LOWER COLORADO RIVER BAT MONITORING PROTOCOL

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INTRODUCTION AND BACKGROUND

European man has drastically changed the natural habitat of the Lower Colorado River (LCR) over the past 150 years. Dams for power, flood control and water export; bank stabilization and channelization have altered the flow and flood patterns, salinity and plant communities of the LCR. The destruction of the native vegetation, most notably the cottonwood/willow riparian, and its replacement by exotics, especially salt cedar continues unabated. Over the past 50 years, declines have been observed in some bat species, such as the cave myotis (*Myotis velifer*) and Townsend's big-eared bat (*Corynorhinus townsendii*), that were at one time relatively abundant along the LCR. Large deposits of the distinctive guano of these colonial species are found in abandoned mines that border the LCR, although the bats are now absent or present in very small numbers. Only four maternity colonies of cave myotis and one maternity colony of *Corynorhinus* are now known along the LCR. The Arizona myotis (*Myotis occultus*) appears to have disappeared from the LCR, with the last museum specimen collected in 1945. The type locality for this species was Ft. Mojave north of Needles. One hypothesis for the decline of some bat species is the removal and replacement of native floodplain vegetation that supported the insect diets of these bats. Another is the heavy pesticide spraying in agricultural areas (conducted principally at night) that directly reduces the preybase and indirectly poisons the bats. A third possible cause is the disturbance of roosts of colonial bat species by the increased resident and recreational human population along the Colorado River.

The goals of the 2001-2002 bat survey funded by the LCR Multi-species Conservation Program (MSCP) were: 1. To provide a better understanding of the past verses current bat assemblage along the LCR; 2. To establish a long-term monitoring protocol for bats utilizing current acoustic technology; 3. To identify potential species-specific threats to bats; and 4. To assist in the protection of critical roosts. During that project, 15 bat species were detected along the LCR by utilizing a combination of acoustic recording techniques (principally Anabat), roost surveys and mist-netting. These surveys were continued through 2005 with BOR support to sample other areas, to increase the baseline data in those sites previously surveyed and to train agency biologists along the LCR. Given the turnover in biologists, training is an ongoing mission.

The Yuma myotis (*Myotis yumanensis*) forages over open still water, and has apparently increased in numbers with the creation of lakes along the LCR. Yuma myotis, western pipistrelles (*Pipistrellus hesperus*), California myotis (*Myotis californicus*), and Mexican free-tailed bats (*Tadarida brasiliensis)* are now the most common species along the LCR. For the first time, red bats (*Lasiurus blossevilleii*) and big free-tailed bats (*Nyctinomops macrotis*) were documented along the LCR. Imperial and Bill Williams National Wildlife refuges support the greatest bat species diversity, and represent some of the areas least impacted by humans along the LCR. Within the refuges, areas of cottonwood willow riparian (including restoration sites) appear to be used by the most species of bats.

The MSCP committee has targeted four bat species for monitoring along the LCR: the tree-roosting red bats and yellow bats (*Lasiurus xanthinus*), and the mine-dwelling Californian leaf-nosed bats (*Macrotus californicus*) and Townsend's big-eared bats. We would also propose inclusion of hoary bats (*Lasiurus cinereus*), another tree-roosting species. Since *Myotis velifer* occurred in greater numbers and occupied more roost sites along the LCR before the destruction of the cottonwood willow riparian, monitoring the population in the four remaining roosts would be a good indication of the health of the ecosystem adjacent to those areas. Although *Myotis occultus* has not been recently captured or detected acoustically, their occurrence along the LCR would also signal riparian recovery. For most bat species, the value of the LCR is for foraging rather than roosting, and roosts may be located 50 km. from the LCR (Rabe *et al*., 1998; Brown and Berry 2005). Below is a discussion of the natural history of the LCR bat species currently selected for monitoring by the MSCP committee, and the additional species that we recommend for inclusion.

SPECIES ACCOUNTS

Red bat (*Lasiurus blossevillii*): This solitary tree-roosting species is identified both visually and acoustically (Corben pers. comm.). The lasiurine bats are unique in giving birth to multiple young (Barbour and Davis 1969; Shump and Shump 1982a). Historically associated with sycamore riparian systems in California, it has become rare throughout the state (Pierson *et al.* 1999 and 2000) and is a CDFG Species of Concern, a T&E Candidate for AGFD, and received a high rating for imperilment from the WBWG. Occurrences of red bats are relatively rare in Arizona (Hoffmeister, 1986). All of the 61 records in AGFD files occurred between May 30 and September 30. Three female red bats collected in July 1902 on Big Sandy Creek (50 miles east of Topock) were the closest record to the LCR. Grinnell (1914) did not collect this species during his expedition. Williams (2001) mist-netted three red bats (two females and a male) in the upper Moapa Valley of southern Nevada. On January 28, 2002, a male red bat was mist-netted over the cliff pond on the BWR about seven miles from Lake Havasu, making this the first record for the LCR drainage, and the first winter record for Arizona. With so few specimens for Arizona, and all California records from further west, it is difficult to assess if the red bat is a vagrant, or if a population exists along the BWR. Potential roosting habitat in cottonwood trees has definitely declined along the LCR.

The echolocation signals of red bats are distinctive if a good sequence is recorded. Single notes can be confused with western pipistrelles. Williams (2001) found that red bats were the sixth most abundant species detected acoustically at Moapa, even though they were one of the rarest captured in mist nets. During the initial 2001-2002 survey, 27 red bat call minutes (representing 0.14% of the total) were recorded at HNWR, BWR and INWR (with the most calls recorded at the INWR cottonwood revegetation site in the warm months). With a species whose occurrence is rare and sporadic, this may not be the best species to evaluate ecosystem health and recovery.

Western yellow bat (*Lasiurus xanthinus*): This species was recently split from the southern yellow bat (*Lasiurus ega*) based on genetic characteristics (Kurta and Lehr, 1995; Baker *et al.*, 1988; Morales and Bickham, 1995). Both species roost in trees, with preference given to palm trees with intact skirts, although some reports suggest the use of hackberry and sycamore, and even yucca (Higginbotham *et al*., 2000). During the bat survey of the BWR, Brown (1996) captured one juvenile and two adult male yellow bats near Planet Ranch in October. They were fitted with transmitters and tracked for the next week. One bat roosted for several days in cottonwood trees along the BWR as he headed towards the LCR. The last fix on this bat was from a palm grove at Gene Pumping Station. The other bat left the BWR, and was detected by airplane roosting in a palm tree in a residential area one mile NE of London Bridge (exact location confirmed from the ground). The third bat disappeared.

There is some evidence to support the hypothesis that this species has expanded its range northward in response to the planting of palms along the LCR, using the river as a corridor. Constantine (1966) collected the first yellow bat along the LCR at Yuma, with a subsequent specimen turned in for rabies testing in 1980 from Blythe (Constantine 1998). Recently, Williams (2001) and O'Farrell (O'Farrell *et al*., 2004) studied a resident population in the exotic palm groves of the upper Moapa Valley, where it was the second most abundant bat captured and acoustically detected. During the 2001-2002 LCR survey, 24 yellow bat call minutes (representing 0.12% of the total) were recorded principally at the cliff pool at BWR and the cottonwood revegetation at INWR, all during the warm season. However, the most reliable place to record yellow bats now along the LCR is the dense palm grove at Cienega Springs north of Parker. As a target species for the MSCP, this is a rare species that may not have been abundant historically along the LCR. The occurrence of this bat may increase with revegetation efforts, although the roost preference appears to be palm trees. The planting of exotic palms would provide additional roosting habitat.

Hoary bat (*Lasiurus cinereus*): Similar in natural history and habits to the red bat, this species is visually and often acoustically distinct (Corben pers. comm.). This bat migrates both altitudinally and latitudinally, (Grinnell 1918; Dalquest 1943; Krutzsch 1948; Shump and Shump 1982b). Most historic California records are from the winter, with fewer in the spring and fall, and almost none in the summer (Grinnell, 1918; Vaughan and Krutzsch, 1954). Grinnell (1914) did not capture this species along the LCR. However in April 1919, a female was collected at Neighbours, and another female at Palo Verde in March 1936 (LACMNH). Another specimen was taken at the mouth of the Gila River and the LCR (Hoffmeister, 1986). In the BWR survey (Brown, 1996) four adult male hoary bats were captured in mist nets at two locations just downstream from

Planet Ranch in October. During the telemetry study, the bats were tracked to roosts in the foliage of the cottonwood and willow trees, and even in a palo verde tree in a dry desert wash.

Some of the hoary bat echolocation calls are acoustically distinct, while others could be confused with those of pocketed free-tailed bats. Of the 42 call minutes (0.21% of the total) recorded during the 2001-2002 study, 41 of them were from May 9, 2002 at the cliff pool of the BWR, and one was near the LCR at INWR in February. Since hoary bats are slightly more abundant than red and yellow bats, and were historically detected along the LCR, their inclusion in the monitoring MSCP list of tree-roosting species that may benefit from restoration activities is appropriate. They do not currently appear on any agency list as a species of concern, but that may be because they are not being actively tracked and surveyed. In southern California, evidence suggests a rapid decline in occurrence (Remington, 2000).

California leaf-nosed bat (*Macrotus californicus*): The California leaf-nosed bat is the most northerly representative of the Phyllostomidae, a predominantly Neotropical family. The type locality of *Macrotus* is Ft. Yuma, California (Baird, 1858). This species occurs in the Lower Sonoran life zone in the deserts of California, southern Nevada, Arizona and south to northwestern Mexico (Sonora and Sinaloa) and Baja California (Greenbaum and Baker, 1976; Hall, 1981; Hoffmeister, 1986). In the 1900s, California leaf-nosed bats were collected in several locations across southern California (Howell, 1920b; Anderson, 1969; Constantine 1998). As recently as 30 years ago, it was observed in southern San Diego County (Brown pers. obs.). Extensive surveys conducted over the past 38 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 2004), and is found primarily in the mountain ranges bordering the Colorado River basin. Grinnell (1914) only captured one *Macrotus* along the LCR, as it was night-roosting in an abandoned adobe building south of Cibola. Stager (1939) and Vaughan (1959) found *Macrotus* 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 and 2003). During their survey of all mines on the Arizona side of INWR, AGFD biologists (Castner *et al*., 1995a) located *Macrotus* roosting in 14 mines in addition to the Eureka. Currently about seven major (>100 bats) maternity colonies occur in mines near the LCR (Golden Dream, Eureka, Hart, Roosevelt, Morningstar, Steece and Californian, with smaller colonies in the Alice, Islander and Jackpot). At least seven mines up the BWR contain colonies of 100 to 1000 *Macrotus* (Brown, 1996). 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 Islander, Reid and Homestake), as well as two mines along the BWR. The largest colony of over 4,000 *Macrotus* inhabits the Stonehouse Mine complex, followed in numbers by the Hart and 3C mines. Two of the adits at the Stonehouse were just gated, so monitoring this roost will be important.

California leaf-nosed bats are dependent on either caves or mines for roosting habitat. While it has been found night roosting in buildings or bridges (Brown and Berry, 1998 and 2003; Constantine, 1961; Hatfield, 1937), all major maternity and over-wintering sites are in mines or caves. During extensive field investigations of this species over the last 35 years, Brown and Berry (1998) found that all known winter and most maternity day-roost sites are in abandoned mines in California. The exceptions are two small maternity colonies of less than 10 bats each in natural small caves. Several caves, which were used earlier in the century and which may have sheltered hundreds of bats (Grinnell, 1918; Howell, 1920b; Constantine, 1998), have been abandoned due to human disturbance and development or habitat alteration in the vicinity.

In Southern Nevada, *Macrotus* 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 Lake Mead NRA. The numbers are reduced in the Homestake Mine from the over 200 observed by Musgrove (Cockrum *et al*., 1996). In Arizona, he also banded *Macrotus* at the mine tunnel at Telephone Pole Cove near Katherine Landing, which has subsequently been closed by the Park Service. Another Musgrove location at the Gold Dome Mine on Havasu NWR is still used by *Macrotus*, primarily in the winter.

Macrotus 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 *Macrotus* 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 yearlong in the temperate zone deserts, *Macrotus* uses warm diurnal roosts in caves, mines and buildings with temperatures that often exceed 80º 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. However in January 2006, a densely-packed cluster of *Macrotus* was observed in a raise in an open and cooler mine, less than 30 m from the portal. 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. At this season, the large colonies of over 1000 bats may contain both males and females, although the sexes may also roost separately. The consistent feature of the areas in the mines used by the bats is warmth and high humidity with no circulating air currents. The temperature of the mines is usually warmer than the annual mean temperature, and the mines may be located in geothermally-heated rock formations. Except for the approximately two hour-nightly foraging period, in winter *Macrotus* inhabits a stable warm environment. Although longevity in this species does not approach the 30 or more years documented for temperate zone vespertilionid bats, banded *Macrotus* in California have been recaptured after 15 years (Brown and Berry, 1998). Banding studies also suggest that distances traveled between summer and winter roosts are generally no more than a few miles (Brown and Berry, 1998). However, Musgrove (Cockrum, *et. al*., 1996) documented movement of two bats banded in the summer at the Rawhide Mine (north of the BWR) and recovered in mines in the Riverside Mountains in the winter--- a distance of 56 miles.

Females congregate in large (>100 bats) maternity colonies in the spring and summer, utilizing different mines or areas within a mine separate from those occupied in the winter, although colonies of only 6-20 bats are also found

(Barbour and Davis, 1969; Vaughan, 1959; Brown and Berry, 1998). Within the larger colonies, clusters of five to 25 females will be associated with a single “harem” male that defends the cluster against intruding males (Berry and Brown, 1995). Large male roosts may also form. The single young (weighing 25-30% 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 the newborn bats are poikilothermic, the maternity colony is located fairly close to the entrance, where temperatures exceed 90º F and daytime outside temperatures can reach over 120º F in the summer. 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, although the same mine might be still occupied (Brown and Berry, 1998).

In the 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 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. In an attempt to locate the day roost, the closest mine in the area was visited---the Hart Mine up Hart Mine Wash about 7 miles from the bridge, where one of the largest winter roosts in a single mine feature was discovered.

California leaf-nosed bats feed primarily on large moths and immobile diurnal insects such as butterflies, grasshoppers and katydids that they glean from surfaces (Anderson, 1969; Huey, 1925; Stager, 1943; Vaughan, 1959). At the Jackpot Mine in HNWR, a *Macrotus* was discovered after dark with a wiggling tree lizard (*Urosaurus ornatus*) hanging from its mouth (Brown and Berry 2004). Although *Macrotus* can echolocate, they appear to forage by utilizing prey-produced sounds and vision, even at low ambient light levels. 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 *Macrotus* in the California desert show that the bats forage almost exclusively among desert wash vegetation within one to three miles 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 the 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.

Within the past 50 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. This species is considered a Candidate for listing by AGFD, a Species of Concern by USFWS and CDFG and a Sensitive Species by BLM. The numbers of California leaf-nosed bat appear to be stable in the mines near the LCR, as judged by exit counts and banding studies conducted over the last 38 years (Brown and Berry, 1998 and 2004). Although they may roost near the LCR, *Macrotus* appear to forage among dry wash vegetation (Brown *et al*., 1993), and may not have been affected by the removal of the cottonwood and willow riparian zone. AGFD biologists (Castner *et al*.,1995a) mist-netted 57 leaf-nosed bats in eight locations at INWR----all of them in dry washes. As mentioned previously, *Macrotus* 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 detect this species, and would potentially underestimate their abundance. Other than near known roosts, they were most frequently recorded along the BWR and at the revegetation site at Monkeyhead, sites that are near major roosts. Roost exit counts are still the best method for censusing *Macrotus*. As a minimum, the Californian, Stonehouse, Mountaineer, Islander, Homestake, Hart and 3C mines should be monitored, as they represent different sections/populations along the LCR and different agency jurisdictions. Winter is the predominant time to census the bats, although in those sites with maternity roosts, a spring count is recommended. Counts should be made using the same methodologies and at the same time of year, and take into consideration that many *Macrotus* may not exit at dusk when moonlight is present. One or two weeks after the full moon is considered optimum.

Townsend's big-eared bat (*Corynorhinus townsendii*): This species has a broad geographic range in the western United States, and occurs in a wide range of habitats from the low deserts to the cool, moist coastal redwood forests to mid-elevation mixed coniferous-deciduous woodlands. The determining factor in their distribution, however, tends to be the availability of cave-like roosting habitat (Pierson, 1998). Population concentrations occur in areas with substantial surface exposures of cavity forming rock (e.g., limestone, sandstone, gypsum or volcanic) and in old mining districts (Genter, 1986; Graham, 1966; Perkins et al., 1994; Perkins and Levesque, 1987). From the perspective of many bat species, old mines are cave habitat and are now sheltering many large colonies (Tuttle and Taylor, 1994; Altenbach and Pierson 1995; Brown *et al*., 1992; 1993).

Along the LCR, all known roosts (historic and current) are in abandoned mines. 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 (1920b) visited the Old Senator Mine near the LCR (6 miles north of Potholes) 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 *Macrotus,* they were quite ready to fly. The only way we could capture them was wildly to grab at a bunch with both hands." Female Townsend's big-eared bat specimens from the Los Angeles County Museum of Natural History (LACMNH) were collected at Rannells in October 1913 and at Palo Verde November 1919. As noted by Stager (1939), *Myotis velifer* in the Alice Mine were "rivaled in numbers by *Corynorhinus rafinesquii pallescens* and *Macrotus californicus* only". Stager (pers. com.) describes a cluster of *Corynorhinus* 3 x 12 feet across in the main level of the Alice Mine. The estimated cluster density in most maternity colonies is 100 bats/ square foot (Pierson and Rainey, 1996a). At this density, the colony in the Alice Mine in the 1930s would have been over 3000 bats. The last specimen collected from the Alice was in April 1954. When I first visited the Alice Mine in August 1968, only piles of old guano remained. Now the guano has been trampled to dust. *Corynorhinus* have not been seen for over 40 years in the Steece, Senator or Alice mines.

The Mountaineer Mine in the Riverside Mountains is the only mine along the LCR that is currently known to shelter *Corynorhinus*. A cluster of less than 50 bats was present on the third level down the mine in July 2003, and pregnant females were mist-netted as they exited the mine. Even down the dangerous ladders in this mine, fresh beer cans were evidence of human intrusion. A bat gate is needed on the Mountaineer to protect people and bats. During several visits in the early 1960s, Musgrove (Cockrum *et al*., 1996) banded or collected from a *Corynorhinus* 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.

This sensitive species 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 Western Bat Working Group rates *Corynorhinus* at high risk of imperilment across its range. AGFD consider it as a Candidate Species, USFWS a Species of Concern and BLM a Sensitive Species. Studies conducted by Pierson and Rainey (1996a) for the California Department of Fish and Game showed marked population declines for this subspecies in many areas of California, and they proposed that Townsend's big-eared bats be recommended for threatened status in the state. Although, several causative factors are identified, roost disturbance or destruction appears to be the most important reason for the decline. In another report, Pierson (1998) suggested that a combination of restrictive roost requirements and intolerance to roost disturbance or destruction has been primarily responsible for population declines of Townsend's big-eared bats in most areas. 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 two 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, 1996a).

The intense recreational use of caves and mines in California provides one explanation for why most otherwise suitable, historically significant roosts are currently unoccupied. 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). 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.

Abandoned mines are also at risk from closure for hazard abatement, renewed mining and reclamation. Liability and safety concerns have led to extensive mine closure programs in western states, particularly on public lands, often without consideration for the biological values of old mines. If closures are done at the wrong time of year, or without prior biological survey, they can result in the death of entire bat colonies (Altenbach, 1995; Navo, 1995; Rainey, 1995). Even if the bats are properly excluded, replacement roosts in the area may no longer be available.

The proximity of good foraging habitat appears to be a determining factor in roost selection. In recent surveys in the Panamint Mountains, mines with suitable temperatures were occupied by large maternity colonies (>100 bats) only if they were within two miles (3.2 km.) of a canyon with water (P.Brown, pers. obs.). Brown *et al.* (1994) determined by radio-telemetry that this species on Santa Cruz Island bypassed the lush introduced vegetation near their day roost, and traveled up to 3 miles (4.8 km.) to feed in native oak and ironwood forest. Although the diet of California populations of Townsend's big-eared bats has not been analyzed, elsewhere this species is a lepidopteran specialist, feeding primarily (>90% of the diet) on medium sized moths (Dalton *et al*., 1986; Ross, 1967; Sample and Whitmore, 1993; Whitaker *et al*., 1997,1981; Shoemaker and Lacki, 1993).

The dense native vegetation 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). 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 floodplain of the BWR, *Corynorhinus* are mist-netted in the warmer months. Two large maternity colonies (>100 bats) are known to roost in mines within sight of the BWR. One of the mines near Planet is a cold air trap in the winter and serves as a hibernaculum (Brown, 1996).

Acoustic studies are not a good method to determine the presence of this species, since the bats emit very faint calls, usually detectable only within ten feet of the microphone. The five *Corynorhinus* call minutes recorded during the 2001-2002 surveys were at the known roost at the Mountaineer Mine and near the Black Rock Mine on BLM land adjacent to INWR. The Mountaineer Mine should be monitored for population estimates, although the challenge is that two other big-eared species (*Macrotus* and *Antrozous*) also roost in the mine, and are difficult to distinguish from during exit counts. Entry into the mine to view the maternity colony is hazardous and will disturb the bats. Periodic capture of exiting bats at the portal is the best method to determine if the mine is still used by this species. This mine is scheduled to be gated in 2006.

Cave myotis (*Myotis velifer*): The largest myotis in North America occurs in large colonies (100s to 1000s) in caves and mines across the southwestern United States (Barbour and Davis, 1969). The cave myotis is a Species of Concern for USFWS and CDFG and a BLM Sensitive Species. 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 (LACMNH). This species was first collected along the LCR in 1909 from a warehouse in Needles (Grinnell, 1918). Joseph Grinnell (1914) did not take any cave myotis on his 1910 survey down the LCR. In 1935, Dr. Ken 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 *Macrotus* and *Myotis velifer* in the Riverside Mountains in the same mine "tunnels" reported by Stager, where "each of several tunnels contained roughly 1000 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. At least four mines in the Riverside Mountains (the Alice, Gold Dollar, Mountaineer and Steece) contained maternity colonies, as determined by museum specimens and information provided by Dr. Ken Stager. We have visited all of the sites (and other mines in the area) in the summer, and only the Steece (and possibly the Mountaineer in some years) still shelters a maternity colony, although not the thousands of bats witnessed by Stager. Some male cave myotis occur in the other mines in the warm season. In addition, large amounts of old *velifer* guano blanket the Jean mine, which now only houses male *Macrotus*. 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. The Gold Dollar 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 since the mine is used by both male and female cave myotis, as well as *Macrotus*. Local teenagers and young adults visit the site and litter the ground with broken beer bottles, ammunition casings and firecrackers. The *Myotis* escape disturbance by roosting down a deep and dangerous winze (internal shaft) inside the mine. A bat gate installed in January 2006 will protect both the bats and the human trespassers.

The largest colony along the LCR is in the Californian Mine in the Whipple Mountains south of Parker Dam, where between 3000 and 5000 cave myotis roost depending on the month or year (pers.obs.). We have also found a few *Myotis velifer* roosting here in the winter among the hundreds of *Macrotus*. Pat Brown 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 a topo map, and is located up a small nondescript canyon about a half mile 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. Currently, BLM volunteers have constructed a rock diversion that appears to be protecting the mine.

The Jackpot Mine on the Arizona side in 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 topo 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 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 (a.k.a.Jackass Flat) 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 (Brown, pers. obs.). Hoffmeister (1986) examined specimens from 8 miles north of Parker (Empire Flat), Ehrenberg and a mine tunnel at Picacho (CA). AGFD biologists (Castner *et al.,* 1995a) located a mine (Imperial #8) east of the Eureka 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 analysis of the guano confirmed that it was from *Myotis velifer* (Zinck, pers.comm.).

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, 1961 and October 1, 1961 respectively (Cockrum *et* *al.*, 1996). The bats probably used the Big Sandy, BWR and LCR as travel corridors. In addition to the Burro Creek site, several large *Myotis velifer* maternity colonies roost in mines bordering the BWR in the vicinity of Planet, Rankin and Lincoln Ranches (Brown, 1996). Here the cottonwoods stretch along the banks of the river, although the trees are not as large or the floodplain as wide as described by Grinnell (1914) or Stager (1939) for the LCR. During the 1994-95 mist-netting surveys along the BWR (Brown 1996), cave myotis were second only to western pipistrelles in the frequency of capture along the BWR (172 individuals in seven 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 floodplain 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 floodplain, or above bodies of water ". Evidently, the insects associated with floodplain riparian habitat are important to cave myotis.

During the current acoustic survey, we recorded echolocation signals attributable to *Myotis velifer* (ending frequency 40 KHz) along the LCR between May and October near the known roosts: in Havasu NWR over Topock Marsh; along the BWR; 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 *Myotis velifer* have been recorded south of the Mule Mountains. More acoustic records are needed to confirm if populations of cave myotis exist in the areas where we have not located active roosts. Since this is a species whose decline along the LCR parallels the demise of the cottonwood willow riparian, it is an appropriate species to target for acoustic monitoring in revegetation sites, as well as tracking roost population through exit counts.

Arizona myotis (*Myotis occultus*): This species had been considered by some to be a subspecies of the little brown bat (*Myotis lucifugus*), and as such was considered to have a much expanded geographic range (Findley and Jones, 1967; Valdez *et al*., 1999). Recent genetic analysis award it specific status (Piaggio *et al*., 2002). When first described in 1905 (Hollister, 1909), it was named Hollister's bat, and the topotype was collected in May 1905, ten miles north of Needles at Ft. Mojave on the California side of the LCR in the "dense cottonwood bottomlands of the Colorado River". In fact, H W Henshaw of the Wheeler Expedition in 1875 had collected a specimen in the "Mojave Desert" and deposited in the U. S. National Museum (Cockrum *et al*. 1996). In May 1910, Joseph Grinnell on a float trip on the LCR from Needles to Yuma, collected a female Hollister bat four miles south of Potholes "shot at late dusk close to the riverbank between files of cottonwoods, in just the same location as those taken by Hollister". The next five specimens were collected "four miles northeast of Yuma, California" and were "shot over water in a back eddy of the river. Here the bats arrived in considerable numbers at early dusk to drink, flitting down to the water's surface and dipping several times before flying off among the willows and cottonwoods." Grinnell "used a boat in shooting and retrieving the specimens". Other specimens were collected in 1924 from Potholes (San Diego County Museum) and in 1930 from Ft. Yuma (Calif. Acad. of Sciences).

In August 1937, Stager (1943a) collected a male Arizona myotis in a mine in the Riverside Mountains, and in 1939 discovered a large maternity colony (~800 bats) roosting between horizontal support beams of a bridge on the LCR at Blythe. Between 1939 and 1945, Drs. Ken Stager and Denny Constantine collected 87 specimens (primarily females) from this bridge (deposited in the Los Angeles County Museum of Natural History [LACMNH]). The bridge was torn down in the 1950s, and the colony has never been rediscovered. In 1942, Couffer collected three females in Ripley, five miles south of Blythe. Since 1945, no more Arizona myotis have been observed or collected from the LCR. The current range of the species is at higher elevations (6,000 to 9,000 feet) across central Arizona (Hoffmeister, 1986) and New Mexico, and south central Colorado (Barbour and Davis, 1969) in oak-woodland, pinyon-juniper, ponderosa pine, and cottonwood-willow riparian habitats, usually near permanent water. We have mist-netted and recorded Arizona myotis at Pine Lake in the Hualapai Mountains at an elevation of 5990 feet in July 1998 (Brown and Berry, 1999). In our surveys along the BWR in 1993-95 and 2001-2005, we did not capture the Arizona myotis (Brown, 1996). However, Musgrove (Cockrum *et al.*, 1996) captured a male on July 16, 1960 and a female on April 28, 1962 in a mine "tunnel" on Burro Creek in Mojave County, Arizona. Burro Creek drains into the Big Sandy River that enters into Alamo Lake, which is upsteam from the BWR. If *Myotis occultus* is ever "re-established" along the LCR, it will probably be in the cottonwood forests in BWNWR.

Has this historic, disjunctive population of Arizona myotis along the LCR been extirpated? Certainly the "dense cottonwood bottomlands" described by Hollister (1909) and Grinnell (1914) no longer exist along the LCR. When the young naturalist Dr. Ken Stager began his collecting career for the LACMNH near the Riverside Mountains in the early 1930s, he witnessed a cottonwood/willow riparian zone a mile wide (Stager, pers. comm.). We visited the Los Angeles County Museum of Natural History in the company of Dr. Stager (now 91 years old) to look at the specimens of *Myotis occultus* and *velifer* collected along the LCR, and video-taped his reminiscences.

During the recent surveys we've attempted to acoustically determine if *Myotis occultus* currently occurs along the LCR. All reference calls for this species have been recorded at higher elevations in Arizona or New Mexico. We assume that the Arizona myotis along the LCR would use a similar signal, although verification would require the capture and recording of the released bat. Of the more than 35,000 call sequences examined during the 2001-2002 survey, we have not discovered any that could unequivocally match voucher calls attributable to *Myotis occultus.* A few signals that were close in characteristics were recorded at the cottonwood revegetation site at INWR in May, June and August. This site is relatively near the Potholes where Grinnell captured the Arizona myotis flying among the cottonwoods. These calls were tentatively identified as a variant of pallid bat calls (since this was the species and *Macrotus* were mist-netted exclusively at the cottonwood revegetation site in July 2003 to May 2005). *Myotis* are usually colonial bats, and the detection of a few isolated calls would be unusual. More effort needs to be invested in capturing a bat. Until an Arizona myotis is actually taken, the tentative conclusion is that they are extirpated along the LCR. In the meantime, all signals recorded while attempting to monitor the targeted red and yellow bats, should also be searched for evidence of Arizona myotis.

Yuma myotis (*Myotis yumanensis*): 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 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 (1920b) reported a colony of about 600 in the Old Senator Mine near Potholes at the one and two-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." Stager (LACM records) collected females from a mine in the Riverside Mountains in 1939 and from the bridge at Blythe in 1940 and 1943 (that also sheltered *M. occultus*). He recalls that they were not a common bat in the mines relative to *M. velifer*. During our previous survey along the BWR (Brown, 1996), Yuma myotis were not encountered as frequently as cave myotis, except in the vicinity of Alamo Dam. In the present 2001-2002 survey, Yuma myotis were not netted at the pond along the BWR.

Yuma myotis are now one of the most common bats along most stretches of the 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 almost 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 3500 were present on 15 April 1962 and estimated 10,000 were present on 17 September 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." Currently, Yuma myotis roost in Davis Dam and Parker Dam, with reports of colonies at Morales Dam. During the AGFD study at Imperial NWR (Castner *et al*., 1995a), 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 one night.

Musgrove also noted a relatively small maternity colony in the Jackass Flat mine (a.k.a Homestake) in southern Nevada. However, on a visit in July 2003, we only captured male *Myotis velifer* and *yumanensis*, and saw some *Macrotus*. Currently along the LCR, several mines (3C, Eureka, Golden Dream, Steece, Roulette, Islander, and the Katherine) support large Yuma myotis maternity colonies, all of them over 1000 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 is no longer a roosting location. 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 waterline, and are difficult to census. The Baseline/Palo Verde Bridge over the LCR at Cibola also shelters a maternity colony of several hundred Yuma myotis and *Tadarida*.

Acoustic signals of Yuma are steep FM (frequency modulated) calls ending at 50 KHz. The shape of some Yuma myotis calls is distinctive, while other signals may be confused with those of California myotis. Fortunately, both species are common along the LCR. After pipistrelles, they were the second most frequently recorded bat at almost every site along the LCR. Monitoring a common species along the LCR may be important since changes in the population may be more significant than for rare or migratory species.

METHODS

Not a single survey method will equally detect all species, or provide equivalent data. Acoustic survey techniques can remotely record the presence of most species over larger time periods. The detection varies with species, with a bias for louder low frequency signals such as those emitted by free-tailed bats. An index of relative abundance can be generated, but no population estimate. Roost exit counts are the most reliable means of tracking populations of colonial bats (O'Shea and Bogan, 2003). Capture near roosts and in restoration sites can be used to validate species identification and reproductive condition.

Acoustic signals recorded via an Anabat II detector on laptop computers and/or storage CFZCAIMs (Compact Flash Zero Crossing Analysis Interface Modules) are used for identification of bat species and to document general bat activity levels (O'Farrell, 1998). Currently, it is possible to install long-term Anabat monitoring stations powered by solar panels, with the equipment placed in weather-proof boxes. Depending on the capacity of the CF card and the amount of bat activity, several months of data could be gathered before downloading. Of course, the potential for theft and vandalism exists. The large amount of data recorded requires analysis time and expertise although search algorithms are evolving that will reduce the effort. The alternative to continuous recording would be to record for one or two nights each month in selected control and restoration plots, although research experience indicates large variations in acoustic activity from night-to-night and the potential to miss migration flocks of the targeted red and yellow bats. If the intermittent recording method of monitoring is chosen, data should be recorded during the same moon phase (or lack of moonlight), and in favorable weather conditions (low winds, no rain, etc.). All recordings should be archived at LCR agencies and the MSCP/BOR database, including those that do not contain the current list of targeted species. Future priorities could change as well as the criteria used to identify species acoustically.

Several factors influence the recording of acoustic data. The sensitivity of different Anabat detectors set at the same sensitivity level can vary, often as a function of battery strength or microphone type. Insects or other ultrasounds not emitted by bats can trigger the detector and clutter the recording of bat data. Moisture in the air affects the detectability of a signal, as does the density of the vegetation (Patriquin *et al*., 2003). Placement of the Anabat in the habitat can have a significant effect on the number of calls recorded, and does not usually equate to the number of bats. Acoustic bat activity near a maternity roost or in an active foraging area (around a light with insects) is often continuous throughout the night because an individual bat spends considerable time calling in the same general area. Recording along a commuting route between the roost and the foraging area may result in a single call sequence per bat and result in fewer calls, but may represent more individual bats. The position of the bat relative to the detector microphone, and the intensity of the bat's call have a profound affect on whether or not the Anabat system will record the sound. Mexican free-tailed bats (*Tadarida brasiliensis*) emit such loud, low frequency calls that they can be recorded from hundreds of feet away, whereas Townsend's big-eared bats (*Corynorhinus townsendii*) emit such faint signals that they are seldom detected from over five feet away. Often the signals of western mastiff bats (*Eumops perotis*) are not recorded on the Anabat since their low frequencies (in the range of many insects) are purposely attenuated by electronic filtering. The calls are audible to most people with good hearing, and the bats may be heard long before being recorded with an Anabat. At times, certain bats will orient visually and emit no echolocation calls. Pallid bats (*Antrozous pallidus*) and California leaf-nosed bats (*Macrotus californicus*) see very well in moonlight and may not always echolocate, although their distinctive communication signals may indicate their presence (Brown, 1976).

Species identification is made from Anabat recordings by comparison with "voucher" calls from known hand-released bats (O'Farrell *et al.*, 1999). A margin of error is inherent in this system (Barclay, 1999). The most definitive calls for a species are the "search phase" calls emitted while bats are foraging, and these might be different from the hand-released bat voucher calls. Usually the ending frequency in a FM (frequency modulated) signal is the most diagnostic, since atmospheric attenuation of the higher frequencies in the call is more severe than the lower frequencies. Different bat species can at times use similar signals, and the same species can employ a variety of sounds based on the perceptual task and the surrounding habitat. Inherent in the acoustic identification process is the knowledge of which bats are common to the area as well as which bats may be present (but uncommon). Several points need to be considered when interpreting the acoustic data: some calls will be misidentified; the louder bats will be over-represented; “whispering” bats such as *Corynorhinus townsendii* may not be recorded; and the number of calls recorded is an index of bat activity and does not equate to the number of bats.

Call minutes are used as a relative activity index to eliminate the bias of over-estimating bat relative abundance if multiple files of the same individual were recorded in a short period of time, or under-estimating bat abundance because of multiple individuals recorded within a single file (Kalcounis *et al*., 1999). A call minute indicates that a given species is present if it was recorded at least once within a one-minute block of time (regardless of the number of call sequences recorded within that minute). The highest rating a bat species can achieve is 60 in an hour, which indicates that the species (not necessarily the same individual) is recorded at a location continuously during the hour (Williams, 2001; Miller, 2001).

Roost Surveys are the best method for tracking bat populations, and the only method to monitor species such as *Corynorhinus townsendii* and *Macrotus californicus*. We have surveyed most mines along the LCR and identified several mines in different sections of the LCR (Brown and Berry 2003) that should be monitored over time. These include winter and maternity colonies of *Macrotus californicus,* and maternity roosts for *Corynorhinus townsendii, Myotis velifer* and *Myotis yumanensis*. Of the 11 mine areas along the LCR surveyed for bats, six had baseline data spanning two decades or more. A total of six bat species were discovered using these mines as day or night roosts. The mines were selected because they represented roost areas along different sections of the LCR (starting north and heading down river): Homestake (LMNRA); Jackpot and Gold Dome (HNWR); Islander and Californian (Lake Havasu BLM); Mountaineer and Stonehouse (BLM Palm Springs); Eureka and Golden Dream (INWR); Hart (Yuma BLM/AGFD) and 3C (El Centro/Yuma BLM).

To obtain accurate exit counts, occupied mines are monitored at dusk with Generation 3 night vision equipment (augmented with infra-red light sources) and finger tallies (to count bats exiting and subtract the bats that return a few times before departing the mine). Sony “Nightshot” video cameras (sensitive in the infrared range) with auxiliary IR lights are actually preferred to remotely monitor mines and to obtain permanent records of exiting bats. The recordings can be played back at half speed in order to obtain a more accurate count of dense outflights. Often, circling bats can challenge real-time exit counts, and the sequence of exiting and entering bats can best be determined by video playback. Acoustic recordings can be done concurrently, and the times of audio and visual records can be used for identification of species.

The timing of the exit counts will depend on the natural history of the species and environmental factors (such as avoiding winds over 10mph and rain). For example, census of *Macrotus californicus* should avoid nights with moonlight. To compare exit counts between years, they should be made in the same month. Maternity colonies should be counted before any of the young have fledged, or after all the young are volant and exiting the roost each night (usually by the end of July). Since time of parturition can vary between years by as much as a month, early May is generally the preferred time (avoiding full moon for *Macrotus*).

Capture techniques (mist-netting and harp traps) across the LCR are usually not feasible. However, we have netted bats among the trees in revegetation areas in Imperial, Cibola and Havasu NWR, at a pond area along the Bill Williams River (BWR) and in palm groves at Cienega Springs and Proctor Palms. The only net captures of red and yellow bats have been along the BWR. Ground-level mist-netting favors the capture of low-flying species (such as *Macrotus*, *Myotis* and *Antrozous*), while the molossids (*Eumops, Tadarida* and *Nyctinomops*) rarely fly low enough for capture. Possible canopy netting may yield better results for tree-roosting species. In addition, wind movement of the nets usually inhibits bat captures, and windy conditions are a frequent occurrence, especially at dusk. Mist nets or harp traps across mine roosts are used to verify the species and reproductive condition but must not be done during an exit count.

Guidelines for the Establishment of a Long-term Monitoring Protocol for Bats

The current bat surveys have attempted to establish baseline bat species lists at selected sites along the LCR. It would be naïve to assume that the technology will not improve in successive decades, as well as the ability to distinguish between species of bats acoustically. A method to determine how many individuals are foraging near a sampling station may even be feasible. For now, generating species lists and relative abundance for locations along the LCR, and tracking them through time is the immediate goal. Most data during 2001-2005 was collected on the four wildlife refuges, with the assumption that these would provide the least disturbed habitat and/or would be the most likely to be restored in the future. In addition, refuge biologists would be most likely to have the time, interest and equipment to carry out future monitoring protocols. With the initiation of the MSCP, future restoration sites have been identified for tracking by BOR biologists from agricultural fields through re-vegetation with cottonwoods and willows.

Remote, nightly recording Anabat/CFZCAIMs powered by solar panels or 120V commercial power at Wildlife Refuge Headquarters would provide statistically significant comparisons between sites, or at a given site through time. Continuous monitoring will be more likely to detect short activity peaks in some migratory species, such as red, hoary and yellow bats. Established stations could be used to monitor population trends in acoustically-detectable bat species over the next 50 years. The goal is to select a minimum of two secure sites where acoustic monitoring could be conducted on each of the National Wildlife Refuges (Imperial, Cibola, Havasu, and Bill Williams), LMNRA, BOR and BLM land along the LCR. Special attention is given to restoration areas to see if bat populations vary with time from the baseline study. Another site could be away from restoration activities, in areas where bats may be flying over rather than attracted for foraging and roosting.

By having established either continuous or selected monthly monitoring periods for equipped and trained biologists along the LCR, the environmental variables (time/ weather/moon phase) introduced by the current sequential surveys could be mitigated. Analyzing the data will be time consuming and require training. This may dictate initially the number and frequency of deployed Anabat units. Since data needs or interpretation may change over time, archiving all Anabat recordings on retrievable storage media is essential. Data on all species is important, especially since the Anabat will not selectively record red and yellow bats, which currently may represent less than 0.5% of signals. Hoary bats should be included in the tree-roosting target species. The importance of the LCR as foraging rather than roosting habitat for bats should not be under-estimated. The re-establishment of the Arizona myotis or the increase in the frequency of detection of the cave myotis are important goals. Tracking common species, such as Yuma myotis, may yield more statistically-significant data than targeting bats that have been historically rare and may remain so in spite of restoration efforts.

Selected bat roosts close to the LCR should be counted annually with Sony Nightshot cameras and/or night vision equipment to provide population data on targeted colonial species. Exit counts can be supplemented with mist netting and acoustic recordings. Mines that are protected from human entry, shelter target species (especially *Corynorhinus, Macrotus or Myotis velifer*) and/or have historic population data are given priority. Twelve possible mines for long-term monitoring along the LCR are described above and included in the attached table along with a proposed monitoring schedule.

Research Goals

In addition to tracking populations of bats at the roosts and recording changes in the diversity and quantity of echolocation signals, some research into understanding the possible causes of population decline in the cave and Arizona myotis along the LCR should be pursued. The Arizona myotis was first described along the LCR at Ft. Mojave, and now this population is only known from museum specimens. The DNA from these study skins should be compared with that from the current known populations in New Mexico. Several labs could possibly accomplish this (Tanya Dewey, University of Michigan, Dr. Jan Zinck and Dr. Toni Piaggio). Since most acoustic voucher calls are from the New Mexico, it is important to confirm that the possibly extirpated LCR Arizona myotis is the same species.

Since preybase changes and/or pesticides may have precipitated the declines in the *Myotis* and *Corynorhinus*, guano from historic colonial roosts could be compared with guano from bats captured along the LCR. Bat DNA, prey DNA and pesticide and other contaminants are all contained in the guano, although some of the information is easier to extract than others. To decipher the preybase, DNA primers would need to be obtained from insects collected along the LCR. We have already sent to Dr. Zinck genetic material (wing punches) of all mine-roosting bats along the LCR.

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