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, 2008-2012. Summary Report

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April 2013

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Lower Colorado River Multi-Species Conservation Program

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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 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 nonnative plants; and brood parasitism by Brown-headed Cowbirds (*Molothrus ater*).

Willow flycatcher studies have been conducted along the Virgin and lower Colorado Rivers and tributaries annually since 1996, in compliance with requirements set forth by the U.S. Fish and Wildlife Service (USFWS) regarding U.S. Bureau of Reclamation (Reclamation) routine operations and maintenance along the lower Colorado River. Biological Assessments and the resulting Biological Opinions on operations and maintenance were prepared as steps to developing a Multi-Species Conservation Program (MSCP) for long-term endangered species compliance and management in the historical floodplain of the lower Colorado River (LCR). The LCR MSCP was signed in April 2005, and implementation of the program began in October 2005. The LCR MSCP calls for continued surveys and monitoring of willow flycatchers along the lower Colorado River. 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 Virgin and lower Colorado River regions in 2003–2012.

Reclamation and 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 of California apportionment water for 75 years. The point of diversion, previously located below Parker Dam, would change to a point above Parker Dam. These changes in water regulation could cause a drop in floodplain groundwater levels of 1.55 feet (0.47 m) or less and have the potential to modify riparian habitats below Parker Dam. A Biological Opinion for Interim Surplus Criteria, Secretarial Implementation Agreements, and Conservation Measures was issued in January 2001 and required monitoring of 150.5 ha of existing, occupied Southwestern Willow Flycatcher habitat between Parker and Imperial Dams. In 2004, Reclamation biologists initiated studies of the microclimate within potentially affected areas. In 2005, these studies were continued and expanded by SWCA to address how the hydrological changes might affect riparian habitats along the Parker to Imperial reach.

Following the breeding season of 2008, USFWS and Reclamation initiated discussions regarding the declining number of willow flycatcher territories at Topock Marsh, the importance of the flycatcher population in the Topock area to flycatcher conservation along the LCR, and possible measures to enhance flycatcher habitat at Topock. A plan was developed to pump water into a portion of the flycatcher breeding habitat at Topock beginning in February or March and continuing into the flycatcher breeding season. Water delivery commenced 1 March 2011 and continued into July. Baseline conditions of vegetation, microclimate, and hydrology in the target area were documented in 2009 and 2010, and these studies were continued in 2011 to document conditions during the water delivery period. Conditions of microclimate and hydrology were monitored again in 2012 to assess the effectiveness of a new water delivery canal at Topock Marsh.

SWCA was retained by Nevada Department of Wildlife (NDOW) in 2010–2012 to complete flycatcher surveys, site descriptions, nest monitoring, and color-banding at Key Pittman Wildlife Management Area (WMA), River Ranch, and Warm Springs Natural Area. We also completed surveys for Yellow-billed Cuckoos at these study areas.

A total of 113 sites was included in the Reclamation study of flycatchers along the Virgin and lower Colorado Rivers in 2008–2012, but a portion of the sites were surveyed biennially rather than annually. At study areas where territorial flycatchers were detected, we searched for nests in all areas occupied by territorial flycatchers; 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 document movement and recruitment. We also measured characteristics of vegetation and microclimate in occupied flycatcher territories.

Surveys – In 2008–2012, we completed presence/absence surveys, following a 5-survey protocol, and site descriptions in at least one year at 113 sites in 17 Reclamation study areas. We detected resident or breeding flycatchers at 33 sites in nine study areas (Pahranagat National Wildlife Refuge [NWR], Littlefield, Mesquite, Mormon Mesa, Muddy River, Grand Canyon, Topock Marsh, Bill Williams River NWR, and Ahakhav).

We completed broadcast surveys or monitored flycatchers at 24 sites in three NDOW study areas in 2010–2012. We detected resident or breeding flycatchers in at least one year at 20 sites in all three study areas (Key Pittman, River Ranch, and Warm Springs). We also completed broadcast surveys for Yellow-billed Cuckoos at the three NDOW study areas. No cuckoos were detected during surveys, and one cuckoo was detected incidentally at Warm Springs in 2010.

From 2003 to 2012, surveys at sites south of the Bill Williams River resulted in 43 to 591 detections annually. Monitoring results and behavioral observations (lack of territorial, aggressive behaviors exhibited toward conspecific broadcasts) at these sites suggest most of these flycatchers were not resident or breeding individuals but were migrants. Banding studies in the Yuma area completed in 2003–2007 also suggested that willow flycatchers detected in mid-June were migrants. Only one resident individual was recorded south of the Bill Williams River in 2003 to 2012. This individual was detected at the Ahakhav study area in 2008, and was not observed singing unsolicited, but instead was responsive to playback on multiple visits and remained in the same location for over one week. Because of the lack of evidence of residency in individuals detected after 15 June south of the Bill Williams River, the currently recommended guideline of 24 June is more appropriate for determining site occupancy status.

Color-banding and Resighting – 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 8 and 10 days of age. From 2003 to 2007, we banded each adult and fledged willow flycatcher with a numbered U.S. federal aluminum band on one leg (either standard issue silver or anodized) and a metal, pin-striped color-band on the other. Nestlings were banded with only a single anodized (colored), numbered federal band, uniquely identifying each bird as a returning nestling in the event it returned in a subsequent year. We found that we were unable to capture and identify all returning nestlings to individual due to either a brief window of detection or difficulty with recapture due to dense vegetation. To remedy this, from 2008 to 2012 we banded each nestling with a numbered U.S. federal aluminum band (either standard issue silver or anodized) on one leg and a metal, pin-stripe color-band on the other.

From 2003 to 2012, field personnel captured 252 new adult flycatchers and banded 555 nestlings from 240 nests at Reclamation study areas. Of these nestlings, 41 were known or suspected to have died before fledging. We captured an additional 18 fledglings that were not banded as nestlings. In 2010–2012 at NDOW study areas, we color-banded 31 new adult flycatchers and banded 94 nestlings from 38 nests.

Of these nestlings, seven were known or suspected to have died before fledging. We captured one additional fledgling that was not banded as a nestling.

From 2003 to 2012, we observed 34 banded individuals with leg injuries. We observed over three times the rate of leg injuries with celluloid-plastic bands (16%) compared to metal color-bands (5%). The rate of leg injuries with metal color-bands was roughly the same as that with federal bands (3%).

Fledgling gender ratio was female biased in the Pahranagat Valley (57% female), male biased in the Virgin Valley (38% female), and not different from 50:50 in the Havasu area (48% female). Adult gender ratios did not reflect the underlying fledgling gender ratios.

Adult flycatchers exhibited strong between-year site fidelity, with half of all adult between-year movements being 40 m or less, and less than 20% of adults moving more than 1 km between years. Over 70% of juveniles, in comparison, dispersed over 1 km from their natal territories, and 90% of all recorded dispersal movements were 75 km or less.

Demography – Survival and detection probabilities for individuals banded and resighted at all study areas were estimated using program MARK 6.1. We used both bootstrap and median c-hat procedures to test goodness of fit of global models and used Akaike Information Criteria (AIC) to select among competing models. We did not have an adequate sample size to estimate survival and detection separately by study area, so we created separate encounter histories for three geographic regions: Pahranagat Valley (Key Pittman WMA and Pahranagat NWR), Virgin River Valley (St. George, Littlefield, Mesquite, Mormon Mesa, Muddy River, Warm Springs, and Grand Canyon), and Havasu (Topock Marsh and Bill Williams). We modeled the effect of age (juvenile versus adult), gender, the interaction of age with gender, and the additive effect of year (for both juveniles and adults) on survival probabilities. For detection probabilities, we modeled the effects of age (second-year versus all other adults), gender, contract time period (TP), and the interactions of age with gender as well as of age with TP. We chose to model the effect of TP because marking techniques varied between contract periods, and effort may have varied. For individuals marked as adults, we examined the effect of the first contract time period (1997–2002) versus the following two combined (2003–2012). For individuals marked as juveniles, we examined the effect of each contract time period on detection probability separately (1997–2002; 2003–2008; 2009–2012), because different marking techniques were used in each of the three periods. We calculated lambda (λ), the per capita annual growth rate of the population, using the following equation: λ = adult survivorship + (juvenile survivorship x seasonal fecundity/2) + immigration. Immigration was calculated from estimates of annual recruitment generated by Pradel models in program MARK. We also determined population trends for each geographic area using an average annual rate of change calculation based on a moving average and a linear regression based on the observed annual number of resident adults.

In the Pahranagat Valley, the top model indicated that survival probability varied by age and gender and detection probability varied by age (second-year versus older adults), TP, and gender. In the Virgin Valley, survival varied by age, and detection varied by age and TP. In the Havasu area, both survival and detection probabilities varied by age and gender. There was evidence that adult male survival was higher (68%) than adult female survival (56%) in the Pahranagat Valley, but adult survival did not differ between the genders in either of the other two geographic areas (46% for Havasu and 61% for Virgin Valley). The adult survival estimate in the Havasu area was lower than in either of the other two geographic areas, which were similar to one another. Across all geographic areas, all juvenile survival estimates (13–39%) were lower than any of the survival estimates for adults (46–68%). Juvenile survival estimates were lowest for females at Havasu (13%) and Pahranagat (20%), and similar for all other estimates (39%, 32%, and 34% for Pahranagat Valley males, Virgin Valley, and Havasu males, respectively). Juvenile survival probability decreased through the season with increasing fledge date, corresponding to a 21% reduction in survival probability between 30 June and 1 August. Adult detection probability increased from the first TP to the second in the Pahranagat and Virgin Valleys but did not vary

between TPs in the Havasu area. Detection probability was higher for females than males in the Pahranagat Valley, but lower for females than males in the Havasu area. Second-year detection probabilities ranged from 29 to 72% and were lower than their respective adult detection probabilities in all three geographic areas. Second-year detection probabilities increased from the second to the third contract time periods in the Pahranagat Valley, but not for the Virgin Valley or Havasu area.

Mean life expectancy for males ranged from 1.7 to 2.5 years after fledging and was highest in the Pahranagat Valley. It ranged from 0.7 to 1.8 years post-fledging for females and was highest in the Virgin Valley. Estimates for both genders were lowest in the Havasu area. Maximum observed age across all geographic areas was at least 12 years old for males and 10 years old for females.

The probability of recruitment and number of recruited fledglings at a particular nest location was predicted by the number of banded fledglings and fledge date. On average, recruiting nests fledged earlier (8 Jul for 3 recruits, 6 Jul for 2 recruits, and 14 Jul for 1 recruit) than non-recruiting nests (19 Jul). The proportion of recruiting nests was higher for nests with four banded fledglings (63%) than those with only one banded fledgling (13%).

Estimates of λ varied among the three geographic areas, with the Pahranagat, Virgin, and Havasu areas having λ values of 1.12, 1.12, and 1.06, respectively. These λ estimates are not directly comparable to the λ estimates presented in our previous summary report (McLeod et al. 2008a), which did not include estimates of immigration. Average immigration was highest in the Havasu area (0.50) and lowest in the Pahranagat Valley (0.17). Calculations of population trends from the total number of observed residents in each geographic region resulted in estimates of the annual rate of change that were considerably lower than the λ estimates for the three geographic areas (-1%, 1%, and -6%, respectively). The difference in λ estimates and the average annual rates of change as calculated through moving averages and linear regression indicate that the λ estimates are potentially biased high.

Nest Monitoring – From 2003 to 2012, we documented 688 willow flycatcher nesting attempts at Pahranagat, Littlefield, Mesquite, Mormon Mesa, Muddy River, Grand Canyon, Topock Marsh, and Bill Williams; 611 of these nests were known to contain flycatcher eggs and were used in calculating nest success and productivity. Two hundred sixty-nine (44%) nests were successful and fledged young, and 328 (54%) failed. Fate was unknown for 14 nests (2%). For all years combined, nest success ranged from 0% at Grand Canyon to 68% at Pahranagat. Mayfield survival probability ranged from 0.213 at Grand Canyon to 0.659 at Pahranagat and was 0.437 for all sites combined. Mayfield survival probabilities did not differ from apparent nest success at most study areas. Depredation was the major cause of nest failure, accounting for 46% (185 of 405) of all failed nests and 56% (185 of 328) of nests that failed after flycatcher eggs were laid. One hundred twenty-three of 555 nests (22%) with flycatcher eggs and known contents were brood parasitized by Brown-headed Cowbirds. An additional 17 nests were parasitized prior to flycatcher eggs being laid and were subsequently abandoned. For nests containing flycatcher eggs, parasitism caused nest failure at 32 nests. Brood parasitism ranged from 0% at Pahranagat to 48% at Muddy River, with Mesquite, Muddy River, and Topock all having parasitism rates above 30%. Across all study areas, nests that contained flycatcher eggs and were brood parasitized were less likely to fledge flycatcher young than nests that were not parasitized. At study areas with variable parasitism rates, the rate of parasitism was clearly inversely related to flycatcher nest success. From 2010 to 2012, we attempted to addle cowbird eggs at 11 of the 24 parasitized nests that contained flycatcher eggs. Nine of the nests at which we attempted to addle cowbird eggs were incubated long enough (≥10 days) for any viable cowbird eggs to have hatched; only one egg hatched. This hatch rate (11%) is significantly less than the 74% hatch rate observed in 2003–2009. Flycatcher fecundity across study areas ranged from 0.00 young per female at Grand Canyon to 2.38 at Pahranagat. Fecundity at Pahranagat was significantly higher than at all other study areas, which did not differ from each other. Mean clutch size was 3.2 at Pahranagat and ranged from 2.5 to 2.7 at all other study areas.

We documented 106 willow flycatcher nesting attempts at Key Pittman, River Ranch, and Warm Springs; 98 of these nests were known to contain flycatcher eggs and were used in calculating nest success and productivity. Forty-one (42%) nests were successful and fledged young, and 55 (56%) failed. Fate was unknown at two (2%) nests. Nest success from 2010 to 2012 was 45% at Key Pittman, 0% at River Ranch, and 17% at Warm Springs. Depredation was the major cause of nest failure, accounting for 64% (41 of 64) of all failed nests and 73% (41 of 56) of nests that failed after flycatcher eggs were laid. Twelve of 92 nests (13%) with flycatcher eggs and known contents were brood parasitized by Brown-headed Cowbirds. One additional nest was parasitized prior to flycatcher eggs being laid and was subsequently abandoned. For nests containing flycatcher eggs, parasitism caused nest failure at three nests. From 2010 to 2012, brood parasitism was 11% at Key Pittman, 75% at River Ranch, and 0% at Warm Springs. Across the three study areas, nests that contained flycatcher eggs and were brood parasitized were less likely to be successful than were unparasitized nests. Fecundity ranged from 0.00 at River Ranch to 1.75 at Key Pittman. Average clutch size was 2.9 at Key Pittman, 1.8 at River Ranch, and 2.8 at Warm Springs.

Clutch size varied by study area, geographic area, parasitism, and with successive nest attempts. The most significant predictors of observed clutch size were parasitism and geographic area, with the Pahranagat Valley having the largest clutch sizes. Further analysis showed that distance to water when the nest was found was a weak predictor of clutch size, with reduced clutch size as distance increased. Parasitism significantly reduced the observed clutch size. The number of fledges per successful nest also varied with parasitism and by geographic area in the same manner as observed clutch size. Minimum lifetime productivity (MLP) for male flycatchers ranged from 0 to 19 in the Pahranagat region, 0 to 17 in the Virgin Valley, and 0 to 10 at Havasu. MLP for female flycatchers showed similar variation, ranging from 0 to 18 in the Pahranagat region, 0 to 12 in the Virgin Valley, and 0 to 10 at Havasu. The proportion of females that failed to fledge any young did not differ by age, but of the successful females, older females were more likely to fledge larger broods.

The number of flycatcher pairs recorded each year at Pahranagat, Muddy River, and Bill Williams from 2003 to 2012 showed no strong trend, but oscillated around their respective means. At Mesquite, the number of pairs declined from 15 to 12 in 2006–2009 and then to 7 in both 2010 and 2011; only 4 pairs were recorded in 2012. The decline in the number of breeding pairs at Mesquite is likely the result of inconsistent water delivery to the main breeding site of Mesquite West in 2009–2012, which has caused a decline in habitat quality and site fidelity. At Topock Marsh, the number of pairs declined from a high of 29 in 2004 to only one pair in 2011. In 2012, for the first time since flycatcher studies began in 1996, no breeding flycatchers were detected, and we detected only two resident flycatchers. Low water levels in Topock Marsh and a decline in the amount of inundated riparian vegetation likely contributed to the decline in flycatcher populations. The number of breeding flycatchers documented in Mormon Mesa increased from 2003 to 2007, and then stabilized from 2007 to 2012. The amount and distribution of suitable habitat at Mormon Mesa has changed over the last 10 years with changes in the course of the Virgin River, and the increase in the number of breeding pairs is likely the result of an increase in the amount of suitable habitat.

Brown-headed Cowbird Trapping – From 2003 to 2007, we trapped brown-headed cowbirds at Pahranagat, Mesquite, and Topock Marsh. We compared flycatcher breeding data from the pre-trapping period of 1997–2002 to that recorded during the trapping period and that recorded during five post-trapping years (2008–2012) to determine whether cowbird trapping and removal affected willow flycatcher brood parasitism rates, flycatcher nest success, or flycatcher productivity. In 2003–2007, we captured and removed 544, 266, and 872 Brown-headed Cowbirds at Pahranagat, Mesquite, and Topock, respectively. The proportion of nests parasitized did not differ among the three trapping periods at Mesquite. The proportion of nests parasitized at Pahranagat was significantly lower during both trapping and post-trapping compared to pre-trapping. At Topock Marsh, a lower proportion of nests was parasitized during the post-trapping years than during trapping. The proportion of successful nests

recorded at Mesquite and Topock did not differ among the trapping periods. Nest success differed between trapping and pre-trapping periods at Pahranagat, with a higher proportion of successful nests recorded during trapping years. Flycatcher productivity, fecundity, and fledge data did not differ among trapping periods at either Mesquite or Topock. At Pahranagat, productivity was higher and average fledge date was earlier during trapping versus pre-trapping. The data indicate that cowbird trapping at Mesquite and Topock Marsh had no discernible positive effects on willow flycatcher reproduction; parasitism rates were not reduced, and flycatcher reproductive output did not increase. The trapping areas at Mesquite and Topock are part of large, contiguous riparian corridors, and cowbirds that are removed by trapping are likely quickly replaced by other individuals. At the end of cowbird trapping in 2007, we concluded that cowbird trapping at Pahranagat had decreased brood parasitism rates, as well as reduced the other effects cowbirds can have on host species, such as decreasing clutch size by ejecting host eggs, removing host young, and delaying fledge dates by causing nest failures. We speculated that the relatively small, isolated nature of Pahranagat may facilitate the effectiveness of trapping. However, the parasitism rate at Pahranagat has continued to be low (1%) during the five post-trapping years, and reproductive metrics during the post-trapping years did not differ from those recorded during the trapping period. It seems unlikely that the effects of trapping in reducing the local cowbird population would last for five years after the cessation of the trapping program. Changes in hydrology, vegetation, and nest distribution that coincided with the end of the trapping program may have affected the suitability of the site for cowbirds, or the susceptibility of flycatcher nests to parasitism, but it is unclear whether these changes account for the continued low rate of parasitism.

Occupied Territory Vegetation – In 2008–2011, we collected vegetation data at 78 unique plots within occupied flycatcher territories at Littlefield, Mesquite, Mormon Mesa, Muddy River, Grand Canyon, Topock Marsh, and Bill Williams. We combined these data with similar vegetation data collected at 261 nest locations and 105 within-territory plots in 2003–2007 with the objective of providing a quantitative summary of the floristic and structural conditions within occupied territories in each study area. Study areas varied in vegetation structure and in species composition. Tamarisk, coyote willow, and/or Goodding willow were the dominant woody species at all study areas. Other woody species such as cottonwood, Russian olive, seep willow, and arrowweed typically formed a negligible portion of the vegetation.

Despite floristic variation, several features were common to occupied flycatcher territories. Flycatchers consistently occupied areas with high canopy closure; across all study areas, 75% of vegetation plots had canopy closure >89%, and 95% of plots had canopy closure >75%, with a median of 94% canopy closure. Canopy height was at least 5.0 m within 75% of the vegetation plots and was at least 4.0 m in 95% of the plots. Vegetation plots that had canopy heights <5.0 m were in proximity to taller vegetation, typically emergent Goodding willow. Occupied territories also had high densities of small (<2.5 cm dbh) and medium (2.5–8 cm dbh) stems. Stem density was more variable than canopy height or canopy closure and varied with floristic composition. Areas with a significant component of coyote willow (Mesquite and Littlefield) had higher stem densities than areas with a significant component of Goodding willow (Mormon Mesa, Muddy River, Grand Canyon, and Bill Williams). All sites, regardless of floristic composition or stem density, showed similar vertical foliage profiles, with overall vegetation density peaking at 2–3 m above the ground and the density of live vegetation peaking 1–2 m higher. Peak densities of live vegetation were in the range of three to four hits per meter interval.

We recommend using the 25th–75th percentile values for stem density, canopy closure, and canopy height from Mesquite West as a target range for habitat creation sites that consist of coyote willow. For habitat creation sites that are primarily Goodding willow, vegetation data from the southern nesting area at Muddy River and Grand Canyon provide guidelines. Mormon Mesa provides data that could be used as guidelines for areas that have a scattered overstory of Goodding willow and an understory of coyote willow. The understory at Mormon Mesa is largely tamarisk, so a multiplier should be applied to the density of stems 2.6–8.0 cm dbh to account for the branching structure in tamarisk that results in an underestimate of stem density when only the largest stem is tallied.

Occupied Territory Microclimate – In 2008–2011, we collected temperature, humidity, and soil moisture data at points within occupied flycatcher territories. We combined these data with similar data collected in 2003–2007 to provide a summary of microclimate conditions within flycatcher territories in each study area. Both temperature and humidity followed season weather patterns at all study areas, with daily high temperatures typically peaking in early July and night time temperatures peaking in late July. Both diurnal and nocturnal humidity rose throughout the season. Median soil moisture at most study areas was at or above 900 mV (corresponding to >40% volumetric water content) throughout May and June. Soil moisture values tended to decrease as the season progressed, except at Mesquite, which is watered by irrigation return flows. Soil moisture also tended to vary more as the season progressed, with some locations becoming quite dry while others remained wet. The distance to standing water showed similar patterns, with distance to water increasing and becoming more variable as the season progressed. In May and June, median distance to water was ≤20 m at most study areas.

Across all study areas, over half of all sample points within occupied flycatcher territories were within 10 m of water in the second half of May and first half of June, when territories are typically established. There are clearly instances when flycatcher territories are established far from surface water, but these instances should not be construed as an indication that water is not necessary for continued flycatcher occupancy. We have observed several instances, most notably at Mesquite West in 2009, where flycatchers established territories in previously occupied areas that had gone dry since the previous year. However, site fidelity in the year following dry conditions was low, indicating that surface water is important to flycatchers. Surface water plays a role in maintaining dense vegetation as well as moderating temperature, and the proximity of surface water is also associated with higher invertebrate abundance. We recommend that randomly selected sample points within habitat creation areas that are managed for willow flycatchers conform to the range and distribution of conditions seen in the 25th–75th percentiles of flycatcher territories in each two-week period throughout the breeding season.

Temperature and humidity at a specific location are the result of the combination of regional climate and the local influences of vegetation and soil moisture. If temperature and humidity of an area do not fall within the conditions used by flycatchers on the LCR, manipulation of temperature and humidity would be accomplished by manipulation of vegetation structure or hydrology. Increases in canopy height, canopy closure, the density of live stems, the amount of live foliage, and soil moisture were associated with more moderate temperatures, while increases in the density of dead stems and dead foliage resulted in plots being less likely to have temperatures within the preferred range. Canopy closure, live foliage above nest height, and soil moisture had similar effects on humidity, with increases in each variable being associated with higher humidity. Management efforts to increase canopy closure, the amount of live foliage above average nest height, and soil moisture would therefore increase suitability of the area for flycatchers by providing the vegetation density found in occupied flycatcher sites, providing the soil moisture needed to attract flycatchers, and promoting the microclimate conditions found in flycatcher territories.

Old Nest Vegetation and Microclimate – We gathered vegetation and microclimate data at 70 old nests at Mesquite, Mormon Mesa, Muddy River, and Topock to investigate whether changes in vegetation characteristics and microclimate conditions might have contributed to the abandonment of some areas by flycatchers. Areas of both Mesquite and Mormon Mesa that contained flycatcher nests at some point during 2003–2007 but were abandoned in 2008 or 2009 were affected by the winter floods of 2004–2005. The changes in vegetation that were noted in qualitative site descriptions for areas that were affected by flooding and sedimentation were also apparent in the vegetation data, with both Mesquite and Mormon Mesa showing fewer live stems, less live foliage, and more dead foliage than when the nests were occupied. Mesquite also had lower canopy closure than when the nests were occupied, and nest sites at Mesquite lost a significant percentage of their native vegetation. Canopy closure and the percent native vegetation were found to be important in differentiating nest sites from non-use areas (McLeod et al. 2008a), and it is likely that decreases in canopy cover and the death of native vegetation at Mesquite and Mormon Mesa contributed to making portions of those study areas unsuitable for nesting flycatchers. Formerly occupied nest sites at Mesquite had higher soil moisture, lower maximum daily temperature, and higher humidity when the nest was occupied than when the area had been abandoned. At Mormon Mesa, soil moisture did not differ between occupied and unoccupied periods, but temperatures were more moderate and humidity was higher when the nests were occupied. The driving factor in these areas becoming unoccupied was likely the change in hydrology, which caused the accompanying changes in vegetation and microclimate.

At Muddy River, the vegetation data showed few differences between the occupied and unoccupied periods, with more dead foliage at nest height and a lower percentage of native vegetation recorded during the unoccupied period, but no differences in stem density or canopy closure. It is possible that bulldozing activities in the immediate vicinity of the territories affected the suitability of the area for flycatchers, either by reducing the amount of suitable habitat or by altering water flow. At Topock Marsh, we did not note any qualitative changes in the vegetation, but vegetation data indicated an increase in the amount of woody ground cover, an increase in the number of dead stems 2.6–8 cm dbh, and a decrease in live foliage hits above nest height. An increase in dead stems and decrease in live foliage could reduce the suitability of the sites for flycatchers. Microclimate did not differ significantly between the occupied and unoccupied periods at either Muddy River or Topock Marsh. This suggests that factors other than changes in the vegetation or microclimate characteristics we measured were responsible for territory abandonment. At Muddy River, bulldozing and dredging in the vicinity of the territories may have affected territory occupancy, and dredging may have reduced the amount of surface water in the territories. At Topock Marsh, marsh levels after 2004 peaked at lower levels, and high water levels were of shorter duration than was the case prior to 2004. The decline in the flycatcher population at Topock and corresponding territory abandonment are likely related to the changes in marsh levels

Soil Texture – We analyzed 104 soil samples from nest and within-territory locations and 43 samples from non-use locations. Soil samples at all study areas consisted primarily of varying proportions of sand and silt, with very little clay. There were no significant differences in the percentage of sand, silt, or clay between occupied (nest and within-territory) versus unoccupied (non-use) locations at any of the study areas or with all data combined. We did observe substantial local variation in the proportions of silt and sand in the soil samples within each study area, and we did not observe any patterns by which one portion of a site had a substantially different soil texture than another portion of the same site. At all study areas, soil types were consistent with the depositional nature of riparian areas. There is no evidence that soil type, within the range of depositional soil types present at both occupied and unoccupied areas, has an influence on the suitability of these sites for occupancy by flycatchers.

Habitat Monitoring: Parker to Imperial – In 2005, we selected 11 sites between Parker and Imperial Dams for inclusion in the habitat monitoring study addressing how changes in water transfer actions might affect riparian habitat. We also selected two control sites above Parker Dam and two below Imperial Dam. At each site we installed three–five temperature/humidity data loggers. These loggers

collected temperature and humidity data at 15-minute intervals through the end of the 2012 season. We collected soil moisture measurements at each data logger location during each flycatcher survey at the site and when logger data were downloaded. Vegetation measurements were also collected at each data logger location after surveys were completed in each year 2005–2012. A piezometer was installed at each site to record water levels.

Piezometer water levels at most test sites were strongly correlated with releases from Parker Dam, and the expected decrease in groundwater levels as the result of a reduction in flow of 1,200 cfs at Parker Dam ranged from 0.25 to 0.42 feet. Average releases from Parker Dam in May, June, and July declined by about 1,200 cfs between 2002 and 2005, when the monitoring study began. Thus, some areas that were inundated with shallow water under river flow conditions in summer prior to 2002 were likely inundated less frequently or not at all during the study. Because flows declined prior to the start of the study, the study may not have been able to detect changes in microclimate or vegetation that occurred as the result of the decrease in flow prior to 2005. We found no evidence that fluctuations in releases from Parker Dam in 2005–2012 affected overall temperature or humidity within the test sites, and we found no evidence of deterioration in vegetation health that was specific to the test sites.

In 2001 when the Biological Opinion requiring habitat monitoring was written, several sites along the lower Colorado River south of Parker were thought to be occupied by willow flycatchers, based on the detection of flycatchers at these sites after 15 June of one or more years. However, no breeding flycatchers were confirmed at these sites in any year; the majority of the detections were of flycatchers that did not appear to be actively defending a territory, and few flycatchers were detected after mid-June. Further investigation of the status of willow flycatchers along the southern stretches of the Colorado River showed no evidence of any resident or breeding flycatchers in or near any of the habitat monitoring sites. The revised willow flycatcher survey protocol suggests using the date of 24 June as a guideline for determining residency, with flycatchers detected after this date considered to be resident. Over the last 10 years, only four flycatchers have been detected south of Parker Dam after June, and none of these flycatchers displayed territorial behavior (extended song) or were detected on more than one occasion. It is likely that the habitat monitoring areas have not been occupied since surveys began in 1996.

Surface Hydrology, Microclimate, and Vegetation Monitoring: Topock Marsh – Supplemental water delivery to support habitat enhancement commenced at Topock Marsh in 2011, periodically flooding portions of In Between and 800M. Water delivery did not appear to have any effects on vegetation that would influence flycatcher occupancy. Water delivery had the expected effect of raising soil moisture, decreasing distance to water, and increasing the percentage of the area surrounding each sample point that was inundated or saturated. Water delivery also increased humidity within the flooded area. Flood events produced a lower maximum temperature, higher minimum temperature, and smaller daily temperature range in the flooded area in comparison to the non-flooded area, but these effects did not seem to persist across two-week periods. Areas occupied by flycatchers typically have higher soil moisture, higher humidity, and more moderate temperatures than unoccupied areas; thus, water delivery appeared to change the conditions within the flooded area in ways that would favor flycatcher occupancy. Water delivery was the most effective at creating conditions favored by flycatchers when the underlying water table was high. Despite the presence of favorable conditions, flycatcher occupancy in the target area did not increase in 2011, possibly because dry conditions elsewhere in Topock Marsh and a low flycatcher population may have limited the ability of flycatchers to colonize the area.

Water levels at Topock Marsh in 2012, under the influence of the new firebreak canal, were intermediate between those recorded in 2009, when the northern inlet canal and the farm ditch supplied water to Topock Marsh, and 2010, when water levels were intentionally reduced in preparation for construction. The firebreak canal did not have a pump in 2012, and structural problems with the canal also prevented it from performing as intended. It is currently unknown whether passive inflow through the firebreak canal will be capable of maintaining the water level in the marsh to the elevation achieved in 2009, or in prior

years, when water was flowing through the northern inlet canal, after the structural problems are addressed. Marsh elevation as measured at the South Dike provides a good index to water levels as measured in the piezometer at In Between, with peak spring water levels generally matching in magnitude and timing in years when the piezometer was functional and no pumping occurred. Marsh levels at the South Dike are likely sufficient to track differences between years in water levels in flycatcher breeding sites at Topock Marsh. We recommend a peak marsh level in early May of at least 456.7 feet (intermediate between the 2004 peak of 456.8 feet and the 2009 peak of 456.64 feet) and maintaining a marsh elevation of at least 456.4 feet at least through the end of June, by which time territory establishment is complete and first breeding attempts are typically into the nestling stage. A marsh elevation of at least 456.4 feet was sufficient to keep surface water in flycatcher breeding sites through mid-June in 2004.

Tamarisk Leaf Beetles – Tamarisk leaf beetles were first released on the Virgin River in St. George, Utah, in 2006. The population established and the first large-scale defoliation was observed in the city in 2008. The population has spread every year since, reaching Lake Mead and the headwaters of the Muddy River at the end of 2011. By the end of 2012, beetles occurred along the entire length of the Virgin and Muddy Rivers, and had reached Lake Mohave. The range of the beetle now overlaps with several flycatcher breeding sites. Beetles have potential impacts on nesting flycatchers because the timing of defoliation coincides with the flycatcher breeding season. Reduction in canopy cover could alter microclimate away from favored conditions and reduce nest concealment, thereby increasing nest predation or brood parasitism. Tamarisk beetles first affected breeding flycatchers in St. George in 2009, when the first defoliation occurred in mid-June. Defoliation in 2009 corresponded with low flycatcher nesting success. Forty percent of the nests with flycatcher eggs failed to hatch, possibly because of high temperatures at unshaded nests. Although flycatchers typically demonstrate high site fidelity, flycatchers in the St. George area vacated tamarisk-dominated sites and colonized nearby, native-dominated sites.

The Mormon Mesa study area was defoliated by tamarisk beetles throughout the 2012 breeding season. Despite the placement of nests in areas that had at least some willow cover, fecundity and nest success were lower than that recorded in this same breeding area in the four previous years. We observed anomalous flycatcher behavior in 2012, with higher than usual rates of nest desertion during laying, and lower than usual rates of renesting following an early nest failure. We expect to see reduced site fidelity and lower numbers of breeding flycatchers in Mormon Mesa in 2013 in response to the poor reproductive success and lower habitat quality documented in 2012. Unlike in St. George, there are no potentially suitable, native-dominated sites in the vicinity of Mormon Mesa that are not already occupied by flycatchers. Adult flycatchers may attempt breeding, possibly in reduced quality habitat; they could spend the breeding season as a non-breeding resident; or they could emigrate from the area in search of suitable habitat elsewhere.

Chapter 1

INTRODUCTION

SPECIES INTRODUCTION

The Southwestern Willow Flycatcher (*Empidonax traillii extimus*) is one of four subspecies of willow flycatcher currently recognized (Unitt 1987), although Browning (1993) posits a fifth subspecies (*E. t. campestris*) occurring in the central portions of the United States (Figure 1.1). The Southwestern Willow Flycatcher 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 (Unitt 1987).

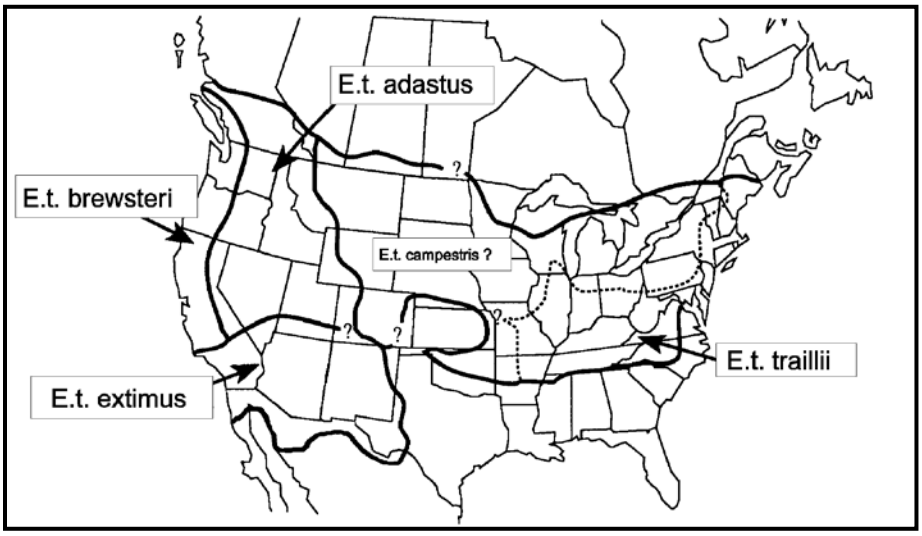

Figure 1.1. Breeding range distribution of the subspecies of the willow flycatcher (*Empidonax traillii*). Adapted from Unitt (1987), Browning (1993), and Sogge et al. (1997).

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, Southwestern Willow Flycatchers have 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; 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 nonnative plants; and brood parasitism by Brown-headed Cowbirds (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.) may 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 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 Littlefield, Arizona, in 2009; the Highway 170 bridge downstream of Bunkerville, Nevada, in 2010; and 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 (Tom Dudley, University of California Santa Barbara, pers. comm.).

PROJECT HISTORY

In 1995, the U.S. 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 Multi-Species Conservation Program (MSCP) for long-term endangered species compliance and management in the historical floodplain of the LCR. As a step to 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 (TES) species. These species included the Southwestern Willow Flycatcher, which was listed by the U.S. Fish and Wildlife Service (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 five 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 (*Molothrus ater*) brood parasitism rates. In 2002, Reclamation reinitiated consultation with USFWS on the effects of continued dam operations and maintenance on TES 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.

Reclamation and 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. In January 2001, a BO for Interim Surplus Criteria, Secretarial Implementation Agreements, and Conservation Measures was issued and required monitoring of 150.5 ha of existing, occupied Southwestern Willow Flycatcher habitat between Parker and Imperial Dams.

The LCR MSCP is a 50-year program that seeks to protect 26 TES 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 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. SWCA has been contracted for these studies since 2003, and results from 2003 to 2007 are summarized in McLeod et al. 2008a.

From 1997 to 2012,[1] breeding populations of Southwestern Willow Flycatchers were documented at eight study areas along the Virgin and lower Colorado Rivers and tributaries: (1) Pahranagat National Wildlife Refuge (NWR), Nevada; (2) Beaver Dam Wash at Littlefield, Arizona; (3) Mesquite and (4) Mormon Mesa on the Virgin River, Nevada; (5) Overton Wildlife Management Area (WMA) along the Muddy River, Nevada; (6) Grand Canyon, Arizona; (7) Topock Marsh on the Colorado River, Havasu NWR, Arizona; and (8) Bill Williams River NWR (Bill Williams), Arizona (Braden and McKernan unpubl. data; this document). From 1997 to 2012, 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.

In compliance with the consultation on Interim Surplus Criteria and Secretarial Implementation Agreements, Reclamation biologists deployed temperature/humidity data loggers in 2004 at a subset of sites currently monitored for Southwestern Willow Flycatcher along the Colorado River in California and Arizona. These studies were expanded the following year to include annual monitoring of groundwater levels, vegetation, and soil moisture in addition to temperature and humidity, and have been completed annually since 2005.

Following the breeding season of 2008, USFWS and Reclamation initiated discussions regarding the declining number of willow flycatcher territories at Topock Marsh in 2004–2008, the importance of the flycatcher population in the Topock area to flycatcher conservation along the LCR, and possible measures to enhance flycatcher habitat at Topock. A plan was developed to pump water into a portion of the flycatcher breeding habitat at Topock beginning in February or March and continuing into the flycatcher breeding season. The selected area at Topock had seen the greatest decline in numbers of resident flycatchers but had not experienced any dramatic changes in vegetation. Water delivery was anticipated to commence in 2010, and monitoring of vegetation, microclimate, and hydrologic conditions in the target area was initiated in 2009 to obtain baseline data. Water delivery was delayed until 2011, so additional monitoring of baseline conditions occurred in 2010. Water delivery was initiated in March 2011, and conditions within the target area were monitored during the 2011 breeding season. In 2012, no water delivery occurred in the target area, but monitoring continued to assess the response of hydrologic conditions to completion of a new water delivery structure.

PURPOSE AND DESCRIPTION OF STUDY

The purpose of this five-year (2008–2012) study 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 region. Lower Grand Canyon was not monitored in 2009–2012 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. This project encompassed four types of studies: (1) presence/absence surveys, including site descriptions, at preselected sites along the lower Colorado River and portions of major

[1] Studies in 1996 did not include any sites in Nevada.

tributaries; (2) intensive studies at all study areas where breeding flycatchers were located to assess Southwestern Willow Flycatcher demographics and ecology, habitat selection, and the effects of Brown-headed Cowbird brood parasitism; (3) monitoring of microclimate, vegetation, and groundwater conditions of selected sites surveyed for Southwestern Willow Flycatchers between Parker and Imperial Dams; and (4) monitoring microclimate, vegetation, and surface hydrology from 2009–2012 in a selected portion of flycatcher habitat within Topock Marsh to document the effects of habitat enhancement efforts.

SWCA's contract specified the following field tasks:

Presence/absence Surveys. At approximately 100 sites along the LCR, conduct presence/absence surveys, following a 5-survey protocol (per USFWS 2000).

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

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.

Banding. Band as many adult and juvenile flycatchers as possible at sites with territorial flycatchers.

Vegetation, Soils, and Microclimate. Collect vegetation, soil, and microclimate data at the within-territory level at breeding locations in order to quantify conditions at flycatcher territories for replication at restoration areas.

Habitat Monitoring. At 15 previously identified sites, monitor vegetation, microclimate, and groundwater conditions to determine how these may be affected by water transfer actions at Parker Dam.

Surface Hydrology, Vegetation, and Microclimate Monitoring. Within a selected portion of Topock Marsh, monitor surface hydrology, microclimate, and vegetation conditions.

Each distinct aspect of this five-year study is addressed in a separate chapter in this report, as follows:

Chapter 2 – Presence/absence Surveys and Site Descriptions. This chapter presents the methodology and results for presence/absence surveys and gives a general site description for each survey site. For all sites that were surveyed in any year from 2008 to 2012, we present a summary of any changes that have occurred at the site over the course of SWCA's surveys, including surveys in 2003–2007. Sites that were not visited in 2008–2012 but were visited in 2003–2007 are not described. Results of habitat reconnaissance from 2008 to 2012 are also presented.

Chapter 3 – Color-banding and Resighting. Summaries of banding activities and resighting of previously banded flycatchers are presented in this chapter, along with details of all observed leg injuries. Also included are summaries of dispersal and movement data for juveniles and adults, as well as the results of mark-recapture modeling and estimates of adult and juvenile survival and detection probabilities. We also present estimates of lambda, the per-capita annual population growth rate. All available data from 1997 to 2012 are included.

Chapter 4 – Nest Monitoring. This chapter summarizes nesting attempts, nest fates, and productivity for all Southwestern Willow Flycatcher nesting activity documented from 2003 to 2012. This chapter also examines the effect of brood parasitism on flycatcher productivity and the effectiveness of addling cowbird eggs on improving flycatcher productivity at parasitized nests. Minimum lifetime productivity and the effect of female age on seasonal productivity are also evaluated.

Chapter 5 – Brown-headed Cowbird Trapping. This chapter summarizes the efforts and results of cowbird trapping from 2003 to 2007, and evaluates the effect of cowbird trapping on flycatcher reproduction by comparing reproductive metrics recorded during the trapping period to those recorded during the preceding (1997–2002) and following (2008–2012) years.

Chapter 6 – Vegetation Characteristics. Vegetation sampling methods are described, and vegetation characteristics are summarized for occupied territories at each study area. Vegetation data collected in 2008–2011 are combined with data collected in occupied flycatcher territories in 2003–2007. We also compare vegetation data at nest sites when the nest was active vs. vegetation at the same location after the area had been abandoned by flycatchers.

Chapter 7 – Microclimate. The methodology of monitoring temperature, humidity, and soil moisture is described, and microclimate characteristics are summarized for occupied territories in each study area. Data collected in 2008–2011 are combined with microclimate data collected in occupied flycatcher territories in 2003–2007. We also compare microclimate characteristics at nest sites when the nest was active vs. microclimate at the same location after the area had been abandoned by flycatchers. Microclimate data are analyzed in conjunction with vegetation data to determine which vegetation characteristics influence microclimate.

Chapter 8 – Habitat Monitoring: Parker to Imperial Dams. The methodology and results of monitoring microclimate, vegetation, and groundwater conditions at sites between Parker and Imperial Dams from 2005 to 2012 are presented.

Chapter 9 – Surface Hydrology, Microclimate, and Vegetation Monitoring: Topock Marsh. This chapter describes sampling methods and compares baseline conditions documented in 2009 and 2010 to those documented in 2011 and 2012 in an area targeted for habitat enhancement.

Chapter 10 – Tamarisk Leaf Beetles. This chapter describes the life history of the tamarisk beetle and its spread along the Virgin, Muddy, and lower Colorado Rivers. Also described are potential impacts of tamarisk leaf beetle defoliation on flycatcher nesting success.

Chapter 11 – Management and Study Design Recommendations. Recommendations from all previous report chapters are summarized for ease of reference.

In any cases where there are discrepancies between data presented in this summary report and data presented in the individual annual reports or the previous summary report, data in this report take precedence.

RELATED STUDIES

Prior to 2010, Nevada Department of Wildlife (NDOW) completed nest monitoring at Key Pittman WMA, and SWCA Environmental Consultants (SWCA) banded flycatcher nestlings and adults opportunistically in cooperation with the monitoring efforts. From 2010 to 2012, NDOW retained SWCA to conduct surveys, site descriptions, nest monitoring, and banding at flycatcher breeding areas at Key Pittman WMA and Warm Springs Natural Area, as well as surveys for Yellow-billed Cuckoo (*Coccyzus americanus*) in both study areas. This work was expanded in 2011 and 2012 to include River Ranch in the Pahranagat Valley. Summaries of survey results, site descriptions, nest monitoring, and banding efforts at Key Pittman, River Ranch, and Warm Springs are presented in Chapters 2, 3, and 4. Data from these study areas are included in analyses of movement patterns, probabilities of survival and detection, and minimum lifetime productivity.

Utah Division of Wildlife Resources has monitored breeding flycatchers annually in St. George, Utah, from 2008 through 2012. In 2008–2011, SWCA banded adults and nestlings opportunistically in St. George in cooperation with the monitoring efforts. Resights and banding results from 2008–2012 in St. George are presented in a separate table in Chapter 3. Data from St. George are included in analyses of movement patterns, probabilities of survival and detection, and minimum lifetime productivity.

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 USFWS (2002), willow flycatchers detected between approximately 15 June and 20 July 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 20 June (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 23 June. 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 unpubl. data). Although migrating willow flycatchers may favor young, native willow habitats (Yong 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.

From 2008 to 2012, as part of our contract with Reclamation, we completed multiple broadcast surveys at sites in 17 study areas[3] (hereafter Reclamation study areas) along the LCR and its tributaries to detect both migrant and resident willow flycatchers (Figure 2.1). From 2010 to 2012, we also completed surveys in three additional study areas (Key Pittman WMA, River Ranch, and Warm Springs Natural Area; hereafter NDOW study areas) as part of our contract with NDOW.

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[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.

[3] Study areas consist of 1–18 survey sites that are grouped geographically (see Figure 2.1).

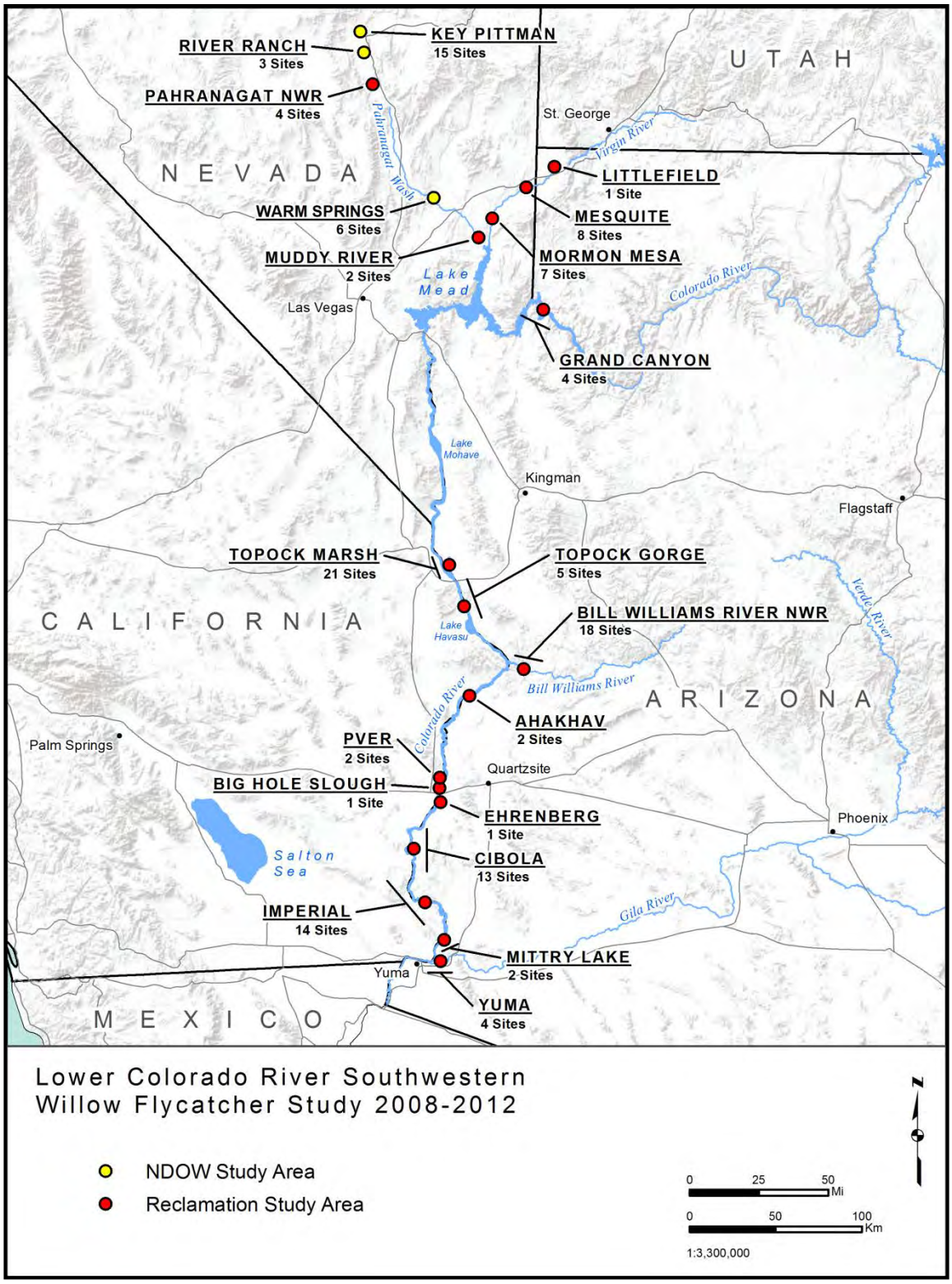

Figure 2.1. Locations of Southwestern Willow Flycatcher study areas along the lower Colorado River and tributaries, 2008–2012. Study area labels represent the approximate center of multiple sites within that region (see Table 2.2.). The number of sites in each study area is indicated below each study area name. The approximate extent of each study area is indicated by a bracket adjacent to the location label.

Special Concern Species

The Yuma Clapper Rail (*Rallus longirostris yumanensis*) is listed as federally endangered by the USFWS, and the Yellow-billed Cuckoo is a candidate for federal listing. Both species occur along the LCR and its tributaries and are of concern to managing agencies. Nine additional avian species [California Black Rail (*Laterallus jamaicensis coturniculus*), Least Bittern (*Ixobrychus exilis*), Elf Owl (*Micrathene whitneyi*), Gila Woodpecker (*Melanerpes uropygialis*), Gilded Flicker (*Colaptes chrysoides chrysoides*), Vermilion Flycatcher (*Pyrocephalus rubinus*), Arizona Bell's Vireo (*Vireo bellii arizonae*), Sonoran Yellow Warbler (*Dendroica petechia sonorana*), and Summer Tanager (*Piranga rubra*)] are considered to be special-concern species under the LCR MSCP. The Yellow-breasted Chat (*Icteria virens*) is also considered a special concern species in California. We did not survey specifically for these species at Reclamation study areas but recorded all incidental detections. We recorded all incidental detections of special concern species at all three NDOW study areas and completed surveys for Yellow-billed Cuckoos at Key Pittman, River Ranch, and Warm Springs.

METHODS

Site Selection

Survey sites were selected annually based on locations surveyed during previous years of willow flycatcher studies on the LCR (McKernan 1997; McKernan and Braden 1998, 1999, 2001a, 2001b, 2002; McLeod et al. 2008a; McLeod and Koronkiewicz 2009, 2010; McLeod and Pellegrini 2011, 2012, 2013) and reconnaissance by either helicopter, boat, or on foot prior to the start of each survey year. Sites consisting of mature native or exotic woody riparian vegetation with high canopy closure (>50%) and standing water or saturated soil under or adjacent to the vegetation were considered the most suitable habitats for flycatchers. 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 survey areas. Reclamation biologists Theresa Olson and Chris Dodge guided and approved site selection. For sites surveyed in previous years, we retained original site names.

In 2008, we implemented a biennial survey schedule (Table 2.1) at selected sites in study areas where resident flycatchers had not been documented in the previous 10 years of surveys. Sites were selected for biennial surveys based on the absence of damp or wet soils within the site and/or the relative absence of dense vegetation that might provide suitable nesting habitat for flycatchers. After the 2008 survey season, we revised the survey schedule based on conditions observed in the field and added several sites at Bill Williams to the biennial schedule. These sites were ones at which no resident flycatchers had been detected since 2003.

We provided field personnel with high-resolution aerial photographs of all selected survey sites. The photographs were overlain with a UTM grid (NAD 83) and an outline of the proposed survey area. The boundaries of all survey sites were refined during the field season to include potential flycatcher habitat actually present. New boundaries were delineated on the aerial photographs based on UTM coordinates obtained in the field. All UTM coordinates were obtained using a Garmin Rino 110 GPS unit and were in NAD 83 to comply with Federal Geographic Data Committee standards.

Table 2.1. Biennial Survey Schedule for Selected Sites

Study Area[1]	Site	Habitat Comments	Survey Schedule		
			Annual	2008, 2010, 2012	2009, 2011
TOGO[2]	Pulpit Rock	Tiny. Wet soil adjacent to river; upland edge dry.			X
	Picture Rock[3]	Wet soil adjacent to river, interior dry.			X
	Blankenship Bend North	Stand of willow adjacent to marsh.	X		
	Blankenship Bend South	Mosaic of cattail, bulrush, willow. Areas with water under vegetation.	X		
	Havasu NE	Mature vegetation; interior of site is completely dry, no water beneath the vegetation.		X	
BIWI	Site #1	Mixed-native vegetation; dry soils and stands of dense arrowweed in the center of the site; coyote willow and surface water along the site edge, bordering an arm of Lake Havasu.		X	
	Site #2[2]	Mature mixed-native vegetation; dry soils and extensive deadfall within the site; bordered by an arm of Lake Havasu.		X	
	Site #11[2]	Mature mixed-native vegetation; dry soils and extensive deadfall within the site; bordered by an arm of Lake Havasu.		X	
	Black Rail	Mixed-native vegetation; generally sparse understory; narrow strip of dense vegetation.		X	
	Mineral Wash	Mixed-native vegetation; sparse canopy closure; dry soil underneath the vegetation; water only within river channels.		X	
	Beaver Pond	Mixed-native vegetation; sparse canopy closure; dry soil underneath the vegetation; water only within river channels.		X	
	Site #8[2]	Mixed-native vegetation; sparse canopy closure; dry soil underneath the vegetation; water only within the river channel.		X	
PVER	PVER Phase 2	Habitat creation area.	X		
	PVER Phase 3	Habitat creation area.	X		
BIHO	Big Hole Slough[3]	Marshy, new willows coming in.	X		
EHRE	Ehrenberg	Emergent cottonwood and Goodding willow; understory primarily arrowweed and *Baccharis* sp.; formerly contained a dense stand of coyote willow but these willows have died.		X	
CIBO	CVCA Phase 1	Habitat creation area.	X		
	CVCA Phase 2	Habitat creation area.	X		
	CVCA Phase 3	Habitat creation area.	X		
	Cibola Nature Trail	Generally dry and sparse. Habitat creation area.	X		
	Cibola Island[3]	Narrow, linear site; patches of dense Goodding willow adjacent to marsh.	X		
	Cibola Site 2	No dense canopy. Mostly tamarisk with some emergent willow. Cattail marshes in parts of the site, but dry soil under the tamarisk.			X
	Cibola Site 1	No dense canopy. Mostly tamarisk with some emergent willow. Cattail marshes in parts of the site, but dry soil under the tamarisk.			X
	Hart Mine Marsh[3]	Mostly tamarisk, with linear stretches of marsh vegetation. Dry soil under the tamarisk.			X
	Three Fingers Lake[3]	Very dry and hot in interior, vegetation short.		X	
	Cibola Lake #1 (North)	Patchy vegetation, hot and dry in interior.		X	

Table 2.1. Biennial Survey Schedule for Selected Sites (Continued)

Study Area[1]	Site	Habitat Comments	Survey Schedule		
			Annual	2008, 2010, 2012	2009, 2011
CIBO	Cibola Lake #2 (East)	Patchy vegetation, hot and dry in interior.			X
	Cibola Lake #3 (West)	Patchy vegetation, hot and dry in interior.		X	
	Walker Lake	Tamarisk with emergent willows; water under vegetation along lake edge.	X		
IMPE	Paradise	Some big willows with tamarisk understory, sometimes has water in marshes.	X		
	Hoge Ranch	Mosaic of tamarisk, willow, and marshes. Sometimes wet.	X		
	Adobe Lake	Perched above river, very dry; dense tamarisk with many dead branches in understory.		X	
	Rattlesnake	Dense willows, wet soils.	X		
	Milemarker 65	Very narrow strip (<50m) of tamarisk adjacent to bulrush marsh. Understory of *Phragmites* creates extremely dense vegetation within 3 m of ground.			X
	Clear Lake/The Alley	Mature tamarisk, very dense understory. Very dry except immediately next to backwater channel.		X	
	Nursery NW	Dense tamarisk interspersed with marsh areas.	X		
	Imperial Nursery	Plantation. No understory.		X	
	Ferguson Lake	Mix of willow and tamarisk with water under vegetation on west side of site. East side dry and scrubby.	X		
	Ferguson Wash	Mature tamarisk with emergent willow. Very dry in interior of site. Borders backwater channel and Ferguson Lake. Moist soils only along channel edge.		X	
	Great Blue Heron	Goodding willow overstory, tamarisk understory; moist soils in parts of the site.	X		
	Powerline	Very small. Stringer of trees around cattail marsh that sometimes contains water. Sparse canopy.			X
	Martinez Lake	Scattered willows, tamarisk and arrowweed understory, sparse canopy closure.			X
MITT	Mittry West	Willow overstory, tamarisk understory, 80% canopy closure; sometimes wet.	X		
	Mittry South[3]	Monotypic tamarisk, lots of deadfall. Interior is dry. Adjacent to lake.		X	
YUMA	Gila Confluence North	Patchy. A few small stands of mature willows around cattail marshes. Marshes sometimes contain water. Half of site burned in 2006. Overall canopy closure 50%.		X	
	Gila River Site #2	Cottonwood/willow overstory, tamarisk and arrowweed understory; dry soils in interior; canopy closure 50%.			X
	Fortuna Site #1	Narrow (30m) strip of cottonwood/willow. Patchy understory of tamarisk and arrowweed on periphery, no understory within cottonwood/willow. Interior dry.			X
	Fortuna North	Mature tamarisk, 80% canopy closure. Interior very dry. Adjacent to Gila River.			X
	Morelos Dam[3]	Recovering from fire, canopy closure less than 50%, widely spaced willow and cottonwood, dense patch of tamarisk on northern end of site.			X

[1] TOGO = Topock Gorge, BIWI = Bill Williams River NWR, PVER = Palo Verde Ecological Reserve, BIHO = Big Hole Slough, EHRE = Ehrenberg, CIBO = Cibola, IMPE = Imperial, MITT = Mittry Lake, YUMA = Yuma.

[2] No surveys were completed in Topock Gorge in 2011 and 2012 or in Bill Williams River NWR Site #2, Site #11, and Site #8 in 2012 because effort was redirected to hydrology monitoring at Topock Marsh.

[3] Surveys at site discontinued prior to 2012.

Additional Site Evaluation

During each survey season, we conducted on-the-ground habitat reconnaissance and evaluation to locate additional potentially suitable willow flycatcher habitat and to reevaluate areas we had visited in previous years and had noted as having the potential to become suitable habitat. Field personnel were provided high-resolution aerial photographs overlain with a UTM grid 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 had vegetation characteristics similar to that of flycatcher breeding sites (i.e., dense vegetation within 2–4 m of the ground and high canopy closure). 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 broadcast 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 5-survey protocol, as recommended by the U.S. Fish and Wildlife Service (USFWS 2000). The 5-survey protocol specified in the project contract calls for one survey between 15 and 31 May, at least one survey between 1 and 15 June, and three additional surveys between 16 June and 25 July. Surveys were separated by a minimum of five 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. Surveyors stopped every 30–40 m and broadcast willow flycatcher primary song (*fitz-bew*) and calls (*breets*). Field personnel watched for flycatchers and listened for vocal responses for approximately one to two minutes before proceeding to the next survey station. Wherever territorial flycatchers were detected, we discontinued broadcast surveys within a radius of 50 m of territories and commenced territory and nest monitoring, which involves more frequent visits (see Chapter 4). 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. To produce a spatial representation of all survey areas, field personnel recorded survey start and stop UTM coordinates as well as the UTM coordinates of intermediate survey points. Observers recorded start and stop times and the location(s) and behavior of all willow flycatchers detected. 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).

Site Description

Because vegetation structure and hydrology within riparian habitats are seasonally dynamic, field personnel completed site description forms 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 vs. exotic) at 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. Information from site description forms was used in conjunction with habitat photographs and comments in field notebooks and on survey forms to

formulate qualitative site descriptions. For each site surveyed in 2008–2012, we present site descriptions summarizing data collected in these years. For sites that were also surveyed during the previous contract period (2003–2007), we present site descriptions summarizing all data available from 2003 to 2012. Recommendations for future survey efforts based on habitat conditions are presented after many of the site descriptions. Unless noted otherwise in the text, we recommend continuation of annual surveys. A table summarizing future survey recommendations is presented in Chapter 11.

Determination of Site Occupancy Status

From 2003 to 2012, we defined occupied Southwestern Willow Flycatcher habitat as patches of vegetation that are similar to and contiguous with areas where willow flycatchers were detected after 15 June (per USBR 1999). Sites where resident or breeding flycatchers were detected before 15 June but not after were not considered occupied. Many survey sites within the project area have been classified as occupied in 2003–2012, with no evidence that any detected flycatchers were residents. In this report, we define occupied Southwestern Willow Flycatcher habitat as patches of vegetation that are similar to and contiguous with areas where willow flycatchers were detected after 24 June (per Sogge et al. 2010) and/or where resident or breeding willow flycatchers were detected. In this chapter, we present metrics for both methods of site occupancy determination for use in discussion of the pros and cons of each method.

RESULTS

Reclamation Study Areas

Flycatcher Surveys

From 2008 to 2012, field personnel spent 2,955.3 observer-hours conducting willow flycatcher broadcast surveys at 113 sites in 17 study areas along the Virgin and lower Colorado Rivers and tributaries. Each site that was not occupied by territorial flycatchers was formally surveyed three to six times. A summary of willow flycatcher survey effort and survey site occupancy status is presented in Appendix A.

We found resident and/or breeding flycatchers at 33 sites in nine study areas (Pahranagat NWR, Littlefield, Mesquite, Mormon Mesa, Muddy River, Grand Canyon, Topock Marsh, Bill Williams River NWR, and Ahakhav); details of occupancy, pairing, color-banding, and breeding are presented in Chapters 3 and 4. The boundaries of survey sites for the most recent survey year and number of years each site was occupied are shown on orthophotos in Appendix B. For details on annual flycatcher surveys, territories, residency, pairing, nesting activity, demography, cowbird detections, and the presence of livestock at sites from 2008 to 2012, see McLeod and Koronkiewicz (2009, 2010) and McLeod and Pellegrini (2011, 2012, 2013).

We detected flycatchers after 15 June in several sites where residency or breeding was not confirmed in 2008 to 2011. None of the flycatchers detected south of Bill Williams exhibited territorial behavior. Behavioral observations are summarized in Table 2.2.

Other Species Detections

We detected Yellow-billed Cuckoos in at least one year in 12 of 17 study areas. Detections were located most consistently south of Lake Mead. Yuma Clapper Rails were detected in 8 of 17 study areas. Only one Yuma Clapper Rail was detected north of Lake Mead. A summary of numbers of detections of all

special concern species along with behavioral details for each cuckoo and rail detection is presented in Appendix C.

Table 2.2. Detections of Willow Flycatchers Recorded after 15 June at Reclamation Sites Where Breeding or Residency Was Not Confirmed, 2008–2012

Study Area[1]	Site	Date	Comments
2008			
LIFI	Poles	22 Jul	Lone flycatcher responded vigorously to broadcast with primary song *(fitz-bew)* and *wheeos*
MESQ	East	22 Jul	Lone flycatcher responded briefly to broadcast with primary song *(fitz-bew)*
TOPO	The Wallows	17 Jun	Lone flycatcher, gave primary song (*fitz-bew*) spontaneously after survey was finished
	250M	18 Jun	Lone flycatcher responded briefly to broadcast with primary song (*fitz-bew*)
BIWI	Site #4	29–30 Jun	Flycatcher singing spontaneously
CIBO	CVCA 1	18 Jun	Two flycatchers. One responded briefly to broadcast with primary song *(fitz-bew)* and *wheeos*; the other gave primary song spontaneously
	Cibola Island	18 Jun	Two flycatchers responded briefly to playback with primary song *(fitz-bew)*
	Three Fingers Lake	19 Jun	Four flycatchers. Three responded to playback with primary song *(fitz-bew)*, one gave primary song spontaneously
	Cibola Lake #1 (North)	18 Jun	Lone flycatcher responded briefly to broadcast with primary song (*fitz-bew*)
	Cibola Lake #3 (West)	18 Jun	Two flycatchers responded to broadcast with primary song *(fitz-bew*) and *brrr-kitters*
IMPE	Hoge Ranch	22 Jun	Lone flycatcher responded to broadcast with primary song *(fitz-bew*)
YUMA	Gila Confluence North	16 Jun	Five flycatchers responded to broadcast with primary song *(fitz-bew*)
		21 Jun	Two flycatchers responded to broadcast with primary song *(fitz-bew*)
2009			
BIHO	Big Hole Slough	17 Jun	Responded briefly to broadcast with primary song (*fitz-bew*)
IMPE	Nursery NW	16 Jun	Responded briefly to broadcast with primary song (*fitz-bew*)
	Ferguson Lake	16 Jun	Two individuals responded briefly to broadcast with primary song (*fitz-bew*)
2010			
MOME	South	16 Jun	Responded to broadcast with *wheeos* and primary song (*fitz-bew*)
BIWI	Site #4	27 Jun–3 Jul	Singing spontaneously (*fitz-bew*)
		27 Jun	Responded briefly to broadcast with *wheeos* and primary song (*fitz-bew*)
2011			
MUDD	Overton WMA Pond	2 Jul	Singing spontaneously (*fitz-bew*)
BIWI	Burn Edge	30 Jun	Occasional unsolicited vocalizations (*fitz-bew* and *wheeo*)
CIBO	Cibola Lake #2 (East)	20 Jun	Brief primary song (*fitz-bew*)
2012	No detections		

[1] LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, TOPO = Topock Marsh, BIWI = Bill Williams River NWR, BIHO = Big Hole Slough, CIBO = Cibola, IMPE = Imperial, YUMA = Yuma.

Habitat Reconnaissance and Site Descriptions

Field personnel spent an additional 177.7 observer-hours completing opportunistic surveys and habitat reconnaissance and evaluation at 59 sites in 12 study areas. The results of reconnaissance for each study area are presented below following the results and site descriptions for regularly surveyed sites. The boundaries of reconnaissance sites are shown on orthophotos in Appendix D. Hydrologic characteristics of each regularly surveyed site are summarized in Appendix E.

Pahranagat National Wildlife Refuge, Nevada

Pahranagat National Wildlife Refuge consists of a series of lakes and marshes in Pahranagat Valley approximately 150 km north of Las Vegas, Nevada. 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 north 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 north end of the lake was not flooded during the 2008 or 2009 breeding seasons. The dam was repaired prior to the 2010 breeding season. Lake levels in 2010–2012 were higher than they had been before dam repair, but not as high as they had been before 2008.

PAHRANAGAT NORTH

Area: 4.6 ha Elevation: 1,026 m

Pahranagat North was surveyed from 2003 to 2012. The site consists of a stand of large-diameter Goodding willow (*Salix gooddingii*) at the inflow of Upper Pahranagat Lake. Fremont cottonwood (*Populus fremontii*; hereafter 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. In 2003–2007, no major changes in vegetation structure or species composition were noted within the site, and canopy closure was consistently >90%. Since 2008, tree mortality has been noted, particularly in the northeastern corner of the site. Scattered cottonwood trees have fallen throughout the rest of the site creating multiple small clearings. Canopy closure is now approximately 80%. From 2003 to 2007, Indian hemp (*Apocynum cannabinum*) was present in the understory but was limited primarily to the dry northern edge of the site. Higher water levels prevented growth along the southern half of the site and delayed germination/sprouting in the northern half until waters had receded in July. Since 2008, as the canopy has become more open and water levels decreased, Indian hemp has spread, and a dense understory of the plant up to 2 m in height is now present throughout the site each year by mid-June.

From 2003 to 2007, the site was inundated annually with up to 1 m of water in mid-May and would become progressively drier through summer. Each year, 100% of the site was inundated in mid-May, and as much as 95% of the site contained standing water and saturated soil in mid-July. In 2008–2012, the site was much drier, with no more than 15% of the site inundated in mid-May in any year. In 2008 and 2009, no standing water or saturated soil was present in the site by mid-July. From 2010 to 2012, 1–2% of the site was inundated along the southern edge in mid-July, with a maximum of 20% of the site containing saturated soils.

Breeding willow flycatchers have been recorded at Pahranagat North since 2003, with 18–26 resident adults detected annually. No trend in number of resident flycatchers has been noted in response to changes in hydrology, but territory locations have shifted away from the center of the site to the perimeter, nearer to the lake bed. A cattle pasture lies immediately adjacent to the northwestern corner

of the survey site, with a portion of the pasture separated from the site by a fence. From 2003 to 2007, high lake levels prevented cattle from going around the fence. Starting in 2008, coincident with lowered lake levels, we observed evidence of increased cattle use of the site. In 2003–2005, cowbirds were detected on one to three surveys. In 2007–2009, cowbirds were detected on one survey near the beginning of the survey season. No cowbirds were detected during surveys in 2006 and 2010–2012.

PAHRANAGAT WEST

Area: 1.5 ha Elevation: 1,026 m

Pahranagat West was surveyed from 2004 to 2012. This native 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 willow 2–4 m in height are also present near the northern end of the site. The site currently has no significant understory vegetation, though some Russian olive (*Elaeagnus angustifolia*) was noted prior to 2007. Canopy closure varies from <50 to 80%. The eastern edge of the site is vegetated with bulrush (*Schoenoplectus californicus*), which extends into the lakebed to the east. The western edge of the site is vegetated in yerba mansa (*Anemopsis californica*) extending into dry, upland desert. No major changes in vegetation structure or species composition have been recorded since 2004. Since surveys were initiated, the upland edge of the site has been dry, and the vegetation along the lake edge has contained varying amounts of standing water through the surveys seasons.

No resident or breeding willow flycatchers were detected at the site from 2004 to 2012. Several adult flycatchers were detected for a single day: one in 2004, one in 2005, two in 2007, two in 2010, and one in 2011. Resights confirmed that several of these detections were of dispersing adults previously documented as resident or breeding at Pahranagat North. No signs of livestock use have been recorded at the site since surveys were initiated. Cowbirds were detected on one to three visits in 2006, 2008, 2011, and 2012. As no resident or breeding flycatchers have been detected at this site and the site lacks the understory and width typical of occupied habitat, we recommend discontinuing surveys. We recommend reassessing this site at the beginning of future seasons to determine if a suitable understory has grown up, or if the site has increased in width.

PAHRANAGAT MAPS

Area: 1.4 ha Elevation: 1,026 m

Pahranagat MAPS was surveyed from 2006 to 2010. The site consists of a stringer of cottonwood on the western edge of the bed of Upper Pahranagat Lake. During the survey years, canopy height was 15–20 m, and canopy closure within the stringer was approximately 70%. The stringer was 20 m wide at the widest point but was narrower in most places. In 2006 and 2007, tamarisk (*Tamarix* spp.) and Russian olive were noted as forming a very sparse understory. From 2008 to 2010, no woody vegetation was noted in the understory, and bulrush lined the eastern edge of the tree line and extended into the lakebed. The western edge of the site was composed of dry, desert upland vegetation. Prior to the start of the 2010 survey season, the southern half the cottonwood stringer burned, removing between 50 and 100% of the overstory canopy in the affected area. Inundated and saturated soils were noted within the site in 2006 and 2007 but not in 2008–2010.

We detected one resident, unpaired male at the site in 2006; no flycatchers were detected from 2007 to 2010. No livestock use was recorded at the site. Cowbirds were detected on one survey in May in 2007, 2009, and 2010. Surveys at this site were discontinued because of the extent of the fire and the complete lack of understory vegetation in the portion of the site that retained an overstory canopy. We recommend reassessing this site if lake levels increase enough to inundate the site again.

PAHRANAGAT SOUTH

Area: 2.5 ha Elevation: 1,023 m

Pahranagat South was surveyed from 2003 to 2010. Through 2009, the site consisted of a relatively small stringer of Goodding willow, coyote willow (*Salix exigua*), and cottonwood lining a human-made channel that carried the outflow from Upper Pahranagat Lake. The cottonwoods were approximately 20 m in height, while the willows were generally less than 10 m tall. Tamarisk and Russian olive formed a sparse understory. In 2003–2007, the site was bordered to the west by an open marsh, which dried out into an open field in 2008–2010. In 2005, we noted that dense coyote willow was increasing on the western side of the site; this area of willow had very sparse canopy in 2006 and 2007 and was almost completely dead by 2008. The majority of this site was affected prior to the start of the 2010 survey season by a fire which removed all understory vegetation and charred the trunks and lower branches of the overstory trees. In 2010, the site consisted of a 20-m-tall stringer of cottonwood along the human-made channel. The understory contained Indian hemp and some small patches of coyote willow 3 m in height. Overall canopy closure within the site remained constant at approximately 50%. The eastern edge of the site bordered upland scrub.

In 2003–2007, standing water was present throughout the survey season in the human-made channel, but was also noted outside the channel in some years. Saturated soils were also noted within the site from 2003 to 2006. In 2008–2010, standing water was only present in the human-made channel, with dry to damp soils immediately adjacent to the channel and throughout the site.

Breeding willow flycatchers were recorded at Pahranagat South from 2003 to 2006, with two to seven resident adults detected annually. In 2007, we detected one resident, unpaired male. No willow flycatchers were detected in 2008 or 2010, but one flycatcher for which residency status could not be confirmed was detected in 2009. No signs of livestock use were recorded at the site. Cowbirds were detected on surveys in May and/or June in 2003–2005 and 2007–2009.

Surveys were discontinued at the end of the 2010 field season due to a lack of understory vegetation. While understory components were present, they were not of sufficient size to resemble typical occupied willow flycatcher habitat. We recommend reassessing this site in future years.

Littlefield, Arizona

From 2003 to 2005, we surveyed two adjacent sites at Littlefield; one at the confluence of the Virgin River with Beaver Dam Wash just upstream of the I-15 overpass (Littlefield North) and the other just downstream of the I-15 overpass (Littlefield South). During the winter of 2004–2005, both sites were completely scoured by floods that removed most of the understory vegetation. Surveys were discontinued in 2006 at Littlefield South and in 2007 at Littlefield North because of the lack of understory vegetation. Starting in 2007, our survey and monitoring activities focused on Beaver Dam Wash near the Highway 91 Bridge (Littlefield Poles). In December 2010, a flood scoured much of the area and changed the hydrology through sediment deposition.

LITTLEFIELD POLES

Area: 1.2 ha Elevation: 565 m

Littlefield Poles, a primarily native site, was surveyed from 2007 to 2010. The site is located on Beaver Dam Wash, immediately upstream of the Highway 91 Bridge. During the survey years, vegetation along the northern edge of the site consisted of a scattered overstory of cottonwood averaging 25 m in height and an understory of tamarisk and Russian olive approximately 6 m in height. The southern portion of the

site consisted of cottonwoods along a network of streams and beaver ponds, with dense stands of coyote willow and young Goodding willow developing over time. Canopy closure in the densest areas of Goodding and coyote willow was >90%, though overall canopy closure ranged from 50 to 70%. In 2008 and 2009, we also surveyed an area downstream of the Highway 91 Bridge as part of the site. Vegetation in this area consisted of young stringers of Goodding and coyote willow up to 5 m in height that formed linear patches 10–15 m wide on the edges of multiple stream channels. Larger Goodding willow was present along the southwestern edge of the site on the edge of a golf course, and a dense patch of Goodding willow was present on the northern edge of the downstream end of the site. The downstream end of the site bordered a cattail (*Typha* spp.) marsh. Surface water was present in stream channels and beaver ponds throughout the survey seasons through 2010.

In December 2010, a flood scoured much of the wash. Sediment deposits from the flood changed the hydrology within the site significantly. After the flood, the southern portion of the site still consisted of stands of coyote willow and young Goodding willow and cottonwood approximately 5 m in height, but canopy closure was reduced to roughly 25%. While surface water was present in the site throughout the survey season in the years prior to the flood, no surface water was present during our checks in 2011 and 2012. The nearest water was Beaver Dam Wash, which was restricted to a channel about 40 m from the site.

One resident, unpaired male was detected in 2007. Breeding flycatchers were detected in 2009 and 2010, with four and three resident adults recorded, respectively. One adult flycatcher, for which residency could not be confirmed, was detected in 2008. Cattle were documented using the site intermittently. Cowbirds were detected on one to five visits in each survey year. Because of the lack of surface water within the site and low canopy closure, this site did not resemble typical occupied flycatcher breeding habitat in 2011 or 2012. We recommend reassessing the site at the beginning of future breeding seasons.

GROUND RECONNAISSANCE RESULTS

Pioneer Road

In 2010 and 2012, we conducted habitat reconnaissance and opportunistic surveys at an area of native vegetation on Beaver Dam Wash approximately 1.2 km upstream of Littlefield Poles. In 2010, strips of dense coyote willow 3–4 m tall and 4 m wide bordered both sides of a stream that ran through the site. Soils were very dry farther from the stream, and vegetation consisted of scattered cottonwood up to 15 m tall. Canopy closure was between 50 and 70%. In 2012, no surface water was noted within the site, and the nearest surface water was Beaver Dam Wash, which surfaced adjacent to a portion of southern edge of the site. Vegetation still consists of cottonwood up to 15 m in height and coyote willow 3–5 m in height. Canopy closure has increased to 70–90%.

We did not detect willow flycatchers in either year. A cowbird was detected on one survey in 2010, and no signs of livestock use were recorded in either year. Because of the lack of surface water within the site, this site does not currently resemble typical occupied flycatcher breeding habitat. We recommend reassessing this site at the beginning of future breeding seasons.

Mesquite, Nevada

The Mesquite study area is in the floodplain of the Virgin River near Mesquite and Bunkerville, Nevada. All sites in the Mesquite study area experienced flooding, scouring, and/or sediment deposition over the 2004–2005 winter. The study area experienced flooding again in December 2010, and while sediment deposition was minimal, scouring was prevalent in areas immediately adjacent to the river.

HAFEN LANE

Area: 5.2 ha Elevation: 475 m

Hafen Lane was surveyed opportunistically in 2006 and formally surveyed from 2010 to 2012. This mixed-exotic site lies within the floodplain of the Virgin River in Mesquite, Nevada, between Hafen Lane and the active river channel. Two drainage ditches that pass underneath Hafen Lane flow into the site; the eastern inflow supports a dense stand of 12-m-tall Goodding willow, with some coyote willow 5 m in height in the understory. The western inflow supports a stringer of coyote willow 5–6 m in height and scattered Goodding willow 12–15 m in height, with 70–80% canopy closure. A few cottonwood up to 25 m in height are scattered along both drainage ditches. Between the stringers, the site is vegetated by 6-m-tall tamarisk with 45–65% canopy closure. Standing water and moist soils were documented only within the drainage ditches, and not with any consistency between years or visits. Soils between the drainage ditches were dry.

Breeding flycatchers were detected in 2010 and 2011, with two and three resident flycatchers recorded, respectively. In 2012, we detected one willow flycatcher for which residency could not be determined. Cowbirds were detected on the majority of surveys in all survey years. No signs of livestock use were recorded.

DUMB LUCK BRIDGE

Area: 1.2 ha Elevation: 475 m

Dumb Luck Bridge was discovered mid-season in 2012 with breeding flycatchers. It is a mixed-native site that lies within the floodplain of the Virgin River in Mesquite, Nevada, immediately upstream from the Riverside Road bridge within the City of Mesquite. The active channel of the Virgin River is approximately 100 m north of the site. Vegetation on the terrace adjacent to the southern boundary of the site burned between 2008 and 2010 and has not yet recovered. The site is dominated by 6-m-tall coyote willow with 70–90% canopy closure. Clumps of emergent Goodding willow 20 m in height are scattered throughout the site. Some tamarisk is present throughout the site, but is most abundant along the site edges. A few emergent cottonwoods are present along the northern edge of the western side of the site. An old road bisects the site north to south, and a drainage ditch from an irrigation canal flows into an area of dense coyote and Goodding willow just east of the road. During our site visits in June and July, water fanned out from this drainage ditch and created an area of very wet soils and standing water. Soils in the remainder of the site were very dry and sandy.

We detected two breeding flycatchers. No signs of livestock were noted. Cowbirds were detected on two surveys.

MESQUITE EAST

Area: 4.4 ha Elevation: 468 m

Mesquite East was surveyed from 2005 to 2010. This mixed-native site lies on several terraces within the floodplain of the Virgin River in Mesquite, Nevada. During the survey years, vegetation on the lowest terrace, on the northern edge of the site adjacent to the river, consisted of cottonwood and Goodding willow generally less than 10 m in height. The central portion of the site was on a slightly higher terrace and was vegetated entirely by dense tamarisk 7–8 m in height with canopy closure around 80%. The uppermost terrace was vegetated with Goodding willow and a few cottonwood 18–25 m in height and an understory of dense clumps of coyote willow about 8 m in height. The western end of this terrace burned over the 2004–2005 winter. Prior to 2009, canopy closure on the upper terrace varied from 50% in the cottonwood/Goodding willow areas to over 90% in the coyote willow clumps. From 2005 to 2008,

standing water was present in the site throughout the survey season in a small pond at the end of an irrigation ditch draining an adjacent field. In 2005 and 2006, some standing water and saturated soils were noted within the site outside of this pond. Starting in 2009, flow from the irrigation ditch apparently ceased, as the site was completely dry during the survey season in both 2009 and 2010. In 2009, the coyote willow on the upper terrace was dead or dying, and in 2010, the vegetation on this upper terrace was mostly dead, with live branches remaining only on the cottonwood and some Goodding willow. By 2010, canopy closure on the upper terrace was approximately 50%.

In 2004, SWCA field personnel from an unrelated project located one lone individual and one pair of willow flycatchers at Mesquite East (see SWCA 2004 for details on flycatcher residency and breeding). We detected one resident, unpaired male at the site in 2005 and in 2007. In 2006, field personnel from an unrelated project located a pair of flycatchers in July; however, surveys both before and after this detection failed to locate any flycatchers, and details of occupancy and breeding were undetermined. One adult flycatcher for which residency could not be determined was detected in 2008. Cowbirds were detected in all survey years. Some signs of cattle were noted in 2006, and cattle usage increased in intensity through 2010. By 2009, many cow trails, signs of fresh cattle use, and a few carcasses were noted throughout the site and survey season. Domestic pigs were also noted within the site at the beginning of the 2009 survey season. Surveys were discontinued in the middle of the 2010 survey season because of the lack of wet soils or live vegetation on the upper terrace. We do not recommend revisiting this site unless irrigation return flow from the adjacent field is restored to the site.

MESQUITE WEST

Area: 10.6 ha Elevation: 470 m

Mesquite West was surveyed from 2003 to 2012. This mixed-native site lies within the floodplain of the Virgin River in Mesquite, Nevada. Golf courses and housing developments border the site to the north, and the Virgin River borders the site to the south. This large site is primarily a mosaic of cattail and bulrush marshes separated by narrow (40–50 m) strips of dense coyote willow with interspersed tamarisk. The eastern portion of the site is primarily coyote willow, while the western portion contains a mix of willow and tamarisk. The coyote willows are generally 5–6 m in height. In 2003–2008, canopy closure varied from 50 to >90%. Water availability became less consistent starting in 2009, and by 2012, canopy closure varied from 30 to >90%. In the eastern third of the site, overall canopy closure, at around 60%, is now notably lower than it has been in previous years, and several small areas of dead coyote willow are now present. Canopy closure in these areas is as low as 30%.

Hydrology at the site is influenced by irrigation return flows and by human manipulation of the channel that carries the return flows. The site contained standing water and muddy soils throughout the 2003–2008 flycatcher breeding seasons. In 2009, irrigation return flows were not present until the last week in June. When return flows resumed, they were present for one day at a time at roughly weekly intervals for the rest of the season and inundated only the eastern portion of the site. Hydrology at the site in 2010 was similar to conditions noted in 2003–2008. In June 2011, the channel that carries the return flows was dredged, resulting in all return flows bypassing the site. The site remained dry until April 2012, when a berm was constructed in the channel to direct flow into the northeastern corner of the site. The site was intermittently inundated throughout the 2012 survey season. When standing water was noted, it only reached a portion of the area inundated in previous years.

Breeding willow flycatchers have been recorded at Mesquite West since 2003, with 6–30 resident adults detected annually. Cowbirds were detected during surveys in all years. Evidence of cattle was observed in 2003, 2004, 2007–2010, and 2012. Signs of cattle, or cattle themselves, were limited to the southern and western edges of the site.

ELECTRIC AVENUE NORTH

Area: 1.8 ha Elevation: 460 m

In 2004, SWCA personnel from an unrelated flycatcher project located territorial willow flycatchers in Electric Avenue North. In 2005, access issues prevented us from surveying the site. Habitat reconnaissance and opportunistic surveys were conducted in 2006, and formal surveys were conducted in 2007 and 2008. This mixed-exotic site was located adjacent to an agricultural field within the floodplain of the Virgin River in Bunkerville, Nevada. In 2006, the site consisted of mixed native vegetation composed of an overstory of cottonwood and Goodding willow averaging 10 m in height with a coyote willow understory. Canopy closure was approximately 70–90%. An isolated patch of tamarisk was located on the western side of the site, and arrowweed (*Pluchea sericea*) and scattered mesquite (*Prosopis* sp.) trees were present on the edges of the site. During the summer of 2007, an area running northwest to southeast was bulldozed through the center of the site, removing approximately 20% of the vegetation present in previous years and creating a drainage ditch. In 2008, the species composition of the overstory vegetation had not changed, but most of the willows were dead and the cottonwoods had sparse leaves, creating canopy closure less than 50%. Coyote willow and tamarisk averaging 4 m in height made up the understory. A cattail marsh on the northwestern edge of the site was lined with narrow (<5 m wide) stringers of young coyote willow. Soils were dry throughout the site, except for the marsh, which held surface water intermittently.

In 2004, SWCA field personnel from an unrelated project located one lone individual and one pair of willow flycatchers at Electric Avenue North (see SWCA 2004 for details on flycatcher residency and breeding). No willow flycatchers were detected at this site from 2006 to 2008. Cowbirds were detected on most surveys in all years. Signs of use by cattle were also noted in all years. Surveys were discontinued after 2008 because most of the vegetation at the site was dead. Most of this site was then scoured away in the December 2010 flood.

ELECTRIC AVENUE SOUTH

Area: 3.9 ha Elevation: 460 m

Habitat reconnaissance and opportunistic surveys were conducted at Electric Avenue South in 2006, and formal surveys were conducted in 2007 and 2008. This mixed-exotic site was located within the floodplain of the Virgin River in Bunkerville, Nevada, between the active river channel to the north and an agricultural field to the south. During the survey years, vegetation at the site consisted of a scattered overstory of cottonwood and Goodding willow averaging 12 m in height with a predominantly tamarisk understory. Some coyote willow was scattered throughout the site, and arrowweed and mesquite trees mixed with the tamarisk in some areas. A tall stand of cottonwood with an open understory was located at the northern end of the site. Canopy closure was approximately 70–90% in 2006. By 2008, the cottonwoods had sparse leaves, many of the willows were dead, and approximately 50% of the tamarisk understory was dead. Canopy closure was less than 50%. No standing water or saturated soils were present during the survey seasons, though water was present in a marshy area along the southeastern edge of the site, between the site and the field. A high embankment prevented water in the marsh from flowing into the site.

No willow flycatchers were detected at this site from 2006 to 2008. Cowbirds were detected in 2006 and 2007. Signs of cattle use were noted in 2007 but not in 2008. Surveys were discontinued in 2008 because most of the vegetation at the site was dead. We do not recommend visiting this site in future years.

BUNKER FARM

Area: 1.9 ha Elevation: 457 m

Bunker Farm was surveyed from 2005 to 2008. This exotic site lies within the floodplain of the Virgin River in Bunkerville, Nevada, approximately 3 km downstream of Mesquite West. The site is between an agricultural field to the southeast and the Virgin River to the northwest. From 2005 to 2007, vegetation within the site was highly heterogeneous. The edge of the site adjacent to the agricultural field consisted primarily of dense stands of coyote willow 7–8 m in height with emergent Russian olive and Goodding willow, interspersed with stands of tamarisk. Canopy closure in this area was 70–90%. Toward the river the vegetation graded into clumps of tamarisk 3–4 m in height with less than 70% canopy closure. Prior to the start of the 2008 survey season, most of the southwestern third of the site was bulldozed. By 2008, many of the emergent Goodding willow were dead or dying, and the coyote willow that had formed dense stands within the site in previous years was completely dead.

During the survey season of 2005, standing water and saturated soil were present in the site when the adjacent agricultural field was irrigated. The agricultural field was fallow during the 2006 and 2007 flycatcher breeding seasons, and the site did not receive agricultural runoff in these years. In 2006, puddles of standing water were present in the site only in May, and the site was completely dry and dusty by mid-July. In 2007, muddy puddles on cattle trails were present until June, and the site was completely dry by mid-July. In 2008, the site was dry throughout the survey season.

In 2004, SWCA field personnel from an unrelated project located one lone individual and one breeding pair of willow flycatchers at Bunker Farm (see SWCA 2004 for details on flycatcher residency and breeding). Breeding willow flycatchers were recorded at the site in 2005, with six adults detected. In 2006, one unpaired male was detected. No flycatchers were detected in 2007, and one willow flycatcher for which residency could not be confirmed was detected in 2008. Cowbirds were detected during surveys in all years. Evidence of use by cattle was observed in all years. Surveys were discontinued at the end of 2008 due to a lack of suitable vegetation and hydrology. Most of this site was then scoured away in the December 2010 flood.

BUNKER MARSH NORTH

Area: 7.1 ha Elevation: 456 m

Bunker Marsh North was opportunistically surveyed in 2006 and formally surveyed from 2009 to 2011. This mixed-exotic site lies within the floodplain of the Virgin River near Bunkerville, Nevada, approximately 4 km downstream of Mesquite West. The site is between agricultural fields to the southeast and the Virgin River to the northwest. The northern portion of the site was scoured by the December 2010 flood. During the survey years, the site was dominated by tamarisk 4–6 m in height. In the southern portion of the site, the vegetation formed an open mosaic of tamarisk, scattered Goodding willows 10–12 m in height, and scattered, isolated patches of coyote willow, with an average canopy closure of 25–50%. One small patch of coyote willow 4–5 m in height occurred in the middle of the site near the western boundary in 2009. Breeding flycatchers were present in this patch in 2009, but by 2010 all of the coyote willows were dead. Canopy closure was highest in the middle of the site, averaging 70–90%.

In 2009, flowing surface water was noted on the site through mid-June. The water flowed through a series of marshy areas, including the small patch of coyote willows that was occupied by breeding flycatchers, and into a larger marsh at the southwestern border of the site before entering the river. By July, all previously inundated areas were dry. Inspection of aerial photos indicated that changes in hydrology were likely due to redirection of irrigation return flows into a new, more direct channel leading to the river. In 2010 and 2011, the portion of the site that contained breeding flycatchers in 2009 remained completely

dry. Surface water was noted within the site only in May in both years in the form of small streams. In 2010, a small stream fed by return flow was located at the very southern edge of the site, but no water was present in the northern end of the site. In 2011, no water was noted at the southern end of the site, but water was again present in the northern end of the site. Due to changes in the river channel, the return flow no longer flowed through the site and the old flycatcher breeding area, but instead flowed directly into the river. The site borders the Virgin River, but a bank 1–2 m high has prevented river water from flowing into the site.

Five resident and breeding flycatchers were detected in 2009. No willow flycatchers were detected in 2010 or 2011. Cowbirds were detected on most surveys in all survey years, and signs of cattle were observed within the site on all visits. Surveys at this site were discontinued in the middle of the 2011 survey season because of the lack of surface water within the vegetation and extensive tamarisk beetle defoliation. We do not recommend visiting this site in future years.

GROUND RECONNAISSANCE RESULTS

Backyard

Habitat reconnaissance was conducted at Backyard in 2012. This mixed-native site lies on the northern side of the Virgin River floodplain approximately 6.5 km upstream from the Riverside Road Bridge in Mesquite, Nevada. The site is a 40-m-wide and 150-m-long band of dense native vegetation consisting of 6–8-m-tall coyote willow, 10–14-m-tall Goodding willow, and 14-m-tall cottonwood. Tamarisk 4–6 m in height surrounds the band of native vegetation and is also present in the understory. Canopy closure reaches 80–90% within the coyote willow. Patches of dead cattail were present within the band of native vegetation. Soils were dry and sandy, and no water was present during our visit in May. Heavy tamarisk defoliation was noted during the visit as well. Due to the lack of standing water, this site does not currently resemble typical occupied flycatcher breeding habitat. We recommend reassessing this site at the beginning of future breeding seasons to determine if the hydrology has changed.

Ball Park

Habitat reconnaissance was conducted at Ball Park in 2012. This mixed-exotic site lies on the northern side of the Virgin River floodplain approximately 200 m upstream from Hafen Lane. It is bordered by a park and housing developments to the north and the active floodplain to the south. The site is dominated by 6-m-tall tamarisk, with an emergent overstory of 12–15-m-tall Goodding willow and some 18–20-m-tall cottonwoods scattered throughout the site. Several small (20 m x 20 m) patches of coyote willow 3–6 m in height with 75–85% canopy closure are scattered throughout the site. Canopy closure throughout the rest of the site averaged 60%, and in places was below 50%. Dense patches of 2-m-tall cattail are also present in the understory. No water was observed in the site during our visit in May. Heavy defoliation by tamarisk beetles was also noted during this visit. Most of the vegetation is not dense enough to be considered suitable flycatcher habitat. The coyote willow patches would be considered suitable if they covered a larger area. This site also does not currently resemble typical occupied flycatcher breeding habitat due to the lack of standing water. We recommend reassessing this site at the beginning of future breeding seasons to determine if the hydrology has changed and if the extent of the coyote willow has increased.

Up the Creek

Habitat reconnaissance and opportunistic surveys were conducted at Up the Creek in 2012. This native site lies within the floodplain of the Virgin River in Mesquite, Nevada, approximately 1 km upstream from the Riverside Road Bridge. The site is bordered by the Virgin River to the north and upland desert

to the south. This site is a mosaic of patches of coyote and Goodding willow approximately 4 m in height with 70–90% canopy closure, and areas of 20-m-tall cottonwood with sandy soils and sparse understory vegetation. Patches of tamarisk and arrowweed occur between the patches of native trees. An outflow channel from an irrigation canal bisects the site and flows into the Virgin River. Water was present during visits in June and July, but was restricted to this channel.

No willow flycatchers were detected during two surveys. Cowbirds were detected on both visits, and no signs of livestock were noted. Because of the lack of surface water within the site, the majority this site does not currently resemble typical occupied flycatcher breeding habitat. The coyote willow are also currently shorter than what is typically found in occupied habitat. We recommend reassessing the site at the beginning of future breeding seasons to determine if the hydrology has changed or the coyote willow have grown in height and extent.

Electric Avenue Pond

Habitat reconnaissance and opportunistic surveys were conducted at Electric Avenue Pond in 2012. This native site is located on the south side of the Virgin River floodplain near Bunkerville, Nevada, approximately 2 km downstream from Mesquite West. It is bordered to the north by Electric Avenue South and to the south by agricultural fields. The site consists of a cattail marsh ringed by a narrow strip (<5 m wide) of coyote willow 2–3 m in height. Overall canopy closure is <25%. A dense patch of coyote willow, 20 m in diameter and 3–4 m in height, is present on the eastern end of the site where water enters the marsh from an irrigation canal. The entire site was wet during our visit in May.

No willow flycatchers were detected during two surveys. Cowbirds were detected on one visit, and signs of cattle were noted. Vegetation in the site is currently too short and limited in extent to be suitable for willow flycatchers. We recommend reassessing the site at the beginning of future breeding seasons to determine if the coyote willow has matured to a more suitable height and extent.

Boomerang

Habitat reconnaissance and opportunistic surveys were conducted at Boomerang in 2012. This mixed-exotic site lies within the floodplain of the Virgin River near Bunkerville, Nevada, approximately 3 km downstream of Mesquite West, and is part of the Bunkerville Marsh proposed restoration site. It is bordered by a pond to the northwest and a wet meadow complex to the east. The northern third of the site consists of tamarisk 3–4 m in height and patches of arrowweed. This portion of the site is perched approximately 1 m above the pond, and soils within this portion of the site were dry during our visits. To the south of this tamarisk area is an open meadow that bisects the site from northeast to southwest. This meadow was wet during our site visit in May but dry in June. South of the meadow, the western half of the site consists of an open mix of tamarisk, arrowweed, and screwbean mesquite (*Prosopis pubescens*) with approximately 30% canopy closure. The southeastern portion of the site consists of a stand of tamarisk 4–6 m in height with 80% canopy cover. This tamarisk stand has a few openings vegetated by sedges (*Carex* sp.) and scattered, spindly clumps of 2-m-tall coyote willow. These openings were wet during our visits in both May and June. Heavy defoliation of the tamarisk within the site was noted by early June.

No willow flycatchers were detected during two surveys, and cowbirds were detected on both visits. Signs of cattle were seen throughout the site. The majority of the vegetation within this site is too short or open to be considered suitable willow flycatcher habitat, and water at the site is confined to open meadows and does not extend into the woody vegetation. The tamarisk at the site was being cleared by Nevada Division of Forestry during a site visit in February 2013. We do not recommend visiting this site in the future unless restoration activities increase the density of native vegetation.

Left Foot

Habitat reconnaissance and opportunistic surveys were conducted at Left Foot in 2012. This mixed-exotic site lies within the Virgin River floodplain, approximately 7 km downstream of the Riverside Bridge, between the Virgin River to the southeast and desert upland to the northwest. The vegetation is composed primarily of a mosaic of 1.5–2-m-tall arrowweed and 2–3-m-tall tamarisk, with pockets of 4–6-m-tall screwbean mesquite. Canopy cover is <25% throughout the site. Soils were dry and sandy throughout the site on all our visits.

We detected one willow flycatcher on 24 May during the initial site evaluation and two additional flycatchers on the follow-up visit on 27 May. None of these flycatchers engaged in unsolicited song or other territorial behaviors, and no flycatchers were detected on three subsequent territory monitoring visits. No willow flycatchers were detected during three surveys following the territory monitoring visits. Cowbirds were detected during all three surveys, and signs of cattle were noted throughout the site on all visits. Vegetation within the site is too short and open to be considered suitable habitat, and the site lacks surface water. We do not recommend visiting this site again.

Mormon Mesa, Nevada

For approximately 15 km upstream of its confluence with the Muddy River, the Virgin River flows through a 1-km-wide floodplain with a mosaic of habitats, including cattail marshes and tamarisk and willow forest. River levels are seasonally influenced by snowmelt in the spring and monsoon rains in mid and late summer, and the entire study area experienced severe flooding over the 2004–2005 and 2010–2011 winters. Hydrology within the survey sites is influenced by water from the Virgin River that surfaces in areas away from the main river channel. All the areas surveyed at Mormon Mesa are at least 10 km upstream of the Muddy River confluence. All of the areas we surveyed are used extensively by cattle, and cowbirds were detected on most surveys in all years.

MORMON MESA NORTH

Area: 8.2 ha Elevation: 390 m

Mormon Mesa North was surveyed from 2003 to 2010. In 2003 and 2004, this mixed-exotic site was north of a dry channel of the Virgin River that cut from east to west across the floodplain, and the active channel of the river was located to the east of the site. The site was bordered to the west by a large, seasonally inundated cattail marsh. From the dry river channel toward the cattails, the site graded from dense arrowweed to tamarisk with arrowweed understory to a mixture of tamarisk, Goodding willow, and coyote willow. Canopy height was generally 4–5 m and extended to 8 m where the willow was present. Canopy closure was approximately 70–90%. In 2003, the areas with a mix of tamarisk and willow forest were inundated to a depth of 0.4 m during site reconnaissance in March. When surveys commenced in May 2003 and 2004, the areas with tamarisk and willow forest had damp and muddy soils under the vegetation; these areas were completely dry by mid-June in both years.

During the winter floods in 2004–2005, the previously dry channel became the main channel of the Virgin River, and the cattail marsh was scoured. The entire site was flooded and flood debris was visible on the trees up to 2 m above the ground. The cattail marsh was an open pond during the summers of 2005 to 2007. The active channel contained water throughout the flycatcher breeding seasons in 2005, while in 2006 and 2007 the channel was dry by approximately the end of June, and surface flow occurred again in July with the onset of monsoons. No standing water or saturated soils were present within the site after the winter floods of 2004–2005.

By 2010, overall canopy closure had decreased to around 50%. Vegetation consisted primarily of tamarisk 3–5 m in height with areas of emergent Goodding willow up to 12 m in height and patches of coyote willow. The western edge of the site had a 100- x 50 m-patch of Goodding willow, 8 m in height, with up to 75% canopy closure and dead cattails in the understory. No standing water or saturated soils were present within the site during a visit in May, and the nearest water was in the river channel approximately 100 m away. The site was perched up to 2 m above the water level. The December 2010 flood scoured away the southeastern quarter of the site, but hydrology within the remainder of the site was unchanged.

Breeding flycatchers were detected in 2003–2005, with two to six resident adults detected annually. No flycatchers have been detected in the site since 2005. Surveys were discontinued in 2010 due to the lack of water within the site. We recommend not visiting this site again unless another flood event occurs that has the potential to change the hydrology within the site.

HEDGEROW

Area: 1.1 ha Elevation: 390 m

Opportunistic surveys were conducted at Hedgerow in 2005, and formal surveys were conducted at the site from 2006 to 2010. This mixed-exotic site is east of Mormon Mesa North, on the eastern side of the Virgin River. During the survey years, the site consisted of a continuous understory of tamarisk 4–5 m in height with scattered emergent Goodding willow up to 12 m in height. Many of the willows had dead branches. The site was surrounded by tamarisk and arrowweed 2–3 m in height. Canopy closure at the site varied from about 50% on the edges of the site up to 80% in the denser areas. No major changes in vegetation structure or species composition were recorded from 2005 to 2010. Soils within the site were dry since surveys were initiated in 2005. The December 2010 flood did not alter the site in any way.

No flycatchers were detected within the site from 2005 to 2010. Surveys were discontinued in 2010 due to a lack of suitable hydrology. We do not recommend visiting this site again unless another flood event occurs that has the potential to change the hydrology within the site.

MORMON MESA SOUTH

North half: Area: 8.4 ha Elevation: 385 m

South half: Area: 3.4 ha Elevation: 385 m

Mormon Mesa South was surveyed from 2003 to 2012. This mixed-exotic site was split into two contiguous areas to facilitate tracking of survey activity. A long strip of scattered Goodding willow up to 20 m, but more typically 12–15 m, in height runs north to south through the site. The willows vary in health, with the healthiest located in the center of the northern half of the site, and the western edge of the southern half. The rest of the willows are dead or dying. The percentage of declining willows within the site has increased over the last 10 years. The understory is patchy and composed primarily of tamarisk 4–6 m in height, with dead cattail and arrowweed scattered in the understory of the northern half. Overall canopy closure is highly variable, ranging from >80% in the densest areas to <50% in openings. Inundated or saturated soils were only noted in May of 2003, 2004, and 2006. Since 2007, only damp soils have been recorded within the site. The presence of dead cattails and deadfall suggests that this site was formerly considerably wetter, and portions of the site still have the structure to provide potential flycatcher habitat with wetter soil conditions.

No resident flycatchers were detected within the site from 2003 to 2012. One to three adult flycatchers for which residency status could not be determined were detected annually in 2003, 2004, 2006–2008, 2010, and 2012. Only one of these adults was detected in the southern half of the site. We recommend

discontinuing surveys in the southern half of the site and continuing to assess the northern half of the site at the beginning of future breeding seasons

VIRGIN RIVER #1

North half: Area: 10.4 ha Elevation: 380 m
South half: Area: 11.1 ha Elevation: 380 m

Virgin River #1 was also divided into two areas, Virgin River #1 North and Virgin River #1 South, to facilitate streamlining of field logistics. Virgin River #1 North was surveyed from 2003 to 2012. Opportunistic surveys were conducted at Virgin River #1 South in 2003, and the site was formally surveyed from 2004 to 2012. Both halves of the site have been reduced by more than half of their original areal extent as improved on-the-ground reconnaissance has identified peripheral areas of poor suitability. Shifts in hydrology have also reduced the suitability of some formerly occupied areas within the site.

Virgin River #1 North is primarily tamarisk 4–6 m in height, with areas of emergent Goodding willow up to 10 m in height. In 2003 to 2007, these willows were located primarily along the eastern half of the site, with another patch along the northwestern edge. By 2008, the emergent willows in the northeastern portion of the site, which supported breeding flycatchers in 2003 and 2004, were completely dead due to sediment deposition by the winter 2004–2005 flood and a corresponding shift in the distribution of surface water within the site. Emergent willows are now located in the central and southwestern portions of the current site extent. Canopy closure has remained constant at 70–85% as unsuitable areas have been removed. Standing water was recorded within the site during May and June of every year, though the extent and distribution shifted. In 2003 and 2004, standing water was present beneath the willows on the eastern side of the site. In 2005, water extent was reduced to several braided channels throughout the site. In 2006 and 2007, water was only present in stagnant pools in cattle trails. Starting in 2008, standing water has been found primarily in the southwestern willow patch, and is limited to stagnant pools in cattle trails throughout the rest of the site.

Breeding willow flycatchers were recorded in the eastern half of Virgin River #1 North in 2003 and 2004, with seven and eight resident adults detected, respectively. In 2005, one resident, unpaired male was detected in this same area of the site. No flycatchers were detected within the site in 2006. In 2007, one resident unpaired male was detected in the southwestern corner of the site. Breeding willow flycatchers were recorded in the southern portion of the site in 2008, 2009, 2011, and 2012, with two to four resident adults detected annually in each of these years. Four adults for which residency could not be established were detected in 2010.

Virgin River #1 South is primarily tamarisk 4–6 m in height with patches of coyote willow 6 m in height and scattered Goodding willow 8–12 m in height. Canopy closure varies from >90% in areas of dense willow to 25–50% in tamarisk and marshy openings. From 2003 to 2006, the site was described as primarily dense, dry tamarisk 5 m in height, with a few emergent Goodding willow along the northeastern and southern portions of the original site. In 2007, flycatchers were discovered around a marsh in the northwestern corner of the site. Standing water was present in the site through at least June in all years, though the extent and distribution shifted. From 2003 to 2006, standing water was only documented through June in an old river channel in the southern portion of the site. Starting in 2007, that channel has either held saturated or dry soils, and the only documented standing water has been located in the northern marsh, which stays inundated throughout the survey season.

No willow flycatchers were detected at Virgin River #1 South in 2003–2005. Breeding flycatchers were detected within the site from 2006 to 2012. In 2006, the breeding flycatchers were located in the very southern portion of the site, with three resident adults recorded. From 2007 to 2012, breeding flycatchers were located in the northern marsh, with 12 to 25 resident adults recorded annually.

VIRGIN RIVER #2

Area: 11.2 ha Elevation: 380 m

Virgin River #2 was opportunistically surveyed in 2003 and 2004 and formally surveyed from 2005 to 2012. Like Virgin River #1, this site has been significantly reduced in extent as reconnaissance has identified areas of unsuitable habitat. In 2003 to 2007, the survey area was primarily a monotypic stand of tamarisk 4 m in height with 50–70% canopy closure. Patches of emergent Goodding willow up to 10 m in height were present, primarily in the southeastern end of the site. Starting in 2010, the extent of the site was reduced to just the southeastern emergent Goodding willow, due to the lack of suitable hydrology and vegetation structure throughout the rest of the site. This site received extensive sedimentation from the December 2010 flood. The depth of new sediment ranges from 15 to 60 cm and is most extensive in the southern portion of the site. Many of the Goodding willow, particularly in the southern third of their extent, are now dead or dying. Canopy closure within the northern willows is 60–85%, while closure in the southern willows is <50%. The Virgin River, on the eastern edge of the site, had surface water throughout most survey seasons, but went dry in July in a few years. A high bank currently prevents water from the river from entering the site. Standing water and saturated soils were documented within the site in 2005 and 2006, but not in 2007–2012.

Breeding willow flycatchers were discovered at Virgin River #2 in 2005 and recorded through 2008, with 6 to 17 resident adults detected annually. The presence of old flagging from prior to 2003 in the occupied area indicated that flycatchers could have been present in 2003 and 2004. One adult for which residency could not be determined was detected in 2009. One resident, unpaired male was detected in 2010. No willow flycatchers were detected in 2011 or 2012. We discontinued surveys at Virgin River #2 partway through the 2012 survey season due to a lack of suitable hydrology and reduced canopy cover due to tamarisk defoliation. We recommend discontinuing surveys at this site except for the stand of Goodding willow at the northern end of the site, which should be evaluated at the beginning of future breeding seasons.

GROUND RECONNAISSANCE RESULTS

Bluff

Habitat reconnaissance was conducted at Bluff in 2012. This exotic site is located approximately 1 km upstream from Mormon Mesa North. It is dominated by clumps of 3-m-tall tamarisk interspersed with open, sandy areas vegetated with arrowweed. Canopy closure reaches 70–90% within the tamarisk clumps. The site was completely dry during our visit in late May. Due to the lack of suitable vegetation and hydrology, we do not recommend visiting this site in the future.

Stillwater Flat

Habitat reconnaissance was conducted at Stillwater Flat in 2008. We explored this mixed-exotic area, northwest of Mormon Mesa North, because emergent willows were visible from the bluff overlooking the floodplain. In 2008, the area was primarily sparse tamarisk 4 m in height with a few emergent Goodding willow up to 10 m in height. The southeastern corner of the site contained a few willows 3 m in height and dense tamarisk. Overall canopy closure was <50%, and soils throughout the site were very dry. Because vegetation was generally sparse and soils were dry, this area did not represent suitable flycatcher habitat at the time of the reconnaissance, and we have not visited it again.

River Mile 30

Habitat reconnaissance was conducted at River Mile 30 in 2008. This mixed-exotic area is along the Virgin River approximately 5 km upstream of the confluence of the Virgin and Muddy Rivers. We had not noted this area during helicopter reconnaissance, but aerial photographs taken after the 2004–2005 winter flood showed side channels bisecting dense vegetation. At the time of our site visit in 2008, the area consisted of tamarisk 3 m in height and arrowweed 2 m in height, and canopy closure was <50%. The only water present during the site visit in early June was in the main channel of the Virgin River. All vegetated areas were perched approximately 2 m above the riverbed, and the side channels that contained water at the time the aerial photograph was taken were dry and sandy. The site did not represent suitable flycatcher habitat, and we have not visited it again.

Virgin Narrows North

Habitat reconnaissance was conducted at Virgin Narrows North in 2008. This native area is on the Virgin River approximately 3 km upstream of the confluence of the Virgin and Muddy Rivers. We noted this area during helicopter reconnaissance in April 2008. At the time of our site visit, the area consisted of a band of Goodding willow approximately 30 m wide and 100 m long paralleling the river on a dry terrace 1–1.5 m above the water. The willows were 4–6 m in height and were densest close to the river, becoming mixed with arrowweed away from the river. Foliage on the willows was not very dense, and canopy closure was 70–90%. Of the areas explored at Mormon Mesa, this one most closely resembled suitable flycatcher habitat, though the vegetation was too sparse and the soils too dry to warrant further surveys. Given that the site was perched well above the water table, habitat conditions in the area seemed unlikely to improve in future years, and we have not visited the site again.

Virgin Narrows East

Habitat reconnaissance was conducted at Virgin Narrows East in 2008. This mixed-native area is on the Virgin River approximately 2.8 km upstream of the confluence of the Virgin and Muddy Rivers. We noted this area during helicopter reconnaissance in April 2008. At the time of our site visit, the area consisted of a series of dry terraces adjacent to the river, with the lowest terrace perched approximately 2 m above the riverbed. Vegetation consisted primarily of a mix of arrowweed and tamarisk 3 m in height with scattered clumps and bands of emergent Goodding willow. Canopy closure was <50%. The site was too dry and sparsely vegetated to provide suitable flycatcher habitat, and we have not visited it again.

Virgin Narrows West

Habitat reconnaissance was conducted at Virgin Narrows West in 2008. This mixed-native area is on the Virgin River approximately 2.5 km upstream of the confluence of the Virgin River and the Overton Arm of Lake Mead. We noted this area during helicopter reconnaissance in April 2008. At the time of our site visit, vegetation consisted of a 10-m-wide band of Goodding willow, approximately 8 m in height, on a narrow terrace perched 2 m above the riverbed. Arrowweed formed an understory 2 m in height. Leaves on the willows were sparse, and overall canopy closure was 70–90%. This area had the vegetation structure of suitable flycatcher habitat but lacked the foliage density, areal extent, and damp soils typical of flycatcher habitat. We have not revisited the site.

Muddy River, Nevada

The Muddy River study area is along the Muddy River in the Overton Wildlife Management Area (WMA) near Overton, Nevada.

OVERTON WMA POND

Area: 0.7 ha Elevation: 378 m

Overton WMA Pond was surveyed or monitored from 2007 to 2012. This site consists of a patch of mixed-native vegetation approximately 150 m long and 75 m wide at the north end of Overton WMA just south of Honeybee Reservoir. The dominant vegetation consists of Goodding willow 15–20 m in height with a sparse 5–7-m-tall tamarisk understory. Cattail and sedges are also present on the edges of the site and along a stream channel that drains through the site. Arrowweed is present in scattered, dense patches within and along the edges of the site. Canopy closure is variable, ranging up to 90%. The small stream channel runs north to south through the site, and held surface water throughout the season in all survey years.

One pair of resident, breeding flycatchers was detected in 2007. Another resident adult flycatcher was detected in 2012. Two flycatchers for which residency could not be determined were detected in 2008 and 2011. Cowbirds were detected on at least one visit in all survey years. No signs of livestock use were recorded at the site.

OVERTON WMA

Area: 9.2 ha Elevation: 378 m

Overton WMA was surveyed from 2004 to 2012. This 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 site flooded heavily during the 2004–2005 winter, but vegetation at the site was relatively unchanged. We will describe the site in two portions (the “northern two-thirds” and “southern portion”) as vegetation structure and species composition, as well as hydrology, differ between the two.

The northern two-thirds of the site is dominated by very dense tamarisk up to 7 m in height with canopy closure of 70–90%. The tallest tamarisk are adjacent to the river channel on the eastern bank, and height and density of the tamarisk decreases with distance from the channel. Two stretches of the channel of the Muddy River within this portion of the site were dredged with heavy equipment over the 2007–2008 winter, resulting in a cleared swath 10–15 m wide on the western bank of the river. The more upstream of the two dredged and cleared areas extended from the northern end of the site southward for approximately 350 m, ending approximately 10 m upstream of the most upstream flycatcher nest recorded in 2005–2007. Dredging resumed less than 5 m downstream of the most downstream nest in that portion of the site and continued southwest along the river channel for approximately 400 m, ending over 100 m from the flycatcher nesting area at the southern end of the site. The river channel in the northern two-thirds of the site has been incised 1–2 m below the surrounding land surface since dredging and contained flowing water throughout all survey seasons. Vegetation in the northern two-thirds of the site has remained unchanged in structure and species composition from 2004 to 2012. In the majority of this portion of the site, soils outside the main river channel were dry throughout all survey seasons. The breeding area in this portion of the site contained more braided channels of flowing water prior to dredging.

Breeding willow flycatchers were recorded in this portion of the site from 2005 to 2007 and in 2012, with three to four resident adults detected in each year. One resident, unpaired male was detected in 2004. One adult flycatcher was detected for one day in both 2009 and 2011. No flycatchers were detected in 2008 or 2010.

Surveys in the southern portion of the site began in 2005. This portion of the site consists primarily of a stand of Goodding willow 10–15 m in height with an understory of tamarisk and cattail. Canopy closure in this area is up to 90%. Beavers have felled swaths of Goodding willow in this portion of the site,

resulting in gaps in the canopy. Approximately 0.3 ha of the southern portion of the site was bulldozed in 2005 as part of Overton WMA efforts to repair flood damage to their water control system, creating an open, marshy area. From the marshy area, water flows through a network of braided channels. Standing water and saturated soils have been present in this portion of the site since 2005, with beaver activity creating peak water levels of 30 cm in depth throughout the survey season in 2008. Since 2008, this portion of the site has been slowly drying out. In May of 2012, standing water was noted in the marsh, and there were some saturated soils in the side channels. By the middle of June, only saturated soil remained in the marsh, and soils throughout the rest of this portion of the site were damp or dry. Near the junction of the main river channel and the marsh, a ditch leads west and runs along the southern edge of the site. The ditch along the southern edge of the site has held flowing water throughout all survey seasons.

Breeding flycatchers were detected in 2005 to 2012, with 8–13 resident adults detected annually. Cowbirds were detected on most surveys in all years. Signs of cattle were seen on the western edge of the site in some years, but were not recorded within the site interior.

GROUND RECONNAISSANCE RESULTS

The Narrows

Habitat reconnaissance and opportunistic surveys were conducted at The Narrows in 2009 and 2010. The Narrows site is along the Muddy River, immediately upstream of the point where the river enters the Moapa Valley, approximately 1.5 km west of Bowman Reservoir. At the time of the surveys, this site consisted of an approximately 125-m-wide swath of tamarisk straddling a reach of the Muddy River approximately 900 m in length. Upland desert bordered the site on the north and the south. The site was dominated by very dense tamarisk up to 8 m in height with canopy closure of 70–90%, and areas of saltbush (*Atriplex* sp.) bordered the tamarisk along the southern uplands. Small patches of willow 3–4 m in height were found along the river in the central portion of the site. Soils throughout most of the site were dry during the reconnaissance visit in May of 2010, with surface water confined to the incised river channel. Two small areas of saturated soil were noted at the eastern end of the site. No signs of livestock use were observed. We do not recommend further visits to this site unless flood events occur that have the potential to alter the hydrology.

Overton Willows

Habitat reconnaissance and opportunistic surveys were conducted at this site in 2005 and 2007, and it was determined that the vegetation was too short and sparse to support flycatchers. We reevaluated the site in 2010 to determine if conditions had improved. This mixed-exotic site is approximately 150 m east of the Overton WMA site. In 2010, the site was dominated by dense tamarisk typically 3–4 m in height but with patches up to 6 m in height. Patches of willow, most of which were dead or dying, were present throughout the site, and stands of common reed (*Phragmites australis*), most of which were also dead, were scattered through the southern portion of the site. Overall canopy closure is 50–70%. Soils within the site were completely dry during all visits. No signs of livestock use were recorded at this site. The quality of the site for willow flycatchers had not improved since 2007, and we do not recommend further visits to this site.

Muddy River Recon

During aerial reconnaissance in March 2009, we noted a flooded area along the riparian corridor of the Muddy River starting approximately 1 km downstream of the southern end of Overton WMA and continuing downstream for approximately 1 km. Ground reconnaissance the following May revealed that

the area consisted primarily of cattail marsh with scattered tamarisk 3 m in height. A few scattered Goodding willow 8 m in height were also present, and overall canopy closure was <25%. The area was flooded with up to 10 cm of water during the site visit. The sparse woody vegetation and open canopy make this area unsuitable for breeding flycatchers. We have not visited this site again.

Grand Canyon, Arizona

The Colorado River in lower Grand Canyon downstream of Separation Canyon is strongly influenced by water levels in Lake Mead. Potential willow flycatcher habitat in this area changed dramatically from 2000 to 2010 as the result of a 40.3 m drop in the level of Lake Mead. Lower Grand Canyon was not surveyed in 2009–2011 because the declining level of Lake Mead severely reduced the amount of potential flycatcher habitat, and the formation of rapids at Pearce Ferry and Iceberg Canyon made access difficult and dangerous.

The level of Lake Mead increased from 330 m above mean sea level in November 2010 to 346 m in January 2012, and lake levels were still high enough (340 m) in July 2012 to allow passage up Iceberg Canyon but not beyond Pearce Ferry rapid. We completed a reconnaissance trip with Reclamation personnel on 8 and 9 July from Iceberg Canyon upstream to the Pearce Ferry rapid. We visited previously surveyed sites and assessed new vegetation along this stretch of river. We noted a small group of cattle within a few river miles of Pearce Ferry, but otherwise no signs of livestock were recorded.

BURNT SPRINGS (RM 259.5N)

Area: 11.0 ha Elevation: 363 m

Burnt Springs was surveyed from 2003 to 2008. During those years, vegetation within the first 200 m of Burnt Springs Canyon upstream from the Colorado River consisted of extremely dense monotypic tamarisk approximately 5 m in height. The next 150 m of the canyon was vegetated by smaller tamarisk 3–4 m in height. This was followed by an approximately 700-m stretch of mature Goodding willow 15 m in height with an understory of cattails. Canopy closure was approximately 70–90%. No major changes in vegetation structure or species composition were recorded from 2003 to 2008. In 2003–2004, no standing water was noted at the site, but the presence of live cattails suggested recent inundation or subsurface water. Muddy soil and slow moving water were present in the creek through the 2005–2007 survey seasons. In 2008, water was present in the streambed in the downstream half of the site through June.

No willow flycatchers were detected at Burnt Springs in 2003, 2005, 2006, or 2008. In 2004, we detected a lone individual on 8 and 24 June. In 2007, we detected one breeding pair of willow flycatchers. Cowbirds were detected on at least one survey in all survey years. No livestock use was recorded at the site. We recommend revisiting this site if surveys resume in Grand Canyon.

RM 274.5N

Area: 18.3 ha Elevation: 354 m

RM 274.5N was surveyed from 2003 to 2008. This mixed-native site lies immediately adjacent to the Colorado River. During the survey years, the site contained several perennial springs, which fed small creeks, beaver ponds, and cattail marshes and flooded willow and tamarisk forest. Perennial creeks lined with coyote and Goodding willow connected the wetlands to the Colorado River. Deep pools of clear, standing water were present at springs, and large areas of the site contained muddy soils and standing water throughout all survey seasons. Although the site had contained large areas of standing water since 2003, continued beaver activity expanded the areas of standing water in the site in 2008 compared to previous years. Vegetation at the site was a mosaic of well developed, mature Goodding willow forest,

willow forest with tamarisk understory, and cattail marsh. Some cottonwoods were also present. Canopy height of the tamarisk was around 5 m, while the willows reached approximately 10 m. Canopy height and relative proportions of willow and tamarisk varied throughout the site. Canopy closure was highly variable but averaged approximately 70%. The survey area was expanded greatly in 2006 to include large adjacent areas of recently developed mature willow. No major changes in vegetation structure or species composition were recorded from 2003 to 2008.

No willow flycatchers were detected at RM 274.5N in 2003 or 2008. We detected one breeding pair in 2004 and one resident, unpaired male in 2005. We detected one breeding pair at this site in 2006 and two resident, unpaired males in 2007. Cowbirds were detected in all survey years. No sign of livestock use was recorded at this site. We recommend revisiting this site if surveys resume in Grand Canyon.

RM 285.3N

Area: 8.6 ha Elevation: 343 m

RM 285.3N was surveyed from 2006 to 2008. This mixed-exotic site lies between the Colorado River and Grand Wash Bay, which was isolated from the Colorado River when the water level dropped in Lake Mead. In 2006, mixed native vegetation at the site consisted primarily of even-aged stands of Goodding willow approximately 8 m in height. The willow was located primarily along the Colorado River on the southern edge of the site and on the northern side of the site adjacent to Grand Wash Bay. The willows near Grand Wash Bay occurred along dry swales that apparently held water as the lake level receded. Canopy closure at the site ranged from 50 to 70%.

In 2007, most of the Goodding and coyote willow that were present in 2006 were dead and dying, except for an area immediately adjacent to the river. A large sandy area devoid of vegetation in 2006 was vegetated with tamarisk approximately 2 m in height in 2007, and large areas of young willow <3 m in height were colonizing areas with wet soil closest to Grand Wash Bay. Canopy closure at the site in 2007 ranged from 25 to 70%.

In 2008, the narrow band of willows colonizing the edge of Grand Wash Bay had grown to 3–4 m in height and comprised the only dense vegetation at the site. New vegetation was continuing to develop on the edge of the bay as additional soils were exposed. The tamarisk had grown to 3 m in height and the remaining patches of willows were all dead. Canopy closure still ranged from 25 to 70%. The site had a steep, high bank adjacent to the river that sloped downward toward the bay. No standing water was present under the vegetation during any survey season, and saturated soils were present only in areas immediately adjacent to Grand Wash Bay.

In 2012, we obtained an overview of the Grand Wash Bay area from the uplands on the eastern edge of the old survey site. No water was visible in the bay, though exposed sediment on the far western side of the bay indicated the presence of water within the recent past. The old survey site was completely dry, and all the willows were dead. A few willow patches were visible on the far side of the bay over a kilometer away, but these did not appear to be near any surface water. The remainder of the riparian vegetation, both in the old survey site and in the bay, was scrubby tamarisk.

Two breeding pairs of flycatchers were detected at RM 285.3N in 2006. No willow flycatchers were detected at the site in 2007 or 2008. Cowbirds were detected on at least one survey in all survey years. Signs of burro use were seen in 2006, and cattle tracks were noted along the bay in 2007. No signs of livestock use were noted in 2008. We do not recommend visiting this site again unless a dramatic increase in lake levels occurs that would improve the hydrology of the site and potentially restore the vegetation.

ICEBERG CANYON

Area: 3.1 ha Elevation: 340 m

Iceberg Canyon was surveyed in 2008 and revisited in July 2012. This small, mixed-native site is along the Colorado River at the mouth of Iceberg Canyon. In 2008, the site contained several small cattail ponds surrounded by bulrush, dense stands of Goodding willow averaging 6 m in height, and 3–4-m-tall tamarisk. Canopy closure ranged from 50 to 70%. The ponds contained standing water in June but were nearly dry by early July.

Currently, vegetation within the site consists primarily of patchy Goodding willow and a sparse, scattered understory of tamarisk. All the tamarisk in the site are dead (if near the water) or defoliated (near the uplands). Some of the tamarisk along the upland edge of the site are resprouting basally. Most of the willows are 3–6 m in height above the water level, with a few trees to 8 m in height. A few of the willow patches are of sufficient height and density but are too small in extent to be suitable for flycatchers. The site was completely flooded during our 2012 visit and showed signs of lowered water levels since earlier in the season. To the southeast of the old site is another patch of inundated Goodding willow approximately 3–5 m in height. This patch has the best potential for suitability given its extent, but it is currently too short and sparse. This site may develop into suitable flycatcher habitat if Lake Mead remains near the level observed in July or recedes very slowly.

We detected one resident, unpaired male at Iceberg Canyon in 2008. No flycatchers were detected during reconnaissance in July 2012. Cowbirds were detected on one survey, and no sign of livestock use was observed. We recommend reassessing this area in future years if it remains accessible.

GROUND RECONNAISSANCE RESULTS

Assorted Canyon Sites

In 2012, we assessed the old survey sites at Chuckwalla Cove, Bradley Bay, Twin Coves, Kowlp Corner, and RM 286. They are all perched roughly 7 m above the level of the river with either no live vegetation or scrubby tamarisk. These sites are clearly no longer suitable for flycatchers, given the lack of water and vegetation. We also assessed the old survey site at Center Point. There are a few small stringers of willows right at the water's edge on either side of Center Point and just upstream from Bradley Bay. There were also two stringers between Iceberg Canyon and Center Point, one on river right and the other on river left. While each of the stringers is of an appropriate height, none is more than 10 m wide and thus is currently too narrow to be suitable for breeding flycatchers. We surveyed in several locations along the willow stringers but detected no flycatchers. If lake levels continue to drop, potentially suitable patches of vegetation may continue to develop along newly exposed sediments. We recommend visits to this stretch of river in future years to assess the development of the vegetation.

Topock Marsh, Arizona

Topock Marsh lies within 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 floodplain between the Colorado River on the western edge of the floodplain and the open water of Topock Marsh on the eastern edge of the floodplain. The vegetation is primarily monotypic tamarisk with isolated patches of tall Goodding willow. Seasonally wet, low-lying areas are interspersed throughout the riparian area. Marsh levels were lowered starting in 2010 in preparation for construction of a new water delivery canal. Construction of the canal was completed between the 2011 and 2012 breeding seasons, and water levels within Topock Marsh were noticeably higher at the beginning of the 2012 season than they were in 2011. Cowbirds were detected throughout the study area in all survey years.

Feral pigs were present throughout the Topock Marsh study area, and evidence of pigs was observed in most survey sites.

PIPES #1

Area: 5.2 ha Elevation: 140 m

Pipes #1 was surveyed from 2003 to 2012. This exotic site is bordered to the east by the refuge road and consists primarily of monotypic tamarisk 6–9 m in height. Arrowweed occurs in dense patches within 50 m of the refuge road. The tamarisk is densest within 100 m of the refuge road and becomes more open toward the western edge of the site. The northern edge of the site has the tallest canopy, and there is relatively little deadfall in this area compared to the rest of the site. The central and southern portions of the site have many dead stems and clusters of fallen trees. Canopy closure is 70–90%. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. Standing water or saturated soils were noted in the site in May of 2003, 2004, and 2007 and in July of 2006. The site has been dry since 2008.

We detected one resident, unpaired male in 2011. In 2004, 2005, 2009, and 2010 we detected one to two adult flycatchers for which residency could not be determined. No flycatchers were detected in 2003, 2006–2008, or 2012.

PIPES #3

Area: 5.7 ha Elevation: 140 m

Pipes #3 was surveyed from 2003 to 2012. This 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 willow up to 15 m in height and open areas with marsh vegetation. Canopy closure generally exceeds 70%. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. Standing water and saturated soils were recorded within this site in every year except 2011. In all other years, the site was inundated in May, often drying out to saturated soils in June, and only wet pig wallows in July.

Paired or breeding flycatchers were detected in 2004, 2006, 2008, 2010, and 2011. Unpaired, resident males were detected in 2005, 2009, and 2012. One adult flycatcher for which residency could not be established was detected in 2003, and no flycatchers were detected in 2007.

THE WALLOWS

Area: 0.7 ha Elevation: 140 m

The Wallows was surveyed from 2005 to 2012. This site is primarily vegetated by tamarisk 5–6 m in height with emergent Goodding willow on the western side of the site. The northwestern edge of the site borders an open cattail marsh. The eastern side is dry and grades from 2-m-tall arrowweed along the refuge road to tamarisk up to 8 m in height in the center of the site. Overall canopy closure ranges from 50% in the marshy area to 90% in the tamarisk. No major changes in vegetation structure or species composition were recorded from 2005 to 2012. Inundated or saturated soils were recorded within the site, primarily in the open cattail marsh, throughout the survey season in every year except 2011.

One resident, unpaired male willow flycatcher was detected at The Wallows in 2005. In 2006, we detected one breeding pair. No flycatchers were detected in 2007. One adult for which residency could not be established was detected in 2008. In 2009, we detected one breeding pair. One to two resident,

unpaired males were detected each year in 2010 and 2011. Two adults for which residency could not be determined were detected in 2012.

PC6-1

Area: 4.8 ha Elevation: 140 m

PC6-1 was opportunistically surveyed in 2003 and formally surveyed from 2004 to 2012. This mixed-exotic site consists primarily of tamarisk 5–6 m in height, with a few patches of arrowweed and cattails present in the understory. A scattered overstory of Goodding willow approximately 10–15 m in height is present in the southwestern corner of the site. Arrowweed 1–2 m in height is present under the willow. A portion of the site within approximately 50 m of the refuge road contains thick stands of arrowweed. Canopy closure in the interior of the site is approximately 90%, while canopy closure on the periphery of the site near the refuge road is approximately 50%. No major changes in vegetation structure or species composition were recorded from 2004 to 2012.

Large areas of standing water, mostly in marshy areas and under the willows, were recorded throughout the survey season in most years. The exceptions to this occurred in 2005 and 2011, when no standing water or saturated soil was recorded, and in 2010, when water was recorded only in a few pig wallows that quickly dried out.

Breeding willow flycatchers were recorded at PC6-1 in 2004 and 2005, with three to eight resident adults detected each year. One resident, unpaired male was detected in 2009. One to two adult flycatchers for which residency could not be established were detected in 2010 and 2011. No flycatchers were detected in 2003, 2006–2008, or 2012.

PIG HOLE

Area: 2.4 ha Elevation: 140 m

Pig Hole was surveyed from 2004 to 2011. This was not a survey site at the beginning of the 2004 survey season, but was delineated when breeding flycatchers were discovered outside of existing survey sites. The site was not surveyed in 2012 in favor of hydrology monitoring elsewhere in the study area. During the survey years, the site consisted of monotypic tamarisk 6–7 m in height, with canopy closure ranging from 70 to 90%. Tamarisk along the northern edge of the site had many wispy branches and smaller-diameter stems than in the rest of the site. The northern portion of the site had the highest stem density, and the center of the site, where flycatchers were detected, was less dense. A few dense patches of arrowweed were present on the eastern edge. No major changes in vegetation structure or species composition were recorded from 2004 to 2011.

In 2004, the presence of standing water or saturated soil was not noted as part of the site description; however, saturated soils were recorded under a flycatcher nest as part of microclimate studies. No part of the site contained standing water or saturated soil in 2005, 2010, or 2011. In 2006, no part of the site contained standing water during the survey season, and saturated soil was only present near a few pig wallows in May. Standing water was present at the site in mid-May 2007, but it was dry by June, and <1% of the site contained saturated soils in July. The site contained standing water or saturated soils throughout the survey season in 2008, and in May and June of 2009.

One breeding pair of willow flycatchers was detected at Pig Hole in 2004, and one resident, unpaired male was detected in 2006. No flycatchers were detected in 2005 or 2007–2011.

IN BETWEEN

Area: 7.7 ha Elevation: 140 m

In Between was surveyed from 2003 to 2012. The site 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 70–90%, and the western edge of the site borders a marsh. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. Standing water or saturated soils were recorded in the site throughout the survey season in all years except 2006, 2009, and 2010. In 2006, saturated soils were recorded only in July and no standing water was noted. In 2009, wet soils were recorded only in May, and no standing water or saturated soils were recorded in 2010. The site was artificially flooded in 2011 in an attempt to improve habitat suitability (see Chapter 9).

Breeding willow flycatchers were detected in In Between from 2003 to 2007, with 3–12 resident adults detected each year. We located one unpaired, resident male in 2008. One adult flycatcher for which residency could not be determined was detected in 2011. No willow flycatchers were detected in 2009, 2010, or 2012.

800M

Area: 4.7 ha Elevation: 140 m

800M was surveyed from 2003 to 2012. The site 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 scattered, emergent Goodding willow. The remainder of the site is vegetated by tamarisk 4–7 m in height. Canopy closure in the tamarisk is generally >90%, while canopy closure in the marsh is around 60%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Standing water and saturated soils are typically present in up to 50% of the site in both May and June, with the site drying out by July in most years. In 2011, 800M received supplemental water, and the cattail and bulrush marsh contained varying amounts of surface water and saturated soil through early July. The site dried out by June in 2006, 2010, and 2012.

Breeding flycatchers were detected from 2003 to 2007, with two to six resident adults detected each year. No flycatchers were detected in 2008 or 2012. One to two resident, unpaired males were detected each year from 2009 to 2011.

PIERCED EGG

Area: 6.7 ha Elevation: 140 m

Pierced Egg was surveyed from 2003 to 2012. This mixed-exotic site borders the western edge of 800M and consists of dense tamarisk 7 m in height, with a scattered overstory of Goodding willow 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 approximately 80%. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. Inundated or saturated soils were recorded throughout the survey season in all years except 2003 and 2011, when the site dried out by July. Typically, the only standing water remaining in June or July was in deep pig wallows.

No willow flycatchers were detected at Pierced Egg in 2003. Breeding flycatchers were detected from 2004 to 2008, with five to nine resident adults detected annually. In 2009 and 2010, we detected two and one resident, unpaired males, respectively. In 2011 and 2012, we detected four and two adult flycatchers, respectively, for which residency could not be confirmed.

SWINE PARADISE

Area: 0.7 ha Elevation: 140 m

Swine Paradise was surveyed from 2003 to 2012. Vegetation at this mixed-exotic site consists of tamarisk 6–8 m in height and scattered, emergent Goodding willow up to 15 m in height. A dense, 25-m-wide patch of coyote willow 3–5 m in height is present in the northeastern corner of the site, adjacent to the new water delivery canal. Overall canopy closure is approximately 80%. The site did span both sides of the main refuge road in 2003 to 2008, but was reduced to cover only the eastern side of the road starting in 2009 due to poor habitat suitability on the western side of the road. In 2011, a 40-m-wide section of habitat was bulldozed through the northern end of the site in preparation for the new water delivery canal. No standing water or saturated soil was detected within the site during the survey seasons, except in May and June 2004, and in 2012 in the coyote willow patch.

We detected one resident, unpaired male in Swine Paradise in 2004. One to two adult flycatchers for which residency could not be determined were detected each year in 2006 and 2010–2012. No flycatchers were detected in 2003, 2005, or 2007–2009. Unless hydrology improves within the site, we recommend limiting future surveys to the coyote willow patch in the northeastern corner.

BARBED WIRE

Area: 2.1 ha Elevation: 140 m

Barbed Wire was surveyed from 2003 to 2011. The site was not surveyed in 2012 in favor of hydrology monitoring elsewhere in the study area. During the survey years, one large, emergent Goodding willow occurred at the site; otherwise, the site was vegetated by tamarisk 6–10 m in height and of varying density. The northeastern portion of the site contained taller stems, less dead wood in the understory, and fewer large canopy openings than the southwestern portion of the site. A 40-m-wide strip was bulldozed through the center of the site east to west for a new water conveyance channel prior to the start of the 2011 survey season. Canopy closure outside the bulldozed area was approximately 70–90%. Limited standing water or saturated soil was recorded at the beginning of the survey season in 2003, 2004, 2008, and 2009. In 2008 and 2009, the standing water was primarily located in pig wallows. In 2011, the only standing water or saturated soil observed in the site was within the new water conveyance channel.

One adult flycatcher for which residency could not be determined was detected in 2004 and 2007. No willow flycatchers were detected in 2003, 2005, 2006, or 2008–2011. Because of the placement of the new water delivery channel and overall unsuitable hydrology of the site, we do not recommend surveying this site in future years.

IRFB03 AND IRFB04

IRFB03: Area: 1.0 ha Elevation: 140 m

IRFB04: Area: 1.5 ha Elevation: 140 m

IRFB03 and IRFB04 were surveyed from 2003 to 2008. These two contiguous sites are separated from the Barbed Wire site by a firebreak road. During the survey years, they were vegetated by a monotypic stand of tamarisk 7 m in height, which formed a dense canopy and relatively open understory. There was little deadfall, although many standing stems were dead, leaving dense areas of dead branches in the understory. Canopy closure was >90%. No major changes in vegetation structure or species composition were recorded from 2003 to 2008. Soils within these sites were completely dry throughout each survey season.

One adult flycatcher for which residency could not be determined was detected at IRFB04 in 2008. No flycatchers were detected at either site from 2003 to 2007 or at IRFB03 in 2008. Soils within these sites were completely dry throughout all survey seasons from 2003 to 2008, and the sites thus did not represent typical breeding habitat for flycatchers. We discontinued surveys at these sites after 2008.

PLATFORM

Area: 1.9 ha Elevation: 140 m

Platform was surveyed from 2003 to 2012. In 2010, the extent of the site was expanded when a pair of breeding flycatchers was discovered south of the previously surveyed area. This 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 willow. A narrow line of 5-m-tall coyote willow approximately 5 m wide runs along the eastern edge of portions of the site. Overall canopy closure is approximately 90%. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. Soils within the site were mostly very dry throughout each survey season, except for the very eastern edge bordering the marsh.

One breeding pair of flycatchers was detected in 2010, and one resident, unpaired male was detected in 2011. One adult flycatcher for which residency could not be determined was detected in 2003 and 2004. No willow flycatchers were detected in 2005–2009 or 2012.

250M

Area: 1.9 ha Elevation: 140 m

250M was surveyed from 2003 to 2012. This site lies between the main refuge road and the open marsh. Vegetation composition and structure varies with distance from the marsh. Closest to the refuge road the site is dominated by mesquite trees with an understory of arrowweed. The center of the site is dominated by tamarisk approximately 7 m in height. Closest to the marsh, the site contains patches of coyote willow and a few emergent Goodding willows approximately 12 m in height. Canopy closure within the site ranges from 70 to 90%. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. In 2003, 2004, and 2009, 10–30% of the site was inundated in May. Inundated conditions in 2009 persisted through June. In 2008, up to 10% of the site contained saturated soils through June. In 2006 and 2007, up to 5% of the site contained standing water along the edge bordering the marsh. In 2005, 2010, 2011, and 2012, no standing water or saturated soils were recorded during the season.

Two adult flycatchers for which residency could not be determined were detected in 2003. One pair of breeding flycatchers was detected in both 2004 and 2005. One resident, unpaired male was detected in 2006. One to three flycatchers for which residency could not be determined were detected each year from 2007 to 2009. No willow flycatchers were detected from 2010 to 2012.

HELL BIRD AND GLORY HOLE

Hell Bird: Area: 6.3 ha Elevation: 140 m

Glory Hole: Area: 5.0 ha Elevation: 140 m

Hell Bird and Glory Hole were surveyed from 2003 to 2012. These contiguous mixed-exotic sites are 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 areas vegetated primarily by a mosaic of tamarisk 6–8 m in height and Goodding willow 15 m in height. Screwbean mesquite 9–10 m in height are also scattered throughout the sites. Canopy closure ranges from 50 to 90%. The survey areas are bordered on the west by a sand dune and on other sides by open marsh. Marshes vegetated by cattail and bulrush

are interspersed throughout both sites. No major changes in woody vegetation structure or species composition were recorded from 2003 to 2012. During the 2011 and 2012 survey seasons most of the marsh vegetation was brown and flattened, with very little to no live growth. The marshes, totaling approximately 50% areal extent in Hell Bird and 35% in Glory Hole, were inundated up to thigh depth throughout the survey season in each year except 2011, when the marshes were completely dry. Adjacent soils were generally dry.

One resident, unpaired male was detected in Hell Bird in 2003. Breeding flycatchers were detected within the site in 2004, with seven resident adults recorded. Two resident, unpaired males were detected in 2009. Two to ten adult flycatchers for which residency could not be determined were detected annually in 2007 and 2010–2012. No flycatchers were detected in 2005, 2006, or 2008. Breeding flycatchers were detected at Glory Hole from 2003 to 2008 and in 2010, with 3 to 10 resident adults recorded annually. We detected four and one resident, unpaired adult flycatchers in 2009 and 2012, respectively. No flycatchers were detected in 2011 in Glory Hole.

SPAGHETTI

Area: 5.4 ha Elevation: 140 m

Spaghetti was opportunistically surveyed in 2010 and formally surveyed in 2011. The site is long and narrow, generally no more than 30 m wide, running along the Farm Ditch to the west of Glory Hole. As of 2011, the site was vegetated by patches of dense coyote willow up to 7 m in height, scattered Goodding willow up to 12 m in height, and mesquite approximately 8 m in height, with tamarisk interspersed throughout the site. Canopy closure in the coyote willow patches was approximately 80%. Deep water in the ditch made the site inaccessible on foot throughout the survey season, and hydrologic conditions within the site were not assessed.

We detected two willow flycatchers for which residency could not be confirmed in 2011. We recommend reassessing this site, including accessing the interior of the site to determine hydrologic conditions within the woody vegetation, before determining whether surveys at this site should continue.

BEAL LAKE

Area: 18.0 ha Elevation: 140 m

Beal Lake was surveyed from 2006 to 2012. This mixed-native habitat creation site consists of a mosaic of cottonwood, Goodding willow, coyote willow, mesquite, and arrowweed, with some tamarisk scattered throughout the site. In 2006 and 2007, canopy height was highly variable and averaged approximately 4 m; canopy closure was sparse, averaging 25%. Canopy height remains highly variable and averages approximately 3–4 m over most of the site and up to 12 m in the cottonwood stands; canopy closure is also still sparse and averages 35%, reaching 90% 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 resident flycatcher in 2009. In 2012, we detected one resident, territorial willow flycatcher that moved from a territory previously held in Pipes #3. One to three adult flycatchers for which residency could not be determined were detected annually in 2006–2008, 2010, and 2011.

LOST SLOUGH

Area: 1.5 ha Elevation: 140 m

Lost Slough was surveyed from 2007 to 2009. The site is located approximately 4 km south of Glory Hole and Hell Bird. This mixed-exotic site runs northeast to southwest for approximately 250 m, and measures 100 m wide at the broadest point. During the survey years, there was a marshy area in the center of the site; a small area of bulrush was present in the marsh, along with stands of coyote willow 6 m in height. Vegetation around the marsh was composed mainly of 6- to 8-m-tall tamarisk with a few emergent Goodding willow and scattered screwbean mesquite. Arrowweed up to 2 m in height made up the understory vegetation. Canopy closure at the site was variable, with open areas toward the edges of the site and over 70% closure in areas with thick vegetation. No major changes in vegetation structure or species composition were noted from 2007 to 2009. Some surface water was present in mid-June in 2007, but the site was dry through the rest of the survey season. The site contained standing water and saturated soils throughout the 2008 survey season. Hydrologic conditions at the site were not assessed in May 2009. In mid-June, the marshy area was inundated, and in mid-July small pools remained in the marsh.

No willow flycatchers were detected in any year from 2007 to 2009. Surveys were discontinued at the end of the 2009 survey season because vegetation lacked the right combination of height and density required for suitable habitat. Three years of surveys indicated that the vegetation was unlikely to change or mature into the right structure, but we recommend visiting this site again if marsh levels return to recommended levels (see Chapter 9).

LOST POND

Area: 1.2 ha Elevation: 140 m

Lost Pond was explored and opportunistically surveyed in 2003 and 2006, and was formally surveyed from 2007 to 2009. This mixed-exotic site is located approximately 700 m southeast of Lost Slough. The site is approximately 200 m long and 125 m wide. During the survey years, there was a small pond at the southern edge of the site and a marshy area at the northern end of the site. The edges of the pond were vegetated with a 30-m-wide border of cattail, bulrush, and sedges. Vegetation within the site consisted primarily of tamarisk 4 to 7 m in height with canopy closure approximately 90%. The area surrounding the site consisted of arrowweed, 3-m-tall tamarisk, and screwbean mesquite. No major changes in vegetation structure or species composition were recorded from 2007 to 2009. In 2007, water remained in the pond throughout the survey season. The site was mostly inundated throughout the 2008 survey season. In May 2009, 75% of the site was inundated, but by mid-June water remained only in the pond and marshy areas adjacent to the site.

No willow flycatchers were detected in any year from 2007 to 2009. While the correct vegetation components were present within the site, dense tamarisk occurred only in a narrow band adjacent to the pond and lacked the areal extent needed to make it suitable habitat. Three years of surveys indicated that the vegetation was unlikely to develop to an appropriate areal extent. We do not recommend visiting this site again.

LOST LAKE

Area: 3.3 ha Elevation: 140 m

Lost Lake was surveyed from 2003 to 2012. This site lies approximately 850 m southeast of Lost Pond. It is 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. Prior to 2007, a stand of dense coyote willow 5–7 m in height dominated the far southeastern corner of the site. By 2008, all of these willows were dead. The western side of the site is dominated by scattered mesquite. Overall canopy closure is approximately 80%. Surface water or saturated soil was present in the marsh on the northern edge of the site throughout the season in most years. The interior of the site was mostly dry, though standing water was noted in the far southeastern corner of the site throughout the year in 2005.

One resident, unpaired flycatcher was detected in 2004. One flycatcher for which residency could not be determined was detected in 2006, 2007, 2009, and 2011. No willow flycatchers were detected in 2003, 2005, 2008, 2010, or 2012.

GROUND RECONNAISSANCE RESULTS

Tractor

Habitat reconnaissance and opportunistic surveys were conducted at Tractor in 2010 and 2011.
This mixed-native site is approximately 1 km north of the inlet ditch at the north end of Topock Marsh. The site is bordered by hayfields to the north and south, a dry concrete channel to the west, and a road and a slough to the east. As of 2011, this site consisted of a dense, 300-m-long stringer of cottonwood 14 m in height with an understory of saltbush, mesquite, and 4-m-tall tamarisk bordering a 15-m-wide cattail marsh. The site is too narrow to represent typical breeding habitat for willow flycatchers, but might attract transient or territorial flycatchers if there is water in the marsh. The site was dry during a visit in July 2010, but the marsh appeared to have been wet earlier in the season. The marsh was still dry on a follow up visit in May 2011. We do not recommend future visits to this site.

NW of Pipes #1

Habitat reconnaissance and an opportunistic survey were conducted at NW of Pipes #1 in 2008. We explored the area immediately northwest of Pipes #1 to determine whether the tall, dense tamarisk with relatively little deadfall present at the north end of Pipes #1 extended outside the area delineated as Pipes #1. We encountered extremely dense tamarisk 8 m in height mixed with arrowweed. Canopy closure at the site was >90%. Soils within the site were completely dry. We abandoned attempts to explore this area because the dense vegetation made access very difficult. We do not recommend future visits to this site.

NW Beal Lake

We explored this area, approximately 600 m northwest of the Beal Lake site, in 2006 after noting a large area of inundated vegetation during aerial reconnaissance. In 2006, vegetation in the area consisted primarily of tamarisk 2–3 m in height with some areas reaching 4 m in height. We returned to this area in 2009 to assess whether vegetation had matured. In 2009, the area was vegetated by tamarisk 3–5 m in height, scattered screwbean mesquite 5–7 m in height, and an understory of arrowweed. Canopy closure was continuous only in low-lying swales; elsewhere, the canopy was broken by open, dry areas in the northwestern portion of the reconnaissance site and by marshes to the southeast. The tamarisk had not grown to a size typical of flycatcher breeding habitat along the LCR. We do not recommend future visits to this site.

NE Lost Lake

We explored and surveyed the northern and eastern borders of Lost Lake in 2009. Woody vegetation consisted entirely of a strip of tamarisk 4 m in height with >90% canopy closure. This strip of tamarisk was 600 m long and generally <50 m wide and was bordered to the west by the cattail marsh on the edge

of Lost Lake and to the east by dry uplands vegetated by arrowweed and scattered mesquite. Water from Lost Lake extended into the tamarisk during the site visit in May, but by mid-June surface water was restricted to the cattails and did not extend under the woody vegetation. This site did not have the canopy height typical of occupied flycatcher habitat along the LCR. We do not recommend future visits to this site.

Lost Lake South

We explored the area between the southern end of NE Lost Lake and the western tip of the Lost Lake polygon in 2009. We had noted this area as being inundated during aerial reconnaissance in March 2009. Vegetation consisted of a mosaic of cattail marshes in low-lying areas and a mix of screwbean mesquite, arrowweed, and bulrush in higher areas. Overall canopy closure was <25%, and the vegetation did not resemble that found in occupied flycatcher habitat. We do not recommend future visits to this site.

Lost Lake Slough #1

This site was visited several times in 2009 and determined to lack the canopy height typical of occupied flycatcher habitat. However, the site is en route to Lost Lake Slough #2 and thus was visited again in 2010. At that time, Lost Lake Slough #1 consisted of a 25- x 50-m patch of tamarisk, 6 m in height, 100 m south of the bridge on South Dike Road. A few mesquite trees were scattered through the site. The site was surrounded by marsh, and a finger of the marsh extended into the center of the site. Water extended under the woody vegetation at the marsh edges during visits in May and June. Vegetation structure was possibly suitable for willow flycatchers, but the site was very small and surrounded by non-suitable marsh habitat or open water. We recommend visiting this site again in 2013 to determine if any change or increase in vegetation has occurred.

Lost Lake Slough #2

Habitat reconnaissance and opportunistic surveys were conducted at Lost Lake Slough #2 in 2009 and 2010. This native site is approximately 200 m south-southeast of Lost Lake Slough #1. During the survey years, the site consisted of a 100- x 50-m patch of coyote willow 4 m in height with some stems emerging 2 m above the main canopy. Canopy closure within the site was around 85%, and the site was surrounded by open marsh. The site was completely inundated in May of both years, and saturated or inundated in mid-June. Vegetation at the site was shorter than that typically found in occupied flycatcher habitat along the LCR. Large stem diameters indicated that the stand was not young, and growth to a suitable height was unlikely. Despite this, we recommend monitoring for changes in vegetation in 2013.

Lost Lake Slough #3

Habitat reconnaissance and opportunistic surveys were conducted at Lost Lake Slough #3 in 2009 and 2010. This mixed-native site is between Lost Lake Slough #2 and New South Dike Road. During the survey years, the site was bordered to the north by marsh and to the south by dry uplands adjacent to the road. Vegetation within the site was primarily tamarisk 6 m in height with some mesquite and an understory of patchy arrowweed and Emory baccharis (*Baccharis salicina*). A strip of coyote willow 4–5 m in height ran along the northern edge of the site and varied in width from 5 to 20 m. Canopy closure was around 80–90%. In 2009, approximately half the site was inundated in May, but only the edge adjacent to the marsh had standing water in mid-June. In 2010, approximately 25% of the site along the northern edge was inundated in May and mid-June. There was an abrupt transition to dry soil where the vegetation changed from coyote willow to tamarisk. The interior of the site was too dry and patchy to resemble typical occupied flycatcher habitat, and the strip of coyote willow along the marsh edge was too

narrow and short. We recommend revisiting the site in 2013 to determine whether the coyote willow area has expanded.

Lost Lake Slough #4

Habitat reconnaissance and opportunistic surveys were conducted at Lost Lake Slough #4 in 2009 and 2010. This mixed-native site is approximately 100 m west of Lost Lake Slough #3. When the site was surveyed, it lay between a marsh to the north and dry uplands to the south. Vegetation at the site graded from a mix of coyote willow and bulrush on the northern border to a very dense mix of coyote willow, tamarisk, and snags on the southern border. Canopy height in the willows was 5 m, while the tamarisk reached 4 m. Canopy closure was approximately 50–70%. The site was completely inundated in mid-June of 2010. This site did not have the canopy height typical of occupied flycatcher habitat along the LCR but we recommend monitoring for changes in vegetation in 2013.

Marina

Habitat reconnaissance and opportunistic surveys were conducted at Marina in 2009. This site is immediately north of the Topock Gorge Marina and extends for approximately 500 m north. When the site was surveyed, it lay between a marsh to the east and dry uplands to the west. The site was less than 50 m wide and graded from a mix of coyote willow and arrowweed along the eastern border to a mix of tamarisk, arrowweed, and screwbean mesquite on the western edge. Canopy height ranged from 3 m in the willows to 4–6 m in the tamarisk, and canopy closure was highly variable, averaging around 60%. Surface water was present only along the eastern edge of the site and did not extend more than a few meters under the woody vegetation. This site did not have the canopy closure typical of occupied flycatcher habitat along the LCR. We do not recommend future visits to this site.

Topock Gorge, Arizona and California

Between Topock Marsh and Lake Havasu, the Colorado River winds through Topock Gorge. Throughout the Gorge, the river is confined between steep cliffs and high bluffs, and little vegetation grows along the river. From 2003 to 2010, we surveyed backwater areas that support marsh and riparian vegetation. Pulpit Rock, Picture Rock, and Havasu NE were put on a biennial survey schedule starting in 2008 (Table 2.1) and were thus not surveyed every year between 2008 and 2012. Surveys were not conducted in Topock Gorge in 2011 and 2012 as effort was redirected to hydrology monitoring within Topock Marsh.

PULPIT ROCK

Area: 2.1 ha Elevation: 140 m

Pulpit Rock was surveyed from 2003 to 2007 and in 2009. This mixed-exotic site lies where an unnamed wash enters the Colorado River from the Mohave Mountains. The northwestern edge of the site was vegetated by cattails and bordered a backwater, and the upland edge was vegetated by arrowweed, honey mesquite (*Prosopis glandulosa*), and ironwood (*Olneya tesota*). Vegetation within the site consisted primarily of tamarisk up to 5 m in height and Goodding willow 8 m in height, with small patches of coyote willow near the marsh edge. Canopy closure was around 80% near the marsh but only 30% at the upland edges of the site. No major changes in vegetation structure or species composition were recorded from 2003 to 2009. Soils were dry in the site interior throughout the survey seasons.

One adult flycatcher for which residency status could not be determined was detected in 2006. No willow flycatchers were detected in any other year. Cowbirds were detected on at least one survey in all survey years except 2006. Burro tracks and trails were observed around the site in most years. The small size of

the site, its isolation from other riparian habitat, and its predominantly dry soils make this site unlikely to support resident flycatchers, and surveys were discontinued at the end of 2009.

PICTURE ROCK

Area: 4.6 ha Elevation: 138 m

Picture Rock was surveyed from 2003 to 2007 and in 2009. This mixed-exotic site consists of two patches of riparian vegetation where an unnamed wash enters the Colorado River from the west. During the survey years, vegetation within the site consisted primarily of tamarisk 5–6 m in height, scattered Goodding willow 12 m in height, and one small patch of coyote willow. Bulrush and cattail were present on the edge of the site along the river, and the upland edges of the site contained arrowweed, mesquite, foothills paloverde (*Parkinsonia microphylla*), and brittlebush (*Encelia farinosa*). Canopy closure within the tamarisk was 70–90%. No major change in vegetation structure or species composition was observed from 2003 to 2009. Except for the bulrush and cattail areas along the river, the interior of the site was dry throughout the survey seasons.

Two adult flycatchers for which residency could not be determined were detected each year from 2005 to 2007. No willow flycatchers were detected in 2003, 2004, or 2009. Cowbirds were detected in all survey years. Feral pigs and burros were observed in and around the site. Surveys at this site were discontinued at the end of 2009.

BLANKENSHIP BEND NORTH

Area: 19.0 ha Elevation: 138 m

Blankenship Bend North was surveyed from 2003 to 2010. The site contains riparian and marsh vegetation along the eastern bank of the Colorado River adjacent to the Blankenship Valley. During the survey years, the eastern edge of Blankenship Bend North consisted of a 100-m-wide strip of vegetation that graded from mesquite 7 m in height at the upland edge to tamarisk and then to a narrow strip of coyote willow 5 m in height. The coyote willow bordered a bulrush marsh, and the western edge of the marsh was also vegetated by a narrow (5–10-m-wide) strip of coyote willow as well as several emergent Goodding willow 12 m in height. The remainder of Blankenship Bend North extended for another 400 m to the west until it reached the open water of the Colorado River. This portion of the site consisted of a mosaic of marshes, tamarisk, coyote willow, arrowweed, and mesquite. Vegetation height generally did not exceed 5 m, and canopy closure within the woody vegetation varied between 60 and 80%. No major changes in vegetation structure or species composition were recorded from 2003 to 2010. Because of the proximity to the Colorado River, the site contained varying amounts of standing water and saturated soils throughout the survey seasons, though soils were dry along the eastern upland border of the site.

Two and four adult flycatchers for which residency could not be determined were detected in 2004 and 2007, respectively. We detected no flycatchers at Blankenship Bend North in any other survey year. Cowbirds were detected in all survey years. Both feral pigs and burros were observed in and around the site. Because vegetation of suitable height and density to support willow flycatchers occurs only in narrow bands at Blankenship North and few flycatchers have been detected over the years, we recommend adding this site to the biennial survey list.

BLANKENSHIP BEND SOUTH

Area: 11.8 ha Elevation: 138 m

Blankenship Bend South was surveyed from 2003 to 2010. During the survey years, the site consisted of a 100-m-wide strip of tamarisk up to 6 m in height with clumps of emergent Goodding willow up to 12 m in height. The central third of the site contained coyote willow 4–6 m in height scattered through the understory. The eastern side of the site was bordered by dry upland and was primarily vegetated by 4–6-m-tall honey mesquite and 2–3-m-tall arrowweed. The western side of the site was bordered by bulrush marsh and open water. Canopy closure was approximately 80%. No major changes in vegetation structure or species composition were recorded from 2003 to 2010. Standing water was present within the site throughout all survey seasons, with up to 30% of the site inundated.

One adult flycatcher for which residency could not be determined was detected in both 2004 and 2007. No flycatchers were detected at Blankenship Bend South in any other survey year. Cowbirds were detected in all survey years. Signs of both feral pigs and burros were observed in and around the site. Because vegetation of suitable density to support willow flycatchers occurs only in small clumps at Blankenship South and few flycatchers have been detected over the years, we recommend adding this site to the biennial survey schedule.

HAVASU NE

Area: 12.6 ha Elevation: 136 m

Havasu NE was surveyed from 2003 to 2008 and in 2010. This mixed-native site consists of a 1.3-km-long and <100-m-wide strip of riparian vegetation along the northeastern shore of Lake Havasu. During the survey years, vegetation at the site graded from cattails along the lakeshore to Goodding willow and tamarisk in the center of the site and a mix of tamarisk and mesquite on the upland edge. Vegetation was very dense and canopy closure was approximately 90%. Many Goodding willows at the site were mature, but showed signs of die-back with dead tops and/or branches; most of the willows stood 5 m above the tamarisk and mesquite, which were 6–8 m in height. No major changes in vegetation structure or species composition were recorded from 2003 to 2010. Soils in the interior of the site were extremely dry throughout the survey seasons, and water from the lake did not extend under the vegetation.

Eight and one adult flycatchers for which residency could not be determined were detected in 2003 and 2004, respectively. No willow flycatchers were detected from 2005 to 2008 or in 2010. Cowbirds were detected in all survey years. Feral pigs have been seen or recorded using the site since 2003, and signs of burros were noted around the site until 2007. Occasional signs of human disturbance (vagrant camps) have been noted near the site as well. Due to the lack suitable hydrology in any survey season, we recommend discontinuing surveys.

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 Bill Williams are listed below from west to east, moving progressively farther upstream. With the exception of some cattle in the vicinity of Cougar Point, Mineral Wash, and Beaver Pond in 2012, no signs of livestock were recorded within the study area. Several sites follow the biennial survey schedule and were not surveyed in 2009 or 2011 (see Table 2.1 for schedule). Several additional sites (Site #2, Site #11, Last Gasp, and Site #8) were not surveyed in 2012 as effort was redirected towards hydrology monitoring in Topock Marsh.

WISPY WILLOW

Area: 0.9 ha Elevation: 140 m

Wispy Willow was opportunistically surveyed in 2010–2011 and formally surveyed in 2012. This site is approximately 200 m downstream of Site #1 along the north bank of the Bill Williams River. The site consists of a patch of young coyote willow approximately 70 x 120 m in size, with some scattered cattail marshes along the western edge. Canopy height is 4–5 m, and stem diameter is generally ~3 cm. Canopy closure is 70–90%. Some 5-m-tall tamarisk are present along the southern and eastern edges of the site. The site has been maturing since it was first visited in 2010. Standing water was present within the majority of the coyote willow throughout the 2012 survey season.

No flycatchers were detected in 2010. In 2011, we detected one flycatcher for one day between Wispy Willow and Site #1. In 2012, 11 willow flycatchers for which residency could not be confirmed were detected. Cowbirds were detected only in 2012.

BILL WILLIAMS SITE #1

Area: 3.0 ha Elevation: 140 m

Site #1 was surveyed from 2003 to 2006 and again in 2010 and 2012, with an opportunistic survey in 2011. It is a mixed-native site near the mouth of the Bill Williams River, on the southern edge of an area that burned in 2006. Surveys were discontinued until 2010 due to the extent of the fire damage. Prior to 2006, the site had an overstory of large Goodding willow and cottonwood 15 m in height with an understory of tamarisk and arrowweed. The site was surrounded by water and accessible by kayak with approximately 40% of the site vegetated by cattail. Large quantities of downed wood were present within the site, and by 2006 some of the overstory trees had dropped large branches, creating gaps in the canopy. Overall canopy closure was approximately 50%.

Currently, Goodding willow dominates the overstory at a height of 20 m but does not form a continuous canopy. Tamarisk 8 m in height dominates the understory throughout much of the site. Towards 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 approximately 70–80%.

From 2003 to 2005, 5–80% of the site contained standing water and an additional 10–30% of the site contained saturated soil throughout the survey seasons. In 2006, only a small pool of water was present within the site and soils were otherwise dry. Very little standing water or saturated soil was noted in 2010. In 2012, standing water was present within the coyote willow stand in June and July.

One resident, unpaired male was detected in 2003, 2004, and 2012. One adult flycatcher for which residency could not be established was detected in 2005 and 2006. No flycatchers were detected in 2010 or 2011. Cowbirds were detected in all survey years.

BILL WILLIAMS SITE #2

Area: 3.1 ha Elevation: 140 m

Site #2 was formally surveyed from 2003 to 2008 and in 2010. It was also opportunistically surveyed in 2011. During survey years, this mixed-native site had an overstory of large Goodding willow and cottonwood up to 15 m in height and an understory of tamarisk 5 m in height. Overall canopy closure was 50–70%. The western portion of the site contained open cattail marshes. The site contained much dead, woody vegetation in the understory. The site was bordered on the southwest by a narrow channel of open

water where an arm of Lake Havasu followed the channel of the Bill Williams River, and vegetation was densest near this channel. Other than many branches and overstory trees falling after the 2003 survey season, no major changes in vegetation structure or species composition were recorded. The interior of the site contained standing water and saturated soil in 2003, 2005, and 2007. The site interior was not accessed in 2004 and 2006. Although the site was bordered by a channel, a steep bank approximately 0.5 m high prevented surface water from the channel from entering the site. The majority of soils within the site were completely dry throughout the season in 2008 and 2010.

Three adult flycatchers for which residency could not be determined were detected in 2004. No willow flycatchers were detected in any other survey year. Cowbirds were detected in all survey years. Because soils in the site have been dry in recent years, we recommend discontinuing surveys at this site.

BILL WILLIAMS SITE #11

Area: 6.3 ha Elevation: 140 m

Site #11 was formally surveyed from 2003 to 2008 and in 2010, and opportunistically surveyed in 2011. During the survey years, this mixed-native site had an overstory of Goodding willow and cottonwood trees up to 20 m in height. Tamarisk ranging from 3 to 5 m in height was the dominant species in the understory, and the ground was covered by thick deadfall up to 2 m in height. Canopy closure was approximately 75%. No major changes in vegetation structure or species composition were recorded from 2003 to 2011. Large areas of standing water were present within the survey site because an arm of Lake Havasu followed the channel of the Bill Williams River through the center of the site. The banks of the channel were steep and approximately 1 m high and did not allow for water to flow under the woody vegetation, leaving soils very dry throughout the survey seasons.

One flycatcher for which residency could not be determined was detected each year in 2003, 2004, 2006, and 2007. No willow flycatchers were observed in 2005, 2008, 2010, or 2011. Cowbirds were detected in all survey years. Because soils in the site have been dry, we recommend discontinuing surveys at this site.

BURN EDGE

Area: 4.1 ha Elevation: 140 m

Burn Edge was opportunistically surveyed in 2008 and formally surveyed from 2009 to 2012. The site 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 willow and cottonwood 15–20 m in height runs east-west through the center of the site. The understory is dominated by tamarisk up to 6 m in height. Canopy closure in the marshy area varies from around 60% at the eastern end to 25% at the western end. The area on either side of the marsh consists of tamarisk 6 m in height with up to 90% canopy closure. No major changes in vegetation structure or species composition were detected from 2008 to 2012. Standing water and saturated soils were present in the marsh in May and June of all survey years, with wet soils mostly gone by July. The site generally dried out to the east, and soils away from the marsh were dry.

No willow flycatchers were detected in 2008 and 2009. One breeding pair of flycatchers was detected in 2010. In 2011 and 2012, one adult flycatcher for which residency could not be determined was detected. Cowbirds were detected in all survey years.

BILL WILLIAMS SITE #4 AND SITE #3

Site #4: Area: 9.9 ha Elevation: 140 m

Site #3: Area: 13.0 ha Elevation: 140 m

Site #4 and Site #3 were surveyed from 2003 to 2012. These two sites are contiguous and together are known as Mosquito Flats. Vegetation is mixed-native, with an overstory of Goodding willow 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 both sites. Canopy closure is variable and overall is approximately 50%. Stands of cattails and marshy areas occupy approximately 10% of Site #3. 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 since 2003, leaving large gaps in the canopy and creating patches of thick, dead, fallen woody vegetation.

Mosquito Flats contains a network of small, flowing streams with some open marshes that are typically inundated in May, saturated in June, and dry in July. Site #4 contains a deep, backwater channel on its western side that is perennially wet, and some braided channels in the southern portion of the site. Soils outside of these areas were very dry throughout the survey seasons. Site #3 contains a larger proportion of braided channels than Site #4, as well as a small marsh in the southeastern corner. The marsh can contain standing water throughout the survey season, but was mostly dry in July from 2008 to 2010 and completely dry in June of 2011 and 2012. From 2003 to 2007, Mosquito Flats contained standing water or saturated soils throughout the survey season, except for 2004 in which the area was mostly dry.

Breeding flycatchers were detected in Site #4 in 2003 and 2005, with four and two resident adults recorded, respectively. Resident, unpaired adults were detected in 2009 and 2011, with two and one adults, respectively. One to two adult flycatchers for which residency could not be determined were detected each year in 2004, 2006, 2008, 2010, and 2012. No flycatchers were detected in 2007.

Breeding flycatchers were detected in Site #3 every year from 2003 to 2012, except for 2004, with 2–12 resident adults recorded annually. In 2004, two resident, unpaired adults were detected. Cowbirds were detected in Mosquito Flats in all survey years.

LAST GASP

Area: 2.1 ha Elevation: 140 m

Last Gasp was surveyed opportunistically in 2008 and formally surveyed from 2009 to 2011. It is a narrow, mixed-native site along a channel on the northern edge of the Bill Williams riparian area, approximately 250 m east of Burn Edge. During the survey years, vegetation within the site consisted of a broken overstory of cottonwood and Goodding willow 15–20 m in height and a tamarisk understory 5–7 m in height. Canopy closure varied from 50% in the channel to 80–90% in the surrounding tamarisk. No major changes in vegetation structure or species composition were recorded from 2008 to 2011. Surface water was present within the channel in May and June of each year, but was completely dry in July. Soils away from the channel were dry throughout the survey seasons.

No willow flycatchers were detected at Last Gasp in any year. Cowbirds were detected in all survey years. Due to the lack of surface water within woody vegetation, we recommend adding Last Gasp to the biennial survey schedule.

GUINNESS

Area: 3.4 ha Elevation: 140 m

Guinness was surveyed in 2012. This site is located approximately 150 m east of Site #3. It is dominated by a patchy overstory of Goodding willow 10–15 m in height, with an understory of 5–6-m-tall tamarisk. Some sporadic, emergent cottonwood are present along the eastern and western edges of the site. Canopy closure is approximately 70%. A stream bisecting the site held water in May but was reduced to isolated pools in June and July. Soils adjacent to the stream were dry.

We detected one willow flycatcher for which residency could not be confirmed in 2012. Cowbirds were detected on four visits. We recommend adding Guinness to the biennial survey schedule and reassessing the site if a flood event occurs that has the potential to alter its hydrology.

BILL WILLIAMS SITE #5

Area: 6.8 ha Elevation: 143 m

Site #5 was surveyed from 2003 to 2012. The site is located on the northeastern edge of the Bill Williams River floodplain. The survey area has significantly changed in size and shape over the years. In 2003 and 2004, the site encompassed 2.8 ha and was bordered to the northeast by desert upland and to the southwest by an open, sandy area. In 2005, the survey area was expanded south to include the trail used to access Site #5 from the southwestern side of the floodplain. Habitat along the trail had become inundated by the Bill Williams River and as a result appeared to be suitable for willow flycatchers. By 2008, the new trail section had been dry for two seasons and was consequently removed from the survey area. In the same year, the original portion of the site was expanded approximately 350 m upstream to the southeast. In 2009, the site boundary changed again. The original portion of the survey site was removed leaving only the expanded upstream portion. The site is now bordered to the southwest by a dry river channel and to the northeast by cliffs and upland desert.

The original portion of the site consisted of Goodding willow and cottonwood up to 20 m in height and an understory of tamarisk 7 m in height. Pools were present in a deeply incised channel, and canopy closure in this area was approximately 25%. Soils beneath the vegetation were dry and sandy. No major changes in vegetation structure or species composition in this portion of the site were recorded from 2003 to 2008. Vegetation along the trail section consisted of tamarisk 6–8 m in height with emergent cottonwood and Goodding willow. Canopy closure in the trail area was 70–90%. No major changes in vegetation structure or species composition in the trail section were recorded from 2005 to 2007. Vegetation within the current site boundary is mixed-native, with Goodding 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 willow and cottonwood. 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 70–90% in the denser vegetation. No major changes in vegetation structure or species composition were recorded in this portion of the site from 2008 to 2012. Water was present in channels and beaver ponds along the northeastern edge of the site in each year from 2008 to 2012.

One resident, unpaired flycatcher was detected in Site #5 in 2009. One adult flycatcher for which residency could not be determined was detected in 2004, and two were detected in 2011. No willow flycatchers were detected in 2003, 2005–2008, 2010, or 2012. Cowbirds were detected in all survey years.

BLACK RAIL

Area: 1.2 ha Elevation: 146 m

We visited Black Rail in 2006 and determined that although the site had suitable hydrology, the site was small and the willows were likely too short to support breeding flycatchers. We recommended revisiting the site in the future to assess any changes. We reassessed this site in 2010 and recommended adding it to the biennial survey schedule. The site was formally surveyed in 2010 and 2012.

Vegetation in this mixed-native site is multi-layered with an overstory of cottonwood and Goodding willow up to 15 m in height. A mid-layer of cottonwood and Goodding willow 7–10 m in height is present throughout the site, along with several clumps of tamarisk 6 m in height in the understory. Patches of dense cattail and bulrush 2–3 m in height are scattered through the interior of the site. Canopy cover varies from 30 to 80%. A stand of even-aged Goodding willow and cottonwood 10–12 m in height, with a continuous canopy, 90% canopy closure, and an open understory is present along the southwestern edge of the site. No major changes in vegetation structure or species composition were recorded from 2010 to 2012. In 2010, standing water was present within the site through June, and 60% of the site contained saturated soils in July. In 2012, standing water was present throughout the site in May, but only damp soils remained by June.

No willow flycatchers were detected in any survey year. Cowbirds were detected in both 2010 and 2012. After revisiting the site in 2012, we recommend adding this site to the annual survey schedule.

COUGAR POINT

Area: 1.3 ha Elevation: 157 m

Cougar Point was added as a site in 2011 when field personnel from an unrelated project reported hearing a willow flycatcher. When we investigated in June, a female flycatcher with an active nest was located. We formally surveyed the site in 2012. The site consists of dense, even-age stands of Goodding willow and cottonwood 9–12 m in height along a channel of the Bill Williams River. Seep willow (*Baccharis salicifolia*) is present in the understory but appears to be dying back as it becomes shaded by the taller cottonwoods and willows. Cattail marshes are present within and around the site. Canopy closure within the woody vegetation exceeds 80%. No major changes in vegetation structure or species composition were recorded from 2011 to 2012. Surface water was present within the site throughout both survey seasons. In 2011, the water extended away from the river channel and marshes at the center of the site to flood adjacent woody vegetation. In 2012, the water remained only in the river channel and marshes.

A breeding pair of flycatchers was detected in 2011. No willow flycatchers were detected in 2012. Cowbirds were detected in both years.

MINERAL WASH

Area: 18.8 ha Elevation: 162 m

Mineral Wash was formally surveyed from 2003 to 2008 and in 2010 and 2012, and opportunistically surveyed in 2011. The majority of this mixed-native site has an overstory of cottonwood and Goodding willow up to 20 m in height and an understory of tamarisk averaging 5 m in height. In the northern third of the site, the vegetation changes to a mix of tamarisk, honey mesquite, and arrowweed with a few emergent cottonwood. The site contains two channels of the Bill Williams River, one along the southwestern edge of the site and the other through the center of the site. Areas of bulrush and cattail and several deep beaver ponds are present in both channels. Overall canopy closure is <50%. In 2004, cattails in the riverbed were primarily dead by the end of the survey season; many trees also appeared to be dead

or dying, and several dead tamarisk fell during the survey season. From 2003 to 2007, the main river channel was flowing in May annually, but dried to a few puddles in July. In 2008, 2010, and 2012, both channels of the Bill Williams River contained surface water throughout the season. Soils away from the channels were dry and sandy throughout the survey seasons.

One resident flycatcher was detected in 2007. One to two flycatchers for which residency could not be determined were detected each year in 2004, 2005, and 2010. No flycatchers were detected in 2003, 2006, 2008, 2011, or 2012. Cowbirds were detected in all survey years. We recommend continuing biennial surveys at this site.

BEAVER POND

Area: 21.7 ha Elevation: 165 m

Beaver Pond was formally surveyed from 2003 to 2008 and in 2010 and 2012, and opportunistically surveyed in 2011. This mixed-native site consists of cottonwood and Goodding willow averaging 15–20 m in height with an understory of tamarisk 5–7 m in height along two channels of the Bill Williams River. One channel runs along the southern border of the site and the other through the center. Areas not immediately adjacent to the channels are vegetated by tamarisk and honey mesquite 5–7 m in height. Cattail and bulrush are present along most of the channels. Overall canopy closure at the site is <50%. From 2003 to 2004, a string of beaver ponds and dams lined with cattails were present along the river. Floods during the winter of 2004–2005 removed the ponds, which had held standing water throughout the 2004 survey season. In 2005 to 2008, a channel of the river flowed along the edge of the site, and an old channel in the center of the site contained pools of water throughout survey seasons. In 2010, both channels contained flowing water throughout the survey season. By 2012, both channels were being actively dammed by beavers, creating several pools that stayed wet throughout the survey season. Soils away from either channel were dry and sandy throughout the survey seasons. Other than the beaver ponds and cattails being removed by flooding or rebuilt, no major changes in vegetation structure or species composition were recorded from 2003 to 2012.

One flycatcher for which residency could not be confirmed was detected in 2003, 2007, and 2010. Twelve willow flycatchers for which residency could not be determined were detected in 2004. No willow flycatchers were detected in 2005, 2006, 2008, 2011, or 2012. Cowbirds were detected in all survey years. We recommend continuing biennial surveys at this site.

BILL WILLIAMS SITE #8

Area: 10.3 ha Elevation: 168 m

Site #8 was surveyed from 2003 to 2008 and in 2010. This narrow, linear site encompasses the river channel approximately 3 km upstream from the Mineral Wash Complex, at the confluence of Mohave Wash and the Bill Williams River. This section of the river is confined between high cliffs on both banks. At the time of the surveys, cottonwood and willow trees 18 m in height lined a flowing river channel, with clumps of tamarisk also present in the understory throughout the site. Overall canopy closure is 25–50%. No major changes in vegetation structure or species composition were recorded from 2003 to 2010. This site had flowing water in the river channel throughout the survey seasons. However, soils beneath the vegetation were very dry.

One willow flycatcher for which residency could not be determined was detected at Site #8 each year from 2003 to 2005 and in 2007. No willow flycatchers were detected in 2006, 2008, or 2010. Cowbirds were detected in all survey years. We recommend continuing biennial surveys at this site.

UPSTREAM FROM SITE #8

Area: 1.5 ha Elevation: 170 m

Upstream from Site #8 was opportunistically surveyed in 2008 and formally surveyed from 2009 to 2012. Vegetation in the majority of the site consists of an overstory of cottonwood and Goodding 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 willow and cottonwood up to 10 m in height. The eastern third is dominated by dry tamarisk 4–6 m in height with scattered, emergent Goodding willow and cottonwoods. The northern edge of the site borders a cattail marsh. Canopy cover is variable and ranges from 50 to 80%. No major changes in vegetation structure or species composition were recorded from 2008 to 2012. The site has contained surface water throughout the survey season annually, but the percentage of the site inundated decreased from 40–60% in 2008 to 2–5% in 2012. In 2012, only the western portion of the site contained surface water throughout the breeding season, with dry soils throughout the rest of the site.

One pair of breeding flycatchers was detected in 2009. One willow flycatcher for which residency could not be determined was detected in 2010. No willow flycatchers were detected in 2008, 2011, or 2012. Cowbirds were detected in all years.

PLANET RANCH ROAD

Area: 3.3 ha Elevation: 170 m

Planet Ranch Road was surveyed from 2009 to 2012. This mixed-native site follows the Bill Williams River at the southern edge of the riparian area. The vegetation immediately adjacent to the river is dominated by Goodding willow and cottonwood up to 15 m in height. Both riverbanks are steep, and vegetation on top of the banks more than a few meters from the water is dominated by arrowweed and tamarisk 4–5 m in height. Canopy closure within the site is highly variable, ranging from <50% on the dry banks to >90% within dense willow and cottonwood stands. In 2010, the site was expanded upstream to include a young stand of cottonwoods. This stand is roughly 6–10 m in height with stems 3–5 cm dbh and canopy cover >90%. In 2011, beaver activity flooded this stand to a depth of a few centimeters. No major changes in vegetation structure or species composition were recorded from 2009 to 2012. The river held surface water throughout the survey seasons, and the extent and location of surface water within woody vegetation has varied between years as a result of beaver activity.

Breeding flycatchers were detected in 2010 and 2011, with two and three resident adults recorded, respectively. No willow flycatchers were detected in 2009 or 2012. The breeding area occupied in 2010 and 2011 was not discovered until 2010 and could have been occupied in 2009. Due to property access issues in 2012, we were unable to reach the site interior, and we surveyed the breeding area from approximately 80 m away. Therefore, resident flycatchers could have gone undetected in 2012. We detected cowbirds in all survey years.

NEW RIVER

Area: 0.6 ha Elevation: 180 m

We first visited this site in 2008, at which time the vegetation appeared too young and sparse to support willow flycatchers, and determined that the site should be reevaluated in future years. We revisited and surveyed the site in 2011. New River consists of narrow stringers of cottonwood and Goodding willow along both sides of the Bill Williams River. In 2011, some patches of vegetation reached 8 m in height, but average height was approximately 5 m. Vegetation closest to the water was typically 3–4 m in height with 90% canopy closure, while the cottonwoods and willows on the periphery of the site reached 8 m in

height but only 25% canopy closure. Soils within and around the site were very sandy. The western portion of the site contained surface water within the river channel throughout the survey season.

No willow flycatchers were detected in 2011. Cowbirds were detected on one survey. Vegetation at the site had matured between 2008 and 2011 but still lacked the combination of extent, size, and density typical of occupied flycatcher habitat. The site should be reevaluated in another two or three years.

GROUND RECONNAISSANCE AND OPPORTUNISTIC SURVEY RESULTS

Burn Edge

In 2008 we explored two areas of riparian vegetation northeast of where an arm of Lake Havasu follows a channel of the Bill Williams River that were designated as Burn Edge. The eastern area became the main survey site described above. The other area is described below.

The western patch of Burn Edge is located approximately 300 m northeast of Site #11. The northwestern end of the site is on the edge of an area that burned in 2006. By 2008, scattered 3-m-tall Goodding willow and tamarisk had sprouted in this area. The unburned portion of the site consisted of 8-m-tall tamarisk with a couple of emergent Goodding willow. Ground cover throughout much of the site consisted of thick, dead, fallen woody vegetation up to 1 m deep. Canopy closure ranged from 70 to 90%, Standing water was present in this area in a side channel of the river. Soils adjacent to the channel and throughout the rest of the site were completely dry. We have not formally visited or described this area since 2008. However, we have traveled through this area en route to the main survey site and have not noted any suitable habitat. We do not recommend visiting this site in the future.

River End

Habitat reconnaissance and opportunistic surveys were conducted at River End in 2008. This site is approximately 350 m southeast of Last Gasp. The southeastern corner of the site is adjacent to standing water within the Bill Williams River, at the point where the river goes subsurface. In 2008, the vegetation at River End consisted of a mosaic of dense tamarisk 5 m in height, a sparse overstory of emergent willow and cottonwood, and clumps of mesquite trees, many of which were dead. Canopy closure ranged from 25 to 70%. Small islands of cattail marsh were confined to the river channel, and saturated soils were present only along the river channel. Because soils within the site were very dry, we do not recommend revisiting this site unless floods occur that have the potential to alter the hydrology of the area.

Flooded Refuge Road

Habitat reconnaissance and opportunistic surveys were conducted at Flooded Refuge Road in 2008. The site is approximately 300 m southwest of Site #5 along the old refuge road, which was washed out during a 2004–2005 winter flood. In 2008, vegetation at the site consisted of scattered, emergent willows and cottonwoods and an understory of tamarisk. Vegetation throughout the site was patchy, with dry, sandy openings and dry river channels bisecting the area. Overall canopy closure was around 50%. No standing water or saturated soils were present during site visits in mid-May and late June. We do not recommend surveying this site in future years unless floods occur that have the potential to alter the hydrology of the site.

New Willow

Habitat reconnaissance and opportunistic surveys were conducted at New Willow in 2008. This area is approximately 1.4 km west of Cougar Point. In 2008, Goodding willow and cottonwood up to 10 m in height composed a patchy overstory in this area. Understory vegetation was primarily tamarisk of varying

height, and canopy closure was around 70%. Cattail and honey mesquite were also present, and areas of young cottonwood and Goodding willow occurred to the east of the site. Soils under the vegetation were dry to damp during site visits in late May and late June, with the nearest surface water approximately 200 m away. Aerial reconnaissance in 2009 revealed that much of the young vegetation had died and surveys were discontinued.

Cliff Pond

Habitat reconnaissance and opportunistic surveys were conducted at Cliff Pond in 2008. The site, located approximately 350 m south of New Willow, is bordered to the west by rocky cliffs and desert upland, and to the east by a dry wash. In 2008, vegetation at Cliff Pond consisted of a stand of Goodding willow and cottonwood 10–15 m in height with a dense, tamarisk understory. Standing water that was observed during helicopter reconnaissance in mid-April was not confirmed because dense vegetation prohibited access of the entire area. During the site visit, small areas of saturated soils were present in cattail stands along the wash. We have not formally visited this site since 2008, but have traveled near the site en route to Cougar Point. No evidence of suitable habitat was noted and we do not recommend visiting this site in the future.

Downstream from Site #8

Habitat reconnaissance and an opportunistic survey were conducted at Downstream from Site #8 in 2008. We started our habitat evaluation approximately 1 km west of Site #8 and evaluated approximately 600 m of vegetation along the Bill Williams River toward Site #8. The site consisted primarily of Goodding willow and cottonwood 8–10 m in height with a tamarisk understory. Canopy closure was highly variable and ranged from 40 to 70%. Cattail and bulrush were present along the river, as were young willows. During the site visit, soils were dry under the vegetation away from the river. We do not recommend surveying this site in future years unless floods occur that have the potential to alter the hydrology of the site.

Upstream from Site #8

In 2008 we evaluated two relatively small areas upstream of Site #8. One area became the main survey site described above. The second area we evaluated is approximately 200 m north of the first and is bordered to the north by desert uplands. The overstory consisted of scattered Goodding willow and cottonwood up to 10 m in height, while the understory consisted of tamarisk up to 4 m in height and dead cattails. Canopy closure was <50%. Approximately 40% of the site was inundated during the site visit in early June, with another 30% having saturated or damp soils. We revisited this site in May 2009 and found no change in vegetation structure and no surface water or saturated soils. Surveys were discontinued.

Planet Ranch

This site starts 200 m east of the current Upstream from Site #8 survey site and extends 400 m east of the starting point. We visited Planet Ranch in 2007, 2008, and 2009 and noted that the central portion of the site had vegetation structure resembling that of occupied flycatcher habitat but that surface water was generally lacking. Goodding willow and cottonwood up to 20 m in height made up a scattered overstory, while tamarisk up to 7 m in height formed a relatively continuous understory. The southern edge of the site was more sparsely vegetated than the center and had many fallen cottonwoods. The center of the site had small channels lined with dead sedges and cattails.

We revisited the site in late May and early June 2010 to determine whether hydrologic conditions had changed as a result of the spring releases from Alamo Dam. Surface water was present in small pools

along a line of cattail that bordered the northern edge of the site. A larger cattail marsh was present on the northeastern border of the site. Overall, <1% of the site contained surface water, and hydrologic conditions seemed unchanged from previous years. We do not recommend visiting this site again unless a flood event occurs that has the potential to change the hydrology of the area.

East of Planet Ranch

Habitat reconnaissance was conducted in 2008 at East of Planet Ranch, which is approximately 1 km upstream from Planet Ranch. We evaluated this area because large trees were visible on the aerial photograph. The large trees were a scattered stringer of cottonwood approximately 25 m in height. The understory consisted of dense tamarisk up to 10 m in height. The area was extremely dry during the site visit and did not resemble suitable flycatcher habitat. We do not recommend future visits to this site.

Ahakhav Tribal Preserve, Arizona

The Ahakhav Tribal Preserve encompasses backwater areas along the Colorado River near Parker, Arizona, and includes restoration sites.

WILLOW BEACH

Area: 2.0 ha Elevation: 104 m

Willow Beach was surveyed in 2008. This site consists of planted cottonwood bordering a backwater channel. At the time of the survey, the interior of the site included an understory of arrowweed and an overstory of cottonwoods up to 10 m in height. Many of the cottonwoods had sparse leaves, and overall canopy closure was <25%. The backwater channel was lined with seep willow, and the edges of the restoration site had areas of tamarisk and mesquite. Surface water was present in the backwater channel and in a small pond during site visits in June and July.

No willow flycatchers were detected. Cowbirds were detected on two surveys, and no evidence of livestock use was present. This site does not resemble suitable flycatcher habitat and further surveys are not recommended.

DEER ISLAND

Area: 91.6 ha Elevation: 104 m

Deer Island was surveyed in 2008 and 2009. During those years, this site consisted of a narrow strip of mixed-native vegetation on the edge of a long backwater slough with extensive areas of cattails. The only dense, woody vegetation occurred in a strip approximately 5 m wide on the edge of the slough and consisted of tamarisk and screwbean mesquite up to 6 m in height and an understory of arrowweed. More than 5 m from the water, vegetation was primarily arrowweed with widely scattered tamarisk and mesquite. Canopy closure was <50%. The southern side of the slough had a steep, high bank, and woody vegetation was perched several meters above the water level. The northern bank was not as high, with woody vegetation approximately 1 m above the water level. Although extensive areas of inundated and saturated soils existed in the slough and the adjacent cattails, water did not extend into the woody vegetation at any time during either survey season.

One resident flycatcher was detected in 2008. No willow flycatchers were detected in 2009. Cowbirds were detected on all visits in both years, and no evidence of livestock use was observed. The majority of the site burned between 2 and 8 July 2009, and surveys were discontinued.

GROUND RECONNAISSANCE RESULTS

Restoration

We evaluated Restoration in 2008. This site consisted of planted stands of cottonwood and Goodding willow up to 15 m in height. The site also contained patches of honey mesquite 4–7 m tall. The edges of the site had coyote willow up to 3 m in height. Understory was minimal and consisted of young willows and cottonwoods. Overall canopy closure was <50%. Soils within the site were dry and sandy during the site visit in mid-June. This site did not provide suitable habitat for flycatchers, and we do not recommend further surveys unless additional management actions create a denser understory, greater canopy closure, and surface water.

Palo Verde Ecological Reserve, California

PVER PHASE 2

Area: 21.4 ha Elevation: 85 m

PVER Phase 2 was surveyed from 2009 to 2012. This habitat creation site is vegetated with a mosaic of cottonwood, Goodding willow, and coyote willow, which reach heights of 12, 10, and 5 m, respectively. Height and density of the vegetation varies within and between cells of the site. Canopy closure is highly variable, ranging from <25 to 90%. The entire site has a ground covering of alfalfa (*Medicado sativa*). Vegetation height and density have increased noticeably since surveys began in 2009. 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.

Migrant willow flycatchers were detected from 2009 to 2012, with 2–11 adults recorded annually. Many cowbirds were detected on all visits in all survey years, and no evidence of livestock use was recorded.

PVER PHASE 3

Area: 21.4 ha Elevation: 85 m

PVER Phase 3 was surveyed from 2010 to 2012. This habitat creation site is vegetated with a mosaic of rectangular cells of cottonwood, Goodding willow, and coyote willow that reach heights of approximately 15, 8, and 5 m, respectively. Height and density of the vegetation varies within and between the cells of the site. Canopy closure is highly variable, ranging from 50 to 90%. The entire site has a ground covering of alfalfa. Vegetation height and density have increased noticeably since surveys began in 2010. 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.

Migrant willow flycatchers were detected in 2011 and 2012, with four and five adults recorded, respectively. No willow flycatchers were detected in 2010. Many cowbirds were detected on all visits in all survey years, and no evidence of livestock use was recorded.

Big Hole Slough, California

BIG HOLE SLOUGH

Area: 29.0 ha Elevation: 82 m

Big Hole Slough was surveyed from 2003 to 2010. During the survey years, this mixed-native site was surrounded by agricultural fields and consisted of cattail marshes edged with narrow bands of coyote

willow 5 m in height and an understory of seep willow. In upland areas away from the marshes, the site contained tamarisk and honey and screwbean mesquite up to 8 m in height with an understory of arrowweed. A few tall Goodding willow and cottonwood were present at the site. Overall canopy closure was approximately 50%. No major changes in vegetation structure or species composition were recorded from 2003 to 2010. The marsh (approximately 30% of the site) contained standing water throughout the survey season in 2003–2006, 2008, and 2009. The marsh was not accessed in 2007. In 2010, it was only accessed in June, during which time standing water was present.

Migrant willow flycatchers were detected from 2003 to 2009, with 1–20 adults recorded annually. Cowbirds were detected on all visits in all years, and no livestock use was observed. Surveys at the site were discontinued in 2010 due to anthropogenic safety concerns. We do not recommend surveys at this site in future years unless it can be confirmed that these safety concerns no longer exist.

Ehrenberg, Arizona

EHRENBERG

Area: 4.7 ha Elevation: 78 m

Ehrenberg was surveyed annually from 2003 to 2008. In 2008, it was put on the biennial survey schedule (Table 2.1) and was surveyed again in 2010 and 2012. This mixed-native site consists primarily of a canopy of cottonwood and Goodding willow 15 m in height with an understory of arrowweed. Approximately 5% of the site contains a cattail marsh surrounded by coyote willow, most of which were dead by the end of the 2008 survey season. In 2012, sparse, wispy coyote willow 3 m in height were growing in and immediately to the south of the marsh. The periphery of the site is vegetated with a mix of tamarisk and mesquite 3–5 m in height. Canopy closure at the site varies from 25 to 50%. The cattail marsh was periodically inundated during the survey seasons, and contained saturated soils throughout each survey season. The site is separated from the Colorado River by a levee.

Migrant willow flycatchers were detected from 2003 to 2007, with one to five adults recorded annually. No flycatchers were detected in 2008, 2010, or 2012. Cowbirds were detected in all survey years. No evidence of livestock use was observed within the site, although burros used the periphery of the site. Most of the site is dry and lacks a live understory other than arrowweed, making it unsuitable for breeding flycatchers. The coyote willow patch appears to be increasing in extent, and we recommend checking this site in the future to see if hydrology and vegetation structure have improved.

Cibola, Arizona and California

The Cibola study area is composed primarily of lands within the Cibola NWR, but also includes some surrounding public lands. Many of the sites were put on a biennial survey schedule starting in 2008 (Table 2.1). Except for one observation of possible evidence of feral pigs (tracks and digging) in Cibola Lake #2 (East) in 2004, no signs of livestock use were noted within any of the sites. Evidence of burros was abundant in upland areas adjacent to the sites.

CVCA PHASE 1

Area: 26.2 ha Elevation: 73 m

CVCA Phase 1 was surveyed from 2008 to 2012. This habitat creation area consists of a mosaic of rectangular cells of cottonwood, Goodding willow, and coyote willow of varying size and density. Each cell generally contains a single species and age class. The tallest cottonwoods are 15 m in height, and the tallest willows are around 12 m in height. Canopy closure in the densest areas is >90%. Coyote willow

reaches 3–6 m in height. Vegetation height and density have increased noticeably since surveys began in 2008. 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. The Colorado River is about 100 m from the northern edge of the site; the southern edge is adjacent to CVCA Phase 2; and the remaining two sides are surrounded by agriculture. An irrigation canal adjacent to the western edge of the site held surface water throughout the season in some years.

Migrant flycatchers were detected from 2008 to 2012, with 1–17 adults recorded annually. Large flocks of cowbirds were detected on all visits in all years.

CVCA PHASE 2

Area: 25.5 ha Elevation: 73 m

CVCA Phase 2 was surveyed from 2010 to 2012. This habitat creation area consists of a mosaic of rectangular cells of cottonwood, Goodding willow, and coyote willow of varying size and density. The tallest cottonwoods and Goodding willow reach approximately 12 m in height, and canopy closure reaches 95% in the densest areas. Coyote willow reach 3–6 m in height. Vegetation height and density have increased noticeably since surveys began in 2010. 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. The northern edge of the site is adjacent to CVCA Phase 1, and the remaining sides are surrounded by agriculture. An irrigation canal 80 m from the western edge of the site held surface water throughout the season in 2010 and 2012. In 2011, an irrigation canal 5 m north of the site held water in May and June, but was dry in July.

Migrant willow flycatchers were detected from 2010 to 2012, with 10–18 adults recorded annually. Large flocks of cowbirds were detected on all visits in all years.

CVCA PHASE 3

Area: 38.4 ha Elevation: 73 m

CVCA Phase 3 was surveyed from 2009 to 2012. This habitat creation area consists of a mosaic of rectangular cells of cottonwood, Goodding willow, and coyote willow of varying size and density. The tallest cottonwoods reach approximately 12 m in height; Goodding willows reach 10 m; and coyote willows reach 5 m. Canopy closure varies from 20 to 90%. Vegetation height and density have increased noticeably since surveys began in 2010. 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. The Colorado River is located 400 m away, and the site is surrounded by agricultural fields.

Migrant willow flycatchers were detected from 2009 to 2012, with 1–18 adults recorded annually. Large flocks of cowbirds were detected on all visits in all years.

CIBOLA NATURE TRAIL

Area: 13.7 ha Elevation: 70 m

Cibola Nature Trail was surveyed from 2006 to 2012. This habitat creation site consists of a mosaic of cottonwood, Goodding willow, and mesquite. Approximately half the site consists of scattered screwbean and honey mesquite up to 5 m in height with a thick understory of Emory baccharis. The northern half of the site contains an extensive stand of Goodding willow 10 m in height. The northern edge of the willow stand has canopy closure <25%, and many of the willow are dead. The southern half of the willow stand has canopy closure around 70%. Overall canopy closure averages 25–50%. The southwestern corner of

the site has a small stand of cottonwoods, and stringers of cottonwoods up to 18 m in height occur throughout the site. No major changes in vegetation structure or species composition were recorded from 2006 to 2012. The amount of standing water and saturated soil is highly variable because the site is flood irrigated.

Migrant willow flycatchers were detected from 2006 to 2012, with 1–12 adults recorded annually. Many cowbirds were detected on all surveys in all years. This site lacks the canopy closure and surface water typical of occupied flycatcher habitat, and we recommend discontinuing surveys unless changes occur in water management or vegetation.

CIBOLA ISLAND

Area: 4.2 ha Elevation: 70 m

Cibola Island was surveyed from 2007 to 2011. This was a mixed-native site located approximately 9.5 km southwest of Cibola Nature Trail. Dirt roads bordered the site to the north, east, and west. Open farm fields lay to the east and west, with irrigation channels alongside the roads. An irrigation canal emptied into the northern end of the site, creating an open, marshy area down the center of the site. Between this marshy area and the western road, vegetation consisted of an overstory of Goodding willow 10–12 m in height with an understory of tamarisk 5–7 m in height. Canopy closure within the willows was 80%. The eastern edge of the marsh was lined with a narrow strip of tamarisk 5–6 m in height with a few emergent Goodding willows on the marsh edge. Between the tamarisk strip and the eastern road, vegetation consisted of honey mesquite and bushy arrowweed. No major changes in vegetation structure or species composition were recorded from 2007 to 2011. The marsh was periodically inundated throughout the survey season in 2008 and 2009, but was primarily dry in 2010 and 2011. The irrigation canal running along the northern border of the site periodically held water each season. The site burned in a fire that started at the end of August 2011.

Migrant willow flycatchers were detected from 2007 to 2009, with three to eight adults recorded annually. No flycatchers were detected in 2010 or 2011. Cowbirds were detected on almost all surveys in all years.

CIBOLA SITE #2 AND CIBOLA SITE #1

Cibola Site #2: Area: 16.4 ha Elevation: 65 m

Cibola Site #1: Area: 7.7 ha Elevation: 65 m

Cibola Site #2 and Cibola Site #1 were surveyed from 2003 to 2007 and in 2009 and 2011. These adjacent, mixed-exotic sites consist of a 200-m-wide strip of riparian vegetation between the channelized Colorado River to the west and a levee road to the east. During the survey years, woody vegetation consisted of a mix of tamarisk and arrowweed, 3–4 m in height, which was dry and scrubby on the eastern edge of the sites and became denser toward cattail marshes on the western edge of the sites. Emergent Goodding willow and cottonwood up to 20 m in height were scattered along the eastern edge of the marshes. Overall canopy closure was less than 50%. No major changes in vegetation structure or species composition were recorded from 2003 to 2011. The hydrologic conditions at these sites were undetermined in many years because dense vegetation inhibited the ability of observers to access the marshes. In the years when hydrologic conditions were assessed, the marshes contained surface water throughout the survey seasons.

Migrant flycatchers were detected at Cibola Site #2 in 2003–2007 and 2011, with 1–24 adults recorded annually. No flycatchers were detected within the site in 2009. At Cibola Site #1, migrant flycatchers were detected in 2004–2007 and 2009, with two to five adults recorded annually. No flycatchers were

detected within the site in 2003 or 2011. Cowbirds were detected on almost all surveys in all years. Due to a lack of dense vegetation >4 m in height, we recommend discontinuing surveys at both sites.

HART MINE MARSH

Area: 31.6 ha Elevation: 65 m

Hart Mine Marsh was surveyed from 2003 to 2007 and in 2009. This mixed-exotic site parallels the channelized Colorado River immediately south of Cibola Site #1. During the survey years, the site consisted of a mix of tamarisk and linear stretches of marsh, which made up about 30% of the site. Height of the tamarisk did not exceed approximately 5 m, and reached this height only within 20 m of the marshes. Away from the marshes, the tamarisk was 3 m in height and partially dead. Canopy closure within the densest tamarisk was 80–90%. An open channel had been dredged down the middle of the northern third of the site in 2009. Other than this, no major changes in vegetation structure or species composition were recorded from 2003 to 2009. The marshes contained standing water and saturated soils throughout the survey seasons, but water did not extend under the woody vegetation.

Migrant willow flycatchers were detected from 2003 to 2007, with four to eight adults recorded annually. No flycatchers were detected in 2009. Cowbirds were detected on almost all surveys in all years. The site lacked the height and extent of woody vegetation typical of occupied flycatcher habitat along the LCR, and surveys were discontinued in July of 2009.

THREE FINGERS LAKE

Area: 67.9 ha Elevation: 65 m

Three Fingers Lake was surveyed from 2003 to 2008 and in 2010. This mixed-exotic site consists of the area immediately surrounding a dredged backwater channel of the Colorado River. During the survey years, the edges of the channel were vegetated by cattail and bulrush. The dominant woody vegetation was tamarisk, which was densest immediately adjacent to the channel and reached heights of 6 m. A few large Goodding willow were also present. Away from the channel, the tamarisk was shorter and sparser and was mixed with honey and screwbean mesquite with an understory of arrowweed. Canopy closure along the shore was approximately 50%. Water was present in the backwater channel throughout the survey seasons, but no water was ever observed under the woody vegetation. The majority of this site burned in a widespread fire that started at the end of August 2011.

Migrant willow flycatchers were detected from 2003 to 2008 and in 2010, with 3–53 adults recorded annually. Large numbers of cowbirds were detected on most visits in all years.

CIBOLA LAKE NORTH

Area: 8.9 ha Elevation: 64 m

Cibola Lake #1 (North) was surveyed from 2003 to 2008 and in 2010 and 2012. This mixed-exotic site borders Cibola Lake. The perimeter of the site adjacent to the lake is vegetated by cattail and bulrush. The area immediately inland from the cattail marshes is vegetated by dense tamarisk 4–6 m in height. Goodding willow 12–15 m in height are scattered around the perimeter. The interior of the site has patchy vegetation with a mix of tamarisk, arrowweed, screwbean mesquite, and open sandy areas. Small patches of coyote willow 5–6 m in height are located on the very northern end of the site around a marshy opening. Canopy closure along the marsh edges is 50–70%, while the interior of the site has canopy closure <25%. No major changes in vegetation structure or species composition were observed from 2003 to 2012. Surface water was confined to the marshes on the periphery of the site, and soils within the interior of the site were very dry throughout the survey seasons.

Migrant flycatchers were detected from 2003 to 2008 and in 2012, with one to three adults recorded annually. No flycatchers were detected in 2010. Cowbirds were detected on all surveys in 2008, 2010, and 2012, and many surveys each year from 2003 to 2007. Hydrology within this site did not resemble that within currently occupied habitat along the LCR and tributaries in any survey season, and we recommend discontinuing surveys.

CIBOLA LAKE EAST

Area: 4.5 ha Elevation: 64 m

Cibola Lake #3 (East) was surveyed from 2003 to 2007 and in 2009 and 2011. This site borders the marsh on the eastern edge of Cibola Lake. During the survey years, vegetation within the site consisted primarily of tamarisk. Within 30 m of the marsh edge, tamarisk reached 6–7 m in height and 90% canopy closure. As distance from the marsh increased, the height and density of the tamarisk decreased, and the tamarisk became mixed with arrowweed. No major changes in vegetation structure or species composition were recorded from 2003 to 2011. Soil within the site was dry throughout the survey seasons, though the marsh held water annually.

Migrant flycatchers were detected in all years except 2005, with one to three adults recorded annually. Cowbirds were detected on all but seven surveys across the years. Hydrology within this site did not resemble that within currently occupied habitat along the LCR and tributaries in any survey season, and we recommend discontinuing surveys at this site.

CIBOLA LAKE WEST

Area: 6.8 ha Elevation: 64 m

Cibola Lake #3 (West) was surveyed from 2003 to 2008 and in 2010 and 2012. This mixed-exotic site borders Cibola Lake. The perimeter of the site adjacent to the lake is vegetated by a narrow strip of cattail and bulrush. Areas immediately inland from the cattail marshes are vegetated by dense tamarisk that is typically 5–6 m in height but occasionally reaches 8 m in height. A few emergent Gooding willow are scattered on the northern perimeter of the site. Cottonwood patches 12–15 m in height are scattered throughout the southern portion of the site. The interior of the site has patchy vegetation with a mix of tamarisk, arrowweed, screwbean mesquite, and open sandy areas. Canopy closure averages 90% in the dense tamarisk and <25% in the clearings. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. Soils within the interior of the site were dry throughout the survey seasons, with surface water in the marshy areas immediately adjacent to the site annually.

Migrant flycatchers were detected in all years except 2007 and 2010, with 1–17 adults recorded annually. Cowbirds were detected in all survey years. Hydrology within this site did not resemble that within currently occupied habitat along the LCR and tributaries in any survey season, and we recommend discontinuing surveys at this site.

WALKER LAKE

Area: 11.4 ha Elevation: 64 m

Walker Lake was surveyed from 2003 to 2012. This mixed-exotic site is located along the northeastern edge of Walker Lake. The majority of the site consists of very dense tamarisk approximately 5 m in height with 90% canopy closure. The southeastern end of the site contains scattered emergent Goodding willow up to 20 m in height, as well as a couple of emergent cottonwoods. This portion of the site also contains a small opening with dead cattails and a small patch of half-dead coyote willow. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. In 2003 and

2004, we surveyed the eastern side of the site. From 2005 to 2012, we shifted our survey efforts to the western side of the site, adjacent to Walker Lake.

In 2003 and 2004, soils under the vegetation adjacent to the river were dry throughout each survey season. From 2005 to 2007, Walker Lake held standing water until June, but had dried to deep mud by July each year; soils in the interior of the site were dry throughout each survey season. Walker Lake held standing water throughout the survey season from 2008 to 2012. Standing water or saturated soils were noted within the very southern tip of the site throughout each survey season in these years. In 2012, the level of Walker Lake rose dramatically in mid-July as the result of unusually intense monsoonal activity during which 3.6 cm of rain were recorded in Blythe over a two-day period.

Migrant willow flycatchers were detected in all years except 2009 and 2012, with 1–36 adults recorded annually. In 2005, one adult flycatcher was detected spontaneously singing on 6 July, and this individual responded aggressively to playback. In 2007, a lone individual, likely a male, responded aggressively to broadcasts and continued to sing for up to 20 minutes after broadcasts ceased on 30 May and 3 June. Although this behavior was observed on two visits, the bird on both occasions was unbanded and it is unknown if it was the same individual. No flycatchers were detected on six subsequent visits in 2007, indicating that no flycatchers remained as residents at the site. Cowbirds were detected in all survey seasons. We recommend discontinuing surveys in all portions of the site except the southeastern end, which should be added to the biennial survey schedule.

Imperial, Arizona and California

The Imperial study area is composed mainly of lands within the Imperial NWR, but also includes some adjacent public lands. Cowbirds are widespread through the study area and were seen in all sites in all survey years, sometimes in large flocks. No evidence of livestock use was observed in any year, although burros were abundant in adjacent uplands. Some signs of pig activity were observed periodically in a small subset of sites, but no feral pigs were observed and the sign may have been from javelinas. Several sites were put on a biennial survey schedule starting in 2008 (Table 2.1).

DRAPER LAKE

Area: 4.6 ha Elevation: 63 m

Draper Lake was surveyed from 2006 to 2008. This site is on the northern edge of Draper Lake, which lies approximately 200 m west of the Colorado River and is surrounded by extensive areas of cattail marsh. This site burned prior to the 2003 survey season, and surveys were initiated in 2006 after aerial reconnaissance revealed a stand of coyote willow. During the survey years, vegetation immediately adjacent to the cattail marsh consisted of a narrow (5–10 m) strip of young, dense tamarisk up to 7 m in height with over 90% canopy closure. The central portion of the site consisted of a stand of coyote willow approximately 100 m x 50 m. Many of these willows were dead at the beginning of the 2008 survey season and had likely been declining for a couple of years. Canopy cover in the willows was around 70%. The northern end of the site consisted of scattered tamarisk clumps up to 5 m in height, an understory of arrowweed, and many open areas. Canopy closure in this portion of the site was <25%. Standing water and saturated soils were present in Draper Lake and the cattail marsh throughout the survey seasons.

Migrant willow flycatchers were detected in 2006–2008, with 1–14 adults recorded annually. Surveys at this site were discontinued in the middle of the 2008 survey season because the stands of coyote willow were dying, and the site did not provide habitat suitable for resident flycatchers.

PARADISE

Area: 7.8 ha Elevation: 62 m

Paradise was surveyed from 2003 to 2012. The center of this mixed-native site consists of stringers of cottonwood and Goodding willow 15–20 m in height. Tamarisk (5 m in height) and arrowweed (3 m in height) make up the understory. The cottonwoods and willows are separated from the Colorado River by a 50-m-wide strip of dense tamarisk. A marsh borders the western side of the southern third of the site. This marsh was vegetated by cattails in previous years but now consists primarily of common reed. Canopy closure within the site is variable, ranging from <25% in the marsh to 90% in the densest tamarisk. Outside of the changing species composition within the marsh, no major changes in vegetation structure or species composition were recorded from 2003 to 2012. Standing water and saturated soils persisted within the marsh throughout most survey seasons.

Migrant willow flycatchers were detected in every year, with 1–40 adults recorded annually. Because surface water exists only in the open marshes and does not extend under the woody vegetation, we recommend discontinuing surveys at this site.

HOGE RANCH

Area: 20.7 ha Elevation: 61 m

Hoge Ranch was surveyed from 2003 to 2012. This mixed-exotic site borders the Colorado River and is dominated by tamarisk 4–6 m in height, with a few emergent cottonwood and Goodding willow (15 to 18 m in height) at the southern end of the site near the old ranch. Linear marshes with cattail, bulrush, and common reed occupy less than 20% of the interior of the site, and there are a few patches of coyote willow. Canopy closure is variable and reaches 70–90% in areas of dense, woody vegetation. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. The marshes in the interior of the site contained fluctuating amounts of standing water and saturated soil throughout the survey seasons.

Migrant willow flycatchers were detected every year, with 2–31 adults recorded annually. Because no resident flycatchers have been detected, we recommend adding this site to the biennial schedule.

ADOBE LAKE

Area: 7.5 ha Elevation: 60 m

Adobe Lake was surveyed from 2003 to 2008 and in 2010 and 2012. This mixed-exotic site consists primarily of dense tamarisk (5 to 7 m in height) with many dead branches in the understory. There are scattered Goodding willows up to 10 m in height. Canopy closure within the site is 70–90%. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. The site is adjacent to the Colorado River, but soils were dry throughout the survey seasons when the interior of the site was accessed.

Migrant willow flycatchers were detected in every year except 2010, with 1–40 adults recorded annually. No flycatchers were detected in 2010. Hydrology within the site did not resemble that of currently occupied habitat along the LCR and tributaries when it was assessed, and we recommend discontinuing surveys.

RATTLESNAKE

Area: 7.6 ha Elevation: 60 m

Rattlesnake was surveyed from 2004 to 2012. This mixed-exotic site is a patchwork of tamarisk 7 m in height and strips of dense coyote willow 6–8 m in height with emergent Goodding willow up to 15 m in height. The coyote willow consists primarily of large-diameter stems (≥10 cm dbh), many of which are leaning over or fallen, creating very tangled habitat. The dense deadfall and debris within the coyote willows reduces the suitability of the area for willow flycatchers. Canopy closure is 70–90%. No major changes in vegetation structure or species composition were recorded from 2004 to 2012. Extensive cattail marshes separate this site from the Colorado River. The amount of standing water and saturated soil within the site fluctuated across survey seasons, and portions of the site held standing water throughout some seasons. No standing water or saturated soils were recorded in the site in 2009.

Migrant willow flycatchers were detected from 2005 to 2011, with one to six adults detected annually. No flycatchers were detected in 2004 and 2012. Because no resident flycatchers have been detected, we recommend adding this site to the biennial schedule.

MILEMARKER 65

Area: 10.0 ha Elevation: 58 m

Milemarker 65 was surveyed from 2003 to 2007 and in 2009 and 2011. The site is a narrow strip of mixed-exotic vegetation between the Colorado River and a backwater marsh. During the survey years, vegetation at the site consisted primarily of dense tamarisk 6 m in height. Dense common reed, approximately 3 m in height, also occurred throughout the site and together with the tamarisk created almost complete canopy closure. No major changes in vegetation structure or species composition were recorded from 2003 to 2011. Because of the impenetrable vegetation at the site, we surveyed it from the river starting in 2005. Soils within the site were completely dry in 2003 and 2004 and were unlikely to have changed in subsequent years.

Migrant willow flycatchers were detected from 2004 to 2007 and in 2011, with one to nine adults recorded annually. We recommend discontinuing surveys at this site due to the lack of surface water within the site.

CLEAR LAKE

Area: 8.3 ha Elevation: 59 m

Clear Lake was surveyed from 2003 to 2008 and in 2010 and 2012. Vegetation at this site is primarily exotic, consisting of monotypic tamarisk 8–10 m in height. Emergent Goodding willows, up to 13 m in height, are scattered throughout the site. The tamarisk is mature, with large amounts of deadfall, and canopy closure is approximately 90%. The site is surrounded on the east, north, and west by upland desert and is bordered on the south by cattail marshes and common reed. No major changes in vegetation structure or species composition were recorded from 2003 to 2010. In 2012, a heavy flash flood flowed through the site, removing trees and opening up several corridors through the site. Additionally, a small area in the southwestern corner of the site burned during the 2012 season. A narrow, backwater channel runs northward from the Colorado River into the center of the site, and soils immediately adjacent to the channel were inundated or saturated. Soils in the interior of the site away from the channel were dry during survey seasons.

Migrant willow flycatchers were detected in all years except 2005, with one to eight adults recorded annually. Hydrology within the survey site did not resemble that of currently occupied habitat along the LCR and tributaries in any survey season, and we recommend discontinuing surveys.

NURSERY NW

Area: 7.0 ha Elevation: 58 m

Nursery NW was surveyed from 2006 to 2012. This mixed-exotic site lies between the Colorado River and a cattail marsh. The dominant vegetation is tamarisk approximately 6–8 m in height with an understory of common reed. Mesquite trees are scattered along the western edge of the site. The eastern edge of the site, adjacent to the cattail marsh, has a stand of Goodding willow 10 m in height. Overall canopy closure is around 70%, and the densest portions of the site have canopy closure >90%. No major changes in vegetation structure or species composition were recorded from 2006 to 2012. Surface water or saturated soils were present in the marsh and the eastern edge of the site throughout the survey seasons.

Migrant willow flycatchers were detected in every year except 2008, with 1–16 adults recorded annually. We recommend improving access to the interior of the site to determine whether surface water extends under the woody vegetation. Because no resident flycatchers have been detected, we recommend adding this site to the biennial schedule.

IMPERIAL NURSERY

Area: 1.4 ha Elevation: 58 m

Imperial Nursery was surveyed from 2003 to 2008 and in 2010 and 2012. This site is a cottonwood planting managed by the Imperial NWR. The cottonwoods are approximately 12 m in height, with canopy closure of approximately 90%. The understory is very sparse, except for two clumps of Goodding willow 5 m in height that each cover an area <20 m in diameter. The edges of the site are vegetated by arrowweed and *Baccharis* sp. with a few honey mesquite in the northwestern corner of the site. The site is bordered to the north by a patchwork of cattails, common reed, and tamarisk, and by open fields to the south. Vegetation height has increased over the years, but canopy closure has remained constant. 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.

Migrant willow flycatchers were detected from 2004 to 2007, with 3 to 10 adults recorded annually. No flycatchers were detected in 2003, 2008, 2010, or 2012. Because no resident flycatchers have been detected, we recommend adding this site to the biennial schedule.

FERGUSON LAKE

Area: 21.1 ha Elevation: 57 m

Ferguson Lake was surveyed from 2003 to 2012. The Ferguson Lake site is on a strip of land between Ferguson Lake and the Colorado River. Vegetation is mixed-native, with scattered, emergent Goodding willow 10 m in height throughout the site and areas of 3-m-tall coyote willow in the northeastern corner of the site. Tamarisk 5–6 m in height is the dominant understory species, and it forms a continuous canopy in portions of the site. The eastern edge of the site also contains patches of arrowweed and scattered screwbean mesquite with little canopy cover. Canopy closure varies from <25% along the eastern edge of the site to 90% within dense tamarisk stands. No major changes in vegetation structure or canopy closure were recorded from 2003 to 2012. Portions of the site up to 50 m from the lakeshore had saturated soils and fluctuating levels of standing water from 2005 to 2012. These areas were not surveyed

or described in 2003 or 2004. Soils along the eastern side of the site were generally dry throughout the survey seasons.

Migrant willow flycatchers were detected in 2003–2007 and 2009–2012, with 2–44 adults recorded annually. No flycatchers were detected in 2008. Because no resident flycatchers have been detected, we recommend adding this site to the biennial schedule.

FERGUSON WASH

Area: 6.8 ha Elevation: 58 m

Ferguson Wash was surveyed from 2003 to 2008 and in 2010 and 2012. This mixed-exotic site, at the outflow of Ferguson Wash into Ferguson Lake, is dominated by dense, mature tamarisk approximately 7 m in height, with dense deadfall in the understory. A few scattered, emergent Goodding willows 10 m in height are present near the lake, and canopy closure is around 90%. The site is bordered on the lakeside by cattails and bulrush and on the upland side by desertscrub. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. A backwater channel penetrates to the interior of the site, although the banks along the channel are abrupt and do not allow water to flow under the vegetation in this area. Soils in the interior of the site were dry throughout the survey seasons.

Migrant willow flycatchers were detected in all years, with 1–13 adults recorded annually. Hydrology within the site did not resemble that of currently occupied habitat along the LCR and tributaries in any survey season, and we recommend discontinuing surveys.

GREAT BLUE HERON

Area: 7.0 ha Elevation: 58 m

Great Blue Heron was surveyed from 2003 to 2012. This site, on the eastern shore of Martinez Lake, consists of mixed-exotic vegetation. Near the shore of Martinez Lake, Goodding willow forms an overstory 15 m in height, with an understory of tamarisk, common reed, and giant reed (*Arundo* sp.). Canopy closure in this area is 80%. Portions of the site contain thickets of willow deadfall. Farther from the lake, the site is vegetated by scattered arrowweed and tamarisk 6 m in height, with canopy closure <50%. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. Soils within the site were dry throughout the survey seasons, though areas adjacent to Martinez Lake occasionally held standing water or saturated soils.

Migrant willow flycatchers were detected in all years except 2010 and 2012, with 2–85 adults recorded annually. No flycatchers were detected in 2010 and 2012. Because no resident flycatchers have been detected, we recommend adding this site to the biennial schedule.

POWERLINE

Area: 1.0 ha Elevation: 58 m

Powerline was surveyed from 2003 to 2007 and in 2009 and 2011. This site is located south of Great Blue Heron along the eastern shore of Martinez Lake. It is a mixed-native site consisting of a strip of Goodding willow and cottonwood along the border of a cattail marsh. During the survey years, overstory height was approximately 12 m and canopy closure was approximately 50%. Tamarisk and arrowweed were present in the understory, and honey mesquite was mixed with the tamarisk on the upland edge of the site. No major changes in vegetation structure or species composition were recorded from 2003 to 2011. Soils within the site were dry throughout the seasons, though the marsh held water throughout many seasons.

Migrant willow flycatchers were detected from 2004 to 2007 and in 2009 and 2011, with one to six adults recorded annually. No flycatchers were detected in 2003. Canopy closure and hydrology within the site did not resemble that of occupied habitat in any survey season, and we recommend discontinuing surveys.

MARTINEZ LAKE

Area: 4.6 ha Elevation: 58 m

Martinez Lake was surveyed from 2003 to 2007 and in 2009 and 2011. This mixed-native site borders the eastern shore of Martinez Lake and is adjacent to and south of the Powerline site. During the survey years, the eastern edge of the site, adjacent to the upland, was dominated by arrowweed with scattered Goodding willow, cottonwood, and tamarisk. Goodding willow <10 m in height and cottonwood up to 15 m in height were more prevalent on the western edge of the site, adjacent to cattails and common reed along the lakeshore. Canopy closure was highly variable. No major changes in vegetation structure or species composition were recorded from 2003 to 2011. Standing water and saturated soils were recorded only along the lake edge; the interior of the site was dry in all years.

Migrant willow flycatchers were detected in 2004–2007 and 2011, with 2–13 flycatchers detected annually. No flycatchers were detected in 2003 and 2009. Because the interior of the site is dry and canopy closure is sparse in many areas, we recommend discontinuing surveys at this site.

GROUND RECONNAISSANCE RESULTS

Imperial Burn

This area is between Nursery NW and the uplands to the northeast. A prescribed burn was being considered for this area, and Reclamation requested that we evaluate it. We visited the area in 2009 and 2010. During those years, the site was dominated by tamarisk with scattered openings of arrowweed and common reed and some mesquite trees that emerged 1–2 m above the tamarisk. Common reed occasionally formed a dense understory in the tamarisk, especially in the southern and western portions of the site. A large stand of athel tamarisk (*Tamarix aphylla*) 11 m in height with 50% canopy closure dominated the northern end of the site. Tamarisk in the rest of the site formed a mosaic of heights and canopy cover, ranging from sparse, open tamarisk 4 m in height to tamarisk 9 m in height with 70% cover and dense understory structure. Surface water was present in the southern portion of the site in channels and open marshes bordered by cattail and common reed, and did not appear to extend beyond the borders of the marshes. To the west of the site boundary, the mosaic of tamarisk, open channels, and open marshes continued with a few widely scattered, emergent Goodding willows. Due to lack of water underneath the woody vegetation and the generally dense understory creating a lack of flight paths, we determined that no suitable willow flycatcher habitat was present within the site.

Mittry Lake, California

Mittry South was put on a biennial survey schedule starting in 2008. Cowbirds are widespread around the lake and were detected in every survey year. No evidence of livestock was documented in any survey site, though burros were present in the surrounding uplands.

MITTRY WEST

Area: 4.4 ha Elevation: 48 m

Mittry West was surveyed from 2003 to 2012. The center of this mixed-native site is dominated by Goodding willow 12 m in height with a dense understory of arrowweed and tamarisk. Deadfall is

common throughout the site, and canopy closure varies from 30% in clearings to 70% under the willows and up to 90% within dense tamarisk patches. Honey and screwbean mesquite are scattered throughout the site but are more common near the periphery. A sparse clump of coyote willow 4–5 m in height and 50 m in diameter is present in the northeastern corner of the site. No major changes in vegetation structure or species composition were recorded from 2003 to 2012. Varying amounts of standing water and saturated soil were present in the site through the survey seasons. In 2006, 2007, and 2009, standing water was present only in May.

Migrant willow flycatchers were detected in all years, with 2–17 adults recorded annually. Because no resident flycatchers have been detected, we recommend adding this site to the biennial schedule.

MITTRY SOUTH

Area: 15.2 ha Elevation: 46 m

Mittry South was surveyed from 2003 to 2008 and in 2010. This monotypic tamarisk site is bordered to the south by Mittry Lake. During the survey years, vegetation at the site was very dense, with abundant dead branches and deadfall in the understory. Canopy closure within the tamarisk was >90%, and canopy height was approximately 8 m. The edge of the lake was vegetated by cattail, bulrush, and common reed. Water along the lake shore did not extend under the woody vegetation, and throughout the survey seasons, all soils encountered in the site were very dry. The site burned in a fire in the middle of the 2011 field season. After the fire, a few small, isolated pockets of water were visible within the site.

Migrant flycatchers were detected in all years except 2006, with 2–16 adults detected annually.

GROUND RECONNAISSANCE RESULTS

Laguna

Laguna was surveyed in 2011. The site encompasses 449 ha between Imperial and Laguna Dams, on the eastern side of the Laguna dredge discharge area. This area will be included in future riparian restoration efforts, and we evaluated the existing habitat to determine whether it is suitable for willow flycatchers. In 2011, vegetation at the site consisted primarily of tamarisk <4 m in height, arrowweed, and quail bush (*Atriplex lentiformis*). A small cattail marsh was present on the eastern edge of the site; surrounding vegetation consisted of tamarisk, arrowweed, and a few 5-m-tall Goodding willow. A patch of Goodding willow 7 m in height with an understory of common reed and tamarisk was present along an old backwater channel in the north-central part of the site, but soils in this area were completely dry during the site visit on 6 June. Overall, the site was lacking in vegetation of sufficient height and density to resemble suitable flycatcher habitat, and surface water was present only in one small area. Soils in most of the site were complete dry. We visited the site once, for a total of 8.0 observer-hours. No willow flycatchers were detected. We discontinued surveys after the initial visit because of the complete lack of potential flycatcher habitat.

Laguna Dam North

We investigated this area, northwest of Mittry West between Imperial Road and the All American Canal, in 2009 after receiving reports of willow flycatcher detections from personnel from an unrelated project. Vegetation in the area consisted of a mix of honey mesquite up to 8 m in height and tamarisk 4 m in height. Scattered Goodding willow up to 6 m in height was also present. Canopy closure was 50–70%. Soils within the site were completely dry at the end of May. The site did not have the vegetation density or mesic conditions typical of occupied flycatcher habitat, and we discontinued surveys after three visits.

We detected one willow flycatcher on 29 May and one on 11 June. No flycatchers were detected on 26 June.

Yuma, Arizona

The Yuma study area is located along the Gila River, starting at the confluence with the Colorado River and moving upstream. Cowbirds are widespread throughout the study area and were detected in all survey years. All current survey sites have been put on a biennial survey schedule (Table 2.1). No evidence of livestock was noted within or around any site in any year.

GILA CONFLUENCE NORTH

Area: 2.2 ha Elevation: 40 m

Gila Confluence North was surveyed from 2003 to 2008 and in 2010 and 2012. This mixed-native site borders the northern side of the Colorado River at the confluence of the Gila and Colorado Rivers. Prior to the 2007 survey season, a fire burned through the western half of the site. In 2003–2006, the site was approximately 650 m long and less than 100 m wide. Overstory vegetation at the site was a combination of Goodding willow, coyote willow, and cottonwood. Mixed stands of these trees surrounded a cattail marsh. Canopy height at the site was variable from 4 to 13 m, and canopy closure was approximately 50%. Arrowweed, tamarisk, and seep willow were common in the understory. From 2003 to 2006, there were no major changes in vegetation structure or species composition recorded.

Currently, overstory vegetation at the site is a combination of Goodding willow and cottonwood 12 m in height. Dense stands of these trees surround a cattail marsh near the northern side of the site. Cattail marsh is also present along the river, and an open area of common reed has grown up in the center of the site in recent years. Canopy closure is variable and averages around 50%. Arrowweed, tamarisk, and Emory baccharis are common in the understory. Outside of the growth of the common reed, no major changes in vegetation structure or species composition were recorded within the site from 2007 to 2012. Soils were dry throughout the survey seasons outside of the cattail marshes. The marshes held varying amounts of standing water and saturated soil.

Migrant willow flycatchers were detected in all years, with 2–20 adults recorded annually. We did not observe suitable hydrology within the site in any survey season, and vegetation within the site was neither extensive enough nor dense enough in any survey season to resemble currently occupied habitat along the LCR and tributaries. We recommend discontinuing surveys.

GILA RIVER SITE #2

Area: 2.9 ha Elevation: 45 m

Gila River Site #2 was surveyed from 2003 to 2007 and in 2009 and 2011. During the survey years, the center of this mixed-native site consisted of an overstory of cottonwood up to 15 m in height and Goodding willow approximately 8 m in height, with an understory of arrowweed. Canopy closure in the center of the site was approximately 50%, and there was deadfall in the understory. The remainder of the site was vegetated by tamarisk 4 m in height and arrowweed, with canopy closure <50%. The site was bordered to the north by agricultural fields and to the south by an open, sandy area vegetated by arrowweed. No major changes in vegetation structure or species composition were recorded from 2003 to 2011. There was no standing water within the site during the survey seasons, but the northwestern edge of the site bordered a marsh, which did hold water throughout survey seasons.

Migrant willow flycatchers were detected in all years except 2005, with 4–18 adults recorded annually. Canopy closure was not dense enough to resemble currently occupied habitat along the LCR and tributaries in any survey season, and no surface water was noted within the site. We recommend discontinuing surveys.

FORTUNA SITE #1

Area: 3.2 ha Elevation: 45 m

Fortuna Site #1 was surveyed from 2004 to 2007 and in 2009 and 2011. During the survey years, this mixed-native site consisted of a narrow strip of cottonwood and Goodding willow up to 15 m in height with 50–70% canopy closure. Tamarisk and arrowweed formed a patchy understory on the periphery of the site. Within the densest cottonwood/willow areas, there was little understory but many downed branches. The site was bordered to the north by agricultural fields and to the south by a cattail marsh and the Gila River. No major changes in vegetation structure or species composition were recorded from 2004 to 2011. The interior of the site was dry throughout most survey seasons, but the adjoining marsh contained surface water annually.

Migrant willow flycatchers were detected in all years except 2004 and 2005, with 2–25 adults recorded annually. No flycatchers were detected in 2004 and 2005, but surveys were not conducted prior to 15 June. Hydrology within the site did not resemble that of currently occupied habitat along the LCR and tributaries in any survey season, and we recommend discontinuing surveys.

FORTUNA NORTH

Area: 3.8 ha Elevation: 46 m

Fortuna North was surveyed from 2003 to 2007 and in 2009 and 2011. During the survey years, this site was vegetated primarily by mature tamarisk approximately 7 m in height. Goodding willow and mesquite, also 7 m in height, were scattered throughout the site but made up less than 10% of the vegetation. Canopy closure was approximately 80% in the densest areas. No major changes in vegetation structure or species composition were recorded from 2003 to 2011. The Gila River ran along the western edge and through the northwestern corner of the site. No surface water or saturated soil was noted within the woody vegetation during any survey season, though the river contained water annually.

Migrant willow flycatchers were detected in every year except 2009, with 3–15 adults recorded annually. Due to the lack of surface water within the site in any survey season, we recommend discontinuing surveys.

NDOW Study Areas

From 2010 to 2012, field personnel spent 26.5 observer-hours completing broadcast surveys for willow flycatchers at 24 sites in three study areas within the Pahranagat Valley and along the Muddy River. Each site not occupied by flycatchers was surveyed five times. A summary of willow flycatcher survey effort and survey site occupancy status is presented in Appendix A.

We found resident and breeding flycatchers in at least one year at 20 sites in all three study areas (Key Pittman WMA, River Ranch, and Warm Springs Natural Area); details of occupancy, pairing, color-banding, and breeding are presented in Chapters 3 and 4. The boundaries of survey sites for the most recent survey year and number of years each site was occupied are shown on orthophotos in Appendix B. For details on annual flycatcher surveys, territories, residency, pairing, nesting activity, demography,

cowbird detections, and the presence of livestock at sites from 2010 to 2012 see McLeod and Pellegrini (2011, 2012, 2013).

In addition to willow flycatcher surveys, field personnel spent 33.9 observer-hours completing broadcast surveys for Yellow-billed Cuckoo at Key Pittman, River Ranch, and Warm Springs. Surveys were conducted according to methods described in the Western Yellow-billed Cuckoo Natural History Summary and Survey Methodology (Halterman et al. 2009). The results of cuckoo surveys are summarized below, following each study area description.

Key Pittman Wildlife Management Area, Nevada

PATCHES 0–12

Area: 1.4 ha Elevation: 1,169 m

Key Pittman WMA was surveyed from 2010 to 2012. This study area is divided into 15 small stands of coyote willow. These stands form a strip of habitat between bulrush marsh on the edge of Nesbitt Lake to the east and dry upland scrub dominated by saltbush and grasses to the west. Most of the stands are independent of each other, but four stands (Patches 6–9) have grown together, forming a larger contiguous stand. Each stand is characterized by very dense, large-diameter stems of coyote willow. Some areas have fallen or leaning stems with wispy growth in the lower 2 m, making traversing those areas difficult. Canopy height ranges from 4 to 8 m with the taller stems occurring in the center of each stand, creating a rounded look. Canopy closure is 70–90%. No major changes in vegetation structure or species composition were recorded from 2010 to 2012, though two of the smaller sites (Patches 0 and 4.5) appeared to increase slightly in extent.

Surface water was present along the eastern edge of the sites in May in all years, with up to 10–15% of the area within the sites inundated and an additional 5% of soils saturated. Lake levels dropped throughout the survey season each year, with only damp to saturated soils present by July. Away from the lake, soils within each site were damp, grading to dry on the western, upland site.

Breeding willow flycatchers were detected each year from 2010 to 2012, with 31–39 resident adults recorded annually. Cowbirds were noted throughout each survey season during nest monitoring activities. Signs of cattle were present in the dry upland scrub, but the sites have been fenced off to prevent damage. Deer were present within the sites, but did not appear to heavily impact the vegetation structure.

YELLOW-BILLED CUCKOO SURVEYS

We completed four surveys for Yellow-billed Cuckoo at Key Pittman in each year from 2010 to 2012. No Yellow-billed Cuckoos were detected. One Yellow-billed Cuckoo was incidentally detected at Key Pittman in 2008 in the middle of June when field personnel were banding flycatchers. This individual was visually observed, but not heard.

River Ranch

River Ranch is in the Pahranagat Valley, approximately 12 km south of Key Pittman, and consists of several isolated patches of vegetation. Each patch is surrounded on all sides by grazed, irrigated cattle pasture, and the perimeter of each site has a distinct browse line at 1.5 m in height. There are cattle trails within each site as well. We surveyed all sites in both 2011 and 2012, and detected cowbirds in both years. Often cowbirds were sighted as large flocks flying past the survey sites.

WEST SIDE

Area: 0.3 ha Elevation: 1,100 m

This site is composed primarily of dense, large-diameter coyote willow 7 m in height. Shorter coyote willow approximately 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 is 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 varies from 0 to 30%. Areas of deadfall up to 1 m deep are scattered throughout the site, making travel difficult in places. No major changes in vegetation structure or species composition were noted from 2011 to 2012. Water levels fluctuated throughout each season depending on irrigation activity. Maximum water extent included a ditch approximately 1 m wide and 0.2 m deep surrounding the site, with 10% saturated soils in the site interior. Minimum water extent included damp soils throughout the site.

Breeding flycatchers were detected in 2011, with three resident adults recorded. No flycatchers were detected in 2012.

EAST SIDE

Area: 0.4 ha Elevation: 1,100 m

This 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 and velvet ash (*Fraxinus velutina*) 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. Canopy closure is primarily 70–90%, except in a few scattered clearings where it ranges from 0 to 25%. No major changes in vegetation structure or species composition were recorded from 2011 to 2012. Water levels fluctuated throughout the season depending on irrigation activity. Maximum water extent 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. Minimum water extent included dry soils throughout the site.

One pair of breeding flycatchers was detected in 2011. In 2012, one adult flycatcher for which residency could not be confirmed was detected after 24 June.

SMALLS

Area: 0.5 ha Elevation: 1,100 m

This 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 approximately 25% of the site, dominates the northern half of the site. This gap is ringed by a stand of shorter coyote willow approximately 4 m in height and 4 m wide on the western, northern, and eastern sides. Canopy closure averages 80–90% in the vegetated areas. Deadfall is scattered throughout the site but typically does not occur in piles as it does in West Side and East Side. No major changes in vegetation structure or species composition were recorded from 2011 to 2012. Water levels were variable throughout the season depending on irrigation activity. Maximum water extent included a pool of water at the northern end of the site and saturated soils throughout the remainder of the site. Minimum water extent included completely dry soils throughout the site.

One pair of flycatchers was detected in 2011, though no nest was located. No willow flycatchers were detected in 2012.

YELLOW-BILLED CUCKOO SURVEYS

We completed four surveys for Yellow-billed Cuckoo at River Ranch in both 2011 and 2012, totaling 6.2 observer-hours. No Yellow-billed Cuckoos were detected in either year.

Warm Springs Natural Area

The Warm Springs study area is located on the headwaters of the Muddy River, west of the town of Moapa. We began surveys at Warm Springs in 2010, and on 1 July of that year, a wildfire burned at least part of all the survey sites at Warm Springs. Due to the severity of fire damage, surveys were discontinued after the fire at all sites except Muddy Mac. Prior to the fire, a few cattle were noted in and around some of the survey sites. No evidence of livestock was documented within the remaining survey site in any year. Cowbirds were documented within the study area in all years from 2010 to 2012.

LDS EAST

Area: 0.9 ha Elevation: 548 m

LDS East was surveyed in 2010. Before the July fire, this was a mixed-native site located just south of State Highway 168. The overstory was dominated by velvet ash up to 15 m in height with a few scattered palms (*Washingtonia* sp.) and cottonwoods. The understory was primarily 5-m-tall tamarisk with some honey mesquite on the margins. The center of the site was dominated by a cattail marsh that held water throughout the season. Canopy closure varied from 25% in the cattail marsh to 90% in the ash/palm stands. The fire significantly damaged this site. Evidence of fire was seen well up the trunks of the tall trees and in the cattail marsh. No understory or canopy cover remained immediately post-fire.

No willow flycatchers were detected. No cowbirds or evidence of livestock were detected.

MUDDY STRINGER #1

Area: 1.4 ha Elevation: 548 m

Muddy Stringer #1 was surveyed in 2010. Before the July fire, this was a mixed-native site consisting primarily of a stringer of velvet ash, Goodding willow, and palm trees 15 m in height along an irrigation channel. Mesquite, coyote willow, and tamarisk comprised the understory, which was approximately 5 m in height. The very southern portion of the site also contained a stand of coyote willow approximately 6 m in height with very dense stands of tamarisk along the channel bed. Canopy closure was approximately 70%. Shallow pools 5–15 cm deep were present within the channel in May. In June the site was almost entirely dry, except for some moist soil in the channel. Water was noted in the channel again in July. Most of this site, including the two nest sites, was heavily burned in the 1 July fire. The very southwestern corner of the site was unburned, but the leaves appeared dead from proximity to high heat. This site was reassessed at the beginning of 2011 and 2012. While still heavily damaged and unsuitable, the coyote willow in the southern portion of the site is slowly regenerating.

We detected three breeding willow flycatchers and one female for which residency and breeding status could not be determined. Cowbirds were detected every visit, and evidence of cattle was seen in the area, though not within the site. We recommend reassessing this site in future years to determine if vegetation in the southern portion of the site has regenerated to a suitable structure.

MUDDY STRINGER #2

Area: 1.4 ha Elevation: 548 m

Muddy Stringer #2 was surveyed in 2010. Before the July fire, this was a mixed-native site consisting of a stringer of trees along an irrigation channel approximately 100 m west of Muddy Stringer #1. The channel formed the shape of a reversed letter "L" with a fork running north-south on the eastern side of the site and another fork running east-west on the southern end. Cottonwoods 20 m in height formed the overstory along with a few scattered palm trees. Tamarisk and mesquite up to 6 m in height formed the understory. Canopy closure was approximately 25–50%. Small pools were present in May in the east-west channel, but the site was completely dry in June and July. The majority of the understory within the site was burned in the 1 July fire. A few 10–15-m-radius patches of unburned habitat remained immediately adjacent to the stringers. Fire scars extended high up into the canopy of some of the cottonwoods.

No willow flycatchers were detected in 2010. Cowbirds were detected on three visits, and evidence of cattle was observed around the site perimeter.

NORTH FORK MUDDY

Area: 5.5 ha Elevation: 548 m

North Fork Muddy was surveyed in 2010. Before the July fire, this was a mixed-native site following a stretch of the Muddy River immediately south of Muddy Stringers #1 and #2, extending from the confluence with Refuge Stream to approximately 600 m upstream of the confluence. Scattered velvet ash up to 15 m in height were present along the channel but did not form a continuous canopy. Palm trees and 5-m-tall tamarisk formed the remainder of the vegetation along the channel. Honey and screwbean mesquite up to 10 m in height were present along the dry channel margins. Canopy closure along the channel was 80%. The channel had very steep banks and was incised up to 5 m below the surrounding uplands, which were dominated by saltbush with no canopy closure. The stream was perennial, but water was confined to the incised channel. This site was heavily damaged in the 1 July fire, with almost all of the vegetation completely consumed.

No willow flycatchers were detected in 2010. Surveys were discontinued prior to the fire because of the incised nature of the channel, dry soils, and poor habitat structure. No cowbirds or signs of livestock were observed.

MUDDY MAC

Area: 0.5 ha Elevation: 548 m

Muddy Mac was surveyed or monitored from 2010 to 2012. This native 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, but live vegetation was only 3 m in height in 2012. We did not survey this northern portion in 2012. The eastern half of the survey area is characterized by a very dense velvet ash stand 8 m in height with no understory and ≥90% canopy closure. The western half is dominated by sparse velvet ash approximately 12 m in height with a damaged canopy that is two-thirds leafless and 50% canopy closure. Velvet ash 2 m in height are regenerating in this portion of the site. The area immediately south of the site has been cleared as part of a restoration effort. The majority of the site contained shallow standing water or saturated soils in May of each year, though soils quickly dried out by June. Surface water was present throughout the survey seasons in a stream flowing through the woody vegetation near the southern edge of the site.

Breeding flycatchers were detected in all three years, with two to three adults recorded annually. Cowbirds were detected periodically during nest monitoring visits in all years. No evidence of livestock was observed.

APCAR

Area: 0.7 ha Elevation: 548 m

Apcar was surveyed in 2010. Before the July fire, this was a mixed-native site lying just north of Warm Springs Road along Apcar Stream. It consisted primarily of a 50- x 50-m stand of velvet ash 15 m in height with scattered tamarisk 5 m in height in the understory. Upstream of the ash stand, the site became narrower, and 100 m from the ash stand the site became a narrow stringer, one tree wide, along the stream. Immediately south of the site was a dense grove of palm trees. Canopy closure was 80%. Water was flowing in the stream at a depth of approximately 40 cm throughout the survey season. Soils were dry immediately adjacent to the stream. This site sustained heavy damage in the 1 July fire and was reduced to charred trunks with only a few live velvet ash remaining immediately adjacent to the stream.

No willow flycatchers were detected in 2010. Cowbirds were detected on one visit. No evidence of livestock was recorded.

YELLOW-BILLED CUCKOO SURVEYS

In 2010, we completed one survey for cuckoos before all survey sites were damaged in the July fire. No cuckoos were detected during the survey, but an incidental detection of a cuckoo was recorded at the southern end of Muddy Mac on 29 June. No surveys were conducted in 2011 due to a lack of suitable habitat. In 2012, we completed four surveys for Yellow-billed Cuckoo at Muddy Mac, totaling 1.1 observer-hours. No Yellow-billed Cuckoos were detected.

DISCUSSION

Since SWCA began surveying for and monitoring flycatchers in 2003, many sites have been discovered and many others have been discontinued. Six Reclamation study areas have held resident and breeding flycatchers annually from 2003 to 2012: Pahranagat NWR, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams River NWR (McLeod et al. 2008a; McLeod and Koronkiewicz 2009, 2010; McLeod and Pellegrini 2011, 2012, 2013; details of residency and breeding are presented in Chapters 3 and 4 of this document). Resident or breeding flycatchers were also detected in at least one year in several additional Reclamation study areas: Littlefield, Grand Canyon, and Ahakhav. Two NDOW study areas (Key Pittman and Warm Springs) were consistently occupied by breeding flycatchers from 2010 to 2012 (McLeod and Pellegrini 2011, 2012, 2013). One additional NDOW study area (River Ranch) held breeding flycatchers in 2011, but not in 2012.

Site Discovery and Loss

In 2003, SWCA surveyed 95 sites. From 2004 to 2012, 61 sites were added (Table 2.3). Twenty-four of these sites were added as familiarity with the project area increased and more pockets of suitable habitat were identified through reconnaissance, or alternative survey sites were selected to replace those lost after 2003. Ten of the additional sites were within the Grand Canyon, and were added after surveys began in 2003. These sites grew as water levels within Lake Mead dropped and new sediments were exposed. Seventeen sites, all located north of Parker Dam, were added after vegetation matured or the site was

discovered with breeding flycatchers. An additional seven sites, six of which are located south of Parker Dam, are habitat creation sites first surveyed starting in 2006.

Table 2.3. Number of Reclamation sites added and removed from the formal survey site list by year, 2003–2012

Status	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Added	95	9	9	17	5	4	7	4	3	3
Discontinued	1	8	2	19	1	20	5	11	2	7

From 2003 to 2012, surveys were discontinued at 76 sites (Table 2.3). Primary reasons for discontinuation of surveys were poor habitat quality, changes in hydrology, and fire (Table 2.4). North of Lake Mead, surveys were discontinued primarily because of a loss of surface water (7 of 18 sites) or a determination of poor habitat quality (5 of 18 sites). Flood waters also scoured three sites, two sites were heavily damaged by fire, and one site was removed in a tamarisk control effort. In the Grand Canyon, surveys at 14 of 23 sites were discontinued due to a loss of surface water and subsequent loss of live vegetation. Between the Grand Canyon and Parker Dam, the primary reason for survey discontinuation was determination of poor habitat quality (10 of 13 sites). South of Parker Dam, the primary reason for survey discontinuation was fire (10 of 22 sites), followed by determination of poor habitat quality (7 of 22 sites). Anthropogenic safety concerns were only present south of Parker Dam. Locations of discontinued surveys and reasons for discontinuation are presented on orthophotos in Appendix F.

Table 2.4. Reasons for Discontinuation of Flycatcher Surveys at Reclamation Study Areas, 2003–2012

Geographic Area	Study Area[1]	Poor Habitat	Dried Up	Scoured	Fire	Bulldozed	Control of Exotics	Safety	Change of Contract	Total
North of Lake Mead	PAHR				2		1			3
	MVWA	3								3
	LIFI			3						3
	MESQ	1	4							5
	MOME	1	3							4
	Total	**5**	**7**	**3**	**2**	**0**	**1**	**0**	**0**	**18**
	GRCA	1	14						8	23
Lake Mead to Parker Dam	TOPO	7				1				8
	TOGO	2			2					4
	BIWI	1								1
	Total	**10**	**0**	**0**	**2**	**1**	**0**	**0**	**0**	**13**
South of Parker Dam	AHAK	1			1					2
	BIHO							1		1
	CIBO	1			2					3
	IMPE	3			2					5
	MITT	2			1					3
	YUMA				4	2		2		8
	Total	**7**	**0**	**0**	**10**	**2**	**0**	**3**	**0**	**22**
Overall Total		***23***	***21***	***3***	***14***	***3***	***1***	***3***	***8***	***76***

[1] PAHR = Pahranagat NWR, MVWA = Meadow Valley Wash, LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, GRCA = Grand Canyon, TOPO = Topock Marsh, TOGO = Topock Gorge, BIWI = Bill Williams River NWR, AHAK = Ahakhav Tribal Preserve, BIHO = Big Hole Slough, CIBO = Cibola, IMPE = Imperial, MITT = Mittry Lake, YUMA = Yuma.

North of Parker Dam, the primary causes of site loss and addition were shifts in surface hydrology driving the growth and death of vegetation. Both the Bill Williams and Virgin Rivers are dynamic with the active channel shifting during large flood events, resulting in scouring and deposition and allowing the generation of new vegetation. Beavers have also helped to create various areas of ponded water, primarily within Littlefield, Muddy River, and Bill Williams. Along the Virgin River, several sites were dependent on return flow from agricultural fields, many of which went out of production as water shares were leased by Southern Nevada Water Authority (Jeff Johnson, SNWA, pers. comm.).

South of Parker Dam, water levels are more constant and flood events within the mainstem are not a factor. Flash floods in washes feeding the LCR can affect habitat quality in certain sites, but are rare. Most of the sites are dry and are therefore prone to fire. Site addition south of Parker Dam has been primarily due to a need to maintain the number of sites surveyed in 2003–2007 after several sites were lost, and the growth of the habitat creation sites. No new sites were designated due to changes in surface water allowing for growth of new vegetation.

Surface Water and Habitat Quality

Flycatcher breeding habitat suitability is driven by both vegetation structure and the presence of standing water or saturated soils (Sogge et al. 2010). The presence of standing water or saturated soils is often required to maintain suitable vegetation structure. As noted in the previous section, shifts in hydrology have been responsible for a large portion of site discontinuation and new site creation, though primarily north of Parker Dam. Here we describe and summarize changes in hydrology along various river segments within the project area and the corresponding changes in vegetation or flycatcher residency.

Hydrology at sites within the Pahranagat Valley is directly related to adjacent lake levels, which are influenced primarily by management decisions and the integrity of the structures creating the lakes. No major changes were noted in Nesbitt Lake at Key Pittman from 2010 to 2012. From the start of flycatcher monitoring at 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 2012 were at their highest since repairs, and riparian vegetation at the northern end of the lake contained more water in 2012 than in the previous two years, but the site was not inundated as it had been prior to 2008. Primary changes in vegetation noted after the shift in hydrology have been increased mortality of Goodding willow in the northeastern corner of the site; increased cottonwood mortality throughout the site, which could be due to old age; and an increase in the prevalence of a dense, 2-m-tall understory of Indian hemp. The overall number of resident or breeding flycatchers has not changed noticeably in response to the hydrology shift. The flycatchers have, however, shifted nesting locations away from the now drier center of the site to the southern perimeter of the site where the seasonal duration of inundated or saturated soils is relatively unchanged.

Hydrology along the Virgin River is strongly influenced by winter flood events and spring snow-melt. The winter flood events have the potential to scour away or deposit sediment in large sections of habitat as well as shift the location of the active river channel within the floodplain. The Littlefield study area is located on the confluence of Beaver Dam Wash with the Virgin River. Beaver Dam Wash is prone to the same flood events experienced by the Virgin River. Breeding flycatchers were first documented in the

study area in 2004, but the winter flood of 2004–2005 scoured away all suitable breeding habitat. What remained of the two survey sites had heavy sediment deposition and reduced surface water, and surveys at both sites were discontinued. Beaver activity upstream of the two former survey sites improved hydrology in the wash and allowed for regeneration of willows and cottonwoods in dense stands. Vegetation grew quickly, and by 2009 breeding flycatchers were once again documented in the study area. The December 2010 flood scoured away a lot of peripheral, potential habitat, leaving the survey site primarily intact, though reduced in stand density. Heavy sediment deposition coupled with a shift in the location of flowing water within the wash significantly reduced the suitability of the site, and surveys were discontinued.

Hydrology within the Mesquite study area is influenced both by the Virgin River and also by sheet flow from adjacent agricultural fields and return flow from irrigation canals. The Virgin River primarily influences sites in the study area through scouring and sedimentation in flood events. Most of the sites within the study area are adjacent to but perched above the active river channel. The presence of surface water within any site occupied within the study area from 2003 to 2012 was directly related to return flow from irrigation. Since 2003, four of the seven occupied sites have lost surface water as water shares were leased by the Southern Nevada Water Authority and the agricultural fields went out of production. Vegetation associated with the occupied portions of each site died when the hydrology changed.

The only consistent breeding site within the Mesquite study area is Mesquite West. Since 2009, hydrologic conditions within the site have been quite variable. The site was largely dry in 2009, and premature leaf abscission was observed as early as May. In 2010, the site was wet throughout the breeding season, and the vegetation appeared to respond with dense growth. In May and early June of 2011, hydrologic conditions were similar to those observed in all prior years except 2009. In mid-June 2011, earthwork at the inflow to the site diverted water along the eastern edge of the site and into the Virgin River. Although the site became dry, the canopy remained largely intact with only a minor amount of leaf abscission detected in August. An earthen berm was constructed in April 2012 in the channel on the eastern edge of the site, diverting water back into the northeastern corner of the site. However, the areal extent of the water in 2012 was not as large as recorded in previous years when the site held water. This could be related to the amount of water entering the site, which seemed reduced from previous years. Water flow was also intermittent, allowing the site to dry out completely between inundations. Many willows have died since 2011, and many of the remaining live willows have reduced canopy cover. A site visit in October 2012 revealed that the temporary earthen berm was gone, and water was again flowing down the channel along the eastern edge of the site. The channel had received significant sedimentation, raising the channel bottom sufficiently to allow water to flow out of the channel and into the eastern edge of the site. All portions of the site that have been occupied by flycatchers over the last several years appeared to have surface water. Another site visit in February 2013 revealed that the channel along the eastern edge of the site had experienced downcutting since the previous October. The channel was dry at the time of the visit, and it was not clear whether the channel was too deep to allow water to flow into the site. The number of resident flycatchers detected at Mesquite West from 2003 to 2012 (Figure 2.2) appears to have responded to shifts in hydrology. The brief dip in number of resident flycatchers recorded in 2005 is due to reduced habitat suitability resulting from the 2004–2005 winter flood, and not from reduced water delivery. The decline in flycatcher numbers between 2009 and 2012 was likely influenced by poor nest success from 2009 to 2011 and poor habitat conditions in 2009 and 2011.

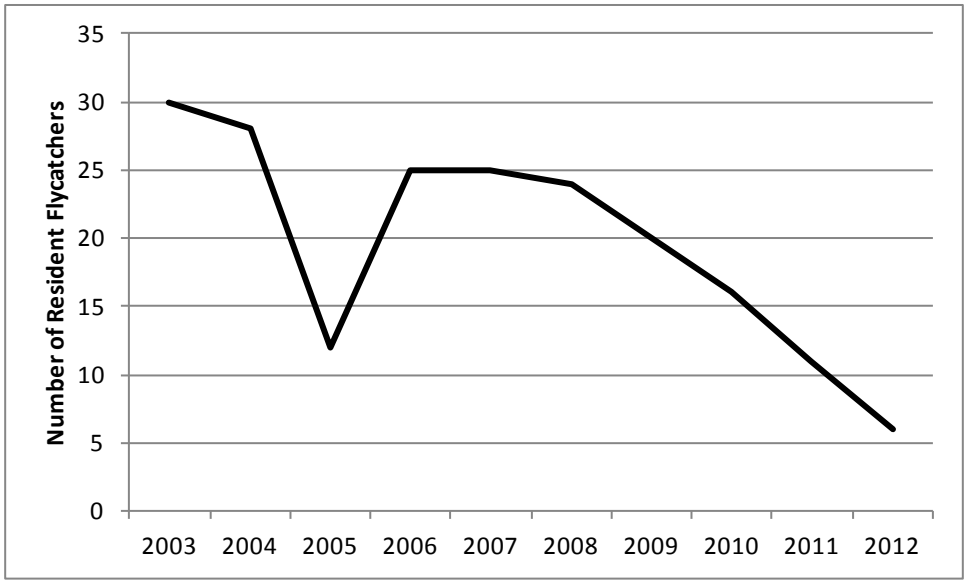

Figure 2.2. Number of resident southwestern willow flycatchers at Mesquite West, 2003–2012.

Mormon Mesa is the most southern study area along the Virgin River. Like at the Mesquite study area, the river influences sites through scouring and sedimentation. Active breeding locations within the Mormon Mesa study area shifted within the landscape from 2003 to 2012 as hydrology shifted. In 2003 and 2004, breeding flycatchers at Mormon Mesa occurred in small, scattered pockets. One such breeding area was at the northern end of the study area in Mormon Mesa North. The winter 2004–2005 flood scoured away part of the site and deposited a thick layer of sediment. Surface water within the site was eliminated and no breeding was documented at the site after 2005. Another pocket of breeding flycatchers occurred on the eastern side of Virgin River #1 North. This area was wet in 2003 and 2004 and supported breeding flycatchers both years. The winter 2004–2005 flood deposited a thick layer of sediment in this area, and surface water was no longer present. No resident flycatchers were detected in this area after 2005, and by 2008 much of the vegetation in this area was dead. The third area of Mormon Mesa that had breeding flycatchers in 2003 and 2004 was Delta West. Delta West was inundated at the beginning of the breeding season in both 2003 and 2004. The river channel shifted away from the site after the 2004–2005 winter flood, and the site was completely dry by 2006 and most of the vegetation within the site was dead by 2007. A fourth breeding area, Virgin River #2, was discovered with breeding flycatchers in 2005, although old flagging from the previous contract (1997–2002) suggested that resident flycatchers may have been present in this area in earlier years but went undiscovered in 2003 and 2004. This area slowly dried out after 2005, and breeding was last recorded in this area in 2008.

The winter flood of 2004–2005 shifted the active river channel from the eastern to the western side of the floodplain in the Mormon Mesa area and likely also influenced where subsurface flows emerged to the surface within riparian areas away from the main channel. The currently occupied breeding area (Virgin River #1 South) was first documented with breeding flycatchers in 2007. Aerial imagery suggests that this area was dry in 2005 and did not support the marshes currently present in the site. In addition, surveys in the area in 2003–2005 did not detect any flycatchers, and no marshy areas were noted on site descriptions. Changes in vegetation within the breeding area between 2005 and 2010 are evident on aerial imagery, with bare ground filling in with green vegetation known to be cattails. This area is now the only portion of Mormon Mesa occupied by breeding flycatchers. Although breeding sites have shifted around the landscape within the study area, the number of resident flycatchers has not showed a consistent trend in any direction. The number of resident flycatchers declined slightly from 2003 to 2005, with 17 and

13 residents recorded, respectively. From 2005 to 2007, the number of residents steadily increased to 24. From 2007 to 2012, the resident population within Mormon Mesa remained steady, ranging between 23 and 27 resident adults. The increase in the number of resident adults coincides with the colonization of the breeding site in Virgin River #1 South in 2007. This breeding area has the largest areal extent of any breeding site documented in the study area between 2003 and 2012.

The main breeding site (Overton WMA) in the Muddy River study area lies along the Muddy River. The Muddy River is strongly channelized throughout the majority of Overton WMA, with dry soils immediately adjacent to the river channel. In 2005–2007, Overton WMA supported two distinct breeding areas approximately 800 m apart. Over the 2007–2008 winter, the Muddy River was dredged immediately upstream and downstream of the northern breeding area. Dredging activities resulted in a cleared swath 10–15 m wide on the western bank of the river and a reduced number of braided channels in the northern breeding area. Resident flycatchers were not documented in the northern breeding area from 2008 to 2011, and all breeding flycatchers were located in the very southern end of the site. When the river reaches the southern end of the site, a portion of the river flow is diverted to a ditch running along the road to the southwest of the site. Any water that flows through the site enters a network of smaller, braided channels that are often ponded by beaver activity, creating a thin sheet flow of water throughout much of this end of the site. Water levels have been slowly receding in this area since 2010, and no new beaver activity was noted in 2011 or 2012. By 2012, no standing water was present in the southern breeding area downstream of the diversion, and only a little saturated soil was noted in the channels at the beginning of the season. However, water was still present in the ditch along the road. Neither vegetation nor the number of resident flycatchers has yet responded to the shift in hydrology within the site. However, nesting attempts were documented in both breeding areas of Overton WMA in 2012 for the first time since 2007. Detections of flycatchers in the historically occupied northern breeding area could be related to the unusually dry conditions present in the southern end of Overton WMA in 2012, which may have influenced flycatchers to occupy alternate areas.

Water levels within the sites at Topock Marsh are directly related to marsh elevation levels, which are heavily managed. Inflow into the marsh currently relies on a passive gravity feed from the mainstem of the LCR along three channels, with two of these channels capable of delivering the majority of water. All three channels rely on river levels being high enough to allow water flow, and one channel has a control structure on the marsh side, allowing for regulation of water flows into the marsh. Outflow from the marsh is also controlled with a water control structure. 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 (Figure 2.3). In 2010 and 2011, marsh elevations at Topock reached record low levels in preparation for construction of the newest of the three water delivery canals. While numerous factors are likely affecting habitat quality throughout the study area, the most obvious is lowered marsh levels. The number of resident flycatchers increased substantially from 2003 to 2004, with 20 and 57 residents recorded, respectively. Reasons for the sudden increase in resident flycatchers in 2004 are still unclear. From 2005 to 2012, the number of resident adults detected at Topock declined, with 36, 29, 18, 20, 14, 11, 5, and 2 detected in each year in 2005 through 2012, respectively. In 2012, one of the two resident flycatchers initially held a territory within the historic breeding area of the marsh, but then moved and established a second territory in Beal Lake, where he spent the majority of the summer. This was the first record of a territorial, banded flycatcher occupying one of the habitat creation sites. The establishment of this territory in the habitat creation site is suggestive of improving habitat suitability for flycatchers in this area, but also of the poor habitat quality throughout the rest of the study area. Changes over the years in the timing and magnitude of fluctuations in marsh levels may have contributed to the decline in the Topock flycatcher population.

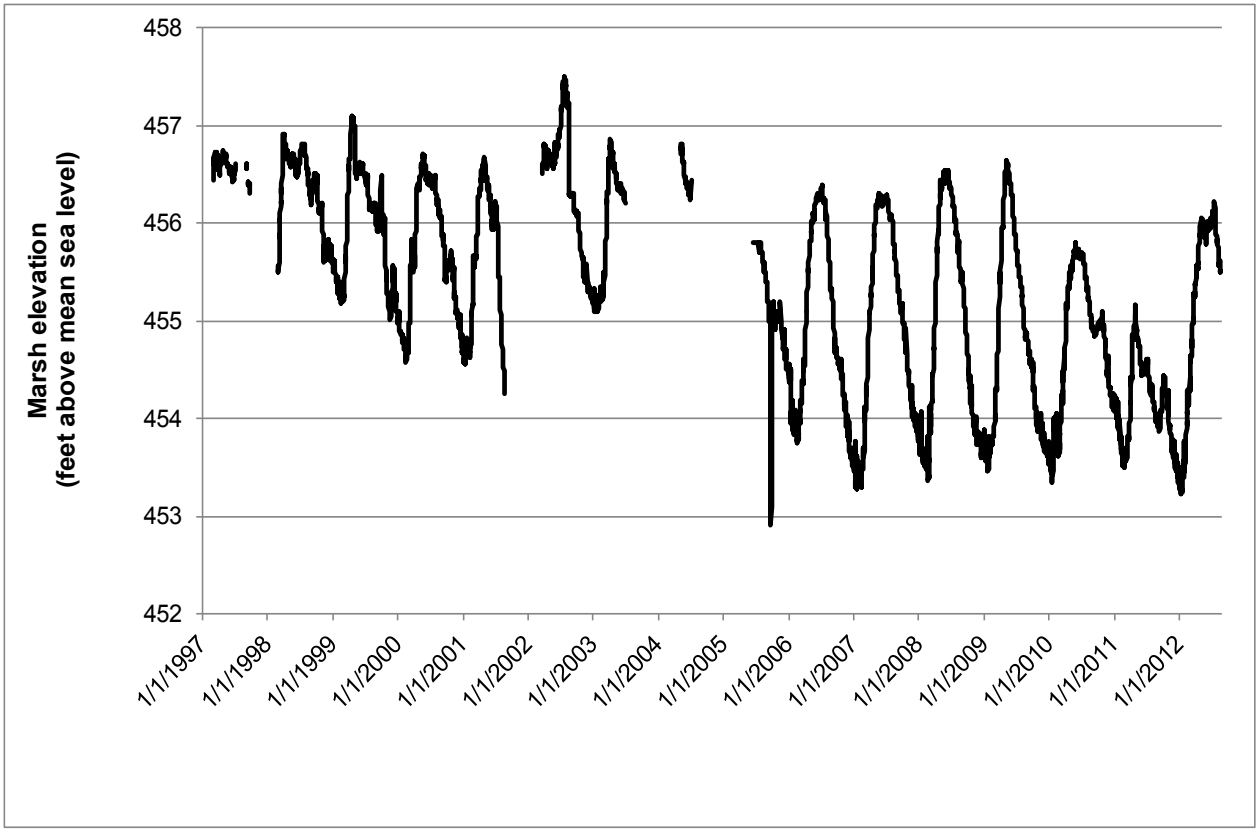

Figure 2.3. Marsh elevation (feet above mean sea level) measured at the South Dike at Topock Marsh, 1997–2012.

Water levels in the Bill Williams River are dependent on releases from Alamo Dam. The dam is capable of a maximum release of 7,000 cfs, and in years when this outflow is necessary to relieve pressure from the reservoir, shifts in surface hydrology within the river floodplain are noted afterwards. Flood events are capable of shifting gravel bars around the landscape, scouring some vegetation, and shifting where the river will surface within the floodplain. Two large flood events, one in the winter of 2004–2005 and the other in the spring of 2010, were noted within the study area between 2003 and 2012. In both cases, new areas became inundated while other areas became more channelized after beaver dams were washed out. Beavers are prevalent within the study area and were able to rebuild within a couple of years after each flood, inundating new areas. The number of resident flycatchers has remained stable across the years, with occupied sites shifting around the landscape as hydrologic conditions shift according to flooding and beaver activity. New stands of willows and cottonwoods have also developed at Cougar Point and Planet Ranch Road since 2003 in response to shifts in hydrology. Between 2003 and 2012, there were only two years, 2004 and 2012, in which successful breeding was not documented within the study area. In 2004, the driest conditions in any year from 2003 to 2012 were recorded (see McLeod et al. 2008a) and no breeding attempts were documented. In 2012, conditions were drier than the previous few years, and breeding attempts were documented, though none were successful.

Water levels in the lower Colorado River south of Parker Dam are regulated by releases from Parker Dam. Average summer releases declined from 2000 to 2003, but remained relatively steady at a new level from 2003 to 2007. Average summer releases again declined in 2008 and 2009, but by 2012 returned to levels noted in 2003–2007. No changes in vegetation structure or composition were noted as average releases declined. Few sites south of Parker Dam have extensive areas where ground level is near the level of the water table, and most sites are therefore not strongly influenced by decreases in water levels

(see Chapter 8). Any changes in hydrology noted within the survey sites have not affected flycatcher residency as only one resident flycatcher has been documented south of Parker Dam. The site it occupied burned and was discontinued.

Livestock

Four types of livestock were documented within the project area from 2003 to 2012: cattle, domestic pigs, feral pigs, and feral burros. With the exception of escaped cattle on the Bill Williams River NWR in 2012, cattle have only been documented within survey sites along the Virgin River, in lower Grand Canyon as far upstream as Pearce Ferry, and periodically at Pahranagat NWR. Cattle have been documented within the majority of habitat/vegetation types, with the exceptions being very dense tamarisk with dense deadfall in the understory and dense stands of young, small-diameter willow or cottonwood. Effects of cattle presence on habitat include the creation of many "trails" and grazing of wet meadows and other sources of herbaceous vegetation. No "browse-line" has been documented on broad-leaf trees in areas that are not formally grazed. Cattle will travel directly adjacent to flycatcher nesting areas, but no nest failure directly due to cattle (i.e., knocking over the nest or nest tree, or eating nest contents) has been documented in this study. While the presence of cattle has not obviously affected flycatcher nest success in this study, cattle likely prevent the natural expansion of native vegetation through selective browsing on young seedlings. All areas occupied by cattle within the project area are now also affected by tamarisk beetles. The arrival of tamarisk beetles increases the necessity of expanding native vegetation extent for all riparian obligate species.

Feral pigs have been documented within survey sites from Topock Marsh to Topock Gorge. No consistent evidence of feral pigs has been noted north or south of these study areas. Domestic pigs were also documented in one year at Mesquite East. Signs of pigs have been noted in the Bill Williams River study area over the years of the study. We have not had visual confirmation of feral pigs at the Bill Williams River study area over the last 10 years, although two feral pigs were seen on the Bill Williams River study area in the mid-1990s (Barb Raulston, Reclamation, pers. comm.). Javelina, however, have been encountered regularly and it is assumed that pig sign south of Lake Havasu is due primarily to javelina and not feral pigs. Where feral pigs are present, they are prevalent in all riparian habitats, except those with exceptionally dense deadfall, and they create small tunnels and trails throughout the habitat they occupy. Aside from trail creation, pigs will disturb the ground, rooting for food, and will create large wallows. In some cases, the wallows may provide the only standing water or saturated soil within the site into July. Ground disturbance does not appear to have any negative impact on habitat suitability for flycatchers.

Feral burros have been seen around survey sites between Topock Gorge and Yuma. Burros have been primarily documented in the adjacent uplands surrounding most of the survey sites in this portion of the project area. Occasionally, they have been documented within a site, but usually in the transition zone between dense riparian habitat and upland scrub. Preferred transition zone habitat is often vegetated with scrubby tamarisk, open mesquite, paloverde, and ironwood with an open understory, creating a shady area that is easy to move through. There is no evidence of any negative impact of burros on flycatcher habitat.

Migrant Flycatchers

From 2003 to 2012, annual flycatcher detections at sites surveyed south of the Bill Williams River ranged from 43 to 591, for a total of 2,571 individuals across all 10 years (McLeod et al. 2008a; McLeod and Koronkiewicz 2009, 2010; McLeod and Pellegrini 2011, 2012, 2013). Monitoring results and behavioral observations (lack of territorial, aggressive behaviors exhibited toward conspecific broadcasts) at these sites suggest most of these flycatchers were not resident or breeding individuals but migrants. Only one

resident individual was recorded south of the Bill Williams River from 2003 to 2012. This individual was detected at the Ahakhav study area in 2008, and was not observed singing unsolicited, but instead was responsive to playback on multiple visits and remained in the same location for over one week.
The current survey protocol (Sogge et al. 2010) suggests that flycatchers detected before 24 June that do not demonstrate territorial behavior are likely migrants. From 2003 to 2007, SWCA followed a 10-survey protocol, which required four surveys by 15 June, and allowed for six surveys prior to 24 June, allocating more survey effort during migration. During this period, field personnel spent a total of 2,832.2 observer-hours in the field conducting surveys and detected 2,075 flycatchers. From 2008 to 2012, SWCA followed a 5-survey protocol, which requires two surveys by 15 June and often allowed for a third survey by 24 June, thereby reducing survey effort during migration. During this contract period, field personnel spent a total of 1019.5 observer-hours in the field conducting surveys and detected 495 flycatchers. The annual number of flycatcher detection differed significantly between survey protocols by contract period ($t = 4.2163$, $df = 9$, $P = 0.002$), suggesting that the number of flycatcher detections was directly related to effort. The relationship between survey effort and flycatcher detections is strongly correlated ($r^2 = 0.515$, $df = 8$, $P = 0.012$; Figure 2.4), but it is not linear, suggesting an additional source of variation. Field observations suggest that the pattern of migration, which occurs in pulses, might explain the extra variation.

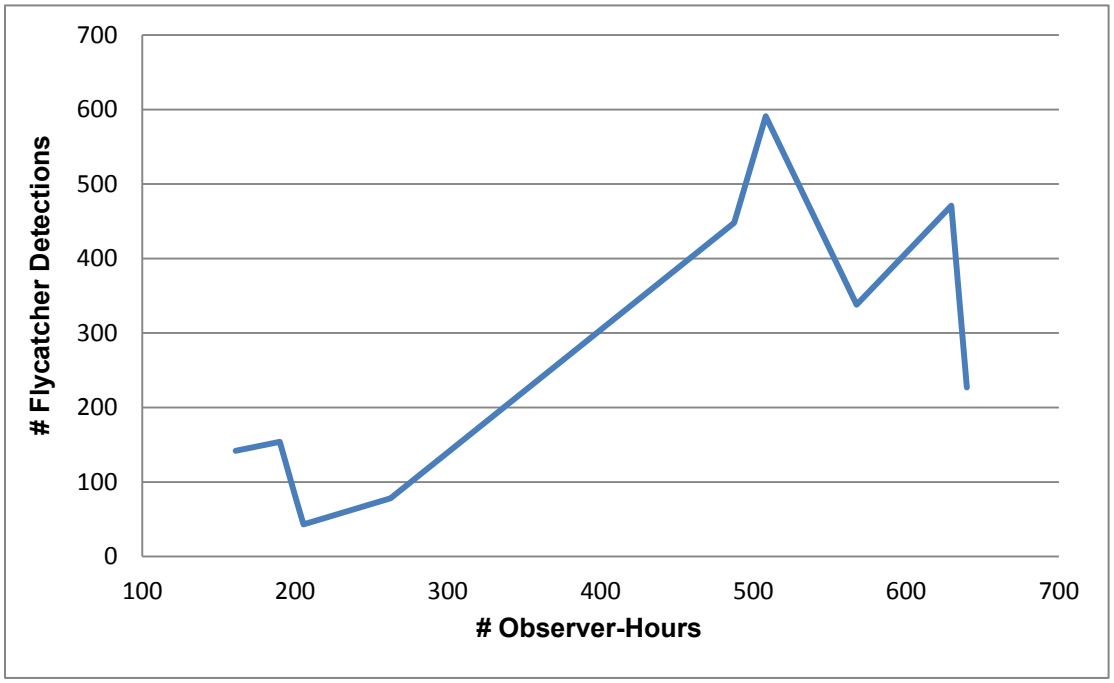

Figure 2.4. Annual number of flycatcher detections by number of observer-hours from 2003 to 2012.

Banding studies in the Yuma area completed in 2003–2007 also suggested that willow flycatchers detected in mid-June were migrants (McLeod et al. 2008a). Migrant willow flycatchers along the lower Colorado River could belong to one of several subspecies (*E. t. extimus*, *E. t. adastus*, or *E. t. brewsteri*), and unless an individual is banded on the breeding grounds, it is impossible to determine in the field whether a migrant is *E. t. extimus* or one of the other two subspecies. A model based on plumage color variation predicted that approximately half of 96 willow flycatchers captured in the Yuma area in mid-June in 2004–2007 were *E. t. extimus* (Paxton et al. 2010), indicating that the southwestern subspecies does use the lower Colorado River as a migration corridor. In addition, two flycatchers banded at breeding sites monitored as part of the lower Colorado River study have been detected at sites south of the

Bill Williams. Both individuals were detected for only one day and did not exhibit territorial behavior, suggesting they were migrants. The first individual was detected along the Gila River in Yuma in May 2005. It was identified by the presence of a single anodized federal band as having been banded as a nestling at one of the Reclamation study areas in either 2003 or 2004. In June 2011, a fully banded flycatcher was detected in PVER 2, one of the Reclamation habitat creation sites along the LCR. While the identity of the individual could not be confirmed by repeated observations, it was very likely banded in southern Nevada. This was the first confirmed sighting of a Southwestern Willow Flycatcher in one of the habitat creation sites south of the Bill Williams. Although the bird was likely a migrant, this detection demonstrates the importance of the habitat creation sites as stopover habitat for migrating Southwestern Willow Flycatchers. Flycatchers from breeding areas along the lower Colorado River and its tributaries may also provide a potential source population for the colonization of habitat creation sites.

Determination of Site Occupancy

In each annual report, per Reclamation instructions, we have classified areas where flycatchers were detected after 15 June as "occupied," regardless of flycatcher behavior or residency. The current survey protocol (Sogge et al. 2010) recommends using 24 June as a guideline for determining occupancy. From 2003 to 2012, many flycatchers were detected in sites where no resident flycatchers were recorded. The number of flycatcher detections in these sites after the occupancy cut-off date varied drastically by the date used. Of the 2,571 total flycatcher detections, 94 were detected after 15 June but only 4 were detected after 24 June. These four detections were all recorded in July in 2003 to 2006. Of the four, three individuals were heard spontaneously singing or were responsive to playback. None of these individuals were detected in the same location for more than one week, and residency could not be confirmed for any of them. None of the flycatchers observed after 15 June exhibited territorial behavior, and it is likely that they were all migrants. The previous guideline of using 15 June as a cut-off for establishing site occupancy resulted in many sites being misclassified as occupied due to the detection of late migrants. The currently recommended guideline of 24 June (Sogge et al. 2010) reduces misclassification, and we recommend use of this guideline in future studies.

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Chapter 3

COLOR-BANDING, RESIGHTING, AND DEMOGRAPHICS

INTRODUCTION

Long-term monitoring of willow flycatchers of known identity, gender, 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, as many willow flycatchers as possible were captured and uniquely color-banded during each year from 2003 to 2012, allowing field personnel to resight individuals throughout each 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 technique allowed field personnel to detect and monitor individuals without recapturing each bird. These studies built upon color-banding initiated at Reclamation sites in 1997 (McKernan and Braden 1998).

Color-banding studies were also conducted at NDOW study areas from 2010 to 2012. Studies at Key Pittman WMA built upon opportunistic color-banding and resighting efforts that were initiated in 2004 in cooperation with NDOW. In addition, opportunistic color-banding and resighting efforts were conducted at St. George, Utah, in cooperation with the Utah Division of Wildlife Resources (UDWR) from 2008 to 2011. In 2008, we also opportunistically banded in Las Vegas Wash in cooperation with Southern Nevada Water Authority.

From 2003 to 2007, we conducted color-banding studies from 10 to 30 June along the extreme southern stretches of the lower Colorado River downstream of Parker Dam. Results from these studies are summarized in McLeod et al. (2008a) and are not presented here.

METHODS

Color-Banding

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 CD 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 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.

In 1997, each nestling, fledgling, and adult willow flycatcher was banded with a numbered U.S. federal aluminum band (hereafter federal band) and a celluloid-plastic color-band (hereafter plastic color-band) on one leg and a plastic color-band on the other leg. From 1998 to 2002, flycatchers were banded with a federal band (either standard issue silver or colored epoxy-enamel) on one leg and a plastic color-band on the other.

Plastic leg bands undergo fading and discoloration to such a degree that within two years primary colors cannot be recognized under field conditions (Lindsey et al. 1995). In addition, plastic bands may deteriorate; we recaptured and resighted returning individuals that had lost one or more plastic bands, likely due to the bands becoming brittle and breaking apart with age. We also found that chipping of the enamel on the colored epoxy-enamel federal bands revealed the underlying silver band color, causing difficulties in correct color identification through binoculars. To remedy these problems, from 2003 to 2007 we banded each newly captured adult and fledged willow flycatcher with a federal band on one leg (either standard issue silver or color-anodized) and a metal, pin-striped color-band (hereafter metal color-band) on the other. These metal color-bands have been shown to be safe for willow flycatchers and colorfast for over six years (Koronkiewicz et al. 2005) and were also used on recaptured flycatchers that wore faded and indistinguishable color-bands. Nestlings were banded with only an anodized federal band, identifying each bird as a returning nestling in the event it returned in a subsequent year but requiring recapture of a returning nestling to identify it to individual.

We found that we were unable to capture and identify all returning nestlings due to either a brief window of detection or difficulty with recapture due to dense vegetation. To remedy this, from 2008 to 2012 we banded each nestling with a federal band (either standard issue silver or color-anodized) on one leg and a metal color-band on the other.

Nestlings were banded at 8 to 10 days of age, when they were large enough to retain 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 accessing the nest and removing and replacing the nestlings would not endanger the nest, nest plant, or nestlings.

For each captured adult willow flycatcher, we recorded morphological measurements, including culmen, tail, wing, fat level, and molt onto standardized data forms. Gender was determined based on the presence of a cloacal protuberance in males or brood patch and/or egg(s) in the oviduct for 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 second-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

Identity of leg-banded flycatchers was determined by observing with binoculars, from a distance, unique color-band combinations. 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. From 2003 to 2012, all field personnel coordinated their resighting efforts and recorded observations of color-banded and unbanded flycatchers onto standardized data forms. 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 one 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.

Inactive territories were visited at least three times (each visit four days apart) before territory visits stopped. 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 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.

Gender Determination

For all analyses involving gender as a factor or covariate, gender was determined through behavioral observations, morphological data, and/or molecular sexing techniques. Blood samples were collected from captured adult and nestling flycatchers from 2004 to 2012. One to two drops of blood were collected via toe-nail clipping and were washed into a vial with blood buffer (100mM TRIS HCl, 50mM EDTA pH 8.0, 100mM NaCl, and 2% SDS). Vials were kept cool until they could be frozen (-20°C) at the end of the field day.

DNA was isolated from the blood of 565 individuals (167 adults and 398 nestlings) using a QIAGEN DNeasy Blood & Tissue kit. Resulting DNA concentrations ranged from 1.2 to 35.5 ng/µL. Gender of each individual was determined using the molecular sexing technique of Fridolfsson and Ellegren (1999). This technique relies on the presence of the CHD-gene on the female sex-linked chromosome and non-sex-linked chromosome. When the polymerase chain reaction (PCR) amplicon is run on an electrophoresis gel, females have two different sized bands, while males only have one band. To verify the accuracy of this technique, we tested 83 individuals of known gender (as determined in the field through behavioral observations or morphological characteristics such as brood patch). We observed a 1% discrepancy between the field and molecular sexing techniques, which was determined to be the result of a field sexing error. All samples with ambiguous results were re-run. PCR consisted of a 5 µL reaction volume with ≤3.6 ng/µL of DNA, 1X KAPA Buffer A, 200nM dNTPs, 2mM $MgCl_2$, 0.25 µM of each primer (2550F and 2718R; Fridolfsson and Ellegren 1999), 0.025 U/µL KAPA 2G Robust polymerase, and 0.2% KAPA enhancer A. Reactions were run with 50 cycles of 30 seconds at 90°C, 45 seconds at 50°C, and 1.5 minutes at 72°C. PCR products were run on a 1% agarose gel, stained with SYBR Safe, and scored manually to determine gender. Because of potential amplification problems wherein the CHD-gene on the female sex-linked chromosome fails to amplify, we confirmed male samples using the methods described above but with different primers (P2 and P8; Griffiths et al. 1998). PCR products resulting from these reactions were run on a 2% agarose gel and manually scored. No discrepancies in results from the two primers were noted.

We used the results from the genetic analysis to calculate the primary, secondary, and tertiary gender ratios by geographic area (Pahranagat Valley, Virgin Valley, and Havasu; see Demographics below). Primary gender ratio was calculated using all nests where every egg hatched and the gender was known for every nestling. Secondary gender ratio was calculated using all nests where the gender was known for every nestling, but not all eggs in the original clutch hatched. Tertiary gender ratio was calculated using all nests where the gender of all fledglings was known, excluding all nests used in the primary and

secondary ratio data sets. We used a chi-square test in R 2.15.1 to determine if gender ratio differed among the three ratio types. We used the "binomdist" function in MS Excel to determine the probability of obtaining the observed number of females out of the total, given a 50:50 ratio. Only individuals from nests where at least one nestling was blood sampled were included in the analysis to reduce bias from any gender-specific juvenile return rates.

Data Analyses

Movement

We used detections of individual flycatchers over all years of the study (1997–2012) to examine patterns of adult between-year movements and juvenile dispersal. UTM coordinates were not available for detections prior to 2003, so analyses incorporating distance were restricted to detections from 2003 to 2012. All movement analyses incorporating distance were analyzed in R 2.15.1 (R Development Core Team 2008). All between-year movement distances are the straight-line distance between the last known location in a given year (year t) and the first known location 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. Data were non-normal and heavily skewed. We examined the effects of drainage, gender, and age on distance moved using a Kruskal-Wallis test.

We analyzed between-year adult movement following methods used for flycatchers in central Arizona (Paxton et al. 2007). Per Paxton et al. (2007), we defined a patch as a distinct patch of riparian vegetation occupied by flycatchers and separated from other riparian vegetation by non-riparian habitat. In cases where we knew clusters of territories existed within a large, contiguous area of riparian habitat, we projected the territory locations onto aerial photographs using ArcMap 10.0 (ESRI, Inc.) and used the distribution of territory clusters to define the breeding patch. In general, distinct territory clusters separated by more than 500 m of unsuitable or unoccupied habitat were considered separate patches. A patch could contain more than one territory cluster. Some territory clusters were separated by both a spatial and temporal component. The temporal component was ignored, and the previously described rules were applied.

Per Paxton et al. (2007), we defined the following types of between-year movement: territory fidelity (movement of <50 m), patch fidelity (movement of >50 m within the same breeding patch), between-patch movement (but still within drainage), and between-drainage movement. We evaluated the effect of drainage and gender on the proportions of between-year movement behaviors using a Pearson's chi-square test (χ^2). We used logistic regression with backward, stepwise elimination in SPSS® Version 16.0 to determine the effects of breeding failure, parasitism, gender, and the interactions of gender with breeding failure and parasitism on the likelihood of territory fidelity and of returning to the same patch. A *P*-value of 0.10 was used to determine which variables to retain in the model. Breeding failure was defined as the failure to produce at least one fledgling in that season. Individuals for which no nesting attempt could be confirmed were assumed not to have produced any fledglings in that year. An individual was considered parasitized during a given season if a cowbird egg was documented in at least one nest during that season. Nests with unknown parasitism status were assumed not to have been parasitized.

Within-season movements were summarized for all individuals who moved between study areas, as defined in Chapter 2, within a given breeding season. We did not compare within-season movements recorded in this study to those presented in Paxton et al. (2007). Paxton et al. (2007) employed intensive passive netting to detect non-breeding resident flycatchers within their study sites. We did not and were consequently less likely to detect mobile, non-breeding residents. We also did not consistently track movements of males within a patch if they were not breeding.

Demographics

Age Structure – We determined the maximum age (age of individual when last detected) of all adults detected within the project area from 1999 to 2010, regardless of residency status. Adults first marked in the first two years of the study (1997 and 1998) were excluded due to the probability that age would be underestimated. We also excluded flycatchers whose minimum age at the end of the study in 2012 was ≤3 because of the likelihood that they had not yet reached their maximum age. We summarized age distributions by geographic area. Individuals detected in more than one geographic area were excluded. Adults fell into two categories: those of known age and those of minimum age. Known-age individuals include returning juveniles and adults first marked as known second-year (SY) individuals (retained juvenile feathers noted at time of banding). Minimum-age individuals are those that were first marked as adults, but no retained feathers were noted at time of banding. These individuals are denoted as after hatch year (AHY); they are at least two years old but could be older. We used a Fisher's exact test in R to determine if the distributions between known-age and minimum-age individuals differed within gender and geographic area (i.e., Pahranagat Valley females, Pahranagat Valley males, etc.), which would indicate that many AHY individuals were older than two years old. No significant differences were found in any of the comparisons, and known-age and minimum-age individuals were pooled into combined age classes (AHY with SY, after third-year [A3Y] with third-year [3Y], and so on). We also calculated mean life expectancy (MLE) estimates as described in Brownie et al. (1985) using adult and juvenile survival probability estimates generated from the models described above.

Adult and Juvenile Survival and Detection Probabilities – Survival (Φ) and detection (p) probabilities for individuals banded and resighted at all study areas were estimated using program MARK 6.1 (White and Burnham 1999). We did not have an adequate sample size to estimate survival and detection separately by study area, so we created separate encounter histories for three geographic regions: Pahranagat Valley (Pahranagat NWR, River Ranch, Key Pittman WMA), Virgin River Valley (St. George, Littlefield, Mesquite, Mormon Mesa, Muddy River, Warm Springs, Grand Canyon), and Havasu (Topock and Bill Williams). Every individual detected in each region and not suspected to be a migrant was included in each encounter history. Individuals were suspected to be migrants if they were detected for a single day prior to 15 June or after15 July, or if they had coloration inconsistent with *E. t. extimus* (e.g., a dark tip on the lower mandible).

Each individual was grouped by age at marking as either adult or juvenile. Gender for each individual, determined through behavioral and morphological data as well as genetic testing, was added as an individual covariate, with males coded as 1, females as -1, and individuals of unknown gender as 0. Our candidate model set (Table 3.1) was determined *a priori*. We modeled the effect of age (juvenile versus adult), gender, the interaction of age with gender, and the additive effect of year (for both juveniles and adults) on survival probabilities. For detection probabilities, we modeled the effects of age (second-year versus all other adults), gender, contract time period (TP), and the interactions of age with gender as well as of age with TP. We chose to model the effect of TP because marking techniques varied between contract periods and effort may have varied. For individuals marked as adults, we examined the effect of the first TP (1997–2002; adults marked with epoxy-enameled federal bands and plastic color-bands) versus the following two periods combined (2003–2012; adults marked with anodized federal bands and metal color-bands). For individuals marked as juveniles, we examined the effect of each TP on detection probability (1997–2002, juveniles marked with epoxy-enameled federal bands; 2003–2008, juveniles marked with anodized federal bands but no color-band; 2009–2012, juveniles marked with anodized federal bands and metal color-bands). The time periods modeled differ slightly from the contract periods due to the one-year lag between marking and detection of returning individuals.

Table 3.1. Candidate Model Set for Evaluating the Effect of Age (a2), Gender (G), and Year (t/t) on Survival Probability and of Age, Gender, and Contract Time Period (TP) on Detection Probability*

Survival (Φ)	Detection (p)	# Parameters
a2*G+t/t	a2*TP+a2*G	25
	a2*TP	23
	a2*G	22
	TP+G	22
G+t/t	a2*TP+a2*G	23
	a2*TP	21
	a2*G	20
	TP+G	20
a2*G	a2*TP+a2*G	11
	a2*TP	9
	a2*G	8
	TP+G	8
a2	a2*TP+a2*G	9
	a2*TP	7
	a2*G	6
	TP+G	6

*a2 for survival indicates that juvenile survival was allowed to differ from that for adults; a2 for detection indicates that the detection probability of second-year individuals was allowed to differ from that for all other adults. Interaction effects are denoted with an asterisk, while additive effects are denoted with a plus sign The main effect term 't/t' indicates that survival was allowed to vary by year for both returning juvenile and adult flycatchers and was allowed to vary differently for returning juveniles versus adults.

We used both bootstrap and median c-hat procedures to test goodness of fit (GOF) of general models. GOF tests were run for all three geographic areas using the most general model that did not include the individual covariate of gender. For the Pahranagat and Virgin Valleys, we used: Φ(a2+t/t) p(a2*TP). In the Havasu area, initial GOF testing indicated that the data were too sparse for this model (c-hat > 3). We therefore chose a less parameterized model that was time-constant for phi: Φ(a2) p(a2*TP). For bootstrap GOF, we used 500 simulations to generate a distribution of expected deviances. The variance inflation factor (c-hat) was then calculated by dividing the observed deviance by the mean expected deviance. For median c-hat GOF, we used the default upper bound (4.7–5.0), with 10 intermediate points and 100 repetitions per point. We ran the test five times per drainage and averaged the resulting c-hat estimates to generate the final c-hat estimate. C-hat values between 1 and 3 indicate slight overdispersion but an acceptable fit of the general model (Lebreton et al. 1992).

We used Akaike Information Criteria (AICc) to select among competing models (Burnham and Anderson 2002). The most supported model in a candidate set is the one with the lowest AICc score. Support for other models in the candidate set is based on the difference between their AICc scores and that of the top model (ΔAICc). All models with a ΔAICc of <2 are considered to have strong support, while models with ΔAICc of 2–7 have some support. In addition to AICc scores, we also used the ratio of the normalized Akaike weights between models to quantify the relative likelihood of a model compared to other models. We considered the entire candidate model set for all model selection. Where ΔAICc indicated support for more than one model (i.e., ΔAICc < 7), we model averaged across the entire candidate model set to obtain parameter estimates.

Juvenile Survival by Fledge Date – We also examined the influence of fledge date on juvenile survival. All juveniles were included in one input file and geographic region (as defined above) was included as a group. We included Julian fledge date as an individual covariate. Detection probability was modeled with the effect of drainage and TP (as defined for juveniles above). Our general model included the effects of drainage, age, and their interaction on survival probability and the effects of drainage and TP on detection probability. We modeled the additive effect of fledge date on survival.

Annual Per Capita Rate of Population Growth – We calculated lambda (λ), the annual per capita growth rate of the population, for each geographic area using the following equation: λ = adult survivorship + (juvenile survivorship x seasonal fecundity/2) + immigration (Pulliam 1988). Lambda values at 1.0 suggest a stable population, >1.0 a growing population, and <1.0 a declining population. Adult and juvenile survival estimates were generated from the models described above. The top model in each geographic area was identified, and survival estimates were obtained from the equivalent model that did not include gender as an effect on survival. Seasonal fecundity for each geographic region was obtained from our nest monitoring efforts (see Chapter 4). To calculate immigration, we used Pradel models in program MARK, which use the number of newly marked adults to estimate total annual recruitment (f) into the population. We then subtracted local recruitment (juvenile survivorship x seasonal fecundity/2) from total annual recruitment to obtain annual estimates for immigration. All estimates of survival, fecundity, and immigration were entered into the equation above to obtain annual estimates of λ. We averaged these annual estimates of λ to obtain the overall annual rate of population change over the period of study.

Pradel models require a constant study area size to estimate recruitment accurately because increases or decreases in study area size mimic large-scale immigration or emigration events. To maintain a constant study area, immigration estimates were generated for the entire Pahranagat Valley for 2010–2012, the Virgin Valley for 1997–2012 (excluding St. George and Warm Springs), and the Havasu region for 1997–2012. The candidate model set for this analysis included all combinations of survival probability, detection probability, and recruitment rate all either constant or varying with time. Time was modeled as the effect of year for survival probability and recruitment rate and as TP for detection probability. We did not include TP in the models for the Pahranagat Valley because the data did not span multiple TPs, and detection probability was modeled only as constant. Currently no GOF tests exist for Pradel models in program MARK and we assumed a c-hat of 1.0 for all model sets. We used AICc to select among competing models as described above.

Population trends were also calculated for each geographic area for comparison with λ estimates. To ensure that the number of resident adults recorded in each year was not biased by changes in study area size or effort, we limited analysis to Pahranagat NWR in 1998–2012, the Virgin Valley (excluding Warm Springs and St. George) from 2000 to 2012, and the Havasu area (Topock Marsh and Bill Williams) from 1997 to 2012. Formal monitoring efforts at Pahranagat did not begin until 1998. In the Virgin Valley, the breeding site at Mesquite West was not discovered until 2000 but may have been occupied prior to that year. We used a three-year moving average of the number of resident adults in each geographic area to calculate average annual rate of change. For the trend line, we applied a linear regression in MS Excel to the number of resident adults on the natural log scale and used the slope of the regression line to calculate the average annual percent change in population size.

Recruitment

We defined recruitment as the return of any fledgling in a subsequent year, regardless of its breeding status. We analyzed data from all successful nests from 2003 to 2011 in which at least one fledgling was banded and could be tracked for return. Data from earlier years were excluded due to lack of covariate data for use in hypothesis testing. Successful nests were categorized as either: ‘recruitment’ (≥1 fledge survived and was identified in a subsequent year) or ‘no recruitment’ (no fledges were seen in any

subsequent year). To determine if patterns of recruitment were associated with individual females, we also determined the number of successful nests per banded female and calculated how many of those nests produced a recruit. We used a nominal logistic regression in JMP 10 (SAS Institute 2012) with backward conditional selection to determine which nest attributes were associated with juvenile recruitment. The cutoff for an effect being retained in the model was $P \leq 0.1$. We selected several factors *a priori* that we thought might affect the likelihood of recruitment: geographic area, distance to water (from the nest when the nest was found), parasitism (whether the nest was parasitized), breeding status (whether the parents were part of a monogamous or polygamous mating), number of banded fledglings, and fledge date. For analyses that included distance to water, all nest locations for which distance to water had not been recorded were excluded. In 2004 and 2005, any distance to water over 30 m was recorded as "30+". We estimated distance to water in these cases whenever sufficient information on hydrology within the site was available; otherwise, these nests were excluded. We used an ordinal logistic regression to determine which of these same factors were associated with the total number of recruits per nest.

We also used a Hot Spot analysis in ArcMap 10.0 to determine the spatial location of areas that produced significantly higher numbers of recruiting fledglings. Z-scores were calculated from the raw number of recruiting fledglings per successful nest. Due to limited sample size, we were only able to run the analysis for data from Pahranagat North, Mesquite West, and Mormon Mesa Virgin River #1 South. Because of the abrupt shift in hydrology at Pahranagat North in 2008 (see Chapter 2), we ran the analysis for Pahranagat North from 2003–2007 and compared those results to results obtained using data from 2008 to 2011. All Hot Spot analyses were run using the Inverse Distance and Euclidean Distance options for spatial conceptualization. We also specified threshold distances for each area: 100 m at Pahranagat North and 50 m at both Mesquite West and Mormon Mesa. These distances were based on knowledge of hydrology within each site and how rapidly hydrology changes across the landscape (dry to inundated). Following this analysis, we used Inverse Distance Weighted interpolation, with an exponent distance variable of 5, to create a surface representing the z-scores of each nest in the analysis.

RESULTS

Reclamation Study Areas

Color-Banding and Resighting – The number of flycatchers banded and resighted at each Reclamation study area in 2003–2012 is summarized in Table 3.2. This table includes all flycatchers detected, including individuals for which residency and/or breeding status was undetermined. For details of the status of individuals detected, please refer to the annual reports (Koronkiewicz et al. 2004, 2006a; McLeod et al. 2005, 2007, 2008b; McLeod and Koronkiewicz 2009, 2010; McLeod and Pellegrini 2011, 2012, 2013). From 2003 to 2012, field personnel captured 252 new adult flycatchers and banded 555 nestlings from 240 nests. Of these nestlings, 41 were known or suspected to have died before fledging. We captured an additional 18 fledglings that were not banded as nestlings. For details on all banded flycatchers detected at the study areas from 2003 to 2012, see Appendix G.

The number of resident flycatchers detected at each Reclamation study area in 2003–2012 is shown in Table 3.3. This table eliminates all flycatchers for which residency could not be confirmed. The overall percentages of resident, adult flycatchers at the monitored study areas that were banded by the end of each season increased from 2003 to 2005 and stayed stable between 2005 and 2012, ranging from 75% to 86% in 2005–2012.

Table 3.2. Willow Flycatchers Detected at Reclamation Study Areas Where Resident Flycatchers Were Observed, 2003–2012*

Study Area	Year	Adults									Juveniles				
		Total Adults Detected	New Captured	Recaptured	Resighted					% of All Adults Banded	Confirmed Fledglings (# nests)[1]	Nestlings Banded (# nests)	Fledglings Captured[2]	Unbanded Fledglings (# nests)	% of All Fledglings Banded
					Color combination confirmed		Banded (color combinations unconfirmed)	Unbanded	Band Status Undetermined						
					Individual Identified	Individual Not Identified									
Pahranagat	2003	21	6	4	1	1[3]	0	6	3	57	24(10)	22(7)	0	5(3)	79
	2004	35	18	9	0	0	3	4	1	86	35(13)	25(10)	5	8(4)	77
	2005	37	14	14	7	1[4]	0	1	0	97	33(11)	21(7)	7	5(4)	85
	2006	36	4	13	16	0	0	2	1	92	24(9)	18(7)	3	5(3)	79
	2007	29	6	8	12	0	0	3	0	90	23(8)	19(7)	1	5(2)	78
	2008	26	3	3	16	0	2	1	1	96	21(8)	19(6)	0	4(2)	81
	2009	24	5	6	11	0	0	0	2	92	22(8)	11(5)	0	13(4)	41
	2010	24	2	1	16	1[5]	0	3	1	83	26(10)	20(7)	0	8(3)	69
	2011	21	4	3	10	0	1	3	0	86	17(7)	11(4)	1	6(3)	65
	2012	22	2	5	13	0	1	1	0	95	23(10)	14(6)	0	9(4)	61
Littlefield	2004	3	1	2	0	0	0	0	0	100	2(1)	2(1)	0	0	100
	2005	2	0	0	1	0	0	0	1	50	--	--	--	--	--
	2007	1	0	1	0	0	0	0	0	100	--	--	--	--	--
	2008	1	0	0	0	0	0	1	0	0	--	--	--	--	--
	2009	5	1	0	1	0	0	1	2	40	0	0	--	--	--
	2010	4	1	0	1	0	0	2	0	50	3(1)	3(1)	0	0	100
Mesquite	2003	38	5	14	5	0	3	7	4	71	17(8)	18(8)	0	2(1)	88
	2004	30	7	9	10	0	2	2	0	93	11(4)	12(5)	0	0	100
	2005	19	4	3	9	1[6]	2	0	0	100	6(5)	13(7)	0	0	100
	2006	28	3	4	11	1[7]	1	4	4	71	23(11)	24(11)	0	0	100
	2007	27	3	5	12	4[4,7,8]	0	2	1	89	15(8)	14(7)	0	3(1)	80
	2008	27	1	2	15	2[4,7]	0	3	4	74	18(9)	20(8)	0	1(1)	94
	2009	28	0	2	13	2[5,7]	3	8	0	71	3(3)	4(4)	0	0	100
	2010	18	4	2	5	0	2	4	1	72	7(4)	9(5)	0	0	100
	2011	14	3	0	6	0	0	3	2	64	3(2)	5(2)	0	0	100
	2012	16	0	0	5	1[5]	2	4	4	50	0	0	--	--	--
Mormon Mesa	2003	19	2	1	1	1[3]	0	10	3	32	0	1(1)	--	--	--
	2004	27	11	1	2	0	1	6	6	56	6(3)	8(4)	0	0	100
	2005	14	1	3	3	2[4]	1	3	1	71	1(1)	2(1)	0	1(1)	0
	2006	23	5	3	8	1[4]	1	5	0	78	8(4)	7(3)	0	1(1)	88
	2007	30	5	2	16	2[4]	2	1	2	90	3(3)	4(3)	0	0	100
	2008	30	4	3	13	3[4]	0	6	1	77	19(8)	23(9)	0	0	100
	2009	33	2	1	21	1[4]	4	4	0	89	22(9)	22(9)	0	3(3)	86
	2010	32	1	2	17	4[4,7]	3	1	4	84	12(5)	9(4)	0	3(1)	75
	2011	26	1	6	9	1[4]	1	8	0	69	16(7)	16(7)	0	3(3)	81
	2012	27	7	1	13	1[4]	1	4	0	86	9(5)	9(5)	0	0	100
Muddy River	2004	4	1	0	0	0	0	0	3	25	--	--	--	--	--
	2005	12	4	1	1	3[4]	0	3	0	75	3(3)	4(2)	1	0	100
	2006	11	2	4	3	1[4]	0	1	0	91	7(4)	8(4)	0	0	100
	2007	16	4	5	3	2[4]	0	1	1	88	0	0	--	--	--
	2008	11	2	2	2	1[4]	1	3	0	73	3(2)	3(1)	0	1(1)	67
	2009	17	2	0	4	2[4]	1	7	1	53	0	1(1)	--	--	--
	2010	14	2	1	5	0	2	4	0	71	7(3)	5(2)	0	2(1)	71
	2011	16	3	4	4	0	0	4	1	69	0	4(2)	--	--	--
	2012	19	2	1	5	0	0	6	5	42	3(1)	3(1)	0	0	100

Table 3.2. Willow Flycatchers Detected at Reclamation Study Areas Where Resident Flycatchers Were Observed, 2003–2012* (Continued)

Study Area	Year	Adults									Juveniles				
		Total Adults Detected	New Captured	Recaptured	Resighted					% of All Adults Banded	Confirmed Fledglings (# nests)[1]	Nestlings Banded (# nests)	Fledglings Captured[2]	Unbanded Fledglings (# nests)	% of All Fledglings Banded
					Color combination confirmed		Banded (color combinations unconfirmed)	Unbanded	Band Status Undetermined						
					Individual Identified	Individual Not Identified									
Grand Canyon	2003	1	0	0	0	0	0	0	1	0	--	--	--	--	--
	2004	3	2	0	0	0	0	1	0	67	0	3(1)	--	--	--
	2005	1	1	0	0	0	0	0	0	100	--	--	--	--	--
	2006	15	10	1	0	0	0	2	2	73	0	0	--	--	--
	2007	7	4	0	2	0	0	0	1	86	0	0	--	--	--
	2008	1	1	0	0	0	0	0	0	100	--	--	--	--	--
Topock	2003	25	7	1	2	1[3]	2	8	4	52	15(8)	16(6)	0	4(2)	73
	2004	67	16	2	9	2[4]	0	24	14	43	25(17)	32(15)	0	4(3)	84
	2005	41	2	4	11	2[4]	2	16	4	51	13(8)	13(7)	0	1(1)	92
	2006	37	3	1	4	8[4]	0	16	5	43	5(4)	6(4)	0	3(2)	40
	2007	31	4	2	2	2[4]	1	8	12	35	12(6)	15(6)	0	0	100
	2008	30	3	0	4	5[4]	0	9	9	40	1(1)	3(2)	0	0	100
	2009	28	1	2	2	2[4]	2	7	12	32	3(1)	3(1)	0	0	100
	2010	28	3	2	3	1[4]	1	8	10	36	2(1)	3(1)	0	0	100
	2011	33	2	1	1	0	1	9	19	15	0	0	--	--	--
	2012	16	1	1	0	0	0	6	8	13	--	--	--	--	--
Bill Williams	2003	13	6	0	0	0	0	4	3	46	3(2)	6(2)	0	0	100
	2004	24	1	0	1	0	0	6	16	8	--	--	--	--	--
	2005	9	5	0	0	0	0	3	1	56	5(2)	3(1)	0	3(1)	40
	2006	9	1	0	2	0	1	3	2	44	2(1)	0	0	2(1)	0
	2007	21	4	1	3	2[4]	0	7	4	48	3(2)	3(2)	0	1(1)	67
	2008	8	4	0	1	0	1	1	1	75	4(2)	6(3)	0	0	100
	2009	15	6	0	3	0	0	4	2	60	6(2)	3(1)	0	3(1)	50
	2010	14	4	0	3	0	0	6	1	50	2(2)	3(2)	0	0	100
	2011	17	2	0	4	0	0	3	8	35	4(2)	4(2)	0	0	100
	2012	29	1	0	1	0	0	9	18	7	0	0	--	--	--
Ahakhav	2008	2	0	0	0	0	0	1	1	0	--	--	--	--	--
All Study Areas[9]	2003	116	26	20	9	3	5	35	18	54	59(28)	63(24)	0	11(6)	81
	2004	193	57	23	22	2	6	43	40	57	79(38)	82(36)	5	12(7)	85
	2005	133	31	25	30	9	5	26	7	75	61(30)	56(25)	8	10(7)	84
	2006	156	28	25	42	11	3	33	14	70	69(33)	63(29)	3	11(7)	84
	2007	158	30	23	47	12	3	22	21	73	56(27)	55(25)	1	9(4)	84
	2008	135	18	10	50	11	4	25	17	69	66(30)	74(29)	0	6(4)	91
	2009	150	17	11	55	7	10	31	19	67	56(23)	44(21)	0	19(8)	66
	2010	134	17	8	50	6	8	28	17	66	59(26)	52(22)	0	13(5)	78
	2011	124	15	14	31	1	3	30	30	52	40(18)	40(17)	1	9(6)	78
	2012	127	13	8	35	2	4	30	35	49	35(16)	26(12)	0	9(4)	74

* 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 adults detected and percent of all adults banded. Juveniles are identified as banded in the nest, banded as fledglings, or unbanded. The percent of all fledglings banded is included.

[1] Number of confirmed fledges is not equal to the sum of banded nestlings, banded fledges, and unbanded fledges. Some banded nestlings were not confirmed as fledges.

[2] Previously unbanded.

[3] Single federal band; identity unknown.

[4] Returning nestling(s) banded with single federal band.

[5] One individual had a duplicate color combination.

[6] Bird had federal band only; left leg was missing below the intertarsal joint.

[7] One individual had a silver federal band only and a visible injury on the unbanded left leg; a male with silver federal band number 2390-92434 and a visible injury on the unbanded left leg was captured at Mesquite in 2005, and this is likely the same individual. This male was recaptured and rebanded in 2011 at Mormon Mesa.

[8] One individual had a single half plastic band on the left leg and a silver federal band on the right.

[9] Several within-season, between study area movements were detected from 2003 to 2012. Individuals who moved are only tallied once in the total.

Table 3.3. Resident Adult Willow Flycatchers Detected at Reclamation Study Areas Where Resident Flycatchers Were Observed, 2003–2012*

Study Area	Year	Total Adults Detected	New Captured	Recaptured	Resighted					% of All Resident Adults Banded
					Color combination confirmed		Banded (color combinations unconfirmed)	Unbanded	Band Status Undetermined	
					Individual Identified	Individual Not Identified				
Pahranagat	2003	20	6	4	1	1[1]	0	6	2	60
	2004	29	16	8	0	0	1	3	1	86
	2005	31	10	13	7	1[2]	0	0	0	100
	2006	34	4	13	16	0	0	0	1	97
	2007	22	2	8	12	0	0	0	0	100
	2008	24	3	3	16	0	1	0	1	96
	2009	21	3	6	11	0	0	0	1	95
	2010	23	2	1	16	1[3]	0	3	0	87
	2011	14	2	3	9	0	0	0	0	100
	2012	22	2	5	13	0	1	1	0	95
Littlefield	2004	3	1	2	0	0	0	0	0	100
	2005	0	0	0	0	0	0	0	0	--
	2007	1	0	1	0	0	0	0	0	100
	2008	0	0	0	0	0	0	0	0	--
	2009	4	1	0	1	0	0	1	1	50
	2010	3	1	0	1	0	0	1	0	67
Mesquite	2003	30	3	10	5	0	3	6	3	70
	2004	28	6	9	10	0	2	1	0	96
	2005	19	4	3	9	1[4]	2	0	0	100
	2006	27	3	4	10	1[5]	1	4	4	70
	2007	26	3	4	12	4[2,5,6]	0	2	1	88
	2008	24	1	1	15	2[2,5]	0	3	2	79
	2009	25	0	2	12	2[3,5]	2	7	0	72
	2010	17	4	2	5	0	2	4	0	76
	2011	14	3	0	6	0	0	3	2	64
	2012	8	0	0	4	1	0	3	0	63
Mormon Mesa	2003	17	2	1	1	1[1]	0	8	3	29
	2004	14	7	0	2	0	0	2	3	64
	2005	13	1	3	3	2[2]	1	3	0	77
	2006	20	5	3	7	1[2]	1	3	0	85
	2007	24	5	2	14	2[2]	0	1	0	96
	2008	26	4	2	13	2[2]	0	5	0	81

Table 3.3. Resident Adult Willow Flycatchers Detected at Reclamation Study Areas Where Resident Flycatchers Were Observed, 2003–2012* (Continued)

Study Area	Year	Total Adults Detected	New Captured	Recaptured	Resighted					% of All Resident Adults Banded
					Color combination confirmed		Banded (color combinations unconfirmed)	Unbanded	Band Status Undetermined	
					Individual Identified	Individual Not Identified				
Mormon Mesa	2009	27	2	1	19	1[2]	1	3	0	89
	2010	25	1	2	15	4[2,5]	2	0	1	96
	2011	23	1	5	9	1[2]	1	6	0	74
	2012	24	7	1	12	1[2]	0	3	0	88
Muddy River	2004	1	1	0	0	0	0	0	0	100
	2005	11	3	1	1	3[2]	0	3	0	73
	2006	11	2	4	3	1[2]	0	1	0	91
	2007	15	4	5	3	2[2]	0	1	0	93
	2008	8	1	2	1	1[2]	1	2	0	75
	2009	13	2	0	4	2[2]	0	5	0	62
	2010	12	2	1	4	0	1	4	0	67
	2011	13	3	4	3	0	0	3	0	77
	2012	13	2	0	5	0	0	6	0	54
Grand Canyon	2004	3	2	0	0	0	0	1	0	67
	2005	1	1	0	0	0	0	0	0	100
	2006	11	7	1	0	0	0	2	1	73
	2007	4	2	0	2	0	0	0	0	100
	2008	1	1	0	0	0	0	0	0	100
Topock	2003	20	7	1	2	1[1]	2	7	0	65
	2004	57	14	2	9	2[2]	0	21	9	47
	2005	36	2	4	11	2[2]	2	15	0	58
	2006	29	3	1	4	8[2]	0	12	1	55
	2007	18	4	2	2	2[2]	1	6	1	61
	2008	20	3	0	4	5[2]	0	7	1	60
	2009	14	1	2	2	2[2]	0	5	2	50
	2010	12	3	2	3	1[2]	0	2	1	75
	2011	5	1	1	1	0	1	0	1	80
	2012	2	0	1	0	0	0	0	1	50

Table 3.3. Resident Adult Willow Flycatchers Detected at Reclamation Study Areas Where Resident Flycatchers Were Observed, 2003–2012* (Continued)

Study Area	Year	Total Adults Detected	New Captured	Recaptured	Resighted					% of All Resident Adults Banded
					Color combination confirmed		Banded (color combinations unconfirmed)	Unbanded	Band Status Undetermined	
					Individual Identified	Individual Not Identified				
Bill Williams	2003	10	6	0	0	0	0	3	1	60
	2004	3	1	0	1	0	0	0	1	67
	2005	6	5	0	0	0	0	1	0	83
	2006	4	1	0	2	0	0	1	0	75
	2007	13	4	1	3	0	0	5	0	62
	2008	7	4	0	1	0	1	1	0	86
	2009	13	6	0	3	0	0	4	0	69
	2010	8	3	0	3	0	0	2	0	75
	2011	8	2	0	4	0	0	1	1	75
	2012	4	0	0	1	0	0	2	1	25
Ahakhav	2008	1	0	0	0	0	0	1	0	0
All Study Areas[7]	2003	97	23	16	10	3	5	30	10	59
	2004	138	49	21	21	2	3	28	14	70
	2005	115	26	24	29	9	5	22	0	81
	2006	133	25	25	40	11	0	25	7	76
	2007	119	24	22	45	10	1	15	2	86
	2008	110	17	8	49	10	3	19	4	79
	2009	117	15	11	52	7	3	25	4	75
	2010	100	16	8	47	6	5	16	2	82
	2011	74	12	13	29	1	2	13	4	77
	2012	70	11	7	32	2	1	15	2	76

* 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.

[1] Single federal band; identity unknown.

[2] Returning nestling(s) banded with single federal band.

[3] One individual had a duplicate color combination.

[4] This individual had a federal band only; left leg was missing below the intertarsal joint.

[5] One individual had a silver federal band only and a visible injury on the unbanded left leg; a male with silver federal band number 2390-92434 and a visible injury on the unbanded left leg was captured at Mesquite in 2005 and this is likely the same individual. This male was recaptured and rebanded in 2011 at Mormon Mesa.

[6] One individual had a single half plastic band on the left leg and a silver federal band on the right.

[7] Several within-season, between study area movements were detected from 2003 to 2012. Individuals who moved are only tallied once in the total.

NDOW Study Areas

Color-Banding and Resighting – The number of flycatchers banded and resighted at each NDOW study area in 2010–2012 is summarized in Table 3.4. This table includes all flycatchers detected, including individuals for which residency and/or breeding status was undetermined. For details of the status of individuals detected, please refer to the annual reports (McLeod and Pellegrini 2011, 2012, 2013). From 2010 to 2012, field personnel captured 31 new adult flycatchers and banded 94 nestlings from 38 nests. Of these nestlings, seven were known or suspected to have died before fledging. We captured one additional fledgling that was not banded as a nestling. For details on all banded flycatchers detected at the study areas from 2010 to 2012, see Appendix G. For details on results of opportunistic banding and resighting activities at NDOW study areas prior to 2010, see the "Sites Monitored by Other Agencies" section below.

The number of resident flycatchers detected at each monitored study area in 2010–2012 is shown in Table 3.5. This table eliminates all flycatchers for which residency could not be determined. The overall percentages of resident, adult flycatchers at the monitored study areas that were banded by the end of each season increased from 2010 to 2011.

Sites Monitored by Other Agencies

These study areas were monitored by other agencies, and here we report only banded flycatchers that were captured by SWCA or resighted either by SWCA or the monitoring agency. Unbanded individuals or those with unknown band status are not included.

Key Pittman Wildlife Management Area – Field personnel captured and color-banded 17 new adults and recaptured nine returning nestlings prior to 2010. We banded 30 nestlings from 11 nests (Table 3.6).

St. George – Field personnel captured and color-banded nine new adults (Table 3.6). We banded 16 nestlings from seven nests.

Las Vegas Wash – Field personnel captured and color-banded one new adult in 2008 (Table 3.6).

Table 3.4. Willow Flycatchers Detected at NDOW Study Areas, 2010–2012*

Study Area	Year	Adults									Juveniles				
		Total Adults Detected	New Captured	Recaptured	Resighted					% of All Adults Banded	Confirmed Fledglings (# nests)	Nestlings Banded (# nests)	Fledglings Captured	Unbanded Fledglings (# nests)	% of All Fledglings Banded
					Color combination confirmed		Banded (color combinations unconfirmed)	Unbanded	Band Status Undetermined						
					Individual Identified	Individual Not Identified									
Key Pittman WMA	2010	35	11	5	8	1[1]	0	9	1	71	37(15)	39(15)	0	3(1)	92
	2011	42	11	7	20	0	2	2	0	95	30(14)	31(12)	0	4(3)	87
	2012	42	4	3	30	1[2]	1	3	0	93	22(11)	19(9)	1	4(2)	82
River Ranch	2011	9	2	0	6	0	0	1	0	89	0	0	--	--	--
	2012	1	0	0	1	0	0	0	0	100	--	--	--	--	--
Warm Springs Natural Area	2010	7	3	1	0	0	1	2	0	71	0	2(1)	--	--	--
	2011	5	0	0	2	0	0	2	1	40	3(1)	3(1)	0	0	100
	2012	3	0	0	2	0	0	0	1	67	0	0	--	--	--
All Study Areas[3]	2010	42	14	6	8	1	1	11	1	71	37(15)	41(16)	0	3(1)	92
	2011	53	13	7	25	0	2	5	1	89	33(15)	34(13)	0	4(3)	88
	2012	46	4	3	33	1	1	3	1	91	22(11)	19(9)	1	4(2)	82

* 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 adults detected and percent of all adults banded. Juveniles are identified as banded in the nest, banded as fledglings, or unbanded. The percent of all fledglings banded is included.

[1] Returning nestling banded with a single federal band.

[2] Duplicate color combination.

[3] Several within-season, between study area movements were detected. Individuals who moved are tallied only once in the total.

Table 3.5. Resident Adult Willow Flycatchers Detected at NDOW Study Areas, 2010–2012*

Study Area	Year	Total Adults Detected	New Captured	Recaptured	Resighted					% of All Adults Banded
					Color combination confirmed		Banded (color combinations unconfirmed)	Unbanded	Band Status Undetermined	
					Individual Identified	Individual Not Identified				
Key Pittman WMA	2010	31	8	5	7	1[1]	0	9	1	68
	2011	34	10	5	17	0	0	2	0	94
	2012	39	4	2	29	0	1	3	0	92
River Ranch	2011	7	2	0	5	0	0	0	0	100
	2012	0	0	0	0	0	0	0	0	--
Warm Springs Natural Area	2010	6	2	1	0	0	1	2	0	67
	2011	2	0	0	2	0	0	0	0	100
	2012	2	0	0	2	0	0	0	0	100
All Study Areas[2]	2010	37	10	6	7	1	1	11	1	68
	2011	40	12	5	21	0	0	2	0	95
	2012	41	4	2	31	0	1	3	0	93

* 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.

[1] Returning nestling banded with a single federal band.

[2] Several within-season, between study area movements were detected. Individuals who moved are tallied only once in the total.

Table 3.6. Willow Flycatchers Color-Banded and Resighted at Sites Monitored by Other Agencies, 2004–2012

Study Area	Year	New Captures	Recaptures[1]	Resighted	Nestlings Banded (# Nests)
Key Pittman	2004	2	1	0	6 (3)
	2005	1	0	0	4 (1)
	2006	2	3	2[2]	3 (1)
	2007	1	2	2	4 (1)
	2008	9	3	4	6 (2)
	2009	2	0	4	7 (3)
St. George	2008	0	0	2[2]	5 (2)
	2009	4	1	3[2]	5 (2)
	2010	3	0	5	5 (2)
	2011	2	1	6	1 (1)
Las Vegas Wash	2008	1	0	0	0

[1] All recaptures from 2004 to 2008 were of returning nestlings.
[2] One resight was of a returning nestling.

Leg Injuries

From 2003 to 2012, we observed 34 banded individuals with leg injuries (Table 3.7). Six (16%) of 37 birds recaptured or resighted with plastic bands exhibited leg injuries on the leg with the plastic band, while 14 (5%) of 292 individuals recaptured or resighted with metal pin-striped bands exhibited injuries on the leg with the metal color-band. Ten individuals had injuries on the leg banded with a federal band and five of these individuals lost their foot and part of the tarsus. Four individuals had injuries on an unbanded leg, but we were unable to capture these birds to determine if the leg had been previously banded. Three nestlings were observed with curved tarsi. One additional individual was recaptured with a hallux caught in one of its bands.

Thirty of the 34 banded individuals with leg injuries were identified. Of those 30, 12 (43%) were female and 16 (57%) were male. Of the 12 leg-injured females, 11 had nesting attempts with known outcome; 5 (45%) of the 11 were successful in at least one year. This rate is lower than that of non-leg-injured females with known nest outcome in 2003–2012 (73%), but the difference was not significant (Fisher's Exact Test, $P = 0.079$). Median minimum age for leg-injured females was 4.5 years (minimum = 2, maximum = 9). Median minimum age for non-leg-injured females in 2003–2012 was 2 years (minimum = 2, maximum = 9). Of the 16 leg-injured males, 15 were resident and 14 (93%) bred in at least one year. This rate is higher than that of non-leg-injured resident males in 2003–2012 (75%), but was not significantly different (Fisher's Exact Test, $P = 0.129$). Ten of the 14 breeding leg-injured males (71%) had at least one successful nesting attempt, which was the same (71%) for non-leg-injured breeding males in 2003–2012. Median minimum age for leg-injured males was 3.5 years (minimum = 2, maximum = 6). Median minimum age for non-leg-injured males in 2003–2012 was 2 years (minimum = 2, maximum = 8).

Leg injury did not appear to affect return rate. Twenty-four individuals of known identity were documented with leg injuries in 2003–2011. Of these 24 individuals, 9 (38%) returned in at least one subsequent year. This return rate did not differ from that of resident adults identified from 2003 to 2011 (49%; Fisher's Exact Test, $P = 0.299$). Median minimum age for these 24 leg-injured individuals was 4 years (minimum = 2, maximum = 9). Median minimum age for resident adults of known identity in 2003–2011 was 2 years (minimum = 2, maximum = 8).

Table 3.7. Leg Injuries or Deformities Observed on Willow Flycatchers, 2003–2012

Year	Study Area[1]	Federal Band #[2]	Color Combination	Gender[3]	Age[4]	Injury
Leg injuries, celluloid plastic bands						
2003	MESQ	2390-92420	XX:R(HP)/V(HP)	M	3Y	Skin on right leg peeled back by band. Plastic band replaced with metal band.
2003	PAHR	2140-66621	Rs:DD(P)	F	A5Y	Lower half of tarsus and foot swollen on right leg. Plastic band replaced with KG(M). In 2004, rebanded as WR(M):UB.
2003	TOPO	2110-78855	O(HP)/D(HP):BEs	M	SY	Very small Injury on left leg under plastic bands. Plastic band replaced with metal band.
2003	TOPO	INA	Bs:Unknown	M	AHY	Could not perch on right leg. Toes deformed. Injury prohibited resight of plastic band on right leg. Bird not captured, resighted only.
2004	MESQ	2390-92434	G(HP)/O(HP):XX	M	4Y	Orange half plastic band cut into flesh and wedged into metatarsus. Bird could not grip with left foot. Plastic band removed, not replaced. In 2005, recaptured, not rebanded. Injury also observed 2006-2011. Recaptured at MOME in 2011; tarsus and hallux swollen, hallux deformed. Bird rebanded as UB:GY(M).
2004	MESQ	2390-92470	B(HP)/G(HP):XX	F	4Y	Left leg bruised under plastic bands. Plastic band replaced with metal band.
Leg injuries, metal pinstripe bands						
2005	PAHR	2320-31663	EE:GK(M)	F	A3Y	Lower half of right leg and foot missing. Bird rebanded as RR(M):UB. Injury also observed 2006-2008. Recaptured in 2008.
2006	MESQ	2320-31652	WG(M):EE	M	A4Y	Could not grip branches with left foot when perched. Bird not captured, resighted only.
2006	MOME	2320-31653	WV(M):EE	M	4Y	Left leg swollen under pinstripe band. Could not move or remove band.
2007	MOME	2360-59702	WB(M):EE	M	3Y	Could not put weight on left leg. Bird not captured, resighted only.
2008	MOME	2320-31485	EE:WO(M)	F	A6Y	Could not put weight on right leg. Bird not captured, resighted only.
2008	MOME	2360-59749	BG(M):EE	M	3Y	Could not grip branches with left foot when perched. Bird not captured, resighted only.
2008	MOME	2370-40173	PU:RO(M)	M	A3Y	Could not put weight on right leg. Bird rebanded as RK(M):UB. Injury also observed in 2009.
2009	PAHR	2370-40194	PU:BR(M)	F	4Y	Right leg swollen at base of foot. Bird rebanded as BR(M):UB. No foot on right leg in 2010.
2009	PAHR	2430-61127	XX:WG(M)	M	A3Y	Could not put weight on right leg. Tarsus swollen, scabbing on right foot. Recaptured, not rebanded.
2011	BIWI	2540-58120	TQ:YKY(M)	F	AHY	Could not put weight on right leg. Bird captured and banded two days prior to injury observation.
2011	KEPI	INA	TQ:Unknown(M)	U	AHY	Right leg injured. Bird not captured, resighted only.
2012	MESQ	INA	Unknown(M):XX	U	AHY	Could not put weight on left leg. Bird not captured, resighted only.
2012	PAHR	2430-61120	XX:KO(M)	F	5Y	Resighted initially with full combination; bird inconsistently putting weight on right leg and not gripping with right foot. Lost right foot. Bird not captured, resighted only.
2012	PAHR	2540-58111	TQ:RYR(M)	F	A3Y	Resighted initially with full combination; bird could not put weight on right leg. Lost lower half of right leg and foot. Bird rebanded as RYR(M):UB.

Table 3.7. Leg Injuries or Deformities Observed on Willow Flycatchers, 2003–2012 (Continued)

Year	Study Area[1]	Federal Band #[2]	Color Combination	Gender[3]	Age[4]	Injury
Leg injuries, federal bands						
2004	PAHR	2190-76604	KK(M):XX	M	A5Y	Right foot scabby and swollen below tarsus. Foot was 1.5 to 2 times larger than normal size. Both bands removed, rebanded as EE:UB. Captured again in 2005, no sign of leg injury, banded as EE:BW(M). Observed bird in 2006 with no note of injury.
2006	PAHR	2360-59724	ZB(M):EE	F	3Y	Lower tarsus and middle toe on right foot swollen. Band moved freely, not removed.
2008	MESQ	2320-31490	EE:OO(M)	M	A6Y	Could not put weight on left leg; tarsus swollen just above foot. Recaptured in 2009; left foot immobile, foot swollen, hallux enlarged and twisted. Tarsus appeared to have broken and then healed just above foot. Bird rebanded as UB:WG(M).
2008	MUDD	2370-39955	BV(M):PU	M	6Y	Could not put weight on right leg. Bird initially resighted with full combination, but lacking right foot. Recaptured; part of right leg and right foot missing. PU band fell off when recaptured.
2008	PAHR	2320-31661	EE:DW(M)	F	6Y	No foot on left leg. Bird not captured, resighted only.
2009	MOME	2370-39988	DW(M):PU	M	5Y	Could not grip branches with right foot when perched; foot swollen. Bird not captured, resighted only. In 2010, no foot on right leg.
2009	STGE	2140-66690	Rs:W(HP)/B(HP)	F	9Y	Left foot did not articulate at digits; inner two digits straight. Bird rebanded as TQ:KY(M).
2011	MOME	2430-61167	XX:KW(M)	M	A5Y	Resighted initially with full combination; bird could not put weight on left leg. Lost left foot. Bird not captured, resighted only.
2011	PAHR	2540-58201	TQ:BO(M)	M	SY	Left foot swollen; bird could not grip branches with foot when perched. In 2012, left leg broken. Right digit of right foot bent outward. Recaptured in 2012; portion of left leg below brake fell off during recapture.
2012	MOME	2360-59788	BO(M):EE	F	8Y	Right leg twisted clockwise at tarsus joint; appeared to be old injury with leg fully functioning. Recaptured; band moved freely, not removed.
Leg injuries unknown if related to bands						
2004	MESQ	INA	UB:EE	F	AHY	No foot on left leg. Bird not captured, resighted only.
2005	MESQ	INA	UB:EE	M	AHY	No foot on left leg. Bird not captured, resighted only.
2007	MOME	INA	EE:UB	M	AHY	Bottom quarter of tarsus and foot missing on right leg. Bird not captured, resighted only.
2010	PAHR	INA	XX:UB	M	AHY	No foot on right leg. Bird not captured, resighted only. Possibly XX:WG(M) above.
Leg deformities unrelated to bands						
2003	PAHR	N/A	UB:UB	U	L	Nestling could not be banded due to curved tarsi on both legs.
2004	TOPO	2320-31520	UB:EE	U	L	Nestling had slightly curved tarsus on left leg.
2009	MOME	2370-40175	PU:UB	M	L	Nestling had curved tarsus on right leg. Recaptured as an adult in 2010 with no injury noted.

Table 3.7. Leg Injuries or Deformities Observed on Willow Flycatchers, 2003–2012 (Continued)

Year	Study Area[1]	Federal Band #[2]	Color Combination	Gender[3]	Age[4]	Injury
Other						
2011	KEPI	2430-61159	OK(M):XX	M	3Y	Could not grip branches with left foot when perched. Recaptured; hallux released from band after which foot seemed fully functioning. Bird observed in 2012 with no apparent injury.

[1] STGE = St. George, KEPI = Key Pittman WMA, PAHR = Pahranagat NWR, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, TOPO = Topock Marsh, BIWI = Bill Williams River NWR.

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

[3] Gender codes: F = female, M = male, U = gender unknown.

[4] Age when injury first observed. L = nestling, 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.

Gender Ratio

We confirmed or determined gender for 155 of 167 adult samples. We used this data in combination with behavioral data to determine the gender of all resident adults from 2004–2011. The average adult gender ratio (% female) is presented in Table 3.8. We also determined the gender for 337 of 398 nestling blood samples. There was no significant difference for nestlings among the primary, secondary, and tertiary gender ratios in any geographic area (Fisher's Exact Test; Pahranagat Valley $P = 0.843$; Virgin Valley |$P = 0.454$; Havasu $P = 0.110$). We therefore pooled all available data on nestling gender and compared gender ratio between geographic areas. We chose to compare gender ratios of all nestlings not known or suspected to have died before fledging in each geographic area because of the potential influence on adult gender ratio. Gender ratio in the Pahranagat Valley was biased towards females (57% female, $P = 0.028$; Table 3.8). It was biased towards males (38% female, $P = 0.006$) in the Virgin Valley, and there was no bias (48% female, $P = 0.112$) in the Havasu area. Gender ratios at a given study area did not necessarily match that of the associated geographic area. Pahranagat NWR had a stronger female bias (59%, $P = 0.029$) than Key Pittman WMA (53%, $P = 0.119$). In the Virgin Valley, Mormon Mesa had the strongest male bias (28% female, $P = 0.001$), while fledgling genders did not differ from an equal ratio at Mesquite (45%, $P = 0.09$) or Muddy River (36%, $P = 0.161$). The gender ratio at Topock Marsh (56%) was more female-biased than the ratio for the geographic area as a whole, but not significantly so ($P = 0.108$), while Bill Williams was slightly biased male (33%; $P = 0.054$). Sample sizes were too small to test for deviance from an equal ratio at Littlefield and Warm Springs, and there were no confirmed fledglings in River Ranch or the Grand Canyon.

Table 3.8. Gender Ratio by Geographic Area, 2004–2011

Geographic Area	Study Area	Fledglings					Adults
		# Female	# Male	% Female	*P*-value[1]	# of Nests	% Female
Pahranagat Valley	Key Pittman WMA	21	19	53	0.119	17	50
	Pahranagat NWR	42	29	59	0.029	27	44
	Overall	*63*	*48*	*57*	*0.028*	*44*	*46*
Virgin Valley	Littlefield	2	1	67	--	1	--
	Mesquite	25	30	45	0.086	28	47
	Mormon Mesa	13	33	28	0.001	22	47
	Muddy River	4	7	36	0.161	6	42
	Warm Springs	1	2	33	--	1	--
	Overall	*45*	*73*	*38*	*0.003*	*58*	*45*

Table 3.8. Gender Ratio by Geographic Area, 2004–2011 (Continued)

Geographic Area	Study Area	Fledglings					Adults
		# Female	# Male	% Female	*P*-value[1]	# of Nests	% Female
Havasu	Topock Marsh	19	15	56	0.108	15	33
	Bill Williams	3	9	33	0.054	7	46
	Overall	*22*	*24*	*48*	*0.112*	*22*	*40*
All Areas		**130**	**145**	**47**	**0.032**	**124**	**44**

[1] P-values indicate the probability that the observed gender ratio differs from 50%.

Adult Between-Year Return and Dispersal

Our definition of patches for the purpose of analyzing between-year movements was the same as the definition of sites described in Chapter 2 and in McLeod et al. (2008a), except for the cases noted in Table 3.9. We made exceptions at Key Pittman and Littlefield to the patch delineation rules described in the methods. Key Pittman consists of a 1.3-km-long series of 12 coyote willow clumps 0.02–0.3 ha in size and separated from one another by upland scrub or marsh vegetation. Gaps between willow clumps range from 10 to 300 m. Despite willow clumps being separated by non-riparian vegetation, we determined from observations of willow flycatchers moving readily between clumps within a season that the clumps were functioning as one long patch. At Littlefield, we documented two breeding sites that were separated both spatially and temporally. The Littlefield study area is small and isolated, with the nearest known breeding site at Hafen Lane in Mesquite, 16.5 km down river. Because there was only a single site at Littlefield at any given time, we delineated Littlefield North and Poles as one patch.

Table 3.9. Patch Delineation Following Methods in Paxton et al. (2007)

Study Area	Site	Patch	Description
Key Pittman	Patches 0-12	Key Pittman	All coyote willow patches functioned as one breeding patch
River Ranch	East Side	River Ranch	All coyote willow patches functioned as one breeding patch
	West Side		
Littlefield	North	Littlefield	Both patches occupied in different years. The study area itself is essentially one patch, due to limited habitat availability.
	Poles		
Mormon Mesa	Virgin River #1 North	Virgin River #1 North	Virgin River #1 North and the adjacent territory clusters in Virgin River #1 South
	Virgin River #1 South		
	Virgin River #1 South	Virgin River #1 South	Territory cluster at the southern end of Virgin River #1 South
Muddy River	Overton WMA	Overton North	Territory cluster at the northern end of Overton WMA
		Overton South	Territory cluster at the southern end of Overton WMA, approximately 600 m from Overton North
Topock Marsh	Pipes #1	Topock North	All areas from Pipes #1 to Pierced Egg. The territory clusters are separated from each other by 200–300 m of dense but unoccupied riparian vegetation. The string of territory clusters functions as one patch, as at Key Pittman.
	Pipes #3		
	The Wallows		
	PC6-1		
	Pig Hole		
	In Between		
	800M		
	Pierced Egg		

Table 3.9. Patch Delineation Following Methods in Paxton et al. (2007), Continued

Study Area	Site	Patch	Description
Topock Marsh	Platform	Topock South	All areas from Platform to Glory Hole
	250M		
	Hell Bird		
	Glory Hole		
Bill Williams	Site #3	Mosquito Flats	All territory clusters from both survey sites combined
	Site #4		

From 1998 to 2012, 588 between-year returns of adult willow flycatchers were identified within the lower Colorado River study areas (Table 3.10). One additional between-year return was identified at Ash Meadows NWR. Of the 589 adult returns, 532 were to the same study area. We calculated dispersal distances for the 487 adult returns detected from 2004 to 2012 (Figure 3.1). We did not calculate dispersal distances for the remaining adult returns because we did not have UTM coordinates for recapture and/or capture locations. Median dispersal distance for the 487 adult returns was 0.04 km (min = 0.001 km, max = 258.6 km), and mean dispersal distance was 6.6 km (SE = 1.3 km).

There was no difference between genders in the distance moved by resident flycatchers (H = 0.209, $P = 0.648$; Figure 3.2). Adult movement distances and patterns varied by drainage (Figure 3.3). Individuals in the Virgin Valley moved significantly farther than those in the Pahranagat Valley (H = 5.6531, $P = 0.017$) or the Havasu area (H = 6.0933, $P = 0.014$). There was no difference in the median distance moved between adults in the Pahranagat Valley and those in the Havasu area (H = 0.160, $P = 0.689$). The majority of movements (75–100%) were ≤5 km (within a study area). Longer movements were clustered around intervals corresponding to the distances between study areas within the drainage. In the Pahranagat Valley, these distances were 10–15 km (River Ranch to Key Pittman) and 30–35 km (Pahranagat NWR to Key Pittman). In the Virgin Valley, these distances were 10–15 km (Mormon Mesa to Muddy River) and 25–30 km (Mesquite to Mormon Mesa). There were no adult movements between study areas in the Havasu region.

Adult between-year movement types included within-patch (range = 0.05–1.5 km), between-patch (range = 0.4–88.8 km), and between-drainage (range = 107.7–258.6 km; Table 3.11). The proportion of between-year movement types did not differ between males and females ($\chi^2 = 4.57$, df = 3, $P = 0.206$), but did differ between drainages ($\chi^2 = 49.10$, df = 6, $P < 0.001$; Table 3.12), with Pahranagat Valley individuals being more likely to return to the same territory than flycatchers in the other two drainages, and Virgin Valley individuals being more likely move between patches than individuals in the other two drainages.

Breeding failure was the only factor that was retained in the logistic regression models examining the effects of breeding failure, parasitism, and gender on territory fidelity and on remaining in the same patch (Table 3.13). A flycatcher that produced no fledglings was 4 times more likely to leave its territory and 11 times more likely to move to a different patch than a flycatcher that produced at least one fledgling.

Table 3.10. Summary of Between-Year Return and Movements of Adult Flycatchers, 1997–2012

Study Area of Subsequent Detection[1]	Study Area Detected[1]												Total
	KEPI	RIRA	PAHR	STGE	LIFI	MESQ	MOME	MUDD	WMSP	GRCA	TOPO	BIWI	
ASME			1										1
KEPI	50	3	4				1						58
RIRA								1					1
PAHR	2	1	163		1	1							168
STGE				14			1						15
LIFI					2								2
MESQ			1		1	101	7						110
MOME						10	101	6		4	1		122
MUDD						4	1	19	1		1		26
WMSP									4		1		5
GRCA										2			2
TOPO										1	60		61
BIWI							1	1				16	18
Total	**52**	**4**	**169**	**14**	**4**	**116**	**112**	**27**	**5**	**7**	**63**	**16**	**589**

[1] ASME = Ash Meadows NWR, KEPI = Key Pittman WMA, RIRA = River Ranch, PAHR = Pahranagat NWR, STGE = St. George, LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, WMSP = Warm Springs NA, GRCA = Grand Canyon, TOPO = Topock Marsh, BIWI = Bill Williams River NWR.

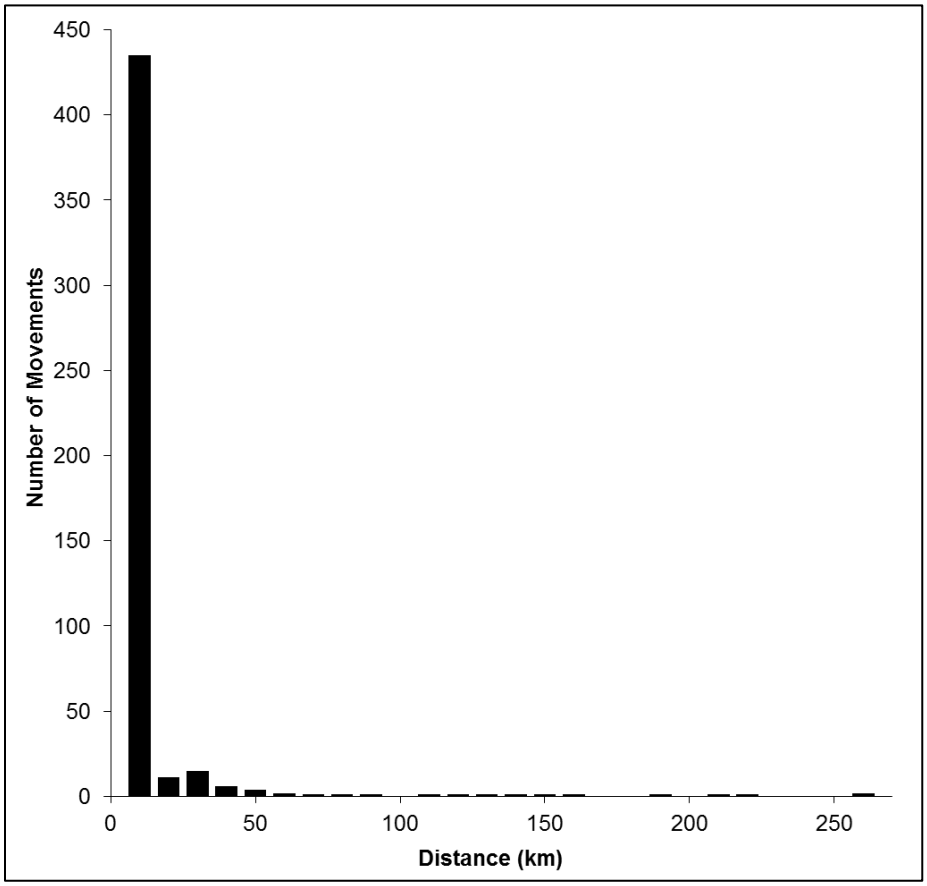

Figure 3.1. Dispersal distances for adult willow flycatchers detected in any year from 2003 to 2011 and detected again in a subsequent year.

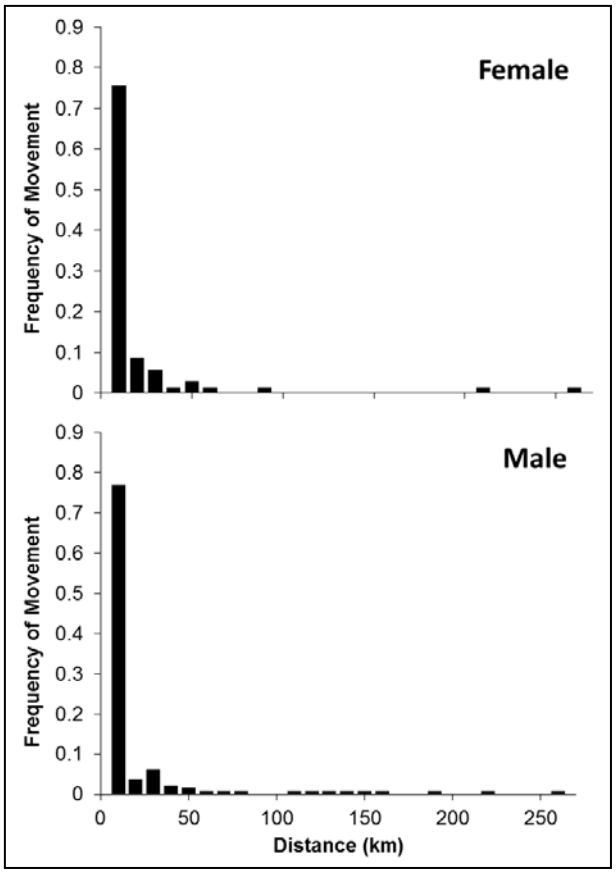

Figure 3.2. Between-year movement distances for resident male and female adult willow flycatchers detected in any year from 2003 to 2011 and detected again in a subsequent year.

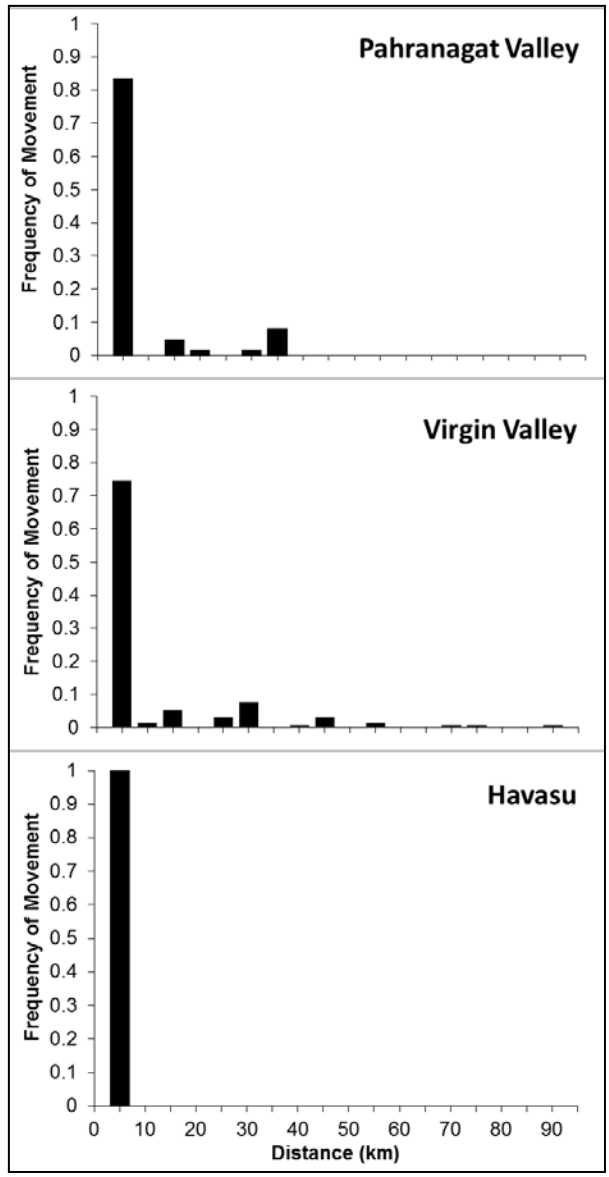

Figure 3.3. Between-year movement distances by drainage for resident adult willow flycatchers detected in any year from 2003 to 2011 and detected again in a subsequent year.

Table 3.11. Between-Year Movement Distances of Adult Flycatchers by Movement Type and Drainage, 2003–2012

Drainage	Type of Movement	n	Distance moved (km)			
			Mean (SE)	Range	Median	25th–75th percentile
Pahranagat Valley	Patch fidelity	44	0.2 (0.03)	0.1–0.9	0.1	0.1–0.2
	Between-patch movement	17	15.1 (3.1)	0.4–33.1	12.0	3.0–30.2
	Between-drainage movement	1	145.2	--	--	--

Table 3.11. Between-Year Movement Distances of Adult Flycatchers by Movement Type and Drainage, 2003–2012 (Continued)

Drainage	Type of Movement	n	Distance moved (km)			
			Mean (SE)	Range	Median	25th–75th percentile
Virgin Valley	Patch fidelity	71	0.2 (0.02)	0.1–0.6	0.1	0.1–0.2
	Between-drainage movement	59	17.8 (2.6)	0.6–88.8	12.2	1.9–27.4
	Between-site movement	7	163.7 (24.1)	107.7–258.6	132.7	121.4–202.0
Havasu	Patch fidelity	23	0.2 (0.08)	0.1–1.5	0.1	0.1–0.1
	Between-drainage movement	3	2.2 (0.2)	2.0–2.6	2.1	2.1–2.1
	Between-site movement	3	201.0 (6.2)	189.3–210.6	203.1	196.2–203.1

Table 3.12. Number of Observed Between-year Movement Types of Adult Flycatchers by Drainage and Gender, 2003–2012

Drainage	Gender	Territory Fidelity	Patch Fidelity	Between-Patch Movement	Between-Drainage Movement	Total Individuals
Pahranagat Valley	M	72	35	13	1	121
	F	55	9	4	0	68
Virgin Valley	M	62	44	40	6	152
	F	44	27	19	1	91
Havasu	M	16	13	1	2	32
	F	10	10	2	1	23

Table 3.13. Results of Logistic Regression Models Examining Effects of Gender, Breeding Success, and Parasitism on Territory Fidelity and Patch Fidelity of Adult Flycatchers, 2003–2012

Movement type	Variables retained	Odds ratio	95% CI	*P*
Territory fidelity	Breeding failure	0.245	(0.159–0.377)	<0.001
Return to same patch	Breeding failure	0.088	(0.042–0.187)	<0.001

Juvenile Between-Year Return and Dispersal

From 1997 to 2011, 848 juveniles were banded and either known or presumed to have survived to fledging. Banded nestlings were assumed to have survived to fledging in the absence of evidence to the contrary (e.g., a reduced number of nestlings observed in the nest immediately prior to fledging or repeated observations of the fledgling(s) that could not account for all of the nestlings.) Of these 848 juveniles, 191 (23%) were recaptured or resighted and identified in a subsequent year (Table 3.14). One of these was recaptured near Isabella Lake on the Kern River, while the remainder were recaptured or resighted within the lower Colorado River study areas. An additional three juveniles banded at Roosevelt Lake were recaptured within the lower Colorado River study areas. These three juveniles are not included in dispersal calculations as they do not represent juvenile dispersal originating in the project area. Of the 191 returning juveniles, 95 (50%) returned to the same study area and 96 (50%) returned to a different study area than where originally banded. We calculated dispersal distances for the 134 returning juveniles that were banded in 2003–2011 and detected in a subsequent year (Figure 3.4). We did not calculate dispersal distances for juveniles banded prior to 2003 because we did not have UTM coordinates for banding and/or recapture locations. Dispersal distances for juveniles were greater than for adults

(median = 13.6 km, minimum = 0.02 km, maximum = 203.0 km, mean = 26.6 km [SE = 3.4 km]). Gender was known for 131 of the 134 returning juveniles; 54 were female and 77 were male. There was no significant difference (H = 0.551, $P = 0.458$) in distance moved between females (median = 4.3 km) and males (median = 12.1 km; Figure 3.5).

In 2003–2011, the majority of juveniles (62%) dispersed away from their natal patch, but stayed within their natal drainage (Table 3.15). Eleven juveniles (8%) dispersed away from their natal drainage. The remainder (30%) returned to their natal patch, with four individuals returning to their natal territory. Two of these individuals were in the Pahranagat Valley, and two were in the Virgin Valley. Pahranagat Valley juveniles were more likely to return to their natal patch than Virgin Valley juveniles ($\chi^2 = 2.65$, $P = 0.019$). There were not enough returning Havasu juveniles to allow for comparison.

Table 3.14. Summary of Number and Dispersal of Juvenile Flycatchers Banded as Hatch Year Birds and Recaptured or Resighted in a Later Year, 1997–2012

Study Area Detected[1]	Study Area Banded[1]									Total
	KEPI	PAHR	STGE	MESQ	MOME	MUDD	TOPO	BIWI	ROOS	
KEPI	13	16			1	1				31
RIRA	4	2								6
PAHR	6	24		2	1					33
STGE		1	2	1						4
LIFI		1		3						4
MESQ		1		21	14	1				37
MOME	1	3	1	8	15	2	3			33
MUDD			1	5	6	2			1	15
GRCA					1				1	2
TOPO					3		17	4	1	25
BIWI				1			1	1		3
ISAB				1						1
Total	**24**	**48**	**4**	**42**	**41**	**6**	**21**	**5**	**3**	**194**

[1] KEPI = Key Pittman WMA, RIRA = River Ranch, PAHR = Pahranagat NWR, STGE = St. George, LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, WMSP = Warm Springs NA, GRCA = Grand Canyon, TOPO = Topock Marsh, BIWI = Bill Williams River NWR, ISAB = Lake Isabella.

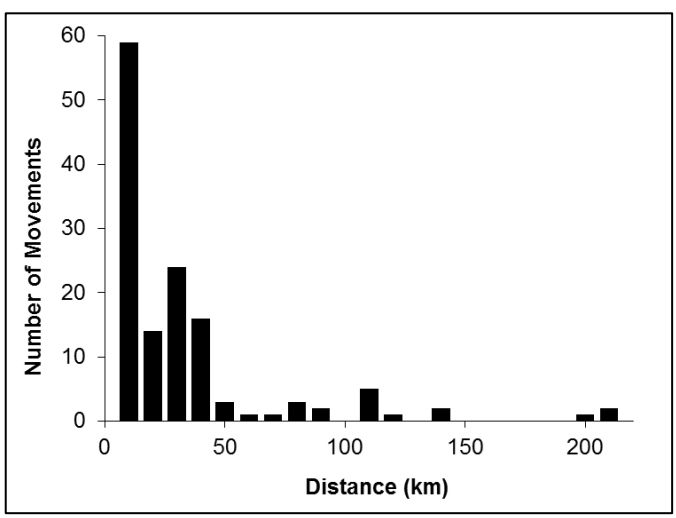

Figure 3.4. Dispersal distances for juvenile willow flycatchers banded in 2003–2011 and detected in a subsequent year.

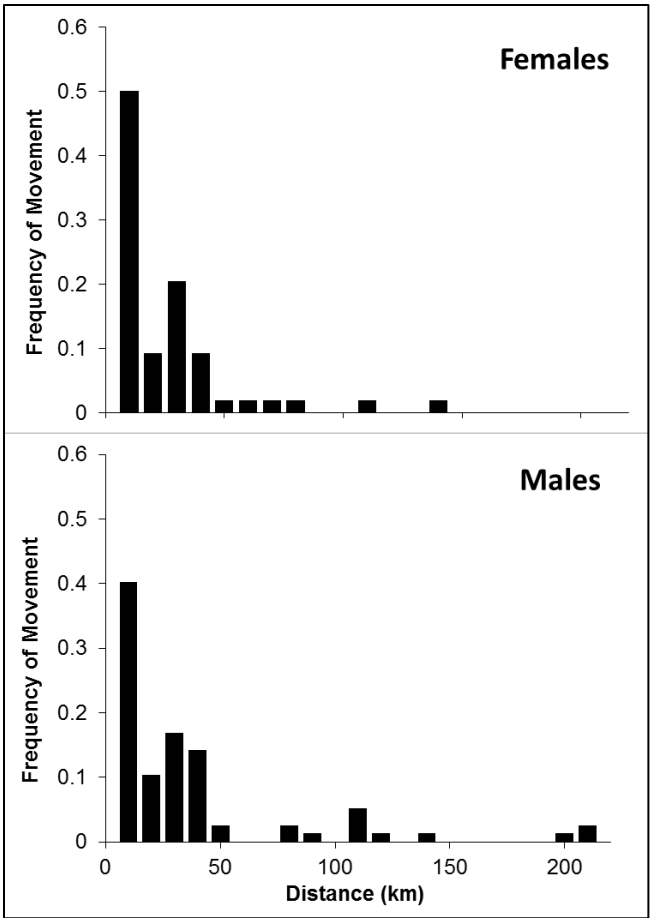

Figure 3.5. Dispersal distances for returning male and female juveniles detected 2003–2012.

Table 3.15. Juvenile dispersal distances grouped by dispersal type, 2003–2012

Type of Dispersal	n	Mean km (SE)	Range	Median km	25th–75th percentile
Patch Fidelity	40	0.3 (0.04)	0.02–1.3	0.2	0.1–0.5
Between-Patch Movement	83	24.9 (2.17)	0.8–100.7	27.3	11.9–30,1
Between-Drainage Movement	11	135.1 (13.59)	77.1–203.0	116.7	105.5–166.3
Overall	*134*	*26.6 (3.43)*	*0.02–203.0*	*13.6*	*0.6–30.1*

Within-Season, Between Study Area Movements

We detected 23 within-season, between study area movements in 2003–2012 (Table 3.16). All 23 movements were by adult flycatchers. One additional within-season movement was recorded in 2002, when a fledgling banded at Topock Marsh was recaptured 16 days later in a passive net at Roosevelt Lake. No other within-season movements were recorded in 1997–2002. We calculated movement distance for all 23 adult within-season, between-study area movements (Figure 3.6). Mean movement distance was 32.9 km (SE = 5.8 km), minimum distance was 11.2 km; maximum distance was 131.7 km, and median distance was 26.9 km. Twenty-one individuals accounted for the 23 adult movements. Of the 21 adults detected moving between study areas during the season prior to 2012, 13 were detected in a

subsequent year. Of the13 returning individuals, 9 (69%) returned to the site where they were last detected in the previous year.

Table 3.16. Within-Season, Between-Study Area Movements of Flycatchers, 1997–2012*

Study Area Subsequently Detected[1]	Study Area Initially Detected[1]								Total
	RIRA	PAHR	LIFI	MESQ	MOME	MUDD	GRCA	TOPO	
KEPI	3	1		1					**5**
RIRA		1							**1**
MESQ			2		2	2	2		**8**
MOME				4		2	1		**7**
MUDD					2				**2**
ROOS								1	**1**
Total	**3**	**2**	**2**	**5**	**4**	**4**	**3**	**1**	**24**

* All individuals were adults except for the individual that moved from TOPO to ROOS; this was a dispersing juvenile.

[1] KEPI = Key Pittman WMA, RIRA = River Ranch, PAHR = Pahranagat NWR, LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, GRCA = Grand Canyon, TOPO = Topock Marsh, ROOS = Roosevelt Lake.

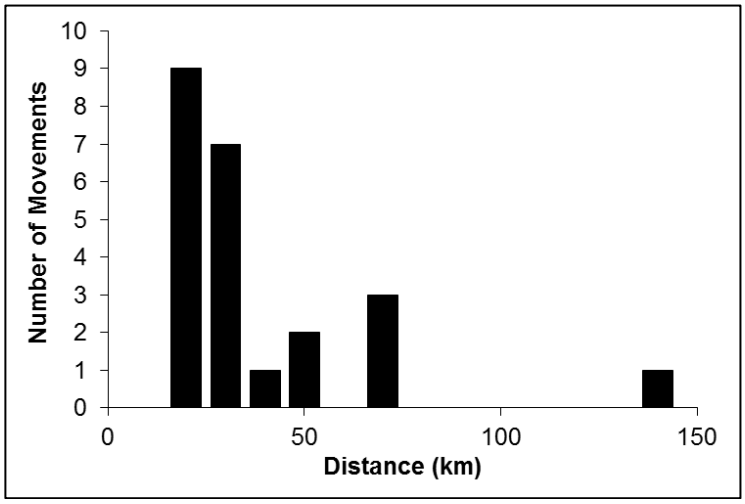

Figure 3.6. Within-season, between study area adult movements detected 2003–2012.

Demographics

From 1997 to 2011, 405 flycatchers were individually marked as adults and 767 flycatchers were banded as juveniles. Of the flycatchers banded as juveniles, 191 were also encountered as adults. One of these was detected at Lake Isabella (Kern River, California) and is not included in analyses of adults for this study. An additional three individuals banded as juveniles at Roosevelt Lake were detected as adults at areas monitored during this study.

Age Structure

Mean life expectancy from time of fledging as generated from adult and juvenile survival probabilities was lower for females than males (Table 3.17). Male mean life expectancy was highest in the Pahranagat Valley (2.5 years) and lowest in the Havasu area (1.7 years). Female mean life expectancy was highest in

the Virgin Valley (1.8 years) and lowest in the Havasu area (0.7 years). The observed age distribution of adults varied between genders and geographic areas (Table 3.17 and Figure 3.7). Maximum age of an individual at Havasu (7) was less than that of all other groups. Maximum age of an individual in the Virgin Valley (12 and 10 for males and females, respectively) was higher than for the respective groups in the other two geographic areas. Mean and median observed maximum ages generally followed the same pattern as mean life expectancy.

Table 3.17. Mean Life Expectancy and Age Distributions by Geographic Area and Gender

Geographic Area	Gender	Mean Life Expectancy	Observed Adult Age Distribution		
			Mean (SE)	Median	Maximum Age
Pahranagat Valley	Male	2.5	4.2 (0.2)	4	10
	Female	1.1	3.2 (0.2)	2	8
Virgin Valley	Male	1.8	3.7 (0.2)	3	12
	Female	1.8	3.6 (0.2)	3	10
Havasu	Male	1.7	2.9 (0.1)	3	7
	Female	0.7	2.9 (0.2)	2	7

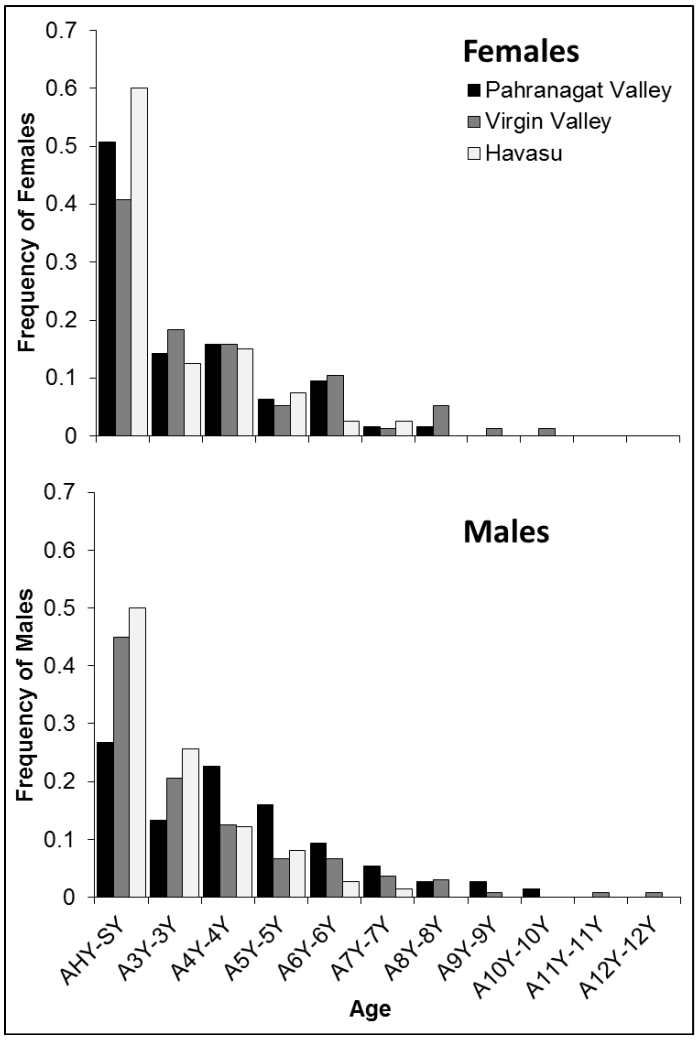

Figure 3.7. Maximum adult age by gender and geographic area.

Survival and Detection: Effects of Age, Gender, and Time

All c-hat estimates were <1.15, and there was little difference in c-hat estimates between the two GOF methods (Table 3.18). Because there was no evidence for overdispersion in our data, we did not adjust c-hat.

Table 3.18. Goodness-of-fit Testing Results by Geographic Area

Geographic Area	Bootstrap	Median c-hat
Pahranagat Valley	1.102	1.063
Virgin Valley	1.140	1.062
Havasu	1.135	1.116

Model results for each drainage indicated that survival probabilities varied by age (juvenile versus adult) but not year (Tables 3.19–3.21).

Table 3.19. AICc Model Selection Results of Effects of Age (a2), Gender (G), and Year (t/t) on Survival Probabilities and Age, Gender, and Contract Period (TP) on Detection Probability in the Pahranagat Valley*

Model	AICc	ΔAICc	AICc Weights	# Parameters	Deviance
Φ (a2*G) p(a2*TP+a2*G)	1106.24	0	0.7555	11	1083.86
Φ (a2*G) p(a2*TP)	1109.52	3.2769	0.1468	9	1091.26
Φ (a2*G+t/t) p(a2*TP+a2*G)	1111.92	5.6805	0.0441	25	1060.00
Φ (a2*G) p(a2*G)	1113.93	7.6836	0.0162	8	1097.72
Φ (a2*G+t/t) p(a2*TP)	1113.99	7.7429	0.0157	23	1066.36
Φ (a2) p(a2*TP)	1115.24	9.0014	0.0084	7	1101.08

* The top five models are shown, as well as the general model.

Table 3.20. AICc Model Selection Results of Effects of Age (a2), Gender (G), and Year (t/t) on Survival Probabilities and Age, Gender, and Contract Period (TP) on Detection Probability in the Virgin Valley*

Model	AICc	ΔAICc	AICc Weights	# Parameters	Deviance
Φ (a2) p(a2*TP)	1413.21	0	0.4868	7	1399.08
Φ (a2) p(a2*TP+a2*G)	1413.96	0.7523	0.3342	9	1395.75
Φ (a2*G) p(a2*TP)	1417.15	3.9387	0.0679	9	1398.93
Φ (a2) p(a2*G)	1417.54	4.3329	0.0558	6	1405.44
Φ (a2*G) p(a2*TP+a2*G)	1418.06	4.8512	0.0430	11	1395.75
Φ (a2*G+t/t) p(a2*TP+a2*G)	1427.54	14.3370	0.0004	25	1375.98

* The top five models are shown, as well as the general model.

Table 3.21. AICc Model Selection Results of Effects of Age (a2), Gender (G), and Year (t/t) on Survival Probabilities and Age, Gender, and Contract Period (TP) on Detection Probability at Havasu*

Model	AICc	ΔAICc	AICc Weights	# Parameters	Deviance
Φ (a2*G) p(a2*G)	526.94	0	0.4263	8	510.56
Φ (a2*G) p(a2*TP)	528.92	1.9778	0.1586	9	510.45
Φ (a2) p(a2*G)	529.04	2.1014	0.1491	6	516.82
Φ (a2*G) p(a2*TP+a2*G)	529.55	2.6088	0.1157	11	506.85
Φ (a2) p(a2*TP)	530.01	3.0759	0.0916	7	515.72
Φ (a2*G+t/t) p(a2*TP+a2*G)	539.70	12.7571	0.0007	25	486.15

* The top five models are shown, as well as the general model.

Pahranagat Valley – In the Pahranagat Valley, the top model indicated that survival probability varied by age and gender, and detection probability varied by age (second-year versus older adults), TP, and gender. The difference in AICc scores (ΔAICc) indicated some support (ΔAICc = 2–7) for the next two models. The second best supported model indicated no effect of gender on detection probability, and the third model included an additive effect of year on survival probability. ΔAICc scores indicated support for more than one model, and model averaging was used to generate parameter estimates (Table 3.22) for the terms indicated in the top model.

Table 3.22. Parameter Estimates and 95% Confidence Intervals for Percent Annual Survival by Age and Gender, and Detection Probabilities by Age, Gender, and Contract Period

Geographic Area	Age	Survival (Φ)		Contract Period	Detection (p)	
		Male	Female		Male	Female
Pahranagat	Adult	68 (57–77)	56 (44–68)	1997–2002	61 (40–78)	75 (50–90)
				2003–2012	81 (72–87)	89 (76–96)
	Juvenile/ SY	39 (25–56)	21 (11–35)	1997–2002	--[1]	--[1]
				2003–2007	31 (16–52)	54 (27–78)
				2008–2012	50 (28–72)	72 (46–89)
Virgin Valley	Adult	61 (56–65)		1997–2002	60 (40–78)	
				2003–2012	84 (78–89)	
	Juvenile/ SY	32 (26–39)		1997–2002	43 (27–61)	
				2003–2007	52 (34–70)	
				2008–2012	49 (31–67)	
Havasu	Adult	46 (36–55)	46 (34–58)	1997–2012	72 (53–86)	62 (37–82)
	Juvenile/ SY	34 (15–60)	13 (3–37)	1997–2012	29 (08–67)	56 (21–86)

[1] Estimates could not be generated.

Virgin Valley – In the Virgin Valley, the top model indicated that survival varied by age, and detection varied by age and TP. There was strong support (Δ AICc <2) for the second model, which indicated that detection probability also varied by gender. There was some support for the following three models, which included various combinations of effects of gender on survival and detection probability and of TP on detection probability. There was strong support for the top two models, and we model averaged to generate the parameter estimates in Table 3.22. The top two models were equivocal regarding the

importance of age*gender in estimating detection probability. Therefore, to determine which detection parameters to estimate, we compared the combined AICc weights for all models that included the age*gender term versus those that did not. Models without the age*gender term had the majority (55%) of the weight, and parameter estimates are presented only for age and TP.

Havasu – In the Havasu area, the top model indicated that both survival and detection probabilities varied by age and gender. There was strong support for the second model, which indicated that detection probability varied by age and TP instead of age and gender. There was some support for the next three models, and we model averaged to generate parameter estimates. We again examined combined AICc weights of the terms in the top two models to determine which parameters to estimate. Models in which detection probability varied by age and gender, rather than age and TP, had the majority of the weight (58%) in the model set, and we present parameter estimates for these terms in Table 3.22.

Survival Parameter Estimates – Across all geographic areas, all juvenile survival estimates (13–39%) were lower than any of the survival estimates for adults (46–68%). For both geographic areas where models supported a difference in survival between males and females, juvenile male survival was higher than that of females (39% versus 20% in Pahranagat Valley and 34% versus 13% in Havasu). There was evidence that adult male survival was higher (68%) than adult female survival (56%) in the Pahranagat Valley, but adult survival did not differ between the genders in either of the other two geographic areas (46% for Havasu and 61% for Virgin Valley). The adult survival estimate in the Havasu area was lower than in either of the other two geographic areas, which were similar to one another. Juvenile survival estimates were lowest for females at Havasu (13%) and Pahranagat (20%), and similar for all other estimates (39%, 32%, and 34% for Pahranagat Valley males, Virgin Valley, and Havasu males, respectively).

Adult Detection Probability Estimates – Detection probability increased from the first TP to the second for females (61% to 81%) and males (75% to 89%) in the Pahranagat Valley and for both genders combined in the Virgin Valley (60% to 84%). Detection probability across both TPs in the Havasu area was 62% for females and 72% for males. Detection probability was higher for females than males in the Pahranagat Valley, but lower for females than males in the Havasu area.

Second-year Detection Probability Estimates – Second-year detection probabilities ranged from 29 to 72% and were lower than their respective adult detection probabilities in all three geographic areas. The effect of TP on detection probability of SY individuals was not consistent among geographic areas. In the Pahranagat Valley, SY detection probability increased from the second (31% and 54%, males and females, respectively) to third TP (50% and 72%, males and females, respectively), but could not be estimated for the first TP because no SY returns were documented prior to 2003. In the Virgin Valley, juvenile detection probability increased from the first (43%) to second (52%) TP and decreased slightly from the second to third (49%) TP. Detection probability across all TPs in the Havasu area was 29% for males and 56% for females. Where SY detection probability varied by gender (Pahranagat Valley and Havasu area), it was higher for females than males.

Juvenile Survival: Effect of Fledge Date

Goodness of fit tests indicated that the general model was a good fit for the data (bootstrap c-hat = 1.02, median c-hat = 1.00). The top model indicated that fledge date influenced survival probability (Table 3.23). There was little support for juvenile survival probability varying between geographic areas (ΔAICc > 5). We used model averaging to obtain survival estimates for the effects in the top model. Survival probability decreased through the season, corresponding to a 21% reduction in survival probability between 30 June and 1 August (Figure 3.8). Mean fledge date was 17 July, corresponding to a survival probability of 32%.

Table 3.23. AICc Model Selection Results of Effects of Geographic Area (Drainage) and Fledge Date on Juvenile Survival Probability along the lower Colorado River and Tributaries*

Model	AICc	ΔAICc	AICc Weights	K	Deviance
Φ (age+Date) p(Drainage *TP)	1783.91	0	0.9243	12	1759.63
Φ (Drainage*age+Date) p(Drainage*TP)	1788.92	5.0077	0.0756	16	1756.43
Φ (age) p(Drainage*TP)	1801.80	17.8875	0.0001	11	1779.56
Φ (Drainage *age) p(Drainage *TP)	1805.94	22.0243	0	15	1775.51
Φ (Drainage +Date) p(Drainage *TP)	1851.84	67.9233	0	13	1825.51
Φ (Drainage) p(Drainage *TP)	1868.06	84.1430	0	12	1843.78

* The entire candidate model set is presented.

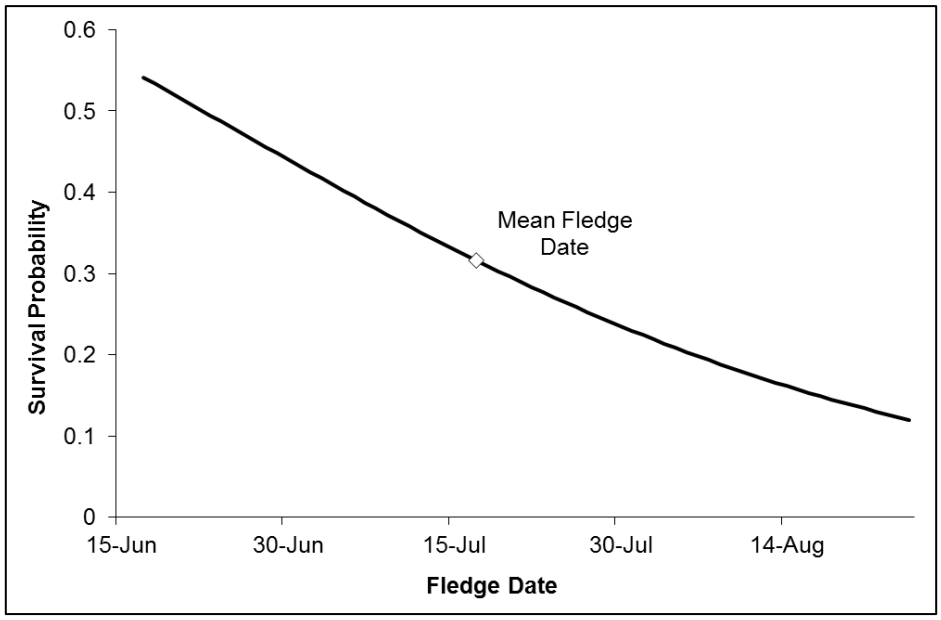

Figure 3.8. Juvenile survival probability by fledge date.

Annual Per Capita Rate of Population Growth

The top model in each geographic area indicated that recruitment varied by year (Tables 3.24–3.26). There was support for more than one model in each candidate set, and we model averaged to produce estimates of recruitment by year. Values presented in Table 3.27 are the average across all years for each term. Estimates of λ were 1.12 for the Pahranagat and Virgin Valleys, suggesting that each population is increasing by 12% per year. The lambda estimate in the Havasu area (1.06) suggested a lower rate of population growth (Table 3.27). The three geographic areas varied in the relative contributions of adult survival, local recruitment, and immigration to the λ estimates. The Pahranagat Valley had the highest rate of local recruitment (0.32) and, conversely, the lowest rate of immigration (0.17). While the Virgin Valley and Havasu areas had similar levels of fecundity, juvenile survival was slightly higher in the Virgin Valley, and therefore local recruitment was higher in the Virgin Valley (0.15) than in the Havasu area (0.11). In addition to having the lowest rate of local recruitment, the Havasu area had the lowest adult survival rate and the highest immigration rate (0.50).

Table 3.24. AICc model selection results of survival probability, detection probability, and recruitment (f) modeled as varying by time (t) or being constant (.) in the Pahranagat Valley*

Model	AICc	ΔAICc	AICc Weights	# Parameters	Deviance
Φ (.) p(.) f(t)	355.18	0	0.5277	4	0.08
Φ (.) p(.) f(.)	356.99	1.8029	0.2142	3	3.99
Φ (t) p(.) f(t)	357.31	2.1303	0.1819	5	0.08
Φ (t) p(.) f(.)	359.05	3.8699	0.0762	4	3.95

* The entire model set is shown. Detection probability is only modeled as constant as only data from 2010–2012 are included.

Table 3.25. AICc model selection results of survival probability, detection probability, and recruitment (f) modeled as varying by time (t or TP) or being constant (.) in the Virgin Valley*

Model	AICc	ΔAICc	AICc Weights	# Parameters	Deviance
Φ (.) p(TP) f(t)	2198.27	0	0.5837	18	238.01
Φ (t) p(TP) f(t)	2201.05	2.7847	0.1451	32	209.75
Φ (.) p(.) f(t)	2201.16	2.8898	0.1376	17	243.05
Φ (t) p(.) f(t)	2201.22	2.9499	0.1336	31	212.19
Φ (.) p(TP) f(.)	2217.56	19.2948	0	4	286.62
Φ (t) p(TP) f(.)	2223.44	25.1761	0	18	263.18

* The top five models are shown, as well as the general model.

Table 3.26. AICc model selection results of survival probability, detection probability, and recruitment (f) modeled as varying by time (t or TP) or being constant (.) at Havasu*

Model	AICc	ΔAICc	AICc Weights	# Parameters	Deviance
Φ (.) p(.) f(t)	1077.24	0	0.3096	17	96.74
Φ (t) p(.) f(.)	1077.86	0.6155	0.2276	17	97.36
Φ (t) p(TP) f(.)	1077.93	0.6891	0.2194	18	95.05
Φ (.) p(TP) f(t)	1078.75	1.5034	0.1460	18	95.86
Φ (.) p(.) f(.)	1080.78	3.5359	0.0529	3	131.29
Φ (t) p(TP) f(t)	1086.04	8.7961	0.0038	32	66.99

* The top five models are shown, as well as the general model.

Table 3.27. Estimates of Per Capita Rate of Population Growth (λ), 1997–2012*

Geographic Area	Survivorship (%)		Fecundity[1]	Local Recruitment	Immigration	λ
	Adult	Juvenile				
Pahranagat Valley	62.91	28.99	2.19	0.32	0.17	1.12
Virgin Valley	60.70	31.87	0.93	0.15	0.36	1.12
Havasu	45.58	21.90	1.00	0.11	0.50	1.06

* Survival estimates presented are for each geographic region in 1997–2012. Fecundity and immigration estimates are for the Pahranagat Valley in 2010–2012, the Virgin Valley (except St. George and Warm Springs) in 1997–2012, and the Havasu area in 1997–2012.

[1] Fecundity prior to 2003 may be inflated because there are no accurate records of females for which no nests were found; this may be especially true in 2002 when a rangewide drought reduced productivity.

When we calculated population trends from the total number of observed residents in each geographic region, we obtained estimates of the annual rate of change that were considerably lower than the lambda estimates (Table 3.28). The average annual rate of change calculated from a moving average of the number of resident individuals indicated an annual decline of 0.8% at Pahranagat NWR, an annual increase in the Virgin Valley of 0.9%, and an annual decline of 4.5% at Havasu. The slopes of the regression lines fitted to the number of observed resident adults in each geographic area were similar to the average rate of change estimates. The regression analysis indicated a non-significant ($r^2 = 0.057$, df = 1, $P = 0.390$) annual decline of 1.2% at Pahranagat NWR and a non-significant ($r^2 = 0.091$, df = 1, $P = 0.316$) increase of 1.5% per year in the Virgin Valley (Table 3.28, Figure 3.9). In the Havasu area, the regression analysis indicated a significant ($r^2 = 0.314$, df = 1, $P = 0.030$) decline of 6.4% per year.

Table 3.28. Annual Rate of Change Estimates from Linear Regression and Moving Average Calculations, 1997–2012

Geographic Area	Moving average	Regression			
	Annual % change	Annual % change	r^2	df	*P*-value
Pahranagat NWR[1]	-0.847	-1.210	0.057	1	0.390
Virgin Valley[2]	0.935	1.501	0.091	1	0.316
Havasu	-4.535	-6.401	0.314	1	0.030

[1] Data used in calculations are from 1998 to 2012 because formal monitoring was not implemented until 1998.

[2] Data used in calculations are from 2000–2012 because Mesquite West was first discovered in 2000.

Recruitment

We tracked the recruitment of 748 banded fledglings from 325 nests between 1997 and 2011. Of the 325 nests, 155 were associated with banded females who could be tracked across years. A total of 137 banded females were tracked, accounting for 532 of the 748 banded fledglings. Of these females, 62% produced at least one banded fledgling in only one nest, while the remainder produced banded fledglings from multiple nests (Figure 3.10). Of the 137 females, 51% never produced a fledgling that recruited into the adult population (Figure 3.11). Of the remaining females who produced at least one recruited fledgling, 81% had recruits from only one nest.

The number of banded fledglings and fledge date were retained in the nominal logistic regression model as predictors of recruitment (Table 3.29). There was no association between probability of a nest recruiting and parental breeding status (monogamous versus polygamous), geographic area, year, distance to water, or parasitism. On average, recruiting nests fledged earlier (12 Jul) than non-recruiting nests (19 Jul). The proportion of recruiting nests was higher for nests with four banded fledglings (63%) than those with only one banded fledgling (13%). The number of banded fledglings and fledge date were also significant predictors of the number of recruited fledglings per nest (Table 3.30). Fledge date was inversely related to the number of recruited fledglings, and, on average, nests that did not produce a recruit fledged later (19 Jul) than nests that produced one recruit (14 Jul), two recruits (6 Jul), or three recruits (8 Jul). The number of banded fledglings per nest was positively related to the number of recruited fledglings.

The Hot Spot analysis identified areas with significantly higher numbers of recruited fledglings per successful nest in all three study areas (Figures 3.12a–d). At Pahranagat North, the area of high recruitment shifted from the southwestern corner in 2003–2007 to the eastern side of the site in 2008–2011. Areas of high recruitment in Mesquite West were located on the eastern and northwestern sides of the site. At Mormon Mesa, areas of high recruitment were located at the northern and southern ends of the main breeding area occupied in 2007–2012.

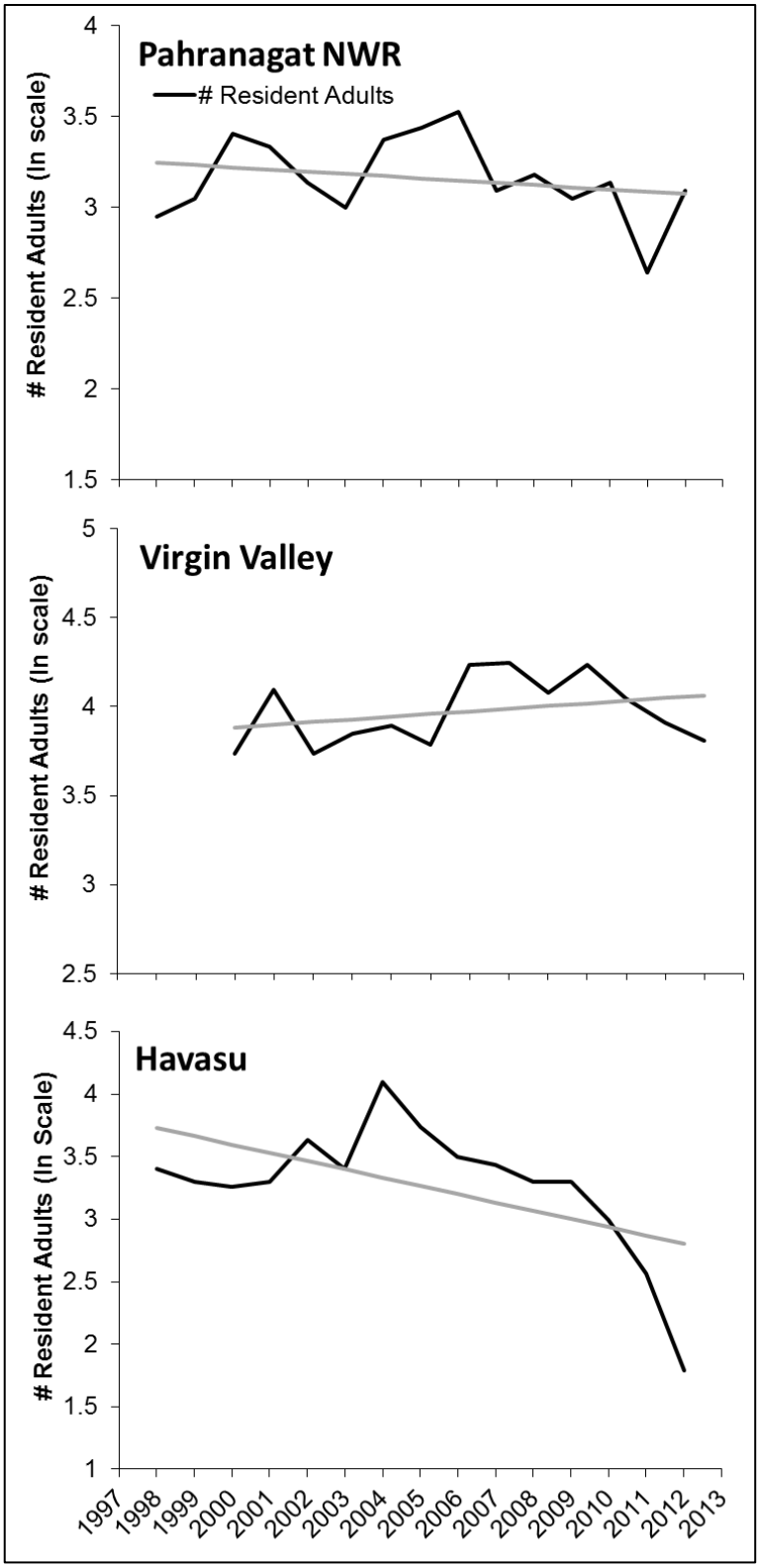

Figure 3.9. Number of resident adults per year by geographic area (ln scale), 1998–2012. Trend line (linear regression) shown in gray. Only data from 2000–2012 were used to calculate the trend line for the Virgin Valley due to expansion of the project area with the discovery of Mesquite West.

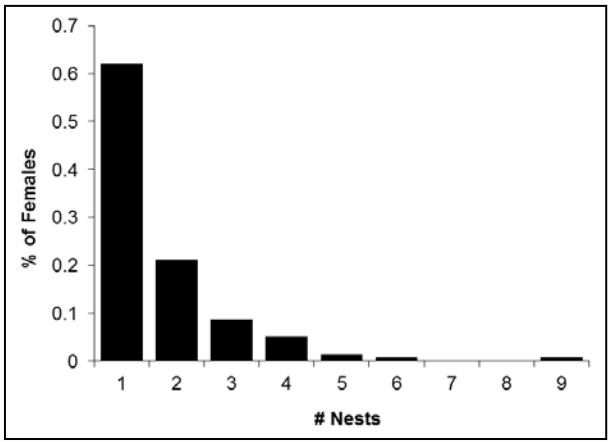

Figure 3.10. Frequency of the number of successful nests per banded female with at least one banded fledgling, 2003–2011.

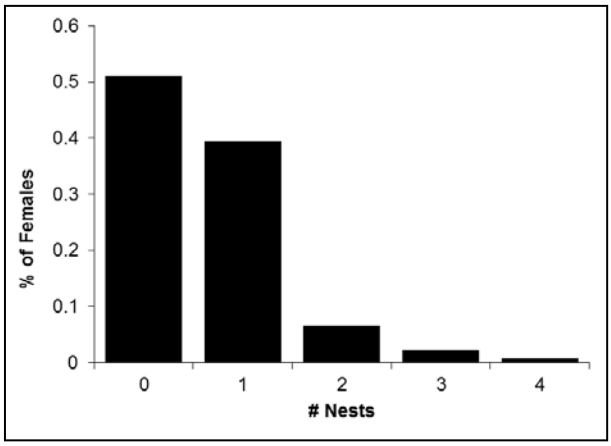

Figure 3.11. Frequency of the number of successful nests in which at least one fledging recruited per banded female, 2003–2011.

Table 3.29. Variables Retained in the Nominal Logistic Regression Investigating Factors That Affect Whether a Nest Produces a Recruit

Effect	Unit Increase	Odds Ratio*	95% CI	*P*-value
Number of Banded Fledglings	1 → 2 fledglings	3.676	1.449–10.318	0.009
	2 → 3 fledglings	2.237	1.086–4.701	0.031
	3 → 4 fledglings	1.039	0.357–3.181	0.945
Fledge Date	7 days (1 week)	0.741	0.616–0.880	<0.001

* Odds ratio indicates the effect than an increase of 1 unit in the predictor variable has on probability of a positive outcome (i.e., recruitment) in the dependent variable.

Table 3.30. Significant Predictors in the Ordinal Logistic Regression Investigating Factors That Affect the Number of Recruits a Nest Produces

Effect	Level	Odds Ratio	SE	X^2	*P*-value
Number of Banded Fledglings	1 WF → 2 WF	-1.320	0.504	6.86	0.009
	2 WF → 3 WF	-0.776	0.368	4.45	0.035
	3 WF → 4 WF	-0.314	0.518	0.37	0.544
Fledge Date		0.049	0.013	14.48	<0.001

[1] In ordinal logistic regression, a negative parameter estimate indicates a positive relationship and vice versa.

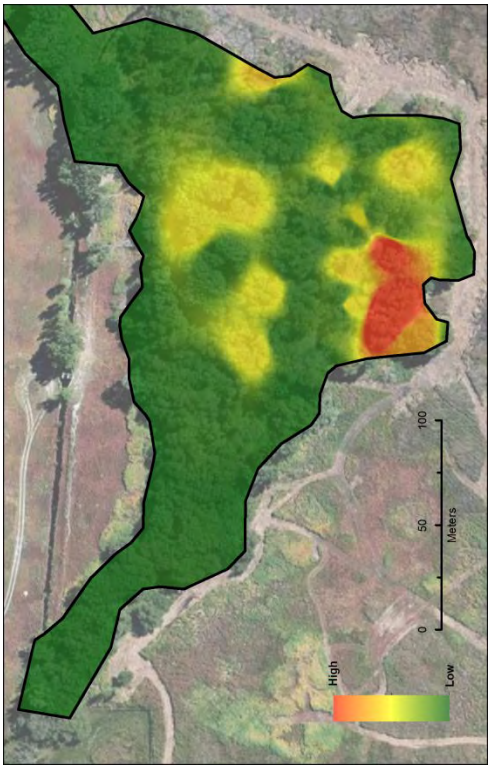

Figure 3.12a. Spatial distribution of the number of recruits per nest at Pahranagat North, 2003–2007. Areas of red have significantly more recruits per nest than areas of green.

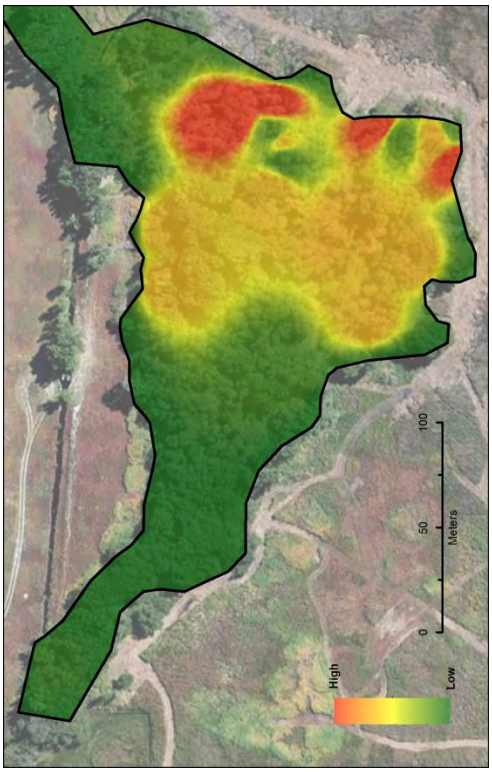

Figure 3.12b. Spatial distribution of the number of recruits per nest at Pahranagat North, 2008–2011. Areas of red have significantly more recruits per nest than areas of green.

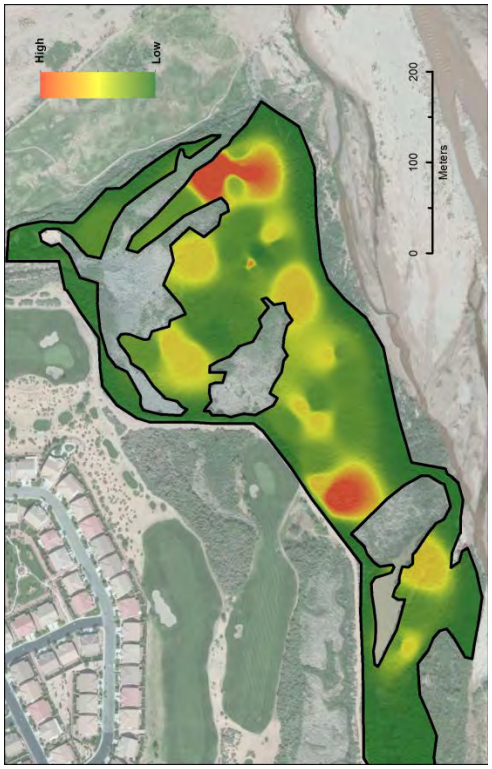

Figure 3.12c. Spatial distribution of the number of recruits per nest at Mesquite West, 2003–2011. Areas of red have significantly more recruits per nest than areas of green.

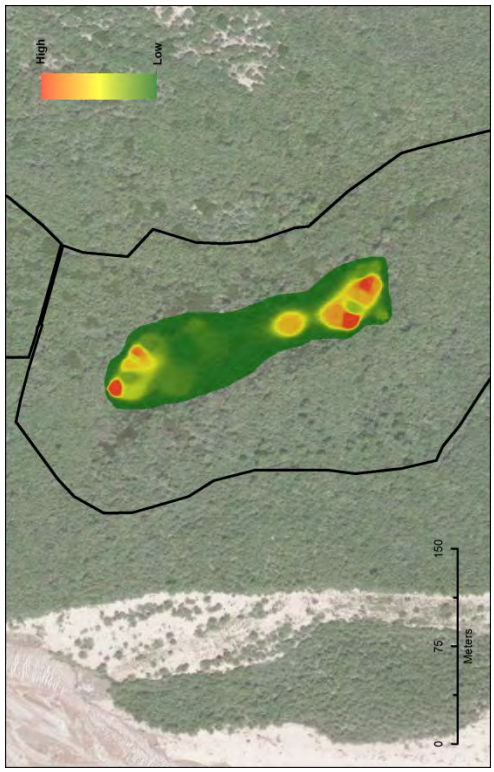

Figure 3.12d. Spatial distribution of the number of recruits per nest at Mormon Mesa Virgin River #1 South, 2008–2011. Areas of red have significantly more recruits per nest than areas of green.

DISCUSSION

We maintained high overall percentages of banded flycatchers annually over the 10-year study, and resights and recaptures of color-banded individuals form the basis for all analyses of movement and demographics. Differences between study areas in the percentage of color-banded individuals are directly related to vegetation density and overall structure, which affected our ability to erect mist-nets in the habitat. For example, in 2003–2012 an average of 92% of the resident flycatcher population at Pahranagat was color-banded versus 60% at Topock. Pahranangat has a relatively open understory, and personnel were able to deploy a large number of long mist-nets over the entire site, whereas the dense vegetation at Topock only allowed for one or two small nets to be deployed in relatively few areas.

Leg Injuries

We observed over three times the rate of leg injuries with plastic bands compared to metal color-bands. These results are similar to those of Koronkiewicz et al. (2005), who showed that metal color-bands reduced leg injuries in the willow flycatcher. Sedgwick and Klus (1997) also reported a high incidence of leg injury (9.6%) in willow flycatchers due to plastic color bands, particularly when plastic bands were used in combination with a federal band on the same leg. The rate of leg injuries with metal color-bands (5%) is roughly the same as that with federal bands (3%). Although the absolute number of injuries has increased from the previous contract period to the current period, the rate of injuries with both federal and metal color-bands has stayed the same or decreased slightly.

The presence of leg injuries did not significantly reduce return rate. While return rate was lower for leg-injured individuals, median age for this group was higher than that of non-leg-injured individuals, and return rate is likely to be lower for older individuals regardless of injury. The presence of a leg injury did not reduce the probability that a male would attract a mate. The proportion of leg-injured resident males that bred at least once while injured was higher than that of non-leg-injured resident males. This could also be related to age, which was higher for leg-injured males and might have allowed the leg-injured males to secure better territories. The presence of a leg injury also did not affect breeding success for males. Data suggested that leg-injured females could be less likely to produce a fledgling than their non-injured counterparts, but sample size was too small to draw definite conclusions. Although leg injuries could potentially impact reproductive success, rate of injuries is low. The potential risks of color-banding do not seem to outweigh the overall benefit of understanding population dynamics through demography studies.

Gender Ratio

Fledgling gender ratio varied by geographic area and study area, ranging from 28 to 67% female, but overall was 47% female, which was significantly different from an equal ratio. While our methods noted a statistically significant difference in the overall ratio from 50:50, we do not believe this is a biologically important bias. These results are similar to those from central Arizona (Paxton et al. 2002), where ratios by geographic area ranged from 40 to 71% female but averaged 55% female. Paxton et al. (2002) hypothesized that a skewed nestling gender ratio could lead to a skewed adult gender ratio in some cases. There is no evidence that fledgling gender ratio influenced the gender ratio of resident adults in any of the geographic areas we studied. The average gender ratio for resident adults across all years from 2003 to 2012 was slightly male biased (33–48% female) in each study area. These adult gender ratios do not reflect their associated fledgling gender ratios. This discrepancy is likely influenced by immigration, which varied from 17 to 50% across all geographic areas (see Demographics: Annual Per Capita Rate of Population Growth).

Between-Year Return and Dispersal

Adult flycatchers exhibited strong between-year site fidelity, with half of all between-year returns resulting in a return to the same territory (<50 m from previous location) and less than 20% of between-year returns resulting in a movement of more than 1 km. From 1997 to 2012, 11 of 589 between-year returns resulted in movement between the Pahranagat Valley, Virgin Valley, and Havasu geographic areas. Adult willow flycatcher return and dispersal data are consistent with range-wide data (Kenwood and Paxton 2001, Koronkiewicz et al. 2002, Newell et al. 2005), with adult flycatchers likely to exhibit high site fidelity to breeding areas.

In contrast, over 70% of juveniles dispersed over 1 km from their natal territories, with 90% of all recorded dispersal movements being 75 km or less. Paxton et al. (2007) also found that natal dispersal distances were greater than the between-year movements exhibited by adults. Natal dispersal is greater than adult dispersal in most birds (Gill 1995). Twenty juveniles (10% of returning juveniles from 1998 to 2012) dispersed out of their natal geographic area. Juvenile dispersal within the Virgin/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. Other populations (e.g., Roosevelt Lake, San Pedro River, Kern River, Camp Pendleton) were monitored during all or part of our study, and only one instance of emigration was recorded, with an individual banded as a juvenile at Mesquite dispersing to Kern River, California. Three instances of immigration from sites outside the Virgin/lower Colorado River region have been recorded since 1997, with individuals banded as juveniles at Roosevelt Lake recaptured at Grand Canyon, Topock, and Muddy River.

These demographic traits fit well with the tenets of contemporary metapopulation theory (Hanski and Simberloff 1997), suggesting the Virgin/lower Colorado River population may be a panmictic sub-population of a greater metapopulation. Occasional juvenile dispersal between subpopulations is likely an important population variable in terms of both gene flow and possibly the establishment of new flycatcher populations. These juvenile movements contribute 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). Physical connectivity of riparian habitats within the greater landscape is crucial in enabling these long-distance movements. Without adequate stop-over habitats and foraging areas, flycatchers attempting long-distance movements are more likely to be exposed to adverse environmental conditions.

Paxton et al. (2007) found that juveniles not only dispersed farther than adults, but that only 2% of them returned to their natal patch. In comparison, 30% of juveniles along the LCR and tributaries returned to their natal patch, and 3% returned to their natal territory. These differences in juvenile dispersal patterns could be indicative of limited habitat distribution in the geographic areas we studied, with juveniles having fewer alternatives to their natal patch than do juvenile flycatchers in central Arizona. The adult between-year movement patterns we observed are also suggestive of a fragmented distribution of breeding habitat. In the Havasu region, there were no adult movements between the Bill Williams and Topock Marsh study areas. The distance between Bill Williams and Topock Marsh (~70 km) is no greater than adult movement distances we recorded within the Virgin Valley, but there is very little riparian habitat between the two study areas, and the lack of connecting habitat may inhibit adult movements. Breeding patches along the Virgin and Muddy Rivers are more evenly distributed than in the Havasu area, and adults within this drainage tended to move farther and switched patches more often than adults in the other two drainages. A similar pattern was seen for Virgin Valley juveniles compared to Pahranagat Valley and Havasu juveniles. In the Virgin Valley, dispersal distances had a clumped distribution, with peaks in the distribution corresponding to the distances between isolated study areas. Paxton et al. (2007) reported a similar phenomenon at Roosevelt Lake, Arizona, where patches were clumped at the two inflows to the reservoir. Adults in the Pahranagat Valley were more likely to return to the same territory

than adults elsewhere. The majority (73%) of adult returns in the Pahranagat Valley were of flycatchers from Pahranagat NWR, and 25% of adult returns in the Pahranagat Valley were from Key Pittman. These two study areas had the highest fecundity rates of any of the study areas we examined (see Chapter 4). The likelihood of a flycatcher exhibiting territory fidelity is highly dependent on breeding success in the previous year, and the propensity of flycatchers in the Pahranagat Valley to return to their previous territory may be influenced by these high rates of breeding success. In central Arizona, the odds of territory fidelity in the following year increased by 1.5 for every fledgling produced (Paxton et al. 2007). Juveniles in the Pahranagat Valley were more likely to return to their natal patch than juveniles elsewhere. However, intensive monitoring of Key Pittman did not begin until 2010, and the apparent high rate of return to the natal patch in the Pahranagat Valley is likely influenced by the low probability that we would have detected return to a different patch before 2010.

Within-Season Movement

We detected several adult within-season, between-study area movements, a majority (56%) of which returned the following year. A large proportion (69%) of the returning individuals returned the following year to the site where they were last observed the previous year. A larger percentage of the returning individuals (54%) were detected as non-territorial adults at the end of the previous year after holding a territory or breeding elsewhere. These individuals may have been 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 Survival and Detection

Mean life expectancy, as calculated from adult and juvenile survival probabilities, varied between genders and geographic areas. Estimates for male mean life expectancy ranged from 1.7 years post-fledging at Havasu to 2.5 years post-fledging in the Pahranagat Valley. Female mean life expectancy estimates ranged from 0.7 years post-fledging at Havasu to 1.8 years post-fledging in the Virgin Valley. Estimates for both genders in the Virgin Valley as well as for Havasu males were similar to that in central Arizona (1.9 years across both genders; Paxton et al. 2007). Life expectancy estimates for females in the Pahranagat Valley and at Havasu were considerably lower than this 1.7–1.9 year-range, while the estimate for males in the Pahranagat Valley was higher. Longevity records were at least 12 years old for males and 10 years old for females. These records are greater than the record of an individual at least 9 years old noted by Paxton et al (2007), whose study was shorter (10 years) than the combined length of this study (15 years). Sedgwick (2000) noted one record of a willow flycatcher that was at least 10 years old in Oregon.

Adult survivorship estimates across both genders in the Pahranagat and Virgin Valleys (63% and 61%, respectively) for the full period of study (1997–2012) were 3% higher in each area than those reported for these same geographic areas in 1997–2007 (McLeod et al. 2008a), and were similar to those reported from central Arizona (64%; Paxton et al. 2007). Adult survivorship rates at Havasu were lower (46%) than at the other two areas, but slightly higher than the estimate of 41% reported in McLeod et al. (2008a). Survival estimates from the Pahranagat and Virgin Valleys are higher than those of many other neotropical migrants (49% cerulean warbler [*Setophaga cerulea*], Jones et al. 2004; 50% warbling vireo [*Vireo gilvus*], Gardali et al. 2000; 56% Swainson's thrush [*Catharus ustulatus*], Gardali et al. 2003). This could be due to the generally large size of the study area that allows for greater detection of movements within and between drainages. Cilimburg et al. (2002) noted a 2–10% increase in estimates of apparent survival probability when their study area was increased to account for emigrants from the core study area.

Our models found evidence that adult survival differed by gender in the Pahranagat Valley, with males having higher survival rates than females. Adult survival estimates did not differ by gender in the Virgin Valley or Havasu areas, and Paxton et al. (2007) found no evidence that survival differed by gender in central Arizona. In McLeod et al. (2008a), we reported equivocal results on whether survival probabilities varied by gender, with models showing some support that males had higher survival rates than females. Gender-specific survival estimates, with males having higher survival than females, have been shown for other passerine species (black-throated blue warbler [*Setophaga caerulescens*], Sillett and Holmes 2002; yellow warber [*Setophaga petechia*], Cilimburg et al. 2002; ovenbird [*Seiurus aurocapilla*]; Bayne and Hobson 2002; northern wheatear [*Oenanthe oenanthe*], Low et al. 2010). One hypothesis for higher survival rates in males is that females experience higher on-nest predation risk (Donald 2007, Low et al 2010). In central Arizona, Paxton et al. (2007) found little evidence for adult mortality within the breeding season (adult survivorship = 97%). Based on survivorship estimates from the breeding and wintering grounds, they estimated that the highest mortality occurred during migration (survivorship = 87%). A similar pattern was found with black-throated blue warblers where monthly survival was high (99–100%) during both the breeding and non-breeding season, but was significantly lower (77–81%) during migration (Sillett and Holmes 2002). No clear explanation for differential mortality during migration from the wintering grounds to the breeding grounds exists, given that both sexes occupy the same habitat and defend individual territories (Koronkiewicz et al. 2006). However, reduced body condition as a result of reproductive effort could reduce female survival during fall migration to the wintering grounds.

Differences in survival estimates between the three geographic areas could be partially due to sample size. Havasu had the smallest sample size, with 43 adults detected in multiple years, compared to 104 in the Pahranagat Valley and116 in the Virgin Valley, and small sample sizes may inhibit the ability of the models to produce accurate survival estimates. However, Havasu also had the smallest proportion (7%, compared to 17% at Pahranagat and 16% at the Virgin Valley) of returning adults that exhibited gaps in their detection histories (i.e., detected in one year and then not detected again until two or more years later). Gaps in detection history suggest the bird is either outside our monitored areas or is a non-territorial resident within monitored areas, and therefore goes undetected for a period of time. The former explanation may account for some gaps in detection histories in the Pahranagat Valley, given the presence of potentially suitable flycatcher habitat on private land that is unmonitored within the Pahranagat Valley and at Key Pittman, which was not monitored by SWCA until 2010. Similarly, patches of suitable habitat within the Virgin Valley may not have been discovered in the first year the site was occupied (e.g., Virgin River #2, Dumb Luck Bridge), which may account for some gaps in detection histories. However, non-territorial resident flycatchers were documented in central Arizona, accounting for 3–25% of the total annual population at Roosevelt Lake in 2001–2005 (Paxton et al. 2007), and also were occasionally detected in this study through resighting or passive netting. It is likely that some gaps in detection histories occurred in years when the individual was present in our study areas but was not territorial. The presence of non-territorial resident adults suggests optimal habitat is full, and the lack of gaps in detections at Havasu indicates there are few non-territorial residents that return in a later year as territorial individuals. This could imply that suitable habitat goes unoccupied, which would be consistent with a declining population, or could mean that flycatchers leave the monitored areas entirely rather than returning in a subsequent year.

Mark-recapture models cannot distinguish death from permanent emigration, so it is possible that Havasu individuals are permanently leaving the study area to search for other breeding sites, although there is little evidence of this in the observed movement data. From 2003 to 2012, only three Havasu adults were detected in another geographic region (the Virgin Valley), and there have been no recorded movements of adults between Topock and Bill Williams. Given the low proportion of resident adults that have been marked within the Havasu area, it is possible that more movements to other areas have occurred and gone undetected. There are no known breeding sites in the Havasu area along the mainstem of the Colorado or

in the Bill Williams River NWR that are not monitored, but Alamo Lake and the Big Sandy River upstream from Bill Williams River NWR have historically supported breeding flycatchers, and flycatchers have also been detected in the Lincoln Ranch area between Alamo Lake and Bill Williams River NWR (Greg Beatty, USFWS, pers. comm.). These areas could be both a source of unbanded flycatchers in the area as well as a destination for emigrating individuals.

Detection probabilities for adults in the Pahranagat and Virgin Valleys were higher during 2003–2012 than in the previous five years; however, detection probabilities did not differ between contract periods for adults in the Havasu area. The higher detection probabilities in the Pahranagat and Virgin Valleys in 2003–2012 may be the result of the switch to metal color-bands, which retain their colors for a longer period than plastic bands and do not fall off, and may also have been influenced by differences in data recording and synthesis techniques between the two periods. High probabilities of detection should result in more precise estimates of survival. Detection probabilities varied by gender in the Pahranagat Valley and Havasu area. Female detection probability was higher than male detection probability in both contract periods (i.e., 1997–2002 and 2003–2012) in the Pahranagat Valley, but lower than that for males in the Havasu area. There is no obvious cause for the differences in pattern of detection probability between the genders in the Pahranagat Valley and Havasu area.

Juvenile Survival and Detection

Model results indicated that apparent juvenile survival was lower than that of adult survival in all geographic areas, ranging from 21 to 39% with an overall survival rate of 32%. Paxton et al. (2007) found similar estimates of juvenile survival in central Arizona (34%). Estimates in all three geographic areas are likely low as the models do not account for emigration outside of the natal geographic area. Models also indicated that juvenile survival varied by gender in the Pahranagat Valley and Havasu area, with survival estimates being higher for males than females. Some studies have attributed lower juvenile female survival probability to higher post-natal dispersal probability (Clarke et al. 1997, Dale 2001). No evidence of higher female post-natal dispersal was found in this study or in central Arizona (Paxton et al. 2007), but Clarke et al. (1997) warn against considering any potential sex bias in dispersal (or lack thereof) to be a species constant. We therefore cannot rule out the possibility that juvenile females in all three geographic areas are dispersing outside our monitored sites in search of alternative suitable habitat. Greenwood (1980) proposed that in systems where males defend the resources or territories necessary for obtaining a mate, females are more likely to disperse and therefore choose among males and defended resources.

Juvenile survival probability varied by fledge date with higher survival probability associated with an earlier fledge date. Survival probability decreased by 1% per day, and ranged from 54% in mid-June to 12% in late August. Mean fledge date across all study areas was 17 July, which was associated with a 32% survival probability. Similar trends were found in central Arizona (Paxton et al. 2007), with survival decreasing by 2% per day. Average fledge date was 10 days earlier in central Arizona than along the LCR and tributaries, though mean survival probability in central Arizona was very similar (34%) to what we recorded in this study. One explanation for survival varying by fledge date is that individuals fledging later in the season may not have enough time to mature sufficiently before migration. Another explanation for the decrease in survival probability through the season could be related to seasonal changes in food resources associated with the seasonal fluctuations in hydrology noted in many of the breeding sites (see Chapter 2). Observed factors that influence fledge date include depredation and parasitism, both of which often force a female to renest, thereby delaying fledge date. The average fledge date for parasitized females that succeed in producing young was 10 days later than for non-parasitized females (see Chapter 4).

Detection probabilities for returning juveniles in their second year differed between contract time periods in the Pahranagat and Virgin Valleys with no consistent pattern, and did not differ between contract time periods at Havasu. Juveniles were banded with full color combinations using plastic bands in 1997–2002, making it possible to resight the individual in subsequent years. In 2003–2007, we marked juveniles with single federal bands only, necessitating recapture of the individual to determine its identity in the event it returned in a subsequent year. In study areas with extremely dense vegetation (e.g., Topock Marsh), capture of individuals was difficult, and each year there were individuals with single federal bands remaining at the end of the season. In 2008–2012, we banded all juveniles with full color combinations, using metal color-bands. We expected detection rate to increase from the second to the third contract period, and that both of those contract periods might differ from the first contract period. While SY detection probability increased from the second to third contract period at Pahranagat, it did not in the Virgin Valley and Havasu area. While detection probabilities do not currently show strong support for the use of full color combinations on juveniles, the effort required to identify returning juveniles with full color combinations is lower than for juveniles banded with single federal bands. Therefore, we recommend continuing to use full color combinations on all nestlings.

Second-year detection probabilities varied by gender in both the Pahranagat Valley and Havasu area and were higher for females than males in both areas. This suggests that females are less likely than males to be resident but non-territorial in their second year.

Annual Per Capita Rate of Population Growth

Lambda values presented in our previous summary report (McLeod et al. 2008a) did not include estimates of immigration and thus are not directly comparable to the λ estimates presented here, which include estimates of immigration derived from Pradel models. Lambda values in the Pahranagat and Virgin Valleys each indicated a 12% annual increase in the flycatcher population. The relative weights of the components that contributed to each estimate differed, however. Adult and juvenile survivorship estimates were similar to their respective counterparts in the two areas, but fecundity in the Virgin Valley was less than half that of the Pahranagat Valley, and immigration was correspondingly higher. Lambda estimates were lowest for the Havasu area at 6% annual growth. Lower adult and juvenile survivorship contributed to this lower estimate. The fecundity rate in the Havasu area was the same as in the Virgin Valley, and immigration in the Havasu area was the highest of all three geographic areas. The λ estimates appear to be over-estimating the rate of population growth in comparison to the annual number of resident adults documented in each geographic area from 1998 to 2012 (Figure 3.9). One explanation may be the difference between the observed number of resident adults and the data used by program MARK to calculate recruitment rates. Pradel models rely on the number of "newly marked" adults on a given occasion (year) to determine the rate of recruitment from one occasion to the next. Newly marked adults can consist of newly captured (i.e., previously unbanded) adults or returning juveniles identified for the first time as adults. The between-year change in number of newly marked individuals did not always reflect the corresponding change in the total number of resident adults (Figure 3.13). It most closely mirrored the annual changes in population size at Pahranagat NWR, where a high percentage of banded birds (92%) has been maintained. The largest discrepancy between the number of newly marked individuals and the number of resident adults was at Havasu, where vegetation structure limits banding opportunities, and an overall low percentage of adults (64%) were banded.

Lambda estimates, as calculated through methods such as Pradel models, have also been demonstrated to have a significant positive bias at small sample sizes with low survival probability (Fiske et al. 2008). To help determine the magnitude of this potential bias, we also calculated the annual population growth rate based on the observed number of resident adults, using both an average annual rate of change based on a three-year moving average as well as a linear regression. These additional methods produced estimates within one percent of one another and 10–13% lower than the λ estimates obtained through Pradel models. As with the λ estimates, the additional population growth rate estimates in the Pahranagat and Virgin Valleys were very similar (-1% per year and 1% per year, respectively), and both were higher than the population growth estimate in the Havasu area (-6% per year).

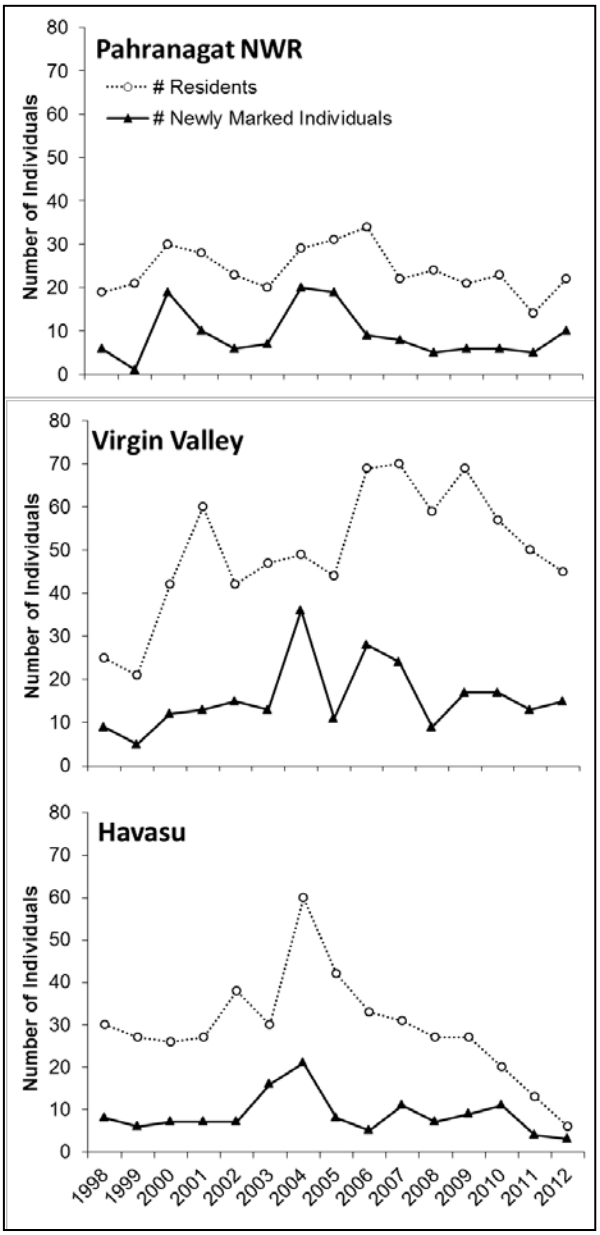

Figure 3.13. Number of resident adults and number of newly marked individuals per year by geographic area, 1998–2012

The difference in λ estimates and the average annual rates of change as calculated through moving averages and linear regression also indicate that the λ estimates are potentially biased high. Fiske et al. (2008) noted that the observed significant bias led to high lambda estimates when sample sizes were small (<100 individuals) and survival probability was low (50%). In all three geographic areas, sample sizes are near or below 100 individuals, and survival probability is relatively low, not exceeding 61%. Despite the bias in λ estimates as calculated from recruitment estimates generated by Pradel models, we recommend continuation of this modeling method. To help determine the presence of any potential bias, the annual rate of population change should be calculated using either a linear regression or the moving average calculation. Unlike the additional population growth rate estimates, Pradel models also help inform a greater understanding of the underlying demographic processes driving population growth rates. Understanding how reliant a population is on immigration versus local recruitment is important for management decisions as high immigration levels indicate that actions may be needed to improve local recruitment.

Recruitment

We ran an exploratory analysis to identify environmental factors that might influence recruitment. The majority of females that produced recruited fledglings did so with only one nest. This indicates that the recruitment probability associated with a given nest was more heavily influenced by environmental factors than parental influence. The probability of a nest recruiting was not directly predicted by any environmental factor. Instead it was positively predicted by the number of banded fledglings and negatively predicted by fledge date. While survival probability for any individual nestling may not be influenced by brood size, increasing productivity is essential to improving local recruitment and consequently population growth rate and stability (see Annual Per Capita Rate of Population Growth). Factors that reduced observed clutch size and consequently the number of fledges produced per nest included parasitism, second or third nest attempts, and increasing distance to water when the nest was found (see Chapter 4: Clutch Size). Reduction in both the predator community and local cowbird population in areas with high depredation and parasitism rates could improve productivity, thereby improving local recruitment.

The Hot Spot analysis showed distinct areas of high recruitment within the sites of Pahranagat North, Mesquite West, and Virgin River #1 South. It is currently not possible to determine what factors are influencing the presence of hot and cold spots within each site, but likely some combination of hydrology and vegetation structure, which have varied over time, have driven the pattern. Surface water has shifted noticeably within both Pahranagat North and Mesquite West over the course of the study. Prior to 2008 at Pahranagat North, the entire site was regularly inundated in May when flycatchers arrived. Now, the area of inundation is limited more to the southeastern corner, which is where the hot spots of recruitment are currently located. At Mesquite West, one of the hot spots is located in an area that is no longer occupied. The flood of 2004–2005 deposited a thick layer of sediment in that portion of the site with the result that surface water no longer reached that area. Certain vegetation structure components may lead to higher depredation rates if nests are more visible. As with all habitat components, these components are likely to vary spatially, potentially leading to distinct hot and cold spots.

Future directions for potential research include calculating individual juvenile survivorship estimates in association with various environmental factors, including the ones considered in this analysis. Other factors could include nest site vegetation and microclimate characteristics and juvenile body condition near fledge date.

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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. From 2003 to 2012, 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) for fecundity calculations, calculating nest success and failure, documenting causes of nest failure (e.g., abandonment, desertion, depredation, and brood parasitism), and calculating nest productivity. 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 two to four days after nest building was complete and incubation was confirmed. Nests at NDOW study areas were monitored less frequently (every four days or more) because of budgetary restrictions. During incubation and after hatching, nest contents were observed directly 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. During each nest check, we recorded 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 onto standardized data forms that included the nest or territory number and UTM coordinates.

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 two 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 two 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 nest was parasitized during egg laying and the disappearance of all flycatcher eggs coincided with the appearance of cowbird eggs.

From 2010 to 2012, we attempted to addle cowbird eggs in easily accessible flycatcher nests at all study areas except Pahranagat. Pahranagat was not included because it was still part of the 5-year post-cowbird-trapping experiment. 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 mm vs. 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.

Data Analyses

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 (2.12, 12.87, and 13.76 days for laying, incubation, and nestling stages, respectively) as observed in this study in 2003–2012 for nests where transition dates were known.

We calculated daily nest survival rate (DSR) for each nest stage in each study area (SA) and calculated the associated variance per methods described in Johnson (1979). We compared DSR between study areas for a given nest stage by entering DSR and variance values into the following equation:

$$Z = \frac{DSR(SA\ 1) - DSR(SA\ 2)}{\sqrt{(Variance\ (SA\ 1) + Variance\ (SA\ 2)}}$$

The resulting Z-score was compared to a standard normal cumulative probability table, and the difference between study areas was considered significant ($\alpha = 0.05$) if $|Z| > 1.65$.

Nest productivity was calculated as the number of young fledged per nesting attempt that produced at least one flycatcher egg. 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. Productivity and fecundity were compared across study areas using ANOVA and Tukey's HSD in SPSS® Version 15.0 (SPSS Inc.). A statistical significance level of $P \leq 0.05$ was chosen to reject null hypotheses.

We pooled data across all study areas and years 2003–2012 to examine whether clutch size varied between study areas or over successive nesting attempts within a season. We limited the data set to nests for which we documented final clutch size (i.e., nests that did not fail during laying and were not parasitized). We used an ANOVA and Tukey's HSD in SPSS for all comparisons. We also compared observed clutch size in parasitized versus non-parasitized nests with an ANOVA. To determine the relative importance of each effect on observed clutch size, we ran an ordinal logistic regression in JMP 10 (SAS Institute 2012) and included geographic area (see Chapter 3), year, nest attempt number, distance to water, breeding status, and parasitism as predictor variables. Data for this analysis were restricted to years in which we had recorded distance to water at the time the nest was found. In 2004 and 2005, any distance to water over 30 m was recorded as "30+". We estimated distance to water in these cases whenever sufficient information on hydrology within the site was available; otherwise, these nests were excluded. We therefore used all nests with a distance to water measurement which contained at least one flycatcher egg and for which nest contents were known from 2004–2012 in analysis of clutch size.

We also determined the relative importance of the same effects on the number of fledglings per nest. All successful nests for which nest contents were known and distance to water was recorded or could be estimated from 2004–2012 were used in analysis of number of fledglings per nest. We again used an ordinal logistic regression and included the observed clutch size, geographic area, year, distance to water, parasitism, breeding status, and fledge date (as a proxy for nest initiation date) as predictor variables.

Age-based Seasonal Productivity

We pooled data across all study areas and years (1997–2012) to analyze the effects of female age on seasonal productivity. We used likelihood ratio tests (G^2) based on a contingency table to determine whether the number of fledges produced in a season was independent of female age. Because the data were not completely independent, owing to some females occurring in multiple cells, we used a Rao-Scott adjustment (Rao and Scott 1981, 1984, 1992; Lavassani et al. 2009) to adjust G^2 and then calculated a new *P*-value based on the adjusted value and adjusted degrees of freedom. The number of fledges produced in a season was rarely more than four, and we collapsed values of 4+ fledges into a single category. We also collapsed female ages of 5+ into a single category because of low sample size. In a separate analysis, we collapsed female ages of 3+ into a single category to determine whether the productivity of second-year females differed from all other age classes.

Using similar methods as above, we examined whether seasonal nest success (the percentage of all nesting attempts in a given season that fledged at least one young) and seasonal parasitism rate (the percentage of all nesting attempts in a given season that contained at least one cowbird egg) were independent of female age. Nest success and parasitism rates were re-categorized as ≤0.50 and >0.50.

Lifetime Productivity

We pooled all available data across all study areas from 1997 to 2012. We excluded individuals of unknown age that were detected as adults only in the first two years of the study, and we excluded all individuals whose minimum age at the end of the study in 2012 was ≤3 (per Paxton et al. 2007). Seventy percent of known-age adults in this study were detected for only one or two seasons as adults and are

presumed to have died following the last detection; therefore, restricting the data set in this way allows us to include only those flycatchers for which we are likely to have observed the majority of their breeding years. For this analysis, nests with unknown fate were presumed to have failed. Individuals with gaps in their encounter histories (i.e., individuals that were not detected for an entire season but were then detected in a subsequent season) were assumed to have zero productivity for the season(s) in which they were not detected. Individuals that were detected but were not determined to be breeding were also assumed to have zero productivity for that year. Extra-pair paternity has been demonstrated in Southwestern Willow Flycatchers (Pearson 2002), but for purposes of this analysis we assumed that all offspring in a nest were sired by the male associated with that nest.

We used a nonparametric ANOVA with 1,000 bootstrap resamples to analyze the effects of gender and geographic region (Pahranagat Valley, Virgin Valley, and Havasu; see Chapter 3) on minimum lifetime productivity. Flycatchers that transitioned between geographic regions during their adult lifetime were represented twice in the database, with total reproductive output within each region considered to be their "lifetime" productivity within that region. The bootstrapped intervals did not differ from the nonparametric results, so the standard nonparametric results are provided.

We used a Poisson regression model to determine whether repeated parasitism events affected lifetime productivity for female flycatchers. We used a hybrid parameter estimation method with a scale parameter deviance method to protect against overdispersion. A robust covariance estimator was used. Estimation was carried out with a maximum of 100 iterations, with an absolute convergence criteria for change of 1E-006. Model effects were tested using Type III SS. We tested the effects of two measures of parasitism in separate models: the proportion of breeding years in which the female was parasitized at least once (hereafter parasitism rate by year), and the proportion of total lifetime nesting attempts that were parasitized (hereafter lifetime parasitism rate). We included geographic region and the number of breeding seasons as effects in the full models and then ran separate models for each geographic region.

RESULTS

Reclamation Study Areas

Nest Monitoring

We documented 688 willow flycatcher nesting attempts at Pahranagat, Littlefield, Mesquite, Mormon Mesa, Muddy River, Grand Canyon, Topock Marsh, and Bill Williams; 611 of these nests were known to contain flycatcher eggs and were used in calculating nest success and productivity. Two hundred sixty-nine (44%) nests were successful and fledged young, and 328 (54%) failed. Fate was unknown for 14 nests (2%). For all years combined, nest success ranged from 0% at Grand Canyon to 68% at Pahranagat (Table 4.1). Mean clutch size was 3.2 at Pahranagat and ranged from 2.5 to 2.7 at all other study areas.

Table 4.1. Summary of Willow Flycatcher Nest Monitoring Results at Reclamation Study Areas, 2003–2012*

Study Area[1]	Year	Pairs	Nests	Nests with 1+ WE[2]	Mean clutch size	Successful Nests[3]	Failed Nests[3]	Nests with Unknown Fate	Parasitized Nests[4]
PAHR	2003	8	12	11	3.3	10 (91)	1 (9)	0	0
	2004	14	17	17	3.5	13 (76)	4 (24)	0	0

Table 4.1. Summary of Willow Flycatcher Nest Monitoring Results at Reclamation Study Areas, 2003–2012* (Continued)

Study Area[1]	Year	Pairs	Nests	Nests with 1+ WE[2]	Mean clutch size	Successful Nests[3]	Failed Nests[3]	Nests with Unknown Fate	Parasitized Nests[4]
	2005	11	21	19	3.3	11 (58)	8 (42)	0	0
	2006	15	18	15	3.1	9 (60)	6 (40)	0	0
	2007	10	12	12	3.0	8 (67)	4 (33)	0	0
	2008	9	12	10	3.1	8 (80)	2 (20)	0	0
	2009	10	18	17	3.1	8 (47)	8 (47)	1 (6)	0
	2010	10	20	17	3.1	10 (59)	7 (41)	0	0
	2011	6	7	7	3.5	7 (100)	0	0	0
	2012	12	14	14	2.9	10 (71)	4 (29)	0	0
	Total	*105*	*151*	*139*	*3.2*	*94 (68)*	*44 (32)*	*1 (1)*	*0*
LIFI	2003	0	--	--	--	--	--	--	--
	2004	1	3	2	3.0	1 (50)	1 (50)	0	0
	2005–2008	0	--	--	--	--	--	--	--
	2009	2	2	1	1.0	0	1 (100)	0	1 (100)
	2010	1	2	2	3.0	1 (50)	1 (50)	0	0
	2011–2012	0	--	--	--	--	--	--	--
	Total	*4*	*7*	*5*	*2.6*	*2 (40)*	*3 (60)*	*0*	*1 (20)*
MESQ	2003	13	19	18	2.8	8 (44)	10 (56)	0	4 (22)
	2004	12	20	17	2.1	4 (24)	13 (76)	0	8 (47)
	2005	7	13	12	2.6	5 (42)	5 (42)	2 (17)	3 (25)
	2006	15	21	20	2.4	11 (55)	9 (45)	0	5 (25)
	2007	12	16	14	2.7	8 (57)	6 (43)	0	5 (38)
	2008	11	11	11	2.9	9 (82)	2 (18)	0	1 (10)
	2009	12	16	14	2.5	3 (21)	10 (72)	1 (7)	7 (50)
	2010	7	16	13	2.0	4 (31)	9 (69)	0	8 (62)
	2011	7	9	7	2.5	2 (29)	5 (71)	0	2 (33)
	2012	4	6	5	1.6	0	5 (100)	0	4 (80)
	Total	*100*	*147*	*131*	*2.5*	*54 (41)*	*74 (56)*	*3 (2)*	*47 (37)*
MOME	2003	7	13	10	2.6	0	10 (100)	0	1 (11)
	2004	7	7	6	2.7	3 (50)	3 (50)	0	1 (17)
	2005	5	6	6	2.7	1 (17)	4 (67)	1 (17)	1 (17)
	2006	7	9	8	2.7	4 (50)	4 (50)	0	0
	2007	11	12	11	2.4	3 (27)	8 (73)	0	2 (18)
	2008	13	14	13	3.0	8 (62)	5 (38)	0	1 (8)
	2009	13	18	17	3.1	9 (53)	8 (47)	0	0
	2010	10	15	12	2.6	5 (42)	7 (58)	0	0
	2011	13	20	18	2.8	7 (39)	10 (55)	1 (6)	1 (7)
	2012	14	17	13	2.2	5 (38)	8 (62)	0	1 (8)
	Total	*100*	*131*	*114*	*2.7*	*45 (39)*	*67 (59)*	*2 (2)*	*8 (7)*
MUDD	2004[5]	0	--	--	--	--	--	--	--
	2005	6	8	8	2.4	3 (38)	5 (63)	0	6 (75)
	2006	7	9	9	2.6	4 (44)	5 (56)	0	1 (11)
	2007	8	12	6	2.3	0	6 (100)	0	2 (33)

Table 4.1. Summary of Willow Flycatcher Nest Monitoring Results at Reclamation Study Areas, 2003–2012* (Continued)

Study Area[1]	Year	Pairs	Nests	Nests with 1+ WE[2]	Mean clutch size	Successful Nests[3]	Failed Nests[3]	Nests with Unknown Fate	Parasitized Nests[4]
MUDD	2008	4	8	8	2.3	2 (25)	6 (75)	0	4 (57)
	2009	6	9	8	2.5	0	8 (100)	0	6 (75)
	2010	4	4	3	3.0	3 (100)	0	0	1 (33)
	2011	5	6	5	2.4	0	4 (80)	1 (20)	3 (60)
	2012	5	6	4	2.5	1 (25)	3 (75)	0	0
	Total	*45*	*62*	*51*	*2.5*	*13 (25)*	*37 (73)*	*1 (2)*	*23 (48)*
GRCA	2003	0	--	--	--	--	--	--	--
	2004	1	1	1	3.0	0	0	1 (100)	0
	2005	0	--	--	--	--	--	--	--
	2006	5	3	3	2.7	0	3 (100)	0	0
	2007	1	1	1	2.0	0	1 (100)	0	0
	2008	0	--	--	--	--	--	--	--
	Total	*7*	*5*	*5*	*2.6*	*0*	*4 (80)*	*1 (20)*	*0*
TOPO	2003	9	12	10	2.9	8 (80)	2 (20)	0	2 (22)
	2004	29	43	38	2.4	17 (45)	20 (53)	1 (3)	12 (33)
	2005	18	38	34	2.3	8 (24)	26 (76)	0	16 (48)
	2006	14	17	17	2.5	4 (24)	10 (59)	3 (18)	5 (31)
	2007	8	8	8	3.1	6 (75)	2 (25)	0	0
	2008	9	12	8	2.4	1 (13)	6 (75)	1 (13)	1 (13)
	2009	1	2	2	3.0	1 (50)	1 (50)	0	0
	2010	3	2	2	3.0	1 (50)	1 (50)	0	0
	2011	1	1	1	1.0	0	1 (100)	0	0
	2012	0	--	--	--	--	--	--	--
	Total	*92*	*135*	*120*	*2.5*	*46 (38)*	*69 (58)*	*5 (4)*	*36 (31)*
BIWI	2003	3	2	2	3.0	2 (100)	0	0	0
	2004	0	--	--	--	--	--	--	--
	2005	2	2	2	3.0	2 (100)	0	0	0
	2006	3	5	5	2.0	1 (20)	4 (80)	0	0
	2007	7	9	8	2.2	2 (25)	6 (75)	0	1 (17)
	2008	4	5	5	2.5	2 (40)	2 (40)	1 (20)	1 (25)
	2009	5	7	6	3.3	2 (33)	4 (67)	0	2 (33)
	2010	4	11	11	2.5	2 (18)	9 (82)	0	3 (30)
	2011	4	6	5	2.5	2 (40)	3 (60)	0	1 (20)
	2012	2	3	2	3.0	0	2 (100)	0	0
	Total	*34*	*50*	*46*	*2.6*	*15 (33)*	*30 (65)*	*1 (2)*	*8 (19)*
Overall Total		**487**	**688**	**611**	**2.7**	**269 (44)**	**328 (54)**	**14 (2)**	**123 (22)**

* Years in which a study area was not monitored are omitted.

[1] PAHR = Pahranagat NWR, LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, GRCA = Grand Canyon, TOPO = Topock Marsh, BIWI = Bill Williams River NWR.

[2] WE = willow flycatcher egg.

[3] Only nests with at least one flycatcher egg were used in 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.

[5] The southern half of Overton WMA was not surveyed.

Nest Failure

Depredation was the major cause of nest failure, accounting for 46% (185 of 405) of all failed nests (Table 4.2) and 56% (185 of 328) of nests that failed after flycatcher eggs were laid. Over 50% of all depredation events occurred during the incubation period, but the daily risk of depredation was 1.3 times higher during the laying stage than the incubation stage. Daily predation risk during incubation was 1.5 times higher than during the nestling stage. Seventy-seven nesting attempts (19% of all failed nests) were abandoned prior to willow flycatcher eggs being laid; 13 of these had been brood parasitized. A total of 84 nests (21%) were deserted; 17 of these were deserted after ≥14 days incubation, 11 were deserted immediately after being brood parasitized, 24 were deserted after partial depredation, 1 was deserted after nestlings were banded, and 1 was deserted after a video camera was deployed. There was no obvious cause of desertion for the remainder. Thirty-two nests (8%) failed because of Brown-headed Cowbird parasitism (see below for more details on parasitism), and 13 nests (3%) were incubated in excess of 20 days. The cause of failure for nine nests (2%) was unknown because nests were too high to permit visual inspection of nest contents. Nestlings died in four nests (1%) before fledging, and one nest (<1%) failed when the nest tree fell over.

Table 4.2. Summary of Causes of Willow Flycatcher Nest Failure at Reclamation Study Areas, 2003–2012*

Study Area[1]	Year	Total # Nests	All Failed Nests	Abandoned	Deserted	Depredated	Parasitized	Addled	Unknown	Tree Fell	Nestling Died in Nest
PAHR	2003	12	2	1 (50)	1 (50)	0	0	0	0	0	0
	2004	17	4	0	0	3 (75)	0	0	1 (25)	0	0
	2005	21	10	2 (20)	0	7 (70)	0	0	1 (10)	0	0
	2006	18	9	3 (33)	3 (33)	2 (22)	0	1 (11)	0	0	0
	2007	12	4	0	1 (25)	1 (25)	0	0	1 (25)	0	1 (25)
	2008	12	4	2 (50)	0	2 (50)	0	0	0	0	0
	2009	18	9	1 (11)	0	5 (56)	0	0	3 (33)	0	0
	2010	20	10	3 (30)	1 (10)	6 (60)	0	0	0	0	0
	2011	7	0	0	0	0	0	0	0	0	0
	2012	14	4	0	1 (7)	3 (21)	0	0	0	0	0
	Total	*151*	*56*	*12 (21)*	*7 (12)*	*29 (52)*	*0*	*1 (2)*	*6 (11)*	*0*	*1 (2)*
LIFI	2004	3	2	1 (50)	0	1 (50)	0	0	0	0	0
	2009	2	2	1 (50)	0	0	1 (50)	0	0	0	0
	2010	2	1	0	0	1 (100)	0	0	0	0	0
	Total	*7*	*5*	*2 (40)*	*0*	*2 (40)*	*1 (20)*	*0*	*0*	*0*	*0*
MESQ	2003	19	11	1 (9)	2 (18)	7 (64)	0	1 (9)	0	0	0
	2004	20	16	3 (19)	4 (25)	4 (25)	5 (31)	0	0	0	0
	2005	13	6	1 (17)	0	4 (66)	1 (17)	0	0	0	0
	2006	21	10	1 (10)	2 (20)	5 (50)	2 (20)	0	0	0	0
	2007	16	8	2 (25)	1 (12)	4 (50)	1 (12)	0	0	0	0
	2008	11	2	0	1 (50)	1 (50)	0	0	0	0	0
	2009	16	12	2 (17)	4 (33)	4 (33)	1 (8)	1 (8)	0	0	0

Table 4.2. Summary of Causes of Willow Flycatcher Nest Failure at Reclamation Study Areas, 2003–2012* (Continued)

Study Area[1]	Year	Total # Nests	All Failed Nests	Abandoned	Deserted	Depredated	Parasitized	Addled	Unknown	Tree Fell	Nestling Died in Nest
MESQ	2010	16	12	3 (25)	2 (17)	4 (33)	3 (25)	0	0	0	0
	2011	9	7	2 (29)	0	4 (57)	0	1 (14)	0	0	0
	2012	6	6	1 (17)	1 (17)	3 (50)	1 (17)	0	0	0	0
	Total	*147*	*90*	*16 (18)*	*17 (19)*	*40 (44)*	*14 (16)*	*3 (3)*	*0*	*0*	*0*
MOME	2003	13	13	3 (23)	4 (31)	4 (31)	0	0	1 (8)	0	1 (8)
	2004	7	4	1 (25)	0	3 (75)	0	0	0	0	0
	2005	6	4	0	0	1 (25)	1 (25)	2 (50)	0	0	0
	2006	9	5	1 (20)	1 (20)	1 (20)	0	2 (40)	0	0	0
	2007	12	9	1 (11)	4 (44)	2 (22)	0	1 (11)	0	0	1 (11)
	2008	14	6	1 (17)	3 (50)	1 (17)	1 (17)	0	0	0	0
	2009	18	9	1 (11)	3 (33)	5 (56)	0	0	0	0	0
	2010	15	10	3 (30)	2 (20)	5 (50)	0	0	0	0	0
	2011	20	12	2 (17)	3 (25)	6 (50)	0	1 (8)	0	0	0
	2012	17	12	4 (33)	4 (33)	4 (33)	0	0	0	0	0
	Total	*131*	*84*	*17 (20)*	*24 (28)*	*32 (38)*	*2 (2)*	*6 (7)*	*1 (1)*	*0*	*2 (2)*
MUDD	2005	8	5	0	1 (20)	2 (40)	2 (40)	0	0	0	0
	2006	9	5	0	2 (40)	3 (60)	0	0	0	0	0
	2007	12	12	6 (50)	1 (8)	4 (33)	1 (8)	0	0	0	0
	2008	8	6	0	1 (17)	4 (67)	1 (17)	0	0	0	0
	2009	9	9	1 (11)	2 (22)	2 (22)	3 (33)	1 (11)	0	0	0
	2010	4	1	1 (100)	0	0	0	0	0	0	0
	2011	6	5	1 (20)	0	2 (40)	1 (20)	1 (20)	0	0	0
	2012	6	5	2 (40)	1 (20)	2 (40)	0	0	0	0	0
	Total	*62*	*48*	*11 (23)*	*8 (17)*	*19 (39)*	*8 (17)*	*2 (4)*	*0*	*0*	*0*
GRCA	2004	1	0	0	0	0	0	0	0	0	0
	2006	3	3	0	1 (33)	2 (67)	0	0	0	0	0
	2007	1	1	0	1 (100)	0	0	0	0	0	0
	Total	*5*	*4*	*0*	*2 (50)*	*2 (50)*	*0*	*0*	*0*	*0*	*0*
TOPO	2003	12	4	2 (50)	2 (50)	0	0	0	0	0	0
	2004	43	25	5 (20)	1 (4)	14 (56)	4 (16)	0	0	0	1 (4)
	2005	38	30	4 (13)	4 (13)	20 (67)	1 (3)	0	0	1 (3)	0
	2006	17	10	0	3 (30)	5 (50)	0	1 (10)	1 (10)	0	0
	2007	8	2	0	1 (50)	1 (50)	0	0	0	0	0
	2008	12	10	4 (40)	2 (20)	4 (40)	0	0	0	0	0
	2009	2	1	0	0	1 (50)	0	0	0	0	0
	2010	2	1	0	1 (100)	0	0	0	0	0	0
	2011	1	1	0	0	1 (100)	0	0	0	0	0
	Total	*135*	*84*	*15 (18)*	*14 (17)*	*46 (55)*	*5 (6)*	*1 (1)*	*1 (1)*	*1 (1)*	*1 (1)*

Table 4.2. Summary of Causes of Willow Flycatcher Nest Failure at Reclamation Study Areas, 2003–2012* (Continued)

Study Area[1]	Year	Total # Nests	All Failed Nests	Abandoned	Deserted	Depredated	Parasitized	Addled	Unknown	Tree Fell	Nestling Died in Nest
BIWI	2003	2	0	0	0	0	0	0	0	0	0
	2005	2	0	0	0	0	0	0	0	0	0
	2006	5	4	0	1 (25)	3 (75)	0	0	0	0	0
	2007	9	7	1 (14)	2 (28)	3 (43)	0	0	1 (14)	0	0
	2008	5	2	0	2 (100)	0	0	0	0	0	0
	2009	7	5	1 (20)	1 (20)	2 (40)	1 (20)	0	0	0	0
	2010	11	9	0	5 (56)	4 (44)	0	0	0	0	0
	2011	6	4	1 (25)	0	2 (50)	1 (25)	0	0	0	0
	2012	3	3	1 (33)	1 (33)	1 (33)	0	0	0	0	0
	Total	*50*	*34*	*4 (12)*	*12 (35)*	*15 (44)*	*2 (6)*	*0*	*1 (3)*	*0*	*0*
Overall Total		**688**	**405**	**77 (19)[2]**	**84 (21)[3]**	**185 (46)**	**32 (8)**	**13 (3)**	**9 (2)**	**1 (0)**	**4 (1)**

* All nesting attempts (those with and without flycatcher eggs) are included. Percentage of failed nests is shown in parentheses for each cause of failure. Years in which no nests were found within a study area are omitted.

[1] PAHR = Pahranagat NWR, LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, GRCA = Grand Canyon, TOPO = Topock Marsh, BIWI = Bill Williams River NWR.

[2] 13 nests abandoned after cowbird parasitism.

[3] 17 nests deserted after ≥14 days incubation, 24 deserted after partial depredation, 11 deserted immediately after being parasitized, 1 deserted after nestlings were banded, 1 deserted after video camera deployment, no obvious cause of desertion for remainder.

Brood Parasitism

One hundred twenty-three of 555[4] nests (22%) with flycatcher eggs and known contents were brood parasitized by Brown-headed Cowbirds (Table 4.3). An additional 17 nests were parasitized prior to flycatcher eggs being laid and were subsequently abandoned. For nests containing flycatcher eggs, parasitism caused nest failure at 32 nests. Brood parasitism ranged from 0% at Pahranagat to 48% at Muddy River, with Mesquite, Muddy River, and Topock all having parasitism rates above 30% (see Table 4.1). Across all study areas, nests that contained flycatcher eggs and were brood parasitized were less likely to fledge flycatcher young than nests that were not parasitized ($\chi^2 = 38.42$, $P < 0.001$). At study areas with variable parasitism rates, the rate of parasitism was clearly inversely related to flycatcher nest success (Figure 4.1). Forty-three percent of female flycatchers that were parasitized at least once during a season successfully produced at least one fledgling, in comparison to 72% of their unparasitized counterparts ($\chi^2 = 21.71$, $P < 0.001$).

Table 4.3. Fates of Willow Flycatcher Nests Parasitized by Brown-headed Cowbirds at Reclamation Study Areas, 2003–2012*

Study Area[1]	Total # Nests	Fledged[2]	Abandoned	Deserted	Depredated	Parasitized	Addled	Unknown[3]	Tree Fell
PAHR	1	0	1	0	0	0	0	0	0
LIFI	2	0	1	0	0	1	0	0	0
MESQ	53	8	6	10	12	14	1	2	0

[4] Table 4.1 shows a total of 611 nests known to contain at least one flycatcher egg. When calculating brood parasitism rates, however, 56 nests whose contents could not be determined were excluded from calculations (e.g., nests that were too high to check contents to determine presence/absence of cowbird eggs or nesting attempts that were discovered late in the nesting cycle).

Table 4.3. Fates of Willow Flycatcher Nests Parasitized by Brown-headed Cowbirds at Reclamation Study Areas, 2003–2012* (Continued)

Study Area[1]	Total # Nests	Fledged[2]	Abandoned	Deserted	Depredated	Parasitized	Addled	Unknown[3]	Tree Fell
MOME	10	1	2	3	2	2	0	0	0
MUDD	25	3	2	3	6	8	2	1	0
TOPO	40	8	4	5	15	5	0	2	1
BIWI	9	3	1	3	0	2	0	0	0
Total	***140***	***23***	***17***	***24***	***35***	***32***	***3***	***5***	***1***

* All nesting attempts are included.

[1] PAHR = Pahranagat NWR, LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, TOPO = Topock Marsh, BIWI = Bill Williams River NWR.

[2] Seven nests fledged a cowbird as well as at least one flycatcher.

[3] These nests suspected to have fledged flycatchers, but fledges not visually confirmed.

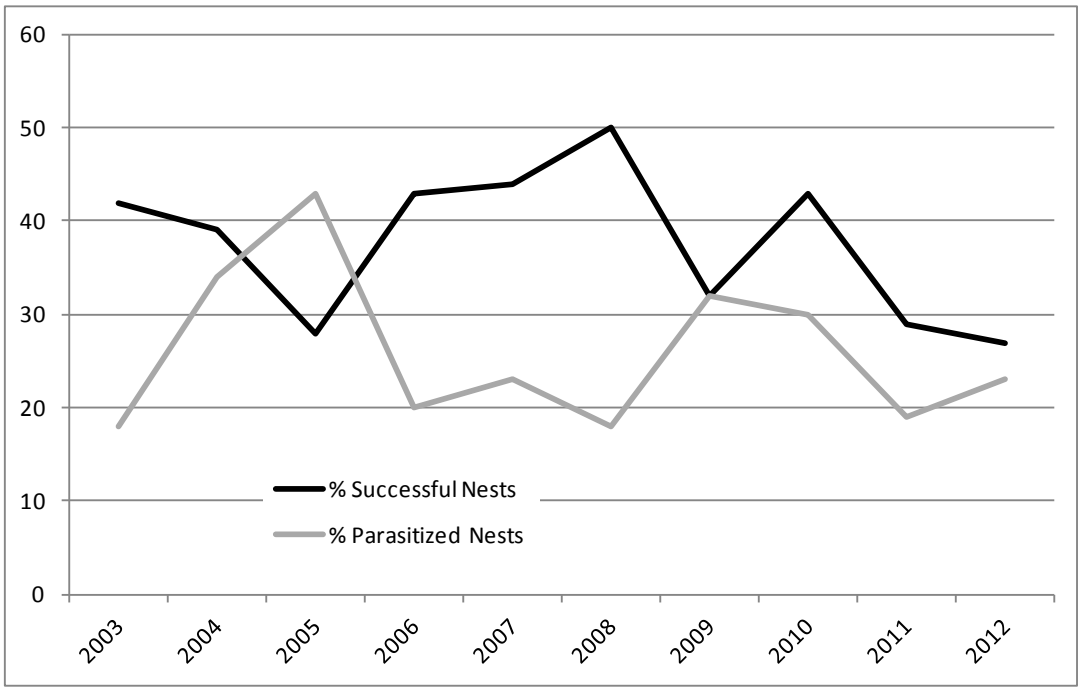

Figure 4.1. Percentage of flycatcher nests parasitized and percentage of flycatcher nests that successfully fledged young at Mesquite, Mormon Mesa, Muddy River, and Topock Marsh combined, 2003–2012.

Cowbird Egg Addling

From 2010 to 2012, we attempted to addle cowbird eggs at 11 of the 24 parasitized nests that contained flycatcher eggs. Two of the remaining nests were too high to reach and both were depredated during incubation. One nest was completely depredated before the following visit when the cowbird egg would have been addled, and two nests were partially depredated and deserted before the following visit when the cowbird egg would have been addled. Two nests had already been deserted on the visit when the cowbird egg was discovered. One nest was found with a cowbird nestling and no other nest contents; the nestling was removed. The parasitism event caused nest failure at five nests (i.e., appearance of the cowbird egg coincided with the disappearance of all flycatcher eggs and the nest was subsequently

abandoned). Nine of the nests in which we attempted to addle cowbird eggs were incubated long enough (≥10 days) for any viable cowbird eggs to hatch; only one egg hatched. The two remaining nests were depredated before hatching could occur.

Over the three years (2010–2012) of the egg addling program, the hatch rate of cowbird eggs was 11%, which is significantly lower (Fisher's exact test, $P < 0.001$) than the 74% hatch rate observed in 2003–2009. The productivity of parasitized nests with known fate that were incubated long enough for flycatcher eggs to hatch has not increased under the addling program (0.63 young per nest in 2010–2012, vs. 0.67 young per nest in 2003–2009); however, sample size in 2010–2012 is small (n = 8) and productivity was strongly influenced by a few instances of addled clutches and depredation events during the nestling period.

Mayfield Nest Success

Mayfield survival probability (MSP) ranged from 0.213 at Grand Canyon to 0.659 at Pahranagat and was 0.437 for all sites combined (Table 4.4). Daily survival rates (DSR) during egg laying were significantly higher at Pahranagat than at Mesquite, Mormon Mesa, Muddy River, Topock, or Bill Williams. Daily survival rate during incubation was higher at Pahranagat than at either Muddy River or Bill Williams, and DSR at Topock was significantly lower than at Pahranagat, Mesquite, or Mormon Mesa. Daily survival rate during the nestling period was higher at Pahranagat than at Mesquite, Mormon Mesa, Muddy River, or Topock. Littlefield and Grand Canyon were excluded from comparisons because of small sample sizes. Across all study areas, DSR during nestling period was higher than during either laying or incubation. Mayfield survival probabilities did not differ substantially from apparent nest success except at Grand Canyon, where apparent nest success was influenced by nests of unknown fate (Table 4.5).

Table 4.4. Daily Survival Rates and Mayfield Survival Probabilities (MSP) for Willow Flycatcher Nest Stages at Reclamation Study Areas, 2003–2012*

Study Area	Nest Stage[1]	Nest Losses/ Observation Days	Daily Survival Rate	Mayfield Survival Probability
Pahranagat	1	3/246.5	0.988 (0.007)	0.974
	2	33/1359.5	0.976 (0.004)	0.729
	3	7/1293	0.995 (0.002)	0.928
	MSP all stages = 0.659			
Littlefield	1	0/7	1.000 (0.000)	0.925
	2	3/39.5	0.924 (0.042)	0.569
	3	0/26	1.000 (0.000)	0.777
	MSP all stages = 0.362			
Mesquite	Laying	15/190	0.921 (0.020)	0.840
	Incubation	41/1238	0.967 (0.005)	0.648
	Nestling	17/839.5	0.980 (0.005)	0.755
	MSP all stages = 0.411			
Mormon Mesa	Laying	9/157	0.943 (0.019)	0.882
	Incubation	37/1095.5	0.966 (0.005)	0.643
	Nestling	20/730	0.973 (0.006)	0.682
	MSP all stages = 0.387			

Table 4.4. Daily Survival Rates and Mayfield Survival Probabilities (MSP) for Willow Flycatcher Nest Stages at Reclamation Study Areas, 2003–2012* (Continued)

Study Area	Nest Stage[1]	Nest Losses/ Observation Days	Daily Survival Rate (Standard Error)	Mayfield Survival Probability
Muddy River	Laying	5/68.5	0.927 (0.031)	0.852
	Incubation	24/462.5	0.948 (0.010)	0.504
	Nestling	7/228.5	0.969 (0.011)	0.652
	MSP all stages = 0.280			
Grand Canyon	Laying	0/8	1.000 (0.000)	1.000
	Incubation	3/60	0.950 (0.028)	0.517
	Nestling	1/16	0.938 (0.061)	0.411
	MSP all stages = 0.213			
Topock	Laying	11/158.5	0.931 (0.020)	0.859
	Incubation	45/924	0.951 (0.007)	0.526
	Nestling	11/725	0.985 (0.005)	0.810
	MSP all stages = 0.366			
Bill Williams	Laying	5/56.5	0.912 (0.038)	0.822
	Incubation	21/394	0.947 (0.011)	0.494
	Nestling	3/226	0.987 (0.008)	0.832
	MSP all stages = 0.338			
Total	**Laying**	**48/892**	**0.946 (0.008)**	**0.889**
	Incubation	**207/5573**	**0.963 (0.002)**	**0.614**
	Nestling	**66/4084**	**0.984 (0.002)**	**0.799**
	MSP all stages = 0.437			

* Mayfield survival probability was calculated using 2.12-day egg laying, 12.87-day incubation, and 13.76-day nestling stages.

Table 4.5. Mayfield Nest Success and Apparent Nest Success at Reclamation Study Areas, 2003–2012

Study Area	Mayfield Nest Success	Apparent Nest Success[1]
Pahranagat	0.659	0.676
Littlefield	0.362	0.400
Mesquite	0.411	0.412
Mormon Mesa	0.387	0.395
Muddy River	0.280	0.255
Grand Canyon	0.213	0.000
Topock	0.366	0.383
Bill Williams	0.338	0.326
Overall	**0.437**	**0.440**

[1] Apparent nest success equals the number of successful nests divided by the total number of nests containing at least one flycatcher egg.

Productivity and Fecundity

At all sites, 580 nestlings were confirmed to have fledged from 597 nests of known outcome (mean number of fledglings/nest = 0.97, SE = 0.05; Table 4.9). Fecundity across study areas ranged from 0.00 young per female at Grand Canyon to 2.38 at Pahranagat (Table 4.6) and averaged 1.23 (SE = 0.06). Productivity at Pahranagat (1.80 young per nest) was significantly higher ($F_{5,582} = 19.44$, $P < 0.001$) than at all other study areas, which did not differ from one another. Fecundity at Pahranagat was significantly higher ($F_{5,457} = 24.66$, $P < 0.001$) than at all other study areas, which did not differ from one another. Grand Canyon and Littlefield were excluded from the analysis because of low sample size.

Table 4.6. Willow Flycatcher Nest Productivity (Young Fledged per Nest) and Fecundity (Young Fledged per Female) at Reclamation Study Areas, 2003–2012*

Study Area[1]	Year	Young Fledged	# Nests	Productivity Mean (SE)	# Females	Fecundity Mean (SE)
PAHR	2003	24	11	2.18 (0.35)	8	3.00 (0.42)
	2004	35	17	2.06 (0.34)	14	2.50 (0.47)
	2005	33	19	1.74 (0.39)	11	3.00 (0.30)
	2006	24	15	1.60 (0.38)	15	1.60 (0.38)
	2007	23	12	1.92 (0.43)	10	2.30 (0.42)
	2008	21	10	2.10 (0.41)	9	2.33 (0.37)
	2009	22	16	1.38 (0.38)	9	2.44 (0.38)
	2010	26	17	1.53 (0.34)	10	2.60 (0.22)
	2011	17	7	2.43 (0.30)	6	2.83 (0.31)
	2012	23	14	1.64 (0.32)	12	1.92 (0.31)
	Total	*248*	*138*	*1.80 (0.12)*	*104*	*2.38 (0.12)*
LIFI	2004	2	2	1.00 (1.00)	1	2.00
	2009	0	1	0.00 (0.00)	2	0.00 (0.00)
	2010	3	2	1.50 (1.50)	1	3.00
	Total	*5*	*5*	*1.00 (0.63)*	*4*	*1.25 (0.75)*
MESQ	2003	17	18	0.94 (0.30)	13	1.31 (0.50)
	2004	11	17	0.65 (0.30)	12	0.92 (0.40)
	2005	6	10	0.60 (0.22)	5	1.20 (0.49)
	2006	23	20	1.15 (0.28)	15	1.53 (0.45)
	2007	15	14	1.07 (0.32)	12	1.25 (0.35)
	2008	18	11	1.64 (0.34)	11	1.64 (0.34)
	2009	3	13	0.23 (0.12)	11	0.27 (0.19)
	2010	7	13	0.54 (0.27)	7	1.00 (0.44)
	2011	3	7	0.43 (0.30)	7	0.43 (0.30)
	2012	0	5	0.00 (0.00)	4	0.00 (0.00)
	Total	*103*	*128*	*0.80 (0.10)*	*97*	*1.06 (0.14)*
MOME	2003	0	10	0.00 (0.00)	7	0.00 (0.00)
	2004	6	6	1.00 (0.52)	7	0.86 (0.46)
	2005	1	5	0.20 (0.20)	4	0.25 (0.25)
	2006	8	8	1.00 (0.42)	7	1.14 (0.46)
	2007	3	11	0.27 (0.14)	11	0.27 (0.14)
	2008	19	13	1.46 (0.37)	13	1.46 (0.37)

Table 4.6. Willow Flycatcher Nest Productivity (Young Fledged per Nest) and Fecundity (Young Fledged per Female) at Reclamation Study Areas, 2003–2012* (Continued)

Study Area[1]	Year	Young Fledged	# Nests	Productivity Mean (SE)	# Females	Fecundity Mean (SE)
MOME	2009	22	17	1.29 (0.35)	13	1.69 (0.44)
	2010	12	12	1.00 (0.39)	10	1.20 (0.44)
	2011	16	17	0.94 (0.30)	12	1.33 (0.48)
	2012	9	13	0.69 (0.31)	14	0.64 (0.29)
	Total	*96*	*112*	*0.86 (0.11)*	*98*	*0.98 (0.13)*
MUDD	2005	3	8	0.38 (0.18)	6	0.50 (0.22)
	2006	7	9	0.78 (0.36)	7	1.00 (0.44)
	2007	0	6	0.00 (0.00)	8	0.00 (0.00)
	2008	3	8	0.38 (0.26)	4	0.75 (0.48)
	2009	0	8	0.00 (0.00)	6	0.00 (0.00)
	2010	7	3	2.33 (0.33)	4	1.75 (0.63)
	2011	0	4	0.00 (0.00)	4	0.00 (0.00)
	2012	3	4	0.75 (0.75)	5	0.60 (0.60)
	Total	*23*	*50*	*0.46 (0.13)*	*44*	*0.52 (0.14)*
GRCA	2004	--	1[1]	--	1	--
	2006	0	3	0.00 (0.00)	5	0.00 (0.00)
	2007	0	1	0.00 (0.00)	1	0.00
	Total	*0*	*4*	*0.00 (0.00)*	*6*	*0.00 (0.00)*
TOPO	2003	15	10	1.50 (0.31)	9	1.67 (0.44)
	2004	25	37	0.68 (0.14)	28	0.89 (0.17)
	2005	13	34	0.38 (0.13)	18	0.72 (0.29)
	2006	5	14	0.36 (0.17)	11	0.45 (0.21)
	2007	12	8	1.50 (0.46)	8	1.50 (0.46)
	2008	1	7	0.14 (0.14)	8	0.13 (0.13)
	2009	3	2	1.50 (1.50)	1	3.00
	2010	2	2	1.00 (1.00)	3	0.67 (0.67)
	2011	0	1	0.00 (0.00)	1	0.00 (0.00)
	Total	*76*	*115*	*0.66 (0.09)*	*87*	*0.87 (0.12)*
BIWI	2003	3	2	1.50 (0.50)	3	1.00 (0.58)
	2005	5	2	2.50 (0.50)	2	2.50 (0.50)
	2006	2	5	0.40 (0.40)	3	0.67 (0.67)
	2007	3	8	0.38 (0.26)	7	0.43 (0.30)
	2008	4	4	1.00 (0.71)	3	1.33 (0.88)
	2009	6	6	1.00 (0.63)	5	1.20 (0.73)
	2010	2	11	0.18 (0.12)	4	0.50 (0.29)
	2011	4	5	0.80 (0.58)	4	1.00 (0.71)
	2012	0	2	0.00 (0.00)	2	0.00 (0.00)
	Total	*29*	*45*	*0.64 (0.16)*	*33*	*0.88 (0.20)*
Overall Total		**580**	**597**	**0.97 (0.05)**	**473**	**1.23 (0.06)**

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

[1] Nest fate was unknown.

NDOW Study Areas

Nest Monitoring

We documented 106 willow flycatcher nesting attempts at Key Pittman, River Ranch, and Warm Springs; 98 of these nests were known to contain flycatcher eggs and were used in calculating nest success and productivity. Forty-one (42%) nests were successful and fledged young, and 55 (56%) failed. Fate was unknown at two (2%) nests. Nest success from 2010 to 2012 was 45% at Key Pittman, 0% at River Ranch, and 17% at Warm Springs (Table 4.7). Average clutch size was 2.9 at Key Pittman, 1.8 at River Ranch, and 2.8 at Warm Springs.

Table 4.7. Summary of Willow Flycatcher Nest Monitoring Results at NDOW Study Areas, 2010–2012

Study Area[1]	Year	Pairs	Nests	Nests with 1+ WE[2]	Mean clutch size	Successful Nests[3]	Failed Nests[3]	Nests with Unknown Fate	Parasitized Nests[4]
KEPI	2010	18	31	30	3.0	15 (50)	15 (50)	0	3 (11)
	2011	18	33	31	2.9	14 (45)	15 (48)	2 (6)	1 (3)
	2012	17	32	27	2.8	11 (41)	16 (59)	0	5 (20)
	Total	*53*	*96*	*88*	*2.9*	*40 (45)*	*46 (52)*	*2 (2)*	*9 (11)*
RIRA[5]	2011	3	4	4	1.8	0	4 (100)	0	3 (75)
	2012	0	--	--	--	--	--	--	--
	Total	*3*	*4*	*4*	*1.8*	*0*	*4 (100)*	*0*	*3 (75)*
WMSP	2010	3	3	3	3.0	0	3 (100)	0	0
	2011	1	1	1	3.0	1 (100)	0	0	0
	2012	1	2	2	2.0	0	2 (100)	0	0
	Total	*5*	*6*	*6*	*2.7*	*1 (17)*	*5 (83)*	*0*	*0*
Overall Total		**61**	**106**	**98**	**2.8**	**41 (42)**	**55 (56)**	**2 (2)**	**12 (13)**

[1] KEPI = Key Pittman WMA, RIRA = River Ranch, WMSP = Warm Springs Natural Area.

[2] WE = willow flycatcher egg.

[3] Only nests with at least one flycatcher egg were used in 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.

[4] RIRA was not monitored by SWCA in 2010.

Nest Failure

Depredation was the major cause of nest failure, accounting for 64% (41 of 64) of all failed nests (Table 4.8) and 73% (41 of 56) of nests that failed after flycatcher eggs were laid. Over 70% of all depredation events occurred during the incubation period. The daily risk of depredation during incubation was 1.1 times higher than during the laying stage and was 3.2 times higher than during the nestling stage. Eight nesting attempts (12% of all failed nests) were abandoned prior to willow flycatcher eggs being laid; one of these had been brood parasitized. Seven nests (11%) were deserted; two were deserted immediately after being brood parasitized. Three nests (5%) failed because of Brown-headed Cowbird parasitism (see below for more details on parasitism), and one nest (2%) was incubated in excess of 20 days. Two nests (3%) failed in a fire, and all nestlings died in two nests (3%) that were still being tended by adult flycatchers.

Table 4.8. Summary of Causes of Willow Flycatcher Nest Failure at NDOW Study Areas, 2010–2012*

Study Area[1]	Year	Total # Nests	All Failed Nests	Abandoned	Deserted	Depredated	Parasitized	Addled	Fire	Nestling(s) died in nest
KEPI	2010	31	16	1 (7)	1 (7)	12 (80)	2 (13)	0	0	0
	2011	33	18	2 (11)	3 (17)	11 (61)	0	0	0	2 (11)
	2012	32	21	5 (24)	2 (10)	13 (62)	0	1 (5)	0	0
	Total	*96*	*55*	*8 (15)*	*6 (11)*	*36 (65)*	*2 (4)*	*1 (2)*	*0*	*2 (4)*
RIRA	2011	4	4	0	1 (25)	2 (50)	1 (25)	0	0	0
	Total	*4*	*4*	*0*	*1 (25)*	*2 (50)*	*1 (25)*	*0*	*0*	*0*
WMSP	2010	3	3	0	0	1 (33)	0	0	2 (67)	0
	2011	1	0	0	0	0	0	0	0	0
	2012	2	2	0	0	2 (100)	0	0	0	0
	Total	*6*	*5*	*0*	*0*	*3 (60)*	*0*	*0*	*2 (40)*	*0*
Overall Total		**106**	**64**	**8 (12)[2]**	**7 (11)[3]**	**41 (64)**	**3 (5)**	**1 (2)**	**2 (3)**	**2 (3)**

* All nesting attempts (those with and without flycatcher eggs) are included. Percentage of failed nests is shown in parentheses for each cause of failure.

[1] KEPI = Key Pittman WMA, RIRA = River Ranch, WMSP = Warm Springs Natural Area.

[2] One nest abandoned after being parasitized.

[3] Two nests deserted immediately after parasitism, one nest deserted after the nest structure was damaged by an unknown cause; no obvious cause of desertion for remainder.

Brood Parasitism

Twelve of 92[5] nests (13%) with flycatcher eggs and known contents were brood parasitized by Brown-headed Cowbirds (Table 4.9). One additional nest was parasitized prior to flycatcher eggs being laid and was subsequently abandoned. For nests containing flycatcher eggs, parasitism caused nest failure at three nests. From 2010 to 2012, brood parasitism was 11% at Key Pittman, 75% at River Ranch, and 0% at Warm Springs (Table 4.9). Across the three study areas, nests that contained flycatcher eggs and were brood parasitized were less likely to be successful (Fisher's exact test, $P = 0.029$) than non-parasitized nests.

Table 4.9. Fates of Willow Flycatcher Nests Parasitized by Brown-headed Cowbirds at NDOW Study Areas, 2010–2012*

Study Area[1]	Total # Nests	Fledged[2]	Abandoned	Deserted	Depredated	Parasitized	Addled	Nestling Died in Nest
KEPI	10	1	1	3	1	2	1	1
RIRA	3	0	0	1	1	1	0	0
Total	*13*	*1*	*1*	*4*	*2*	*3*	*1*	*1*

* All nesting attempts are included.

[1] KEPI = Key Pittman WMA, RIRA = River Ranch.

[2] No cowbirds fledged in any study area.

[5] Table 4.7 shows 98 nests known to contain at least one flycatcher egg. When calculating brood parasitism rates, however, six nests whose contents could not be determined were excluded from calculations (e.g., nesting attempts that were discovered late in the nesting cycle).

Cowbird Egg Addling

From 2010 to 2012, we attempted to addle cowbird eggs at 4 of 12 parasitized nests that contained flycatcher eggs at River Ranch and Key Pittman; no parasitized nests were observed at Warm Springs. We removed a cowbird nestling from each of three nests that were found late in incubation or in the nestling period. One of these nests was found with only a cowbird nestling. In the other two nests, the cowbird nestling was removed at ≤5days old, but both nests failed; in one nest, the flycatcher nestling disappeared before the cowbird nestling was removed, and at the other, the remaining flycatcher nestling developed very slowly and eventually died in the nest. Of the remaining five nests, one was too high to reach but was deserted during incubation, and the parasitism event caused failure (i.e., appearance of the cowbird egg coincided with the disappearance of all flycatcher eggs and the nest was subsequently abandoned) at another. At one nest, the cowbird egg appeared after at least five days of incubation and was removed after the flycatcher egg hatched. The remaining two nests were deserted immediately after the parasitism event.

Two of the addled nests were incubated long enough (≥10 days) for the cowbird egg to hatch, though neither egg did. The two remaining addled nests were deserted several days after the parasitism event. No formal analysis of the success of addling at NDOW sites was conducted due to small sample size.

Mayfield Nest Success

Mayfield survival probability (MSP) was 0.409 at Key Pittman, 0.193 at Warm Springs, and could not be calculated across all nest stages at River Ranch because of lack of data for some stages. MSP was 0.374 for all three sites combined (Table 4.10). Due to small sample sizes at Warm Springs and River Ranch, daily survival rates (DSR) at Key Pittman were compared to the Reclamation study areas of Pahranagat, Mesquite, Mormon Mesa, Muddy River, Topock, and Bill Williams. Daily survival rate during laying did not differ from any Reclamation study area. Daily survival rates during incubation and nestling stages at Key Pittman were both significantly lower than at Pahranagat, but did not differ from any other study area. For all NDOW study areas combined, DSR during the nestling period was higher than during incubation but did not differ from that during the laying period. Mayfield survival probabilities did not differ substantially from apparent nest success (Table 4.11).

Table 4.10. Daily Survival Rates and Mayfield Survival Probabilities (MSP) for Willow Flycatcher Nest Stages at NDOW Study Areas, 2010–2012*

Study Area	Nest Stage[1]	Nest Losses/ Observation Days	Daily Survival Rate (Standard Error)	Mayfield Survival Probability
Key Pittman	Laying	4/111	0.964 (0.018)	0.925
	Incubation	32/746.5	0.957 (0.007)	0.569
	Nestling	11/604.5	0.982 (0.005)	0.777
	MSP all stages = 0.409			
River Ranch	Laying	2/5	0.600 (0.219)	0.339
	Incubation	2/13.5	0.852 (0.097)	0.127
	Nestling	0/0		
	MSP all stages = N/A[2]			
Warm Springs	Laying	0/7	1.000 (0.000)	1.000
	Incubation	3/63.5	0.953 (0.027)	0.536
	Nestling	2/28	0.929 (0.049)	0.361
	MSP all stages = 0.193			

Table 4.10. Daily Survival Rates and Mayfield Survival Probabilities (MSP) for Willow Flycatcher Nest Stages at NDOW Study Areas, 2010–2012* (Continued)

Study Area	Nest Stage[1]	Nest Losses/ Observation Days	Daily Survival Rate (Standard Error)	Mayfield Survival Probability
Total	**Laying**	**6/123**	**0.951 (0.019)**	**0.899**
	Incubation	**37/823.5**	**0.955 (0.007)**	**0.553**
	Nestling	**13/632.5**	**0.979 (0.006)**	**0.751**
	MSP all stages = 0.374			

[*] Mayfield survival probability was calculated using 2.12-day egg laying, 12.87-day incubation, and 13.76-day nestling stages.
[2] MSP cannot be calculated for all stages because of lack of data.

Table 4.11. Mayfield Nest Success and Apparent Nest Success at NDOW Study Areas, 2010–2012

Study Area	Mayfield Nest Success	Apparent Nest Success[1]
Key Pittman	0.409	0.455
River Ranch	--	0.000
Warm Springs	0.193	0.167
Overall	0.374	0.418

[1] Apparent nest success is calculated from the number of successful nests out of the total number of nests with at least one flycatcher egg.

Productivity and Fecundity

At all sites, 92 nestlings were confirmed to have fledged from 96 nests of known outcome (mean number of fledglings/nest = 0.96, SE = 0.13). Fecundity across study areas ranged from 0.0 young per female at River Ranch to 1.75 at Key Pittman and averaged 1.56 (SE = 0.18) (Table 4.12). Productivity at Key Pittman was lower than at Pahranagat, higher than at Muddy River, and did not differ from the other Reclamation study areas ($F_{6,667} = 15.61$, $P < 0.001$). Fecundity at Key Pittman did not differ significantly from Pahranagat but was higher than fecundity at the other Reclamation study areas. River Ranch, Warm Springs, Littlefield, and Grand Canyon were excluded from the comparisons because of low sample size.

Table 4.12. Willow Flycatcher Nest Productivity (Young Fledged per Nest) and Fecundity (Young Fledged per Female) at NDOW Study Areas, 2010–2012*

Study Area	Year	Young Fledged	# Nests	Productivity Mean (SE)	# Females	Fecundity Mean (SE)
Key Pittman	2010	37	30	1.23 (0.27)	18	2.06 (0.32)
	2011	30	29	1.03 (0.24)	16	1.88 (0.29)
	2012	22	27	0.81 (0.23)	17	1.29 (0.34)
	Total	*89*	*86*	*1.03 (0.14)*	*51*	*1.75 (0.19)*
River Ranch	2011	0	4	0.00 (0.00)	3	0.00 (0.00)
	Total	*0*	*4*	*0.00 (0.00)*	*3*	*0.00 (0.00)*
Warm Springs	2010	0	3	0.00 (0.00)	3	0.00 (0.00)
	2011	3	1	3.00	1	3.00
	2012	0	2	0.00	1	0.00
	Total	*3*	*6*	*0.50 (0.50)*	*5*	*0.60 (0.60)*
Overall Total		**92**	**96**	**0.96 (0.13)**	**59**	**1.56 (0.18)**

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

All Study Areas

Clutch Size

Mean clutch size decreased consistently over subsequent nesting attempts within a season, from 3.0 eggs in first nests to 2.6 eggs in third nests ($F_{2,476} = 4.69$, $P = 0.010$; Figure 4.2). Mean clutch size also varied between study areas ($F_{6,328} = 4.56$, $P = 0.001$). This variation was not the result of some study areas having higher nest failure rates, and therefore more second or third nesting attempts with lower clutch sizes, but was also evident when only initial nesting attempts were considered (Figure 4.3). Clutch size at Pahranagat was higher than at Mormon Mesa, Muddy River, and Topock Marsh (Tukey's HSD, $P < 0.05$). When data were pooled by geographic regions, the Pahranagat region had a higher clutch size than either the Virgin or Havasu regions, which did not differ from one another.

Most cowbird parasitism events occurred during the laying phase. Female cowbirds often remove one or more host eggs when they parasitize a nest, and therefore the number of eggs a flycatcher laid in a parasitized nest could often not be determined. However, parasitized nests contained, on average, 2.3 flycatcher eggs while unparasitized nests contained an average of 2.9 eggs ($F_{1,593} = 80.34$, $P < 0.001$). The difference in clutch size between parasitized and unparasitized nests was consistent across study areas.

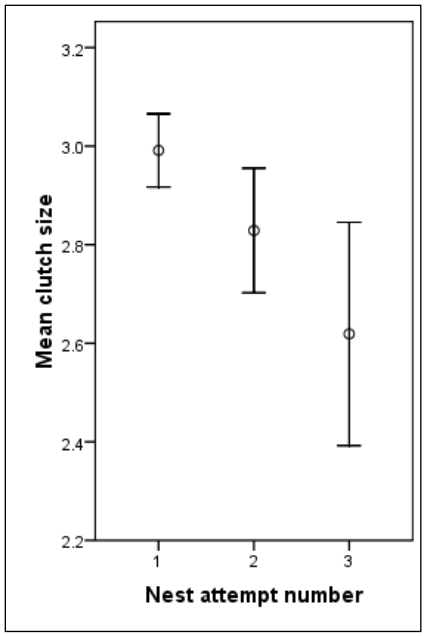

Figure 4.2. Mean clutch size for first, second, and third nesting attempts for individual females within a given season, 2003–2012. Parasitized nests were excluded from the analysis.

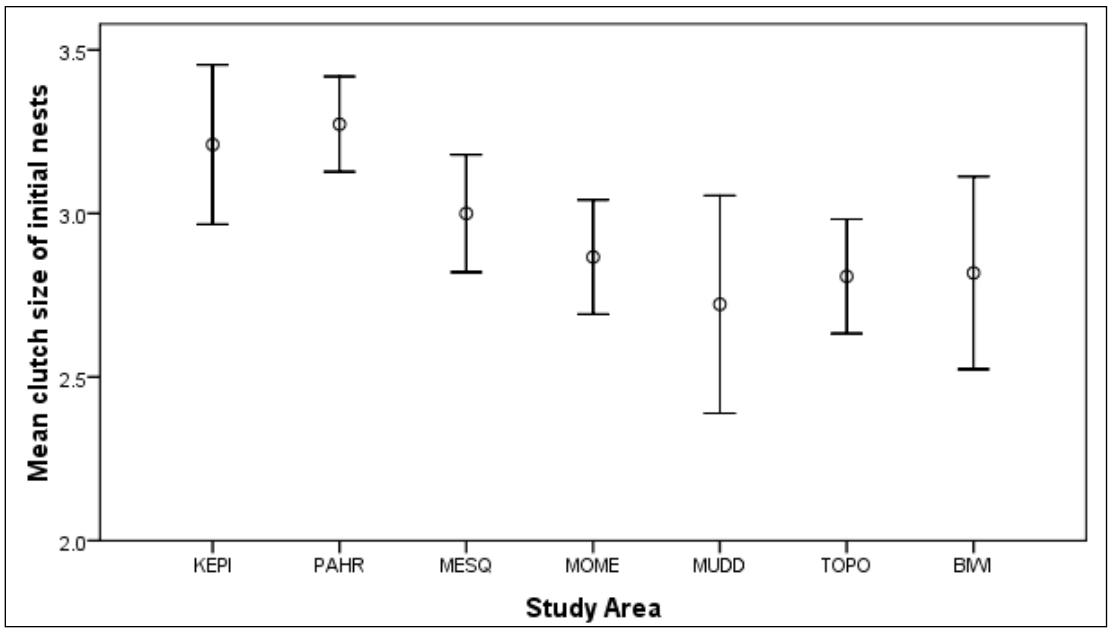

Figure 4.3. Clutch size (mean and 95% confidence intervals) for unparasitized initial nest attempts at Key Pittman (KEPI), Pahranagat (PAHR), Mesquite (MESQ), Mormon Mesa (MOME), Muddy River (MUDD), Topock Marsh (TOPO), and Bill Williams River (BIWI), 2003–2012. Study areas with a sample size ≤5 were excluded.

Results from the ordinal regression on observed clutch size indicated that year, geographic area, nest attempt number, and parasitism were all associated with clutch size. However, parasitism and geographic area were the most significant predictors of clutch size (Table 4.13). Distance to water was a weak predictor ($P = 0.062$). Most years were not significant predictors, but differences from 2009–2010 and 2011–2012 showed significant decreases in clutch size across all geographic areas. Estimates indicated that the Pahranagat Valley had significantly larger observed clutch sizes than either the Virgin Valley or Havasu area. Nests that were not parasitized had larger clutch sizes than nests that were parasitized. There was a weak inverse relationship of distance to water with clutch size.

Productivity

Results from the ordinal regression on the number of fledglings per nest found that geographic area, observed clutch size, and parasitism were significant predictors of the number of fledglings per nest (Table 4.14). Clutch size and geographic area were more important that parasitism in predicting the number of fledglings per nest. Pahranagat Valley produced more fledglings per nest than either the Virgin Valley or Havasu area. Parasitized nests produced fewer fledges than non-parasitized nests. Clutch size was positively related to the number of fledglings.

Table 4.13. Significant Predictors in the Ordinal Logistic Regression Investigating Factors That Affect Clutch Size

Effect	Level	Estimate[1]	SE	X^2	*P*-value
Geographic Area	Virgin Valley → Pahranagat	-0.773	0.138	31.60	<0.001
	Pahranagat → Havasu	0.387	0.137	7.96	0.005
Distance to Water		0.004	0.002	3.47	0.062
Parasitized	Yes → No	-0.662	0.102	41.92	<0.001
Year	2009 → 2010	0.732	0.341	4.60	0.032
	2011 → 2012	0.705	0.339	4.33	0.037

[1] In ordinal logistic regression, a negative parameter estimate indicates a positive relationship and vice versa.

Table 4.14. Significant Predictors in the Ordinal Logistic Regression Investigating Factors That Affect the Number of Fledglings a Nest Produces

Effect	Level	Estimate[1]	SE	X^2	*P*-value
Clutch Size[2]	2 eggs → 3 eggs	-1.207	0.360	11.23	<0.001
	3 eggs → 4 eggs	-2.381	0.406	34.34	<0.001
Geographic Area	Virgin Valley → Pahranagat	-0.641	0.191	11.19	<0.001
	Pahranagat → Havasu	0.391	0.219	3.20	0.074
Parasitized	Yes → No	-0.608	0.260	5.51	0.019

[1] In ordinal logistic regression, a negative parameter estimate indicates a positive relationship and vice versa.

[2] Limited sample size prevented the calculation of estimate from 1 egg to 2 eggs.

Age-based Seasonal Productivity

From 1997 to 2012, we tracked the reproductive output of 108 females of known age. When female ages 2, 3, 4, and 5+ were considered as separate categories, age was independent of seasonal productivity ($G^2_{adj} = 19.71$, $P = 0.072$), seasonal percent nest success ($G^2_{adj} = 6.54$, $P = 0.365$), and seasonal parasitism rate ($G^2_{adj} = 3.53$, $P = 0.740$). When female age categories were collapsed to 2 and 3+, seasonal productivity was not independent of age ($G^2_{adj} = 15.47$, $P = 0.004$). Success rate ($G^2_{adj} = 1.79$, $p = 0.408$)

and parasitism rate (G^2_{adj} = 3.13, p = 0.209) were independent of the collapsed age classes. The proportion of females that failed to fledge any young did not differ by age, but of the successful females, older females were more likely to fledge larger broods (Figure 4.4).

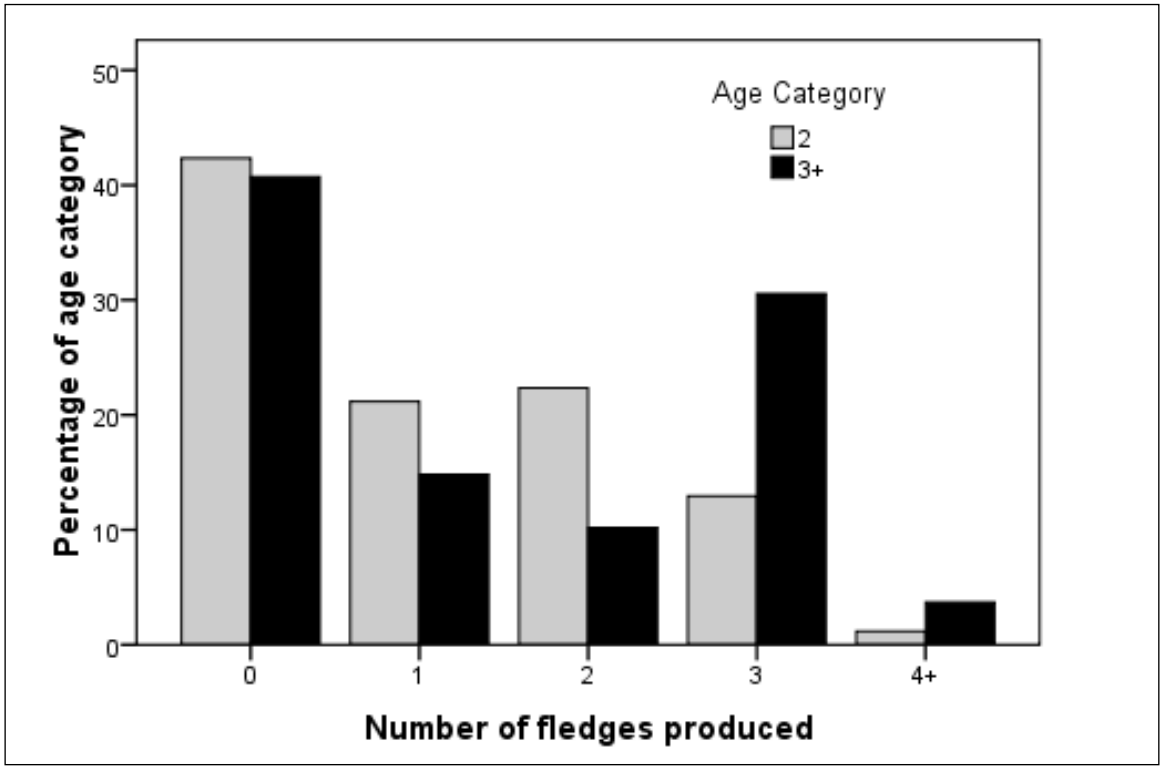

Figure 4.4. The percentage of willow flycatcher females in each of two age classes (2 years vs. 3 or more years old) that produced a given number of flycatcher fledglings in a season, all study areas, 1997–2012.

Minimum Lifetime Productivity

From 1997 to 2012, we tracked the annual reproductive efforts of 182 females and 272 males. Eight male and three female flycatchers transitioned between geographic areas during their adult lives, and the reproductive output for these individuals within each geographic area was considered to be their "lifetime" reproductive output for that region. Minimum lifetime productivity (MLP) for male flycatchers ranged from 0 to 19 in the Pahranagat region, 0 to 17 in the Virgin Valley, and 0 to 10 at Havasu. MLP for female flycatchers showed similar variation, ranging from 0 to 18 in the Pahranagat region, 0 to 12 in the Virgin Valley, and 0 to 10 at Havasu (Table 4.15; Figure 4.5). A non-parametric ANOVA showed a weak effect of gender on MLP ($F_{1,459}$ = 3.966, P = 0.047) and a strong effect of region on MLP ($F_{2,459}$ = 23.92, $P < 0.001$). There was no significant interaction between gender and region ($F_{2,459}$ = 0.134, P = 0.874), although when regions were analyzed separately, there was a significant difference between males and females only for the Virgin region. Mean ranks of females were higher than those for males, and mean ranks for Pahranagat were higher than those for either the Virgin Valley or Havasu, which did not differ from one another. Regions differed in the frequency at which flycatchers were observed with high MLP, with 20.9% of flycatchers in the Pahranagat Valley having MLP >8, compared to 3.3% of flycatchers in the Virgin region and 2.6% of flycatchers in the Havasu region. Regions also differed in the proportion of individuals that were never known to have produced offspring, with 50.9% of flycatchers at Havasu producing no fledges, compared to 44.8% in the Virgin Valley and 24.5% in the Pahranagat

Valley (Figure 4.6). Lifetime productivity increased for both male and female flycatchers with the number of seasons an individual was detected (Figure 4.7).

In addition to differing in MLP, males and females differed in the proportion of years in which they were confirmed to be breeding, given that they were known to be alive. Both genders were detected for a comparable proportion of the years in which they were known to be alive, but females were rarely detected unless they were breeding, whereas males were often detected as unpaired individuals. Therefore, females were detected as breeding in a higher proportion of years of their known lives than were males (Figure 4.8), with nearly 80% of all females detected as breeding in all years, while less than 40% of males were detected as breeding in all years. A higher percentage of males (44.9%) than females (30.2%) produced no offspring in their lifetime.

In our analysis of the effects of repeated parasitism on female MLP, preliminary models with interaction effects were attempted. No interaction effects were significant, and only the main effects models are presented here. In the full models with geographic region, number of breeding seasons, and either the parasitism rate by year or the lifetime parasitism rate, all main effects were significant predictors of MLP. When each region was analyzed separately, the number of breeding seasons was a significant predictor of MLP within each region. The effect of parasitism on MLP varied between regions, however. In the Pahranagat Valley, parasitism rate by year was a significant predictor of MLP ($F = 8.613$, $P = 0.005$), as was the lifetime parasitism rate ($F = 7.742$, $P = 0.007$). Parasitism rate by year was also a significant predictor of MLP in the Havasu region ($F = 6.033$, $P = 0.019$), as was lifetime parasitism rate ($F = 5.307$, $P = 0.027$). However, neither measure of parasitism was a significant predictor of MLP in the Virgin Valley (parasitism rate by year $F = 1.713$, $P = 0.195$; lifetime parasitism rate $F = 0.395$, $P = 0.531$). In all cases where parasitism was a predictor of MLP, increased parasitism rate resulted in lower MLP.

Table 4.15. Minimum Lifetime Productivity (MLP) for Female and Male Southwestern Willow Flycatchers in the Pahranagat, Virgin Valley, and Havasu Regions, 1997–2012

	Pahranagat		Virgin Valley		Havasu	
Minimum lifetime productivity	**Females (n = 63)**	**Males (n = 76)**	**Females (n = 82)**	**Males (n = 128)**	**Females (n = 40)**	**Males (n = 76)**
Mean (SE) range	4.62 (0.55) 0–18	4.58 (0.55) 0–19	2.50 (0.32) 0–12	1.98 (0.26) 0–17	1.65 (0.34) 0–10	1.43 (0.25) 0–10
Median 25th–75th percentile	3.0 2.0–7.0	3.0 0–7.0	2.0 0–4.0	0.5 0–3.0	1.0 0–2.0	0.0 0–2.0

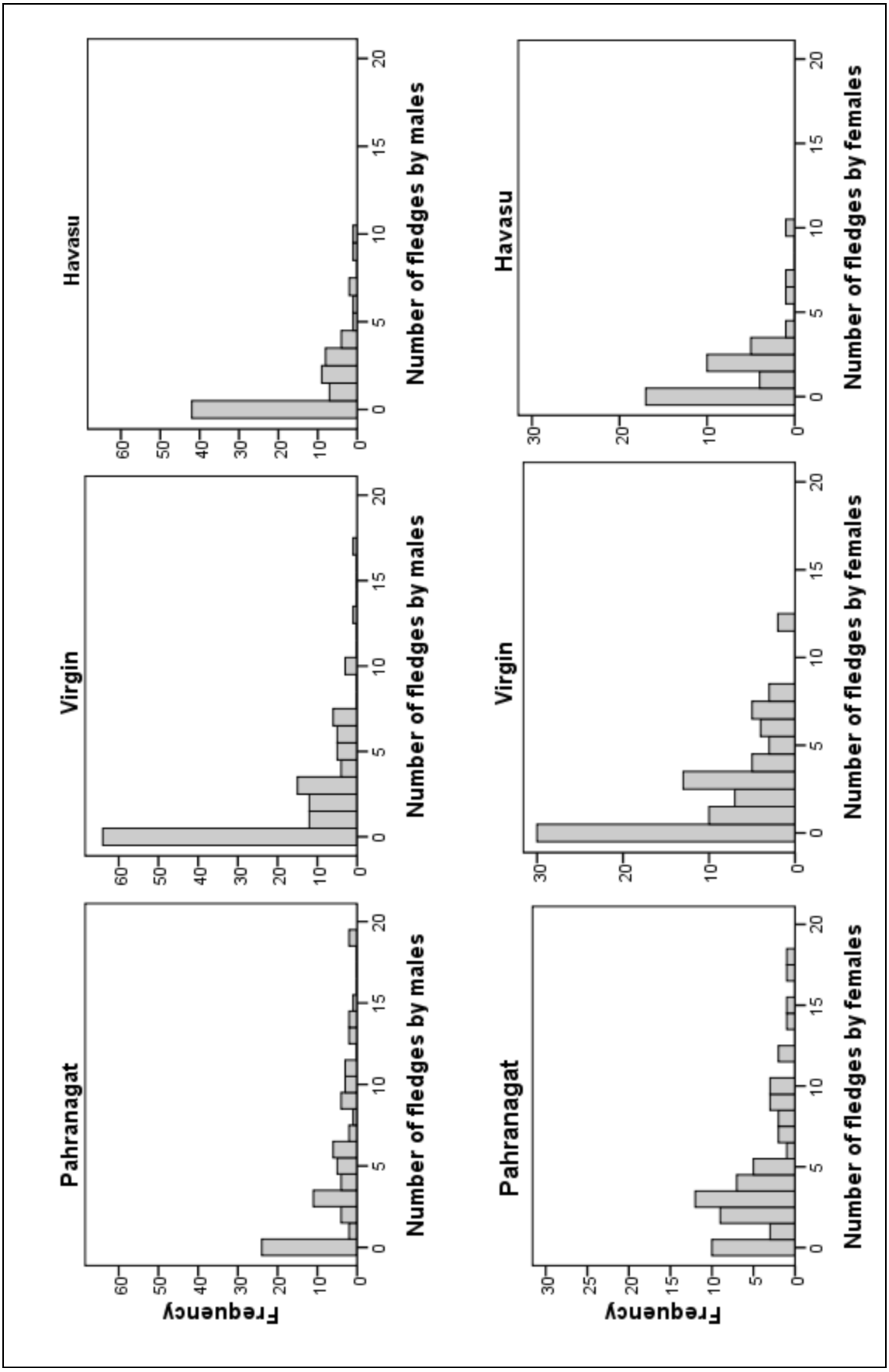

Figure 4.5. Minimum lifetime productivity for male and female southwestern willow flycatchers in the Pahranagat, Virgin, and Havasu regions, 1997–2012.

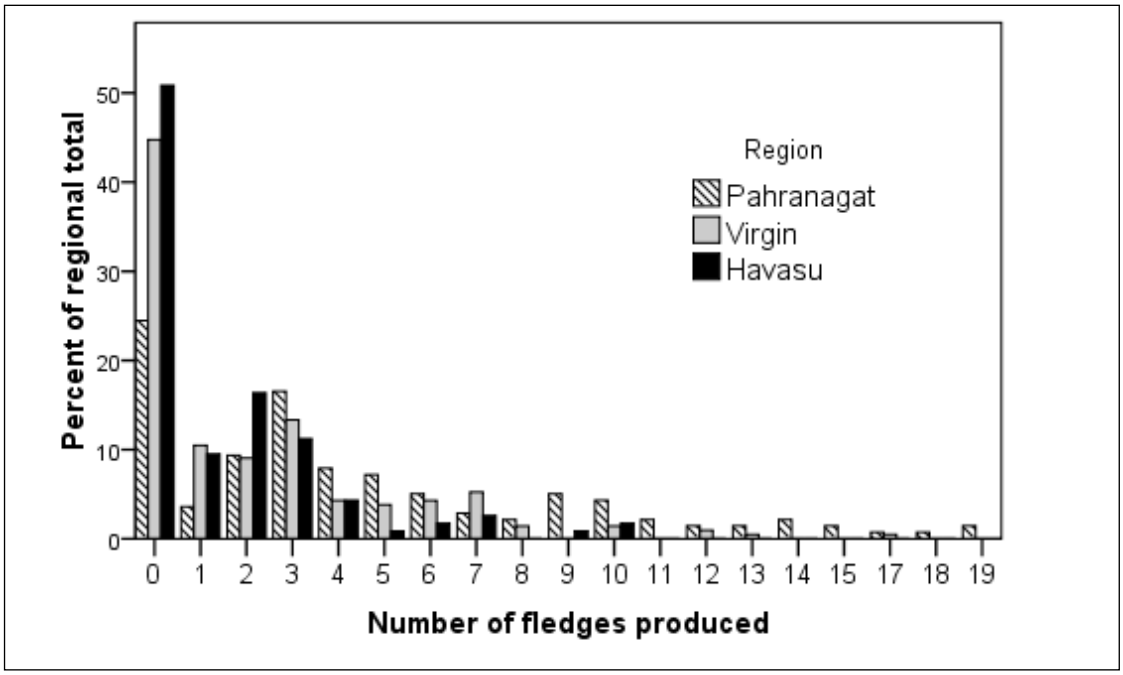

Figure 4.6. The percentage of adult flycatchers of known gender within the Pahranagat, Virgin, and Havasu regions that produced a given number of fledglings over their lifetime, 1997–2012.

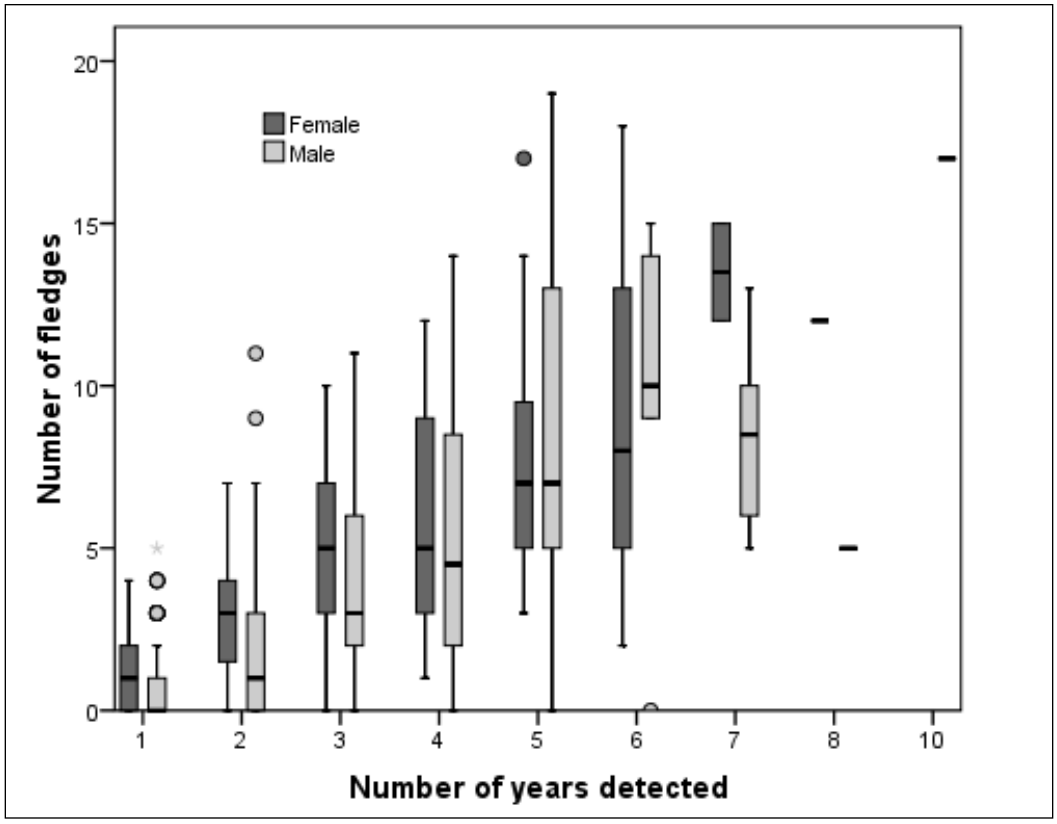

Figure 4.7. The number of fledgling flycatchers produced by male and female flycatchers as a function of the number of years the adult flycatcher was detected. Boxes show median and interquartile range (IQR), and whiskers show 1.5 IQR.

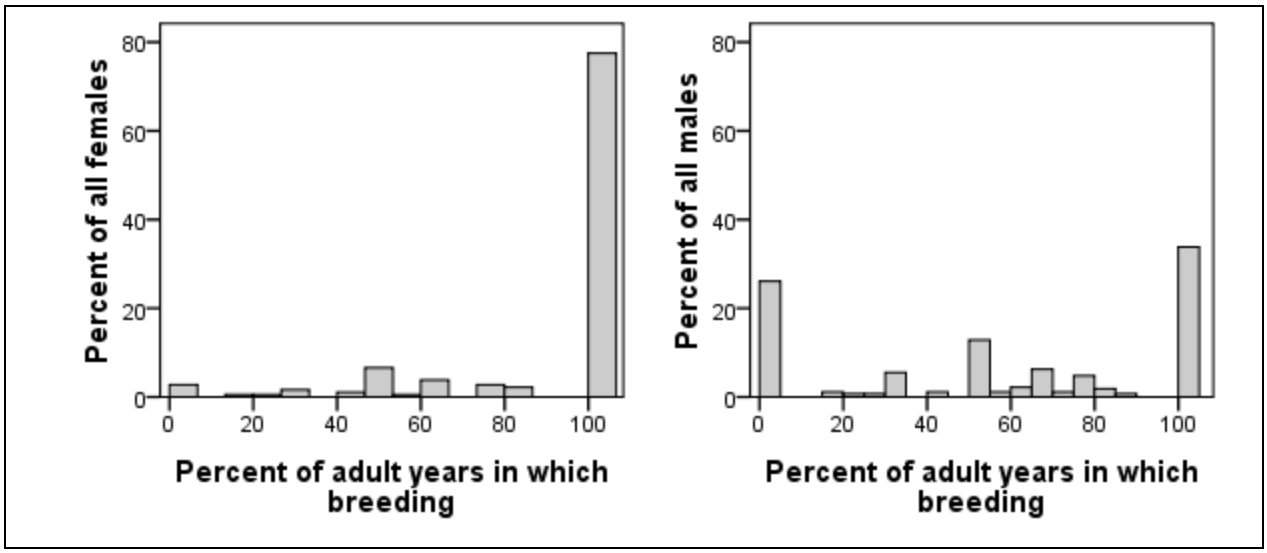

Figure 4.8. Percentage of a flycatcher's known adult life span in which it was detected breeding, male and female flycatchers, all study areas.

DISCUSSION

Number of Breeding Flycatchers

Willow flycatcher nesting was documented every year from 2003 to 2012 at Pahranagat, Mesquite, and Mormon Mesa, and all years except 2012 at Topock Marsh and 2004 at Bill Williams. Breeding was documented every year starting in 2005 at Muddy River, and in some years at Littlefield and lower Grand Canyon. 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. The number of flycatcher pairs recorded each year at Pahranagat, Muddy River, and Bill Williams from 2003 to 2012 showed no strong trend, but oscillated around their respective means. The number of breeding flycatchers documented in Mormon Mesa increased from 2003 to 2007, and then stabilized from 2007 to 2012 (see Chapter 2). Declines were noted in the number of pairs at both Mesquite and Topock Marsh starting in 2010 and 2005, respectively (see Chapter 2).

At Mesquite, the number of pairs declined from 15 to 12 in 2006–2009 and then to 7 in both 2010 and 2011; only 4 pairs were recorded in 2012. The main breeding site at Mesquite (Mesquite West) was dry in 2009, and nesting success was poor that year (McLeod and Koronkiewicz 2010). Flycatchers appeared to respond to the poor conditions by returning to other breeding sites in 2010 rather than returning to Mesquite (McLeod and Pellegrini 2011), and the number of breeding flycatchers at Mesquite was consequently reduced. Mesquite West was wet at the beginning of the 2011 breeding season but became completely dry by mid-season (McLeod and Pellegrini 2012). Water was present intermittently in 2012 and did not reach the same areal extent as in previous years, and qualitative habitat observations indicated that canopy cover in portions of the site was reduced in comparison to previous years (see Chapter 2). Site fidelity to Mesquite of returning adult flycatchers was low again in 2012 (McLeod and Pellegrini 2013), resulting in another decrease in the number of breeding flycatchers and further suggesting poor habitat quality.

At Topock Marsh, the number of pairs declined from a high of 29 in 2004 to only one pair in 2011. In 2012, for the first time since flycatcher studies began in 1996, no breeding flycatchers were detected,

and we detected only two resident flycatchers. The number of resident flycatchers at Topock has also been declining steadily since 2004. Low water levels in Topock Marsh and a decline in the amount of inundated riparian vegetation likely contributed to the decline in flycatcher populations (see Discussion in Chapter 2 and Chapter 9).

Nest Success and Productivity

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 would have been produced if the initial nesting attempt had been successful. Thus, nest productivity (young produced per nesting attempt) and fecundity (young produced per female) in conjunction with nest success provide additional information on the success of a given breeding season. All three breeding season success metrics exhibited yearly fluctuations, illustrating that the demographic patterns of passerine populations often vary year to year, and sometimes to a very large degree (Wiens 1989a). The variable patterns of nest success observed at the study areas over many years demonstrate the need for long-term data.

Overall, apparent nest success and MSP were highest at Pahranagat and lowest at Muddy River. Pahranagat also had significantly higher daily survival rates in each nesting stage than most of the other study areas. Multiple factors may contribute to high nest success rates at Pahranagat. The vegetation at Pahranagat is completely native and consists of tall, large-diameter trees; this structure is not found at any other study area. The Pahranagat Valley is at an elevation approximately 500 m higher than the Virgin Valley and nearly 900 m higher than the Havasu region and has a correspondingly cooler climate (see McLeod et al. 2008a). Differences between Pahranagat and the other study areas in geographic location, vegetation structure, climate, and landscape characteristics may result in Pahranagat having a different suite of predators and in flycatchers at Pahranagat being exposed to different predation pressures than at other study areas. Of the study areas where sample size allowed comparisons, Pahranagat had the lowest depredation rate (25.2% of all nests containing flycatcher eggs); depredation rates at the other study areas varied from 28.9% at Mormon Mesa to 40.9% at Key Pittman. The most obvious difference in predator communities between Pahranagat and the other study areas is the relative lack of cowbirds (a documented nest predator; see Brood Parasitism below), as evidenced by a lack of parasitism events at Pahranagat. We have also documented numerous instances of flycatchers abandoning or deserting their nests following parasitism events, and Pahranagat had the lowest rates of nest abandonment and desertion among the study areas. Therefore, the relatively low rates of depredation, abandonment, and desertion and the correspondingly high rate of nest success at Pahranagat can likely be attributed in large part to the lack of cowbirds. Conversely, the low nest success rate at Muddy River corresponds with Muddy River having the highest parasitism rate of any of the study areas.

In addition to having the highest nest success rate, flycatchers at Pahranagat also produced the highest number of fledglings per successful nest and per female. Flycatchers at Pahranagat had the largest mean clutch size of any of the study areas (see Clutch Size, below), and therefore had the highest reproductive potential. We have not analyzed the occurrence of partial depredation events, hatch rate, or nestling survival to see whether these metrics differed among study areas. Clutch size and geographic region were both important predictors of the number of fledges per successful nest. Both were both more important predictors than parasitism, which also had a significant negative influence on the number of fledges per nest.

Mayfield nest success did not differ substantially from apparent nest success, suggesting that the majority of nesting attempts were identified. Eighty-two percent of all documented nesting attempts were located during the building or laying stages. With a high proportion of nests located early in the nesting cycle, it

is not surprising that apparent nesting success mirrors Mayfield success, which is designed to adjust for nests that fail before they are found. If intensive nest searching results in the discovery of most nests early in the nesting cycle, Mayfield estimates may be unnecessary for obtaining accurate nest success estimates. Calculating Mayfield estimates requires frequent visits to the nest around transition dates (e.g. hatch date); if Mayfield estimates were not necessary, fewer visits could be made to the nest, and nest disturbance could be reduced with no loss of nest success information.

Nest Failure

Depredation was the major cause of willow flycatcher nest failure in 2003–2012, accounting for 46% of all failed nests. These results are consistent with those reported at the Reclamation study areas from 1998 to 2002 (Braden and McKernan unpubl. data) and at sites across Arizona from 1996 to 2008 (Graber et al. 2007, Ellis et al. 2008, Graber and Koronkiewicz 2009a). Depredation also accounted for the majority of all willow flycatcher nest failures in those studies. Factors influencing the increases and decreases in nest depredation at the monitored study areas are inherently complex and at this time remain largely undetermined. 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 1989b, Robinson 1992, Howlett and Stutchbury 1996).

In 2008, Northern Arizona University (NAU) initiated a nest camera study in cooperation with SWCA on open-cup nesting passerines at selected study areas along the lower Colorado River and tributaries. The study used video and still cameras on real and artificial nests to identify depredation rates and nest predators. Video and still cameras were deployed in both Topock Marsh and Bill Williams in 2008. Low sample sizes and technical difficulties affected the detection of depredation events and identification of nest predators. Artificial nests were deployed from 2008 to 2010 at Mesquite and Pahranagat. Both Brown-headed Cowbirds and Yellow-breasted Chats were identified by still cameras as depredating artificial nests. Marks on clay eggs indicated that most depredation events at Mesquite were from birds, while at Pahranagat both birds and rodents depredated artificial nests (NAU unpubl. data).

Video cameras were deployed on flycatcher nests from 2008 to 2010 at Mesquite, from 2008 to 2011 at Pahranagat, and in 2010 and 2011 at Key Pittman. At Mesquite, only cowbirds were documented on video depredating flycatcher nests. At Pahranagat, only avian predators were documented on video depredating flycatcher nests. These predators included Bewick's Wren (*Thyromanes bewickii*), Gray Catbird (*Dumetella carolinensis*), American Crow (*Corvus brachrynchos*), and Red-shouldered Hawk (*Buteo lineatus*). At Key Pittman, avian and reptilian nest predators were documented on video depredating flycatcher nests. Nest predators included Sharp-shinned Hawk (*Accipiter striatus*) and kingsnake (*Lampropeltis getulus*). Field personnel also witnessed a depredation event by a short-tailed weasel (*Mustela frenata*). Results of this study suggest that avian species may be important predators on flycatcher nests at Reclamation study areas. Ellis et al. (2008) also identified Cooper's Hawks (*Accipiter cooperii*) and Yellow-breasted Chats depredating flycatcher nests at sites in Arizona.

Brood Parasitism

Brood parasitism by Brown-headed Cowbirds across all Reclamation study areas ranged from 0 to 48% and averaged 22% (see Table 4.1). These parasitism rates are consistent with those reported at the study areas from 1998 to 2002 (Braden and McKernan unpubl. data), but are 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).

We observed multiple occasions in which the disappearance of flycatcher eggs coincided with the parasitism event. In these cases, 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 the 2008–2010 camera study, and cowbirds were documented on video depredating flycatcher nests during both the incubation and nestling phases. Therefore, it is likely that other depredation events on eggs and nestlings are attributable to cowbirds.

Parasitism does not invariably cause nest failure, but the success rate (19%) for parasitized nests at all Reclamation study areas in 2003–2012 was less than half that of unparasitized nests (49%). 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 vs. 57% of unparasitized nests (Ellis et al. 2008). Parasitized nests that did succeed in fledging flycatcher young at all Reclamation study areas in 2003–2012 produced on average fewer young (1.3 young/nest) than did successful, unparasitized nests (2.2 young/nest; $F_{1,2273} = 22.74$, $P < 0.001$). 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 2012, 42% 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).

Female flycatchers that are parasitized at least once during the season were significantly less likely to fledge any young than their unparasitized counterparts. Given that adult flycatchers often exhibit high site fidelity to breeding areas (Braden and McKernan unpubl. data, this document), females returning to sites with high brood parasitism may have reduced lifetime fecundity (see Minimum Lifetime Productivity, below). Female flycatchers may desert their nests after a parasitism event and attempt renesting. 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, this document), suggesting additional effects of parasitism and subsequent renesting on flycatcher demography. Across all study areas, 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 ($F_{1,225} = 16.836$, $P < 0.001$). This 10-day delay corresponds to a reduced survival probability of approximately 6% (see Chapter 3).

Cowbird Egg Addling

We did not include NDOW study areas in our quantitative analysis of the effects of egg addling because we do not have nest monitoring data from before 2010, when the addling program began, with which to compare. Addling cowbird eggs markedly reduced the cowbird hatch rate at Reclamation study areas, and no female flycatcher at any study area deserted her nest in response to egg addling. Although the addling program has not increased nest productivity, small sample sizes in 2010–2012 and the proportionally larger effect of instances of depredation and addled flycatcher clutches may obscure any positive effects of addling cowbird eggs. It is clear from nest monitoring data collected in 2003–2009 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%) did not differ from nests with both flycatcher and cowbird nestlings (52%, Fisher's exact test, $P = 0.73$). However, parasitized nests that hatched at least one flycatcher and no cowbirds produced an average of 1.40 flycatchers per nest, compared to 0.57 flycatchers per nest in nests with a cowbird nestling ($t = 2.79$, $df = 13.47$, $P = 0.015$). Additionally, the percentage of flycatcher nestlings that

survived to banding age (8 days) in nests that did not hatch cowbird eggs (95%) was significantly higher (Fisher's exact test, $P = 0.004$) than the proportion (58%) 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.

A possible alternative to addling cowbird eggs is to replace the cowbird egg with a dummy cowbird egg. This method has been practiced with success in the Kern River Valley (Mary Whitfield, pers. comm.), and can potentially reduce the number of visits to a nest by eliminating the possibility the cowbird egg will hatch. This method also requires only one physical trip to the nest to switch the real and fake cowbird eggs, as compared with the two trips required by addling to remove, addle, and replace the real cowbird egg. It also eliminates the risk of mimicking a partial depredation event due to accidental damage to the cowbird egg during addling.

Clutch Size

We documented decreasing clutch size with subsequent nest attempts within a season. This pattern has been documented in other studies of willow flycatchers (Holcomb 1974, Ellis et al. 2008) and is widely recognized in other avian species (Decker et al. 2012). In addition, clutch size varied between study areas and between geographic regions. Seasonal reductions in clutch size may be influenced by food availability, female body condition, or perceived risk of nest predation following a failed nest (reviewed in Decker et al. 2012). Food availability and female body condition could also influence differences in clutch sizes between study areas. We have not assessed either food availability or female body condition to determine if these differ between study areas or are correlated with clutch size.

Analysis of the relative importance of nest attempt number and geographic area, as well as parasitism and distance to water when the nest was found, on observed clutch size indicated that both geographic region and nest attempt were significant predictors of clutch size. However, geographic area was more important than nest attempt, as was whether the nest had been parasitized. Distance to water was almost as important a factor as nest attempt in predicting clutch size, with distance to water inversely related to clutch size. A similar pattern was found along the San Pedro and Gila rivers, with nests containing the largest clutches (4 eggs) almost always being over standing water (A. Graber, SWCA, pers. comm.). Distance to water could also be related to food availability as noted by a recent study in the Pahranagat Valley (NAU unpublished data).

Age-based Seasonal Productivity

We found a significant difference in seasonal fecundity but not seasonal nest success between second-year females and older females, with younger individuals producing fewer fledglings. This same pattern was observed in willow flycatchers in central Arizona (Paxton et al. 2007). We also found that seasonal parasitism rate was not affected by female age. Because seasonal nest success and parasitism rate did not vary with age, neither age nor experience seems to improve a female's chances of avoiding depredation, parasitism, or other events that cause complete nest failure. Age-specific reproductive success is commonly observed in birds, and several hypotheses (reviewed in Mauck et al. 2004) have been proposed to explain this phenomenon: (1) older individuals have more reproductive experience and therefore can increase their output without additional effort (i.e., greater parental efficiency); (2) older individuals have increased reproductive effort; and (3) high-productivity individuals also have a higher probability of survival, and thus the proportion of highly productive individuals increases with age. The flycatcher data appear to support the third hypothesis: female flycatchers that were detected only in their second year (and thus presumably died before their third year) produced an average of 0.8 young (n = 35), whereas

female flycatchers that survived at least to their third year produced an average of 1.4 young (n = 25) in their second year and an average of 1.5 young per year for breeding seasons beyond the second year. We have not analyzed the data to determine whether higher seasonal productivity for these individuals is related to larger initial clutch sizes, higher hatch rates, higher nestling survival, or some combination of these factors.

Minimum Lifetime Productivity

Females had a slightly higher MLP than males, although this difference was significant only in the Virgin region. This is in contrast to what was observed in central Arizona, where male flycatchers had a slightly higher MLP (mean = 3.77) than females (mean = 3.29), though this difference was not statistically significant (Paxton et al. 2007). Paxton et al. (2007) suggested that although a higher proportion of males than females produced zero young, males had a mean MLP similar to that of females because polygyny allowed males to achieve higher MLP than females. Along the lower Colorado River and tributaries, females were more likely than males to produce at least one offspring and also had higher MLP than males, despite having a shorter life expectancy (see Chapter 3); thus, polygyny did not appear to compensate completely for males being more likely to produce zero offspring.

The mean MLP we recorded in the Virgin and Havasu regions was below that recorded in central Arizona, while mean MLP recorded in the Pahranagat region was higher than that recorded in central Arizona. This was the case even when we adjusted the number of presumed fledges to include all nestlings that were known to be alive at 10 days of age, to replicate the methods followed in Paxton et al. (2007). This adjustment resulted in an increase in MLP ranging from 0.31 to 0.41 young for both males and females in each region. The high MLP observed in the Pahranagat Valley was the result primarily of high annual productivity but may also have been influenced by male flycatchers in the Pahranagat Valley having the highest mean adult age of flycatchers in any of the regions (see Chapter 3).

A high parasitism rate, as measured either by the proportion of total lifetime nesting attempts that were parasitized or the proportion of years in which at least one nest was parasitized, resulted in reduced MLP for female flycatchers in all geographic regions; this effect was significant in both the Pahranagat and Havasu regions but not in the Virgin Valley. There were several instances in the Virgin Valley of female flycatchers having MLP >5 despite repeated parasitism events; in one case, a female successfully produced two broods in a season when she was not parasitized. These unusual cases of high productivity despite repeated parasitism likely contribute to parasitism rate not being a significant predictor of MLP in the Virgin Valley. Despite the lack of statistical significance of parasitism rates in the model, parasitized nests in the Virgin Valley, as in the other two regions, were less likely to fledge flycatcher young than unparasitized nests, and if at least one nest attempt by a given female was parasitized in a season, her reproductive output for that season was more likely to be zero. It is apparent that cowbird parasitism has adverse effects on both annual and lifetime productivity for willow flycatchers in the study areas we monitored. Parasitism rates have been particularly high at Mesquite, Muddy River, and Topock Marsh, and parasitism is likely one of the factors limiting the ability of Virgin Valley and Havasu populations to sustain themselves through local recruitment (see Chapter 3).

Chapter 5

BROWN-HEADED COWBIRD TRAPPING

INTRODUCTION

From 1997 to 2002, willow flycatcher breeding data (brood parasitism rates, nest success, and productivity) were documented at Pahranagat, Mesquite, and Topock Marsh (McKernan and Braden unpubl. data), with no cowbird trapping conducted in the proximity of the breeding sites.[6] In this chapter we compare data from 1997 to 2002 (pre-trapping period) to that recorded during five years (2003–2007) of cowbird trapping (trapping period), and five years (2008–2012) with no cowbird trapping (post-trapping period). Our objectives were to determine if cowbird trapping and removal affects willow flycatcher brood parasitism rates, flycatcher nest success, or flycatcher productivity.

METHODS

From 2003 to 2007, we conducted cowbird trapping, following methods outlined in Griffith Wildlife Biology (1994), at the Pahranagat, Mesquite, and Topock Marsh study areas. We also trapped cowbirds at Mormon Mesa in 2003–2005; this trapping effort was discontinued because of the difficulty in placing traps within 400 m of areas occupied by willow flycatchers, and the trapping effort at Mormon Mesa is not described here. To minimize the number of parasitism days (the number of days a host population is exposed to each female cowbird), cowbird traps were deployed at least two weeks prior to the initiation of flycatcher nesting (mid-May) and continually operated until all nests at the study area were at least past the egg laying and incubation stages (late July or early August).

Trap Design

In 2003 and 2004, we used a variation of the Australian crow trap (per the design of Ahlers and Tisdale 1999) to capture Brown-headed Cowbirds (Figure 5.1). These flat-topped, portable, wood-framed traps were 1.2 m high, 1.2 m wide, and 2.4 m long, with a door located on one end. The panels consisted of 5 × 5–cm wood supports covered with 1.3-cm wire mesh. A piece of plywood, with two 3.5-cm-wide slots down the middle, was attached to the top of each trap for cowbird entry.

In 2005, we experimented with two different trap designs: the flat-topped trap (described above), which we had used in 2003 and 2004, and a trap with a funnel-shaped top. The funnel-shaped traps were 1.8 m high, 1.8 m wide, and 2.4 m long, and had a funnel-shaped top (Figure 5.2). All panels consisted of 5 × 5–cm wood supports covered with 1.3-cm wire mesh. Each trap had a door located on one end. A piece of plywood, with two 3.2-cm-wide slots down the middle, was attached to the top of each trap for cowbird entry. In 2006 and 2007, we experimented with slots of two different widths to determine if slight variations in slot size had any effect on capture rates of cowbirds or non-target species. Three of the six traps at Topock had 3.8-cm-wide slots and three had 3.2-cm-wide slots. The results of the experiments comparing trap designs and slot widths are presented in McLeod et al. (2008a) and are not repeated here.

[6] Limited cowbird trapping occurred at Topock in 1998 (White et al. 1998), but no traps were deployed within 400 m of flycatcher breeding areas.

Figure 5.1. Flat-topped Brown-headed Cowbird trap used in 2003–2005

Figure 5.2. Funnel-shaped top Brown-headed Cowbird trap used in 2005–2007

During this study, signs were posted on all trap doors to inform the public of the nature and relevance of the trapping program. The signs were clearly marked and laminated to maintain legibility over the season. Padlocks were used on the doors of traps in public locations to discourage vandalism. Each trap was situated in an accessible location and was visible from above with some natural tree cover.

To attract cowbirds, at least two male and three female live-decoy cowbirds were maintained in each trap whenever possible. Each trap was leveled, and the wire mesh floor covered with a thin layer of soil to encourage natural foraging and social behavior among the decoy birds. Six or more horizontal perches were provided in the trap corners, and shadecloth was attached to sections of the outside of each trap to provide adequate shade.

Trap Maintenance

An abundant supply of wild birdseed (not containing sunflower seeds, which attract non-target species) and a 1-gallon guzzler of water were kept in each trap and replenished daily. Each trap was checked every 24 hours, and findings were recorded on a daily data sheet. Upon entering a trap, field personnel carefully flushed out any non-target birds, recording the number of each species, and, when possible, sex and age. Each day we recorded the number, sex, and age of newly trapped cowbirds, and we clipped the wings of all cowbirds at the edge of the secondary and primary feathers, thus lowering the probability of injury in the trap and the likelihood that any escaped bird would be able to survive. We also recorded any cowbirds that were missing, dead, or removed from the trap as well as any pertinent notes. The disposition (transferred to another trap or euthanized) of all removed cowbirds was noted. Excess numbers of cowbirds were removed periodically, placed in a small holding cage, and euthanized off-site using carbon monoxide.

Trap Number and Location

We attempted to deploy traps in sufficient numbers and locations such that all flycatcher nests were within 400 m (the effective trapping radius; John Griffith, Griffith Wildlife Biology, pers. comm.) of a cowbird trap.

Data Analysis

We used SPSS® Version 15.0 (SPSS Inc.) software for statistical analyses. A statistical significance level of $P \leq 0.05$ was chosen to reject null hypotheses. Although we attempted to trap at Mesquite in 2003, trapping was ineffective and no cowbirds were removed. Thus, data from 2003 at Mesquite were included in the pre-trapping period. We examined data from each study area separately and used Pearson chi-square tests to compare the likelihood of a nest being parasitized during the pre-trapping, trapping, and post-trapping periods. We also used Pearson chi-square tests to compare nest success rates during the pre-trapping, trapping, and post-trapping periods at individual study areas.

We used ANOVA to compare the number of fledges produced per nest and the number of fledges produced per female during the three trapping periods. Because studies have shown that the most important predictor of survivorship for juvenile willow flycatchers is fledge date, with nestlings fledging later in the breeding season having lower survivorship than those fledged early in the breeding season (Paxton et al. 2007, McLeod et al. 2008a), we used ANOVA to compare nestling fledge date between trapping periods.

RESULTS

Trap Operation

From 2003 to 2007, we operated two traps at Pahranagat and six at Topock, all of which remained in essentially the same locations across years. Two traps were operated at Mesquite in 2003, and three traps were operated in 2004–2007. Because few cowbirds were captured at Mesquite in 2003, traps were placed in different locations in 2004. Trap locations were essentially unchanged between 2004 and 2005. In 2006, one of two traps at Mesquite East was moved to Mesquite West. The remaining trap location at Mesquite East was moved between 2006 and 2007 from the west end to the center of the site. For details on trap locations from 2003 to 2007 see orthophotos presented in Koronkiewicz et al. (2004, 2006) and McLeod et al. (2005, 2007, 2008b).

We operated all traps from approximately mid-May to late July or early August each year. In 2003–2007, we captured and removed 544, 266, and 872 Brown-headed Cowbirds at Pahranagat, Mesquite, and Topock, respectively (Table 5.1). Approximately 1% of cowbirds captured at Pahranagat were juveniles, compared to 6% at Mesquite and 9% at Topock.

Table 5.1. Summary of Brown-headed Cowbirds Trapped and Removed at Pahranagat NWR, Mesquite, NV, and Topock Marsh, AZ, 2003–2007

Study Area	Year	# Males	# Females	# Juveniles	Total # Brown-headed Cowbirds
Pahranagat	2003	65	85	2	**152**
	2004	100	59	3	**162**
	2005	32	24	0	**56**
	2006	45	25	0	**70**
	2007	55	48	1	**104**
	Total	**297**	**241**	**6**	**544**
Mesquite	2003	-4	-4	1	**-7**
	2004	8	6	2	**16**
	2005	34	24	3	**61**
	2006	73	44	8	**125**
	2007	41	29	1	**71**
	Total	**152**	**99**	**15**	**266**
Topock	2003	38	30	22	**90**
	2004	24	15	4	**43**
	2005	133	77	33	**243**
	2006	195	108	20	**323**
	2007	88	82	3	**173**
	Total	**478**	**312**	**82**	**872**

Brood Parasitism Rates

The proportion of nests parasitized (Table 5.2) did not differ among the three trapping periods at Mesquite ($\chi^2 = 1.53$, $P = 0.47$). The proportion of nests parasitized at Pahranagat was significantly lower during both trapping and post-trapping compared to pre-trapping ($\chi^2 = 19.75$, $P < 0.001$). At Topock Marsh, a lower proportion of nests was parasitized during the post-trapping years than during trapping ($\chi^2 = 6.78$, $P = 0.034$).

Willow Flycatcher Nest Success

The proportion of successful nests recorded at Mesquite and Topock (Table 5.2) did not differ among the trapping periods ($\chi^2 = 0.64$, $P = 0.73$ and $\chi^2 = 1.36$, $P = 0.51$, respectively). Nest success differed between trapping and pre-trapping periods at Pahranagat ($\chi^2 = 4.3$, $P = 0.039$), with a higher proportion of successful nests recorded during trapping years. Nest success during post-trapping years at Pahranagat did not differ from that during trapping ($\chi^2 = 0.05$, $P = 0.828$), and was marginally higher than that during pre-trapping ($\chi^2 = 3.1$, $P = 0.078$).

Willow Flycatcher Productivity

The ANOVA examining the effects of trapping, study area, and their interaction on mean number of flycatcher young fledged per nest (productivity; Table 5.2) showed that productivity varied by study area ($F_{2,551} = 23.37$, $P < 0.001$), but not by trapping period ($F_{2,551} = 0.80$, $P = 0.45$), with Pahranagat fledging more young per successful nest than either Topock or Mesquite; Topock and Mesquite did not differ from each other. The interaction between study area and trapping period was significant ($F_{4,551} = 3.24$, $P = 0.012$), with mean number of fledges per nest being higher at Pahranagat during trapping versus pre-trapping but not differing at the other study areas between trapping periods (Figure 5.3). Mean number of young produced per female flycatcher (Table 5.2) also differed between study areas ($F_{2,400} = 37.3$, $P < 0.001$) but did not differ by trapping period ($F_{2,400} = 1.10$, $P = 0.33$), and there was no significant interaction between trapping period and study area ($F_{4,400} = 2.13$, $P = 0.076$; Figure 5.4). Mean fledge date did not differ significantly by study area ($F_{2,273} = 0.29$, $P = 0.75$) or trapping period ($F_{2,273} = 1.60$, $P = 0.203$), and there was no significant interaction between study area and trapping period ($F_{4,273} = 1.61$, $P = 0.170$). However, when data from Pahranagat were analyzed separately, average fledge date was earlier at Pahranagat during the trapping compared to the pre-trapping period (Figure 5.5; $F_{2,131} = 5.23$, $P = 0.007$).

DISCUSSION

Cowbird brood parasitism of *E. t. extimus* is of particular concern because brood parasitism usually results in reduced reproductive output (Sedgwick and Knopf 1988, Harris 1991, Whitfield and Sogge 1999, Rothstein et al. 2003, this document). Brown-headed Cowbird management issues are complicated because it is still unclear how brood parasitism rates affect willow flycatcher population sizes (Rothstein et al. 2003), and cowbird control methods are costly. The frequency of cowbird brood parasitism of the willow flycatcher across its range is known to be highly variable, ranging from less than 5% at some sites to over 60% at others (Sedgwick 2000). Furthermore, the effectiveness of cowbird control in reducing parasitism in the willow flycatcher varies across studies or cannot be assessed because flycatcher productivity data were not collected before cowbird control began (Rothstein et al. 2003).

Table 5.2. Brown-Headed Cowbird Brood Parasitism Rates, Nest Success, Number of Fledges, and Fecundity at Pahranagat, Mesquite, and Topock, 1997–2012*

	Year	Pahranagat					Mesquite[1]					Topock				
		# Nests	% Parasitism	% Nest Success	Productivity	Fecundity	# Nests	% Parasitism	% Nest Success	Productivity	Fecundity	# Nests	% Parasitism	% Nest Success	Productivity	Fecundity
Pre-trapping	1997	Nm[2]	--	--	--	--	3	66.7	66.7	0.7	0.7	INA[3]	--	--	--	--
	1998	22	0.0	47.4	1.1	2.0	7	83.3	0.0	0.0	0.0	19	31.6	53.3	1.1	1.4
	1999	16	8.3	60.0	1.5	2.3	0	--	--	--	--	20	30.0	40.0	0.8	1.0
	2000	19	13.3	62.5	1.7	2.1	8	25.0	66.7	1.0	1.0	19	15.8	36.4	0.7	0.6
	2001	21	16.7	50.0	1.2	1.6	18	29.4	52.9	1.3	1.8	19	27.8	35.7	0.9	1.2
	2002	18	47.1	40.0	0.8	1.3	17	28.6	58.8	1.1	1.5	8	12.5	50.0	1.5	1.8
	Mean		**17.1**	**52.0**	**1.3**	**1.9**		**42.4**	**48.3**	**0.8**	**1.1**		**23.5**	**43.1**	**1.0**	**1.2**
Trapping	2003	12	0.0	90.9	2.2	3.0	19	21.1[4]	44.4	0.9	1.3	12	18.2	80.0	1.5	1.7
	2004	17	0.0	76.5	2.1	2.5	20	45.0	23.5	0.7	0.9	43	31.7	45.9	0.7	0.9
	2005	21	0.0	57.9	1.7	3.0	7	28.6	60.0	0.6	1.0	38	51.4	23.5	0.4	0.8
	2006	18	0.0	60.0	1.6	1.6	21	23.8	55.0	1.2	1.8	17	31.3	28.6	0.4	0.6
	2007	12	0.0	66.7	1.9	2.3	16	40.0	57.1	1.1	1.3	8	0.0	75.0	1.5	1.7
	Mean		**0.0**	**70.4**	**1.9**	**2.5**		**34.4**	**48.9**	**0.9**	**1.3**		**26.5**	**50.6**	**0.9**	**1.1**
Post-trapping	2008	12	0.0	80.0	2.1	2.3	11	10.0	81.8	1.6	1.8	12	8.3	14.3	0.1	0.1
	2009	18	0.0	50.0	1.4	2.4	13	53.8	30.0	0.3	0.4	2	0.0	50.0	1.5	3.0
	2010	20	5.6	58.8	1.5	2.6	15	60.0	33.3	0.6	1.2	2	0.0	50.0	1.0	1.0
	2011	7	0.0	100.0	2.4	2.8	8	14.3	33.3	0.5	0.5	1	0.0	0.0	0.0	0.0
	2012	14	0.0	71.4	1.6	2.1	5	80.0	0.0	0.0	0.0	0	--	--	--	--
	Mean		**1.1**	**72.0**	**1.8**	**2.4**		**43.6**	**35.7**	**0.6**	**0.8**		**2.1**	**28.6**	**0.7**	**1.0**

* Number of nests includes all nesting attempts. Percent parasitism is calculated using only nests for which contents could be determined. Percent nest success is calculated using only nests in which at least one flycatcher egg was laid and nest outcome was known. Productivity indicates the average number of confirmed fledges per nest with flycatcher eggs and a known outcome, and fecundity indicates number of young fledged per nesting female. Data for pre-trapping periods (1997–2002) are from Braden and McKernan (unpubl. data); these numbers have been verified with the raw data and may differ from those presented in annual reports.

[1] Study area includes Mesquite East in 1997–1999 and Mesquite West in 2000–2012. Hafen Lane, Bunker Farm, Bunker Marsh North, and Dumb Luck Bridge are not included.

[2] Study area not monitored.

[3] Unpublished data were not available.

[4] Data for Mesquite in 2003 were included in pre-trapping years because although cowbird trapping was attempted, no cowbirds were removed.

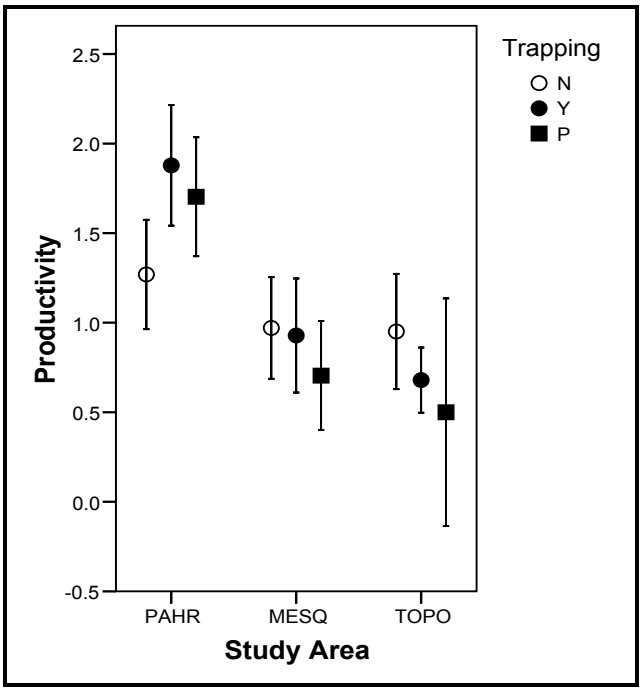

Figure 5.3. Mean number of fledges produced per nest with flycatcher eggs during pre-trapping (N), trapping (Y), and post-trapping (P) periods at each study area. Error bars indicate 95% confidence intervals.

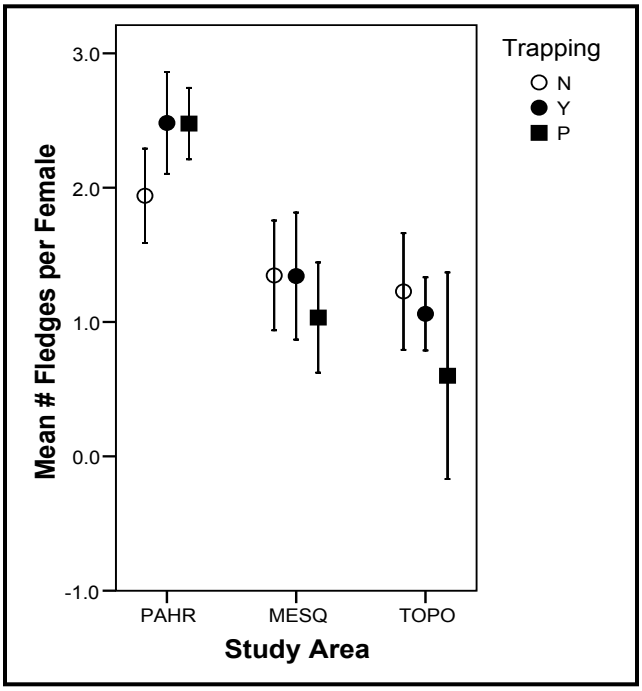

Figure 5.4. Mean number of fledges produced per nesting female during pre-trapping (N), trapping (Y), and post-trapping (P) periods at each study area. Error bars indicate 95% confidence intervals.

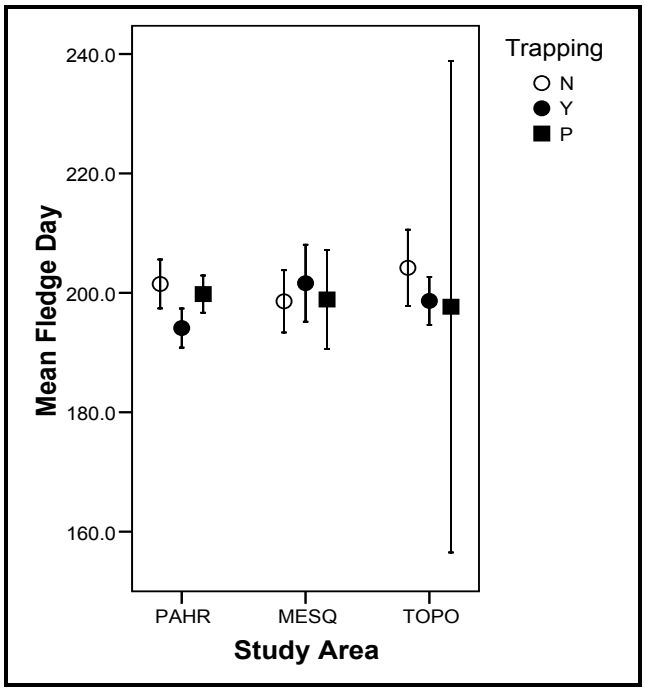

Figure 5.5. Mean Julian fledge date during pre-trapping (N), trapping (Y), and post-trapping (P) periods at each study area. Error bars indicate 95% confidence intervals.

As reported in McLeod et al. (2008a), none of the reproductive metrics we analyzed differed at Mesquite or Topock Marsh between pre-trapping and trapping periods. These metrics did not change during the post-trapping period at Mesquite, further indicating that trapping efforts at Mesquite had no effect on parasitism rates, nest success, productivity, fecundity, or fledge date. The parasitism rate during the post-trapping period at Topock Marsh was lower than during the trapping period, but the sample size of nests was much lower during the post-trapping period (17 nests) than during the pre-trapping (84 nests) or trapping (113 nests) period, and the apparent decrease in parasitism rate may be a spurious effect of low sample size. The data indicate that cowbird trapping at Mesquite and Topock Marsh had no discernible positive effects on willow flycatcher reproduction; parasitism rates were not reduced, and flycatcher reproductive output did not increase. The trapping areas at Mesquite and Topock are part of large, contiguous riparian corridors, and cowbirds that are removed by trapping are likely quickly replaced by other individuals. The Rio Grande serves as a migratory corridor for cowbirds, and as cowbirds are removed, local individuals prospecting for home ranges quickly fill unoccupied habitat (Darrell Ahlers, U.S. Bureau of Reclamation, pers. comm.). The riparian corridors along the lower Colorado and Virgin Rivers probably serve as similar migratory corridors for cowbirds, and cowbirds removed in any given year are probably replaced by other individuals. Reclamation (2001) reported that four years (1997–2000) of cowbird trapping along the Middle Rio Grande did not appear to increase nest success for Neotropical migrant songbirds, including the willow flycatcher.

The parasitism rate at Pahranagat was significantly lower during trapping compared to pre-trapping, with no brood parasitism recorded in any trapping year. Nest success and productivity were higher at Pahranagat during the trapping vs. pre-trapping years, and average fledge date was earlier. In McLeod et al. (2008a), we concluded that cowbird trapping at Pahranagat had decreased brood parasitism rates, as well as reduced the other effects cowbirds can have on host species, such as decreasing clutch size by ejecting host eggs, removing host young, and delaying fledge dates by causing nest failures.

We speculated that the relatively small, isolated nature of Pahranagat may facilitate the effectiveness of trapping. However, the parasitism rate at Pahranagat has continued to be low (1%) during the five post-trapping years, and reproductive metrics during the post-trapping years did not differ from those recorded during the trapping period. It seems unlikely that the effects of trapping in reducing the local cowbird population would last for five years after the cessation of the trapping program.

Other changes at Pahranagat that coincided with the cessation of trapping may have affected parasitism rates. Breeding flycatchers were present in small numbers at Pahranagat South, at the lower end of Upper Pahranagat Lake, from 1998 to 2006 but not in years after 2006. Flycatcher nests at Pahranagat South had a much higher parasitism rate (45%) in the pre-trapping years than did nests at Pahranagat North (17%). Trapping may have controlled parasitism at Pahranagat South during the trapping years. In the post-trapping period, all flycatcher nests have been in Pahranagat North, where they may be inherently less susceptible to parasitism because of the larger size and denser cover of Pahranagat North. The hydrological conditions at Pahranagat North changed markedly between the breeding seasons of 2007 and 2008 (see Chapter 2), when failure of the dam that impounds Upper Pahranagat Lake forced lake levels to be drawn down in 2008–2012 compared to all previous years. Instead of being completely inundated with up to 1 m of water at the beginning of each breeding season, Pahranagat North has developed a thick understory of herbaceous vegetation. The distribution of flycatcher nests within the site has shifted in accordance with the water, with nests now being located primarily along the southern edge of the site closest to the lake. These shifts in hydrology, vegetation, and nest distribution may have affected the suitability of the site for cowbirds, or the susceptibility of flycatcher nests to parasitism, but it is unclear whether these changes account for the continued low rate of parasitism.

Cowbird trapping may have been effective at reducing parasitism rates and increasing flycatcher productivity at Pahranagat during the trapping period, but it was clearly ineffective at Mesquite and Topock Marsh. Kostecke et al. (2005) found that cowbird control efforts in Texas steadily reduced brood parasitism and increased Black-capped Vireo nesting success over time. Whitfield et al. (1999) also found nest success to increase in the willow flycatcher with cowbird control along the South Fork of the Kern River. However, both Kostecke et al. (2005) and Whitfield et al. (1999) used combinations of intensive cowbird control measures (shooting cowbirds, cattle removal, addling cowbird eggs, removing cowbird nestlings) in addition to trapping. Summers et al. (2006) report that shooting cowbirds was a more efficient and cost effective method of removing potential local breeders in May and June.

Brood parasitism rates at Reclamation study areas have been particularly high at Mesquite and Muddy River over the last 10 years, and there is a clear, inverse relationship between parasitism and the likelihood of a nest producing flycatcher young (see Chapter 4). Trapping has proven ineffective at Mesquite but has not been attempted at Muddy River. The flycatcher breeding area at Overton WMA is in a smaller riparian corridor than either Mesquite or Topock Marsh, where trapping was ineffective, but is not as isolated as Pahranagat, where trapping may have had some benefits, and the effectiveness of trapping in reducing parasitism rates at Muddy River is uncertain. Addling cowbird eggs has the potential to improve success at parasitized nests (see Chapter 4) but does not address the other detrimental effects of cowbirds and parasitism, such as clutch size reduction, depredation of nestlings, and causing nest abandonment. Given the equivocal benefits of trapping, the clearly detrimental effects of cowbirds on flycatcher nest success, and the likely reduction in flycatcher reproduction along the Virgin River with the arrival of tamarisk beetles (see Chapter 10), other methods of cowbird control, such as shooting, should be considered in combination with cowbird egg addling.

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Chapter 6

VEGETATION AND HABITAT CHARACTERISTICS

INTRODUCTION

Our objective for vegetation sampling is to provide a quantitative summary of the floristic and structural conditions within occupied flycatcher territories in each study area. These descriptive summaries will provide guidance for managers working to restore and create riparian habitat to meet the obligations of the LCR MSCP and will provide a means to evaluate habitats to determine if they resemble occupied flycatcher territories. The Pahranagat study area was excluded from the characterization of occupied territories because the vegetation consists primarily of very large and widely spaces trees, and these characteristics are unique to the site and not likely to be replicated in restoration areas.

In addition, we investigated whether changes in vegetation characteristics might have contributed to the abandonment of some areas by flycatchers. In 2008 and 2009, we identified several areas that had been occupied by nesting flycatchers in at least one previous year from 2003 to 2007 but were unoccupied (more than 50 m from a currently occupied nest or territory center) in 2008 or 2009. Within these areas, we relocated old nest sites at which we had collected vegetation information in the year the nest was active. We resampled the vegetation at these nests and compared the vegetation data collected when the area was unoccupied to that collected when the nest site was active to elucidate how changes in vegetation through time may influence flycatcher occupancy.

Nest site data from 2003–2007 used in this study were collected as part of an earlier effort to understand how habitat characteristics at sites used by nesting willow flycatchers differ from those at unused sites, and to identify specific variables that may contribute to the characterization of breeding habitat throughout the Virgin and lower Colorado River riparian systems. In that study we collected data at flycatcher nests, at points within flycatcher territories 5–10 m from each nest, and at points in unoccupied areas 50–200 m from any nest or territory center. We compared characteristics of nest sites versus within-territory and unoccupied sites and also used logistic regression models to determine which vegetation characteristics were the best predictors of nest sites. Those analyses are reported in McLeod et al. (2008a) and are not repeated here.

METHODS

Occupied Territories

We described and measured vegetation and habitat features following a modification of the methods of James and Shugart (1970). Vegetation characteristics were measured within a 5-m-radius circle. To avoid disrupting flycatcher breeding activities, we measured vegetation late in the summer when the nest, territory, and adjacent flycatcher territories were inactive.

In 2008, we measured vegetation and habitat characteristics at one plot for each resident (i.e., detected for at least one week) male flycatcher we identified, regardless of whether or not he obtained a mate. Plot center locations were determined as soon as territories were identified. We estimated the center of the male's activity by observing his use of singing perches and selecting a location that was approximately equidistant from the perches at the perimeter of his use area. We then proceeded from that location in a randomly selected compass direction for a randomly selected distance between 0 and 20 m. We used

additional random numbers to select the exact location in which to hang a temperature/humidity data logger (see Chapter 7) and used that location as plot center. This process resulted in the random selection of a point that was still within the male's territory. The sampling points were marked in the field with flagging that remained in place over the winter.

In 2009, we identified the territory center for each resident male as described above. If an existing sampling point from 2008 was within 20 m of the territory center identified in 2009, we assigned that existing point to the current territory. If there was no existing point within 20 m of the territory center, we located a new sampling point as described above. All sampling points that were assigned to active territories in 2009 were marked with flagging that remained in the field over the winter. We repeated this point selection procedure for territories that were active in 2010 and 2011, assigning a sampling point that was used in the previous year if one was within 20 m of the current territory center and selecting a new sampling point if no existing point were available. Each year, sampling points that were identified in the previous year but were not within 20 m of a territory center in the current year were resampled in the current year. In other words, we collected data from previously, but not currently, occupied territories as well as from currently occupied territories. Data from the year in which the territory was not occupied are not included in the summaries of conditions in occupied territories. We had intended to use these data to identify temporal changes in conditions that might lead to territory abandonment, but small sample size precluded a meaningful analysis.

We combined the data collected at occupied territories in 2008–2011 with similar data collected at nest and within-territory locations at Littlefield, Mesquite, Mormon Mesa, Muddy River, Grand Canyon, Topock Marsh, and Bill Williams in 2003–2007 (see McLeod et al. 2008a for details). Vegetation data were collected in all years from 2003 to 2007 at a plot centered on each flycatcher nest. We also collected vegetation data in 2005–2007 at within-territory locations at a randomly selected subset of flycatcher nests. The within-territory sampling point was selected by using random number sequences to determine the distance (5–10 m) and direction to travel from the nest. We used additional random numbers to select the exact location in which to hang a temperature/humidity data logger (see Chapter 7) and used that location as plot center.

In both the 2003–2007 and 2008–2011 sampling efforts, once the plot center was established the following methods were used to quantify vegetation characteristics. At each plot, we laid out four 5-m-long ropes from plot center, one in each of the four cardinal directions. Each rope was marked at 1 m and 5 m from the center of the plot. At plot center and at 1 m from the center of the plot in each cardinal direction, we measured vertical foliage density using a 7.5-m-tall survey rod. Working our way up the rod, we recorded the presence of vegetation, by species, within a 10-cm radius of the rod in 0.1-m intervals (presence of the species within the 0.1-m interval equaled one "hit" on the rod), and summed all hits in 1-m intervals. Presence of dead vegetation (snags) was recorded in the same manner, but not identified to species. If canopy vegetation continued above 8.0 m, we estimated the number of hits as zero, greater than five, or less than five hits per 1-m interval until the canopy vegetation stopped (modified from Rotenberry 1985). In 2008–2011, we measured vertical foliage density at 5 m from plot center in each cardinal direction, in addition to the plot center and 1-m readings.

We measured total canopy closure using a Model-A spherical densiometer at 1 m north and south of the center of each plot and averaged these measurements to obtain a single canopy closure value for each plot. We measured average canopy height within each plot by selecting a representative tree and using a survey rod or a clinometer and measuring tape to measure the height of the selected tree. We estimated percent woody ground cover, alive and dead, within 0.5 m of the ground using a Daubenmire-type frame with the lower edge of the frame centered at 1 m north, south, east, and west of plot center. These percentages were averaged to obtain a single measure of percent woody ground cover for each plot.

We tallied the number of live stems for each species within 5 m of the center of the plot. Stems were tallied if they were at least 1.4-m tall and >2.5 cm in diameter at 10 cm above the ground. Stems were tallied by the following diameter at breast height (dbh) categories: <1 cm, 1–2.5 cm, 2.6–5.5 cm, 5.6–8 cm, 8.1–10.5 cm, and 10.6–15 cm. Any stems >15 cm dbh were measured and the exact dbh was recorded. Dead stems were also tallied in these categories, but not identified to species. In each year from 2009 to 2011, we marked each stem with a piece of chalk after it was tallied to facilitate accurate stem counts.

During vegetation sampling in 2003–2007, if a stem branched above 10 cm but below 1.4 m above the ground, only the largest stem was tallied. In habitats (e.g., tamarisk) where stems frequently branch in this height interval, this method of counting stems may underestimate the density of stems that form an important part of the habitat structure. Therefore, in 2008–2011 we tallied stems as we had in previous years and then for each stem that branched between 10 cm and 1.4 m from the ground, we tallied the number of additional stems that were at least 2.5 cm in diameter at 10 cm above the point where it branched from the main stem.

Additional information recorded at each plot included the date when the measurements were taken, observer initials, and UTM coordinates for each plot center.

Nests in Formerly Occupied Areas

The same measurements that were completed at occupied territories were also taken at old nest sites. We used the UTM coordinates of the nest, nest tree species, nest height, and nest flags that remained in the field to locate the old nests. Vegetation plots were centered on the nest location.

Data Analyses

Vegetation characteristics for occupied territories are summarized by study area. For each site within each study area, the corresponding vegetation classification, as defined in Younker and Andersen (1986) and used in the LCR MSCP, is given in Appendix H. For occupied territory plots that were sampled in multiple years, we used the mean of each vegetation measure across the years the territory was occupied so that each individual point was represented only once in the database, regardless of the number of times it had been sampled. Given the observer variation we have noted (see Discussion in Chapter 8), we believe that yearly variation in many vegetation measures from a given point that has not changed visibly would be as likely to represent observer variation as any true change in the vegetation. We used SPSS® Version 16.0 (SPSS Inc.) software for statistical analyses.

Stem counts were grouped into the following size categories for analysis: ≤2.5 cm dbh, 2.6–8 cm dbh, and >8 cm dbh. For each size category, stem counts are reported separately for live and dead stems; the sum of these is the equivalent of the stem counts per size category that were reported in the 2003–2007 summary report (McLeod et al. 2008a). Counts of live stems are also reported by species. Vertical foliage density measurements above 8.0 m that were recorded as < or >5 hits per meter were converted to 2.5 and 7.5 hits, respectively, to allow analyses of these data as continuous rather than categorical. Vertical foliage density was calculated for each meter interval as the mean of the number of hits recorded within the interval at all locations in the plot. In 2003–2007, we had measured vertical foliage density only at plot center and 1 m from plot center in each cardinal direction, and foliage density measures per meter interval were presented as the sum of the hits recorded at the five locations in the plot. Thus, vertical foliage data presented in reports from 2003 to 2007 should be divided by 5 to be comparable to data presented here. Vertical foliage data are grouped into three categories of above, at, and below the nest. For data collected at nest sites or within-territory locations in 2003–2007, we used the actual nest height

to delineate these categories. We used average nest height as measured in 2003–2011 at each study area to demarcate vertical foliage categories in 2008–2011. Vertical foliage data are presented as total live and dead hits and also by species.

Percent native vegetation was calculated as the average of the percent basal area that was native and the percent native vertical foliage hits. To obtain basal area, we multiplied the number of stems tallied in each size class by the average basal area of a stem in that class, given an even distribution of stems within each size class. We calculated Spearman correlation coefficients for all summary variables (canopy height, canopy closure, woody ground cover, live and dead stem counts in each size category, live and dead vertical foliage hits in each height category, and percent native vegetation).

We used non-parametric Wilcoxon signed rank tests with exact *P*-values for related samples to compare vegetation measurements collected at old nests to the measurements collected during the year the nest was active. We chose non-parametric tests because the differences between paired samples were not normally distributed for several parameters. Vertical foliage data used in these comparisons were restricted to data collected within 1 m of plot center so as to be directly comparable to data collected prior to 2008. A statistical significance level of $P \leq 0.05$ was chosen to reject null hypotheses.

RESULTS

Occupied Territories

We measured vegetation at 261 nest site plots, 105 within-territory plots, and 78 unique occupied territory plots at Littlefield, Mesquite, Mormon Mesa, Muddy River, Grand Canyon, Topock Marsh, and Bill Williams (Table 6.1). We also collected vegetation data at a single point in Deer Island at Ahakhav in 2008. We detected a flycatcher, presumed to be the same individual during each visit, at this site from 21 May to
6 June. However, the flycatcher did not sing spontaneously or appear to be defending a territory. Data from this point are summarized in McLeod and Koronkiewicz (2009); we do not include those data here, as data from a single point are not very informative, and the flycatcher did not exhibit territorial behavior.

Table 6.1. Number of Vegetation Plots Measured in Occupied Southwestern Willow Flycatcher Territories, by Study Area, 2003–2011.

Study Area	Plot type					Total
			Occupied territory			
	Nest	Within-territory	Sampled one year	Sampled two years	Sampled three years	
Littlefield	2	0	2	0	0	4
Mesquite	77	31	11	6	3	128
Mormon Mesa	39	23	7	8	0	77
Muddy River	22	23	1	4	0	50
Grand Canyon	4	0	0	0	0	4
Topock Marsh	101	28	17	4	0	150
Bill Williams	16	0	11	3	1	31

Average nest height recorded in 2003–2011 and used to assign vertical foliage strata for each study area were 2.3, 2.2, 2.4, 2.7, 2.4, 3.8, and 4.0 m for Littlefield, Mesquite, Mormon Mesa, Muddy River, Grand Canyon, Topock Marsh, and Bill Williams, respectively.

Of the vegetation variables we considered (canopy height, canopy closure, woody ground cover, live and dead stem counts, live and dead vertical foliage counts, and percent native vegetation), only four pairs of vegetation variables had correlation coefficients |r|>0.5 (Table 6.2). No vegetation variables showed strong correlations (|r|>0.7) with one another, and we present summaries of all variables for each study area.

Table 6.2. All Pairs of Vegetation Variables with Spearman Correlation Coefficient |r|>0.5 in Occupied Southwestern Willow Flycatcher Territories, 2003–2011

Variable 1	Variable 2	Spearman correlation coefficient (|r|)	*P*-value
# live stems >8 cm dbh per ha	canopy height	0.558	<0.001
# live stems 2.6–8 cm dbh per ha	# live stems ≤2.5 cm dbh per ha	0.578	<0.001
live vertical foliage (hits) at nest height	live vertical foliage (hits) below nest height	0.582	<0.001
dead vertical foliage (hits) above nest height	dead vertical foliage (hits) at nest height	0.619	<0.001

Study areas varied in vegetation structure (Table 6.3 and Figures 6.1–6.2) and in species composition (Tables 6.4–6.10 and Figure 6.3). Tamarisk, coyote willow, and/or Goodding willow were the dominant woody species at all study areas. Other woody species such as cottonwood, Russian olive, seep willow, and arrowweed typically formed a negligible portion of the vegetation. Littlefield was the only study area where species other than tamarisk, coyote willow, and Goodding willow made up a significant proportion of vertical foliage (Figure 6.3); cattail and bulrush formed part of the understory, and Russian olive was present in the overstory.

Despite floristic variation, several features were common to occupied flycatcher territories. Flycatchers consistently occupied areas with high canopy closure; across all study areas, 75% of vegetation plots had canopy closure >89%, and 95% of plots had canopy closure >75%, with a median of 94% canopy closure. Canopy height was at least 5.0 m within 75% of the vegetation plots and was at least 4.0 m in 95% of the plots. Vegetation plots that had canopy heights <5.0 m were in proximity to taller vegetation, typically emergent Goodding willow. Occupied territories also had high densities of small (≤2.5 cm dbh) and medium (2.6–8 cm dbh) stems. Stem density was more variable than canopy height or canopy closure and varied with floristic composition. Areas with a significant component of coyote willow (Mesquite and Littlefield) had higher stem densities than areas with a significant component of Goodding willow (Mormon Mesa, Muddy River, Grand Canyon, and Bill Williams).

All sites, regardless of floristic composition or stem density, showed similar vertical foliage profiles, with overall vegetation density peaking at 2–3 m above the ground, and live vegetation density peaking 1–2 m higher than that. Peak densities of live vegetation were in the range of three to four hits per meter interval.

The number of stems omitted from stem counts by counting only the largest stem of a cluster that branched between 10 cm and 1.4 m above the ground varied both by size and species of the main stem (Table 6.11). Larger stems typically had more branches that were omitted, and tamarisk had a higher number of omitted stems than coyote or Goodding willow. The method of counting only the largest stem of a cluster therefore likely underestimates the stem density that provides important structure in flycatcher territories, particularly in tamarisk habitats.

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Table 6.3. Summary of Vegetation Characteristics at Occupied Southwestern Willow Flycatcher Territories in Each Study Area, Lower Colorado River and Tributaries, 2003–2011*

Parameter	Littlefield		Mesquite		Mormon Mesa		Muddy River		Grand Canyon		Topock Marsh		Bill Williams	
	Mean (SE) range	Median 25th–75th percentile	Mean (SE) range	Median 25th–75th percentile	Mean (SE) range	Median 25th–75th percentile	Mean (SE) range	Median 25th–75th percentile	Mean (SE) range	Median 25th–75th percentile	Mean (SE) range	Median 25th–75th percentile	Mean (SE) range	Median 25th–75th percentile
Average canopy height (m)	7.6 (2.0) 5.4–13.5	5.7 5.5–9.7	5.0 (0.1) 3.4–7.5	5.0 4.5–5.5	6.0 (0.2) 2.8–13.4	5.5 4.8–6.5	6.9 (0.2) 3.6–12.9	6.5 6.0–7.5	8.3 (1.6) 4.3–12.0	8.5 6.2–10.5	6.7 (0.1) 3.5–11.5	6.5 6.0–7.0	9.9 (0.8) 5.1–24.5	8.8 6.7–12.0
% total canopy closure	95.2 (2.4) 88.5–100.0	96.1 92.2–98.2	92.1 (0.6) 59.4–100.0	94.0 90.0–96.9	90.0 (0.8) 71.3–99.5	91.0 86–95.1	91.7 (0.9) 69.5–100.0	94.0 88.0–96.0	84.0 (10.1) 54.0–97.0	92.4 72–95.9	93 (0.7) 34.9–100.0	95.3 92.2–97.7	88.7 (1.9) 60.9–100.0	91.0 83–96.9
% woody ground cover	9.7 (2.6) 4.8–13.6	10.8 4.8–13.6	18.7 (1.6) 0.0–91.3	12.2 4.3–28.5	17.1 (1.6) 0.0–76.3	12.0 5.6–26.0	26.7 (3.1) 1.0–94.0	20.3 11.0–37.0	10.8 (3) 5.0–18.0	10.0 6.0–15.5	19.2 (1.6) 0.9–100.0	12.4 6.0–28.0	22.2 (3.8) 1.0–90.0	13.0 5.5–36.5
# live stems ≤2.5 cm dbh per ha	7066 (1910) 2928–10313	7512 3820–10313	5916 (366) 0–22282	4966.0 3024–8149	2338 (298) 0–13496	1401.0 764–2928	2443 (322) 0–12860	2228 891–3183	1623 (544) 127–2546	1910 828–2419	1511 (108) 0–6112	1146.0 509–2292	908 (215) 0–4838	382 127–1273
# live stems 2.6–8 cm dbh per ha	7608 (656) 6494–9040	7448 6494–8722	7935 (265) 1401–15152	8021 5730–10250	4878 (521) 255–27375	3692 2292–6494	4417 (380) 700–12605	3756 2674–5475	2324 (803) 0–3565	2865 1273–3374	4961 (246) 0–14006	4711 2419–6748	2240 (413) 0–9931	1528 509–3310
# live stems >8 cm dbh per ha	350 (229) 0–1019	191 64–637	183 (34) 0–2801	0 0–255	511 (70) 0–3438	382 0–764	965 (103) 0–3183	859 255–1528	2515 (1340) 509–6366	1592 700–4329	1365 (110) 0–14515	1273 637–1783	686 (109) 0–2037	382 255–1146
# dead stems ≤2.5 cm dbh per ha	382 (227) 0–891	318 0–764	3414 (259) 0–13878	2610 1146–5348	3541 (187) 573–7512	3310 2292–4711	2571 (363) 0–12605	1846 637–3629	1496 (962) 0–4202	891 127–2865	3492 (247) 0–12096	2546 1146–4711	723 (230) 0–6621	255 0–1146
# dead stems 2.6–8 cm dbh per ha	477 (197) 127–1019	382 191–764	3073 (258) 0–13878	1974 1146–4202	2270 (213) 0–7703	1783 891–3565	2926 (309) 0–7767	2610 1019–4584	541 (305) 0–1401	382 127–955	1907 (175) 0–11205	1273 382–2546	511 (125) 0–2419	255 0–637
# dead stems >8 cm dbh per ha	0 (0) 0–0	0 0–0	41 (10) 0–637	0 0–0	71 (27) 0–1910	0 0–0	109 (24) 0–637	0 0–191	95 (61) 0–255	64 0–191	72 (22) 0–2801	0 0–0	74 (33) 0–891	0.0 0–0
Live vertical foliage (hits) below nest	7.9 (3.1) 2.4–16.8	6.1 3.8–12	3.2 (0.3) 0.0–23.2	2.6 1.0–4.2	2.0 (0.3) 0.0–11.0	0.8 0–3.2	1.5 (0.3) 0.0–6.8	0.7 0.2–2.0	1.2 (0.2) 0.8–1.6	1.1 0.8–1.5	4.4 (0.4) 0.0–30.8	3.1 1.4–5.6	8.7 (1.2) 0.6–23.6	6.9 2.7–12.7
Live vertical foliage (hits) at nest	3.9 (1.5) 0.4–7.4	3.9 1.9–6	3.7 (0.2) 0–9.6	3.6 2.4–4.6	2.2 (0.2) 0–8.4	1.9 0.8–3.2	1.8 (0.2) 0–6.2	1.6 0.8–2.6	2.9 (0.6) 1.2–3.8	3.2 1.9–3.8	3.3 (0.2) 0–9	3.2 2–4.4	2.9 (0.3) 0.2–6.0	2.6 2.0–4.0
Live vertical foliage (hits) above nest	14.1 (3.4) 4–18.8	16.8 9.9–18.3	10.3 (0.4) 2–23.4	9.6 7–12.7	10.9 (1) 1–42	7.8 5.8–13.4	13.1 (0.8) 4.2–27	12.5 8–17.8	19.9 (4.2) 12–30.2	18.7 13.1–26.7	12.3 (0.6) 0.3–52.4	11.0 6.8–16.8	11.9 (2) 0.9–50.1	8.0 4.8–15.1
Dead vertical foliage (hits) below nest	1.4 (0.5) 0.2–2.6	1.4 0.5–2.3	3.4 (0.2) 0.0–12.2	3.0 1.6–5	6.0 (0.4) 0.6–15.0	5.4 3.6–7.8	5.1 (0.4) 0.0–12.0	4.8 3.4–6.4	3.7 (1.5) 0.0–7.2	3.8 1.9–5.5	10.0 (0.4) 0–25.8	9.2 6–13.6	9.0 (1.1) 0.4–23.2	7.7 3.2–13.6
Dead vertical foliage (hits) at nest	1.0 (0.7) 0.0–3.0	0.4 0.1–1.8	1.8 (0.1) 0.0–5.8	1.6 0.9–2.6	3 (0.2) 0.0–8.8	2.4 1.6–4.4	2.5 (0.2) 0.0–6.4	2.3 1.4–3.3	2.1 (1) 0.0–4.2	2.1 0.4–3.8	2.1 (0.2) 0.0–7.8	1.6 0.6–3.2	0.7 (0.2) 0.0–6.4	0.2 0.0–0.8
Dead vertical foliage (hits) above nest	0.3 (0.2) 0.0–0.8	0.3 0.0–0.7	1.3 (0.1) 0.0–6.6	1.0 0.2–2.0	2 (0.3) 0.0–11.4	1.2 0.4–2.6	2.0 (0.3) 0.0–10.8	1.4 0.4–3.0	1.2 (0.8) 0.0–3.4	0.7 0–2.4	1.5 (0.2) 0–11.8	0.8 0.1–2	0.7 (0.2) 0.0–3.8	0.0 0.0–0.6
Percent native	91.2 (8.8) 64.8–100	100.0 82.3–100	73.5 (2.1) 0–100	80.9 61.3–90.7	36.2 (4.2) 0–100	21.0 0–75.6	59.1 (5.1) 0–99.3	73.8 28.2–90.9	99.3 (0.7) 97.3–100	99.9 98.6–100	6.9 (1.4) 0–100	0.0 0–1.5	43.8 (7.3) 0–100	31.3 1.3–91.4

* Stem counts include only the largest stem of any cluster that branched above 10 cm above the ground.

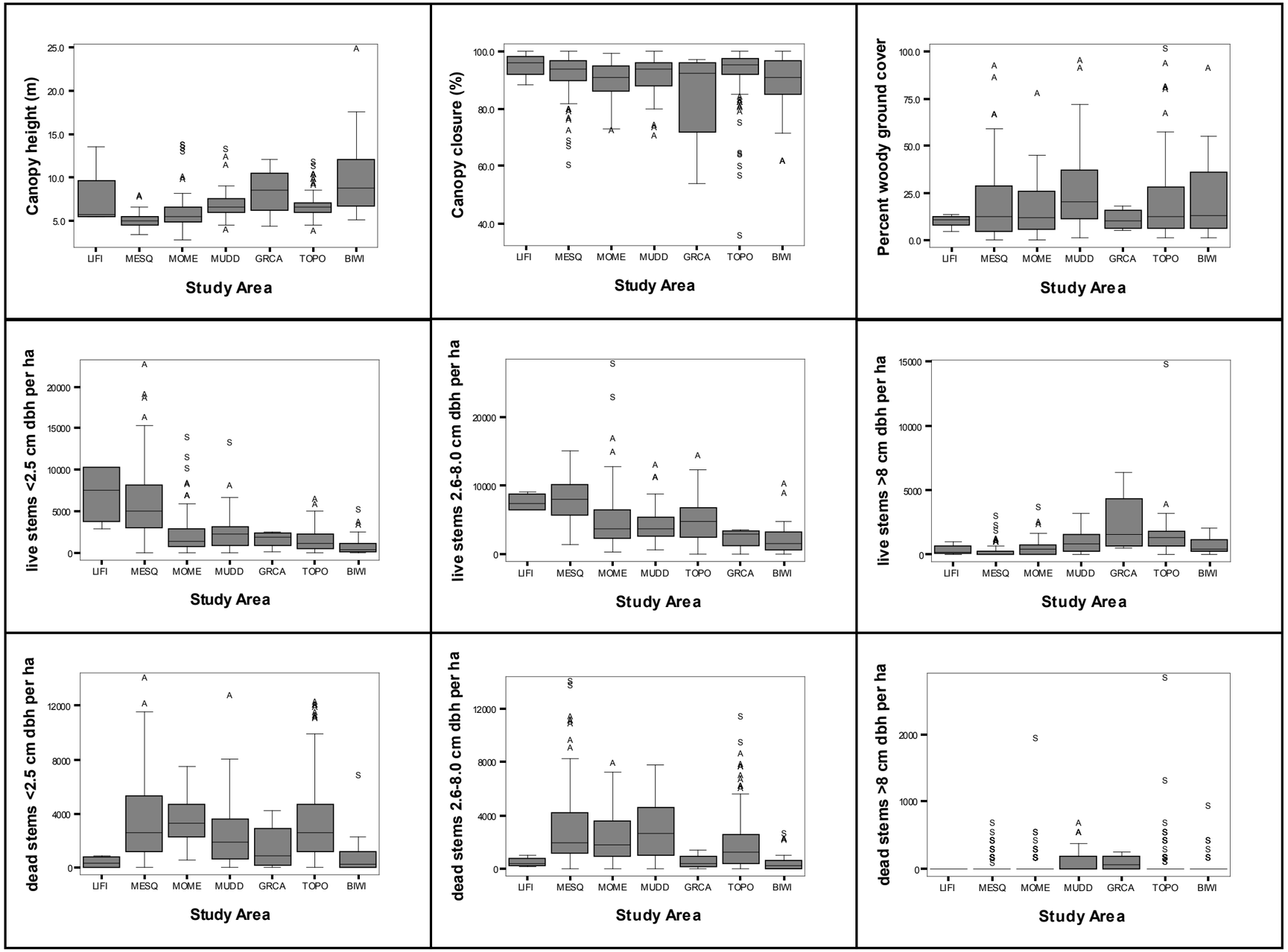

Figure 6.1. Boxplots showing vegetation variables across study areas in occupied willow flycatcher territories, 2003–2011.

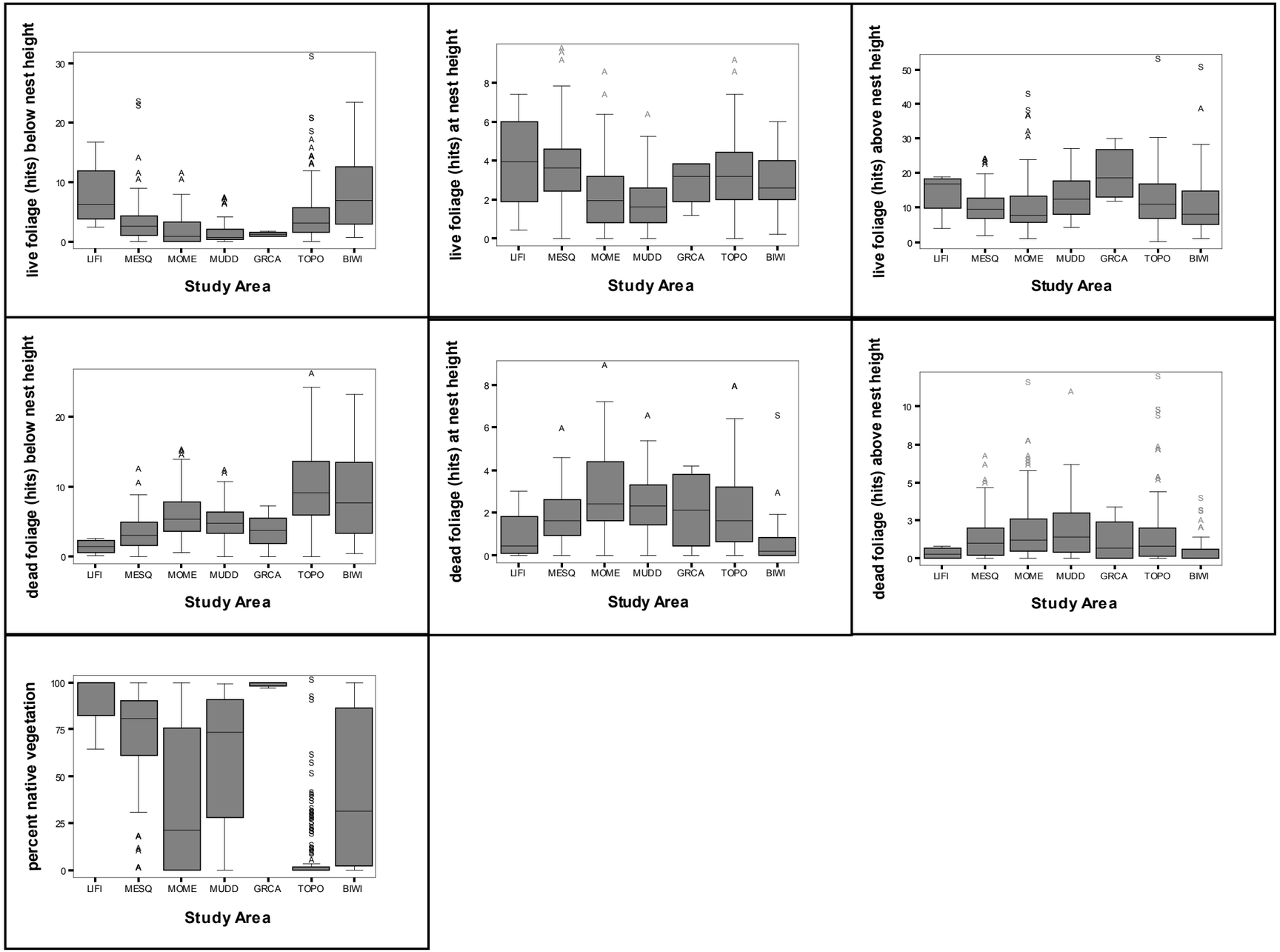

Figure 6.1. Boxplots showing vegetation variables across study areas in occupied willow flycatcher territories, 2003–2011.

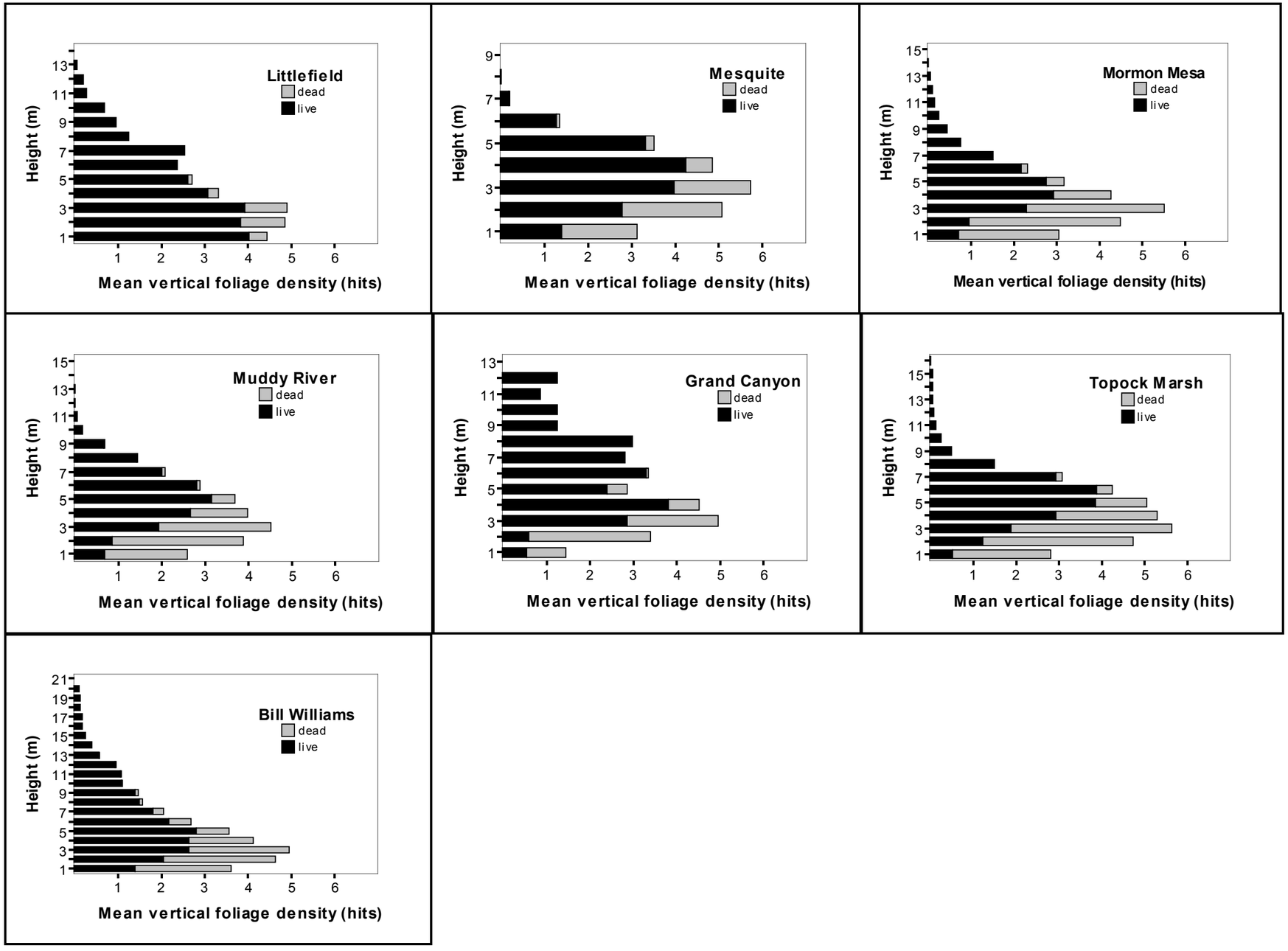

Figure 6.2. Vertical foliage density in occupied flycatcher territories by study area, lower Colorado River and tributaries, 2003–2011.

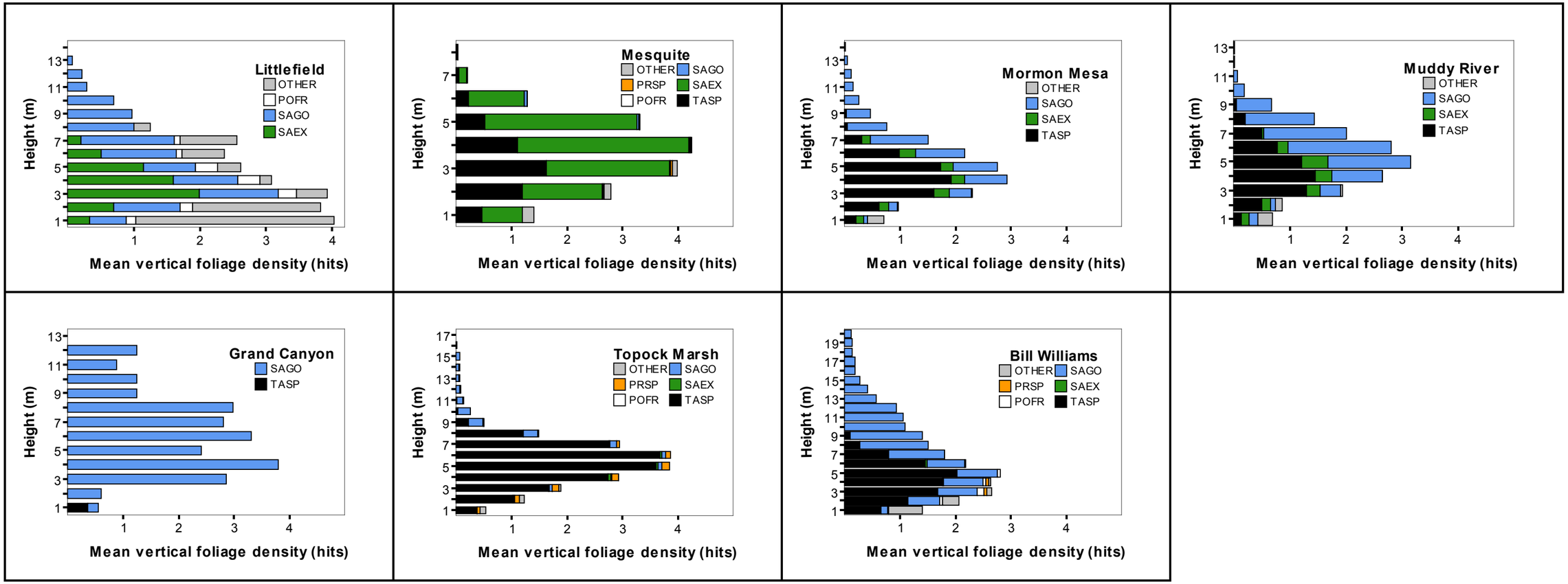

Figure 6.3. Species composition of vertical foliage density in occupied flycatcher territories, by study area, lower Colorado River and tributaries, 2003–2011. TASP = tamarisk, SAEX = coyote willow, SAGO = Goodding willow, POFR = Fremont cottonwood, PRSP = mesquite, OTHER = other.

Table 6.4. Density, Relative Density, Frequency, and Relative Frequency of Woody Stems in Three Size Categories in Occupied Flycatcher Territories, Littlefield, AZ, 2004–2009

Stem size	Species	Stems per ha Mean (SE)	Relative density	Frequency	Relative frequency
≤2.5 cm dbh	TASP	32 (32)	0.5	25.0	10.0
	SAEX	4934 (2108)	69.8	75.0	30.0
	SAGO	1369 (1119)	19.4	75.0	30.0
	POFR	700 (618)	9.9	50.0	20.0
	BASL	32 (32)	0.5	25.0	10.0
2.6–8.0 cm dbh	SAEX	5093 (1896)	66.9	75.0	42.9
	SAGO	1114 (811)	14.6	50.0	28.6
	POFR	1369 (1369)	18.0	25.0	14.3
	ELAN	32 (32)	0.4	25.0	14.3
>8cm dbh	SAGO	159 (80)	41.7	75.0	60.0
	POFR	159 (159)	41.7	25.0	20.0
	ELAN	64 (64)	16.7	25.0	20.0

Table 6.5. Density, Relative Density, Frequency, and Relative Frequency of Woody Stems in Three Size Categories in Occupied Flycatcher Territories, Mesquite, NV, 2003–2010

Stem size	Species	Stems per ha Mean (SE)	Relative density	Frequency	Relative frequency
≤2.5 cm dbh	TASP	1679 (152)	28.5	95.3	47.5
	SAEX	4176 (316)	70.9	93.8	46.7
	BASL	22 (10)	0.4	6.3	3.1
	PLSE	13 (12)	0.2	1.6	0.8
	PRSP	25 (12)	0.4	3.9	1.9
2.6–8.0 cm dbh	TASP	1587 (164)	20.0	88.3	45.7
	SAEX	6283 (303)	79.2	95.3	49.4
	BASL	3 (2)	0.0	3.1	1.6
	PLSE	0 (0)	0.0	0.8	0.4
	PRSP	59 (26)	0.7	4.7	2.4
	ELAN	2 (2)	0.0	0.8	0.4
>8cm dbh	TASP	43 (12)	22.8	17.2	31.4
	SAEX	130 (28)	69.2	32.0	58.6
	SAGO	8 (6)	4.2	1.6	2.9
	ELAN	7 (3)	3.7	3.9	7.1

Table 6.6. Density, Relative Density, Frequency, and Relative Frequency of Woody Stems in Three Size Categories in Occupied Flycatcher Territories, Mormon Mesa, NV, 2003–2009

Stem size	Species	Stems per ha Mean (SE)	Relative density	Frequency	Relative frequency
≤2.5 cm dbh	TASP	1717 (193)	73.4	90.9	74.5
	SAEX	496 (135)	21.2	23.4	19.1
	SAGO	125 (88)	5.3	7.8	6.4
2.6–8.0 cm dbh	TASP	3215 (238)	65.9	97.4	67.0
	SAEX	1394 (464)	28.6	26.0	17.9
	SAGO	270 (131)	5.5	22.1	15.2
>8cm dbh	TASP	237 (38)	46.4	49.4	62.3
	SAEX	6 (6)	1.1	1.3	1.6
	SAGO	268 (67)	52.4	28.6	36.1

Table 6.7. Density, Relative Density, Frequency, and Relative Frequency of Woody Stems in Three Size Categories in Occupied Flycatcher Territories, Muddy River, NV, 2005–2009

Stem size	Species	Stems per ha Mean (SE)	Relative density	Frequency	Relative frequency
≤2.5 cm dbh	TASP	1551 (315)	63.5	94.0	58.0
	SAEX	484 (134)	19.8	26.0	16.0
	SAGO	390 (139)	15.9	36.0	22.2
	BASL	19 (13)	0.8	6.0	3.7
2.6–8.0 cm dbh	TASP	1821 (238)	41.2	88.0	50.0
	SAEX	744 (202)	16.8	30.0	17.0
	SAGO	1853 (435)	41.9	58.0	33.0
>8cm dbh	TASP	323 (84)	33.5	42.0	38.2
	SAEX	28 (12)	2.9	10.0	9.1
	SAGO	614 (110)	63.6	58.0	52.7

Table 6.8. Density, Relative Density, Frequency, and Relative Frequency of Woody Stems in Three Size Categories in Occupied Flycatcher Territories, Grand Canyon, AZ, 2004–2006

Stem size	Species	Stems per ha Mean (SE)	Relative density	Frequency	Relative frequency
≤2.5 cm dbh	TASP	95 (95)	5.9	25.0	25.0
	SAGO	1528 (557)	94.1	100.0	80.0
2.6–8.0 cm dbh	SAGO	2324 (803)	100.0	75.0	100.0
>8cm dbh	SAGO	2525 (1340)	100.0	100.0	100.0

Table 6.9. Density, Relative Density, Frequency, and Relative Frequency of Woody Stems in Three Size Categories in Occupied Flycatcher Territories, Topock Marsh, AZ, 2003–2009

Stem size	Species	Stems per ha Mean (SE)	Relative density	Frequency	Relative frequency
≤2.5 cm dbh	TASP	1470 (109)	97.3	90.6	89.4
	SAEX	1 (1)	0.1	1.3	1.3
	SAGO	16 (11)	1.1	2.0	2.0
	POFR	2 (2)	0.1	0.7	0.7
	PRSP	15 (7)	1.0	4.7	4.6
	PLSE	7 (4)	0.5	2.0	2.0
2.6–8.0 cm dbh	TASP	4908 (249)	98.9	98.0	86.4
	SAEX	0 (0)	0.0	0.7	0.6
	SAGO	22 (14)	0.4	4.0	3.6
	POFR	3 (3)	0.1	0.7	0.6
	PRSP	28 (9)	0.6	10.1	8.9
>8cm dbh	TASP	1340 (111)	98.2	93.3	90.3
	SAGO	6 (3)	0.4	3.4	3.2
	PRSP	19 (7)	1.4	6.7	6.5

Table 6.10. Density, Relative Density, Frequency, and Relative Frequency of Woody Stems in Three Size Categories in Occupied Flycatcher Territories, Bill Williams River NWR, AZ, 2003–2011

Stem size	Species	Stems per ha	Relative density	Frequency	Relative frequency
≤2.5 cm dbh	TASP	768 (207)	84.6	83.9	78.8
	SAGO	66 (43)	7.2	12.9	12.1
	POFR	53 (38)	5.9	6.5	6.1
	BASL	21 (21)	2.3	3.2	3.0
2.6–8.0 cm dbh	TASP	1616 (251)	72.1	90.3	73.7
	SAGO	347 (216)	15.5	25.8	21.1
	POFR	277 (193)	12.4	6.5	5.3
>8cm dbh	TASP	433 (100)	63.2	64.5	60.6
	SAGO	224 (72)	32.6	38.7	36.4
	POFR	29 (29)	4.2	3.2	3.0

Table 6.11. Number of Branches Omitted per Main Stem That Was Tallied in Stem Counts

Size category[1]	Species			
	Tamarisk	Coyote willow	Goodding willow	Dead stems
≤2.5 cm dbh	0.15	0.05	0.06	0.11
2.6–8 cm dbh	0.54	0.31	0.06	0.28
>8 cm dbh	2.00	0.64	0.64	0.70

[1] Size category indicates the size of the main stem that was tallied. All stems that were omitted from the stem count are equal to or smaller than the size of the main stem but at least 1.0 cm in diameter at 10 cm above the branching point.

Nests in Formerly Occupied Areas

We gathered vegetation data at 70 old nests at Mesquite, Mormon Mesa, Muddy River, and Topock. We were able to locate the exact nest fork in 45 cases and located the nest tree but were unsure of the correct fork in 17 additional cases. In seven cases we located the nest vicinity (within 5 m of the nest location) but were unable to verify that we had located the exact nest tree, and in one case the nest tree was clearly no longer there, and we centered the vegetation plot on the nearest adjacent tree. With the exception of a single nest at Muddy River in 2012, no flycatchers have nested within 50 m of the old nests in any year 2009–2012.

Mesquite showed the highest degree of change in vegetation between occupied and unoccupied periods, with decreases in canopy closure, decreases in the amount of live vegetation, increases in the amount of dead vegetation, and a decrease in the percentage of vegetation that consisted of native species (Table 6.12). At Mormon Mesa, there were fewer live stems ≤2.5 cm dbh and a greater number of dead foliage hits above nest height during the unoccupied period (Table 6.12). At Muddy River, the number of dead foliage hits above nest height was higher during the unoccupied period, and the percent of vegetation that consisted of native species declined (Table 6.13). At Topock Marsh, we noted an increase in woody ground cover, an increase in the number of dead woody stems 2.6–8 cm dbh, a decrease in the amount of live vertical foliage above nest height, and a decrease in the amount of dead vertical foliage at nest height (Table 6.13). When all study areas were combined, abandoned nest sites had lower canopy closure, fewer live stems ≤2.5 cm dbh, more live stems >8 cm dbh, more dead stems 2.6–8 cm dbh, less live foliage at nest height, more dead foliage at and above nest height, and less native vegetation (Table 6.14). The direction and magnitude of change at each individual study area is indicated in the last four columns of Table 6.14 to indicate the contribution of each study area to the overall results.

DISCUSSION

Occupied Territories

While the vegetation characteristics of flycatcher territories varied within and between study areas, occupied areas have several common characteristics. Canopy height is typically at least 5.0 m; in cases where the dominant vegetation layer is shorter than 5.0 m, emergent Goodding willow are present. Stem density varies depending on the dominant species of vegetation, but density in every vegetation type is sufficient to produce canopy closure of 85% or more. We recommend using the 25th–75th percentile values for stem density, canopy closure, and canopy height from Mesquite West as a target range for habitat creation sites that consist of coyote willow (Table 6.15). For habitat creation sites that are primarily Goodding willow, Muddy River and Grand Canyon provide guidelines; however, because only the southern nesting area of Muddy River contains a significant proportion of Goodding willow, using the relevant subset of the data from that study area would provide more focused guidelines than using the full dataset (Table 6.15). Mormon Mesa provides data that could be used as guidelines for areas that have a scattered overstory of Goodding willow and an understory of coyote willow. The understory at Mormon Mesa is largely tamarisk, so a multiplier should be applied to the density of stems 2.6–8.0 cm dbh to account for the branching structure in tamarisk that results in an underestimate of stem density when only the largest stem is tallied. According to our tally of skipped stems, this multiplier would be 1.17 when adjusting for coyote willow habitat and 1.45 when adjusting for young Goodding willow habitat. Even with this multiplier, densities of tamarisk may underestimate the required density of less bushy species. Data shown in Table 6.15 use a multiplier of 1.17 to represent a coyote willow understory.

Table 6.12. Wilcoxon Signed Rank Test Results Comparing Vegetation Characteristics at Willow Flycatcher Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, Mesquite and Mormon Mesa

Variable	Mesquite (n = 15)				Mormon Mesa (n = 21)			
	Difference, Unoccupied-Occupied			*P*	Difference, Unoccupied-Occupied			*P*
	Median	25th percentile	75th percentile		Median	25th percentile	75th percentile	
Canopy height (m)	-0.4	-0.8	-0.1	0.087	0.5	-0.6	0.9	0.636
% canopy closure	-9.9	-47.4	-4.2	**<0.001**	2.3	-15.7	6.9	0.734
% woody ground cover	3.8	-5.0	5.7	0.446	1.8	-14.8	5.8	0.397
# live stems <2.5 cm dbh per ha	-1910	-2674	509	**0.026**	-509	-1783	127	**0.012**
# live stems 2.5–8 cm dbh per ha	-509	-3183	2419	0.551	-255	-1146	509	0.279
# live stems >8 cm dbh per ha	127	0	509	0.069	0	-382	382	0.897
# dead stems <2.5 cm dbh per ha	2419	-382	5093	0.121	0	-2165	1401	0.516
# dead stems 2.5–8 cm dbh per ha	7257	2801	11077	**<0.001**	764	0	1401	0.052
# dead stems > 8cm dbh per ha	0	-127	382	0.418	0	-127	0	0.750
Live vertical foliage density (hits) below nest	-0.2	-2.2	0.6	0.199	0.0	-1.2	0	0.366
Live vertical foliage density (hits) at nest	-1.6	-2.4	-0.4	**0.008**	-0.2	-0.8	0.4	0.462
Live vertical foliage density (hits) above nest	-1.2	-6.0	2.8	0.224	-1.0	-7.6	1.7	0.304
Dead vertical foliage density (hits) below nest	1.0	-0.4	5.0	0.088	-1.2	-2.8	0.2	0.316
Dead vertical foliage density (hits) at nest	1.4	0.0	2.0	**0.018**	-0.2	-1.8	1.4	0.471
Dead vertical foliage density (hits) above nest	2.4	-0.6	4.2	**0.026**	0.8	0.0	2.2	**0.035**
Percent native	-16.2	-40.3	-5.8	**0.004**	0.0	-13.3	0	0.129

Table 6.13. Wilcoxon Signed Rank Test Results Comparing Vegetation Characteristics at Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, Muddy River and Topock Marsh

Variable	Muddy River (n = 11)				Topock Marsh (n = 22)			
	Difference, Unoccupied-Occupied			*P*	Difference, Unoccupied-Occupied			*P*
	Median	25th percentile	75th percentile		Median	25th percentile	75th percentile	
Canopy height (m)	-0.2	-0.8	1.0	0.977	0.3	-0.1	0.6	0.120
% canopy closure	-5.3	-7.5	-0.1	0.075	-0.8	-5.2	3.1	0.445
% woody ground cover	-3.5	-38.0	11.5	0.577	9.0	2.0	15.0	**0.005**
# live stems ≤2.5 cm dbh per ha	-764	-2419	0	0.083	-255	-1019	764	0.488
# live stems 2.6–8 cm dbh per ha	637	-764	2419	0.365	-764	-3692	891	0.084
# live stems >8 cm dbh per ha	382	0	1019	0.129	509	-392	1019	0.163
# dead stems ≤2.5 cm dbh per ha	-127	-509	764	0.983	-764	-5093	764	0.076
# dead stems 2.6–8 cm dbh per ha	382	-1273	1401	1.000	1145	637	3692	**<0.001**
# dead stems >8 cm dbh per ha	0	-382	127	0.344	0	0	127	0.422
Live vertical foliage density (hits) below nest	0.0	-1.2	2.6	0.557	-0.4	-2.4	0.6	0.406
Live vertical foliage density (hits) at nest	0.0	-1.4	1.0	0.496	-0.8	-2.0	1.2	0.066
Live vertical foliage density (hits) above nest	2.2	0.0	10.2	0.064	-3.9	-9.6	0.2	**0.004**
Dead vertical foliage density (hits) below nest	0.8	-0.8	1.4	0.425	-2.4	-4.8	1.2	0.124
Dead vertical foliage density (hits) at nest	2.2	0.4	3.2	**0.019**	-1.0	-2.6	0	**0.025**
Dead vertical foliage density (hits) above nest	0.6	-0.8	1.0	0.373	-0.2	-1.4	0.6	0.447
Percent native	-6.9	-23.2	0.0	**0.027**	0.0	0.0	0.0	0.563

Table 6.14. Wilcoxon Signed Rank Test Results Comparing Vegetation Characteristics at Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, All Study Areas Combined

Variable	All Study Areas (n = 70)				Direction and Magnitude of Change[1]			
	Difference, Unoccupied-Occupied			*P*	MESQ	MOME	MUDD	TOPO
	Median	25th percentile	75th percentile					
Canopy height (m)	0.1	-0.6	0.9	0.717	↓	--	--	--
% canopy closure	-3.7	-8.5	2.7	**0.003**	↓	--	↓	--
% woody ground cover	3.6	-7.0	11.2	0.214	--	--	--	↑
# live stems <2.5 cm dbh per ha	-509	-1910	255	**<0.001**	↓	↓	↓	--
# live stems 2.5–8 cm dbh per ha	-255	-2165	-891	0.125	--	--	--	↓
# live stems >8 cm dbh per ha	191	-127	637	**0.012**	↑	--	--	-
# dead stems <2.5 cm dbh per ha	127	-2165	1783	0.760	--	--	--	↓
# dead stems 2.5–8 cm dbh per ha	1146	255	3692	**<0.001**	↑	↑	--	↑
# dead stems >8 cm dbh per ha	0	00.6	127	0.735	--	--	--	--
Live vertical foliage density (hits) below nest	-0.2	-1.6	0.6	0.103	↓	--	--	--
Live vertical foliage density (hits) at nest	-0.5	-1.6	0.4	**0.002**	↓	--	--	↓
Live vertical foliage density (hits) above nest	-1.1	-6.6	2.2	0.052	--	--	↑	↓
Dead vertical foliage density (hits) below nest	-0.2	-2.8	1.4	0.547	↑	--	--	--
Dead vertical foliage density (hits) at nest	0.0	-1.6	1.6	0.657	↑	--	↑	↓
Dead vertical foliage density (hits) above nest	0.5	-0.6	2.0	**0.015**	↑	↑	--	--
Percent native	-0.0	-12.9	0.0	**<0.001**	↓	--	↓	--

[1] Arrows indicate the direction of change of the variable between occupied and unoccupied periods for each study area (MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, TOPO = Topock Marsh, while color indicates the statistical significance of the change as follows: red is $P < 0.01$, blue is $0.01 < P < 0.05$, black is $0.05 < P < 0.10$, no arrow is $P > 0.1$.

Table 6.15. Recommended Ranges of Canopy Height, Canopy Closure, and Stem Density in Various Vegetation Types to Provide Habitat Structure Similar to That Found in Occupied Southwestern Willow Flycatcher Habitat

Vegetation measure	Vegetation type		
	Coyote willow	Goodding willow	Scattered Goodding willow with coyote willow understory
Canopy height (m)	4.4–5.5	7.0–9.0	4.8–6.5
Canopy closure (%)	89.0–97.0	89.0–97.0	86.0–95.1
# live stems ≤2.5 cm dbh per ha	3183–9167	509–2801	764–2928
# live stems 2.6–8.0 cm dbh per ha	5730–10441	2419–5730	2682–7598
# live stems >8.0 cm dbh per ha	0–255	637–1753	0–764

Nests in Formerly Occupied Areas

The areas of Mesquite and Mormon Mesa that contained flycatcher nests at some point during 2003–2007 but were abandoned in 2008 or 2009 primarily consisted of areas that were affected by the winter floods of 2004–2005. The eastern edge of Mesquite West experienced flooding and deposition, which appeared to change the flow of water such that the area was no longer inundated. In 2005, we noted that this portion of Mesquite West had reduced foliage density and many of the willows were yellow and dying (Koronkiewicz et al. 2006a). The vegetation did not recover in subsequent years, and this area has not been occupied by flycatchers since 2005. The vegetation at Bunker Farm also changed noticeably since it was last occupied by breeding flycatchers in 2005. The adjacent agricultural field, which supplied runoff to the site, has been fallow since 2005, and the stands of coyote willow and many of the Goodding willow at Bunker Farm were dead by 2008.

Areas of Mormon Mesa containing most of the old nests were also affected by the 2004–2005 winter floods, which deposited sediment and changed water flow patterns such that nesting areas were no longer inundated. We sampled old nests in Mormon Mesa North and the eastern half of Virgin River #1 North, both of which experienced progressive death of native vegetation after the flood and were not occupied by flycatchers after 2005. We sampled one nest from 2006 in the southern end of Virgin River #1 South; this area was unoccupied in 2007–2008, though no obvious changes in vegetation were noted. We also sampled nests in Virgin River #2, which had dried out and become unoccupied, though no dramatic changes in vegetation between 2005 and 2009were apparent from the site descriptions.

The changes in vegetation that were noted in qualitative site descriptions for areas that were affected by flooding and sedimentation were also apparent in the vegetation data, with both Mesquite and Mormon Mesa showing fewer live stems, less live foliage, and more dead foliage than when the nests were occupied. Mesquite also had lower canopy closure than when the nests were occupied, and nest sites at Mesquite lost a significant percentage of their native vegetation. Canopy closure and the percent native vegetation were found to be important in differentiating nest sites from non-use areas (McLeod et al. 2008a), and it is likely that decreases in canopy cover and the death of native vegetation at Mesquite and Mormon Mesa contributed to making portions of those study areas unsuitable for nesting flycatchers.

Flycatcher nests at Muddy River have occurred primarily in two areas, one in the northern half of Overton WMA and the other at the southern tip of Overton WMA. The northern portion was occupied each year from 2004 to 2007 but was abandoned in 2008, and the majority of the old nests occurred in this area. This area remained unoccupied until 2012, when a single nest was found. We sampled one additional nest at Overton Pond, which was occupied in 2007 but not 2008. Areas adjacent to the old nests sites in the

northern portion of Overton WMA were bulldozed prior to the 2008 breeding season and the river channel was dredged. Channel dredging may have reduced the amount of surface water in the nesting area (see Chapter 2), but no obvious changes in vegetation were noted at the old nest sites themselves. The vegetation data showed few differences between the occupied and unoccupied periods, with more dead foliage at nest height and a lower percentage of native vegetation recorded during the unoccupied period, but no differences in stem density or canopy closure. It is possible that bulldozing activities in the immediate vicinity of the territories affected the suitability of the area for flycatchers, either by reducing the amount of suitable habitat or by altering water flow.

The majority of old nests at Topock occurred in the adjacent sites of 800M and In Between, with additional nests in Pipes #3, PC6-1, Pig Hole, and 250M. No dramatic changes in vegetation were apparent over the years at any of these sites. Despite there being no qualitative changes noted, vegetation data indicated an increase in the amount of woody ground cover, an increase in the number of dead stems 2.6–8 cm dbh, and a decrease in live foliage hits above nest height. An increase in dead stems and decrease in live foliage could reduce the suitability of the sites for flycatchers. Marsh levels at Topock since 2005 have been lower than in previous years (see Chapters 2 and 9), and lower water levels could contribute to subtle changes in vegetation that make sites less suitable for flycatchers. Lower water levels themselves could also be a cause of the decrease in total number of territories documented at Topock between 2004 and 2012.

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Chapter 7

MICROCLIMATE AND SOIL TEXTURE

INTRODUCTION

Our objective for microclimate sampling is to provide a quantitative summary of microclimate conditions within occupied territories in various vegetation types. These descriptive summaries will provide guidance for managers working to restore and create riparian habitat to meet the obligations of the LCR MSCP and will provide a means to evaluate habitats to determine if the microclimate resembles that in occupied flycatcher territories. The Pahranagat study area was excluded from the characterization of occupied territories in 2008–2012 because the study area is approximately 650 m higher in elevation and experiences a cooler climate than the LCR MSCP planning area.

Soil texture strongly influences capillary action and therefore overall soil moisture (Sumner 2000). Soil texture also has a strong influence on water availability for vegetation, and thus may affect vegetation as well as soil moisture. In 2003–2011, we collected soil samples at all locations where we measured microclimate and vegetation. We analyzed a subset of these soil samples to identify soil types present in occupied flycatcher habitat and assess whether soil types varied within occupied areas and between occupied and unoccupied areas.

In addition, we investigated whether changes in microclimate characteristics might have contributed to the abandonment of some areas by flycatchers. In 2008 and 2009, we identified several areas that had been occupied by nesting flycatchers in at least one previous year from 2003 to 2007 but were unoccupied (more than 50 m from a currently occupied nest or territory center) in 2008 or 2009. Within these areas, we relocated old nest sites at which we had collected microclimate information in the year the nest was active. We resampled the microclimate at these nests to see whether microclimate characteristics had changed. Comparison of microclimate data collected when a nest site was active versus when the area was abandoned may elucidate how changes in microclimate through time influence flycatcher occupancy.

METHODS

Occupied Territories

Microclimate measurements were collected at one location for each resident (i.e., present for at least one week) male flycatcher we identified, regardless of the length of time the male was resident and whether or not he obtained a mate. In 2008, we estimated the center of each male's territory (see Chapter 5) and then determined the location of the sampling point by means of the following instructions:

1) The compass direction to walk from the territory center, given in degrees from north, was determined from a random number sequence.
2) The distance (between 0 and 20 m) to walk in the designated direction was determined from a random number sequence. Once that distance was traveled, the closest woody tree or shrub was selected.

If these directions took field personnel outside of the riparian zone or to a site without trees or shrubs, they returned to the territory center and used the next sequence of random numbers. The precise location of the sample point within that tree or shrub was determined as described below. The sampling locations representing active territories in 2008 were marked in the field with flagging, which remained in place

over the winter. During the breeding season of 2009, we identified the territory center for each resident male. If an existing sampling point was within 20 m of the territory center identified in 2008, we assigned that existing point to the current territory. If there was no existing point within 20 m of the territory center, we located a new sampling point as described above. We repeated this point selection procedure for territories that were active in 2010 and 2011, assigning a sampling point that was within an active territory in the previous year if one was within 20 m of the current territory center and selecting a new sampling point if no existing point were available. Each year, sampling points that were within active territories in the prior year but were not within 20 m of a territory center in the current year were resampled in the current year. Data from points that were not occupied in the current year are not included in the summaries of conditions in occupied territories. We had intended to use these data to identify temporal changes in conditions that might lead to territory abandonment, but small sample size precluded a meaningful analysis.

We collected microclimate data in this manner at all Reclamation study areas in 2008 and 2009. In 2010, we collected microclimate data at occupied territories at Mesquite and Bill Williams, and in 2011 only at Bill Williams. No further microclimate data were collected at occupied territories in 2012. We combined the data collected at occupied territories in 2008–2011 with similar data collected at within-territory locations and at seasonal variation (SV) locations that were <20 m from a nest or territory center at Mesquite, Mormon Mesa, Muddy River, and Topock Marsh in 2003–2007 (see McLeod et al. 2008 for details). Microclimate data were collected at one randomly chosen location within 5–10 m of each flycatcher nest. The sampling point was selected in a manner similar to that described above, using random number sequences to determine the direction and distance (5–10 m) to travel from the nest.

Temperature and Relative Humidity (T/RH) Measurements

Measurements of temperature and humidity were recorded automatically every 15 minutes using a HOBO H8 Pro (Onset Computer Corporation, Pocasset, MA) that combines a thermometer (degrees Celsius), humidity monitor, and digital data logger. We camouflaged all HOBO units by suspending them in an inverted Nalgene 500 ml straight-sided polypropylene jar coated with spray adhesive and local vegetation. We used a hole saw to cut a 7.6-cm-diameter hole in the lid, and this opening was covered with shadecloth, allowing free air circulation around the unit.

Once the tree or shrub had been selected as described above, the exact location of the HOBO unit was determined by the following instructions:

1) The HOBO unit was placed at a randomly selected height within the range of flycatcher nest heights documented at that study area. The distribution of random numbers followed the distribution of nest heights. If the chosen tree or shrub was of insufficient height to accept the height from the random number sequence, then field personnel placed the HOBO unit at the first height in the sequence that was less than the height of the tree or shrub. If no nests had been previously recorded at that study area, field personnel used the height sequences from the nearest study area with known nests.
2) The distance (0–2 m) at which the HOBO was placed from the bole of the tree or center of the shrub was determined from a random number sequence. If the tree or shrub was of insufficient radius to accept the distance from the random number sequence, then field personnel placed the unit at the first number in the sequence that was less than the radius of the tree or shrub.
3) The compass direction, given in degrees from north, at which the unit was placed from the bole of the tree or center of the shrub was determined from a random number sequence. If there was no branch in this compass direction that would support the data logger at the height and distance specified in (3) and (4), field personnel proceeded clockwise around the tree or shrub until a suitable branch was located.

If, as presented in (1) and (2), a number from a subsequent random number sequence (sequence meaning a row in the random number table) was used because the number in the initial sequence was too high, then both sequences were considered used and no longer available for future use.

In 2008, HOBO data loggers were deployed in active territories as soon as the male was confirmed as being resident and were left in place throughout the breeding season. The logger was downloaded when vegetation measurements were collected at the end of the breeding season. HOBO units remained in the field over the 2008–2009 winter but were removed from the field at the end of all subsequent breeding seasons. In all subsequent years, HOBO loggers were deployed at the beginning of the breeding season at the previous year's active territory locations, and at additional territories as they were identified.

In 2003–2007, microclimate data were collected at within-territory locations over a two-week period immediately following nest failure or fledging.

Soil Moisture Measurements

A ThetaProbe ML2x coupled to an HH2 Moisture Meter Readout (Macaulay Land Use Research Institute, Aberdeen, UK, and Delta-T Devices, Cambridge, UK, respectively) was used to gather soil moisture data. Soil moisture readings were recorded directly beneath each HOBO logger (plot center) and at 1.0 and 2.0 m from plot center in each cardinal direction. In 2008–2011, soil moisture readings were collected when the HOBO logger was deployed and at two-week intervals throughout the breeding season until the HOBO logger was downloaded at the end of the season. In 2004–2007, soil moisture readings were collected twice at each HOBO logger, once when the HOBO was deployed and again two weeks later when the HOBO was removed. No soil moisture measurements were collected in 2003. Soil moisture was recorded both as voltage (mV) and as volumetric water content (%).[7] Soil type on the HH2 was set to mineral soil. For any soil moisture measurement point that was underwater, we recorded the depth of standing water and assigned a value of 994 mV, which is equivalent to 50% volumetric water content, or fully saturated soil. All mV values greater than 994 were also reassigned as 994 mV, because this reading represents fully saturated soil and because the mV to percent relationship becomes excessively nonlinear for mV readings above this point. Each time we collected soil moisture data, we also recorded the distance to the nearest standing water or saturated soil (as measured by visual estimate, GPS, or aerial photo). Soil moisture data were collected within 2 m of the plot center and were thus subject to the effect of very local variation in ground level and soil texture. Therefore, in 2008–2011, we also recorded the approximate percentage, as estimated in the field by visual observation in combination with aerial photo, of the site within 20 and 50 m of plot center that contained inundated or saturated soil.

Soil Texture

We collected a soil sample from beneath each HOBO at nest, within-territory (5–10 m from the nest), and non-use (50–200 m from any active nest or territory center) locations in 2003–2007 (see McLeod et al. 2008a) and at occupied territory locations in 2008–2011. Samples were approximately the size of a medium apple, collected from the surface down to and including a depth of 5 cm, and placed in a heavy zip-lock plastic bag labeled with the location and date.

[7] The soil moisture logger measures the dielectric constant of moist soil via a direct current voltage, which is converted to volumetric soil moisture with conversion tables. For very high (above ~1000 mV) or low (below ~90 mV) voltage readings, the HH2 reports volumetric soil moisture as "above" or "below" the table, respectively. To enable the use of all data with minimal conversion, we analyzed and reported only the mV readings in the early years of collecting soil moisture data. Per agreement with Reclamation, we continue to present only mV readings in this report. Both mV and percentage were recorded in the field to facilitate data proofing. Voltage is related to soil moisture as follows: $1.07 + 6.4V - 6.4V^2 + 4.7V^3 = 1.6 + 8.4\theta$, where θ = volumetric soil moisture.

We selected a subset of the soil samples collected in 2003–2007 at occupied (nest and within-territory) and unoccupied (non-use) locations at Pahranagat, Mesquite, Mormon Mesa, Muddy River, and Topock Marsh for analysis. Each sample was air-dried in accordance with ASTM D421. Soil aggregations in the dry samples were broken up using a mortar and a rubber-covered pestle, and the sample was passed through a U.S. Standard Sieve No. 4 (4.75 mm) using a Keck Sand Shaker to remove organic matter such as leaves and sticks. The sample was then placed in a straight-sided jar, mixed well with distilled water and a dispersing agent (Cascade detergent) and then left undisturbed to allow for sedimentation.

The relationship between particle diameter and falling velocity is described by Stokes' Law:

$$D = \sqrt{\frac{L \times 18 \times u}{T \times g \times (pp - pm)}}$$

Where:

D = diameter (m)
L = distance traveled (m)
T = time traveled (s)
u = dynamic viscosity (N*s/m^2)
g = acceleration of gravity (9.8 m/s^2)
pp = density of particle (kg/m^3) (245 to 285)
pm = density of medium (kg/m^3)

In the conditions specific to this experiment, L = .094, u = 1.0x10^{-3} @ 20°C, pm = 100, and pp = 265 (average density of soil particles).

We recorded the sedimentation depth at three different time intervals (40 seconds, 6 hours, and 48 hours). These times correspond, according to Stokes' Law, with the settling times of particles >0.16 mm (sand), particles 0.007–0.16 mm (silt), and particles 0.002–0.007 mm (clay). The depth of each layer was divided by the total depth to obtain the percentage by volume of each layer.

Statistical Analyses

Soil moisture data were entered into a database as they were collected during the field season. We downloaded data from the HOBO data loggers into databases at the end of the field season. We summarized the following variables for each HOBO location:

- Mean soil moisture from plot center to 2.0 m from plot center
- Distance to nearest standing water or saturated soil
- % of the area within 20 m of plot center that was inundated or saturated
- % of the area within 50 m of plot center that was inundated or saturated
- Maximum diurnal temperature
- Minimum nocturnal temperature
- Daily temperature range (diurnal maximum minus nocturnal minimum)
- Mean diurnal vapor pressure[8]
- Mean nocturnal vapor pressure

[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). We calculated vapor pressure from the absolute humidity and temperature recorded by the HOBOs.

Soil moisture variables were summarized per visit, and temperature/humidity variables were summarized on a daily basis. We determined diurnal and nocturnal periods by using the actual daily sunrise and sunset times reported for the region by the National Weather Service. We selected the above measures of temperature and humidity for analysis because they were the most highly correlated with other variables or were the most useful in distinguishing use areas from non-use locations (McLeod et al. 2008a). Microclimate variables from each sample point were averaged over the following two-week periods: 16–31 May, 1–15 June, 15–30 June, 1–15 July, and 16–31 July. For occupied territory plots that were sampled in multiple years, we used the mean of each microclimate measure across the years the territory was occupied so that each individual point was represented only once in the database, regardless of the number of years it had been sampled. We then calculated the median and mean of these two-week averages across all sample points. Data are summarized separately for each study area and are presented as mean (standard error) and median (25th–75th percentile).

We compared the percentages of sand, silt, and clay in the soil samples from occupied versus unoccupied locations using Mann-Whitney U tests.

Analyses were conducted using Stata/IC 12.1 (StataCorp LP) and SPSS® Version 16.0 (SPSS Inc.).

Relationship of Vegetation and Soil Moisture to Microclimate

The microclimate characteristics of a particular location are a product of regional climate, surrounding landscape characteristics, and local conditions of vegetation and hydrology. We examined vegetation (see Chapter 6), soil moisture, and microclimate data collected in 2003–2011 to determine whether certain vegetation and soil moisture measures were associated with the observed microclimate conditions. We combined data collected at occupied territories in 2008–2011 with that collected at nest sites, within-territory locations, and non-use locations in 2003–2007 and at old nest locations in formerly occupied areas in 2008 and 2009. We excluded Pahranagat from the analysis but included every point at all other study areas for which we had both vegetation and microclimate data.

Statistical Analyses

As an initial attempt to gain an understanding of the putative relationships among microclimate and vegetation, an exploratory cluster analysis was investigated. The intent of this analysis was to find potential clusters of vegetation that shared similar patterns of measured characteristics and then to relate microclimate variables to the clusters to investigate patterns that might explain how differences in vegetation were associated with differences in microclimate.

A hierarchical cluster analysis was undertaken using Ward's method with a squared Euclidean distance similarity measure. The data were standardized prior to the analysis. Investigation of the resulting dendrogram was uninformative and no clear clusters were evident in the data; in short, the data clustered into a single entity. This result was inconclusive, as the complexity of the data may have masked clear partitions. Therefore, the TwoStep cluster analysis in SPSS (v. 19) was attempted. Both the log-likelihood and the Euclidean distance measures were attempted, and Akaike's Information Criterion was used to determine the optimal number of clusters. In all runs of the data, two clusters emerged; however, the result was that one cluster contained <10 cases, and the remaining cases were clustered together. Because the small cluster did not contain the same cases using different distance measures, this small percentage of cases likely represented simple outliers and did not provide informative results.

After cluster analysis proved uninformative, we attempted a predictive modeling approach to identifying associations between vegetation, surface hydrology, and microclimate. We divided the data set into test and validation subsets; data from 1 July through mid-August (about 2/3 of the data set) were used to develop the model, and data from mid-May through the end of June were used to validate the model. We identified a set of vegetation measures (Table 7.1) that we felt *a priori* would be most likely to affect temperature and humidity. Measures of soil moisture (mean soil moisture, distance to nearest standing water, and percent of area within 20 m and 50 m that was inundated) were also considered as potential predictors in the models. We looked at the correlations among the vegetation variables (Spearman's rho) and soil moisture variables (Pearson's correlation) and removed any highly correlated variables. A preliminary examination of a subset of the data indicated no correlations between soil moisture and vegetation variables, and these were not analyzed further.

Table 7.1. Vegetation Measures Considered as Potential Predictors in Microclimate Models

Variable name
Canopy height
Canopy closure
No. live stems ≤2.5 cm dbh per ha
No. live stems 2.6–8.0 cm dbh per ha
No. live stems >8.0 cm dbh per ha
No. dead stems ≤2.5 cm dbh per ha
No. dead stems 2.6–8.0 cm dbh per ha
No. dead stems >8.0 cm dbh per ha
Percent live stems ≤2.5 cm dbh
Percent live stems 2.6–8.0 cm dbh
Percent live stems >8.0 cm dbh
Live vertical foliage (hits) below nest height
Live vertical foliage (hits) at nest height
Live vertical foliage (hits) above nest height
Dead vertical foliage (hits) below nest height
Dead vertical foliage (hits) at nest height
Dead vertical foliage (hits) above nest height
Percent of basal area native
Percent of basal area and vertical foliage native

Willow flycatcher nest sites in the Reclamation study areas were characterized by having lower maximum daily temperature, higher minimum nocturnal temperature, smaller daily temperature range, and higher diurnal and nocturnal vapor pressure than within-territory and non-use sites (McLeod et al. 2008a). We wanted to identify vegetation and soil moisture conditions that were associated with the temperature and humidity conditions found in suitable flycatcher habitat. Therefore, we dichotomized the microclimate measures in each subset of data so that a "1" indicated conditions (i.e., moderate temperatures and high humidity) that were associated with flycatcher nests and a "0" indicated otherwise. We used the 25th or 75th percentile of each of the five microclimate measures as observed within occupied territories (see Currently Occupied Territories below) in the same year, study area, and time period (May/June and July/August) to establish the break points between 0 and 1 as follows: for maximum daily temperature and daily temperature range, 1 = <75th percentile and 0 = otherwise; for minimum nocturnal temperature and both measures of humidity, 1 = >25th percentile and 0 = otherwise; the ranges corresponding with "1" are hereafter referred to as the preferred range. For the test subset, we used a logistic regression model with backward stepwise elimination to identify the best set of variables that predicted the outcome (0 or 1) for each microclimate variable. This stepwise regression used a likelihood ratio test with $P < 0.05$ to determine which variables to retain in the model. We ran the logistic regression models using three different sets of variables: (1) all vegetation variables, (2) all vegetation variables, mean soil moisture, and distance to water, and (3) all vegetation and soil moisture variables. We used these three sets of variables because data on percent of the area that was inundated were not collected before 2008, distance to water was not collected as a continuous variable until 2005, and mean soil moisture was not collected in 2003; running models with only the full set of variables would have severely restricted the data set.

After determining which variables were retained as predictors in the logistic regression models using the test subset of the data, we used the area (AUC) under the Receiver Operating Characteristic (ROC) curve to evaluate the performance of the models on the validation subset. For each measure of temperature and humidity, we calculated an AUC value for the set of variables that was retained in each of the three

models. An AUC >0.80 is considered a good result, AUC 0.70–0.79 is fair, and AUC 0.50–0.69 is poor or useless.

Nests in Formerly Occupied Areas

We used the UTM coordinates of the nest, nest tree species, nest height, and nest flags that remained in the field to locate old nests in formerly occupied areas. During the year when each nest was active, microclimate data were collected for a two-week period immediately following the nest being vacated. At each nest, in either 2008 or 2009, we hung a HOBO logger at the old nest location on or before the date on which the HOBO was deployed in the year the nest was active and removed the logger on or after the date the logger was removed in the year the nest was active. Soil moisture measurements and soil samples were taken as described above. In 2008, soil moisture measurements were taken at two-week intervals throughout the season, and in 2009, measurements were taken at the beginning and the end of the two-week period during which the HOBO was deployed in the year the nest was active. We analyzed soil samples for all old nest locations visited in 2008 for which we had samples both from the year in which the nest was active and from 2008.

Statistical Analyses

We truncated the temperature and humidity data collected to match the two-week period during which data were collected in the year the nest was active. We summarized the following variables for each HOBO location:

- Mean soil moisture from plot center to 2.0 m from plot center
- Maximum diurnal temperature
- Minimum nocturnal temperature
- Daily temperature range (diurnal maximum minus nocturnal minimum)
- Mean diurnal vapor pressure
- Mean nocturnal vapor pressure

We used paired t-tests to compare measures of microclimate at old nests to the measurements collected during the year the nest was active. Analyses were conducted using Stata/IC 12.1 (StataCorp LP). Missing data were excluded test-wise.

We used Wilcoxon signed rank tests to compare the percentages of sand, silt, and clay at nest sites in the year the site was occupied versus after the site had been abandoned. Analyses were conducted using SPSS® Version 16.0 (SPSS Inc.).

RESULTS

Currently Occupied Territories

We collected microclimate data within flycatcher territories at Littlefield, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams (Table 7.2) from 2003 to 2011. Data loggers in 19 locations failed to collect any useable data, and 6 additional loggers had faulty humidity sensors. Data on mean soil moisture were unavailable for 37 locations.

Table 7.2. Number of Microclimate Sample Points in Occupied Southwestern Willow Flycatcher Territories, by Study Area, 2003–2011.

Study Area	Plot type					Total
			Occupied territory			
	Seasonal Variation	Within-territory	Sampled one year	Sampled two years	Sampled three years	
Littlefield	0	0	2	0	0	2
Mesquite	6	70	10	6	3	95
Mormon Mesa	1	37	7	8	0	53
Muddy River	0	22	1	4	0	27
Topock Marsh	5	101	16	4	0	126
Bill Williams	0	0	9	3	1	13

Summary microclimate data are presented in Tables 7.3–7.8 for Littlefield, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams, respectively. Boxplots depicting these summary data are shown in Figures 7.1–7.5 for soil moisture, distance to standing water, percent of area inundated, maximum and minimum temperature, and diurnal and nocturnal vapor pressure.

Microclimate characteristics varied within and between study areas. Both temperature and humidity followed season weather patterns at all study areas, with daily high temperatures typically peaking in early July and nighttime temperatures peaking in late July. Both diurnal and nocturnal humidity rose throughout the season. Soil moisture at most study areas was highest early in the season and declined as the season progressed. Median soil moisture at most study areas was at or above 900 mV (corresponding to >40% volumetric water content) throughout May and June. Soil moisture values tended to decrease as the season progressed, except at Mesquite, which is watered by irrigation return flows. Soil moisture also tended to vary more as the season progressed, with some locations becoming quite dry while others remained wet. The distance to standing water showed similar patterns, with distance to water increasing and becoming more variable as the season progressed. In May and June, median distance to water was ≤20 m at most study areas. Distance to water from some territories, particularly at Mormon Mesa and Bill Williams, exceeded 500 m by the end of the season as rivers and marshes dried up, but these were exceptional cases.

With the exception of points within the Mesquite study area, which experienced an abnormally dry year in 2009 (see Chapter 2), sample points were typically in locations where at least 20%, and often much more, of the surrounding area was inundated. When 2009 data were eliminated from the Mesquite data set, it also showed a high degree of inundation, with 40% of the surrounding area being inundated through the season. As with soil moisture and proximity to water, the percent inundation declined at many study areas through the season.

Table 7.3. Microclimate Measures in Southwestern Willow Flycatcher Territories at Littlefield, 2009*

Microclimate Measure	May 16–31		June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
Soil Moisture (n=2)	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 soil moisture (mv)	n/a	n/a	n/a	n/a	697.9 (416.2–979.7)	697.9 (281.7)	988.0 (n/a)	988.0 (n/a)	646.3 (320.6–972.0)	646.3 (325.7)	619.9 (261.2–978.7)	619.9 (358.7)
Mean distance to nearest standing water	n/a	n/a	n/a	n/a	1.4 (0.2–2.5)	1.4 (1.2)	0.5 (n/a)	0.5 (n/a)	1.5 (0.5–2.5)	1.5 (1.0)	1.5 (0.5–2.5)	1.5 (1.0)
% of area within 20 m that was inundated	n/a	n/a	n/a	n/a	17.5 (15.0–20.0)	17.5 (2.5)	20.0 (n/a)	20.0 (n/a)	15.0 (15.0–15.0)	15.0 (0.0)	15.0 (15.0–15.0)	15.0 (0.0)
% of area within 50 m that was inundated	n/a	n/a	n/a	n/a	12.0 (9.0–15.0)	12.0 (3.0)	10.0 (n/a)	10.0 (n/a)	25.0 (20.0–30.0)	25.0 (5.0)	25.0 (20.0–30.0)	25.0 (5.0)
Temperature (n = 2)												
Mean maximum diurnal temperature (°C)	n/a	n/a	n/a	n/a	n/a	n/a	39.2 (n/a)	39.2 (n/a)	39.2 (38.9–39.5)	39.2 (0.2)	40.3 (38.8–41.8)	40.3 (1.5)
Mean minimum nocturnal temperature (°C)	n/a	n/a	n/a	n/a	n/a	n/a	18.1 (n/a)	18.1 (n/a)	21.7 (20.5–22.9)	21.7 (1.2)	18.1 (16.8–19.4)	18.1 (1.3)
Mean daily temperature range (°C)	n/a	n/a	n/a	n/a	n/a	n/a	21.1 (n/a)	21.1 (n/a)	17.5 (16.6–18.3)	17.5 (0.9)	22.2 (19.4–25.0)	22.2 (2.8)
Humidity (n = 2)												
Mean diurnal vapor pressure (Pa)	n/a	n/a	n/a	n/a	n/a	n/a	1569.3 (n/a)	1569.3 (n/a)	2065.6 (1924.7–2206.5)	2065.6 (140.9)	1662.6 (1502.0–1823.2)	1662.6 (160.6)
Mean nocturnal vapor pressure (Pa)	n/a	n/a	n/a	n/a	n/a	n/a	1384.4 (n/a)	1384.4 (n/a)	1758.0 (1635.5–1880.5)	1758.0 (122.5)	1428.2 (1242.0–1614.3)	1428.2 (186.2)

* n/a = data not available.

Table 7.4. Microclimate Measures in Southwestern Willow Flycatcher Territories at Mesquite, 2003–2010

Microclimate Measure	May 16–31		June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
Soil Moisture (n=78)	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 soil moisture (mv)	735.9 (531.0–901.0)	710.1 (46.0)	779.0 (513.4–900.6)	701.6 (50.6)	799.4 (649.4–897.4)	729.8 (37.2)	797.9 (596.5–872.3)	707.2 (30.9)	838.1 (598.8–920.9)	744.7 (29.4)	897.2 (801.0–931.7)	824.6 (29.3)
Mean distance to nearest standing water	82.4 (1.2–100.0)	75.2 (14.5)	60.0 (1.8–175.0)	81.9 (19.7)	35.0 (1.5–86.7)	50.5 (9.4)	11.0 (2.0–85.0)	42.7 (7.8)	20.0 (2.0–94.0)	50.8 (8.4)	6.2 (0.4–60.0)	32.8 (7.4)
% of area within 20 m that was inundated	5.0 (0.0–22.5)	15.5 (6.1)	0.0 (0.0–50.0)	22.6 (7.5)	26.7 (0.0–42.5)	23.3 (4.6)	10.0 (5.0–25.0)	18.4 (4.7)	5.0 (0.0–15.0)	10.4 (3.2)	17.5 (2.5–32.5)	21.9 (5.6)
% of area within 50 m that was inundated	6.7 (0.0–30.0)	15.8 (5.6)	0.0 (0.0–50.0)	22.1 (7.5)	25.0 (1.0–45.0)	26.5 (5.5)	15.0 (5.0–30.0)	20.2 (4.5)	11.7 (0.0–20.0)	13.7 (3.6)	18.8 (3.0–35.0)	23.1 (6.1)
Temperature (n = 89)												
Mean maximum diurnal temperature (°C)	38.0 (36.7–39.8)	38.5 (0.8)	37.9 (35.6–40.1)	37.8 (0.6)	40.2 (37.9–43.8)	40.8 (0.7)	41.6 (37.8–45.1)	41.7 (0.6)	41.1 (38.2–44.2)	41.7 (0.6)	38.5 (35.8–40.5)	38.5 (0.5)
Mean minimum nocturnal temperature (°C)	13.6 (12.3–14.3)	13.1 (0.4)	14.0 (13.3–14.7)	14.1 (0.3)	15.9 (15.4–17.2)	16.1 (0.2)	18.4 (17.0–19.5)	18.2 (0.2)	21.7 (20.6–22.7)	21.7 (0.2)	20.3 (19.4–20.8)	20.1 (0.2)
Mean daily temperature range (°C)	24.6 (23.1–27.2)	25.4 (0.6)	24.6 (21.5–26.7)	23.7 (0.8)	24.4 (22.5–27.9)	24.7 (0.6)	22.6 (19.2–27.7)	23.6 (0.7)	19.4 (16.7–23.0)	20.1 (0.6)	18.2 (15.5–20.7)	18.4 (0.6)
Humidity (n = 86)												
Mean diurnal vapor pressure (Pa)	1200.5 (1044.0–1301.5)	1186.9 (45.5)	1293.4 (1037.2–1423.4)	1258.4 (60.0)	1613.2 (1340.8–1897.5)	1646.8 (71.5)	1952.1 (1707.5–2405.4)	1982.0 (60.5)	2359.7 (2057.7–2637.5)	2356.0 (50.5)	2370.4 (2137.7–2582.8)	2294.5 (56.8)
Mean nocturnal vapor pressure (Pa)	1103.8 (1017.0–1198.4)	1107.2 (31.0)	1125.8 (957.9–1212.0)	1126.2 (44.6)	1344.1 (1195.9–1485.5)	1372.7 (39.0)	1689.5 (1498.9–1904.0)	1676.8 (38.9)	2059.2 (1866.4–2230.5)	2046.6 (34.3)	2059.3 (1907.9–2158.3)	2017.2 (36.2)

Table 7.5. Microclimate Measures in Southwestern Willow Flycatcher Territories at Mormon Mesa, 2003–2009

Microclimate measure	May 16–31		June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
Soil Moisture (n = 45)	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 soil moisture (mV)	942.2 (897.8–968.7)	921.3 (20.5)	903.7 (840.0–955.9)	884.1 (25.8)	900.9 (680.6–924.3)	812.4 (36.7)	833.1 (480.6–891.2)	672.3 (49.7)	823.8 (503.4–909.0)	701.5 (44.8)	864.9 (666.1–930.1)	798.1 (37.6)
Mean distance to nearest standing water	0.8 (0.3–21.5)	19.1 (10.5)	1.2 (0.2–55.5)	25.5 (9.9)	27.5 (10.0–90.0)	165.5 (60.9)	466.7 (20.0–750.3)	447.9 (86.5)	64.0 (5.0–567.0)	306.2 (77.4)	13.0 (1.7–100.0)	118.2 (61.0)
% of area within 20 m that was inundated	45.0 (12.5–76.3)	45.9 (12.9)	50.0 (1.0–70.0)	38.9 (9.9)	17.5 (0.0–47.5)	24.0 (7.0)	2.0 (0.0–37.5)	19.1 (8.2)	5.0 (0.0–35.0)	18.3 (6.3)	5.0 (0.0–24.3)	15.4 (6.0)
% of area within 50 m that was inundated	50.0 (10.0–65.0)	41.6 (10.9)	47.3 (5.0–65.0)	39.7 (9.6)	45.5 (0.5–67.5)	38.2 (8.4)	6.7 (0.0–30.0)	18.0 (6.2)	20.0 (1.5–35.0)	18.6 (4.5)	21.3 (0.0–33.5)	21.8 (5.9)
Temperature (n = 52)												
Mean maximum diurnal temperature (°C)	37.0 (32.3–38.3)	37.4 (1.7)	38.4 (35.6–42.5)	38.7 (1.2)	43.9 (40.6–46.5)	43.9 (1.0)	44.9 (42.6–49.0)	45.8 (0.8)	44.4 (41.1–47.3)	44.4 (0.8)	41.5 (39.9–44.9)	41.9 (0.7)
Mean minimum nocturnal temperature (°C)	14.1 (12.3–14.7)	13.7 (0.4)	13.1 (12.0–13.8)	13.0 (0.3)	15.8 (14.9–17.3)	16.2 (0.4)	19.1 (17.6–22.0)	19.5 (0.4)	22.2 (20.9–22.9)	22.0 (0.2)	20.1 (18.6–22.2)	20.2 (0.5)
Mean daily temperature range (°C)	23.1 (21.1–26.3)	23.7 (1.7)	26.7 (23.3–28.3)	25.8 (1.3)	27.8 (25.1–30.1)	27.6 (1.0)	25.7 (22.4–29.7)	26.4 (0.8)	22.3 (19.4–26.3)	22.4 (0.8)	21.4 (18.8–24.8)	21.8 (0.8)
Humidity (n = 51)												
Mean diurnal vapor pressure (Pa)	1204.2 (1032.1–1261.8)	1171.0 (43.4)	995.4 (882.5–1220.4)	1026.4 (42.8)	1221.0 (1086.7–1457.4)	1281.1 (53.1)	1545.2 (1363.9–1813.8)	1567.2 (52.8)	2034.7 (1709.3–2320.1)	1997.3 (53.8)	1867.3 (1745.2–2032.3)	1925.8 (63.7)
Mean nocturnal vapor pressure (Pa)	1320.0 (1204.7–1385.4)	1266.2 (50.3)	1140.3 (1048.0–1259.1)	1154.2 (48.1)	1380.7 (1170.9–1494.3)	1356.3 (45.4)	1569.8 (1423.1–1800.9)	1599.4 (44.2)	1938.3 (1771.8–2081.4)	1924.5 (38.0)	1911.4 (1792.0–2064.0)	1933.0 (53.3)

Table 7.6. Microclimate Measures in Southwestern Willow Flycatcher Territories at Muddy River, 2003–2009

Microclimate measure	May 16–31		June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
Soil Moisture (n = 26)	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 soil moisture (mV)	994.0 (985.4–994.0)	989.7 (4.3)	994.0 (926.2–994.0)	958.6 (22.7)	866.3 (769.7–988.4)	832.7 (60.7)	770.7 (519.7–966.8)	725.1 (63.9)	755.7 (408.8–837.9)	683.7 (50.0)	910.9 (815.2–951.9)	812.9 (48.8)
Mean distance to nearest standing water	0.0 (0.0–0.3)	0.1 (0.1)	0.0 (0.0–0.5)	1.0 (0.8)	2.3 (0.0–7.0)	3.7 (1.3)	2.8 (0.4–8.9)	10.5 (4.1)	6.8 (1.3–13.5)	12.3 (3.5)	6.3 (2.0–15.0)	11.6 (3.7)
% of area within 20 m that was inundated	95.0 (75.0–100.0)	87.5 (9.5)	83.8 (62.5–93.8)	78.1 (10.4)	90.0 (90.0–95.0)	85.5 (8.5)	60 (40.0–82.5)	58.8 (12.2)	35.0 (26.5–71.7)	48.6 (15.0)	40.0 (26.7–41.7)	43.3 (12.0)
% of area within 50 m that was inundated	85.0 (70.0–100.0)	85.0 (8.7)	80.0 (80.0–82.5)	81.3 (1.3)	90.0 (80.0–92.5)	84.0 (7.4)	40.0 (40.0–67.5)	51.8 (7.5)	40.0 (30.0–70.0)	49.0 (11.0)	45.0 (33.3–50.0)	47.7 (8.9)
Temperature (n = 27)												
Mean maximum diurnal temperature (°C)	42.2 (36.3–49.2)	42.8 (3.8)	36.6 (35.0–41.1)	37.4 (1.8)	37.9 (37.7–40.4)	39.7 (1.4)	40.1 (38.2–46.1)	41.5 (1.1)	40.2 (38.2–44.8)	41.9 (1.0)	39.5 (36.9–47.4)	41.8 (1.6)
Mean minimum nocturnal temperature (°C)	17.4 (17.4–17.6)	17.5 (0.1)	15.6 (15.6–15.8)	15.5 (0.3)	17.9 (16.8–18.2)	17.3 (0.5)	20.2 (18.3–21.3)	20.2 (0.4)	23.6 (22.8–24.2)	23.5 (0.2)	20.3 (19.4–21.5)	20.5 (0.5)
Mean daily temperature range (°C)	24.8 (18.7–31.8)	25.3 (3.8)	20.8 (20.5–25.5)	22.0 (1.7)	21.5 (19.5–24.2)	22.4 (1.5)	20.2 (18.1–27.2)	21.3 (1.4)	17.1 (14.9–20.5)	18.4 (1.1)	19.8 (18.0–27.2)	21.2 (1.7)
Humidity (n = 27)												
Mean diurnal vapor pressure (Pa)	1308.3 (1189.3–1425.3)	1307.3 (69.5)	1149.6 (1090.3–1182.6)	1138.1 (28.6)	1458.1 (1405.4–1531.0)	1487.7 (79.3)	1792.1 (1534.9–1947.6)	1762.1 (69.6)	2405.6 (2208.1–2478.7)	2328.7 (49.8)	1889.9 (1729.8–2398.4)	2007.3 (116.7)
Mean nocturnal vapor pressure (Pa)	1342.7 (1239.8–1464.0)	1351.9 (69.5)	1208.7 (1200.8–1216.4)	1171.8 (68.0)	1443.9 (1299.6–1512.2)	1443.2 (58.2)	1596.7 (1428.2–1742.3)	1606.7 (55.8)	2150.0 (1969.9–2324.5)	2104.4 (50.8)	1891.2 (1741.5–2185.3)	1941.0 (79.1)

Table 7.7. Microclimate Measures in Southwestern Willow Flycatcher Territories at Topock Marsh, 2003–2009

Microclimate measure	May 16–31		June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
Soil Moisture (n = 115)	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 soil moisture (mV)	908.7 (512.3–979.6)	748.0 (78.0)	909.6 (857.6–969.7)	792.9 (59.8)	903.8 (778.6–927.9)	795.3 (32.8)	880.8 (724.1–932.0)	773.4 (28.8)	867.6 (638.7–930.4)	760.4 (27.6)	822.4 (550.0–923.2)	726.6 (35.8)
Mean distance to nearest standing water	8.0 (0.0–29.5)	32.8 (12.5)	19.0 (1.8–30.5)	34.9 (11.4)	30.0 (10.0–170.0)	75.2 (12.6)	45.0 (23.0–135.0)	80.3 (10.2)	60.0 (20.0–155.0)	88.0 (10.9)	60.0 (20.0–120.0)	79.1 (12.0)
% of area within 20 m that was inundated	20.0 (15.0–60.0)	35.9 (9.5)	17.5 (7.5–60.0)	31.1 (7.9)	10.0 (0.5–15.0)	9.7 (2.1)	0.3 (0.0–5.0)	2.8 (1.0)	0.0 (0.0–5.0)	4.4 (2.0)	0.0 (0.0–0.0)	0.0 (0.0)
% of area within 50 m that was inundated	37.5 (31.7–45.0)	39.0 (6.7)	30 (20.0–47.5)	36.1 (5.5)	14.5 (6.5–35.0)	19.0 (3.3)	7.5 (0.0–20.0)	11.3 (2.9)	2.5 (0.0–10.0)	6.1 (1.9)	0.0 (0.0–0.5)	0.2 (0.1)
Temperature (n = 113)												
Mean maximum diurnal temperature (°C)	38.3 (34.3–41.0)	37.8 (1.0)	38.3 (34.9–39.6)	38.2 (0.8)	38.8 (36.7–41.9)	40.0 (0.7)	39.7 (37.5–43.5)	40.6 (0.5)	39.8 (37.4–42.7)	40.4 (0.5)	39.0 (36.6–42.4)	39.8 (0.6)
Mean minimum nocturnal temperature (°C)	15.6 (13.7–16.3)	14.9 (0.6)	15.4 (14.0–16.9)	15.4 (0.4)	17.3 (15.8–18.6)	17.3 (0.3)	19.8 (18.0–21.7)	19.7 (0.3)	23.7 (22.2–24.7)	23.2 (0.2)	22.3 (21.3–23.4)	22.0 (0.3)
Mean daily temperature range (°C)	22.6 (20.5–25.1)	22.9 (0.7)	22.2 (19.9–25.0)	22.8 (0.8)	21.6 (20.2–25.0)	22.7 (0.6)	20.7 (17.9–23.8)	20.8 (0.6)	16.5 (13.6–20.2)	17.2 (0.5)	17.3 (13.7–20.8)	17.8 (0.7)
Humidity (n = 111)												
Mean diurnal vapor pressure (Pa)	1311.8 (1241.7–1573.7)	1424.2 (68.7)	1548.2 (1329.8–1690.0)	1519.8 (47.5)	1947.5 (1675.5–2291.0)	1967.8 (60.6)	2352.4 (2017.39–2647.4)	2340.4 (50.3)	2767.3 (2618.0–2995.5)	2781.6 (35.4)	2743.6 (2458.5–2968.8)	2711.6 (45.9)
Mean nocturnal vapor pressure (Pa)	1294.8 (1192.8–1475.5)	1309.9 (39.4)	1413.8 (1255.4–1489.9)	1395.0 (43.7)	1650.8 (1530.1–1869.6)	1699.4 (34.1)	2035.0 (1697.5–2251.7)	1999.1 (39.2)	2443.9 (2292.8–2547.9)	2417.2 (24.1)	2464.5 (2134.2–2608.5)	2364.5 (40.4)

Table 7.8. Microclimate Measures in Southwestern Willow Flycatcher Territories at Bill Williams, 2008–2011

Microclimate measure	May 16–31		June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
Soil Moisture (n = 13)	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 soil moisture (mV)	894.7 (839.0–944.3)	864.7 (46.2)	909.5 (831.7–962.1)	891.6 (26.3)	925.4 (770.2–966.4)	841.3 (62.0)	886.4 (758.0–943.1)	830.8 (55.1)	856.5 (790.8–912.9)	808.9 (63.4)	860.4 (694.0–883.4)	781.8 (46.5)
Mean distance to nearest standing water	9.0 (1.0–15.0)	8.8 (3.1)	2.8 (1.5–15.0)	8.0 (3.1)	3.0 (1.5–15.0)	9.4 (4.1)	23.0 (4.0–80.0)	91.1 (46.1)	290.0 (6.0–475.0)	268.2 (91.2)	300.0 (14.0–470.0)	266.4 (86.4)
% of area within 20 m that was inundated	45.0 (25.0–50.0)	36.7 (10.8)	22.5 (10.0–50.0)	31.8 (8.8)	5.0 (1.0–40.0)	21.9 (8.1)	1.0 (0.0–44.5)	18.1 (8.7)	0.0 (0.0–3.0)	11.0 (8.3)	0.0 (0.0–1.0)	7.0 (6.6)
% of area within 50 m that was inundated	40.0 (30.0–47.5)	34.7 (9.4)	22.5 (15.0–35.0)	27.5 (6.8)	15.0 (3.5–35.0)	19.9 (6.2)	1.0 (0.0–20.0)	10.8 (5.6)	0.0 (0.0–1.0)	9.8 (7.3)	0.0 (0.0–1.0)	5.8 (5.5)
Temperature (n = 13)												
Mean maximum diurnal temperature (°C)	35.3 (32.0–41.2)	35.9 (1.9)	37/9 (36.0–39.6)	37.8 (1.2)	39.7 (36.8–42.4)	39.7 (1.1)	41.6 (37.1–43.5)	40.2 (1.1)	39.4 (37.0–44.3)	40.3 (1.2)	40.0 (36.0–44.7)	40.3 (1.8)
Mean minimum nocturnal temperature (°C)	12.5 (11.5–14.6)	13.1 (0.7)	15.4 (13.6–16.0)	14.9 (0.4)	16.5 (15.7–17.1)	16.5 (0.3)	19.7 (18.8–21.8)	20.2 (0.4)	22.4 (21.5–23.5)	22.5 (0.4)	21.5 (20.3–22.5)	21.1 (0.8)
Mean daily temperature range (°C)	22.0 (20.5–27.3)	22.8 (1.8)	23.6 (20.3–25.6)	22.9 (1.3)	23.0 (20.3–27.0)	23.1 (1.3)	21.6 (15.1–24.2)	20.0 (1.4)	17.9 (15.0–21.0)	17.9 (1.1)	19.4 (12.7–23.5)	19.2 (2.4)
Humidity (n = 13)												
Mean diurnal vapor pressure (Pa)	1310.2 (1259.0–1736.8)	1426.8 (98.5)	1717.5 (1568.8–1793.9)	1649.8 (61.7)	2250.6 (1996.7–2479.4)	2166.8 (118.0)	2738.9 (2331.0–2919.0)	2619.1 (113.2)	3073.5 (2834.8–3159.6)	2986.4 (93.6)	2809.6 (2675.3–3045.6)	2812.6 (115.8)
Mean nocturnal vapor pressure (Pa)	1309.2 (1037.5–1336.0)	1204.1 (89.5)	1433.1 (1309.8–1440.4)	1383.7 (56.7)	1772.1 (1563.4–1839.0)	1665.5 (78.9)	2057.7 (1994.0–2247.8)	2089.0 (82.1)	2546.3 (2409.0–2588.8)	2442.5 (60.0)	2430.4 (2249.5–2647.4)	2449.8 (94.6)

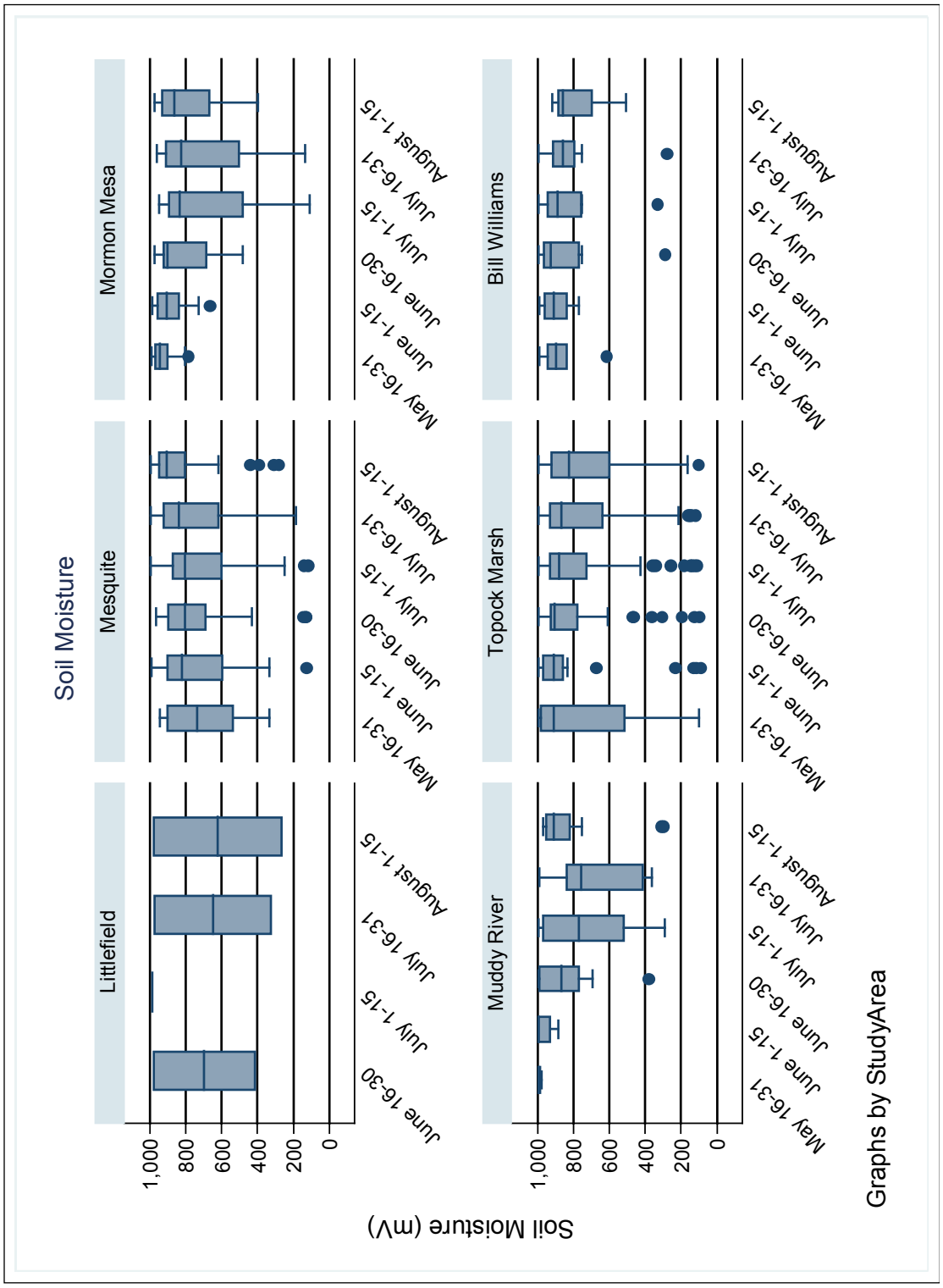

Figure 7.1. Boxplots showing median, 25th–75th percentile, and outliers for soil moisture in occupied flycatcher territories at Littlefield, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams, 2003–2011.

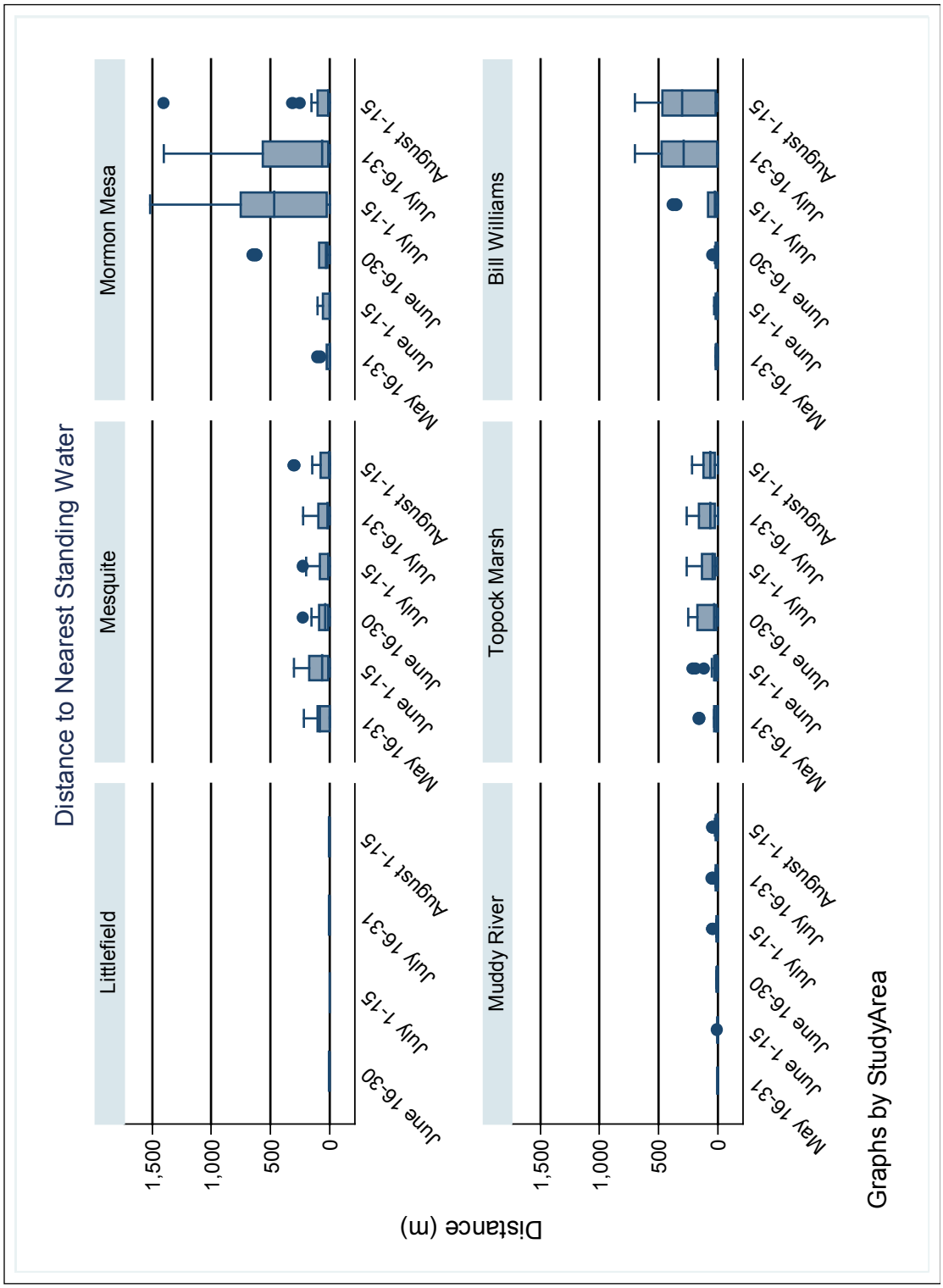

Figure 7.2. Boxplots showing median, 25th–75th percentile, and outliers for distance to water in occupied flycatcher territories at Littlefield, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams, 2003–2011.

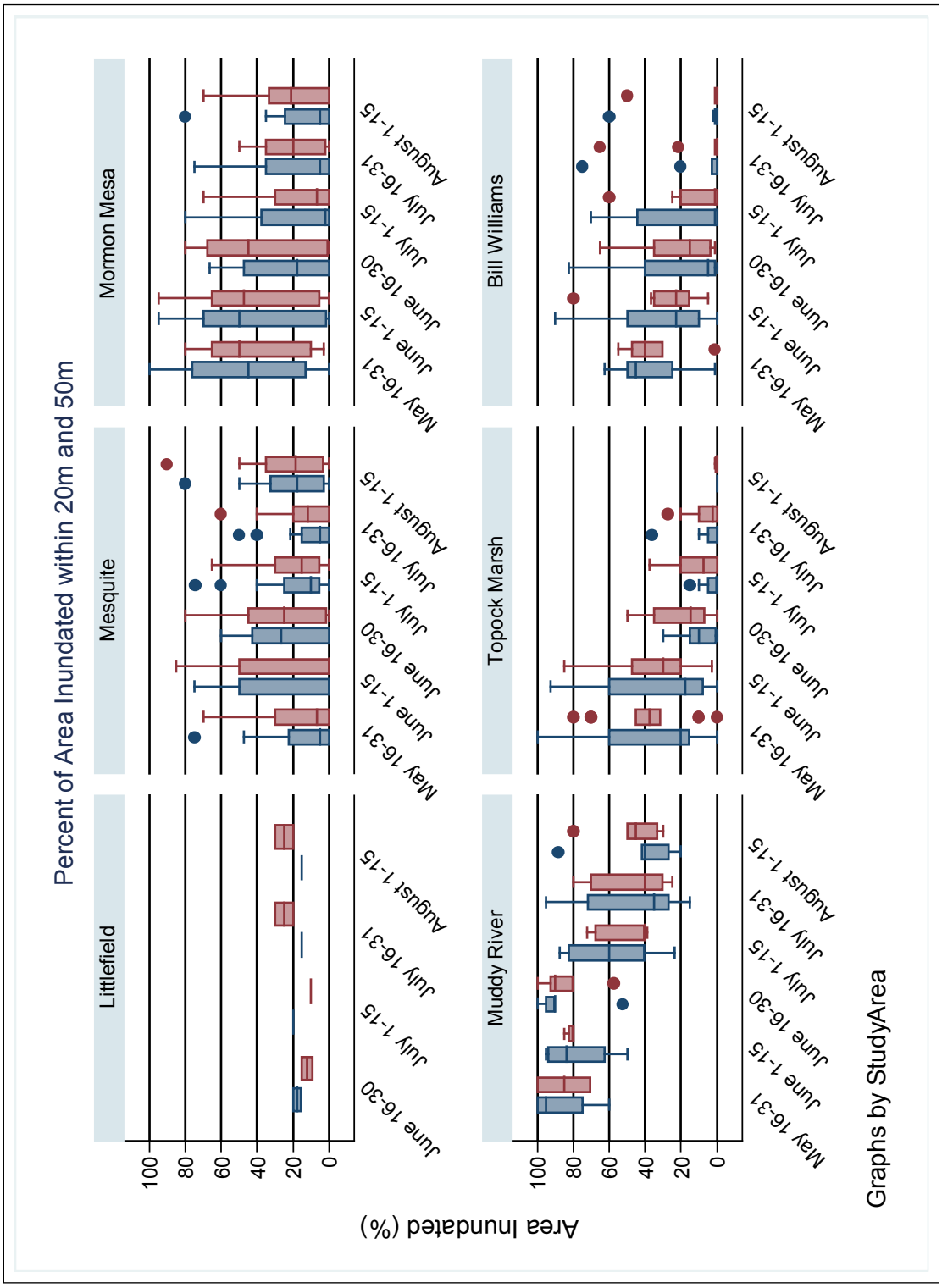

Figure 7.3. Boxplots showing median, 25th–75th percentile, and outliers for the percent of the area within 20 m (blue) and 50 m (red) of the sample point that was inundated in occupied flycatcher territories at Littlefield, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams, 2003–2011.

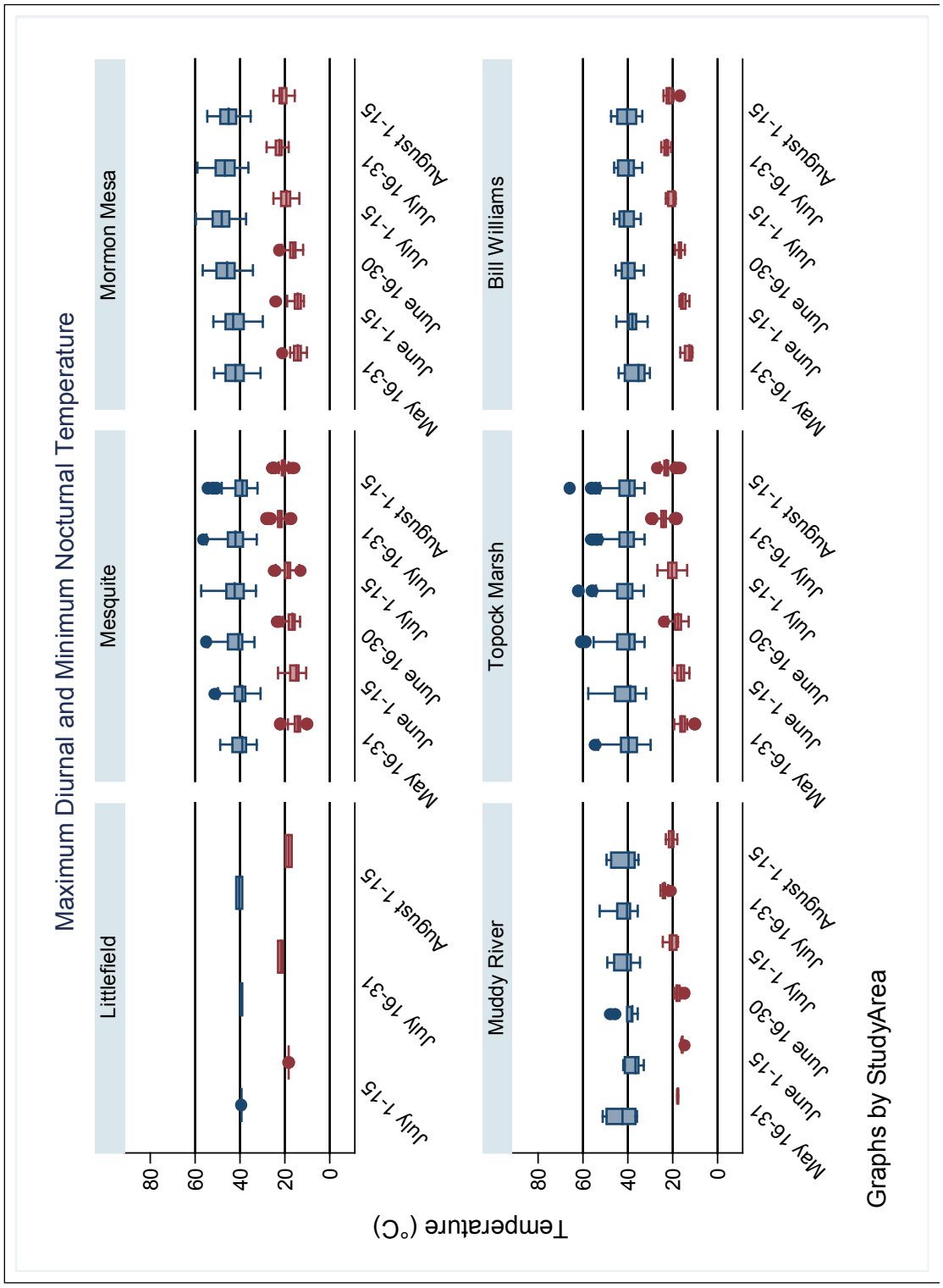

Figure 7.4. Boxplots showing median, 25th–75th percentile, and outliers for maximum diurnal temperature (blue) and minimum nocturnal temperature (red) in occupied flycatcher territories at Littlefield, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams, 2003–2011.

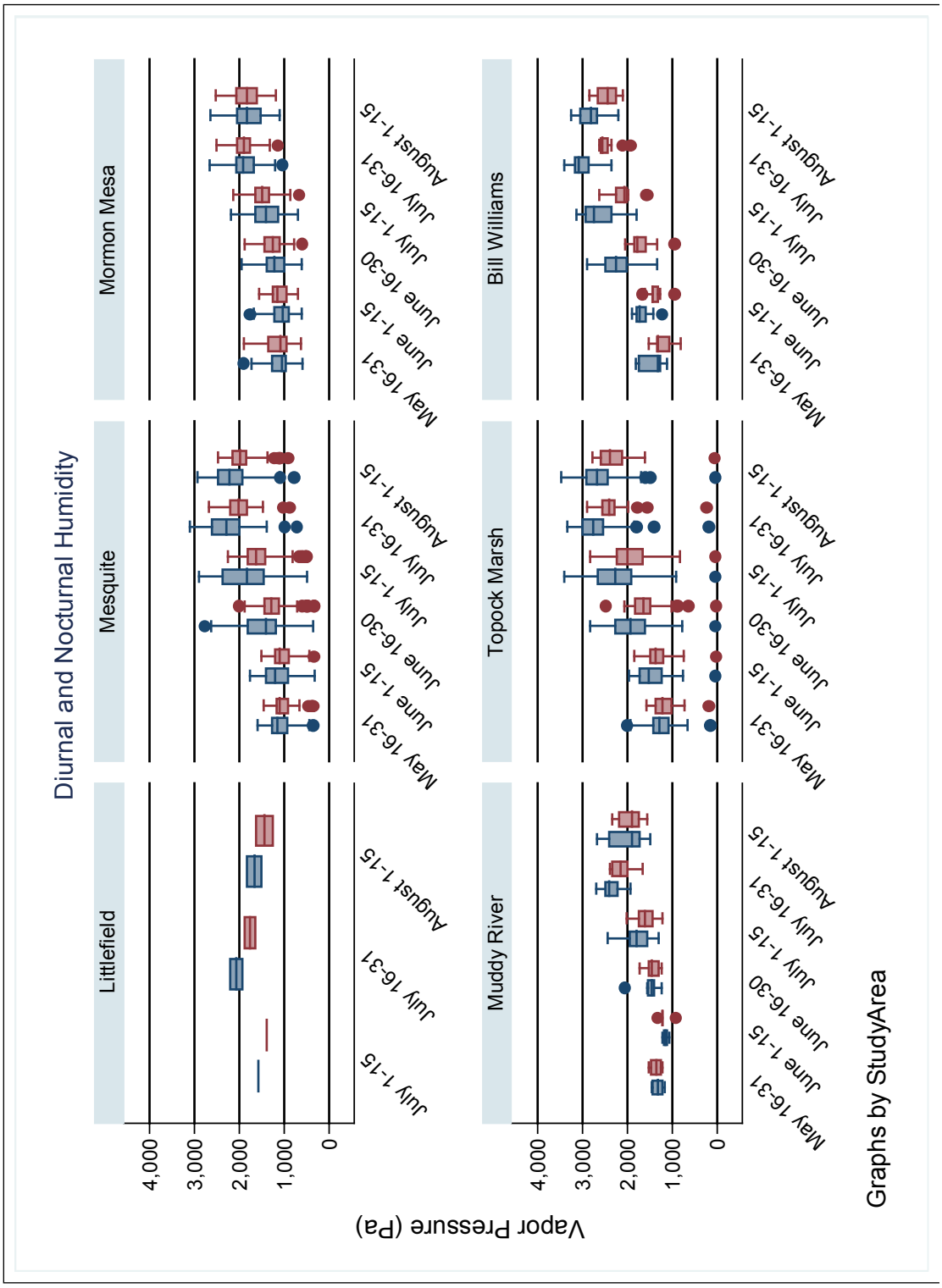

Figure 7.5. Boxplots showing median, 25th–75th percentile, and outliers for mean diurnal vapor pressure (blue) and mean nocturnal vapor pressure (red) in occupied flycatcher territories at Littlefield, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams, 2003–2011.

Soil Texture

We analyzed 104 soil samples from nest and within-territory locations and 43 samples from non-use locations. Soil samples at all study areas consisted primarily of varying proportions of sand and silt, with very little clay (Figure 7.6). All soil particles were small enough to pass through the 4.75-mm sieve, and the water in all sedimentation samples was clear after 48 hours (and typically after 24 hours), indicating no soil particles were smaller than 0.002 mm.

There were no significant differences (Mann-Whitney U tests, all $P > 0.05$) in the percentage of sand, silt, or clay between occupied (nest and within-territory) versus unoccupied (non-use) locations at any of the study areas or with all data combined (Table 7.9), although our ability to detect differences was hampered at some study areas (Mormon Mesa and Muddy River) because of low sample sizes for unoccupied areas. We did observe substantial local variation in the proportions of silt and sand in the soil samples within each study area, and we did not observe any patterns by which one portion of a site had a substantially different soil texture than another portion of the same site. In four instances, we analyzed two soil samples that had been collected within 1 m from each other at the same HOBO location within the same year. In two of those cases, the pair of soil samples were very similar to one another, with the percentages of sand and silt varying less than 5% between samples. The other two pairs of samples showed considerably more variation, with differences in percentages of sand and silt in excess of 25%.

Relationship of Vegetation and Soil Moisture to Microclimate

Of the vegetation variables we considered for inclusion in the models, several pairs of variables were highly correlated ($|r| > 0.6$). All three measures of the percentage of a stem size class that consisted of live stems were correlated with the corresponding measure of the number of dead stems in that size class; we retained the number of dead stems in the model. The two measures of percent native were also highly correlated; we retained percent basal native in the models. The percentage of the surrounding area within 20 m and within 50 m that was inundated were correlated ($r = 0.94$), and we retained only the percentage inundated within 20 m.

Models with Vegetation Variables Only – Canopy closure was a significant predictor of four of the five microclimate measures in the logistic regression models that included only vegetation variables (Table 7.10). In all cases, an increase in canopy closure resulted in an odds ratio >1, meaning a greater likelihood of temperature and humidity being in the preferred range (i.e., lower maximum temperature, smaller daily temperature range, higher humidity). Canopy height was a significant predictor for all three measures of temperature; an increase in canopy height resulted in a greater likelihood of temperature measures being in the preferred range. Other vegetation variables that were significant predictors of multiple measures of microclimate were the number of live stems in each of the three size categories, live vertical foliage above nest height, and dead vertical foliage below nest height. In general, increases in the measures of live vegetation increased the odds of a favorable microclimate, while increases in the measures of dead vegetation decreased the odds of a favorable microclimate.

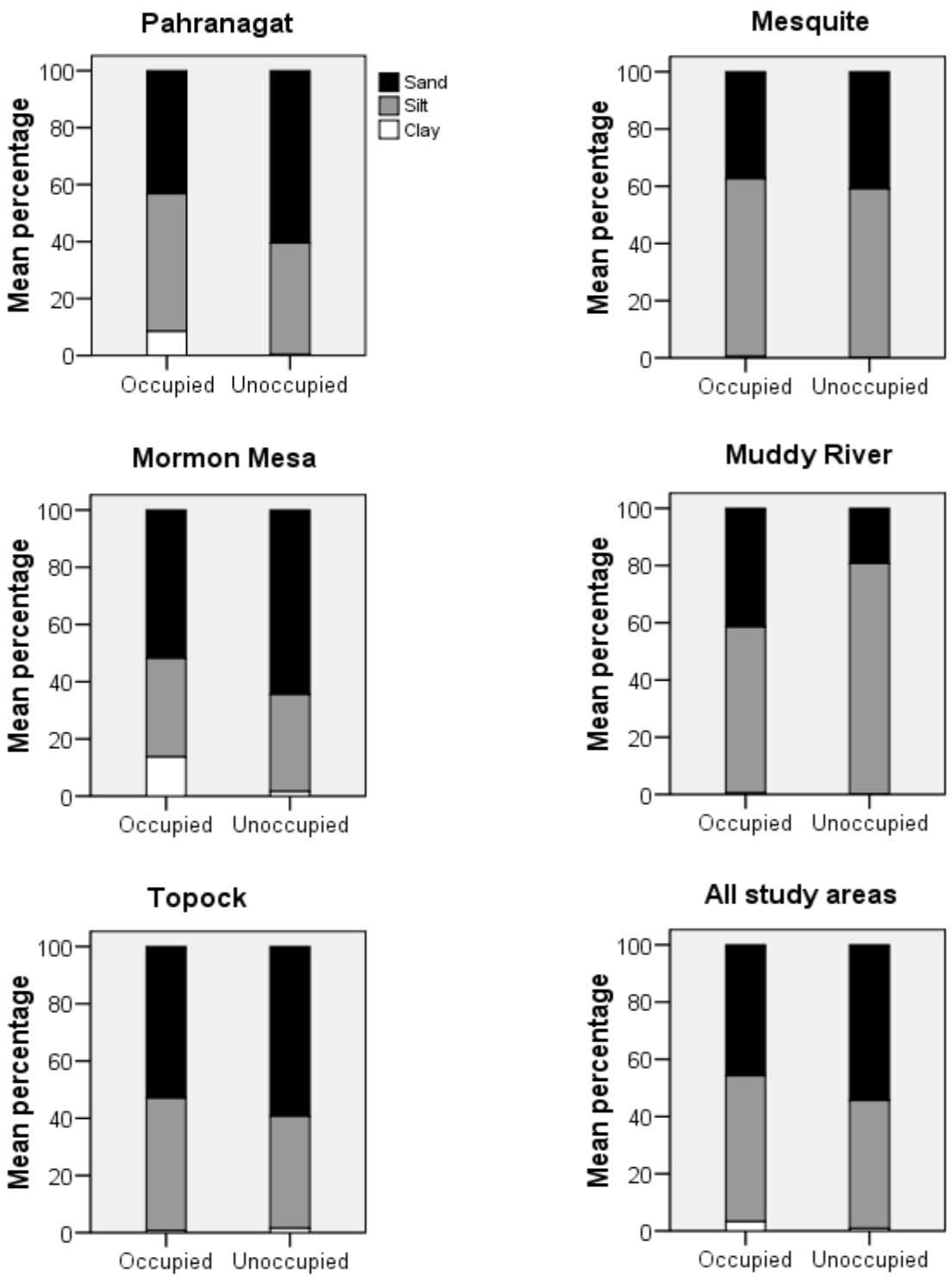

Figure 7.6. Mean percentage by volume of sand, silt, and clay in soil samples from occupied and unoccupied areas at Pahranagat, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and all study areas combined, 2003–2007.

Table 7.9. Percent Volume of Sand, Silt, and Clay in Soil Samples From Occupied and Unoccupied Areas at Pahranagat, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and All Study Areas Combined, 2003–2007.

Study Area and Sample Size	Particle size	Occupied		Unoccupied	
		Median	25th–75th percentile	Median	25th–75th percentile
Pahranagat	Sand	48.7	32.3–56.5	64.4	44.3–71.9
Occupied n = 7	Silt	46.2	32.3–67.7	35.6	28.1–53.2
Unoccupied n = 9	Clay	5.1	0.0–13.5	0.0	0.0–0.0
Mesquite	Sand	33.8	27.3–46.1	33.3	31.0–36.6
Occupied n = 32	Silt	66.2	53.9–72.7	66.7	63.4–69.0
Unoccupied n = 9	Clay	0.0	0.0–0.0	0.0	0.0–0.0
Mormon Mesa	Sand	49.3	34.1–81.2	85.5	32.7–90.8
Occupied n = 17	Silt	24.5	6.7–55.9	9.2	8.1–67.3
Unoccupied n = 5	Clay	0.0	0.0–4.4	0.0	0.0–1.9
Muddy River	Sand	41.2	32.0–52.1	19.3	0.0–38.5
Occupied n = 14	Silt	58.4	45.0–68.0	80.7	61.5–100
Unoccupied n = 2	Clay	0.0	0.0–0.0	0.0	0.0–0.0
Topock Marsh	Sand	56.6	34.7–72.7	65.4	44.1–76.1
Occupied n = 34	Silt	41.2	27.3–65.3	34.6	21.3–54.3
Unoccupied n = 18	Clay	0.0	0.0–0.0	0.0	0.0–0.0
All Study Areas	Sand	45.2	30.5–61.1	49.2	33.3–76.1
Occupied n = 104	Silt	52.9	32.0–68.8	47.7	21.3–66.7
Unoccupied n = 43	Clay	0.0	0.0–0.0	0.0	0.0–0.0

Table 7.10. Variables Retained in Backward Stepwise Logistic Regression Models Examining the Effect of Vegetation Variables on Measures of Microclimate, All Study Areas Combined, 2003–2011

Measure of microclimate	Variables retained	Definition of unit increase	Odds ratio	95% CI	*P*
Maximum diurnal temperature	Canopy height	1 m	1.17	(1.01–1.35)	0.043
	Canopy closure	10%	1.43	(1.25–1.64)	<0.001
	No. live stems 2.6–8 cm dbh	500 stems per ha	1.04	(1.01–1.07)	0.005
	No. live stems >8 cm dbh	500 stems per ha	1.27	(1.06–1.52)	0.008
	Live vertical foliage above nest height	10 hits	1.98	(1.38–2.85)	<0.001
	Dead vertical foliage below nest height	5 hits	0.76	(0.62–0.94)	0.011
Minimum nocturnal temperature	Canopy height	1 m	1.15	(1.02–1.29)	0.026
	No. dead stems 2.6–8 cm dbh	500 stems per ha	1.06	(1.02–1.11)	0.005
	Live vertical foliage at nest height	3 hits	0.69	(0.52–0.91)	0.009
	Percent basal area native	10%	1.08	(1.03–1.14)	0.002
Daily temperature range	Canopy height	1 m	1.22	(1.04–1.43)	0.013
	Canopy closure	10%	1.45	(1.26–1.67)	<0.001
	No. live stems 2.6–8 cm dbh	500 stems per ha	1.04	(1.01–1.07)	0.009
	No. live stems >8 cm dbh	500 stems per ha	1.32	(1.10–1.60)	0.004
	No. dead stems >8 cm dbh	500 stems per ha	0.59	(0.38–0.90)	0.015
	Live vertical foliage above nest height	10 hits	2.21	(1.47–3.32)	<0.001
	Dead vertical foliage below nest height	5 hits	0.73	(0.59–0.91)	<0.005

Table 7.10. Variables Retained in Backward Stepwise Logistic Regression Models Examining the Effect of Vegetation Variables on Measures of Microclimate, All Study Areas Combined, 2003–2011 (Continued)

Measure of microclimate	Variables retained	Definition of unit increase	Odds ratio	95% CI	*P*
	Dead vertical foliage at nest height	3 hits	1.58	(1.08–2.32)	0.019
Diurnal vapor pressure	Canopy closure	10%	1.33	(1.19–1.49)	<0.001
	No. live stems ≤2.5 cm dbh	500 stems per ha	1.04	(1.01–1.07)	0.007
	Live vertical foliage above nest height	10 hits	1.42	(1.09–1.84)	0.008
Nocturnal vapor pressure	Canopy height	1 m	1.12	(1.00–1.25)	0.051
	Canopy closure	10%	1.22	(1.09–1.35)	<0.001
	No. live stems ≤2.5 cm dbh	500 stems per ha	1.04	(1.01–1.07)	0.023
	No. live stems >8 cm dbh	500 stems per ha	0.86	(0.76–0.98)	0.024

Models with Vegetation Variables, Mean Soil Moisture, and Distance to Water – When mean soil moisture and distance to water measures were added to the logistic regression models, the most notable change in the retained vegetation variables was that canopy height was no longer a significant predictor for any measure of microclimate. Canopy closure remained a strong predictor for four microclimate variables, and the amount of live foliage above nest height was also a strong predictor of maximum daily temperature, daily temperature range, and diurnal vapor pressure. In all cases, an increase in canopy closure or the amount of live vegetation above nest height led to greater odds of microclimate being within the preferred range. The number of live stems >8 cm dbh was also a significant predictor of all variables except minimum nocturnal temperature, but an increase in this variable had the effect of increasing the odds of a moderate temperature but decreasing the odds of high humidity. In addition to the vegetation variables, mean soil moisture was retained as a significant predictor of all variables except minimum temperature (Table 7.11). In all cases, an increase in soil moisture increased the odds of moderate temperature and high humidity.

Models with All Variables –The measure of percentage of the surrounding area that was inundated was not retained as a predictor for any of the microclimate variables. In this set of models, canopy closure, live foliage above nest height, and soil moisture were again predictors of all variables except minimum nocturnal temperature, with increases in each predictor variable increasing the odds of the microclimate measures being within the preferred range (Table 7.12). Other variables that were predictors of multiple microclimate measures were the number of live stems 2.6–8 cm dbh, the number of live stems >8 cm dbh, and dead foliage above nest height. An increase in dead foliage above nest height increased the odds of lower humidity, while an increase in the number of stems 2.6–8 cm dbh increased the odds of moderate temperature. An increase in the number of live stems >8 cm dbh again had the effect of increase the odds of a moderate temperature but decreasing the odds of high humidity.

Performance of Models on Validation Subset – The variables that were retained in the stepwise models that included only vegetation measures were fair (AUC 0.7–0.79) at predicting all measures of temperature and useless (AUC < 0.7) at predicting either measure of vapor pressure (Table 7.13). The variables that were retained in the stepwise models that considered mean soil moisture and distance to water in addition to vegetation variables were better than the vegetation variables alone at predicting all measures of microclimate except minimum nocturnal temperature; AUC values were good (>0.8) for daily temperature range and fair for the remaining four microclimate variables. The variables that were retained in the models using all variables were no better at predicting microclimate conditions than those from the models that included soil moisture and distance to water.

Table 7.11. Variables Retained in Backward Stepwise Logistic Regression Models Examining the Effect of Vegetation Variables, Soil Moisture, and Distance to Water on Measures of Microclimate, All Study Areas Combined, 2006–2011

Measure of microclimate	Variables retained	Definition of unit increase	Odds ratio	95% CI	*P*
Maximum diurnal temperature	Canopy closure	10%	1.50	(1.27–1.77)	<0.001
	No. live stems 2.6–8 cm dbh	500 stems per ha	1.07	(1.02–1.11)	0.002
	No. live stems >8 cm dbh	500 stems per ha	1.39	(1.14–1.69)	0.001
	No. dead stems ≤2.5 cm dbh	500 stems per ha	0.93	(0.90–0.97)	0.001
	No. dead stems 2.6–8 cm dbh	500 stems per ha	1.07	(1.02–1.11)	0.003
	No. dead stems >8 cm dbh	500 stems per ha	0.43	(0.25–0.74)	0.002
	Live vertical foliage above nest height	10 hits	2.29	(1.46–3.59)	<0.001
	Mean soil moisture	100 mV	1.16	(1.06–1.26)	0.001
	Distance to water	20 m	1.03	(1.00–1.06)	0.058
Minimum nocturnal temperature	No. dead stems 2.6–8 cm dbh	500 stems per ha	1.07	(1.01–1.13)	0.019
	Live vertical foliage at nest height	3 hits	0.60	(0.41–0.86)	0.005
	Percent basal native	10%	1.13	(1.06–1.21)	<0.001
Daily temperature range	Canopy closure	10%	1.44	(1.22–1.70)	<0.001
	No. live stems 2.6–8 cm dbh	500 stems per ha	1.06	(1.02–1.11)	0.002
	No. live stems >8 cm dbh	500 stems per ha	1.41	(1.15–1.73)	0.001
	No. dead stems ≤2.5 cm dbh	500 stems per ha	0.95	(0.92–0.99)	0.017
	No. dead stems 2.6–8 cm dbh	500 stems per ha	1.06	(1.01–1.10)	0.011
	No. dead stems >8 cm dbh	500 stems per ha	0.43	(0.28–0.76)	0.003
	Live vertical foliage above nest height	10 hits	2.77	(1.73–4.43)	<0.001
	Mean soil moisture	100 mV	1.15	(1.06–1.26)	0.002
Diurnal vapor pressure	Canopy closure	10%	1.47	(1.25–1.72)	<0.001
	No. live stems >8 cm dbh	500 stems per ha	0.85	(0.73–0.98)	0.029
	Live vertical foliage above nest height	10 hits	1.48	(1.02–2.15)	0.041
	Dead vertical foliage below nest height	5 hits	0.70	(0.53–0.91)	0.008
	Mean soil moisture	100 mV	1.23	(1.13–1.33)	<0.001
Nocturnal vapor pressure	Canopy closure	10%	1.36	(1.18–1.56)	<0.001
	No. live stems >8 cm dbh	500 stems per ha	0.83	(0.72–0.97)	0.016
	Dead vertical foliage below nest height	5 hits	0.71	(0.54–0.93)	0.011
	Mean soil moisture	100 mV	1.25	(1.16–1.36)	<0.001

Table 7.12. Variables Retained in Backward Stepwise Logistic Regression Models Examining the Effect of Vegetation Variables, Soil Moisture, Distance to Water, and Percentage of the Area Within 20 m That Was Inundated on Measures of Microclimate, All Study Areas Combined, 2008–2011

Measure of microclimate	Variables retained	Definition of unit increase	Odds ratio	95% CI	*P*
Maximum diurnal temperature	Canopy closure	10%	1.52	(1.19–1.95)	0.001
	No. live stems 2.6–8 cm dbh	500 stems per ha	1.17	(1.07–1.28)	<0.001
	Live vertical foliage at nest height	3 hits	2.63	(1.29–5.36)	0.008
	Live vertical foliage above nest height	10hits	2.11	(1.10–4.05)	0.025
	Mean soil moisture	100 mV	1.34	(1.13–1.59)	0.001
Minimum nocturnal temperature	Canopy closure	10%	1.28	(1.03–1.58)	0.024
	Live vertical foliage at nest height	3 hits	0.42	(0.21–0.84)	0.013
Daily temperature range	Canopy closure	10%	1.47	(1.15–1.89)	0.002
	No. live stems 2.6–8 cm dbh	500 stems per ha	1.22	(1.10–1.35)	<0.001
	No. live stems >8 cm dbh	500 stems per ha	1.89	(1.11–3.20)	0.018
	No. dead stems >8 cm dbh	500 stems per ha	0.20	(0.07–0.60)	0.004
	Live vertical foliage above nest height	10 hits	4.10	(1.58–10.66)	0.004
	Mean soil moisture	100 mV	1.59	(1.28–1.98)	<0.001
	Distance to water	20 m	1.11	(0.99–1.23)	0.069
Diurnal vapor pressure	Canopy closure	10%	1.84	(1.37–2.48)	<0.001
	No. live stems >8 cm dbh	500 stems per ha	0.66	(0.45–0.99)	0.043
	Live vertical foliage above nest height	10 hits	2.16	(1.08–4.31)	0.030
	Dead vertical foliage above nest height	10 hits	0.05	(0.01–0.43)	0.006
	Mean soil moisture	100 mV	1.58	(1.30–1.92)	<0.001
	Distance to water	20 m	1.14	(1.01–1.30)	0.039
Nocturnal vapor pressure	Canopy closure	10%	1.70	(1.27–2.27)	<0.001
	No. live stems >8 cm dbh	500 stems per ha	0.44	(0.29–0.65)	<0.001
	Live vertical foliage above nest height	10 hits	2.00	(1.08–3.72)	0.028
	Dead vertical foliage above nest height	10 hits	0.02	(0.00–0.16)	<0.001
	Mean soil moisture	100 mV	1.42	(1.20–1.68)	<0.001

Table 7.13. Area Under the Curve (AUC) for Sets of Variables Retained in Logistic Regression Models Using Vegetation and Soil Moisture Variables to Predict Microclimate

Measure of microclimate	AUC for models with just vegetation variables	AUC for models with vegetation, soil moisture, and distance to water	AUC for models with vegetation, soil moisture, distance to water, and percent inundated
Maximum diurnal temperature	0.71	0.78	0.78
Minimum nocturnal temperature	0.75	0.70	0.57
Daily temperature range	0.77	0.81	0.77
Mean diurnal vapor pressure	0.55	0.70	0.66
Mean nocturnal vapor pressure	0.60	0.72	0.72

Nests in Formerly Occupied Areas

Microclimate

Formerly occupied nest sites at Mesquite had higher soil moisture, lower maximum daily temperature, and higher humidity when the nest was occupied than when the area had been abandoned (Table 7.14). At Mormon Mesa, soil moisture did not differ between occupied and unoccupied periods, but temperatures were more moderate and humidity was higher when the nests were occupied (Table 7.15). There were no differences between occupied and unoccupied periods at Muddy River (Table 7.16) or at Topock Marsh (Table 7.17). When all study areas were combined, mean maximum daily temperature and daily temperature range were lower when the nest was occupied, and diurnal and nocturnal vapor pressure were higher when the nest was occupied (Table 7.18). The direction and magnitude of change at each individual study area are indicated in the last four columns of Table 7.18 to indicate the contribution of each study area to the overall results.

Table 7.14. Paired T-test Results Comparing Microclimate Characteristics at Willow Flycatcher Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, Mesquite, NV

Microclimate measure	Occupied	Unoccupied	Difference	*P*
Soil Moisture (n = 14)				
Mean soil moisture (mV)	681.7 (84.5)	335.0 (37.7)	-346.6 (85.1)	<0.001
Temperature (n = 13)				
Mean maximum diurnal temperature (°C)	39.7 (1.1)	42.4 (0.9)	2.7 (1.2)	0.044
Mean minimum nocturnal temperature (°C)	19.7 (0.7)	20.4 (0.5)	0.7 (0.4)	0.108
Mean daily temperature range (°C)	20.1 (1.2)	22.1 (0.9)	2.0 (1.3)	0.163
Humidity (n = 13)				
Mean diurnal vapor pressure (Pa)	1,959.0 (110.5)	1,805.8 (61.5)	-153.2 (68.2)	0.044
Mean nocturnal vapor pressure (Pa)	1,734.5 (97.8)	1,610.3 (56.5)	-124.3 (52.9)	0.037

Table 7.15. Paired T-test Results Comparing Microclimate Characteristics at Willow Flycatcher Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, Mormon Mesa, NV

Microclimate measure	Occupied	Unoccupied	Difference	*P*
Soil Moisture (n = 18)				
Mean soil moisture (mV)	627.9 (61.3)	719.6 (42.6)	91.7 (62.9)	0.163
Temperature (n = 21)				
Mean maximum diurnal temperature (°C)	42.8 (0.8)	46.8 (1.1)	4.0 (1.2)	<0.004
Mean minimum nocturnal temperature (°C)	21.5 (0.6)	20.2 (1.3)	-1.3 (0.4)	<0.007
Mean daily temperature range (°C)	21.3 (1.1)	26.6 (1.5)	5.3 (1.3)	<0.001
Humidity (n = 20)				
Mean diurnal vapor pressure (Pa)	1,765.4 (107.1)	1,409.3 (63.4)	-356.1 (106.2)	<0.003
Mean nocturnal vapor pressure (Pa)	1,785.4 (100.9)	1,430.4 (61.3)	-355.0 (96.7)	<0.002

Table 7.16. Paired T-test Results Comparing Microclimate Characteristics at Willow Flycatcher Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, Muddy River, NV

Microclimate measure	Occupied	Unoccupied	Difference	*P*
Soil Moisture (n = 11)				
Mean soil moisture (mV)	660.8 (46.6)	584.6 (58.9)	-76.2 (73.7)	0.326
Temperature (n = 9)				
Mean maximum diurnal temperature (°C)	38.0 (0.7)	39.8 (1.1)	1.8 (1.2)	0.159
Mean minimum nocturnal temperature (°C)	21.6 (1.0)	22.3 (0.6)	0.7 (0.6)	0.267
Mean daily temperature range (°C)	16.4 (1.3)	17.5 (1.5)	1.1 (1.1)	0.327
Humidity (n = 9)				
Mean diurnal vapor pressure (Pa)	2,106.6 (136.0)	1,875.0 (99.4)	-231.6 (129.9)	0.112
Mean nocturnal vapor pressure (Pa)	1,863.4 (148.0)	1,697.1 (85.6)	-166.3 (134.6)	0.252

Table 7.17. Paired T-test Results Comparing Microclimate Characteristics at Willow Flycatcher Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, Topock Marsh, AZ

Microclimate measure	Occupied	Unoccupied	Difference	*P*
Soil Moisture (n = 21)				
Mean soil moisture (mV)	822.5 (40.5)	869.8 (25.0)	47.3 (37.3)	0.219
Temperature (n = 16)				
Mean maximum diurnal temperature (°C)	39.1 (0.6)	38.4 (0.6)	-0.7 (0.7)	0.324
Mean minimum nocturnal temperature (°C)	20.6 (0.8)	21.2 (0.6)	0.7 (0.6)	0.306
Mean daily temperature range (°C)	18.6 (1.0)	17.2 (0.6)	-1.4 (0.9)	0.146
Humidity (n = 14)				
Mean diurnal vapor pressure (Pa)	2,382.4 (135.6)	2,575.3 (123.3)	192.8 (154.2)	0.233
Mean nocturnal vapor pressure (Pa)	2,107.2 (105.8)	2,218.1 (90.8)	110.9 (107.5)	0.321

Table 7.18. Paired T-test Results Comparing Microclimate Characteristics at Willow Flycatcher Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, All Study Areas Combined*

Microclimate measure	Occupied	Unoccupied	Difference	*P*	Direction of Change			
					MESQ	MOME	MUDD	TOPO
Soil Moisture (n = 64)								
Mean soil moisture (mV)	709.1 (30.7)	661.5 (31.4)	-47.6 (37.0)	0.202	↓	--	--	--
Temperature (n = 59)								
Mean maximum diurnal temperature (°C)	40.4 (0.5)	42.5 (0.7)	2.1 (0.6)	<0.001	↑	↑	--	--
Mean minimum nocturnal temperature (°C)	20.9 (0.4)	20.8 (0.3)	0.0 (0.3)	0.910	--	↓	--	--
Mean daily temperature range (°C)	19.5 (0.6)	21.7 (0.9)	2.1 (0.7)	0.004	--	↑	--	--
Humidity (n = 56)								
Mean diurnal vapor pressure (Pa)	2,019.4 (67.9)	1,867.7 (74.0)	-151.7 (65.2)	0.024	↓	↓	--	--
Mean nocturnal vapor pressure (Pa)	1,866.6 (57.4)	1,711.9 (54.7)	-154.7 (54.7)	<0.007	↓	↓	--	--

* Data are presented as mean (standard error).

[1] Arrows indicate the direction of change of the variable between occupied and unoccupied periods for each study area (MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, TOPO = Topock Marsh, while color indicates the statistical significance of the change as follows: red is $P < 0.01$, blue is $0.01 < P < 0.05$, black is $0.05 < P < 0.10$, no arrow is $P > 0.1$.

Soil Texture

The percentages of sand, silt, and clay in the soil samples at nests in formerly occupied areas did not change significantly (all $P > 0.05$) at Mesquite (n = 9), Mormon Mesa (n = 7), or Topock (n = 7) between when the nests were occupied and when the area was abandoned. At Muddy River (n = 7), the percentage of sand decreased ($P = 0.018$) and the percentage of silt increased ($P = 0.018$).

DISCUSSION

Currently Occupied Territories

Microclimate

The microclimate characteristics recorded in occupied flycatcher territories provide guidelines for determining whether the conditions present in habitat creation sites resemble those found in flycatcher territories. Comparisons of conditions in habitat creation sites with those in flycatcher territories must consider the compatibility of the equipment used to collect the data. In 2003, at the beginning of our studies of microclimate within flycatcher territories, we were placing data loggers directly beneath recently vacated nests, and we chose a method of housing the data loggers that allowed for camouflage. During periods of the day when the logger was not in complete shade, the temperature readings recorded by the data logger were not necessarily the same as ambient temperature, and the discrepancy between logger readings and ambient temperature increased with decreasing shade (SWCA, unpublished data).

Therefore, before the high temperature readings reported here for flycatcher territories can be used as a guide for temperatures at habitat creation sites, the equipment we used and that used at the restoration sites must be calibrated.

The presence of surface water is clearly an important component of occupied flycatcher habitat, and the association of flycatchers with surface water has been emphasized by other investigators (e.g., Finch and Stoleson 2000, Sogge et al. 2010). Across all study areas, over half of all sample points within occupied flycatcher territories were within 10 m of water in the second half of May and first half of June, when territories are typically established. There were clearly instances when flycatcher territories were established far from surface water, but these instances should not be construed as an indication that water is not necessary for successful reproduction (see Chapter 3) or continued flycatcher occupancy. We have observed several instances, most notably at Mesquite West in 2009, where flycatchers established territories in previously occupied areas that had gone dry since the previous year. However, site fidelity in the year following dry conditions was low (McLeod and Pellegrini 2011, 2013), indicating that surface water is important to flycatchers. Surface water plays a role in maintaining dense vegetation as well as moderating temperature, and the proximity of surface water was also associated with higher invertebrate abundance at study areas (Pahranagat and Key Pittman) where this relationship was investigated (NAU, unpublished data). Other studies have found that the abundance of emergent aquatic insects decreased exponentially with distance from water (Iwata et al. 2003, Hagen and Sabo 2011), and that flycatchers (family Muscicapidae) concentrated their foraging over streams or at stream edges (Iwata et al. 2003).

To obtain a summary of soil moisture and surface water across all study areas, we pooled data from all study areas (Table 7.19). The data from all study areas include years and study areas where conditions clearly were not optimal, such as Mesquite West in 2009 and Topock Marsh in 2005, and the full range of data should not be construed as constituting suitable conditions, despite the presence of territorial flycatchers. We recommend that randomly selected sample points within habitat creation areas that are managed for habitat credits for willow flycatchers conform to the range and distribution of conditions seen in the 25th–75th percentiles of flycatcher territories in each two-week period. Cumulative histograms showing soil moisture, distance to water, and percentage of the surrounding area that was inundated are shown in Figures 7.7–7.10 to illustrate the recommended distribution of conditions. Conditions that are wetter than those described by the 25th–75th percentile would also be suitable for willow flycatchers, since prolonged inundation that would result in mortality of the vegetation is unlikely to occur.

In occupied flycatcher territories at most study areas, hydrologic conditions are essentially constant from one day to the next and change slowly over the season. Because these are the conditions we have observed, we are unable to determine if there is a minimum frequency of flooding necessary to maintain suitable conditions in areas, such as flood irrigated sites, where hydrologic conditions may vary dramatically from one day to the next.

As with surface hydrology conditions, we recommend using the 25th–75th percentile of conditions observed across all occupied territories as guidelines for temperature and humidity (Table 7.19). Because flycatcher nest sites and territories typically have lower maximum daily temperatures, higher minimum nocturnal temperatures, a small daily temperature range, and higher diurnal and nocturnal vapor pressure than surrounding, unused areas, conditions that are outside the 25th–75th percentile but in the direction preferred by flycatchers would also be considered suitable for flycatchers.

Table 7.19. Soil Moisture and Microclimate Measures in Southwestern Willow Flycatcher Territories at All Study Areas Combined, 2003–2011

Microclimate measure	May 16–31		June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
Soil Moisture	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 soil moisture (mV)	902.8 (688.8–954.0)	776.2 (24.2)	896.1 (770.9–961.6)	790.3 (21.7)	875.6 (693.3–935.0)	768.1 (17.5)	848.7 (628.0–919.4)	735.1 (16.0)	837.9 (598.8–921.9)	730.1 (15.1)	881.9 (694.0–929.7)	778.4 (16.7)
Mean distance to nearest standing water	6.5 (0.1–54.0)	42.2 (6.1)	6.0 (0.0–31.0)	38.6 (6.0)	12.0 (1.5–50.0)	54.5 (7.9)	25.5 (3.0–100.0)	119.1 (19.3)	20.0 (3.0–110.0)	101.5 (13.3)	13.0 (1.0–70.0)	64.4 (11.1)
% of area within 20 m that was inundated	20.0 (0.0–60.0)	33.3 (4.5)	20.0 (0.0–75.0)	36.7 (3.8)	10.0 (0.0–40.0)	26.0 (3.1)	4.0 (0.0–20.0)	17.5 (2.7)	0.0 (0.0–15.0)	14.3 (2.3)	5.0 (0.0–30.0)	19.3 (3.0)
% of area within 50 m that was inundated	30.0 (0.0–60.0)	33.7 (4.0)	30.0 (5.0–70.0)	36.8 (3.4)	15.0 (2.0–50.0)	30.4 (3.0)	10.0 (0.0–30.0)	18.4 (2.3)	3.0 (0.0–30.0)	16.2 (2.1)	10.0 (0.0–35.0)	22.1 (3.1)
Temperature												
Mean maximum diurnal temperature (°C)	37.7 (34.4–41.5)	38.0 (0.2)	37.8 (34.9–40.6)	38.0 (0.1)	40.1 (37.0–44.4)	40.7 (0.1)	40.6 (37.5–45.4)	41.6 (0.1)	40.9 (37.7–44.9)	41.6 (0.1)	39.2 (36.1–42.5)	39.5 (0.1)
Mean minimum nocturnal temperature (°C)	13.7 (12.0–16.4)	14.1 (0.1)	14.1 (12.6–16.0)	16.6 (0.1)	16.4 (14.7–18.3)	16.6 (0.1)	19.4 (17.1–21.7)	19.3 (0.1)	22.5 (21.0–24.0)	22.5 (0.1)	21.3 (19.0–22.9)	21.0 (0.1)
Mean daily temperature range (°C)	23.8 (20.0–27.9)	23.9 (0.2)	23.7 (20.0–27.1)	23.6 (0.2)	23.9 (20.1–27.8)	24.1 (0.2)	22.0 (18.1–26.3)	22.3 (0.1)	18.5 (14.6–23.2)	19.1 (0.1)	18.2 (14.2–22.4)	18.5 (0.2)
Humidity												
Mean diurnal vapor pressure (Pa)	1260.3 (1081.7–1489.7)	1296.3 (11.7)	1273.6 (1030.2–1602.6)	1327.7 (12.3)	1678.9 (1311.9–2154.0)	1753.5 (14.4)	2021.5 (1645.3–2524.5)	2077.2 (13.3)	2504.1 (2081.4–2868.5)	2474.4 (11.4)	2474.5 (1993.3–2870.4)	2428.9 (15.8)
Mean nocturnal vapor pressure (Pa)	1224.2 (1062.5–1408.1)	1221.8 (8.9)	1219.1 (1023.5–1430.6)	1234.0 (8.8)	1512.1 (1294.4–1734.0)	1530.8 (8.8)	1771.7 (1513.8–2096.7)	1806.9 (9.2)	2196.9 (1904.3–2471.8)	2181.6 (8.2)	2159.1 (1875.0–2498.9)	2181.1 (11.4)

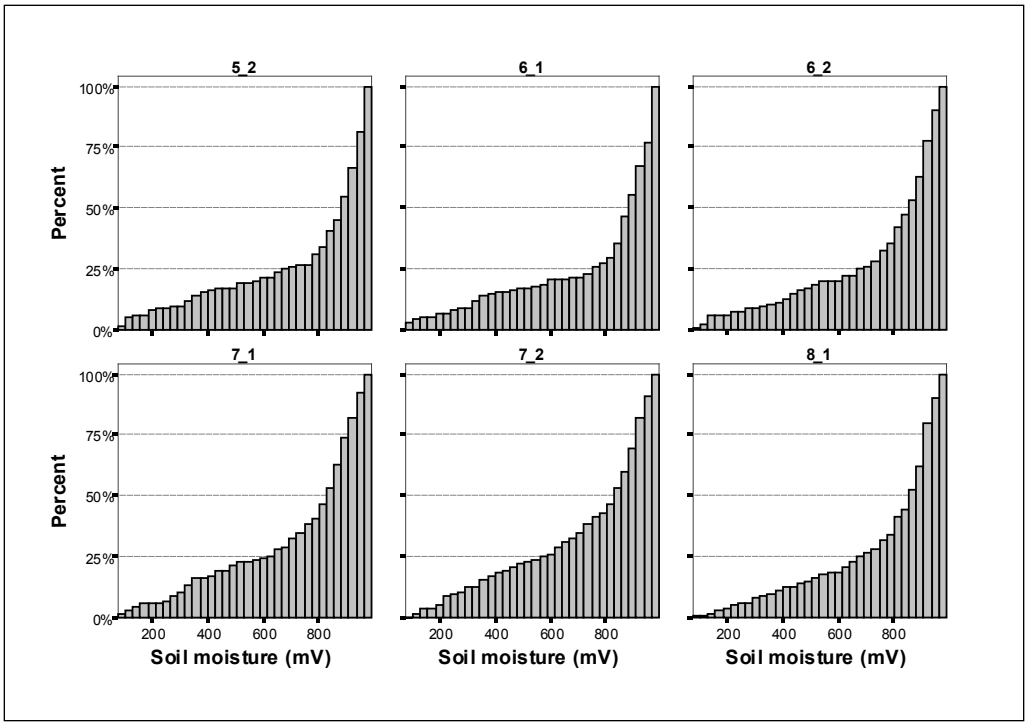

Figure 7.7. Cumulative histogram of mean soil moisture in occupied flycatcher territories across all study areas, 2004–2011. Each histogram corresponds to a two-week period: 5_2 = 16–31 May, 6_1 = 1–15 June, 6_2 = 16–30 June, 7_1 = 1–15 July, 7_2 = 16–31 July, 8_1 = 1–15 August.

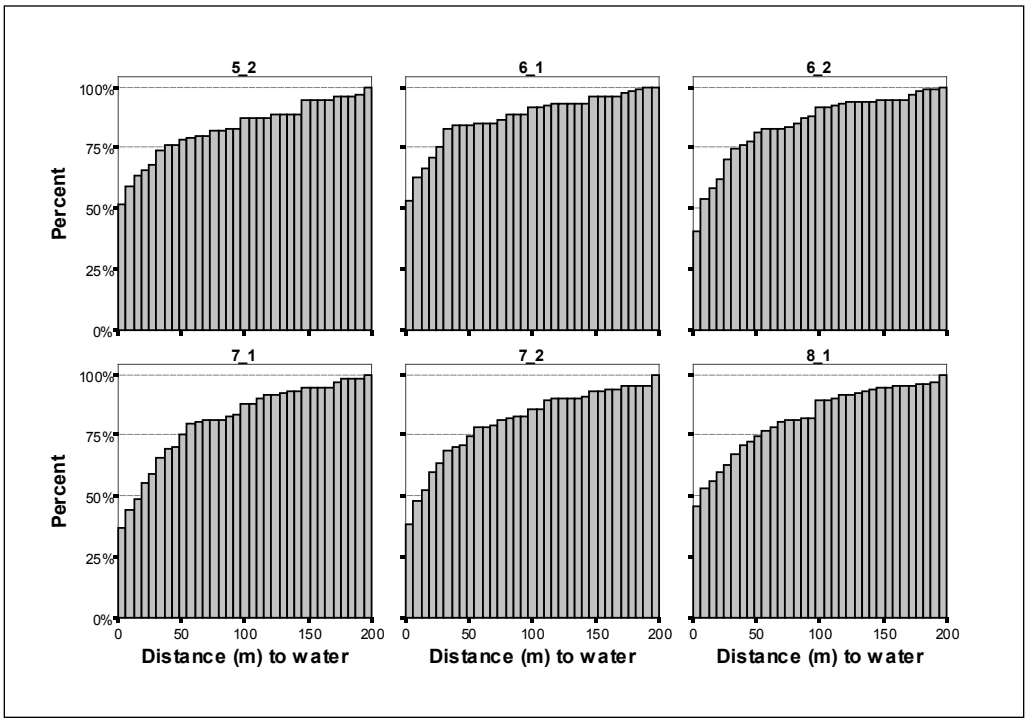

Figure 7.8. Cumulative histogram of distance to water in occupied flycatcher territories across all study areas, 2005–2011. Each histogram corresponds to a two-week period: 5_2 = 16–31 May, 6_1 = 1–15 June, 6_2 = 16–30 June, 7_1 = 1–15 July, 7_2 = 16–31 July, 8_1 = 1–15 August.

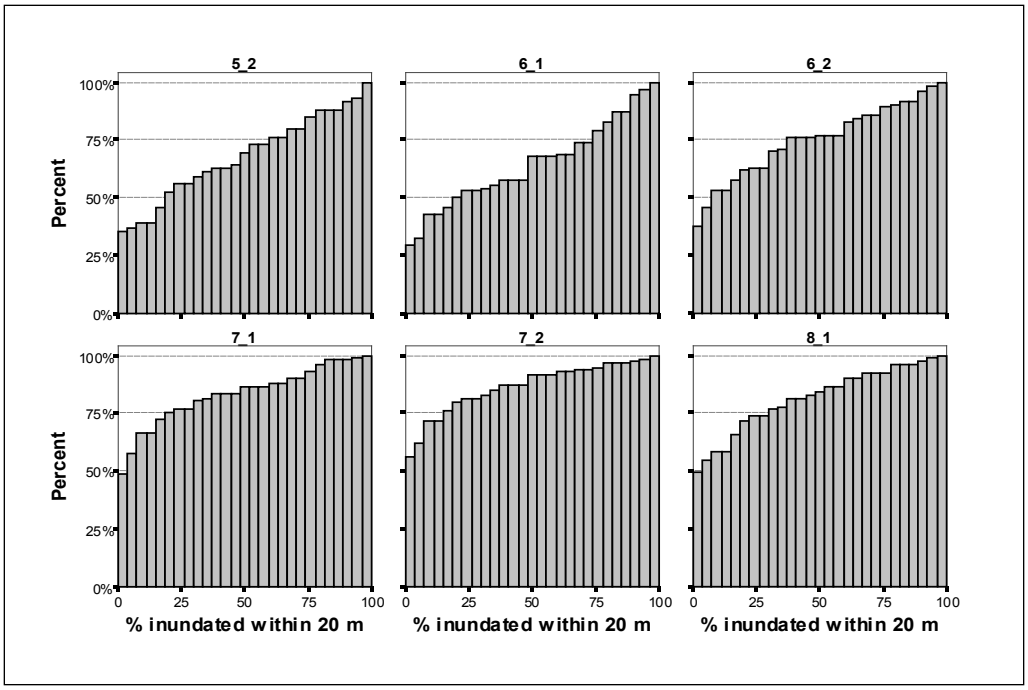

Figure 7.9. Cumulative histogram of the percentage of surrounding area within 20 m of the sample point that was inundated in flycatcher territories across all study areas, 2008–2011. Each histogram corresponds to a two-week period: 5_2 = 16–31 May, 6_1 = 1–15 June, 6_2 = 16–30 June, 7_1 = 1–15 July, 7_2 = 16–31 July, 8_1 = 1–15 August.

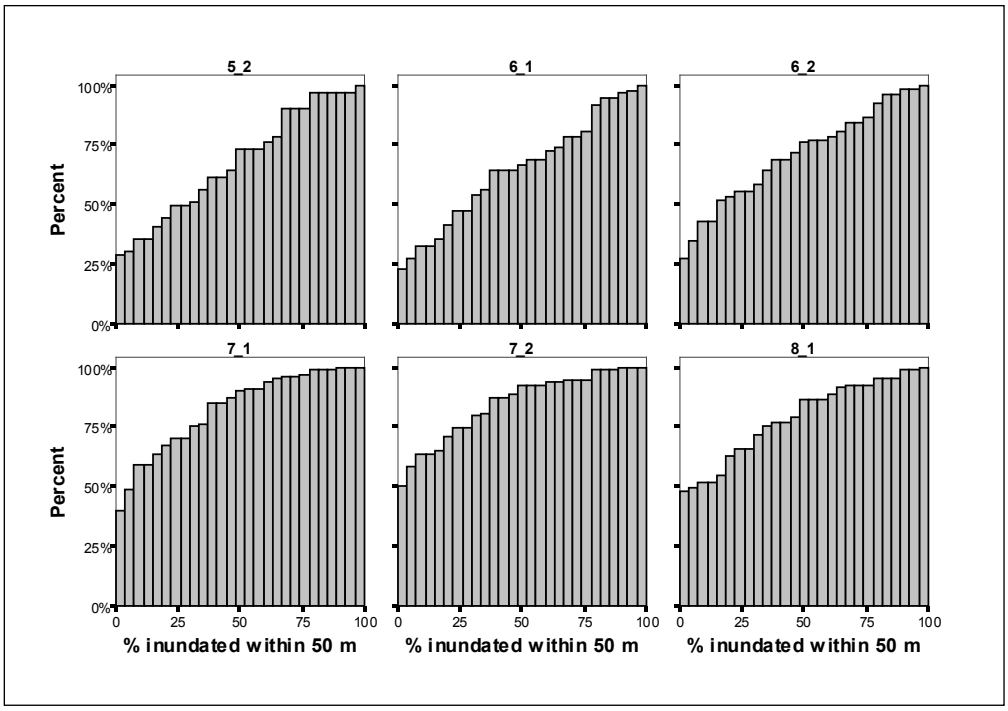

Figure 7.10. Cumulative histogram of the percentage of surrounding area within 50 m of the sample point that was inundated in flycatcher territories across all study areas, 2008–2011. Each histogram corresponds to a two-week period: 5_2 = 16–31 May, 6_1 = 1–15 June, 6_2 = 16–30 June, 7_1 = 1–15 July, 7_2 = 16–31 July, 8_1 = 1–15 August.

Relationship of Vegetation and Soil Moisture to Microclimate

Temperature and humidity at a specific location are the result of the combination of regional climate and the local influences of vegetation and soil moisture. If temperature and humidity of an area do not fall within the conditions used by flycatchers on the LCR, manipulation of temperature and humidity would be accomplished by manipulation of vegetation structure or hydrology. Data collected as part of the Topock hydrology monitoring and at Mesquite in 2008–2010 indicated that the presence of surface water affects local temperature and humidity. At Topock, flooding events resulted in higher humidity and more moderate temperatures in flooded areas compared to non-flooded areas (see Chapter 9). There was no evidence that conditions of vegetation at Topock were affected by a season of flood events, and changes in microclimate were apparently influenced primarily by the flood events. At Mesquite West, dry conditions were also associated with less vigorous vegetation (McLeod and Pellegrini 2011), so vegetation and surface hydrology may have both had effects on temperature and humidity. Dry conditions produced the highest maximum daily temperatures, exceeding those recorded at a local weather station, while wet conditions produced the lowest maximum daily temperatures, not reaching those recorded at the same weather station (McLeod and Pellegrini 2011). Wet surface conditions were also associated with higher humidity, though no humidity data were available from local weather stations for comparison.

Multiple studies have shown that habitats used by willow flycatchers typically have taller and denser vegetation than unused locations (Allison et al. 2003, Paradzick 2005, Moore 2007, McLeod et al. 2008a). Wet soils are necessary for the establishment, growth, and persistence of tall, dense, riparian vegetation. In addition to creating vegetation that produces cooler, more humid conditions, moist soils also moderate temperature and increase humidity directly, as shown by the flooding experiment at Topock. Our formal analysis of the relationship between vegetation and microclimate confirmed the associations between soil moisture, vegetation, and microclimate that we had observed at Mesquite West and Topock Marsh. Canopy closure and foliage density above nest height were consistently strong predictors of microclimate conditions, and canopy height was also a strong predictor in models that considered only vegetation variables but not soil moisture. Soil moisture was a significant predictor of maximum daily temperature, daily temperature range, and both diurnal and nocturnal humidity. While vegetation variables alone were fair at predicting microclimate conditions, the addition of soil moisture to the suite of variables improved the ability of the models to predict when microclimate would be in the preferred range for all characteristics except minimum nocturnal temperature. In the hot and arid regions of the Southwest, minimum temperature is likely of little concern to a nesting flycatcher, whereas maximum daily temperatures may reach levels (41°C; Webb 1987) high enough to kill embryos in the egg. Minimum nocturnal temperature consistently had few variables retained in the logistic regression models, and the models all had poor predictive ability for minimum temperature. Management efforts should therefore focus on means of reducing high temperatures and increasing humidity.

The logistic regression models overwhelmingly showed that increases in canopy height, canopy closure, the density of live stems, the amount of live foliage, and soil moisture were associated with more moderate temperatures, while increases in the density of dead stems and dead foliage resulted in plots being less likely to have temperatures within the preferred range. Canopy closure, live foliage above nest height, and soil moisture had similar effects on humidity, with increases in each variable being associated with higher humidity. Management efforts to increase canopy closure, the amount of live foliage above average nest height, and soil moisture would therefore increase suitability of the area for flycatchers by providing the vegetation density found in occupied flycatcher sites (see Chapter 6), providing the soil moisture needed to attract flycatchers, and promoting the microclimate conditions (Table 7.19) found in flycatcher territories.

Soil Texture

At all study areas, soil types were consistent with the depositional nature of riparian areas, consisting primarily of varying ratios of sand and silt, with very little clay. Soil within occupied flycatcher breeding areas varied locally in the percentages of sand and silt present within surface samples, as is typical within fluvial depositional environments (Lark 2009). We did not use a coring method to collect soil samples, and variation in soil texture between samples may also have been influenced by variations in collection methods; i.e., samples may have varied in the proportion of the sample that came from the surface vs. a depth of 5 cm.

We saw no differences in soil texture between occupied and unoccupied areas, and thus there is no evidence that soil type, within the range of depositional soil types present at both occupied and unoccupied types, has an influence on the suitability of these sites for occupancy by flycatchers. At most of the flycatcher sites (i.e., Pahranagat, Littlefield, Mormon Mesa, Muddy River, Topock Marsh, Bill Williams), surface water and saturated soils are present because of high groundwater tables. The presence of high groundwater tables minimizes the importance of soil texture, because the saturated or inundated conditions are maintained by groundwater or streamflow rather than by moisture retained in the soil after a rainfall or irrigation event. The exception to this is Mesquite West, where return flows from the Mesquite Irrigation District are the main source of water for the site. When these return flows are cut off, the site dries completely within a few days and its suitability as flycatcher habitat also decreases (see Chapter 2).

Although soil texture does not appear to be a determining factor in flycatcher occupancy of currently known breeding areas, it has an influence on infiltration rates and the ability of the soil to retain moisture. Soil texture will therefore likely influence soil moisture and retention of surface water in habitat creation areas where riparian vegetation is maintained through intermittent irrigation, and may have an influence on the frequency of irrigation needed to maintain the saturated and inundated conditions preferred by flycatchers.

Nests in Formerly Occupied Area

In formerly occupied areas of Mesquite and Mormon Mesa that were affected by flooding over the 2004–2005 winter, we did not observe any changes in soil texture as the result of flooding and deposition. Significant deposition in portions of Mesquite and Mormon Mesa did alter water flow patterns within the sites, however, causing formerly wet, occupied areas to become dry. The change in hydrological conditions was likely a strong influence on the suitability of the area for occupancy by flycatchers, and abandonment of the area was unrelated to surface soil texture. At Muddy River, the soil samples collected in 2008, when the nesting area was unoccupied, had less sand and more silt than the samples collected in 2005–2007 when the nesting area was active. There were no known floods in those years, and there was no evidence of soil disturbance at the nests, so the difference in soil texture of the samples may be a spurious result and likely does not reflect an overall change in soil texture within the site.

Microclimate characteristics in formerly occupied areas of Mesquite and Mormon Mesa were hotter and drier during the unoccupied period than when the nests were occupied. These results are not surprising, given that much of the formerly occupied areas at these two study areas had been affected by floods and sedimentation and had visibly changed, with drier soils and more dead or dying vegetation (see Chapter 6). The driving factor in these areas becoming unoccupied was likely the change in hydrology, which caused the accompanying changes in vegetation and microclimate. At Topock Marsh and Muddy River, there were no dramatic changes in the vegetation in the formerly occupied areas, and microclimate did not differ significantly between the occupied and unoccupied periods. This suggests that factors other

than changes in the vegetation or microclimate characteristics we measured were responsible for territory abandonment. At Muddy River, bulldozing and dredging in the vicinity of the territories may have affected territory occupancy, and dredging may have reduced the amount of surface water in the territories (see Chapter 2). At Topock Marsh, marsh levels after 2004 peaked at lower levels, and high water levels were of shorter duration than was the case prior to 2004 (see Chapters 2 and 9). The decline in the flycatcher population at Topock (see Chapters 2, 3, and 9) and corresponding territory abandonment are likely related to the changes in marsh levels, although these changes were not reflected in changes in soil moisture values or microclimate measures. It is possible that variables such as the percent of the area that was inundated surrounding the sample point would be more sensitive to changes in marsh levels than the soil moisture measurements from a point location; however, these measures were not collected in the year the nest was active. In addition, 8 of the 21 nests used in the analysis for Topock were occupied in 2005, a year in which marsh levels were unusually low and the flycatcher population at Topock was just beginning to decline from the peak in 2004. Inclusion of these data may have masked any changes in surface water and microclimate conditions that contributed to territory abandonment at Topock Marsh.

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Chapter 8

HABITAT MONITORING: PARKER TO IMPERIAL DAMS

INTRODUCTION

Southwestern Willow Flycatcher nests and breeding territories are typically located near rivers, streams, and open water (Sogge and Marshall 2000) or over wet soil (Flett and Sanders 1987, Harris et al. 1987, Harris 1991). Nest substrate plants are often rooted in or overhang standing water. Although the association between breeding flycatchers and open water or wet soil is widely recognized by managers and scientists alike, the exact nature of the association is poorly quantified. Water may be a direct environmental cue for flycatcher nesting behavior or it may be the ultimate cause of proximate factors such as vegetation composition and structure, prey base, and microclimate.

Anthropogenic or natural modifications to surface water resources (i.e., fluvial hydrology and geomorphology) can modify existing and potential flycatcher breeding habitat and therefore have the potential to modify flycatcher abundance, distribution, and nesting success (Graf et al. 2002). For example, nine flycatcher territories at San Marcial on the middle Rio Grande in New Mexico exhibited a near absence of nesting attempts in 1996 when a combination of drought, upstream dam operations, and upstream withdrawals for irrigation removed all surface water (Johnson et al. 1999). This was in contrast to previous (1994, 1995) and subsequent (1997) years when active nests were documented at the site, with the river flowing in those years. A nearby control site that contained water exhibited multiple nesting attempts during all four years, leading Johnson et al. (1999) to suggest that the presence of water was a fundamental requirement for nesting. A similar pattern was observed along the Gila River in Arizona when decreased streamflow from 2002 to 2004 coincided with the number of flycatcher territories declining by nearly half each year (Munzer et al. 2005). From 2004 to 2011, flows within the Gila River were greater and more consistent and corresponded with a continuing increase in flycatcher territories (14 to 188) over those years (Graber et al. 2012).

Flow characteristics of the lower Colorado River have been modified by numerous dams and irrigation withdrawals (Rosenberg et al. 1991). The river reach between Parker Dam and Imperial Dam is regulated by releases from Parker Dam, which has been in operation since 1939. Existing riparian habitat in the Parker to Imperial reach has likely adjusted to historical water release patterns from Parker Dam and appears to be in a stable or declining condition (LCR MSCP 2004). Implementation of the Secretarial Implementation Agreements/California 4.4 Plan (hereafter SIAs) by Reclamation would change the point of diversion for up to 400,000 acre-feet of California apportionment water for up to 75 years (USFWS 2001). The point of diversion, previously located below Parker Dam at Imperial Dam, would change to a point above Parker Dam, resulting in lower water levels in the river between Parker and Imperial. The change in point of diversion was scheduled to begin in 2002.

River flow changes related to the change in point of diversion have the potential to further modify riparian habitats below Parker Dam, habitats that were considered potentially suitable for willow flycatchers (USFWS 2001:47). Reclamation (2000) estimated that implementation of the SIAs would cause a drop in floodplain groundwater levels of 1.55 feet (0.47 m) or less. As a result, 372 acres (151 ha) of what at the time was thought to be occupied flycatcher habitat could lose their moist soils[9]. This loss

[9] Occupied habitat was defined as patches of vegetation that were similar to and contiguous with areas where willow flycatchers were detected after 15 June in any year since surveys began in 1996, regardless of whether those flycatchers were determined to be residents. Studies in subsequent years determined that these sites were used by migrant flycatchers, but there was no evidence of resident flycatchers using these sites (see Chapter 2).

could influence plant species composition (loss of cottonwood and willow) and structure (loss of vegetation volume) over an undetermined length of time. In addition, Reclamation estimated that 5, 404 acres (2,187 ha) of potential flycatcher habitat could be influenced by the drop in groundwater level. Because sites between Parker and Imperial Dams were thought to be occupied by resident flycatchers, these changes were thought to have the potential to affect the distribution, abundance, occupancy, and prey base of Southwestern Willow Flycatchers in the Parker to Imperial reach.

In 2004, Reclamation completed a pilot year of habitat monitoring by deploying temperature/humidity data loggers at several sites in the Parker to Imperial reach. Reclamation then initiated a more comprehensive, long-term study in 2005 for the purpose of addressing how the above hydrological changes might affect riparian habitats along the Parker to Imperial reach. The objective was to monitor 151 ha (372 acres) of what was thought to be occupied Southwestern Willow Flycatcher habitat between Parker and Imperial Dams for 10–15 years to determine how microclimate, vegetation, and groundwater conditions might be affected by water transfer actions under the SIAs. Monitoring did not commence until after diversions started; therefore, antecedent conditions are unknown and monitoring analyses focus on detecting change through time rather than comparing current conditions to a baseline.

By the time the more comprehensive monitoring began in 2005, there was growing evidence that the areas targeted for habitat monitoring were not occupied by resident flycatchers. Therefore, an additional objective was to compare microclimate and soil characteristics of sites in the Parker to Imperial reach with those at flycatcher breeding areas farther north to determine whether sites in the Parker to Imperial reach had limiting characteristics that made them unsuitable for flycatchers. We also wanted to determine whether there was a latitudinal gradient in microclimate characteristics such that sites south of Parker Dam were too hot or dry to be suitable for resident flycatchers.

METHODS

In 2005, we selected a subset of sites that were surveyed annually for the presence of willow flycatchers for inclusion in the habitat monitoring study. We chose 11 sites distributed along the Parker to Imperial reach that were reasonably accessible and where we believed groundwater levels were influenced primarily by river levels and not by outside sources such as irrigation return flows. Chosen sites equated to at least 75.3 ha (186 acres) on the California side of the lower Colorado River and at least 75.3 ha (186 acres) on the Arizona side. We also chose four control sites, two above Parker Dam and two below Imperial Dam, to distinguish any changes in microclimate, groundwater, or vegetation caused by water transfer actions from those caused by fluctuations in climate or rainfall. The 11 test sites are Ehrenberg, Three Fingers Lake, Cibola Lake, Walker Lake, Paradise, Hoge Ranch, Rattlesnake, Clear Lake, Ferguson Lake, Ferguson Wash, and Great Blue Heron, and the four control sites are Blankenship Bend, Havasu NE, Mittry West, and Gila Confluence North (Figure 8.1). We completed a preliminary reconnaissance of each selected site on the ground and by helicopter in April 2005 to focus our study area to the portion of each site most likely to be affected by changes in river flows; i.e., those portions of the sites that had shallow, standing water or saturated soils. We attempted to eliminate or minimize portions of the sites that had dry soils and contained upland vegetation such as mesquite. We monitored these same 15 sites from 2005 to 2011. The entirety of the Three Finger Lake site burned in August of 2011, and the 14 remaining sites were monitored through July of 2012. In August of 2006, we initiated similar monitoring at Topock Marsh within what had been a consistently occupied breeding site to obtain groundwater levels and patterns with which to compare results obtained at the habitat monitoring (test and control) sites.

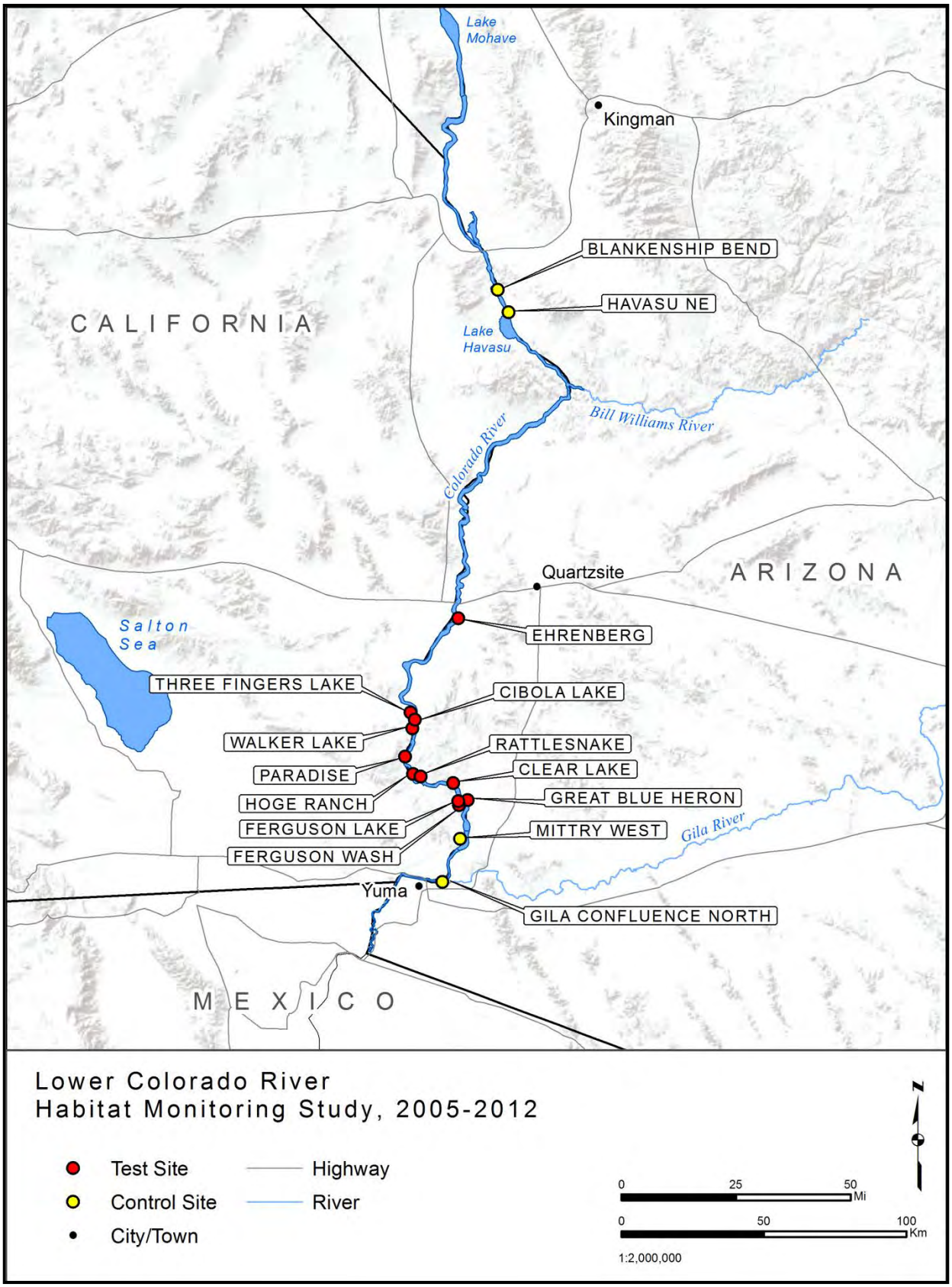

Figure 8.1. Locations of test and control sites, habitat monitoring study, 2005–2012.

Microclimate

Temperature/Humidity

In 2005, we deployed HOBO H8 Pro (Onset Computer Corporation, Pocasset, MA) temperature/humidity data loggers at several locations within each site selected for habitat monitoring. A total of 60 HOBO loggers were deployed, with the number of loggers deployed at each site corresponding with the size of each habitat monitoring area: three loggers were deployed at sites <4.0 ha, four at sites 4.0–12.1 ha, and five at sites >12.1 ha. All loggers collected data at 15-minute intervals and were placed in inverted plastic containers and camouflaged as described in Chapter 7.

Locations for each HOBO logger were selected by superimposing a 25 × 25–m grid on an ArcGIS 9.0 software shapefile of the habitat monitoring area boundary, numbering the grid blocks, selecting blocks by using a random number generator, and using the centroid of each selected block. These points were located in the field by navigating to the given UTM coordinates using a Rino 110 GPS unit. The exact location of the logger was determined by selecting the closest woody tree or shrub at least 3 m in height and using the random number procedures described in Chapter 7 to determine the height and distance and direction from the bole at which to place the logger. The random numbers used to assign logger heights were distributed according to the distribution of observed nest heights at Pahranagat, Mesquite, Mormon Mesa, and Topock Marsh in 2003 and 2004. If the chosen point was inaccessible (e.g., impenetrable vegetation or deep water) or was in clearly unsuitable habitat for flycatchers (e.g., open marsh), the next UTM coordinate was used.

After the precise location for the logger was chosen, field personnel inserted a piece of rebar into the ground at the chosen location. A piece of ½-inch conduit was placed over the rebar and cut or spliced so that it extended 30–50 cm above the chosen location for the logger. Field personnel then bent the top of the conduit at a 90-degree angle at the height at which the logger was to be hung, and the logger was wired to the horizontal portion of the conduit so that when the conduit was reset on the rebar, the logger was hanging in the desired location. We hung the HOBO loggers in this manner to facilitate periodic download and maintenance of the loggers and subsequent reinstallation in exactly the same location. At each download, we examined the data to determine if there were any problems with data logger function. Data loggers were replaced whenever a potential problem with the sensors was detected. Battery level was also checked at each download, and the battery was replaced if needed.

Soil Moisture

Soil moisture measurements and distance to water were recorded, as described in Chapter 7, during each presence/absence survey between 15 May and 25 July and when HOBO data were downloaded. Beginning in 2008, we also recorded the percentage of the surrounding area containing saturated or inundated soil, as described in Chapter 7.

Soil Texture

Soil samples were collected beneath each HOBO logger in 2005. Collection and analysis of the soil samples followed the methods described in Chapter 7.

Vegetation

We completed vegetation measurements at each active HOBO location in late July of each year, following the methods described in Chapter 6. All HOBO loggers were also downloaded at this time.

Groundwater

Piezometer Installation

Piezometers were installed in May–August 2005 near each of the 15 sites selected for habitat monitoring. One additional piezometer was installed at Topock Marsh in August 2006. The piezometers were constructed with pre-formed ¾-inch-diameter PVC well points. These well points were approximately 1 foot in length, had a pre-installed permeable well screen, and were sturdy enough to be driven into the ground. The well points were glued to standard ¾-inch-diameter Schedule 40 PVC pipe, which was then cut long enough to extend several feet above land surface. The piezometer was protected at the surface against vandalism and damage by a 2-inch diameter PVC surface casing that extended several feet below ground and was secured in place with a small amount of concrete. A locking, watertight PVC cap was glued to the top 2-inch-diameter surface casing.

Although the piezometers can be driven into the ground, in most cases this was not the most efficient method of installation. We installed most of the piezometers by first digging a 2-inch-diameter borehole using either a hand auger or a powered auger. The powered auger was used initially, but it soon became apparent that a hand auger worked just as well, and was less cumbersome. The holes were bored as deeply as possible. Groundwater was usually encountered within several feet of the ground surface. Most of the soils encountered were sandy once below the water table, and the boreholes often became unstable and would not stay open. Once the hole had been bored as deeply as possible, the piezometer was placed in the hole and then driven as deeply as possible using a hammer drill or hand maul.

Given the relatively large amount of equipment needed to install the piezometers, locations were generally limited to areas of available access. In most cases, the piezometers were installed within 20 feet of surface water. We attempted to install all piezometers within the designated habitat monitoring area. In some cases this was not possible, either because sufficient access was not available for the equipment or because depth-to-water at the accessible locations would have been too great. At these locations, we installed the piezometers as close as possible to the habitat polygons given the access and depth-to-water restrictions. Based on conditions observed in the field, the water levels in piezometers near the designated habitat polygons are likely hydrologically similar to those beneath the habitat.

Data Collection

A pressure transducer combined with a data logger (mini-Troll Standard-P, 5psi, manufactured by In-Situ Corporation) was installed in each of the piezometers. These devices measure and record pressure from the water column present in the well, and these pressure measurements are then converted into water levels (in distance below the top of casing). Vented cables with data-transfer ports were also used for each data logger. With these cables there is no need to correct measurements for atmospheric pressure changes, and the data can be downloaded at the wellhead without disturbing the pressure transducer in the well. Each piezometer was downloaded approximately three times per year. At each download we checked the battery level and function of the data logger. Batteries were replaced as necessary, and data were examined to detect potential equipment malfunction.

After we placed the pressure transducers at their desired depth, we measured water levels in the piezometers using an electric water level sounder (Solinst-brand). These known water levels were then used to program the pressure transducer with a baseline measurement from which all other water levels were calculated. The pressure transducers recorded water levels in the piezometers every hour.

Because the pressure transducer is almost the same diameter as the inside of the piezometer, inserting the pressure transducers tends to change the water levels in the piezometer temporarily but drastically. This disturbance cannot be corrected until the water levels in the piezometer come back into equilibrium with water levels in the aquifer. Because some of the data loggers were in tight, clayey soils, in many cases we declined to wait until this equilibrium occurred, which could take hours or days. Instead, we planned to reprogram the piezometers upon the next field visit. This was done with the understanding that (1) the resulting data (discussed in the next section) would still be valid in terms of precision and ability to monitor water level fluctuations, but simply had an offset from the actual water level, and (2) the first several days of data might show the recovery from the disturbance and would not accurately reflect aquifer water level trends. In this document, this phenomenon will be referred to as "install offset error."

We obtained additional hydrologic data from the U.S. Geological Survey (USGS) regarding streamflow and stage height in the Colorado River at two gages: Colorado River below Parker Dam (09427520) and Colorado River below Imperial Dam (09429500). Lake water levels were also obtained from the USGS for Lake Havasu. In addition, daily water releases were obtained from the Bureau of Reclamation for Parker Dam.[10] Our goal was to define the relationship between the water levels in the piezometers and operation of the reservoirs on the Colorado River.

Data Validation

We identified several sources of error in the water levels recorded by the piezometers. We developed a rigorous protocol to validate each data download, determine if any errors existed with the data, and correct the raw data if possible. We applied this validation protocol to all data obtained from the piezometers.

At each download, we compared the water level recorded by the piezometer with the manual measurement. We also checked the data logger parameters to determine whether the data logger was initialized properly. If a discrepancy >0.3 feet existed between the data logger and the manual measurement, and this discrepancy could not be accounted for and corrected by examining the setup parameters and applying an appropriate correction factor, the data were not used for analysis. Specific sources of error are identified below.

Install Drift. Because piezometers are constructed such that the pressure transducer is almost the same diameter as the inside of the piezometer, removing and re-inserting the pressure transducers to change batteries can change the water levels in the piezometer temporarily but drastically. This type of error was first recognized in the data following initial piezometer installation and occurred with increasing frequency as aging equipment needed new batteries at each download. In cases of install drift, a correction factor was applied to all data for the entire duration between downloads. The correction factor was usually calculated as the difference between the manual measurement at the end of the download period and the last data logger measurement of the download period. In situations, such as battery failure, where data were lost at the end of the download period, the correction factor was the difference between the manual measurement at the beginning of the download period and the first data logger measurement of the download period.

[10] Because hydrologic data are generally collected and presented in English units, hydrologic data within this chapter are in English, rather than metric, units.

Improper Setup. After each data download, the data loggers were reset for the next round of measurements. Conducting the startup procedure improperly can lead to errors; fortunately, most of these setup errors can be corrected. Common errors include mistakenly setting the type of reference used (i.e., recording water level elevation instead of depth), not resetting the starting water level reference value to the water level value measured manually in the field, and not restarting the data logger but continuing with the previous setup. In these cases, the correction factor applied to the data could either be a conversion from an absolute benchmark or water level elevation to a depth-to-water measurement, or simply a correction to bring the initial data logger measurement back to the initial manual measurement. In some cases, if no error was observed between manual and data logger measurements, no correction was needed even if the data logger was improperly set up.

Operational Drift. In rare cases, the accuracy of the data loggers can change in the time period between downloads. This type of error is typically indicated only if no other likely cause can be identified, such as install drift or improper setup. Identifying this error involved fully evaluating the field data logs and even interviewing the field technician collecting the data. After fully vetting this information, if operational drift was thought to occur, the data were incrementally adjusted so that they matched both the beginning and ending manual measurements.

Piezometer Removal

All piezometers at the 15 habitat monitoring sites were removed in 2010. The piezometer at Topock Marsh was left in place, in anticipation of monitoring water level changes associated with pumping water into the site in 2011 (see Chapter 9). After a final data download and manual measurement of water level, the data logger and download cable were removed from the well at each site. The 2-inch PVC well housing and ¾--inch PVC casing for the data logger were removed either fully or partially, depending on conditions. If possible, the two PVC pipes were pulled out of the ground. This was possible if the well was shallow, if sub-surface soil structure was not excessively compacted, and if there was no concrete foundation attached. Otherwise, sediment was cleared from the base of the well and a hacksaw was used to cut both pipes below ground level. The remaining pipe below ground surface was filled with surrounding sediments and left in place. Some wells had concrete foundations that had deteriorated over the years and were removed. If the pipes were cut to ground level and a foundation could not be removed or had not deteriorated, it was left in place and covered with surrounding sediments.

Data Analyses

Microclimate

The following values were calculated for all 15 habitat monitoring sites:

- Mean soil moisture from plot center to 2.0 m from plot center
- Mean maximum diurnal temperature
- Mean minimum nocturnal temperature
- Mean daily temperature range (diurnal maximum minus nocturnal minimum)
- Mean diurnal vapor pressure
- Mean nocturnal vapor pressure

The diurnal and nocturnal periods were determined from the daily sunrise and sunset times reported for the region by the National Weather Service.

Between-year Comparison of Microclimate Characteristics – We assigned all plots as a control site (above Parker Dam or below Imperial Dam) or as a test site (between Parker and Imperial). We used repeated measures linear mixed models to analyze between-year differences in humidity and soil moisture values within these two groups and to analyze the between-year differences among the test sites compared to the control sites. These analyses were restricted to 1 June–1 August. Models assumed an unstructured covariance, and analyses were conducted using Stata/IC 12.1 (StataCorp LP).

Comparison of Habitat Monitoring Sites to Topock Marsh – Values for each microclimate variable were calculated for all habitat monitoring sites combined and compared to the same variables for random locations within flycatcher territories at Topock Marsh (see Chapter 7). During each year in 2005–2008, these analyses were restricted to the dates during which microclimate data were collected both within territories at Topock and at habitat monitoring locations.

Effect of Latitude on Temperature and Humidity – Overall mean values for each microclimate variable were calculated for each habitat monitoring site for the period 1 June–31 July in years 2005–2008. Each variable was regressed against latitude, as expressed by the UTM Northing of the site centroid.

Vegetation

We used repeated measures linear mixed models to evaluate changes through time at control sites and at test sites for canopy height, canopy closure, percent woody ground cover, three categories of stem sizes for both live and dead stems, the percentage of each stem size category that consisted of live stems, the percentage of the basal area within the plot that consisted of native vegetation, live foliage density summed over all height intervals, dead foliage density summed over all height intervals, and the percentage of live foliage summed over all height intervals. We then used repeated measures linear mixed models to analyze the interaction between site (control vs. test) and time for these same variables. Models assumed unstructured covariance. These analyses and all descriptive statistics were produced using SPSS® Version 16.0 (SPSS Inc.) software. We excluded vertical foliage density measurements at 5 m from plot center from the analysis so as to have comparable data across years.

Soil Texture

We compared the percentages of sand, silt, and clay at the habitat monitoring sites to those within occupied flycatcher territories at Pahranagat, Mesquite, Mormon Mesa, Muddy River, and Topock Marsh multiple (see Chapter 7) using Mann-Whitney U tests. Analyses were completed using SPSS® Version 16.0 (SPSS Inc.) software.

Groundwater

We examined monthly water release data from below Parker Dam from 2000 to 2012 to determine whether there has been a decrease in water levels since the scheduled implementation in 2002 of the change in point of diversion from Imperial Dam to above Parker Dam.

Correlation of Piezometer Water Levels with Reservoir Operations – Groundwater fluctuations under potential flycatcher habitat are expected to be tied most closely to water level, or stage, rather than to the streamflow of the Colorado River. In 2005, we examined the relationship between streamflow and stage height (i.e., the rating curve) at the USGS gaging station below Parker Dam (Station 09427520) for data collected between 1983 and 2005. Although multiple-order polynomial regressions had the highest

correlation between streamflow and stage height, the linear regression had a good fit ($r^2 = 0.95$), and we correlated releases from Parker Dam directly with piezometer water levels without any additional manipulation of the data. For data collected in 2005–2010, we examined the following correlations: (1) correlation between average daily water levels measured at the Havasu NE and Blankenship Bend piezometers (control sites) with daily Lake Havasu water levels as measured at the USGS gage near Parker Dam (Station ID 09427500); (2) correlation of average daily water levels in each of the 11 test site piezometers between Parker and Imperial Dams (Ehrenberg, Three Fingers Lake, Cibola Lake, Walker Lake, Paradise, Hoge Ranch, Rattlesnake, Clear Lake, Ferguson Lake, Ferguson Wash, and Great Blue Heron) with average daily releases from Parker Dam; and (3) correlations of average daily water levels measured at the Mittry West and Gila Confluence North piezometers (control sites) with releases from Imperial Dam. Release data were obtained from Reclamation. To account for the travel time of river water from Parker or Imperial Dam downstream to the piezometer sites, we examined correlations with time lags varying from zero to four days.

Reclamation (2000) estimated the expected change in flow between Parker and Imperial Dams that would result from a 400,000 acre-foot reduction in releases from Parker Dam. We used the regression equations we developed from the correlations of each piezometer with releases from Parker Dam along with these expected changes in flow to predict the expected change in water level at each piezometer, given a 400,000 acre-foot reduction in releases from Parker Dam.

Correlation of Piezometer Water Levels with Soil Moisture – We computed Pearson's correlation coefficient and two-tailed *t*-tests to examine potential relationships between piezometer water level and soil moisture for each soil moisture sample location and for the average daily soil moisture for each site. The analysis for the site as a whole included all days on which there was a piezometer reading and on which all soil moisture locations within the site were sampled. These analyses were conducted using SPSS® Version 16.0 (SPSS Inc.) software.

Relationship Between Piezometer Water Levels and Humidity Measurements – In 2007, we consulted with the Departments of Statistics and Biostatistics at the University of Washington for assistance with the analysis of the relationship between piezometer levels and average daily absolute humidity. The analysis used a linear mixed effects model to model absolute humidity as a function of groundwater, adjusting for time and regional relative humidity.

Evapotranspiration Signature – A distinct daily change in water levels occurs due to removal of water from the shallow aquifer by vegetation. Typically, water levels are lowest in the afternoon, during and following times of peak water use by plants, and water levels are highest in the morning after the shallow aquifer has been able to recharge. For the purposes of this report, we refer to this daily fluctuation as the "evapotranspiration signature." Since the 1930s, various researchers have sought to use this daily fluctuation in groundwater levels to estimate the amount of water lost from the aquifer due to evapotranspiration. Various approaches have been tried, most under highly controlled field conditions (e.g., White 1932, Gatewood et al. 1950, Bowie and Kam 1968, Hays 2003). Several studies refer to this as the "transpiration-well" method.

The transpiration-well method is based on the premise that during the day, water is lost to evapotranspiration at a faster rate than it can be replenished by the hydrostatic pressure of the aquifer. This leads to a decline in the water table between the hours of approximately 6:00 a.m. and 5:00 p.m. The water table rises overnight as evapotranspiration decreases and recharge is greater than losses to vegetation. White (1932) reasoned that if water levels had no net rise or fall over the course of a day, then the net loss of water from the aquifer from evapotranspiration must equal the recharge rate. White assumed that the recharge rate was best estimated between the hours of midnight and 4:00 a.m., when very little, if any, evapotranspiration was occurring. If water levels were falling day to day, then

evapotranspiration must exceed recharge, and the evapotranspiration rate would equal the daily recharge rate, plus the amount of decline in day-to-day water levels. White used the following formula (see Figure 8.2):

$$q = y(24r \pm s)$$

Where:

q = the daily evaporation rate (in inches)

y = the specific yield of the soil (unitless)

r = the hourly recharge rate between midnight and 4:00 a.m. (in inches/hour)

s = H2-H1 = the difference in water levels on consecutive days (in inches). The value s is subtracted when water levels are rising and added when water levels are falling.

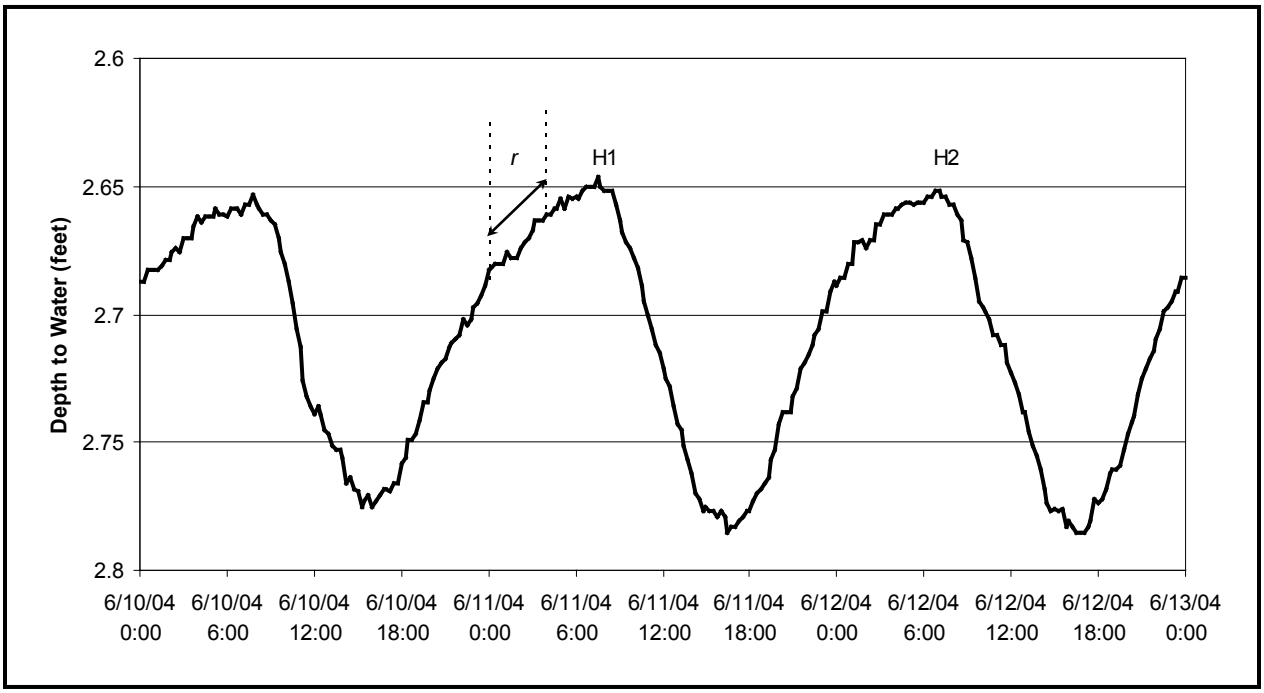

Figure 8.2. Typical daily fluctuation in groundwater levels as the result of evapotranspiration and recharge. H1 and H2 are the maximum water levels on consecutive days, while r is the recharge rate as calculated between midnight and 4 a.m.

The White formula is based on two fundamental assumptions about the shallow aquifer:

- The aquifer has a source of recharge. This source of recharge could be any surface water, either a river or a lake, or it could simply be the surrounding aquifer beyond the influence of the transpiring plants. Without some source of recharge, water levels would only decline and not rebound during the night.
- However, this source of recharge is not close or immediate enough to cause any changes in groundwater levels other than those due to evapotranspiration. Changes in overall water levels from day to day are considered to be indicative of evapotranspiration losses. If water levels rise or fall due to an outside influence (such as changes in river water levels), the calculation of evapotranspiration is rendered invalid.

We used the White formula to calculate evapotranspiration signature, with the following modifications:

- The White formula includes a term for specific yield of the soil. This term allows conversion from water level changes as observed in a piezometer to water level changes as occurring in the actual soil pore space of the aquifer. Because we are only interested in relative changes between years as a method of estimating vegetation health, we dropped the specific yield term from the White formula. Because of this, our calculations of the "evapotranspiration signature" are not directly equivalent to volumetric water loss.
- White did not specify a method for calculating daily water level changes. We used the maximum daily water level for each day, instead of using the water level at any set hour. This is advantageous because the time of highest water level changes somewhat throughout the season with changing day length.

Because evapotranspiration is strongest during the summer months and diminishes over the winter, only the months of May–September were used for this analysis. The evapotranspiration signature reflects changes on an hourly basis, and as such is highly localized, reflecting water use by plants only in the immediate vicinity of the piezometer. The evapotranspiration signature attenuates in the aquifer the farther it is from vegetation. Therefore, we limited the evapotranspiration analysis to sites where piezometers were located within the riparian vegetation surveyed for flycatchers (Topock Marsh, Blankenship Bend, Havasu NE, Ehrenburg, Cibola Lake, Paradise, Hoge Ranch, Clear Lake, Ferguson Lake, and Ferguson Wash).

The intent of the evapotranspiration analysis was to assess whether changes in the evapotranspiration signature over time could be used as a proxy to detect changes in vegetation density or vegetation cover resulting from changes in river level. Evapotranspiration is affected by other parameters besides vegetation density, including temperature, humidity, groundwater level, solar radiation, and wind. To be effective as a proxy for vegetation density, concurrent changes in these other parameters must be taken into account. As such, we first examined the correlation between the evapotranspiration signature as calculated from the modified White formula and mean diurnal temperature and mean daily water level in the piezometers.

RESULTS

Microclimate

Temperature/humidity Logger Operation

All 60 logger locations selected in 2005 were retained in 2006. Two additional data loggers were installed at Topock Marsh in August 2006. A portion of Gila Confluence North, one of the control sites below Imperial Dam, burned in December 2006. As a result of the fire, all vegetation at one HOBO location at the site was killed, and vegetation at another HOBO location was dramatically reduced. These two HOBOs were replaced in May 2007 with HOBOs at new locations within unburned portions of the site. All five HOBO locations at Three Fingers Lake burned in late August of 2011, and no monitoring was completed at Three Fingers Lake after the fire. All HOBO loggers were removed at the end of the 2012 field season.

All HOBO loggers were downloaded two or three times per year. Gaps in the temperature and humidity data (Table 8.1) occurred for several reasons: (1) loggers sometimes failed to launch or could not be downloaded; (2) we did not use data from any logger that had fallen to the ground since the previous download; and (3) loggers sometimes developed faulty humidity sensors but had useable temperature data.

Table 8.1. Summary of Temperature/humidity Data Logger Operation at Habitat Monitoring Sites, Lower Colorado River, 2005–2012

Site	Location number	Height (m)	Dates of operation	Data breaks[1]
Topock Marsh	1	2.8	8/29/06–8/1/12	none
	2	2.8	8/29/06–8/1/12	5/16–8/1/12 (RH)
Blankenship Bend	1	4.4	5/19/05–7/31/12	3/13–5/18/06, 3/29–5/12/07, 8/3/07–5/15/08, 7/3–7/24/08, 12/13/08–5/19/09, 7/29/09–8/5/10, 5/22–6/5/12 (RH)
Blankenship Bend	2	1.9	5/18/05–7/31/12	none
	3	3.3	5/22/05–7/31/12	7/24/08–5/19/09, 7/29/09–5/24/10, 5/22/11–7/31/12
	4	3.1	5/22/05–7/31/12	3/13–5/18/06, 6/22–3/29/07 (RH), 3/29–5/12/07, 5/12–6/7/07 (RH), 8/27–10/3/09, 7/31/11–5/22/12 (RH)
Havasu NE	1	3.5	5/19/05–8/1/12	5/18–7/17/08
	2	1.3	5/19/05–8/1/12	none
	3	2.3	5/19/05–7/31/12	8/5/10–5/28/11
	4	2.5	5/19/05–7/31/12	7/24/07–2/26/08
Ehrenberg	1	3.5	5/20/05–7/30/12	7/27/09–6/10/10, 5/13–7/25/11, 7/31/11–5/14/12
	2	4.8	5/20/05–7/30/12	2/15–5/16/07, 7/25/08–5/10/09, 7/27/09–6/10/10
	3	1.4	5/20/05–7/30/12	7/25/08–5/10/09, 7/28/10–5/14/12 (RH)
	4	3.1	5/23/05–7/30/12	7/28–12/12/05, 5/10–7/27/09
Three Fingers Lake	1	3.2	5/12/05–8/28/11	7/30/06–2/15/07 (RH), 2/25/08–5/17/08, 6/19–8/28/11
	2	3.2	5/12/05–8/28/11	7/25–8/28/11
	3	2.1	5/23/05–8/28/11	12/12/05–5/31/06, 2/15–5/23/07, 7/27/08–5/15/09, 7/27/10–6/19/11 (RH), 6/19–8/28/11
	4	1.3	5/12/05–8/28/11	7/27/08–5/15/09, 7/29/09–7/27/10 (RH), 6/19–8/28/11
	5	1.6	5/23/05–8/28/11	2/15–5/19/07, 6/19–8/28/11
Cibola Lake	1	5.0	5/10/05–7/29/12	7/30/05–6/1/06, 7/28/06–2/16/07, 2/25/08–5/20/08, 7/28/10-5/26/11, 5/26–7/25/11 (RH), 7/25/11–5/29/12
	2	3.2	5/10/05–7/29/12	7/28/06–2/16/07, 2/25/08–5/20/08, 7/25/11–5/29/12 (RH)
	3	2.7	5/10/05–7/29/12	12/12/05–6/1/06, 7/28/06–5/18/07, 7/26/08–5/12/09, 7/21–7/28/10, 5/26–7/25/11, 7/25/11–5/29/12 (RH)
	4	1.8	5/10/05–7/29/12	none
	5	4.6	5/11/05–7/29/12	12/12/05–6/1/06, 2/25/08–5/16/08, 7/25/11–5/29/12 (RH)

Table 8.1. Summary of Temperature/humidity Data Logger Operation at Habitat Monitoring Sites, Lower Colorado River, 2005–2012 (Continued)

Site	Location number	Height (m)	Dates of operation	Data breaks[1]
Walker Lake	1	2.0	6/2/05–present[2]	5/19–7/27/07, 7/29/10-6/15/11 (RH), after 5/20/12
	2	3.0	6/6/05–present[2]	3/13/06–2/15/07, after 5/20/12
	3	2.0	6/2/05–present[2]	6/2–7/25/05, 3/13/06–7/27/06, 11/17/06–7/27/07, after 5/20/12
Paradise	1	3.5	5/17/05–7/26/12	7/27–12/15/05, 7/29/06–2/22/07, 7/30/07–5/27/08
	2	1.5	5/17/05–7/26/12	5/16–7/26/12 (RH)
	3	2.5	5/17/05–7/26/12	7/29/06–2/22/07, 2/21/08–5/27/08, 8/2/10–5/18/11
	4	1.1	5/20/05–7/26/12	none
Hoge Ranch	1	2.1	6/1/05–7/26/12	5/17–7/27/07
	2	3.4	6/1/05–7/26/12	5/17/07–5/31/08, 8/3/10–5/21/11, 7/17–7/26/12
	3	3.0	5/18/05–7/26/12	5/22–7/29/06, 5/17–7/27/07, 2/21/08–5/31/08, 8/3/10–6/2/11, 7/19/11–5/30/12
	4	1.8	6/7/05–7/26/12	2/22–5/16/07
Rattlesnake	1	2.8	5/11/05–7/27/12	5/15–7/26/07
	2	2.4	5/20/05–7/27/12	3/16–5/16/06, 5/15–7/26/07, 7/29/08–9/30/09 (RH)
	3	2.0	5/25/05–7/27/12	4/17–5/15/07 (RH), 5/15–7/26/07, 6/8–8/3/10
	4	2.1	6/15/05–7/27/12	3/15–5/16/06, 5/15–7/26/07
Clear Lake	1	3.0	4/22/05–7/28/12	7/29/06–2/23/07, 4/12–5/21/07, 7/26/11–6/1/12 (RH)
	2	4.7	5/10/05–7/28/12	6/1–7/28/12
	3	1.6	5/10/05–7/28/12	none
Ferguson Lake	1	3.2	5/8/05–7/27/12	none
	2	4.0	5/9/05–7/27/12	5/29–8/1/08
	3	1.6	5/9/05–7/27/12	none
	4	2.5	5/9/05–7/27/12	7/22/06–5/18/07 (RH), 6/20–7/2/10
	5	3.1	5/9/05–7/27/12	5/18–7/28/07, 8/1/08–9/30/09 (RH), 7/31/10–7/27/11 (RH)
Ferguson Wash	1	2.5	4/21/05–7/28/12	5/8–7/28/07, 5/22–7/31/10, 7/27/11–5/19/12
	2	1.5	4/22/05–7/28/12	7/25/06–7/28/07, 5/29–8/1/08
	3	2.0	4/22/05–7/28/12	2/21–5/18/07, 7/28/07–5/29/08
	4	3.5	4/22/05–7/28/12	5/8–5/18/07, 2/20/08–5/29/08
Great Blue Heron	1	1.0	4/19/05–7/25/12	none
	2	3.5	4/19/05–7/25/12	none
	3	3.5	4/19/05–7/25/12	8/4/10–5/18/12 (RH), 5/18–7/17/12
	4	2.0	4/19/05–7/25/12	7/21/06–5/7/07 (RH), 7/16–7/25/12

Table 8.1. Summary of Temperature/humidity Data Logger Operation at Habitat Monitoring Sites, Lower Colorado River, 2005–2012 (Continued)

Site	Location number	Height (m)	Dates of operation	Data breaks[1]
Mittry West	1	1.5	4/21/05–8/2/12	5/6–5/15/07
	2	2.5	4/21/05–8/2/12	5/6–5/15/07
	3	3.5	4/21/05–8/2/12	5/21–7/20/06, 5/6–5/15/07
	4	3.0	4/21/05–8/2/12	5/6–5/15/07, 7/31/08–5/29/09, 5/29–7/31/09 (RH), 7/31–10/9/09
Gila Confluence North	1	3.0	4/20/05–12/3/06	7/28–12/3/06
	2	3.0	4/20/05–8/1/12	7/19/07–2/19/08, 7/31/08–5/30/09, 7/18/11–5/17/12
	3	3.0	4/20/05–12/3/06	none
	4	1.6	5/10/07–8/1/12	7/30–8/4/10, 7/13–8/1/12
	5	2.7	5/10/07–8/1/12	5/10–7/19/07, 7/31/08–5/30/09, 6/3–6/17/10

[1] RH = gap in humidity data only

[2] Site inaccessible in July 2012; logger not removed

Between-year Comparisons of Microclimate Characteristics

All microclimate characteristics varied significantly over time at test sites (Ehrenberg, Three Fingers Lake, Cibola Lake, Walker Lake, Paradise, Hoge Ranch, Rattlesnake, Clear Lake, Ferguson Lake, Ferguson Wash, and Great Blue Heron; Table 8.2). At control sites (Blankenship Bend, Havasu NE, Mittry West, and Gila Confluence North), mean minimum nocturnal temperature varied significantly over time, along with measures of soil moisture and humidity. Neither test nor control sites showed a unidirectional change in any of the microclimate measures in 2005–2012 (Figures 8.3a-8.3f). The changes over time differed between test and control sites only for soil moisture (right-most column of Table 8.2). Soil moisture fluctuated among years at both test and control sites, but the patterns did not mirror one another (Figure 8.3a). Between 2005 and 2006, soil moisture decreased more dramatically at control sites than at test sites, whereas the reverse was true between 2009 and 2010. Between 2011 and 2012, soil moisture rose at test sites but declined at control sites.

Comparison of Habitat Monitoring Sites to Topock Marsh

Habitat monitoring sites differed from occupied territories at Topock Marsh in having lower soil moisture, higher maximum daily temperature, higher minimum nocturnal temperature, larger daily temperature range, and lower diurnal and nocturnal vapor pressure (Table 8.3).

Effect of Latitude on Temperature and Humidity

Latitude had no significant linear relationship with any temperature variables (Table 8.4). Humidity appeared to be weakly related to latitude, with lower humidity at higher latitudes. This relationship was driven largely by the relatively low humidity recorded at Blankenship Bend and Havasu NE, which are considerably farther north than any of the other habitat monitoring sites. When these sites were removed from the analysis, humidity was no longer significantly related to latitude.

Table 8.2. Change in Microclimatic Variables at Habitat Monitoring Sites from 2005 to 2012*

Descriptive Statistics	Test (n = 45)									Control (n = 15)									*P*-value for difference between years among test sites compared to control sites
	2005	2006	2007	2008	2009	2010	2011	2012	*P*-value for the difference between years	2005	2006	2007	2008	2009	2010	2011	2012	*P*-value for the difference between years	
Soil Moisture																			
Mean soil moisture (mV)	634.2 (16.5)	628.4 (17.5)	677.5 (16.0)	706.1 (19.4)	796.9 (16.6)	623.0 (20.7)	709.0 (25.4)	745.1 (19.4)	<0.001	707.9 (31.8)	568.5 (39.1)	618.7 (37.1)	632.1 (42.8)	774.3 (41.1)	689.9 (35.6)	750.9 (60.8)	721.5 (40.9)	<0.001	<0.001
Temperature																			
Mean maximum diurnal temperature (°C)	45.0 (0.1)	46.2 (0.1)	45.7 (0.2)	46.5 (0.1)	44.1 (0.1)	45.3 (0.1)	44.0 (0.1)	43.9 (0.1)	<0.001	45.6 (0.2)	48.0 (0.2)	46.8 (0.2)	45.7 (0.2)	44.4 (0.2)	46.2 (0.2)	45.0 (0.2)	44.2 (0.2)	0.014	0.441
Mean minimum nocturnal temperature (°C)	20.6 (0.1)	22.7 (0.1)	19.9 (0.1)	20.7 (0.1)	21.2 (0.1)	20.5 (0.1)	20.3 (0.1)	20.7 (0.1)	<0.001	20.2 (0.2)	22.4 (0.1)	19.8 (0.2)	20.8 (0.2)	21.2 (0.1)	21.0 (0.2)	20.3 (0.2)	20.5 (0.1)	<0.001	0.572
Mean daily temperature range (°C)	24.4 (0.2)	23.5 (0.2)	25.8 (0.2)	25.8 (0.2)	22.9 (0.1)	24.8 (0.2)	24.1 (0.1)	23.2 (0.2)	<0.001	25.4 (0.2)	25.6 (0.3)	27.0 (0.3)	24.9 (0.3)	23.2 (0.2)	25.3 (0.3)	24.8 (0.3)	23.7 (0.3)	0.021	0.516
Humidity																			
Mean diurnal vapor pressure (Pa)	1798.8 (13.1)	2031.9 (13.5)	1607.4 (14.9)	1770.9 (12.8)	1744.2 (13.0)	1593.0 (12.4)	1673.6 (14.7)	1673.6 (15.4)	<0.001	1727.1 (20.4)	1957.4 (20.7)	1601.1 (19.7)	1691.6 (20.6)	1718.4 (18.4)	1589.4 (17.3)	1578.4 (21.8)	1632.2 (22.3)	<0.001	0.812
Mean nocturnal vapor pressure (Pa)	1688.5 (11.3)	1861.4 (10.6)	1530.6 (12.4)	1679.6 (10.3)	1617.0 (10.2)	1494.4 (10.3)	1557.1 (12.7)	1553.7 (13.0)	<0.001	1638.9 (17.6)	1748.3 (18.2)	1463.4 (18.3)	1581.9 (18.5)	1591.6 (16.5)	1488.1 (15.8)	1489.7 (19.2)	1555.4 (19.5)	<0.001	0.690

*Data are presented as means (standard error). The analysis was restricted to 1 June–1 August each year.

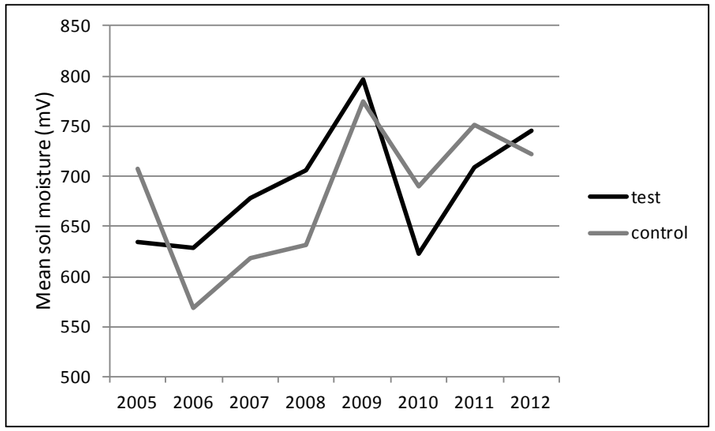

Figure 8.3a. Mean soil moisture at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

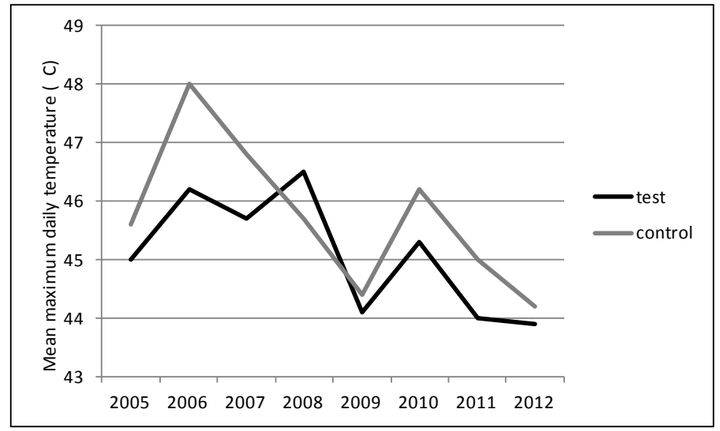

Figure 8.3b. Mean maximum daily temperature at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

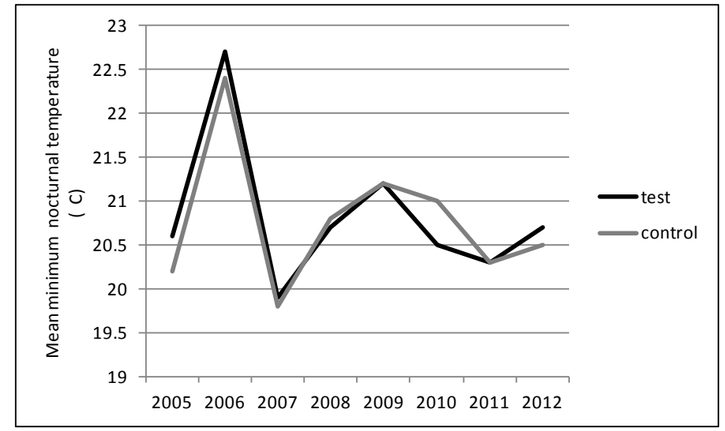

Figure 8.3c. Mean minimum nocturnal temperature at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

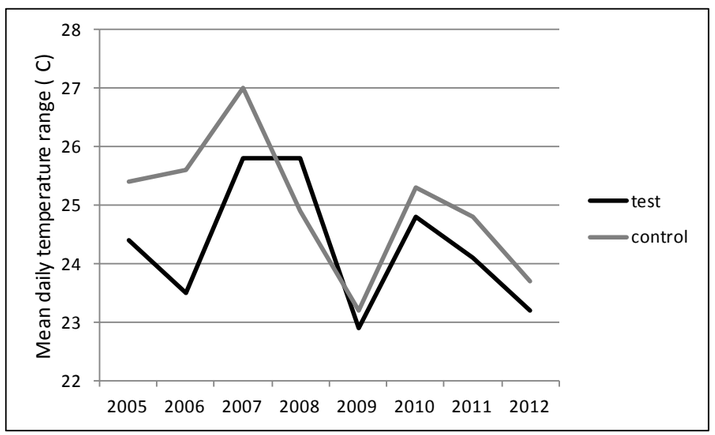

Figure 8.3d. Mean daily *temperature range at test and control habitat monitoring sites, lower Colorado River, 2005–2012.*

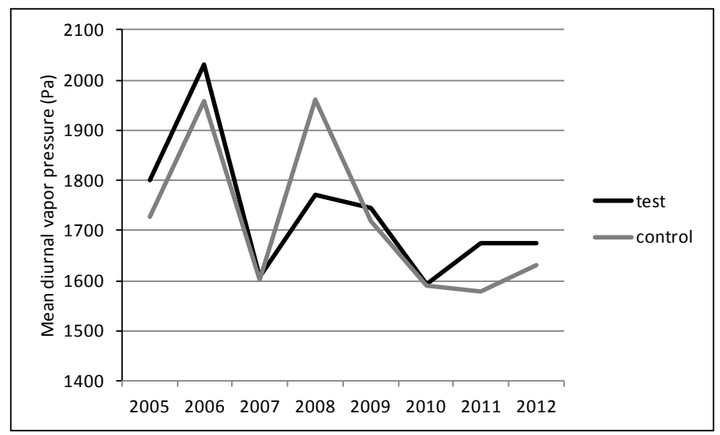

Figure 8.3e. Mean diurnal vapor pressure at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

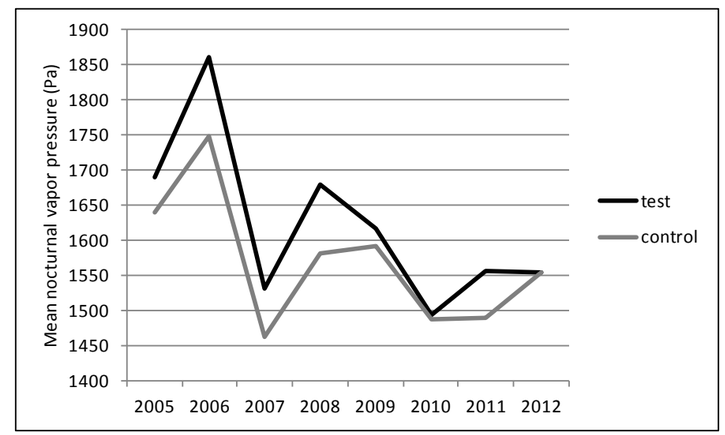

Figure 8.3f. Mean nocturnal vapor pressure at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

Table 8.3. Comparison of Microclimatic Variables at Habitat Monitoring Sites to Territories at Topock Marsh, 2005–2008*

Descriptive Statistics	Habitat Monitoring Sites	Topock Marsh	*P*
Soil Moisture			
Mean soil moisture (mV)	656.7 (7.8)	807.4 (19.6)	<0.001
Temperature			
Mean maximum diurnal temperature (°C)	46.0 (0.1)	40.3 (0.1)	<0.001
Mean minimum nocturnal temperature (°C)	21.0 (0.0)	19.6 (0.1)	<0.001
Mean daily temperature range (°C)	25.0 (0.1)	20.7 (0.2)	<0.001
Humidity			
Mean diurnal vapor pressure (Pa)	1797.1 (5.8)	2367.2 (20.3)	<0.001
Mean nocturnal vapor pressure (Pa)	1677.6 (4.8)	2014.2 (16.2)	<0.001

* Data are presented as means (standard error). The analysis was restricted to 1 June–1 August each year.

Table 8.4. Summary of Temperature (T) and Vapor Pressure (VP) at Habitat Monitoring Sites, 1 June–31 July, 2005–2008*

Site	UTM Northing	Mean max diurnal T (°C)	Mean min diurnal T (°C)	Mean daily T range (°C)	Diurnal VP (Pa)	Nocturnal VP (Pa)
Blankenship Bend	3831571	47.07	20.29	26.79	1544.43	1519.16
Havasu NE	3824239	45.29	22.75	22.54	1674.12	1479.57
Ehrenberg	3715859	47.98	21.35	26.63	1492.98	1551.49
Three Fingers Lake	3682253	51.26	19.42	31.83	1425.40	1475.71
Cibola Lake	3680194	51.03	21.96	29.08	1379.17	1554.65
Walker Lake	3675951	45.59	20.60	24.99	1948.03	1746.28
Paradise	3666336	46.28	21.24	25.04	1784.58	1665.35
Hoge Ranch	3660346	46.43	20.68	25.75	1890.93	1734.42
Rattlesnake	3659614	38.98	19.56	19.42	2474.84	2099.15
Clear Lake	3657985	40.99	21.03	19.97	2135.71	1780.26
Great Blue Heron	3652424	42.24	20.05	22.19	2132.26	1891.67
Ferguson Lake	3651948	42.43	22.58	19.85	1976.90	1863.23
Ferguson Wash	3650544	46.13	22.53	23.61	1848.30	1552.85
Mittry West	3638678	45.12	20.53	24.60	1929.19	1726.42
Gila Confluence North	3623131	49.26	19.20	30.06	1870.11	1761.05
Linear regression *P*-value		0.592	0.364	0.823	0.082	0.031

Soil Texture

We analyzed 45 soil samples from the habitat monitoring sites. Soil samples at all sites consisted primarily of varying proportions of sand and silt, with very little clay (Figure 8.4). All soil particles were small enough to pass through the 4.75-mm sieve, and the water in all sedimentation samples was clear after 48 hours (and typically after 24 hours), indicating all soil particles were larger than 0.002 mm.

Soil texture at habitat monitoring sites (test and control) differed from that in occupied flycatcher territories (Pahranagat, Mesquite, Mormon Mesa, Muddy River, and Topock Marsh combined) in having a higher percentage of sand (Figure 8.5; U = 1837, $P = 0.038$). The percentages of silt and clay were not significantly different. Although habitat monitoring sites overall had a higher percentage of sand in the soil, soils at occupied territories had a wider range of composition than did those at habitat monitoring sites (Figure 8.5).

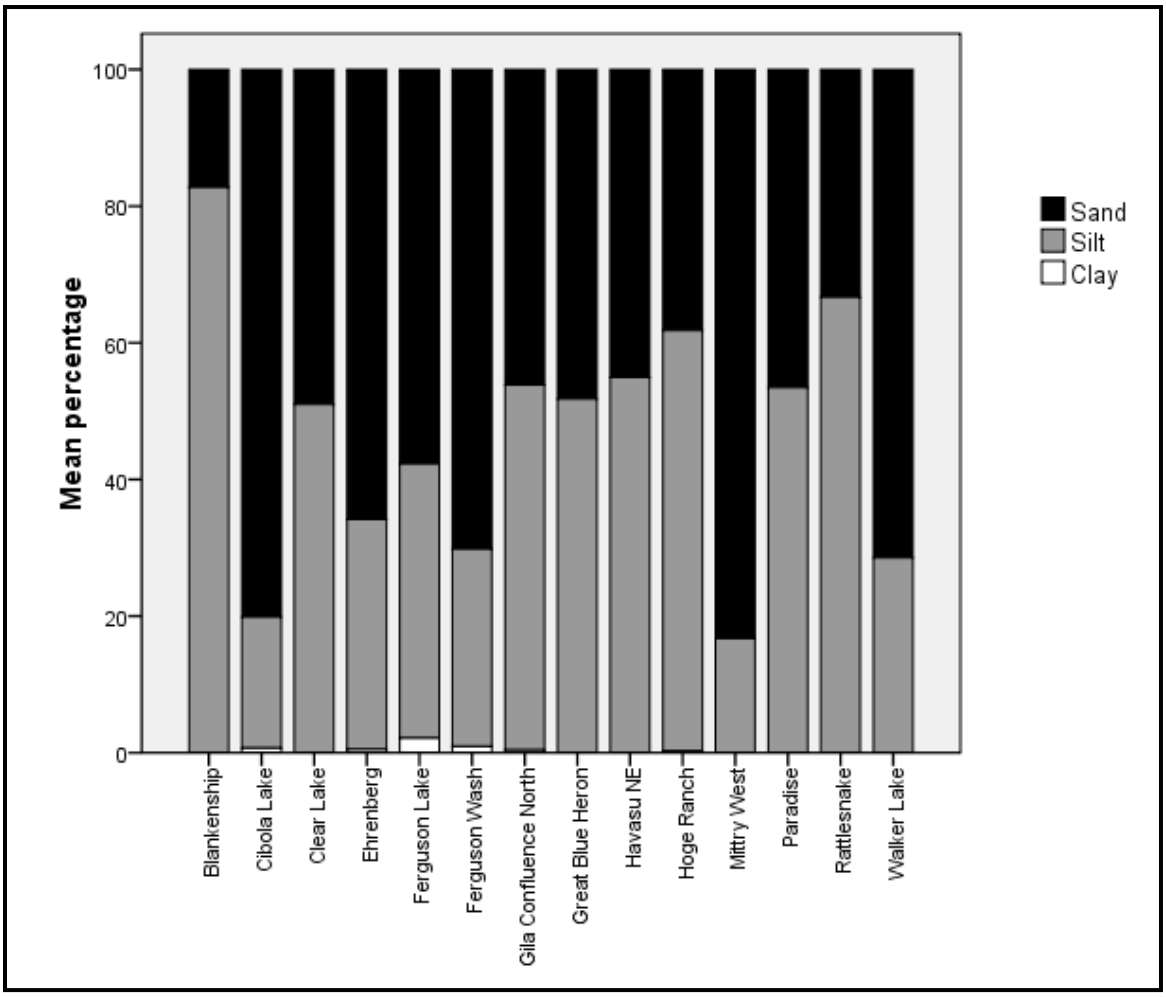

Figure 8.4. Mean percentage by volume of sand, silt, and clay in soil samples from habitat monitoring sites, 2005.

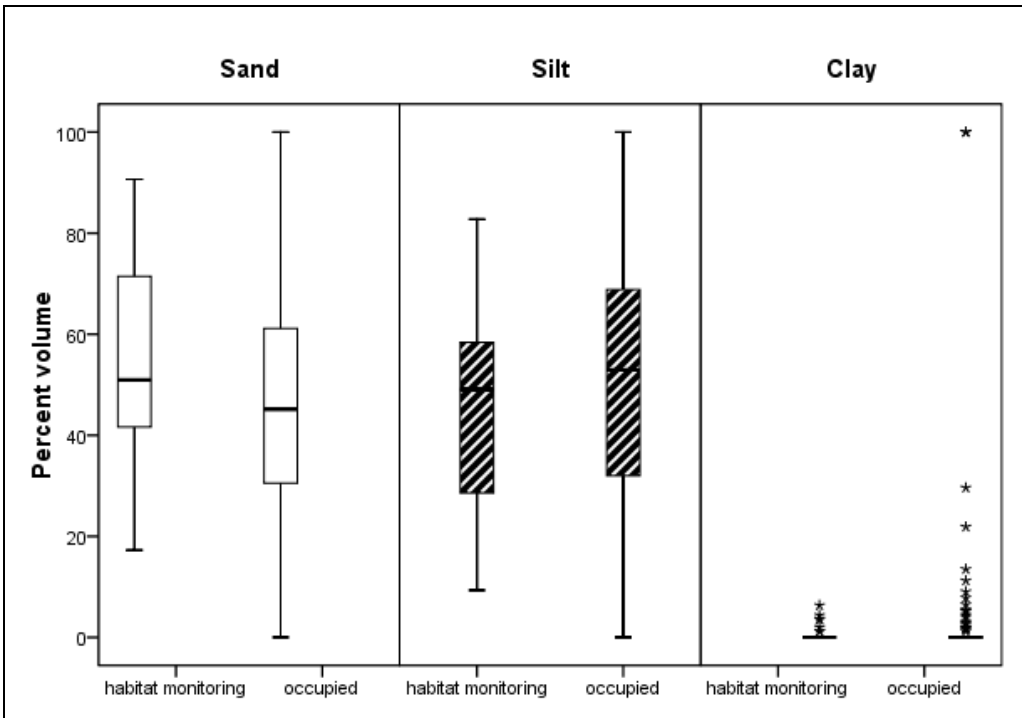

Figure 8.5. Box plots showing distribution of sand, silt, and clay in soil samples from habitat monitoring sites (test and control) and occupied flycatcher territories (Pahranagat, Mesquite, Mormon Mesa, Muddy River, and Topock Marsh combined).

Vegetation Measurements

Vegetation measurements were collected in every year from 2005 through 2012 at 47 of the 62 data logger locations. Data were collected only in 2005 and 2006 at the two locations in Gila Confluence North that were affected by a fire after the 2006 season. These two locations were replaced by new sampling points in 2007. No vegetation measurements were collected at 11 locations in 2012; all 5 points at Three Fingers Lake burned in 2011, the 3 points at Walker Lake were inaccessible because flash floods had washed out the road, and 2 points at Blankenship Bend and 1 point at Ferguson Lake were not sampled because inundated conditions hampered accurate stem counts. Counts for stems ≤2.5 cm dbh in 2012 were excluded from the analysis because field personnel did not follow the criteria for excluding stems ≤2.5 cm in diameter at 10 cm above the base of the stem.

Between-year Comparisons of Vegetation Characteristics

Most vegetation variables varied between years within the test and control groups (Table 8.5), but none of the variables exhibited change in a consistent direction over time (Figures 8.6a–8.6p). There was a significant interaction between year and location (meaning that the change between years among test sites was significantly different from the change at control sites) for woody ground cover ($P = 0.001$), number of live stems ≤2.5 cm dbh ($P = 0.043$), number of dead stems ≤2.5 cm dbh ($P = 0.040$), percent of live stems ≤2.5 cm dbh ($P = 0.022$), and dead vertical foliage hits ($P = 0.006$). Average woody ground cover increased at control plots between 2005 and 2006 and then decreased in 2007, while it did not change at test plots across those years. The number of live and dead stems ≤2.5 cm dbh and the percentage of live stems ≤2.5 cm dbh all showed considerable annual fluctuations, but none showed a consistent pattern (Figures 8.6d, 8.6g, and 8.6j). The amount of dead vertical foliage hits increased through time at both test and control plots, but peaked in 2010 at test plots but not at control plots (Figure 8.6o).

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Table 8.5. Annual Means (Standard Error) of Vegetation Characteristics at Plots between Parker and Imperial Dams (Test Sites) and Plots above Parker or below Imperial (Control Sites), 2005–2012, and Results of Linear Mixed Models

Parameter	Test (n = 45)									Control (n = 15)									*P*-value for difference in means between years among test sites compared to control sites
	2005	2006	2007	2008	2009	2010	2011	2012	*P*-value for the difference between years	2005	2006	2007	2008	2009	2010	2011	2012	*P*-value for the difference between years	
Average canopy height (m)	6.6 (0.6)	7.0 (0.7)	5.8 (0.5)	6.7 (0.6)	7.1 (0.7)	6.5 (0.6)	6.2 (0.5)	8.4 (0.9)	0.013	6.6 (0.6)	7.0 (0.7)	6.8 (0.5)	7.7 (0.9)	7.0 (0.6)	6.9 (0.5)	6.2 (0.8)	8.2 (1.0)	0.005	0.480
% total canopy closure	84.7 (2.7)	78.3 (2.5)	87.9 (1.8)	88.1 (2.2)	86.7 (2.1)	85.3 (3.0)	89.7 (2.5)	90.6 (3.0)	0.001	80.8 (3.9)	76.9 (3.3)	85.7 (3.1)	85.5 (3.8)	82.5 (3.6)	80.5 (4.3)	86.2 (3.4)	93.8 (2.5)	<0.001	0.077
% woody ground cover	31.1 (3.8)	27.3 (3.3)	30.0 (4.1)	41.6 (3.7)	23.5 (2.9)	35.6 (3.8)	48.7 (4.3)	33.7 (3.5)	<0.001	24.4 (6.8)	46.7 (7.8)	40.2 (7.3)	53.0 (6.9)	31.4 (7.5)	38.0 (4.7)	54.5 (6.3)	21.7 (4.5)	<0.001	**0.001**
# live stems ≤2.5 cm dbh per ha	1932 (338)	2272 (350)	2515 (285)	1358 (344)	2530 (438)	1316 (306)	671 (133)	--	<0.001	985 (281)	2574 (694)	1842 (472)	883 (196)	1210 (345)	1010 (263)	900 (332)	--	<0.001	**0.043**
# live stems 2.6–8 cm dbh per ha	3107 (404)	2722 (359)	3143 (287)	3899 (547)	2314 (263)	3271 (402)	3030 (399)	1825 (281)	<0.001	1655 (319)	2310 (515)	1918 (471)	2139 (461)	1401 (309)	1859 (394)	1986 (436)	1450 (401)	0.004	0.333
# live stems >8 cm dbh per ha	481 (98)	430 (72)	654 (93)	671 (108)	597 (93)	637 (90)	628 (91)	980 (118)	0.001	603 (143)	646 (171)	730 (135)	730 (123)	546 (121)	586 (167)	722 (144)	764 (149)	0.080	0.234
# dead stems ≤2.5 cm dbh per ha	340 (72)	1282 (318)	1259 (178)	1084 (252)	1949 (277)	1075 (240)	161 (38)	--	<0.001	1214 (470)	1492 (504)	1367 (251)	1384 (207)	1455 (454)	552 (167)	552 (237)	--	<0.001	**0.040**
# dead stems 2.6–8 cm dbh per ha	1234 (229)	821 (137)	925 (130)	1879 (303)	1081 (124)	1310 (225)	778 (179)	1132 (208)	0.011	1061 (459)	437 (147)	747 (169)	1392 (233)	609 (162)	475 (132)	526 (180)	1175 (288)	<0.001	0.224
# dead stems >8 cm dbh per ha	48 (24)	59 (18)	96 (32)	108 (40)	91 (27)	110 (33)	54 (24)	180 (44)	0.114	59 (35)	82 (54)	127 (83)	59 (30)	118 (62)	85 (37)	68 (27)	157 (61)	0.628	0.913
% live stems ≤2.5 cm dbh	81.7 (3.5)	66.1 (4.1)	66.3 (3.1)	61.0 (4.8)	52.4 (3.9)	57.2 (4.6)	75.2 (5.5)	--	<0.001	51.9 (10.5)	63.2 (9.1)	55.7 (7.1)	41.4 (7.2)	41.8 (8.7)	70.3 (8.5)	65.8 (9.6)	--	0.082	**0.022**
% live stems 2.6–8 cm dbh	72.8 (4.0)	74.6 (3.7)	77.1 (2.9)	68.3 (4.1)	66.1 (3.7)	69.1 (3.7)	77.8 (4.1)	58.7 (4.0)	0.002	70.8 (7.9)	79.2 (7.8)	70.2 (6.5)	58.6 (6.8)	64.6 (7.7)	79.5 (5.0)	76.0 (8.2)	52.4 (7.8)	<0.001	0.166
% live stems >8 cm dbh	92.8 (2.7)	84.6 (5.0)	87.7 (3.7)	91.8 (2.6)	89.0 (3.3)	88.4 (3.4)	96.0 (1.4)	85.8 (3.4)	0.024	90.8 (4.4)	89.1 (5.2)	89.4 (4.6)	89.9 (6.7)	81.9 (8.8)	84.5 (7.6)	86.0 (7.3)	79.1 (6.6)	0.150	0.588
Percent basal area native	27.2 (5.6)	20.3 (5.2)	28.9 (5.6)	23.8 (5.5)	21.6 (5.4)	22.1 (5.4)	24.1 (5.3)	25.7 (6.3)	0.152	42.7 (11.6)	52.8 (12.5)	59.9 (11.9)	46.9 (11.9)	45.0 (12.8)	57.9 (11.3)	51.4 (11.4)	42.1 (12.5)	0.384	0.054
Total live foliage hits	17.4 (2.1)	17.7 (2.6)	11.3 (0.9)	17.0 (1.9)	19.3 (2.5)	17.1 (1.6)	17.8 (2.2)	17.8 (2.4)	0.001	18.1 (2.2)	15.5 (2.1)	16.5 (2.6)	18.4 (2.8)	17.5 (2.2)	16.9 (1.9)	14.3 (2.4)	16.1 (2.5)	0.385	0.446
Total dead foliage hits	9.3 (0.9)	10.0 (2.4)	5.1 (0.6)	10.8 (1.1)	9.1 (0.7)	14.1 (1.0)	10.5 (0.9)	11.2 (1.0)	<0.001	8.4 (1.2)	6.6 (1.3)	6.1 (0.9)	11.0 (1.6)	6.3 (1.2)	8.5 (1.6)	9.2 (1.5)	11.5 (1.3)	0.005	**0.006**
Percent live foliage hits	62.7 (2.3)	62.0 (2.7)	65.8 (3.2)	58.7 (2.5)	63.8 (2.4)	56.1 (2.3)	59.3 (2.7)	57.3 (3.3)	0.011	69.1 (4.4)	70.0 (4.7)	69.6 (4.9)	64.8 (4.3)	72.9 (4.0)	67.6 (5.4)	58.7 (5.6)	55.0 (5.3)	0.036	0.239

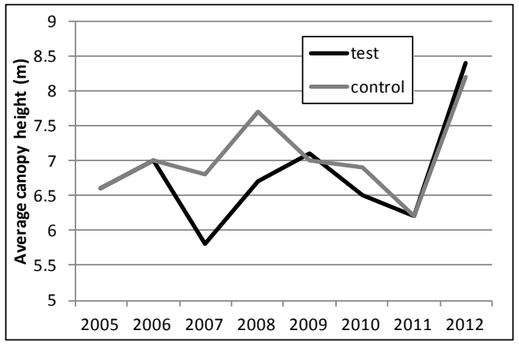

Figure 8.6a. Average canopy height at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

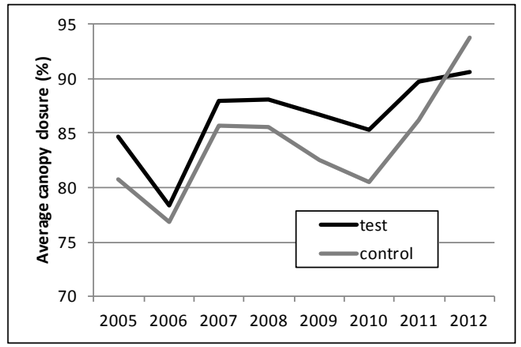

Figure 8.6b. Average canopy closure at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

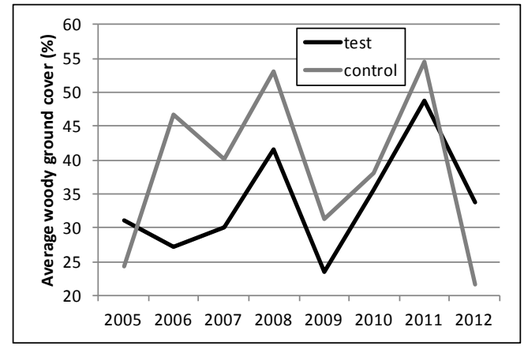

Figure 8.6c. Average percent woody ground cover at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

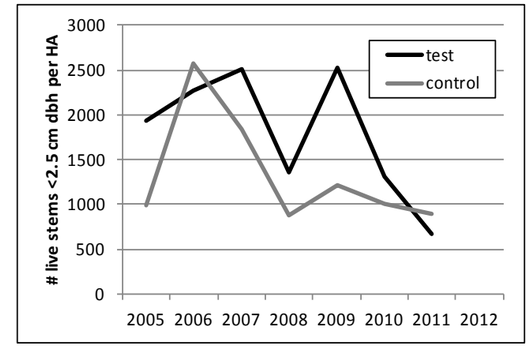

Figure 8.6d. Average number of live stems ≤2.5 cm dbh per hectare at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

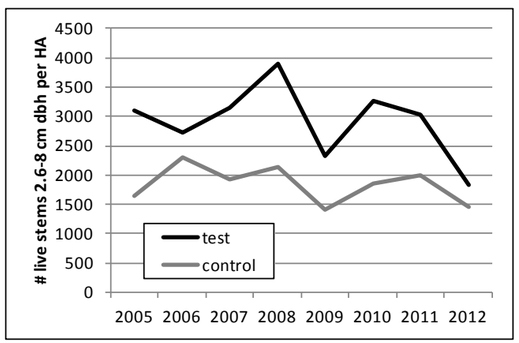

Figure 8.6e. Average number of live stems 2.6–8 cm dbh per hectare at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

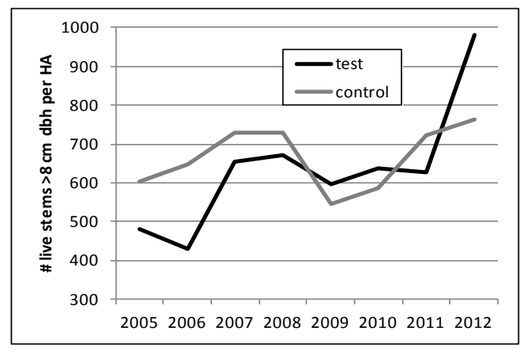

Figure 8.6f. Average number of live stems >8 cm dbh per hectare at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

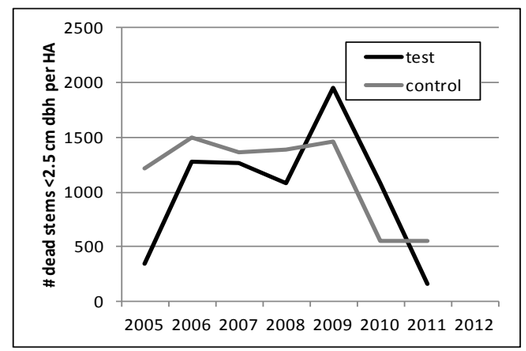

Figure 8.6g. Average number of dead stems ≤2.5 cm dbh per hectare at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

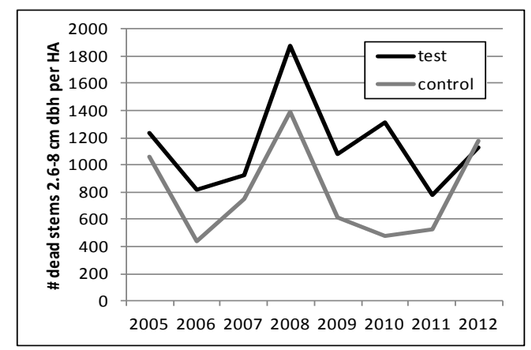

Figure 8.6h. Average number of dead stems 2.6–8 cm dbh per hectare at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

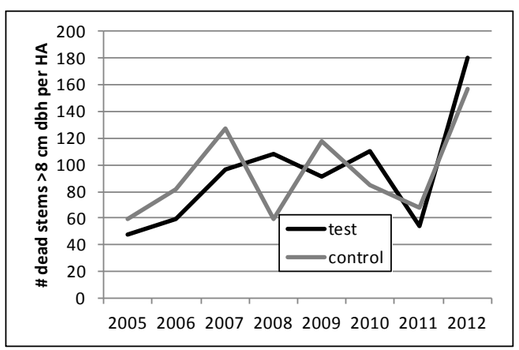

Figure 8.6i. Average number of dead stems >8 cm dbh per hectare at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

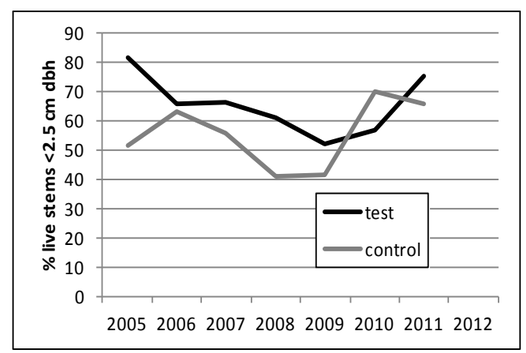

Figure 8.6j. Percent of stems ≤2.5 cm dbh that were live at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

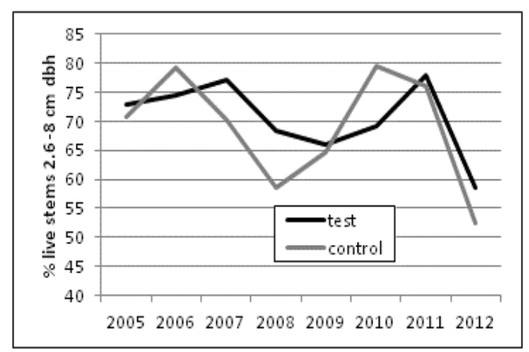

Figure 8.6k. Percent of stems 2.6–8 cm dbh that were live at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

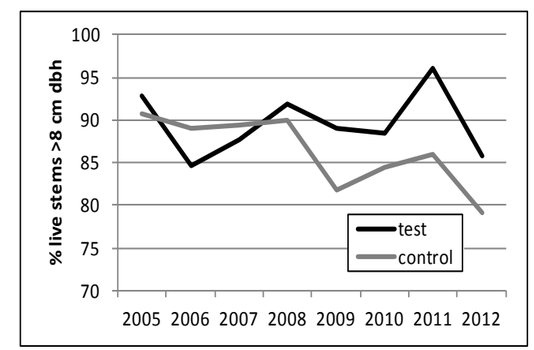

Figure 8.6l. Percent of stems >8 cm dbh that were live at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

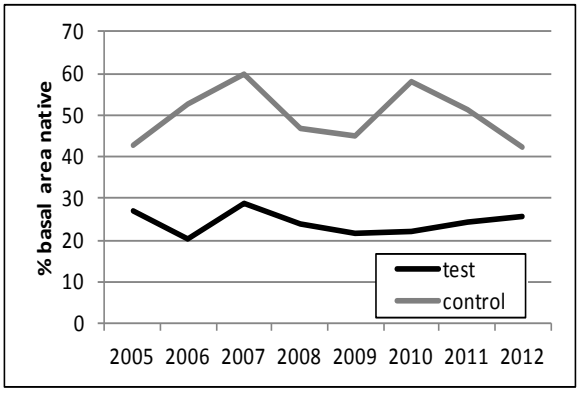

Figure 8.6m. Percent of basal area that consisted of native vegetation at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

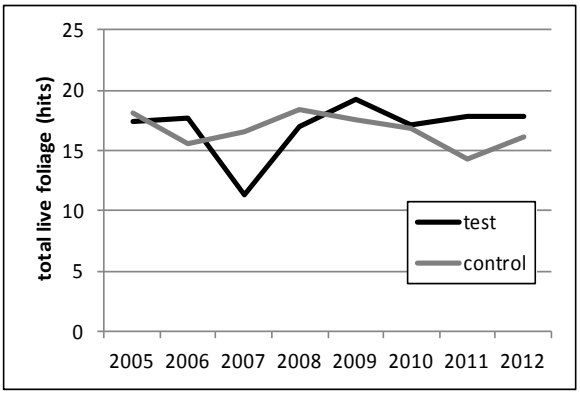

Figure 8.6n. Total live vertical foliage hits at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

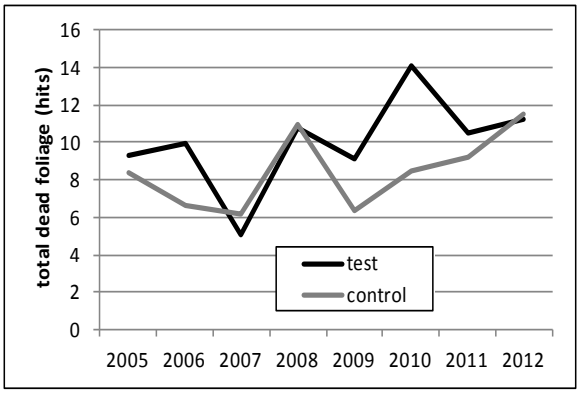

Figure 8.6o. Total dead vertical foliage hits at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

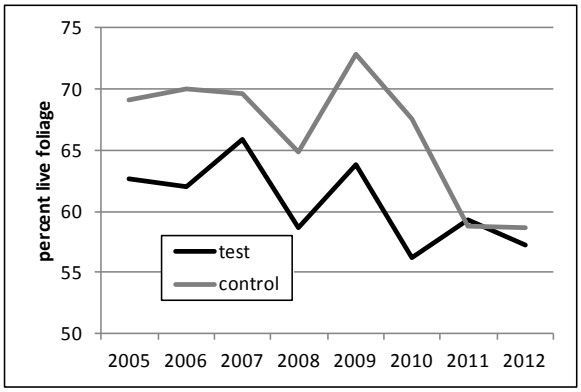

Figure 8.6p. Percent live vertical foliage hits at test and control habitat monitoring sites, lower Colorado River, 2005–2012.

Groundwater

Piezometer Operation

All piezometers at the habitat monitoring sites were installed in 2005 (Table 8.6). The piezometer at Topock Marsh was installed in 2006. Piezometers were installed within the site in 10 cases and as close as possible to the site in the remaining six instances (Table 8.6). A brush fire destroyed the aboveground portion of the piezometer at Gila Confluence North in December 2006. Data collection was unaffected by the fire, and the data were recovered in July 2007, at which time a replacement piezometer was installed approximately 150 m from of the original location. Upon arrival to the Cibola Lake piezometer in July 2007, we discovered that the area surrounding it had been cleared and bulldozed, and no trace of the piezometer could be found. A replacement piezometer was installed in March 2008. Many of the piezometers began to experience equipment malfunction and battery failure in 2008, and battery failure became a chronic problem with the originally installed equipment. Five of the malfunctioning units were replaced with In-Situ LevelTroll 500 pressure transducers. By 2010, the piezometers were experiencing widespread, chronic equipment failure and had fulfilled their original function of evaluating the relationship between river level and groundwater beneath the habitat monitoring sites (see below). In addition, piezometer data were not useful in relating groundwater levels to changes in humidity, soil moisture, or vegetation density (see below). Because the piezometers were experiencing widespread failure and were no longer providing useful data, they were removed in 2010.

Table 8.6. Summary of Piezometer Operation at Habitat Monitoring Sites, Lower Colorado River, 2005–2010*

Site	Depth (ft)	Stickup height (ft)	Dates of operation	Data breaks	Distance (ft) from habitat
Topock Marsh[1]	INA	2.5	8/13/06–present	8/27/07–2/27/08 6/24/08–3/5/09 11/10/10–2/28/11	Within
Blankenship Bend	7.2	3.4	8/28/05–6/2/10	After 8/12/07	Within
Havasu NE	6.1	2.2	5/9/05–6/2/10	12/26/07–2/26/08 1/9/09–3/5/09 After 10/9/09	Within
Ehrenberg	7.4	2.6	8/29/05–8/5/10	After 2/15/10	Within
Three Fingers Lake	7.7	4.1	5/31/05–8/5/10	After 3/3/09	540
Cibola Lake[2]	7.2 INA	3.4 3.6	5/30/05–2/15/07 3/27/08–8/5/10	9/29/05–12/12/05 2/15/07–3/3/09 After 9/29/09	Within
Walker Lake	7.4	2.9	5/30/05–8/5/10	11/8/08–3/3/09 After 7/12/10	230
Paradise[1]	11.7	0.6	5/11/05–8/4/10	5/7/06–6/12/06 8/3/07–8/29/07 9/15/07–2/21/08 3/5/08–9/29/09	Within

Table 8.6. Summary of Piezometer Operation at Habitat Monitoring Sites, Lower Colorado River, 2005–2010* (Continued)

Site	Depth (ft)	Stickup height (ft)	Dates of operation	Data breaks	Distance (ft) from habitat
Hoge Ranch[1]	8.7	2.8	5/11/05–8/4/10	6/12/06–9/15/06 After 9/10/07	Within
Rattlesnake	7.0	2.8	5/10/05–8/4/10	4/15/08–9/30/09 After 1/11/10	1,080
Clear Lake	8.7	2.4	5/10/05–8/4/10	4/17/08–9/30/09 After 10/20/09	Within
Ferguson Lake	7.6	2.7	5/10/05–8/4/10	4/7/08–9/3/08 9/15/08–9/30/09 After 12/13/09	Within
Ferguson Wash[1]	INA	2.2	5/10/05–8/4/10	After 1/24/08	Within
Great Blue Heron	7.3	1.7	5/31/05–8/4/10	8/30/05–12/15/05 7/28/08–9/3/08 After 1/31/09	60
Mittry West	5.0	3.0	8/29/05–8/4/10	12/8/08–3/3/09 After 5/30/09	270
Gila Confluence North[1,3]	7.9	2.7	8/29/05–7/5/07	7/6/08–10/15/08	50
	INA	4.7	7/5/07–8/4/10	After 11/27/08	

* INA = information not available.

[1] Original piezometer replaced with new model LevelTroll.

[2] Piezometer destroyed by clearing activity between February and July 2007; replaced 27 March 2008.

[3] Location of original piezometer burned in December 2006; piezometer replaced on 5 July 2007.

Data Validation

A total of 170 download periods were assessed using the data validation protocol. Of these, 117 download periods (69%) required no correction. An additional 31 download periods (18%) had identifiable errors, and a correction factor was applied to the data. Data from 22 download periods (13%) were unable to be validated, and the data were deemed unusable for analysis. Improper setup errors and/or equipment malfunction caused these 22 download periods to be unusable. Of the 31 download periods with correctable errors, 12 experienced install drift and 4 experienced operational drift. Fifteen download periods required corrections due to improper setup, primarily of reference points.

Overview of Piezometer Groundwater Levels

Daily and weekly cycles were apparent in the piezometer hydrographs. General daily trends included low water levels during the afternoon hours when vegetation water demands and evapotranspiration were greatest and high water levels in early morning hours. General weekly trends followed the changes in river water levels due to power generation and water delivery demands, with low levels on weekends and higher levels in the middle of the week.

In addition to daily and weekly cycles, a majority of the sites between Parker and Imperial Dams showed a seasonal pattern, with the lowest water levels occurring in December through February and highest water levels occurring in April (see hydrographs in Appendix I).

Parker Releases

Average monthly release data from Parker Dam from 2000 to 2012 (Table 8.7) show that between-year differences were not consistent among months. Overall, average yearly releases declined from 10,010 cfs in 2002 to 8,526 cfs in 2005 and then varied between 8,700 and 9,300 cfs in 2006–2011. Reservoir releases during the flycatcher breeding season of May–July showed a stronger decrease over time (Figure 8.7), declining from over 13,000 cfs in 2001 to 10,389 cfs in 2009, and then rising to between 11,000 and 12,000 cfs in 2010–2012. By the time monitoring began in 2005, summer releases had already dropped to <12,000 cfs.

Correlation of Piezometer Water Levels with Reservoir Operations

Lake Havasu Water Levels – There was a strong correlation (r = -0.99) between water levels in Lake Havasu and depth to groundwater as measured in the Havasu NE piezometer. The piezometer at Blankenship Bend was less strongly influenced by lake levels (r = -0.59).

Parker Dam Releases – The "best fit" time lag varied from two days for the upstream piezometers (Ehrenberg, Three Fingers Lake, Cibola Lake, Paradise, and Hoge Ranch) to three days for the downstream piezometers (Rattlesnake, Clear Lake, Ferguson Lake, Ferguson Wash, and Great Blue Heron). The best fit r statistics varied from -0.80 to -0.96 (Table 8.8). Piezometer levels at Walker Lake had no correlation (best fit r = 0.06) to releases from Parker Dam. Based on an annual reduction in releases from Parker Dam of 400,000 acre-feet, Reclamation (2000) predicted declines in average flow at Parker Dam of 1,200 cfs in April, 632 cfs in August, 274 cfs in December, and 552 cfs over the year. For the piezometers that showed a strong correlation with Parker releases, the corresponding expected decrease in average piezometer water level, as calculated from the best-fit regression, ranged from 0.25 to 0.42 feet in April, 0.13–0.22 feet in August, 0.06–0.09 feet in December, and 0.11–0.19 feet over the year (Table 8.9).

Imperial Dam Releases – Water levels in the piezometer at Mittry West showed no correlation with releases from Imperial Dam (r = -0.06 for all time lags). The best fit time lag at Gila Confluence North was one day, with r = -0.80.

Correlation of Piezometer Water Levels with Soil Moisture

Of the 61 sampling points with available data, 10 showed a strong correlation ($|r| > 0.5$ and $P < 0.05$) between average daily soil moisture and average daily piezometer water levels (Table 8.10). Of the 16 sites, only three (Blankenship Bend, Rattlesnake, and Ferguson Lake) showed an overall strong correlation between soil moisture and piezometer water level. All strong correlations were negative, as would be expected, indicating that high soil moisture levels occurred when depth to groundwater was shallow. Many of the strong correlations occurred at sampling points that became inundated when the water level in the corresponding piezometer was shallow.

Table 8.7. Average Monthly Releases (cfs) From Parker Dam, 2000–2012

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
January	6703	5459	6372	6145	5421	4108	6136	5945	4973	6171	3793	6366	6208
February	8874	8507	9074	6765	7266	4864	8036	8491	8444	7154	5968	7470	8632
March	11400	9738	11605	11838	11775	9953	10005	11117	12099	11967	10872	11281	11555
April	14177	13269	13742	13447	12624	11558	12186	12618	14090	13184	11265	13217	13185
May	13578	12857	12415	11539	11942	11267	12188	11718	11118	10530	10765	11241	11538
June	13280	13144	12660	12019	12412	11517	12268	12124	11618	9991	10931	11904	12078
July	13555	13228	13197	12049	11892	12218	12064	12180	11833	10646	12092	12393	
August	10903	10967	11389	9877	10636	9070	10341	10312	10335	9459	10508	10881	
September	10427	10031	9716	9619	8822	9243	9207	9319	8730	8487	9803	9038	
October	9161	8017	8138	8282	6832	7085	7425	7398	7359	7247	7562	7674	
November	7205	6713	6580	5651	4808	6363	6089	5639	6366	6130	7187	5387	
December	6640	5552	5235	5645	3855	5068	5428	4390	3836	4888	4713	4344	
Year average	**10492**	**9790**	**10010**	**9406**	**9024**	**8526**	**9281**	**9271**	**9233**	**8821**	**8788**	**9266**	

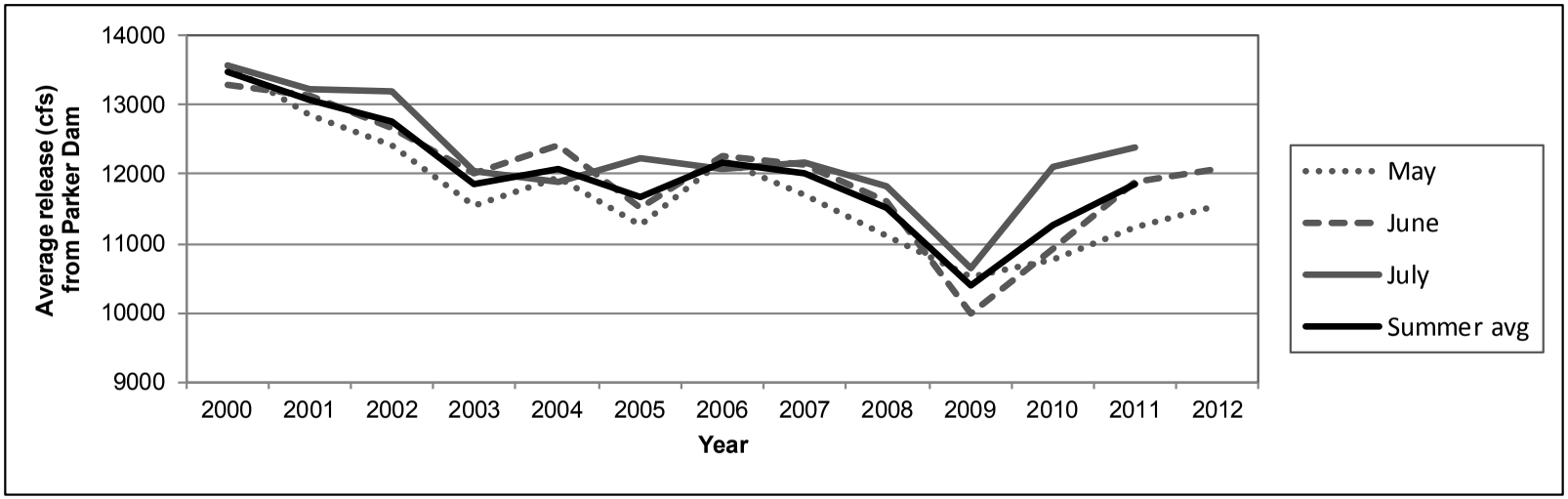

Figure 8.7. Average monthly releases from Parker Dam for May, June, July, and the average of these three months, 2000–2012.

Table 8.8. Correlation (r Statistic) of Parker Dam Daily Releases (cfs) with Average Daily Groundwater Levels (feet bgs) of Piezometers at Habitat Monitoring Sites, 2005–2010*

Site	Time Lag				
	None	1 day	2 days	3 days	4 days
Ehrenberg	-0.89	-0.95	-0.96	-0.92	-0.88
Three Fingers Lake	-0.83	-0.90	-0.94	-0.88	-0.83
Cibola Lake	-0.72	-0.78	-0.82	-0.79	-0.74
Walker Lake	0.06	0.06	0.05	0.05	0.06
Paradise	-0.80	-0.87	-0.94	-0.89	-0.83
Hoge Ranch	-0.78	-0.87	-0.96	-0.89	-0.80
Rattlesnake	-0.65	-0.71	-0.78	-0.80	-0.74
Clear Lake	-0.83	-0.87	-0.93	-0.95	-0.92
Ferguson Lake	-0.76	-0.82	-0.91	-0.95	-0.88
Ferguson Wash	-0.77	-0.81	-0.88	-0.91	-0.86
Great Blue Heron	-0.72	-0.73	-0.77	-0.80	-0.78

* Shaded cells indicate best correlation.

Table 8.9. Estimated Decrease (ft) in Piezometer Water Levels at Habitat Monitoring Sites as the Result of Predicted Average Decreases in River Flow*

Site	April	August	December	Annual
Ehrenberg	0.42	0.22	0.09	0.19
Three Fingers Lake	0.33	0.18	0.08	0.15
Cibola Lake	0.35	0.18	0.08	0.16
Paradise	0.33	0.18	0.08	0.15
Hoge Ranch	0.41	0.22	0.09	0.19
Rattlesnake	0.35	0.18	0.08	0.16
Clear Lake	0.31	0.16	0.07	0.14
Ferguson Lake	0.28	0.15	0.06	0.13
Ferguson Wash	0.28	0.15	0.06	0.13
Great Blue Heron	0.25	0.13	0.06	0.11

* Reclamation (2000) predicted average decreases in releases from Parker Dam in April (1200 cfs), August (632 cfs), December (274 cfs), and annually (552 cfs) based on a total annual reduction in releases of 400,000 acre-feet.

Table 8.10. Results of Linear Regression Between Average Daily Piezometer Groundwater Levels and Soil Moisture at Habitat Monitoring Sites, Lower Colorado River, 2005–2010

Site	Location	n	Range of daily average soil moisture values (mV)	Median soil moisture value (mV)	r	*P*
Topock	1	36	770–949	899	-0.02	0.909
	2	35	770–959	879	-0.25	0.140
	Site average	**34**	**839–938**	**885**	**-0.12**	**0.498**

Table 8.10. Results of Linear Regression Between Average Daily Piezometer Groundwater Levels and Soil Moisture at Habitat Monitoring Sites, Lower Colorado River, 2005–2010 (Continued)

Site	Location	n	Range of daily average soil moisture values (mV)	Median soil moisture value (mV)	r	*P*
Blankenship Bend	1	7	994–944	994	N/A	N/A
	2	15	799–994	915	-0.39	0.154
	3	0	--	--	--	--
	4	10	755–994	994	-0.72	0.019
	Site average	**8**	**939–994**	**988**	**-0.75**	**0.033**
Havasu NE	1	30	64–455	137	0.13	0.501
	2	30	91–773	395	0.23	0.220
	3	30	56–586	108	0.07	0.153
	4	30	80–607	153	0.30	0.106
	Site average	**28**	**105–378**	**196**	**0.17**	**0.383**
Ehrenburg	1	32	428–846	674	0.01	0.977
	2	32	572–944	870	-0.75	<0.001
	3	32	426–868	766	-0.45	0.009
	4	32	70–581	186	0.25	0.165
	Site average	**32**	**449–764**	**628**	**-0.24**	**0.179**
Three Fingers Lake	1	39	399–950	850	-0.05	0.757
	2	34	130–711	263	-0.11	0.528
	3	39	116–775	413	0.02	0.921
	4	39	155–915	490	-0.12	0.453
	5	38	150–914	498	0.03	0.847
	Site average	**30**	**200–816**	**488**	**0.05**	**0.786**
Cibola Lake	1	19	92–165	105	0.10	0.694
	2	20	253–994	610	-0.28	0.234
	3	20	141–346	244	0.46	0.041
	4	19	96–215	132	0.42	0.076
	5	19	239–598	400	0.01	0.976
	Site average	**17**	**222–409**	**288**	**0.06**	**0.131**
Walker Lake	1	44	746–994	972	-0.31	0.039
	2	44	704–994	864	0.12	0.449
	3	44	854–994	959	-0.01	0.934
	Site average	**44**	**811–975**	**930**	**-0.06**	**0.712**
Paradise	1	25	402–954	803	-0.34	0.138
	2	24	289–901	794	-0.62	0.001
	3	33	815–994	947	0.08	0.677
	4	33	170–852	355	0.15	0.510
	Site average	**22**	**544–873**	**719**	**-0.32**	**0.141**

Table 8.10. Results of Linear Regression Between Average Daily Piezometer Groundwater Levels and Soil Moisture at Habitat Monitoring Sites, Lower Colorado River, 2005–2010 (Continued)

Site	Location	n	Range of daily average soil moisture values (mV)	Median soil moisture value (mV)	r	*P*
Hoge Ranch	1	24	847–994	927	-0.23	0.270
	2	24	850–994	940	0.01	0.959
	3	24	786–964	890	0.00	0.999
	4	23	667–869	798	0.00	0.987
	Site average	**22**	**823–933**	**876**	**-0.04**	**0.843**
Rattlesnake	1	35	728–994	856	-0.49	0.003
	2	35	321–826	614	-0.07	0.691
	3	33	614–994	955	-0.76	0.000
	4	32	664–935	833	-0.42	0.018
	Site average	**31**	**672–923**	**819**	**-0.57**	**0.001**
Clear Lake	1	31	642–994	917	0.00	0.997
	2	31	108–652	166	0.21	0.258
	3	31	96–663	130	0.28	0.133
	Site average	**31**	**298–756**	**404**	**0.24**	**0.199**
Ferguson Lake	1	35	636–934	850	-0.48	0.004
	2	35	766–944	896	-0.51	0.002
	3	35	817–994	949	-0.75	<0.001
	4	35	907–994	994	-0.75	<0.001
	5	35	835–994	994	-0.75	<0.001
	Site average	**34**	**821–964**	**936**	**-0.73**	**<0.001**
Ferguson Wash	1	34	137–423	169	0.27	0.127
	2	34	104–529	153	0.27	0.124
	3	34	122–225	149	0.27	0.126
	4	34	121–489	161	0.37	0.032
	Site average	**34**	**126–480**	**160**	**0.30**	**0.080**
Great Blue Heron	1	31	729–966	891	-0.60	<0.001
	2	31	792–962	925	-0.02	0.922
	3	30	877–967	937	0.17	0.355
	4	32	840–959	930	-0.35	0.053
	Site average	**28**	**852–939**	**902**	**-0.04**	**0.832**
Mittry West	1	31	896–994	950	-0.08	0.682
	2	31	811–994	919	-0.02	0.214
	3	31	700–760	870	-0.62	<0.001
	4	31	760–994	881	-0.20	0.287
	Site average	**31**	**801–994**	**908**	**-0.47**	**0.008**
Gila Confluence North	1	11	306–836	386	0.13	0.689
	2	19	112–699	182	-0.13	0.606
	3	12	144–665	376	-0.09	0.792
	Site average	**11**	**210–733**	**316**	**0.02**	**0.945**

Relationship Between Piezometer Water Levels and Humidity

The linear mixed effects model showed that, after adjusting for time and regional humidity, there was an overall inverse relationship between depth to groundwater and absolute humidity, such that a 1-foot increase in depth to groundwater was associated with a decrease of 0.35 gm/m^3 in absolute humidity. This relationship varied from site to site and over time (see Appendix J).

Evapotranspiration Signature

Of the10 piezometers within the riparian vegetation surveyed for flycatchers, 6 (Topock Marsh, Blankenship Bend, Havasu NE, Cibola Lake, Paradise, and Hoge Ranch) yielded usable evapotranspiration signature data over multiple years (Table 8.11). The evapotranspiration signature was calculated for these six piezometers; however, several anomalous patterns became apparent in the piezometers along the river (Blankenship Bend, Havasu NE, Cibola Lake, Paradise, and Hoge Ranch). Notably, sharp reductions in the evapotranspiration signature were occurring with regularity every seven days, suggesting some control other than a seasonal change. Upon close inspection of the hydrographs, we realized that the intraday groundwater level changes in the piezometers were influenced much more strongly by river water levels than anticipated. As reported above, the river exhibits a strong weekly pattern in water levels, with low levels on the weekend and higher levels during the week. The sharp rise and fall of the river level during the transitions between week and weekend overwhelmed any water level changes due to the evapotranspiration of water by riparian vegetation. The White formula requires that the source of recharge be distant and consistent; the recharge provided by the river is too strong and immediate to allow use of the White method at these piezometers.

The piezometer within Topock Marsh was deemed the sole location at which the recharge source appeared to be consistent enough to meet the assumptions for the White formula, and we limited further analysis of the evapotranspiration signature to this location. Complete piezometer and temperature data were available at Topock Marsh only for May–August in 2007 and 2009.

Over the course of each season, the White evapotranspiration signature increased steadily, while the groundwater level in the aquifer declined steadily (Figures 8.8 and 8.9). The linear regression for mean diurnal temperature versus evapotranspiration signature showed a weak, direct correlation, with $r = 0.64$ and $r = 0.55$ for 2007 and 2009, respectively (Figures 8.10 and 8.11). The linear regression for mean daily water level versus evapotranspiration signature showed a strong, direct correlation, with $r = 0.82$ and $r = 0.98$ for 2007 and 2009, respectively (Figures 8.12 and 8.13). The direct relationship between depth to water and evapotranspiration (i.e.; the deeper the water dropped over the season, the greater the evapotranspiration from the vegetation) is the opposite of the relationship indicated in the literature, which shows decreasing evapotranspiration with increasing depth to groundwater (e.g., Blaney 1954).

The remaining four piezometers within flycatcher habitat (Ehrenberg, Clear Lake, Ferguson Lake, and Ferguson Wash) yielded water levels that did not consistently reflect daily changes in evapotranspiration. This lack of signature is likely the result of imperfect or delayed communication with the aquifer, caused by tight sediments surrounding the well screen, or possibly plugged well screens. Negative values shown in Table 8.11 are indicative of those piezometers that did not follow the typical daily signature caused by evapotranspiration losses from the aquifer. In these cases, either changes in water levels were significantly delayed (resulting in a reversal of the evapotranspiration signature) or showed no daily pattern at all (resulting in a random evapotranspiration signature).

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Table 8.11. Median Daily Evapotranspiration Signature by Month, May–Sep, 2005–2009

Site	Median Daily Fluctuation of Groundwater Level (feet)																								
	2005					2006					2007					2008					2009				
	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep
Topock Marsh	-	-	-	-	-	-	-	-	0.499	2.466	0.948	0.266	0.358	0.45	-	2.757	-	-	-	-	-1.317	0.218	0.479	0.563	1.056
Blankenship Bend	-	-	-	-	0.772	0.793	0.715	0.787	0.76	0.683	0.706	0.607	0.678	0.67*	-	-	-	-	-	-	-	-	-	-	-
Havasu NE	1.096*	0.077	0.088	0.13	2.83	2.308	0.182	0.171	0.156	2.168	1.313	0.215	0.236	0.214	1.862	2.03	0.04	0.046	0.071	0.802	0.58	0.036	0.078	0.08	1.252
Ehrenberg	-	-	-	-	-0.503	-0.409	-0.571	-0.482	-0.598	-0.503	-0.286	-0.318	-0.162	-0.558	-0.434	0.103	0.017	0.068	0.053*	-0.324	-0.28	-0.353	-0.445	-0.447	-0.323
Cibola Lake	-	0.043	0.02	0.309	0.388	0.355	0.436	0.37	0.483	0.481	-	-	-	-	-	-	-	-	-	-	0.002	0.018	0.021	0.03	0.033
Paradise	0.314*	0.311	0.202	0.451	0.487	0.611*	0.70*	0.625	0.521	0.457	0.621	0.617	0.546	0.73*	0.518*	-	-	-	-	-	-	0.391	0.489	0.476	-
Hoge Ranch	0.634*	0.483	0.383	0.513	0.521	0.78	0.814	0.727	0.627	0.056*	0.936	0.903	0.802	0.943	0.586*	-	-	-	-	-	-	-	-	-	-
Clear Lake	0.046*	0.013	0.017	0.019	-0.046	-0.02	-0.047	-0.035	-0.071	-0.069	0.003	-0.022	0.026	-0.041	-0.012	-	-	-	-	-	-	0.002	0.003	0.01*	-
Ferguson Lake	-0.035*	-0.067	-0.03	-0.082	-0.055	-0.104	-0.107	-0.098	-0.125	-0.065	-0.113	-0.166	-0.076	-0.127	-0.07	-	-	-	-	0.033*	-	-	-	-	-
Ferguson Wash	0.02*	0.002	0.011	-0.112	-0.059	-0.092	-0.098	-0.107	-0.133	-0.093	-0.098	-0.15	-0.069	-	-0.013	-	-0.053	-0.034	0.04*	-	-	-0.054	-0.059	-0.088	-

* Data for the month not complete.

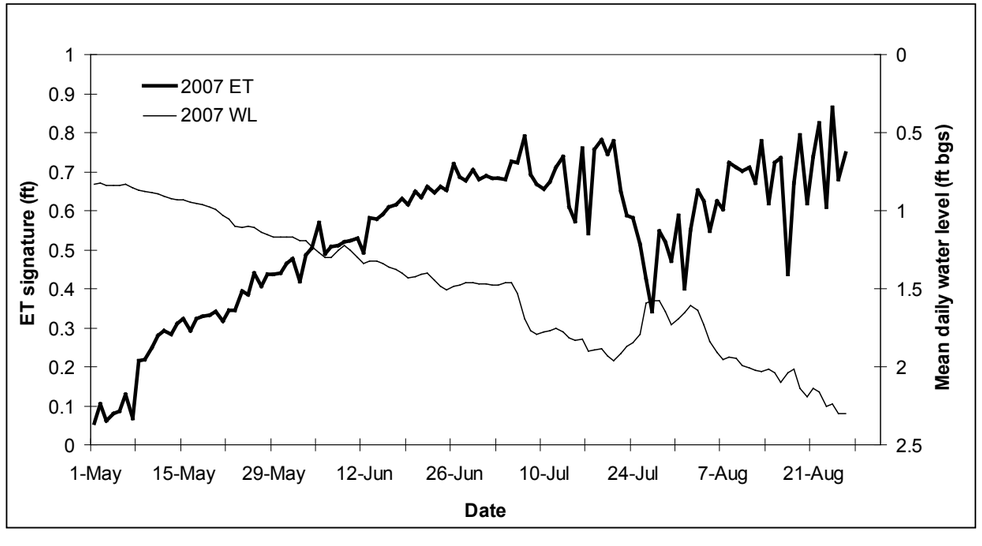

Figure 8.8. Daily evapotranspiration (ET) signature (ft) and mean daily water level [WL; feet below ground surface (bgs)] at Topock Marsh, May–August, 2007.

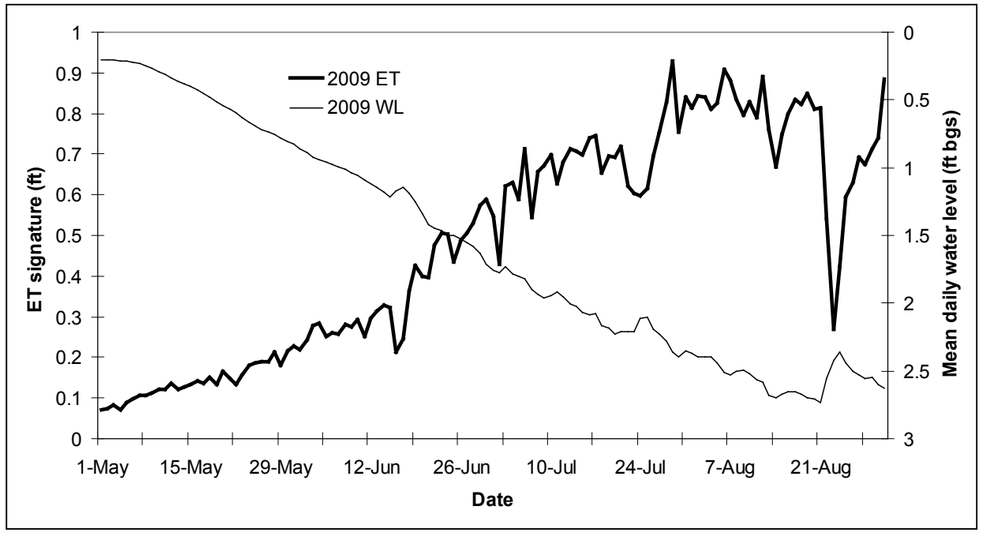

Figure 8.9. Daily evapotranspiration (ET) signature (ft) and mean daily water level [WL; feet below ground surface (bgs)] at Topock Marsh, May–August, 2009.

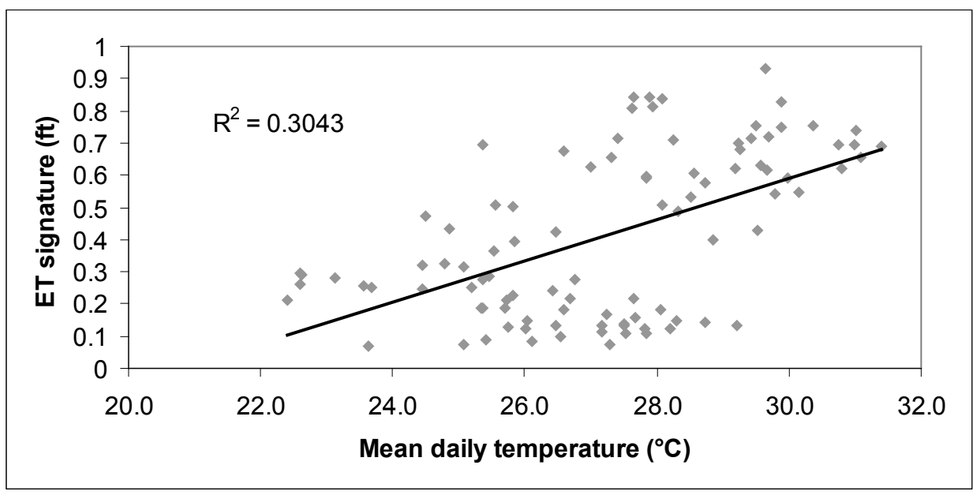

Figure 8.11. Linear regression between daily evapotranspiration (ET) signature (ft) and mean daily temperature (°C) at Topock Marsh, May–August, 2009.

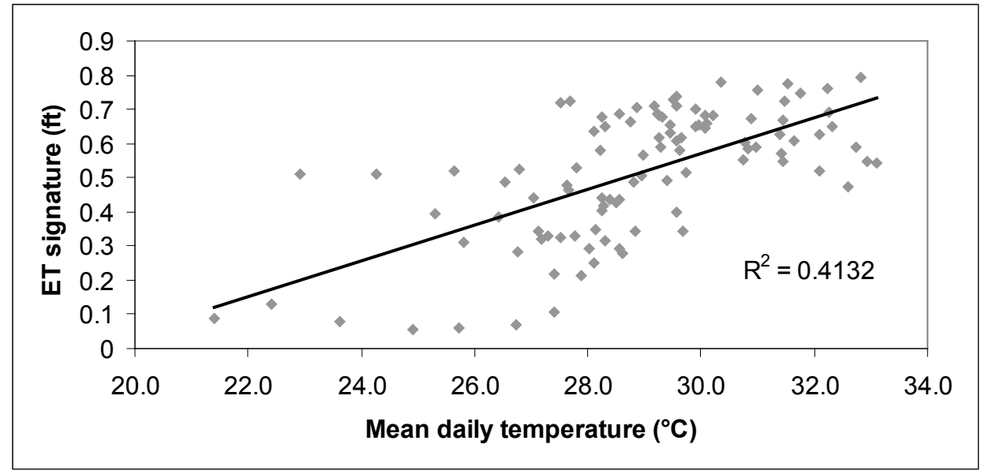

Figure 8.10. Linear regression between daily evapotranspiration (ET) signature (ft) and mean daily temperature (°C) at Topock Marsh, May–August, 2007.

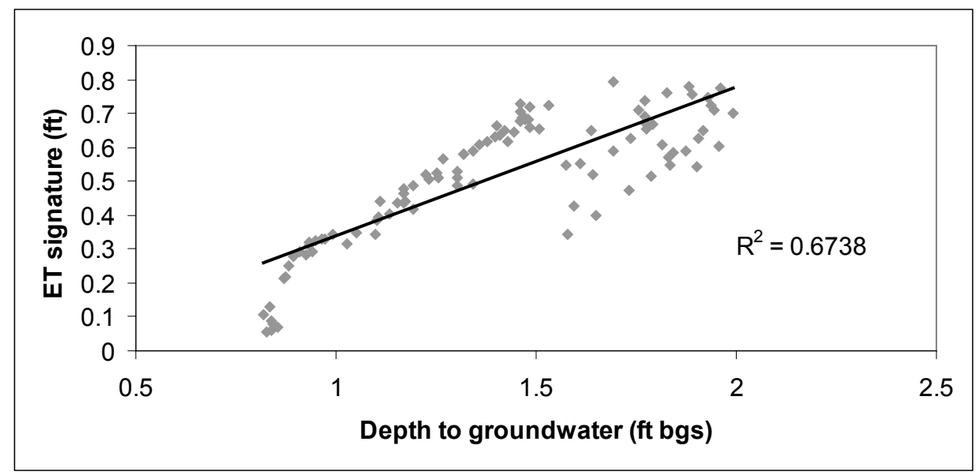

Figure 8.12. Linear regression between daily evapotranspiration (ET) signature (ft) and mean daily depth to groundwater (feet below ground surface) at Topock Marsh, May–August, 2007.

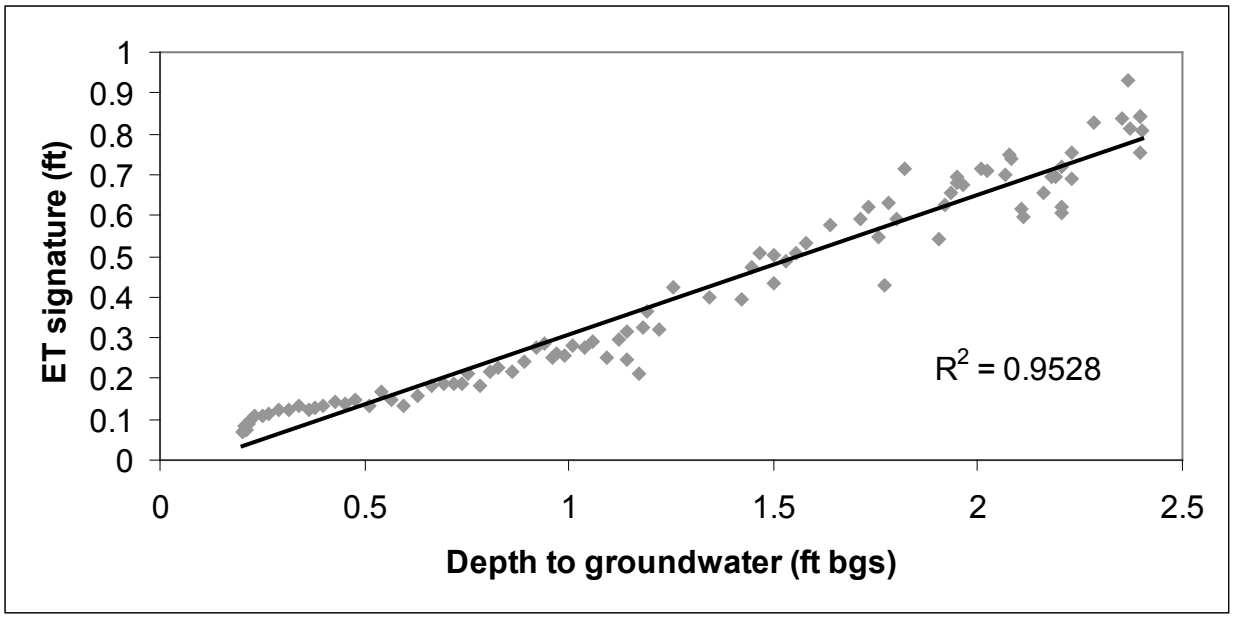

Figure 8.13. Linear regression between daily evapotranspiration (ET) signature (ft) and mean daily depth to groundwater (feet below ground surface) at Topock Marsh, May–August, 2009.

DISCUSSION

Microclimate

Between-year Comparisons of Microclimate Characteristics

Comparisons of microclimate characteristics among years in 2005–2012 at the habitat monitoring sites indicated hotter and more humid conditions in 2006 than in the other years and cooler conditions in 2009. The interannual changes in temperature and humidity were similar between test and control sites, suggesting that these changes were regional rather than being influenced by local conditions. Both test and control sites exhibited fluctuations in vapor pressure that were consistent with the annual fluctuations in dew point recorded at the Needles, California, weather station (Coop ID 46118; Figure 8.14). Thus, regional weather appeared to have an overriding influence on both temperature and humidity within both test and control sites. The interannual changes in soil moisture were not always similar between test and control sites, suggesting that local conditions, in addition to regional climate, may have influenced soil moisture. However, river flows appeared to influence soil moisture only in locations where high river levels caused inundation. It is possible that river level also influenced temperature and humidity in specific locations that become inundated with high river levels, since the presence of surface water does appear to moderate temperature and increase humidity (see Chapters 7 and 9). However, points that became inundated under high flow conditions constituted a small proportion of the total sample points, and any effect that surface water had on temperature and humidity was likely masked by the prevalence of sample points that did not become inundated.

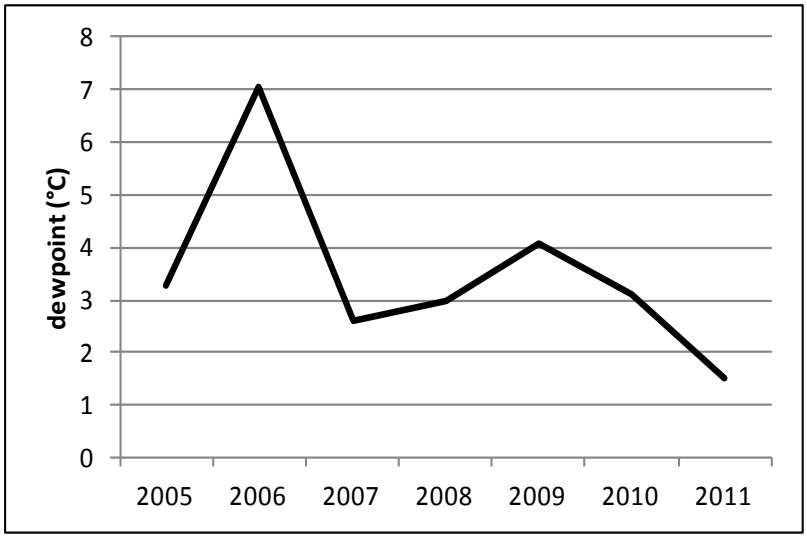

Figure 8.14. Mean dew point recorded at the Needles, California, weather station in July through August of each year, 2005–2011.

Comparison of Habitat Monitoring Sites to Topock Marsh and Effect of Latitude on Temperature and Humidity

Habitat monitoring sites were, on average, warmer and less humid than occupied flycatcher territories at Topock Marsh. The habitat monitoring sites are at slightly lower elevation and at lower latitudes than Topock Marsh, and thus might be expected to be warmer. However, there was no linear association between latitude and temperature, and temperature varied widely between habitat monitoring sites. Humidity at habitat monitoring sites appeared to have a weak association with latitude, but this association was driven by the relatively low vapor pressure observed at the two sites in Topock Gorge, which are over 100 km north of any other habitat monitoring sites. In addition, flycatcher territories within Topock Marsh, which is farther north than any of the habitat monitoring sites, had high humidity, further illustrating that humidity was not affected solely by latitude. It appears that local temperature and humidity along the lower Colorado River south of Topock Marsh are affected by factors such as local hydrology and vegetation, rather than latitude. Therefore, it is reasonable to assume that with suitable hydrology and vegetation structure, areas south of Parker Dam could have microclimate similar to that seen in occupied flycatcher habitat.

Vegetation

Between-year differences across all sites were noted for most variables, but none showed unidirectional trends over time, suggesting there has been no overall, detectable change in vegetation. Many vegetation characteristics that varied over time showed parallel changes at control and test sites, suggesting either widespread yearly variation or observer variation between years.

Few variables showed changes that were specific to control or test sites, and several of those variables had marginally significant (>0.01) *P*-values. Only woody ground cover and dead vertical foliage had *P*-values < 0.01. Ground cover did not differ from 2005 to 2007 at test locations but increased at control plots in 2006 and then decreased in 2007. It is not clear whether this represents actual changes in the amount of woody ground cover or whether it is a result of observer variation. The significant interaction

for dead vertical foliage is likely the result of dead foliage counts peaking in 2010 at test plots but not at control plots. Vertical foliage counts of dead vegetation have increased overall since 2007 at both test and control plots, and the percentage of the vertical foliage that consists of live vegetation has dropped accordingly. We also recorded the lowest percentage of live stems 2.6–8 cm dbh at both test and control plots in 2012. The interannual fluctuations in all these variables make it difficult to draw inferences about general trends in vegetation health, and the data show no evidence of deterioration in vegetation health that was specific to test sites.

The pooling of all sites into a test vs. control analysis may obscure changes in vegetation at specific sites. For example, one vegetation plot at Ehrenberg contained a significant coyote willow component (98% of the total basal area) in 2005. The willow gradually died over the next several years until no live willow remained in 2009. Most of the vegetation along the LCR, including at the sites selected for habitat monitoring, consists primarily of tamarisk, which is less sensitive than willow to changes in water availability. Measurable changes in overall vegetation as a response to reduced groundwater levels may take several years to develop in tamarisk, or the tamarisk may change very little if at all.

It has become apparent, after measuring the same vegetation plots for several consecutive years, that stem counts in very dense vegetation are inherently imprecise and can vary from year to year when there has likely been no appreciable change in stem density. Repeatability of stem counts depends on having a plot of fixed size. Each plot was divided into quadrants, with a rope extended in each cardinal direction from plot center with the 5-m distance (the edge of the plot) clearly marked. It can be nearly impossible to extend the rope flat or straight, introducing variability into the size of the plot. Even more problematic than this, however, is the inability of the observers in very dense vegetation to see plot center or the adjacent rope when at the end of one of the cardinal ropes. Observers vary widely in their ability to estimate distance, and when reference points are not visible, it is very difficult to envision an arc connecting the ends of two adjacent cardinal ropes and to determine whether a stem near the edge of the plot falls within the plot. Another factor that inhibits precise stem counts in dense vegetation is the difficulty in keeping track of which stems have already been counted. In 2009, we began using chalk to mark stems that had already been counted to try to minimize omission or double-counting of stems. The use of rectangular plots, where plot boundaries can by physically demarcated in the field, would greatly reduce observer variation in stem counts.

Given the difficulties in producing repeatable stem counts in circular plots, absolute stem counts are likely not a suitable metric for detecting subtle changes in vegetation in this study. The proportion of live stems may provide a more sensitive metric by which to detect change; the accuracy of this measure depends only on each observer counting live stems in a manner consistent with how s/he counts dead stems. Similarly, the proportion of live vertical foliage is likely to provide a more sensitive measure of changes in vegetation than do the absolute vertical foliage counts. A formal assessment of the magnitude of observer variation in stem counts, vertical foliage counts, and other vegetation measures would assist with data interpretation and would allow a determination of which vegetation variables can be measured with sufficient precision to allow the detection of changes that might be important to willow flycatchers.

The detection of changes in vegetation as the result of the diversion of water at Parker rather than Imperial Dam is further hampered by the complete lack of vegetation measurements prior to the beginning of the diversion in 2002. Vegetation measurements did not commence until 2005, by which time it is possible that some changes in vegetation, particularly in sensitive species such as coyote willow, had already occurred as the result of decreasing flows from 2001 to 2005 (see Table 8.7 and Figure 8.7). Other methods, such as analysis of satellite imagery, would have to be used to detect any changes in vegetation that might have occurred prior to 2005.

Soil Texture

Soil texture at the habitat monitoring sites was a mix of sand and silt, and is consistent with what would be expected in a depositional environment. Although habitat monitoring sites had, on average, a higher percentage of sand than did occupied flycatcher territories, occupied territories had a wider range of soil textures than were found at the habitat monitoring sites. There is no evidence that soil texture is a limiting factor in the suitability of the habitat monitoring sites for flycatchers.

Groundwater Levels

Correlation of Piezometer Water Levels with Reservoir Operations

Reduction in flow of 1,200 cfs would cause a drop in groundwater of 0.25–0.42 feet at each monitoring site. A drop in cfs of this magnitude occurred during the summer months between 2001 and 2003, and river levels remained at this new, lower level through 2012. Areas that were inundated with shallow water under river flow conditions in summer months prior to 2002 were likely inundated less frequently or not at all after 2002. The areal extent of each habitat monitoring site that has been affected varies greatly from site to site depending on the elevation profile of the site and how much of the site occurs at the critical level that would be affected by changes in river flow. Some sites, such as Ferguson Lake and Rattlesnake, have substantial areas that are low-lying and have probably been affected by reduced river flows. Other sites, such as Ferguson Wash, are primarily well above the river level and probably have been affected very little. Despite likely changes in the amount and frequency of inundation at some habitat monitoring sites, flycatcher occupancy of the sites has probably been unaffected (see below).

Correlation of Piezometer Groundwater Levels with Soil Moisture

The strongest relationships between piezometer groundwater levels and surface soil moisture were found at sites that had the highest soil moisture values. This suggests that unless groundwater is very close to the surface, surface soil moisture content is not influenced by groundwater levels, and soil moisture measurements are unlikely to reflect any changes in river levels.

Relationship of Piezometer Water Levels to Humidity Measurements

Although an inverse relationship was detected between depth to groundwater and absolute humidity, this relationship varied among sites and did not appear to be a strong contributor to humidity patterns within the sites. Seasonal fluctuations in humidity (average of 16.8 g/m^3 recorded August vs. 3.4 g/m^3 in January over the period of study) were of much greater magnitude than the influence of groundwater fluctuations (0.35 g/m^3 change with a 1-foot fluctuation in groundwater). Diurnal absolute humidity differed between nest and non-use sites at all life history study areas combined by 2.0 g/m^3 (McLeod et al. 2008a); it is unclear whether a change of less than 1.0 g/m^3 would affect site suitability for willow flycatchers.

Evapotranspiration Signature

The evapotranspiration signature at Topock Marsh was weakly correlated with temperature; i.e., increasing temperature was associated with an increased evapotranspiration signature. However, temperature was also correlated with depth to groundwater, because both increased over the May–August period each year. Data from the fall months—when plants are still active, depth to groundwater is high, but temperatures are dropping—may be helpful in distinguishing the effects of temperature from those of depth to groundwater.

The evapotranspiration signature at Topock Marsh was directly related to depth to groundwater, rather than showing the inverse relationship demonstrated in the literature. We therefore suspected that the relationship was coincidental, rather than causal. To determine why evapotranspiration might be increasing despite a lowered water table, we deconstructed the White formula. We determined that two fundamental assumptions of the formula likely had been glossed over in previous applications reported in the literature:

- The recharge of the aquifer as measured at the piezometer is driven by basic groundwater hydraulics, and is a function of the aquifer material and the hydraulic gradient between the source of recharge (surface water) and the piezometer. The aquifer material does not change over the season, but the hydraulic gradient does. We realized that as water levels dropped through the season at the piezometer, that lowering of the water table likely affected the overall hydraulic gradient, increasing recharge to the aquifer. The effect of this increasing recharge cannot be controlled for or easily extracted from the evapotranspiration signature.
- Similarly, we realized that the source of recharge to the aquifer, specifically the standing water within Topock Marsh, might also change in location or amount through the season. This would cause a change in hydraulic gradient as well.

These hydraulic effects had not been considered in previous literature on the technique of using the evapotranspiration signature; those studies focused largely on monthly snapshots of evapotranspiration with an eye towards estimating gross volumes of water used by riparian vegetation, without being concerned with stability of the formula through the season. While these findings do not invalidate the White technique, we found that being unable to correct for the changing hydraulic effects rendered the evapotranspiration technique ineffective in tracking vegetation changes over time.

Flycatcher Occupancy in Habitat Monitoring Sites

When the Biological Opinion requiring habitat monitoring was written in 2001, several sites along the lower Colorado River south of Parker were thought to be occupied by willow flycatchers, based on the detection of flycatchers at these sites after 15 June of one or more years. However, no breeding flycatchers were confirmed at these sites in any year, the majority of the detections were of flycatchers that did not appear to be actively defending a territory, and few flycatchers were detected after mid-June (SBCM unpublished data). Further investigation of the status of willow flycatchers along the southern stretches of the Colorado River showed no evidence of any resident or breeding flycatchers in or near any of the habitat monitoring sites (see Chapter 2). The revised willow flycatcher survey protocol (Sogge et al. 2010) suggests using 24 June as a guideline for determining residency, with flycatchers detected after this date considered to be territorial. Over the last 10 years, only four flycatchers have been detected south of Parker Dam after 24 June (see Chapter 2 and Appendix A), and none of these flycatchers displayed territorial behavior (extended song) or were detected on more than one occasion. It is likely that the habitat monitoring areas have not been occupied since surveys began in 1996.

The reduction in water releases from Parker Dam that has occurred since 2002 has likely caused a lowering of the groundwater table along sites adjacent to the river, as Reclamation predicted. Some low-lying portions of the sites that were periodically or continuously inundated during May–July in years before 2002 have probably been inundated less frequently, if at all, in subsequent years. This change in the water table may have affected riparian vegetation in some areas, but vegetation monitoring did not begin until 2005, when dam releases had been at new, lower levels for the three previous summers. Sensitive vegetation may already have been affected by changes in groundwater level by the time monitoring began, and microclimate in these specific areas may also have changed. However, flycatchers were likely unaffected, since these areas are used by migrant flycatchers and not by residents.

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Chapter 9

SURFACE HYDROLOGY, MICROCLIMATE, AND VEGETATION MONITORING: TOPOCK MARSH

INTRODUCTION

Monitoring of Southwestern Willow Flycatcher populations at Topock Marsh began in 1997, and data on number of flycatcher pairs and nest success are available for 1998–2012. The breeding population at Topock declined from a high of 29 pairs in 2004 to fewer than 10 pairs in 2007 and 2008. This decline prompted concern from USFWS about the flycatcher population at Topock, which was presumed to be the likely source population for any flycatchers that would colonize restoration areas on the lower Colorado River. USFWS and Reclamation initiated discussions after the breeding season of 2008 to identify habitat enhancement measures that could be implemented at Topock Marsh in an attempt to raise the number and productivity of flycatchers.

The affinity of breeding Southwestern Willow Flycatchers with standing water and saturated soil is noted consistently in the literature (e.g., Johnson et al. 1999, Munzer et al. 2005, McLeod et al. 2008a, Graber and Koronkiewicz 2009b), and flycatcher nests along the Middle Rio Grande that were above inundated or saturated soil all season produced more young per successful nest than nests that were above dry soil all season (Moore and Ahlers 2008). An examination of water levels within Topock Marsh from 1997 to the present shows that after 2004, water levels peaked at lower levels, high water levels were of shorter duration, and over-winter lows were lower than was the case prior to 2004 (Figure 9.1). Because of the influence of surface water on flycatcher occupancy and productivity, USFWS and Reclamation developed a plan to pump water into a portion of the flycatcher habitat at Topock Marsh.

Two adjacent areas within Topock, known as In Between and 800M, were selected in 2008 as the location for habitat enhancement via supplemental water delivery. The number of breeding flycatcher pairs in these areas declined steadily from 10 in 2004 to 0 in 2008, but the vegetation in the area had not changed markedly during that time (McLeod and Koronkiewicz 2010). The addition of surface water and saturated soil to this area might make it more attractive to flycatchers and increase nest success and productivity of any flycatchers that nest in the area. In addition, widespread inundation could make portions of In Between, 800M, and the surrounding area that typically had been dry during surveys since 2003 and not occupied by flycatchers more suitable for flycatcher occupancy.

In the absence of water delivery, the presence and extent of surface water within all flycatcher breeding sites at Topock Marsh is influenced solely by marsh elevation. In 2009, water flowed into Topock Marsh through the northern inlet canal and the farm ditch, as had been the case in all prior years. In 2010, marsh levels were lowered intentionally in anticipation of construction of a new firebreak canal. Construction did not occur until 2011, and marsh levels were intentionally lowered in 2011 as well, through closure of the northern inlet canal. The firebreak canal was in place during the 2012 breeding season, but no pump had yet been installed, and water delivery into the marsh relied on sufficient river elevation and passive flow through the canal. The new canal also was found to be leaking. The northern inlet canal was not functional in 2012, so water delivery into Topock Marsh was supplied only by the farm ditch and the new firebreak canal.

Supplemental water delivery was expected to begin in 2010. In 2009, we monitored hydrological, microclimate, and vegetation conditions at In Between, 800M, and the adjacent area of Pierced Egg to assess baseline habitat conditions. In 2010, supplemental water delivery was delayed and we again assessed baseline habitat conditions. Supplemental water delivery commenced in March 2011, and we

completed the same monitoring of habitat conditions for comparison with baseline conditions. In 2012, no supplemental water delivery occurred. However, a new water delivery canal was completed, and we monitored hydrological and microclimate conditions in 2012 to evaluate the ability of the new canal to maintain wet conditions in the target area. The results are presented in two sections: one for analyses related to habitat enhancement via supplemental water delivery (hereafter water delivery year) and one for analyses related to conveyance efficacy of the new water delivery canal (hereafter marsh elevation years).

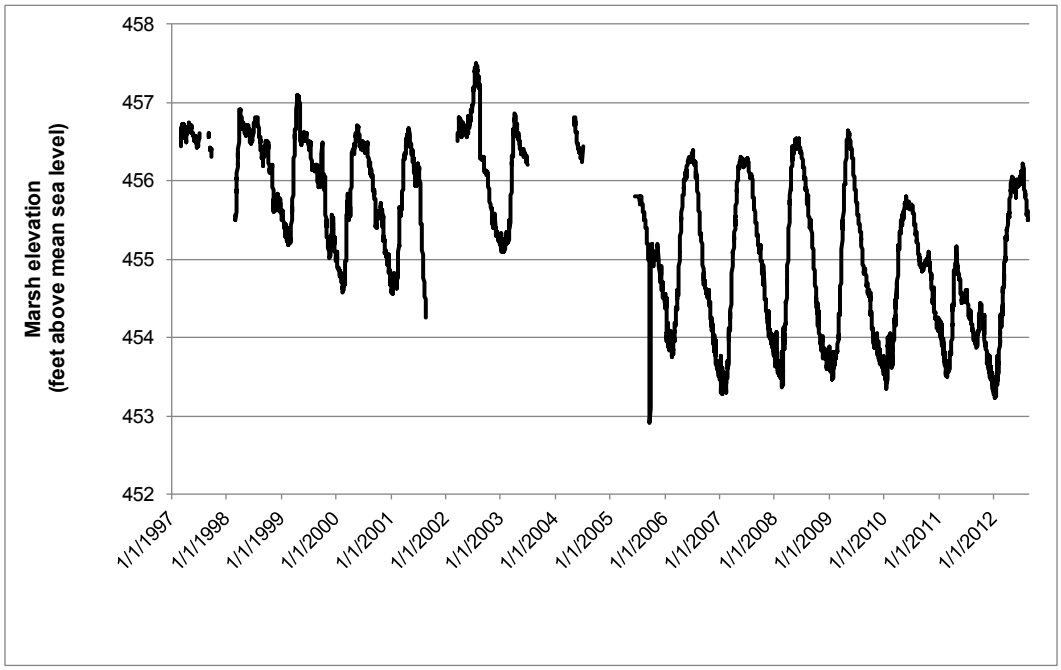

Figure 9.1. Marsh elevation (feet above mean sea level) measured at the South Dike at Topock Marsh, 1997–2012.

METHODS

Surface Water Mapping

Marsh Elevation Years

We mapped surface water at weekly intervals each year from 2009 to 2012, between the start and end dates listed in Table 9.1. During each visit, we traversed trails throughout each site and used GPS and aerial photographs to map the extent and depth of surface water within the sites. At the conclusion of each visit, we compiled our GPS points and field notes to prepare a hardcopy map of the sites, with areas of surface water and saturated soils delineated on the map and indexed to a key detailing the nature (e.g., pig wallow, open marsh, flooded forest) and depth of each wet area. All hardcopy maps were digitized after the field season using ArcGIS. From the digitized shapefiles, we calculated the percentage of the target area that contained surface water at each visit.

Table 9.1. Start and end dates for surface water mapping at Topock Marsh, 2009–2012

Year	Water Source	Start Date	End Date
2009	Marsh Elevation	10 March	8 August
2010	Marsh Elevation	14 March	21 July
2011	Water Delivery	28 February	15 July
2012	Marsh Elevation	14 May	30 July

Water Delivery Year

In 2011, we mapped water within the target area immediately prior to the initiation of water delivery on 1 March and for three days following the initial pumping. This provided baseline data on water levels, the maximum extent of water, and the longevity of water within the target area. We continued visiting In Between, 800M, and Pierced Egg at approximately weekly intervals thereafter. Data were compiled as described above.

Groundwater Measurements

A small-diameter shallow well, or piezometer, equipped with a pressure transducer and data logger was installed in 2006 at In Between in Topock Marsh as part of habitat monitoring between Parker and Imperial Dams (see Chapter 8 for a description of the piezometers and data collection procedures). This piezometer is within the target area of water delivery and thus was left in place when the other piezometers used in the study were removed. This piezometer is described in McLeod et al. (2007) and has been downloaded approximately three times per year since installation. At each download we checked the battery level and function of the data logger. Batteries were replaced as necessary and data were examined to ascertain potential equipment malfunction (see Chapter 8 for details on data validation).

Microclimate

In 2009, the In Between, 800M, and Pierced Egg polygons were stratified into use (occupied by flycatchers) and non-use (unoccupied by flycatchers) areas, as observed in 2003–2008. Use areas tend to be wetter than non-use areas and thus are presumably low-lying and more likely to be affected by water delivery into the habitat. We excluded the cattail marsh in the center of the 800M polygon from either the use or non-use areas. We superimposed a 25- x 25-m grid on a GIS software shapefile of the use and non-use areas, numbered the grid blocks, and selected blocks using a random number generator. We used the centroid of the selected block as the sample point and located each point in the field by navigating to the given coordinates using a Rino 110 GPS unit. We determined the exact location of each sample point by means of random number sequences as described in Chapter 7. All sample points used in 2009 were marked in the field with flagging that remained in place over the following three winters, allowing for relocation at the beginning of each subsequent season. We relocated each sample point at the start of surface water mapping each year in 2010–2012 and redeployed a data logger in the same location. We used HOBO H8 Pro data loggers (see Chapter 7) to record temperature and humidity at each sample point at 15-minute intervals. Each logger remained in place until the end of the flycatcher breeding season. We collected soil moisture readings, as described in Chapter 7, below each data logger at bi-weekly intervals.

Vegetation

In late July of each year 2009–2011, at the end of the flycatcher breeding season, we collected vegetation measurements at each HOBO logger location. Vegetation plots were centered on the logger, and we collected the vegetation measurements described in Chapter 6, with the exception of stem counts. Given the relatively short time span between the implementation of water delivery and the subsequent vegetation measurements, any responses in vegetation are more likely to be apparent in canopy closure and vertical foliage density than in stem counts. The vegetation data we collected did not indicate any substantial changes in vegetation as a result of water delivery, and we did not repeat vegetation measurements in 2012.

Water Delivery

Over the winter of 2010–2011, the water delivery system was installed. The system consisted of a Crisafulli trailer pump, modified to be hydraulically driven and capable of moving approximately 41.6 m^3 (11,000 gallons) of water per minute, along with a 0.61-m (24-inch) -diameter pipe carrying the water into the target area from the open water of Topock Marsh.

Data Analyses

Marsh Elevation Years

Microclimate data were summarized as described in Chapter 7, and we pooled data across all sample points. Qualitative comparisons between years were summarized in graphs.

Water Delivery Year

We had originally stratified the sample points into use and non-use areas on the assumption that the use areas were more likely to be inundated during water delivery. The water that was pumped into the target area did not reach all the use areas; therefore, we reclassified the points into flooded and non-flooded areas (also referred to as flood groups) according to whether the point was within 20 m (i.e., within a distance that would be encompassed by a flycatcher territory [Sedgwick and Knopf 1992]) of the maximum extent of water recorded immediately post water delivery in 2011. We compared data collected during 2011 to those collected in 2010. We did not include data from 2009 in the comparison because temperature and humidity data collected at the Needles, California, weather station (Coop ID 46118) indicated that weather conditions in 2011 were overall more similar to those in 2010 than in 2009, and similar weather data between years may facilitate interpretation of between-year comparisons.

MICROCLIMATE

Microclimate data were summarized as described in Chapter 7. All data were summarized separately for flooded and non-flooded areas. We used a repeated measures analysis using a linear mixed model to compare the seasonal changes in flooded versus non-flooded areas in 2010 and 2011. We also used a repeated measures analysis using a linear mixed model to compare temperature and humidity variables the day after a flood event to those recorded the day before the flood event in flooded versus non-flooded areas in 2011. Linear mixed models assumed unstructured covariance, and all analyses were completed using SAS® Version 9.2 (SAS Institute 2009).

VEGETATION

Vertical foliage data were summarized as described in Chapter 6. Percent native vegetation was calculated as the percent of the foliage hits that consisted of native vegetation. We used the average nest height (3.78 m) recorded at In Between, 800M, and Pierced Egg from 2003 to 2008 to delineate the below, at, and above nest height categories. All data were summarized separately for flooded and non-flooded areas. We used a repeated measures linear mixed model to compare the conditions measured in each flood group in 2011 versus those measured at those same points in 2010. We also used this model to detect any year*flood group interactions, which indicate that the between-year change detected for a given variable in the flooded area differed from the change detected in the non-flooded areas. All models assumed unstructured covariance. We used SPSS® Version 16.0 (SPSS Inc.) software for statistical analyses.

RESULTS

Marsh Elevation Years

Surface Water Mapping

In 2009, 2010, and 2012, surface water in the target area was influenced solely by marsh elevation. The percentage of the site that was inundated rose rapidly in late March and early April in both 2009 and 2010 to a high of almost 45% and 23%, respectively (Figure 9.2 and 9.3). We did not begin water mapping until May in 2012 and thus missed the peak extent of surface water, which likely happened in mid-April when water levels peaked in the piezometer (Figure 9.4) Water levels declined rapidly following the spring peak in all three years. The minimum surface water extent of <5% was reached in late June 2009, mid-May 2010, and mid-June 2012. Surface water mapping indicated that conditions in 2012 were intermediate between the conditions observed in 2009 and the much drier conditions observed in 2010 (Figures 9.4 and 9.5). A small increase in inundation is apparent in mid-July of 2012 as the result of unusually heavy monsoon rains.

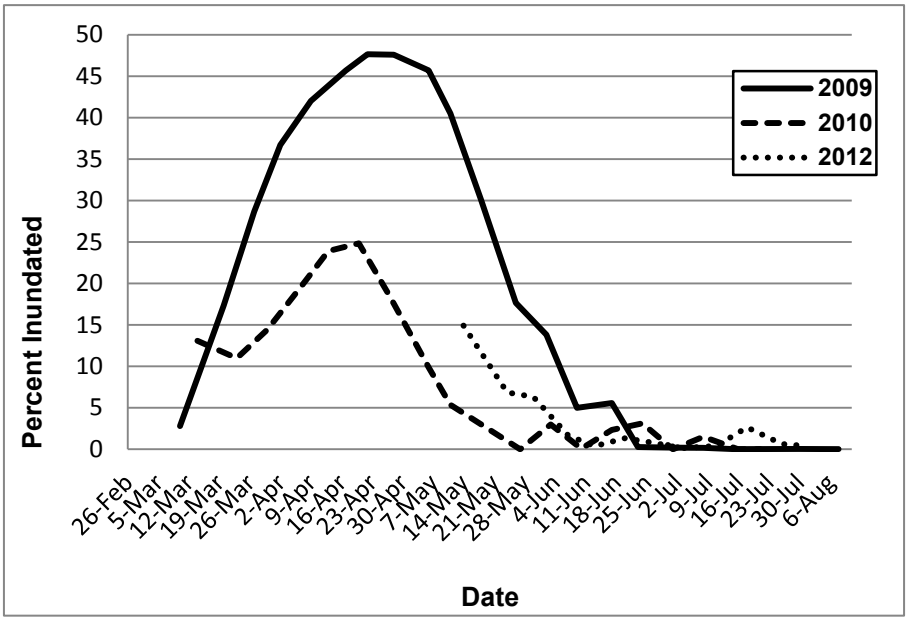

Figure 9.2. Percentage of In Between, 800M, and Pierced Egg, combined, that was inundated in March–July 2009, 2010, and 2012.

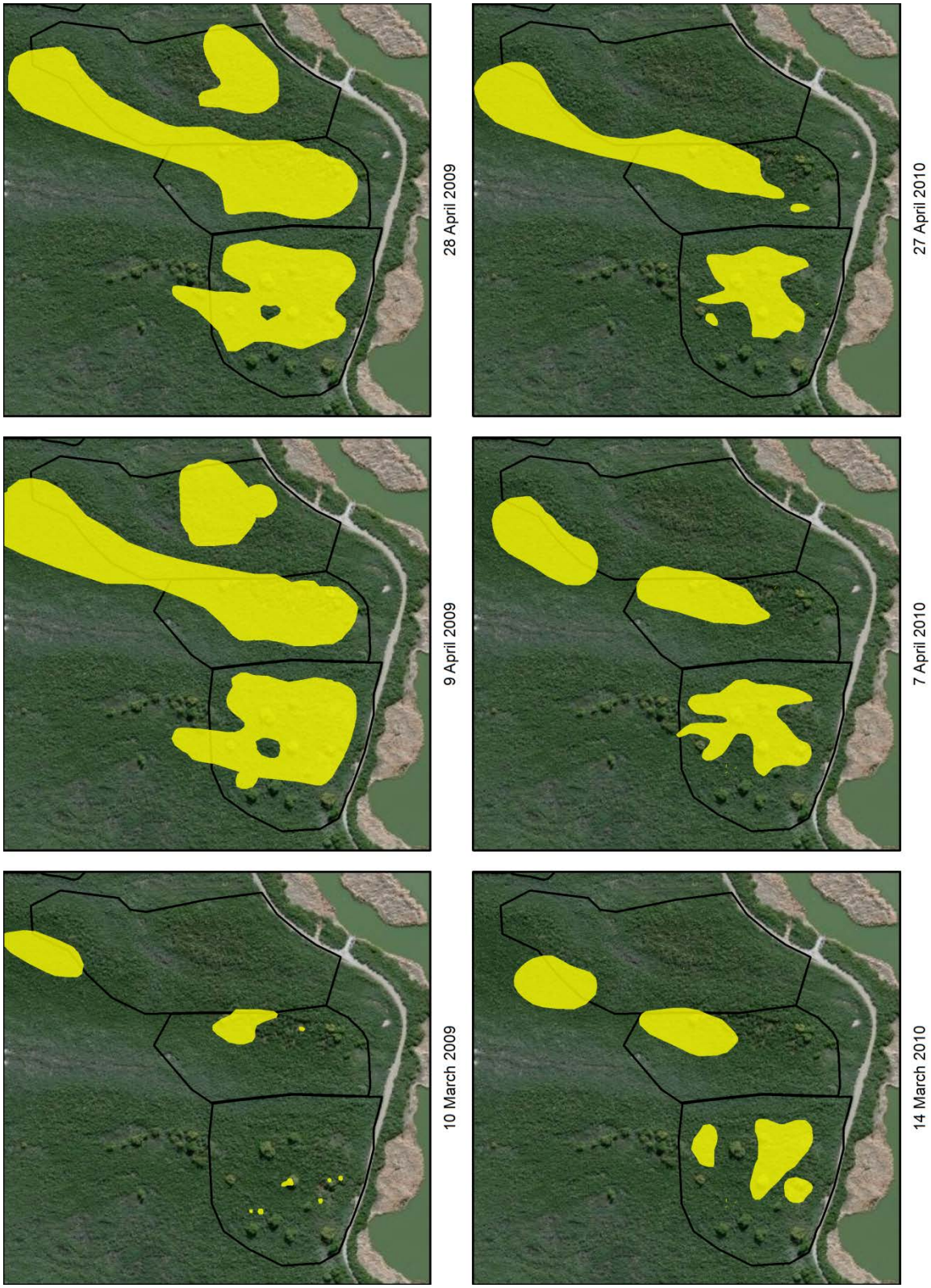

Figure 9.3. Extent of surface water within In Between, 800M, and Pierced Egg, mid-March and April, 2009 and 2010.

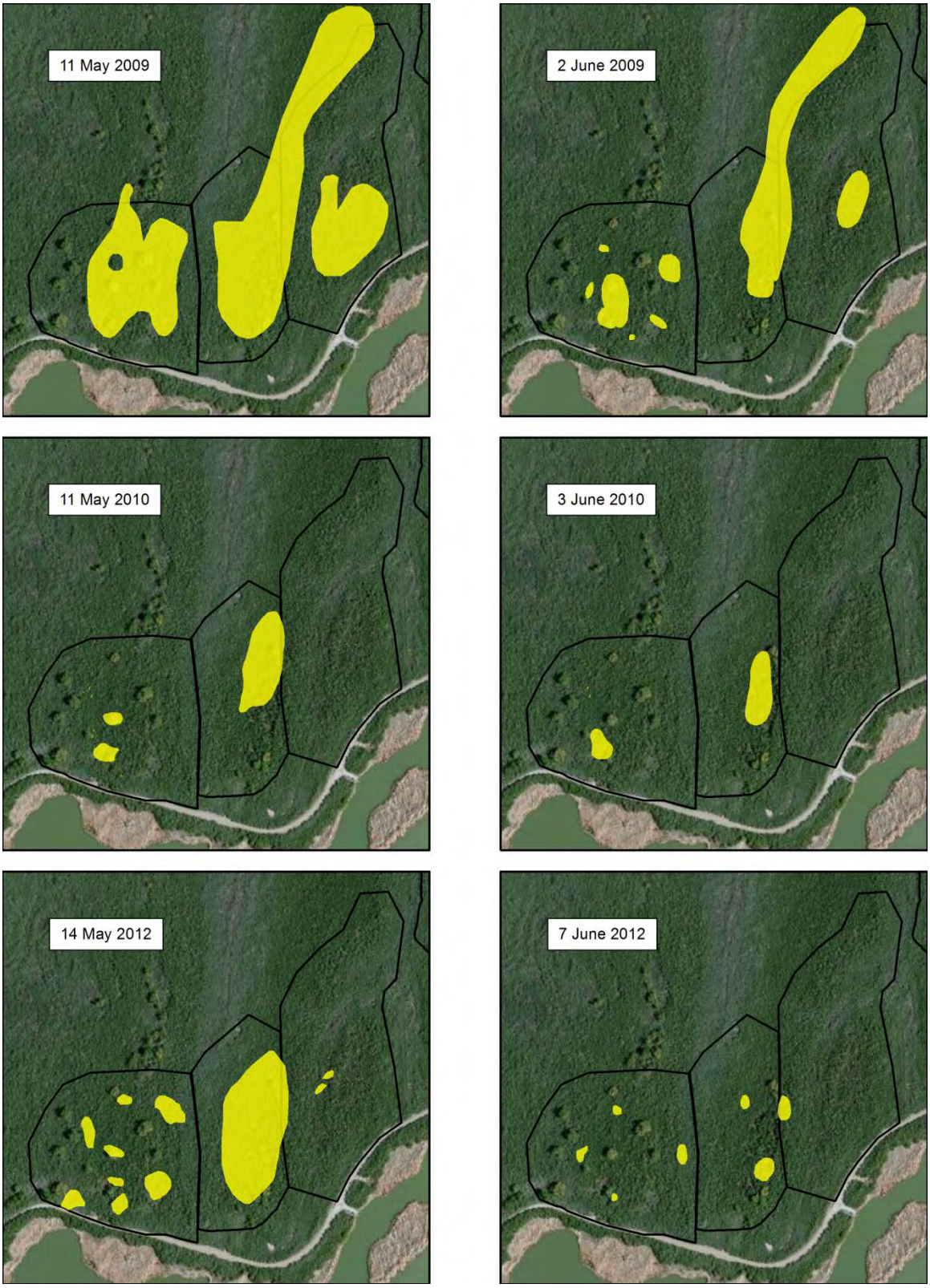

Figure 9.4. Extent of surface water within In Between, 800M, and Pierced Egg, mid-May and early June, 2009, 2010, and 2012.

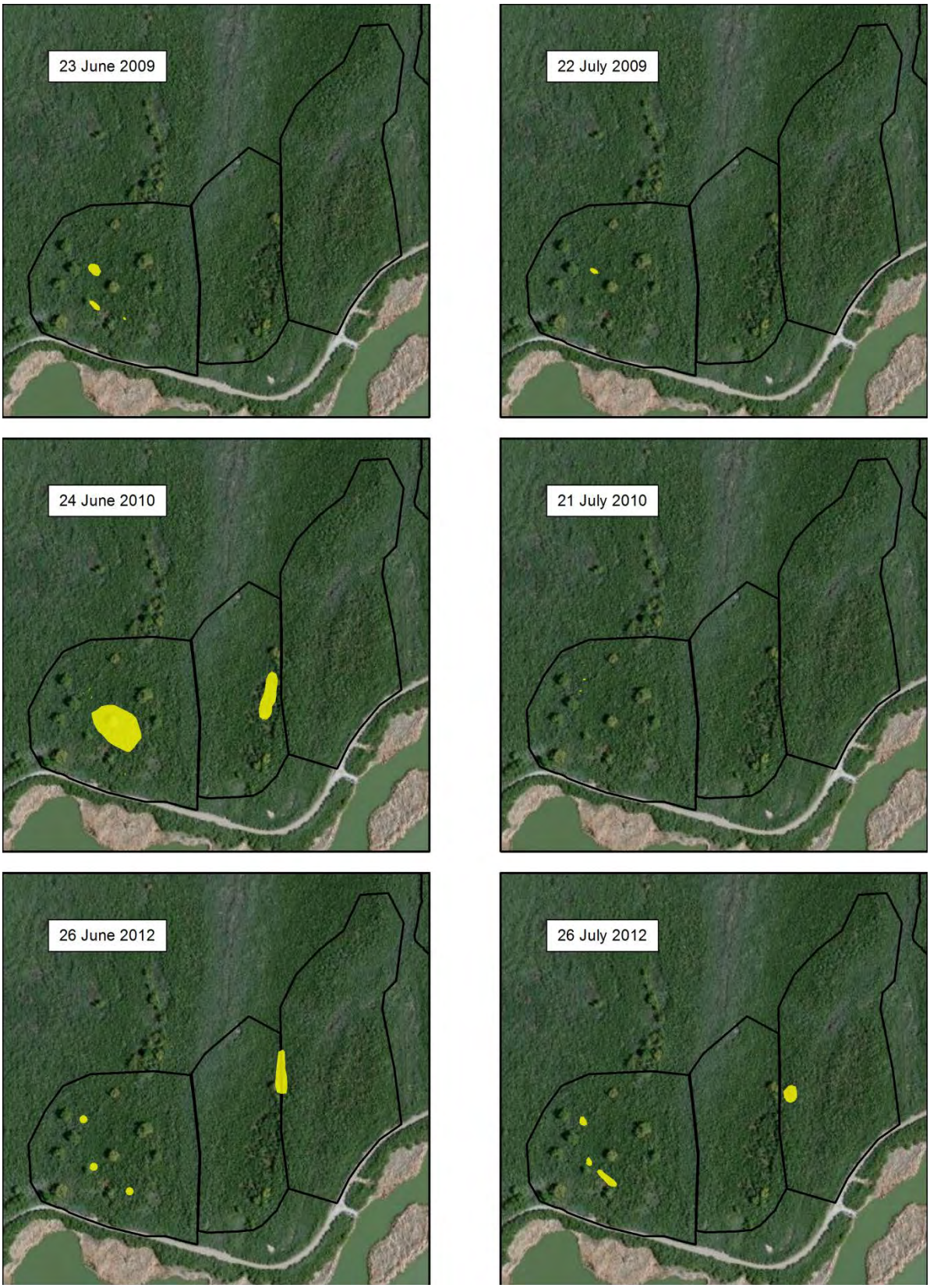

Figure 9.5. Extent of surface water within In Between, 800M, and Pierced Egg, late June and July, 2009, 2010, and 2012.

Groundwater Monitoring

The piezometer at Topock Marsh shows that local groundwater levels typically peak each year in April (Figure 9.6). Water levels recorded in the piezometer corroborate the results of the surface water mapping, showing that the peak water level in 2010 was less than in 2009, and that peak water levels in 2012 were intermediate between those of 2009 and 2012.

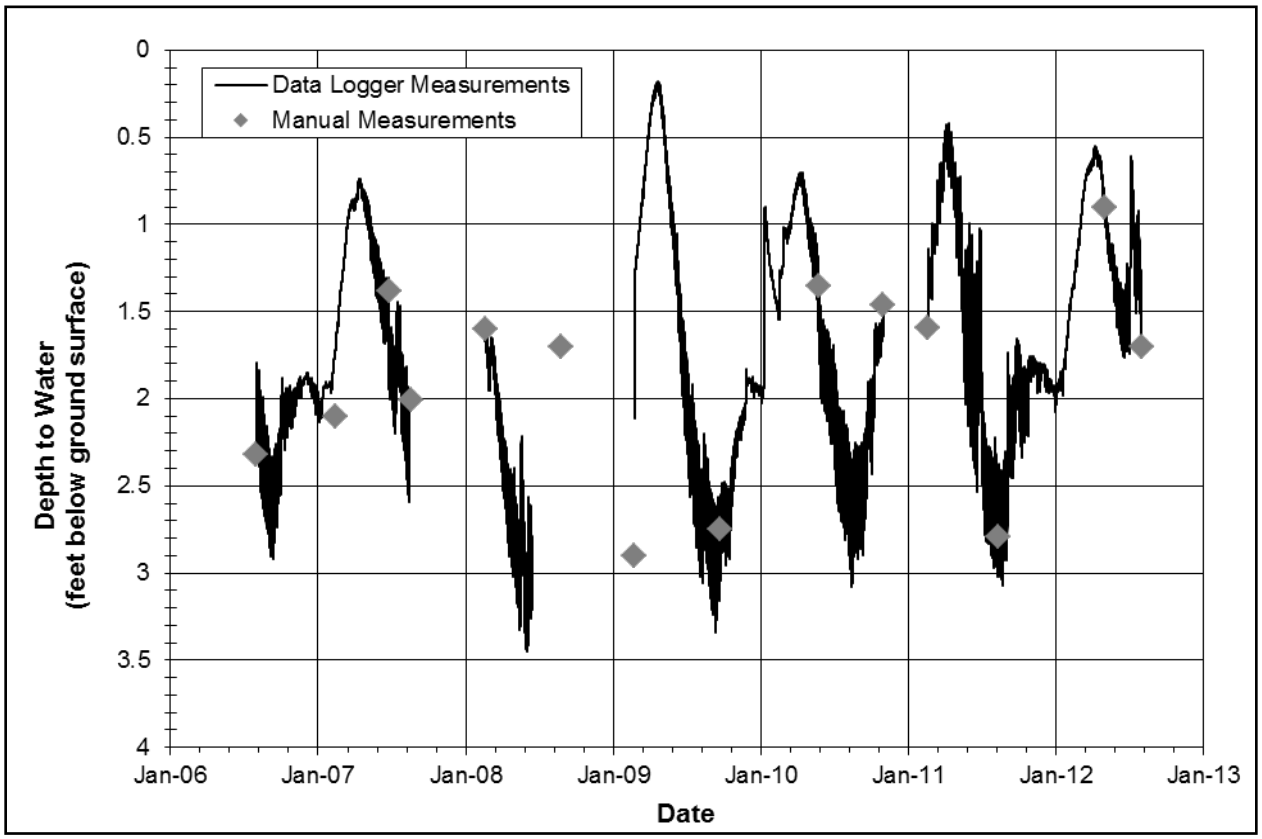

Figure 9.6. Topock Marsh hydrograph, 2006–2012.

Microclimate

Soil moisture data corroborate the results of surface water mapping in suggesting that conditions in 2012 were intermediate between those observed in 2009 and 2010 (Figure 9.7). In 2012, soil moisture values in May and the first half of June were intermediate between those of 2009 and 2010, then dipped below the values recorded in either 2009 or 2010 in the second half of June and first half of July, before rising at the end of July to levels above those recorded in either of the other two years. The increase in soil moisture values in July is the result of unusually heavy monsoon rains in the region in mid-July. Distance to water was also intermediate in May and early June of 2012 as compared to 2009 and 2010, and distance to water was considerably less at the end of the season in 2012 as compared to the other two years (Figure 9.8).

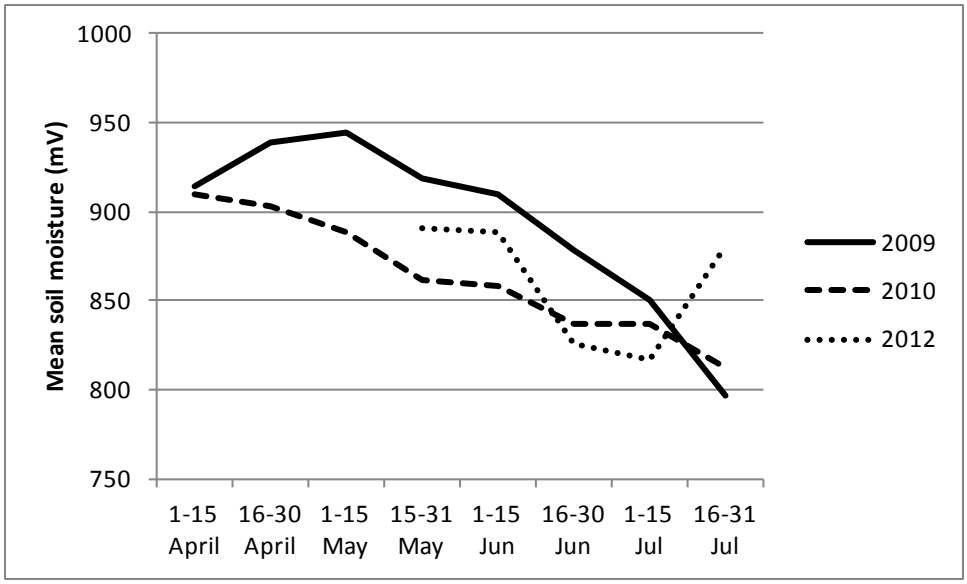

Figure 9.7. Mean soil moisture (mV) in the target area in 2009, 2010, and 2012.

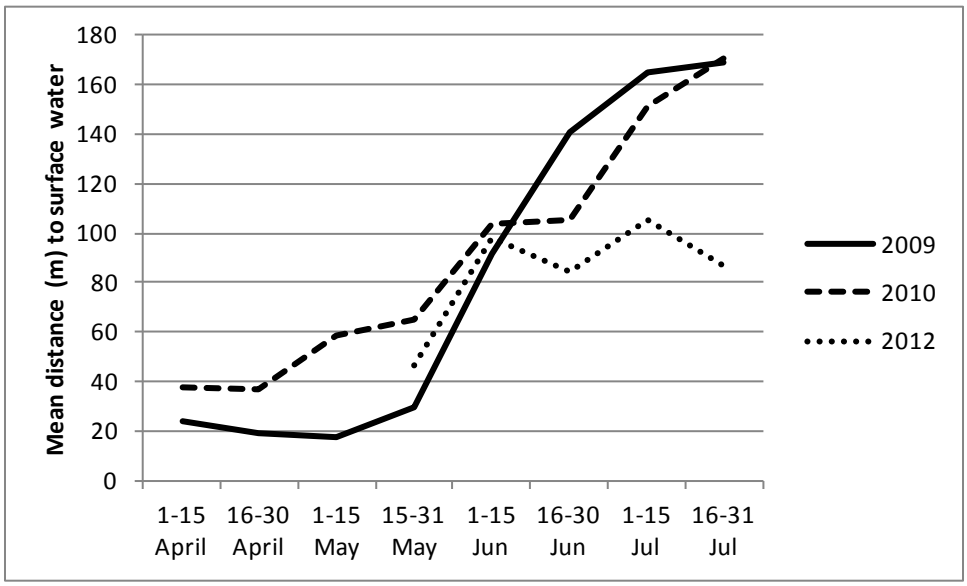

Figure 9.8. Mean distance (m) to water in the target area in 2009, 2010, and 2012.

Maximum diurnal temperature in the target area in 2009 and 2010 fluctuated in accordance with temperatures recorded at the Needles weather station (Coop ID 46118). In both years, maximum diurnal temperature recorded in the target area was higher than that at the weather station in the first part of the season and lower in the latter part of the season (Figure 9.9). Maximum daily temperatures recorded in the target area in late May and June 2012 exceeded those recorded in the other two years, and temperatures recorded at the weather station in June 2012 also exceeded those recorded in 2009 and 2010. Maximum daily temperatures recorded in the target area in 2012 did not fall below those recorded at the weather station in the latter part of the summer, as they had in the other years. Minimum nocturnal temperatures in all three years were lower in the target area than at the weather station, but typically followed the seasonal pattern seen at the weather station (Figure 9.10).

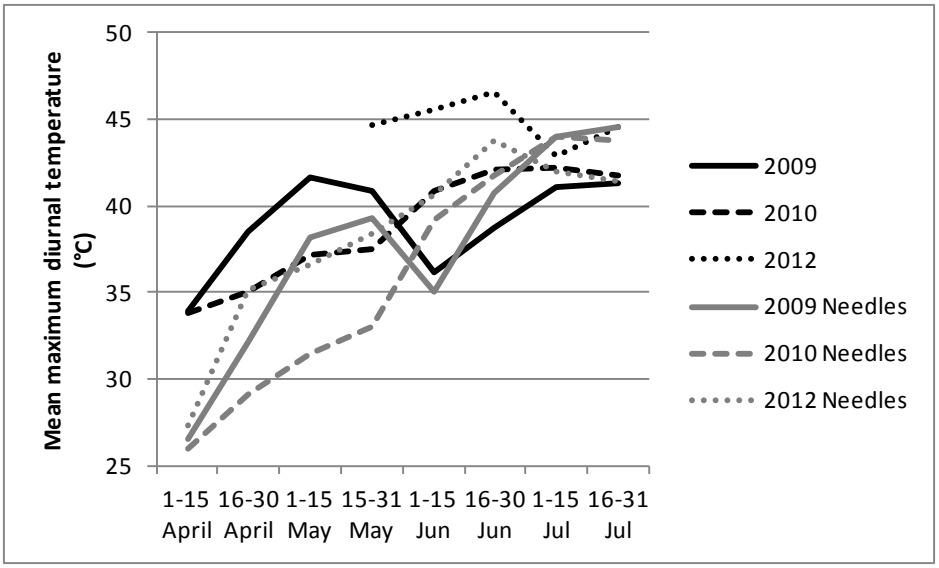

Figure 9.9. Mean maximum daily temperature in the target area and at the Needles weather station in 2009, 2010, and 2012.

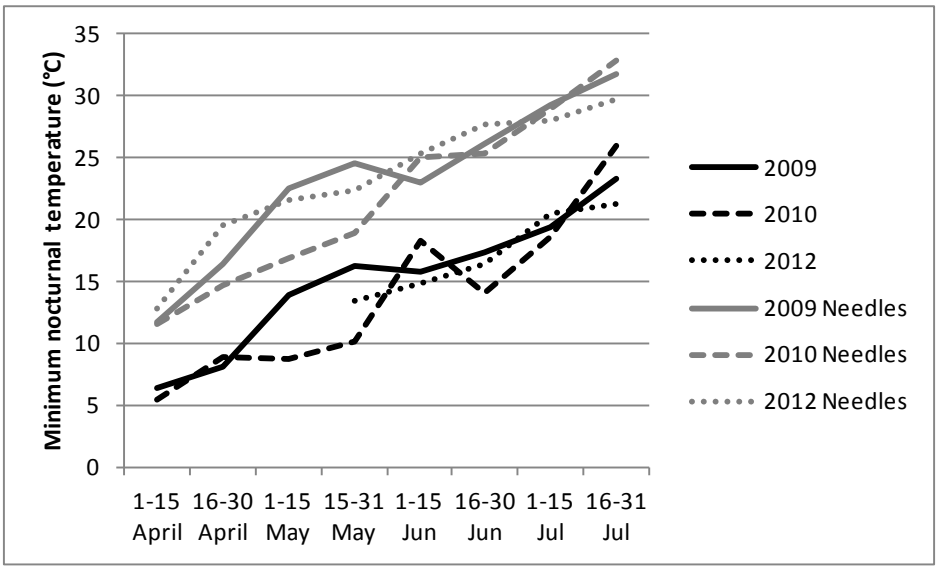

Figure 9.10. Mean minimum nocturnal temperature in the target area and at the Needles weather station in 2009, 2010, and 2012.

Vapor pressure in the target area (Figure 9.11) fluctuated in 2009 and 2010 in accordance with the dew point recorded at the Needles weather station. Vapor pressure recorded in 2012 was similar to that recorded in the other two years, but no dew point data were available from the weather station for comparison.

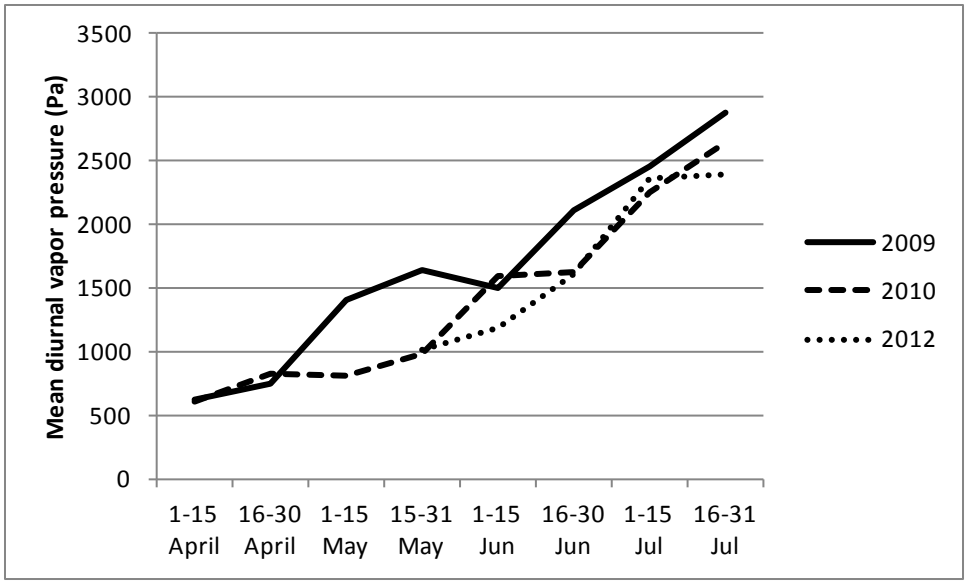

Figure 9.11. Mean diurnal vapor pressure in the target area in 2009, 2010, and 2012.

Water Delivery Year

Water Delivery

Water delivery was initiated on 1 March 2011 and continued through 7 July 2011. The pump was operated once a week for several hours (Table 9.2), and the hours of operation and flowmeter readings were recorded in a log book.

Table 9.2. Dates of Water Mapping and Water Delivery, Length of Pump Operation, and Total Pump Output, Topock Marsh, 2011

Date of Pumping	Hours Operated	Total Pump Output (millions of gallons)	Total Pump Output (cubic meters)	Date(s) of Water Mapping
1 Mar	4.7	3.10	11735	27–28 Feb, 1–3 Mar
10 Mar	5.9	3.89	14725	11 Mar
17 Mar	3.3	2.18	8252	18 Mar
24 Mar	4.8	3.17	12000	25 Mar
31 Mar	5.3	3.50	13249	1 Apr
7 Apr	4.5	2.97	11243	8 Apr
13 Apr	4.3	2.84	10751	15 Apr
21 Apr	4.3	2.84	10751	22 Apr
28 Apr	4.5	2.97	11243	29 Apr
5 May	5.6	3.70	10221	---
12 May	4.0	2.64	9994	14 May

Table 9.2. Dates of Water Mapping and Water Delivery, Length of Pump Operation, and Total Pump Output, Topock Marsh, 2011 (Continued)

Date of Pumping	Hours Operated	Total Pump Output (millions of gallons)	Total Pump Output (cubic meters)	Date(s) of Water Mapping
19 May	4.1	2.71	10258	20 May
26 May	1.8	1.19	4505	24 and 29 May
2 Jun	3.5	2.31	8744	3 Jun
9 Jun[1]	4.2	2.77	10493	8 Jun
16 Jun[1]	4.2	2.77	10493	17 Jun
23 Jun	4.0	2.64	9994	22 Jun
30 Jun	4.5	2.97	11243	1 Jul
7 Jul	4.0	2.64	9994	6 and 15 Jul

[1] No data recorded, hours and pump output estimated from flowmeter reading on 23 Jun.

Surface Water Mapping

In 2011, immediately prior to the start of water delivery on 1 March, surface water was limited to pig wallows in Pierced Egg (Figure 9.12, map from 28 February). Surface water covered portions of In Between and 800M immediately after pumping on 1 March (Figure 9.12, map from 1 March). There was a noticeable decrease in water extent over the following two days (Figure 9.12, maps from 2 and 3 March; and Figure 9.13), but we determined that weekly pumping would be sufficient to maintain elevated water levels within the target area. From March to late May, all weekly visits occurred on the day immediately following water delivery. Starting in late May, we alternated our weekly visits to fall on the day before water delivery and the day after water delivery so we could document minimum and maximum extent of water. During this latter part of the season, the extent of the inundated and saturated area in In Between and 800M remained relatively constant throughout each week following pumping (Figure 9.14). In general, water delivery maintained water levels above those of 2010 (Figure 9.13), despite the markedly lower water levels within Topock Marsh in 2011 compared to 2010.

We noted an increase in surface water within Pierced Egg starting in March 2011 and peaking by mid-April; by the end of April, Pierced Egg was completely dry (Figure 9.15). Surface water from the pumping did not flow into Pierced Egg, and the fluctuation of water levels in Pierced Egg was likely the result of a rise in local groundwater levels, which typically peak in April (see Groundwater Monitoring, below) and could also have been influenced by water delivery. The peak in groundwater levels is reflected in the overall percentage of In Between, 800M, and Pierced Egg that was inundated or saturated, which also peaked in mid-April and fell rapidly by early May (Figure 9.13). Water delivery appeared to result in a greater extent of surface water early in the season when overall groundwater levels throughout the area were relatively high. Later in the season, when overall groundwater levels had dropped, surface water was generally restricted to In Between, with portions of 800M sometimes having saturated soil.

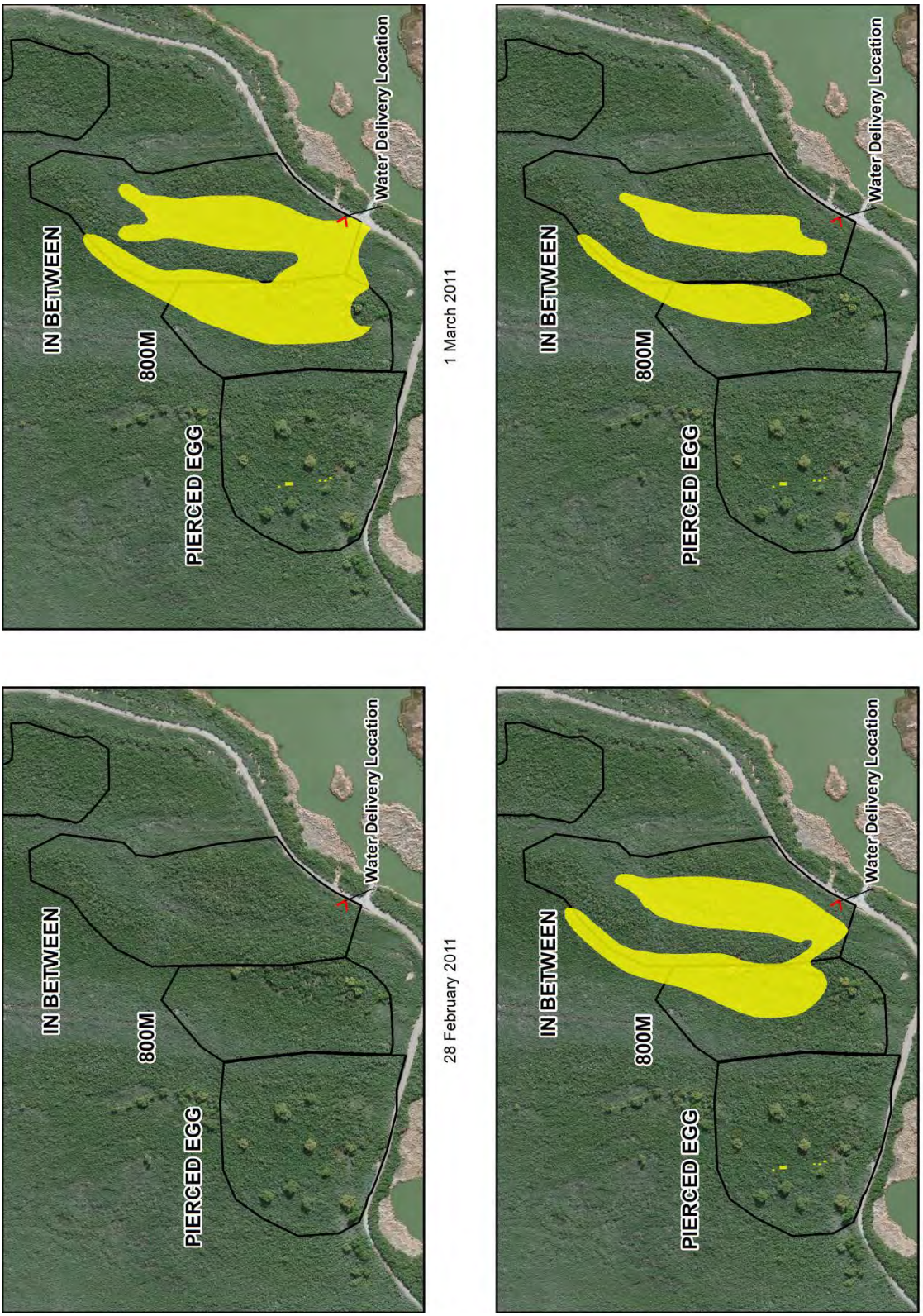

Figure 9.12. Extent of surface water within In Between, 800M, and Pierced Egg for the day before, the day of, and two days after the start of water delivery, 2011.

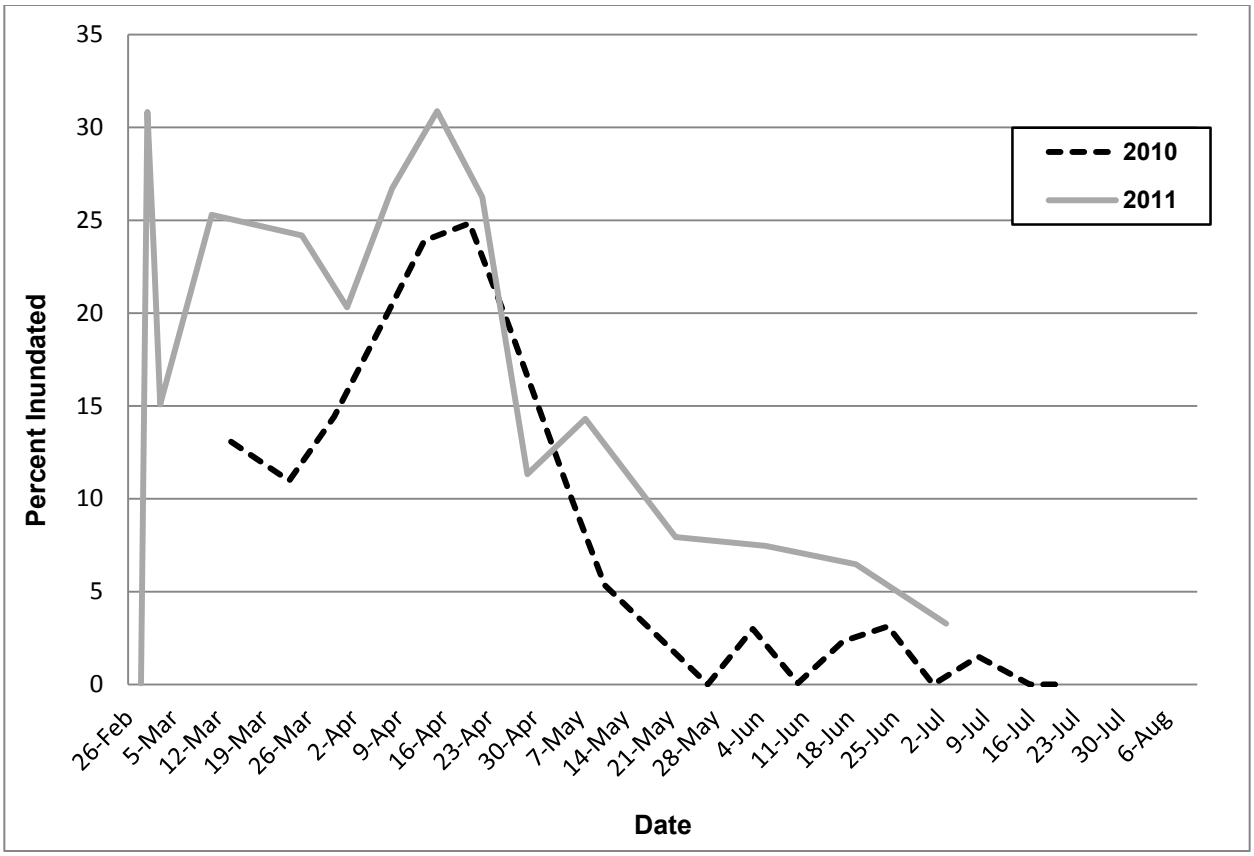

Figure 9.13. Percentage of In Between, 800M, and Pierced Egg, combined, that was inundated in March–July 2010 and 2011. Percentages are averaged over two-week periods for June and July 2011, because weekly visits alternated between the day before and the day after pumping.

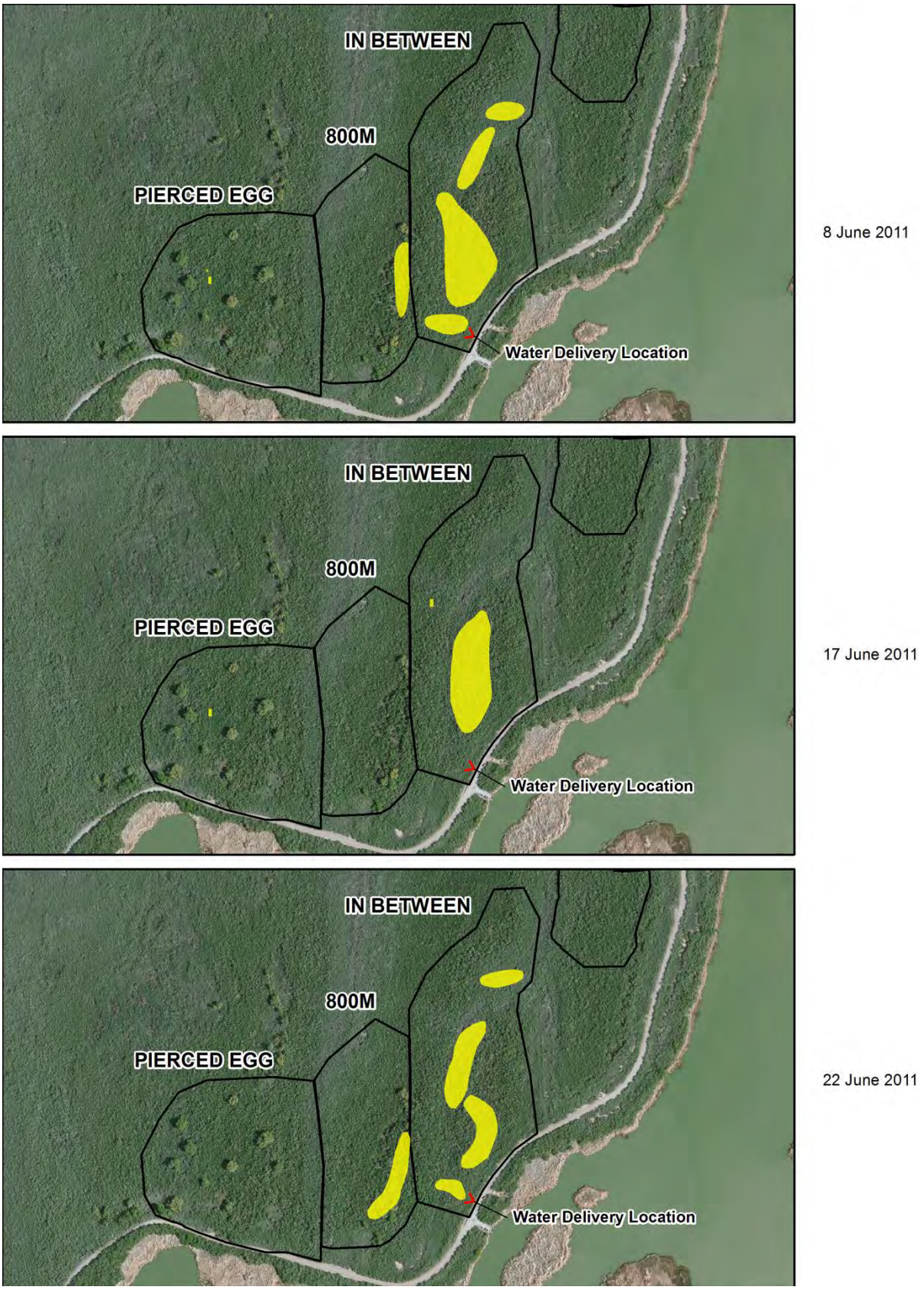

Figure 9.14. Extent of water within In Between, 800M, and Pierced Egg in June 2011.

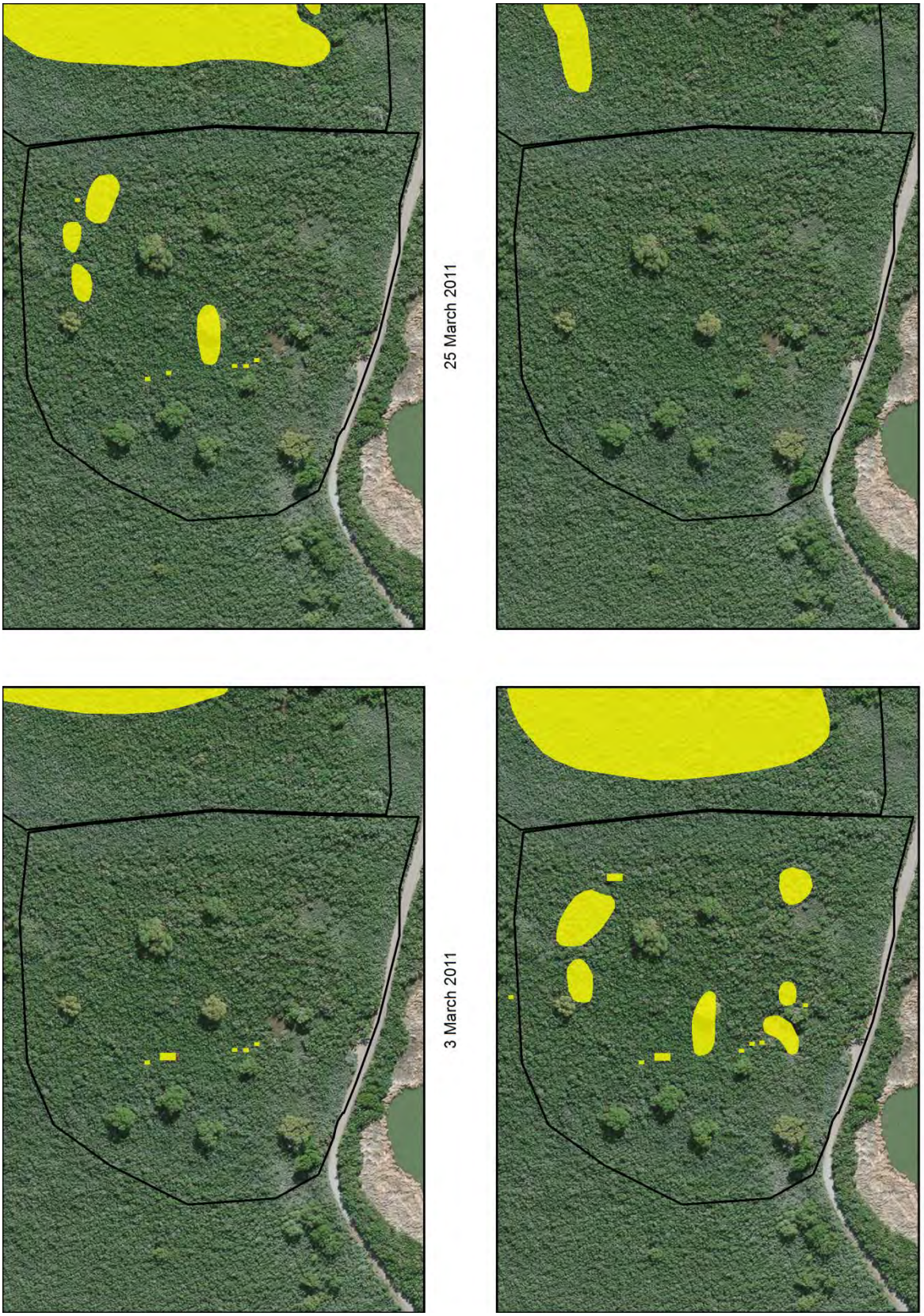

Figure 9.15. Extent of surface water within Pierced Egg at approximately bi-weekly intervals in March and April, 2011.

Groundwater Monitoring

Weekly trends in groundwater levels were apparent in March–July 2011 (Figure 9.16) and paralleled the pumping schedule, with groundwater rising on the day of pumping and falling through the week until the next pumping. When groundwater levels were at relatively high levels in March and April, each pumping session increased the groundwater level at the piezometer approximately 0.08 m (0.25 feet) and then the water level fell linearly through the week until the next pumping session. As water levels dropped in May and June, the effect of each pumping session on the water level at the piezometer increased; each pumping session increased the water level by up to 0.23 m (0.75 feet), and water levels fell more rapidly immediately following pumping than they did later in the week. The groundwater level recorded by the piezometer peaked at the highest level recorded in any year since 2006, showing that water delivery raised the local groundwater table within the target area despite the overall lower water table in the marsh.

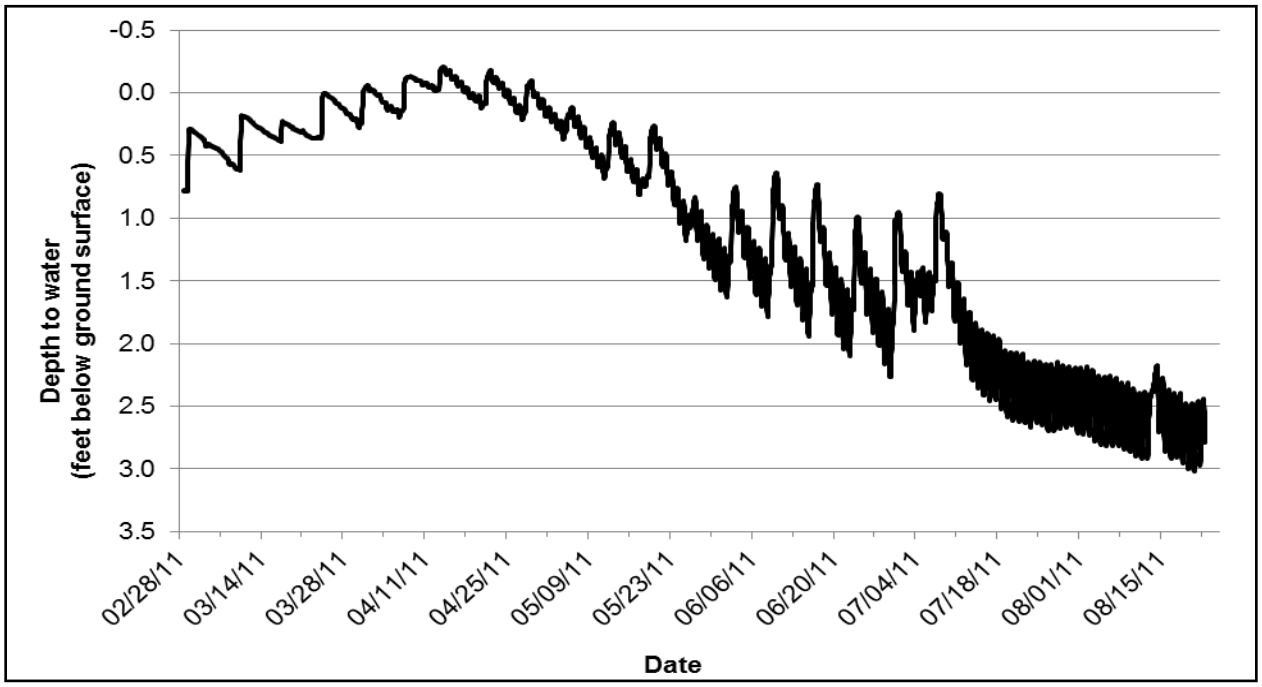

Figure 9.16. Topock Marsh hydrograph, February–July, 2011.

Microclimate

In 2010, we deployed 15 HOBO loggers in the flooded area and 17 loggers in the non-flooded area between 14 and 29 March (Figure 9.17). All loggers functioned correctly in 2010. In 2011, we deployed HOBO loggers in these same locations between 27 February and 11 March. In 2011, two loggers, one in the flooded area and one in the non-flooded area, failed to launch and collected no data; one logger in the flooded area had a faulty humidity sensor, and humidity data from this logger were excluded from the analysis. Data analyses were restricted to the period between 1 April and 15 July to encompass the dates when all loggers were deployed in both years. In 2010, soil conditions became progressively drier throughout the season for both the flooded and non-flooded areas, while temperatures rose throughout the season and vapor pressure values showed the typical rise seen in July with the onset of summer monsoons (Tables 9.3 and 9.4). These same overall patterns were seen in 2011 (Tables 9.5 and 9.6). These data are shown graphically for easier comparison of data between years (Figures 9.18a–9.26a). Data are also shown as the difference between the flooded and non-flooded areas in both 2010 (the control year) and

2011 (Figures 9.18b–9.26b). If flooding had no effect, we would expect the differences between the flooded and non-flooded areas to be similar in both years.

Table 9.7 presents the significance test results (*P*-values) for the comparison of flooded versus non-flooded areas in 2010 and 2011. The first two columns show the comparison of each microclimate variable, overall across the season, in the flooded versus non-flooded areas in 2010 and 2011, respectively. Baseline data were collected in 2010, so significant *P*-values in this column indicate inherent differences between the flooded and non-flooded areas. A significant *P*-value in the column for a given year indicates a difference between flood groups, and corresponds to a significant gap between the solid (flooded) and dashed (non-flooded) lines for that year in Figures 9.18a–9.26a. A significant *P*-value for a given variable in only one year but not both suggests an effect of flooding. We also examined how each microclimate variable changed through the season. The third and fourth columns of Table 9.7 show *P*-values for the comparison of seasonal change in the flooded vs. non-flooded areas (i.e., the time*flood group interaction) in 2010 and 2011, respectively. Significant *P*-values in either column indicate that the microclimate variable changed through the season in the flooded area in a different way than in the non-flooded area in that year, and corresponds to non-parallel solid (flooded) and dashed (non-flooded) lines for that year in Figures 9.18a–9.26a. Again, a significant *P*-value for a given variable in one year but not the other suggests an effect of flooding.

We also examined between-year differences for soil moisture variables within the non-flooded and flooded areas (columns 5 and 6, respectively, of Table 9.7). We did not include results for the between-year analysis for temperature and humidity variables because significant between-year differences could be the result of variation in climate between years, and any between-year differences are difficult to interpret in a meaningful way. A significant *P*-value indicates an overall between-year difference within the flood group and corresponds to a significant gap between the gray (2010) and black (2011) lines for that flood group in Figures 9.18a–9.21a.

Finally, we compared change through the season for soil moisture variables in 2010 versus 2011 (i.e., the time*year interaction) within the non-flooded and flooded areas (columns 7 and 8, respectively, of Table 9.7). Again, we did not include the results of this analysis for temperature and humidity variables because any between-year differences are difficult to interpret in a meaningful way. A significant *P*-value indicates that, within the given flood group, the variable changed through time in 2010 in a different way than it changed through time in 2011. This corresponds to non-parallel gray (2010) and black (2011) lines for the flood group in Figures 9.18a–9.21a.

None of the measures of soil moisture and presence of surface water differed overall between flooded and non-flooded areas in 2010 under baseline conditions (Table 9.7, column 1). In 2011, three measures of surface water (distance to surface water, percentage of the area within 20 m that was flooded, and percentage of the area within 50 m that was flooded) differed between the flooded and non-flooded area (Table 9.7, column 2), with all three variables indicating wetter overall conditions in the flooded area (Figures 9.19–9.21). Soil moisture and both measures of the percentage of the area inundated showed a significant interaction between flood group and time in 2011 (Table 9.7, column 4); soil moisture declined more rapidly in the flooded versus the non-flooded area as the extent of the flooding decreased through the season (Figure 9.18), and the measures of the percentage inundated decreased throughout the season in the flooded area while they remained constant (at zero) through the season in the non-flooded area (Figures 9.20 and 9.21). The non-flooded area differed significantly between years in soil moisture, distance to water, and percentage of the area within 50 m that was inundated (Table 9.7, column 5); all measures reflected the overall lower marsh levels and resulting drier conditions in 2011. The flooded area differed between years in all measures of surface water (Table 9.7, column 5), with all variables indicating wetter conditions in 2011. Overall soil moisture in the flooded area did not differ significantly between years (Table 9.7, column 6) but did show a significant interaction between year and time (Table 9.7, column 8); soil moisture was higher in 2011 than in 2010 early in the season but had dropped to a

lower level in 2011 than in 2010 by early June, again illustrating the overall dry conditions in 2011 (Figure 9.18).

All measures of temperature (mean daily maximum, mean daily minimum, mean temperature range) tended toward being different (*P*-values between 0.04 and 0.07) between flooded and non-flooded areas in 2010 under baseline conditions (Table 9.7, column 1), with the flooded area having lower maximum temperatures, higher minimum temperatures, and a smaller daily temperature range than the non-flooded area (Figures 9.22–9.24). This pattern persisted in 2011 (Table 9.7, column 2; Figures 9.22–9.24). The change in temperature variables through the season was similar in the flooded and non-flooded areas in 2010 (Table 9.7, column 3) but not in 2011 (Table 9.7, column 4). In 2011, the flooded area began the season with lower maximum temperatures, higher minimum temperatures, and a smaller daily temperature range when compared to the non-flooded area; these differences diminished steadily as the season progressed (Figures 9.22–9.24).

Diurnal and nocturnal vapor pressure did not differ significantly between flooded and non-flooded areas under baseline conditions in 2010 (Table 9.7, column 1). In 2011, both measures of humidity were higher in the flooded versus non-flooded area (Figures 9.25 and 9.26), but this difference was significant only for nocturnal vapor pressure (Table 9.7, column 2). The difference in nocturnal vapor pressure between flooded and non-flooded areas decreased through the season in 2011 (Table 9.7, column 4; Figure 9.26).

Comparison between day before and day after flood events – A comparison of temperature and humidity variables the day before and the day after each flood event in 2011 showed that, overall, flood events appeared to affect all temperature and humidity variables, and the effect was not constant through the season for any variable except mean diurnal vapor pressure (Table 9.8). The effect of flooding is graphed (Figures 9.27–9.30) to aid in interpretation of flooding effects. In each figure there are three graphs. The first graph shows the difference in the given microclimate variable between the day before and the day after each flood event for the flooded and non-flooded areas. The fluctuation in the non-flooded area between the day before and day after each flood events indicates the baseline change in general weather conditions; deviation in the flooded area from this baseline change suggests an effect of flooding. This deviation (the difference between the non-flooded and flooded areas) is depicted in the second graph in each figure. The third graph in each figure plots this deviation against baseline weather conditions to show whether the direction and magnitude of any effects of flooding varied based on underlying weather conditions.

Overall, the flooded area had a lower maximum diurnal temperature in relation to the non-flooded area on the day after a flood event than on the day before a flood event (Table 9.8, Figures 9.27a and 9.27b). The effect of flooding on the maximum diurnal temperature was related to the maximum temperature recorded on the day after a flood event in the non-flooded area (Figure 9.27c); flooding had the greatest effect of lowering the maximum temperature on hot days but raised the maximum temperature on relatively cool days. Overall, minimum nocturnal temperature on the day after a flood event was higher in the flooded area in relation to the non-flooded area than on the day before a flood event (Table 9.8, Figures 9.28a and 9.28b). The effect of flooding on minimum nocturnal temperature did not appear to be related to minimum nocturnal temperature (Figure 9.28c). Overall, the daily temperature range on the day after a flood event was smaller in the flooded area in relation to the non-flooded area than on the day before a flood event (Table 9.8, Figures 9.29a and 9.29b). This effect was strongly related to the maximum temperature on the day after a flood event, with flooding having the greatest effect of reducing the daily temperature range on hot days (Figure 9.29c).

Both diurnal and nocturnal vapor pressure on the day after a flood event were higher in the flooded area in relation to the non-flooded area than on the day before a flood event (Table 9.8, Figures 9.30a, 9.30b, 9.31a, and 9.31b). Diurnal vapor pressure was affected the most strongly in the middle of the season (Figure 9.30b), but this effect was not related to overall vapor pressure (Figure 9.30c). The effect on nocturnal vapor pressure was weakly, inversely related to ambient vapor pressure.

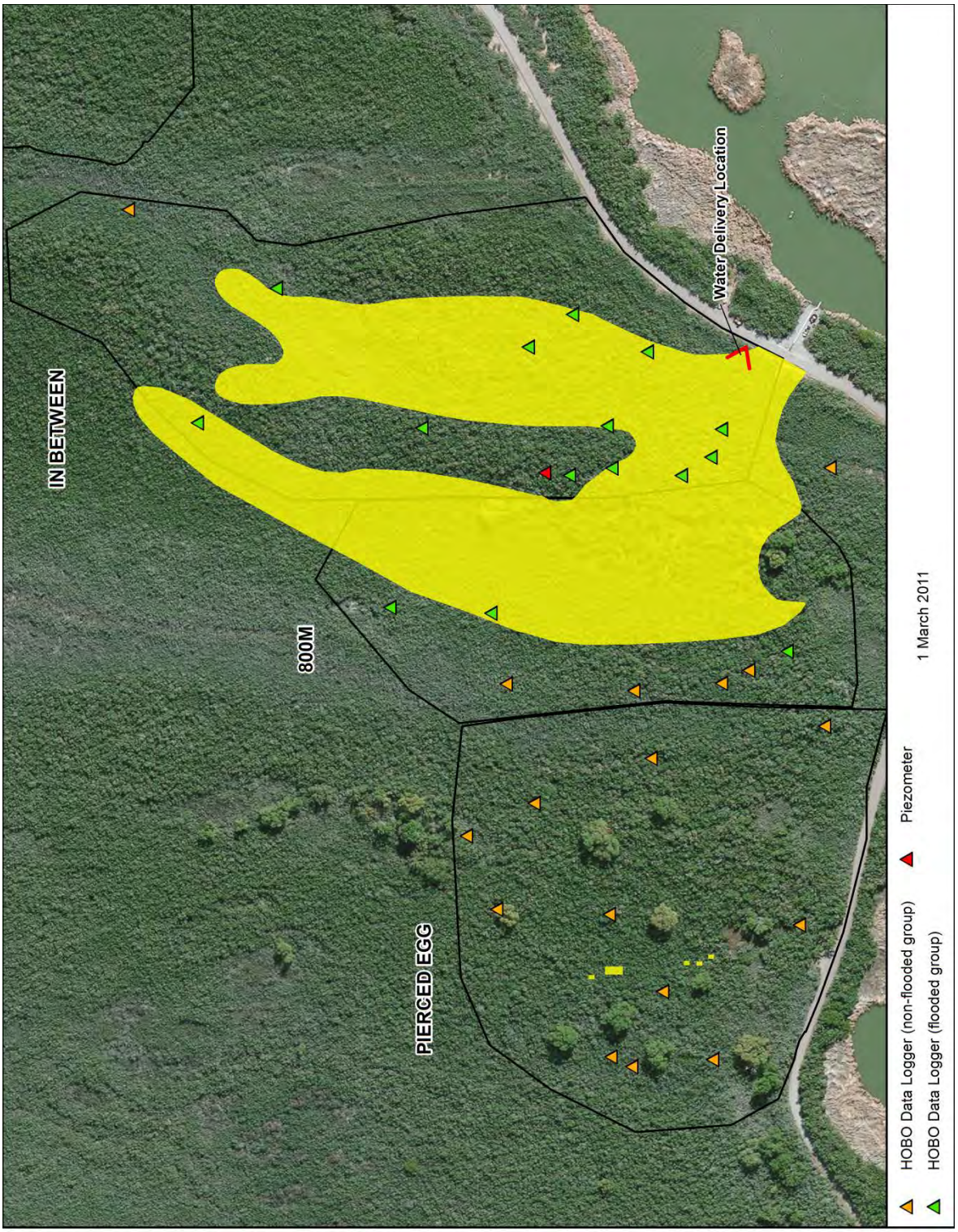

Figure 9.17. Locations of HOBO data loggers and piezometer at Topock Marsh, 2009–2012.

Table 9.3. Microclimate Measures at Topock Hydrology Monitoring Sites – Non-flooded Area (n = 17), 2010*

Microclimate Measure	April 1–15	April 16–30	May 1–15	May 16–31	June 1–15	June 16–30	July 1–15
Soil Moisture							
Mean soil moisture (mV)	911.4 (14.0)	897.9 (13.4)	881.2 (14.0)	878.6 (10.8)	863.2 (9.8)	836.8 (12.1)	867.3 (16.3)
Mean distance to nearest standing water	31.0 (6.2)	31.9 (6.1)	62.5 (8.7)	68.5 (8.1)	101.6 (10.6)	98.4 (10.8)	110.3 (17.9)
% of area within 20 m that was inundated	10.7 (6.3)	10.0 (5.0)	1.9 (1.9)	1.9 (1.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
% of area within 50 m that was inundated	18.7 (5.6)	12.4 (3.8)	1.8 (1.0)	2.0 (1.1)	0.0 (0.0)	0.3 (0.3)	0.0 (0.0)
Temperature							
Mean maximum diurnal temperature (°C)	35.3 (0.3)	36.2 (0.4)	38.4 (0.3)	38.5 (0.3)	41.9 (0.3)	43.1 (0.3)	43.4 (0.4)
Mean minimum nocturnal temperature (°C)	5.0 (0.2)	8.5 (0.3)	8.4 (0.2)	9.9 (0.2)	18.0 (0.2)	13.8 (0.2)	18.3 (0.2)
Mean daily temperature range (°C)	30.3 (0.3)	27.7 (0.4)	30.0 (0.3)	28.6(0.4)	23.9 (0.3)	29.4 (0.3)	25.1 (0.4)
Humidity							
Mean diurnal vapor pressure (Pa)	597.4 (9.3)	818.4 (13.4)	798.1 (14.1)	976.4 (16.2)	1588.5 (23.5)	1649.4 (28.5)	2279.7 (36.0)
Mean nocturnal vapor pressure (Pa)	652.2 (8.7)	888.1 (11.9)	890.9 (11.2)	1022.4 (12.4)	1537.7 (17.5)	1423.7 (16.8)	1929.9 (22.3)

* Data are presented as mean (standard error). Sample size indicates the number of data logger locations.

Table 9.4. Microclimate Measures at Topock Hydrology Monitoring Sites – Flooded Area (n = 15), 2010*

Microclimate Measure	April 1–15	April 16–30	May 1–15	May 16–31	June 1–15	June 16–30	July 1–15
Soil Moisture							
Mean soil moisture (mV)	908.1 (13.7)	908.0 (12.9)	892.7 (13.8)	838.4 (20.6)	853.9 (11.8)	834.3 (19.8)	804.5 (17.9)
Mean distance to nearest standing water	44.9 (9.7)	42.8 (9.3)	54.0 (10.2)	60.6 (17.1)	102.8 (11.9)	115.0 (13.4)	192.0 (23.3)
% of area within 20 m that was inundated	8.0 (6.7)	6.2 (4.4)	5.3 (4.6)	6.4 (5.7)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
% of area within 50 m that was inundated	13.5 (4.8)	15.5 (4.8)	10.1 (4.1)	6.7 (4.4)	4.1 (3.0)	0.0 (0.0)	0.0 (0.0)
Temperature							
Mean maximum diurnal temperature (°C)	32.2 (0.3)	33.7 (0.4)	35.7 (0.3)	36.3 (0.4)	39.8 (0.4)	40.9 (0.4)	40.9 (0.4)
Mean minimum nocturnal temperature (°C)	6.0 (0.2)	9.4 (0.3)	9.1 (0.2)	10.6 (0.2)	18.7 (0.2)	14.5 (0.2)	18.9 (0.2)
Mean daily temperature range (°C)	26.2 (0.4)	24.3 (0.5)	26.6 (0.4)	25.7 (0.4)	21.1 (0.4)	26.5 (0.4)	22.0 (0.5)
Humidity							
Mean diurnal vapor pressure (Pa)	611.7 (10.1)	834.7 (14.5)	813.2 (15.4)	998.5 (17.9)	1595.6 (24.6)	1612.9 (26.8)	2209.8 (35.8)
Mean nocturnal vapor pressure (Pa)	676.5 (9.5)	913.3 (12.7)	906.3 (11.5)	1043.2 (13.0)	1535.3 (18.6)	1418.7 (16.8)	1921.6 (23.7)

* Data are presented as mean (standard error). Sample size indicates the number of data logger locations.

Table 9.5. Microclimate Measures at Topock Hydrology Monitoring Sites – Non-flooded Area, 2011*

Microclimate Measure	April 1–15	April 16–30	May 1–15	May 16–31	June 1–15	June 16–30	July 1–15
Soil Moisture (n = 17)							
Mean soil moisture (mV)	883.8 (14.4)	904.1 (13.3)	878.4 (22.7)	835.4 (16.8)	811.4 (19.0)	819.4 (12.1)	817.4 (11.4)
Mean distance to nearest standing water	N/A	N/A	122.0 (61.1)	138.9 (21.6)	149.4 (19.4)	120.4 (16.3)	115.6 (13.9)
% of area within 20 m that was inundated	3.6 (10.9)	N/A	0.0 (1.9)	0.0 (0.0)	0.0 (0.0)	0.0 (40.0)	1.7 (1.7)
% of area within 50 m that was inundated	3.6 (3.6)	N/A	1.9 (1.4)	0.0 (0.0)	0.0 (0.0)	0.1 (0.1)	0.1 (0.1)
Temperature (n = 16)							
Mean maximum diurnal temperature (°C)	34.8 (0.5)	38.2 (0.3)	38.7 (0.3)	36.6 (0.3)	40.3 (0.3)	43.5 (0.2)	41.3 (0.3)
Mean minimum nocturnal temperature (°C)	6.8 (0.3)	11.0 (0.2)	9.3 (0.3)	11.6 (0.2)	12.5 (0.2)	18.0 (0.2)	20.0 (0.2)
Mean daily temperature range (°C)	28.1 (0.5)	27.2 (0.4)	29.4 (0.4)	25.0 (0.4)	27.8 (0.3)	25.5 (0.3)	21.3 (0.5)
Humidity (n = 16)							
Mean diurnal vapor pressure (Pa)	666.5 (14.2)	761.1 (13.8)	858.8 (15.9)	1066.2 (14.9)	1229.4 (24.5)	1598.9 (20.7)	2467.8 (43.7)
Mean nocturnal vapor pressure (Pa)	666.3 (12.5)	817.0 (13.8)	922.1 (13.6)	1033 (10.4)	1178.1 (19.1)	1436.8 (12.9)	2215.1 (32.2)

* Data are presented as mean (standard error). N/A = data not available. Sample size indicates the number of data logger locations at which useable data were collected.

Table 9.6. Microclimate Measures at Topock Hydrology Monitoring Sites – Flooded Area, 2011*

Microclimate Measure	April 1–15	April 16–30	May 1–15	May 16–31	June 1–15	June 16–30	July 1–15
Soil Moisture (n = 15)							
Mean soil moisture (mV)	955.6 (12.1)	944.3 (14.7)	893.7 (17.8)	867.8 (17.8)	779.1 (28.5)	768.8 (23.4)	809.6 (24.0)
Mean distance to nearest standing water	N/A	N/A	12.0 (4.7)	48.5 (23.6)	84.7 (20.5)	73.0 (18.7)	98.11 (20.0)
% of area within 20 m that was inundated	57.7 (10.9)	N/A	39.6 (10.0)	18.3 (8.1)	18.0 (8.3)	17.5 (6.4)	5.8 (3.2)
% of area within 50 m that was inundated	54.6 (10.5)	N/A	36.1 (7.7)	23.4 (8.3)	20.1 (9.7)	26.3 (8.7)	11.7 (4.9)
Temperature (n = 14)							
Mean maximum diurnal temperature (°C)	31.8 (0.5)	34.8 (0.3)	36.0 (0.4)	34.5 (0.4)	38.5 (0.3)	42.1 (0.3)	40.5 (0.4)
Mean minimum nocturnal temperature (°C)	8.1 (0.3)	12.1 (0.3)	10.3 (0.3)	12.3 (0.2)	13.2 (0.2)	18.9 (0.2)	20.6 (0.2)
Mean daily temperature range (°C)	23.7 (0.5)	22.7 (0.4)	25.6 (0.5)	22.2 (0.4)	25.2 (0.4)	23.2 (0.5)	19.9 (0.5)
Humidity (n = 13)							
Mean diurnal vapor pressure (Pa)	732.4 (16.5)	843.4 (16.5)	917.4 (18.5)	1110.9 (16.2)	1250.5 (25.1)	1631.8 (21.3)	2501.8 (49.7)
Mean nocturnal vapor pressure (Pa)	773.6 (14.4)	926.0 (17.1)	1031.2 (16.0)	1112.5 (12.8)	1255.2 (21.5)	1516.9 (16.6)	2251.2 (35.6)

* Data are presented as mean (standard error). N/A = data not available. Sample size indicates the number of data logger locations at which useable data were collected.

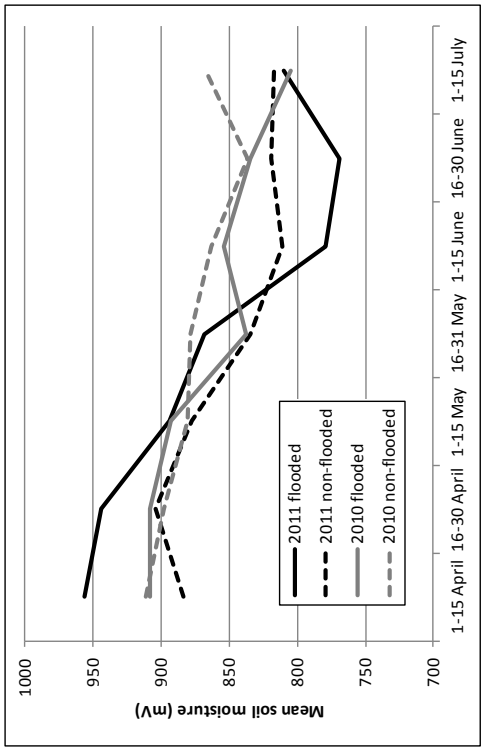

Figure 9.18a. Mean soil moisture by two-week periods in flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

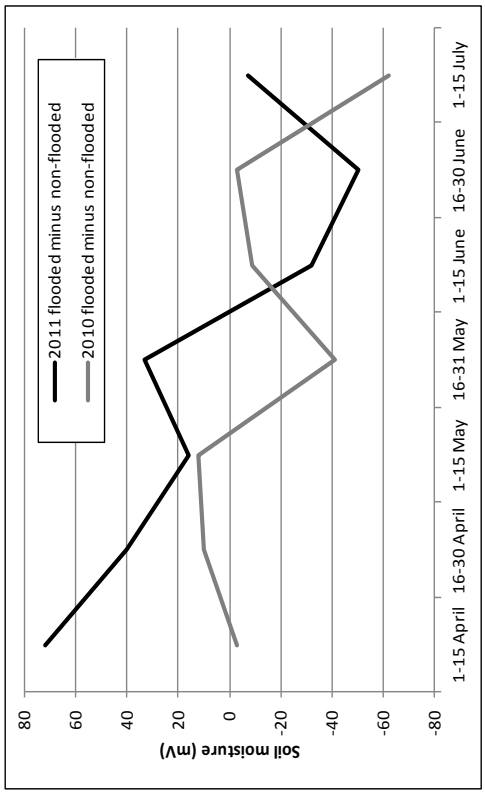

Figure 9.18b. Difference in soil moisture between flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

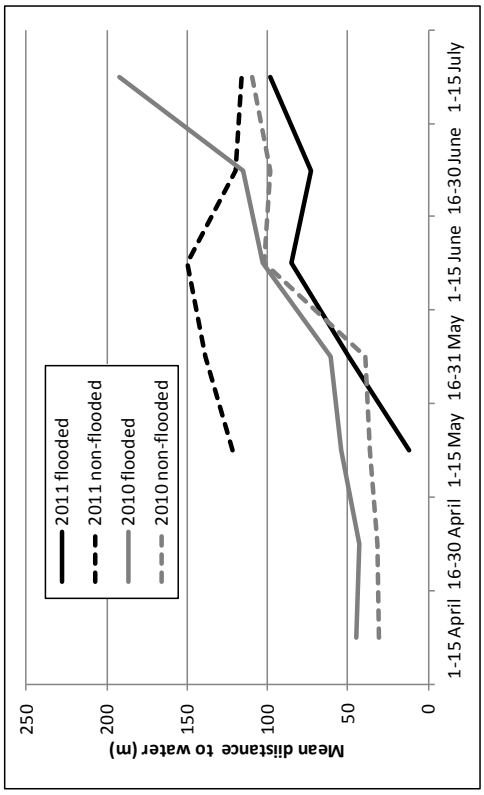

Figure 9.19a. Mean distance to water by two-week periods in flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

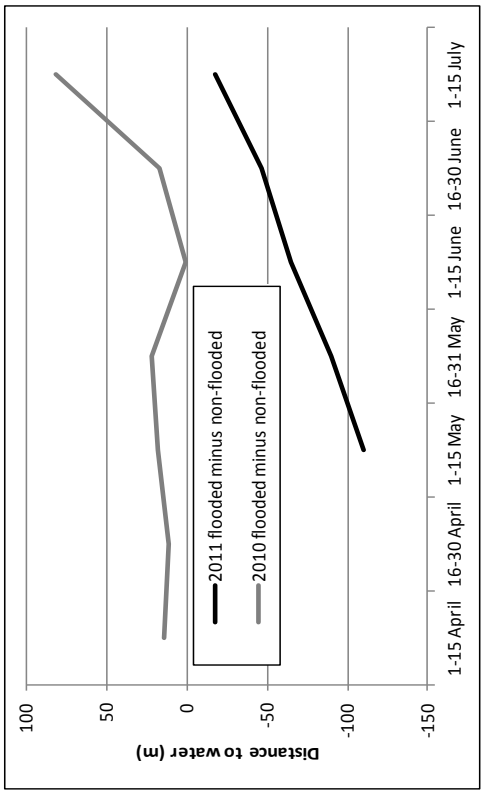

Figure 9.19b. Difference in distance to water between flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

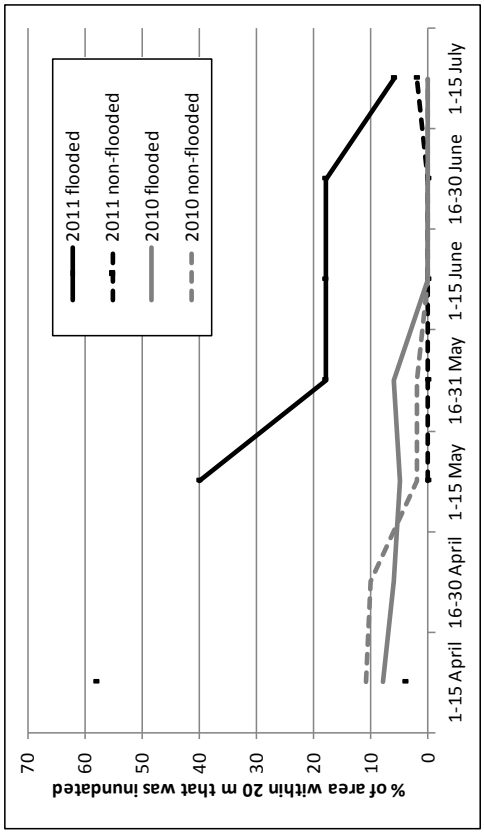

Figure 9.20a. Mean percent of area within 20 m that was inundated by two-week periods in flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

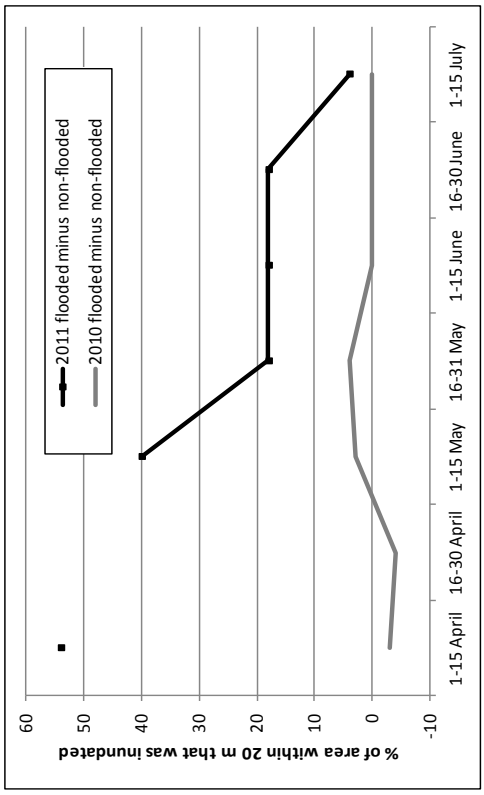

Figure 9.20b. Difference between flooded and non-flooded areas in percent of area within 20 m that was inundated, Topock Marsh, 2010 and 2011.

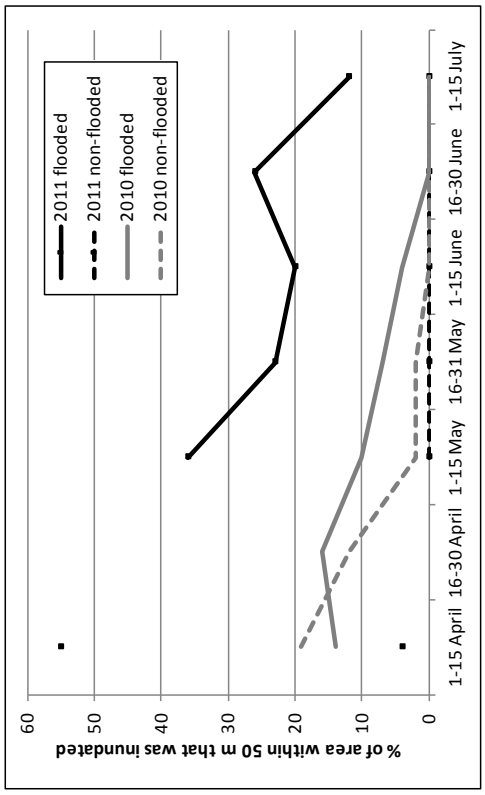

Figure 9.21a. Mean percent of area within 50 m that was inundated by two-week periods in flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

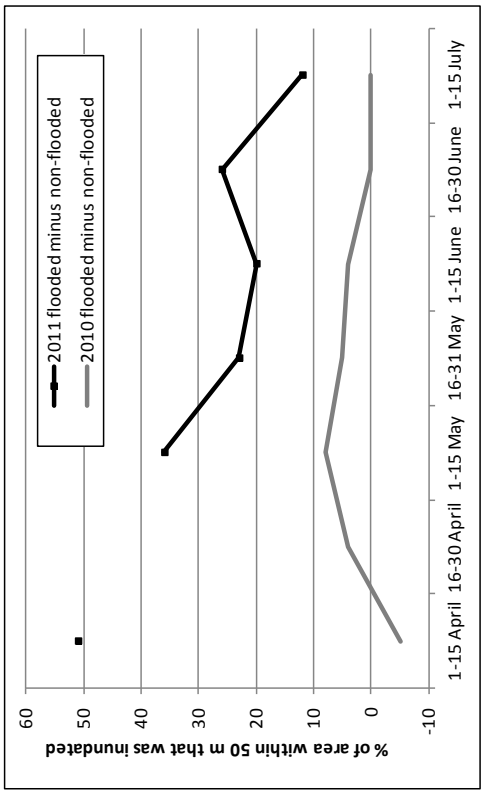

Figure 9.21b. Difference between flooded and non-flooded areas in percent of area within 50 m that was inundated, Topock Marsh, 2010 and 2011.

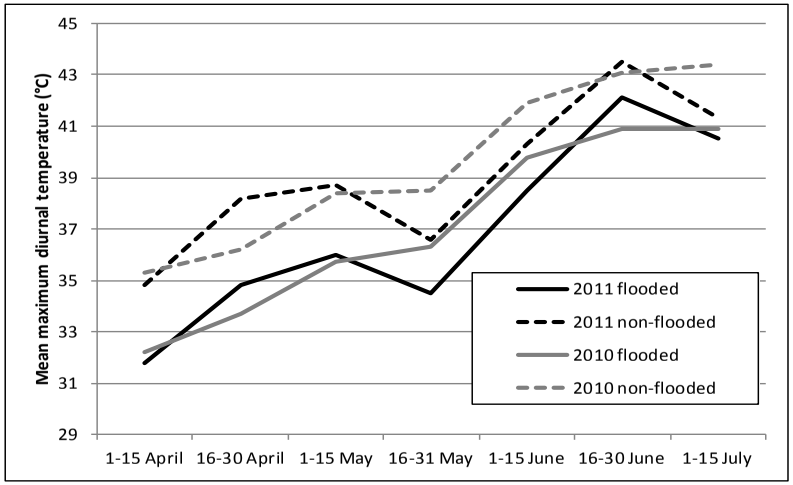

Figure 9.22a. Mean maximum diurnal temperature by two-week periods in flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

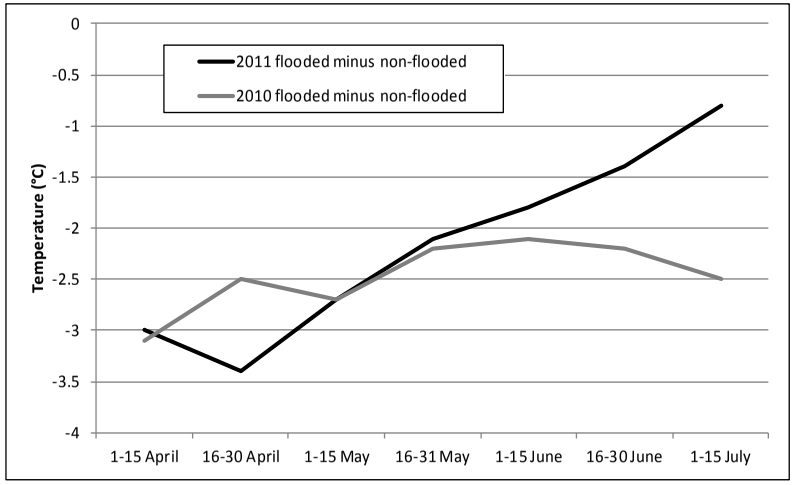

Figure 9.22b. Difference in mean maximum daily temperature between flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

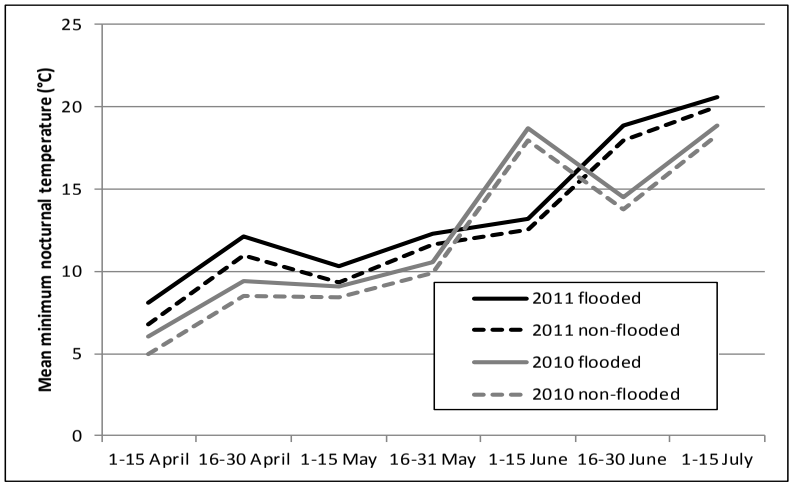

Figure 9.23a. Mean minimum nocturnal temperature by two-week periods in flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

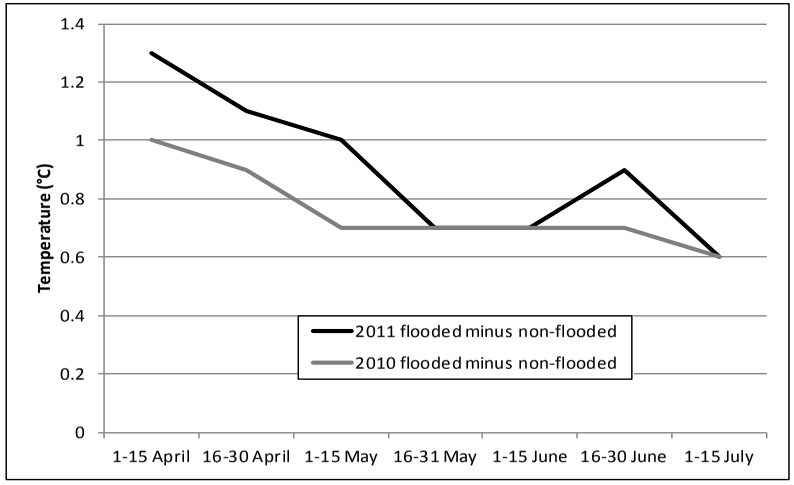

Figure 9.23b. Difference in mean minimum nocturnal temperature between flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

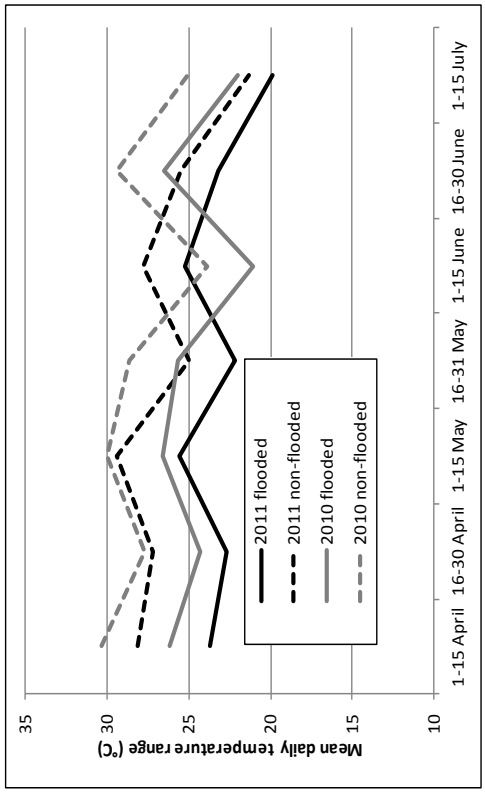

Figure 9.24a. Mean daily temperature range by two-week periods in flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

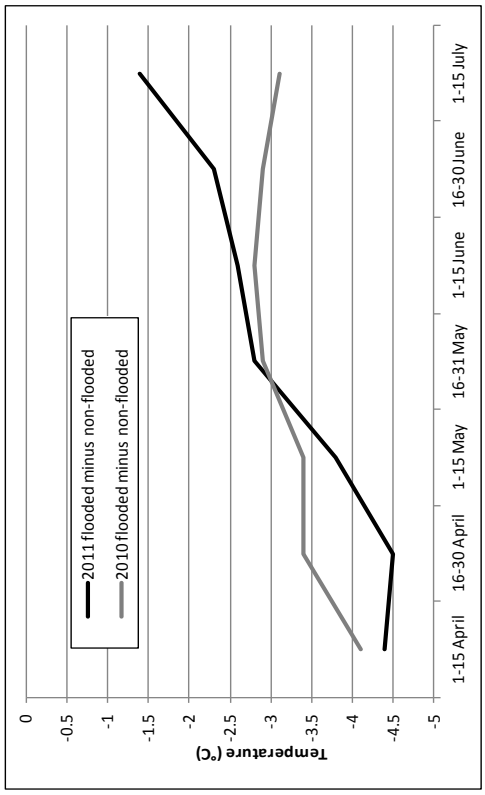

Figure 9.24b. Difference in daily temperature range between flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

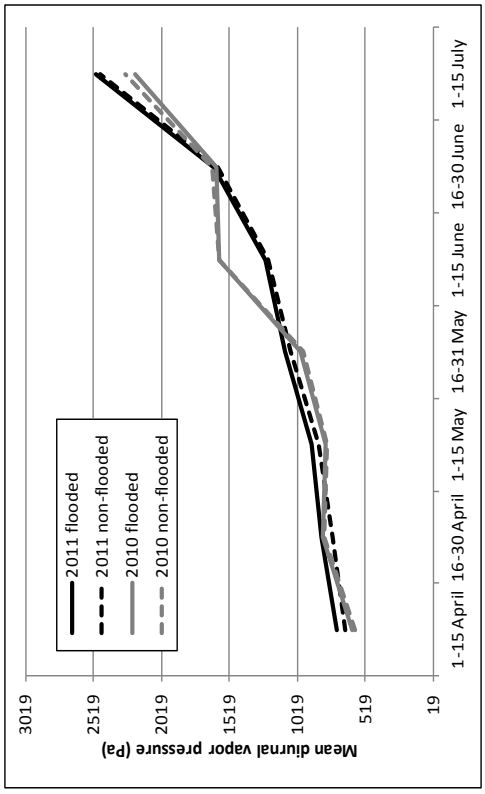

Figure 9.25a. Mean diurnal vapor pressure by two-week periods in flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

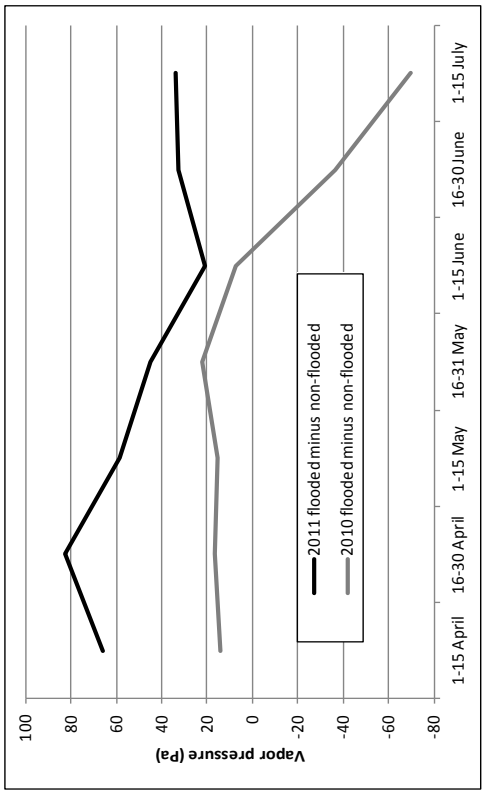

Figure 9.25b. Difference in diurnal vapor pressure between flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

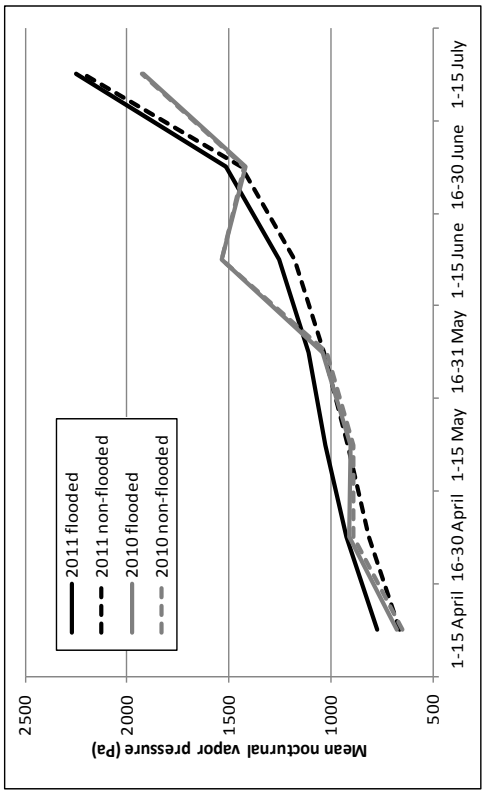

Figure 9.26a. Mean nocturnal vapor pressure by two-week periods in flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

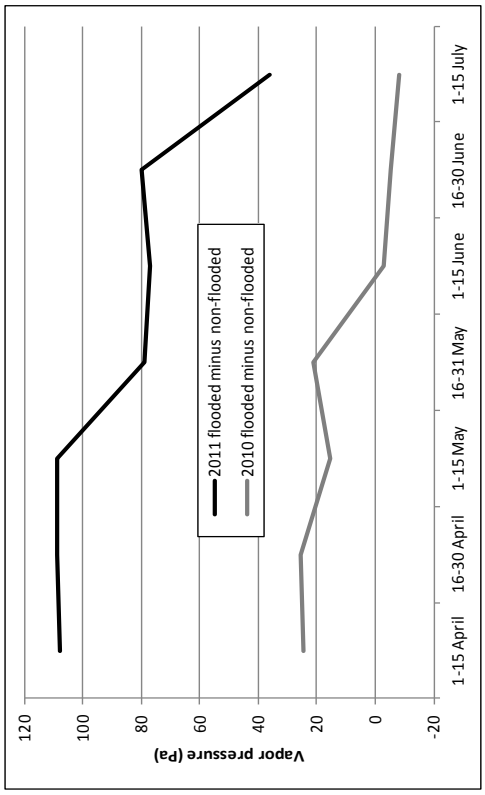

Figure 9.26b. Difference in nocturnal vapor pressure between flooded and non-flooded areas, Topock Marsh, 2010 and 2011.

Table 9.7. *P*-values from Repeated Measures Linear Mixed Model Analysis of Flooded and Non-flooded Areas, Topock Marsh, 2010 and 2011.

	Flooded vs. non-flooded areas overall, within the year (between flood group differences)		Change over the season for flooded vs. non-flooded areas, by year (interaction between flood group and time)		2010 vs. 2011 overall, within flood group (between-year differences)		Change over the season for 2010 vs. 2011, by flood group (interaction between year group and time)	
Parameter	**2010**	**2011**	**2010**	**2011**	**Non-flooded**	**Flooded**	**Non-flooded**	**Flooded**
Soil Moisture								
Mean soil moisture (mV)	0.329	0.563	0.014	<0.001	<0.001	0.884	0.131	0.009
Mean distance to nearest standing water	0.124	0.009	<0.001	0.173	<0.001	<0.001	0.066	0.023
% of area within 20 m that was inundated	0.997	<0.001	0.750	<0.001	0.208	<0.001	0.718	0.010
% of area within 50 m that was inundated	0.497	<0.001	0.147	0.001	0.026	<0.001	0.004	0.407
Temperature								
Mean maximum diurnal temperature (°C)	0.067	0.071	0.954	0.009	--	--	--	--
Mean minimum nocturnal temperature (°C)	0.069	0.044	0.088	<0.001	--	--	--	--
Mean daily temperature range (°C)	0.041	0.047	0.802	0.001	--	--	--	--
Humidity								
Mean diurnal vapor pressure (Pa)	0.943	0.349	0.618	0.845	--	--	--	--
Mean nocturnal vapor pressure (Pa)	0.751	0.011	0.170	0.012	--	--	--	--

* Data restricted from April 1 through July 15 for both years. For 2011, distance-to-water measures do not include April and percent inundated measures do not include April 16-30.

Table 9.8. Difference in Temperature and Humidity Measures Between the Day After and Day Before Pumping in Flooded and Non-flooded Areas, Topock Marsh, 2011*

Day of flooding	Maximum diurnal temperature		Minimum nocturnal temperature		Daily temperature range		Mean diurnal vapor pressure		Mean nocturnal vapor pressure	
	Non-Flooded	Flooded	Non-Flooded	Flooded	Non-Flooded	Flooded	Non-Flooded	Flooded	Non-Flooded	Flooded
31 March	9.3	8.6	5.8	6.3	3.5	2.3	113.2	190.7	155.2	275.4
7 April	-18.9	-15.5	-1.5	-3.6	-17.4	-11.9	-194.4	-191.8	-443.1	-495.4
13 April	-5.5	-5.0	2.6	2.6	-8.0	-7.6	-263.6	-338.0	-263.7	-292.1
21 April	0.1	-0.9	-3.6	-2.9	3.6	2.0	-193.7	-154.0	-41.8	-21.3
28 April	2.4	1.9	11.1	9.1	-8.7	-7.2	201.0	239.3	-152.9	-264.2
5 May	3.0	2.0	4.5	4.3	-1.3	-2.3	261.9	323.6	260.4	249.5
12 May	5.5	5.0	2.8	4.0	2.7	1.0	95.5	149.7	93.4	175.2
19 May	11.9	11.1	-0.4	0.4	12.2	10.7	-269.0	-170.6	26.8	83.3
26 May	0.6	0.7	4.7	4.7	-4.1	-3.9	57.7	132.3	-38.9	50.1
2 June	4.8	3.6	-3.4	-2.5	8.2	6.1	-150.2	-40.7	93.0	158.1
9 June	3.0	3.0	1.3	2.4	1.8	0.5	196.3	220.0	96.7	157.7
16 June	-3.9	-4.4	3.5	4.4	-7.3	-8.7	-328.5	-223.9	-90.9	-61.9
23 June	-0.8	-1.7	4.8	5.5	-5.6	-7.2	-84.3	-85.4	-7.2	55.6
30 June	0.2	-0.7	-11.4	-11.3	11.6	10.6	522.0	587.7	402.6	565.5
7 July	11.0	8.0	0.7	1.5	10.3	6.5	-190.4	-136.2	-212.0	-178.1
Mean (SE)	1.5 (0.6)	1.0 (0.6)	1.4 (0.4)	1.7 (0.4)	0.1 (0.7)	-0.6 (0.6)	-15.1 (22.3)	33.5 (23.9)	-8.2 (18.3)	30.5 (24.0)
P-values, flooded vs. non-flooded areas, overall	0.034		0.031		0.008		0.011		0.007	
P-values, change over the season for flooded vs. non-flooded areas (interaction between flood group and time)	0.003		<0.001		<0.001		0.542		<0.001	

* Differences are the day after flooding minus the day before flooding.

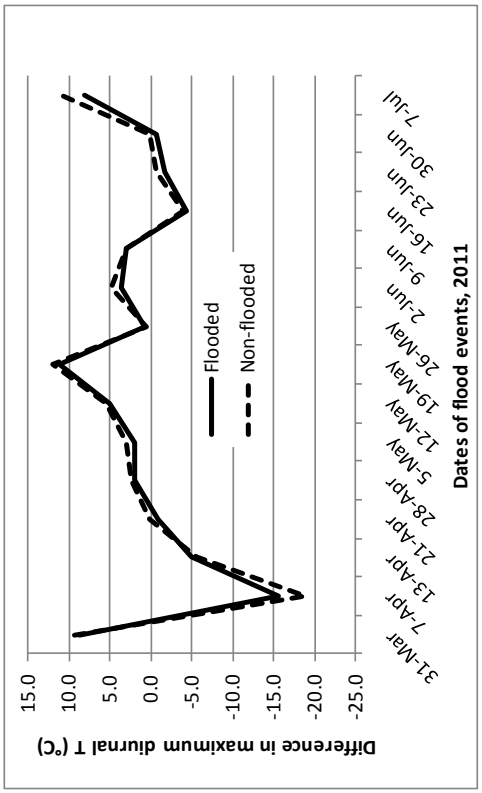

Figure 9.27a. Difference between the day before and day after (day after minus day before) each flood event in maximum diurnal temperature, flooded and non-flooded areas, Topock Marsh, 2011.

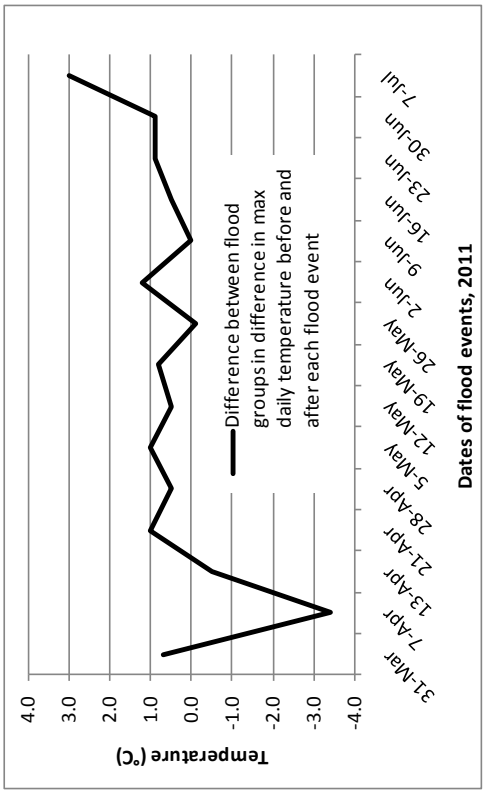

Figure 9.27b. Difference between flood groups (non-flooded minus flooded) in difference in maximum daily temperature before and after each flood event, Topock Marsh, 2011.

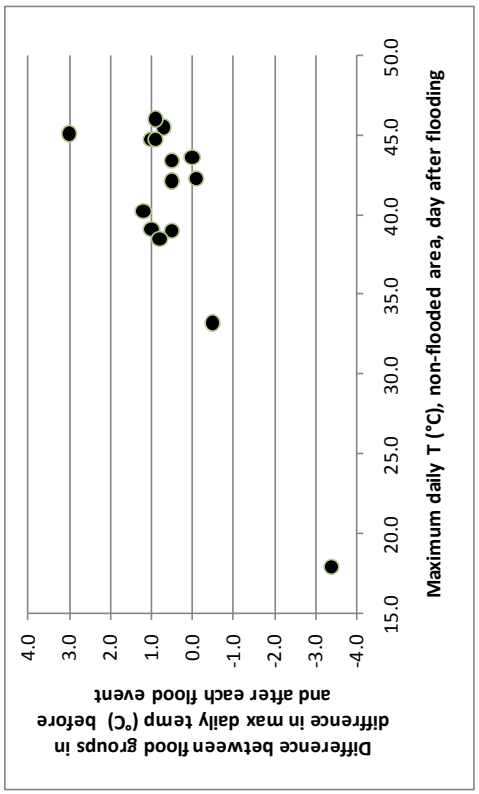

Figure 9.27c. Difference between flood groups in difference in maximum daily temperature before and after each flood event, plotted against maximum daily temperature in the non-flooded area on the day after flooding, Topock Marsh, 2011.

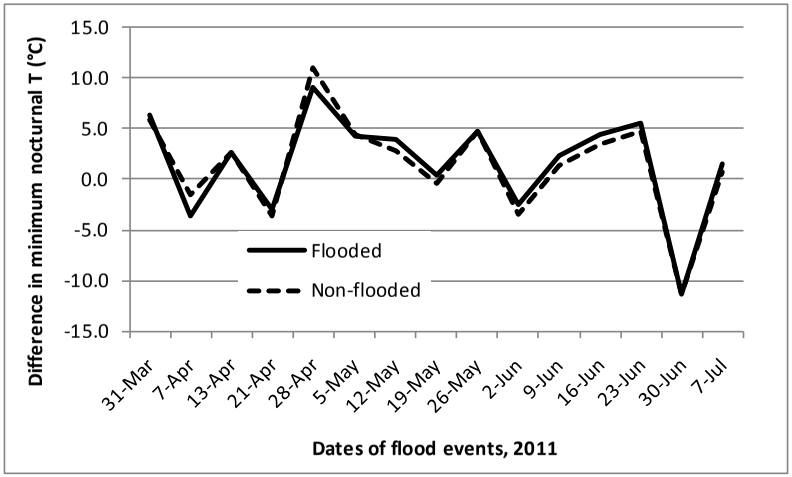

Figure 9.28a. Difference between the day before and day after (day after minus day before) each flood event in minimum nocturnal temperature, flooded and non-flooded areas, Topock Marsh, 2011.

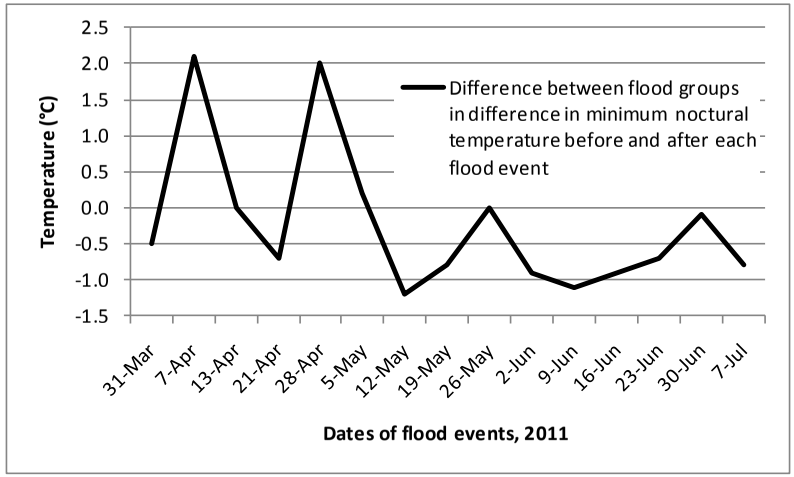

Figure 9.28b. Difference between flood groups (non-flooded minus flooded) in difference in minimum nocturnal temperature before and after each flood event, Topock Marsh, 2011.

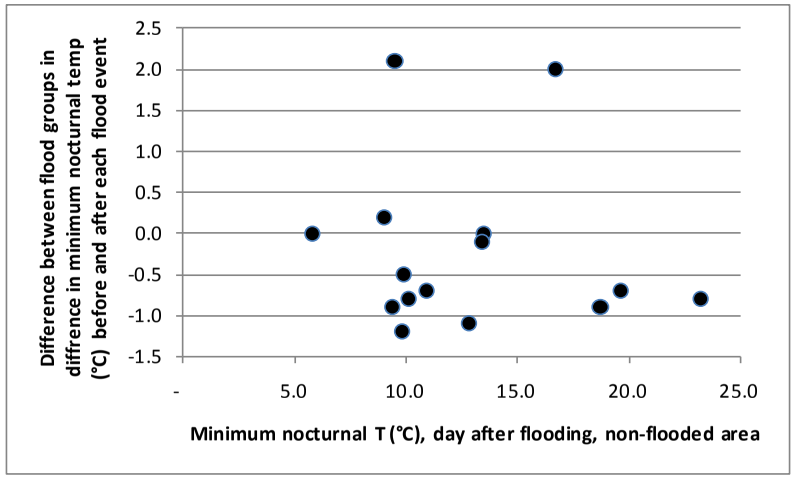

Figure 9.28c. Difference between flood groups in difference in minimum nocturnal temperature before and after each flood event, plotted against minimum daily temperature in the non-flooded area on the day after flooding, Topock Marsh, 2011.

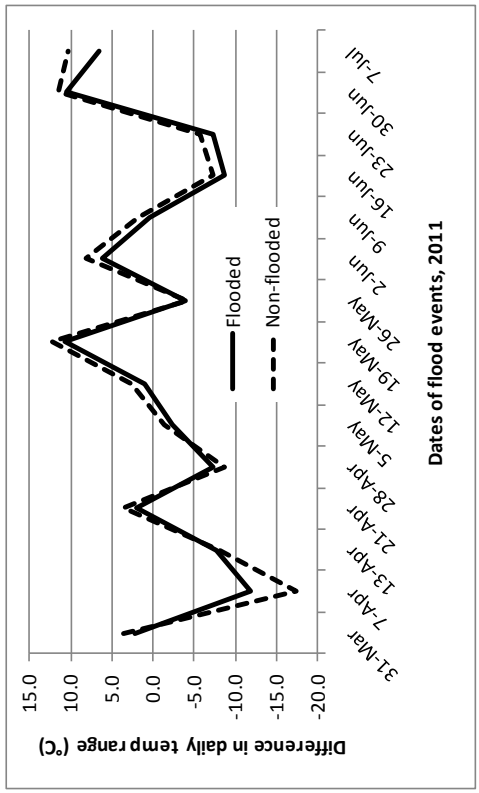

Figure 9.29a. Difference between the day before and day after (day after minus day before) each flood event in daily temperature range, flooded and non-flooded areas, Topock Marsh, 2011.

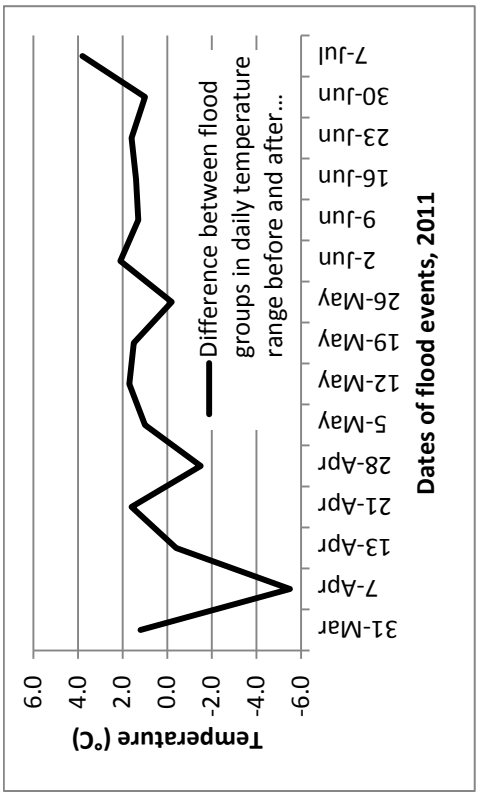

Figure 9.29b. Difference between flood groups (non-flooded minus flooded) in difference in daily temperature range before and after each flood event, Topock Marsh, 2011.

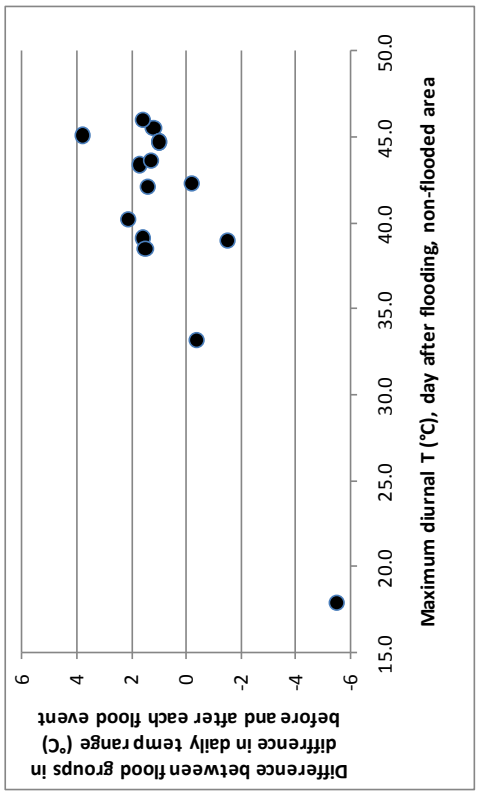

Figure 9.29c. Difference between flood groups in difference in daily temperature range before and after each flood event, plotted against maximum daily temperature in the non-flooded area on the day after flooding, Topock Marsh, 2011.

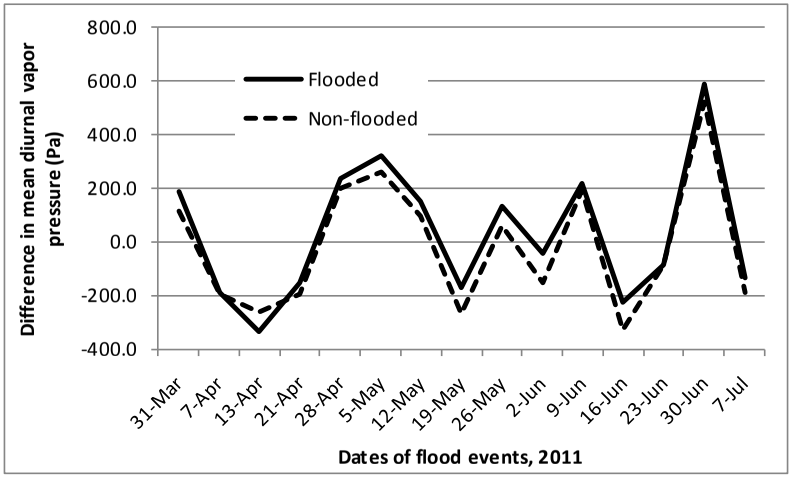

Figure 9.30a. Difference between the day before and day after (day after minus day before) each flood event in mean diurnal vapor pressure, flooded and non-flooded areas, Topock Marsh, 2011.

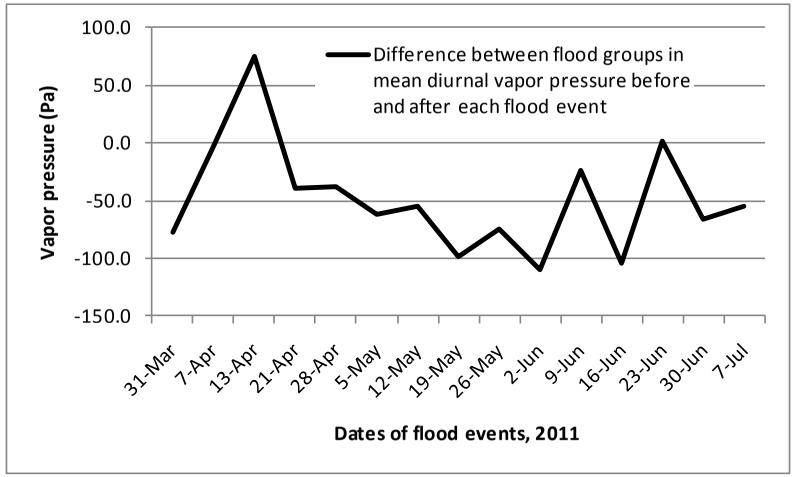

Figure 9.30b. Difference between flood groups (non-flooded minus flooded) in difference in mean diurnal vapor pressure before and after each flood event, Topock Marsh, 2011.

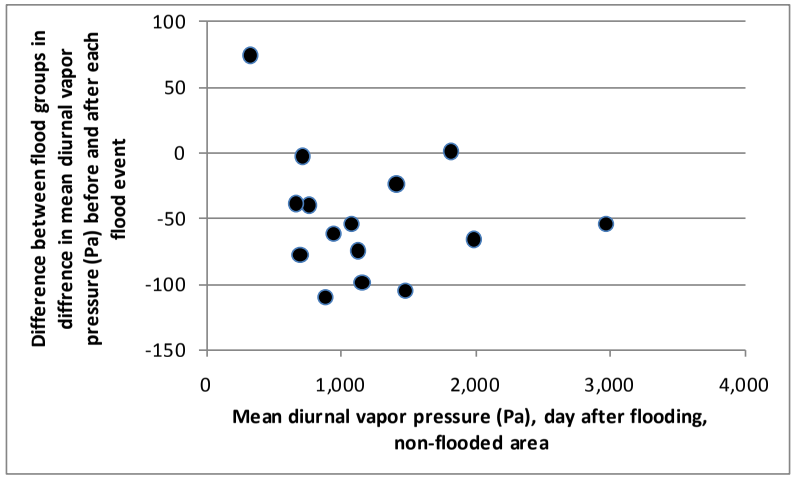

Figure 9.30c. Difference between flood groups in difference in mean diurnal vapor pressure before and after each flood event, plotted against mean diurnal vapor pressure in the non-flooded area on the day after flooding, Topock Marsh, 2011.

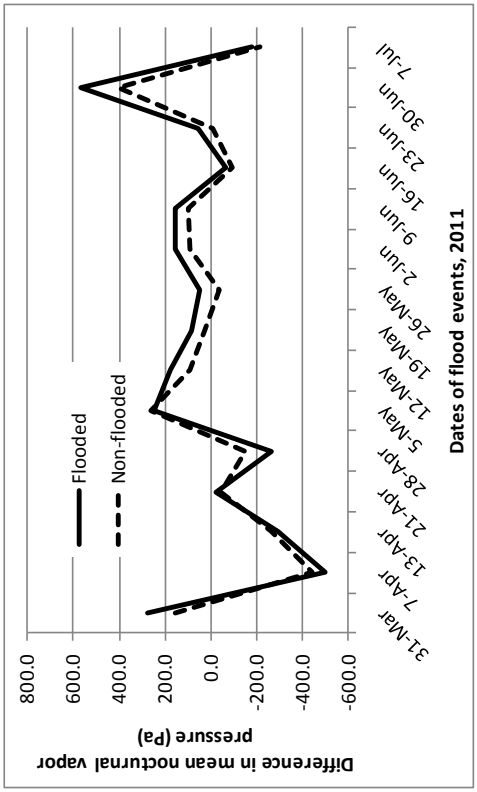

Figure 9.31a. Difference between the day before and day after (day after minus day before) each flood event in mean nocturnal vapor pressure, flooded and non-flooded areas, Topock Marsh, 2011.

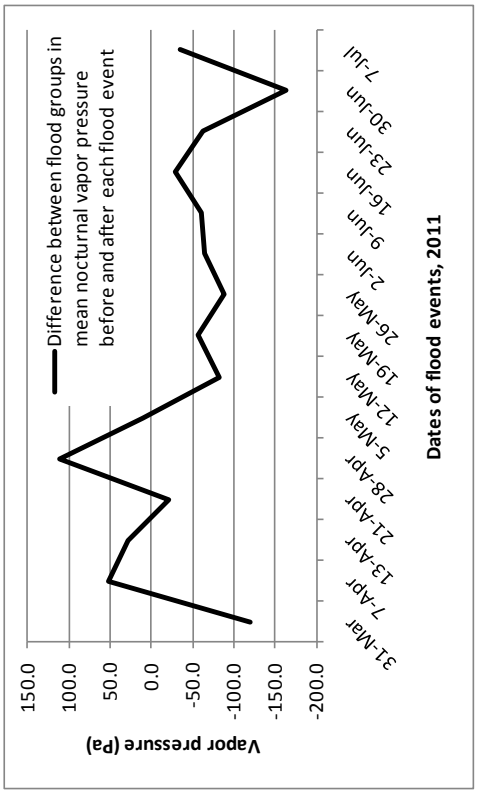

Figure 9.31b. Difference between flood groups (non-flooded minus flooded) in difference in mean nocturnal vapor pressure before and after each flood event, Topock Marsh, 2011.

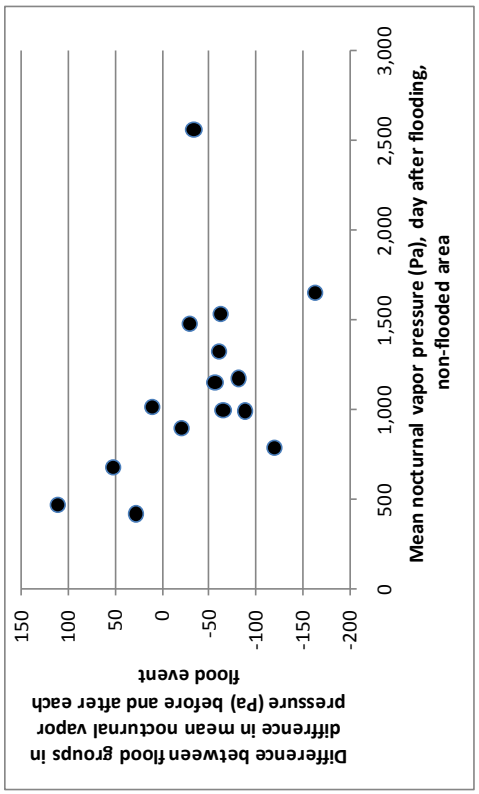

Figure 9.31c. Difference between flood groups in difference in mean nocturnal vapor pressure before and after each flood event, plotted against mean nocturnal vapor pressure in the non-flooded area on the day after flooding, Topock Marsh, 2011.

Vegetation

We collected vegetation data at all 15 flooded and 17 non-flooded locations. Vegetation characteristics in 2010 and 2011 are summarized in Table 9.9, and vertical foliage profiles are shown in Figures 9.32–9.35. Vegetation characteristics are typical of those documented in dense, tamarisk stands at Topock Marsh in previous years (McLeod et al. 2008a), with dense canopy closure and a small percentage of native vegetation.

Vegetation characteristics differed between years in both flooded and non-flooded areas in percent canopy closure, percent woody ground cover, and the amount of live vegetation in all height categories (Table 9.9, *P*-values in "Year" column). Percent canopy closure and percent woody ground cover were higher in 2011 than in 2010, while the number of hits of live vegetation recorded in all height categories was lower in 2011. Woody ground cover was the only variable that showed an interaction between year and flood group, meaning that the change in woody ground cover was different in the flooded area versus the non-flooded area (right-most column of Table 9.9). Woody ground cover increased more dramatically in the non-flooded area than in the flooded area.

Table 9.9. Summary of Vegetation Characteristics within Portions of Topock Marsh Selected for Habitat Enhancement, 2010 and 2011*

Parameter	2010		2011		*P*-value	
	Flooded	Non-flooded	Flooded	Non-flooded	Year	Year*flood group
Average canopy height (m)	6.3 (0.3)	5.9 (0.3)	6.2 (0.2)	5.9 (0.3)	0.725	0.904
	4.2–7.4	3.4–8.3	4.0–7.0	3.5–8.5		
% total canopy closure	89.5 (1.5)	88.7 (2)	94.3 (1)	90.7 (1.4)	0.007	0.260
	78.6–97.9	63–97.4	85.9–100	77.6–97.4		
% woody ground cover	23.7 (5.4)	13.2 (3.6)	45.8 (8.9)	77.1 (5.3)	<0.001	<0.001
	2.5–66.3	1–52.8	5.0–100.0	17.5–100		
Live vertical foliage (hits) below average nest height	2.6 (0.7)	3.0 (0.6)	1.4 (0.3)	2.1 (0.5)	0.018	0.718
	0.3–12.1	0.0–7.4	0.0–3.3	0.0–6.7		
Live vertical foliage (hits) at average nest height	2.6 (0.4)	2.7 (0.4)	1.6 (0.3)	2.0 (0.2)	<0.001	0.335
	0.1–5	0.8–6	0.2–3.8	0.3–3.9		
Live vertical foliage (hits) above average nest height	9.7 (0.7)	7.0 (1.1)	6.0 (0.6)	4.2 (0.7)	<0.001	0.433
	4.7–13.8	0.9–18.4	2.8–10.1	0.2–9.7		
Dead vertical foliage (hits) below average nest height	8.2 (0.7)	9.3 (0.5)	8.1 (0.7)	9.0 (0.6)	0.762	0.858
	2.4–13.1	5.1–13.4	4.8–13.4	5.1–14.2		
Dead vertical foliage (hits) at average nest height	1.9 (0.3)	2.0 (0.3)	2.2 (0.2)	1.9 (0.3)	0.460	0.241
	0.3–5.0	0.1–4.2	0.9–4.0	0.1–4.2		
Dead vertical foliage (hits) above average nest height	1.3 (0.4)	1.0 (0.2)	1.4 (0.3)	1.3 (0.2)	0.358	0.613
	0.0–3.9	0.0–2.9	0.0–3.2	0.0–4.1		
Percent native	0.0 (0.0)	5.3 (3.1)	0.0 (0.0)	7.5 (5)	0.680	0.680
	0.0–0.0	0.0–48.7	0.0–0.0	0.0–78.5		

* Data are presented as mean, standard error, and range. *P*-values for year indicate differences between years for both flooded and non-flooded locations combined. *P*-values for year*flooded indicate whether flooded areas changed between years differently than did non-flooded areas.

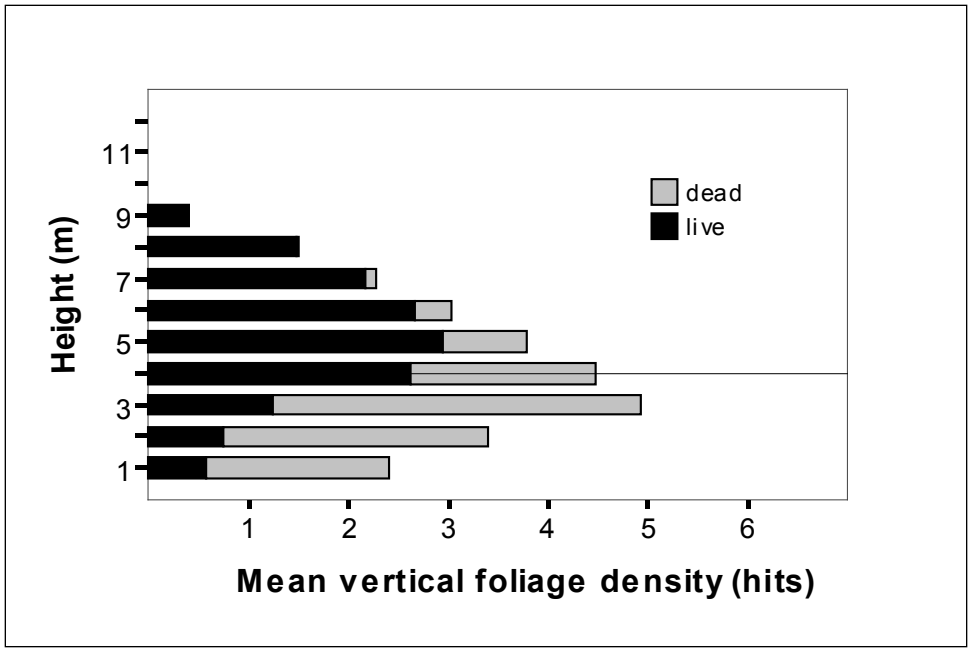

Figure 9.32. Vertical foliage density in flooded areas within the habitat enhancement project area, Topock Marsh, 2010. Horizontal line shows average nest height in the project area, 2003–2008.

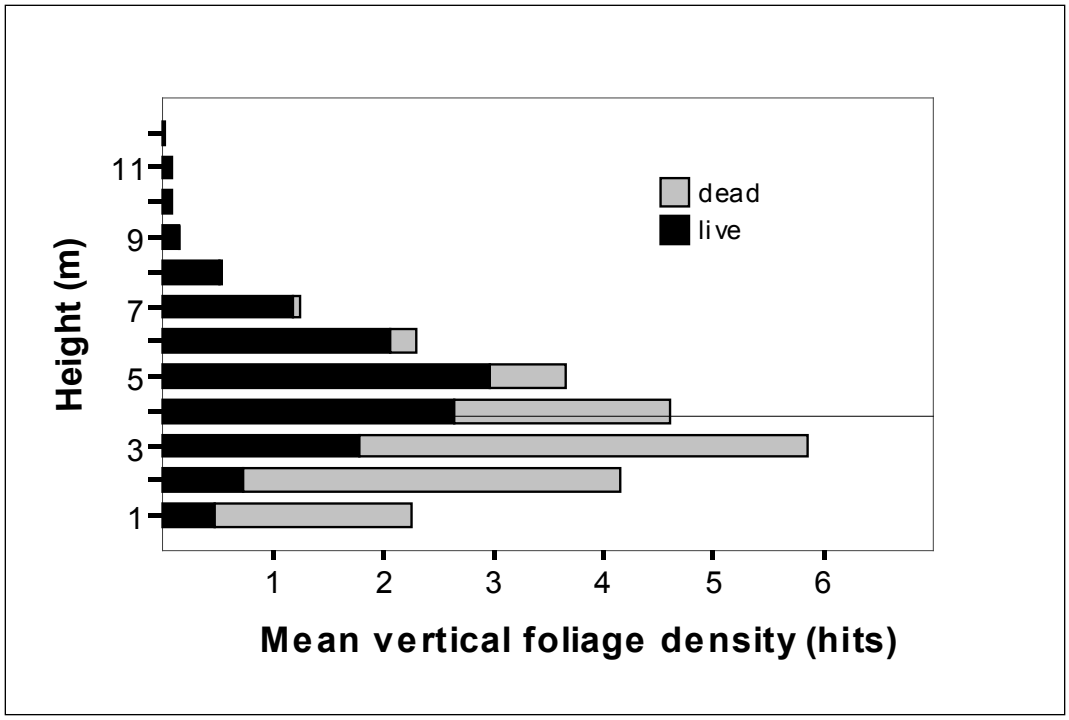

Figure 9.33. Vertical foliage density in non-flooded areas within the habitat enhancement project area, Topock Marsh, 2010. Horizontal line shows average nest height in the project area, 2003–2008.

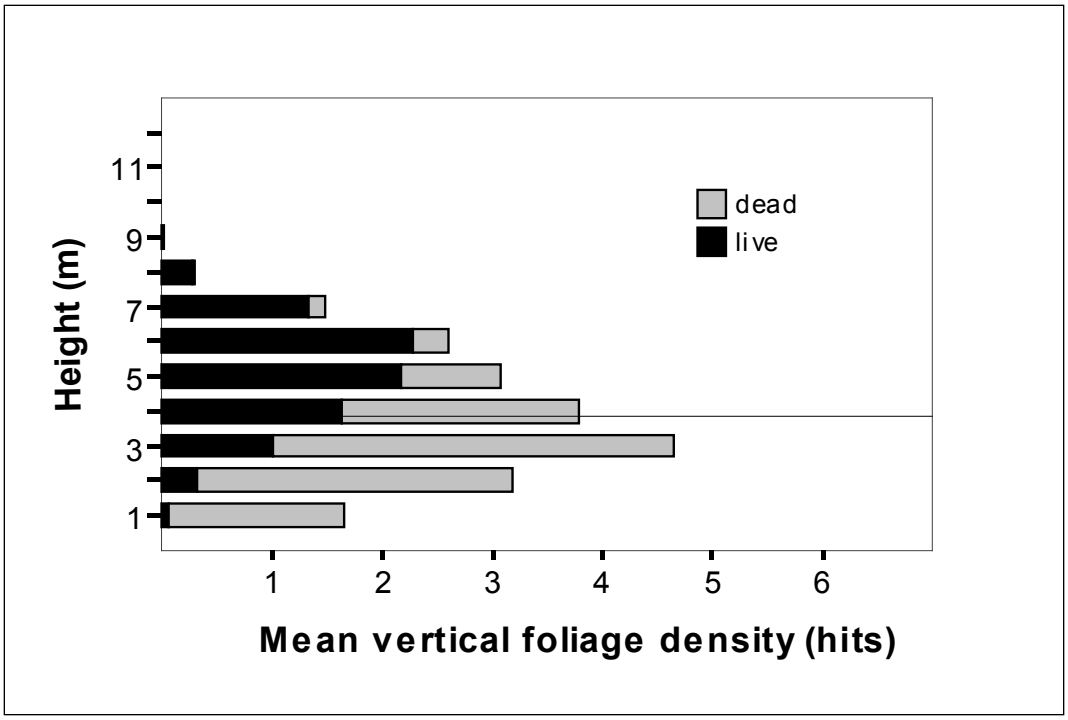

Figure 9.34. Vertical foliage density in flooded areas within the habitat enhancement project area, Topock Marsh, 2011. Horizontal line shows average nest height in the project area, 2003–2008.

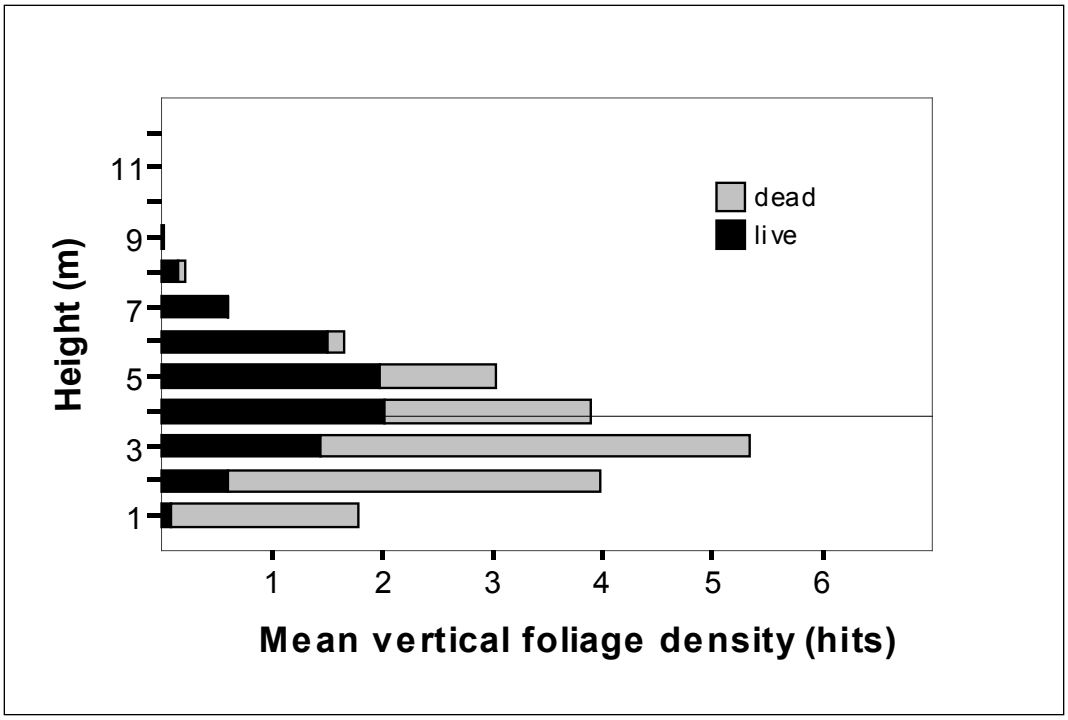

Figure 9.35. Vertical foliage density in non-flooded areas within the habitat enhancement project area, Topock Marsh, 2011. Horizontal line shows average nest height in the project area, 2003–2008.

DISCUSSION

Marsh Elevation

Mapping of surface water, piezometer measurements, marsh elevation as recorded at the South Dike, and measures of soil moisture and distance to water all indicated that water levels in 2012, under the influence of the new firebreak canal, were intermediate between those recorded in 2009, when the northern inlet canal and the farm ditch supplied water to Topock Marsh, and 2010, when water levels were intentionally reduced in preparation for construction. In 2012, the firebreak canal was not equipped with a pump and also developed leaks, and it did not raise or maintain the water level in the marsh to the elevation achieved in 2009, or in prior years, when water was flowing through the northern inlet canal. It is unknown whether passive inflow through the firebreak canal will be capable of maintaining marsh elevation to the levels recorded in 2009 after the leaks are repaired (J. Burtka, USFWS, pers. comm.). The variation in water levels within the target area did not have any obvious effects on temperature and humidity, although we did not complete a formal analysis. It is possible that a quantitative analysis that compared conditions at a subset of points that were most affected by the fluctuations in water level might show an effect on temperature and humidity, since water delivery in 2011 did affect microclimate in flooded areas (see below).

Marsh elevation as measured at the South Dike provides a good index to water levels as measured in the piezometer at In Between (Figure 9.36), with peak spring water levels generally matching in magnitude and timing in years when the piezometer was functional and no pumping occurred. Marsh levels at the South Dike are likely sufficient to track differences between years in water levels in flycatcher breeding sites at Topock Marsh, particularly given the equipment problems that have compromised the usefulness of the piezometers (see Chapter 8), and the recent occurrence of operational drift at this piezometer. Knowing that marsh levels as measured at the South Dike reflect water levels at In Between, and presumably in the other flycatcher sites at Topock Marsh as well, we can make recommendations on the marsh elevations that would be sufficient to provide standing water within the flycatcher breeding sites.

Of the last five years, 2009 had the highest peak marsh elevation, and this corresponded with the greatest extent of water and water depth in flycatcher breeding areas (Appendix E). Marsh levels in 2008 did not peak at as high a level, but elevated marsh levels persisted later in to the breeding season (Appendix E; Figure 9.37). Of the years 2003–2007, 2004 had the greatest extent and depth of water within flycatcher breeding areas (McLeod et al. 2008a) and also supported the largest number of flycatcher recorded at Topock Marsh since monitoring began in 1997. Marsh elevation in 2004 was slightly higher than that in 2009 (Figure 9.38). Except in 2001, marsh elevations in 1997–2002 reached or exceeded the levels seen in 2009 and persisted at elevated levels throughout the flycatcher breeding season (Figure 9.39), and population levels during these years appeared to be stable (SBCM, unpublished data).

We recommend a peak marsh level in early May of at least 456.7 feet (intermediate between the 2004 peak of 456.8 feet and the 2009 peak of 456.64 feet) and maintaining a marsh elevation of at least 456.4 feet at least through the end of June, by which time territory establishment is complete and first breeding attempts are typically into the nestling stage. A marsh elevation of 456.4 feet was sufficient to keep surface water in flycatcher breeding sites through mid-June in 2004. Marsh levels at Topock are managed for various purposes and to benefit various species, including Yuma clapper rails, which require stable marsh levels from March through the middle of June (J. Burtka, USFWS, pers. comm.). The needs of both flycatchers and rails could be accommodated by providing high and constant marsh levels from March through June.

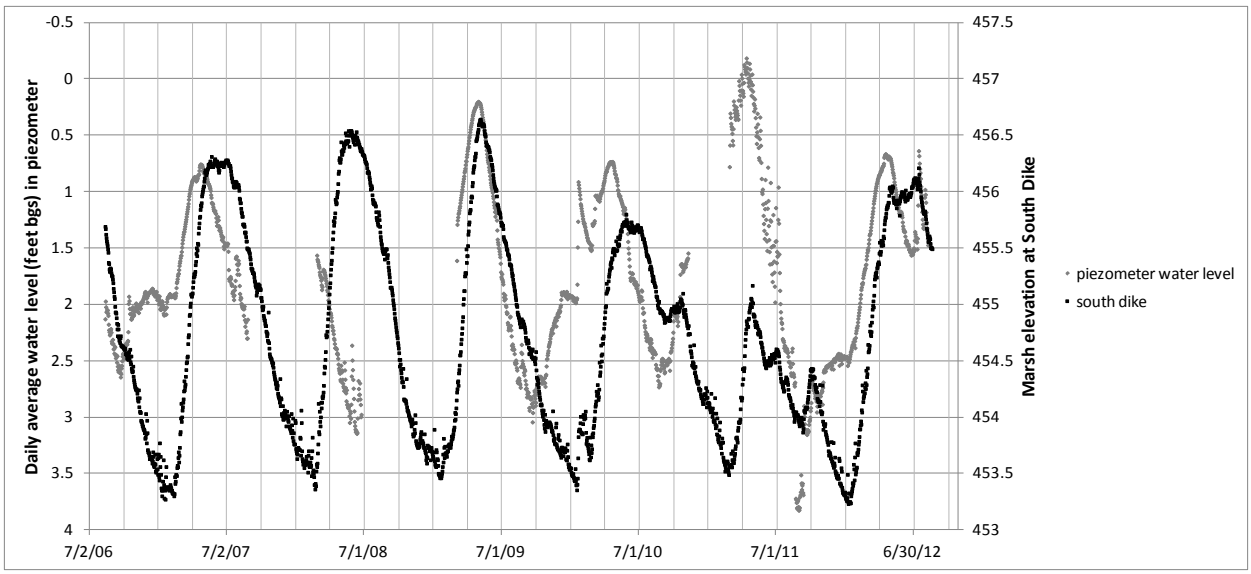

Figure 9.36. Marsh elevation as measured at the South Dike and water levels measured in the piezometer at In Between, Topock Marsh, 2006–2012.

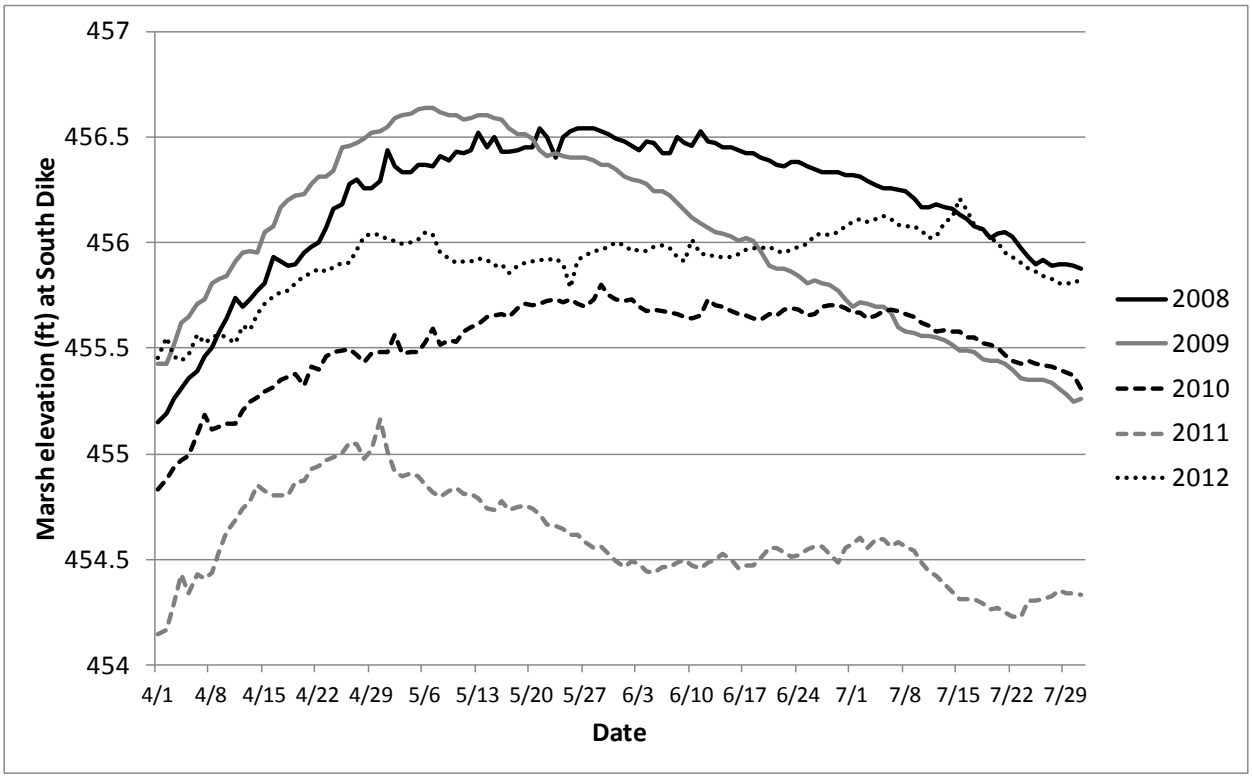

Figure 9.37. Marsh elevation as measured at the South Dike, April–July, 2008–2012.

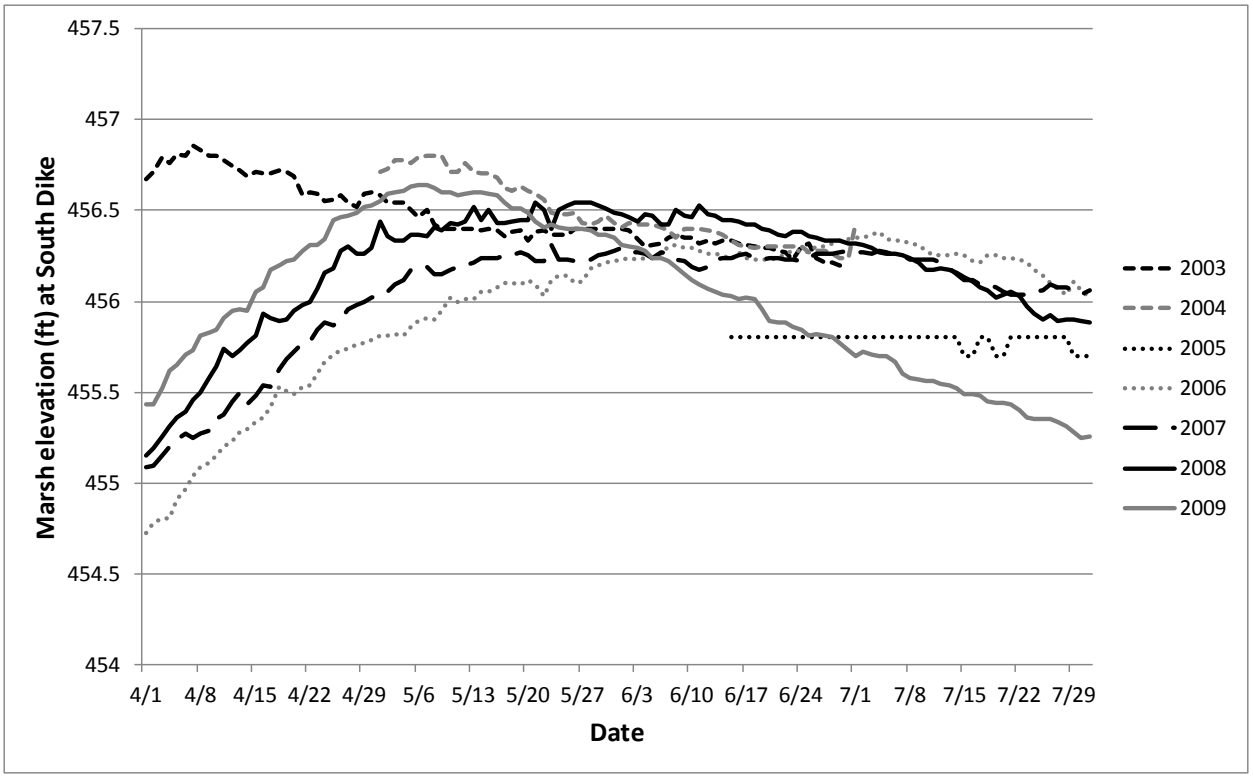

Figure 9.38. Marsh elevation as measured at the South Dike, April–July, 2003–2009.

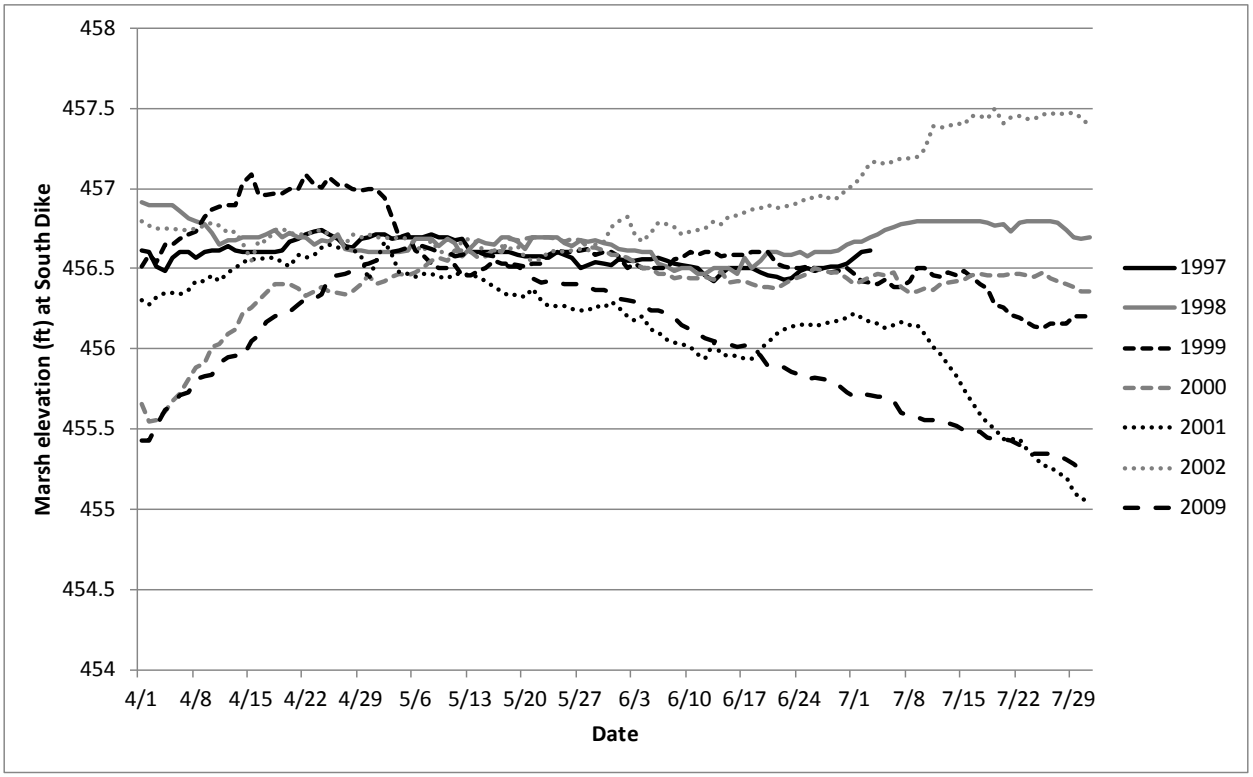

Figure 9.39. Marsh elevation as measured at the South Dike, April–July, 1997–2002 and 2009.

Water Delivery

Water delivery had the expected effect of increasing the extent and duration of surface water present within the target area in 2011 in comparison with the previous year, despite the overall lower level of Topock Marsh in 2011. Surface water from a given pumping event covered a larger extent and declined more slowly when the underlying water table was high, indicating that pumping was more effective in creating the surface water conditions favored by flycatchers when coupled with a high underlying water table.

In the area affected by flooding, water delivery had the expected effect of raising soil moisture, decreasing distance to water from the sample points, and increasing the percentage of the area surrounding each sample point that was inundated or saturated. Water delivery also appeared to increase humidity within the flooded area; both diurnal and nocturnal vapor pressure were higher in the flooded area than in the non-flooded area in 2011 but not in 2010. In addition to the overall effect on humidity, flooding also had short-term effects on humidity as shown by the analysis of conditions on the day before versus the day after each flood event. On average, flood events produced higher diurnal and nocturnal vapor pressure in the flooded area in comparison to the non-flooded area.

The effect of water delivery on temperature was not as clear. The analysis comparing the flooded and non-flooded areas throughout the year did not show a statistically significant overall effect of flooding on any of the temperature variables, but there was an interaction between flood group and time in 2011, showing that all temperature variables changed through the year in the flooded area in a different way than they changed in the non-flooded area. In 2011, the difference between the flooded and non-flooded areas in all temperature variables declined as the season progressed. An analysis of temperature variables on the day before versus the day after each flood event showed that, on average, flood events produced a lower maximum temperature, higher minimum temperature, and smaller daily temperature range in the flooded area in comparison to the non-flooded area. Thus, flood events did affect temperature, but these effects did not seem to persist between flood events. The interaction between flood group and time in 2011 suggests that the effect on temperature from a given flood event persisted for shorter periods of time as the season progressed.

Areas occupied by flycatchers typically have higher soil moisture, higher humidity, lower maximum temperatures, and smaller daily temperature ranges than unoccupied areas (McLeod et al. 2008a); thus, water delivery appeared to change the microclimate conditions within the flooded area in ways that would favor flycatcher occupancy.

The between-year changes in several of the vegetation variables appear somewhat contradictory, with canopy closure increasing between 2010 and 2011 but the amount of live vertical foliage decreasing between 2010 and 2011 in all height categories. It is difficult to distinguish between true changes in the vegetation and observer variation. The between-year differences were recorded in both flooded and non-flooded areas, indicating that flooding had no effect on changes in canopy closure or density of live vegetation. Woody ground cover increased between 2010 and 2011 in both flooded and non-flooded areas but increased much more dramatically in non-flooded areas. The overall increase in the percentage of woody ground cover could be strongly influenced by observer variation, but the significant interaction between year and flooded category suggests that the presence of surface water had an effect on the amount of woody cover, with flooding resulting in less woody cover. Woody ground cover was not identified as a vegetation component that is important in distinguishing flycatcher nest locations from unoccupied areas (McLeod et al. 2008a), and a change in woody ground cover should not, by itself, affect the suitability of an area for flycatchers. In general, water delivery did not appear to have any effects on vegetation that would influence flycatcher occupancy.

Water delivery resulted in the flooded area of In Between and 800M being the only portion of the sites surveyed for flycatchers within Topock Marsh that contained surface water during the 2011 breeding season. Five flycatcher territories were recorded in Topock Marsh in 2011; one of these territories was within the flooded portion of 800M and consisted of an unpaired male flycatcher. This flycatcher was detected at the territory in 800M through the end of June and then was detected for a few days in early July at another site approximately 1.5 km away. In 2010, the area that was affected by flooding in 2011 contained two resident, unpaired male flycatchers; in 2009, this same area contained one resident, unpaired male flycatcher. Water delivery thus did not result in increased flycatcher occupancy in the target area.

The number of flycatchers at Topock Marsh has been declining since 2004 (see Chapter 2), and few flycatcher young have been produced locally in recent years (see Chapter 4). Thus, there may be few adult flycatchers in the local population, and the lack of response by flycatchers to water delivery may be indicative of there being few adults available to establish territories. In addition, low water levels in 2011 throughout areas of Topock Marsh that have been historically occupied by flycatchers likely reduced the overall suitability of the area for flycatchers. Although supplemental water delivery appeared to produce conditions that would be favorable to flycatcher occupancy, the confounding factors of dry conditions elsewhere in Topock Marsh and a low population may have limited the ability of flycatchers to colonize the area. Flycatchers are capable of finding and colonizing new habitats quickly, with flycatchers occupying areas of vegetation as young as two years (Paxton et al. 2007). We observed similar behavior in lower Grand Canyon in 2006, with flycatchers occupying several sites that had grown up in the previous two years on newly exposed sediments (McLeod et al. 2008a). Given the dynamic nature of riparian habitats in the Southwest, it is likely that flycatchers have evolved the capacity to find and occupy new habitats as soon as they become suitable. Therefore, it seems unlikely that the lack of immediate response by flycatchers to the improved hydrologic conditions at In Between and 800M are the result of flycatchers being unable to locate the site immediately.

The supplemental pumping at Topock Marsh showed that delivering surface water into potentially suitable flycatcher habitat can shift the hydrological and microclimate conditions towards those favored by flycatchers. The effectiveness of pumping depends in part on the underlying water table, with a high water table resulting in a greater extent and longer retention of surface water. Water delivery also had the greatest effect on moderating temperature when the underlying water table was high. Thus, weekly water delivery may be effective only under certain conditions, and more frequent pumping may be required to maintain favorable microclimate and hydrology if the water table is not immediately beneath the ground surface.

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Chapter 10

TAMARISK LEAF BEETLES

BACKGROUND INFORMATION

Tamarisk, or salt cedar, is a woody shrub that is native to Eurasia. Starting in the 1850s, several species of tamarisk were imported to the United States as ornamentals and for use in erosion control. Tamarisk has spread throughout riparian areas in the western U.S., where it forms dense, often monotypic stands. Tamarisk grows rapidly, can survive in very saline soil, and spreads easily, often out-competing native vegetation. Tamarisk stands often support lower biodiversity than do similar stands of native vegetation. Because of its invasive nature, the relatively low value it provides to wildlife, and reports that tamarisk uses more water than native vegetation, tamarisk removal efforts have become increasingly widespread. However, tamarisk is difficult to eradicate by mechanical means, resprouting easily after fire or cutting.

The search began in the 1980s for biocontrol agents for tamarisk. Tamarisk leaf beetles (*Diorhabda* spp.; hereafter beetles), also native to Eurasia, were identified as selective tamarisk feeders, and research into use of beetles to control tamarisk in the United States began in the 1990s. Cage releases commenced in 1999, and the first open field release took place in 2001. Several releases of beetles have occurred between 2001 and 2008. The success of the releases in establishing beetle populations has been variable.

LIFE HISTORY OF THE TAMARISK LEAF BEETLE

Cage studies have described various aspects of *D. carinulata* (Desbrochers) biology (Lewis et al. 2003), one of three beetle species released in the United States. All life stages feed exclusively on tamarisk and prefer leaves, but adults will feed on the epidermis of twigs and first-year shoots. Beetles overwinter as adults in diapause in leaf litter or a few centimeters below the soil surface. Cage studies noted adults emerged from diapause between 24 April and 8 May at locations in California, Nevada, Utah, and Colorado between the 37th and 40th parallels (Lewis et al. 2003). Emergence was dependent on temperature and local weather conditions rather than day length. Upon emergence, adults began feeding and reproducing. A female beetle lays 10–20 eggs per day, laying up to 300–500 eggs over her 2–4 week lifespan. Lewis et al. (2003) documented beetles producing two generations per year, and it was hypothesized that three to four generations might be possible depending on elevation and latitude.

Eggs are laid singly or in masses of 2–20 eggs, averaging 2–3 eggs per mass. Average time to hatch in cage studies was 5–6 days depending on temperature. The eggs hatch into small black larvae that feed heavily for an average of 5 days, grow to 1–2 mm in length, and then molt into the second larval stage. The second instar larvae are black with an indistinct yellowish stripe on each side of the abdomen. They feed for another 4–6 days and grow to ~4 mm in length before molting into the third instar larvae. Third instar larva are distinguished by a conspicuous yellow band running down each side of the abdomen. They feed for an average of 7 days and grow to ~9 mm in length. When these larvae are mature, they stop feeding and drop to the ground. There they enter the leaf litter or soil beneath the tamarisk plant and pupate within cocoons made of leaf litter or sand. The pupae within these cocoons are very delicate and bright yellow. After about 7 days the pupae molt to adults, leave the cocoons, crawl up the tamarisk plants and begin feeding. Beetle adults are yellow and black, 5–6 mm long and 2.5 mm wide.

As population levels increase, >90% of tamarisk can be defoliated in an area (Figure 10.1). Tamarisk can refoliate between beetle generations and therefore be defoliated multiple times in a year, depending on the

number of generations. In heavily defoliated areas, the adults gather on the upper branches of tamarisk plants and move off as a group, often in large numbers, to the next area of non-defoliated tamarisk. Little is published on flight capabilities, but the adults probably rely on wind for long-range dispersal. Dispersal distances within one season vary depending on environmental conditions, but distances over 30 km have been documented.

Figure 10.1. Completely defoliated tamarisk along the Virgin River at Mormon Mesa, 7 August 2012.

As day length shortens at the end of summer, adult beetles cease reproducing and enter diapause. Unlike emergence, entrance into diapause is based exclusively on day length. Initial studies of critical day length (the day length that induces adult beetles to enter diapause) indicated that beetles would be limited to a range north of the 38th parallel. Since the release of the beetle, documented critical day lengths have decreased, allowing for up to 16 extra days of reproduction (Bean et al. 2012). This has allowed the beetle to establish in areas farther south than initially thought possible.

OCCURRENCE IN SOUTHERN NEVADA

Beetles were first released on the Virgin River in St. George, Utah, in 2006. The population became established, and the first large-scale defoliation was observed in the city in 2008. The population has spread every year since, reaching Lake Mead and the headwaters of the Muddy River at the end of 2011 (Figure 10.2). By the end of 2012, beetles occurred along the entire length of the Virgin and Muddy Rivers, and had reached Lake Mohave. The range of the beetle now overlaps several flycatcher breeding sites. In 2009 and 2010, the earliest recorded defoliation of the year on the Virgin River occurred in mid-June with a subsequent defoliation in late July. Timing and patterns of defoliation differed in 2011 and 2012. In 2011, defoliation occurred in St. George later in the season than in the previous two years, and only one defoliation event was observed (Rob Dobbs, UDWR, pers. comm.). In other portions of the Virgin River, however, defoliation occurred in mid-June, as it had in the previous two years.

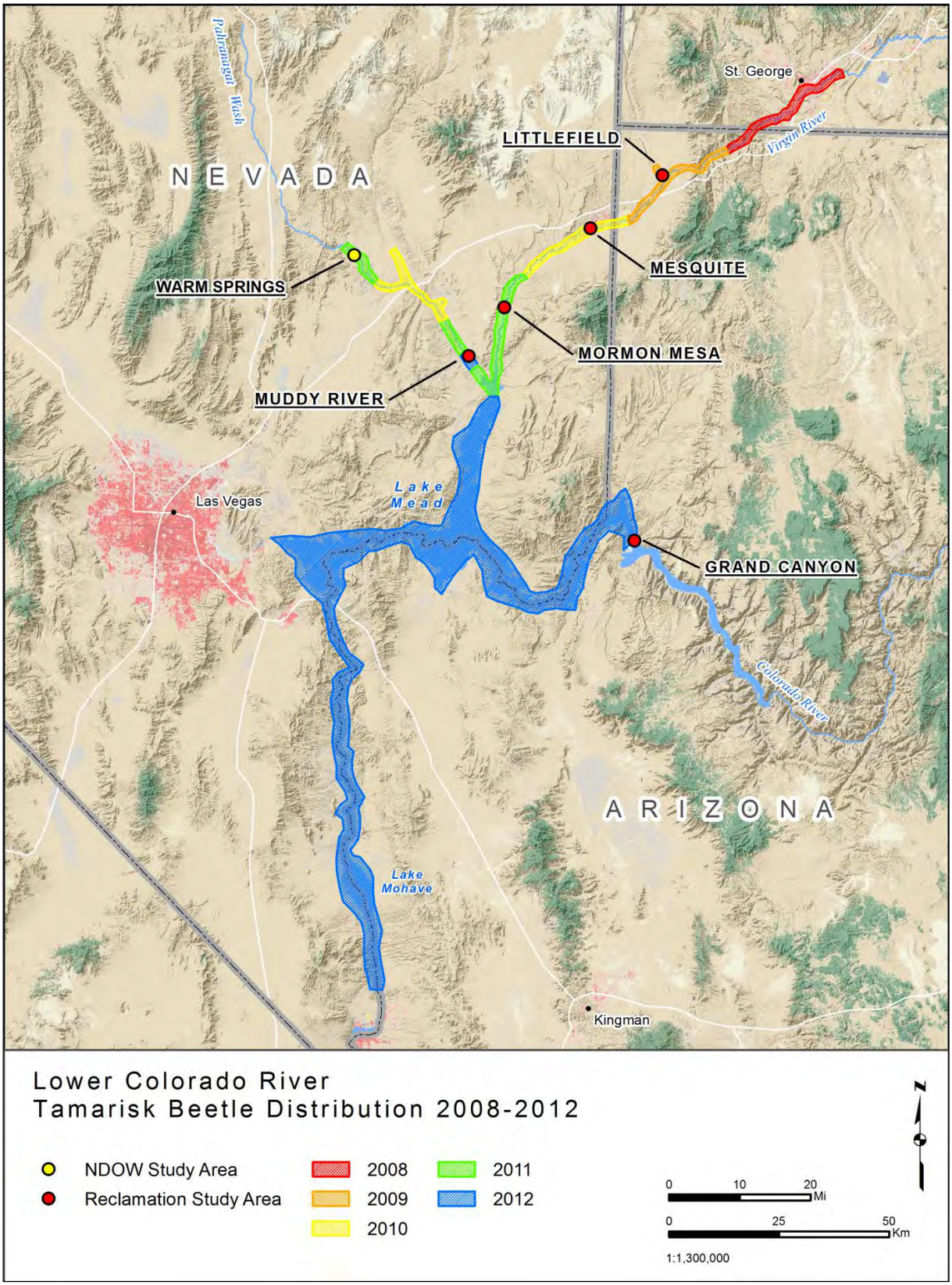

Figure 10.2. Distribution of tamarisk beetles along the Virgin, Muddy, and lower Colorado Rivers, 2008–2012.

The timing of the first yearly defoliation is related to the location of overwintering adults; early defoliation (typically in mid-June on the Virgin River) occurs where adults overwinter and emerge in the spring, and later defoliation (typically near the end of July) occurs where beetles disperse after going through one generation. In 2012, emergence and timing of the first defoliation were earlier than previously noted along much of the Virgin River, with >50% defoliation recorded at the end of May in some areas. Dispersal distance of beetles was also longer than previously recorded, with beetles located at Lake Mohave at the end of the season.

POTENTIAL IMPACTS ON FLYCATCHERS

Beetles have potential impacts on nesting flycatchers because the timing of defoliation coincides with the flycatcher breeding season. Flycatchers along the Virgin River begin to establish territories in mid-May and begin building nests in very late May to early June, with the average start of incubation in mid-June. Defoliation that begins in mid-June, as was the case on the Virgin River in 2009 and 2010, coincides with late incubation for the earliest flycatcher nests. The suitability of flycatcher breeding habitat is dependent on both vegetation structure and hydrology, but not necessarily species composition. In flycatcher breeding sites along the Virgin, Muddy, and lower Colorado Rivers, tamarisk makes up between 0% and 92% of the live foliage within occupied flycatcher territories (see Chapter 6). Reduction in canopy cover could reduce nest concealment, thereby increasing nest predation or brood parasitism (Figure 10.3). It could also alter microclimate away from favored conditions. Bateman et al. (2013) found that tamarisk defoliation significantly reduced humidity and significantly increased solar radiation measures within defoliated habitat along the Virgin River. Temperature also increased following defoliation, though the difference was not significant. To date, the beetle range has overlapped five monitored flycatcher breeding sites.

Figure 10.3. Female willow flycatcher panting while she shades her nest, St. George, Utah. Photo credit: Pam Wheeler, UDWR.

St. George

Beetles were released in St. George in 2006, but the first large defoliation did not occur until the end of the breeding season in 2008. In 2009, the first defoliation occurred in mid-June. In both years, flycatchers nested in sites dominated by tamarisk. Defoliation in 2009 corresponded with low flycatcher nesting success (Figure 10.4). Forty percent of the nests with flycatcher eggs failed to hatch (UDWR, unpublished data), possibly because of high temperatures at unshaded nests.

Flycatchers typically demonstrate high site fidelity (Paxton et al. 2007; this document). Along the LCR and tributaries, greater than 90% of between-year movements are to the same study area, with half of all between-season returns resulting in a movement of 50 m or less (see Chapter 3). Fidelity is affected by both habitat quality (McLeod and Pellegrini 2011, 2013) and nest success, with flycatchers being more likely to move after an unsuccessful breeding season (Paxton et al. 2007, this document). In St. George in 2010, the previously occupied tamarisk areas were largely vacated by flycatchers, which colonized nearby areas that contained a significant component of native vegetation (UDWR unpublished data). By 2012, all

females were located in willow-dominated areas (Rob Dobbs, UDWR, pers. comm.). Fecundity in 2010–2012 was higher than the very low level recorded in 2009, but average fecundity has not returned to the level seen in 2008. However, there was no nest monitoring in St. George prior to 2008, so typical fecundity levels for this area are unknown.

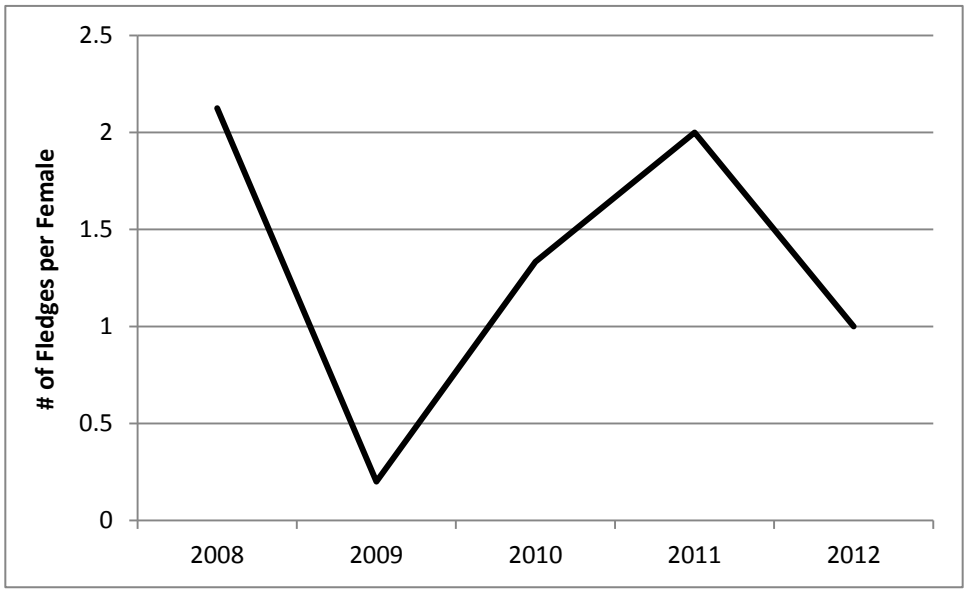

Figure 10.4. Fecundity in St. George, Utah, 2008–2012. Data courtesy of UDWR.

Littlefield

The first Reclamation flycatcher breeding site to experience beetle defoliation was Littlefield in 2009. Breeding was recorded in Littlefield in 2009 and 2010, before the site was scoured in the December 2010 flood. The site was primarily native, with a few scattered tamarisk present around the site perimeter. Defoliation occurred in late July in 2009 and mid-June 2010. Both nesting attempts recorded in 2009 failed prior to tamarisk defoliation. In 2010, defoliation and breeding activity did overlap, but tamarisk comprised such a small percentage of the vegetation at the very edge of the site that no impacts on overall habitat suitability or nesting success were recorded.

Mesquite

By the end of the 2010 breeding season, the beetle range overlapped the Mesquite breeding site. Full defoliation (>90%) was not documented until the very end of July, at which point the only active nests were located in Mesquite West. Mesquite West is a mixed native site, with large stands of >95% coyote willow on the eastern side of the site. Around the perimeter of the site, and towards the western side, the percentage of tamarisk increases. At the very western edge of the site, tamarisk makes up >90% of the vegetation. At the end of July 2010, when the tamarisk was completely defoliated, only three nests were active in the Mesquite West site. Two of these nests were within pure coyote willow stands on the eastern side of the site and fledged less than a week after defoliation. The third nest was in a mixed stand of tamarisk and coyote willow on the northwestern edge of the site. While significant defoliation was noted in the area, the nest already contained nestlings at the time of defoliation and successfully fledged less than a week later. Therefore, in 2010, no negative impacts of defoliation on flycatcher nesting success were noted.

In 2011, beetles and tamarisk defoliation were noted within the Mesquite area starting in mid to late June. Tamarisk was completely defoliated twice, once in mid-June and again around 20 July, and defoliation overlapped at least a portion of the nesting cycle of every flycatcher nest in the study area. Apparent nest success in 2011 was 33%, which is among the lowest success rates recorded in 2003–2012 (Figure 10.5). Roughly one week before tamarisk defoliation, the location where water enters the site was dredged, allowing water to completely bypass the site along the eastern edge. The site was mostly dry by the time tamarisk was first defoliated. Some early leaf abscission was noted by the end of July in the coyote willow, slightly reducing the overall canopy cover. The lack of surface water was confounded with the effects of tamarisk defoliation, and we were therefore unable to determine how much of an effect tamarisk defoliation had on nesting success.

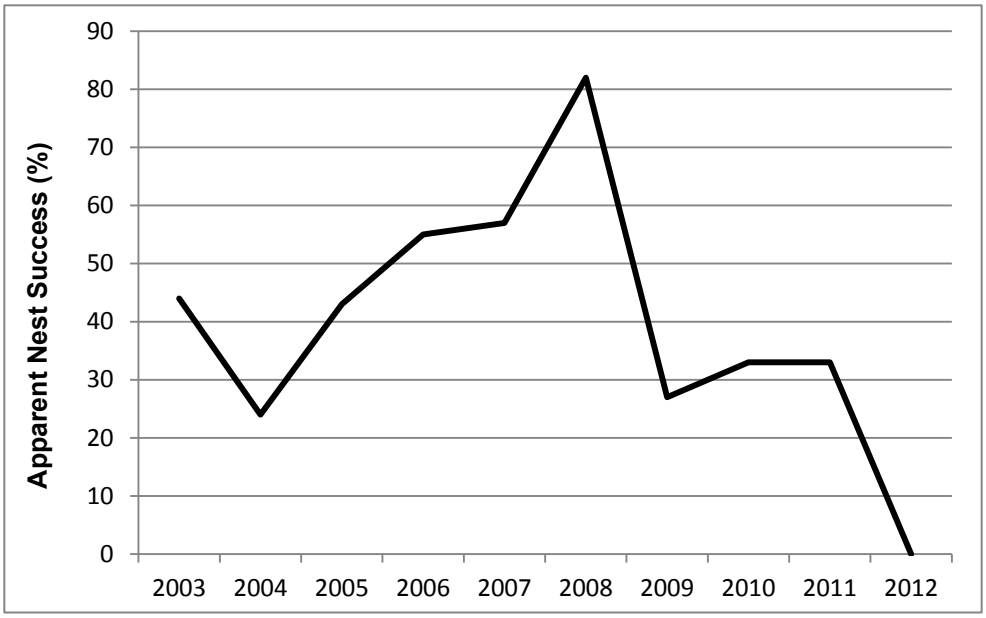

Figure 10.5. Apparent Nest Success at Mesquite West, 2003–2012.

In 2012, surface water was restored within the site, but in a much reduced areal extent. The presence of surface water was also intermittent, and the site dried out completely between inundations (see Chapter 2). Tamarisk defoliation was first noted within the study area starting in late May. All nests were initiated shortly after the first tamarisk defoliation and were located in periodically inundated, mixed tamarisk-coyote willow stands on the western side of the site. Each stand was predominantly willow, but covered a smaller areal extent than the main willow patch on the eastern side of the site, and was surrounded by monotypic tamarisk (see Chapter 2). It is possible that tamarisk defoliation affected vegetation and microclimate conditions in the flycatcher territories, but the intermittent nature of the water in 2012 could have had similar effects. No flycatcher nests were successful in Mesquite West in 2012 (Figure 10.5), but we cannot determine the relative effects of defoliation and hydrology.

Mormon Mesa

The range of the beetle first overlapped the Mormon Mesa study area at the end of the 2011 breeding season. Heavy defoliation was noted throughout the study area starting in mid-July, but the main breeding site was not completely defoliated until early August. Only four nests were still active after 15 July 2011. Three of these nests fledged successfully before complete defoliation and were located adjacent to or on the very edge of willow patches. The fourth nest successfully fledged a few days after complete

defoliation, but was located within a primarily coyote willow stand. No negative effects of tamarisk defoliation on flycatcher nesting success were documented in 2011.

In 2012, widespread defoliation was noted throughout the study area in late May and again at the very beginning of August. Nests were initiated at the very end of May, shortly after defoliation, and all were located within or on the edge of a willow patch. Willows within the Mormon Mesa breeding site occur in fragmented stands and are surrounded by tamarisk. Defoliation did not affect cover in the immediate vicinity of nests that were in dense willow stands, but defoliation reduced overall cover in the breeding area and likely affected microclimate as well. Despite the placement of nests in areas that had at least some willow cover, fecundity and nest success were lower than that recorded in this same breeding area in the four previous years (Figure 10.6). From 2003 to 2012, changes in annual nest success along the Virgin and Muddy Rivers were most often correlated with changes in parasitism rates or habitat quality. No strong change in parasitism rate was recorded in 2012, and depredation rates were lower in 2012 than the previous three years, so depredation and parasitism were not the cause of reduced reproductive success in 2012. We did observe some anomalous behavior in 2012, when four nests at Mormon Mesa were deserted during laying without any obvious disturbance to the nest such as parasitism or partial depredation. This behavior is not common and was recorded only four other times within any breeding site on the LCR and major tributaries from 2003 to 2012. We also observed an unusually high incidence of females not attempting a second nest after failure of the first nesting attempt. Our conclusions were that beetle defoliation adversely affected vegetation density surrounding the territories and microclimate within the territories, and flycatcher reproductive success reflected this.

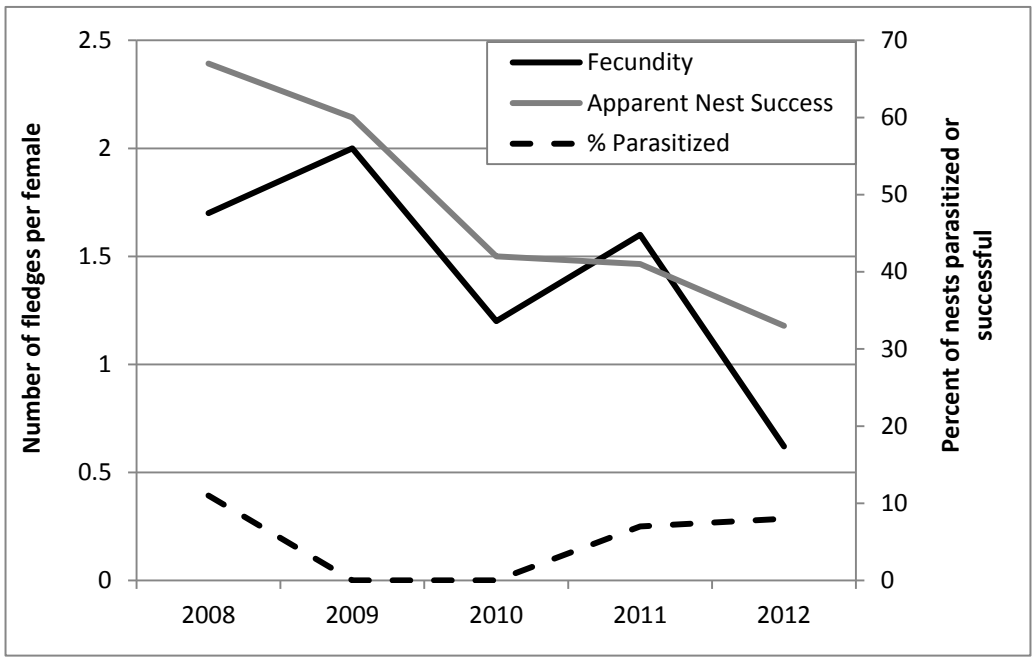

Figure 10.6. Mean annual fecundity and parasitism rate at Virgin River #1 South, Mormon Mesa, 2008–2012.

Muddy River

The Muddy River breeding site was defoliated for the first time in 2012. Extensive defoliation was noted within the site by mid-June. Five of the six nests found in the study area were active after defoliation. Only one nest was successful. This breeding site had the highest overall rate of nest failure out of all of the main Reclamation breeding sites from 2003 to 2012, and the failure rate in 2012 was typical for the site. Additionally, surface water and saturated soils were absent from the majority of the breeding site in 2012 for the first time since monitoring began in 2005. The typically high rates of nest failure coupled with the abnormal lack of suitable hydrology within the site make it impossible to determine the effect of tamarisk defoliation on flycatcher breeding success at this site in 2012.

Warm Springs

The Warm Springs study area is located at the head waters of the Muddy River and was first defoliated at the end of 2011. One small breeding site is located within the study area. The breeding site is 100% velvet ash, and any beetle activity within the study area does not affect habitat suitability within the breeding site.

DISCUSSION

Effects of tamarisk defoliation on flycatcher nesting success were noted at St. George in 2009 and at Mormon Mesa in 2012. Effects of defoliation on nesting success could not be determined, or did not exist, in any other flycatcher breeding site along the Virgin and Muddy Rivers. Habitat types across all study areas ranged from primarily non-native to primarily native. Both St. George and Mormon Mesa have a significant component of tamarisk. While most nests at St. George in 2008 and 2009 were in tamarisk stands, Mormon Mesa is mixed-native. Despite the presence of native vegetation, the patches of native vegetation were apparently not large enough to buffer the effects of defoliation. Larger, more contiguous patches of native vegetation are needed in areas surrounded by monotypic tamarisk to effectively buffer any effects of defoliation.

In St. George, flycatchers demonstrated lowered site fidelity and began to nest in nearby native vegetation the year after tamarisk defoliation negatively impacted flycatcher nesting success. Along the Virgin River at Mesquite, both reduced site fidelity and lower numbers of resident flycatchers were recorded in response to reduced nest success and habitat quality as the result of dry site conditions (McLeod and Pellegrini 2011, 2013). We expect to see a similar pattern of reduced site fidelity and lower numbers of breeding flycatchers at Mormon Mesa in 2013 in response to the poor reproductive success and lower habitat quality documented in 2012. Adult flycatchers may attempt breeding, possibly in reduced quality habitat; they could spend the breeding season as non-breeding residents; or they could emigrate from the site in search of suitable habitat elsewhere. There are no known sites along the Virgin and Muddy Rivers that contain dense, native vegetation and surface water that are not already occupied by breeding flycatchers. Additionally, the two nearby breeding sites of Mesquite and Muddy River are both currently experiencing diminished water flow, thereby reducing habitat suitability (see Chapter 2). Given the lack of available habitat along the Virgin River, emigration may occur to areas outside the drainage and would be difficult to track if they are to sites outside the project area. We recommend an increased effort of passive netting at breeding sites along the Virgin and Muddy Rivers in 2013 to identify non-territorial flycatchers.

Chapter 11

MANAGEMENT AND STUDY DESIGN RECOMMENDATIONS

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

BROADCAST SURVEYS

Recommendations for annual or biennial surveys, re-evaluation, or discontinuation of surveys at each Reclamation survey or reconnaissance site that was visited in 2008–2012 are presented in Table 11.1.

Table 11.1. Recommendations for Annual Willow Flycatcher Surveys, Biennial Surveys, Re-evaluation, or Discontinuation of Surveys at All Reclamation Sites Visited in 2008–2012

Study Area	Site	Annual	Biennial	Re-evaluate	Discontinue
Pahranagat	North	X			
	West			X	
	MAPS			X	
	South			X	
Littlefield	Pioneer Road			X	
	Poles			X	
Mesquite	Backyard			X	
	Ball Park			X	
	Hafen Lane	X			
	Up the Creek			X	
	Dumb Luck Bridge	X			
	Mesquite East				X
	Mesquite West	X			
	Electric Avenue North				X
	Electric Avenue South				X
	Electric Avenue Pond			X	
	Bunker Farm				X
	Boomerang				X
	Bunker Marsh North				X
	Left Foot				X
Mormon Mesa	Bluff				X
	Stillwater Flat				X
	Mormon Mesa North				X
	Hedgerow				X
	Mormon Mesa South (North)			X	
	Mormon Mesa South (South)				X

Table 11.1. Recommendations for Annual Willow Flycatcher Surveys, Biennial Surveys, Re-evaluation, or Discontinuation of Surveys at All Reclamation Sites Visited in 2008–2012 (Continued)

Study Area	Site	Annual	Biennial	Re-evaluate	Discontinue
Mormon Mesa	Virgin River #1	X			
	Virgin River #2			X	
	River Mile 30				X
	Virgin Narrows North				X
	Virgin Narrows East				X
	Virgin Narrows West				X
Muddy River	The Narrows				X
	Overton WMA Pond	X			
	Overton WMA	X			
	Overton Willows				X
	Muddy River Recon				X
Grand Canyon	Burnt Springs	X			
	River Mile 274.5N	X			
	RM 285.3N				X
	Iceberg Canyon			X	
Topock Marsh	Tractor				X
	NW of Pipes #1				X
	Pipes #1	X			
	Pipes #3	X			
	The Wallows	X			
	PC6-1	X			
	Pig Hole	X			
	In Between	X			
	800M	X			
	Pierced Egg	X			
	Swine Paradise	X			
	Barbed Wire				X
	IRFB03				X
	IRFB04				X
	Platform	X			
	250M	X			
	Hell Bird	X			
	Glory Hole	X			
	Spaghetti			X	
	NW Beal Lake				X
	Beal Lake	X			
	Lost Slough			X	
	Lost Pond				X

Table 11.1. Recommendations for Annual Willow Flycatcher Surveys, Biennial Surveys, Re-evaluation, or Discontinuation of Surveys at All Reclamation Sites Visited in 2008–2012 (Continued)

Study Area	Site	Annual	Biennial	Re-evaluate	Discontinue
Topock Marsh	NE Lost Lake				X
	Lost Lake South				X
	Lost Lake	X			
	Lost Lake Slough #1			X	
	Lost Lake Slough #2			X	
	Lost Lake Slough #3			X	
	Lost Lake Slough #4			X	
	Marina				X
Topock Gorge	Pulpit Rock				X
	Picture Rock				X
	Blankenship Bend North		X		
	Blankenship Bend South		X		
	Havasu NE				X
Bill Williams	Wispy Willow	X			
	Site #1	X			
	Site #2				X
	Site #11				X
	Burn Edge	X			
	Site #4	X			
	Site #3	X			
	Last Gasp		X		
	River End				X
	Guinness		X		
	Site #5	X			
	Black Rail	X			
	Flooded Refuge Road				X
	New Willow				X
	Cliff Pond				X
	Cougar Point	X			
	Mineral Wash		X		
	Beaver Pond		X		
	Downstream from Site #8				X
	Site #8		X		
	Upstream from Site #8	X			
	Planet Ranch Road	X			
	Planet Ranch				X
	New River			X	
	East of Planet Ranch				X

Table 11.1. Recommendations for Annual Willow Flycatcher Surveys, Biennial Surveys, Re-evaluation, or Discontinuation of Surveys at All Reclamation Sites Visited in 2008–2012 (Continued)

Study Area	Site	Annual	Biennial	Re-evaluate	Discontinue
Ahakhav	Willow Beach				X
	Deer Island				X
	Restoration				X
Palo Verde Ecological Reserve	PVER Phase 2	X			
	PVER Phase 3	X			
Big Hole Slough	Big Hole Slough				X
Ehrenberg	Ehrenberg			X	
Cibola	CVCA Phase 1	X			
	CVCA Phase 2	X			
	CVCA Phase 3	X			
	Cibola Nature Trail				X
	Cibola Island				X
	Cibola Site #2				X
	Cibola Site #1				X
	Hart Mine Marsh				X
	Three Fingers Lake				X
	Cibola Lake North				X
	Cibola Lake East				X
	Cibola Lake West				X
	Walker Lake		X		
Imperial	Draper Lake				X
	Paradise				X
	Hoge Ranch		X		
	Adobe Lake				X
	Rattlesnake		X		
	Milemarker 65				X
	Clear Lake				X
	Nursery NW		X		
	Imperial Nursery		X		
	Ferguson Lake		X		
	Ferguson Wash				X
	Great Blue Heron		X		
	Powerline				X
	Martinez Lake				X
Mittry Lake	Mittry West		X		
	Mittry South				X
	Laguna				X
	Laguna Dam North				X

Table 11.1. Recommendations for Annual Willow Flycatcher Surveys, Biennial Surveys, Re-evaluation, or Discontinuation of Surveys at All Reclamation Sites Visited in 2008–2012 (Continued)

Study Area	Site	Annual	Biennial	Re-evaluate	Discontinue
Yuma	Gila Confluence North				X
	Gila River Site #2				X
	Fortuna Site #1				X
	Fortuna North				X

COLOR-BANDING, RESIGHTING, AND DEMOGRAPHICS

Though detection probabilities do not currently show strong support for the use of full color combinations on juveniles, the effort required to identify returning juveniles with full color combinations is lower than juveniles banded with single federal bands. Therefore, we recommend continuing to use full color combinations on all nestlings.

NEST MONITORING

Mayfield nest success did not differ substantially from apparent nest success, suggesting that the majority of nesting attempts were located. Eighty-two percent of all documented nesting attempts were located during the building or laying stages. With a high proportion of nests located early in the nesting cycle, it is not surprising that apparent nesting success mirrors Mayfield success, which is designed to adjust for nests that fail before they are found. If intensive nest searching results in the discovery of most nests early in the nesting cycle, Mayfield estimates may be unnecessary for obtaining accurate nest success estimates. Calculating Mayfield estimates requires frequent visits to the nest around transition dates (e.g., hatch date); if Mayfield estimates were not necessary, fewer visits could be made to the nest and nest disturbance could be reduced with no loss of nest success information.

COWBIRD CONTROL

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. An alternative option is to explore cowbird egg replacement. This method has been practiced with success in the Kern River Valley (Mary Whitfield, pers. comm.), and can potentially reduce the number of visits to a nest by eliminating the possibility the cowbird egg will hatch. This method also requires only one physical trip to the nest to switch the real and fake cowbird eggs, as compared with the two required by addling to remove, addle, and replace the real cowbird egg. It also eliminates the risk of mimicking a partial depredation event due to accidental damage to the cowbird egg during addling.

Brood parasitism rates at Reclamation study areas have been particularly high at Mesquite and Muddy River over the last 10 years, and there is a clear, inverse relationship between parasitism and the likelihood of a nest producing flycatcher young (see Chapter 4). Trapping has proven ineffective at Mesquite but has not been attempted at Muddy River. The flycatcher breeding area at Overton WMA is in a smaller riparian corridor than either Mesquite or Topock Marsh, where trapping was ineffective,

but is not as isolated as Pahranagat, where trapping may have had some benefits; therefore, the potential effectiveness of trapping in reducing parasitism rates at Muddy River is uncertain. Addling cowbird eggs has the potential to improve success at parasitized nests (see Chapter 4) but does not address the other detrimental effects of cowbirds and parasitism, such as clutch size reduction, depredation of nestlings, and causing nest abandonment. Given the equivocal benefits of trapping, the clearly detrimental effects of cowbirds on flycatcher nest success, and the likely reduction in flycatcher reproduction along the Virgin River with the arrival of tamarisk beetles (see Chapter 10), other methods of cowbird control, such as shooting, should be considered in combination with cowbird egg addling.

VEGETATION IN OCCUPIED TERRITORIES

While the vegetation characteristics of flycatcher territories varied within and between study areas, occupied areas have several common characteristics. Canopy height is typically at least 5.0 m; in cases where the dominant vegetation layer is shorter than 5.0 m, emergent Goodding willow are present. Stem density varies depending on the dominant species of vegetation, but density in every vegetation type is sufficient to produce canopy closure of 85% or more. We recommend using the 25th–75th percentile values for stem density, canopy closure, and canopy height from Mesquite as a target range for habitat creation sites that consist of coyote willow (Table 11.2). For habitat creation sites that are primarily Goodding willow, Muddy River and Grand Canyon provide guidelines; however, because only the southern nesting area of Muddy River contains a significant proportion of Goodding willow, using the relevant subset of the data from that study area would provide more focused guidelines than using the full dataset. Mormon Mesa provides data that could be used as guidelines for areas that have a scattered overstory of Goodding willow and an understory of coyote willow. The understory at Mormon Mesa is largely tamarisk, so a multiplier might be applied to the density of stems 2.6–8.0 cm dbh to account for the branching structure in tamarisk that results in an underestimate of stem density when only the largest stem is tallied. According to our tally of skipped stems, this multiplier would be 1.17 when adjusting for coyote willow habitat and 1.45 when adjusting for young Goodding willow habitat. Even with this multiplier, densities of tamarisk may underestimate the required density of less bushy species.

Table 11.2. Recommended Ranges of Canopy Height, Canopy Closure, and Stem Density in Various Vegetation Types to Provide Habitat Structure Similar to That Found in Occupied Southwestern Willow Flycatcher Habitat

Vegetation measure	Vegetation type		
	Coyote willow	Goodding willow	Scattered Goodding willow with coyote willow understory
Canopy height (m)	4.4–5.5	7.0–9.0	4.8–6.5
Canopy closure (%)	89.0–97.0	89.0–97.0	86.0–95.1
# live stems ≤2.5 cm dbh per ha	3183–9167	509–2801	764–2928
# live stems 2.6–8.0 cm dbh per ha	5730–10441	2419–5730	2682–7598
# live stems >8.0 cm dbh per ha	0–255	637–1753	0–764

MICROCLIMATE IN OCCUPIED TERRITORIES

Microclimate conditions of temperature and humidity are influenced by regional climate, vegetation, and hydrological conditions. To obtain a summary of soil moisture and surface water across all study areas, we pooled data from all study areas. The data from all study areas include years and study areas where conditions clearly were not optimal, such as Mesquite West in 2009 and Topock Marsh in 2005;

therefore, the full range of data should not be construed as constituting suitable conditions, despite the presence of territorial flycatchers. We recommend that randomly selected sample points within habitat creation areas that are managed for willow flycatchers conform to the range and distribution of conditions seen in the 25th–75th percentiles of flycatcher territories in each two-week period (Table 11.3). Conditions that are wetter, cooler, or more humid than those described by the 25th–75th percentile range would also be suitable.

In occupied flycatcher territories at most study areas, hydrologic conditions are essentially constant from one day to the next and change slowly over the season. Because these are the conditions we have observed, we are unable to determine if there is a minimum frequency of flooding necessary to maintain suitable conditions in areas, such as flood irrigated sites, where hydrologic conditions may vary dramatically from one day to the next.

Temperature and humidity at a specific location are the result of the combination of regional climate and the local influences of vegetation and soil moisture. If temperature and humidity of an area do not fall within the conditions used by flycatchers on the LCR, manipulation of temperature and humidity would be accomplished by manipulation of vegetation structure or hydrology. Management efforts to increase canopy closure, the amount of live foliage above average nest height, and soil moisture would increase suitability of the area for flycatchers by providing the vegetation density found in occupied flycatcher sites, providing the soil moisture needed to attract flycatchers, and promoting the microclimate conditions found in flycatcher territories.

TAMARISK BEETLES

In St. George, flycatchers demonstrated lowered site fidelity and began to nest in nearby native vegetation the year after tamarisk defoliation negatively impacted flycatcher nesting success. Along the Virgin River at Mesquite, both reduced site fidelity and lower numbers of resident flycatchers were recorded in response to reduced nest success and habitat quality as the result of dry site conditions (McLeod and Pellegrini 2011, 2012b). We expect to see a similar pattern of reduced site fidelity and lower numbers of breeding flycatchers at Mormon Mesa in 2013 in response to the poor reproductive success and lower habitat quality documented in 2012. Adult flycatchers may attempt breeding, possibly in reduced quality habitat; they could spend the breeding season as non-breeding residents; or they could emigrate from the site in search of suitable habitat elsewhere. There are no known sites along the Virgin and Muddy Rivers that contain dense, native vegetation and surface water that are not already occupied by breeding flycatchers. Additionally, the two closest breeding sites of Mesquite West and Overton WMA are both currently experiencing reduced surface water, thereby reducing habitat suitability (see Chapter 2). Given the lack of available habitat along the Virgin River, emigration may occur to areas outside the drainage and would be difficult to track if it is to sites outside the project area. We recommend an increased effort of passive netting at breeding sites along the Virgin and Muddy Rivers in 2013 to identify non-territorial flycatchers.

Defoliation from tamarisk beetles will almost certainly continue to reduce the suitability of existing nesting areas at Mormon Mesa and Muddy River, and the future suitability of the Overton WMA and Mesquite West sites depends on surface water being restored in these areas. Given that the future suitability of all three main flycatcher breeding areas on the lower Virgin and Muddy Rivers is uncertain, restoration efforts along the Virgin and Muddy Rivers are needed to provide alternative nesting areas consisting of native vegetation. These restoration efforts could consist of expanding the area of native vegetation on the periphery of currently occupied sites, such as the current breeding area at Mormon Mesa. Surface water is present in tamarisk areas on the western and southern boundaries of the currently occupied area. Willow plantings on these edges of the breeding area could increase the suitability of the currently occupied area and provide new nesting areas. Restoration efforts could also entail creating entirely new sites, if locations with reliable surface water are identified.

Table 11.3. Soil Moisture and Microclimate Measures in Southwestern Willow Flycatcher Territories at All Study Areas Combined, 2003–2011

Microclimate measure	May 16–31		June 1–15		June 16–30		July 1–15		July 16–31		August 1–15	
Soil Moisture	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 soil moisture (mV)	902.8 (688.8-954.0)	776.2 (24.2)	896.1 (770.9-961.6)	790.3 (21.7)	875.6 (693.3-935.0)	768.1 (17.5)	848.7 (628.0-919.4)	735.1 (16.0)	837.9 (598.8-921.9)	730.1 (15.1)	881.9 (694.0-929.7)	778.4 (16.7)
Mean distance to nearest standing water	6.5 (0.1-54.0)	42.2 (6.1)	6.0 (0.0-31.0)	38.6 (6.0)	12.0 (1.5-50.0)	54.5 (7.9)	25.5 (3.0-100.0)	119.1 (19.3)	20.0 (3.0-110.0)	101.5 (13.3)	13.0 (1.0-70.0)	64.4 (11.1)
% of area within 20 m that was inundated	20.0 (0.0-60.0)	33.3 (4.5)	20.0 (0.0-75.0)	36.7 (3.8)	10.0 (0.0-40.0)	26.0 (3.1)	4.0 (0.0-20.0)	17.5 (2.7)	0.0 (0.0-15.0)	14.3 (2.3)	5.0 (0.0-30.0)	19.3 (3.0)
% of area within 50 m that was inundated	30.0 (0.0-60.0)	33.7 (4.0)	30.0 (5.0-70.0)	36.8 (3.4)	15.0 (2.0-50.0)	30.4 (3.0)	10.0 (0.0-30.0)	18.4 (2.3)	3.0 (0.0-30.0)	16.2 (2.1)	10.0 (0.0-35.0)	22.1 (3.1)
Temperature												
Mean maximum diurnal temperature (°C)	37.7 (34.4-41.5)	38.0 (0.2)	37.8 (34.9-40.6)	38.0 (0.1)	40.1 (37.0-44.4)	40.7 (0.1)	40.6 (37.5-45.4)	41.6 (0.1)	40.9 (37.7-44.9)	41.6 (0.1)	39.2 (36.1-42.5)	39.5 (0.1)
Mean minimum nocturnal temperature (°C)	13.7 (12.0-16.4)	14.1 (0.1)	14.1 (12.6-16.0)	16.6 (0.1)	16.4 (14.7-18.3)	16.6 (0.1)	19.4 (17.1-21.7)	19.3 (0.1)	22.5 (21.0-24.0)	22.5 (0.1)	21.3 (19.0-22.9)	21.0 (0.1)
Mean daily temperature range (°C)	23.8 (20.0-27.9)	23.9 (0.2)	23.7 (20.0-27.1)	23.6 (0.2)	23.9 (20.1-27.8)	24.1 (0.2)	22.0 (18.1-26.3)	22.3 (0.1)	18.5 (14.6-23.2)	19.1 (0.1)	18.2 (14.2-22.4)	18.5 (0.2)
Humidity												
Mean diurnal vapor pressure (Pa)	1260.3 (1081.7-1489.7)	1296.3 (11.7)	1273.6 (1030.2-1602.6)	1327.7 (12.3)	1678.9 (1311.9-2154.0)	1753.5 (14.4)	2021.5 (1645.3-2524.5)	2077.2 (13.3)	2504.1 (2081.4-2868.5)	2474.4 (11.4)	2474.5 (1993.3-2870.4)	2428.9 (15.8)
Mean nocturnal vapor pressure (Pa)	1224.2 (1062.5-1408.1)	1221.8 (8.9)	1219.1 (1023.5-1430.6)	1234.0 (8.8)	1512.1 (1294.4-1734.0)	1530.8 (8.8)	1771.7 (1513.8-2096.7)	1806.9 (9.2)	2196.9 (1904.3-2471-8)	2181.6 (8.2)	2159.1 (1875.0-2498.9)	2181.1 (11.4)

HABITAT IMPROVEMENT BY STUDY AREA

Herein we provide recommendations for improvement of flycatcher habitat by study area or drainage for ease of locating information of interest.

Key Pittman WMA

We recommend maintaining lake levels to those observed during the breeding seasons of 2010–2012. Fencing should be maintained to keep cattle out of the habitat. There is room to expand the current extent of coyote willow habitat along the western edge of Nesbitt Lake. While this is not necessary, it would likely be occupied, increasing the total population size at the site. Depredation rates are high at Key Pittman WMA and we recommend cowbird control.

Pahranagat NWR

We recommend maintaining lake levels in Upper Pahranagat Lake as high as possible during the breeding season in May and June. In addition, we recommend the creation of additional habitat along the margins of Upper Pahranagat Lake. The establishment of coyote willow patches along the edges of the lake, similar to the vegetation currently present at Key Pittman, would provide additional nesting sites for flycatchers.

Mesquite

Restoration efforts along the Virgin River are needed to provide alternative nesting areas consisting of native vegetation (see Tamarisk Beetles, above). Existing flycatcher breeding sites with significant components of native vegetation also need to be maintained. The amount of surface water within Mesquite West is influenced by the amount of water flowing from the pipe that provides water to the site and by the condition of the conveyance ditch (i.e., whether the ditch conveys water into the site or diverts it along the western edge of the site). Dialogue should be maintained with the local landowner as well as the Mesquite Irrigation District to ensure continued water delivery. Dialogue should also be maintained with the Bunkerville Irrigation District to ensure the presence of surface water at Dumb Luck Bridge. Cowbird control at Mesquite should also be considered (see Cowbird Control, above).

Muddy River

At Overton WMA, the flycatcher breeding area at the southern end of the site has slowly dried over the last several years, possibly as the result of sedimentation in the river channel. The point at which water formerly entered this portion of the site should be evaluated to determine whether the channel can be modified to restore surface water to the site. Cowbird control at Overton WMA should also be considered (see Cowbird Control, above).

Warm Springs Natural Area

The presence of surface water during the breeding season as well as suitable vegetation structure limit available habitat at Warm Springs Natural Area. Stands of native vegetation such as coyote and Goodding willow and velvet ash should be planted in areas where surface hydrology is appropriate.

Topock Marsh

The extent of suitable habitat within Havasu NWR has been reduced since 2010 due to lower marsh levels limiting the presence of surface water within woody vegetation. We recommend a peak marsh level in early May of at least 456.7 feet (intermediate between the 2004 peak of 456.8 feet and the 2009 peak of 456.64 feet) and maintaining a marsh elevation of at least 456.4 feet at least through the end of June, by which time territory establishment is complete and first breeding attempts are typically into the nestling stage. A marsh elevation of 456.4 feet was sufficient to keep surface water in flycatcher breeding sites through mid-June in 2004. Additionally, with the threat of tamarisk beetles establishing within the refuge boundary in the next few years, we recommend preemptive restoration of habitat to native vegetation.

Bill Williams River NWR

The extent of dense, woody vegetation in combination with surface water is limited within Bill Williams River NWR. Maintaining surface water within recently occupied areas during the flycatcher breeding season, via releases from Alamo Dam, is necessary to retain breeding flycatchers at Bill Williams. New flycatcher habitat at Bill Williams might also be created by flood flows from Alamo Dam.

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Appendix A

SOUTHWESTERN WILLOW FLYCATCHER SURVEY RESULTS, 2003–2012

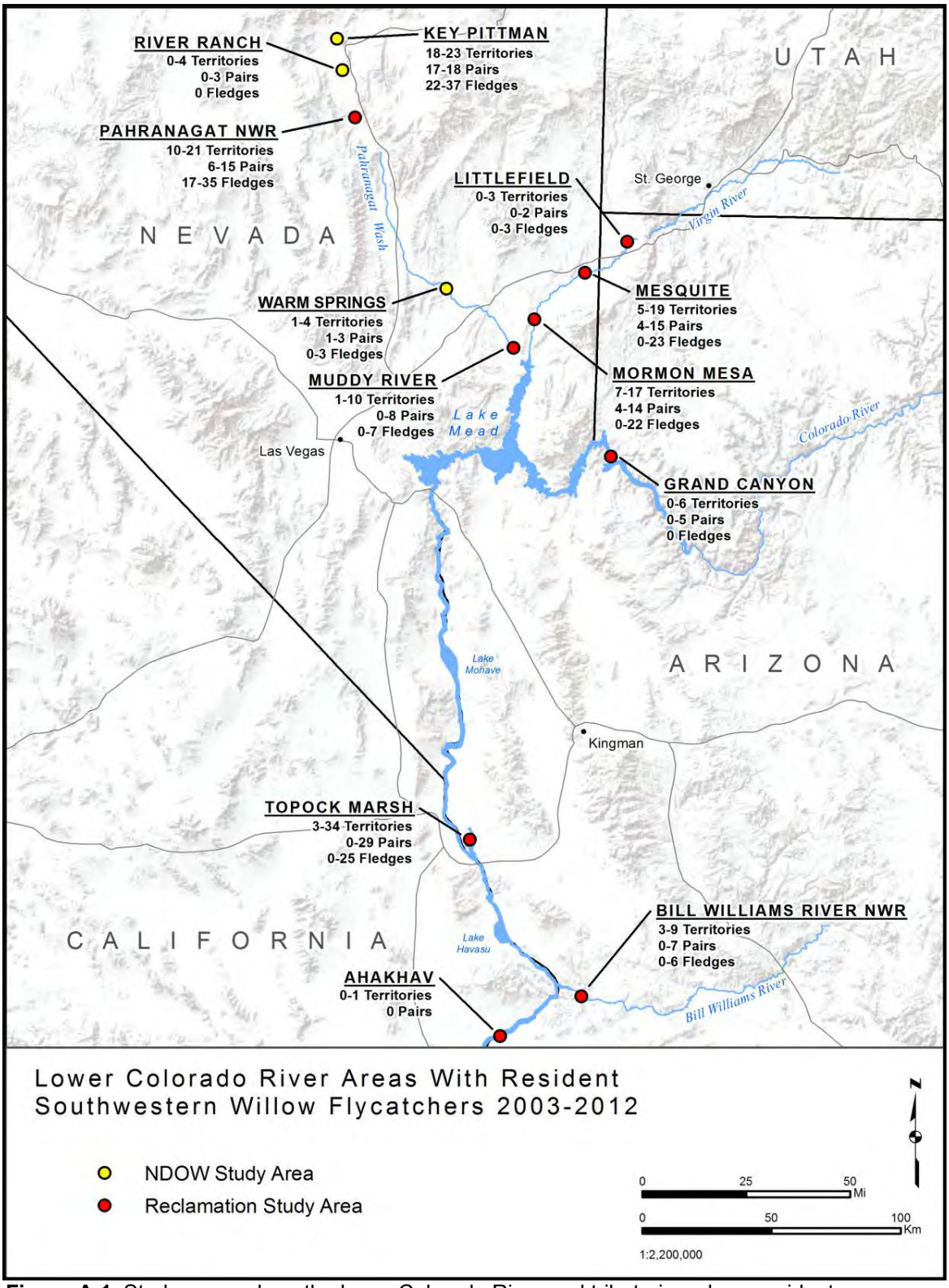


Figure A.1. Study areas along the lower Colorado River and tributaries where resident or breeding Southwestern Willow Flycatchers were detected, 2003–2012. The numbers presented below each study area name represent the range in annual number of territories, pairs, and confirmed fledges from 2003 to 2012.

Table A.1. Southwestern Willow Flycatcher Survey and Monitoring Results by Management Unit within the Lower Colorado Recovery Unit, 2003–2012*

Management Unit	Year	Area (ha)	Survey Hours	Resident Adults[1]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[2]			
									Before June 15	After June 15	Before June 24	After June 24
Pahranagat	2003	21.8	49.8	20	14	8	12	24	0	1	0	1
	2004	19.5	46.0	30	18	14	17	35	6	4	7	3
	2005	23.6	65.9	42	28	17	29	36	2	5	3	4
	2006	28.3	37.0	45	28	22	27	31	0	2	0	2
	2007	26.1	58.3	37	23	18	24	23	5	3	5	3
	2008	26.9	49.9	32	23	13	20	24	2	3	3	2
	2009	26.9	40.9	34	20	16	27	22	4	3	5	2
	2010	38.2	56.3	72	44	34	58	70	3	5	3	5
	2011	25.2	26.3	69	42	33	51	50	7	15	8	14
	2012	19.3	34.0	76	48	35	54	48	7	4	7	4
Virgin	2003	256.5	237.1	47	29	21	32	17	5	5	5	5
	2004	256.7	214.3	45	25	20	30	19	10	5	11	4
	2005	166.6	220.4	31	20	12	19	7	3	0	3	0
	2006	188.3	131.6	47	30	22	30	31	1	2	2	1
	2007	151.7	344.3	51	31	24	28	18	4	0	4	0
	2008	133.6	223.7	50	31	24	25	37	3	5	5	3
	2009	139.4	185.1	56	35	27	36	25	3	7	5	5
	2010	85.2	134.7	45	28	18	33	22	5	4	8	1
	2011	69.1	76.5	37	22	20	29	19	0	2	0	2
	2012	62.6	108.2	31	21	18	23	9	8	4	9	3
Middle Colorado	2003	99.5	134.7	0	0	0	0	0	0	1	0	1
	2004	69.5	183.3	3	2	1	1	0	0	0	0	0
	2005	56.1	145.7	1	1	0	0	0	0	0	0	0
	2006	72.5	91.3	11	6	5	3	0	2	2	4	0
	2007	63.2	68.8	4	3	1	1	0	2	1	3	0
	2008	41.0	24.6	1	1	0	0	0	0	0	0	0

Table A.1. Southwestern Willow Flycatcher Survey and Monitoring Results by Management Unit within the Lower Colorado Recovery Unit, 2003–2012* (Continued)

Management Unit	Year	Area (ha)	Survey Hours	Resident Adults[1]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[2]			
									Before June 15	After June 15	Before June 24	After June 24
Hoover to Parker	2003	177.0	324.3	20	11	9	11	15	12	1	13	0
	2004	164.4	188.3	57	34	29	43	25	10	4	11	3
	2005	145.4	187.6	36	21	18	38	13	6	1	6	1
	2006	186.6	188.2	29	18	14	17	5	8	3	10	1
	2007	186.4	197.1	18	11	8	8	12	19	1	20	0
	2008	143.9	117.0	20	12	9	12	1	6	4	10	0
	2009	133.1	159.9	14	13	1	2	3	10	4	12	2
	2010	114.0	147.7	11	10	3	2	2	15	2	16	1
	2011	82.7	99.0	5	5	1	1	0	27	1	28	0
	2012	72.6	74.7	2	3	0	0	0	13	1	13	1
Bill Williams	2003	67.9	149.5	10	7	3	2	3	2	1	3	0
	2004	73.8	163.9	3	3	0	0	0	18	3	21	0
	2005	85.9	79.7	6	4	2	2	5	2	1	3	0
	2006	86.5	65.8	4	3	3	5	2	5	0	5	0
	2007	83.7	94.3	13	9	7	9	3	7	1	7	1
	2008	88.6	65.0	7	4	4	5	4	0	1	0	1
	2009	35.6	54.2	13	8	5	7	6	0	2	2	0
	2010	100.8	121.8	8	5	4	11	2	3	3	4	2
	2011	95.2	89.6	8	5	4	6	4	6	3	7	2
	2012	88.9	70.9	4	3	2	3	0	21	4	23	2
Parker to Southerly International Boundary	2003	442.5	663.4	0	0	0	0	0	218	14	231	1
	2004	436.7	533.6	0	0	0	0	0	609	2	610	1
	2005	397.9	594.9	0	0	0	0	0	328	15	342	1
	2006	436.6	659.3	0	0	0	0	0	449	24	472	1
	2007	431.2	509.2	0	0	0	0	0	437	17	454	0
	2008	375.4	210.2	1	1	0	0	0	60	19	79	0
	2009	335.7	222.5	0	0	0	0	0	40	4	44	0
	2010	398.0	263.8	0	0	0	0	0	78	0	78	0

Table A.1. Southwestern Willow Flycatcher Survey and Monitoring Results by Management Unit within the Lower Colorado Recovery Unit, 2003–2012* (Continued)

Management Unit	Year	Area (ha)	Survey Hours	Resident Adults[1]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[2]			
									Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary	2011	292.0	190.0	0	0	0	0	0	153	1	154	0
	2012	280.2	161.1	0	0	0	0	0	142	0	142	0

* This table includes results from all sites where regular surveys were scheduled, and habitat reconnaissance and opportunistic surveys were conducted. All detections of flycatchers, regardless of site association, are included.

[1] Several within-season, between-study area movements were detected. Individuals who moved between study areas within a management unit are only counted once.
[2] Total number of individuals recorded that could not be classified as resident or migrant because of brief appearance.

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012*

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Pahraganat Key Pittman WMA Pahranagat Valley	Patch 0 Lincoln, NV 1169	2010	0.02	1	0.5	0	0	0	0	0	0	0	0	0
		2011	0.04	0	0	2	1	1	1	0	0	0	0	0
		2012	0.04	0	0	1	1	0	0	0	0	0	0	0
	Patch 1 Lincoln, NV 1169	2010	0.1	1	0.5	2	1	1	2	3	0	0	0	0
		2011	0.1	0	0	2	1	1	1	3	0	0	0	0
		2012	0.1	0	0	2	1	1	2	3	0	0	0	0
	Patch 2 Lincoln, NV 1169	2010	0.1	1	0.5	3	2	1	2	0	0	0	0	0
		2011	0.1	0	0	2	1	1	2	2	0	0	0	0
		2012	0.1	0	0	3	2	1	2	3	0	0	0	0
	Patch 3 Lincoln, NV 1169	2010	0.1	1	0.5	3	1	1	2	2	0	0	0	0
		2011	0.1	0	0	1	1	0	0	0	0	1	0	1
		2012	0.1	0	0	2	1	1	1	1	0	0	0	0
	Patch 4 Lincoln, NV 1169	2010	0.1	1	0.5	2	1	1	2	1	0	1	0	1
		2011	0.1	0	0	2	1	1	1	2	0	3	0	3
		2012	0.1	0	0	1	1	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Pahraganat Key Pittman WMA Pahranagat Valley	Patch 4.5 Lincoln, NV 1169	2010	0.02	1	0.5	0	0	0	0	0	0	0	0	0
		2011	0.02	5	0.3	0	0	0	0	0	0	0	0	0
		2012	0.02	0	0	1	1	0	0	0	0	1	0	1
	Patch 5 Lincoln, NV 1169	2010	0.1	1	0.5	2	1	1	3	3	0	0	0	0
		2011	0.1	0	0	2	1	1	2	2	0	0	0	0
		2012	0.1	0	0	2	1	1	1	0	0	0	0	0
	Patch 6 Lincoln, NV 1169	2010	0.2	1	0.5	4	3	3	4	6	0	1	0	1
		2011	0.2	0	0	5	3	3	3	3	0	0	0	0
		2012	0.2	0	0	2	1	1	3	3	0	0	0	0
	Patch 7 Lincoln, NV 1169	2010	0.1	1	0.5	2	1	1	1	4	0	1	0	1
		2011	0.1	0	0	2	1	1	2	3	0	0	0	0
		2012	0.1	0	0	4	2	2	4	0	0	0	0	0
	Patch 8 Lincoln, NV 1169	2010	0.1	1	0.5	4	3	3	5	6	0	0	0	0
		2011	0.1	0	0	2	1	1	2	0	0	0	0	0
		2012	0.1	0	0	1	1	0	0	0	0	0	0	0
	Patch 9 Lincoln, NV 1169	2010	0.3	1	0.5	2	1	1	1	3	0	0	0	0
		2011	0.3	0	0	4	2	2	3	3	0	0	0	0
		2012	0.3	0	0	6	3	3	4	4	0	1	0	1
	Patch 10 Lincoln, NV 1169	2010	0.1	1	0.5	3	2	2	4	3	0	0	0	0
		2011	0.1	0	0	3	2	2	4	5	0	0	0	0
		2012	0.1	0	0	3	2	2	5	3	0	0	0	0
	Patch 10.5 Lincoln, NV 1169	2010	0.02	1	0.5	0	0	0	0	0	0	1	0	1
		2011	0.02	0	0	0	0	0	0	0	0	2	0	2
		2012	0.02	0	0	3	2	1	2	0	0	0	0	0
	Patch 11 Lincoln, NV 1169	2010	0.1	1	0.5	2	1	1	3	3	0	0	0	0
		2011	0.1	0	0	4	2	2	6	4	0	1	0	1
		2012	0.1	0	0	2	1	1	3	3	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Pahraganat Key Pittman WMA Pahranagat Valley	Patch 12 1169	2010	0.1	1	0.5	2	1	1	2	3	0	0	0	0
		2011	0.1	0	0	3	2	2	6	3	0	2	0	2
		2012	0.1	0	0	6	3	3	5	2	0	1	0	1
	Fence[5]	2011	---	0	---	0	0	0	0	0	1	0	1	0
	TOTAL	2010	1.56	1	7.5	31	18	17	31	37	0	4	0	4
		2011	1.58	5	0.3	34	19	18	33	30	1	7	1	7
		2012	1.58	0	0	39	23	17	32	22	0	3	0	3
Pahraganat River Ranch Pahranagat Valley	West Side Lincoln, NV 1,100	2011	0.3	1	0.3	3	2	1	1	0	0	2	1	1
		2012	0.3	5	1.1	0	0	0	0	0	0	0	0	0
	East Side Lincoln, NV 1,100	2011	0.4	1	0.3	2	1	1	3	0	0	0	0	0
		2012	0.4	4	1.8	0	0	0	0	0	0	1	0	1
	Smalls Lincoln, NV 1,100	2011	0.5	1	0.3	2	1	1	0	0	0	0	0	0
		2012	0.5	5	1.1	0	0	0	0	0	0	0	0	0
	TOTAL	2011	1.2	1	0.9	7	4	3	4	0	0	2	1	1
		2012	1.2	---	4.0	0	0	0	0	0	0	1	0	1
Pahraganat Pahranagat NWR Pahranagat Valley	North Lincoln, NV 1,026	2003	4.4	14	23.2	18	13	7	11	20	0	0	0	0
		2004	4.5	10	11.8	26	15	13	15	32	3	3	4	2
		2005	4.5	5	11.3	26	18	9	18	26	1	3	1	3
		2006	4.5	7	7.3	26	15	12	15	24	0	2	0	2
		2007	3.8	10	8.9	21	13	10	12	23	0	3	0	3
		2008	4.6	5	6.9	24	17	9	12	21	0	2	0	2
		2009	4.6	5	6.1	21	12	10	18	22	0	2	0	2
		2010	4.6	0	0	23	14	10	20	26	0	0	0	0
		2011	4.6	4	1.5	14	10	6	7	17	3	3	3	3
		2012	4.6	5	1.8	22	14	12	14	23	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Pahraganat Pahranagat NWR Pahranagat Valley	West Lincoln, NV 1,026	2004	---	3	1.5	0	0	0	0	0	1	0	1	0
		2005	0.6	6	3.8	0	0	0	0	0	1	0	1	0
		2006	0.6	6	1.3	0	0	0	0	0	0	0	0	0
		2007	1.5	9	3.4	0	0	0	0	0	2	0	2	0
		2008	1.5	5	2.8	0	0	0	0	0	0	0	0	0
		2009	1.5	5	3.2	0	0	0	0	0	0	0	0	0
		2010	1.5	5	4.0	0	0	0	0	0	1	0	1	0
		2011	1.5	5	3.1	0	0	0	0	0	0	0	0	0
		2012	1.5	5	3.0	0	0	0	0	0	0	0	0	0
	MAPS[6] Lincoln, NV 1,026	2004	---	1	0.5	0	0	0	0	0	0	0	0	0
		2005	---	0	---	0	0	0	0	0	0	1	1	0
		2006	2.7	5	3.9	1	1	0	0	0	0	0	0	0
	MAPS[6] Lincoln, NV 1,026	2007	2.7	9	6.0	0	0	0	0	0	1	0	1	0
		2008	2.7	5	4.8	0	0	0	0	0	0	0	0	0
		2009	2.7	5	3.5	0	0	0	0	0	0	0	0	0
		2010	1.4	4	4.1	0	0	0	0	0	0	0	0	0
	South[6] Lincoln, NV 1,023	2003	2.8	9	7.0	2	1	1	1	4	0	1	0	1
		2004	2.4	13	8.4	3	2	1	2	3	0	0	0	0
		2005	2.4	6	2.8	5	3	2	3	7	0	0	0	0
		2006	2.5	7	1.6	7	4	3	3	0	0	0	0	0
		2007	2.5	10	7.0	1	1	0	0	0	1	0	1	0
		2008	2.5	7	4.0	0	0	0	0	0	0	0	0	0
		2009	2.5	5	2.8	0	0	0	0	0	0	1	1	0
		2010	2.5	5	2.7	0	0	0	0	0	0	0	0	0
	Salt Cedar[7] Lincoln, NV 975	2003	3.1	1	0.5	0	0	0	0	0	0	0	0	0
		2005	3.1	6	10.0	0	0	0	0	0	0	0	0	0
		2006	3.1	6	3.9	0	0	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Pahraganat Pahranagat NWR Pahranagat Valley	TOTAL	2003	10.3	---	30.7	20	14	8	12	24	0	1	0	1
		2004	6.9	---	22.2	29	17	14	17	35	4	3	5	2
		2005	10.6	---	27.9	31	21	11	21	33	2	4	3	3
		2006	13.4	---	18.0	34	20	15	18	24	0	2	0	2
		2007	10.5	---	25.3	22	14	10	12	23	4	3	4	3
		2008	11.3	---	18.5	24	17	9	12	21	0	2	0	2
		2009	11.3	---	15.6	21	12	10	18	22	0	3	1	2
		2010	10.0	---	10.8	23	14	10	20	26	1	0	1	0
		2011	6.1	---	4.6	14	10	6	7	17	3	3	3	3
		2012	6.1	---	4.8	22	14	12	14	23	0	0	0	0
Pahranagat Meadow Valley Wash Meadow Valley Wash	Meadow Valley #6[7] Lincoln, NV 1,182	2003	7.1	10	11.9	0	0	0	0	0	0	0	0	0
	Meadow Valley #3[7] Lincoln, NV 1,128	2003	3.2	10	2.8	0	0	0	0	0	0	0	0	0
	Meadow Valley #4[7] Lincoln, NV 1,048	2003	1.2	10	4.4	0	0	0	0	0	0	0	0	0
	TOTAL	2003	11.5	---	19.1	0	0	0	0	0	0	0	0	0
Pahranagat Warm Springs NA Muddy River	LDS East[6] Clark, NV 548	2010	0.9	4	2.0	0	0	0	0	0	0	0	0	0
	Muddy Stringer #1[6] Clark, NV 548	2010	1.4	4	2.8	3	2	2	2	0	1	0	1	0
	Muddy Stringer #2[6] Clark, NV 548	2010	1.4	5	4.8	0	0	0	0	0	0	0	0	0
	North Fork Muddy[6] Clark, NV 548	2010	5.5	1	2.0	0	0	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Pahranagat Warm Springs NA Muddy River	Muddy Mac Clark, NV 548	2010	1.1	4	2.3	3	2	1	1	0	0	0	0	0
		2011	0.7	0	0	2	1	1	1	3	3	0	3	0
		2012	0.5	0	0	2	1	1	2	0	1	0	1	0
	Apcar[6] Clark, NV 548	2010	0.7	2	0.8	0	0	0	0	0	0	0	0	0
	TOTAL	2010	11.0	---	14.7	6	4	3	3	0	1	0	1	0
		2011	0.7	0	0	2	1	1	1	3	3	0	3	0
		2012	0.5	0	0	2	1	1	2	0	1	0	1	0
Pahranagat Muddy River Muddy River	Overton WMA Pond Clark, NV 378	2007	0.7	0	0	2	1	1	1	0	0	0	0	0
		2008	0.7	6	5.1	0	0	0	0	0	1	0	1	0
		2009	0.7	5	3.4	0	0	0	0	0	0	0	0	0
		2010	0.7	5	3.5	0	0	0	0	0	0	0	0	0
		2011	0.7	5	2.5	0	0	0	0	0	0	1	0	1
		2012	0.7	5	6.2	1	1	0	0	0	5	0	5	0
	Overton WMA Clark, NV 378	2004	12.6	11	23.8	1	1	0	0	0	2	1	2	1
		2005	13.0	11	38.0	11	7	6	8	3	0	1	0	1
		2006	14.9	6	19.0	11	8	7	9	7	0	0	0	0
		2007	14.9	8	33.0	13	8	7	11	0	1	0	1	0
		2008	14.9	5	26.3	8	6	4	8	3	1	1	2	0
		2009	14.9	5	21.9	13	8	6	9	0	4	0	4	0
		2010	14.9	5	19.8	12	8	4	4	7	1	1	1	1
		2011	14.9	6	18.0	13	8	5	6	0	0	2	0	2
		2012	9.2	5	19.0	12	9	5	6	3	1	0	1	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Pahranagat Muddy River Muddy River	TOTAL	2004	12.6	---	23.8	1	1	0	0	0	2	1	2	1
		2005	13.0	---	38.0	11	7	6	8	3	0	1	0	1
		2006	14.9	---	19.0	11	8	7	9	7	0	0	0	0
		2007	15.6	---	33.0	15	9	8	12	0	1	0	1	0
		2008	15.6	---	31.4	8	6	4	8	3	2	1	3	0
		2009	15.6	---	25.3	13	8	6	9	0	4	0	4	0
		2010	15.6	---	23.3	12	8	4	4	7	1	1	1	1
		2011	15.6	---	20.5	13	8	5	6	0	0	3	0	3
		2012	9.9	---	25.2	13	10	5	6	3	6	0	6	0
Virgin Littlefield Virgin River	North[7] Mohave, AZ 543	2003	9.3	10	25.0	0	0	0	0	0	0	0	0	0
		2004	9.3	11	18.0	3	2	1	3	2	0	0	0	0
		2005	4.7	6	8.5	0	0	0	0	0	1	0	1	0
		2006	4.7	4	4.8	0	0	0	0	0	0	0	0	0
	South[7] Mohave, AZ 543	2003	5.7	10	21.9	0	0	0	0	0	0	0	0	0
		2004	5.7	11	15.3	0	0	0	0	0	0	0	0	0
		2005	1.6	5	2.0	0	0	0	0	0	0	0	0	0
Virgin Littlefield Beaver Dam Wash	Poles[7] Mohave, AZ 565	2007	1.0	2	0.5	1	1	0	0	0	0	0	0	0
		2008	2.6	5	5.5	0	0	0	0	0	0	1	0	1
		2009	4.7	5	14.5	4	3	2	2	0	0	1	0	1
		2010	1.2	5	10.0	3	2	1	2	3	1	0	1	0
	TOTAL	2003	15.0	---	46.9	0	0	0	0	0	0	0	0	0
		2004	15.0	---	33.3	3	2	1	3	2	0	0	0	0
		2005	6.3	---	10.5	0	0	0	0	0	2	0	2	0
		2006	4.7	---	4.8	0	0	0	0	0	0	0	0	0
		2007	1.0	---	0.5	1	1	0	0	0	0	0	0	0
		2008	2.6	---	5.5	0	0	0	0	0	0	1	0	1
		2009	4.7	---	14.5	4	3	2	2	0	0	1	0	1
		2010	1.2	---	10.0	3	2	1	2	3	1	0	1	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Virgin Mesquite Virgin River	Hafen Lane Clark, NV 475	2006	5.6	2	8.4	0	0	0	0	0	0	0	0	0
		2010	6.1	5	6.8	2	1	1	1	0	0	0	0	0
		2011	6.1	5	16.2	3	1	1	1	0	0	0	0	0
		2012	5.2	5	17.3	0	0	0	0	0	1	0	1	0
	Dumb Luck Bridge Clark, NV 475	2012	1.2	2	2.3	2	1	1	1	0	0	0	0	0
	East[7] Clark, NV 468	2005	3.8	5	13.5	1	1	0	0	0	0	0	0	0
		2006	3.8	6	7.0	2	1	1	0	0	0	0	0	0
		2007	3.7	8	16.4	1	1	0	0	0	0	0	0	0
		2008	4.4	5	8.8	0	0	0	0	0	0	1	0	1
		2009	4.4	5	8.6	0	0	0	0	0	0	0	0	0
		2010	4.4	1	1.0	0	0	0	0	0	0	0	0	0
	West Clark, NV 470	2003	18.2	11	51.0	30	19	13	18	16	3	5	3	5
		2004	18.2	16	19.5	28	16	12	20	11	0	2	0	2
		2005	13.8	9	29.7	12	7	5	7	3	0	0	0	0
		2006	13.1	6	15.3	24	14	14	21	23	1	0	1	0
		2007	12.0	9	21.2	25	14	13	16	15	0	0	0	0
		2008	11.5	8	23.2	24	14	11	11	18	0	1	0	1
		2009	11.5	1	2.0	20	12	9	13	3	0	1	0	1
		2010	10.5	5	14.4	16	8	6	15	7	0	1	1	0
		2011	10.4	5	7.4	11	7	6	8	3	0	0	0	0
		2012	10.6	5	16.8	6	4	3	5	0	2	2	3	1
	Electric Avenue North[7] Clark, NV 460	2006	2.1	3	2.2	0	0	0	0	0	0	0	0	0
		2007	1.8	9	12.5	0	0	0	0	0	0	0	0	0
		2008	1.8	1	1.5	0	0	0	0	0	0	0	0	0
	Electric Avenue South[7] Clark, NV 460	2006	4.0	3	2.4	0	0	0	0	0	0	0	0	0
		2007	3.9	10	17.2	0	0	0	0	0	0	0	0	0
		2008	3.9	1	1.6	0	0	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Virgin Mesquite Virgin River	Bunker Farm[7] Clark, NV 457	2005	3.1	3	2.5	6	4	2	6	3	0	0	0	0
		2006	3.1	8	8.2	1	1	0	0	0	0	0	0	0
		2007	3.1	9	11.0	0	0	0	0	0	0	0	0	0
		2008	1.9	5	8.0	0	0	0	0	0	1	0	1	0
	Bunker Marsh North[7] Clark, NV 456	2006	13.6	3	2.4	0	0	0	0	0	0	0	0	0
		2009	13.6	5	17.0	5	3	3	3	0	0	2	2	0
		2010	8.0	5	15.4	0	0	0	0	0	0	0	0	0
		2011	7.1	2	3.7	0	0	0	0	0	0	0	0	0
	Left Foot[8] Clark, NV 415	2012	1.1	3	2.6	0	0	0	0	0	3	0	3	0
	TOTAL	2003	18.2	---	51.0	30	19	13	19	17	3	5	3	5
		2004	18.2	---	19.5	28	16	12	20	11	0	2	0	2
		2005	20.7	---	45.7	19	12	7	13	6	0	0	0	0
		2006	45.3	---	45.9	27	16	15	21	23	1	0	1	0
		2007	24.5	---	78.3	26	15	13	16	15	0	0	0	0
		2008	23.5	---	43.1	24	14	11	11	18	1	2	1	2
		2009	29.5	---	27.6	25	15	12	16	3	0	3	2	1
		2010	29.0	---	37.6	17	9	7	16	7	0	1	1	0
		2011	23.6	---	27.3	14	8	7	9	3	0	0	0	0
		2012	18.1	---	39.0	8	5	4	6	0	6	2	7	1
Virgin Mormon Mesa Virgin River	Mormon Mesa North[7] Clark, NV 390	2003	15.8	11	30.2	6	3	3	7	0	1	0	1	0
		2004	15.8	12	23.8	2	1	1	1	3	2	0	2	0
		2005	13.5	8	20.3	5	3	2	3	0	0	0	0	0
		2006	12.4	7	15.7	0	0	0	0	0	0	0	0	0
		2007	13.4	10	39.2	0	0	0	0	0	0	0	0	0
		2008	8.2	6	18.2	0	0	0	0	0	0	0	0	0
		2009	8.2	5	16.4	0	0	0	0	0	0	0	0	0
		2010	8.2	1	3.8	0	0	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Virgin Mormon Mesa Virgin River	Hedgerow[7] Clark, NV 390	2005	1.3	2	0.8	0	0	0	0	0	0	0	0	0
		2006	1.3	7	3.1	0	0	0	0	0	0	0	0	0
		2007	1.4	8	5.6	0	0	0	0	0	0	0	0	0
		2008	1.1	5	3.9	0	0	0	0	0	0	0	0	0
		2009	1.1	5	2.3	0	0	0	0	0	0	0	0	0
		2010	1.1	1	1.5	0	0	0	0	0	0	0	0	0
	Mormon Mesa South (North) Clark, NV 385	2003	24.0	11	21.6	0	0	0	0	0	1	0	1	0
		2004	24.0	10	25.3	0	0	0	0	0	2	1	3	0
		2005	14.8	7	20.3	0	0	0	0	0	0	0	0	0
		2006	14.5	8	12.8	0	0	0	0	0	0	1	1	0
		2007	13.3	9	38.6	0	0	0	0	0	1	0	1	0
		2008	12.9	5	23.3	0	0	0	0	0	2	0	2	0
		2009	8.9	5	12.3	0	0	0	0	0	0	0	0	0
		2010	8.6	5	13.8	0	0	0	0	0	0	1	1	0
		2011	8.4	4	9.3	0	0	0	0	0	0	0	0	0
		2012	8.4	5	10.7	0	0	0	0	0	1	0	1	0
	Mormon Mesa South (South) Clark, NV 385	2003	11.6	11	15.2	0	0	0	0	0	0	0	0	0
		2004	11.6	10	17.8	0	0	0	0	0	0	0	0	0
		2005	9.1	5	14.8	0	0	0	0	0	0	0	0	0
		2006	9.1	8	10.2	0	0	0	0	0	0	0	0	0
		2007	8.3	8	25.0	0	0	0	0	0	1	0	1	0
		2008	7.0	5	18.3	0	0	0	0	0	0	0	0	0
		2009	3.4	5	7.5	0	0	0	0	0	0	0	0	0
		2010	3.4	5	7.5	0	0	0	0	0	0	0	0	0
		2011	3.4	3	4.8	0	0	0	0	0	0	0	0	0
		2012	3.4	5	8.9	0	0	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Virgin Mormon Mesa Virgin River	Virgin River #1 (North) Clark, NV 380	2003	43.3	13	33.6	7	4	3	4	0	0	0	0	0
		2004	43.3	12	40.3	8	4	4	5	1	5	2	5	2
		2005	25.5	9	36.3	1	1	0	0	0	1	0	1	0
		2006	25.4	6	18.4	0	0	0	0	0	0	0	0	0
		2007	24.9	11	52.4	1	1	0	0	0	1	0	1	0
		2008	16.5	5	37.3	2	1	1	1	3	0	0	0	0
		2009	12.0	5	23.5	3	2	2	2	0	1	0	1	0
		2010	11.4	5	30.3	0	0	0	0	0	3	1	3	1
		2011	11.4	4	12.9	4	2	2	1	0	0	1	0	1
		2012	10.4	5	21.4	2	1	1	1	1	1	0	1	0
	Virgin River #1 (South) Clark, NV 380	2003	49.2	2	2.0	0	0	0	0	0	0	0	0	0
		2004	49.3	11	29.6	0	0	0	0	0	0	0	0	0
		2005	25.0	5	18.5	0	0	0	0	0	0	0	0	0
		2006	24.8	5	6.8	3	2	1	1	0	1	0	1	0
		2007	28.0	10	49.1	12	7	7	6	3	1	0	1	0
		2008	24.9	5	38.8	18	12	9	10	15	0	1	1	0
		2009	34.7	5	29.5	24	15	11	16	22	1	3	1	3
		2010	11.1	5	17.5	25	16	10	15	12	1	0	1	0
		2011	11.1	3	5.5	19	12	11	19	16	0	1	0	1
		2012	11.1	6	16.8	22	15	13	16	8	0	2	0	2
	Virgin River #2[7] Clark, NV 380	2003	67.2	4	7.4	0	0	0	0	0	0	0	0	0
		2004	67.2	1	6.6	0	0	0	0	0	0	0	0	0
		2005	38.2	6	36.2	6	3	3	3	1	0	0	0	0
		2006	50.8	6	13.9	17	12	6	8	8	0	1	0	1
		2007	36.9	11	55.6	11	7	4	6	0	0	0	0	0
		2008	36.9	5	35.3	6	4	3	3	1	0	1	1	0
		2009	36.9	5	51.5	0	0	0	0	0	1	0	1	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Virgin Mormon Mesa Virgin River	Virgin River #2[7] Clark, NV 380	2010	11.2	5	12.7	1	1	0	0	0	1	1	2	0
		2011	11.2	5	16.8	0	0	0	0	0	0	0	0	0
		2012	11.2	3	11.4	0	0	0	0	0	0	0	0	0
	Delta West[7] Clark, NV 370	2003	12.2	11	29.2	5	3	2	2	0	0	0	0	0
		2004	12.3	11	18.1	4	2	2	1	2	1	0	1	0
		2005	12.2	3	17.0	1	1	0	0	0	0	0	0	0
	TOTAL	2003	223.3	---	139.2	17	10	8	13	0	2	0	2	0
		2004	223.5	---	161.5	14	7	7	7	6	10	3	11	2
		2005	139.6	---	164.2	13	7	5	6	1	1	0	1	0
		2006	138.3	---	80.9	20	14	7	9	8	1	2	2	1
		2007	126.2	---	265.5	24	15	11	12	3	4	0	4	0
		2008	107.5	---	175.1	26	17	13	14	19	2	2	4	0
		2009	105.2	---	143.0	27	17	13	18	22	3	3	3	3
		2010	55.0	---	87.1	25	17	10	15	12	4	3	6	1
		2011	45.5	---	49.3	23	14	13	20	16	0	2	0	2
		2012	44.5	---	69.2	24	16	14	17	9	2	2	2	2
Middle Colorado Grand Canyon Colorado River	Separation Canyon[7] Mohave, AZ 378	2003	8.0	10	12.1	0	0	0	0	0	0	0	0	0
		2004	8.0	10	9.8	0	0	0	0	0	0	0	0	0
		2005	5.3	9	14.7	0	0	0	0	0	0	0	0	0
		2006	5.3	2	2.0	0	0	0	0	0	0	---	0	---
	RM 243S[7] Mohave, AZ 366	2003	1.8	11	9.6	0	0	0	0	0	0	1	0	1
		2004	1.8	10	7.3	0	0	0	0	0	0	0	0	0
		2005	1.8	9	9.0	0	0	0	0	0	0	0	0	0
	Spencer Canyon (RM 246S)[7] Mohave, AZ 366	2003	5.5	10	14.7	0	0	0	0	0	0	0	0	0
		2004	5.5	10	12.6	0	0	0	0	0	0	0	0	0
		2005	5.0	9	16.6	0	0	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Middle Colorado Grand Canyon Colorado River	Surprise Canyon[7] Mohave, AZ 365	2004	4.8	9	7.5	0	0	0	0	0	0	0	0	0
		2005	4.9	9	7.8	0	0	0	0	0	0	0	0	0
	Clay Tank Canyon[7] Mohave, AZ 363	2003	0.5	10	4.2	0	0	0	0	0	0	0	0	0
		2004	0.5	10	2.5	0	0	0	0	0	0	0	0	0
		2005	0.4	9	2.7	0	0	0	0	0	0	0	0	0
	No WIFL Point[7] Mohave, AZ 363	2004	0.9	9	3.4	0	0	0	0	0	0	0	0	0
		2005	1.2	10	9.2	0	0	0	0	0	0	0	0	0
	No WIFL Bay[7] Mohave, AZ 363	2004	1.1	9	4.5	0	0	0	0	0	0	0	0	0
		2005	1.1	10	8.1	0	0	0	0	0	0	0	0	0
	Reference Point Creek[7] Mohave, AZ 360	2003	4.2	10	9.6	0	0	0	0	0	0	0	0	0
		2004	4.2	10	18.2	0	0	0	0	0	0	0	0	0
		2005	4.2	10	15.7	0	0	0	0	0	0	0	0	0
	RM 257.5N[7] Mohave, AZ 360	2003	7.1	10	6.6	0	0	0	0	0	0	0	0	0
		2004	7.1	11	20.4	0	0	0	0	0	0	0	0	0
		2005	1.2	9	7.1	0	0	0	0	0	0	0	0	0
	Burnt Springs (RM 259.5N) Mohave, AZ 363	2003	11.0	10	12.9	0	0	0	0	0	0	0	0	0
		2004	11.0	11	26.9	1	1	0	0	0	0	0	0	0
		2005	11.0	10	16.2	0	0	0	0	0	0	0	0	0
		2006	11.0	9	10.9	0	0	0	0	0	0	0	0	0
		2007	11.0	10	7.3	2	1	1	1	0	0	0	0	0
		2008	11.0	4	3.5	0	0	0	0	0	0	0	0	0
	Quartermaster Canyon[7] Mohave, AZ 360	2003	2.8	10	9.0	0	0	0	0	0	0	0	0	0
		2004	2.8	10	11.2	0	0	0	0	0	0	0	0	0
		2005	3.3	10	12.2	0	0	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Middle Colorado Grand Canyon Colorado River	RM 260.5N[7] Mohave, AZ 354	2003	3.4	10	4.7	0	0	0	0	0	0	0	0	0
		2004	3.5	9	12.8	0	0	0	0	0	0	0	0	0
	RM 262.5S[7] Mohave, AZ 354	2003	12.8	10	15.3	0	0	0	0	0	0	0	0	0
	PTCNT1[7] Mohave, AZ 354	2003	9.3	1	0.8	0	0	0	0	0	---	0	---	0
	RM 268N[7] Mohave, AZ 354	2003	7.2	4	2.2	0	0	0	0	0	---	0	---	0
	Wheeo (RM 268S)[7] Mohave, AZ 354	2003	14.2	5	7.3	0	0	0	0	0	0	0	0	---
	Columbine Falls[7] Mohave, AZ 354	2003	7.2	10	10.8	0	0	0	0	0	0	0	0	0
		2004	7.2	10	15.1	0	0	0	0	0	0	0	0	0
		2005	6.3	10	11.3	0	0	0	0	0	0	0	0	0
	RM 274.5N Mohave, AZ 354	2003	4.5	10	14.9	0	0	0	0	0	0	0	0	0
		2004	11.1	11	31.1	2	1	1	1	0	0	0	0	0
		2005	10.4	9	15.1	1	1	0	0	0	0	0	0	0
		2006	18.3	12	33.5	2	1	1	1	0	1	0	1	0
		2007	18.3	10	18.8	2	2	0	0	0	1	1	2	0
		2008	18.3	4	13.5	0	0	0	0	0	0	0	0	0
	Pearce Ferry[7] Mohave, AZ 343	2006	0.8	5	1.4	0	0	0	0	0	0	1	1	0
		2007	0.8	9	2.5	0	0	0	0	0	1	0	1	0
	RM 285.3N[7] Mohave, AZ 343	2006	8.7	8	12.2	4	2	2	2	0	1	0	1	0
		2007	8.7	9	7.9	0	0	0	0	0	0	0	0	0
		2008	8.6	4	2.6	0	0	0	0	0	0	0	0	0
	Kowlp Corner[7] Mohave, AZ 342	2006	5.4	6	5.4	1	1	0	0	0	0	0	0	0
		2007	5.4	10	7.0	0	0	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Middle Colorado Grand Canyon Colorado River	RM 286N[7] Mohave, AZ 342	2006	3.4	5	2.1	0	0	0	0	0	0	0	0	0
		2007	3.4	10	5.8	0	0	0	0	0	0	0	0	0
	Driftwood Island[7] Mohave, AZ 342	2006	3.7	6	3.8	0	0	0	0	0	0	0	0	0
		2007	3.7	10	3.9	0	0	0	0	0	0	0	0	0
	Twin Coves[7] Mohave, AZ 342	2006	1.8	6	3.1	2	1	1	0	0	0	0	0	0
		2007	1.4	10	3.7	0	0	0	0	0	0	0	0	0
	Bradley Bay[7] Mohave, AZ 341	2006	7.6	7	9.4	0	0	0	0	0	0	0	0	0
		2007	5.6	11	7.0	0	0	0	0	0	0	0	0	0
	Chuckwalla Cove[7] Mohave, AZ 341	2006	3.4	7	6.3	2	1	1	0	0	0	1	1	0
		2007	1.8	10	3.2	0	0	0	0	0	0	0	0	0
	Center Point[7] Mohave, AZ 341	2006	3.1	4	1.2	0	0	0	0	0	0	0	0	0
		2007	3.1	10	1.7	0	0	0	0	0	0	0	0	0
	Iceberg Canyon Mohave, AZ 340	2008	3.1	3	5.0	1	1	0	0	0	0	0	0	0
	TOTAL	2003	99.5	---	134.7	0	0	0	0	0	0	1	0	1
		2004	69.5	---	183.3	3	2	1	1	0	0	0	0	0
		2005	56.1	---	145.7	1	1	0	0	0	0	0	0	0
		2006	72.5	---	91.3	11	6	5	3	0	2	2	4	0
		2007	63.2	---	68.8	4	3	1	1	0	2	1	3	0
		2008	41.0	---	24.6	1	1	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Hoover to Parker Topock Marsh Colorado River	Pipes #1 Mohave, AZ 140	2003	5.3	11	25.6	0	0	0	0	0	0	0	0	0
		2004	5.2	10	17.9	0	0	0	0	0	1	0	1	0
		2005	5.2	10	14.7	0	0	0	0	0	1	1	1	1
		2006	5.2	9	13.1	0	0	0	0	0	0	0	0	0
		2007	5.2	10	18.6	0	0	0	0	0	0	0	0	0
		2008	5.2	5	9.5	0	0	0	0	0	0	0	0	0
		2009	5.2	5	9.0	0	0	0	0	0	1	0	1	0
		2010	5.2	5	10.8	0	0	0	0	0	2	0	2	0
		2011	5.2	5	8.5	1	1	0	0	0	0	0	0	0
		2012	5.2	5	6.8	0	0	0	0	0	0	0	0	0
	Pipes #2[7] Mohave, AZ 140	2003	2.8	9	11.3	0	0	0	0	0	0	0	0	0
		2004	2.8	5	7.0	0	0	0	0	0	0	0	0	0
		2005	2.8	10	3.3	0	0	0	0	0	0	0	0	0
		2006	2.8	5	3.9	0	0	0	0	0	0	0	0	0
	Pipes #3 Mohave, AZ 140	2003	4.9	11	19.3	0	0	0	0	0	1	0	1	0
		2004	5.7	11	16.2	5	3	3	5	1	0	0	0	0
		2005	5.7	10	11.0	1	1	0	0	0	1	0	1	0
		2006	5.7	10	13.5	2	1	1	0	0	0	1	1	0
		2007	5.7	11	21.1	0	0	0	0	0	0	0	0	0
		2008	5.7	5	6.0	2	1	1	1	0	0	0	0	0
		2009	5.7	5	5.3	1	1	0	0	0	1	0	1	0
		2010	5.7	6	7.3	3	2	1	0	0	0	0	0	0
		2011	5.7	5	4.6	2	1	1	1	0	0	0	0	0
		2012	5.7	5	7.1	1	1	0	0	0	1	0	1	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Hoover to Parker Topock Marsh Colorado River	The Wallows Mohave, AZ 140	2005	0.4	0	0	1	1	0	0	0	0	0	0	0
		2006	0.4	5	1.9	2	1	1	1	0	0	0	0	0
		2007	0.4	10	4.3	0	0	0	0	0	0	0	0	0
		2008	0.4	6	1.8	0	0	0	0	0	0	1	1	0
		2009	0.4	5	5.0	2	1	1	2	3	1	0	1	0
		2010	0.7	5	3.1	2	2	0	0	0	1	1	1	1
		2011	0.7	5	2.1	1	1	0	0	0	2	0	2	0
		2012	0.7	5	2.0	0	0	0	0	0	2	0	2	0
	PC6-1 Mohave, AZ 140	2003	3.9	1	2.3	0	0	0	0	0	0	0	0	0
		2004	4.8	10	16.8	8	4	4	6	2	0	1	0	1
		2005	4.8	4	8.8	3	2	1	2	0	0	0	0	0
		2006	4.8	9	12.4	0	0	0	0	0	0	0	0	0
		2007	4.8	10	14.3	0	0	0	0	0	0	0	0	0
		2008	4.8	6	11.4	0	0	0	0	0	0	0	0	0
		2009	4.8	5	11.0	1	1	0	0	0	1	0	1	0
		2010	4.8	5	9.8	0	0	0	0	0	2	0	2	0
		2011	4.8	5	8.0	0	0	0	0	0	1	0	1	0
		2012	4.8	5	6.0	0	0	0	0	0	0	0	0	0
	PB 2001[7] Mohave, AZ 140	2003	3.9	1	0.7	0	0	0	0	0	0	0	0	0
		2004	2.1	2	4.0	0	0	0	0	0	0	0	0	0
		2005	2.1	11	5.4	0	0	0	0	0	0	0	0	0
	Pig Hole Mohave, AZ 140	2004	1.8	---	0	2	1	1	1	1	0	0	0	0
		2005	2.4	10	5.1	0	0	0	0	0	0	0	0	0
		2006	2.4	8	7.5	1	1	0	0	0	0	0	0	0
		2007	2.4	10	7.2	0	0	0	0	0	0	0	0	0
		2008	2.4	6	4.8	0	0	0	0	0	0	0	0	0
		2009	2.4	5	5.3	0	0	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Hoover to Parker Topock Marsh Colorado River	Pig Hole Mohave, AZ 140	2010	2.4	5	5.0	0	0	0	0	0	0	0	0	0
		2011	2.4	5	5.1	0	0	0	0	0	0	0	0	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	In Between Mohave, AZ 140	2003	8.0	5	8.2	12	6	6	7	9	0	0	0	0
		2004	8.0	4	8.5	12	8	8	15	8	0	0	0	0
		2005	7.7	10	8.2	10	5	5	8	7	0	0	0	0
		2006	7.7	8	9.1	8	5	3	4	0	1	0	1	0
		2007	7.8	10	10.3	3	2	1	1	1	0	0	0	0
		2008	7.7	6	11.5	1	1	0	0	0	0	0	0	0
		2009	7.7	5	9.8	0	0	0	0	0	0	0	0	0
		2010	7.7	5	9.3	0	0	0	0	0	0	0	0	0
		2011	7.7	5	9.9	0	0	0	0	0	1	0	1	0
		2012	7.7	5	7.4	0	0	0	0	0	0	0	0	0
	800M Mohave, AZ 140	2003	6.2	3	7.6	4	2	2	2	5	0	0	0	0
		2004	6.2	5	8.8	4	2	2	3	5	0	0	0	0
		2005	6.1	5	2.5	6	4	4	11	3	0	0	0	0
		2006	6.1	4	2.7	2	1	1	0	0	0	0	0	0
		2007	6.1	2	2.5	2	1	1	1	0	0	0	0	0
		2008	6.1	6	5.8	0	0	0	0	0	0	0	0	0
		2009	6.1	5	6.5	1	1	0	0	0	0	0	0	0
		2010	4.7	5	7.8	2	2	0	0	0	2	0	2	0
		2011	4.7	5	4.7	1	1	0	0	0	1	1	2	0
		2012	4.7	5	6.1	0	0	0	0	0	0	0	0	0
	Pierced Egg Mohave, AZ 140	2003	6.8	12	28.3	0	0	0	0	0	0	0	0	0
		2004	6.8	2	5.3	5	3	2	2	3	0	0	0	0
		2005	6.7	10	16.2	8	4	4	5	2	0	0	0	0
		2006	6.7	5	7.9	5	3	3	6	2	0	1	1	0
		2007	6.8	3	4.6	6	4	2	1	2	1	0	1	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Hoover to Parker Topock Marsh Colorado River	Pierced Egg Mohave, AZ 140	2008	6.7	1	2.3	9	5	5	5	0	1	2	3	0
		2009	6.7	5	8.5	2	2	0	0	0	1	2	3	0
		2010	6.7	5	9.7	1	1	0	0	0	2	0	2	0
		2011	6.7	5	8.5	0	0	0	0	0	4	0	4	0
		2012	6.7	5	9.0	0	0	0	0	0	1	1	1	1
	Swine Paradise Mohave, AZ 140	2003	3.3	10	5.6	0	0	0	0	0	0	0	0	0
		2004	3.7	10	11.6	1	1	0	0	0	2	0	2	0
		2005	3.7	10	6.5	0	0	0	0	0	0	0	0	0
		2006	3.7	10	6.9	0	0	0	0	0	2	0	2	0
		2007	3.7	10	6.0	0	0	0	0	0	0	0	0	0
		2008	2.4	5	3.0	0	0	0	0	0	0	0	0	0
		2009	1.0	5	4.0	0	0	0	0	0	0	0	0	0
		2010	1.0	5	6.0	0	0	0	0	0	1	0	1	0
		2011	0.9	5	4.0	0	0	0	0	0	1	0	1	0
		2012	0.7	5	1.5	0	0	0	0	0	2	0	2	0
	Barbed Wire Mohave, AZ 140	2003	2.6	12	19.1	0	0	0	0	0	0	0	0	0
		2004	2.6	9	10.5	0	0	0	0	0	1	0	1	0
		2005	2.6	10	7.0	0	0	0	0	0	0	0	0	0
		2006	2.6	10	7.8	0	0	0	0	0	0	0	0	0
		2007	2.6	10	8.0	0	0	0	0	0	1	0	1	0
		2008	2.6	5	4.5	0	0	0	0	0	0	0	0	0
		2009	2.4	5	7.3	0	0	0	0	0	0	0	0	0
		2010	2.4	5	5.6	0	0	0	0	0	0	0	0	0
		2011	2.1	5	4.0	0	0	0	0	0	0	0	0	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Hoover to Parker Topock Marsh Colorado River	IRFB03[7] Mohave, AZ 140	2003	1.0	7	3.3	0	0	0	0	0	0	0	0	0
		2004	1.0	10	4.0	0	0	0	0	0	0	0	0	0
		2005	1.0	10	3.8	0	0	0	0	0	0	0	0	0
		2006	1.0	10	4.7	0	0	0	0	0	0	0	0	0
		2007	1.0	10	3.9	0	0	0	0	0	0	0	0	0
		2008	1.0	5	1.8	0	0	0	0	0	0	0	0	0
	IRFB04[7] Mohave, AZ 140	2003	1.5	7	2.6	0	0	0	0	0	0	0	0	0
		2004	1.5	10	5.1	0	0	0	0	0	0	0	0	0
		2005	1.5	10	2.8	0	0	0	0	0	0	0	0	0
		2006	1.5	10	5.5	0	0	0	0	0	0	0	0	0
		2007	1.5	10	3.4	0	0	0	0	0	0	0	0	0
		2008	1.5	5	2.0	0	0	0	0	0	1	0	1	0
	Platform Mohave, AZ 140	2003	1.3	11	6.8	0	0	0	0	0	1	0	1	0
		2004	1.3	10	3.2	0	0	0	0	0	1	0	1	0
		2005	1.3	10	3.5	0	0	0	0	0	0	0	0	0
		2006	1.3	10	3.5	0	0	0	0	0	0	0	0	0
		2007	1.3	10	3.1	0	0	0	0	0	0	0	0	0
		2008	1.3	5	1.3	0	0	0	0	0	0	0	0	0
		2009	1.3	5	3.5	0	0	0	0	0	0	0	0	0
		2010	1.9	5	3.8	2	1	1	1	0	0	0	0	0
		2011	1.9	5	4.6	1	1	0	0	0	0	0	0	0
		2012	1.9	5	2.5	0	0	0	0	0	0	0	0	0
	250M Mohave, AZ 140	2003	2.3	11	16.2	0	0	0	0	0	2	0	2	0
		2004	2.3	7	9.3	2	1	1	1	1	0	0	0	0
		2005	2.3	3	2.1	2	1	1	2	0	0	0	0	0
		2006	2.3	8	5.7	1	1	0	0	0	0	0	0	0
		2007	2.3	10	5.8	0	0	0	0	0	2	0	2	0
		2008	2.3	5	4.0	0	0	0	0	0	0	1	1	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Hoover to Parker Topock Marsh Colorado River	250M Mohave, AZ 140	2009	1.9	5	5.3	0	0	0	0	0	2	1	2	1
		2010	1.9	5	4.4	0	0	0	0	0	0	0	0	0
		2011	1.9	5	3.3	0	0	0	0	0	0	0	0	0
		2012	1.9	5	2.0	0	0	0	0	0	0	0	0	0
	Hell Bird Mohave, AZ 140	2003	3.7	5	10.1	1	1	0	0	0	0	1	1	0
		2004	3.7	3	8.5	7	4	3	3	1	0	2	0	2
		2005	3.7	11	13.8	0	0	0	0	0	0	0	0	0
		2006	3.7	9	11.7	0	0	0	0	0	0	0	0	0
		2007	3.7	10	10.9	0	0	0	0	0	2	0	2	0
		2008	3.7	5	5.5	0	0	0	0	0	0	0	0	0
		2009	3.3	5	10.0	2	2	0	0	0	0	0	0	0
		2010	3.3	5	5.8	0	0	0	0	0	1	0	1	0
		2011	6.3	5	6.0	0	0	0	0	0	10	0	10	0
		2012	6.3	5	6.1	0	0	0	0	0	2	0	2	0
	Glory Hole Mohave, AZ 140	2003	1.0	6	8.3	3	2	1	2	1	0	0	0	0
		2004	3.8	1	4.0	10	6	5	7	3	0	0	0	0
		2005	3.8	2	5.3	5	3	3	10	1	0	0	0	0
		2006	4.3	2	2.5	8	5	5	6	3	0	1	0	1
		2007	4.3	2	4.5	7	4	4	5	9	0	0	0	0
		2008	5.0	2	5.0	8	5	3	6	1	0	0	0	0
		2009	5.0	5	1.9	4	4	0	0	0	2	1	2	1
		2010	5.0	5	7.1	3	2	1	1	2	0	0	0	0
		2011	5.0	5	8.3	0	0	0	0	0	0	0	0	0
		2012	5.0	5	6.0	1	1	0	0	0	0	0	0	0
	Spaghetti[7] Mohave, AZ 140	2011	5.4	5	3.4	0	0	0	0	0	2	0	2	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Hoover to Parker Topock Marsh Colorado River	Beal Lake Mohave, AZ 140	2006	42.8	10	10.2	0	0	0	0	0	1	0	1	0
		2007	42.8	10	4.3	0	0	0	0	0	1	1	2	0
		2008	13.9	5	5.0	0	0	0	0	0	3	0	3	0
		2009	13.9	5	9.3	1	1	0	0	0	1	0	1	0
		2010	13.9	5	10.7	0	0	0	0	0	2	0	2	0
		2011	18.0	5	10.6	0	0	0	0	0	1	0	1	0
		2012	18.0	5	9.5	1	1	0	0	0	3	0	3	0
	Lost Slough[7] Mohave, AZ 140	2007	4.0	9	5.5	0	0	0	0	0	0	0	0	0
		2008	1.5	5	4.5	0	0	0	0	0	0	0	0	0
		2009	1.5	5	5.0	0	0	0	0	0	0	0	0	0
	Lost Pond[7] Mohave, AZ 140	2007	1.7	10	6.2	0	0	0	0	0	0	0	0	0
		2008	1.2	5	2.1	0	0	0	0	0	0	0	0	0
		2009	1.2	5	6.3	0	0	0	0	0	0	0	0	0
	Lost Lake Mohave, AZ 140	2003	8.7	13	36.8	0	0	0	0	0	0	0	0	0
		2004	8.9	10	15.5	1	1	0	0	0	0	0	0	0
		2005	9.1	10	14.7	0	0	0	0	0	0	0	0	0
		2006	9.1	9	15.3	0	0	0	0	0	1	0	1	0
		2007	4.0	9	5.2	0	0	0	0	0	1	0	1	0
		2008	3.3	5	4.0	0	0	0	0	0	0	0	0	0
		2009	3.3	5	4.5	0	0	0	0	0	1	0	1	0
		2010	3.3	5	6.5	0	0	0	0	0	0	0	0	0
		2011	3.3	5	3.4	0	0	0	0	0	1	0	1	0
		2012	3.3	5	2.7	0	0	0	0	0	0	0	0	0
	South Dike Road[5]	2004	---	0	---	0	0	0	0	0	1	1	2	0
	BHCO Trap 6[5]	2005	---	0	---	0	0	0	0	0	2	0	2	0
	Channel[5]	2007	---	0	---	0	0	0	0	0	1	0	1	0
		2008	---	0	---	0	0	0	0	0	1	0	1	0
	Kermit[5]	2007	---	0	---	0	0	0	0	0	3	0	3	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Hoover to Parker Topock Marsh Colorado River	MAM[5]	2010	---	0	---	0	0	0	0	0	2	0	2	0
	Dock[5]	2011	---	0	---	0	0	0	0	0	3	0	3	0
	Marshside[5]	2012	---	0	---	0	0	0	0	0	2	0	2	0
	TOTAL	2003	67.2	---	212.1	20	11	9	11	15	4	1	5	0
		2004	72.2	---	156.2	57	34	29	43	25	6	4	7	3
		2005	72.9	---	134.7	36	21	18	38	13	4	1	4	1
		2006	114.1	---	145.8	29	18	14	17	5	5	3	7	1
		2007	112.1	---	149.7	18	11	8	8	12	12	1	13	0
		2008	78.7	---	95.8	20	12	9	12	1	6	4	10	0
		2009	73.8	---	117.5	14	13	1	2	3	10	4	12	2
		2010	70.6	---	112.7	12	10	3	2	2	15	1	15	1
		2011	82.7	---	99.0	5	5	1	1	0	27	1	28	0
		2012	72.6	---	74.7	2	3	0	0	0	13	1	13	1
Hoover to Parker Topock Gorge Colorado River	Pulpit Rock Mohave, AZ 140	2003	1.8	10	5.0	0	0	0	0	0	0	0	0	0
		2004	1.8	8	3.3	0	0	0	0	0	0	0	0	0
		2005	1.8	10	1.8	0	0	0	0	0	0	0	0	0
		2006	1.8	9	2.2	0	0	0	0	0	1	0	1	0
		2007	2.1	8	2.4	0	0	0	0	0	0	0	0	0
		2008	---	---	---	---	---	---	---	---	---	---	---	---
		2009	2.1	5	2.5	0	0	0	0	0	0	0	0	0
	Picture Rock[7] San Bernadino, CA 138	2003	5.5	10	14.9	0	0	0	0	0	0	0	0	0
		2004	5.5	9	7.5	0	0	0	0	0	0	0	0	0
		2005	5.5	10	8.6	0	0	0	0	0	2	0	2	0
		2006	5.5	9	9.6	0	0	0	0	0	2	0	2	0
		2007	7.0	9	8.0	0	0	0	0	0	2	0	2	0
		2008	---	---	---	---	---	---	---	---	---	---	---	---
		2009	4.6	5	7.3	0	0	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Hoover to Parker Topock Gorge Colorado River	Blankenship Bend North Mohave, AZ 138	2003	18.9	10	16.8	0	0	0	0	0	0	0	0	0
		2004	27.6	8	5.0	0	0	0	0	0	2	0	2	0
		2005	26.7	10	15.7	0	0	0	0	0	0	0	0	0
		2006	26.7	8	10.2	0	0	0	0	0	0	0	0	0
		2007	26.7	9	14.0	0	0	0	0	0	4	0	4	0
		2008	26.7	5	7.5	0	0	0	0	0	0	0	0	0
		2009	26.7	5	18.3	0	0	0	0	0	0	0	0	0
		2010	19.0	5	12.2	0	0	0	0	0	0	0	0	0
	Blankenship Bend South Mohave, AZ 138	2003	43.7	11	16.1	0	0	0	0	0	0	0	0	0
		2004	43.7	8	6.8	0	0	0	0	0	1	0	1	0
		2005	25.9	9	8.6	0	0	0	0	0	0	0	0	0
		2006	25.9	9	7.3	0	0	0	0	0	0	0	0	0
		2007	25.9	7	4.2	0	0	0	0	0	1	0	1	0
		2008	25.9	5	5.8	0	0	0	0	0	0	0	0	0
		2009	25.9	5	14.3	0	0	0	0	0	0	0	0	0
		2010	11.8	5	10.0	0	0	0	0	0	0	0	0	0
	Topock Gorge North[6] San Bernadino, CA 136	2003	3.8	10	7.1	0	0	0	0	0	0	0	0	0
	Topock Gorge South[6] San Bernadino, CA 140	2003	2.6	9	5.8	0	0	0	0	0	0	0	0	0
	Havasu NE Mohave, AZ 136	2003	33.5	12	46.5	0	0	0	0	0	8	0	8	0
		2004	13.6	9	9.5	0	0	0	0	0	1	0	1	0
		2005	12.6	10	18.2	0	0	0	0	0	0	0	0	0
		2006	12.6	9	13.1	0	0	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Hoover to Parker Topock Gorge Colorado River	Havasu NE Mohave, AZ 136	2007	12.6	9	18.8	0	0	0	0	0	0	0	0	0
		2008	12.6	5	8.0	0	0	0	0	0	0	0	0	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	12.6	5	12.8	0	0	0	0	0	0	0	0	0
	TOTAL	2003	109.8	---	112.2	0	0	0	0	0	8	0	8	0
		2004	92.2	---	32.1	0	0	0	0	0	4	0	4	0
		2005	72.5	---	52.9	0	0	0	0	0	2	0	2	0
		2006	72.5	---	42.4	0	0	0	0	0	3	0	3	0
		2007	74.3	---	47.4	0	0	0	0	0	7	0	7	0
		2008	65.2	---	21.3	0	0	0	0	0	0	0	0	0
		2009	59.3	---	42.4	0	0	0	0	0	0	0	0	0
		2010	43.4	---	35.0	0	0	0	0	0	0	0	0	0
Bill Williams Bill Williams River NWR Bill Williams River	Wispy Willow La Paz, AZ 140	2011	0.5	3	2.8	0	0	0	0	0	1	0	1	0
		2012	0.9	5	4.5	0	0	0	0	0	11	0	11	0
	Site #1 La Paz, AZ 140	2003	1.9	10	15.5	1	1	0	0	0	0	0	0	0
		2004	2.2	9	11.0	1	1	0	0	0	0	0	0	0
		2005	2.8	10	6.0	0	0	0	0	0	1	0	1	0
		2006	2.8	9	8.5	0	0	0	0	0	1	0	1	0
		2008[6]	---	---	---	---	---	---	---	---	---	---	---	---
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	2.2	5	10.5	0	0	0	0	0	0	0	0	0
		2011	2.2	1	0.5	0	0	0	0	0	0	0	0	0
		2012	3.0	4	2.1	1	1	0	0	0	7	3	8	2
	Site #2 La Paz, AZ 140	2003	2.6	10	17.6	0	0	0	0	0	0	0	0	0
		2004	3.9	8	11.3	0	0	0	0	0	3	0	3	0
		2005	3.1	10	6.1	0	0	0	0	0	0	0	0	0
		2006	3.1	8	5.4	0	0	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Bill Williams Bill Williams River NWR Bill Williams River	Site #2 La Paz, AZ 140	2007	3.1	10	7.9	0	0	0	0	0	0	0	0	0
		2008	3.1	6	4.0	0	0	0	0	0	0	0	0	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	3.1	6	4.3	0	0	0	0	0	0	0	0	0
		2011	3.1	1	0.5	0	0	0	0	0	0	0	0	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	Site #11 La Paz, AZ 140	2003	2.2	9	9.0	0	0	0	0	0	0	1	1	0
		2004	4.2	8	5.1	0	0	0	0	0	0	1	1	0
		2005	6.3	10	3.8	0	0	0	0	0	0	0	0	0
		2006	6.3	7	4.5	0	0	0	0	0	1	0	1	0
		2007	6.3	10	10.2	0	0	0	0	0	1	0	1	0
		2008	6.3	5	4.3	0	0	0	0	0	0	0	0	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	6.3	6	6.4	0	0	0	0	0	0	0	0	0
		2011	6.3	1	0.8	0	0	0	0	0	0	0	0	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	Burn Edge Mohave, AZ 140	2008	---	3	5.0	0	0	0	0	0	0	0	0	0
		2009	3.7	5	5.8	0	0	0	0	0	0	0	0	0
		2010	4.1	5	5.8	2	1	1	3	0	0	0	0	0
		2011	4.1	5	6.3	0	0	0	0	0	0	1	0	1
		2012	4.1	5	3.2	0	0	0	0	0	1	0	1	0
	Site #4 La Paz, AZ 140	2003	5.8	7	26.0	4	3	1	0	0	0	0	0	0
		2004	5.8	15	38.8	0	0	0	0	0	0	1	1	0
		2005	9.9	10	13.8	2	1	1	1	2	0	0	0	0
		2006	9.9	10	14.0	0	0	0	0	0	2	0	2	0
		2007	9.9	11	24.8	0	0	0	0	0	0	0	0	0
		2008	9.9	5	7.2	0	0	0	0	0	0	1	0	1
		2009	9.9	5	14.3	2	2	0	0	0	0	2	2	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Bill Williams Bill Williams River NWR Bill Williams River	Site #4 La Paz, AZ 140	2010	9.9	5	12.8	0	0	0	0	0	0	2	0	2
		2011	9.9	5	16.8	1	1	0	0	0	0	2	1	1
		2012	9.9	5	8.7	0	0	0	0	0	1	1	2	0
	Site #3 La Paz, AZ 140	2003	3.7	6	19.2	5	3	2	2	3	0	0	0	0
		2004	3.7	11	23.7	2	2	0	0	0	1	0	1	0
		2005	7.7	10	14.9	4	3	1	1	3	0	0	0	0
		2006	8.3	9	7.6	4	3	3	5	2	1	0	1	0
		2007	8.3	10	13.7	12	8	7	9	3	1	1	1	1
		2008	9.5	5	11.9	7	4	4	5	4	0	0	0	0
		2009	9.5	5	7.3	8	4	4	5	6	0	0	0	0
		2010	9.5	5	13.8	4	3	2	6	1	0	0	0	0
		2011	13.0	5	19.6	2	1	1	2	1	1	0	1	0
		2012	13.0	5	15.8	3	2	2	3	0	0	0	0	0
	Last Gasp Mohave, AZ 140	2008	---	2	2.3	0	0	0	0	0	0	0	0	0
		2009	2.1	5	7.0	0	0	0	0	0	0	0	0	0
		2010	2.1	5	7.3	0	0	0	0	0	0	0	0	0
		2011	2.1	5	4.6	0	0	0	0	0	0	0	0	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	Guinness La Paz, AZ 140	2012	3.4	5	3.2	0	0	0	0	0	1	0	1	0
	Site #5 Mohave, AZ 143	2003	2.8	11	10.8	0	0	0	0	0	0	0	0	0
		2004	2.8	9	12.3	0	0	0	0	0	1	0	1	0
		2005	5.3	10	5.9	0	0	0	0	0	0	0	0	0
		2006	5.3	5	3.9	0	0	0	0	0	0	0	0	0
		2007	5.3	10	6.6	0	0	0	0	0	0	0	0	0
		2008	9.0	5	10.8	0	0	0	0	0	0	0	0	0
		2009	6.8	5	10.0	1	1	0	0	0	0	0	0	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Bill Williams Bill Williams River NWR Bill Williams River	Site #5 Mohave, AZ 143	2010	6.8	5	11.5	0	0	0	0	0	0	0	0	0
		2011	6.8	5	8.9	0	0	0	0	0	2	0	2	0
		2012	6.8	5	7.5	0	0	0	0	0	0	0	0	0
	Black Rail Mohave, AZ 146	2010	1.2	5	6.1	0	0	0	0	0	0	0	0	0
		2011	---	---	---	---	---	---	---	---	---	---	---	---
		2012	1.2	5	3.0	0	0	0	0	0	0	0	0	0
	New Willow[8] La Paz, AZ 146	2007	---	0	---	0	0	0	0	0	1	0	1	0
	Cougar Point Mohave, AZ 157	2011	1.3	0	---	2	1	1	1	0	0	0	0	0
		2012	1.3	5	3.4	0	0	0	0	0	0	0	0	0
	Mineral Wash La Paz, AZ 162	2003	19.6	10	22.0	0	0	0	0	0	0	0	0	0
		2004	19.6	9	16.5	0	0	0	0	0	1	0	1	0
		2005	18.8	10	8.8	0	0	0	0	0	0	1	1	0
		2006	18.8	5	6.4	0	0	0	0	0	0	0	0	0
		2007	18.8	6	10.8	1	1	0	0	0	2	0	2	0
		2008	18.8	5	8.0	0	0	0	0	0	0	0	0	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	18.8	5	14.8	0	0	0	0	0	2	0	2	0
		2011	18.8	1	2.3	0	0	0	0	0	0	0	0	0
		2012	18.8	5	7.0	0	0	0	0	0	0	0	0	0
	Beaver Pond La Paz, AZ 165	2003	19.0	3	5.3	0	0	0	0	0	1	0	1	0
		2004	21.3	10	25.8	0	0	0	0	0	11	1	12	0
		2005	21.7	10	10.0	0	0	0	0	0	0	0	0	0
		2006	21.7	5	6.6	0	0	0	0	0	0	0	0	0
		2007	21.7	6	9.0	0	0	0	0	0	1	0	1	0
		2008	21.7	5	5.0	0	0	0	0	0	0	0	0	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Bill Williams Bill Williams River NWR Bill Williams River	Beaver Pond La Paz, AZ 165	2010	21.7	5	8.9	0	0	0	0	0	0	1	1	0
		2011	21.7	1	5.5	0	0	0	0	0	0	0	0	0
		2012	21.7	5	7.9	0	0	0	0	0	0	0	0	0
	Site #8 La Paz, AZ 168	2003	10.3	10	24.1	0	0	0	0	0	1	0	1	0
		2004	10.3	10	19.4	0	0	0	0	0	1	0	1	0
		2005	10.3	10	10.4	0	0	0	0	0	1	0	1	0
		2006	10.3	5	8.9	0	0	0	0	0	0	0	0	0
		2007	10.3	7	11.3	0	0	0	0	0	1	0	1	0
		2008	10.3	5	4.5	0	0	0	0	0	0	0	0	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	10.3	5	10.8	0	0	0	0	0	0	0	0	0
		2011	---	---	---	---	---	---	---	---	---	---	---	---
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	Upstream from Site #8 La Paz, AZ 170	2008	---	2	2.0	0	0	0	0	0	0	0	0	0
		2009	1.5	5	4.0	2	1	1	2	0	0	0	0	0
		2010	1.5	5	4.0	0	0	0	0	0	1	0	1	0
		2011	1.5	5	5.1	0	0	0	0	0	0	0	0	0
		2012	1.5	4	1.8	0	0	0	0	0	0	0	0	0
	Planet Ranch Road La Paz, AZ 170	2009	2.1	5	5.8	0	0	0	0	0	0	0	0	0
		2010	3.3	5	4.8	2	1	1	2	1	0	0	0	0
		2011	3.3	5	12.0	3	2	2	3	3	2	0	2	0
		2012	3.3	4	2.8	0	0	0	0	0	0	0	0	0
	New River[7] La Paz, AZ 180	2011	0.6	5	3.9	0	0	0	0	0	0	0	0	0
	TOTAL	2003	67.9	---	149.5	10	7	3	2	3	2	1	3	0
		2004	73.8	---	163.9	3	3	0	0	0	18	3	21	0
		2005	85.9	---	79.7	6	4	2	2	5	2	1	3	0
		2006	86.5	---	65.8	4	3	3	5	2	5	0	5	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Bill Williams Bill Williams River NWR Bill Williams River	TOTAL	2007	83.7	---	94.3	13	9	7	9	3	7	1	7	1
		2008	88.6	---	65.0	7	4	4	5	4	0	1	0	1
		2009	35.6	---	54.2	13	8	5	7	6	0	2	2	0
		2010	100.8	---	121.8	8	5	4	11	2	3	3	4	2
		2011	95.2	---	89.6	8	5	4	6	4	6	3	7	2
		2012	88.9	---	70.9	4	3	2	3	0	21	4	23	2
Parker to Southerly International Boundary Ahakhav Tribal Preserve Colorado River	Willow Beach[7] La Paz, AZ 104	2008	2.0	3	1.5	0	0	0	0	0	0	0	0	0
	Deer Island[6] La Paz, AZ 104	2008	91.6	5	14.5	1	1	0	0	0	1	0	1	0
		2009	15.2	4	4.0	0	0	0	0	0	0	0	0	0
	TOTAL	2008	93.6	---	16.0	1	1	0	0	0	1	0	1	0
		2009	15.2	---	4.0	0	0	0	0	0	0	0	0	0
Parker to Southerly International Boundary Palo Verde Ecological Reserve Colorado River	PVER Phase 2 Riverside, CA 85	2009	28.7	5	15.0	0	0	0	0	0	2	0	2	0
		2010	28.7	5	14.2	0	0	0	0	0	3	0	3	0
		2011	21.4	6	16.5	0	0	0	0	0	11	0	11	0
		2012	21.4	5	8.8	0	0	0	0	0	5	0	5	0
	PVER Phase 3 Riverside, CA 85	2010	15.8	5	12.3	0	0	0	0	0	0	0	0	0
		2011	21.4	6	14.5	0	0	0	0	0	4	0	4	0
		2012	21.4	5	9.9	0	0	0	0	0	5	0	5	0
	TOTAL	2009	28.7	---	15.0	0	0	0	0	0	2	0	2	0
		2010	44.5	---	26.5	0	0	0	0	0	3	0	3	0
		2011	42.8	---	31.0	0	0	0	0	0	15	0	15	0
		2012	42.8	---	18.7	0	0	0	0	0	10	0	10	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary Big Hole Slough Colorado River	Big Hole Slough[7] Riverside, CA 82	2003	16.5	11	23.7	0	0	0	0	0	5	0	5	0
		2004	16.5	10	25.5	0	0	0	0	0	20	0	20	0
		2005	16.5	10	27.4	0	0	0	0	0	4	1	5	0
		2006	16.5	10	29.8	0	0	0	0	0	2	0	2	0
		2007	20.0	10	21.7	0	0	0	0	0	6	0	6	0
		2008	16.6	5	9.8	0	0	0	0	0	1	0	1	0
		2009	29.0	5	17.0	0	0	0	0	0	0	1	1	0
		2010	29.0	1	1.3	0	0	0	0	0	0	0	0	0
Parker to Southerly International Boundary Ehrenberg Colorado River	Ehrenberg La Paz, AZ 78	2003	4.7	9	9.5	0	0	0	0	0	1	0	1	0
		2004	4.7	10	14.5	0	0	0	0	0	5	0	5	0
		2005	4.7	10	9.3	0	0	0	0	0	4	0	4	0
		2006	4.7	10	8.9	0	0	0	0	0	1	1	2	0
		2007	4.7	10	6.5	0	0	0	0	0	4	1	5	0
		2008	4.7	5	7.3	0	0	0	0	0	0	0	0	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	4.7	5	5.1	0	0	0	0	0	0	0	0	0
		2011	---	---	---	---	---	---	---	---	---	---	---	---
		2012	4.7	5	4.1	0	0	0	0	0	0	0	0	0
Parker to Southerly International Boundary Cibola Colorado River	CVCA Phase 1 La Paz, AZ 73	2008	26.2	5	8.3	0	0	0	0	0	0	2	2	0
		2009	26.2	5	17.0	0	0	0	0	0	1	0	1	0
		2010	26.2	5	14.8	0	0	0	0	0	17	0	17	0
		2011	26.2	6	16.0	0	0	0	0	0	12	0	12	0
		2012	26.2	5	11.5	0	0	0	0	0	17	0	17	0
	CVCA Phase 2 La Paz, AZ 73	2010	25.5	5	16.5	0	0	0	0	0	18	0	18	0
		2011	25.5	6	16.0	0	0	0	0	0	11	0	11	0
		2012	25.5	5	10.1	0	0	0	0	0	10	0	10	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary Cibola Colorado River	CVCA Phase 3 La Paz, AZ 73	2009	41.2	5	15.8	0	0	0	0	0	4	0	4	0
		2010	38.4	5	17.0	0	0	0	0	0	4	0	4	0
		2011	38.4	5	14.0	0	0	0	0	0	18	0	18	0
		2012	38.4	5	9.9	0	0	0	0	0	1	0	1	0
	Cibola Nature Trail La Paz, AZ 70	2006	13.7	10	14.0	0	0	0	0	0	5	0	5	0
		2007	13.7	10	9.8	0	0	0	0	0	12	0	12	0
		2008	13.7	5	4.0	0	0	0	0	0	1	0	1	0
		2009	13.7	5	4.6	0	0	0	0	0	4	0	4	0
		2010	13.7	5	9.0	0	0	0	0	0	2	0	2	0
		2011	13.7	5	6.0	0	0	0	0	0	1	0	1	0
		2012	13.7	5	3.9	0	0	0	0	0	4	0	4	0
	Cibola Island[6] La Paz, AZ 70	2007	9.0	5	3.5	0	0	0	0	0	8	0	8	0
		2008	4.2	5	5.7	0	0	0	0	0	3	2	5	0
		2009	4.2	5	5.1	0	0	0	0	0	7	0	7	0
		2010	4.2	5	5.8	0	0	0	0	0	0	0	0	0
		2011	4.2	3	2.3	0	0	0	0	0	0	0	0	0
	Cibola Site #2 La Paz, AZ 65	2003	16.4	11	26.8	0	0	0	0	0	3	0	3	0
		2004	16.4	10	17.3	0	0	0	0	0	24	0	24	0
		2005	16.4	10	21.5	0	0	0	0	0	8	0	8	0
		2006	16.4	10	15.6	0	0	0	0	0	1	0	1	0
		2007	16.4	10	5.8	0	0	0	0	0	0	1	1	0
		2008	---	---	---	---	---	---	---	---	---	---	---	---
		2009	16.4	5	7.1	0	0	0	0	0	0	0	0	0
		2010	---	---	---	---	---	---	---	---	---	---	---	---
		2011	16.4	5	6.2	0	0	0	0	0	5	0	5	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary Cibola Colorado River	Cibola Site #1 La Paz, AZ 65	2003	7.7	11	23.2	0	0	0	0	0	0	0	0	0
		2004	7.7	10	15.5	0	0	0	0	0	5	0	5	0
		2005	7.7	10	11.4	0	0	0	0	0	5	0	5	0
		2006	7.7	10	9.7	0	0	0	0	0	2	0	2	0
		2007	7.7	10	6.9	0	0	0	0	0	5	0	5	0
		2008	---	---	---	---	---	---	---	---	---	---	---	---
		2009	7.7	5	5.3	0	0	0	0	0	1	0	1	0
		2010	---	---	---	---	---	---	---	---	---	---	---	---
		2011	7.7	5	4.1	0	0	0	0	0	0	0	0	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	Hart Mine Marsh[7] La Paz, AZ 65	2003	31.6	11	27.4	0	0	0	0	0	5	0	5	0
		2004	31.6	10	18.3	0	0	0	0	0	8	0	8	0
		2005	31.6	10	15.1	0	0	0	0	0	7	0	7	0
		2006	31.6	10	14.9	0	0	0	0	0	4	0	4	0
		2007	31.6	10	15.7	0	0	0	0	0	8	3	11	0
		2008	---	---	---	---	---	---	---	---	---	---	---	---
		2009	31.6	4	7.8	0	0	0	0	0	0	0	0	0
	Three Fingers Lake[6] Imperial, CA 65	2003	70.1	10	23.8	0	0	0	0	0	17	0	17	0
		2004	70.2	10	35.7	0	0	0	0	0	53	0	53	0
		2005	67.9	10	36.0	0	0	0	0	0	17	1	18	0
		2006	67.9	10	32.4	0	0	0	0	0	37	0	37	0
		2007	67.9	10	26.2	0	0	0	0	0	17	1	18	0
		2008	67.9	5	13.0	0	0	0	0	0	3	4	7	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	67.9	5	20.2	0	0	0	0	0	5	0	5	0
		2011	---	---	---	---	---	---	---	---	---	---	---	---

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary Cibola Colorado River	Cibola Lake #1 (North) La Paz, AZ 64	2003	8.5	11	9.8	0	0	0	0	0	3	0	3	0
		2004	8.5	10	14.4	0	0	0	0	0	2	0	2	0
		2005	8.5	10	21.1	0	0	0	0	0	1	0	1	0
		2006	8.5	10	15.0	0	0	0	0	0	3	0	3	0
		2007	8.5	10	14.3	0	0	0	0	0	2	0	2	0
		2008	8.5	5	11.0	0	0	0	0	0	1	1	2	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	8.5	5	9.5	0	0	0	0	0	0	0	0	0
		2011	---	---	---	---	---	---	---	---	---	---	---	---
		2012	8.9	5	8.4	0	0	0	0	0	1	0	1	0
	Cibola Lake #2 (East) La Paz, AZ 64	2003	4.5	11	12.6	0	0	0	0	0	1	0	1	0
		2004	4.5	10	13.8	0	0	0	0	0	2	0	2	0
		2005	4.5	10	11.0	0	0	0	0	0	0	0	0	0
		2006	4.5	10	12.9	0	0	0	0	0	3	0	3	0
		2007	4.5	10	8.3	0	0	0	0	0	3	0	3	0
		2008	---	---	---	---	---	---	---	---	---	---	---	---
		2009	4.5	5	6.3	0	0	0	0	0	1	0	1	0
		2010	---	---	---	---	---	---	---	---	---	---	---	---
		2011	4.5	5	5.0	0	0	0	0	0	1	1	2	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	Cibola Lake #3 (West) La Paz, AZ 64	2003	7.0	10	9.3	0	0	0	0	0	1	0	1	0
		2004	7.0	10	16.4	0	0	0	0	0	17	0	17	0
		2005	7.0	10	22.9	0	0	0	0	0	3	0	3	0
		2006	7.0	10	16.3	0	0	0	0	0	3	0	3	0
		2007	6.8	10	14.6	0	0	0	0	0	0	0	0	0
		2008	6.8	5	11.5	0	0	0	0	0	3	2	5	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary	Cibola Lake #3 (West) La Paz, AZ 64	2010	6.8	5	6.8	0	0	0	0	0	0	0	0	0
		2011	---	---	---	---	---	---	---	---	---	---	---	---
Cibola		2012	6.8	5	6.5	0	0	0	0	0	4	0	4	0
Colorado River	Walker Lake Imperial, CA 64	2003	24.0	9	13.4	0	0	0	0	0	1	0	1	0
		2004	24.0	10	11.0	0	0	0	0	0	36	0	36	0
		2005	11.4	10	21.1	0	0	0	0	0	0	1	0	1
		2006	11.4	10	25.9	0	0	0	0	0	5	1	6	0
		2007	11.4	10	15.8	0	0	0	0	0	2	0	2	0
		2008	11.4	5	13.0	0	0	0	0	0	2	0	2	0
		2009	11.4	5	11.4	0	0	0	0	0	0	0	0	0
		2010	11.4	4	10.8	0	0	0	0	0	1	0	1	0
		2011	11.4	3	4.9	0	0	0	0	0	1	0	1	0
		2012	11.4	5	6.3	0	0	0	0	0	0	0	0	0
	TOTAL	2003	169.8	---	146.3	0	0	0	0	0	31	0	31	0
		2004	169.9	---	142.4	0	0	0	0	0	147	0	147	0
		2005	155.0	---	160.1	0	0	0	0	0	41	2	42	1
		2006	168.7	---	156.7	0	0	0	0	0	63	1	64	0
		2007	177.5	---	120.9	0	0	0	0	0	57	5	62	0
		2008	138.7	---	66.5	0	0	0	0	0	13	11	24	0
		2009	156.9	---	80.4	0	0	0	0	0	18	0	18	0
		2010	202.6	---	110.4	0	0	0	0	0	47	0	47	0
		2011	148.0	---	74.5	0	0	0	0	0	49	1	50	0
		2012	130.9	---	56.6	0	0	0	0	0	37	0	37	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary Imperial Colorado River	Draper Lake[7] Imperial, CA 63	2006	4.6	10	17.2	0	0	0	0	0	14	0	14	0
		2007	4.6	10	14.5	0	0	0	0	0	3	0	3	0
		2008	4.6	1	1.5	0	0	0	0	0	1	0	1	0
	Paradise Imperial, CA 62	2003	5.2	10	13.2	0	0	0	0	0	1	0	1	0
		2004	6.1	10	14.4	0	0	0	0	0	20	0	20	0
		2005	7.8	10	23.3	0	0	0	0	0	39	1	40	0
		2006	7.8	10	28.5	0	0	0	0	0	19	1	20	0
		2007	7.8	10	19.1	0	0	0	0	0	8	0	8	0
		2008	7.8	5	10.9	0	0	0	0	0	2	0	2	0
		2009	7.8	5	6.8	0	0	0	0	0	1	0	1	0
	Paradise Imperial, CA 62	2010	7.8	5	9.0	0	0	0	0	0	1	0	1	0
		2011	7.8	3	3.3	0	0	0	0	0	3	0	3	0
		2012	7.8	5	6.6	0	0	0	0	0	5	0	5	0
	Hoge Ranch La Paz, AZ 61	2003	21.8	12	12.3	0	0	0	0	0	4	2	5	1
		2004	21.8	10	15.9	0	0	0	0	0	28	0	28	0
		2005	20.7	10	27.0	0	0	0	0	0	31	0	31	0
		2006	20.7	10	20.3	0	0	0	0	0	22	0	22	0
		2007	20.7	10	17.2	0	0	0	0	0	7	0	7	0
		2008	20.7	5	9.8	0	0	0	0	0	6	1	7	0
		2009	20.7	5	9.7	0	0	0	0	0	4	0	4	0
		2010	20.7	5	12.7	0	0	0	0	0	2	0	2	0
		2011	20.7	5	5.9	0	0	0	0	0	14	0	14	0
		2012	20.7	5	6.3	0	0	0	0	0	5	0	5	0
	Adobe Lake La Paz, AZ 60	2003	8.2	11	9.8	0	0	0	0	0	2	0	2	0
		2004	8.2	10	3.3	0	0	0	0	0	8	0	8	0
		2005	7.6	10	5.5	0	0	0	0	0	40	1	41	0
		2006	7.6	10	4.7	0	0	0	0	0	3	0	3	0
		2007	7.6	10	3.6	0	0	0	0	0	3	0	3	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary Imperial Colorado River	Adobe Lake La Paz, AZ 60	2008	7.6	5	5.5	0	0	0	0	0	12	0	12	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	7.6	5	2.3	0	0	0	0	0	0	0	0	0
		2011	---	---	---	---	---	---	---	---	---	---	---	---
		2012	7.5	5	1.0	0	0	0	0	0	1	0	1	0
	Rattlesnake La Paz, AZ 60	2004	1.7	5	7.6	0	0	0	0	0	---	0	0	0
		2005	7.6	10	22.4	0	0	0	0	0	5	0	5	0
		2006	7.6	10	17.1	0	0	0	0	0	5	0	5	0
		2007	7.6	10	10.7	0	0	0	0	0	6	0	6	0
		2008	7.6	5	8.9	0	0	0	0	0	4	0	4	0
		2009	7.6	5	6.1	0	0	0	0	0	1	0	1	0
		2010	7.6	5	7.4	0	0	0	0	0	2	0	2	0
		2011	7.6	5	6.4	0	0	0	0	0	5	0	5	0
		2012	7.6	5	7.1	0	0	0	0	0	0	0	0	0
	Taylor Lake[6] La Paz, AZ 60	2003	3.1	10	15.0	0	0	0	0	0	2	0	2	0
		2004	---	0	---	0	0	0	0	0	2	0	2	0
	Norton South[7] Imperial, CA 60	2004	1.5	6	6.2	0	0	0	0	0	1	0	1	0
		2005	1.2	10	10.7	0	0	0	0	0	1	0	1	0
		2006	1.2	10	12.2	0	0	0	0	0	2	0	2	0
		2007	1.2	10	8.2	0	0	0	0	0	2	0	2	0
	Picacho NW[7] Imperial, CA 59	2003	3.2	10	7.2	0	0	0	0	0	1	0	1	0
		2004	11.0	10	13.4	0	0	0	0	0	11	0	11	0
		2005	8.8	10	21.3	0	0	0	0	0	8	2	10	0
		2006	8.8	10	18.1	0	0	0	0	0	10	0	10	0
		2007	8.8	10	16.6	0	0	0	0	0	3	0	3	0
	Picacho Camp Store[6] Imperial, CA 58	2003	3.3	12	21.6	0	0	0	0	0	4	1	5	0
		2004	---	0	---	0	0	0	0	0	1	0	1	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary Imperial Colorado River	Milemarker 65 Imperial, CA 58	2003	10.0	10	11.4	0	0	0	0	0	0	0	0	0
		2004	10.0	10	6.4	0	0	0	0	0	8	0	8	0
		2005	10.0	10	7.9	0	0	0	0	0	9	0	9	0
		2006	10.0	10	6.3	0	0	0	0	0	3	0	3	0
		2007	10.0	10	5.1	0	0	0	0	0	6	0	6	0
		2008	---	---	---	---	---	---	---	---	---	---	---	---
		2009	10.0	5	2.9	0	0	0	0	0	0	0	0	0
		2010	---	---	---	---	---	---	---	---	---	---	---	---
		2011	10.0	2	0.9	0	0	0	0	0	1	0	1	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	Clear Lake La Paz, AZ 59	2003	8.3	12	25.3	0	0	0	0	0	2	0	2	0
		2004	8.3	11	8.7	0	0	0	0	0	5	0	5	0
		2005	8.3	10	6.1	0	0	0	0	0	0	0	0	0
		2006	8.3	10	8.6	0	0	0	0	0	1	1	2	0
		2007	8.3	10	7.2	0	0	0	0	0	1	0	1	0
		2008	8.3	5	11.6	0	0	0	0	0	6	0	6	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	8.3	5	9.8	0	0	0	0	0	1	0	1	0
		2011	---	---	---	---	---	---	---	---	---	---	---	---
		2012	8.3	5	10.3	0	0	0	0	0	8	0	8	0
	Nursery NW Yuma, AZ 58	2006	7.0	10	10.8	0	0	0	0	0	6	0	6	0
		2007	7.0	10	11.2	0	0	0	0	0	16	0	16	0
		2008	7.0	5	3.1	0	0	0	0	0	0	0	0	0
		2009	7.0	5	4.4	0	0	0	0	0	0	1	1	0
		2010	7.0	5	5.6	0	0	0	0	0	0	0	0	0
		2011	7.0	5	6.9	0	0	0	0	0	6	0	6	0
		2012	7.0	5	4.4	0	0	0	0	0	8	0	8	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary Imperial Colorado River	Imperial Nursery Yuma, AZ 58	2003	1.4	13	7.5	0	0	0	0	0	0	0	0	0
		2004	1.4	13	7.5	0	0	0	0	0	10	0	10	0
		2005	1.4	9	4.1	0	0	0	0	0	3	0	3	0
		2006	1.4	10	7.7	0	0	0	0	0	6	0	6	0
		2007	1.4	10	5.7	0	0	0	0	0	7	0	7	0
		2008	1.4	5	2.2	0	0	0	0	0	0	0	0	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	1.4	5	1.4	0	0	0	0	0	0	0	0	0
		2011	---	---	---	---	---	---	---	---	---	---	---	---
		2012	1.4	5	1.2	0	0	0	0	0	0	0	0	0
	Ferguson Lake Imperial, CA 57	2003	29.1	10	22.9	0	0	0	0	0	2	0	2	0
		2004	29.1	10	18.6	0	0	0	0	0	27	0	27	0
		2005	26.0	10	32.5	0	0	0	0	0	18	0	18	0
		2006	26.0	10	29.9	0	0	0	0	0	13	0	13	0
		2007	21.1	10	25.1	0	0	0	0	0	28	1	29	0
		2008	21.1	5	6.8	0	0	0	0	0	0	0	0	0
		2009	21.1	5	16.8	0	0	0	0	0	3	2	5	0
		2010	21.1	5	15.1	0	0	0	0	0	7	0	7	0
		2011	21.1	3	7.0	0	0	0	0	0	2	0	2	0
		2012	21.1	5	10.3	0	0	0	0	0	44	0	44	0
	Ferguson Wash Imperial, CA 58	2003	6.8	11	20.5	0	0	0	0	0	1	0	1	0
		2004	6.8	10	12.8	0	0	0	0	0	11	0	11	0
		2005	6.8	10	18.6	0	0	0	0	0	10	0	10	0
		2006	6.8	10	18.2	0	0	0	0	0	5	0	5	0
		2007	6.8	10	15.5	0	0	0	0	0	8	0	8	0
		2008	6.8	5	9.2	0	0	0	0	0	2	0	2	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary	Ferguson Wash Imperial, CA 58	2010	6.8	5	7.3	0	0	0	0	0	3	0	3	0
		2011	---	---	---	---	---	---	---	---	---	---	---	---
Imperial		2012	6.8	5	3.8	0	0	0	0	0	13	0	13	0
Colorado River	Great Blue Heron Yuma, AZ 58	2003	7.1	13	32.0	0	0	0	0	0	9	0	9	0
		2004	7.1	11	38.2	0	0	0	0	0	85	0	85	0
		2005	7.1	10	42.4	0	0	0	0	0	16	2	18	0
		2006	7.1	10	30.2	0	0	0	0	0	43	1	44	0
		2007	7.1	10	32.8	0	0	0	0	0	12	0	12	0
		2008	7.1	5	13.8	0	0	0	0	0	3	0	3	0
		2009	7.1	5	19.4	0	0	0	0	0	2	0	2	0
		2010	7.1	5	18.2	0	0	0	0	0	0	0	0	0
		2011	7.1	5	15.9	0	0	0	0	0	21	0	21	0
		2012	7.0	5	15.0	0	0	0	0	0	0	0	0	0
	Powerline Yuma, AZ 58	2003	2.0	12	7.3	0	0	0	0	0	0	0	0	0
		2004	2.1	11	7.4	0	0	0	0	0	2	0	2	0
		2005	2.0	10	6.9	0	0	0	0	0	2	0	2	0
		2006	2.0	10	8.6	0	0	0	0	0	5	0	5	0
		2007	2.1	10	10.8	0	0	0	0	0	6	0	6	0
		2008	---	---	---	---	---	---	---	---	---	---	---	---
		2009	2.0	5	6.3	0	0	0	0	0	1	0	1	0
		2010	---	---	---	---	---	---	---	---	---	---	---	---
		2011	1.0	5	4.2	0	0	0	0	0	3	0	3	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	Martinez Lake Yuma, AZ 58	2003	4.6	12	17.8	0	0	0	0	0	0	0	0	0
		2004	4.6	11	11.1	0	0	0	0	0	8	1	9	0
		2005	4.6	10	10.2	0	0	0	0	0	3	0	3	0
		2006	4.6	10	17.8	0	0	0	0	0	13	0	13	0
		2007	4.6	10	8.2	0	0	0	0	0	5	0	5	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary Imperial Colorado River	Martinez Lake Yuma, AZ 58	2008	---	---	---	---	---	---	---	---	---	---	---	---
		2009	4.6	5	6.0	0	0	0	0	0	0	0	0	0
		2010	---	---	---	---	---	---	---	---	---	---	---	---
		2011	4.6	5	8.8	0	0	0	0	0	2	0	2	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	TOTAL	2003	114.1	---	223.8	0	0	0	0	0	28	3	30	1
		2004	119.7	---	171.5	0	0	0	0	0	227	1	228	0
		2005	119.9	---	238.9	0	0	0	0	0	185	6	191	0
		2006	131.5	---	256.2	0	0	0	0	0	170	3	173	0
		2007	126.7	---	211.5	0	0	0	0	0	121	1	122	0
		2008	100.0	---	83.3	0	0	0	0	0	36	1	37	0
		2009	87.9	---	78.4	0	0	0	0	0	12	3	15	0
		2010	95.4	---	88.8	0	0	0	0	0	16	0	16	0
		2011	86.9	---	59.3	0	0	0	0	0	57	0	57	0
		2012	95.2	---	66.0	0	0	0	0	0	84	0	84	0
Parker to Southerly International Boundary Mittry Lake Colorado River	Mittry West Imperial, CA 48	2003	4.4	15	37.2	0	0	0	0	0	10	1	11	0
		2004	4.4	10	17.0	0	0	0	0	0	12	0	12	0
		2005	4.4	10	19.4	0	0	0	0	0	6	0	6	0
		2006	4.4	10	17.8	0	0	0	0	0	9	0	9	0
		2007	4.4	10	17.5	0	0	0	0	0	17	0	17	0
		2008	4.4	5	10.5	0	0	0	0	0	2	0	2	0
		2009	4.4	5	7.9	0	0	0	0	0	2	0	2	0
		2010	4.4	5	10.0	0	0	0	0	0	4	0	4	0
		2011	4.4	3	4.3	0	0	0	0	0	3	0	3	0
		2012	4.4	5	7.5	0	0	0	0	0	3	0	3	0
	Mittry South[6] Yuma, AZ 46	2003	15.5	13	18.8	0	0	0	0	0	3	0	3	0
		2004	15.5	10	15.2	0	0	0	0	0	16	0	16	0
		2005	13.8	10	11.0	0	0	0	0	0	6	0	6	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary Mittry Lake Colorado River	Mittry South[6] Yuma, AZ 46	2006	13.8	11	16.7	0	0	0	0	0	0	0	0	0
		2007	15.2	10	15.7	0	0	0	0	0	6	0	6	0
		2008	15.2	5	6.5	0	0	0	0	0	2	0	2	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	15.2	5	12.4	0	0	0	0	0	5	0	5	0
	Potholes East[7] Imperial, CA 54	2003	2.0	12	5.8	0	0	0	0	0	1	0	1	0
		2004	2.0	10	4.9	0	0	0	0	0	7	0	7	0
		2005	2.0	10	4.7	0	0	0	0	0	1	0	1	0
		2006	2.0	10	5.0	0	0	0	0	0	6	0	6	0
		2007	2.0	10	5.4	0	0	0	0	0	3	0	3	0
	Potholes West[7] Imperial, CA 53	2003	6.6	12	9.1	0	0	0	0	0	1	0	1	0
		2004	6.6	10	7.5	0	0	0	0	0	6	0	6	0
		2005	6.6	10	7.6	0	0	0	0	0	2	0	2	0
		2006	6.6	10	7.9	0	0	0	0	0	4	0	4	0
		2007	6.6	10	6.3	0	0	0	0	0	11	0	11	0
	TOTAL	2003	28.5	---	70.9	0	0	0	0	0	15	1	16	0
		2004	28.5	---	44.6	0	0	0	0	0	41	0	41	0
		2005	26.8	---	42.7	0	0	0	0	0	15	0	15	0
		2006	26.8	---	47.4	0	0	0	0	0	19	0	19	0
		2007	28.2	---	44.9	0	0	0	0	0	37	0	37	0
		2008	19.6	---	17.0	0	0	0	0	0	4	0	4	0
		2009	4.4	---	7.9	0	0	0	0	0	2	0	2	0
		2010	19.6	---	22.4	0	0	0	0	0	9	0	9	0
		2011	4.4	---	4.3	0	0	0	0	0	3	0	3	0
		2012	4.4	---	7.5	0	0	0	0	0	3	0	3	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary	I-8 Site #1[7] Yuma, AZ 39	2003	17.9	2	6.9	0	0	0	0	0	0	0	0	0
Yuma Colorado River	River Mile 33[6] Yuma, AZ 38	2003	20.6	13	39.7	0	0	0	0	0	16	1	17	0
		2004	20.6	11	34.2	0	0	0	0	0	16	0	16	0
		2005	17.6	10	28.2	0	0	0	0	0	10	0	10	0
		2006	17.6	5	19.6	0	0	0	0	0	14	---	14	---
	Gila Confluence West[7] Yuma, AZ 37	2003	5.6	12	10.5	0	0	0	0	0	2	1	3	0
		2004	5.6	10	9.7	0	0	0	0	0	15	0	15	0
		2005	3.8	9	9.9	0	0	0	0	0	10	0	10	0
		2006	3.8	10	10.1	0	0	0	0	0	2	1	3	0
	Gila Confluence North Yuma, AZ 40	2003	4.6	10	13.4	0	0	0	0	0	2	0	2	0
		2004	4.6	10	14.3	0	0	0	0	0	20	0	20	0
		2005	4.6	10	17.2	0	0	0	0	0	7	0	7	0
		2006	4.6	10	16.7	0	0	0	0	0	9	3	11	1
		2007	2.2	10	11.9	0	0	0	0	0	6	0	6	0
		2008	2.2	5	10.3	0	0	0	0	0	5	7	12	0
		2009	---	---	---	---	---	---	---	---	---	---	---	---
		2010	2.2	5	9.3	0	0	0	0	0	3	0	3	0
		2011	---	---	---	---	---	---	---	---	---	---	---	---
		2012	2.2	5	8.2	0	0	0	0	0	8	0	8	0
	Gila River Site #1[7] Yuma, AZ 44	2003	5.7	12	12.1	0	0	0	0	0	8	0	8	0
		2004[6]	5.7	3	5.2	0	0	0	0	0	10	---	10	---
		2006	5.7	10	10.1	0	0	0	0	0	4	0	4	0
		2007	5.7	10	7.5	0	0	0	0	0	14	0	14	0
	Gila River Site #2 Yuma, AZ 45	2003	8.0	11	17.0	0	0	0	0	0	18	0	18	0
		2004	8.1	11	14.4	0	0	0	0	0	6	0	6	0
		2005	5.1	6	8.9	0	0	0	0	0	---	0	0	0
		2006	5.1	10	11.1	0	0	0	0	0	9	0	9	0
		2007	5.1	10	7.5	0	0	0	0	0	11	0	11	0

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary Yuma Colorado River	Gila River Site #2 Yuma, AZ 45	2008	---	---	---	---	---	---	---	---	---	---	---	---
		2009	5.1	5	8.2	0	0	0	0	0	4	0	4	0
		2010	---	---	---	---	---	---	---	---	---	---	---	---
		2011	2.9	4	5.3	0	0	0	0	0	7	0	7	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	Fortuna Site #1 Yuma, AZ 45	2004	2.8	4	4.4	0	0	0	0	0	---	0	---	0
		2005	2.5	6	3.9	0	0	0	0	0	---	0	0	0
		2006	2.5	10	6.1	0	0	0	0	0	10	0	10	0
		2007	2.5	10	5.6	0	0	0	0	0	25	0	25	0
		2008	---	---	---	---	---	---	---	---	---	---	---	---
		2009	5.1	5	5.3	0	0	0	0	0	2	0	2	0
		2010	---	---	---	---	---	---	---	---	---	---	---	---
		2011	3.2	4	6.1	0	0	0	0	0	15	0	15	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	Fortuna North Yuma, AZ 46	2003	4.8	12	18.1	0	0	0	0	0	15	0	15	0
		2004	4.8	10	10.2	0	0	0	0	0	7	0	7	0
		2005	3.8	10	11.8	0	0	0	0	0	4	0	4	0
		2006	3.8	10	16.6	0	0	0	0	0	3	1	4	0
		2007	3.8	10	8.9	0	0	0	0	0	13	0	13	0
		2008	---	---	---	---	---	---	---	---	---	---	---	---
		2009	3.4	5	6.3	0	0	0	0	0	0	0	0	0
		2010	---	---	---	---	---	---	---	---	---	---	---	---
		2011	3.8	4	9.5	0	0	0	0	0	7	0	7	0
		2012	---	---	---	---	---	---	---	---	---	---	---	---
	Morelos Dam[7] Yuma, AZ 34	2006	7.7	9	14.1	0	0	0	0	0	0	0	0	0
		2007	11.4	10	16.8	0	0	0	0	0	11	0	11	0
	Gadsden Bend[7] Yuma, AZ 28	2003	4.4	12	18.8	0	0	0	0	0	25	2	27	0
		2004	4.4	11	10.9	0	0	0	0	0	20	1	20	1
		2005	4.4	8	8.0	0	0	0	0	0	18	5	23	0
		2006	4.4	5	8.2	0	0	0	0	0	34	---	34	---

Table A.2. Southwestern Willow Flycatcher Survey Results and Detections by Site within the Lower Colorado Recovery Unit, 2003–2012 (Continued)

Management Unit Study Area[1] Drainage	Survey Site[2] County, State Elevation (m)	Year	Area (ha)	# Surveys	Survey Hours	Resident Adults[3]	Territories	Pairs	Nests	# Confirmed Fledges	Unknown Status[4]			
											Before June 15	After June 15	Before June 24	After June 24
Parker to Southerly International Boundary Yuma Colorado River	Gadsden[7] Yuma, AZ 25	2003	24.3	11	17.9	0	0	0	0	0	27	3	30	0
		2004	24.3	10	16.0	0	0	0	0	0	29	0	29	0
		2005	17.3	10	12.5	0	0	0	0	0	19	0	19	0
		2006	17.3	10	18.9	0	0	0	0	0	50	14	64	0
		2007	19.3	10	19.8	0	0	0	0	0	84	10	94	0
	Hunter's Hole[7] Yuma, AZ 26	2003	13.0	12	34.8	0	0	0	0	0	25	3	28	0
		2004	16.5	10	15.8	0	0	0	0	0	46	0	46	0
		2005	15.9	10	16.1	0	0	0	0	0	11	1	12	0
		2006	15.9	9	28.8	0	0	0	0	0	59	0	59	0
		2007	24.1	10	25.7	0	0	0	0	0	48	0	48	0
	TOTAL	2003	108.9	---	189.2	0	0	0	0	0	138	10	148	0
		2004	97.4	---	135.1	0	0	0	0	0	169	1	169	1
		2005	75.0	---	116.5	0	0	0	0	0	79	6	85	0
		2006	88.4	---	160.3	0	0	0	0	0	194	19	212	1
		2007	74.1	---	103.7	0	0	0	0	0	212	10	222	0
		2008	2.2	---	10.3	0	0	0	0	0	5	7	12	0
		2009	13.6	---	19.8	0	0	0	0	0	6	0	6	0
		2010	2.2	---	9.3	0	0	0	0	0	3	0	3	0
		2011	9.9	---	20.9	0	0	0	0	0	29	0	29	0
		2012	2.2	---	8.2	0	0	0	0	0	8	0	8	0

[*] This table includes results from all sites where regular surveys were scheduled, and habitat reconnaissance and opportunistic surveys were conducted. All detections of flycatchers, regardless of site association, are included.

[1] Study areas consist of 1-18 survey sites that are grouped geographically.

[2] Survey site is equivalent to the Arizona Department of Game and Fish site definition.

[3] Several within-season, within-study area movements were detected. Individuals who moved between sites are only counted once in the study area total. Individuals who were resident in one site, but detected briefly in another are only reported in their site of residence.

[4] Total number of individuals recorded that could not be classified as resident or migrant because of brief appearance.

[5] Not an official survey site. Incidental detections recorded.

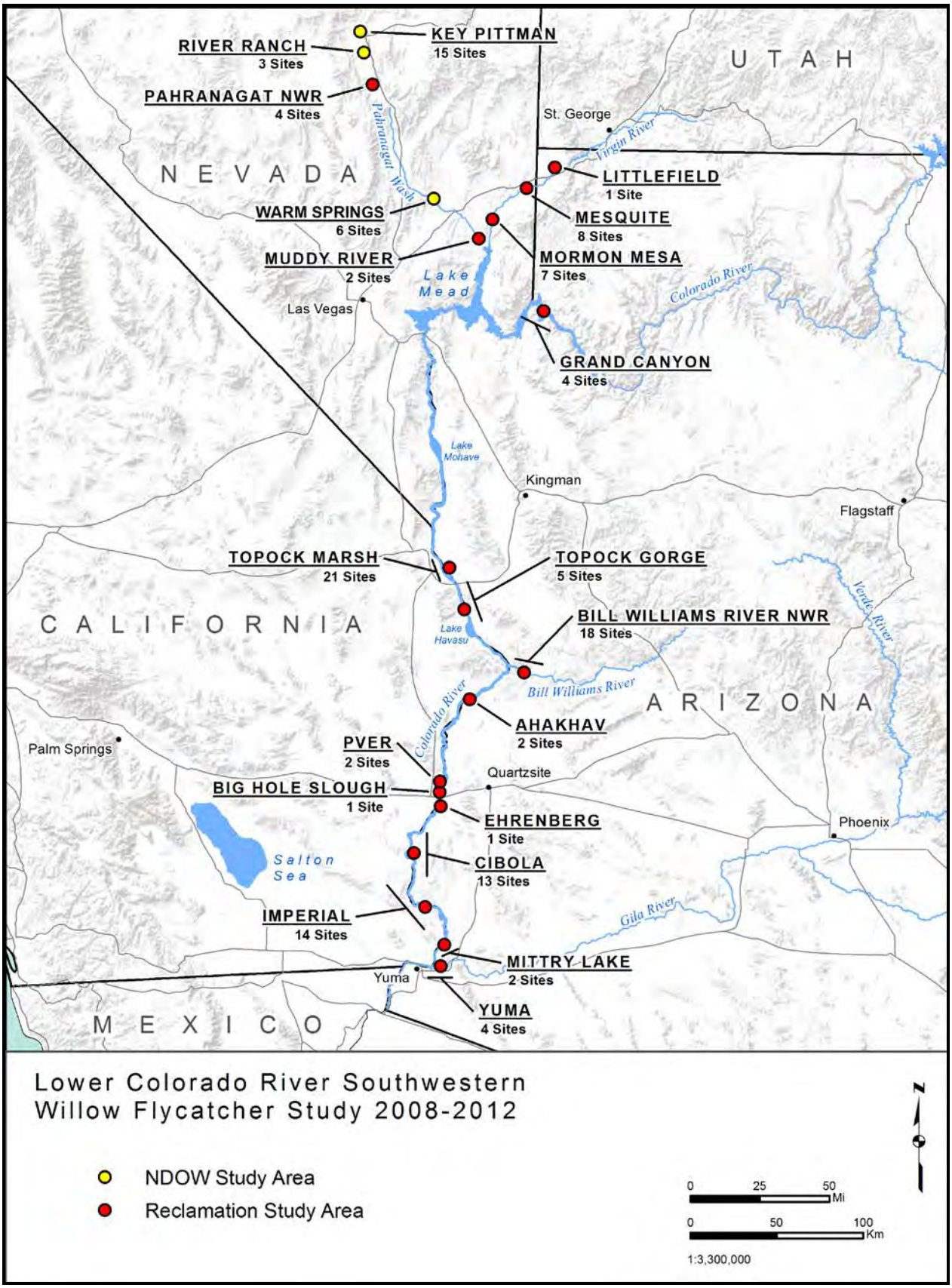
[6] Surveys discontinued due to heavy fire damage.

[7] Surveys discontinued due to poor habitat quality or other loss of site suitability.

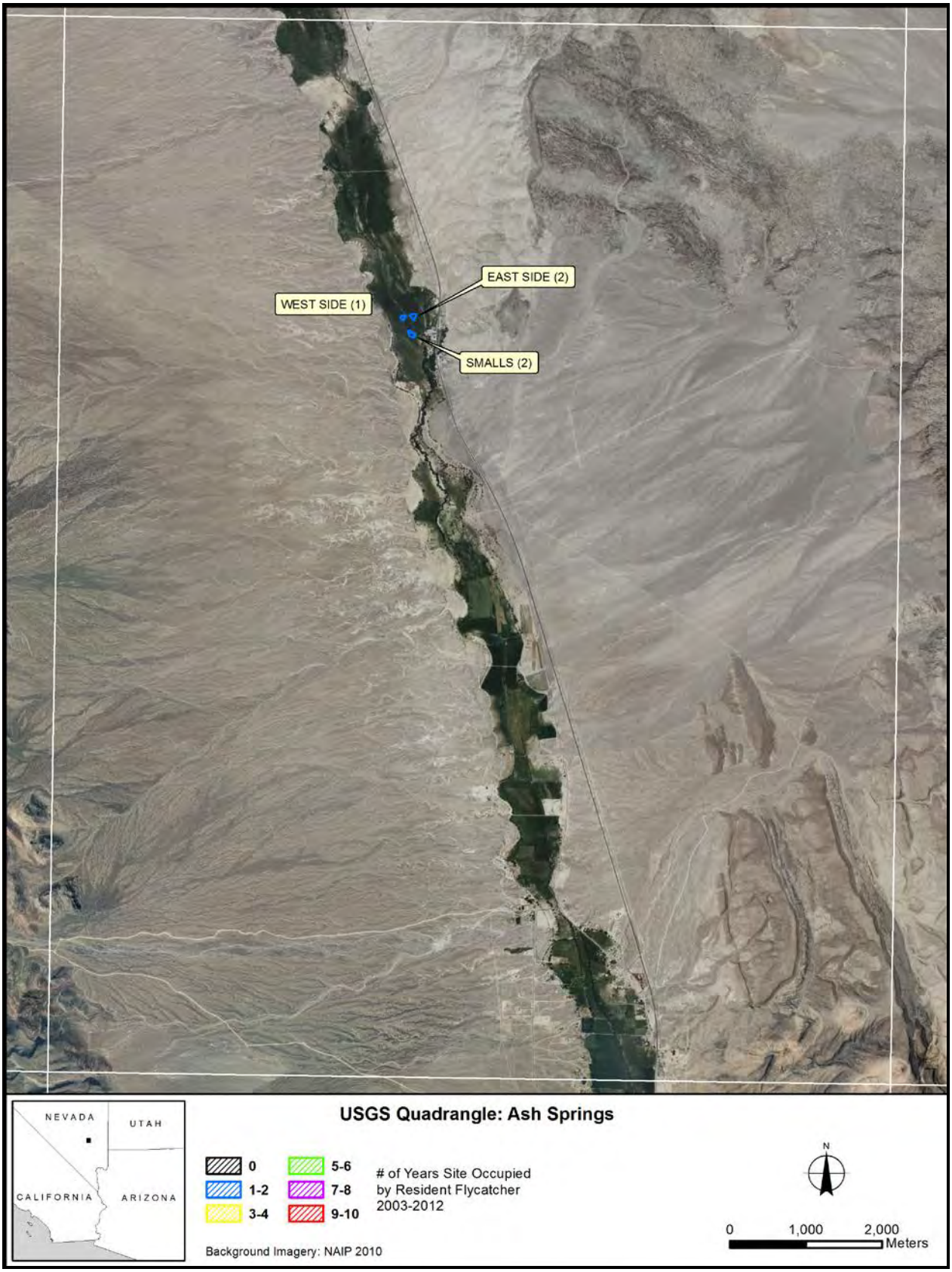
[8] Reconnaissance site. Survey results reported if a flycatcher was detected.

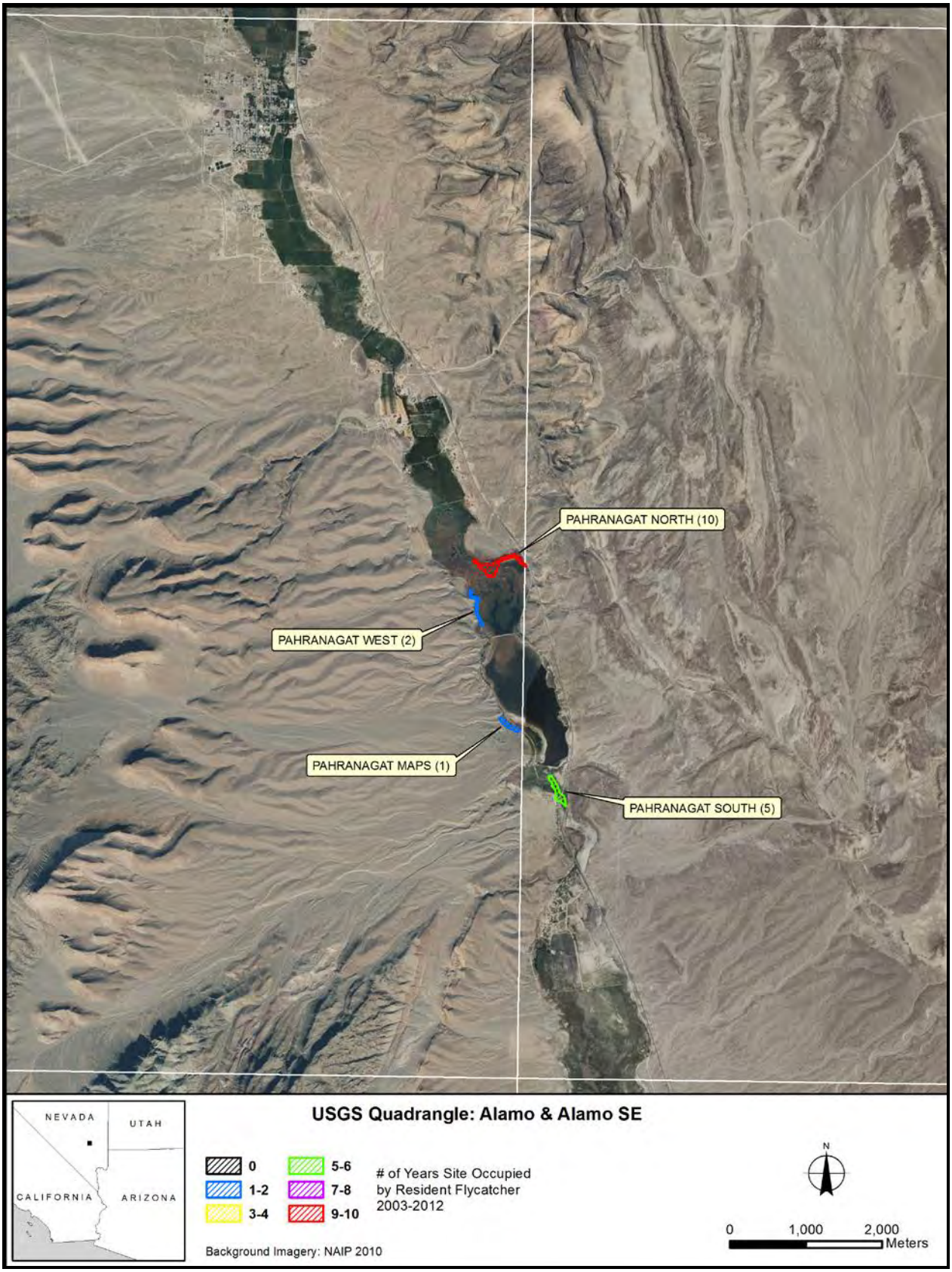
Appendix B

ORTHOPHOTOS SHOWING STUDY SITES SURVEYED, 2008–2012

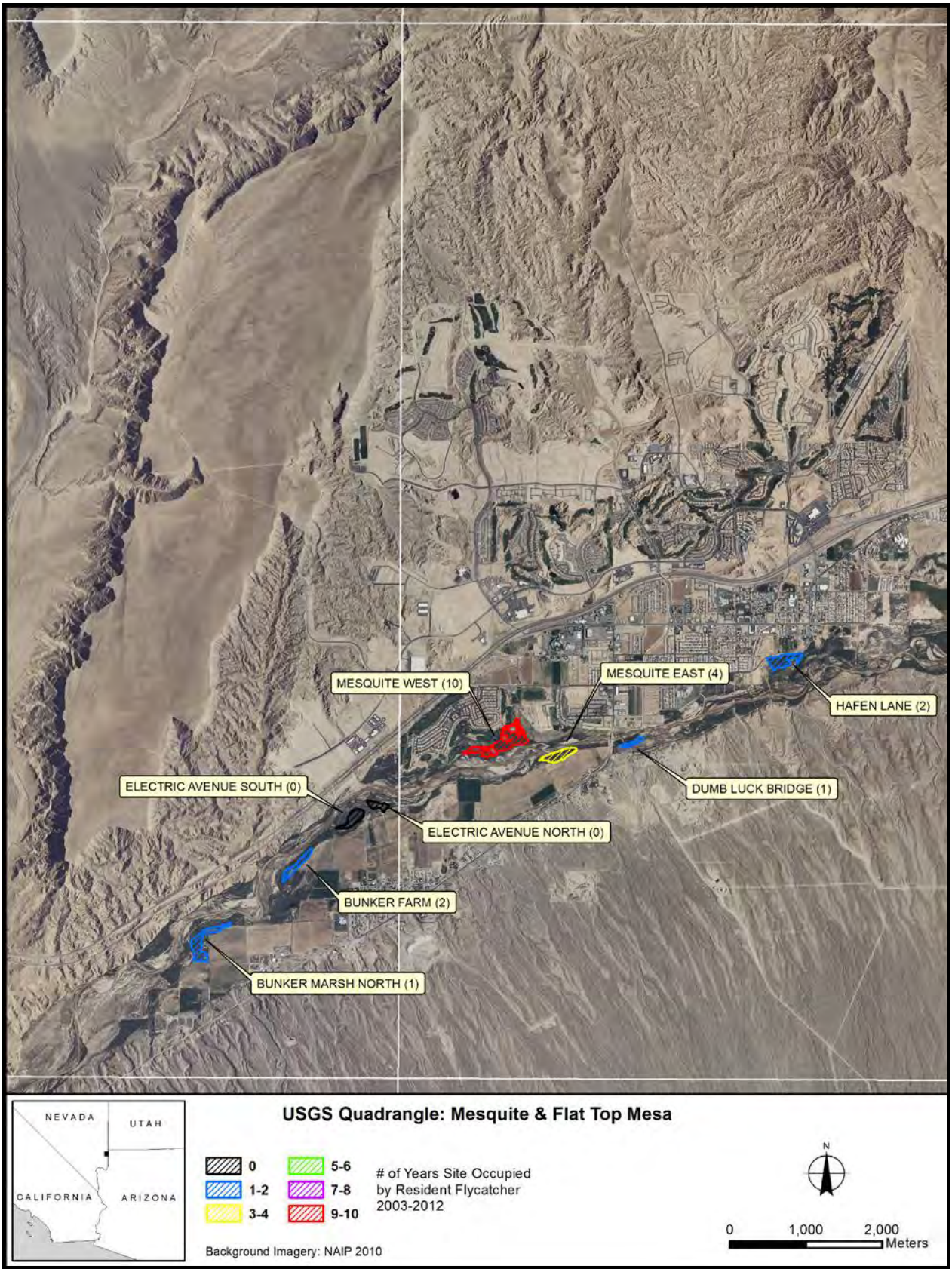

KEY PITTMAN
15 Sites
RIVER RANCH
3 Sites
PAHRANAGAT NWR
4 Sites
Pahranagat Wash
U T A H
St. George
Virgin River
N E V A D A
LITTLEFIELD
1 Site
WARM SPRINGS
6 Sites
MESQUITE
8 Sites
MUDDY RIVER
2 Sites
MORMON MESA
7 Sites
Lake Mead
Colorado River
Las Vegas
GRAND CANYON
4 Sites
Lake Mohave
Kingman
Flagstaff
TOPOCK MARSH
21 Sites
TOPOCK GORGE
5 Sites
Verde River
C A L I F O R N I A
Lake Havasu
BILL WILLIAMS RIVER NWR
18 Sites
Bill Williams River
A R I Z O N A
Colorado River
AHAKHAV
2 Sites
Palm Springs
PVER
2 Sites
Quartzsite
BIG HOLE SLOUGH
1 Site
EHRENBERG
1 Site
Phoenix
Salton Sea
CIBOLA
13 Sites
IMPERIAL
14 Sites
Gila River
MITTRY LAKE
2 Sites
Yuma
YUMA
4 Sites
M E X I C O
Lower Colorado River Southwestern
Willow Flycatcher Study 2008-2012
NDOW Study Area
Reclamation Study Area
0 25 50 Mi
0 50 100 Km
1:3,300,000
N

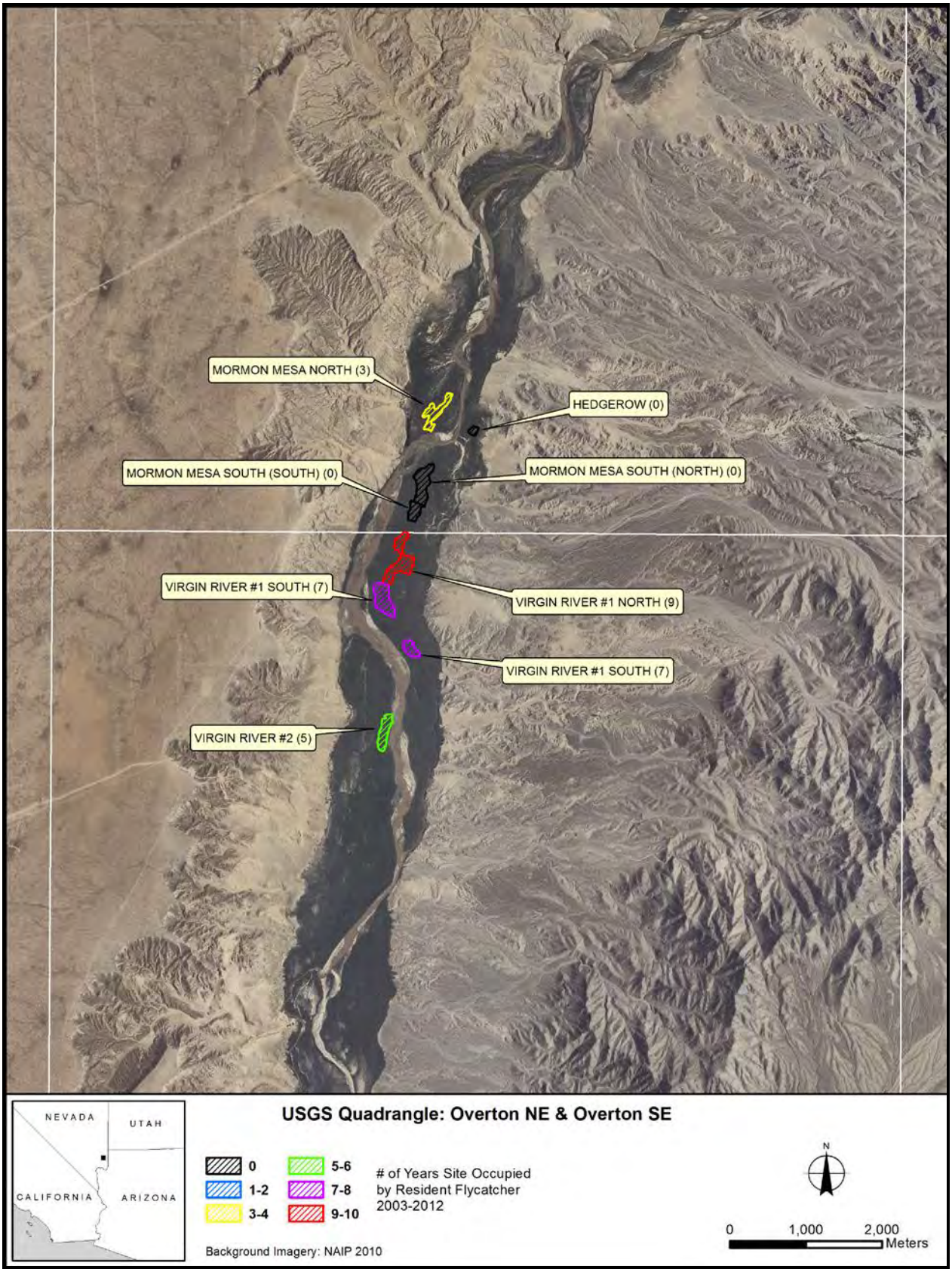
KEY PITTMAN PATCH 1 - 12
3
1
3
1
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Hiko
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied
by Resident Flycatcher
2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters


EAST SIDE (2)
WEST SIDE (1)
SMALLS (2)
USGS Quadrangle: Ash Springs
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters


PAHRANAGAT NORTH (10)
PAHRANAGAT WEST (2)
PAHRANAGAT MAPS (1)
PAHRANAGAT SOUTH (5)
USGS Quadrangle: Alamo & Alamo SE
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

LITTLEFIELD POLES (4)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Littlefield
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

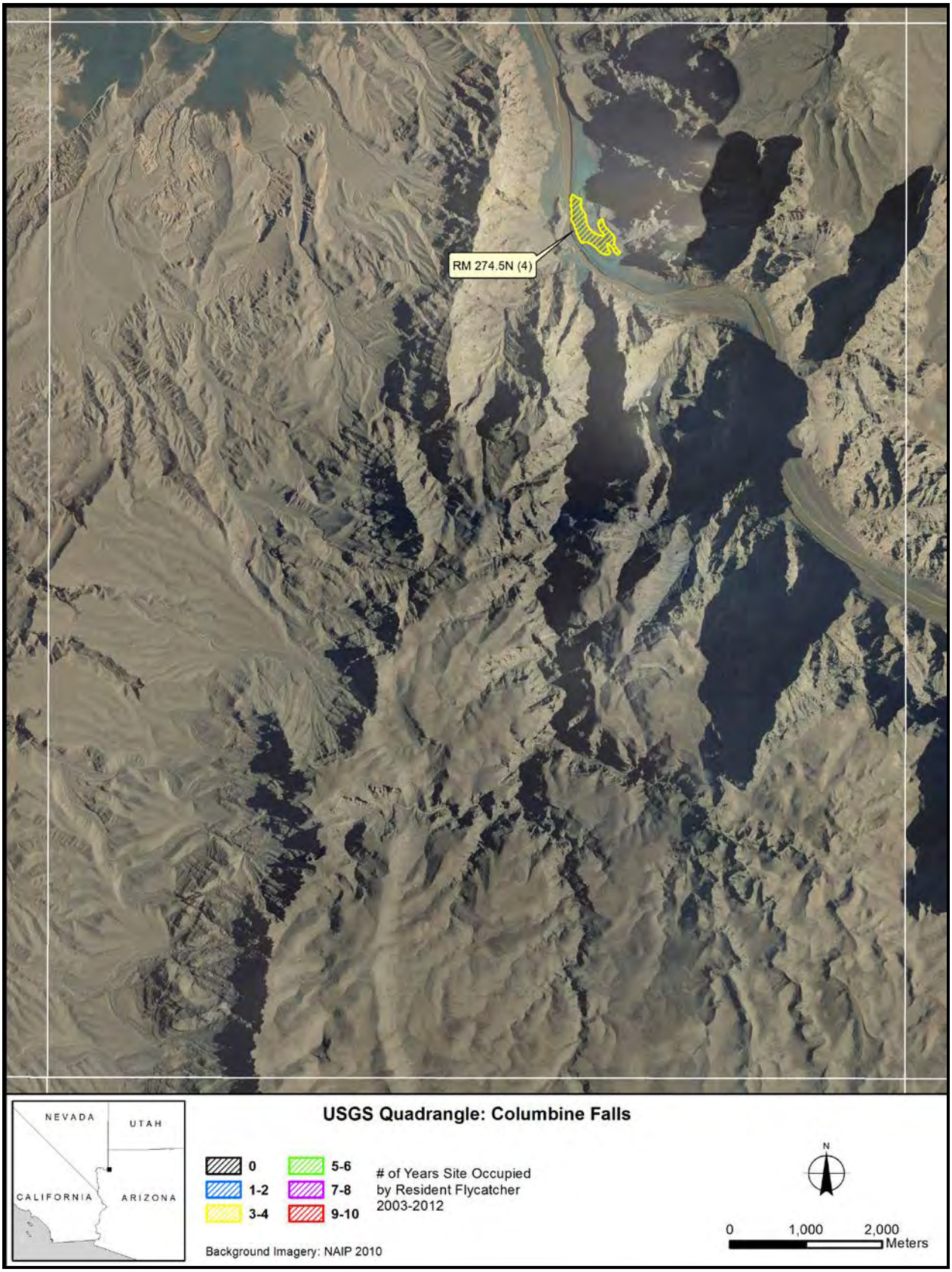

MESQUITE WEST (10)
MESQUITE EAST (4)
HAFEN LANE (2)
DUMB LUCK BRIDGE (1)
ELECTRIC AVENUE SOUTH (0)
ELECTRIC AVENUE NORTH (0)
BUNKER FARM (2)
BUNKER MARSH NORTH (1)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Mesquite & Flat Top Mesa
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied
by Resident Flycatcher
2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters


MORMON MESA NORTH (3)
HEDGEROW (0)
MORMON MESA SOUTH (SOUTH) (0)
MORMON MESA SOUTH (NORTH) (0)
VIRGIN RIVER #1 SOUTH (7)
VIRGIN RIVER #1 NORTH (9)
VIRGIN RIVER #1 SOUTH (7)
VIRGIN RIVER #2 (5)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Overton NE & Overton SE
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

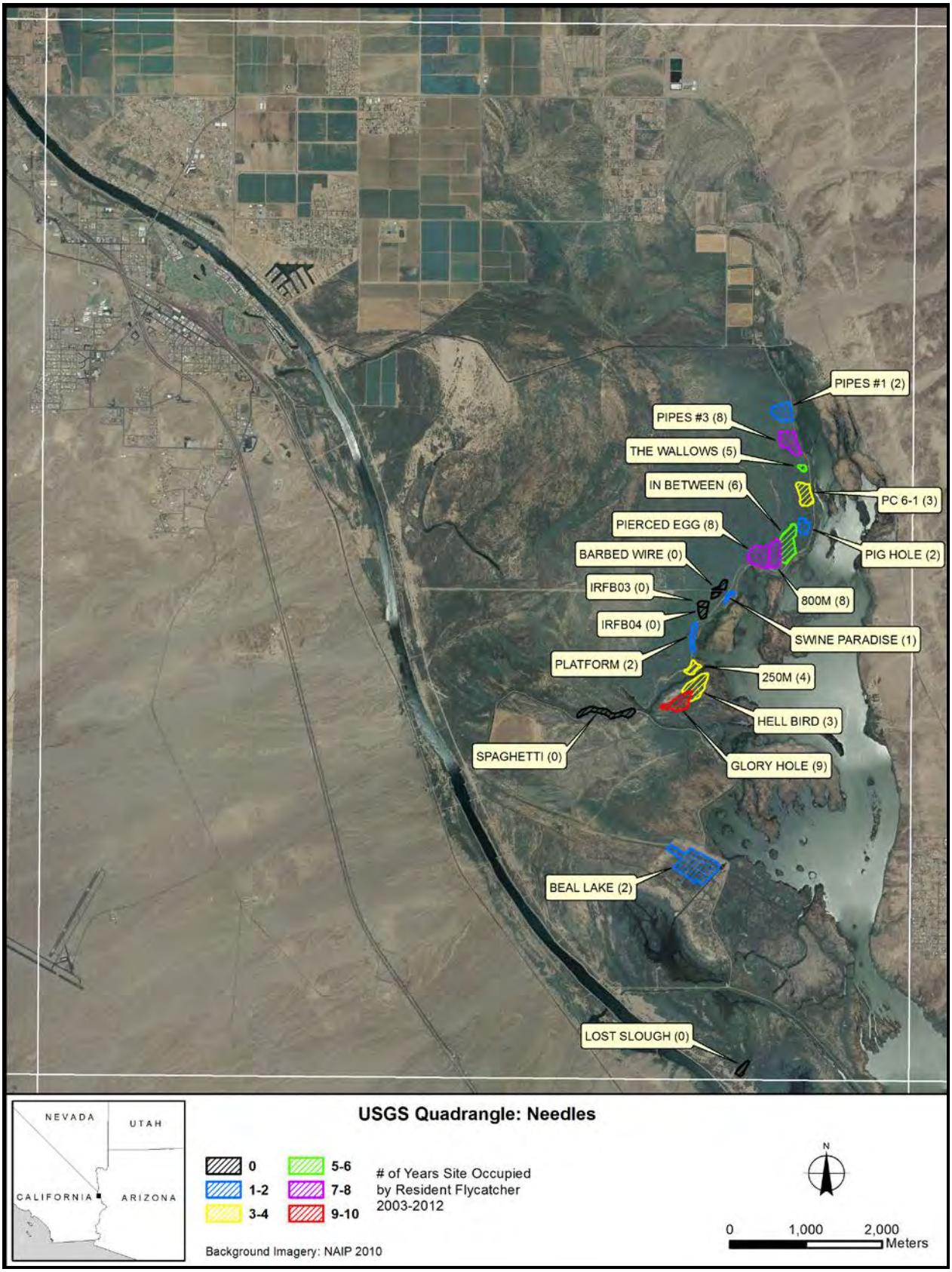
OVERTON WMA POND (3)
OVERTON WMA (9)
USGS Quadrangle: Overton
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

LDS EAST (0)
MUDDY STRINGER 2 (0)
MUDDY STRINGER 1 (1)
MUDDY MAC (3)
NORTH FORK MUDDY (0)
APCAR (0)
USGS Quadrangle: Moapa West
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

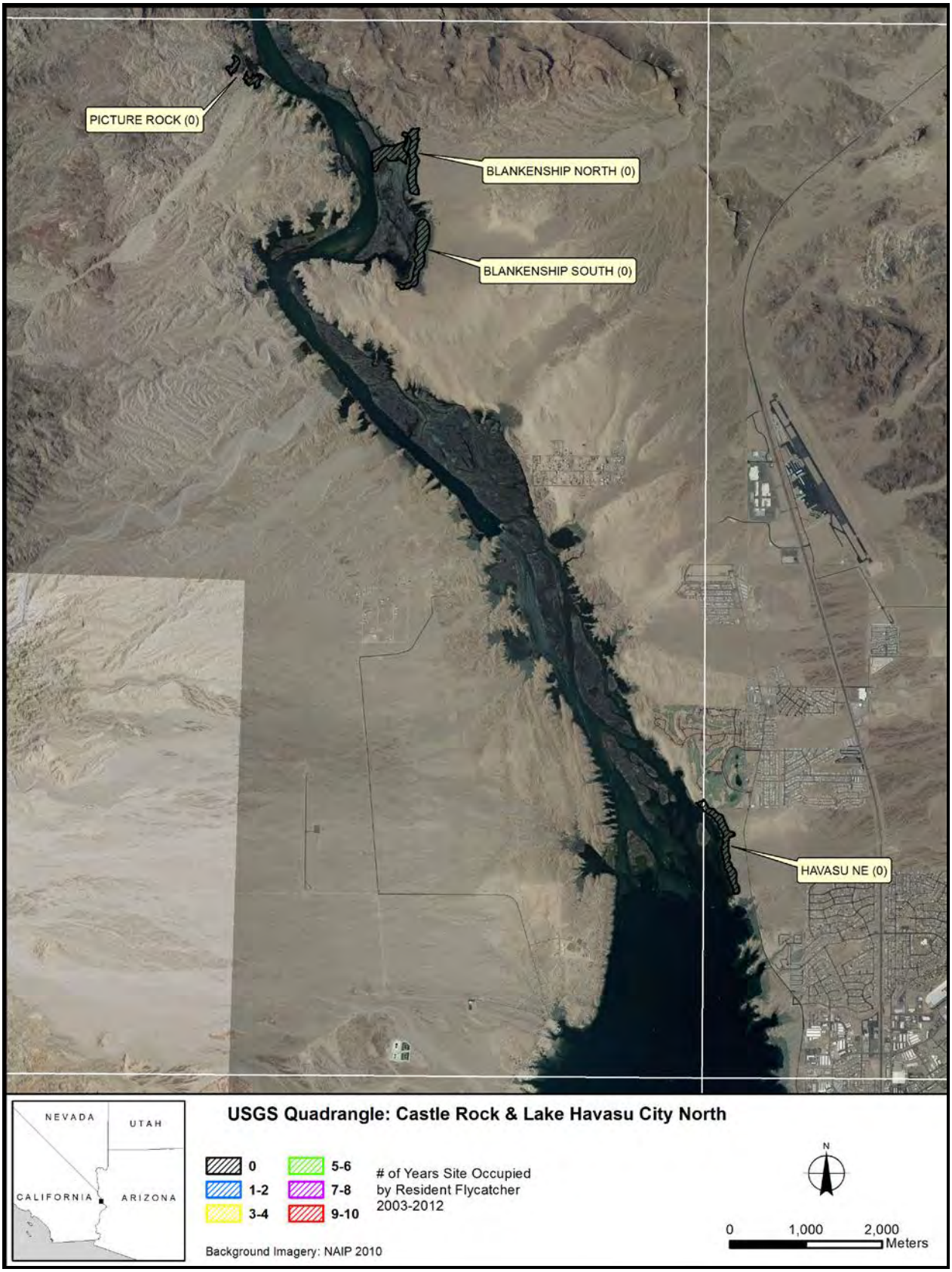
BURNT SPRINGS/RM 259.5N (2)
USGS Quadrangle: Devils Slide Rapids
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied
by Resident Flycatcher
2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters


RM 274.5N (4)
USGS Quadrangle: Columbine Falls
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

RM 285.3N (1)
ICEBERG CANYON (1)
USGS Quadrangle: Iceberg Canyon
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

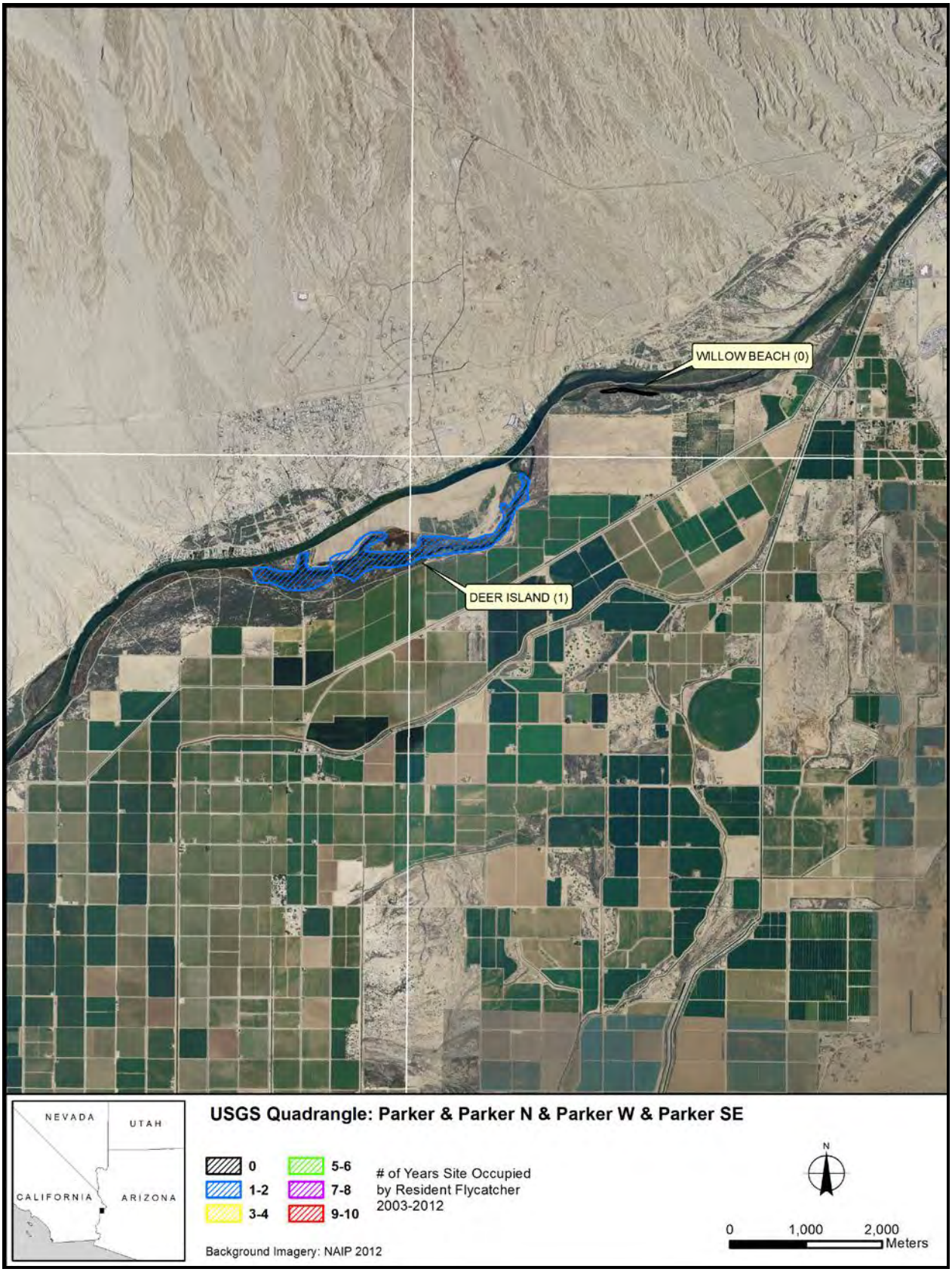

PIPES #1 (2)
PIPES #3 (8)
THE WALLOWS (5)
IN BETWEEN (6)
PC 6-1 (3)
PIERCED EGG (8)
PIG HOLE (2)
BARBED WIRE (0)
IRFB03 (0)
800M (8)
IRFB04 (0)
SWINE PARADISE (1)
PLATFORM (2)
250M (4)
HELL BIRD (3)
SPAGHETTI (0)
GLORY HOLE (9)
BEAL LAKE (2)
LOST SLOUGH (0)
USGS Quadrangle: Needles
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

LOST POND (0)
LOST LAKE (1)
PULPIT ROCK (0)
USGS Quadrangle: Whale Mountain & Topock
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters


PICTURE ROCK (0)
BLANKENSHIP NORTH (0)
BLANKENSHIP SOUTH (0)
HAVASU NE (0)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Castle Rock & Lake Havasu City North
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

SITE #1 (3)
BURN EDGE (2)
WISPY WILLOW (0)
LAST GASP (0)
SITE #2 (0)
GUINNESS (0)
SITE #11 (0)
SITE #5 (1)
SITE #4 (6)
SITE #3 (10)
BLACK RAIL (0)
COUGAR POINT (1)
MINERAL WASH (1)
BEAVER POND (0)
USGS Quadrangle: Monkeys Head
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

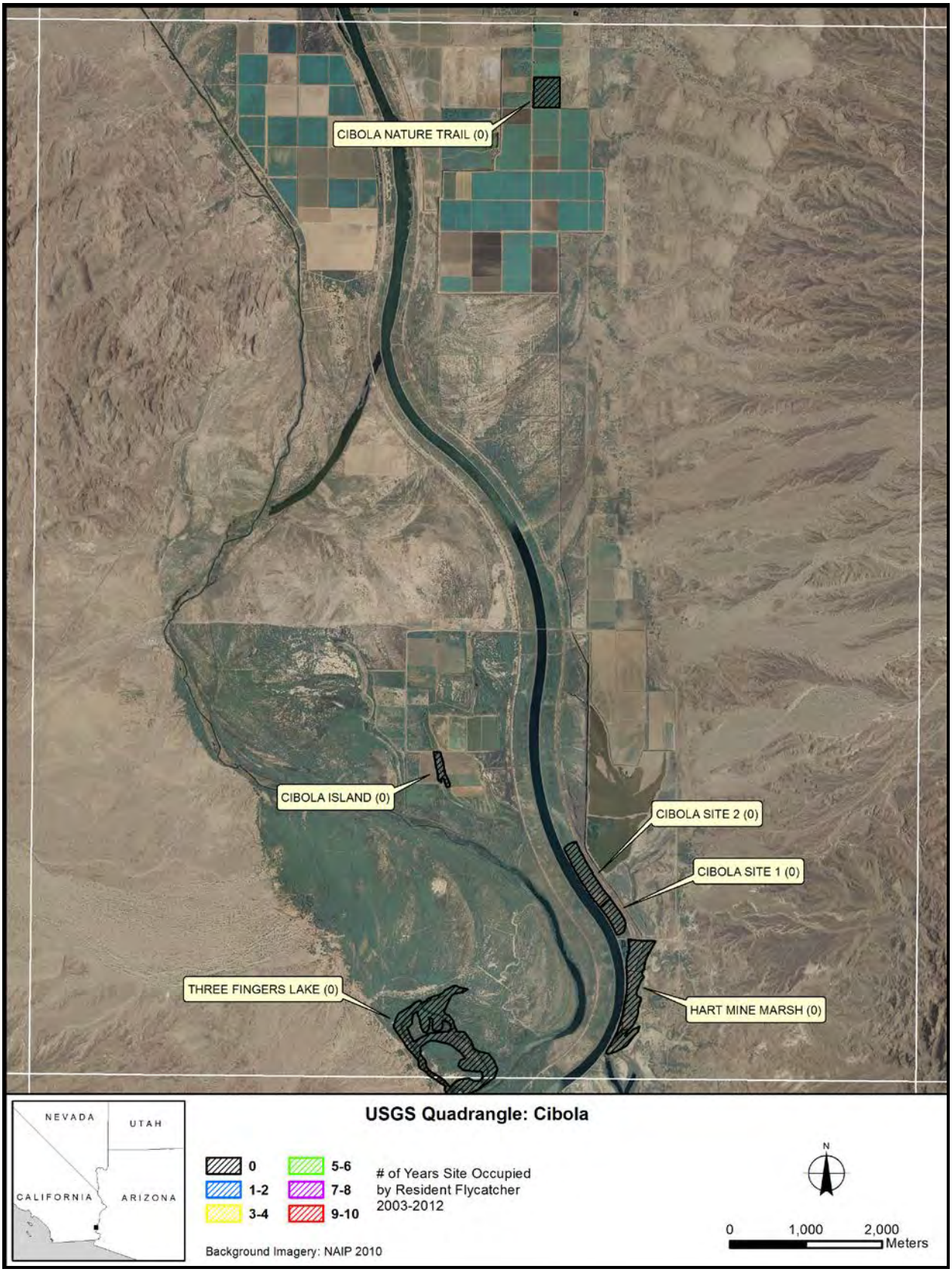
NT
UPSTREAM FROM SITE #8 (1)
SITE 8 (0)
PLANET RANCH ROAD (2)
NEW RIVER (0)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Castaneda Hills SW
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters


WILLOW BEACH (0)
DEER ISLAND (1)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Parker & Parker N & Parker W & Parker SE
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2012
N
0
1,000
2,000
Meters

PVER PHASE 2 (0)
PVER PHASE 3 (0)
BIG HOLE SLOUGH (0)
USGS Quadrangle: Blythe NE
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2012
N
0
1,000
2,000
Meters

EHRENBERG (0)
USGS Quadrangle: Blythe
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2012
N
0
1,000
2,000
Meters

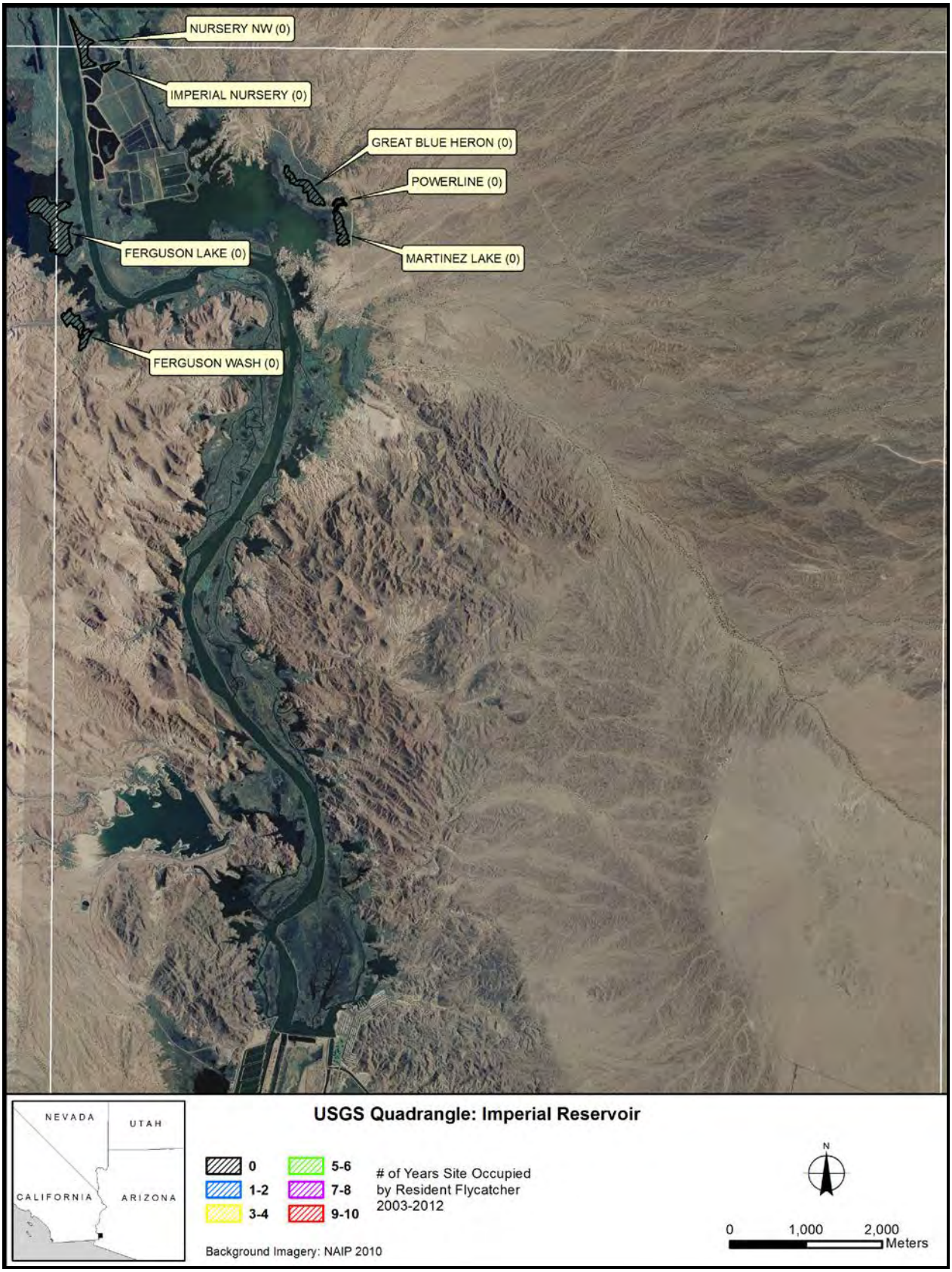
CVCA PHASE 1 (0)
CVCA PHASE 2 (0)
CVCA PHASE 3 (0)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Palo Verde
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2012
N
0
1,000
2,000
Meters


CIBOLA NATURE TRAIL (0)
CIBOLA ISLAND (0)
CIBOLA SITE 2 (0)
CIBOLA SITE 1 (0)
THREE FINGERS LAKE (0)
HART MINE MARSH (0)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Cibola
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

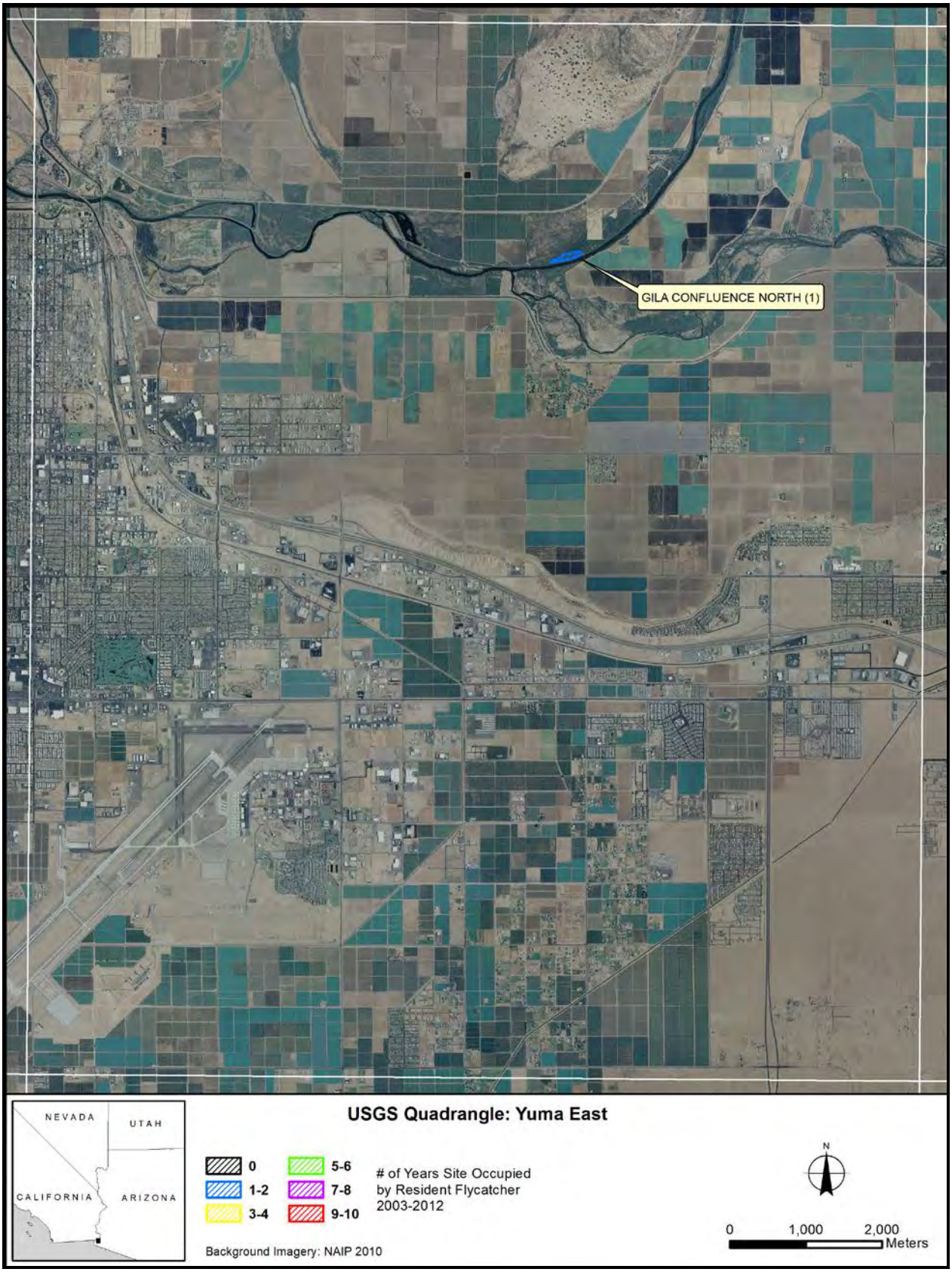
CIBOLA LAKE NORTH (0)
CIBOLA LAKE EAST (0)
CIBOLA LAKE WEST (0)
WALKER LAKE (1)
DRAPER LAKE (0)
USGS Quadrangle: Picacho NW
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

PARADISE (0)
HOGE RANCH (1)
RATTLESNAKE (0)
ADOBE LAKE (0)
USGS Quadrangle: Picacho SW
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2012
N
0
1,000
2,000
Meters

AKE (0)
MILEMARKER 65 (0)
CLEAR LAKE (0)
USGS Quadrangle: Picacho
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters


NURSERY NW (0)
IMPERIAL NURSERY (0)
GREAT BLUE HERON (0)
POWERLINE (0)
FERGUSON LAKE (0)
MARTINEZ LAKE (0)
FERGUSON WASH (0)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Imperial Reservoir
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

MITTRY WEST (0)
MITTRY SOUTH (0)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Laguna Dam
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters


GILA CONFLUENCE NORTH (1)
USGS Quadrangle: Yuma East
NEVADA
UTAH
CALIFORNIA
ARIZONA
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

FORTUNA NORTH (0)
GILA RIVER SITE #2 (0)
FORTUNA SITE #1 (0)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Fortuna
0
1-2
3-4
5-6
7-8
9-10
# of Years Site Occupied by Resident Flycatcher 2003-2012
Background Imagery: NAIP 2010
N
0
1,000
2,000
Meters

Appendix C

DETECTIONS OF SPECIAL CONCERN SPECIES, 2008–2012

Table C.1. Yellow-billed Cuckoo Detections, 2008–2012

Study Area[1]	Site	Year	Date	Behavioral Observations
KEPI	Key Pittman	2008	26 Jun	One individual observed visually
PAHR	North	2008	13 Jun	One individual observed visually
		2010	27 Jun	One individual heard (*kowlp*)
		2012	21 Jun	One individual heard (primary song)
MESQ	Hafen Lane	2010	21 Jul	One individual heard
		2011	23 Jun	One individual detected
	West	2010	14 Jul	One individual seen and heard (*kuk* and *kowlp*)
			16 Jul	One individual heard (*kuk*)
			18 Jul	Two individuals (one seen) counter-calling (*kuk* and *kowlp*)
		2011	19–22 Jul	Repeated detections of one or two individuals
MOME	Mormon Mesa South (South)	2012	18 Jun	One individual heard
	Virgin River #1 North	2008	9 Jul	One individual seen and heard calling in northwestern corner of site
	Virgin River #1 South	2009	13 Jul	One individual heard calling continuously for 10 minutes
		2010	12 Jul	One silent individual seen
MUDD	Overton WMA	2010	6 Jul	One silent individual seen
		2011	14 Jul	One individual heard
WMSP	Muddy Mac	2010	29 Jun	One individual heard (*kuk* and *kowlp*)
TOPO	Pipes #3	2012	13 Jul	One individual heard
	PC6-1	2009	2 Jul	One individual seen flying across the road
	Barbed Wire	2010	2 Jul	One individual heard (*kuk* and *kowlp*)
	Glory Hole	2009	29 Jun	One individual seen
	Beal Lake	2008	21 Jun	One individual observed visually
		2010	8 Jul	Two individuals heard (*kuk* and *kowlp*)
		2011	29 Jun	One individual detected
			13 Jul	Two individuals detected
	Lost Lake	2010	9 Jul	Two individuals heard (*kuk* and *kowlp*)
			18 Jul	One individual heard (*kuk* and *kowlp*)
TOGO	Havasu NE	2012	31 Jul	One individual heard
BIWI	Site #4	2009	20 Jul	One individual heard
		2010	21 Jun	One individual heard
			27 Jun	Two individuals heard (*kuk* and *kowlp*)
	Site #3	2009	30 Jun	One individual heard calling throughout the morning
			7 Jul	One individual heard calling in the same location as on 30 Jun
			9 Jul	Two individuals heard calling in the same location as on 30 Jun
			12 Jul	One individual heard calling in the same location as on 30 Jun
			13 Jul	One individual heard calling in the same location as on 30 Jun
			24 Jul	One individual heard calling in the same location as on 30 Jun

Table C.1. Yellow-billed Cuckoo Detections 2008–2012 (Continued)

Study Area[1]	Site	Year	Date	Behavioral Observations
BIWI	Site #3	2010	18 Jun	One individual heard
			29 Jun	One individual heard (*kuk* and *kowlp*) several times in two hours
			1 Jul	One individual heard
			11 Jul	One individual heard (*kuk* and *kowlp*)
		2011	30 Jun	One individual heard
			16 Jul	Two individuals heard (*coo* and *kowlp*)
	Last Gasp	2010	20 Jul	One individual heard (*kuk*, *kowlp*, and *coo*)
	Site #5	2008	7 Jul	No notes taken
		2009	24 Jun	One individual detected; no notes taken
			9 Jul	Two individuals seen
		2011	10 Jul	One individual detected
		2012	2 Jul	One individual heard
			14 Jul	One individual heard
	Mineral Wash	2010	21 Jun	One individual heard (*kuk* and *kowlp*)
			30 Jun	One individual heard (*kuk* and *kowlp*)
	Beaver Pond	2010	21 Jun	Two individuals heard (*kuk*, *kowlp*, and *coo*)
			9 Jul	One individual heard
			20 Jul	One individual heard (*kuk* and *kowlp*)
			26 Jul	One individual heard
	Site #8	2008	8 Jul	No notes taken
		2010	29 Jun	One individual heard (*kuk* and *kowlp*)
			14 Jul	One individual heard (*kuk* and *kowlp*)
	Upstream from Site #8	2009	18 Jun	One individual heard
			4 Jul	At least two individuals heard
			14 Jul	One individual heard
			18 Jul	One individual detected; no notes taken
			27 Jul	One individual heard in the same location as on 18 Jun
		2010	3 Jun	One individual heard (*coo*)
			14 Jul	One individual heard
	Planet Ranch Road	2009	12 Jun	One individual heard calling
			8 Jul	At least two individuals heard
			18 Jul	One individual detected; no notes taken
			22 Jul	One adult and one fledgling seen
		2010	30 May–21 Jul	Repeated detections of one or two cuckoos (*kuk*, *kowlp*, and *coo*)
		2011	2–17 Jul	Repeated detections of one or two cuckoos
	New River	2011	7 Jul	One individual detected
			17 Jul	One individual detected

Table C.1. Yellow-billed Cuckoo Detections 2008–2012 (Continued)

Study Area[1]	Site	Year	Date	Behavioral Observations
PVER	Phase 2	2010	21 Jun	One individual heard
			29 Jun	One individual heard
			13 Jul	Three individuals heard (*kuk* and *kowlp*)
		2011	13 Jun	One individual seen and heard (*kuk* and *kowlp*)
			12 Jul	Two or three individuals heard (*kuk* and *coo*)
		2012	12 Jul	Two individuals heard
	Phase 3	2010	21 Jun	One individual heard
			29 Jun	Four individuals heard (*kuk* and *kowlp*)
		2011	12 Jul	One individual heard
		2012	12 Jul	One individual heard
CIBO	CVCA Phase 1	2010	24 Jun	One individual heard
			8 Jul	Four individuals heard (*kuk* and *kowlp*)
		2011	17 Jun	One individual detected
			13 Jul	Two individuals heard
		2012	4 Jul	One individual heard
	CVCA Phase 2	2010	24 Jun	Two individuals heard (*kuk* and *kowlp*)
			8 Jul	Four detections; unclear if four separate individuals
		2011	17 Jun	One individual heard (*coo*)
			13 Jul	Three or four individuals detected
		2012	10 Jul	Two individuals heard
	CVCA Phase 3	2010	15 Jun	One individual heard
			13 Jul	One individual heard (*kuk* and *kowlp*)
		2011	8 Jun	One individual seen
	Cibola Nature Trail	2012	19 Jul	One individual heard
	Cibola Island	2011	7 Jul	Two individuals heard (*kuk* and *coo*), one silent cuckoo seen
	Three Fingers Lake	2010	22 Jun	One individual heard (*kuk* and *kowlp*)
	Cibola Lake North	2008	18 Jul	Individual heard calling
IMPE	Imperial Nursery	2012	2 Jul	One individual seen
MITT	Mittry West	2010	17 Jun	One individual heard (*kuk*, *kowlp*, and repeated *coo*)
			16 Jul	One individual heard (*kuk*, *kowlp*, and repeated *coo*)
	Mittry South	2010	17 Jun	Two individuals heard (*kuk* and *kowlp*)
YUMA	Gila Confluence North	2010	4 Jul	One individual heard (*kuk* and *kowlp*)
		2010	20 Jul	Two individuals heard (*kuk* and *kowlp*)

[1] KEPI = Key Pittman WMA, PAHR = Pahranagat NWR, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, WMSP = Warm Springs NA, TOPO = Topock Marsh, TOGO = Topock Gorge, BIWI = Bill Williams River NWR, PVER = Palo Verde Ecological Reserve, CIBO = Cibola, IMPE = Imperial, MITT = Mittry Lake, YUMA = Yuma.

Table C.2. Yuma Clapper Rail Detections at Reclamation Study Areas, 2008–2012

Study Area[1]	Site	Year	Date(s)	Behavioral Observations
MESQ	Bunker Marsh North	2009	27 May	One individual heard calling
TOPO	800M	2009	13 Jul	One individual heard kekking
		2010	13 May	One individual heard
	Pierced Egg	2010	27 May	Two or three individuals clattering
			4 Jun	Two individuals clattering on marsh edge
	Swine Paradise	2008	3 Jun	One individual heard calling
	IRFB03	2008	12 May	One individual heard calling
	Platform	2008	5 July	One individual heard calling
		2010	11 Jun	Two individuals heard kekking
			30 Jun	One individual heard kekking on marsh edge
	250M	2009	21 Jul	Keks heard from marsh
		2010	15 May	One individual heard
	Hell Bird	2009	5 Jun	Two individuals heard calling
	Glory Hole	2010	23 May	Three to four individuals heard clattering
			26 Jun	One individual heard
	NW Beal Lake	2009	30 May	One individual heard kekking
	Beal Lake	2009	3 Jun	One individual heard calling in marsh to north of site
	NE Lost Lake	2009	25 May	Three individuals heard calling
			10 Jun	Four individuals heard calling; two were interacting
	Lost Lake	2008	14 May	One individual heard calling
		2009	29 May	Two individuals heard calling from cattail marsh
		2010	27 May	Two pairs heard clattering
			30 Jun	One individual heard
			9 Jul	Two pairs heard clattering
		2012	7 Jul	One individual heard
	Lost Lake Slough #2	2010	13 Jun	One individual heard kekking
	Lost Lake Slough #3	2010	13 May	Pair heard clattering
			13 Jun	Pair heard clattering
	Lost Lake Slough #4	2009	27 May	One individual recorded; no notes taken
TOGO	Picture Rock	2009	9 Jul	One individual recorded; no notes taken
	Blankenship Bend North	2009	29 May	Three individuals recorded; single bird kekking and pair clatter
		2010	17 May	Multiple pairs heard clattering
			1 Jun	One individual heard kekking
			24 Jun	One individual seen, second individual heard kekking
	Blankenship Bend South	2009	10 Jun	One individual heard kekking
			24 Jun	One individual recorded; no notes taken
			21 Jul	Two individuals recorded; pair clatter
		2010	1 Jun	Pair heard clattering
			24 Jun	Pair heard clattering

Table C.2. Yuma Clapper Rail Detections at Reclamation Study Areas, 2008–2012 (Continued)

Study Area[1]	Site	Year	Date(s)	Behavioral Observations
BIWI	Wispy Willow	2011	13 Jun	One individual heard
		2012	21 Jul	One individual heard
	Site #1	2010	15 Jun	Two individuals heard
	Site #2	2008	15 May	Two detections recorded, no notes taken
	Site #3	2009	14 May	One individual seen
	Site #5	2010	14 May	Pair heard clattering
	Mineral Wash	2010	16 May	One individual seen
	Planet Ranch Rd	2012	22 Jul	One individual heard
CIBO	Cibola Site #2	2011	28 Jun	One individual heard
	Hart Mine Marsh	2009	9 Jun	Three individuals heard calling
	Three Fingers Lake	2008	18 May	One individual heard calling
			3 Jul	One individual heard calling
		2010	27 May	One individual heard
			2 Jun	One individual heard
	Cibola Lake North	2008	19 May	One individual heard calling
		2010	23 Jun	One individual heard
			14 Jul	Three individuals heard
	Cibola Lake East	2009	26 May	One individual heard kekking
	Cibola Lake West	2010	23 Jun	One individual heard
	Walker Lake	2008	18 May	One individual heard calling
IMPE	Draper Lake	2008	27 May	Pair heard calling
	Nursery NW	2008	1 Jun	Four detections recorded, no notes taken
			14 Jun	One detection recorded, no notes taken
	Imperial Nursery	2008	1 Jun	One individual heard calling
	Ferguson Lake	2008	15 Jul	One detection recorded, no notes taken
		2009	22 Jul	One individual recorded; no notes taken
		2012	5 Jun	Two pairs, clattering
	Powerline	2009	28 May	One individual heard kekking
		2011	5 Jul	One individual heard
MITT	Mittry South	2008	28 Jun	One individual heard calling
YUMA	Fortuna Site #1	2009	28 Jun	One individual heard kekking
	Fortuna North	2009	24 Jul	One individual recorded; no notes taken

[1] MESQ = Mesquite, TOPO = Topock Marsh, TOGO = Topock Gorge, BIWI = Bill Williams River NWR, CIBO = Cibola, IMPE = Imperial, MITT = Mittry Lake, YUMA = Yuma.

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012*

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
PAHR	North	2008	5	0	0	0	1	0	0	0	0	0	24	0	3
		2009	5	0	0	0	0	0	0	0	0	0	85	1	4
		2010	0	--	--	--	--	--	--	--	--	--	--	--	--
		2011	4	0	0	0	0	0	0	0	0	0	1	1	0
		2012	5	0	0	0	0	0	0	0	0	0	14	1	6
	West	2008	5	0	0	0	0	0	0	0	0	0	9	0	1
		2009	5	0	0	0	0	0	0	0	1	2	25	0	5
		2010	5	0	0	0	0	0	0	0	0	0	37	0	7
		2011	5	0	0	0	0	0	0	0	0	0	10	0	1
		2012	5	0	0	0	0	0	0	0	0	0	6	0	5
	MAPS[3]	2008	5	0	0	0	0	0	0	0	1	0	7	0	2
		2009	5	0	0	0	0	0	0	0	0	0	35	0	4
		2010	4	0	0	0	0	0	0	0	0	0	25	0	1
	South[3]	2008	7	0	0	0	0	0	0	0	0	1	15	1	7
		2009	5	0	0	0	0	0	0	0	0	1	16	0	18
		2010	5	0	0	0	0	0	0	0	2	8	27	0	9
		2011	0	--	--	--	--	--	--	--	--	--	--	--	--
		2012[4]	1	0	0	0	0	0	0	0	0	0	2	0	0
LIFI	Poles[3]	2008	5	0	0	0	0	0	0	0	0	4	13	2	6
		2009	5	0	0	0	0	0	0	0	0	0	59	10	5
		2010	5	0	0	1	0	0	0	0	1	2	44	2	9
MESQ	Hafen Lane	2010	5	0	0	0	0	0	0	1	0	1	40	0	16
		2011	5	0	0	0	2	0	0	0	0	1	41	2	20
		2012	5	0	0	0	0	0	0	0	0	6	54	1	57
	Up the Creek[4]	2012	2	0	0	0	0	0	0	0	0	2	15	0	20
	Dumb Luck Bridge	2012	2	0	0	0	0	0	0	0	0	0	12	0	10

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
MESQ	East[3]	2008	5	0	0	0	0	0	0	0	0	2	18	2	17
		2009	5	0	0	0	0	0	0	0	0	1	75	1	40
	West	2008	8	0	0	0	0	0	0	0	0	1	45	1	3
		2009	1	0	0	0	0	0	0	0	0	1	36	0	3
		2010	5	0	0	0	0	0	0	0	0	1	40	0	20
		2011	5	0	0	0	0	0	0	0	0	0	49	0	22
		2012	5	0	0	0	0	0	0	0	0	7	103	0	110
	Electric Avenue North[3]	2008	1	0	0	0	0	0	0	0	0	1	0	0	0
	Electric Avenue South[3]	2008	1	0	0	0	0	0	0	0	0	2	12	0	10
	Electric Avenue Pond[4]	2012	2	0	0	0	0	0	0	0	0	0	4	0	5
	Boomerang[4]	2012	2	0	0	0	0	0	0	0	0	0	2	0	4
	Bunker Farm[3]	2008	5	0	0	0	0	0	0	0	0	1	20	2	5
	Bunker Marsh North[3]	2009	5	0	1	0	0	0	0	0	0	2	43	0	38
		2010	5	0	0	0	0	0	0	0	0	4	58	0	65
		2011	2	0	0	0	0	0	0	0	0	0	3	0	1
	Left Foot[4]	2012	3	0	0	0	0	0	0	0	0	0	2	0	2
MOME	Mormon Mesa North[3]	2008	6	0	0	0	0	0	0	0	0	4	63	0	42
		2009	5	0	0	0	0	0	0	0	0	13	88	0	66
		2010	1	0	0	0	0	0	0	0	0	0	8	0	4
	Hedgerow[3]	2008	5	0	0	0	0	0	0	0	0	1	18	1	10
		2009	5	0	0	0	0	0	0	0	0	2	21	0	10
		2010	1	0	0	0	0	0	0	0	0	0	7	0	5
	Mormon Mesa South	2008	5	0	0	0	0	0	0	0	0	15	104	3	134
		2009	5	0	0	0	0	0	0	0	0	24	114	1	97
		2010	5	0	0	0	0	0	0	0	0	39	65	0	73
		2011	4	0	0	0	0	0	0	0	0	18	78	0	98

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
MOME	Mormon Mesa South	2012	5	0	0	0	1	0	0	0	0	20	53	0	71
	Virgin River #1	2008	5	0	0	0	0	0	0	0	0	8	117	0	100
		2009	5	0	0	0	0	0	0	0	0	15	201	1	235
		2010	5	0	0	0	0	0	0	0	0	27	133	0	130
		2011	4	0	0	0	0	0	0	0	0	2	27	2	37
		2012	6	0	0	0	0	0	0	0	0	23	90	0	163
	Virgin River #2[3]	2008	5	0	0	0	0	0	0	0	0	9	69	8	75
		2009	5	0	0	1	0	0	0	0	0	21	197	1	209
		2010	5	0	0	0	0	0	0	0	0	5	51	2	31
		2011	5	0	0	0	0	0	0	0	0	12	48	4	54
		2012	3	0	0	0	0	0	0	0	0	0	24	0	28
MUDD	Overton WMA Pond	2008	6	0	0	0	0	0	0	0	0	0	21	1	3
		2009	5	0	0	0	0	0	0	0	0	0	26	0	6
		2010	5	0	0	0	9	0	0	0	0	1	58	1	35
		2011	5	0	0	0	0	0	0	0	0	1	17	2	16
		2012	5	0	0	0	0	0	0	0	0	0	9	0	14
	Overton WMA	2008	5	0	0	0	0	0	0	0	0	2	60	0	37
		2009	5	0	0	0	0	0	0	0	0	4	66	0	50
		2010	5	0	0	0	0	0	0	0	0	0	11	0	5
		2011	6	0	0	0	9	0	0	0	0	0	63	0	64
		2012	5	0	0	0	0	0	0	0	0	2	59	0	80
GRCA	Burnt Springs	2008	4	0	0	0	0	0	0	0	0	23	20	6	23
	RM 274.5N	2008	4	1	0	2	0	0	0	0	0	33	34	2	27
	RM 285.3N[3]	2008	4	0	0	0	0	0	0	0	0	9	0	0	2
	Iceberg Canyon	2008	3	0	0	0	0	0	0	0	0	2	1	0	2

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
TOPO	Pipes #1	2008	5	0	0	0	0	0	0	0	0	3	5	0	27
		2009	5	0	0	0	0	0	0	0	0	0	0	2	18
		2010	5	0	0	0	0	0	0	0	0	0	1	0	48
		2011	5	0	0	0	0	0	0	0	0	0	1	1	42
		2012	5	0	0	0	0	0	0	0	0	1	5	1	25
	Pipes #3	2008	5	0	0	0	0	0	0	0	0	4	7	4	24
		2009	5	0	0	0	0	0	0	1	0	0	1	1	19
		2010	6	0	0	0	0	0	0	2	0	0	4	1	51
		2011	5	0	0	0	0	0	0	4	0	0	11	5	41
		2012	5	0	0	0	1	0	0	1	0	0	13	3	27
	The Wallows	2008	6	0	0	0	0	0	0	1	0	1	0	0	11
		2009	5	0	0	0	0	0	0	0	0	5	8	4	14
		2010	5	0	0	0	0	0	0	0	0	0	5	2	14
		2011	5	0	0	0	0	0	0	3	0	0	9	2	17
		2012	5	0	0	0	0	0	0	1	0	0	2	2	3
	PC6-1	2008	6	0	0	0	0	0	0	3	0	0	8	3	29
		2009	5	0	0	0	0	0	0	5	0	1	8	1	29
		2010	5	0	0	0	0	0	0	2	0	3	9	4	64
		2011	5	0	0	0	0	0	0	1	0	1	9	3	60
		2012	5	0	0	0	0	0	0	4	0	1	5	1	8
	Pig Hole	2008	6	0	0	0	0	0	0	1	0	0	4	0	11
		2009	5	0	0	0	0	0	0	0	0	0	0	0	7
		2010	5	0	0	0	0	0	0	1	0	0	0	2	41
		2011	5	0	0	0	0	0	0	0	0	0	3	0	27
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
TOPO	In Between	2008	6	0	0	0	0	0	0	1	0	0	13	0	15
		2009	5	0	0	0	0	0	0	0	0	0	3	1	15
		2010	5	0	0	0	0	0	0	0	0	0	0	0	42
		2011	5	0	0	0	0	0	0	0	0	0	4	3	39
		2012	5	0	0	0	0	0	0	1	0	0	8	0	27
	800M	2008	6	0	0	1	0	0	0	3	0	1	5	4	15
		2009	5	0	0	0	0	0	0	0	0	0	4	1	12
		2010	5	0	0	0	0	0	0	2	0	1	6	0	20
		2011	5	0	0	0	0	0	0	0	0	0	1	3	20
		2012	5	0	0	0	0	0	0	2	0	0	12	0	10
	Pierced Egg	2008	1	0	0	0	0	0	0	2	0	1	4	5	14
		2009	5	0	0	0	0	0	0	3	0	0	7	4	17
		2010	5	0	2	0	0	0	0	2	0	1	9	0	43
		2011	5	0	0	0	0	0	0	5	0	0	19	5	55
		2012	5	0	0	0	0	0	0	1	0	4	16	1	19
	Swine Paradise	2008	5	0	1	0	0	0	0	2	0	1	9	0	14
		2009	5	0	0	0	0	0	0	0	0	0	7	4	14
		2010	5	0	0	0	0	0	0	1	0	0	6	3	38
		2011	5	0	0	0	0	0	0	1	0	0	14	4	13
		2012	5	0	0	0	0	0	0	0	0	0	3	4	5
	Barbed Wire[3]	2008	5	0	0	0	0	0	0	1	0	2	3	0	14
		2009	5	0	0	0	0	0	0	1	0	0	4	4	20
		2010	5	0	0	0	1	0	0	3	0	0	3	3	40
		2011	5	0	0	0	0	0	0	1	0	0	5	6	26
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--
	IFRB03[3]	2008	5	0	1	0	0	0	0	0	0	0	0	0	5

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
TOPO	IFRB04[3]	2008	5	0	0	0	0	0	0	0	0	0	0	0	5
	Platform	2008	5	0	1	0	0	0	0	1	0	1	5	1	11
		2009	5	0	0	0	0	0	0	0	0	0	3	2	7
		2010	5	0	5	1	0	0	0	3	0	0	12	1	16
		2011	5	0	0	0	0	0	0	1	0	0	6	1	26
		2012	5	0	0	0	0	0	0	0	0	0	7	0	10
	250M	2008	5	0	0	0	0	0	0	0	0	0	13	0	16
		2009	5	0	1	0	0	0	0	7	0	0	7	3	13
		2010	5	0	1	0	0	0	0	2	0	0	8	3	42
		2011	5	0	0	0	0	0	0	2	0	0	6	1	15
		2012	5	0	0	0	0	0	0	2	0	1	2	0	6
	Hell Bird	2008	5	0	0	0	0	0	0	0	0	0	14	1	12
		2009	5	0	2	0	0	0	0	10	0	0	23	6	57
		2010	5	0	0	0	0	0	0	8	1	0	23	3	53
		2011	5	0	0	0	0	0	0	9	0	0	7	4	23
		2012	5	0	0	0	0	0	0	8	0	2	12	5	13
	Glory Hole	2008	2	0	0	2	0	0	0	8	0	3	10	4	10
		2009	5	1	0	0	0	0	0	2	0	0	4	4	11
		2010	5	0	1	0	0	0	0	4	0	0	18	0	23
		2011	5	0	0	0	0	0	0	6	0	1	9	2	40
		2012	5	0	0	0	0	0	0	3	0	0	9	0	21
	Spaghetti[3]	2011	5	0	0	0	0	0	0	1	0	0	2	2	19
	Beal Lake	2008	5	0	0	0	0	0	0	0	0	2	4	0	10
		2009	5	0	1	0	0	0	0	0	0	36	9	1	21
		2010	5	0	0	1	2	0	0	2	0	67	11	1	40
		2011	5	0	0	0	3	0	0	1	0	40	22	10	57

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
TOPO	Beal Lake	2012	5	0	0	0	0	0	0	0	0	39	11	1	32
	Lost Slough[3]	2008	5	0	0	0	0	0	0	0	0	0	0	0	11
		2009	5	0	0	0	0	0	0	0	0	1	2	0	10
	Lost Pond[3]	2008	5	0	0	1	0	0	0	0	0	0	0	0	5
		2009	5	0	0	0	0	0	0	0	0	0	3	0	2
	Lost Lake	2008	5	0	1	1	0	0	0	0	0	1	5	1	17
		2009	5	0	0	0	0	0	0	0	0	1	3	1	10
		2010	5	0	6	3	3	0	0	0	0	1	3	2	19
		2011	5	0	0	2	0	0	0	0	0	0	5	2	8
		2012	5	0	1	1	0	0	0	0	0	0	14	0	23
TOGO	Pulpit Rock[3]	2008	0	--	--	--	--	--	--	--	--	--	--	--	--
		2009	5	0	0	0	0	0	0	0	0	0	0	0	4
	Picture Rock[3]	2008	0	--	--	--	--	--	--	--	--	--	--	--	--
		2009	5	0	1	0	0	0	0	0	0	2	8	1	14
	Blankenship Bend North	2008	5	0	0	0	0	0	0	0	0	11	3	0	18
		2009	5	2	3	0	0	0	0	0	0	13	0	2	38
		2010	5	3	5	3	0	0	0	1	0	5	12	2	83
	Blankenship Bend South	2008	5	0	0	2	0	0	0	0	0	7	0	0	17
		2009	5	4	4	4	0	0	0	0	0	9	0	0	25
		2010	5	1	5	4	0	0	0	2	0	4	2	2	36
	Havasu NE	2008	5	0	0	0	0	0	0	0	0	0	4	0	16
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	0	0	0	0	0	0	0	1	2	0	27
BIWI	Wispy Willow	2011	3	0	1	1	0	0	0	1	0	5	0	2	11
		2012	5	0	1	0	0	0	0	0	0	3	0	0	10

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
BIWI	Site #1	2010	5	0	2	0	0	0	0	8	0	15	0	0	42
		2011[4]	1	0	0	2	0	0	0	1	0	1	0	1	3
		2012	4	0	0	1	0	0	0	1	0	11	0	0	8
	Site #2	2008	6	1	2	4	0	0	0	3	0	4	10	0	24
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	6	0	0	1	0	0	0	2	0	4	2	1	22
		2011[4]	1	0	0	0	0	0	0	0	0	0	0	1	4
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--
	Site #11	2008	5	0	0	0	0	0	0	3	0	2	11	0	26
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	6	0	0	1	0	1	1	5	1	2	8	1	40
		2011[4]	1	0	0	0	0	0	0	2	0	1	0	0	5
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--
	Burn Edge	2008[4]	2	0	0	0	0	0	0	1	0	5	7	0	17
		2009	5	0	0	0	0	0	0	13	0	7	3	0	31
		2010	5	0	0	0	0	0	0	11	0	14	11	1	36
		2011	5	0	0	0	0	0	0	2	0	7	8	1	55
		2012	5	0	0	0	0	0	0	4	0	4	5	0	13
	Site #4	2008	5	0	0	0	0	0	0	13	0	13	10	2	49
		2009	5	0	0	0	1	0	0	2	0	32	31	3	66
		2010	5	0	0	0	3	0	0	10	0	13	23	2	78
		2011	5	0	0	0	0	0	0	22	0	11	32	11	97
		2012	5	0	0	0	0	0	0	2	0	5	21	1	41
	Site #3	2008	5	6	0	0	0	0	0	8	0	13	17	7	46
		2009	5	0	0	0	0	0	0	6	0	8	26	4	50
		2010	5	0	0	0	2	0	0	10	0	4	24	3	69

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
BIWI	Site #3	2011	5	0	0	0	3	1	0	4	0	11	51	8	119
		2012	5	0	0	0	0	0	0	3	0	7	39	2	57
	Last Gasp	2008[4]	2	0	0	0	0	0	1	1	0	3	0	0	8
		2009	5	0	0	0	0	0	0	8	0	22	0	1	61
		2010	5	0	0	0	1	0	0	6	0	21	5	3	67
		2011	5	0	0	0	0	0	0	6	0	1	5	1	70
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--
	Guinness	2012	5	0	0	0	0	0	0	2	0	3	12	0	10
	Site #5	2008	5	0	0	0	1	0	2	10	0	11	22	3	57
		2009	5	0	0	0	3	0	0	13	0	10	7	2	30
		2010	5	0	2	0	0	0	1	13	0	20	21	3	28
		2011	5	0	0	0	1	0	0	7	0	13	16	6	81
		2012	5	0	0	0	2	0	0	1	0	3	21	2	39
	Black Rail	2010	5	0	0	0	0	0	0	12	0	21	3	3	32
		2011	0	--	--	--	--	--	--	--	--	--	--	--	--
		2012	5	0	0	0	0	0	0	4	0	16	0	0	16
	Cougar Point	2011	0	--	--	--	--	--	--	--	--	--	--	--	--
		2012	5	0	0	0	0	0	0	0	0	7	3	2	20
	Mineral Wash	2008	5	3	0	0	0	0	0	5	1	17	2	1	21
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	1	1	0	0	0	18	0	63	12	5	105
		2011[4]	1	0	0	0	0	0	0	0	0	8	5	0	9
		2012	5	0	0	0	0	0	0	4	0	15	10	2	32
	Beaver Pond	2008	5	3	0	0	0	0	0	3	1	18	5	0	24
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
BIWI	Beaver Pond	2010	5	0	0	0	3	1	0	5	0	28	17	6	78
		2011[4]	1	0	0	0	0	0	0	3	0	8	14	1	35
		2012	5	0	0	0	0	0	0	7	0	17	13	8	47
	Site #8	2008	5	1	0	0	1	0	0	2	0	16	11	1	20
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	0	1	2	0	0	18	0	13	20	2	40
		2011	0	--	--	--	--	--	--	--	--	--	--	--	--
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--
	Upstream from Site #8	2008[4]	1	0	0	0	0	0	0	0	0	0	0	0	2
		2009	5	3	0	1	5	0	0	6	0	3	5	0	14
		2010	5	0	0	0	2	0	0	7	0	3	4	0	36
		2011	5	0	0	0	1	0	0	3	0	2	9	0	32
		2012	4	2	0	0	0	0	0	2	0	2	0	0	15
	Planet Ranch Road	2009	5	0	0	0	4	0	0	1	0	23	21	1	19
		2010	5	0	0	0	6	0	0	3	0	40	16	1	60
		2011	5	1	0	0	3	0	0	6	0	14	22	5	44
		2012	4	0	1	0	0	0	0	2	0	9	7	3	19
	New River	2011	5	2	0	0	2	0	0	0	0	9	2	1	22
AHAK	Willow Beach	2008	3	0	0	0	0	0	0	0	0	0	3	0	2
	Deer Island	2008	5	0	0	6	0	0	0	0	0	2	8	0	2
		2009	4	0	0	1	0	0	0	0	0	1	0	0	3
PVER	PVER Phase 2	2009	5	0	0	0	0	0	0	0	0	2	3	0	5
		2010	5	0	0	0	5	0	0	0	0	9	13	1	0
		2011	6	0	0	0	3	0	0	0	0	3	12	0	2
		2012	5	0	0	0	2	0	0	0	0	0	12	0	10

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
PVER	PVER Phase 3	2010	5	0	0	0	4	0	0	0	0	0	2	1	0
		2011	6	0	0	0	3	0	0	0	0	0	5	2	4
		2012	5	0	0	0	1	0	0	0	0	0	0	0	5
BIHO	Big Hole Slough[3]	2008	5	0	0	1	0	0	0	3	0	0	0	0	3
		2009	5	0	0	0	0	0	0	1	0	0	0	0	12
		2010	1	0	0	0	0	0	0	0	0	0	0	0	0
EHRE	Ehrenberg	2008	5	0	0	0	0	0	0	1	0	1	2	1	7
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	0	0	0	0	0	1	0	0	2	0	8
		2011	0	--	--	--	--	--	--	--	--	--	--	--	--
		2012	5	0	0	0	0	0	0	0	0	5	1	0	18
CIBO	CVCA Phase 1	2008	5	0	0	0	0	0	0	0	0	1	4	0	2
		2009	5	0	0	0	0	0	0	0	0	0	21	0	9
		2010	5	0	0	0	6	0	0	0	0	1	5	0	3
		2011	6	0	0	0	5	0	0	1	0	0	10	6	7
		2012	5	0	0	0	1	0	0	0	0	0	12	0	6
	CVCA Phase 2	2010	5	0	0	0	6	0	0	0	0	1	10	0	6
		2011	6	0	0	0	4	0	0	0	0	0	7	0	4
		2012	5	0	0	0	2	0	0	0	0	0	2	0	20
	CVCA Phase 3	2009	5	0	0	0	0	0	0	0	0	0	5	0	2
		2010	5	0	0	0	2	0	0	0	0	2	0	0	0
		2011	5	0	0	0	0	0	0	0	0	0	1	4	4
		2012	5	0	0	0	0	0	0	0	0	0	5	0	8
	Cibola Nature Trail	2008	5	0	0	0	0	0	0	0	0	0	0	0	2
		2009	5	0	0	0	0	0	0	0	0	2	4	0	7
		2010	5	0	0	0	0	0	0	1	0	4	28	0	9

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
CIBO	Cibola Nature Trail	2011	5	0	0	0	0	0	0	0	0	1	17	1	13
		2012	5	0	0	0	1	0	0	0	0	6	2	1	10
	Cibola Island[3]	2008	5	0	0	0	0	0	0	0	0	0	2	0	7
		2009	5	0	0	0	0	0	0	0	0	0	3	1	7
		2010	5	0	0	0	0	0	0	0	0	0	1	0	6
		2011	3	0	0	0	3	0	0	0	0	0	0	0	4
	Cibola Site #2	2008	0	--	--	--	--	--	--	--	--	--	--	--	--
		2009	5	0	0	0	0	0	0	1	0	0	0	0	12
		2010	0	--	--	--	--	--	--	--	--	--	--	--	--
		2011	5	0	1	0	0	0	0	0	0	0	0	0	14
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--
	Cibola Site #1	2008	0	--	--	--	--	--	--	--	--	--	--	--	--
		2009	5	0	0	0	0	0	0	3	0	0	0	0	14
		2010	0	--	--	--	--	--	--	--	--	--	--	--	--
		2011	5	0	0	3	0	0	0	3	0	0	1	1	10
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--
	Hart Mine Marsh[3]	2008	0	--	--	--	--	--	--	--	--	--	--	--	--
		2009	4	0	3	2	0	0	0	2	0	0	0	0	7
	Three Fingers Lake[3]	2008	5	0	2	15	0	0	1	1	0	8	0	1	30
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	2	26	1	0	0	2	0	0	2	0	43
	Cibola Lake #1 (North)	2008	5	0	1	4	1	0	1	2	0	3	0	3	15
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	1	4	0	0	0	2	0	3	0	4	14
		2011	0	--	--	--	--	--	--	--	--	--	--	--	--
		2012	5	0	0	4	0	0	0	8	0	0	0	0	37

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
CIBO	Cibola Lake #2 (East)	2008	0	--	--	--	--	--	--	--	--	--	--	--	--
		2009	5	0	1	0	0	0	0	0	0	0	0	0	10
		2010	0	--	--	--	--	--	--	--	--	--	--	--	--
		2011	5	0	0	0	0	0	0	0	0	0	0	0	14
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--
	Cibola Lake #3 (West)	2008	5	1	0	4	0	0	2	1	0	6	0	0	18
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	1	5	1	0	0	0	0	0	0	0	10
		2011	0	--	--	--	--	--	--	--	--	--	--	--	--
		2012	5	0	0	6	0	0	0	1	0	0	0	0	36
	Walker Lake	2008	5	0	1	0	0	0	0	2	0	0	0	1	9
		2009	5	0	0	0	0	0	0	5	0	0	0	0	18
		2010	4	0	0	0	0	0	0	10	0	0	0	1	15
		2011	3	0	0	0	0	0	0	4	0	0	0	0	8
		2012	5	0	0	0	0	0	0	6	0	0	1	0	23
IMPE	Draper Lake[3]	2008	1	0	2	0	0	0	0	0	0	1	0	0	2
	Paradise	2008	5	2	0	0	0	0	1	10	0	1	1	1	14
		2009	5	0	0	0	0	0	0	7	0	0	0	0	12
		2010	5	0	0	0	0	0	2	12	0	0	2	0	21
		2011	3	0	0	0	0	0	0	4	0	0	0	0	6
		2012	5	0	0	0	0	0	0	7	0	0	2	0	11
	Hoge Ranch	2008	5	0	0	0	0	0	1	0	0	5	2	3	21
		2009	5	0	0	0	0	0	0	1	0	0	0	3	25
		2010	5	0	0	2	0	0	0	2	0	0	3	0	21
		2011	5	0	0	3	0	0	0	2	0	0	0	0	13
		2012	5	0	0	0	0	0	0	3	0	0	0	0	28

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
IMPE	Adobe Lake	2008	5	0	0	0	0	0	0	1	0	1	3	5	16
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	0	0	0	0	0	1	0	0	0	0	7
		2011	0	--	--	--	--	--	--	--	--	--	--	--	--
		2012	5	0	0	0	0	0	0	2	0	0	0	0	1
	Rattlesnake	2008	5	0	0	0	0	0	0	3	0	3	2	10	27
		2009	5	0	0	0	0	0	0	0	0	0	2	3	22
		2010	5	0	0	0	0	0	0	6	0	0	4	1	38
		2011	5	0	0	0	0	0	0	6	0	0	0	1	30
		2012	5	0	0	0	0	0	0	5	0	0	0	3	31
	Milemarker 65	2008	0	--	--	--	--	--	--	--	--	--	--	--	--
		2009	5	0	0	0	0	0	0	0	0	0	0	0	7
		2010	0	--	--	--	--	--	--	--	--	--	--	--	--
		2011	2	0	0	1	0	0	0	0	0	0	1	0	4
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--
	Clear Lake	2008	5	0	0	4	0	0	0	4	0	6	0	1	33
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	0	8	0	0	0	2	0	0	1	0	20
		2011	0	--	--	--	--	--	--	--	--	--	--	--	--
		2012	5	0	0	3	0	0	0	1	0	0	0	0	33
	Nursery Northwest	2008	5	1	5	1	0	0	0	2	0	4	0	0	10
		2009	5	0	0	0	0	0	0	0	0	0	0	1	24
		2010	5	1	0	0	0	0	0	0	0	0	0	0	23
		2011	5	7	0	2	0	0	0	1	0	1	3	0	22
		2012	5	3	0	1	0	0	0	2	0	0	0	0	20

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
IMPE	Imperial Nursery	2008	5	0	2	0	0	0	0	3	0	0	1	2	3
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	0	1	0	0	0	0	0	0	1	1	3
		2011	0	--	--	--	--	--	--	--	--	--	--	--	--
		2012	5	0	0	0	1	0	0	1	0	0	2	1	3
	Ferguson Lake	2008	5	0	1	4	0	0	0	7	0	5	0	0	14
		2009	5	0	2	5	0	0	0	8	0	0	0	0	25
		2010	5	0	0	11	0	0	0	14	0	4	2	0	38
		2011	3	0	0	9	0	0	0	2	0	0	0	0	19
		2012	5	1	4	10	0	0	0	9	0	2	1	0	44
	Ferguson Wash	2008	5	0	0	4	0	0	0	0	0	1	1	0	13
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	0	0	0	0	0	0	0	0	4	0	17
		2011	0	--	--	--	--	--	--	--	--	--	--	--	--
		2012	5	0	0	1	0	0	0	1	0	0	0	0	16
	Great Blue Heron	2008	5	0	0	0	0	0	0	3	0	3	0	0	13
		2009	5	0	0	1	0	0	0	4	0	1	3	0	31
		2010	5	0	0	0	0	0	0	8	0	2	5	0	55
		2011	5	0	0	0	0	0	0	13	0	1	16	2	67
		2012	5	0	0	1	0	0	0	16	0	0	6	3	72
	Powerline	2008	0	--	--	--	--	--	--	--	--	--	--	--	--
		2009	5	0	1	1	0	0	0	3	0	0	0	0	15
		2010	0	--	--	--	--	--	--	--	--	--	--	--	--
		2011	5	0	1	1	0	0	0	5	0	0	1	1	15
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
IMPE	Martinez Lake	2008	0	--	--	--	--	--	--	--	--	--	--	--	--
		2009	5	0	0	0	0	0	0	2	0	0	0	1	11
		2010	0	--	--	--	--	--	--	--	--	--	--	--	--
		2011	5	1	0	1	0	0	0	1	0	2	5	0	24
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--
MITT	Mittry West	2008	5	0	0	0	0	0	0	12	0	5	0	1	22
		2009	5	0	0	0	0	0	0	5	0	1	1	0	15
		2010	5	0	0	0	2	0	0	5	0	4	4	0	15
		2011	3	0	0	0	0	0	0	4	0	1	0	0	8
		2012	5	0	0	0	0	0	0	7	0	3	0	0	29
	Mittry South[3]	2008	5	0	1	1	0	0	0	1	0	2	0	0	3
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	0	3	1	0	0	5	0	0	4	0	9
YUMA	Gila Confluence North	2008	5	0	0	0	0	0	0	2	0	0	0	2	8
		2009	0	--	--	--	--	--	--	--	--	--	--	--	--
		2010	5	0	0	0	3	0	1	1	0	0	0	0	9
		2011	0	--	--	--	--	--	--	--	--	--	--	--	--
		2012	5	0	0	0	0	0	0	0	0	0	0	0	2
	Gila River Site #2	2008	0	--	--	--	--	--	--	--	--	--	--	--	--
		2009	5	0	0	0	0	0	0	1	0	0	1	0	5
		2010	0	--	--	--	--	--	--	--	--	--	--	--	--
		2011	4	0	0	0	0	0	0	0	0	0	0	0	0
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--

Table C.3. Number of Detections of Each Special Concern Species Recorded at Each Reclamation Survey Site, 2012* (Continued)

Study Area[1]	Survey Site	Year	# Surveys	Special Concern Species[2]											
				BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
YUMA	Fortuna Site #1	2008	0	--	--	--	--	--	--	--	--	--	--	--	--
		2009	5	0	1	0	0	0	0	1	0	0	3	0	9
		2010	0	--	--	--	--	--	--	--	--	--	--	--	--
		2011	4	0	0	0	0	0	0	0	0	0	1	1	9
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--
	Fortuna North	2008	0	--	--	--	--	--	--	--	--	--	--	--	--
		2009	5	0	1	2	0	0	0	0	0	0	0	0	2
		2010	0	--	--	--	--	--	--	--	--	--	--	--	--
		2011	4	0	0	0	0	0	0	0	0	0	1	0	14
		2012	0	--	--	--	--	--	--	--	--	--	--	--	--

* Numbers presented represent the sum of all detections during the survey season. "—" = No Survey.

[1] PAHR = Pahranagat NWR; MESQ = Mesquite; MOME = Mormon Mesa; MUDD = Muddy River; TOPO = Topock Marsh; BIWI = Bill Williams River NWR; AHAK = Ahakhav Tribal Preserve; PVER = Palo Verde Ecological Reserve; BIHO = Big Hole Slough; EHRE = Ehrenberg; CIBO = Cibola; IMPE = Imperial; MITT = Mittry Lake; YUMA = Yuma.

[2] BLRA = Black Rail, CLRA = Clapper Rail, LEBI = Least Bittern, YBCU = Yellow Billed Cuckoo, ELOW = Elf Owl, GIFL = Gilded Flicker, GIWO = Gila Woodpecker, VEFL = Vermilion Flycatcher, BEVI = Bell's Vireo, YWAR = Yellow Warbler, SUTA = Summer Tanager, YBCH = Yellow-breasted Chat.

[3] Surveys at site discontinued.

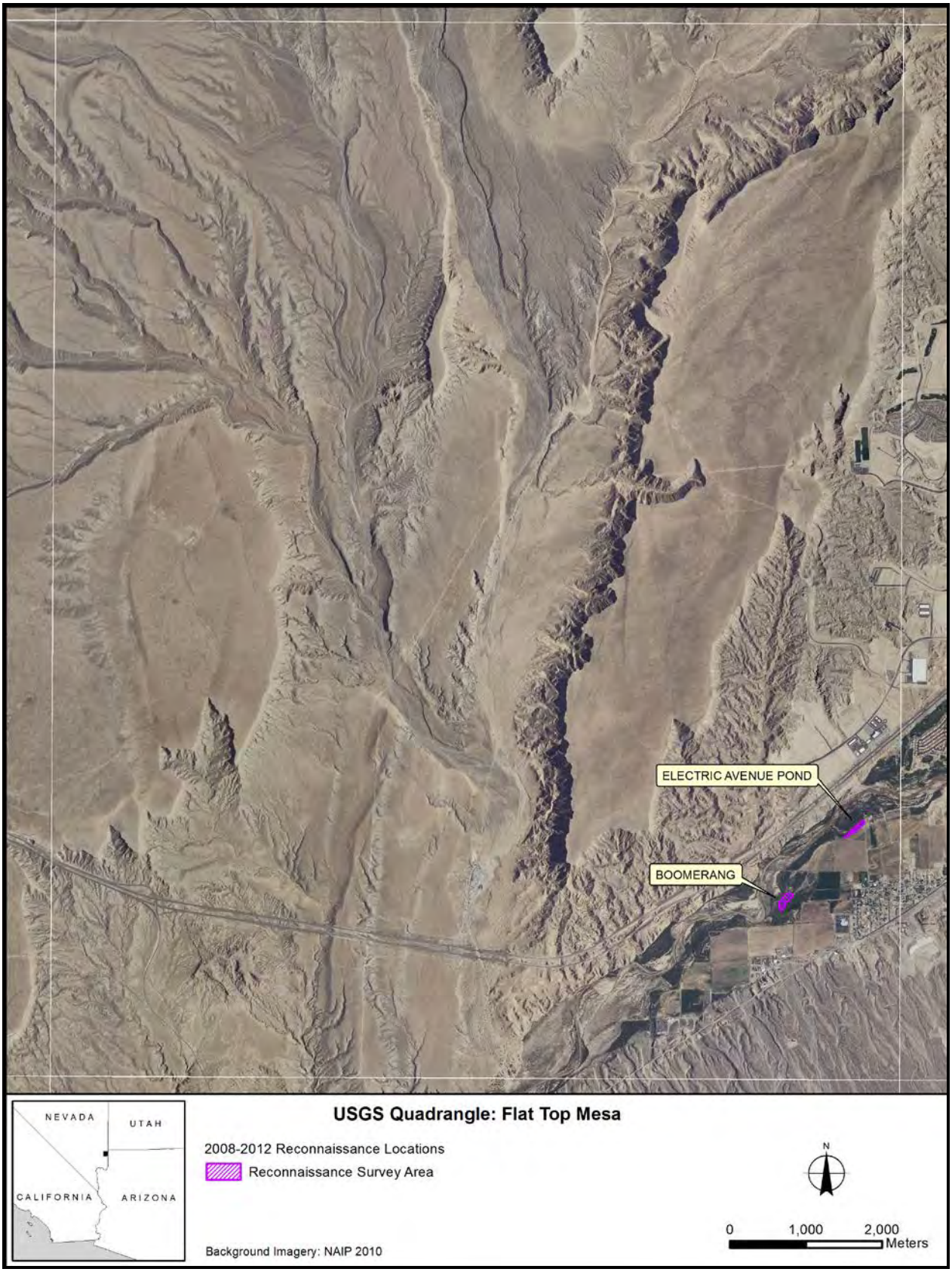
[4] Site surveyed as part of an opportunistic effort or reconnaissance.

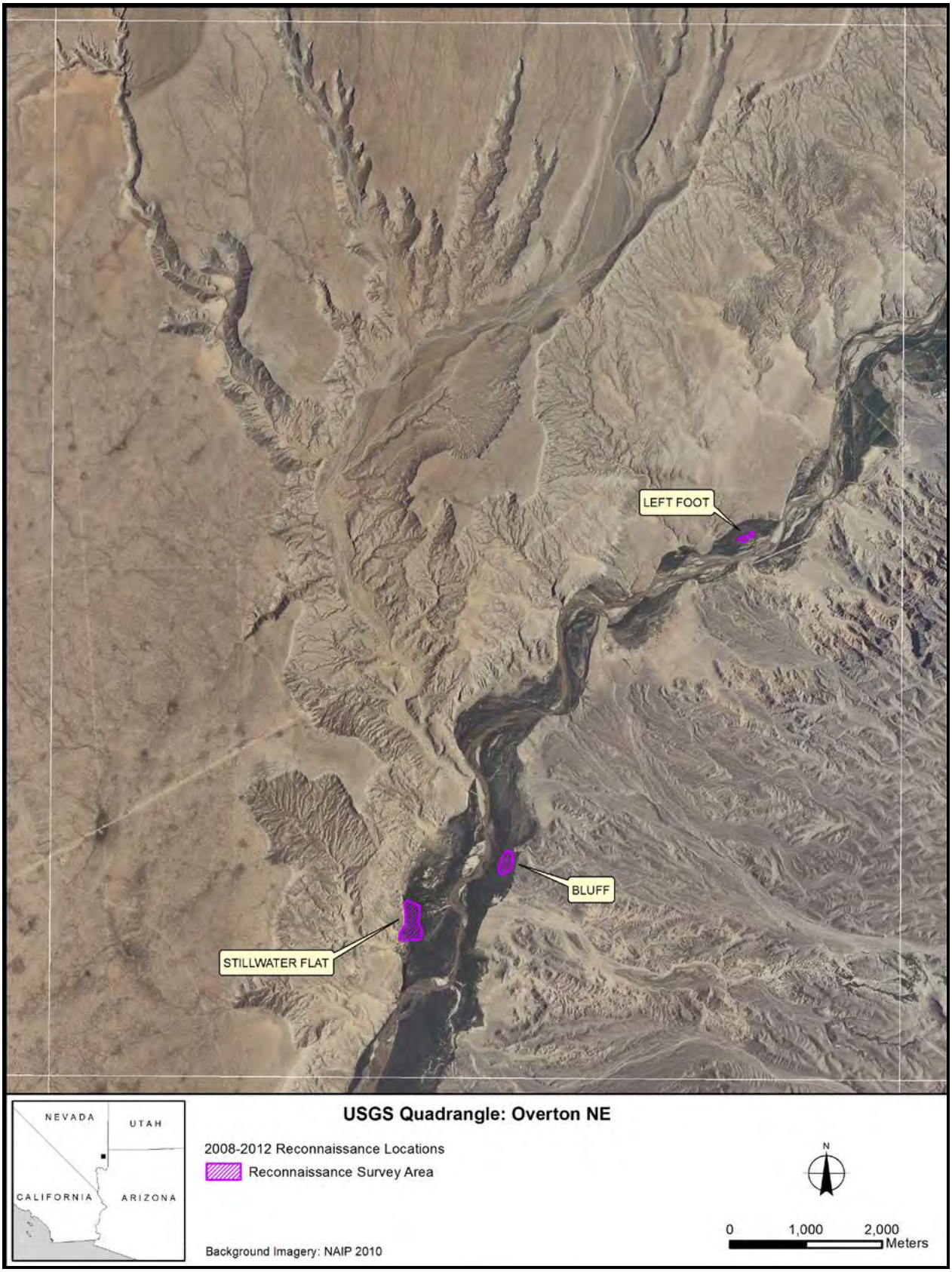
Appendix D

ORTHOPHOTOS SHOWING RECONNAISSANCE SITES, 2008–2012

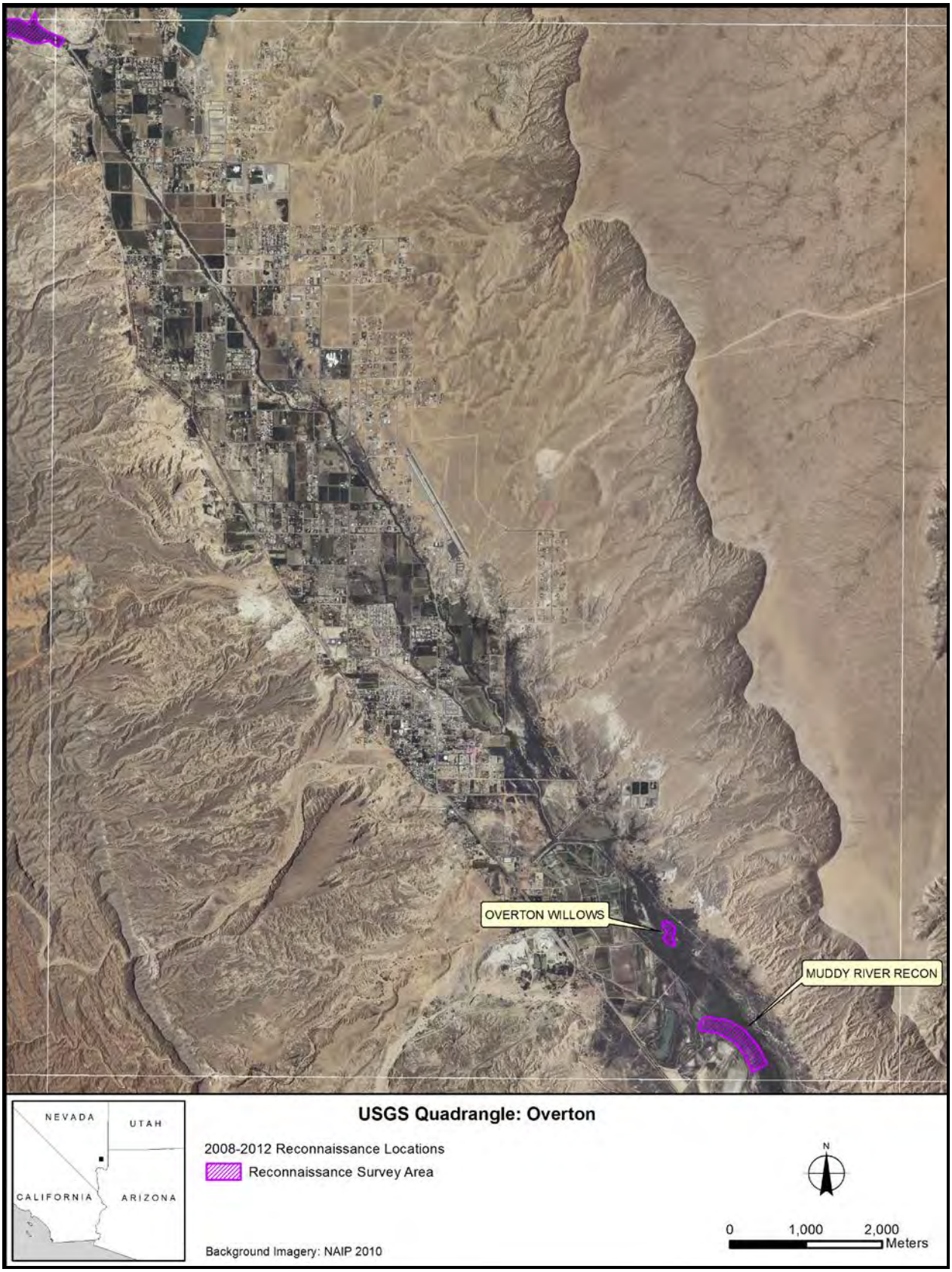
PIONEER ROAD
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Littlefield
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010

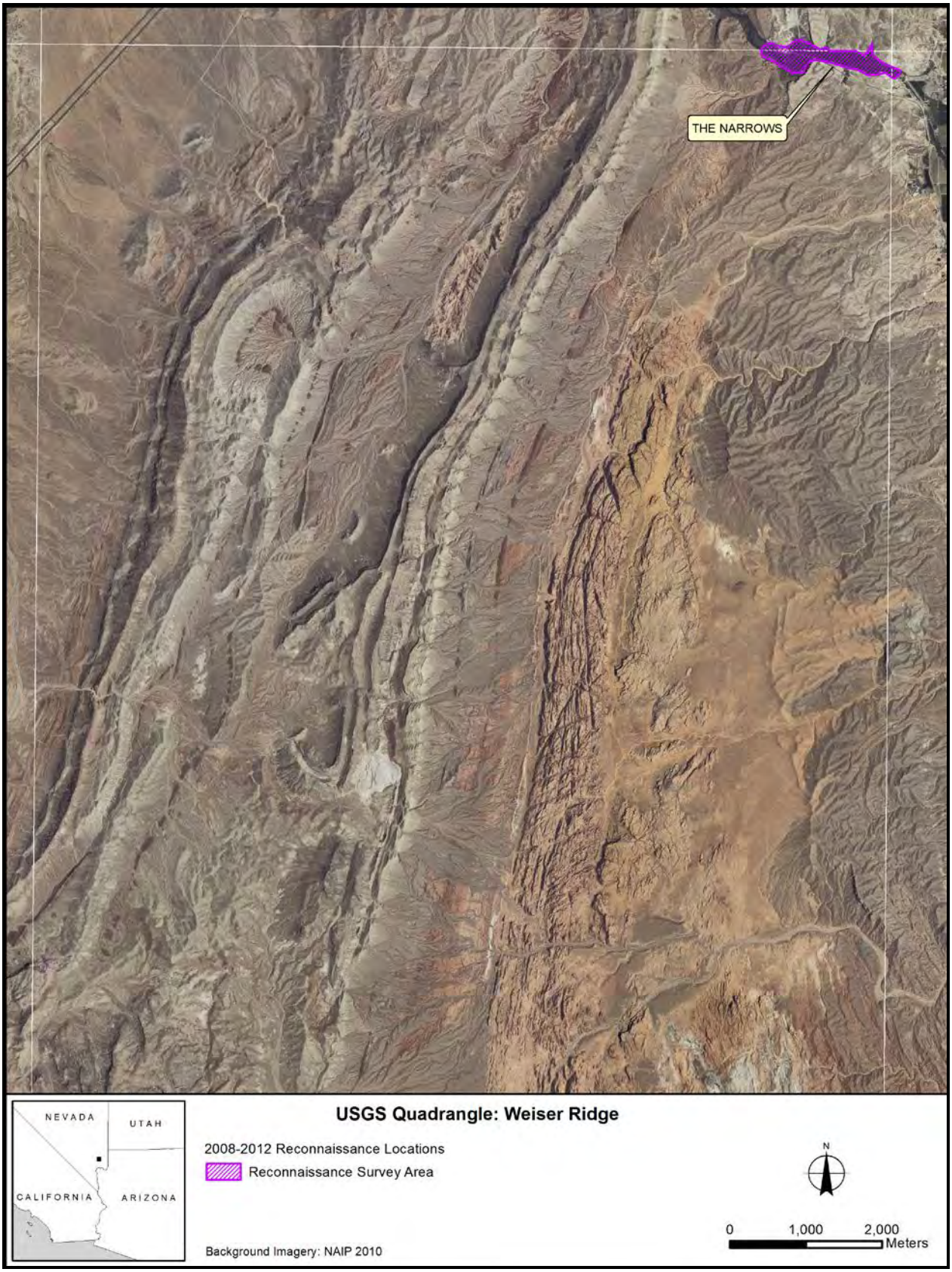
BACK YARD
UP THE CREEK
BALL PARK
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Mesquite
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010


ELECTRIC AVENUE POND
BOOMERANG
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Flat Top Mesa
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010

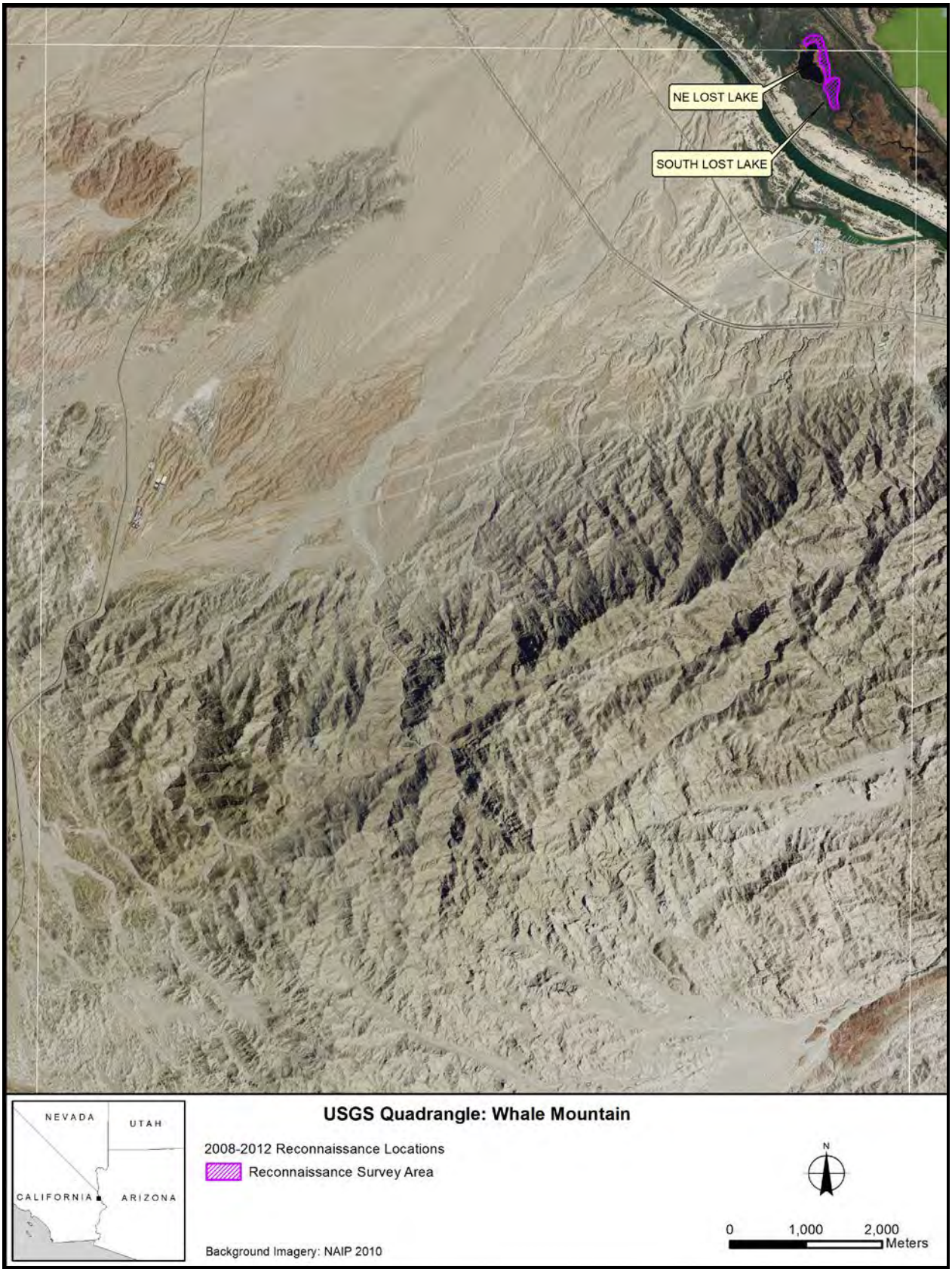

LEFT FOOT
BLUFF
STILLWATER FLAT
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Overton NE
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010

RIVER MILE 30
VIRGIN NARROWS NORTH
VIRGIN NARROWS EAST
VIRGIN NARROWS WEST
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Overton Beach
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010


OVERTON WILLOWS
MUDDY RIVER RECON
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Overton
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010

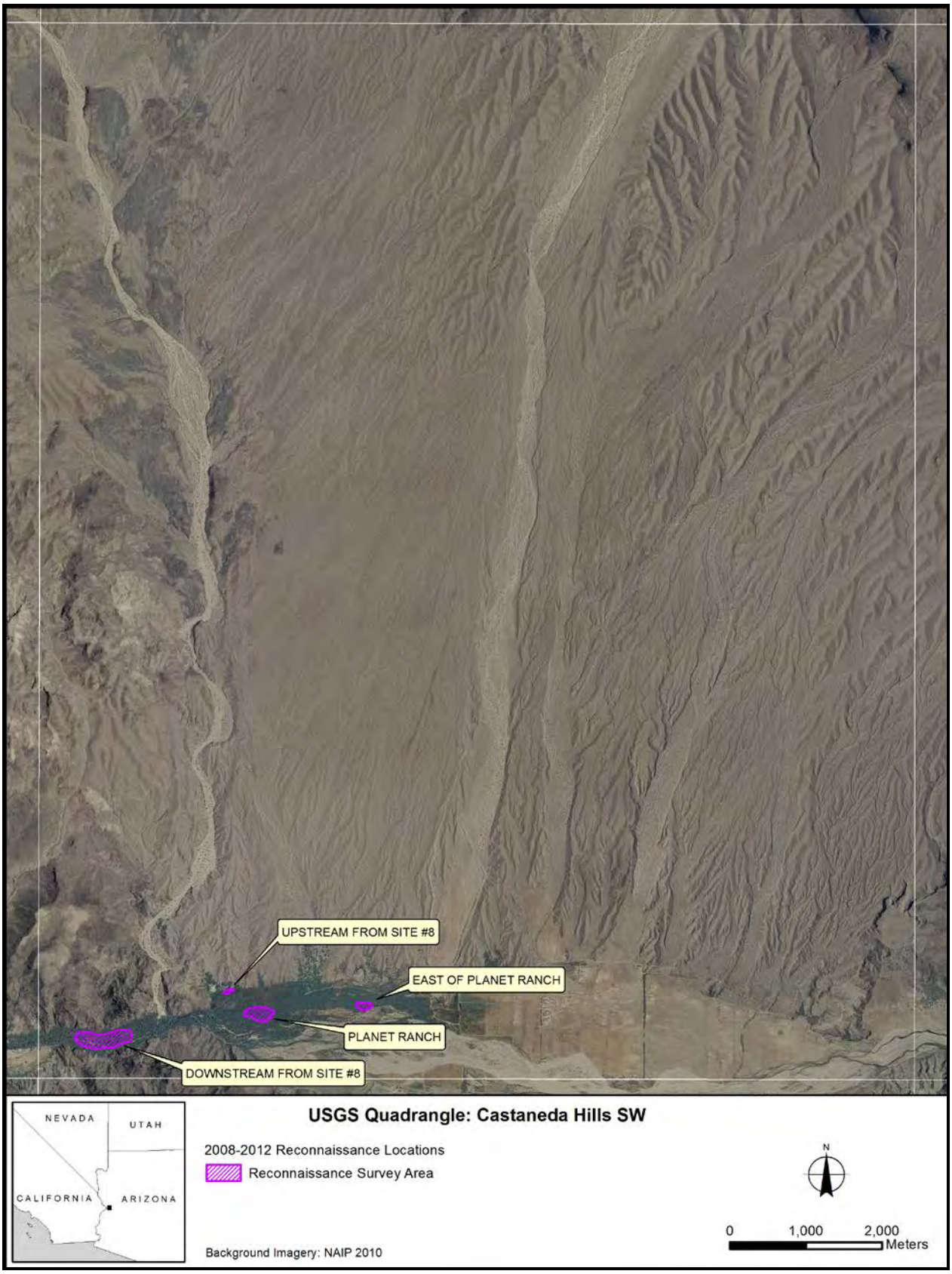

THE NARROWS
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Weiser Ridge
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010

TRACTOR
NW OF PIPES #1
NW OF BEAL LAKE
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Needles
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010


NE LOST LAKE
SOUTH LOST LAKE
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Whale Mountain
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010

LOST LAKE SLOUGH #1
LOST LAKE SLOUGH #2
LOST LAKE SLOUGH #3
LOST LAKE SLOUGH #4
MARINA
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Topock
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010

BURN EDGE
RIVER END
FLOODED REFUGE ROAD
NEW WILLOW
CLIFF POND
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Monkeys Head
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010


UPSTREAM FROM SITE #8
EAST OF PLANET RANCH
PLANET RANCH
DOWNSTREAM FROM SITE #8
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Castaneda Hills SW
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010

RESTORATION
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Parker
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2012

LAGUNA DAM NORTH
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Laguna Dam
2008-2012 Reconnaissance Locations
Reconnaissance Survey Area
N
0
1,000
2,000
Meters
Background Imagery: NAIP 2010

Appendix E

HYDROLOGIC CONDITIONS IN SURVEY SITES, 2008–2012

Table E.1. Summary of Hydrologic Conditions at Each Survey Site at Reclamation Study Areas, 2008–2012*

Study Area[1]	Survey Site	Year	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
PAHR	North[4]	2008	8/5/0	5/10/0	20/10/0	0/0/0
		2009	3/1/0	10/10/0	1/0/0	0/0/30
		2010	10/3/1	10/25/25	--/20/20	0/0/0
		2011	8/--/2	15/--/5	4/--/1	0/--/0
		2012	15/--/<1	20/--/20	15/--/4	0/--/0
	West[4]	2008	0/0/0	0/0/0	0/0/0	20/20/250
		2009	0/0/0	0/0/0	0/0/0	2/4/15
		2010	0/0/0	0/0/0	5/1/0	0/0/0
		2011	0/0/0	0/0/0	0/0/0	2/5/15
		2012	0/0/0	0/0/0	0/0/0	8/15/10
	MAPS	2008	0/0/0	0/0/0	0/0/0	30/30/70
		2009	0/0/0	0/0/0	0/0/0	130/20/200
		2010	0/0/--	0/0/--	0/0/--	25/10/--
	South	2008	10/10/10	25/25/10	0/0/0	0/0/0
		2009	3/5/0	40/30/0	0/0/0	0/0/--
		2010	2/1/0	10/3/0	0/1/0	0/0/115
LIFI	Poles	2008	10/10/10	20/20/20	10/10/10	0/0/0
		2009	10/10/10	20/20/20	5/5/5	0/0/0
		2010	50/50/50	25/25/25	10/10/1	0/0/0
MESQ	Hafen Lane[4]	2010	1/25/1	3/10/3	0/5/0	0/0/0
		2011	0/0/0	0/0/0	0/0/0	1/1/1
		2012	35/1/1	20/3/10	5/1/1	0/0/0
	Dumb Luck Bridge	2012	--/15/--	--/20/--	--/5/--	--/0/--
	East[4]	2008	1/1/1	35/5/--	0/0/1	0/0/0
		2009	0/0/0	0/0/0	0/0/0	5/5/5
		2010	0/--/--	0/--/--	0/--/--	0/--/--
	West[4]	2008	65/35/65	25/25/15	10/10/20	0/0/0
		2009	0/0/0	0/0/0	0/0/0	25/25/25
		2010	50/50/50	30/30/30	20/20/20	0/0/0
		2011	2/--/0	15/--/0	15/--/0	0/--/0
		2012	20/1/2	15/10/10	1/1/<1	0/0/0
	Bunker Farm	2008	0/0/0	0/0/0	0/0/0	50/50/50
	Bunker Marsh North[4]	2009	20/10/0	30/15/0	10/5/0	0/0/10
		2010	2/0/0	25/0/0	1/0/0	0/150/150
		2011	5/--/--	15/--/--	0/--/--	0/--/--

Table E.1. Summary of Hydrologic Conditions at Each Survey Site at Reclamation Study Areas, 2008–2012* (Continued)

Study Area[1]	Survey Site	Year	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
MOME	Mormon Mesa North	2008	0/0/0	0/0/0	0/0/0	0/0/200
		2009	0/0/0	0/0/0	0/0/0	0/5/125
		2010	0/--/--	0/--/--	0/--/--	100/--/--
		2011	0/--/--	0/--/--	0/--/--	40/--/--
		2012	0/--/--	0/--/--	0/--/--	0/--/--
	Hedgerow	2008	0/0/0	0/0/0	0/0/0	100/100/100
		2009	0/0/0	0/0/0	0/0/0	100/100/100
		2010	0/--/--	0/--/--	0/--/--	100/--/--
		2011	0/--/--	0/--/--	0/--/--	300/--/--
	Mormon Mesa South	2008	0/0/0	0/0/0	1/0/0	--/10/10
		2009	0/0/0	0/0/0	0/0/0	200/200/200
		2010	0/0/0	0/0/0	0/0/0	200/200/200
		2011	--/0/0	--/0/0	--/0/0	--/0/0
		2012	0/0/0	--/0/0	--/0/0	40/40/40
	Virgin River #1	2008	10/10/0	10/10/0	5/5/0	0/0/2
		2009	10/10/10	30/20/20	5/5/5	0/0/0
		2010	20/15/10	30/20/10	10/15/10	0/0/0
		2011	--/10/10	--/10/20	--/5/8	--/--/0
		2012	15/12/4	10/10/4	5/8/1	0/0/0
	Virgin River #2[4]	2008	0/0/0	0/0/0	0/0/0	10/10/650
		2009	0/0/0	0/0/0	0/0/0	0/0/0
		2010	0/0/0	0/0/0	0/0/0	0/0/0
		2011	0/0/0	0/0/0	0/0/0	20/20/20
		2012	0/0/--	0/0/--	0/0/--	0/0/--
MUDD	Overton WMA Pond	2008	5/5/5	25/5/10	3/3/5	0/0/0
		2009	1/1/1	20/20/10	1/1/1	0/0//0
		2010	5/5/5	10/10/10	--/--/--	0/0/0
		2011	2/--/2	40/--/10	0/--/0	0/--/0
		2012	5/5/3	10/20/5	0/10/0	0/0/0
	Overton WMA	2008	30/25/35	50/30/30	1/10/10	0/0/0
		2009	25/25/5	30/30/10	2/10/3	0/0/0
		2010	5/5/5	30/30/30	2/2/2	0/0/0
		2011	--/--/10	--/--/30	--/--/8	--/0/0
		2012	3/1/3	40/40/40	5/2/5	0/0/0
GRCA	Burnt Springs[4]	2008	10/10/0	10/10/0	5/10/0	0/0/15
	RM 274.5N[4]	2008	70/70/60	30/30/30	10/10/15	0/0/0
	RM 285.3N[4]	2008	0/0/0	0/0/0	10/15/3	0/0/0

Table E.1. Summary of Hydrologic Conditions at Each Survey Site at Reclamation Study Areas, 2008–2012* (Continued)

Study Area[1]	Survey Site	Year	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
GRCA	Iceberg Canyon[4]	2008	--/10/5	--/10/--	--/20/30	--/0/0
TOPO	Pipes #1	2008	0/0/0	0/0/0	0/0/0	50/50/50
		2009	0/0/0	0/0/0	0/0/0	50/50/50
		2010	0/0/0	0/0/0	0/0/0	40/40/40
		2011	0/0/0	0/0/0	0/0/0	40/40/40
		2012	0/0/0	0/0/0	0/0/0	40/40/40
	Pipes #3	2008	80/10/1[5]	10/10/25	10/20/5	0/0/0
		2009	30/1[5]/1[5]	30/30/10	10/10/0	0/0/0
		2010	5/<1[5]/0	15/30/0	20/<1/0	0/0/40
		2011	0/0/0	0/0/0	0/0/0	40/40/40
		2012	15/1[5]/1[5]	10/5/5	20/5/5	0/0/0
	The Wallows	2008	40/10/10	25/3/10	15/10/10	0/0/0
		2009	50/1/1[5]	25/10/10	10/30/--	0/0/0
		2010	25/<1/<1[5]	15/3/15	5/50/2	0/0/0
		2011	0/0/0	0/0/0	1/0/0	0/80/80
		2012	20/1/20	30/5/15	2/10/1	0/0/0
	PC6-1	2008	80/30/10	10/3/3	5/20/40	0/0/0
		2009	60/1/0	--/3/0	10/10/1	0/0/0
		2010	<1[5]/0/0	--/0/0	0/<1/0	0/0/40
		2011	0/0/0	0/0/0	0/0/0	40/40/40
		2012	15/2/20	10/10/10	10/10/5	0/0/0
	Pig Hole	2008	25/25/0	10/3/0	50/30/5	0/0/0
		2009	15/0/0	10/0/0	15/10/0	0/0/130
		2010	0/0/0	0/0/0	0/0/0	120/120/120
		2011	0/0/0	0/0/0	0/0/0	120/120/120
		2012	NS	NS	NS	NS
	In Between	2008	10/5/5	3/3/5	5/10/5	0/0/0
		2009	20/0/0	10/0/0	15/0/0	0/50/50
		2010	0/0/0	0/0/0	0/0/0	0/30/50
		2011	25/15/20	30/40/10	30/10/5	0/0/0
		2012	1/0/5	5/0/5	1/0/2	0/45/0
	800M	2008	35/3/0	10/10/0	15/20/0	0/0/55
		2009	40/1/0	10/3/0	25/50/0	0/0/55
		2010	5/0/0	5/0/0	5/10/1	0/0/0
		2011	0/0/0	0/0/0	0/10/0	70/0/70
		2012	15/0/5	8/0/10	50/0/5	0/70/0

Table E.1. Summary of Hydrologic Conditions at Each Survey Site at Reclamation Study Areas, 2008–2012* (Continued)

Study Area[1]	Survey Site	Year	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
TOPO	Pierced Egg	2009	40/1[5]/1[5]	10/10/10	15/5/0	0/0/0
		2008	20/15/2[5]	10/10/10	15/50/3	0/0/0
		2010	3/2[5]/1[5]	3/30/30	15/5/0	0/0/0
		2011	1[5]/1[5]/0	10/3/0	0/0/0	0/0/30
		2012	5/2/1[5]	10/10/5	1/15/1	0/0/0
	Swine Paradise[6]	2008	10/10/10	25/25/25	2/0/3	0/0/0
		2009	0/0/0	0/0/0	0/0/0	0/0/10
		2010	0/0/0	0/0/0	0/0/0	10/40/40
		2011	0/0/0	0/0/0	0/0/0	40/40/40
		2012	0/5/5	0/10/10	0/1/1	10/0/0
	Barbed Wire	2008	1[5]/0/0	10/0/0	5/0/0	0/100/100
		2009	1[5]/1[5]/0	10/5/0	0/0/0	0/0/120
		2010	0/0/0	0/0/0	<1/0/0	150/150/150
		2011	0/2/0	0/10/0	0/0/0	150/0/150
		2012	NS	NS	NS	NS
	IRFB03	2008	0/0/0	0/0/0	0/0/0	150/150/150
	IRFB04	2008	0/0/0	0/0/0	0/0/0	75/75/75
	Platform[6]	2008	--/--/--	--/--/--	--/--/--	0/0/0
		2009	0/0/0	0/0/0	2/2/0	0/0/10
		2010	0/0/0	0/0/0	0/0/0	5/0/5
		2011	0/0/0	0/0/0	0/0/0	20/20/20
		2012	1/0/5	5/0/15	1/0/1	0/20/0
	250M[6]	2008	0/3/5	0/10/5	10/10/5	0/0/0
		2009	15/15/0	10/--/0	5/5/5	0/0/0
		2010	0/0/0	0/0/0	0/0/0	0/0/0
		2011	0/0/0	0/0/0	0/0/0	0/0/0
		2012	0/0/0	0/0/0	0/0/0	0/0/0
	Hell Bird[6]	2008	55/55/60	50/50/25	10/10/10	0/0/0
		2009	70/10/00	50/30/0	20/30/40	0/0/0
		2010	5/15/5	15/30/20	2/4/5	0/0/0
		2011	0/0/0	0/0/0	0/0/0	0/0/0
		2012	25/30/85	50/40/50	10/10/2	0/0/0
	Glory Hole	2008	35/40/15	70/25/70	5/15/2	0/0/0
		2009	--/35/0	--/50/0	--/10/0	0/0/150
		2010	1/4/3	5/20/20	1/5/3	0/0/0
		2011	0/0/0	0/0/0	0/0/0	70/70/70
		2012	25/35/25	50/70/50	1/1/10	0/0/0

Table E.1. Summary of Hydrologic Conditions at Each Survey Site at Reclamation Study Areas, 2008–2012* (Continued)

Study Area[1]	Survey Site	Year	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
TOPO	Spaghetti	2011	--/--/--	--/--/--	--/--/--	0/0/0
	Beal Lake[7]	2008	0/0/0	0/0/0	0/0/0	10/100/100
		2009	0/0/0	0/0/0	0/0/0	30/30/30
		2010	0/0/0	0/0/0	0/0/0	20/20/20
		2011	0/0/45	0/0/3	0/0/0	20/20/0
		2012	50/1/2	10/5/5	15/0/2	0/0/0
	Lost Slough	2008	30/3/10	25/3/10	10/3/10	0/0/0
		2009	--/15/5	--/30/10	--/0/3	--/0/0
	Lost Pond[4]	2008	40/40/30	>100/>100/>100	5/3/5	0/0/0
		2009	75/0/0	30/0/0	10/5/0	0/0/15
	Lost Lake[6]	2008	10/5/0	10/25/0	20/3/0	0/0/0
		2009	0/0/0	0/0/0	10/2/0	2/0/--
		2010	0/3/0	0/0/0	0/0/0	5/0/10
		2011	0/0/0	0/0/0	0/0/0	20/20/20
		2012	3/2/0	10/5/0	--/1/0	0/0/5
TOGO	Pulpit Rock[4]	2008	NS	NS	NS	NS
		2009	--/--/--	--/--/--	--/--/--	0/0/0
	Picture Rock[4]	2008	NS	NS	NS	NS
		2009	0/0/0	0/0/0	5/10/--	0/0/0
	Blankenship Bend North[4]	2008	20/15/15	100/100/30	3/3/10	0/0/0
		2009	15/15/15	50/50/50	5/5/5	0/0/0
		2010	15/15/15	50/50/50	5/--/5	0/0/0
	Blankenship Bend South[4]	2008	60/60/25	50/50/30	20/20/15	0/0/0
		2009	80/10/40	50/10/10	5/10/--	0/0/0
		2010	5/33/30	60/30/30	3/15/5	0/0/0
	Havasu NE[4]	2008	0/0/0	0/0/0	0/0/0	0/0/0
		2009	NS	NS	NS	NS
		2010	0/0/0	0/0/0	0/0/0	0/0/0
BIWI	Wispy Willow[4]	2012	35/15/80	10/10/20	5/15/10	0/0/0
	Site 1[4]	2010	10/0/0	3/0/0	3/2/0	0/0/0
		2011	NS	NS	NS	NS
		2012	--/25/80	--/<5/20	--/1/15	--/0/0
	Site #2[4]	2008	0/2/0	0/10/0	0/0/0	0/0/0
		2009	NS	NS	NS	NS
		2010	15/5/3	5/--/5	1/0/0	0/0/0

Table E.1. Summary of Hydrologic Conditions at Each Survey Site at Reclamation Study Areas, 2008–2012* (Continued)

Study Area[1]	Survey Site	Year	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
BIWI	Site #11[4]	2008	0/0/0	0/0/0	0/0/0	0/0/0
		2009	NS	NS	NS	NS
		2010	18/18/18	>100/>100/>100	0/0/0	0/0/0
	Burn Edge	2008	NS	NS	NS	NS
		2009	30/15/1	30/10/30	20/5/0	0/0/0
		2010	25/5/1	40/30/15	1/15/1	0/0/0
		2011	20/1/<1	10/10/40	30/1/0	0/0/0
		2012	3/1/5	15/10/30	2/0/2	0/0/0
	Site #4[4]	2008	15/3/3	10/25/25	20/3/3	0/0/0
		2009	2/2/1	10/10/30	1/1/1	0/0/0
		2010	5/5/1	7/7/>100	10/3/1	0/0/0
		2011	5/1/1	10/>100/>100	0/2/0	0/0/0
		2012	8/5/10	50/50/60	2/0/1	0/0/0
	Site #3	2008	30/3/3	10/25/3	10/8/3	0/0/0
		2009	5/3/0	10/3/0	1/5/0	0/0/300
		2010	15/15/3	10/5/3	10/5/5	0/0/0
		2011	4/0/0	10/0/0	2/5/0	0/0/250
		2012	15/0/0	10/0/0	2/0/0	0/250/250
	Last Gasp	2009	5/1/0	30/30/0	0/2/0	0/0/500
		2010	10/5/1	90/50/3	1/0/2	0/0/0
		2011	10/1/0	30/3/0	5/0/0	0/0/>750
	Guinness	2012	20/2/1	70/35/20	5/2/1	0/0/0
	Site #5	2008	--/3/3	--/>100/>100	--/3/3	0/0/0
		2009	2/2/1	>100/>100/--	5/5/1	0/0/0
		2010	15/5/2	15/15/15	5/10/5	0/0/0
		2011	10/5/5	30/100/100	3/0/0	0/0/0
		2012	3/2/2	10/--/50	<1/0/0	0/0/0
	Black Rail	2010	45/5/0	10/15/0	25/70/60	0/0/0
		2011	NS	NS	NS	NS
		2012	10/0/0	<5/0/0	80/0/0	0/660/660
	Cougar Point	2011	--/--/70	--/--/10	--/--/25	--/--/0
		2012	10/10/15	30/30/15	3/3/5	0/0/0
	Mineral Wash[4]	2008	30/10/10	25/25/25	15/13/0	0/0/0
		2009	NS	NS	NS	NS
		2010	5/5/5	40/40/40	3/3/1	0/0/0
		2011	NS	NS	NS	NS
		2012	8/5/5	60/60/60	5/5/5	0/0/0

Table E.1. Summary of Hydrologic Conditions at Each Survey Site at Reclamation Study Areas, 2008–2012* (Continued)

Study Area[1]	Survey Site	Year	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
BIWI	Beaver Pond[4]	2008	30/10/20	25/25/25	10/10/5	0/0/0
		2009	NS	NS	NS	NS
		2010	13/10/5	20/15/15	0/5/2	0/0/0
		2011	NS	NS	NS	NS
		2012	10/10/10	60/40/50	3/5/3	0/0/0
	Site #8[4]	2008	10/10/15	25/50/30	0/5/3	0/0/0
		2009	NS	NS	NS	NS
		2010	8/8/8	15/40/40	1/0/0	0/0/0
	Upstream from Site #8[6]	2009	60/40/50	15/20/10	20/10/1	0/0/0
		2010	25/20/20	10/10/10	10/15/10	0/0/0
		2011	10/10/10	10/10/10	5/5/5	0/0/0
		2012	--/5/2	--/10/<5	--/2/5	--/0/0
	Planet Ranch Road	2009	50/30/10	70/505/50	30/5/0	0/0/0
		2010	15/10/8	40/40/40	0/2/5	0/0/0
		2011	50/40/50	40/60/50	30/10/3	0/0/0
		2012	--/--/--	--/--/--	--/--/--	--/--/--
	New River	2011	15/15/15	10/10/10	5/10/--	0/0/0
AHAK	Willow Beach[4]	2008	--/--/1	--/--/10	--/--/0	0/0/0
	Deer Island[4]	2008	60/60/60	>100/>100/>100	10/10/10	0/0/0
		2009	50/50/50	>100/>100/>100	1/1/1	0/0/0
PVER	PVER Phase 2[7]	2009	0/0/0	0/0/0	0/0/0	0/0/0
		2010	0/0/0	0/0/0	0/5/0	5/5/5
		2011	0/10/0	0/3/0	0/5/0	300/0/5
		2012	30/0/0	15/0/0	<5/0/0	0/20/20
	PVER Phase 3[7]	2010	0/12/0	0/5/0	0/5/0	8/0/8
		2011	0/25/30	0/10/10	0/40/10	10/0/0
		2012	0/0/0	0/0/0	0/0/0	20/20/20
BIHO	Big Hole Slough	2008	40/30/25	30/10/50	15/10/20	0/0/0
		2009	5/15/25	5/100/50	5/5/5	0/0/0
		2010	--/5/--	--/--/--	--/--/--	--/0/--
EHRE	Ehrenberg	2008	--/0/5	3/0/3	5/10/10	0/--/0
		2009	NS	NS	NS	NS
		2010	0/0/0	0/0/0	5/5/3	0/0/0
		2011	NS	NS	NS	NS
		2012	10/0/0	5/0/0	3/5/10	0/0/0

Table E.1. Summary of Hydrologic Conditions at Each Survey Site at Reclamation Study Areas, 2008–2012* (Continued)

Study Area[1]	Survey Site	Year	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
CIBO	CVCA Phase 1[7]	2008	10/1/5	10/3/3	50/0/20	0/0/0
		2009	0/0/0	0/0/0	0/0/0	0/0/0
		2010	0/0/10	0/0/5	0/0/3	10/10/0
		2011	20/0/15	10/0/10	40/0/5	0/10/0
		2012	30/0/0	10/0/0	0/0/0	0/10/10
	CVCA Phase 2[7]	2010	0/0/0	0/0/0	0/0/0	5/5/2
		2011	0/0/0	0/0/0	0/0/5	5/5/0
		2012	<1/0/0	5/0/0	<1/0/0	0/10/10
	CVCA Phase 3[7]	2009	0/0/0	0/0/0	0/0/0	0/0/0
		2010	9/0/0	7/0/0	10/0/0	0/0/0
		2011	0/75/0	0/10/0	0/15/0	10/0/5
		2012	20/0/0	10/0/0	25/0/0	0/400/400
	Cibola Nature Trail[7]	2008	65/0/0	10/0/0	15/0/5	0/0/0
		2009	0/80/0	0/10/0	0/10/0	--/0/75
		2010	15/0/0	7/0/0	10/0/0	0/10/10
		2011	0/0/0	0/0/0	0/0/0	12/15/15
		2012	1/0/0	5/0/0	0/0/0	0/5/5
	Cibola Island	2008	0/50/50	0/40/50	--/1/10	--/0/0
		2009	20/10/1	30/10/3	10/7/5	0/0/0
		2010	0/0/0	0/0/0	0/0/0	5/5/5
		2011	--/0/0	--/0/0	--/0/0	--/--/5
	Three Fingers Lake[4]	2008	20/20/20	>100/>100/>100	5/5/5	0/0/0
		2009	NS	NS	NS	NS
		2010	15/15/15	100/100/100	0/0/0	0/0/0
	Cibola Site #2	2008	NS	NS	NS	NS
		2009	0/0/0	0/0/0	0/5/0	15/0/15
		2010	NS	NS	NS	NS
		2011	0/10/10	0/10/--	--/5/5	100/0/0
		2012	NS	NS	NS	NS
	Cibola Site #1	2008	NS	NS	NS	NS
		2009	0/0/0	0/0/0	0/0/0	10/10/10
		2010	NS	NS	NS	NS
		2011	30/15/30	10/10/--	--/10/3	0/0/0
		2012	NS	NS	NS	NS
	Hart Mine Marsh	2008	NS	NS	NS	NS
		2009	15/25/30	--/--/--	--/--/--	0/0/0

Table E.1. Summary of Hydrologic Conditions at Each Survey Site at Reclamation Study Areas, 2008–2012* (Continued)

Study Area[1]	Survey Site	Year	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
CIBO	Cibola Lake #1 (North)[4]	2008	3/3/3	10/3/10	0/0/0	0/0/0
		2009	NS	NS	NS	NS
		2010	--/0/5	--/0/5	--/5/5	--/0/0
		2011	NS	NS	NS	NS
		2012	<1/<1/2	3/3/3	0/0/3	0/0/0
	Cibola Lake #2 (East)[4]	2008	NS	NS	NS	NS
		2009	0/0/0	0/0/0	0/0/0	10/80/50
		2010	NS	NS	NS	NS
		2011	0/0/0	0/0/0	0/0/0	0/0/0
		2012	NS	NS	NS	NS
	Cibola Lake #3 (West)[4]	2008	3/3/3	3/3/3	3/3/3	0/0/0
		2009	NS	NS	NS	NS
		2010	--/0/5	--/0/5	--/5/5	--/0/0
		2011	NS	NS	NS	NS
		2012	0/<1/1	0/5/5	3/1/3	0/0/0
	Walker Lake[4]	2008	3/0/0	10/0/0	5/1/2	0/0/0
		2009	0/0/0	0/0/0	2/0/0	0/10/5
		2010	0/0/0	0/0/0	1/1/1	0/0/0
		2011	--/20/5	--/3/3	--/--/5	--/0/0
		2012	5/<1/10	5/3/60	3/10/--	0/0/0
IMPE	Draper Lake[8]	2008	0/--/--	0/--/--	0/--/--	0/0/0
	Paradise[4]	2008	--/10/5	10/10/--	--/10/5	0/0/0
		2009	3/--/0	2/--/0	2/--/0	0/--/0
		2010	25/2/3	11/--/--	10/0/5	0/0/0
		2011	40/--/0	25/--/0	--/--/3	0/0/0
		2012	20/3/5	20/2/10	5/5/5	0/0/0
	Hoge Ranch[4]	2008	--/--/--	--/--/--	--/--/--	0/0/0
		2009	0/0/1	0/0/3	0/0/2	0/0/0
		2010	3/4/5	40/--/70	15/10/0	0/0/0
		2011	--/5/5	--/25/20	--/3/3	0/0/0
		2012	10/20/5	15/40/10	3/8/8	0/0/0
	Adobe Lake[4]	2008	--/--/--	--/--/--	--/--/--	0/0/0
		2009	NS	NS	NS	NS
		2010	--/--/--	--/--/--	--/--/--	0/0/0
		2011	NS	NS	NS	NS
		2012	--/--/--	--/--/--	--/--/--	0/0/0

Table E.1. Summary of Hydrologic Conditions at Each Survey Site at Reclamation Study Areas, 2008–2012* (Continued)

Study Area[1]	Survey Site	Year	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
IMPE	Rattlesnake[6]	2008	5/5/5	3/3/10	80/10/20	0/0/0
		2009	0/0/0	0/0/0	0/0/0	160/160/160
		2010	0/0/35	0/0/20	0/0/3	160/160/0
		2011	0/10/0	0/10/0	30/10/0	0/0/5
		2012	0/3/0	0/3/0	0/5/0	160/0/160
	Milemarker 65[4]	2008	NS	NS	NS	NS
		2009	--/--/--	--/--/--	--/--/--	0/0/0
		2010	NS	NS	NS	NS
		2011	--/--/--	--/--/--	--/--/--	0/0/0
		2012	NS	NS	NS	NS
	Clear Lake[4]	2008	2/2/2	50/50/50	0/2/2	0/0/0
		2009	NS	NS	NS	NS
		2010	3/3/3	60/60/60	0/0/0	0/0/0
		2011	NS	NS	NS	NS
		2012	0/3/15	0/10/10	0/1/40	5/0/0
	Nursery NW[6]	2008	3/0/0	--/0/0	5/5/5	0/0/0
		2009	3/3/--	10/10/--	5/3/--	0/0/--
		2010	--/1/0	--/5/0	--/--/--	--/0/2
		2011	30/50/15	30/30/10	10/10/10	0/0/0
		2012	--/--/--	--/--/--	--/--/--	0/0/0
	Imperial Nursery[7]	2008	0/0/40	0/0/0	0/20/20	30/0/0
		2009	NS	NS	NS	NS
		2010	0/0/0	0/0/0	0/0/0	25/25/5
		2011	NS	NS	NS	NS
		2012	0/0/0	0/0/0	0/0/0	15/15/15
	Ferguson Lake[4]	2008	3/3/10	25/3/10	0/1/10	0/0/0
		2009	0/10/5	0/3/3	3/5/10	0/0/0
		2010	5/1/5	3/5/5	5/2/10	0/0/0
		2011	5/--/25	25/--/25	5/--/5	0/0/0
		2012	0/3/5	0/10/10	4/1/4	0/0/0
	Ferguson Wash[4]	2008	1/1/5	--/3/3	5/0/10	0/0/0
		2009	NS	NS	NS	NS
		2010	1/1/1	100/100/100	1/1/1	0/0/0
		2011	NS	NS	NS	NS
		2012	0/0/3	0/0/--	0/0/1	0/0/0

Table E.1. Summary of Hydrologic Conditions at Each Survey Site at Reclamation Study Areas, 2008–2012* (Continued)

Study Area[1]	Survey Site	Year	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
IMPE	Great Blue Heron[6]	2008	5/0/0	3/0/0	10/10/5	0/0/0
		2009	0/0/5	0/0/10	0/0/5	60/150/0
		2010	0/0/0	0/0/0	0/0/0	100/100/100
		2011	0/0/--	0/0/--	0/0/--	100/100/--
		2012	0/0/1	0/0/10	0/0/0	100/100/0
	Powerline[6]	2008	NS	NS	NS	NS
		2009	1/0/1	3/0/3	5/0/5	0/50/0
		2010	NS	NS	NS	NS
		2011	10/20/--	10/25/--	40/10/--	0/0/--
		2012	NS	NS	NS	NS
	Martinez Lake	2008	NS	NS	NS	NS
		2009	0/0/0	0/0/0	0/0/0	50/50/50
		2010	NS	NS	NS	NS
		2011	0/10/--	0/10/--	25/8/--	0/0/--
		2012	NS	NS	NS	NS
MITT	Mittry West	2008	20/15/0	3/3/0	55/40/30	0/0/0
		2009	3/0/0	10/0/0	7/0/0	0/180/180
		2010	5/0/0	4/0/0	10/15/0	0/0/180
		2011	90/5/--	40/5/--	5/25/--	0/0/--
		2012	15/<1/0	5/1/0	10/5/10	0/0/0
	Mittry South[4]	2008	0/0/0	0/0/0	0/0/0	0/0/0
		2009	NS	NS	NS	NS
		2010	0/0/0	0/0/0	0/0/0	5/5/5
YUMA	Gila Confluence North[4]	2008	1/1/5	3/3/3	10/5/20	0/0/0
		2009	NS	NS	NS	NS
		2010	--/3/5	--/5/5	--/0/5	--/0/0
		2011	NS	NS	NS	NS
		2012	0/0/0	0/0/0	0/0/0	5/5/5
	Gila River Site #2[4]	2008	NS	NS	NS	NS
		2009	0/0/0	0/0/0	0/0/0	15/0/5
		2010	NS	NS	NS	NS
		2011	--/0/0	--/0/0	--/0/0	--/5/5
		2012	NS	NS	NS	NS

Table E.1. Summary of Hydrologic Conditions at Each Survey Site at Reclamation Study Areas, 2008–2012* (Continued)

Study Area[1]	Survey Site	Year	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
YUMA	Fortuna Site #1[4]	2008	NS	NS	NS	NS
		2009	6/0/0	10/0/0	10/0/2	0/5/0
		2010	NS	NS	NS	NS
		2011	--/0/0	--/0/0	--/5/0	--/0/0
		2012	NS	NS	NS	NS
	Fortuna North[4]	2008	NS	NS	NS	NS
		2009	0/0/0	0/0/0	5/0/0	0/10/10
		2010	NS	NS	NS	NS
		2011	--/10/10	--/10/15	--/5/5	--/0/0
		2012	NS	NS	NS	NS

[*] Values are given for each site as recorded in mid-May, mid-June, and mid-July.

[1] PAHR = Pahranagat NWR, LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, GRCA = Grand Canyon, TOPO = Topock Marsh, BIWI = Bill Williams River NWR, AHAK = Ahakhav Tribal Preserve, PVER = Palo Verde Ecological Reserve, BIHO = Big Hole Slough, EHRE = Ehrenberg, CIBO = Cibola, IMPE = Imperial, MITT = Mittry Lake, YUMA = Yuma.

[2] -- = Hydrologic information not recorded; NS = not surveyed.

[3] Percent of site with saturated soil does not include inundated areas.

[4] Site bordered by a river, lake, or pond.

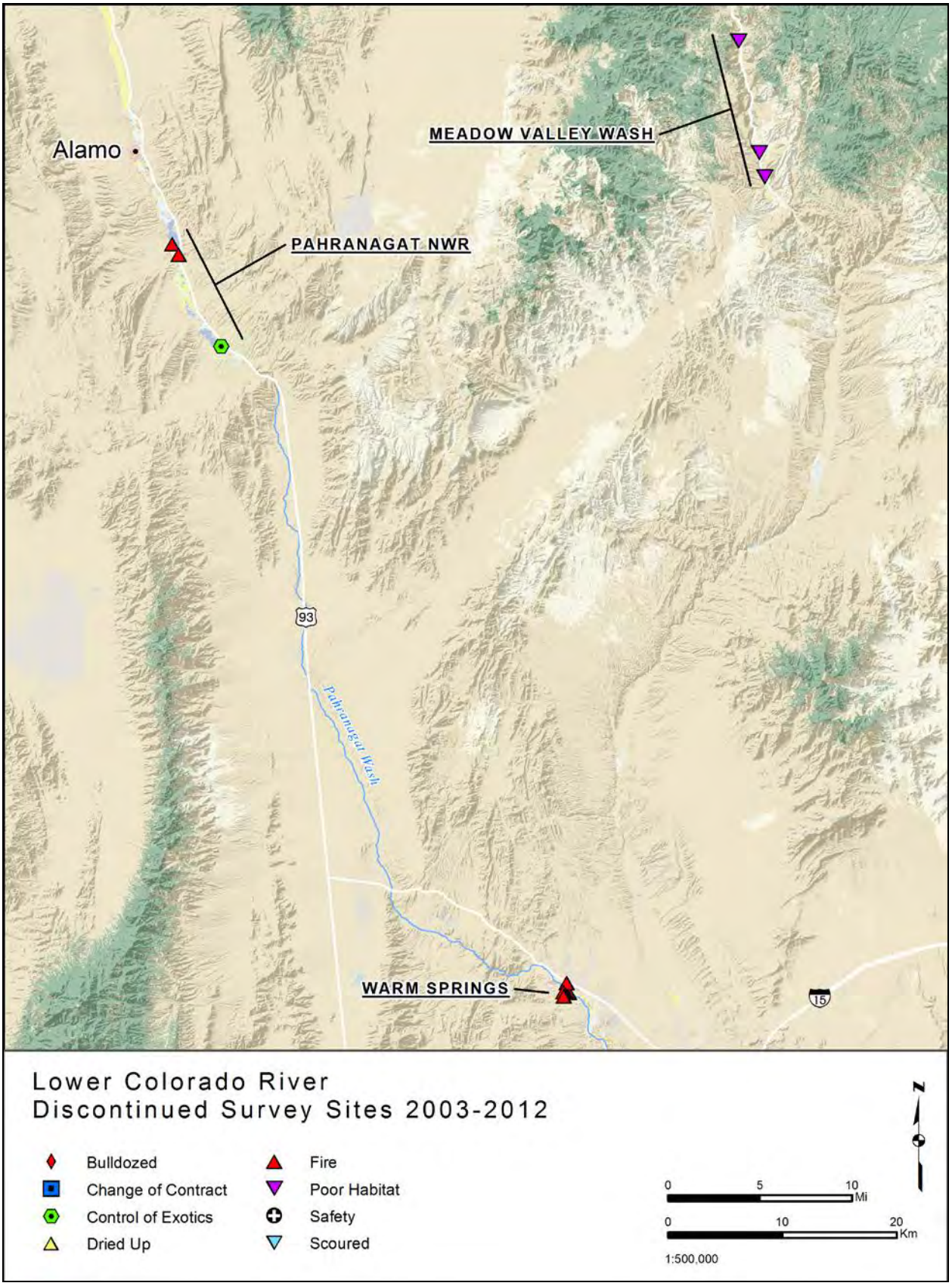
[5] Saturated soil or water was present only in pig wallows.

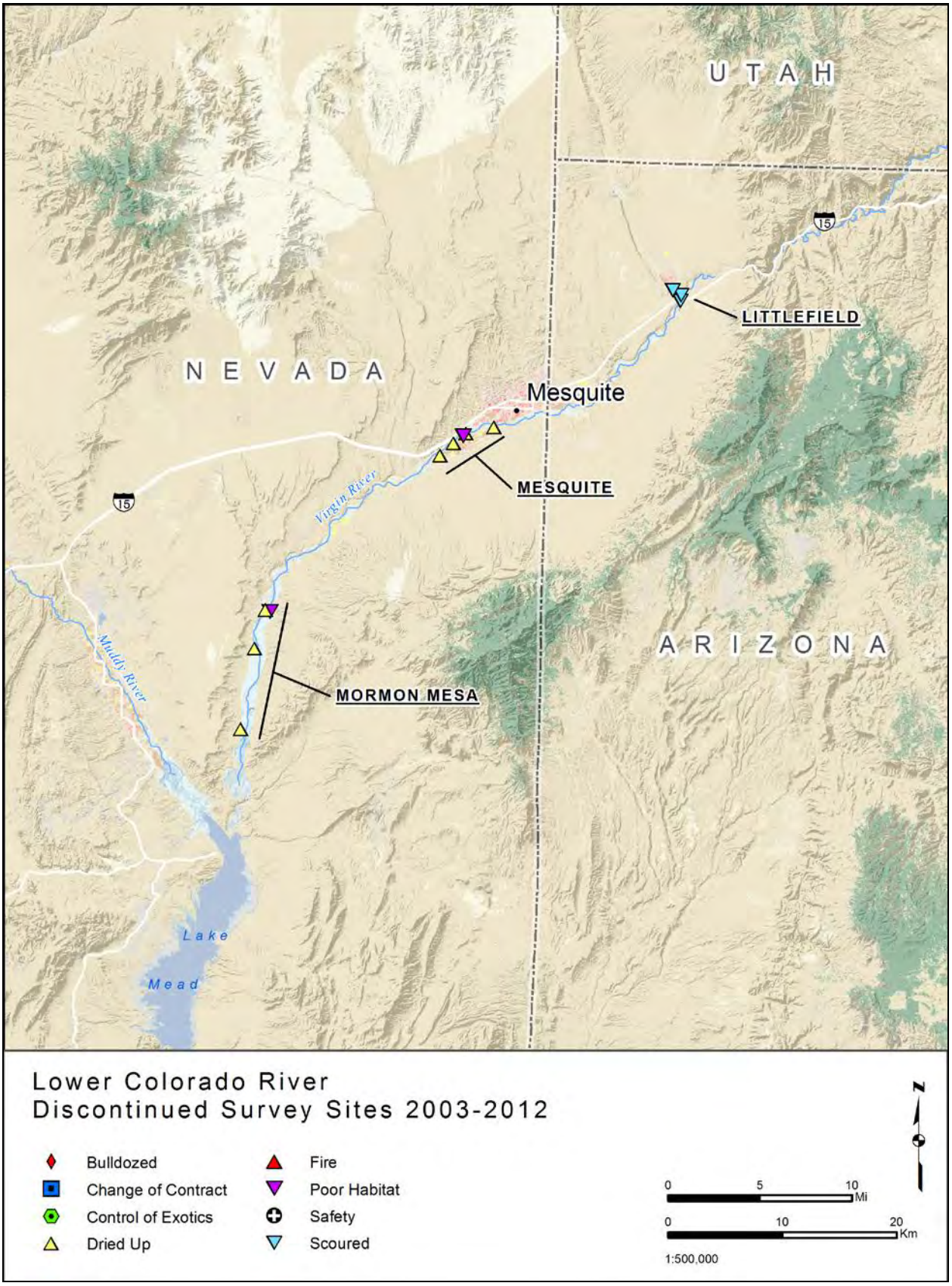
[6] Site borders marsh.

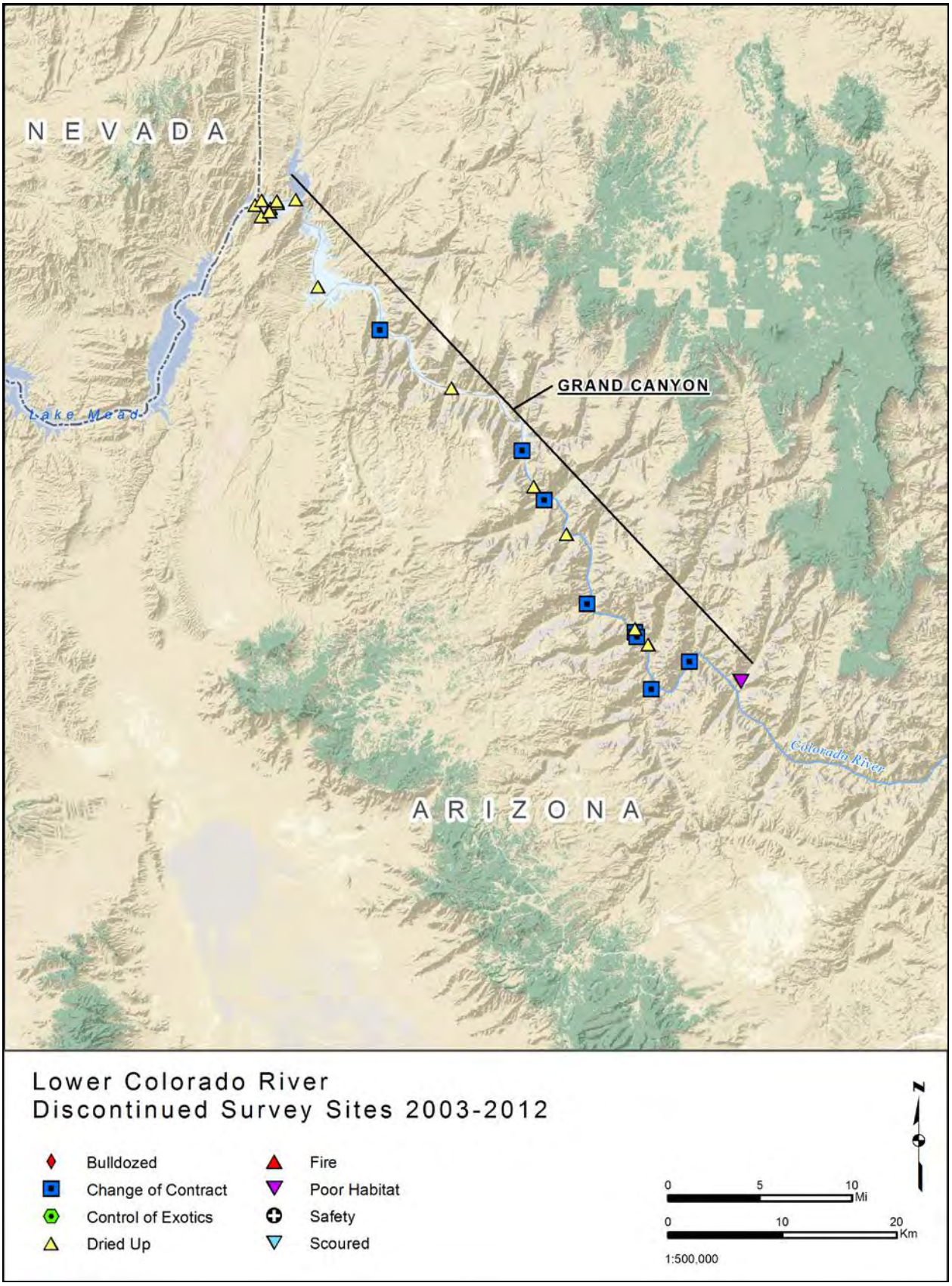
[7] Site is irrigated as part of restoration efforts; amount of standing water highly variable throughout survey season.

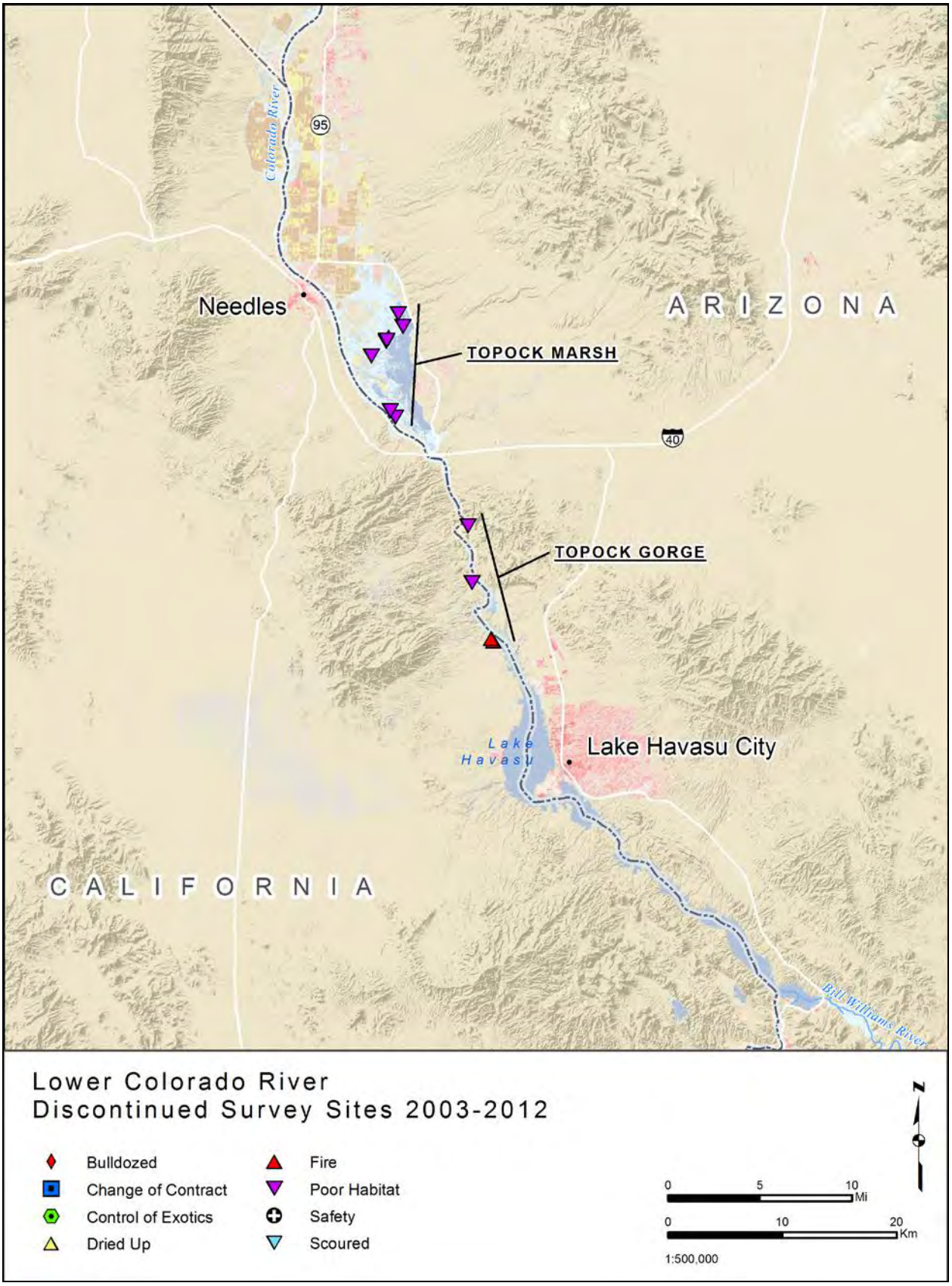
Appendix F

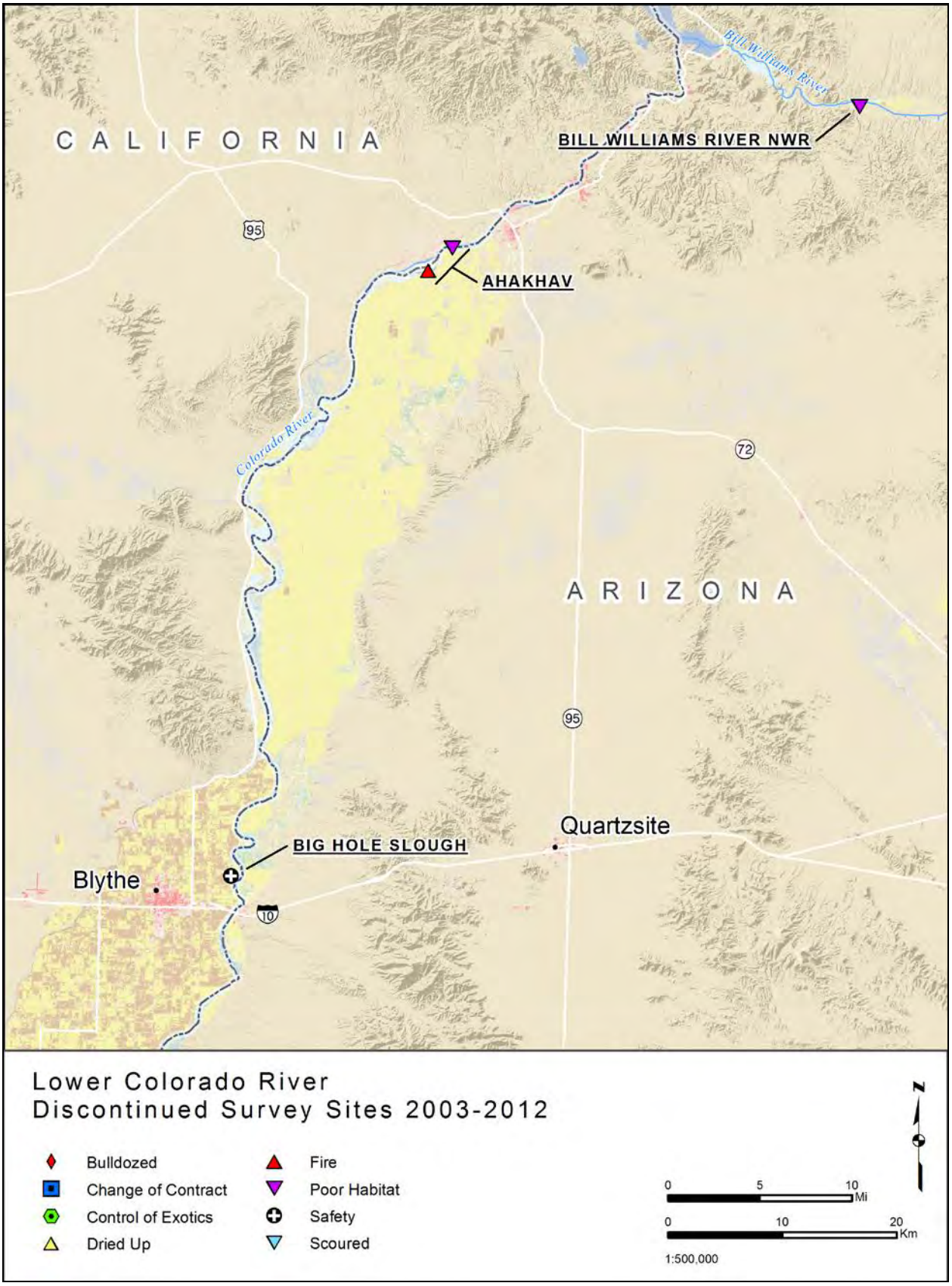
ORTHOPHOTOS SHOWING DISCONTINUED SITES, 2003–2012

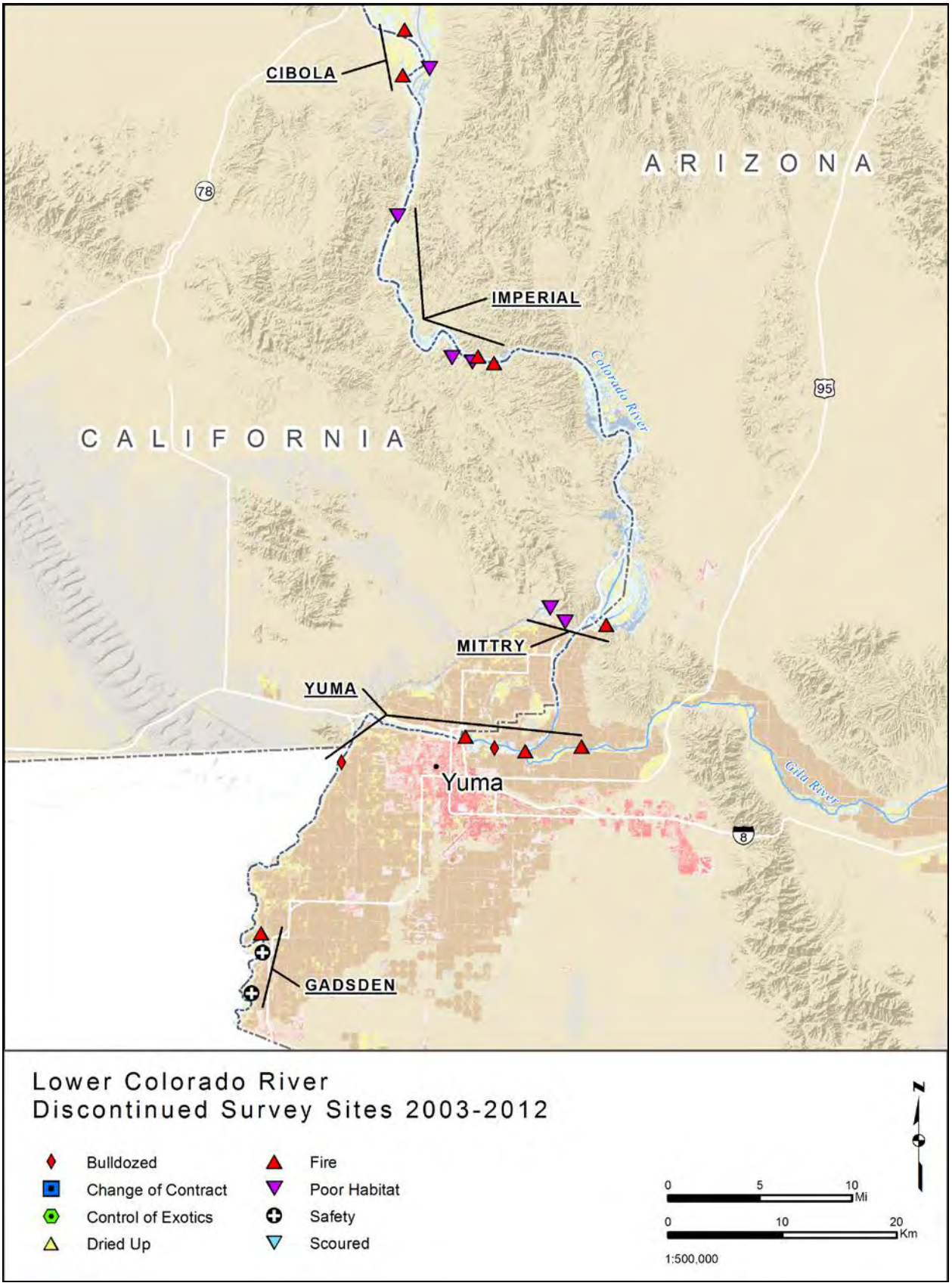

Alamo
MEADOW VALLEY WASH
PAHRANAGAT NWR
93
Pahranagat Wash
WARM SPRINGS
15
Lower Colorado River
Discontinued Survey Sites 2003-2012
Bulldozed
Change of Contract
Control of Exotics
Dried Up
Fire
Poor Habitat
Safety
Scoured
0 5 10 Mi
0 10 20 Km
1:500,000
N


UTAH
NEVADA
ARIZONA
Mesquite
LITTLEFIELD
MESQUITE
MORMON MESA
Virgin River
Muddy River
Lake
Mead
15
15
Lower Colorado River
Discontinued Survey Sites 2003-2012
Bulldozed
Change of Contract
Control of Exotics
Dried Up
Fire
Poor Habitat
Safety
Scoured
0
5
10
Mi
0
10
20
Km
1:500,000
N


NEVADA
GRAND CANYON
Lake Mead
Colorado River
ARIZONA
Lower Colorado River
Discontinued Survey Sites 2003-2012
Bulldozed
Change of Contract
Control of Exotics
Dried Up
Fire
Poor Habitat
Safety
Scoured
0 5 10 Mi
0 10 20 Km
1:500,000
N


Colorado River
95
Needles
ARIZONA
TOPOCK MARSH
40
TOPOCK GORGE
Lake Havasu
Lake Havasu City
CALIFORNIA
Bill Williams River
Lower Colorado River
Discontinued Survey Sites 2003-2012
Bulldozed
Change of Contract
Control of Exotics
Dried Up
Fire
Poor Habitat
Safety
Scoured
0 5 10 Mi
0 10 20 Km
1:500,000
N


CALIFORNIA
BILL WILLIAMS RIVER NWR
Bill Williams River
95
AHAKHAV
Colorado River
72
ARIZONA
95
Quartzsite
BIG HOLE SLOUGH
Blythe
10
Lower Colorado River
Discontinued Survey Sites 2003-2012
Bulldozed
Change of Contract
Control of Exotics
Dried Up
Fire
Poor Habitat
Safety
Scoured
0 5 10 Mi
0 10 20 Km
1:500,000
N


CIBOLA
ARIZONA
78
IMPERIAL
Colorado River
95
CALIFORNIA
MITTRY
YUMA
Yuma
Gila River
8
GADSDEN
Lower Colorado River
Discontinued Survey Sites 2003-2012
Bulldozed
Change of Contract
Control of Exotics
Dried Up
Fire
Poor Habitat
Safety
Scoured
0 5 10 Mi
0 10 20 Km
1:500,000
N

Appendix G

ALL WILLOW FLYCATCHERS COLOR-BANDED AND/OR RESIGHTED, 2003–2012

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012*

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1490-89889	M	J							R		D	D	D	D				
1590-97338	M	A	P				P	P	P	P								
1710-20312	M	J							R		T							
1710-20638	M	A		G	M	M	M	M	M	M	M							
2090-42022	F	J		M					Q									
2110-78841	F	J						T	T	T	T							
2110-78842	M	A						Q	Q	Q								
2110-78855	M	J						T	T									
2110-78861	M	J						T	M[4]	Q								
2110-78863	M	J						T	T	T								
2140-66502	M	J						Q	Q									
2140-66503	F	J						Q		Q								
2140-66517	F	A						Q	Q	Q	D							
2140-66518	M	A						Q	Q									
2140-66561	M	A						P			P	P	P	P				
2140-66564	F	J						P	P									
2140-66566	M	J						P			P							
2140-66568	M	A						P	P		P	P	P	P				
2140-66606	M	J		M		Q	Q		Q									
2140-66621	F	A				P	P	P	P	P								
2140-66627	F	A				P	P	P		P								
2140-66690	F	J					P								S			
2140-66693	M	J					M	Q	Q									
2140-66696	F	J					Q		Q									
2140-66697	M	J					Q			P	P	P	P	P	P			
2140-66709	M	A						Q	Q	Q		Q[5]	M	M	M	M	M	M[6]
2140-66728	M	J					T			T								
2140-66743	M	J			T					T								
2140-66775	M	J				T	M		Q	Q	Q							
2190-76604	M	A					P		P	P	P	P						
2320-31401	M	A							B									
2320-31402	M	A							B									
2320-31403	M	A							Y									
2320-31404	F	A							B									
2320-31405	F	A							B									
2320-31406	U	J							B									
2320-31407	F	J							B	T								
2320-31408	U	J							B									
2320-31409	U	J							B									
2320-31410	U	J							B									
2320-31411	U	J							B									

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2320-31412	M	A							B	B								
2320-31413	U	A							Q									
2320-31414	M	A								T	T							
2320-31415	F	A								T								
2320-31416	U	J								T								
2320-31417	U	J								T								
2320-31418	M	A								T	T							
2320-31419	U	J								T								
2320-31420	U	J								T								
2320-31421	U	J								T								
2320-31422	U	J								T								
2320-31423	U	A								T								
2320-31424	M	J								T	T							
2320-31425	U	J								T								
2320-31426	F	A							M									
2320-31427	M	A							M									
2320-31428	M	J							Q	M	Q[7]		M	M				
2320-31429	U	J							Q									
2320-31430	U	J							P									
2320-31431	U	J							Q									
2320-31432	U	J							P									
2320-31433	U	J							Q									
2320-31434	U	J							Q									
2320-31435	U	J							P									
2320-31436	U	J							P									
2320-31437	U	J							P									
2320-31438	M	J							Q	Q								
2320-31439	U	J							Q									
2320-31440	F	J							Q	M								
2320-31441	U	J							M									
2320-31443	U	J							Q									
2320-31444	F	A							Q	Q	Q	Q			M			
2320-31445	F	A							Q	Q	Q	Q	Q	Q	Q	Q		
2320-31446	U	J								P								
2320-31447	U	J								P								
2320-31448	U	J								P								
2320-31449	U	J								P								
2320-31450	U	J								P								
2320-31451	M	A							P	P	P	P						
2320-31452	M	A							P									

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2320-31453	M	A							P	P								
2320-31454	M	A							P	P								
2320-31455	M	A							P									
2320-31456	U	J							P									
2320-31457	M	J							P	K								
2320-31458	M	J							P		P							
2320-31459	M	J							P	P								
2320-31460	U	J							P									
2320-31461	U	J							P									
2320-31462	U	J							P									
2320-31463	F	J							P			K	K			K		
2320-31464	U	J							P									
2320-31465	U	J							P									
2320-31466	F	A							P									
2320-31467	M	J							P		P	P						
2320-31468	M	J							P		P	P		K				
2320-31469	U	J							P									
2320-31470	U	J							P									
2320-31471	M	J							Q	Q			M		M			
2320-31472	U	J							Q									
2320-31473	M	J							Q	Q								
2320-31474	U	J							Q									
2320-31475	M	J							P	L								
2320-31476	F	A							Q									
2320-31477	U	J							Q									
2320-31479	F	A							Q	Q								
2320-31480	F	J							Q	Q								
2320-31481	U	J							P									
2320-31482	U	J							P									
2320-31483	U	J								Q								
2320-31484	M	J								P	P			K	K			
2320-31485	F	A								M		M	M	M				
2320-31486	F	J							Q	L	Q	M	M	M				
2320-31487	U	J							Q									
2320-31488	U	J							Q									
2320-31489	U	A								M								
2320-31490	M	A								L	L[8]	Q	Q	Q	Q			
2320-31491	M	A								Q								
2320-31493	M	A								D								
2320-31494	U	A								Q								

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2320-31495	M	A								T								
2320-31496	U	J								M								
2320-31497	U	J								M								
2320-31498	F	J								M		G[9]	Q	Q	Q	Q		
2320-31499	M	A								Q								
2320-31500	U	J								Q								
2320-31501	M	A							B									
2320-31502	F	A							T	T								
2320-31503	U	A								I								
2320-31504	U	A								I								
2320-31505	M	A								T								
2320-31506	U	J								T								
2320-31507	U	J								T								
2320-31508	U	J								T								
2320-31510	U	J								T								
2320-31511	U	J								T								
2320-31512	U	J								T								
2320-31513	U	J								T								
2320-31514	U	J								T								
2320-31515	F	A								T	T	T						
2320-31516	F	A								G								
2320-31517	M	A								G	M	M			M			
2320-31518	U	J								T								
2320-31519	U	J								T								
2320-31520	U	J								T								
2320-31521	F	A								T	T							
2320-31522	U	J											Q					
2320-31523	U	J											M					
2320-31524	U	J											P					
2320-31525	U	J											P					
2320-31526	F	A							T	T	T							
2320-31527	F	A							T									
2320-31528	M	A							T									
2320-31529	U	J							T									
2320-31530	U	J							T									
2320-31531	U	J							T									
2320-31532	U	J							T									
2320-31533	U	J							T									
2320-31534	U	J							T									
2320-31535	U	J							T									
2320-31536	U	J							T									

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2320-31537	U	J							T									
2320-31538	M	A								T								
2320-31539	M	A								B								
2320-31540	F	A								T								
2320-31541	M	A								T	T							
2320-31542	U	J								T								
2320-31543	U	J								T								
2320-31544	U	J								T								
2320-31545	U	J											P					
2320-31546	U	J											P					
2320-31547	U	J											P					
2320-31548	U	J											P					
2320-31549	U	J											P					
2320-31550	U	J											P					
2320-31551	M	A								Q								
2320-31552	M	A								M								
2320-31553	M	A								M		M						
2320-31554	U	J								T								
2320-31555	U	J								T								
2320-31556	U	J								T								
2320-31557	U	J								T								
2320-31558	U	J								T								
2320-31559	M	A								T	T	T	T					
2320-31560	M	A								T	T	T	T	T				
2320-31561	U	J								T								
2320-31562	M	J								T		T		T	T	T		
2320-31563	U	J								T								
2320-31564	U	J								T								
2320-31565	F	A								T	T							
2320-31566	U	J										T						
2320-31567	M	A								T	T							
2320-31568	F	A								P								
2320-31569	U	J								P								
2320-31570	U	J								P								
2320-31571	U	J								P								
2320-31572	M	A								M								
2320-31573	F	A								Q	Q	Q	Q	Q				
2320-31574	U	J									P							
2320-31575	U	J										Q						
2320-31576	M	A							T	T								

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2320-31577	F	A							T	T	T							
2320-31578	U	A							Y									
2320-31579	U	A							Y									
2320-31580	U	A							Y									
2320-31581	U	J							T									
2320-31582	U	J							T									
2320-31583	U	J							T									
2320-31584	F	A							T	T	T	T						
2320-31585	U	J							T									
2320-31586	U	J							T									
2320-31587	U	J							T									
2320-31588	U	J							T									
2320-31589	M	A								P	P	P	P					
2320-31590	M	A								P	P	P	P	P				
2320-31591	M	A								P	P	P	P					
2320-31593	M	A								P	P	P						
2320-31594	M	A								P								
2320-31595	M	A								P	P	P	P	P	P	P	P	P
2320-31596	M	A								P								
2320-31598	M	A								T								
2320-31599	U	A								I								
2320-31600	U	A								I								
2320-31601	U	J								P								
2320-31602	U	J								P								
2320-31603	U	J								P								
2320-31604	M	J								P		K	K					
2320-31605	U	J								P								
2320-31606	U	J								P								
2320-31607	U	J								P								
2320-31608	U	J								P								
2320-31609	U	J								P								
2320-31610	U	J								P								
2320-31611	U	J								Q								
2320-31612	U	J								Q								
2320-31616	F	J								Q		D						
2320-31617	U	J								Q								
2320-31618	F	J								Q	M	M	M					
2320-31619	U	J								M								
2320-31620	U	J								M								
2320-31621	F	A								M								

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2320-31622	M	A								Q								
2320-31623	U	J								M								
2320-31624	U	J								M								
2320-31625	F	A								M								
2320-31627	M	A								Q								
2320-31628	U	A								M								
2320-31629	U	J								M								
2320-31630	U	J								Q								
2320-31631	F	J								Q		D	D					
2320-31632	F	A								Q		M	M	M[10]		M	M	M
2320-31633	U	J								Q								
2320-31634	U	J								Q								
2320-31635	M	A								K								
2320-31636	U	J								K								
2320-31637	F	J								K	P							
2320-31638	U	J								K								
2320-31639	U	J											P					
2320-31640	U	J											Q					
2320-31641	U	J											Q					
2320-31642	U	J											Q					
2320-31643	U	J											P					
2320-31644	U	J											M					
2320-31645	U	J											M					
2320-31646	U	J											P					
2320-31647	U	J														M		
2320-31648	U	J														M		
2320-31649	U	J											P					
2320-31650	F	J										T	T					
2320-31651	M	A								M								
2320-31652	M	A								M	Q	Q						
2320-31653	M	A								M	M	M	M					
2320-31654	M	A								Q								
2320-31655	F	A								Q	Q	Q						
2320-31656	F	A								P	P	P						
2320-31657	F	A								P	P	P	P	P	P			
2320-31658	F	A								P								
2320-31659	M	J								Q		D	D	D		D		
2320-31660	F	J								Q			M	S	S	S		
2320-31661	F	A								P	P	P	P	P				
2320-31662	F	A								P								

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2320-31663	F	A								P	P	P	P	P				
2320-31664	F	A								P								
2320-31665	U	J								P								
2320-31666	U	J								P								
2320-31667	U	J								P								
2320-31668	F	A								P								
2320-31669	F	A								P								
2320-31670	U	J											Q					
2320-31671	U	J										M						
2320-31672	U	J											P					
2320-31673	U	J										T						
2320-31674	M	J										P		K	K	K		
2320-31675	U	J									T							
2320-31676	U	J									T							
2320-31677	U	J										T						
2320-31678	U	J										P						
2320-31679	U	J											P					
2320-31680	U	J									T							
2320-31681	U	J									T							
2320-31682	U	J									P							
2320-31683	M	J									P		K					
2320-31684	U	J									P							
2320-31685	U	J									P							
2320-31686	M	J									P	P						
2320-31687	U	J									P							
2320-31688	M	J									Q	Q	Q	Q	Q	Q	Q	Q
2320-31689	U	J									Q							
2320-31690	U	J									Q							
2320-31691	U	J									Q							
2320-31692	M	J									P	K						
2320-31693	U	J									P							
2320-31694	M	J									P		K	K				
2320-31695	F	J									P	P						
2320-31696	U	J									Q							
2320-31697	U	J									P							
2320-31698	F	J									P		P	P	P			
2320-31699	U	J									P							
2320-31700	U	J									P							
2360-59701	F	J									Q	Q						
2360-59702	M	J									Q	D	M					

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2360-59703	U	J									Q							
2360-59704	U	J									M							
2360-59705	U	J									M							
2360-59706	U	J									K							
2360-59707	F	J									P	P						
2360-59708	F	J									P	P						
2360-59709	U	J									P							
2360-59710	U	J									P							
2360-59711	M	J									K			P	P	P		
2360-59712	M	J									K			P		P	P	
2360-59713	U	J									K							
2360-59714	U	J									Q							
2360-59715	U	J									Q							
2360-59716	U	J									Q							
2360-59717	M	A								Q								
2360-59718	U	J									P							
2360-59719	U	J									T							
2360-59720	U	J									T							
2360-59721	U	J								P								
2360-59722	U	J									T							
2360-59723	U	J								P								
2360-59724	F	J								P		P						
2360-59725	U	J									B							
2360-59727	M	J									B		B					
2360-59728	U	J									B							
2360-59729	U	J									T							
2360-59730	U	J									T							
2360-59731	U	J									T							
2360-59732	U	J									T							
2360-59733	U	J									T							
2360-59734	U	J									T							
2360-59735	U	J										P						
2360-59736	U	J										P						
2360-59737	U	J										D						
2360-59738	U	J										D						
2360-59739	U	J										Q						
2360-59740	U	J									P							
2360-59741	U	J									Q							
2360-59742	U	J									Q							
2360-59743	F	J											P	K				

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2360-59744	U	J										T						
2360-59745	U	J										P						
2360-59746	U	J								G								
2360-59747	U	J										D						
2360-59748	U	J										D						
2360-59749	M	J										D	D[11]	M				
2360-59750	F	J										M	Q					
2360-59751	M	J										M	Q	Q	Q			
2360-59752	M	J										Q		Q	M			
2360-59753	U	J										Q						
2360-59754	M	J										Q	Q	Q	Q	P	P	
2360-59755	U	J										Q						
2360-59756	U	J										P						
2360-59757	U	J								K								
2360-59758	U	J										P						
2360-59759	U	J										P						
2360-59760	U	J								L								
2360-59761	U	J								L								
2360-59762	U	J								Q								
2360-59763	U	J								Q								
2360-59764	U	J											P					
2360-59765	U	J											P					
2360-59766	U	J								Q								
2360-59767	U	J								K								
2360-59768	U	J										T						
2360-59769	U	J										M						
2360-59770	U	J								K								
2360-59771	U	J								G								
2360-59772	F	A								K								
2360-59773	U	J											Q					
2360-59775	U	J											Q					
2360-59776	U	J											Q					
2360-59777	F	J											Q				M	M
2360-59778	U	J											Q					
2360-59779	U	J											K					
2360-59780	U	J											K					
2360-59781	U	J											K					
2360-59782	F	J											K			M		
2360-59785	U	J									D							
2360-59786	U	J									D							

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2360-59787	U	J									D							
2360-59788	F	J									D	D	M	M	M	M	M	M
2360-59789	U	J										Q						
2360-59790	U	J										Q						
2360-59791	U	J										P						
2360-59792	U	J										P						
2360-59793	U	J										P						
2360-59794	U	J										P						
2360-59795	U	J										P						
2360-59796	U	J										P						
2360-59797	M	J										P	P					
2360-59798	U	J										P						
2360-59799	M	J										M	D	M		M		
2360-59800	U	J								G								
2370-39901	U	A								P								
2370-39902	U	J								P								
2370-39904	U	J								P								
2370-39911	M	A									P							
2370-39912	M	A									Q		Q					
2370-39913	M	A									G							
2370-39914	U	J									P							
2370-39915	M	A									P	P	P	P[12]	P	P		
2370-39916	M	A										T	T	T				
2370-39917	U	A										Y						
2370-39918	U	A										Y						
2370-39919	U	A										Y						
2370-39920	U	A										Y						
2370-39921	U	A										Y						
2370-39922	U	A										Y						
2370-39923	U	A										Y						
2370-39924	U	A										Y						
2370-39925	U	A										Y						
2370-39926	U	A										Y						
2370-39927	U	A										Y						
2370-39928	U	A										Y						
2370-39929	M	A										G	G					
2370-39930	M	J													M	Q	D[13]	
2370-39932	F	A									B	B	B					
2370-39933	U	A									Y							
2370-39934	U	A									Y							

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2370-39935	U	A									Y							
2370-39937	M	A										Q	Q	Q				
2370-39938	M	A										M	M	M	M	M	M	M
2370-39939	F	A										Q	Q					
2370-39940	M	A										M	M	M	Q			
2370-39941	M	J										Q	L[14]					
2370-39942	U	J										D						
2370-39943	U	J										D						
2370-39944	U	J										D						
2370-39945	U	J										P						
2370-39946	M	J										P	P					
2370-39947	U	J										P						
2370-39948	F	A										M						
2370-39949	U	J										Q						
2370-39950	U	J										Q						
2370-39951	M	A									P	P	P	P				
2370-39953	M	A									P	P	P	P				
2370-39954	M	A									Q	Q	Q	Q				
2370-39956	F	A									D	D	D			M	M	M
2370-39957	F	A									Q	Q						
2370-39958	F	A									P							
2370-39959	M	A									P		A					
2370-39960	M	A									K							
2370-39961	M	A									P							
2370-39962	F	A									P							
2370-39964	F	A									P	P	P					
2370-39965	U	A									D							
2370-39966	M	J									D		M					
2370-39967	M	A										M	D[15]	Q	Q			
2370-39968	M	A															D	
2370-39969	F	A													B			
2370-39970	U	J															M	
2370-39971	U	A									P							
2370-39972	U	A									I							
2370-39973	U	A									Y							
2370-39974	U	A									I							
2370-39975	M	A									D	M						
2370-39976	M	A									D							
2370-39977	U	J									P							
2370-39978	F	A									P							

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2370-39979	U	J									P							
2370-39980	M	J									P	K	K	K	K			
2370-39981	U	J									P							
2370-39982	U	A										Y						
2370-39983	U	A										Y						
2370-39984	U	A										Y						
2370-39985	U	A										Y						
2370-39986	M	A										G						
2370-39987	M	A										G						
2370-39988	M	A										G	M	M	M	M		
2370-39989	M	A										G						
2370-39990	F	A										G						
2370-39992	M	A										T						
2370-39993	U	A										Y						
2370-39994	U	A										Y						
2370-39995	U	A										Y						
2370-39996	U	A										Y						
2370-39997	U	A										Y						
2370-39998	U	A										Y						
2370-39999	M	A														Q		
2370-40000	M	A														D	D	D
2370-40001	U	J														P		
2370-40002	U	J														P		
2370-40003	M	A										T						
2370-40004	F	A										B			B			
2370-40005	U	J														S		
2370-40007	U	J														S		
2370-40008	U	J														D		
2370-40009	U	J														D		
2370-40010	M	J														D	K	K
2370-40011	F	A														Q		
2370-40012	M	A									Q	Q	Q					
2370-40013	M	A									P	P						
2370-40014	F	A									P	P	P					
2370-40016	U	J									P							
2370-40017	M	A									M	M						
2370-40019	U	J									P							
2370-40020	U	J									P							
2370-40021	M	A									P	P						
2370-40022	M	A														K		
2370-40023	U	J													M			

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2370-40024	M	J													K	K	K	K
2370-40025	U	J													K			
2370-40026	U	J													P			
2370-40027	F	J													P	E	K	
2370-40029	M	J													M		D	
2370-40030	U	J													M			
2370-40031	M	J													K	K	K	
2370-40032	M	A									B							
2370-40033	U	A									Y							
2370-40034	U	A									Y							
2370-40035	U	A									Y							
2370-40036	M	A										G[16]						
2370-40037	F	A										G	M		M	M	M	M
2370-40038	M	A										G						
2370-40039	U	A										Y						
2370-40040	U	A										Y						
2370-40041	U	A										Y						
2370-40042	U	A										Y						
2370-40043	U	A										Y						
2370-40044	U	A										Y						
2370-40045	U	A										Y						
2370-40046	M	A										G	G[17]	M	M	M	M	M
2370-40047	F	A										P	P	P	P	P	P	P
2370-40048	U	J													T			
2370-40049	U	J													T			
2370-40050	U	J													T			
2370-40051	U	J														K		
2370-40052	M	A									B	B	B	B				
2370-40053	M	A									B							
2370-40054	M	A									B							
2370-40055	F	A									T							
2370-40056	M	A									T							
2370-40057	M	A										D						
2370-40058	M	A										M	B					
2370-40059	F	A										D	D	D				
2370-40060	M	A										P		P	P	P	P	
2370-40061	F	A										P						
2370-40062	F	A										P	P					
2370-40063	U	J										Q						
2370-40064	U	J										P						
2370-40065	U	J										Q						

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2370-40066	F	A										Q	Q	Q	Q			
2370-40067	U	J										Q						
2370-40068	U	J										Q						
2370-40069	U	J										M						
2370-40070	U	J										M						
2370-40071	U	J										P						
2370-40072	U	J													M			Q
2370-40073	F	A													P	P		
2370-40074	U	J													P			
2370-40075	U	J													P			
2370-40076	U	J													P			
2370-40078	U	J															K	
2370-40079	U	J															K	
2370-40080	U	J										Q						
2370-40081	M	A										K						
2370-40082	F	A										K						
2370-40083	U	J										Q						
2370-40084	U	J										Q						
2370-40085	U	J											Q					
2370-40086	U	J											Q	M	M			
2370-40087	F	A											Q	Q	Q	Q	Q	
2370-40088	M	A														D	D	D
2370-40089	U	J														M		
2370-40090	U	J														M		
2370-40091	F	J														M	D	
2370-40093	U	J														M		
2370-40096	U	J												K				
2370-40097	M	J												K		K	K	
2370-40098	U	J												K				
2370-40099	U	J													S			
2370-40100	U	J										K						
2370-40101	U	J										K						
2370-40102	U	J										K						
2370-40103	U	J										Q						
2370-40104	U	J										Q						
2370-40105	U	J										Q						
2370-40106	U	J										Q						
2370-40107	U	J										Q						
2370-40108	U	J										Q						
2370-40110	U	J											T					

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2370-40111	U	J											T					
2370-40112	M	J											T			T		
2370-40113	U	J											B					
2370-40114	M	J											T		T			
2370-40115	U	J											T					
2370-40116	U	J											T					
2370-40117	U	J											T					
2370-40118	U	J											T					
2370-40119	U	J											T					
2370-40120	U	J											T					
2370-40121	U	J											T					
2370-40122	U	J											T					
2370-40123	U	J											T					
2370-40124	M	J											T		M			
2370-40125	U	J											T					
2370-40126	M	A											G					
2370-40127	M	A											G					
2370-40129	M	A											G					
2370-40130	F	A													B			
2370-40132	F	A											T					
2370-40133	F	A											B					
2370-40134	U	A											B					
2370-40135	F	A											B					
2370-40136	F	A											T					
2370-40137	M	A											B					
2370-40138	M	A											T					
2370-40139	M	A											T	T				
2370-40140	F	A													P			
2370-40141	M	A													K	K	K	
2370-40142	U	J													M			
2370-40143	U	J													Q			
2370-40144	M	J													M	T		
2370-40145	U	J													M			
2370-40146	U	J													S			
2370-40147	F	J												S	D			
2370-40148	F	J												S	S	S	S	
2370-40149	U	J												S				
2370-40150	U	J													M			
2370-40151	F	J													M	M		
2370-40152	U	J													M			

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2370-40153	U	J													S			
2370-40154	U	J													S			
2370-40155	M	A													L			P
2370-40156	M	A													B			
2370-40157	M	A											P		P	P		
2370-40158	M	J											B		T			
2370-40159	U	J											B					
2370-40160	F	A											G					
2370-40161	M	A											M	M	M			
2370-40162	U	J													B			
2370-40163	U	J													B			
2370-40164	U	J											Q					
2370-40165	M	A													B			
2370-40166	U	A											P					
2370-40167	U	J											P					
2370-40168	F	A											P	P	P			
2370-40169	U	J											M					
2370-40170	F	A											Q	Q				
2370-40171	F	A											D					
2370-40173	M	A											M	M	M	M		
2370-40174	U	J													M			
2370-40175	M	J													M	Q	Q	D
2370-40176	M	A													M			
2370-40177	U	J														T		
2370-40179	U	J														K		
2370-40180	M	A													B			
2370-40181	M	A													T			
2370-40182	U	J													B			
2370-40183	F	A											M					
2370-40184	M	A											D					
2370-40185	M	A											P					
2370-40186	M	A											D					
2370-40187	M	A											K					
2370-40188	U	J											Q					
2370-40190	M	J											P				K	K
2370-40191	F	A											M	M	M			
2370-40192	F	A											D			B		
2370-40193	F	A											Q	Q	Q	D		
2370-40194	F	A											P	P	P	P		
2370-40195	F	A											P	P	P			

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2370-40197	M	A											M	Q	Q	M	M	M
2370-40199	U	J											P					
2390-92348	F	J		T						T								
2390-92350	M	A				M	Q		Q	Q								
2390-92365	M	J				D			Q	Q	Q							
2390-92410	M	A					Q		Q									
2390-92420	M	J					Q	Q	Q									
2390-92421	M	J					Q	Q	Q	Q	M	M						
2390-92427	F	J					M		Q									
2390-92433	M	J					Q		Q	Q								
2390-92434	M	J					Q	Q		Q	Q	Q	Q	Q	Q	M	M	
2390-92451	F	J			M	M		Q		Q								
2390-92470	F	J					Q			Q								
2390-92475	M	J					M	Q	Q	Q	Q	Q	Q	Q				
2430-61006	U	A											Y					
2430-61007	U	A											Y					
2430-61008	U	A											Y					
2430-61009	U	A											Y					
2430-61010	U	A											Y					
2430-61011	U	A											Y					
2430-61012	U	A											Y					
2430-61013	U	A											Y					
2430-61014	U	A											Y					
2430-61015	U	A											Y					
2430-61016	U	A											Y					
2430-61017	U	A											Y					
2430-61018	U	A											Y					
2430-61019	U	A											Y					
2430-61020	U	A											Y					
2430-61021	U	A											Y					
2430-61023	U	A											Y					
2430-61024	U	A											Y					
2430-61025	U	A											Y					
2430-61026	U	A											Y					
2430-61027	U	A											Y					
2430-61028	U	A											Y					
2430-61029	U	A											Y					
2430-61030	U	A											Y					
2430-61031	U	A											Y					
2430-61032	U	A											Y					

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2430-61033	U	A											Y					
2430-61034	U	A											Y					
2430-61035	U	A											Y					
2430-61036	U	A											Y					
2430-61037	U	A											Y					
2430-61038	U	A											Y					
2430-61039	U	A											Y					
2430-61040	U	A											Y					
2430-61041	U	A											Y					
2430-61042	U	A											Y					
2430-61043	U	A											Y					
2430-61044	U	A											Y					
2430-61045	U	A											Y					
2430-61046	U	A											Y					
2430-61047	U	A											Y					
2430-61048	U	A											Y					
2430-61049	U	A											Y					
2430-61050	U	A											Y					
2430-61051	U	A											Y					
2430-61052	U	A											Y					
2430-61053	U	A											Y					
2430-61054	U	A											Y					
2430-61055	U	A											Y					
2430-61056	U	A											Y					
2430-61058	U	A											Y					
2430-61059	U	A											Y					
2430-61060	U	A											Y					
2430-61061	U	A											Y					
2430-61062	U	A											Y					
2430-61063	U	A											Y					
2430-61064	U	A											Y					
2430-61065	U	A											Y					
2430-61067	U	A											Y					
2430-61068	U	A											Y					
2430-61069	U	A											Y					
2430-61070	U	A											Y					
2430-61071	U	A											Y					
2430-61072	M	A												G			T	
2430-61073	M	A												B				
2430-61074	U	J												B				

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2430-61075	U	J												B				
2430-61076	U	J												B				
2430-61077	U	J												M				
2430-61078	U	J												Q				
2430-61079	F	A												M				
2430-61080	M	A												P	P	P	P	P
2430-61081	U	J												M				
2430-61082	U	J												Q				
2430-61083	M	A												P	P	P	P	P
2430-61084	M	J												Q		D		
2430-61085	M	A													D	D	D	D
2430-61086	U	J													M			
2430-61087	F	A													P	P	P	P
2430-61088	M	A														N	D	E
2430-61089	U	J														M		
2430-61090	U	J														M		
2430-61091	U	J														S		
2430-61092	F	A														S		
2430-61093	M	A														S	S	
2430-61094	U	J														D		
2430-61095	M	A														M		
2430-61096	F	A														L		
2430-61097	U	J														P		
2430-61098	M	J														P	E[18]	
2430-61099	M	J														K	E[19]	K
2430-61100	F	A														K	K	K
2430-61101	U	J												K				
2430-61102	U	J												K				
2430-61103	M	A												D				
2430-61104	M	A												M				
2430-61105	M	A												Q				
2430-61106	M	J												P		M	M	
2430-61107	U	J												P				
2430-61108	U	J												P				
2430-61109	F	A												K				
2430-61110	U	J												K				
2430-61111	U	J												P				
2430-61112	U	J												P				
2430-61113	U	J												P				
2430-61114	M	J												P		K	K	

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2430-61115	U	J												P				
2430-61116	F	A												M	M			
2430-61117	U	J												P				
2430-61118	M	J												P	M	M	K	
2430-61119	U	J												P				
2430-61120	F	J												P	P	P	P	P
2430-61121	U	J												Q				
2430-61122	U	J												P				
2430-61123	F	J												P		P		
2430-61124	F	J												P		K		
2430-61125	M	A												K				
2430-61126	U	J												S				
2430-61127	M	A												P	P			
2430-61128	U	J												M				
2430-61129	U	J												Q				
2430-61130	U	J												Q				
2430-61131	U	J												M				
2430-61132	U	J												M				
2430-61133	U	J												M				
2430-61134	M	A												T		N	N	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
2430-61138	F	A												B				
2430-61139	F	A												T				
2430-61140	U	J												B				
2430-61141	U	J												B				
2430-61142	U	J												B				
2430-61143	U	J												T				
2430-61144	U	J												T				
2430-61145	U	J												T				
2430-61151	U	J														K		
2430-61152	U	J														P		
2430-61153	F	A													M			
2430-61154	F	J													Q	S	S	S
2430-61155	U	J													Q			
2430-61156	U	J													K			
2430-61157	U	J													K			
2430-61158	M	A													K	K	K	K
2430-61159	M	J													M		K	K
2430-61160	U	J													M			

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2430-61161	U	J													D			
2430-61162	M	A													S			
2430-61163	F	A														K		
2430-61165	M	J												Q	Q	M		
2430-61167	M	A												M	M	M	M	
2430-61168	U	J												M				
2430-61169	U	J												M				
2430-61170	U	J												M				
2430-61171	U	J												M				
2430-61172	F	J												M	M			
2430-61173	U	J												M	M			
2430-61174	F	J												M		Q		
2430-61175	U	J												Q				
2430-61176	M	J												Q		P	P	P
2430-61177	U	J												Q				
2430-61178	M	A												K				
2430-61179	M	A												K	P	P	P	P
2430-61180	M	A												K		K	K	K
2430-61181	F	A												K	K			
2430-61182	M	A												K				
2430-61183	M	A												K				
2430-61184	U	J												Q				
2430-61185	F	J												Q	M			
2430-61186	U	J												Q				
2430-61187	M	J												Q	L	L		
2430-61188	U	J												Q				
2430-61189	M	J												Q		M		
2430-61190	U	J												Q				
2430-61191	M	J												M	D			
2430-61192	U	J												M				
2430-61193	U	J												M				
2430-61194	U	J												Q	Q			
2430-61195	U	J												Q				
2430-61196	U	J												Q				
2430-61197	M	J												P		K	K	K
2430-61198	U	J												P	Q			
2430-61199	U	J												P				
2430-61200	U	J												P				
2430-61202	U	J												M				
2430-61203	U	J												M				

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2430-61204	U	J												M				
2430-61205	U	J												M				
2430-61206	M	J												M		M		
2430-61207	F	J												M	D	D		
2430-61208	U	J												D				
2430-61209	M	A												V	D			
2430-61210	U	A												K				
2430-61211	U	J												S				
2430-61212	U	J												M				
2430-61213	U	J														K		
2430-61214	M	A															K	
2430-61215	U	J															P	
2430-61216	U	J															Q	
2430-61217	U	J															Q	
2430-61218	F	J															P	P
2430-61219	U	J															M	
2430-61220	F	J															P	P
2430-61221	U	J														P		
2430-61223	U	J												D				
2430-61224	U	J												D				
2430-61225	U	J												D				
2430-61226	U	J														P		
2430-61227	U	J														P		
2430-61228	U	J														K		
2430-61229	U	J														K		
2430-61230	F	A														S	S	S
2430-61231	U	J														S		M
2430-61232	U	J														L		
2430-61233	U	J														L		
2430-61234	F	A														Q	Q	
2430-61235	U	J														Q		
2430-61236	U	J														K		
2430-61237	U	J															B	
2430-61257	M	A																P
2430-61258	U	J																K
2430-61259	M	A																M
2430-61260	M	A																D
2430-61261	M	A																D
2430-61262	U	J																K
2430-61263	U	J																K
2430-61264	U	J																K

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2430-61265	U	J																M
2430-61266	U	J																M
2430-61267	F	A																P
2430-61271	U	J													P			
2430-61276	U	J														Q		
2430-61277	F	J													P	P		
2430-61278	M	J													P			
2430-61279	F	J													P	K	K	K
2430-61280	U	J														M		
2430-61281	M	A																M
2430-61282	M	A																M
2430-61285	U	J													M			
2430-61286	M	A																M
2430-61287	U	J																K
2430-61288	U	J																K
2430-61289	U	J																K
2430-61290	U	J																P
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
2430-61299	U	J																M
2430-61300	U	J																P
2540-58101	U	J														K		
2540-58102	U	J														K		
2540-58103	U	J														K		
2540-58104	M	J														K		
2540-58105	U	J														Q		
2540-58106	U	J														Q		
2540-58107	M	J														Q		
2540-58108	U	A															T	
2540-58109	M	A															P[20]	
2540-58110	F	A															P	
2540-58111	F	A															P	P
2540-58112	U	J															Q	
2540-58113	U	J															M	

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2540-58114	F	J															P	P
2540-58115	U	J															B	
2540-58116	M	J														B		T
2540-58117	U	J														B		
2540-58118	U	J														K		
2540-58119	U	J														K		
2540-58120	F	A															B	
2540-58132	M	A													S	S	S	S
2540-58141	U	J													M			
2540-58142	U	J													M			
2540-58143	M	A													D			
2540-58144	U	J													K			
2540-58145	U	J													K			
2540-58146	M	A													B			
2540-58147	U	J														B		
2540-58148	U	J														Q		
2540-58149	U	J														Q		
2540-58150	U	J														Q		
2540-58151	U	J														Q		
2540-58152	F	A															Q	
2540-58154	M	J													M	T	D[21]	M
2540-58155	U	J													M			
2540-58156	F	A														K	K	K
2540-58157	U	J														K	E	
2540-58158	M	J														K	K	K
2540-58159	F	J														K	K	K
2540-58160	M	J														S		S
2540-58161	U	J														L		
2540-58162	U	J														K		
2540-58163	U	J														K		
2540-58164	U	J														K		
2540-58165	F	J														K	K	
2540-58166	U	J														K		
2540-58172	M	A															Q	
2540-58173	U	J															M	D
2540-58174	U	J															M	M[22]
2540-58175	F	A															K	K
2540-58176	M	A															Q	
2540-58177	F	A															K	K
2540-58178	F	J															K	K

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2540-58179	M	J															K	K
2540-58180	U	J															K	
2540-58182	U	J															K	
2540-58183	U	J															K	
2540-58184	F	A															M	M
2540-58185	U	J													P			
2540-58186	M	A													S			
2540-58187	F	A													P		K	
2540-58188	U	J													P			
2540-58189	F	A													P			
2540-58190	U	J														T		
2540-58191	U	J														P		
2540-58192	M	A														Q	Q[23]	M
2540-58193	F	A														N	N	N
2540-58194	U	J														D		
2540-58195	U	J														P		
2540-58196	U	J														P		
2540-58197	U	J														P		
2540-58198	U	J														P		
2540-58199	M	J														K		P
2540-58200	U	J														K		
2540-58201	M	J														K	P	P
2540-58202	M	A														K		K
2540-58203	F	A														K	K	
2540-58204	F	A														K		
2540-58205	U	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
2540-58212	U	J															K	
2540-58213	U	J															M	
2540-58214	U	J															K	
2540-58216	U	J													M			
2540-58217	M	A													S	S		
2540-58218	U	J													S			
2540-58219	U	J													Q			
2540-58220	M	A														B	B	
2540-58221	M	A														B		
2540-58222	U	J														K		

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2540-58223	M	A														K	K	K
2540-58224	F	J														K	K	K
2540-58225	U	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
2540-58232	U	J														T		
2540-58233	F	A														N		
2540-58235	U	J														N		
2540-58236	U	J														N		
2540-58237	U	J														K		
2540-58238	F	J														K	E[24]	
2540-58239	U	J														K		
2540-58240	F	J														K	E	K
2540-58241	F	A														K	K	
2540-58242	U	J														K		
2540-58243	U	J														K		
2540-58244	U	J														K		
2540-58245	M	A															P	K
2540-58246	M	A															E	P
2540-58247	F	J															K	K
2540-58258	U	J																K
2540-58259	U	J																K
2540-58260	U	J																M
2540-58261	F	A																M
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
2540-58274	U	J															N	
2540-58275	U	J															N	
2540-58276	U	J															K	
2540-58277	U	J															K	K
2540-58278	U	L															D	
2540-58279	U	J															D	

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2540-58280	U	J															K	
2540-58282	U	J															K	
2540-58283	U	J															K	
2540-58284	U	J															P	
2540-58285	M	J															P	K
2540-58286	F	J															P	P
2540-58287	M	A															S	S
2540-58288	U	J														P		
2540-58289	F	A														K		
2540-58290	F	J														K		P
2540-58291	U	J														K		
2540-58292	U	J														K		
2540-58293	F	A														P	P	P
2540-58294	U	J														P		
2540-58295	U	J														P		
2540-58296	U	J														P		
2540-58297	F	A															K	
2540-58298	U	J															K	
2540-58299	U	J															K	
2540-58300	U	J																K
2540-58301	U	J																P
2540-58302	U	J																P
2540-58303	U	J																P
2540-58304	U	J																P
2540-58320	U	J																K
2540-58321	U	J																D
2540-58322	F	A																K
2540-58323	U	J																P
2540-58325	U	J																K
2540-58326	U	J																K
2540-58327	U	J																K
2540-58373	U	J																M
2540-58378	U	J															K	
2540-58385	U	J															S	
2540-58386	F	A															K	
2540-58387	M	A															K	K
2590-53101	U	J															P	
2590-53102	U	J															P	
2590-53103	U	J															P	
2590-53104	U	J															P	

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2590-53105	F	A															D	
2590-53106	U	J															M	
2590-53107	M	J															M	Q[25]
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	U	J															K	
2590-53114	U	J															K	
2590-53115	U	J															M	
2590-53116	U	J															M	
2590-53117	U	J															M	Q
2590-53118	U	J															K	
2590-53119	U	J															M	
2590-53121	F	A															K	K
2590-53122	U	J															K	
2590-53123	U	J															K	
2590-53124	M	A															K	
2590-53125	U	J															K	
2590-53126	U	J															D	
2590-53127	U	J															K	
2590-53141	U	J															M	
2590-53142	U	J															M	
2590-53143	U	J															N	
2590-53144	U	J															K	
2590-53145	M	A															S	
2590-53147	U	J															D	
2590-53148	M	A															K	K
2590-53149	U	J															K	
2590-53150	U	J															M	
2590-53151	U	J															M	
2590-53152	U	J															Q	
2590-53153	M	A																K
2590-53154	U	J															Q	
2590-53155	U	J																M
2590-53156	F	A																M
2590-53157	U	J																M
2590-53158	U	J																K
2590-53162	M	A															T	
2590-53163	F	A															B	

Table G.1. Willow Flycatchers Banded and/or Resighted by SWCA along the Virgin and Lower Colorado Rivers in 2003–2012* (Continued)

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]															
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2590-53164	U	J															B	
2590-53165	F	A																B
2590-53166	M	A																T
2590-53171	F	A															E	K
2590-53172	U	J															K	
2590-53173	F	A															K	K
2590-53182	U	J															B	
2660-23012	U	J																K
2660-23014	U	J																P
2660-23024	U	J																M
3500-68963	U	J								T								
3500-68968	U	J								P								
3500-68969	U	J								P								
3500-68972	F	J								P	P	P						

* Table includes individuals banded at sites prior to 2003 (Braden and McKernan, unpubl. data) and recaptured or resighted by SWCA.

[1] K = Key Pittman, 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, I = Imperial, Y = Yuma, S = St. George, V = Las Vegas Wash, R = Roosevelt Lake, A = Ash Meadows. 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, U = unknown.

[3] A = adult, J = juvenile.

[4] Within-season movement from Mormon Mesa to Mesquite.

[5] Within-season movement from Mesquite to Mormon Mesa.

[6] Within-season movement from Mormon Mesa to Mesquite, then from Mesquite back to Mormon Mesa.

[7] Within-season movement from Mesquite to Mormon Mesa.

[8] Within-season movement from Littlefield to Mesquite.

[9] Within-season movement from Grand Canyon to Mesquite.

[10] Within-season movement from Mormon Mesa to Muddy River.

[11] Within-season movement from Muddy River to Mormon Mesa.

[12] Within-season movement from Pahranagat to Key Pittman.

[13] Within-season movement from Muddy River to Mesquite.

[14] Within-season movement from Littlefield to Mesquite.

[15] Within-season movement from Muddy River to Mesquite.

[16] Within-season movement from Grand Canyon to Mesquite.

[17] Within-season movement from Grand Canyon to Mormon Mesa.

[18] Within-season movement from River Ranch to Key Pittman.

[19] Within-season movement from River Ranch to Key Pittman.

[20] Within-season movement from Pahranagat to River Ranch.

[21] Within-season movement from Muddy River to Mormon Mesa. Likely also within-season movement from Topock to Muddy River in 2010.

[22] Within-season movement from Mormon Mesa to Muddy River.

[23] Within-season movement from Mesquite to Mormon Mesa.

[24] Within-season movement from River Ranch to Key Pittman.

[25] Within-season movement from Mesquite to Key Pittman.

Appendix H

ANDERSON-OHMART VEGETATION CLASSIFICATIONS OF SITES OCCUPIED BY SOUTHWESTERN WILLOW FLYCATCHERS

Table H.1. Anderson-Ohmart Vegetation Classification of Sites Occupied by Southwestern Willow Flycatchers and Sampled for Vegetation Characteristics, 2003–2011

Study Area[1]	Survey Site	Community[2]	Structural Class	Comments
LIFI	North	CW	III	
	Poles	CW	II and III	CW III in nest area. CW II for remainder of site.
MESQ	West	CW	III	
	Bunker Farm	CW	III	CW III in nest area. SC III for remainder of site.
	Bunker Marsh North	CW	III	CW III in nest area. SC III for remainder of site.
MOME	North	CW	III	
	Virgin River #1 North	CW	I	
	Virgin River #1 South	CW	III	
	Virgin River #2	CW	I	
	Delta West	CW	I	
MUDD	Overton Pond	CW	I	
	Overton WMA	CW	II and III	CW III in northern nesting area, CW II in southern nesting area, SC II for remainder of site
GRCA	RM 274.5	CW	II	
	RM 285.3	CW	II	
TOPO	Pipes #3	SC	II	A few emergent willows
	The Wallows	CW	I	CW I immediately surrounding the marsh
	PC6-1	SC	II	A few emergent willows
	Pig Hole	SC	II	
	In Between	SC	II	
	800M	SC	II	
	Pierced Egg	SC	II	A few emergent willows
	Hell Bird	CW	III	
	Glory Hole	CW	III	
BIWI	Burn Edge	CW	I	
	Site #4	CW	I	
	Site #3	CW	I and III	CW I in majority of site. CW III in main nest area
	Site #5	CW	I	
	Upstream from Site #8	CW	I	
	Planet Ranch Road	CW	III	

[1] LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, GRCA = Grand Canyon, TOPO = Topock Marsh, BIWI = Bill Williams River NWR.

[2] CW = cottonwood-willow, SC = salt cedar

Appendix I

HYDROGRAPHS FOR PIEZOMETERS AT HABITAT MONITORING SITES

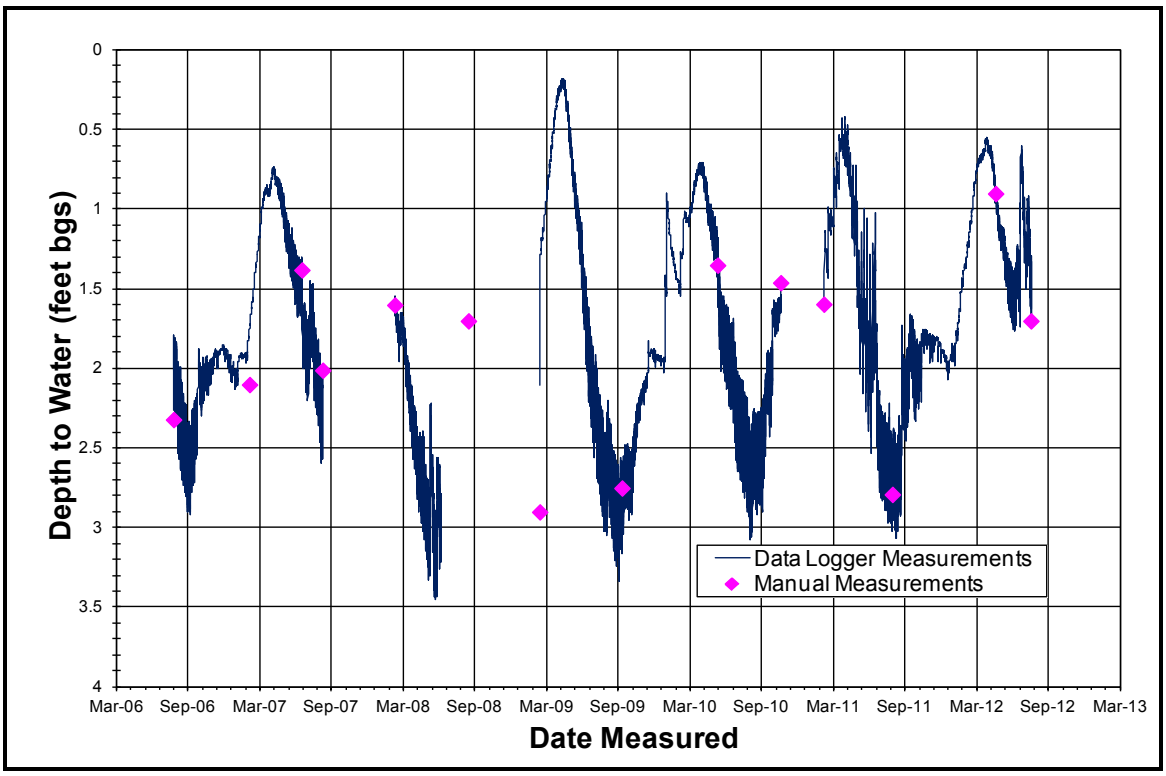


Figure I.1. Hydrograph for piezometer at Topock Marsh.

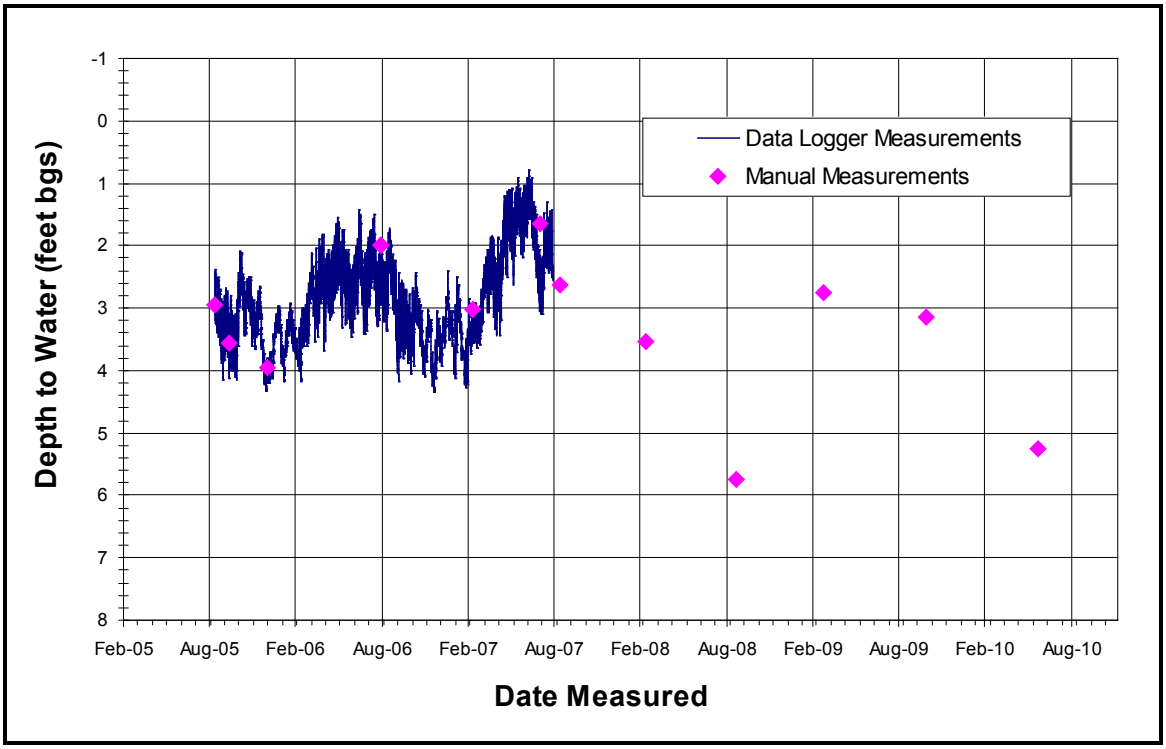


Figure I.2. Hydrograph for piezometer at Blankenship Bend.

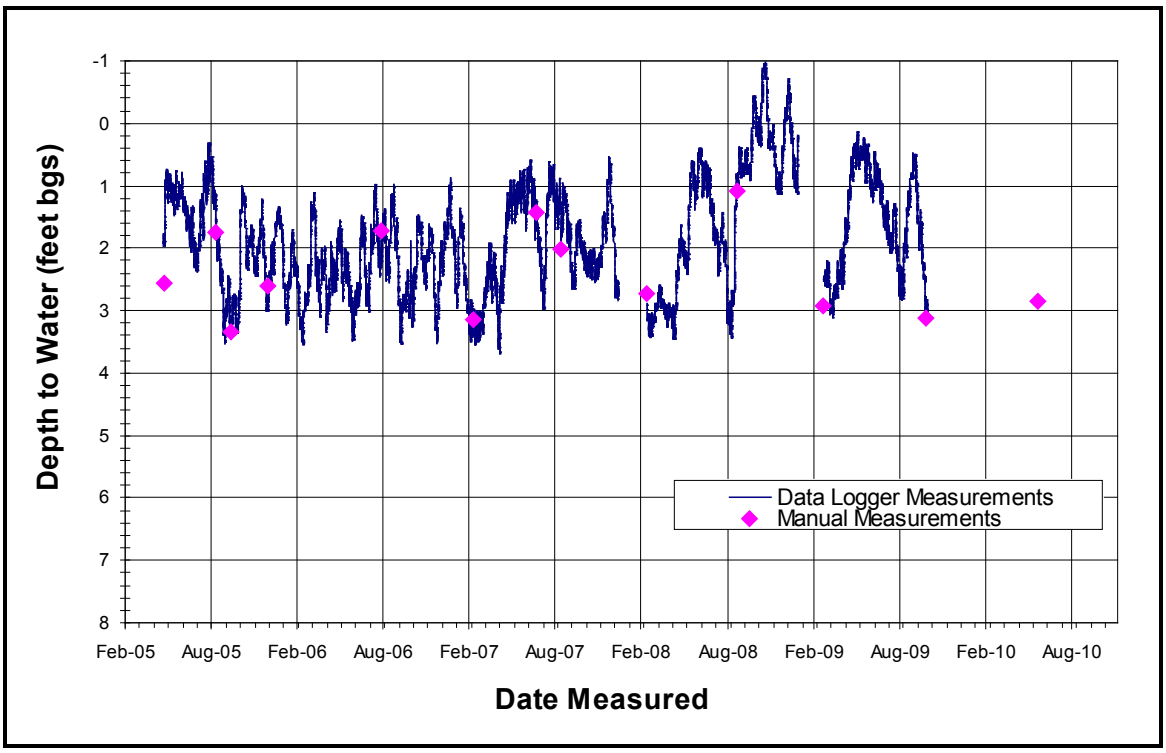


Figure I.3. Hydrograph for piezometer at Havasu NE.

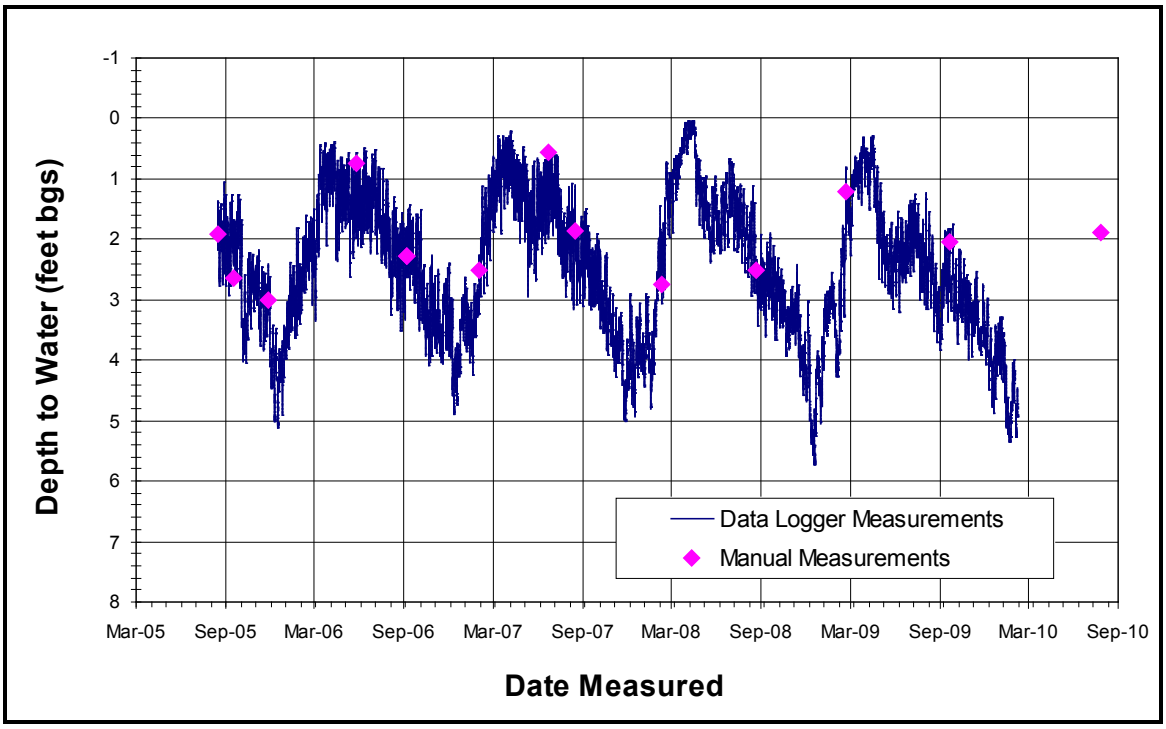


Figure I.4. Hydrograph for piezometer at Ehrenberg.

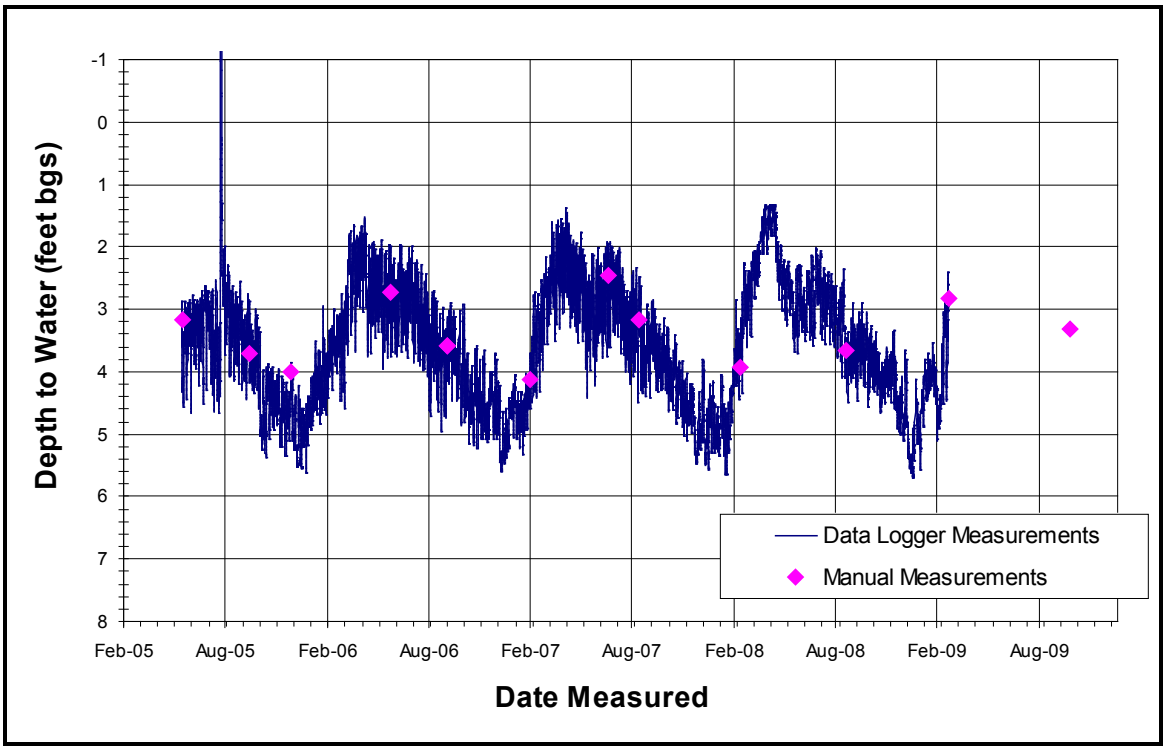


Figure I.5. Hydrograph for piezometer at Three Fingers Lake.

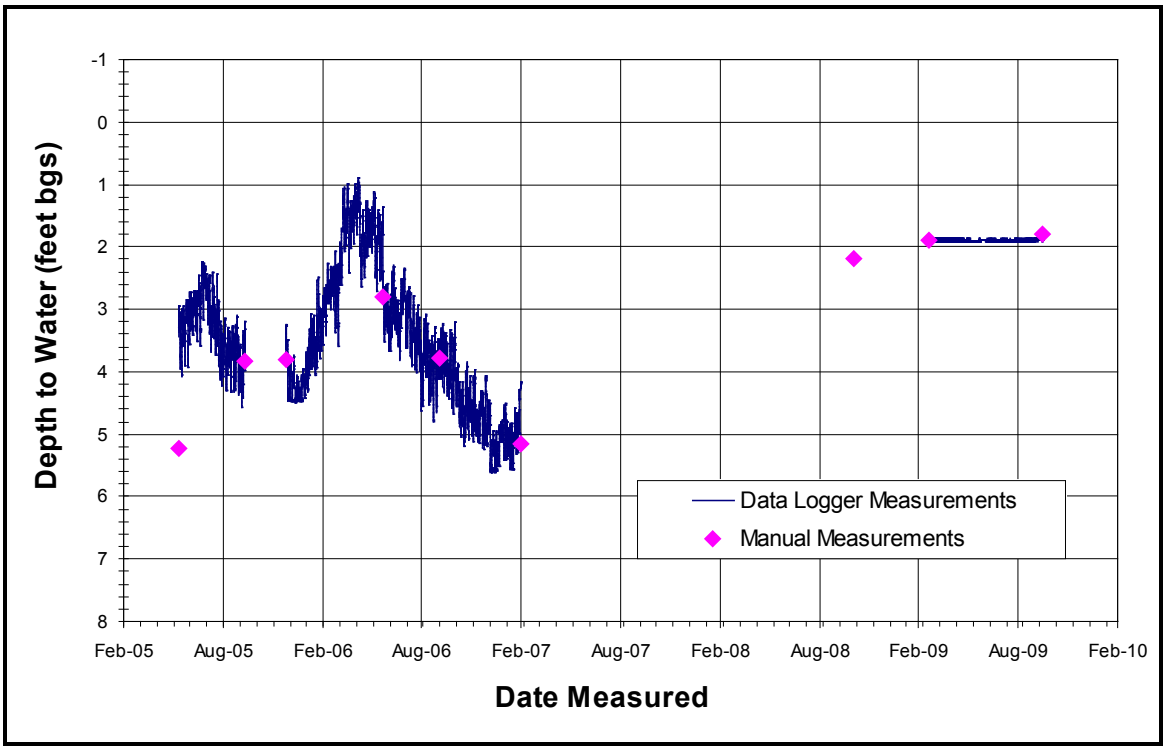


Figure I.6. Hydrograph for piezometer at Cibola Lake.

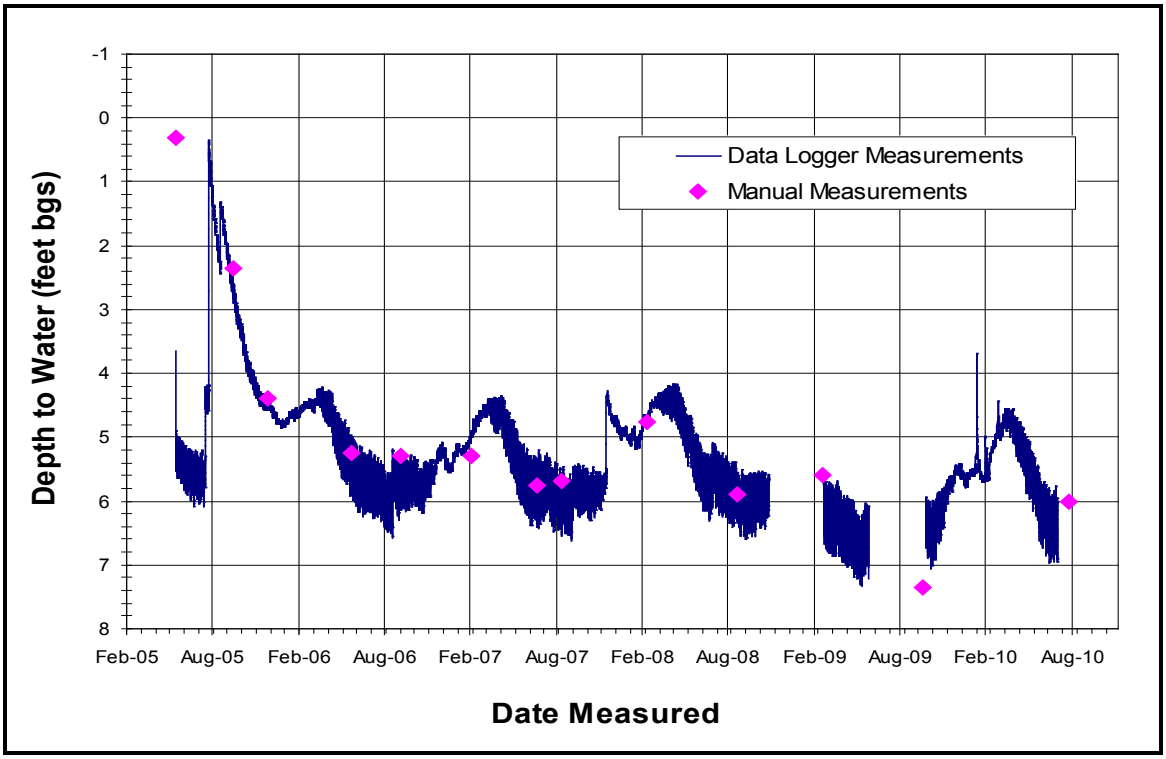


Figure I.7. Hydrograph for piezometer at Walker Lake.

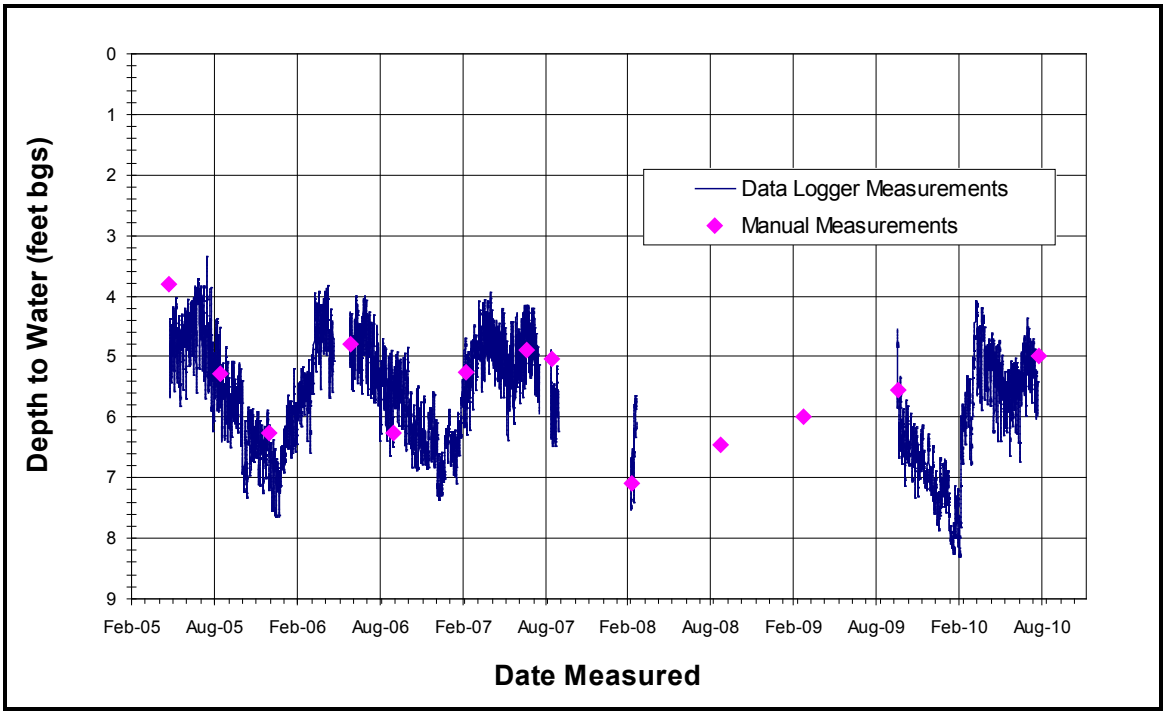


Figure I.8. Hydrograph for piezometer at Paradise.

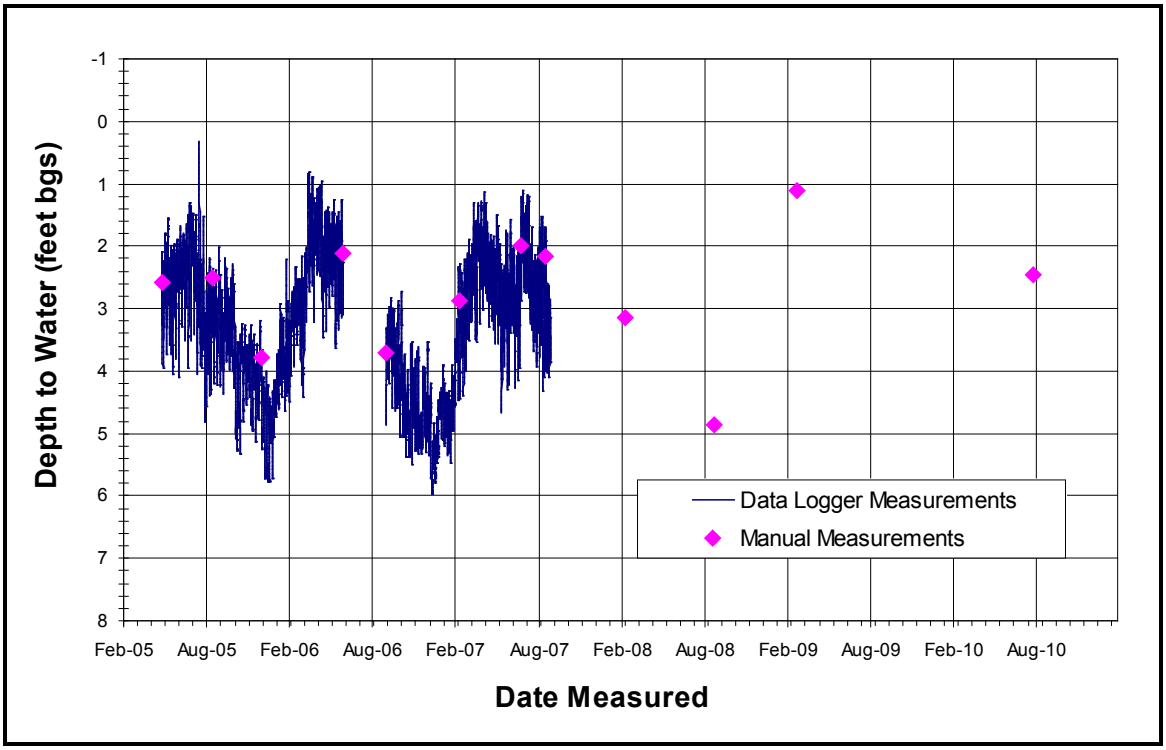


Figure I.9. Hydrograph for piezometer at Hoge Ranch.

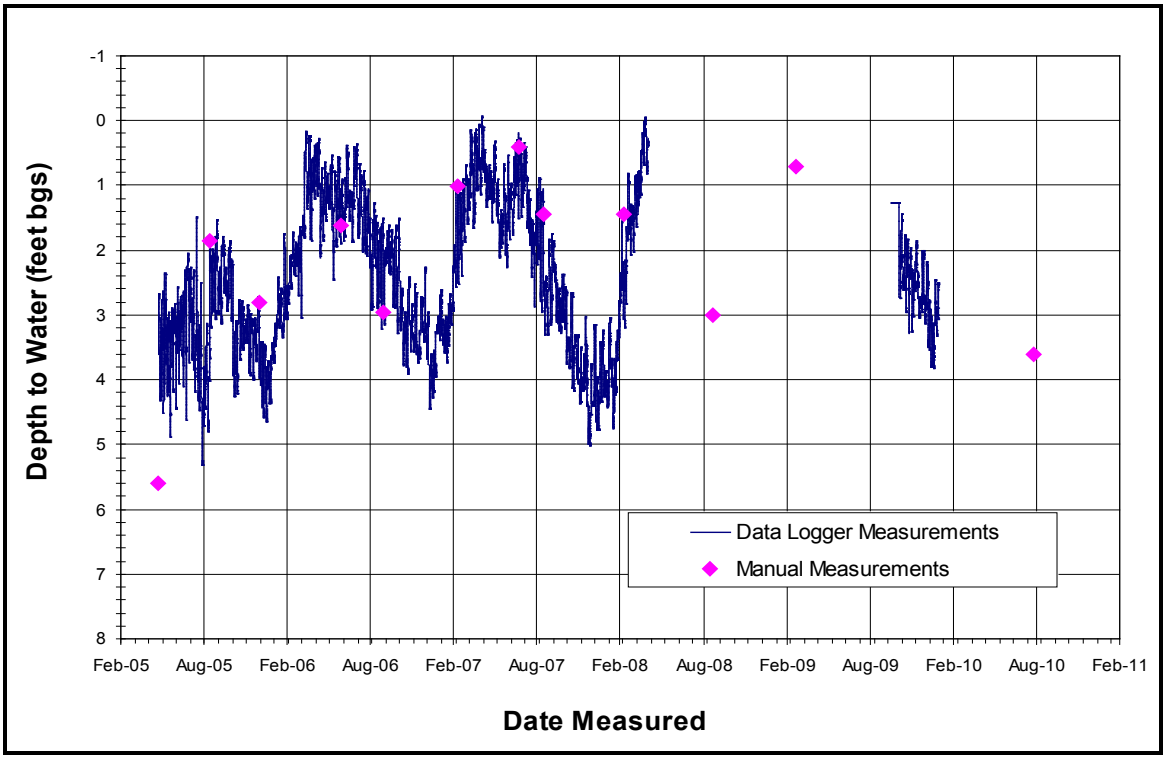


Figure I.10. Hydrograph for piezometer at Rattlesnake.

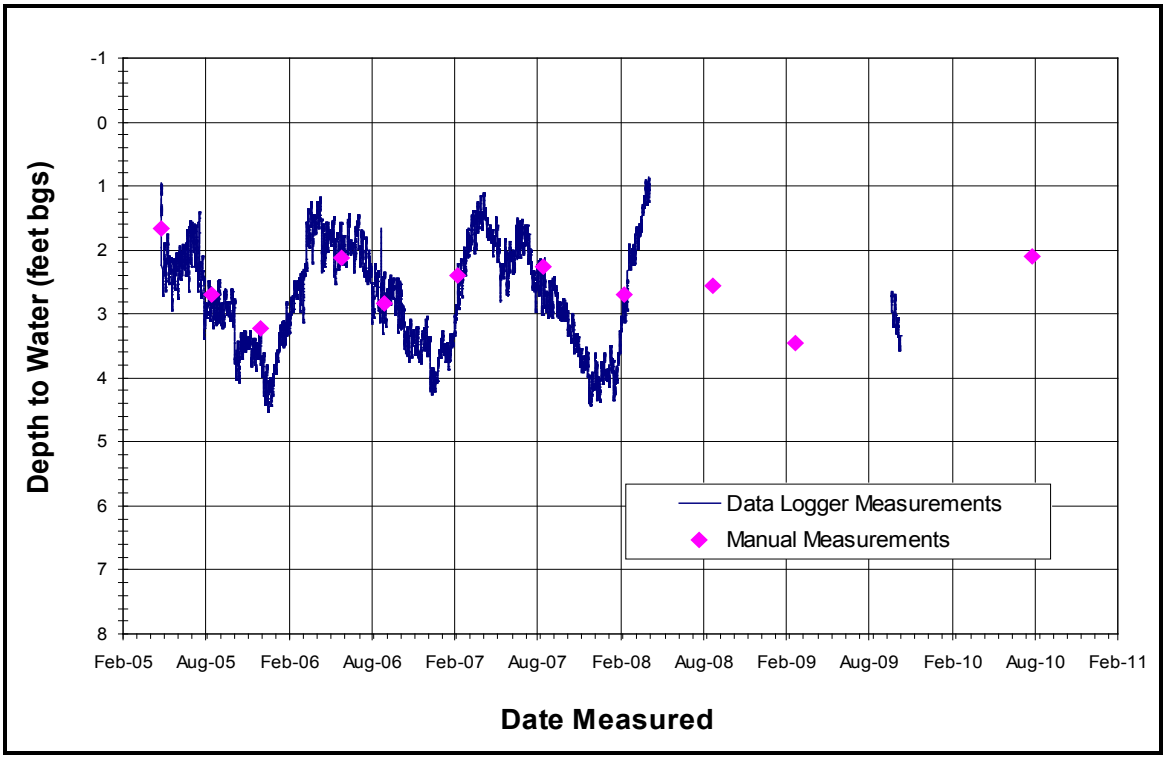


Figure I.11. Hydrograph for piezometer at Clear Lake.

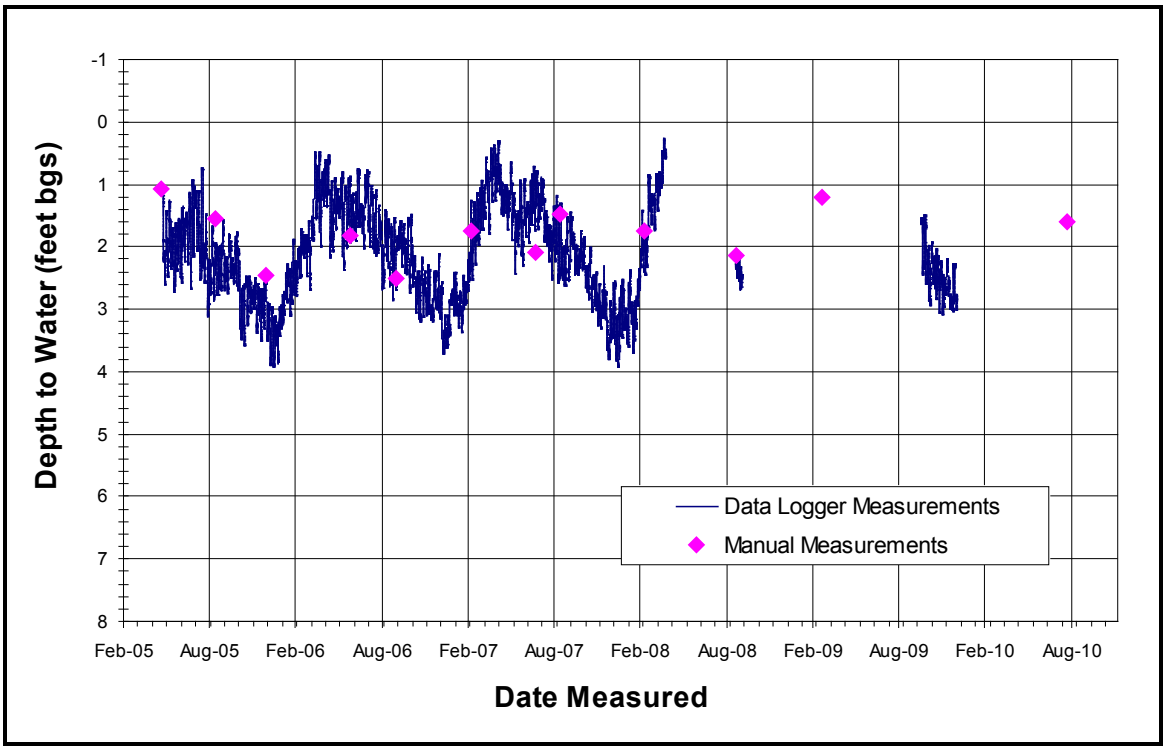


Figure I.12. Hydrograph for piezometer at Ferguson Lake.

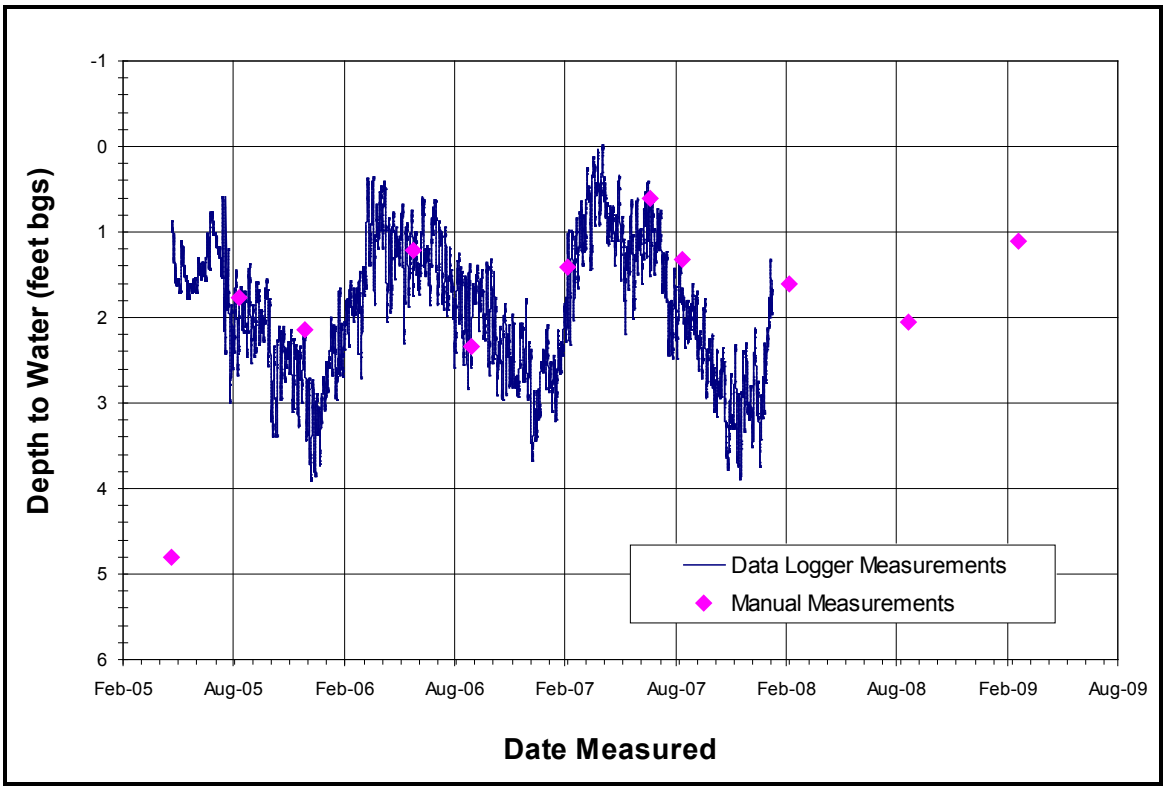


Figure I.13. Hydrograph for piezometer at Ferguson Wash.

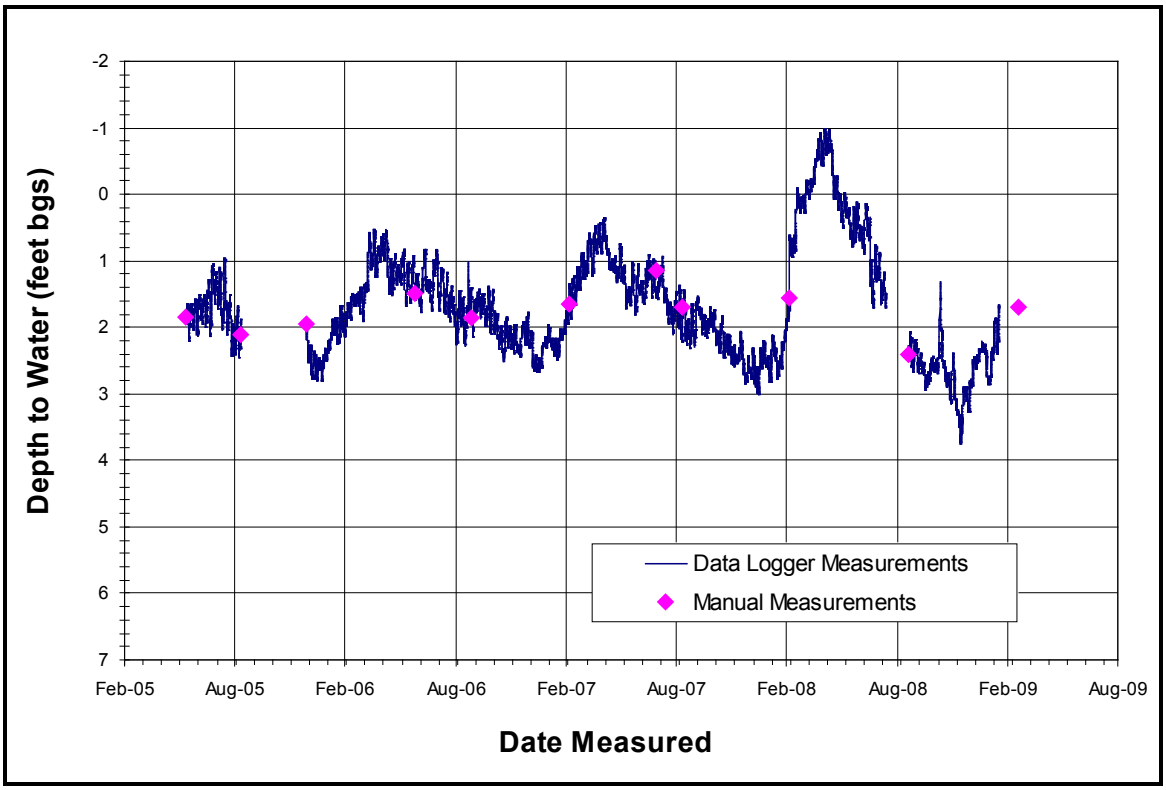


Figure I.14. Hydrograph for piezometer at Great Blue Heron.

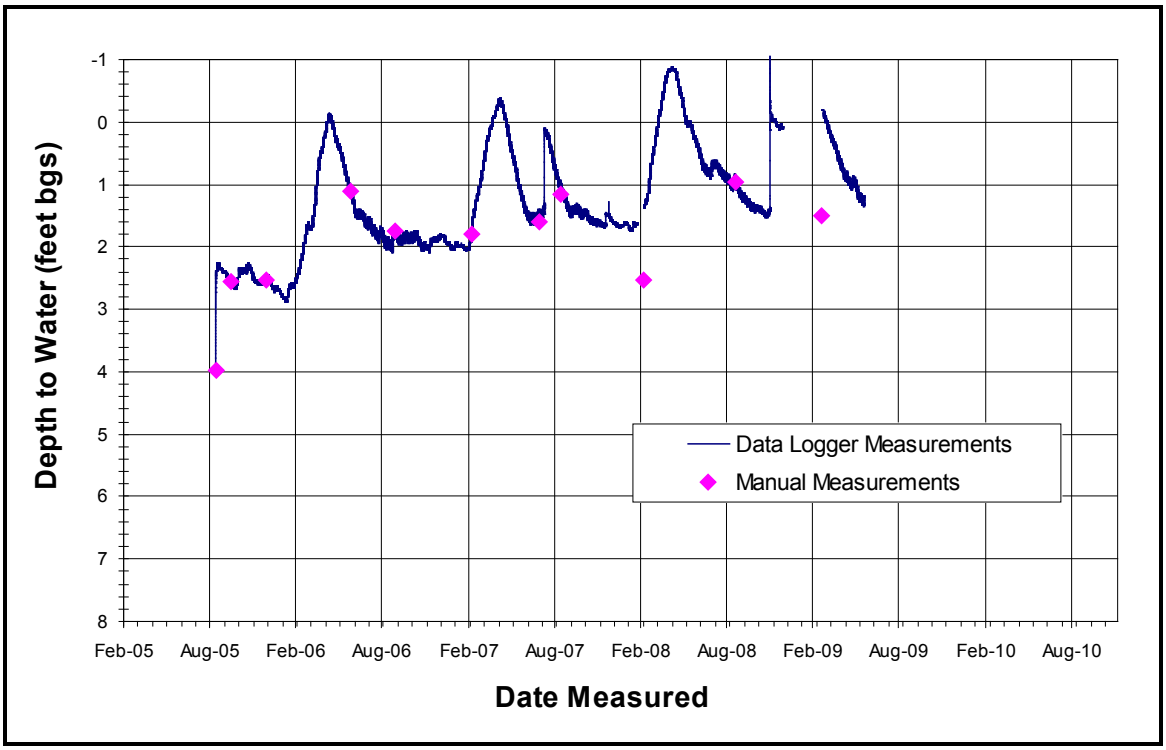


Figure I.15. Hydrograph for piezometer at Mittry West.

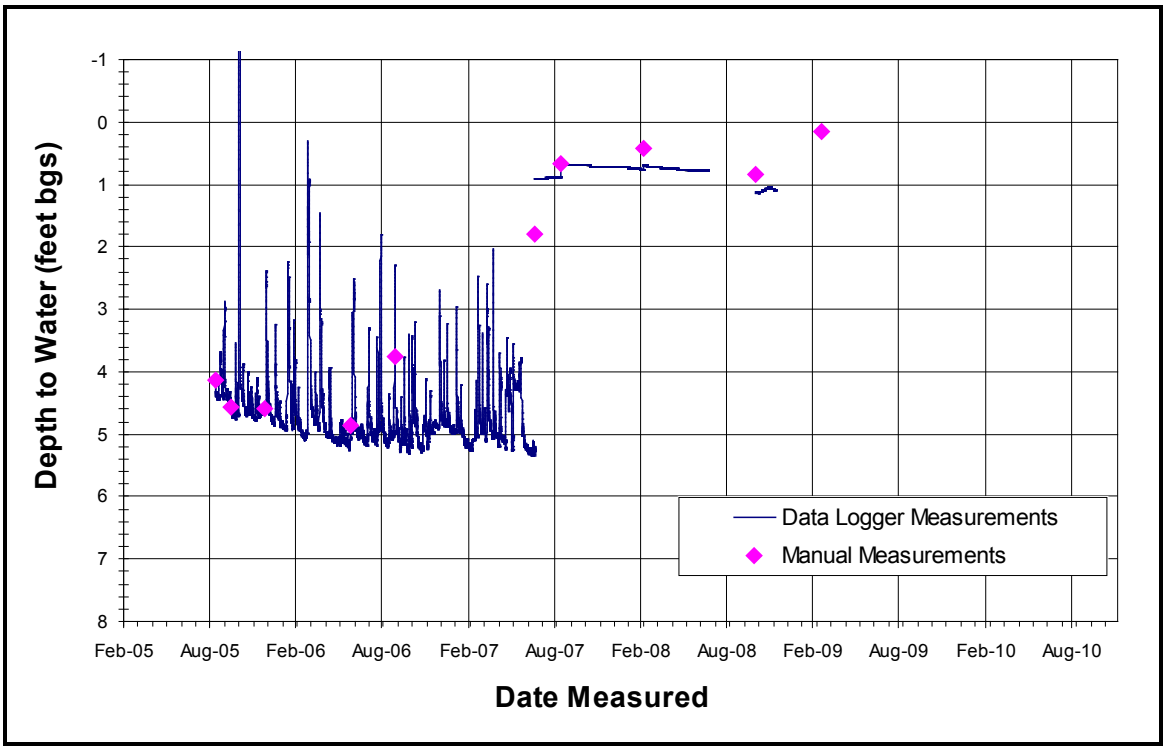


Figure I.16. Hydrograph for piezometer at Gila Confluence North.

Appendix J

ANALYSIS OF RELATIONSHIP BETWEEN PIEZOMETER WATER LEVEL AND HUMIDITY

Statistical Consulting Report

Statistical Consulting Service

Departments of Statistics and Biostatistics

University of Washington

To: Wendy Langeberg

Department: Epidemiology

From: Michael Sachs

Consultants: Paul Sampson, Michael Sachs, Frankline Onchiri

Report Date: November 6, 2007

Consultation Date: October 19, 2007

Dear Wendy,

This report discusses our meeting and the subsequent analysis of your research problem. You came to us seeking advice for your study of the microclimate of Southwestern Willow Flycatcher nesting habitats. The study involved several territories in which these birds preferred to make their nests. One territory was different in that it is near a river that has been dammed. The dam has caused changes in ground water levels at the nesting sites. One of the specific aims of the study is to assess the association between ground water levels and absolute humidity at the nesting sites. The longitudinal and nonlinear nature of the data made the analysis somewhat difficult, which is why I offered to write this report.

In the following report I will first summarize the research problem to show my understanding of the scientific problem you wish to address, then present my analysis plan and results. My analysis uses a linear mixed effects model that models absolute humidity as a function of ground water, adjusting for time and relative humidity. I used a natural spline to model the time ef-

feet, which was strong and non-linear. We found a statistically significant negative association between ground water and absolute humidity. The site-specific association was significant, but the marginal association was not. On average, we observed about a -0.35 unit change in absolute humidity associated with a unit deviation in ground water from the site-specific mean. This association tends to vary with time. We observed a quadratic relationship between the association over time. Further details are in the text.

I sincerely hope you find this helpful for your research. It has been an interesting problem to work on. If you have any questions about the report you can contact me by e-mail.

Sincerely,

Michael Sachs

1 Background

The client is doing a study of bird habitats and how they're related to microclimate. She has gathered data at several nesting sites in several territories. One of the territories is along a river which has been dammed. In this particular territory, the client is interested in assessing the association between ground water and humidity.

The client has collected longitudinal data for 15 sites near a river. These sites will be treated as independent units. She has daily measurements spanning a 1.5 year period between Spring 2005 and Fall 2006. There are 463 distinct time points, with an average of about 394 time points per site. The humidity at each nesting site is measured with a sensor called a hobo and the ground water is measured using a piezometer. She also has data for the relative humidity for the region, which is the same at each site for any given time. Relative humidity is measured both at the top and the bottom of the dam. The available variables are summarized in table 1. Her specific questions are

1. Is absolute humidity at the nests associated with ground water levels, adjusting for regional relative humidity?
2. If so, does this association differ by time?

2 Analysis Plan

Table 2 presents some descriptive statistics of the variables. There are several negative values for ground water, which I suppose indicates that the water level was below the reference point. Figure 1 shows a scatterplot of absolute humidity versus ground water. This suggests a weak negative association, but this figure completely ignores time. Figure 2 shows a plot of

absolute humidity, the outcome of interest, over time. You can see that there is a strong, non-linear time trend. Similarly, figure 3 shows a plot of ground water, our predictor of interest, over time. There is a lowess smoother fit for each of the 15 sites. Again we observe a non-linear association. Time here is clearly a confounder, since it is associated with both our outcome and predictor of interest. We want to adjust for time, but in a flexible way since the time trend is non-linear. We will do this using a natural spline. Figure 4 shows the absolute humidity residuals from a spline fit versus time. You can see that the spline removes the mean effect, but the variation does appear to differ over time.

Let X_{it} denote the ground water level at site i, at time t, and let Y_{it} denote the absolute humidity at site i and time t. W_t will denote the relative humidity at time t. We want to fit the linear model

$$Y_{it} = \alpha_i + \beta_M \overline{X}_{i\cdot} + \beta_S(X_{it} - \overline{X}_{i\cdot}) + \gamma W_t + f(t) + \varepsilon_{it}$$

where $\overline{X}_{i\cdot}$ is the mean ground water level at site i, α_i is a site-specific random slope and f is a spline (a piece-wise cubic polynomial). β_M can be interpreted as the expected difference in absolute humidity associated with a unit increase in the time-averaged value of ground water. This is a measure of the marginal association, since it is averaged over time and suggests the overall trend across the sites. β_S is interpreted as the expected difference in absolute humidity associated with a unit difference in ground water from the site average. This is the site-specific association, because the difference is relative to the site-specific averages. γ is the unit difference in absolute humidity associated with a unit difference in relative humidity. This parameter is not of interest. $f(t)$ can be estimated by representing time in terms of the 8 basis functions that determine the spline and including those bases in the linear model. The 8 parameters associated with the bases are impossible to interpret. The time trend is apparent from the plots, and

including it in the model ensures that we are adjusting for that confounder.

If β_S is found to be significantly different from zero, then we will test the interaction between ground water and time. That is we will fit the model,

$$Y_{it} = \alpha_i + \beta_M \overline{X}_{i\cdot} + \beta_S(X_{it} - \overline{X}_{i\cdot}) + f(t) \cdot \beta_S(X_{it} - \overline{X}_{i\cdot}) + \gamma W_t + f(t) + \varepsilon_{it}$$

and then test whether the fourth term (the interaction) contributes to the overall model fit using a likelihood ratio test. Again, the interaction parameters are impossible to interpret, but the test will give us some idea whether the association between ground water and absolute humidity varies over time.

3 Results

Figure 5 shows scatterplots absolute humidity and ground water versus the two regional humidity measures. Regional humidity appears to be associated with absolute humidity, but not with ground water. Regional humidity is thus a precision variable and so we will adjust for it. Figure 6 shows a scatterplot of the absolute humidity residuals from a natural spline fit versus ground water. The solid line is the linear fit. You can see that there is a weak negative association. This association is confirmed in the fitted models summarized in table 3. The parameter estimates corresponding to the spline bases are omitted from the table. The parameter estimates suggest that there is not a significant marginal association, but the site-specific association is significant. The site-specific effect is significant both in the unadjusted and the adjusted models. Figure 7 shows the linear trends from site-specific fits, and the solid line is the average or marginal trend. This plot shows that overall there is a slight negative association, but there is some variability in the association between sites.

The likelihood ratio test for the interaction effect was found to be highly

significant ($p < 0.0001$), both marginally, and adjusting for regional humidity. This suggests that the association between ground water and absolute humidity does vary with time. To explore this further I fit a separate linear model for each unique time point with more than 9 observations. The linear model has absolute humidity as the outcome and ground water as the predictor. Figure 8 shows a plot of the coefficients over time. You can see that there is a quadratic trend. At the start of the study period, the association tends to be stronger and negative. The strength of the association weakens toward zero until about Spring of 2006, when the association tends to strengthen negatively again.

In summary, based on these analyses, I conclude that ground water is negatively associated with absolute humidity, both independently of and adjusting for regional humidity. This association does differ over time, but this interaction effect is non-linear. Time is clearly the strongest predictor of absolute humidity, but adjusting for time we do observe an association between ground water and absolute humidity.

4 Figures and Tables

abbreviation	description	units	role
site	nesting site	1-15	cluster identifier
time	time of measurement	days	potential confounder
reghum1	regional humidity at top of dam	percent	confounder/precision variable
reghum2	regional humidity at bottom of dam	percent	confounder/precision variable
abshumid	absolute humidity at nest	g/m^3	outcome
gdh20	ground water level at nest/time	(height)	predictor of interest
gdh20.bar	mean ground water level over time	(height)	predictor of interest (marginal)

Table 1: Variable description

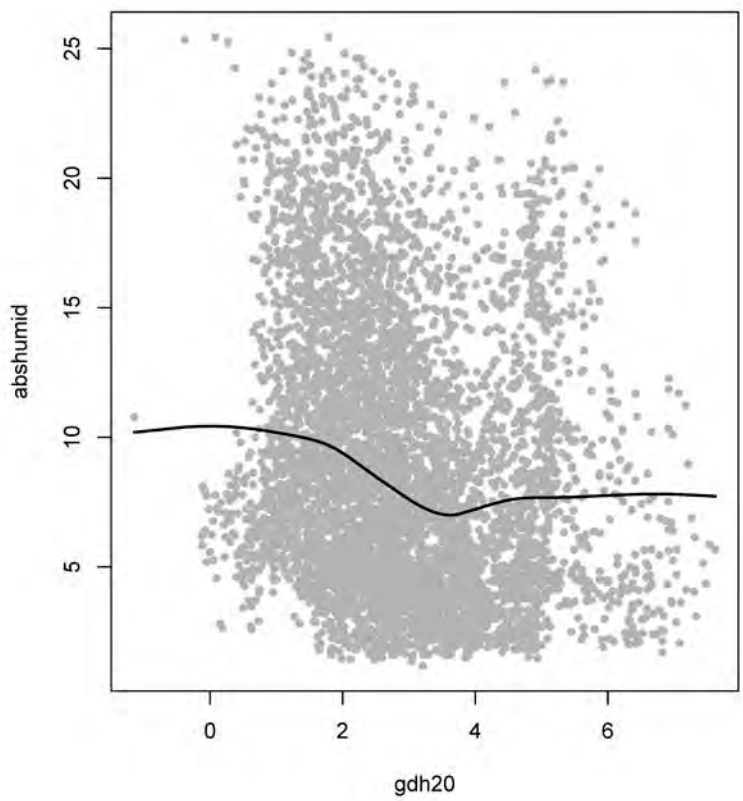


Figure 1: Naive plot of ground water (gdh20) versus absolute humidity. This plot ignores the time effect.

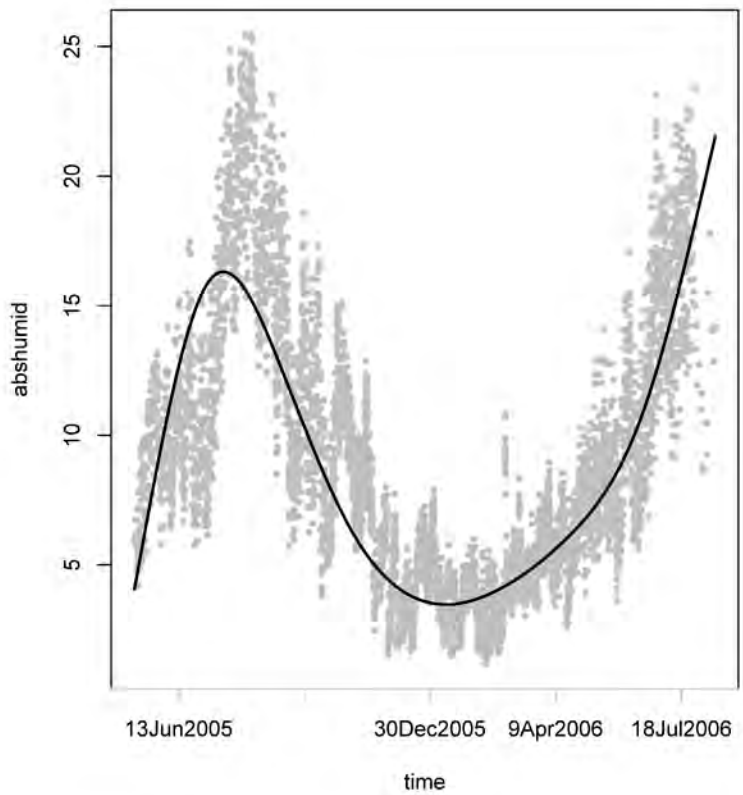


Figure 2: Plot of absolute humidity over time and a natural spline fit with 8 degrees of freedom. You can see that the time trend is strong and non-linear. Since there is such a strong association with the outcome, time is something we want to adjust for in assessing the association with ground water.

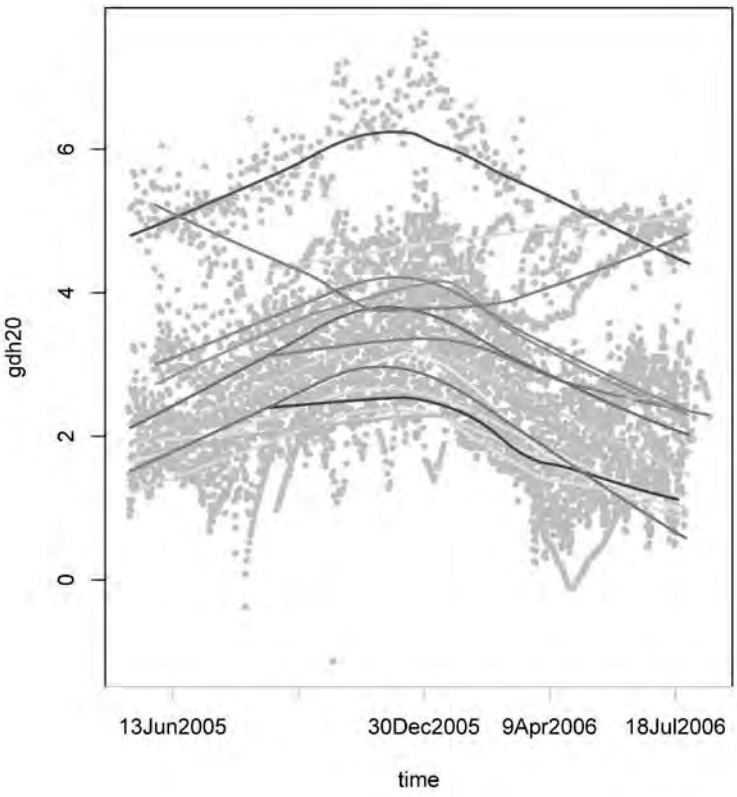


Figure 3: Plot of ground water over time, with a lowess smooth for each nesting site. Time is clearly associated with ground water in a nonlinear way, although the association is not as strong as that with absolute humidity.

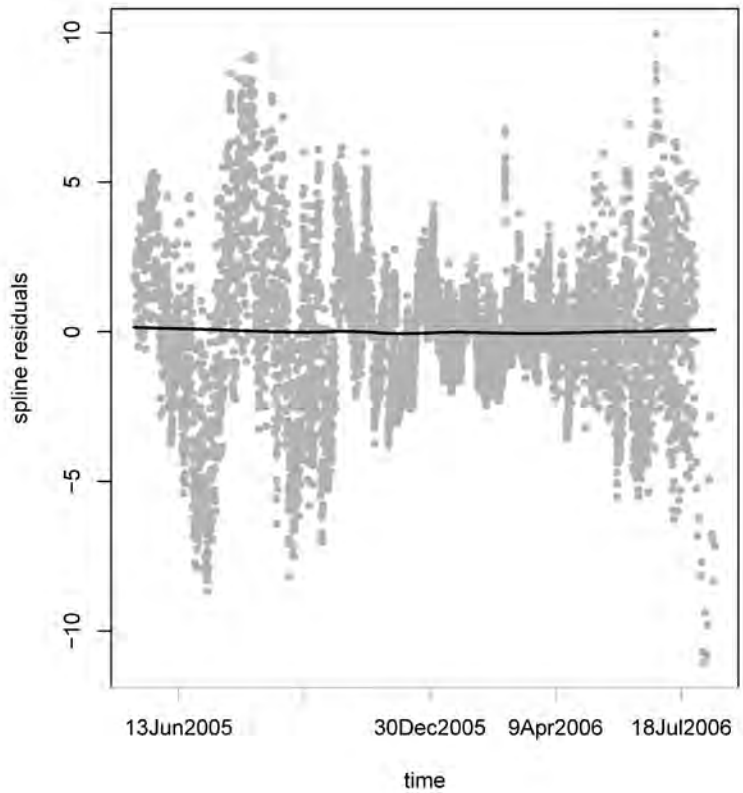


Figure 4: This is a plot of the residuals from a fit of absolute humidity as a function of time, using a natural spline with 8 degrees of freedom. This removed the mean time effect, but you can still see that the variance in not constant in time. The plan is to fit a linear mixed model with these residuals as the outcome and ground water as the predictor. It remains to choose an appropriate variance model. Based on the science and some exploratory analysis, I think a model with random intercepts would be appropriate.

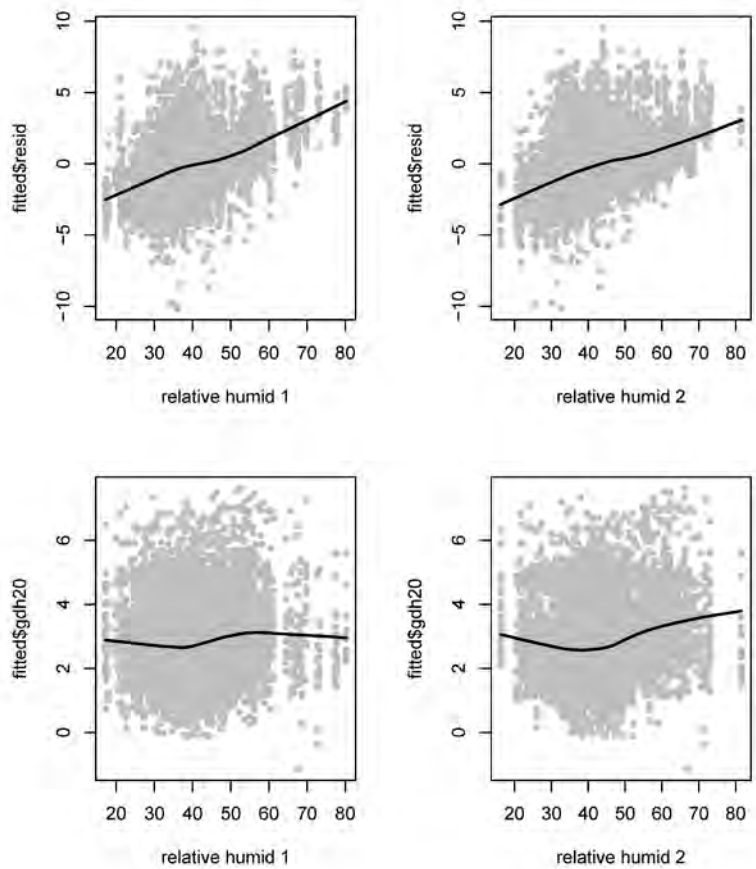


Figure 5: This plot explores associations with the two potential confounders: relative humidity at the top of the dam (reghum1) and relative humidity at the bottom of the dam (reghum2). They are highly correlated with each other (R = .79), but they are only associated with the outcome of interest (residuals from absolute humidity). They are potential precision variables, but we should only adjust for one of them, since they are so highly correlated.

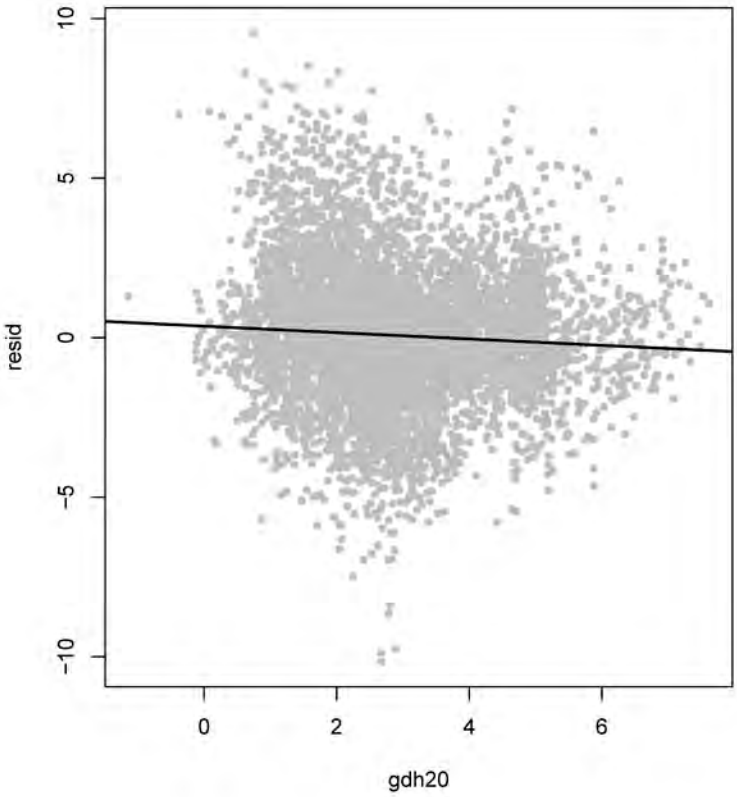


Figure 6: This is a plot of ground water versus the residuals with a linear fit. You can see that there is a very weak negative association. The marginal slope is about −0.1.

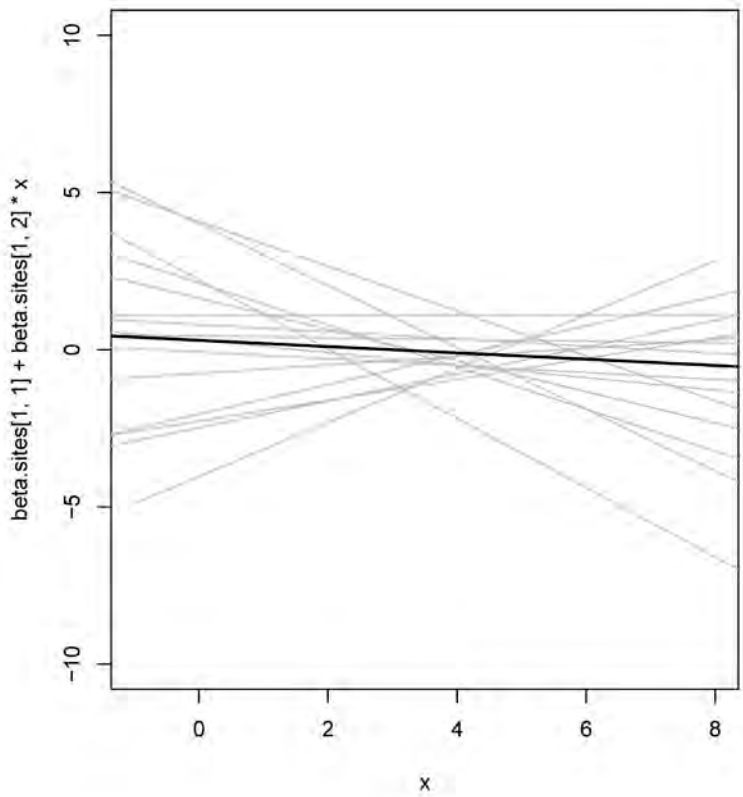


Figure 7: This is a plot of the site specific linear fits in gray, and the marginal fit in black. You can see how much the association varies from site to site.

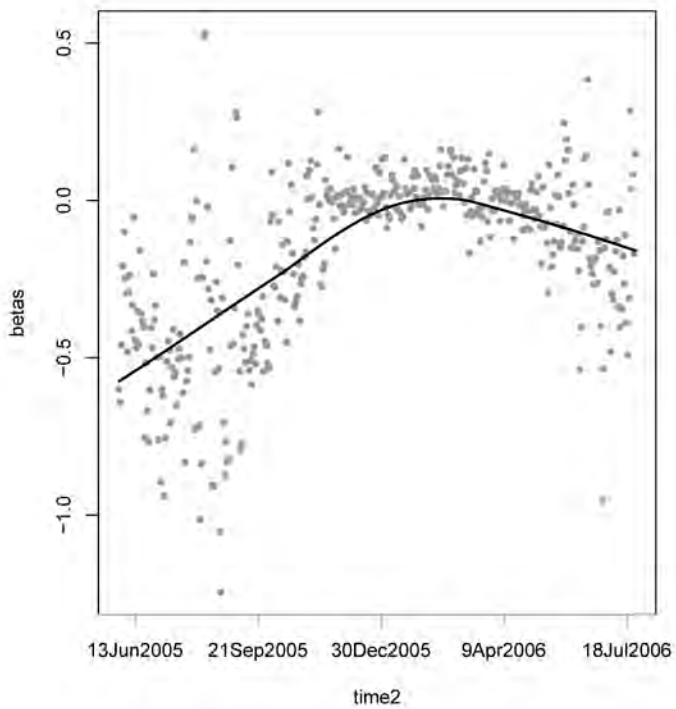


Figure 8: A linear model was fit for each time point that had more than 9 observations. This is a plot of the coefficients for ground water over time. The solid line is a lowess smoother.

variable	mean	sd	min	max
reghum1	41.21	10.16	17.19	80.17
reghum2	43.65	11.25	16.29	81.51
abshumid	8.88	5.16	1.18	25.44
gdh20	2.9	1.34	-1.14	7.62
gdh20.bar	2.9	1.05	1.68	5.58

Table 2: Simple descriptive statistics

	estimate	95% CI		p-value
	Unadjusted			
intercept	3.97	2.48	5.46	< 0.001
gdh20.bar	-0.12	-0.58	0.35	0.61
gdh20 - gdh20.bar	-0.34	-0.43	-0.24	<0.001
	Adjusted for relative humidity at top of dam			
intercept	-4.44	-5.90	-2.98	<0.001
gdh20.bar	-0.12	-0.58	0.34	0.61
gdh20 - gdh20.bar	-0.35	-0.43	-0.28	< 0.001
relhumid1	0.15	0.14	0.15	< 0.001
	Adjusted for relative humidity at bottom of dam			
intercept	-5.64	-7.10	-4.18	<0.001
gdh20.bar	-0.11	-0.57	0.34	0.63
gdh20 - gdh20.bar	-0.34	-0.41	-0.26	<0.001
relhumid2	0.15	0.15	0.16	<0.001

Table 3: Summary table of linear mixed model estimates. The gdh20.bar term is the ground water level at each site averaged over time. The estimate for that parameter is interpreted as the marginal association with absolute humidity. The gdh20 - gdh20.bar term is the difference in ground water from the average for that site. Its parameter is interpreted as the "site-specific" association. All models with fit using maximum likelihood with random intercepts. The marginal associations are not significantly different from zero. The site specific associations are very small as a unit difference in ground water is associated with about a -0.35 unit difference in absolute humidity. This association is significant both in the unadjusted model and when we adjust for either measure of regional humidity.