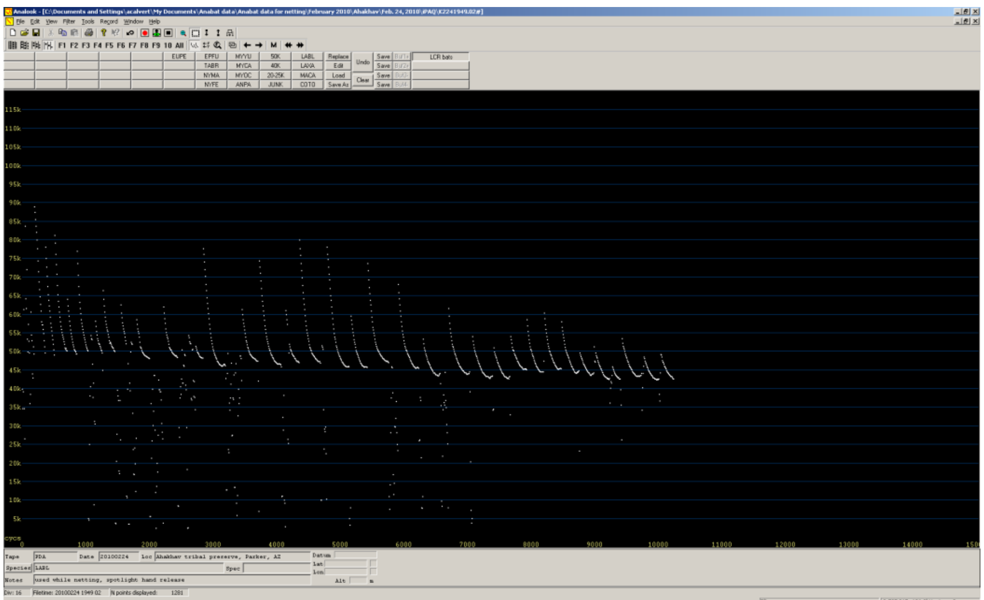
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Monitoring of LCR MSCP Bat Species as Determined by Acoustic Sampling

2013 Summary Findings



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March 2014

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Lower Colorado River Multi-Species Conservation Program

Monitoring of LCR MSCP Bat Species as Determined by Acoustic Sampling

2013 Summary Findings

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Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Region
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ACRONYMS AND ABBREVIATIONS

AKTP	‘Ahakhav Tribal Preserve
BWRNWR	Bill Williams River National Wildlife Refuge
CF	compact flash
CNWR	Cibola National Wildlife Refuge
CVCA	Cibola Valley Conservation Area
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
Reclamation	Bureau of Reclamation

Symbols

%	percent

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ABSTRACT

We deployed four permanent acoustic detector stations along the lower Colorado River (LCR) in order to analyze magnitudinal and seasonal activity and 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 have collected calls nightly from June 2010 through December 2013 at the four stations. We analyzed the data in a presence/absence framework and present it as days per month of occupancy as well as a call minute analysis to measure relative activity. 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. Our analysis of relative activity using call minutes 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 spring. We recorded the majority of call minutes at CNWR in late summer and a sizeable majority in winter at MLWA. These data indicate either a wintering population of western yellow bats at MLWA or utilization of the site as an early migration stopover. The activity at BWRNWR in spring suggests a stopover 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 have recorded a downward trend in total occupancy from season 1 to season 3 and provide possible explanations. We also provide a comparison between seasons 1, 2, and 3 and include 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 ESA. 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*) (LABL), western yellow bat (*Lasiurus xanthinus*) (LAXA), Townsend's big-eared bat (*Corynorhinus townsendii*) (COTO), and California leaf-nosed bat (*Macrotus californicus*) (MACA). Proposed under the LCR MSCP is the creation of 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 and continue to be supplemented along the LCR as a long-term monitoring methodology. Work Task D9 (covered bat species) is the funding source for this project.

The objective of this project is to continue collecting and analyzing acoustic data from the four permanent stations at non-restoration areas along the LCR, which are 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).

METHODS

We deployed permanent Anabat detectors 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 willows (*Salix gooddingii*) with salt cedar (*Tamarix* spp.) and mesquite (*Prosopis* spp.) in the understory and along the margins. A small number of California Fan Palms

Figure 1.—Permanent station located on the BWRNWR.

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

Community	Criteria
Cottonwood-willow (CW)	*Salix gooddingii* and *Populus fremontii* (the latter 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 to 15 feet tall, and understory from 0 to 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 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 and 2 feet tall.

(*Washingtonia filifera*) are 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 are 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 willows. 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 is 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 is 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).

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 (CF) 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), which is about 4 months for the 1-gigabyte cards that we used. Our visits to the stations were generally more frequent in order to more timely address any maintenance issues (attachment 1). Recording for this analysis began in June 2010 and ended in December 2013 (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 red bats, western yellow bats, California leaf-nosed bats, and Townsend's big-eared bats using the following procedures. Acoustic bat calls were recorded nightly from sunset to sunrise, and calls for the four focal species were processed using filters and methods provided by Susan Broderick (personal comm.; Broderick 2008). It was determined in the 2010 final report (Vizcarra et al. 2010) that files above 8 kilobytes containing recognizable calls were often misidentified by our filters due to the presence of large amounts of interference from insect, vegetation, and electronic noise. The presence of this background noise distorts the bat call in the file. 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 comm.) revealed they had recorded western red bat calls at higher frequencies along the LCR. We compared our calls and tested our filters on known reference calls recorded along the LCR provided by Broderick and Calvert (personal comm.) and reference calls from across the southwestern United States.

Townsend’s big-eared bats are known to emit low-intensity vocalizations in an attempt to capture their Lepidoptera prey that has evolved sensitive ears to detect these vocalizations. This makes 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 is defined as a 1-minute interval in which a particular species is 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 also analyzed our data using a presence/absence framework as the measure of occupancy at our permanent stations. We used the presence/absence of each of the four LCR MSCP bat species to create a proportion of occupied days within each month. Our approach is based on naïve occupancy (i.e., if the species is present, and within range of our stations, we will detect it). Therefore, we do not take into account detection probabilities (i.e., imperfect detections). It should be noted that detection is indicative of presence but non-detection of the species is not equivalent to absence (MacKenzie et al. 2002). Our monitoring is limited to the distance in which our station can record reliable bat calls, and we do not know if a bat is present or absent just beyond the range of our station. Measuring relative activity by means of call minutes was helpful in assessing seasonal patterns at the four permanent stations concerning western yellow bats and, to a lesser extent, California leaf-nosed bats. We used mixed model analyses of variance and Fisher’s Least Significant Difference ($p < 0.05$) to compare bat use at each station by species across sites, months, and years. We used days*month*year as replicates. Comparisons were made using the model: Y = year(month) + year + site*year. We used the Proc Mixed procedure in the statistical software SAS to conduct these comparisons (SAS Institute 2005).

The occupancy results are represented in months and years. Our "year" starts in June and runs until the end of May because that is the timeframe we started collecting data. Therefore, the years are classified as June 2010–May 2011, June 2011–May 2012, and June 2012–May 2013, with partial results from June 2013–December 2013. We report findings from June 2012–May 2013 in the "Results" section as well as yearly comparisons of occupancy. Detailed findings from June 2010–May 2011 and June 2011–May 2012 can be found in Mixan et al. 2012 and Mixan et al. 2013.

RESULTS

Overall, the stations functioned 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 did not record any calls again from June 16, 2012, to July 17, 2012, because interference caused the CF card to reach capacity, and it did not record any calls 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 8, 2011. A fire at Cibola 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. 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. The station at BWRNWR malfunctioned and did not record calls from September 5, 2013, through January 2, 2014. We visited the station three times during this period, and each time thought we had alleviated the problem. We have experienced no problems with the station at MLWA.

Overall, we recorded 265 total days of occupancy for the four focal species combined during June 2012–May 2013. We detected the most total days of occupancy for the four focal species at BWRNWR (139 days) followed by MLWA (52 days), PSRA (38 days), and CNWR (36 days). Western red bats were the most ubiquitous of the focal species, with 153 days of occupancy between the stations, followed by western yellow bats (57 days), California leaf-nosed bats (52 days), and Townsend's big-eared bats (3 days). We also provide partial results for the season starting in June 2013 through December 2013 (table 3).

Table 3.—Total days of occupancy per species through seasons (June 2012–May 2013)

	June 2012—May 2013				Partial results June 2013—December 2013			
	BWRNWR	CNWR	MLWA	PSRA	BWRNWR	CNWR	MLWA	PSRA
LABL	93	16	36	8	14	3	26	11
LAXA	32	8	14	3	6	1	5	2
MACA	11	12	2	27	35	1	6	31
COTO	3	0	0	0	2	1	0	0
Totals	139	36	52	38	57	6	37	44

Occupancy and Call Minute Results 2012–2013

Western Red Bat

BWRNWR

We recorded western red bat occupancy to be the most prevalent at this site during 2012–2013 (93 days) (see table 3), with the highest total of occupied days per month generally coming in summer and fall (June–November). We recorded relative activity to be at its highest at BWRNWR with 150 call minutes documented (figure 2).

CNWR

We documented western red bat occupancy to be the third highest of the four permanent stations with 16 days in 2012–2013 (see table 3). CNWR is primarily occupied from June through September, with no occupancy recorded from December through February. We also recorded a total of 18 call minutes at CNWR (figure 3).

MLWA

We observed western red bat occupancy at this station to be the second highest of all the permanent stations with 36 days of occupancy in 2012–2013 (see table 3). We recorded the bulk of occupancy between the months of April through October, with none recorded in November through February. We recorded 47 western red bat call minutes at MLWA (figure 4).

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 8 days of occupancy in 2012–2013 (see table 3). We recorded occupancy to be sporadic, with detections in August, November, March, and April. We recorded 9 call minutes

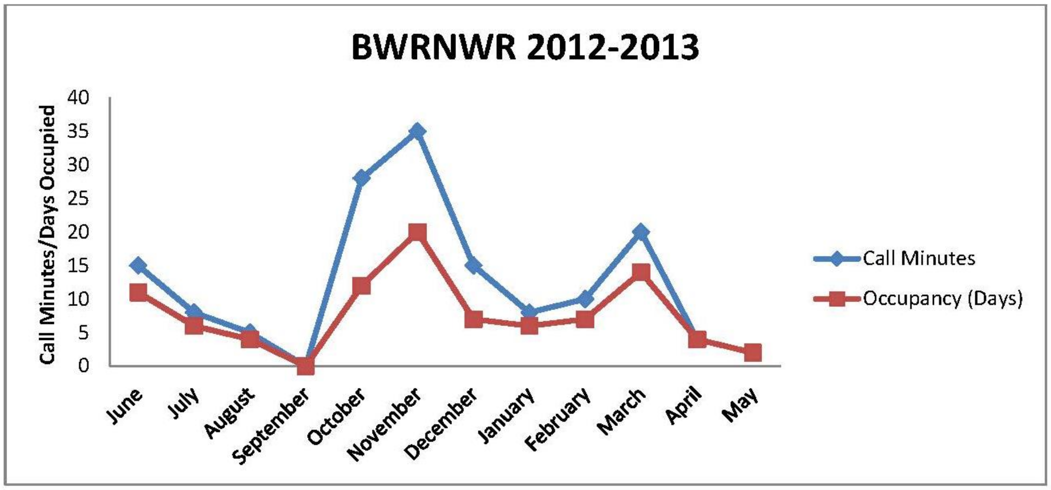

Figure 2.—Western red bat occupancy at BWRNWR.

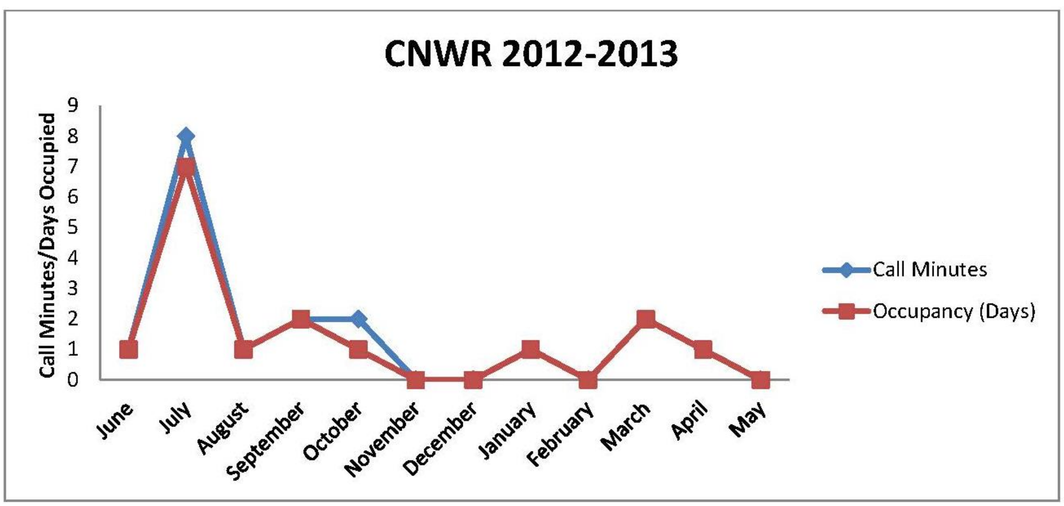

Figure 3.—Western red bat occupancy at CNWR.

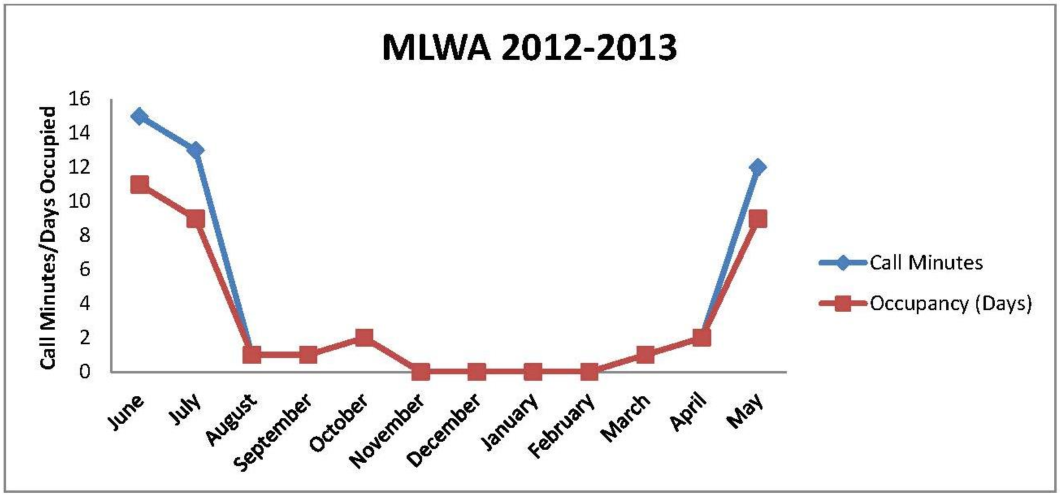

Figure 4.—Western red bat occupancy at MLWA.

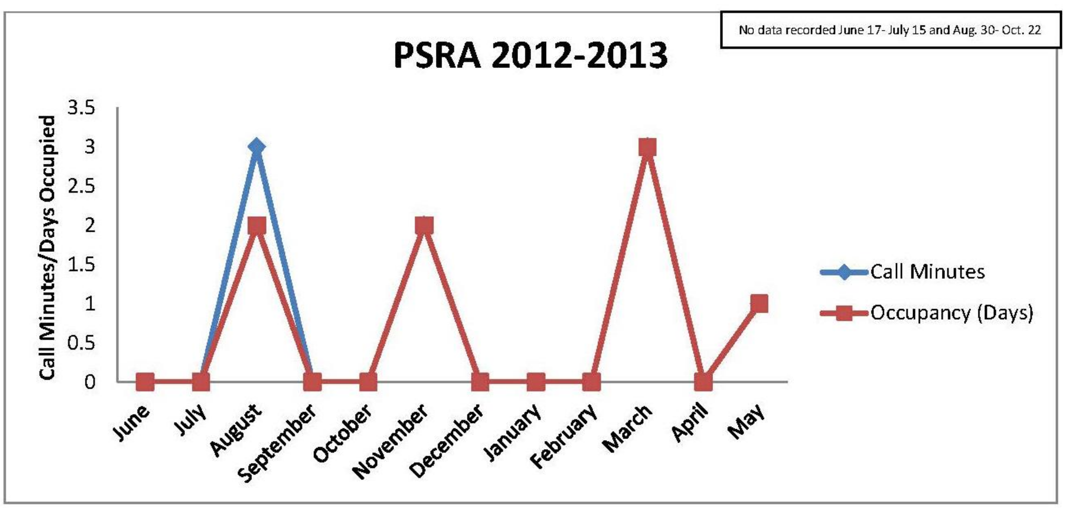

Figure 5.—Western red bat occupancy at PSRA.

at PSRA (figure 5). The CF card at this station reached capacity on June 16, resulting in 16 days of sampling in June and 16 days of sampling in July. Again, the CF card reached capacity at the end of August, resulting in 30 days of sampling in August, zero days in September, and 9 days at the end of October.

Western Yellow Bat

BWRNWR

We documented western yellow bat occupancy to be the highest at this station in 2012–2013 (32 days) (see table 3). We also recorded the highest relative activity with 56 call minutes. We determined BWRNWR is mostly occupied between the months of March through November, with no occupancy recorded in June and December through February (figure 6). We recorded 59 percent (%) of call minutes between March 20 and April 10, 2013, for western yellow bats at BWRNWR.

CNWR

We observed this location to have the third highest occupancy of western yellow bats in 2012-2013 (8 days) (see table 3). We documented 9 call minutes at CNWR. We recorded all of the occupancy and relative activity at CNWR during the months of April, May, and June (figure 7).

MLWA

We recorded the second highest amount of western yellow bat occupancy at this station in 2012–2013 (14 days) (see table 3). We detected the majority of occupancy and relative activity in the month of February. We observed 54% of western yellow bat activity occurring on February 26 and 27 (figure 8).

PSRA

We observed this site to be the least occupied of the four permanent stations, with only 3 days of occupancy in 2012–2013 (see table 3). We have recorded occupancy in January and August at this site (figure 9), and only recorded 3 call minutes at PSRA for western yellow bats. The CF card at this station reached capacity on June 16, resulting in 16 days of sampling in June and 16 days of sampling in July. Again, the CF card reached capacity at the end of August, resulting in 30 days of sampling in August, zero days in September, and 9 days at the end of October.

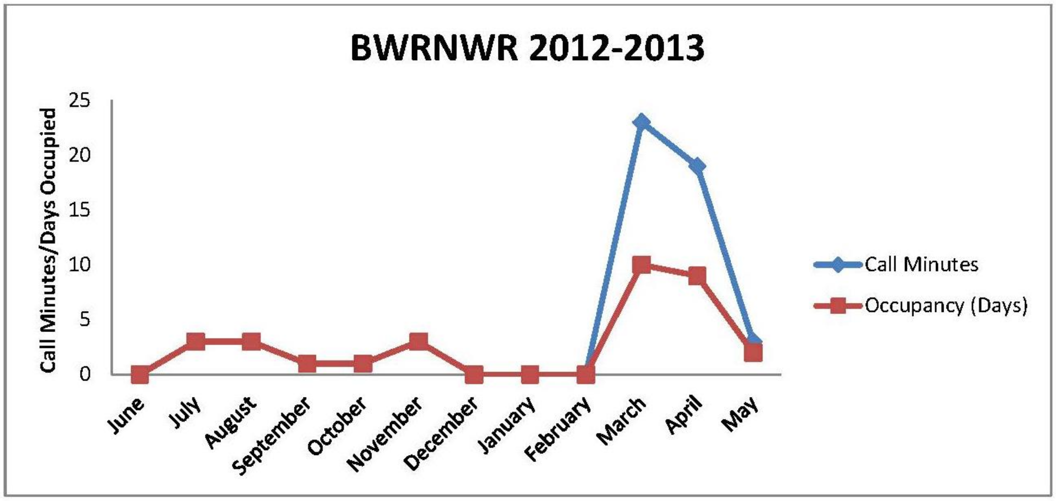

Figure 6.—Western yellow bat occupancy at BWRNWR.

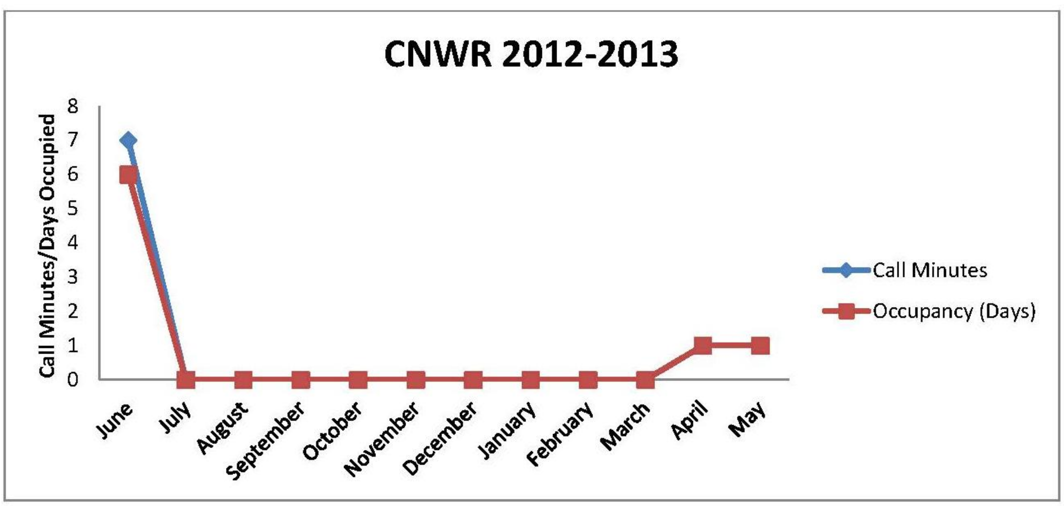

Figure 7.—Western yellow bat occupancy at CNWR.

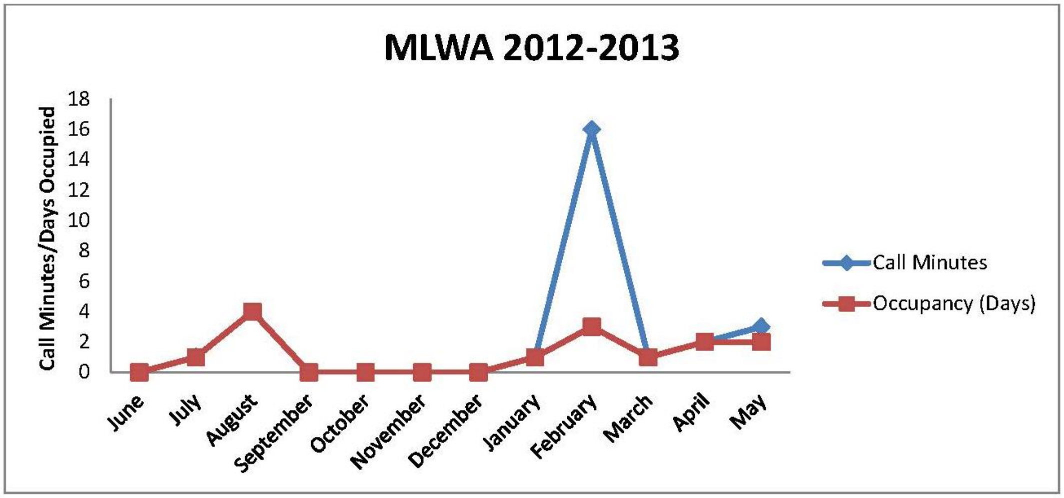

Figure 8.—Western yellow bat occupancy at MLWA.

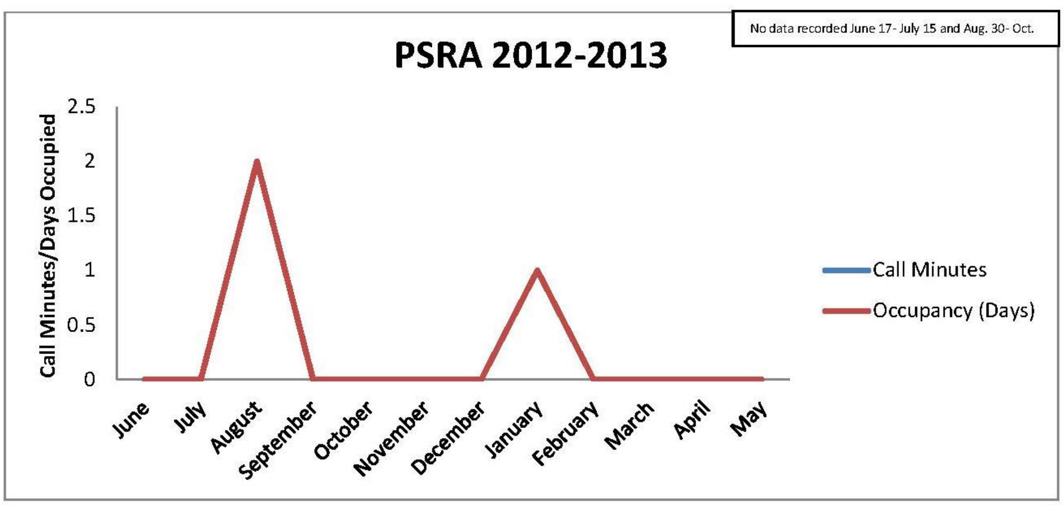

Figure 9.—Western yellow bat occupancy at PSRA.

California Leaf-Nosed Bat

BWRNWR

We recorded the third highest amount of California leaf-nosed occupancy at this location in 2012–2013 (11 days) (see table 3). We also observed a total of 12 call minutes at this site. Occupancy at BWRNWR was sporadic, with California leaf-nosed bats only present in the months of June, July, March, April, and May (figure 10).

CNWR

We observed the second highest amount of California leaf-nosed occupancy at CNWR in 2012–2013 (12 days) (see table 3). We documented a total of 16 call minutes at CNWR. As with BWRNWR, CNWR occupancy was sporadic, with occupancy being documented in June, August, September, November, March, and May (figure 11).

MLWA

We observed occupancy (2 days) and relative activity (2 call minutes) to be lowest at MLWA during 2012–2013 (see table 3). We only documented occupancy in the months of June and July (figure 12).

PSRA

We verified California leaf-nosed bats at this site to have the highest total occupancy (27 days) and relative activity (74 call minutes) in 2012–2013 (see table 3). Occupancy during 2012–2013 was concentrated in summer, with the vast majority of occupancy and activity taking place in May and August. We detected occupancy at PSRA in the months of April, May, June, and August (figure 13). The CF card at this station reached capacity on June 16, resulting in 16 days of sampling in June and 16 days of sampling in July. Again, the CF card reached capacity at the end of August, resulting in 30 days of sampling in August, zero days in September, and 9 days at the end of October.

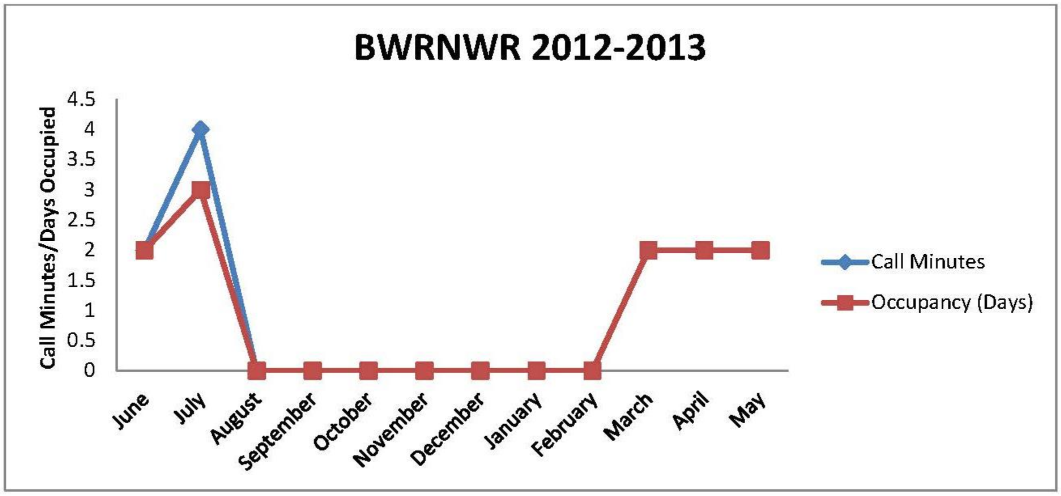

Figure 10.—California leaf-nosed bat occupancy at BWRWNR.

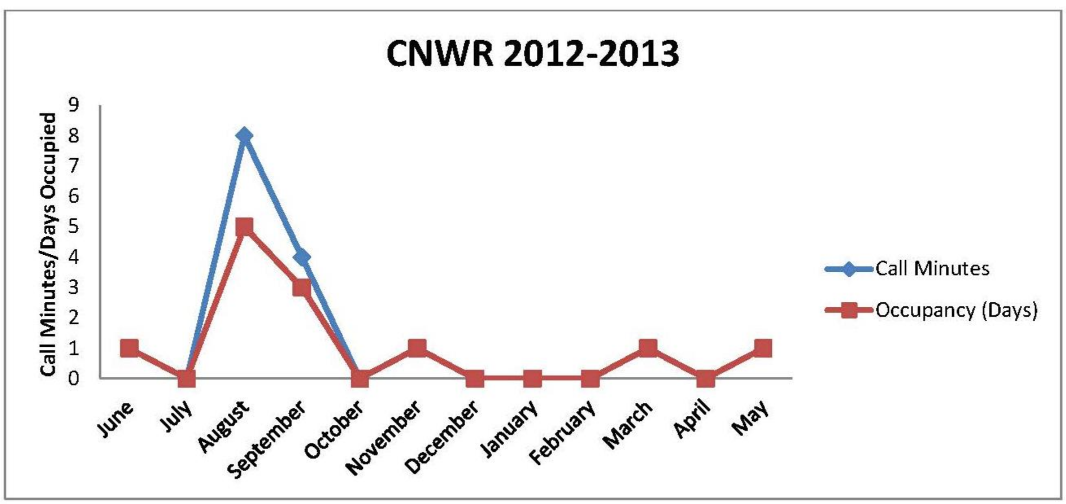

Figure 11.—California leaf-nosed bat occupancy at CNWR.

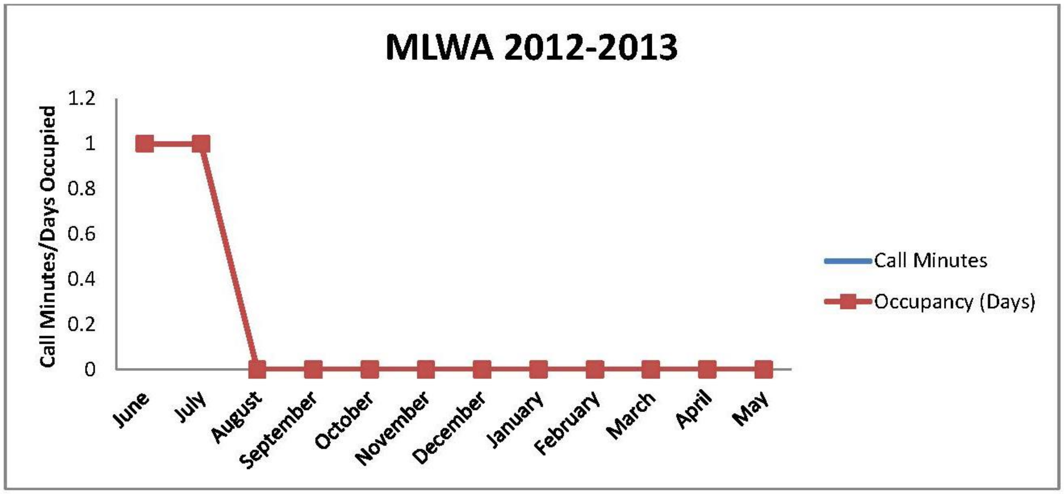

Figure 12.—California leaf-nosed bat occupancy at MLWA.

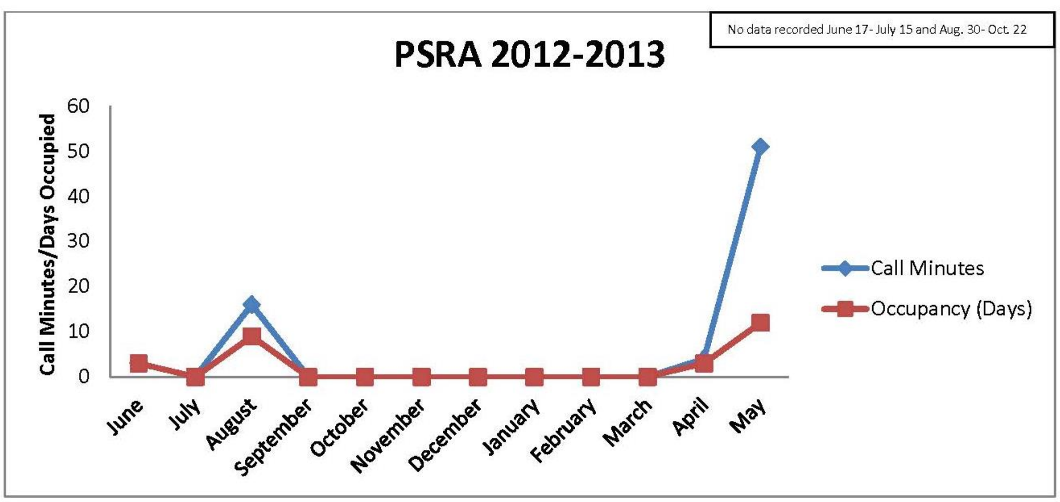

Figure 13.—California leaf-nosed bat occupancy at PSRA.

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; therefore, we provide no graphs for this species.

BWRNWR

We did document 3 days of occupancy and 3 call minutes at this location throughout 2012–2013. We recorded 2 days of occupancy in July and 1 in September (see table 3).

CNWR

We did not confirm any presence of Townsend's big-eared bats at CNWR at all during 2012–2013. We did record 1 call in our partial results for June to December 2013 (see table 3).

PSRA

We did not verify presence of Townsend's big-eared bats during 2012–2013 at PSRA (see table 3). The CF card at this station reached capacity on June 16, resulting in 16 days of sampling in June and 16 days of sampling in July. Again, the CF card reached capacity at the end of August, resulting in 30 days of sampling in August, zero days in September, and 9 days at the end of October.

MLWA

We did not record any occupancy at MLWA from 2012–2013 (see table 3).

Yearly Station Occupancy Results

We observed BWRNWR to have the highest occupancy rate for all four focal species combined for the first two seasons (table 4). During season 3, we again observed BWRNWR and MLWA as having the highest occupancy rates followed by PSRA and CNWR. We recorded the highest number of sampling nights at BWRNWR followed by MLWA, PSRA, and CNWR, respectively (table 5). Again, our "yearly" comparisons span a calendar year (June through May), which is why our results are labeled 2010–2011 (season 1), 2011–2012 (season 2), 2012–2013 (season 3). We will refer to our results by their season nomenclature in our yearly comparison. We display partial results for 2013–2014 (season 4), but do not comment on them due to the fact they are partial results.

Table 4.—Yearly comparison of occupancy across stations

	Season 1 (2010–2011)				Season 2 (2011–2012)				Season 3 (2012–2013)			
	BWRNWR	CNWR	MLWA	PSRA	BWRNWR	CNWR	MLWA	PSRA	BWRNWR	CNWR	MLWA	PSRA
LABL	134	50	45	9	90	44	72	27	93	16	36	8
LAXA	39	11	51	1	25	22	21	4	32	8	14	3
MACA	5	11	48	9	12	8	10	32	11	12	2	27
COTO	0	0	1	2	4	0	1	0	3	0	0	0
Totals	178	72	145	21	131	74	104	63	139	36	52	38

Table 5.—Nights of sampling per season

Location	Season 1 (2010–2011)	Season 2 (2011–2012)	Season 3 (2012–2013)	Total
BWRNWR	363	365	365	1,093
CNWR	289	240	365	894
MLWA	348	365	365	1,078
PSRA	341	348	280	969
Total	1,341	1,318	1,375	4,034

Western Red Bats

We recorded western red bats occupying BWRNWR at a significantly higher rate than our other three stations ($F = 19.34$; $p < 0.001$). We also observed CNWR and MLWA to have significantly higher occupancy rates than PSRA (figure 14). We observed a statistically significant decrease in occupancy rates at BWRNWR from season 1 to season 2 ($F = 2.45$; $p = 0.006$) (figure 15). We also recorded a statistically significant decrease in occupancy at CNWR from season 2 to season 3. The decrease at CNWR between seasons 2 and 3 may be attributable to a fire that inhibited our data flow from September 2011 to January 2012. We documented a statistically significant increase in occupancy at MLWA from season 1 to season 2 and a significant decrease to season 3. We did not record any significant increases or decreases in occupancy at PSRA. Western red bat occupancy estimates did increase significantly from season 1 to season 2 and then decreased between seasons 2 and 3 ($F = 10.38$; $p = 0.002$). The increase at PSRA between seasons 1 and 2 may be attributable to our station performing more efficiently during season 2 (figure 15).

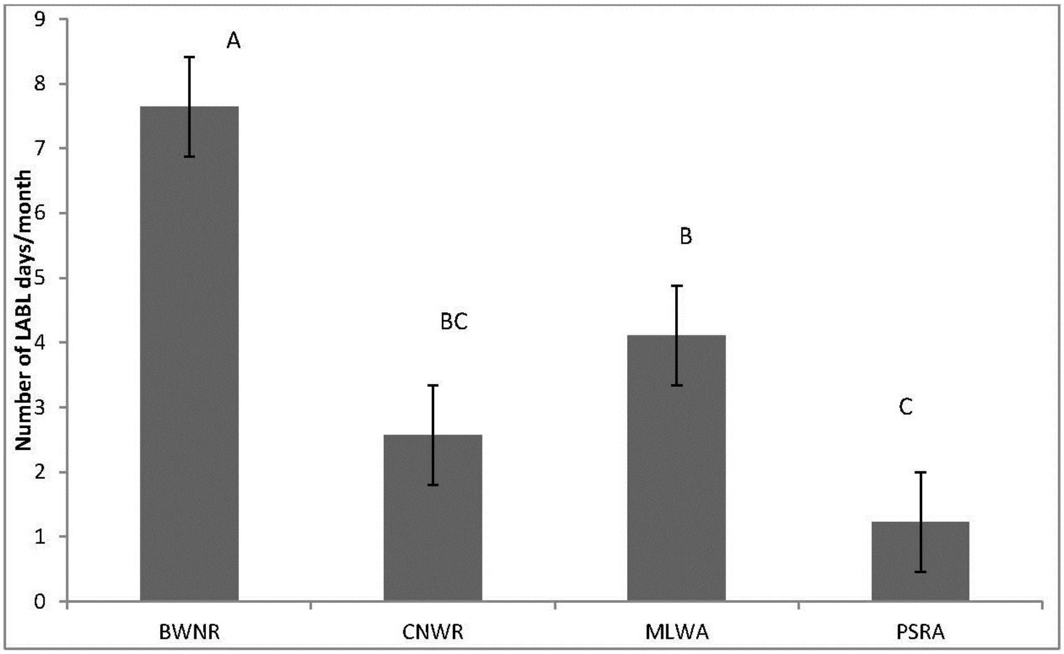

Figure 14.—Mean and standard error across sites for western red bat occupancy per station.
Letters indicate statistical significance (F = 19.34; p <0.001).

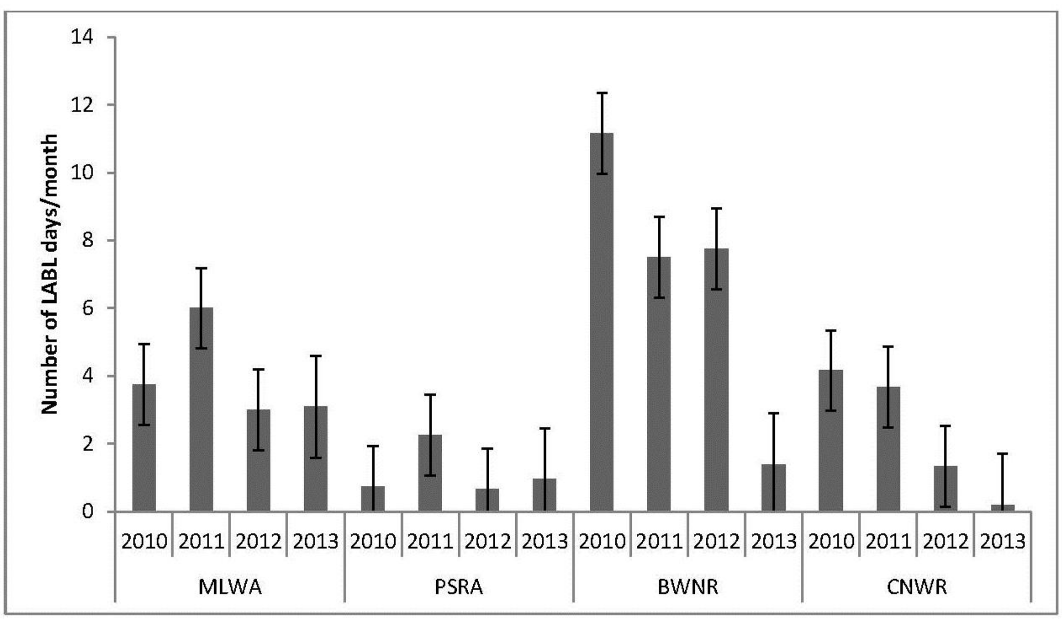

Figure 15.—Mean and standard error for western red bat yearly occupancy rates per station.
Letters indicate statistical significance (F = 2.45; p = 0.006).

Western Yellow Bat

We recorded occupancy rates at BWRNWR and MLWA to be significantly higher than CNWR and PSRA ($F = 8.00$; $p < 0.001$) (figure 16). 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 seasons 2 and 3 ($F = 8.79$; $p = 0.004$) (figure 17). We observed decreases in days of occupancy between seasons 1 and 2 at BWRNWR with an increase between seasons 2 and 3. Though we observed these variations in occupancy, we did not observe any statistically significant changes in occupancy between seasons. We recorded an increase in occupancy at CNWR between seasons 1 and 2 followed by a decline between seasons 2 and 3. Once again, although we observed these variations in occupancy, we did not detect any significant shifts in occupancy rates between seasons. We documented a significant decrease at MLWA from season 1 to season 2 and a further, but not significant decline between seasons 2 and 3. PSRA displayed the lowest occupancy during all three seasons, with no significant increases or decreases in occupancy (figure 17). We did not detect any significant differences across seasons with the stations combined ($F = 1.48$; $p = 0.14$)

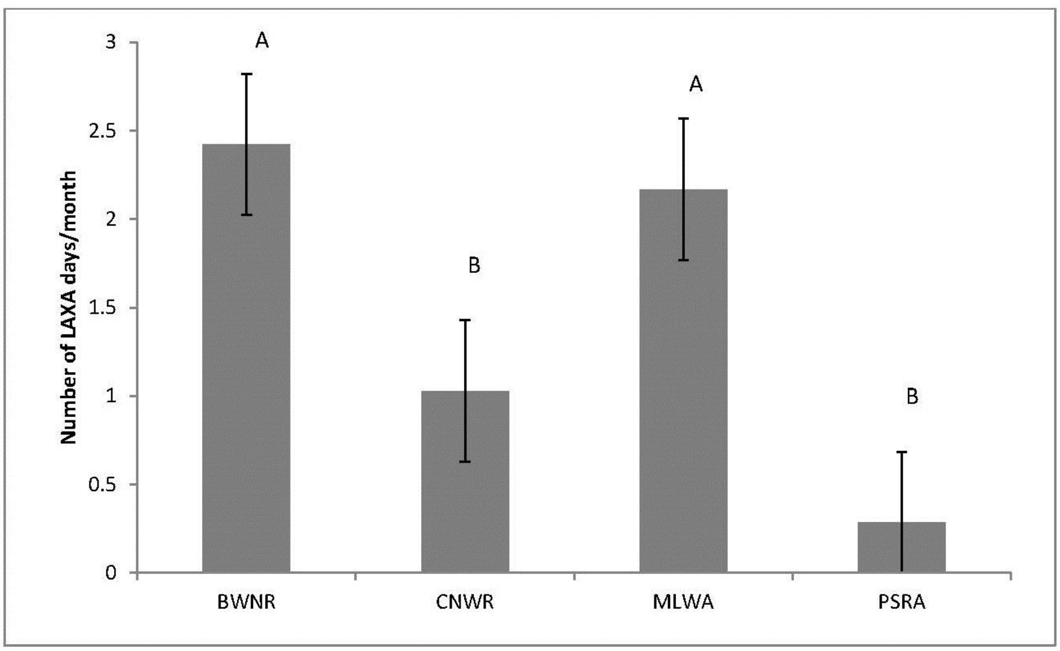

Figure 16.—Mean and standard error across sites for western yellow bat occupancy per station.
Letters indicate statistical significance ($F = 8.00$; $p < 0.001$).

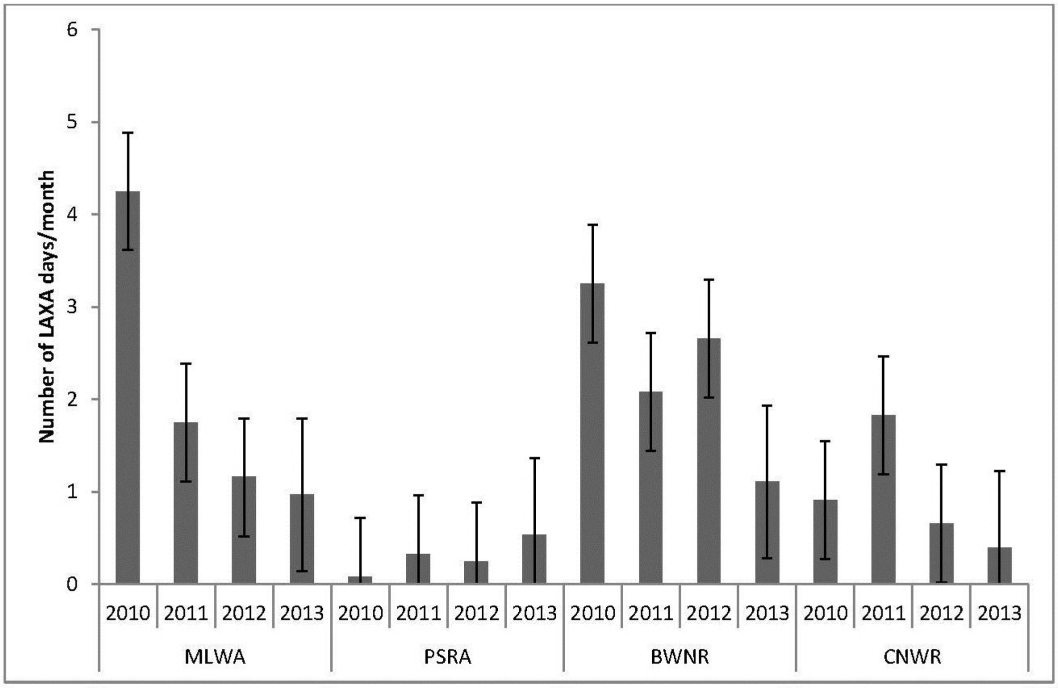

Figure 17.—Mean and standard error for western yellow bat yearly occupancy rates per station.
Letters indicate statistical significance ($F = 8.79$; $p = 0.004$).

California Leaf-Nosed Bat

Generally, we observed a higher mean of California leaf-nosed bat activity at PSRA with all years combined (figure 18). However, these patterns of activity varied widely across survey years (figure 19). We detected significant differences in California leaf-nosed bat occupancy within stations across seasons ($F = 4.20$; $p < 0.0001$) (figure 19). We observed no significant increases or decreases in occupancy at BWRNWR or CNWR between seasons 1, 2, and 3 (figure 19). We did note a significant decrease in occupancy at MLWA from seasons 1 to 2 and a significant increase in occupancy from season 1 to 2 at PSRA. Again, the increase at PSRA between seasons 1 and 2 may be attributable to our station recording more nights of data during season 2 (figure 19). We did not detect any significant change in California leaf-nosed bat occupancy across seasons with the stations combined ($F = 0.59$; $p = 0.831$).

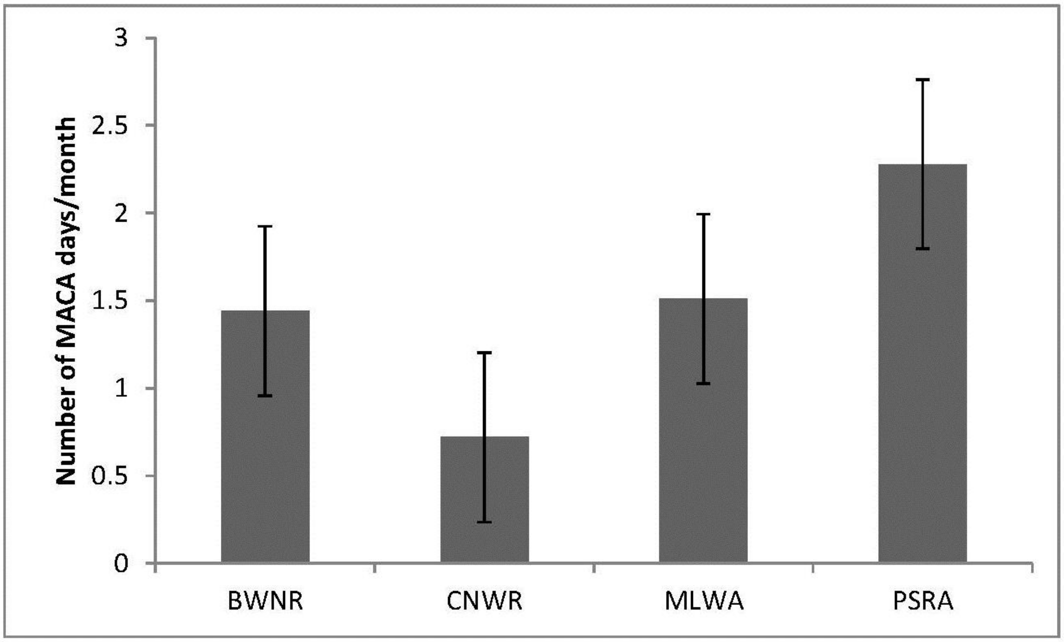

Figure 18.—Mean and standard error across sites California leaf-nosed bat occupancy per station.

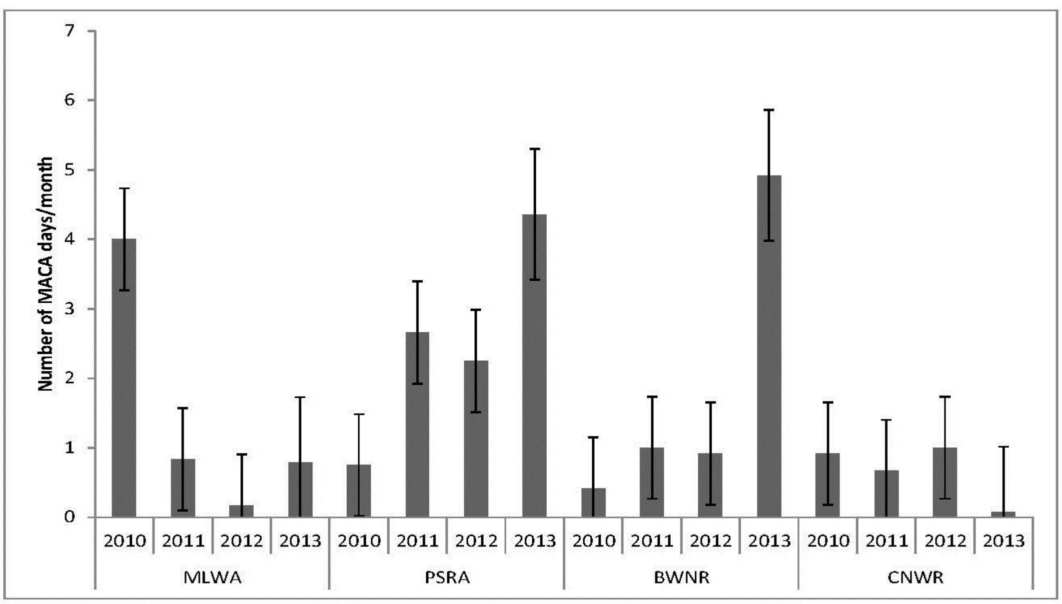

Figure 19.—Mean and standard error for California leaf-nosed bat yearly occupancy rates per station.
Letters indicate statistical significance ($F = 4.20$; $p < 0.0001$).

Townsend's Big-Eared Bat

We observed significant differences across stations with the years combined (F = 2.82; p = 0.045). We documented BWRNWR having significantly higher occupancy as compared to CNWR, MLWA and PSRA (figure 20). It should be noted that this higher occupancy rate at BWRNWR is based on a small sample size. Because of our small sample size across seasons, we did not observe any significant increases or decreases in occupancy between seasons (F = 2.91; p = 0.095) (figure 21). We also did not detect any significant differences across seasons with the stations combined (F = 1.56; p = 0.118).

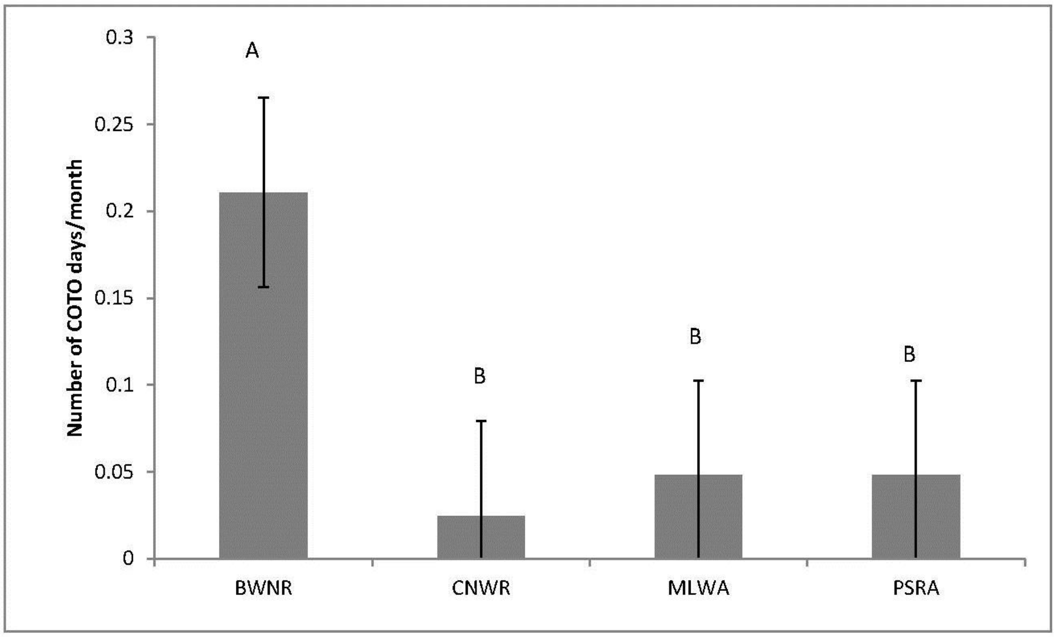

Figure 20.—Mean and standard error across Townsend's big-eared bat occupancy per station.
Letters indicate statistical significance (F = 2.82; p = 0.045).

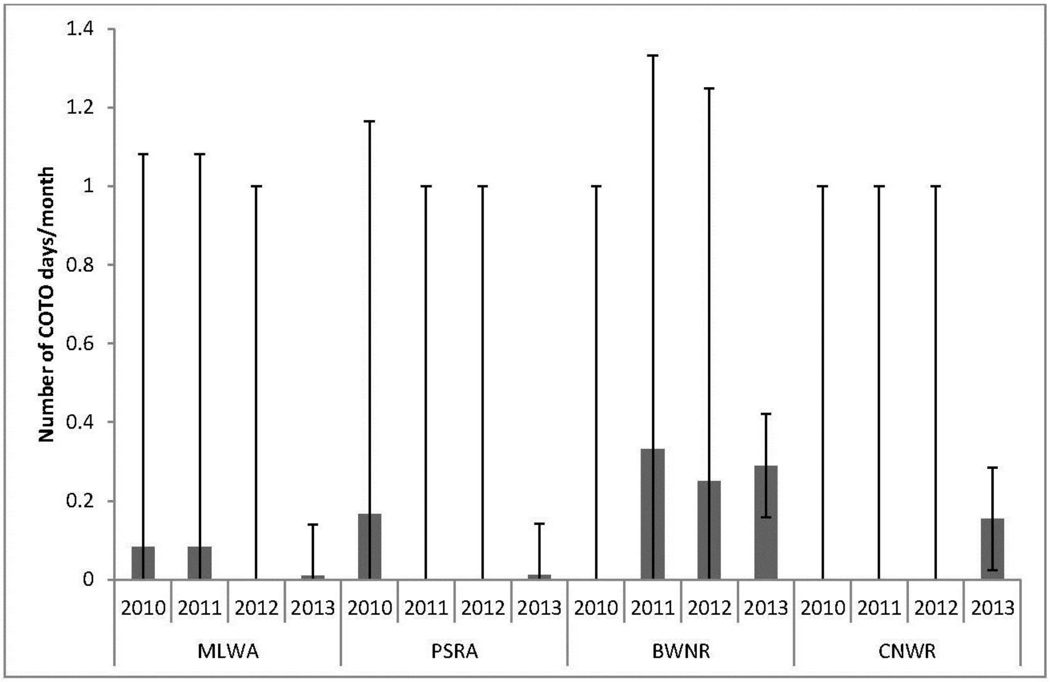

Figure 21.—Mean and standard error for Townsend's big-eared bat yearly occupancy rates per station.
Letters indicate statistical significance (F = 2.91; p = 0.095).

DISCUSSION

The total nights of data collection across stations remained relatively consistent between seasons, with 1,341 nights recorded during season 1, 1,318 nights during season 2, and 1,375 nights during season 3. The total nights of data collection between stations did vary between seasons, with 1,093 nights of data recorded at BWRNWR, 1,078 nights recorded at MLWA, 969 nights recoded at PSRA, and 894 nights at CNWR.

Western Red Bats

Overall, we documented western red bat occupancy trending down slightly from 2010–2011 (season 1) (238 days) to 2011–2012 (season 2) (233 days) across the four permanent stations. We also documented a further decrease in occupancy in 2012–2013 (season 3) (153 days). Though the reason for this trend cannot be positively determined without further investigation, the drop in occupancy rates at non-restoration areas may be the result of Bureau of Reclamation (Reclamation) restoration areas along the LCR maturing and providing more favorable ecological conditions for 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. Continued monitoring may also reveal that this could be a natural fluctuation in occupancy patterns. The magnitude of western red bat occupancy was highest during all three seasons at BWRNWR and lowest at PSRA, respectively. We have detected like patterns of occupancy at BWRNWR, CNWR, MLWA, and PSRA even though magnitude at the sites has varied between seasons.

Western Yellow Bats

We recorded western yellow bat occupancy declining between season 1 (102 days) and season 2 (72 days) with a further decline in season 3 (57 days) across the four permanent stations. Though the reason for this trend cannot be positively determined without further investigation, the decline in overall occupancy may be attributable to the factors mentioned for western red bats, although the maturing restoration areas would be providing only foraging habitat, as western yellow bats are found to roost in the skirts of dead palm fronds. We observed MLWA to have the highest occupancy rate during season 1 and BWRNWR to have the highest occupancy rate during seasons 2 and 3. PSRA displayed the least amount of occupancy during all three seasons. While the magnitude of occupancy differed between seasons, we observed related patterns of occupancy between seasons at the four stations. 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. As with seasons 1 and 2, we documented a similar pattern of occupancy during season 3, with 59% of call minutes recorded between March 20 and April 10, 2013. These patterns suggest 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. We only recorded 9 call minutes for western yellow bats during season 3, with most occurring in June. Data from seasons 1 and 2 imply that western yellow bats are utilizing CNWR as a stopover 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; and 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. During season 3, we observed 54% of western yellow bat activity occurring over 2 days, February 26 and 27. PSRA produced a low sample size, with only 9 call minutes and days of occupancy combined between the three seasons. The low sample size at PSRA may be attributable to the low number of palms along that stretch of the LCR.

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) and again into season 3 (52 days) across our four permanent stations. However, partial results from season 4 have already yielded 73 days of occupancy for this species. We recorded MLWA to have the highest rate of occupancy during season 1 and PSRA to have the highest during seasons 2 and 3. 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). There is a recurring pattern of increased occupancy and relative activity across sites during late summer. This rise in occupancy is compatible with reproduction behavior, where 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.

Townsend's Big-Eared Bat

As mentioned earlier, Townsend's big-eared bat occupancy is difficult to quantify using acoustic methods and it is difficult to assess spatial and temporal occupancy and relative activity trends. Our identification criteria for this species are stringent. We are likely recording calls that may be attributable to Townsend's, but in the absence of a dual harmonic, it cannot be positively identified as such. We have recorded only 11 days of occupancy across sites and seasons combined. We have detected 7 days of occupancy at BWRNWR between seasons most likely because the station at BWRNWR is close in proximity to a known roost.

Permanent Station Occupancy

BWRNWR

We documented a decrease from 178 days of occupancy for the four focal species combined at BWRNWR during season 1 to 131 days during season 2 and then a slight increase to 139 days for season 3. 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. We have documented the highest magnitude of winter occupancy for western red bats at BWRNWR. Winter occupancy of western red bats has also been detected by acoustic monitoring at restoration areas near Blythe, California (Cibola Valley Conservation Area [CVCA] and Palo Verde Ecological Reserve [PVER]) and Parker, Arizona (‘Ahakhav Tribal Preserve [AKTP]) (Broderick 2010). Winter occupancy of western red bats has also been confirmed by mist-netting at CVCA, PVER, and AKTP (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. We noted a decline in overall occupancy between seasons 2 and 3 (36 days). A pump broke at CNWR during season 3 and did not deliver water to an area near our station. This lack of water may have shifted foraging patterns and contributed to our decline in occupancy for season 3.

PSRA

We noted an increase at PSRA between seasons 1 and 2, with 21 days of occupancy documented during season 1 to 63 days during season 2. We then recorded a decline from season 2 to season 3 (38 days). 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) and a further decline for season 3 (52).

CONCLUSION

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 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, MLWA, and PSRA 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) to season 3 (265 days). This decline in occupancy may be the result of ongoing restoration efforts by Reclamation 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 would expect to see these species start to expand their distribution on the river. We believe maturing restoration areas may be providing more suitable habitat, leading to the decline in occupancy we have documented at our non-restoration sites. It should also be noted that additional monitoring will be conducted at these stations as this decline in occupancy may be temporary and part of a natural fluctuation in occupancy patterns. Our future objective for this project is to collaborate with Reclamation biologists analyzing occupancy and relative activity patterns at the restoration stations and 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. We will continue to monitor stations at non-restoration areas and increase our visits to address maintenance issues in a timely manner. A fifth non-restoration station will be added in spring 2014 on Havasu National Wildlife Refuge in the Pintail Slough area. This station will be maintained by Reclamation biologists, and the call data will be analyzed by Arizona Game and Fish biologists and added to future reports.

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ATTACHMENT 1

Station Maintenance Log

Bill Williams	
5/20/12	Switched CF card – normal operation; reset ZCAIM time – slow by 3 minutes; reset OWL time – fast by 2 minutes; downloaded OWL
8/8/12	Switched CF card – normal operation
10/11/12	Switched CF card – normal operation; tried to reset ZCAIM time, but battery was dead; reset OWL time – fast by 6 minutes; downloaded OWL
12/27/12	Switched CF card – normal operation
5/14/13	Switched CF card – normal operation; reset ZCAIM time – slow by 3 minutes; reset OWL time – fast by 4 minutes; downloaded OWL
7/2/13	Switched CF card – normal operation, but fewer files than expected; no noise!
9/5/13	Switched CF card – normal operation, some noise
11/27/13	Switched CF card – no files recorded since 9/5, but status file indicated proper OWL operation
11/29/13	Sensitivity had been bumped to 2; turned back up to 6.5
12/29/13	Switched CF card – no files recorded; card appeared to have been the unerased card from 11/27–11/29
1/2/14	No files recorded again; brought units back to office
Cibola	
5/20/12	Switched CF card; reset ZCAIM time – fast by 2 minutes; downloaded OWL and reset time – fast by 8 minutes; OWL data stopped on 5/02; clip on negative battery terminal was detached, but not sure if it happened prior to my visit or if related to OWL problem
8/8/12	Switched CF card; copied CAPTURE file, but nothing was appended after 5/20; deleted file from card and waited; new file was created with new records appended; deleted that file with the assumption that another new file would be created
11/8/12	Switched CF card, normal operation; copied CAPTURE file; reset OWL time – fast by 10 minutes; reset ZCAIM time – fast by 6 minutes
1/8/13	Switched CF card, normal operation, but very few recent files
5/13/13	Switched CF card – normal operation except lots of noise files in early May (maybe lost some bat files); reset ZCAIM time – fast by 2 minutes; reset OWL time – fast by 6 minutes; copied CAPTURE file
7/2/13	Switched CF card – quite a bit of noise
9/6/13	Switched CF card; lots of noisy files, over half were > 8 kilobytes; site flooded
11/27/13	Switched CF card – normal operation and not a lot of noise; site flooded
1/2/14	Switched CF card – normal operation; site flooded

Picacho	
7/18/12	Switched CF card; wash ran heavily from rains on 7/13; mesquite encroaching heavily in front of microphone; stopped recording on 6/15 after 84,000 files - may have reached capacity but DAT+TXT was only 574 megabytes on 1-gigabyte card; lots of interference
8/6/12	Switched CF card, lots of large files due to interference from mesquite; pruned mesquite back, including branch that was impeding anemometer (recent zero readings should be ignored)
10/23/12	Switched CF card – stopped recording on 8/30 with lots of large static files that apparently filled card - DAT+TXT was 574 megabytes; probably noise from encroaching mesquites; pruned trees heavily to create more opening; downloaded OWL (normal readings) and reset time – fast by 10 minutes; reset ZCAIM time – fast by 3 minutes; earthwork had been done after flooding, with earth piled up against pole
11/20/12	Switched CF card – normal operation
2/8/13	Switched CF card – normal operation
5/1/13	Switched CF card – normal operation; downloaded OWL; reset OWL time – fast by 3 minutes; reset ZCAIM – slow by 4 minutes; pruned nearby mesquite branches
6/28/13	Switched CF card – normal operation, but many large files; wind vane a little sticky
9/10/13	Switched CF card – some noise
11/21/13	Switched CF card – some noise
1/3/14	Switched CF card – normal operation
Mittry	
7/16/12	Switched CF cards – normal operation
10/18/12	Switched CF cards – normal operation; reset Anabat time – fast by 6 minutes; reset OWL time – fast by 3 minutes; downloaded OWL, some bad values for extemp and humidity
2/11/13	Switched CF cards – normal operation; reset Anabat time, which was correct; reset OWL time – slow by 1 minute; downloaded OWL, some bad values for extemp and humidity
4/29/13	Switched CF cards – normal operation; reset Anabat time – fast by 1 minute; reset OWL time – fast by 1 minute; downloaded OWL, some bad values for extemp and humidity
6/28/13	Switched CF cards – normal operation
9/10/13	Switched CF cards – insect noise in evening for a few weeks
11/21/13	Switched CF cards – normal operation
1/3/14	Switched CF cards – normal operation