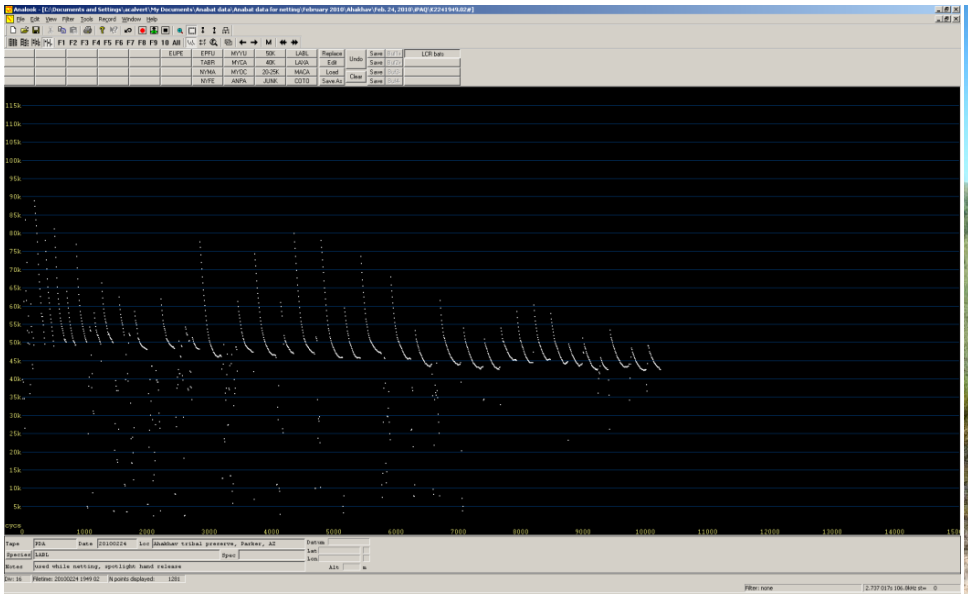
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Monitoring of LCR MSCP Bat Species as Determined by Acoustic Sampling

2012 Summary Findings



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April 2013

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Monitoring of LCR MSCP Bat Species as Determined by Acoustic Sampling

2012 Summary Findings

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Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada
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ACRONYMS AND ABBREVIATIONS

BWRNWR	Bill Williams River National Wildlife Refuge
CF	compact flash
CNWR	Cibola National Wildlife Refuge
CVCA	Cibola Valley Conservation Area
CW	cottonwood-willow
ESA	Endangered Species Act
kb	kilobyte(s)
kHz	kilohertz
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
MLWA	Mittry Lake Wildlife Area
PSRA	Picacho State Recreation Area
PVER	Palo Verde Ecological Reserve
SC	salt cedar

Symbols

%	percent

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Attachment

1 Nightly Activity Patterns at the Four Permanent Stations

ABSTRACT

We deployed four permanent acoustic detector stations along the lower Colorado River (LCR) in order to analyze magnitudinal and seasonal activity as well as occupancy patterns of the western red bat (*Lasiurus blossevillii)*, western yellow bat (*Lasiurus xanthinus)*, Townsend's big-eared bat *(Corynorhinus townsendii)*, and the California leaf-nosed bat *(Macrotus californicus)*. We placed our acoustic monitors at the Bill Williams River National Wildlife Refuge (BWRNWR), Cibola National Wildlife Refuge (CNWR), Picacho State Recreation Area (PSRA), and Mittry Lake Wildlife Area (MLWA). Our detectors collected calls nightly from June 2010 to August, October, and November 2012 at the four stations. We analyzed the data in a presence/absence framework and presented it as days per month of occupancy. We found BWRNWR fosters the greatest amount of total occupancy for the four focal species and supports more consistent seasonal occupancy patterns than the other sites. We also analyzed relative measures of activity patterns using call minutes. We noted migratory activity patterns in western yellow bats at BWRNWR, CNWR, and MLWA (the PSRA sample size is not robust enough to make any conclusions). The large majority of call minutes at BWRNWR is documented over a brief period in the spring. We recorded the majority of call minutes at CNWR in late summer and a sizeable majority in the winter at MLWA. These data indicate either a wintering population of western yellow bats at MLWA, or a utilization of the site as an early migration stopover. The activity at BWRNWR in the spring suggests a stop on this species migration northward. And, alternatively, the figures at CNWR in late summer suggest that it is a stopover site on their migration southward. We provide a comparison between years 1 and 2 and also provide future recommendations for a predictive occupancy model to examine the covered species distribution along the length of the LCR.

INTRODUCTION

This document is a summary of acoustic data collected at four Anabat® stations along the lower Colorado River (LCR). The purpose of this project is to implement conservation measures identified within the Lower Colorado River Multi-Species Conservation Program (LCR MSCP). The LCR MSCP is a multi-stakeholder Federal and non-Federal partnership responding to the need to balance the use of LCR water resources and the conservation of native species and their habitats in compliance with the Endangered Species Act (ESA). This program works toward the recovery of listed species through habitat and species conservation and reduces the likelihood of additional species listings under the Endangered Species Act. Bats have been proposed as indicators of the integrity of natural communities because they integrate a number of resource attributes (e.g., roosting, watering, and foraging habitats) and, thus, may show population declines quickly if a resource attribute is missing (Hutson et al. 2001; Williams et al. 2006). This project specifically targets conservation measures that address the data gaps necessary to implement the conservation needs for the western red bat (*Lasiurus blossevillii*), western yellow bat (*Lasiurus xanthinus*), Townsend's big-eared bat (*Corynorhinus townsendii*), and California leaf-nosed bat (*Macrotus californicus*). The LCR MSCP proposes to create 765 acres of western red bat roosting habitat, 765 acres of western yellow bat roosting habitat, covered species habitat near California leaf-nosed bat roost sites, and covered species roosting habitat near Townsend's big-eared bat roost sites. In implementing the conservation measures required for the four focal species, permanent Anabat® stations were deployed in 2008 along the LCR as a long-term monitoring methodology.

The objective for this project is to continue collecting and analyzing acoustic data from the four permanent stations along the LCR, located at Bill Williams River National Wildlife Refuge (BWRNWR), Cibola National Wildlife Refuge (CNWR), Picacho State Recreation Area (PSRA), and Mittry Lake Wildlife Area (MLWA). The end product will be a predictive occupancy model based on covariates (land form, land cover, climatic factors, vegetation, etc.) that will be able to be applied to the entire length of the LCR and across the bats' range. This model will provide land managers with a tool to evaluate covered bat species presence along the LCR on a broad scale and aid in future management decisions.

METHODS

Permanent Anabat® detectors were deployed in four locations along the LCR in 2008 (figure 1). The first station at BWRNWR was installed on a ridge overlooking Mosquito Flats along the south side of the Bill Williams River. Mosquito Flats is a large area of mature cottonwoods (*Populous fremontii*) and Goodding's willow (*Salix gooddingii*) with salt cedar (*Tamarix spp.*) and

Figure 1.—Permanent station located on the BWRNWR.

mesquite (*Prosopis spp.*) in the understory and along the margins. A small number of California fan palms (*Washingtonia filifera*) is also present along the river's edge. The 2004 vegetation classification of the site is CW IV (tables 1 and 2). The station and the microphone were positioned to detect bats that were flying over the canopy of this dense riparian woodland. The second station was located within CNWR on the Island Unit in a wet, grassy meadow with scattered mature Goodding's willow. Marsh, agricultural fields, and dense stands of mesquite and salt cedar were adjacent to this station. The 2004 vegetation classification is SC IV, but there is a diversity of habitat at and adjacent to the site. The third station was deployed at MLWA along the southeast shoreline of Mittry Lake within an area of arrowweed (*Pluchea sericea)*, salt cedar, and mesquite. The microphone was directed toward a patch of mesquite and cottonwoods, with marsh vegetation just beyond. The 2004 classification is SC IV. The final station was located at PSRA just west of the parking area of the lower boat launch. It is on a dirt ridge in a stand comprised of mesquite, salt cedar, and arrowweed. The microphone was aimed toward a cottonwood-willow revegetation site that could be classified as CW II. The 2004 classification is SC IV (Anderson and Ohmart 1984; Yonker and Anderson 1986; Bio-West, Inc. and GEO/Graphics, Inc. 2006).

Table 1.—Vegetation communities at permanent stations along the LCR

Community	Criteria
Cottonwood-willow (CW)	*Salix gooddingii* and *Populus fremontii* (the later in extremely low densities) constituting at least 10 percent of total trees
Salt cedar (SC)	*Tamarix spp.* constituting 80–100 percent of total trees

Table 2.—Structural categories used in classification along the LCR

Structural type	Description
I	Mature stand with distinctive overstory greater than 15 feet high, intermediate class from 2–15 feet tall, and understory from 0–2 feet tall
II	Stand where the overstory (greater than 15 feet tall) constitutes greater than 50 percent of trees with little or no intermediate class present
III	Stand where largest proportion of trees are 10–20 feet high with a few trees greater than 20 feet tall or less than 5 feet tall
IV	Few trees greater than 15 feet present; 50 percent of vegetation is 5–15 feet tall with the other 50 percent between 0–2 feet tall

These four stations provide a temporal and spatial estimate of bat species diversity and presence. Three stations consisted of Anabat II detectors with associated ZCAIM (a device that takes a frequency signal from an Anabat® detector, detects the zero-crossings in the signal, and stores these on a compact flash card), while a single station used an Anabat SD1. Each station also included sensors and a data logger for temperature, wind, and humidity. Compact flash cards at our stations accumulated data at the rate of about 12 megabytes per night during periods of very high bat activity (about 1,500 calls per night). Our visits to the stations were generally more frequent in order to more timely address any maintenance issues. Recording for this analysis began in June 2010 and ended in August, October, and November 2012 at varying sites (see table 3). Data from 2008 to June 2010 were analyzed and reported previously (Vizcarra et al. 2010).

We quantified the volume of call minutes for western yellow bats, western red bats, Townsend's big-eared bats, and California leaf-nosed bats using the following procedures. Acoustic bat calls were recorded nightly, and calls for the four focal species were processed using filters and methods provided by Susan Broderick (Broderick 2008, personal communication). It was determined in the 2010 final report (Vizcarra et al. 2010) that files above 8 kilobytes (kb) containing recognizable calls were often misidentified by our filters due to the presence of large amounts of interference from insect, vegetation, and electronic noise. Therefore, files larger than 8 kb were omitted from our analysis. After this omission, we ran files through an "all bats" filter designed by Chris Corben.

We ran the remaining calls through species-specific filters and analyzed them individually to sort out species with similar call envelopes to the four focal species. We ran western red bat calls through two species-specific filters (Low H and High H). The Low H filter detected bat call bodies ending between 40–47.5 kilohertz (kHz), while the High H filter detected bat call bodies ending between 52–80 kHz. We applied the High H filter after discussions with Broderick and Calvert (personal communication) revealed they had recorded western red bat calls at higher frequencies along the LCR. We then applied a canyon bat *(Parastrellus hesperus)* filter to clean out the canyon bat calls the western red bat filter initially missed. We analyzed California leaf-nosed bat calls by running them through a species-specific filter and then applied a high 40–50 kHz filter to separate the calls of California myotis *(Myotis californicus)* and Yuma myotis (*Myotis yumanensis).* We compared our calls and tested our filters on known reference calls recorded along the LCR provided by Broderick and Calvert (personal communication) and reference calls from across the Southwestern United States.

Townsend's big-eared bats are known to emit low-intensity vocalizations, which make them difficult to detect with acoustic methods (O'Farrell and Gannon 1999). These bats produce a dual harmonic and were not positively identified unless the presence of this diagnostic harmonic was detected. We used call minutes in order to reduce bias in estimating bat activity at Anabat® stations. A call minute was defined as a 1-minute interval in which a particular species was recorded at least once, regardless of the number of call sequences, or the number of files for that species recorded within that minute (Broderick 2010; Brown 2006; Kalcounis et al. 1999). The call minutes index reduces the bias associated with the tendency for individual bats to be detected multiple times or for multiple bats of a single species to be detected within an individual file (Miller 2001; Williams et al. 2006; Vizcarra et al. 2010). Bat minutes give us a relative measure of activity, but do not tell us if we are detecting the same bat night after night or multiple bats within the same 1-minute interval. Therefore, we changed our analysis to a presence/absence framework as the measure of activity at our permanent stations and applied that change to the previous years' data as well. We will use the presence/absence of each of the four LCR MSCP bat species to create a proportion of occupied days within each month and year.

We also quantified nightly activity patterns for the four focal species by documenting the time a call was recorded and placing it into one of three predetermined timeframes (i.e., 1700–2200, 2200–0200, and 0200–0700). With these data, we can infer how the focal species may be using the habitat around the permanent stations (i.e., roosting or foraging habitat).

The occupancy results will be represented in months and years. Our "year" starts in June and runs until the end of May because that is the timeframe we started recording data. Therefore, the years we will be representing are

June 2010 – May 2011 and June 2011 – May 2012, with partial results from 2012–2013. We discuss finding from June 2011 – May 2012 in the "Results" section, with a yearly comparison in the "Discussion" section.

RESULTS

Overall, the stations functioned relatively well during this reporting period with a few exceptions. The unit at PSRA recorded a low amount of calls from June 2010 to February 2011. We visited the station in October 2010 and noted the low activity levels, but the unit seemed to be functioning properly. We visited again in March 2011 and noted low activity levels again. This time, it was determined that the cable needed to be replaced. The PSRA station also malfunctioned and did not collect data from June 27, 2011, to July 13, 2011. The PSRA station again did not record any calls from June 16, 2012, to July 17, 2012, because interference caused the CF card to reach capacity and again from August 30 to October 22, 2012, because capacity was reached. The unit at CNWR also failed to collect data from February 23, 2011, to May 9, 2011. A fire at CNWR on August 29, 2011, melted most of the external components at the station, though the Anabat and microphone continued to function for another couple of weeks until the battery voltage became too low. The external components were replaced over the next few months; however, the station battery was apparently damaged during the fire, and some additional data were lost as a result. Full function at this station was not restored until January 16, 2012. We have experienced no problems with the stations at BWRNWR and MLWA. We have recorded a total of 819,568 bat calls at the four permanent stations. We verified a total of 285,966 (35 percent [%]) call files at BWRNWR, 217,357 (27%) at CNWR, 160,070 (20%) at PSRA, and 156,175 (19%) at MLWA (table 3).

Table 3.—Usable bat call files and days of data collection recorded at permanent stations

Anabat® site	Start date	End date	Total days	Total calls
BWRNWR	June 3, 2010	October 10, 2012	858	285,966
CNWR	June 3, 2010	November 7, 2012	646	217,357
PSRA	June 25, 2010	August 30, 2012	749	160,070
MLWA	June 18, 2010	October 17, 2012	852	156,175
Totals			3,105	819,568

Overall, we recorded 372 total days of occupancy for the four focal species combined during June 2011 – May 2012. We detected the most total days of occupancy for the four focal species at BWRNWR (131 days) followed by MLWA (104 days), CNWR (74 days), and PSRA (63 days). Western red bats

were the most ubiquitous of the focal species, with 233 days of occupancy between the stations, followed by western yellow bats (72 days), California leaf-nosed bats (62 days), and Townsend's big-eared bats (5 days) (table 4).

Table 4.—Total days of occupancy per species through seasons (June – May)

	2010–2011				2011–2012			
	BWRNWR	**CNWR**	**PSRA**	**MLWA**	**BWRNWR**	**CNWR**	**PSRA**	**MLWA**
LABL	134	50	9	45	90	44	27	72
LAXA	39	11	1	51	25	22	4	21
MACA	5	11	9	48	12	8	32	10
COTO	0	0	2	1	4	0	0	1
Totals	**178**	**72**	**21**	**145**	**131**	**74**	**63**	**104**

Western Red Bat

BWRNWR

We recorded western red bat occupancy to be the most prevalent at this site during 2011–2012 (90 days) (see table 4), with the highest total of occupied days per month generally coming in summer and fall (June – November). We have verified occupancy every month at BWRNWR since the permanent stations were deployed (figure 2).

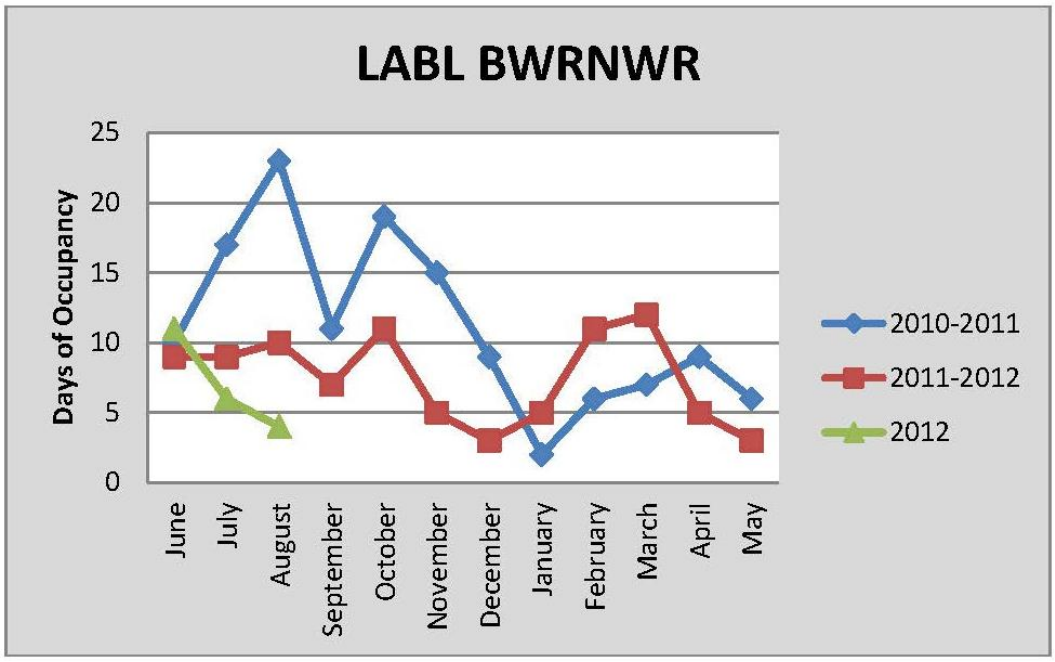

Figure 2.—Western red bat occupancy at BWRNWR.

CNWR

We documented western red bat occupancy to be the third highest of the four permanent stations with 44 days in 2011–2012 (see table 4). CNWR is primarily occupied from June – September, with no occupancy recorded from December – February (figure 3).

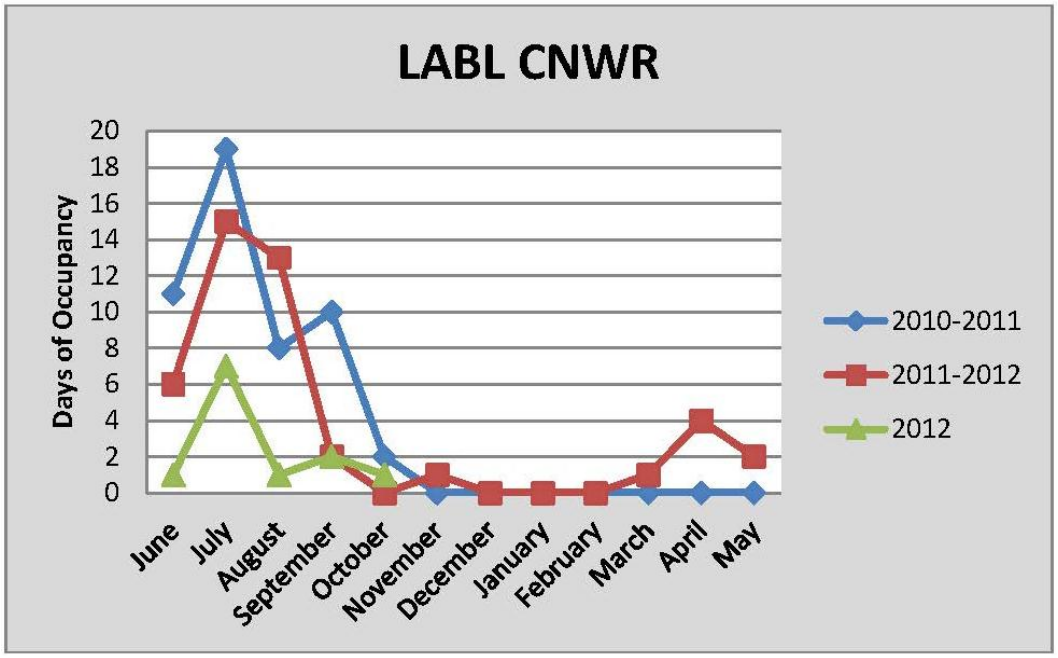

Figure 3.—Western red bat occupancy at CNWR.

PSRA

We observed this site to possess the least amount of western red bat occupancy in relation to the four permanent stations. PSRA produced only 27 days of occupancy in 2011–2012 (see table 4). We recorded the majority of occupancy evenly spread between the months of March – October, with zero occupancy recorded from December – February (figure 4).

MLWA

We observed western red bat occupancy at this station to be the second highest of all the permanent stations, with 72 days of occupancy in 2011–2012 (see table 4). We recorded the bulk of occupancy between the months of April – October, with none recorded in November or January, and only 1 day recorded in December (figure 5).

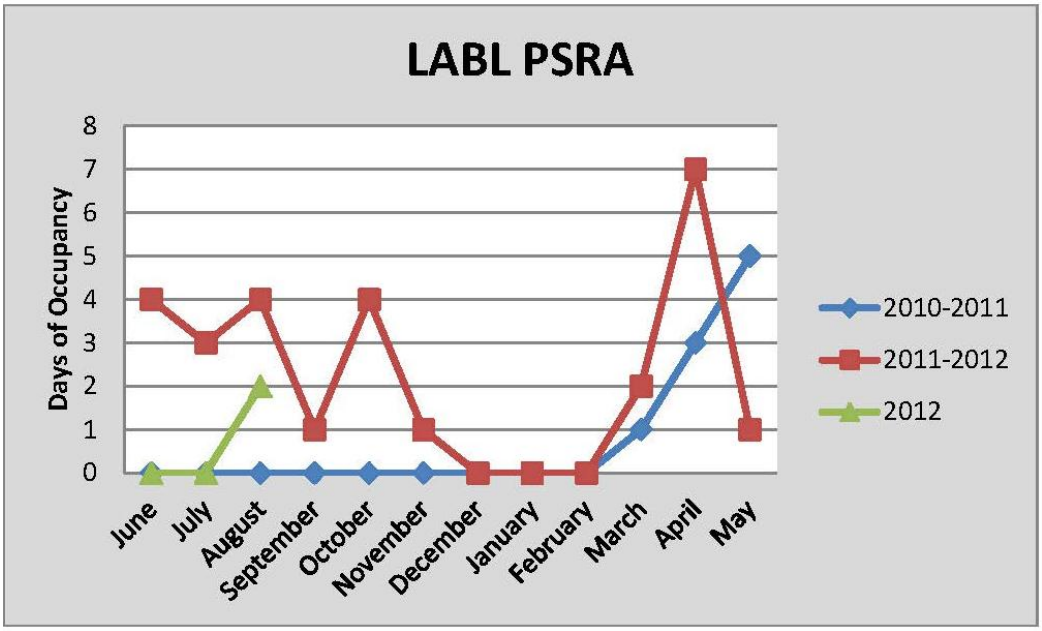

Figure 4.—Western red bat occupancy at PSRA.

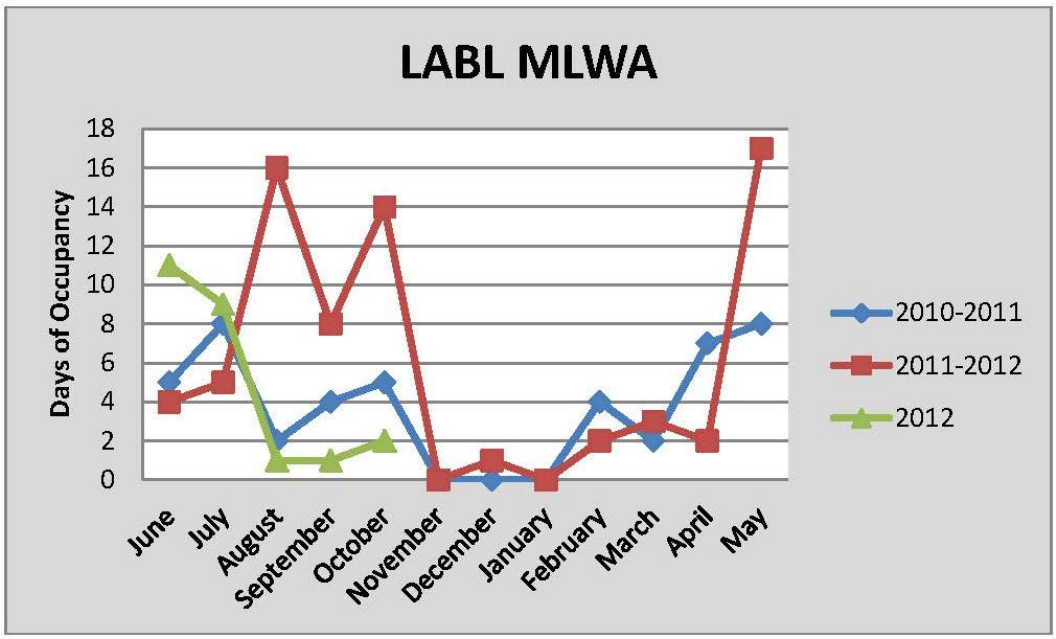

Figure 5.—Western red bat occupancy at MLWA.

Western Yellow Bat

BWRNWR

We documented western yellow bat occupancy to be the highest at this station in 2011–2012 (25 days) (see table 4). We determined BWRNWR is mostly occupied between the months of March – November, with no occupancy recorded in July and December – February (figure 6). We recorded 92% of call minutes between March 26 and April 5, 2012, for western yellow bats at BWRNWR.

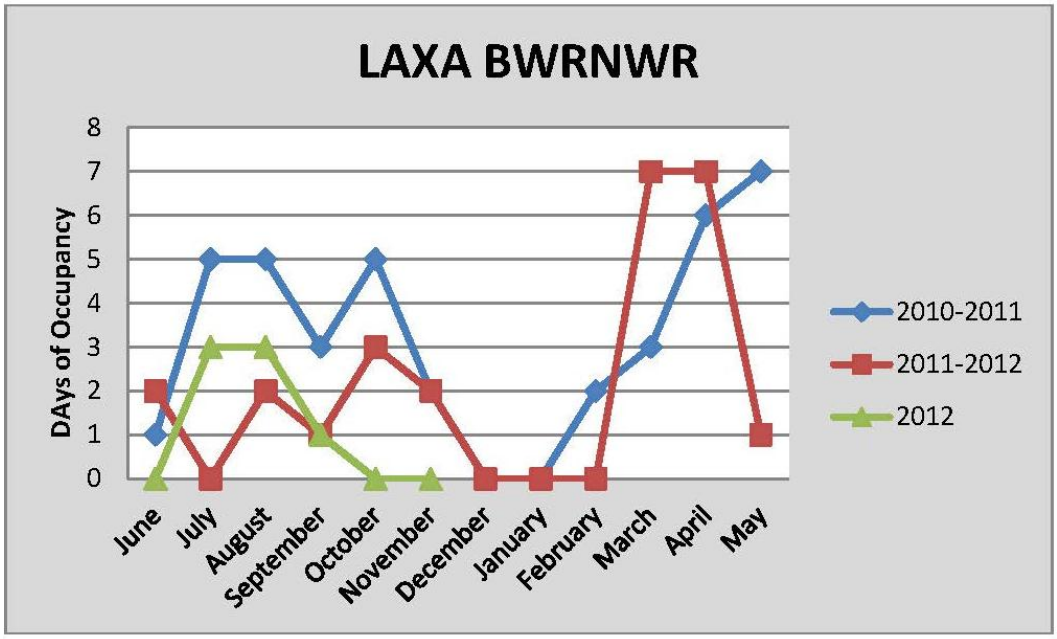

Figure 6.—Western yellow bat occupancy at BWRNWR.

CNWR

We observed this location to have the second highest occupancy of western yellow bats in 2011–2012 (22 days) (see table 4). We recorded all of the occupancy at CNWR between the months of April – September, with no occupancy detected from September – March (figure 7). We recorded 58% of call minutes between July 13 and August 7, 2011, for western yellow bats at CNWR.

PSRA

We observed this site to be the least occupied of the four permanent stations, with only 4 days of occupancy in 2011–2012 (see table 4). We have recorded occupancy in April, July, and August at this site (figure 8) and only recorded 4 call minutes at PSRA for western yellow bats.

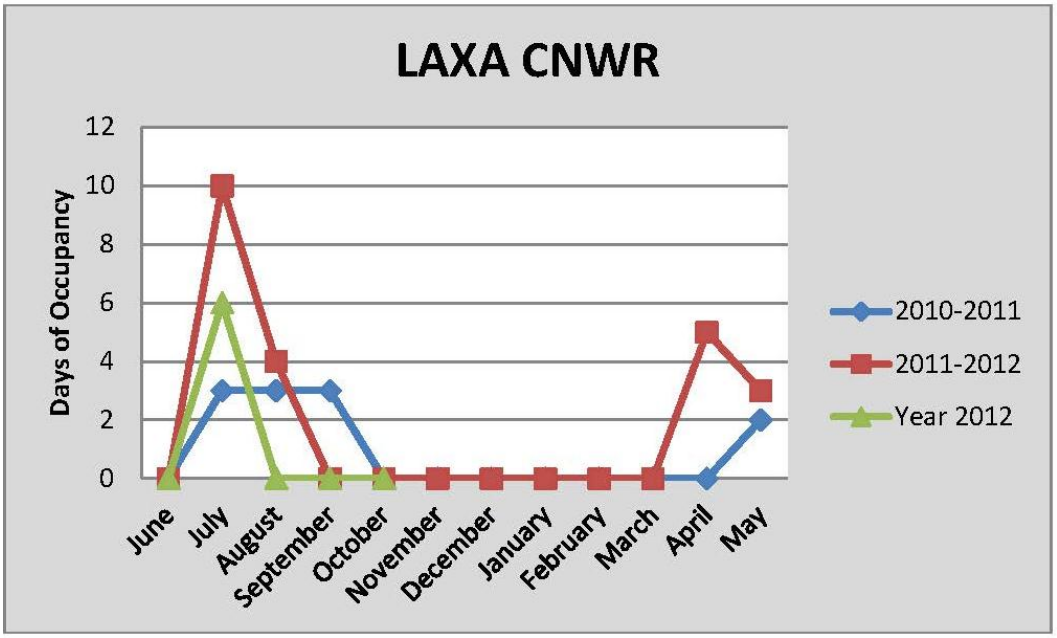

Figure 7.—Western yellow bat occupancy at CNWR.

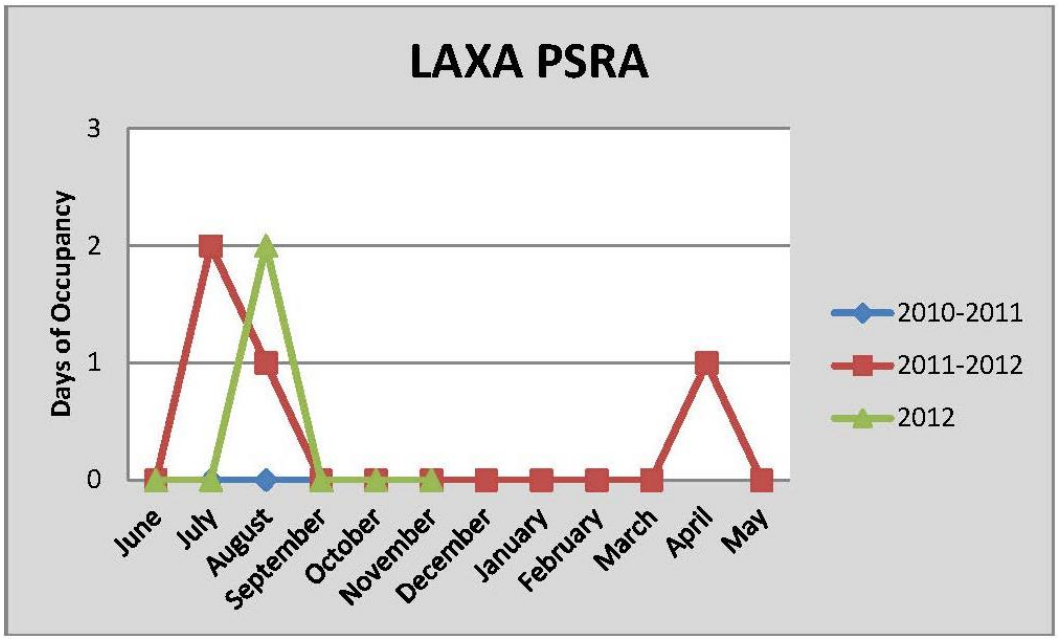

Figure 8.—Western yellow bat occupancy at PSRA.

MLWA

We recorded the third highest amount of western yellow bat occupancy at this station in 2011–2012 (21 days) (see table 4). We detected the majority of occupancy between the months of January – August, with January, February, and March producing the highest total days of occupancy. We did not detect occupancy for western yellow bats at this site in the months of June, October, or April (figure 9). We observed 77% of western yellow bat call minutes falling between the dates of January 24 – March 2, 2012.

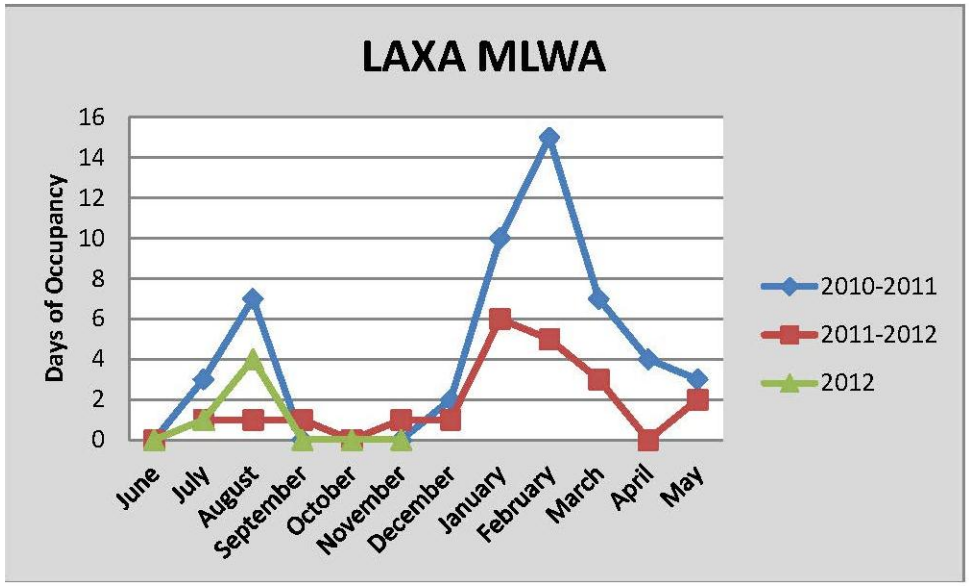

Figure 9.—Western yellow bat occupancy at MLWA.

California Leaf-Nosed Bat

BWRNWR

We recorded the second highest amount of California leaf-nosed occupancy at this location in 2011–2012 (12 days) (see table 4). Occupancy at BWRNWR was sporadic, with California leaf-nosed bats only present in the months of October, December, March, and April (figure 10).

CNWR

We determined this station to have the least total California leaf-nosed bat occupancy in 2011–2012 (8 days) (see table 4). As with BWRNWR, CNWR presence was sporadic, with occupancy being documented in June, July, February, April, and May (figure 11).

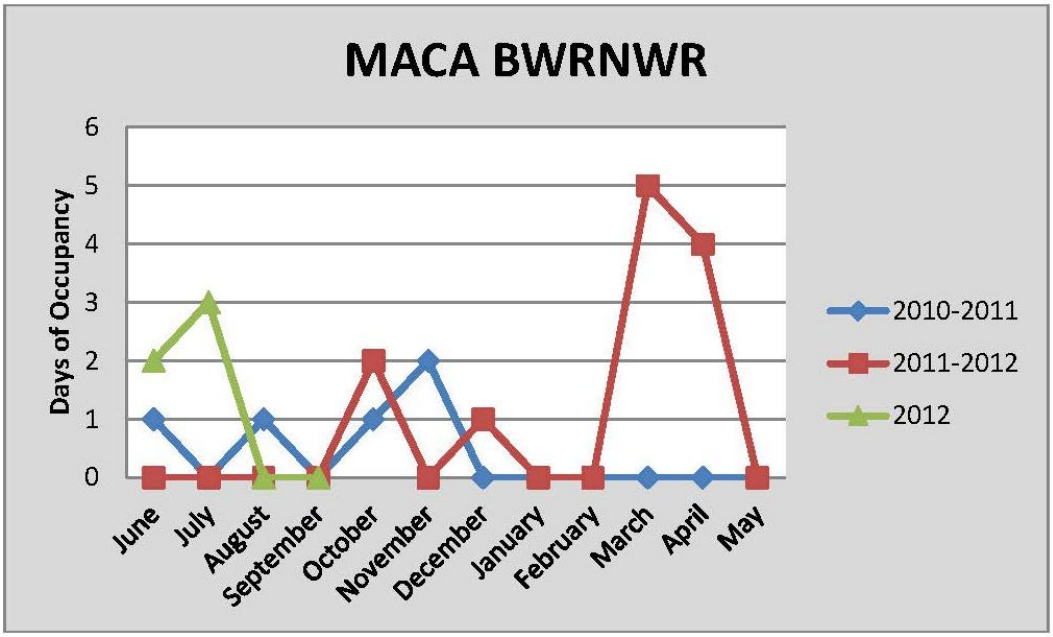

Figure 10.—California leaf-nosed bat occupancy at BWRWNR.

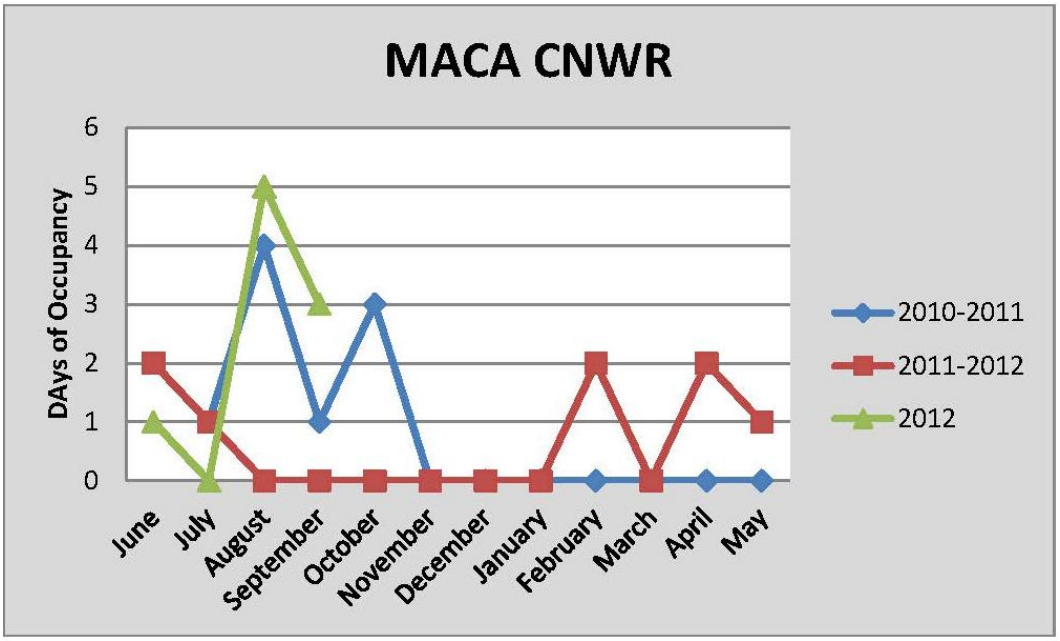

Figure 11.—California leaf-nosed bat occupancy at CNWR.

PSRA

We verified California leaf-nosed bats at this site to have the highest total occupancy in 2011–2012 (32 days) (see table 4). Occupancy during 2011–2012 was infrequent, with spikes in May and August. We did not detect occupancy at PSRA in the months of June, November, December, or January (figure 12).

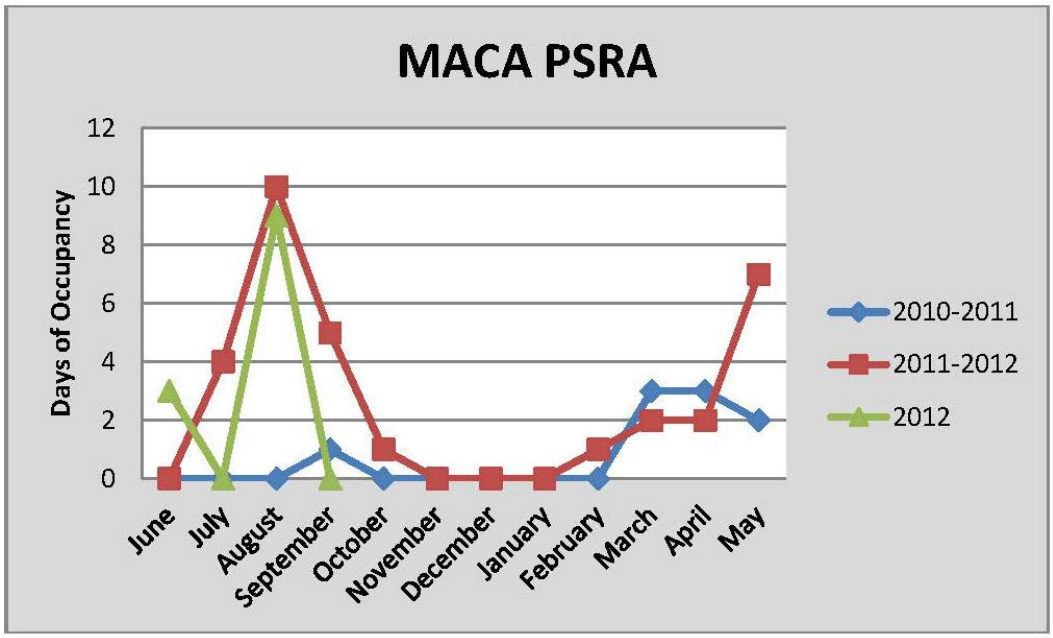

Figure 12.—California leaf-nosed bat occupancy at PSRA.

MLWA

We observed occupancy to be third highest at this location during 2011–2012 (10 days) (see table 4). We documented infrequent presence throughout 2011–2012, with no occupancy recorded October – December and again from March – May (figure 13).

Townsend's Big-Eared Bat

Townsend's big-eared bat occupancy is difficult to quantify using acoustic detection methods as mentioned above. Because they are whispering bats, we recorded relatively little activity throughout the year.

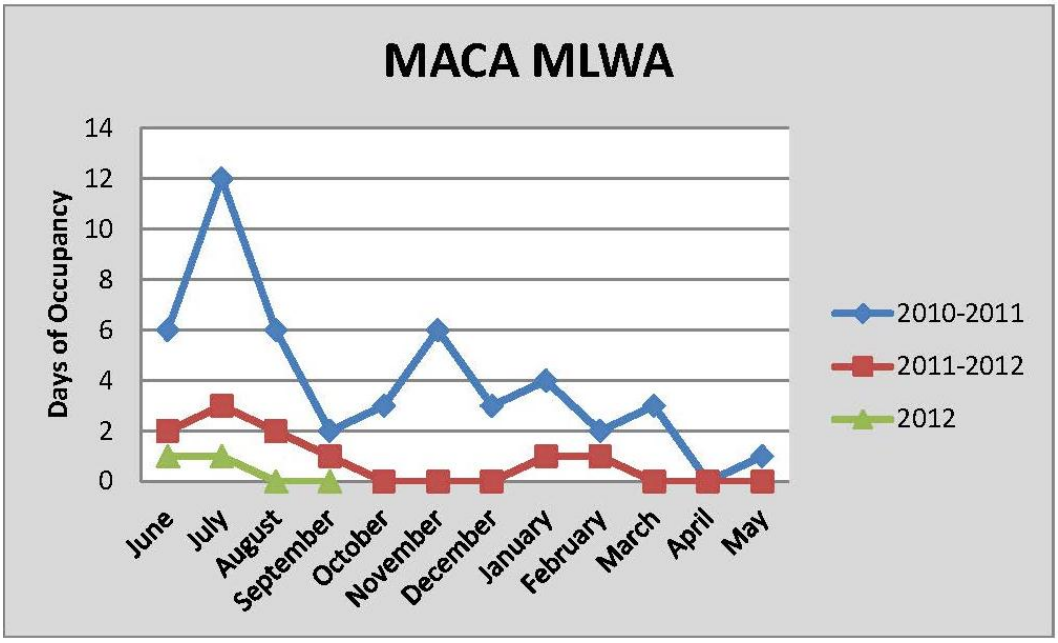

Figure 13.—California leaf-nosed bat occupancy at MLWA.

BWRNWR

We did document 4 days of occupancy by Townsend's big-eared bats (see table 4) at this location throughout 2011–2012, with the detections occurring from March – May (figure 14).

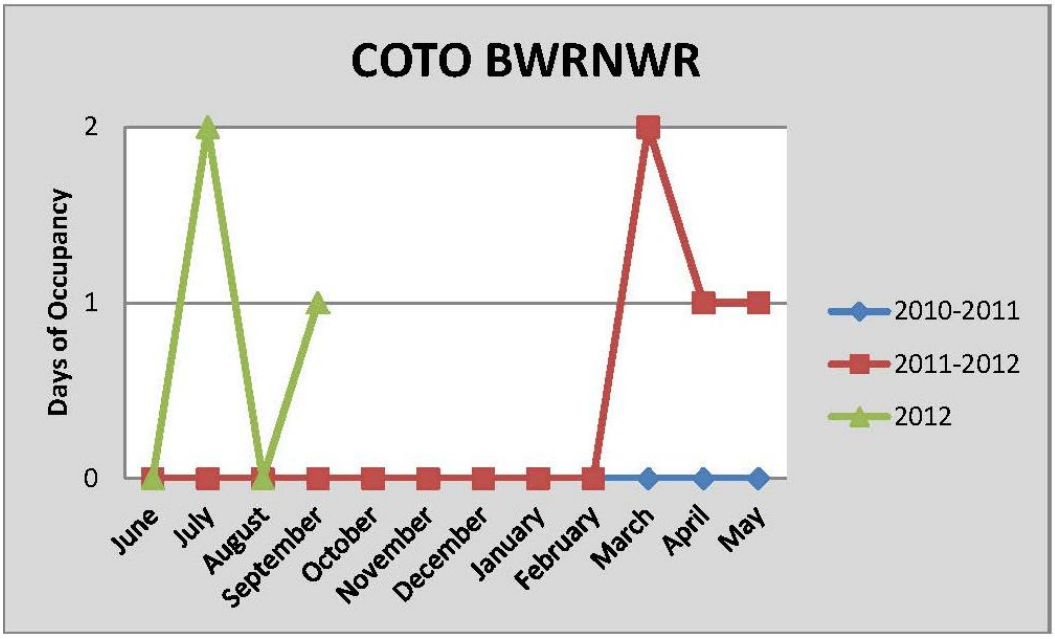

Figure 14.—Townsend's big-eared bat occupancy at BWRNWR.

CNWR

We did not observe any presence of Townsend's big-eared bats at CNWR during 2011–2012 (see table 4).

PSRA

We did not verify the presence of Townsend's big-eared bats during 2011–2012 at PSRA (see table 4) (figure 15).

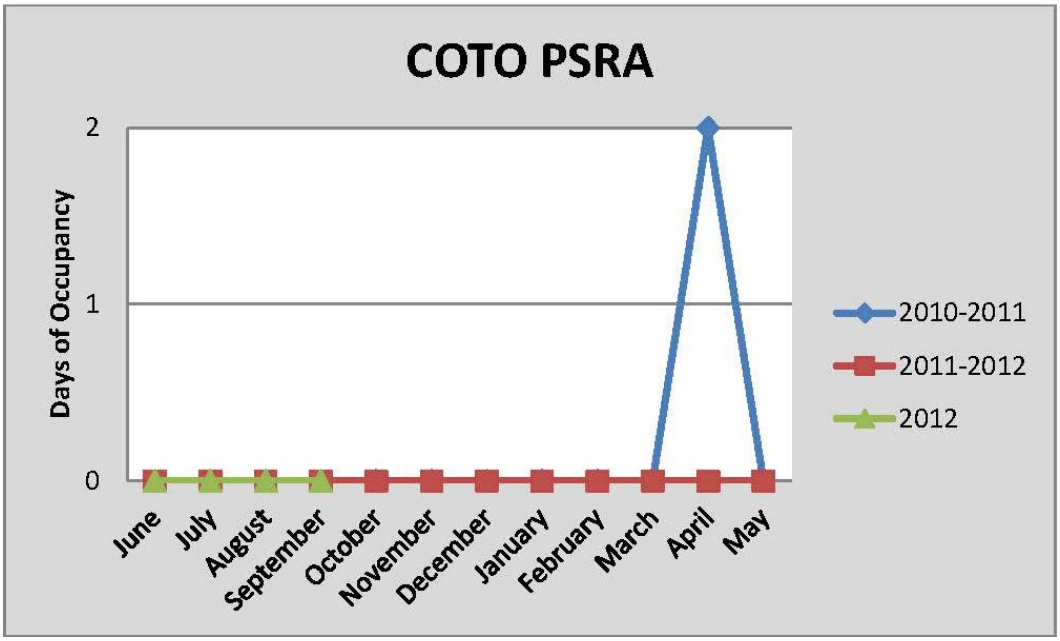

Figure 15.—Townsend's big-eared bat occupancy at PSRA.

MLWA

We did record 1 day (see table 4) of occupancy of Townsend's big-eared bats during 2011–2012 in May at MLWA (figure 16).

Nightly Activity 2011–2012

We observed the majority of western red bat calls (55%) during the evening period (1700–2200), with 26% recorded during the morning 0200–0700 and 19% in the mid-night (2200–0200) category. We recorded a plurality of western yellow bat calls (41%) during the evening period, with similar percentages between the mid-night (29%) and morning (30%) timeframe. We verified a plurality (40%) of California leaf-nosed calls during the mid-night (2200–0200) timeframe, followed closely by evening activity (36%) and morning (24%), respectively. The sample size for Townsend's big-eared bat calls was trivial, with

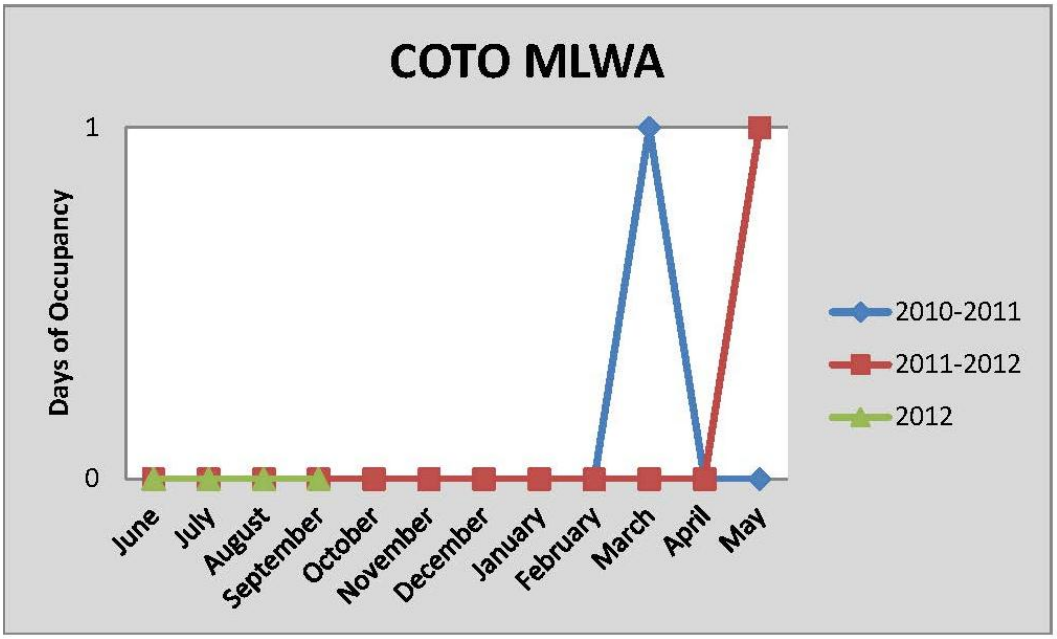

Figure 16.—Townsend's big-eared bat occupancy at MLWA.

the majority of calls falling in the mid-night period (75%), with evening and morning calls both at 13% (figures 17–19) (See attachment 1 for nightly activity at separate stations).

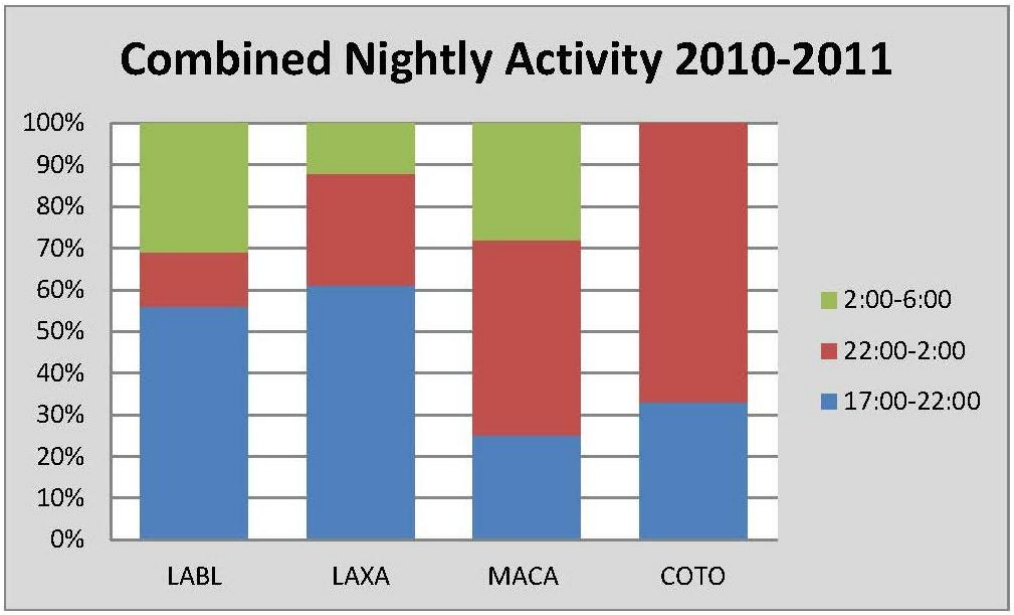

Figure 17.—Nightly activity patterns of the four focal species, 2010–2011.

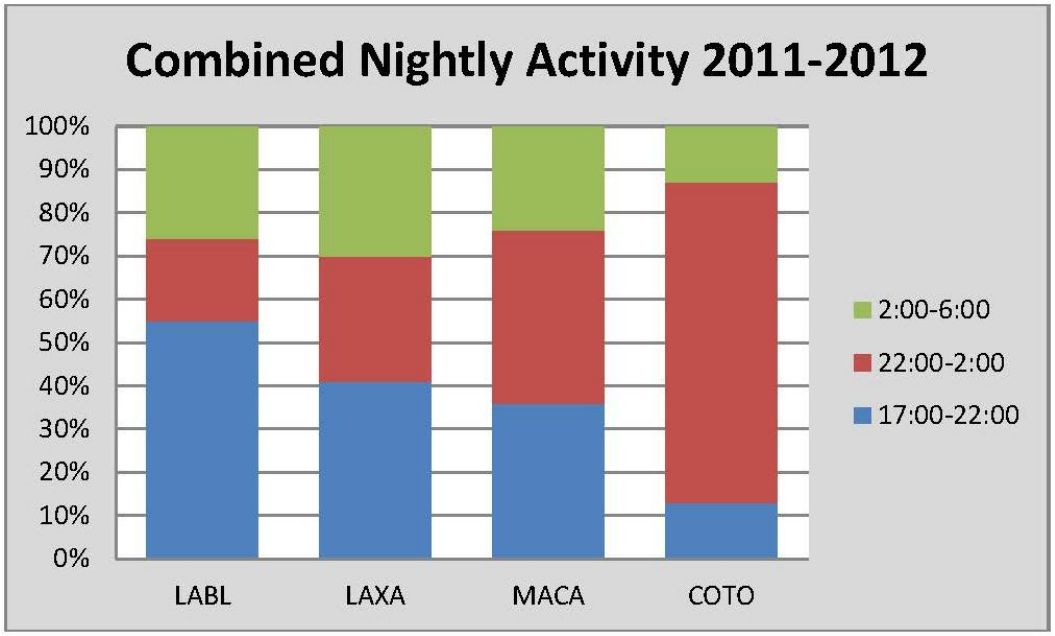

Figure 18.—Nightly activity patterns of the four focal species, 2011–2012.

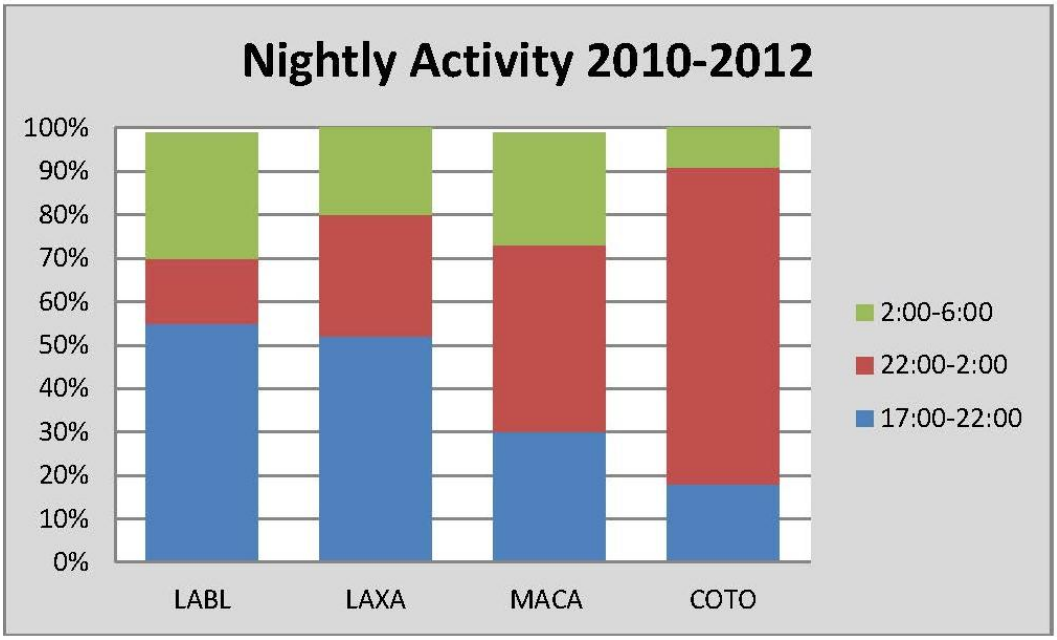

Figure 19.—Nightly activity patterns of the four focal species combined.

DISCUSSION

Western Red Bats

Overall, we documented western red bat occupancy trending down slightly from 2010–2011 (subsequently called Season 1) (238 days) to 2011–2012 (Season 2) (233 days) across the four permanent stations. We observed a decrease in occupancy rates at BWRNWR and CNWR in Season 2, coupled with increases at PSRA and MLWA. The decrease at CNWR may be attributable to a fire that inhibited our data flow from September 2011 – January 2012. Conversely, the increase at PSRA may be attributable to our station performing more efficiently during Season 2. This shift between localities without a significant overall change in occupancy may be signifying western red bat populations along the LCR are stable and that they are moving between these localities when ecological conditions are more favorable to their roosting and foraging habits. Measuring habitat characteristics around these habitats on an annual basis may identify the factors driving the movement patterns we have recorded and interpreted from these data. The magnitude of western red bat occupancy was highest during both seasons at BWRNWR and lowest at PSRA, respectively. We detected like patterns of occupancy at BWRNWR, CNWR, and MLWA even though magnitude at the sites varied between seasons. Occupancy patterns and magnitude differed at PSRA between seasons, with Season 2 displaying an increase in magnitude and occupancy during the months of June – October 2011 (see figures 2–5). This is possibly the result of station malfunction that resulted in data gaps in 2010 instead of an actual change in occupancy.

We observed western red bat nightly activity throughout Season 1 to be similar to Season 2. We recorded the majority of activity during the evening hours (1700–2200). This verification of evening activity is a probable result of western red bats emerging from their cottonwood roosts near our permanent stations.

Western Yellow Bats

We recorded western yellow bat occupancy declining from Season 1 (102 days) to Season 2 (72 days) between the four permanent stations. We observed decreases in days of occupancy between Season 1 and 2 at BWRNWR and MLWA, with increases at CNWR and PSRA. Once again, these increases at CNWR and PSRA during Season 2 may be attributable to the improved functionality at PSRA and may have been even larger had the CNWR station functioned properly. We detected the magnitude of western yellow bat occupancy to differ between seasons, with MLWA producing the highest during Season 1 and BWRNWR seeing the highest in Season 2. PSRA displayed the least amount of occupancy during both seasons. While the magnitude of occupancy differed between seasons, we observed related patterns of occupancy between seasons at the four

stations (see figures 6–9). The decline in occupancy at BWRNWR from Season 1 to 2 may be partially explained by the numbers and timing of western yellow bat migratory pulses along the LCR. During Season 1 at BWRNWR, we recorded 69% of all western yellow bat call minutes between April 3 and May 2, 2011. In addition, during Season 2, we recorded 92% of call minutes between March 26 and April 5, 2012, an 11-day period. This pattern suggests that western yellow bats are utilizing BWRNWR as a stopover on their migration northward. We documented a similar occurrence at CNWR. We recorded 61% of call minutes during Season 1 between July 20 and August 29, 2010. During Season 2, we recorded 58% of call minutes between July 13 and August 7, 2011. These data imply that western yellow bats are utilizing CNWR as a stop on their migration southward. We confirmed like results at MLWA as well. MLWA is an outlier on the LCR in regard to western yellow bat activity. There is no known wintering population on the LCR, as western yellow bats are thought to be migratory and summer residents at this latitude (Williams 2001; O'Farrell et al. 2004; O'Farrell 2006). Yet, we record their calls in January and February at this site. This may point to a wintering population or an early migratory pulse. Individuals have been found in torpor in dead palm fronds in Tucson during January and February (Adams 2003; Hoffmeister 1986; Cockrum et al. 1996), and such findings would not be surprising on the LCR as they expand their palm-associated range northward. We recorded 77% of call minutes at MLWA during Season 1 between January 24 and March 8, 2011. We then observed an equivalent number of 77% of call minutes during Season 2 between similar dates, January 24 and March 2, 2012. PSRA produced a low sample size, with only 6 call minutes combined between the two seasons.

We documented the majority of western yellow bat activity in Season 1 occurring in the evening timeframe (1700–2200). However, during Season 2, we recorded a decrease in the percentage of evening calls and a corresponding increase in the percentage of morning calls (0200–0700). Mid-night calls (2200–0200) stayed at similar levels between seasons.

California Leaf-Nosed Bat

California leaf-nosed bats are known to produce vocalizations of low intensity and are difficult to detect at distances greater than 15 meters (Williams et al. 2006). We did detect them with some regularity at our permanent stations, giving credence that this is the most efficient means of long-term monitoring for this species in a riparian habitat. We noted an overall decline in California leaf-nosed bat occupancy from Season 1 (73 days) to Season 2 (63 days) across our four permanent stations. We observed a reduction in days of occupancy between Seasons 1 and 2 at CNWR and MLWA and an increase at BWRNWR and PSRA (see figures 10–13). This decrease in occupancy at CNWR and increase at PSRA correlate with the functionality of the stations between Seasons 1 and 2.

California leaf-nosed bat occupancy patterns were sporadic at all our sites. This sporadic occupancy can be attributed to their low-intensity vocalizations and their generalist behavior. California leaf-nosed bats have been found to be equally common in all desert riparian habitats (marsh, shrubland, woodland, and mesquite bosque) (Williams et al. 2006). BWRNWR exhibited the most consistent occupancy pattern with the exception of a spike in March and April during Season 2. There is a recurring pattern of increased occupancy across sites during late summer. This rise in occupancy is compatible with reproduction behavior in which males (who start to become reproductively active July/August) attract females by flapping their wings and vocalizing while in the roost (lekking sites). Breeding takes place in September. We are most likely detecting these bats at greater magnitudes as they move between roosts. We documented the largest increase in occupancy from Season 1 to Season 2 at PSRA (9–32 days) and the largest decrease at MLWA (48–10 days), which corresponded to MLWA having the highest occupancy rates during Season 1 and PSRA during Season 2. BWRNWR and CNWR occupancy stayed consistent but low, with BWRNWR demonstrating the least amount of occupancy during Season 1 and CNWR during Season 2.

We detected a plurality of California leaf-nosed calls during the mid-night hours (2200–0200) in both Seasons 1 and 2. We did record a slight shift in percentages during Season 2, with evening calls increasing and mid-night calls similarly decreasing. The plurality of calls recorded in the mid-night hours suggests California leaf-nosed bats are using these areas primarily as foraging areas or possibly as movement corridors between roosts and foraging areas.

Townsend's Big-Eared Bat

As mentioned earlier, Townsend's big-eared bat occupancy is difficult to quantify using acoustic methods. We have recorded only 8 days of occupancy across sites and seasons combined (see figures 14–16). We detected 4 days of occupancy at BWRNWR between both seasons, 0 days at CNWR, 2 days at PSRA, and 2 days at MLWA, respectively.

Permanent Station Occupancy

BWRNWR

We documented a decrease from 178 days of occupancy for the 4 focal species combined at BWRNWR during Season 1 to 131 days during Season 2 (see table 4). This drop in occupancy was the result of a decrease in the presence of western red and yellow bats. Overall, BWRNWR displayed the most consistent occupancy patterns for western red and yellow bats across seasons. The BWRNWR station is the only one located off the main stem of the LCR. The

Bill Williams River, as opposed to the LCR, possesses a more natural riparian corridor with a mixed cottonwood-willow gallery. The Bill Williams River does have sizeable patches of tamarisk, but still retains large areas of the cottonwood-willow gallery. This natural riparian corridor is the most probable explanation of why we see such consistent occupancy patterns with a higher magnitude at BWRNWR. BWRNWR is also the only station where we have documented year-round western red bat occupancy. Winter occupancy of western red bats has also been detected by acoustic monitoring at restoration areas near Blythe, California, at Cibola Valley Conservation Area (CVCA), and Palo Verde Ecological Reserve (PVER) (Broderick 2010). Winter occupancy of western red bats has also been confirmed by mist netting at CVCA and PVER (Diamond et al. 2012).

CNWR

We noted a slight increase at CNWR from 72 days of occupancy during Season 1 to 74 days of occupancy in Season 2. The major factor for the increase here was mostly due to an increase of western yellow bat occupancy. The increase in occupancy at CNWR may have been even greater in magnitude if the fire did not destroy our station, causing a loss of data.

PSRA

An increase was also noted at PSRA, with 21 days of occupancy documented during Season 1 to 63 days in Season 2. This increase was due to a greater presence of western red and California leaf-nosed bats. The increase in occupancy at PSRA during Season 2 was due in part to the station's increased efficiency.

MLWA

We detected a drop in occupancy at MLWA from Season 1 (145 days) to Season 2 (104 days). This decrease in occupancy is attributable to lower western yellow and California leaf-nosed bat presence. The drop in occupancy at MLWA was even offset by a larger western red bat presence in Season 2 as opposed to Season 1.

Overall, our seasonal occupancy patterns displayed the majority of occupancy occurring from spring through fall. These results are consistent with many other studies involving seasonal activity patterns and are in line with Broderick (2008, 2010) who acoustically sampled along the LCR using temporary stations and found seasonal activity to be highest in summer and fall.

The CNWR, PSRA, and MLWA stations seem to be inhabited by the four focal species on a seasonally ephemeral basis compared to BWRNWR, which appears

to be providing a more stable environment for consistent occupancy. Overall, total days of occupancy for the four focal species dropped from Season 1 (416 days) to Season 2 (372 days). This decline in occupancy may be the result of ongoing restoration efforts along the LCR. These restoration efforts are resulting in greater structural diversity of habitat along the river. As more foraging and roosting habitat becomes available, we will see these species start to expand their distribution on the river. Our future objective for this project is to provide a predictive occupancy model using variables (such as land form, cover, climate, and vegetation) to evaluate where these covered species are expanding their range as the habitat changes.

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ATTACHMENT 1

Nightly Activity Patterns at the Four Permanent Stations

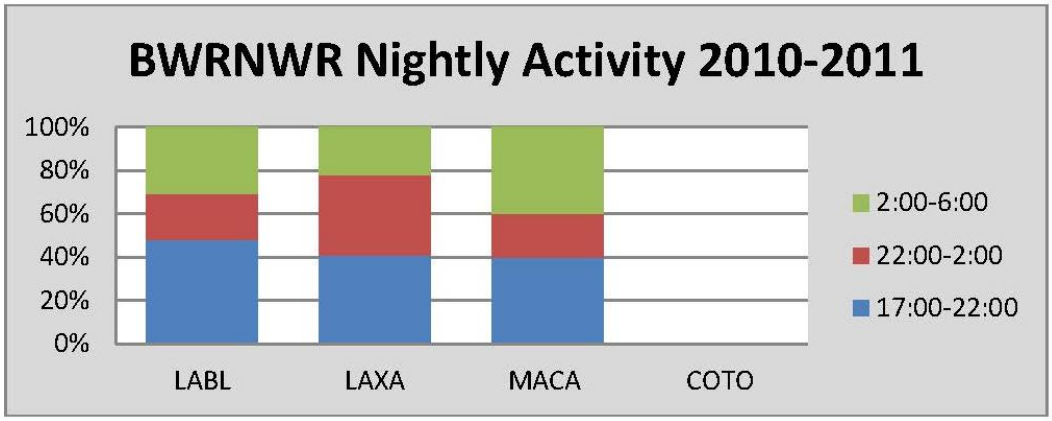

Figure A-1.—2010–2011 Bill Williams River National Wildlife Refuge (BWRNWR) nightly activity.

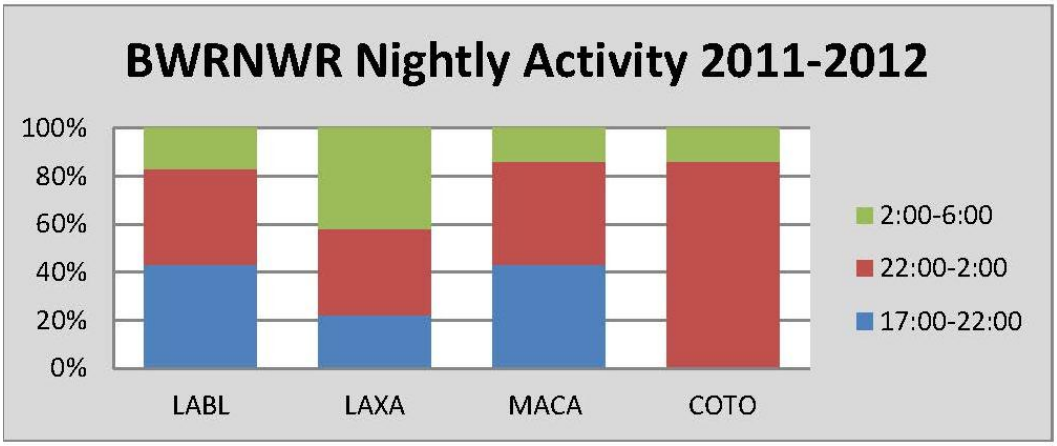

Figure A-2.—2011–2012 BWRNWR nightly activity.

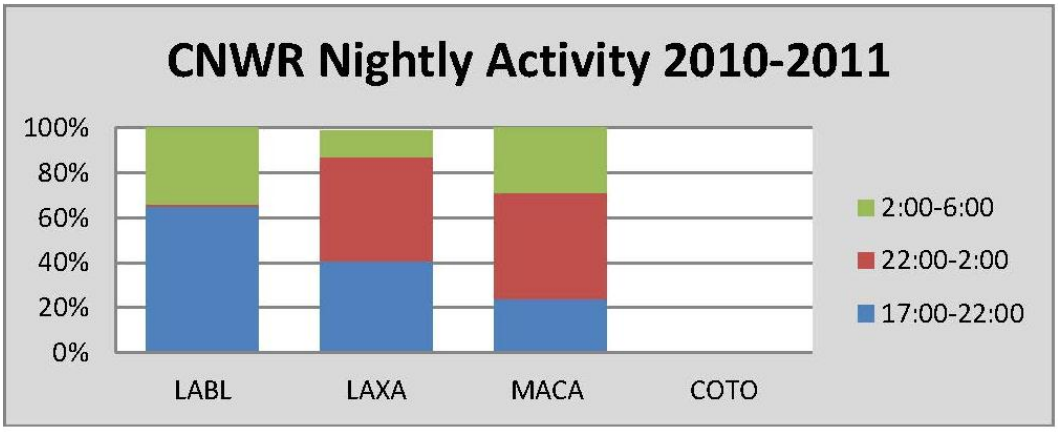

Figure A-3.—2010–2011 Cibola National Wildlife Refuge (CNWR) nightly activity.

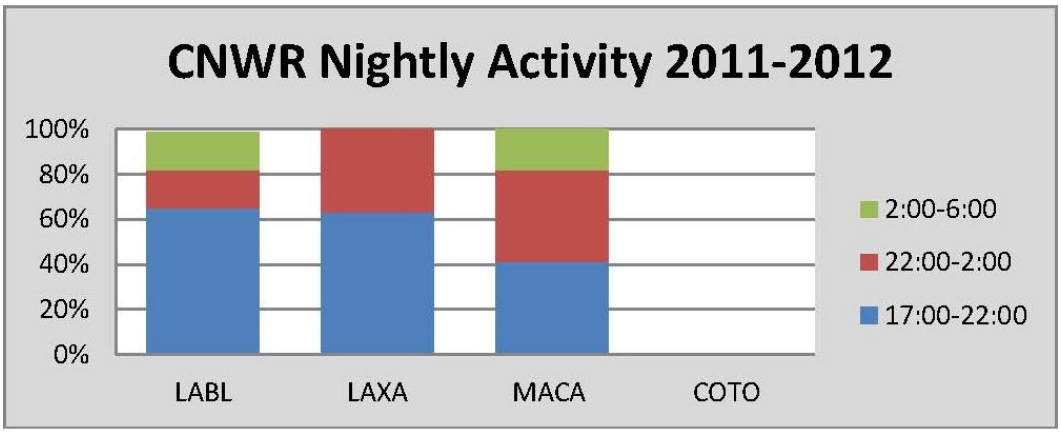

Figure A-4.—2011–2012 CNWR nightly activity.

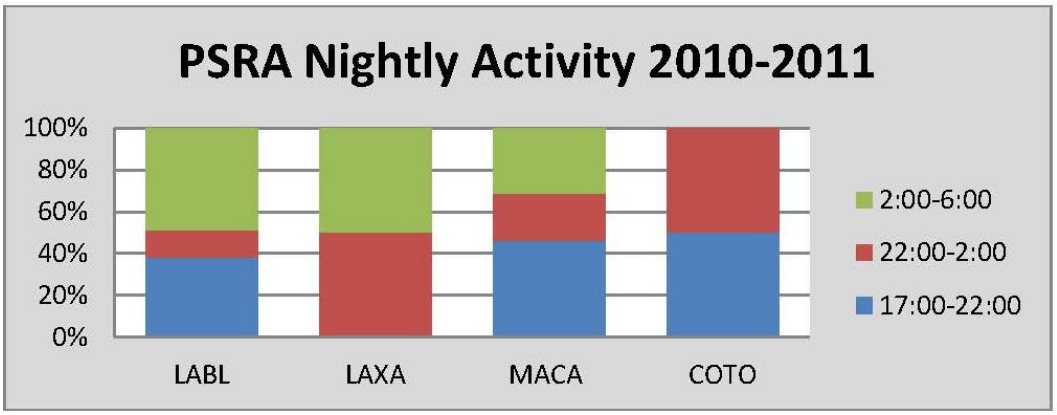

Figure A-5.—2010–2011 Picacho State Recreation Area (PSRA) nightly activity.

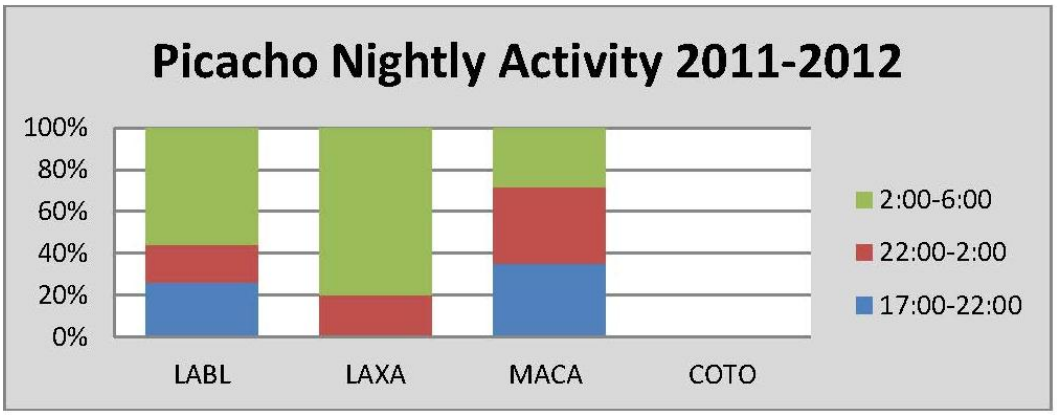

Figure A-6.—2011–2012 PSRA nightly activity.

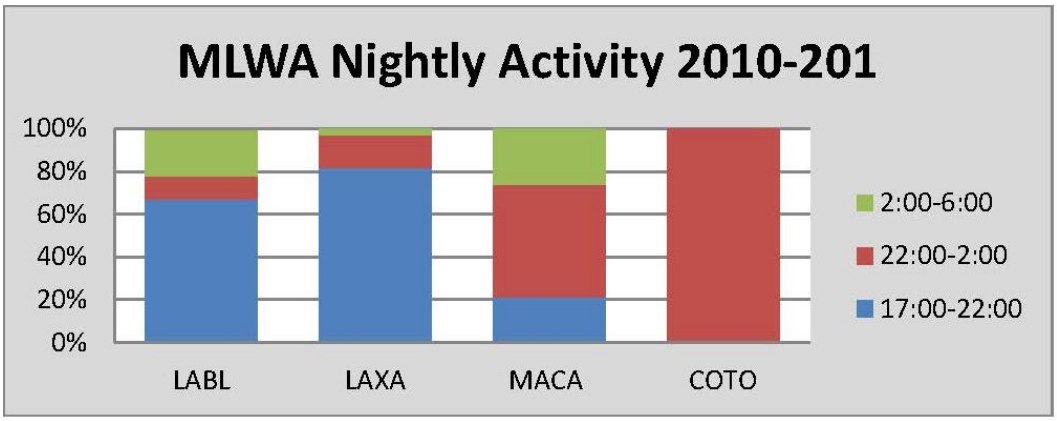

Figure A-7.—2010–2011 Mittry Lake Wildlife Area (MLWA) nightly activity.

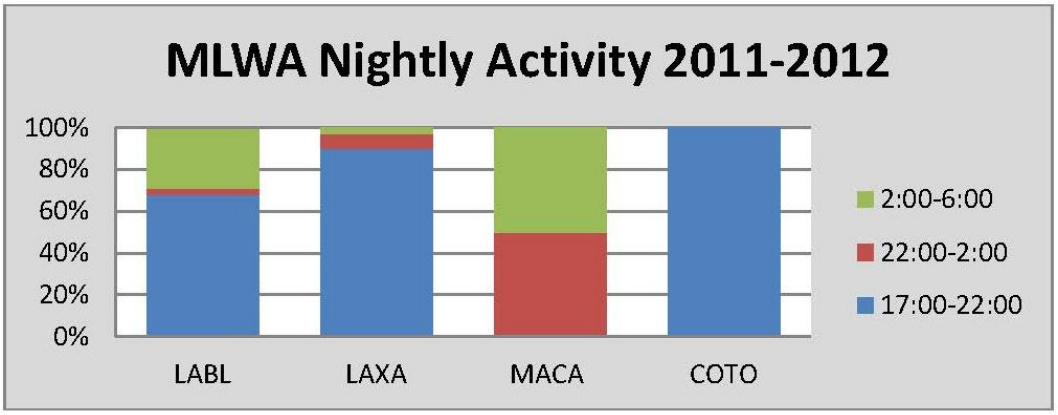

Figure A-8.—2011–2012 MLWA nightly activity.