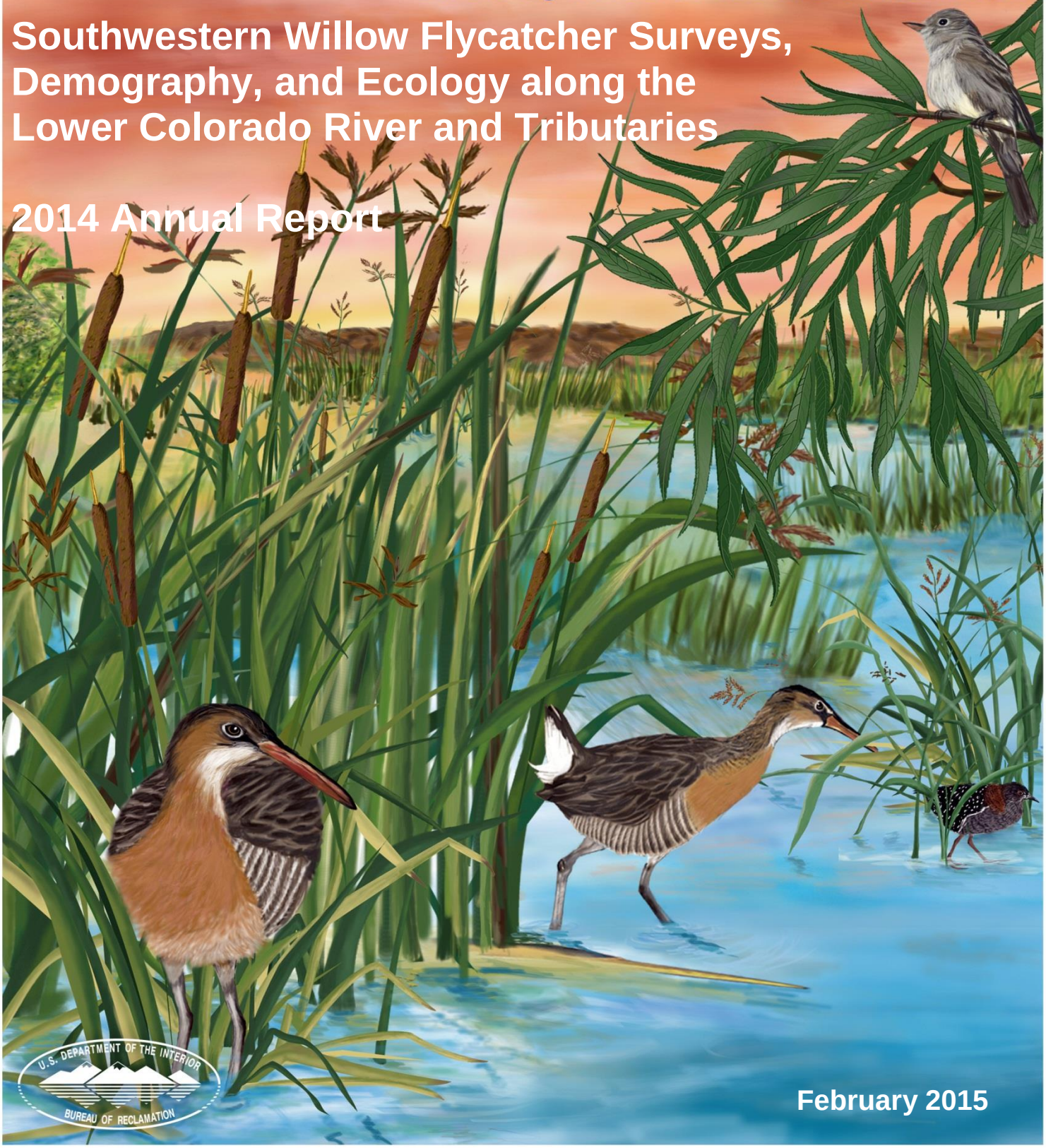
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Southwestern Willow Flycatcher Surveys, Demography, and Ecology along the Lower Colorado River and Tributaries

2014 Annual Report



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February 2015

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Lower Colorado River Multi-Species Conservation Program

Southwestern Willow Flycatcher Surveys, Demography, and Ecology along the Lower Colorado River and Tributaries

2014 Annual Report

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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

AIC	Akaike's information criterion
BA	biological assessment
BBIRD	Breeding Biology Research and Monitoring Database
Bill Williams	Bill Williams River National Wildlife Refuge
BO	biological opinion
cfs	cubic feet per second
CI	confidence interval
cm	centimeter(s)
CV	coefficient of variation
CVCA	Cibola Valley Conservation Area
df	degrees of freedom
GLM-GEE	generalized linear model with general estimating equation
GLMM	generalized linear mixed model
GPS	Global Positioning System
ha	hectare(s)
Havasu NWR	Havasu National Wildlife Refuge
HCP	habitat conservation plan
km	kilometer(s)
LB	lower bound
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
LMM	linear mixed model
lx	lux (lumen per square meter; unit of illuminance and luminous emittance)
m	meter(s)
mm	millimeter(s)
MSP	Mayfield survival probability
NAU	Northern Arizona University
NDOW	Nevada Department of Wildlife
Pa	Pascal(s)
Pahranagat NWR	Pahranagat National Wildlife Refuge
PVER	Palo Verde Ecological Reserve
Reclamation	Bureau of Reclamation
RH	relative humidity
SE	standard error
SWCA	SWCA Environmental Consultants
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VP	vapor pressure
Warm Springs	Warm Springs Natural Area
WMA	Wildlife Management Area

Symbols

≈	approximately (nearly equal to)
°	degrees
°C	degrees Celsius
>	greater than
≥	greater than or equal to
~	is modeled as a function of
<	less than
≤	less than or equal to
#	number
%	percent

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Attachments

Attachment

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EXECUTIVE SUMMARY

The southwestern willow flycatcher (*Empidonax traillii extimus*), listed as federally endangered in 1995, breeds in dense, mesic riparian habitats at scattered, isolated sites in New Mexico, Arizona, southern California, southern Nevada, southern Utah, southwestern Colorado, and, at least historically, extreme northwestern Mexico. Historical breeding records and museum collections indicate a sizable population of southwestern willow flycatchers may have existed along the extreme southern stretches of the lower Colorado River (LCR) region. Factors contributing to the decline of flycatchers on the breeding grounds include loss, degradation, and/or fragmentation of riparian habitat; invasion of riparian habitat by non-native plants; and brood parasitism by brown-headed cowbirds (*Molothrus ater*).

Willow flycatcher studies have been conducted along the LCR and tributaries annually since 1996 in compliance with requirements set forth by the U.S. Fish and Wildlife Service regarding Bureau of Reclamation (Reclamation) routine operations and maintenance along the LCR. Biological assessments and the resulting biological opinions on operations and maintenance were prepared as steps to developing a Lower Colorado River Multi-Species Conservation Program (LCR MSCP) for long-term endangered species compliance and management in the historical flood plain of the LCR. The LCR MSCP documents were signed in April 2005, and implementation of the program began in October 2005. Under the LCR MSCP, there will be continued surveys and monitoring of willow flycatchers along the LCR. SWCA Environmental Consultants (SWCA) was contracted by Reclamation to continue surveys, monitoring, and demographic and ecological studies of the southwestern willow flycatcher in suitable and/or historical riparian and wetland habitats throughout the LCR region and along its tributaries in 2014. Studies in 2014 were originally intended to include the Virgin River, but due to access restrictions, the effort was redirected to Alamo Lake and Meadow Valley Wash and to supplement effort in the Pahranagat Valley.

SWCA was also retained by the Nevada Department of Wildlife in 2014 to conduct work in the Pahranagat Valley at the Key Pittman Wildlife Management Area (Key Pittman WMA), River Ranch, and Pahranagat National Wildlife Refuge (Pahranagat NWR), and by Southern Nevada Water Authority at the Warm Springs Natural Area (Warm Springs). Work completed at these four study areas included flycatcher surveys, site descriptions, nest monitoring, and color banding. We also completed broadcast surveys for yellow-billed cuckoos (*Coccyzus americanus occidentalis*) at the Pahranagat NWR, River Ranch, and Warm Springs.

Approximately 100 sites are included in the Reclamation study of flycatchers along the Virgin and lower Colorado Rivers, but in 2013, we began surveying a portion of the sites triennially rather than annually. In 2014, we completed

presence/absence surveys, following a 5-survey protocol, and site descriptions at a subset of the 100 sites, not including those on the triennial schedule. We searched for nests in all areas occupied by territorial flycatchers in 2014; monitored willow flycatcher nests to document nest fate, brood parasitism, and causes of nest failure; and color banded and resighted as many willow flycatchers as possible to determine the breeding status of territorial flycatchers and to document movement and recruitment.

We used recorded broadcasts of willow flycatcher songs and calls to elicit flycatcher responses at 87 sites, ranging in size from < 1 to 41 hectares, along the LCR and tributaries from Caliente, Nevada, south to Cibola, Arizona, between May 15 and July 17, 2014. We detected willow flycatchers on at least 1 occasion at 55 of these sites, and 6 additional sites were completely occupied by flycatchers throughout the breeding season and were therefore not surveyed. Breeding or resident flycatchers were detected at 35 sites within the Key Pittman WMA, Pahranagat NWR, Meadow Valley Wash, Muddy River, and Warm Springs, Nevada; and Topock Marsh, Bill Williams River National Wildlife Refuge, and Alamo Lake, Arizona, study areas. One of the resident adults in Topock Marsh was detected in CPhase 05, a habitat creation site. We did not observe any territorial behaviors or any bands on this bird, making it impossible to confirm that the bird detected on each visit was the same individual, but because it was detected in the same area on each visit over a span of more than 7 days, it is considered a resident. South of the Bill Williams River, 46 willow flycatcher detections were recorded between May 28 and June 12, 2014. Monitoring results suggest these flycatchers were not resident, breeding individuals and were most likely spring migrants. One additional flycatcher was detected on July 7; this individual was detected very briefly and did not display territorial behavior, and it was likely not a resident flycatcher.

We completed broadcast surveys for yellow-billed cuckoos at River Ranch, Pahranagat NWR, and Warm Springs. One cuckoo was detected during a survey in July at River Ranch. Two cuckoos were detected during surveys in July at the Pahranagat NWR; one cuckoo was detected in early July and the other in late July.

We used targeted mist net and passive netting techniques to capture and uniquely color-band adult and fledgling willow flycatchers at all sites where resident willow flycatchers were detected. Nestlings were banded between 7 and 10 days of age. We banded each willow flycatcher with a single, numbered U.S. Federal aluminum band on one leg and one pinstriped, aluminum band on the other. We used binoculars to determine the identity of previously color-banded flycatchers by observing, from a distance, the unique color combinations on their legs.

At all monitored study areas, we color banded 41 new adult flycatchers. An additional 52 adults were identified to individual via resighting, and two adults were resighted but did not have their color combinations confirmed. Of the adults

we identified in 2014, 13 were identified for the first time since they were banded as nestlings. Thirty-eight adult flycatchers remained unbanded, and banding status was undetermined (i.e., we were unable to determine if these individuals were banded) for 45 adults. We banded 65 nestlings from 30 nests and 3 unbanded fledglings, 2 of which came from 2 additional nests. We resighted 15 unbanded fledglings from an additional 10 nests.

In 2013, we individually identified 57 adult, resident willow flycatchers at all study areas that were monitored in both 2013 and 2014. Of these 57 adult flycatchers, 42 (74 percent [%]) were detected in 2014. Of the returning resident adults, 7 (17%) were detected at a different study area than where they were resident in 2013. We detected two within-year, between-study area movements from two individuals in 2014.

In 2013, we banded 42 nestlings and 3 fledglings at all monitored study areas and an additional 13 nestlings at St. George, Utah. Ten nestlings were known or suspected to have died before fledgling. Of the 48 remaining juveniles, 13 (27%) were identified in 2014. Two individuals originally banded as nestlings in 2011 and one individual originally banded as a nestling in 2012 were also identified for the first time in 2014. Of the 16 returning nestlings identified in 2014, 7 (44%) dispersed away from their natal study area. The median dispersal distance for all returning juvenile flycatchers in 2014 was 2.4 kilometers (km).

We recorded 92 territories at all monitored study areas. Of these, 68 (74%) consisted of breeding flycatchers, 6 (6%) consisted of pairs for which no nest could be found, 17 (18%) consisted of unpaired individuals, and 1 (1%) consisted of an individual for which gender could not be determined. Twelve breeding males were each polygynous with two females, four males were each polygynous with three females, and one male was polygynous with four females. One unpaired male moved within season and established a second territory.

At all monitored study areas, we documented 81 willow flycatcher nesting attempts, 73 of which contained eggs and were used in calculating nest success and productivity. Thirty-three (45%) nests were successful and fledged young, 31 (42%) failed, and 9 (12%) were of unknown fate. Apparent nest success ranged from 20% at Muddy River to 100% at Topock Marsh and Meadow Valley Wash. Depredation was the major cause of nest failure, accounting for 38% of all failed nests and 48% of nests that failed after flycatcher eggs were laid. No breeding flycatchers were recorded at Warm Springs.

Nine of 62 nests (15%) with flycatcher eggs and known contents were brood parasitized by brown-headed cowbirds. Brood parasitism ranged from 0 to 60% and was highest at Muddy River. We addled cowbird eggs via vigorous shaking at all easily accessible flycatcher nests; none of the cowbird eggs we addled hatched. The addling program reduced the hatch rate of cowbird eggs in 2010–14 to 12%, compared to the 68% hatch rate of unaddled eggs observed at all study

areas in 2003–14. During the years prior to the addling program, parasitized nests that hatched at least one flycatcher and no cowbirds produced an average of 1.40 flycatchers per nest, compared to 0.57 flycatcher per nest in nests with a cowbird nestling. We recommend continuing the addling program because of the potential to increase flycatcher reproductive output.

We described surface hydrology conditions up to four times during the season at 79 flycatcher nests in the Key Pittman WMA, Pahranagat NWR, Meadow Valley Wash, Muddy River, Topock Marsh, Bill Williams, and Alamo Lake. The descriptions included conditions of soil moisture at the nest (inundated, saturated, damp, or dry), depth of water (if any) at the nest, distance to water from the nest, and the percent of the area within 20 and 50 meters (m) of the nest that contained inundated or saturated soils (hereafter wet soils). Soil moisture conditions were known at the time the nest site was selected by a flycatcher for 68 of the 79 nests. Of the 68 nests, 39 (57%) were within 5 m of wet soils, 5 nests (7%) were built within 35 m of wet soils, and 24 (35%) were built more than 50 m from wet soils. All 24 nests built more than 50 m from wet soils were in study areas with unusually dry conditions (Alamo Lake and Bill Williams); site fidelity or lack of alternate available habitat likely influenced nest site selection in these areas. Over the history of this project we have seen several instances where flycatchers, which typically have high site fidelity, nested in previously occupied areas that were wet when they were initially occupied but had since gone dry. Site fidelity in the year following dry conditions was low, and if sites remained dry, they became unoccupied.

Surface hydrology data indicate that the Key Pittman WMA and Pahranagat NWR experienced a gradual reduction in the areal extent of surface water through the flycatcher breeding season. Conditions at Muddy River, Bill Williams, and Alamo Lake did not change through the season. No seasonal trend in surface hydrology was apparent at Meadow Valley Wash or Topock Marsh, but sample sizes were small.

We recorded the species of tree or shrub in which the nest was placed as well as a visual estimate of the percentage of vegetation volume that consisted of tamarisk (*Tamarix* spp.) within 2 and 5 m of the nest. Twenty-nine percent of the nests were built in tamarisk trees in 2014, and 57% of the nests had tamarisk within 5 m of the nest. No tamarisk was present in the vicinity of nests at the Key Pittman WMA, Pahranagat NWR, or Meadow Valley Wash. The purpose of quantifying the amount of tamarisk in the vicinity of each nest is to determine the potential impact of defoliation, but since we started recording these data, defoliation has only been recorded at a very small number of active nests. It is therefore difficult to determine a threshold percentage of tamarisk foliage at which adverse effects on nest success might occur during a defoliation event.

We deployed a temperature/humidity data logger at each flycatcher nest that was confirmed to be in the incubation phase. These loggers recorded data every

30 minutes and remained in place until the end of the breeding season. We recorded temperature and humidity at each of three flycatcher nests at Topock Marsh, two nests at Bill Williams, and nine nests at Alamo Lake. The sample sizes were too small to permit meaningful comparisons between conditions recorded at nests and those recorded in similar vegetation but at non-nest locations, between nests monitored in 2014 versus those from other years, or between nests and habitat creation sites. Despite small sample sizes, a few trends were apparent. Nests at Alamo Lake had markedly lower vapor pressure and markedly higher maximum daily temperature and daily temperature range than nests at either Topock Marsh or Bill Williams. However, the temperatures and vapor pressures recorded at Alamo Lake were similar to those recorded at Mormon Mesa in 2003–2009.

Tamarisk beetles (*Diorhabda* spp.) defoliate tamarisk plants during flycatcher breeding season, likely exposing flycatcher nests to adverse microclimate conditions and increased risk of depredation and parasitism. Tamarisk beetles (*D. carinulata*) were released in St. George, Utah, in 2006, and widespread defoliation was first observed in St. George in 2008. The area of defoliation on the Virgin River has expanded downstream annually since then, encompassing the entire stretch of the Virgin River to Lake Mead by the end of the breeding season in 2011. Tamarisk beetles continued spreading downstream on the LCR in 2012 and 2013, and by the end of the 2013 breeding season were found approximately (≈) 11 km downstream from Lake Mohave. In 2014, we formally monitored the Topock Marsh and Bill Williams River NWR study areas for the presence and effect of tamarisk beetles.

All monitoring data were collected at permanent monitoring points established in 2013 in recently occupied flycatcher habitat. We deployed a temperature/humidity data logger and a light logger at each monitoring point, and we visited each point at intervals throughout the breeding season to record visual estimates of foliar color, the percentage of leafless stems, and the number of beetle eggs, larvae, and adults. At each visit, we also recorded percent total canopy closure. At each study area, we also deployed a control light logger in a sunny location. In 2013, we discovered that extended exposure to sunlight caused the logger housing to become cloudy, so in 2014, we changed the housing of the control logger monthly.

In 2014, we implemented a calibration protocol with the goal of quantifying and reducing observer variation and identifying any individual observer drift through the season. At the beginning of the season, all observers visited the same five monitoring points as a group. Each observer independently recorded the beetle and vegetation data at a given monitoring point. The results for that monitoring point were then discussed before the group proceeded to the next monitoring point. At the end of the season, all observers returned to the same five monitoring points. This time, each observer independently recorded the beetle and vegetation data, but the results were not discussed.

The calibration exercise was successful in reducing observer variation at the beginning of the season, identifying lapses in adherence to protocol during the season, and quantifying overall observer variation. We were unable to quantify observer drift over the season because the change among readings recorded for each variable during the initial and end calibration exercises tended to be unidirectional across observers and across calibration points, making it difficult to distinguish any observer drift from actual change in the vegetation.

Following field season, we completed two brief experiments to determine whether light intensity readings were affected by small deviations from horizontal in the position of the light logger or by the condition of the logger. These tests showed that a deviation of ≈ 6 degrees (°) from horizontal can have marked effects on light readings, particularly during sunny periods, with as much as twice the light intensity recorded when the logger was tipped toward the sun versus away from the sun. The sensitivity of the logger to deviations from horizontal illustrated the importance of ensuring that each logger is positioned carefully. In future years, we will use a level, in addition to a visual assessment, to ensure that each light logger is horizontal. The accumulation of dirt on the logger housing had a much smaller effect on light readings than the orientation of the logger. Dirt appeared to have a stronger effect when the sun was at a low angle, but confidence intervals among loggers of different cleanliness rankings still overlapped. In future years, we will instruct field personnel to clean each light logger on every monitoring visit to further reduce any variation in light readings that might be caused by the accumulation of dirt.

Beetles were not detected in 2014 at Topock Marsh or on the Bill Williams River, and baseline conditions of vegetation, microclimate, and light levels at these study areas in 2014 are summarized in the body of this report.

We did not complete any formal analysis of the relationships among vegetation, temperature, humidity, and light intensity, but some general associations are apparent from the data. In instances where we saw a change through the season in canopy closure, we saw a change in percent light in the expected direction. In 2013, we noted that the tamarisk at Topock Marsh appeared to have sustained substantial damage from splendid tamarisk weevils, with lower canopy closure noted in many sites in comparison to previous years (McLeod and Pellegrini 2014). Although weevils were again noted at Topock Marsh in 2014, the tamarisk appeared much healthier, with increased canopy closure (as visually estimated) noted in many sites in comparison to 2013 (McLeod and Pellegrini 2013; chapter 2 of this document). Canopy closure recorded with a densiometer at beetle monitoring points in tamarisk was also higher in 2014 (95–98%) than in 2013 (90–94%). In 2014, canopy closure in tamarisk with emergent Goodding's willow was still greater than in tamarisk, but there was a smaller difference in canopy closure between the two vegetation types in 2014 (median difference = 1.4%, range = -0.4–3.3%) than in 2013 (median difference = 4.2%, range = 3.1–6.0%).

We observed a similar pattern in maximum daily temperature, where temperatures in 2014 were still higher in tamarisk than in tamarisk with emergent Goodding's willow, but the difference in temperatures between the two vegetation types was not as large in 2014 (median difference = 2.8 degrees Celsius [°C], and range = 2.0–4.0 °C) as in 2013 (median difference = 3.6 °C, range = 2.5–4.5 °C). In addition, unlike in 2013, percent light in 2014 was lower in tamarisk than in tamarisk with emergent Goodding's willow. Thus, canopy closure, percent light, and maximum temperature all reflected the improved health of the tamarisk.

In 2003–12, all temperature and relative humidity data were collected using HOBO H8 temperature/humidity data loggers. In 2013, we stopped using the aging and increasingly unreliable HOBOs and switched to iButtons. Therefore, we wanted to compare the readings collected by HOBO loggers to those collected by iButtons as a prerequisite to any future analyses that might compare HOBO data to iButton data. In 2014, we hung a HOBO H8 Pro logger next to the iButton at each beetle monitoring point. We used linear mixed models (LMMs) to generate plots showing regression lines and 95% prediction intervals for maximum and minimum daily temperature and mean diurnal and nocturnal vapor pressure. We used generalized linear mixed models to investigate whether canopy closure had an effect on the differences between logger types in maximum daily temperature, and we used generalized linear models with general estimating equations (GLM-GEEs) to predict iButton values from HOBO measurements for all four microclimate measures.

All LMMs accounted for random effects, used a first-order autoregressive correlation structure, and assumed homogeneous variance. Bias in maximum daily temperature varied with HOBO maximum daily temperature measurements by the formula $\text{Bias}_{\text{HOBO - iButton daily maximum T}} = -5.3144754 + 0.137665*\text{HOBO}$. Both intercept and mean slope were significant ($P < 0.0001$), but bias was not significantly different from 0 for the range of temperatures that was analyzed. Measurement error represented by the prediction interval varied from ± 1.94° at 25 °C to ± 2.03° at 47 °C.

Bias in minimum nightly temperature varied with HOBO minimum nightly temperature measurements by the formula $\text{Bias}_{\text{HOBO - iButton nightly minimum T}} = 0.8114905 - 0.0178387*\text{HOBO}$. Both intercept and mean slope were significant ($P < 0.0001$), but bias was not significantly different from 0 at nightly minimum temperatures < 12.5 °C; below 12.5 °C, bias was positive. Measurement error represented by the prediction interval varied from ± 0.61° at 7 °C to ± 0.60° at 27 °C.

Bias in mean daily vapor pressure varied with the HOBO mean daily vapor pressure measurements by the formula $\text{Biaslog}_{\text{HOBO DVP-log iButton DVP}} = -0.05400657 + 0.09299289*\text{HOBO}_{\text{centered}} + 0.03133665*\text{HOBO}^2 + 0.04771687*\text{HOBO}^3$. Both intercept and mean slope were significant

($P < 0.0001$). After back-transformation, bias was negative below ≈ 1,800 Pascals (Pa), positive when the mean measurement was above ≈ 3,250 Pa, and not significantly different from 0 for vapor pressures in between. Measurement error represented by the prediction interval varied from ± 21.84 Pa at 660 Pa to ± 174.1636 Pa at 4,124 Pa.

Bias in mean nightly vapor pressure varied with HOBO mean nightly vapor pressure measurements by the formula $Bias_{logHOBO\ NVP\text{-}log\ iButton\ NVP} = -0.04417141 + 0.07212292*HOBO_{centered} -0.03376254*HOBO^2 + 0.0852626*HOBO^3$. Both intercept and mean slope were significant ($P < 0.0001$). After back-transformation, bias was negative below 1,730–1,734 Pa and not significantly different from 0 at pressures > 1,734 Pa. Measurement error represented by the prediction interval varied from ± 21.1874 Pa at 712 Pa to ± 112.9261 Pa at 3,173 Pa.

Canopy cover did not significantly affect the difference in maximum daily temperatures measured by HOBO and iButton data loggers in any model. The lack of a significant effect of canopy cover on differences in maximum daily temperature measured between HOBO and iButton data loggers may be due to the high percentage of and low variation in canopy cover at all sample points.

Maximum and minimum daily temperature as recorded by iButtons were not affected by study area ($P = 0.1125$ and $P = 0.7008$, respectively [n = 2,283]) or canopy closure ($P = 0.4158$ and $P = 0.1481$, respectively [n = 180]), and temperatures were modeled as $MDT_{iButton} = 6.7975 + 0.8223* MDT_{HOBO}$ and $MNT_{iButton} = 6.7975 + 0.8223* MNT_{HOBO}$. Mean diurnal vapor pressure as recorded by iButtons was affected by study area ($P = 0.0083$) but not canopy cover ($P = 0.8316$) and was modeled as $DVP_{iButton} = 383.1692 -53.5113 (Topock) + 0.8482* DVP_{HOBO}$. The model without study area or canopy cover was $DVP_{iButton} = 352.0363 + 0.8481* DVP_{HOBO}$. Nightly vapor pressure was not significantly affected by either study area ($P = 0.7194$) or canopy cover ($P = 0.7592$) and was modeled as $NVP_{iButton} = 208.2312 + 0.9081* NVP_{HOBO}$.

As long as the sites and study areas used in 2014 for generating GLM-GEEs of iButton measurements are representative of sites and study areas in general, the GLM-GEEs without study area or canopy cover variables can be used to predict iButton maximum daily temperature, minimum nightly temperature, and mean nightly vapor pressure from HOBO data (2012 and earlier) at all sites and study areas in the southwestern willow flycatcher study. Conversely, if study sites not used to generate the GLM-GEEs (e.g., Mormon Mesa and Mesquite) are quite different from the sites used to generate the GLM-GEEs, then the GLM-GEEs should either not be applied to HOBO data from those sites or should be updated with pairwise comparisons from those sites in 2015.

It is not clear how much variation there would be in readings recorded by two data loggers of the same type hung in close proximity to one another. Deploying pairs of iButton loggers and pairs of HOBO loggers would help distinguish the effects of small changes in location from those of different logger types.

Chapter 1 – Introduction

SPECIES INTRODUCTION

The southwestern willow flycatcher (*Empidonax traillii extimus*) is one of four subspecies of willow flycatcher currently recognized (Unitt 1987). It breeds in dense, mesic riparian habitats at scattered, isolated sites in New Mexico, Arizona, southern California, southern Nevada, southern Utah, southwestern Colorado, and, at least historically, extreme northwestern Mexico and western Texas (figure 1-1) (Unitt 1987).

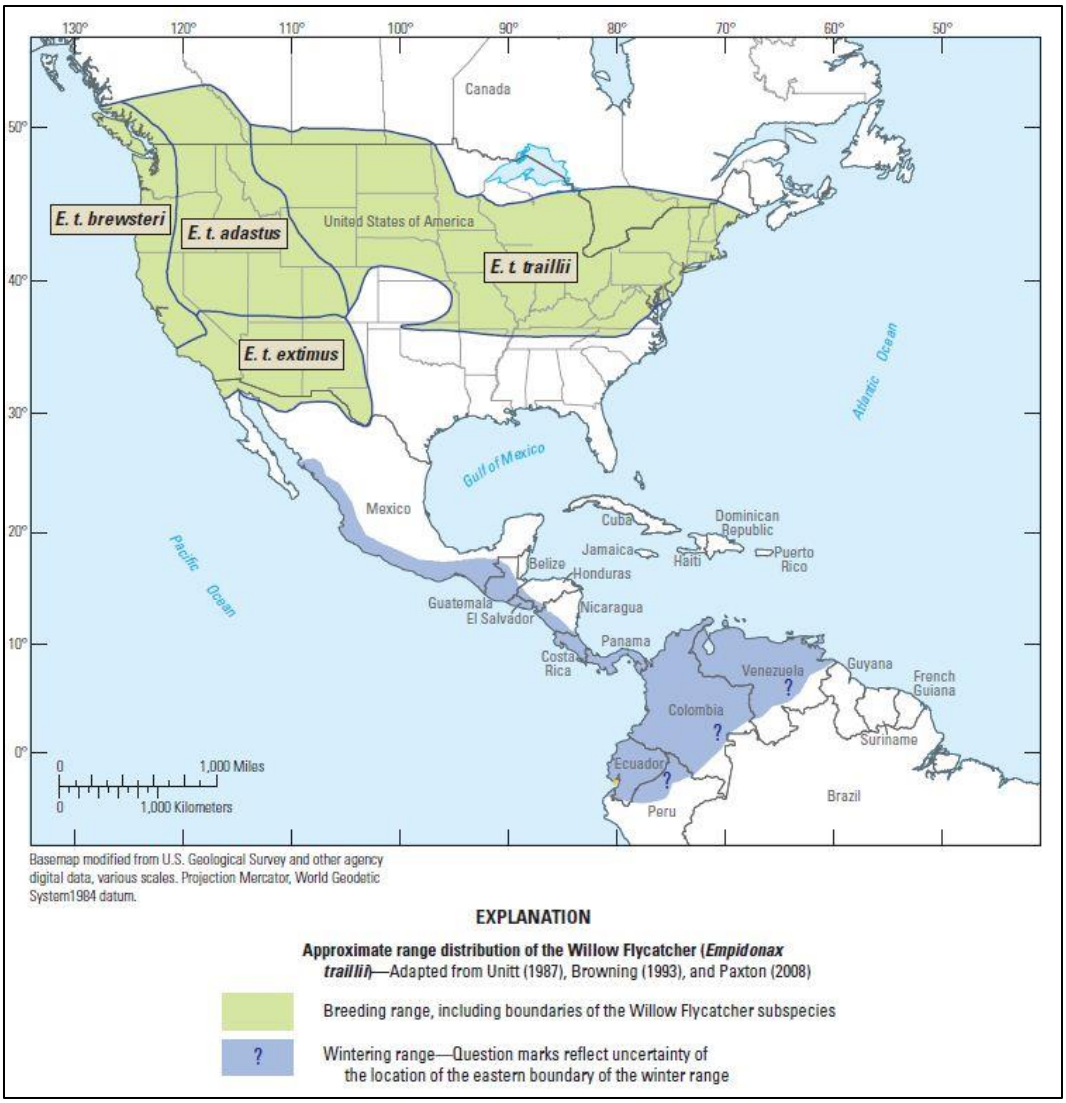

Figure 1-1.—Breeding range distribution of the subspecies of the willow flycatcher (*Empidonax traillii*).
From Sogge et al. (2010).

In the Southwest, most willow flycatcher breeding territories are found within small breeding sites containing five or fewer territories (Durst et al. 2006). One of the last long-distance neotropical migrants to arrive in North America in spring, the southwestern willow flycatcher has a short, approximately (≈) 100-day breeding season, with individuals typically arriving in May or June and departing in August (Sogge et al. 2010). All four subspecies of willow flycatchers spend the non-breeding season in portions of southern Mexico, Central America, and northwestern South America (Stiles and Skutch 1989; Ridgely and Tudor 1994; Howell and Webb 1995; Unitt 1997), with wintering ground habitat similar to the breeding grounds (Lynn et al. 2003). Willow flycatchers have been recorded on the wintering grounds from central Mexico to southern Central America as early as mid-August (Stiles and Skutch 1989; Howell and Webb 1995), and wintering, resident individuals have been recorded in southern Central America as late as the end of May (Koronkiewicz et al. 2006b).

Historical breeding records and museum collections indicate that a sizable population of southwestern willow flycatchers may have existed along the extreme southern stretches of the lower Colorado River (LCR) region (Unitt 1987). However, no nests have been located south of the Bill Williams River, Arizona, in over 65 years (Unitt 1987), though northbound and southbound migrant willow flycatchers use the riparian corridor (Phillips et al. 1964; Brown et al. 1987; McKernan and Braden 2002; McLeod et al. 2008; McLeod and Pellegrini 2013, 2014, this document). Factors contributing to the decline of flycatchers on the breeding grounds include loss, degradation, and/or fragmentation of riparian habitat; invasion of riparian habitat by non-native plants; and brood parasitism by brown-headed cowbirds (*Molothrus ater*) (U.S. Fish and Wildlife Service [USFWS] 1995; Marshall and Stoleson 2000). Because of low population numbers range-wide, identifying and conserving willow flycatcher breeding sites is thought to be crucial to the recovery of the species (USFWS 2002).

Tamarisk beetles (*Diorhabda* spp.) pose an additional threat to southwestern willow flycatchers. Tamarisk beetles defoliate tamarisk (*Tamarix* spp.) plants during flycatcher breeding season, likely exposing flycatcher nests to adverse microclimate conditions and increased risk of depredation and parasitism. Tamarisk beetles (*D. carinulata*) were released in St. George, Utah, in 2006, and widespread defoliation was first observed in St. George in 2008. The area of defoliation on the Virgin River expanded downstream annually, encompassing the entire stretch of the Virgin River to Lake Mead by the end of the breeding season in 2011. Tamarisk beetles continued spreading downstream on the LCR in 2012 and by the end of the 2012 breeding season were found as far downstream as the lower end of Lake Mohave (T. Dudley 2012, personal communication). By the fall of 2013, tamarisk beetles were detected ≈ 11 kilometers (km) south of Lake Mohave (B. Bloodworth 2014, personal communication). No substantial southerly movement was recorded in 2014 (T. Dudley 2014, personal

communication). Tamarisk beetles (*D. carinulata* and *D. sublineata*) are also present on the Rio Grande in Texas and New Mexico and are expected to arrive at breeding areas that support large numbers of willow flycatchers in the next several years.

BUREAU OF RECLAMATION PROJECT HISTORY

In 1995, the Bureau of Reclamation (Reclamation); other Federal, State, and Tribal agencies; and environmental and recreational interests agreed to form a partnership to develop and implement a Lower Colorado River Multi-Species Conservation Program (LCR MSCP) for long-term endangered species compliance and management in the historical flood plain of the LCR. As a step in developing the LCR MSCP, Reclamation prepared a biological assessment (BA) in August 1996, evaluating the effects of dam operations and maintenance activities on threatened, endangered, and sensitive species. These species included the southwestern willow flycatcher, which was listed by the USFWS as endangered in 1995 (60 FR 10694–10715). In response to the BA, the USFWS issued a biological opinion (BO) in April 1997, outlining several terms and conditions Reclamation must implement in order not to jeopardize the species. Among these terms and conditions was the requirement to survey and monitor occupied and potential habitat for southwestern willow flycatchers along the LCR for a period of 5 years. The studies were intended to determine the number of willow flycatcher territories, status of breeding pairs, flycatcher nest success, the biotic and abiotic characteristics of occupied willow flycatcher sites, and brown-headed cowbird brood parasitism rates. In 2002, Reclamation reinitiated consultation with the USFWS on the effects of continued dam operations and maintenance on threatened, endangered, and sensitive species along the LCR. The USFWS responded with a BO in April 2002, requiring continued southwestern willow flycatcher studies along the LCR through April 2005. The BO also required implementation of a study to evaluate the effectiveness of brown-headed cowbird trapping for conservation of the flycatcher. Trapping was completed at several study areas in 2003–07 (McLeod et al. 2008), and post-trapping monitoring continued through 2012 (McLeod and Pellegrini 2013).

Reclamation and the USFWS completed a separate consultation on the potential effects to threatened and endangered species from implementation of surplus guidelines through 2016 and an annual change in the point of diversion for up to 400,000 acre-feet for 75 years. A Biological Opinion for Interim Surplus Criteria, Secretarial Implementation Agreements, and Conservation Measures was issued in January 2001. It required monitoring of 150.5 hectares (ha) of existing, occupied southwestern willow flycatcher habitat between Parker and Imperial Dams. Annual monitoring of groundwater levels, vegetation, soil moisture, temperature, and humidity was completed in 2005–12 (McLeod and Pellegrini 2013).

The LCR MSCP is a 50-year program that seeks to protect 26 threatened, endangered, and sensitive species and their habitats along the LCR while maintaining river regulation and water management required by law. The LCR MSCP was approved in April 2005 with the signing of a Record of Decision by the Secretary of the U.S. Department of the Interior, and implementation of the program began in October 2005. Documentation for the LCR MSCP includes a habitat conservation plan (HCP), BA/BO, and an environmental impact statement. The HCP specifies monitoring and research measures that call for surveys and research to better define habitat requirements for the southwestern willow flycatcher and studies to determine the effects of cowbird nest parasitism on flycatcher reproduction.

Reclamation initiated willow flycatcher studies along the LCR in 1996 in anticipation of the requirements outlined in the BOs that were part of LCR MSCP development. These studies have been conducted annually since 1996 and were completed in 1996–2002 by the San Bernardino County Museum and in 2003–14 by SWCA Environmental Consultants (SWCA). Prior to 2014, breeding southwestern willow flycatchers were documented in at least one year at nine study areas along the Virgin and lower Colorado Rivers and tributaries: (1) Pahranagat National Wildlife Refuge (Pahranagat NWR), Nevada; (2) Meadow Valley Wash, Nevada; (3) Beaver Dam Wash, Littlefield, Arizona; (4) Mesquite and (5) Mormon Mesa on the Virgin River, Nevada; (6) Overton Wildlife Management Area (Overton WMA) along the Muddy River, Nevada; (7) Grand Canyon, Arizona; (8) Topock Marsh on the Colorado River, Havasu National Wildlife Refuge (Havasu NWR), Arizona; and (9) Bill Williams River National Wildlife Refuge (Bill Williams River NWR), Arizona (Braden and McKernan 2006; McLeod et al. 2008; McLeod and Pellegrini 2013, 2014). From 1997 to 2013, willow flycatchers, including two banded migrant southwestern willow flycatchers (Koronkiewicz et al. 2006a; McLeod and Pellegrini 2012), were detected during the breeding season at several sites along the Colorado River south of the Bill Williams River to the Mexico border, but no nesting activity was confirmed.

Following the breeding season of 2008, the USFWS and Reclamation initiated discussions regarding the declining number of willow flycatcher territories at Topock Marsh in 2004–08. A plan was developed to pump water into a portion of the flycatcher breeding habitat at Topock Marsh and to monitor vegetation, hydrology, and microclimate, as well as flycatcher occupancy, in the target area. This study was completed in 2009–12 (McLeod and Pellegrini 2013). Water delivery did not appear to have any effects on vegetation that would influence flycatcher occupancy. Delivery of water did shift hydrology and microclimate conditions toward those favored by flycatchers, increasing the extent and duration of surface water present in the target area as well as increasing humidity and decreasing the daily temperature range in flooded areas versus non-flooded areas. Water delivery did not, however, result in increased occupancy by flycatchers.

RELATED STUDIES

Prior to 2010, the Nevada Department of Wildlife (NDOW) completed nest monitoring at the Key Pittman Wildlife Management Area (Key Pittman WMA), and SWCA banded flycatcher nestlings and adults opportunistically in 2003–09 in cooperation with the monitoring efforts. In 2010, the NDOW retained SWCA to conduct surveys, nest monitoring, and banding at flycatcher breeding areas as well as provide site descriptions at the Key Pittman WMA and Warm Springs Natural Area (Warm Springs). This work was expanded in 2011 to include River Ranch in the Pahranagat Valley. The Pahranagat NWR, which had previously been monitored under SWCA's contract with Reclamation, was added in 2013 to the list of study areas monitored under the contract with the NDOW. In 2014, Warm Springs was monitored under SWCA's contract with the Southern Nevada Water Authority. SWCA completed flycatcher monitoring at all four study areas in 2014 as well as broadcast surveys for yellow-billed cuckoo (*Coccyzus americanus occidentalis*) at River Ranch, the Pahranagat NWR, and Warm Springs.

The Utah Division of Wildlife Resources monitored breeding flycatchers annually in St. George, Utah, from 2008 through 2014, and SWCA banded adults and nestling flycatchers opportunistically in cooperation with these monitoring efforts.

PURPOSE AND DESCRIPTION OF STUDIES

The purpose of the 2014 studies was to continue surveys, monitoring, and demographic and ecological studies of the southwestern willow flycatcher in suitable and/or historical riparian and wetland habitats throughout the lower Colorado and Virgin River regions. Lower Grand Canyon was not monitored in 2009–14 as part of Reclamation's study because the declining level of Lake Mead dramatically reduced the amount of potential flycatcher habitat, and the formation of rapids at Pearce Ferry and Iceberg Canyon made access difficult and dangerous.[1] At Reclamation's direction, SWCA did not visit sites on the Virgin River in 2014 due to safety concerns related to the management of trespass cattle. Effort was redirected to Meadow Valley Wash in Nevada and Alamo Lake in Arizona as well as to supplementing survey and monitoring efforts in the Pahranagat Valley at study areas covered under the NDOW contract. These projects currently encompass three types of studies: (1) presence/absence surveys, including site descriptions, at pre-selected sites along the LCR and portions of major tributaries; (2) intensive studies at all study areas where breeding flycatchers are located to assess southwestern willow flycatcher

[1] Surveys completed in 2010–12 by the Grand Canyon National Park between Diamond Creek and Pearce Ferry resulted in the detection of two flycatchers at River Mile 275 on June 24, 2010. Neither flycatcher was detected on subsequent surveys (Stroud-Settles et al. 2013).

demographics and productivity; and (3) monitoring of habitat and microclimate conditions, including the presence and effects of tamarisk beetles, at selected study areas. Specific components of the 2014 study include:

- **Presence/Absence Surveys**. At pre-selected survey sites along the LCR, conduct presence/absence surveys, following a five-survey protocol (per the USFWS 2000). A portion of the sites is surveyed every 3 years.

- **Site Descriptions**. Provide a general site description, including major types of vegetation and hydrological conditions, for each survey site at least three times during the survey season.

- **Banding and Resighting**. Band as many adult and juvenile flycatchers as possible at sites with territorial flycatchers and resight banded flycatchers to determine their identity.

- **Nest Monitoring**. Search for nests in all areas occupied by territorial flycatchers and monitor all nests to determine nest fate, brood parasitism, and causes of nest failure.

- **Nest Microclimate Studies**. Collect data on surface hydrology at all nest locations and collect data on microclimate at nests that proceeded to the incubation phase at selected study areas.

- **Habitat and Threats Monitoring**. Monitor vegetation and microclimate to determine the timing and effects of tamarisk beetle defoliation in occupied flycatcher habitat at Topock Marsh and Bill Williams River NWR.

These components are addressed in chapters of this report as follows:

Chapter 2 – Presence/Absence Surveys and Site Descriptions. This chapter presents the methodology and results of presence/absence surveys and gives a general description for each survey site.

Chapter 3 – Color Banding and Resighting. This chapter details banding activities and resighting of previously banded flycatchers. Also included are discussions of within- and between-year movement of individual flycatchers.

Chapter 4 – Nest Monitoring. This chapter summarizes nesting attempts, nest fates, and productivity for all southwestern willow flycatcher nesting activity.

Chapter 5 – **Nest Site Characteristics**. This chapter summarizes the conditions of hydrology, temperature, and humidity recorded at nest sites.

Chapter 6 – **Habitat and Threats Monitoring**. This chapter summarizes any threats to willow flycatcher habitat that were noted during the breeding season and reports the results of the monitoring of the presence and effects of tamarisk beetles at Topock Marsh and Bill Williams River NWR.

Chapter 7 – **Management and Study Design Recommendations**. This chapter summarizes recommendations from all previous report chapters for ease of reference.

Chapter 2 – Presence/Absence Surveys and Site Descriptions

INTRODUCTION

Broadcasts of recorded conspecific vocalizations are useful in eliciting responses from nearby willow flycatchers, and multiple broadcast surveys conducted throughout the breeding season are the standard technique for determining the presence or absence of *E. t. extimus* (Sogge et al. 2010). According to Sogge et al. (2010) and the USFWS (2002), willow flycatchers detected between ≈ June 15 and July 20 in the breeding range of *E. t. extimus* probably belong to the southwestern subspecies. However, because northbound individuals of all western subspecies of the willow flycatcher migrate through areas where *E. t. extimus* are actively nesting and southbound migrants occur where *E. t. extimus* are still breeding (Sogge et al. 2010; USFWS 2002), field confirmation of the southwestern subspecies is problematic.[2] For example, the northwestern *E. t. brewsteri*, far more numerous than *E. t. extimus*, has been documented migrating north in southern California as late as June 20 (Garrett and Dunn 1981 as cited in Unitt 1987), and Phillips et al. (1964 as cited in Unitt 1987) documented *E. t. brewsteri* collected in southern Arizona on June 23. An understanding of willow flycatcher migration ecology in combination with multiple broadcast surveys conducted throughout the breeding season is therefore needed to assess the presence and residency of southwestern willow flycatchers.

Migration routes used by *E. t. extimus* are not well documented, though more is known of northbound migration in spring than the southbound migration in fall because flycatchers are more vocal in spring and can therefore be distinguished from other *Empidonax* species. During northbound migration, all subspecies of willow flycatchers use riparian habitats similar to breeding habitat along major river drainages in the Southwest such as the Rio Grande (Finch and Kelly 1999), Colorado River (McKernan and Braden 1999), San Juan River (Johnson and Sogge 1997), and the Green River (M. Johnson, unpublished data). Although migrating willow flycatchers may favor young, native willow habitats (Young and Finch 1997), migrants are also found in both spring and fall in a variety of habitats that are unsuitable for breeding. These migration stopover habitats, even though not used for breeding, are likely important for both reproduction and survival. For most long-distance neotropical migrant passerines, migration stopover habitats are needed to replenish energy reserves to continue northbound or southbound migration.

[2] Throughout this document, the terms "flycatcher" and "willow flycatcher" refer to *E. t. extimus* when individuals are confirmed as residents. For individuals for which residency is undetermined, subspecies is unknown.

In 2014, as part of our contract with Reclamation, we completed multiple broadcast surveys at sites in eight study areas[3] (hereafter Reclamation study areas) along the LCR and its tributaries to detect both migrant and resident willow flycatchers (figure 2-1). We also completed surveys in three additional study areas (hereafter the NDOW study areas) as part of our contract with the NDOW and in one additional study area as part of our contract with the Southern Nevada Water Authority. Per Reclamation's direction, no surveys were conducted in any study area along the Virgin River in 2014, and effort that would have been spent on the Virgin River was redirected to Meadow Valley Wash and Alamo Lake as well as to supplementing survey and monitoring efforts at all the NDOW study areas.

METHODS

Site Selection

Survey sites were selected based on locations surveyed during previous years of willow flycatcher studies on the LCR (McLeod and Pellegrini 2013, 2014) and reconnaissance on foot during the 2014 survey period. Sites consisting of mature native or exotic woody riparian vegetation ≥ 4.5 meters (m) in height with high canopy closure (≥ 85%) and standing water or saturated soil under or adjacent to the vegetation were considered the most suitable habitats for flycatchers (see McLeod and Pellegrini 2013 for a summary of habitat conditions documented in flycatcher territories on the LCR). Early successional stands of young riparian vegetation > 3 m in height in proximity to surface water or saturated soil were also considered potentially suitable flycatcher habitat. Riparian vegetation contiguous with suitable habitat was often included as part of the survey areas. Reclamation biologist Chris Dodge guided and approved survey site selection at the eight Reclamation study areas.

In 2013, a three-tiered geographic naming convention was instituted under the LCR MSCP that designated area, site, and section, with area covering the largest extent and section the smallest. Our designation of "survey site" is equivalent to section. Throughout the history of this project, survey sites have been grouped into "study areas." A study area does not always correspond to an LCR MSCP area; in some cases, a study area encompasses multiple areas, and in others, an area encompasses multiple study areas. The relationship of the new LCR MSCP area and site classifications to the existing designations of survey site and study area is shown in attachment 1. Throughout this report, we continue to use the terminology of survey site and study area for ease of comparison with earlier

[3] Each study area consists of 2–20 survey sites that are grouped geographically (see table 2-1).

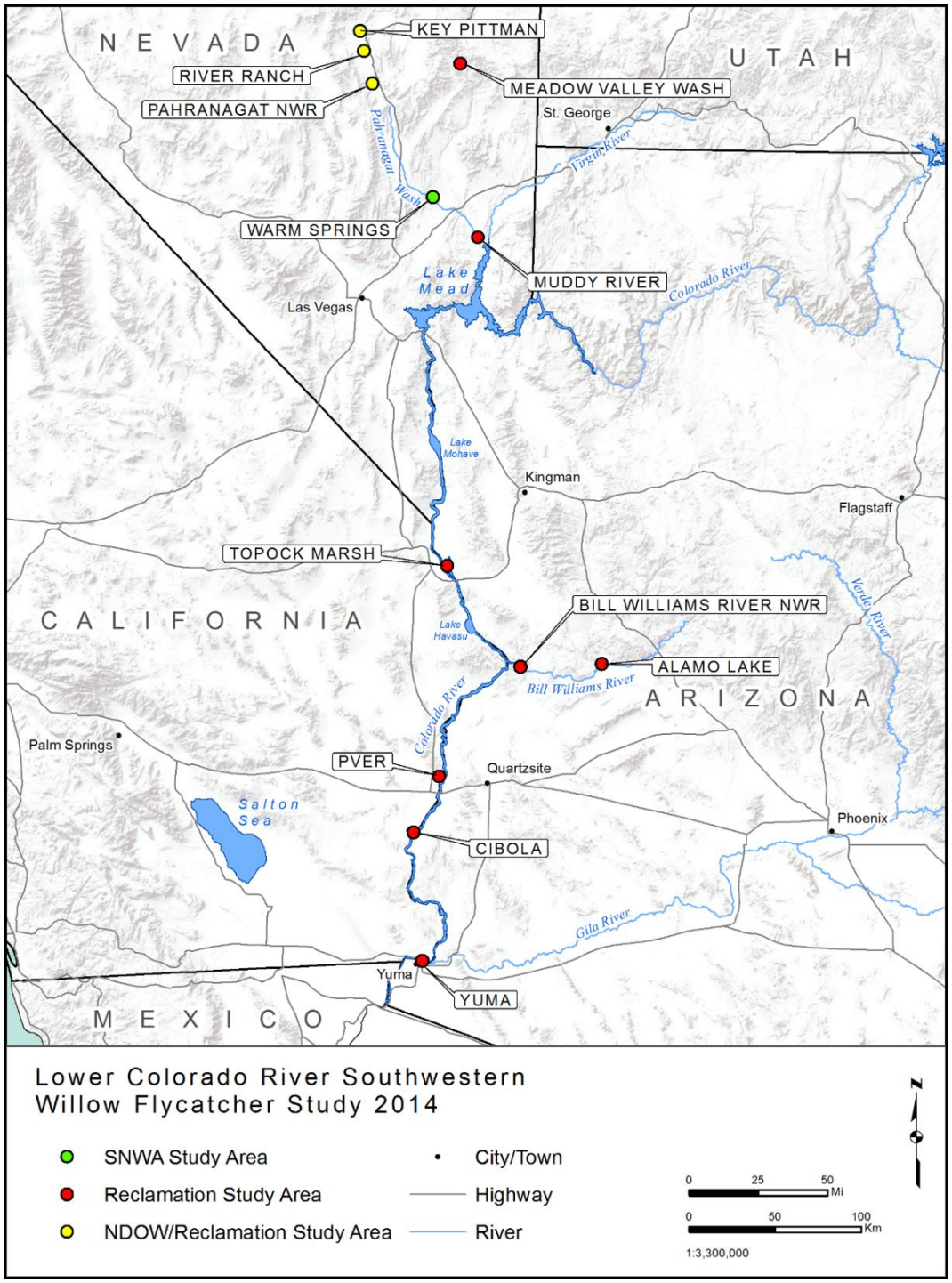

Figure 2-1.—Locations of southwestern willow flycatcher study areas along the LCR and tributaries, 2014.

Note: Study area labels represent the approximate center of multiple sites within that region; see table 2-1.

reports. For most sites surveyed in previous years, we retained the original survey site names; in the few instances where the names were changed, the old name is noted in parentheses.

The majority of survey sites located south of Parker Dam are currently surveyed every 3 years, with the next surveys in 2015. The habitat creation sites, however, are surveyed annually. Survey sites in the Topock Gorge and Bill Williams River NWR study areas that were previously placed on a biennial survey schedule (McLeod and Pellegrini 2013) are also surveyed every 3 years. All sites that are surveyed every 3 years are ones at which resident flycatchers have not been detected in recent years and at which vegetation and hydrology are unlikely to change without a major flood event.

We provided field personnel with high-resolution hard copy and/or digital aerial photographs of all survey sites. Aerial imagery was georeferenced and overlain with an outline of the proposed survey area. If the boundary of a survey site was refined during the season to include potential flycatcher habitat actually present, new boundaries were delineated based on Universal Transverse Mercator (UTM) coordinates obtained in the field. All UTM coordinates were obtained using Trimble® TerraSync™ 5.61 on a Trimble Juno 3B and were in NAD 83 to comply with Federal Geographic Data Committee standards.

Additional Site Evaluation

During the survey season, we conducted on-the-ground habitat reconnaissance and evaluation to locate additional potentially suitable willow flycatcher habitat and to re-evaluate areas we had visited in previous years and had noted as having the potential to become suitable habitat. Field personnel were provided high-resolution, georeferenced aerial imagery overlain with a potential site boundary to aide with navigation and the identification of potentially suitable flycatcher habitat. We focused habitat reconnaissance and evaluation in areas that contained or were adjacent to standing water or saturated soils and that appeared, from visual estimation, to have vegetation characteristics similar to those of flycatcher breeding sites (i.e., canopy height ≥ 4.5 m, dense vegetation within 2–4 m of the ground, and high canopy closure) or that had the potential to develop those characteristics. Broadcast surveys were conducted opportunistically during ground reconnaissance. Field personnel formulated qualitative site descriptions of all evaluated areas.

Broadcast Surveys

To elicit responses from nearby willow flycatchers, we broadcasted conspecific vocalizations previously recorded throughout the Southwest from 1996 to 1998.

All flycatcher surveys were conducted according to methods described in Sogge et al. (2010), and we followed a five-survey protocol as recommended by the USFWS (2000). The five-survey protocol calls for one survey between May 15 and 30, two surveys between June 1 and 24, and two additional surveys between June 25 and July 17. The surveys were separated by a minimum of 5 days whenever logistically possible. Field personnel surveyed within the habitat wherever possible using a Sansa® ClipMP3 player coupled to a Radio Shack 277-1008C mini amplified speaker. The surveyors stopped every 30–40 m and broadcast the willow flycatcher primary song (*fitz-bew*) and calls (*breets*). Field personnel watched for flycatchers and listened for vocal responses for ≈ 1 to 2 minutes before proceeding to the next survey station. If an unidentified *Empidonax* flycatcher was observed but did not respond with song to the initial broadcast, we broadcast other conspecific vocalizations, including *creets/breets*, *wee-oos*, *whitts*, *churr/kitters*, and a set of interaction calls given by a mated pair of flycatchers (per Lynn et al. 2003). These calls are frequently effective in eliciting a *fitz-bew* song, thereby enabling surveyors to positively identify willow flycatchers. All survey data, including survey locations, start and stop times, the number of special concern species detected at each survey point, and the location(s) and behavior of all willow flycatchers detected, were collected in TerraSync 5.61 on a Trimble Juno 3B, allowing a spatial representation of each survey area to be created. Field personnel also recorded the presence of brown-headed cowbirds (hereafter cowbirds) and livestock as requested by the Arizona Game and Fish Department. Cowbirds may affect flycatcher populations by decreasing flycatcher productivity (see chapter 4), while livestock may substantially alter the vegetation in an area (USFWS 2002). Survey data were exported from TerraSync to a Microsoft Access database and were summarized on the standard southwestern willow flycatcher survey form (see attachment 2).

Wherever territorial flycatchers were detected, we discontinued broadcast surveys within a radius of 50 m of territories and commenced territory and nest monitoring, which involved more frequent visits (see chapter 4). In study areas where breeding activity was previously documented (Key Pittman WMA, River Ranch, Pahranagat NWR, Meadow Valley Wash, Muddy River, Warm Springs, Topock Marsh, Bill Williams River NWR, and Alamo Lake), all detections of flycatchers were assigned a unique alphanumeric code and monitored to determine residency status regardless of behavior during the initial detection. If no activity was detected after three visits in the vicinity of the original detection, monitoring visits stopped and surveys resumed. In study areas where no breeding activity has been detected in any year from 2003 to present (Palo Verde Ecological Reserve [PVER], Cibola study area, and the Yuma study area), flycatcher detections were followed up with monitoring visits only if territorial behavior was observed.

Special Concern Species

Incidental, Passive Detections

The Yuma clapper rail (*Rallus longirostris yumanensis*) is listed as federally endangered by the USFWS, and the western population of the yellow-billed cuckoo is listed as threatened. Both species occur along the LCR and its tributaries and are of concern to managing agencies. We did not survey specifically for either of these species at the eight Reclamation study areas but recorded all incidental detections. We also recorded incidental detections of two additional avian species, gilded flicker (*Colaptes chrysoides*) and vermilion flycatcher (*Pyrocephalus rubinus*), which are special concern species under the LCR MSCP. Specific locations and behavioral data for the Yuma clapper rail and yellow-billed cuckoo were recorded in TerraSync 5.61 on a Trimble Juno 3B. We also recorded all incidental detections of these four special concern species at the three NDOW study areas and at Warm Springs.

Yellow-billed Cuckoo Broadcast Surveys

We completed broadcast surveys for yellow-billed cuckoos at the Pahranagat NWR, River Ranch, and Warm Springs. We completed three broadcast surveys at the Pahranagat NWR and River Ranch at 2-week intervals from late June through July, and four broadcast surveys at Warm Springs from late June to early August, following methods described in Halterman et al. (2011).

Site Description

Because vegetation structure and hydrology within riparian habitats are seasonally dynamic, field personnel completed site description forms (attachment 2) for each survey site at least three times throughout the survey season: early season (mid-May), mid-season (mid-June), and late season (mid-July). Vegetation composition (native versus exotic) at the survey sites followed the definitions of Sogge et al. (2010) and the Southwestern Willow Flycatcher Range-Wide Database. Vegetation composition was defined as: (1) native: > 90% of the vegetation at a site was native; (2) exotic: > 90% of the vegetation at a site was exotic/ introduced; (3) mixed-native: 50 to 90% of the vegetation at a site was native; or (4) mixed-exotic: 50 to 90% of the vegetation at a site was exotic/introduced. The information from the site description forms was used in conjunction with habitat photographs and comments in field notebooks and on survey forms to formulate qualitative site descriptions.

RESULTS

Willow Flycatcher Broadcast Surveys

Field personnel spent 398.5 observer hours conducting willow flycatcher broadcast surveys at 87 sites across all study areas. In the Pahranagat Valley, we spent 15.6 observer hours conducting willow flycatcher broadcast surveys at 21 of 23 sites at the NDOW study areas.[4] At Warm Springs, field personnel surveyed two sites for a total of 5.2 observer hours.[5] We spent 377.7 observer hours conducting willow flycatcher broadcast surveys at 64 of 68 sites[6] at Reclamation study areas. Willow flycatcher survey and monitoring results are summarized in table 2-1 and are presented below along with site descriptions. One flycatcher was detected after June 24 at the PVER, but residency status of this individual could not be confirmed. Details of occupancy, pairing, color banding, and breeding are presented in chapters 3 and 4. The boundaries of survey sites and occupancy in 2014 are shown on orthophotos in attachment 3, along with historically occupied habitat.[7] Each site that was not occupied by territorial flycatchers was formally surveyed four or five times, except at Alamo Lake, where no site was surveyed more than twice. A list of survey dates is given in attachment 4, and a summary of willow flycatcher survey efforts and survey site occupancy status is presented in attachment 5. Field personnel spent an additional 9.9 observer hours completing habitat reconnaissance and evaluation and opportunistic surveys. The results of reconnaissance for each study area are presented below following the results for the regularly surveyed sites. Passive, incidental detections of yellow-billed cuckoos and Yuma clapper rails are listed in tables 2-2 and 2-3, respectively. Several incidental detections of yellow-billed cuckoos were recorded during the season at survey sites monitored for cuckoos as part of another LCR MSCP project (Parametrix, Inc., and Southern Sierra Research Station, in prep.); we do not report numbers or locations of those detections in this chapter. Overall numbers of passive detections of all special concern species are listed in attachment 6. Hydrologic characteristics of each survey site are summarized in table 2-4.

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[4] We started the survey season with 21 sites scheduled for surveys in the Pahranagat Valley. Two survey sites were added after they were discovered with breeding flycatchers; neither site was formally surveyed because it was occupied.

[5] We started the survey season with one site scheduled for surveys at Warm Springs. A second survey site was added after reconnaissance revealed that the vegetation had recovered sufficiently from the July 2010 fire.

[6] We started the survey season with 45 sites schedule for surveys. We added 4 sites in Meadow Valley Wash and 19 sites at Alamo Lake following site evaluation. One site at Topock Marsh and three sites at Alamo Lake were not surveyed because they were occupied by flycatchers the entire season.

[7] We defined occupied southwestern willow flycatcher habitat as survey sites where flycatchers were detected after June 24 and before July 20, or where resident or breeding flycatchers were detected regardless of time of year, in any year since 2003. Historically occupied habitat is depicted as the maximum extent of the survey site in any year(s) it was occupied in 2003–13.

Table 2-1.—Adult willow flycatchers detected during survey and monitoring activities, 2014*

Study area[1]	Survey site	Area (ha)	Number detected (date[s] of detection)[2,3,4]
KEPI	Nesbitt Forest	0.2	2 (July 2–27)
	Patch 00	0.03	1 (June 24–July 2)[5]
	Patch 01	0.1	2 (May 27–July 30)
	Patch 02	0.1	3 (May 16 – August 2)
	Patch 03	0.1	1 (May 24 – July 28)[6]
	Patch 04	0.1	2 (May 20 – July 26)
	Patch 04.5	0.04	ND
	Patch 05	0.1	1 (May 5), 1 (May 31), 1 (June 9), 1 (June 16)
	Patch 06	0.2	7 (May 13 – August 2), 1 (June 4)
	Patch 07	0.1	2 (May 13 – August 2)
	Patch 08	0.1	2 (May 29– August 2)
	Patch 09	0.3	7 (May 16 – July 30)
	Patch 10	0.1	2 (May 22 – July 30)
	Patch 10.5	0.02	ND
	Patch 11	0.1	3 (May 16 – August 2)
	Patch 12	0.1	3 (May 8 – August 2), 1 (June 24)
RIRA	East Side	0.4	ND
	West Side	0.3	2 (May 21)
	Smalls	0.2	1 (May 21–25)
PAHR	Pahranagat North	3.2	24 (May 7 – August 14), 1 (August 3)[6]
	Pahranagat West	1.3	ND
	Pahranagat MAPS	0.2	4 (June 7 – July 23), 1 (July 21)[5]
	Pahranagat South	1.4	ND
MVWA	Etna	9.9	ND
	Dog Leg	41.2	3 (June 11 – July 29), 1 (June 18–26)
	Ford	21.0	ND
	Kyle	22.1	ND
	Cottonwood Canyon	20.0	ND
MUDD	Overton WMA Pond	0.6	1 (May 17), 1 (May 25), 1 (June 2–5)
	Overton WMA	7.8	8 (May 21 – August 9)

Table 2-1.—Adult willow flycatchers detected during survey and monitoring activities, 2014*

Study area[1]	Survey site	Area (ha)	Number detected (date[s] of detection)[2,3,4]
WMSP	Muddy Mac	0.5	1 (May 25 – June 5)[7]
	Muddy Stringer 01	0.8	1 (June 11 – July 29)[7]
TOPO	Pipes 01	5.2	ND
	Pipes 03	5.7	1 (May 29)
	The Wallows	0.7	1 (May 18), 1 (May 29), 1 (June 5), 1 (July 16), 1 (July 24)
	PC 6-1	4.8	1 (May 18)
	Pig Hole	2.4	ND
	In Between	7.7	ND
	800M	4.7	ND
	Pierced Egg	6.7	1 (May 20), 1 (May 21), 1 (June 15)
	Swine Paradise	1.0	4 (May 19 – August 7), 1 (July 16)
	Platform	1.9	2 (May 19), 1 (May 29)
	250M	1.9	ND
	Hell Bird	5.8	ND
	Glory Hole	5.0	1 (May 19), 1 (June 9)
	CPhase 05	18.0	1 (May 21 – June 2), 2 (May 21), 1 (May 27)
	Lost Lake	3.3	1 (June 1–17), 5 (May 21)
BIWI	Wispy Willow	1.3	3 (May 29 – July 30), 1 (May 29 – June 16), 1 (May 29), 1 (June 3)
	Site 01	2.4	1 (May 28), 1 (May 28 – June 3), 1 (June 3)
	Burn Edge	4.1	ND
	Site 04	9.9	ND
	Site 03	12.9	2 (June 3 – August 9)
	Site 05	6.8	ND
	Black Rail	1.2	ND
	Cougar Point	1.3	ND
	Upstream from Site 08	1.5	ND
	Planet Ranch Road[8]	3.3	ND

Table 2-1.—Adult willow flycatchers detected during survey and monitoring activities, 2014*

Study area[1]	Survey site	Area (ha)	Number detected (date[s] of detection)[2,3,4]
ALAM[9]	Sidebar 01	1.7	ND
	Camp 01	0.7	2 (May 23 – June 22)
	Camp 04	0.3	1 (June 5 – July 2)
	Camp 02	0.3	ND
	Camp 03	1.9	2 (May 24 – July 10), 1 (July 1–4)
	Middle Earth 01	6.1	8 (May 22 – August 2), 1 (May 22 – June 6)
	Middle Earth 02	6.7	13 (May 22 – July 23), 1 (June 18 and July 4), 1 (May 22)
	Prospect 01	1.1	ND
	Burro Wash 01	3.9	ND
	Burro Wash 02	6.8	ND
	Motherlode 01	3.3	4 (May 22 – July 3)
	Motherlode 02	21.6	4 (May 23 – July 21)
	Motherlode 03	12.6	10 (May 22 – July 10), 1 (May 22)
	Motherlode 04	0.5	2 (May 24 – July 1)
	Confluence 02	15.8	1 (May 24)
	Confluence 01	5.3	ND
	Sandy South 01	14.9	ND
	Santa Maria South 01	30.2	2 (May 25 – July 3)
	Santa Maria North 01	29.5	6 (June 20 – July 22)
PVER	Phase 02	21.4	2 (May 28), 1 (June 10)
	Phase 03	21.4	1 (May 28), 1 (May 29)
	Phase 04 Block 01	7.7	1 (May 28)
	Phase 04 Block 02	4.0	2 (May 28), 2 (June 10)
	Phase 04 Block 03	23.7	ND
	Phase 05 Block 01	14.8	1 (May 29)
	Phase 05 Block 02	23.6	ND
	Phase 05 Block 03	29.6	ND
	Phase 06 Block 01	38.7	4 (May 30), 1 (June 12)
	Phase 06 Block 02	37.6	5 (May 29), 1 (July 7)

Table 2-1.—Adult willow flycatchers detected during survey and monitoring activities, 2014*

Study area[1]	Survey site	Area (ha)	Number detected (date[s] of detection)[2,3,4]
CIBO	Phase 01	26.2	2 (May 30), 3 (June 12)
	Phase 02	25.5	1 (May 30)
	Phase 03	38.4	2 (May 30), 3 (June 12)
	Nature Trail	13.7	1 (May 31), 2 (June 12)
YUMA	J	8.4	4 (May 31)
	South AC	0.8	3 (May 31)
	I	6.4	4 (May 31)

* This table includes only sites where regular surveys were scheduled or where flycatchers were detected and does not include sites where habitat reconnaissance or opportunistic surveys were conducted and no flycatchers were detected.
[1] KEPI = Key Pittman WMA, RIRA = River Ranch, PAHR = Pahranagat NWR, MVWA = Meadow Valley Wash, MUDD = Muddy River, WMSP = Warm Springs Natural Area, TOPO = Topock Marsh, BIWI = Bill Williams River NWR, ALAM = Alamo Lake, PVER = Palo Verde Ecological Reserve, CIBO = Cibola, and YUMA = Yuma study area.
[2] ND = No willow flycatchers were detected.
[3] See chapter 3 for details on territories, residency, pairing, and color banding; see chapter 4 for details on nesting activity.
[4] Flycatchers in territories that were occupied throughout the breeding season are shown as being present throughout the season. Flycatchers detected on a single occasion or for a short period of time are listed separately.
[5] One individual was detected in KEPI Patch 00 from June 24 to July 2 and was resighted at PAHR Pahranagat MAPS on July 21.
[6] One individual was detected in KEPI Patch 03 through July 28 and was resighted at PAHR Pahranagat North on August 3.
[7] One individual was detected in WMSP Muddy Mac through June 5 and was then detected in WMSP Muddy Stringer 01 from June 11 to July 29.
[8] The majority of this survey site lies on private property. All surveys were conducted from the property boundary.
[9] No site was surveyed more than twice at Alamo Lake, and monitoring visits were less frequent than at the other study areas.

Table 2-2.—Passive detections of yellow-billed cuckoo, 2014*

Study area[1]	Survey site	Date(s)	Behavioral observations
KEPI	Patch 12	June 8	One silent individual seen
TOPO	Swine Paradise	June 25	One individual heard (*kuk*)
ALAM	Middle Earth 01	July 10	One individual heard (*kuk*)
	Burro Wash 01	July 1	One individual heard (*coo*)
	Motherlode 01	July 24	One individual heard (*kuk-kowlp*)

* All individuals were detected passively, and no protocol surveys were conducted. These detections indicate presence of the species in a given location but cannot be used to estimate population size or infer absence of the species in other locations. Detections at sites that are monitored for cuckoos as part of another LCR MSCP project are not included.
[1] KEPI = Key Pittman WMA, TOPO = Topock Marsh, and ALAM = Alamo Lake.

Table 2-3.—Passive detections of Yuma clapper rail, 2014*

Study area[1]	Survey site	Date(s)	Behavioral observations
TOPO	Pierced Egg	May 15	One individual heard in marsh south of site (*kek-kek-kek*)
		June 15	Two individuals counter-calling (*kek-kek-kek*)
	Hell Bird	June 9	Two individuals heard (both using *kek-burr* call)
	Lost Lake	May 21	One individual heard (*kek-bur*)
		June 9	Two individuals heard (*kek-kek-kek*)
		June 23	One individual heard (*kek-kek-kek*)
		July 8	Two individuals heard (*kek-kek-kek*)

* All individuals were detected passively, and no protocol surveys were conducted. These detections indicate presence of the species in a given location but cannot be used to estimate population size or infer absence of the species in other locations.

[1] TOPO = Topock Marsh.

Table 2-4.—Summary of hydrologic conditions by survey site, 2014*

Study area[1]	Survey site	Percent of site inundated[2]	Depth (centimeters) of surface water[2]	Percent of site with saturated soil[2,3]	Distance (m) to surface water or saturated soil[2]
KEPI	Nesbitt Forest[4]	–/–/–	–/–/–	–/–/–	–/–/–
	Patches 00-12[5]	40/16/2	30/15/< 5	25/15/10	0/0/0
RIRA	East Side	5/0/0	7/0/0	80/0/0	0/50/50
	West Side	10/60/75	4/5/7	10/10/15	0/0/0
	Smalls	20/100/100	8/5/7	80/0/0	0/0/0
PAHR	Pahranagat North[5]	40/13/1	24/15/3	10/5/1	0/0/0
	Pahranagat West[5]	15/5/2	10/–/5	10/5/2	0/0/0
	Pahranagat MAPS[5]	–/–/–	–/–/–	–/–/–	–/–/–
	Pahranagat South	5/5/5	10/30/15	5/5/3	0/0/0
MVWA	Etna	5/5/5	10/15/10	0/0/5	0/0/0
	Dog Leg	5/20/15	15/10/10	2/10/10	0/0/0
	Ford	10/15/15	20/30/48	5/0/0	0/0/0
	Kyle	10/20/10	20/50/50	10/20/0	0/0/0
	Cottonwood Canyon	15/30/35	15/50/70	5/10/3	0/0/0
MUDD	Overton WMA Pond	3/2/2	6/6/15	5/2/2	0/0/0
	Overton WMA	3/3/3	25/20/60	0/3/3	0/0/0

Table 2-4.—Summary of hydrologic conditions by survey site, 2014*

Study area[1]	Survey site	Percent of site inundated[2]	Depth (centimeters) of surface water[2]	Percent of site with saturated soil[2,3]	Distance (m) to surface water or saturated soil[2]
WMSP	Muddy Mac	10/0/3	15/0/15	5/0/0	0/20/0
	Muddy Stringer 01	5/0/0	10/0/0	5/0/0	0/100/100
TOPO	Pipes 01	0/0/0	0/0/0	0/0/25	40/40/0
	Pipes 03	20/< 1[6]/1[6]	20/12/25	20/0/0	0/0/0
	The Wallows	50/60/40	25/10/15	20/0/0	0/0/0
	PC 6-1	80/< 1[6]/30	20/3/8	0/60/20	0/0/0
	Pig Hole	70/0/0	20/0/0	5/0/0	0/120/120
	In Between[5]	1/0/0	3/0/0	9/0/0	0/20/10
	800M	10/0/0	5/0/0	60/2/7	0/0/0
	Pierced Egg	30/ 1[6]/< 1[6]	7/9/–	0/5/3	0/0/0
	Swine Paradise[6]	10/20/15	40/30/60	1/5/0	0/0/0
	Platform[5]	10/2/2	15/12/10	1/18/1	0/0/0
	250M[5]	0/0/0	0/0/0	1/0/0	0/0/0
	Hell Bird[5]	60/55/60	50/60/50	0/0/0	0/0/0
	Glory Hole[5]	45/40/40	40/40/40	0/0/0	0/0/0
	CPhase 05[7]	6/0/5	15/0/3	1/0/0	0/20/0
	Lost Lake[5]	0/15/< 1	0/30/2	6/18/15	0/0/0
BIWI	Wispy Willow[4]	30/25/30	30/15/12	30/10/0	0/0/0
	Site 01[4]	10/50/30	7/15/6	5/0/10	0/0/0
	Burn Edge	1/< 1/1	24/10/15	0/0/0	0/0/0
	Site 04[4]	30/15/15	75/50/25	0/0/2	0/0/0
	Site 03	0/0/0	0/0/0	5/0/0	0/200/200
	Site 05	3/3/3	–/–/60	0/0/0	0/0/0
	Black Rail	0/0/0	0/0/0	0/0/0	640/640/640
	Cougar Point	0/0/0	0/0/0	0/0/0	180/–/–
	Upstream from Site 08[5]	13/10/–	5/8/–	5/0/–	0/0/–
	Planet Ranch Road[8]	–/–/–	–/–/–	–/–/–	–/–/–

Table 2-4.—Summary of hydrologic conditions by survey site, 2014*

Study area[1]	Survey site	Percent of site inundated[2]	Depth (centimeters) of surface water[2]	Percent of site with saturated soil[2,3]	Distance (m) to surface water or saturated soil[2]
ALAM[9]	Sidebar 01	0/–/–	0/–/–	0/–/–	280/–/–
	Camp 01	0/–/–	0/–/–	0/–/–	10/–/–
	Camp 04	–/–/–	–/–/–	–/–/–	–/–/–
	Camp 02	0/–/–	0/–/–	0/–/–	20/–/–
	Camp 03[3]	0/–/–	0/–/–	0/–/–	0/–/–
	Middle Earth 01	0/–/–	0/–/–	0/–/–	735/–/–
	Middle Earth 02	0/–/–	0/–/–	0/–/–	735/–/–
	Prospect 01	0/0/–	0/0/–	0/0/–	1300/1300/–
	Burro Wash 01	0/–/–	0/–/–	0/–/–	250/–/–
	Burro Wash 02	0/–/–	0/–/–	0/–/–	640/–/–
	Motherlode 01	0/–/–	0/–/–	0/–/–	522/–/–
	Motherlode 02	0/0/–	0/0/–	0/0/–	1120/1120/–
	Motherlode 03	0/–/–	0/–/–	0/–/–	1600/–/–
	Motherlode 04	–/–/–	–/–/–	–/–/–	–/–/–
	Confluence 02	0/0/–	0/0/–	0/0/–	675/675/–
	Confluence 01	0/0/–	0/0/–	0/0/–	150/150/–
	Sandy South 01	0/0/–	0/0/–	0/0/–	450/450/–
	Santa Maria South 01	0/0/–	0/0/–	0/0/–	5/10/–
	Santa Maria North 01	0/0/–	0/0/–	0/0/–	10/25/–
PVER	Phase 02[7]	0/30/0	0/15/0	0/5/0	380/0/380
	Phase 03[7]	0/0/0	0/0/0	0/0/0	20/20/20
	Phase 04 Block 01[7]	0/0/0	0/0/0	0/0/0	50/50/50
	Phase 04 Block 02[7]	0/0/0	0/0/0	0/0/0	20/20/20
	Phase 04 Block 03[7]	2/0/0	2/0/0	0/0/0	0/0/150
	Phase 05 Block 01[7]	0/0/0	0/0/0	0/0/0	30/30/30
	Phase 05 Block 02[7]	0/0/0	0/0/0	0/0/0	35/35/35
	Phase 05 Block 03[7]	70/0/0	15/0/0	0/0/0	0/100/100
	Phase 06 Block 01[7]	8/90/0	5/15/0	2/5/0	0/0/40
	Phase 06 Block 02[7]	60/0/0	10/0/0	5/0/0	0/105/105
CIBO	Phase 01[7]	0/0/0	0/0/0	0/0/0	100/10/100
	Phase 02[7]	0/0/0	0/0/0	0/0/0	460/68/460
	Phase 03[7]	0/60/35	0/25/15	0/0/0	400/0/0
	Nature Trail[7]	1/0/0	2/0/0	0/0/0	0/5/1,770

Table 2-4.—Summary of hydrologic conditions by survey site, 2014*

Study area[1]	Survey site	Percent of site inundated[2]	Depth (centimeters) of surface water[2]	Percent of site with saturated soil[2,3]	Distance (m) to surface water or saturated soil[2]
YUMA	J[7]	35/5/0	–/20/0	0/0/0	0/0/35
	South AC[5]	15/33/0	20/20/0	1/0/0	0/0/20
	I[7]	33/< 1/0	20/20/0	0/0/0	0/0/140

* Values are given for each site as recorded in mid-May, mid-June, and mid-July.
[1] KEPI = Key Pittman WMA, RIRA = River Ranch, PAHR = Pahranagat NWR, MVWA = Meadow Valley Wash, MUDD = Muddy River, WMSP = Warm Springs Natural Area, TOPO = Topock Marsh, BIWI = Bill Williams River NWR, ALAM = Alamo Lake, PVER = Palo Verde Ecological Reserve, CIBO = Cibola, and YUMA = Yuma study area.
[2] – = Hydrologic information not recorded.
[3] Percent of site with saturated soil does not include inundated areas.
[4] Site bordered by a river, lake, or pond.
[5] Site borders a marsh.
[6] Saturated soil or water was present only in pig wallows.
[7] Site is irrigated as part of restoration efforts; the amount of standing water was highly variable throughout the survey season.
[8] Due to property access issues, this site was surveyed from the periphery.
[9] Although site description forms were not completed for many sites in June or July, hydrology data collected at nests (see chapter 5) show that conditions throughout Alamo Lake were unchanged through the breeding season.

Key Pittman Wildlife Management Area, Nevada

The Key Pittman WMA lies at the northern end of the Pahranagat Valley in the town of Hiko, Nevada. It consists of a series of small patches of coyote willow (*Salix exigua*) along the western edge of Nesbitt Lake. Land west of the survey sites is periodically grazed, but the sites have been fenced on the upland side to exclude cattle.

Patches 00–12 and Nesbitt Forest

Area: 1.5 ha Elevation: 1171 m

This study area is divided into 15 small stands (Patches 00–12) of coyote willow plus a small stand (Nesbitt Forest) of Fremont cottonwood (*Populus fremontii*), (hereafter cottonwood). The coyote willow stands form a strip of habitat between bulrush (*Schoenoplectus californicus*) marsh to the east and dry upland scrub dominated by saltbush (*Atriplex* sp.) and grasses to the west. Most of the stands are separate from each other, but four stands (Patches 06–09) have grown together, forming a larger contiguous stand. Each coyote willow stand is characterized by very dense, large-diameter stems. Some areas have fallen or leaning stems with wispy growth in the lower 2 m, making traversing those areas difficult. Canopy height within the coyote willow ranges from 4 to 8 m, with the taller stems occurring in the center of each stand, creating a rounded look. Several stands have large gaps in the canopy, and canopy closure varies from 50 to 90%. The cottonwood stand is at the very southern end of the study area, along the southern end of Nesbitt Lake, and contains 18-m-tall trees planted on either side of an entrance road and along a fence line. The trees on either side of

the entrance road form a stand of vegetation roughly 30 x 60 m in size with 90% canopy closure and little understory. The stringer along the fence line is only one tree wide and has a narrow canopy, with canopy closure around 60%. Surface water and saturated soils were present along the eastern edge of the willow stands during all visits, though lake levels had declined noticeably by July.

We located 29 paired willow flycatchers across 11 of the 16 sites. We also detected six resident, unpaired males and six individuals for which residency status could not be confirmed. Each site was surveyed at least once at the beginning of the season, and 4 of the 15 stands were not occupied for the entire season and were surveyed up to five times, for a total of 3.0 observer hours. Cowbirds were noted during four surveys and throughout the season during nest monitoring activities. Deer were present within the sites but do not appear to heavily impact the vegetation structure.

River Ranch, Nevada

River Ranch is in the Pahranagat Valley, ≈ 12 km south of the Key Pittman WMA, and consists of several isolated patches of vegetation. Each patch is surrounded on all sides by grazed, irrigated cattle pasture, and signs of cattle were noted in each site.

East Side

Area: 0.4 ha Elevation: 1101 m

This survey site is composed primarily of dense, large-diameter coyote willow 6 to 7 m in height. Tree height is shorter at the perimeter, giving the site a rounded appearance. Russian olive (*Eleagnus angustifolia*) and velvet ash (*Fraxinus velutina*) trees occur in low numbers. There are numerous piles of deadfall scattered throughout the site. Little to no understory is present, except where the willow is able to regenerate, and also in some small clearings where herbaceous vegetation dominates. Some wild grape (*Vitis* sp.) also grows in the northwestern corner, creating extremely dense habitat. Canopy closure is primarily 70–90%, except in a few scattered clearings, where it ranges from 25 to 50%. Maximum water extent was recorded in May and included damp to almost saturated soils throughout the site and a ditch of water 1 m wide and 0.2 m deep surrounding the site. No standing water was recorded in or adjacent to the site in June or July, but soils were never completely dry.

No willow flycatchers were detected. We surveyed the site five times, totaling 1.8 observer hours. Cowbirds were detected during two surveys.

West Side

Area: 0.3 ha Elevation: 1101 m

This survey site is composed primarily of dense, large-diameter coyote willow 6 m in height. Shorter coyote willow ≈ 4 m in height is present around the perimeter, giving the site a rounded look. A gap 3 to 5 m wide runs diagonally through the site from the northwestern to the southeastern corner. Some Russian olive trees are scattered along the perimeter of this gap. There is little to no understory, except where willows are regenerating and in the gap, where grasses and other herbaceous plants dominate. Canopy closure is 90% throughout most of the site, except in the gap, where it is ≈ 50%. Areas of deadfall up to 1 m deep are scattered throughout the site, making travel difficult in places. Water levels fluctuated throughout the season depending on irrigation activity, but standing water was noted in the site throughout the season. Maximum water extent included ankle deep, standing water in 75% of the site, with the rest of the site containing either saturated or damp soils. Minimum water extent included dry soils in 20% of the site.

We detected two willow flycatchers, one within the site and another in a small strip of vegetation south-southwest of the site, on May 21, and this site is not considered occupied. We surveyed the site five times, totaling 1.7 observer hours. Cowbirds were detected on two surveys.

Smalls

Area: 0.2 ha Elevation: 1099 m

This survey site is composed primarily of coyote willow 5 m tall. There is little understory except sparse, regenerating willow in the densely vegetated areas. A large gap in the vegetation, totaling ≈ 25% of the site, dominates the northern half of the site. This gap is ringed on the western, northern, and eastern sides by a stand of shorter coyote willow ≈ 4 m in height and 4 m wide. Canopy closure averages 80–90% in the southern half of the site and 65–85% the shorter stands of willow in the northern half. Deadfall is scattered throughout the site but typically does not occur in piles as it does in East Side and West Side. The site was almost completely inundated with gently flowing water throughout the season.

We detected one willow flycatcher on May 21 and 25, and this site is not considered occupied in 2014. We surveyed the site five times, totaling 0.9 observer hour. Cowbirds were detected on three surveys.

Pahranagat National Wildlife Refuge, Nevada

The Pahranagat NWR consists of a series of lakes and marshes in the Pahranagat Valley ≈ 150 km north of Las Vegas, Nevada, and 30 km south of the Key Pittman WMA. Patches of primarily native vegetation exist at the inflow and outflow of Upper Pahranagat Lake and along the lakeshore. Prior to the 2008 survey season, the majority of the riparian vegetation along the northern side of the upper lake (Pahranagat North) was inundated annually with up to 1 m of water, with the highest water levels occurring in May. Major structural problems with the dam that impounds the upper lake resulted in the upper lake being drained in early 2008, and the riparian vegetation at the northern end of the lake was not flooded during the 2008 or 2009 breeding seasons. The dam was repaired prior to the 2010 breeding season, resulting in a limited amount of inundation in May 2010 and in May of each subsequent year. The lake levels in 2014 were similar to those in 2013, which were the highest recorded since the dam was repaired. These levels are still not as high as they had been before 2008.

Pahranagat North

Area: 3.2 ha Elevation: 1020 m

Pahranagat North is a stand of large-diameter Goodding's willow (*Salix gooddingii*) at the inflow of Upper Pahranagat Lake. Cottonwood lines the northern, upland edge of the site and extends in narrow stringers around the edge of the lakebed. Canopy height within the patch is around 20 m. Canopy closure varies from ≈ 80% at the center of the site to ≈ 50% along the site exterior. Many of the large trees in the northeastern section of the site are dead or dying. Scattered cottonwoods have fallen throughout the site, creating multiple small clearings. A dense understory of Indian hemp (*Apocynum cannabinum*) up to 2 m in height is present in the northern half of the site. Very little understory vegetation is present in the southern half of the site due to inundation. Standing water was present throughout the 2014 season in an inflow channel that runs along the northern side of the site and drains into the lakebed at the southeastern corner of the site. Standing water and saturated soils were also present in May within the southern half of the site. The site slowly dried out during the survey season and, except for the inflow channel, only a small area in the southeastern corner of the site contained saturated soils by the middle of July.

Pahranagat North was occupied by 22 breeding willow flycatchers and 2 resident, unpaired males. In addition, we detected one flycatcher for which residency status could not be determined. The site lies immediately adjacent to a cattle pasture, and a lack of fencing coupled with low lake levels allowed cattle to access the site periodically in the latter half of the breeding season. We surveyed

unoccupied portions of the site five times, totaling 3.0 observer hours. No cowbirds were detected during surveys, but they were noted during monitoring activities.

Pahranagat West

Area: 1.3 ha Elevation: 1,023 m

This native survey site consists of a stringer of cottonwood, one-to-three trees wide and 20 m in height, on the western edge of Upper Pahranagat Lake. A few Goodding's willows 10 m in height are present in the northern half of the site. The site has no significant understory vegetation, and canopy closure varies from < 50 to 90%. The eastern edge of the site is vegetated with bulrush, which extends into the lakebed. The western edge of the site is vegetated in yerba mansa (*Anemopsis californica*) extending into dry, upland desert. During the survey season, the interior of the site was dry, but surface water was present adjacent to the site in the lakebed.

No flycatchers were detected. We surveyed the site five times, totaling 2.4 observer hours. Cowbirds were detected on one survey, and some signs of cattle use were noted, but it is unclear if the signs were from this year or last.

Pahranagat MAPS

Area: 0.2 ha Elevation: 1022 m

Pahranagat MAPS is a stringer of cottonwood on the southwestern edge of the bed of Upper Pahranagat Lake. The majority of this survey site was affected prior to the start of the 2010 survey season by a fire that significantly damaged the majority of the trees in the southern half of the site. Surveys at this site were discontinued due to the lack of suitable vegetation structure in the remaining portion of the site. This site was first visited in 2014 in early June after personnel from an unrelated field crew reported hearing willow flycatchers on multiple occasions. The area we surveyed prior to the fire still lacks suitable structure and consists of a stringer of cottonwood 12–15 m in height, with canopy closure reaching 70% in the unburned northern half of the site but only 30% in the damaged southern half. Little to no understory other than grass is present. Soils were damp throughout the tall cottonwoods during a visit in early June.

There are three tiny (no larger than 15 x 15 m) patches of regenerating cottonwood located in the marsh to the east of the original survey site, and all contained resident or breeding flycatchers in 2014. Each patch of cottonwood contains dense, small-diameter stems up to 5 m in height with 85–95% canopy closure. The regeneration is occurring on hummocks of land where mature cottonwoods were located prior to the fire, as indicated by the presence of a

large-diameter snag in each patch. Soils within each patch were damp in early June, and each patch was surrounded by inundated bulrush marsh up to 50 centimeters (cm) deep.

Pahranagat MAPS was occupied by three breeding willow flycatchers and one resident, unpaired male. We also detected one individual for which residency could not be determined. The suitable areas of this site were occupied throughout the season, and no surveys were conducted. No signs of livestock were noted during a visit in early June.

Pahranagat South

Area: 1.4 ha Elevation: 1025 m

Vegetation within this survey site consists of a stringer of cottonwood, 20 m tall, along a human-made channel that carries the outflow from Upper Pahranagat Lake. The understory contains mostly Indian hemp, yerba mansa, cattails (*Typha* sp.), and bulrush. Canopy closure within the cottonwood stringer is ≈ 50%. Two small (10- x 40-m) patches of coyote willow 3–4 m in height are present near the center of the site. Canopy closure within these patches is > 90%, and stem density is extremely high, creating very tangled vegetation. A third patch of coyote willow 15 x 40 m in size and 4–5 m in height is present at the northern end of the site. This patch contains young, small-diameter stems, and canopy closure does not exceed 80%. Saturated and inundated soils were present in the northern coyote willow patch in May. The channel held water throughout the season, and soils immediately adjacent to the channel were saturated; with the exception of the northern coyote willow patch, soils in the remainder of the site were dry.

No willow flycatchers were detected. We surveyed the site five times, totaling 2.8 observer hours. Cowbirds were detected on four surveys, and no signs of livestock use were noted.

Meadow Valley Wash

Meadow Valley Wash flows south from Caliente, Nevada, through a narrow valley known as Rainbow Canyon and past Elgin, Nevada. We last surveyed in this area in 2003. At the end of the 2003 season, we determined that there was no suitable habitat, and surveys were discontinued. Habitat within the valley consists of narrow bands of native vegetation along a perennial stream. The water is ponded in several places due to beaver activity and is also subsurface in several locations. Habitat within the wash is dynamic, as scouring floods occur regularly. In 2014, we conducted reconnaissance at six new survey sites, four of which we surveyed. We also surveyed a fifth site where NDOW personnel had detected resident flycatchers in 2013. A tree-like willow species that did not resemble

Goodding's willow was noted in several survey sites but was not identified to species. This willow species had leaves that were proportionately wider, with a glossier dark green upper surface and noticeably more glabrous underside than those of Goodding's willow; twigs were also noticeably redder. A researcher not associated with this project collected a sample of willow in 2014 within 1 km of Etna and identified it as red willow (*Salix laevigata* Bebb) (Southwest Environment Information Network 2014).

Etna

Area: 9.9 ha Elevation: 1282 m

Etna is located ≈ 7 km downstream from Caliente. This survey site consists of a narrow patch of habitat ≈ 25 m wide and 200 m long. The dominant vegetation consists of an unidentified tree-like willow species 8–10 m in height with several small clumps of 3–4-m-tall coyote willow. Canopy closure within the willow ranges up to 85%. A shallow stream 2–5 m wide runs through the site and held standing water throughout the season. The banks of this stream are incised 1 to 1.5 m high, and most soils away from the stream were dry.

No willow flycatchers were detected. We surveyed the site five times, totaling 1.9 observer hours. A cowbird was detected on one visit, and signs of horses were noted on all but one survey.

Dog Leg

Area: 41.2 ha Elevation: 1207 m

This survey site is located ≈ 8 km downstream from Etna. The dominant vegetation consists of coyote willow 5–6 m in height with scattered, emergent cottonwood and an unidentified willow 8 m in height. Some velvet ash and tamarisk (*Tamarix* spp.) 5 m in height are scattered throughout the site. Canopy closure varies from 40 to 90%. The densest habitat is in the west central portion of the site, with canopy closure of 80–90%. Habitat in the southern end of the site and along the very eastern edge is generally very sparse and open, with a 5-m-tall canopy and 40–60% canopy closure. Standing water was present throughout in the survey season in the western half of the site in the form of a narrow stream that was braided in places and flowed through a small cattail marsh and several small beaver ponds. Soils away from the stream were damp to dry.

Dog Leg was occupied by three breeding flycatchers and one resident, unpaired male. We surveyed the site five times, totaling 13.6 observer hours. One cowbird was detected on one visit, and signs of horses were observed during every visit.

Ford

Area: 21.0 ha Elevation: 1119 m

Ford is located ≈ 7 km downstream from Dog Leg. Vegetation within the site consists primarily of 12-m-tall cottonwood with coyote willow 3–5 m in height. Cottonwood makes up the dominant overstory in the northern three-quarters of the site; cottonwood is lacking in the southern quarter, and coyote willow forms the dominant overstory. A few unidentified willow trees 8–10 m in height are scattered throughout the site. Canopy closure is variable and ranges from 50 to 90%, with the densest canopy closure found in some areas of cottonwood. Standing water was present throughout the season in the form of a flowing stream up to 15 m wide. Soils away from the stream were largely dry and sandy.

No willow flycatchers were detected. We surveyed the site five times, totaling 2.9 observer hours. No cowbirds were detected, and no signs of livestock use were observed.

Kyle

Area: 22.1 ha Elevation: 971 m

Kyle is located ≈ 13 km downstream from Ford. This survey site consists primarily of cottonwood and velvet ash 8–10 m in height with scattered patches of coyote willow 3–4 m in height in the understory. Some taller, unidentified willow trees up to 8 m in height are scattered throughout the site. A stream 1–4 m wide bisects the site from east to west. North of the stream, the canopy consists mostly of taller trees with very little understory. One clump of cottonwoods in the north-central portion of the site reaches 15 m in height. South of the stream, coyote willow is more prevalent in the understory. Canopy closure is variable, ranging from 60 to 90%, and is generally denser north of the stream under the taller cottonwoods. Surface water was present in the stream throughout the season. Soils away from the stream were largely dry and sandy.

No willow flycatchers were detected. We surveyed the site five times, totaling 2.7 observer hours. A cowbird was detected on one visit, and old signs of cattle were noted during two visits.

Cottonwood Canyon

Area: 20.0 ha Elevation: 940 m

Cottonwood Canyon is located ≈ 2.5 km downstream from Kyle, near the confluence of Meadow Valley Wash and Cottonwood Canyon. This site is bisected by a flowing stream that is ponded due to beaver activity on the western

end of the site. South of the stream, vegetation consists of a 10-m-tall cottonwood overstory, with coyote willow and baccharis (*Baccharis* sp.) 3–5 m in height in the understory. The very southwestern corner of the site is dominated by 5–6-m-tall tamarisk. The far eastern portion of the site is dominated by coyote willow and an unidentified willow species 4–5 m in height. Vegetation north of the stream is primarily shorter cottonwood and coyote willow, with some honey mesquite (*Prosopis glandulosa*). Canopy closure ranges from 50 to 95% and is densest in the tamarisk and most open in the eastern willow patch. Canopy closure is also generally higher south of the stream than north of the stream. The stream held water throughout the season, but soils away from the channel were dry and sandy.

No willow flycatchers were detected. We surveyed the site five times, totaling 3.9 observer hours. No cowbirds were detected, but signs of cattle, including two carcasses, were noted on several visits.

Ground Reconnaissance Results

East Stine

East Stine is located ≈ 1.5 km upstream from Dog Leg. It consists of a stand of cottonwood and unidentified willow 15–18 m in height. Coyote willow up to 7 m in height is present in the understory in the western half of the site. Most of the coyote willow is dead as is parts of the upper canopy in the western half of the site. Canopy closure varied from 70% in the western half to 90% in the eastern half of the site. All soils within the site were completely dry, and the nearest water was in a downcut channel ≈ 35 m away.

No flycatchers were detected during the visit in May. We surveyed the site once, totaling 0.5 observer hour. We do not recommend surveying this site again due to the lack of surface water and stressed or dead vegetation.

West Stine

West Stine is located 150 m west of East Stine. The survey site consists of cottonwood and unidentified willow 12 m in height, with patches of coyote willow 7 m in height in the understory. Overall, the vegetation structure looked suitable, despite the coyote willow being mostly dead or very spindly. Canopy closure ranged from 80 to 90%. Soils were very dry with a loose, sandy texture during a visit in May. The nearest noted water was in an incised channel ≈ 100 m to the east.

No flycatchers were detected during the visit in May. We surveyed the site once, totaling 0.3 observer hour. We do not recommend surveying this site again due to the lack of surface water.

Muddy River, Nevada

The Muddy River study area is along the Muddy River in the Overton WMA near Overton, Nevada. Tamarisk in this study area was defoliated throughout the summer of 2012, and a reduction in live tamarisk canopy was evident in some areas in 2013. Large numbers of tamarisk beetle larvae were noted in mid-May 2014, and extensive defoliation was noted on the perimeter of the survey sites by early June and in the interior of the sites by early July.

Overton WMA Pond

Area: 0.6 ha Elevation: 380 m

This survey site consists of a patch of mixed-native vegetation ≈ 150 m long and 75 m wide at the northern end of the Overton WMA just south of Honeybee Reservoir. The dominant vegetation consists of Goodding's willow 15–20 m in height, with a sparse 5–7-m-tall tamarisk understory. Arrowweed (*Pluchea sericea*) and common reed (*Phragmites australis*) are present in scattered, dense patches within and along the edges of the site. Canopy closure is variable, ranging from 60 to 90%. Yerba mansa covers the ground in areas with lower canopy closure. A channel that looks recently dug bisects the site from north to south. Standing water was present in the channel throughout the season, and some shallow, flowing water was noted in the northeastern corner of the site in May. Soils were largely damp away from the channel.

We detected three willow flycatchers for which residency status could not be confirmed. These individuals were detected on May 17, May 25, and June 2–5, respectively, and this site is not considered occupied in 2014. We surveyed the site five times, totaling 2.4 observer hours. Cowbirds were detected on two visits, and no sign of livestock use was observed.

Overton WMA

Area: 7.8 ha Elevation: 375 m

This survey site consists of a 150-m-wide strip of riparian vegetation along both sides of the Muddy River. The site is bordered to the southwest by open agricultural fields and to the northeast by sparser areas of riparian vegetation. The northern two-thirds of the site is dominated by very dense tamarisk up to 7 m in height, with canopy closure ranging from 50 to 85%. The tamarisk is tallest adjacent to the river channel on the eastern bank, with height and density decreasing with distance from the channel. Additionally, much of the tamarisk in this portion of the site is heavily damaged from previous years' defoliation. The level of damage (and canopy reduction) resulting from defoliation increases with distance from the river channel. Several small patches of coyote willow 5–6 m in height are present on the eastern bank of the river near the center of this portion of

the site. Canopy closure is 70–90% in the coyote willow. Two stretches of the channel of the Muddy River within this portion of the site were dredged with heavy equipment over the 2007–08 winter, resulting in a cleared swath 10–15 m wide on the western bank of the river. This swath is now vegetated with quailbush (*Atriplex lentiformis*), Emory baccharis (*Baccharis salicina*), and tamarisk 2–3 m in height. The river channel in the northern two-thirds of the site is incised 1–2 m below the surrounding land surface and contained flowing water throughout the survey season. Soils outside the channel were dry throughout the survey season.

The southern portion of the site consists primarily of a stand of Goodding's willow 10–15 m in height, with an understory of tamarisk and cattail. Some coyote willow up to 6 m in height and Emory baccharis are also present. Canopy closure in the southern portion ranges from 50 to 90%. Beavers have felled swaths of Goodding's willow in the southern portion of the site, resulting in gaps in the canopy. The channel of the Muddy River flows into the northern end of this portion of the site and then splits into two channels, one which runs through the site and another that skirts the southwestern edge of the site. In 2005, the channel through the site was dredged, and ≈ 0.3 ha was bulldozed as part of the Overton WMA efforts to repair flood damage to their water control system. This dredged channel carried water through the southern part of the site in subsequent years but slowly filled in with sediment and cattails. By 2013, water no longer flowed through the area but rather flowed only in the channel along the southwestern boundary of the site. Over the 2013–14 winter, the NDOW, in cooperation with Partners in Conservation, Great Basin Institute, Nevada Conservation Corps, and the Walton Family Foundation, created a sandbag structure at the point where the two channels diverged to direct the water back into the center of the site. The diversion worked for ≈ 1 week, after which the sandbag structure was breached, and water once again flowed only in the channel along the southwestern boundary of the site. This channel is incised, and all soils outside of the channel were dry throughout the season.

The Overton WMA was occupied by eight breeding willow flycatchers. No flycatchers were detected in the southern portion of the Overton WMA; all flycatchers were detected in the northern portion. Portions of the site not known to be occupied by flycatchers were surveyed five times, totaling 17.4 observer hours. Cowbirds were detected on all surveys, but no signs of livestock were observed.

Warm Springs Natural Area

On July 1, 2010, a wildfire burned at least part of every survey site at Warm Springs. Due to the severity of fire damage, surveys were discontinued after the fire at all sites except one.

Muddy Mac

Area: 0.5 ha Elevation: 536 m

This native survey site lies near the head of Apcar Stream. The northern portion of the former site was heavily damaged in the 2010 fire, with the overstory being completely killed. Dense basal regeneration of velvet ash is occurring, and live vegetation is now at least 3 m in height. We did not survey this northern portion but recommend reconnaissance in 2015. The eastern half of the survey area is characterized by a very dense velvet ash stand 4–7 m in height, with no understory, and up to 95% canopy closure. Canopy closure in the eastern half is slightly lower (70–80%) along the southern edge of the site. The western half is dominated by sparse velvet ash ≈ 12 m in height, with 50% canopy closure due to a damaged canopy that is two-thirds leafless. There is a regenerating 4–5-m-tall velvet ash understory in this portion. The area immediately south of the site has been cleared as part of a restoration effort. Surface water was present in the very southern portion of the site in May but by July was limited to a cattail marsh on the southern edge of the site.

This site was occupied by an unpaired male. This male moved after June 5 and established a second territory in Muddy Stringer 01. We surveyed the site five times, totaling 2.9 observer hours. Cowbirds were detected on two surveys, and no evidence of livestock was observed.

Muddy Stringer 01

Area: 0.8 ha Elevation: 532 m

Muddy Stringer 01 was last surveyed in 2010. Most of this survey site was heavily burned in the July 1 fire. The very southwestern corner of the site was unburned, but the leaves appeared dead from proximity to high heat. We reassessed the site at the beginning of 2011, 2012, and 2013 and found that while it was still damaged and unsuitable, the coyote willow in the southern portion of the site was regenerating. We reassessed this site in 2014 and determined that the coyote willow had regenerated enough to resemble suitable habitat.

This site contains two distinct portions: a narrow, linear northern arm and a bulbous southern end. Both portions of the site contain a stringer of palm trees (*Washingtonia* sp.) along an irrigation canal. The northern arm of the site contains the highest structural heterogeneity, consisting mostly of widely spaced palm trees, with scattered clumps of vegetation in the understory. At the very northern end of site is a small clump of coyote willow ≈ 10 x 50 m in size, reaching 4 m in height and 80% canopy closure. The southern end of the site is more densely vegetated, with a mosaic of young coyote willow and velvet ash 4–6 m in height surrounding the palm trees. The southwestern portion of the site contains a stand of coyote willow roughly 50 x 45 m in size, reaching 5–6 m in

height, with 80–90% canopy closure. This southwestern portion of the site is the most suitable for willow flycatchers. The southeastern portion of the site contains a mix of 6-m-tall velvet ash, tamarisk, and honey mesquite, with 80% canopy closure. Some cattails are present along the eastern edge of the site. Standing water was present in the channel in May, but by June, all soils were damp.

This site was occupied by an unpaired male from June 11 to July 29. This male moved from a previously established territory at Muddy Mac. We surveyed this site five times, totaling 2.2 observer hours. Cowbirds were detected on all surveys, and no evidence of livestock was observed.

Topock Marsh, Arizona

Topock Marsh lies within the Havasu NWR and encompasses over 3,000 ha of open water, cattail and bulrush marsh, and riparian vegetation. A large expanse (over 2,000 ha) of riparian vegetation occupies the Colorado River flood plain between the Colorado River on the western edge of the flood plain and the open water of Topock Marsh on the eastern edge of the flood plain. The vegetation is primarily monotypic tamarisk with isolated patches of tall Goodding's willow. Seasonally wet, low-lying areas are interspersed throughout the riparian area. Marsh elevation data collected at the South Dike gaging station show that water levels within Topock Marsh were ≈ 0.2 foot higher throughout the 2014 breeding season than they were on the corresponding day in 2013. Feral pigs are present throughout the Topock Marsh study area, and evidence of pigs was observed in most survey sites.

Pipes 01

Area: 5.2 ha Elevation: 140 m

This exotic survey site is bordered to the east by the refuge road and consists primarily of monotypic tamarisk 6–8 m in height. Arrowweed occurs in dense patches within 50 m of the road. The tamarisk is densest and tallest within 100 m of the road; vegetation is 7–8 m in height, and canopy closure is 80–95%. The tamarisk becomes shorter (6–7 m tall) and more open (70–85% canopy closure) toward the western edge of the site. Deadfall is scattered throughout the understory in clumpy patches. The site contained no standing water during the survey season, but saturated soils from recent rain storms were noted in July.

No willow flycatchers were detected. We surveyed the site five times, totaling 9.0 observer hours. Cowbirds were detected on four surveys.

Pipes 03

Area: 5.7 ha Elevation: 139 m

This survey site is bordered to the east by the refuge road. Arrowweed occurs in dense patches within 50 m of the road. Most of the site is vegetated by tamarisk 5–7 m in height. The southern portion of the site has a few emergent Goodding's willows up to 15 m in height and open areas with marsh vegetation. Canopy closure ranges from 70 to 95%. The southwestern portion of the site held standing water surrounded by saturated soils in May, but by June, the only standing water present was in pig wallows. Soils in the rest of the site were dry throughout the season.

We detected one willow flycatcher on May 29 for which residency status could not be confirmed, and this site is not considered occupied in 2014. We surveyed the site five times, totaling 7.3 observer hours. Cowbirds were detected on all surveys.

The Wallows

Area: 0.7 ha Elevation: 139 m

The Wallows is primarily vegetated by tamarisk 5–7 m in height, with emergent Goodding's willow on the western side of the site. The Goodding's willow surrounds an open cattail marsh, which dominates the southwestern corner of the site. The eastern side is dry and grades from 2-m-tall arrowweed along the refuge road to tamarisk in the center of the site. Overall canopy closure ranges from 50% in the marshy area to 90% in the tamarisk. The open marsh held standing water through late June and again in early July following heavy rain. Soils away from the marsh and under the tamarisk were dry.

We detected single individuals on May 18, May 29, June 5, July 16, and July 24, and The Wallows is considered occupied in 2014. We surveyed the site five times, totaling 2.4 observer hours. Cowbirds were detected on four surveys.

PC 6-1

Area: 4.8 ha Elevation: 139 m

PC 6-1 is a mixed-exotic survey site. The northern half of the site consists primarily of tamarisk 6 m in height, while the southern half is more heterogeneous with several large patches of arrowweed 1–2 m in height and a scattered overstory of Goodding's willow ≈ 10–15 m in height mixing with the tamarisk. A portion of the site within ≈ 50 m of the refuge road contains thick stands of arrowweed. Canopy closure in the interior of the site averages 90%, while canopy closure on the periphery of the site near the refuge road is ≈ 50%. Approximately

three-quarters of the site was inundated in mid-May, but only saturated soils and pig wallows remained in the middle of the site by mid-June. In early July, ≈ one-third of the site was covered in shallow pools of standing water from recent heavy rains.

We detected one willow flycatcher on May 18, and PC 6-1 is not considered occupied. The site was surveyed five times, totaling 8.3 observer hours. Cowbirds were detected on four surveys.

Pig Hole

Area: 2.4 ha Elevation: 139 m

Pig Hole consists of monotypic tamarisk 6–8 m in height, with canopy closure ranging from 70 to 90%. Tamarisk along the northern edge of the site has many wispy branches and smaller-diameter stems than in the rest of the site. A few dense patches of arrowweed are present on the eastern edge. Standing water covered ≈ two-thirds of the site in May, but the site contained only damp soils by mid-June.

No willow flycatchers were detected. The site was surveyed five times, totaling 3.8 observer hours. Cowbirds were detected on four surveys.

In Between

Area: 7.7 ha Elevation: 139 m

In Between consists of monotypic tamarisk 6–8 m in height. The lowest 3 m of the stand generally lacks foliage, resulting in a relatively open understory. Canopy closure is 80–90% and is lowest in the northeastern portion of the site. The western edge of the site borders a marsh. The site was mostly dry throughout the season, with a small area of inundated and saturated soils noted in the center of the site in May. This area quickly dried, and almost the entire site was dry in mid-June. Standing water and/or saturated soil was found throughout the season in the marsh along the western border of the site.

No willow flycatchers were detected. We surveyed the site five times, totaling 8.1 observer hours. Cowbirds were observed on all surveys.

800M

Area: 4.7 ha Elevation: 139 m

800M adjoins the western edge of In Between, and the eastern half of the site consists of a cattail and bulrush marsh with clumps of tamarisk 5–7 m in height

and a few scattered, emergent Goodding's willows. The remainder of the site is vegetated by tamarisk 4–7 m in height. Canopy closure in the tamarisk is generally > 90%, except on the western edge of the site, where it drops to 70%. Canopy closure in the marsh is around 60%. Some standing water was present in the marsh in May, but only small pockets of saturated soils remained by June. The rest of the site was dry throughout the season.

No willow flycatchers were detected. The site was surveyed five times, totaling 5.6 observer hours. Cowbirds were observed on all surveys.

Pierced Egg

Area: 6.7 ha Elevation: 140 m

This mixed-exotic survey site borders the western edge of 800M and consists of dense tamarisk 7 m in height, with scattered emergent Goodding's willows 15 m in height. Areas with willows tend to have a more open understory and contain patches of cattail and bulrush. Overall canopy closure is ≈ 80% throughout the majority of the site, lowering to 70% along the eastern edge. Some areas of inundated and saturated soils were noted in May in the southern, central, and northeastern portions of the site, totaling about 30% of the site. By June, the only standing water present was in pig wallows, with some saturated soils noted in a small bulrush marsh in the south-central portion of the site. Soils elsewhere in the site were generally damp, with dry soils noted throughout the season along the border with 800M.

We detected one flycatcher on May 20, one on May 21, and one on June 15, and the site is not considered occupied. We surveyed the site five times, totaling 8.9 observer hours. Cowbirds were observed on four surveys.

Swine Paradise

Area: 1.0 ha Elevation: 140 m

This mixed-exotic survey site is bisected by the firebreak canal. Vegetation on the northern side of the canal was not formally described but contains coyote willow bordered by tamarisk to the north and west and cattail marsh to the east. Vegetation south of the canal consists of tamarisk 6–8 m in height and scattered, emergent Goodding's willows up to 15 m in height. A dense, 25- x 60-m patch of coyote willow 3–6 m in height is present in the northeastern corner of the southern portion of site, adjacent to the firebreak canal. Large patches of arrowweed dominate the understory in the southern half of the site. Canopy closure ranges from 85 to 95% in the monotypic tamarisk and under the Goodding's willows and ranges from 70 to 90% in the coyote willow, with

shorter coyote willow also being more open. The coyote willow patches on either side of the canal were inundated throughout the season, but the remainder of the site was dry.

Swine Paradise was occupied by four breeding flycatchers. We detected one additional individual for which residency status could not be confirmed. Due to occupancy status, this site was not surveyed.

Platform

Area: 1.9 ha Elevation: 139 m

This survey site lies between the main refuge road to the west and open bulrush and cattail marsh to the east. Vegetation at the site consists of tamarisk 8 m in height with a few emergent Goodding's willows. A few screwbean mesquite trees (*Prosopis pubescens*) are present along the northwestern edge and in the center of the site. A narrow line of 5-m-tall coyote willow ≈ 5 m wide runs along the eastern edge near the center of the site. This coyote willow is expanding at the northern end of its extent and now covers an area ≈ 30 x 40 m. Overall canopy closure is ≈ 90%. Soils within the site were very dry throughout the survey season, except for on the very eastern edge bordering the marsh, which was inundated to saturated throughout the season.

We detected two willow flycatchers on May 19 and one on May 29, and the site is not considered occupied. The site was surveyed five times, totaling 2.2 observer hours. Cowbirds were detected on four surveys.

250M

Area: 1.9 ha Elevation: 139 m

This survey site lies between the main refuge road to the northwest and open marsh to the northeast and southeast. Vegetation composition and structure varies with distance from the marsh. Closest to the refuge road, the site is dominated by mesquite trees (*Prosopis* sp.) with an understory of arrowweed. The center of the site is dominated by tamarisk ranging from 3 to 4 m in height near the refuge road to 6 to 7 m in height near the marsh. Closest to the marsh, the site contains a few emergent Goodding's willows ≈ 12 m in height. A patch of coyote willow 45 x 90 m in size is present along the northeastern edge of the site. Canopy closure ranges from 60 to 90% and is most dense on the marsh side of the site. A tiny pocket of saturated soil was noted during a visit in mid-May, but soils were otherwise very dry throughout the season. No more than one-third of the site contained damp soils at any given time.

No willow flycatchers were detected. The site was surveyed five times, totaling 3.4 observer hours. Cowbirds were detected on one survey.

Hell Bird

Area: 5.8 ha Elevation: 139 m

This mixed-exotic survey site is located on an island separated from the main riparian area by a narrow, deep channel. Vegetation composition and structure are highly variable, with the survey area vegetated primarily by a mosaic of tamarisk 6–8 m in height and Goodding's willow 15 m in height. Screwbean mesquite trees 4–6 m in height are also scattered throughout the site. Canopy closure ranges from 50 to 90%. The survey area is bordered to the north by the open channel and to the east and south by marshes. Marshes vegetated by cattail and bulrush are also interspersed throughout the site. The marshes, totaling ≈ 50% of the areal extent of the site, were inundated to 60 cm in depth throughout the season. Adjacent soils were generally dry.

No willow flycatchers were detected. The site was surveyed five times, totaling 5.5 observer hours. Cowbirds were detected during all surveys.

Glory Hole

Area: 5.0 ha Elevation: 140 m

This mixed-exotic survey site is contiguous with Hell Bird and is located immediately to the southwest. Vegetation composition and structure are highly variable, with the survey area vegetated primarily by a mosaic of tamarisk 6–8 m in height and Goodding's willow 15 m in height. Screwbean mesquite trees 9–10 m in height are also scattered throughout the site. Canopy closure ranges from 50 to 90%. The survey area is bordered on the north by a sand dune and on other sides by a mix of woody vegetation and marshes. Marshes vegetated by cattail and bulrush are interspersed throughout the site. The marshes, totaling ≈ 40% of the areal extent of Glory Hole, were inundated to 50 cm in depth throughout the season. Adjacent soils were generally dry.

We detected one willow flycatcher on May 19 and one on June 9, and the site is not considered occupied. We surveyed this site five times, totaling 7.0 observer hours. Cowbirds were detected during all surveys.

CPhase 05 (Formerly Beal Lake)

Area: 18.0 ha Elevation: 140 m

This native restoration site consists of a mosaic of cottonwood, Goodding's willow, coyote willow, mesquite, and arrowweed, with some tamarisk scattered throughout the site. Canopy height is highly variable and averages ≈ 3–4 m over most of the site and up to 15 m in the cottonwood stands. Canopy closure is sparse and averages 35%, reaching 95% in the cottonwood stands. The amount of standing water and saturated soil is highly variable because the site is flood irrigated. Sandy soil at the site allows the water to drain rapidly after irrigation.

We detected one willow flycatcher in the same general area on three consecutive visits from May 21 to June 2. We did not observe any territorial behaviors or any bands on this bird, making it impossible to confirm that the bird detected on each visit was the same individual, but because it was detected in the same area on each visit over a span of more than 7 days, it is considered resident, and the site is considered occupied in 2014. We also detected two additional willow flycatchers on May 21 and one flycatcher on May 27 for which residency status could not be confirmed. Portions of this site not known to be occupied were surveyed five times, totaling 10.1 observer hours. Cowbirds were detected on all surveys.

Lost Lake

Area: 3.3 ha Elevation: 140 m

This site consists of a narrow (< 100-m-wide) strip of riparian vegetation separated from the Colorado River to the southwest by a low ridge of barren sand dunes and bordered to the northeast by marshy areas. The northern edge of the site consists of an overstory of planted cottonwoods 10–15 m in height, with an understory of tamarisk 5 m in height on the edge of a cattail marsh. South of the cottonwoods, the site is primarily tamarisk, 5–8 m in height, with small openings vegetated by arrowweed. The western edge of the site is dominated by scattered mesquite trees. A 30- x 70-m patch of coyote willow 5 m in height, with a dense arrowweed understory, is present in the western third of the site, but the willows do not form a closed canopy. Canopy closure is 90% in the monotypic tamarisk and varies from 80 to 95% in the cottonwood. Surface water and saturated soil were present in the marsh on the northern edge of the site and in the western portion of the site throughout the season. The remainder of the interior was dry.

Lost Lake was occupied by one unpaired willow flycatcher. We also detected five flycatchers on May 21 for which residency status could not be determined. We surveyed the site five times, totaling 4.9 observer hours. Cowbirds were detected on all surveys.

Ground Reconnaissance Results

Farm Ditch Road (Formerly Spaghetti)

During aerial reconnaissance in 2010, we noted an area of riparian vegetation along a wet channel adjacent to the refuge road due west of the boat launch to Glory Hole/Hell Bird island. The area we wanted to evaluate starts ≈ 400 m west of the boat launch and continues another 500 m to the west. This site has been surveyed and described from the refuge road, but suitability has not been assessed from the interior. The interior of the eastern third of the area was explored in June. Vegetation in the eastern third consists of a mosaic of arrowweed, emergent Goodding's willow, coyote willow, screwbean mesquite, Emory baccharis, tamarisk, and pockets of bulrush marsh. Coyote willow is the dominant tree species and ranges in height from 2 m at the eastern end of the site to 4 m at the western end of the area we explored. The shorter coyote willow was inundated, while the taller coyote willow was not. Canopy closure averages 70% but reaches 80–85% in the more mature coyote willow. The mature coyote willow may provide pockets of habitat that are suitable for willow flycatchers, but the areal extent of these pockets was not noted, and it is not clear how suitable the site is overall. This site should be explored further next year.

Bill Williams River National Wildlife Refuge, Arizona

The Bill Williams River NWR contains the last expanse of native cottonwood-willow forest in the LCR region. The refuge encompasses over 2,500 ha along the Bill Williams River upstream from its mouth at Lake Havasu and contains a mixture of native forest, stands of monotypic tamarisk, beaver ponds, and cattail marsh. Survey sites within the Bill Williams River NWR are listed below from west to east, moving progressively farther upstream. The only signs of livestock noted were cattle tracks near the very eastern edge of the refuge.

Wispy Willow

Area: 1.3 ha Elevation: 143 m

This survey site is located at the farthest downstream extent of woody riparian vegetation on the north side of the Bill Williams River. The site is vegetated primarily with 6-m-tall coyote willow, with some scattered cattail marshes along the western and southern edges. Tamarisk 5–6 m in height dominates the northern two arms of the site and is scattered along the southern and eastern edges of the site. Canopy closure is 85% within the coyote willow, 85–95% within the tamarisk, and as low as 60% within the marshy areas. Standing water was present within the majority of the coyote willow throughout the season.

Wispy Willow was occupied by two pairs of breeding flycatchers and one unpaired male. We also detected one flycatcher on May 29 and one on June 3

for which residency status could not be confirmed. We surveyed the site twice, totaling 2.1 observer hours, before it became occupied. No cowbirds were detected during either survey.

Site 01

Area: 2.4 ha Elevation: 144 m

Site 01 is a mixed-native survey site just upstream of Wispy Willow on the southern edge of an area that burned in 2006. Goodding's willow dominates the overstory at a height of 15 m but does not form a continuous canopy. Tamarisk 8 m in height dominates the understory throughout much of the site. Toward the center of the site, there are patches of dense arrowweed 2–3 m in height. A stand of large-diameter coyote willow 6–8 m in height is present along the western and southern edges of the site. Canopy closure is ≈ 70–90% within the coyote willow and 60–80% throughout the rest of the site. Standing water was present within the coyote willow stand throughout the season.

We detected one willow flycatcher on May 28, one from May 28 to June 3, and one on June 3. Residency status could not be confirmed for any individual, and this site is not considered occupied. The site was surveyed five times, totaling 6.7 observer hours. Cowbirds were detected on four visits.

Burn Edge

Area: 4.1 ha Elevation: 145 m

Burn Edge is near the northern edge of the Bill Williams riparian corridor on the eastern edge of an area that burned in 2006. A cattail marsh with an overstory of Goodding's willow and cottonwood 15–20 m in height runs east-west through the center of the site. Canopy closure in the marshy area varies from around 60% at the eastern end to 25% at the western end. The understory on either side of the marsh is dominated by tamarisk up to 6 m in height, with up to 90% canopy closure. Standing water and saturated soils were noted in a small area at the western end of the marsh in May, June, and July. Soils away from the marsh were dry. Soils were noticeably drier in June than they were in May. In July, recent rains caused the small pool of water in the marsh to increase in size and resulted in all other soils being damp.

No willow flycatchers were detected. The site was surveyed five times, totaling 4.3 observer hours. Cowbirds were detected on all surveys.

Site 04

Area: 9.9 ha Elevation: 145 m

Vegetation in this survey site is mixed-native, with an overstory of Goodding's willow and cottonwood 15–20 m in height and patches of monotypic tamarisk up to 8 m in height. Small patches of coyote willow 3–5 m in height are also present throughout the site. Canopy closure is variable and overall is 50–70%. The understory in some areas is very open, and the ground in these areas is covered with herbaceous vegetation. Many large willows and cottonwoods have fallen over the past several years, leaving large gaps in the canopy and creating patches of thick, dead, fallen woody vegetation. A small stream was noted flowing through the middle of the site in May. By mid-June, almost all soils in the site were dry, and the only surface water remaining was in a deep backwater channel on the western side of the site.

No flycatchers were detected. We surveyed the site five times, totaling 8.8 observer hours. Cowbirds were detected on all surveys.

Site 03

Area: 12.9 ha Elevation: 145 m

This survey site is contiguous with Site 04 and is located immediately to the east; together, Site 03 and Site 04 are known as Mosquito Flats. Vegetation is mixed-native, with an overstory of Goodding's willow and cottonwood 15–20 m in height and patches of monotypic tamarisk up to 8 m in height. Small patches of coyote willow are also present throughout the site. Canopy closure is variable and overall is 50–70%. Stands of cattails and marshy areas occupy ≈ 10% of the site. The understory in some areas is very open, and the ground in these areas is covered with herbaceous vegetation. Many large willows and cottonwoods have fallen over the past several years, leaving large gaps in the canopy and creating patches of thick, dead, fallen woody vegetation. A small patch of saturated soil was noted in a marshy area near the southern end of the site in May, but by June, almost all soils were completely dry. All soils were damp from heavy rains during a visit in July.

Site 03 was occupied by one pair of breeding flycatchers. Portions of the site not known to be occupied were surveyed five times, totaling 12.6 observer hours. Cowbirds were detected on all surveys.

Site 05

Area: 6.8 ha Elevation: 145 m

Site 05 is located on the eastern edge of the Bill Williams River flood plain and is bordered to the northeast by steep cliffs and to the west by a dry river channel. Vegetation in the site is mixed-native, with Goodding's willow 12–15 m in height and cottonwood 15–20 m in height forming a broken overstory. The understory consists of tamarisk 6–8 m in height as well as some young Goodding's willows and cottonwoods. Ground cover in portions of the site consists of thick, dead, fallen woody vegetation. Canopy closure in the site is variable, ranging from 25% in open areas to 50–90% in the denser vegetation. Standing water was present throughout the survey season along the northeastern edge of the site in a series of deep beaver ponds. Soils in the majority of the site were dry.

No willow flycatchers were detected. We surveyed the site five times, totaling 7.8 observer hours. Cowbirds were detected on all surveys.

Black Rail

Area: 1.2 ha Elevation: 145 m

This survey site is located 0.3 km southeast of Site 05 on the eastern edge of the Bill Williams River flood plain. Vegetation in this mixed-native site contains a broken overstory of cottonwood and Goodding's willow up to 15 m in height. Several clumps of tamarisk 4 m in height are scattered in the understory. Patches of dense, mostly brown cattail and bulrush 1–2 m in height are scattered through the interior of the site. Canopy cover in the majority of the site is 80%, reaching 90% in some denser areas. A dense stand of even-aged Goodding's willow 12–15 m in height, with a continuous canopy, is present along the southwestern edge of the site. Soils were completely dry in May and June but completely damp from rains the previous night during a visit in July.

No willow flycatchers were detected. We surveyed the site five times, totaling 2.4 observer hours. No cowbirds were detected.

Cougar Point

Area: 1.3 ha Elevation: 156 m

This survey site consists of dense, even-age stands of Goodding's willow and cottonwood 6–8 m in height along a channel of the Bill Williams River. Cattail marshes are present within the site along the river channel. During the first visit in May, the vegetation appeared stressed, and several small, dead willows were noted. By July, the entire site was dead or dying, and less than 10% of the woody

vegetation had green leaves. Most of the trees were leafless, though some brown leaves remained on some of the Goodding's willow. Canopy closure within the woody vegetation averaged 60% during the last visit in July, reaching 80% in the densest areas with brown leaves. Some damp soils were noted in May within the cattail marsh, but by June, all soils were completely dry.

No willow flycatchers were detected. We surveyed the site five times, totaling 3.4 observer hours. Cowbirds were detected on three surveys. This site currently lacks the combination of surface water and live vegetation found in occupied habitat along the LCR and tributaries. We recommend discontinuing surveys at this site.

Upstream from Site 08

Area: 1.5 ha Elevation: 173 m

Vegetation in the majority of the site consists of an overstory of cottonwood and Goodding's willow up to 15 m in height and an understory of tamarisk. The western third and southern edge of the site are vegetated by Goodding's willow and cottonwood up to 12 m in height. The eastern third is dominated by dry tamarisk 4–6 m in height, with scattered, emergent Goodding's willows and cottonwoods. The northern edge of the site borders a cattail marsh. Canopy cover is variable and ranges from 40 to 70%. The western portion of the site contained surface water during visits in May and June, with damp to dry soils throughout the rest of the site. The site was not described in July.

No willow flycatchers were detected. We surveyed the site four times, totaling 2.9 observer hours. Cowbirds were detected on two surveys.

Planet Ranch Road

Area: 3.3 ha Elevation: 174 m

This mixed-native site follows the Bill Williams River at the southern edge of the riparian area and is outside the refuge property boundary. We were not permitted to access the site in 2013 or 2014, and we completed our surveys from the property boundary, ≈ 80 m away from the previously occupied breeding area. In previous years, the vegetation immediately adjacent to the river was dominated by Goodding's willow and cottonwood up to 15 m in height. Both riverbanks were steep, and vegetation on top of the banks more than a few meters from the water was dominated by arrowweed and tamarisk 4–5 m in height. Canopy cover and hydrological conditions are unknown for 2014.

No willow flycatchers were detected, but our ability to detect flycatchers was limited by the distance of our survey points from the area flycatchers were most likely to occupy. We surveyed three times, totaling 2.5 observer hours. We detected cowbirds on two surveys.

Ground Reconnaissance Results

Bill Willow

While examining aerial imagery, we noted an area of potentially suitable habitat along the downstream edge of riparian habitat along the Bill Williams River starting ≈ 75 m northeast of Wispy Willow and continuing another 300 m to the northeast. The western two-thirds of this site was explored in early July. Vegetation within the site consisted of 3–6-m-tall tamarisk, with 70–90% canopy closure. Vegetation became taller and denser toward the east. Some dead cattail was noted in the understory. No surface water was noted, but all soils in the area explored were damp. Vegetation in the westernmost portion of the site was too short to be considered suitable, but habitat was potentially more suitable to the east. This site should be explored further next year.

Alamo Lake, Arizona

The Alamo Lake study area is located along the Big Sandy and Santa Maria Rivers, near their confluence, and downstream along the Bill Williams River to the current shore of Alamo Lake. Many survey sites are located in areas that were inundated by the lake until a few years ago. The level of Alamo Lake rose early in 2010 following a large rain event but has been declining since then, falling over 5 feet each year from 2012 to 2014 (Lakes Online 2014). Imagery available on Google Earth shows that Sidebar, Camp 01–04, Middle Earth 01–02, and Burro Wash were still under water as of June 24, 2011. Burros and cattle were noted in and near many of the survey sites.

Sidebar 01

Area: 1.7 ha Elevation: 377 m

This mixed-native survey site is located 1 km downstream from the end of Brown's Crossing Road on the eastern edge of the riparian area. Vegetation within the site consists of a 20–30-m-wide strip of Goodding's willow 8 m in height. Seep willow (*Baccharis salicifolia*) and tamarisk up to 2 m in height are scattered in the understory. Canopy closure is 95%. Soils were completely dry during our visit in May.

No willow flycatchers were detected. We surveyed once, totaling 1.0 observer hour. One cowbird was detected during our visit.

Camp 01

Area: 0.7 ha Elevation: 377 m

This native survey site is located 1.8 km west of the end of Brown's Crossing Road on the western edge of the riparian area. The site is bordered by dry upland scrub to the northwest and historic lakebed vegetated with baccharis and herbaceous plants to the southeast. Dominant vegetation within the survey site consists of Goodding's willow 8 m in height, with 95% canopy closure. An understory is lacking in much of the site, but clumps of tamarisk 1–2 m in height occur in more open areas. Soils were dry during a visit in May. Water was present in a stream channel 10 m southeast of the site; an incised bank separates the site from the stream channel.

Camp 01 was occupied by a pair of flycatchers. This site was not surveyed because of occupancy status.

Camp 04

Area: 0.3 ha Elevation: 377 m

Camp 04 is located ≈ 180 m northeast of Camp 01. This area was not designated as an individual survey site until after field season, and no detailed notes on vegetation structure or composition were recorded. Vegetation in this survey site consists of a narrow, linear stand of Goodding's willow. The site is bordered to the east by a dense stand of arrowweed and to the west by a narrow beaver pond. The bank of the beaver pond is incised and at least 1 m in height. Soils were dry during territory visits in early June and early July, though the beaver pond contained standing water.

Camp 04 was occupied by one unpaired flycatcher. This site was not surveyed because of occupancy status.

Camp 02

Area: 0.3 ha Elevation: 377 m

Camp 02 is located 45 m northwest of Camp 04 and lies at the outflow of a wash. It is bordered to the west, north, and south by dry upland scrub and to the east by a beaver pond. Vegetation within the site consists primarily of Goodding's willow 8–9 m in height, with cottonwood 7–8 m in height dominating the very western end of the site. Tamarisk 1–2 m in height dominates the understory. Canopy closure is 90% in the Goodding's willow and 80% in the cottonwood. Soils were completely dry during a visit in May, though the beaver pond 20 m to the east held water. The site sits on a bench above the water.

No willow flycatchers were detected. We surveyed once, totaling 0.2 observer hours No cowbirds were detected during our visit.

Camp 03

Area: 1.9 ha Elevation: 377 m

Camp 03 is located 150 m north of Camp 02. This survey site is located at the outflow of a wash and is bordered to the north and west by dry upland scrub and to the south and east by a large beaver pond. The widest part of the site, in the northern third, is vegetated by a stand of dense Goodding's willow 8 m in height, with no understory, and 95% canopy closure. The rest of the site is vegetated with a mix of cottonwood and Goodding's willow 6–7 m in height, with an understory of 1-m-tall tamarisk. Trees in the mixed portion of the site are more widely spaced, with 70–85% canopy closure. Soils were completely dry during a visit in May, though the beaver pond held water. The banks of the pond were steeply incised 2–3 m high.

Camp 03 was occupied by one breeding pair of flycatchers. We also detected one flycatcher from July 1 to 4 for which residency status could not be confirmed. We surveyed once, totaling 0.4 observer hour. No cowbirds were detected during our visit.

Middle Earth 01

Area: 6.1 ha Elevation: 377 m

This mixed-native survey site is located ≈ 700 m southwest of the end of Brown's Crossing Road on the eastern side of the riparian zone. The site is surrounded on all sides by historic lakebed, which is patchily vegetated with 2-m-tall tamarisk and baccharis, scattered patches of arrowweed, and several herbaceous species. Vegetation within the site consists of Goodding's willow 9–10 m in height, with a scattered tamarisk understory up to 5 m in height. The tamarisk is patchy and becomes very dense in places. Canopy closure ranges from 60 to 95% and is more open along the southern edge of the site. Soils within the site were completely dry during a visit in May, and the nearest surface water throughout the season was nearly 700 m away in the beaver pond by Camp 03.

Middle Earth 01 was occupied by five pairs of breeding flycatchers and one unpaired male. We surveyed once, totaling 1.0 observer hour. No cowbirds were detected during our survey.

Middle Earth 02

Area: 6.7 ha Elevation: 377 m

This mixed-native survey site is located 75 m north of Middle Earth 01 and 400 m due west of the end of Brown's Crossing Road. It is surrounded on all sides by historic lakebed. Vegetation within the southern portion of the site consists of Goodding's willow 7–9 m in height, with clumpy tamarisk 3–4 m in height in the understory, and canopy closure of 95%. The northern arm of the site has clumps of Goodding's willow 6–8 m in height surrounded by tamarisk 2–4 m in height and seep willow up to 2 m in height. Overall canopy closure in this area is only 50%. Soils were completely dry during a visit in May, and the nearest surface water throughout the season was 800 m away in the beaver pond by Camp 03.

Middle Earth 02 was occupied by seven pairs of breeding flycatchers. We also detected one unpaired resident flycatcher and one flycatcher for which residency status could not be confirmed. We surveyed once, totaling 1.2 observer hours. Cowbirds were detected during our survey.

Prospect 01

Area: 1.1 ha Elevation: 377 m

This mixed-native survey site is located 100 m west of the end of Brown's Crossing Road on the eastern edge of the riparian zone. The site consists of a 20–30-m-wide strip of Goodding's willow 5–7 m in height, with 60–95% canopy closure. Tamarisk 2–3 m in height is scattered throughout the understory. Several gaps are present in the site, creating a slightly patchy effect. Soils were completely dry during visits in May and June, and the nearest surface water throughout the season was over 1 km away in the beaver pond by Camp 03.

No willow flycatchers were detected. We surveyed twice, totaling 2.9 observer hours. Cowbirds were detected during both surveys.

Burro Wash 01

Area: 3.9 ha Elevation: 377 m

This mixed-native survey site is located 350 m northwest of the upper arm of Middle Earth 02, along the southern edge of a large, dry cattail marsh near the western edge of the riparian zone. The site is bordered to the north by the dry cattail marsh and to the south by open, dry river channel. Vegetation within the site consists of Goodding's willow 6–8 m in height, with 80–95% canopy closure. Some tamarisk 3 m in height and cattails are present in the understory along the

northern edge of the site. Soils were completely dry during a visit in May, and the nearest surface water throughout the season was 300 m away in the beaver pond by Camp 03.

No willow flycatchers were detected. We surveyed once, totaling 0.7 observer hour. Cowbirds were detected during our visit.

Burro Wash 02

Area: 6.8 ha Elevation: 377 m

This mixed-native survey site is located ≈ 100 m northeast of Burro Wash 01, along the eastern edge of a large, dry cattail marsh. It is bordered to the north by dry upland scrub, to the west by dry cattail marsh, to the east by a large swath of dead and downed trees, and to the south by live riparian forest in Motherlode 01. Vegetation within the site consists of Goodding's willow 6–8 m in height, with 80–95% canopy closure. Tamarisk and cattails are present in the understory, mostly in the northern half of the site. The southern half of the site has a primarily open understory. Soils were completely dry during a visit in May, and the nearest surface water throughout the season was 700 m away in the beaver pond by Camp 03.

No willow flycatchers were detected. We surveyed once, totaling 0.7 observer hours. Cowbirds were detected during our visit.

Motherlode 01

Area: 3.3 ha Elevation: 377 m

This native survey site is located 20 m east of Burro Wash 01 and 25 m south of Burro Wash 02. It is bordered to the south by open, dry river channel, to the north by a large swath of dead and downed trees, and to the east by sparse riparian forest. Vegetation within the site consists of Goodding's willow 6–8 m in height. In the western third of the site, the willow forms a very dense stand of small-diameter stems, with 95% canopy closure. The stand structure is more open in the eastern portion of the site, with more gaps present, and a canopy closure of 90%. Soils were dry during a visit in May, and the nearest surface water throughout the season was 600 m away in the beaver pond by Camp 03.

Motherlode 01 was occupied by two pairs of breeding flycatchers. We surveyed once, totaling 0.6 observer hour. Cowbirds were detected during our survey.

Motherlode 02

Area: 21.6 ha Elevation: 377 m

This mixed-native survey site is located 275 m east of Burro Wash 02. It is bordered to the north by dry upland scrub, to the east and south by a matrix of live riparian forest and pockets of deadfall, and to the west by a large swath of dead and downed trees. Vegetation within the site consists of Goodding's willow 10–15 m in height, with significant amounts of deadfall scattered in the understory. Several tall, large-diameter willows (> 40 cm diameter at breast height) are present within the site, but many of the 10-m-tall trees have relatively narrow diameters (< 20 cm diameter at breast height) and are starting to lean. Canopy closure ranges from 80 to 95% and averages 90%. Soils were completely dry during visits in May and June, and the nearest surface water throughout the season was over 1 km away in the beaver pond by Camp 03.

Motherlode 02 was occupied by two pairs of breeding flycatchers. We surveyed twice, totaling 5.3 observer hours. No cowbirds were detected during our surveys.

Motherlode 03

Area: 12.6 ha Elevation: 377 m

This mixed-exotic survey site is located 100 m east of Motherlode 02. It is bordered to the east by open, dry river channel, to the west and south by a matrix of live riparian forest and dead trees, and to the north by dry upland scrub. Vegetation within the site consists primarily of tamarisk 6–8 m in height, with a scattered, non-contiguous overstory of Goodding's willow 8–12 m in height. A few cottonwood trees 10–12 m in height are present along the eastern edge of the site. Many dead trees are scattered throughout the site, and several large gaps in the canopy were noted. Deadfall is also prevalent in the understory. Canopy closure ranges from 75 to 90%, depending on the prevalence of gaps in the canopy. Soils within the site were dry during a visit in May, and the nearest water throughout the season was over 1.5 km away.

Motherlode 03 was occupied by three breeding pairs of flycatchers and two pairs for which no nest was found. We also detected one flycatcher for which residency status could not be confirmed. We surveyed once, totaling 1.5 observer hours. No cowbirds were detected during our survey.

Motherlode 04

Area: 0.5 ha Elevation: 377 m

This survey site was discovered in late May with breeding flycatchers. The site is located 85 m west of Confluence 02 and 200 m east of Motherlode 03. The site consists of a patch of vegetation 120 x 50 m in size in the middle of the dry, open river channel. Vegetation within the site consists of a dense Goodding's willow patch 10–12 m in height surrounded by tamarisk 1–4 m in height and arrowweed 2–3 m in height. Canopy closure within the willow reaches 90%. The arrowweed and tamarisk are generally too short to create a canopy. The nearest water throughout the season was ≈ 2 km away.

Motherlode 04 was occupied by one pair of breeding flycatchers. This site was not surveyed because of occupancy status.

Confluence 02

Area: 15.8 ha Elevation: 377 m

This mixed-exotic survey site is located along the eastern edge of the riparian zone. The northern end of the site is at the confluence of the Big Sandy and Santa Maria Rivers, and the site stretches south for 1.3 km. The site is bordered by dry upland scrub to the east and open river channel to the west. Vegetation within the site consists of tamarisk 3–8 m in height with scattered Goodding's willow 10 m in height. Some cottonwood 10 m in height is also present primarily in the northern end of the site. Many snags and a lot of dead fall are scattered throughout the site. Canopy closure varies from 40% in open areas to > 95% in dense tamarisk. There are generally a greater number of open areas in the southern portion of the site. Soils were dry during visits in May and June.

We detected one willow flycatcher on May 24 for which residency status could not be confirmed, and this site is not considered occupied. We surveyed twice, totaling 5.2 observer hours. Cowbirds were detected during both surveys.

Confluence 01

Area: 5.3 ha Elevation: 377 m

This mixed-exotic survey site is located at the confluence of the Big Sandy and Santa Maria Rivers. It is bordered to the north by dry upland scrub and on all other sides by open river channels. Vegetation within the site consists of tamarisk 3–8 m in height with emergent Goodding's willow and cottonwood 10–15 m in height. The Goodding's willow and cottonwood are more prevalent along the edges of the site. There is a significant amount of standing and fallen deadwood scattered throughout the site. Canopy closure ranges from 10% in very open areas

with short vegetation to 95% in the densest tamarisk, but it averages 80% across the site. Soils were dry during visits in May and June. The site sits on a terrace 2–3 m above either riverbed, making inundation unlikely.

No willow flycatchers were detected. We surveyed twice, totaling 2.7 observer hours. Cowbirds were detected during both surveys.

Sandy South 01

Area: 14.8 ha Elevation: 377 m

This mixed-exotic survey site is located along the western edge of the very southern end of the Big Sandy River. The site is bordered to the west by dry upland scrub and to the east by open river channel. Vegetation within the site consists of tamarisk 6–10 m in height with emergent cottonwood and Goodding's willow 8–15 m in height. Goodding's willow is more prevalent than cottonwood, and both are more prevalent in the southern two-thirds of the site. The northern third of the site is dominated by 10-m-tall tamarisk. A strip of cottonwood and Goodding's willow is present along the very eastern edge of the site. Large amounts of woody debris and standing or fallen snags are present in the site. Canopy closure varies from 50 to 90%, with the lowest canopy closure in areas with more woody debris and highest in the native strip along the eastern edge of the site. The site sits on a terrace 3–4 m above the river channel. Soils were dry during visits in May and June.

No willow flycatchers were detected. We surveyed twice, totaling 8.4 observer hours. Cowbirds were detected during both surveys.

Santa Maria South 01

Area: 30.2 ha Elevation: 377 m

This mixed-exotic survey site is located along the southern edge of the riparian area bordering the Santa Maria River and stretches upstream for 1.8 km from the confluence with the Big Sandy River. The site is bordered to the south by dry upland scrub and to the north by a mixture of beaver pond, riparian forest, and open river channel. Vegetation within the site consists of tamarisk 3–10 m in height (average 5–6 m) with some emergent Goodding's willow and cottonwood along the northern edge of the site. Canopy closure averages 90% throughout the site. A 20- x 300-m patch of 5-m-tall Goodding's willow and cottonwood with 95% canopy closure is present along the very northwestern edge of the site. A beaver pond is located adjacent to the western end of the site, but the site sits on a terrace, preventing water from entering the vegetation. Soils were dry during visits in May and June.

This site was occupied by one pair of flycatchers for which no nest was found. We surveyed twice, totaling 7.2 observer hours. Cowbirds were detected during both surveys.

Santa Maria North 01

Area: 29.5 ha Elevation: 377 m

This mixed-exotic survey site is located along the northern edge of the riparian area bordering the Santa Maria River and stretches upstream for 1.4 km from the confluence with the Big Sandy River. The site is bordered by open river channel and a beaver pond to the south and dry upland scrub to the north. Vegetation within the site consists primarily of tamarisk up to 10 m in height with emergent cottonwood and Goodding's willow up to 20 m in height. The cottonwood and Goodding's willow are more prevalent along the northern edge of the site. Large amounts of thick deadfall are found throughout the site, and the tamarisk becomes quite dense in places, both in canopy closure and stem density. Canopy closure ranges from 70 to 90%, being more open in areas with less tamarisk. The southern edge of the site has a steep bank 1–2 m in height that separates the vegetation from the river channel. Soils were dry during visits in May and June.

This site was occupied by two breeding pairs of flycatchers and one pair for which no nest was found. We surveyed twice, totaling 11.3 observer hours. Cowbirds were detected during both surveys.

Ground Reconnaissance Results

Edgewater

Edgewater is located 300 m downstream from Middle Earth 01, in the middle of the riparian zone. The entire site consists of dense 2-m-tall tamarisk with the occasional 3–4-m-tall Goodding's willow. Soils were dry during our visit in May. Vegetation within this site is not currently tall enough to be considered suitable and does not resemble occupied flycatcher habitat found along the LCR. We recommend reassessing this site in future years to determine whether the vegetation has developed suitable structure.

Palo Verde Ecological Reserve, California

The PVER is a collection of habitat creation sites located on the California bank of the Colorado River. All sites are periodically flood irrigated. Lands immediately to the west are dominated by agricultural fields. No evidence of livestock has been documented in or around the PVER study area.

Phase 02

Area: 21.4 ha Elevation: 86 m

This habitat creation site is vegetated with alternating 30–40-m-wide swaths of Goodding's willow reaching 8 m in height and coyote willow up to 6 m in height. There are two large blocks of 10-m-tall cottonwood at the southern end of the site. Height and density of the vegetation varies within and between cells of the site. Canopy closure is highly variable and is 80–85% in the Goodding's willow, 70–90% in the coyote willow, and 85–95% in the cottonwood. Some baccharis bushes were sparsely scattered in the understory of the site. A portion of the site contained surface water during a visit in late June.

We detected two willow flycatchers on May 28 and one on June 10, and this site is not considered occupied. We surveyed the site five times, totaling 9.3 observer hours. Many cowbirds were detected on all visits.

Phase 03

Area: 21.4 ha Elevation: 86 m

This habitat creation site is vegetated primarily with 40–50-m-wide swaths of cottonwood reaching 12 m in height. The cottonwood blocks are separated by rows ≤ 10 m wide of mixed Goodding's willow 5–8 m in height and small-diameter coyote willow up to 3 m in height. Baccharis shrubs 1.5 m in height occur occasionally along the borders between the willows and cottonwoods. The overall effect is a mosaic of vegetation types. Height and density of the vegetation vary within and between the cells of the site. Canopy closure under the cottonwood reaches 95% but is as low as 50% in the coyote willow. The eastern 20% of the site is vegetated with smaller-diameter Goodding's willow reaching 10 m in height and clumps of baccharis reaching 1.5 m in height. Canopy closure here reaches 85%. No surface water was documented within the site during any visits.

We detected one willow flycatcher on May 28 and one on May 29, and this site is not considered occupied. We surveyed the site five times, totaling 7.3 observer hours. Cowbirds were detected on four visits.

Phase 04 Block 01

Area: 7.6 ha Elevation: 87 m

Block 01 is vegetated primarily by Goodding's willow up to 10 m in height. Five evenly spaced, 20-m-wide strips of cottonwood up to 12 m in height are dispersed throughout the site. Some coyote willow 2–3 m in height is present near the cottonwood-Goodding's willow boundaries. Canopy closure was 85–95% in the

cottonwood and 60–80% in the Goodding's willow. Baccharis is planted on the northern edge of the survey site. No surface water was documented within the site during any visits.

We detected one willow flycatcher on May 28, and this site is not considered occupied. We surveyed this block five times, totaling 5.9 observer hours. Cowbirds were detected on four visits.

Phase 04 Block 02

Area: 4.0 ha Elevation: 87 m

Block 02 lies due east of Block 01 and is adjacent to the Colorado River. This survey site is primarily vegetated with Goodding's willow 8–10 m in height. Canopy height is shorter along the northern and southern edges. Some coyote willow 4–6 m in height is present in small clumps or strips along the northern and southern edges of the western half of the site. Cottonwood 10–12 m in height is present in a square patch roughly 35 x 35 m in size near the center of the site. Canopy closure is 85–95% in the Goodding's willow and 95% in the cottonwood. In general, canopy closure is sparser along the northern and southern edges and in the eastern half of the site. No surface water was documented within the site during any visits.

We detected two willow flycatchers on May 28 and two on June 10, and this site is not considered occupied. We surveyed the site five times, totaling 3.9 observer hours. Cowbirds were detected on four visits.

Phase 04 Block 03

Area: 23.7 ha Elevation: 87 m

Block 03 lies due north of Block 02 and is also adjacent to the Colorado River. This survey site is vegetated by cottonwood, Goodding's willow, and coyote willow that occur in a much more heterogeneous mix than in the other two blocks in Phase 04. Cottonwood 9–12 m in height forms the overstory for the majority of the block. Goodding's willow 7–9 m in height and spindly coyote willow 3–6 m in height occur throughout the understory. There are a few narrow (20-m-wide) strips containing only Goodding's and coyote willow. Cottonwood is less prevalent in the north-central portion of the site, and coyote willow 4–6 m in height is the dominant woody species in the gaps between the cottonwoods. Canopy closure is 95% within the cottonwood and as low as 50% in areas with only coyote willow. This site contained surface water during a visit in May.

No willow flycatchers were detected. We surveyed the site five times, totaling 11.2 observer hours. Cowbirds were detected on all visits.

Phase 05 Block 01

Area: 14.8 ha Elevation: 88 m

Block 01 contains the greatest proportion of grassy fields of the three survey sites in Phase 05. These fields are broken up by a matrix of sparse 10-m-wide stringers of cottonwood and Goodding's willow up to 5 m in height and occasional clumps of baccharis. The most suitable habitat is located within 100 m of the eastern and southern edges and the northwestern corner of the site, and these are the only portions we surveyed. The habitat within 100 m of the southern edge of the site is vegetated primarily with Goodding's willow up to 8 m in height, with some small clumps of coyote willow 4 m in height. Canopy closure was densest along the very southern edge of the site, reaching 85–90% in the Goodding's willow and up to 95% in the coyote willow. The western third of this area (i.e., the southwestern corner of the site) contains mixed cottonwood and Goodding's willow up to 8 m in height. Most vegetation in southwestern corner showed signs of severe stress, with yellowing leaves, early leaf abscission, lower foliage density compared to the rest of the site, and a canopy closure of 55%. Some trees in this area had turned completely brown by mid-June. Habitat within 100 m of the eastern edge of the site is vegetated with cottonwood 5–8 m in height and Goodding's willow 4–7 m in height, with the shorter trees being to the north and along the very eastern edge of the site. Canopy closure varies directly with canopy height in the eastern portion of the site and is highest (85%) in the tallest vegetation and lowest (50–70%) in the shortest vegetation. The northwestern corner of the block contains cottonwood and Goodding's willow 7–9 m in height, with 85–90% canopy closure. No surface water was documented within the block during any visits.

We detected one willow flycatcher on May 29, and this block is not considered occupied. We surveyed the block five times, totaling 6.4 observer hours. Cowbirds were detected on all visits.

Phase 05 Block 02

Area: 23.6 ha Elevation: 88 m

Block 02 lies due east of Block 01 and is adjacent to the Colorado River. This survey site contains a lower percentage of open, grassy fields than Block 01. It is primarily vegetated with cottonwood up to 7–9 m in height in the western half of the site and Goodding's willow up to 8–9 m in height in the eastern half. Vegetation height for all trees becomes shorter along the northern edge of the site, reaching only 5–6 m in height. Canopy closure varies directly with vegetation height, reaching 95% in the tallest cottonwood stands and 90% in the tallest Goodding's willow stands, but only 60–70% along the northern edge of the site. A few small clumps of spindly 4-m-tall coyote willow are scattered throughout the understory. No surface water was documented within the block during any visits.

No willow flycatchers were detected. We surveyed the site five times, totaling 7.9 observer hours. Cowbirds were detected on all visits.

Phase 05 Block 03

Area: 29.6 ha Elevation: 88 m

Block 03 is located due north of Block 02. It contains the smallest proportion of open grassy areas of the three survey sites in Phase 05. The site is primarily vegetated with a mix of cottonwood and Goodding's willow. The western third of the site is predominantly cottonwood 8–9 m in height, with many thin (≤ 10-m-wide) strips of Goodding's willow 6–8 m in height. Canopy closure in this portion of the site averages 90% but ranges from 80 to 95%. The center third of the block is predominantly Goodding's willow 5–7 m in height with a dense patch of 3-m-tall coyote willow in the southern end. Canopy closure in this portion varies from 70 to 90%. The eastern third of the site is planted in a similar manner to the western third, but there are more gaps in the vegetation, and trees with yellow leaves were noted. Canopy closure in this portion of the site ranges from 50% in the gaps to 95% in the densest cottonwood. A majority of the site was inundated during a visit in May; no surface water was documented in June or July.

No willow flycatchers were detected. We surveyed the site five times, totaling 10.1 observer hours. Cowbirds were detected on all visits.

Phase 06 Block 01

Area: 38.7 ha Elevation: 87 m

This survey site contains a few open areas but is vegetated primarily with a mosaic of cottonwood and Goodding's willow. The two species are occasionally planted in monotypic strips but are often planted together in mixed strips. The cottonwood is 4–9 m in height and the Goodding's willow is 3–6 m in height, but the most frequent height for both is 5–6 m. Canopy closure ranges from 30% in open areas to 95% in the tallest, densest cottonwood but is typically 85%. The center of the site contains the tallest, densest vegetation, with shorter, sparser vegetation present along all edges. Coyote willow is also present in narrow (1–5-m-wide) rows throughout the site. Canopy height in the coyote willow rows varies from 2 to 5 m, and canopy cover varies directly with canopy height and width of the row, ranging from < 25 to 50–60%. Seep willow and another *Baccharis* species are scattered throughout the understory, and alfalfa is present in the open areas. Surface water was noted during visits in May and June, but soils were dry in July.

We detected four willow flycatchers on May 30 and one on June 12, and this site is not considered occupied. We surveyed the site five times, totaling 17.6 observer hours. Many cowbirds were detected on all visits.

Phase 06 Block 02

Area: 37.6 ha Elevation: 87 m

Block 02 is located between Block 01 and Phase 05 Block 03. This survey site is vegetated with a mosaic of Goodding's willow, cottonwood, and coyote willow, with Goodding's willow being most prevalent and coyote willow least prevalent. Vegetation height is typically 6–7 m and is tallest (7–8 m) in the southern third of the site and shortest (4–5 m) in the northern third. Canopy closure varies directly with canopy height and is typically 75–85%. Canopy closure is 30–50% in the northern third of the site and reaches 90% in the tallest vegetation in the southern third. Coyote willow varies from 2-m-tall, with wispy stems that are widely spaced, to 5-m-tall stands with 60% canopy closure. Seep willow is scattered throughout the site, and alfalfa is present in areas with sparser vegetation. Surface water was noted during a visit in May, but soils were dry or damp in June and July.

We detected five willow flycatchers on May 29 and one on July 7, and this site is considered occupied. The individual detected on July 7 was heard briefly from a distance at the beginning of the survey prior to any playback. Field personnel attempted to get closer to the flycatcher, but it was unresponsive to playback and could not be located. No flycatchers were detected during a subsequent survey on July 14. We surveyed the site five times, totaling 18.5 observer hours. Many cowbirds were detected on all visits.

Cibola, Arizona

The only sites surveyed within the Cibola, Arizona, study area in 2014 were habitat creation sites. Of the four surveyed sites in Cibola, three are in the Cibola Valley Conservation Area (CVCA), a collection of habitat creation sites north of the town of Cibola, Arizona, and south of the Colorado River. The fourth site is the Nature Trail near the Cibola National Wildlife Refuge headquarters. All sites are periodically flood irrigated, and the CVCA sites are surrounded by agricultural fields. No evidence of livestock was documented in or around these sites.

Phase 01

Area: 26.2 ha Elevation: 74 m

Phase 01 consists of a mosaic of rectangular cells of cottonwood, Goodding's willow, and coyote willow of varying size and density. Each cell generally contains a single species and age class, though some emergent Goodding's

willows are present in the coyote willow cells. The tallest cottonwoods are 15 m in height, and the tallest Goodding's willows are around 12 m in height. Coyote willow reaches 3–6 m in height. Canopy closure is 60–90% in the cottonwood, 60–70% in the Goodding's willow, and 70–95% in the coyote willow. A few of the cells have scattered trees in grassy fields with canopy closure ≥ 25%. No surface water was documented within the site during any visits. An irrigation canal adjacent to the western edge of the site held water during a visit in late June.

We detected two willow flycatchers on May 30 and three on June 12, and this site is not considered occupied. The site was surveyed five times, totaling 10.2 observer hours. Large flocks of cowbirds were detected on all visits.

Phase 02

Area: 25.5 ha Elevation: 74 m

This habitat creation site is located immediately south of Phase 01. It consists of rectangular cells of mixed cottonwood and Goodding's willow alternating with cells of coyote willow with emergent cottonwood. Vegetation within 20 m of the southern edge of the site is cottonwood 8–9 m in height with 80–85% canopy cover. The tallest, densest vegetation for all species is located within 10 m of the northern edge of the site. The coyote willow is 3–7 m in height, with 50–95% canopy cover. Canopy cover varies directly with vegetation height, but many of the willows of both species are severely stressed, with some up to half dead. The mixed cottonwood/Goodding's willow cells consist of cottonwood 7–9 m in height, with Goodding's willow up to 8 m in height. Most of the Goodding's willow is dying back, and in some areas, live foliage is present only on the lower half of the tree. Canopy closure in these cells varies from 60 to 90%. No surface water was documented within the site during any visits. An irrigation canal 80 m west of the site held surface water during a visit in late June.

We detected one willow flycatcher on May 30, and this site is not considered occupied. The site was surveyed five times, totaling 10.4 observer hours. Large flocks of cowbirds were detected on all visits.

Phase 03

Area: 38.4 ha Elevation: 73 m

This habitat creation area is located 2.5 km west of Phases 01 and 02. It consists of a mosaic of rectangular cells of cottonwood, Goodding's willow, and coyote willow of varying size and density. Each cell generally contains one species and age class, though emergent cottonwoods are present in some of the coyote willow cells. The tallest cottonwoods reach ≈ 12 m in height, Goodding's willows reach 10 m, and coyote willows reach 5 m. Many of the willows of both species are at

least half dead. Canopy closure within the cottonwood varies from 60 to 90%, depending on planting density. Canopy closure within both willow species varies from 50 to 80%, depending on the degree of partial mortality. Standing water was noted within the site during visits in June and July.

We detected two willow flycatchers on May 30 and three on June 12, and this site is not considered occupied. The site was surveyed five times, totaling 11.4 observer hours. Large flocks of cowbirds were detected on all visits.

Nature Trail

Area: 13.7 ha Elevation: 71 m

This habitat creation site is ≈ 700 m west of the Cibola National Wildlife Refuge headquarters and consists of a mosaic of cottonwood, Goodding's willow, mesquite, and Emory baccharis. Approximately one-half the site consists of scattered screwbean and honey mesquite up to 6 m in height, with a thick understory of Emory baccharis. Canopy closure reaches 60% in the mesquite. The northern half of the site contains an extensive, but sparse, stand of Goodding's willow 5–10 m in height. The interior of the willow stand contains the shorter trees with a canopy closure of < 25%, and many of the willow trees are dead. The tallest willows are present around the perimeter of the willow stand, and canopy closure reaches 60% under these trees. The southwestern corner of the site has a small stand of cottonwoods 12–18 m in height, with canopy closure of 70%, and stringers of cottonwood up to 18 m in height occur throughout the site. The site contained a small amount of surface water during a visit in May. Water was present in an irrigation canal on the western side of the site in June.

We detected one willow flycatcher on May 31 and two flycatchers on June 12, and this site is not considered occupied. The site was surveyed five times, totaling 3.7 observer hours. Cowbirds were detected on all surveys.

Yuma, Arizona

We surveyed three sites in Yuma East Wetlands, a collection of habitat creation sites on either side of the Colorado River, ≈ 4 km downstream from the confluence of the Colorado and Gila Rivers. Yuma East Wetlands is bordered by agricultural fields to the north, east, and south and by urban landscape to the west. The sites we surveyed are periodically flood irrigated. No evidence of livestock was documented in or around these sites.

J (MSCP Section: C4703)

Area: 8.4 ha Elevation: 38 m

This survey site consists primarily of cottonwood 3–7 m in height with a 2-m-tall understory of Emory baccharis and honey mesquite and is bisected by a dirt road and irrigation channel. The cottonwood trees are taller and the understory less prevalent on the northern side of the site. Canopy closure ranges from 50 to 90% and is densest in the northwestern corner of the site and lowest in the southern half of the site. A stand of 3–4-m-tall coyote willow 60 x 120 m in size with 85% canopy closure is present along the western edge of the site. Standing water was noted during visits in May and June, but the site was dry in July.

We detected four willow flycatchers on May 31, and this site is not considered occupied. The site was surveyed five times, totaling 3.0 observer hours. Cowbirds were detected on all visits.

South AC (MSCP Section: C4711)

Area: 0.8 ha Elevation: 37 m

This survey site consists of a stringer of cottonwood and Goodding's willow 5–7 m in height along the northern edge of a cattail/bulrush marsh. The site is bisected by an open water channel extending north from the marsh. East of the channel, the stringer is only one tree wide, and the trees are very widely spaced, with canopy closure averaging 50%. Soils were dry in this portion, and honey mesquite is scattered in low density in the understory. West of the channel, the stringer widens slightly, and canopy closure increases to 60–90%. Seep willow, Emory baccharis, and honey mesquite form a dense understory. The very western end of the stringer is bordered to the south by a dense stand of coyote willow 3–5 m in height with 80–95% canopy closure. Standing water was documented within the coyote willow in May and June, but only damp soils remained by July.

We detected three willow flycatchers on May 31, and this site is not considered occupied. The site was surveyed five times, totaling 1.3 observer hours. Cowbirds were detected on three visits.

I (MSCP Section: C4702)

Area: 6.4 ha Elevation: 38 m

This survey site consists primarily of cottonwood 5–8 m in height, with an understory of 2-m-tall Emory baccharis and 4-m-tall honey mesquite. The habitat is divided into cells that are separated by dirt roads, and vegetation density varies by cell, ranging from 50 to 90%. Areas with lower canopy closure are characterized by more widely spaced trees and a more dominant understory. One

cell on the western side of the site contains a 20-m-wide, dense stand of cottonwood 6–7 m in height, with 90–95% canopy closure and no understory. This cottonwood stand is bordered to the west by a stand of coyote willow 2–5 m in height, with 70–90% canopy cover that covers an area roughly 70 x 50 m in size. The westernmost cells were inundated during a visit in May, but only a small pool of water remained in June.

We detected four willow flycatchers on May 31, and this site is not considered occupied. The site was surveyed five times, totaling 4.4 observer hours. Cowbirds were detected on four visits.

Yellow-billed Cuckoo Broadcast Surveys

Field personnel spent 22.8 observer hours conducting yellow-billed cuckoo broadcast surveys at River Ranch, Pahranagat NWR, and Warm Springs. The results of the surveys are summarized below. Boundaries of the survey areas at each study area are shown on orthophotos in attachment 7.

River Ranch

We detected one yellow-billed cuckoo at River Ranch on July 13. The individual responded briefly to playback with a contact call. We did not detect any cuckoos on one subsequent survey, and we did not complete any followup (e.g., nest searching) visits; thus, the residency and breeding status of this cuckoo is unknown. All potentially suitable habitat was surveyed three times, totaling 5.8 observer hours.

Pahranagat National Wildlife Refuge

We detected one yellow-billed cuckoo on the eastern shore of the Pahranagat NWR on July 11 and one cuckoo during the next survey on July 24 at Pahranagat South. Each detection consisted of a brief response to playback of either knocking or knocking plus a contact call. The detections were located ≈ 2 km apart, and it is possible that each detection was of a separate individual. However, because of the limited and fragmented nature of habitat at the Pahranagat NWR and the timing of the detections, it is also possible that they were of the same individual. We did not complete any followup (e.g., nest searching) visits; thus, the residency and breeding status is unknown. All potentially suitable habitat was surveyed three times, totaling 14.2 observer hours.

Warm Springs Natural Area

We completed four surveys for yellow-billed cuckoo at Warm Springs, totaling 2.8 observer hours. No yellow-billed cuckoos were detected.

DISCUSSION

Five of the eight study areas occupied in 2014 by resident or breeding flycatchers (Key Pittman WMA Pahranagat NWR, Muddy River, Topock Marsh, and the Bill Williams River NWR) held resident or breeding flycatchers in each year they were surveyed (Braden and McKernan 2006; McLeod et al. 2008; McLeod and Pellegrini 2013, 2014; details of residency and breeding in 2014 are presented in chapters 3 and 4 of this document). While resident flycatchers were detected in all of the typically occupied study areas, breeding and resident flycatchers were detected in new locations within the Key Pittman WMA, Pahranagat NWR, and Bill Williams River NWR. Of the other three occupied study areas, two (Warm Springs and Meadow Valley Wash) have been intermittently occupied over the years, and one (Alamo Lake) had not been surveyed as part of this project prior to 2014. One additional study area, River Ranch, has also been intermittently occupied; no resident flycatchers were detected there in 2014. Each study area is discussed in detail below.

As was the case in each year (2010–14) that we surveyed at the Key Pittman WMA, we found resident and breeding flycatchers in the patches of coyote willow surrounding Nesbitt Lake. For the first time, however, we also found a flycatcher nest in the stand of cottonwoods at the southern end of the lake, adjacent to Patch 00. This nest was attended by a flycatcher that was the second female of a polygynous male who also had a nest 60 m away in Patch 01. This male was observed flying back and forth between the two nest areas.

Occupancy at River Ranch has been variable since SWCA began monitoring in 2011, ranging from a single flycatcher detected for 1 day up to several pairs of breeding flycatchers. In 2014, hydrology appeared to have improved over any previous year, with standing water documented almost continuously throughout the season within two of the survey sites. Although the sites were wetter than in previous years, no resident flycatchers were documented. Intermittent occupancy despite apparently improved habitat conditions could be indicative of both small habitat extent and suboptimal habitat conditions. Dispersal from River Ranch to other breeding areas is suggestive of suboptimal habitat conditions at River Ranch. Additionally, all but one banded flycatcher identified at this site since 2011 were second-year birds. Second-year birds of many species are known to disperse greater distances than returning adults (Gill 1995), and they frequently colonize new habitats. The best habitats are typically occupied by older individuals, who may be more competitive or arrive sooner on the breeding grounds, leaving habitat of lesser quality for younger birds (Hill 1988; Holmes

et al. 1996). Habitat at River Ranch was established many years prior to 2011, and the continued presence of young flycatchers indicates suboptimal habitat conditions.

From the start of flycatcher monitoring at the Pahranagat NWR in 1997 through 2007, occupied flycatcher habitat at Pahranagat North, near the inflow to Upper Pahranagat Lake, was inundated annually with up to 1 m of water recorded under the vegetation in mid-May. From 2003 to 2007, as much as 100% of the site contained standing water in mid-May, and as much as 95% of the site contained standing water and saturated soil until mid-July. Major structural problems with the dam that impounds the upper lake resulted in the upper lake being drained in early 2008, and the riparian vegetation at the north end of the lake was not flooded during the 2008 and 2009 flycatcher breeding seasons. The dam was repaired prior to the 2010 breeding season, and although lake levels have been higher since this repair, they have not returned to the levels maintained prior to dam failure. Lake levels in 2014 were at their highest since the repairs, and up to 50% of the riparian vegetation at the northern end of the lake contained standing water and saturated soils at the beginning of the breeding season. While the number of resident flycatchers at Pahranagat North has not changed since 2003, the distribution of breeding pairs has shifted away from the center of the site toward the lakeside edge. This distribution persisted in 2014, with no nest located more than 10 m away from the maximum extent of water documented within the site in May (SWCA, unpublished data).

Breeding flycatchers were documented at Pahranagat MAPS for the first time. No resident flycatchers had been documented at this site since 2006. The original survey site was heavily damaged by a fire in 2010, and this area remained unoccupied in 2014. The two pairs and one unpaired flycatcher recorded in 2014 occupied three tiny (15 x 15 m) patches of regenerating cottonwood adjacent to the original survey site. Despite their small size, each occupied patch contained suitable structure and hydrology. Habitat suitability is likely to diminish as the cottonwood matures, self-thins, and loses the understory structure and density typically used by flycatchers along the LCR and tributaries.

Meadow Valley Wash was last monitored as part of this project in 2003, and it was unoccupied in that year. Sites within Meadow Valley Wash were surveyed in 1998–2001, and flycatchers were detected only in 1998 (Braden and McKernan 2006). NDOW biologists located breeding flycatchers in the study area in 2013 (C. Klinger 2013, personal communication), and we added Meadow Valley Wash to our survey areas in 2014 because of that discovery. Meadow Valley Wash is a narrow canyon and, thus, is not capable of supporting wide expanses of riparian habitat or a large flycatcher population. In addition, the canyon is subject to periodic scouring floods, and the amount and quality of riparian habitat thus fluctuates between years. Meadow Valley Wash is > 50 km from the nearest flycatcher population in the Pahranagat Valley, and this distance likely results in

the study area not being rapidly re-colonized once vegetation has recovered after a flood event (Paxton et al. 2007). All these factors contribute to Meadow Valley Wash being periodically occupied by small numbers of flycatchers.

Breeding flycatchers have been documented at Muddy River in the Overton WMA survey site annually since 2005, though varying portions of the site have been occupied. In 2005–07, the Overton WMA supported two distinct breeding areas ≈ 800 m apart. Over the 2007–08 winter, the Muddy River was dredged immediately upstream and downstream from the northern breeding area. Dredging activities resulted in a cleared swath 10–15 m wide on the western bank of the river. Resident flycatchers were not documented in the northern breeding area from 2008–11, and all breeding flycatchers were located in the very southern end of the site. In 2012, nesting attempts were documented in both breeding areas of the Overton WMA, though the majority of attempts were in the southern breeding area. In 2013, nesting attempts were again documented in both breeding areas, but the majority of attempts were located in the northern breeding area. In 2014, all nesting attempts and resident flycatchers were detected in the northern breeding area; the southern breeding area was unoccupied. The return of flycatchers to the northern breeding area is likely related to the unusually dry conditions present in the southern end of the Overton WMA in 2012–14, which probably influenced flycatchers to occupy an alternate location.

Warm Springs was again occupied in 2014, after holding at least one breeding pair each year from 2010 to 2012 and being unoccupied in 2013. The male who had occupied a territory in each year 2010–12 was documented breeding in Topock Marsh in 2013. This male returned to Warm Springs in 2014 and established a territory in each of the two survey sites. One of these sites had been heavily damaged in the 2010 fire but has now recovered enough to attract resident flycatchers. Lack of nest success at Topock Marsh in 2013 may have contributed to this individual's return to Warm Springs in 2014.

All breeding flycatchers at Topock Marsh in 2014 were located in Swine Paradise, on either side of the new firebreak canal. Aerial imagery shows that coyote willow near the nest locations has expanded noticeably toward the marsh since 2010. The expansion is likely a result of the record low marsh levels in 2011, which allowed the coyote willow to expand into formerly inundated bulrush marsh along the edge of the woody vegetation. The coyote willow now creates a buffer of inundated woodland between the marsh and the dry tamarisk in the site interior. It is likely this recent, localized change to which the flycatchers responded.

Marsh elevations at Topock Marsh on any given day during the breeding season of 2014 were 0.13–0.72 foot higher than on the same day in 2013 (figure 2-2). These higher marsh elevations were reflected in the survey sites generally containing more standing water at the beginning of the season and retaining water later in the season than in 2013. In addition, tamarisk that was presumed to have

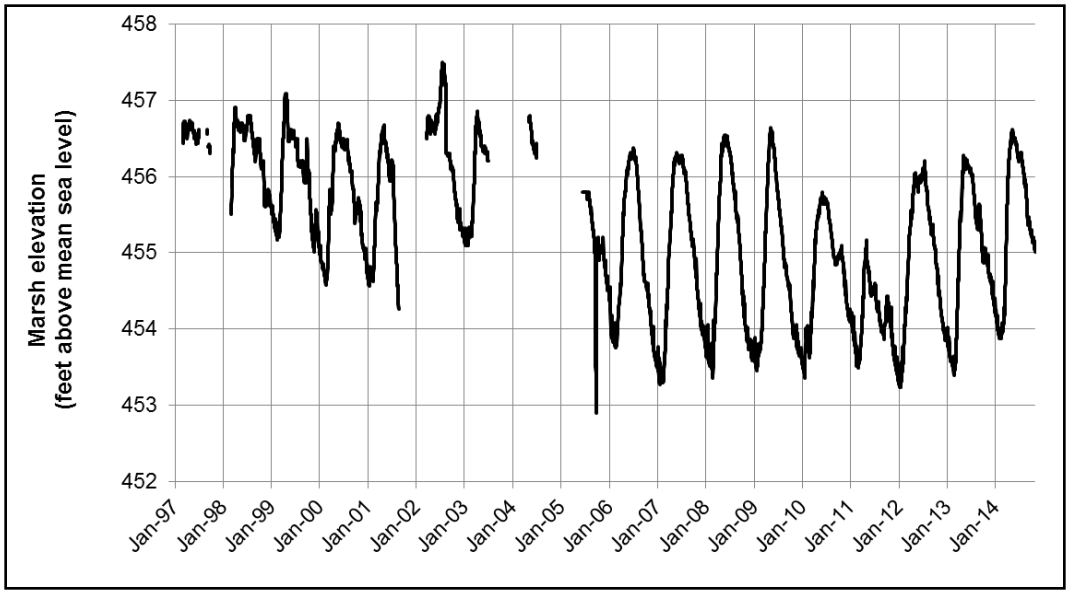

Figure 2-2.—Marsh elevation (feet above sea level) measured at the South Dike at Topock Marsh, 1997–2014.

been damaged by splendid tamarisk weevils (*Coniatus splendidulus*) in 2013 appeared to have recovered in 2014 (see chapter 6). Despite the wetter conditions and locally improved vegetation density, the number of resident adults detected at Topock Marsh in 2014 did not increase over the number detected in 2013 (figure 2-3). Recruitment of young flycatchers to Topock Marsh may be slow because few flycatcher young have been produced at Topock Marsh or the Bill Williams River NWR in recent years.

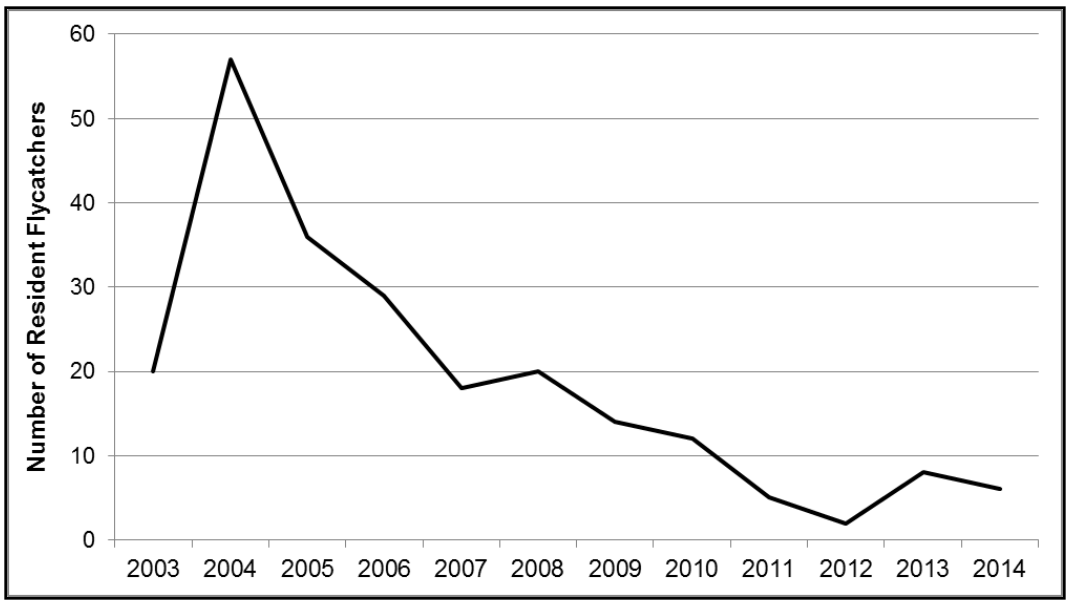

Figure 2-3.—Number of resident flycatchers at Topock Marsh, 2003–14.

The number of flycatchers at Topock Marsh showed a strong decline from 2004 to 2012 (see figure 2-3). While habitat quality throughout the study area could be affected by multiple factors, including changes in vegetation structure, the most noticeable change is lowered marsh levels. An examination of water levels within Topock Marsh shows that after 2004, water peaked at lower levels, high water levels were of shorter duration, and over-winter lows were lower than was the case prior to 2004 (see figure 2-2). These changes in the timing and magnitude of fluctuations in marsh levels may have contributed to the decline in the Topock Marsh flycatcher population. However, marsh levels in May and June increased annually in 2011–14, and water levels in 2014 peaked higher, and high water was of longer duration, than in many years between 2004 and 2014. Continued management of the marsh to attain and maintain high water levels during flycatcher breeding season is crucial to giving the flycatcher population at Topock Marsh a chance of recovering.

At the Bill Williams River NWR, streamflow in May and June was the lowest on record since 2004; streamflow in July was similar to that in 2013, which was also the lowest on record since 2004 (figure 2-4). Daily discharge in 2014 at the U.S. Geological Survey (USGS) gaging station (#09426620) on the Bill Williams River near Parker, Arizona, was 0.0 cubic feet per second (cfs) from May 15 through September 8. At the beginning of the season, water was present only in the deepest channels and in marsh vegetation surrounding the main stem of the river. As the season progressed, the areal extent of the water did not change, but the depth in isolated pools grew shallower. Despite the low water levels, resident and breeding flycatchers were once again detected within the refuge boundary, unlike in 2013. Breeding flycatchers were detected in two places: the most frequently occupied area in Mosquito Flats and, for the first time, in Wispy Willow. The most frequently occupied territory in Mosquito Flats consists of dense tamarisk, with a Goodding's willow overstory surrounding a small cattail marsh. This marsh contained damp soils in May. Wispy Willow consists of coyote willow that has been slowly filling in an inundated cattail marsh. In both locations, the flycatchers likely responded to the co-occurrence of suitable vegetation structure with moist or inundated soils.

Alamo Lake was not surveyed as part of this project until 2014, but it was known to be occupied annually from 1996 to 2006, with 5–24 territories and 1–16 pairs documented in each year (Ellis et al. 2008). We documented 31 territories and 28 pairs in 2014. Seventeen of the 28 pairs were in sites (Camp 01, Camp 03, Middle Earth 01, Middle Earth 02, and Motherlode 01) that were inundated by Alamo Lake in June 2007, 2010, and 2011, as shown in aerial imagery on Google Earth, or had been recently scoured (Motherlode 04). Vegetation in all these sites consists primarily of relatively small-diameter, even-aged Goodding's willow that was no more than 3 years old in 2014. The colonization of young habitat that emerges on recently exposed sediments has also been documented at Roosevelt Lake, Arizona, where new habitats were colonized when they were 2.5–3.5 years old (Paxton et al. 2007), and occupancy declined at older sites as they became farther from water (Ellis et al. 2008). Several of these young sites at Alamo Lake

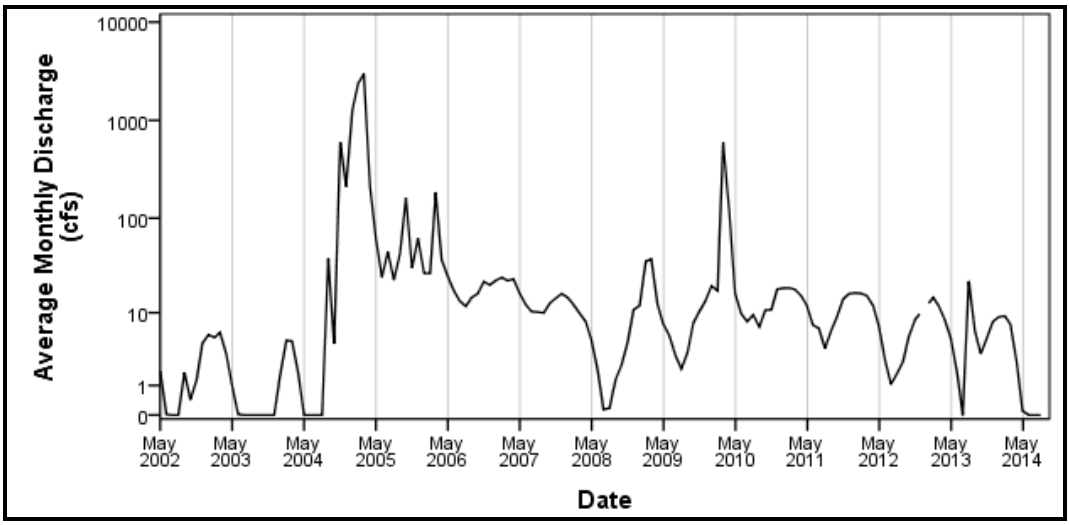

Figure 2-4.—Monthly average streamflow (cfs) recorded at the Bill Williams River near Parker, Arizona (USGS gaging station #09426620), 2002–14.

(e.g., Middle Earth 01, Middle Earth 02, Motherlode 01, and Motherlode 04) were already several hundred meters (m) from surface water in 2014, nest success was poor (see chapter 4), and microclimate monitoring revealed higher temperatures and lower humidity than at either Topock Marsh or the Bill Williams River NWR (see chapter 5). We anticipate willow mortality and a decrease in habitat suitability and occupancy at these sites if lake levels continue to decline.

Although 47 flycatcher detections were recorded at habitat creation sites south of the Bill Williams River NWR, monitoring results and behavioral observations (lack of territorial, aggressive behaviors exhibited toward conspecific broadcasts) at these sites suggest these flycatchers were not resident or breeding individuals but migrants. These results are consistent with those recorded in the same survey sites in 2003–2013 (McLeod et al. 2008; McLeod and Pellegrini 2013, 2014). One of these flycatchers was detected on July 7 at the PVER. This date is well after June 24 and well before July 20, the dates we use as the cutoff for determining whether a site is considered occupied, but the individual was not territorial or responsive to playback, and the observer was unable to locate it after the initial auditory detection, as it never vocalized again. Only two other instances of early July detections were recorded south of the Bill Williams River NWR in 2003–14, and neither of the other two flycatchers acted territorial either. A flycatcher was detected at Hoge Ranch on July 2, 2003; it vocalized prior to broadcast but did not respond to broadcast and could not be relocated on any of five subsequent visits. A flycatcher was detected at Walker Lake on July 6, 2005; this individual also vocalized prior to broadcast. It flew in to investigate the broadcast and then flew away, still vocalizing as it moved off until it either stopped vocalizing or was out of auditory range. Given that willow flycatchers are one of the last long-distance neotropical migrant passerines to arrive in the Southwest in spring, the occurrence of northbound, migrant flycatchers along the Colorado River until late June and early July is not surprising.

Chapter 3 – Color Banding and Resighting

INTRODUCTION

Long-term monitoring of willow flycatchers of known identity, sex, and age is the only effective way to determine demographic life history parameters such as annual survivorship of adults and young, site fidelity, seasonal and between-year movements, and population structure. Thus, as an integral part of our studies, we captured and uniquely color banded as many willow flycatchers as possible, allowing field personnel to resight individuals throughout the breeding season as well as in subsequent years. Resighting consisted of using binoculars to determine the identity of a color-banded flycatcher by observing, from a distance, the unique color combination on its legs. This allowed field personnel to detect and monitor individuals without recapturing each bird. This was our 12th consecutive year of color-banding studies and builds upon color banding initiated at these sites in 1997 (McKernan and Braden 1998).

METHODS

Color Banding

From mid-May through mid-August, we captured, uniquely color banded, and subsequently monitored adult and nestling willow flycatchers at all study areas where resident willow flycatchers were detected. Adult flycatchers were captured with mist nets, which provide the most effective technique for live capture of adult songbirds (Ralph et al. 1993). We used a targeted capture technique (per Sogge et al. 2001), whereby a variety of conspecific vocalizations were broadcast from a compact disk player and remote speakers to lure territorial flycatchers into the nets. In addition, we used "passive netting," whereby several mist nets were erected and periodically checked, with no broadcast of conspecific vocalizations. We banded each adult willow flycatcher with a single, numbered U.S. Federal aluminum band on one leg and a colored metal band on the other. The aluminum Federal bands are either standard silver or anodized in one of several colors. We coordinated all color combinations with the Federal Bird Banding Laboratory and all other southwestern willow flycatcher banding projects to minimize duplication of color combinations. For each color-banded bird recaptured, we visually inspected the legs and noted any evidence of irritation or injury that may be related to the presence of leg bands.

Nestlings were banded at 7 to 10 days of age, when they were large enough to retain the leg bands, yet young enough that they would not prematurely fledge from the nest (Whitfield 1990; Paxton et al. 1997). Nestlings were banded only when the location of the nest was such that nest access and removal/replacement

of the nestlings would not endanger the nest, nest plant, or nestlings. Nestlings were also banded with a single, numbered Federal band (standard silver or anodized) on one leg and a metal color band on the other leg.

For each captured adult willow flycatcher, we recorded morphological measurements, including culmen, tail, wing, fat level, and molt, onto standardized data forms (attachment 2). Sex was determined based on the presence of a cloacal protuberance in males or brood patch and/or egg(s) in the oviduct of females. Captured flycatchers lacking breeding characteristics and not observed engaging in male advertising song (see below) were sexed as unknown. Flycatchers with retained primary, secondary, and/or primary covert feathers (multiple aged remiges) were aged as second year adults, and those without (uniformly aged remiges) were aged as after hatch year (per Kenwood and Paxton 2001 and Koronkiewicz et al. 2002). Individuals in juvenile plumage (unworn flight feathers and body plumage with broad, buff-colored wing bars and fleshy gape) were aged as hatch year.

Resighting

We determined the identity of a color-banded flycatcher by observing, with binoculars, from a distance, the unique color combination on its legs. Typically, territories and active nests were focal areas for resighting, but entire sites were surveyed. Field personnel typically spent the early part of each morning color banding and directed their efforts to resighting as daylight increased and flycatchers became more difficult to capture. All banding, monitoring, and survey field personnel coordinated resighting efforts and recorded observations of color-banded and unbanded flycatchers into an electronic database. For resighted flycatchers (i.e., ones for which at least one leg was seen clearly enough to determine the presence or absence of a band), we recorded color-band combinations, territory number, site, standardized confidence levels of the resight, and behavioral observations. Willow flycatchers for which detections spanned 1 week or longer were considered resident at a site regardless of the portion of the breeding season in which the bird was observed or whether a possible mate was observed. Flycatchers observed engaging in breeding behaviors (e.g., carrying nest material) were also considered resident regardless of the period of time over which they were observed. Flycatchers observed engaging in lengthy, primary song from high perches (male advertising song) were sexed as male, and flycatchers observed carrying nest material or constructing or incubating a nest were sexed as female. Flycatchers not observed engaging in one of these diagnostic activities were sexed as unknown.

Prior to July 15, inactive territories were visited at least three times (each visit 4 days apart) before territory visits stopped. After July 15, inactive territories

were visited at least two times (each visit 4 days apart) before the territory was deemed closed for the season. All territories were assigned a unique alphanumeric code and were plotted onto high-resolution aerial photographs, thus producing a spatial representation of the flycatcher population at each study location. If multiple females were paired with a single male, each female received a unique territory number. Flycatchers were determined to be unpaired if none of the following breeding behaviors were observed: presence of another unchallenged flycatcher in the immediate vicinity, counter calling (*whitts*) with a nearby flycatcher, interaction twitter calls (*churr/kitters*) with a nearby flycatcher, a flycatcher in the immediate vicinity carrying nesting material, a flycatcher in the immediate vicinity carrying food or a fecal sac, or adult flycatchers feeding young (per Sogge et al. 2010).

Unbanded flycatchers could not be identified to individual, but an unbanded flycatcher detected in a given location on multiple, consecutive visits was assumed to be the same individual. If an unbanded flycatcher or a flycatcher whose legs were not observed was detected at a given location on multiple visits but one or more intervening visits failed to detect a flycatcher, the detections were considered to be different individuals in the absence of behavioral observations, indicating the flycatcher was actively defending a territory or was a member of a breeding pair.

Data Analyses

Movement

We defined all movements as the straight line distance between two known locations of activity. Activity can include breeding, defense of a territory, or the brief (< 7 days) detection of an individual in a particular area. Adult movements can either occur between years or within season but are always between study areas; we do not describe movements within a study area or survey site. All adult between-year movement distances were calculated from the last known location in one study area in a given year (year t) and the first known location in another study area in a subsequent year (year t + 1). Years are not always consecutive. For juvenile dispersal, the last known location is always the nest location even if the juvenile was detected as a fledgling elsewhere. The distance between the nest location and the first known location of the juvenile in a subsequent year is always calculated even if the individual returned to its natal survey site. We summarized all known movements as described above and present the median, minimum, and maximum movement distances for all adult between-year movements and juvenile dispersal.

RESULTS

All Study Areas

Field personnel color banded 41 new adult flycatchers and recaptured 8 adults. An additional 52 adults were identified to individual via resighting, while 2 individuals were resighted but did not have their color combinations confirmed. Thirty-eight adult flycatchers remained unbanded, and banding status was undetermined (i.e., we were unable to determine if these individuals were banded) for 45 adults. Overall, 55% of the adult flycatchers detected at the monitoring sites were known to be color banded by the end of the breeding season (table 3-1). Of the adults that were identified in 2014, 16 were identified for the first time since they were banded in their hatch year (see "Juvenile Between-Year Return and Dispersal," below). We banded 65 nestlings from 30 nests and 3 unbanded fledglings, 2 of which came from 2 additional nests. We resighted 15 unbanded fledglings from an additional 9 nests. Of the 186 adult flycatchers detected in all study areas, 144 were resident; 70% of the resident adult flycatchers were known to be color banded by the end of the breeding season (table 3-2). For details on all banded flycatchers detected at the study areas from 2010 to 2014, see attachment 8. Details on all banded flycatchers detected at the study areas from 2003 to 2012 can be found in McLeod and Pellegrini (2013).

Individual Study Areas

Key Pittman Wildlife Management Area

We detected 35 resident, adult willow flycatchers from 23 territories at the Key Pittman WMA. In addition to resident adults, we detected six willow flycatchers for which residency could not be determined (table 3-3). Of the 23 territories at the Key Pittman WMA, 17 consisted of breeding individuals and 6 consisted of an unpaired male. Five males were each polygynous with two females. Two unpaired males were detected briefly at the Pahranagat NWR after they vacated their territories at the Key Pittman WMA; one male was detected at Pahranagat North and the other at Pahranagat MAPS (see table 3-8).

Field personnel captured and color banded three new adults and recaptured one flycatcher. We resighted and identified 30 additional adults. Of the adults identified in 2014, eight were identified for the first time since their hatch year. Four adults remained unbanded, color combinations could not be confirmed for two adults, and the band status could not be determined for one adult. We banded 21 nestlings from 10 nests and resighted 1 unbanded fledgling from an additional nest; 4 nestlings from 2 nests were suspected to have died before fledging.

Table 3-1.—Summary of willow flycatchers detected at study areas where resident flycatchers were observed during the 2014 breeding season*

		Adults									Juveniles			
					Resighted									
Study area	Survey site	Total adults detected	New captured	Recaptured	Color combination confirmed	Banded (color combinations unconfirmed)	Unbanded	Band status undetermined	Percent of all adults resident	Percent of all adults banded	Nestlings banded (# nests)	Fledglings captured (# nests)	Unbanded fledglings (# nests)	Percent of all fledglings banded[1]
Key Pittman WMA	Nesbitt Forest	2[2]	0	0	2[2]	0	0	0	100	100	0	0	0	–
	Patch 00	1	0	0	1[3]	0	0	0	100	100	0	0	0	–
	Patch 01	2[2]	1[2]	0	0	1	0	0	100	100	0	0	0	–
	Patch 02	3	1	0	2	0	0	0	100	100	0	0	0	–
	Patch 03	1	0	0	1[4]	0	0	0	100	100	0	0	0	–
	Patch 04	2	0	0	2	0	0	0	100	100	3 (1)	0	0	100
	Patch 05	4	0	0	0	0	3	1	0	0	0	0	0	–
	Patch 06	8	1	0	6	1	0	0	88	100	2 (1)	0	0	–
	Patch 07	2[5]	0	0	2[5]	0	0	0	100	100	0	0	1 (1)	0
	Patch 08	2[5]	0	0	2[5]	0	0	0	100	100	2 (1)[6]	0	0	–
	Patch 09	7	0	1	6	0	0	0	100	100	9 (4)	0	0	100
	Patch 10	2	0	0	2	0	0	0	100	100	2 (1)	0	0	100
	Patch 11	3	0	0	3	0	0	0	100	100	1 (1)	0	0	100
	Patch 12	4	0	0	3	0	1	0	75	75	2 (1)[6]	0	0	–
	Study area total	**41[2,5]**	**3**	**1**	**30[2,5]**	**2**	**4**	**1**	**85**	**88**	**21 (10)**	**0**	**1 (1)**	**92**
Pahranagat NWR	Pahranagat North	25	5	7	13[4]	0	0	0	96	100	17 (6)[7]	3 (3)[8]	6 (4)	71
	Pahranagat MAPS	5	1	0	4[3]	0	0	0	80	100	4 (1)	0	0	100
	Study area total	**30**	**6**	**7**	**17**	**0**	**0**	**0**	**93**	**100**	**21 (7)**	**3 (3)**	**6 (4)**	**76**
Meadow Valley Wash	Dog Leg	4	3	0	0	0	1	0	100	75	5 (2)	0	0	100
	Study area total	**4**	**3**	**0**	**0**	**0**	**1**	**0**	**100**	**75**	**5 (2)**	**0**	**0**	**100**
Muddy River	Overton WMA Pond	3	0	0	0	0	3	0	0	0	0	0	0	–
	Overton WMA	8	3	0	5	0	0	0	100	100	3 (3)	0	0	100
	Study area total	**11**	**3**	**0**	**5**	**0**	**3**	**0**	**73**	**73**	**3 (3)**	**0**	**0**	**100**
Warm Springs	Muddy Mac	1[9]	0	0	1[9]	0	0	0	100	100	0	0	0	–
	Muddy Stringer 01	1[9]	0	0	1[9]	0	0	0	100	100	0	0	0	–
	Study area total	**1[9]**	**0**	**0**	**1[9]**	**0**	**0**	**0**	**100**	**100**	**0**	**0**	**0**	**–**
Topock	Pipes 03	1	0	0	0	0	0	1	0	0	0	0	0	–
	The Wallows	5	0	0	0	0	0	5	0	0	0	0	0	–
	PC 6-1	1	0	0	0	0	0	1	0	0	0	0	0	–
	Pierced Egg	3	0	0	0	0	1	2	0	0	0	0	0	–
	Swine Paradise	5	2	0	1	0	2	0	80	60	6 (3)	0	0	100
	Platform	3	0	0	0	0	0	3	0	0	0	0	0	–
	Glory Hole	2	0	0	0	0	0	2	0	0	0	0	0	–
	CPhase 05	4	0	0	0	0	2	2	25	0	0	0	0	–
	Lost Lake	6	1	0	0	0	2	3	17	17	0	0	0	–
	Study area total	**30**	**3**	**0**	**1**	**0**	**7**	**19**	**20**	**13**	**6 (3)**	**0**	**0**	**100**

Table 3.1.—Summary of willow flycatchers detected at study areas where resident flycatchers were observed during the 2014 breeding season* (continued)

		Adults									Juveniles			
					Resighted									
Study area	Survey site	Total adults detected	New captured	Recaptured	Color combination confirmed	Banded (color combinations unconfirmed)	Unbanded	Band status undetermined	Percent of all adults resident	Percent of all adults banded	Nestlings banded (# nests)	Fledglings captured (# nests)	Unbanded fledglings (# nests)	Percent of all fledglings banded[1]
Bill Williams River NWR	Wispy Willow	6	2	0	0	0	1	3	67	33	2 (1)	0	0	100
	Site 01	3	0	0	0	0	0	3	0	0	0	0	0	–
	Site 03	2	0	0	0	0	2	0	100	0	0	0	3 (1)	0
	Study area total	**11**	**2**	**0**	**0**	**0**	**3**	**6**	**55**	**18**	**2 (1)**	**0**	**3 (1)**	**25**
Alamo Lake	Camp 01	2	2	0	0	0	0	0	100	100	0	0	0	–
	Camp 04	1	1	0	0	0	0	0	100	100	0	0	0	–
	Camp 03	3	1	0	0	0	1	1	67	33	0	0	0	–
	Middle Earth 01	9	4	0	0	0	3	2	100	44	2 (2)	0	0	100
	Middle Earth 02	15	7	0	0	0	4	4	93	47	1 (1)	0	2 (1)	33
	Motherlode 01	4	3	0	0	0	1	0	100	75	4 (1)	0	0	100
	Motherlode 02	4	0	0	0	0	3	1	100	0	0	0	2 (1)	0
	Motherlode 03	11	1	0	0	0	6	4	91	9	0	0	0	–
	Motherlode 04	2	2	0	0	0	0	0	100	100	0	0	0	–
	Confluence 02	1	0	0	0	0	0	1	0	0	0	0	0	–
	Santa Maria South 01	2	0	0	0	0	1	1	100	0	0	0	0	–
	Santa Maria North 01	6	0	0	0	0	1	5	100	0	0	0	1 (1)	0
	Study area total	**60**	**21**	**0**	**0**	**0**	**20**	**19**	**93**	**35**	**7 (4)**	**0**	**5 (3)**	**50**
	Total	**186[3,4]**	**41**	**8**	**52[3,4]**	**2**	**38**	**45**	**77**	**55**	**65 (30)**	**3 (3)**	**15 (9)**	**77**

* Adults are identified as new captures (previously unbanded), recaptures of previously banded birds, resightings of banded birds for which band combinations were confirmed, birds known to be unbanded, birds for which band status could not be determined, and resightings of banded birds for which band combinations were undetermined. Total numbers of adults detected, percent of adults that were resident, and percent of all adults banded are included. Juveniles are identified as banded in the nest, banded as fledglings, or unbanded. The percent of all fledglings banded is included. For breeding and/or residency status of adults and fledging status of nestlings, see table 3-3.

[1] Percentage calculated based on birds confirmed to have fledged.
[2] One individual was captured in Patch 01 and detected in Nesbitt Forest and is tallied only once in the study area total.
[3] One individual was detected in both KEPI Patch 00 and PAHR Pahranagat MAPS and is tallied only once in the overall total.
[4] One individual was detected in both KEPI Patch 03 and PAHR Pahranagat North and is tallied only once in the overall total.
[5] One individual was detected in both Patch 07 and Patch 08 and is tallied only once in the study area total.
[6] Nestlings suspected to have died before fledging.
[7] Three nestlings from one nest died before fledgling.
[8] One fledgling known to have died.
[9] One individual was detected in both Muddy Mac and Muddy Stringer 01 and is tallied only once in the study area total.

Table 3-2.—Summary of resident adult willow flycatchers detected during the 2014 breeding season*

Study area	Survey site	Total resident adults detected	New captured	Recaptured	Resighted				Percent of all resident adults banded
					Color combination confirmed	Banded (color combinations unconfirmed)	Unbanded	Band Status Undetermined	
Key Pittman WMA	Nesbitt Forest	2[1]	0	0	2[1]	0	0	0	100
	Patch 00	1	0	0	1	0	0	0	100
	Patch 01	2[1]	1[1]	0	0	1	0	0	100
	Patch 02	3	1	0	2	0	0	0	100
	Patch 03	1	0	0	1	0	0	0	100
	Patch 04	2	0	0	2	0	0	0	100
	Patch 06	7	1	0	6	0	0	0	100
	Patch 07	2[2]	0	0	2[2]	0	0	0	100
	Patch 08	2[2]	0	0	2[2]	0	0	0	100
	Patch 09	7	0	1	6	0	0	0	100
	Patch 10	2	0	0	2	0	0	0	100
	Patch 11	3	0	0	3	0	0	0	100
	Patch 12	3	0	0	3	0	0	0	100
	Study area total	**35[1,2]**	**3**	**1**	**30[1,2]**	**1**	**0**	**0**	**100**
Pahranagat NWR	Pahranagat North	24	5	7	12	0	0	0	100
	Pahranagat MAPS	4	1	0	3	0	0	0	100
	Study area total	**28**	**6**	**7**	**15**	**0**	**0**	**0**	**100**
Meadow Valley Wash	Dog Leg	4	3	0	0	0	1	0	75
	Study area total	**4**	**3**	**0**	**0**	**0**	**1**	**0**	**75**
Muddy River	Overton WMA	8	3	0	5	0	0	0	100
	Study area total	**8**	**3**	**0**	**5**	**0**	**0**	**0**	**100**
Warm Springs	Muddy Mac	1[3]	0	0	1[3]	0	0	0	100
	Muddy Stringer 01	1[3]	0	0	1[3]	0	0	0	100
	Study area total	**1[3]**	**0**	**0**	**1[3]**	**0**	**0**	**0**	**100**

Table 3-2.—Summary of resident adult willow flycatchers detected during the 2014 breeding season*

Study area	Survey site	Total resident adults detected	New captured	Recaptured	Resighted				Percent of all resident adults banded
					Color combination confirmed	Banded (color combinations unconfirmed)	Unbanded	Band Status Undetermined	
Topock	Swine Paradise	4	1	0	1	0	2	0	50
	CPhase 05	1	0	0	0	0	1	0	0
	Lost Lake	1	1	0	0	0	0	0	100
	Study area total	**6**	**2**	**0**	**1**	**0**	**3**	**0**	**50**
Bill Williams River NWR	Wispy Willow	4	2	0	0	0	1	1	50
	Site 03	2	0	0	0	0	2	0	0
	Study area total	**6**	**2**	**0**	**0**	**0**	**3**	**1**	**33**
Alamo Lake	Camp 01	2	2	0	0	0	0	0	100
	Camp 04	1	1	0	0	0	0	0	100
	Camp 03	2	1	0	0	0	0	1	50
	Middle Earth 01	9	4	0	0	0	3	2	44
	Middle Earth 02	14	7	0	0	0	4	3	50
	Motherlode 01	4	3	0	0	0	1	0	75
	Motherlode 02	4	0	0	0	0	3	1	0
	Motherlode 03	10	1	0	0	0	5	4	10
	Motherlode 04	2	2	0	0	0	0	0	100
	Santa Maria South 01	2	0	0	0	0	1	1	0
	Santa Maria North 01	6	0	0	0	0	1	5	0
	Study area total	**56**	**21**	**0**	**0**	**0**	**18**	**17**	**38**
	Total	**144**	**40**	**8**	**52**	**1**	**25**	**18**	**70**

* Adults are identified as new captures (previously unbanded), recaptures of previously banded birds, resightings of banded birds for which band combinations were confirmed, birds known to be unbanded, birds for which band status could not be determined, and resightings of banded birds for which band combinations were undetermined. Included are total numbers of resident adults detected and percent of all resident adults banded. For breeding status of resident adults, see table 3-3.

[1] One individual was captured in Patch 01 and detected in Nesbitt Forest and is tallied only once in the study area total.

[2] One individual was detected in both Patch 07 and Patch 08 and is tallied only once in the study area total.

[3] One individual was detected in both Muddy Mac and Muddy Stringer 01 and is tallied only once in the study area total.

Table 3-3.—Details of willow flycatchers detected at study areas where resident flycatchers were observed during the 2014 breeding season

Study area[1]	Survey site	Date banded[2]	Federal band #[2]	Color combination[3]	Age[4]	Sex[5]	Territory or location[6]	Observation status[7]
KEPI	Nesbitt Forest	July 3, 2013	2540-58248	DWD(M):TQ	SY	F	77	RS
		June 4, 2014	N/A[8]	YG(M):UB	AHY	M	55,77	RS; N at 55 in Patch 01
	Patch 00	July 13, 2013	2660-23031	VI:YR(M)	SY	M	T20	RS; detected June 24 – July 2. Detected July 21 at F07 in PAHR Pahranagat MAPS.
	Patch 01	INA	INA	banded	AHY	F	55	RS
	Patch 02	July 13, 2003	2540-58305	VR(M):TQ	SY	F	45	RS
		July 2, 2009	2370-40024	PU:BV(M)	6Y	M	45,79	RS
		July 28, 2014	2660-23053	VI:RGR(M)	AHY	F	79	N
	Patch 03	July 8, 2010	2540-58158	RB(M):TQ	5Y	M	T33	RS; detected May 24 – July 28. Detected on August 3 in PAHR North F15
	Patch 04	July 13, 2013	2540-58270	TQ:WGW(M)	3Y	F	26	RS
		July 9, 2013	2540-58376	TQ:WDW(M)	3Y	M	26	RS
		June 30, 2014	2540-58153	ROR(M):TQ	L	U	26	N
		June 30, 2014	2660-23041	VI:DD(M)	L	U	26	N; not confirmed as fledged
		June 30, 2014	2660-23043	VR(M):VI	L	U	26	N
	Patch 05	N/A	N/A	UB:UB	AHY	U	F09	RS; detected May 25
		N/A	N/A	UB:UB	AHY	U	F90	RS; detected May 31
		N/A	N/A	UB:UB	AHY	U	F91	RS; detected June 9
		INA	INA	undetermined	AHY	M	F92	Detected June 16
	Patch 06	July 20, 2013	2660-23042	VI:YB(M)	SY	F	05	RS
		June 8, 2010	2430-61088	XX:BKB(M)	A6Y	M	05	RS
		July 20, 2013	2540-58377	TQ:WYW(M)	SY	F	42	RS
		July 16, 2011	2540-58277	TQ:YY(M)	4Y	M	42	RS
		July 18, 2014	2660-23096	YV(M):VI	L	U	42	N; not confirmed as fledged
		July 18, 2014	2540-58358	VRV(M):TQ	L	U	42	N; not confirmed as fledged
		June 20, 2013	2660-23001	VI:BV(M)	A3Y	M	T04	RS; detected May 24 – June 12
		July 9, 2013	2660-23029	VI:OR(M)	A3Y	M	T07	RS; detected May 24 – August 2
		June 22, 2014	2660-23067	VI:WKW(M)	AHY	M	T10	N; detected May 13 – July 8
		INA	INA	banded	AHY	M	F18	RS; detected June 4

Table 3-3.—Details of willow flycatchers detected at study areas where resident flycatchers were observed during the 2014 breeding season

Study area[1]	Survey site	Date banded[2]	Federal band #[2]	Color combination[3]	Age[4]	Sex[5]	Territory or location[6]	Observation status[7]
KEPI	Patch 07	July 1, 2012	2540-58320	KO(M):TQ	3Y	F	17	RS
		July 28, 2010	2540-58202	TQ:BB(M)	6Y	M	11,17	RS
		N/A	N/A	UB:UB	HY	U	17	RS
	Patch 08	July 28, 2011	2540-58175[9]	no foot:WO(M)	A5Y	F	11	RS
		July 20, 2014	2660-23095	OGO(M):VI	L	U	11	N; suspected to have died before fledging
		July 20, 2014	2590-53169	DRD(M):XX	L	U	11	N; suspected to have died before fledging
	Patch 09	July 14, 2009	2430-61279	XX:DW(M)	6Y	F	24	RS
		June 30, 2010	2540-58239	RD(M):TQ	5Y	M	24,47	RS
		July 5, 2014	2660-23076	OKO(M):VI	L	U	24	N
		July 5, 2014	2540-58334	DV(M):TQ	L	U	24	N; not confirmed as fledged
		July 5, 2011	2590-53121	XX:WRW(M)	A5Y	F	25	RS
		July 8, 2011	2590-53101	XX:DOD(M)	4Y	M	25	R 24 May
		July 4, 2014	2540-58333	YVY(M):TQ	L	U	25	N
		July 4, 2014	2660-23075	VDV(M):VI	L	U	25	N; not confirmed as fledged
		July 4, 2014	2660-23074	VI:DG(M)	L	U	25	N
		July 17, 2012	2430-61300	VRV(M):XX	3Y	F	28	RS
		June 23, 2009	2430-61159	OK(M):XX	6Y	M	28	RS
		July 4, 2014	2660-23073	VI:WY(M)	L	U	28	N
		June 30, 2010	2540-58240	KYK(M):TQ	5Y	F	47	RS
		July 5, 2014	2660-23077	WYW(M):VI	L	U	47	N
		July 5, 2014	2540-58335	GDG(M):TQ	L	U	47	N
		July 5, 2014	2660-23078	VI:DWD(M)	L	U	47	N
	Patch 10	July 6, 2011	2540-58177	TQ:KRK(M)	A5Y	F	54	RS
		July 16, 2009	2430-61158	RB(M):XX	A7Y	M	54	RS
		June 28, 2014	2540-58138	TQ:VK(M)	L	U	54	N
		June 28, 2014	2660-23037	OD(M):VI	L	U	54	N
	Patch 11	June 27, 2011	2590-53171	XX:ORO(M)	5Y	F	23	RS
		July 10, 2010	2540-58223	YV(M):TQ	6Y	M	23,38	RS
		July 6, 2014	2660-23079	DY(M):VI	L	U	23	N
		July 4, 2013	2540-58254	TQ:WOW(M)	SY	F	38	RS

Table 3-3.—Details of willow flycatchers detected at study areas where resident flycatchers were observed during the 2014 breeding season

Study area[1]	Survey site	Date banded[2]	Federal band #[2]	Color combination[3]	Age[4]	Sex[5]	Territory or location[6]	Observation status[7]
KEPI	Patch 12	July 17, 2013	2540-58281	VDV(M):TQ	A3Y	F	21	RS
		July 27, 2011	2540-58387	GWG(M):TQ	A4Y	M	21	RS
		July 10, 2014	2660-23047	VI:RY(M)	L	U	21	N; suspected to have died before fledging
		July 10, 2014	2660-23046	WB(M):VI	L	U	21	N; suspected to have died before fledging
		June 13, 2011	2540-58245	TQ:KYK(M)	5Y	M	T22	RS; detected May 16 – July 16
		N/A	N/A	UB:UB	AHY	U	F13	RS; detected June 24
PAHR	Pahranagat North	June 15, 2014	2540-58136	KGK(M):TQ	AHY	F	01	N
		July 24, 2008	2430-61083	XX:YR(M)	8Y	M	01	RS
		July 31, 2012	2540-58269	KVK(M):TQ	A4Y	F	02	RS
		June 21, 2010	2370-40088	PU:VG(M)	6Y	M	02,76	R July 1
		June 29, 2014	2590-53175	WVW(M):XX	L	U	02	N; not confirmed as fledged
		June 29, 2014	2540-58139	TQ:VDV(M)	L	U	02	N; not confirmed as fledged
		June 29, 2014	2660-23038	VI:BG(M)	L	U	02	N
		July 7, 2014	2660-23080	VD(M):VI	HY	U	02	N
		June 11, 2014	2540-58135	WDW(M):TQ	AHY	F	03	N
		July 21, 2010	2540-58201[9]	no foot:BO(M)	5Y	M	03	R May 7
		July 1, 2014	2660-23044	VI:KB(M)	L	U	03	N
		July 1, 2014	2660-23045	DVD(M):VI	L	U	03	N
		July 3, 2011	2540-58114	YDY(M):TQ	4Y	F	12	RS
		May 26, 2014	2660-23060	VI:RW(M)	AHY	M	12	N, R July 23
		June 28, 2014	2370-40094	GRG(M):PU	L	U	12	N; died before fledging
		June 28, 2014	2540-58137	TQ:OB(M)	L	U	12	N; died before fledging
		June 28, 2014	2660-23036	KO(M):VI	L	U	12	N; died before fledging
		July 30, 2010	2540-58238	TQ:GOG(M)	5Y	F	14	RS
		July 8, 2010	2540-58157	OY(M):TQ	5Y	M	14	RS
		July 13, 2014	2540-58215	VKV(M):TQ	L	U	14	N
		July 13, 2014	2660-23048	VI:KYK(M)	L	U	14	N
		July 13, 2014	2660-23049	WVW(M):VI	L	U	14	N
		July 30, 2014	2540-58271	TQ:YGY(M)	3Y	F	20	RS
		July 21, 2010	2540-58199	TQ:BW(M)	5Y	M	20,72	RS
		July 7, 2014	2660-23081	KW(M):VI	HY	U	20	N
		N/A	N/A	UB:UB	HY	U	20	RS
		July 11, 2014	2660-23100	VI:WK(M)	AHY	F	27	N
		July 7, 2012	2540-58259	ORO(M):TQ	3Y	M	27	R July 11
		N/A	N/A	UB:UB	HY	U	27	RS
		N/A	N/A	UB:UB	HY	U	27	RS

Table 3-3.—Details of willow flycatchers detected at study areas where resident flycatchers were observed during the 2014 breeding season

Study area[1]	Survey site	Date banded[2]	Federal band #[2]	Color combination[3]	Age[4]	Sex[5]	Territory or location[6]	Observation status[7]
PAHR	Pahranagat North	Aug 6, 2013	2540-58127	OB(M):TQ	SY	F	31	RS
		July 1, 2012	2430-61262	XX:GYG(M)	3Y	M	31	R May 19 and 28
		July 19, 2014	2660-23098	VKV(M):VI	L	U	31	N
		July 19, 2014	2590-53183	XX:DG(M)	L	U	31	N
		July 19, 2014	2540-58361	TQ:GRG(M)	L	U	31	N
		July 3, 2011	2430-61220	RGR(M):XX	4Y	F	43	R July 11
		June 27, 2011	2540-58246	BR(M):TQ	5Y	M	43,49,74	RS
		July 19, 2014	2660-23099	VI:DRD(M)	HY	L	43	N; died after fledging
		N/A	N/A	UB:UB	HY	U	43	RS
		July 17, 2012	2430-61267	ROR(M):XX	4Y	F	49	RS
		N/A	N/A	UB:UB	HY	U	49	RS
		N/A	N/A	UB:UB	HY	U	49	RS
		July 22, 2014	2540-58312	GVG(M):TQ	AHY	F	72	N
		Aug 6, 2013	2540-58309	TQ:GDG(M)	SY	F	74	R July 23
		July 6, 2011	2540-58286[9]	KY(M):no foot[10]	4Y	F	76	R July 16
		July 16, 2014	2540-58311	DOD(M):TQ	L	U	76	N
		July 16, 2014	2660-23006	VI:YWY(M)	L	U	76	N
		July 16, 2014	2660-23051	ROR(M):VI	L	U	76	N
		July 7, 2011	2540-58179	GK(M):TQ	4Y	M	T13	RS; detected May 18 – July 5
		July 17, 2012	2540-58262	OG(M):TQ	3Y	M	T30	RS; detected May 21 – July 11
		July 8, 2010	2540-58158	RB(M):TQ	5Y	M	F15	RS; detected August 3. At T33 in KEPI Patch 03 May 24 – July 28
PAHR	Pahranagat MAPS	July 4, 2012	2430-61298	KGK(M):XX	4Y	F	08	RS
		July 2, 2013	2660-23021	VI:RD(M)	SY	M	08,35	RS
		July 3, 2014	2660-23072	VI:GO(M)	L	U	08	N
		July 3, 2014	2540-58331	TQ:VD(M)	L	U	08	N
		July 3, 2014	2540-58332	RGR(M):TQ	L	U	08	N
		July 3, 2014	2660-23071	KVK(M):VI	L	U	08	N
		June 25, 2014	2660-23065	VI:KOK(M)	SY	F	35	N
		July 3, 2013	2540-58250	KRK(M):TQ	SY	M	T06	RS; detected June 7–29
		July 13, 2013	2660-23031	VI:YR(M)	SY	M	F07	RS; detected July 21. At T20 in KEPI Patch 00 June 24 – July 2

Table 3-3.—Details of willow flycatchers detected at study areas where resident flycatchers were observed during the 2014 breeding season

Study area[1]	Survey site	Date banded[2]	Federal band #[2]	Color combination[3]	Age[4]	Sex[5]	Territory or location[6]	Observation status[7]
MVWA	Dog Leg	N/A	N/A	UB:UB	AHY	F	41	RS
		June 18, 2014	2370-40077	PU:OGO(M)	SY	M	41,73	N
		July 3, 2014	2660-23070	RVR(M):VI	L	U	41	N; not confirmed as fledged
		July 3, 2014	2540-58330	TQ:VRV(M)	L	U	41	N
		July 3, 2014	2660-23069	VI:YVY(M)	L	U	41	N
		June 30, 2014	2540-58140	TQ:DWD(M)	AHY	F	73	N
		June 30, 2014	2660-23039	RB(M):VI	L	U	73	N
		June 30, 2014	2660-23040	VI:GYG(M)	L	U	73	N
		June 26, 2014	2540-58363	OK(M):TQ	SY	M	T62	N; detected June 18–26
MUDD	Overton WMA Pond	N/A	N/A	UB:UB	AHY	U	F30	RS; detected May 17
		N/A	N/A	UB:UB	AHY	U	F31	RS; detected June 2–5
		N/A	N/A	UB:UB	AHY	U	F42	RS; detected May 25
	Overton WMA	June 8, 2010	2540-58193	TQ:DB(M)	A6Y	F	15	RS
		June 6, 2013	2660-23017	VI:DYD(M)	3Y	M	15,19,71,75	RS
		July 6, 2012	2590-53157	YVY(M):XX	3Y	F	16	RS
		May 21, 2014	2540-58134	VD(M):TQ	AHY	M	16,70	N
		July 1, 2014	2660-23068	VI:GVG(M)	L	U	16	N; not confirmed as fledged
		July 10, 2014	2660-23083	VI:OYO(M)	SY	F	19	N
		July 12, 2014	2540-58360	WRW(M):TQ	L	U	19	N; not confirmed as fledged
		July 19, 2013	2660-23016	WOW(M):VI	3Y	F	70	RS
		July 12, 2011	2590-53106	XX:OGO(M)	4Y	F	71	RS
		July 10, 2014	2660-23082	WG(M):VI	SY	F	75	N
		Aug 5, 2014	2660-23052	VI:VW(M)	L	U	75	N
WMSP	Muddy Stringer 01	May 20, 2008	2540-58234	KD(M):TQ	A8Y	M	T01, T36	RS; detected June 11 – July 29. At T36 in WMSP Muddy Mac through June 5
TOPO	Pipes 03	INA	INA	undetermined	AHY	U	F06	Detected May 29
	The Wallows	INA	INA	undetermined	AHY	U	F09	Detected July 24
		INA	INA	undetermined	AHY	U	F10	Detected July 16
		INA	INA	undetermined	AHY	U	F30	Detected June 5
		INA	INA	undetermined	AHY	U	F31	Detected May 18
		INA	INA	undetermined	AHY	U	F38	Detected May 29
	PC 6-1	INA	INA	undetermined	AHY	U	F11	Detected May 18
	Pierced Egg	INA	INA	undetermined	AHY	U	F01	Detected May 20
		N/A	N/A	UB:UB	AHY	U	F13	RS; detected June 15
		INA	INA	undetermined	AHY	U	F35	Detected May 21

Table 3-3.—Details of willow flycatchers detected at study areas where resident flycatchers were observed during the 2014 breeding season

Study area[1]	Survey site	Date banded[2]	Federal band #[2]	Color combination[3]	Age[4]	Sex[5]	Territory or location[6]	Observation status[7]
TOPO	Swine Paradise	June 29, 2010	2540-58231	TQ:GR(M)	6Y	F	04	RS
		N/A	N/A	UB:UB	AHY	M	04,14,32	RS
		June 28, 2014	2540-58347	TQ:DVD(M)	L	U	04	N
		June 28, 2014	2660-23089	VI:OY(M)	L	U	04	N
		June 28, 2014	2590-53131	VR(M):XX	L	U	04	N
		N/A	N/A	UB:UB	AHY	F	14	RS
		Aug 1, 2014	2540-58344	TQ:WVW(M)	L	U	14	N
		July 3, 2014	2540-58349	RY(M):TQ	AHY	F	32	N
		July 3, 2014	2660-23090	VI:RDR(M)	L	U	32	N
		July 3, 2014	2540-58348	TQ:GWG(M)	L	U	32	N
		July 16, 2014	2590-53168	YOY(M):XX	SY	M	F15	N; detected July 16
	Platform	INA	INA	undetermined	AHY	U	F33	Detected May 19
		INA	INA	undetermined	AHY	U	F34	Detected May 19
		INA	INA	undetermined	AHY	U	F36	Detected May 29
	Glory Hole	INA	INA	undetermined	AHY	U	F07	Detected June 9
		INA	INA	undetermined	AHY	U	F12	Detected May 19
	CPhase 05	N/A	N/A	UB:UB	AHY	U	T46	RS; detected May 21 – June 2
		N/A	N/A	UB:UB	AHY	U	F02	RS; detected May 21
		INA	INA	undetermined	AHY	U	F03	Detected May 21
		INA	INA	undetermined	AHY	U	F05	Detected May 27
	Lost Lake	June 4, 2014	2590-53167	XX:VDV(M)	SY	M	T41	N; detected June 1–17
		N/A	N/A	UB:UB	AHY	U	F51	RS; detected May 21
		INA	INA	undetermined	AHY	U	F52	Detected May 21
		INA	INA	undetermined	AHY	U	F53	Detected May 21
		N/A	N/A	UB:UB	AHY	U	F54	RS; detected May 21
		INA	INA	undetermined	AHY	U	F57	Detected May 21
BIWI	Wispy Willow	July 17, 2014	2540-58356	DGD(M):TQ	SY	F	52	N
		July 17, 2014	2660-23087	VI:ORO(M)	SY	M	52,53	N
		July 12, 2014	2660-23092	BK(M):VI	L	U	52	N; not confirmed as fledged
		July 12, 2014	2540-58352	GRG(M):TQ	L	U	52	N
		N/A	N/A	UB:UB	AHY	F	53	RS
		INA	INA	undetermined	AHY	M	T50	Detected May 29 – June 16
		INA	INA	undetermined	AHY	U	F57	Detected June 3
		INA	INA	undetermined	AHY	U	F58	Detected May 29

Table 3-3.—Details of willow flycatchers detected at study areas where resident flycatchers were observed during the 2014 breeding season

Study area[1]	Survey site	Date banded[2]	Federal band #[2]	Color combination[3]	Age[4]	Sex[5]	Territory or location[6]	Observation status[7]
BIWI	Site 01	INA	INA	undetermined	AHY	U	F51	Detected May 28 – June 3
		INA	INA	undetermined	AHY	U	F54	Detected May 23
		INA	INA	undetermined	AHY	U	F56	Detected June 3
	Site 03	N/A	N/A	UB:UB	AHY	F	01	RS
		N/A	N/A	UB:UB	AHY	M	01	RS
		N/A	N/A	UB:UB	HY	U	01	RS
		N/A	N/A	UB:UB	HY	U	01	RS
		N/A	N/A	UB:UB	HY	U	01	RS
ALAM	Camp 01	June 5, 2014	2540-58362	TQ:YWY(M)	AHY	F	50	N
		June 5, 2014	2590-53129	DG(M):XX	AHY	M	50	N
	Camp 04	June 5, 2014	2590-53128	XX:YRY(M)	AHY	M	T71	N; detected June 5 – July 2
	Camp 03	INA	INA	undetermined	AHY	F	53	
		July 10, 2014	2540-58350	WOW(M):TQ	AHY	M	53	N
		N/A	N/A	UB:UB	AHY	M	F40	RS; detected July 1–4
	Middle Earth 01	INA	INA	undetermined	AHY	F	02	
		N/A	N/A	UB:UB	AHY	M	02	RS
		INA	INA	undetermined	AHY	F	03	
		June 6, 2014	2660-23102	VI:RO(M)	AHY	M	03,07,72	N
		July 11, 2014	2540-58353	VWV(M):TQ	AHY	F	07	N
		July 11, 2014	2660-23091	DOD(M):VI	AHY	M	07,72, 99	N; R July 23; displaced VI:RO(M) at 07 and 72
		July 11, 2014	2540-58351	YKY(M):TQ	L	U	07	N; not confirmed as fledged
		N/A	N/A	UB:UB	AHY	F	72	RS
		July 23, 2014	2540-58342	TQ:YDY(M)	SY	F	99	N
		July 23, 2014	2540-58343	WGW(M):TQ	L	U	99	N
		N/A	N/A	UB:UB	AHY	M	T01	RS; detected May 22 – June 6
	Middle Earth 02	N/A	N/A	UB:UB	AHY	F	06	RS
		July 11, 2014	2540-58341	OYO(M):TQ	AHY	M	06	N
		July 11, 2014	2540-58340	GKG(M):TQ	L	U	06	N
		N/A	N/A	UB:UB	AHY	F	10	RS
		INA	INA	undetermined	AHY	M	10	
		N/A	N/A	UB:UB	HY	U	10	RS
		N/A	N/A	UB:UB	HY	U	10	RS
		INA	INA	undetermined	AHY	F	11	
		June 5, 2014	2660-23064	OY(M):VI	AHY	M	11,49	N
		June 4, 2014	2660-23063	GR(M):VI	AHY	F	47	N
		June 4, 2014	2540-58317	TQ:VYV(M)	AHY	M	47	N

Table 3-3.—Details of willow flycatchers detected at study areas where resident flycatchers were observed during the 2014 breeding season

Study area[1]	Survey site	Date banded[2]	Federal band #[2]	Color combination[3]	Age[4]	Sex[5]	Territory or location[6]	Observation status[7]
ALAM	Middle Earth 02	INA	INA	undetermined	AHY	F	48	
		N/A	N/A	UB:UB	AHY	M	48	RS
		June 4, 2014	2540-58318	DG(M):TQ	AHY	F	49	N
		June 4, 2014	2540-58316	TQ:WRW(M)	AHY	F	66	N
		June 4, 2014	2660-23061	VI:BK(M)	AHY	M	66	N
		N/A	N/A	UB:UB	AHY	U	T12	RS; detected June 18 and July 4; likely a female
		INA	INA	undetermined	AHY	U	F46	Detected May 22
	Motherlode 01	N/A	N/A	UB:UB	AHY	F	51	RS
		June 6, 2014	2540-58329	TQ:RDR(M)	AHY	M	51	N
		June 22, 2014	2660-23085	VI:DR(M)	L	U	51	N; 3 or 4 nestlings fledged, this one not confirmed
		June 22, 2014	2540-58339	TQ:KD(M)	L	U	51	N; 3 or 4 nestlings fledged, this one not confirmed
		June 22, 2014	2660-23086	KGK(M):VI	L	U	51	N
		June 22, 2014	2540-58338	RV(M):TQ	L	U	51	N
		June 6, 2014	2540-58328	GYG(M):TQ	AHY	F	55	N
		June 6, 2014	2660-23066	VI:VR(M)	AHY	M	55	N
	Motherlode 02	N/A	N/A	UB:UB	AHY	F	24	RS
		INA	INA	undetermined	AHY	M	24	
		N/A	N/A	UB:UB	HY	U	24	RS
		N/A	N/A	UB:UB	HY	U	24	RS
		N/A	N/A	UB:UB	AHY	F	52	RS
		N/A	N/A	UB:UB	AHY	M	52	RS
	Motherlode 03	N/A	N/A	UB:UB	AHY	F	21	RS
		N/A	N/A	UB:UB	AHY	M	21	RS
		INA	INA	UB:UB	AHY	F	22	RS
		N/A	N/A	undetermined	AHY	M	22	
		N/A	N/A	UB:UB	AHY	F	23	RS
		INA	INA	undetermined	AHY	M	23	
		INA	INA	undetermined	AHY	F	41	
		June 5, 2014	2590-53130	XX:DWD(M)	AHY	M	41	N
		N/A	N/A	UB:UB	AHY	U	42	RS
	Motherlode 03	INA	INA	undetermined	AHY	U	42	
		N/A	N/A	UB:UB	AHY	M	F43	RS; detected May 22
	Motherlode 04	June 5, 2014	2540-58319	WO(M):TQ	AHY	F	05	N
		June 5, 2014	2660-23062	BV(M):VI	AHY	M	05	N
	Confluence 02	INA	INA	undetermined	AHY	U	F04	Detected May 24

Table 3-3.—Details of willow flycatchers detected at study areas where resident flycatchers were observed during the 2014 breeding season

Study area[1]	Survey site	Date banded[2]	Federal band #[2]	Color combination[3]	Age[4]	Sex[5]	Territory or location[6]	Observation status[7]
ALAM	Santa Maria South 01	INA	INA	undetermined	AHY	F	25	
		N/A	N/A	UB:UB	AHY	M	25	RS
	Santa Maria North 01	INA	INA	undetermined	AHY	F	08	
		INA	INA	undetermined	AHY	M	08	
		N/A	N/A	UB:UB	HY	U	08	RS
		INA	INA	undetermined	AHY	F	09	
		INA	INA	undetermined	AHY	M	09	
		INA	INA	undetermined	AHY	F	33	
		N/A	N/A	UB:UB	AHY	M	33	RS

[1] KEPI = Key Pittman WMA, PAHR = Pahranagat NWR, MVWA = Meadow Valley Wash, MUDD = Muddy River, WMSP = Warm Springs Natural Area, TOPO = Topock Marsh, BIWI = Bill Williams River NWR, and ALAM = Alamo Lake.

[2] N/A = not applicable, and INA = information not available.

[3] **Color-band codes**: PU = pumpkin Federal band, XX = standard silver Federal band, TQ = turquoise Federal band, VI = violet Federal band, (M) = metal pinstriped band, UB = unbanded, R = red,
O = orange, Y = yellow, G = green, D = dark blue, B = light blue, V = violet, W = white, K = black, banded = bird was banded but combination could not be determined, and undetermined = presence of bands could not be determined. Color combinations are read as the bird's left leg and right leg, top to bottom; two or three letters designate every band; color-band designations for right and left legs are separated with a colon.

[4] **Age in 2014**: L = nestling, HY = hatch year, SY = 2 years, AHY = 2 years or older, 3Y = 3 years, A3Y = 3 years or older, 4Y = 4 years, A4Y = 4 years or older, etc.

[5] **Sex codes**: M = male, F = female, and U = unknown.

[6] **Territory or location code**: Number without an alpha code indicates a flycatcher pair, T = territorial individual detected for at least 7 days, and F = individual detected for less than 7 days. Number indicates unique location.

[7] **Observation status codes**: N = new capture, R = recapture followed by date recaptured, and RS = resight. Banded nestlings are confirmed to have fledged unless noted otherwise.

[8] Captured with pre-existing leg injury. No Federal band applied. Band number tracked internally as 9999-99999.

[9] Original Federal band number.

[10] Recaptured with color combination "TQ:no foot" and rebanded.

Pahranagat National Wildlife Refuge

We detected 28 resident, adult willow flycatchers from 18 territories at the Pahranagat NWR. In addition to resident adults, we detected two willow flycatchers for which residency could not be determined; both flycatchers held territories at the Key Pittman WMA earlier in the season (table 3-3). Of the 18 territories recorded at the Pahranagat NWR, 15 consisted of breeding pairs, and 3 consisted of unpaired males. Of the breeding individuals, three males were each polygynous with two females, and one male was polygynous with three females.

Field personnel captured and color banded six new adults and recaptured seven adult flycatchers. We resighted and identified an additional 17 adults. All detected adults were known to be banded and were identified to individual by the end of the season. Of the adults identified in 2014, four were identified for the first time since their hatch year. We banded 21 nestlings from 7 nests; 3 of these nestlings from 1 nest died before fledging. One additional nestling was too small to band when the rest of its siblings were banded; this nestling was captured and banded as a fledgling. We resighted eight additional unbanded fledglings from five additional nests; two of these fledglings were captured and banded.

Meadow Valley Wash

We detected four resident, adult willow flycatchers from three territories at Meadow Valley Wash (table 3-3). Two territories consisted of breeding individuals and the other consisted of an unpaired male. The breeding male was polygynous with two females.

Field personnel captured and color banded three new adult flycatchers. One adult remained unbanded. We banded five nestlings from two nests.

Muddy River

We detected eight resident, adult willow flycatchers from six territories at Muddy River. In addition to resident adults, we detected three individuals for which residency could not be confirmed (table 3-3). All six territories consisted of breeding pairs. Of the breeding individuals, one male was polygynous with two females, and the other male was polygynous with four females.

Field personnel captured and color banded three new adult flycatchers. We resighted and identified five other adults. Three additional adults remained unbanded. Of the adults identified in 2014, one was identified for the first time since its hatch year. We banded three nestlings from three nests.

Warm Springs Natural Area

We detected one resident, adult willow flycatcher at Warm Springs. This individual established two territories, each in a different survey site within Warm Springs (table 3-3).

We resighted and identified the one detected adult flycatcher.

Topock Marsh

We detected six resident, adult willow flycatchers from five territories at Topock Marsh. In addition to resident adults, we detected 24 individuals for which residency could not be confirmed (table 3-3). Three of the territories recorded at Topock consisted of breeding pairs, one consisted of an unpaired male, and one territory contained an individual for which gender could not be determined. The breeding male was polygynous with three females.

Field personnel captured and color banded three new adult flycatchers. One adult was resighted and identified to individual. Seven adults remained unbanded, and the band status of 19 individuals could not be determined. We banded six nestlings from three nests.

Bill Williams River National Wildlife Refuge

We detected six resident, adult willow flycatchers from four territories at the Bill Williams River NWR. In addition to resident adults, we detected five individuals for which residency could not be confirmed (table 3-3). Three of the territories consisted of breeding individuals, and one consisted of an unpaired male. One male was polygynous with two females.

Field personnel captured and color banded two new adult flycatchers. Three adults remained unbanded, and band status could not be determined for six adults. We banded two nestlings from one nest and resighted three unbanded fledglings from an additional nest.

Alamo Lake

We detected 56 resident, adult willow flycatchers from 31 territories at Alamo Lake. In addition to resident adults, we detected four individuals for which residency could not be confirmed (table 3-3). Of the 31 territories recorded at Alamo Lake, 22 consisted of breeding pairs, 6 consisted of pairs for which no nest could be found, and 3 consisted of an unpaired male. One male was polygynous with two females. Two males were each polygynous with three females; one of these males displaced the other male at two territories.

Field personnel captured and color banded 21 new adult flycatchers. Twenty adults remained unbanded, and band status could not be determined for 19 adults. We banded seven nestlings from four nests and resighted five unbanded fledglings from three additional nests.

Non-monitoring Sites

These study areas were monitored by other agencies, and here we report only banded flycatchers that were captured or resighted (table 3-6). Unbanded individuals or those with unknown band status are not included.

St. George

Personnel from the Utah Division of Wildlife Resources resighted and identified five adult flycatchers and resighted an additional four banded flycatchers that could not be definitively identified (table 3-4). Of the five identified adults, three were identified for the first time since their hatch year.

Table 3-4.—Banded willow flycatchers detected at non-monitoring sites, 2014

Study area[1]	Survey site	Date banded	Federal band #	Color combination[2]	Age[3]	Sex[4]	Observation status[5]
STGE	Y-Drain	July 9, 2010	2540-58160	DD(M):TQ	5Y	M	RS
		INA	INA	banded	AHY	F	RS
	Schmutz Drain	July 17, 2013	2660-23007	RG(M):VI	SY	M	RS
	Snipe Pond	July 17, 2013	2660-23010	VI:KVK(M)	SY	F	RS
	Seegmiller Marsh	July 20, 2013	2590-53160	GYG(M):XX	SY	F	RS
		INA	INA	banded	AHY	M	RS
		INA	INA	banded	AHY	F	RS
	Riverside Marsh	July 14, 2009	2540-58217	TQ:BR(M)	7Y	M	RS
		INA	INA	banded	AHY	M	RS

[1] STGE = St. George.
[2] **Color-band codes**: TQ = turquoise Federal band, XX = standard silver Federal band, VI = violet Federal band, (M) = metal pinstriped band, R = red, Y = yellow, G = green, B = light blue, D = dark blue, V = violet, K = black, and banded = bird was banded but combination could not be determined. Color combinations are read as the bird's left leg and right leg, top to bottom; two or three letters designate every band; color-band designations for right and left legs are separated with a colon.
[3] **Age in 2014:** AHY = 2 years or older, 5Y = 5 years, 7Y = 7 years, and SY = second year.
[4] **Sex codes**: M = male, and F = female.
[5] **Observation status codes**: RS = resight.

Adult Between-Year Return and Dispersal

In 2013, we individually identified 57 adult, resident willow flycatchers at study areas that were monitored in both 2013 and 2014. Of these 57 flycatchers, 42 (74%) were detected in 2014, with 7 (17%) being detected at a different study area than where they were resident in 2013 (table 3-5). Of all the adult

flycatchers identified in 2014, nine were detected at a different study area than where they were last detected in a previous year (table 3-6). The median dispersal distance for all returning adult flycatchers exhibiting between-year movements in 2014 was 30.4 km (minimum = 11.4 km, and maximum = 213.7 km).

Table 3-5.—Resident adult willow flycatcher annual return from 2013 to 2014

Study area	# identified in 2013	# of 2013 birds detected in 2014	Percent return	Percent return to same study area
Key Pittman WMA	32	23	72	87
River Ranch	1	1	100	0
Pahranagat NWR	15	14	93	93
Muddy River	8	3	38	100
Topock Marsh	1	1	100	0
Total	**57**	**42**	**74**	**83**

Table 3-6.—Adult willow flycatcher between-year movements for all individuals identified in a previous year and recaptured or resighted at a different study area in 2014

Study area/survey site/year detected[1]	Study area/survey site detected 2014[1]	Distance moved (km)	Federal band #	Color combination[2]	Sex[3]
TOPO/Glory Hole/2013	WMSP/Muddy Mac	213.7	2540-58234	KD(M):TQ	M
MOME/Virgin River 01 South/2013	TOPO/Swine Paradise	201.7	2540-58231	TQ:GR(M)	F
MOME/Virgin River 01 South/2013	PAHR/Pahranagat MAPS	103.2	2430-61298	KGK(M):XX	F
WMSP/Muddy Mac/2012	MUDD/Overton WMA	34.5	2540-58193	TQ:DB(M)	F
PAHR/Pahranagat West/2013	KEPI/Patch 09	30.4	2430-61300	VRV(M):XX	F
KEPI/Patch 04.5/2013	PAHR/Pahranagat North	29.7	2540-58259	ORO(M):TQ	M
KEPI/Patch 04/2013	PAHR/Pahranagat North	29.6	2540-58179	GK(M):TQ	M
RIRA/East Side/2013	PAHR/Pahranagat North	18.2	2540-58262	OG(M):TQ	M
RIRA/West Side/2013	KEPI/Patch 04	11.4	2540-58376	TQ:WDW(M)	M

[1] TOPO = Topock Marsh, MOME = Mormon Mesa, WMSP = Warm Springs, PAHR = Pahranagat NWR, KEPI = Key Pittman WMA, and RIRA = River Ranch.

[2] **Color-band codes**: XX = silver Federal band, TQ = turquoise Federal band, (M) = metal pinstriped band, R = red, O = orange, G = green, B = light blue, D = dark blue, V = violet, K = black, and W = white. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[3] **Sex codes**: F = female, and M = male.

Juvenile Between-Year Return and Dispersal

In 2013, we banded 42 nestlings and 3 fledglings at all study areas and opportunistically banded an additional 13 nestlings at St. George. Ten of the nestlings were known or suspected to have died before fledging. Of the 48 remaining juveniles, 13 (27%) were identified in 2014 (table 3-7). One individual originally banded as a nestling in 2012, and two individuals originally banded as nestlings in 2011 were also identified for the first time in 2014. Of the 16 returning nestlings identified in 2013, 7 (44%) dispersed away from their natal study area. The median dispersal distance for all returning juvenile flycatchers in 2014 was 2.4 km (minimum = 0.5 km, and maximum = 32.3 km).

Table 3-7.—Juvenile flycatchers banded as hatch year birds in a prior year and identified as adults for the first time in 2014

Study area/survey site banded[1]	Year hatched	Study area/survey site detected 2014[1]	Distance moved (km)	Federal band #	Color combination[2]	Sex[3]
KEPI/Patch 09	2013	PAHR/Pahranagat MAPS	32.3	2660-23021	VI:RD(M)	M
KEPI/Patch 11	2013	PAHR/Pahranagat North	30.3	2540-58127	OB(M):TQ	F
KEPI/Patch 11	2013	PAHR/Pahranagat North	30.3	2540-58309	TQ:GDG(M)	F
PAHR/Pahranagat North	2011	KEPI/Patch 09	30.1	2590-53101	XX:DOD(M)	M
PAHR/Pahranagat North	2013	KEPI/Patch 11	30.1	2540-58254	TQ:WOW(M)	F
PAHR/Pahranagat North	2013	KEPI/Nesbitt Forest	29.4	2540-58248	DWD(M):TQ	F
MOME/Virgin River 01 South	2011	MUDD/Overton WMA	13.5	2590-53106	XX:OGO(M)	F
PAHR/Pahranagat North	2013	PAHR/Pahranagat MAPS	2.4	2540-58250	KRK(M):TQ	M
STGE/Y-Drain	2013	STGE/Snipe Pond	2.4	2660-23010	VI:KVK(M)	F
STGE/Y-Drain	2013	STGE/Schmutz Drain	1.7	2660-23007	RG(M):VI	M
KEPI/Patch 01	2012	KEPI/Patch 07	0.7	2540-58320	KO(M):TQ	F
STGE/Y-Drain	2013	STGE/Seegmiller Marsh	0.7	2590-53160	GYG(M):XX	F
KEPI/Patch 08	2013	KEPI/Patch 02	0.7	2540-58305	VR(M):TQ	F
KEPI/Patch 08	2013	KEPI/Patch 00	0.7	2660-23031	VI:YR(M)	M
KEPI/Patch 03	2013	KEPI/Patch 06	0.5	2660-23042	VI:YB(M)	F
KEPI/Patch 03	2013	KEPI/Patch 06	0.5	2540-58377	TQ:WYW(M)	F

[1] KEPI = Key Pittman WMA, PAHR = Pahranagat NWR, MOME = Mormon Mesa, and STGE = St. George.
[2] **Color-band codes**: XX = standard silver Federal band, TQ = turquoise Federal band, VI = violet Federal band, (M) = metal pinstriped band, R = red, O = orange, Y = yellow, G = green, B = light blue, D = dark blue, V = violet, W = white, and K = black. Color combinations are read as the bird's left leg and right leg, top to bottom; two or three letters designate every band; color-band designations for right and left legs are separated with a colon.
[3] **Sex codes**: F = female, and M = male.

Within-Year, Between-Study Area Movements

We detected two within-year, between-study area movements in 2014 (table 3-8). One unpaired male was at the Key Pittman WMA Patch 00 from June 24 through July 2 and was then was resighted on July 21 in Pahranagat North. A second unpaired male was at the Key Pittman WMA Patch 03 from May 24 to July 28 and then was resighted at Pahranagat North on August 3.

Table 3-8.—Adult willow flycatcher within-year movements for all individuals identified at two different study areas in 2014

Start study area/ survey site[1]	End study area/ survey site[1]	Distance moved (km)	Federal band #	Color combination[2]	Sex[3]
KEPI/Patch 00	PAHR/Pahranagat MAPS	31.7	2660-23031	VI:YR(M)	M
KEPI/Patch 03	PAHR/Pahranagat North	29.5	2540-58158	RB(M):TQ	M

[1] KEPI = Key Pittman WMA, and PAHR = Pahranagat NWR.
[2] **Color-band codes**: TQ = turquoise Federal band, VI = violet Federal band, (M) = metal pinstriped band, Y = yellow, R = red, and B = light blue. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.
[3] **Sex codes**: M = male.

DISCUSSION

Color-banding Effort

The proportion of adult flycatchers that were known to be banded varied widely among study areas, ranging from 13% at Topock Marsh to 100% at the Pahranagat NWR and Warm Springs. These percentages include non-resident flycatchers, which are typically detected only once and do not exhibit territorial behaviors, making them difficult to capture. Consequently, almost all non-resident flycatchers are unbanded or have an undetermined band status, and study areas such as Topock Marsh and the Bill Williams River NWR that had a low proportion of resident adults (20 and 55%, respectively) also had low proportions of banded adults (13 and 18%, respectively). Over the years, we have typically detected higher numbers of non-resident flycatchers at Topock Marsh and the Bill Williams River NWR than at the other study areas, with the lowest number of non-resident flycatchers being detected at the Pahranagat NWR and Key Pittman WMA. The majority of these detections occur prior to the middle of June, suggesting that these individuals are migrants. Lowland riparian areas throughout the desert Southwest are heavily used by many migrant birds (Skagen et al. 2005), and the LCR likely provides a major migratory pathway. It is therefore not surprising that a higher number of migrant flycatchers would be detected at study areas on or near the main stem of the river.

The proportion of resident adult flycatchers that were known to be banded also varied among study areas, ranging from 33% at the Bill Williams River NWR to 100% at the Key Pittman WMA, Pahranagat NWR, Muddy River, and Warm Springs. Differences among study areas in the percentage of resident individuals that are banded are typically related to vegetation density and overall structure, which affect our ability to capture flycatchers. Topock Marsh, where dense tamarisk limits our ability to erect mist nets in the habitat and where flycatchers often sing from the tops of emergent Goodding's willows and are unwilling to come down to mist net level, consistently has a low proportion of banded, resident flycatchers in comparison to the proportions at many other study areas.

The Alamo Lake study area was new to this project in 2014. No banding had occurred at Alamo Lake prior to 2014, and the entire population was unmarked at the beginning of the breeding season. Alamo Lake also had the highest number of resident flycatchers of any of the study areas. The amount of effort available to capture adult flycatchers was insufficient to band a majority of the population, and at the end of the breeding season, Alamo Lake had the second lowest proportion (38%) of banded resident adults.

Adult and Juvenile Between-Year Dispersal

Adult and juvenile dispersal data for the 2014 field season show overall high site fidelity exhibited by adult flycatchers and lower natal site fidelity exhibited by juveniles, with juveniles dispersing among study areas. These dispersal data are consistent with the patterns observed at all study areas from 1998 to 2013, over which period 90% of adult returns were to the same study area, while only 50% of all juvenile returns were to the natal study area (McLeod and Pellegrini 2013, 2014). These dispersal data are also consistent with range-wide data (Paxton et al. 2007), which show adult flycatchers exhibiting high site fidelity to breeding areas. Juvenile dispersal within the Virgin and lower Colorado River population(s) is largely limited to this region, and while reciprocal juvenile movements among geographically isolated flycatcher populations of the greater Southwest do occur, they are rare. Only three instances of willow flycatcher immigration from sites outside the Virgin and lower Colorado River region have been recorded since 1997 (McKernan and Braden, unpublished data; McLeod et al. 2008), with two males originally banded as nestlings in 2003 at Roosevelt Lake recaptured in 2005 at Muddy River and Topock Marsh, and one male banded as a nestling in 1999 at Roosevelt Lake recaptured in 2002 in Grand Canyon. Although movements of this magnitude are infrequent, other instances of dispersal distances greater than 140 km have been reported for the southwestern willow flycatcher (Paxton et al. 2007) and have been noted within the Virgin and lower Colorado River population (McLeod and Pellegrini 2013). Banding studies at Roosevelt Lake and along the San Pedro River were discontinued after 2005, so immigration of juveniles produced in those areas after 2005 would have gone undetected.

The observed dispersal patterns fit well with the tenets of contemporary metapopulation theory (Hanski and Simberloff 1997), suggesting the Virgin and lower Colorado River population may be a panmictic subpopulation of a greater metapopulation. Occasional juvenile dispersal between subpopulations is likely an important population variable in terms of gene flow, with movements contributing to an understanding of the observed patterns of high genetic diversity within, and low genetic isolation among, southwestern willow flycatcher populations (Busch et al. 2000). Dispersal by juveniles or adults is required for the colonization of new breeding sites, and long-distance movements will be required if newly established Reclamation habitat creation sites are to be colonized. The known breeding sites that are closest to habitat creation sites are the Bill Williams River NWR, Topock Marsh, and Alamo Lake; each is ≈ 75–150 km from the PVER and CVCA habitat creation sites (see chapter 2) and within the range of dispersal distances (0.02–203.0 km for juveniles and 0.001–258.6 km for adults) recorded within the Virgin and lower Colorado River population (McLeod and Pellegrini 2013). Returning juveniles are more likely than returning adults to colonize new areas. The number of known returning nestlings since 1997 from Topock Marsh and the Bill Williams River NWR are 21 and 5, respectively. Four of the Bill Williams River NWR nestlings dispersed the 80 km between the two study areas, which is comparable to the distance from the Bill Williams study area to the PVER habitat creation sites. The most recent observation of a dispersing Bill Williams River NWR nestling is the territorial flycatcher that was present in 2012 in the CPhase 05 (formerly Beal Lake) habitat creation site; this demonstrates that long-distance colonization of a habitat creation site is possible if suitable habitat is available. However, the flycatcher population at Topock Marsh declined strongly between 2004 and 2012 (see chapter 2), and no flycatcher young were produced at either Topock Marsh or the Bill Williams River NWR in 2012 or 2013 (see chapter 4), reducing the likelihood of colonization from these sources. While young were produced at Topock Marsh, Bill Williams River NWR, and Alamo Lake in 2014, the total number of confirmed fledges among the three study areas is only 20. Accounting for typical juvenile survival (13–34% at Topock Marsh and the Bill Williams River NWR) (McLeod and Pellegrini 2013), the number of returning nestlings from the 2014 cohort available for dispersal and colonization will not be large.

The habitat creation sites could also be colonized by individuals from more distant breeding areas such as those along the Virgin River. Although such long-distance movements are relatively infrequent, multiple instances of adult and juvenile dispersal between the Virgin River, Topock Marsh, and the Bill Williams River NWR have been documented in recent years (McLeod and Pellegrini 2013, 2014; this document). Productivity along the Virgin River was lower in 2012 and 2013 compared to earlier years, and the likelihood of long-distance juvenile dispersal in the near future is therefore lower.

The likelihood of flycatchers colonizing habitat creation sites might be improved by broadcasting conspecific vocalizations in the sites. Territorial songbirds use song to defend territories and attract mates, but song may also attract other males to settle in an area. The use of playback during territory establishment in the spring was shown to attract the target species in multiple studies, in some cases inducing them to settle in apparently suitable but previously unoccupied habitat (black-capped vireo, Ward and Schlossberg 2004; Baird's sparrow, Ahlering et al. 2006; American redstarts, Hahn and Silverman 2006; black-throated blue warblers, Hahn and Silverman 2007). Although playbacks often increased the number of territorial males, these males did not always succeed in attracting a mate, and few studies examined whether breeding pairs were successful in producing young. None of these studies attempted to attract birds to settle in an area that was far from an established population, and it is unclear whether this technique would successfully attract flycatchers to habitat creation sites at the PVER or CVCA. These sites also lack the constant presence of surface water that is typical of flycatcher territories during the first half of the breeding season, which may affect whether flycatchers would settle there. It is also unknown whether any flycatchers that settled at the PVER or CVCA sites would be able to attract a mate or reproduce successfully. Many factors can influence reproductive success, but both areas have large numbers of cowbirds, and parasitism reduces flycatcher nest success (see chapter 4). Care should be taken to ensure that all habitat characteristics documented in occupied flycatcher territories along the LCR are present in the habitat creation sites prior to considering enticing flycatchers to settle.

Within-Year, Between Study Area Movement

In 2014, we detected two within-year, between study area movements. This is similar to the annual number of movements in 2003–13 when we detected between zero and seven (median = 2) movements per year. Both of the 2014 within-year, between study area movements were of unpaired males detected briefly as non-territorial adults in a second study area near the end of the breeding season. Of the 25 within-year, between study area movements detected in 2003–13, 9 (36%) were of individuals detected as non-territorial adults at the end of the breeding season after breeding or defending a territory elsewhere. Of these 9 individuals, 7 returned in a subsequent year, and 5 of the 7 returning individuals (71%) returned to the same survey site where they were last detected. These individuals were likely prospecting for potential breeding sites, a life history trait that may benefit the willow flycatcher given the ephemeral, dynamic nature of riparian habitats (i.e., riparian vegetation and hydrology changing from one year to the next).

Adult and Juvenile Survivorship

Annual survivorship is defined as the number of individuals that survive from one year to the next, and accurate estimates depend on year-to-year detection of uniquely marked birds. Seventy-four percent of the adult, resident willow flycatchers identified in 2013 were detected again in 2014, while of the 35 juveniles banded in monitored sites in 2013 and not known or suspected to have died before fledging, only 10 (29%) were identified in 2014. Thus, minimum estimated adult and juvenile survival from 2013 to 2014 at all monitored sites was 74 and 29%, respectively. These simple annual percent survivorship calculations assume that all living flycatchers are detected in a given year, and individuals not detected are assumed to have died, unless detected elsewhere. The annual adult survivorship estimate for Muddy River in 2014 was 38%, well below the overall average of 74%. Any flycatchers that dispersed from Muddy River to another study area would be most likely to go to the Virgin River, which was not monitored in 2014. Thus, the survival estimate for Muddy River in 2014 may be well below the actual rate of survival. To provide more robust estimates of annual survival, demographic data acquired from 2013 to 2017 will be combined with data collected during 1997–2012. Survival and detection probabilities will be estimated using program MARK (White and Burnham 1999) and presented in a summary report in 2017.

Chapter 4 – Nest Monitoring

INTRODUCTION

Documentation of nest success and productivity is critical to understanding local population status and demographic patterns of the southwestern willow flycatcher. In 2014, at all sites where willow flycatcher breeding activity was suspected, we conducted intensive nest searches and nest monitoring. Specific objectives of nest monitoring included identifying breeding individuals (see Chapter 3 – Color Banding and Resighting), calculating nest success and failure, documenting causes of nest failure (e.g., abandonment, desertion, depredation, and brood parasitism), and calculating nest productivity. Nest monitoring results from 2014 were compared with those at the study areas from 1996 to 2013 (Braden and McKernan unpublished data; McLeod et al. 2008; McLeod and Pellegrini 2013, 2014). Although aspects of willow flycatcher breeding ecology can vary widely across the species' broad geographical and elevational ranges throughout the Southwest (Whitfield et al. 2003), we compared monitoring results with range-wide data to identify specific variables that may contribute to the characterization of flycatcher breeding ecology throughout the lower Colorado and Virgin River riparian systems.

METHODS

Upon locating territorial willow flycatchers, regardless of whether a possible mate was observed, we conducted intensive nest searches following the methods of Rourke et al. (1999). Nest monitoring followed a modification of the methods described by Rourke et al. (1999) and the Breeding Biology Research and Monitoring Database (BBIRD) protocol by Martin et al. (1997).

Nests were located primarily by observing adult flycatchers return to a nest or by systematically searching suspected nest sites. Nests were monitored every 2 to 4 days after nest building was complete and incubation was confirmed. Nests at Alamo Lake were monitored less frequently, sometimes with 10 or more days between visits. During incubation and after hatching, nest contents were observed directly whenever possible using a telescoping mirror pole to determine nest contents and transition dates. Nest monitoring during nest building and egg laying stages was limited to reduce the chance of abandonment during these periods. To reduce the risk of depredation (Martin et al. 1997), brood parasitism by the brown-headed cowbird, and premature fledging of young (Rourke et al. 1999), we observed nests from a distance with binoculars once the number and age of nestlings were confirmed. If no activity was observed at a previously

occupied nest, the nest was checked directly to determine nest contents and cause of failure. If no activity was observed at a nest close to or on the estimated fledge date, we conducted a systematic search of the area to locate possible fledglings.

Per instructions from Reclamation biologists, we considered a willow flycatcher nest successful only if fledglings were observed near the nest or in surrounding areas. The number of young fledged from each nest was counted based on the number of fledglings actually observed. This method of determining success differs from that recommended by some nest monitoring protocols (e.g., Martin et al. 1997; Rourke et al. 1999), which consider a nest as successful if chicks are observed in the nest within 2 days of the estimated fledge date. The method we follow produces a conservative estimate of both nest success rate and number of fledges.

We considered a nest to have failed if: (1) the nest was abandoned prior to egg laying (abandoned), (2) the nest was deserted with flycatcher eggs or young remaining (deserted), (3) the nest was found empty or destroyed more than 2 days prior to the estimated fledge date (depredated), (4) nestlings died in the nest despite being tended by the adults (nestlings died in nest), or (5) the entire clutch was incubated for an excess of 20 days (infertile/addled). For nests containing flycatcher eggs, parasitism was considered the cause of nest failure if: (1) cowbird young outlived any flycatcher eggs or young or (2) the disappearance of all flycatcher eggs coincided with the appearance of cowbird eggs.

For each nest check, we recorded the date and time of the visit, observer initials, monitoring method (observation via binoculars or mirror pole), nesting stage, nest contents, and number and behavior of adults and/or fledges present into an electronic (Microsoft Word) form that included the nest or territory number and UTM coordinates. We calculated flycatcher nest success using both apparent nesting success (number of successful nests/total number of nests containing at least one flycatcher egg) and the Mayfield method (Mayfield 1961, 1975), which calculates daily nest survival to account for nests that failed before they were found. We assumed one egg was laid per day, and incubation was considered to start the day the last egg was laid (per Martin et al. 1997). The nestling period was considered to start the day the first egg hatched and end the day the first nestling fledged. If exact transition dates or dates of depredation events were unknown, we estimated the transition date as halfway between observations. For nests where fate was unknown, we used the last known date of activity to determine the number of observation days. To calculate Mayfield survival probabilities (MSP), we used the average length of each nest stage (2.13, 12.88, and 13.74 days for laying, incubation, and nestling stages, respectively) as observed in this study in 2003–14 for nests where transition dates were known. Nest productivity was calculated as the number of young fledged per nesting attempt that produced at least one flycatcher egg and had a known outcome.

Fecundity was calculated as number of young produced per female over the breeding season. Parasitism rates were calculated as the percentage of nests with known contents that included at least one flycatcher egg and one cowbird egg.

We attempted to addle cowbird eggs in easily accessible flycatcher nests at all study areas. If the nest was accessible without a ladder, the cowbird egg was addled as soon as it was discovered. If a ladder was required, the cowbird egg was addled on the next regularly scheduled nest visit. Cowbird eggs were addled only if we could obtain a direct view of the nest contents from a secure location, either on the ground or on a ladder. We carefully removed the cowbird egg from the nest and placed it in a padded film canister. We then shook the canister vigorously for about one minute, incorporating sharp, jerky movements. The egg was then returned to the nest. The cowbird egg was not permanently removed from the nest so as not to mimic a partial depredation event, which might result in nest desertion. If a nest was found with a cowbird nestling already in the nest, or if a shaken cowbird egg still hatched, we removed the cowbird nestling from the nest.

All field personnel practiced egg addling with several button quail (*Coturnix chinensis*) eggs at the start of field season to determine how vigorously they could shake an egg without breaking it. Button quail eggs are slightly larger than cowbird eggs (19 x 25 millimeters [mm] versus 16 x 21 mm) but provide a reasonable and easily available substitute. Shaken eggs were carefully opened to determine whether any damage to the internal structure of the egg was apparent. Field personnel varied in their ability to shake an egg to the point of causing internal damage without breaking the shell.

Summary statistics were calculated using IBM ® SPSS ® v. 22.0. One-sided confidence intervals (CIs) around differences in proportions followed Agresti and Caffo 2000 (formula provided by Reclamation staff).

RESULTS

Nest Monitoring

We documented 81 willow flycatcher nesting attempts at the Key Pittman WMA, Pahranagat NWR, Meadow Valley Wash, Muddy River, Topock Marsh, Bill Williams River NWR, and Alamo Lake; 73 of these nests were known to contain flycatcher eggs and were used in calculating nest success and productivity. Thirty-three (45%) nests were successful and fledged young, 31 (42%) failed, and 9 (12%) had an unknown fate. Nest success ranged from 20% at Muddy River to 100% at Meadow Valley Wash and Topock Marsh (table 4-1). For a comparison of apparent nest success at all monitoring sites from 1997 to 2013, see table 4-2. No flycatcher pairs were detected at River Ranch or Warm Springs in 2014.

Table 4-1.—Summary of willow flycatcher nest monitoring results at all study areas, 2014

Study area[1]	Survey site	Pairs	Nests	Nests with 1+ WE[2]	Successful nests[3]	Failed nests[3]	Nests with unknown fate	Parasitized nests[4]
KEPI	*Nesbitt Forest*	1	1	1	0	1 (100)	0	0
	Patch 01	1	1	1	0	1 (100)	0	1 (100)
	Patch 02	2	1	1	0	1 (100)	0	0
	Patch 04	1	1	1	1 (100)	0	0	0
	Patch 06	2	2	2	0	1 (50)	1 (50)	1 (50)
	Patch 07	1	2	1	1 (100)	0	0	0
	Patch 08	1	3	2	0	1 (50)	1 (50)	0
	Patch 09	4	4	4	4 (100)	0	0	0
	Patch 10	1	1	1	1 (100)	0	0	0
	Patch 11	2	3	2	1 (50)	1 (50)	0	1 (50)
	Patch 12	1	2	2	0	1 (50)	1 (50)	1 (50)
	Total	*17*	*21*	*18*	*8 (44)*	*7 (39)*	*3 (17)*	*4 (22)*
PAHR	Pahranagat North	13	17	15	10 (67)	5 (33)	0	1 (8)
	Pahranagat MAPS	2	3	2	1 (50)	1 (50)	0	0
	Total	*15*	*20*	*17*	*11 (65)*	*6 (35)*	*0*	*1 (7)*
MVWA	Dog Leg	2	2	2	2 (100)	0	0	0
	Total	*2*	*2*	*2*	*2 (100)*	*0*	*0*	*0*
MUDD	Overton WMA	6	7	5	1 (20)	2 (40)	2 (40)	3 (60)
	Total	*6*	*7*	*5*	*1 (20)*	*2 (40)*	*2 (40)*	*3 (60)*
TOPO	Swine Paradise	3	3	3	3 (100)	0	0	0
	Total	*3*	*3*	*3*	*3 (100)*	*0*	*0*	*0*
BIWI	Wispy Willow	2	2	2	1 (50)	1 (50)	0	0
	Site 03	1	2	2	1 (50)	1 (50)	0	0
	Total	*3*	*4*	*4*	*2 (50)*	*2 (50)*	*0*	*0*
ALAM	Camp 01	1	0	0	–	–	–	–
	Camp 03	1	1	1	0	1 (100)	0	0
	Middle Earth 01	5	6	6	1 (17)	4 (67)	1 (17)	1 (17)
	Middle Earth 02	7	6	6	2 (33)	4 (67)	0	0
	Motherlode 01	2	2	2	1 (50)	1 (50)	0	0
	Motherlode 02	2	2	2	1 (50)	1 (50)	0	0
	Motherlode 03	5	4	4	0	2 (50)	2 (50)	0
	Motherlode 04	1	1	1	0	1 (100)	0	0
	Santa Maria South 01	1	0	0	–	–	–	–
	Santa Maria North 01	3	2	2	1 (50)	0	1 (50)	0
	Total	*28*	*24*	*24*	*6 (25)*	*14 (58)*	*4 (17)*	*1 (6)*
	Overall total	**74**	**81**	**73**	**33 (45)**	**31 (42)**	**9 (12)**	**9 (15)**

[1] KEPI = Key Pittman WMA, PAHR = Pahranagat NWR, MVWA = Meadow Valley Wash, MUDD = Muddy River, TOPO = Topock Marsh. BIWI = Bill Williams River NWR, and ALAM = Alamo Lake.
[2] WE = willow flycatcher egg.
[3] Only nests with at least one flycatcher egg were used in tallies and percentage calculations. Percentages are given in parentheses.
[4] Parasitized nests include all nests that contained at least one flycatcher egg and one cowbird egg regardless of nest fate. Percentages include only nests with at least one flycatcher egg and for which contents could be determined.

Table 4-2.—Willow flycatcher percent apparent nest success recorded at all study areas, 1996–2014*

Year	Key Pittman WMA[1]	River Ranch[2]	Pahranagat NWR	Meadow Valley Wash	Littlefield	Mesquite	Mormon Mesa[3]	Muddy River	Warm Springs	Grand Canyon	Topock Marsh	Bill Williams River NWR	Alamo Lake[4]
1996	–	–	Nm	Nm	Nm	Nm	Nm	Nm	Nm	Nc	Nc	Nm	–
1997	–	–	Nm	Nm	Nd	67 (3)	42 (12)	Nc	Nm	Nc	Nc	Nd	–
1998	–	–	47 (19)	0 (2)	Nd	0 (7)	70 (10)	Nm	Nm	Nc	53 (15)	Nd	–
1999	–	–	60 (15)	Nd	Nm	Nd	45 (11)	Nm	Nm	Nc	38 (16)	100 (1)	–
2000	–	–	63 (16)	Nd	Nd	50 (8)	38 (13)	100 (1)	Nm	Nc	36 (11)	100 (1)	–
2001	–	–	50 (18)	Nd	Nd	53 (17)	54 (13)	Nc	Nm	Nc	36 (14)	50 (4)	–
2002	–	–	33 (12)	Nm	Nd	59 (17)	0 (9)	Nd	Nm	Nd	50 (6)	78 (9)	–
2003	–	–	91 (11)	Nd	Nd	44 (18)	0 (10)	Nd	Nm	Nd	78 (9)	100 (2)	–
2004	–	–	76 (17)	Nm	50 (2)	24 (17)	50 (6)	Nd	Nm	0 (1)[5]	45 (38)	Nd	–
2005	–	–	58 (19)	Nm	Nd	42 (12)	17 (6)	38 (8)	Nm	Nd	24 (34)	100 (2)	–
2006	–	–	60 (15)	Nm	Nd	55 (20)	50 (8)	44 (9)	Nm	0 (3)	23 (17)[6]	20 (5)	–
2007	–	–	67 (12)	Nm	Nd	57 (14)	27 (11)	0 (6)	Nm	0 (1)	75 (8)	25 (8)	Nm
2008	–	–	80 (10)	Nm	Nd	82 (11)	62 (13)	25 (8)	Nm	Nd	13 (8)[5]	40 (5)[5]	Nm
2009	–	–	47 (17)[5]	Nm	0 (1)	21 (14)[5]	53 (17)	0 (8)	Nm	Nm	50 (2)	33 (6)	Nm
2010	50 (30)	–	59 (17)	Nm	50 (2)	31 (13)	42 (12)	100 (3)	0 (3)	Nm	50 (2)	18 (11)	Nm
2011	45 (31)	0 (4)	100 (7)	Nm	Nd	29 (7)	39 (18)[7]	0 (5)[5]	100 (1)	Nm	0 (1)	40 (5)	Nm
2012	41 (27)	Nd	71 (14)	Nm	Nd	0 (5)	38 (13)	25 (4)	0 (2)	Nm	Nd	0 (2)	Nm
2013	35 (23)[8]	0 (2)	86 (7)	Nm	Nd	0 (0)	20 (5)	25 (4)	Nd	Nm	0 (2)	Nd	Nm
2014	44 (18)[9]	Nd	65 (17)	100 (2)	Nm	Nm	Nm	20 (5)[10]	Nd	Nm	100 (3)	50 (4)	25 (24)[7]

* Data from 1997 to 2002 are from Braden and McKernan (unpublished data); these numbers have been verified with the raw data and may differ from those presented in earlier annual reports. Data from 2003 to 2007 are from McLeod et al. 2008; data from 2008 to 2012 are in McLeod and Pellegrini 2013; data from 2013 are in McLeod and Pellegrini 2014. Total number of nests containing at least one flycatcher egg is indicated in parentheses. Nm = not monitored, Nd = study area surveyed, no breeding documented, and Nc = breeding confirmed, nest success not calculated.

[1] Key Pittman WMA was monitored by the NDOW prior to 2010, and those data are not included here.
[2] River Ranch was monitored by the NDOW prior to 2011, and those data are not included here.
[3] Study area includes the Virgin River delta at Lake Mead.
[4] Alamo Lake was surveyed by the Arizona Game and Fish Department prior to 2007, and those data are not included here.
[5] Fate of one nest was unknown.
[6] An additional 3 nests (18%) were suspected to have fledged, but fledglings were not visually confirmed.
[7] Fate of four nests was unknown.
[8] One additional nest (4%) was suspected to have fledged, but fledglings were not visually confirmed.
[9] Fate of three nests was unknown.
[10] Fate of two nests was unknown.

Sixty-seven nesting females, of which 65 were known to have produced at least 1 egg, were followed through all of their nesting attempts. Of the 67 nesting females, 54 had 1 nesting attempt, 12 had 2 nesting attempts, and 1 had 3 attempts. Twelve of the 13 females with multiple nesting attempts re-nested after failed nests, and one re-nested after a successful nest. We detected an additional seven females (one at the Key Pittman WMA and six at Alamo Lake) for which no nest was found.

Nest Failure

Depredation was the major cause of nest failure for all study areas combined, accounting for 38% (15 of 39) of all failed nests (table 4-3). Eight nests (21%) were abandoned before flycatcher eggs were laid. Of the 31 nests that failed after flycatcher eggs were laid, depredation accounted for 48% of failures, while parasitism caused failure at 3% of these nests. Nestlings were found dead in 2 (5%) of all the failed nests, and 11 (28%) nests were deserted during either laying or incubation. The cause of failure was unknown at two nests where the contents of the nest could not be determined.

Table 4-3.—Summary of causes of willow flycatcher nest failure at all study areas, 2014*

Study area[1]	Total # nests	All failed nests	Abandoned	Deserted	Depredated	Parasitized	Addled	Nestlings died in nest	Cause of failure unknown
KEPI	21	10	3 (30)	3 (30)	3 (30)	0	0	1 (10)	0
PAHR	20	9	3 (33)	2 (22)	3 (33)	1 (11)	0	0	0
MVWA	2	0	0	0	0	0	0	0	0
MUDD	7	4	2 (50)	0	1 (25)	0	0	1 (25)	0
TOPO	3	0	0	0	0	0	0	0	0
BIWI	4	2	0	2 (100)	0	0	0	0	0
ALAM	24	14	0	4 (29)	8 (57)	0	0	0	2 (14)
Total	**81**	**39**	**8 (21)**	**11 (28)**	**15 (38)**	**1 (3)**	**0**	**2 (5)**	**2 (5)**

* All nesting attempts (those with and without flycatcher eggs) are included. The percentage of failed nests is shown in parentheses for each cause of failure. Abandoned = no flycatcher eggs were laid, deserted = deserted with eggs or young remaining in the nest, depredated = nest empty or destroyed 2 days or more before anticipated fledge date, parasitized = cowbird young outlived any flycatcher young or appearance of cowbird egg(s) coincided with disappearance of all flycatcher eggs, and addled = entire clutch incubated > 20 days.

[1] KEPI = Key Pittman WMA, PAHR = Pahranagat NWR, MVWA = Meadow Valley Wash, MUDD = Muddy River, TOPO = Topock Marsh, BIWI = Bill Williams River NWR, and ALAM = Alamo Lake.

Brood Parasitism

Nine of 62 nests (15%) with flycatcher eggs and known contents were brood parasitized by brown-headed cowbirds, and one flycatcher nest was abandoned with a cowbird egg (table 4-4). Brood parasitism ranged from 0 to 60% and was

Table 4-4.—Fates of willow flycatcher nests parasitized by brown-headed cowbirds at all study areas, 2014*

Study area[1]	Nest ID code	Outcome[2]
KEPI	05A	Nest depredated after 16 days incubation; CE addled and did not hatch
	21A	Nest deserted during laying with one WE and one CE
	38B	Depredated during nestling period; nest not easily accessible; CE was not addled and hatched
	55A	Nest deserted during laying with one WE and one CE
PAHR	12B	Appearance of CE coincided with disappearance of WE; nest failed because of parasitism event
MUDD	19A	Abandoned with one CE
	70A	All WE depredated during incubation; female continued to defend the nest with one CE, which had been addled and did not hatch
	71A	Nest not easily accessible; CE was not addled and hatched; CN removed before WEs hatched; WNs died in nest at 7 days old
	75A	CE addled and did not hatch; fledged one flycatcher
ALAM	07A	CE was not addled and hatched; CN removed; fate of nest unknown

* All nesting attempts are included.
[1] KEPI = Key Pittman WMA, PAHR = Pahranagat NWR, MUDD = Muddy River, and ALAM = Alamo Lake.
[2] WE = willow flycatcher egg, CE = cowbird egg, WN = willow flycatcher nestlings, and CN = cowbird nestling.

highest at Muddy River (see table 4-1). For nests containing flycatcher eggs, parasitism caused failure at one nest where the parasitism event coincided with the disappearance of the single flycatcher egg in the nest. Parasitism likely contributed to the failure of two additional nests that were deserted after being parasitized during laying. One parasitized nest successfully fledged a flycatcher, and the fate of another nest was unknown. None of the four remaining parasitized nests fledged a flycatcher; however, nest failure is attributed to other causes. In 2014, 24 of 45 (53.3%) unparasitized nests were successful, whereas one of nine (11%) of parasitized nests were successful (one-sided Fisher's exact test, $P = 0.037$; difference in proportions = 0.42, 95% lower bound [LB] = 0.12).

Cowbird Egg Addling

We attempted to addle cowbird eggs at three of the nine parasitized nests that contained flycatcher eggs. Of the six nests where we did not attempt to addle the cowbird egg, three failed immediately after the parasitism event. The remaining three nests were not easily accessible, and the cowbird hatched in all three of these nests. Of the three nests where we addled the cowbird egg, two were incubated long enough for the cowbird egg to hatch, but neither did.

Mayfield Nest Success and Nest Productivity

MSP ranged from 0.231 at Alamo Lake to 1.000 at Topock Marsh and was 0.514 for all study areas combined (table 4-5). At all sites, 63 nestlings were confirmed to have fledged from 64 nests of known outcome (mean number of fledglings/nest = 0.98, standard error [SE] = 0.14). Fecundity across study areas ranged from 0.25 to 2.00 young per female and averaged 0.97 (SE = 0.14) (table 4-6).

Table 4-5.—Daily survival rates and MSP for willow flycatcher nest stages at all study areas, 2014*

Study area	Nest stage[1]	Nest losses/ observation days	Daily survival rate	MSP
Key Pittman WMA	1	3/36.5	0.918	0.833
	2	1/197	0.995	0.937
	3	3/149.5	0.980	0.757
	MSP all stages = 0.591			
Pahranagat NWR	1	1/36.5	0.973	0.943
	2	3/182.5	0.984	0.808
	3	2/162.5	0.988	0.844
	MSP all stages = 0.642			
Meadow Valley Wash	1	0/0	–	–
	2	0/24	1.000	1.000
	3	0/28.5	1.000	1.000
	MSP all stages = N/A[2]			
Muddy River	1	0/6	1.000	1.000
	2	1/59.5	0.983	0.804
	3	1/40.5	0.975	0.709
	MSP all stages = 0.570			
Topock Marsh	1	0/4	1.000	1.000
	2	0/39	1.000	1.000
	3	0/41	1.000	1.000
	MSP all stages = 1.000			
Bill Williams River NWR	1	1/3.5	0.714	0.488
	2	1/40	0.975	0.722
	3	0/26.5	1.000	1.000
	MSP all stages = 0.352			
Alamo Lake	1	0/13	1.000	1.000
	2	9/177.5	0.949	0.512
	3	5/89	0.944	0.452
	MSP all stages = 0.231			
Total	**1**	**5/99.5**	**0.950**	**0.896**
	2	**15/719.5**	**0.979**	**0.762**
	3	**11/537.5**	**0.980**	**0.753**
	MSP all stages = 0.514			

* MSP was calculated using 2.13-day egg laying, 12.88-day incubation, and 13.74-day nestling stages.
[1] 1 = egg laying, 2 = incubation, and 3 = nestling.
[2] MSP cannot be calculated for all stages because of lack of data.

Table 4-6.—Willow flycatcher nest productivity (young fledged per nest) and fecundity (young fledged per female) at all study areas, 2014*

Study area	# young fledged	# nests with known outcome	Productivity mean (SE)	# females with known outcome	Fecundity mean (SE)
Key Pittman WMA	13	15	0.87 (0.26)	14	0.93 (0.27)
Pahranagat NWR	25	17	1.47 (0.32)	15	1.67 (0.35)
Meadow Valley Wash	4	2	2.00 (0.00)	2	2.00 (0.00)
Muddy River	1	3	0.33 (0.33)	4	0.25 (0.25)
Topock Marsh	6	3	2.00 (0.58)	3	2.00 (0.58)
Bill Williams River NWR	4	4	1.00 (0.71)	3	1.33 (0.88)
Alamo Lake	10	20	0.50 (0.20)	24	0.42 (0.17)
Total	**63**	**64**	**0.98 (0.14)**	**65**	**0.97 (0.14)**

* Productivity calculations include nests that contained flycatcher eggs and had a known outcome. Fecundity calculations include all females for which nest outcomes were known.

DISCUSSION

Number of Breeding Flycatchers

In 2014, breeding was documented in seven study areas (Key Pittman WMA, Pahranagat NWR, Meadow Valley Wash, Muddy River, Topock Marsh, Bill Williams River NWR, and Alamo Lake). Breeding has been documented in each of these study areas in previous years (Braden and McKernan 2006; Ellis et al. 2008; McLeod and Pellegrini 2013, 2014; C. Klinger, 2013, personal communication). The number of flycatcher pairs (17) detected at the Key Pittman WMA was the same as numbers detected annually in 2010–13 (17–18 pairs) (figure 4-1). At the Pahranagat NWR, the number of flycatcher pairs increased in 2014 to 15 pairs and equalled the highest number of breeding pairs recorded in the study area in 2003–13 (range = 6–15 pairs, average = 10.4 pairs) (figure 4-1). The high number of pairs at the Pahranagat NWR was partially influenced by the discovery of two pairs outside of the primary breeding site of Pahranagat North. Breeding flycatchers were detected in 2014 for the first time at Pahranagat MAPS. Since SWCA began monitoring in 2003, breeding has been documented outside of Pahranagat North in six years (2003–06, 2012, and 2014), with the number of pairs never exceeding three.

The number of flycatcher pairs recorded at Muddy River (6) was similar to that recorded in 2005–13 (range = 4–8 pairs, average = 5.4 pairs) (figure 4-1), but all of the breeding activity occurred in the central portion of the site rather than at

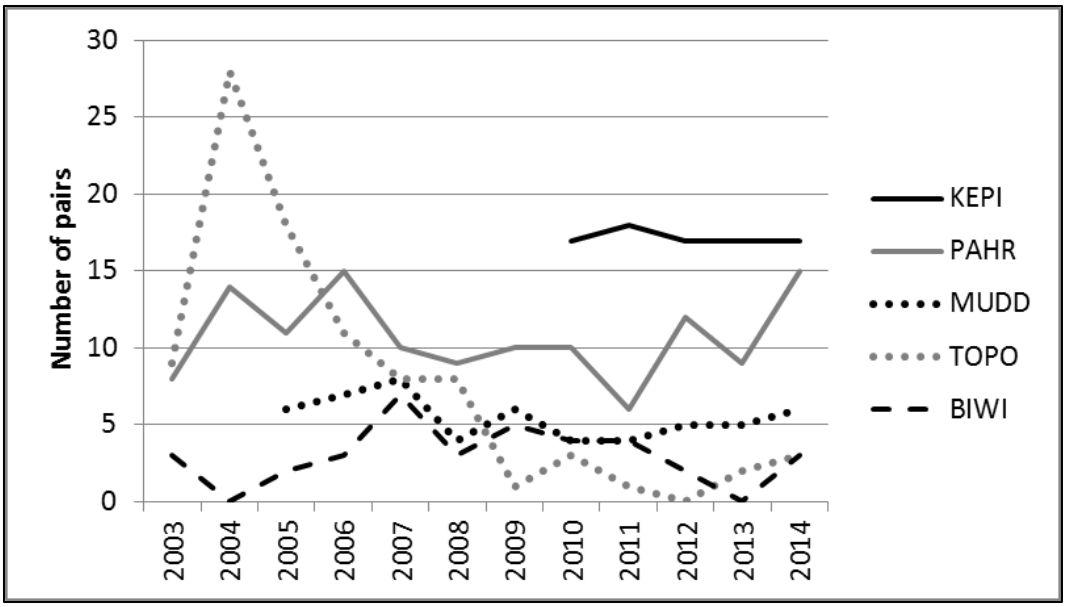

Figure 4-1.—Number of pairs of flycatchers detected at the Key Pittman WMA (KEPI), Pahranagat NWR (PAHR), Muddy River (MUDD), Topock Marsh (TOPO), and Bill Williams River NWR (BIWI) during years of intensive nest monitoring.

the southern end where it was concentrated in recent years. This shift in distribution was likely the result of the majority of the southern end of the site being dry in 2012–14 (see chapter 2).

Three breeding pairs were detected at Topock Marsh in 2014, which is the most in any year since 2008 (three pairs were detected in 2010, but no nest was found for one pair). The number of flycatcher pairs at Topock Marsh declined sharply from 2004 to 2012; fluctuations in marsh levels are likely to have influenced the number of breeding flycatchers just as they appear to have influenced the number of resident flycatchers (see chapter 2 for discussion).

We again detected breeding flycatchers at the Bill Williams River NWR despite very dry conditions (see chapter 2), with the number of breeding pairs (3) similar to the number recorded annually in 2003–13 (range = 0–7 pairs, average = 3 pairs) (figure 4-1). Breeding flycatchers were again detected in Site 03, which has contained breeding flycatchers in all but two years (2004 and 2013) since SWCA began monitoring in 2003. For the first year, breeding flycatchers were detected in Wispy Willow, which now contains vegetation of suitable structure adjacent to inundated soils (see chapter 2). Flow in the Bill Williams River in May 2014 was the lowest recorded in that month since 2004 and was 0.0 cfs in June and July (see chapter 2), and flycatcher occupancy was likely affected by the lack of surface water in most areas. Given that southwestern riparian ecosystems experience dynamic change and are not ecologically static

(Periman and Kelly 2000), willow flycatcher occupancy and nesting are likely to be affected by changes in habitat suitability, with breeding flycatchers detected at a given site in one year and not in another.

Nest Success

Nest success alone is an incomplete measure of the production of young. Successful nests produce from one to four young, and variations in nest productivity are not reflected in nest success rates. In addition, although every failed nest attempt lowers percent nest success and MSP, success of a subsequent nesting attempt may result in the same number of young produced as if the initial nesting attempt had been successful. Thus, nest productivity (young produced per nesting attempt of known outcome) and fecundity (young produced per female with known outcome) in conjunction with nest success provide additional information on the success of a given breeding season.

No strong trends in nest success were observed from 2010 to 2014 at the Key Pittman WMA, but fecundity has been declining and, in 2014, was the lowest recorded since SWCA began monitoring in 2010 (figure 4-2). A decline in fecundity, but not in nest success, could be caused by a number of factors that can affect the number of young produced per successful nest, such as smaller clutch size, lower hatching rate, partial depredation of clutches, or partial mortality of broods. A decrease in fecundity but not in nest success could also be caused by more detections of females for whom no nest with eggs was found (and who thus contributed to the fecundity estimate but not to the nest success estimate) or by a decline in the proportion of females who had successful nests along with a concomitant decrease in the number of nesting attempts required for successful females to produce young.

At the Key Pittman WMA, two factors appear to be contributing to the decline in fecundity. The proportion of females with at least one successful nest declined from 88% in 2010 to 47% in 2013 and 2014 (figure 4-3). In addition, the average number of young produced from each successful nest has been declining. Initial clutch size has not declined (ranged from 3.2 eggs per successful nest in 2010, 2011, and 2012 to 3.5 eggs per successful nest in 2014), but the proportion of those eggs that survived to fledging has decreased over the years. In 2010, an average of 0.5 egg per nest failed to make it to fledging, while in 2014, nearly 1.9 eggs per nest failed to fledge, with the primary increase in loss coming from partial depredation of the clutch during incubation (figure 4-4). A diverse suite of potential nest predators has been observed at the Key Pittman WMA, and it is unknown which predators are responsible for the egg losses we observed.

At the Pahranagat NWR, NWR fecundity also appears to be declining; it was below 2.0 young per female in each of the last 3 years (2012–14), but this occurred only once (2006) in the preceding 9 years. Average apparent nest

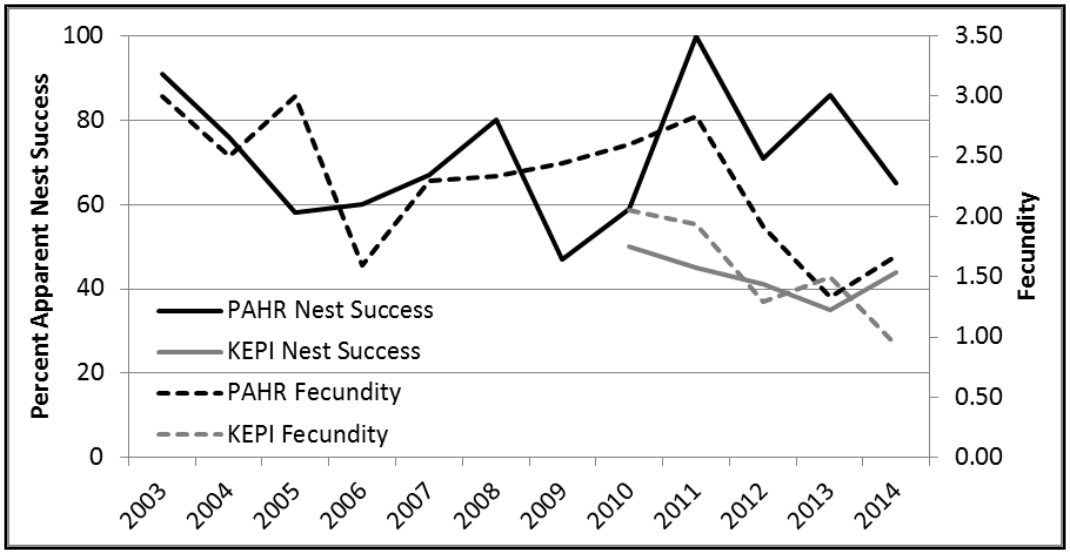

Figure 4-2.—Annual apparent nest success and fecundity (number of young produced per adult female) at the Key Pittman WMA (KEPI) and Pahranagat NWR (PAHR), 2003–14.

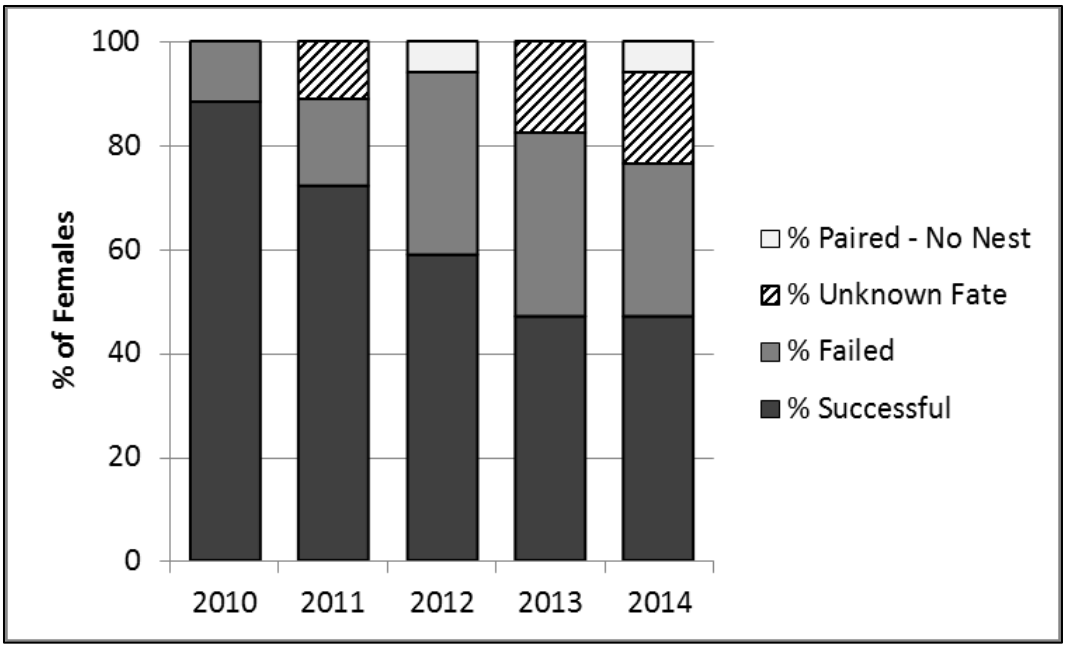

Figure 4-3.—Proportion of females by final reproductive outcome at the Key Pittman WMA, 2010–14.

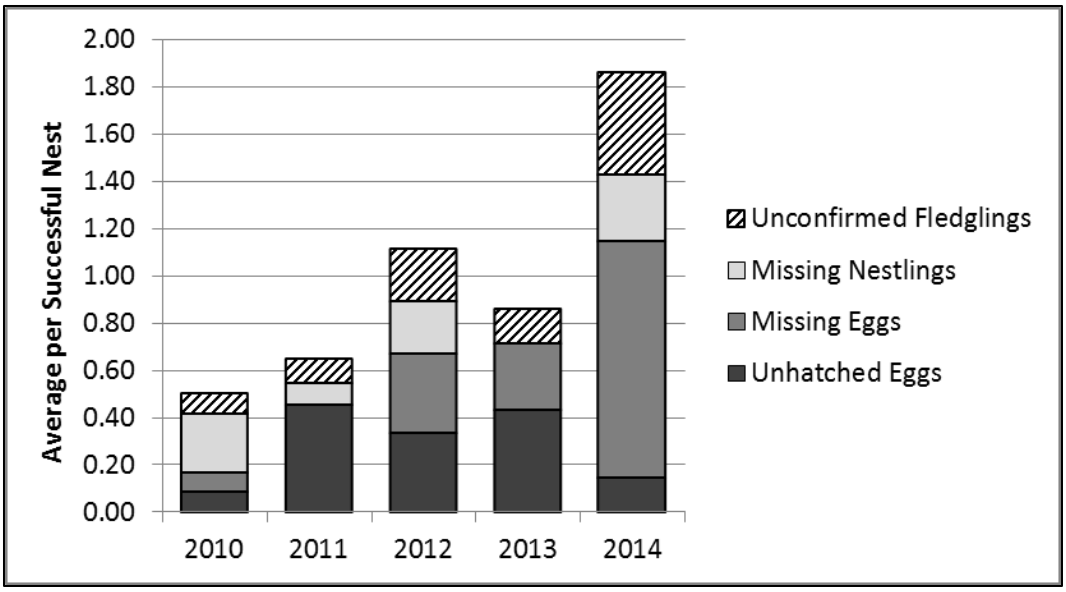

Figure 4-4.—Source of losses of potential fledglings at the Key Pittman WMA, 2010–14.

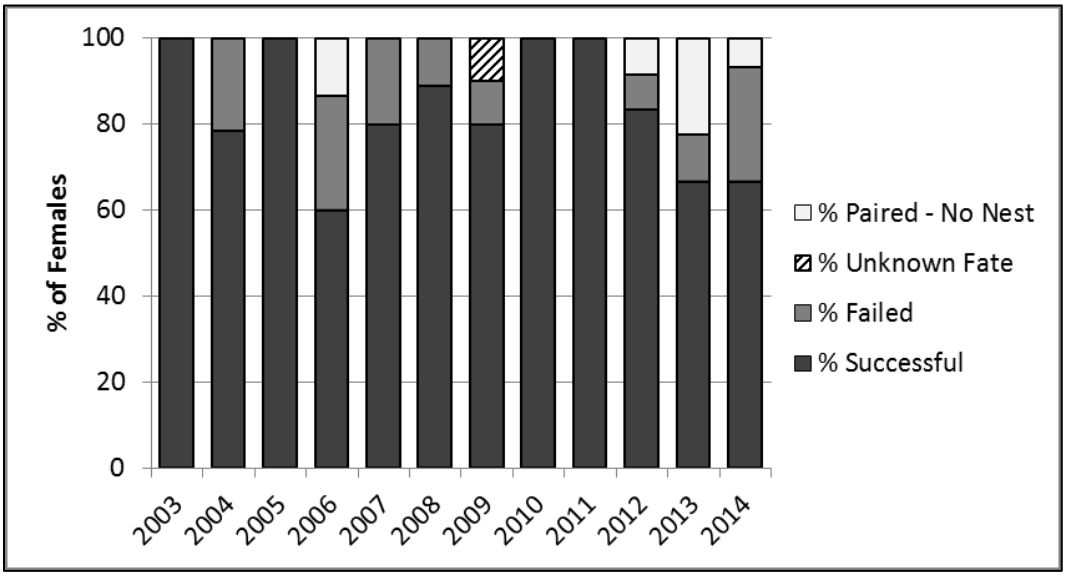

Figure 4-5.—Proportion of females by final reproductive outcome at the Pahranagat NWR, 2003–14.

success at the Pahranagat NWR in 2012–14 (74%) was similar to the average (71%) recorded over the previous 9 years. At the Pahranagat NWR, we did not see any obvious trends in clutch size, hatch rate, partial depredation of clutches, or partial brood mortality. However, in each of the 4 years (2006, 2012–14) with the

lowest fecundity, we detected females for whom no nests with eggs were found. In three of those years (2006, 2013, 2014), the proportion of females that succeeding in fledging young was below 70%, but nest success remained relatively high because no more than one successful female in each year required more than two nesting attempts before having a successful nest. It is unclear whether the lower fecundity levels noted in 2012–14 are representative of a new normal level or are a temporary low. Regardless, the disparity between nest success and fecundity highlights the importance of using multiple measures to assess reproductive success.

Nest success (20%) at Muddy River in 2014 was similar to that observed since breeding was first recorded in 2005 (average = 28.6%), while fecundity (0.25 young/female) was half the average fecundity(0.56 young/female) observed in 2005–2013 (figures 4-6 and 4-7). The Muddy River study area has the lowest average percent nest success and fecundity of any of the study areas that have been monitored for multiple years. This study area consistently has high rates of brood parasitism, which result in low productivity (see "Brood Parasitism," below). At Topock Marsh and the Bill Williams River NWR, nest success and fecundity were among the highest recorded in any year 2003–14, though the number of breeding flycatchers was small and total reproductive output was not large in either study area (6 and 4 fledglings, respectively). Alamo Lake had very low nest success and fecundity, which is likely due to poor habitat conditions with very dry soils throughout the study area (see "Nest Failure," below).

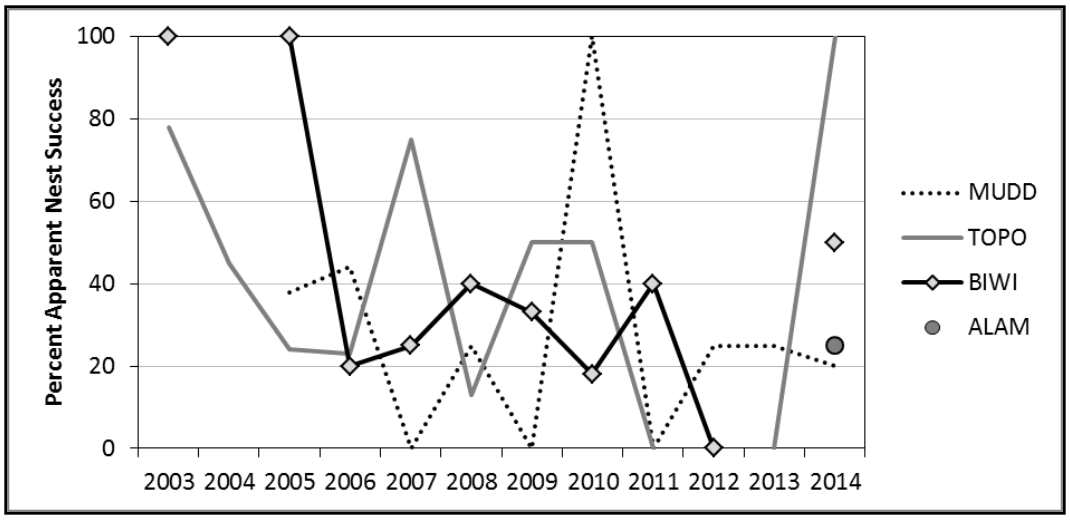

Figure 4-6.—Annual percent apparent nest success at Muddy River (MUDD), Topock Marsh (TOPO), Bill Williams River NWR (BIWI), and Alamo Lake (ALAM), 2003–14.

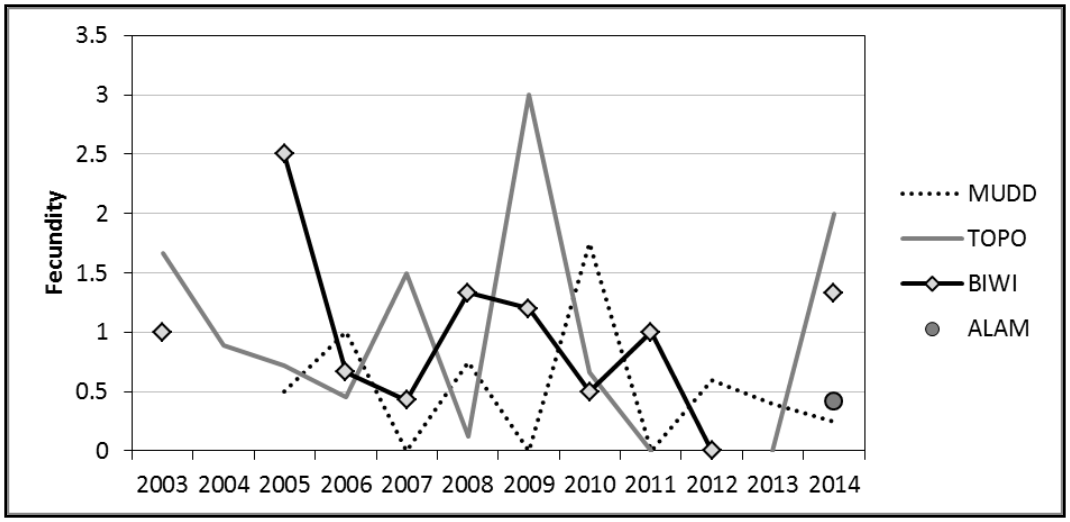

Figure 4-7.—Annual fecundity at Muddy River (MUDD), Topock Marsh (TOPO), Bill Williams River NWR (BIWI), and Alamo Lake (ALAM), 2003–14.

Nest Failure

Depredation was the leading cause of nest failure in 2014, as has been the case in previous years. These results are consistent with those reported in other studies at sites across Arizona (Graber et al. 2007; Ellis et al. 2008; Graber and Koronkiewicz 2009). Depredation rates were highest at Alamo Lake and may be related to habitat quality (see chapter 2). The Alamo Lake study area was extremely dry in 2014, and conditions similar to these have been linked to higher depredation rates likely because of increased nest visibility with decreased canopy density or because of easier access to nest areas by terrestrial predators (H. English 2014, personal communication). In 2013, we observed several instances at the Key Pittman WMA of known or suspected nest failure very late in the nestling stage. These nests were in the vicinity of a pair of nesting Cooper's hawks, and the hawks may have been responsible for these nest failures. Cooper's hawks nested in the Key Pittman WMA again in 2014, and while there was no obvious pattern of nest failure in the vicinity of the hawks' nest, they likely contributed to some of the nest failure. Cooper's hawks have also nested at the Pahranagat NWR for the last several years, and while they may not be a primary nest predator in the study area, they may reduce fledgling survival rate, as evidenced by remains of a banded fledgling found after the hawks had fledged. Cooper's hawks were the primary nest predator documented in a nest camera study in central Arizona (Ellis et al. 2008). This study also determined that several nests were depredated late in the nesting cycle and would have been erroneously considered successful if traditional methods of determining nest success (nestlings present within 2 days of fledge date) were used. For open-cup nesting passerines, nest depredation rates can vary year to year, and

sometimes substantially, with depredation of eggs and young ultimately linked to landscape characteristics and fluctuations in predator densities, abundance, and richness (Wiens 1989; Robinson 1992; Howlett and Stutchbury 1996).

Brood Parasitism

The overall parasitism rate we observed in 2014 (15%) is higher than those reported at other monitored sites across Arizona in 1996–2006, which were less than 10% at most sites in most years (Graber et al. 2007; Ellis et al. 2008). Of the study areas where parasitism was documented in 2014 (Key Pittman WMA, Pahranagat NWR, Muddy River, and Alamo Lake), both the Pahranagat NWR and Alamo Lake had low parasitism rates (7 and 6%, respectively). Brood parasitism at the Key Pittman WMA (22%) was higher than that recorded in any year from 2010 to 2013 (range = 3.3–20.0%, average = 12.3%), while the high parasitism rate observed at Muddy River (60%) was consistent with the rates observed in previous years (range = 0–75%, average = 41.0%). Until 2014, no brood parasitism of nests with flycatcher eggs had been documented at the Pahranagat NWR since SWCA began monitoring in 2003, though one flycatcher nest was found abandoned in 2010 with a cowbird egg. In 2014, one nest was parasitized, and the parasitism event caused nest failure. Both parasitized nests were located in a territory in the northwestern corner of Pahranagat North, on the very edge of the habitat, adjacent to the inlet canal. Nest location in both cases may have made the nests more accessible to cowbirds. No flycatcher nests at Topock Marsh or the Bill Williams River NWR were parasitized, though cowbirds were detected regularly in both study areas. Parasitism rates at both study areas have fluctuated widely over previous years, ranging from 0 to 48% at Topock Marsh and from 0 to 33% at the Bill Williams River NWR.

In cases where the disappearance of flycatcher eggs coincided with the parasitism event, cowbirds were suspected of ejecting the eggs. Female brown-headed cowbirds are known to physically attack willow flycatcher nestlings (Woodward and Stoleson 2002), remove single eggs, and occasionally destroy entire broods after laying is complete or after hatching (Lowther 1993 as cited in Woodward and Stoleson 2002). In addition, cowbirds were photographed removing eggs from artificial nests during a camera study completed in 2008–10 by Northern Arizona University (NAU), and cowbirds were documented on video depredating flycatcher nests during both the incubation and nestling phases. In the Virgin Valley, only cowbirds were documented depredating flycatcher nests. The NAU camera study documented other avian predators at both artificial and flycatcher nests in other areas, with diversity of predators correlated to the diversity of the local avian community. While it is possible that other species, such as yellow-breasted Chats, are also responsible for some depredation events, it is likely that many depredation events on eggs and nestlings are attributable to cowbirds.

Parasitism does not invariably cause nest failure, but the success rate (17%) for parasitized nests at all study areas in 2003–14 was one-third that of unparasitized nests (50%). Similar results were recorded for willow flycatchers in Oregon, with parasitism resulting in a 50% decrease in success rates compared to unparasitized nests (Sedgwick and Iko 1999) and at other sites in Arizona, where in 1996–2005, 20% of parasitized nests fledged flycatcher young versus 57% of unparasitized nests (Ellis et al. 2008). Parasitized nests that did succeed in fledging flycatcher young at all study areas in 2003–14 produced on average fewer young (1.3 young/nest) than did unparasitized nests (2.2 young/nest; $F_{1,307} = 23.27$, $P < 0.001$). Cowbirds may eject flycatcher eggs during the parasitism event, thus reducing clutch size, and cowbird young also cause interspecific nestling competition, as evidenced by the presence of severely underdeveloped nestlings in some parasitized nests. For all nests monitored from 2003 to 2014, 40% of nests that fledged a cowbird also fledged flycatcher young. This is a higher rate of success than that observed in southwestern willow flycatchers at Kern River, California (9%) (Whitfield and Sogge 1999) but comparable to that observed at other Arizona sites (40%) (Ellis et al. 2008).

Repeated parasitism events over a female flycatcher's lifetime can reduce lifetime productivity (McLeod and Pellegrini 2013). In addition, willow flycatchers that fledge late in the season have been shown to have a lower survival rate than those that fledge early in the season (Paxton et al. 2007; McLeod and Pellegrini 2013), suggesting additional hidden effects of parasitism and subsequent re-nesting on flycatcher demography. Across all study areas and all years through 2012, female flycatchers that were parasitized at least once during the season and still produced a successful nest had fledge dates that were, on average, 10 days later than successful females who were not parasitized. This 10-day delay corresponds to a reduced survival probability of ≈ 6% (McLeod and Pellegrini 2013).

Cowbird Egg Addling

The hatch rate of cowbird eggs that were incubated for a minimum of 10 days and that we did not attempt to addle was 68% (36 of 53 eggs) across all years and study areas. In contrast, only 12% (2 of 16 eggs) of the cowbird eggs that we attempted to addle hatched after a minimum of 10 days of incubation. It is apparent that addling cowbird eggs has significantly reduced the cowbird hatch rate (Fisher's exact test, $P < 0.001$; difference in proportions = 0.55, 95% LB = 0.29), and no female flycatcher at any study area deserted her nest in response to egg addling. It is clear from nest monitoring data collected prior to the addling program that parasitized flycatcher nests in which the cowbird egg(s) never hatched fared better than nests that had a cowbird nestling. Apparent nest success of parasitized nests that hatched at least one flycatcher but no cowbirds (64%; 9 of 14 nests) did not differ from nests with both flycatcher and cowbird nestlings (52%; 11 of 21 nests; Fisher's exact test, $P = 0.73$; difference in

proportions = 0.12, 95% LB = -0.16). However, parasitized nests that hatched at least one flycatcher and no cowbirds produced an average of 1.40 flycatchers per nest (n = 10 nests), compared to 0.57 flycatcher per nest (n = 21 nests) in nests with a cowbird nestling (unequal variance t-test, t = 2.79, df = 13.47, P = 0.015, 95% CI = 0.19–1.47). Additionally, the percentage of flycatcher nestlings that survived to banding age (8 days) in nests that did not hatch cowbird eggs (95%; 20 of 21 flycatcher nestlings) was significantly higher (Fisher's exact test, P = < 0.001; difference in proportions = 0.44; 95% LB = 0.23) than the proportion (52%; 16 of 31 flycatcher nestlings) in nests with cowbird nestlings. Because parasitized nests in which the cowbird eggs fail to hatch produce, on average, more flycatcher fledglings than nests with a cowbird nestling, we recommend that the addling program be continued. Field personnel should also continue to practice egg addling with button quail eggs at the beginning of the season to maximize the effectiveness of shaking eggs in preventing hatching.

Chapter 5 – Nest Site Characteristics

INTRODUCTION

It is apparent that willow flycatchers along the LCR and tributaries select territories and nest sites that are in close proximity to surface water (McLeod and Pellegrini 2013). This preference for surface water has been demonstrated with flycatcher populations in the Cliff-Gila Valley (Stoleson and Finch 2003) and along the Gila and San Pedro Rivers (Paradzick 2005). Paradzick and Woodward (2003) also found that the majority of occupied sites in Arizona from 1993 to 2000 were less than 50 m from water. Despite the general knowledge that flycatchers are drawn to surface water, relatively little data are available regarding the persistence of water at occupied areas throughout the breeding season, though Whitfield and Enos (1996) noted that most breeding areas dried up before young fledged. To broaden our understanding of the patterns of inundation throughout the breeding season, we documented surface water conditions periodically throughout the nesting cycle for each flycatcher nest. We also gathered general information on each nest, such as nesting substrate and percentage of the vegetation around the nest that consisted of tamarisk. This latter estimate provides a qualitative assessment of the potential impact of tamarisk defoliation on each nesting attempt. In addition, we measured temperature and humidity via data loggers at nests that progressed to the incubation phase at Topock Marsh, the Bill Williams River NWR, and Alamo Lake. These data will add to the database, describing conditions in occupied flycatcher territories, and will also provide measures of temperature and humidity with which data collected concurrently at habitat creation sites can be compared.

METHODS

Surface Hydrology

We described surface hydrology near all active nests two to three times during the life of each nest. The descriptions included conditions of soil moisture at the nest (inundated, saturated, damp, or dry), depth of water (if any) at the nest, distance to water from the nest, and the percent of the area within 20 and 50 m of the nest that was inundated or saturated. Soil moisture categories were qualitatively determined as follows: inundated soils were those that had water visible on the surface, soils were considered saturated if compression of the soil (e.g., by stepping on it) caused water to be expressed, soils were considered dry if squeezing a handful of soil did not result in the soil sticking together, and damp soils were any that did not have surface water and did not meet the criteria for either saturated or dry (i.e., compressing a handful of soil caused the soil to stick together but no water was expressed). Estimates of distance to water were

determined by one of three methods: a visual estimate in the field (if water was visible from the nest), by Global Positioning System (GPS) in the field (finding the nearest water, recording the GPS location, and setting the GPS unit to navigate back to the nest, thus displaying distance from water back to the nest), or by measuring on a georeferenced aerial photograph (either on a hardcopy aerial photo or by using the measuring tool on Google Earth). The percentages of the area within 20 and 50 m of the nest that was inundated or saturated were estimated either visually in the field or, more often, by using on-the-ground knowledge of surface hydrology coupled with an aerial photograph to help with visualizing the area encompassed within a 20- or 50-m-radius circle around the nest. These data were scheduled to be collected when the nest was found, at the nest check before the estimated hatch day (or, if estimated hatch day was unknown, the nest check when nestlings were first detected), and again at fledge or failure. If a nest failed during laying or incubation or was found with nestlings, only two measurements of surface hydrology were collected.

In 2013, we identified potential biases in surface hydrology data collected at several study areas. At the Key Pittman WMA, the accuracy of the estimates of distance to water declined as the season progressed and water receded away from the coyote willow stands and into the dense bulrush marsh. When water was not visible from the edge of the coyote willow, field personnel often used the aerial photograph to determine distance to water and identified the nearest water as being the open water of the lake, rather than its true location in the dense bulrush, somewhere between the edge of the coyote willow and the open water. Distance to water was thus overestimated, and the percentage of wet soils within 20 and 50 m (hereafter wet soil extent estimates) was correspondingly underestimated. We identified similar patterns at the Pahranagat NWR, where we mapped the presence of surface water and saturated soil twice during the breeding season and then created shapefiles after the field season was over showing the extent of wet soil on those particular dates. We then compared the estimates of wet soil extent recorded during the field season with those calculated from the shapefiles. We found that estimates of wet soil extent declined in accuracy as the season progressed and water receded. At Muddy River, wet soils have been confined to the river channel itself in recent years, and the linear distribution of these soils seems to lead observers to overestimate their presence in the vicinity of the nest.

In 2014, we mapped the location of surface water and saturated soils at both the Key Pittman WMA and Pahranagat NWR on a biweekly schedule starting in late May for use in generating more accurate wet soil extent estimates near each nest. Field personnel were generally able to walk the edge of the water at the Pahranagat NWR; at the Key Pittman WMA, we walked several transects perpendicular to the shoreline and out into the marsh until we encountered wet soils. We interpolated between these transects to estimate the location of the water's edge along the length of the shoreline. GPS data collected during water mapping in the two study areas were used to generate a series of shapefiles in ESRI® ArcMap v 10.2. These shapefiles were overlain with 20- and 50-m

buffers around each nest location. The areas where the two layers intersected were extracted, and the percentage of each buffer that intersected the water mapping shapefile was calculated. At the Key Pittman WMA and Pahranagat NWR, we compared the field estimates to the corresponding water mapping estimates closest (≤ 7 days) to a nest's transition date (found, hatch, fledge, or fail). We chose the data source closest to the transition date unless the map and the field estimate were at odds regarding the soil condition (saturated or inundated versus damp or dry) at the nest. If the discrepancy in soil condition was consistent with the site gradually drying out (i.e., the data collected at a later date showed a drier soil condition), we used the data source closest to the transition date. If the discrepancy in soil condition was inconsistent with the site gradually drying out, we used the field estimate. In instances where both field and water mapping estimates were equidistant from the transition date, the field estimate was selected unless it had already been excluded, as described above.

At Muddy River, water was confined to the river channel throughout the breeding season, and we generated a shapefile of the river channel using aerial imagery. Wet soil extents were calculated from the shapefile as described above and compared to the field estimates.

Vegetation

At each nest, we recorded the species of tree or shrub in which the nest was placed (nest substrate) as well as a visual estimate of the percentage of vegetation volume that consisted of tamarisk within 2 and 5 m of the nest. We chose these two distances to try to assess whether the level of defoliation in the immediate vicinity of the nest (2 m) or in the more general vicinity (5 m) had a greater influence on nest success and microclimate. It is typically not possible to see more than 5 m, so we did not estimate the percentage of tamarisk at distances > 5 m. We also assigned one of the following vegetation types to each nest based on the plant species present within 5 m of the nest:

- TASP = > 75% tamarisk
- SAGO = > 75% Goodding's willow
- SAEX = > 75% coyote willow
- POFR = > 75% Fremont cottonwood
- TASP_SAEX = tamarisk and coyote willow mix, neither > 75%
- SAGO_POFR = Goodding's willow and Fremont cottonwood mix, neither > 75%

- TASP_SAGO = tamarisk with emergent Goodding's willow
- SAGO_TASP = Goodding's willow overstory with tamarisk understory

Temperature and Humidity

We deployed a Hygrochron iButton (Maxim Integrated, San Jose, California) at each flycatcher nest that was confirmed to be in the incubation phase at Topock Marsh, the Bill Williams River NWR, and Alamo Lake. The iButton was mounted on a key fob and hung in an inconspicuous location, no higher than 2 m above the ground but below nest height, and within 2 m horizontal distance of the nest. The loggers recorded temperature and relative humidity every 30 minutes and remained in place until the end of the breeding season.

Statistical Analyses

We truncated temperature and humidity data to the midnight after the logger was deployed and the midnight before the logger was removed so that only full 24-hour periods were represented. We converted temperature (T, degrees Celsius [°C]) and relative humidity (RH) to vapor pressure[8] (VP) (in Pascals [Pa]) as follows:

$$VP = RH*(610.7*10^{((7.5*T)/(237.3+T))})/100$$

We calculated the following temperature and humidity variables for each location:

- Maximum daily temperature
- Minimum daily temperature
- Daily temperature range (diurnal maximum minus nocturnal minimum)
- Mean diurnal vapor pressure
- Mean nocturnal vapor pressure

For vapor pressure calculations, we assigned times from 0530 to 2000 hours as day and all others as night. We summarized each variable over 2-week periods by study area and by vegetation type within each study area. We then plotted nest data with data obtained at beetle monitoring points (see chapter 6) within the same study area and, if possible, the same vegetation type.

[8] Vapor pressure, unlike relative humidity, is not influenced by ambient temperature and may be a more biologically meaningful measure of water content of the air (e.g., the relative vapor pressure inside and outside an egg determines whether the egg loses moisture).

Analyses of temperature and humidity were completed in IBM ® SPSS ® v. 22.0. Vegetation data were summarized using R v. 3.0.2.

RESULTS

Surface Hydrology

We described soil moisture conditions up to four times during the season at 57 flycatcher nests in 6 study areas: the Key Pittman WMA (21 nests), Pahranagat NWR (20 nests), Meadow Valley Wash (2 nests), Muddy River (7 nests), Topock Marsh (3 nests), and Bill Williams River NWR (4 nests). Although we had intended to describe soil moisture conditions up to three times (when the nest was found, at hatch, and at fail or fledge), soil moisture conditions were sometimes described four times when duplicate estimates were accidently recorded for a particular nest stage. We described soil moisture conditions at 56 of the 57 nests when found; 45 were found during building, 6 were found during laying, and 5 were found during incubation. We also described soil moisture conditions up to 3 times during the season at all 22 nests at Alamo Lake. We described soil moisture within 1 week of the nest being found at 21 of the 22 nests; 7 nests were found during building, 1 nest was found during laying, 11 nests were found during incubation, and 3 nests were found with nestlings.

We mapped the presence of surface water and saturated soil four times during the season at the Key Pittman WMA and five times at the Pahranagat NWR. The second round of water mapping at the Pahranagat NWR was excluded after the observer confirmed that saturated soils had not been included on the map. One observer's field estimates were excluded after it became apparent from the observer's qualitative site descriptions and field estimates that the observer often grossly overestimated the amount of wet soils within the site. One additional field estimate from a second observer was excluded when comparison to the field estimates collected at nearby nests as well as to the water maps showed it to be a gross underestimate. For the transition dates when both water mapping and field estimates were available, there were no instances where there were discrepancies in soil condition at the nest as recorded by the field observer versus via water mapping and the discrepancy was at odds with the site drying out over time; thus, in all instances, we chose the data source closest to the transition date. At the Key Pittman WMA, 13 of 55 estimates (24%) were generated from water mapping, while at the Pahranagat NWR, 18 of 51 estimates (35%) were generated from water mapping. At Muddy River, nearly all field observations resulted in an overestimate of wet soil extent, though some observers were able to estimate wet soil extent to within 10% of the water mapping values. We present only water mapping estimates below.

At the Key Pittman WMA and Pahranagat NWR, we observed a strong drying trend through the season in all measures of surface hydrology (figure 5-1). At the Key Pittman WMA, the proportion of nests over wet soils decreased from 100% in May and early June to 0% by late July, average distance to water increased from 0 m in May and early June to 7 m by late July, average depth of standing water decreased from 18 cm in early June to 0 cm by early July, and the average percentage of wet soils within 20 and 50 m decreased from 71 and 62%, respectively, in early June to 25 and 30%, respectively, in August. At the Pahranagat NWR, the proportion of nests over wet soils decreased from 100% in May and early June to 0% in late July; average distance to water increased from 0 m in May and early June to 86 m by August; average depth of surface water decreased from 33 cm in May to 0 cm in late July; and the average percentage of wet soils within 20 and 50 m decreased from 95 and 85%, respectively, in May to 0 and 1%, respectively, in late July. Surface water was present under and within the vicinity of the last active nest when it was successful in mid-August due to heavy rains in the preceding week. Sample sizes were small at Meadow Valley Wash and Topock Marsh, and no seasonal trend in any of the soil moisture variables was apparent (figure 5-1).

The areal extent of water did not change through the season at Muddy River, as all surface water and saturated soils were contained in the narrow river channel. Consequently, even though no nest at Muddy River was farther than 2 m from surface water throughout the season, the extent of wet soils in the vicinity of each nest was small (figure 5-1). The depth of surface water below each nest varied in accordance with river depth (figure 5-1). Surface water and wet soils were largely confined to deep channels at the Bill Williams River NWR, and little variation in soil moisture conditions was noted through the season (figure 5-1). Alamo Lake was the driest study area with breeding flycatchers in 2014, with completely dry soils under each nest throughout the season. The distance to known standing water varied from 48 m at one nest up to 2 km. The median distance to water for all nests was 950 m and did not vary through the breeding season. Because of the extremely dry conditions in this study area, we do not present the data graphically below.

Vegetation

We recorded vegetation characteristics at 79 flycatcher nests (21 at the Key Pittman WMA, 20 at the Pahranagat NWR, 2 at Meadow Valley Wash, 7 at Muddy River, 3 at Topock Marsh, 4 at the Bill Williams River NWR, and 22 at Alamo Lake) (table 5-1). No tamarisk was present within 5 m of any nest at the Key Pittman WMA, Pahranagat NWR, or Meadow Valley Wash. Tamarisk was present to some extent within 5 m of each nest location at the Muddy River (range = 10–70%), Topock Marsh (range = 80–100%), and the Bill Williams River NWR (range = 40–100%) study areas. At Alamo Lake, some tamarisk was

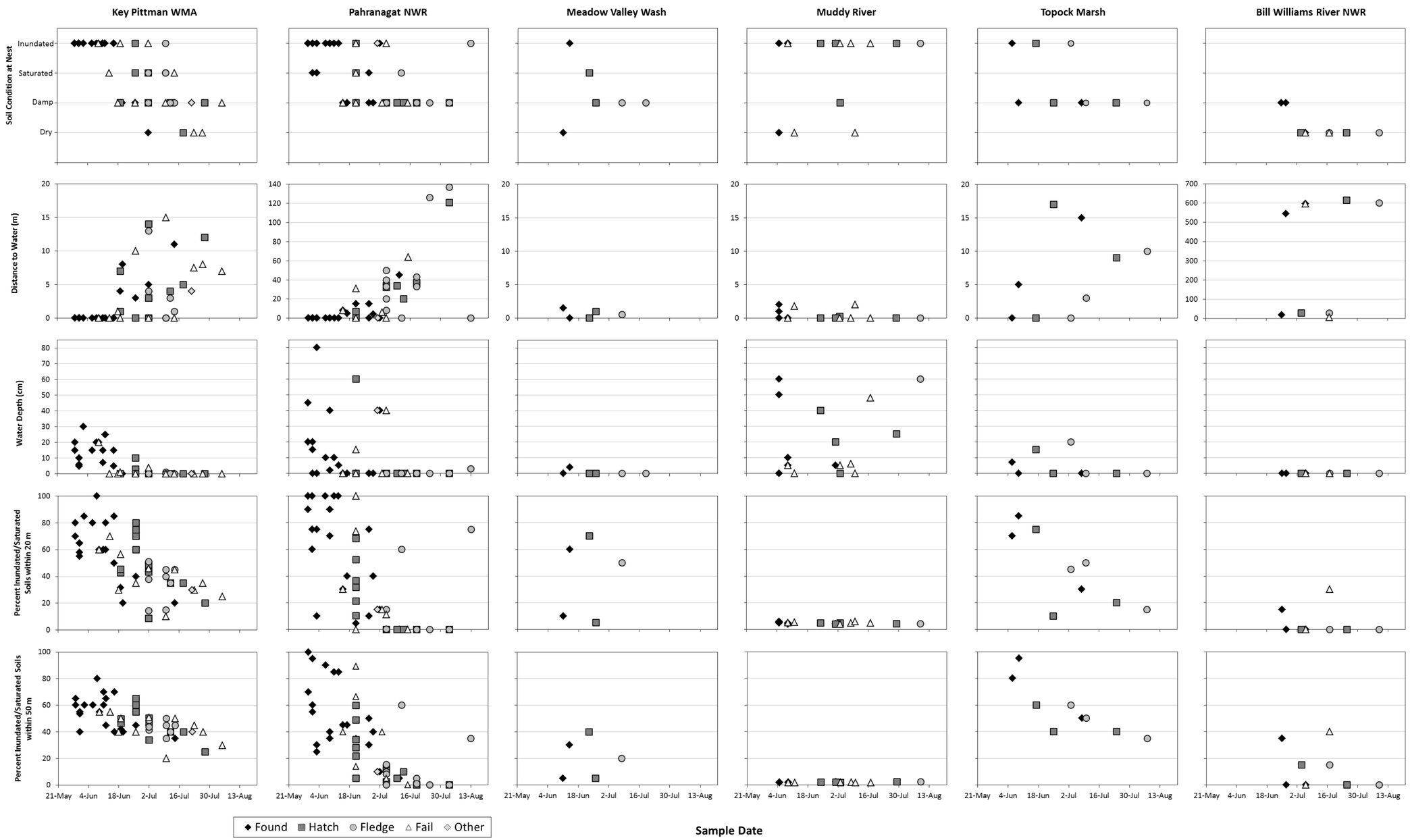

Figure 5-1.—Soil moisture characteristics at flycatcher nests in the Key Pittman WMA, Pahranagat NWR, Meadow Valley Wash, Muddy River, Topock Marsh, and Bill Williams River NWR, 2014.

present within 5 m of 20 of the 22 nests (range = 5–95%). Of the study areas with tamarisk present in the vicinity of a nest location, Alamo Lake had the lowest overall percentage of tamarisk within 5 m of flycatcher nests (30.4%), and Topock Marsh had the highest (93.3%) (table 5-1).

Table 5-1.—Nest substrate and percentage of tamarisk at flycatcher nests by vegetation type in all study areas, 2014

Study area	Vegetation type[1]	Nest substrate				% tamarisk within 2 m		% tamarisk within 5 m	
		SAEX	SAGO	POFR	TASP	Median (25th– 75th percentile)	Mean (standard deviation)	Median (25th– 75th percentile)	Mean (standard deviation)
Key Pittman WMA	SAEX (n = 20)	20	0	0	0	0.0 (0.0 – 0.0)	0.0 (0.0)	0.0 (0.0 – 0.0)	0.0 (0.0)
	POFR (n = 1)	0	0	1	0	0.0	0.0	0.0	0.0
	Total	20	0	1	0	0.0 (0.0 – 0.0)	0.0 (0.0)	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)
Pahranagat NWR	SAGO (n = 17)	0	17	0	0	0.0 (0.0 – 0.0)	0.0 (0.0)	0.0 (0.0 – 0.0)	0.0 (0.0)
	POFR (n = 3)	0	0	3	0	0.0 (0.0 – 0.0)	0.0 (0.0)	0.0 (0.0 – 0.0)	0.0 (0.0)
	Total	0	17	3	0	0.0 (0.0 – 0.0)	0.0 (0.0)	0.0 (0.0 – 0.0)	0.0 (0.0)
Meadow Valley Wash	SAEX (n = 2)	2	0	0	0	0.0 (0.0 – 0.0)	0.0 (0.0)	0.0 (0.0 – 0.0)	0.0 (0.0)
Muddy River	SAEX_TASP (n = 5)	1	0	0	4	60.0 (30.0 – 80.0)	55.0 (38.1)	30.0 (20.0 – 40.0)	35.0 (21.8)
	SAEX (n = 2)	1	0	0	1	7.5 (6.2 – 8.7)	7.5 (3.5)	10.0 (10.0 – 10.0)	10.0 (0.0)
	Total	2	0	0	5	30.0 (7.5 – 70.0)	41.4 (38.8)	20.0 (12.5 – 35.0)	27.8 (21.6)
Topock Marsh	TASP (n = 3)	0	0	0	3	100.0 (97.5 – 100.0)	98.3 (2.9)	100.0 (90.0 – 100.0)	93.3 (11.5)
Bill Williams River NWR	SAEX_TASP (n = 1)	0	0	0	1	25.0	25.0	40.0	40.0
	TASP (n = 3)	0	0	0	3	100.0 (100.0 – 100.0)	100.0 (0.0)	100.0 (95.0 – 96.7)	96.7 (5.8)
	Total	0	0	0	4	100.0 (81.2 – 100.0)	81.2 (37.5)	95.0 (77.5 – 100.0)	82.5 (28.7)
Alamo Lake	SAGO (n = 10)	0	10	0	0	5.0 (0.0 – 5.0)	3.0 (2.6)	5.0 (5.0 – 5.0)	4.5 (2.8)
	SAGO_TASP (n = 7)	0	0	0	7	50.0 (42.5 – 72.5)	54.3 (27.1)	40.0 (32.5 – 50.0)	40.0 (10.4)
	TASP (n = 2)	0	0	0	2	100.0 (100.0 – 100.0)	100.0 (0.0)	95.0 (95.0 – 95.0)	95.0 (0.0)
	TASP_SAGO (n = 2)	0	0	0	2	70.0 (55.0 – 85.0)	70.0 (42.4)	77.5 (68.7 – 86.2)	77.5 (24.7)
	SAGO_POFR (n = 1)	0	1	0	0	0.0	0.0	0.0	0.0
	Total	0	11	0	11	7.5 (5.0 – 61.2)	34.1 (38.6)	17.5 (5.0 – 50.0)	30.4 (32.6)

[1] SAEX = coyote willow, POFR = cottonwood, SAGO = Goodding's willow, SAEX_TASP = mixed coyote willow and tamarisk, TASP = tamarisk, SAGO_TASP = Goodding's willow with tamarisk understory, TASP_SAGO = tamarisk with emergent Goodding's willow, and SAGO_POFR = mixed cottonwood and Goodding's willow.

Nests in 2014 were built in coyote willow (30%), Goodding's willow (35%), cottonwood (5%), and tamarisk (29%). At the Muddy River, Topock Marsh, and Bill Williams River NWR study areas, 12 of 14 nests (86%) were built in tamarisk, and the same percentage was located in either tamarisk or coyote willow-tamarisk mix vegetation types (see table 5-1). At Alamo Lake, 50% of nests were built in tamarisk (see table 5-1).

Temperature and Humidity

An iButton was deployed at each of three flycatcher nests at Topock Marsh, two nests at the Bill Williams River NWR, and nine nests at Alamo Lake. The loggers were deployed between early June and mid-July and remained in place until late July or early August. All iButtons functioned properly.

The maximum daily temperatures at nests in all three vegetation types at Alamo Lake were 5 to 15 °C higher than at nests at either the Bill Williams River NWR or Topock Marsh (attachment 9 and figure 5-2). Minimum temperatures were less variable among study areas and were typically highest at Topock Marsh (attachment 9 and figure 5-2), while the daily temperature range followed the same pattern as the maximum daily temperature, being much higher at Alamo Lake than at the other study areas (attachment 9 and figure 5-2). Both diurnal and nocturnal vapor pressures were markedly lower in all three vegetation types at Alamo Lake than they were at either the Bill Williams River NWR or Topock Marsh (attachment 9 and figure 5-2). Although nest sample sizes were too small to permit a formal comparison between nests and beetle monitoring points (see chapter 6), simple visual comparisons show that flycatcher nest locations at Topock Marsh were cooler and more thermally moderate than were beetle monitoring points particularly in the first half of the breeding season; vapor pressure, however, differed little between nests and beetle monitoring points (figure 5-3). A similar pattern was apparent at the Bill Williams River NWR where nest sites had lower maximum daily temperatures through early July when compared to beetle monitoring points, but vapor pressure did not differ between nests and beetle monitoring points (figure 5-4).

DISCUSSION

Surface Hydrology

Surface hydrology conditions that were recorded within a week of a nest being found in the building stage closely represent the conditions present when the nest location was selected by the flycatcher. This was the case for 51 of the 79 nests in all study areas. We described soil moisture conditions for 17 additional nests at

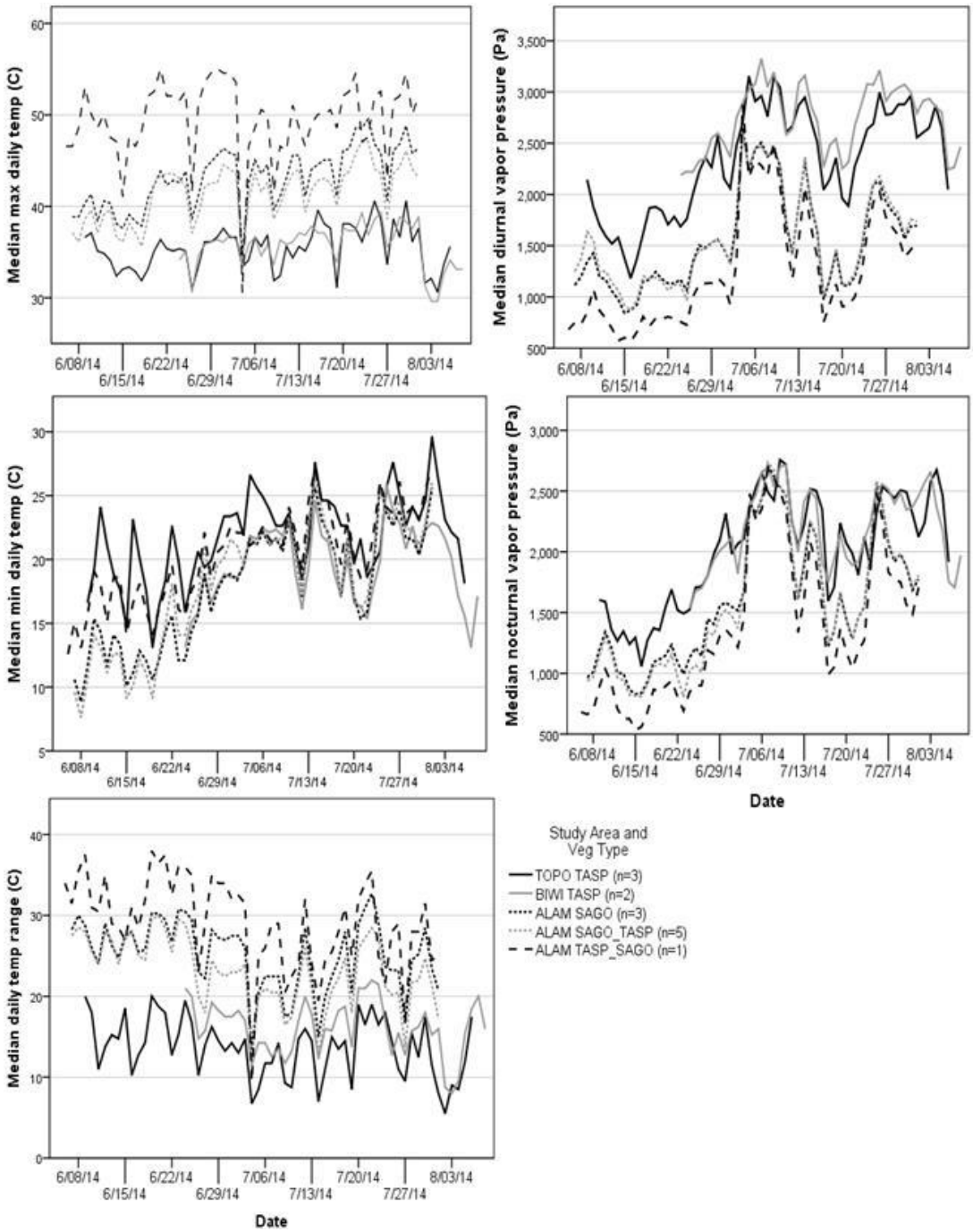

Figure 5-2.—Median maximum and minimum daily temperature, median daily temperature range, and median diurnal and nocturnal vapor pressure at flycatcher nests at Topock Marsh (TOPO), Bill Williams River NWR (BIWI), and Alamo Lake (ALAM), 2014.

Vegetation types are SAGO = Goodding's willow, SAGO_TASP = Goodding's willow overstory with tamarisk understory, TASP = tamarisk, and TASP_SAGO = tamarisk with emergent Goodding's willow.

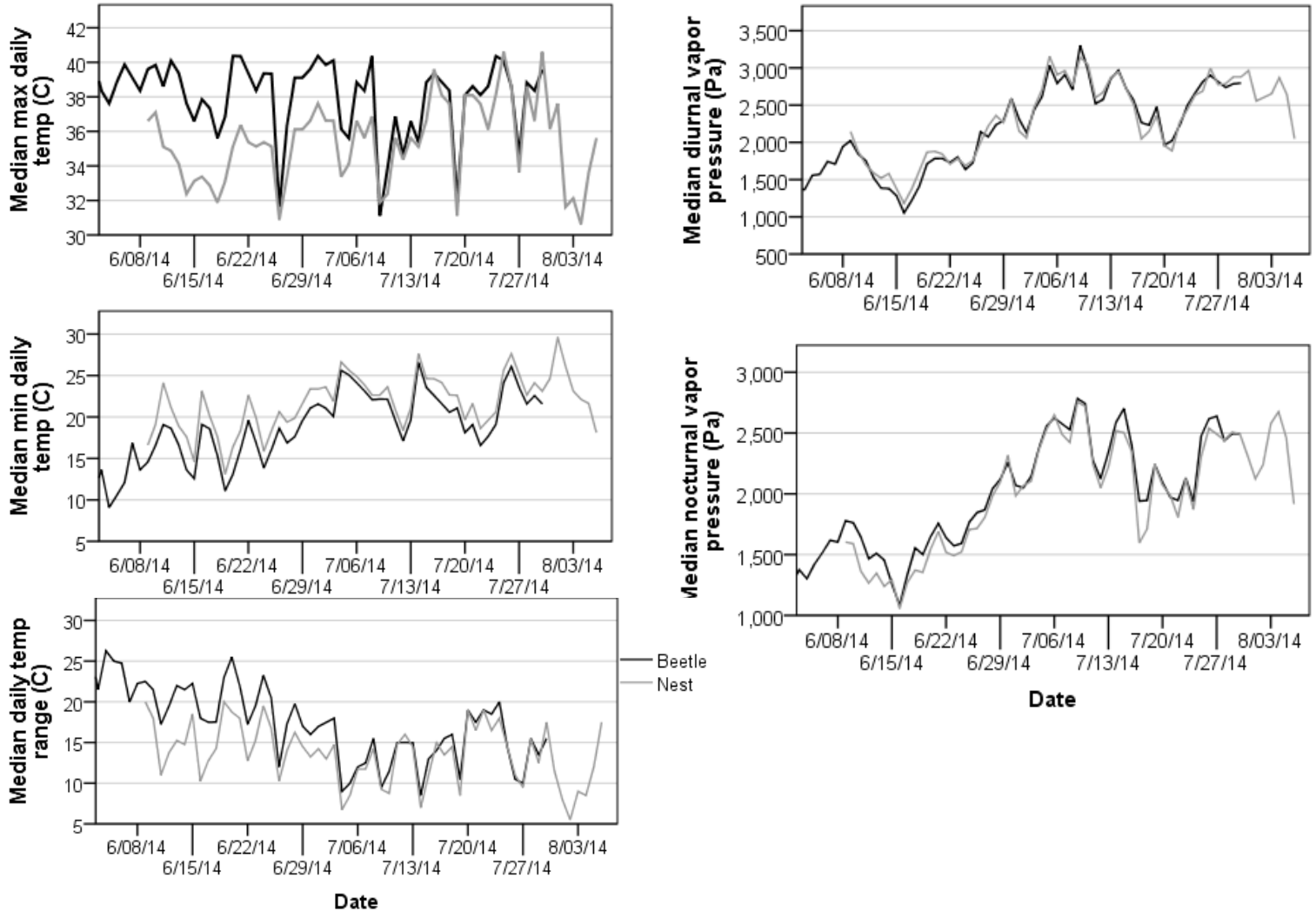

Figure 5-3.—Median daily maximum temperature, median daily minimum temperature, median daily temperature range, and diurnal and nocturnal vapor pressure at a flycatcher nests (n = 3) and beetle monitoring points in tamarisk vegetation (n = 10), Topock Marsh, 2014.

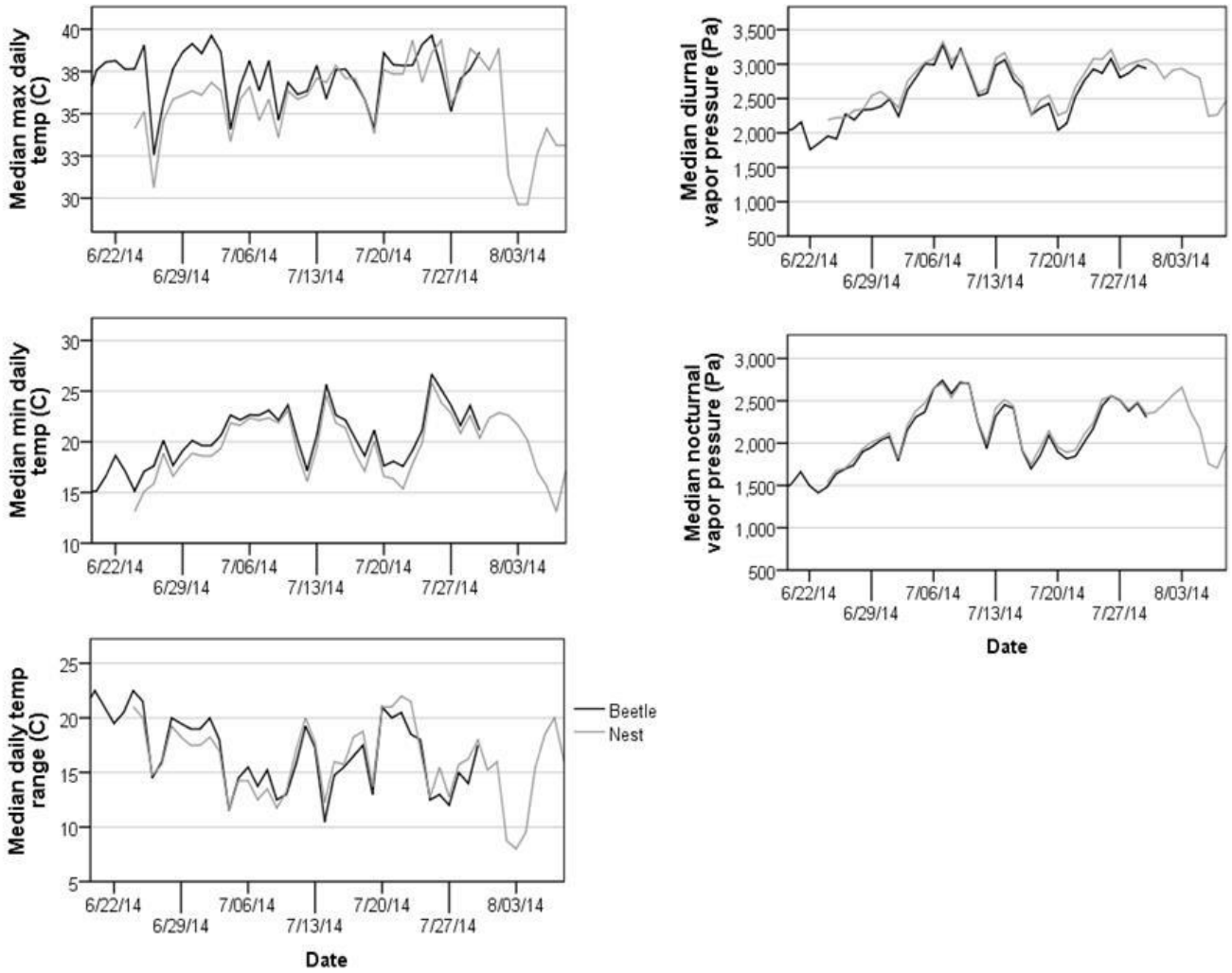

Figure 5-4.—Median daily maximum temperature, median daily minimum temperature, median daily temperature range, and diurnal and nocturnal vapor pressure at flycatcher nests (n = 4) and beetle monitoring points (n = 15), Bill Williams River NWR, 2014.

The Bill Williams River NWR and Alamo Lake that were found after they were already built. Hydrological conditions remained constant through the season in these study areas (see chapter 2), and the data we recorded at these additional nests are thus representative of the conditions that were present when the nest site was selected. Of these 68 nests, 39 (57%) were built within 5 m of standing water or saturated soil, and an additional 5 nests were within 35 m of water. Willow flycatchers are known for their propensity to nest near surface water (Sogge and Marshall 2000; McLeod and Pellegrini 2013), which affects vegetation density, food availability (Iwata et al. 2003; NAU unpublished data), and microclimate (McLeod and Pellegrini 2013).

Hydrological conditions at sites in the desert Southwest can vary dramatically within and between seasons. Saturated and inundated soils were more widely distributed in May and June than in July at the Key Pittman WMA and Pahranagat NWR, with all active nests in May and early June located over wet soils, nearly one-half (48%) of all active nests located over wet soils through the end of June, but no active nests located over wet soils by the end of July. Hydrological conditions can also vary dramatically between years, particularly at sites influenced by reservoir levels (Sogge and Marshall 2000). This was evident at Alamo Lake, where soils within 50 m of all 22 nests were completely dry; only one nest was within 100 m of water, and many nests were 500 m or more from surface water or saturated soil. The extremely dry conditions at Alamo Lake may have contributed to the low nest success observed at that study area (see chapter 4). It is clear from aerial imagery that at least some of the sites at Alamo Lake were closer to water in previous years. Over the history of this project, we have seen several instances in which flycatchers, which typically have high site fidelity (see chapter 3), nested in previously occupied areas that were wet when they were initially occupied but had since gone dry (McLeod and Pellegrini 2013). Site fidelity in the year following dry conditions was low, and if sites remained dry, they became unoccupied. Future years of monitoring will be required to determine whether the same pattern occurs at Alamo Lake.

Vegetation

Overall, tamarisk was present near 57% of the nests monitored in 2014, though the percentage of the vegetation that consisted of tamarisk ranged from 5 to 100%. The majority (68%) of nests with tamarisk present in the vicinity were located in tamarisk trees, which is likely because young tamarisk tends to have a very suitable branching structure. While the purpose of quantifying the amount of tamarisk in the vicinity of each nest is to determine the potential impact of defoliation, defoliation was noted only at Muddy River in 2014. Extensive defoliation was noted within the breeding site by early July (see chapter 2), but

only two nests were still active in the study area by this time. It is therefore difficult to determine a threshold percentage of tamarisk foliage at which adverse effects on nest success might occur during a defoliation event.

Temperature and Humidity

Too few nests were sampled in 2014 to permit meaningful comparisons between conditions recorded at nests and those recorded in similar vegetation but at non-nest locations, between nests monitored in 2014 versus those from other years, or between nests and habitat creation sites. Future years of data collection should improve our ability to compare conditions at nests to those at non-nest locations. Despite small sample sizes, a few trends were apparent. Within Topock Marsh and the Bill Williams River NWR, non-nest sites had higher maximum daily temperatures than nest sites through early July, though vapor pressure did not differ between nests and beetle monitoring points. Microclimate studies completed in 2003–07 also showed that nest sites at multiple study areas were cooler than non-nest sites within the territory but that vapor pressure did not always differ between nests and within-territory points (McLeod et al. 2008).

Nests at Alamo Lake had markedly lower vapor pressures and markedly higher maximum daily temperatures and daily temperature ranges than nests at either Topock Marsh or the Bill Williams River NWR. However, the temperatures and vapor pressures recorded at Alamo Lake are not outside the range of conditions recorded within flycatcher territories at other study areas. Mormon Mesa had lower vapor pressures and higher maximum daily temperatures than the other regularly occupied study areas (Mesquite, Muddy River, Topock Marsh, and Bill Williams River NWR) (McLeod and Pellegrini 2013), but the values recorded at Mormon Mesa in 2003–09 are similar to those recorded at Alamo Lake in 2014 (figure 5-5). The onset of monsoon season in early July was apparent at Alamo Lake, where temperatures were lower and vapor pressures higher than during early July at Mormon Mesa. Soil moisture is a strong predictor of maximum daily temperature and humidity, with increases in soil moisture increasing the odds of the microclimate variables being within the preferred range (McLeod and Pellegrini 2013). Soil moisture data indicated that Alamo Lake was considerably drier in 2014 (median distance from a nest to water = 950 m in June – early July) than Mormon Mesa in 2003–09 (median distance from occupied flycatcher territories to water = 1 m in June and 467 m in early July). This suggests that microclimate variables at Alamo Lake might resemble those in other occupied study areas (Mesquite, Muddy River, Topock Marsh, and Bill Williams River NWR) if wet soils are present in flycatcher territories in future years.

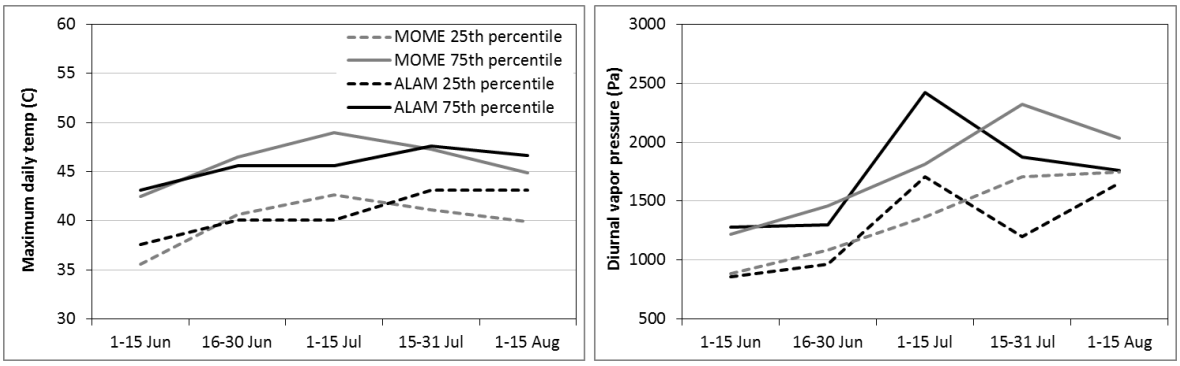

Figure 5-5.—Maximum daily temperature (°C) and diurnal vapor pressure (Pa) recorded at Mormon Mesa (MOME) in 2003–09 and at Alamo Lake (ALAM) in 2014.

At all locations where microclimate was measured in 2014, nighttime low temperatures did not differ greatly across or within study areas. Modeling of the effects of vegetation and soil moisture variables on temperature and humidity showed that vegetation and soil moisture variables were poor predictors of minimum temperature (McLeod and Pellegrini 2013), which is consistent with there being little difference in minimum temperature between locations.

Chapter 6 – Habitat and Threats Monitoring

INTRODUCTION

Flycatcher breeding habitat faces several threats, including loss of habitat as the result of floods, desiccation, and defoliation by tamarisk leaf beetles. We monitored all survey sites for the presence of threats to habitat integrity; any general changes in habitat suitability, including changes in soil moisture, are noted in chapter 2 under the individual site descriptions. In addition to this general monitoring, we specifically monitored the Topock Marsh and Bill Williams River NWR study areas for the presence and effects of tamarisk beetles. The Mesquite and Mormon Mesa study areas were not monitored in 2014 due to access restrictions on the Virgin River.

METHODS

All tamarisk beetle monitoring at the Topock Marsh and Bill Williams River NWR study areas was conducted at permanent monitoring and photo points that were established in 2013 in sites that had been occupied within the previous 5 years (McLeod and Pellegrini 2013, 2014). Each monitoring and photo point was marked with flagging and a piece of rebar to facilitate relocation between visits and between years. The monitoring points are distributed among the available vegetation types at each study area as follows:

- Topock Marsh: tamarisk (10 points), tamarisk with emergent Goodding's willow (10 points)

- Bill Williams River NWR: Goodding's willow overstory with tamarisk understory (15 points)

We established five photo points at Topock Marsh and the Bill Williams River NWR in 2013. These points were placed strategically in locations that afforded a view of the surrounding vegetation. Photos were taken at each visit at a specific height and compass bearing. We used a monopod, a level, and a compass to help align the camera to ensure that the same view was captured at each visit.

All data were collected in the field using Trimble® Terrasync™ 5.61 on a Juno 3B. We visited each monitoring point and photo point every 2 weeks, unless beetles were active in the area, in which case we visited weekly.

Beetle Monitoring and Vegetation Measurements

We recorded visual estimates of foliar color and leafless stems at each monitoring point. We faced outward from the rebar marking the monitoring point and estimated the percentage of all foliage visible from eye level and above in each of four 90-degree quadrants (45º left and right of each cardinal direction) that was green, yellow, and brown. We also estimated in a similar manner the percentage of visible stems that were leafless. We did not include main branches that would be expected to be leafless in the estimate of leafless stems. We measured percent total canopy closure in each cardinal direction using a Model-A spherical densiometer.

We estimated the number of all beetles visible within each 90-degree quadrant by life stage (adults, larvae, and egg clusters). The total time spent facing each cardinal direction did not exceed 30 seconds. We counted adult beetles first and then moved closer to the vegetation if necessary to count the number of larvae and egg clusters. We recorded counts in the following categories:

- Category 0: 0
- Category 1: 1–10
- Category 2: 11–100
- Category 3: 101–1,000
- Category 4: > 1,000

Calibration

In 2013, we identified the differences between observers as a source of variation in the visual estimates of foliar color, percent leafless, and canopy closure. In 2014, we implemented a calibration protocol, with the goal of quantifying and reducing observer variation and identifying any individual observer drift through the season. At the beginning of the season, all observers visited the same five monitoring points as a group. Each observer independently recorded the beetle and vegetation data at a given monitoring point. The results for that monitoring point were then discussed before the group proceeded to the next monitoring point. At the end of the season, all observers returned to the same five monitoring points. This time, each observer independently recorded the beetle and vegetation data, but the results were not discussed.

Temperature and Humidity Measurements

We used a Hygrochron iButton (Maxim Integrated, San Jose, California) to record the temperature and relative humidity on every hour and half hour at each monitoring point. The iButton was mounted on a key fob and hung in a shaded location 1.5–2.0 m above the ground and as close to the monitoring point as

possible (i.e., within 2 m). An iButton was deployed when each monitoring point was established and was removed after the final round of monitoring at the end of the flycatcher breeding season. We obtained daily maximum and minimum temperatures from the Needles Airport, California (Station ID USW00023179) weather station.

Comparison of HOBOs to iButtons

In 2003–12, all temperature and relative humidity data were collected using HOBO H8 Pro (Onset Computer Corporation, Pocasset, Massachusetts) temperature/humidity data loggers. In 2013, we stopped using the aging and increasingly unreliable HOBOs and switched to iButtons. A brief experiment conducted in 2013 suggested that the degree of canopy closure might affect the comparability of data between the two logger types, with a HOBO logger that was in a sunny location recording a higher maximum daily temperature than an iButton in the same location (McLeod and Pellegrini 2014). Therefore, we wanted to compare the readings collected by HOBO loggers to those collected by iButtons as a prerequisite to any future analyses that might compare HOBO data to iButton data (e.g., comparing pre-beetle data on the Virgin River to post-beetle data collected in 2013). In 2014, we hung a HOBO H8 Pro logger next to (i.e., within ≈ 30 cm of) the iButton at each beetle monitoring point (n = 31). Each HOBO logger collected data on every hour and quarter hour. We camouflaged all HOBO loggers by placing them in an inverted small, plastic container coated with spray adhesive and local vegetation. The opening at the bottom was covered with shadecloth, allowing free air circulation around the logger.

Light Intensity Measurements

We used a HOBO Pendant® temperature/light data logger (Onset Computer Corporation, Pocasset, Massachusetts) to measure light intensity or lux (lx) every 15 minutes at each sampling point. We attached the data logger to a rebar safety cap and then placed the cap on the rebar, marking the sample point location, visually ensuring that the cap was level and the light sensor was pointing directly up. We also placed a light logger at a control location in full sun at each study area. We retained the same control logger location at the Bill Williams River NWR that was used in 2013, but we moved the control logger at Topock Marsh to a new location because the location used in 2013 had afternoon shadows from nearby vegetation. In 2013, we discovered that the plastic housing of the loggers gradually becomes opaque when exposed to intense sunlight; because of this, the housing of each control logger was changed at monthly intervals. All light loggers were programmed to log a data point on the hour and every quarter hour. Observers were instructed to inspect each logger during beetle monitoring visits and clean the logger if it appeared to have accumulated dirt or debris. After light

loggers were retrieved at the end of field season, we noted the condition of each logger as: (1) clean, (2) appearing clean but having a film of dirt or sap that could be felt, (3) visibly dirty, or (4) visibly dirty even from a distance.

Following field season, we completed a brief experiment to determine whether light intensity readings were affected by small deviations from horizontal in the position of the light logger. We set out eight loggers, each tilted slightly (≈ 6 degrees) toward one of the cardinal directions. We rotated the loggers periodically over a span of 2 days to control for any differences between individual loggers. We conducted a separate experiment to determine whether the condition of the logger housing affected light intensity readings. We set out 22 loggers (all the Topock Marsh loggers and the control logger from the Bill Williams River NWR) all facing in the same direction and allowed the loggers to collect data for 2 days. These loggers had not been cleaned after they were returned from the field, and they still retained any dirt that had accumulated over the field season.

Statistical Analyses

For each vegetation measurement, we averaged the four readings collected in each cardinal direction to obtain a single value for each monitoring point during each visit. For the densiometer readings, we converted each reading to percent canopy closure before averaging.

For each calibration point, we summarized the data as described above and then averaged across observers, resulting in one mean per calibration point. We calculated observer variation (range in plot-means across observers) for each calibration point. Five observers participated in the initial calibration exercise, but one observer collected data only during the very first round of sampling and did not participate in the final calibration exercise. We present data only for the four observers who participated in both calibration exercises. Maximum observer variation was identified for use in determining whether an observed change in measurement of a vegetation variable was likely to be the result of differences among observers or whether it represented a real change in the vegetation. Data were partitioned by vegetation type, and the largest observer variation recorded for a given vegetation variable for any point within that vegetation type during either the initial or final calibration exercise was used as the benchmark for determining whether an observed change was real.

We grouped data by sampling round (i.e., the day or pair of days on which all points within a study area were visited), and for each sampling round, we summarized vegetation and beetle data for each vegetation type within each study area and for each study area as a whole. Data collection often spanned several days within a given sampling week for both study areas combined, and we present

the data by the week during which the sampling round occurred. The date at the beginning of each sample week is presented. Data were not normally distributed for any of the vegetation measurements, and we present median data. For the first round of sampling at Topock Marsh, we included the data collected as part of calibration, using the mean value across all observers at a given point.

We summarized temperature and humidity data from the iButtons as described in chapter 5. We truncated light data to the midnight after the logger was deployed and the midnight before the logger was removed so that only full 24-hour periods were represented. We calculated the percentage of available light that was recorded at each sampling point by dividing each sample point reading by the reading taken on the same date and time at the control logger and multiplying the result by 100. In 2013, we restricted the analysis of light data to times between 0900 and 1500 hours to avoid the effects of early morning or late afternoon shadows at the control loggers. The logger locations used in 2014 did not have shadows after 0800 hours, but we truncated the data to 0900 and 1500 hours so as to be comparable to data collected in 2013. Both luminance and percent light had non-normal distributions, and we present median data. We summarized data by vegetation type within each study area and for each study area as a whole. Summary statistics for temperature, humidity, and light were completed in IBM® SPSS® v. 22.0.

Comparison of HOBOs and iButtons

We removed the readings collected on quarter-hours from the data collected by HOBOs and then summarized the remaining data as we did for the iButton data. We calculated the difference between and average of each pair of measurements of maximum daily temperature, minimum daily temperature, mean diurnal vapor pressure, and mean nocturnal vapor pressure. Vapor pressure was calculated from relative humidity (see chapter 5).

Our analysis had three objectives: (1) to calculate the bias and measurement error between HOBO and iButton data loggers for maximum daily temperature, minimum daily temperature, mean diurnal vapor pressure, and mean nocturnal vapor pressure to determine whether current data from iButtons and earlier data from HOBOs can be used in the same analyses; (2) in the event that there is acceptable agreement between iButton readings and HOBO readings, to determine how the bias in maximum daily temperature readings between HOBO and iButton data loggers is affected by canopy cover; and (3) in the event that there is acceptable agreement between iButton readings and HOBO readings, to generate a model for predicting the iButton measurements from HOBO data logger measurements for each of the four microclimate variables.

We used two different methods to assess the agreement between data loggers: (1) the Bland-Altman method and (2) regression, using a modified Bland-Altman plot. The traditional Bland-Altman or “limits of agreement” (Altman and Bland

1983, Bland and Altman 1986) involves the creation of a plot in which the difference in a pair of measurements (one from each brand of data logger) on each measurement occasion is plotted against the average of that pair of measurements on the same occasion. Although the Bland-Altman method has still seen little use in ecological studies (Dransfield and Brightwell 2012), it has been used in thousands of medical studies (Myles and Cui 2007).

Some authors have argued that the actual amount of bias calculated from the Bland-Altman method is contaminated by proportional bias that increases with the mean of values being measured (Hopkins 2004; Zaki et al. 2013). Hopkins (2004) advocates doing away with the Bland-Altman method entirely and replacing it with ordinary least-squares regression, while Zaki et al. (2013) advocate assessing bias with more than one method, including the Bland-Altman method. However, updated versions of the Bland-Altman method use repeated-measures analysis of variance or linear mixed models (LMMs) of repeated measures per subject to account for proportional bias when calculating limits of agreement (Bland and Altman 1999; Myles and Cui 2007). Another drawback of the Bland-Altman method is that it generates only a single mean estimate for both bias and measurement error and cannot show how measurement error varies with the values being measured, for which regression is recommended (Fernandez and Fernandez 2009). We report on how we used the Bland-Altman method and the results we obtained in attachment 10.

While advocating a return to using regression for assessing measurement error between methods, Hopkins (2004) did not clearly indicate how ordinary least-squares regression of one method's values against another method's values could produce estimates of measurement error. Fernandez and Fernandez (2009) recommended a modified Bland-Altman plot of the differences in paired measurements against the values of the standard method (here, the HOBO values) instead of against the mean of measurements from the two methods on each measurement occasion. Instead of limits of agreement, Fernandez and Fernandez used a regression line and 95% prediction intervals for the relationship to see how the actual bias and measurement error vary across a range of values being measured and for what values bias is significantly different from zero (values where prediction interval limits are either both greater than or both less than zero). This is in contrast to the Bland-Altman method, which calculates a single measure of mean bias and measurement error.

We generated regression plots similar to the ones recommended by Fernandez and Fernandez (2009), except that we used linear mixed regression models given that we had repeated paired measurements per site (**lme** function, *nlme* package: Pinheiro et al. 2014). Our methods also differed in that our final regression models did not include heteroscedastic-consistent standard errors used by Fernandez and Fernandez (2009) in their models because the resulting prediction intervals were much too narrow, excluding a majority of actual data points. Thus, we generated regression lines and 95% prediction intervals for the LMMs that we

used to calculate limits of agreement for each variable (*ggplot2* package [Wickham 2009] or **plot** function), assuming homoscedasticity of variance, after log-transformation where necessary.

Influence of Canopy Cover on Maximum Daily Temperature Bias

We used generalized linear mixed models (GLMMs) to investigate whether canopy closure had an effect on the differences between HOBOs and iButtons in maximum daily temperature. Canopy closure was recorded during each monitoring visit to each point. Using just the measurements of maximum temperature from dates with canopy cover measurements, we ran the following GLMMs, including a model with an interaction between canopy cover and mean daily maximum temperature:

- Difference (HOBO-iButton) ~ Mean daily maximum temperature
- Difference (HOBO-iButton) ~ Canopy cover
- Difference (HOBO-iButton) ~ Mean daily maximum temperature + canopy cover
- Difference (HOBO-iButton) ~ Mean daily maximum temperature + canopy cover + interaction

We used Akaike's information criterion (AIC) (Burnham and Anderson 2002) to select the preferred model (the model with the lowest AIC value).

Predicting iButton Measurements from HOBO Measurements

We used GLMMs to predict corresponding iButton values in 2014 from HOBO data logger values in 2014 for maximum daily temperature, minimum daily temperature, mean diurnal vapor pressure, and mean nocturnal vapor pressure. For variables that showed heterogeneity of variance, we log-transformed the data before modeling. We ran the following set of models for each variable, specifying different random effects:

- iButton ~ HOBO + fixed intercept + random intercept (point)
- iButton ~ HOBO + fixed intercept + random intercept (point nested within study area)
- iButton ~ HOBO + fixed intercept + random slope (point)
- iButton ~ HOBO + fixed intercept + random intercept (point) + random slope (point)

- iButton ~ HOBO + fixed intercept + random intercept + random slope (point nested within study area)

We evaluated the GLMMs, predicting each kind of iButton measurement using AIC, and graphed the predicted relationship against the actual data.

Because results from the GLMMs can be applied only to the sites that were used in the generation of the GLMMs (because parameter estimates represent "typical" effects of independent variables after accounting for site-specific random effects), we also used generalized linear models with general estimating equations (GLM-GEEs) (Zeger and Liang 1986) to predict iButton values from HOBO measurements. GLM-GEEs account for repeated measurements per site by modeling the overall correlation structure of measurements at sites over time; thus, parameter estimates in GLM-GEEs represent "marginal" effects of independent variables averaged across a population. If the sites used to generate GLM-GEEs are a representative sample of a larger set of sites, the GLM-GEE results can be applied to the whole set of sites.

We generated semivariograms to graphically represent the average correlation structure of repeated measurements across time at the 31 sites and then ran GLM-GEEs (geeglm function, geepack package R) (Yan 2002; Yan and Fine 2004; Højsgaard et al. 2006) with an appropriate correlation structure. We wanted to know whether study area or canopy cover affected the iButton measurement, and we ran the following models for all four microclimate variables:

- iButton ~ Study area (Topock Marsh = 1, Bill Williams River NWR = 0) + HOBO; n = 2,283

- iButton ~ Canopy cover + HOBO; n = 180

If neither study area nor canopy cover was significant, we ran a simpler GLM-GEE with HOBO measurement as the only variable:

- iButton ~ HOBO; n = 2283

RESULTS

Beetle Monitoring and Vegetation Measurements

Calibration

We used five points in Topock Marsh (TM-1, TM-2, TM-4, and TM-5 in tamarisk with emergent Goodding's willow and TM-3 in tamarisk) for calibration. We present calibration data in the order the points were visited (TM-1, TM-2, TM-5,

TM-4, and TM-3) during the calibration exercise at the beginning of the season. No yellow foliage was noted during either calibration event, and we present data for percent green foliage only.

During the first calibration exercise, observer variation was highest at the first calibration point across all vegetation variables (figure 6-1). We discovered during the discussion following the first calibration point that some observers did not fully understand the protocol, and data from the first calibration point during the initial calibration exercise are not used in the determination of maximum observer variation. For most variables at most calibration points, the range among observers decreased between the start of the field season and the end (figure 6-1). Exceptions to this include percent tamarisk readings at several points and percent leafless stems at one point. Most observers recorded lower percent tamarisk within 2 m, percent tamarisk within 5 m, and percent leafless stems at the end of the season than at the beginning, while the reverse was true for percent canopy cover and percent green foliage (figure 6-1).

Maximum observer variation is summarized by vegetation type for the beginning and end of the field season in table 6-1. For end values of percent tamarisk within 2 and 5 m, we excluded data from observer 3, who did not consistently follow protocol when estimating percent tamarisk in the vicinity of a sample point. Maximum observer variation was lower at the end of the season than at the beginning of the season for all variables within tamarisk with emergent Goodding's willow. Within tamarisk, maximum observer variation was higher at the end of the field season than at the beginning for percent tamarisk within 2 and 5 m and percent leafless stems but was lower at the end of the season than at the beginning for percent canopy cover and percent green foliage.

Table 6-1.—Maximum range in observer variation by vegetation variable and type at the start and end of sampling at calibration points, Topock Marsh, 2014*

Vegetation variable	TASP_SAGO (n = 4) [1]		TASP (n = 1)	
	Start	End	Start	End
Percent TASP within 2 m	40	15	25	30
Percent TASP within 5 m	40	30	15	35
Percent leafless stems	13.7	26.2	6.2	13.7
Percent canopy cover	3.4	2.3	3.9	1.8
Percent green foliage	20	8.7	3.7	2.5

* TASP_SAGO = tamarisk with emergent Goodding's willow, and TASP = tamarisk.
[1] Only three calibration points were used in determining maximum observer variation during the initial calibration exercise at the start of the field season; the fourth point was excluded because not all observers followed protocol.

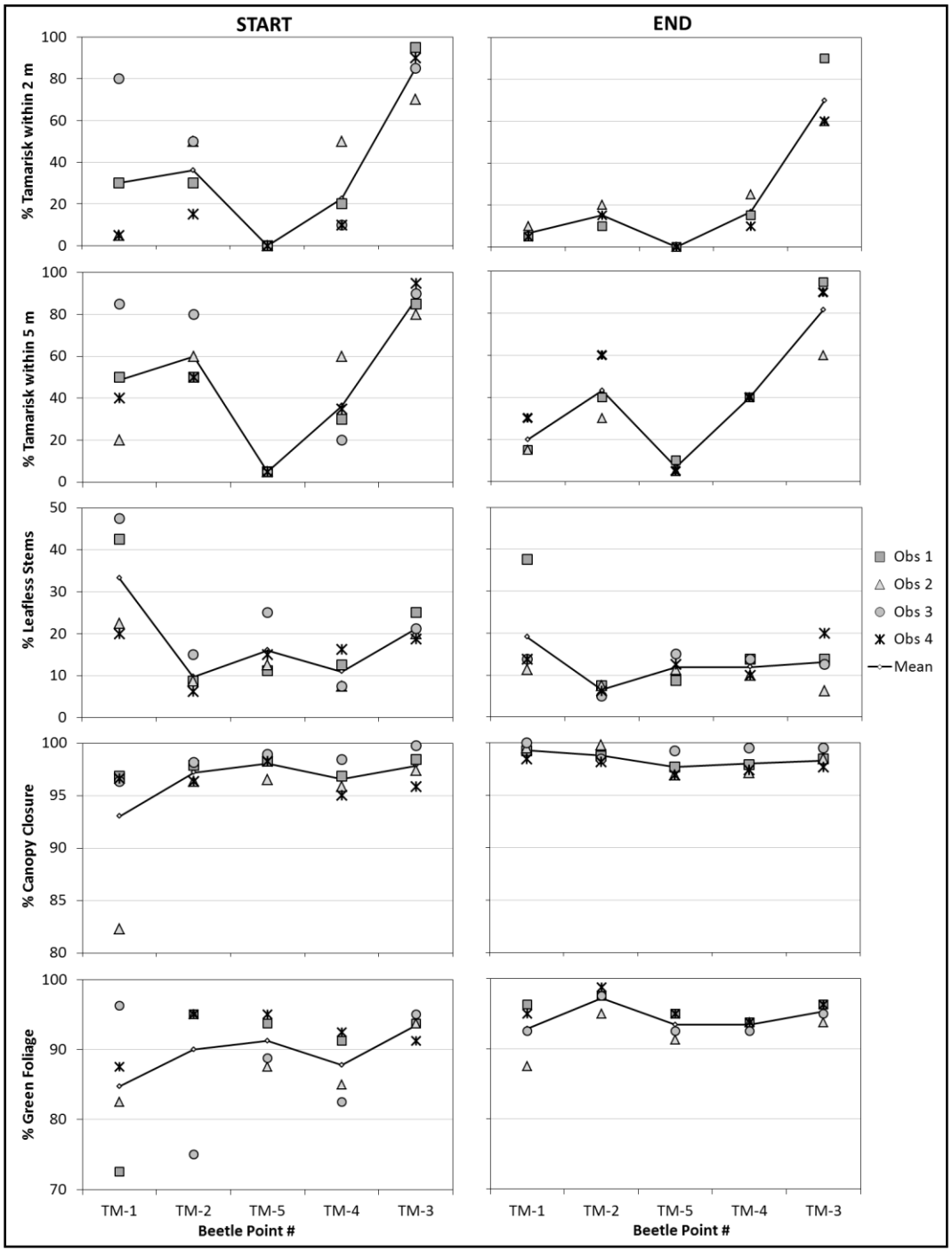

Figure 6-1.—Calibration data by observer at the start (mid-May) and end (late July) of the field season for five vegetation variables at monitoring points in Topock Marsh, 2014.

Beetle Monitoring and Vegetation Measurements

We visited the monitoring points biweekly throughout the season at Topock Marsh and the Bill Williams River NWR, starting on May 14 and ending July 24. No beetles were detected at either study area, though splendid tamarisk weevils were observed at Topock Marsh. We did not use foliar color data from points in the tamarisk vegetation type for one observer during the first sampling round at Topock Marsh because the observer incorrectly included tamarisk duff in estimations of brown foliage.

Overall, the percentage of foliage that was green was slightly higher at the Bill Williams River NWR than at Topock Marsh (figure 6-2). Foliage was at least 95% green for almost the entire season at the Bill Williams River NWR. At Topock Marsh, foliage was between 90 and 95% green throughout the season in both tamarisk and areas with emergent Goodding's willow. In both vegetation types at Topock Marsh, there was an initial increase in percent green foliage in late May (5% in tamarisk and 2% in tamarisk with emergent Goodding's willow), followed by a gradual decrease through the rest of the season (3% in tamarisk and 2% in tamarisk with emergent Goodding's willow). No more than 2% of the vegetation was yellow in either study area.

Overall, the percentage of leafless stems was higher in tamarisk at Topock Marsh and lower at the Bill Williams River NWR and in areas with emergent Goodding's willow at Topock Marsh (figure 6-3). At Topock Marsh, the percentage of leafless stems in tamarisk decreased from 43 to 20% in May and then fluctuated between 14 and 19%. In areas with emergent Goodding's willow in Topock Marsh and in the Bill Williams River NWR, measurements of the percentage of leafless stems were similar and varied between 9–12% and 7–14%, respectively.

In Topock Marsh, percent canopy closure varied between 95 and 98% in tamarisk and increased from 96 to 100% in areas with emergent Goodding's willow (figure 6-4). At the Bill Williams River NWR, percent canopy closure varied between 93 and 99%, with a sharp decrease of 6% in early July.

Temperature and Humidity Measurements

HOBO and iButton loggers were deployed at Topock Marsh on May 14 and 15 and at the Bill Williams River NWR on May 16. All loggers at both study areas were taken down on July 31. Two iButtons at the Bill Williams River NWR failed to launch and collected no data; this was probably the result of user error. Two additional iButtons, one at Topock Marsh and one at the Bill Williams River NWR, fell down partway through the season, and data were truncated to exclude the period when the logger was on the ground. Two HOBO loggers at Topock Marsh failed to collect data, and one HOBO at the Bill Williams River NWR fell partway through the season, and data were truncated to exclude the period the logger was on the ground.

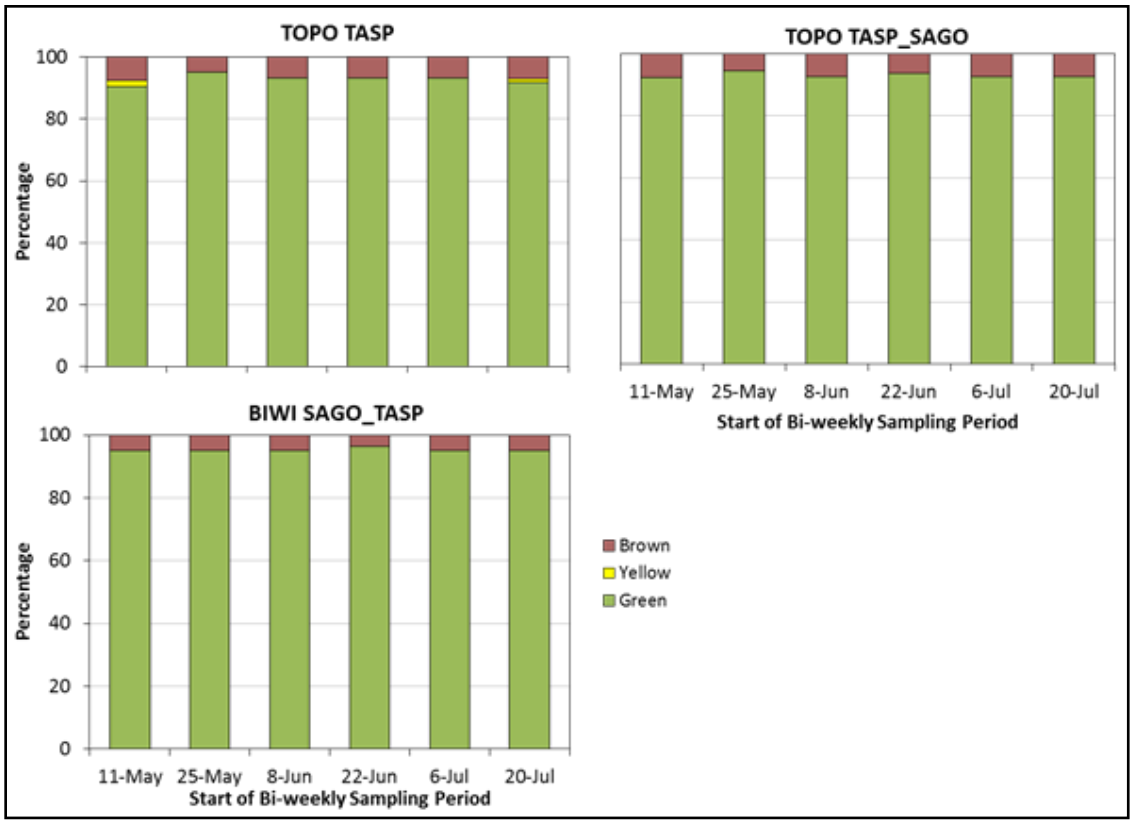

Figure 6-2.—Median percentage of foliage color at beetle monitoring points at Topock Marsh (TOPO) and the Bill Williams River NWR (BIWI), 2014.
Vegetation types are: TASP = tamarisk, TASP_SAGO = tamarisk with emergent Goodding's willow, and SAGO_TASP = Goodding's willow overstory with tamarisk understory.

Overall temperatures were very similar between the Bill Williams River NWR and Topock Marsh (table 6-2 and figure 6-5). However, the temperature differed among vegetation types at Topock Marsh, with tamarisk having higher temperatures and a larger daily temperature range than tamarisk with emergent Goodding's willow.

Humidity varied relatively little among study areas or vegetation types at Topock Marsh and the Bill Williams River NWR (table 6-3 and figure 6-6). Vapor pressure at the Bill Williams River NWR fluctuated more widely between day and night, being higher during the day and lower during the night than at Topock Marsh. Both study areas showed a rise in humidity with the onset of monsoon season in July.

At Topock Marsh and the Bill Williams River NWR, daytime highs and nighttime lows in all vegetation types were considerably lower than those recorded at the Needles weather station (figure 6-7). Maximum and minimum daily temperatures recorded at beetle points generally mirrored the seasonal patterns recorded at the

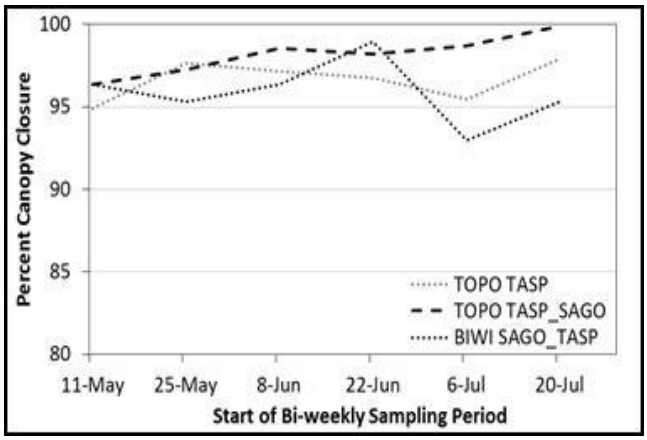

Figure 6-3.—Median percentage of leafless stems by vegetation type at beetle monitoring points at Topock Marsh (TOPO) and the Bill Williams River NWR (BIWI), 2014. Vegetation types are TASP = tamarisk, TASP_SAGO = tamarisk with emergent Goodding's willow, and SAGO_TASP = Goodding's willow overstory with tamarisk understory.

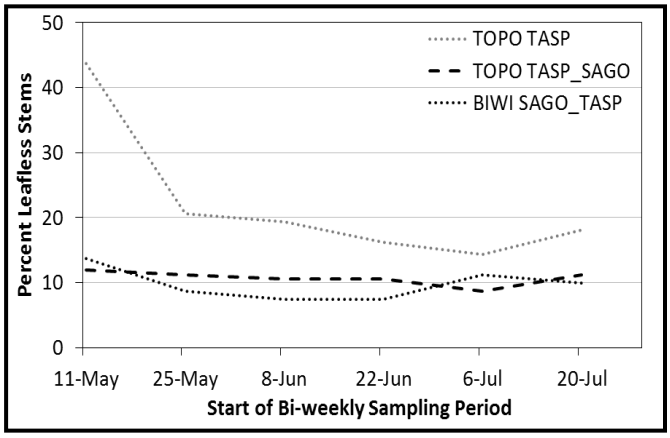

Figure 6-4.—Median percent canopy closure by vegetation type at beetle monitoring points at Topock Marsh (TOPO) and the Bill Williams River NWR (BIWI), 2014. Vegetation types are TASP = tamarisk, TASP_SAGO = tamarisk with emergent Goodding's willow, and SAGO_TASP = Goodding's willow overstory with tamarisk understory.

weather station, though minimum daily temperatures at beetle points rose markedly in late June in comparison to that at the weather station. The difference in daytime highs between the weather station and the beetle monitoring points tended to be larger on hot days than on cooler days.

Comparison of HOBOs and iButtons

Average Measurement Error from Limits of Agreement

Only the most important results from the Bland-Altman analysis are summarized here, with full details of results in attachment 10.

Within-subject coefficients of variation (CV) for HOBO data logger measurements were below 1.5% for all microclimate variables, and CVs of iButton measurements were similar to those of HOBO measurements for all variables. Using the HOBO CVs, we calculated the maximum allowable measurement error between paired iButton and HOBO values of ± 3.95% (maximum daily temperature), ± 2.33% (minimum daily temperature), ± 2.87% (mean daily vapor pressure), and ± 2.46% (mean nightly vapor pressure).

For all four microclimate measures, the percent error calculated from LMMs of the differences between HOBO and iButton readings exceeded the threshold measurement error calculated from HOBO data. The percent error exceeded the threshold to the greatest degree for maximum daily temperature (5.63 versus 3.95%, respectively) and to the least degree for mean diurnal vapor pressure

Table 6–2.—Maximum and minimum daily temperature and daily temperature range (°C) recorded by iButtons at beetle monitoring points at Topock Marsh and the Bill Williams River NWR, 2014*

Study area	Vegetation type[1]	May 16–31		June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
		Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th–75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)
Maximum daily temperature													
TOPO	TASP	36.8 (34.6–40.6)	37.3 (0.3)	39.1 (36.1–41.1)	38.9 (0.3)	38.6 (35.6–40.6)	38.0 (0.3)	36.6 (34.1–40.1)	37.2 (0.3)	38.6 (35.1–41.6)	38.6 (0.3)	n/a	n/a
	TASP_SAGO	34.9 (31.1–37.1)	34.2 (0.3)	35.1 (33.7–37.1)	35.3 (0.2)	35.6 (33.1–37.1)	35.2 (0.2)	34.6 (33.6–36.3)	34.8 (0.2)	36.1 (34.6–37.1)	35.8 (0.2)	n/a	n/a
	Overall	36.1 (33.1–38.6)	35.8 (0.2)	36.6 (34.6–39.1)	37.1 (0.2)	36.6 (34.1–38.6)	36.6 (0.2)	35.6 (33.6–38.1)	36.1 (0.2)	36.6 (35.1–39.1)	37.3 (0.2)	n/a	n/a
BIWI	SAGO_TASP	35.6 (32.1–37.6)	35.2 (0.3)	36.6 (34.6–39.1)	36.9 (0.2)	37.6 (35.6–39.1)	37.3 (0.2)	37.1 (35.6–38.6)	37.2 (0.2)	37.6 (36.1–39.6)	37.7 (0.2)	n/a	n/a
Minimum daily temperature													
TOPO	TASP	15.1 (12.1–17.1)	14.6 (0.3)	14.1 (11.6–16.6)	14.1 (0.3)	17.6 (15.1–19.6)	17.1 (0.3)	22.1 (20.6–24.2)	22.4 (0.2)	21.6 (19.1–22.6)	21.2 (0.2)	n/a	n/a
	TASP_SAGO	14.6 (12.3–16.6)	14.5 (0.2)	13.6 (12.1–16.6)	13.9 (0.2)	16.7 (15.2–18.6)	16.7 (0.2)	22.1 (20.1–23.9)	22.2 (0.2)	21.1 (19.1–22.6)	20.9 (0.2)	n/a	n/a
	Overall	15.1 (12.1–16.7)	14.6 (0.2)	13.7 (12.1–16.6)	14.0 (0.2)	17.1 (15.1–19.1)	16.9 (0.2)	22.1 (20.2–24.1)	22.3 (0.2)	21.2 (19.1–22.6)	21.1 (0.2)	n/a	n/a
BIWI	SAGO_TASP	15.6 (14.1–16.6)	15.3 (0.2)	14.6 (13.6–15.7)	14.9 (0.1)	16.7 (15.6–18.6)	17.1 (0.1)	22.2 (20.2–22.7)	21.7 (0.1)	21.1 (18.6–23.1)	21.2 (0.2)	n/a	n/a
Daily temperature range													
TOPO	TASP	22.0 (19.5–26.0)	22.7 (0.4)	24.5 (21.5–28.0)	24.8 (0.4)	21.0 (17.5–24.0)	20.9 (0.4)	14.5 (11.0–18.5)	14.7 (0.4)	17.5 (13.5–21)	17.4 (0.4)	n/a	n/a
	TASP_SAGO	19.5 (17.0–21.0)	19.7 (0.3)	21.5 (19.5–23.0)	21.4 (0.2)	18.0 (16.0–21.0)	18.5 (0.3)	12.5 (10.0–15.0)	12.7 (0.3)	15.5 (11.7–17.5)	14.9 (0.3)	n/a	n/a
	Overall	20.5 (18.0–24.5)	21.2 (0.3)	22.5 (20.0–25.5)	23.1 (0.3)	19.5 (17.0–22.5)	19.7 (0.3)	13.5 (10.0–16.5)	13.8 (0.3)	16.0 (13.0–19.0)	16.2 (0.3)	n/a	n/a
BIWI	SAGO_TASP	19.5 (18.5–22.0)	19.9 (0.2)	22.0 (20.0–24.0)	22.0 (0.2)	20.5 (18.5–22)	20.2 (0.2)	15.5 (13–18)	15.5 (0.2)	16.5 (14.0–19.0)	16.5 (0.3)	n/a	n/a

* n/a = data not available.
[1] TASP = tamarisk, TASP_SAGO = tamarisk with emergent Goodding's willow, and SAGO_TASP = Goodding's willow overstory with tamarisk understory.

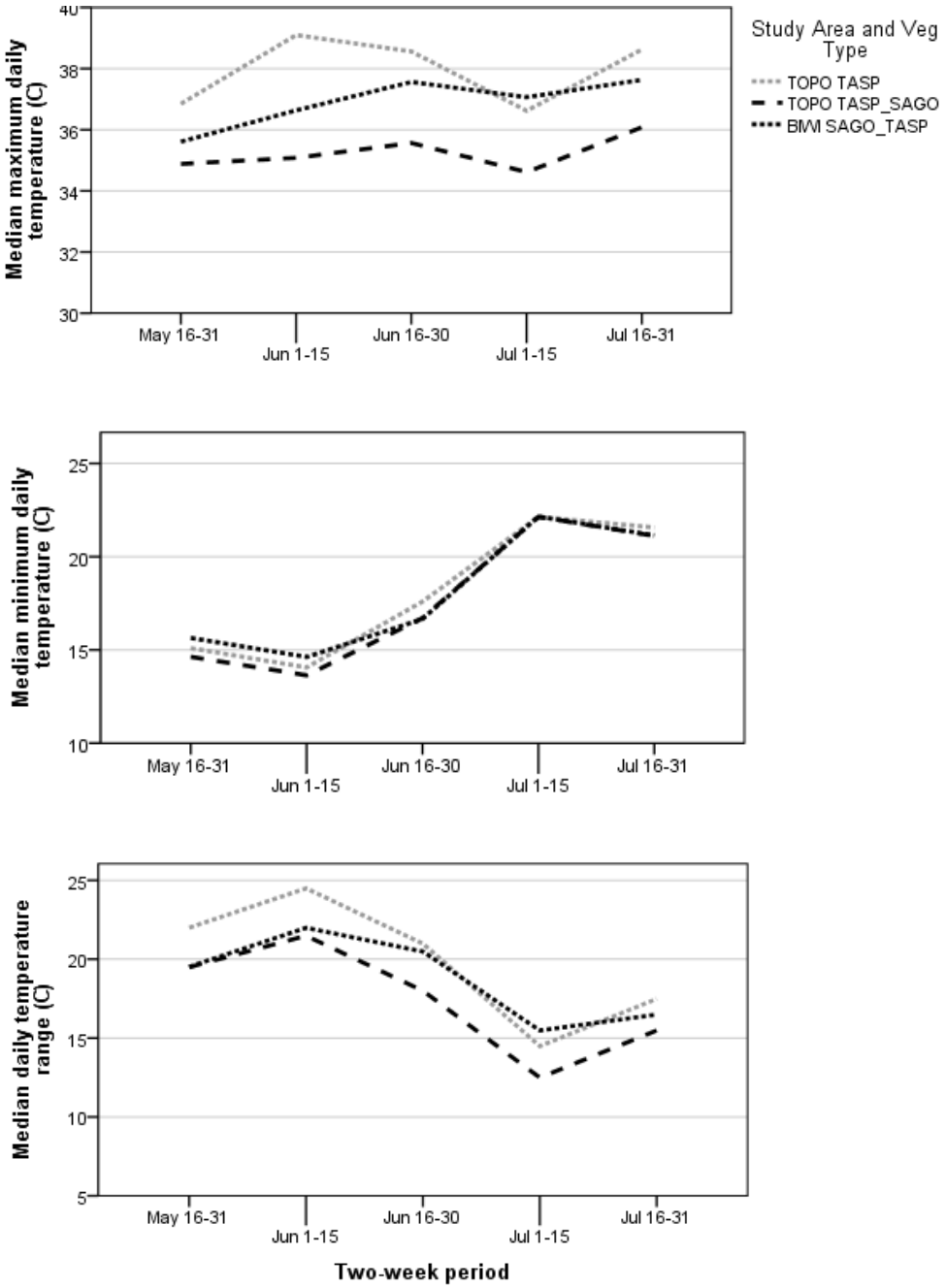

Figure 6-5.—Median maximum and minimum daily temperature and daily temperature range (°C) recorded by iButtons at beetle monitoring points at Topock Marsh (TOPO) and the Bill Williams River NWR (BIWI), 2014.
Vegetation types are TASP = tamarisk, TASP_SAGO = tamarisk with emergent Goodding's willow, and SAGO_TASP = Goodding's willow overstory with tamarisk understory.

Table 6–3.—Mean diurnal and nocturnal vapor pressure (Pa) recorded by iButtons at beetle monitoring points at Topock Marsh and the Bill Williams River NWR, 2014*

Study area	Vegetation type[1]	May 16–31		June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
		Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)
Mean diurnal vapor pressure													
TOPO	TASP	1,455 (1,186–1,718)	1,472 (29)	1,593 (1376–1815)	1,626 (26)	1,797 (1,581–2,171)	1,844 (37)	2,765 (2,545–3,010)	2,763 (30)	2,634 (2,248–2,831)	2,549 (32)	n/a	n/a
	TASP_SAGO	1,553 (1,224–1,758)	1,529 (28)	1,652 (1429–1825)	1,653 (23)	1,786 (1,592–2,125)	1,834 (35)	2,760 (2,530–2,933)	2,717 (29)	2,559 (2,262–2,790)	2,522 (31)	n/a	n/a
	Overall	1,491 (1,210–1,747)	1,501 (20)	1,643 (1405–1818)	1,640 (17)	1,797 (1,582–2,158)	1,839 (26)	2,761 (2,533–2,977)	2,742 (21)	2,577 (2,251–2,811)	2,537 (22.2)	n/a	n/a
BIWI	SAGO_TASP	1,598 (1,255–1,859)	1,565 (27)	1,771 (1,588–1,961)	1,780 (19)	1,983 (1,749–2,214)	1,948 (26)	2,847 (2,619–3,032)	2,813 (22)	2,734 (2,358–2,916)	2,639 (24)	n/a	n/a
Mean nocturnal vapor pressure													
TOPO	TASP	1,333 (1,135–1,574)	1,344 (22)	1,370 (1,232–1,501)	1,367 (17)	1,566 (1,384–1,797)	1,586 (25)	2,445 (2,164–2,591)	2,386 (23)	2,190 (1,918–2,430)	2,188 (24)	n/a	n/a
	TASP_SAGO	1,453 (1,275–1,771)	1,501 (23)	1,536 (1,402–1,681)	1,538 (16)	1,743 (1,574–1,909)	1,746 (26)	2,519 (2,254–2,681)	2,475 (22)	2,304 (2,073–2,536)	2,294 (24)	n/a	n/a
	Overall	1,411 (1,184–1,652)	1,423 (17)	1,459 (1,302–1,594)	1,453 (13)	1,652 (1,464–1,868)	1,666 (19)	2,462 (2,228–2,650)	2,428 (16)	2,226 (2,006–2,499)	2,238 (17)	n/a	n/a
BIWI	SAGO_TASP	1,374 (1,101–1,484)	1,298 (17)	1,282 (1,230–1,329)	1,312 (10)	1,544 (1,416–1,724)	1,579 (18)	2,367 (2,157–2,627)	2,358 (21)	2,123 (1,884–2,437)	2,142 (21)	n/a	n/a

* n/a = data not available.
[1] TASP = tamarisk, TASP_SAGO = tamarisk with emergent Goodding's willow, and SAGO_TASP = Goodding's willow overstory with tamarisk understory.

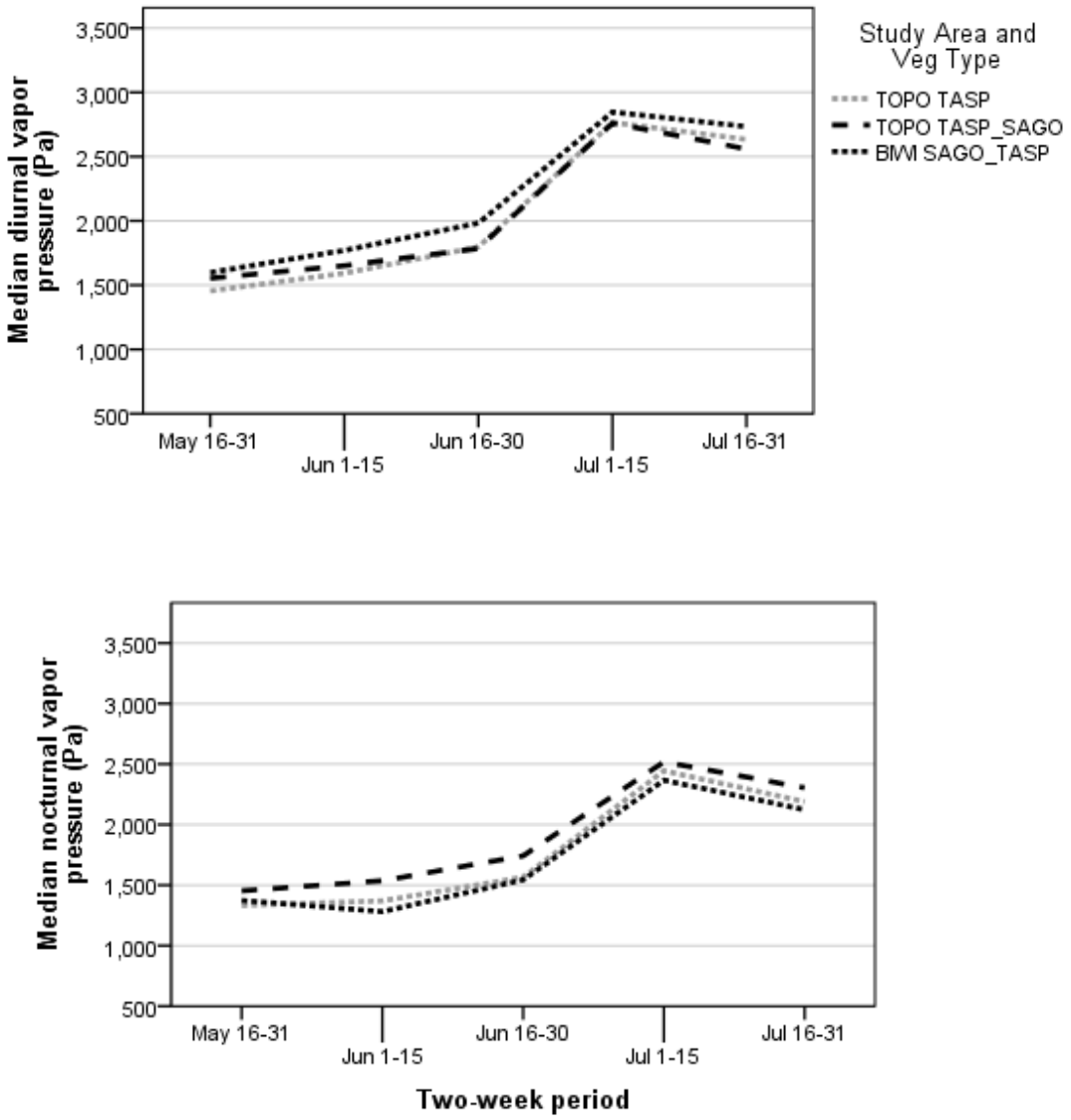

Figure 6-6.—Median diurnal and nocturnal vapor pressure (Pa) recorded by iButtons at beetle monitoring points at Topock Marsh (TOPO) and the Bill Williams River NWR (BIWI), 2014.
Vegetation types are TASP = tamarisk, TASP_SAGO = tamarisk with emergent Goodding's willow, and SAGO_TASP = Goodding's willow overstory with tamarisk understory.

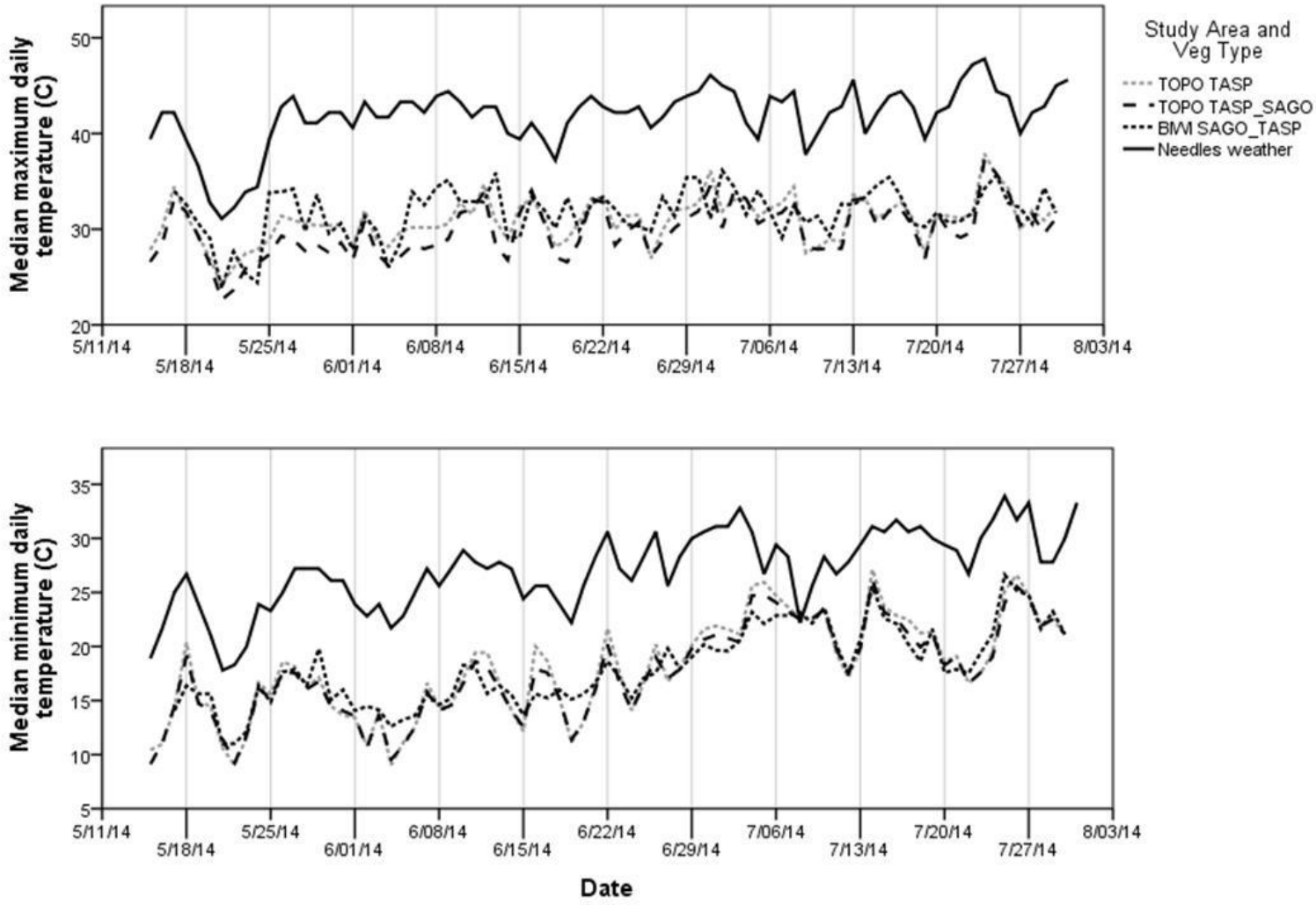

Figure 6-7.—Median maximum and minimum daily temperature (°C) at beetle monitoring points within tamarisk (TASP) and tamarisk with emergent Goodding's willow (TASP_SAGO) at Topock Marsh (TOPO) and Goodding's willow overstory with tamarisk understory (SAGO_TASP) at the Bill Williams River NWR (BIWI) as compared to the maximum and minimum daily temperature recorded at the Needles weather station, 2014.

(3.50 versus 2.87%, respectively). Measurement error was probably underestimated by the limits of agreement for both diurnal and nocturnal vapor pressure, with most observed bias being within ± 200 Pa (9.84% of mean HOBO value) and ± 150 Pa (8.64% of mean HOBO value), respectively.

Calculating Measurement Error from Regression – An Alternative to Limits of Agreement

All models accounted for random effects, used a first-order autoregressive correlation structure, and assumed homogeneous variance. Bias in maximum daily temperature varied with HOBO maximum daily temperature measurements by the formula:

$$\text{Bias}_{\text{HOBO - iButton daily maximum T}} = -5.3144754 + 0.137665*\text{HOBO}$$

Both intercept and mean slope were significant ($P < 0.0001$), but bias was not significantly different from 0 for the range of temperatures that was analyzed. Measurement error represented by the prediction interval varied from ± 1.94° at 25 °C to ± 2.03° at 47 °C (figure 6-8).

Bias in minimum nightly temperature varied with HOBO minimum nightly temperature measurements by the formula:

$$\text{Bias}_{\text{HOBO - iButton nightly minimum T}} = 0.8114905 -0.0178387*\text{HOBO}$$

Both intercept and mean slope were significant ($P < 0.0001$), but bias was not significantly different from 0 at nightly minimum temperatures < 12.5 °C; below 12.5 °C, bias was positive. Measurement error represented by the prediction interval varied from ± 0.61° at 7 °C to ± 0.60° at 27 °C (figure 6-9).

Bias in mean daily vapor pressure varied with the HOBO mean daily vapor pressure measurements by the formula:

$$\text{Biaslog}_{\text{HOBO DVP-log iButton DVP}} = -0.05400657 + 0.09299289*\text{HOBO}_{\text{centered}} + 0.03133665*\text{HOBO}^2 + 0.04771687*\text{HOBO}^3$$

Both intercept and mean slope were significant ($P < 0.0001$). After back-transformation, bias was negative below ≈ 1,800 Pa, positive when the mean measurement was above ≈ 3,250 Pa, and not significantly different from 0 for vapor pressures in between. Measurement error represented by the prediction interval varied from ± 21.84 Pa at 660 Pa to ± 174.1636 Pa at 4,124 Pa (figure 6-10).

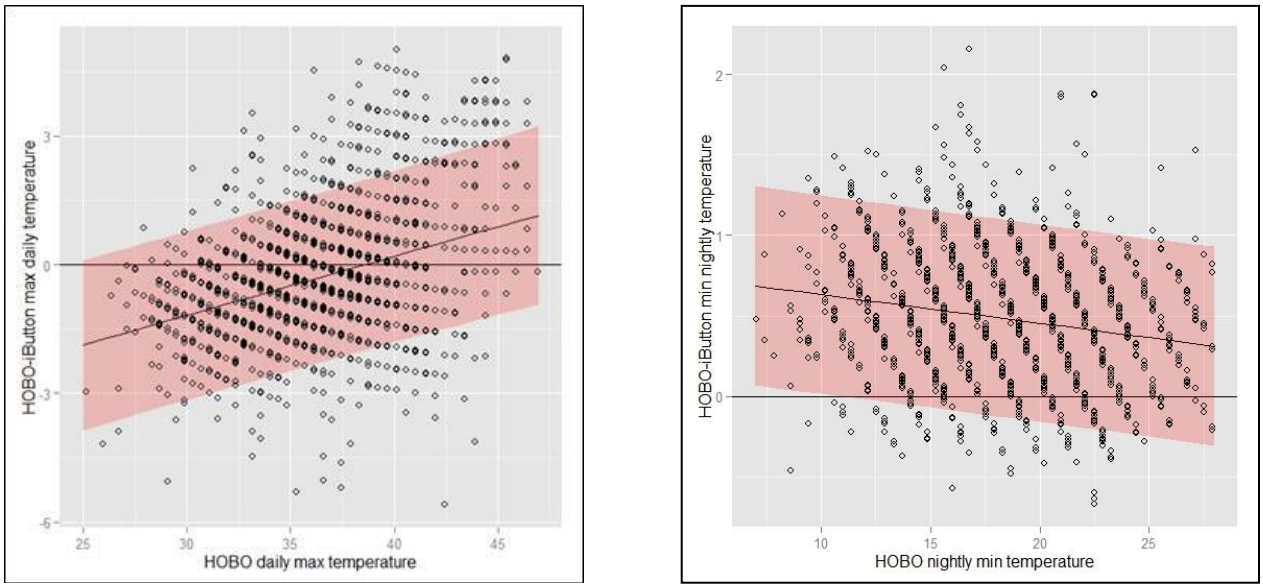

Figure 6-8.—Regression and 95% prediction intervals (based on regular model standard errors) for the difference in maximum daily temperature recorded by HOBO and iButton data loggers at beetle monitoring points at Topock Marsh and the Bill Williams River NWR, May 15 – July 31, 2014.

Bias in mean nightly vapor pressure varied with HOBO mean nightly vapor pressure measurements by the formula:

$$\text{Bias}_{\text{logHOBO NVP-log iButton NVP}} = -0.04417141 + 0.07212292*\text{HOBO}_{\text{centered}} - 0.03376254*\text{HOBO}^2 + 0.0852626*\text{HOBO}^3$$

Both intercept and mean slope were significant ($P < 0.0001$). After back-transformation, bias was negative below 1,730–1,734 Pa and not significantly different from 0 at pressures > 1,734 Pa. Measurement error represented by the prediction interval varied from ± 21.1874 Pa at 712 Pa to ± 112.9261 Pa at 3,173 Pa (figure 6-11).

Influence of Canopy Cover on Maximum Daily Temperature Bias

Canopy cover did not significantly affect the difference in maximum daily temperatures measured by HOBO and iButton data loggers in any model, although average maximum temperature measurement did. Models including canopy cover did not have a lower AIC than models without canopy cover. Thus, the canopy cover that was measured in 2014 probably did not affect the bias in measurements of maximum daily temperature.

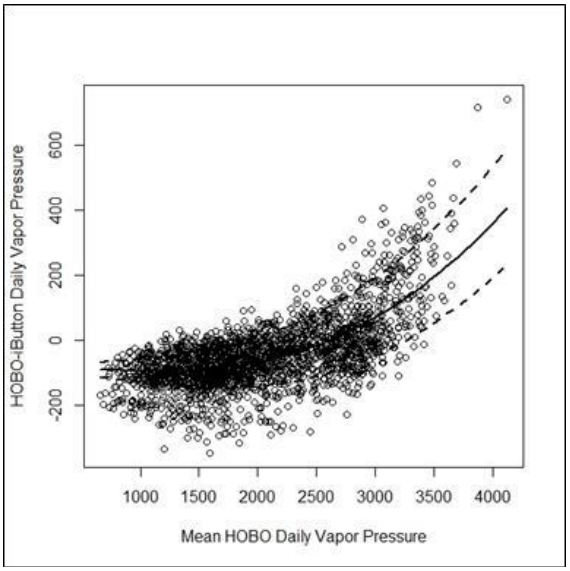

Figure 6-10.—Regression and 95% prediction intervals (back-transformed, based on regular model standard errors) for the difference in daily vapor pressure plotted against mean HOBO daily vapor pressure measurements.

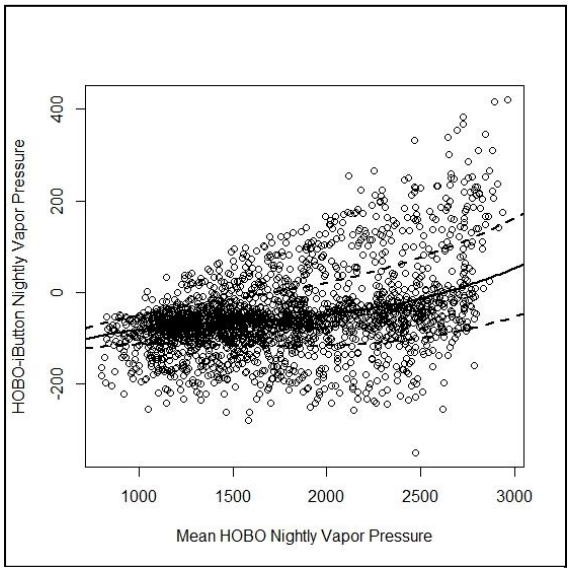

Figure 6-11.—Regression and 95% prediction intervals (back-transformed, based on regular model standard errors) for the difference in nightly vapor pressure plotted against mean HOBO nightly vapor pressure measurements.

Predicting iButton Measurements from HOBO Measurements

The best model for predicting iButton values from HOBO values using GLMMs was iButton ~ HOBO + random intercept (point) + random slope (point) for all four microclimate variables (figures 6-12–6-15).

Semivariograms suggested that correlations among repeated measurements per site were generally time dependent and decreased as the time lag between measurement occasions increased, although correlations were much weaker for minimum daily temperature. This justified the use of the first-order autoregressive correlation structure in GLM-GEEs. Maximum and minimum daily temperature as recorded by iButtons were not affected by study area (P = 0.1125 and P = 0.7008, respectively [n = 2283]) or canopy closure (P = 0.4158 and P = 0.1481, respectively [n = 180]), and temperatures were modeled as $MDT_{iButton} = 6.7975 + 0.8223^* MDT_{HOBO}$ and $MNT_{iButton} = 6.7975 + 0.8223^* MNT_{HOBO}$. Mean diurnal vapor pressure as recorded by iButtons was affected by study area (P = 0.0083) but not canopy cover (P = 0.8316) and was modeled as $DVP_{iButton} = 383.1692 - 53.5113$ (Topock) $+ 0.8482^* DVP_{HOBO}$. The model without study area or canopy cover was $DVP_{iButton} = 352.0363 + 0.8481^* DVP_{HOBO}$. Nightly vapor pressure was not significantly affected by either study area (P = 0.7194) or canopy cover (P = 0.7592) and was modeled as $NVP_{iButton} = 208.2312 + 0.9081^* NVP_{HOBO}$.

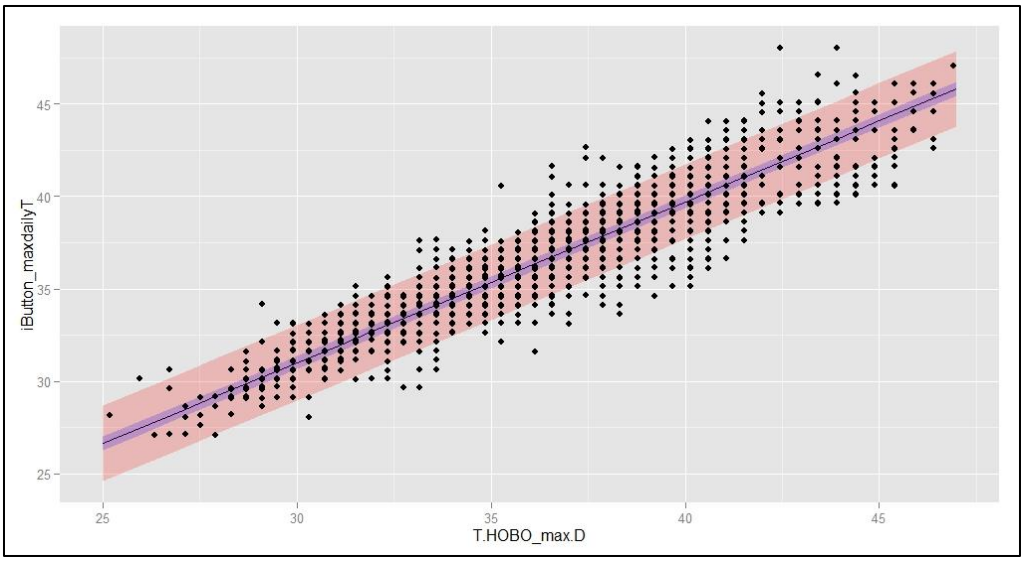

Figure 6-12.—Predicted and actual relationships between iButton and HOBO measurements of maximum daily temperature (MDT) at each beetle monitoring point, Topock Marsh and the Bill Williams River NWR, May 15 – July 31, 2014 (n = 2,283 paired observations, 31 points).
The predicted relationship is $MDT_{iButton} = 4.56 + 0.88^* MDT_{HOBO}$ + random $intercept_{point}$ + random $slope_{point}^* MDT_{HOBO}$. The red band indicates the 95% CI for the predicted values. Points on the graph indicate the actual iButton and HOBO values.

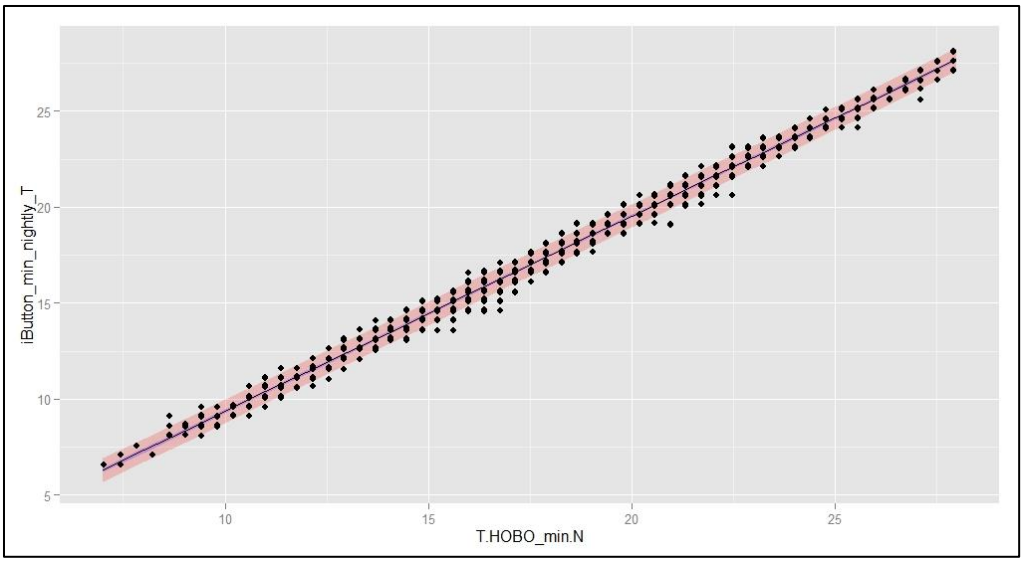

Figure 6-13.—Predicted and actual relationships between iButton and HOBO measurements of minimum daily temperature (MNT) at each beetle monitoring point, Topock Marsh and the Bill Williams River NWR, May 15 – July 31, 2014 (n = 2,283 paired observations, 31 points).
The predicted relationship is $MNT_{iButton} = 0.82 + 1.02^* MNT_{HOBO}$ + random $intercept_{point}$ + random $slope_{point}^* MNT_{HOBO}$. The red band indicates the 95% CI for the predicted values. Points on the graph indicate the actual iButton and HOBO values.

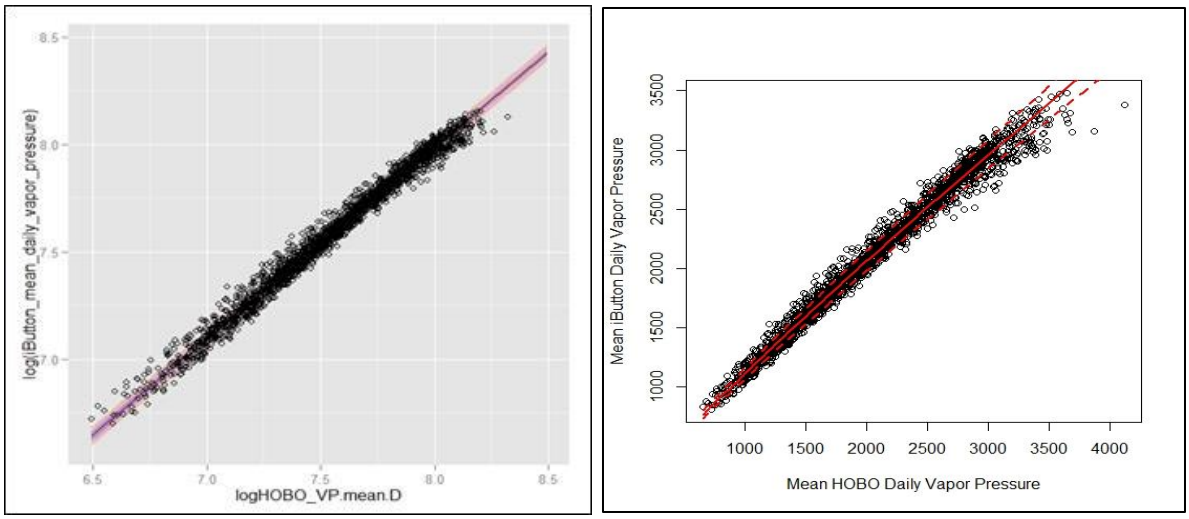

Figure 6-14.—Predicted and actual relationships between iButton and HOBO measurements of mean diurnal vapor pressure (DVP) at each beetle monitoring point, Topock Marsh and the Bill Williams River NWR, May 15 – July 31, 2014 (n = 2,283 paired observations, 31 points).
The predicted relationship is $\log(DVP_{iButton}) = 0.85 + 0.89*\log(DVP_{HOBO})$ + random $intercept_{point}$ + random $slope_{point}$* $\log(DVP_{HOBO})$.The red band indicates the 95% CI for the predicted values. Points on the graph indicate the actual iButton and HOBO values.

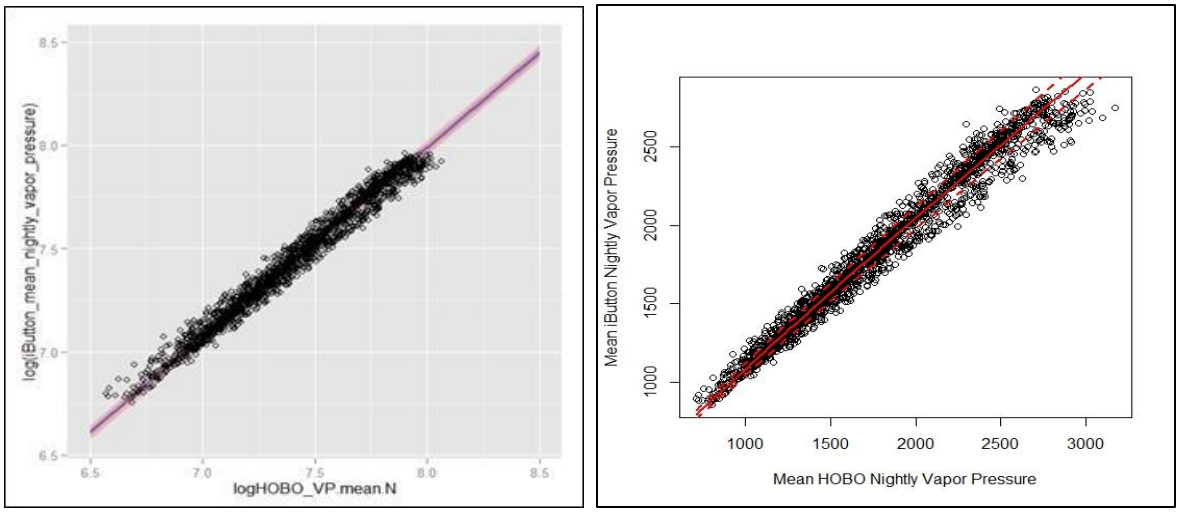

Figure 6-15.—Predicted and actual relationships between iButton and HOBO measurements of mean nocturnal vapor pressure (NVP) at each beetle monitoring point, Topock Marsh and the Bill Williams River NWR, May 15 –July 31, 2014 (n = 2,283 paired observations, 31 points).
The predicted relationship is $\log(NVP_{iButton}) = 0.65 + 0.92*\log(NVP_{HOBO})$ + random $intercept_{point}$ + random $slope_{point}$* $\log(NVP_{HOBO})$. The red band indicates the 95% CI for the predicted values. Points on the graph indicate the actual iButton and HOBO values.

Light Intensity Measurements

All HOBO light loggers functioned properly. Light loggers were deployed at Topock Marsh on May 14 and 15. Light loggers at all beetle monitoring points at the Bill Williams River NWR were deployed on May 16, but the control logger was not installed until May 20. All light loggers at both study areas were taken down on July 31. The housing of the control logger at Topock Marsh was changed on June 17 and July 9, while the housing of the control logger at the Bill Williams River NWR was changed on June 17 and July 17. There were only two occasions (May 29 at point TM-1 and June 25 at point TM-3) when observers noted cleaning dirt or debris from the light loggers.

The control loggers at both study areas recorded daily median light levels between 0900 and 1500 hours around 225,000 lx when the loggers were first deployed (figure 6-16). Overcast days were clearly apparent as marked dips in light levels; on several days (e.g., June 24 and July 14 and 19), control data at both study areas reflected regionally cloudy conditions. Median light levels recorded on sunny days at the control loggers declined through the season at the Bill Williams River NWR but remained relatively constant at Topock Marsh.

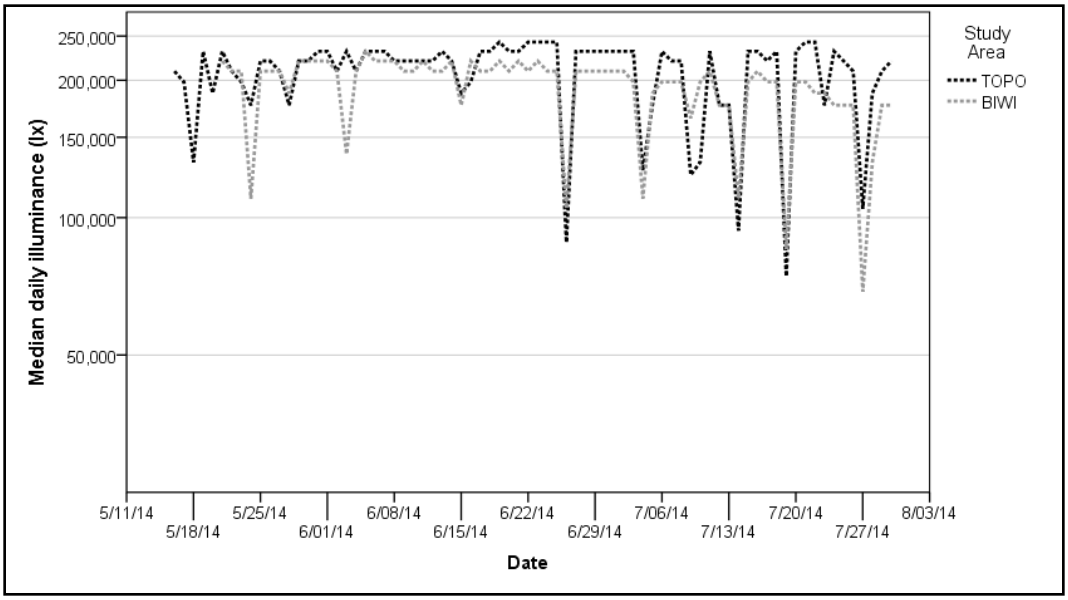

Figure 6-16.—Median daily illuminance (lux) between 0900 and 1500 hours at control points at Topock Marsh (TOPO) and the Bill Williams River NWR (BIWI), 2014.

Percent light readings at the Bill Williams River NWR showed a dip in the second half of June and then an upward trend in the second half of July, while percent light generally declined from mid-May through mid-July at Topock Marsh (figure 6-17). At both study areas, percent light readings were inversely related to

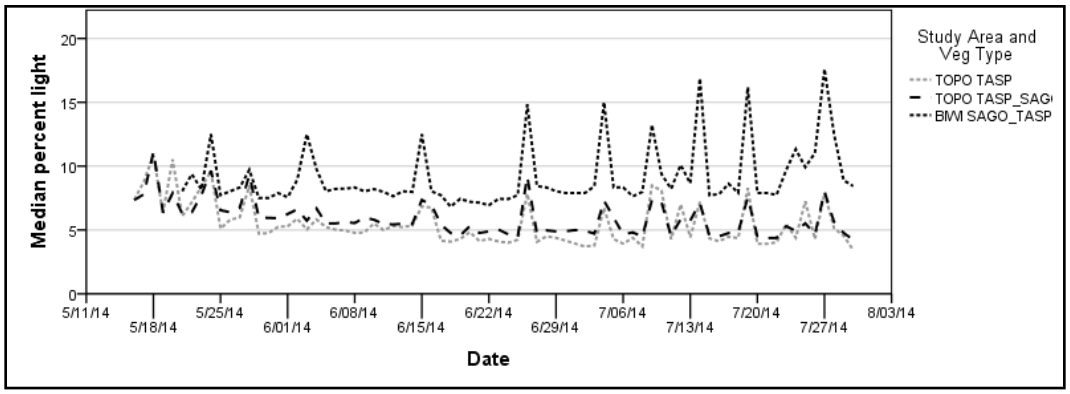

Figure 6-17.—Median percent daily illuminance between 0900 and 1500 hours at all monitoring points at Topock Marsh (TOPO; TASP = tamarisk, n = 10 and TASP_SAGO = tamarisk with emergent Goodding's willow, n = 10) and the Bill Williams River NWR (BIWI; SAGO_TASP = Goodding's willow with tamarisk understory, n = 15), 2014.

luminance readings at the control loggers) (i.e., a greater percentage of available light was recorded at the monitoring points on cloudy days than on sunny days. Percent light at Topock Marsh was slightly lower in tamarisk vegetation than in tamarisk with emergent Goodding's willow, and both vegetation types at Topock Marsh had lower percent light than did Goodding's willow with tamarisk understory at the Bill Williams River NWR.

The decline over the season in median light levels recorded on sunny days at the Bill Williams River NWR, despite the logger housing being changed, prompted us to test and inspect the control logger. We discovered that when the housing was changed in July, the logger was cross-threaded into the slots on the inside of the housing, resulting in the light sensor not being perfectly parallel to the surface of the housing. This discovery led to the post-season tests of directional orientation. We included the Bill Williams River NWR control logger in these tests, after it had been correctly seated in new housing. There was a clear effect of orientation on light meter readings, with loggers that were tilted ≈ 6 degrees to the east or south showing the highest readings in the morning hours, while south-facing loggers had the highest readings midday, and west-facing loggers had the highest readings in the late afternoon (figure 6-18). The effect of directionality was most pronounced during sunny periods (e.g., before 10:30 a.m. on figure 6-18), with light readings from loggers that were tilted toward the sun being approximately twice as high as from loggers tilted away from the sun.

Of the 20 light loggers that were deployed at Topock Marsh, 4 loggers had a cleanliness ranking of 1 (clean), 9 loggers had a ranking of 2 (appeared clean but a film of dirt or sap could be felt, 6 loggers were ranked as 3 (visibly dirty), and 1 logger was ranked as 4 (visibly dirty even from a distance). Of the 15 light loggers deployed at the Bill Williams River NWR, 8 were ranked as 1, and 7 were

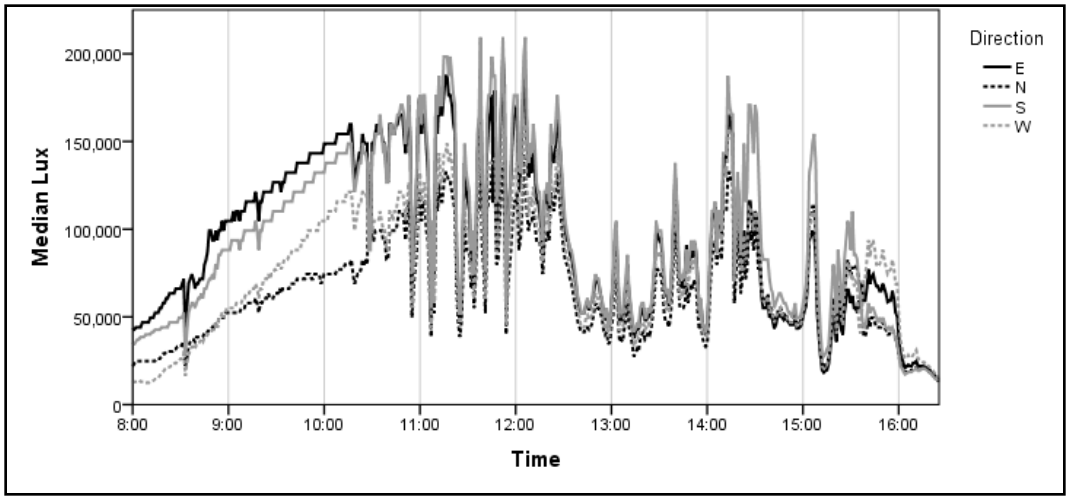

Figure 6-18.—Light intensity (lux) recorded by loggers tilted ≈ 6 degrees toward each of the cardinal directions, October 26, 2014.

ranked as 2. The collection of dirt and debris on the loggers had a much smaller effect on light readings than the orientation of the logger. At midday in full sun, there was no difference in light readings between loggers that had different cleanliness rankings (figure 6-19). Dirt appeared to have a stronger effect when the sun was at a lower angle (figure 6-20), but CIs among loggers of different cleanliness rankings still overlapped.

One of the 22 loggers used in the test of the condition of the logger housing on light readings had a deep scratch in the housing above the light sensor. Light intensity readings recorded by this logger were ≈ 20,000 lx lower than those recorded by any of the other data loggers during the portion of the day when the scratch obscured the light sensor. Data from this logger are not included in the analysis. No scratches were noted on the logger during the field season, and the scratch may have been incurred when the logger was removed at the end of the season.

DISCUSSION

Beetle Monitoring and Vegetation Measurement

Calibration

The calibration exercise was successful in reducing observer variation at the beginning of the season, identifying lapses in adherence to protocol during the season, and quantifying overall observer variation. The maximum observer variation recorded within vegetation type can be used as a benchmark for discerning whether or not an observed change in a particular variable during the

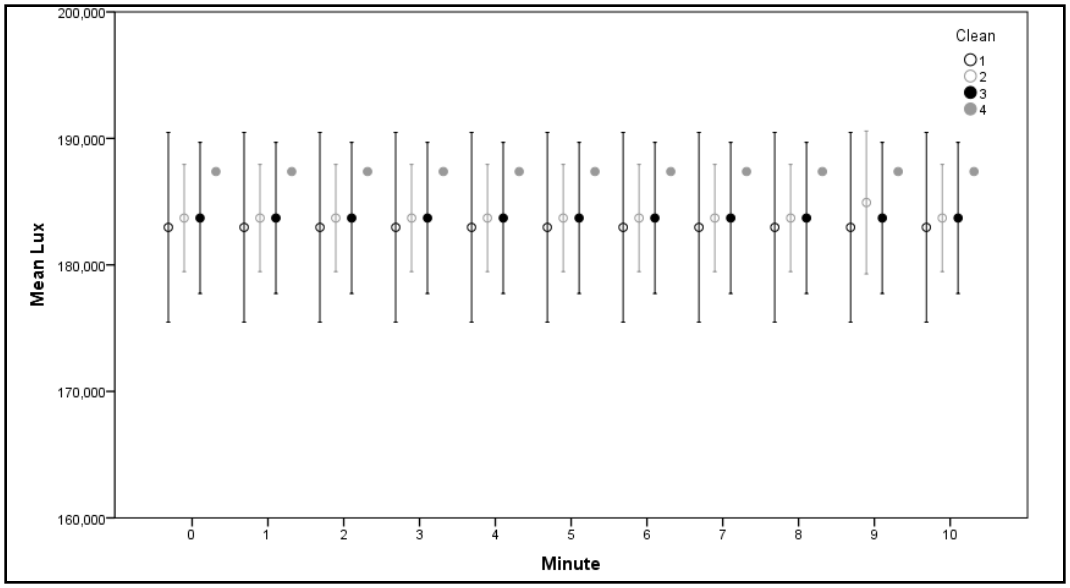

Figure 6-19.—Mean light intensity (lux) and 95% CIs recorded by loggers with varying cleanliness ratings: 1 = clean (n = 5), 2 = appears clean but has a film of dirt or sap that can be felt (n = 9), 3 = visibly dirty (n = 6), or 4 = visibly dirty even from a distance (n = 1) between 1200 and 1210 hours on October 30, 2014.

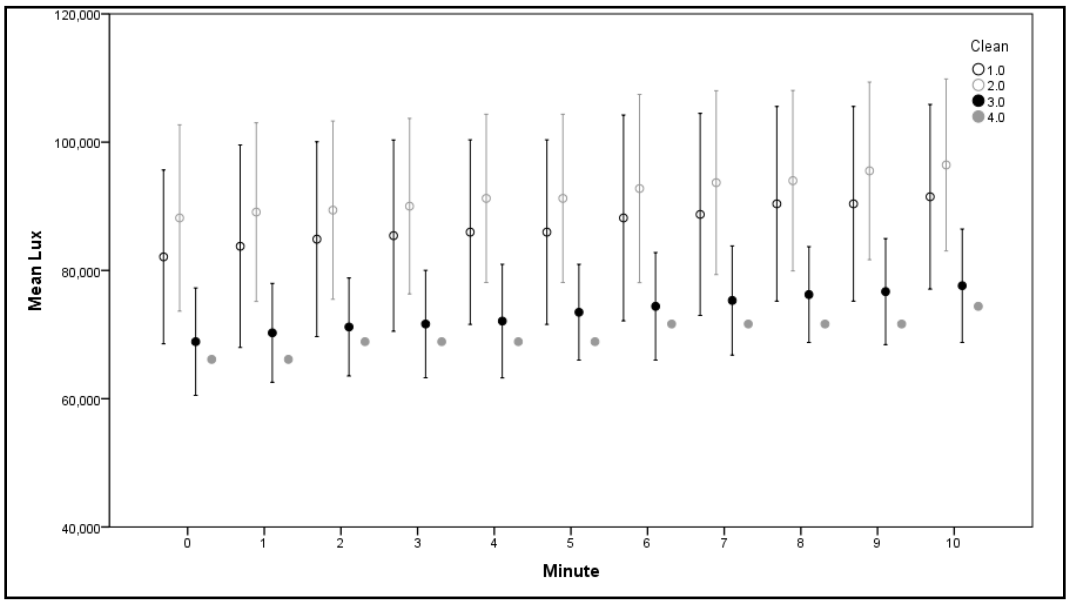

Figure 6-20.—Mean light intensity (lux) and 95% CIs recorded by loggers with varying cleanliness ratings: 1 = clean (n = 5), 2 = appears clean but has a film of dirt or sap that can be felt (n = 9), 3 = visibly dirty (n = 6), or 4 = visibly dirty even from a distance (n = 1) between 0900 and 0910 hours on October 30, 2014.

season is likely attributable to observer variation or reflects a real change in the vegetation. In addition, calibration identified some inadequacies in training. The initial calibration occurred after training, during which all observers were trained in how to collect each vegetation estimate. During the first calibration point, it became clear that the training provided was insufficient to make each observer proficient in the protocol. Training in 2015 will include a complete round of data collection at a beetle point with the group of observers in addition to group training in how to measure each vegetation variable. This additional group training at a beetle point prior to calibration will help identify and correct any misunderstandings of protocol. Calibration data also indicated that vegetation structure and species composition could influence observer variation in some variables. This makes it difficult to draw conclusions across all vegetation types from a limited sample composed primarily of one vegetation type. We will include three calibration points in each vegetation type during the calibration exercise in 2015.

The calibration data identified the variables with the largest observer variation as the two estimates of percent tamarisk in the vicinity of a location. Two potential causes for the large variation were identified in 2014: (1) difficulty in visually estimating horizontal distance to the boundary of the sample "cylinder" and (2) inconsistent adherence to sampling protocol. Because these estimates are also collected at nest locations, all observers should be calibrated for this variable at the beginning of the season regardless of whether they will collect beetle data. A pole of known length, such as a mirror pole, should also be used to aid in determining the location of the 2- and 5-m sample boundaries.

One additional goal of the calibration exercise was to be able to identify observer drift over the course of the season. However, the change between readings recorded for each variable during the initial and end calibration exercises tended to be unidirectional across observers and across calibration points, making it difficult to distinguish any observer drift from actual change in the vegetation.

Vegetation Measurements

No dramatic changes were observed in most variables in either Topock Marsh or the Bill Williams River NWR. In tamarisk at Topock Marsh in late May, there was a 5% increase in percent green foliage and a 23% decrease in percent leafless stems. While a majority of the data were excluded from the first sampling round for percent green foliage, the change in percent green foliage in late May did not change in magnitude when only the subset of data used in each sampling round were compared. Each of these changes was larger than the maximum observer variation for percent green foliage and percent leafless stems (3.7 and 13.7%, respectively) and therefore likely reflects actual changes in the vegetation. No other changes in any variable in this vegetation type were larger than their respective maximum observer variation. The observed changes in vegetation variables indicate a distinct "greening-up" event in late May. These changes

could be the result of tamarisk recovering from splendid tamarisk weevil activity. Tamarisk weevils are initially active in late March to early May and cause slight to extensive yellowing and defoliation in tamarisk. The weevils may then become inactive during the hottest portion of the summer as do other weevil species (Yeoh et al. 2012), allowing the tamarisk to recover, or the tamarisk could recover between generations of weevils as has been noted with tamarisk beetles.

No significant changes (i.e., larger than maximum observer variation) were observed at the Bill Williams River NWR or within tamarisk with emergent Goodding's willow at Topock Marsh in percent green foliage or percent leafless stem measurements, though percent green within tamarisk with emergent Goodding's willow at Topock Marsh mirrored the same pattern observed within tamarisk.

There was a gradual increase in percent canopy closure across the season in tamarisk with emergent Goodding's willow (3.5%) that was slightly larger than maximum observer variation (3.4%) and may reflect actual changes in the vegetation. We did not see this gradual increase within the tamarisk vegetation type, and thus, if the increase in canopy closure reflects a change in the vegetation, it is likely related to phenology of the willow trees. There was also a decrease in canopy closure at the Bill Williams River NWR (6.0%) in early July that was larger than maximum observer variation; this change could be related to the onset of monsoon season, as strong storms often bring down leaves or branches.

Temperature and Humidity

In 2014, the seasonal changes we recorded in maximum and minimum temperatures typically paralleled those recorded at weather stations, although in cases where riparian vegetation provided a moderating effect on daily high temperatures, this effect tended to be stronger on particularly hot days. We expect that defoliation would result in changes in temperature that did not mirror seasonal changes as recorded at weather stations. The comparisons with weather station data presented here provide a baseline with which to compare data from future years in which defoliation events may occur.

Comparison of HOBOs to iButtons

Measurement Error from Limits of Agreement

Measurement errors calculated from limits of agreement between HOBO and iButton data loggers were more than the allowable thresholds we calculated from the CVs of variables using HOBO data loggers as the reference. However, the absolute amount of error may be more important, and whether or not data from different data loggers are used in the same analysis or model should depend on

whether the absolute error is as large as a significant difference in a variable influencing habitat selection or nesting success of southwestern willow flycatchers.

Measurement errors from the prediction intervals of regression are absolute values in the same units as the variables being measured by data loggers. For the southwestern willow flycatcher study, whether or not these values are acceptably small could be determined by what temperature or humidity difference we consider to be a biologically significant difference (e.g., between occupied and unoccupied sites or between failed and successful nests). Maximum daily temperature and mean diurnal and nocturnal vapor pressure differed significantly between occupied and unoccupied sites (McLeod and Pellegrini 2013; table 7.18, all study sites combined), with the maximum daily temperature being 2.1 °C higher on average at unoccupied sites than at occupied sites while mean diurnal and nocturnal vapor pressures were on average 151.7 and 154.7 Pa, respectively, lower at unoccupied versus occupied sites. If we used these values as thresholds, then measurement errors between iButton and HOBO data loggers will be within these thresholds for most HOBO values.

Influence of Canopy Cover on Maximum Daily Temperature Bias

The lack of a significant effect of canopy cover on differences in maximum daily temperature measured between HOBO and iButton data loggers may be due to the high percentage of and low variation in canopy cover at all 31 points. The canopy closure recorded at Topock Marsh and the Bill Williams River NWR ranged from 78.7 to 100% and from 91.9 to 100%, respectively. High canopy cover at all sites may also explain why measurements of maximum daily temperatures were not higher for HOBO data loggers than for iButton data loggers in 2014 despite the evidence of a positive bias in HOBO temperature measurements in full sun during pilot tests in 2013. These results suggest that at sites with high canopy closure, canopy cover does not need to be included as a factor for predicting iButton values from HOBO values from 2012 and earlier. If sites with lower canopy closure are included in the analysis, then the influence of canopy cover on the difference between HOBO and iButton measurements should be revisited. Paired HOBO and iButton loggers could be deployed in the field in 2015 in areas with lower canopy closure to facilitate this analysis.

Predicting iButton Measurements from HOBO Measurements

Results from the GLMMs predicting iButton measurements from HOBO measurements in 2014 are conditional on the random effects due to repeated measurements at each of the 31 points and on a single year of measurements from each site. In a single year of data, the random effect of site could result from data logger readings being affected by environmental features unique to each site or by intrinsic differences within individual data loggers. If a second year of

comparisons is conducted, and site locations of individual data loggers are tracked in both years, it may be possible to model site environment and individual data loggers as distinct random effects if data loggers are moved among sites between years.

As long as the sites and study areas used in 2014 for generating GLM-GEEs of iButton measurements are representative of sites and study areas in general, the GLM-GEEs without study area or canopy cover variables can be used to predict iButton maximum daily temperature, minimum nightly temperature, and mean nightly vapor pressure from HOBO data (2012 and earlier) at all sites and study areas in the southwestern willow flycatcher study. Conversely, if study sites not used to generate the GLM-GEEs (e.g., Mormon Mesa, Mesquite) are quite different from the sites used to generate the GLM-GEEs, then the GLM-GEEs should either not be applied to HOBO data from those sites or should be updated with pairwise comparisons from those sites in 2015. There was a statistically significant negative effect on iButton daily vapor pressure readings for sites located in the Topock Marsh study area. This suggests that the study area should be kept as a factor for predicting daily vapor pressure readings on iButton data; however, only the Topock Marsh and the Bill Williams River NWR study areas were used to generate the GLM-GEEs. Thus, this model should probably not be used to predict iButton daily vapor pressure for 2012 and earlier at the Mesquite or Mormon Mesa study areas, although the model can be applied to all Topock Marsh and Bill Williams River NWR sites.

It is not clear how much variation there would be in readings recorded by two data loggers of the same type hung in close proximity to one another. Deploying pairs of iButton loggers and pairs of HOBO loggers would help distinguish the effects of small changes in location from those of different logger types.

Light Intensity

There were no defoliation events at Topock Marsh or the Bill Williams River NWR in 2014, and we were therefore unable to determine how defoliation might affect light intensity.

In 2013, we noted that light levels recorded by the control loggers declined steadily from mid-June through the end of the monitoring period, and we suspected this was caused by sun exposure causing the housing of the loggers to become opaque. To avoid this problem in 2014, we replaced the housing of each control logger every month. The control logger at Topock Marsh showed no trend in median daily illuminance recorded on sunny days through the season, but the control logger at the Bill Williams River NWR still showed a gradual decrease in median daily illuminance despite the housing being changed. We could not find any clear cause for this; when tested side by side with other loggers after the

season, the logger we used at the control point at the Bill Williams River NWR returned the same readings as other loggers, so the logger did not appear to be malfunctioning.

Tests of the effect of slight deviations from horizontal in the position of the logger showed that a deviation of ~ 6° from horizontal can have marked effects on light readings, particularly during sunny periods, with as much as twice the light intensity recorded when the logger was tipped toward the sun versus away from the sun. While the positioning of the Bill Williams River NWR control logger could have influenced the light readings, particularly following July 17 when the logger was cross-threaded into the new housing, these changes should have occurred abruptly following installation of the new housing and not gradually over the season. The sensitivity of the logger to deviations from horizontal illustrated the importance of ensuring that each logger is positioned carefully. The logger specifications provided by the manufacturer note that the light sensor response is "roughly cosine dependent with the angle from vertical. Therefore, … the logger must be mounted horizontally so that the sensor is pointing straight up toward the sky." However, the manufacturer makes this difficult to achieve by placing the sensor in housing that is thicker at one end than at the other and also has a ridge running down the center of the housing on the surface on which the logger would be placed to orient the light sensor up (figure 6-21). We attempted to correct for these problems before light loggers were initially deployed in 2013 by carving the rebar caps to accommodate the bumps and ridges of the logger housing and allow the light sensor to be oriented directly up (figure 6-22). In future years, we will use a level, in addition to a visual assessment, to ensure that each light logger is horizontal.

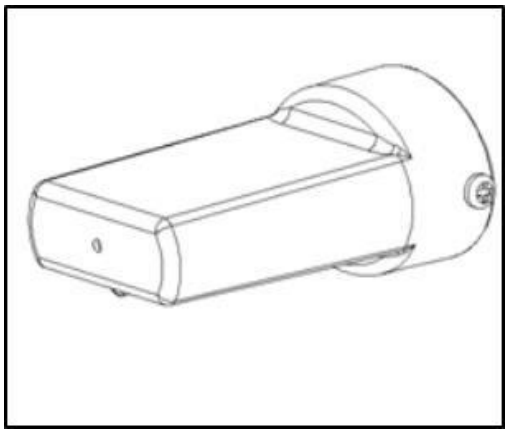

Figure 6-21.—Schematic of the housing for HOBO light pendant loggers.

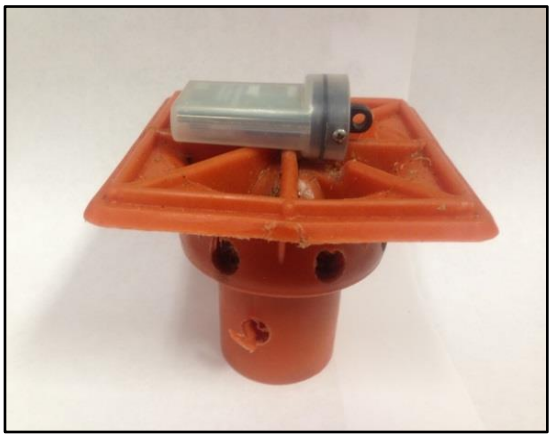

Figure 6-22.—Rebar cap altered to accommodate a HOBO light pendant logger.

The control logger at Topock Marsh showed no change through the season in median daily illuminance, but the loggers at beetle points in both tamarisk and tamarisk with emergent Goodding's willow showed a decline in median percent light from mid-May through mid-June. This suggests that shadiness at the beetle points at Topock Marsh increased from mid-May through mid-June. A decrease in percent light could also be caused by light loggers becoming coated with dust or debris. This explanation seems less likely, given that cleanliness rankings had no effect on the light intensity recorded during the middle of the day and that over one-half of the loggers (13 of 20) had cleanliness rankings of 1 or 2, which had light intensity readings that were indistinguishable from one another even at low sun angles. In future years, we will instruct field personnel to clean each light logger on every monitoring visit to further reduce any variation in light readings that might be caused by the accumulation of dirt.

Median daily illuminance recorded on sunny days at the control logger at the Bill Williams River NWR gradually declined through the season; if no change in vegetation occurred at beetle points, we would expect percent light to increase accordingly. We did see an increase in percent light toward the end of the season, but percent light was lower during the second half of June than it was either before or after that period, suggesting that canopy closure increased at the Bill Williams River NWR in the second half of June.

Relationships among Vegetation, Microclimate, and Light

We did not complete any formal analyses of the relationships between vegetation, temperature, humidity, and light intensity, but some general associations are apparent from the data. In instances where we saw a change through the season in canopy closure (increase through the season at Topock Marsh in tamarisk with emergent Goodding's willow; decrease between mid-June and early July at the Bill Williams River NWR), we saw a change in percent light in the expected direction (i.e., percent light decreased through the season at Topock Marsh and was lower in mid-June than in early July at the Bill Williams River NWR).

In 2013, we noted that the tamarisk at Topock Marsh appeared to have sustained substantial damage from splendid tamarisk weevils, with lower canopy closure noted in many sites in comparison to previous years (McLeod and Pellegrini 2014). Although weevils were again noted at Topock Marsh in 2014, the tamarisk appeared much healthier, with increased canopy closure (as visually estimated) noted in many sites in comparison to 2013 (McLeod and Pellegrini 2013; chapter 2 of this document). Canopy closure recorded with a densiometer at beetle monitoring points in tamarisk was also higher in 2014 (95–98%) than in 2013 (90–94%). In 2014, canopy closure in tamarisk with emergent Goodding's willow was still greater than in tamarisk, but there was a smaller difference in

canopy closure between the two vegetation types in 2014 (median difference = 1.4%, range = -0.4–3.3%) than in 2013 (median difference = 4.2%, range = 3.1–6.0%).

We observed a similar pattern in maximum daily temperature, where temperatures in 2014 were still higher in tamarisk than in tamarisk with emergent Goodding's willow, but the difference in temperatures between the two vegetation types was not as large in 2014 (median difference = 2.8 °C, range = 2.0–4.0 °C) as in 2013 (median difference = 3.6 °C, range = 2.5–4.5 °C). In addition, unlike in 2013, percent light in 2014 was lower in tamarisk than in tamarisk with emergent Goodding's willow. Thus, canopy closure, percent light, and maximum temperature all reflected the improved health of the tamarisk.

Chapter 7 – Management and Study Design Recommendations

For ease of reference, this chapter summarizes all of the study design and management recommendations discussed in previous chapters.

BROADCAST SURVEYS AND SITE ASSESSMENT

We assessed two sites in Meadow Valley Wash (East Stine and West Stine) at the beginning of the 2014 field season. Though both sites contain native tree species with suitable height and canopy closure, soils were completely dry in both sites. Distance to water was 35 m for East Stine and 100 m for West Stine, with the nearest water located in an incised channel. Much of the coyote willow in both sites had begun to die. Because of the lack of surface water and stressed vegetation, we do not recommend surveying these sites again.

The northern end of Muddy Mac in Warm Springs was heavily damaged in the July 1, 2010, fire. We have not formally assessed this portion of the site since then, but we pass by this portion of the site on the way to surveying and monitoring in the southern end of the site. The vegetation has nearly reached its former height (5–6 m), though many dead branches are still visible above the existing live canopy. We recommend reassessing this site at the beginning of the 2015 breeding season to determine if vegetation structure has recovered.

Cougar Point in the Bill Williams River NWR was first discovered in 2011 with breeding flycatchers. In that year, the majority of the site was covered with a shallow layer of water. Soils have dried over the years, and by the beginning of 2014, only trace amounts of damp soil were present in the very center of the site. Vegetation was already stressed in May, with several small, dead willows noted. By the last survey in mid-July, the entire site was dead or dying, and less than 10% of the woody vegetation had green leaves. We recommend discontinuing surveys at this site.

At the beginning of the 2014 field season, we assessed a site at Alamo Lake (Edgewater), which lies in the middle of the riparian zone near the current shore of the lake. Vegetation within the site consists primarily of 2-m-tall tamarisk with the occasional 3–4-m-tall Goodding's willow. Vegetation within this site is not currently tall enough to be considered suitable and does not resemble occupied flycatcher habitat found along the LCR, but we recommend reassessing this site in future years to determine whether the vegetation has developed suitable structure.

HABITAT IMPROVEMENT

The southern end of the Overton WMA was completely dry in 2014, and for the first year since 2005, no breeding or resident flycatchers were documented in this portion of the site. The river formerly flowed through a network of small, braided channels that were often ponded by beaver activity, creating a sheet flow of water throughout much of this end of the site. In recent years, an increasing portion of the riverflow has been diverted to a ditch running along the road to the southwest of the site. Over the 2013–14 winter, the NDOW, in cooperation with Partners in Conservation, Great Basin Institute, Nevada Conservation Corps, and the Walton Family Foundation, created a sandbag structure at the point where the two channels diverged to direct the water back into the center of the site. The diversion worked for ≈ 1 week, after which the sandbag structure was breached, and water once again flowed only in the channel along the southwestern boundary of the site. We recommend reassessing other options to return water to this portion of the site.

COWBIRD CONTROL

In 2010–13, we addled cowbird eggs in easily accessible flycatcher nests, and this reduced the hatch rate of the cowbird eggs and did not cause desertion of any nests by the flycatchers. It is clear from nest monitoring data collected in 2003–13 that parasitized flycatcher nests in which the cowbird egg(s) never hatched produced, on average, more flycatcher fledglings than nests that had a cowbird nestling. We recommend this addling program be continued in the future.

HABITAT THREATS AND MONITORING

The calibration exercise was successful in reducing observer variation at the beginning of the season, identifying lapses in adherence to protocol during the season, and quantifying overall observer variation. In addition, calibration identified some inadequacies in training. The initial calibration occurred after training, during which all observers were trained in how to collect each vegetation estimate. During the first calibration point, it became clear that the training provided was insufficient to make each observer proficient in the protocol. Training in 2015 will include a complete round of data collection at a beetle point with the group of observers in addition to group training in how to measure each vegetation variable. This additional group training at a beetle point prior to calibration will help identify and correct any misunderstandings of protocol. Calibration data also indicated that vegetation structure and species composition could influence observer variation in some variables. This makes it difficult to

draw conclusions across all vegetation types from a limited sample composed primarily of one vegetation type. We will include three calibration points in each vegetation type during the calibration exercise in 2015.

The calibration data identified the variables with the largest observer variation as the two estimates of percent tamarisk in the vicinity of a location. Two potential causes for the large variation were identified in 2014: (1) difficulty in visually estimating horizontal distance to the boundary of the sample "cylinder" and (2) inconsistent adherence to sampling protocol. Because these estimates are also collected at nest locations, all observers should be calibrated for this variable at the beginning of the season regardless of whether they will collect beetle data. A pole of known length, such as a mirror pole, should also be used to aid in determining the location of the 2- and 5-m sample boundaries.

Tests of the effect of slight deviations from horizontal in the position of the logger showed that a deviation of $\approx 6°$ from horizontal can have marked effects on light readings, particularly during sunny periods, with as much as twice the light intensity recorded when the logger was tipped toward the sun versus away from the sun. The sensitivity of the logger to deviations from horizontal illustrated the importance of ensuring that each logger is positioned carefully. In future years, we will use a level, in addition to a visual assessment, to ensure that each light logger is horizontal.

The collection of dirt and debris on the loggers appeared to have an overall weak effect on light readings, though the effect was stronger when the sun was at a lower angle than at midday. In future years, we will instruct field personnel to clean each light logger on every monitoring visit to further reduce any variation in light readings that might be caused by the accumulation of dirt.

Comparisons between data collected by HOBO loggers and those collected by iButtons suggest that at sites with high canopy closure, canopy cover does not need to be included as a factor for predicting iButton values from HOBO values from 2012 and earlier. If sites with lower canopy closure are included in the analysis, then the influence of canopy cover on the difference between HOBO and iButton measurements should be revisited. Paired HOBO and iButton loggers could be deployed in the field in 2015 in areas with lower canopy closure to facilitate this analysis.

It is not clear how much variation there would be in readings recorded by two data loggers of the same type hung in close proximity to one another. Deploying pairs of iButton loggers and pairs of HOBO loggers would help distinguish the effects of small changes in location from those of different logger types.

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ATTACHMENT 1

Study Area and Survey Site Organization within Lower Colorado River Multi-Species Conservation Program (LCR MSCP) Areas and Sites

Table 1-1.—Study area and survey site organization within LCR MSCP areas and sites, 2014*

Study area	LCR MSCP area	LCR MSCP site	LCR MSCP section(s) (former survey site name)
Key Pittman Wildlife Management Area	Alamo	Key Pittman WMA	Nesbitt Forest
			Patch 00
			Patch 01
			Patch 02
			Patch 03
			Patch 04
			Patch 04.5
			Patch 05
			Patch 06
			Patch 07
			Patch 08
			Patch 09
			Patch 10
			Patch 10.5
			Patch 11
			Patch 12
River Ranch	Alamo	River Ranch	East Side
			West Side
			Smalls
Pahranagat National Wildlife Refuge	Alamo	Pahranagat NWR	Pahranagat North
			Pahranagat West
			Pahranagat MAPS (MAPS)
			Pahranagat South
Meadow Valley Wash	Meadow Valley Wash	Meadow Valley Wash North	Etna
		Meadow Valley Wash Middle	East Stine
			West Stine
			Dog Leg
			Ford
			Kyle
			Cottonwood Canyon

Table 1-1.—Study area and survey site organization within LCR MSCP areas and sites, 2014*

Study area	LCR MSCP area	LCR MSCP site	LCR MSCP section(s) (former survey site name)
Muddy River	Muddy River	Overton Above High-Water Mark	Overton WMA Pond
		Overton Wildlife	Overton WMA
Warm Springs Natural Area	Muddy River	Warm Springs	Muddy Mac
			Muddy Stringer 01
Topock Marsh	Topock	Topock Marsh	Pipes 01
			Pipes 03
			The Wallows
			PC 6-1
			Pig Hole
			In Between
			800M
			Pierced Egg
			Swine Paradise
			Platform
			250M
			Hellbird
			Glory Hole
			Farm Ditch Road (Spaghetti)
	Beal Lake Conservation Area	CPhase 05	CPhase 05 (Beal Lake)
	Topock	Topock Bay	Lost Lake
Bill Williams River National Wildlife Refuge	Bill Williams River West	North of Main Delta	Bill Willow
		North Burn	Wispy Willow
			Site 01
			Burn Edge
		Mosquito Flats	Site 04
			Site 03
		Sandy Wash	Site 05
			Black Rail
	Bill Williams River East	Cougar Point	Cougar Point
		Cave Wash	Upstream from Site 08
	Planet Ranch	Planet Ranch West	Planet Ranch Road

Table 1-1.—Study area and survey site organization within LCR MSCP areas and sites, 2014*

Study area	LCR MSCP area	LCR MSCP site	LCR MSCP section(s) (former survey site name)
Alamo Lake	Alamo Lake	Browns Crossing	Sidebar 01
			Edgewater 01
			Camp 01
			Camp 04
			Camp 02
			Camp 03
			Middle Earth 01
			Middle Earth 02
			Prospect 01
			Burro Wash 01
			Burro Wash 02
			Motherlode 01
			Motherlode 02
			Motherlode 03
Alamo Lake	Alamo Lake	Browns Crossing	Motherlode 04
			Confluence 02
			Confluence 01
			Sandy South 01
			Santa Maria South 01
			Santa Maria North 01
Palo Verde Ecological Reserve	Palo Verde Ecological Reserve	Phase 02	Phase 02
		Phase 03	Phase 03
		Phase 04	Phase 04 Block 01
			Phase 04 Block 02
			Phase 04 Block 03
		Phase 05	Phase 05 Block 01
			Phase 05 Block 02
			Phase 05 Block 03
		Phase 06	Phase 06 Block 01
			Phase 06 Block 02

Table 1-1.—Study area and survey site organization within LCR MSCP areas and sites, 2014*

Study area	LCR MSCP area	LCR MSCP site	LCR MSCP section(s) (former survey site name)
Cibola	Cibola Valley Conservation Area	Phase 01	Phase 01
		Phase 02	Phase 02
		Phase 03	Phase 03
	Cibola National Wildlife Refuge Unit 1	Nature Trail	Nature Trail
Yuma	Yuma East Wetlands[1]	J	C4703
		South AC	C4711
		I	C4702

* Except where noted, the LCR MSCP section name corresponds to the current survey site name, though the geography of corresponding sections and survey sites may not be identical.

[1] Data collected at Yuma East Wetlands are reported under the LCR MSCP site name; each survey site constitutes only a small portion of each LCR MSCP site.

ATTACHMENT 2

Field Data Forms

Willow Flycatcher (WIFL) Survey and Detection Form (revised April 2010)

Site Name_____ State_____ County _____
USGS Quad Name _____ Elevation _____ (meters)
Creek, River, Wetland, or Lake Name_____

Is copy of USGS map marked with survey area and WIFL sightings attached (as required)? Yes___ No___

Survey Coordinates: Start: E_____ N_____ UTM Datum_____(See instructions)
Stop: E_____ N_____ UTM Zone _____

If survey coordinates changed between visits, enter coordinates for each survey in comments section on back of this page.

***** Fill in additional site information on back of this page *****

Survey # Observer(s) (Full Name)	Date (m/d/y) Survey time	Number of Adult WIFLs	Estimated Number of Pairs	Estimated Number of Territories	Nest(s) Found? Y or N If Yes, number of nests	Comments (e.g., bird behavior; evidence of pairs or breeding; potential threats [livestock, cowbirds, *Diorhabda* spp.]). If *Diorhabda* found, contact USFWS and State WIFL coordinator	GPS Coordinates for WIFL Detections (this is an optional column for documenting individuals, pairs, or groups of birds found on each survey). Include additional sheets if necessary			
Survey # 1 Observer(s)	Date						# Birds	Sex	UTM E	UTM N
	Start									
	Stop									
	Total hrs									
Survey # 2 Observer(s)	Date						# Birds	Sex	UTM E	UTM N
	Start									
	Stop									
	Total hrs									
Survey # 3 Observer(s)	Date						# Birds	Sex	UTM E	UTM N
	Start									
	Stop									
	Total hrs									
Survey # 4 Observer(s)	Date						# Birds	Sex	UTM E	UTM N
	Start									
	Stop									
	Total hrs									
Survey # 5 Observer(s)	Date						# Birds	Sex	UTM E	UTM N
	Start									
	Stop									
	Total hrs ___									
Overall Site Summary Totals do not equal the sum of each column. Include only resident adults. Do not include migrants, nestlings, and fledglings. Be careful not to double count individuals. Total Survey Hrs		Total Adult Residents	Total Pairs	Total Territories	Total Nests	Were any Willow Flycatchers color-banded? Yes___ No ___ If yes, report color combination(s) in the comments section on back of form and report to USFWS.				

Reporting Individual _____ Date Report Completed_____ _____
US Fish and Wildlife Service Permit #_____State Wildlife Agency Permit #_____

Submit form to USFWS and State Wildlife Agency by September 1st. Retain a copy for your records.

Fill in the following information completely. Submit form by September 1st. Retain a copy for your records.

Reporting Individual _____ Phone # _____
Affiliation _____ E-mail _____
Site Name_____ Date Report Completed _____
Was this site surveyed in a previous year? Yes___ No ___ Unknown ____
Did you verify that this site name is consistent with that used in previous years? Yes ____ No _____ Not Applicable ___
If site name is different, what name(s) was used in the past?_____
If site was surveyed last year, did you survey the same general area this year? Yes ____ No ____ If no, summarize below.
Did you survey the same general area during each visit to this site this year? Yes ____ No ____ If no, summarize below.

Management Authority for Survey Area: Federal____ Municipal/County ____ State ____ Tribal ____ Private ____
Name of Management Entity or Owner (e.g., Tonto National Forest) _____

Length of area surveyed: _____ (km)

Vegetation Characteristics: Check (only one) category that best describes the predominant tree/shrub foliar layer at this site:

_____ Native broadleaf plants (entirely or almost entirely, > 90% native)

_____ Mixed native and exotic plants (mostly native, 50 - 90% native)

_____ Mixed native and exotic plants (mostly exotic, 50 - 90% exotic)

_____ Exotic/introduced plants (entirely or almost entirely, > 90% exotic)

Identify the 2-3 predominant tree/shrub species in order of dominance. Use scientific names.

_____

Average height of canopy (Do not include a range): _____ (meters)

Attach the following: 1) copy of USGS quad/topographical map (REQUIRED) of survey area, outlining survey site and location of WIFL detections; 2) sketch or aerial photo showing site location, patch shape, survey route, location of any detected WIFLs or their nests; 3) photos of the interior of the patch, exterior of the patch, and overall site. Describe any unique habitat features in Comments.

Comments (such as start and end coordinates of survey area if changed among surveys, supplemental visits to sites, unique habitat features. Attach additional sheets if necessary.

_____
_____
_____
_____
_____
_____

Territory Summary Table. Provide the following information for each verified territory at your site.

Territory Number	All Dates Detected	UTM E	UTM N	Pair Confirmed? Y or N	Nest Found? Y or N	Description of How You Confirmed Territory and Breeding Status (e.g., vocalization type, pair interactions, nesting attempts, behavior)

Attach additional sheets if necessary

SWFL General Site Description

[Complete at least 3 times during season: early (10–25 May), mid-season (10–25 June), and late season (10–25 July)]

Study Area: _____ **Survey Site:** _____ **Date:** _____

Observer(s): _____ **early**_____ **mid**_____ **late**_____ **other**_____

MSCP Area: _____ **MSCP Site:** _____

VEGETATION		
Overall vegetation at site: >90% native 50–90% native 50–90% exotic >90% exotic		
Vegetation Type 1	**Vegetation Type 2**	**Vegetation Type 3**
Overstory: ht (m): _____	**Overstory: ht (m):** _____	**Overstory: ht (m):** _____
Dominant overstory sp: _____	**Dominant overstory sp:** _____	**Dominant overstory sp:** _____
Understory height (m): _____	**Understory height (m):** _____	**Understory height (m):** _____
Dominant understory sp: _____	**Dominant understory sp:** _____	**Dominant understory sp:** _____
% canopy closure: _____	**% canopy closure:** _____	**% canopy closure:** _____
Percentage of site: _____	**Percentage of site:** _____	**Percentage of site:** _____
Patch l x w (if applicable): _____	**Patch l x w** (if applicable): _____	**Patch l x w** (if applicable): _____
Inundated? Yes No	**Inundated?** Yes No	**Inundated?** Yes No

Other vegetation types present (e.g., cattail)? Yes No

If yes, type of vegetation: _____ **percentage of site:** _____

type of vegetation: _____ **percentage of site:** _____

HYDROLOGY			
% INUNDATED (% of site)	**% SATURATED Soils** (NOT including inundated areas!)	**% DAMP Soils** (NOT including inundated or saturated areas!)	**% DRY Soils** (NOT including moist soils!)

If INUNDATED:

Describe type of surface water (e.g., open marsh, surface water within woody vegetation, stream, etc):

_____

Average depth of surface water (cm): _____

If NO Inundated or Saturated Soils are present:

Distance (m) to Standing Water or Saturated Soil from EDGE of site: _____

How was distance determined? _____

Describe type of nearest surface water: _____

NARRATIVE and PICTORIAL DESCRIPTION

Does this description cover the entire site? Y N **If not, which portion is described?** _____

_____

On the reverse, sketch and label the locations of the major vegetation types you observed. Delineate marshes, open areas, and other habitat that may be unsuitable for flycatchers. If water was present, show its location.

Give a narrative description of the site, including adjacent habitats:

_____

Additional comments: _____

STUDY AREA: _____ SITE: _____ BANDER: _____ DATE: _____ TIME: _____ TERR/NEST #: _____

UTM NAD___ Zone___ _____ E _____ N NBN: ____ of ____

NOTES:_____

FEDERAL BAND #	COLOR COMBO		STATUS	SEX	AGE	FECAL SAMPLE? (Y or N)	GENETIC SAMPLE? (Y or N)	# PHOTOS TAKEN
	L	R						

STATUS: NCP = new cap passive, NCT = new cap target, RCP = recap passive, RCT = recap target, NBN = nestling banded
SEX: U = unknown, F = female, M = male
AGE: AHY = after hatch year; SY = second year; L = nestling banded in nest; HY = hatch year/young of the year

Adults								
CP	BP	WING CHORD (mm)	TAIL (mm)	CULMEN LENGTH (mm)	CULMEN WIDTH (mm)	FAT	RETAINED FEATHERS? Y or N, if Y use diagram, detail in notes	ACTIVE MOLT?

Nestlings	
Developmental Age (days)	MASS (g)

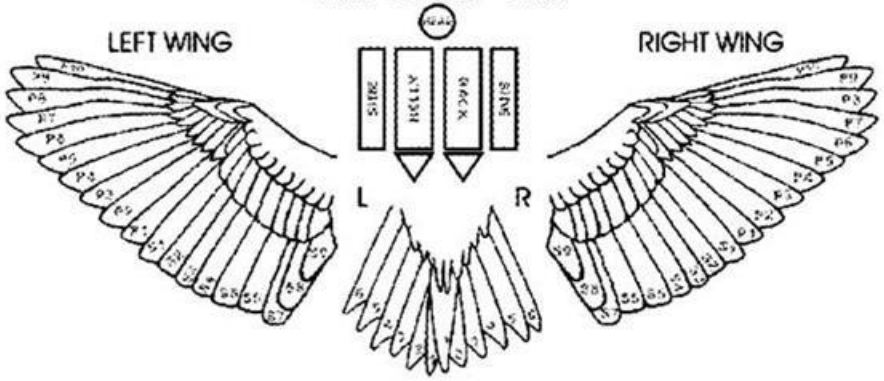
CP: 0 = non-breeding, S = partial breeding, M = full breeding
BP: 0 = none, 1 = smooth, 2 = vascularized and filled with fluid, 3 = wrinkled, 4 = molting
FAT: 0 = no fat; 1 = trace of fat in furculum, deeply concave, scattered patches, less than 5 percent filled; 2 = thin layer of fat in furculum, less than a third filled, trace of thin layer of fat in abdomen; 3 = furculum is ½ filled or more; small patches, not covering some areas, on abdomen; 4 = furculum more than 2/3 filled, level with clavicles, slightly mounded on abdomen

If a genetic sample or metric was not taken, explain why in notes

BODY MOLT

(CIRCLE AREA OF MOLT, AND USE 1, 2, OR 3 TO DESIGNATE DEGREE OF MOLT)

1=SLIGHT 2=MODERATE 3=HEAVY



Resight Data Record

Resight Data Record Form

Record: (New) Date OBS Study Area: Territory Nest

Left:

Band Type: Unbanded

Band Color: Unbanded

Right:

Band Type: Unbanded

Band Color: Unbanded

Color Combo Text

Confidence Level

Capture? If, yes... Service Tag #

WIFLs Present Sex:

Observations and Comments

Office use only

Record: 1 of 1 No Filter Search

Willow Flycatcher Territory/Nest Record Form

Year: Year Study Area: Study Area Survey Site: Survey Site Territory/Nest #: Num
MSCP Area: Do Not Use MSCP Site: Do Not Use

Territory/Nest Location:
NAD 83, Zone: Zone
Original Territory UTMs:
Easting: Easting
Northing: Northing
GPS Accuracy: Acc m
Territory UTMs (if moved):
Easting: Easting
Northing: Northing
GPS Accuracy: Acc m
Nest Flag UTMs (optional):
Easting: Easting
Northing: Northing
GPS Accuracy: Acc m
Nest UTMs:
Easting: Easting
Northing: Northing
GPS Accuracy: Acc m

Nest Height: Estimated: Ht m Measured: Ht m
Nest Substrate: Subst. (e.g., TASP, SAGO, SAEX)

Distance from nest to standing water or saturated soil:
When found: Date: Date Observer: Obs
At hatch: Date: Date Observer: Obs
At fledge/fail: Date: Date Observer: Obs

% Veg Volume = TASP: Date: Date Observer: Obs

Vegetation type at nest: Date: Date Observer: Obs

Nest tree double-flagged: Date: Date Observer Obs

General comments: Comments

Confirmed color combos: Female: female combo
Male: male combo

FEMALE Color band combination: Band combo **Band Number:** Band number
MALE Color band combination: Band combo **Band Number:** Band number

JUVENILES					
Color combo: Band combo	**Band #:** Band number	**Fledged?** Y/N/U	**Color combo:** Band combo	**Band #:** Band number	**Fledged?** Y/N/U
Color combo: Band combo	**Band #:** Band number	**Fledged?** Y/N/U	**Color combo:** Band combo	**Band #:** Band number	**Fledged?** Y/N/U

Willow Flycatcher

Trans dates	Date known?	
		Found/Phase
		First egg
		Clutch completion
		Hatching
		Fledged or Failed

Willow Flycatcher

No.	Presumed	Confirmed	
			Eggs
			Nestlings
			Fledglings

Cowbird

Trans dates	
	First egg
	Hatched
	Fledged

Cowbird

No.	
	Eggs
	Nestlings
	Fledgling

Outcome: Choose an item: Description

Outcome codes:
UN= unknown; **FY**= at least one fledge visually confirmed; **PE**= probable predation, nest empty and intact; **PD**= probable predation, damage to nest structure; **AB**=nest abandoned prior to egg(s) being laid; **DE**=deserted with egg(s) or young; **PA**= parasitized, cowbird eggs or young outlived host's; **AD**= addled, no eggs hatched after >20 d inc; **OT**= failure due to other, or unknown, causes.
Mayfield success codes: **S**=successful; **D**= depredated; **U**=fate unknown; **M**= mortality other than predation; **A**=deserted with host egg(s) or young; **Z**=abandoned, no host eggs laid.

Mayfield Success		
(WIFL) Period	# Exposure days	Success
Egg Laying		
Incubation		
Nestling		

Willow Flycatcher Territory/Nest Record Form (continued)

Year: Year Study Area: Study Area Survey Site: Survey Site. Territory/Nest #: Num

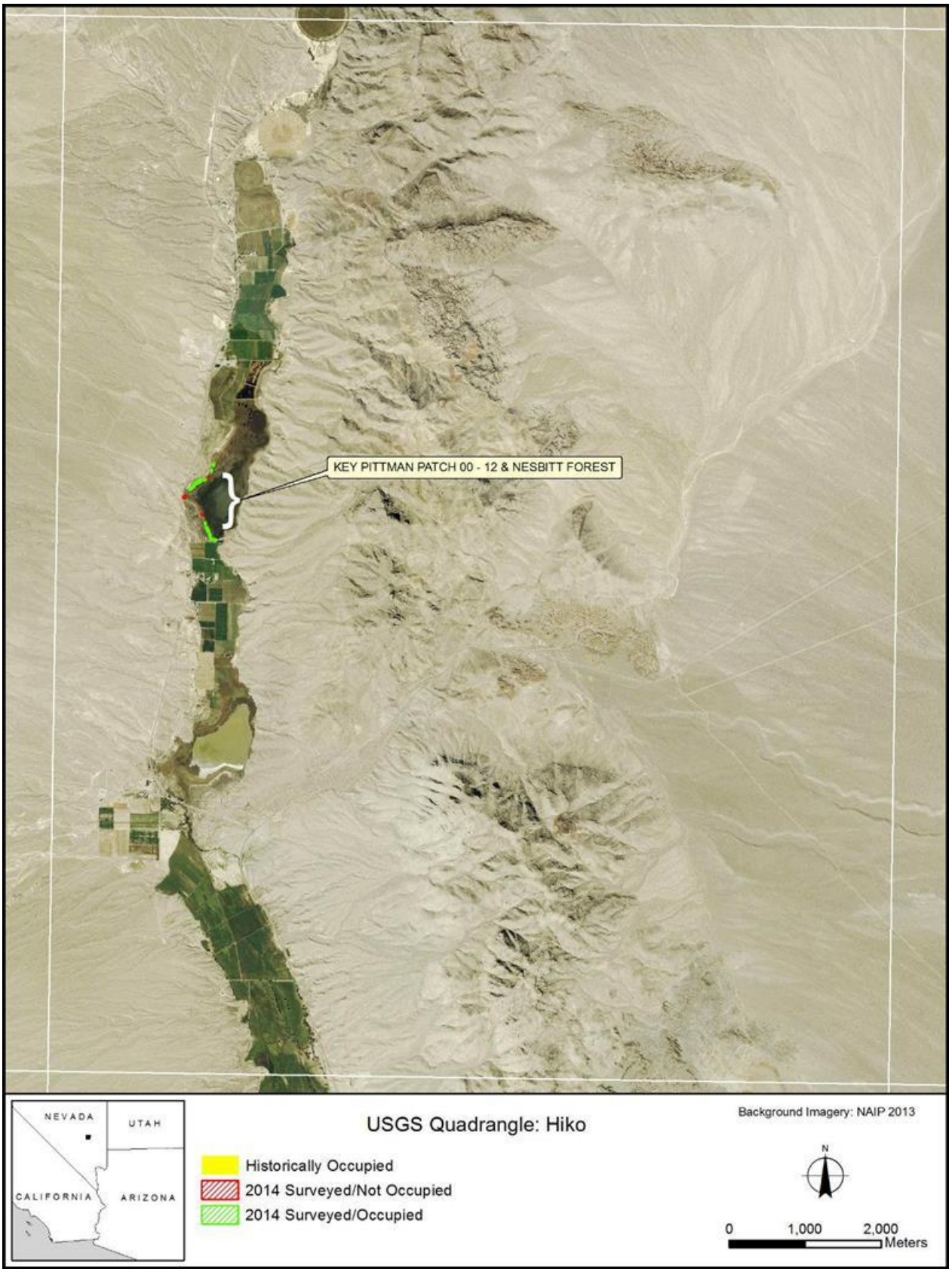
Mon Type: M=mirror, O=obs. with binocs. **Stage**: * =single male, Δ=pair, B=building, L=laying, I=incubating, N=nestling, F=fledgling **Field Tasks**: RSM=resight male, RSF=resight female, RSB=resight both, OB=observe in territory, CP=confirm pair, LN=locate nest, LRN=locate renest, PN=pole nest, CA=confirm activity or stage, VN# =verify nestling number, VF# =verify fledgling #, BN=band nestlings, AE=addle cowbird egg, GPS=GPS nest, DW=measure distance to water, PT=% TASP; VT=Veg type at nest

Date	Time		Obs	Mon Type	Stage	# Ad	# WE	# CE	# WN	# CN	# WF	Age Yng	Field Tasks
	In	Out											

ATTACHMENT 3

Orthophotos Showing Study Sites

Definition of Survey Site Occupancy – Survey sites are considered occupied if resident (i.e., detected in one location for at least 7 days) or breeding flycatchers are detected, or if a flycatcher is detected between June 24 and July 20, regardless of residency status. A site is considered historically occupied if this criterion was met in any year 2003–13.


KEY PITTMAN PATCH 00 - 12 & NESBITT FOREST
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Hiko
Background Imagery: NAIP 2013
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
N
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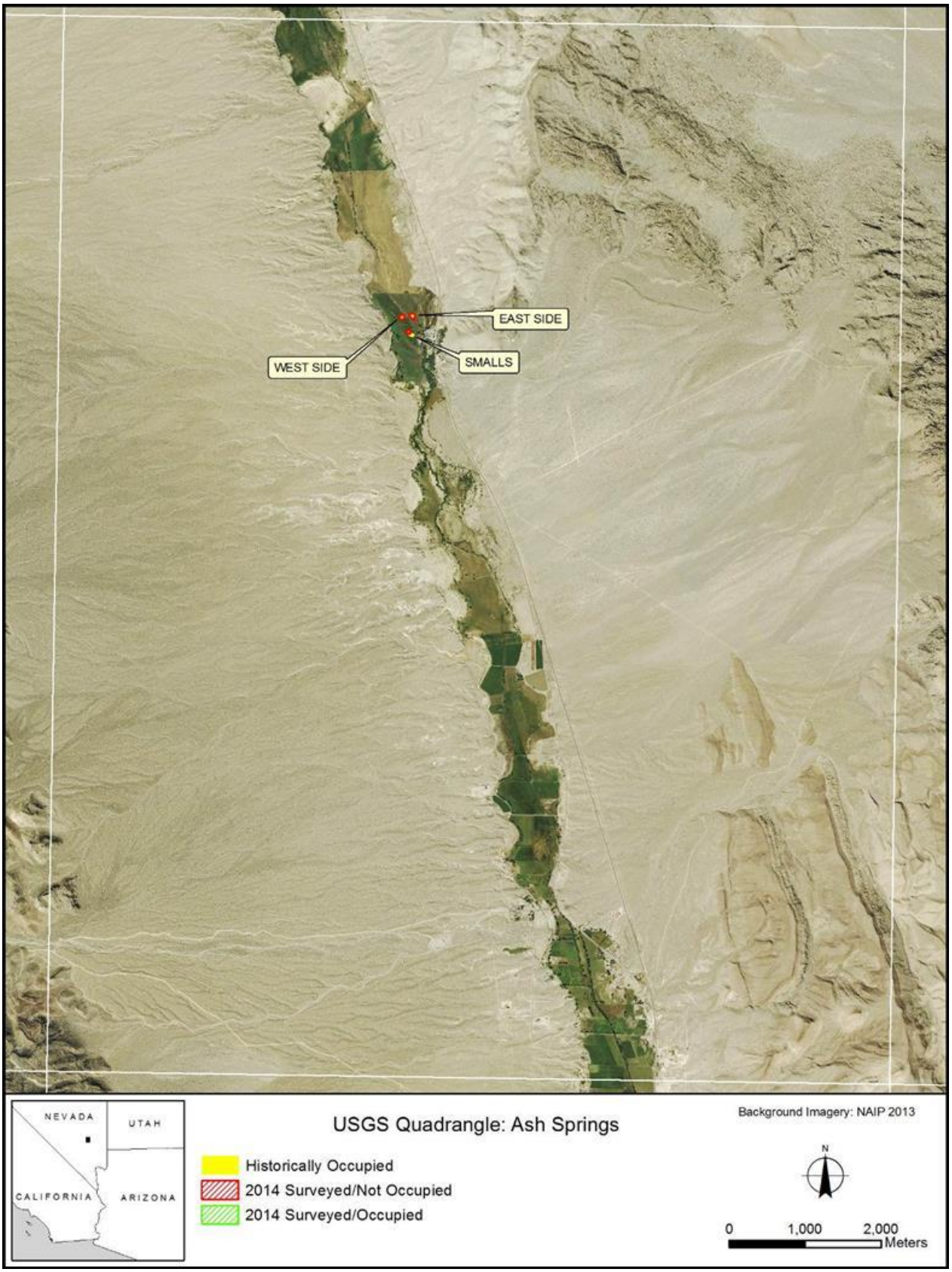
2,000
Meters


EAST SIDE
WEST SIDE
SMALLS
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Ash Springs
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
Background Imagery: NAIP 2013
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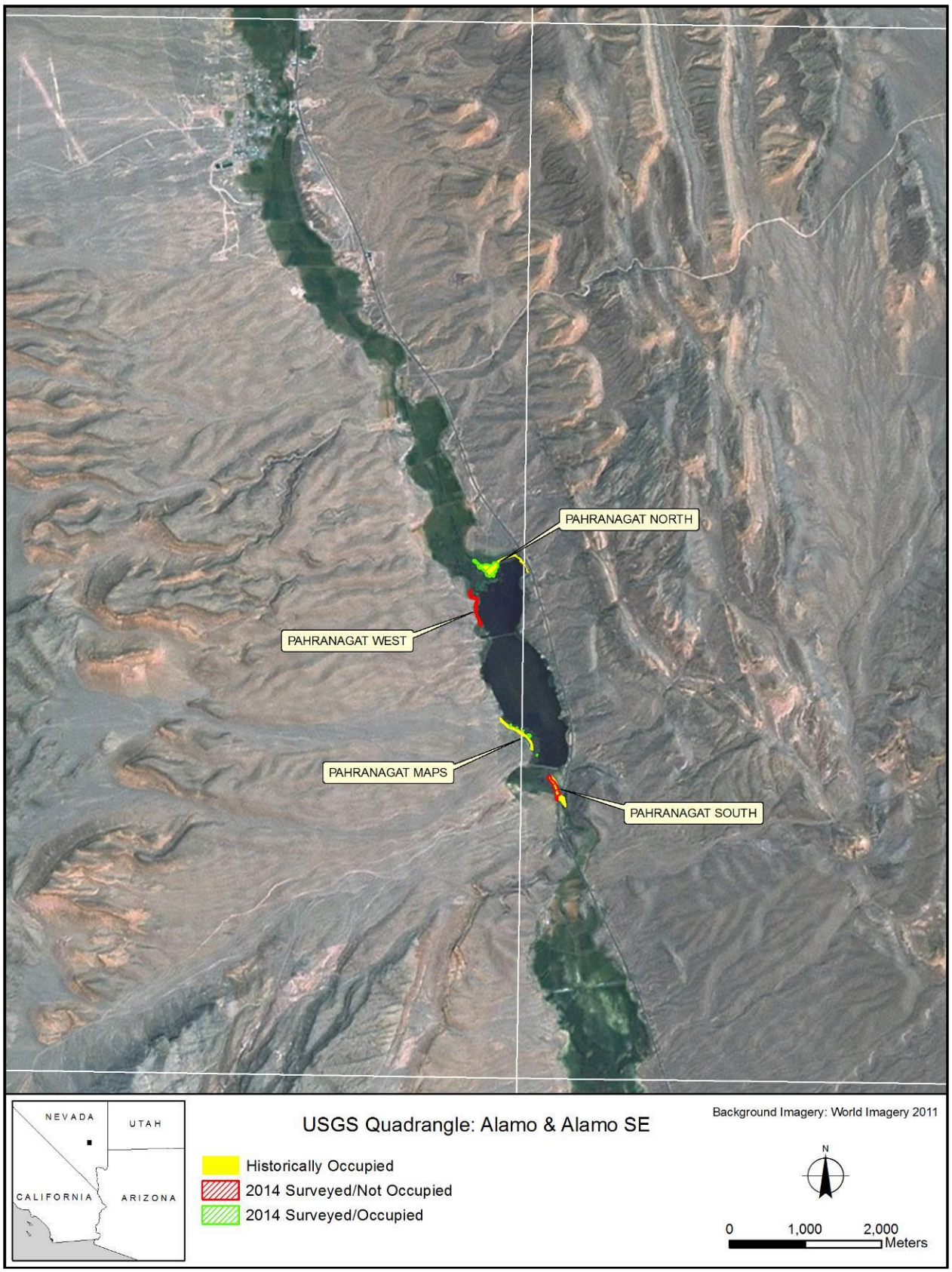
Meters


PAHRANAGAT NORTH
PAHRANAGAT WEST
PAHRANAGAT MAPS
PAHRANAGAT SOUTH
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Alamo & Alamo SE
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
Background Imagery: World Imagery 2011
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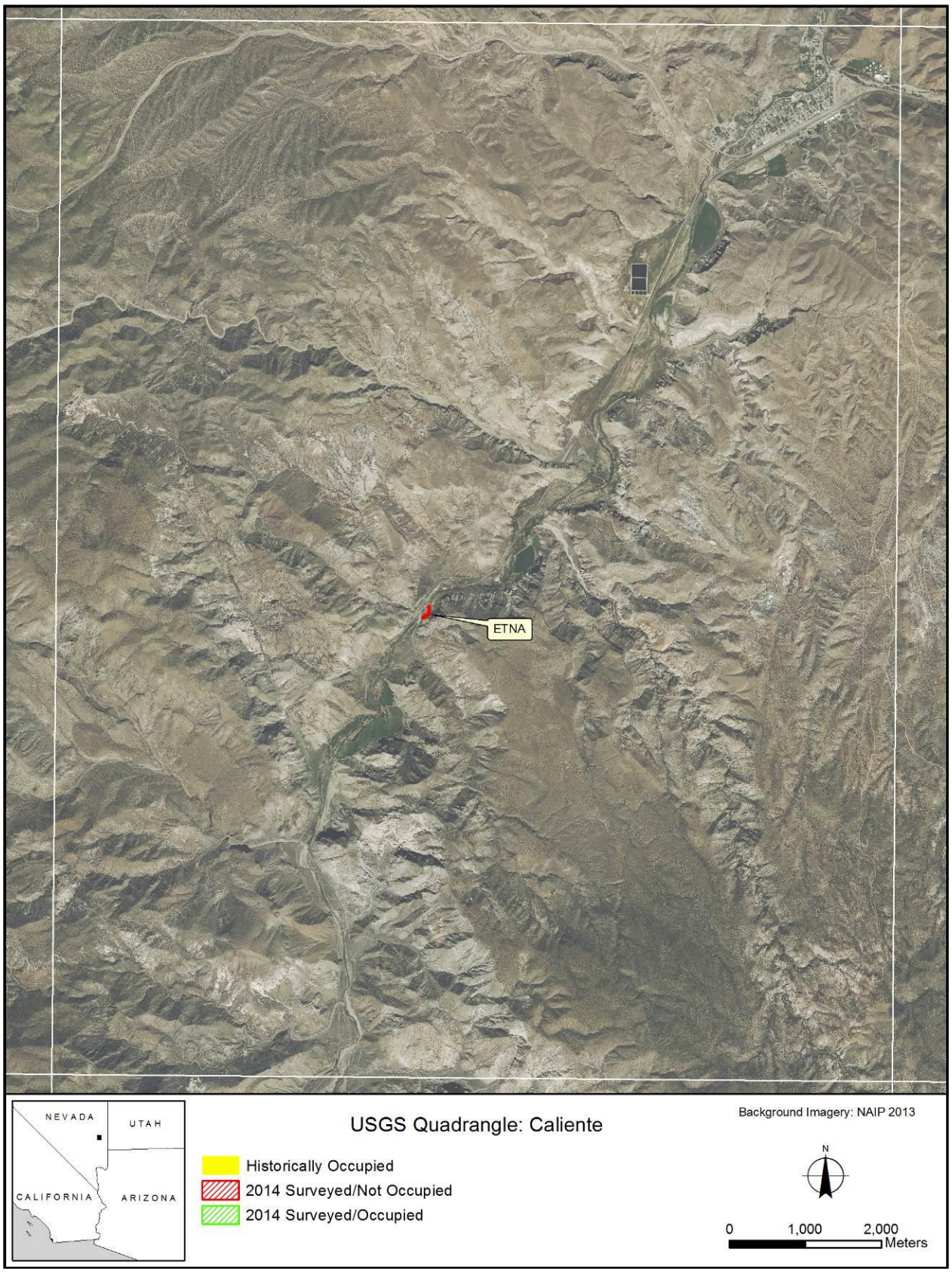
2,000
Meters


ETNA
NEVADA
UTAH
CALIFORNIA
ARIZONA
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Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
Background Imagery: NAIP 2013
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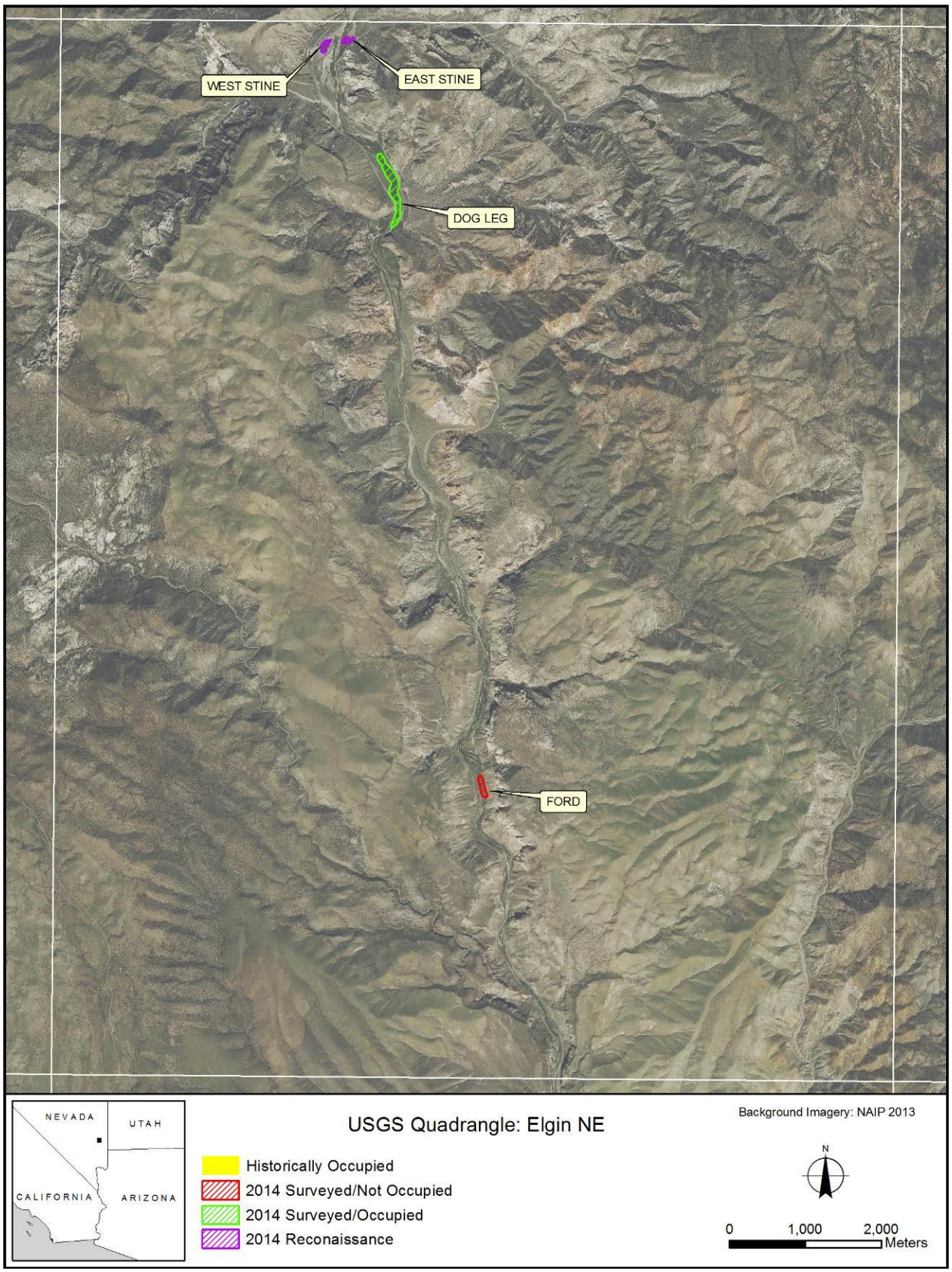
1,000
2,000
Meters


WEST STINE
EAST STINE
DOG LEG
FORD
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Elgin NE
Background Imagery: NAIP 2013
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
2014 Reconaissance
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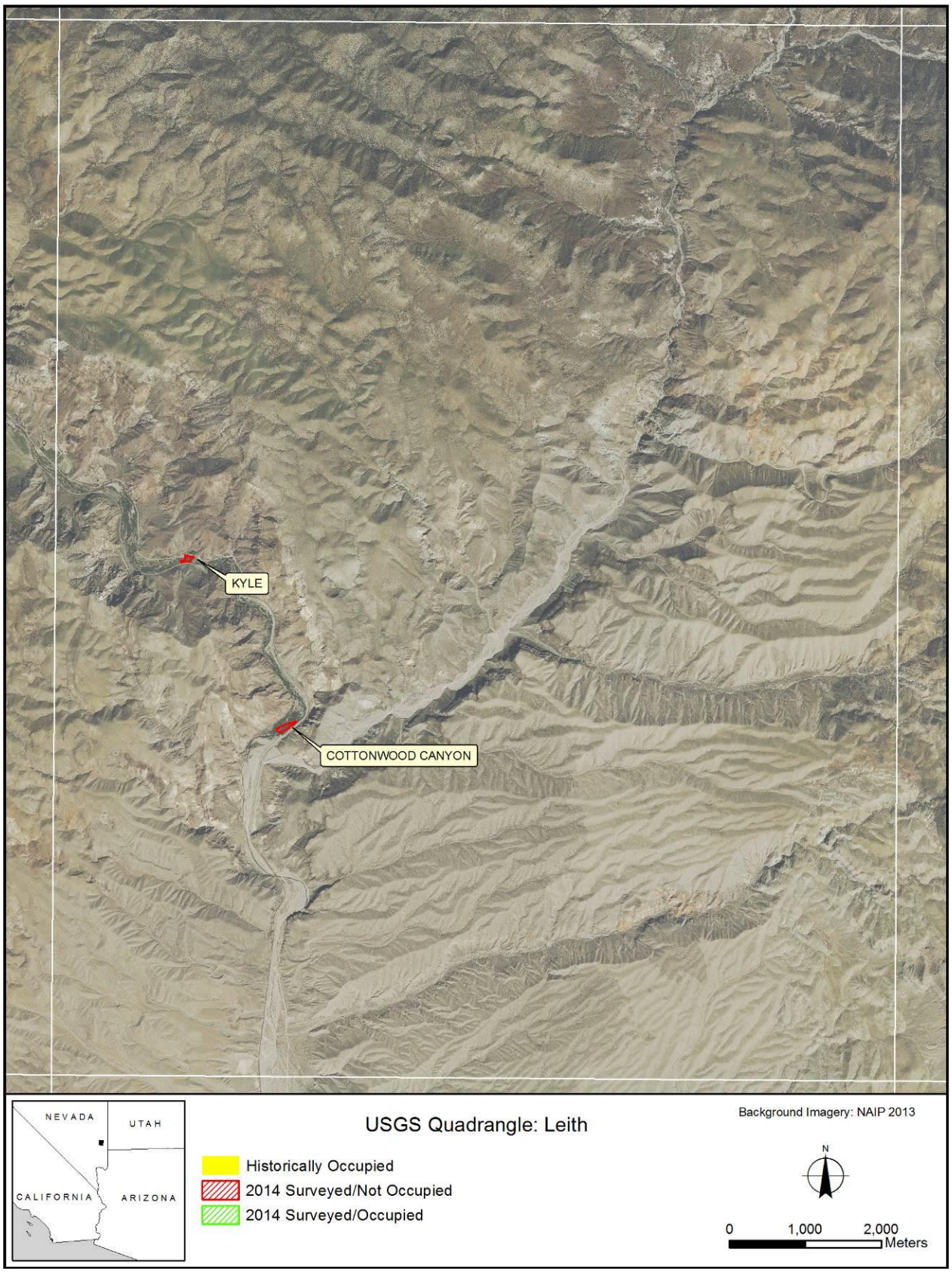
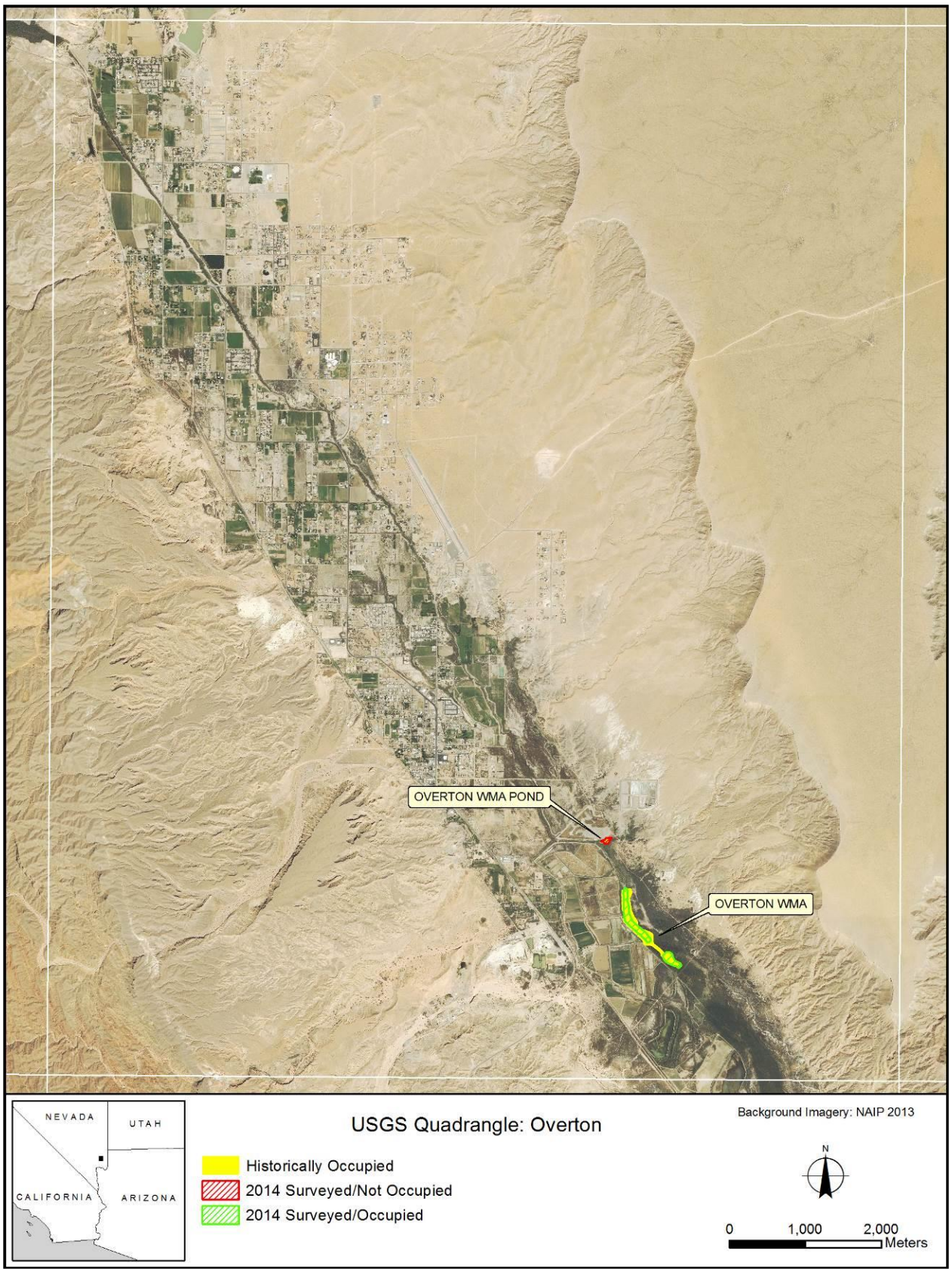
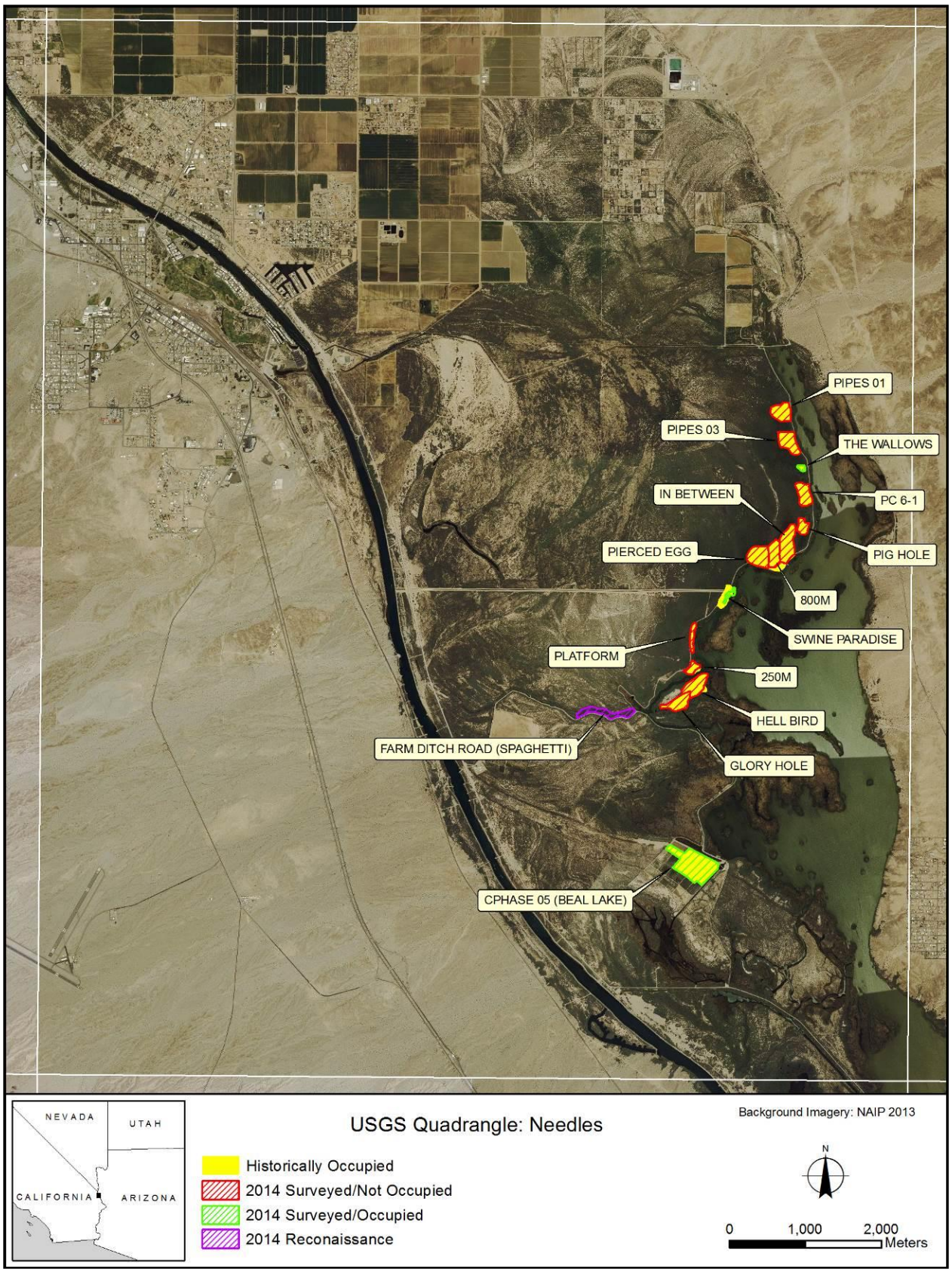
1,000
2,000
Meters


KYLE
COTTONWOOD CANYON
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Leith
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
Background Imagery: NAIP 2013
N
0
1,000
2,000
Meters


OVERTON WMA POND
OVERTON WMA
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Overton
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
Background Imagery: NAIP 2013
N
0
1,000
2,000
Meters

MUDDY STRINGER 01
MUDDY MAC
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Moapa West
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
Background Imagery: NAIP 2013
N
0
1,000
2,000
Meters


PIPES 01
PIPES 03
THE WALLOWS
IN BETWEEN
PC 6-1
PIERCED EGG
PIG HOLE
800M
SWINE PARADISE
PLATFORM
250M
HELL BIRD
FARM DITCH ROAD (SPAGHETTI)
GLORY HOLE
CPHASE 05 (BEAL LAKE)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Needles
Background Imagery: NAIP 2013
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
2014 Reconaissance
N
0
1,000
2,000
Meters

LOST LAKE
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Whale Mountain
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
Background Imagery: NAIP 2013
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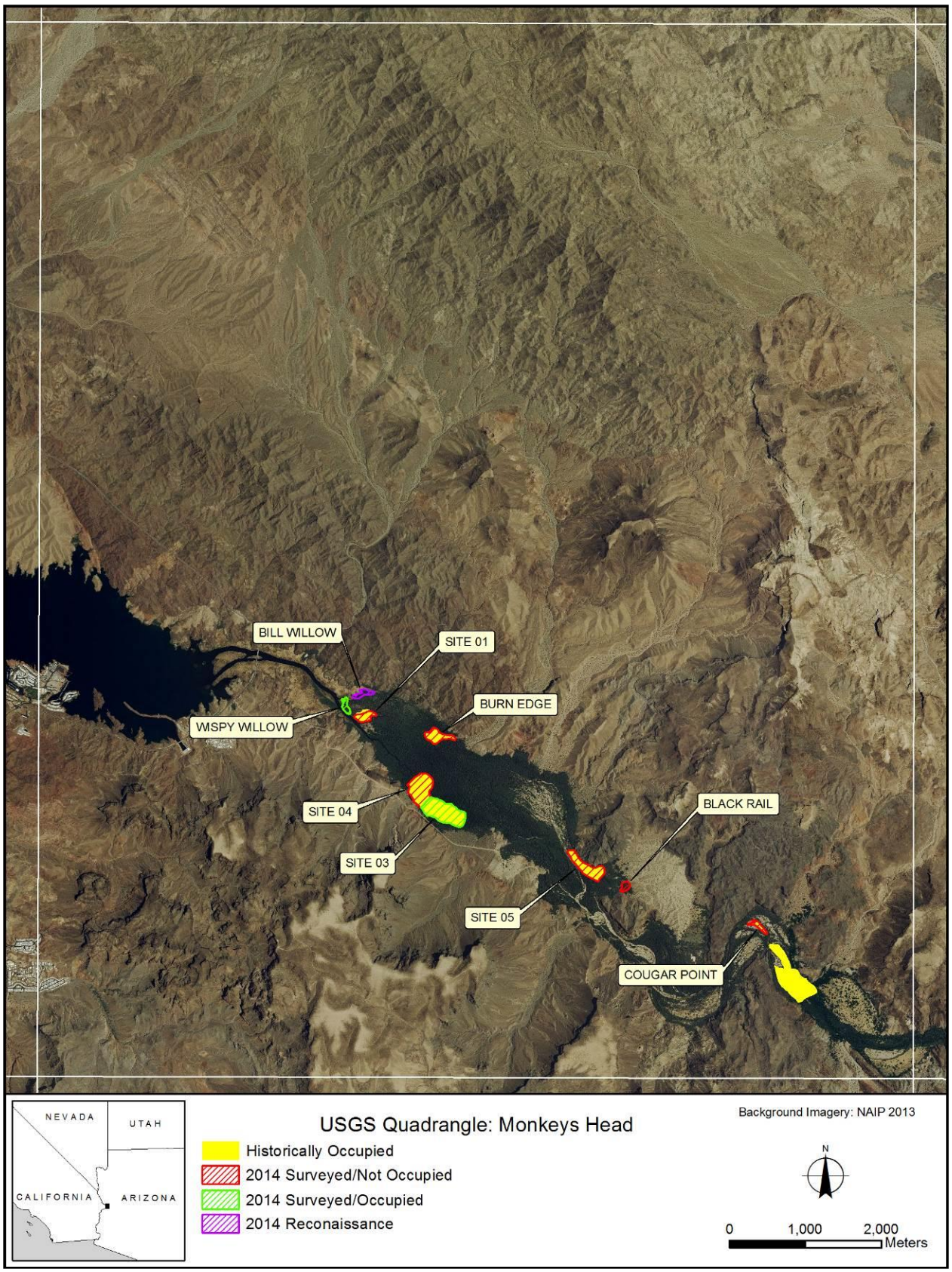
1,000
2,000
Meters


BILL WILLOW
SITE 01
BURN EDGE
WISPY WILLOW
SITE 04
BLACK RAIL
SITE 03
SITE 05
COUGAR POINT
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Monkeys Head
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
2014 Reconaissance
Background Imagery: NAIP 2013
N
0
1,000
2,000
Meters

UPSTREAM FROM SITE 08
PLANET RANCH ROAD
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Castaneda Hills SW
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
2014 Surveyed/Occupancy Undetermined
Background Imagery: NAIP 2013
N
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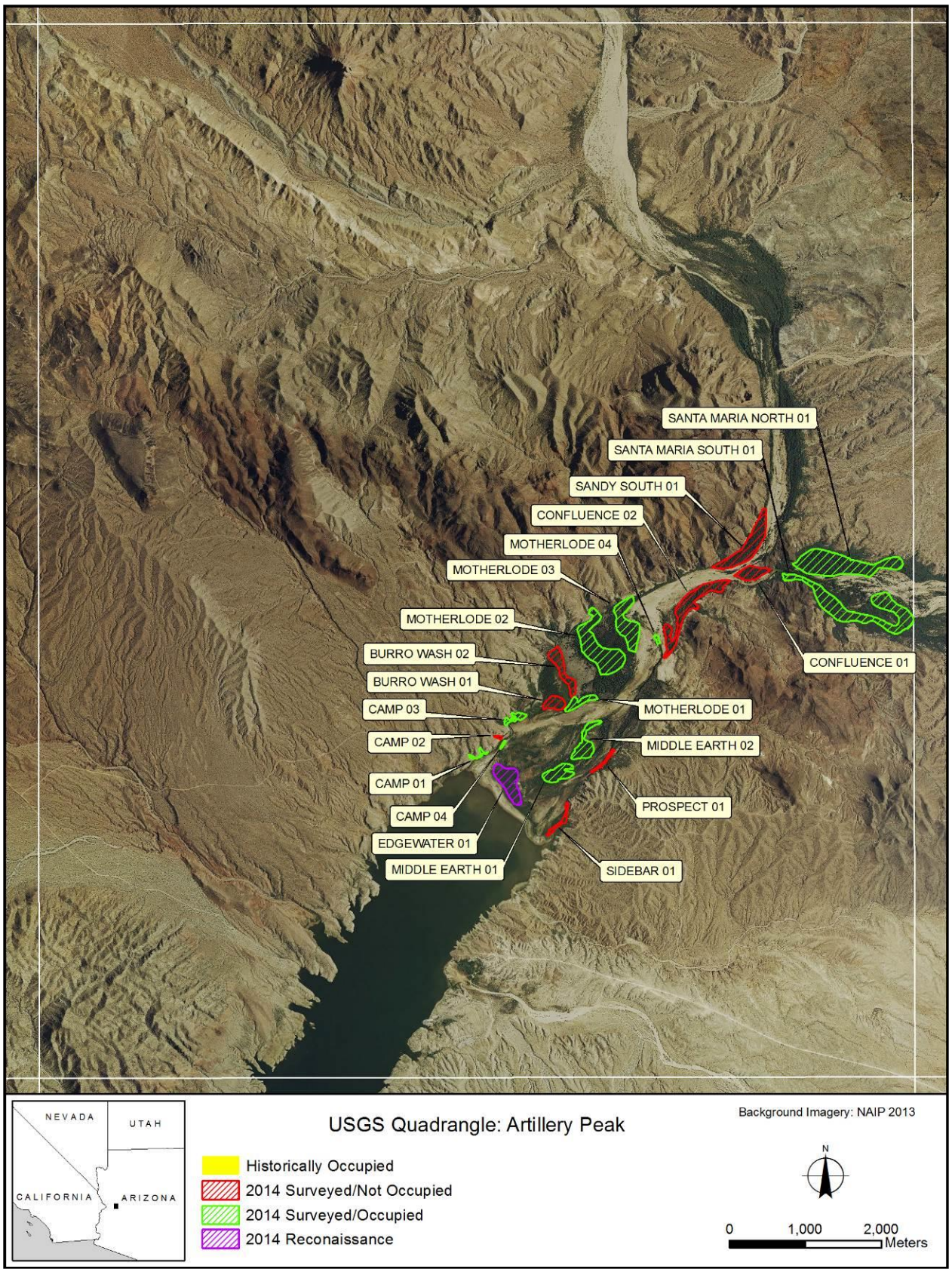
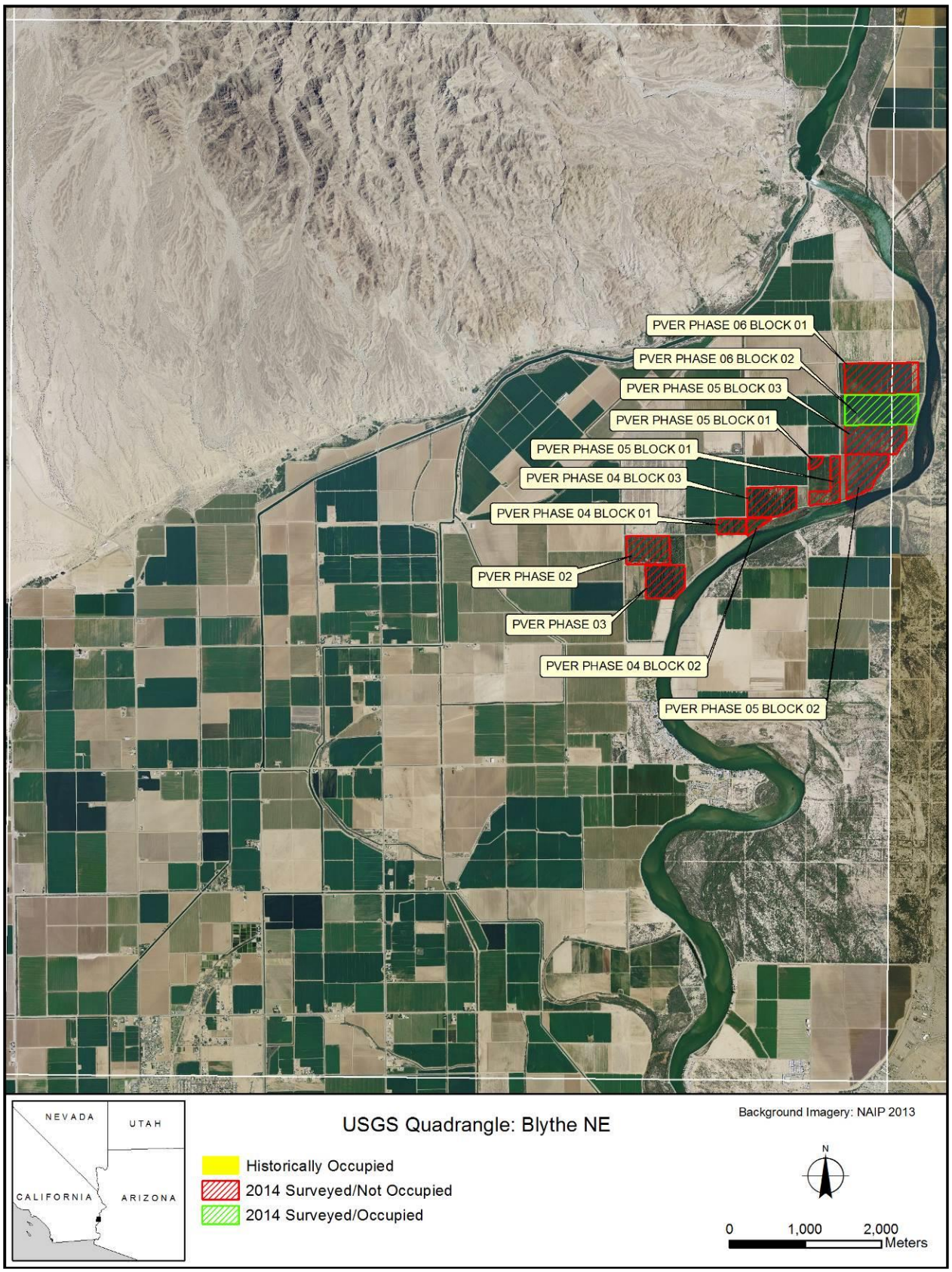
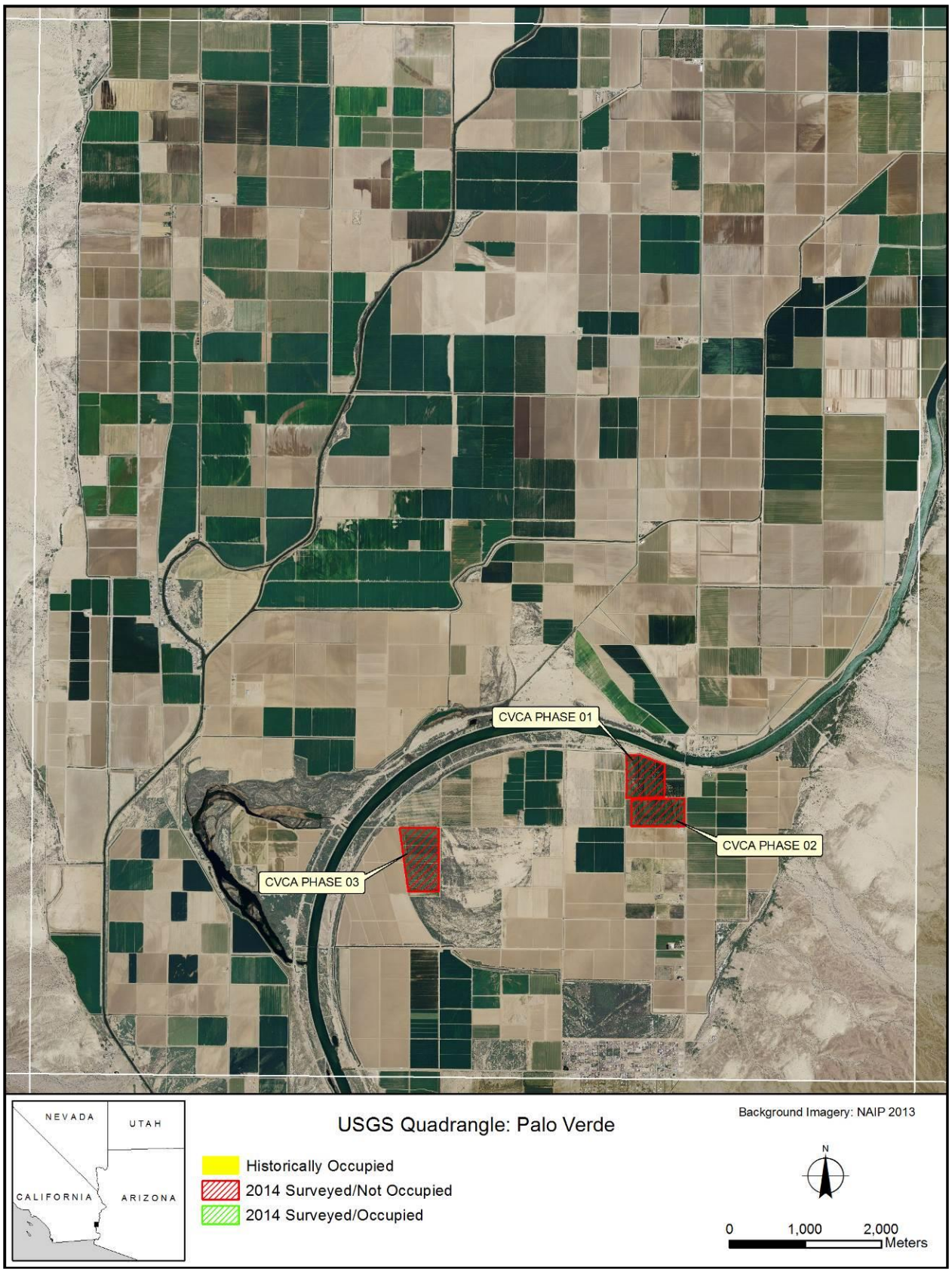
1,000
2,000
Meters


SANTA MARIA NORTH 01
SANTA MARIA SOUTH 01
SANDY SOUTH 01
CONFLUENCE 02
MOTHERLODE 04
MOTHERLODE 03
MOTHERLODE 02
BURRO WASH 02
BURRO WASH 01
CAMP 03
CAMP 02
CAMP 01
CAMP 04
EDGEWATER 01
MIDDLE EARTH 01
CONFLUENCE 01
MOTHERLODE 01
MIDDLE EARTH 02
PROSPECT 01
SIDEBAR 01
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Artillery Peak
Background Imagery: NAIP 2013
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
2014 Reconaissance
N
0
1,000
2,000
Meters


PVER PHASE 06 BLOCK 01
PVER PHASE 06 BLOCK 02
PVER PHASE 05 BLOCK 03
PVER PHASE 05 BLOCK 01
PVER PHASE 05 BLOCK 01
PVER PHASE 04 BLOCK 03
PVER PHASE 04 BLOCK 01
PVER PHASE 02
PVER PHASE 03
PVER PHASE 04 BLOCK 02
PVER PHASE 05 BLOCK 02
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Blythe NE
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
Background Imagery: NAIP 2013
N
0
1,000
2,000
Meters


CVCA PHASE 01
CVCA PHASE 02
CVCA PHASE 03
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Palo Verde
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
Background Imagery: NAIP 2013
N
0
1,000
2,000
Meters

NATURE TRAIL
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Cibola
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
Background Imagery: NAIP 2013
N
0
1,000
2,000
Meters

J
I
SOUTH AC
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Yuma East
Background Imagery: NAIP 2013
Historically Occupied
2014 Surveyed/Not Occupied
2014 Surveyed/Occupied
N
0
1,000
2,000
Meters

ATTACHMENT 4

Southwestern Willow Flycatcher Survey Dates, 2014

Table 4-1.—Dates of presence/absence surveys for willow flycatchers, 2014

Study area[1]	LCR MSCP area	LCR MSCP site	LCR MSCP section (survey site)	Survey dates
KEPI	Alamo	Key Pittman WMA	Nesbitt Forest	–[2]
			Patch 00	May 16, Jun e 14, June 22[3]
			Patches 01-04	May 16[3]
			Patch 04.5	May 16, June 14, June 22, July 2
			Patch 05	May 16, June 14, July 2, July 14
			Patch 06-10	May 16[3]
			Patch 10.5	May 16, June 14 , June 22 , July 2, July 14
			Patches 11-12	May 16[3]
RIRA	Alamo	River Ranch	East Side	May 21, June 13,June 22, July 4, July 13
			West Side	May 21, June 13, June 22, July 4, July 13
			Smalls	May 21, June 13, June 22, July 4, July 13
PAHR	Alamo	Pahranagat NWR	Pahranagat North	May 21, June 17, June 23, July 12, July 17
			Pahranagat West	May 18, June 5, June 19, June 27, July 13
			MAPS	–[2]
			Pahranagat South	May 18, June 5, June 19, June 27, July 13
MVWA	Meadow Valley Wash	Meadow Valley Wash North	Etna	May 28, June 11, June 18, July 2, July 15
		Meadow Valley Wash Middle	Dog Leg	May 22, June 11, June 18, July 2, July 15
			Ford	May 22, June 5, June 18, July 2, July 16
			Kyle	May 22, June 5, June 18, July 2, July 16
			Cottonwood Canyon	May 28, June 5, June 18, July 2, July 16
MUDD	Muddy River	Overton Above High-Water Mark	Overton WMA Pond	May 16, June 12, June 17, July 1, July 17
		Overton Wildlife	Overton WMA	May 15–17, June 10, 12, 17, June 23–24, July 1, July 17
WMSP	Muddy River	Warm Springs	Muddy Mac	May 15, June 17, June 23, July 1, July 15
			Muddy Stringer 01	May 15, June 17, June 23, July 1, July 15
TOPO	Topock	Topock Marsh	Pipes 01	May 18, June 6, June 18, June 26, July 10
			Pipes 03	May 15, June 3, June 16, June 26, July 9
			The Wallows	May 18, June 3, June 14, June 26, July 9
			PC 6-1	May 18, June 5, June 17, July 1, July 10
			Pig Hole	May 18, June 4, June 20, July 3, July 9
			In Between	May 20, June 4, June 18, June 28, July 9
			800M	May 20, June 4, June 18, June 28, July 8
			Pierced Egg	May 20-21, June 4, June 15, June 28, July 8
			Swine Paradise	–[4]
			Platform	May 19, June 3, June 14, June 29, July 5
			250M	May 21, June 4, June 16, June 29, July 5
			Hell Bird	May 27, June 9, June 15, July 3, July 10
			Glory Hole	May 19, June 9, June 18, July 1, July 10

Table 4-1.—Dates of presence/absence surveys for willow flycatchers, 2014

Study area[1]	LCR MSCP area	LCR MSCP site	LCR MSCP section (survey site)	Survey dates
TOPO	Beal Lake Conservation Area	CPhase 05	CPhase 05 (Beal Lake)	May 21, June 5, June 16, June 26, July 8
	Topock	Topock Bay	Lost Lake	May 21, 26, June 9, June 17, June 26, July 8
BIWI	Bill Williams River West	North Burn	Wispy Willow	May 29, June 8[3]
			Site 01	May 28, June 8, June 17, July 2, 4, July 8
			Burn Edge	May 27, June 10, June 17, June 27, July 9
		Mosquito Flats	Site 04	May 17, June 3, June 18, June 26, July 8
			Site 03	May 17, June 3, June 15, June 26, July 8
		Sandy Wash	Site 05	May 20, June 7, June 17, June 27, July 6
			Black Rail	May 20, June 11, June 17, July 4, July 9
	Bill Williams River East	Cougar Point	Cougar Point	May 27, June 14, June 24, July 4, July 9
		Cave Wash	Upstream from Site 08	May 27, June 13, June 24, July 5
	Planet Ranch	Planet Ranch West	Planet Ranch Road[5]	May 27, June 13, July 5
ALAM[6]	Alamo Lake	Brown's Crossing	Sidebar 01	May 23
			Camp 01	May 24
			Camp 04	–[2]
			Camp 02	May 23
			Camp 03	May 23
			Middle Earth 01	May 22-23
			Middle Earth 02	May 22-23
			Prospect 01	May 22, June 21
			Burro Wash 01	May 24
			Burro Wash 02	May 24
			Motherlode 01	May 22, 24
			Motherlode 02	May 23, June 5
			Motherlode 03	May 22-23
			Motherlode 04	–[2]
			Confluence 02	May 24, June 21
			Confluence 01	May 24, June 21
			Sandy South 01	May 24, June 21
			Santa Maria South 01	May 25, June 20
			Santa Maria North 01	May 25, June 20
PVER	Palo Verde Ecological Reserve	Phase 02	Phase 02	May 28, June 10, June 25, July 5, July 13
		Phase 03	Phase 03	May 28-29, June 10, June 25, July 5, July 13
		Phase 04	Phase 04 Block 01	May 28, June 10, June 25, July 5, July 13
			Phase 04 Block 02	May 28, June 10, June 25, July 5, 8, July 13
			Phase 04 Block 03	May 28, June 10, June 24, July 8, July 13
		Phase 05	Phase 05 Block 01	May 28, June 11, June 21, July 7, July 13
			Phase 05 Block 02	May 29, June 11, June 21, July 7, July 13

Table 4-1.—Dates of presence/absence surveys for willow flycatchers, 2014

Study area[1]	LCR MSCP area	LCR MSCP site	LCR MSCP section (survey site)	Survey dates
PVER	Palo Verde Ecological Reserve	Phase 05	Phase 05 Block 03	29 May, June 11, June 24, July 7, July 14
		Phase 06	Phase 06 Block 01	30 May, June 12, June 24, July 7, July 14
			Phase 06 Block 02	29 May, June 11, June 24, July 7, July 14
CIBO	Cibola Valley Conservation Area	Phase 01	Phase 01	30 May, June 12, June 22, July 6, July 15
		Phase 02	Phase 02	30 May, June 12, June 22, July 6, July 15
		Phase 03	Phase 03	30 May, June 12, June 25, July 6, July 15
	Cibola National Wildlife Refuge Unit 1	Nature Trail	Nature Trail	31 May, June 12, June 25, July 6, July 15
YUMA	Yuma East Wetlands	J	C4703 (J)	31 May, June 11, June 23, July 6, July 15
		South AC	C4711 (South AC)	31 May, June 11, June 23, July 6, July 15
		I	C4702 (I)	31 May, June 11, June 23, July 6, July 15

[1] KEPI = Key Pittman WMA, RIRA = River Ranch, PAHR = Pahranagat NWR, MVWA = Meadow Valley Wash, MUDD = Muddy River, WMSP = Warm Springs NA, TOPO = Topock Marsh, BIWI = Bill Williams River NWR, ALAM = Alamo Lake, PVER = Palo Verde Ecological Reserve, CIBO = Cibola, and YUMA = Yuma.

[2] Site discovered occupied partway through the survey season; no surveys conducted.

[3] Surveys ceased partway through the season due to occupancy status.

[4] Site occupied during survey season; no surveys conducted.

[5] Due to property access issues, all surveys were conducted from the property boundary, up to 100 meters from the site. Site only intermittently surveyed due to access issues.

[6] Survey effort at Alamo Lake was reduced in 2014; no site was surveyed more than twice.

ATTACHMENT 5

Southwestern Willow Flycatcher Survey Results, 2014

Table 5-1.—Southwestern willow flycatcher survey and monitoring results by survey site along the lower Colorado River and tributaries, 2014*

Study area LCR MSCP area River drainage, State	LCR MSCP site	LCR MSCP section (survey site)[1]	Area (hectares)	# surveys	Survey hours	Resident adults	Territories	Pairs	Nests	# confirmed fledges	Unknown status[2]	
											Before June 24	After June 24
Key Pittman Wildlife Management Area (Key Pittman WMA) Alamo Pahranagat Valley, NV	Key Pittman WMA[3]	Nesbitt Forest	0.2	0	–	2[4]	1	1	1	0	0	0
		Patch 00	0.03	3	–	1[5]	1	0	0	0	0	0
		Patch 01	0.1	1	–	2[4]	1	1	1	0	0	0
		Patch 02	0.1	1	–	3[6]	2	2	1	0	0	0
		Patch 03	0.1	1	–	1[7]	1	0	0	0	0	0
		Patch 04	0.1	1	–	2	1	1	1	2	0	0
		Patch 04.5	0.04	4	–	0	0	0	0	0	0	0
		Patch 05	0.1	4	–	0	0	0	0	0	4	0
		Patch 06	0.2	1	–	7	5	2	2	0	1	0
		Patch 07	0.1	1	–	2[8]	1	1	2	1	0	0
		Patch 08	0.1	1	–	2[8]	1	1	3	0	0	0
		Patch 09	0.3	1	–	7[6]	4	4	4	7	0	0
		Patch 10	0.1	1	–	2	1	1	1	2	0	0
		Patch 10.5	0.02	5	–	0	0	0	0	0	0	0
		Patch 11	0.1	1	–	3[6]	2	2	3	1	0	0
		Patch 12	0.1	1	–	3	2	1	2	0	1	0
		TOTAL	**1.52**	**–**	**3.0**	**35**	**23**	**17**	**21**	**13**	**6**	**0**
River Ranch Alamo Pahranagat Valley, NV	River Ranch	East Side	0.4	5	1.8	0	0	0	0	0	0	0
		West Side	0.3	5	1.7	0	0	0	0	0	2	0
		Smalls	0.2	5	0.9	0	0	0	0	0	1	0
		TOTAL	**1.0**	**–**	**4.4**	**0**	**0**	**0**	**0**	**0**	**3**	**0**
Pahranagat National Wildlife Refuge (Pahranagat NWR) Alamo Pahranagat Valley, NV	Pahranagat NWR	Pahranagat North	3.2	5	3.0	24	15	13	17	21	0	1[7]
		Pahranagat West	1.3	5	2.4	0	0	0	0	0	0	0
		Pahranagat MAPS	0.2	0	–	4	3	2	3	4	0	1[5]
		Pahranagat South	1.4	5	2.8	0	0	0	0	0	0	0
		TOTAL	**6.1**	**–**	**8.2**	**28**	**18**	**15**	**20**	**25**	**0**	**2**

Table 5-1.—Southwestern willow flycatcher survey and monitoring results by survey site along the lower Colorado River and tributaries, 2014*

Study area LCR MSCP area River drainage, State	LCR MSCP site	LCR MSCP section (survey site)[1]	Area (ha)	# surveys	Survey hours	Resident adults	Territories	Pairs	Nests	# confirmed fledges	Unknown status[2]	
											Before June 24	After June 24
Meadow Valley Wash Meadow Valley Wash Meadow Valley Wash, NV	Meadow Valley Wash North	Etna	9.9	5	1.9	0	0	0	0	0	0	0
	Meadow Valley Wash Middle	Dog Leg	41.2	5	13.6	4[6]	3	2	2	4	0	0
		Ford	21.0	5	2.9	0	0	0	0	0	0	0
		Kyle	22.1	5	2.7	0	0	0	0	0	0	0
		Cottonwood Canyon	20.0	5	3.9	0	0	0	0	0	0	0
		TOTAL	**114.3**	**–**	**25.0**	**4**	**3**	**2**	**2**	**4**	**0**	**0**
Muddy River Muddy River Muddy River, NV	Overton Above High-Water Mark	Overton WMA Pond	0.6	5	2.4	0	0	0	0	0	3	0
	Overton Wildlife	Overton WMA	7.8	5	17.4	8	6	6	7	1	0	0
		TOTAL	**8.4**	**–**	**19.8**	**8**	**6**	**6**	**7**	**1**	**3**	**0**
Warm Springs Natural Area (Warm Springs) Muddy River Muddy River, NV	Warm Springs	Muddy Mac	0.5	5	2.9	1[9]	1	0	0	0	0	0
		Muddy Stringer 01	0.8	5	2.2	1[9]	1	0	0	0	0	0
		TOTAL	**1.3**	**–**	**5.1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
Topock Marsh Topock Colorado River, AZ	Topock Marsh	Pipes 01	5.2	5	9.0	0	0	0	0	0	0	0
		Pipes 03	5.7	5	7.3	0	0	0	0	0	1	0
		The Wallows	0.7	5	2.4	0	0	0	0	0	3	2
		PC 6-1	4.8	5	8.3	0	0	0	0	0	1	0
		Pig Hole	2.4	5	3.8	0	0	0	0	0	0	0
		In Between	7.7	5	8.1	0	0	0	0	0	0	0
		800M	4.7	5	5.6	0	0	0	0	0	0	0
		Pierced Egg	6.7	5	8.9	0	0	0	0	0	3	0
		Swine Paradise	1.0	0	–	4	3	3	3	6	0	1
		Platform	1.9	5	2.2	0	0	0	0	0	3	0
		250M	1.9	5	3.4	0	0	0	0	0	0	0
		Hell Bird	5.8	5	5.5	0	0	0	0	0	0	0
		Glory Hole	5.0	5	7.0	0	0	0	0	0	2	0

Table 5-1.—Southwestern willow flycatcher survey and monitoring results by survey site along the lower Colorado River and tributaries, 2014*

Study area LCR MSCP area River drainage, State	LCR MSCP site	LCR MSCP section survey site)[1]	Area (ha)	# surveys	Survey hours	Resident adults	Territories	Pairs	Nests	# confirmed fledges	Unknown status[2]	
											Before June 24	After June 24
Topock Marsh Beal Lake Conservation Area Colorado River, AZ	CPhase 05	CPhase 05 (Beal Lake)	18.0	5	10.1	1	1	0	0	0	3	0
Topock Marsh Topock Colorado River, AZ	Topock Bay	Lost Lake	3.3	5	4.9	1	1	0	0	0	5	0
		TOTAL	**74.9**	**–**	**86.5**	**6**	**5**	**3**	**3**	**6**	**21**	**3**
Bill Williams River National Wildlife Refuge (Bill Williams River NWR) Bill Williams River West Bill Williams River, AZ	North Burn	Wispy Willow	1.3	2	2.1	4	3	2	2	1	2	0
		Site 01	2.4	5	6.7	0	0	0	0	0	3	0
		Burn Edge	4.1	5	4.3	0	0	0	0	0	0	0
	Mosquito Flats	Site 04	9.9	5	8.8	0	0	0	0	0	0	0
		Site 03	12.9	5	12.6	2	1	1	2	3	0	0
	Sandy Wash	Site 05	6.8	5	7.8	0	0	0	0	0	0	0
		Black Rail	1.2	5	2.4	0	0	0	0	0	0	0
Bill Williams River NWR Bill Williams River East Bill Williams River, AZ	Cougar Point	Cougar Point	1.3	5	3.4	0	0	0	0	0	0	0
	Cave Wash	Upstream from Site 08	1.5	4	2.9	0	0	0	0	0	0	0
Bill Williams River NWR Planet Ranch Bill Williams River, AZ	Planet Ranch West	Planet Ranch Road[10]	3.3	3	2.5	0	0	0	0	0	0	0
		TOTAL	**44.7**	**–**	**53.5**	**6**	**4**	**3**	**4**	**4**	**5**	**0**
Alamo Lake[11] Alamo Lake Big Sandy River, Santa Maria River, Bill Williams River, Alamo Lake, AZ	Browns Crossing	Sidebar 01	1.7	1	1.0	0	0	0	0	0	0	0
		Camp 01	0.7	0	–	2	1	1	0	0	0	0
		Camp 04	0.3	0	–	1	1	0	0	0	0	0
		Camp 02	0.3	1	0.2	0	0	0	0	0	0	0
		Camp 03	1.9	1	0.4	2	1	1	1	0	0	1
		Middle Earth 01	6.1	1	1.0	9	6	5	6	1	0	0
		Middle Earth 02	6.7	1	1.2	14	8	7	6	3	1	0
		Prospect 01	1.1	2	2.9	0	0	0	0	0	0	0

Table 5-1.—Southwestern willow flycatcher survey and monitoring results by survey site along the lower Colorado River and tributaries, 2014*

Study area LCR MSCP area River drainage, State	LCR MSCP site	LCR MSCP section (survey site) [1]	Area (ha)	# surveys	Survey hours	Resident adults	Territories	Pairs	Nests	# confirmed fledges	Unknown status[2]	
											Before June 24	After June 24
Alamo Lake[11] Alamo Lake Big Sandy River, Santa Maria River, Bill Williams River, Alamo Lake, AZ	Browns Crossing	Burro Wash 01	3.9	1	0.7	0	0	0	0	0	0	0
		Burro Wash 02	6.8	1	0.7	0	0	0	0	0	0	0
		Motherlode 01	3.3	1	0.6	4	2	2	2	3	0	0
		Motherlode 02	21.6	2	5.3	4	2	2	2	2	0	0
		Motherlode 03	12.6	1	1.5	10	5	5	3	0	1	0
		Motherlode 04	0.5	0	–	2	1	1	1	0	0	0
		Confluence 02	15.8	2	5.2	0	0	0	0	0	1	0
		Confluence 01	5.3	2	2.7	0	0	0	0	0	0	0
		Sandy South 01	14.8	2	8.4	0	0	0	0	0	0	0
		Santa Maria South 01	30.2	2	7.2	2	1	1	0	0	0	0
		Santa Maria North 01	29.5	2	11.3	6	3	3	2	1	0	0
		TOTAL	**163.2**	**–**	**50.3**	**56**	**31**	**28**	**23**	**10**	**3**	**1**
Palo Verde Ecological Reserve Palo Verde Ecological Reserve Colorado River, CA	Phase 02	Phase 02	21.4	5	9.3	0	0	0	0	0	3	0
	Phase 03	Phase 03	21.4	5	7.3	0	0	0	0	0	2	0
	Phase 04	Phase 04 Block 01	7.6	5	5.9	0	0	0	0	0	1	0
		Phase 04 Block 02	4.0	5	3.9	0	0	0	0	0	4	0
		Phase 04 Block 03	23.7	5	11.2	0	0	0	0	0	0	0
	Phase 05	Phase 05 Block 01	14.8	5	6.4	0	0	0	0	0	1	0
		Phase 05 Block 02	23.6	5	7.9	0	0	0	0	0	0	0
		Phase 05 Block 03	29.6	5	10.1	0	0	0	0	0	0	0
	Phase 06	Phase 06 Block 01	38.7	5	17.6	0	0	0	0	0	5	0
		Phase 06 Block 02	37.6	5	18.5	0	0	0	0	0	5	1
		TOTAL	**222.5**	**–**	**98.1**	**0**	**0**	**0**	**0**	**0**	**21**	**1**
Cibola Cibola Valley Conservation Area Colorado River, AZ	Phase 01	Phase 01	26.2	5	10.2	0	0	0	0	0	5	0
	Phase 02	Phase 02	25.5	5	10.4	0	0	0	0	0	1	0
	Phase 03	Phase 03	38.4	5	11.4	0	0	0	0	0	5	0

Table 5-1.—Southwestern willow flycatcher survey and monitoring results by survey site along the lower Colorado River and tributaries, 2014*

Study area LCR MSCP area River drainage, State	LCR MSCP site	MSCP section (survey site)[1]	Area (ha)	# surveys	Survey hours	Resident adults	Territories	Pairs	Nests	# confirmed fledges	Unknown status[2]	
											Before June 24	After June 24
Cibola Cibola National Wildlife Refuge Unit 1 Colorado River, AZ	Nature Trail	Nature Trail (Cibola Nature Trail)	13.7	5	3.7	0	0	0	0	0	3	0
		TOTAL	**103.8**	**–**	**35.7**	**0**	**0**	**0**	**0**	**0**	**14**	**0**
Yuma[12] Yuma East Wetlands Colorado River, AZ	J	C4703 (J)	8.4	5	3.0	0	0	0	0	0	4	0
	South AC	C4711 (South AC)	0.8	5	1.3	0	0	0	0	0	3	0
	I	C4702 (I)	6.4	5	4.4	0	0	0	0	0	4	0
		TOTAL	**15.6**	**–**	**8.7**	**0**	**0**	**0**	**0**	**0**	**11**	**0**

* This table includes only sites where regular surveys were scheduled and territory monitoring was conducted. Sites where habitat reconnaissance and opportunistic surveys were conducted are not included.

[1] Survey site is equivalent to the Arizona Department of Game and Fish definition of site. LCR MSCP section names correspond to those of their respective survey sites, though geographies may not be identical.

[2] Total number of individuals recorded that could not be classified as resident or migrant because of brief appearance.

[3] Survey hours not tallied by survey site; total survey hours for the study area are presented.

[4] One male was polygynous with a female in Key Pittman WMA Patch 01 and Key Pittman WMA Nesbitt Forest.

[5] This individual was detected at Key Pittman WMA Patch 00 from June 24 to July 2 and was then detected on July 21 at Pahranagat MAPS.

[6] One male was polygynous with two females.

[7] One male was detected at Key Pittman WMA Patch 03 through July 28 and was then detected August 3 at Pahranagat MAPS.

[8] One male was polygynous with a female in Key Pittman WMA Patch 07 and Key Pittman WMA Patch 08.

[9] This individual first established a territory in Warm Springs Muddy Mac, then moved and established a second territory in Warm Springs Muddy Stringer 01, starting June 11.

[10] Due to access issues, this site was only surveyed from the property boundary of the Bill Williams River NWR.

[11] Survey and monitoring effort at Alamo Lake was reduced in 2014 compared to all other study areas.

[12] Data collected at Yuma East Wetlands are reported under the LCR MSCP site name; each survey site constitutes only a small portion of each LCR MSCP site.

ATTACHMENT 6

Detections of Special Concern Species, 2014

Table 6-1.—Number of detections of each special concern species recorded at each survey site, 2014*

Study area	LCR MSCP area	LCR MSCP site	LCR MSCP section (survey site)	Species of special concern[1]			
				CLRA	YBCU	GIFL	VEFL
Key Pittman WMA	Alamo	Key Pittman WMA	Nesbitt Forest[2]	–	–	–	–
			Patches 00-12	0	0	0	0
River Ranch	Alamo	River Ranch	East Side	0	0	0	0
			West Side	0	0	0	0
			Smalls	0	0	0	3
Pahranagat NWR	Alamo	Pahranagat NWR	Pahranagat North	0	0	0	0
			Pahranagat West	0	0	0	0
			Pahranagat MAPS[2]	–	–	–	–
			Pahranagat South	0	0	0	0
Meadow Valley Wash	Meadow Valley Wash	Meadow Valley Wash North	Etna	0	0	0	0
		Meadow Valley Wash Middle	Dog Leg	0	0	0	0
			Ford	0	0	0	0
			Kyle	0	0	0	0
			Cottonwood Canyon	0	0	0	0
Muddy River	Muddy River	Overton Above High-Water Mark	Overton WMA Pond	0	0	0	0
		Overton Wildlife	Overton WMA	0	0	0	0
Warm Springs NA	Muddy River	Warm Springs	Muddy Mac	0	0	0	2
			Muddy Stringer 01	0	0	0	0
Topock Marsh	Topock	Topock Marsh	Pipes 01	0	0	0	0
			Pipes 03	0	0	0	0
			The Wallows	0	0	?[3]	0
			PC 6-1	0	0	0	0
			Pig Hole	0	0	0	0
			In Between	0	0	0	0
			800M	0	0	0	0
			Pierced Egg	2	0	0	0
			Swine Paradise[2]	–	–	–	–
			Platform	0	0	0	0
			250M	0	0	0	0
			Hell Bird	2	0	0	0
			Glory Hole	0	0	0	0
	Beal Lake Conservation Area	CPhase 05	CPhase 05 (Beal Lake)	0	0	0	0
	Topock	Topock Bay	Lost Lake	5	0	0	0
Bill Williams River NWR	Bill Williams River West	North Burn	Wispy Willow	0	0	0	0
			Site 01	0	0	0	0
			Burn Edge	0	*	0	0

Table 6-1.—Number of detections of each special concern species recorded at each survey site, 2014*

Study area	LCR MSCP area	LCR MSCP site	LCR MSCP section (survey site)	Species of special concern[1]			
				CLRA	YBCU	GIFL	VEFL
Bill Williams River NWR	Bill Williams River West	Mosquito Flats	Site 04	0	0	0	0
			Site 03	0	0	0	0
		Sandy Wash	Site 05	0	0	0	0
			Black Rail	0	0	0	0
	Bill Williams River East	Cougar Point	Cougar Point	0	0	0	0
		Cave Wash	Upstream from Site 08	0	*	0	0
	Planet Ranch	Planet Ranch West	Planet Ranch Road	0	0	0	0
Alamo Lake	Alamo Lake	Brown's Crossing	Sidebar 01	0	0	0	0
			Camp 01	0	0	0	0
			Camp 04[2]	–	–	–	–
			Camp 02	0	0	0	0
			Camp 03	0	0	0	0
			Middle Earth 01	0	0	0	0
			Middle Earth 02	0	0	0	0
			Prospect 01	0	0	0	0
			Burro Wash 01	0	0	0	0
			Burro Wash 02	0	0	0	0
			Motherlode 01	0	0	0	0
			Motherlode 02	0	0	0	1
			Motherlode 03	0	0	0	0
			Motherlode 04[2]	–	–	–	–
			Confluence 02	0	0	0	0
			Confluence 01	0	0	0	0
			Sandy South 01	0	0	0	0
			Santa Maria South 01	0	0	0	0
			Santa Maria North 01	0	0	0	3
Palo Verde Ecological Reserve	Palo Verde Ecological Reserve	Phase 02	Phase 02	0	*	0	0
		Phase 03	Phase 03	0	0	0	0
		Phase 04	Phase 04 Block 01	0	*	0	0
			Phase 04 Block 02	0	*	0	0
			Phase 04 Block 03	0	*	0	0
		Phase 05	Phase 05 Block 01	0	*	0	0
			Phase 05 Block 02	0	*	0	0
			Phase 05 Block 03	0	*	0	0
		Phase 06	Phase 06 Block 01	0	*	0	0
			Phase 06 Block 02	0	*	0	0

Table 6-1.—Number of detections of each special concern species recorded at each survey site, 2014*

Study area	LCR MSCP area	LCR MSCP site	LCR MSCP section (survey site)	Species of special concern[1]			
				CLRA	YBCU	GIFL	VEFL
Cibola	Cibola Valley Conservation Area	Phase 01	Phase 01	0	*	0	0
		Phase 02	Phase 02	0	*	0	0
		Phase 03	Phase 03	0	*	0	0
	Cibola National Wildlife Refuge Unit 1	Nature Trail	Nature Trail	0	0	0	0
Yuma	Yuma East Wetlands	J	C4703 (J)	0	0	0	0
		South AC	C4711 (South AC)	0	0	0	0
		I	C4702 (I)	0	0	0	0

* Passive YBCU detections were recorded at several survey sites monitored for YBCU as part of another LCR MSCP project (see McNeil and Tracy 2014). We do not report the number of individuals detected at these sites.

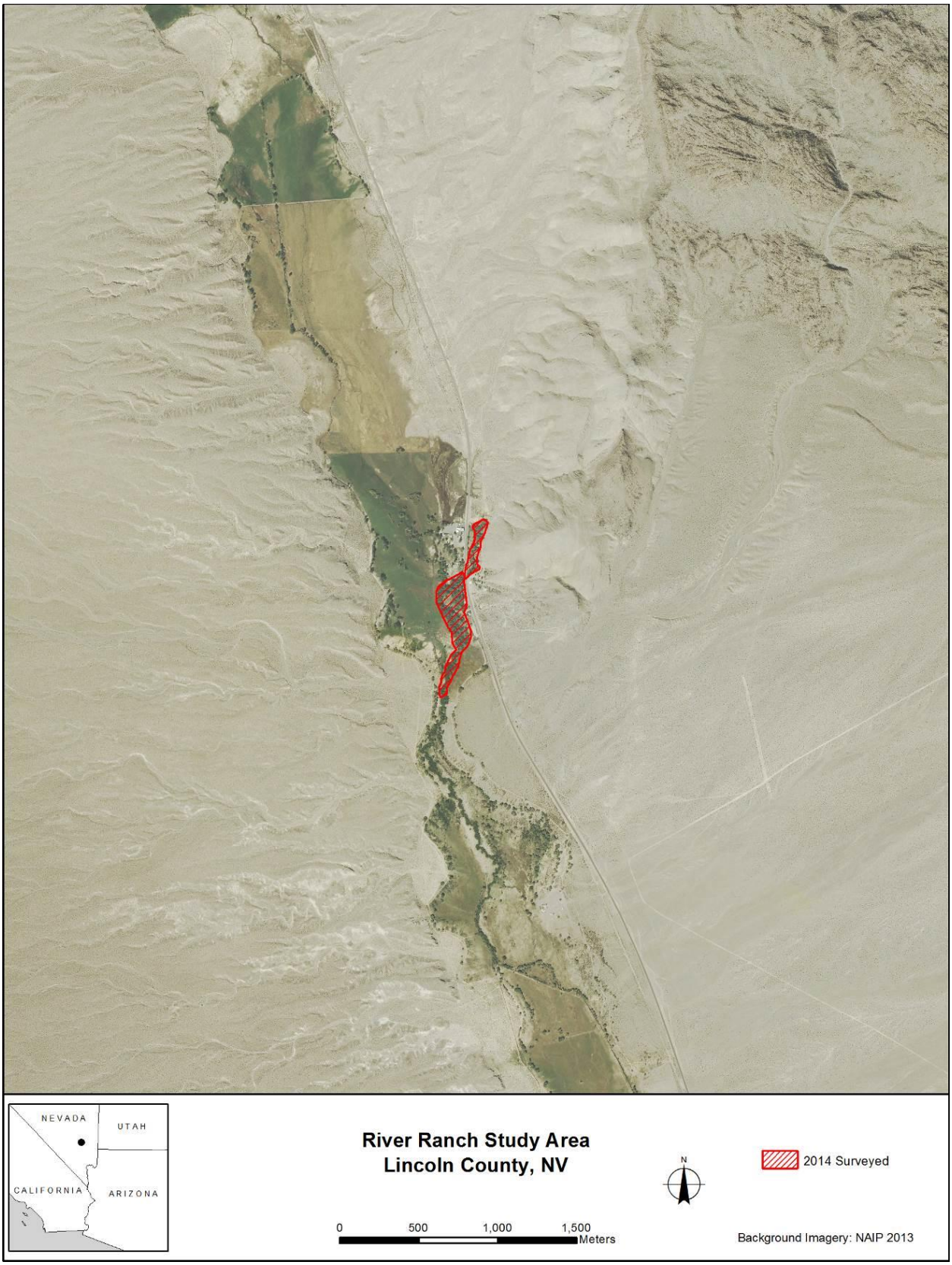
[1] CLRA = clapper rail, YBCU = yellow-billed cuckoo, GIFL = gilded flicker, and VEFL = vermilion flycatcher.

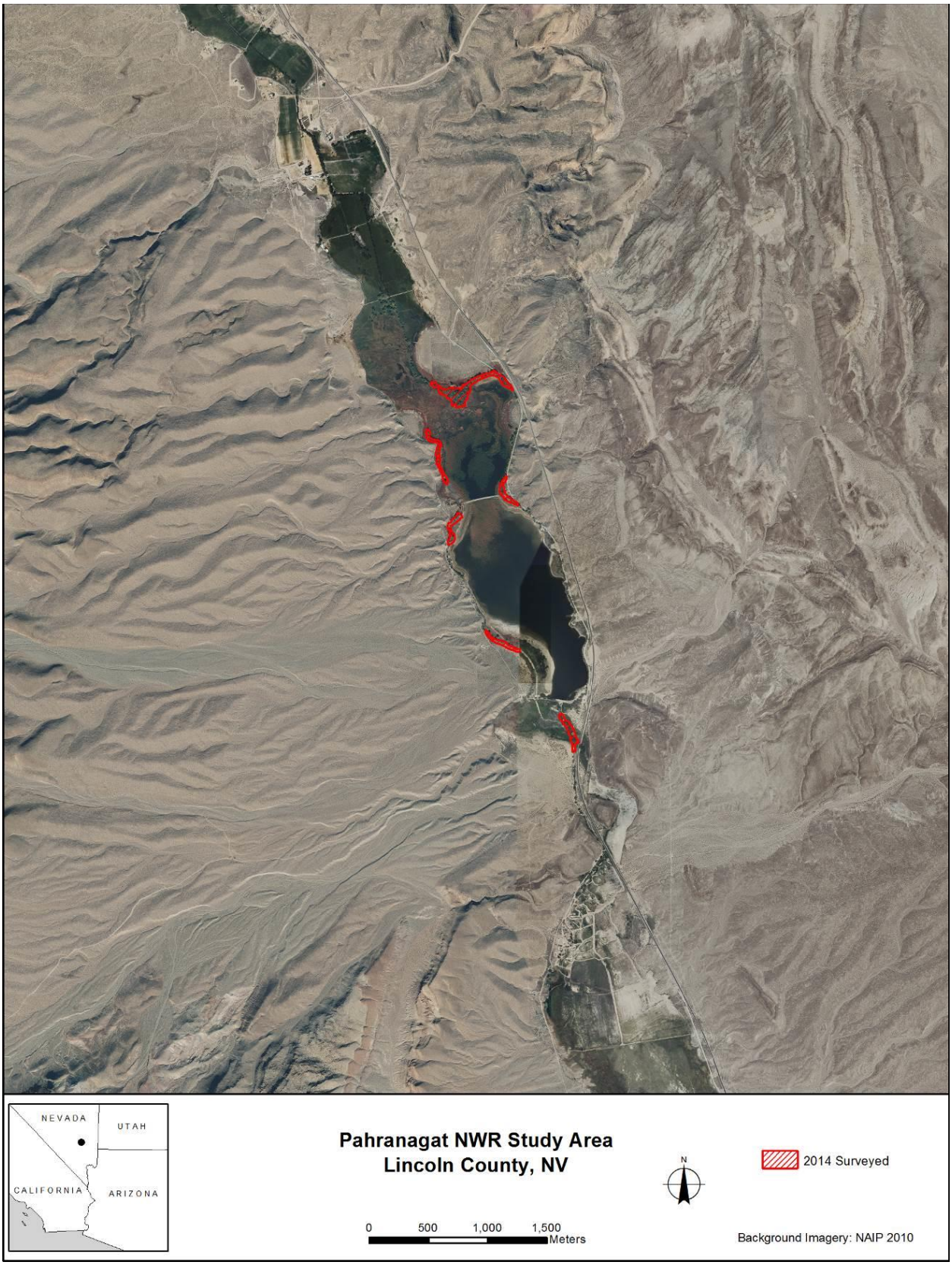
[2] This survey site was not surveyed; site occupied during the breeding season.

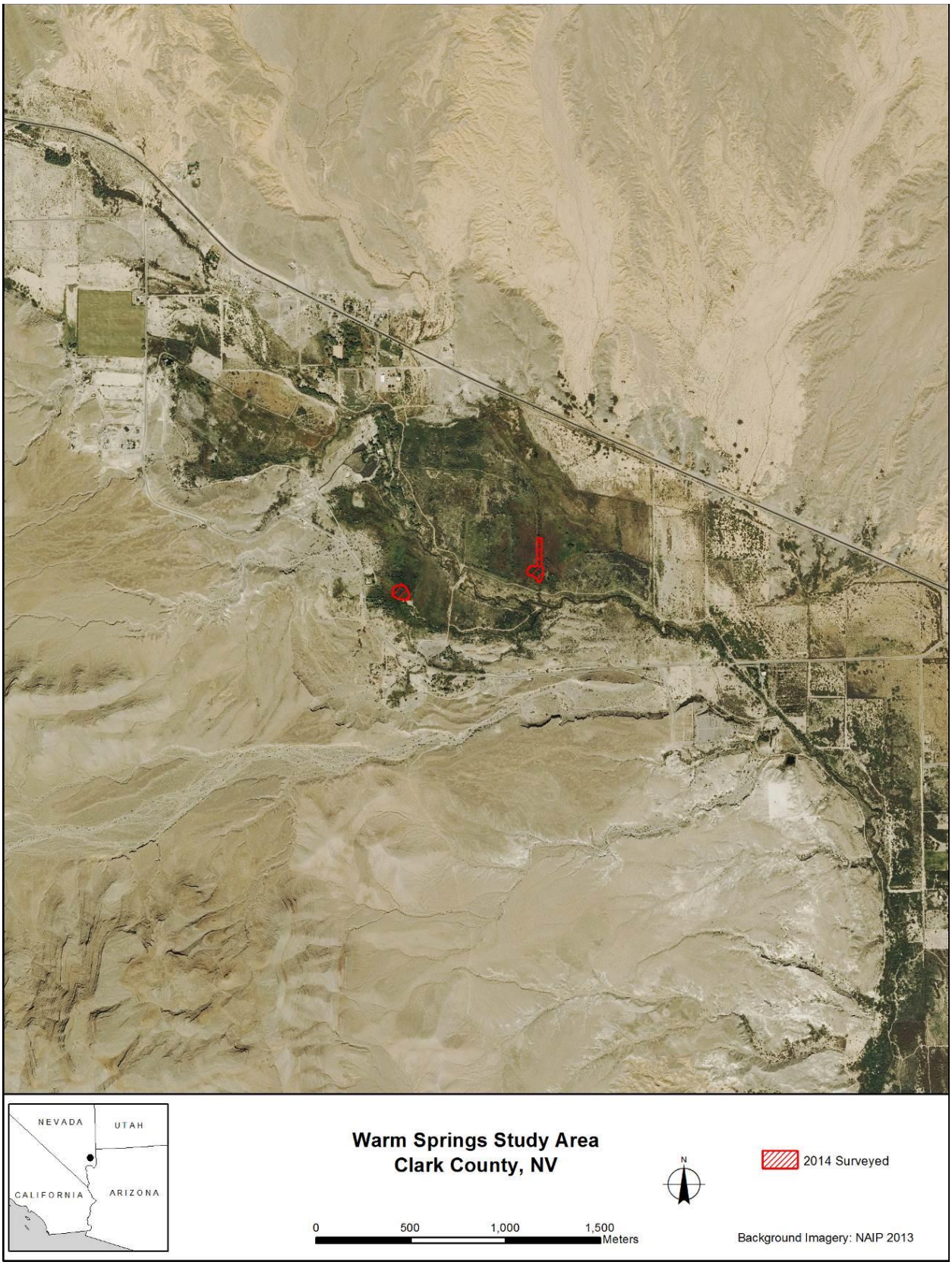
[3] A flicker was detected at this site in early June, but no positive identification to species was made.

ATTACHMENT 7

Orthophotos Showing Yellow-billed Cuckoo Survey Sites


NEVADA
UTAH
CALIFORNIA
ARIZONA
River Ranch Study Area
Lincoln County, NV
N
2014 Surveyed
0
500
1,000
1,500
Meters
Background Imagery: NAIP 2013


NEVADA
UTAH
CALIFORNIA
ARIZONA
Pahranagat NWR Study Area
Lincoln County, NV
N
2014 Surveyed
0
500
1,000
1,500
Meters
Background Imagery: NAIP 2010


NEVADA
UTAH
CALIFORNIA
ARIZONA
Warm Springs Study Area
Clark County, NV
N
2014 Surveyed
0
500
1,000
1,500
Meters
Background Imagery: NAIP 2013

ATTACHMENT 8

All Willow Flycatchers Color Banded and/or Resighted, 2010–2014

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2140-66709	M	A		Q	Q	Q		Q[4]	M	M	M	M	M	M[5]	M	
2320-31445	F	A			Q	Q	Q	Q	Q	Q	Q	Q				
2320-31463	F	J			P			K	K			K				
2320-31498	F	J				M		G[6]	Q	Q	Q	Q				
2320-31562	M	J				T		T		T	T	T				
2320-31595	M	A				P	P	P	P	P	P	P	P	P		
2320-31632	F	A				Q		M	M	M[7]		M	M	M	M	
2320-31647	M	J										M				
2320-31648	M	J										M				
2320-31659	M	J				Q		D	D	D		D				
2320-31660	F	J				Q			M	S	S	S				
2320-31674	M	J						P		K	K	K				
2320-31688	M	J					Q	Q	Q	Q	Q	Q	Q	Q		
2360-59711	M	J					K			P	P	P				
2360-59712	M	J					K			P		P	P			
2360-59754	M	J						Q	Q	Q	Q	P	P			
2360-59777	F	J							Q				M	M		
2360-59782	F	J							K			M				
2360-59788	F	J					D	D	M	M	M	M	M	M	M	
2360-59799	M	J						M	D	M		M				
2370-39915	M	A					P	P	P	P[8]	P	P				
2370-39930	M	J									M	Q	D[9]			
2370-39938	M	A						M	M	M	M	M	M	M	M	
2370-39956	F	A					D	D	D			M	M	M		
2370-39968	M	A											D			
2370-39970	F	J											M			
2370-39988	M	A						G	M	M	M	M				
2370-39999	M	A										Q				
2370-40000	M	A										D	D	D	D	
2370-40001	U	J										P				
2370-40002	U	J										P				
2370-40005	U	J										S				
2370-40007	M	J										S				
2370-40008	M	J										D				
2370-40009	U	J										D				
2370-40010	M	J										D	K	K		
2370-40011	F	A										Q				
2370-40022	M	A										K				
2370-40024	M	J									K	K	K	K	K	K
2370-40027	F	J									P	E	K			
2370-40029	M	J									M		D			
2370-40031	M	J									K	K	K			
2370-40037	F	A						G	M		M	M	M	M		
2370-40046	M	A						G	G[10]	M	M	M	M	M	M	
2370-40047	F	A						P	P	P	P	P	P	P		

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2370-40051	M	J										K				
2370-40060	M	A						P		P	P	P	P			
2370-40072	F	J									M			Q		
2370-40073	F	A									P	P				
2370-40077	M	A														W
2370-40078	F	J											K			
2370-40079	U	J											K			
2370-40087	F	A							Q	Q	Q	Q	Q			
2370-40088	M	A										D	D	D	P	P
2370-40089	U	J										M				
2370-40090	F	J										M				
2370-40091	F	J										M	D		D	
2370-40093	M	J										M				
2370-40094	U	J														P
2370-40097	M	J								K		K	K			
2370-40112	M	J							T			T				
2370-40141	M	A									K	K	K			
2370-40144	M	J									M	T				
2370-40148	F	J								S	S	S	S			
2370-40151	F	J									M	M				
2370-40155	M	A									L			P		
2370-40157	M	A							P		P	P				
2370-40173	M	A							M	M	M	M				
2370-40175	M	J									M	Q	Q	D	D	
2370-40177	F	J										T				
2370-40179	U	J										K				
2370-40190	M	J							P				K	K	K	
2370-40192	F	A							D			B				
2370-40193	F	A							Q	Q	Q	D				
2370-40194	F	A							P	P	P	P				
2370-40197	M	A							M	Q	Q	M	M	M	M	
2390-92434	M	J	Q	Q		Q	Q	Q	Q	Q	Q	M	M			
2430-61072	M	A								G			T			
2430-61080	M	A								P	P	P	P	P		
2430-61083	M	A								P	P	P	P	P	P	P
2430-61084	M	J								Q		D				
2430-61085	M	A									D	D	D	D		
2430-61087	F	A									P	P	P	P	P	
2430-61088	M	A										N	D	E	K	K
2430-61089	F	J										M				
2430-61090	M	J										M				
2430-61091	U	J										S				
2430-61092	F	A										S				
2430-61093	M	A										S	S			
2430-61094	M	J										D				
2430-61095	M	A										M				

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2430-61096	F	A										L				
2430-61097	M	J										P				
2430-61098	M	J										P	E[11]			
2430-61099	M	J										K	E[11]	K		
2430-61100	F	A										K	K	K		
2430-61106	M	J								P		M	M			
2430-61114	M	J								P		K	K			
2430-61118	M	J								P	M	M	K			
2430-61120	F	J								P	P	P	P	P		
2430-61123	F	J								P		P				
2430-61124	F	J								P		K			K	
2430-61134	M	A								T		N	N	N	T	N
2430-61135	M	A								T	T	T				
2430-61136	M	A								B	B	B	B			
2430-61137	F	A								B	B	B	B	B		
2430-61151	F	J										K				
2430-61152	M	J										P				
2430-61154	F	J									Q	S	S	S		
2430-61158	M	A									K	K	K	K	K	K
2430-61159	M	J									M		K	K	K	K
2430-61163	F	A										K				
2430-61165	M	J								Q	Q	M				
2430-61167	M	A								M	M	M	M			
2430-61174	F	J								M		Q				
2430-61176	M	J								Q		P	P	P		
2430-61179	M	A								K	P	P	P	P		
2430-61180	M	A								K		K	K	K		
2430-61187	M	J								Q	L	L				
2430-61189	F	J								Q		M				
2430-61197	M	J								P		K	K	K		
2430-61206	M	J								M		M				
2430-61207	F	J								M	D	D				
2430-61213	F	J										K				
2430-61214	M	A											K			
2430-61215	F	J											P			
2430-61216	F	J											Q			
2430-61217	F	J											Q			
2430-61218	F	J											P	P		
2430-61219	U	J											M			
2430-61220	F	J											P	P	P	P
2430-61221	M	J										P				
2430-61226	F	J										P				
2430-61227	U	J										P				
2430-61228	F	J										K				
2430-61229	M	J										K				
2430-61230	F	A										S	S	S		

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2430-61231	U	J										S		M		
2430-61232	F	J										L				
2430-61233	M	J										L				
2430-61234	F	A										Q	Q			
2430-61235	U	J										Q				
2430-61236	M	J										K				
2430-61237	M	J											B			
2430-61257	M	A												P		
2430-61258	U	J												K		
2430-61259	M	A												M		
2430-61260	M	A												D	D	
2430-61261	M	A												D		
2430-61262	M	J												K	P	P
2430-61263	U	J												K		
2430-61264	U	J												K		
2430-61265	U	J												M		
2430-61266	U	J												M		
2430-61267	F	A												P	P	P
2430-61276	U	J										Q				
2430-61277	F	J									P	P				
2430-61279	F	J									P	K	K	K	K	K
2430-61280	M	J										M				
2430-61281	M	A												M	M	
2430-61282	M	A												M	M	
2430-61286	M	A												M	M	
2430-61287	U	J												K		
2430-61288	U	J												K		
2430-61289	U	J												K		
2430-61290	M	J												P	E	
2430-61291	U	J												P		
2430-61292	U	J												P		
2430-61293	U	J												P		
2430-61294	U	J												P		
2430-61295	U	J												K		
2430-61296	U	J												D		
2430-61297	U	J												D		
2430-61298	F	A												M	M	P
2430-61299	U	J												M		
2430-61300	F	J												P	P	K
2540-58101	M	J										K				
2540-58102	F	J										K				
2540-58103	M	J										K				
2540-58104	F	J										K				
2540-58105	M	J										Q				
2540-58106	U	J										Q				
2540-58107	F	J										Q				

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2540-58108	M	A											T			
2540-58109	M	A											P[12]			
2540-58110	F	A											P			
2540-58111	F	A											P	P		
2540-58112	M	J											Q			
2540-58113	U	J											M			
2540-58114	F	J											P	P	P	P
2540-58115	M	J											B			
2540-58116	M	J										B		T		
2540-58117	M	J										B				
2540-58118	U	J										K				
2540-58119	M	J										K				
2540-58120	F	A											B			
2540-58121	U	J													K	
2540-58122	U	J													K	
2540-58123	U	J													K	
2540-58124	U	J													S	
2540-58125	U	J													S	
2540-58126	U	J													S	
2540-58127	F	J													K	P
2540-58128	U	J													K	
2540-58129	U	J													K	
2540-58130	U	J													D	
2540-58132	M	A									S	S	S	S		
2540-58133	U	J													D	
2540-58134	M	A														D
2540-58135	F	A														P
2540-58136	F	A														P
2540-58137	U	J														P
2540-58138	U	J														K
2540-58139	U	J														P
2540-58140	F	A														W
2540-58147	F	J										B				
2540-58148	M	J										Q				
2540-58149	M	J										Q				
2540-58150	M	J										Q				
2540-58151	M	J										Q				
2540-58152	F	A											Q			
2540-58153	U	J														K
2540-58154	M	J									M	T[13]	D[14]	M		
2540-58156	F	A										K	K	K		
2540-58157	M	J										K	E		P	P
2540-58158	M	J										K	K	K	K	K[15]
2540-58159	F	J										K	K	K		
2540-58160	M	J										S		S	S	S
2540-58161	F	J										L				

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2540-58162	M	J										K				
2540-58163	M	J										K				
2540-58164	M	J										K				
2540-58165	F	J										K	K			
2540-58166	M	J										K				
2540-58172	M	A											Q			
2540-58173	M	J											M	D		
2540-58174	F	J											M	M[7]		
2540-58175	F	A											K	K	K	K
2540-58176	M	A											Q			
2540-58177	F	A											K	K	K	K
2540-58178	F	J											K	K		
2540-58179	M	J											K	K	K	P
2540-58180	M	J											K			
2540-58182	F	J											K		K	
2540-58183	U	J											K			
2540-58184	F	A											M	M		
2540-58187	F	A									P		K			
2540-58190	F	J										T				
2540-58191	F	J										P				
2540-58192	M	A										Q	Q[4]	M	M	
2540-58193	F	A										N	N	N		D
2540-58194	F	J										D				
2540-58195	F	J										P				
2540-58196	M	J										P				
2540-58197	M	J										P				
2540-58198	F	J										P				
2540-58199	M	J										K		P	P	P
2540-58200	M	J										K				
2540-58201	M	J										K	P	P	P	P
2540-58202	M	A										K		K	K	K
2540-58203	F	A										K	K			
2540-58204	F	A										K				
2540-58205	F	J										K				
2540-58206	U	J										P				
2540-58207	U	J										P				
2540-58208	U	J										P				
2540-58209	F	A										P				
2540-58211	M	J											K	K	K	
2540-58212	U	J											K			
2540-58213	M	J											M			
2540-58214	F	J											K			
2540-58215	U	J														P
2540-58217	M	A									S	S			S	S
2540-58220	M	A										B	B			
2540-58221	M	A										B				

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2540-58222	F	J										K				
2540-58223	M	A										K	K	K	K	K
2540-58224	F	J										K	K	K	K	
2540-58225	F	J										K				
2540-58226	F	A										K				
2540-58227	M	A										T				
2540-58228	M	A										T	T			
2540-58229	M	A										B				
2540-58230	F	A										B	B			
2540-58231	F	A										T	M	M	M	T
2540-58232	F	J										T				
2540-58233	F	A										N				
2540-58235	F	J										N				
2540-58236	F	J										N				
2540-58237	F	J										K				
2540-58238	F	J										K	E[11]		P	P
2540-58239	M	J										K			K	K
2540-58240	F	J										K	E	K	K	K
2540-58241	F	A										K	K			
2540-58242	U	J										K				
2540-58243	M	J										K				
2540-58244	M	J										K				
2540-58245	M	A											P	K	K	K
2540-58246	M	A											E	P	P	P
2540-58247	F	J											K	K		
2540-58248	F	J													P	K
2540-58249	U	J													P	
2540-58250	M	J													P	P
2540-58251	U	J													P	
2540-58252	U	J													K	
2540-58253	U	J													K	
2540-58254	F	J													P	K
2540-58255	F	A													M	
2540-58258	U	J												K		
2540-58259	M	J												K	K	P
2540-58260	U	J												M		
2540-58261	F	A												M		
2540-58262	M	J												K	E	P
2540-58263	U	J												K		
2540-58264	U	J												K		
2540-58265	U	J												M		
2540-58266	U	J												P		
2540-58267	U	J												P		
2540-58268	M	A												K		
2540-58269	F	A												K	K[15]	P
2540-58270	F	A													K	K

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2540-58271	F	A													P	P
2540-58274	F	J											N			
2540-58275	M	J											N			
2540-58276	M	J											K			
2540-58277	M	J											K	K		K
2540-58278	U	J											D			
2540-58279	U	J											D			
2540-58280	M	J											K			
2540-58281	F	A													K	K
2540-58282	F	J											K			
2540-58283	U	J											K			
2540-58284	F	J											P			
2540-58285	M	J											P	K		
2540-58286	F	J											P	P	P	P
2540-58287	M	A											S	S		
2540-58288	M	J										P				
2540-58289	F	A										K				
2540-58290	M	J										K				
2540-58291	F	J										K				
2540-58292	F	J										K				
2540-58293	F	A										P	P	P		
2540-58294	F	J										P				
2540-58295	U	J										P				
2540-58296	F	J										P				
2540-58297	F	A											K			
2540-58298	M	J											K			
2540-58299	F	J											K			
2540-58300	F	J												K	K	
2540-58301	M	J												P	W	
2540-58302	U	J												P		
2540-58303	U	J												P		
2540-58304	F	J												P	K	
2540-58305	F	J													K	K
2540-58306	U	J													P	
2540-58307	U	J													K	
2540-58308	U	J													K	
2540-58309	F	J													K	P
2540-58310	U	J													K	
2540-58311	U	J														P
2540-58312	F	A														P
2540-58316	F	A														O
2540-58317	M	A														O
2540-58318	F	A														O
2540-58319	F	A														O
2540-58320	F	J												K		K
2540-58321	U	J												D		

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2540-58322	F	A												K	K	
2540-58323	U	J												P		
2540-58325	U	J												K		
2540-58326	M	J												K	P	
2540-58327	U	J												K		
2540-58328	F	A														O
2540-58329	M	A														O
2540-58330	U	J														W
2540-58331	U	J														P
2540-58332	U	J														P
2540-58333	U	J														K
2540-58334	U	J														K
2540-58335	U	J														K
2540-58338	U	J														O
2540-58339	U	J														O
2540-58340	U	J														O
2540-58341	M	A														O
2540-58342	F	A														O
2540-58343	U	J														O
2540-58344	U	J														T
2540-58347	U	J														T
2540-58348	U	J														T
2540-58349	F	A														T
2540-58350	M	A														O
2540-58351	U	J														O
2540-58352	U	J														B
2540-58353	F	A														O
2540-58356	F	A														B
2540-58358	U	J														K
2540-58360	U	J														D
2540-58361	U	J														P
2540-58362	F	A														O
2540-58363	M	A														W
2540-58373	U	J												M		
2540-58374	M	A													V	
2540-58375	M	A													P	
2540-58376	M	A													E	K
2540-58377	F	J													K	K
2540-58378	F	J											K			
2540-58385	U	J											S			
2540-58386	F	A											K			
2540-58387	M	A											K	K	K	K
2590-53101	M	J											P			K
2590-53102	M	J											P			
2590-53103	F	J											P			
2590-53104	M	J											P			

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2590-53105	F	A											D			
2590-53106	F	J											M			D
2590-53107	M	J											M	Q[16]		
2590-53108	F	A											D			
2590-53109	U	J											P			
2590-53110	F	A											K			
2590-53111	U	J											K			
2590-53112	M	J											K	K		
2590-53113	F	J											K			
2590-53114	M	J											K		K	
2590-53115	M	J											M			
2590-53116	F	J											M			
2590-53117	M	J											M	Q	Q[17]	
2590-53118	M	J											K			
2590-53119	F	J											M			
2590-53120	U	J													K	
2590-53121	F	A											K	K	K	K
2590-53122	U	J											K			
2590-53123	U	J											K			
2590-53124	M	A											K			
2590-53125	M	J											K			
2590-53126	F	J											D			
2590-53127	F	J											K			
2590-53128	M	A														O
2590-53129	M	A														O
2590-53130	M	A														O
2590-53131	U	J														T
2590-53141	M	J											M			
2590-53142	M	J											M			
2590-53143	M	J											N			
2590-53144	F	J											K			
2590-53145	M	A											S			
2590-53147	U	J											D			
2590-53148	M	A											K	K		
2590-53149	M	J											K			
2590-53150	U	J											M			
2590-53151	M	J											M			
2590-53152	F	J											Q			
2590-53153	M	A												K		
2590-53154	M	J											Q			
2590-53155	U	J												M		
2590-53156	F	A												M	M	
2590-53157	F	J												M	D	D
2590-53158	U	J												K		
2590-53159	U	J													S	
2590-53160	F	J													S	S

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1d]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2590-53162	M	A											T			
2590-53163	F	A											B			
2590-53164	M	J											B			
2590-53165	F	A												B		
2590-53166	M	A												T		
2590-53167	M	A														T
2590-53168	M	A														T
2590-53169	U	J														K
2590-53171	F	A											E	K	K	K
2590-53172	M	J											K			
2590-53173	F	A											K	K		
2590-53174	U	J													S	
2590-53175	U	J														P
2590-53177	M	A													Q	
2590-53178	U	J													K	
2590-53179	U	J													K	
2590-53180	U	J													K	
2590-53181	U	J													K	
2590-53182	M	J											B			
2590-53183	U	J														P
2660-23001	M	A													K	K
2660-23002	U	J													M	
2660-23003	U	J													K	
2660-23004	U	J													K	
2660-23005	U	J													K	
2660-23006	U	J														P
2660-23007	M	J													S	S
2660-23008	U	J													S	
2660-23009	U	J													S	
2660-23010	F	J													S	S
2660-23011	U	J													S	
2660-23012	U	J												K		
2660-23013	U	J													S	
2660-23014	U	J												P		
2660-23015	U	J													S	
2660-23016	F	A													D	D
2660-23017	M	A													D	D
2660-23018	U	J													K	
2660-23019	U	J													K	
2660-23020	U	J													K	
2660-23021	M	J													K	P
2660-23022	U	J													K	
2660-23023	U	J													K	
2660-23024	U	J												M		
2660-23025	U	J													K	
2660-23026	U	J													K	

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2660-23027	U	J													K	
2660-23028	U	J													K	
2660-23029	M	A													K	K
2660-23031	M	J													K	K[15]
2660-23033	U	J													P	
2660-23034	U	J													K	
2660-23036	U	J														P
2660-23037	U	J														K
2660-23038	U	J														P
2660-23039	U	J														W
2660-23040	U	J														W
2660-23041	U	J														K
2660-23042	F	J													K	K
2660-23043	U	J														K
2660-23044	U	J														P
2660-23045	U	J														P
2660-23046	U	J														K
2660-23047	U	J														K
2660-23048	U	J														P
2660-23049	U	J														P
2660-23051	U	J														P
2660-23052	U	J														D
2660-23053	F	A														K
2660-23060	M	A														P
2660-23061	M	A														O
2660-23062	M	A														O
2660-23063	F	A														O
2660-23064	M	A														O
2660-23065	F	A														P
2660-23066	M	A														O
2660-23067	M	A														K
2660-23068	U	J														D
2660-23069	U	J														W
2660-23070	U	J														W
2660-23071	U	J														P
2660-23072	U	J														P
2660-23073	U	J														K
2660-23074	U	J														K
2660-23075	U	J														K
2660-23076	U	J														K
2660-23077	U	J														K
2660-23078	U	J														K
2660-23079	U	J														K
2660-23080	U	J														P
2660-23081	U	J														P
2660-23082	F	A														D

Table 8-1.—Willow flycatchers banded and/or resighted by SWCA along the Virgin and lower Colorado Rivers in 2010–14*

Original Federal band number	Sex[2]	Age when banded[3]	Study area detected[1]													
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2660-23083	F	A														D
2660-23085	U	J														O
2660-23086	U	J														O
2660-23087	M	A														B
2660-23089	U	J														T
2660-23090	U	J														T
2660-23091	M	A														O
2660-23092	U	J														B
2660-23095	U	J														K
2660-23096	U	J														K
2660-23098	U	J														P
2660-23099	U	J														P
2660-23100	F	A														P
2660-23102	M	A														O
2660-58330	U	J														W
9999-99999	M	A														K

* Table includes individuals banded at sites prior to 2010, including some individuals banded prior to 2003 (Braden and McKernan, unpublished data), and recaptured or resighted by SWCA between 2010 and 2014.

[1] K = Key Pittman WMA, E = River Ranch, P = Pahranagat NWR, W = Meadow Valley Wash, L = Littlefield, Q = Mesquite, M = Mormon Mesa, D = Muddy River, N = Warm Springs, G = Grand Canyon, T = Topock Marsh, B = Bill Williams River NWR, S = St. George, V = Las Vegas Wash, and O = Alamo Lake. Study area indicated is the study area where the individual was first detected during the given season. Within-season movements are indicated with individual footnotes.

[2] M = male, F = female, and U = unknown.

[3] A = adult, and J = juvenile.

[4] Within-season movement from Mesquite to Mormon Mesa.

[5] Within-season movement from Mormon Mesa to Mesquite, then from Mesquite back to Mormon Mesa.

[6] Within-season movement from Grand Canyon to Mesquite.

[7] Within-season movement from Mormon Mesa to Muddy River.

[8] Within-season movement from the Pahranagat NWR to Key Pittman WMA.

[9] Within-season movement from Muddy River to Mesquite.

[10] Within-season movement from Grand Canyon to Mormon Mesa.

[11] Within-season movement from River Ranch to the Key Pittman WMA.

[12] Within-season movement from the Pahranagat NWR to River Ranch.

[13] Likely within-season movement from Topock to Muddy River.

[14] Within-season movement from Muddy River to Mormon Mesa.

[15] Within-season movement from the Key Pittman WMA to Pahranagat NWR.

[16] Within-season movement from Mesquite to the Key Pittman WMA.

[17] Within-season movement from Mesquite to Muddy River.

ATTACHMENT 9

Temperature and Humidity at Flycatcher Nests at Topock Marsh, Bill Williams River National Wildlife Refuge, and Alamo Lake, 2014

Table 9-1.—Maximum daily temperature (°C) at flycatcher nests at Topock Marsh, Bill Williams River National Wildlife Refuge, and Alamo Lake, 2014*

Study area	Vegetation type[1]	June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
		Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)
TOPO	TASP (n = 3)	34.1 (32.6–35.6)	34.3 (0.5)	34.6 (33.1–36.1)	34.5 (0.4)	35.6 (33.6–37.1)	35.3 (0.4)	37.9 (35.4–39.8)	37.4 (0.4)	32.9 (31.6–35.6)	33.5 (1.1)
BIWI	TASP (n = 2)	n/a	n/a	35.1 (33.9–36.3)	34.7 (0.7)	35.4 (34.1–37.6)	35.9 (0.4)	35.9 (34.6–40.3)	37.3 (0.6)	32.9 (30.6–34.1)	33.3 (1.1)
ALAM	SAGO (n = 3)	39.6 (37.6–40.6)	39.4 (0.5)	42.1 (39.6–44.1)	41.9 (0.5)	42.6 (38.1–45.6)	41.8 (0.7)	46.1 (44.6–48.1)	45.0 (0.7)	46.3 (46.1–46.6)	46.3 (0.2)
	SAGO_TASP (n = 5)	37.1 (36.6–39.1)	37.8 (0.5)	42.1 (38.6–43.1)	41.0 (0.7)	42.1 (40.1–43.6)	41.4 (0.4)	44.1 (42.6–45.1)	43.7 (0.3)	43.1 (42.8–43.4)	43.1 (0.2)
	TASP_SAGO (n = 1)	48.1 (46.6–50.1)	47.9 (1)	52.1 (48.1–53.6)	51.1 (0.9)	48.6 (46.6–51.1)	47.9 (1.5)	51.1 (49.3–52.3)	50.6 (0.7)	52.1 (52.1–52.1)	52.1 (0)
	Overall	39.6 (37.6–43.1)	41.3 (0.8)	42.8 (40.1–45.6)	43.9 (0.6)	42.6 (40.1–45.6)	42.5 (0.5)	45.1 (43.1–47.6)	45.1 (0.4)	43.6 (43.1–46.6)	45.3 (1.3)

* n/a = data not available.

[1] TASP = tamarisk, SAGO = Goodding's willow, SAGO_TASP = Goodding's willow with tamarisk understory, TASP_SAGO = tamarisk with emergent Goodding's willow, and n = number of nests.

Table 9-2.—Minimum daily temperature (°C) at flycatcher nests at Topock Marsh, Bill Williams River National Wildlife Refuge, and Alamo Lake, 2014*

Study area	Vegetation type[1]	June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
		Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)
TOPO	TASP (n = 3)	18.6 (16.6–20.2)	18.6 (0.9)	19.6 (17.6–21.6)	19.4 (0.5)	23.6 (22.2–25.1)	23.5 (0.4)	23.1 (21.1–24.6)	22.8 (0.4)	22.6 (21.6–26.1)	23.5 (1.6)
BIWI	TASP (n = 2)	n/a	n/a	17.4 (15.9–18.6)	17.0 (0.5)	21.6 (19.1–22.1)	20.8 (0.4)	20.4 (17.6–22.4)	20.1 (0.5)	20.9 (17.1–22.6)	19.6 (1.1)
ALAM	SAGO (n = 3)	12.3 (10.6–13.6)	12.2 (0.5)	13.6 (12.1–16.6)	14.3 (0.5)	21.6 (20.1–22.6)	21.3 (0.3)	21.1 (18.6–22.1)	20.5 (0.5)	25.6 (25.1–26.1)	25.6 (0.5)
	SAGO_TASP (n = 5)	11.1 (9.6–12.6)	11.2 (0.7)	14.1 (12.1–17.6)	15.0 (0.9)	21.7 (21.1–22.7)	21.9 (0.3)	21.6 (18.9–23.1)	21.1 (0.4)	26.1 (25.9–26.1)	26.0 (0.1)
	TASP_SAGO (n = 1)	15.3 (14.1–18.6)	16.0 (0.8)	17.6 (16.1–19.6)	17.9 (0.6)	22.1 (21.1–24.1)	22.5 (0.5)	23.6 (21.1–24.3)	22.9 (0.6)	27.1 (27.1–27.1)	27.1 (0)
	Overall	13.1 (11.1–15.1)	13.0 (0.5)	15.4 (13.1–18.1)	15.3 (0.4)	21.6 (20.7–22.6)	21.7 (0.2)	21.6 (19.1–23.1)	21.2 (0.3)	26.1 (25.7–26.1)	26.0 (0.2)

* n/a = data not available.

[1] TASP = tamarisk, SAGO = Goodding's willow, SAGO_TASP = Goodding's willow with tamarisk understory, TASP_SAGO = tamarisk with emergent Goodding's willow, and n = number of nests.

Table 9-3.—Daily temperature range (°C) at flycatcher nests at Topock Marsh, Bill Williams River National Wildlife Refuge, and Alamo Lake, 2014*

Study area	Vegetation type[1]	June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
		Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)
TOPO	TASP (n = 3)	15.5 (14.0–18.0)	15.8 (0.8)	15.2 (13.0–17.5)	15.1 (0.6)	12.5 (9.5–14.0)	11.8 (0.6)	14.7 (11.5–17.5)	14.6 (0.5)	8.7 (8.0–12.0)	10.1 (1.7)
BIWI	TASP (n = 2)	n/a	n/a	18.0 (16.2–19.5)	17.7 (0.6)	15.0 (13.0–17.5)	15.1 (0.6)	17.2 (14.0–19.7)	17.2 (0.7)	14.5 (9.0–18.5)	13.7 (1.5)
ALAM	SAGO (n = 3)	27.5 (26.0–28.5)	27.2 (0.5)	27.7 (26–30.5)	27.6 (0.5)	20.5 (16.0–25.0)	20.5 (0.8)	24.5 (21.5–29.0)	24.5 (0.9)	20.7 (20.5–21.0)	20.7 (0.2)
	SAGO_TASP (n = 5)	27.0 (25.5–28.0)	26.6 (0.6)	26.0 (24.5–29.0)	26.0 (0.9)	20.0 (17.0–22.0)	19.5 (0.6)	22.7 (20.2–25.5)	22.6 (0.5)	17.2 (16.7–17.5)	17.1 (0.2)
	TASP_SAGO (n = 1)	31.2 (29.0–35.0)	31.9 (1.1)	34.0 (31.0–36.0)	33.2 (1.0)	25.0 (22.5–31.5)	25.4 (1.6)	28.0 (25.0–31.2)	27.7 (1.2)	25.0 (25.0–25.0)	25.0 (0.0)
	Overall	28.0 (26.5–29.5)	28.3 (0.5)	28.5 (25.5–30.5)	28.5 (0.5)	20.5 (17.0–24.5)	20.8 (0.5)	23.5 (20.5–27.9)	23.9 (0.5)	17.5 (17.0–21.0)	19.3 (1.2)

* n/a = data not available.

[1] TASP = tamarisk, SAGO = Goodding's willow, SAGO_TASP = Goodding's willow with tamarisk understory, TASP_SAGO = tamarisk with emergent Goodding's willow, and n= number of nests.

Table 9-4.—Mean diurnal vapor pressure (Pa) at flycatcher nests at Topock Marsh, Bill Williams River National Wildlife Refuge, and Alamo Lake, 2014*

Study area	Vegetation type[1]	June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
		Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)
TOPO	TASP (n = 3)	1574 (1465-1699)	1624 (68)	1845 (1671-2178)	1875 (67)	2798 (2640-2952)	2747 (54)	2542 (2172-2809)	2497 (52)	2623 (2556-2653)	2562 (112)
BIWI	TASP (n = 2)	n/a	n/a	2375 (2196-2518)	2375 (56)	2945 (2775-3160)	2897 (56)	2880 (2495-3045)	2781 (59)	2818 (2467-2881)	2698 (85)
ALAM	SAGO (n = 3)	1119 (1002-1289)	1146 (47)	1196 (1095-1454)	1230 (39)	2280 (1813-2444)	2152 (66)	1592 (1200-1796)	1569 (57)	1696 (1652-1741)	1696 (45)
	SAGO_TASP (n = 5)	1248 (1136-1370)	1269 (75)	1187 (1085-1334)	1208 (50)	2267 (1773-2401)	2093 (59)	1638 (1231-1903)	1614 (47)	1738 (1706-1791)	1749 (28)
	TASP_SAGO (n = 1)	737 (682-849)	760 (46)	791 (727-1124)	865 (51)	2075 (1333-2283)	1856 (147)	1383 (967-1654)	1355 (99)	1546 (1546-1546)	1546 (0)
	Overall	1086 (862-1280)	1072 (45)	1131 (968-1302)	1136 (33)	2248 (1704-2419)	2083 (44)	1605 (1200-1873)	1564 (35)	1719 (1652-1757)	1705 (33)

* n/a = data not available.

[1] TASP = tamarisk, SAGO = Goodding's willow, SAGO_TASP = Goodding's willow with tamarisk understory, TASP_SAGO = tamarisk with emergent Goodding's willow, and n = number of nests.

Table 9-5.—Mean nocturnal vapor pressure (Pa) at flycatcher nests at Topock Marsh, Bill Williams River National Wildlife Refuge, and Alamo Lake, 2014*

Study area	Vegetation type[1]	June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
		Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)	Median (25th– 75th percentile)	Mean (standard error)
TOPO	TASP (n = 3)	1317 (1238–1455)	1349 (43)	1550 (1431–1759)	1630 (59)	2458 (2205–2541)	2380 (42)	2275 (1953–2448)	2179 (43)	2349 (2124–2578)	2332 (118)
BIWI	TASP (n = 2)	n/a	n/a	1878 (1700–2010)	1852 (50)	2439 (2231–2615)	2394 (49)	2188 (1945–2427)	2191 (47)	2389 (1971–2513)	2270 (112)
ALAM	SAGO (n = 3)	1004 (957–1208)	1047 (39)	1142 (1088–1400)	1194 (39)	2244 (1881–2485)	2170 (60)	1662 (1425–1956)	1721 (61)	1775 (1773–1777)	1775 (2)
	SAGO_TASP (n = 5)	965 (938–1139)	1006 (54)	1068 (998–1215)	1105 (50)	2249 (1928–2479)	2173 (58)	1721 (1417–2002)	1762 (49)	1809 (1772–1843)	1808 (22)
	TASP_SAGO (n = 1)	688 (626–884)	737 (50)	893 (805–1158)	930 (59)	2081 (1448–2476)	2000 (132)	1512 (1181–1801)	1539 (109)	1707 (1707–1707)	1707 (0)
	Overall	957 (824–1044)	953 (34)	1095 (911–1230)	1106 (30)	2247 (1869–2479)	2147 (40)	1689 (1402–1964)	1719 (37)	1778 (1757–1829)	1784 (18)

* n/a = data not available.

[1] TASP = tamarisk, SAGO = Goodding's willow, SAGO_TASP = Goodding's willow with tamarisk understory, TASP_SAGO = tamarisk with emergent Goodding's willow, and n = number of nests.

ATTACHMENT 10

Bland-Altman Method

METHODS

Determining Acceptable Limits for Measurement Error

We calculated a threshold value for acceptable measurement error *a priori* for each microclimate variable using the following equation (Critchley and Critchley 1999; Cecconi et al. 2009):

$$CV_{A\text{-}B} = [(CV_A)^2 + (CV_B)^2]^{1/2}$$

where $CV_{A\text{-}B}$ = CV (coefficient of variation) of the differences (bias) between the two methods CV_A = CV of method A (HOBO) and CV_B = CV of method B (iButton). Method B would be considered an acceptable replacement for method A if the precision of measurements from method B is as good as or better than (i.e., CV is equal to or lower than) the precision of measurements from method A. If $CV_B < CV_A$ then:

$$CV_{(A\text{-}B)} = [(CV_A)^2 + (CV_B)^2]^{1/2} < [(CV_A)^2 + (CV_A)^2]^{1/2}$$

resulting in total measurement error < $[2*(CV_A)^2]^{1/2}$. Thus, we used $[2*(CV_{HOBO})^2]^{1/2}$ as the threshold for acceptable measurement error of the bias between HOBO and iButton measurements. Total measurement error of the bias is based on three sources of variation: error in method A, error in method B, and variation in the differences between measurement methods.

Within-subject variance for subjects (in our case, monitoring points) with repeated measurements can be contaminated by changing mean values for the variable being measured (Hopkins 2000). Generalized linear mixed models (GLMMs) can account for the effect of a changing mean by modeling the mean of the paired HOBO and iButton measurements on each measurement occasion (noted as "daily mean" in models below) as a fixed effect (Myles and Cui 2007). The within-group standard deviation from these models (i.e., the random effects) provides an estimate of standard deviation that is uncontaminated by the changing mean.

For each variable, we produced a diagnostic scatterplot of the iButton value on each measurement occasion plotted against the corresponding value measured by the HOBO. Perfect agreement between the methods would produce a line with slope = 1 and intercept = 0. We also produced a basic Bland-Altman plot of the difference between each pair of measurements plotted against the average of the pair of measurements. If these plots showed heterogeneity of variance with changing mean measurement values, we log-transformed the data before running GLMMs. We calculated CVs of log-transformed data as

$$CV = 100 * (e^{\text{within-subject SD of log-transformed measurement}} - 1)$$

while CVs of untransformed data were calculated as

$$CV = 100 * (\text{within-subject SD})/(\text{mean of all daily measurements}).$$

We ran the following GLMM models for each microclimate variable:

> Daily HOBO measurement ~ Daily mean + random intercept (point) + random slope (point)
>
> Daily iButton measurement ~ Daily mean + random intercept (point) + random slope (point)

We also ran models where the random effects were modeled as a point nested within a study area, but these models had higher Akaike's Information Criterion (AIC) values than the models where the point was the only random effect. Models were fit in R (version 3.03) using the **lme** function in the *nlme* package (Pinheiro et al. 2014). The output from these models for each microclimate variable included parameters for the fixed effect (mean of daily paired data logger measurements per point) and random intercept and slope effects. The variance of the model that was due to random effects was used as the within-subject variance ($[SD_{HOBO}]^2$ and $[SD_{iButton}]^2$), and SD_{HOBO} was used to calculate CV_{HOBO} and, thus, the threshold for acceptable measurement error $[2*(CV_{HOBO})^2]^{1/2}$.

Calculating Actual Measurement Error

We assessed whether the observed measurement error of the difference (bias) between HOBO and iButton readings fell within the threshold for acceptable measurement error by using GLMMs to calculate the within-subject standard deviation of the differences in measurements. We used these standard deviations to calculate 95-percent (%) limits of agreement (mean ± $1.96*SD_{bias}$) and then calculated percent error by dividing the difference in the limits of agreement by the mean value of the reference method (HOBO). Measurement error was then calculated as ± percent error/2. For variables that showed heterogeneity of variance with changing mean measurements, we log-transformed the data before running GLMMs, calculated limits of agreement for the transformed data, and then back-transformed the limits of agreement to obtain upper and lower ratios for iButton:HOBO values. We converted these ratios to percentages to calculate the total range of percent error and measurement error (Bland and Altman 1986).

We ran the following GLMMs for each microclimate variable:

> Difference (HOBO-iButton) ~ Random intercept (point) + random slope (point) (i.e., null model: no fixed effects)
>
> Difference (HOBO-iButton) ~ Daily mean + random intercept (point) + random slope (point)
>
> Difference (HOBO-iButton) ~ Daily mean + random intercept (a point nested within a study area)

For variables for which basic Bland-Altman plots suggested that bias was not linearly related to mean measurements, we also modeled the daily measurement difference as a quadratic and cubic function of the daily mean of measurements:

> Difference (HOBO-iButton) ~ Daily mean + (daily mean)^2 + random intercept (point) + random slope (point)
>
> Difference (HOBO-iButton) ~ Daily mean + (daily mean)^2 + (daily mean)^3 + random intercept (point) + random slope (point)

We selected the model with the lowest AIC value. We then used the within-subject standard deviation of the preferred model to calculate limits of agreement and measurement error as explained above.

Limits of agreement often overestimate measurement error when the relationship between the difference and mean of paired measurements is complex (Bland and Altman 1986). Therefore, we also plotted limits of agreement as diagonal lines on a Bland-Altman plot expressed using untransformed data with the original scale of measurement (Euser et al. 2008) and compared the actual measurement error with what was predicted by limits of agreement (Bland and Altman 1986). In this case, limits of agreement were diagonal lines because the limits had been back-transformed first. On the original scale, the limits represent ratios of the iButton values relative to the HOBO values at different values of HOBO daily and nightly vapor pressure (Euser et al. 2008).

RESULTS

Diagnostic Scatterplots and Basic Bland-Altman Plots

As expected, daily measurements of each microclimate variable as recorded by the iButtons were positively correlated with corresponding measurements from the HOBOs (figures 10-1–10-4). Throughout much of the range of recorded temperatures, iButtons tended to record higher maximum daily temperatures than did HOBO loggers as indicated by the slightly higher density of points above the line of agreement; however, at high temperatures, HOBO loggers appeared to record higher temperatures than did iButtons (figure 10-1). IButtons typically recorded lower minimum daily temperatures than did HOBO loggers as shown by most data points falling below the line of agreement (figure 10-2). For both diurnal and nocturnal vapor pressure, iButtons tended to measure higher vapor pressure than did HOBOs when humidity was low, but iButtons measured lower vapor pressure than did HOBOs when humidity was high (figures 10-3 and 10-4).

Basic Bland-Altman plots (figures 10-5–10-7) showed that variability in the bias between data logger types increased as measurement values increased for mean diurnal and nocturnal vapor pressure but not for daily maximum and minimum temperature. Log-transformation visibly decreased this heteroscedasticity (figures 10-6–10-7), and we log-transformed all vapor pressure data before running GLMMs.

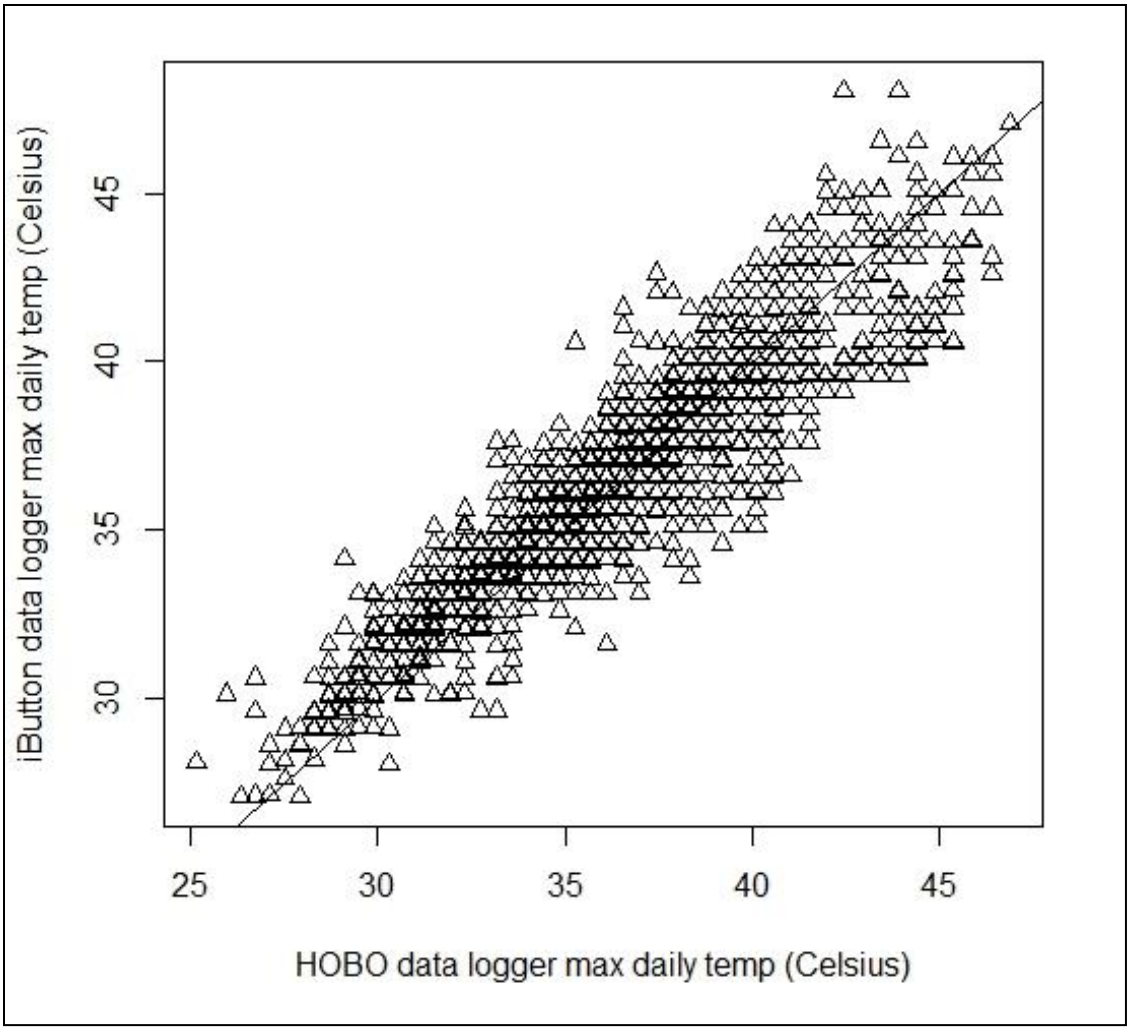


Figure 10-1.—Diagnostic scatterplot of maximum daily temperature measurements from iButton data loggers plotted against the corresponding HOBO data logger values at 31 beetle monitoring points, Topock Marsh and the Bill Williams River National Wildlife Refuge, May 15 – July 31, 2014 (n = 2,283 paired observations).

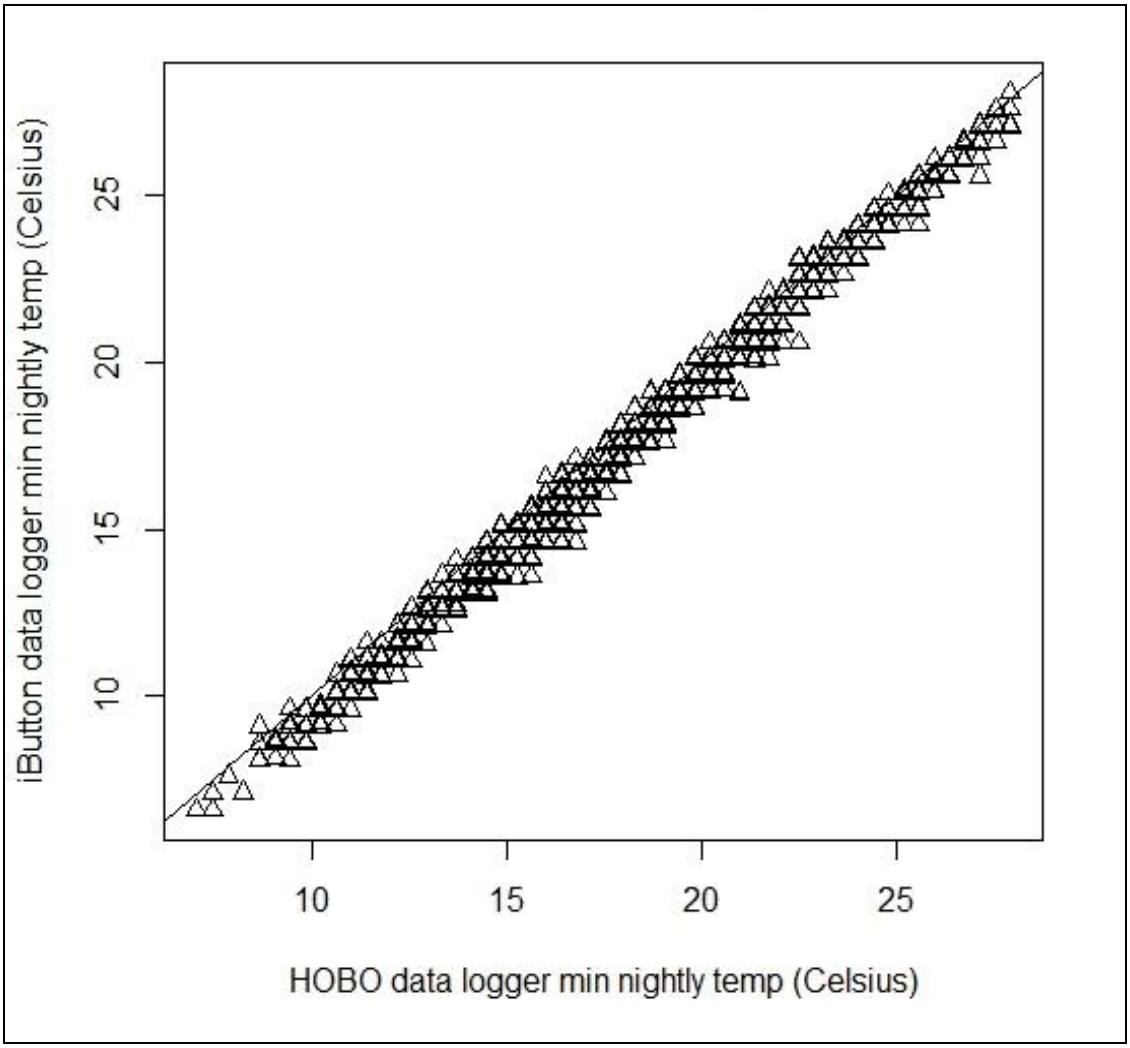


Figure 10-2.—Diagnostic scatterplot of minimum daily temperature measurements from iButton data loggers plotted against the corresponding HOBO data logger values at 31 beetle monitoring points, Topock Marsh and the Bill Williams River National Wildlife Refuge, May 15 – July 31, 2014 (n = 2,283 paired observations).

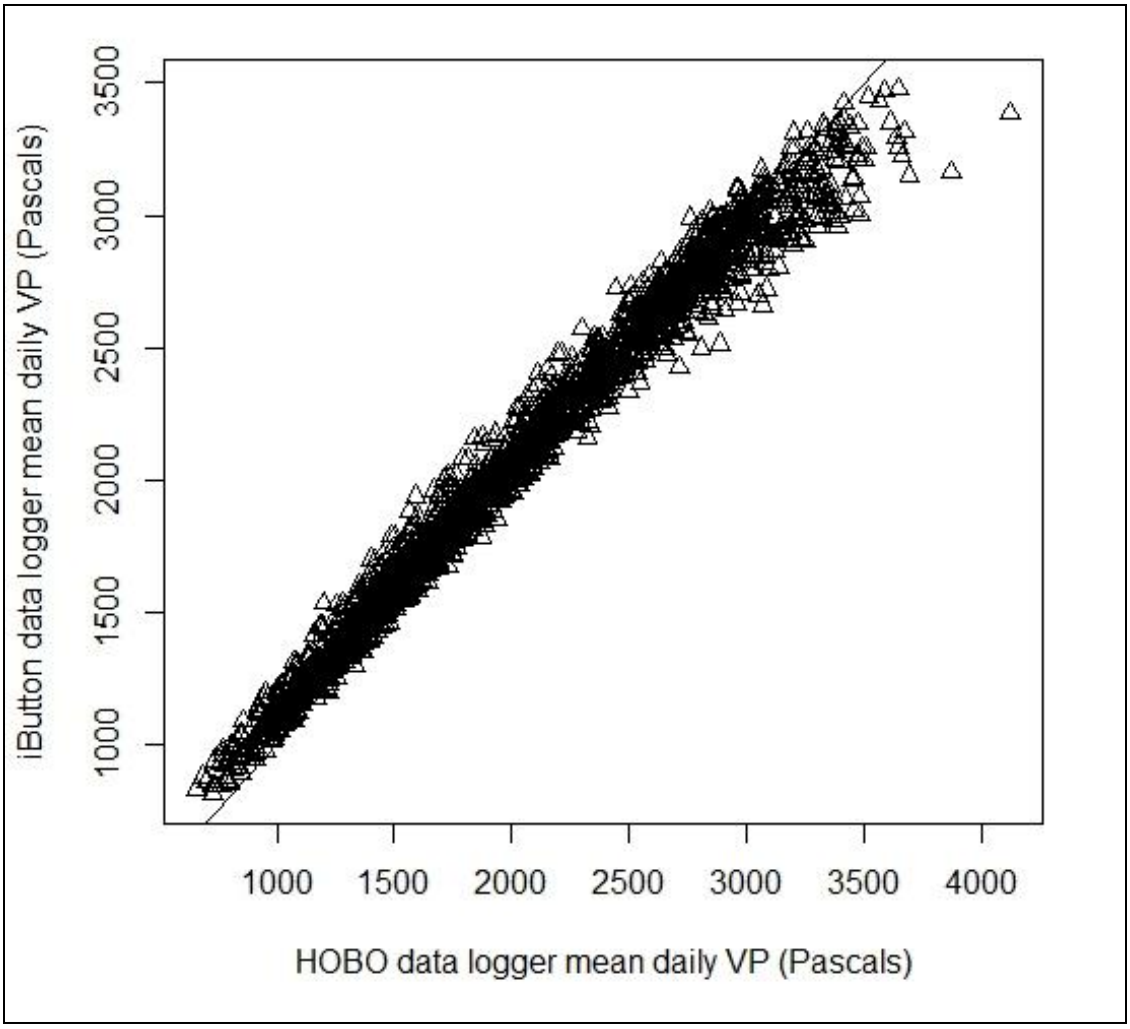


Figure 10-3.—Diagnostic scatterplot of mean diurnal vapor pressure measurements from iButton data loggers plotted against the corresponding HOBO data logger values at 31 beetle monitoring points, Topock Marsh and the Bill Williams River National Wildlife Refuge, May 15 – July 31, 2014 (n = 2,283 paired observations).

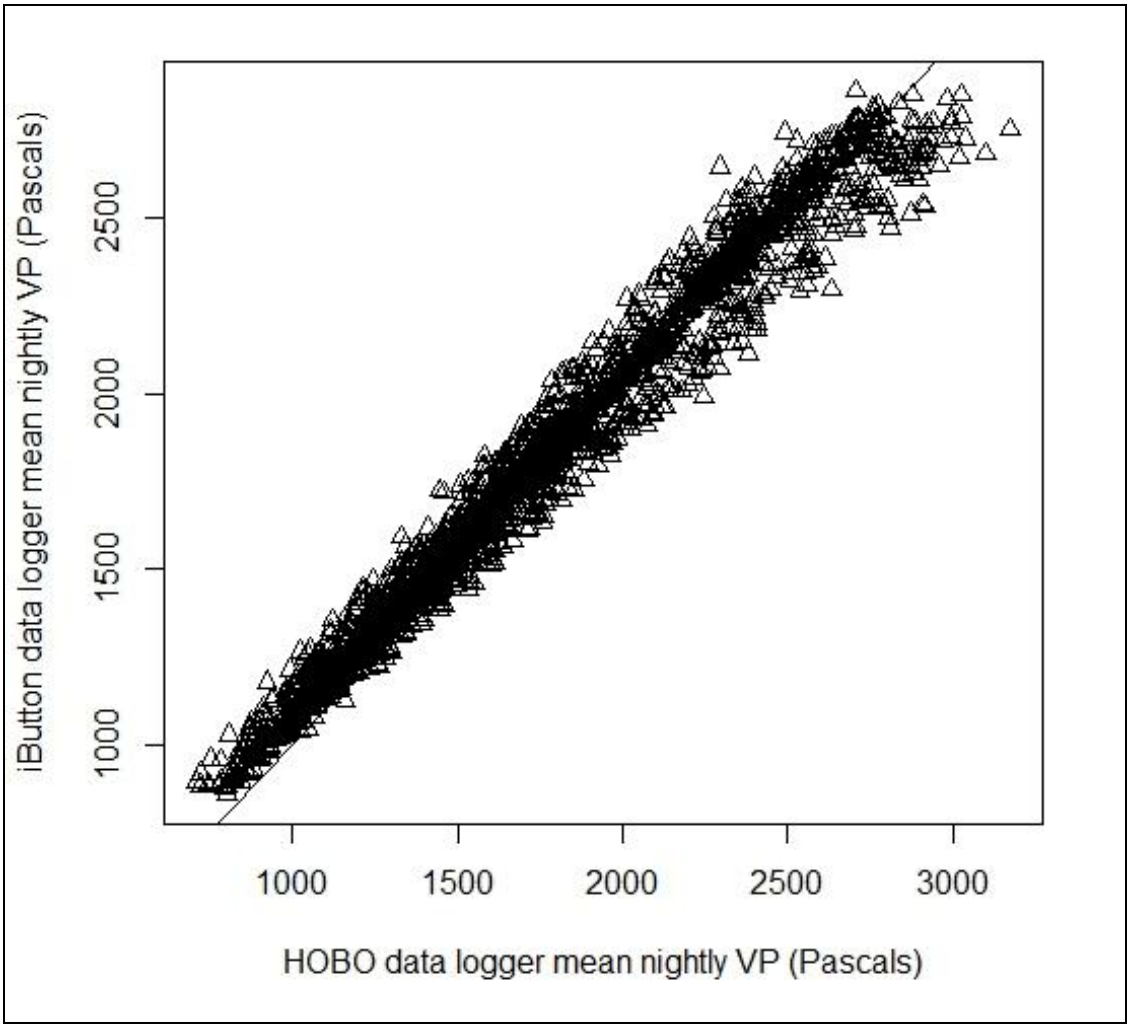


Figure 10-4.—Diagnostic scatterplot of mean nocturnal vapor pressure measurements from iButton data loggers plotted against the corresponding HOBO data logger values at 31 beetle monitoring points, Topock Marsh and the Bill Williams River National Wildlife Refuge, May 15 – July 31, 2014 (n = 2,283 paired observations).

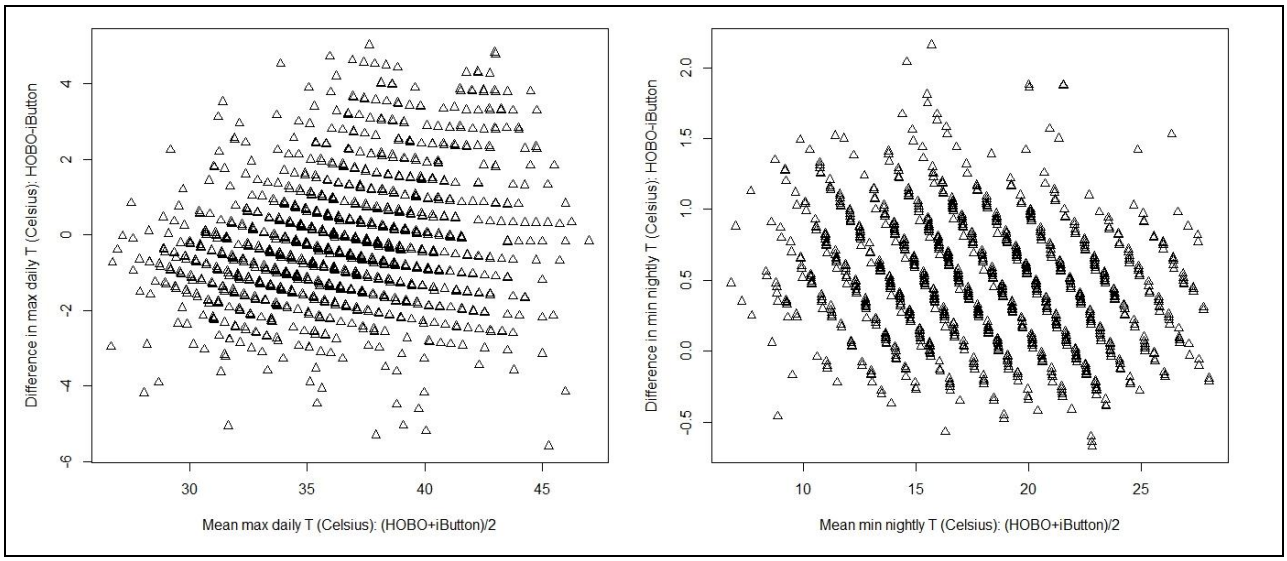


Figure 10-5.—Plots of daily differences (HOBO - iButton) against daily means of paired measurements of daily maximum and minimum temperature at 31 beetle monitoring points, Topock Marsh and the Bill Williams River National Wildlife Refuge, May 15 – July 31, 2014 (n = 2,283 paired observations).

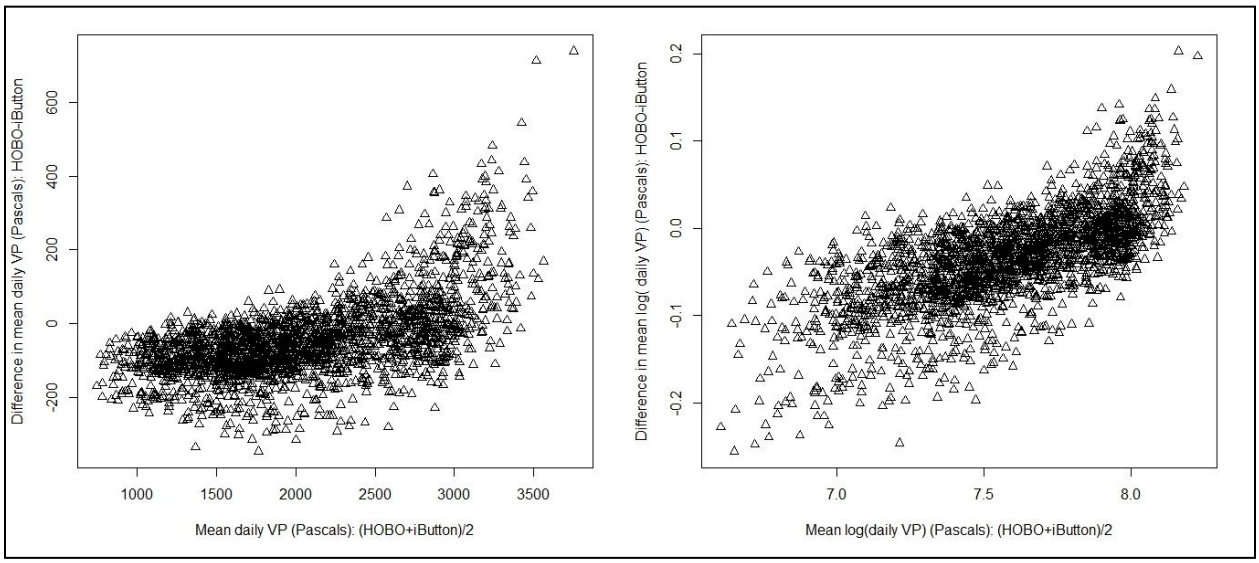


Figure 10-6.—Plots of daily differences (HOBO - iButton) against daily means of paired measurements of mean diurnal vapor pressure at 31 beetle monitoring points, Topock Marsh and the Bill Williams River National Wildlife Refuge, May 15 – July 31, 2014 (n = 2,283 paired observations). Log-transformed data were less heteroscedastic, and differences were modeled as a cubic function of the means.

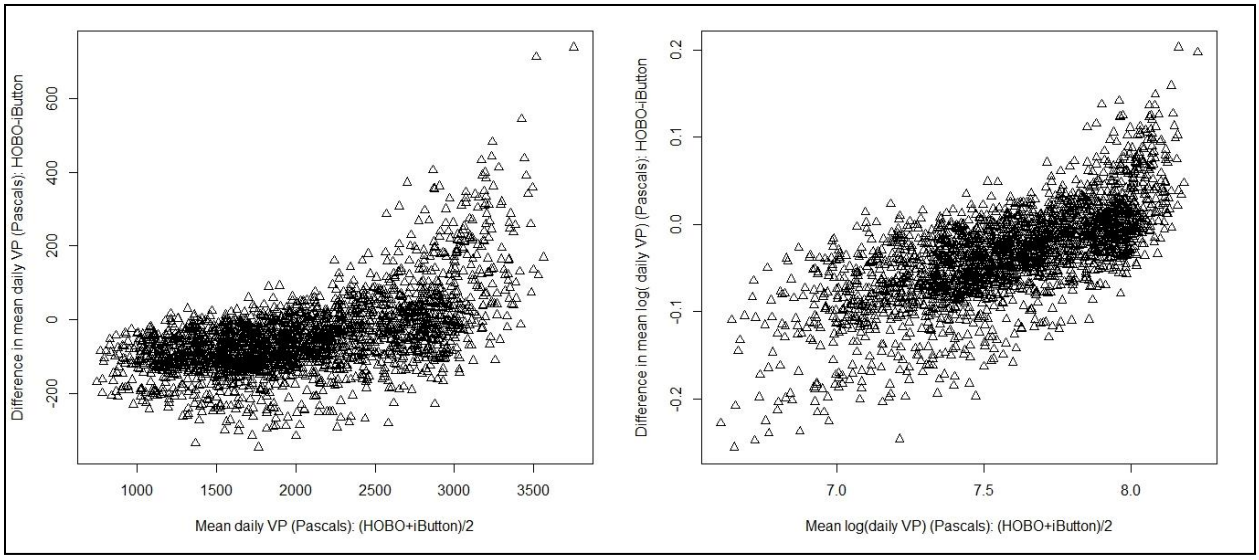


Figure 10-7.—Plots of daily differences (HOBO - iButton) against daily means of paired measurements of mean nocturnal vapor pressure at 31 beetle monitoring points, Topock Marsh and the Bill Williams River National Wildlife Refuge, May 15 – July 31, 2014 (n = 2,283 paired observations). Log-transformed data were less heteroscedastic, and differences were modeled as a cubic function of the means.

Determining Acceptable Limits for Measurement Error

Within-subject coefficients of variation for HOBO data logger measurements were below 1.5% for all microclimate variables, and CVs of iButton measurements were similar to those of HOBO measurements for all variables (table 10-1). Using the HOBO CVs, we calculated maximum allowable measurement error between paired iButton and HOBO values of ± 3.95% (maximum daily temperature), ± 2.33% (minimum daily temperature), ± 2.87% (mean daily vapor pressure), and ± 2.46% (mean nightly vapor pressure).

Table 10-1.—Within-subject standard deviation (SD) and coefficients of variation (CV) estimated via linear mixed models for HOBO and iButton data loggers*

Variable	SD_{HOBO}	$SD_{iButton}$	CV_{HOBO}	$CV_{iButton}$
Maximum daily temperature	0.51	0.51	1.40	1.39
Minimum nightly temperature	0.15	0.15	0.82	0.85
Mean diurnal vapor pressure	0.0101[1]	0.0100[1]	1.01	1.01
Mean nocturnal vapor pressure	0.0086[1]	0.0083[1]	0.87	0.83

* All models included the daily mean of the HOBO and iButton measurements as a fixed effect.
[1] SD based on log-transformed data.

Calculating Measurement Error

Mean diurnal and nocturnal vapor pressure were heteroscedastic, and we log-transformed data for both variables; maximum and minimum daily temperatures were analyzed without log transformation. For each dependent variable, the model (Difference [HOBO-iButton] ~ Daily mean + random intercept [point] + random slope [point]) had a higher log-likelihood and lower AIC than the null model or a model with the same fixed effect but random effects of a point nested within a study area. We used the within-subject standard deviation from this model to calculate 95% limits of agreement and measurement error for daily maximum and minimum temperature. Diagnostic scatterplots showed that bias in mean diurnal and nocturnal vapor pressure appeared to be non-linearly related to mean measurements, and we modeled the daily measurement difference as a quadratic and cubic function of the daily mean of measurements for these variables. The model containing the cubic function had the lowest AIC for both variables, and we used this model (Difference [HOBO-iButton] ~ Daily mean + [daily mean]^2 + [daily mean]^3 + random intercept [point] + random slope [point]) to obtain within-subject standard deviation and calculate measurement error.

For all four microclimate measures, the percent error calculated from GLMMs of the differences between HOBO and iButton readings exceeded the threshold measurement error calculated from HOBO data (table 10-2, figures 10-8–10-11). Percent error exceeded the threshold to the greatest degree for maximum daily temperature (5.63 versus 3.95%, respectively) and to the least degree for mean diurnal vapor pressure (3.50 versus 2.87%, respectively). Measurement error was probably underestimated by the limits of agreement for both diurnal and nocturnal vapor pressure, with most observed bias being within ± 200 Pa (9.84% of mean HOBO value) and ± 150 Pa (8.64% of mean HOBO value), respectively (figures 10-10 and 10-11).

Table 10-2.—Average bias, within-subject standard deviation (SD), percent measurement error, and measurement error thresholds for microclimate data recorded by HOBO and iButton data loggers

Variable	Average bias	SD_{bias}	% error	Threshold (%)
Maximum daily temperature (degrees Celsius [°C])	-0.184 °C	1.049 °C	5.63	3.95
Minimum nightly temperature	0.484 °C	0.301 °C	3.23	2.33
Mean diurnal vapor pressure	-45.98 Pa	0.0194[1]	3.50	2.87
Mean nocturnal vapor pressure	-49.87 Pa	0.0165[1]	3.50	2.46

[1] Based on log-transformed data.

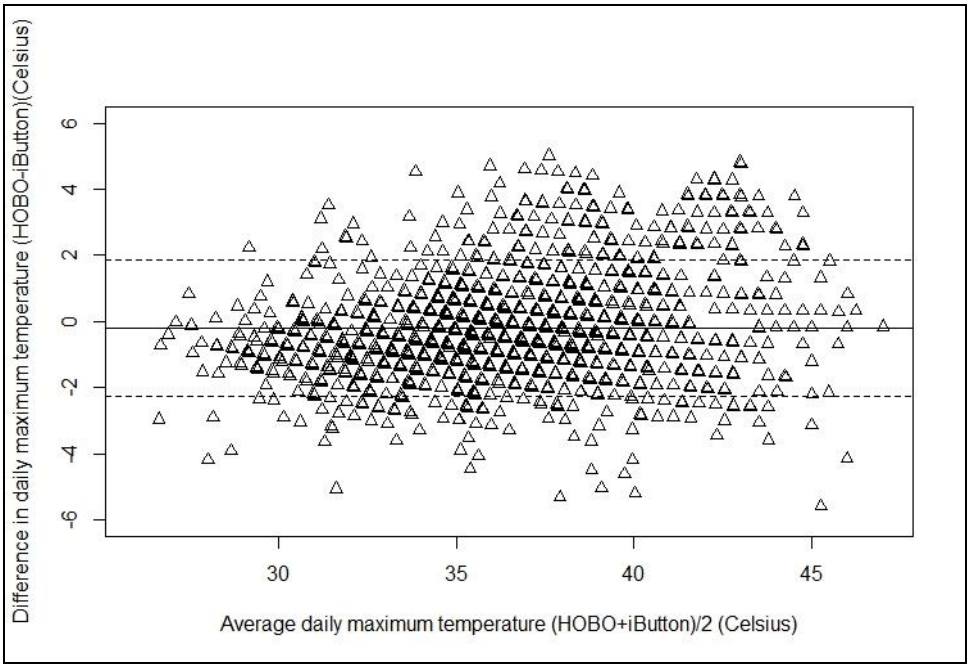


Figure 10-8.—Final Bland-Altman plot for maximum daily temperature recorded by HOBO and iButton data loggers at 31 beetle monitoring points at Topock Marsh and the Bill Williams River National Wildlife Refuge, May 15 – July 31, 2014 (n = 2,283 paired observations). Dotted lines are acceptable limits of measurement error estimated with linear mixed models.

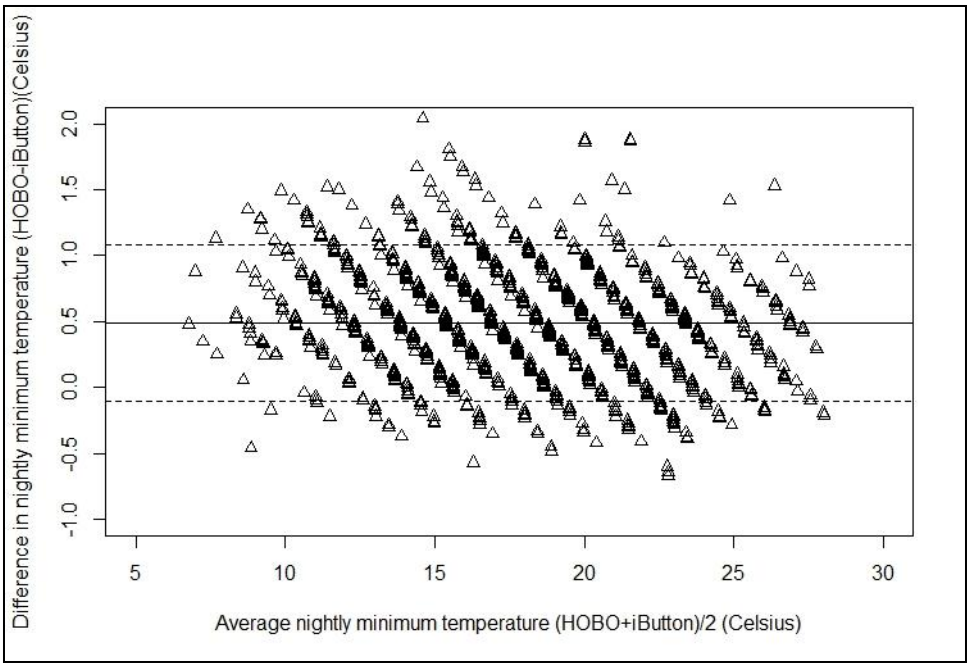


Figure 10-9.—Final Bland-Altman plot for minimum daily temperature recorded by HOBO and iButton data loggers at 31 beetle monitoring points at Topock Marsh and the Bill Williams River National Wildlife Refuge, May 15 – July 31, 2014 (n = 2,283 paired observations). Dotted lines are acceptable limits of measurement error estimated with linear mixed models.

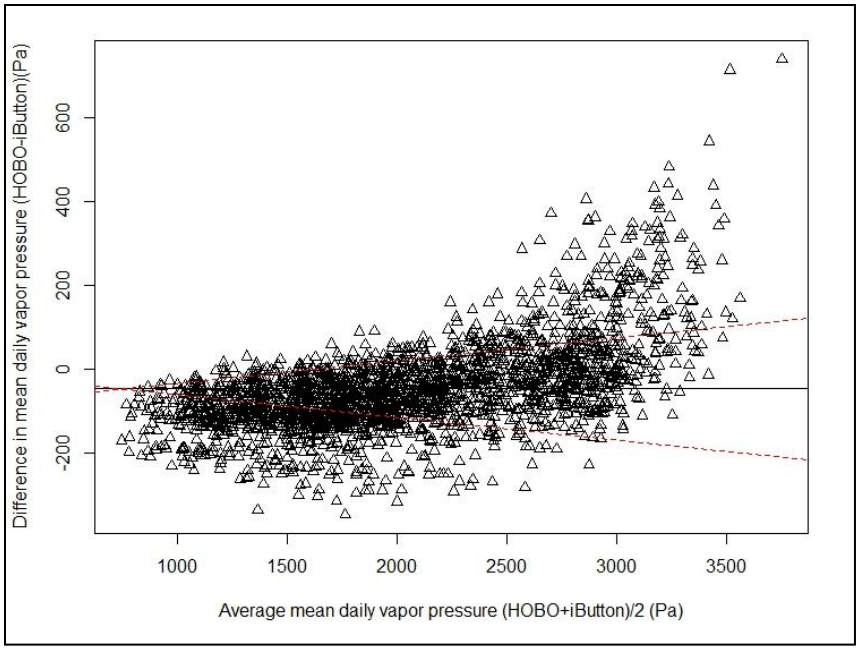


Figure 10-10.—Final Bland-Altman plot for mean diurnal vapor pressure recorded by HOBO and iButton data loggers at 31 beetle monitoring points at Topock Marsh and the Bill Williams River, May 15 – July 31, 2014 (n = 2,283 paired observations). Dotted lines are acceptable limits of measurement error estimated with linear mixed models.

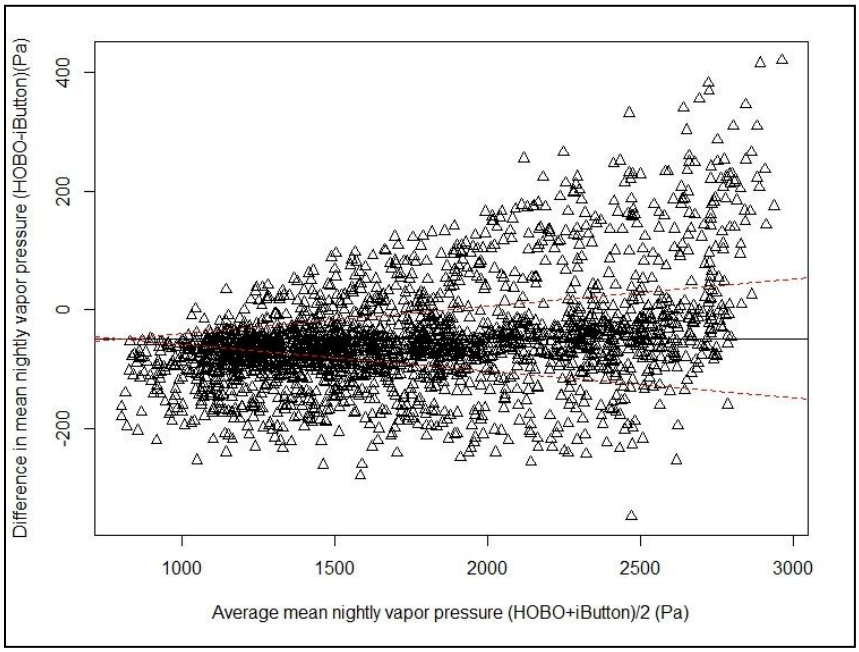


Figure 10-11.—Final Bland-Altman plot for mean nocturnal vapor pressure recorded by HOBO and iButton data loggers at 31 beetle monitoring points at Topock Marsh and the Bill Williams River National Wildlife Refuge, May 15 – July 31, 2014 (n = 2,283 paired observations). Dotted lines are acceptable limits of measurement error estimated with linear mixed models.

DISCUSSION

Measurement Error from Limits of Agreement

Measurement errors calculated from limits of agreement between HOBO and iButton data loggers were more than the allowable thresholds we calculated from the CVs of variables using HOBO data loggers as the reference. If we used the methods of Critchley and Critchley (1999) and Cecconi et al. (2009) for setting allowable thresholds of measurement error for each variable, we would conclude that we probably should not combine unpaired iButton and HOBO data from separate years in the same analysis because the measurement error for all variables exceeded the calculated thresholds. On the other hand, the measurement error that we calculated for each variable was much smaller than the allowable thresholds calculated for other studies (≈ 30%) (Critchley and Critchley 1999). The absolute amount of error may be more important, and whether or not data from different data loggers are used in the same analysis or model should depend on whether the absolute error is as large as a significant difference in a variable influencing habitat selection or nesting success of Southwestern Willow Flycatchers.

In the Bland-Altman method, measurement error is calculated around a constant bias; if bias is not constant across the range of values being measured, measurement error may exceed the allowable threshold calculated from the CVs even though the two methods may be equally precise. Given the generally greater precision of iButton measurements relative to corresponding HOBO measurements, the main issue is if we can confidently predict iButton values from HOBO values or vice versa (due to sufficiently low measurement error) and thus include unpaired iButton data and HOBO data from separate years of the southwestern willow flycatcher study in the same analyses. In contrast to a single mean bias and measurement error estimate from limits of agreement, regression lines and 95% prediction intervals in a Bland-Altman plot show how bias and measurement error change with individual values of the mean of measurements. Also in contrast to the limits of agreement method, the measurement error from a regression line's prediction intervals may vary with increases in the means of values being measured whether or not the data are log-transformed before doing the regression.

Measurement errors from the prediction intervals of regression are absolute values in the same units as the variables being measured by data loggers. For the southwestern willow flycatcher study, whether or not these values are acceptably small could be determined by what temperature or humidity difference we consider to be a biologically significant difference (e.g., between occupied and unoccupied sites or between failed and successful nests). Maximum daily temperature and mean diurnal and nocturnal vapor pressure differed significantly between occupied and unoccupied sites (McLeod and Pellegrini 2013; Table 7.18, all study sites combined), with maximum daily temperature being 2.1 degrees Celsius higher on average at unoccupied sites than at occupied sites, while mean diurnal and nocturnal vapor pressures were on average 151.7 and 154.7 Pascals, respectively, lower at unoccupied versus occupied sites. If we used these values as thresholds, then measurement errors between iButton and HOBO data loggers will be within these thresholds for most HOBO values.

ATTACHMENT 11

Contributing Personnel

Contributor	Role
Mary Anne McLeod, M.S.	Project Manager/Scientific Investigator/Field Supervisor
Anne Pellegrini, M.S.	Project Coordinator/Scientific Investigator/Field Supervisor
Thomas J. Koronkiewicz, M.S.	Banding Lead
Glenn A. Dunno, M.A.	Geographic Information System Specialist
Kimberly Proa	Project Administrator/Data Entry/Formatting Specialist
Dorothy A. House, M.A.	Technical Editor
Callie Gesmundo	Field Coordinator/Bander
Sarah Nichols	Field Coordinator/Bander
Katie Barnes, M.S.	Bander/Nest Monitor
Marissa Buschow, M.S.	Bander/Nest Monitor
Wanda Bruhns	Nest Monitor/Surveyor
Sam Flake	Nest Monitor/Surveyor
Jazelle Mondeau	Nest Monitor/Surveyor
Nate Turner	Nest Monitor/Surveyor
Heath Weaver, M.S.	Nest Monitor/Surveyor