial NWR biologists have monitored the mine since 1994. The spring count (before the young are volant) varied between 1,822 and 3,316, while the mid-summer count after the juveniles became volant was almost double (2,480 to 6,022) through 2004. The equipment used to make the counts also varied from just back-lighting, in the earlier counts, to the use of night vision equipment and/or Nightshot cameras at all four entrances in the later census. Since 2008, the population has declined, and there are now less than 1,000 bats exiting from the four portals (figure 16). This coincides with the installation of the cupolas and gates on the upper shafts. Yuma myotis are the principal species, but a colony of approximately 200 California leaf-nosed bats also use the mine during the warm season. At times, a maternity colony of as many as 168 bats used a separate three-entrance mine at the head of the Eureka drainage, but this number has declined to less than 20 in recent years. In winter, about 20 California leaf-nosed bats are present in the Eureka Mine complex. This mine is a long-term monitoring site for Imperial NWR and AGFD biologists. Currently, the mine is surveyed only in spring.

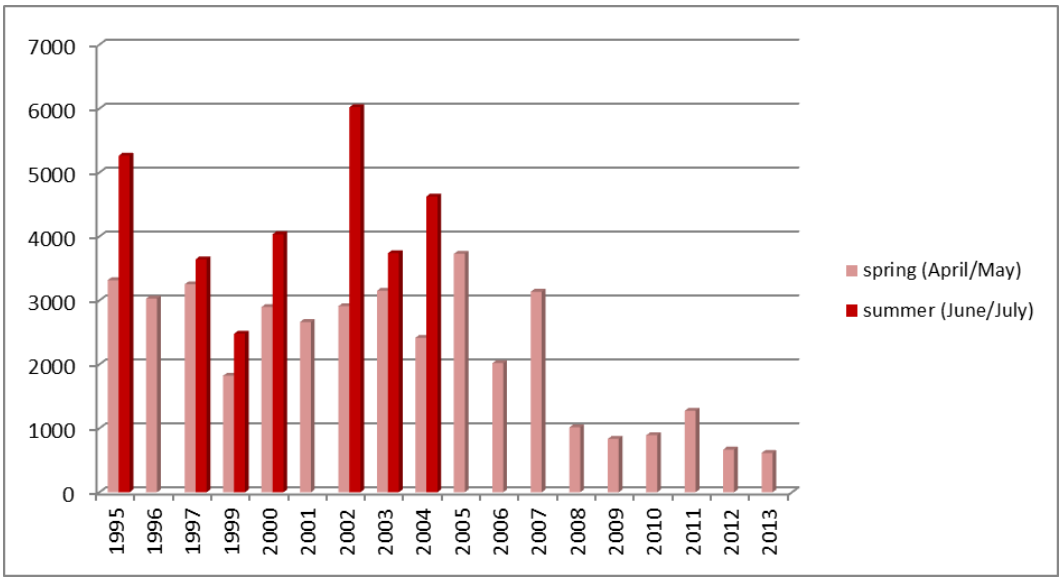

Figure 16.—Eureka Mine spring and summer exit counts of California leaf-nosed bats and Yuma myotis.

Golden Dream Mine

This collection of several adits and shafts is located on the Imperial NWR on the California side of the LCR, slightly downstream from the Eureka Mine. Kirke King (King et al. 2001) used the mine as a collecting site for bats and guano. When we visited the mine in July 2001, we discovered a large maternity colony of California leaf-nosed bats (> 700 bats) in the upper tunnel (#4) and a maternity colony of about 30 big brown bats in a lower adit (#3). The population in both these workings has declined precipitously, and less than 100 California leaf-nosed bats have been counted in the past 7 years (figure 17), and no big brown bats have been observed in adit #3 in the past 3 years. In winter, a few California leaf-nosed bats roost in the upper tunnel. One of the three shafts located closer to the river contained a colony of about 2,000 Yuma myotis (figure 18). In July 2003, this mine was verified as a maternity colony when lactating Yuma myotis were captured in mist nets as they exited the mine. The population in this shaft has been relatively stable and does not appear to have increased as the Eureka Mine count decreased (see figure 16). The Golden Dream Mine complex does not seem to receive much visitation (there is not a good landing site for boaters), but one end of the tunnel is clearly visible from the LCR. There are no fences around the shafts, and the tunnel contains a hazardous winze. In the future, some bat-compatible closures may be required.

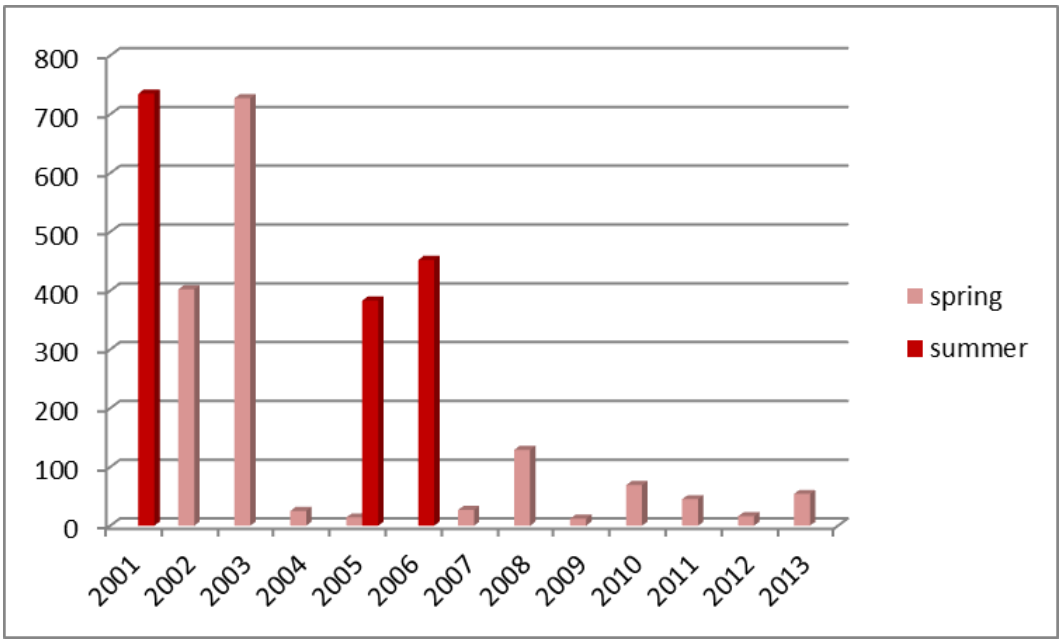

Figure 17.—Golden Dream shaft #4 spring and summer exit counts of California leaf-nosed bats.

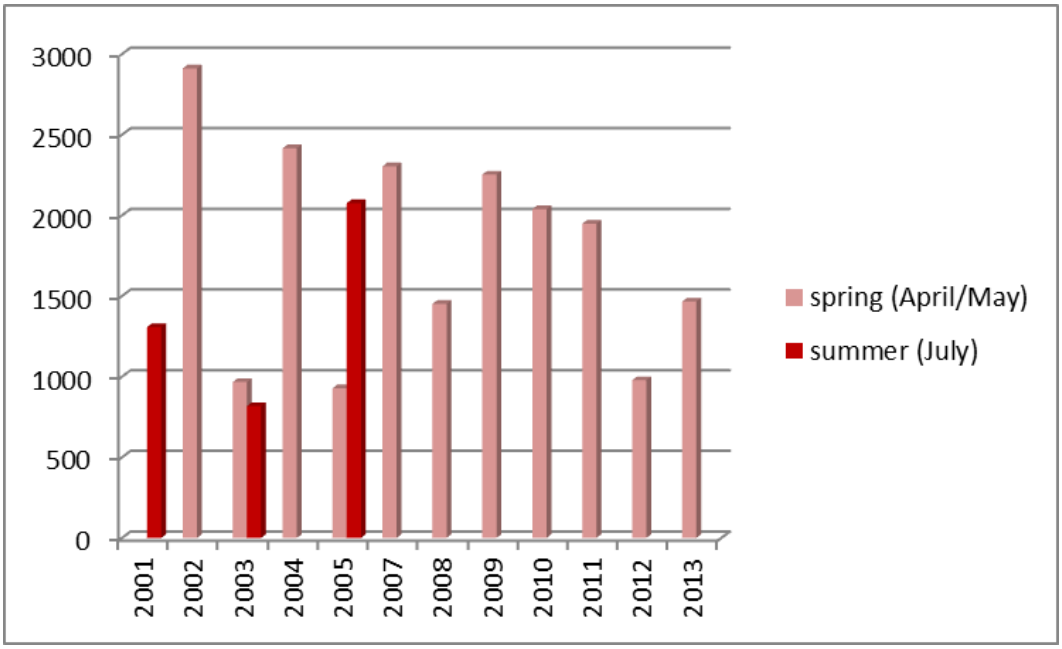

Figure 18.—Golden Dream shaft #1 spring and summer exit counts of Yuma myotis.

3C Mine

This mine complex is located on the California side of the LCR about 3 km north of the historic site of Potholes (which is just north of Laguna Dam and on the boundary of El Centro and Yuma BLM districts). The mine site was visited by Constantine in the 1950s (personal communication), and consisted of an adit connected to an open stope and shaft, plus another separate adit (Duncan adit). In 1985, all but the 3C Mine adit entrance had been closed by the claimant. Through the efforts of the BLM and Bat Conservation International, a bat gate was installed in 1994. The mine currently has a large winter population of California leaf-nosed bats (approximately 2,500 bats), which has increased overall since 2001, and a spring population of about 400 male California leaf-nosed bats and a maternity colony of up to 1,500 Yuma myotis, which has 500 more bats exiting in 2013 than in 2001 (although with some declines in the intervening years) (figures 19 and 20). A small adit near the Potholes Mine is used as a night roost and "courtship site" by hundreds of Mexican free-tailed bats in January and February. This mine was visited in May 2010, and a small maternity colony of approximately 20 big brown bats was present as well as about 50 California leaf-nosed bats. Both the Potholes and 3C Mines are long-term bat monitoring sites.

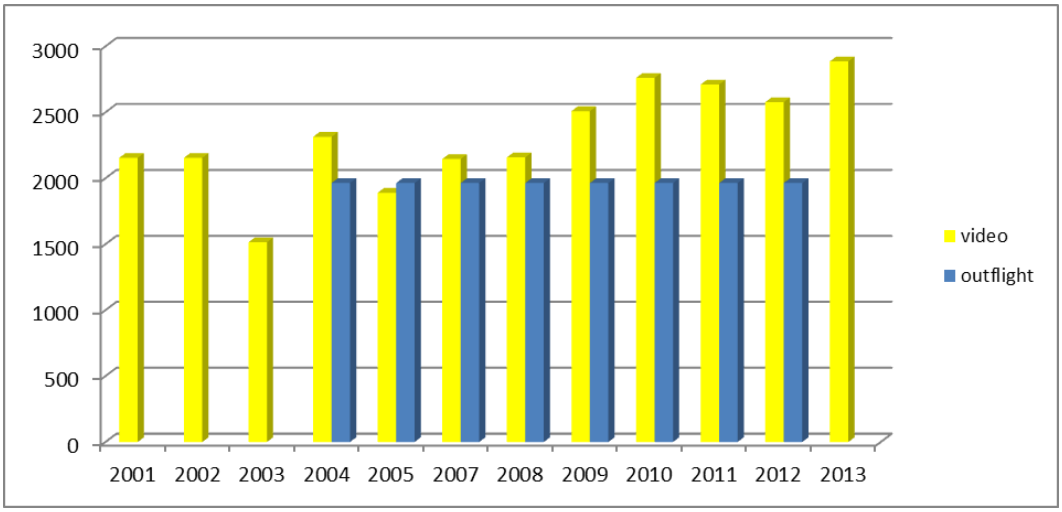

Figure 19.—3C Mine winter exit counts of California leaf-nosed bats.

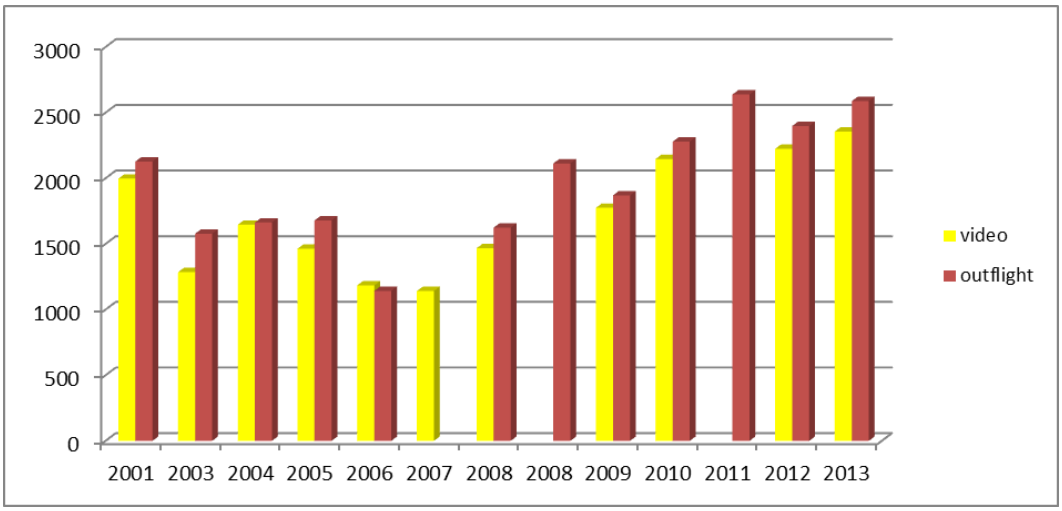

Figure 20.—3C Mine spring exit counts of California leaf-nosed bats and Yuma myotis.

Senator Mine[1]

This mine is located just west of Imperial Dam in Imperial County, California, and was a historic collecting site for Howell (1920). In 1918, a large maternity colony of about 100 Townsend's big-eared bats roosted in the mine. At the time, Howell also found large maternity colonies of Yuma myotis and California leaf-nosed bats. Constantine (personal communication) also collected California leaf-nosed bats here in the 1950s at the same time as he visited the Duncan and 3C Mine complexes. After some fatalities of U.S. Marines in the mine, the main shaft was covered with chain link fence by the claimant. An open stope still provides access for bats, although only California leaf-nosed bats are now present. The large stope with multiple openings is difficult to count and impossible to video tape. About 360 bats exited the mine in June 1991, and 168 bats emerged in January 2001. Recently, over 350 California leaf-nosed bats exited from the mine in January 2012 and over 150 in May 2012 and 2013. The main mine complex is on patented/private land, although several smaller workings to the west are on BLM land. Although no bats were observed during internal surveys of these workings in April 2011, the abundant guano attests to night roost use by California leaf-nosed bats.

Roosevelt Mine[1]

This mine in the Mule Mountains was first visited by Patricia Brown in 1976 and sheltered a maternity colony in the warmer months, although bats banded in winter in the Stonehouse Mine (3 km to the northeast) were recaptured here. The main mine is accessed via an adit, with four raises to the surface. One of the

[1] Mine complexes that have recently begun having outflight counts again do not have graphs due to the lack of data.

raises (Roosevelt 2) connects indirectly to the main mine complex. Windy and cold weather in spring 2011 and 2012 inhibited bats from exiting the mine at night, but in May 2013, with good weather conditions, over 500 bats emerged from the complex (Roosevelt 1 and 2). A separate deep shaft (Roosevelt 3) in the canyon to the southwest shelters about 250 bats in winter and is used as a night roost or by a few males during the maternity season. All of the features are scheduled by BLM to receive bat-compatible closures in 2014.

Rio Vista Mine[2]

This mine complex in the Buckskin Mountains, La Paz County, Arizona, north of Parker, was first visited in the 1970s by Patricia Brown while searching for sites for banding California leaf-nosed bats in winter. Although bats previously banded in the Californian Mine were recaptured here, the mine was deemed too complex to capture most bats for banding. No comprehensive count was made of the bats, nor was a map of the mine workings made. Subsequently, BLM placed bat gates (without removable bars) on the adits; therefore, connections between some of the 14 openings are not known (Rio Vista 1, 4, 5, 6, and 8). One complex with four openings (Rio Vista 7) can be accessed by climbing down through a shallow shaft (7C), while four horizontal prospects could be entered and contained only a single bat or guano. Exit counts made of the complex in May 2012 censused 392 bats, while a total of only 218 emerged in May 2013. When the Rio Vista 7 complex was entered after the 2013 exit counts, at least 100 California leaf-nosed bats and about 20 pallid bats were still in the mine. In January 2013, 177 California leaf-nosed bats emerged from all openings, with the majority from Rio Vista 1 (which appears to be a single entrance mine). Without being able to enter the mine, the bats that do not exit due to weather (cold or wind) make an accurate count difficult. Of the features without bat gates, Rio Vista 9 (with three connected openings) could be used as a maternity colony if bat-compatible closures were installed by the BLM. Dead bats killed by pellet shots were discovered in the Rio Vista 7 complex, and cupolas need to be installed in place of the fences over the shafts.

Planet Mines[2]

This mine complex was first visited in December 1972 as part of Dr. Brown's California leaf-nosed bats banding project. At this time, the shafts were not entered, and the 489 bats banded were clustered in Great Central 5 B adit. No bats were located at this mine during a subsequent visit in December 1977, although no other features were surveyed. Under a 1993–94 project funded by the Arizona Game and Fish Heritage Fund and administered by the BLM Lake Havasu Field Office, bats were surveyed along the entire Bill Williams River from Alamo Dam to Lake Havasu (Brown 1996). As part of this survey, a

[2] Mine complexes that have recently begun having outflight counts again do not have graphs due to the lack of data.

detailed survey was made of the mines at Planet at different seasons and utilizing exit surveys with night vision equipment and entry into the mines, including rappelling into vertical shafts. By entry into the War Eagle #1 shaft, a maternity colony of about 150 Townsend's big-eared bats was discovered as well as maternity colonies of cave myotis and California leaf-nosed bats. Other mine features contained maternity colonies of California leaf-nosed bats, but no other mines sheltered the other two species. Fifty mine features (some with multiple entrances) were surveyed for bats, and all had evidence of bat use (either bats or guano present). A winter population of over 800 California leaf-nosed bats roosted in the Planet Mines in the immediate vicinity of the Planet Mine Canyon and were concentrated in five mine features, with the greatest number in the War Eagle 1. The largest California leaf-nosed bats maternity colony of over 900 bats was in the Argus Mine complex, located about 1.5 km east of the Planet Mines. It was during this survey in October 1994 and 1995 that we discovered the fall "lek" mating behavior, when some mines with little bat use at other seasons became display sites for males attracting receptive females.

Between the current surveys commencing in August 2011 and the previous surveys ending in 1996, the Arizona Division on Minerals installed "gates" on many of the adits; however, these gates had vertical steel instead of the recommended horizontal angle iron bars for bat gates. Most adits in the Planet Mine Canyon area have had chicken wire placed over the portals, although some of these barriers have been subsequently removed by vandals. Some of the shafts had bars placed across them with spaces that would not allow bat access, while others were fenced. This has changed the distribution of some bats in the Planet Mine area. The bats in the Argus complex now number around 400 pregnant female California leaf-nosed bats in May, with the majority exiting from the one opening that is fenced rather than vertically gated. A large maternity colony of California leaf-nosed bats also occupies the Great Central 1 complex.

The fence around the War Eagle #1 shaft does not impede the flight of bats, and the May 2012 and 2013 exit counts were over 2,500 bats, the majority appearing to be cave myotis. With so many bats exiting, it is impossible to tell the difference between Townsend's big-eared bats and California leaf-nosed bats. A few echolocation signals of Townsend's big-eared bats were recorded near the War Eagle #1 shaft, but a maternity colony of at least 150 females was found in the Great Central 5B adit (as well as a maternity colony of cave myotis). The latter species has also established a maternity roost in the War Eagle #4 adit. The apparent increase in the Townsend's big-eared bat and cave myotis populations in the Planet Mine area may be the result of the recovery of the cottonwood and willow riparian habitat along the Bill Williams River immediately north of the Planet Mine Canyon in parts of the Planet Ranch not being farmed. At the time of the 1994–96 surveys, the Planet Ranch area was still planted in alfalfa and pumping groundwater, and the riparian habitat along the Bill Williams River National Wildlife Refuge began several kilometers downstream. The current ecosystem can now support more riparian-dependent bat species.

DISCUSSION

Roost Census

Colonial bats that roost in mines or caves provide a unique opportunity to track population trends by counting bats emerging in the evening to forage. With revegetation projects underway and scheduled along the LCR, it is hypothesized that bat numbers will increase. Since 2000, biannual censuses have been conducted of eight California leaf-nosed bat winter and summer mine roosts along the LCR from the Homestake Mine above Davis Dam to the 3C Mine near Laguna Dam. The Mountaineer Mine in the Riverside Mountains also shelters a maternity colony of Townsend's big-eared bats. Several of the California leaf-nosed bat mines are also used in spring and summer by large numbers of cave and Yuma myotis. The latter is currently one of the most abundant bat species along the LCR, and relative changes in their population could indicate changes in ecosystem health. Cave myotis were at one time more abundant in the mines along the LCR, and increases in their population in the remaining roosts or the recolonization of abandoned roosts would indicate restoration success.

Several factors influence exit count data and can contribute to the sometimes considerable variation in numbers between years. Exit censusing can differ from the absolute number of bats that reside in a mine. By counting for the first 60 to 90 minutes of the exodus in a standardized manner under favorable environmental conditions, we hope to get an index of relative abundance between years. The absolute number of bats present in a mine is determined only by entering the mine during the day and capturing or counting all of the bats. The most accurate census comes from the banding surveys that I have conducted at the Californian Mine since 1969 where all of the bats are captured. This activity is disturbing to the bats, and currently banding happens about every 4 years. When conducting exit counts, usually all bats do not exit simultaneously after dark as evidenced by entering mines where the whole mine is visible after the count has ended. The only mines on the LCR monitoring list where this is possible are the Californian, Jackpot, Hart, Islander, Roosevelt, and Lower Stonehouse adit (if the key is available). Fewer bats remain inside the mine after dark during the winter verses the spring or summer surveys. However, bats may enter a mine to night roost often before the resident bats finish exiting. The entering bats may be bats that do not actually reside in the mine during the day, and so when entering bats are subtracted from exiting bats for the "net" count, the number of resident bats could be undercounted.

In addition to the absolute number of bats in a mine, other factors influence the exit data presented. In winter, California leaf-nosed bats will not exit the roost on very cold nights, preferring to remain in the warm mines that match their narrow thermal neutral zone. For that reason, we are missing data for some cold years, such as 2006. In 2013, during a very cold week in mid-January, relatively few

bats exited, and some of the mines were counted again in February after temperatures had increased. At all seasons, most bats will not exit to forage during rain or when wind speeds exceed 20 km per hour. Most California leaf-nosed bats will not exit during a bright moon at any season (figure 21), probably as a genetic response to ancestral predation, as we do not observe owls or other predators lurking outside of California leaf-nosed bat roosts during a full moon. Since we made this correlation in 2003, we avoid counting the roosts the week before a full moon. We do not know whether lunar phobia occurs for bat species other than California leaf-nosed bats. Paired counts of myotis mines would contribute valuable data.

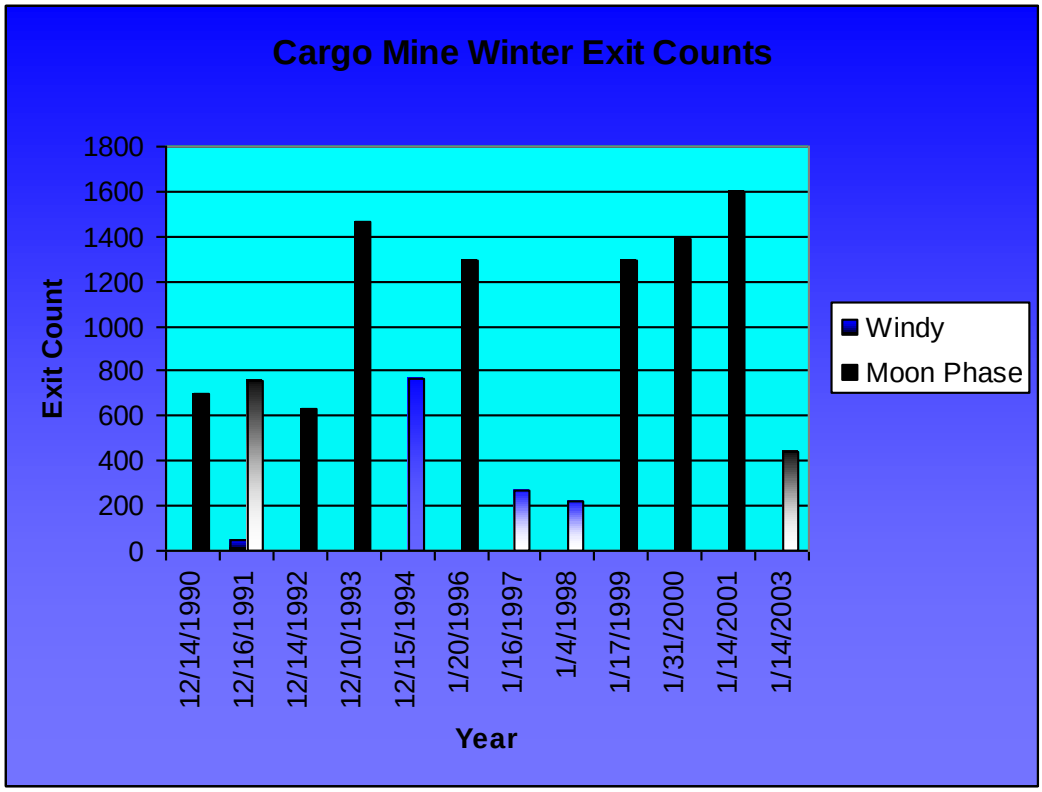

Figure 21.—The effects of wind and moonlight on exit counts of California leaf-nosed bats.

The final variable that influences exit count data is the skill and experience of the observers with finger tallies to keep up with the rapid entry and exits of hundreds of bats swirling around the mine portal. When several people observe the same portal as several thousand bats exit, the counts may differ twofold or even threefold. For this reason, infrared sensitive Nightshot cameras are used to simultaneously record exiting bats, especially at those mines with several thousand residents. When compared to the taped exodus, the observers will both over- and undercount (see figures 3, 4, 6, 7, 8, 11, 12, 14, 19, and 20), but over half the time, the observer counts are close to those of the tapes when they are

reviewed. The 3C Mine is usually undercounted by observers in winter but overcounted in spring (see figures 19 and 20). The tapes are slowed to half speed when they are watched. Even then, the results of different people watching the same tape can vary as much as 10 percent. The portal size or configuration of some mines make video taping difficult (i.e., Stonehouse shaft #1, Senator Mine, Golden Dream shafts #1 and #4, Homestake shafts, and Mountaineer Mine). The maximum tape duration is 90 minutes, and during the maternity season, the exodus may continue longer than this because the camera must be turned on prior to the first bat exiting so as not to influence the emerging bats.

Winter Surveys

As previously mentioned, winter surveys target California leaf-nosed bats at a time when they concentrate in relatively few roosts along the LCR. Occasionally a few canyon bats and California and Yuma myotis are present in the mines, especially in warm winter weather. Islander 2 and Potholes Mine adits attract mating Mexican free-tailed bats during winter months. During other times of the year, a "pure" species count is usually impossible, except for at the Hart Mine (California leaf-nosed bats), Roosevelt Mine (California leaf-nosed bats) and Golden Dream shaft #1 (Yuma myotis). The greatest numbers of species reside in the Mountaineer Mine, and where it is possible to determine differences in the size and exit behavior of California leaf-nosed bats and *Myotis* sp., differentiating between the three big-eared species (California leaf-nosed bats, Townsend's big-eared bats, and pallid bats) is impossible during an exit count.

Spring Maternity Roost Surveys

The time of parturition varies between and within species and between years. I have observed 2-week-old Yuma myotis in the Riverview Mine in the Whipple Mountains on April 1, at a time when others of this species in the roost were still several weeks from delivering. In other years, Yuma myotis are still pregnant in mid-May. The time of parturition of California leaf-nosed bats can occur from early May through early June. The average time for juveniles to begin to fly and exit the mine can be between 3 to 6 weeks post-natal depending on species and roost temperature. The female California leaf-nosed bats often are still arriving at the maternity roost at the time that the *Myotis* sp. are already giving birth. All of these variables contribute to some inaccuracy of the exit counts between years, especially in mines shared by *Myotis* sp. and California leaf-nosed bats. Lactating females may not readily exit a roost and will circle many times at the portal. If juvenile bats are learning to fly, they often may accompany their mothers after this repeated circling. In maternity colonies with nonvolant young in the roost, some adult females will always be present after dark throughout the night, so an absolute census is impossible without entering and disturbing the colony. For this reason, spring surveys are conducted prior to parturition for California leaf-nosed bats and Townsend's big-eared bats.

Other Bat Census Methods

Even with all of the variables and pitfalls in conducting roost exit surveys, the data acquired are a better indicator of the population trends of colonial bats in an area than capture (mist netting) or acoustic surveys. Mist netting has a bias as to which species are most easily captured, and no population numbers can be inferred. Acoustic detections give relative abundance data, but no population estimates, since it is impossible to determine if one bat was recorded 100 times or 100 bats were recorded once. There is also a difference in detectability of different species. For example, Townsend's big-eared bats emit very faint echolocation signals and are rarely detected acoustically even when near a roost site.

Despite peaks and troughs, overall, many colonies appear to have been stable or slightly increasing between 2002 and 2013. The exceptions are precipitous declines in the Eureka Mine Yuma myotis and the Golden Dream tunnel California leaf-nosed bat maternity colonies and lesser declines in the Californian Mine cave myotis and the Islander Mine Yuma myotis maternity populations. The absolute numbers of bats living in a mine can be an indicator of the carrying capacity of the foraging habitat rather than the size of the mine. The number of juveniles that survive is determined by the complex interplay between the quality of the foraging habitat, the distance between the roost and the foraging site, the temperature of the roost, and the lack of disturbance from people and predators (P. Brown, unpublished data) . The status of the LCR MSCP target and indicator species as determined by exit counts is discussed below.

Townsend's Big-eared Bat

Along the LCR, all known Townsend's big-eared bat roosts (historic and current) are in abandoned mines (Brown and Berry 2003). Grinnell (1914) first discovered the "pale lump-nosed bat" in the Riverside Mountains roosting "at the end of a sloping drift in the Steece copper mine." Howell (1920) visited the Old Senator Mine near the LCR (9.5 km north of Potholes Mine) on May 14, 1918, and "found about a hundred females, each with a naked young from a few days old to a quarter grown, clinging to the roof of a gallery at the two-hundred-foot level. They were in close formation, but not touching one another, and, although not as wild as California leaf-nosed bats, they were quite ready to fly. The only way we could capture them was wildly to grab at a bunch with both hands."

As noted by Stager (1939), cave myotis in the Alice Mine were "rivaled in numbers by *Corynorhinus rafinesquii pallescens* and *Macrotus californicus* only." Dr. Stager (personal communication) described a cluster of Townsend's big-eared bats 3 x 12 feet across in the main level of the Alice Mine. The estimated cluster density in most maternity colonies is 100 bats per square foot (Pierson and Rainey, 1996). At this density, the colony in the Alice Mine in the

1930s would have been over 3,000 bats. The last specimen collected from the Alice was in April 1954. When I first visited the Alice Mine in August 1968, piles of old guano remained, but these have now been trampled to dust. During several visits in the early 1960s, Musgrove (Cockrum et al. 1996) banded or collected from a Townsend's big-eared bat maternity colony in the Homestake Mine near Davis Dam. During several visits to this mine since May 2001, we have not found any evidence of this species.

The Mountaineer Mine in the Riverside Mountains is the only mine along the main LCR that is currently known to shelter a Townsend's big-eared bat maternity colony. Pregnant females have been captured in mist nets or harp traps as they exited the Mountaineer Mine after dark. The number of bats captured has been increasing since we started to employ a harp trap. This capture method increase may not be an indication of the increase in the colony size. As noted previously, it is impossible to differentiate between the three big-eared bat species as they exit the mine. Entry into the roost can be disturbing and could cause abandonment, as Townsend's big-eared bats are very sensitive to disturbance. A cluster of less than 50 bats was present on the third level down the mine in July 2003 when we entered during the day. Fresh (not dusty) beer cans were evidence of human intrusion even at the lower levels, which require climbing down dangerous old mining ladders. A bat gate was installed on the adit and a large cupola over the shaft was installed in late fall 2012 on the Mountaineer Mine to protect people and bats. Besides the colony in the Mountaineer Mine, a male Townsend's big-eared bat was captured at Jackpot 3 in spring, and a hibernating bat was observed in Islander Mine #1 in winter.

Along the Bill Williams River, two mines contained maternity colonies of several hundred Townsend's big-eared bats during our surveys in 1994–95 (Brown 1996). One of the mines near Planet Ranch is also a cold air trap in winter and serves as a hibernaculum (Brown 1996). Current surveys at Planet Mine canyon have shown another mine adit now serving as a maternity roost since the initial 1994–95 surveys. Even in the 1990s, the riparian system along the Bill Williams River was relatively intact compared to the LCR, and with the current cessation of agriculture and groundwater pumping at Planet Ranch, the foraging habitat is more extensive and closer to the Planet Mines.

The Townsend's big-eared bat has declined in numbers across the Western United States as documented in the conservation assessment and strategy (Pierson et al. 1999) prepared by scientists and land managers for the Idaho Conservation Effort. The former Category 2 candidate is currently a USFWS and California Department of Fish and Wildlife species of concern, and considered sensitive by most districts of the BLM and Forest Service. The Western Bat Working Group rates the Townsend's big-eared bat as having a high risk of imperilment across its range. Studies conducted by Pierson and Rainey (1996) for the California Department of Fish and Game showed marked population declines for this species in many areas of California, and they recommended that Townsend's big-eared

bats be listed as threatened status in the State. As of September 2014, the species is a candidate for listing under the California Endangered Species Act. Although several causative factors can be identified, roost disturbance or destruction appears to be the most important reason for the decline of Townsend's big-eared bats in most areas (Pierson et al. 1999). The tendency for this species to roost in highly visible clusters on open surfaces near roost entrances makes them highly vulnerable to disturbance. Additionally, low reproductive potential and high roost fidelity increase the risks for the species. In all but 2 of 38 documented cases, roost loss in California was directly linked to human activity (e.g., demolition, renewed mining, entrance closure, human-induced fire, renovation, or roost disturbance) (Pierson and Rainey 1996). Townsend's big-eared bats are so sensitive to human disturbance that a single entry into a maternity roost can cause a colony to abandon or move to an alternate roost (Graham 1966; Stebbings 1966; Stihler and Hall 1993; P. Brown, personal observation). Inappropriate behavior on the part of well-intentioned researchers and others (i.e., entry into maternity roosts or hibernacula and capturing animals in roosts) can also contribute to population declines.

Possible Reasons for Decline

The dense native vegetation documented by Dr. Stager has been removed along the LCR over the past 50 years and replaced with agricultural fields that are subjected to extensive pesticide spraying. In forested areas, spraying for lepidopteran species may alter the prey base for big-eared bats (Perkins and Schommer 1991; Brown et al. 1994). The loss of foraging habitat, combined with pesticide spraying, may be contributing factors in the decline of Townsend's big-eared bat populations. Along the relatively pristine flood plain of the Bill Williams River, Townsend's big-eared bats are mist netted in the warmer months (Brown and Berry 2003; Calvert 2012b; Vizcarra and Piest 2010). Acoustic studies may not be a good method to determine the presence of this species because the bats emit very faint calls, usually detectable only within 10 feet. Only a few Townsend's big-eared bat calls were recorded during past LCR surveys (Brown and Berry 2003) – outside the known roosts at the Mountaineer Mine and near the Black Rock Mine on BLM land adjacent to the Imperial NWR.

California Leaf-nosed Bat

The California leaf-nosed bat is the most northerly representative of Phyllostomidae, a predominantly neotropical family. The type locality is Ft. Yuma, California (Baird 1858). This species occurs in the lower Sonoran life zone in the deserts of California, southern Nevada, and Arizona and south to northwestern Mexico (Sonora and Sinaloa) and Baja California (Hall 1981; Hoffmeister 1986). In the 1900s, California leaf-nosed bats were collected in several locations across southern California (Howell 1920; Anderson 1969; Constantine 1998). As recently as 25 years ago, they were observed in southern

San Diego County (P. Brown, personal observation). Extensive surveys conducted over the past 40 years indicate that the species now appears to be limited to the eastern portion of its former range in California (Brown and Berry 1998), and the largest colonies are found in the mountain ranges bordering the Colorado River basin. Grinnell (1914) only captured one California leaf-nosed bat along the LCR as it was night roosting in an abandoned adobe building south of Cibola. Stager (1939) and Vaughan (1959) found California leaf-nosed bats to be one of the most common bats in the mines of the Riverside Mountains, and this is still the case (Brown and Berry 1998). During their survey of all mines on the Arizona side of the Imperial NWR, AGFD biologists (Castner et al. 1995) located California leaf-nosed bats roosting in 14 mines in addition to the Eureka Mine. Currently, 7 major (> 100 bats) maternity colonies occur in mines near the LCR (Senator, Eureka, Roosevelt, Rio Vista, Morningstar, Steece, and Californian, with smaller colonies in the Alice, Islander, Homestake, and Golden Dream). The maternity colony in the Golden Dream Mine has declined considerably in the past 6 years. At least 7 mines up the Bill Williams River contain colonies of 100 to 1,000 *Macrotus* (Brown 1996). Five of these mines are in the Planet Mine area. Larger winter roosts (> 300 bats) occur in only eight mines along the LCR (3C, Hart, Stonehouse, Steece, Mountaineer, Alice, Californian, and Jackpot, with smaller colonies in the Roosevelt, Rio Vista, Senator, Islander, Reid, and Homestake) as well as several along the Bill Williams River, two of which are located in the Planet Mine area. The largest colony of over 4,000 bats inhabits the Stonehouse Mine complex, followed in numbers by the Hart and 3C Mines.

California leaf-nosed bats are dependent on either caves or mines for roosting habitat. While they have been found night roosting in buildings or bridges (Brown and Berry 1998; Constantine 1961; Hatfield 1937; Grinnell 1914), all major maternity and overwintering sites are in mines or caves. During extensive field investigations of this species over the last 45 years in California, Brown and Berry (1998) found that all known winter and most maternity diurnal roost sites are in abandoned mines. The exceptions are two small maternity colonies of less than 10 bats each in small natural caves, one of which (Itaglio) is in the Big Maria Mountains near the LCR. Several caves, which were used earlier in the century and which may have sheltered hundreds of bats (Grinnell 1918; Howell 1920; Constantine 1998), have been abandoned due to human disturbance and development or foraging habitat alteration in the vicinity.

Along the LCR in southern Nevada, California leaf-nosed bats occurred in at least three mines that were inundated by the formation of Lakes Mojave and Mead (O'Farrell 1970). They still occur in several mines (Rockefeller Mine, Reid adit, and Homestake Mine) on the Lake Mead NRA. The numbers are reduced by about 50 percent in the Homestake Mine from the over 200 observed by Musgrove (Cockrum et al. 1996). In Arizona, Musgrove also banded *Macrotus* at the mine tunnel at Telephone Pole Cove near Katherine Landing, which has subsequently been sealed by the National Park Service. Another Musgrove location at the Gold Dome Mine on the Havasu NWR is still used by California leaf-nosed bats, primarily in winter.

California leaf-nosed bats neither hibernate nor migrate and have a narrow thermal-neutral zone. They are incapable of lowering their body temperature to become torpid. No special physiological adaptations occur in California leaf-nosed bats for desert existence, and behavioral adaptations such as foraging methods and roost selection contribute to their successful exploitation of the temperate zone desert even during the cooler months (Bell et al. 1986). To remain active year long in the temperate zone deserts, California leaf-nosed bats use warm, diurnal roosts in caves, mines and buildings with temperatures that often exceed 27 degrees Celsius (°C) (80 degrees Fahrenheit [°F]). Depending on the season, they roost singly or in groups of up to several hundred individuals, hanging separately from the ceiling rather than clustering. Often the bats hang from one foot, using the other to scratch or groom themselves. Most diurnal, winter roosts are in warm mine tunnels at least 100 meters long. During this season, the large colonies of over 1,000 bats may contain both males and females, although the sexes may also roost separately. All known winter roosts in the deserts of California, Arizona and southern Nevada exhibit stable temperatures close to 27 °C (80 °F) and relative humidities above 22 percent. The annual mean temperature in the California desert in the range of California leaf-nosed bats is approximately 23 °C (73 °F), and the mean winter temperature is 14 °C (57 °F). The temperature of the occupied mines is warmer than the annual mean temperature, and the mines may be located in geothermally heated rock formations (Higgins and Martin 1980). Except for the approximately 2-hour nightly foraging period in winter, California leaf-nosed bats inhabit a stable, warm environment.

A long-term banding study was initiated in January 1964 by Dr. Phil Leitner, and he was joined by Dr. Brown in 1970 (unpublished data; Brown and Berry 1998) to study movements and longevity in this species. During the last 40 years, over 25,000 California leaf-nosed bats from mine roosts along the Colorado River from Parker Dam to Yuma were banded with USFWS bat bands. On yearly trips, usually in winter, many of these bats were recaptured up to 10 times with an average 50-percent recapture success rate, suggesting strong roost fidelity, although seasonal movements do occur between roosts. The longest distance between the site of banding and that of recapture was a movement over two mountain ranges for a linear distance of 87 km. Most banded California leaf-nosed bats traveled only a few kilometers between summer and winter roosts (Brown and Berry 1998). However, bats recently banded in winter at the Californian Mine have been recaptured in mist nets in summer near Planet Ranch along the Bill Williams River (Calvert 2012a, personal communication). Musgrove (Cockrum et al. 1996) documented movement of two bats banded in summer at the Rawhide Mine (north of the Bill Williams River) and recovered in mines in the Riverside Mountains in winter—a distance of 90 km. The greatest interval so far between initial banding and recapture is 15 years. Assuming that the bat was born in the spring previous to winter banding, this would indicate a

possible longevity of at least 15½ years. This record for California leaf-nosed bats is remarkable because a long lifespan in bats is usually attributed in some part to their ability to undergo daily and seasonal torpor.

Females congregate in large (> 100 bats) maternity colonies in spring and summer, utilizing different mines or areas within a mine separate from those occupied in winter, although colonies of only 6-20 bats are also found (Barbour and Davis 1969; Vaughan 1959; Brown and Berry 1998). Mine complexes mines often provide both summer and winter roosting areas, with the females moving closer to the entrance in the maternity season. The males may continue to roost in the deeper sections of the mine. Multiple-entrance mines are a common feature for most maternity colonies; the entrances create cross-ventilation, which may make the roosts warmer during the day, a factor that could facilitate development of young bats. A single young (weighing 25–30 percent of the mother's mass) is born between mid-May and early July, following a gestation of almost 9 months. This species exhibits "delayed development" following ovulation, insemination, and fertilization in September (Bradshaw 1962). In March, with increased temperatures and insect availability, embryonic development accelerates. Since newborn bats are poikilothermic, the maternity colony is located fairly close to the entrance where temperatures range between 30–40 °C (86–100 °F). This allows the bats to use shallow, natural rock caves that would be too cold for a winter roost. Maternity colonies disband once the young are independent in late summer (Brown and Berry 1998).

Within the larger maternity colonies, clusters of 5 to 25 females will be associated with a single "harem" male that defends the cluster against intruding males (Berry and Brown 1995). The discovery of possible "harem" formation within the maternity colony has several interesting interpretations (Brown and Berry 1991). Males are observed "wing flapping" and vocalizing in the presence of pregnant females and those with young babies at a time when viable sperm are not present. The males appear to drive away other males that enter their sphere of influence. Although some male wing flapping is observed at all times of the year, this behavior is most pronounced when females have babies. Possible explanations are that the male has sired the young and is protecting them or that the females are "imprinting" on the male for future breeding purposes. Large male-only roosts may also form in spring and summer, such as at the Hart Mine.

In early fall, males aggregate in display roosts and attempt to attract females with a courtship display consisting of wing flapping and vocalizations. Aggression between males occurs at this time. The areas used as "lek" sites are usually in or near a mine that had been occupied by a maternity colony (Berry and Brown 1995). During the LCR surveys, displaying males and associated females were discovered under the Island Unit bridge in the Cibola NWR and at an abandoned house near Mitchell's Camp on the California side of the LCR. The Island Bridge is used as a night roost by some bats throughout the year, but the largest

congregation is in October. The closest mine is the Hart Mine, up Hart Mine Wash about 11 km east of the bridge, where one of the largest winter roosts in a single mine working was discovered.

California leaf-nosed bats feed primarily on large moths and immobile, diurnal insects such as butterflies, grasshoppers, and katydids, which they glean from surfaces (Anderson 1969; Huey 1925; Stager 1943; Vaughan 1959). Although *Macrotus* can echolocate, they appear to forage by utilizing prey-produced sounds and vision, even at low ambient light levels. More evidence for this foraging mode is that wings of diurnally active painted lady butterflies are found in the night roosts in great numbers during spring. During surveys at the Jackpot Mine, we discovered a California leaf-nosed bat in a night roost at Jackpot 3 chewing on the head of a wiggling tree lizard (*Urosaurus ornatus*), which spends most of its time in trees and scrubs, often clinging head downward (Stebbins 1985). The California leaf-nosed bat probably gleaned it from the branches of a desert tree when the lizard was sleeping. Since then, we have observed with night vision equipment as California leaf-nosed bats carry lizards back into the mines after dark. The intestinal tract appears to be all that remains after the bat consumes the lizard. The strategy of gleaning larger prey from the substrate as compared to aerial insectivory appears to reduce the total time and energy necessary for foraging (Bell 1985; Bell and Fenton 1986).

Radio telemetry studies of California leaf-nosed bats in the California Cargo Muchacho Mountains west of Yuma showed that the bats foraged almost exclusively among desert wash vegetation within 2 to 5 km of their roost. The close proximity of foraging areas to the roost is most important in winter, when the bats forage closer to the roost and are above ground for shorter periods than in summer. The bats emerge from their roosts 30 or more minutes after sunset and fly near the ground or vegetation in slow, maneuverable flight (Vaughan 1959; Brown et al. 1993). Shallow caves and mines, buildings, and bridges are used by both sexes as night roosts between foraging bouts at all seasons except for the coldest winter months. Wings and other culled prey parts are found under night roosts.

Open water for drinking does not appear to be a criterion for roost selection, as some roosts are located over 50 km away from the nearest known water source. Bats exist primarily on moisture contained in the juicy prey that they consume (Bell et al. 1986). Radio telemetry studies designed to determine the foraging habitat of California leaf-nosed bats in the California and Arizona deserts indicated that bats did not visit areas of open water (Brown et al. 1993, 1999; Dalton et al. 2000). Schmidt (1999) mist netted California leaf-nosed bats (especially lactating females) over water sources in the southern Arizona desert. California leaf-nosed bats are regularly netted at a pool along the Bill Williams River (Brown and Berry 2003).

In most areas of the California desert, California leaf-nosed bats appear to forage among dry wash vegetation (Brown et al. 1993). At least some of the bats that roost near the LCR forage in the cottonwood and willow restoration sites (Brown and Berry 2003; Calvert 2009a, 2009b, 2010). AGFD biologists (Castner et al. 1995) mist netted 57 leaf-nosed bats in eight locations at the Imperial NWR, all of them in dry washes. As mentioned previously, the California leaf-nosed bat is a visually orienting bat that uses prey-produced sounds while foraging. When echolocation signals are used, they are of relatively low intensity. Therefore, acoustic surveys may not always detect this species and would potentially underestimate their abundance. Other than near known roosts, we most frequently recorded them along the Bill Williams River and at the revegetation site at Monkeyhead in the Parker Strip (Brown and Berry 2003). Roost exit counts are still the best method for censusing California leaf-nosed bats.

Within the past 60 years, the range of California leaf-nosed bats has contracted, and the species no longer occurs outside of desert habitats in California. The primary factors responsible for the declines are roost disturbance, the closure of mines for renewed mining and hazard abatement, and the destruction of foraging habitat. The combination of limited distribution, restrictive roosting requirements, and the tendency to form large, but relatively few colonies, make this species especially vulnerable. As judged by exit counts and banding studies conducted over the last 45 years (Brown and Berry 2003), the numbers of California leaf-nosed bats appear to be stable in mines near the LCR.

Cave Myotis

The largest cave myotis in North America occurs in large colonies (100s to 1,000s) in caves and mines across the Southwestern United States (Barbour and Davis 1969). In California, most records are from the mountains bordering the LCR, with a few isolated specimens from southern California (Constantine 1998) and the Kingston Mountains (Stager 1939). This species was first collected along the LCR in 1909 from a warehouse in Needles (Grinnell 1918). Joseph Grinnell (1914) did not collect any cave myotis on his 1910 survey down the LCR. In 1935, Stager (1939) studied this species in several mines in the Riverside Mountains. In the Alice Mine, "*Myotis velifer* was observed throughout the mine in countless hundreds, and was by far the commonest of the seven species known to be occupying the mine. It was rivaled in numbers by *Corynorhinus rafinesquii pallescens* and *Macrotus californicus* only." In 1953, Terry Vaughan (1954 and1959) studied California leaf-nosed bats and cave myotis in the Riverside Mountains in the same mine "tunnels" reported by Dr. Stager, where "each of several tunnels contained roughly 1,000 cave myotis, and each of the other tunnels was inhabited by several hundred individuals." As Vaughan's focus was functional morphology and not natural history, he did not provide exact locations of the mines he surveyed, other than mentioning the Mountaineer Mine. As determined by museum specimens and information provided by Dr. Stager, at least four mines in the Riverside Mountains (Alice, Gold Dollar, Mountaineer,

and Steece) contained maternity colonies. We have visited all of these sites (and other mines in the area) in summer, and only the Steece and the Mountaineer Mines in some years still shelter maternity colonies, although not the thousands of bats witnessed by Dr. Stager. Since Yuma myotis also use the Steece Mine, determining how many of each species is present is not possible. The Mountaineer Mine used to have a maternity colony present on the second level down the winze, but recent mist netting and harp trapping at the portal has not captured any exiting bats and only a few lactating females entering the mine after dark. A small maternity colony may roost near the shaft entrance across the wash, but it is difficult without ropes to enter this portion of the mine. A few male cave myotis occur in the other mines in the Riverside Mountains during the warm season. In addition, large amounts of old cave myotis guano blanket the Jean Mine, which now only houses male California leaf-nosed bats. Human trash and signs of visitation are abundant at most of these mines. Gating the Alice, Mountaineer, and Steece Mines would protect the bats, and possibly the maternity colonies would return. However, many *Myotis* sp. maternity colonies do not accept gates. The Gold Dollar Mine is located in a wilderness area and is a steep hike, therefore receiving less human visitation. The demise of the maternity colony here is probably not linked to human disturbance.

The Stonehouse (Hodge) Mine in the Mule Mountains southwest of Blythe also contains a cave myotis maternity colony of several hundred bats, but an accurate census is difficult because the mine is used by both male and female cave myotis as well as California leaf-nosed bats. Local teenagers and young adults visit the site and litter the ground with broken beer bottles, ammunition casings, and firecrackers. Before the bat gates were installed in 2006, the bats escaped disturbance by roosting down a deep and dangerous winze inside the mine.

The largest colony of cave myotis along the LCR is in the Californian Mine in the Whipple Mountains south of Parker Dam where between 3,000 and 5,000 roost depending on the month or year (see figure 8). We have also found a few cave myotis roosting here in winter among the hundreds of California leaf-nosed bats. I was first introduced to the mine in 1968 by a local teenager, who referred to it as the "bat cave." However, the mine does not appear to receive much visitation, as it is not shown on topographic maps, and it is located up a small, nondescript canyon about a 0.8 km from the LCR. The greatest danger is the dirt and debris that are gradually filling in the portal. A major flash flood event could totally close the mine, possibly entombing the bats. For this reason, a gabian or some other method to deflect the water and flood debris is recommended rather than a bat gate.

The Jackpot Mine on the Arizona side in the Havasu NWR south of Needles is the northernmost cave myotis maternity roost on the LCR. Currently, about 700–800 cave myotis occupy the site in the warm season. As mentioned in the roost section, the mine is located within a wilderness area and is not sited properly on the topographic map. At this time, no additional protection is necessary except

to prevent dirt and rocks from washing down and sealing the portal. The Gold Dome Mine, to the south of the Jackpot Mine, is currently used by male cave myotis and Yuma myotis. In 1962, Musgrove (Cockrum et al. 1996) banded both males and females at this mine. The Homestake Mine is the only known cave myotis roost in Nevada (Cockrum and Musgrove 1964) and, in the 1960s, sheltered a maternity colony (Cockrum et al. 1996). Currently, only a few males are found here in the warm season (P. Brown, personal observation). Hoffmeister (1986) examined specimens from 13 km north of Parker (Empire Flat), Ehrenberg, and a mine tunnel at Picacho (California). AGFD biologists (Castner et al. 1995) located a mine (Imperial #8) east of the Eureka Mine on the Yuma Proving Grounds with a small maternity colony of cave myotis in June 1994. When we visited this mine in late May 2003, no bats were present, and only an old pile of guano remained. DNA analyses of the guano confirmed that it was from cave myotis (J. Zinck, personal communication).

In October 2003, two adits not sited on the topographic map were discovered during an airplane search for mines on BLM land along the Parker Strip (Brown and Berry 2005). A BLM intern was the first to reach the mine after a boat trip across Lake Havasu. "Luba's" Mine is reachable only by boat and is located approximately 1.5 km east of the Islander Mine (as the bat flies). The lowest and longest adit contains mounds of *Myotis* sp. guano several feet deep, which has the odor of cave myotis, although the top guano layer is more typical of Yuma myotis. Both species have been captured in the mine in low numbers as well as a single Townsend's big-eared bat and California leaf-nosed bat. More Yuma myotis have been seen after dark in the mine, and our tentative hypothesis is that the mine is used as a night roost by Yuma myotis foraging over Lake Havasu and possibly day roosting in the Islander Mine. However, it is probably also an example of another colony of cave myotis that has disappeared.

Cave myotis can travel great distances and cross State boundaries as evidenced by the recovery of two banded females by Al Beck on July 30, 1961, and August 4, 1964, at mines in the Riverside Mountains. Both bats had been initially banded at a mine tunnel on Burro Creek in Mojave County (the same as the Arizona myotis record) on May 17 and October 1, 1961, respectively (Cockrum et al. 1996). The bats probably used the Big Sandy, Bill Williams River, and LCR as travel corridors. In addition to the Burro Creek site, several large cave myotis maternity colonies roost in mines bordering the Bill Williams River in the vicinity of Planet, Rankin, and Lincoln Ranches (Brown 1996). During the current 2012–13 surveys, cave myotis colonies were discovered in two mines that they had not occupied in 1994–95. The population may be increasing due to the expansion of the riparian habitat close to the mines. Here, the cottonwoods stretch along the banks of the river, although the trees are not as large or the flood plain as wide as described by Grinnell (1914) or Stager (1939) for the LCR. During the 1994–95 mist netting surveys, cave myotis were second only to canyon bats in the frequency of capture along the Bill Williams River (172 individuals in 7 locations). In 1953, Vaughan (1959) noted that "in the Riverside Mountains

area, after leaving their daytime retreats, cave myotis usually flew directly down the eastern slope of the range to the flood plain of the Colorado River where they foraged…and where they pursue foraging beats over low vegetation, along files of dense vegetation that line the oxbows and main channel of the river, between the scattered thick patches of vegetation that dot the flood plain, or above bodies of water." Evidently, the insects associated with flood plain riparian habitat are important to cave myotis, making this species a good indicator of the success of LCR MSCP restoration activities.

During the 2001–02 acoustic survey (Brown and Berry 2003), echolocation signals attributable to cave myotis (ending frequency 40 kilohertz) were recorded along the LCR between May and October near the known roosts: in the Havasu NWR over Topock Marsh, along the Bill Williams River, in the wash below the Californian Mine and at nearby Quail Hollow and Monkeyhead below Parker Dam, at the Mountaineer Mine, and at Lost Lake River Camp on the east side of the Riverside Mountains. Only a few call minutes that may be attributed to cave myotis were recorded south of the Mule Mountains. More mine searches are needed to confirm if populations of cave myotis exist in the areas where we have not located active roosts.

Yuma Myotis

This species is probably the bat that has most benefited by human activities along the LCR. Historically present, it was first collected at Ft. Yuma, California, by Major G.H. Thomas prior to 1864 (Allen 1864). Another specimen was taken at Ft. Mojave in 1911 (Grinnell 1918). However, Grinnell (1914) did not report or collect any bat of this species during his 1910 float trip along the LCR. Howell (1920) reported a colony of about 600 in the old Senator Mine near Potholes Mine at the 100- and 200-hundred foot levels where they "were gathered in two knots of a hundred each and one lot of over three hundred, in a compact mass, on the uneven roof of a chamber." Dr. Stager (personal communication) collected females from a mine in the Riverside Mountains in 1939 and from the bridge at Blythe in 1940 and 1943 (that also sheltered Arizona myotis). He recalls that they were not a common bat in the mines relative to cave myotis. During our previous survey along the Bill Williams River (Brown 1996), Yuma myotis were not encountered as frequently as cave myotis except in the vicinity of Alamo Dam. In the 2001–02 survey, Yuma myotis were not netted at the pond along the Bill Williams River (Brown 1996).

Yuma myotis are now one of the most common bats along most stretches of the main LCR (both visually and acoustically) especially in the vicinity of water impoundments. Foraging habitat is usually near open water (Brigham et al. 1992), and the bats fly low over the water, feeding on emerging aquatic insects. They can be viewed working the water surface everywhere along the LCR. This species is more closely associated with lakes and reservoirs than any other bat in the Southwest, often roosting in bridges and dams. Musgrove (Cockrum et al.

1996) noted that "large numbers were seen in crevices of Davis Dam on the Colorado River where an estimated 3,500 were present on April 15, 1962, and an estimated 10,000 were present on September 17, 1960. Since that time various efforts have been made by professional pest control groups on behalf of the U.S. Army Corps of Engineers to eliminate bats from Davis Dam." We were not able to verify when this effort was successful. However, we did observe Yuma myotis roosting in Parker Dam. During an AGFD study at the Imperial NWR (Castner et al. 1995), Yuma myotis were the most frequently mist netted species especially near or over the LCR. Of the 303 bats captured in 20 nights, 88 were Yuma myotis, and 69 of these were netted over a sandbar on 1 night.

Musgrove also noted a relatively small maternity colony in the Jackass Flat Mine (a.k.a. Homestake Mine) in southern Nevada. However, on a visit in July 2003, we only captured male Yuma and cave myotis and saw some California leaf-nosed bats. Currently along the LCR, several mines (3C, Eureka, Golden Dream, Steece, Roulette, Islander, and possibly Katherine) support large Yuma myotis maternity colonies, all of them over 1,000 individuals. Males roost singly or in smaller groups, sometimes in the same mine as the maternity colony, or in other mines in the vicinity. For example, of six mine workings visited in July 2003 in the Riverside Mountains, all sheltered male Yuma myotis, while only one (the Steece) had a maternity colony. The old Senator Mine was no longer a roosting location when surveyed in 1991 and more recently in 2011. This colony could have relocated to the 3C Mine. However, the London Bridge at Lake Havasu is home to a maternity colony of several thousand bats. They emerge from many cracks and crevices of the bridge, some almost at water line, and are difficult to census. The Baseline Bridge over the LCR at Cibola also shelters a maternity colony of several hundred Yuma myotis and Mexican free-tailed bats.

Since 2003, the number of Yuma myotis has declined in the Eureka and Islander Mines. Possibly the gating of the Eureka Mine in 2007 may have contributed to the decline. The gating in 2013 of the Islander Mine has also had a negative effect. Some maternity colonies of myotis (i.e., endangered grey bats [*Myotis griscesens*]) have declined after gate installation. However, the 3C Mine colony of Yuma myotis appear to be tolerating the gate. Yuma myotis is a good indicator species, as it is numerous and should remain so.

MANAGEMENT RECOMMENDATIONS AND FUTURE RESEARCH

Roost Protection and Monitoring

When new bat roosts are discovered, they can be evaluated as candidates for protective measures such as gates. The largest known cave myotis maternity colony on the LCR (the Californian Mine located in the Whipple Mountains on

BLM Lake Havasu land) requires a diversion of wash debris that is threatening to seal the mine. The mine is also an important winter roost for California leaf-nosed bats. Although close to the LCR, this mine is hidden in a side canyon. To prevent human visitation, the road leading to the mine should be obliterated. The Jackpot Mine on the Havasu NWR is another cave myotis maternity roost and a California leaf-nosed bat winter roost. It is located in wilderness area and receives minimal human visitation. A gabian structure or some other method of water diversion needs to be maintained above the mine to prevent soil from washing down and closing the portal. A trench has been dug above the portal to divert water, but that may be a short-term solution.

The Alice Mine in the Riverside Mountains was the site of the largest Townsend's big-eared bat colony along the LCR. The old guano pile (still visible during my first visit in 1968) has been ground to dust by human feet. Gating the three portals and closing the road to the mine would also protect people from a potentially hazardous mine. The nearby Steece Mine was a maternity colony for five species of bats (California leaf-nosed, pallid and big brown bats, and Yuma and cave myotis) as of the last visit in 2003. A more recent survey should be conducted and the upper and lower adits gated to protect both bats and humans. The Senator Mine, just north of the 3C Mine, was one of the most important historic bat roosts along the LCR, especially for Townsend's big-eared bats. The Steece, Alice, and Senator Mines are patented (on private property), and gating would need to be done with the cooperation of the landowner.

Roost Monitoring and Additional Mine Surveys

After mines are gated, they should be monitored on a regular basis by counting and video taping exit flights. If bat populations increase, this documented success will provide an incentive for future gates. If bat populations decline following gating, the gate may need to be redesigned or removed. This may be the case for the Eureka and Islander Mines if populations continue to decline. A properly constructed and installed bat gate should be free from vandalism, but regular monitoring will determine if repairs are necessary.

Additional areas to survey for bat colonies include the mines either within or just east of the Cibola NWR and Imperial NWR (some of which were visited by AGFD biologists T. Snow and S. Castner). The goal of this bat mine monitoring program is to assess population trends on a system-wide scale and to try to determine if LCR MSCP restoration activities are having an effect (positively or negatively) on colonial roosting bat species along the length of the LCR.

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