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SOUTHWESTERN WILLOW FLYCATCHER SURVEYS, DEMOGRAPHY, AND ECOLOGY ALONG THE LOWER COLORADO RIVER AND TRIBUTARIES, 2007

Contract No. 03-CS-30-0093

Submitted to
Bureau of Reclamation
Lower Colorado Region
500 Fir Street
Boulder City, NV 89005

Submitted by
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Flagstaff, Arizona
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Bureau of Reclamation

SOUTHWESTERN WILLOW FLYCATCHER SURVEYS, DEMOGRAPHY, AND ECOLOGY ALONG THE LOWER COLORADO RIVER AND TRIBUTARIES, 2007

Contract # 03-CS-30-0093

Annual Report

Submitted to

BUREAU OF RECLAMATION
Lower Colorado Region
500 Fir Street
Boulder City, Nevada 89005

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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 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 calls for continued surveys and monitoring of willow flycatchers along the lower Colorado River. The LCR MSCP was signed in April 2005, and implementation of the program began in October 2005.

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, will 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 2005–2007, these studies were continued and expanded by SWCA Environmental Consultants (SWCA) to address how the hydrological changes might affect riparian habitats along the Parker to Imperial reach.

From 1997 to 2007, breeding populations of Southwestern Willow Flycatchers were documented along the Virgin and lower Colorado Rivers and tributaries at eight study areas from Pahranagat National Wildlife Refuge, Nevada, south to the Bill Williams River in Arizona. Willow flycatchers also have been detected during the breeding season at several sites along the Colorado River south of the Bill Williams River to the Mexico border, with over 200 detections recorded in 2003, over 600 in 2004, over 300 in 2005, and over 450 detections in 2006 and 2007. Behavioral observations and timing of detections strongly suggest this section of the river corridor is a major flyway for migrant willow flycatchers in spring. The degree to which migrant Southwestern Willow Flycatchers use the lower Colorado River corridor is unknown and requires further study.

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 2007. We completed presence/absence surveys and site descriptions at 101 sites in 15 study areas from the Pahranagat National Wildlife Refuge (NWR), Nevada, south to Yuma, Arizona. We also conducted intensive life history studies at 4 of the 15 areas: Pahranagat NWR, Mesquite, and Mormon Mesa, Nevada, and Topock Marsh, Arizona. At these life history study areas, we monitored willow flycatcher nests to document depredation and brood parasitism rates and nesting success; color-banded and resighted as many willow flycatchers as possible to determine the breeding status of territorial flycatchers and document movement and recruitment; and measured characteristics of vegetation and microclimate at nest sites and at unused sites to assess factors important in nest-site selection. We implemented trapping and removal of Brown-headed Cowbirds at three of the four life history study areas to evaluate the effects of trapping on nest brood parasitism and flycatcher nest success. Additionally, we conducted nest monitoring, color-banding, and resighting, and measured characteristics of vegetation at the Muddy River Delta, Nevada, and at Grand Canyon and Bill Williams, Arizona; microclimate studies were also conducted at the Muddy River Delta.

We used recorded broadcasts of willow flycatcher song and calls to elicit responses from willow flycatchers at 101 sites, ranging in size from 1 to 68 ha, along the Virgin and lower Colorado Rivers and tributaries between 15 May and 28 July 2007, following a 10-survey protocol. We detected willow flycatchers on at least one occasion at 73 of these sites. Resident, breeding flycatchers were detected at 11 sites within the following seven study areas: Pahranagat NWR, Mesquite, Mormon Mesa, Muddy River, Grand Canyon, Topock Marsh, and Bill Williams. A resident flycatcher was also detected at Littlefield, AZ. South of Bill Williams, over 450 willow flycatchers were recorded between 9 May and 20 June; no flycatcher detections were recorded at any sites south of Bill Williams after 20 June. Monitoring results suggest these flycatchers were not resident, breeding individuals and were most likely spring migrants.

We used targeted mist-net and passive netting techniques to capture and uniquely color-band adult and fledgling willow flycatchers at the four life history study areas and at all survey sites where resident willow flycatchers were detected. Nestlings were banded between 8 and 10 days of age. We banded each adult and fledged willow flycatcher with a single anodized (colored), numbered U.S. federal aluminum band on one leg and one colored, aluminum band on the other. Nestlings were banded with a single anodized numbered federal band, uniquely identifying it as a returning nestling in the event it returns in a subsequent year. We used binoculars to determine the identity of previously color-banded flycatchers by observing, from a distance, the unique color combinations on their legs.

At the four life history study areas and at Muddy River, Grand Canyon, and Bill Williams (all monitoring sites), we color-banded 30 new adult flycatchers and recaptured 23 individuals banded in previous years, including 11 flycatchers banded as juveniles in previous years. An additional 62 previously banded flycatchers were resighted, of which 47 could be identified to individual; 10 were banded as juveniles in 2003–2006 but could not be recaptured to determine origin and identity, 1 had a federal band on one leg and an injury on the other leg, 1 had a half plastic band on one leg and a federal band on the other, and 3 did not have their band combinations confirmed. We banded 55 nestlings from 25 nests. In addition, we captured one previously unbanded fledgling. We banded flycatchers opportunistically at Key Pittman Wildlife Management Area, capturing and color-banding one new adult and recapturing two returning nestlings. Four nestlings from one nest were banded.

For the fifth consecutive year, we conducted color-banding studies from 10–30 June along the lower Colorado River downstream of Parker Dam to better determine flycatcher residency, breeding status, and movement patterns in this area. We recorded 52 willow flycatcher detections at 12 sites along the Colorado River from Big Hole Slough south to Hunter's Hole, and along the Gila River near Yuma. All these detections were recorded from 10 to 20 June. From 10 to 20 June, field personnel captured and color-banded 30 new adults at Gadsden, of which all but 2 were second-year birds. Reconnaissance efforts on 8 and 9 June resulted in the capture and color-banding of 34 willow flycatchers at Gadsden. All but six were second-year birds. One individual was recaptured at the same site 5 hours later. Another individual was recaptured at the same site 2 days later. None of the other 62 banded individuals were detected post-capture, and no flycatcher detections were recorded at any sites south of Bill Williams between 21 June and 24 July, suggesting these individuals were northbound migrants.

At the four life history study areas and at Muddy River, Grand Canyon, and Bill Williams we recorded a total of 77 territories. Of these, 58 (75%) consisted of paired flycatchers and 19 (25%) consisted of unpaired individuals. Eight breeding males were polygynous; five were paired with two females, and three were paired with three females. One female mated consecutively with two different males.

Of the 96 adult willow flycatchers identified to individual in 2006, 55 (57%) returned in 2007; six (11%) were detected at a different study area from where they were detected in 2006. We detected four within-year, between study area movements in 2007. One of these was from Littlefield Poles to Mesquite West, a second was from Muddy River to Mesquite West, a third was from Muddy River to Mormon Mesa Virgin River #1 South, and the fourth was from Grand Canyon RM 274.5N to Mormon Mesa Virgin River #1 South.

Of the 64 juveniles banded in 2006, 9 (14%) were recaptured or resighted and identified in 2007. Of these, four were detected at a different study area from where originally banded, and five were detected at the same study area. Five individuals originally banded as nestlings in 2005 and one banded in 2004 were also recaptured, of which four returned to a different study area than where originally banded. The median dispersal distance for all returning juvenile flycatchers exhibiting between-year movements in 2007 was 28.5 km.

We documented a total of 70 willow flycatcher nesting attempts at the four life history study areas, Muddy River, Grand Canyon and Bill Williams, 60 of which contained eggs and were used in calculating nest success and productivity. Twenty-seven (45%) nests were successful and fledged young; 33 (55%) failed. Mayfield survival probability at the four life history study areas, Muddy River, Grand Canyon and Bill Williams ranged from 0.001 to 0.753 and was 0.459 for all sites combined. Depredation was the major cause of nest failure, accounting for 35% of all failed nests and 45% of nests that failed after flycatcher eggs were laid.

Ten of 55 nests (18%) with flycatcher eggs and known contents were brood parasitized by Brown-headed Cowbirds. Brood parasitism at all study areas ranged from 0 to 36% and was highest at Mesquite. We observed the fifth consecutive year of no brood parasitism at Pahranagat. In addition, we observed no brood parasitism at Topock Marsh in 2007. This is the first time since monitoring began at Topock Marsh in 1997 that brood parasitism by Brown-headed cowbirds was not observed. Nests that contained flycatcher eggs and were brood parasitized were not less likely to fledge flycatcher young than nests that were not parasitized.

For the fifth consecutive year, we used a modification of the Australian crow trap to capture and remove Brown-headed Cowbirds at three of the four life history study areas. Because traps could not be deployed close enough to the flycatcher breeding habitat at Mormon Mesa, trapping there was discontinued in 2006. 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.

We captured and removed 104, 71, and 173 Brown-headed Cowbirds at Pahranagat, Mesquite, and Topock, respectively. Though data showed a tendency for traps with wide slots to capture more individuals, no significant difference was found in the capture rate of traps with narrow slots versus wide slots. The escape rate of captured cowbirds did not differ significantly between the wide and narrow slots. Data also showed a trend toward traps with wider slots capturing larger non-target individuals, but no significant difference was found in capture rates between the two slot sizes.

A comparison of the proportion of flycatcher nests parasitized during the pre-trapping (1997–2002) and trapping (2003–2007) periods showed a statistical difference only at Pahranagat, where we documented the fifth consecutive year of no brood parasitism. At Mesquite, brood parasitism continues to remain high, with 40.0% recorded in 2007.

At the four life history study areas, Muddy River, Grand Canyon, and Bill Williams, we gathered data on vegetation and habitat characteristics at 59 nest plots, 50 non-use plots, and 45 within-territory plots. To obtain an overall description of entire habitat blocks at each life history study area, we gathered data at an additional 55 randomly selected plots. The life history study areas vary in vegetation age, structure, and species composition. The habitat block at Pahranagat consists of mature, native, large-diameter trees with little shrub and sapling understory. The habitat blocks at Mesquite, Mormon Mesa, and Topock are composed primarily of very dense stands of both mixed-native (Mesquite and Mormon Mesa) and exotic (Topock) woody vegetation.

We found willow flycatchers nesting in a diverse array of riparian habitats. Willow flycatcher nest heights ranged from 1.5 to 7.6 m (mean = 3.3 m, SE = 0.2). Flycatchers placed 63% of all nests in tamarisk (*Tamarix* sp.), 7% in coyote willow (*Salix exigua*), 29% in Goodding willow (*Salix gooddingii*), and 2% in snags. Differences in nest-site characteristics between study areas were reflective of the differences in overall habitat characteristics of the sites. Nest sites consistently differed from non-use sites in several variables. Nest sites had significantly greater canopy heights than non-use sites at Mesquite and Muddy River. Canopy closure values at nest sites were significantly higher than at non-use sites at three (Pahranagat, Mesquite, and Topock) of the four life history study areas. At all study areas, vertical foliage density was greatest at and immediately above mean nest height. Breeding riparian birds in the desert Southwest are exposed to extreme environmental conditions, and dense vegetation at the nest may be needed to provide a more suitable microclimate for raising offspring. There was a strong trend for nest sites to be closer to water or saturated soil than non-use sites for the entire season, except at Pahranagat, where standing water under flycatcher nests at the beginning of the breeding season recedes as the season progresses, while non-use sites are along the perimeter of the lake and along inflow and outflow canals that experience less of a temporal change in water levels.

We collected microclimate data simultaneously at nest, within-territory, and non-use sites at the four life history study areas and Muddy River between May and August 2007. Similar to findings from 2003 to 2006, nests in 2007, on average, were located in areas that exhibited higher relative humidity and a smaller daily temperature range when compared to unused locations.

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 3–5 temperature/humidity data loggers and one groundwater observation well (piezometer). All logger and piezometer locations selected in 2005 were retained in 2006. Two loggers and one piezometer were damaged or destroyed in a fire in December 2006 and were replaced in 2007. Soil moisture measurements were collected at each data logger location during each of approximately 10 flycatcher surveys between 15 May and 25 July. Vegetation measurements were also collected at each data logger location after surveys were completed.

Daily, weekly, and seasonal cycles in groundwater levels were apparent. Water levels drop during afternoon hours when evapotranspiration is high and on the weekends when water releases from Parker Dam decline. The seasonal cycle in groundwater levels mirrors the seasonal fluctuation in river flow.

Analyses of groundwater data indicate a strong correlation between piezometer water levels and releases from Parker Dam. Data did not show strong correlations between piezometer water level and soil moisture within the habitat monitoring sites. A linear mixed effects model did reveal an inverse relationship between depth to groundwater and absolute humidity, but this influence appears to be minor in comparison to seasonal humidity fluctuations. Most microclimatic variables at the combined habitat monitoring sites differed significantly from those at Topock Marsh. Topock was cooler, and exhibited higher soil moisture, diurnal/nocturnal relative humidity, and diurnal/nocturnal vapor pressure than habitat monitoring sites. In general, the habitat monitoring sites exhibited a greater mean diurnal temperature, greater number of 15-minute intervals above 41°C each day, greater mean daily temperature range, and lower measures of relative humidity and vapor pressure than the five study areas where we measured microclimate variables within occupied flycatcher habitat.

Comparisons of microclimate characteristics among 2005, 2006, and 2007 at the habitat monitoring sites indicated generally hotter and more humid conditions in 2006 than in 2005 or 2007. The interannual changes were generally similar between test and control sites, suggesting that changes in temperature and humidity conditions may have been regional, rather than being influenced by changes in river operations. Soil moisture was lower in 2006 than in 2005 or 2007, and while this pattern was exhibited at both test and control sites, the interannual change was greater at control than at test sites.

We noted between-year differences at the habitat monitoring sites for canopy closure, woody ground cover, distance to water, tree counts, and vertical foliage densities in several meter intervals. There was no evidence that the differences in canopy closure and tree counts occurred exclusively at control sites or at test sites; rather, the differences occurred across all sites. Ground cover did not differ between years at test locations but increased at control plots between 2005 and 2006 and then decreased in 2007. This may represent an actual change in the amount of woody ground cover or may be a spurious result of observer variation. Distance to water increased at control sites between 2005 and 2006, while it did not change at test plots across years. These apparent changes in distance to water are likely the result of differences in aerial photo interpretation between years and do not reflect real differences in hydrology. In all cases were vertical foliage density differed between years, foliage density was lowest in 2007. There was a significant interaction between vertical foliage density and location (test vs. control sites) for the first, second, fourth, and fifth meter intervals. In all cases, vertical foliage density decreased more at the test plots than the control plots.

CHAPTER 1

INTRODUCTION

PROJECT HISTORY

In 1995, the Bureau of Reclamation (Reclamation), other federal, state, and tribal agencies, and environmental and recreational interests agreed to form a partnership to develop and implement a Multi-Species Conservation Program (MSCP) for long-term endangered species compliance and management in the historical floodplain of the lower Colorado River (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 (*Empidonax traillii extimus*), 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 lower Colorado River 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 lower Colorado River. The USFWS responded with a BO in April 2002 requiring continued Southwestern Willow Flycatcher studies along the lower Colorado River 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. 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.

The LCR MSCP is a 50-year program that seeks to protect 26 TES species and their habitats along the lower Colorado River 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 lower Colorado River 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. 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 in 2005–2007 to include monitoring of groundwater levels, vegetation, and soil moisture in addition to temperature and humidity.

SPECIES INTRODUCTION

The Southwestern Willow Flycatcher 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).

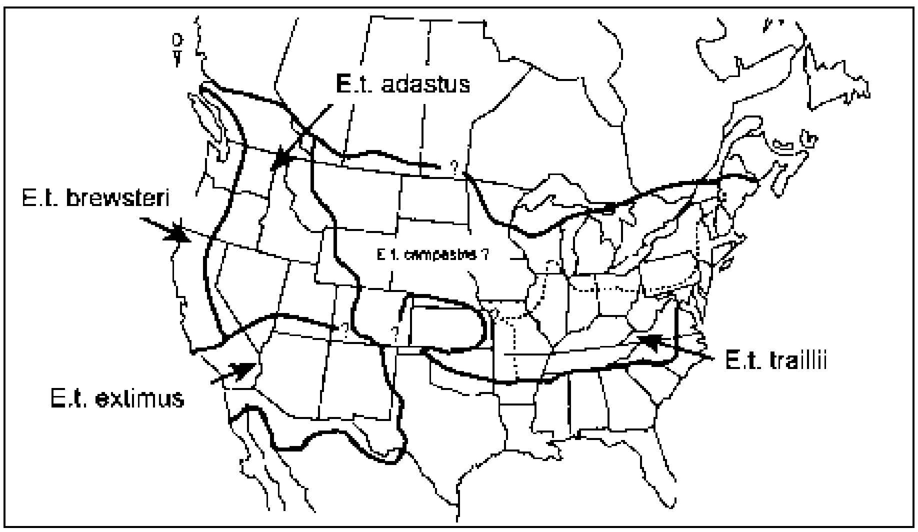

Figure 1.1. Breeding range distribution of the subspecies of the willow flycatcher (*Empidonax traillii*). Adapted from Unitt (1987), Browning (1993), and Sogge et al. (1997).

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. 1997). 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 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, Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007, 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).

From 1997 to 2007,[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/Virgin River confluence at Littlefield, Arizona; (3) Mesquite and (4) Mormon Mesa on the Virgin River, Nevada; (5) Overton Wildlife Management Area 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 (McKernan and Braden 2002, Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007, Braden and McKernan unpubl. data). Willow flycatchers, including one banded migrant Southwestern Willow Flycatcher (Koronkiewicz et al. 2006a), 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.

PURPOSE AND DESCRIPTION OF STUDY

The purpose of the 2007 study is 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. This project encompasses three types of studies: (1) presence/absence surveys, including site descriptions, at pre-selected sites along the lower Colorado and Virgin Rivers and tributaries, including the lower Grand Canyon and Bill Williams River; (2) intensive, long-term life history studies at four specific study areas (Pahranagat NWR, Mesquite, and Mormon Mesa, Nevada, and Topock Marsh, Arizona) to assess Southwestern Willow Flycatcher demographics and ecology, habitat selection, and the effects of Brown-headed Cowbird brood parasitism; and (3) monitoring of

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

microclimate, vegetation, and groundwater conditions of currently occupied[2] Southwestern Willow Flycatcher habitat between Parker and Imperial Dams. SWCA's contract specifies the following field tasks:

(1) **Presence/absence Surveys**: At approximately 136 sites[3] along the lower Colorado River, complete the following:

- (a) conduct presence/absence surveys, following a 10-survey protocol (per Braden and McKernan 1998);
- (b) provide a general site description for each site;
- (c) conduct nest searches if territorial flycatchers are located and monitor any nests found;
- (d) collect habitat and physical measurements around each nest site; and
- (e) band as many adult and juvenile flycatchers as possible with unique color-bands.

(2) **Life History Studies:** At the four life history study areas, complete the following tasks in addition to all tasks listed above under Presence/absence Surveys:

- (a) conduct Brown-headed Cowbird trapping and determine its effectiveness in reducing brood parasitism rates;
- (b) conduct in-depth vegetation sampling of the whole habitat block;
- (c) replicate all habitat measurements collected at nest sites at unused sites of similar structure; and
- (d) monitor microclimatic conditions of soil moisture, temperature, and humidity.

(3) **Habitat Monitoring**: At 150.5 ha of currently occupied Southwestern Willow Flycatcher habitat between Parker and Imperial Dams complete the following:

- (a) at sites equating to at least 75.3 ha each on the California and Arizona sides of the Colorado River, monitor microclimate, vegetation, and groundwater conditions within and under habitat stands to determine the effects of water transfer actions at Parker Dam;
- (b) at four control sites, two above Parker Dam and two below Imperial Dam, monitor microclimate, vegetation, and groundwater conditions within and under habitat stands to distinguish any changes in microclimate, groundwater, or vegetation caused by water transfer actions from those caused by fluctuations in climate or rainfall; and
- (c) conduct a detailed analysis consisting of a comparison and correlation of microclimate, vegetation, and groundwater levels within years, among sites, and with Southwestern Willow Flycatcher life history sites.

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[2] As per Reclamation (1999), 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 in any year, 1996–2007.

[3] A site is defined as one contiguous area that can be surveyed by one person in one morning. The contract specifies 136 survey sites; however, this number reflects studies performed before 2003 in which several areas were counted as multiple sites. In 2007, 101 sites were surveyed as described in the results section of Chapter 2 of this report.

Each distinct aspect of the 2007 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, including life history sites.
>
> Chapter 3 – Color-banding and Resighting. Details of banding activities in 2007 and resighting of previously banded flycatchers are presented in this chapter. Also included are the identities and locations of all Southwestern Willow Flycatchers that could be identified to individual and discussions of within- and between-year movement of individual flycatchers.
>
> Chapter 4 – Nest Monitoring. This chapter summarizes nesting attempts, nest fates, and productivity for all Southwestern Willow Flycatcher nesting activity documented during this study.
>
> Chapter 5 – Brown-headed Cowbird Trapping. This chapter summarizes the efforts and results of cowbird trapping at the life history study areas.
>
> Chapter 6 – Vegetation Sampling. Vegetation and habitat characteristics of all nest and non-use sites are presented and compared in this chapter. Vegetation characteristics of the whole habitat block at each life history study area are also presented.
>
> Chapter 7 – Microclimate. The methodology and results of monitoring temperature, humidity, and soil moisture within each life history study area at nest and non-use sites are presented.
>
> Chapter 8 – Habitat Monitoring. The methodology and results of monitoring microclimate, vegetation, and groundwater conditions at occupied sites between Parker and Imperial Dams are presented.

Management recommendations will be included in the 5-year summary report and are not presented in this annual report.

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. 1997). According to Sogge et al. (1997) 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. 1997, USFWS 2002), field confirmation of the southwestern subspecies is problematic.[1] 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 spring is the only time that migrant willow flycatchers sing 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 a variety of unsuitable breeding habitats in both spring and fall. 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.

In 2007, we completed multiple broadcast surveys at sites in 15 study areas[2] along the lower Colorado River and its tributaries to detect both migrant and resident willow flycatchers (Figure 2.1).

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[1] 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.

[2] Study areas consist of 1–20 survey sites that are grouped geographically (see Table 2.1). Four of these study areas are also life history study areas, where intensive demographic and ecology studies are conducted.

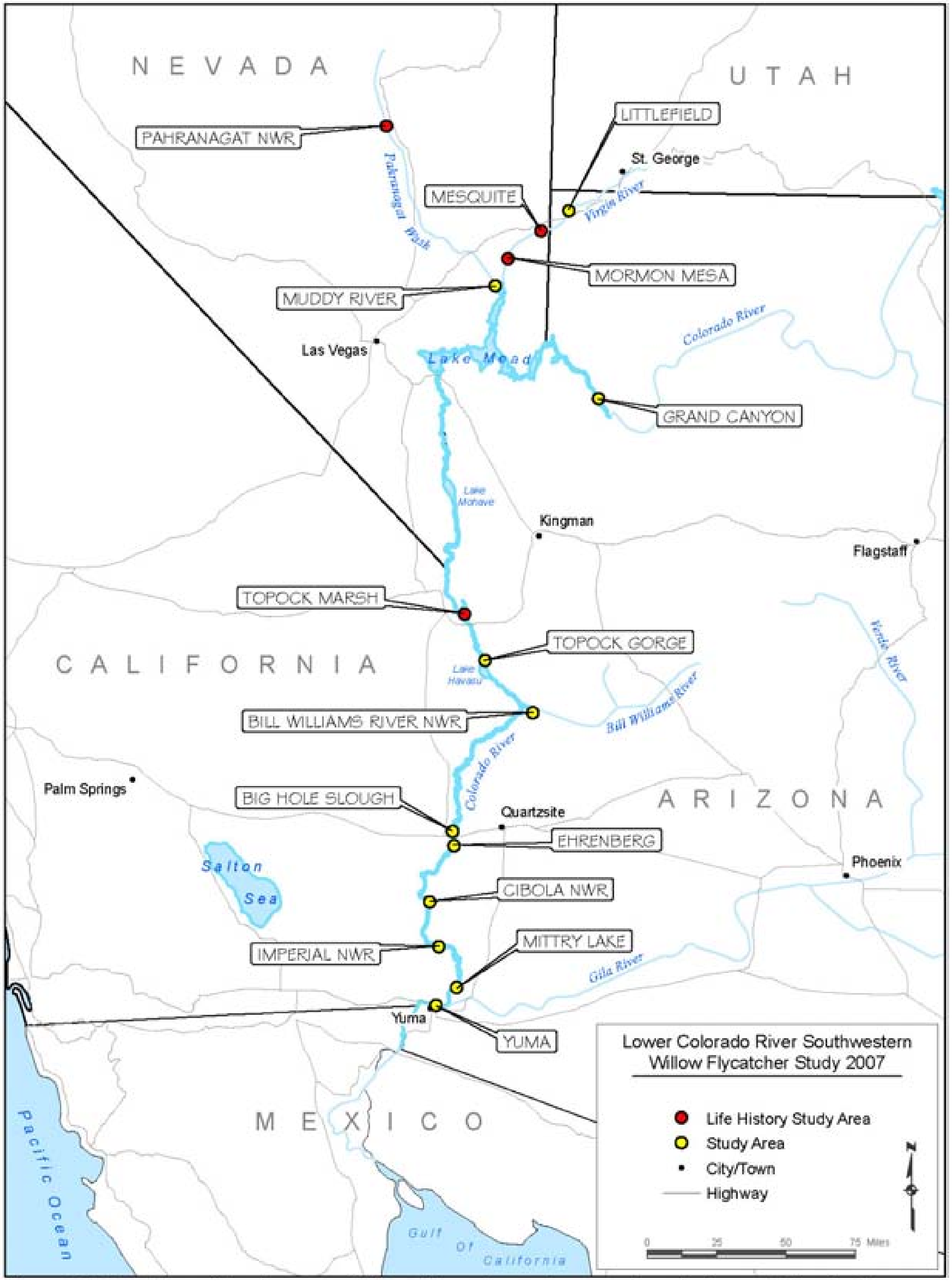

Figure 2.1. Locations of Southwestern Willow Flycatcher study areas along the lower Colorado River and tributaries, 2007. (Note, study area labels represent the approximate center of multiple sites within that region; see Table 2.1)

Yellow-billed Cuckoo and Yuma Clapper Rail

The Yuma Clapper Rail (*Rallus longirostris yumanensis*) is listed as federally endangered by the USFWS, and the Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*) is a candidate for federal listing. Both species occur along the lower Colorado River and its tributaries and are of concern to managing agencies. We did not survey specifically for these species but recorded all incidental detections.

Methods

Site Selection

Survey sites were selected based on locations surveyed during previous years of willow flycatcher studies on the lower Colorado River (McKernan 1997; McKernan and Braden 1998, 1999, 2001a, 2001b, 2002; Koronkiewicz et al. 2004; McLeod et al. 2005; Koronkiewicz et al. 2006a; McLeod et al. 2007) and reconnaissance by helicopter, by boat, and on foot prior to the start of the 2007 survey period. 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 suitable flycatcher habitat. Riparian vegetation contiguous with suitable habitat was often included as part of survey areas. Reclamation biologist Theresa Olson guided and approved site selection. For sites surveyed in previous years, we retained original site names. 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 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 in NAD 83 using a Garmin Rino 110 GPS unit and were in NAD 83 to comply with Federal Geographic Data Committee standards.

Additional Site Selection

During the survey season, we conducted on-the-ground habitat reconnaissance to locate additional potentially suitable willow flycatcher habitat in Mesquite, Mormon Mesa, Muddy River, and Bill Williams River NWR. 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 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, and subsequent surveys were conducted at sites where potentially suitable habitat was present and logistical considerations permitted repeated access. If territorial individuals were located, broadcast surveys were discontinued and territory/nest monitoring was initiated. Field personnel formulated qualitative site descriptions of potentially suitable flycatcher habitat.

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. (1997), and we followed a modification of the 10-survey protocol proposed by Braden and McKernan (1998). We completed at least two surveys between 15 and 30 May, at least two surveys between 1 and 15 June, and six 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 portable CD player (various models were used) 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, broadcast surveys were discontinued within a radius of 50 m of territories, and territory and nest monitoring commenced (see Chapter 4). If a willow 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 were 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 (see survey form, Appendix A). Field personnel also recorded the presence of Brown-headed Cowbirds and livestock, as requested by the Arizona Game and Fish Department. Cowbirds may affect flycatcher populations by decreasing flycatcher productivity (see Chapter 5), 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 (Appendix A) 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. (1997) 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.

RESULTS

Field personnel spent 1,282 observer-hours conducting willow flycatcher broadcast surveys at 101 sites along the Virgin and lower Colorado Rivers and tributaries.[3,4] Willow flycatcher survey results are summarized in Table 2.1 and are presented below along with site descriptions. The boundaries of survey sites and occupancy in 2007 are shown on orthophotos in Appendix B, along with historically occupied habitat.[5] Each site that was not occupied by territorial flycatchers was formally surveyed between 5 and 11 times. Because subspecies identification of willow flycatchers detected between approximately 15 June and 20 July in the breeding range of *E. t. extimus* is problematic (Sogge et al. 1997, USFWS 2002), flycatcher detections after 15 June at sites where breeding or residency was not confirmed are summarized in Table 2.2. Yellow-billed Cuckoo and Yuma Clapper Rail detections are summarized in Tables 2.3 and 2.4. Hydrologic characteristics of each site are summarized in Table 2.5.

Table 2.1. Willow Flycatcher Detections at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2007*

Study Area[1]	Survey Site	Area (ha)	Number Detected (Date(s) of Detection)[2,3]
PAHR	North	3.8	30 (9 May–8 August)
	West	1.5	2 (8 June)
	MAPS	2.7	1 (8 June)
	South	2.5	2 (17 May–17 June)
LIFI	Poles[4]	1.0	1 (25 June–17 July)
MESQ	East	3.8	1 (7 June–19 June)
	West	12.0	26 (18 May–18 August)
	Bunker Farm	3.1	ND
	Electric Avenue North	1.8	ND
	Electric Avenue South	3.9	ND
MOME	Mormon Mesa North	13.4	ND
	Hedgerow	1.4	ND
	Mormon Mesa South	21.6	2 (14 June)
	Virgin River #1	52.9	17 (17 May–30 July)
	Virgin River #2	36.9	12 (11 May–6 July)
MUDD	Overton WMA Pond	0.7	2 (18 June–16 July)
	Overton WMA	14.9	15 (15 May–28 July)
GRCA	Burnt Springs	11.0	2 (17 June–2 July)
	RM 274.5N	18.3	4 (20 May–2 July)

[3] For sites surveyed prior to 2003, we counted each survey area with a distinct name as one site. In previous years, several of these areas were counted as multiple sites. For example, the report from the 2001 field season (McKernan and Braden 2002) lists 41 sites at Topock (Table 2), but only 19 sites are named on the map (Appendix 4). Total acreage surveyed for all sites in 2007 differed little from previous years.

[4] We started the 2007 survey season with 99 survey sites. Two sites were added after field personnel from an unrelated project detected a willow flycatcher at each location.

[5] As per Reclamation (1999), 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.

Table 2.1. Willow Flycatcher Detections at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2007,* continued

Study Area[1]	Survey Site	Area (ha)	Number Detected (Date(s) of Detection)[2,3]
GRCA	Pearce Ferry	0.8	1 (3 June)
	RM 285.3N	8.7	ND
	Kowlp Corner	5.4	ND
	RM 286N	3.4	ND
	Driftwood Island	3.7	ND
	Twin Coves	1.4	ND
	Bradley Bay	5.6	ND
	Chuckwalla Cove	1.8	ND
	Center Point	3.1	ND
TOPO	Pipes #1	5.2	ND
	Pipes #3	5.7	ND
	The Wallows	0.4	ND
	PC6-1	4.8	ND
	Pig Hole	2.4	ND
	In Between	7.8	3 (4 May–9 July)
	800M	6.1	2 (12 May–28 June)
	Pierced Egg	6.8	7 (8 May–29 July)
	Swine Paradise	3.7	ND
	Barbed Wire	2.6	1 (10 June)
	IRFB03	1.0	ND
	IRFB04	1.5	ND
	Platform	1.3	ND
	250M	2.3	1 (15 May), 1 (26 May)
	Channel[4]	--	1 (24 May)
	Hell Bird	3.7	2 (9 May)
	Glory Hole	4.3	7 (16 May–6 August)
	Kermit[4]	--	1 (24 May), 2 (7 June)
	Beal Lake	42.8	1 (6 June), 1 (17–21 June)
	Lost Slough	4.0	ND
	Lost Pond	1.7	ND
	Lost Lake	4.0	1 (6 June)
TOGO	Pulpit Rock	2.1	ND
	Picture Rock	7.0	2 (7 June)
	Blankenship Bend North	26.7	1 (23 May), 3 (7 June)
	Blankenship Bend South	25.9	1 (7 June)
	Havasu NE	12.6	ND

Table 2.1. Willow Flycatcher Detections at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2007,* continued

Study Area[1]	Survey Site	Area (ha)	Number Detected (Date(s) of Detection)[2,3]
BIWI	Site #2	3.1	ND
	Site #11	6.3	1 (7 June)
	Site #4	9.9	ND
	Site #3	8.3	14 (2 May–1 August)
	Site #5	5.3	ND
	New Willow[5]	--	1 (5 June)
	Mineral Wash Complex	18.8	1 (30 May–6 June), 1 (6 June), 1 (12 June)
	Beaver Pond	21.7	1 (6 June)
	Site #8	10.3	1 (6 June)
BIHO	Big Hole Slough	20.0	4 (16 May), 1 (20 May), 2 (5 June)
EHRE	Ehrenberg	4.7	1 (20 May), 1 (1 June), 2 (5 June), 1 (18 June)
CIBO	Cibola Nature Trail	13.7	1 (17 May), 1 (20 May), 3 (2 June), 6 (6 June), 1 (14 June)
	Cibola Island	9.0	8 (6 June)
	Cibola Site 2	16.4	1 (19 June)
	Cibola Site 1	7.7	1 (17 May), 2 (2 June), 2 (4 June)
	Hart Mine Marsh	31.6	3 (17 May), 3 (20 May), 1 (31 May), 1 (4 June), 1 (16 June), 2 (19 June)
	Three Fingers Lake	67.9	1 (19 May), 11 (23 May), 1 (30 May), 2 (3 June), 2 (14 June), 1 (20 June)
	Cibola Lake #1 (North)	8.5	1 (31 May), 1 (4 June)
	Cibola Lake #2 (East)	4.5	1 (20 May), 2 (6 June)
	Cibola Lake #3 (West)	6.8	ND
	Walker Lake	11.4	1 (30 May), 1 (3 June)
IMPE	Draper Lake	4.6	1 (16 May), 2 (8 June)
	Paradise	7.8	2 (16 May), 1 (21 May), 3 (24 May), 2 (8 June)
	Hoge Ranch	20.7	1 (17 May), 1 (3 June), 6 (7 June)
	Adobe Lake	7.6	2 (3 June), 1 (7 June)
	Rattlesnake	7.6	1 (15 May), 3 (23 May), 2 (3 June)
	Norton South	1.2	2 (2 June)
	Picacho NW	8.8	3 (4 June)
	Milemarker 65	10.0	2 (29 May), 4 (4 June)
	Clear Lake/The Alley	8.3	1 (4 June)
	Nursery NW	7.0	11 (22 May), 2 (1 June), 3 (7 June)
	Imperial Nursery	1.4	2 (18 May), 4 (22 May), 1 (1 June)
	Ferguson Lake	21.1	3 (18 May), 12 (22 May), 12 (5 June), 1 (12 June), 1 (18 June)
	Ferguson Wash	6.8	1 (22 May), 5 (5 June), 2 (12 June)
	Great Blue Heron	7.1	2 (23 May), 1 (31 May), 9 (7 June)
	Powerline	2.1	1 (12 May), 1 (30 May), 4 (7 June)
	Martinez Lake	4.6	2 (22 May), 3 (7 June)
MITT	Mittry West	4.4	3 (15 May), 2 (20 May), 2 (2 June), 10 (6 June)
	Mittry South	15.2	1 (18 May), 3 (22 May), 2 (6 June)
	Potholes East	2.0	3 (15 May)
	Potholes West	6.6	1 (9 May), 4 (15 May), 1 (29 May), 5 (2 June)

Table 2.1. Willow Flycatcher Detections at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2007,* continued

Study Area[1]	Survey Site	Area (ha)	Number Detected (Date(s) of Detection)[2,3]
YUMA	Gila Confluence North	2.2	6 (6 June)
	Gila River Site #1	5.7	1 (8 May), 1 (19 May), 6 (24 May), 4 (6 June), 2 (12 June)
	Gila River Site #2	5.1	2 (18 May), 2 (24 May), 5 (6 June), 2 (12 June)
	Fortuna Site #1	2.5	6 (10 May), 1 (19 May), 6 (24 May), 2 (31 May), 8 (6 June), 2 (12 June)
	Fortuna North	3.8	1 (19 May), 2 (24 May), 8 (6 June), 2 (12 June)
	Morelos Dam	11.4	3 (10 May), 1 (20 May), 2 (1 June), 5 (5 June)
	Gadsden	19.3	4 (10 May), 8 (15 May), 4 (20 May), 1 (29 May), 12 (4 June), 17 (8 June), 17 (9 June), 6 (10 June), 5 (11 June), 4 (12 June), 1 (13 June), 2 (14 June), 3 (15 June), 2 (16 June), 2 (17 June), 2 (18 June), 3 (19 June), 1 (20 June)
	Hunter's Hole	24.1	2 (9 May), 4 (15 May), 2 (21 May), 2 (29 May), 38 (3 June)

* Because opportunistic broadcast surveys were conducted at selected sites in 2007, sites where broadcast surveys were conducted less than four times during the flycatcher breeding season are not included.

1 PAHR = Pahranagat National Wildlife Refuge; LIFI = Littlefield; MESQ = Mesquite; MOME = Mormon Mesa; MUDD = Muddy River Delta; GRCA = Grand Canyon; TOPO = Topock Marsh; TOGO = Topock Gorge; BIWI = Bill Williams River National Wildlife Refuge; BIHO = Big Hole Slough; EHRE = Ehrenberg; CIBO = Cibola National Wildlife Refuge; IMPE = Imperial National Wildlife Refuge; MITT = Mittry Lake; YUMA = Yuma.

2 ND = No willow flycatchers were detected.

3 See Chapter 3 for details on territories, residency, pairing, and color-banding; see Chapter 4 for details on nesting activity.

4 Not a formal survey site. Flycatchers detected en route. Site is not included in the total number of sites surveyed.

5 Not a formal survey site. Flycatcher detected during habitat reconnaissance. Site is not included in the total number of sites surveyed.

Table 2.2. Detections of Willow Flycatchers Recorded after 15 June 2007 at Sites Where Breeding or Residency Was Not Confirmed

Study Area[1]	Site	Date	Comments
TOPO	Beal Lake	17–21 June	Lone flycatcher, primary song (***fitz-bew***) heard prior to playbacks; no response to playbacks
EHRE	Ehrenberg	18 June	Lone flycatcher, responded to playbacks with calls (***whitts)*** and primary song (***fitz-bew***)
CIBO	Cibola Site #2	19 June	Lone flycatcher, responded to playbacks
	Hart Mine Marsh	16 June	Lone flycatcher, responded to playbacks
		19 June	Two flycatchers detected, both responded to playbacks
	Three Fingers Lake	20 June	Lone flycatcher not very responsive to playbacks
IMPE	Ferguson Lake	18 June	Lone flycatcher, responded to playbacks with primary song (***fitz-bew***)
YUMA	Gadsden	16 June	Two flycatchers captured passively in mist nets
		17 June	Two flycatchers captured passively in mist nets
		18 June	Two flycatchers captured passively in mist nets
		19 June	Three flycatchers captured passively in mist nets
		20 June	One flycatcher captured passively in mist net

1 TOPO = Topock Marsh; EHRE = Ehrenberg; CIBO = Cibola NWR; IMPE = Imperial National Wildlife Refuge; YUMA = Yuma.

Table 2.3. Yellow-Billed Cuckoo Detections along the Virgin, Bill Williams, and Lower Colorado Rivers, 2007*

Study Area[1]	Site	Date(s)	Behavioral Observations
MOME	Virgin River #1	16 July	Individual heard calling
BIWI	Site #3	2 July	Individual heard calling
	Site #5	26 June	Calls heard
	Mineral Wash	13 July	Individual heard calling; individual observed north of Mineral Wash
	Beaver Pond/Site #8	25 July	Individual heard calling; individual detected between Beaver Pond and Site #8
IMPE	Imperial Nursery	3 July	Individual heard calling
	Great Blue Heron	24 July	Two individuals heard counter-singing
YUMA	Gila Confluence North	11 July	Individual heard calling
	Gadsden	19 June	Individual captured in mist net

* Unless otherwise stated, number of individual cuckoos was undetermined.

[1] MOME = Mormon Mesa; BIWI = Bill Williams River National Wildlife Refuge; IMPE = Imperial National Wildlife Refuge; YUMA = Yuma

Table 2.4. Yuma Clapper Rail Detections along the Lower Colorado Rivers, 2007

Study Area[1]	Site	Date(s)	Behavioral Observations
TOPO	PC6-1	11 May	Three individuals heard calling
	In Between	6 May	One individual heard calling
	Pierced Egg	14 May	One individual heard calling
	Platform	21 June	One individual heard calling
	250M	15 May	One individual heard calling
		30 May	One individual heard calling
		31 May	Three individuals heard calling
		21 June	One individual heard calling
	Lost Slough	9 June	One individual heard calling
	Lost Lake	22 May	Four individuals heard calling
		27 May	Four individuals heard calling
		9 June	Three individuals heard calling
		3 July	One individual heard calling
TOGO	Blankenship Bend South	12 May	One individual heard calling
IMPE	Ferguson Lake	18 May	Pair heard calling
MITT	Mittry South	16 July	One individual heard calling
YUMA	Gadsden	8–23 June	Pair heard every day, same location

[1] TOPO = Topock Marsh; TOGO = Topock Gorge; IMPE = Imperial National Wildlife Refuge; MITT = Mittry Lake; YUMA = Yuma.

Table 2.5. Summary of Hydrologic Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2007*

Study Area[1]	Survey Site	% 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]	75/40/5	50/10/3	5/20/10	0/0/0
	West[4]	30/15/0	3/3/0	3/15/0	0/0/0
	MAPS[4]	40/15/0	3/3/0	3/15/0	0/0/0
	South	2/20/20	25/50/50	5/0/0	0/0/0
LIFI	Poles	--/20/3	--/10/10	--/5/1	0/0/0
MESQ	East[11]	1/1/2	50/50/50	0/0/5	0/0/0
	West[12]	20/15/--	25/50/--	10/10/--	0/0/0
	Bunker Farm[11]	0/5/0	0/3/0	2/10/0	0/0/80
	Electric Avenue North	3/0/1	10/0/10	0/2/1	0/100/0
	Electric Avenue South	0/0/0	0/0/0	0/0/0	25/25/25
MOME	Mormon Mesa North[4]	0/0/0	0/0/0	0/0/0	0/0/0
	Hedgerow	0/0/0	0/0/0	0/0/0	100/100/100
	Mormon Mesa South[4]	0/0/0	0/0/0	0/0/0	0/0/0
	Virgin River #1	7/5/0	10/15/0	5/3/0	0/0/500
	Virgin River #2[4]	0/1/0	0/5/0	0/5/0	0/0/650
MUDD	Overton WMA, Pond	--/5/5	--/5/5	--/10/10	--/0//0
	Overton WMA	5/5/10	30/70/10[5]	10/10/5	0/0/0
GRCA	Burnt Springs[4]	--/8/10	--/10/25	--/3/10	0/0/0
	RM 274.5N[4]	20/20/20	30/50/30	10/45/20	0/0/0
	Pearce Ferry[4]	0/0/0	0/0/0	0/0/0	0/0/0
	RM 285.3N[4]	0/0/0	0/0/0	3/0/--	0/0/0
	Kowlp Corner[4]	0/0/0	0/0/0	0/0/0	0/0/0
	RM 286N[4]	0/0/0	0/0/0	3/3/--	0/0/0
	Driftwood Island[4]	0/0/--	0/0/--	0/--/--	0/0/0
	Twin Coves[4]	0/0/0	0/0/0	3/0/--	0/0/0
	Bradley Bay[4]	0/0/0	0/0/0	2/0/0	0/0/0
	Chuckwalla Cove[4]	0/0/0	0/0/0	2/0/--	0/0/0
	Center Point[4]	--/0/0	--/0/0	--/0/0	0/0/0
TOPO	Pipes #1	0/0/0	0/0/0	10/0/3[6]	0/50/0
	Pipes #3	10/5/1	10/10/10	1/40/0	0/0/0
	The Wallows	20/40/10[6]	10/20/10	5/20/18[6]	0/0/0
	PC6-1	50/30/3	10/3/3	10/50/10	0/0/0
	Pig Hole	2/0/0	3/0/0	5/0/1	0/130/0
	In Between	5/0/0	3/0/0	10/3/3	0/0/0
	800M	--/0/0	--/0/0	25/40/20	0/0/0
	Pierced Egg	7/1/0	3/15/0	15/10/3	0/0/0
	Swine Paradise[7]	10/0/0	20/0/0	5/0/0	0/0/0
	Barbed Wire	--/0/0	--/0/0	--/0/0	160/160/160
	IRFB03	0/0/0	0/0/0	0/0/0	150/150/150

Table 2.5. Summary of Hydrologic Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2007,* continued

Study Area[1]	Survey Site	% 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	IRFB04	0/0/0	0/0/0	0/0/0	75/75/75
	Platform[7]	--/0/--	--/0/--	--/0/--	0/0/0
	250M[7]	5/0/3	3/0/10	5/0/0	0/0/0
	Hell Bird	55/25/60	25/10/25	8/1/2	0/0/0
	Glory Hole	10/30/50	10/50/90	1/0/10	0/0/0
	Beal Lake[10]	5/30/0	10/3/0	5/0/0	0/0/25
	Lost Slough	0/25/0	0/10/0	0/0/0	235/0/235
	Lost Pond[4]	30/25/3	>100/>100/10	30/40/25	0/0/0
	Lost Lake[7]	8/5/0	--/3/0	8/1/0	0/0/0
TOGO	Pulpit Rock[4]	--/--/--	--/--/--	--/--/--	0/0/0
	Picture Rock[8]	--/--/--	--/--/--	--/--/--	0/0/0
	Blankenship Bend North[4]	15/15/15	100/100/100	10/10/10	0/0/0
	Blankenship Bend South[4]	25/20/25	50/25/50	15/15/15	0/0/0
	Havasu NE[4]	0/0/0	0/0/0	0/0/0	0/0/0
BIWI	Site #2[4]	0/1/0	0/5/0	1/0/0	0/0/0
	Site #11[4]	0/0/0	0/0/0	0/0/0	0/0/0
	Site #4[4]	10/5/3	40/15/60	10/10/5	0/0/0
	Site #3[4]	10/15/0	25/25/0	10/30/10	0/0/0
	Site #5	0/15/3	0/100/60	1/5/0	25/0/0
	Mineral Wash Complex[4]	0/20/25	0/10/20	10/1/25	0/0/0
	Beaver Pond[4]	20/20/25	20/15/20	15/1/25	0/0/0
	Site #8[4]	30/50/25	25/25/20	20/10/20	0/0/0
BIHO	Big Hole Slough	--/--/--	--/--/--	--/--/--	--/--/--
EHRE	Ehrenberg[9]	0/0/0	0/0/0	--/3/0	15/0/15
CIBO	Cibola Nature Trail[10]	25/3/10	25/3/20	10/3/5	0/0/0
	Cibola Island	--/0/--	--/0/--	--/--/--	--/230/--
	Cibola Site #2[8,9]	--/--/--	--/--/--	--/--/--	0/0/0
	Cibola Site #1[8,9]	--/--/--	--/--/--	--/--/--	0/0/0
	Hart Mine Marsh[7]	25/20/20	10/10/10	8/10/12	0/0/0
	Three Fingers Lake[4]	25/18/18	>100/>100/>100	5/5/5	0/0/0
	Cibola Lake #1 (North)[4]	7/5/3	25/10/10	3/3/3	0/0/0
	Cibola Lake #2 (East)[4]	0/0/0	0/0/0	0/0/0	0/0/0
	Cibola Lake #3 (West)[4]	15/5/3	3/3/3	10/3/3	0/0/0
	Walker Lake[4]	20/10/5	25/10/3	10/22/27	0/0/0
IMPE	Draper Lake[7]	--/5/10	50/10/10	5/1/8	0/0/0
	Paradise[4]	40/0/3	10/0/3	--/--/10	0/0/0
	Hoge Ranch[4]	35/35/20	50/30/70	20/15/3	0/0/0
	Adobe Lake[4]	--/--/--	--/--/--	--/--/--	0/0/0
	Rattlesnake[7]	8/5/10	10/10/25	10/5/5	0/0/0

Table 2.5. Summary of Hydrologic Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2007,* continued

Study Area[1]	Survey Site	% 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	Norton South[7]	15/20/20	25/50/50	5/5/5	0/0/0
	Picacho NW[4]	0/0/0	0/0/0	0/0/0	30/30/30
	Milemarker 65[4]	--/--/--	--/--/--	--/--/--	0/0/0
	Clear Lake/The Alley[4]	0/0/0	0/0/0	0/0/0	0/0/0
	Nursery NW[7]	--/0/--	--/0/--	--/--/10	0/0/0
	Imperial Nursery[10]	0/0/40	0/0/25	0/0/10	10/10/0
	Ferguson Lake[4]	3/10/3	25/3/10	3/5/0	0/0/45
	Ferguson Wash[4]	0/0/0	0/0/0	0/0/0	0/0/0
	Great Blue Heron[4]	0/0/0	0/0/0	0/0/0	0/0/0
	Powerline[4]	10/5/10	10/3/10	5/5/5	0/0/0
	Martinez Lake[4]	0/0/3	0/0/3	0/0/2	0/0/0
MITT	Mittry West	3/0/0	10/0/0	3/--/0	0/250/250
	Mittry South[4]	0/0/--	0/0/--	--/--/--	0/0/0
	Potholes East[9]	5/10/--	--/10/0	--/5/--	0/0/0
	Potholes West[9]	10/20/10	>100/>100/>100	--/3/3	0/0/0
YUMA	Gila Confluence North[4]	3/0/1	10/0/10	3/0/1	0/0/0
	Gila River Site #1[4]	10/10/0	30/--/0	8/--/0	0/0/0
	Gila River Site #2[4]	0/0/0	0/0/0	0/0/0	0/0/0
	Fortuna Site #1[4]	0/0/0	0/0/0	0/0/0	0/0/0
	Fortuna North[4]	0/0/0	0/0/0	0/0/0	0/0/0
	Morelos Dam[4]	0/0/0	0/0/0	0/0/0	0/0/0
	Gadsden[4]	5/5/5	50/50/50	5/5/5	0/0/0
	Hunter's Hole	0/0/0	0/0/0	0/0/0	25/25/25

* Values are given for each site as recorded in mid-May, mid-June, and mid-July.

1 PAHR = Pahranagat National Wildlife Refuge; LIFI = Littlefield; MESQ = Mesquite West; MOME = Mormon Mesa; MUDD = Muddy River; GRCA = Grand Canyon; TOPO = Topock Marsh; TOGO = Topock Gorge; BIWI = Bill Williams River National Wildlife Refuge; BIHO = Big Hole Slough; EHRE = Ehrenberg; CIBO = Cibola National Wildlife Refuge; IMPE = Imperial National Wildlife Refuge; MITT = Mittry Lake; YUMA = Yuma.

2 -- = Hydrologic information not recorded.

3 Percent of site with saturated soil does not include inundated areas.

4 Site bordered by a river, lake, or pond.

5 The deepest water occurred within a channel of the Muddy River that runs through the center of the site.

6 Saturated soil or water was present in pig wallows.

7 Site borders marsh.

8 Site contains marshes, but hydrologic conditions within marshes unknown.

9 Site borders canal.

10 Site is irrigated as part of restoration efforts; amount of standing water highly variable throughout survey season.

11 Site receives irrigation runoff from nearby agricultural fields; amount of standing water highly variable throughout survey season.

12 The amount of surface water present within the site varies daily and throughout the survey season; hydrology at the site is influenced by irrigation runoff from two golf courses immediately adjacent to the site.

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.

PAHRANAGAT NORTH

Area: 3.8 ha Elevation: 1,026 m

Pahranagat North is a stand of large-diameter Goodding willow (*Salix gooddingii*) at the inflow of Upper Pahranagat Lake. Fremont cottonwood (*Populus fremontii*) lines the northern, upland edge of the site and extends in narrow stringers around the edge of the lake. Canopy height within the patch is 15–18 m, and canopy closure is >90%. The majority of the site is inundated annually, with up to 1 m of water present in mid-May and becoming progressively drier through the survey season. In mid-May, 75% of the site had standing water, with 5% of the site inundated in late July.

We located 18 resident, breeding willow flycatchers, as well as four unpaired males at Pahranagat North. One additional male who originally held a territory at Pahranagat South was later detected at the North site feeding fledges bred by another pair. We also detected seven additional flycatchers for which occupancy and/or breeding status could not be determined; at least three of these individuals were suspected migrants. Details of occupancy, pairing, color-banding, and breeding are presented in Chapters 3 and 4. Areas of Pahranagat North not known to be occupied by willow flycatchers were surveyed 10 times throughout the breeding season, totaling 8.9 observer-hours. The site lies immediately adjacent to a cattle pasture, but livestock have access only to the cottonwood stringer on the northwest corner of the lake, which is separated from the survey site by a fence. Brown-headed Cowbirds were detected during one survey.

PAHRANAGAT WEST

Area: 1.5 ha Elevation: 1,026 m

This native site consists of a stringer of Fremont cottonwood 20 m in height on the western edge of Upper Pahranagat Lake. A few Goodding willow 2–4 m in height are also present, and some Russian olive (*Elaeagnus angustifolia*) is present in the understory. The edge of the lake is vegetated with bulrush (*Schoenoplectus californicus*). During the survey season, the upland edge of the site was dry, while the lake edge had standing water until mid-June.

We detected two willow flycatchers at this site on 8 June. We surveyed the site nine times throughout the breeding season, totaling 3.4 observer-hours. No cowbirds or signs of livestock use were detected.

PAHRANAGAT MAPS

Area: 2.7 ha Elevation: 1,026 m

Pahranagat MAPS is a mixed-native stringer consisting predominantly of Fremont cottonwood on the western edge of Upper Pahranagat Lake. Canopy height is 15–20 m, and canopy closure is approximately 50%. Tamarisk (*Tamarix* spp.) and Russian olive form a very sparse understory, and cattail (*Typha* sp.) and bulrush line the eastern edge of the tree line. Portions of the site held standing water and saturated soils until mid-June.

We detected one willow flycatcher at Pahranagat MAPS on 8 June. We surveyed the site nine times throughout the breeding season, totaling 6.0 observer-hours. Cowbirds were detected during one survey, and no sign of livestock use was detected.

PAHRANAGAT SOUTH

Area: 2.5 ha Elevation: 1,023 m

Pahranagat South consists of a relatively small stringer of Goodding willow, coyote willow (*Salix exigua*), and Fremont cottonwood lining a human-made channel that carries the outflow from Upper Pahranagat Lake. The channel held varying amounts of water throughout the survey season. The cottonwoods reach approximately 20 m in height, while the willows are generally less than 10 m. In 2005, we noted that dense coyote willow was increasing on the western side of the patch; this area of willow had very sparse canopy in 2006 and 2007. The site is bordered to the west by an open marsh and to the east by upland scrub. Tamarisk and Russian olive form a sparse understory. Overall canopy closure at this site is approximately 50%.

We detected one resident, unpaired willow flycatcher at Pahranagat South, as well as one male for which residency and/or breeding status could not be confirmed. Details of occupancy, color-banding, and breeding are presented in Chapters 3 and 4. Areas of Pahranagat South not known to be occupied by willow flycatchers were surveyed 10 times throughout the breeding season, totaling 7.0 observer-hours. Cowbirds were detected during one survey, and no sign of livestock use was recorded.

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). No detections were recorded in 2003, and flycatcher breeding was documented at North in 2004. During the winter of 2004–2005, both sites were completely scoured by floods that removed most of the understory vegetation. In 2005, two males were detected at North on a single occasion, and no detections were recorded at South. Surveys at South were discontinued in 2006 and 2007 because of the lack of understory vegetation. At North, we completed periodic habitat evaluation and surveys in 2006, and no surveys were conducted at the site in 2007 because of the lack of understory vegetation.

In 2007, personnel from an unrelated field project located a willow flycatcher along Beaver Dam Wash; therefore, our surveys and subsequent monitoring focused on this area (Littlefield Poles).

LITTLEFIELD POLES

Area: 1.0 ha Elevation: 565 m

Littlefield Poles consists of a relatively small patch of mixed-native vegetation located on Beaver Dam Wash, immediately upstream of the Highway 91 Bridge. Vegetation on the site consists of a scattered overstory of Fremont cottonwood averaging 25 m in height. Fremont cottonwood and Goodding willow averaging 10 m in height are present below the overstory but do not form a continuous canopy. Lower strata vegetation approximately 6 m in height consists of coyote willow, tamarisk, and some Russian olive. In the wettest areas containing Goodding and coyote willow, canopy closure is >90%. Canopy closure ranges from 50 to 70% in the cottonwood areas. Flowing water runs in channels along the northern and southern edges of the site, and the center of the site is dry and sandy. Cattail is present along the southern edge of the site, though not under the trees. Surface water was present until mid-July.

We detected one resident, unpaired male willow flycatcher at Littlefield Poles. This individual was later detected at Mesquite West. Details of occupancy and color-banding are presented in Chapter 3. Areas of Littlefield Poles not known to be occupied by willow flycatchers were surveyed two times, totaling 0.5 observer-hours. Cowbirds were detected during one survey, and cattle use the site.

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 sediment deposition over the 2004–2005 winter. In 2003 and 2004, we surveyed and monitored one site in the area, Mesquite West. In 2005–2007, we surveyed and/or monitored two additional sites, Mesquite East and Bunker Farm, where SWCA personnel from an unrelated flycatcher project had located territorial flycatchers in 2004.

In 2006, we conducted habitat reconnaissance and opportunistic surveys at five additional sites in the Virgin River floodplain between Mesquite and Bunkerville. Two of these sites, Electric Avenue North and South, were surveyed in 2007.

MESQUITE EAST

Area: 3.8 ha Elevation: 468 m

This mixed-native site lies on several terraces within the floodplain of the Virgin River in Mesquite, Nevada. Vegetation on the lowest terrace, on the northern edge of the site adjacent to the river, consists of Fremont cottonwood and Goodding willow generally less than 10 m in height. The central portion of the site lies on a slightly higher terrace and is vegetated entirely by dense tamarisk 7–8 m in height with canopy closure around 80%. The uppermost terrace is vegetated with Goodding willow and a few Fremont cottonwood 18–25 m in height and an understory of dense clumps of coyote willow about 8 m in height. Canopy closure on this terrace varies from 50% in the cottonwood/Goodding willow areas to over 90% in the coyote willow clumps. This site borders an agricultural field and periodically receives varying amounts of irrigation runoff during flycatcher breeding. A small drainage pond is present at the end of an irrigation ditch and held standing water throughout the survey season. The western half of the upper terrace burned over the 2004–2005 winter and was not included in the survey area. During the survey season, the portions of the burned area that received irrigation runoff were growing thick stands of coyote willow, common reed (*Phragmites australis*), and cattail.

We detected one resident, unpaired male willow flycatcher at Mesquite East. Details of occupancy and color-banding are presented in Chapter 3. Areas of Mesquite East not known to be occupied by willow flycatchers were surveyed eight times throughout the flycatcher breeding season, totaling 16.4 observer-hours. Cowbirds were detected on all but one survey, and some evidence of livestock use was observed.

MESQUITE WEST

Area: 12.0 ha Elevation: 470 m

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 coyote willows are generally 4 m in height, and canopy closure varies from 50 to >90%. On the western end of the site, some Goodding willow (averaging 7 m) mixed with tamarisk and coyote willow is present, and this area may become suitable for flycatchers in subsequent years. Hydrology at the site is influenced by irrigation runoff from the two adjacent golf courses, and the amount of surface water present under the vegetation varied daily and throughout the season. The site contained standing water and muddy soils throughout the survey season, and the irrigation runoff supports much of the vegetation within the site.

The southeastern portion of the site was completely inundated during floods in the winter of 2004–2005, which deposited up to 0.5 m of sediment in the vegetation, reducing overall canopy height and foliage density in this area. Adjacent cattail/bulrush marshes were also scoured, but they have regenerated. Portions of the site where deposition occurred had no surface water in 2007, and only the western and northern portions of the site were inundated throughout the flycatcher breeding season. The lack of surface water within the southeastern portion of the site may have been the result of the sediment deposition noted above, with this area now perched higher than the runoff from the golf courses, and may also have been influenced by changes in irrigation patterns on the golf course.

We located 24 resident, breeding willow flycatchers and one unpaired male, which had previously been observed breeding at Muddy River. One additional male, for which occupancy and/or breeding status could not be confirmed at Mesquite, had been previously detected at Littlefield. Details of occupancy, color-banding, and breeding are presented in Chapters 3 and 4. Areas of Mesquite West not known to be occupied by flycatchers were surveyed nine times throughout the flycatcher breeding season, totaling 21.2 observer-hours. Cowbirds were detected on all but one survey. In contrast to previous years, when no livestock use was detected, portions of the site were used by cattle during the flycatcher breeding season of 2007.

BUNKER FARM

Area: 3.1 ha Elevation: 457 m

This mixed-exotic site lies within the floodplain of the Virgin River in Bunkerville, Nevada, approximately 3 km downstream of Mesquite West. The site varies in width from 50 to 100 m and lies between an agricultural field to the southeast and the Virgin River to the northwest. Vegetation within the site is highly variable. The edge of the site adjacent to the agricultural field consists 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 is 70–90%. Toward the river, the vegetation grades into clumps of tamarisk 3–4 m in height with less than 70% canopy closure. Muddy puddles on livestock trails were present until June, and the site was completely dry and dusty by mid-July. The agricultural field adjacent to the site was fallow during the flycatcher breeding seasons of 2006 and 2007, and, in contrast to 2005, the site did not receive agricultural runoff.

We did not detect any flycatchers at this site. We surveyed the site nine times, totaling 11.0 observer-hours. Cowbirds were detected on all but three surveys and evidence of livestock use was observed.

ELECTRIC AVENUE NORTH

Area: 1.8 ha Elevation: 460 m

This mixed-exotic site lies adjacent to an agricultural field within the floodplain of the Virgin River in Bunkerville, Nevada. Between mid-May and mid-June, an area running northwest to southeast was bulldozed through the center of the site, removing approximately 20% of the vegetation present in previous years. Vegetation at the site now consists of an overstory of Fremont cottonwood, Goodding willow, and tall coyote willow averaging 10 m in height. Much of the coyote willow in the overstory is dead. Shorter coyote willow and tamarisk averaging 8 m in height make up the understory. Canopy closure is approximately 50–70%. An isolated patch of tamarisk is located on the western side of the site, and arrowweed and scattered mesquite (*Prosopis* sp.) trees are present on the edges of the site. A small cattail marsh on the northwestern edge of the site held standing water in May and July. A small stream running west to east held standing water in May.

We did not detect any flycatchers at this site. We surveyed the site nine times, totaling 12.5 observer-hours. Cowbirds were detected on all but one survey, and evidence of livestock use was observed.

ELECTRIC AVENUE SOUTH

Area: 3.9 ha Elevation: 460 m

This mixed-exotic site lies adjacent to an agricultural field within the floodplain of the Virgin River in Bunkerville, Nevada. Vegetation on the site consists of a stringer of Fremont cottonwood and Goodding willow averaging 12 m in height with a predominantly tamarisk understory. Some coyote willow is scattered throughout the site, and arrowweed and mesquite trees mix with the tamarisk in some areas. Canopy closure is approximately 50–70%. A tall stand of Fremont cottonwood with an open understory is located on the north end of the site. No standing water or saturated soils were present during the survey season, although a dry channel indicated the Virgin River previously flowed through the site.

We did not detect any flycatchers at this site. We surveyed the site 10 times, totaling 17.2 observer-hours. Cowbirds were detected on all but one survey, and evidence of livestock use was observed.

OTHER SURVEY AREAS

"Mesquite Area Recon"

Habitat reconnaissance and opportunistic surveys were conducted at Mesquite Area Recon in 2007. This mixed-exotic site lies within the floodplain of the Virgin River in Mesquite, Nevada, approximately 6.9 km northeast of Mesquite West and 4.5 km east of Riverside Bridge. Vegetation at the site consists primarily of tamarisk 6 m in height with 3-m-tall coyote willow and Fremont cottonwood also present. The site is on the edge of a recent burn, with very dense tamarisk nearest to the burned area. Many open sandy areas are present throughout the interior of the site. Canopy closure varies throughout the site, averaging around 35%. Soils within the site were dry and sandy.

We did not detect any flycatchers at this site. The site was visited two times, with a total of 4.0 observer-hours. Cowbirds were detected during both surveys, and signs of cattle use were recorded.

MORMON MESA, NEVADA

For approximately 15 km upstream from its outflow to Lake Mead, the Virgin River flows through a 1-km-wide floodplain with a mosaic of habitats, including cattail marshes and tamarisk and willow forest. Much of the area is typically seasonally inundated from snowmelt in the spring and monsoon rains in mid and late summer, and the entire study area experienced severe flooding over the 2004–2005 winter. Vegetation in much of the floodplain where the Virgin River enters Lake Mead is dead or dying as the result of fluctuating reservoir levels. All the areas surveyed at Mormon Mesa are at least 10 km upstream of Lake Mead. All of the areas we surveyed are used extensively by cattle, and cowbirds were detected on most surveys.

MORMON MESA NORTH

Area: 13.4 ha Elevation: 390 m

This mixed-exotic site is north of a channel of the Virgin River that cuts from east to west across the floodplain. In 2003 and 2004, this channel was dry, and the active channel of the river was located to the east of the site. During those years, the site was bordered to the west by a large, seasonally inundated cattail marsh. During winter flooding in 2004–2005, the previously dry channel became the main channel of the Virgin River, and the cattail marsh was scoured. The active channel contained water during throughout the flycatcher breeding season 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 monsoon rains. The cattail marsh was an open pond during the summers of 2005–2007, and flood debris is still visible on the trees up to 2 m above the ground.

From the river channel toward the pond, vegetation at the site grades from dense arrowweed to tamarisk with arrowweed understory to a mixture of tamarisk and dead and dying Goodding willow. Many of the Goodding willows on the western side of the site are snapped in half. Canopy height in Mormon Mesa North is generally 4–5 m and extends to 8 m where willow is present. The site contained dead and dying coyote willow in 2006, and no live coyote willow was present in 2007. Canopy closure at the site is approximately 50–70%. No standing water or saturated soils were present within the site during the survey season.

We did not detect any flycatchers at this site. We surveyed the site 10 times, totaling 39.2 observer-hours.

HEDGEROW

Area: 1.4 ha Elevation: 390 m

This mixed-exotic site is east of Mormon Mesa North, on the eastern side of the Virgin River. The site consists primarily of mature Goodding willow up to 20 m in height with a sparse understory of Goodding willow and tamarisk. The stand of mature willows is surrounded by tamarisk 3–8 m in height. Canopy closure at the site is 50–70%. Soils within the site were dry throughout the survey season.

We did not detect any flycatchers at Hedgerow. We surveyed the site eight times, totaling 5.6 observer-hours.

MORMON MESA SOUTH

North half: Area: 13.3 ha Elevation: 385 m
South half: Area: 8.3 ha Elevation: 385 m

Mormon Mesa South was split into two contiguous areas to facilitate tracking of survey activity. Mormon Mesa South consists of a mosaic of tamarisk 4 m in height and patches of Goodding willow and cattail. A long stringer of willow runs north to south through the site. The willows on the western side of the site are dead and dying, and the cattails have been trampled by cattle.

Canopy height of the willows is up to 10 m. Canopy closure varies throughout the site, averaging around 70%. Soils within the site were dry throughout the survey season.

We detected two willow flycatchers in Mormon Mesa South, each for a single day in June. Details of banding and occupancy are presented in Chapter 3. We surveyed the north half of the site nine times totaling 38.6 observer-hours; the south half was surveyed eight times totaling 25.0 observer-hours.

VIRGIN RIVER #1

North half: Area: 24.9 ha Elevation: 380 m
South half: Area: 28.0 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 contains both tamarisk and willow habitats. The western half of Virgin River #1 North contains dense tamarisk 5 m in height, with a patch of tall Goodding willow on the northwestern edge. The eastern half is a mixture of tamarisk, Goodding willow, and coyote willow. Many of the willows on the eastern side of the site are either dead or dying. Canopy height in the willow areas is approximately 10 m. Canopy closure throughout the site is approximately 70%. The soil in the site is mostly sandy with few areas of damp, slippery clay. The only standing water present during the survey season was limited to stagnant pools on cattle trails early in the season.

We detected one resident, unpaired male and one male for which residency and/or breeding status could not be confirmed at Virgin River #1 North. Details of occupancy and color-banding are presented in Chapter 3. We visited the site 11 times, totaling 52.4 observer-hours. Cowbirds were detected on all surveys, and cattle were also observed at the site.

Virgin River #1 South is primarily dense tamarisk approximately 5 m in height with many dry, open areas. Canopy closure in vegetated areas is approximately 90%. The northeastern and southern portions of Virgin River #1 South contain a few emergent Goodding willow. The northwestern portion is the site of a marsh, where coyote and Goodding willows are mixed in with the tamarisk. Goodding and coyote willows in the site average 8 and 5 m in height, respectively. Overall, the soil in the site was mostly dry with a few damp areas persisting throughout the season. Standing water was present in the marsh through June.

At Virgin River #1 South we detected 12 resident, breeding individuals and three males that were detected for a single day in June or July; one that was known to be breeding at Muddy River earlier in the season, one that was previously detected at Grand Canyon, and one for which residency and/or breeding status could not be determined. Details of occupancy, color-banding, and nesting are presented in Chapters 3 and 4. Areas of the site not known to be occupied by willow flycatchers were surveyed 10 times throughout the breeding season, totaling 49.1 observer-hours.

VIRGIN RIVER #2

Area: 36.9 ha Elevation: 380 m

This site is primarily a monotypic stand of tamarisk 6 m in height with 70–90% canopy closure. Patches of emergent Goodding willow up to 10 m in height are also present, primarily in the southeastern end of the site. The soil in the site is mostly dry to damp, with only a small patch of soil inundated in mid-June.

At Virgin River #2 we located eight resident, breeding individuals and three unpaired males. One additional male was briefly detected at Virgin River #2 before moving to Virgin River #1 South. Details of occupancy, color-banding, and nesting are presented in Chapters 3 and 4. Portions of the site not known to be occupied by flycatchers were visited 11 times, totaling 55.6 observer-hours.

OTHER SURVEY AREAS

"Virgin River #2 Recon"

Habitat reconnaissance and opportunistic surveys were conducted at Virgin River #2 Recon in 2007. This mixed-exotic site is approximately 900 m south of Virgin River #2. Vegetation at the site consists primarily of tamarisk up to 7 m in height, with occasional patches of Goodding willow reaching 15 m in height. Much of the tamarisk understory is dead. Canopy closure varies throughout the site, averaging around 45%. Soils within the site were dry throughout the season.

We did not detect any flycatchers at this site. The site was visited two times, with a total of 16.5 observer-hours.

MUDDY RIVER, NEVADA

OVERTON WMA POND

Area: 0.7 ha Elevation: 378 m

This site consists of a patch of mixed-native vegetation approximately 150 m long and 150 m wide at the north end of Overton Wildlife Management Area (WMA) just south of Honeybee Reservoir. The dominant vegetation consists of 10-m-tall Goodding willow with a 5-m tamarisk understory. Cattail and sedges are also present on the edge of a small marsh on the western side of the site. The site was mostly dry, except for the marsh, which held water throughout the season.

We detected two resident, breeding flycatchers at this site. Details of occupancy, color-banding, and nesting are presented in Chapters 3 and 4. This site was not formally surveyed. Cowbirds were detected at the site on several occasions. No sign of livestock use was recorded.

OVERTON WMA

Area: 14.9 ha Elevation: 378 m

This site consists of a 150-m-wide strip of riparian vegetation on 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. The northern portion of the site is dominated by very dense tamarisk up to 7 m in height with canopy closure of 70–90%. The southern portion of the site consists primarily of a stand of Goodding willow 10–12 m in height with an understory of tamarisk and cattail. 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. Flowing water and muddy soils were present in and adjacent to the Muddy River throughout the survey season.

We detected 12 resident, breeding willow flycatchers, one unpaired male, and one flycatcher for which occupancy and/or breeding status were unknown. One additional female was briefly detected at the site early in the season before moving to Overton WMA Pond. Details of occupancy, color-banding, and nesting are presented in Chapters 3 and 4. Portions of the site not known to be occupied by flycatchers were surveyed eight times, totaling 33.0 observer-hours. Cowbirds were detected on all surveys, and cattle were observed at the site.

OTHER SURVEY AREAS

“Willow Patch Recon”

Habitat reconnaissance and opportunistic surveys were conducted at Willow Patch Recon in 2007. This mixed-exotic area lies approximately 150 m east of the Overton WMA site and is approximately 125 m long and 75 m wide. Vegetation consists primarily of tamarisk to 5 m in height with 5-m-tall Goodding willow scattered throughout. Much of the tamarisk and Goodding willow in the understory are dead. Dead cattails are also present, covering approximately 20% of the site. Canopy closure is 25–50% throughout the site. Soils within the site are very dry, with the nearest water approximately 200 m away.

We did not detect any flycatchers at this site. The site was visited two times, with a total of 2.3 observer-hours. Cowbirds were detected at the site, but no signs of livestock use were recorded.

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 has changed dramatically in the last seven years as the result of a 30.2-m drop in the level of Lake Mead from 2000 to July 2007.[6] Much of the riparian vegetation in lower Grand Canyon from

[6] The water level in Lake Mead Reservoir rose approximately 7 m from mid-2004 to early 2005 because of record precipitation during the winter of 2004–2005. Since mid-2005, the water level has continued to drop.

approximately RM 259.5 to RM 274 that was inundated and potentially suitable for flycatchers in the late 1990s is now terraced well above the current river level, and the existing vegetation in most of these areas is dead or dying. Therefore, in June 2006 we conducted habitat reconnaissance in the extensive areas of recently developed willow along the Colorado River in Lake Mead National Recreation Area. We identified and subsequently surveyed nine new sites within the recreation area in 2006, detecting resident and breeding willow flycatchers at four of the sites. In 2007, most of the 2006 occupied flycatcher habitat in the recreation area was dead and dying as the result of receding water tables under the vegetation as the level of Lake Mead continued to drop. No resident willow flycatchers were detected in the recreation area in 2007, and it is likely the existing willow stands in the area will further degenerate in future years.

Surveys that had been conducted by SWCA on river left between Separation Canyon (RM 239.5) and RM 274.5 in 2003–2005 were conducted in 2006 and 2007 by the Hualapai Department of Natural Resources. The remaining survey sites on river right upstream of Burnt Springs (RM 259.5N) were discontinued in June 2006 to allow time for surveys and monitoring in new areas within the Lake Mead National Recreation Area.

Site names below indicate historical names (if applicable) and the river mile, as measured downstream from Lees Ferry. River left and river right are indicated by “S” (south) and “N” (north), respectively.

BURNT SPRINGS (RM 259.5N)

Area: 11.0 ha Elevation: 363 m

Vegetation within the first 200 m of Burnt Springs Canyon upstream from the Colorado River consists of extremely dense monotypic tamarisk approximately 4 m in height. The next 150 m of the canyon is vegetated by very young tamarisk. This is followed by an approximately 700-m stretch of mature Goodding willow 15 m in height with an understory of cattails. Canopy closure is approximately 70–90%. Through July, muddy soil and slow flowing water in the streambed were present.

We detected one breeding pair of willow flycatchers at Burnt Springs. Details of occupancy, color-banding, and breeding are presented in Chapters 3 and 4. Areas of Burnt Springs not known to be occupied by willow flycatchers were surveyed 10 times throughout the breeding season, totaling 7.3 observer-hours. Brown-headed Cowbirds were detected during all but three surveys, and no sign of livestock use was recorded.

RM 274.5N

Area: 18.3 ha Elevation: 354 m

This mixed-native site lies immediately adjacent to the Colorado River and contains several perennial springs, which feed small creeks, flooded willow and tamarisk forest, beaver ponds, and cattail marshes. Perennial creeks lined with coyote and Goodding willow connect the wetlands to the Colorado River. Throughout the survey season, deep pools of clear, standing water were present at springs, and large areas of the site contained muddy soils and standing water. Vegetation at the site is a mosaic of well developed, mature Goodding willow forest, willow forest with tamarisk understory, and cattail marsh. Canopy height averages 7 m, but canopy height and relative proportions of willow and tamarisk vary throughout the site. Overall canopy closure is highly variable throughout the site, but averages approximately 70%. The survey area was expanded greatly in 2006 to include large adjacent areas of recently developed mature willow, and these areas were also surveyed in 2007.

We detected two resident, unpaired males, one male for three days in June, and one probable migrant at this site. One of the unpaired males was later detected at Mormon Mesa in July. Details of occupancy and color-banding are presented in Chapters 3 and 4. Portions of the site not known to be occupied by flycatchers were surveyed 10 times, totaling 18.8 observer-hours. Brown-headed Cowbirds were detected on all but three surveys, and no sign of livestock use was recorded.

PEARCE FERRY

Area: 0.8 ha Elevation: 343 m

This mixed-native site lies immediately adjacent to the Colorado River and consists primarily of a 30-m-wide strip of Goodding willow averaging 8 m in height. On the upland edge of the site, the vegetation consists of dense stands of tamarisk 3 m in height. Patches of young arrowweed are scattered throughout the site. Canopy closure in May was 50–70%, but had decreased by July to 25–50% because much of the willow was dead and dying. Soils throughout the site were dry and sandy during the survey season.

We detected one male at the site for a single day in June. Details of occupancy and color-banding are presented in Chapter 3. Portions of the site not known to be occupied by flycatchers were surveyed nine times, totaling 2.5 observer-hours. Cowbirds were detected during two surveys, and no evidence of livestock use was recorded at the site.

RM 285.3N

Area: 8.7 ha Elevation: 343 m

RM 285.3N 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 site also contained patches of dense coyote willow, tamarisk, and cattail near 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 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 is now vegetated with tamarisk approximately 2 m in height. Young willow <3 m in height are colonizing areas with wet soil closest to Grand Wash Bay. Canopy closure at the site in 2007 ranged from 25 to 70%. No standing water was present under the vegetation during the survey season, and saturated soils were present only in areas immediately adjacent to Grand Wash Bay.

We did not detect any flycatchers at RM 285.3N. The site was surveyed nine times, totaling 7.9 observer-hours. Brown-headed Cowbirds were detected on four surveys, and there was sign of burro and livestock use at the site.

KOWLP CORNER

Area: 5.4 ha Elevation: 342 m

This site lies immediately adjacent to the Colorado River. In 2006, mixed-native vegetation at the site consisted of even-aged stringers of Goodding willow averaging 7 m in height, with a few small tamarisk scattered throughout in the understory. Canopy closure was 50–70%. In 2007, much of the Goodding willow present in 2006 was dead and dying, and canopy closure decreased to 25–50%. Much of the remaining willow closest to the river progressively died off from May to July. Soils throughout the site were dry and sandy during the survey season.

We did not detect any flycatchers at Kowlp Corner. The site was surveyed 10 times, totaling 7.0 observer-hours. Cowbirds were detected on six surveys, and no livestock were observed at the site.

RM 286N

Area: 3.4 ha Elevation: 342 m

RM 286N lies between the Colorado River and high desert bluffs. In 2006, this mixed-native site consisted of three distinct strips of vegetation. An approximately 10-m-wide strip of vegetation adjacent to the river consisted of very young Goodding and coyote willow <2 m in height. Small, scattered patches of arrowweed and cattail were also present next to the river. Behind this was an approximately 10-m-wide band of more mature Goodding willow, approximately 10 m tall, with some coyote willow in the understory. Along the foot of the bluffs, vegetation consisted of a band of tamarisk averaging 4 m in height. On the downstream end of the site was a dry cove vegetated with short, scattered tamarisk and a few dead and dying Goodding willows. Canopy closure in 2006 ranged from 50 to 70%. Vegetation structure and species composition were similar in May 2007; however, much of the Goodding and coyote willow was dead and dying by July. During the survey season, no standing water was present under the vegetation, and saturated soils were present only along the river.

We did not detect any flycatchers at RM 286N. The site was surveyed 10 times, totaling 5.8 observer-hours. Cowbirds were detected on six surveys, and signs of cattle were observed at the site.

DRIFTWOOD ISLAND

Area: 3.7 ha Elevation: 342 m

This mixed-native site lies immediately adjacent to the Colorado River and consists of a narrow band (<25 m wide) of even-aged Goodding and coyote willow 6 m in height. Tamarisk 1–2 m in height forms a sparse understory and is also present along the river. Small, scattered patches of cattail are present next to the river. Canopy closure is 50–70%. During the survey season, no standing water was present under the vegetation, and saturated soils were present only along the river. Because a site description is not available for July, any vegetation or hydrological changes that may have occurred during the end of the survey season are unknown.

We did not detect willow flycatchers at Driftwood Island. The site was surveyed 10 times, totaling 3.9 observer-hours. Brown-headed Cowbirds were detected during six surveys, and cattle were observed using the site.

TWIN COVES

Area: 1.4 ha Elevation: 342 m

Twin Coves lies along the Colorado River. In 2006, vegetation at the site was mixed-native and consisted primarily of a narrow band (<35 m wide) of Goodding willow 8 m in height with scattered 2-m-tall tamarisk in the understory. Along the riverbank, the vegetation consisted of young Goodding willow up to 2 m in height. On the upland edge of the site, tamarisk 2–3 m in height was scattered along open sandy areas. Canopy closure was 50–70% and patchy. Most of the willow overstory progressively died off from May to July in 2007, and canopy closure decreased to 25–50%. Tamarisk approximately 3 m in height is now the dominant vegetation. During the survey season, no standing water was present under the vegetation, and saturated soils were present only along the river.

We did not detect willow flycatchers at Twin Coves. The site was surveyed 10 times, totaling 3.7 observer-hours. Brown-headed Cowbirds were detected during three surveys, and no sign of livestock use was recorded.

BRADLEY BAY

Area: 5.6 ha Elevation: 341 m

Bradley Bay is a relatively large, mixed-exotic site located in a dry, backwater bay adjacent to the Colorado River. In 2006, the vegetation adjacent to river consisted primarily of even-aged bands of Goodding willow, 8 m in height, along dry swales that parallel the river. These swales held standing water as the water level in Lake Mead receded. Farther up the dry bay away from the river, the willow forest graded into a dense mixture of willow and tamarisk, which averaged 6 m in height. Along the upland edges of the site, the vegetation consisted of dense stands of tamarisk 3 m in height. Small, scattered patches of arrowweed and cattail were present next to the river. Canopy closure throughout the site was variable and ranged from 50 to 70%. Vegetation structure and species composition were similar in May 2007; however, much of the willow was dead and dying by July, and young tamarisk was sprouting in large areas along the shoreline. During the survey season, no standing water was present under the vegetation, and saturated soils were present only along the river.

We did not detect willow flycatchers at Bradley Bay. The site was surveyed 11 times, totaling 7.0 observer-hours. Brown-headed Cowbirds were detected during six surveys, and no sign of livestock use was recorded.

CHUCKWALLA COVE

Area: 1.8 ha Elevation: 341 m

Chuckwalla Cove is located in a dry cove between high bluffs and the Colorado River. In 2006, vegetation at the site was mixed-native and consisted of stringers of Goodding willow, 10–15 m in height, separated by dry, sandy areas vegetated by scattered tamarisk and dead cattail. Coyote willow was mixed with Goodding willow throughout the site. Canopy closure throughout the site in 2006 was 25–90% and highly variable. Vegetation structure and species composition were similar in May 2007; however, much of the Goodding and coyote willow were dead and dying by July. During the survey season, no standing water was present under the vegetation, and saturated soils were present only along the river.

We did not detect willow flycatchers at Chuckwalla Cove. The site was surveyed 10 times, totaling 3.2 observer-hours. Brown-headed Cowbirds were detected during three surveys, and livestock use was recorded.

CENTER POINT

Area: 3.1 ha Elevation: 341 m

Center Point lies immediately adjacent to the Colorado River. In 2006, the site was mixed-native and consisted of a narrow band (<25 m wide) of Goodding willow approximately 8 m in height. Coyote willow and tamarisk were scattered throughout the site, and small, scattered patches of cattail were present next to the river. Canopy closure in 2006 was 25–50%. Vegetation structure and species composition were similar in May 2007; however, much of the Goodding and coyote willow were dead and dying by July. Tamarisk approximately 3 m in height is now the dominant vegetation. During the survey season, no standing water was present under the vegetation, and saturated soils were present only along the river.

We did not detect willow flycatchers at Center Point. The site was surveyed 10 times, totaling 1.7 observer-hours. No Brown-headed Cowbirds or sign of livestock use were recorded during surveys.

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, and seasonally wet, low-lying areas are interspersed throughout the riparian area. Brown-headed Cowbirds were detected during the entire season. No cattle were present, but feral pigs frequented all areas surveyed.

The amount of standing water throughout the entire Topock study area was markedly reduced in 2005 compared to 2003 and 2004. Compared to 2005 the amount of standing water in 2006 increased at breeding sites, and was similar to that of 2003 and 2004. Quantities of standing water generally remained the same in 2007.

PIPES

Pipes #1: Area: 5.2 ha Elevation: 140 m
Pipes #3: Area: 5.7 ha Elevation: 140 m

These two sites are bordered to the east by the refuge road and are vegetated primarily by monotypic tamarisk 5–7 m in height. Within approximately 50 m of the refuge road, the sites contain large areas of dense arrowweed. Canopy closure at the sites generally exceeds 70%. The northern edge of Pipes #1 has larger stems and taller canopy than Pipes #3 and has little deadfall. The central and southern portions of Pipes #1 have many dead stems and clusters of fallen trees, and a few Goodding willow are scattered throughout the site. The western portion of Pipes #3 contains marshes and scattered Goodding willow. Pipes #1 contained no standing water during the survey season, but the site did contain saturated soils until July. Standing water was present at Pipes #3 through the survey season.

No willow flycatcher detections were recorded at Pipes in 2007. Pipes #1 was surveyed 10 times, totaling 18.6 hours; Pipes #3 was surveyed 11 times, totaling 21.1 observer-hours. Brown-headed cowbirds were detected on seven visits at Pipes #1 and eight visits at Pipes #3.

THE WALLOWS

Area: 0.4 ha Elevation: 140 m

The Wallows is located between Pipes #3 and PC6-1. The site is primarily vegetated by tamarisk 5–6 m in height with an occasional emergent Goodding willow. Overall canopy closure ranges from 70 to 90%. The western edge of the site borders an open cattail marsh. The Wallows contained standing water and saturated soils throughout the survey season, and an increase in the amount of standing water was recorded mid-season.

No willow flycatcher detections were recorded at the Wallows. The site was surveyed 10 times, totaling 4.3 hours. Brown-headed cowbirds were detected on five visits.

PC6-1

Area: 4.8 ha Elevation: 140 m

PC6-1 is a mixed-exotic site consisting primarily of tamarisk 6–7 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%. PC6-1 contained standing water and saturated soils throughout the survey season.

No willow flycatchers were detected at the site. The site was surveyed 10 times, totaling 14.3 observer-hours. Brown-headed cowbirds were detected on six visits.

PIG HOLE

Area: 2.4 ha Elevation: 140 m

Pig Hole consists of monotypic tamarisk 5–6 m in height, with canopy closure ranging from 70 to 90%. The northern portion of the site is the densest area, and the center of the site, where flycatchers were detected in previous years, is less dense. Dense patches of arrowweed occur in approximately 5% of the site. Standing water was present at the site in mid- May, but it dried up by June and <1% of the site contained saturated soils in July.

No willow flycatchers were detected at the site. The site was surveyed 10 times, totaling 7.2 observer-hours. Brown-headed cowbirds were detected on five visits.

IN BETWEEN AND 800M

In Between: Area: 7.8 ha Elevation: 140 m
800M: Area: 6.1 ha Elevation: 140 m

These two contiguous sites consist of approximately 50-m-wide linear patches of monotypic tamarisk between swampy areas that have contained varying amounts of standing water across years. The tamarisk patches have stems spaced at approximately 0.5- to 1.0-m intervals. Canopy height is approximately 7 m, with the lowest 3 m of the stand generally lacking foliage, resulting in a relatively open understory. Canopy closure in the tamarisk stands is generally over 90%. At both 800M and In Between, standing water was present in and along small areas of marsh and in pig wallows, mainly early in the season. Saturated soils were present only near the marsh edges.

We located one breeding pair and one unpaired male at In Between. One pair was located in 800M. Details of pairing, occupancy, color-banding, and nesting are presented in Chapters 3 and 4. Portions of In Between not known to be occupied by willow flycatchers were surveyed 10 times, totaling 10.3 observer-hours; cowbirds were recorded during four surveys. Portions of 800M not known to be occupied by willow flycatchers were surveyed two times, totaling 2.5 observer-hours. Cowbirds were recorded during both surveys.

PIERCED EGG

Area: 6.8 ha Elevation: 140 m

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 cattails. Overall canopy closure is approximately 80%. Standing water was present in a small marsh through mid-June, and saturated soils persisted throughout the season.

We located two breeding pairs, two unpaired males, and one additional bird for which occupancy and/or breeding status could not be confirmed at Pierced Egg. Details of occupancy, color-banding, and nesting are presented in Chapters 3 and 4. Portions of the site not known to be occupied by willow flycatchers were surveyed three times, totaling 4.6 observer-hours. Cowbirds were recorded on all surveys.

SWINE PARADISE

Area: 3.7 ha Elevation: 140 m

This mixed-exotic site borders the open water of Topock Marsh. Near the marsh, vegetation at the site is dominated by Goodding willow to 15 m in height, with some coyote willow and very little tamarisk. The remainder of the site, on both sides of the main refuge road, is vegetated by tamarisk 6–8 m in height. Overall canopy closure is approximately 80%. Saturated soil was recorded early in the season but dried out by mid-June. No standing water was present within the site during the flycatcher breeding season.

No willow flycatchers were detected at Swine Paradise. We surveyed the site 10 times, totaling 6.0 observer-hours. Cowbirds were detected on three visits.

BARBED WIRE

Area: 2.6 ha Elevation: 140 m

This site is contiguous with Swine Paradise. One large, emergent Goodding willow occurs at the site; otherwise, the site is vegetated by tamarisk of varying height and density. The northeastern portion of the site contains taller stems, less dead wood in the understory, and fewer large canopy openings than the southwestern portion of the site. Canopy closure is approximately 90%. No standing water or saturated soils were present during the flycatcher breeding season.

One willow flycatcher was detected at Barbed Wire on 10 June. Details of occupancy and color-banding are presented in Chapter 3. We surveyed the site 10 times, totaling 8.0 observer-hours. Cowbirds were detected on four visits.

IRFB03 AND IRFB04

IRFB03: Area: 1.0 ha Elevation: 140 m
IRFB04: Area: 1.5 ha Elevation: 140 m

These two contiguous sites are separated from the Barbed Wire site by a firebreak road. They are vegetated by a monotypic stand of tamarisk 7 m in height, which forms a dense canopy and relatively open understory. There is little deadfall, although many standing stems are dead, leaving dense areas of dead branches in the understory. Soils within these sites were completely dry throughout the survey season.

We did not detect willow flycatchers at either IRFB03 or IRFB04. We surveyed these sites 10 times each, totaling 16.3 observer-hours. Cowbirds were detected on three visits at IRFB03 and five visits at IRFB04.

PLATFORM

Area: 1.3 ha Elevation: 140 m

This site forms a narrow strip of vegetation between the main refuge road and the open marsh. Vegetation at the site consists of tamarisk 7 m in height with a few isolated, emergent Goodding willow. Overall canopy closure is approximately 80%. Bulrush and cattail line the eastern edge of the site adjacent to the marsh. Soils in the interior of the site were saturated only early in the survey season.

No willow flycatchers were detected at Platform. We surveyed the site 10 times, totaling 3.1 observer-hours. Cowbirds were detected on three visits.

250M

Area: 2.3 ha Elevation: 140 m

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 one large Goodding willow. Canopy closure within the site is approximately 70%. Small patches of inundated soil were present throughout the flycatcher breeding season.

We detected two willow flycatchers at 250M. Details of occupancy and color-banding are presented in Chapter 3. Portions of the site not known to be occupied by flycatchers were surveyed 10 times, totaling 5.8 observer-hours. Cowbirds were detected on two surveys.

HELL BIRD AND GLORY HOLE

Hell Bird: Area: 3.7 ha Elevation: 140 m
Glory Hole: Area: 4.3 ha Elevation: 140 m

These contiguous sites are located on an island separated from the main riparian area by a narrow, deep channel. Vegetation composition and structure is highly variable, with the survey areas vegetated primarily by a mosaic of tamarisk 6 m in height and Goodding willow 12 m in height. Canopy closure ranges from 50 to 90%. The survey areas are bordered on the west by a sand dune and on other sides by dense bulrush. Large swampy areas vegetated by cattail and bulrush are interspersed throughout the survey areas. Hell Bird and Glory Hole both contained standing water throughout the flycatcher breeding season.

We recorded two willow flycatchers at Hell Bird on 9 May. Seven breeding flycatchers were recorded at Glory Hole. Details of occupancy, color-banding, and nesting activity are presented in Chapters 3 and 4. Portions of Hell Bird not known to be occupied by flycatchers were surveyed 10 times, totaling 10.9 observer-hours; cowbirds were detected on all but two surveys. Portions of Glory Hole not known to be occupied by flycatchers were surveyed twice, totaling 4.5 observer-hours; cowbirds were detected on both surveys.

BEAL LAKE

Area: 42.8 ha Elevation: 140 m

This mixed-native restoration site consists of a mosaic of relatively young Fremont cottonwood, Goodding willow, coyote willow, and arrowweed, with some tamarisk and mesquite scattered throughout the site. Canopy height is highly variable and averages approximately 4 m; canopy closure is sparse, averaging 25%. The amount of standing water and saturated soil at the site is highly variable because it is flood irrigated.

We detected two willow flycatchers at Beal Lake. Details of occupancy and color-banding are presented in Chapter 3. Portions of Beal Lake not known to be occupied by flycatchers were surveyed 10 times, totaling 4.3 observer-hours; cowbirds were detected on four surveys.

LOST SLOUGH

Area: 4.0 ha Elevation: 140 m

Lost Slough is located approximately 4 km south of Glory Hole and Hell Bird. The site runs north-south for approximately 250 m, and measures 100 m wide at the broadest point. Vegetation at the site is composed mainly of 6- to 8-m-tall tamarisk with a small amount of emergent Goodding willow and mesquite scattered throughout. Tamarisk and coyote willow up to 3 m in height make up the understory. Canopy closure at the site is variable, with open areas toward the edges of the site and up to 70% closure in areas with thick vegetation. Some surface water was present in mid-June, but the site was dry through the rest of the survey season.

We did not detect any willow flycatchers at the site. We surveyed the site nine times throughout the breeding season, totaling 5.5 observer-hours. Cowbirds were detected during four surveys.

LOST POND

Area: 1.7 ha Elevation: 140 m

This mixed-exotic site is located approximately 700 m southeast of Lost Slough. The site is approximately 200 m long and 125 m wide, with a small pond in the southern end of the site. The area surrounding the site consists of arrowweed and 3-m tamarisk, with tamarisk height increasing closer toward the pond. Screwbean mesquite is also present around the edges of the site. Vegetation within the site consists mostly of tamarisk, with a few emergent Goodding willow scattered throughout. The pond is surrounded by a 30-m-wide border of cattail, bulrush, and sedges. Immediately surrounding the pond area is an inundated strip of 6- to 8-m-tall tamarisk. Overall canopy closure is approximately 50%. Water remained in the pond throughout the flycatcher breeding season.

No willow flycatchers were detected at this site. We surveyed the site 10 times, totaling 6.2 observer-hours. Cowbirds were detected during four surveys.

LOST LAKE

Area: 4.0 ha Elevation: 140 m

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 west by a low ridge of barren sand dunes and bordered to the east by marshy areas. Lost Lake (a 200- × 500-m body of open water) is located northwest of the site. Vegetation at the site is variable. The northern edge of the site consists of an overstory of planted cottonwoods 10 m in height, with an understory of tamarisk 5 m in height. Southeast of the cottonwoods, the site is a monotypic stand of tamarisk, 5–8 m in height. To the southwest of the cottonwoods, the site consists primarily of tamarisk and arrowweed. Cattails are present in a marshy area on the northern edge of the site. Overall canopy closure is approximately 60%. Areas adjacent to the marsh edges held some standing water through mid-June.

We detected one willow flycatcher at Lost Lake on 6 June. Details of occupancy and color-banding are presented in Chapter 3. Portions of Lost Lake not known to be occupied by flycatchers were surveyed nine times, totaling 5.2 observer-hours; cowbirds were detected on all surveys.

OTHER SURVEY AREAS

PB 2001

Area: 2.1 ha Elevation: 140 m

We conducted habitat reconnaissance at PB 2001, between PC6-1 and Pig Hole, in May. Surveys were not conducted because the dense understory that dominates the site is not typically used by flycatchers. This mixed-exotic site consists primarily of very dense tamarisk 4–5 m in height with patches of dense arrowweed in the understory. A few emergent Goodding willow approximately 15 m in height are present in the center of the site, with a few patches of cattails in the understory. Canopy closure ranges from 50 to 70%, with the site containing small areas of open canopy. No part of the site contained water or wet soil in May 2007.

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. We surveyed backwater areas that support marsh and riparian vegetation.

PULPIT ROCK

Area: 2.1 ha Elevation: 140 m

Pulpit Rock is a small backwater area where an unnamed wash enters the Colorado River from the Mohave Mountains. The site is vegetated primarily by tamarisk and young Goodding willow 8 m in height. The northwestern edge of the site borders the river and is vegetated by cattails. The upland edges of the site are vegetated by arrowweed and mesquite. Overall canopy closure at the site is approximately 70%. Hydrological conditions within the vegetation were not recorded, but the northwestern edge of the site lies adjacent to the Colorado River and it is likely this area was partially inundated during the survey season.

No willow flycatchers were detected at this site. We surveyed the site eight times, totaling 2.4 observer-hours. Cowbirds were detected during three surveys. Evidence of burros was recorded at the site.

PICTURE ROCK

Area: 7.0 ha Elevation: 138 m

Picture Rock is a backwater area where an unnamed wash enters the Colorado River from the west. The vegetation is mixed-exotic and is dominated by tamarisk 8 m in height with thick deadfall throughout the site. A few isolated, emergent Goodding willow are present. Canopy closure within the site is 70–90%. Bulrush and cattail are present on the edge of the site along the river, and the upland edges of the site contain arrowweed, mesquite, foothills paloverde (*Parkinsonia microphylla*), and brittlebush (*Encelia farinosa*), especially along the wash. Hydrological conditions within the vegetation were not recorded, but bulrush and cattail areas along the river likely held standing water and/or saturated soils during the survey season.

We detected two willow flycatchers at Picture Rock on 7 June. We surveyed the site nine times, totaling 8.0 observer-hours. Cowbirds were detected on four surveys. Feral pigs and burros use the site and adjacent uplands.

BLANKENSHIP BEND

Blankenship Bend North: Area: 26.7 ha Elevation: 138 m
Blankenship Bend South: Area: 25.9 ha Elevation: 138 m

Blankenship Bend is a 2-km-long strip of riparian and marsh vegetation that lies along the east bank of the Colorado River adjacent to the Blankenship Valley. The eastern, upland edge of the site is vegetated by a 100-m-wide strip of mature tamarisk and mesquite. The northern half of the site contains a stand of large Goodding willows adjacent to a cattail marsh. Between the river and the strip of tamarisk, the southern half of the site consists of a mosaic of cattail, bulrush, and scattered islands of small willows and tamarisk. Canopy closure and height are highly variable throughout this mixed-exotic site. Because of the proximity to the Colorado River, both sites contained standing water and saturated soils throughout the survey season.

We detected four willow flycatchers at Blankenship Bend North and one at Blankenship Bend South. Blankenship Bend North was surveyed nine times, totaling 14.0 observer-hours; cowbirds were detected on all but two surveys. Blankenship Bend South was surveyed seven times, totaling 4.2 observer-hours; cowbirds were detected on three visits. Feral pigs, bighorn sheep, and burros use the sites and adjacent uplands.

HAVASU NE

Area: 12.6 ha Elevation: 136 m

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. Vegetation at the site grades 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. Canopy closure is approximately 50%. Many Goodding willows at the site are mature and stand 5 m above the 10-m-tall tamarisk and mesquite. Soils in the interior of the site were dry throughout the survey season.

We did not detect any willow flycatchers at this site. We surveyed the site nine times, totaling 18.8 observer-hours. Cowbirds were detected on all visits. No livestock use at the site was recorded, but evidence of wild burros and human disturbance (vagrant camps) was observed.

BILL WILLIAMS RIVER NATIONAL WILDLIFE REFUGE, ARIZONA

The Bill Williams River NWR contains the last expanse of native cottonwood-willow forest on the lower Colorado River. 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. In late July 2006, a fire burned through portions of the Bill Williams River NWR from the Highway 95 bridge upstream through Site #1, which was not surveyed in 2007 because the fire consumed much of the vegetation. Survey sites within Bill Williams are listed below from west to east, moving progressively farther upstream.

In an effort to locate all potentially suitable willow flycatcher habitat within the Bill Williams River NWR, we reduced the number of surveys at the most upstream sites, which are difficult to access, and instead explored additional areas. Results of this reconnaissance effort are presented below after the survey results.

BILL WILLIAMS SITE #2

Area: 3.1 ha Elevation: 140 m

This mixed-native site has an overstory of large Goodding willow and Fremont cottonwood trees up to 15 m in height and an understory of tamarisk 5 m in height. Overall canopy closure is approximately 50%. Soils in the interior of the site were dry throughout the flycatcher breeding season. The site is bordered on the southwest by a narrow channel of open water where an arm of Lake Havasu follows the channel of the Bill Williams River. The site is accessible by kayak.

No willow flycatchers were detected at Site #2. We surveyed the site 10 times, totaling 7.9 observer-hours. Cowbirds were detected on eight visits, and there was no evidence of livestock at the site.

BILL WILLIAMS SITE #11

Area: 6.3 ha Elevation: 140 m

This mixed-native site has an overstory of Goodding willow and Fremont cottonwood trees up to 20 m in height, with canopy closure approximately 50%. Tamarisk ranging from 3 to 5 m in height is the dominant species in the understory. Large areas of standing water are present because an arm of Lake Havasu follows the channel of the Bill Williams River through the site. However, no saturated soils were present under the vegetation during the survey season. The site is accessible by kayak.

We detected one willow flycatcher, likely a migrant, at Site #11 on 7 June. We surveyed the site 10 times, totaling 10.2 observer-hours. Cowbirds were detected on all visits, and there was no evidence of livestock at the site.

BILL WILLIAMS SITE #4 AND SITE #3

Site #4: Area: 9.9 ha Elevation: 140 m
Site #3: Area: 8.3 ha Elevation: 140 m

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. Canopy closure is approximately 50%. Stands of cattails occupy approximately 10% of the site. Many large willows and cottonwoods have fallen in the last four years, leaving large gaps in the canopy. Ground cover in portions of the site consists of thick, dead, fallen woody vegetation, and large amounts of flood debris are lodged in the understory. Mosquito Flats contained areas of standing water and saturated soil throughout the flycatcher breeding season.

No willow flycatchers were detected in Site #4. In Site #3 we detected 11 resident, breeding willow flycatchers, 1 unpaired male, and 2 individuals for which residency and/or breeding status could not be determined. Details of color-banding, occupancy, and nesting are presented in Chapters 3 and 4. Portions of the sites not known to be occupied by flycatchers were visited 11 times, totaling 38.5 observer-hours. Cowbirds were detected on 10 visits to Site #4 and 8 visits to Site #3. No evidence of livestock was observed at either site.

BILL WILLIAMS SITE #5

Area: 5.3 ha Elevation: 143 m

Site #5 is located on the eastern edge of the Bill Williams River floodplain and is bordered to the east by upland desert. Vegetation in the site is mixed-native, with Goodding willow and Fremont cottonwood 20 m in height in the overstory. The understory consists of tamarisk 7 m in height as well as some young Goodding willow and Fremont cottonwood. Canopy closure in the site varies, with an average of 70%. Soils in the site were mostly dry, with a couple of small ponds containing water through June and July.

No willow flycatchers were detected at Site #5. We visited the site 10 times, totaling 6.6 observer-hours. Cowbirds were detected on seven visits, and evidence of burros was observed at the site.

MINERAL WASH COMPLEX

Area: 18.8 ha Elevation: 162 m

A channel of the Bill Williams River runs through this mixed-native site, approximately 3 km upstream of Site #5. The site is similar in structure and composition to the other survey sites at Bill Williams, with an overstory of Fremont cottonwood and Goodding willow up to 20 m in height and an understory of tamarisk averaging 5 m in height. Overall canopy closure is <50%. A channel of the Bill Williams River was flowing along the edge of the site throughout the flycatcher breeding season, and the site contained saturated soils through July.

We detected three willow flycatchers at Mineral Wash; two in early June, and one from 30 May–6 June. The site was surveyed six times, totaling 10.8 observer-hours. Cowbirds were detected on all but one visit, and no sign of livestock was detected at the site.

BEAVER POND

Area: 21.7 ha Elevation: 165 m

This mixed-native site consists of Fremont cottonwood and Goodding willow averaging 15 m in height with an understory of tamarisk along the Bill Williams River. Areas not immediately adjacent to the river channel are vegetated by tamarisk and honey mesquite 5–7 m in height and were dry during the surveys. Overall canopy closure at the site is <50%. A channel of the Bill Williams River was flowing along the edge of the site, and an old channel in the center of the site contained small pools of water throughout the flycatcher breeding season. The site contained saturated soils throughout the season.

We detected one willow flycatcher, likely a migrant, in Beaver Pond on 6 June. We surveyed the site six times, totaling 9.0 observer-hours. Cowbirds were detected on all but one visit, and no sign of livestock was recorded at the site.

BILL WILLIAMS SITE #8

Area: 10.3 ha Elevation: 168 m

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. Cottonwood and willow trees 18 m in height line a flowing river channel, with an understory of tamarisk also present throughout the site. Overall canopy closure is 25–50%. This site had flowing water in the river channel throughout the flycatcher breeding season.

One willow flycatcher, likely a migrant, was detected at Site #8 on 6 June. The site was surveyed seven times, totaling 11.3 observer-hours. Cowbirds were detected on all but one visit, and evidence of burros was recorded on one visit.

GROUND RECONNAISSANCE RESULTS

Field personnel spent a total of 13.3 person-hours conducting habitat reconnaissance and opportunistic broadcast surveys along the Bill Williams River corridor. We evaluated four areas, Burn Edge, Upstream of Site #5, New Willow, and Planet Ranch (see below for details), that should be visited in subsequent years. One willow flycatcher was located during habitat reconnaissance.

Below, we qualitatively describe vegetation and hydrology for habitat sections as related to our current study sites (see Figures 2.2 and 2.3 and Appendix B). The following descriptions are organized from downstream to upstream along the Bill Williams River.

"Burn Edge"

Starting our habitat reconnaissance at Site #1 (burned in 2006), we followed an approximately 800-m-long route east-southeast from the eastern edge the site. Tall willow forest with a tamarisk understory is present in this area. In some areas, lower strata vegetation from ground level up to approximately 2 m is choked with deadfall, creating an almost impenetrable understory. Other areas are relatively open, with patches of tamarisk present. Soils under the vegetation were generally damp, with small puddles present in some areas through July. Parts of the site are adjacent to a waterway and can be surveyed by boat. With standing water present throughout the breeding season and vegetation typical of flycatcher habitat, this area should be further evaluated in future years.

"Upstream from Site #5"

This area is adjacent to Site #5, extending approximately 350 m southeast from the eastern boundary of the site. Desert uplands border the area to the north, and it is difficult to access the site. The dominant vegetation consists of tall Fremont cottonwood and a tamarisk understory. Goodding willows are also present in areas with standing water. When the site was visited on 11 May, a small stream ran through the site, and several beaver ponds, as deep as 1.5 m, were also present. Most of the site was inundated, and should be evaluated in future years.

"New Willow"

This area is located approximately 1.7 km southeast of Site #5. Goodding willow and Fremont cottonwood up to 10 m in height compose a patchy overstory in this area. Understory vegetation includes tamarisk, Goodding willow, coyote willow, and arrowweed averaging 3 m in height. Cattail and honey mesquite are also present in the area. When the site was visited on 5 June, soils under the vegetation were dry to damp, with the nearest running water approximately 200 m away. Though no standing water was present in the area, a willow flycatcher was briefly detected in this site. Therefore, the site should be evaluated in future years.

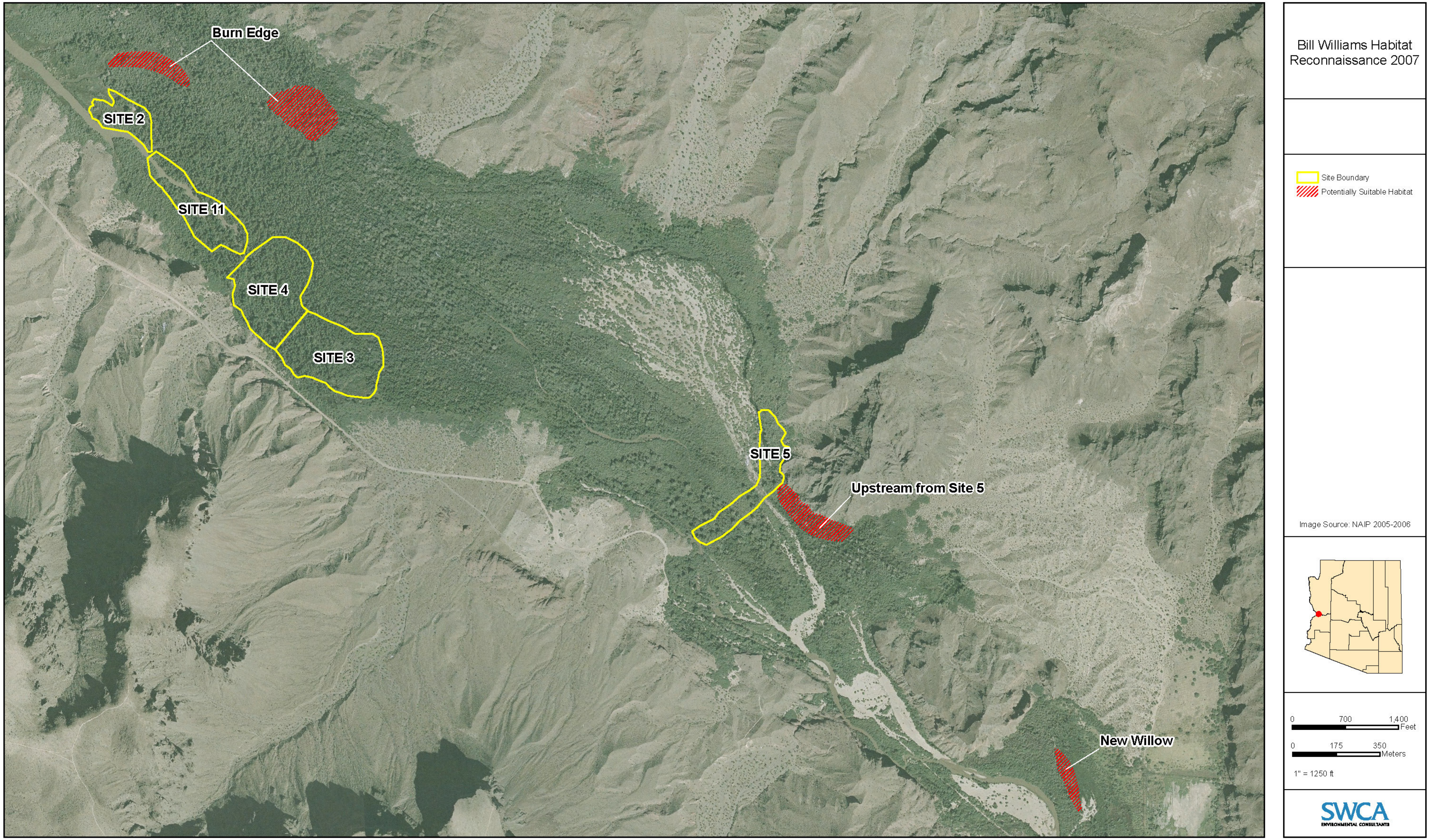

Figure 2.2. Bill Williams River NWR habitat reconnaissance 2007.

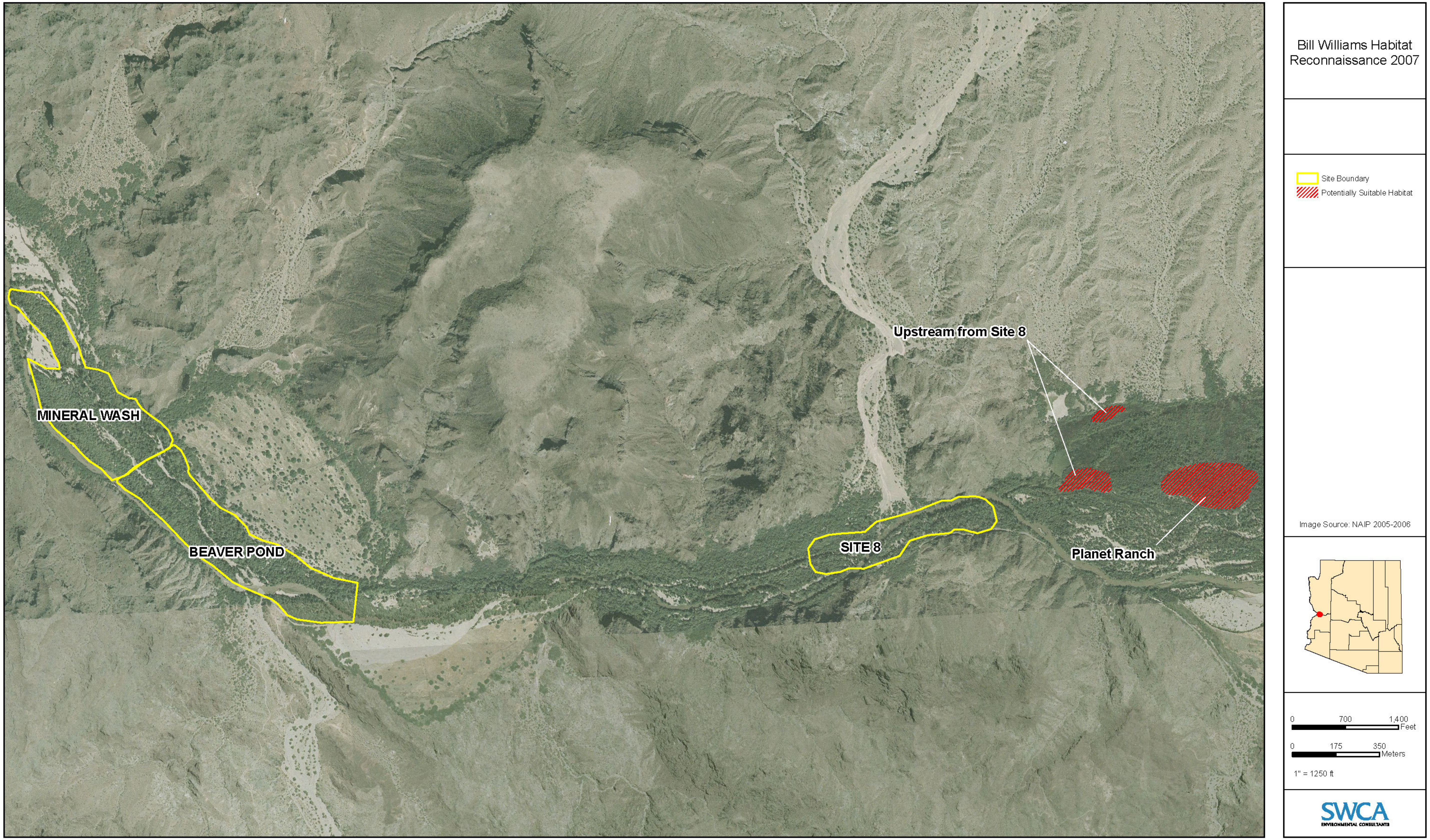

Figure 2.3. Bill Williams River NWR habitat reconnaissance 2007, continued.

"Upstream from Site #8"

We started our habitat reconnaissance approximately 300 m east of Site #8 and evaluated two relatively small areas bordering the adjacent upland habitat. In the southern area, the overstory consists of Goodding willow and Fremont cottonwood to 14 m in height, while tamarisk 6 m in height is the dominant understory species. Several large, open cattail marshes are present in the area. Approximately 10% of the evaluated area was inundated in late May, with another 35% of the soils saturated or damp. Heading south toward the river, the soil became dry and sandy.

In the northern area, Goodding willows 10 m in height are present in the overstory, with 3-m-tall tamarisk dominating the understory. This area lies on the edge of a marsh, and many cattails are present throughout, though most are dead or dying. A majority of the soils were inundated or saturated when the site was visited in mid-May.

Both of the above areas exhibit features that are characteristic of willow flycatcher habitat, and therefore should be evaluated in future years.

"Planet Ranch"

Starting approximately 250 m east of the "Upstream from Site 8" recon sites, we evaluated an area extending approximately 300 m east and 200 m north of the start point. Goodding willow and Fremont cottonwood to 18 m in height make up the overstory in the area, while understory species include Goodding willow, tamarisk, mesquite, and arrowweed. Some areas of understory include dense patches of deadfall. One large cattail marsh is present in the central part of the site. Small streams and a cattail marsh are also present in the eastern section of the site. Hydrologic conditions, as well as vegetation characteristics, are typical of willow flycatcher habitat. Therefore, this site should be evaluated in future years.

BIG HOLE SLOUGH, CALIFORNIA

BIG HOLE SLOUGH

Area: 20.0 ha Elevation: 82 m

This mixed-native site consists of a cattail marsh edged with narrow bands of coyote willow 5 m in height and an understory of seep willow. Away from the marsh, the site contains tamarisk and honey and screwbean mesquite (*Prosopis pubescens*) 8 m in height with an understory of arrowweed. A few tall Goodding willow and Fremont cottonwood are present at the site. Overall canopy closure is approximately 50%. The cattail marsh (approximately 30% of the site) was not accessed during the survey season.

We detected four flycatchers at the site on 16 May, one on 20 May, and two on 5 June. No willow flycatchers were detected during the remaining seven surveys. The site was surveyed 10 times, totaling 21.7 observer-hours. Large flocks of cowbirds were detected on all visits. No livestock use was recorded at the site.

EHRENBERG, ARIZONA

EHRENBERG

Area: 4.7 ha Elevation: 78 m

This mixed-native site consists of a canopy of Fremont cottonwood and Goodding willow 15 m in height with an understory of coyote willow. The periphery of the site is vegetated with a mix of tamarisk and mesquite. Canopy closure at the site is approximately 50%. Approximately 5% of the site is a cattail marsh that contained saturated soils in June. The site is separated from the Colorado River by a levee.

We detected one willow flycatcher on 20 May, one on 1 June, two on 5 June, and one on 18 June. No willow flycatchers were detected during the four surveys after 18 June. The site was surveyed 10 times, totaling 6.5 observer-hours. Cowbirds were detected on six surveys, and no livestock use was recorded at the site.

CIBOLA NATIONAL WILDLIFE REFUGE, ARIZONA AND CALIFORNIA

CIBOLA NATURE TRAIL

Area: 13.7 ha Elevation: 70 m

This mixed-native restoration site consists of a mosaic of Fremont cottonwood, Goodding willow, coyote willow, and mesquite. The site is completely surrounded by plowed agricultural fields. Canopy height varies from 15–20 m in the cottonwood areas to 5–7 m in the willows and 4–5 m in the mesquite. Canopy closure ranges from 25 to 50%. Standing water and saturated soil were recorded throughout the survey season. The amount of standing water and saturated soil is highly variable because the site is flood irrigated.

We detected one willow flycatcher on 17 May, one on 20 May, three on 2 June, six on 6 June, and one on 14 June. No willow flycatchers were detected during the five surveys after 14 June. The site was surveyed 10 times, totaling 9.8 observer-hours. Cowbirds were detected on all surveys.

CIBOLA ISLAND

Area: 9.0 ha Elevation: 70 m

This mixed-native site is located approximately 9.5 km southwest of Cibola Nature Trail. The site runs north to south, extending approximately 600 m lengthwise, with a width of 100–150 m. Dirt roads border the site to the north, east, and west. Open farm fields lie across the eastern road, with irrigation channels alongside the road. Vegetation at the site consists of an overstory of Goodding willow and Fremont cottonwood 7 m in height and an understory of Goodding willow, tamarisk and arrowweed 2 m in height. Honey mesquite and Goodding willow are plentiful throughout the site, while tamarisk is more abundant in the southern end of the site.

We detected eight willow flycatchers on 6 June at Cibola Island. No flycatchers were detected on the two surveys after 6 June. The site was surveyed five times, totaling 3.5 observer-hours. Cowbirds were detected on three surveys.

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

These adjacent, mixed-exotic sites lie approximately 950 m east of Cibola Island, and consist of a 200-m-wide strip of vegetation bordering the channelized Colorado River. The sites are vegetated primarily by tamarisk, which is dry and scrubby on the eastern edge of the sites and becomes denser toward the cattail marshes on the western edge of the sites adjacent to the canal. Emergent Fremont cottonwood and Goodding willow occur primarily along the eastern edge of these marshy areas. The cottonwoods and tamarisk reach heights of 20 and 6 m, respectively, and overall canopy closure is 50–70%. The hydrologic conditions at these sites were undetermined because dense vegetation inhibited the ability of observers to access the marshes, but standing water was likely present within the cattail marshes.

We detected one willow flycatcher on 19 June at Site #2 and detected one flycatcher on 17 May, two on 2 June and two on 4 June at Site #1. No flycatchers were detected on the four surveys at Site #2 after 19 June and the six surveys at Site #1 after 4 June. The sites were surveyed 10 times each, totaling 12.7 observer-hours. Cowbirds were recorded on all visits, and burro trails were noted on the periphery of the sites.

HART MINE MARSH

Area: 31.6 ha Elevation: 65 m

This mixed-exotic site parallels the channelized Colorado River, immediately south of Cibola Site #1. The site consists of a mix of tamarisk and linear stretches of marsh, which make up approximately half the site. Canopy height of the tamarisk is approximately 5 m, and canopy closure is approximately 70%. The marsh held standing water until July. Tamarisk areas contained dry soils throughout the survey season.

We detected three willow flycatchers on 17 May, three on 20 May, one on 31 May, one on 4 June, one on 16 June, and two on 19 June. No willow flycatchers were detected during the remaining four surveys. The site was surveyed 10 times, totaling 15.7 observer-hours. Cowbirds were detected on all visits, and burros use the site.

THREE FINGERS LAKE

Area: 67.9 ha Elevation: 65 m

This mixed-exotic site consists of a large island separated from the surrounding area by a dredged backwater channel. The shores of the island are vegetated by cattails, bulrush, tamarisk 6 m in height, and a few large Goodding willow. Canopy closure along the shore is approximately 50%. The interior of the island is vegetated primarily by arrowweed and had dry soils throughout the survey period. Saturated soils were only present along the shore of the island.

We detected one willow flycatcher on 19 May, 11 on 23 May, one on 30 May, two on 3 June, two on 14 June, and one on 20 June. No willow flycatchers were detected during the remaining four surveys. The site was surveyed 10 times, totaling 26.2 observer-hours. Large numbers of cowbirds were detected on all visits, and burros use the site.

CIBOLA LAKE NORTH, EAST, AND WEST

Cibola Lake North:	Area: 8.5 ha	Elevation: 64 m
Cibola Lake East:	Area: 4.5 ha	Elevation: 64 m
Cibola Lake West:	Area: 6.8 ha	Elevation: 64 m

These mixed-exotic sites border Cibola Lake. The perimeter of each site adjacent to the lake is vegetated by cattail and bulrush. Areas immediately inland from the cattail marshes are vegetated by dense tamarisk 4–6 m in height with scattered Goodding willow. The interiors of the sites have patchy vegetation with a mix of tamarisk, arrowweed, and open sandy areas. Canopy closure along the marsh edges is 50–70%, while the interiors of sites have canopy closure <25%. Except for along the shores, soils within the interior of all sites were dry throughout the survey period.

We detected one willow flycatcher at Cibola Lake North on 31 May and one on 4 June. At Cibola Lake East, we detected one willow flycatcher on 20 May and two on 6 June.

No willow flycatchers were detected at Cibola Lake West. No willow flycatchers were detected during the six surveys at Cibola Lake North and East after 4 and 6 June, respectively. The sites were surveyed 10 times each, totaling 37.1 observer-hours. Cowbirds were detected on all visits, and burro sign was noted at Cibola Lake East.

WALKER LAKE

Area: 11.4 ha Elevation: 64 m

This mixed-exotic site is located between Walker Lake and the Colorado River. In 2003 and 2004, we surveyed the area adjacent to the river. In 2005–2007 we shifted our survey efforts to the area adjacent to Walker Lake. A mix of cattail and tamarisk up to 7 m in height border the eastern edge of Walker Lake. A band of emergent Fremont cottonwood and Goodding willow approximately 15 m in height is present farther east, away from the lake edge. Walker Lake contained standing water and saturated soil throughout the survey season. Areas of the site adjacent to Walker Lake had standing water and saturated soils through July, while soils in the interior of the site were dry throughout the survey season.

We detected one willow flycatcher on 30 May and one on 3 June. On both occasions, the flycatcher responded aggressively to broadcasts and continued to sing for up to 20 minutes after broadcasts ceased. The flycatcher was unbanded, so it is unknown whether the same individual was present on both occasions. No willow flycatchers were detected during the six surveys after

3 June. The site was visited 10 times, totaling 15.8 observer-hours. Cowbirds were detected on all but two surveys, and burro sign was recorded.

IMPERIAL NATIONAL WILDLIFE REFUGE, ARIZONA AND CALIFORNIA

DRAPER LAKE

Area: 4.6 ha Elevation: 63 m

The main landscape feature of the site is Draper Lake, which lies approximately 200 m west of the Colorado River. This site burned prior to the 2003 survey season and was surveyed in 2006 and 2007. Between the lake and the river is mixed-exotic vegetation consisting mostly of tamarisk averaging 4 m in height. Goodding and coyote willow averaging 5 m in height are scattered throughout the site, and a large patch of coyote willow extends approximately 100 m west of Draper Lake. Cattail marsh lies in areas closest to the lake and along the edge of the river. Standing water and saturated soils were present throughout the survey season in the cattail marsh.

We detected one willow flycatcher on 16 May and two on 8 June. No willow flycatchers were detected during the six surveys after 8 June. The site was surveyed 10 times, totaling 14.5 observer-hours. Cowbirds were detected on all surveys, and burro sign was recorded.

PARADISE

Area: 7.8 ha Elevation: 62 m

This site is mixed-native habitat, with stringers of Fremont cottonwood and Goodding willow, 15–20 m in height, bordering a small cattail marsh. 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 narrow (50-m-wide) strip of dense tamarisk. A cattail marsh borders the site to the south. Overall canopy closure is approximately 25%. Standing water was present within the marsh in May and July, and saturated soil persisted in the marsh throughout the survey season.

We detected two willow flycatchers on 16 May, one on 21 May, three on 24 May, and two on 8 June. No willow flycatchers were detected during the remaining six surveys. The site was surveyed 10 times, totaling 19.1 observer-hours. Cowbirds were detected on every visit, and burro sign was recorded.

HOGE RANCH

Area: 20.7 ha Elevation: 61 m

This large, wetland site is mixed-exotic habitat, dominated by tamarisk (4–6 m in height), with some young (8 m in height) Goodding willows and, at the southern end of the site near the old ranch, a few emergent Fremont cottonwoods (15 to 18 m in height). Pockets of cattails, bulrush, and common reed occupy less than 20% of the site. Canopy closure is approximately 70%.

The marshes in the interior of the site contained fluctuating amounts of standing water and saturated soil throughout the survey season. The site also borders the Colorado River.

We detected one willow flycatcher at Hoge Ranch on 17 May, one on 3 June, and six on 7 June. No flycatchers were detected during the six surveys after 7 June. The site was surveyed 10 times, totaling 17.2 observer-hours. Cowbirds were detected on all surveys, and there were signs of burros using portions of the site.

ADOBE LAKE

Area: 7.6 ha Elevation: 60 m

This site consists primarily of dense tamarisk (5 to 7 m in height) with many dead branches in the understory. There are scattered Goodding willows (10 m in height) on the site, but no contiguous stands of willows. Canopy closure within the site is 70–90%. The site is adjacent to the Colorado River, but hydrological conditions in the interior of the site were undetermined.

We detected two willow flycatchers on 3 June and one on 7 June. No willow flycatchers were detected during the six surveys after 7 June. The site was surveyed 10 times, totaling 3.6 observer-hours. Cowbirds were detected on five visits, and there was sign of burro use at the site.

RATTLESNAKE

Area: 7.6 ha Elevation: 60 m

This mixed-native site is a patchwork of emergent Goodding willow, strips of dense coyote willow 6–8 m in height, and tamarisk. Tamarisk is widespread in patches throughout the site but is not the dominant vegetation. Canopy closure is 70–90%. Large cattail marshes separate this site from the Colorado River. Water levels within the site fluctuated, and portions of the site held standing water throughout the season.

We detected one willow flycatcher on 15 May, three on 23 May, and two on 3 June. No willow flycatchers were detected during the remaining seven surveys. The site was surveyed 10 times, totaling 10.7 observer-hours. Cowbirds were detected on all but one survey, and there were signs of burros using the site.

NORTON SOUTH

Area: 1.2 ha Elevation: 60 m

This mixed-native site consists of a planted stand of Goodding willow and Fremont cottonwood approximately 20 × 100 m in size. Canopy height is 15–20 m, and overall canopy closure is around 50%. The understory is varied and contains tamarisk, arrowweed, seep willow, cattail, mesquite, and coyote willow. The site is bordered to the north by a cattail marsh on the margin of Taylor Lake and to the south by desert upland. Standing water and saturated soils were present in the cattail marsh on the northern edge of the site throughout the survey season.

We detected two willow flycatchers on 2 June. No willow flycatchers were detected during the six surveys after 2 June. This site was surveyed 10 times, totaling 8.2 observer-hours. Cowbirds were detected on three visits, and burros use portions of the site.

PICACHO NW

Area: 8.8 ha Elevation: 59 m

This site is mixed-native habitat that was intensively managed in the 1990s to remove tamarisk and plant cottonwoods. It is currently a gallery forest of Fremont cottonwood and Goodding willow, 15–20 m in height, with canopy closure approximately 50%. The understory is 2–4 m in height and contains honey mesquite, arrowweed, seep willow, and tamarisk. The site borders the Colorado River, but no standing water or saturated soil was present within the site during the survey season. The eastern portion of the site is fenced to exclude burros, and this portion of the site has a denser understory than unfenced portions. Outside of the managed area, the habitat is dominated by tamarisk and common reed.

We detected three willow flycatchers on 4 June. No willow flycatchers were detected during the six surveys after 4 June. The site was surveyed 10 times, totaling 16.6 observer-hours. Cowbirds were detected on all but two visits, and there was evidence of heavy use of the site by burros.

MILEMARKER 65

Area: 10.0 ha Elevation: 58 m

Milemarker 65 is a narrow strip of mixed-exotic vegetation between the Colorado River and a backwater marsh, which is dominated by impenetrable bulrush. Vegetation at the site consists primarily of dense tamarisk 6 m in height. Dense common reed, approximately 3 m in height, also occurs throughout the site and together with the tamarisk creates almost complete canopy closure. Because of the impenetrable vegetation at this site, we surveyed it from the river. Thus, hydrologic conditions of the interior of the site were undetermined.

We detected two willow flycatchers on 29 May and four on 4 June. No willow flycatchers were detected on the remaining six surveys after 4 June. The site was surveyed 10 times, totaling 5.1 observer-hours. Cowbirds were recorded on all but two visits.

CLEAR LAKE/THE ALLEY

Area: 8.3 ha Elevation: 59 m

Vegetation at this site is primarily exotic, consisting of monotypic tamarisk 8–10 m in height. Emergent Goodding willow, up to 13 m in height, are scattered throughout the site. The tamarisk is mature, with large amounts of deadfall ground cover, 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. A narrow, backwater channel runs northward from the Colorado River into the center of the site, but soils outside of the channel were dry during the survey period.

We detected one willow flycatcher on 4 June. No willow flycatchers were detected on the six surveys after 4 June. The site was surveyed 10 times, totaling 7.2 observer-hours. Cowbirds were detected on all but three visits.

NURSERY NW

Area: 7.0 ha Elevation: 58 m

This mixed-exotic site lies between the Colorado River and a cattail marsh. The dominant vegetation is tamarisk 5–7 m in height with an understory of common reed. The site also contains marshy areas vegetated by common reed, cattail, and bulrush. Overall canopy closure is around 25%.

We detected 11 willow flycatchers on 22 May, 2 on 1 June, and 3 on 7 June. No willow flycatchers were detected on the five surveys after 7 June. The site was surveyed 10 times, totaling 11.2 observer-hours. Cowbirds were detected on all but one visit, and there was no evidence of livestock using the site.

IMPERIAL NURSERY

Area: 1.4 ha Elevation: 58 m

This site is a cottonwood planting managed by the Imperial NWR. The cottonwoods are approximately 10 m in height, and a 10-m-diameter clump of willows 4 m in height grows in one portion of the understory. Except for this clump of willows, the understory is completely open, and canopy closure is approximately 90%. The site is bordered to the north by a patchwork of cattails, common reed, and tamarisk. Refuge personnel periodically inundate the cottonwood plantation with up to 25 cm of water.

We detected two willow flycatchers on 18 May, four on 22 May, and one on 1 June. No willow flycatchers were detected on the six surveys after 1 June. The site was surveyed 10 times, totaling 5.7 observer-hours. Cowbirds were detected on all but three visits, and there was no evidence of livestock using the site.

FERGUSON LAKE

Area: 21.1 ha Elevation: 57 m

The Ferguson Lake site is on a strip of land between Ferguson Lake and the Colorado River. Vegetation is mixed-native, with stringers of Goodding willow and Fremont cottonwood, up to 15 m in height, forming a sparse overstory with <50% canopy closure along the western edge of the site bordering Ferguson Lake. On the eastern edge of the site adjacent to the Colorado River the area is vegetated by scattered tamarisk, arrowweed, and mesquite. Portions of the site up to 50 m from the lakeshore had saturated soils and fluctuating levels of standing water throughout the survey season.

We detected 3 willow flycatchers on 18 May, 12 on 22 May, 12 on 5 June, 1 on 12 June, and 1 on 18 June. No flycatchers were detected on the four visits after 18 June. The site was surveyed 10 times, totaling 25.1 observer-hours. Cowbirds were detected on all visits.

FERGUSON WASH

Area: 6.8 ha Elevation: 58 m

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 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. A backwater channel penetrates to the interior of the site. Soils in the interior of the site were dry throughout the survey season.

We detected one willow flycatcher on 22 May, five on 5 June, and two on 12 June. No willow flycatchers were detected during the five surveys after 12 June. The site was visited 10 times, totaling 15.5 observer-hours. Cowbirds were recorded on all visits, and burro trails were abundant on the periphery of the site.

GREAT BLUE HERON

Area: 7.1 ha Elevation: 58 m

This site, on the eastern shore of Martinez Lake, consists of mixed-exotic vegetation. Near the shore of Martinez Lake, Goodding willows form 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%. Farther from the lake, the site is vegetated by scattered arrowweed and tamarisk 6 m in height, with canopy closure <50%. No standing water or saturated soils were noted within the site, though soils near Martinez Lake were damp throughout the survey season.

We detected two willow flycatchers on 23 May, one on 31 May, and nine on 7 June. No flycatchers were detected on the five surveys after 7 June. The site was surveyed 10 times, with 32.8 observer-hours spent at the site. Large numbers of cowbirds were recorded on all visits.

POWERLINE

Area: 2.1 ha Elevation: 58 m

This site is located south of the Great Blue Heron site along the eastern shore of Martinez Lake. Vegetation is mixed-native, and consists of a strip of Goodding willow and Fremont cottonwood along the border of a cattail marsh. Overstory height is approximately 12 m, and canopy closure is <50%. Tamarisk, arrowweed, and seep willow are present in the understory. The only standing water and saturated soil noted within the site occurred within the cattail marsh, which held standing water throughout the survey season.

We detected one willow flycatcher at this site on 12 May, one on 30 May, and four on 7 June. No willow flycatchers were detected during the five surveys after 7 June. The site was surveyed 10 times, with 10.8 observer-hours spent at the site. Cowbirds were recorded on all visits, and burros use the uplands on the periphery of the site.

MARTINEZ LAKE

Area: 4.6 ha Elevation: 58 m

This mixed-native site is adjacent to and south of the Powerline site on the eastern shore of Martinez Lake. Goodding willows <10 m in height are scattered throughout the northern portion of the site, and clustered Goodding willows and Fremont cottonwoods up to 15 m in height are present in the southern portion. Arrowweed and tamarisk dominate the understory, and overall canopy closure is <25%. Cattails and common reed border the site along the lakeshore. Some standing water and saturated soil was recorded at the west end of the site in July.

We detected two willow flycatchers at Martinez Lake on 22 May and three on 7 June. No flycatchers were detected on the five surveys after 7 June. The site was visited 10 times, totaling 8.2 observer-hours. Cowbirds were detected on all visits, and burros use the adjacent uplands.

MITTRY LAKE, ARIZONA AND CALIFORNIA

MITTRY WEST

Area: 4.4 ha Elevation: 48 m

The center of this mixed-native site is dominated by Goodding willow 12 m in height with a dense understory of arrowweed and tamarisk. Canopy closure is approximately 80%. Honey and screwbean mesquite are scattered throughout the site but are more common near the periphery. Portions of the site appear to have burned within the last several years. There are patches of cattail within the site. Surface water was present in the site only during May.

We detected three willow flycatchers on 15 May, two on 20 May, two on 2 June, and 10 on 6 June. No flycatchers were detected during the five surveys after 6 June. The site was visited 10 times, totaling 17.5 observer-hours. Cowbirds were detected during all surveys.

MITTRY SOUTH

Area: 15.2 ha Elevation: 46 m

This monotypic tamarisk site lies immediately adjacent to Mittry Lake. Vegetation at the site is very dense, with abundant dead branches and deadfall in the understory. Canopy closure within the tamarisk is >90%, and canopy height is approximately 7 m. The site is bordered to the south by Mittry Lake, and the marshy edge of the site is vegetated by cattail, bulrush, and common reed. The land north of the western half of the site was recently bulldozed and converted to fields. In 2006, an approximately 50- × 50-m patch of vegetation in the center of the site was removed for a pump and canal, which water the nearby fields.

We detected one willow flycatcher on 18 May, three on 22 May, and two on 6 June. No flycatchers were detected during the four surveys after 6 June. The site was visited 10 times, totaling 15.7 observer-hours. Cowbirds were detected during all surveys, and no evidence of livestock use was recorded.

POTHOLES EAST

Area: 2.0 ha Elevation: 54 m

This mixed-exotic site is adjacent to the All American Canal. A cattail pond in the center of the site is surrounded by athel (*Tamarix aphylla*) and tamarisk 8 m in height and a few emergent Fremont cottonwoods up to 15 m in height. Overall canopy closure is <25%. Fan palms (*Washingtonia* sp.) are also present at the site, and honey mesquite trees grow on the upland edges of the site. Standing water and saturated soil, present at least until June, were confined to the center and edges of the cattails, respectively.

We detected three willow flycatchers on 15 May. No willow flycatchers were detected during the eight surveys after 15 May. The site was surveyed 10 times, totaling 5.4 observer-hours. Cowbirds were detected on all visits, and evidence of burros was abundant in the upland areas surrounding the site.

POTHOLES WEST

Area: 6.6 ha Elevation: 53 m

This mixed-exotic site is adjacent to the All American Canal. A pond with cattail and bulrush occupies the center of the site and is surrounded by tamarisk and athel. Canopy closure is 50–70%, and canopy height is 5–10 m. Standing water and saturated soil, present throughout the survey season, were confined to the center and edges of the cattails, respectively. A patch of mesquite trees grows on the north side of the site. Soils away from the pond were very dry during the survey period.

We detected one willow flycatcher on 9 May, four on 15 May, one on 29 May, and five on 2 June. No willow flycatchers were detected during the six surveys after 2 June. The site was surveyed 10 times, totaling 6.3 observer-hours. Cowbirds were detected on all visits, and burros use the uplands surrounding the site.

YUMA, ARIZONA

GILA CONFLUENCE NORTH

Area: 2.2 ha Elevation: 40 m

This mixed-native site borders the north side of the Colorado River at the confluence of the Gila and Colorado Rivers. In previous years the site was approximately 650 m long and less than 100 m wide. Prior to the 2007 survey season, a fire removed approximately 50% of the vegetation on the west side of the site, and all of the vegetation at the nearby Gila Confluence West site. Overstory vegetation at the site is a combination of Goodding willow and Fremont cottonwood. Dense stands of these trees surround a cattail marsh near the center of the site. Cattail marsh is also present along the river, and this area contained standing water throughout the survey season. Canopy height is approximately 9 m, and canopy closure is approximately 50%. Arrowweed and tamarisk are common in the understory.

We detected six willow flycatchers at Gila Confluence North on 6 June. No willow flycatchers were detected during the five surveys after 6 June. The site was surveyed 10 times, totaling 11.9 observer-hours. Cowbirds were detected on all visits, and no evidence of livestock use was noted.

GILA RIVER SITE #1

Area: 5.7 ha Elevation: 45 m

This site was surveyed in 2003 but not in 2004 and 2005 because a fire removed most of the vegetation early in the 2004 survey season. The site has regenerated with mixed-native vegetation and was surveyed in 2006 and 2007. The western third of the site consists of a narrow stringer of Fremont cottonwood and Goodding willow which averages 15 m in height; canopy closure is <25%. The central part of the site has regenerated with Goodding willow up to 5 m in height, but canopy closure is sparse (15–25%). The site is bordered to the north by agricultural fields and to the south by the Gila River. A channel bordered with tamarisk and cattail marsh, which held standing water until at least mid-survey season, passes through the central part of site. The eastern portion of the site has regenerated with dense arrowweed and some Goodding willow and Fremont cottonwood (up to 3 m in height recorded in 2006). The eastern area may become more suitable for flycatchers in subsequent years.

One willow flycatcher was detected on 8 May, one on 19 May, six on 24 May, four on 6 June, and two on 12 June. No willow flycatchers were detected during the four surveys after 12 June. We surveyed the site 10 times, totaling 7.5 observer-hours. Cowbirds were detected on all visits.

GILA RIVER SITE #2

Area: 5.1 ha Elevation: 45 m

This mixed-native site consists of an overstory (up to 15 m in height) of Fremont cottonwood and Goodding willow, with an understory of arrowweed. Tamarisk is present along the northern edge of the site, and canopy closure is <50%. The site is bordered to the north by agricultural fields and to the south by an open, sandy area vegetated by arrowweed. A stringer of cottonwood and Goodding willow extends to the west along the edge of the agricultural fields. No standing water or saturated soils were present within the site during the survey period, but the western edge of the site borders a large pond.

Two willow flycatchers were detected at this site on 18 May, two on 24 May, five on 6 June, and two on 12 June. No willow flycatchers were detected during the four surveys after 12 June. We surveyed the site 10 times, totaling 7.5 observer-hours. Cowbirds were detected on all visits, and no evidence of livestock use was noted at the site.

FORTUNA SITE #1

Area: 2.5 ha Elevation: 45 m

This mixed-native site consists of a narrow patch of Fremont cottonwood and Goodding willow about 10 m in height with 50–70% canopy closure. Tamarisk and arrowweed form a patchy understory on the periphery of the site. Within the densest cottonwood/willow areas, there is little understory but many downed branches. No standing water or saturated soils were observed at the site. The site is bordered to the north by agricultural fields and to the south by a cattail marsh and the Gila River.

Six willow flycatchers were detected at this site on 10 May, one on 19 May, six on 24 May, two on 31 May, eight on 6 June, and two on 12 June. No willow flycatchers were detected during the remaining four surveys. We surveyed the site 10 times, totaling 5.6 observer-hours. Cowbirds were detected on all visits, and no evidence of livestock use was noted at the site.

FORTUNA NORTH

Area: 3.8 ha Elevation: 46 m

This site is vegetated primarily by mature tamarisk approximately 8 m in height. Goodding willow and honey mesquite are scattered throughout the site but make up less than 10% of the vegetation. Canopy closure is approximately 80%. The site did not contain any standing water or saturated soils during the survey period. The western edge of the site borders the Gila River. One willow flycatcher was detected on 19 May, two on 24 May, eight on 6 June, and two on 12 June. No willow flycatchers were detected during the four surveys after 12 June. The site was surveyed 10 times, totaling 8.9 observer-hours. Cowbirds were detected on all visits, and no sign of livestock use was recorded.

MORELOS DAM

Area: 11.4 ha Elevation: 34 m

This mixed-native site lies next to the Colorado River. The site burned prior to the 2003 survey season and was first surveyed in 2006. The site consists primarily of widely spaced Goodding willow averaging 8 m in height with scattered Fremont cottonwood and an understory of common reed. The northern end of the site contains a patch of dense tamarisk. Canopy closure is 25–50%. Much burned, downed, dead wood is scattered throughout the site along with tall burned snags. A small body of water formed by Morelos Dam lies adjacent to the northwest side of the site.

We detected three willow flycatchers on 10 May, one on 20 May, two on 1 June, and five on 5 June. No flycatchers were detected during the five surveys after 5 June. The site was visited 10 times, totaling 16.8 observer-hours. Cowbirds were detected during all visits, and the site receives foot traffic by illegal immigrants.

GADSDEN

Area: 19.3 ha Elevation: 25 m

This mixed-native site consists of stringers of Goodding willow and scattered Fremont cottonwood lining backwater channels of the Colorado River. Canopy height is variable, ranging from approximately 8 to 12 m, and canopy closure is <25%. The site is bordered to the east by agricultural fields. The backwater channels, portions of which are vegetated by cattail and bulrush, have open, sandy shores. Standing water and saturated soil were recorded within the site throughout the survey season. Between the backwater channels, much of the site comprises open, sandy areas, sparsely vegetated by arrowweed. Prior to the survey season, much of the vegetation along the southern portion of the site was bulldozed and removed.

During surveys, we detected 4 willow flycatchers on 10 May, 8 on 15 May, 4 on 20 May, 1 on 29 May, 12 on 4 June, and 1 on 14 June. No flycatchers were detected during the remaining four surveys. The site was surveyed 10 times, totaling 19.8 observer-hours. An additional 84.4 hours (154.0 person-hours) were spent at the site conducting banding studies from 8 to 23 June. We detected and banded a total of 64 willow flycatchers during this time. The number of birds banded on each date are as follows: 17 (8 June), 17 (9 June), 6 (10 June), 5 (11 June), 4 (12 June), 1 (13 June), 2 (14 June), 3 (15 June), 2 (16 June), 2 (17 June), 2 (18 June), 3 (19 June), and 1 (20 June). Cowbirds were recorded on all survey visits. No livestock use was recorded, but the site receives heavy foot traffic by illegal immigrants.

HUNTER'S HOLE

Area: 24.1 ha Elevation: 26 m

This mixed-native site consists of two patches of Goodding willow separated by a dry pond surrounded by cattail and common reed. In the southern patch, stringers of willow 10 m in height surround a dry oxbow. Areas away from the dry oxbow are vegetated by arrowweed and tamarisk with sparse canopy. The northern patch is a mixture of willow and scattered Fremont cottonwood in stringers along dry channels and small dry ponds that had not contained standing water the previous survey season. Canopy closure along the stringers is approximately 50%. Between the stringers, vegetation is a mix of tamarisk and arrowweed. Agricultural fields border the site to the east. An irrigation canal that contained water during the 2007 surveys lies approximately 25 m from the edge of the site.

We detected 2 willow flycatchers on 9 May, 4 on 15 May, 2 on 21 May, 2 on 29 May, and 38 on 3 June. No flycatchers were detected during the remaining five surveys. The site was surveyed 10 times, totaling 25.7 observer-hours. Cowbirds were recorded on all visits. No livestock use was recorded, but the site receives heavy foot traffic by illegal immigrants.

DISCUSSION

In 2007, we found resident[7] and breeding Southwestern Willow Flycatchers at the four life history study areas (Pahranagat NWR, Mesquite, Mormon Mesa, and Topock Marsh) as well as at Littlefield, the Muddy River Delta, lower Grand Canyon and the Lake Mead Delta, and Bill Williams River NWR (details of residency and breeding are presented in Chapters 3 and 4).

Habitat occupancy by resident or breeding flycatchers at some sites differed from that of previous years (McKernan and Braden 2002, Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007). Flycatcher breeding at Littlefield, Arizona, was recorded for the first time in 2004, but flycatchers abandoned the site in 2005 because winter floods caused extensive loss of vegetation. No flycatchers were recorded at the site in 2006. In 2007, one resident, unpaired willow flycatcher was detected approximately 1.2 km upstream from the previously occupied Littlefield sites. Willow flycatcher breeding was documented at Bill Williams from 1999 to 2003, with residency but no breeding recorded in 2004, and residency and breeding recorded again in 2005–2007. The fluctuating availability of surface water at Bill Williams is likely one factor influencing willow flycatcher residency and breeding at the site in any given year, with flycatchers breeding in years when sites contained standing water. The influence of the availability of surface water on flycatcher breeding was also observed along the Virgin River at the Bunker Farm site, which periodically receives runoff from an adjacent agricultural field. In 2005, the site contained standing water and saturated soils throughout the flycatcher breeding season, and two flycatcher pairs produced six nests. In 2006 and 2007, the Bunker Farm site did not receive any agricultural runoff. In 2006, only an unpaired male occupied the site for one week in May, and no flycatchers were detected at the site in 2007.

Willow flycatchers have been detected within lower Grand Canyon since surveys began in 1997, with breeding flycatchers detected in 1999–2001 but not in 2002 or 2003 when the declining water levels in Lake Mead left most vegetated areas on high, dry river banks. Breeding and residency was recorded again in 2004 and 2005, respectively, at a spring-fed site (RM 274.5N) in lower Grand Canyon. In 2006 we conducted habitat reconnaissance and surveys in the extensive areas of recently developed willow in Lake Mead National Recreation Area, detecting 12 resident and/or breeding individuals at nine sites; a breeding pair was also detected at RM 274.5N. In 2007, most of the 2006 occupied flycatcher habitat in the recreation area was dead and dying as the result of receding water tables under the vegetation as the level in Lake Mead continued to drop. No resident willow flycatchers were detected in the recreation area in 2007, and it is likely the existing willow stands in the area will further degenerate in future years. In 2007, flycatcher residency and breeding was recorded only at RM 274.5N and Burnt Springs, respectively.

Although only small amounts of saturated soil were present within the vegetation at occupied flycatcher sites in the Lake Mead National Recreation Area in 2006, the presence of meandering, dry swales indicated surface water was present at one time. It is likely that at the time vegetation began to develop at these sites circa 2004, surface water was periodically present within the

[7] An individual present for a week or longer was considered resident.

riparian stands as the result of slight fluctuations in reservoir levels. However, by the time the vegetation reached the height and density to be occupied by flycatchers, water levels had receded such that soils underneath the vegetation were dry. It is likely the willow stands in the recreation area will not retain the current vegetation structure if lake levels continue to drop. In the period between August 2006 and July 2007, we observed a rapid increase in the amount of dead or dying vegetation. Although tamarisk is colonizing areas where the willow is dying, it will likely take several years to become suitable for flycatchers.

The amount of standing water throughout the entire Topock study area was markedly reduced in 2005 compared to 2003 and 2004. Compared to 2005 the amount of standing water increased in 2006 at PC6-1, 800M, Pierced Egg, Hell Bird, and Glory Hole, and was similar to that of 2003 and 2004. Conditions in 2007 were similar to those in 2006, except at The Wallows, where an increase in standing water was recorded. It is undetermined whether annual fluctuations in the amount of standing water at Topock contribute to the annual fluctuation in the total numbers of adults detected from 2003 to 2007, with 25, 67, 41, 37 and 31 individuals, respectively. A combination of biotic and abiotic factors may be driving the demographics of this local population.

In an effort to locate all potentially suitable willow flycatcher habitat within the Bill Williams River NWR, we continued habitat reconnaissance and opportunistic surveys initiated in 2006 throughout the 2007 survey season. Although the Bill Williams River NWR contains the largest expanse of native cottonwood-willow forest on the lower Colorado River, vegetation structure and hydrological conditions along most of the river corridor are not characteristic of willow flycatcher breeding habitat at this time. Currently, willow flycatchers are known to breed on the refuge at one small site (Bill Williams Site #3). The hydrological characteristics of the site may not be strongly influenced by the Bill Williams River. A perched water table influenced by Lake Havasu lies beneath the site (K. Blair, pers. comm.), and it is likely that the mesic conditions observed at the site are influenced more by this water table than by the Bill Williams River. As far as we know, these hydrological conditions do not exist anywhere else on the refuge.

Because of Alamo Dam, the Bill Williams River does not typically flood to the degree required for scouring, which would remove deadfall from the understory. If scouring were to occur on Bill Williams, it is likely much impenetrable understory vegetation would be removed and young vegetation would develop, which would provide habitat for successional habitat specialists such as the willow flycatcher. Additionally, scouring floods would also likely de-channelize much of the Bill Williams River, altering the drainage such that overbank flooding would occur more often. Overbank flooding over time would create the hydrological conditions necessary for the generation of multi-aged stands of riparian vegetation characteristic of “natural” riparian ecosystems and willow flycatcher breeding habitat. Although periodic water releases from Alamo Dam did occur during the 2007 flycatcher breeding season, only small amounts of water were released.

Although many flycatchers were recorded at sites surveyed south of Bill Williams until 15 June, and 17 detections were recorded post 15 June, monitoring results at these sites suggest these flycatchers were not resident or breeding individuals. A flycatcher detected at Walker Lake did respond aggressively to broadcasts and continued to sing for up to 20 minutes after broadcasts ceased. This behavior was observed on two visits 5 days apart, but because the bird on both occasions was unbanded, it is unknown if it was the same individual. No flycatchers were detected on six subsequent visits, indicating that no flycatchers remained as residents at the site.

Results at survey sites south of Bill Williams in 2007 are consistent with those of previous years from 1997 to 2006 (McKernan and Braden 2002, Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007), with no confirmed nesting recorded since 1938 (Unitt 1987). Based upon the variation in total numbers of flycatchers detected at a particular site over the survey period (e.g., 4 flycatcher detections at Gadsden on 10 May, 8 on 15 May, 4 on 20 May, 1 on 29 May, 12 on 4 June, and 2 on 14 June, and 0 on four subsequent surveys), and the overall lack of territorial, aggressive behaviors exhibited toward conspecific broadcasts, willow flycatchers detected at sites south of Bill Williams in 2007 were most likely migrants. These results are consistent with those recorded in 2003–2006 (Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007). Given that willow flycatchers are one of the last long-distance migrant passerines to arrive in the Southwest in spring,[8] and fall migrant ***E. t. brewsteri*** can arrive in southern California as early as 18 July (Unitt 1987), the occurrence of northbound migrant willow flycatchers along the lower Colorado River until late June and southbound migrants in late July is not surprising. Regarding the early fall migration of willow flycatchers in the West, Unitt (1987) notes "[18 July] may seem inordinately early for fall migration of a land bird, but is in fact no earlier than the beginning of fall migration of such familiar species as Western Tanager (*Piranga ludoviciana*) and Black-headed Grosbeak (*Pheucticus melanocephalus*)." Furthermore, with over 200 willow flycatcher detections recorded in 2003 (Koronkiewicz et al. 2004), over 600 detections recorded in 2004 (McLeod et al. 2005), over 300 detections in 2005 (Koronkiewicz et al. 2006a), and over 450 detections in 2006 and 2007 (McLeod et al. 2007, this document), this section of the lower Colorado River corridor is undoubtedly a major flyway for migrant willow flycatchers in spring. The degree to which willow flycatchers use the corridor during fall migration is undetermined.

Although conservative estimates of the total number of flycatchers detected at a site on a particular survey day are presented above, estimating the total number of flycatchers detected at a site throughout the season is problematic. Unless the birds are uniquely color-banded there is no way of determining if the same individuals were observed at a site multiple times or if different individuals were present on subsequent surveys. We conducted color-banding studies at sites south of Bill Williams in 2007, as in 2003–2006 (see Chapter 3). We captured and color-banded willow flycatchers at one site on several consecutive days. One individual was recaptured 5 hours after banding, and another was recaptured at the same site two days later. Out of the 64 banded individuals, this was the only one detected on a later day, suggesting that the remaining 63 flycatchers did not remain at the site for multiple days.

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[8] Migrants have been documented as late as 23 June in southern Arizona (Phillips et al. 1964), and resident, wintering individuals have been recorded as far south as Costa Rica until the end of May (Koronkiewicz et al. 2006b).

CHAPTER 3

COLOR-BANDING AND RESIGHTING

INTRODUCTION

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

METHODS

COLOR-BANDING

From early May through mid-August, we captured, uniquely color-banded, and subsequently monitored adult, nestling, and fledged willow flycatchers at the four life history study areas. Color-banding and monitoring were also conducted at all survey areas where resident willow flycatchers were detected. These additional sites were Littlefield near the confluence of Beaver Dam Wash and the Virgin River, the Overton Wildlife Management Area on the Muddy River Delta, several sites along the Colorado River in Grand Canyon and on the Lake Mead Delta, and the Bill Williams River National Wildlife Refuge. The color-banding effort also included opportunistic banding, in cooperation with Nevada Division of Wildlife, at Key Pittman Wildlife Management Area in Nevada, approximately 30 km north of Pahranagat NWR.

For the fifth consecutive year, we conducted color-banding studies from 10–30 June along the extreme southern stretches of the lower Colorado River downstream of Parker Dam. Banding attempts focused along the Colorado River near the Mexico border at Gadsden. These banding studies were conducted in conjunction with subsequent surveys and resighting at the site through late July to better determine flycatcher residency, breeding status, and movement patterns in this area. Because of extremely dense vegetation, banding effort was primarily dependent upon the ability of field personnel to erect nets within the habitat.

Adult and fledgling 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 are 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 are erected and periodically checked, with no broadcast of conspecific vocalizations. We banded each adult and fledged willow flycatcher with a single anodized (colored), numbered U.S. federal aluminum band on one leg and a colored metal band on the other. We coordinated all color combinations with the Federal Bird Banding Laboratory and all other Southwestern Willow Flycatcher banding projects to minimize replication of color combinations. For each color-banded bird recaptured, we visually inspected the legs and noted any evidence of irritation or injury that may be related to the presence of leg bands.

Nestlings were banded at 8 to 10 days of age, when they were large enough to retain the leg bands, yet young enough that they would not prematurely fledge from the nest (Whitfield 1990, Paxton et al. 1997). Nestlings were banded only when the location of the nest was such that nest access and removal/replacement of the nestlings would not endanger the nest, nest plant, or nestlings. Nestlings were banded with a single anodized, numbered federal band, uniquely identifying each bird as a returning nestling in the event it returns in a subsequent year.

For each captured adult and fledged willow flycatcher, we recorded morphological measurements including culmen, tail, wing, fat level, and molt onto standardized data forms (Appendix A). Sex was determined based on the presence of a cloacal protuberance in males or brood patch and/or egg(s) in the oviduct for females. Because physical breeding characteristics are not always present on captured individuals, flycatchers observed engaging in lengthy, primary song from high perches (male advertising song) prior to capture were sexed as male. Captured flycatchers lacking breeding characteristics and not observed engaging in male advertising song as noted above 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

We determined the identity of a color-banded flycatcher by observing with binoculars, from a distance, the unique color combination on its legs. Typically, territories and active nests were focal areas for resighting, but entire sites were surveyed. Field personnel typically spent the early part of each morning color-banding, and then redirected their efforts to resighting as daylight increased and flycatchers became more difficult to capture. All banding, monitoring, and survey field personnel coordinated resighting efforts and recorded observations of color-banded and unbanded flycatchers onto standardized data forms (Appendix A). For resighted flycatchers, 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. Resighted flycatchers observed engaging in lengthy, primary song from high perches (male advertising song) were sexed as male. Resighted flycatchers observed carrying nest material or constructing or incubating a nest were sexed as female. Resighted flycatchers not observed engaging in one of these diagnostic activities were sexed as unknown. All 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. 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. 1997).

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 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.

RESULTS

ALL MONITORING SITES

Color-Banding and Resighting – Field personnel color-banded 30 new adult flycatchers and recaptured 12 individuals banded in previous years, not including individuals banded as juveniles in a previous year and not identified since. An additional 62 adults banded in previous years were resighted, of which 47 (76%) could be identified to individual; 10 were banded as juveniles in a previous year but could not be recaptured to determine origin and identity, 1 had a federal band on one leg and an injury on the other leg, 1 had a half plastic band on one leg and a federal band on the other, and 3 did not have their band combinations confirmed. We banded 55 nestlings from 25 nests and captured 1 fledgling from a nest that was too high to band. Of the 55 nestlings banded, 6 were known or suspected to have died before fledging. We detected 21 individuals originally banded as juveniles in a previous year, with 11 (52%) identified to individual via recapture. Overall, 73% of the adult flycatchers detected at the monitoring sites were color-banded by the end of the breeding season (Table 3.1). For 21 adult flycatchers detected, we were unable to determine if these individuals were color-banded (that is, banding status was undetermined). Thus, the percentage of color-banded adult flycatchers at sites is a conservative estimate. For details on all banded flycatchers detected at the study areas from 2003 to 2007, see Appendix C.

SITE-BY-SITE COLOR-BANDING AND RESIGHTING

MONITORING SITES

Pahranagat – We detected 22 resident, adult willow flycatchers from 14 territories at Pahranagat. In addition to resident adults, we detected seven individuals for which residency and/or breeding status could not be confirmed, of which three were suspected migrants

(Tables 3.2 and 3.3). Of the 14 territories recorded at Pahranagat, 10 consisted of breeding pairs and 4 consisted of unpaired males. Of the resident individuals, one male was known to have moved from the South site to the North site. Of the breeding individuals, one male was polygynous with three females.

Field personnel captured and color-banded six new adults and recaptured eight adult flycatchers banded in previous years, including two individuals originally banded as nestlings (one from 2005, one from 2006). Of the returning nestlings, one was a breeding female and one was an unpaired male (see Table 3.21 for juvenile dispersal data). We resighted and confirmed band combinations for an additional 12 adults. Of all the adults detected, three, for which residency and/or breeding status could not be confirmed, remained unbanded. We banded 19 nestlings from 7 nests and 1 fledgling from a nest that was too high to band. Of the banded nestlings, one was known to have died before fledging.

Littlefield **–** We detected one resident, adult willow flycatcher at Littlefield. Field personnel captured and color-banded this adult, which was banded as a nestling in 2006 (Table 3.4). This individual was later recaptured at Mesquite.

Mesquite **–** We detected 26 resident, adult willow flycatchers from 15 territories at Mesquite. In addition to resident adults, we detected one individual that held a territory at Littlefield earlier in the season. Of the 15 territories recorded at Mesquite, 13 consisted of breeding individuals and 2 consisted of unpaired males (Tables 3.5 and 3.6). Of the resident individuals, one unpaired male was previously detected as part of a breeding pair at Muddy River. Of the breeding individuals, one male was polygynous with two females, and one female mated consecutively with two different males.

Field personnel captured and color-banded three new adults and recaptured five banded adult flycatchers, including three individuals originally banded as nestlings in 2006. We resighted 16 other returning banded individuals. Of these, four could not be identified to individual, including one individual with plastic bands, and a second individual with only a federal band because the opposite leg was injured. The two remaining unidentified individuals were returning nestlings; however, study area and year banded could not be determined because we were unable to recapture these individuals. Two additional resident adults resighted at Mesquite in 2007 remained unbanded, and band status could not be determined for one. We banded 14 nestlings from 7 nests. Of the banded nestlings, two were suspected to have died before fledging.

Table 3.1. Summary of Willow Flycatchers Detected at Monitored Sites during the 2007 Breeding Season*

Study Area	Site	Adults									Nestlings Banded (# nests)	Fledglings Captured	% of All Adults Banded
		Total Adults Detected	New Captured	Recaptured		Resighted							
				Not Including Returning Nestlings	Returning Nestlings	Color combination confirmed		Unbanded	Band Status Undetermined	Banded (color combinations unconfirmed)			
						Individual Identified	Individual Not Identified						
Pahranagat	North	25	5	6[7]	2	12	0	0	0	0	19(7)	1[1]	**100**
	West	2	0	0	0	0	0	2	0	0	0	0	0
	MAPS	1	0	0	0	0	0	1	0	0	0	0	0
	South	2	1	0	0	1[7]	0	0	0	0	0	0	100
	Study Area Total	**29[13]**	**6**	**6**	**2**	**12[13]**	**0**	**3**	**0**	**0**	**19(7)**	**1**	**90**
Littlefield	Poles	1	0	0	1[2]	0	0	0	0	0	0	0	100
Mesquite	East	1	0	0	0	0	1[12]	0	0	0	0	0	100
	West	26	3	2[2]	3	12[3]	3[10,11,12]	2	1	0	14(7)	0	88
	Study Area Total	**27**	**3**	**2**	**3**	**12**	**4**	**2**	**1**	**0**	**14(7)**	**0**	**89**
Mormon Mesa	Mormon Mesa South (North)	1	0	0	0	0	0	0	1	0	0	0	0
	Mormon Mesa South (South)	1	0	0	0	0	0	0	0	1	0	0	100
	Virgin River #1 (North)	2	1	0	0	0	0	0	0	1	0	0	100
	Virgin River #1 (South)	15	2	1	0	9[4,5,8]	1[12]	1	1	0	4(3)	0	87
	Virgin River #2	12	2	0	1	8[8]	1[12]	0	0	0	0	0	100
	Study Area Total	**30[13]**	**5**	**1**	**1**	**16[13]**	**2**	**1**	**2**	**2**	**4(3)**	**0**	**90**
Muddy River	Overton WMA Pond	2	0	0	1	1[9]	0	0	0	0	0	0	100
	Overton WMA	15	4	3[3]	1[4]	3[9]	2[12]	1	1	0	0	0	86
	Study Area Total	**16[13]**	**4**	**3**	**2**	**3[13]**	**2**	**1**	**1**	**0**	**0**	**0**	**88**
Grand Canyon	Burnt Springs/RM 259.5N	2	2	0	0	0	0	0	0	0	0	0	100
	RM 274.5N	4	1	0	0	2[5]	0	0	1	0	0	0	75
	Pearce Ferry	1	1	0	0	0	0	0	0	0	0	0	0
	Study Area Total	**7**	**4**	**0**	**0**	**2**	**0**	**0**	**1**	**0**	**0**	**0**	**86**
Topock	In Between	3	1	0	0	0	2[12]	0	0	0	1(1)	0	100
	800M	2	1	0	0	1	0	0	0	0	0	0	100
	Pierced Egg	7	1	0	0	1	0	4	1	0	3(1)	0	29
	Barbed Wire	1	0	0	0	0	0	0	1	0	0	0	0
	250M	2	0	0	0	0	0	0	2	0	0	0	0
	Channel[14]	1	0	0	0	0	0	0	1	0	0	0	0
	Hell Bird	2	0	0	0	0	0	0	2	0	0	0	0
	Glory Hole	7	1	1	1	0	0	3	0	1	11(4)	0	57
	Kermit[14]	3	0	0	0	0	0	1	2	0	0	0	0
	Beal Lake	2	0	0	0	0	0	0	2	0	0	0	0
	Lost Lake	1	0	0	0	0	0	0	1	0	0	0	0
	Study Area Total	**31**	**4**	**1**	**1**	**2**	**2**	**8**	**12**	**1**	**15(6)**	**0**	**35**

Table 3.1. Summary of Willow Flycatchers Detected at Monitored Sites during the 2007 Breeding Season,* continued

Study Area	Site	Adults									Nestlings Banded (# nests)	Fledglings Captured	% of All Adults Banded
				Recaptured		Resighted							
						Color combination confirmed							
		Total Adults Detected	New Captured	Not Including Returning Nestlings	Returning Nestlings	Individual Identified	Individual Not Identified	Unbanded	Band Status Undetermined	Banded (color combinations unconfirmed)			
Bill Williams	Site 11	1	0	0	0	0	0	0	1	0	0	0	0
	Site 3	14	4	0	1	3	2[12]	4	0	0	3(2)	0	67
	New Willow	1	0	0	0	0	0	0	1	0	0	0	0
	Mineral Wash	3	0	0	0	0	0	2	1	0	0	0	0
	Beaver Pond	1	0	0	0	0	0	0	1	0	0	0	0
	Site 8	1	0	0	0	0	0	1	0	0	0	0	0
	Study Area Total	**21**	**4**	**0**	**1**	**3**	**2**	**7**	**4**	**0**	**3(2)**	**0**	**48**
Total		**158[13]**	**30**	**12[13]**	**11**	**47[13]**	**12**	**22**	**21**	**3**	**55(25)**	**1**	**73**

* Individuals are identified as new captures (previously unbanded), recaptures of previously banded birds, resightings of previously banded birds for which band combinations were confirmed, birds known to be unbanded, birds for which band status could not be determined, and resighting of previously banded birds for which band combinations were undetermined. Included are total numbers of adults detected and percent of all adults banded. For breeding and/or residency status of adults see Tables 3.2–3.15.

1 Fledgling previously unbanded.

2 One individual recaptured at Littlefield, then recaptured in Mesquite.

3 One individual recaptured at Muddy River, then moved to Mesquite.

4 One individual banded at Muddy River, then moved to Mormon Mesa.

5 One individual moved from Grand Canyon to Mormon Mesa.

7 One individual moved from Pahranagat South to Pahranagat North.

8 One individual moved from Mormon Mesa Virgin River #2 to Virgin River #1 South.

9 One individual moved from Muddy River Overton WMA to Overton WMA Pond.

10 Bird had silver federal band only and had 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.

11 Bird has a single half plastic band on left leg and silver federal band on right.

12 Returning nestling(s).

13 The individuals that moved between sites are tallied only once in the total.

14 Not a formal survey site. Flycatchers detected en route.

Table 3.2. Paired, Nestling, and Fledgling Willow Flycatchers Banded and Resighted at Pahranagat NWR, NV, 2007

Site	Date Banded	Federal Band #[1]	Color Combination[2]	Old Color Combination[1,2,3]	Age[4]	Sex[5]	Territory	Observation status[6]
North	17-Jun-07	2370-40194	PU:BR(M)	N/A	SY	F	21	N
North	15-May-04	2320-31591	GY(M):EE	N/A	A5Y	M	21, 29, 75	R 19 Jun
North	6-Jul-07	2320-31679	UB:EE	N/A	L	U	21	N
North	6-Jul-07	2360-59765	EE:UB	N/A	L	U	21	N
North	6-Jul-07	2320-31643	EE:UB	N/A	L	U	21	N
North	6-Jul-07	2320-31646	UB:EE	N/A	L	U	21	N
North	17-Jun-04	2320-31661	EE:DW(M)	N/A	5Y	F	22	RS
North	23-Jul-02	2370-39952	BB(M):PU	N/A	A7Y	M	22	R 28 Jul
North	29-Jun-07	2320-31525	UB:EE	N/A	L	U	22	N
North	29-Jun-07	2320-31546	UB:EE	N/A	L	U	22	N
North	29-Jun-07	2320-31547	EE:UB	N/A	L	U	22	N
North	29-Jun-07	2320-31548	EE:UB	N/A	L	U	22	N
North	30-Jun-05	2320-31698	RB(M):EE	UB:EE	3Y	F	25	R 19 Jun
North	15-May-04	2320-31590	GR(M):EE	N/A	A5Y	M	25	RS
North	14-Jul-07	2320-31639	UB:EE	N/A	L	U	25	N
North	14-Jul-07	2370-40199	PU:UB	N/A	L	U	25	N
North	14-Jul-07	2370-40190	UB:PU	N/A	L	U	25	N
North	20-Jun-04	2320-31657	WO(M):EE	N/A	A5Y	F	27	RS
North	4-Jun-02	2370-40015	PU:WG(M)	N/A	A7Y	M	27	R 9 May
North	28-Jun-07	2320-31545	UB:EE	N/A	L	U	27	N
North	28-Jun-07	2320-31524	EE:UB	N/A	L	U	27	N
North	18-Jun-04	N/A	RR(M):no foot	N/A	A5Y	F	29	RS
North	22-Jul-07	2320-31649	EE:UB	N/A	L	U	29	N
North	1-Jul-06	2370-40047	PU:DD(M)	N/A	A3Y	F	30	RS
North	2-Jun-05	2370-39953	OB(M):PU	N/A	A4Y	M	30	R 8 May
North	29-Jun-07	2360-59764	UB:EE	N/A	L	U	30	N
North	29-Jun-07	2320-31672	EE:UB	N/A	L	U	30	N
North	3-Jul-05	2370-40014	PU:VY(M)	N/A	A4Y	F	31	RS
North	6-Aug-01	2320-31592	GO(M):EE	N/A	7Y	M	31	RS
North	29-Jun-07	2320-31549	EE:UB	N/A	L	U	31	N
North	29-Jun-07	2320-31550	UB:EE	N/A	L	U	31	N
North	29-Jun-07	2360-59743	EE:UB	N/A	L	U	31	N
North	5-Jul-06	2370-40062	YK(M):PU	N/A	3Y	F	40	RS
North	1-Jun-05	2370-39951	PU:OZ(M)	N/A	A4Y	M	40	R 26 Jul
North	27-Jul-07	2370-40167	KYK(M):PU	N/A	HY	U	40	N
North	19-Jun-07	2370-40195	YWY(M):PU	N/A	SY	F	75	N
North	8-Jul-05	2370-39964	BY(M):PU	N/A	A4Y	F	84	RS
North	11-Jul-06	2370-39946	GW(M):PU	N/A	SY	M	84	RS

[1] N/A = not applicable.

[2] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, (M) = metal pin striped band, UB = unbanded, W = white, R = red, G = green, Z = gold, D = dark blue, B = light blue, K = black, O = orange, Y = yellow, V = violet. Color combinations are read as the bird's left leg and right leg, top to bottom; two or three letters designate every band; color-band designations for right and left legs are separated with a colon.

[3] Old combination included only if rebanded in 2007.

[4] **Age in 2007**: L = nestling, HY = hatch year, SY = 2 years, AHY = 2 years or older, 3Y = 3 years, A3Y = 3 years or older, 4Y = 4 years, A4Y = 4 years or older, etc.

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

[6] **Observation status codes**: N = new capture, R = recapture followed by date recaptured, RS = resight.

Table 3.3. Unpaired, Resident Willow Flycatchers and Individuals for which Residency and/or Breeding Status Could Not Be Confirmed, Pahranagat NWR, 2007

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Old Color Combination[1,2,3]	Age[4]	Sex[5]	Location[6]	Observation status[7]
North	5-July-06	2360-59797	EE:RB(M)	EE:UB	SY	M	T41	R 30 Jun, unpaired, detected 12 Jun–5 Jul
North	14-May-04	2320-31589	EE:YD(M)	N/A	A5Y	M	T60	RS, unpaired, detected 12 May–4 Jun
South	18-May-04	2320-31595	WKW(M):EE	GV(M):EE	A5Y	M	T70	RS, unpaired 17 May–17 Jun at South site; later displaced 21 male at North site, detected 12–26 Jul, R 21 Jul
North	25-Jul-05	2370-39915	PU:RZ(M)	N/A	A4Y	M	T76	RS, unpaired, detected 10 Jun–20 Jul
South	10-Jun-07	2370-40185	PU:WK(M)	N/A	AHY	M	F71	N, unpaired, detected 9–13 Jun
West	N/A	N/A	UB:UB	N/A	AHY	U	F72	RS, detected 8 Jun, probable migrant
West	N/A	N/A	UB:UB	N/A	AHY	U	F73	RS, detected 8 Jun, probable migrant
MAPS	N/A	N/A	UB:UB	N/A	AHY	U	F74	RS, detected 8 Jun, probable migrant
North	29-Jul-07	2370-40157	DWD(M):PU	N/A	AHY	U	F87	N, not detected post-capture[8]
North	26-Jul-07	2370-40168	PU:KOK(M)	N/A	SY	F	F88	N, not detected post-capture[8]
North	28-Jul-07	2370-40166	PU:WGW(M)	N/A	U	U	F89	N, not detected post-capture[8]

[1] N/A = not applicable.

[2] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, (M) = metal pin striped band, UB = unbanded, W = white, R = red, G = green, D = dark/navy blue, B = light blue, O = orange, Y = yellow, K = black, Z = gold. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[3] Old combination included only if rebanded in 2007.

[4] **Age in 2007**: SY = 2 years, AHY = 2 years or older, 3Y = 3 years, A3Y = 3 years or older, 4Y = four years, A4Y = 4 years or older, etc., U = unknown.

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

[6] **Location code**: T = territorial individual detected for at least 7 days, F = individual detected for less than 7 days. Number indicates unique location.

[7] **Observation status codes**: N = new capture, R = recapture followed by date recaptured, RS = resight.

[8] No unbanded birds were known pre-capture; therefore, breeding status for these individuals at this site is unknown.

Table 3.4. Unpaired, Resident Willow Flycatchers Banded at Littlefield, AZ, 2007

Site	Date Banded	Federal Band #	Color Combination[1]	Old Color Combination[1]	Age 2007[2]	Sex[3]	Location	Observation Status[4]
Poles	4-Jul-06	2370-39941	ZW(M):PU	UB:PU	SY	M	73	R 25 Jun, unpaired 17 Jun–17 Jul; recaptured 27 Jul at Mesquite West

[1] **Color-band codes**: PU = pumpkin federal band, (M) = metal pin striped band, UB = unbanded, Z = gold, W = white. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[2] **Age in 2007**: SY = 2 years.

[3] **Sex codes**: M = male.

[4] **Observation status codes**: R = recapture - followed by date recaptured.

Table 3.5. Paired and Nestling Willow Flycatchers Banded and Resighted at Mesquite, NV, 2007

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Old Color Combination[1,2,3]	Age[4]	Sex[5]	Territory	Observation status[6]
West	20-Jul-06	2370-40066	YO(M):PU	N/A	3Y	F	1	RS
West	18-May-06	2370-39937	KK(M):PU	N/A	3Y	M	1	RS
West	3-Jul-07	2370-40170	RG(M):PU	N/A	AHY	F	2	N
West	8-Jun-05	2370-39954	BO(M):PU	N/A	A4Y	M	2, 92	RS
West	27-Jun-07	2320-31670	UB:EE	N/A	L	U	2	N
West	N/A	N/A	UB:UB	N/A	AHY	F	10	RS
West	3-Jun-04	2320-31490	EE:OO(M)	N/A	A5Y	M	10	RS
West	23-Jun-07	2360-59773	EE:UB	N/A	L	U	10	N
West	23-Jun-07	2360-59775	UB:EE	N/A	L	U	10	N
West	23-Jun-07	2360-59776	EE:UB	N/A	L	U	10	N
West	INA	INA	Y(HP):XX	N/A	AHY	F	26	RS
West	3-Jun-05	2370-40012	OY(M):PU	N/A	A4Y	M	26	RS
West	23-Jun-04	2320-31498	KW(M):EE	N/A	4Y	F	28	RS, nested consecutively with two different males
West	15-Jul-05	2320-31688	EE:BG(M)	N/A	3Y	M	28[8]	RS
West	INA	INA	UB:XX[7]	N/A	7Y	M	28[8]	RS
West	6-Jul-06	2360-59750	EE:OB(M)	EE:UB	SY	F	42	R 29 Jul
West	INA	INA	undetermined	N/A	AHY	M	42	
West	9-Aug-07	2370-40164	PU:UB	N/A	L	U	42	N
West	5-Jul-07	2370-40193	GY(M):PU	N/A	AHY	F	50	N
West	8-Jun-05	2370-40198	RZ(M):PU	VK(M):PU	4Y	M	50	R 21 May and 5 Jul
West	5-Jul-07	2320-31642	UB:EE	N/A	L	U	50	N
West	5-Jul-07	2320-31641	EE:UB	N/A	L	U	50	N
West	5-Jul-07	2320-31640	UB:EE	N/A	L	U	50	N
West	26-Jul-07	2370-40087	PU:BZ(M)	N/A	AHY	F	51	N
West	N/A	N/A	UB:UB	N/A	AHY	M	51	RS
West	26-Jul-07	2370-40086	UB:PU	N/A	L	U	51	N

Table 3.5. Paired and Nestling Willow Flycatchers Banded and Resighted at Mesquite, NV, 2007, continued

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Old Color Combination[1,2,3]	Age[4]	Sex[5]	Territory	Observation status[6]
West	26-Jul-07	2370-40085	PU:UB	N/A	L	U	51	N
West	26-Jul-07	2370-40188	UB:PU	N/A	L	U	51	N
West	6-Jul-04	2320-31573	WY(M):EE	N/A	A5Y	F	65	RS
West	6-Jul-06	2360-59751	OG(M):EE	UB:EE	SY	M	65	R 21 Jun
West	25-Jun-07	2360-59777	EE:UB	N/A	L	U	65	N
West	25-Jun-07	2360-59778	UB:EE	N/A	L	U	65	N
West	1-Aug-03	2320-31445	EE:WK(M)	N/A	A6Y	F	71	RS
West	26-Jul-01	2390-92475	XX:WY(M)	N/A	7Y	M	71	RS
West	1-Jul-07	2320-31522	UB:EE	N/A	L	U	71	N
West	INA	INA	UB:EE	N/A	AHY	F	72	RS
West	7-Jul-06	2360-59754	OR(M):EE	UB:EE	SY	M	72	R 22 Jun
West	22-Jun-06	2370-39939	KD(M):PU	N/A	ASY	F	92	RS

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

[2] **Color-band codes**: EE = electric yellow federal band, XX = standard silver federal band, PU = pumpkin federal band, (M) = metal pin striped band, (HP) = half plastic bands/ bands cut to half the height, UB = unbanded, K = black, R = red, O = orange, G = green, V = violet, Y = yellow, W = white, D = dark blue, B = light blue, Z = gold, undetermined = presence of bands could not be determined. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[3] Old combination included only if rebanded in 2007.

[4] **Age in 2007**: 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.

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

[6] **Observation status codes**: N = new capture, R = recapture followed by date recaptured, RS = resight.

[7] Band number likely 2390-92434 but cannot be confirmed because bird was not captured in 2007. Bird had a visible injury on left leg.

[8] These two individuals mated consecutively with the same female; therefore, they are counted as two different territories though they are labeled with the same number.

Table 3.6. Unpaired, Resident Willow Flycatchers and Individuals for which Residency and/or Breeding Status Could Not Be Confirmed, Mesquite, NV, 2007

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Age[3]	Sex[4]	Location[5]	Observation status[6]
West	7-Jun-06	2370-39967	KO(M):PU	A3Y	M	T39	RS, detected 3–15 Jul; breeding 15 May–28 Jun at Muddy River
East	INA	INA	EE:UB	AHY	M	T66	RS, detected 7–19 Jun
West	4-July-06	2370-39941	ZW(M):PU	SY	M	F96	R 27 Jul; detected 17 Jun–17 Jul at Littlefield Poles

[1] INA = information not available.

[2] **Color-band codes**: PU = pumpkin federal band, EE = electric yellow federal band, (M) = metal pin striped band, K = black, O = orange, Z = gold, W = white. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[3] **Age in 2007**: SY = 2 years, AHY = 2 years or older, A3Y = 3 years or older.

[4] **Sex codes**: M = male.

[5] **Location Codes**: T = territorial individual detected for at least 7 days, F = individual detected for less than 7 days. Number indicates unique location.

[6] **Observation status codes**: R = recapture followed by date recaptured, RS = resight.

Mormon Mesa – We detected 24 resident, adult willow flycatchers from 15 territories at Mormon Mesa. In addition to resident adults, we detected six individuals for which residency could not be confirmed (Tables 3.7 and 3.8). Of the 15 territories recorded at Mormon Mesa, 11 consisted of breeding individuals and 4 consisted of unpaired males. Of the resident individuals, one male was detected briefly at Virgin River #2 and moved to Virgin River #1 South, where he was detected as part of a breeding pair. Two additional males, one from Muddy River and one from Grand Canyon, also moved to Virgin River #1 South after being detected at different study areas. Of the breeding individuals, two males were each polygynous with two females.

Field personnel captured and color-banded five new adults and recaptured two adult flycatchers banded in previous years, including one female originally banded as a nestling in 2004. We resighted 20 other returning banded individuals. Of these, two were returning nestlings; however, study area and year banded could not be determined because we were unable to recapture these individuals. Color combinations could not be confirmed for two individuals; one remained unbanded; and the band status of two individuals, for which residency could not be confirmed, was undetermined. We banded four nestlings from three nests. Of the banded nestlings, one was suspected to have died before fledging.

Table 3.7. Paired and Nestling Willow Flycatchers Banded and Resighted at Mormon Mesa, NV, 2007

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Old Color Combination[1,2,3]	Age[4]	Sex[5]	Territory	Observation status[6]
Virgin River #1 South	N/A	N/A	UB:UB	N/A	AHY	F	20	RS
Virgin River #1 South	22-Jul-02	2140-66709	Bs:GW(M)	N/A	A7Y	M	20, 63	RS
Virgin River #1 South	2-Jun-06	2370-39938	KG(M):PU	N/A	A3Y	F	32	RS
Virgin River #1 South	8-Jun-06	2370-40037	PU:DR(M)	N/A	3Y	M	32	RS
Virgin River #1 South	9-Jul-07	2320-31644	EE:UB	N/A	L	U	32	N
Virgin River #1 South	9-Jul-07	2320-31523	UB:EE	N/A	L	U	32	N
Virgin River #1 South	4-Jul-07	2370-40183	BZ(M):PU	N/A	AHY	F	33	N
Virgin River #1 South	12-Jun-03	2320-31428	EE:DB(M)	EE:GZ(M)	5Y	M	33, 90	R 4 Jul
Virgin River #1 South	6-Aug-05	2360-59788	BO(M):EE	N/A	3Y	F	40	RS
Virgin River #1 South	3-Aug-05	2370-39966	YB(M):PU	N/A	3Y	M	40	RS, detected 18 May at Virgin River #2
Virgin River #1 South	7-Jul-07	2320-31645	UB:EE	N/A	L	U	40	N
Virgin River #2	23-Jul-03	2320-31486	YV(M):EE	N/A	5Y	F	50	RS
Virgin River #2	23-Jun-06	2370-39940	GY(M):PU	N/A	A3Y	M	50	RS
Virgin River #2	8-Jul-04	2320-31618	EE:GB(M)	N/A	4Y	F	51	RS
Virgin River #2	21-Jun-06	2370-39988	DW(M):PU	N/A	3Y	M	51	RS
Virgin River #1 South	21-Jun-07	2370-40191	PU:RYR(M)	N/A	AHY	F	63	N
Virgin River #1 South	10-Jul-07	2370-40169	PU:UB	N/A	L	U	63	N
Virgin River #1 South	30-Jun-04	2320-31485	EE:WO(M)	N/A	A5Y	F	64	RS
Virgin River #1 South	21-Jun-05	2360-59702	WB(M):EE	N/A	3Y	M	64	RS

Table 3.7. Paired and Nestling Willow Flycatchers Banded and Resighted at Mormon Mesa, NV, 2007, continued

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Old Color Combination[1,2,3]	Age[4]	Sex[5]	Territory	Observation Status[6]
Virgin River #2	21-Jun-04	2320-31660	BZ(M):EE	UB:EE	4Y	F	70	R 28 Jun
Virgin River #2	27-May-04	2320-31653	WV(M):EE	N/A	5Y	M	70	RS
Virgin River #2	16-Jul-04	2320-31632	RZ(M):EE	N/A	5Y	F	72	RS
Virgin River #2	INA	INA	EE:UB	N/A	AHY	M	72	RS
Virgin River #1 South	INA	INA	EE:UB	N/A	AHY	F	90	RS

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

[2] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, Bs = blue federal band, (M) = metal pin striped band, UB = unbanded, W = white, K = black, Y = yellow, B = light blue, V = violet, O = orange, R = red, G = green, Z = gold, D = dark blue. Color combinations are read as the bird's left leg and right leg, top to bottom; two or three letters designate every band; color-band designations for right and left legs are separated with a colon.

[3] Old combination included only if rebanded in 2007.

[4] **Age in 2007**: L = nestling, AHY = 2 years or older, 3Y = 3 years, A3Y = 3 years or older, 4Y = 4 years, A4Y = 4 years or older, etc.

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

[6] **Observation status codes**: N = new capture, R = recapture followed by date recaptured, RS = resight.

Table 3.8. Unpaired, Resident Willow Flycatchers and Individuals for which Residency and/or Breeding Status Could Not Be Confirmed, Mormon Mesa, NV, 2007

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Age[3]	Sex[4]	Location[5]	Observation Status[6]
Virgin River #2	29-Jun-03	2320-31471	EE:OW(M)	5Y	M	T10	RS, detected 22 May–5 Jul
Virgin River #2	15-May-07	2370-40161	PU:DY(M)	AHY	M	T27	N, detected 14 May–11 Jun
Virgin River #2	3-Jun-07	2370-40197	OG(M):PU	AHY	M	T34	N, detected 24 May–15 Jun
Virgin River #1 North	12-Jun-07	2370-40172	PU:RO(M)	AHY	M	T43	N; R 19 Jun, detected 9–23 Jun
Virgin River #1 North	INA	INA	banded	AHY	M	F36	RS, detected 12 Jun
Mormon Mesa South South	INA	INA	banded	AHY	U	F37	RS, detected 14 Jun
Virgin River #1 South	29-Jun-06	2360-59749	BG(M):EE	SY	M	F56	RS, detected 15 Jul, breeding at Muddy River 30 May–30 Jun
Virgin River #1 South	INA	INA	undetermined	AHY	M	F73	Detected 13 Jun
Mormon Mesa South North	INA	INA	undetermined	AHY	M	F74	Detected 14 Jun
Virgin River #1 South	14-Jun-06	2370-40046	PU:DK(M)	3Y	M	F99	RS, detected 28 Jul, detected in Grand Canyon 31 May–20 Jun

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

[2] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, (M) = metal pin striped band, W = white, Y = yellow, R = Red, O = orange, D = dark blue, B = light blue, G = green, K = black, banded = bird has color-bands but combination could not be confirmed, undetermined = presence of bands could not be determined. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[3] **Age in 2007**: SY = 2 years, AHY = 2 years or older, 3Y = 3 years, 5Y = 5 years

[4] **Sex codes**: M = male.

[5] **Location code**: T = territorial individual detected for at least 7 days, F = individual detected for less than 7 days. Number indicates unique location.

[6] **Observation status codes**: N = new capture, R = recapture followed by date recaptured, RS = resight.

Muddy River – We detected 15 resident, adult willow flycatchers from 9 territories at Muddy River. In addition to resident adults, we detected one individual for which residency could not be confirmed. Of the nine territories recorded, eight consisted of breeding individuals and one consisted of an unpaired male (Tables 3.9 and 3.10). Of the resident individuals, several were known to have moved between sites or study areas: one moved from Overton WMA to Overton WMA Pond, one moved from Overton WMA to Mesquite West, and one moved from Overton WMA to Mormon Mesa Virgin River #1 South. Of the breeding individuals, one male was polygynous with three females.

Field personnel captured and color-banded four new adults and recaptured five adults, including two returning nestlings from 2006 (see Table 3.21 for juvenile dispersal data). We resighted five other returning banded individuals, of which two were returning nestlings; however, study area and year banded could not be determined because we were unable to recapture these individuals. Of the resident adults, only one remained unbanded. The band status of one additional adult, for which residency and/or breeding status was not confirmed, could not be determined. We did not band any nestlings at Muddy River in 2007.

Table 3.9. Paired and Nestling Willow Flycatchers Banded and Resighted at Muddy River Delta, NV, 2007

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Old Color Combination[1,2,3]	Age[4]	Sex[5]	Territory	Observation status[6]
Overton WMA	9-Jun-05	2370-39956	PU:ZZ(M)	N/A	4Y	F	1	RS
Overton WMA	21-Jun-04	2320-31615	EE:OY(M)	N/A	4Y	M	1, 51, 73	R 7 Jun
Overton WMA	2-Jun-07	2370-40192	PU:RB(M)	N/A	AHY	F	11	N
Overton WMA	26-Jun-03	2370-39955	BV(M):PU	N/A	5Y	M	11	R 14 Jun
Overton WMA Pond	16-Jul-04	2320-31631	BB(M):EE	N/A	4Y	F	12	RS, detected at main site 19–25 May
Overton WMA Pond	6-Jul-06	2360-59799	EE:OZ(M)	EE:UB	SY	M	12	R 1 Jul
Overton WMA	INA	INA	EE:UB	N/A	AHY	F	35	RS
Overton WMA	29-Jun-06	2360-59749	BG(M):EE	UB:EE	SY	M	35	R 31 May; detected 15 Jul at Mormon Mesa
Overton WMA	14-Jun-06	2370-40059	PU:BY(M)	N/A	A3Y	F	41	RS
Overton WMA	7-Jun-07	2370-40184	PU:WO(M)	N/A	SY	M	41	N
Overton WMA	20-Jun-07	2370-40171	DB(M):PU	N/A	AHY	F	50	N
Overton WMA	7-Jun-06	2370-39967	KO(M):PU	N/A	A3Y	M	50	R 20 Jun; detected 3–15 Jul at Mesquite
Overton WMA	INA	INA	UB:EE	N/A	AHY	F	51	RS
Overton WMA	N/A	N/A	UB:UB	N/A	AHY	F	73	RS

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

[2] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, (M) = metal pin striped band, UB = unbanded, W = white, Y = yellow, B = light blue, D = dark blue, V = violet, Z = gold, O= orange, R = red, G = green, K = black. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[3] Old combination included only if rebanded in 2007.

[4] **Age in 2007**: SY = 2 years, AHY = 2 years or older, A3Y = 3 years or older, 4Y = 4 years, 5Y = 5 years.

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

[6] **Observation status codes**: N = new capture, R = recapture followed by date recaptured, RS = resight.

Table 3.10. Unpaired, Resident Willow Flycatchers, Muddy River Delta, NV, 2007

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Age[3]	Sex[4]	Location[5]	Observation Status[6]
Overton WMA	1-Jun-07	2370-40186	KB(M):PU	SY	M	T85	N, detected 30 May–18 Jun, displaced by another male
Overton WMA	INA	INA	undetermined	AHY	U	F10	Detected 15 May, probable migrant

[1] INA = information not available.

[2] **Color-band codes**: PU = pumpkin federal band, (M) = metal pin striped band, K = black, B = light blue, undetermined = presence of bands could not be determined. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[3] **Age in 2007**: AHY = 2 years or older, SY = 2 years.

[4] **Sex codes**: M = male, U = sex unknown.

[5] **Location codes**: T = territorial individual detected for at least 7 days, F = individual detected for less than 7 days. Number indicates unique location.

[6] **Observation status codes**: N = new capture.

Grand Canyon – We detected four resident, adult willow flycatchers from three territories at various sites in lower Grand Canyon and on the Lake Mead Delta. In addition to resident adults, we detected three adult willow flycatchers for which residency and/or breeding status could not be confirmed (Tables 3.11 and 3.12). Of the three territories, one consisted of a breeding pair, and two consisted of unpaired males. One territorial male was known to have moved from Grand Canyon RM 274.5N to Mormon Mesa Virgin River #1 South.

Field personnel captured and color-banded four new adults. We resighted two returning banded individuals, and band status could not be determined for one adult.

Table 3.11. Paired Willow Flycatchers Banded at Grand Canyon, AZ, 2007

Site	Date Banded	Federal Band #	Color Combination[1]	Age[2]	Sex[3]	Territory	Observation Status[4]
Burnt Springs/RM 259.5N	17-Jun-07	2370-40127	YRY(M):PU	AHY	M	109	N
Burnt Springs/RM 259.5N	29-Jun-07	2370-40160	RWR(M):PU	SY	F	109	N

[1] **Color-band codes**: PU = pumpkin federal band, (M) = metal pin striped band, Y = yellow, W = white, R = red. Color combinations are read as the bird's left leg and right leg, top to bottom; two or three letters designate every band; color-band designations for right and left legs are separated with a colon.

[2] **Age in 2007**: SY = 2 years, AHY = 2 years or older.

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

[4] **Observation status codes**: N = new capture.

Table 3.12. Unpaired, Resident Willow Flycatchers and Individuals for which Residency and/or Breeding Status Could Not Be Confirmed, Grand Canyon, AZ, 2007

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Age[3]	Sex[4]	Location[5]	Observation Status[6]
RM 274.5N	14-Jun-06	2370-40046	PU:DK(M)	3Y	M	T13	RS, unpaired, detected 31 May–20 Jun; detected 28 Jul at Mormon Mesa
RM 274.5N	4-Jul-06	2370-39929	PU:YG(M)	A3Y	M	T67	RS, unpaired, detected 17 May–2 Jul
RM 274.5N	INA	INA	undetermined	AHY	U	F14	Detected 4 Jun, probable migrant
RM 274.5N	18-Jun-07	2370-40126	PU:KY(M)	SY	M	F15	N, detected 18–20 Jun
Pearce Ferry	3-Jun-07	2370-40129	PU:OD(M)	SY	M	F40	N, detected 3 Jun

[1] INA = information not available.

[2] **Color-band codes**: PU = pumpkin federal band, (M) = metal pin striped band, D = dark blue, K = black, Y = yellow, O = orange, G = green, undetermined = presence of bands could not be determined. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[3] **Age in 2007**: SY = 2 years, AHY = 2 years or older, 3Y = 3 years, A3Y = 3 years or older.

[4] **Sex codes**: M = male, U = sex unknown.

[5] **Location codes**: T = territorial individual detected for at least 7 days, F = individual detected for less than 7 days. Number indicates unique location.

[6] **Observation status codes**: N = new capture, RS = resight.

Topock – We detected 18 resident, adult willow flycatchers from 11 territories at Topock. In addition to resident adults, we detected 13 individuals for which residency and/or breeding status could not be confirmed (Tables 3.13 and 3.14). Twelve of these individuals were detected for only one day in mid- to late May or early June and were suspected to be migrants. Of the 11 territories recorded at Topock, 8 consisted of paired individuals and 3 consisted of unpaired males. Of the breeding individuals, one male was polygynous with two females.

Field personnel captured and color-banded four new adults and recaptured two adults banded in previous years, including one originally banded as a nestling in 2006. We resighted five other returning banded adults, of which two were returning nestlings. We were unable to recapture the returning nestlings, and study area and year banded could not be determined. The band status of one resident individual could not be determined, one resident individual was banded but the color combination could not be confirmed, and six resident individuals remained unbanded. Eleven of the thirteen individuals for which residency and/or breeding status could not be confirmed were of unknown band status and two were unbanded. We banded 15 nestlings from six nests. One banded nestling was suspected to have died before fledging.

Table 3.13. Paired, Nestling, and Fledgling Willow Flycatchers Banded and Resighted at Topock, Havasu NWR, AZ, 2007

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Old Color Combination[1,2,3]	Age[4]	Sex[5]	Territory	Observation Status[6]
Pierced Egg	N/A	N/A	UB:UB	N/A	AHY	F	2	RS
Pierced Egg	1-Jun-06	2370-39916	PU:YD(M)	N/A	A3Y	M	2	RS
Pierced Egg	16-Jul-07	2370-40112	UB:PU	N/A	L	U	2	N
Pierced Egg	16-Jul-07	2370-40111	PU:UB	N/A	L	U	2	N
Pierced Egg	16-Jul-07	2370-40110	UB:PU	N/A	L	U	2	N
Pierced Egg	INA	INA	undetermined	N/A	AHY	F	3	
Pierced Egg	N/A	N/A	UB:UB	N/A	AHY	M	3	RS
Glory Hole	N/A	N/A	UB:UB	N/A	AHY	F	5	RS
Glory Hole	17-May-07	2370-40139	PU:ZB(M)	N/A	AHY	M	5, 74	N
Glory Hole	10-Jul-07	2370-40121	UB:PU	N/A	L	U	5	N
Glory Hole	10-Jul-07	2370-40120	PU:UB	N/A	L	U	5	N
Glory Hole	10-Jul-07	2370-40119	UB:PU	N/A	L	U	5	N
In Between	10-Jun-07	2370-40136	PU:OG(M)	N/A	SY	F	32	N
In Between	INA	INA	UB:EE	N/A	AHY	M	32	RS
In Between	11-Jul-07	2370-40118	UB:PU	N/A	L	U	32	N
Glory Hole	N/A	N/A	UB:UB	N/A	AHY	F	34	RS
Glory Hole	25-Jul-04	2320-31560	EE:GY(M)	N/A	5Y	M	34	R 11 Jun
Glory Hole	29-Jun-07	2370-40125	UB:PU	N/A	L	U	34	N
Glory Hole	29-Jun-07	2370-40124	PU:UB	N/A	L	U	34	N
Glory Hole	29-Jun-07	2370-40123	UB:PU	N/A	L	U	34	N
Glory Hole	29-Jun-07	2370-40122	PU:UB	N/A	L	U	34	N
Glory Hole	23-Jul-06	2320-31650	EE:BB(M)	EE:UB	SY	F	35	R 4 Jul
Glory Hole	INA	INA	banded	INA	AHY	M	35	RS
Glory Hole	13-Jul-07	2370-40117	UB:PU	N/A	L	U	35	N
Glory Hole	13-Jul-07	2370-40116	PU:UB	N/A	L	U	35	N
Glory Hole	N/A	N/A	UB:UB	N/A	AHY	F	74	RS
Glory Hole	13-Jul-07	2370-40114	UB:PU	N/A	L	U	74	N
Glory Hole	13-Jul-07	2370-40115	PU:UB	N/A	L	U	74	N
800M	27-Jun-07	2370-40132	DO(M):PU	N/A	AHY	F	88	N
800M	25-Jul-04	2320-31559	OK(M):EE	N/A	5Y	M	88	RS

[1] N/A = not applicable; INA = information not available.

[2] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, (M) = metal pin striped band, UB = unbanded, Y = yellow, D = dark blue, B = light blue, G = green, O = orange, K = black, Z = gold, banded = bands were present but colors could not be confirmed, undetermined = presence of bands could not be determined. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[3] Old combination included only if rebanded in 2007.

[4] **Age in 2007**: 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.

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

[6] **Observation status codes**: N = new capture, R = recapture followed by date recaptured, RS = resight.

Table 3.14. Unpaired, Resident Willow Flycatchers and Individuals for which Residency and/or Breeding Status Could Not Be Confirmed, Topock, Havasu NWR, AZ, 2007

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Age[3]	Sex[4]	Location[5]	Observation Status[6]
Pierced Egg	24-May-07	2370-40138	PU:BD(M)	AHY	M	T1	N, detected 10 May–15 Jul
Pierced Egg	N/A	N/A	UB:UB	AHY	M	T30	RS, Detected 8 May–9 Jul
In Between	INA	INA	UB:EE	AHY	M	T80	RS, detected 4 May–28 Jun
250M	INA	INA	undetermined	AHY	U	F4	Detected 15 May, probable migrant
Pierced Egg	N/A	N/A	UB:UB	AHY	U	F10	Detected 14 May, probable migrant
Beal Lake	INA	INA	undetermined	AHY	M	F38	Detected 6 Jun, probable migrant
Lost Lake	INA	INA	undetermined	AHY	M	F39	Detected 6 Jun, probable migrant
Channel[7]	INA	INA	undetermined	AHY	M	F71	Detected 24 May, probable migrant
Kermit[7]	N/A	N/A	UB:UB	AHY	M	F72	RS, detected 24 May, probable migrant
Hell Bird	INA	INA	undetermined	AHY	U	F82	Detected 9 May, probable migrant
Hell Bird	INA	INA	undetermined	AHY	U	F83	Detected 9 May, probable migrant
Kermit[7]	INA	INA	undetermined	AHY	M	F86	Detected 7 Jun, probable migrant
Kermit[7]	INA	INA	undetermined	AHY	M	F87	Detected 7 Jun, probable migrant
Barbed Wire	INA	INA	undetermined	AHY	U	F96	Detected 10 Jun, probable migrant
250M	INA	INA	undetermined	AHY	U	F97	Detected 26 May, probable migrant
Beal Lake	INA	INA	undetermined	AHY	U	F99	Detected 17–21 Jun

[1] N/A = not applicable; INA = information not available.

[2] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, B = light blue, D = dark blue, UB = unbanded, undetermined = presence of bands could not be determined. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[3] **Age in 2007**: AHY = 2 years or older.

[4] **Sex codes**: M = male, U = sex unknown.

[5] **Location codes**: T = territorial individual detected for at least 7 days, F = individual detected for less than 7 days. Number indicates unique location.

[6] **Observation status codes**: N = new capture, RS = resight.

[7] Not a formal survey site.

Bill Williams – We detected 13 resident willow flycatchers from nine territories at Bill Williams. In addition to resident adults, we detected eight individuals for which residency and/or breeding status could not be determined. At least five of these individuals were suspected to be migrants (Tables 3.15 and 3.16). Of the nine territories recorded at Bill Williams, seven consisted of paired individuals and two consisted of lone males. Of the breeding individuals, one male was polygynous with three females, and one was polygynous with two females.

Field personnel captured and color-banded four new adults and recaptured one returning nestling that was originally banded in 2005. We resighted five other returning banded individuals. Two of these were known returning nestlings; however, study area and year banded could not be determined because we were unable to capture these individuals. Five resident adults and two suspected migrants were unbanded, and band status was undetermined for four individuals. We banded three nestlings from two nests. One of the banded nestlings was suspected to have died before fledging.

Table 3.15. Paired Willow Flycatchers Banded and Resighted at Bill Williams River NWR, AZ, 2007

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Old Color Combination[1, 2]	Age[3]	Sex[4]	Territory	Observation Status[5]
Site 3	24-May-05	2370-39932	BK(M):PU	N/A	A4Y	F	9	RS
Site 3	24-May-05	2370-40052	KV(M):PU	N/A	A4Y	M	9, 21, 77	RS
Site 3	22-Jun-07	2370-40133	DR(M):PU	N/A	AHY	F	21	N
Site 3	18-Jul-07	2370-40158	UB:PU	N/A	L	U	21	N
Site 3	18-Jul-07	2370-40159	PU:UB	N/A	L	U	21	N
Site 3	N/A	N/A	UB:UB	N/A	AHY	F	31	RS
Site 3	7-Jun-06	2370-40058	PU:BK(M)	N/A	A3Y	M	31	RS
Site 3	N/A	N/A	UB:UB	N/A	AHY	F	33	RS
Site 3	8-Jul-05	2360-59727	EE:YW(M)	EE:UB	3Y	M	33	R 12 Jul
Site 3	15-Jul-07	2370-40113	UB:PU	N/A	L	U	33	N
Site 3	N/A	N/A	UB:UB	N/A	AHY	F	42	RS
Site 3	N/A	N/A	UB:UB	N/A	AHY	M	42, 85	RS
Site 3	14-Jun-07	2370-40135	GG(M):PU	N/A	AHY	F	77	N
Site 3	20-Jun-07	2370-40134	DY(M):PU	N/A	SY	F	85	N

[1] N/A = not applicable.
[2] **Color-band codes**: PU = pumpkin federal band, EE = electric yellow federal band, (M) = metal pin striped band, UB = unbanded, B = light blue, D = dark blue, R = red, Y = yellow, K = black, V = violet, W = white, G = green. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.
[3] **Age in 2007**: L = nestling, SY = 2 years, AHY = 2 years or older, 3Y = 3 years, A3Y = 3 years or older, A4Y = 4 years or older.
[4] **Sex codes**: F = female, M = male, U = sex unknown.
[5] **Observation status codes**: N = new capture, R = recapture, RS = resight.

Table 3.16. Unpaired, Resident Willow Flycatchers and Individuals for which Residency and/or Breeding Status Could Not Be Confirmed, Bill Williams River NWR, AZ, 2007

Site	Date Banded[1]	Federal Band #[1]	Color Combination[2]	Age[3]	Sex[4]	Location[5]	Observation Status[6]
Site 3	25-May-07	2370-40137	PU:RD(M)	AHY	M	T44	N, detected 23 May–24 Jun
Mineral Wash	N/A	N/A	UB:UB	AHY	M	T101	RS, detected 30 May–6 Jun
Beaver Pond	INA	INA	undetermined	AHY	U	F6	Detected 6 Jun, probable migrant
Mineral Wash	N/A	N/A	UB:UB	AHY	U	F7	Detected 6 Jun, probable migrant
Mineral Wash	INA	INA	undetermined	AHY	U	F8	Detected 12 Jun, probable migrant
Site 11	INA	INA	undetermined	AHY	U	F11	Detected 7 Jun, probable migrant
Site 8	N/A	N/A	UB:UB	AHY	U	F20	RS, detected 6 Jun, probable migrant
Site 3	INA	INA	UB:PU	AHY	U	F89	RS, detected 17 May
Site 3	INA	INA	UB:EE	AHY	U	F90	RS, detected 6 Jul
New Willow	INA	INA	undetermined	AHY	U	F91	Detected 5 Jun

[1] N/A = not applicable, INA = information not available.
[2] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, R = red, D = dark blue, UB = unbanded, undetermined = presence of bands could not be determined. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.
[3] **Age in 2007**: AHY = 2 years or older.
[4] **Sex codes**: M = male, U = sex unknown.
[5] **Location codes**: T = territorial individual detected for at least 7 days, F = individual detected for less than 7 days. Number indicates unique location.
[6] **Observation status codes**: RS = resight, N = new capture.

NON-MONITORING SITE

Key Pittman Wildlife Management Area – Field personnel captured and color-banded one new adult and recaptured two returning nestlings from 2005 (see Table 3.21 for juvenile dispersal data). We resighted the color combinations of three returning banded adults. We banded four nestlings from one nest (Table 3.17).

Table 3.17. Willow Flycatchers Color-Banded and Resighted, Key Pittman Wildlife Management Area, NV, 2007

Site	Date Banded	Federal Band #	Color Combination[1]	Old Color Combination[1]	Age[2]	Sex[3]	Observation Status[4]
Key Pittman	21-Jul-05	2320-31683	EE:BO(M)	EE:UB	3Y	M	R 24 May
Key Pittman	26-Jun-03	2320-31463	EE:WB(M)	N/A	5Y	F	RS
Key Pittman	27-Jun-07	2360-59779	EE:UB	N/A	L	U	N
Key Pittman	27-Jun-07	2360-59780	UB:EE	N/A	L	U	N
Key Pittman	27-Jun-07	2360-59781	EE:UB	N/A	L	U	N
Key Pittman	27-Jun-07	2360-59782	UB:EE	N/A	L	U	N
Key Pittman	23-May-07	2370-40187	RB(M):PU	N/A	AHY	M	N
Key Pittman	30-Jul-05	2370-39980	WO(M):PU	N/A	3Y	U	RS
Key Pittman	25-Jun-04	2320-31604	KR(M):EE	N/A	4Y	M	RS
Key Pittman	3-Jul-05	2320-31694	EE:BK(M)	EE:UB	3Y	M	R 24 May

[1] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, (M) = metal pin striped band, UB = unbanded, B = light blue, O = orange, W = white, R = red, K = black. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[2] **Age in 2007:** L = nestling, AHY = 2 years or older, 3Y = 3 years, 4Y = 4 years, 5Y = 5 years.

[3] **Sex codes**: M = male, F = female, U = sex unknown.

[4] **Observation status codes**: N = new capture, R = recapture followed by date recaptured, RS = resight.

COLOR-BANDING AND RESIGHTING DOWNSTREAM OF PARKER DAM

From 10 to 20 June 2007, we recorded 52 willow flycatcher detections at 12 sites along the Colorado River from Big Hole Slough south to Hunter's Hole, and along the Gila River near Yuma (see Chapter 2 for details). No willow flycatcher detections were recorded after 20 June. From 10 to 20 June, field personnel captured and color-banded 30 new adults at Gadsden. Reconnaissance efforts on 8 and 9 June resulted in the capture and color-banding of 34 willow flycatchers at Gadsden. Of the 64 individuals captured, all but 8 were second-year birds (Table 3.18). One individual (# 2430-61006) was recaptured at the same site five hours later. Another individual (# 2430-61013) was recaptured at the same site two days later. None of the other 62 banded individuals were detected post-capture, and no flycatcher detections were recorded at any sites south of Bill Williams between 21 June and 24 July, suggesting these individuals were northbound migrants.

Table 3.18. Willow Flycatchers Color-Banded along the Lower Colorado River South of the Bill Williams River NWR to the Mexico Border, 2007

Site	Date Banded	Federal Band #	Color Combination[1]	Age[2]	Sex[3]	Observation Status[4]
Gadsden	8-Jun-07	2430-61006	XX:RR(M)	AHY	U	N; recaptured same site, 5 hours later
Gadsden	8-Jun-07	2430-61007	XX:RR(M)	AHY	U	N
Gadsden	8-Jun-07	2430-61008	XX:RR(M)	AHY	U	N
Gadsden	8-Jun-07	2430-61009	XX:RR(M)	AHY	U	N
Gadsden	8-Jun-07	2430-61010	XX:RR(M)	SY	U	N
Gadsden	8-Jun-07	2430-61011	XX:RR(M)	SY	U	N
Gadsden	8-Jun-07	2430-61012	XX:RR(M)	SY	U	N
Gadsden	8-Jun-07	2430-61013	XX:RR(M)	SY	U	N; recaptured same site 10 Jun
Gadsden	8-Jun-07	2430-61014	XX:RR(M)	SY	U	N
Gadsden	8-Jun-07	2430-61015	XX:RR(M)	SY	U	N
Gadsden	8-Jun-07	2430-61016	XX:RR(M)	AHY	U	N
Gadsden	8-Jun-07	2430-61017	XX:RR(M)	SY	U	N
Gadsden	8-Jun-07	2430-61018	XX:RR(M)	SY	U	N
Gadsden	8-Jun-07	2430-61019	XX:RR(M)	SY	U	N
Gadsden	8-Jun-07	2430-61020	XX:RR(M)	SY	U	N
Gadsden	8-Jun-07	2430-61021	XX:RR(M)	SY	U	N
Gadsden	8-Jun-07	2430-61023	XX:RR(M)	AHY	U	N
Gadsden	9-Jun-07	2430-61024	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61025	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61026	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61027	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61028	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61029	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61030	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61031	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61032	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61033	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61034	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61035	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61036	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61037	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61038	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61039	XX:RR(M)	SY	U	N
Gadsden	9-Jun-07	2430-61040	XX:RR(M)	SY	U	N
Gadsden	10-Jun-07	2430-61041	XX:RR(M)	SY	U	N
Gadsden	10-Jun-07	2430-61042	XX:RR(M)	SY	U	N

Table 3.18. Willow Flycatchers Color-Banded along the Lower Colorado River South of the Bill Williams River NWR to the Mexico Border, 2007, continued

Site	Date Banded	Federal Band #	Color Combination[1]	Age[2]	Sex[3]	Observation Status[4]
Gadsden	10-Jun-07	2430-61043	XX:RR(M)	SY	U	N
Gadsden	10-Jun-07	2430-61044	XX:RR(M)	SY	U	N
Gadsden	10-Jun-07	2430-61045	XX:RR(M)	SY	U	N
Gadsden	10-Jun-07	2430-61046	XX:UB	SY	U	N
Gadsden	11-Jun-07	2430-61047	XX:UB	SY	U	N
Gadsden	11-Jun-07	2430-61048	XX:UB	SY	U	N
Gadsden	11-Jun-07	2430-61049	XX:UB	SY	U	N
Gadsden	11-Jun-07	2430-61050	XX:UB	SY	U	N
Gadsden	11-Jun-07	2430-61051	XX:UB	SY	U	N
Gadsden	12-Jun-07	2430-61052	XX:UB	SY	U	N
Gadsden	12-Jun-07	2430-61053	XX:UB	AHY	U	N
Gadsden	12-Jun-07	2430-61054	XX:UB	SY	U	N
Gadsden	12-Jun-07	2430-61055	XX:UB	SY	U	N
Gadsden	13-Jun-07	2430-61056	XX:RR(M)	SY	U	N
Gadsden	14-Jun-07	2430-61058	XX:RR(M)	SY	U	N
Gadsden	15-Jun-07	2430-61059	XX:RR(M)	SY	U	N
Gadsden	15-Jun-07	2430-61060	XX:RR(M)	SY	U	N
Gadsden	15-Jun-07	2430-61061	XX:RR(M)	SY	U	N
Gadsden	16-Jun-07	2430-61062	XX:RR(M)	SY	U	N
Gadsden	16-Jun-07	2430-61063	XX:RR(M)	SY	U	N
Gadsden	17-Jun-07	2430-61064	XX:RR(M)	SY	U	N
Gadsden	17-Jun-07	2430-61065	XX:RR(M)	AHY	U	N
Gadsden	18-Jun-07	2430-61066	XX:RR(M)	SY	U	N
Gadsden	18-Jun-07	2430-61067	XX:RR(M)	SY	U	N
Gadsden	19-Jun-07	2430-61068	XX:RR(M)	SY	U	N
Gadsden	19-Jun-07	2430-61069	XX:RR(M)	SY	U	N
Gadsden	19-Jun-07	2430-61070	XX:RR(M)	SY	U	N
Gadsden	20-Jun-07	2430-61071	XX:RR(M)	SY	U	N

[1] **Color-band codes**: XX = standard silver federal band, (M) = metal pin striped band, UB = unbanded, RR = red. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

[2] **Age in 2007**: SY = 2 years, AHY = 2 years or older.

[3] **Sex codes**: U = sex unknown.

[4] **Observation status codes**: N = new capture.

Adult Between-Year Return and Dispersal

In 2006 we identified 96 adult, resident willow flycatchers at the life history study areas, Muddy River, Grand Canyon, and Bill Williams, of which 55 (57%) were detected in 2007 (Table 3.19). Of the returning adults, six (11%) were detected at a different study area than where they were detected in 2006 (Table 3.20). An additional adult that was detected in 2004 and 2007 but not in 2005 or 2006 exhibited between-year movement. The median dispersal distance for all returning adult flycatchers exhibiting between-year movements in 2007 was 40.5 km (min = 14 km, max = 259 km).

Table 3.19. Resident Adult Willow Flycatcher Annual Return from 2006 to 2007

Study Area	# Identified in 2006	# of 2006 Birds Detected in 2007	% Return	% Return to Same Study Area
Pahranagat	33	17	52	100
Mesquite	18	12	67	100
Mormon Mesa	16	10	63	80
Muddy River	9	7	78	71
Grand Canyon	9	4	44	50
Topock	8	3	38	100
Bill Williams	3	2	67	100
Total	**96**	**55**	**57**	**89**

Table 3.20. Summary of Adult Willow Flycatcher Between-Year Movements for All Individuals Identified in a Previous Year and Recaptured or Resighted at a Different Study Area in 2007

Study Area/ Site/ Year Detected [1]	Study Area/ Site Detected 2007[1]	Distance Moved (km)	Federal Band #	Color Combination[2]	Sex[3]
MOME/Virgin River #2/2006	BIWI/Site #3	259	2370-40058	PU:BK(M)	M
GRCA/RM 285.3N/2006	MOME/Virgin River #1	55	2370-40037	PU:DR(M)	F
GRCA/Chuckwalla Cove/2006	MOME/Virgin River #2	52	2370-39988	DW(M):PU	M
MESQ/West/2004	MOME/Virgin River #2	29	2320-31471	EE:OW(M)	M
MUDD/Overton WMA/2006	MOME/Virgin River #1	14	2360-59788	BO(M):EE	F
MUDD/Overton WMA/2006	MOME/Virgin River #1	14	2360-59702	WB(M):EE	M

[1] MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, GRCA = Grand Canyon, BIWI = Bill Williams River National Wildlife Refuge.

[2] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, (M) = metal pin striped band, B = light blue, D = dark blue, O = orange, R = red, Z = gold, K = black, W = white. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

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

JUVENILE BETWEEN-YEAR RETURN AND DISPERSAL

In 2006, we banded 63 nestlings and 3 fledglings at the life history study areas, Muddy River, and Bill Williams. Two of these nestlings were known to have died before fledging. Of the 64 remaining juveniles, 9 (14%) were recaptured or resighted and identified in 2007. Of the nine returning 2006 juveniles, four were detected at a different study area from where originally banded, and five were detected at the same study area. Five individuals originally banded as nestlings in 2005 and one banded in 2004 were also recaptured for the first time, of which four returned to a different study area than where originally banded (Table 3.21). The median dispersal distance for all returning juvenile flycatchers exhibiting between-year movements in 2007 was 28.5 km (min = 12 km, max = 33 km).

Table 3.21. Summary of Juvenile Flycatchers Banded as Hatch Year Birds in 2004, 2005, or 2006 and Recaptured or Resighted for the First Time in 2007*

Study Area/Site Banded	Year Hatched	Study Area/ Site Detected 2007	Distance Moved (km)	Federal Band #	Color Combination[2]	Sex[3]
PAHR/North	2005	KEPI	30	2320-31694	EE:BK(M)	M
PAHR/South	2005	KEPI	33	2320-31683	EE:BO(M)	M
MESQ/West	2006	LIFI/Poles	20	2370-39941	ZW(M):PU	M
MOME/Virgin River #2	2006	MESQ/West	29	2360-59751	OG(M):EE	M
MOME/Virgin River #2	2006	MESQ/West	28	2360-59750	EE:OB(M)	F
MESQ/West	2004	MOME/Virgin River #2	29	2320-31660	BZ(M):EE)	F
MUDD/Overton WMA	2005	MOME/Virgin River #2	12	2370-39966	YB(M):PU)	M
MOME/Virgin River #2	2006	MUDD/Pond	12	2360-59799	EE:OZ(M)	M
PAHR/North	2006	PAHR/North	--	2370-39946	GW(M):PU	M
BIWI/Site #4	2005	BIWI/Site #3	--	2360-59727	EE:YW(M)	F
MESQ/West	2006	MESQ/West	--	2360-59754	OR(M):EE	M
MUDD/Overton WMA	2006	MUDD/Overton WMA	--	2360-59749	BG(M):EE	M
PAHR/North	2006	PAHR/North	--	2360-59797	EE:RB(M)	M
PAHR/North	2005	PAHR/North	--	2320-31698	RB(M):EE	F
TOPO/Pierced Egg	2006	TOPO/Glory Hole	--	2320-31650	EE:BB(M)	F

* Dispersal distances are given for flycatchers that moved between study areas.

[1] KEPI = Key Pittman Wildlife Management Area, PAHR = Pahranagat National Wildlife Refuge, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, TOPO = Topock Marsh, BIWI = Bill Williams River National Wildlife Refuge

[2] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, (M) = metal pin striped band, B = light blue, G = green, O = orange, R = red, Z = gold, W = white, Y = yellow, K = black. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.

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

Ten additional returning nestlings from 2003–2006 were resighted in 2007 (two each at Mesquite, Mormon Mesa, Muddy River, Topock, and Bill Williams), but the identity of these individuals was undetermined because we were unable to recapture them.

Within-Year, Between-Study Area Movements

We detected four within-year, between study area movements in 2007. One male held a territory at Grand Canyon RM 274.5 from 31 May to 20 June and then was detected at Mormon Mesa Virgin River #1 on 28 July. Another male held a territory at Littlefield Poles from 17 June to 17 July and was recaptured at Mesquite West on 27 July. A third male was initially detected breeding at Overton WMA from 30 May to 30 June, where it had three unsuccessful nesting attempts. This individual was later detected on 15 July at Mormon Mesa Virgin River #1. The fourth male nested unsuccessfully at Muddy River Overton WMA from 15 May to 28 June and then was detected at Mesquite West on 8 July.

Discussion

Color-Banding Effort – Overall, 73% of the adult flycatchers detected at the monitoring sites during 2007 were color-banded by the end of the breeding season. This compares to 55% in 2003, 57% in 2004, 75% in 2005, and 70% in 2006. Unbanded migrant willow flycatchers are included in calculating these percentages; therefore, in most cases, these numbers under-represent the actual proportion of resident banded flycatchers at a given site. If only resident flycatchers were included in the calculations, the percentage of banded birds at each site would be higher, especially at sites where large numbers of migrants are detected. We have maintained high overall percentages of banded birds annually over the five years, which has enabled us to detect movements and generate dispersal data. The demographic information collected via observing known individuals in multiple years provides the framework for analyses of population structure, survivorship, and fecundity, which will be presented in the five-year summary report. Also, a large number of color-banded flycatchers are vital for detecting flycatcher movements as a response to stochastic events (e.g., fire, drought, flood) at flycatcher breeding sites.

Differences between study areas in the percentage of color-banded individuals are directly related to vegetation density and overall structure, which affect our ability to erect mist-nets in the habitat. For example, in 2003–2007 an average of 86% of the flycatcher population at Pahranagat was color-banded versus 46% at Topock. Pahranagat has a relatively open understory, and personnel are able to deploy a large number of long mist-nets over the entire site, whereas the dense vegetation at Topock only allows for one or two small nets to be deployed in relatively few areas. Because sites with dense vegetation have relatively few open areas, these areas may be used multiple times for netting during any given season and in multiple years, which may result in some resident flycatchers who return each year becoming “net smart” and avoiding the nets during target or passive netting.

Breeding vs. Unpaired Territories – Given the high incidence of unpaired, resident individuals at all the monitoring sites across years, it is apparent that unpaired and floater individuals make up a substantial part of the Virgin/lower Colorado River population(s). At the monitoring sites, we recorded a total of 77 willow flycatcher territories in 2007. Of these, 58 (75%) consisted of paired flycatchers and 19 (25%) consisted of unpaired individuals. Over five years, the annual proportion of paired and unpaired territories at the monitoring sites has been relatively constant, with an average of 73 and 27%, respectively. As discussed at length in McLeod et al. (2005), this is not surprising given that the spacing of any territorial bird species in a fragmented landscape excludes some individuals from the breeding population(s). According to the tenets of avian territorial social systems, as prime and sub-optimal habitats are filled, the remaining non-breeding individuals must wait for vacancies as unpaired individuals or floaters (Brown 1964, Gill 1995). These non-breeding individuals use adjacent or nearby "sub-optimal" and/or non-breeding habitats unoccupied by breeding individuals. The highly heterogeneous environment found along the Colorado River and its tributaries likely facilitates such habitat use. It has been shown via radiotelemetry that in addition to the well-developed vegetation in which they nest, willow flycatchers also use surrounding non-riparian and sparsely vegetated young riparian habitat adjacent to active breeding sites (Paxton et al. 2003, Cardinal and Paxton 2005). Given the highly dynamic nature of riparian habitats (Periman and Kelly 2000), the vagile nature of willow flycatchers, and the propensity of flycatchers to use successional habitats, it is not surprising that not all individuals breed in any given year. Fragmented, "sub-optimal" riparian habitats adjacent to breeding sites may be crucial to the species as these areas may provide habitat for individuals that serve as population reservoirs and replace other individuals that move or die. Further, a large number of juvenile flycatchers go undetected for up to three years after being banded, and habitat use by these individuals remains largely unknown. Undetected, returning juveniles are likely a portion of the unpaired and floater individuals using these "sub-optimal" habitats.

Adult and Juvenile Between-Year Return and Dispersal – Fifty-seven percent of the adult, resident willow flycatchers identified in 2006 were detected again in 2007. Eighty-nine percent of the returning individuals were detected at the same study area in both years. For 2003–2007, 93% of all adults detected in consecutive years returned to the same site. Adult willow flycatcher return and dispersal data at the monitoring sites for 2003–2007 are consistent with range-wide data (Kenwood and Paxton 2001, Koronkiewicz et al. 2002, Newell et al. 2005) and results from previous years at the study areas (McKernan and Braden 2002), with adult flycatchers exhibiting high site fidelity to breeding areas.

Of the 15 individuals that were banded as juveniles in 2003–2006 and detected for the first time in 2007, 47% returned to the same study area where originally banded. Since 1997, 106 juvenile flycatchers have been banded at monitored sites and recaptured or resighted in subsequent years. Of these, 43 (41%) dispersed away from the natal area (McKernan and Braden unpubl. data, Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007, this document).

Demographic data collected thus far show high site fidelity exhibited by adult flycatchers and lower natal site fidelity exhibited by juveniles, with juveniles dispersing among study areas annually. 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. Only three instances of willow flycatcher immigration from sites outside the Virgin/lower Colorado River region have been recorded since 1997 (McKernan and Braden unpubl. data, Koronkiewicz et al. 2006a), with two males originally banded as nestlings in 2003 at Roosevelt Lake recaptured in 2005 at Muddy River and Topock, and one male banded as a nestling in 1999 at Roosevelt Lake recaptured in 2002 in Grand Canyon. Although movements of this magnitude are infrequent, other instances of dispersal distances greater than 140 km have been reported for Southwestern Willow Flycatcher (Kenwood and Paxton 2001).

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 sub-populations 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. The degree to which these rare, long-distance juvenile movements affect the population dynamics of Southwestern Willow Flycatcher sub-populations warrants further investigation.

Adult and Juvenile Survivorship – Annual survivorship is defined as the number of individuals that survive from one year to the next, and accurate estimates depend on year-to-year detection of uniquely marked birds. In 2006 we identified 96 adult and 64 juvenile willow flycatchers at the monitoring sites, of which 55 (57%) and 9 (14%), respectively, were detected in 2007. Thus, minimum estimated adult and juvenile survival from 2006 to 2007 was 57 and 14%, respectively. These simple annual percent survivorship calculations assume that all living flycatchers are detected in a given year, and individuals not detected are assumed to have died, unless detected elsewhere. As discussed above, some adults and juveniles go undetected for up to three years after being banded, and simple annual percent survivorship thus underestimates survival. To provide more robust estimates of annual survival, software programs (e.g., White and Burnham 1999) incorporating both survival and detection probabilities have been developed in recent years. Demographic data acquired at the life history study areas and other monitoring sites over the last 5 years will be combined with data collected during 1997–2002, and demographic analyses will be presented in the 5-year summary report.

Habitat Change at Lake Mead – The five-fold increase in the number of breeding adults detected in lower Grand Canyon from 2004 (2 breeding adults) to 2006 (10 breeding or paired adults) is likely the result of the recent development of extensive areas of willow along the Colorado River near Lake Mead. During two to three years preceding 2006, suitable flycatcher habitat had developed in Lake Mead National Recreation Area on sediments previously inundated by Lake Mead. In the past year, however, water levels in Lake Mead have continued to decline, leaving once suitable habitat elevated above the current water table. As a result, much of the vegetation that was occupied by willow flycatchers in 2006 is now dead or dying (see Chapter 2 for details).

Given the highly dynamic nature of riparian habitats, with some patches becoming too dry, too mature, or too sparse for breeding flycatchers, while other patches develop and become suitable for flycatcher breeding, willow flycatchers would be expected to respond to changes in habitat quality. Willow flycatcher demographic data and the habitat requirements of the species correlate well with the recent synthesis of metapopulation theory and landscape ecology (Wiens 1997), with local flycatcher population dynamics strongly influenced by variation in patch quality over space and time (environmental stochasticity) and the connectivity of patches within the greater landscape.

Surface Water and Flycatcher Breeding at Bill Williams – Flycatcher habitat occupancy and breeding patterns at Bill Williams seem to be correlated with the presence/absence of standing water, with flycatchers breeding only in years when sites contained standing water.[1] Since we began monitoring at Bill Williams in 2003, all flycatcher breeding has been documented at two contiguous sites, Sites 3 and 4, collectively known as Mosquito Flats. In 2003, Mosquito Flats contained up to 100 cm of standing water in May, with saturated soils present until July. Three pairs produced two successful nests at the site in 2003. In 2004, Mosquito Flats contained no standing water, with the nearest standing water >100 m away, and no flycatcher breeding was documented at the site. Because of above-normal winter precipitation during the winter of 2004–2005, Mosquito Flats contained standing water throughout the 2005 and 2006 flycatcher breeding seasons, with flycatcher breeding recorded in each year. In 2007, Mosquito Flats again held standing water (see Chapter 2 for details), and seven pairs produced two successful nests. Although other biotic and/or abiotic factors may be contributing to this pattern, the fluctuating availability of standing water at Mosquito Flats is likely one factor influencing willow flycatcher habitat occupancy and breeding in any given year. No obvious change in the woody vegetation at Mosquito Flats has been observed from 2003 to 2007, with only the presence or absence of standing water changing over this period. Although the willow flycatcher's affinity with standing water is noted consistently in the literature, the biological explanation as to why willow flycatchers breeding sites are associated with standing water remains largely undetermined.

COLOR-BANDING AND RESIGHTING DOWNSTREAM OF PARKER DAM

In 2007, we continued the color-banding studies initiated in 2003 on the extreme southern stretches of the Colorado River. We captured and color-banded 64 individuals downstream of Parker Dam; one individual was recaptured five hours later, and a second individual was recaptured two days later. None of the other 62 color-banded individuals were detected post-capture. As in 2003–2006, flycatcher behavioral observations in this area strongly suggest that the individuals detected at these sites were northbound migrants (see Chapter 2). It is apparent that the lower Colorado and Gila River riparian corridors are important flyways and stopover habitat for willow flycatchers. The degree to which migrant Southwestern Willow Flycatchers use these riparian corridors is unknown and requires further study.

Of the 110 flycatchers captured from 7 to 20 June in 2003–2007, 95 (86%) were second-year birds (hatched the year before), based on the presence of retained flight feathers (per Kenwood and Paxton 2001 and Koronkiewicz et al. 2002). Given the relatively high frequency of second-year birds during these banding attempts across years, there may be differential age patterns in willow flycatcher northbound migration along the lower Colorado River. Differential age patterning of southbound migrant willow flycatchers in the Caribbean lowlands of Costa Rica has been documented extensively, with adults migrating before juveniles (C.J. Ralph unpubl. data). Determining whether northbound willow flycatchers along the lower Colorado River also

[1] Willow flycatchers were recorded as breeding at Bill Williams from 2000 to 2002. Although data on the availability of standing water at Mosquito Flats is limited for this period, it is suspected that saturated soils and/or surface water were present at the site.

exhibit differential age patterns would require sampling over a larger portion of the annual migratory period.

During the 10–30 June sampling periods in 2005, 2006 and 2007, we captured 9, 22, and 30 flycatchers, respectively. In 2003 and 2004, only four individuals were captured in each year. The increase in captures in 2005–2007 has been influenced by a change in mist-netting strategy. In 2003–2004, we actively surveyed for flycatchers and then, after one or more individuals had been detected in an area, erected either passive or target mist-nets. In 2005–2007, we primarily identified areas where the vegetation structure allowed us to erect multiple mist-nets, and we set up as many nets as possible regardless of whether a flycatcher had been detected at the site that day. This strategy resulted in many more net-hours and a corresponding increase in the number of flycatchers captured.

CHAPTER 4

NEST MONITORING

INTRODUCTION

Documentation of nest success and productivity is critical to understanding local population status and demographic patterns of the Southwestern Willow Flycatcher. In 2007, 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 subsequent fecundity studies, calculating nest success and failure, documenting causes of nest failure (e.g., abandonment, desertion, depredation, and brood parasitism), and calculating nest productivity. Nest monitoring results from 2007 were compared with those at the study areas from 1996 to 2006 (McKernan 1997; McKernan and Braden 1998, 1999, 2001a, 2001b, 2002; Koronkiewicz et al. 2004; McLeod et al. 2005; Koronkiewicz et al. 2006a; McLeod et al. 2007; Braden and McKernan, unpubl. data). Although aspects of willow flycatcher breeding ecology can vary widely across its 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 the methods described by Rourke et al. (1999) and a modification of 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. 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.

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 and thus is a conservative estimate. 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) the nest was destroyed due to weather (weather); 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 flycatcher eggs coincided with the appearance of cowbird eggs.

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 (Appendix A) that included the nest or territory number and UTM coordinates. We calculated flycatcher nest success using both simple nesting success (number of successful nests/total number of nests) 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. To calculate Mayfield survival probabilities (MSP), we used the average length of each nest stage (2.10, 12.87, and 13.68 days for laying, incubation, and nestling stages, respectively) as observed in this study in 2003–2007 for nests where transition dates were known. Nest productivity was calculated as the number of young fledged per nesting attempt. Only willow flycatcher nests that contained at least one flycatcher egg were used in calculating nest success and productivity. Fecundity was calculated as number of young produced per female over the breeding season.

RESULTS

NEST MONITORING

We documented 70 willow flycatcher nesting attempts at the four life history study areas, Muddy River Delta, Grand Canyon, and Bill Williams; 60 of these nests were known to contain flycatcher eggs and were used in calculating nest success and productivity. Twenty-seven (45%) nests were successful and fledged young, and 33 (55%) failed. Nest success ranged from 0% at Muddy River and Grand Canyon to 75% at Topock (Table 4.1). For a comparison of nest success at all monitoring sites from 1998 to 2007, see Table 4.2.

Fifty-four nesting females, of which all but three were known to have produced at least one egg, were followed through all of their nesting attempts. Three additional females were detected for which no nesting attempt could be confirmed. Of the 54 nesting females, 42 had one nesting attempt, 8 had two nesting attempts, and 4 had three nesting attempts. All 12 of the females who had multiple nesting attempts renested after unsuccessful nests.

Table 4.1. Summary of Willow Flycatcher Nest Monitoring Results at the Four Life History Study Areas, Muddy River Delta, NV, and Grand Canyon and Bill Williams, AZ, 2007*

Study Area[1]	Site	# Pairs	# Nests	# Nests with 1+ WE[2]	# Successful Nests	# Failed Nests	# Parasitized Nests[3]
PAHR	North	10	12	12	8 (67)	4 (33)	0
	Total	**10**	**12**	**12**	**8 (67)**	**4 (33)**	**0**
MESQ	West	13	16	14	8 (57)	6 (43)	5 (36)
	Total	**13**	**16**	**14**	**8 (57)**	**6 (43)**	**5 (36)**
MOME	Virgin River #1 South	7	6	6	3 (50)	3 (50)	0
	Virgin River #2	4	6	5	0	5 (100)	2 (40)
	Total	**11**	**12**	**11**	**3 (27)**	**8 (73)**	**2 (18)**
MUDD	Overton WMA	7	11	5	0	5 (100)	2 (40)
	Overton WMA Pond	1	1	1	0	1 (100)	0
	Total	**8**	**12**	**6**	**0**	**6 (100)**	**2 (33)**
GRCA	Burnt Springs/RM 259.5	1	1	**1**	0	1 (100)	0
	Total	**1**	**1**	**1**	**0**	**1 (100)**	**0**
TOPO	In Between	1	1	1	1	0	0
	800M	1	1	1	0	1 (100)	0
	Pierced Egg	2	1	1	1 (50)	0	0
	Glory Hole	4	5	5	4 (80)	1 (20)	0
	Total	**8**	**8**	**8**	**6 (75)**	**2 (25)**	**0**
BIWI	Site 3	7	9	8	2 (25)	6 (75)	1 (13)
	Total	**7**	**9**	**8**	**2 (25)**	**6 (75)**	**1 (13)**
Overall Total		**58**	**70**	**60**	**27 (45)**	**33 (55)**	**10 (17)**

* Only nests with at least one flycatcher egg were used in percentage calculations. Percentages are given in parentheses.

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

[2] WE = willow flycatcher egg.

[3] Parasitized nests include all nests that contained at least one flycatcher egg and one cowbird egg, regardless of nest fate. Percentages include only nests for which contents could be determined.

Table 4.2. Willow Flycatcher Percent Nest Success Recorded at Breeding Sites along the Virgin and Lower Colorado Rivers and Tributaries from 1996 to 2007*

Year	Pahranagat	*Littlefield*	Mesquite[1]	Mormon Mesa[2]	Muddy River Delta	Grand Canyon	Topock	Bill Williams
1996	Nm[3]	Nm[3]	Nm[3]	Nm[3]	Nm[3]	57 (7)	100 (1)	Nm[3]
1997	Nm[3]	Nd[4]	40 (5)	38 (16)	Bc[9]	29 (14)	78 (9)	Nd[4]
1998	37 (19)	Nd[4]	0 (7)	58 (13)	Nm[3]	Nd[4]	43 (21)	Nd[4]
1999	56 (16)	Nm[3]	Nm[3]	50 (12)	Nm[3]	Nc[5]	35 (20)	Nd[4]
2000	52 (21)	Nd[4]	56 (9)	31 (16)	100 (1)	Nc[5]	28 (18)	100[6] (1)
2001	33 (27)	Nd[4]	47 (19)	35 (20)	33 (3)	Nc[7]	25 (20)	60[6] (5)
2002	29 (21)	Nd[4]	53 (19)	0 (10)	Nd[4]	Nd[4]	25 (12)	50[6] (11)
2003	91 (11)	Nd[4]	44 (18)	0 (10)	Nd[4]	Nd[4]	78 (9)	100 (2)
2004	76 (17)	50 (2)	24 (17)	50 (6)	Nd[4]	Bc[8]	45 (38)	Nd[4]
2005	58 (19)	Nd[4]	42 (12)	17 (6)	38[9] (8)	Nd[4]	24 (34)	100 (2)
2006	60 (15)	Nd[4]	55 (20)	50 (8)	44 (9)	0 (3)	23 (17)[10]	20 (5)
2007	67 (12)	Nd[4]	57 (14)	27 (11)	0 (6)	0 (1)	75 (8)	25 (8)

* Data from 1997 to 2002 are from McKernan (1997), McKernan and Braden (2002), and Braden and McKernan (unpubl. data) unless noted otherwise; 2003 data are from Koronkiewicz et al. (2004); 2004 data are from McLeod et al. (2005), 2005 data are from Koronkiewicz et al. (2006a), 2006 data are from McLeod et al. (2007), and data from 2007 can be found in this document. Total number of nests is indicated in parentheses. For 2003–2007, this is the number of nests with at least one flycatcher egg.

[1] Study area includes the Mesquite East, Mesquite West, and Bunker Farm sites.

[2] Study area includes the Virgin River Delta at Lake Mead.

[3] Study area not monitored.

[4] Study area surveyed, no breeding documented.

[5] Breeding suspected, nest success not calculated.

[6] Nest success calculated by Paradzick et al. (2001), and Smith et al. (2002, 2003).

[7] Breeding confirmed, nest success not calculated.

[8] Breeding confirmed, undetermined if nestlings from a single nest fledged.

[9] Nest success was reported in 2005 as 25%, with the fate of one additional nest unknown; a fledgling from this nest was recaptured in 2006.

[10] An additional 3 nests (18%) were suspected to have fledged but fledglings were not visually confirmed.

NEST FAILURE

Depredation was the major cause of nest failure, accounting for 35% (15 of 43) of all failed nests (Table 4.3) and 45% (15 of 33) of nests that failed after flycatcher eggs were laid. Ten nesting attempts (23% of all failed nests) were abandoned prior to willow flycatcher eggs being laid and 11 nests (26%) were deserted. Two nests (5%) failed because of Brown-headed Cowbird parasitism (see below for more details on parasitism). In two cases (5%), nestlings died in the nest. One nest (2%) failed because of infertile or addled eggs. The cause of failure for two nests (5%) is unknown.

Table 4.3. Summary of Causes of Willow Flycatcher Nest Failure at the Four Life History Study Areas, Muddy River Delta, NV, and Grand Canyon and Bill Williams, AZ, 2007*

Study Area[1]	Total # Nests	All Failed Nests	Abandoned	Deserted	Depredated	Parasitized	Nestling Died in Nest	Addled	Unknown
PAHR	12	4	0	1 (25)[2]	1 (25)	0	1 (25)	0	1 (25)
MESQ	16	8	2 (25)	1 (13)[3]	4 (50)	1 (13)	0	0	0
MOME	12	9	1 (11)	4 (44)[4]	2 (22)	0	1 (11)	1 (11)	0
MUDD	12	12	6 (50)	1 (8)[5]	4 (33)	1 (8)	0	0	0
GRCA	1	1	0	1 (100)[6]	0	0	0	0	0
TOPO	8	2	0	1 (50)[7]	1 (50)	0	0	0	0
BIWI	9	7	1 (14)	2 (29)[8]	3 (43)	0	0	0	1 (14)
Total	**70**	**43**	**10 (23)**	**11 (26)**	**15 (35)**	**2 (5)**	**2 (5)**	**1 (2)**	**2 (5)**

* 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] PAHR = Pahranagat National Wildlife Refuge, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River Delta, GRCA = Grand Canyon, TOPO = Topock Marsh, BIWI = Bill Williams River NWR.

[2] Nest deserted, possibly after partial depredation.

[3] Nest deserted after partial depredation.

[4] Two nests deserted after partial depredation, one deserted after being parasitized, one deserted during laying.

[5] Nest deserted after partial depredation.

[6] Nest deserted during incubation.

[7] Nest deserted after possible partial depredation.

[8] One nest deserted after partial depredation, one deserted after being parasitized.

BROOD PARASITISM

Ten of 55[1] nests (18%) with flycatcher eggs and known contents were brood parasitized by Brown-headed Cowbirds (Table 4.4). An additional two nests (one at Mesquite, one at Mormon Mesa) were parasitized prior to flycatcher eggs being laid and were subsequently abandoned. For nests containing flycatcher eggs, parasitism caused nest failure at two nests. In both cases, the nests were found during incubation with one flycatcher egg and one or two cowbird eggs; both fledged cowbirds. Two parasitized nests fledged flycatchers but no cowbirds. Of the remaining six parasitized nests that failed, three nests were abandoned following partial depredation with both flycatcher and cowbird eggs or young in the nest, two nesting attempts were deserted with flycatcher and cowbird eggs in the nest, and one nest contained a cowbird nestling that died in the nest. Brood parasitism at the four life history study areas, Muddy River Delta, and Bill Williams ranged from 0 to 36% and was highest at Mesquite (see Table 4.1). In 2007, nests that contained flycatcher eggs and were brood parasitized were not less likely to fledge flycatcher young than nests that were not parasitized (Chi-square = 2.78, $P = 0.096$).

[1] Table 4.1 shows a total of 60 nests known to contain at least one flycatcher egg. When calculating brood parasitism rates, however, five nests whose contents could not be determined were excluded from calculations (i.e., nests that were too high to check contents to determine presence/absence of cowbird eggs). Fifty-five nests were used in brood parasitism calculations.

Table 4.4. Fates of Willow Flycatcher Nests Parasitized by Brown-Headed Cowbirds, 2007*

Study Area[1]	Nest ID Code	Outcome[2]
MESQ	28A	Parasitized during egg laying; partially depredated with 3 WE and1 CE; deserted with 2 WE remaining
	28B	Parasitized during egg laying; partially depredated with 2 WE and 1 CE; abandoned with 1 CE remaining
	51A	Parasitized prior to WE being laid; abandoned with 1 CE
	65A	Parasitized during incubation; appearance of two CE coincided with disappearance of two WE (one each on two separate visits); CE did not hatch; nest fledged two flycatchers
	71A	Parasitized during incubation; partially depredated with 1 WN and 2 CN; nest fledged one flycatcher
	92A	Nest fledged one cowbird; WE did not hatch
MOME	51B	Parasitized during laying; partially depredated with 2 WE and 1 CE; deserted with 1 WE remaining
	72B	Parasitized during egg laying; deserted with 1 WE and 1 CE
MUDD	1A	Nest fledged one cowbird; WE did not hatch
	35B	Parasitized prior to WE being laid; abandoned with 1 CE
	50A	Parasitized during laying; partially depredated with 2 WE and 1 CE; remaining CE hatched but died in nest; female incubated last WE until nest was depredated
BIWI	85A	Parasitized during egg laying; deserted with 1 WE and 1 CE

* All nesting attempts are included.

[1] MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River Delta, BIWI = Bill Williams NWR.

[2] WE = willow flycatcher egg, CE = cowbird egg.

MAYFIELD NEST SUCCESS AND NEST PRODUCTIVITY

Mayfield survival probability (MSP) at the four life history study areas, Muddy River Delta, and Bill Williams ranged from 0.001 to 0.753 and was 0.459 for all sites combined (Table 4.5). At all sites, 56 nestlings were confirmed to have fledged from 60 nests of known outcome (mean number of nestlings/nest = 0.93, SE = 0.16). Fecundity across study areas ranged from 0.0 to 2.30 young per female and averaged 0.98 (SE = 0.17) (Table 4.6).

Table 4.5. Daily Survival Rates and Mayfield Survival Probabilities (MSP) for Willow Flycatcher Nest Stages at the Four Life History Study Areas, Muddy River Delta, NV, and Grand Canyon and Bill Williams, AZ, in 2007*

Study Area	Nest Stage[1]	Nest Losses/ Observation Days	Daily Survival Rate	Mayfield Survival Probability
Pahranagat	1	2/25	0.920	0.839
	2	0/121.5	1.000	1.000
	3	1/126.5	0.992	0.897
	MSP all stages = 0.753			
Mesquite	1	0/18	1.000	1.000
	2	4/144.5	0.972	0.697
	3	2/100	0.980	0.759
	MSP all stages = 0.529			
Mormon Mesa	1	2/12	0.833	0.682
	2	4/122	0.967	0.651
	3	2/56.5	0.965	0.611
	MSP all stages = 0.271			
Muddy River	1	0/8	1.000	1.000
	2	4/83.5	0.952	0.532
	3	2/5.5	0.636	0.002
	MSP all stages = 0.001			
Grand Canyon	1	0/1	1.000	1.000
	2	1/14	0.929	0.385
	3	0/0	---	---
	MSP all stages = ---			
Topock	1	0/17.5	1.000	1.000
	2	2/85.5	0.977	0.737
	3	0/82	1.000	1.000
	MSP all stages = 0.737			
Bill Williams	1	1/9	0.889	0.781
	2	4/65	0.938	0.442
	3	1/39.5	0.975	0.704
	MSP all stages = 0.243			
TOTAL	1	5/90.5	0.945	0.887
	2	19/636	0.970	0.677
	3	8/410	0.980	0.764
	MSP all stages = 0.459			

* Mayfield survival probability was calculated using 2.10-day egg laying, 12.87-day incubation, and 13.68-day nestling stages.

[1] 1 = egg laying, 2 = incubation, 3 = nestling.

Table 4.6. Willow Flycatcher Nest Productivity (Young Fledged per Nest) and Fecundity (Young Fledged per Female) at the Four Life History Study Areas, Muddy River Delta, NV, and Grand Canyon and Bill Williams, AZ, 2007*

Study Area	# Young Fledged (# Nests)	Productivity Mean (SE)	Fecundity Mean (SE)
Pahranagat	23 (12)	1.92 (0.43)	2.30 (0.42)
Mesquite	15 (14)	1.07 (0.32)	1.25 (0.35)
Mormon Mesa	3 (11)	0.27 (0.14)	0.27 (0.14)
Muddy River	0 (6)	0.00 (0.00)	0.00 (0.00)
Grand Canyon	0 (1)	0.00 (0.00)	0.00 (0.00)
Topock	12 (8)	1.50 (0.46)	1.50 (0.46)
Bill Williams	3 (8)	0.38 (0.26)	0.43 (0.30)
Total	**56 (60)**	**0.93 (0.16)**	**0.98 (0.17)**

* Productivity calculations include nests that contained flycatcher eggs and had a known outcome.

DISCUSSION

In 2007, willow flycatcher nesting was documented at the four life history study areas, Muddy River Delta, lower Grand Canyon, and Bill Williams. The number of breeding pairs recorded at Bill Williams NWR in 2007 (7) was more than double the number observed in 2006 (3), while the number of breeding pairs at Topock Marsh in 2007 (8) was just over half the number observed in 2006 (14). Given that southwestern riparian ecosystems experience dynamic change and are not ecologically static (Periman and Kelly 2000), willow flycatcher occupancy and nesting are likely to be affected by changes in habitat suitability, with breeding flycatchers detected at a given site in one year and not in another.

NEST SUCCESS

In 2003–2006, Pahranagat exhibited the highest nest success of the four life history study areas. In 2007, however, nest success was highest at Topock Marsh (see Table 4.2 for nest success at study areas in 1996–2007). All nesting attempts were unsuccessful at Muddy River in 2007. Nest success at the remaining study areas continued to exhibit the yearly fluctuations seen since nest monitoring began in 1996. Nest success results again illustrate 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 further demonstrate the need for long-term data.

NEST FAILURE

As in 2003–2006, depredation was the major cause of willow flycatcher nest failure, accounting for 35% of all failed nests in 2007 (see Table 4.3). Depredation accounted for 25, 50, 22, 33, 0, 50, and 43% of all failed nests at Pahranagat, Mesquite, Mormon Mesa, Muddy River, Grand Canyon, Topock, and Bill Williams, respectively. These results are consistent with those reported at the life history study areas from 1998 to 2007 (McKernan and Braden 2002, Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007, Braden and McKernan unpubl. data) and at monitored sites across Arizona from 2000 to 2006 (Paradzick et al. 2001; Smith et al. 2002, 2003, 2004; Munzer et al. 2005; English et al. 2006; Graber et al. 2007), which indicate depredation as accounting for the majority of all willow flycatcher nest failures. Factors influencing the increases and decreases in nest depredation at the life history study areas are inherently complex and at this time remain undetermined. For open-cup nesting passerines, it has been shown that 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).

BROOD PARASITISM

Brood parasitism by Brown-headed Cowbirds across all study areas ranged from 0 to 36% and averaged 17% (see Table 4.1). These results are consistent with those reported at the study areas from 1998 to 2006 (McKernan and Braden 2002, Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007, Braden and McKernan, unpubl. data; see Table 5.3 in Chapter 5). These parasitism rates are higher than those reported at monitored sites across Arizona, which averaged 4, 5, 11, 2, 6, 7, and 13% in 2000, 2001, 2002, 2003, 2004, 2005, and 2006, respectively (Paradzick et al. 2001; Smith et al. 2002, 2003, 2004; Munzer et al. 2005; English et al. 2006; Graber et al. 2007). We observed the fifth consecutive year of no brood parasitism at Pahranagat. In addition, we observed no brood parasitism at Topock Marsh in 2007. This is the first time since monitoring began at Topock Marsh in 1997 that brood parasitism by Brown-headed Cowbirds was not observed. Cowbird trapping and removal studies were initiated at all the life history studies in 2003, and we discuss trends in brood parasitism rates in detail in Chapter 5.

We observed two 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). Therefore, it is also possible that some depredation events on eggs and nestlings are attributable to cowbirds. In addition, four nests were abandoned or deserted immediately after a cowbird egg was laid. Thus, cowbird brood parasitism negatively affects overall flycatcher productivity by multiple mechanisms, including interspecific nestling competition, depredation, and causing female flycatchers to expend energy renesting following parasitism events. Moreover, given that adult flycatchers exhibit high site fidelity to breeding areas (McKernan and Braden 2002, Koronkiewicz et al. 2004, this document) and renest most often after failed nests (Sedgwick 2000), females returning to sites with high brood parasitism are likely to reduce lifetime fecundity because they are expending energy on multiple failed nesting attempts over many years. In addition, willow flycatchers that fledge late in the season have been shown to have a lower survival rate than those that fledge early in the season (Paxton et al. 2007), suggesting additional hidden effects of parasitism and subsequent renesting on flycatcher demography. Cowbird impacts to flycatcher populations may therefore be more severe than parasitism rates alone suggest.

MAYFIELD NEST SUCCESS AND NEST PRODUCTIVITY

As presented in McLeod et al. (2005), calculating Mayfield survival probabilities (MSP) using slightly different average nest stage lengths results in MSP estimates that differ less than two percent. Thus, MSP comparisons between study areas or across years can be used to evaluate trends in nest success. Overall MSP (0.459) was higher than the overall MSP (0.383) reported at the life history study areas for 1997–2002 for the egg laying, incubation, and nestling stages (Braden and McKernan, unpubl. data). Overall MSP in 2007 was lower than in 2003 (0.556), and higher than in 2004 (0.436), 2005 (0.365), and 2006 (0.457).

MSP alone, however, 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 MSP. In addition, although every failed nest attempt lowers percent nest success and MSP, success of a subsequent nesting attempt may result in the same number of young produced as if the initial nesting attempt had been successful. Thus, nest productivity (young produced per nesting attempt) and fecundity (young produced per female), in conjunction with nest success, provide additional information on the success of a given breeding season. Fecundity in 2007 (0.98) did not differ significantly from that recorded in previous years ($F_{4,262} = 1.06$, $P = 0.38$).

CHAPTER 5

BROWN-HEADED COWBIRD TRAPPING

INTRODUCTION

In 2003, we initiated intensive Brown-headed Cowbird trapping at all the life history study areas and continued the same effort in 2004 and 2005. In 2006, we discontinued trapping at Mormon Mesa because logistical constraints prevented placement of traps within 400 m of breeding areas. From 1997 to 2002, willow flycatcher nest success and brood parasitism rates were documented at the life history study areas (McKernan and Braden 2002), with no cowbird trapping conducted in the proximity of the breeding sites except for one year of trapping at Topock Marsh in 1998 (White et al. 1998). In this study we compare willow flycatcher life history data under the influence of cowbird trapping (2003–2007) with data gathered at the life history study areas from 1997 to 2002 to determine if cowbird trapping and removal affects brood parasitism rates and willow flycatcher nest success and productivity.

METHODS

We conducted Brown-headed Cowbird trapping at Pahranagat, Mesquite, and Topock Marsh, following methods outlined in Griffith Wildlife Biology (1994). 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 2005, we experimented with two different trap designs: a flat-topped trap, which we had used in 2003 and 2004, and a trap with a funnel-shaped top. The traps with funnel-shaped tops captured significantly more cowbirds than the flat-topped traps (Koronkiewicz et al. 2006a), so in 2006 and 2007 all traps were of the funnel-topped design. The traps used in 2006 and 2007 were 1.8 m high, 1.8 m wide, and 2.4 m long, and had a funnel-shaped top (Figure 5.1). All panels consisted of 5 × 5–cm wood supports covered with 1.27-cm wire mesh and included a bottom panel. Each trap had a door located on one end. A piece of plywood, with two slots down the middle, was attached to the top of each trap for cowbird entry.

The width of the entrance slot in cowbird traps varies from project to project, ranging from 3.1 cm (1.2 inches) to 4.4 cm (1.7 inches) (Reclamation 2004). The Texas Parks and Wildlife Department (n.d.) emphasizes the importance of using a 3.2-cm (1.25-inch) slot, while Griffith Wildlife Biology (2001) recommends a 3.5-cm (1.38-inch) slot. In 2006 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. We repeated the experiment at Topock in 2007. Each year, three of the six traps at Topock had 3.8-cm-wide slots and three had 3.2-cm-wide slots.

The slot size on each trap was exchanged half way through the season to control for location effects when evaluating trapping success of the different slot sizes.

Figure 5.1. Brown-headed Cowbird trap design used at life history study areas, 2007.

Signs were posted on each trap door 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 LOCATION

We operated two traps at Pahranagat, three at Mesquite, and six at Topock. Traps at Pahranagat and Topock remained in essentially the same locations used in 2006. One trap that had been on the west side of Mesquite East in 2006 was moved approximately 250 meters east of its previous location because the previous location had become overgrown (Figures 5.2–5.4). The number of traps set in each life history study area was determined by landscape characteristics and area of the site. Each trap had an effective trapping radius of 0.4 km (John Griffith, GWB, pers. comm., March 2002), and we deployed as many traps as needed at each site such that previously known areas of occupied willow flycatcher habitat were under the influence of trapping, within the limitations imposed by vegetation, hydrology, and landownership. Reclamation biologists approved trap numbers and locations.

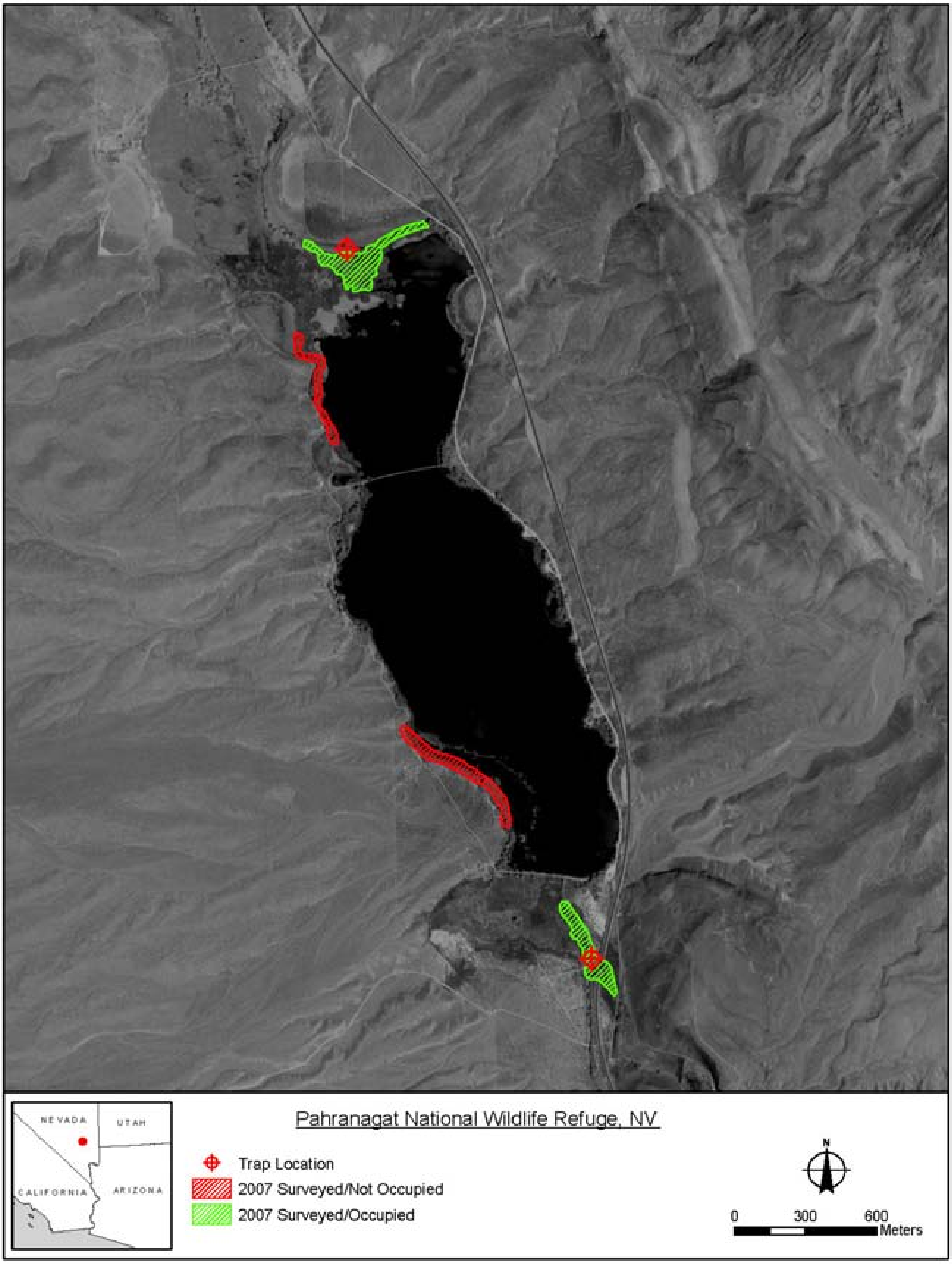

Figure 5.2. Cowbird trap locations at Pahranagat NWR, NV, 2007.

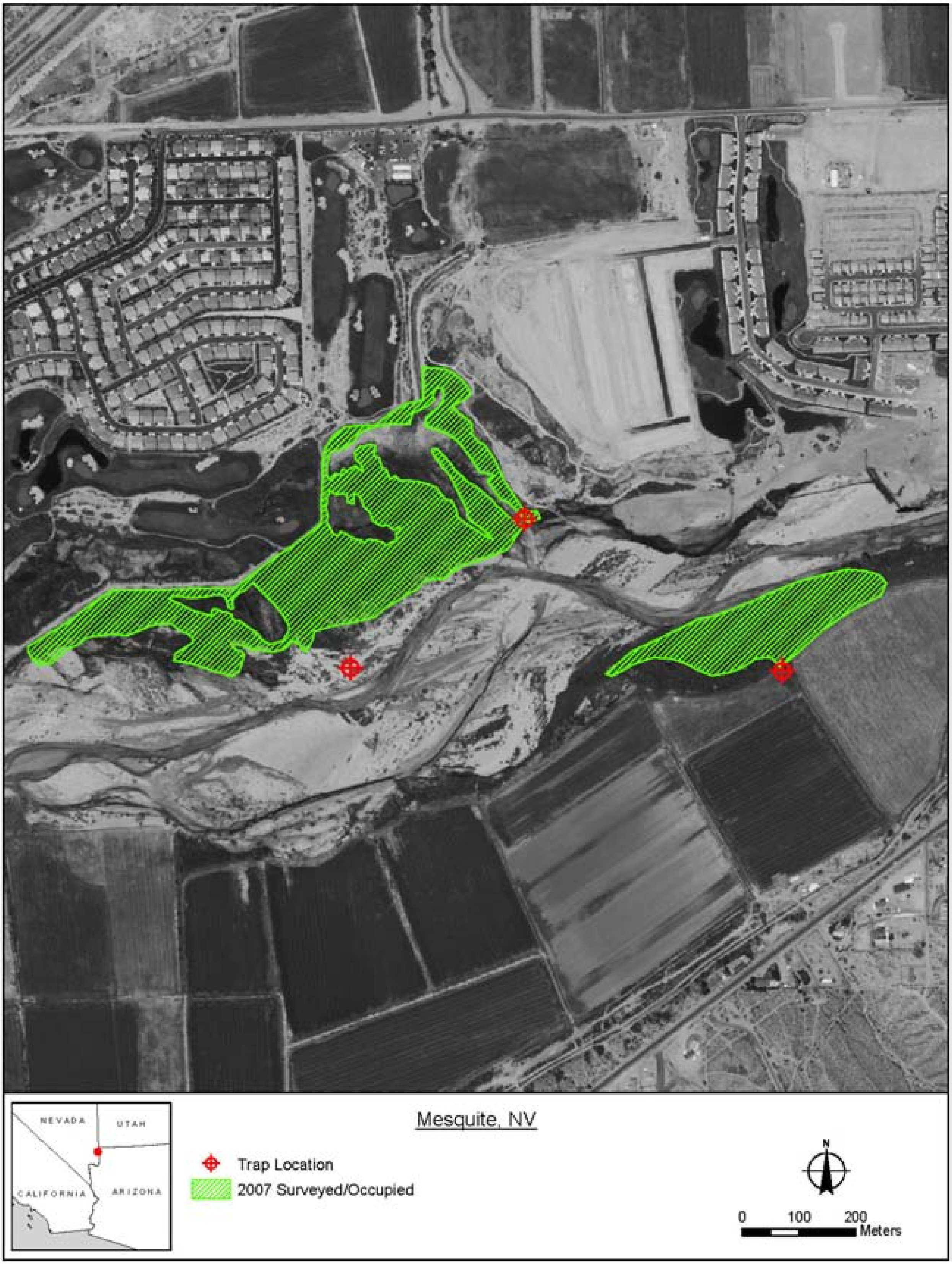

Figure 5.3. Cowbird trap locations at Mesquite, NV, 2007.

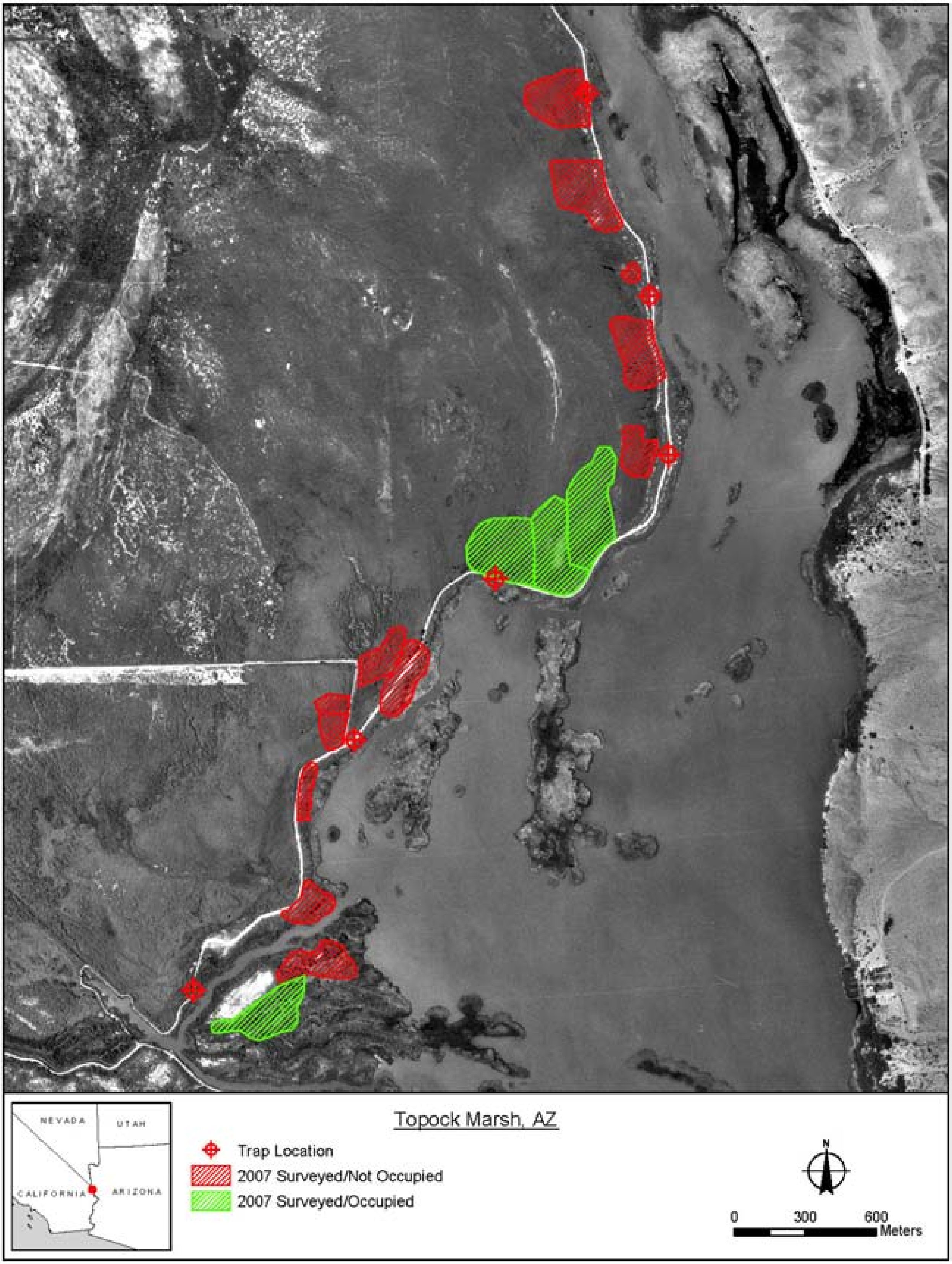

Figure 5.4. Cowbird trap locations at Topock Marsh, AZ, 2007.

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 (Appendix A). Each day we recorded the number, sex, and age of newly trapped cowbirds, and replaced existing bait birds with newly trapped cowbirds if necessary. We clipped the wings of all bait birds 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 daily, placed in a small holding cage, and euthanized using carbon monoxide. Cowbird carcasses were frozen and donated to feed captive raptors.

NON-TARGET BANDING

In 2006, many captures of non-target species were recorded in cowbird traps. A number of these captures were the same individuals, identifiable from distinct markings or injuries, returning to the traps multiple times, but we did not have data to quantify the proportion of captures that were returning individuals. Therefore, in 2007, we initiated a non-target banding program to identify individuals and determine how many captures were multiple captures of the same individual(s). Upon entering a trap, field personnel banded and released any non-target birds, recording the federal band number, species, and, when possible, sex and age. Recaptured individuals were released after their federal band number was recorded. Any injuries or mortalities were also noted.

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.

Analysis of trap design – We used a one-way ANOVA to compare capture rates (number of cowbirds captured per trap-day) and escape rates (number of cowbirds reported to have escaped per trap-day) of the two slot widths at Topock.

Analysis of brood parasitism rates: pre-trapping vs. trapping periods – Percent brood parasitism at each of the life history study areas during the pretrapping period (1997–2002) and trapping period (2003–2007) were compared using one-way ANOVA. Data from 1998 at Topock were excluded from the analysis.

RESULTS

TRAP OPERATION

We operated cowbird traps at Pahranagat, Mesquite, and Topock (see Figures 5.2–5.4) from 16 May to 29 July, 16 May to 7 August, and 5 May to 31 July, respectively, for a total of 146, 247, and 474 trap-days at each study area.

BROWN-HEADED COWBIRD TRAPPING

We captured and removed 104, 71, and 173 Brown-headed Cowbirds at Pahranagat, Mesquite, and Topock, respectively (Table 5.1).

Table 5.1. Summary of Brown-headed Cowbirds Trapped and Removed at Pahranagat NWR, Mesquite, NV, and Topock Marsh, AZ, 2007

Study Area	Trap #	# Males	# Females	# Juveniles	Total # Brown-headed Cowbirds
Pahranagat	1	11	8	1	20
	2	44	40	0	84
	Total	**55**	**48**	**1**	**104**
Mesquite	1	14	14	1	29
	2	24	13	0	37
	3	3	2	0	5
	Total	**41**	**29**	**1**	**71**
Topock	1	25	22	0	47
	2	9	3	0	12
	3	15	21	0	36
	4	9	10	2	21
	5	10	12	0	22
	6	20	14	1	35
	Total	**88**	**82**	**3**	**173**

TRAP DESIGN

Overall, traps with the wider slots had a daily capture rate of 0.49 cowbirds per trap-day, while the narrow slots captured 0.39 cowbirds per trap-day ($F_{1, 474} = 0.87$, $P = 0.35$). The escape rate of cowbirds did not differ significantly ($F_{1, 526} = 0.16$, $P = 0.33$) between the wide slots (0.03 cowbirds per trap-day) and the narrow slots (0.04 cowbirds per trap-day).

BROOD PARASITISM RATES

The proportion of flycatcher nests parasitized during the pretrapping (1997–2002) and trapping (2003–2007) periods shows no significant difference at Mesquite (P = 0.80), Mormon Mesa (P = 0.239), and Topock (P = 0.555) (Table 5.2). Parasitism rates at Pahranagat were significantly lower during the trapping than pre-trapping period (P = 0.023), with the fifth consecutive year of no brood parasitism recorded in 2007. No brood parasitism was recorded at Topock in 2007. At Mesquite, brood parasitism rates remained substantial, with 40.0% recorded in 2007.

Table 5.2. Brown-Headed Cowbird Brood Parasitism Rates at the Four Life History Study Areas, 1997–2007*

	Year	Pahranagat	Mesquite[1]	Mormon Mesa[2]	Topock
Pre-trapping periods	1997	nm[3]	60.0% (5)	18.8% (16)	11.1% (9)
	1998	0.0% (19)	57.1% (7)	15.4% (13)	28.6% (21)[4]
	1999	12.5% (16)	nd[5]	0.0% (12)	30.0% (20)
	2000	14.3% (21)	22.2% (9)	25.0% (16)	16.7% (18)
	2001	14.8% (27)	15.8% (19)	20.0% (20)	25.0% (20)
	2002	33.3% (21)	31.6% (19)	0.0% (10)	16.7% (12)
Trapping periods	2003	0.0% (11)	21.0% (19)[6]	16.7% (12)[7]	18.2% (11)
	2004	0.0% (11)	45.0%(20)	28.6% (7)	31.7% (41)
	2005	0.0% (19)	28.6% (7)	16.7% (6)[8]	51.4% (37)
	2006	0.0% (14)	23.8% (21)	0.0% (8)[9]	31.2% (16)
	2007	0.0% (10)	40.0% (15)	16.7% (12)[10]	0.0% (8)
% parasitism pretrapping periods (SE)		14.9% (5.3)	37.3% (9.0)	13.2% (4.4)	21.4% (3.1)
% parasitism trapping periods (SE)		0.0% (0.0)	34.4% (4.9)	28.6%	26.5% (8.5)

[*] Total number of nests is indicated in parentheses for each year. In Koronkiewicz et al. (2004) and McLeod et al. (2005) total number of nests included only nests that contained at least one flycatcher egg. These numbers have been revised here to include all parasitized nests. Data for pre-trapping periods (1997–2002) are from McKernan and Braden (2002) and Braden and McKernan (unpubl. data); data for trapping periods (2003–2007) are from Koronkiewicz et al. (2004), McLeod et al. (2005), Koronkiewicz et al. (2006a), McLeod et al. (2007), and this document. Total number of nests for 2003–2007 includes nests for which contents could be determined.

[1] Study area includes Mesquite East in 1997–1999 and Mesquite West in 2000–2007. Bunker Farm is not included.

[2] Study area included Virgin River Delta sites in 1997–2004.

[3] Study area not monitored.

[4] A total of 232 cowbirds were trapped and removed from the local population in 1998 at Topock (White et al. 1998).

[5] Study area monitored, no breeding documented.

[6] Brood parasitism rate at Mesquite in 2003 was not used in calculating mean percent parasitism during trapping periods because the low number of cowbirds removed from the site (4 males, 2 juveniles) would likely have little effect on parasitism rate.

[7] Brood parasitism rate at Mormon Mesa in 2003 was not used in calculating mean percent parasitism during trapping periods because the low number of cowbirds removed from the site (3 males) would likely have little effect on parasitism rate.

[8] Brood parasitism rate at Mormon Mesa in 2005 was not used in calculating mean percent parasitism during trapping periods because logistical constraints precluded deployment and operation of traps within 400 m of nesting flycatchers.

[9] Brood parasitism rate at Mormon Mesa in 2006 was not used in calculating mean percent parasitism during trapping periods because no trapping occurred at Mormon Mesa in 2006.

[10] Brood parasitism rate at Mormon Mesa in 2007 was not used in calculating mean percent parasitism during trapping periods because no trapping occurred at Mormon Mesa in 2007.

NON-TARGET SPECIES

Fifteen non-target species were captured and identified at all life history study areas during cowbird trapping (Table 5.3). Non-target species captures included Abert's Towhee (*Pipilo aberti*), Bronzed Cowbird (*Molothrus aeneus*), Bullock's Oriole (*Icterus bullockii)*, Canyon Wren (*Catherpes mexicanus*), Common Yellowthroat (*Geothlypis trichas*), Gray Catbird (*Dumetella carolinensis*), Great-tailed Grackle (*Quiscalus mexicanus*), House Finch (*Carpodacus mexicanus*), Ladder-backed Woodpecker (*Picoides scalaris*), Lark Sparrow (*Chondestes grammacus*), Mourning Dove (*Zenaida macroura*), Northern Mockingbird (*Mimus polyglottos*), Red-winged Blackbird (*Agelaius phoeniceus*), Song Sparrow (*Melospiza melodia*), and White-winged Dove (*Zenaida asiatica*). Abert's Towhee and House Finch accounted for the vast majority of captures. A total of 215 non-target captures were recorded at Pahranagat, Mesquite, and Topock. Mortalities consisted of two Abert's Towhees and four House Finches. Injuries to one Abert's Towhee, one Common Yellowthroat, and three House Finches were also noted (see Table 5.3).

We banded 72 non-target individuals. Fifty-one (24%) of the 215 non-target captures were recaptures of banded birds. At Topock, one Abert's Towhee was captured 34 times and accounted for 85% of all Abert's Towhee captures at the study area. A single Bronzed Cowbird was captured seven times, and was the only individual of the species recorded in the cowbird traps at Topock. The same pattern of birds returning to the traps multiple times was also seen at Mesquite, where 50% of Abert's Towhee captures were recaptures. Based on recapture data for banded non-target birds, we calculated a minimum and maximum number of individuals captured for each species (Table 5.4). The minimum and maximum numbers of captured non-target individuals of all species were 108 and 164, respectively.

Table 5.3. Summary of Non-target Species Captured during Brown-headed Cowbird Trapping, 2007*

Species	Pahranagat				Mesquite				Topock			
	Instance	Occurrence	Injured	Died	Instance	Occurrence	Injured	Died	Instance	Occurrence	Injured	Died
Abert's Towhee	-	-	-	-	15	16	1[a]	2	39	40	-	-
Bronzed Cowbird	-	-	-	-	-	-	-	-	7	7	-	-
Bullock's Oriole	-	-	-	-	-	-	-	-	1	1	-	-
Canyon Wren	-	-	-	-	1	1	-	-	-	-	-	-
Common Yellowthroat	1	1	1[b]	-	-	-	-	-	-	-	-	-
Gray Catbird	-	-	-	-	1	1	-	-	-	-	-	-
Great-tailed Grackle	-	-	-	-	-	-	-	-	1	1	-	-
House Finch	2	3	1[c]	-	10	26	-	3	27	105	2[d,e]	1
Ladder-backed Woodpecker	1	1	-	-	-	-	-	-	-	-	-	-
Lark Sparrow	1	3	-	-	-	-	-	-	-	-	-	-
Mourning Dove	-	-	-	-	2	3	-	-	-	-	-	-
Northern Mockingbird	-	-	-	-	-	-	-	-	1	1	-	-
Red-winged Blackbird	-	-	-	-	1	2	-	-	-	-	-	-
Song Sparrow	-	-	-	-	-	-	-	-	1	1	-	-
White-winged Dove	-	-	-	-	-	-	-	-	2	2	-	-

* Data are presented as the number of capture instances (number of trap-days that resulted in capture of the species) and capture occurrences (number of individuals of a species captured each day summed over all days).

[a] Cut above bill.

[b] Missing feathers and bloody around base of bill.

[c] Missing left leg and eye.

[d] No skin under left wing.

[e] Eye injury.

Table 5.4. Summary of Non-target Species Banded during Brown-headed Cowbird Trapping, 2007

Species	Pahranagat					Mesquite					Topock				
	Total captures	Number banded	Recap-tures	Min. # captured[1]	Max. # captured	Total captures	Number banded	Recap-tures	Min. # captured[1]	Max. # captured	Total captures	Number banded	Recap-tures	Min. # captured[1]	Max. # captured
Abert's Towhee	-	-	-	-	-	16	5	8	8	8	40	1	33	3	7
Bronzed Cowbird	-	-	-	-	-	-	-	-	-	-	7	1	6	1	1
Bullock's Oriole	-	-	-	-	-	-	-	-	-	-	1	1	0	1	1
Canyon Wren	-	-	-	-	-	1	-	-	1	1	-	-	-	-	-
Common Yellowthroat	1	1	0	1	1	-	-	-	-	-	-	-	-	-	-
Gray Catbird	-	-	-	-	-	1	-	-	1	1	-	-	-	-	-
Great-tailed Grackle	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1
House Finch	3	1	0	3	3	26	18	3	23	23	105	39	1	54	104
Ladder-backed Woodpecker	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Lark Sparrow	3	3	0	3	3	-	-	-	-	-	-	-	-	-	-
Mourning Dove	-	-	-	-	-	3	-	-	2	3	-	-	-	-	-
Northern Mockingbird	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1
Red-winged Blackbird	-	-	-	-	-	2	2	0	2	2	-	-	-	-	-
Song Sparrow	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1
White-winged Dove	-	-	-	-	-	-	-	-	-	-	2	-	-	1	2

[1] Minimum number captured was calculated from the dates and numbers of banded and unbanded captures and known mortalities and injuries

TRAP DESIGN

We examined the non-target capture data from Topock to determine whether the two slot widths had different capture rates for non-target species (Table 5.5). The traps with wider slots had a daily capture rate of 0.31 non-targets per trap-day, while the traps with narrow slots captured 0.34 non-target birds per trap-day ($F_{1,474}$ = 0.04, P = 0.84). Though there was no significant difference in the number of non-targets captured due to slot width, the traps with wider slots had a tendency toward more occurrences of large species (Great-tailed Grackle, Northern Mockingbird, White-winged Dove) than traps with narrow slots.

Table 5.5. Non-target Species Captured during Brown-headed Cowbird Trapping in Traps with Wide and Narrow Slots, Topock, 2007

Species	Narrow slot				Wide slot			
	Instance	Occurrence	Injured	Died	Instance	Occurrence	Injured	Died
Abert's Towhee	28	28	-	-	11	12	-	-
Bronzed Cowbird	4	4	-	-	3	3	-	-
Bullock's Oriole	1	1	-	-	-	-	-	-
Great-tailed Grackle	-	-	-	-	1	1	-	-
House Finch	12	48	-	-	15	57	2	1
Northern Mockingbird	-	-	-	-	1	1	-	-
Song Sparrow	-	-	-	-	1	1	-	-
White-winged Dove	-	-	-	-	2	2	-	-

DISCUSSION

Brown-headed cowbird management issues are complicated, particularly because it is still unclear how brood parasitism rates affect willow flycatcher population sizes (Rothstein et al. 2003). The frequency of cowbird brood parasitism of 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). 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, Koronkiewicz et al. 2006a).

Because traps could not be deployed close enough to the flycatcher breeding habitat at the Mormon Mesa study area, trapping was not conducted there in 2007. The effectiveness of other cowbird control measures (e.g., shooting) in lowering parasitism rates should be evaluated for sites where parasitism is a concern and trapping is impractical.

A comparison of the proportion of flycatcher nests parasitized during the pretrapping (1997–2002) and trapping (2003–2007) periods showed a statistical difference only at Pahranagat, where we documented the fifth consecutive year of no brood parasitism. It is likely cowbird trapping at Pahranagat has lowered flycatcher brood parasitism, with the landscape characteristics of the site facilitating the efficacy of trapping. The trapping area at Pahranagat consists of small, relatively isolated patches of mature riparian forest, and cowbird immigration to the site probably occurs at a relatively low rate. The trapping areas at Mesquite and Topock are part of larger, contiguous riparian corridors, and cowbirds that are removed by trapping are likely quickly replaced by other individuals (L. White, pers. comm.).

In 2006, we found that cowbird traps with wider slots captured significantly more cowbirds per trap-day than those with narrower slots. The same trend was observed in 2007, though it was not statistically significant. The escape rate of captured cowbirds did not differ significantly between the wide and narrow slots in either year. Therefore, to maximize the capture rates of cowbirds, traps should have slots 3.8 cm rather than 3.2 cm wide. We have not evaluated the efficacy of slots wider than 3.8 cm.

Fifteen non-target species were captured at Pahranagat, Mesquite, and Topock during cowbird trapping in 2007. This number compared to 8 non-target species captured in each year in 2003 and 2004, 14 in 2005, and 16 in 2006. The greater variety of non-target species captured in 2005–2007 is likely the result of use of the funnel-topped traps. Comparison of the number of non-target captures for wide and narrow slots showed no difference between the two slot sizes. However, traps with wide slots captured larger species of non-target individuals (e.g., Great-tailed Grackle, Mourning Dove, White-winged Dove).

Though we were able to band many of the non-target birds captured in the cowbird traps, some individuals were released unbanded. House finches, which tend to be captured in large flocks and were sometimes released unbanded to avoid causing heat stress, accounted for the vast majority (50 individuals) of the discrepancy between the minimum known individuals and the maximum possible individuals. Because the same unbanded individual(s) may be captured and released on multiple days, the total number of individuals of each species captured cannot be determined when there are multiple capture instances of unbanded birds. Given that many birds were released unbanded and the tendency for birds to return to the traps multiple times, it is likely that there were instances of recaptures of unbanded birds. Therefore, the proportion of non-target recaptures is likely higher than 24%, and the reported numbers of captured non-targets on projects where banding does not occur are likely inflated from the true number of captures.

The capture of non-target species is of concern but has been found to be unavoidable. Species other than cowbirds have higher mortality rates in traps and may incur reduced breeding success because of time spent away from the nest (Rothstein et al. 2003). This emphasizes the need to check traps every 24 hours as specified in the above methods.

CHAPTER 6

VEGETATION AND HABITAT CHARACTERISTICS

INTRODUCTION

During the 2007 field season, we measured vegetation and habitat characteristics at plots located throughout the four life history study areas to obtain an overall description of the whole habitat block. We measured vegetation and habitat characteristics in Southwestern Willow Flycatcher nest, within-territory, and non-use plots at the four life history study areas and at Muddy River Delta. We also measured vegetation and habitat characteristics at flycatcher nest sites at Bill Williams. Field methods at each sampling plot were identical in 2007 to those used in 2003–2006. Our specific objectives for vegetation sampling are 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. Vegetation data collected in 2003–2007 will be analyzed in conjunction with microclimate data (see Chapter 7) obtained during the same period to contribute to an understanding of the interaction of vegetation and microclimate characteristics in Southwestern Willow Flycatcher breeding habitat. These results will be presented in a five-year report summarizing findings from 2003 to 2007.

METHODS

At each of the four life history study areas, we described and measured vegetation and habitat features following a modification of the methods of James and Shugart (1970). These methods were developed over several seasons by the Arizona Game and Fish Department (see data form, Appendix A). All vegetation characteristics were measured within an 11.3-m-radius (0.04 ha) circle. A plot this size centered on a nest is likely to be sufficient to describe variability within a flycatcher territory without measuring areas outside the territory (Sedgwick and Knopf 1992). We also chose a distance of 30 m from plot centers to record presence or absence of certain habitat features. An area of this size (0.28 ha) should represent an unbiased characterization of willow flycatcher habitat selection given that it encompasses approximately 25–50% of the home range of a breeding willow flycatcher (Paxton et al. 2003, Sedgwick 2000). To avoid disrupting flycatcher breeding activities, we measured vegetation late in the summer when the nest, territory, and adjacent flycatcher territories were inactive.

We measured habitat characteristics at 30 plots throughout each of the four life history study areas to obtain a description of the overall characteristics and the variability of habitat characteristics within the habitat block. We considered the habitat block to include all riparian areas that were potential nesting habitat or use areas (e.g., foraging, roosting, feeding young) for willow flycatchers. At Pahranagat, these areas were contiguous with habitat that was occupied in 2007, while at Mesquite, Mormon Mesa, and Topock, portions of the habitat block were separated from occupied habitat by roads, open water, dry washes, marshes, agricultural areas, or dead vegetation. All life history study areas in 2007 consisted of several sites, and the number of plots measured in each site was proportional to the area of the site in relation to the total area of all sites in the study area to obtain a representative sampling of the habitat. Nest, within-territory, and non-use plots (see below) were included in the habitat block measurements as long as they did not overlap with an adjacent plot and did not result in disproportionate representation of a site.

Plot center locations for habitat block points were selected by superimposing a 25 × 25–m grid on an ArcGIS 9.1 software shapefile of the study area boundary, numbering the grid blocks, selecting blocks by using a random number generator, and using the centroid of each selected block. Plot centers were located in the field by navigating to the given coordinates using a Rino 110 GPS unit.

At each plot, we laid out four 11.3-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 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 tallied 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 7.5 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). We measured total canopy and sub-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 11.3-m 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 measured the distance, if less than 30 m, from plot center to the nearest native broadleaf tree (e.g., cottonwood, willow, or mesquite); canopy gap (at least 1-m square); and standing water or saturated soil. Distances >30 m were either measured in the field using GPS or were estimated, when possible, using ArcMap and high-resolution aerial photographs. For distances that were >30 m that could not be estimated using ArcMap (e.g., distance to canopy gap), distance was recorded as >30 m.

We estimated percent woody ground cover, alive and dead, 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 shrub and sapling stems for each species, by quadrant, within 5 m of the center of the plot and summed all species over all quadrants to obtain the total stem count for each plot. Shrub and sapling stems were tallied if they were at least 1.4-m tall and >2.5 cm in diameter at 10 cm above the ground. If a stem branched above 10 cm but below 1.4 m above the ground, only the largest stem was tallied. Stems were tallied by the following diameter at breast height (dbh) categories: <1 cm, 1–2.5 cm, 2.6–5.5 cm, and 5.6–8 cm. Dead stems were also tallied in these categories, but not identified to species. We tallied live trees (defined as dbh >8 cm) by species, in each quadrant of the 5-m-radius circle, in 8.1–10.5 cm and 10.5–15 cm dbh categories. Any trees greater than 15 cm dbh were measured and the exact dbh was recorded. Snags were also recorded in these categories, but not identified to species. Within each quadrant between 5 and 11.3 m of plot center, we tallied live trees >8 cm dbh by species but did not separate trees into size categories. Snags >8 cm dbh were also tallied, and tallies for each species and quadrant were summed to obtain a total tree count for the plot.

Additional information recorded at each plot included the date when the measurements were taken, observer initials, and UTM coordinates for each plot center.

We recorded these habitat and vegetation characteristics at each willow flycatcher nest located at the life history study areas, Muddy River, and Bill Williams during the 2007 breeding season, including renests by the same female, in which at least one flycatcher egg had been laid. In addition to the variables described above, we recorded nest height and substrate species, dbh of substrate species, and height of the nesting substrate. Distance to standing water or saturated soil was also measured at the time the nest was found.

All habitat characteristics, excluding those specific to the nest, were also measured at within-territory plots located at a randomly selected distance 5–10 m from the nest in a randomly selected compass direction. We sampled approximately 10 within-territory locations at each life history study area and Muddy River to investigate any differences between nest and non-nest locations within the nest stand. If more than 10 within-territory locations had been designated in a study area for microclimate sampling (see Chapter 7), the 10 sites used for vegetation sampling were randomly selected from all the within-territory locations in the study area.

We also measured habitat characteristics at non-use plots located 50–200 m from any willow flycatcher nest or territory center. In 2007, non-use plot locations were established and distance to water was measured when the corresponding nest was determined to contain flycatcher eggs. We sampled one non-use plot for each willow flycatcher nest in which at least one flycatcher egg was laid at the four life history sites and Muddy River. Each non-use plot was surveyed multiple times throughout the season to confirm the absence of flycatchers. Non-use plot locations were randomly selected by superimposing a 25 × 25–m grid over an ArcGIS 9.1 software shapefile of the study area boundaries, including nest and territory locations, and clipping the grid to include areas between 50 and 200 m of known nests or territories, and within the study area boundaries. Each grid square was numbered, and grid squares were chosen using a random number generator. The centroid of each selected grid was the target location for the non-use plots. Non-use plots were located in the field by navigating to the given coordinates using a Rino 110 GPS unit and selecting the nearest woody plant at least 3-m tall. The plot was centered at a distance and direction from the bole of the tree determined by random number tables. Because randomly chosen non-use plots in clearly unsuitable habitat (e.g., desertscrub or open cattail or bulrush marsh) would have exaggerated differences between nesting and non-use plots, we only used non-use plots that contained at least one live, woody stem a minimum of 3 m in height (approximate average nest height in 2003–2007), per Allison et al. (2003).

DATA ANALYSES

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. Data presented are means ± standard error (SE) unless otherwise stated.

Analyses of habitat blocks – Canopy closure, canopy height, percent woody ground cover, and total stem counts at habitat block plots were compared across study areas using one-way analysis of variance (ANOVA). If differences across study areas were indicated by the ANOVA, we used Tukey's multiple comparison test to determine which study areas differed.

Measures of distance to canopy gap contained both continuous and categorical (>30 m) data. If less than 5% of the measurements for a given variable were categorical, we converted all >30 m measurements to 31 m and analyzed distance using ANOVA. If greater than 5% of the measurements were categorical, we categorized all data as ≤30 m or >30 m and analyzed the data across sites using 4 × 2 contingency tables. If differences were indicated across sites, we used Tukey's multiple comparison test or 2 × 2 contingency tables to determine which sites differed.

Vertical foliage density data in each habitat block were summarized graphically, but we did not make between-site comparisons. Vertical foliage density measurements above 7.5 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.

Analyses of nest characteristics – Characteristics specific to the nest (nest height, nest substrate height, and nest substrate dbh) were compared between study areas using ANOVA and Tukey's multiple comparison test.

Analyses of nest vs. within-territory vs. non-use sites – Canopy closure, canopy height, percent woody ground cover, distance to water, total stem counts, and vertical foliage density within each meter interval were compared between nest, within-territory, and non-use sites at each study area using one-way ANOVA and Tukey's multiple comparison test. Distance to canopy gap was analyzed as described above. We did not pool data across study areas because of significant differences in many variables between study areas.

RESULTS

We gathered data at 55 habitat block plots at the life history study areas. At the four life history study areas, Muddy River, and Bill Williams, we gathered data on vegetation and habitat characteristics at 59 nest plots, 45 within-territory plots, and 50 non-use plots.

VEGETATION MEASUREMENTS OF ENTIRE HABITAT BLOCKS

Quantitative measurements of vegetation and habitat characteristics across habitat blocks at the four life history study areas varied between sites in canopy height, percent woody ground cover, distance to water or saturated soil, distance to canopy gap, distance to nearest broadleaf, and number of shrub/sapling and tree stems (Table 6.1). All sites had the densest foliage within 4 m of the ground (Figures 6.1–6.4).

Table 6.1. Summary of Vegetation and Habitat Characteristics of Entire Habitat Blocks at the Four Life History Study Areas, 2007*

Parameter	Pahranagat (n = 28)	Mesquite (n = 30)	Mormon Mesa (n = 30)	Topock (n = 30)
Average canopy height (m)	19.0 (1.5) 4.1-35.0 A	5.1 (0.3) 2.7–11.0 B	4.5 (0.3) 1.0-9.5 B	6.1 (0.3) 3.0-10.0 B
% total canopy closure	83.2 (3.0) 40.0-99.0 A	79.6 (3.4) 24.0-98.0 A	86.4 (2.0) 40.0-97.0 A	76.9 (5.0) 10.0-97.0 A
% woody ground cover	77.2 (4.6) 5.0–100.0 A	40.9 (4.6) 2.0-88.0 B	31.1 (3.6) 2.0-90.0 B	26.4 (4.7) 0.0-100.0 B
Distance (m) to nearest standing water or saturated soil	43.2 (8.0) 0.0–128.0 A	35.2 (8.1) 0.0–180.0 A	244.6 (48.4) 2.0-1305.0 B	71.3 (14.1) 0.0-315.0 A
Distance (m) to nearest canopy gap	6.6 (0.7) 1.0-16.5 A,B	4.3 (0.6) 0.0–12.0 B	4.8 (0.8) 0.0–20.0 B	17.0 (6.1) 0.0–150.0 A
Distance (m) to nearest broadleaf tree	1.2 (0.4) 0.0–6.8 A	7.3 (2.6) 0.0–55.0 A,B	23.2 (7.0) 0.0-160.0 B,C	37.0 (7.2) 0.0–148.8 C
# shrub/sapling stems within 5-m radius of plot center	6.9 (4.4) 0-119 A	106.0 (11.4) 21-259 B	106.7 (7.6) 30-227 B	97.4 (10.0) 19-274 B
# tree stems within 11.3-m radius of plot center	11.9 (2.4) 2-66 A	5.3 (1.4) 0–28 A	6.7 (1.5) 0–29 A	24.8 (3.7) 0–74 B

* Data presented for continuous variables are means, (standard error), and range. Significant differences (Tukey's test, α=0.05) between sites for a given continuous variable are indicated by alpha codes; sites with different letters differed from one another, while sites with the same letter did not.

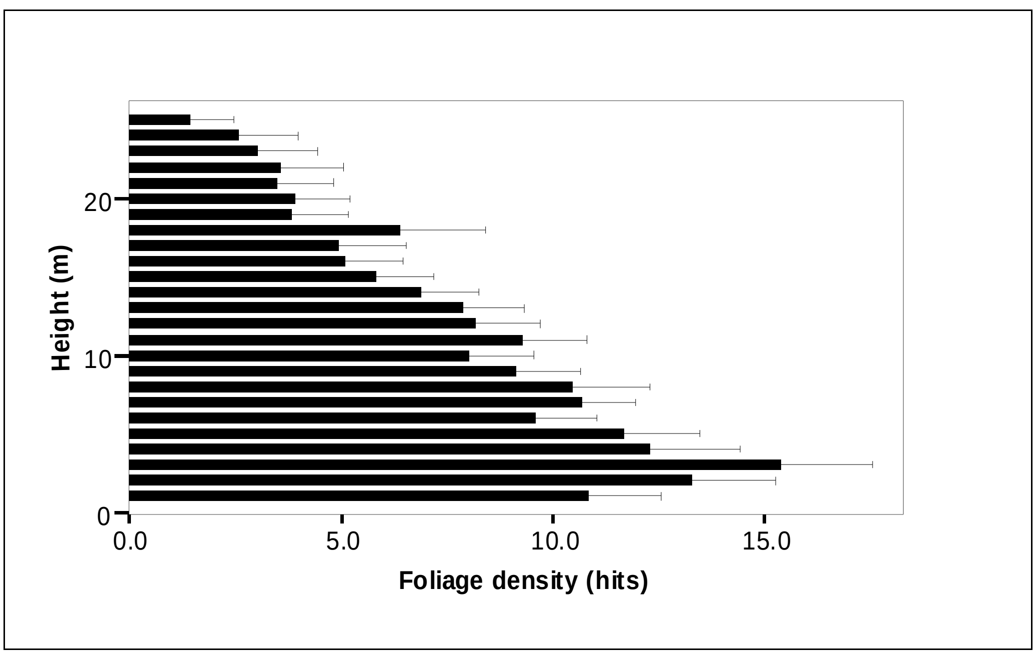

Figure 6.1. Vertical foliage density at habitat block points, Pahranagat NWR, NV, 2007. Values shown are mean and standard error of hits per meter interval.

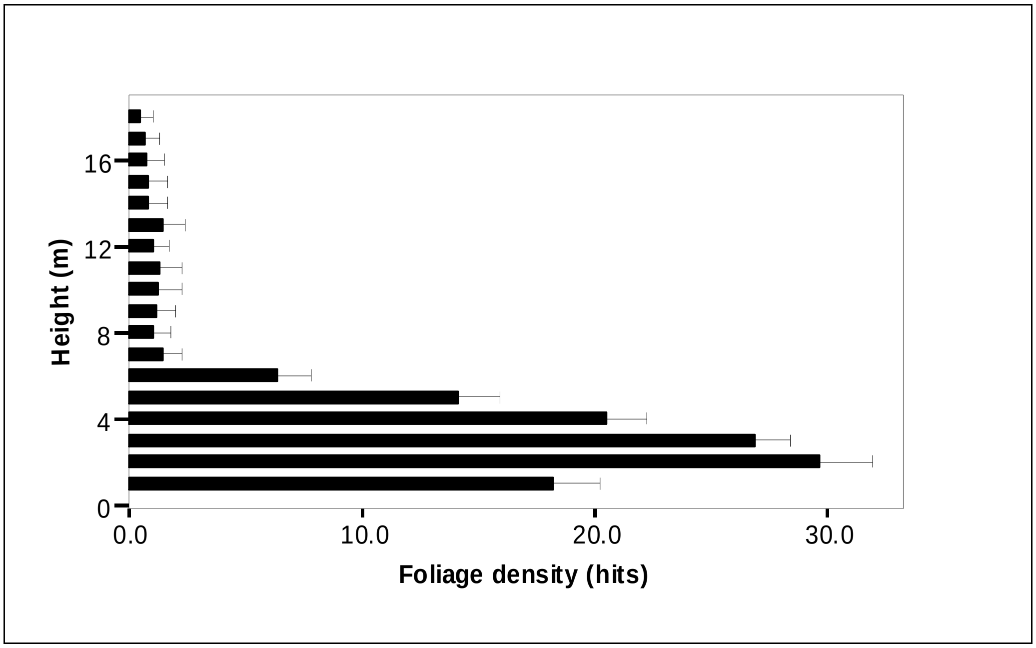

Figure 6.2. Vertical foliage density habitat block points, Mesquite, NV, 2007. Values shown are mean and standard error of hits per meter interval.

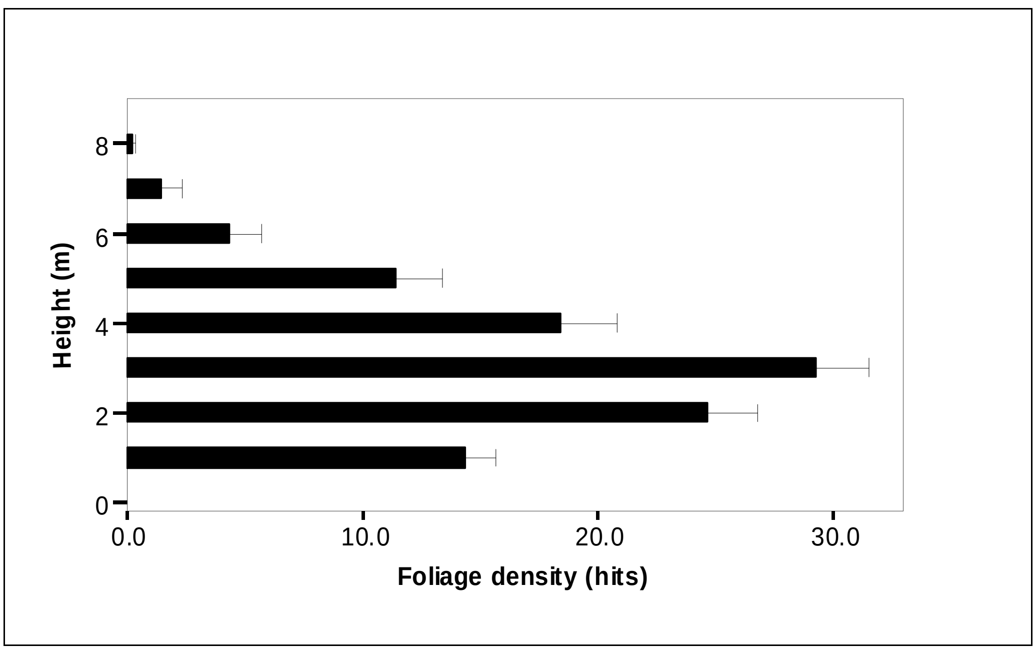

Figure 6.3. Vertical foliage density at habitat block points, Mormon Mesa, NV, 2007. Values shown are mean and standard error of hits per meter interval.

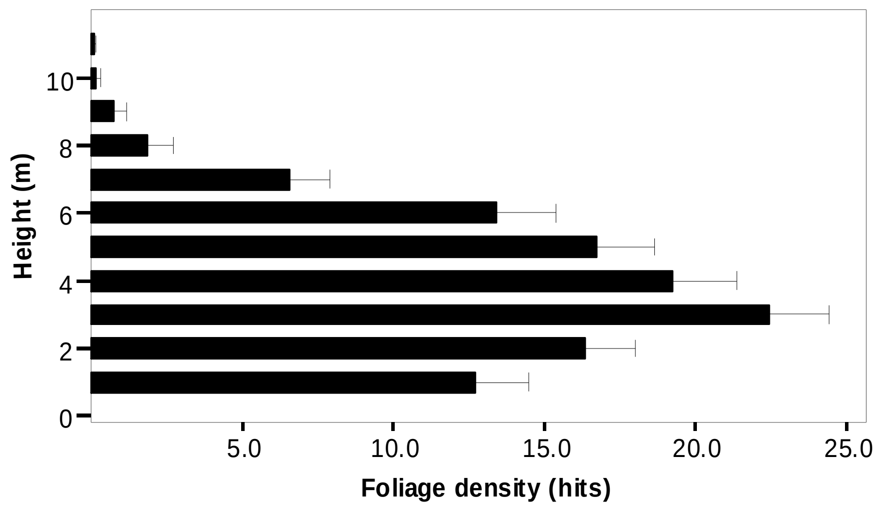

Figure 6.4. Vertical foliage density at habitat block points, Topock Marsh, AZ, 2007. Values shown are mean and standard error of hits per meter interval.

VEGETATION MEASUREMENTS AT THE NEST

Willow flycatcher nest height at the four life history study areas, Muddy River Delta, and Bill Williams ranged from 1.5 to 7.6 m, with a mean nest height of 3.3 m (SE = 0.2). Nest substrate included three woody species of trees, two native and one exotic, as well as dead trees. Flycatchers placed 63% of all nests at the study areas in tamarisk, 7% in coyote willow, 29% in Goodding willow, and 2% in snags. Nest substrate height at all sites ranged from 2.3 to 20.9 m, with a mean nest substrate height of 6.6 m (SE = 0.6). Nest substrate dbh was highly variable, ranging from 1.0 to 235.0 cm, with a mean nest substrate dbh of 17.0 cm (SE = 4.5). Nest height at Bill Williams was higher than at Mesquite, Mormon Mesa, or Muddy River, and nest substrate height was greater at Pahranagat than at all other study areas except for Bill Williams. Nest substrate dbh was greater at Pahranagat than at the other study areas (Table 6.2). Nest height, substrate height, and substrate dbh at the life history study areas did not differ significantly from 2003 to 2007.

VEGETATION MEASUREMENTS AT NEST, WITHIN-TERRITORY, AND NON-USE PLOTS

Canopy height, percent canopy closure, distance to water, distance to water during nesting, distance to canopy gap, distance to broadleaf, and number of shrub/sapling stems differed among nest, within-territory, and non-use plots in at least one study area (Table 6.3). Average canopy height was taller at nest and within-territory sites than at non-use sites at Mesquite and Muddy River. Percent canopy closure was greater at nest than at non-use locations at Pahranagat, Mesquite, and Topock.

Table 6.2. Summary of Nest Measurements at the Four Life History Study Areas, Muddy River Delta, and Bill Williams, 2007*

Parameter	**Pahranagat (n = 11)**	**Mesquite (n = 13)**	**Mormon Mesa (n = 11)**	**Muddy River (n = 7)**	**Topock (n = 8)**	**Bill Williams (n = 9)**
Nest height (m)	3.8 (0.6) 1.5–7.0 A,B,C	2.2 (0.1) 1.8–2.8 A	2.5 (0.2) 1.7–3.3 A,B	2.8 (0.2) 2.1–3.5 A,B	3.9 (0.4) 2.1–4.8 B,C	4.9 (0.6) 3.0–7.6 C
Nest substrate[1]	100% SAGO	77% TASP 23% SAEX	91% TASP 9% SNAG[2]	43% TASP 14% SAEX 43% SAGO	100% TASP	66% TASP 33% SAGO
Nest substrate height (m)	12.3 (1.8) 5.2–20.9 C	3.7 (0.3) 2.3–5.8 A	4.1 (0.3) 2.6–6.5 A	5.6 (0.8) 2.9-10.0 A,B	5.9 (0.3) 3.8-6.8 A,B	8.6 (1.2) 4.5–16.0 B,C
Nest substrate dbh (cm)	62.3 (18.7) 6.1–235.0 B	2.3 (0.2) 1.0–3.8 A	4.1 (0.6) 1.5–8.9 A	6.9 (1.9) 1.9–14.3 A	7.3 (1.0) 4.4–13.0 A	13.6 (4.9) 2.5–38.8 A

* Numerical data presented are means, (standard error), and range. Significant differences (Tukey's test, α = 0.05) between sites for a given continuous variable are indicated by alpha codes; sites with different letters differed from one another, while sites with the same letter did not.

[1] TASP = ***Tamarix*** sp**.** (tamarisk), SAEX = ***Salix exigua*** (coyote willow), SAGO = ***Salix gooddingii*** (Goodding willow), SNAG = standing dead tree.

[2] Snag was TASP.

Shrub/sapling stem count was significantly lower at non-use sites vs. both nest and within-territory sites at Mesquite. There was no significant difference in stem counts among plot types at the other study areas.

Percent woody ground cover did not differ between nest, within-territory, and non-use sites at any study area. Distance to water or saturated soil as measured during vegetation sampling was greater at nest and within-territory sites than non-use sites at Pahranagat. Mesquite, Mormon Mesa, Topock, and Muddy River demonstrated the opposite trend, with distance to water during vegetation sampling being greater at non-use sites than at nest and within-territory sites, but not statistically so. At Pahranagat, distance to water was greater at non-use than at nest sites during nesting, but the difference was not statistically significant. During nesting, distance to water was greater at non-use sites than at nest sites at Mormon Mesa and Topock. Nest and within-territory sites were farther from canopy gaps than were non-use sites at Mesquite, while nest and within-territory sites were closer than non-use sites to broadleaf trees at Mormon Mesa and Muddy River.

Vertical foliage density differed between nest and within-territory plots in the 8-, 9-, 10-, and 12-m intervals at Pahranagat and in the 4-m interval at Mormon Mesa. In all cases, nest sites had greater foliage density than within-territory locations (ANOVA and Tukey's multiple comparison test, $\alpha = 0.05$). Within-territory plots were excluded from further analyses.

Vertical foliage density was greatest in the upper strata of the canopy at nest sites vs. non-use sites at Mesquite, Mormon Mesa, and Muddy River (Figures 6.5–6.9). No significant differences in vertical foliage density were recorded at Pahranagat or Topock at nest vs. non-use sites.

Table 6.3. Comparison of Habitat Characteristics between Willow Flycatcher Nest (NS), Within-Territory (WT), and Non-Use (NU) Sites at the Four Life History Study Areas and Muddy River Delta, 2007*

Parameter	Pahranagat			Mesquite			Mormon Mesa			Topock			Muddy River		
	NS (n=11)	**WT (n=10)**	**NU (n=11)**	**NS (n=13)**	**WT (n=10)**	**NU (n=13)**	**NS (n=11)**	**WT (n=10)**	**NU (n=11)**	**NS (n=8)**	**WT (n=8)**	**NU (n=8)**	**NS (n=7)**	**WT (n=7)**	**NU (n=7)**
Canopy height (m)	18.3 (1.6) A,B	15.1 (1.7) A	23.0 (3.0) B*	5.2 (0.2) A	5.2 (0.3) A	3.9 (0.2) B****	5.0 (0.3) A	5.1 (0.3) A	4.3 (0.2) A	7.4 (0.5) A	6.7 (0.5) A	5.7 (0.4) A	7.3 (0.4) A	7.6 (0.9) A	4.1 (0.5) B**
% canopy closure	93.4 (1.3) A	89.2 (1.8) A,B	79.5 (4.9) B**	93.2 (1.0) A	91.0 (1.7) A	70.9 (6.2) B***	90.5 (1.3) A	91.4 (1.2) A	85.0 (2.7) A	96.1 (0.7) A	92.6 (2.0) A,B	88.6 (2.2) B*	87.7 (1.6) A	91.0 (1.7) A	72.6 (11.4) A
% woody ground cover	57.2 (10.3) A	60.6 (7.7) A	79.3 (5.8) A	31.4 (6.9) A	27.2 (6.5) A	43.9 (4.7) A	24.4 (3.1) A	24.3 (3.8) A	39.2 (7.5) A	18.8 (3.7) A	25.6 (5.3) A	13.5 (6.4) A	53.1 (8.2) A	44.3 (8.4) A	36.7 (8.5) A
Distance (m) to nearest water or saturated soil	89.0 (11.0) A	92.1 (10.7) A	33.8 (12.1) B**	25.2 (12.2) A	11.6 (5.7) A	38.0 (15.8) A	139.0 (41.7) A	151.3 (43.7) A	475.7 (164.1) A	23.3 (10.6) A	24.3 (9.3) A	75.0 (26.8) A	6.0 (1.5) A	7.9 (3.1) A	21.1 (9.4) A
Distance (m) to nearest water or saturated soil during nesting	7.3 (3.6) A	--	14.6 (5.9) A	9.2 (5.7) A	--	22.4 (7.9) A	144.3 (77.0) A	--	473.1 (111.8) B*	11.3 (5.9) A	--	63.4 (17.1) B*	6.0 (1.3) A	--	23.6 (8.7) A
Distance (m) to nearest canopy gap	8.6 (1.5) A	6.2 (1.8) A	8.5 (1.0) A	4.2 (0.7) A	6.1 (0.9) A	1.5 (0.5) B***	6.8 (1.3) A	5.5 (1.0) A	5.7 (1.6) A	7.2 (3.5) A	6.5 (1.7) A	20.9 (11.8) A	5.3 (0.9) A,B	7.8 (1.6) B**	1.9 (0.6) A
Distance (m) to nearest broadleaf tree	0.6 (0.3) A	0.7 (0.3) A	0.7 (0.5) A	0.3 (0.1) A	0.1 (0.1) A	3.4 (2.1) A	9.2 (2.5) A	6.2 (2.7) A	68.1 (23.8) B**	22.8 (10.5) A	16.9 (10.2) A	68.6 (20.9) A	0.8 (0.4) A	1.0 (0.6) A	41.9 (10.2) B****
# shrub/sapling stems within 5 m of plot center	0.8 (0.6) A	0.5 (0.5) A	2.8 (1.6) A	165.0 (10.7) A	163.5 (13.2) A	60.6 (8.7) B****	109.6 (10.9) A	100.5 (7.8) A	94.1 (14.4) A	70.6 (14.6) A	77.0 (15.0) A	118.5 (20.4) A	111.6 (15.8) A	107.4 (18.4) A	81.7 (15.8) A
# tree stems within 11.3 m of plot center	10.4 (1.3) A	11.8 (1.7) A	14.2 (3.1) A	3.0 (1.5) A	5.1 (2.4) A	1.4 (0.6) A	9.7 (2.8) A	11.8 (4.3) A	5.5 (2.1) A	20.9 (8.7) A	30.1 (10.5) A	12.3 (4.9) A	31.6 (5.4) A	34.1 (7.0) A	12.0 (9.0) A

* Data are presented as means (SE). Significant differences ($\alpha = 0.05$) between nest, within-territory, and non-use plots in a given study area are indicated by alpha codes; plots with different letters differed from one another, while plots with the same letter did not. Level of significance is indicated by asterisks as follows: * ***P*** <0.05; ** ***P*** <0.01; *** ***P*** <0.001; **** ***P*** <0.0001.

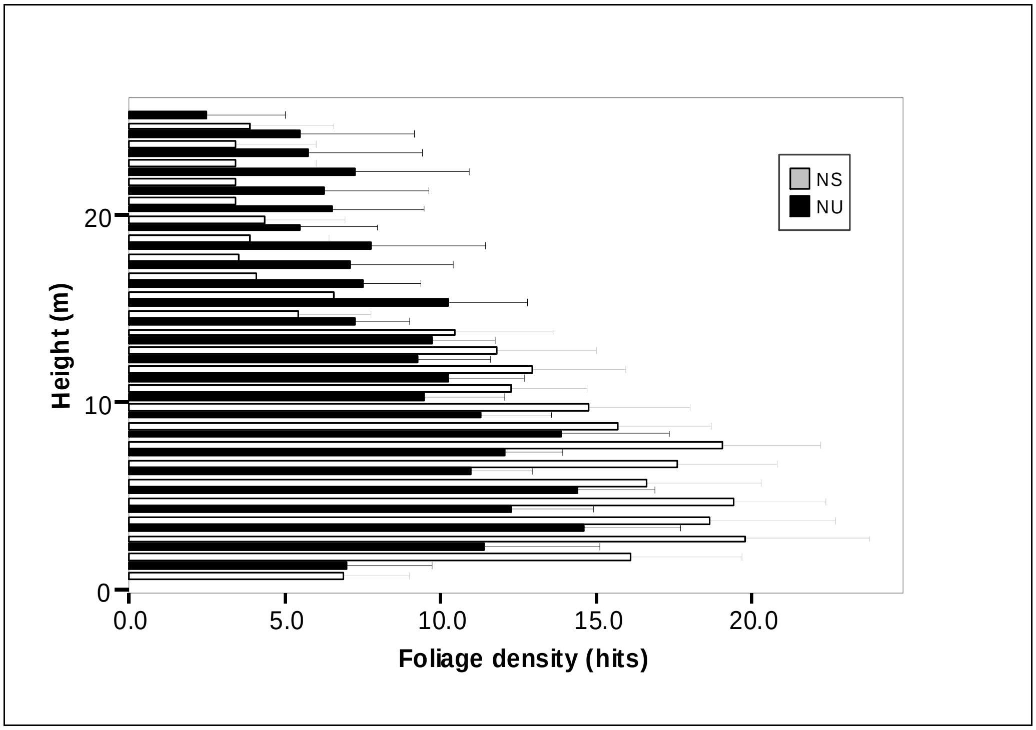

Figure 6.5. Vertical foliage density and standard error at willow flycatcher nest sites versus non-use sites at Pahranagat NWR, NV, 2007.

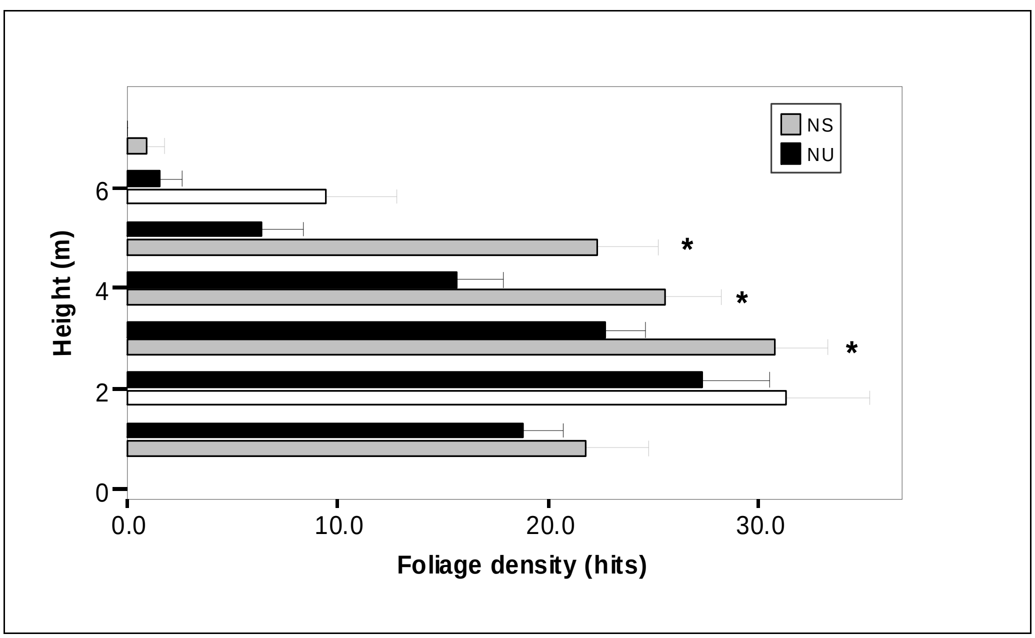

Figure 6.6. Vertical foliage density and standard error at willow flycatcher nest (NS) vs. non-use (NU) sites at Mesquite, NV, 2007. Differences (Student's t-test, α=0.05) between nest and non-use sites within a given meter interval are indicated by asterisks.

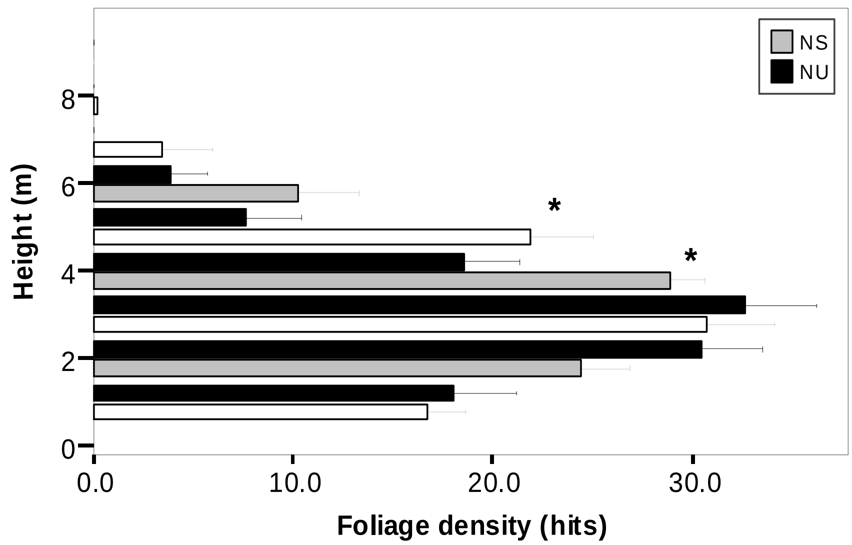

Figure 6.7. Vertical foliage density and standard error at willow flycatcher nest (NS) vs. non-use (NU) sites at Mormon Mesa, NV, 2007. Differences (Student's t-test, α=0.05) between nest and non-use sites within a given meter interval are indicated by asterisks.

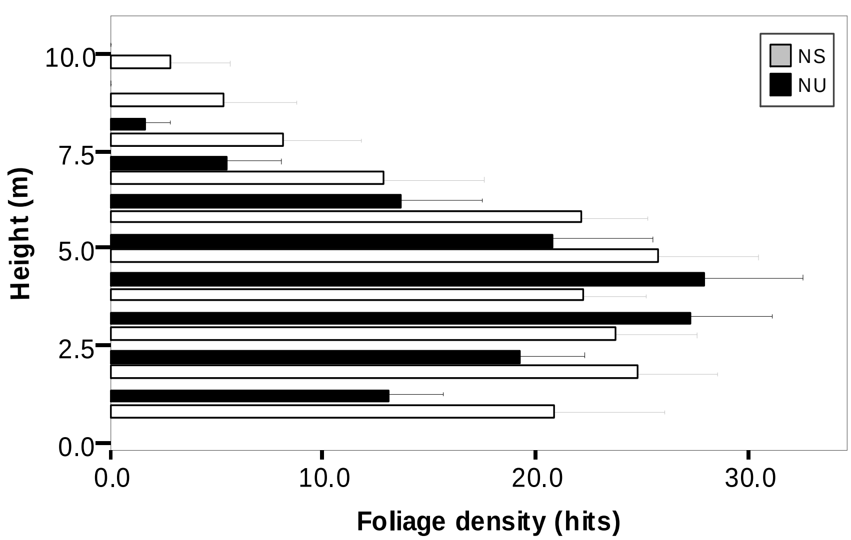

Figure 6.8. Vertical foliage density and standard error at willow flycatcher nest (NS) vs. non-use (NU) sites at Topock Marsh, AZ, 2007.

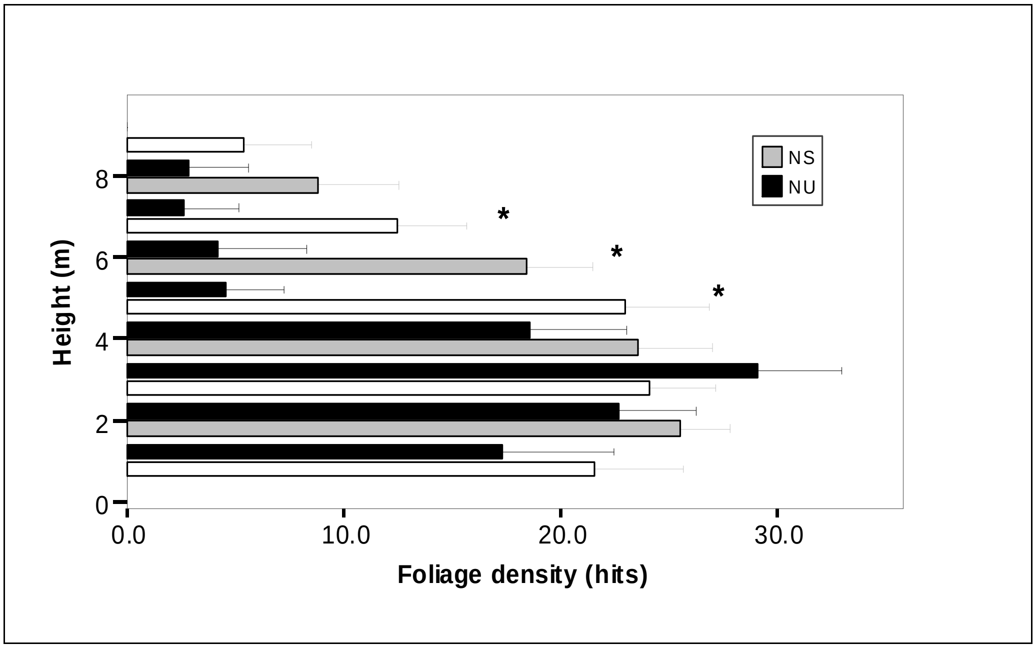

Figure 6.9. Vertical foliage density and standard error at willow flycatcher nest (NS) vs. non-use (NU) sites at Muddy River, NV, 2007. Differences (Student's t-test, $\alpha=0.05$) between nest and non-use sites within a given meter interval are indicated by asterisks.

DISCUSSION

Overall, the vegetation and habitat characteristics of entire habitat blocks at the four life history study areas show willow flycatchers breed in widely different types of riparian habitat throughout the Virgin and lower Colorado River regions. Although occupied flycatcher habitat at each of the four life history study areas consists of relatively homogeneous, contiguous stands of riparian vegetation, the sites differ from each other both structurally and compositionally. Pahranagat differs markedly in structure and vegetation species composition from Mesquite, Mormon Mesa, and Topock. The habitat block at Pahranagat consists of mature, native, large-diameter trees up to 20 m in height with relatively little shrub and sapling understory, while the habitat blocks at Mesquite, Mormon Mesa, and Topock are composed primarily of very dense stands of both mixed-native (Mesquite and Mormon Mesa) and exotic (Topock) woody vegetation 4–8 m in height. The very dense vegetation at Mesquite, Mormon Mesa, and Topock is reflected in higher shrub counts at these sites than at Pahranagat. The Topock habitat block also has a significantly greater number of tree stems than the other study areas.

At all study areas, habitat blocks have relatively high canopy closure with vertical foliage profiles showing no distinct understory, overstory, or structural layers. These results are consistent with those of McKernan and Braden (2001a) and indicate that high vegetation volume (amount of 3-dimensional space occupied by the vegetation) may be more important than a particular habitat structure for breeding flycatchers. The greatest vertical foliage density at all life history study areas occurs within 3 m of the ground. At Pahranagat, vertical foliage density within a given meter interval is generally less than at the other study areas but is relatively evenly distributed 3–18 m above the ground. Although any given meter interval at Pahranagat is less dense than at other sites, combined they equate to high canopy closure.

In 2007, as in 2003–2006, differences in nest characteristics between study areas reflected general differences in habitat structure, with nest substrates at Pahranagat being significantly taller and having larger dbh than substrates at the other life history study areas and Muddy River. Nest height, substrate height, and substrate dbh did not differ significantly between years in 2003–2007 at any of the life history study areas. As in previous years, nests at Pahranagat were placed in native species, while at least 50% of nests at Mesquite and Mormon Mesa were placed in tamarisk. All nests at Topock were in tamarisk, as was the case in 2003–2006, with the exception of one nest in a screwbean mesquite in 2006. Although nest substrates may not be chosen in proportion to their availability in the habitat, it is clear that willow flycatchers nest in both predominantly native and predominantly exotic habitats. Analyses of nest productivity as related to native vs. non-native vegetation will be included in the five-year report to determine the relative importance of species composition at flycatcher breeding sites along the lower Colorado River.

Comparisons between nest and non-use sites in 2007 demonstrated patterns similar to those that emerged in 2003–2006. Nest sites had significantly greater canopy heights than non-use sites at Mesquite and Muddy River. Canopy closure values at nest sites were significantly higher than at non-use sites at three (Pahranagat, Mesquite, and Topock) of the four life history study areas. These results are consistent with those of Allison et al. (2003) who reported a trend for Southwestern Willow Flycatcher nest sites to have a higher percentage canopy closure and taller canopy than non-use sites. Paradzick (2005) also found occupied willow flycatcher sites in Arizona to have higher canopy cover than unoccupied sites.

We concur with Allison et al. (2003) and Sogge and Marshall (2000) in that breeding riparian birds in the desert Southwest are exposed to extreme environmental conditions and that dense vegetation at the nest may be needed to provide a more suitable microclimate for raising offspring. In 2003–2007, vertical foliage density at nest sites was generally greatest around mean nest height. Allison et al. (2003) found the greatest foliage density to be at nest height at three large willow flycatcher breeding sites in Arizona. Paradzick (2005) also found occupied willow flycatcher sites to have denser foliage in the upper (7–9 m) strata of the canopy than unoccupied sites. Greater canopy closure, taller canopy height, and dense foliage at or immediately above nest height may facilitate a more favorable nesting microclimate and may be useful parameters in predicting preferred willow flycatcher riparian breeding habitat within the larger expanses of riparian vegetation along the Virgin and lower Colorado Rivers.

The affinity of breeding flycatchers with standing water and saturated soil is noted consistently in the literature, and presence of water may be a factor in sustaining particular vegetation features at breeding sites (Paradzick 2005) and providing a more suitable microclimate for raising offspring (Sogge and Marshall 2000). From 2003 to 2005, our inability to detect differences in distance to water between nest and non-use sites at some study areas may have been influenced by our sampling methodology, with distance to water measured at the end of the flycatcher breeding season. Because of extreme seasonal changes in hydrology at study areas, with many nest sites dry by July or August, distance to water as measured at the end of the breeding season may not reflect hydrologic conditions during nest-site selection. Therefore, in

2006 and 2007 we measured distance to surface water or saturated soil at nest and non-use sites as soon as flycatcher eggs were observed in a nest and at the end of the breeding season. Nest sites were significantly closer to surface water or saturated soil during nesting than were non-use sites at Mormon Mesa and Topock, while Pahrangat and Muddy River showed a strong trend for nest sites to be closer to water. At Pahranagat, distance to water was greater at non-use than at nest sites during nesting, but less at non-use than at nest sites at the end of the season. This is because the standing water under flycatcher nests at the beginning of the breeding season recedes as the season progresses, while non-use sites are along the perimeter of the lake and along inflow and outflow canals that experience less of a temporal change in water levels. Results at Pahranagat illustrate the importance of measuring hydrologic conditions in a way that accounts for temporal changes.

Woody ground cover did not differ between nest and non-use sites in any of the study areas from 2003 to 2007. These results suggest that percent woody ground cover may not be a useful variable in distinguishing between nest and non-use sites. The vegetation sampling variables used in our study were identified by the Arizona Game and Fish Department, and percent woody ground cover was included as a way to quantify ground cover available to potential nest predators.

Distance to nearest broadleaf did not differ significantly between nest and non-use plots at any of the study areas from 2003 to 2005, and differed only at one site (Muddy River) in 2006 and at two sites (Mormon Mesa and Muddy River) in 2007. Allison et al. (2003) reported that distance to the nearest native plant was useful in distinguishing nesting and non-nesting plots at two large sites composed of even-aged vegetation. Because of the variation in species composition among our study areas, distance to nearest broadleaf may not be a variable useful in distinguishing between flycatcher nest and non-use plots along the Virgin and lower Colorado Rivers.

Nests were farther from canopy gaps than were non-use plots at Mesquite in 2003, 2004, 2006, and 2007. Results at the other study areas have been inconclusive across years. Allison et al. (2003) reported that, compared to the center of non-use plots, Southwestern Willow Flycatchers placed nests closer to canopy gaps, while Sedgwick and Knopf (1992) reported that a willow flycatcher population in northern Colorado placed nests farther from canopy gaps. Because of the variation in vegetation structure among the study areas, presence of canopy gaps may not be a good predictor of flycatcher breeding habitat along the Virgin and lower Colorado Rivers.

CHAPTER 7

NEST MICROCLIMATE

INTRODUCTION

Innate selection of beneficial nest-site microclimate by birds can moderate extreme environmental conditions and has the potential to improve reproductive success and increase fitness (Webb and King 1983, Walsberg 1985). Although nest microclimate may influence avian reproductive success, other factors such as habitat and food availability also are important (Cody 1985, Gloutney and Clark 1997). Potential covariance with other evolutionary forces such as predation further complicates any investigation of microclimatic nest-site selection (Martin 1995).

Most studies of microclimatic nest-site selection have concentrated on non-passerines. Waterfowl (Gloutney and Clark 1997), hummingbirds (Calder 1973), and woodpeckers (Connor 1975, Inouye 1976, Inouye et al. 1981) in particular have been evaluated with respect to various aspects of microclimatic regulation. Selected species from each of these groups have demonstrated a preference for specific physical attributes within their nesting habitat as strategies to maximize heat gain, minimize heat loss, or manipulate wind exposure depending on the situation. Several species of woodpeckers excavate cavities whose entrance holes are oriented toward or away from the sun, again depending on the situation and the need to regulate nest microclimate.

Microclimatic selection by passerines has received less attention than that of non-passerines, with most investigations of passerines directed at either ground-nesters or those building covered nests. Horned Lark (*Eremophila alpestris*) is probably the most thoroughly studied ground-nesting passerine, and numerous studies indicate that it selects nest locations based on compass orientation as a way to manipulate wind exposure, solar insolation, and resulting nest microclimate (Cannings and Threlfall 1981, With and Webb 1993, Hartman and Oring 2003). Cactus Wren (*Campylorhynchus brunneicapillus*) and Verdin (*Auriparus flaviceps*) orient the entrances to their covered nests either away from or toward prevailing winds in different parts of the nesting season to moderate nest microclimate (Austin 1974, 1976).

Microclimatic nest-site selection has been investigated in only a few open-cup, shrub- or tree-nesting passerines. The Warbling Vireo (*Vireo gilvus*) is very sensitive to fluctuations in nest microclimate (Walsberg 1981), and the San Miguel Island Song Sparrow (*Melospiza melodia micronyx*) may benefit from microhabitats that maintain higher nest relative humidity (Kern et al. 1990).

Gloutney and Clark (1997) pointed out that nonrandom distribution of nests strongly supports the microhabitat (i.e., microclimate) selection hypothesis. For example, nest-site selection for thermal advantages has been offered as an explanation as to why nonrandom nest-site placement occurs in many species (Kern and van Riper 1984, Bekoff et al. 1987, van Riper et al. 1993).

Nests placed in dense vegetation have been suggested to be less susceptible to predation (Cody 1985), and may also benefit from protection from wind, nocturnal heat loss, and diurnal heat gain (Walsberg 1981, 1985). Because the microhabitat of an individual can influence energy expenditure (Warkentin and West 1990), calories conserved through beneficial nest-site selection can aid reproductive efforts and improve fitness (Gloutney and Clark 1997).

Air temperature alone cannot portray the microclimate of an incubating bird (Gloutney and Clark 1997). Solar insolation, vapor pressure, relative humidity, and wind speed interact in a complex manner with temperature to define microclimate (McArthur 1990), so that many physiological investigators instead calculate 'operative temperature' in a complex formula that integrates all the above factors (Gloutney and Clark 1997).

The purpose of this microclimate investigation was to document temperature, relative humidity, vapor pressure, and soil moisture at nests of Southwestern Willow Flycatchers, an open-cup nesting passerine. We tested the null hypothesis that no difference existed between (1) a flycatcher nest site, (2) a randomly located adjacent site within that flycatcher territory, and (3) unoccupied riparian habitat outside of that territory. Air temperature, relative humidity, vapor pressure, and soil moisture were used as indices to microclimate, although it was recognized that substantial interaction likely occurred among those four variables.

METHODS

OVERVIEW

We located active flycatcher nests at four life history study areas (Pahranagat, Mesquite, Mormon Mesa, and Topock) and at Muddy River Delta between May and August 2007. Microclimate variables were measured at three locations relative to each nest for the purpose of examining microclimate at three levels of potentially increasing differences in flycatcher nesting habitat use, as follows:

1. Within 2 m of a nest (i.e., the nest site [NS]).
2. Within the territory associated with that nest (but 5–10 m from the nest; i.e., within-territory site [WT]).
3. Within unoccupied riparian habitat 50–200 m from the nearest known nest or territory (i.e., non-use site [NU]).

We began collecting microclimate data simultaneously at nest, within-territory, and non-use sites within 48–72 hours of the time an active nest was vacated. A nest was defined as vacated if it met one of the following criteria: (1) it had been deserted for any reason (including brood parasitism) at any stage of the nesting cycle after the first flycatcher egg was laid, (2) it had fledged young and was no longer active, or (3) it had been depredated after a flycatcher egg was laid. This technique minimized disturbance due to equipment placement or increased human activity near the nest as recommended by Hartman and Oring (2003), while still allowing for quantitative post-use comparisons of microclimate.

Microclimate data were collected over a period of 14 full days (midnight to midnight; with some exceptions in the case of equipment failure, etc.), after which time we transferred the equipment and effort used to collect microclimate data to the nest, within-territory, and non-use sites for another recently vacated nest (i.e., including a second brood or second nesting attempt). The 14-day study period for each nest became the focus of all final analyses. Renests, or second nests of a known pair, were treated as independent data points because nests were the unit of analysis of this study and not individuals or pairs. All equipment used to collect microclimate data was removed after 14 full days from the time the last active nest had been vacated.

TEMPERATURE AND RELATIVE HUMIDITY (T/RH) MEASUREMENTS

Measurements of temperature and relative humidity (T/RH) were recorded automatically every 15 minutes using a HOBO H8 Pro (Onset Computer Corporation, Pocasset, MA) that combines a thermometer (degrees Celsius), relative humidity monitor, and digital data logger (hereafter referred to as a sensor array). We camouflaged all HOBO sensor arrays by placing them in an inverted small, plastic bowl coated with spray adhesive and local vegetation. The opening at the bottom was covered with shadecloth, allowing free air circulation around the sensor array. The HOBO sensor arrays were placed in four different location types in a manner consistent with an overall randomization design, as follows:

(1) Seasonal-variation (SV) sensor arrays: When field personnel arrived at the four life history study areas in early May, they placed SV sensor arrays at randomly selected locations within known flycatcher breeding areas and at representative locations in adjacent desertscrub habitat. The riparian SV sensor arrays (SVR) were designed to monitor T/RH fluctuations throughout the nesting season within the riparian zone to document ambient environmental conditions throughout the study period. Specific locations for SVR sensors were selected by superimposing a 25 × 25–m grid on flycatcher breeding areas known from the previous year, numbering the grid blocks, selecting blocks by using a random number generator, and using the centroid of each selected block. The SVR site was located in the field using the UTM coordinates and a Rino 110 GPS unit. The exact location of the sensor array was determined by selecting the closest woody tree or shrub and using the procedures in 3C–3E below. The desertscrub SV sensor arrays (SVD) at each study area were placed in desert habitat outside of the riparian zone to document local extremes in T/RH.

(2) Nest-site (NS) sensor arrays: Once a known nest was vacated, an NS sensor array was placed less than 1 m from the nest, preferably hanging directly below it. Sensor arrays were camouflaged so as not to disturb birds that may have returned to the nest to recycle nesting material.

(3) Within-territory (WT) sensor arrays: A WT sensor array was placed at a location within the territory of the pair that attended the corresponding nest. The WT sensor array sites were determined by means of the following instructions and the use of random number sequences:

A. The compass direction to walk from the nest, given in degrees from north, was determined from a random number sequence.

B. The distance (between 5 and 10 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 for sensor array placement.

C. The sensor array was placed at a randomly selected height within the range of flycatcher nest heights documented at that study area in 2003–2006 (Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007). The distribution of random numbers followed the distribution of nest heights. If the tree or shrub chosen for a sensor array location was of insufficient height to accept the height from the random number sequence, then field personnel placed the sensor array at the first height in the sequence that was less than the height of the tree or shrub.

D. The distance (0–3 m) at which the sensor array 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 sensor array at the first number in the sequence that was less than the radius of the tree or shrub.

E. The compass direction, given in degrees from north, at which the sensor array 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 sensor array at the height and distance specified in (C) and (D), field personnel proceeded clockwise around the tree or shrub until a suitable branch was located.

   If, as presented in C and D, 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. If these directions took field personnel outside of the riparian zone or to a site without trees or shrubs, they returned to the nest site and used the next sequence of random numbers.

(4) Non-use habitat (NU) sensor arrays: At all life history study areas and Muddy River, we identified NU habitat after the first territories and nests were located. We used ArcGIS 9.1 software to generate two circles centered on each nest site or territory center, one 50 m in radius and one 200 m in radius. The area between the two circles that was within the study area boundaries and was at least 50 m from all other nests or territory centers was classified as NU. Specific locations for non-use sensors were selected by superimposing a 25 × 25–m grid on the NU habitat, numbering the grid blocks, selecting blocks by using a random number generator, and using the centroid of each selected block. The NU site was located in the field using the UTM coordinates and a Rino 110 GPS unit. The exact location of the sensor array was determined by selecting the closest woody tree or shrub and using the procedures in 3C–3E above. If the NU site was inaccessible (e.g., impenetrable vegetation or deep water) or was in clearly unsuitable habitat (e.g., open marsh), the next UTM coordinate for a random NU site was used.

At each location where we deployed a HOBO sensor array, we also visually estimated canopy closure as <25%, 25–75%, or >75%, and habitat type was identified as native (cottonwood/ willow), exotic (tamarisk), or mixed native and exotic (see data forms in Appendix A).

SOIL MOISTURE (SM) MEASUREMENTS

Hand-held probes were used to document soil moisture (SM) at NS, WT, and NU sites at the time the T/RH sensor arrays were placed, and at the time the T/RH sensor arrays were removed 14 days later. In addition, SM readings were taken at SVR locations at least twice a week throughout the season. No SM readings were taken at SVD locations because SM was assumed to be at or near zero.

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. The SM readings (nine per site) were recorded directly beneath the HOBO logger (plot center) and at 1.0 and 2.0 m from plot center in each cardinal direction for each SVR, NS, WT, and NU site. Soil moisture was recorded both as voltage (mV) and as volumetric water content (%).[1] Soil type on the HH2 was set to mineral soil. For any SM 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.

Soil samples were collected at each SM site (SVR, NS, WT, NU) when sensor arrays were initially set up. 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 site designation. Because soil texture strongly influences capillary action and therefore overall SM (Sumner 2000), analysis of soil composition will be conducted in future years.

STATISTICAL ANALYSES

We downloaded data from the T/RH and SM sensor arrays at SV, NS, WT, and NU sites into databases at the end of the field season. We merged all data to create one dataset for further analysis, with the exception of the SV dataset, which was summarized separately for descriptive purposes and was not included in any of the analyses. We calculated the following variables for each sensor array by overall study period:

- Mean soil moisture from plot center to 2.0 m from plot center
- Mean diurnal temperature

[1] 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 eliminate these qualitative readings, we recorded both mV and volumetric soil moisture in 2005–2007, rather than just volumetric soil moisture, which we had recorded in 2004.

- Mean number of 15-minute intervals above 41°C each day[2]
- Mean nocturnal temperature
- Mean daily temperature range (diurnal maximum minus nocturnal minimum)
- Mean diurnal relative humidity
- Mean diurnal vapor pressure[3]
- Mean nocturnal relative humidity
- Mean nocturnal vapor pressure

The overall study period constituted the entire season for SV sensor arrays and the 14 days of monitoring for sites (NS, WT, and NU) associated with nests. We determined diurnal and nocturnal periods by using the actual daily sunrise and sunset times reported for the region by the National Weather Service (2007).

We tested the mean weekly diurnal temperature and mean soil moisture of the SV sensor arrays at each study area in 2003 and 2004 (Koronkiewicz et al. 2004, McLeod et al. 2005) to determine whether placing the sensor arrays ***after*** the nest had been vacated was appropriate. Any consecutive weeks at a study area which were significantly different would be an indication that placing the sensor arrays after nests had been vacated was inappropriate. Both years revealed few differences between consecutive weeks for T/RH and SM measurements, so we did not perform these tests again in 2005, 2006, or 2007, as we were confident in the validity of measuring nest microclimate after nests were vacated.

We used repeated measures analysis of variance to determine the association between location type (NS, WT, NU) and microclimate variables. This was done for each life history area and then overall, taking into account the matched relationship between NS, WT, and NU. This methodology is a change from the analyses of previous years because formerly there was no evaluation of whether using matched location types affected the associations. Data were truncated so the time period for each matched NS, WT, NU set was equal, and only matched sets with data for all three location types were included in the analyses. To determine the association between the microclimate variables and life history area, habitat type, and canopy cover, we used one-way analysis of variance. If significant differences were found ($P < 0.05$), paired t-tests and Tukey's test were used to determine significant pairwise differences.

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[2] In 2003 and 2004, we analyzed mean maximum diurnal temperature. However, the length of time for which an organism experiences high temperatures may be more indicative of stresses than the maximum temperature reached. Estimated thermal tolerance of avian embryos for short exposures in most species is 16 to 41°C (Webb 1987).

[3] In prior years, we evaluated humidity by examining relative humidity. In 2005–2007, we decided to add an analysis of vapor pressure. 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.

Logistic regression was used to test the association of NS versus WT or NU with a combination of the predictor variables to determine if a minimum set of variables could distinguish the microclimate at NS sites versus randomly chosen sites. All uncorrelated predictor variables with significant individual effects were included in the models, and backward selection was used to create the most parsimonious model.

Analyses were conducted using SAS® v.9.1.3 (SAS Institute 2003) and Stata® v.9.2 (StataCorp 2006).

RESULTS

SEASONAL VARIATION

Twenty-four SV T/RH sensor arrays were placed at the four life history study areas in early May and remained in place until August. One T/RH sensor in riparian habitat in Topock Marsh failed to function. The results from all SV sensor arrays indicated desertscrub sites were substantially hotter and drier than riparian sites (Tables 7.1 and 7.2).

Table 7.1. Seasonal Variation in Riparian Habitat by Study Area for Southwestern Willow Flycatcher Microclimate Data from along the Virgin and Lower Colorado Rivers, May–August, 2007*

Descriptive Statistics	Pahranagat	Mesquite	Mormon Mesa	Topock
n (Temp./Humidity Sensor Arrays)	4	4	4	3
Mean soil moisture (mV)	890.0 (11.7)	804.0 (122.3)	708.3 (65.0)	913.1 (7.5)
Mean diurnal temperature (°C)	24.7 (1.3)	28.5 (1.1)	33.5 (1.8)	27.7 (1.4)
Mean no. of 15-min. intervals above 41°C each day	0.0 (0.1)	0.9 (1.3)	15.1 (5.2)	0.4 (0.6)
Mean nocturnal temperature (°C)	20.8 (1.4)	21.8 (1.8)	23.3 (2.2)	22.0 (2.3)
Mean daily temperature range (°C)	17.1 (2.2)	20.7 (2.6)	29.5 (4.0)	19.9 (3.9)
Mean diurnal relative humidity (%)	38.5 (7.0)	59.7 (6.2)	31.0 (5.8)	58.9 (7.3)
Mean diurnal vapor pressure (Pa)	1,138.1 (251.8)	2,146.3 (307.8)	1,270.3 (298.5)	2,160.8 (396.5)
Mean nocturnal relative humidity (%)	41.8 (7.5)	68.9 (6.8)	48.4 (6.3)	73.1 (6.3)
Mean nocturnal vapor pressure (Pa)	1,020.5 (220.5)	1,792.3 (276.2)	1,351.1 (241.9)	1,974.3 (338.5)

*All values are means (standard error in parentheses).

Table 7.2. Seasonal Variation in Desertscrub Habitat by Study Area for Southwestern Willow Flycatcher Microclimate Data along the Virgin and Lower Colorado Rivers, May–August, 2007*

Descriptive Statistics	Pahranagat	Mesquite	Mormon Mesa	Topock
n (Temp./Humidity Sensor Arrays)	2	2	2	2
Mean diurnal temperature (°C)	33.0 (3.1)	40.5 (2.8)	39.8 (2.7)	38.9 (2.3)
Mean no. of 15-min. intervals above 41°C each day	15.7 (10.1)	35.0 (8.0)	33.1 (7.7)	31.3 (6.1)
Mean nocturnal temperature (°C)	21.8 (2.4)	29.2 (3.1)	25.6 (2.8)	28.2 (3.1)
Mean daily temperature range (°C)	27.9 (4.2)	28.7 (4.1)	30.7 (3.8)	30.7 (6.5)
Mean diurnal relative humidity (%)	18.2 (9.3)	13.8 (6.6)	16.3 (6.8)	22.1 (7.1)
Mean diurnal vapor pressure (Pa)	747.7 (368.8)	819.7 (362.6)	984.4 (366.9)	1,178.5 (442.1)
Mean nocturnal relative humidity (%)	27.8 (12.9)	20.2 (9.9)	34.6 (9.4)	31.3 (11.0)
Mean nocturnal vapor pressure (Pa)	715.2 (370.0)	793.8 (396.3)	1,136.4 (387.4)	1,190.4 (484.5)

*All values are means (standard error in parentheses). No SM data were gathered in desertscrub habitat.

Location Types: Descriptive Statistics and Single Effects

One-hundred fifty T/RH sensor arrays were placed in the five study areas from June through mid-August. Twenty-one sensors (14%) failed to launch, fell during the period of deployment, had faulty sensors, or failed to download. Data were collected for 32 matched sets of NS, WT, and NU sites (Tables 7.3–7.11). Because of the low number of successful sets of measures from Topock Marsh, no significance testing was performed for that study area (Table 7.6).

Habitat type did not differ between the matched NS, WT, and NU sites in any of the five study areas. Canopy closure was different at two of the five study areas (Mesquite and Muddy River); NU sites there exhibited <25% canopy closure more often than NS or WT sites. Soil moisture was different at one of the five study areas (Mesquite), where NU sites were drier than NS and WT sites.

The NS, WT, and NU sites were significantly different at two of the five study areas (Pahranagat and Mesquite) for mean diurnal temperature; NU sites were hotter than NS and WT sites. The mean number of 15-minute intervals >41°C was different at two study areas (Mesquite and Muddy River); again, NU sites were hotter than NS and WT sites. Nocturnal temperature did not differ between NS, WT, and NU sites. Daily temperature range was also significantly different among NS, WT, and NU sites at three study areas (Pahranagat, Mesquite, and Muddy River); in general, NU sites exhibited a greater daily temperature range than NS and WT sites.

Significant differences in the humidity measures between the matched NS, WT, and NU sites were found only at Pahranagat and Mesquite. Diurnal relative humidity and diurnal vapor pressure differed at both areas; the NU sites were less humid than NS and WT sites. Nocturnal relative humidity and nocturnal vapor pressure also differed at Mesquite; again, NU sites were less humid than NS and WT sites.

Table 7.3. Southwestern Willow Flycatcher Microclimate Measures by Location Type at **Pahranagat NWR**, June–August, 2007*

Response Variable	Nest Site	Within Territory	Non-Use	***P***	Significant Pairwise Differences
n (Temp./Humidity Sensor Arrays)	10	10	10		
Habitat					
Native (cottonwood or willow)	10 (100.0)	10 (100.0)	10 (100.0)	N/A	N/A
Exotic (tamarisk)	0 (0.0)	0 (0.0)	0 (0.0)		
Mixed (native and exotic)	0 (0.0)	0 (0.0)	0 (0.0)		
Canopy Cover					
Less than 25%	0 (0.0)	1 (10.0)	1 (10.0)	0.099	N/A
25–75%	1 (10.0)	6 (60.0)	3 (30.0)		
More than 75%	9 (90.0)	3 (30.0)	6 (60.0)		
Soil Moisture					
Mean soil moisture (mV)	785.0 (38.4)	768.6 (29.3)	683.3 (59.0)	0.357	N/A
Temperature					
Mean diurnal temperature (°C)	26.3 (0.3)	26.6 (0.5)	28.6 (0.7)	0.003	NU>NS, WT
Mean no. of 15-min. intervals above 41°C each day	0.1 (0.1)	1.1 (0.6)	1.6 (1.2)	0.115	N/A
Mean nocturnal temperature (°C)	23.2 (0.4)	22.9 (0.5)	24.0 (0.6)	0.056	N/A
Mean daily temperature range (°C)	15.7 (1.3)	18.4 (1.5)	18.3 (1.6)	0.019	NS<WT
Humidity					
Mean diurnal relative humidity (%)	47.6 (3.9)	47.4 (3.6)	38.6 (4.7)	0.007	NU<NS, WT
Mean diurnal vapor pressure (Pa)	1555.2 (126.1)	1554.5 (117.5)	1373.9 (149.6)	0.033	NU<NS, WT
Mean nocturnal relative humidity (%)	48.6 (4.1)	50.6 (3.5)	45.5 (4.8)	0.096	N/A
Mean nocturnal vapor pressure (Pa)	1355.4 (118.2)	1387.6 (100.2)	1287.3 (131.1)	0.095	N/A

* Habitat and canopy cover variables are presented as n followed by % of column totals (in parentheses), while soil moisture and temperature/humidity values are means (standard error in parentheses).
N/A = data not available or not applicable.

Table 7.4. Southwestern Willow Flycatcher Microclimate Measures by Location Type at **Mesquite**, June–August, 2007*

Response Variable	Nest Site	Within Territory	Non-Use	*P*	Significant Pairwise Differences
n (Temp./Humidity Sensor Arrays)	10	10	10		
Habitat					
Native (cottonwood or willow)	3 (30.0)	3 (30.0)	2 (20.0)	0.154	N/A
Exotic (tamarisk)	1 (10.0)	2 (20.0)	3 (30.0)		
Mixed (native and exotic)	5 (50.0)	5 (50.0)	1 (10.0)		
Canopy Cover					
Less than 25%	1 (10.0)	0 (0.0)	8 (80.0)	<0.001	NU<NS, WT
25–75%	4 (40.0)	8 (80.0)	1 (10.0)		
More than 75%	5 (50.0)	2 (20.0)	1 (10.0)		
Soil Moisture					
Mean soil moisture (mV)	834.1 (58.8)	815.6 (60.0)	457.5 (87.4)	0.004	NU<NS, WT
Temperature					
Mean diurnal temperature (°C)	29.9 (0.3)	30.1 (0.1)	34.8 (0.8)	0.003	NU>NS, WT
Mean no. of 15-min. intervals above 41°C each day	0.6 (0.4)	0.8 (0.4)	17.2 (3.4)	0.001	NU>NS, WT
Mean nocturnal temperature (°C)	24.8 (0.3)	24.7 (0.3)	25.8 (0.4)	0.136	N/A
Mean daily temperature range (°C)	15.7 (1.0)	17.2 (0.6)	24.8 (1.6)	0.001	NU>NS, WT
Humidity					
Mean diurnal relative humidity (%)	59.4 (1.6)	58.1 (1.6)	42.0 (2.7)	0.003	NU<NS, WT
Mean diurnal vapor pressure (Pa)	2347.8 (38.6)	2308.8 (62.6)	1904.0 (113.9)	0.025	NU<NS, WT
Mean nocturnal relative humidity (%)	65.7 (1.6)	65.8 (2.1)	56.4 (3.1)	0.056	N/A
Mean nocturnal vapor pressure (Pa)	2019.8 (52.8)	1999.7 (64.3)	1760.3 (85.5)	0.018	NU<NS, WT

* Habitat and canopy cover variables are presented as n followed by % of column totals (in parentheses), while soil moisture and temperature/humidity values are means (standard error in parentheses).
N/A = data not available or not applicable.

Table 7.5. Southwestern Willow Flycatcher Microclimate Measures by Location Type at **Mormon Mesa**, June–August, 2007*

Response Variable	Nest Site	Within Territory	Non-Use	*P*	Significant Pairwise Differences
n (Temp./Humidity Sensor Arrays)	3	3	3		
Habitat					
Native (cottonwood or willow)	0 (0.0)	0 (0.0)	0 (0.0)	N/A	N/A
Exotic (tamarisk)	3 (100.0)	3 (100.0)	3 (100.0)		
Mixed (native and exotic)	0 (0.0)	0 (0.0)	0 (0.0)		
Canopy Cover					
Less than 25%	0 (0.0)	1 (33.3)	0 (0.0)	0.406	N/A
25–75%	2 (66.6)	1 (33.3)	3 (100.0)		
More than 75%	1 (33.3)	1 (33.3)	0 (0.0)		
Soil Moisture					
Mean soil moisture (mV)	526.2 (131.0)	466.3 (155.4)	697.7 (157.8)	0.716	N/A
Temperature					
Mean diurnal temperature (°C)	32.9 (1.5)	34.9 (2.7)	35.2 (0.5)	0.141	N/A
Mean no. of 15-min. intervals above 41°C each day	13.4 (6.3)	17.4 (8.3)	21.3 (4.7)	0.125	N/A
Mean nocturnal temperature (°C)	25.1 (2.1)	24.6 (2.0)	24.9 (3.1)	0.744	N/A
Mean daily temperature range (°C)	22.0 (3.8)	27.7 (5.7)	26.1 (5.3)	0.222	N/A
Humidity					
Mean diurnal relative humidity (%)	36.8 (9.6)	35.9 (11.9)	33.9 (6.7)	0.271	N/A
Mean diurnal vapor pressure (Pa)	1538.6 (370.8)	1560.4 (454.0)	1497.4 (386.4)	0.769	N/A
Mean nocturnal relative humidity (%)	50.4 (8.1)	52.6 (8.8)	54.6 (7.8)	0.263	N/A
Mean nocturnal vapor pressure (Pa)	1550.0 (300.3)	1583.0 (346.5)	1637.9 (247.3)	0.568	N/A

* Habitat and canopy cover variables are presented as n followed by % of column totals (in parentheses), while soil moisture and temperature/humidity values are means (standard error in parentheses).
N/A = data not available or not applicable

Table 7.6. Southwestern Willow Flycatcher Microclimate Measures by Location type **Topock**, June–August, 2007*

Response Variable	Nest Site	Within Territory	Non-Use	***P***	Significant Pairwise Differences
n (Temp./Humidity Sensor Arrays)	2	2	2		
Habitat					
Native (cottonwood or willow)	0 (0.0)	0 (0.0)	0 (0.0)	N/A	N/A
Exotic (tamarisk)	1 (50.0)	1 (50.0)	2 (100.0)		
Mixed (native and exotic)	1 (50.0)	1 (50.0)	0 (0.0)		
Canopy Cover					
Less than 25%	0 (0.0)	0 (0.0)	1 (50.0)	N/A	N/A
25–75%	2 (100.0)	1 (50.0)	1 (50.0)		
More than 75%	0 (0.0)	1 (50.0)	0 (0.0)		
Soil Moisture					
Mean soil moisture (mV)	956.7 (37.2)	918.9 (6.8)	232.8 (58.9)	N/A	N/A
Temperature					
Mean diurnal temperature (°C)	30.5 (1.2)	30.8 (1.2)	35.7 (5.6)	N/A	N/A
Mean no. of 15-min. intervals above 41°C each day	1.4 (1.4)	1.7 (1.7)	18.7 (18.7)	N/A	N/A
Mean nocturnal temperature (°C)	24.1 (3.4)	24.3 (3.3)	23.2 (3.0)	N/A	N/A
Mean daily temperature range (°C)	18.8 (6.1)	19.0 (1.1)	26.3 (15.1)	N/A	N/A
Humidity					
Mean diurnal relative humidity (%)	64.8 (1.1)	61.8 (3.5)	49.4 (19.3)	N/A	N/A
Mean diurnal vapor pressure (Pa)	2747.7 (280.6)	2678.9 (342.4)	2344.4 (514.4)	N/A	N/A
Mean nocturnal relative humidity (%)	74.6 (0.6)	70.2 (2.7)	72.2 (2.2)	N/A	N/A
Mean nocturnal vapor pressure (Pa)	2267.3 (432.2)	2164.6 (506.5)	2082.2 (441.3)	N/A	N/A

* Habitat and canopy cover variables are presented as n followed by % of column totals (in parentheses), while soil moisture and temperature/humidity values are means (standard error in parentheses).
N/A = not applicable because of the small sample size.

Table 7.7. Southwestern Willow Flycatcher Microclimate Measures by Location type at **Muddy River**, June–August, 2007*

Response Variable	Nest Site	Within Territory	Non-Use	***P***	Significant Pairwise Differences
n (Temp./Humidity Sensor Arrays)	7	7	7		
Habitat					
Native (cottonwood or willow)	2 (28.5)	2 (28.5)	0 (0.0)	0.251	N/A
Exotic (tamarisk)	1 (14.2)	1 (14.2)	5 (71.4)		
Mixed (native and exotic)	3 (42.8)	3 (42.8)	2 (28.5)		
Canopy Cover					
Less than 25%	0 (0.0)	0 (0.0)	4 (57.1)	0.014	NU<NS, WT
25–75%	3 (42.8)	1 (14.2)	2 (28.5)		
More than 75%	4 (57.1)	6 (85.7)	1 (14.2)		
Soil Moisture					
Mean soil moisture (mV)	660.3 (72.5)	727.3 (73.3)	666.1 (92.5)	0.608	N/A
Temperature					
Mean diurnal temperature (°C)	31.1 (0.3)	31.1 (0.6)	34.9 (1.2)	0.072	N/A
Mean no. of 15-min. intervals above 41°C each day	1.3 (0.9)	2.1 (1.3)	16.2 (3.7)	0.038	NU>NS, WT
Mean nocturnal temperature (°C)	25.9 (0.6)	25.8 (0.7)	16.2 (2.6)	0.883	N/A
Mean daily temperature range (°C)	16.9 (1.4)	17.4 (1.2)	25.2 (2.6)	0.047	NU>NS, WT
Humidity					
Mean diurnal relative humidity (%)	48.0 (2.3)	47.8 (2.3)	39.5 (2.5)	0.151	N/A
Mean diurnal vapor pressure (Pa)	2026.5 (113.0)	2024.9 (116.4)	1817.5 (88.8)	0.185	N/A
Mean nocturnal relative humidity (%)	54.4 (3.2)	54.6 (3.8)	51.9 (1.0)	0.876	N/A
Mean nocturnal vapor pressure (Pa)	1793.9 (132.0)	1791.6 (133.7)	1639.1 (108.9)	0.251	N/A

* Habitat and canopy cover variables are presented as n followed by % of column totals (in parentheses), while soil moisture and temperature/humidity values are means (standard error in parentheses).
N/A = data not available or not applicable.

INDIVIDUAL EFFECT OF PREDICTOR VALUES

The individual effect that location type, life history area, habitat type, and canopy cover had on microclimate measures across study areas in 2007 is presented in Tables 7.8–7.11. The NU sites were significantly different (lower soil moisture, hotter, lower humidity, less vapor pressure) from both NS and WT sites for most measures of temperature and humidity. All microclimate measures except soil moisture differed significantly between study areas in 2007, as would be expected given their different elevations, latitudes, and other environmental attributes (see Table 7.9). All temperature and humidity measures except nocturnal temperature differed significantly between habitat types (Table 7.10). Native habitats exhibited cooler diurnal temperatures and lower fluctuations in daily temperature, as well as lower humidity and vapor pressure compared to exotic habitats. Sites with the greatest canopy closure level (>75%) were significantly cooler and more humid during the daytime as compared to sites with less canopy closure (Table 7.11).

MULTIPLE EFFECTS MODELS

The logistic regression model initially included all of the variables found to have significant individual effects: canopy cover, diurnal and nocturnal temperature, daily temperature range, diurnal and nocturnal relative humidity, and soil moisture. The number of 15-minute intervals above 41°C each day, and diurnal and nocturnal vapor pressure, were found to be ≥90% correlated with another variable in the model and so were not included. The backward elimination process removed the variables in this order: canopy cover (P = 0.807), nocturnal relative humidity (P = 0.740), soil moisture (P= 0.687), diurnal temperature (P = 0.265), diurnal relative humidity (P = 0.357), and nocturnal temperature (P = 0.119). Only mean daily temperature range remained significant ($P < 0.05$) in the final model for NS vs. WT. Only diurnal relative humidity remained as a significant predictor for NS vs. NU.

DISCUSSION

Incorporating the matched nature of the NS, WT, and NU sites did not appear to affect the overall results. As in previous years, the NS sites were significantly different from the NU sites for almost all variables, in all life history areas: the NU sites were consistently drier, hotter, and less humid than NS sites. However, the NS and WT sites only differed in terms of mean daily temperature, and this difference was only seen when all life history areas were combined.

The 2006 multivariate model evaluated the relative contribution of microclimate variables (McLeod et al. 2007). In that analysis, daily temperature range and nocturnal temperature were the strongest predictors of NS vs. WT, although neither achieved statistical significance. When backward elimination was used in the 2007 analysis, only daily temperature range remained significant. This suggests the most important microclimate variable was not the absolute temperature per se, as much as the variability (i.e., range) of the temperature each day.

The multivariate model used in 2006 found that daily temperature range contributed the *least* in terms of predicting NS vs. NU. In the 2006 model, diurnal and nocturnal relative humidity and soil moisture were the significant predictors of flycatcher occupancy. When backward elimination was used in 2007, only diurnal relative humidity remained as a significant predictor for NS vs. NU.

Table 7.8. Southwestern Willow Flycatcher Microclimate Measures by Location Type for All Life History Areas, June–August, 2007*

Response Variable	Location Type			*P*	Significant Pairwise Differences
	Nest Site	Within Territory	Non-Use		
n (Temp./Humidity Sensor Arrays)	32	32	32		
Soil Moisture					
Mean soil moisture (mV)	759.5 (33.9)	755.3 (33.6)	582.2 (46.1)	0.022	NU<NS, WT
Temperature					
Mean diurnal temperature (°C)	29.4 (0.4)	29.7 (0.5)	33.0 (0.7)	<0.001	NU>WT, NS
Mean no. of 15-min. intervals above 41°C each day	1.8 (0.8)	2.8 (1.1)	12.6 (2.1)	<0.001	NU>NS
Mean nocturnal temperature (°C)	24.6 (0.3)	24.4 (0.3)	25.0 (0.4)	0.056	N/A
Mean daily temperature range (°C)	16.7 (0.7)	18.7 (0.8)	23.1 (1.3)	<0.001	NU>WT>NS
Humidity					
Mean diurnal relative humidity (%)	51.4 (2.0)	50.6 (2.0)	40.1 (2.0)	<0.001	NU<NS, WT
Mean diurnal vapor pressure (Pa)	1978.9 (89.9)	1964.0 (90.0)	1708.8 (86.7)	<0.001	NU<NS, WT
Mean nocturnal relative humidity (%)	57.0 (2.2)	57.7 (2.0)	52.8 (2.3)	0.036	NU<NS, WT
Mean nocturnal vapor pressure (Pa)	1734.2 (78.4)	1734.1 (75.3)	1594.6 (72.2)	0.001	NU<NS, WT

* All values are means (standard error in parentheses); N/A = data not available or not applicable.

Table 7.9. Southwestern Willow Flycatcher Microclimate Measures by Life History Area, June–August, 2007*

Response Variable	Study Area					*P*	Significant Pairwise Differences
	Pahranagat (PA)	Mesquite (MW)	Mormon Mesa (MM)	Topock (TM)	Muddy River (MD)		
n (Temp./Humidity Sensor Arrays)	30	30	9	6	21		
Soil Moisture							
Mean soil moisture (mV)	745.6 (25.9)	702.4 (50.5)	563.4 (81.9)	702.8 (149.8)	684.6 (44.3)	0.353	N/A
Temperature							
Mean diurnal temperature (°C)	27.2 (0.3)	31.6 (0.5)	34.3 (1.0)	32.4 (1.8)	32.4 (0.6)	<0.001	PA<MM, MD, TM, MW
Mean no. of 15-min. intervals above 41°C each day	0.9 (0.4)	6.2 (1.8)	17.3 (3.5)	7.3 (6.0)	6.5 (1.9)	<0.001	MM>MD, MW, PA
Mean nocturnal temperature (°C)	23.4 (0.3)	25.1 (0.2)	24.8 (1.2)	23.9 (1.4)	25.8 (0.4)	0.001	PA<MD, MW
Mean daily temperature range (°C)	17.5 (0.8)	19.2 (0.9)	25.3 (2.6)	21.4 (4.5)	19.9 (1.3)	0.021	PA<MM
Humidity							
Mean diurnal relative humidity (%)	44.5 (2.4)	53.1 (1.8)	35.5 (4.8)	58.6 (5.8)	45.1 (1.6)	<0.001	MM<TM MW>PA, MM
Mean diurnal vapor pressure (Pa)	1494.5 (75.1)	2186.9 (57.3)	1532.1 (202.8)	2590.4 (192.1)	1956.3 (62.4)	<0.001	TM>MD, MM, PA MW>MM, PA MD>PA
Mean nocturnal relative humidity (%)	48.2 (2.3)	62.6 (1.5)	52.5 (4.1)	72.3 (1.2)	53.6 (1.9)	<0.001	TM>MD, MM, PA MW>MD, PA
Mean nocturnal vapor pressure (Pa)	1343.4 (65.7)	1926.6 (44.2)	1590 (150.9)	2171.4 (209.0)	1741.6 (70.5)	<0.001	TM>MM, PA PA<MW, MD

* All values are means (standard error in parentheses); N/A = data not available or not applicable.

Table 7.10. Southwestern Willow Flycatcher Microclimate Measures by Habitat Type for All Life History Areas, June–August, 2007*

Response Variable	Habitat Type			*P*	Significant Pairwise Differences
	Native (Cottonwood or Willow)	Exotic (Tamarisk)	Mixed (Native and Exotic)		
n (Temp./Humidity Sensor Arrays)	42	26	21		
Soil Moisture					
Mean soil moisture (mV)	715.3 (25.3)	586.7 (55.0)	827.1 (39.1)	0.002	E<M
Temperature					
Mean diurnal temperature (°C)	28.3 (0.4)	33.4 (0.7)	30.8 (0.3)	<0.001	E>M>N
Mean no. of 15-min. intervals above 41°C each day	1.7 (0.6)	12.6 (2.4)	2.8 (1.1)	<0.001	E>M, N
Mean nocturnal temperature (°C)	24.1 (0.3)	25.0 (0.5)	24.9 (0.4)	0.198	N/A
Mean daily temperature range (°C)	17.5 (0.6)	23.0 (1.5)	18.1 (1.1)	0.001	E>M, N
Humidity					
Mean diurnal relative humidity (%)	46.8 (1.8)	44. (2.9)	53.3 (2.0)	0.088	N/A
Mean diurnal vapor pressure (Pa)	1693.7 (74.4)	1923.9 (119.4)	2174.3 (61.8)	0.003	N<M
Mean nocturnal relative humidity (%)	51.1 (1.8)	58.0 (2.4)	60.9 (2.5)	0.008	N<M
Mean nocturnal vapor pressure (Pa)	1497.5 (61.6)	1792.5 (90.5)	1871.7 (67.7)	0.001	N<M, E

* All values are means (standard error in parentheses); N/A = data not available or not applicable. N = native; E = exotic; M = mixed.

Table 7.11. Southwestern Willow Flycatcher Microclimate Measures by Canopy Closure for All Life History Areas, June–August, 2007*

Response Variable	Canopy Closure Categories			*P*	Significant Pairwise Differences
	<25%	25–75%	>75%		
n (Temp./Humidity Sensor Arrays)	17	39	40		
Soil Moisture					
Mean soil moisture (mV)	550.7 (71.6)	723.1 (32.9)	738.5 (31.6)	0.011	LT25<GT75, 25-75
Temperature					
Mean diurnal temperature (°C)	34.8 (1.1)	30.4 (0.4)	29.2 (0.4)	<0.001	LT25>GT75, 25-75
Mean no. of 15-min. intervals above 41°C each day	18.2 (3.0)	4.2 (1.1)	22.3 (20.7)	<0.001	LT25<GT75 , LT25>25-75
Mean nocturnal temperature (°C)	25.3 (0.6)	24.5 (0.3)	24.4 (0.3)	0.419	N/A
Mean daily temperature range (°C)	25.5 (1.8)	19.1 (0.9)	17.2 (0.6)	<0.001	LT25>GT75, 25-75
Humidity					
Mean diurnal relative humidity (%)	39.3 (2.4)	50.4 (2.0)	48.5 (1.8)	0.009	LT25<GT75, 25-75
Mean diurnal vapor pressure (Pa)	1779.1 (96.2)	1992.2 (87.2)	1841.7 (77.4)	0.223	N/A
Mean nocturnal relative humidity (%)	54.4 (2.5)	58.4 (2.0)	54.3 (2.0)	0.258	N/A
Mean nocturnal vapor pressure (Pa)	1668.9 (75.7)	1764.1 (72.3)	1632.8 (67.7)	0.327	N/A

* All values are means (standard error in parentheses); N/A = data not available or not applicable. LT = less than; GT = greater than.

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, this document Chapters 2 and 3). 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. The high degree to which willow flycatchers are associated with standing water can also be seen by correlating flycatcher habitat occupancy and breeding patterns with the presence/absence of standing water at Bill Williams and Bunker Farm at Mesquite, with flycatchers breeding only in years when sites contained standing water (this document Chapters 2 and 3).

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 (Lower Colorado River Multi-Species Conservation Program 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 are presently considered potentially suitable for willow flycatcher (USFWS 2001:47). Reclamation (2000) estimated that implementation of the SIAs will cause a drop in floodplain groundwater levels of 1.55 feet (0.47 m) or less. As a result, 372 acres (151 ha) of occupied[1] Southwestern Willow Flycatcher habitat could lose their moist soils. This loss 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. These changes may 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, 3-year study (2005–2007) 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 372 acres (151 ha) of currently occupied Southwestern Willow Flycatcher habitat between Parker and Imperial Dams to determine how microclimate, vegetation, and groundwater conditions might be affected by the SIAs water transfer actions. An additional objective was to compare microclimate characteristics of sites in the Parker to Imperial reach with those at flycatcher breeding areas. This chapter reports the results of this study.

METHODS

In 2005, we selected a subset of sites that are currently surveyed 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 are 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. We monitored the same 15 sites in 2007 that were monitored in 2005 and 2006. In August of 2006, we initiated habitat monitoring within a consistently occupied breeding site at Topock Marsh to obtain groundwater levels and patterns with which we can compare results obtained at the habitat monitoring sites.

TEMPERATURE/HUMIDITY (T/RH) LOGGERS

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.

[1] As per the USFWS, occupied Southwestern Willow Flycatcher habitat is defined as patches of vegetation that are similar to and contiguous with areas where willow flycatchers were detected after 15 June.

All loggers collected data at 15-minute intervals and were placed in inverted plastic containers and camouflaged as described in Chapter 7. All 60 logger locations selected in 2005 were retained in 2006. Two additional data loggers were installed in the Topock Marsh monitoring site in August 2006. A portion of Gila Confluence North, one of the control sites below Imperial Dam, burned in December 2006. All vegetation at one HOBO location was killed by the fire, and vegetation at another HOBO location was also dramatically altered. These two HOBOs were replaced in May 2007 with HOBOs at new locations within unburned portions of the site. Categorical data on percent canopy closure and habitat type were collected in 2005 when data loggers were deployed and again during May 2007. More detailed quantification of canopy closure and vegetation composition was completed as part of vegetation measurements in 2005, 2006, and 2007 (see below).

SOIL MOISTURE (SM) MEASUREMENTS

Soil moisture beneath each HOBO logger was measured and recorded using a hand-held ThetaProbe ML2x coupled to an HH2 Moisture Meter Readout (Macaulay Land Use Research Institute, Aberdeen, UK, and Delta-T Devices, Cambridge, UK, respectively). Soil moisture measurements were collected during each of approximately 10 presence/absence surveys between 15 May and 25 July and when HOBO data were downloaded. Soil moisture measurements were recorded directly beneath the HOBO logger and at estimated 1.0-m intervals at 1.0 and 2.0 m in each cardinal direction for a total of nine measurements per location. Soil moisture readings were recorded in mV and percent volume, as described in Chapter 7. Each time soil moisture readings were taken at a site, we also recorded the nearest distance to inundated or saturated soil. Distances were estimated visually in the field or measured either with a GPS unit or from high-resolution aerial photographs.

VEGETATION MEASUREMENTS

We completed vegetation measurements, following the methods described in Chapter 6, at each HOBO location after flycatcher surveys were completed in late July. All HOBO loggers were also downloaded at this time. Vegetation measurements were completed at the same locations and following the same methods as in 2005 and 2006, with the exception of Gila Confluence North, where vegetation measurements were collected at the two new HOBO locations instead of at the burned locations.

GROUNDWATER MEASUREMENTS

A small-diameter shallow well, or piezometer, was installed in May–August 2005 near each of the 15 sites selected for habitat monitoring to monitor groundwater levels. These 15 piezometers are described in Koronkiewicz et al. (2006a) and were initially downloaded in August–September 2005. Piezometers have been collecting water level data every hour since installation. One additional piezometer was installed at Topock Marsh in 2006. A new piezometer was installed at the Gila Confluence North monitoring site in July 2007 to replace the original station, which was damaged in a local brush fire.

PIEZOMETER INSTALLATION

The installation of the Gila Confluence North replacement piezometer (discussed below in Results) employed the same installation process as described in previous reports.

DATA COLLECTION

A pressure transducer/data logger (mini-Troll Standard-P, 5psi, manufactured by In-Situ Corporation) collected data at each piezometer. These devices measure and record pressure of the water column present in the well, and these pressure measurements are then easily converted into water levels (in distance below 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.

During the initial installation of the pressure transducers, as well as at each data download thereafter, water levels were measured 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 can be corrected when the water levels in the piezometer come back into equilibrium with water levels in the aquifer. In areas where there are tight, clayey soils, there can be a slight discrepancy between the pressure transducer measurement of water levels and actual water levels. This discrepancy can be adjusted with a simple correction.

We obtained additional hydrologic data from the U.S. Geological Survey (USGS) regarding streamflow and stage height in the Colorado River at several gages: Colorado River below Parker Dam (09427520), Colorado River below Palo Verde Dam (09429010), Colorado River below Imperial Dam (09429500), and Colorado River below Laguna Dam (09429600). 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 and Imperial Dams.[2] Our goal was to define the relationship between the water levels in the piezometers and operation of the reservoirs on the Colorado River.

STATISTICAL 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

[2] Because hydrologic data are generally collected and presented in English units, hydrologic data within this chapter are in English, rather than metric, units.

- Mean distance to saturated/inundated soil
- Mean diurnal temperature
- Mean number of 15-minute intervals above 41°C each day
- Mean nocturnal temperature
- Mean daily temperature range (diurnal maximum minus nocturnal minimum)
- Mean diurnal relative humidity
- Mean diurnal vapor pressure
- Mean nocturnal relative humidity
- 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 (2007).

These values were then calculated for all sites combined and compared to the same values for within-territory (WT; see Chapter 7) locations at the Topock Marsh life history breeding area combined with three SVR locations and two sensors placed near the piezometer at Topock Marsh, all of which were within 50 m of a territory center. These analyses were restricted to 6 May–31 July 2007, the dates during which microclimate data were collected both within territories at Topock and at habitat monitoring locations. We chose within-territory locations (rather than nest or non-use locations) because these represent locations within flycatcher breeding areas that were chosen using the same random number techniques that were used for locations at habitat monitoring sites. Chi-square (χ^2) tests were used to test for significant differences in the proportion of habitat types and canopy cover. One-way ANOVA tests were used to test the difference in means for the T/RH and SM values.

We assigned all plots as a control site (above Parker Dam or below Imperial Dam) or as a test site (between Parker and Imperial), then analyzed between-year differences in T/RH and SM values within these two groups using paired t-tests. We then analyzed the between-year differences among the test sites compared to the control sites using one-way repeated measures ANOVA. These analyses were restricted to 1 June–1 August. Analyses were conducted using SAS® Version 9.1 (SAS Institute 2003).

VEGETATION

We analyzed the between-year differences among the test sites compared to the control sites using one-way repeated measures ANOVA. These analyses and all descriptive statistics were produced using SPSS® Version 15.0 (SPSS Inc.) software.

GROUNDWATER LEVELS

We examined the following correlations between piezometer levels and reservoir operations: 1) correlation of the Havasu NE and Blankenship Bend piezometers (control sites) with Lake Havasu water levels; and 2) correlation of the 11 test site piezometers between Parker and Imperial Dams (Ehrenberg, Cibola Lake, Three Fingers Lake, Walker Lake, Paradise, Hoge

Ranch, Rattlesnake, Clear Lake, Ferguson Wash, Ferguson Lake, and Great Blue Heron) with releases (in cubic feet per second, or cfs) from Parker Dam, which largely regulates streamflow in the lower Colorado River between Parker and Imperial Dams.

Groundwater fluctuations under potential flycatcher habitat are expected to be tied most closely to the water level, or stage, rather than to the streamflow of the Colorado River. The relationship between stage and streamflow is not necessarily linear; however, initial analyses from 2005 indicate it is close enough to a linear relationship to allow a very close match between Parker releases and piezometer water levels. To account for the travel time of river water from Parker Dam, several regression analyses were conducted with time lags varying from zero to four days.

We examined monthly river flow data from below Parker Dam from 2000 to 2007 to determine whether there has been a decrease in water levels since the scheduled implementation of the change in point of diversion from Imperial Dam to above Parker Dam.

Reclamation (2000) estimated the expected change in river stage between Parker and Imperial Dams that would result from a 400,000 acre-foot reduction in releases from Parker Dam. SWCA developed regression equations correlating average daily gage height at the USGS gage below Parker Dam to average daily piezometer water levels for data collected from May 2005 through August 2006. Using the estimated decreases in river stage and these regression equations, we estimated the corresponding decrease in water levels that would be expected at each habitat polygon.

In addition to correlating piezometer levels with reservoir operations, we used linear regression to examine potential relationships between average daily piezometer level and average daily soil moisture. These analyses were conducted using the built-in analysis functions of Microsoft Excel. Daily averages for water levels, humidity, temperature, and locational and daily averages for soil moisture were also calculated using Microsoft Access and Microsoft Excel.

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.

Piezometer water levels were also compared to ground surface to determine whether any inundation or standing water was observed at the piezometer locations.

Groundwater fluctuations are the reflection of various inflows or outflows from the shallow aquifer system below the habitat. Longer-term fluctuations, on the weekly or seasonal scale, are mostly linked to variation in reservoir releases and flow in the Colorado River. Shorter-term fluctuations, those that take place over the course of a single day, are the result of the removal of water from the shallow aquifer through evapotranspiration by riparian habitat. The magnitude of these fluctuations can potentially be used to estimate changes in vegetation density or vegetation cover over time. The magnitude of the daily evapotranspiration signature was calculated from the difference between the minimum and maximum water levels that occured during each given day, and the median of the daily results was calculated for each month during 2006 (the first full season of data). These data will provide a baseline from which to monitor future increases or decreases in evapotranspiration, which will be compared to actual field measurements of vegetation density or cover.

RESULTS

HOBO LOGGER MAINTENANCE

HOBO loggers have been downloaded three times per year since installation. At each download, we examine the data to determine if there are any problems with data logger function. Data loggers are replaced whenever a potential problem with the sensors is detected. Battery level is also checked at each download, and the battery is replaced if needed.

PIEZOMETER INSTALLATION AND MAINTENANCE

Table 8.1 lists details on installation parameters and median depth to water for all piezometers. Data from all 15 original piezometers were downloaded in December 2005, June and September 2006, and February, July, and August of 2007. Three pressure transducers temporarily failed to collect water levels: Ferguson Wash and Paradise lost approximately three weeks of data due to battery failure, and Ehrenberg lost approximately two months of data due to a setup error.

Table 8.1. Summary of Piezometer Construction and Data Collection at Habitat Monitoring Sites, Lower Colorado River, 2005–2007*

Site	Depth (ft)	Stickup height (ft)	Date installed	Median depth (ft bgs) to water			Distance (ft) from habitat
				Aug 2005	Aug 2006	Aug 2007	
Topock Marsh	INA	2.5	13-Aug-06	N/A	N/A	2.02	Within
Blankenship Bend	7.2	3.4	28-Aug-05	2.86	2.58	4.56	Within
Havasu NE	6.1	2.2	09-May-05	1.77	2.00	1.18	Within
Ehrenburg	7.4	2.6	29-Aug-05	2.01	1.98	N/A	Within
Three Fingers Lake	7.7	4.1	31-May-05	3.03	3.38	3.26	540
Cibola Lake	7.2	3.4	30-May-05[1]	3.12	3.68		Within
Walker Lake	7.4	2.9	30-May-05	1.41	5.05	5.803	230
Paradise	11.7	0.6	11-May-05	5.5	5.32	5.383	Within
Hoge Ranch	8.7	2.8	11-May-05	3.11	3.30	3.291	Within
Rattlesnake	7.0	2.8	10-May-05	2.41	1.76	0.075	1,080
Clear Lake	8.7	2.4	10-May-05	2.71	2.41	2.474	Within
Ferguson Lake	7.6	2.7	10-May-05	2.27	1.86	1.881	Within
Ferguson Wash	INA	2.2	10-May-05	1.93	1.66	2.42	Within
Great Blue Heron	7.3	1.7	31-May-05	2.28	1.69	1.78	60
Mittry West	5.0	3.0	29-Aug-05	2.77	1.85	0.72	270
Gila Confluence North	7.9	2.7	29-Aug-05[2]	4.32	4.98	N/A	50

* INA = information not available, N/A = not applicable, bgs = below ground surface.
[1] Piezometer destroyed by clearing activity between February and July 2007.
[2] Location of original piezometer burned in December 2006; piezometer replaced on 5 July 2007.

Two events occurred since the 2006 field season that disrupted data collection. A brush fire destroyed the aboveground portion of the piezometer at Gila Confluence North in December 2006. As a result, data were not downloaded during the February 2007 visit because field personnel did not have the tools necessary to cut into the piping and gain access to the pressure transducer data port. All data, which were unaffected by the fire, were recovered from the data logger in July 2007. A replacement piezometer was installed approximately 0.1 mile north of the original location in July 2007. This station used the original pressure transducer, which was not damaged in the fire; however, a replacement cable was installed.

Upon arrival to the Cibola Lake piezometer in July, we discovered that the area surrounding it had been cleared and bulldozed, and no trace of the piezometer could be located. Consequently no groundwater level data has been retrieved from this site since the February download. No replacement station install has occurred as of the writing of this report.

MICROCLIMATE

2007 MICROCLIMATE DESCRIPTIVE STATISTICS

Soil moisture, temperature, relative humidity, and vapor pressure parameters from the 15 study sites monitored in 2007 exhibited substantial variation among sites (Table 8.2). Soil moisture varied by a factor of six among the 2007 study sites, from a low of 168.9 mV at Havasu NE to a high of 985.1 at Blankenship Bend. Mean diurnal temperatures ranged from a low of 29.1^{o}C at Rattlesnake to a high of 37.3^{o}C at Cibola Lake. Mean number of 15-minute intervals above 41^{o}C each day varied from 2.5 at Rattlesnake to 48.8 at Cibola Lake. Mean nocturnal temperatures ranged from a low of 21.9^{o}C again at Rattlesnake to a high of 26.8^{o}C at Ferguson Wash. Mean daily temperature range varied from 21.8^{o}C at Rattlesnake to 36.2^{o}C at Three Fingers Lake.

Mean diurnal relative humidity ranged from 25.6% at Cibola Lake to 58.1% at Rattlesnake. Mean diurnal vapor pressure was lowest at Cibola Lake (1,221.1 Pa) and highest at Rattlesnake (2,252.0 Pa). Mean nocturnal vapor pressure was lowest at Blankenship Bend (1,284.0 Pa) and highest at Rattlesnake (1,906.1 Pa).

BETWEEN-YEAR COMPARISONS OF MICROCLIMATE CHARACTERISTICS

On average, temperature and humidity at habitat monitoring sites increased from 2005 to 2006 then decreased from 2006 to 2007 (Table 8.3). Soil moisture and daily temperature range showed the reverse trend, decreasing from 2005 to 2006 and increasing in 2007. These changes between 2005, 2006, and 2007 were the same for test sites versus controls (right-most column of Table 8.3), except for soil moisture: the decrease in soil moisture between 2005 and 2006, and the increase in 2007, was greater at control sites than at test sites.

Table 8.2. Microclimatic Data Summaries Collected From Habitat Monitoring Sites, Lower Colorado River, May–July **2007***

Descriptive Statistics	Blankenship Bend	Havasu NE	Ehrenberg	Three Fingers Lake	Cibola Lake	Walker Lake	Paradise	Hoge Ranch	Rattlesnake	Clear Lake	Ferguson Lake	Ferguson Wash	Great Blue Heron	Mittry West	Gila Confluence North
Soil Moisture															
Mean soil moisture (mV)	985.1 (10.2)	168.9 (14.1)	622.3 (40.8)	462.3 (34.0)	381.7 (36.1)	929.7 (8.6)	714.8 (36.4)	906.1 (11.1)	854.0 (19.6)	471.9 (57.4)	933.3 (8.5)	189.5 (16.1)	906.1 (4.8)	906.5 (9.8)	544.7 (51.3)
Temperature/Humidity															
Mean diurnal temperature (°C)	35.2 (0.1)	33.8 (0.1)	35.8 (0.1)	36.6 (0.2)	37.3 (0.1)	31.6 (0.2)	33.2 (0.1)	32.6 (0.1)	29.1 (0.1)	30.3 (0.1)	32.2 (0.1)	34.2 (0.2)	30.4 (0.1)	32.6 (0.1)	33.9 (0.2)
Mean no. of 15-min. intervals above 41°C each day	39.1 (1.3)	23.0 (1.1)	31.4 (0.9)	46.8 (1.1)	48.8 (1.0)	12.5 (0.8)	25.2 (1.1)	12.8 (0.4)	2.5 (0.1)	6.4 (0.5)	16.6 (0.8)	27.0 (1.1)	10.8 (0.6)	20.7 (0.9)	22.0 (0.9)
Mean nocturnal temperature (°C)	24.5 (0.2)	24.8 (0.2)	25.2 (0.2)	23.8 (0.2)	25.3 (0.1)	23.6 (0.2)	24.7 (0.1)	24.6 (0.2)	21.9 (0.2)	24.2 (0.1)	26.0 (0.1)	26.8 (0.2)	22.9 (0.1)	23.9 (0.1)	22.6 (0.2)
Mean daily temperature range (°C)	32.3 (0.3)	27.7 (0.4)	29.7 (0.3)	36.2 (0.3)	33.2 (0.3)	26.2 (0.5)	29.1 (0.5)	26.6 (0.4)	21.8 (0.3)	23.5 (0.3)	24.2 (0.3)	28.5 (0.5)	26.4 (0.3)	28.3 (0.3)	32.4 (0.3)
Mean diurnal relative humidity (%)	29.3 (0.4)	31.3 (0.4)	26.7 (0.3)	29.9 (0.5)	25.6 (0.3)	43.4 (0.6)	37.3 (0.4)	41.3 (0.5)	58.1 (0.6)	45.5 (0.7)	41.1 (0.4)	37.2 (0.4)	46.3 (0.5)	39.5 (0.4)	38.2 (0.3)
Mean diurnal vapor pressure (Pa)	1,285.6 (28.7)	1,488.0 (26.0)	1,321.8 (26.8)	1,277.6 (28.0)	1,221.1 (25.5)	1,742.1 (49.8)	1,602.4 (30.4)	1,766.6 (37.9)	2,252.0 (41.8)	1,855.8 (41.2)	1,731.5 (29.3)	1,648.8 (32.5)	1,862.3 (36.9)	1,673.2 (31.4)	1,653.7 (32.3)
Mean nocturnal relative humidity (%)	43.0 (0.6)	41.2 (0.5)	44.3 (0.5)	46.5 (0.5)	44.1 (0.4)	54.6 (0.8)	49.3 (0.5)	51.9 (0.5)	70.2 (0.6)	50.5 (0.6)	49.9 (0.4)	39.8 (0.5)	57.5 (0.5)	49.8 (0.4)	54.6 (0.4)
Mean nocturnal vapor pressure (Pa)	1,284.0 (28.7)	1,308.3 (24.4)	1,389.0 (25.5)	1,321.6 (24.0)	1,382.5 (22.8)	1,557.5 (39.1)	1,505.6 (26.6)	1,610.3 (32.8)	1,906.1 (32.7)	1,556.5 (34.3)	1,663.3 (25.6)	1,363.0 (28.6)	1,654.1 (28.9)	1,492.4 (27.7)	1,511.7 (28.4)

* Soil moisture and temperature/humidity values are means (standard error in parentheses).

Table 8.3. Change in Microclimatic Variables at Habitat Monitoring Sites from 2005 to 2007*

Parameter	Test (n = 42)						Control (n = 13)						P-value for difference in means between years among test sites compared to control sites[1]
	2005	2006	2007	Change 2005 to 2006	Change 2006 to 2007	P-value for the difference between years	2005	2006	2007	Change 2005 to 2006	Change 2006 to 2007	P-value for the difference between years	
Soil Moisture													
Mean soil moisture (mV)	650.3	622.7	659.1	-27.6	36.4	0.288	697.3	620.1	635.2	-77.2	15.1	0.004	0.003
Temperature/Humidity													
Mean diurnal temperature (°C)	33.7	36.1	34.0	2.4	-2.1	0.007	34.0	36.8	34.5	2.8	-2.3	<0.001	0.589
Mean no. of 15-min. intervals above 41°C each day	14.9	17.1	15.3	2.2	-1.8	0.265	14.8	19.8	16.4	5.0	-3.4	0.002	0.456
Mean nocturnal temperature (°C)	25.7	28.7	25.1	3.0	-3.6	<0.001	25.2	28.4	24.9	3.2	-3.5	<0.001	0.739
Mean daily temperature range (°C)	24.5	21.4	25.3	-3.1	3.9	0.040	24.5	23.7	26.9	-0.8	3.2	<0.001	0.242
Mean diurnal relative humidity (%)	40.2	45.2	38.9	5.0	-6.3	0.231	35.8	38.8	35.1	3.0	-3.7	<0.001	0.972
Mean diurnal vapor pressure (Pa)	1,749.2	2,306.5	1,671.2	557.3	-635.3	0.016	1,623.3	2,038.7	1,593.2	415.4	-445.5	0.061	0.605
Mean nocturnal relative humidity (%)	51.4	55.5	50.6	4.1	-4.9	0.467	49.1	49.9	46.9	0.8	-3.0	0.008	0.980
Mean nocturnal vapor pressure (Pa)	1,639.4	2,102.4	1,567.0	463.0	-535.4	0.004	1,546.2	1,858.1	1,452.2	311.9	-405.9	<0.001	0.299

* The analysis was restricted to 6/1-8/1 each year.

COMPARISON OF PARKER/IMPERIAL TO TOPOCK: MICROCLIMATE

All microclimate parameters were significantly different between Topock Marsh and the habitat monitoring sites except for mean diurnal and nocturnal temperature (Table 8.4). On average, Topock was cooler and exhibited higher soil moisture and higher diurnal and nocturnal relative humidity and vapor pressure than habitat monitoring sites.

Table 8.4. Comparison of Microclimatic Variables at Habitat Monitoring Sites to Within-Territory Locations at the Topock Marsh Life History Study Area, 2007*

Response Variable	Habitat Monitoring Sites	Topock Marsh WT	P^1
N (Temp./Humidity Sensor Arrays)	54	9[2]	N/A
Mean soil moisture (mV)	662.5 (42.6)	903.5 (10.7)	0.035
Mean diurnal temperature (°C)	32.3 (0.5)	29.6 (0.7)	0.062
Mean no. of 15-min. intervals above 41°C each day	13.3 (1.4)	1.6 (0.9)	0.001
Mean nocturnal temperature (°C)	22.5 (0.4)	23.3 (0.9)	0.435
Mean daily temperature range (°C)	27.5 (0.8)	19.8 (1.3)	<0.001
Mean diurnal relative humidity (%)	35.9 (1.2)	59.5 (1.3)	<0.001
Mean diurnal vapor pressure (Pa)	1,370.9 (40.8)	2,428.9 (148.6)	<0.001
Mean nocturnal relative humidity (%)	49.4 (1.2)	70.8 (01.4)	<0.001
Mean nocturnal vapor pressure (Pa)	1,309.0 (28.3)	2,073.8 (131.1)	<0.001

* Soil moisture and temperature/humidity values are means (standard error in parentheses). N/A = data not available or not applicable.
[1] For the significance testing, the analysis was restricted to the dates when monitoring occurred at both habitat monitoring sites and within-territory locations at Topock: 5/6/07–7/31/07.
[2] This includes 4 WT sensors, 3 SVR sensors, and 2 sensors placed near the piezometer.

VEGETATION MEASUREMENTS

Vegetation characteristics varied widely both between and within the selected habitat monitoring sites (Table 8.5). Average canopy height ranged from 3.7 m (Three Fingers Lake) to 10.3 m (Paradise), and average canopy closure ranged from 66.0% (Ehrenberg) to 96.0% (Clear Lake). Measures of other habitat characteristics were similarly variable. Vertical foliage profiles for each site are shown in Figure 8.1. Sites typically exhibited the densest foliage within 4 m of the ground.

Table 8.5. Summary of Vegetation Characteristics at Habitat Monitoring Sites, Lower Colorado River, 2007*

Parameter	Blankenship Bend (n=4)	Havasu NE (n=4)	Ehrenberg (n=4)	Cibola Lake (n=5)	Three Fingers Lake (n=5)	Walker Lake (n=3)	Paradise (n=4)	Hoge Ranch (n=4)	Rattlesnake (n=4)	Clear Lake (n=3)	Ferguson Lake (n=5)	Ferguson Wash (n=4)	Great Blue Heron (n=4)	Mittry West (n=4)	Gila Confluence North (n=3)
Average canopy height (m)	6.7 (1.6)	5.7 (0.5)	6.0 (3.0)	4.1 (1.0)	3.7 (0.4)	5.0 (1.3)	10.3 (3.1)	4.1 (0.6)	7.2 (1.9)	7.0 (0.0)	4.4 (0.2)	4.5 (0.3)	8.8 (0.5)	8.3 (1.0)	6.7 (0.5)
	4.2-10.8	4.6-6.9	2.5-15.0	3.0-8.0	3.0-5.0	3.5-7.5	4.0-16.0	3.1-5.5	5.2-11.0	7.0-7.0	4.0-5.0	4.0-5.0	7.5-10.0	6.0-10.0	6.0-7.6
% total canopy closure	91.5 (2.4)	80.3 (8.5)	66.0 (4.0)	80.2 (9.6)	83.6 (6.3)	90.7 (3.8)	94.0 (1.6)	87.3 (2.1)	93.3 (1.1)	96.0 (2.0)	93.2 (2.7)	92.0 (2.5)	94.8 (2.0)	94.3 (1.1)	74.0 (5.0)
	86.0-96.0	55.0-92.0	60.0-77.0	43.0-96.0	59.0-93.0	85.0-98.0	90.0-98.0	82.0-91.0	90.0-95.0	94.0-100.0	84.0-99.0	85.0-97.0	90.0-98.0	91.0-96.0	68.0-84.0
% woody ground cover	60.5 (16.4)	34.8 (8.6)	15.0 (6.8)	37.2 (14.3)	9.0 (3.7)	28.7 (10.9)	64.8 (17.8)	26.8 (8.2)	31.0 (3.9)	18.0 (7.1)	45.4 (22.3)	37.3 (4.6)	13.0 (6.6)	31.0 (10.8)	32.7 (24.2)
	20.0-90.0	13.0-49.0	6.0-35.0	12.0-91.0	2.0-21.0	8.0-45.0	15.0-100.0	9.0-48.0	23.0-39.0	9.0-32.0	7.0-100.0	28.0-50.0	2.0-32.0	6.0-56.0	6.0-81.0
Distance (m) to nearest standing water or saturated soil	19.1 (17.0)	68.8 (12.0)	52.5 (11.8)	72.0 (14.3)	132.0 (24.0)	46.7 (3.3)	60.0 (11.4)	17.3 (9.3)	58.8 (23.8)	38.3 (16.9)	19.2 (6.8)	70.0 (14.7)	136.3 (16.5)	267.5 (24.2)	61.7 (14.8)
	0.0-70.0	50.0-100.0	20.0-70.0	30.0-110.0	60.0-200.0	40.0-50.0	30.0-85.0	6.0-45.0	0.0-100.0	5.0-60.0	4.0-40.0	40.0-100.0	100.0-175.0	225.0-325.0	40.0-90.0
Distance (m) to nearest canopy gap	1.4 (0.7)	2.9 (1.3)	1.3 (0.4)	1.4 (0.4)	5.1 (1.8)	3.3 (0.9)	3.1 (1.0)	0.4 (0.2)	3.8 (1.9)	3.3 (1.2)	13.8 (4.5)	6.5 (1.4)	3.6 (1.3)	5.6 (0.4)	1.0 (0.5)
	0.0-2.5	1.4-6.8	0.0-2.0	0.0-2.0	0.0-11.0	2.0-5.0	0.2-5.0	0.0-1.0	0.2-7.0	1.0-5.0	1.0-20.0	3.0-10.0	1.0-6.6	4.7-6.4	0.5-2.0
Distance (m) to nearest broadleaf tree	10.5 (5.5)	3.2 (1.9)	0.6 (0.3)	187.2 (135.2)	349.0 (108.6)	12.0 (5.7)	25.1 (10.4)	25.5 (24.8)	1.3 (0.6)	211.5 (81.5)	13.4 (3.8)	6.5 (5.3)	8.1 (4.2)	2.5 (0.6)	0.7 (0.2)
	0.0-25.0	0.0-8.7	0.0-1.5	10.0-726.0	76.0-729.0	1.0-20.0	2.5-50.0	0.5-100.0	0.0-2.5	130.0-293.0	4.0-25.0	0.0-22.0	0.5-20.0	1.0-4.0	0.5-1.0
# shrub/sapling stems within 5-m radius of plot center	52.3 (8.3)	17.5 (1.8)	49.8 (16.2)	69.2 (7.5)	93.4 (9.1)	57.0 (2.1)	59.5 (24.9)	80.5 (16.0)	47.8 (5.1)	40.0 (4.2)	51.6 (13.6)	49.8 (3.0)	65.3 (21.5)	56.5 (20.0)	62.3 (22.7)
	31.0-66.0	15.0-23.0	23.0-93.0	54.0-91.0	69.0-119.0	54.0-61.0	17.0-131.0	40.0-114.0	38.0-58.0	34.0-48.0	8.0-82.0	44.0-58.0	20.0-118.0	14.0-103.0	17.0-85.0
# tree stems within 11.3-m radius of plot center	4.8 (1.6)	28.5 (4.3)	5.3 (0.7)	8.2 (3.3)	1.2 (0.5)	4.7 (3.3)	9.0 (4.1)	7.5 (1.0)	17.0 (3.5)	20.7 (6.1)	9.8 (2.8)	15.3 (4.3)	31.5 (4.7)	11.0 (3.2)	17.7 (4.3)
	2.0-8.0	22.0-41.0	4.0-6.0	0.0-19.0	0.0-2.0	0.0-11.0	0.0-17.0	5.0-10.0	10.0-26.0	11.0-32.0	2.0-19.0	9.0-28.0	21.0-43.0	4.0-17.0	12.0-26.0

* Data presented for continuous variables are means, (standard error), and range.

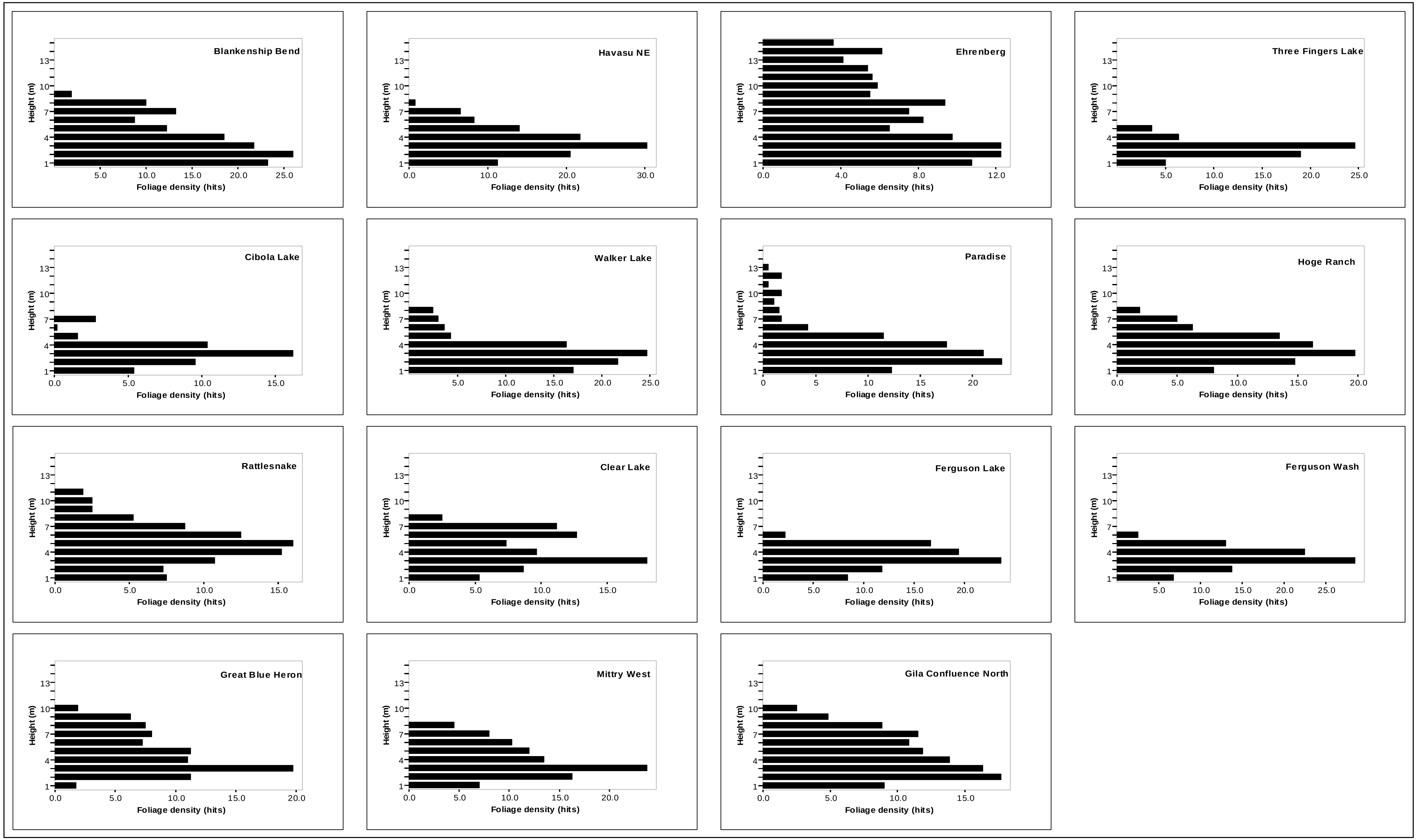

Figure 8.1. Vertical foliage profiles for each habitat monitoring site, lower Colorado River, 2007.

Between-year Comparisons of Vegetation Characteristics

Average values of canopy height, canopy closure, woody ground cover, distance to water, distance to canopy gap, distance to broadleaf tree, total shrub stem count, and total tree stem count for both test and control sites by year are shown in Table 8.6. Repeated measures ANOVA comparing these variables between years showed an overall between-year difference in canopy closure ($F_{2,55}$ = 9.7, P < 0.001), woody ground cover ($F_{2,54}$ = 3.5, P = 0.037), distance to water ($F_{2,55}$ = 6.4, P = 0.003), and tree counts ($F_{2,53}$ = 10.0, P < 0.001) for all plots combined. There were no significant interactions between canopy closure or tree counts and location (test vs. control sites), meaning the change in these variables between years among test sites was not significantly different from the change at control sites. There was a significant interaction between year and location for woody ground cover ($F_{2,54}$ = 7.5, P = 0.001) and distance to water ($F_{2,55}$ = 5.6, P = 0.006). Distance to water increased at control sites between 2005 and 2006, while it did not change at test plots across years. 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 years.

Repeated measures ANOVAs for vertical foliage in each meter interval showed significant between-year differences for the first, second, third, fourth, sixth, and ninth meter intervals above the ground. In all cases, foliage density was lowest in 2007. There was a significant interaction between vertical foliage density and location (test vs. control sites) for the first, second, fourth, and fifth meter intervals. In all cases, vertical foliage density decreased more at the test plots than at the control plots.

Groundwater Monitoring

Overview of Piezometer Water Levels

At least two full years of data have been collected at 15 of the 16 piezometers (excluding Topock Marsh, which has only one full year of data). Data collected after fall 2005 are relatively complete; however, Great Blue Heron and Cibola each experienced a recording error between August and December of 2005, and Paradise had no data between May and July of 2006. Gila Confluence North experienced a recording error in July and August of 2007, after it was reinstalled. Paradise, Ferguson Lake, and Ferguson Wash had data loss due to battery failure for less than one month, starting in early August 2007.

The piezometer hydrographs generally exhibit some common characteristics. Two general trends, a weekly trend and a daily cycle, are apparent. Water levels were lowest during the afternoon hours and on weekends, while high water was observed in early morning hours and in the middle of the week.

Table 8.6. Annual Means of Vegetation Characteristics at Plots between Parker and Imperial Dams (Test Sites) and Plots above Parker or below Imperial (Control Sites), 2005–2007

Parameter	Test			Control			P-value for overall difference in means between years	P-value for difference in means between years among test sites compared to control sites
	2005	2006	2007	2005	2006	2007		
Average canopy height (m)	6.6	7.0	5.8	6.6	7.0	6.8	0.696	0.199
% total canopy closure	84.7	78.3	87.9	80.8	76.9	85.7	<0.001	0.788
% woody ground cover	31.1	27.3	30.0	24.4	46.7	40.2	0.037	0.001
Distance (m) to nearest standing water or saturated soil	63.8	72.1	65.6	59.5	102.8	107.1	0.003	0.006
Distance (m) to nearest canopy gap	8.1	5.3	4.1	2.7	2.4	2.8	0.178	0.078
Distance (m) to nearest broadleaf tree	53.1	55.0	79.7	5.2	4.1	4.4	0.637	0.385
# shrub/sapling stems within 5-m radius of plot center	51.9	55.7	61.6	38.6	55.4	46.1	0.299	0.769
# tree stems within 11.3-m radius of plot center	7.6	12.0	11.6	11.7	21.2	15.3	<0.001	0.413

A third general trend, a seasonal pattern, has appeared in the hydrographs as multiple years of data have been recorded. In the majority of the hydrographs, the lowest water levels occurred in the winter and highest water levels occurred in the spring (Table 8.7). Average seasonal water level change ranges from less than one foot at Gila Confluence North to almost 3 feet at Hoge Ranch, Rattlesnake and Cibola Lake, with an average seasonal water level change of 2 feet. Hydrographs for all piezometers are included in Appendix D. For 2007, the data trend is very similar to that of 2005 and 2006, with some sites having slightly higher and lower maximum and minimum water levels.

Table 8.7. High and Low Average Monthly Water Depths Recorded at Piezometers at Habitat Monitoring Sites, August 2005–August 2007

Location	Shallowest water level (ft bgs)	Month occurred	Deepest water level (ft bgs)	Month occurred
Topock[1]	0.84	April	2.49	September
Blankenship Bend	1.99	June	3.70	December
Havasu NE	1.63	August	2.81	February
Ehrenburg	0.93	April	3.56	December
Three Fingers Lake	2.32	April	4.74	December
Cibola Lake	2.16	April	4.87	January
Walker Lake	4.47	March	5.84	August
Paradise	4.61	April	6.66	December
Hoge Ranch	1.99	April	4.68	December
Rattlesnake	0.79	April	3.48	December
Clear Lake	1.55	April	3.74	January
Ferguson Lake	1.02	April	3.06	December
Ferguson Wash	1.15	April	3.19	December
Great Blue Heron	0.80	April	2.32	December
Mittry West	0.05	April	2.36	January
Gila Confluence North	4.35	March	4.92	July

[1] Data from August 2006–August 2007

CORRELATION OF PIEZOMETER WATER LEVELS WITH RESERVOIR RELEASES

Lake Havasu Water Levels – There is a strong correlation (R^2 = 0.96) between water levels in Lake Havasu as measured by the USGS and water levels below the habitat as measured in the Havasu NE piezometer (Figure 8.2). The piezometer at Blankenship Bend appears to be too far upstream to be strongly correlated with lake levels, showing a correlation through the same period with an R^2 value of only 0.09.

Colorado River Water Levels – Data were collected between August 2005 and September 2007 in hourly intervals and averaged by the day. The “best fit” time lag varied from two days for the upstream piezometers (Paradise, Hoge Ranch, Ehrenberg, Cibola Lake, Three Fingers Lake) to three days for the downstream piezometers (Rattlesnake, Clear Lake, Ferguson Lake, Ferguson

Wash, and Great Blue Heron). The best fit R^2 statistics vary from 0.74 to 0.97 (Table 8.8). Walker Lake was the only site that had no correlation (R^2 = 0.02–0.05).

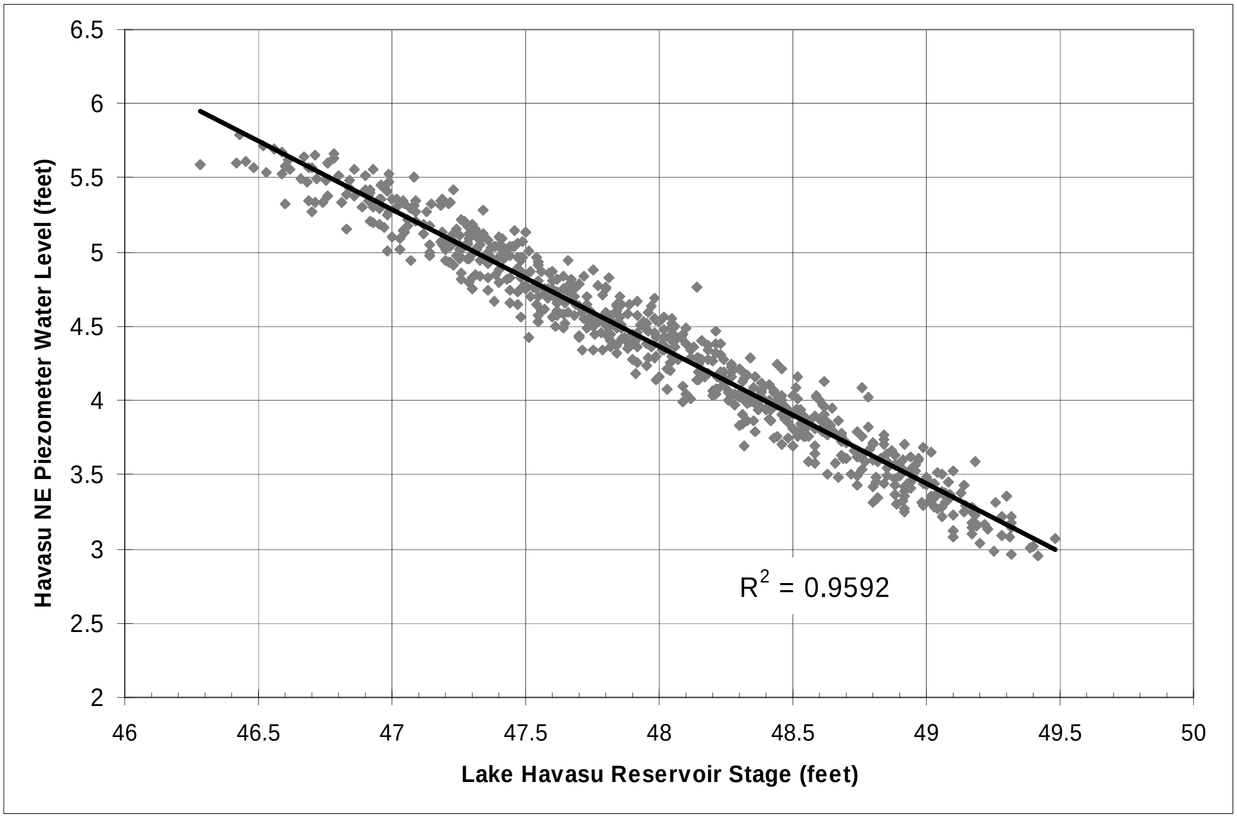

Figure 8.2. Correlation of Havasu NE piezometer and Lake Havasu water levels, September 2005–August 2007. Line shows linear regression.

Table 8.8. Correlation (R^2 Statistic) of Parker Dam Daily Releases (cfs) with Average Daily Water Levels (feet bgs) of Piezometers at Habitat Monitoring Sites, January 2006–September 2007*

Site	Time Lag				
	None	1 day	2 days	3 days	4 days
Ehrenberg	0.87	0.94	0.95	0.89	0.84
Cibola Lake	0.82	0.86	0.92	0.89	0.85
Three Fingers Lake	0.84	0.91	0.96	0.89	0.83
Walker Lake	0.04	0.05	0.04	0.02	0.03
Paradise	0.82	0.89	0.97	0.92	0.85
Hoge Ranch	0.79	0.86	0.94	0.87	0.80
Rattlesnake	0.77	0.82	0.88	0.91	0.86
Clear Lake	0.82	0.86	0.92	0.95	0.91
Ferguson Lake	0.77	0.83	0.92	0.95	0.88
Ferguson Wash	0.75	0.80	0.88	0.91	0.85
Great Blue Heron	0.74	0.78	0.84	0.90	0.88

* Shaded cells indicate best correlation.

Planned Declines in Parker Releases – An examination of monthly river flows below Parker Dam from 2000 to 2007 (Table 8.9) revealed there has been a noticeable decline in reservoir releases during most months. While there is significant variation, average monthly flow decreased from 2001 (the year prior to the scheduled change in point of diversion) to present, with the percent decrease ranging from 7.8% in December to 18.7% in July. The decreases occurred primarily during the summer months; releases for January, February, and March were equivalent or slightly increased since 2001.

Table 8.9. Average Monthly Flows (cfs) Below Parker Dam, 2000–2007

	2000	2001	2002	2003	2004	2005	2006	2007	Difference (present–2001)	% Change (2001–present)
January	6,820	5,599	6,478	6,327	5,536	4,166	5,842	5,945	+346	+6.18%
February	9,123	8,505	8,978	6,881	7,129	4,888	7,798	8,491	-14	-0.16%
March	11,594	10,524	11,334	12,360	11,523	9,699	9,752	11,122	+598	+5.68%
April	14,613	14,090	13,610	13,803	12,824	11,356	11,985	12,618	-1,472	-10.45%
May	14,174	14,068	12,826	11,990	12,252	11,428	11,998	11,718	-2,350	-16.70%
June	13,803	14,733	13,713	12,778	12,741	12,444	12,383	12,116	-2,617	-17.76%
July	14,210	14,974	14,439	13,100	12,331	13,842	11,688	12,180	-2,794	-18.66%
August	11,441	12,047	12,118	10,803	11,420	10,316	10,141	10,317	-1,730	-14.36%
September	11,233	10,837	10,429	11,159	9,566	9,048	7,334		-3,503	-32.32%
October	9,362	8,852	8,765	9,761	7,405	6,967	7,424		-1,428	-16.13%
November	7,437	7,357	7,049	6,153	5,163	6,335	6,094		-1,263	-17.17%
December	6,706	5,970	5,615	5,737	4,129	4,841	5,507		-463	-7.76%

Correlations between river stage and groundwater levels show an approximately 1:1 ratio, with regression slopes ranging from 0.86 (i.e., a 1-foot change in river stage would result in an 0.86-foot change in groundwater level) to 1.4 (Table 8.10).

CORRELATION OF PIEZOMETER WATER LEVELS WITH SOIL MOISTURE MEASUREMENTS

Linear regressions between the average soil moisture measurements at all 15 of the habitat monitoring sites and the average daily water level in the piezometer for that site show little to no correlation between these two variables (R^2 = 0.0–0.50; Table 8.11). Analysis included 2005, 2006, and 2007 data.

RELATIONSHIP BETWEEN PIEZOMETER WATER LEVELS AND HUMIDITY MEASUREMENTS

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.

Table 8.10. Estimated Decrease (ft) in Piezometer Water Levels at Habitat Monitoring Sites as the Result of Decreases in River Stage*

Site	April	August	December
Ehrenberg	0.71	0.16	0.07
Cibola Lake	0.62	0.14	0.06
Three Fingers Lake	0.85	0.19	0.08
Paradise	0.90	0.20	0.09
Hoge Ranch	0.74	0.17	0.07
Rattlesnake	0.70	0.16	0.07
Clear Lake	0.90	0.20	0.09
Ferguson Lake	0.95	0.21	0.09
Ferguson Wash	1.00	0.22	0.10
Great Blue Heron	0.68	0.15	0.07

* Reclamation (2000) predicted a decrease in river stage of 0.71, 0.16, and 0.07 feet for April, August, and December, respectively, based on hourly maximum flows at river mile 171.3.

Table 8.11. Results of Linear Regression Between Average Daily Piezometer Water Levels and Soil Moisture at Habitat Monitoring Sites, Lower Colorado River, 2005–2007

Site	Number of data points	Range of soil moisture values (mV)	Median soil moisture value (mV)	R^2
Blankenship Bend	14	393–1070	960	0.24
Havasu NE	19	12–907	183	0.01
Ehrenburg	17	92–1018	627	0.01
Cibola Lake	29	11–994	296	0.04
Three Fingers Lake	31	59–958	470	0.06
Walker Lake	27	599–1504	931	0.18
Paradise	23	45–1020	683	0.00
Hoge Ranch	29	452–1313	880	0.02
Rattlesnake	31	99–994	816	0.37
Clear Lake	29	54–1017	404	0.03
Ferguson Lake	30	437–1020	938	0.50
Ferguson Wash	30	34–607	158	0.03
Great Blue Heron	22	336–987	904	0.03
Mittry West	21	431–1006	904	0.22
Gila Confluence North	14	96–937	332	0.00
Topock	24	864-975	931	0.18

Presence of Standing Water

Data from Gila Confluence North indicate that the piezometer location was inundated from 18 to 20 October 2005 to a depth up to 1.4 feet. The Mittry West piezometer location was inundated from 22 April to 2 May 2006 to a depth up to 0.2 feet. Data from two other sites, Three Fingers Lake and Rattlesnake, also indicated possible inundation, but repeated differences between data logger and manual measurements suggest these data may not be accurate. Topock did not appear to have encountered standing water based on piezometer measurements.

Evapotranspiration Signature

Nearly all the sites exhibit a typical seasonal trend in evapotranspiration, with the magnitude of the evapotranspiration signature peaking between June and September (Table 8.12). The Ehrenberg piezometer appears to have artificially shallow measurements that occur in a 23-hour cycle; this appears to be an equipment malfunction that is being investigated with the manufacturer. Ehrenberg data are not presented here.

Table 8.12. Results of Statistical Analysis of Magnitude of Evapotranspiration Signature, January–December 2006

Site	Median of Daily Water Level Fluctuation (feet)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Blankenship Bend	0.231	0.294	0.499	0.769	0.812	0.732	0.802	0.834	0.841	0.680	0.407	0.239
Havasu NE	0.150	0.180	0.236	0.277	0.304	0.288	0.302	0.300	0.243	0.208	0.157	0.177
Cibola Lake	0.331	0.434	0.417	0.394	0.476	0.535	0.488	0.538	0.544	0.462	0.499	0.310
Three Fingers Lake	0.418	0.587	0.637	0.820	0.972	0.982	0.900	0.878	0.817	0.651	0.626	0.390
Walker Lake	0.043	0.045	0.066	0.432	0.759	0.900	0.847	0.792	0.677	0.612	0.442	0.074
Paradise	0.373	0.411	0.464	0.488	0.611	0.716	0.646	0.609	0.562	0.526	0.489	0.327
Hoge Ranch	0.587	0.707	0.725	0.702	0.895	0.903	0.800	0.889	0.839	0.786	0.666	0.525
Rattlesnake	0.224	0.215	0.202	0.256	0.272	0.327	0.239	0.285	0.319	0.273	0.237	0.255
Clear Lake	0.129	0.126	0.117	0.148	0.138	0.148	0.126	0.162	0.168	0.145	0.120	0.108
Ferguson Lake	0.221	0.202	0.218	0.236	0.247	0.279	0.182	0.257	0.253	0.201	0.226	0.178
Ferguson Wash	0.239	0.221	0.219	0.225	0.271	0.254	0.176	0.239	0.27	0.235	0.248	0.202
Great Blue Heron	0.073	0.094	0.102	0.105	0.154	0.154	0.174	0.205	0.184	0.142	0.133	0.080
Mittry West	0.014	0.024	0.041	0.042	0.077	0.108	0.131	0.140	0.122	0.083	0.058	0.019
Gila Confluence North	0.061	0.130	0.062	0.084	0.090	0.110	0.108	0.113	0.106	0.145	0.083	0.039
Topock	-	-	-	-	-	-	-	0.509	0.515	0.239	0.093	0.016

DISCUSSION

MICROCLIMATE

COMPARISON OF PARKER/IMPERIAL TO TOPOCK

Most microclimatic variables at the combined habitat monitoring sites differed significantly from those at Topock Marsh. The habitat monitoring sites were lower in elevation and at lower latitudes than Topock and therefore were more likely to be warmer, an expectation confirmed by two of the three diurnal temperature parameters compared in Table 8.4.

In general, the habitat monitoring sites exhibited a greater mean diurnal temperature, greater number of 15-minute intervals above 41°C each day, and mean daily temperature range, and lower measures of relative humidity and vapor pressure than the five study areas where we measured microclimate variables (compare Table 8.4 to WT mean diurnal temperatures in Tables 7.3 through 7.7). As noted previously in Chapter 7, the five study areas differed significantly from one another with respect to most microclimate variables due to their different elevations, latitudes, and other environmental attributes.

BETWEEN-YEAR COMPARISONS OF MICROCLIMATE CHARACTERISTICS

Comparisons of microclimate characteristics among 2005, 2006, and 2007 at the habitat monitoring sites indicated generally hotter and more humid conditions in 2006 than in 2005 or 2007. The interannual changes were generally similar between test and control sites, suggesting that changes in temperature and humidity conditions may have been regional, rather than being influenced by changes in river operations. Soil moisture was lower in 2006 than in 2005 or 2007, and while this pattern was exhibited at both test and control sites, the interannual change was greater at control than at test sites. This suggests that river operations, in addition to regional climatic conditions, influenced soil moisture.

VEGETATION

Between-year differences were noted for canopy closure, woody ground cover, distance to water, and tree counts. There was no evidence that differences in canopy closure or tree counts occurred exclusively at control sites or at test sites; rather, the differences occurred across all sites. Canopy closure decreased between 2005 and 2006 and then increased in 2007 to values higher than those recorded in 2005. Tree counts increased between 2005 and 2006 but did not differ between 2006 and 2007.

Increases in tree counts do not seem to be explainable by stems growing larger and thus being counted as shrubs in one year and trees in a subsequent year; increases in tree counts were not associated either with increases or decreases in shrub counts. Differences in tree counts may be the result of difficulties in the field in determining whether certain stems fall inside or outside the 5- and 11.3-m circles because dense vegetation often prohibits visual estimation even of short distances. Changes in canopy closure could be caused by changes in overall weather conditions between the years or could be the result of systematic observer variation.

Differences in distance to water between 2005 and 2006 seemed to be driven largely by Mittry West and Great Blue Heron. A wetland area near Mittry West that was recorded as containing water in 2005 was not noted to be wet in 2006. Distance to water at Great Blue Heron was determined from aerial photos in both years; the photos were not updated between years, and any differences in values recorded were thus clearly the result of differing interpretations of the aerial photo and were not related to actual differences on the ground.

Ground cover did not differ between years at test locations but increased at control plots in 2006 and then decreased in 2007. This may represent actual changes in the amount of woody ground cover or may be a spurious result of observer variation. Additional years of vegetation measurements will help clarify these trends.

Vertical foliage values in several meter intervals have decreased through time at both test and control plots. These decreases were greater at test than control plots in four of the intervals. These differences suggest that foliage density is decreasing in general, but is decreasing more dramatically at test plots relative to control plots. It is unclear whether this decrease in foliage density might be related to water control actions.

GROUNDWATER LEVELS

PIEZOMETER WATER LEVELS

The general daily and weekly cycles that were attributed to evapotranspiration and river operations, respectively, in the 2005 data are still visible in the 2006 and 2007 data. Water levels drop during afternoon hours and on the weekends, while higher water levels occur in early morning hours and in the middle of the week. The daily small-scale water level fluctuations are caused by evapotranspiration of plants. During the day, the riparian vegetation removes water from aquifer storage, which is then replenished as evapotranspiration lessens near the end of the day.

The seasonal cycle in groundwater levels mirrors the seasonal fluctuation in river flow. This is driven primarily by the operational decrease in releases from Parker Dam. Evapotranspiration would be expected to decrease during the winter months, which should result in higher river and groundwater levels during the winter; however, this trend is not observed. Any seasonal effect of evapotranspiration appears to be overwhelmed by operations at Parker Dam.

Several anomalous hydrograph features deserve discussion:

> *Walker Lake* – The Walker Lake piezometer recovered slowly from two apparent inundations in the late summer of 2005 and went through a period of declining water levels until the 5 December 2005 download. From the point of restart, this piezometer began to show the same general seasonal trend as seen in the other piezometers, with a seasonal high occurring in winter 2006 and seasonal low occurring in spring 2006. Water levels, however, have continued to drop from the seasonal high spring levels to levels more like those first recorded before the summer 2005 inundation, suggesting this lower water level is closer to the seasonal low than that recorded in the winter 2006. We speculated in the 2006 report that Walker Lake represented a backwater area that gets periodically inundated, but otherwise

does not respond strongly to fluctuations in the Colorado River. However, since the spike in summer 2005, the seasonal pattern appears to match the pattern at most of the piezometer locations between Parker and Imperial dams, including Rattlesnake, Cibola Lake, and Paradise. The spike, which we speculated may have been an inundation of a backwater lake, does not appear to have been repeated.

Mittry West – While the hydrograph for the Mittry West piezometer was almost flat from installation through December 2005, the data now show a seasonal trend. A peak in water level occurred on 29 April 2006, from which point water levels declined into the summer months. Weekly fluctuations and daily fluctuations are not as apparent on the rising leg of the 2006 seasonal curve, but reappear on the declining leg of the curve. This may be attributed to the onset of evapotranspiration with the regrowth of vegetation in the immediate area surrounding the piezometer. Because of the inexplicable flat data from the first data downloads, we considered reinstalling the Mittry West piezometer at a different location within the habitat polygon. It now appears that this piezometer is functioning properly, and the flat data likely reflect the true groundwater levels at the site.

Havasu NE and Gila Confluence North – Daily and weekly changes in water level are apparent in both the Havasu NE and Gila Confluence North hydrographs; however, neither shows signs of the seasonal trend common in the other hydrographs. This lack of a seasonal trend at the Havasu NE piezometer can be attributed to the highly regulated water level at Lake Havasu. The lack of a seasonal trend at the Gila Confluence North hydrograph is most likely due to other outside influences such as flow releases from Imperial Dam and irrigation diversion/return flow.

Topock – Only one year of data exists of Topock. However, it appears that the site exhibits a seasonal cycle: inundation in spring, followed by declining water levels through the summer.

CORRELATION OF PIEZOMETER WATER LEVELS WITH RESERVOIR RELEASES

Regression analyses indicated that, as would be expected, piezometer readings were best correlated with flow release data that had been time-lagged to allow for the progression of releases downstream. The most upstream site included in the analyses (Ehrenberg) showed a two-day lag, while the most downstream site (Great Blue Heron) showed a three-day lag. This was the case during both the 2006 and 2007 data collection periods. Based on Reclamation's estimate of river stage change due to a 400,000 acre-foot reduction in releases from Parker Dam, we estimate that the lowering of the water table below habitat polygons will range from up to 1 foot in April to less than 0.1 foot in December.

CORRELATION OF PIEZOMETER WATER LEVELS WITH SOIL MOISTURE MEASUREMENTS

With 2½ years of data at most sites, we have not found a linear relationship between piezometer water levels and soil moisture measurements at the subset of habitat monitoring sites for which we have complete data sets. Soil texture influences the capillary rise of groundwater from a shallow aquifer, and variability in soil texture among sites may confound the relationship between piezometer water levels and soil moisture. Future analyses will examine soil texture and incorporate these data into a more complex analysis of the influence of water levels on soil moisture.

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 does 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) are of a 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; it is unclear whether a change of less than 1.0 g/m^3 would affect site occupancy by willow flycatchers.

Presence of Standing Water

Standing water does not appear to be a consistent factor at any of the sites; future monitoring, particularly of Topock, will confirm whether there is a difference between occupied sites and non-occupied sites.

Evapotranspiration Signature

At this time, the evapotranspiration signature is of little use for comparison. To compare between sites, the actual evapotranspiration must be calculated, which takes into account other factors, primarily soil properties. The usefulness of the evapotranspiration signature will be to assess relative changes in evapotranspiration, and thus vegetation density, at a given site over time.

LITERATURE CITED

Ahlers, D. and R. Tisdale. 1999. Cowbird control program Middle Rio Grande, New Mexico 1998. U.S. Department of the Interior, Bureau of Reclamation, Albuquerque and Technical Service Center, Ecological Planning and Assessment, Denver. 47 pp.

Allison, L.J., C.E. Paradzick, J.W. Rourke, and T.D. McCarthey. 2003. A characterization of vegetation in nesting and non-nesting plots for Southwestern Willow Flycatchers in Arizona. Pages 81–90 *in* Sogge, M.K., B.E. Kus, S.J. Sferra and M.J. Whitfield (eds.). Ecology and conservation of the willow flycatcher. Studies in Avian Biology No. 26. Cooper Ornithological Society.

Austin, G.T. 1974. Nesting success of the Cactus Wren in relation to nest orientation. Condor 76:216–217.

Austin, G.T. 1976. Behavioral adaptations of the Verdin to the desert. Auk 93:245–262.

Bekoff, M., A.C. Scott, and D.A. Conner. 1987. Nonrandom nest-site selection in Evening Grosbeaks. Condor 89:819–829.

Braden, G.T., and R.L. McKernan. 1998. Observations on nest cycles, vocalization rates, the probability of detection, and survey protocols for the Southwestern Willow Flycatcher. Report to the Bureau of Reclamation, Boulder City, Nevada. 38 pp.

Brown, J.L. 1964. The evolution of diversity in avian territorial systems. Wilson Bulletin 76:160–169.

Brown, B.T., S.W. Carothers, and R.R. Johnson. 1987. Grand Canyon birds. The University of Arizona Press, Tucson, Arizona. 302 pp.

Browning, M.R. 1993. Comments on the taxonomy of *Empidonax traillii* (willow flycatcher). Western Birds 24:241–257.

Busch, J.D., M.P. Miller, E.P. Paxton, M.K. Sogge, and P. Keim. 2000. Genetic variation in the endangered Southwestern Willow Flycatcher. Auk 117:586–595.

Calder, W.A. 1973. Microhabitat selection during nesting of hummingbirds in the Rocky Mountains. Ecology 54:127–134.

Cannings, R.J., and W. Threlfall. 1981. Horned Lark breeding biology at Cape St. Mary's, Newfoundland. Wilson Bulletin 93:519–530.

Cardinal, S.N., and E.H. Paxton. 2005. Homerange, movement, and habitat use of the Southwestern Willow Flycatcher, Roosevelt Lake, AZ – 2004. U.S. Geological Survey report to the Bureau of Reclamation, Phoenix, Arizona. 26pp.

Cody, M.L. 1985. An introduction to habitat selection in birds. Pages 4–56 *in* M.L. Cody (ed.). Habitat selection in birds. Academic Press, New York.

Connor, R.N. 1975. Orientation of entrances to woodpecker nest-cavities. Auk 92:371–374.

Durst, S.L., M.K. Sogge, H.C. English, S.O. Williams, B.E. Kus, and S.J. Sferra. 2006. Southwestern Willow Flycatcher breeding site and territory summary – 2005. USGS Southwest Biological Science Center report to the Bureau of Reclamation.

English, H.C., A.E. Graber, S.D. Stump, H.E. Telle, and L.A. Ellis. 2006. Southwestern willow flycatcher 2005 survey and nest monitoring report. Nongame and Endangered Wildlife Program Technical Report 248. Arizona Game and Fish Department, Phoenix, Arizona.

Finch, D.M., and J.F. Kelly. 1999. Status of management of the Southwestern Willow Flycatcher in New Mexico. Pages 197–203 *in* Finch, D.M., J.C. Whitney, J.F. Kelly and S.R. Loftin (eds.). Rio Grande ecosystems: linking land, water, and people. USDA Forest Service Rocky Mountain Research Station Proceedings, RMRS-P-7.

Finch, D.M., J.F. Kelly, and J.E. Cartron. 2000. Migration and Winter Ecology. Pages 71–82 *in* Finch, D.M., and S.H. Stoleson (eds.). Status, ecology, and conservation of the Southwestern Willow Flycatcher. General Technical Report, RMRS-GTR-60. U.S. Forest Service, Rocky Mountain Research Station, Ogden, Utah. 131 pages.

Flett, M.A., and S.D. Sanders. 1987. Ecology of a Sierra Nevada population of Willow Flycatchers. Western Birds 18:37–42.

Garrett, K., and J. Dunn. 1981. Birds of Southern California. Los Angeles Audubon Society, Los Angeles, California.

Gloutney, M.L., and R.G. Clark. 1997. Nest-site selection by Mallards and Blue-winged Teal in relation to microclimate. Auk 114:381–395.

Gill, F.B. 1995. Ornithology, Second Edition. W.H. Freeman and Company, New York.

Graber, A.E., D.M. Weddle, H.C. English, S.D. Stump, H.E. Telle, and L.A. Ellis. 2007. Southwestern willow flycatcher 2006 survey and nest monitoring report. Nongame and Endangered Wildlife Program. Technical report 249. Arizona Game and Fish Department, Phoenix, Arizona.

Graf, W.L., J. Stromberg, and B. Valentine. 2002. Rivers, dams, and willow flycatchers: a summary of their science and policy connections. Geomorphology 47:169–188.

Griffith Wildlife Biology. 1994. Brown-headed Cowbird trapping protocol. Unpublished document prepared by J.C. Griffith and J.T. Griffith, Griffith Wildlife Biology, Calumet, Michigan.

Griffith Wildlife Biology. 2001. Brown-headed Cowbird control. Online: http://www.griffithwildlife.com/cowbird.html.

Hanski, I.A., and D. Simberloff. 1997. The metapopulation approach, its history, conceptual domain, and application to conservation. Pages 5–26 ***in*** Hanski, I.A. and Gilpin, M.E. (eds). Metapopulation biology: Ecology, genetics, and evolution. Academic Press, San Diego, California.

Harris, J.H. 1991. Effects of Brown-headed Cowbirds on willow flycatcher nesting success along the Kern River, California. Western Birds 22:13–26.

Harris, J.H., S.D. Sanders, and M.A. Flett. 1987. Willow Flycatcher surveys in the Sierra Nevada. Western Birds 18:27–36.

Hartman, C.A., and L.W. Oring. 2003. Orientation and microclimate of Horned Lark nests: The importance of shade. Condor 105:158–163.

Howell, N.G., and S. Webb. 1995. A guide to the birds of Mexico and northern Central America. Oxford University Press, New York.

Howlett, J.S., and B.J. Stutchbury. 1996. Nest concealment and predation in Hooded Warblers: experimental removal of nest cover.

Inouye, D.W. 1976. Nonrandom orientation of entrance holes to woodpecker nests in aspen trees. Condor 78:101–102.

Inouye, R.S., N.J. Huntly, and D.W. Inouye. 1981. Non-random orientation of Gila Woodpecker nest entrances in saguaro cactus. Condor 83:88–89.

James, F.C., and H.H. Shugart, Jr. 1970. A quantitative method of habitat description. Audubon Field Notes 24:727–736.

Johnson, D.H. 1979. Estimated nest success: the Mayfield method and an alternative. The Auk: 96(4):651–661.

Johnson, K., P. Mahlhop, C. Black, and K. Score. 1999. Reproductive failure of endangered Southwestern Willow Flycatchers on the Rio Grande, New Mexico. The Southwestern Naturalist 44:226–231.

Johnson, M.J., and M.K. Sogge. 1997. Southwestern Willow Flycatcher surveys along portions of the San Juan River, Utah (Montezuma Creek – Mexican Hat and Clay Hills Crossing), 1997. USGS Colorado Plateau Field Station, Flagstaff, Arizona.

Kenwood, K.E., and E.H. Paxton. 2001. Survivorship and movements of Southwestern Willow Flycatchers in Arizona – 2001. U.S. Geological Survey report to the Bureau of Reclamation, Phoenix, Arizona. 44 pp.

Kern, M., and C. van Riper. 1984. Altitudinal variations in nests of the Hawaiian Honeycreeper *Hemignathus virens virens*. Condor 86(4):443–453.

Kern, M.D., M.K. Sogge, and C. van Riper III. 1990. Water-vapor pressure in nests of the San Miguel Island Song Sparrow. Condor 92:761–767.

Koronkiewicz, T.J., S.N. Cardinal, M.K. Sogge, and E.H. Paxton. 2002. Survivorship and movements of Southwestern Willow Flycatchers at Roosevelt Lake, Arizona – 2002. Report to the Bureau of Reclamation, Phoenix, Arizona. USGS Southwest Science Center, Colorado Plateau Field Station, Flagstaff, Arizona. 43 pp.

Koronkiewicz, T.J., M.A. McLeod, B.T. Brown, and S.W. Carothers. 2004. Southwestern Willow Flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2003. Annual report submitted to Bureau of Reclamation, Boulder City, NV, by SWCA Environmental Consultants, Flagstaff, Arizona. 125 pp.

Koronkiewicz, T.J., M.A. McLeod, B.T. Brown, and S.W. Carothers. 2006a. Southwestern Willow Flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2005. Annual report submitted to Bureau of Reclamation, Boulder City, NV by SWCA Environmental Consultants, Flagstaff, AZ. 176 pp.

Koronkiewicz, T.J., M.K. Sogge, C. Van Riper III, and E.H. Paxton. 2006b. Territoriality, site fidelity, and survivorship of willow flycatchers wintering in Costa Rica. Condor 108:558–570.

Lower Colorado River Multi-Species Conservation Program. 2004. Lower Colorado River Multi-Species Conservation Program, Volume II: Habitat Conservation Plan. Final. December 17. (J&S 00450.00.) Sacramento, California.

Lowther, P.E. 1993. Brown-headed Cowbird (Molothrus ater). *In* Poole, A., and F. Gill (eds.). The birds of North America, No. 47. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Lynn, J.C., T.J. Koronkiewicz, M.J. Whitfield, and M.K. Sogge. 2003. Willow flycatcher winter habitat in El Salvador, Costa Rica, and Panama: characteristics and threats. Pages 41–51 *in* Sogge, M.K., B.E. Kus, S.J. Sferra and M.J. Whitfield (eds.). Ecology and conservation of the willow flycatcher. Studies in Avian Biology No. 26. Cooper Ornithological Society.

Marshall, R.M., and Stoleson S.H. 2000. Threats. Pages 13–24 *in* Status, ecology, and conservation of the Southwestern Willow Flycatcher. USDA Forest Service General Technical Report, RMRS-GTR-60.

Martin, T.E. 1995. Avian life history evolution in relation to nest sites, nest predation, and food. Ecological Monographs 65:101–127.

Martin, T.E., C.R. Paine, C.J. Conway, W.M. Hochachka, P. Allen, and W. Jenkins. 1997. BBIRD Field Protocol. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula.

Mayfield, H. 1961. Nesting success calculated from exposure. Wilson Bulletin 73(3):255–261.

Mayfield, H. 1975. Suggestions for calculating nest success. Wilson Bulletin 87(4):456–466.

McArthur, A.J. 1990. Thermal interaction between animal and microclimate: Specification of a McArthur, A.J. 1990. Thermal interaction between animal and microclimate: Specification of a "standard environmental temperature" for animals outdoors. Journal of Theoretical Biology 148:331–343.

McKernan, R.L. 1997. Status, distribution, and habitat affinities of the Southwestern Willow Flycatcher along the lower Colorado River, Year 1 – 1996. Unpublished report submitted to the Bureau of Reclamation, Boulder City, Nevada, [and] the U.S. Fish and Wildlife Service, Carlsbad, California by the San Bernardino County Museum, Redlands, California. 42 pp.

McKernan, R.L., and G. Braden. 1998. Status, distribution, and habitat affinities of the Southwestern Willow Flycatcher along the lower Colorado River, Year 2 – 1997. Unpublished report submitted to the Bureau of Reclamation, Boulder City, Nevada [and] the U.S. Fish and Wildlife Service, Carlsbad, California, by the San Bernardino County Museum, Redlands, California. 64 pp.

McKernan, R.L., and G. Braden. 1999. Status, distribution, and habitat affinities of the Southwestern Willow Flycatcher along the lower Colorado River, Year 3 – 1998. Unpublished report submitted to the Bureau of Reclamation, Boulder City, Nevada, the U.S. Fish and Wildlife Service, Carlsbad, California, and Reno, Nevada, and the U.S. Bureau of Land Management, Caliente, Nevada, by the San Bernardino County Museum, Redlands, California. 71 pp.

McKernan, R.L., and G. Braden. 2001a. Status, distribution, and habitat affinities of the Southwestern Willow Flycatcher along the Lower Colorado River: Year 4 – 1999. Unpublished report submitted to the Bureau of Reclamation, Boulder City, Nevada, the U.S. Fish and Wildlife Service, Carlsbad, California, and Reno, Nevada, and the U.S. Bureau of Land Management, Caliente, Nevada, by the San Bernardino County Museum, Redlands, California. 83 pp.

McKernan, R.L., and G. Braden. 2001b. Status, distribution, and habitat affinities of the Southwestern Willow Flycatcher along the lower Colorado River, Year 5 – 2000. Unpublished report submitted to the Bureau of Reclamation, Boulder City, Nevada, the U.S. Fish and Wildlife Service, Carlsbad, California, and Reno, Nevada, and the U.S. Bureau of Land Management, Caliente, Nevada, by the San Bernardino County Museum, Redlands, California. 86 pp.

McKernan, R.L., and G. Braden. 2002. Status, distribution, and habitat affinities of the Southwestern Willow Flycatcher along the lower Colorado River, Year 6 – 2001. Unpublished report submitted to the Bureau of Reclamation, Boulder City, Nevada, the U.S. Fish and Wildlife Service, Carlsbad, California, and Reno, Nevada by San Bernardino County Museum, Redlands, California. 58 pp.

McLeod, M.A., T.J. Koronkiewicz, B.T. Brown, and S.W. Carothers. 2005. Southwestern Willow Flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2004. Annual report submitted to Bureau of Reclamation, Boulder City, NV, by SWCA Environmental Consultants, Flagstaff, Arizona. 155 pp.

McLeod, M.A., T.J. Koronkiewicz, B.T. Brown, and S.W. Carothers. 2007. Southwestern Willow Flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2006. Annual report submitted to Bureau of Reclamation, Boulder City, NV by SWCA Environmental Consultants, Flagstaff, AZ. 194 pp.

Munzer, O.M., H.C. English, A.B. Smith, and A.A. Tudor. 2005. Southwestern willow flycatcher 2004 survey and nest monitoring report. Nongame and Endangered Wildlife Program Technical Report 244. Arizona Game and Fish Department, Phoenix, Arizona.

National Weather Service. 2007. Online: http://aa.usno.navy.mil/data/docs/RS_OneYear.html.

Newell, P.J., J.C. Causey, M. Pollock, E.H. Paxton and M.K. Sogge. 2005. Survivorship and movements of Southwestern Willow Flycatchers at Roosevelt Lake, Arizona – 2004. U.S. Geological Survey report to the Bureau of Reclamation, Phoenix, Arizona.

Otahal, C.D. 1998. Fall stopover behavior of willow flycatchers using a riparian corridor in central California. North American Bird Bander 23(4): 115–123.

Paradzick, C.E. 2005. Southwestern Willow Flycatcher habitat selection along the Gila and lower San Pedro Rivers, Arizona: Vegetation and hydrogeomorphic considerations. M.Sc. thesis, Arizona State University, Tempe, Arizona.

Paradzick, C.E., T.D. McCarthey, R.F. Davidson, J.W. Rourke, M.W. Sumner, and A.B. Smith. 2001. Southwestern Willow Flycatcher 2000 survey and nest monitoring report. Nongame and Endangered Wildlife Program Technical Report 175. Arizona Game and Fish Department, Phoenix, Arizona.

Paxton, E., S. Langridge, and M.K. Sogge. 1997. Banding and population genetics of Southwestern Willow Flycatchers in Arizona - 1997 Summary Report. USGS Colorado Plateau Research Station / Northern Arizona University report. 63 pp.

Paxton, E.H., M.K. Sogge, S.L. Durst, T.C. Theimer, and J. Hatten. 2007. The ecology of the Southwestern Willow Flycatcher in Central Arizona – a 10-year synthesis report. USGS Open-File Report 2007-1381.

Paxton, E.H., S.N. Cardinal, and T.J. Koronkiewicz. 2003. Using radiotelemetry to determine home range size, habitat use, and movement patterns of Willow Flycatchers. Pages 185–189 *in* Sogge, M.K., B.E. Kus, S.J. Sferra and M.J. Whitfield (eds.). Ecology and conservation of the willow flycatcher. Studies in Avian Biology No. 26. Cooper Ornithological Society.

Periman, R.D., and J.F. Kelly. 2000. The dynamic environmental history of Southwest Willow Flycatcher habitat: A survey of changing riparian conditions through time. Pages 25–42 *in* Finch, D.M., and S.H. Stoleson (eds.). Status, ecology, and conservation of the Southwestern Willow Flycatcher. General Technical Report, RMRS-GTR-60. U.S. Forest Service, Rocky Mountain Research Station, Ogden, Utah. 131 pages.

Phillips, A., J. Marshall, and G. Monson. 1964. The birds of Arizona. University of Arizona Press, Tucson. 212 pp.

Ralph, C.J., G.R. Geupel, P. Pyle, T.E. Martin, and D.F. DeSante. 1993. Handbook of field methods for monitoring landbirds. General Technical Report PSW-GTR-144. U.S. Forest Service Pacific Southwest Research Station, Albany, California. 41 pp.

Ridgely, R.S., and G. Tudor. 1994. The birds of South America; Volume II: the Suboscine passerines. University of Texas Press, Austin, Texas.

Robinson, S.K. 1992. Population dynamics of breeding Neotropical migrants in Illinois. Pages 408–418. *In* J.M. Hagan III and D.W. Johnston [eds.]. Ecology and Conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington D.C.

Rosenberg, K. V., R. C. Ohmart, W. C. Hunter, and B. W. Anderson. 1991. Birds of the lower Colorado River Valley. University of Arizona Press, Tucson, Arizona.

Rotenberry, J.T. 1985. The role of habitat in avian community composition: Physiognomy or floristics? Oecologia 67:213–217.

Rothstein, S.I., B.E. Kus, M.J. Whitfield, and S.J. Sferra. 2003. Recommendations for cowbird management in recovery efforts for the Southwestern Willow Flycatcher. Pages 157–167 *in* Sogge, M.K., B.E. Kus, S.J. Sferra and M.J. Whitfield (eds.). Ecology and conservation of the willow flycatcher. Studies in Avian Biology No. 26. Cooper Ornithological Society.

Rourke, J.W., T.D. McCarthey, R.F. Davidson, and A.M. Santaniello. 1999. Southwestern Willow Flycatcher nest monitoring protocol. Nongame and Endangered Wildlife Program Technical Report No. 144. Arizona Game and Fish Department, Phoenix, Arizona.

SAS Institute Inc. 2003. SAS OnlineDoc®, Version 9.1. Cary, North Carolina.

Sedgwick, J.A. 2000. Willow flycatcher (*Empidonax traillii*). *In* Poole, A., and F. Gill (eds.). The birds of North America, No. 533. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Sedgwick, J.A., and F.L. Knopf. 1988. A high incidence of Brown-headed Cowbird parasitism of willow flycatchers. Condor 90:253–256.

Sedgwick, J.A., and F.L. Knopf. 1992. Describing willow flycatcher habitats: Scale perspectives and gender differences. Condor 94:720–733.

Smith, A.B., C.E. Paradzick, A.A. Woodward, P.E.T. Dockens, and T.D. McCarthey. 2002. Southwestern Willow Flycatcher 2001 survey and nest monitoring report. Nongame and Endangered Wildlife Program Technical Report 191. Arizona Game and Fish Department, Phoenix, Arizona.

Smith, A.B., A.A. Woodward, P.E.T. Dockens, J.S. Martin, and T.D. McCarthey. 2003. Southwestern Willow Flycatcher 2002 survey and nest monitoring report. Nongame and Endangered Wildlife Program Technical Report 210. Arizona Game and Fish Department, Phoenix, Arizona.

Smith, A.B., P.E.T. Dockens, A.A. Tudor, H.C. English, and B.L. Allen. 2004. Southwestern Willow Flycatcher 2003 survey and nest monitoring report. Nongame and Endangered Wildlife Program Technical Report 210. Arizona Game and Fish Department, Phoenix, Arizona.

Sogge, M.K., and R.M. Marshall. 2000. A survey of current breeding habitats. Pages 43–56 *in* Finch, D.M., and S.H. Stoleson (eds.). Status, ecology, and conservation of the Southwestern Willow Flycatcher. General Technical Report, RMRS-GTR-60. U.S. Forest Service, Rocky Mountain Research Station, Ogden, Utah. 131 pages.

Sogge, M.K., R.M. Marshall, S.J. Sferra, and T.J. Tibbits. 1997. A Southwestern Willow Flycatcher natural history summary and survey protocol. National Park Service Technical Report USGS/NAUCPRS/NRTR-97/12.

Sogge, M.K., J.C. Owen, E.H. Paxton, S.M. Langridge, and T.J. Koronkiewicz. 2001. A targeted mist net capture technique for the willow flycatcher. Western Birds 32:167–172.

Sogge, M.K., S.J. Sferra, T.D. McCarthey, S.O. Williams, and B.E. Kus. 2003. Distribution and characteristics of Southwestern Willow Flycatcher breeding sites and territories: 1993–2001. Pages 5–11 *in* Sogge, M.K., B.E. Kus, S.J. Sferra and M.J. Whitfield (eds.). Ecology and conservation of the willow flycatcher. Studies in Avian Biology No. 26. Cooper Ornithological Society.

StataCorp LP. 2006. Stata for Windows®, Version 9.2. College Station, Texas.

Stiles, F.G., and A.F. Skutch. 1989. A guide to the birds of Costa Rica. Cornell University Press, New York.

Sumner, M.E. (ed.). 2000. Handbook of soil science. CRC Press, Boca Raton, Florida.

Texas Parks and Wildlife Department. n.d. Trapping Brown-headed Cowbirds to control songbird nest parasitism. Online: http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_bk_w7000_1148.pdf.

Unitt, P. 1987. *Empidonax traillii extimus*: an endangered subspecies. Western Birds 18:137–162.

Unitt, P. 1997. Winter range of *Empidonax traillii extimus* as documented by existing museum collections. San Diego Natural History Museum report to Bureau of Reclamation, Phoenix, Arizona.

U.S. Bureau of Reclamation (Reclamation). 1999. Long-term restoration program for the historical Southwestern Willow Flycatcher (*Empidonax traillii extimus*) habitat along the lower Colorado River. Report submitted by USBR Lower Colorado Region to Lower Colorado Multi-Species Conservation Program. USBR: Boulder City, Nevada. 70 pp.

U.S. Bureau of Reclamation (Reclamation). 2000. Biological Assessment for proposed Interim Surplus Criteria, Secretarial Implementation Agreements for California Water Plan components and conservation measures on the Lower Colorado River (Lake Mead to the Southerly International Boundary). Prepared by Bureau of Reclamation, Lower Colorado Region. 80 pp.

U.S. Bureau of Reclamation (Reclamation). 2004. Brown-headed Cowbird management techniques manual. Technical Service Center, Ecological Planning and Assessment Group. Denver, Colorado. 58 pp.

U.S. Fish and Wildlife Service (USFWS). 1995. Final rule determining endangered status for the Southwestern Willow Flycatcher. Federal Register 60:10694–10715.

U.S. Fish and Wildlife Service (USFWS). 2001. Biological opinion for Interim Surplus Criteria, Secretarial Implementation Agreements, and Conservation Measures on the Lower Colorado River, Lake Mead to the Southerly International Boundary, Arizona, California, and Nevada. Final Biological Opinion, U.S. Fish and Wildlife Service, Phoenix, Arizona. 90 pp.

U.S. Fish and Wildlife Service (USFWS). 2002. Final recovery plan Southwestern Willow Flycatcher (*Empidonax trailli extimus*). Prepared by Southwestern Willow Flycatcher Recovery Team Technical Subgroup, August 2002.

van Riper III, C., M.D. Kern, and M.K. Sogge. 1993. Changing nest placement of Hawaiian Common Amakihi during the breeding cycle. Wilson Bulletin 105:436–447.

Walsberg, G.E. 1981. Nest-site selection and the radiative environment of the Warbling Vireo. Condor 83:86–88.

Walsberg, G.E. 1985. Physiological consequences of microhabitat selection. Pages 389–413 *in* M.L. Cody (ed.). Habitat selection in birds. Academic Press, Orlando, Florida.

Warkentin, I.G., and N.H. West. 1990. Ecological energetics of wintering Merlins *Falco columbarius*. Physiological Zoology 63:308–333.

Webb, D.R. 1987. Thermal tolerance of avian embryos: a review. Condor 89:874–898.

Webb, D.R., and J.R. King. 1983. An analysis of the heat budgets of the eggs and nest of the White-crowned Sparrow, *Zonotrichia leucophrys,* in relation to parental attentiveness. Physiological Zoology 56:493–505.

White, G.S., and K.P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46 (supplement):S120–139.

White, L. E. Best, G. Clune, B. Marette, and J. Sechrist. 1998. Brown-headed Cowbird control program; Virgin and Muddy Rivers (Overton State Wildlife Area), Nevada, Colorado River (Havasu National Wildlife Refuge), Arizona: results of 1998 program. Bureau of Reclamation, Lower Colorado Regional Office and Technical Service Center Ecological Planning and Assessment Group. 32 pp.

Whitfield, M.J. 1990. Willow flycatcher reproductive response to Brown-headed Cowbird parasitism. M.S. Thesis, California State University, Chico, California. 25 pp.

Whitfield, M.J., and M.K. Sogge. 1999. Range-wide impacts of Brown-headed Cowbird parasitism on the Southwestern Willow Flycatcher (*Empidonax traillii extimus*). Studies in Avian Biology 18:182–190.

Wiens, J.A. 1989a. The ecology of bird communities. Volume 1: Foundations and patterns. Cambridge University Press, New York.

Wiens, J.A. 1989b. The ecology of bird communities. Volume 2: Processes and variations. Cambridge University Press, New York.

Wiens, J.A. 1997. Metapopulation dynamics and landscape ecology. Pages 43–60 *in* Hanski, I.A., and M.E. Gilpin (eds.). Metapopulation biology: ecology, genetics and evolution. Academic Press, San Diego, California.

With, K.A., and D.R. Webb. 1993. Microclimate of ground nests: The relative importance of radiative cover and wind breaks for three grassland species. Condor 95:401–413.

Woodward, H.D., and S.H. Stoleson. 2002. Brown-headed Cowbird attacks on Southwestern Willow Flycatcher nestlings. The Southwestern Naturalist. Vol. 47 No. 4:626–628.

Yong, W., and D.M. Finch. 1997. Migration of the willow flycatcher along the Middle Rio Grande. Wilson Bulletin 109:253–268.

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