SOUTHWESTERN WILLOW FLYCATCHER SURVEYS, DEMOGRAPHY, AND ECOLOGY ALONG THE LOWER COLORADO RIVER AND TRIBUTARIES, 2003–2007

Contract # 03-CS-30-0093

Five-Year Summary Report

Submitted to

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

Submitted by

Mary Anne McLeod
Thomas J. Koronkiewicz
Bryan T. Brown
Wendy J. Langeberg
Steven W. Carothers

SWCA ENVIRONMENTAL CONSULTANTS
114 N. San Francisco St., Suite 100
Flagstaff, Arizona 86001
(928) 774-5500
www.swca.com

SWCA Project No. 6595-133

March 12, 2008

RECOMMENDED CITATION:

McLeod, M.A., T.J. Koronkiewicz, B.T. Brown, W.J. Langeberg, and S.W. Carothers. 2008. Southwestern Willow Flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2003–2007. Five-year summary report submitted to Bureau of Reclamation, Boulder City, NV by SWCA Environmental Consultants, Flagstaff, AZ. 206 pp.

TABLE OF CONTENTS

APPENDIX

List of Figures

List of Figures, continued

List of Tables

List of Tables, continued

List of Tables, continued

List of Tables, continued

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.

From 1997 to 2002, breeding populations of Southwestern Willow Flycatchers were documented along the Virgin and lower Colorado Rivers and tributaries at seven study areas from Pahranagat National Wildlife Refuge (NWR), Nevada, south to the Bill Williams River in Arizona. Willow flycatchers were also detected during the breeding season at several sites along the Colorado River south of the Bill Williams River to the Mexico border, but no nests were located.

SWCA was contracted by Reclamation to continue surveys, monitoring, and demographic and ecological studies of the Southwestern Willow Flycatcher in suitable and/or historical riparian and wetland habitats throughout the Virgin and lower Colorado River regions in 2003–2007. We completed presence/absence surveys and site descriptions at 131 sites in 16 study areas from the Pahranagat 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; measured characteristics of vegetation and microclimate at nest sites and at unused sites to assess factors important in nest-site selection; and implemented trapping and removal of Brown-headed Cowbirds 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 Littlefield, 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 131 sites, ranging in size from 1 to 63 ha, along the Virgin and lower Colorado Rivers and tributaries each year between 15 May and 28 July, following a 10-survey protocol. We found resident and breeding Southwestern Willow Flycatchers at 33 sites in eight study areas (Pahranagat NWR, Littlefield, Mesquite, Mormon Mesa, Muddy River, Grand Canyon, Topock Marsh, and Bill Williams River NWR). Although approximately 2,000 willow flycatchers detections were recorded over the five-year study at sites surveyed south of Bill Williams, monitoring results at these sites suggest these individuals were not resident or breeding individuals and were most likely 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 returned 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. We combined the capture and resighting data collected in 2003–2007 with that obtained in 1997–2002 to create a 10-year data set for analyses.

From 1997 to 2006, 269 flycatchers were individually marked as adults and 505 flycatchers were banded as juveniles. Of the flycatchers banded as juveniles, 107 were also encountered as adults. Of the 107 returning juveniles, 59% returned to the same study area and 41% returned to a different study area. Mean dispersal distance was 31.7 km. A total of 289 between-year returns of adult willow flycatchers were identified; of these 92% returned to the same study area while 8% returned to a different study area. Mean movement distance for adult returns was 4.9 km.

Mark-recapture analyses did not reveal strong evidence that adult survival or detection probabilities varied by gender. We pooled study areas into the following geographic regions based on proximity and observed movement of individuals between study areas: Nevada (Pahranagat, Key Pittman, Meadow Valley Wash, Ash Meadows), Virgin (Littlefield, Mesquite, Mormon Mesa, Muddy River, Grand Canyon), and Havasu (Topock and Bill Williams). Adult survivorship varied by geographic area but not by year, with the Nevada and Virgin areas showing higher adult survival than the Havasu area. Juvenile survival was lower than that for adults, but models did not indicate that juvenile survival varied significantly between geographic areas. Probability of detection for second-year birds was lower than that for adults. Estimates of the annual per capita rate of population growth (λ) revealed differences in λ between geographic areas, with Nevada having the highest rate, followed by the Virgin area and then Havasu. Estimates of λ in the Virgin area indicated a declining population, but this is not supported by the annual census numbers of willow flycatchers in the monitored study areas. Estimates of λ in the Havasu area also indicated a declining population. A large increase in the number of resident individuals detected at Topock Marsh was observed in 2004, and the number of resident adults detected since 2004 is consistent with a declining population. Numbers of flycatchers observed in the Havasu area over the next few years will help clarify whether the population is declining. Estimates of λ in the Nevada area indicated a stable population.

From 10 to 20 June in 2003–2007, field personnel captured and color-banded 69 new adult flycatchers at seven sites along the extreme southern stretches of the lower Colorado River south of Bill Williams. Reconnaissance efforts from 7 to 9 June 2006 resulted in the capture and color-banding of seven willow flycatchers at two sites, and reconnaissance efforts from 8 to 9 June 2007 resulted in the capture and color-banding of 34 flycatchers at one site. Of the 110 individuals captured, 95 (86%) were second-year birds. Fourteen individuals (13%) exhibited flight feather and/or body molt. The lack of agonistic behaviors exhibited toward conspecific broadcasts and the variation in numbers of flycatchers detected at a given site over the survey season suggest that these individuals were migrants.

We documented 389 willow flycatcher nesting attempts at the four life history study areas, Littlefield, Muddy River Delta, Grand Canyon, and Bill Williams; 350 of these nests were known to contain flycatcher eggs and were used in calculating nest success and productivity. One hundred fifty-six (45%) nests were successful and fledged young, and 186 (53%) failed. For all years combined, nest success ranged from 0% at Grand Canyon to 69% at Pahranagat. Mayfield nest success estimates mirrored apparent nest success. Depredation was the major cause of nest failure, accounting for 47% of all failed nests.

Seventy-five of 325 nests (23%) with flycatcher eggs and known contents were brood parasitized by Brown-headed Cowbirds. An additional nine nests were parasitized prior to flycatcher eggs being laid and were subsequently abandoned. For nests containing flycatcher eggs, parasitism caused nest failure at 18 nests. Brood parasitism at the four life history study areas, Muddy River Delta, and Bill Williams ranged from 0 to 39%, with Mesquite, Muddy River, and Topock all having parasitism rates above 30%. Across all study areas, nests that contained flycatcher eggs and were brood parasitized were less likely to be successful than nests that were not parasitized.

From 2003 to 2007, we used a modification of the Australian crow trap to capture and remove Brown-headed Cowbirds at the 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 traps of two different designs and entrance slots of two different widths to determine if variations in trap design and slot size had any effect on capture rates of cowbirds or non-target species.

We captured and removed 544, 266, 43, and 872 Brown-headed Cowbirds at Pahranagat, Mesquite, Mormon Mesa, and Topock, respectively. Traps with funnel-shaped tops resulted in more captures of both cowbirds and non-target species and also resulted in fewer cowbird escapes. Entrance slots 3.8 cm wide had a tendency to capture more cowbirds than slots 3.2 cm wide, and cowbird escape rates did not differ 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 five consecutive years of no brood parasitism. Nest success, productivity, and fecundity differed between pre-trapping and trapping periods only at Pahranagat, where all metrics were higher during the trapping period.

At the four life history study areas, Littlefield, Muddy River, Grand Canyon, and Bill Williams, we gathered data on vegetation and habitat characteristics at 339 nest plots, 307 non-use plots, and 134 within-territory plots. We gathered data at an additional 229 habitat block plots at the life history study areas. No consistent trends through time were evident at Pahranagat or Mesquite in any of the vegetation variables we measured. At Mormon Mesa, percent canopy closure and percent woody ground cover showed increasing trends through time, though this may have been the result of a shift in the location of survey areas. The number of stems >8.0 cm dbh increased over time at habitat block points at Topock. Survey areas have changed little over the years at Topock, so this may be the result of vegetation maturing over time. However, no changes in stem counts in other categories were recorded. Habitat changes that occurred at Mesquite and Mormon Mesa as the result of widespread flooding in the 2004–2005 winter were evident in vertical foliage density measurements, which were lowest in 2005.

We found willow flycatchers nesting in a diverse array of riparian habitats. Willow flycatcher nest heights ranged from 1.0 to 15.0 m, with a mean nest height of 3.2 m. Flycatchers placed 63% of all nests in tamarisk (*Tamarix* sp.), 23% in Goodding willow (*Salix gooddingii*), 10% in coyote willow (*Salix exigua*), 1% in Fremont cottonwood (*Populus fremontii*), 0.3% in screwbean mesquite (*Prosopis pubescens*), and 3% in snags. Nest sites differed from within-territory locations by having more stems 2.5–8 cm dbh and greater foliage density above nest height. Nest sites typically had taller canopy, greater canopy closure, and greater vertical foliage density above the nest layer when compared to non-use locations. Nests were also closer to standing water or saturated soil than were non-use locations.

We successfully collected microclimate data simultaneously at 639 nest, within-territory, and non-use sites at the four life history study areas and Muddy River. Nest sites differed from both within-territory locations and non-use sites in most measures of microclimate. Nests were located in areas that exhibited higher humidity and a smaller daily temperature range when compared to unused locations. Microclimate characteristics that resulted in a location being more likely to be a nest site were associated with increased canopy height, canopy closure, stems 2.5–8.0 cm dbh, stems >8.0 cm dbh, and proportion of basal area that was native. Nest sites also tended to be associated with decreased stems <2.5 cm dbh and foliage density below the nest.

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 river 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.

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.

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 eastern Texas (Unitt 1987).

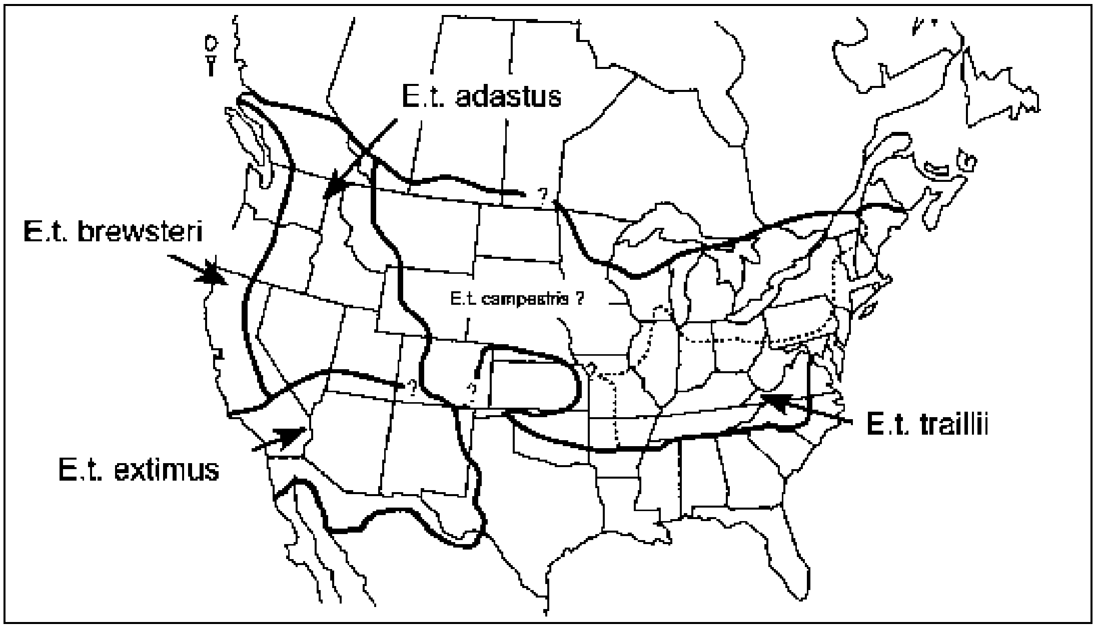

Figure 1.1. Breeding range distribution of the subspecies of the willow flycatcher (***Empidonax traillii***). Adapted from Unitt (1987), Browning (1993), and Sogge et al. (1997).

In the Southwest, most willow flycatcher breeding territories are found within small breeding sites containing five or fewer territories (Sogge et al. 2003). 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). On the wintering grounds both sexes maintain and defend mutually exclusive territories using song and aggressive behaviors similar to those exhibited on the breeding grounds (Sogge et al. 2007). 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 almost 70 years (Unitt 1987), though northbound and southbound migrant willow flycatchers use the riparian corridor (Phillips et al. 1964, Brown et al. 1987, McKernan and Braden 2002, this document). Factors contributing to the decline of flycatchers on the breeding grounds include loss, degradation, and/or fragmentation of riparian habitat; invasion of riparian habitat by nonnative plants; and brood parasitism by Brown-headed Cowbirds (USFWS 1995, Marshall and Stoleson 2000). Because of low population numbers range-wide, identifying and conserving willow flycatcher breeding sites is thought to be crucial to the recovery of the species (USFWS 2002).

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/Lake Mead, Arizona; (7) Topock Marsh on the Colorado River, Havasu NWR, Arizona; and (8) Bill Williams River NWR (Bill Williams), Arizona (McKernan and Braden 2002, this document). Willow flycatchers, including one banded migrant Southwestern Willow Flycatcher, 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 residency or nesting activity was confirmed.

PURPOSE AND DESCRIPTION OF STUDY

The purpose of this five-year (2003–2007) study was to conduct presence/absence 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 encompassed two 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; and (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. SWCA's contract specified the following field tasks:

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

(1) **Presence/absence Surveys**: At approximately 136 sites[2] 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 entire habitat blocks;

(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.

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

Chapter 2 – Presence/absence Surveys and Site Descriptions. This chapter presents the methodology and results for presence/absence surveys and gives a general site description for each survey site, including life history sites. Site descriptions include a summary of any changes that occurred over the five-year study.

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

Chapter 4 – Nest Monitoring. This chapter summarizes nesting attempts, nest fates, and productivity for all Southwestern Willow Flycatcher nesting activity documented during this study.

[2] A site is defined as one contiguous area that can be surveyed by one person in one morning. The contract specified 136 survey sites; however, this number reflects studies performed before 2003 in which several areas were counted as multiple sites. From 2003 to 2007, a total of 131 sites were surveyed as described in the results section of Chapter 2 of this report.

Chapter 5 – Brown-headed Cowbird Trapping. This chapter summarizes the efforts and results of cowbird trapping at the four 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 and analyzed for evidence of changes in vegetation over time.

Chapter 7 – Microclimate. The methodology and results of monitoring temperature, humidity, and soil moisture within each life history study area at nest, within-territory, and non-use sites are presented. Microclimate data are also analyzed in conjunction with vegetation data to determine which vegetation characteristics may influence microclimate.

Chapter 8 – Management Recommendations. All management recommendations are consolidated into one chapter for ease of reference.

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

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 (USFWS 2002, Sogge et al. 1997), 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 and monitoring 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 western 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.

From 2003 to 2007, we completed multiple broadcast surveys at sites in 16 study areas[2] along the lower Colorado River and its tributaries to detect both migrant and resident[3] willow flycatchers (Figure 2.1).

---

[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 1–19 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.

[3] A willow flycatcher present for a week or longer was considered resident.

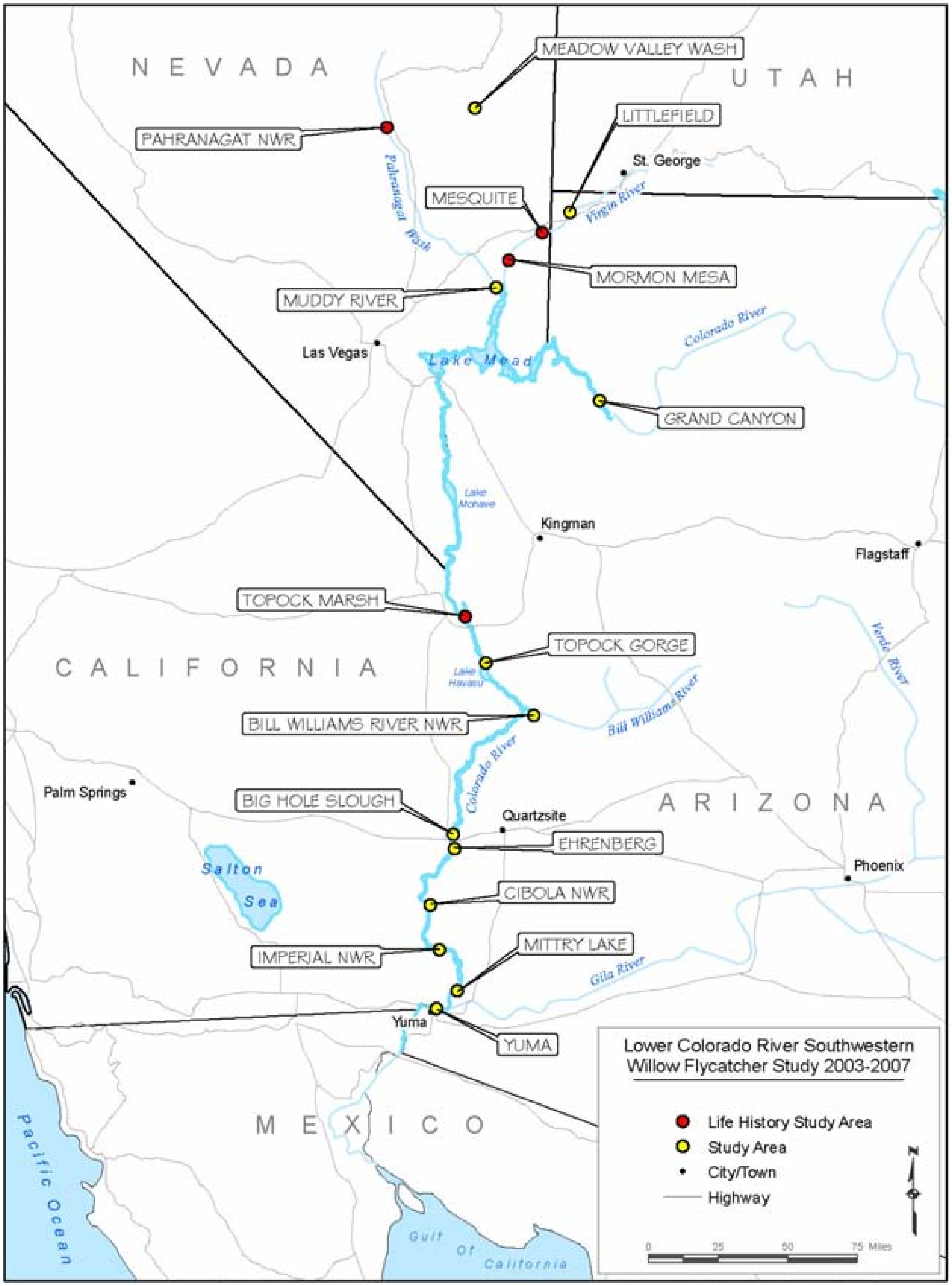

Figure 2.1. Locations of Southwestern Willow Flycatcher study areas along the lower Colorado River and tributaries, 2003–2007. (Note, study area labels represent the approximate center of multiple sites within that region; see Table 2.1).

METHODS

SITE SELECTION

Over the course of this five-year study, survey sites were selected annually based on locations surveyed during previous years of willow flycatcher studies on the lower Colorado River and tributaries (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. 2007a) and reconnaissance by helicopter, by boat, and on foot prior to the start of each survey year. Sites consisting of mature native or exotic woody riparian vegetation with high canopy closure (>50%) and standing water or saturated soil under or adjacent to the vegetation were considered the most suitable habitats for flycatchers. Developing 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 and an outline of the proposed survey area. The boundaries of survey sites were refined during field visits to include potential flycatcher habitat actually present. New boundaries were delineated on the aerial photographs based on UTM coordinates obtained in the field. All UTM coordinates were obtained using a Garmin Rino 110 GPS unit and were in NAD 83 to comply with Federal Geographic Data Committee standards.

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.[4] 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

[4] In 2003, we completed at least one survey between 15 and 30 May, at least one survey between 1 and 15 June, and eight additional surveys between 16 June and 25 July.

representation of all survey areas, field personnel recorded survey start and stop UTM coordinates as well as the UTM coordinates of intermediate survey points. Observers recorded start and stop times and the location(s) and behavior of all willow flycatchers detected. Field personnel also recorded the presence of Brown-headed Cowbirds 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 for each survey site at least three times throughout each survey year: 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; and (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

Flycatcher Surveys – From 2003 to 2007, field personnel spent 6,614 observer-hours conducting willow flycatcher broadcast surveys at 131 sites in 16 study areas along the Virgin and lower Colorado Rivers and tributaries. We found resident and breeding Southwestern Willow Flycatchers at 33 sites in eight study areas (Pahranagat National Wildlife Refuge [NWR], Littlefield, Mesquite, Mormon Mesa, Muddy River, Grand Canyon, Topock Marsh, and Bill Williams River NWR); details of residency and breeding are presented in Chapters 3 and 4. Willow flycatcher survey results and flycatcher occupancy at sites from 2003 to 2007 are summarized in Table 2.1 and are presented below along with site descriptions.[5] For details on annual flycatcher surveys, territories, residency, pairing, nesting activity, demography, cowbird detections, and the presence of livestock at sites from 2003 to 2007 see Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007, and McLeod et al. 2008. The boundaries of survey sites for the most recent survey year and the number of years each site was occupied by territorial flycatchers are shown on orthophotos in Appendix A. See Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007, and McLeod et al. 2008 for orthophotos of annual site boundaries and flycatcher occupancy for 2003–2007.

[5] Area of survey sites included in the site descriptions represents the most recent survey year.

Table 2.1. Willow Flycatcher Detections and Occupancy at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2003–2007*

Study Area[1]	Survey Site	2003		2004		2005		2006		2007	
		Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]
PAHR	North	18	O, B	32	O, B	30	O, B	28	O, B	25	O, B
	West	NS		NS		1	U, Un	ND		3	U, Un
	MAPS	NS		NS		NS		1	O, R	ND	
	South	3	O, B	3	O, B	5	O, B	7	O, B	2	O, R
	Salt Cedar	NS		NS		ND		ND		NS	
MVWA	Meadow Valley #6	ND		NS		NS		NS		NS	
	Meadow Valley #3	ND		NS		NS		NS		NS	
	Meadow Valley #4	ND		NS		NS		NS		NS	
LIFI	Poles	NS		NS		NS		NS		1	O, R
	North	ND		3	O, B	2[4]	U	ND		NS	
	South	ND		ND		ND		NS		NS	
MESQ	East	NS		3	O, P[8]	1	O, R	2	O, P[9]	1	O, R
	West	38	O, B	30	O, B	12	O, B	25	O, B	26	O, B
	Electric Avenue North	NS		3	O, P[8]	NS		NS[7]		ND	
	Electric Avenue South	NS		NS		NS		NS[7]		ND	
	Bunker Farm	NS		3	O, B[8]	6	O, B	1	U, R	ND	
MOME	Mormon Mesa North	7	O, B	4	O, B	4	O, B	ND		ND	
	Hedgerow	NS		NS		ND		ND		ND	
	Mormon Mesa South	1	U, Un	3	O, Un	ND		1	O, Un	2	U, Un
	Virgin River #1 (North)	7	O, B	15	O, B	2	U, R	ND		2	O, R
	Virgin River #1 (South)	NS		ND		ND		4	O, B	15	O, B
	Virgin River #2	NS		NS		7	O, B	16	O, B	12	O, B
	Delta West	5	O, B	5	O, B	1	U, R	NS		NS	

Table 2.1. Willow Flycatcher Detections and Occupancy at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2003–2007,* continued

Study Area[1]	Survey Site	2003		2004		2005		2006		2007	
		Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]
MUDD	Overton WMA, Pond	NS		NS		NS		NS		2	O, B
	Overton WMA	NS		4	O, R	12	O, B	11	O, B	15	O, B
GRCA	Separation Canyon	ND		ND		ND		NS		NS	
	RM 243S	1	O, Un	ND		ND		NS		NS	
	Spencer Canyon	ND		ND		ND		NS		NS	
	Surprise Canyon	NS		ND		ND		NS		NS	
	Clay Tank Canyon	ND		ND		ND		NS		NS	
	No Wifl Point	NS		ND		ND		NS		NS	
	No Wifl Bay	NS		ND		ND		NS		NS	
	Reference Point Creek	ND		ND		ND		NS		NS	
	RM 257.5N	ND		ND		ND		NS		NS	
	Burnt Springs	ND		1	O, R	ND		ND		2	O, B
	Quartermaster Canyon	ND		ND		ND		NS		NS	
	RM 260.5N	ND		ND		NS		NS		NS	
	RM 262.5S	ND		NS		NS		NS		NS	
	RM 268N	ND		NS		NS		NS		NS	
	Columbine Falls	ND		ND		ND		NS		NS	
	RM 274.5N	ND		2	O, B	1	O, R	3	O, B	4	O, R
	Pearce Ferry	NS		NS		NS		1	O, Un	1	U, Un
	RM 285.3N	NS		NS		NS		5	O, B	ND	
	Kowlp Corner	NS		NS		NS		1	O, R	ND	
	RM 286N	NS		NS		NS		ND		ND	
	Driftwood Island	NS		NS		NS		ND		ND	
	Twin Coves	NS		NS		NS		2	O, P	ND	
	Bradley Bay	NS		NS		NS		ND		ND	
	Chuckwalla Cove	NS		NS		NS		3	O, P	ND	
	Center Point	NS		NS		NS		ND		ND	

Table 2.1. Willow Flycatcher Detections and Occupancy at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2003–2007,* continued

Study Area[1]	Survey Site	2003		2004		2005		2006		2007	
		Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]
TOPO	Pipes #1	ND		1	U, Un	2	O, Un	ND		ND	
	Pipes #2	ND		ND		ND		ND		NS	
	Pipes #3	1	U, Un	5	O, B	2	O, R	3	O, P	ND	
	The Wallows	NS		NS		1	O, R	2	O, B	ND	
	PC6-1	NS		9	O, B	3	O, B	ND		ND	
	PB 2001	NS		NS		ND		NS		NS	
	Pig Hole	NS		2	O, B	ND		1	U, R	ND	
	In Between	12	O, B	12	O, B	10	O, B	8	O, B	3	O, B
	800M	4	O, B	4	O, B	6	O, B	2	O, P	2	O, B
	Pierced Egg	ND		5	O, B	8	O, B	6	O, B	7	O, B
	Swine Paradise	ND		3	U, R	ND		2	U, Un	ND	
	Barbed Wire	ND		1	U, Un	ND		ND		1	U, Un
	IRFB03	ND		ND		ND		ND		ND	
	IRFB04	ND		ND		ND		ND		ND	
	Platform	1	U, Un	1	U, Un	ND		ND		ND	
	250M	2[5]	U, Un	2	O, B	2	O, B	1	U, R	2	U, Un
	Hell Bird	2	O, R	9	O, B	ND		ND		2	U, Un
	Glory Hole	3	O, B	10	O, B	5	O, B	9	O, B	7	O, B
	Beal Lake	NS		NS		NS		1	U, Un	2	O, Un
	Lost Slough	NS		NS		NS		NS		ND	
	Lost Pond	NS		NS		NS		NS		ND	
	Lost Lake	ND		1	O, R	ND		1	U, Un	1	U, Un
TOGO	Pulpit Rock	ND		ND		ND		1	U, M	ND	
	Picture Rock	ND		ND		2	U, M	2	U, M	2	U, M
	Blankenship Bend North	ND		2	U, M	ND		ND		4	U, M
	Blankenship Bend South	ND		1	U, M	ND		ND		1	U, M
	Topock Gorge North	ND		NS		NS		NS		NS	
	Topock Gorge South	ND		NS		NS		NS		NS	
	Havasu NE	8	U, M	1	U, M	ND		ND		ND	

Table 2.1. Willow Flycatcher Detections and Occupancy at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2003–2007,* continued

Study Area[1]	Survey Site	2003		2004		2005		2006		2007	
		Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]
BIWI	Site #1	1	O, R	1	O, R	1	U, Un	1	U, Un	NS	
	Site #2	ND		3	U, Un	ND		ND		ND	
	Site #11	1	O, Un	1	O, Un	ND		1	U, Un	1	U, Un
	Site #4	4	O, P	1	O, Un	2	O, B	2	U, Un	ND	
	Site #3	5	O, B	3	O, R	4	O, B	5	O, B	14	O, B
	Site #5	ND		1	U, Un	ND		ND		ND	
	Mineral Wash Complex	ND		1	U, Un	1	O, Un	ND		3	U, Un
	Beaver Pond	1	U, Un	12	O, Un	ND		ND		2	U, Un
	Site #8	1	U, Un	1	U, Un	1	U, Un	ND		1	U, Un
BIHO	Big Hole Slough	5	U, M	20	U, M	5	O, M	2	U, M	7	U, M
EHRE	Ehrenberg	1	U, M	5	U, M	4	U, M	2	O, M	5	O, M
CIBO	Cibola Nature Trail	NS		NS		NS		5	U, M	12	U, M
	Cibola Island	NS		NS		NS		NS		8	U, M
	Cibola Site 2	3	U, M	24	U, M	8	U, M	1	U, M	1	O, M
	Cibola Site 1	ND		5	U, M	5	U, M	2	U, M	5	U, M
	Hart Mine Marsh	5	U, M	8	U, M	7	U, M	4	U, M	11	O, M
	Three Fingers Lake	17	U, M	53	U, M	18	O, M	37	U, M	18	O, M
	Cibola Lake #1 (North)	3	U, M	2	U, M	1	U, M	3	U, M	2	U, M
	Cibola Lake #2 (East)	1	U, M	2	U, M	ND		3	U, M	3	U, M
	Cibola Lake #3 (West)	1	U, M	17	U, M	3	U, M	3	U, M	ND	
	Walker Lake	1	U, M	36	U, M	1	O, M	6	O, M	2	U, M
IMPE	Draper Lake	NS		NS		NS		14	U, M	3	U, M
	Paradise	1	U, M	20	U, M	40	O, M	20	O, M	8	U, M
	Hoge Ranch	6	O, M	28	U, M	31	O, M	22	U, M	8	U, M
	Adobe Lake	2	U, M	8	U, M	41	O, M	3	O, M	3	U, M
	Taylor Lake	2	U, M	NS		NS		NS		NS	
	Rattlesnake	NS		ND		5	U, M	5	U, M	6	U, M

Table 2.1. Willow Flycatcher Detections and Occupancy at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2003–2007,* continued

Study Area[1]	Survey Site	2003		2004		2005		2006		2007	
		Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]
IMPE	Norton South	NS		1	O, M	1	U, M	2	U, M	2	U, M
	Picacho NW	1	U, M	21	O, M	10	O, M	10	U, M	3	U, M
	Picacho Camp Store	5	O, M	NS		NS		NS		NS	
	Milemarker 65	ND		8	U, M	9	U, M	3	U, M	6	U, M
	Clear Lake/The Alley	2	U, M	5	U, M	ND		2	O, M	1	U, M
	Nursery NW	NS		NS		NS		6	U, M	16	U, M
	Imperial Nursery	ND		10	U, M	3	U, M	6	U, M	7	U, M
	Ferguson Lake	2	U, M	27	U, M	18	U, M	13	U, M	29	O, M
	Ferguson Wash	1	U, M	11	U, M	10	U, M	5	U, M	8	U, M
	Great Blue Heron	9	U, M	85	U, M	18	O, M	44	O, M	12	U, M
	Powerline	ND		2	U, M	2	U, M	5	U, M	6	U, M
	Martinez Lake	ND		9	O, M	3	U, M	13	U, M	5	U, M
MITT	Mittry West	11	O, M	12	U, M	6	U, M	9	U, M	17	U, M
	Mittry South	3	U, M	16	U, M	6	U, M	ND		6	U, M
	Potholes East	1	U, M	7	U, M	1	U, M	6	U, M	3	U, M
	Potholes West	1	U, M	6	U, M	2	U, M	4	U, M	11	O, M
YUMA	River Mile 33	17	O, M	16	U, M	10[6]	U, M	14	U, M	NS	
	Gila Confluence West	3	O, M	15	U, M	11	U, M	3	O, M	NS	
	Gila Confluence North	2	U, M	20	U, M	7	U, M	12	O, M	6	U, M
	Gila River Site #1	8	U, M	NS		NS		4	U, M	14	U, M
	Gila River Site #2	18	U, M	6	U, M	ND		9	U, M	11	U, M
	Fortuna Site #1	NS		ND		ND		10	U, M	25	U, M
	Fortuna North	15	U, M	7	U, M	4	U, M	4	O, M	13	U, M
	Morelos Dam	NS		NS		NS		ND		11	U, M
	Gadsden Bend	27	O, M	21	O, M	23	O, M	34	O, M	NS	
	Gadsden	30	O, M	29	U, M	19	U, M	82	O, M	93	O, M
	Hunter's Hole	28	O, M	46	U, M	12	O, M	59	O, M	48	U, M

Table 2.1. Willow Flycatcher Detections and Occupancy at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2003–2007,* continued

Study Area[1]	Survey Site	2003		2004		2005		2006		2007	
		Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]	Number Adults Detected[2]	Site Occupancy[3]

* 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. 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. For unidentified, non-resident willow flycatchers detected at study areas where flycatcher residency or breeding has been recorded in any given year since 2003, it is unknown if these individuals were migrants or floaters. We define a floater willow flycatcher as "an individual member of a largely territorial population who is not defending a territory, and whose movements encompass an area substantially larger than those of the average territorial conspecific" (Winker 1998). For details on territories, residency, pairing, nesting activity, and demography see Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007, and McLeod et al. 2008. Sites where broadcast surveys were conducted less than four times are not included.

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

[2] NS = no surveys conducted or surveys discontinued early in the season because of poor habitat quality; ND = no willow flycatchers detected.

[3] O = occupied; U = unoccupied; B = breeding site; R = resident Southwestern Willow Flycatcher(s) recorded at site, no pairing/breeding behavior observed; P = paired willow flycatchers recorded at site, no nests located; Un = unknown if flycatcher(s) were migrants or floaters; M = migrant willow flycatcher(s) recorded at site, subspecies unknown.

[4] Two willow flycatchers were detected during the first survey in mid-May, one was later detected at Mesquite West where it held a breeding territory.

[5] Two, interacting willow flycatchers detected. As mating behavior and agonistic flycatcher interactions (other than copulation or aggressive displacement) are similar, this observation is difficult to interpret.

[6] Included in the total is one Southwestern Willow Flycatcher detected and resighted on 17 May that was originally banded as a nestling at an unidentified life history study area in 2003 or 2004.

[7] Site surveyed opportunistically; 3 surveys conducted.

[8] Site surveyed by SWCA field personnel from unrelated project; see SWCA (2004) for details on flycatcher residency and breeding.

[9] Flycatchers detected by personnel from an unrelated project; flycatcher presence could not be confirmed by SWCA personnel.

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 were not confirmed are summarized in Table 2.2.

Hydrological Conditions at Survey Sites - Except for one site in 2005 (PC6-1, Topock), during any given year since 2003 when willow flycatcher residency or breeding was recorded at sites, standing water and/or saturated soil were always present within or immediately adjacent to site boundaries. Of the 33 sites occupied by flycatchers in 2003–2007, all of which are located north of Parker Dam, 26 (79%) contained standing water and/or saturated soil under the vegetation, 6 (18%) did not contain standing water and/or saturated soil under the vegetation but were located adjacent to a river or marsh, and 1 (3%) was located 50 m from standing water. Although 39 (87%) of the 45 survey sites located south of Parker Dam were located immediately adjacent to standing water or saturated soil (e.g., a river, lake, pond, marsh, or canal), the sites contained much less standing water or saturated soil under the vegetation than sites located north of Parker Dam. Hydrologic characteristics of each site are summarized in Tables 2.3–2.5.

Table 2.2. Detections of Willow Flycatchers Recorded after 15 June at Sites Where Breeding or Residency Was Not Confirmed, 2003–2007

Study Area[1]	Site	Date	Comments
2003			
GRCA	RM 243 S	18 July	Hualapai Division of Natural Resources biologist reported that a willow flycatcher was detected "nearby" on 2 July. Flycatchers were not detected on any other dates despite multiple surveys.
BIWI	Bill Williams Site #11	17 June	Lone bird responded to playbacks. This was the only detection of a willow flycatcher at this site.
IMPE	Hoge Ranch	2 July	This bird vocalized with only a single call (***wheeo***) when it was startled by the arrival of the observer. It did not vocalize in response to playbacks.
	Picacho Camp Store	16 June	Lone flycatcher not very responsive to playbacks or territorial
MITT	Mittry West	18 June	Lone bird mildly responsive to playbacks
YUMA	Gila Confluence West	17 June	Lone bird responded to playbacks
	River Mile 33	17 June	Lone bird responded to playbacks
	Gadsden Bend	17 June	2 willow flycatchers responded to playbacks; neither could be relocated 45 minutes later
	Gadsden	16 June	3 willow flycatchers detected. 1 sang spontaneously, 2 others responded to playbacks. None could be relocated when surveyor entered area where birds had been singing.
	Hunter's Hole	16 June	2 willow flycatchers detected, not very responsive to playbacks
2004			
IMPE	Martinez Lake	24 June	Lone flycatcher not very responsive to playbacks or territorial
YUMA	Gadsden Bend	23 July	Lone flycatcher responded to playbacks
2005			
BIWI	Mineral Wash Complex	23 June	Lone flycatcher, responded to playbacks with sporadic song (***fitz-bew***)
BIHO	Big Hole Slough	18 June	Lone flycatcher, responded to playbacks with calls (***whitts)*** and primary song (***fitz-bew***)

Table 2.2. Detections of Willow Flycatchers Recorded after 15 June at Sites Where Breeding or Residency Was Not Confirmed, 2003–2007, continued

Study Area[1]	Site	Date	Comments
CIBO	Three Fingers Lake	17 June	Lone flycatcher, primary song (***fitz-bew***) heard prior to playbacks; no response to playbacks
	Walker Lake	6 July	Lone flycatcher, primary song (***fitz-bew***) heard prior to playbacks; responded strongly to playbacks
IMPE	Paradise	16 June	Lone flycatcher, responded to playbacks with primary song (***fitz-bew***)
	Adobe Lake	20 June	Lone flycatcher, responded to playbacks with primary song (***fitz-bew***)
	Picacho NW	17 June	Two flycatchers, approximately 60 m apart, responded to playbacks with primary song (***fitz-bew***) and calls
	Great Blue Heron	18 June	At least two flycatchers heard singing (spontaneously), one captured passively in mist net.
YUMA	Gadsden Bend	16 June	At least two flycatchers detected while mist netting, one individual responded to playbacks
		17 June	Three flycatchers captured passively in mist nets; unresponsive to playbacks prior to capture
	Hunter's Hole	17 June	One flycatcher heard singing (***fitz-bew***)
2006			
EHRE	Ehrenberg	19 June	Lone flycatcher, responded to playbacks with calls (***whitts)*** and primary song (***fitz-bew***)
CIBO	Walker Lake	20 June	Lone flycatcher, responded to playbacks with primary song (***fitz-bew***)
IMPE	Paradise	21 June	Lone flycatcher, responded to playbacks with primary song (***fitz-bew***)
	Great Blue Heron	17 June	Lone flycatcher detected spontaneously singing (***fitz-bew***) and calling (***breets***)
YUMA	Gila Confluence West	16 June	Lone flycatcher, responded to playbacks with primary song (***fitz-bew***)
	Gila Confluence North	28 July	Individual heard spontaneously singing (***fitz-bew***)
	Fortuna North	21 June	Lone flycatcher, responded to playbacks with calls (***whitts)*** and primary song (***fitz-bew***)
	Gadsden	17 June	Five flycatchers captured passively in mists nets, and three flycatchers detected spontaneously vocalizing
		18 June	Three flycatchers captured passively in mists nets, and three flycatchers detected spontaneously singing (***fitz-bew***)
2007			
TOPO	Beal Lake	17 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	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]GRCA=Grand Canyon; TOPO = Topock Marsh, BIWI=Bill Williams River NWR, BIHO = Big Hole Slough, EHRE = Ehrenberg, CIBO = Cibola NWR IMPE=Imperial NWR; MITT= Mittry Lake; YUMA=Yuma.

Table 2.3. Summary of Inundated Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2003–2007*

Study Area[1]	Survey Site	% Site Inundated (Depth (cm) of Surface Water)[2, 3]														
		2003			2004			2005			2006			2007		
		May	June	July	May	June	July	May	June	July	May	June	July	May	June	July
PAHR	North[4]	100(50)	80(50)	50(20)	90(50)	20(10)	10(10)	90(100)	70(70)	5(10)	80(70)	45(15)	20(5)	75(50)	40(10)	5(3)
	West[4]		NS			NS		50(30)	50(30)	50(5)	50(30)	15(30)	15(5)	30(3)	15(3)	0
	MAPS[4]		NS			NS			NS		30(10)	10(10)	5(10)	40(3)	15(3)	0
	South	20(20)	20(20)	20(20)	10(50)	10(30)	10(50)	10(50)	10(50)	5(10)	10(10)	10(10)	10(10)	2(25)	20(50)	20(50)
	Salt Cedar[4]		NS			NS		90(70)	60(50)	40(25)	5(25)	0	0		NS	
MVWA	Meadow Valley #6	40(30)	40(30)	55(50)		NS			NS			NS			NS	
	Meadow Valley #3	20(50)	20(30)	30(30)		NS			NS			NS			NS	
	Meadow Valley #4	25(30)	25(30)	20(40)		NS			NS			NS			NS	
LIFI	Poles		NS			NS			NS			NS		--	20(10)	3(10)
	North	40(40)	30(20)	30(25)	30(30)	20(30)	20(50)	0	0	0	0	0	0		NS	
	South	10(10)	5(10)	5(10)	5(50)	5(30)	5(30)	0	0	0		NS			NS	
MESQ	East[12]		NS			NS		1(--)	5(40)	1(5)	80(100)	0	1(100)	1(50)	1(50)	2(50)
	West[5]	60(30)	20(10)	5(2)	50(30)	10(10)	40(10)	20(40)	15(30)	15(30)	30(25)	30(25)	50(25)	20(25)	15(50)	--
	Electric Avenue North		NS			NS			NS			NS		3(10)	0	1(10)
	Electric Avenue South		NS			NS			NS			NS		0	0	0
	Bunker Farm[12]		NS			NS		1(10)	1(10)	1(10)	2(5)	0	0	0	5(3)	0
MOME	Mormon Mesa North[4]	10(40)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hedgerow		NS			NS		--	0	--	0	0	0	0	0	0
	Mormon Mesa South[4]	25(50)	0	0	0	0	0	--	--	0	1(3)	0	0	0	0	0
	Virgin River #1 (North)	10(30)	0	0	35(25)	10(3)	0	10(35)	--	10(25)	5(25)	0	0	1(5)	--	0
	Virgin River #1 (South)[4]		NS		5(70)	0	0	--	--	0	0	1(70)	0	12(15)	10(25)	0
	Virgin River #2[4]		NS			NS		--	--	10(10)	3(10)	1(5)	--	0	1(5)	0
	Delta West[4]	90(30)	0	0	80(30)	0	0	95(10)	--	--		NS			NS	
MUDD	Overton WMA, Pond		NS			NS			NS			NS		--	5(5)	5(5)
	Overton WMA		NS		20(30)	30(70)	10(30)	5(5)	--	5(5)[6]	5(100)	5(100)	5(100)[7]	5(30)	5(70)	10(10)
GRCA	Separation Canyon	5(4)	1(4)	1(4)	1(5)	0	0	15(10)	10(5)	5(10)		NS			NS	
	RM 243S[4]	0	1(50)	1(100)	0	0	2(30)	0	0	0		NS			NS	
	Spencer Canyon	30(100)	30(100)	30(100)	15(15)	10(25)	10(15)	10(25)	10(25)	10(25)		NS			NS	
	Surprise Canyon		NS		15(30)	5(--)	20(30)	15(10)	15(10)	15(10)		NS			NS	
	Clay Tank Canyon[4]	3(50)	5(100)	5(100)	15(15)	5(--)	10(10)	20(10)	20(10)	10(10)		NS			NS	
	No Wifl Point[4]		NS		0	0	0	0	0	0		NS			NS	
	No Wifl Bay[4]		NS		0	0	0	0	0	0		NS			NS	
	Reference Point Creek[4]	0	0	0	0	0	0	5(10)	5(10)	10(10)		NS			NS	
	RM 257.5N[4]	0	0	0	0	0	0	0	0	0		NS			NS	
	Burnt Springs	--	--	--	0	0	0	20(10)	20(10)	15(25)	5(25)	5(25)	5(25)	--	8(10)	10(25)
	Quartermaster Canyon	1(5)	1(5)	1(5)	--	0	0	20(15)	20(25)	10(10)		NS			NS	
	RM 260.5N[4]	0	0	0	0	0	0		NS			NS			NS	
	RM 262.5S[4]	0	0	0		NS			NS			NS			NS	
	RM 268N[4]	--	--	0		NS			NS			NS			NS	
	Columbine Falls	3(15)	3(10)	3(10)	2(5)	3(5)	10(--)	10(5)	10(5)	15(5)		NS			NS	
	RM 274.5N[4]	5(50)	1(30)	10(50)	3(10)	2(50)	4(--)	20(10)	20(10)	15(10)	15(70)	15(70)	15(70)	20(30)	20(50)	20(30)
	Pearce Ferry[4]		NS			NS			NS		--	0	0	0	0	0
	RM 285.3N		NS			NS			NS		--	0	0	0	0	0

Table 2.3. Summary of Inundated Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2003–2007,* continued

Study Area[1]	Survey Site	% Site Inundated (Depth (cm) of Surface Water)[2, 3]														
		2003			2004			2005			2006			2007		
		May	June	July	May	June	July	May	June	July	May	June	July	May	June	July
GRCA	Kowlp Corner[4]		NS			NS			NS		--	0	0	0	0	0
	RM 286N[4]		NS			NS			NS		--	0	0	0	0	0
	Driftwood Island[4]		NS			NS			NS		--	0	0	0	0	--
	Twin Coves[4]		NS			NS			NS		--	0	0	0	0	0
	Bradley Bay[4]		NS			NS			NS		--	0	0	0	0	0
	Chuckwalla Cove[4]		NS			NS			NS		--	0	0	0	0	0
	Center Point[4]		NS			NS			NS		--	0	0	--	0	0
TOPO	Pipes #1	10(0)	0	0	0	0	0	0	0	0	0	0	1(5)	0	0	0
	Pipes #2	35(100)	5(10)	0	0	0	--	0	0	0	0	--	--		NS	
	Pipes #3	60(15)	10(10)	0	80(30)	10(5)	1(5)	1(5)	0	0	5(10)	5(10)	0	10(10)	5(10)	1(10)
	The Wallows		NS			NS		--	5(10)	--	0	2(5)	10(10)	20(10)	40(20)	10(10)
	PC6-1		NS		--	5(5)	1(5)	0	0	0	30(5)	10(10)	5(10)	50(10)	30(3)	3(3)
	PB 2001		NS			NS		5(5)	0	0		NS			NS	
	Pig Hole		NS		--	--	--	0	0	0	0	0	0	2(3)	0	0
	In Between	60(20)	--	0	2(10)	0	--	5(5)	0	0	0	0	0	5(3)	0	0
	800M	0	--	0	--	10(5)	--	0	0	1(5)	30(5)	10(5)	0	0[13]	0	0
	Pierced Egg	30(6)	0	0	20(10)	1(10)	1(5)	0	0	0	20(5)	0	2(5)	7(3)	1(15)	0
	Swine Paradise[8]	0	0	0	0	5(5)	0	0	0	0	0	0	0	10(20)	0	0
	Barbed Wire	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0
	IRFB03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	IRFB04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Platform[8]	5(15)	3(5)	0	--	0	--	0	0	0	0	0	0	--	0	--
	250M[8]	30(--)	5(5)	0	10(30)	1(5)	1(5)	0	0	0	0	5(10)	0	5(3)	0	3(10)
	Hell Bird	90(100)	75(--)	--	50(30)	40(30)	30(10)	0	2(5)	15(5)	40(25)	60(25)	50(25)	55(25)	25(10)	60(25)
	Glory Hole	20(45)	5(45)	--	50(30)	30(30)	35(30)	10(5)	10(15)	10(15)	30(30)	30(30)	20(30)	10(10)	30(50)	50(90)
	Beal Lake[9]		NS			NS			NS		40(25)	0	5(25)	5(10)	30(3)	0
	Lost Slough		NS			NS			NS			NS		0	25(10)	0
	Lost Pond[4]		NS			NS			NS			NS		30(>100)	25(>100)	3(10)
	Lost Lake[8]	0	0	0	10(10)	30(30)	--	5(10)	5(10)	5(10)	--	--(5)	5(5)	8(--)	5(3)	0
TOGO	Pulpit Rock[4]	0	0	0	1(5)	1(5)	1(5)	10(5)	10(5)	10(5)	10(100)	0	0	--	--	--
	Picture Rock[10]	5(10)	5(10)	0	10(10)	10(10)	10(5)	--	--	--	--	--	--	--	--	--
	Blankenship Bend North[4]	5(30)	5(30)	0	20(30)	20(30)	20(30)	15(100)	15(100)	15(100)	15(100)	15(100)	15(100)	15(100)	15(100)	15(100)
	Blankenship Bend South[4]	5(30)	5(30)	0	20(30)	20(30)	20(30)	20(30)	20(30)	20(30)	20(30)	20(30)	20(30)	85(50)	40(25)	75(--)
	Topock Gorge North[4]	10(10)	0	0		NS			NS			NS			NS	
	Topock Gorge South[4]	10(10)	0	0		NS			NS			NS			NS	
	Havasu NE[4]	5(20)	0	--	--	0	--	0	0	0	0	0	0	0	0	0
BIWI	Site #1[4]	80(50)	10(50)	40(20)	5(10)	15(10)	10(10)	10(40)	10(40)	10(40)	5(25)	0	1(10)		NS	
	Site #2[4]	--	20(10)	10(20)	--	--	--	5(25)	0	0	--	--	--	0	1(5)	0
	Site #11[4]	0	--	--	0	--	--	--	--	--	0	0	0	0	0	0
	Site #4[4]	25(100)	0	0	0	0	0	20(50)	10(30)	5(30)	10(30)	10(30)	1(5)	10(40)	5(15)	3(60)
	Site #3[4]	20(80)	0	0	0	0	0	10(50)	10(30)	10(10)	15(10)	10(10)	1(5)	10(25)	15(25)	0
	Site #5[4]	50(100)	30(80)	0	3(30)	3(10)	0	20(100)	--	--	10(70)	1(50)	--	0	15(100)	3(60)
	Mineral Wash Complex[4]	5(80)	25(80)	1(80)	1(10)	1(5)	0	10(25)	10(25)	10(10)	10(25)	10(10)	10(10)	0	20(10)	25(20)

Table 2.3. Summary of Inundated Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2003–2007,* continued

Study Area[1]	Survey Site	% Site Inundated (Depth (cm) of Surface Water)[2, 3]														
		2003			2004			2005			2006			2007		
		May	June	July	May	June	July	May	June	July	May	June	July	May	June	July
BIWI	Beaver Pond[4]	50(50)	--	--	30(30)	10(30)	1(5)	20(15)	5(15)	5(15)	5(25)	5(10)	5(10)	20(20)	20(15)	25(20)
	Site #8[4]	--	1(80)	1(80)	--	10(70)	--	30(30)	--(30)	20(20)	15(25)	15(25)	15(25)	30(25)	50(25)	25(20)
BIHO	Big Hole Slough	5(8)	0	5(5)	25(10)	25(5)	25(--)	10(10)	10(10)	10(10)	10(10)	10(10)	10(10)	--	--	--
EHRE	Ehrenberg[11]	0	0	0	1(5)	0	0	0	0	5(10)	0	3(3)	5(10)	0	0	0
CIBO	Cibola Nature Trail[9]		NS			NS			NS		0	5(3)	0	25(25)	3(3)	10(20)
	Cibola Island		NS			NS			NS			NS		--	0	--
	Cibola Site #2[10, 11]	5(5)	5(5)	3(--)	--	--	--	--	--	--	--	--	--	--	--	--
	Cibola Site #1[10, 11]	10(5)	10(5)	5(--)	--	--	--	--	--	--	--	--	--	--	--	--
	Hart Mine Marsh[8]	50(100)	40(100)	5(20)	30(70)	25(50)	20(30)	10(50)	10(50)	10(35)	40(70)	30(50)	5(10)	25(10)	20(10)	20(10)
	Three Fingers Lake[4]	30(150)	30(150)	--	30(>100)	30(>100)	30(>100)	25(>100)	25(>100)	25(>100)	25(>100)	25(>100)	25(>100)	25(>100)	18(>100)	18(>100)
	Cibola Lake #1 (North)[4]	0	0	0	0	0	0	0	0	0	10(5)	5(5)	0	7(25)	5(10)	3(10)
	Cibola Lake #2 (East)[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cibola Lake #3 (West)[4]	0	0	0	0	0	0	0	0	0	5(20)	0	0	15(3)	5(3)	3(3)
	Walker Lake[4]	0	0	0	0	0	0	0	0	0	15(10)	5(--)	0	20(25)	10(10)	5(3)
IMPE	Draper Lake[8]		NS			NS			NS		5(10)	5(10)	5(10)	--(50)	5(10)	10(10)
	Paradise[4]	5(100)	5(75)	1(40)	20(10)	0	5(10)	30(5)	15(25)	0	30(5)	0	0	40(10)	0	3(3)
	Hoge Ranch[4]	--	0	0	--	40(10)	45(15)	15(5)	5(10)	25(30)	25(25)	5(50)	30(15)	35(50)	35(30)	20(70)
	Adobe Lake[4]	0	0	0	0	0	0	0	0	0	--	--	--	--	--	--
	Taylor Lake[4]	0	0	0		NS			NS			NS			NS	
	Rattlesnake[8]		NS		--	0	--	0	1(5)	5(5)	5(3)	--	0	8(10)	8(10)	10(25)
	Norton South[8]		NS		--	15(10)	10(30)	1(5)	15(10)	10(30)	30(30)	15(25)	10(10)	15(25)	20(50)	20(50)
	Picacho NW[4]	0	0	0	1(5)	0	0	0	0	0	0	0	0	0	0	0
	Picacho Camp Store[4]	10(20)	0	3(10)		NS			NS			NS			NS	
	Milemarker 65[4]	5(40)	0	--	0	0	0	--	--	--	--	--	--	--	--	--
	Clear Lake/The Alley[4]	5(10)	5(--)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nursery NW[8]		NS			NS			NS		90(25)	5(10)	20(5)	--	0	--
	Imperial Nursery[9]	5(25)	30(25)	0	0	0	20(0)	2(5)	0	0	80(3)	0	0	0	0	40(25)
	Ferguson Lake[4]	5(5)	0	0	0	0	0	1(10)	5(10)	10(25)	5(5)	1(3)	15(10)	3(25)	10(3)	3(10)
	Ferguson Wash[4]	1(--)	3(--)	5(--)	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	0	0	0
	Powerline[4]	0	0	0	0	0	0	5(--)	5(--)	5(--)	1(0)	0	10(5)	10(10)	5(3)	10(10)
	Martinez Lake[4]	0	0	0	0	0	0	0	0	5(--)	0	0	0	0	0	3(3)
MITT	Mittry West	5(--)	5(15)	3(15)	70(30)	5(30)	15(30)	0	0	0	5(5)	0	0	3(10)	0	0
	Mittry South[4]	8(20)	0	0	0	0	0	0	0	0	0	0	0	0	0	--
	Potholes East[11]	30(--)	30(--)	30(--)	30(--)	30(--)	30(--)	30(--)	30(--)	30(--)	10(--)	10(--)	10(--)	5(--)	10(10)	--
	Potholes West[11]	20(>100)	20(>100)	20(>100)	20(>100)	20(>100)	20(>100)	20(>100)	20(>100)	20(>100)	20(>100)	15(>100)	20(>100)	10(>100)	20(>100)	10(>100)
YUMA	I-8 Site #1	--	--	--		NS			NS			NS			NS	
	River Mile 33	10(50)	10(30)	0	10(40)	2(10)	5(--)	2(50)	5(25)	5(25)	0	0	--		NS	
	Gila Confluence West[4]	0	0	0	1(5)	0	0	5(30)	5(30)	5(30)	5(30)	5(30)	0		NS	
	Gila Confluence North[4]	0	0	0	15(30)	0	0	15(10)	10(50)	10(10)	0	15(10)	0	3(10)	0	1(10)
	Gila River Site #1[4]	0	0	0		NS			NS		10(40)	10(40)	10(40)	10(30)	10(--)	0
	Gila River Site #2[4]	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0
	Fortuna Site #1[4]		NS		--	--	15(30)	--	0	0	0	0	0	0	0	0

Table 2.3. Summary of Inundated Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2003–2007,* continued

Study Area[1]	Survey Site	% Site Inundated (Depth (cm) of Surface Water)[2, 3]														
		2003			2004			2005			2006			2007		
		May	June	July	May	June	July	May	June	July	May	June	July	May	June	July
YUMA	Fortuna North[4]	0	0	0	0	0	0	5(10)	--	0	0	0	0	0	0	0
	Morelos Dam[4]		NS			NS			NS		0	0	0	0	0	0
	Gadsden Bend	1(10)	0	5(20)	0	5(10)	15(--)	5(50)	5(10)	5(30)	0	0	--		NS	
	Gadsden[4]	20(40)	20(40)	20(40)	5(30)	5(50)	5(50)	8(50)	10(50)	5(70)	5(50)	5(50)	5(50)	5(50)	5(50)	5(50)
	Hunter's Hole	20(75)	25(50)	10(50)	7(30)	10(70)	15(50)	0	0	0	1(10)	10(10)	1(5)	0	0	0

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

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

2 -- = Hydrologic information not recorded.

3 NS = site not visited/no hydrological data collected.

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

5 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.

6 Water within the channel of the Muddy River was up to 100 cm deep.

7 Water was confined to the channel of the Muddy River which intersects the site.

8 Site borders marsh.

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

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

11 Site borders canal.

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

13 Although no standing water was recorded at the site as part of site descriptions, standing water was observed at the site in May during microclimate data collection.

Table 2.4. Summary of Saturated Soil Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2003–2007*

Study Area[1]	Survey Site	% Site with Saturated Soil (% Site Inundated)[2, 3]														
		2003			2004			2005			2006			2007		
		May	June	July	May	June	July	May	June	July	May	June	July	May	June	July
PAHR	North[4]	0(100)	20(80)	35(50)	0(90)	30(20)	10(10)	10(90)	30(70)	85(5)	10(80)	35(45)	75(20)	5(75)	20(40)	10(5)
	West[4]		NS			NS		5(50)	5(50)	5(50)	5(50)	5(15)	5(15)	3(30)	15(15)	0(0)
	MAPS[4]		NS			NS			NS		20(30)	15(10)	5(5)	3(40)	15(15)	0(0)
	South	30(20)	10(20)	0(20)	5(10)	5(10)	0(10)	15(10)	15(10)	5(5)	10(10)	10(10)	10(10)	5(2)	0(20)	0(20)
	Salt Cedar[4]		NS			NS		5(90)	35(60)	25(40)	5(5)	0(0)	0(0)		NS	
MVWA	Meadow Valley #6	10(40)	10(40)	10(55)		NS			NS			NS			NS	
	Meadow Valley #3	5(20)	0(20)	10(30)		NS			NS			NS			NS	
	Meadow Valley #4	15(25)	0(25)	5(20)		NS			NS			NS			NS	
LIFI	Poles		NS			NS			NS			NS		--	5(20)	1(3)
	North	40(40)	20(30)	15(30)	10(30)	5(20)	20(20)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)		NS	
	South	20(10)	15(5)	15(5)	0(5)	0(5)	0(5)	0(0)	0(0)	0(0)		NS			NS	
MESQ	East[10]		NS			NS		2(1)	15(5)	10(1)	10(80)	0(0)	0(1)	0(1)	0(1)	5(2)
	West[5]	30(60)	15(20)	5(5)	40(50)	40(10)	50(40)	5(20)	5(15)	5(15)	25(30)	10(30)	10(50)	10(20)	10(15)	--
	Electric Avenue North		NS			NS			NS			NS		0(3)	2(0)	1(1)
	Electric Avenue South		NS			NS			NS			NS		0(0)	0(0)	0(0)
	Bunker Farm[10]		NS			NS		20(1)	20(1)	20(1)	0(2)	0(0)	0(0)	2(0)	10(5)	0(0)

Table 2.4. Summary of Saturated Soil Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2003–2007,* continued

Study Area[1]	Survey Site	% Site with Saturated Soil (% Site Inundated)[2, 3]														
		2003			2004			2005			2006			2007		
		May	June	July	May	June	July	May	June	July	May	June	July	May	June	July
MOME	Mormon Mesa North[4]	25(10)	0(0)	0(0)	20(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
	Hedgerow		NS			NS		--	0(0)	--	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
	Mormon Mesa South[4]	30(25)	0(0)	0(0)	10(0)	5(0)	0(0)	--	--	0(0)	10(1)	0(0)	0(0)	0(0)	0(0)	0(0)
	Virgin River #1 (North)	0(10)	0(0)	0(0)	20(35)	20(10)	0(0)	80(10)	--	20(10)	8(5)	10(0)	2(0)	0(1)	--	0(0)
	Virgin River #1 (South)[4]		NS		0(5)	0(0)	0(0)	--	--	0(0)	0(0)	5(1)	0(0)	10(12)	5(10)	0(0)
	Virgin River #2[4]		NS			NS		--	--	20(10)	20(3)	20(1)	--	0(0)	5(1)	0(0)
	Delta West[4]	10(90)	0(0)	0(0)	20(80)	10(0)	0(0)	5(95)	--	--		NS			NS	
MUDD	Overton WMA, Pond		NS			NS			NS			NS		--	10(5)	10(5)
	Overton WMA		NS		30(20)	20(30)	20(10)	20(5)	--	20(5)	10(5)	10(5)	10(5)	10(5)	10(5)	5(10)
GRCA	Separation Canyon	1(5)	1(1)	1(1)	0(1)	0(0)	0(0)	25(15)	20(10)	10(5)		NS			NS	
	RM 243S[4]	0(0)	0(1)	0(1)	4(0)	0(0)	0(2)	0(0)	0(0)	0(0)		NS			NS	
	Spencer Canyon	5(30)	5(30)	5(30)	25(15)	10(10)	10(10)	15(10)	15(10)	15(10)		NS			NS	
	Surprise Canyon		NS		40(15)	3(5)	0(20)	20(15)	20(15)	15(15)		NS			NS	
	Clay Tank Canyon[4]	3(3)	0(5)	0(5)	20(15)	2(5)	15(10)	25(20)	25(20)	15(10)		NS			NS	
	No Wifl Point[4]		NS		0(0)	0(0)	0(0)	0(0)	0(0)	0(0)		NS			NS	
	No Wifl Bay[4]		NS		0(0)	0(0)	0(0)	0(0)	0(0)	0(0)		NS			NS	
	Reference Point Creek[4]	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	10(5)	10(5)	15(10)		NS			NS	
	RM 257.5N[4]	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)		NS			NS	
	Burnt Springs	--	--	--	0(0)	0(0)	0(0)	50(20)	50(20)	20(15)	10(5)	10(5)	10(5)	--	3(8)	10(10)
	Quartermaster Canyon	15(1)	15(1)	5(1)	--	0(0)	0(0)	40(20)	40(20)	15(10)		NS			NS	
	RM 260.5N[4]	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)		NS			NS			NS	
	RM 262.5S[4]	0(0)	0(0)	0(0)		NS			NS			NS			NS	
	RM 268N[4]	--	--	5(0)		NS			NS			NS			NS	
	Columbine Falls	4(3)	5(3)	3(3)	5(2)	2(3)	0(10)	15(10)	15(10)	20(15)		NS			NS	
	RM 274.5N[4]	15(5)	5(1)	50(10)	5(3)	8(2)	6(4)	30(20)	35(20)	20(15)	10(15)	10(15)	10(15)	10(20)	45(20)	20(20)
	Pearce Ferry[4]		NS			NS			NS		--	0(0)	0(0)	0(0)	0(0)	0(0)
	RM 285.3N		NS			NS			NS		--	10(0)	10(0)	3(0)	0(0)	--(0)
	Kowlp Corner[4]		NS			NS			NS		--	0(0)	0(0)	0(0)	0(0)	0(0)
	RM 286N[4]		NS			NS			NS		--	0(0)	0(0)	3(0)	3(0)	--(0)
	Driftwood Island[4]		NS			NS			NS		--	0(0)	0(0)	0(0)	--(0)	--
	Twin Coves[4]		NS			NS			NS		--	0(0)	0(0)	3(0)	0(0)	--(0)
	Bradley Bay[4]		NS			NS			NS		--	0(0)	0(0)	2(0)	0(0)	0(0)
	Chuckwalla Cove[4]		NS			NS			NS		--	0(0)	0(0)	2(0)	0(0)	--(0)
	Center Point[4]		NS			NS			NS		--	0(0)	0(0)	--	0(0)	0(0)
TOPO	Pipes #1	10(10)	0(0)	0(0)	5(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1(0)	0(0)	5(1)	10(0)	0(0)	3(0)
	Pipes #2	5(35)	10(5)	0(0)	0(0)	0(0)	--	0(0)	0(0)	0(0)	0(0)	--	--		NS	
	Pipes #3	10(60)	25(10)	0(0)	20(80)	70(10)	10(1)	50(1)	70(0)	0(0)	0(5)	5(5)	10(0)	1(10)	40(5)	0(1)
	The Wallows		NS			NS		--	70(5)	--	0(0)	2(2)	20(10)	5(20)	20(40)	18(10)
	PC6-1		NS		--	95(5)	50(1)	0(0)	0(0)	0(0)	40(30)	10(10)	10(5)	10(50)	50(30)	10(3)
	PB 2001		NS			NS		5(5)	5(0)	5(0)		NS			NS	
	Pig Hole		NS		--	--	--	0(0)	0(0)	0(0)	3(0)	0(0)	0(0)	5(2)	0(0)	1(0)
	In Between	40(60)	--	(5)	1(2)	2(0)	--	5(5)	5(0)	5(0)	0(0)	0(0)	5(0)	10(5)	3(0)	3(0)
	800M	15(0)	--	0(0)	--	30(10)	--	5(0)	50	30(1)	30(30)	10(10)	0(0)	25(0)[11]	40(0)	20(0)
	Pierced Egg	70(30)	90(0)	0(0)	60(20)	5(1)	--(1)	15(0)	15(0)	15(0)	30(20)	5(0)	10(2)	15(7)	10(1)	3(0)
	Swine Paradise[6]	0(0)	0(0)	0(0)	15(0)	0(5)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	5(10)	0	0
	Barbed Wire	70	0(0)	0(0)	10(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	--	0(0)	0(0)

Table 2.4. Summary of Saturated Soil Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2003–2007,* continued

Study Area[1]	Survey Site	% Site with Saturated Soil (% Site Inundated)[2, 3]														
		2003			2004			2005			2006			2007		
		May	June	July	May	June	July	May	June	July	May	June	July	May	June	July
TOPO	IRFB03	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
	IRFB04	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
	Platform[6]	10(5)	3(3)	0(0)	--	10(0)	--	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	--	0(0)	--
	250M[8]	--(30)	5(5)	0(0)	30(10)	--(1)	--(1)	0(0)	0(0)	0(0)	0(0)	5(5)	0(0)	5(5)	0(0)	0(3)
	Hell Bird	5(90)	--(75)	--	40(50)	60(40)	50(30)	0(0)	5(2)	10(15)	5(40)	5(60)	5(50)	8(55)	1(25)	2(60)
	Glory Hole	5(20)	--(5)	--	40(50)	60(30)	65(35)	10(10)	10(10)	5(10)	5(30)	5(30)	5(20)	1(10)	0(30)	10(50)
	Beal Lake[7]		NS			NS			NS		0(40)	1(0)	2(5)	5(5)	0(30)	0(0)
	Lost Slough		NS			NS			NS			NS		0(0)	0(25)	0(0)
	Lost Pond[4]		NS			NS			NS			NS		30(30)	40(25)	25(3)
	Lost Lake[6]	0(0)	0(0)	0(0)	50(10)	10(30)	--	10(5)	15(5)	15(5)	0(--)	3(--)	20(5)	8(8)	1(5)	0(0)
TOGO	Pulpit Rock[4]	0(0)	0(0)	0(0)	--(1)	5(1)	5(1)	5(10)	5(10)	5(10)	5(10)	0(0)	0(0)	--	--	--
	Picture Rock[8]	5(5)	5(5)	0(0)	2(10)	2(10)	2(10)	--	--	--	--	--	--	--	--	--
	Blankenship Bend North[4]	5(5)	5(5)	0(0)	10(20)	10(20)	10(20)	10(15)	10(15)	10(15)	10(15)	10(15)	10(15)	10(15)	10(15)	10(15)
	Blankenship Bend South[4]	5(5)	5(5)	0(0)	10(20)	10(20)	10(20)	30(20)	30(20)	30(20)	30(20)	30(20)	30(20)	15(85)	15(40)	--(75)
	Topock Gorge North[4]	10(10)	5(0)	0(0)		NS			NS			NS			NS	
	Topock Gorge South[4]	10(10)	5(0)	0(0)		NS			NS			NS			NS	
	Havasu NE[4]	5(5)	0(0)	--	--	0(0)	--	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
BIWI	Site #1[4]	20(80)	10(10)	10(40)	10(5)	30(15)	20(10)	10(10)	5(10)	10(10)	0(5)	0(0)	0(1)		NS	
	Site #2[4]	--	50(20)	30(10)	--	--	--	5(5)	2(0)	0(0)	--	--	--	1(0)	0(1)	0(0)
	Site #11[4]	0(0)	--	--	0(0)	--	--	--	--	--	--(0)	0(0)	--(0)	0(0)	0(0)	0(0)
	Site #4[4]	15(25)	1(0)	10	0(0)	0(0)	0(0)	60(20)	60(10)	60(5)	5(10)	10(10)	10(1)	10(10)	10(5)	5(3)
	Site #3[4]	50(20)	1(0)	10	3(0)	2(0)	2(0)	90(10)	60(10)	60(10)	10(15)	10(10)	5(1)	10(10)	30(15)	10(0)
	Site #5[4]	50(50)	30(30)	1(0)	0(3)	0(3)	2(0)	5(20)	--	--	0(10)	0(1)	--	0(0)	5(15)	0(3)
	Mineral Wash Complex[4]	5(5)	25(25)	1(1)	5(1)	5(1)	0(0)	10(10)	5(10)	5(10)	10(10)	5(10)	5(10)	10(0)	1(20)	25(25)
	Beaver Pond[4]	0(50)	--	--	10(30)	5(10)	5(1)	20(20)	5(5)	5(5)	5(5)	5(5)	5(5)	15(20)	1(20)	25(25)
	Site #8[4]	--	1(1)	1(1)	--	--(10)	--	30(30)	5(--)	5(20)	5(15)	5(15)	5(15)	20(30)	10(50)	20(25)
BIHO	Big Hole Slough	5(5)	5(0)	5(5)	--(25)	--(25)	--(25)	10(10)	10(10)	10(10)	5(10)	5(10)	5(10)	--	--	--
CIBO	Cibola Nature Trail[7]		NS			NS			NS		0(0)	5(5)	0(0)	10(25)	3(3)	5(10)
	Cibola Island		NS			NS			NS			NS		--	--(0)	--
	Cibola Site #2[8, 9]	10(5)	10(5)	0(3)	--	--	--	--	--	--	--	--	--	--	--	--
	Cibola Site #1[8, 9]	10(10)	10(10)	3(5)	--	--	--	--	--	--	--	--	--	--	--	--
	Hart Mine Marsh[6]	5(50)	3(40)	3(5)	4(30)	15(25)	--(20)	10(10)	10(10)	10(10)	10(40)	10(30)	5(5)	8(25)	10(20)	12(20)
	Three Fingers Lake[4]	0(30)	0(30)	--	--(30)	0(30)	--(30)	5(25)	5(25)	5(25)	5(25)	5(25)	5(25)	5(25)	5(18)	5(18)
	Cibola Lake #1 (North)[4]	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	5(10)	1(5)	--(0)	3(7)	3(5)	3(3)
	Cibola Lake #2 (East)[4]	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
	Cibola Lake #3 (West)[4]	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	5(5)	0(0)	5(0)	10(15)	3(5)	3(3)
	Walker Lake[4]	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	20(15)	5(5)	--(0)	10(20)	22(10)	27(5)
IMPE	Draper Lake[6]		NS			NS			NS		10(5)	10(5)	10(5)	5(--)	1(5)	8(10)
	Paradise[4]	0(5)	0(5)	0(1)	30(20)	5(0)	10(5)	35(30)	--(15)	0(0)	10(30)	50(0)	0(0)	--(40)	--(0)	10(3)
	Hoge Ranch[4]	--	3(0)	0(0)	--	0(40)	--(45)	30(15)	15(5)	45(25)	10(25)	5(5)	10(30)	20(35)	15(35)	3(20)
	Adobe Lake[4]	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	--	--	--	--	--	--
	Taylor Lake[4]	0(0)	0(0)	0(0)		NS			NS			NS			NS	
	Rattlesnake[6]		NS		--	25(0)	--	0(0)	2(1)	2(5)	5(5)	--	0(0)	10(8)	5(5)	5(10)
	Norton South[6]		NS		--	--(15)	15(10)	5(1)	--(15)	10(10)	0(30)	1(15)	20(10)	5(15)	5(20)	5(20)
	Picacho NW[4]	0(0)	0(0)	0(0)	6(1)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
	Picacho Camp Store[4]	--(10)	0(0)	3(3)		NS			NS			NS			NS	

Table 2.4. Summary of Saturated Soil Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2003–2007,* continued

Study Area[1]	Survey Site	% Site with Saturated Soil (% Site Inundated)[2, 3]														
		2003			2004			2005			2006			2007		
		May	June	July	May	June	July	May	June	July	May	June	July	May	June	July
IMPE	Milemarker 65[4]	--(5)	0(0)	--	--(0)	0(0)	--(0)	--	--	--	--	--	--	--	--	--
	Clear Lake/The Alley[4]	10(5)	5(5)	--(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
	Nursery NW[6]		NS			NS			NS		5(90)	0(5)	15(20)	--	--(0)	10(--)
	Imperial Nursery[7]	5(5)	--(30)	0(0)	0(0)	0(0)	5(20)	5(2)	0(0)	0(0)	10(80)	0(0)	0(0)	0(0)	0(0)	10(40)
	Ferguson Lake[4]	--(5)	0(0)	0(0)	0(0)	0(0)	0(0)	1(1)	--(5)	15(10)	10(5)	5(1)	5(15)	3(3)	5(10)	0(3)
	Ferguson Wash[4]	0(1)	1(3)	2(5)	0(0)	--(0)	--	0(0)	0(0)	0(0)	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)	0(0)	0(0)	0(0)	0(0)	0(0)	5(0)	0(0)	0(0)	0(0)
	Powerline[4]	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	2(5)	2(5)	2(5)	0(1)	--(0)	0(10)	5(10)	5(5)	5(10)
	Martinez Lake[4]	0(0)	0(0)	0(0)	0(0)	2(0)	0(0)	5(0)	0(0)	5(5)	0(0)	0(0)	0(0)	0	0	3(3)
MITT	Mittry West	--(5)	3(5)	3(3)	30(70)	40(5)	20(15)	0(0)	35(0)	15(0)	10(5)	0(0)	0(0)	3(3)	--(0)	0(0)
	Mittry South[4]	15(8)	3(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	--(0)	0(0)	--(0)	--(0)	--
	Potholes East[9]	0(30)	0(30)	0(30)	0(30)	0(30)	0(30)	5(30)	5(30)	5(30)	5(10)	5(10)	5(10)	--(5)	5(10)	--
	Potholes West[9]	0(20)	0(20)	0(20)	0(20)	0(20)	0(20)	5(20)	5(20)	5(20)	5(20)	5(15)	5(20)	--(10)	3(20)	3(10)
YUMA	I-8 Site #1	--	--	--		NS			NS			NS			NS	
	River Mile 33	15(10)	5(10)	0(0)	1(10)	25(2)	15(5)	0(2)	10(5)	10(5)	0(0)	0(0)	--		NS	
	Gila Confluence West[4]	0(0)	0(0)	0(0)	0(1)	0(0)	0(0)	5(5)	5(5)	5(5)	1(5)	1(5)	0(0)		NS	
	Gila Confluence North[4]	5(0)	5(0)	5(0)	10(15)	15(0)	0(0)	10(15)	15(10)	10(10)	5(0)	0(15)	--(0)	3(3)	0(0)	1(1)
	Gila River Site #1[4]	0(0)	0(0)	0(0)		NS			NS		0(10)	0(10)	1(10)	8(10)	--(10)	0(0)
	Gila River Site #2[4]	0(0)	0(0)	0(0)	2(0)	0(0)	0(0)	--	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
	Fortuna Site #1[4]		NS		--	--	15(15)	0(--)	0(0)	0(0)	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)	45(5)	--	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
	Morelos Dam[4]		NS			NS			NS		0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
	Gadsden Bend	0(1)	5(0)	0(5)	0(0)	10(5)	--(15)	1(5)	1(5)	5(5)	0(0)	0(0)	--		NS	
	Gadsden[4]	0(20)	0(20)	0(20)	0(5)	0(5)	0(5)	3(8)	5(10)	10(5)	5(5)	5(5)	5(5)	5(5)	5(5)	5(5)
	Hunter's Hole	5(20)	--(25)	2(10)	2(7)	0(10)	2(15)	0(0)	0(0)	0(0)	1(1)	10(10)	1(1)	0(0)	0(0)	0(0)

* Values are given for each site as recorded in mid-May, mid-June, and mid-July in each year. Percent of site with saturated soil does not include inundated areas.

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

[2] -- = Hydrologic information not recorded.

[3] NS = site not visited/no hydrological data collected.

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

[5] The amount of saturated soil 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.

[6] Site borders marsh.

[7] Site is irrigated as part of restoration efforts; amount of standing water highly variable throughout the survey season.

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

[9] Site borders canal.

[10] Site receives irrigation runoff from nearby agricultural fields; amount of saturated soil highly variable throughout survey season.

[11] Although no standing water was recorded at the site as part of site descriptions, standing water was observed at the site in May during microclimate data collection.

Table 2.5. Summary of Distances to Surface Water or Saturated Soil at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2003–2007*

Study Area[1]	Survey Site	Distance (m) to Surface Water or Saturated Soil[2, 3]														
		2003			2004			2005			2006			2007		
		May	June	July	May	June	July	May	June	July	May	June	July	May	June	July
PAHR	North[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	West[4]		NS			NS		0	0	0	0	0	0	0	0	0
	MAPS[4]		NS			NS			NS		0	0	0	0	0	0
	South	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Salt Cedar[4]		NS			NS		0	0	0	0	0	0		NS	
MVWA	Meadow Valley #6	0	0	0		NS			NS			NS			NS	
	Meadow Valley #3	0	0	0		NS			NS			NS			NS	
	Meadow Valley #4	0	0	0		NS			NS			NS			NS	
LIFI	Poles		NS			NS			NS			NS		0	0	0
	North	0	0	0	0	0	0	35	35	35	35	35	35		NS	
	South	0	0	0	0	0	0	0	--	40		NS			NS	
MESQ	East[10]		NS			NS		0	0	0	0	10	0	0	0	0
	West[5]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Electric Avenue North		NS			NS			NS			NS		0	100	0
	Electric Avenue South		NS			NS			NS			NS		25	25	25
	Bunker Farm[10]		NS			NS		0	0	0	0	80	80	0	0	80
MOME	Mormon Mesa North[4]	0	>1000	>1000	0	0	>30	0	0	0	0	0	0	0	0	0
	Hedgerow		NS			NS		--	110	--	100	100	100	100	100	100
	Mormon Mesa South[4]	0	>1000	>1000	0	0	>100	0	0	0	0	0	0	0	0	0
	Virgin River #1 (North)	0	>1000	>1000	0	0	>100	0	--	0	0	0	0	0	--	1050
	Virgin River #1 (South)[4]		NS		0	0	>100	0	0	0	0	0	0	0	0	500
	Virgin River #2[4]		NS			NS		--	--	0	0	0	--	0	0	650
	Delta West[4]	0	>1000	>1000	0	0	>100	0	--	--		NS			NS	
MUDD	Overton WMA, Pond		NS			NS			NS			NS		--	0	0
	Overton WMA		NS		0	0	0	0	0	0	0	0	0	0	0	0
GRCA	Separation Canyon	0	0	0	0	0	0	0	0	0		NS			NS	
	RM 243S[4]	0	0	0	0	0	0	0	0	0		NS			NS	
	Spencer Canyon	0	0	0	0	0	0	0	0	0		NS			NS	
	Surprise Canyon		NS		0	0	0	0	0	0		NS			NS	
	Clay Tank Canyon[4]	0	0	0	0	0	0	0	0	0		NS			NS	
	No Wifl Point[4]		NS		0	0	0	0	0	0		NS			NS	
	No Wifl Bay[4]		NS		0	0	0	0	0	0		NS			NS	
	Reference Point Creek[4]	0	0	0	0	0	0	0	0	0		NS			NS	
	RM 257.5N[4]	0	0	0	0	0	0	0	0	0		NS			NS	
	Burnt Springs	--	--	--	0	0	0	0	0	0	0	0	0	--	0	0
	Quartermaster Canyon	0	0	0	0	0	0	0	0	0		NS			NS	
	RM 260.5N[4]	0	0	0	0	0	0		NS			NS			NS	
	RM 262.5S[4]	0	0	0		NS			NS			NS			NS	
	RM 268N[4]	--	--	0		NS			NS			NS			NS	
	Columbine Falls	0	0	0	0	0	0	0	0	0		NS			NS	
	RM 274.5N[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Pearce Ferry[4]		NS			NS			NS		--	0	0	0	0	0
	RM 285.3N		NS			NS			NS		--	0	0	0	0	0
	Kowlp Corner[4]		NS			NS			NS		--	0	0	0	0	0
	RM 286N[4]		NS			NS			NS		--	0	0	0	0	0
	Driftwood Island[4]		NS			NS			NS		--	0	0	0	0	0
	Twin Coves[4]		NS			NS			NS		--	0	0	0	0	0
	Bradley Bay[4]		NS			NS			NS		--	0	0	0	0	0
	Chuckwalla Cove[4]		NS			NS			NS		--	0	0	0	0	0
	Center Point[4]		NS			NS			NS		--	0	0	0	0	0
TOPO	Pipes #1	0	100	100	0	100	100	50	50	50	0	50	0	0	50	0
	Pipes #2	0	0	100	100	100	--	50	50	50	50	--	-		NS	
	Pipes #3	0	0	100	0	0	0	0	0	100	0	0	0	0	0	0
	The Wallows		NS			NS		--	0	--	90	0	0	0	0	0
	PC6-1		NS		0	0	0	50	50	50	0	0	0	0	0	0
	PB 2001		NS			NS		0	0	0		NS			NS	
	Pig Hole		NS		--	--	--	130	130	130	0	130	130	0	130	0
	In Between	0	--	100	0	0	--	0	0	0	50	50	0	0	0	0
	800M	0	--	100	--	0	--	0	0	0	0	0	50	0	0	0
	Pierced Egg	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0
	Swine Paradise[6]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Barbed Wire	0	200	200	0	200	200	160	160	160	160	160	160	160	160	160
	IRFB03	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
	IRFB04	100	100	100	100	100	100	75	75	75	75	75	75	75	75	75
	Platform[6]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	250M[8]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hell Bird	0	0	--	0	0	0	30	0	0	0	0	0	0	0	0
	Glory Hole	0	0	--	0	0	0	0	0	0	0	0	0	0	0	0
	Beal Lake[7]		NS			NS			NS		0	0	0	0	0	25
	Lost Slough		NS			NS			NS			NS		235	0	235
	Lost Pond[4]		NS			NS			NS			NS		0	0	0
	Lost Lake[6]	0	0	0	0	0	--	0	0	0	0	0	0	0	0	0
TOGO	Pulpit Rock[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Picture Rock[8]	0	0	0	0	0	0	--	--	--	0	0	0	0	0	0
	Blankenship Bend North[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Blankenship Bend South[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Topock Gorge North[4]	0	0	0		NS			NS			NS			NS	
	Topock Gorge South[4]	0	0	0		NS			NS			NS			NS	
	Havasu NE[4]	0	0	--	--	0	--	0	0	0	0	0	0	0	0	0

Table 2.5. Summary of Distances to Surface Water or Saturated Soil at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2003–2007,* continued

Study Area[1]	Survey Site	Distance (m) to Surface Water or Saturated Soil[2, 3]														
		2003			2004			2005			2006			2007		
		May	June	July	May	June	July	May	June	July	May	June	July	May	June	July
BIWI	Site #1[4]	0	0	0	0	0	0	0	0	0	0	0	0		NS	
	Site #2[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Site #11[4]	0	30	30	0	0	0	0	0	0	0	0	0	0	0	0
	Site #4[4]	0	--	--	>100	>100	>100	0	0	0	0	0	0	0	0	0
	Site #3[4]	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	Site #5[4]	0	0	0	0	0	0	0	--	--	0	0	--	25	0	0
	Mineral Wash Complex[4]	0	0	0	0	0	>35	0	0	0	0	0	0	0	0	0
	Beaver Pond[4]	0	--	--	0	0	0	0	0	0	0	0	0	0	0	0
	Site #8[4]	--	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BIHO	Big Hole Slough	0	0	0	0	0	0	0	0	0	5	5	5	--	--	--
EHRE	Ehrenberg[9]	0	0	0	0	10	10	15	15	0	15	0	0	15	0	15
CIBO	Cibola Nature Trail[7]		NS			NS			NS		--	0	--	0	0	0
	Cibola Island		NS			NS			NS			NS		--	230	--
	Cibola Site #2[8, 9]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cibola Site #1[8, 9]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hart Mine Marsh[6]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Three Fingers Lake[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cibola Lake #1 (North)[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cibola Lake #2 (East)[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cibola Lake #3 (West)[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Walker Lake[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IMPE	Draper Lake[6]		NS			NS			NS		0	0	0	0	0	0
	Paradise[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hoge Ranch[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Adobe Lake[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Taylor Lake[4]	0	0	0		NS			NS			NS			NS	
	Rattlesnake[6]		NS		--	0	--	0	0	0	0	0	0	0	0	0
	Norton South[6]		NS		--	0	0	0	0	0	0	0	0	0	0	0
	Picacho NW[4]	75	75	75	0	30	30	30	30	30	30	30	30	30	30	30
	Picacho Camp Store[4]	0	0	0		NS			NS			NS			NS	
	Milemarker 65[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Clear Lake/The Alley[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nursery NW[6]		NS			NS			NS		0	0	0	0	0	0
	Imperial Nursery[7]	0	0	40	40	40	0	0	10	10	0	10	10	10	10	0
	Ferguson Lake[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ferguson Wash[4]	0	0	0	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	0	0	0
	Powerline[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Martinez Lake[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MITT	Mittry West	0	0	0	0	0	0	0	0	0	0	180	180	0	250	250
	Mittry South[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Potholes East[9]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Potholes West[9]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YUMA	I-8 Site #1	0	0	0		NS			NS			NS			NS	
	River Mile 33	0	0	--	0	0	0	0	0	0	100	100	--		NS	
	Gila Confluence West[4]	0	0	0	0	0	0	0	0	0	0	0	0		NS	
	Gila Confluence North[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gila River Site #1[4]	0	200	0		NS			NS		0	0	0	0	0	0
	Gila River Site #2[4]	300	300	300	0	0	0	--	0	0	0	0	0	0	0	0
	Fortuna Site #1[4]		NS		--	--	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	0	0
	Morelos Dam[4]		NS			NS			NS		0	0	0	0	0	0
	Gadsden Bend	0	0	0	0	0	0	0	0	0	0	0	--		NS	
	Gadsden[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hunter's Hole	0	0	0	0	0	0	25	25	25	0	0	0	25	25	25

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

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

2 -- = Hydrologic information not recorded.

3 NS = site not visited/no hydrological data collected.

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

5 The amount and location 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.

6 Site borders marsh.

7 Site is irrigated as part of restoration efforts; amount and location of standing water highly variable throughout the survey season.

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

9 Site borders canal.

10 Site receives irrigation runoff from nearby agricultural fields; distance to water highly variable throughout survey season.

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 mature, native vegetation exist at the inflow and outflow of Upper Pahranagat Lake. Hydrological conditions within the riparian habitats are influenced by fluctuating water levels of Pahranagat Lake, with the highest water levels and inundation under the vegetation occurring annually in winter and spring. Water levels in Pahranagat Lake are human controlled.

Pahranagat North

Area: 3.8 ha Elevation: 1,026 m

Pahranagat North was surveyed from 2003 to 2007. The site consists of 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%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007.

The site has been inundated annually since 2003, with up to 1 m of water recorded under the vegetation in mid-May. The site becomes progressively drier through summer. From 2003 to 2007, as much as 100% of the site contained standing water in mid-May, and as much as 95% of the site contained standing water and saturated soil until mid-July.

Breeding willow flycatchers have been recorded at Pahranagat North since 2003, with 18–32 adults detected annually. 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 surveys in 2003–2005, and none were detected in 2006. Cowbirds were detected during one survey in 2007.

Pahranagat West

Area: 1.5 ha Elevation: 1,026 m

Pahranagat West was surveyed from 2005 to 2007. This native site consists of a patch 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*). No major changes in vegetation structure or species composition were recorded since 2005. Since surveys were initiated, the upland edge of the site has been dry, while the vegetation along the lake edge contained varying amounts of standing water through survey seasons.

We did not detect any resident or breeding willow flycatchers at this site, though one adult was detected for a single day in June 2005, and three adults were detected for one day in June 2007. No livestock use has been recorded at the site since surveys were initiated. Cowbirds were detected during surveys in 2005 and 2006.

PAHRANAGAT MAPS

Area: 2.7 ha Elevation: 1,026 m

Pahranagat MAPS was surveyed in 2006 and 2007. The site consists of a mixed native patch dominated by Fremont cottonwood and is located 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. No major changes in vegetation structure or species composition were recorded since surveys were initiated. Varying amounts of standing water and saturated soils were present during survey seasons.

We detected one resident, unpaired male at the site in 2006; no flycatchers were detected in 2007. No livestock use has been recorded at the site. Cowbirds were detected during one survey in 2007.

PAHRANAGAT SOUTH

Area: 2.5 ha Elevation: 1,023 m

Pahranagat South was surveyed from 2003 to 2007. The site consists of a relatively small patch of Goodding willow, coyote willow (*Salix exigua*), and Fremont cottonwood lining a human-made channel that carries the outflow from Upper Pahranagat Lake. The cottonwoods reach approximately 20 m in height, while the willows are generally less than 10 m. Tamarisk and Russian olive form a sparse understory and overall canopy closure at this site is approximately 50%. The site is bordered to the west by an open marsh and to the east by upland scrub. In 2005, we noted that dense coyote willow was increasing on the western side of the patch; this area of willow had a very sparse canopy in 2006 and 2007. Although in some years standing water was present only within a human-made canal, the site contained standing water throughout survey seasons.

Breeding willow flycatchers were recorded at Pahranagat South from 2003 to 2006, with 3–7 adults detected annually. No breeding was recorded at the site in 2007, though two unpaired males were detected. Brown-headed Cowbirds were detected during surveys in 2003–2005 and 2007. No livestock use has been recorded at the site.

PAHRANAGAT SALT CEDAR

Area: 3.1 ha Elevation: 975 m

This site consists of dense clumps of tamarisk 3–4 m in height interspersed with open areas at the southern end of Lower Pahranagat Lake. Canopy closure at the site is approximately 50%.

The site is bordered to the north by the lake and to the south by upland desert. We investigated this site in 2003 and 2004 but did not survey it those years because it was completely dry. The site was surveyed in 2005, with over half the site containing standing water and saturated soil until July. The site was surveyed again in 2006 at the request of the refuge manager in preparation for tamarisk removal at the site. Only 5% of the site was inundated in May 2006, and the site was completely dry by mid-June. No surveys were conducted in 2007 because the site was dry. No major changes in vegetation structure or species composition were noted since 2003.

We did not detect any flycatchers during surveys in 2005 and 2006, and cowbirds were detected in both years. Signs of previous use by cattle were noted.

MEADOW VALLEY WASH, NEVADA

Meadow Valley Wash has its headwaters in the Wilson Creek Range near the Nevada/Utah border, flows south through a narrow valley past Elgin and Carp, and joins the Muddy River near Glendale, Nevada. In 2003, we surveyed three sites in Rainbow Canyon between Elgin and Caliente, where Meadow Valley Wash is perennial. All sites consist of native vegetation, with narrow patches of mature cottonwood and willow on either side of the stream and little to no understory vegetation. Canopy height varies from 10 to 15 m, and canopy closure along the creek ranges from 50 to 80%. All sites are used intermittently by livestock. Surveys were discontinued in 2004 because the riparian stands within the study area lack the well developed understory used by willow flycatchers.

MEADOW VALLEY #6

Area: 7.1 ha Elevation: 1,182 m

This site extends for 2 km along Meadow Valley Wash approximately 12 km north of Elgin. We did not detect any willow flycatchers at this site, and cowbirds were detected during surveys.

MEADOW VALLEY #3

Area: 3.2 ha Elevation: 1,128 m

This site extends for 800 m along Meadow Valley Wash approximately 3 km north of Elgin. We did not detect willow flycatchers or cowbirds during surveys.

MEADOW VALLEY #4

Area: 1.2 ha Elevation: 1,048 m

This site extends for 500 m along Meadow Valley Wash approximately 1.5 km north of Elgin. We did not detect willow flycatchers or cowbirds during surveys.

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. Cattail is present along the southern edge of the site, though not under the trees. Flowing water was present in channels along the northern and southern edges of the site, while the center of the site was dry and sandy. Surface water was present until mid-July.

We detected one resident, unpaired male willow flycatcher at Littlefield Poles in 2007. Cowbirds were detected during one survey, and sign of livestock use was recorded.

LITTLEFIELD NORTH

Area: 4.7 ha Elevation: 543 m

Littlefield North was surveyed from 2003 to 2006. This site originally extended from the I-15 bridge over the Virgin River upstream to the confluence of the Virgin River and Beaver Dam Wash and up Beaver Dam Wash approximately 250 m to a golf course. Much of the flycatcher habitat was completely removed by floods during the winter of 2004–2005. The remaining vegetation consisted of a mixed-native stand of mature Fremont cottonwood with a very sparse understory of willow, tamarisk, and arrowweed (*Pluchea sericea*) on the northwestern corner of the confluence of Beaver Dam Wash and the Virgin River. The understory in this area was almost completely scoured by winter floods, but in 2006 a few tamarisk had sprouted, and coyote willow was regenerating between the cottonwood stand and

Beaver Dam Wash. In 2006, canopy height in the cottonwood stand was 10–15 m, and overall canopy closure was 25–50%.

In 2003 and 2004, much of the site contained standing water in mid-May, with standing water present through survey seasons. During 2005 and 2006, no part of the remaining vegetation contained standing water or saturated soils, although the Virgin River was less than 50 m away.

No willow flycatcher detections were recorded at Littlefield North in 2003. Flycatcher breeding was recorded at the site in 2004, with three adults detected. Two unpaired males, one of which was later detected breeding in Mesquite West, were detected at the site on a single occasion in 2005, and no flycatcher detections were recorded in 2006. Cowbirds were detected during surveys in 2003–2005, and none were detected in 2006. No livestock use has been recorded at the site, although signs of hunting (two tree stands) and ATV tracks were recorded at the site in 2005.

LITTLEFIELD SOUTH

Area: 2.4 ha Elevation: 543 m

Littlefield South is a mixed-native site that was surveyed from 2003 to 2005. This site originally extended along the Virgin River for 550 m immediately downstream from the I-15 bridge and encompassed a backwater area. The backwater area was scoured by 2004–2005 winter floods. In 2005, the site consisted of a narrow strip of vegetation on the right bank of the Virgin River, extending for 320 m immediately downstream of the I-15 bridge. Vegetation in the area was primarily an overstory of cottonwood and willow 10–15 m in height with a very scattered understory consisting primarily of tamarisk 3 m in height but also containing coyote willow and honey mesquite (***Prosopis glandulosa***). The site also contained small areas of cattail (***Typha*** sp.) and arrowweed. Overall canopy closure was 25–50%.

In 2003 and 2004, much of the site contained standing water and saturated soil in mid-May, with standing water present through survey seasons. During 2005, the only surface water was within the Virgin River channel, which was adjacent to the site in May but had receded to 30 m from the site in July.

We did not detect willow flycatchers at Littlefield South. Cowbirds were detected during surveys in 2003 and 2004, and no cowbirds were detected in 2005. No livestock use has been recorded at 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 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

Mesquite East was surveyed from 2005 to 2007. 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, and standing water and saturated soil were present through each survey season. A small drainage pond is present at the end of an irrigation ditch, and it held standing water throughout survey seasons. The western half of the upper terrace burned over the 2004–2005 winter and was not surveyed in 2006–2007. Portions of the burned area that receive irrigation runoff are growing thick stands of coyote willow, common reed (***Phragmites australis***), and cattail.

In 2004, SWCA field personnel from an unrelated project located one lone individual and one pair of willow flycatchers at Mesquite East (see SWCA 2004 for details on flycatcher residency and breeding). We detected one resident, unpaired male at the site in 2005. In 2006, field personnel from an unrelated project located a pair of flycatchers in July; however, surveys both before and after this detection failed to locate any flycatchers, and details of occupancy and breeding were undetermined. We detected one resident unpaired male at the site in 2007. Cowbirds were detected in all survey years, and livestock use has been recorded at the site.

MESQUITE WEST

Area: 12.0 ha Elevation: 470 m

Mesquite West was surveyed from 2003 to 2007. This mixed-native site lies within the floodplain of the Virgin River in Mesquite, Nevada. Golf courses and home 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. 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 has varied daily and across seasons. The site contained standing water and muddy soils throughout the 2003–2007 flycatcher breeding seasons, 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. In 2005–2007, portions of the site where deposition occurred had no surface water, and only the western and northern portions of the site were inundated throughout the flycatcher breeding seasons. 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. The Goodding willow present on the western end of the site may become suitable for flycatchers in subsequent years.

Breeding willow flycatchers have been recorded at Mesquite West since 2003, with 12–38 adults detected annually. Cowbirds were detected during surveys in all years. Sign of livestock use was recorded in 2003, 2004, and 2007.

Electric Avenue North

Area: 1.8 ha Elevation: 460 m

Electric Avenue North lies adjacent to an agricultural field within the floodplain of the Virgin River in Bunkerville, Nevada. SWCA personnel from an unrelated flycatcher project located territorial willow flycatchers at the site in 2004, but access to the site was denied in 2005 by a local landowner. In 2006, we conducted habitat reconnaissance and opportunistic surveys at the site, and formal surveys were conducted in 2007.

In 2006, the site consisted of mixed native vegetation composed of an overstory of Fremont cottonwood averaging 10 m in height with a coyote willow understory. Canopy closure was approximately 70–90%. An isolated patch of tamarisk was located on the western side of the site, and arrowweed and scattered mesquite (***Prosopis*** sp.) trees were present on the edges of the site. During the survey season, standing water was present in a canal that runs through the northern portion of the site. Soils throughout the site were dry.

Between mid-May and mid-June 2007, an area running northwest to southeast was bulldozed through the center of the site, removing approximately 20% of the vegetation present in previous years. Vegetation at the site is now mixed exotic and 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 trees are present on the edges of the site. A small cattail marsh, which held standing water in May and July, is present on the northwest edge of the site. A small stream running west to east held standing water in May.

In 2004, SWCA field personnel from an unrelated project located one lone individual and one pair of willow flycatchers at Electric Avenue North (see SWCA 2004 for details on flycatcher residency and breeding). No flycatchers were detected at the site in 2006–2007. Cowbirds were detected during surveys, and evidence of livestock use was observed.

ELECTRIC AVENUE SOUTH

Area: 3.9 ha Elevation: 460 m

Habitat reconnaissance and opportunistic surveys were conducted at Electric Avenue South in 2006, and formal surveys were conducted in 2007. 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 are interspersed with the tamarisk in some areas. A tall stand of Fremont cottonwood with on open understory is located on the northern end of the site. Canopy closure was approximately 70–90% in 2006. In 2007, canopy closure decreased, ranging from 50–70%. No standing water or saturated soils were present during survey seasons, although a dry channel indicated the Virgin River previously flowed through the site.

We did not detect any flycatchers at this site. Cowbirds were detected during surveys and evidence of livestock use was observed.

BUNKER FARM

Area: 3.1 ha Elevation: 457 m

Bunker Farm was surveyed from 2005 to 2007. 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. No major changes in vegetation structure or species composition were recorded from 2005–2007.

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

In 2004, SWCA field personnel from an unrelated project located one lone individual and one breeding pair of willow flycatchers at Bunker Farm (see SWCA 2004 for details on flycatcher residency and breeding). Breeding willow flycatchers were recorded at the site in 2005, with six adults detected. In 2006, one unpaired male was detected. No flycatchers were detected in 2007. Cowbirds were detected during surveys in 2005–2007, and sign of livestock use has been recorded at the site.

Other Survey Areas

Mesquite Area Recon

Area: 20.7 ha Elevation 500 m

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%. During surveys, soils within the site were dry and sandy.

We did not detect any flycatchers at this site. Cowbirds were detected, and signs of cattle use were recorded.

Hafen Lane

Area: 5.6 ha Elevation: 475 m

Habitat reconnaissance and opportunistic surveys were conducted at Hafen Lane in 2006. This mixed-exotic site lies within the floodplain of the Virgin River in Mesquite, Nevada. Vegetation at the site consists primarily of tamarisk averaging 5 m in height. Canopy closure is approximately 70–90%. Several emergent Goodding willow and tamarisk are scattered throughout the site, and coyote willow is present on the eastern portion of the site. On the northern end of the site there is a small marsh vegetated with cattail and bulrush. During the survey season, standing water was present in channels that connect to the Virgin River, which forms the southern boundary of the site. During surveys, saturated soils were confined to the edges of the channels and the river.

We did not detect any flycatchers at this site. Cowbirds were detected, and evidence of livestock use was observed.

Bunker Marsh North

Area: 13.6 ha Elevation: 453 m

Habitat reconnaissance and opportunistic surveys were conducted at Bunker Marsh North in 2006. This exotic site lies within the floodplain of the Virgin River in Bunkerville, Nevada. The dominant vegetation at the site is tamarisk, which averages 7–9 m in height. Scattered mesquite trees are present on the edges of the site. Canopy closure is approximately 70–90%. The site lies adjacent to an agricultural field, and a large pond vegetated with cattail and bulrush is located on the southeastern edge of the site. During surveys, standing water was present in the marsh, and soils were dry under the vegetation.

We did not detect any flycatchers at this site. Cowbirds were detected, and evidence of livestock use was observed.

Bunker Marsh South

Area: 3.8 ha Elevation: 450 m

Habitat reconnaissance and opportunistic surveys were conducted at Bunker Marsh South in 2006. This exotic site lies within the floodplain of the Virgin River in Bunkerville, Nevada. The site consists of a marsh vegetated with cattail and bulrush, with widely spaced tamarisk trees averaging 5 m in height. Canopy closure is <25%. The site lies adjacent to an agricultural field. A large area west and north of the site had been recently bulldozed. During surveys, standing water and saturated soils were present in the marsh.

We did not detect any flycatchers at this site. Cowbirds were detected and evidence of livestock use was not observed.

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. Except for one small site, 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

Mormon Mesa North was surveyed from 2003 to 2007. In 2003 and 2004, this mixed-exotic site was north of a dry channel of the Virgin River that cut from east to west across the floodplain, and the active channel of the river was located to the east of the site. The site was bordered to the west by a large, seasonally inundated cattail marsh. From the dry river channel toward the cattails, the site graded from dense arrowweed to tamarisk with arrowweed understory to a mixture of tamarisk, Goodding willow, and coyote willow. Canopy height was generally 4–5 m and extended to 8 m where the willow was present. Canopy closure was approximately 70–90%. In 2003, the areas with a mix of tamarisk and willow forest were inundated to a depth of 0.4 m during site reconnaissance in March. When surveys commenced in May 2003 and 2004, the areas with tamarisk and willow forest had damp and muddy soils under the vegetation; these areas were completely dry by mid-June in both years.

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

In 2007, many of the Goodding willows on the western side of the site were snapped in half. Canopy height in Mormon Mesa North was generally 4–5 m and extended to 8 m where willow was present. The site contained dead and dying coyote willow in 2006, and no coyote willow was present in 2007. Canopy closure at the site has decreased since 2005, with approximately 50–70% closure recorded in 2007.

Breeding willow flycatchers were recorded at Mormon Mesa North from 2003 to 2005, with 4–7 adults detected annually. No flycatchers were detected at the site in 2006–2007.

HEDGEROW

Area: 1.4 ha Elevation: 390 m

Opportunistic surveys were conducted at Hedgerow in 2005, and formal surveys were conducted at the site in 2006 and 2007. This mixed-native 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%. No major changes in vegetation structure or species composition were recorded from 2005–2007. Soils within the site were dry since surveys were initiated in 2005. We did not detect any flycatchers at Hedgerow.

MORMON MESA SOUTH

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

Mormon Mesa South was surveyed from 2003 to 2007. Mormon Mesa South consists of a mosaic of tamarisk 4 m in height and patches of Goodding willow and cattail. A long strip of willow runs north to south through the site. Since 2006, many of the willows on the western side of the site have died, 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%. Standing water and saturated soil under the vegetation were recorded only early during survey seasons, and not in all years.

In 2003, we detected one willow flycatcher at the site for a single day in May. In 2004, three flycatchers were detected, each for a single day in May or June. No flycatcher detections were recorded in 2005, and a lone individual was detected in 2006. In 2007, we detected two willow flycatchers at the site, each for a single day in June.

VIRGIN RIVER #1

Northern half: Area: 24.9 ha Elevation: 380 m
Southern half: Area: 28.0 ha Elevation: 380 m

Virgin River #1 was divided into two areas, Virgin River #1 North and Virgin River #1 South, to facilitate streamlining of field logistics. Virgin River #1 North was surveyed from 2003 to 2007, and Virgin River #1 South was surveyed from 2004 to 2007.

Virgin River #1 North contains both tamarisk and willow habitats. The western half of Virgin River #1 North contains dense tamarisk up to 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, with cattails in the understory. Canopy height in the willow areas is approximately 10 m. Canopy closure throughout the site is approximately 70%. At Virgin River #1 North no major changes in vegetation structure or species composition were recorded from 2003 to 2007. Standing water and saturated soil were present in 2003–2004; however, after the winter floods of 2004–2005 no water was recorded within the site.

Breeding willow flycatchers were recorded at Virgin River #1 North in 2003 and 2004, with 7–15 adults detected annually in the Goodding willow areas in the eastern half of the site. In 2005, one resident flycatcher and one additional flycatcher for which residency status could not be determined were detected in the same area. No willow flycatchers were detected in 2006. One resident, unpaired male was detected in the southwestern corner of the site in 2007, as well as one flycatcher for which residency and/or breeding status could not be determined.

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 northwest portion of the site is a marsh, discovered in 2007, where coyote and Goodding willows are mixed in with the tamarisk. The Goodding and coyote willows average 8 and 5 m in height, respectively. No major changes to vegetation structure or species composition were recorded from 2004 to 2007. Standing water was present in an old river channel through June in all survey years, and in 2007, standing water was also present through June in the marsh area. Saturated soil was often present in old river braids and on cow trails throughout survey seasons.

No willow flycatchers were detected at Virgin River #1 South in 2004 and 2005. In 2006, we detected four breeding adult flycatchers, and in 2007 we detected 12 resident, breeding adults, as well as 3 males for which occupancy and/or breeding could not be determined.

VIRGIN RIVER #2

Area: 36.9 ha Elevation: 380 m

Virgin River #2 was surveyed from 2005 to 2007. This site is primarily a monotypic stand of tamarisk 4 m in height with 50–70% canopy closure. Patches of emergent Goodding willow up to 10 m in height are also present, primarily in the southeastern end of the site. No major changes in vegetation structure or species composition were recorded from 2005 to 2007.

Approximately 20% of the site contained surface water and saturated soil through the 2005 and 2006 survey seasons. No standing water was present in the site in 2007.

Breeding willow flycatchers have been recorded at Virgin River #2 since 2005, with 7–16 adults detected annually.

DELTA WEST

Area: 12.2 ha Elevation: 370 m

Delta West was surveyed from 2003 to 2005. At the end of May 2005, further access to the site was denied by a local landowner. This site is approximately 7 km downstream of Virgin River #2 and in some previous years was called Virgin River Delta #4. The site lies along the western edge of the floodplain, between the river channel and upland desert. The upland edge of the site was vegetated by tamarisk and arrowweed, while the interior of the site contained a mix of Goodding and coyote willow forest with an understory of tamarisk. Canopy height of the willows was up to 15 m and overall canopy closure was around 70%. The eastern portion of the site closest to the river channel was primarily small-diameter tamarisk 4–5 m in height with patches of cattails. In 2003 and 2004, the site contained a large, active Great Blue Heron (*Ardea herodias*) and Black-crowned Night Heron (*Nycticorax nycticorax*) rookery.

In 2003–2004, approximately 85% of the site was inundated with up to 0.5 m of water in mid-May, and by mid-July the site was completely dry. In May of 2005, the central portion of the site was almost completely inundated with approximately 10 cm of water. An opportunistic site visit in early spring of 2006 revealed that 2004–2005 winter floods had altered the river channel such that no water was present under the vegetation at the site. Helicopter reconnaissance in late March 2007 confirmed that much of vegetation in the site was dead.

Breeding willow flycatchers were recorded at Delta West in 2003 and 2004, with five adults detected each year. In May of 2005, we detected one territorial willow flycatcher, which was later detected in Virgin River #2.

OTHER SURVEY AREAS

Virgin River #2 Recon

Area: 16.9 ha Elevation: 380 m

Habitat reconnaissance and opportunistic surveys were conducted at Virgin River #2 Recon in 2007. This mixed-exotic site lies approximately 900 m south of Virgin River #2. Vegetation at the site consists primarily of tamarisk 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 during visits in May and June.

We did not detect any flycatchers at this site. Cowbirds were detected, and old signs of livestock were recorded at the site.

MUDDY RIVER, NEVADA

OVERTON WILDLIFE MANAGEMENT AREA, POND

Area: 0.7 ha Elevation: 378 m

This site was monitored in 2007, after personnel from an unrelated project detected a flycatcher. The site consists of a patch of mixed native vegetation approximately 150 m long and 150 m wide at the northern end of Overton Wildlife Management Area (WMA) just south of Honeybee Reservoir. The dominant vegetation consists of 10-m-tall Goodding willows 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 patch. The site was mostly dry, except for the marsh, which held water throughout the season.

We detected one pair of resident, breeding flycatchers at this site. Cowbirds were detected at the site. No sign of livestock use was recorded.

OVERTON WILDLIFE MANAGEMENT AREA

Area: 14.9 ha Elevation: 378 m

The site was surveyed from 2004 to 2007. The flycatcher survey site consists of a 150-m-wide strip of riparian vegetation located 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 remained 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. Other than this bulldozed area, no major changes in vegetation structure or species composition have been recorded since 2004. Flowing water and muddy soils were present in and adjacent to the Muddy River throughout survey seasons.

Resident and/or breeding willow flycatchers have been recorded at Overton WMA since 2004, with 4–15 adults detected annually. Brown-headed Cowbirds were detected during surveys in all years. Livestock use was recorded at the site in 2007, but not in 2004–2006.

OTHER SURVEY AREAS

Willow Patch Recon

Area: 2.2 ha Elevation: 378 m

Site reconnaissance and an opportunistic survey were conducted at this site in 2005. Additional habitat reconnaissance and opportunistic surveys were conducted 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. During surveys, soils within the site were very dry, with the nearest water approximately 200 m away.

We did not detect any flycatchers at this site. 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 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. Starting in approximately 2004, suitable flycatcher habitat developed in Lake Mead National Recreation Area on sediments previously inundated by Lake Mead. 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/or breeding willow flycatchers at four of the sites. In 2007, most of the habitat that was occupied by flycatchers in 2006 was dead and dying as the result of receding water tables 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.

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.

In 2003–2004, we conducted habitat reconnaissance and opportunistic surveys at four additional sites from RM 247 to 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.

---

[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.

SEPARATION CANYON (RM 239.5N)

Area: 5.3 ha Elevation: 378 m

Separation Canyon was surveyed from 2003 to 2005. In 2006, surveys were discontinued in June to allow time for habitat reconnaissance and surveys in the extensive areas of recently developed willow in Lake Mead National Recreation Area. This mixed-exotic site consisted of dense patches of tamarisk 6 m in height interspersed with open areas along a streambed in a narrow side canyon of the Colorado River. Overall canopy closure was 25–50%. Seep willow (*Baccharis salicifolia*) dominated the understory near the mouth of the canyon, while young coyote willow (1–3 m in height) dominated the understory farther up the canyon. Mesquite trees were also present at this site. No major changes in vegetation structure or species composition were recorded at the site. The streambed that ran through the site held surface water throughout survey seasons.

We did not detect willow flycatchers, livestock, or Brown-headed Cowbirds at this site.

RM 243S

Area: 1.8 ha Elevation: 366 m

RM 243S was surveyed from 2003 to 2005. This site was located immediately adjacent to the Colorado River and was vegetated by dense tamarisk 5 m in height. Canopy closure was 70–90%. A dry wash draining a narrow side canyon cut through the downstream end of the site. In 2003 and 2004, a small pool adjacent to the river was filled periodically during survey seasons by high river flows. No standing water or saturated soils occurred in the site during the survey season of 2005, and the site was elevated approximately 2 m above the Colorado River. No major changes in vegetation structure or species composition were recorded at the site.

In 2003, we detected one willow flycatcher at the site on 18 July. The flycatcher responded to broadcasts but did not vocalize spontaneously and could not be relocated on two subsequent visits. No willow flycatchers were detected in 2004 and 2005. We did not detect livestock or cowbirds at this site.

SPENCER CANYON (RM 246S)

Area: 5.0 ha Elevation: 366 m

Spencer Canyon was surveyed from 2003 to 2005. This mixed-native site consisted of a patch of dense tamarisk approximately 5 m in height bordering the Colorado River and strips of cottonwood and Goodding and coyote willow along Spencer Creek, which is perennial. Fremont cottonwood and Goodding willow formed an overstory of variable height, and willow and tamarisk were present in the understory. Portions of the stream were lined with cattails and seep willow, and overall canopy closure was around 70%. The site had periodically experienced flooding, scouring, and sediment deposition from monsoon and winter floods. Floods prior to the 2004 survey season had removed most of the vegetation closest to the river.

We did not detect willow flycatchers, livestock, or Brown-headed Cowbirds at this site.

SURPRISE CANYON (RM 248.5N)

Area: 4.9 ha Elevation: 365 m

Surprise Canyon was surveyed in 2004 and 2005. This mixed-exotic site consisted of patches and strips of tamarisk and coyote willow along both sides of a stream in the bottom of a narrow canyon. In 2004, canopy height was approximately 4–5 m, and overall canopy closure was <25%. The stream contained pools of water throughout the 2004 survey season but did not have a continuous, aboveground flow. Most of the vegetation present in 2004 was scoured and removed during winter floods, which created cutbanks 2–3 m in height. In 2005, the stream contained flowing water throughout the survey season.

We did not detect willow flycatchers, livestock, or Brown-headed Cowbirds at this site.

CLAY TANK CANYON (RM 249S)

Area: 0.4 ha Elevation: 363 m

Clay Tank Canyon was surveyed from 2003 to 2005. This mixed-exotic site consisted of a small patch of tamarisk and arrowweed between the Colorado River and a large pond. Small patches of seep and coyote willow were also present. Tamarisk at this site ranged from 3 to 5 m in height, and overall canopy closure was approximately 70%. No major changes in vegetation structure or species composition were recorded at the site. A stream was flowing from the pond to the river throughout survey seasons.

We did not detect willow flycatchers, livestock, or Brown-headed Cowbirds at this site.

NO WIFL POINT (RM 249.5S)

Area: 1.2 ha Elevation: 363 m

No Wifl Point was surveyed in 2004 and 2005. This mixed-exotic site consisted of a narrow (20–40 m) band of tamarisk 3–5 m in height with seep willow bordering the site along the river. Canopy closure ranged from 50–70%. No standing water or saturated soils occurred in the site during survey seasons, but the site bordered the Colorado River.

We did not detect willow flycatchers, livestock, or Brown-headed Cowbirds at this site.

NO WIFL BAY (RM 249.5N)

Area: 1.1 ha Elevation: 363 m

No Wifl Bay was surveyed in 2004 and 2005. This mixed-exotic site borders the Colorado River and consisted of a narrow (20–40 m) band of tamarisk 4 m in height with seep willow bordering the edge of the site along the river and arrowweed scattered throughout the site. Canopy closure was approximately 70%. No standing water or saturated soils occurred in the site during the survey seasons, and the site was elevated approximately 2.5 m above the Colorado River.

We did not detect willow flycatchers, livestock, or Brown-headed Cowbirds at this site.

REFERENCE POINT CREEK (RM 252S)

Area: 4.2 ha Elevation: 360 m

Reference Point Creek was surveyed from 2003 to 2005. This site, at the confluence of Reference Point Creek and the Colorado River, was vegetated almost entirely by a dense stand of tamarisk 5 m in height. The tributary canyon opened up approximately 500 m upstream of the Colorado River into a 200-m-wide patch of tamarisk. Open, grassy areas occurred in the center of the site. Overall canopy closure at the site was approximately 80%. No major changes in vegetation structure or species composition were recorded at the site. The site was completely dry during the surveys of 2003 and 2004, but a small stream flowed through the site throughout the survey season of 2005.

We did not detect willow flycatchers or livestock at this site, and cowbirds were detected in 2004.

RM 257.5N

Area: 1.2 ha Elevation: 360 m

RM 257.5N was surveyed from 2003 to 2005. This mixed-exotic site bordered the Colorado River. Immediately adjacent to the river, vegetation was primarily a thin band of dead willow approximately 5 m in height. Behind the willow, the site was dominated by dense tamarisk 5 m in height. Most of the vegetation was alive during the survey season of 2003 but was dead or dying, particularly in the northern half of the site, in 2005. Canopy closure at the site was approximately 90% in 2003 and 60% in 2005. The site was dry during all survey seasons, and in 2005 was elevated approximately 4–5 m above the level of the river.

We did not detect willow flycatchers or livestock at this site, and cowbirds were detected in 2003 and 2005.

BURNT SPRINGS (RM 259.5N)

Area: 11.0 ha Elevation: 363 m

Burnt Springs was surveyed from 2003 to 2007. 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%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. In 2003–2004, no standing water was noted at the site, but the presence of live cattails suggested recent inundation or subsurface water. Muddy soil and slow moving water were present in the creek through the 2005–2007 survey seasons.

No willow flycatchers were detected at Burnt Springs in 2003. In 2004, we detected a lone individual on 8 and 24 June. No flycatchers were detected in 2005–2006. In 2007, we detected one breeding pair of willow flycatchers at the site. No livestock use was recorded at the site, and cowbirds were detected in all survey years.

QUARTERMASTER CANYON (RM 260S)

Area: 3.3 ha Elevation: 360 m

Quartermaster Canyon was surveyed from 2003 to 2005. This mixed-exotic site was located at the confluence of the Colorado River and Quartermaster Canyon. Vegetation along the river was predominately tamarisk 4 m in height, and canopy height decreased with distance from the river. Patches of Goodding and coyote willow occupied approximately 10% of the site, and cattail marshes occupied 10% of the site. Canopy closure was approximately 50–90%. Although the site periodically experienced flooding, scouring, and sediment deposition from monsoon and/or winter floods, no major changes in vegetation structure or species composition were recorded. In 2003, the site contained saturated soil near a small spring. Soils were dry throughout the 2004 survey season. In 2005, a small stream flowed through the site and soils were saturated throughout the survey season.

We did not detect willow flycatchers or livestock at this site, and cowbirds were detected in all survey years.

RM 260.5N

Area: 3.5 ha Elevation: 354 m

RM 260.5N was surveyed in 2003 and 2004, and surveys were discontinued in 2005. The site bordered the Colorado River, and in 2005 the site stood about 4 m above the river level. From 2003 to 2004, vegetation at the site was dominated by tamarisk ranging in height from 1 to 4 m. The interior of the site was open and dry, with many dead and dying trees, and dead willows lined the riverbank. In 2003 and 2004, canopy closure at the site was 50–70%. Surveys at this site were discontinued because of poor habitat quality for willow flycatchers, with the site demonstrating dying vegetation, dry soils, and little canopy closure.

We did not detect willow flycatchers or livestock at this site, and cowbirds were detected in all survey years.

RM 262.5S

Area: 12.8 ha Elevation: 354 m

RM 262.5S was surveyed in 2003. In 2004, surveys were discontinued because most of the vegetation was dead. The site was mixed-native and located immediately adjacent to the

Colorado River. In 2003, vegetation at the site consisted of a mix of Goodding willow and tamarisk, varying in density with proximity to the river. In a 10-m-wide strip adjacent to the river, canopy closure was >90%, while interior portions of the site contained dead and dying vegetation with 20% canopy closure. Soils at the site in 2003 were dry throughout the survey season.

We did not detect willow flycatchers or livestock at this site, but cowbirds were detected in both survey years.

RM 268N

Area: 7.2 ha Elevation: 354 m

RM 268N was surveyed in 2003. In 2004, surveys were discontinued because most of the vegetation was dead. The site was mixed-exotic and located immediately adjacent to the Colorado River. In 2003, vegetation at the site consisted of a mix of Goodding willow 6 m in height and tamarisk 3 m in height. The interior of the site contained a low-lying area that appeared to have been wet in previous years. Canopy closure at the site in 2003 was approximately 50%. Soils within the site were dry throughout the 2003 survey season.

No willow flycatchers or livestock were detected at this site, and cowbirds were detected in both survey years.

COLUMBINE FALLS (RM 274.5S)

Area: 6.3 ha Elevation: 354 m

Columbine Falls was surveyed from 2003 to 2005. This mixed-native site was located at the confluence of Cave Canyon and the Colorado River, and the site received water from springs above Columbine Falls. Vegetation at the site was a mix of willow 5–6 m in height and tamarisk 2–3 m in height, and canopy closure was approximately 50%. The site periodically experienced flooding, scouring, and sediment deposition from monsoon and winter floods. The site contained shallow, standing water or saturated soil through survey seasons.

No willow flycatchers or livestock were detected at this site, and cowbirds were detected in all survey years.

RM 274.5N

Area: 18.3 ha Elevation: 354 m

RM 274.5N was surveyed from 2003 to 2007. 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. Deep pools of clear, standing water are present at springs, and large areas of the site contained muddy soils and standing water throughout the survey seasons. 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007.

No willow flycatchers were detected at RM 274.5N in 2003. In 2004, we detected one breeding pair, and one unpaired male was detected in 2005. We detected one breeding pair and one unpaired male at this site in 2006. In 2007, we detected two resident unpaired males, one male for three days in June, and one probable migrant. No livestock use has been recorded at the site, and cowbirds were detected in all survey years.

PEARCE FERRY

Area: 0.8 ha Elevation: 343 m

Pearce Ferry was surveyed in 2006 and 2007. This site lies immediately adjacent to the Colorado River. In 2006, the site was mixed native and consisted primarily of a 30-m-wide strip of Goodding willow averaging 8 m in height. On the upland edge of the site, the vegetation consisted of dense stands of tamarisk 3 m in height. Patches of young arrowweed were scattered throughout the site, and canopy closure was 50–70%. In May 2007, canopy closure was similar to that recorded in 2006, but had decreased to 25–50% by July because much of the willow was dead and dying. Soils throughout the site were dry and sandy during the survey seasons.

In 2006, we detected one unpaired male at the site. We detected one male at the site for a single day in June 2007. Brown-headed Cowbirds were detected during surveys in 2007, and no livestock use has been recorded at the site.

RM 285.3N

Area: 8.7 ha Elevation: 343 m

RM 285.3N was surveyed in 2006 and 2007. This site lies between the Colorado River and Grand Wash Bay, which was isolated from the Colorado River when the water level dropped in Lake Mead. In 2006, mixed native vegetation at the site consisted primarily of even-aged stands of Goodding willow approximately 8 m in height. The willow was located primarily along the Colorado River on the southern edge of the site and on the northern side of the site adjacent to Grand Wash Bay. The 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 was vegetated with tamarisk approximately 2 m in height in 2007, and large areas of young willow <3 m in height were colonizing areas with wet soil closest to Grand Wash Bay. Canopy closure at the site in 2007 ranged from 25 to 70%. No standing water was present under the vegetation during survey seasons, and saturated soils were present only in areas immediately adjacent to Grand Wash Bay.

In 2006, we detected two breeding pairs and one additional male at RM 285.3N. No flycatchers were detected at the site in 2007. Brown-headed Cowbirds were detected in both survey years, and there was sign of burro and cattle use.

KOWLP CORNER

Area: 5.4 ha Elevation: 342 m

Kowlp Corner was surveyed in 2006 and 2007. 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 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 in 2007. Soils throughout the site were dry and sandy during survey seasons.

We detected one unpaired male at the site in 2006. No willow flycatchers were detected in 2007. Brown-headed Cowbirds were detected in both survey years, and there was sign of burro and livestock use at the site.

RM 286N

Area: 3.4 ha Elevation: 342 m

RM 286N was surveyed in 2006 and 2007. This site 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 next 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 survey seasons, no standing water was present under the vegetation, and saturated soils were present only along the river.

In 2006, we detected a single flycatcher at this site, but this individual was heard singing alternately with an individual across the river at Kowlp Corner, and we suspect it to be the same individual as the one documented holding a territory at Kowlp Corner. No willow flycatchers were detected in 2007. Brown-headed Cowbirds were detected in both survey years, and livestock use was recorded at the site.

DRIFTWOOD ISLAND

Area: 3.7 ha Elevation: 342 m

Driftwood Island was surveyed in 2006 and 2007. 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 survey seasons, no standing water was present under the vegetation, and saturated soils were present only along the river. As a site description is not available for July 2007, 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. Brown-headed Cowbirds were detected in both survey years, and cattle were observed using the site.

TWIN COVES

Area: 1.4 ha Elevation: 342 m

Twin Coves lies along the Colorado River and was surveyed in 2006 and 2007. In 2006, vegetation on 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 survey seasons, no standing water was present under the vegetation, and saturated soils were present only along the river.

We detected one pair of willow flycatchers at this site in 2006. No flycatchers were detected in 2007. Brown-headed Cowbirds were detected in both survey years, and no livestock use was recorded.

BRADLEY BAY

Area: 5.6 ha Elevation: 341 m

Bradley Bay was surveyed in 2006 and 2007. This relatively large mixed-exotic site is 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 apparently 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 survey seasons, 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. Brown-headed Cowbirds were detected in both survey years, and no livestock use was recorded.

CHUCKWALLA COVE

Area: 1.8 ha Elevation: 341 m

Chuckwalla Cove was surveyed in 2006 and 2007. This site is located in a dry cove between high bluffs and the Colorado River. In 2006, vegetation on 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 survey seasons, no standing water was present under the vegetation, and saturated soils were present only along the river.

We detected one pair of willow flycatchers and one additional male at this site in 2006. No flycatchers were detected in 2007. Brown-headed Cowbirds were detected in both survey years, and livestock use was recorded.

CENTER POINT

Area: 3.1 ha Elevation: 341 m

Center Point was surveyed in 2006 and 2007. This site 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 survey seasons, 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. No Brown-headed Cowbirds or sign of livestock use were recorded at the site.

OTHER SURVEY AREAS

The Strip (RM 247N)

Area: 0.8 ha		Elevation: 366 m

The Strip is located between Spencer and Surprise Canyons, and was opportunistically surveyed three times in June and July 2004. The site consisted of a strip of tamarisk with an understory of arrowweed. Overall canopy closure was approximately 70%. No surface water was present in the site, though the site bordered the Colorado River. We did not detect willow flycatchers, livestock, or Brown-headed Cowbirds at this site.

Dry Falls/RM 251N

Area: 1.5 ha		Elevation: 362 m

Dry Falls/RM 251N was opportunistically surveyed three times in June and July 2004, and two times in May and June 2006. In 2006, surveys were discontinued to allow time for habitat reconnaissance and surveys in the extensive areas of recently developed willow in Lake Mead National Recreation Area. The site was mixed-exotic and consisted of a 50-m-wide strip of tamarisk, averaging 3 m in height, along the Colorado River. Some Goodding willow was scattered throughout the site. Canopy closure was approximately 50%. The site was terraced approximately 2 m above the Colorado River, and soils throughout the site were completely dry during surveys. We did not detect willow flycatchers, livestock, or Brown-headed Cowbirds at this site.

Tincanebitts (RM 263.5N)

Area: 7.2 ha		Elevation: 354 m

Habitat reconnaissance of Tincanebitts in May and June 2004 did not reveal potential flycatcher habitat, and surveys were discontinued after two visits. This site consisted of patches of tamarisk 3–5 m in height separated by areas of dead willows. Canopy closure was 25–50%. No surface water was present at the site. We did not detect willow flycatchers, livestock, or Brown-headed Cowbirds at this site.

Lake Mead Delta

Area: Not available		Elevation: 354 m

Lake Mead Delta was surveyed once in June 2003. Surveys were discontinued because vegetation in the area was sparse and less than 2 m in height. Most of the vegetation present in previous years had since fallen off because of steep cutbanks.

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 throughout the study area in all survey years. No cattle were present in the study area, but feral pigs frequented all sites surveyed.

The amount of standing water throughout the entire Topock study area was markedly reduced in 2005 compared to 2003–2004 and 2006–2007.

PIPES

Pipes #1:	Area: 5.2 ha	Elevation: 140 m
Pipes #2:	Area: 2.8 ha	Elevation: 140 m
Pipes #3:	Area: 5.7 ha	Elevation: 140 m

Pipes #1 and #3 were surveyed from 2003 to 2007. Pipes #2 was surveyed from 2003 to 2006, with surveys discontinued in 2007 because the dense, small-diameter vegetation and deadfall that dominate the site are not typically used by flycatchers.

These three contiguous 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 the rest of Pipes 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. Pipes #2 is very dense, with most stems <3 cm in diameter; large, impenetrable areas of deadfall are present within the site. The western portion of Pipes #3 contains marshes and scattered Goodding willow. No major changes in vegetation structure or species composition were recorded at Pipes from 2003 to 2007.

Pipes #3 is the wettest site at Pipes, with varying amounts of standing water and saturated soils recorded throughout survey seasons. In 2003–2005 and in 2007 there was an increase in the amount of saturated soil mid-survey season at Pipes #3. Except for early in the survey season in 2003, Pipes #1 and #2 contained little to no water or saturated soils throughout survey seasons.

In 2003, we detected one adult willow flycatcher for a single day in June at Pipes #3. In 2004, one individual was detected for a single day in May and five breeding willow flycatchers were detected at Pipes #1 and #3, respectively. In 2005, two individuals, each detected for a single day in May, and two unpaired males were detected at Pipes #1 and #3, respectively. One pair and one additional male were detected at Pipes #3 in 2006. No willow flycatcher detections were recorded at Pipes in 2007.

THE WALLOWS

Area: 0.4 ha Elevation: 140 m

The Wallows was surveyed from 2005 to 2007. This was not a survey site at the beginning of the 2005 survey season, but a new site was delineated when breeding birds were discovered outside of existing survey sites. The site is located between Pipes #3 and PC6-1, and 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. No major changes in vegetation structure or species composition were recorded from 2005 to 2007. The Wallows contained standing water and saturated soils throughout the 2006–2007 survey seasons, and an increase in the amount of standing water was recorded mid-season in 2007.

One resident, unpaired male willow flycatcher was detected at The Wallows in 2005. In 2006, we detected one breeding pair. No flycatchers were detected at the site in 2007.

PC6-1

Area: 4.8 ha Elevation: 140 m

PC6-1 was surveyed from 2004 to 2007. This mixed-exotic site consists 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%. No major changes in vegetation structure or species composition were recorded from 2004 to 2007.

In 2004, large areas of standing water and saturated soil were present through the survey season, mostly in marshy areas and under the willows. No part of the site contained standing water or saturated soil in 2005. In contrast to 2005, the site contained standing water and saturated soils throughout the 2006 and 2007 survey seasons.

Breeding willow flycatchers were recorded at PC6-1 in 2004 and 2005, with 3–9 adults detected annually. No willow flycatcher detections were recorded in 2006 and 2007.

PB 2001

Area: 2.1 ha Elevation: 140 m

PB 2001 was explored and surveyed once in May 2003 and twice in May 2004. The site was surveyed formally in 2005, and habitat reconnaissance was conducted at the site again in May 2007. Surveys were discontinued in 2003, 2004, and 2007 because the dense, small-diameter vegetation 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. The site contained a small amount (5%) of saturated soil throughout the 2005 survey season. No part of the site contained water or wet soil in May 2007.

We did not detect willow flycatchers at this site.

PIG HOLE

Area: 2.4 ha Elevation: 140 m

Pig Hole was surveyed from 2004 to 2007. This was not a survey site at the beginning of the 2004 survey season, but a new site was delineated when breeding birds were discovered outside of existing survey sites. The site 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, is less dense. Dense patches of arrowweed occur in approximately 5% of the site. No major changes in vegetation structure or species composition were recorded from 2004 to 2007.

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

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

IN BETWEEN AND 800M

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

In Between and 800M were surveyed from 2003 to 2007. 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 (0–60% of the site) and saturated soil (0–40% of the site) throughout survey seasons and 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%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007.

Breeding willow flycatchers have been recorded at In Between and 800M annually since 2003, with 5–16 adults detected each year.

PIERCED EGG

Area: 6.8 ha Elevation: 140 m

Pierced Egg was surveyed from 2003 to 2007. 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. The northern portion of the site is drier than the southern portion and contains stands of dense arrowweed. Overall canopy closure is approximately 80%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Throughout survey seasons and across years, the site contained varying amounts of standing water (0–30% of the site) and saturated soil (5–70% of the site). Standing water and saturated soil were present mostly early in each survey season, along a marsh in the southern portion of the site.

No willow flycatchers were detected at Pierced Egg in 2003. Breeding willow flycatchers have been recorded at the site since 2004, with 5–8 adults detected annually.

SWINE PARADISE

Area: 3.7 ha Elevation: 140 m

Swine Paradise was surveyed from 2003 to 2007. This mixed-exotic site borders the open water of Topock Marsh. Near the marsh, vegetation at the site is dominated by Goodding willow up 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%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Except for May and June 2004, no standing water or saturated soil was present within the site during survey seasons.

No willow flycatchers were detected at Swine Paradise in 2003, 2005, or 2007. In 2004, one resident adult and two adult individuals (each detected for a single day in June) were detected. In 2006, two adult individuals (each detected for a single day in June) were detected.

BARBED WIRE

Area: 2.6 ha Elevation: 140 m

Barbed Wire was surveyed from 2003 to 2007. This site is contiguous with Swine Paradise. There is one large, emergent Goodding willow 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Except for mid-May 2003 and 2004, no standing water or saturated soil was present within the site during survey seasons.

No willow flycatchers were detected at Barbed Wire in 2003, 2005, or 2006. One adult male willow flycatcher was detected at Barbed Wire in late May 2004, and one flycatcher of unknown sex was detected in early June 2007.

IRFB03 and IRFB04

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

IRFB03 and IRFB04 were surveyed from 2003 to 2007. These two contiguous sites are separated from the Barbed Wire site by a firebreak road. The sites 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 lower in the understory. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Soils within these sites were completely dry throughout each survey season.

We did not detect willow flycatchers at either IRFB03 or IRFB04.

Platform

Area: 1.3 ha Elevation: 140 m

Platform was surveyed from 2003 to 2007. 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Soils in the interior of the site were mostly dry throughout each survey season.

One lone adult willow flycatcher was detected at Platform in early May 2003 and 2004. No flycatchers were detected in 2005–2007.

250M

Area: 2.3 ha Elevation: 140 m

250M was surveyed from 2003 to 2007. 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%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Except for May 2003 and 2004, soils within the site were mostly dry throughout surveys seasons.

In 2003, two interacting willow flycatchers were detected for a single day in June. One breeding pair of willow flycatchers was detected at the site in 2004 and 2005. In 2006, one resident adult flycatcher was detected. In 2007, two flycatchers were each detected for a single day in May.

HELL BIRD AND GLORY HOLE

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

Hell Bird and Glory Hole were surveyed from 2003 to 2007. 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Throughout survey seasons and across years, both sites contained varying amounts of standing water (2–90% of the sites) and saturated soil (1–65% of the sites).

Resident and breeding willow flycatchers were detected at Hell Bird in 2003 and 2004, with 2–9 adults detected each year. No flycatcher detections were recorded at Hell Bird in 2005 and 2006. In 2007, two individuals were each detected for a single day in early May. Breeding willow flycatchers have been recorded at Glory Hole annually since 2003, with 3–10 adults detected each year.

BEAL LAKE

Area: 42.8 ha Elevation: 140 m

Beal Lake was surveyed in 2006 and 2007. 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 one willow flycatcher, likely a migrant, at Beal Lake in 2006. Two individuals were detected in 2007; one was detected on 6 June and the other from 17 to 21 June.

LOST SLOUGH

Area: 2.1 ha Elevation: 140 m

Lost Slough was explored and surveyed opportunistically in July 2006 and formally surveyed in 2007. This site is located approximately 4 km south of Glory Hole and Hell Bird. The site consists of a low-lying swale running 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.

LOST POND

Area: 1.7 ha Elevation: 140 m

Lost Pond was explored and surveyed opportunistically in 2003 and again in 2006, and was formally surveyed in 2007. 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 (***Prosopis pubescens***) 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.

LOST LAKE

Area: 4.0 ha Elevation: 140 m

Lost Lake was surveyed from 2003 to 2007. 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, and the far southeastern end of the site is dominated by dense stands of coyote willow, 5–7 m in height, with an understory of arrowweed. 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 to the south and west of Lost Lake burned prior to the 2003 survey season, and contain patches of young tamarisk and small willows. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Areas adjacent to the marsh edges held some standing water and saturated soil throughout survey seasons.

No willow flycatcher detections were recorded at Lost Lake in 2003 and 2005. In 2004, one resident adult was detected. One adult flycatcher was detected at the site for a single day in 2006. One individual was detected for a single day in early June in 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. From 2003 to 2007, we surveyed backwater areas that support marsh and riparian vegetation.

PULPIT ROCK

Area: 2.1 ha Elevation: 140 m

Pulpit Rock was surveyed from 2003 to 2007. The site 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%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. The northwestern edge of the site lies adjacent to the Colorado River and varying amounts of standing water and saturating soils were recorded in this area across survey seasons.

No willow flycatchers were detected at Pulpit Rock in 2003–2005 or 2007. One migrant flycatcher was detected at the site in 2006. Cowbirds were detected at the site in all years except 2006. Evidence of use by burros was recorded in 2007.

PICTURE ROCK

Area: 7.0 ha Elevation: 138 m

Picture Rock was surveyed from 2003 to 2007. The site 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Except for the bulrush and cattail areas along the river, the interior of the site was dry throughout survey seasons.

No willow flycatchers were detected at Picture Rock in 2003 and 2004. Two migrant willow flycatchers were detected at the site in each year from 2005 to 2007. Cowbirds were detected at the site in all years, and feral pigs and burros used 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 North and South were surveyed from 2003 to 2007. Collectively, the site is a 2-km-long strip of riparian and marsh vegetation that lies along the eastern 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Because of the proximity to the Colorado River, both sites contained varying amounts of standing water and saturated soils throughout survey seasons.

Three migrant willow flycatchers were detected at Blankenship Bend in 2004 and five migrants were detected in 2007. Cowbirds were detected at the sites in all years. Feral pigs, bighorn sheep, and burros used the site and adjacent uplands.

TOPOCK GORGE

Topock Gorge North:	Area: 3.8 ha	Elevation: 136 m
Topock Gorge South:	Area: 2.6 ha	Elevation: 140 m

Topock Gorge North and South were surveyed in 2003. Both sites burned prior to the 2004 survey season and surveys were discontinued. These two mixed-exotic sites were located in adjacent backwater coves separated by a narrow, rocky ridge. An unnamed wash entered the Colorado River at each site. The vegetation at both sites graded from cattails and bulrush along the river to a strip of young, closely spaced willow. Close to the center of each site, a mix of tamarisk and willow 6 m in height merged with tamarisk and mesquite (both honey and screwbean), which bordered the upland edge of the sites. Within the sites, canopy closure was >90% with a few emergent Goodding willow, approximately 15 m in height. In mid-May, there was standing water in the portions of the site with young willow, but by the end of May the interiors of the sites were dry.

We did not detect any willow flycatchers at the sites, and cowbirds were detected. Burros used the sites and adjacent uplands.

HAVASU NE

Area: 12.6 ha Elevation: 136 m

Havasu NE was surveyed from 2003 to 2007. 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Soils in the interior of the site were dry throughout survey seasons.

Eight migrant willow flycatchers were detected at the site in 2003, and one migrant willow flycatcher was detected in 2004. No willow flycatchers were detected in any other survey year. Cowbirds were detected at the site in all years. 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. 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, in 2006 and 2007 we reduced the number of surveys at the most upstream sites, which became difficult to access after the winter flood of 2004–2005 that washed out the refuge road, and instead explored additional areas. Results of these reconnaissance efforts are presented below after the survey results.

BILL WILLIAMS SITE #1

Area: 2.8 ha Elevation: 140 m

Bill Williams Site #1 was surveyed from 2003 to 2006. This mixed-native site had an overstory of large Goodding willow and Fremont cottonwood 15 m in height and an understory of tamarisk and arrowweed. The site was surrounded by water and accessible by kayak, with approximately 40% of the site vegetated by cattail. The site contained large quantities of downed wood, and as of 2006, some of the overstory trees had dropped large branches, creating gaps in the canopy. Overall canopy closure was approximately 50%. No major changes in vegetation structure or species composition were recorded from 2003 to 2006. The site contained standing water (5–80% of the site) and saturated soil (10–30% of the site) throughout the survey seasons of 2003–2005. In 2006, only one small pool of standing water was present throughout the survey season, and no saturated soil was present. In late summer 2006, the site burned, leaving only sparse areas of surviving Goodding willow and patches of burned or mainly dead vegetation. As of May 2007, tamarisk and arrowweed had begun to fill in the open areas. The site was not surveyed in 2007.

One resident, unpaired male was detected at Site #1 in 2003 and 2004. One adult willow flycatcher was detected for a single day in 2005 and 2006. Cowbirds were detected in all survey years. No evidence of livestock use was recorded at the site.

BILL WILLIAMS SITE #2

Area: 3.1 ha Elevation: 140 m

Bill Williams Site #2 was surveyed from 2003 to 2007 and is accessible by kayak. 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%. Live and dead cattail are present along the edges of the site. Other than many branches and overstory trees falling after the 2003 survey season, no major changes in vegetation structure or species composition were recorded. The interior of site contained standing water and saturated soil in 2003, 2005, and 2007. The interior of the site was not accessed in 2004 and 2006; however, 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.

Three adult willow flycatchers were detected, each for a single day, in 2004. No willow flycatchers were detected in any other survey year, and cowbirds were detected in all years. There was no evidence of livestock at the site.

BILL WILLIAMS SITE #11

Area: 6.3 ha Elevation: 140 m

Bill Williams Site #11 was surveyed from 2003 to 2007, and the site is accessible by kayak. 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, and there is thick deadfall up to 2 m in height. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. The amount of standing water and saturated soil within the site was largely undetermined because we were unable to traverse the site on foot because of thick vegetation and deadfall. However, large areas of standing water are present adjacent to the vegetation because an arm of Lake Havasu follows the channel of the Bill Williams River through the site.

We detected one willow flycatcher at the site in each year from 2003 to 2004, and one willow flycatcher in each year from 2006 to 2007. No flycatcher detections were recorded in 2005. Cowbirds were detected in all survey years. There was no evidence of livestock use 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

Bill Williams Site #4 and #3 were surveyed from 2003 to 2007. These two sites are contiguous and together are known as Mosquito Flats. Vegetation at this site is mixed-native, with an overstory of Goodding willow and Fremont cottonwood 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 since 2003, 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.

In 2003, Mosquito Flats contained up to 100 cm of standing water in May, with saturated soils present until the end of the survey season. In 2004, the site contained little to no standing water. Mosquito Flats contained standing water (1–20% of the site) throughout the 2005, 2006, and 2007 flycatcher breeding seasons.

Breeding willow flycatchers were recorded at Mosquito Flats in 2003 and from 2005 to 2007, with 4–14 adults detected annually. Three resident willow flycatchers were detected in 2004, but no breeding was recorded. Brown-headed cowbirds were detected at Mosquito Flats in all survey years. There was no evidence of livestock use at the site.

BILL WILLIAMS SITE #5

Area: 5.3 ha Elevation: 143 m

Bill Williams Site #5 was surveyed from 2003 to 2007. Site #5 is located on the eastern edge of the Bill Williams River floodplain and is bordered to the east by upland desert. The survey area was expanded in 2005 to include the trail used to access Site #5 from the western side of the floodplain. The portion of the site on the eastern side of the floodplain consists of mixed-native vegetation, with a canopy of Goodding willow and Fremont cottonwood up to 20 m in height and an understory of tamarisk 7 m in height. Canopy closure in this area is approximately 25%. Vegetation along the trail consists of tamarisk 6–8 m in height with emergent Fremont cottonwood and Goodding willow. Canopy closure in this area is 70–90%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Bill Williams Site #5 contained varying amounts of standing water (0–50% of the site) and saturated soil (0–50% of the sites) throughout survey seasons. In 2005 and 2007, the Bill Williams River flowed through and/or along the trail section of the site.

Other than one adult flycatcher detected for single day in 2004, no willow flycatcher detections have been recorded at Site #5. Brown-headed cowbirds were detected in all survey years. Evidence of burro use was recorded at the site in 2007.

MINERAL WASH COMPLEX

Area: 18.8 ha Elevation: 162 m

Mineral Wash Complex was surveyed from 2003 to 2007. 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 15–20 m in height and an understory of tamarisk 5 m in height. Overall canopy closure is <50%. In 2004, cattails in the riverbed were primarily dead by the end of the survey season; many trees also appeared to be dead or dying; and several dead tamarisk fell during the survey season. A channel of the Bill Williams River was flowing through and along the edge of the site in May annually, but by July only isolated puddles and small areas of saturated soil remained.

One adult willow flycatcher was detected for a single day in 2004 and 2005. No flycatcher detections were recorded in 2003 and 2006. Three willow flycatchers were detected in 2007; two each for a single day in early June and one lone male detected from 30 May to 6 June. Cowbirds were detected in all survey years. Use by feral pigs has been recorded at the site.

BEAVER POND

Area: 21.7 ha Elevation: 165 m

Beaver Pond was surveyed from 2003 to 2007. This mixed-native site consists of Fremont cottonwood and Goodding willow with an understory of tamarisk along the Bill Williams River. The cottonwoods are up to 20 m in height and are emergent above the willows. Areas not immediately adjacent to the river channel are vegetated by tamarisk and honey mesquite 5–7 m in height. Overall canopy closure at the site is <50%. From 2003 to 2004, a string of beaver ponds and dams lined with cattails were present along the river. Floods during the winter of 2004–2005 removed the ponds, which had held standing water throughout the 2004 survey season. In 2005 to 2007, a channel of the river flowed along the edge of the site, and an old channel in the center of the site contained pools of water throughout survey seasons; 10-20% of the site contained water and saturated soils until July. Other than the beaver ponds and cattail being removed from flooding, no major changes in vegetation structure or species composition were recorded.

One willow flycatcher was detected at Beaver Pond in 2003, 12 were detected in 2004, and 2 were detected in 2007. No willow flycatchers were detected in 2005 and 2007. Cowbirds were detected in all survey years. Use by feral pigs was recorded at the site.

BILL WILLIAMS SITE #8

Area: 10.3 ha Elevation: 168 m

Site #8 was surveyed from 2003 to 2007. This narrow, linear site borders the Bill Williams 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 <50%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. From 2003 to 2004, beaver ponds were present along the river; floods during the winter of 2004–2005 removed the ponds. This site had flowing water in the river channel throughout the survey seasons.

One willow flycatcher was at Site #8 in each year from 2003 to 2005, and one willow flycatcher was detected in 2007. No willow flycatchers were detected in 2006. Cowbirds were detected in all survey years. Evidence of use by burros was recorded in 2007.

GROUND RECONNAISSANCE RESULTS

In 2006 and 2007, field personnel spent a total of 67.3 person-hours conducting habitat reconnaissance and opportunistic broadcast surveys, which covered much of the Bill Williams River corridor within the refuge. We identified eight areas (Last Gasp, River End, Flooded Refuge Road, Black Rail, Burn Edge, Upstream of Site #5, New Willow, and Planet Ranch; see below for details) that should be visited and evaluated in subsequent years. Other than in these eight areas, vegetation structure and/or hydrological conditions in the remaining areas we evaluated were not characteristic of willow flycatcher breeding habitat. One willow flycatcher was located during habitat reconnaissance.

Because the vegetation along the Bill Williams River consists of large, contiguous stretches of riparian habitat, it is not practicable to formulate descriptions of discrete sites assessed during our reconnaissance. Therefore, below we qualitatively describe vegetation and hydrology for contiguous stretches of habitat by section as related to our current study sites (see Figures 2.2 and 2.3). The following descriptions are organized from downstream to upstream along the Bill Williams River.

"North of Site #2 to Site #1"

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area in 2006. Starting our habitat reconnaissance at Site #2, we followed an approximately 150-m-long route north to the southern edge of Site #1. Tall willow forest with a dense tamarisk understory was present in this area. Lower strata vegetation from ground level up to approximately 2 m was choked with deadfall, creating an almost impenetrable understory that is used little by most passerines (K. Blair, pers. comm.), including the willow flycatcher. Although slow moving and standing water were present in a channel nearby, soils under the vegetation were completely dry. Based on aerial photography, similar habitat extends for at least 400 meters east of this route. The impenetrable understory and dry soils encountered during the reconnaissance were not characteristic of willow flycatcher habitat.

"Burn Edge"

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area for a single day in 2007. Starting our habitat reconnaissance at Site #1 (burned in 2006), we followed an approximately 800-m route east and then 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 damp to muddy. Parts of the site are adjacent to a waterway and can be surveyed by boat. With damp and muddy soils present and vegetation in some areas typical of flycatcher habitat, this area should be further evaluated in future years.

"Upstream From Mosquito Flats"

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area in 2006. The historical flycatcher breeding sites Site #3 and Site #4 are contiguous, and together are known as Mosquito Flats. Starting our habitat reconnaissance at this breeding area, we followed the edge of standing water and saturated soils upstream/east for approximately 100 m, at which point the water went subsurface and soils became completely dry. We followed this eastern bearing for another approximately 350 m. Vegetation in this section consisted of live and dead tamarisk with tangles of cottonwood and willow deadfall. Vegetation became more and more dense as we progressed upstream. When the vegetation became impenetrable, we headed due south for approximately 300 m until we reached the riparian/desert upland interface. Based on aerial photography, similar habitat extends for approximately 450 meters east of this route to "*Transect #9*" (see below).

Excluding the 100 m immediately adjacent to Site #3, vegetation encountered during the reconnaissance was not suitable flycatcher habitat. The understory was nearly or completely impenetrable, with much deadfall tangled in with dead and live tamarisk. Hydrological conditions encountered during the reconnaissance were not characteristic of occupied flycatcher habitat, with only dry soils present under the vegetation.

"Last Gasp"

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area in 2006. This area is depicted as a wetland on the U.S. Geological Survey (USGS) Monkey's Head 7.5-min topographic map. We attempted to reach this area by following the river downstream from Site #5 (see Downstream from Site #5 to River End, below) but encountered impenetrable vegetation just upstream of the "wetland" area. We then accessed the area by crossing the river at Site #5 and following the desert uplands on the northern edge of the riparian zone. The area depicted as a wetland consisted of tall cottonwood/willow forest with a dense tamarisk understory and abundant deadfall. Surface water was present in multiple channels ranging from small, ponded areas over 100 cm deep to narrow, flowing streams. We attempted to follow the water to its terminus in both the upstream and downstream directions but encountered very dense vegetation. Soils away from the channels were dry. Because of the presence of surface water within the vegetation, this area should be evaluated in future years.

"Transect #9"

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area in 2006. The reconnaissance route followed a transect cut through the vegetation that is used by the USGS for sedimentation studies (K. Blair, pers. comm.). The transect runs southwest to northeast for approximately 460 m, and it is located approximately halfway between Mosquito Flats and Site #5.

Vegetation encountered during the reconnaissance was not suitable flycatcher habitat. Although scattered emergent willow and cottonwood with a dense tamarisk understory were present within the southern half of the transect, most of the area consisted primarily of impenetrable tamarisk. Hydrological conditions encountered during the reconnaissance are not characteristic of habitat occupied by breeding flycatchers, with only sandy soils present under the vegetation. Based on aerial photography, similar habitat extended for approximately 685 meters southeast of this route to Site #5.

"Downstream From Site #5 to River End"

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area in 2006. Starting habitat reconnaissance at Site #5, we followed vegetation along the Bill Williams River downstream/northwest for approximately 1.3 km. The river along this route was channelized, with banks averaging 1–2 m in height. Standing water was limited to the channel, and dry soils were present under the riverside vegetation. Toward the end of the route, the river became wider and less channelized and terminated in a small body of standing water, where the Bill Williams River went subsurface. Downstream of this area soils were completely dry, and we followed dry, sandy, braided channels downstream for another approximately 300 m. Here the dry channels terminated near the eastern end of Last Gasp in a stand of cottonwood/willow forest with dense tamarisk understory.

The vegetation along the river consisted of a mosaic of dense tamarisk, emergent willow and cottonwood trees, and mesquite. Small islands of cattail marsh were scattered along this stretch of river and were confined to the channel. Understory vegetation along the northern bank of the river and where the river went subsurface was almost impenetrable. Vegetation along the southern bank of the river had a more open understory. Hydrological conditions along the channelized section of the Bill Williams River were not characteristic of occupied flycatcher habitat because standing water was confined to the channel. Although dry swales adjacent to the river indicate overbank flooding occurred during extreme high flows, no standing water or saturated soils were present under the vegetation. The area where surface water of the Bill Williams River went subsurface was less channelized and contained tall, dense vegetation with some standing water. Because of standing water, this "River End" area should be evaluated in future years.

"Upstream of Site #5"

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area in 2007. This area is adjacent to Site #5, extending approximately 350 m southeast from the eastern boundary of Site #5. This is a different area from what was called "Upstream from Site #5" in 2006 in that it follows the edge of the desert upland habitat to the north rather than the river to the south. Access to the site is difficult. Tall Fremont cottonwood and a tamarisk understory compose the dominant vegetation. Goodding willows are also present in areas with standing water. A small stream runs through the site, and several beaver ponds, as deep as 1.5 m, are also present. Most of the site is inundated and should be evaluated in future years.

"Flooded Refuge Road"

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area in 2006. This area was located approximately 300 m southeast of Site #5 and straddled the refuge road, which was flooded. The habitat reconnaissance routes followed the flooded refuge road and small meandering channels that penetrated the vegetation, which consisted primarily of flooded tamarisk forest. A few emergent willows and cottonwoods were scattered throughout the area. Because standing water was present under the vegetation, this area should be evaluated in future years.

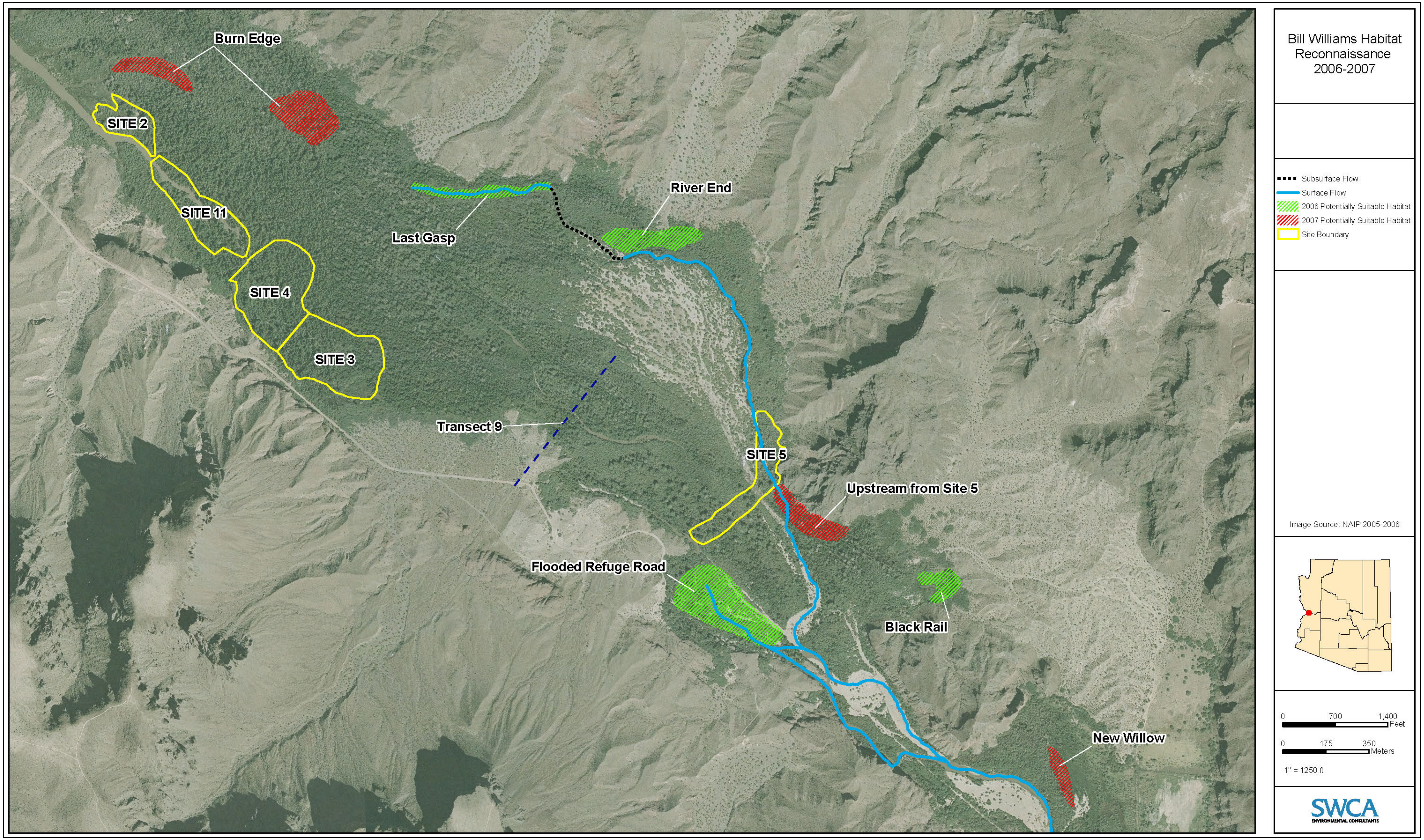

Figure 2.2. Bill Williams River NWR habitat reconnaissance 2006 and 2007.

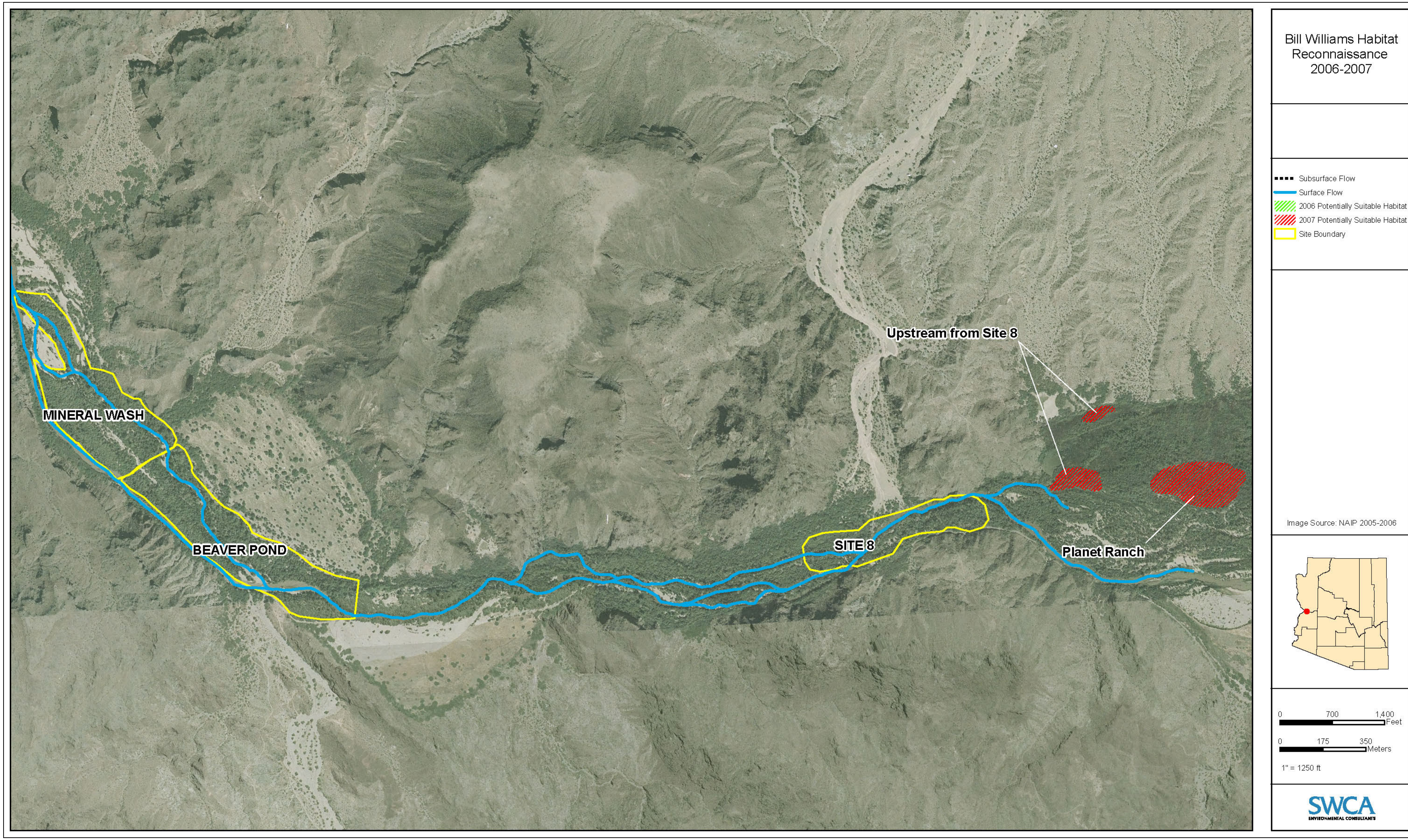

Figure 2.3. Bill Williams River NWR habitat reconnaissance 2006 and 2007, continued.

“Black Rail”

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area in 2006. This area is approximately 840 m east/southeast of Site #5, is difficult to access, and is located adjacent to the desert uplands approximately 350 m from the Bill Williams River. In 2006, access to the site was possible only via 4x4 ATV over the desert uplands to the north. This small site consisted of a mosaic of coyote willow, cattail marsh, and tamarisk. A small stand of cottonwoods with a tamarisk understory was located adjacent to marsh, which is likely spring-fed, and mesquite trees were present in drier areas. Hydrological conditions were characteristic of occupied flycatcher habitat, with standing water present under the vegetation and in the marsh. Although this site was small in area, it has characteristics typical of flycatcher habitat and should be evaluated in future years.

“Upstream From Site #5 to Mineral Wash”

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area in 2006. Starting habitat reconnaissance at Site #5, we followed vegetation along the Bill Williams River upstream/southeast for approximately 3,800 m to the Mineral Wash site. In an effort to get a better view of the habitat and better access to the vegetation along the river, routes also followed dry washes west of the river near Site #5, and the desert uplands east and west of the river. The vegetation along the river consisted of a mosaic of dense tamarisk, willow and cottonwood forest, and scattered mesquite. Although some patches of Goodding willow forest with tamarisk understory closest to the river had structure typical of suitable flycatcher habitat, soils under the vegetation were dry. Because surface water and saturated soils were confined to the river, this area was not typical of flycatcher habitat.

“New Willow”

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area in 2007. This area is approximately 1.7 km southeast of Site #5. Goodding willow and Fremont cottonwood to heights of 10 m 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. During surveys, soils under the vegetation were dry to damp, with the nearest running water approximately 200 m away. Although 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.

“Beaver Pond to Site #8”

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area in 2006. Starting habitat reconnaissance at the Beaver Pond site, we followed the Bill Williams River upstream/east for approximately 1,800 m to Site #8. The vegetation in this area consisted primarily of grassy areas and scattered cottonwood and willow trees with no understory vegetation. Because surface water was confined to the river, and because soils were dry under the vegetation and there was no understory vegetation, this area was not suitable flycatcher habitat.

"Upstream from Site #8"

We conducted habitat reconnaissance and opportunistic surveys in this area in 2007. 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"

We conducted habitat reconnaissance and opportunistic broadcast surveys in this area in 2007. Starting our habitat reconnaissance approximately 300 m east of Site #8, we evaluated an area extending 700 m east and 300 m north of the start point. Tall Goodding willow and Fremont cottonwood make up the overstory in the area, while understory species include tamarisk, arrowweed, Fremont cottonwood, and Goodding willow. Some areas of understory include dense patches of deadfall. Many marshes and streams are present throughout the site, with cattails surrounding the marshes. 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

Big Hole Slough was surveyed from 2003 to 2007. 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 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%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. A cattail marsh (approximately 30% of the site) had shallow, standing water throughout survey seasons in 2003–2006. The marsh was not accessed in 2007.

We detected a total of 39 migrant willow flycatchers at this site from 2003 to 2007. Brown-headed cowbirds were detected in all survey years. Although no livestock use was noted, evidence of human traffic was recorded at the site.

EHRENBERG, ARIZONA

EHRENBERG

Area: 4.7 ha Elevation: 78 m

Ehrenberg was surveyed from 2003 to 2007. 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%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Approximately 5% of the site is a cattail marsh that contained standing water and saturated soil periodically during survey seasons. The site is separated from the Colorado River by a levee.

We detected a total of 17 migrant willow flycatchers at this site from 2003 to 2007. Brown-headed cowbirds were detected in all survey years, and burros used the periphery of the site.

CIBOLA NATIONAL WILDLIFE REFUGE, ARIZONA AND CALIFORNIA

CIBOLA NATURE TRAIL

Area: 13.7 ha Elevation: 70 m

Cibola Nature Trail was surveyed in 2006 and 2007. 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%. No major changes in vegetation structure or species composition were recorded in 2006 and 2007. The amount of standing water and saturated soil is highly variable because the site is flood irrigated.

We detected 5 migrant willow flycatchers at this site in 2006 and 12 in 2007. Brown-headed cowbirds were detected in both survey years, and signs of burros were recorded at the site.

CIBOLA ISLAND

Area: 9.0 ha Elevation: 70 m

This mixed-native site is approximately 9.5 km southwest of Cibola Nature Trail and was surveyed in 2007. 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 at Cibola Island in 2007. Cowbirds were detected on three surveys, and use by burros was recorded.

CIBOLA SITE 2 AND CIBOLA SITE 1

Cibola Site 2: Area: 16.4 ha Elevation: 65 m
Cibola Site 1: Area: 7.7 ha Elevation: 65 m

Cibola Site 2 and Site 1 were surveyed from 2003 to 2007. These adjacent, mixed-exotic sites 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%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. The hydrologic conditions at these sites were undetermined in most years because dense vegetation inhibited the ability of observers to access the marshes, but standing water was likely present within the cattail marshes.

At Cibola Site 2, we detected 37 migrant willow flycatchers in 2003–2007. At Cibola Site 1, we detected 17 migrant willow flycatchers. Cowbirds were recorded at both sites in all survey years, and burro trails were noted on the periphery of the sites.

HART MINE MARSH

Area: 31.6 ha Elevation: 65 m

Hart Mine Marsh was surveyed in 2003–2007. 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%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. The marsh retained standing water and saturated soil through survey seasons. The tamarisk areas contained dry soils throughout survey seasons.

We detected a total of 35 migrant willow flycatchers at Hart Mine Marsh from 2003 to 2007. Cowbirds were recorded in all survey years, and burro trails were noted on the eastern side of the site.

THREE FINGERS LAKE

Area: 67.9 ha Elevation: 65 m

Three Fingers Lake was surveyed in 2003–2007. 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 survey seasons. Saturated soils were only present along the shore of the island. No major changes in vegetation structure or species composition were recorded from 2003 to 2007.

We detected a total of 143 migrant willow flycatchers at Three Fingers Lake from 2003 to 2007. Cowbirds were recorded in all survey years, and burros used the adjacent uplands.

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

Cibola Lake North, East, and West were surveyed from 2003 to 2007. 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%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Except for along the shores, soils within the interior of all sites were dry throughout survey seasons.

We detected a total of 44 migrant willow flycatchers at Cibola Lake North, East, and West from 2003 to 2007. Cowbirds were detected at all sites in all survey seasons, and tracks of burros and feral pigs were noted at Cibola Lake East.

WALKER LAKE

Area: 11.4 ha Elevation: 64 m

Walker Lake was surveyed from 2003 to 2007. 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. This portion of the site consists of monotypic tamarisk approximately 5 m in height with 50–70% canopy closure; patches of arrowweed, short tamarisk, and individual Goodding willow and Fremont cottonwood trees are interspersed throughout. From 2005 to 2007, we shifted our survey efforts to the area adjacent to the eastern edge of Walker Lake. The area adjacent to the lake consists of a mix of cattail and tamarisk up to 7 m in height. A band of emergent Fremont cottonwood and Goodding willow approximately 15 m in height is present farther east, away from the lake edge. No major changes in vegetation structure or species composition were recorded from 2003 to 2007.

In 2003 and 2004, soils under the vegetation adjacent to the river were dry throughout survey seasons. From 2005 to 2007, Walker Lake held standing water until June, but had dried to deep mud by July each year; soils in the interior of the site were dry throughout survey seasons.

We detected a total of 46 migrant willow flycatchers at Walker Lake from 2003 to 2007. A lone individual, likely a male, responded aggressively to broadcasts and continued to sing for up to 20 minutes after broadcasts ceased on 30 May and 3 June 2007. Although this behavior was observed on two visits, the bird on both occasions was unbanded and it is unknown if it was the same individual. No flycatchers were detected on six subsequent visits, indicating that no flycatchers remained as residents at the site. Cowbirds were detected in all survey seasons, and evidence of burros was recorded.

IMPERIAL NATIONAL WILDLIFE REFUGE, ARIZONA AND CALIFORNIA

DRAPER LAKE

Area: 4.6 ha Elevation: 63 m

Draper Lake was surveyed in 2006 and 2007. This site burned prior to the 2003 survey season. The main landscape feature of the site is Draper Lake, which lies approximately 200 m west of the Colorado River. 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 survey seasons in the cattail marsh. No major changes in vegetation structure or species composition were recorded from 2006 to 2007.

We detected a total of 17 migrant willow flycatchers at Draper Lake in 2006 and 2007. Cowbirds were detected in both survey years, and signs of use by burros were recorded in 2007.

PARADISE

Area: 7.8 ha Elevation: 62 m

Paradise was surveyed from 2003 to 2007. 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 strip (50 m wide) of dense tamarisk. A cattail marsh borders the site to the south. Overall canopy closure is approximately 25%. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Standing water and saturated soil persisted in the marsh throughout most survey seasons.

We detected a total of 89 migrant willow flycatchers at Paradise from 2003 to 2007. Cowbirds were detected in all survey years, and no sign of livestock use was observed on the site.

HOGE RANCH

Area: 20.7 ha Elevation: 61 m

Hoge Ranch was surveyed from 2003 to 2007. 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%. No major changes in vegetation structure or species composition were recorded from 2006 to 2007. The marshes in the interior of the site contained fluctuating amounts of standing water and saturated soil throughout survey seasons. The site also borders the Colorado River.

We detected a total of 95 migrant willow flycatchers at Hoge Ranch from 2003 to 2007. Cowbirds were detected in all survey years, and there were signs of burros using portions of the site.

ADOBE LAKE

Area: 7.6 ha Elevation: 60 m

Adobe Lake was surveyed from 2003 to 2007. 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 soils under the vegetation were dry throughout the survey seasons when the interior of site was accessed. No major changes in vegetation structure or species composition were recorded from 2003 to 2007.

We detected a total of 57 migrant willow flycatchers at Adobe Lake from 2003 to 2007. Cowbirds were detected in all survey years, and there was sign of burro use at the site.

TAYLOR LAKE

Area: 3.0 ha Elevation: 60 m

Taylor Lake was surveyed only in 2003; the site burned prior to the 2004 survey season. Taylor Lake was a mixed-native site, consisting of an overstory of Goodding willow (15 m in height) and an understory (3–4 m in height) of varying densities of tamarisk, seep willow, and arrowweed. Dead willow branches composed much of the ground cover, and canopy closure was approximately 50%. The site bordered the Colorado River, and the interior of the site was separated from the river by hummocks of live and dead common reed. Soils in the interior of the site were dry throughout the survey period.

We detected two migrant willow flycatchers at Taylor Lake in 2003. Cowbirds were detected during surveys, and there was evidence of occasional use of the site by burros.

RATTLESNAKE

Area: 7.6 ha Elevation: 60 m

Rattlesnake was surveyed from 2004 to 2007. 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. No major changes in vegetation structure or species composition were recorded from 2004 to 2007. The amount of standing water and saturated soil within the site fluctuated across survey seasons, and portions of the site held standing water throughout some seasons.

We detected a total of 16 migrant willow flycatchers at Rattlesnake from 2004 to 2007. Cowbirds were detected in all survey years, and there were signs of feral burros and pigs using portions of the site.

NORTON SOUTH

Area: 1.2 ha Elevation: 60 m

Norton South was surveyed from 2004 to 2007. 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. No major changes in vegetation structure or species composition were recorded from 2004 to 2007. Varying amounts standing water and saturated soil were present in the cattail marsh on the northern edge of the site throughout all survey seasons.

We detected a total of 6 migrant willow flycatchers at Norton South from 2004 to 2007. Cowbirds were detected in all survey years, and burros used portions of the site.

PICACHO NW

Area: 8.8 ha Elevation: 59 m

Picacho NW was surveyed from 2003 to 2007. 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 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. The site borders the Colorado River, but no standing water or saturated soil was present within the site during survey seasons.

We detected a total of 45 migrant willow flycatchers at Picacho NW from 2003 to 2007. Cowbirds were detected in all survey years, and there was evidence of heavy use of the site by burros.

PICACHO CAMP STORE

Area: 3.3 ha Elevation: 58 m

Picacho Camp Store was surveyed only in 2003; the site burned prior to the 2004 survey season. The site was a mixed-native site, dominated by Goodding willow 20 m in height with an understory of common reed and tamarisk 3 m in height. Canopy closure was 50–70%. The site was bordered to the north by the Colorado River and to the south and west by a patchwork of cattail marshes bordered by Goodding willow and tamarisk 4 m in height. Standing water was present in approximately 5% of the site throughout the survey season.

We detected five migrant willow flycatchers at Picacho Camp Store in 2003. Cowbirds were recorded during surveys, and there was evidence of occasional use of the site by burros.

MILEMARKER 65

Area: 10.0 ha Elevation: 58 m

Milemarker 65 was surveyed from 2003 to 2007. The site 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Because of the impenetrable vegetation at this site, we surveyed it from the river in 2004–2007. Thus, hydrologic conditions of the interior of the site were undetermined in most years.

We detected a total of 26 migrant willow flycatchers at Picacho NW from 2003 to 2007. Cowbirds were recorded in all survey years. No sign of livestock use was recorded.

CLEAR LAKE/THE ALLEY

Area: 8.3 ha Elevation: 59 m

Clear Lake/The Alley was surveyed from 2003 to 2007. 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. 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 survey seasons.

We detected a total of 10 migrant willow flycatchers at Clear Lake/The Alley from 2003 to 2007. Cowbirds were recorded in all survey years, and burros were recorded in the surrounding uplands through 2006.

NURSERY NW

Area: 7.0 ha　　　　Elevation: 58 m

Nursery NW was surveyed in 2006 and 2007. 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 approximately 25%. No major changes in vegetation structure or species composition were recorded from 2006 to 2007.

We detected a total of 22 migrant willow flycatchers at Nursery NW from 2006 to 2007. Cowbirds were detected during surveys, and signs of burros in the site were recorded in 2007.

IMPERIAL NURSERY

Area: 1.4 ha　　　　Elevation: 58 m

Imperial Nursery was surveyed from 2003 to 2007. 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. The amount of standing water and saturated soil within the site was highly variable during survey seasons. Refuge personnel periodically inundate the cottonwood plantation with up to 25 cm of water.

We detected a total of 26 migrant willow flycatchers at Imperial Nursery from 2003 to 2007. Cowbirds were detected in all survey seasons, and there was no evidence of livestock using the site.

FERGUSON LAKE

Area: 21.1 ha　　　　Elevation: 57 m

Ferguson Lake was surveyed from 2003 to 2007. The site is located 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. In 2003 and 2004, soils under the vegetation were mostly dry during survey seasons. Portions of the site up to 50 m from the lakeshore had saturated soils and fluctuating levels of standing water throughout the 2005–2007 survey seasons; however, these area were not surveyed or described in 2003–2004.

We detected a total of 89 migrant willow flycatchers at Ferguson Lake from 2003 to 2007. Cowbirds were detected in all survey years, and evidence of burros using the site was documented.

FERGUSON WASH

Area: 6.8 ha Elevation: 58 m

Ferguson Wash was surveyed from 2003 to 2007. 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Soils under the vegetation in the interior of the site were dry throughout survey seasons.

We detected a total of 35 migrant willow flycatchers at Ferguson Wash from 2003 to 2007. Cowbirds were recorded in all survey years, and burro trails were abundant on the periphery of the site.

GREAT BLUE HERON

Area: 7.1 ha Elevation: 58 m

Great Blue Heron was surveyed from 2003 to 2007. 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 major changes in vegetation structure or species composition were recorded from 2003 to 2007. No standing water or saturated soils were noted within the site, though soils near Martinez Lake were damp throughout survey seasons.

We detected a total of 168 migrant willow flycatchers at Great Blue Heron from 2003 to 2007. Brown-headed Cowbirds were recorded in all survey years, and burros used the uplands on the periphery of the site.

POWERLINE

Area: 2.1 ha Elevation: 58 m

Powerline was surveyed from 2003 to 2007. 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. The only standing water and saturated soil noted within the site occurred within the cattail marsh. The marsh was dry during the 2003 and 2004 survey seasons, and from 2005 to 2007, the marsh retained standing water and saturated soil throughout survey seasons.

We detected a total of 15 migrant willow flycatchers at Powerline from 2003 to 2007. Cowbirds were recorded in all survey years, and burros used the uplands on the periphery of the site.

MARTINEZ LAKE

Area: 4.6 ha Elevation: 58 m

Martinez Lake was surveyed from 2003 to 2007. 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Standing water and saturated soils were recorded only along the lake edge; the interior of the site was dry.

We detected a total of 30 migrant willow flycatchers at Martinez Lake from 2003 to 2007. Cowbirds were detected in all survey years, and burros used the adjacent uplands.

MITTRY LAKE, ARIZONA AND CALIFORNIA

MITTRY WEST

Area: 4.4 ha Elevation: 48 m

Mittry West was surveyed from 2003 to 2007. 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. There are patches of cattail within the site, and portions of the site appear to have burned prior to the 2003 survey season. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Varying amounts of standing water and saturated soil were present in the site through the 2003–2005 survey seasons. In 2006 and 2007, surface water was present in the site only during May.

We detected a total of 55 migrant willow flycatchers at Mittry West from 2003 to 2007. Cowbirds were detected in all survey years, and burros used the adjacent uplands.

MITTRY SOUTH

Area: 15.2 ha Elevation: 46 m

Mittry South was surveyed from 2003 to 2007. 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. Prior to the 2003 survey season, the land north of the western half of the site had been bulldozed and converted to fields, which were inundated in June 2006. In 2006, an approximately 50- x 50-m patch of vegetation in the center of the site had been removed for a pump and canal, which water the nearby fields. No standing water or saturated soils were recorded in the interior of the site. The only standing water and saturated soil were recorded along the marsh edge, which retained water through survey seasons.

We detected a total of 31 migrant willow flycatchers at Mittry South from 2003 to 2007. Cowbirds were detected in all survey years, and no evidence of livestock use was recorded.

POTHOLES EAST

Area: 2.0 ha Elevation: 54 m

Potholes East was surveyed from 2003 to 2007. 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Standing water and saturated soil, present throughout survey seasons, were confined to the center and edges of the cattails, respectively.

We detected a total of 18 migrant willow flycatchers at Potholes East from 2003 to 2007. Cowbirds were detected in all survey years, and evidence of burros was abundant in the upland areas surrounding the site.

POTHOLES WEST

Area: 6.6 ha Elevation: 53 m

Potholes West was surveyed from 2003 to 2007. 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. A patch of mesquite trees grows on the northern side of the site. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. Standing water and saturated soil, present throughout survey seasons, were confined to the center and edges of the cattails, respectively. Soils away from the pond were very dry through survey seasons.

We detected a total of 24 migrant willow flycatchers at Potholes West from 2003 to 2007. Cowbirds were detected in all survey years, and burros used the uplands surrounding the site.

YUMA, ARIZONA

RIVER MILE 33

Area: 17.6 ha Elevation: 38 m

River Mile 33 was surveyed from 2003 to mid-June 2006. Because of safety concerns of our field personnel (large numbers of homeless people inhabiting the area immediately south of the site), surveys were discontinued in 2006. Between 2006 and 2007, the entire area was bulldozed as part of the Yuma East Wetlands vegetation restoration project.

This mixed-native site was approximately 100 m south of the Colorado River approximately 2 km downstream of the confluence with the Gila River. The main portion of the site consisted of a stand of Goodding willow and Fremont cottonwood with a multilayered canopy up to 15 m in height. Tamarisk was present in the understory, and common reed occurred in dense clumps. Cottonwoods and willows also occurred in narrow stringers along irrigation ditches on the periphery of the site. Canopy cover was variable from 25 to 70%. The area north of the stringer on the western end of the site burned prior to the 2005 survey season, but the stringer of trees was not affected. The northern portion of the eastern end of the site, including part of the Goodding willow stand, burned during the first half of June 2006.

In 2003 and 2004, the Goodding willow and Fremont cottonwood stand contained standing water and saturated soil early in the survey season, but no surface water was recorded in this area in 2005. Small areas of standing water and saturated soil were present throughout the 2005 survey season along a stream channel to the southeast of the main willow and cottonwood stand. No surface water was recorded at the site in 2006.

We detected a total of 57 migrant willow flycatchers at River Mile 33 from 2003 to 2006. One individual, detected and resighted on 17 May 2005, was originally banded as a nestling at an unidentified life history study area in 2003 or 2004.

Cowbirds were recorded in all survey years, and there was no evidence of livestock use at the site.

GILA CONFLUENCE WEST

Area: 3.8 ha Elevation: 37 m

Gila Confluence West was surveyed from 2003 to 2006. Prior to the 2007 survey season, a fire burned all of the vegetation at the site. This mixed-native site bordered the Colorado and Gila Rivers. Sparse Goodding willows and Fremont cottonwoods surrounded a cattail marsh in the center of the site. Canopy height was approximately 10 m, and canopy closure was 25–50%. Arrowweed and tamarisk formed a patchy understory, with sandy, open areas throughout the site. Prior to the fire, there were no major changes in vegetation structure or species composition recorded. In 2003 and 2004, soils within the site were primarily dry through survey seasons. In 2005 and 2006, standing water and saturated soil, present intermittently throughout survey seasons, were confined to the center and edges of the cattails, respectively.

We detected a total of 32 migrant willow flycatchers at Gila Confluence West from 2003 to 2006. Cowbirds were detected in all survey years, and no evidence of livestock use was noted. The area receives human recreational activity and off-road vehicle use.

GILA CONFLUENCE NORTH

Area: 2.2 ha Elevation: 40 m

Gila Confluence North was surveyed from 2003 to 2007. This mixed-native site borders the northern side of the Colorado River at the confluence of the Gila and Colorado Rivers. Prior to the 2007 survey season, a fire burned through the western half of the site. In 2003–2006, the site was approximately 650 m long and less than 100 m wide. Overstory vegetation at the site was a combination of Goodding willow, coyote willow, and Fremont cottonwood. Dense stands of these trees surrounded a cattail marsh. Canopy height at the site was variable from 4 to 13 m, and canopy closure was approximately 50%. Arrowweed, tamarisk, and seep willow were common in the understory. From 2003 to 2006, there were no major changes in vegetation structure or species composition recorded. In 2003 and 2004, the areas of cattail within the site were dry throughout survey seasons, and the only saturated soils were adjacent to the Colorado River. In 2005 and 2006, the cattail marsh did contain standing water and saturated soil.

In 2007, overstory vegetation at the site consisted of 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 a total of 47 migrant willow flycatchers at Gila Confluence North from 2003 to 2007. Cowbirds were detected in all survey years, and no evidence of livestock use was noted.

GILA RIVER SITE #1

Area: 5.7 ha Elevation: 45 m

Gila River Site #1 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 now 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 <15%. 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 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 for most of the 2006 and 2007 survey seasons, passes through the central part of site. The eastern area may become more suitable for flycatchers in subsequent years.

We detected 8 migrant willow flycatchers at Gila River Site #1 in 2003, and 18 migrant flycatchers were detected at the site in 2006–2007. Cowbirds were detected in all survey years, and human disturbance was recorded at the site.

GILA RIVER SITE #2

Area: 5.1 ha Elevation: 45 m

Gila River Site #2 was surveyed from 2003 to 2007. 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 major changes in vegetation structure or species composition were recorded from 2003 to 2007. There was no standing water or saturated soils within the site during survey seasons, but the western edge of the site borders a large pond that held water throughout survey seasons.

We detected a total of 44 migrant willow flycatchers at Gila River Site #2 from 2003 to 2007. Cowbirds were detected in all survey years, and no evidence of livestock use was noted.

FORTUNA SITE #1

Area: 2.5 ha Elevation: 45 m

Fortuna Site #1 was surveyed from 2004 to 2007. 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. The site is bordered to the north by agricultural fields and to the south by a cattail marsh and the Gila

River. No major changes in vegetation structure or species composition were recorded from 2004 to 2007. Little to no standing water or saturated soil was recorded at the site.

We detected a total of 35 migrant willow flycatchers at Fortuna Site #1 from 2004 to 2007. Cowbirds were detected in all survey years, and no evidence of livestock use was noted.

FORTUNA NORTH

Area: 3.8 ha Elevation: 46 m

Fortuna North was surveyed from 2003 to 2007. 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 western edge of the site borders the Gila River. No major changes in vegetation structure or species composition were recorded from 2003 to 2007. The site did not contain standing water or saturated soil during survey seasons.

We detected a total of 43 migrant willow flycatchers at Fortuna North from 2003 to 2007. Cowbirds were detected in all survey years, and burro sign was recorded in 2003.

MORELOS DAM

Area: 11.4 ha Elevation: 34 m

Morelos Dam was surveyed in 2006 and 2007. This mixed-native site lies next to the Colorado River. The site burned prior to the 2003 survey season, and was not surveyed again until 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. No standing water or saturated soil was recorded under the vegetation, but a small body of water formed by Morelos Dam lies adjacent to the northwestern side of the site.

No willow flycatchers were recorded in 2006. A total of 11 willow flycatchers were detected at Morelos Dam in 2007. Cowbirds were detected in both survey years, and no evidence of livestock use was recorded.

GADSDEN BEND

Area: 4.4 ha Elevation: 28 m

Gadsden Bend was surveyed from 2003 to mid-June 2006. Surveys were discontinued because the site had been burned and bulldozed, removing most of the understory vegetation, prior to the 2006 survey season. Prior to 2006, this mixed-native site consisted of a stand of Fremont cottonwood and Goodding willow that reached 20 m in height; many of these trees appeared to be dying and canopy closure was <50%. The site contained a sparse understory of scattered tamarisk and patches of arrowweed and common reed. After the fire, only sparse stands of Fremont cottonwood and Goodding willow remained, of which only 50% were alive in 2006. The site is bordered to the north and east by agricultural fields and to the south and west by a large stand of mesquite. Small areas of standing water and saturated soil (5–20% of the site) were recorded within the site throughout survey seasons, and the site lies adjacent to a pond along backwater channels of the Colorado River.

We detected a total of 105 migrant willow flycatchers at Gadsden Bend from 2003 to 2006. Cowbirds were detected in all survey years, and no evidence of livestock use was recorded. The site receives heavy foot traffic by illegal immigrants.

GADSDEN

Area: 19.3 ha Elevation: 25 m

Gadsden was surveyed from 2003 to 2007. 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 channels, portions of which are vegetated by cattail and bulrush, have open, sandy shores. Much of the site comprises open, sandy areas, some of which are sparsely vegetated by arrowweed, between the backwater channels. No major changes in vegetation structure or species composition were recorded from 2003 to 2006. Prior to the 2007 survey season, much of the vegetation along the southern portion of the site was bulldozed and removed. Standing water and saturated soil were recorded within the site throughout survey seasons.

We detected a total of 253 migrant willow flycatchers at Gadsden from 2003 to 2007. Cowbirds were detected in all survey years, and no evidence of livestock use was recorded. The site receives heavy foot traffic by illegal immigrants.

HUNTER'S HOLE

Area: 24.1 ha Elevation: 26 m

Hunter's Hole was surveyed from 2003 to 2007. This mixed-native site consists of two patches of Goodding willow separated by a pond surrounded by cattail and common reed. In the southern patch, stringers of willow 10 m in height surround an oxbow. Areas away from the 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 channels and small ponds. 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. No major changes in vegetation structure or species composition were recorded from 2003 to 2007.

In 2003, 2004, and 2006, varying amounts of standing water and saturated soil were present in the ponds and a stream channel throughout the survey seasons. No standing water or saturated soil were recorded within the site in 2005 and 2007, with the nearest surface water in an irrigation canal that lies approximately 25 m from the edge of the site.

We detected a total of 193 migrant willow flycatchers at Hunter's Hole from 2003 to 2007. Cowbirds were detected in all survey years, and no evidence of livestock use was recorded. The site receives heavy foot traffic by illegal immigrants.

OTHER SURVEY AREAS

I-8 Site 1: Area: 17.9 ha Elevation: 38 m

I-8 Site 1 was surveyed twice in 2003 before it burned between 11 and 28 June of that year. This mixed-native site was vegetated by Goodding willow and dense tamarisk. Soils were dry, except on the western edge of the site adjacent to a backwater channel. The site borders the Colorado River and is now part of the Yuma East Wetlands project.

No willow flycatchers were detected, and cowbirds were detected during surveys.

DISCUSSION

Habitat occupancy by resident or breeding flycatchers at some sites differed over the years, both during the five years of this study and when compared to previous years of study at the same sites (McKernan and Braden 2002). 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 previously surveyed 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, 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 were 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 flycatcher habitat in the recreation area that had been occupied in 2006 was dead or 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 continue to degenerate in future years. Although tamarisk is colonizing areas where the willow is dying, it will likely take several years to become suitable for flycatchers. In 2007, flycatcher residency and breeding were 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 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.

The amount of standing water throughout the entire Topock study area was markedly reduced in 2005 compared to 2003–2004 and 2006–2007. It is undetermined whether annual fluctuations in the amount of standing water at Topock contributed 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 initiated habitat reconnaissance and opportunistic surveys in 2006 and continued these efforts in the 2007 survey season. Although the Bill Williams River NWR contains the largest expanse of native cottonwood-willow forest in the lower Colorado River region, vegetation structure and hydrological conditions along most of the Bill Williams 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 dechannelize 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 approximately 2,000 willow flycatchers detections were recorded over the five-year study prior to 15 June at sites surveyed south of Bill Williams, and 43 detections were recorded post 15 June, monitoring results at these sites suggest these individuals were not resident or breeding individuals. Our only observation of a possibly territorial willow flycatcher south of the Bill Williams was in 2007 at Walker Lake where a lone individual, likely a male, responded aggressively to broadcasts and continued to sing for up to 20 minutes after broadcasts ceased. This behavior was observed on two visits five 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 over the five-year study are consistent with those recorded in 1997–2002 (McKernan and Braden 2002), with no nests recorded since 1938 (Unitt 1987). Based upon the variation in total numbers of flycatchers detected at a given site over each survey season, and the overall lack of territorial, aggressive behaviors exhibited toward conspecific broadcasts, willow flycatchers detected at sites south of Bill Williams were most likely migrants. Given that willow flycatchers are one of the last long-distance migrant passerines to arrive in the Southwest in spring,[7] 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, over 600 detections recorded in 2004, over 300 detections in 2005, and over 450 detections in 2006 and 2007, this section of the lower Colorado River corridor is undoubtedly a major flyway for migrant willow flycatchers in spring. The degree to which Southwestern Willow Flycatchers use this riparian corridor during spring migration is unknown, as is the degree to which willow flycatchers use the corridor during fall migration.

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 did conduct color-banding studies at sites south of Bill Williams in 2003–2007 (see Chapter 3), and recaptured one individual at the same site (Gadsden) two days after it was banded in 2007. Of the 110 individuals banded over the five-year study, this was the only one detected on a later day, suggesting that the remaining 109 flycatchers did not remain at the site for multiple days. It is not unusual for Neotropical migrant birds including the willow flycatcher to "rest" and replenish fat reserves during migration, and this individual may have been using Gadsden as a stopover site. Otahal (1998) recorded the mean length of stopover days for fall migrant willow flycatchers at a riparian site in central California to be six days.

[7] 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).

Of the 33 sites occupied by Southwestern Willow Flycatchers in 2003–2007, approximately 80% contained standing water and/or saturated soil under the vegetation. Although 39 (87%) of the 45 survey sites located downstream of the Bill Williams River were located immediately adjacent to standing water or saturated soil (e.g., a river, lake, pond, marsh, or canal), the sites contained much less standing water or saturated soil under the vegetation than at flycatcher breeding sites. Because the Colorado River in this area is largely channelized and water levels are regulated, overbank flooding into adjacent riparian vegetation does not occur. The lack of standing water under the vegetation at the southernmost survey sites may be a factor as to why willow flycatchers do not remain as residents at these sites.

CHAPTER 3

COLOR-BANDING, RESIGHTING, AND DEMOGRAPHICS

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 growth potential. Thus, as many willow flycatchers as possible were captured and color-banded each year from 1997 to 2007 at sites where resident flycatchers were detected, 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. From 2004 to 2007, we also captured and resighted willow flycatchers opportunistically at Key Pittman Wildlife Management Area, in cooperation with Nevada Division of Wildlife.

METHODS

COLOR-BANDING

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). In 2003–2007, 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, flycatchers were captured by using “passive netting,” whereby several mist-nets are erected and periodically checked, with no broadcast of conspecific vocalizations. 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.

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

As has been shown by Lindsey et al. (1995), celluloid-plastic leg bands undergo fading and discoloration to such a degree that within two years primary colors cannot be recognized under field conditions. In addition, we recaptured and resighted returning individuals that had lost one or more celluloid-plastic bands, likely due to the bands becoming brittle and breaking apart with age. We also found that chipping of the enamel on the epoxy-enamel colored federal bands revealed the original silver band color, causing difficulties in correct color identification through binoculars. To remedy these problems, from 2003–2007 we banded each adult and fledged willow flycatcher with a single anodized (colored), numbered U.S. federal aluminum band on one leg and a metal, pin-striped color-band on the other. Nestlings were banded with a single anodized, numbered federal band, uniquely identifying each bird as a returning nestling in the event it returned in a subsequent year. These bands have shown to be safe for willow flycatchers and colorfast for over six years (Koronkiewicz et al. 2005). These metal color-bands were used on all newly captured flycatchers and on recaptured flycatchers that wore faded or indistinguishable color-bands. From 2003 to 2007, 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 could be related to the presence of leg bands.

For each captured adult and fledged willow flycatcher, we recorded morphological measurements including culmen, tail, wing, fat level, and molt onto standardized data forms. 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 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.

From 2003 to 2007, 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 were focused at sites from Hoge Ranch (Imperial NWR) south to the Mexico border, and along the Gila River near Yuma. These banding studies were conducted in conjunction with subsequent surveys and resighting at these sites through late July to better determine flycatcher residency, breeding status, and movement patterns in this area. Because of extremely dense vegetation in these areas, banding effort at all sites was primarily dependent upon the ability of field personnel to erect nets within the habitat.

RESIGHTING

The identity of a color-banded flycatcher was determined 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. From 2003 to 2007, all banding, monitoring, and survey field personnel coordinated resighting efforts and recorded observations of color-banded and unbanded flycatchers onto standardized data forms. For resighted flycatchers, we recorded color-band combinations, territory number, site, standardized confidence levels of the resight, and behavioral observations. 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.

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.

DEMOGRAPHIC ANALYSES

Survival (Φ) and detection (p) probabilities for individuals banded and resighted at monitoring areas were estimated using program MARK 5.1 (White and Burnham 1999). We used bootstrap procedures to test goodness of fit of global models. We used Akaike Information Criteria (AIC) to select among competing models.

We created separate encounter histories for adults (all individuals banded as adults plus all individuals banded as juveniles with the juvenile encounter removed) and juveniles (all individuals banded as juveniles). Survival and detection parameters were thus estimated separately for adults and juveniles. We used a subset of the adult encounter histories, including only adults of known gender, to evaluate whether there were gender differences in survival or detection probabilities. Genders were pooled for all other analyses. We used multistrata models to examine whether there were differences in survival or detection probabilities by geographic region. We pooled study areas into the following geographic regions based on proximity and observed movement of individuals between study areas: Nevada (Pahranagat, Key Pittman, Meadow Valley Wash, Ash Meadows), Virgin (Littlefield, Mesquite, Mormon Mesa, Muddy River, Grand Canyon), and Havasu (Topock and Bill Williams). We also examined whether detection probabilities differed under the first contract from 1997 to 2002 versus this contract in 2003–2007. To examine the effect of fledge date on juvenile survival, we included fledge date as a continuous covariate.

We calculated lambda (λ), the per capita annual growth rate of the population, using the following equation: λ = adult survivorship + (juvenile survivorship × seasonal fecundity/2) (Pulliam 1988). Lambda values at 1.0 suggest a stable population, above 1.0 suggest a growing population, and below 1.0 a declining population. We calculated λ by year and geographic area. Fecundity rates (number of young produced per female) were calculated in two ways: the number of young known to have fledged successfully and the number of young presumed to have fledged successfully, based on the number of young in the nest at 10 days of age. Lambda was calculated for each of these fecundity rates to provide minimum and maximum estimates of λ.

RESULTS

ALL MONITORING SITES

Color-Banding and Resighting – The number of flycatchers banded and resighted at each monitored study area in 2003–2007 is summarized in Table 3.1. This table includes all flycatchers detected, including individuals for which residency and/or breeding status was undetermined. For details of the status of individuals detected, please refer to the annual reports (Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006, McLeod et al. 2007, McLeod et al. 2008) From 2003 to 2007, we captured 172 previously unbanded adults and banded 322 nestlings from 141 nests. Of these nestlings, 26 were known or suspected to have died before fledging. We captured an additional 17 fledglings that were not banded as nestlings.

The number of resident flycatchers detected at each monitored study area in 2003–2007 is shown in Table 3.2. This table eliminates all flycatchers seen on a single occasion prior to 15 June or after 1 August and suspected to be migrants (e.g., not displaying territorial behaviors such as unsolicited song). The overall percentages of resident, adult flycatchers banded at the monitored study areas by the end of each season have generally been increasing over the five-year study, from 60% in 2003 to 85% in 2007.

NON-MONITORING SITE

Key Pittman Wildlife Management Area – Field personnel captured and color-banded six new adults and recaptured six returning nestlings. We banded 17 nestlings from six nests (Table 3.3).

COLOR-BANDING AND RESIGHTING DOWNSTREAM OF PARKER DAM

From 10 to 30 June in 2003–2007, we recorded a total of 266 willow flycatcher detections at 35 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). All these detections were recorded from 10 to 24 June. From 10 to 20 June in 2003–2007, field personnel captured and color-banded 69 new adult flycatchers at seven sites (Hoge Ranch, Great Blue Heron, River Mile 33, Gila River Site #2, Gadsden Bend, Gadsden, Hunter's Hole). Reconnaissance efforts from 7 to 9 June 2006 resulted in the capture and color-banding of seven willow flycatchers at Gadsden and Hunter's Hole. Reconnaissance efforts from 8 to 9 June 2007 resulted in the capture and color-banding of 34 flycatchers at Gadsden. Of the total number of individuals captured (110), 95 (86%) were second-year birds (Table 3.4). Fourteen individuals (13%) exhibited flight feather (primaries, secondaries, coverts, rectrices) and/or body molt. In 2007 at Gadsden, one individual was recaptured at the site five hours later; another individual was recaptured two days later. With the exception of lone flycatchers detected for a single day on 2, 23, 6, and 28 July in 2003–2006, respectively, no willow flycatcher detections were recorded at any sites south of the Bill Williams River post 24 June, and it is likely the captured flycatchers were migrants.

Table 3.1. Summary of Willow Flycatchers Detected at Monitored Sites, 2003–2007*

Study Area	Year	Adults									Nestlings Banded (# Nests)	Banded Nestlings Recaptured as Fledges	Previously Unbanded Fledges Captured	% of All Adults Banded
		Total Adults Detected	New Captured	Recaptured		Resighted								
				Not Including Returning Nestlings	Returning Nestlings[1]	Color Combination Confirmed		Unbanded	Band Status Undetermined	Banded (Color Combinations Unconfirmed)				
						Individual Identified	Individual Not Identified							
Pahranagat	2003	21	6	4	0	1	1	6	3	0	22(7)	0	0	57
	2004	35	18	7	2	0	0	4	1	3	25(10)	0	5	86
	2005	37	14	7	7	7	1[2]	1	0	0	22(7)	1	7	97
	2006	36	4	8	5	16	0	2	1	0	18(7)	0	3	92
	2007	29	6	6	2	12	0	3	0	0	19(7)	0	1	90
Littlefield	2004	3	1	0	2	0	0	0	0	0	2(1)	0	0	100
	2005	2	0	0	0	1	0	0	1	0	0	0	0	50
	2007	1	0	0	1	0	0	0	0	0	0	0	0	100
Mesquite	2003	38	5	10	4	5	0	7	4	3	18(7)	3	0	71
	2004	30	7	6	3	10	0	2	0	2	14(5)	2	0	93
	2005	19	4	3	0	9	1	0	0	2	13(7)	0	0	100
	2006	28	3	2	2	11	1	4	4	1	24(11)	0	0	71
	2007	27	3	2	3	12	4[3]	2	1	0	14(7)	0	0	89
Mormon Mesa	2003	19	2	1	0	1	2	10	3	0	1(1)	0	0	32
	2004	27	11	0	1	2	0	6	6	1	8(4)	0	0	56
	2005	14	1	2	1	3	2[2]	3	1	1	2(1)	0	0	71
	2006	23	5	3	0	8	1[2]	5	0	1	7(3)	0	0	78
	2007	30	5	1	1	16	2[2]	1	2	2	4(3)	0	0	90
Muddy River	2004	4	1	0	0	0	0	0	3	0	0	0	0	25
	2005	12	4	0	1	1	3	3	0	0	4(2)	0	1	75
	2006	11	2	0	4	3	1[2]	1	0	0	8(4)	0	0	91
	2007	16	4	3	2	3	2[2]	1	1	0	0	0	0	88
Grand Canyon	2003	1	0	0	0	0	0	0	1	0	0	0	0	0
	2004	3	2	0	0	0	0	1	0	0	3(1)	0	0	67
	2005	1	1	0	0	0	0	0	0	0	0	0	0	100
	2006	15	10	0	1	0	0	2	2	0	0	0	0	73
	2007	7	4	0	0	2	0	0	1	0	0	0	0	86
Topock	2003	25	7	0	1	2	0	8	4	3	16(6)	0	0	52
	2004	67	16	0	2	9	2[2]	24	14	0	32(14)	1	0	43
	2005	41	2	2	2	11	2[2]	16	4	2	13(7)	0	0	51
	2006	37	3	1	0	4	8[2]	16	5	0	6(4)	0	0	43
	2007	31	4	1	1	2	2	8	12	1	15(6)	0	0	35
Bill Williams	2003	13	6	0	0	0	0	4	3	0	6(2)	0	0	46
	2004	24	1	0	0	1	0	6	16	0	0	0	0	8
	2005	9	5	0	0	0	0	3	1	0	3(1)	0	0	56
	2006	9	1	0	0	2	0	3	2	1	0	0	0	44
	2007	21	4	0	1	3	2[2]	7	4	0	3(2)	0	0	48
All Study Areas	2003	116	26	15	5	8	3	35	18	6	63(23)	3	0	54
	2004	193	57	13	10	22	2	43	40	6	84(35)	3	5	57
	2005	133	31	14	11	30	9	26	7	5	57(25)	1	8	75
	2006	156	28	13	12	42	11	33	14	3	63(33)	0	3	70
	2007	158	30	12	11	47	12	22	21	3	55(25)	0	1	73

* All individuals are included, regardless of residency or breeding status. 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. Individuals that moved between study areas within a given year are tallied only once in the yearly total.

[1] Returning nestlings are individuals detected for the first time since their hatch year.

[2] Returning nestling(s).

[3] Two individuals were returning nestlings.

Table 3.2. Summary of Resident Adult Willow Flycatchers Detected at Monitored Sites, 2003–2007*

Study Area	Year	Total Adults Detected	New Captured	Recaptured		Resighted					% of Resident Adults Banded
				Not Including Returning Nestlings	Returning Nestlings[1]	Color Combination Confirmed		Unbanded	Band Status Undetermined	Banded (Color Combinations Unconfirmed)	
						Individual Identified	Individual Not Identified				
Pahranagat	2003	20	6	4	0	1	1	6	2	0	60
	2004	33	17	7	2	0	0	3	1	3	88
	2005	35	13	7	7	7	1[3]	0	0	0	100
	2006	34	4	8	5	16	0	0	1	0	97
	2007	26	6	6	2	12	0	0	0	0	100
Littlefield	2004	3	1	0	2	0	0	0	0	0	100
	2005	1	0	0	0	1	0	0	0	0	100
	2007	1	0	0	1	0	0	0	0	0	100
Mesquite	2003	36	4	10	4	5	0	7	3	3	72
	2004	30	7	6	3	10	0	2	0	2	93
	2005	19	4	3	0	9	1	0	0	2	100
	2006	28	3	2	2	11	1	4	4	1	71
	2007	27	3	2	3	12	4	2	1	0	89
Mormon Mesa	2003	18	2	1	0	1	2	9	3	0	33
	2004	23	11	0	1	2	0	4	4	1	65
	2005	14	1	2	1	3	2[3]	3	1	1	71
	2006	23	5	3	0	8	1[3]	5	0	1	78
	2007	30	5	1	1	16	2	1	2	2	90
Muddy River	2004	4	1	0	0	0	0	0	3	0	25
	2005	12	4	0	1	1	3	3	0	0	75
	2006	11	2	0	4	3	1[3]	1	0	0	91
	2007	15	4	3	2	3	2	1	0	0	93
Grand Canyon	2004	3	2	0	0	0	0	1	0	0	67
	2005	1	1	0	0	0	0	0	0	0	100
	2006	14	10	0	1	0	0	2	1	0	79
	2007	6	4	0	0	2	0	0	0	0	100
Topock	2003	21	7	0	1	2	0	7	1	3	62
	2004	64	16	0	2	9	2[3]	24	11	0	45
	2005	38	2	2	2	11	2[3]	16	1	2	55
	2006	32	3	1	0	4	8[3]	14	2	0	50
	2007	19	4	1	1	2	2	6	2	1	58
Bill Williams	2003	10	6	0	0	0	0	2	2	0	60
	2004	8	1	0	0	1	0	3	3	0	25
	2005	7	5	0	0	0	0	1	1	0	56
	2006	6	1	0	0	2	0	2	0	1	67
	2007	15	4	0	1	3	2	5	0	0	67
All Study Areas	2003	104	25	15	5	8	3	32	10	6	60
	2004	168	56	13	10	22	2	37	22	6	65
	2005	125	30	14	11	30	9	23	3	5	79
	2006	145	28	13	12	42	11	28	8	3	75
	2007	135	30	12	11	47	12	15	5	3	85

* All individuals are included, regardless of residency or breeding status. 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. Individuals that moved between study areas within a given year are tallied only once in the yearly total.

[1] Returning nestlings are individuals detected for the first time since their hatch year.

Table 3.3. Willow Flycatchers Color-Banded and Resighted, Key Pittman Wildlife Management Area, NV, 2004–2007

Year	New Captures	Recaptures[1]	Resighted	Nestlings Banded (# Nests)
2004	2	1	0	6 (3)
2005	1	0	0	4 (1)
2006	2	3	2[2]	3 (1)
2007	1	2	2	4 (1)

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

Table 3.4. Willow Flycatchers Color-Banded along the Lower Colorado River South of the Bill Williams River NWR to the Mexico Border, 2003–2007

Year	Total # banded	# SY individuals[1]
2003	4	4
2004	4	4
2005	9	4
2006	29	27
2007	64	56
Total	110	95

[1] SY = 2 years of age; for all other individuals age was AHY (after hatch year/2 years or older).

LEG INJURIES

We observed 15 banded individuals with leg injuries (Table 3.5). Six (25%) of 22 birds recaptured or resighted with plastic bands exhibited leg injuries on the leg with the plastic band, while 4 (7.5%) of 53 individuals recaptured or resighted with metal pin-striped bands exhibited injuries on the leg with the metal color-band. Two individuals had injuries on the leg banded with a federal band, and three individuals had injuries on an unbanded leg, but we were unable to capture these birds to determine if the leg had been previously banded. Two nestlings were observed with curved tarsi.

Table 3.5. Leg Injuries or Deformities Observed on Willow Flycatchers, 2003–2007

Year	Study Area	Federal Band #[1]	Color Combination	Sex[2]	Injury
Leg injuries, celluloid plastic bands					
2003	PAHR	2140-66621	Rs:DD(P)	F	Lower half of tarsus and foot swollen on right leg. Plastic band replaced with metal band.
2003	MESQ	2390-92420	XX:R(HP)/V(HP)	M	Skin on right leg peeled back by band. Plastic band replaced with metal band.
2003	TOPO	2110-78855	O(HP)/D(HP):BEs	M	Very small Injury on left leg under plastic bands. Plastic band replaced with metal band.
2003	TOPO	INA	Bs:Unknown	M	Bird could not perch on right leg. Toes deformed. Injury prohibited resight of color of plastic band on right leg. Bird not captured, resighted only.
2004	MESQ	2390-92434	G(HP)/O(HP):XX	M	Orange half plastic band cut into flesh and wedged into metatarsus. Bird could not grip with left foot. Plastic band removed, not replaced.
2004	MESQ	2390-92470	B(HP)/G(HP):XX	F	Left leg bruised under plastic bands. Plastic band replaced with metal band.
Leg injuries, metal pinstripe bands					
2005	PAHR	2320-31663	EE:GK(M)	F	Lower half of right leg and foot missing. Bird rebanded as RR(M):UB.
2006	MESQ	2320-31652	WG(M):EE	M	Bird could not grip branches with left foot when perched. Bird not captured, resighted only.
2006	MOME	2320-31653	WV(M):EE	M	Left leg swollen under pinstripe band. Could not move or remove band.
2007	MOME	2360-59702	WB(M):EE	M	Could not put weight on left leg. Bird not captured, resighted only.
Leg injuries, federal bands					
2004	PAHR	2190-76604	KK(M):XX	M	Right foot scabby and swollen below tarsus. Foot was 1.5 to 2 times larger than normal size. Both bands removed, rebanded as EE:UB. Captured again in 2005, no sign of leg injury, banded as EE:BW(M).
2006	PAHR	2360-59724	ZB(M):EE	F	Lower tarsus and middle toe on right foot swollen. Band moved freely, not removed.
Leg injuries unknown if related to bands					
2004	MESQ	INA	UB:EE	F	No foot on left leg. Bird not captured, resighted only.
2005	MESQ	INA	UB:EE	M	No foot on left leg. Bird not captured, resighted only.
2007	MOME	INA	EE:UB	M	Bottom quarter of tarsus and foot missing on right leg. Bird not captured, resighted only.
Leg deformities unrelated to bands					
2003	PAHR	N/A	UB:UB	U	Nestling could not be banded due to curved tarsi on both legs.
2004	TOPO	2320-31520	UB:EE	U	Nestling had slightly curved tarsus on left leg.

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

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

ADULT BETWEEN-YEAR RETURN AND DISPERSAL

From 1998 to 2007, 288 between-year returns of adult willow flycatchers were identified within the lower Colorado River study areas (Table 3.6). One additional between-year return was identified at Ash Meadows National Wildlife Refuge. Of the 289 adult returns, 266 (92%) were to the same study area and 23 (8%) were to a different study area. We calculated dispersal distances for the 187 adult returns that we detected in 2004–2007 (Figure 3.1). We did not calculate dispersal distances for the remaining adult returns because we did not have UTM coordinates for recapture and/or capture locations. Mean dispersal distance for the 187 adult returns was 4.9 km (SE = 1.7 km), minimum distance was 0.003 km, maximum distance was 258.5 km, and median distance was 0.07 km.

Table 3.6. Summary of Between-Year Return and Movements of Adult Flycatchers, 1997–2007

Study Area of Subsequent Detection[1]	Study Area Detected[1]									Total
	KEPI	PAHR	LIFI	MESQ	MOME	MUDD	GRCA	TOPO	BIWI	
ASME		1								**1**
KEPI	3									**3**
PAHR		95								**95**
LIFI			1							**1**
MESQ		1	1	63	5					**70**
MOME				5	39	3	4			**51**
MUDD				1	1	7				**9**
GRCA							2			**2**
TOPO								51		**51**
BIWI					1				5	**6**
Total	**3**	**97**	**2**	**69**	**46**	**10**	**6**	**51**	**5**	**289**

[1] ASME = Ash Meadows National Wildlife Refuge, KEPI = Key Pittman Wildlife Management Area, PAHR = Pahranagat National Wildlife Refuge, LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, GRCA = Grand Canyon, TOPO = Topock Marsh, BIWI = Bill Williams River National Wildlife Refuge.

JUVENILE BETWEEN-YEAR RETURN AND DISPERSAL

From 1997 to 2006, 505 juveniles were banded and either known or presumed to have survived to fledging. Of these 505 juveniles, 107 (21%) were recaptured or resighted and identified in a subsequent year (Table 3.7). One of these was recaptured near Isabella Lake on the Kern River, while the remainder were recaptured or resighted within the lower Colorado River study areas. An additional three juveniles banded at Roosevelt Lake were recaptured within the lower Colorado River study areas. Of the 107 returning juveniles, 63 (59%) returned to the same study area and 44 (41%) returned to a different study than where originally banded. We calculated dispersal distances for the 54 returning juveniles that were banded in 2003–2006 and detected in a subsequent year, including 2 from Roosevelt Lake (Figure 3.2). We did not calculate dispersal distances for the remaining returning juveniles because we did not have UTM coordinates for banding and/or recapture locations. Mean dispersal distance for the 54 returning juveniles was 31.7 km (SE = 10.4 km), minimum distance was 0.02 km, maximum distance was 444.0 km, and median distance was 7.6 km.

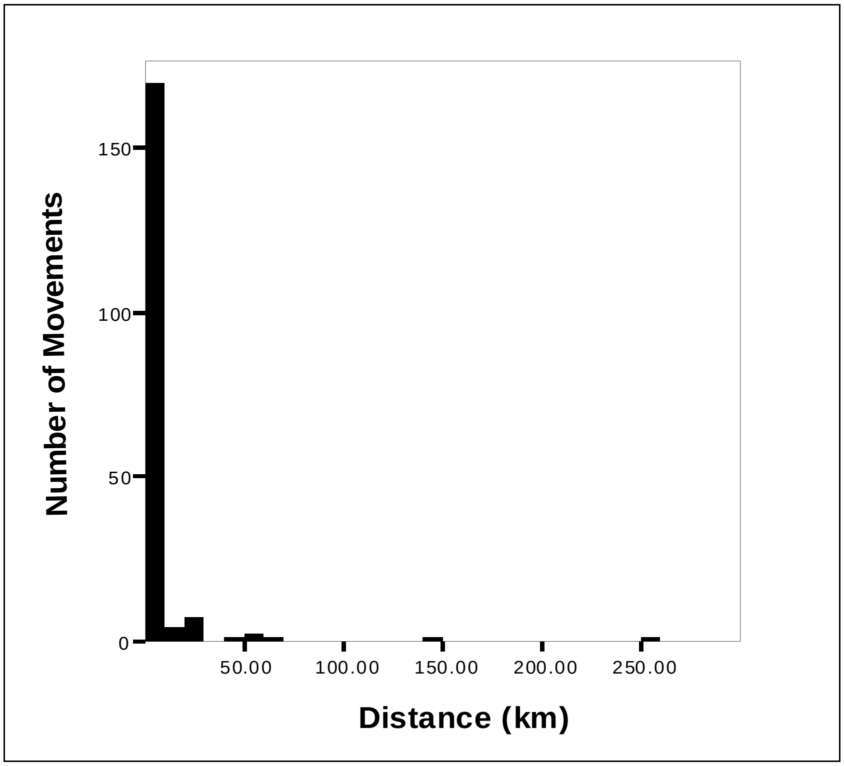

Figure 3.1. Dispersal distances for adult willow flycatchers detected in any year from 2003 to 2006 and detected again in a subsequent year.

Table 3.7. Summary of Number and Dispersal of Juvenile Flycatchers Banded as Hatch Year Birds and Recaptured or Resighted in a Later Year, 1997–2007

Study Area Detected[1]	**Study Area Banded**[1]								**Total**
	KEPI	**PAHR**	**MESQ**	**MOME**	**MUDD**	**TOPO**	**BIWI**	**ROOS**	
KEPI		8							**8**
PAHR	1	17	1	1					**20**
LIFI		1	2						**3**
MESQ			18	8	1				**27**
MOME		1	4	10	2	2			**19**
MUDD			4	1	2			1	**8**
GRCA				1				1	**2**
TOPO				1		15	2	1	**19**
BIWI			1			1	1		**3**
ISAB			1						**1**
Total	**1**	**27**	**31**	**22**	**5**	**18**	**3**	**3**	**110**

[1] KEPI = Key Pittman Wildlife Management Area, PAHR = Pahranagat National Wildlife Refuge, LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, GRCA = Grand Canyon, TOPO = Topock Marsh, BIWI = Bill Williams River National Wildlife Refuge, ROOS = Roosevelt Lake, ISAB = Lake Isabella.

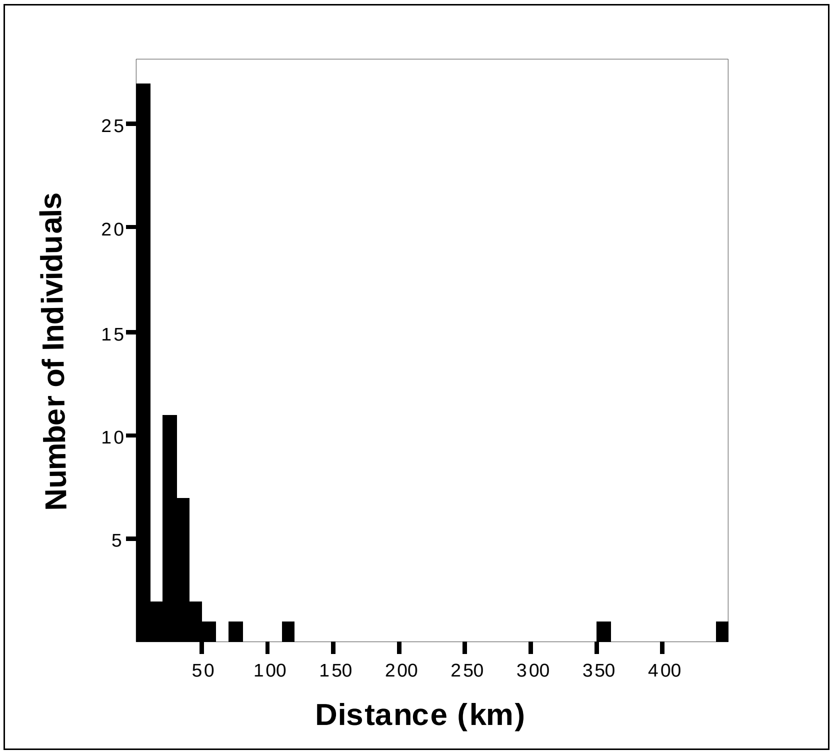

Figure 3.2. Dispersal distances for juvenile willow flycatchers banded in 2003–2006 and detected in a subsequent year.

WITHIN-YEAR MOVEMENTS

We detected 10 within-year, between study area movements in 2003–2007 (Table 3.8). All 10 movements were by adult flycatchers. One additional within-year movement was recorded in 2002, when a fledgling banded at Topock Marsh was recaptured 16 days later in a passive net at Roosevelt Lake. No other within-year movements were recorded in 1997–2002. We also detected six within-year, between site movements in 2003–2007. We calculated movement distance for all 16 adult within-season movements (Figure 3.3). Mean movement distance was 25.0 km (SE = 5.9 km), minimum distance was 1.1 km, maximum distance was 68.1 km, and median distance was 20.1 km. Of the 10 adults detected moving between sites or study areas during the season prior to 2007, 7 were detected in a subsequent year. All but one returned to the site where they were last seen in the prior year, while the seventh moved 1.6 km to an adjacent site within the same study area.

Table 3.8. Within-Year, Between Study Area Movements of Flycatchers, 1997–2007*

Study Area Subsequently Detected[1]	Study Area Initially Detected[1]						Total
	LIFI	MESQ	MOME	MUDD	GRCA	TOPO	
MESQ	2		1	1	2		**6**
MOME		2		1	1		**4**
ROOS						1	**1**
Total	**2**	**2**	**1**	**2**	**3**	**1**	**11**

* All individuals were adults except for the individual that moved from TOPO to ROOS; this was a dispersing juvenile.
[1] LIFI = Littlefield, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, GRCA = Grand Canyon, TOPO = Topock Marsh, ROOS = Roosevelt Lake.

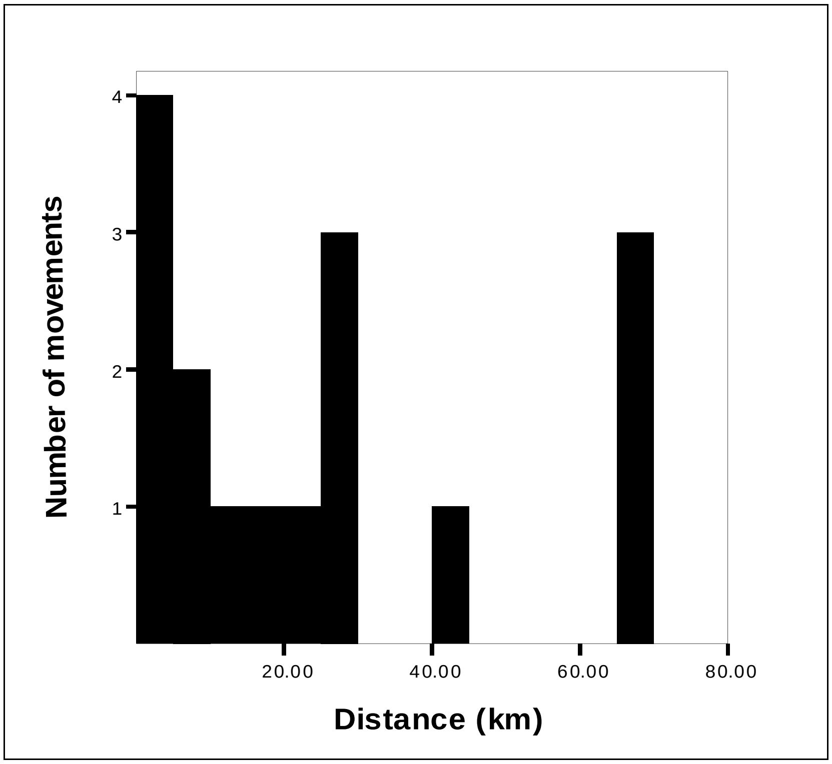

Figure 3.3. Within-season adult movements detected 2003–2007.

DEMOGRAPHICS

From 1997 to 2006, 269 flycatchers were individually marked as adults and 505 flycatchers were banded as juveniles. Of the flycatchers banded as juveniles, 107 were also encountered as adults. One of these was detected at Lake Isabella (Kern River, CA) and is not included in analyses of adults for this study. An additional three individuals banded as juveniles at Roosevelt Lake were detected as adults at areas monitored during this study. Of the 378 individuals encountered as adults in study areas along the lower Colorado River and tributaries, 352 were of known gender.

ADULT SURVIVAL AND DETECTION: EFFECTS OF GENDER AND YEAR

We modeled the effects of year and gender on survival and detection probabilities for adults of known gender. Model results were equivocal regarding whether survival and detection probabilities varied by year and whether survival varied by gender (Table 3.9), with the top four models having approximately equal weight. There was no evidence that probability of detection varied by gender. We averaged the top four models to obtain estimates for survival and detection probability (Table 3.10). Because there was no strong support that survival varied by gender, we pooled genders for all other analyses.

Table 3.9. QAIC Model Selection Results of Effects of Gender on Adult Survival and Detection Probabilities*

Model	QAIC	Δ QAIC	QAIC Weight	K	QDeviance
Φ(year)p(.)	828.39	0.0000	0.31019	11	169.50
Φ(.)p(.)	898.88	0.4897	0.24283	2	188.44
Φ(.)p(year)	829.06	0.6723	0.22164	11	170.17
Φ(gender)p(.)	830.04	1.6477	0.16309	3	187.58
Φ(.)p(gender)	860.88	2.4916	0.08925	3	188.42
Φ(gender*year)p(gender*year)	861.59	33.2016	0.00000	38	143.57

* The top five models are shown, as well as the global model. We used QAIC to correct for slight overdispersion ($\hat{c}$ = 1.21).

Table 3.10. Parameter Estimates and 95% Confidence Intervals for Percent Adult Survival and Detection Probabilities, by Year and Gender, 1997–2007

Year	Survival (Φ)		Detection (p)
	Female	Male	
1997–1998	54 (36–71)	55 (36–72)	77 (52–91)
1998–1999	58 (45–70)	58 (46–70)	76 (57–88)
1999–2000	62 (42–79)	63 (43–79)	76 (58–88)
2000–2001	59 (46–70)	59 (47–70)	77 (64–87)
2001–2002	52 (34–69)	52 (34–70)	71 (41–90)
2002–2003	55 (43–67)	56 (43–68)	75 (56–88)
2003–2004	61 (46–73)	61 (47–74)	81 (64–91)
2004–2005	53 (40–66)	54 (40–67)	78 (67–86)
2005–2006	61 (46–75)	62 (48–75)	81 (65–91)
2006–2007	62 (45–77)	63 (46–77)	83 (55–95)
Overall[1]	**56 (48–63)**	**60 (54–66)**	**79 (71–84)**

[1] Overall estimates were obtained using the time-constant model.

ADULT SURVIVAL AND DETECTION: EFFECTS OF GEOGRAPHIC AREA AND YEAR

The data were inadequate to support a full global model [Φ(area*year)p(area*year)Ψ(area*year)] so we used a reduced model [Φ(area*year)p(area)Ψ(.)] as the global model. The top two models were approximately equally weighted (Table 3.11). In both models, survivorship varied by geographic area but not by year. Probability of detection varied by area in one model but was constant in the other. We averaged the top two models to obtain parameter estimates (Table 3.12). Annual survivorship estimates in the Nevada, Virgin, and Havasu areas were 60, 59, and 41%, respectively, while probability of detection was 77, 80, and 88%. The probability of an adult moving from one area to another was 0.3%.

Table 3.11. QAIC Model Selection Results of Effects of Year and Geographic Area on Adult Survival and Detection Probabilities*

Model	QAIC	Δ QAIC	QAIC Weight	K	QDeviance
Φ(area)p(area)Ψ(.)	823.69	0.0000	0.40748	7	230.88
Φ(area)p(.)Ψ(.)	824.03	0.3393	0.34390	5	235.31
Φ(year)p(.)Ψ(.)	826.29	2.6064	0.11070	12	223.13
Φ(area*year)p(.)Ψ(.)	828.25	4.5645	0.04159	32	181.84
Φ(area*year)p(area)Ψ(.)	828.47	4.7822	0.03730	34	177.56

* The top five models are shown, including the global model. We used QAIC to correct for slight overdispersion ($\hat{c}$ = 1.26).

Table 3.12. Parameter Estimates and 95% Confidence Intervals for Adult Survival (Φ), Detection (p), and Transition (Ψ) Probabilities, Nevada, Virgin, and Havasu Areas, 1997–2007*

Nevada			Virgin			Havasu			Ψ
n	Φ	p	n	Φ	p	n	Φ	p	
120	60 (51-68)	77 (64-86)	163	59 (52–66)	80 (70–87)	96	41 (32–51)	88 (58–98)	0.3 (0–0.8)

* Transition probabilities were constant across years and geographic areas.

Adult Detection: Effects of Time Period

We pooled all adult encounters across study areas to test for effects of the contract time period (i.e., 1997–2002 vs. 2003–2007) in probability of detection. The top two models, which together had 76% of the model weight, both indicated that detection probabilities differed between the two time periods (Table 3.13). We averaged the top two models to obtain estimates for detection probability. Probability of detection was 69.1% (95% CI 55.0–80.3%) for 1997–2002 and 85.4% (95% CI 76.0–91.5%) for 2003–2007.

Table 3.13. QAIC Model Selection Results of Effects of Time Period on Adult Survival and Detection Probabilities*

Model	QAIC	Δ QAIC	QAIC Weight	K	QDeviance
Φ(t)p(contract)	823.65	0.0000	0.50849	12	104.93
Φ(.)p(contract)	825.02	1.3684	0.25653	3	124.80
Φ(t)p(.)	826.14	2.4880	0.14656	11	109.50
Φ(.)p(t)	828.52	4.8644	0.04467	11	111.88
Φ(.)p(.)	828.69	5.0339	0.04104	2	130.48
Φ(t)p(t)	834.12	10.4660	0.00271	19	100.60

* The top five models are shown, plus the global model. We used QAIC to correct for slight overdispersion ($\hat{c}$ = 1.2198).

JUVENILE SURVIVAL AND DETECTION: EFFECTS OF GEOGRAPHIC AREA AND YEAR

The data were inadequate to support a full global model so we used a reduced model [$\Phi(\text{area*age}_{2\text{-t/.}})p(\text{area*age}_{2\text{-./.}})\Psi(\text{age}_{2\text{-./.}})$] as the global model. This model allows juvenile survival probabilities to differ by year and allows juvenile survival, as well as detection and transition probabilities for second-year birds, to differ from those of adults. The top model had approximately 11 times more support than the next best model (Table 3.14), and we obtained parameter estimates from the top model (Table 3.15). The model indicated that juvenile survival and second-year detection probabilities differed from adult survival and detection but did not vary over time, and that second-year detection probabilities varied by geographic area. Annual juvenile survival was 37%, and overall probability of detection was 40%.

Table 3.14. AIC Model Selection Results of Effects of Year and Geographic Area on Juvenile Survival and Detection Probabilities*

Model	QAIC	Δ QAIC	QAIC Weight	K	QDeviance
$\Phi(\text{age}_{2\text{-./.}})p(\text{area*age}_{2\text{-./.}})\Psi(\text{age}_{2\text{-./.}})$	998.36	0.0000	0.81998	10	290.41
$\Phi(\text{area*age}_{2\text{-./.}})p(\text{area*age}_{2\text{-./.}})\Psi(\text{age}_{2\text{-./.}})$	1003.10	4.7476	0.07636	14	286.83
$\Phi(\text{area*age}_{2\text{-./.}})p(\text{age}_{2\text{-./.}})\Psi(\text{age}_{2\text{-./.}})$	1003.68	5.3231	0.05727	10	295.73
$\Phi(\text{age}_{2\text{-./.}})p(\text{age}_{2\text{-./.}})\Psi(.)$	1005.59	7.2334	0.02203	9	299.71
$\Phi(\text{age}_{2\text{-./.}})p(\text{age}_{2\text{-./.}})\Psi(\text{age}_{2\text{-./.}})$	1006.44	8.0802	0.01443	6	306.71
$\Phi(\text{area*age}_{2\text{-t/.}})p(\text{area*age}_{2\text{-./.}})\Psi(\text{age}_{2\text{-./.}})$	1023.30	24.9484	0.00000	40	250.23

* The top five models are shown, plus the global model. We used QAIC to correct for slight overdispersion ($\hat{c}$ = 1.026).

Table 3.15. Parameter Estimates and 95% Confidence Intervals for Annual Juvenile Survival, Detection, and Transition Probabilities, Nevada, Virgin River, and Havasu Areas, 1997–2007*

Area	N[1]	Apparent Survival[2]	Survival (Φ)	Detection (p)	Transition (Ψ)
Nevada	149	19	37 (29–46)	30 (16–48)	4 (2–8)
Virgin	213	27	37 (29–46)	48 (34–61)	4 (2–8)
Havasu	142	15	37 (29–46)	25 (14–41)	4 (2–8)
Overall	**504**	**21**	**37 (29–46)**	**40 (30–51)**[3]	**4 (2–8)**

[1] Number of flycatchers banded as juveniles in each area.
[2] Percentage of juveniles banded in each area that were subsequently detected.
[3] Average obtained from model held constant across geographic areas.

JUVENILE DETECTION: EFFECTS OF TIME PERIOD

We pooled data on juveniles across study areas to test for effects of the contract time period (i.e., 1997–2002 vs. 2003–2007) in probability of detection. As with the models testing effects of year and geographic area on survival and detection probabilities, these models showed no evidence that juvenile survival varied by year (Table 3.16). The top model, which showed that juvenile detection probabilities did not differ by time period, was 2.7 times better supported than the second model. Together the top two models had 98% of the model weight, and we averaged these top two models to obtain estimates for probability of detection. Probability of detection was 39.0% (95% CI 28.1–51.0%) for 1997–2002 and 38.7% (95% CI 28.3–50.3%) for 2003–2007.

Table 3.16. QAIC Model Selection Results of Effects of Time Period on Juvenile Survival and Detection Probabilities*

Model	QAIC	Δ QAIC	QAIC Weight	K	Deviance
Φ(a2–./.)p(a2–./.)	916.76	0.0000	0.72396	4	135.15
Φ(a2–./.)p(a2–contract/.)	918.79	2.0224	0.26337	5	135.14
Φ(a2–./.)p(a2–t/.)	925.34	8.5777	0.00993	13	125.22
Φ(a2–t/.)p(a2–./.)	927.94	11.1721	0.00271	13	127.81
Φ(a2–t/.)p(a2–t/.)	937.54	20.7770	0.00002	21	120.52
Φ(a2–t/t)p(a2–t/t)	947.04	30.2755	0.00000	36	97.16

* The top five models are shown, plus the global model. We used QAIC to correct for slight overdispersion ($\hat{c}$ = 1.087).

JUVENILE DETECTION: EFFECTS OF FLEDGE DATE

The model including fledge date as a covariate for juvenile survival received very strong support when compared to the model with juvenile survivorship held constant (Table 3.17). Young fledging earlier in the season had a better chance of surviving than those fledging later in the season, with survival decreasing from 57% in mid-June to 18% in mid-July.

Table 3.17. QAIC Model Selection Results of Effects of Fledge Date on Juvenile Survival*

Model	QAIC	Δ QAIC	QAIC Weight	K	Deviance
Φ(a2–fledgeday/.)p(a2–./.)	896.55	0.0000	0.98125	5	886.45
Φ(a2–./.)p(a2–./.)	904.46	7.9153	0.01875	4	896.40

* The top five models are shown, plus the global model. We used QAIC to correct for slight overdispersion ($\hat{c}$ = 1.087).

ANNUAL PER CAPITA RATE OF POPULATION GROWTH

Estimates of λ varied among the three geographic areas, with the Nevada, Virgin, and Havasu areas exhibiting overall population growth rates of 0.99, 0.77, and 0.60, respectively (Table 3.17). Calculating λ using the maximum fecundity estimates raised the population growth rates slightly to 1.03, 0.80, and 0.64 for the Nevada, Virgin, and Havasu areas, respectively. Models had shown (Tables 3.12 and 3.14) that adult and juvenile survival did not vary over time, and Kruskal-Wallis tests showed that fecundity at each geographic area did not vary significantly between years; therefore, lambda estimates are given for all years combined.

Table 3.17. Estimates of Annual Per Capita Rate of Population Growth (λ), 1997–2007

Year	Survivorship (%)		Fecundity	λ	Max Fecundity	Max λ
	Adult	Juvenile				
Nevada	59.9	36.8	2.15	0.995	2.32	1.026
Virgin	59.2	36.8	0.99	0.774	1.15	0.804
Havasu	41.4	36.8	1.03	0.604	1.25	0.644

DISCUSSION

We have maintained high overall percentages of banded birds annually over the five-year study, and resights and recaptures of color-banded individuals form the basis for all analyses of movement and demographics. Differences between study areas in the percentage of color-banded individuals are directly related to vegetation density and overall structure, which affect our ability to erect mist-nets in the habitat. For example, in 2003–2007 an average of 89% of the resident flycatcher population at Pahranagat was color-banded versus 54% at Topock. Pahranangat 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.

COLOR-BANDING AND RESIGHTING DOWNSTREAM OF PARKER DAM

Results of the color-banding study on the extreme southern stretches of the Colorado River strongly suggest the individuals detected and captured at these sites were migrants. Despite many instances of observers banding at a site on multiple consecutive days, only one individual was detected on a subsequent day after it was banded. As discussed in Chapter 2, it is not unusual for Neotropical migrant birds including the willow flycatcher to "rest" and replenish fat reserves during migration, and this individual may have been using Gadsden as a stopover site. Willow flycatcher behavioral observations recorded while individuals were exposed to conspecific playbacks in 2003 and 2004 also suggested targeted individuals were not defending territories. Although flycatchers detected did sing and call in response to conspecific broadcasts used for target capture, the agonistic behaviors exhibited toward broadcasts were weak (i.e., no direct movements toward speaker locations) in comparison to flycatchers at breeding sites. Because of the overall lack of agonistic behaviors exhibited by flycatchers toward playback during this study, the target capture technique was discontinued in 2005 and passive netting was used instead.

The variation in the numbers of flycatchers detected at a particular site over a survey season also suggests the individuals detected and captured at these sites were migrants. The molt patterns exhibited on a relatively large proportion of captured individuals further indicate these individuals were migrants. Willow flycatchers molt on the wintering grounds (Pyle 1997, 1998; T. Koronkiewicz unpubl. data), and active molt at breeding sites is rare in Southwestern Willow Flycatcher populations (P. Unitt pers. comm., T. Koronkiewicz unpubl. data).

Although numerous willow flycatchers were detected at sites south of Bill Williams during this five-year study, no resident individuals were located (see Chapter 2). It is apparent that the lower Colorado and Gila River riparian corridors are important flyways and stopover habitat for migrating willow flycatchers. However, the degree to which Southwestern Willow Flycatchers use these riparian corridors during spring or fall migration is unknown and requires further study (see Chapter 8).

LEG INJURIES

We observed over three times the rate of leg injuries with celluloid-plastic bands compared to metal color-bands developed by Koronkiewicz et al. (2005). These results are similar to those of

Koronkiewicz et al. (2005), who had shown that metal color-bands reduced leg injuries in the willow flycatcher. Sedgwick and Klus (1997) also reported a high incidence of leg injury (9.6%) in willow flycatchers due to celluloid-plastic color bands, particularly when plastic bands were used in combination with a federal band on the same leg. Therefore, we recommend the use of metal color-bands for the willow flycatcher.

BETWEEN-YEAR RETURN AND DISPERSAL

Adult flycatchers exhibited strong between-year site fidelity, with half of all adult between-year movements being less than 70 m and less than 10% of adults moving more than 1 km between years. From 1997 to 2007, two adults moved between the Nevada, Virgin, and Havasu geographic areas. Adult willow flycatcher return and dispersal data are consistent with range-wide data (Kenwood and Paxton 2001, Koronkiewicz et al. 2002, Newell et al. 2005), with adult flycatchers likely to exhibit high site fidelity to breeding areas.

Over 70% of juveniles, in comparison, dispersed over 1 km from their natal territories, though 90% of all recorded dispersal movements were 40 km or less. Paxton et al. (2007) also found that natal dispersal distances were greater than the between-year movements exhibited by adults. Natal dispersal is greater than adult dispersal in most birds (Gill 1995). Nine juveniles (8% of returning juveniles from 1998 to 2007) dispersed out of their natal geographic area. Juvenile dispersal within the Virgin/lower Colorado River population(s) was largely limited to this region, and while reciprocal juvenile movements among geographically isolated flycatcher populations of the greater Southwest did occur, they were rare. One instance of emigration was recorded, with an individual banded as a juvenile at Mesquite dispersing to Kern River, California. Three instances of immigration from sites outside the Virgin/lower Colorado River region have been recorded since 1997, with individuals banded as juveniles at Roosevelt Lake recaptured at Grand Canyon, Topock, and Muddy River.

These demographic traits fit well with the tenets of contemporary metapopulation theory (Hanski and Simberloff 1997), suggesting the Virgin/lower Colorado River population may be a panmictic sub-population of a greater metapopulation. Occasional juvenile dispersal between 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.

We detected a number of adult within-year, between study area and between site movements, with a large proportion of individuals returning the following year to the site where they were last observed the prior year. These individuals may have been prospecting for potential breeding sites, a life history trait that may benefit the willow flycatcher given the ephemeral, dynamic nature of riparian habitats (i.e., riparian vegetation and hydrology changing from one year to the next).

ADULT SURVIVAL AND DETECTION

We found no strong evidence that adult survivorship differed between genders, and this finding was similar to that of the U.S. Geological Survey (unpubl. data). Given that both sexes of willow flycatcher likely use the same migratory routes to and from the wintering grounds, and there is no sexual habitat segregation on the wintering grounds (Koronkiewicz et al. 2006b), this is not surprising. In the willow flycatcher, it appears that both sexes are exposed to the same environmental perturbations throughout the annual cycle.

Adult survival and detection probabilities differed between the three geographic areas, with results from the Nevada and Virgin areas essentially identical, while results from Havasu differed. Survivorship rates at the Nevada and Virgin areas (~60%) were similar to those reported from central Arizona (64%; Paxton et al. 2007). Survivorship rates at Havasu were lower (40%), while detection probabilities were high. Havasu had the smallest sample size, with 35 adults detected in multiple years, compared to 47 in Nevada and 73 in Virgin, and small sample sizes may affect the precision and accuracy of survival estimates. However, Havasu also had by far the smallest proportion (1 of 35, compared to 10 of 47 at Nevada and 12 of 73 at Virgin) of returning adults that exhibited gaps in their detection histories (i.e., detected in one year and then not detected again until two or more years later). Gaps in detection history suggest the bird was either outside our monitored areas or was a floater within monitored areas, and therefore went undetected for a period of time. The former explanation is plausible for the Nevada and Virgin sites, given the presence of potentially suitable flycatcher habitat on private land that is unmonitored within the Pahranagat Valley and the presence of currently occupied sites at Mormon Mesa that were not known at the beginning of the study. Floating suggests optimal habitat is full, and the lack of gaps in detections at Havasu suggests there were few floaters, implying suitable habitat went unoccupied, which might be consistent with a declining population. The highest incidence of gaps in detection history was in the Nevada geographic area, suggesting optimal habitat was full.

Mark-recapture models cannot distinguish death from permanent emigration, so it is possible Havasu individuals were permanently leaving the study area to occupy another breeding site. However, this idea is not supported by the observed movement data. Havasu adults have never been detected in another geographic region; there have been no recorded movements of adults between Topock and Bill Williams; and there are no known breeding areas in the Havasu area that are not monitored.

Detection probabilities for adults were higher during 2003–2007 than in the previous five years. This may be result of the switch to metal color-bands, which retain their colors for a longer period than celluloid-plastic bands, and may also have been influenced by differences in data recording and synthesis techniques between the two contract periods. High probabilities of detection should result in more precise estimates of survival.

JUVENILE SURVIVAL AND DETECTION

Our annual juvenile survivorship estimate of 37% was similar to that obtained at study areas in central Arizona (34%; Paxton et al. 2007). Our models showed no evidence that juvenile survivorship differed substantially between geographic areas. Small and variable sample sizes in each year may have obscured any between-site differences. We found similar effects of fledge date on juvenile survival to those reported by Paxton et al. (2007), with juvenile survival decreasing with later fledge dates.

Unlike for adults, detection probabilities for juveniles did not differ substantially between contract periods. Juveniles were banded with full color combinations in 1997–2002, making it possible to resight the individual in subsequent years. In 2003–2007, we used only federal bands on juveniles, necessitating recapture of the individual to determine its identity in the event it returned in a subsequent year. In study areas with extremely dense vegetation (e.g., Topock Marsh), capture of individuals is difficult and each year there have been individuals there were known to be returning nestlings but could not be recaptured. Therefore, we recommend using full color combinations on nestlings in areas where recapture of individuals is problematic.

PER CAPITA POPULATION GROWTH RATE

Lambda values in the Nevada area were approximately 1.0, indicating a stable population. The Virgin area had identical survivorship estimates as Nevada, but lower fecundity rates, resulting in an overall lambda estimate of approximately 0.77, indicating a 23% annual decline. Using the maximum fecundity estimate rather than the minimum observed fecundity made little difference in lambda estimates. Fecundity rates at the Virgin and Havasu areas were similar, but Havasu had lower adult survivorship, resulting in the lowest lambda value (0.60) of all three geographic areas.

The number of resident adults (see Table 3.2) detected in the Virgin area over the last five years does not seem to indicate a declining population. A decline in population might not be immediately evident because floaters would fill unoccupied territories, but in a short-lived species such as the willow flycatcher, the floater population would decline quickly, and an overall population decline should be evident in the number of resident individuals detected. A similar discrepancy between the vital rates estimated by population modeling and the number of territorial individuals observed was noted in central Arizona (Paxton et al. 2007), with the models apparently underestimating vital rates. We did not include immigration in our estimates of lambda because observed long-distance movements of willow flycatchers are so rare. However, the numbers of unbanded adult, resident willow flycatchers observed each year in 2004–2007 in both the Virgin and Havasu areas far exceeded the number of unbanded fledges known to have been produced in those areas in 2003–2006. This suggests that either a portion of the local, breeding population went undetected or that immigration (from a more distant, unbanded population) was higher than would be expected based on observed movement patterns.

A large increase in the number of resident individuals detected at Topock Marsh was observed in 2004, and the number of resident adults detected since 2004 is consistent with a declining population. Numbers of flycatchers observed in the Havasu area over the next few years will help clarify whether the population is declining or vital rates are underestimated.

CHAPTER 4

NEST MONITORING

INTRODUCTION

Documentation of nest success and productivity is critical to understanding local population status and demographic patterns of the Southwestern Willow Flycatcher. From 2003 to 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, Resighting, and Demographics) for fecundity studies, calculating nest success and failure, documenting causes of nest failure (e.g., abandonment, desertion, depredation, and brood parasitism), and calculating nest productivity. Our main objectives of this study were to 1) identify specific variables that may contribute to the characterization of flycatcher breeding ecology throughout the lower Colorado and Virgin River riparian systems, and 2) calculate specific productivity metrics to be used for demographic analyses.

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 all 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 that included the nest or territory number and UTM coordinates.

DATA ANALYSES

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. We calculated exposure days using the midpoint method for failed and successful nests and the last active date for nests of unknown fate. This method has been demonstrated to provide the least biased Mayfield estimate (Manolis et al. 2000). To calculate Mayfield survival probabilities (MSP), we used the average length of each nest stage (2.12, 12.86, and 13.75 days for laying, incubation, and nestling stages, respectively) as observed in this study in 2003–2007 for nests where transition dates were known. We calculated the variance associated with daily survival estimates using techniques outlined by Johnson (1979), and compared daily survival rates between study areas using z-tests.

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. Productivity and fecundity were compared across years and study areas using ANOVA and Tukey’s HSD.

RESULTS

NEST MONITORING

We documented 389 willow flycatcher nesting attempts at the four life history study areas, Littlefield, Muddy River Delta, Grand Canyon, and Bill Williams; 350 of these nests were known to contain flycatcher eggs and were used in calculating nest success and productivity. One hundred fifty-six (45%) nests were successful and fledged young, and 186 (53%) failed. Fate was unknown for eight nests (2%). For all years combined, nest success ranged from 0% at Grand Canyon to 69% at Pahranagat (Table 4.1).

Table 4.1. Summary of Willow Flycatcher Nest Monitoring Results at All Study Areas Where Nesting Was Documented, 2003–2007*

Study Area[1]	Year	# Nests	# Nests with 1+ WE[2]	# Successful Nests	# Failed Nests	# Nests with Unknown Fate[3]	# Parasitized Nests[4]
PAHR	2003	12	11	10	1	0	0
	2004	17	17	13	4	0	0
	2005	21	19	11	8	0	0
	2006	18	15	9	6	0	0
	2007	12	12	8	4	0	0
	All Years	80	74	51 (69)	23 (31)	0	0
LIFI	2004	3	2	1(50)	1 (50)	0	0
MESQ	2003	19	18	8	10	0	4
	2004	20	17	4	13	0	8
	2005	13	12	5	5	2	3
	2006	21	20	11	9	0	5
	2007	16	14	8	6	0	5
	All Years	89	81	36 (44)	43 (53)	2 (3)	25 (31)
MOME	2003	13	10	0	10	0	1
	2004	7	6	3	3	0	1
	2005	6	6	1	4	1	1
	2006	9	8	4	4	0	0
	2007	12	11	3	8	0	2
	All Years	47	41	11 (27)	29 (71)	1 (2)	5 (13)
MUDD	2005	8	8	3	5	0	6
	2006	9	9	4	5	0	1
	2007	12	6	0	6	0	2
	All Years	29	23	7 (30)	16 (70)	0	9 (39)
GRCA	2004	1	1	0	0	1	0
	2006	3	3	0	3	0	0
	2007	1	1	0	1	0	0
	All Years	5	5	0	4 (80)	1 (20)	0
TOPO	2003	12	10	8	2	0	2
	2004	43	38	17	20	1	12
	2005	38	34	8	26	0	16
	2006	17	17	4	10	3	5
	2007	8	8	6	2	0	0
	All Years	118	107	43 (40)	60 (56)	4 (4)	35 (34)
BIWI	2003	2	2	2	0	0	0
	2005	2	2	2	0	0	0
	2006	5	5	1	4	0	0
	2007	9	8	2	6	0	1
	All Years	18	17	7 (41)	10 (59)	0	1 (7)
Total		**389**	**350**	**156 (45)**	**186 (53)**	**8 (2)**	**75 (23)**

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

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

2 WE = willow flycatcher egg.

3 No fledglings were visually located but nests are suspected to have fledged.

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

NEST FAILURE

Depredation was the major cause of nest failure, accounting for 47% of all failed nests (Table 4.2) and 57% of nests that failed after flycatcher eggs were laid. Over half of all depredation events occurred during the incubation period, but accounting for the differing number of exposure days in each nest stage indicated that the daily risk of depredation was 1.8 times higher during the laying stage than the incubation stage. Daily predation risk during incubation was 1.2 times higher than during the nestling period. Thirty-nine nesting attempts (17% of all failed nests) were abandoned prior to willow flycatcher eggs being laid; nine of these had been brood parasitized. A total of 43 nests (19%) were deserted with flycatcher eggs or young; 8 of these were deserted after >14 days incubation, 7 were deserted immediately after being brood parasitized, and 13 were deserted after partial depredation. Eighteen nests (8%) failed because of Brown-headed Cowbird parasitism (see below for more details on parasitism), and eight nests (4%) failed because of infertile or addled eggs. The cause of failure for 10 nests (4%) was unknown because nests were too high to permit visual inspection of nest contents.

BROOD PARASITISM

Seventy-five of 325[1] nests (23%) with flycatcher eggs and known contents were brood parasitized by Brown-headed Cowbirds (Table 4.3). An additional nine nests were parasitized prior to flycatcher eggs being laid and were subsequently abandoned. For nests containing flycatcher eggs, parasitism caused nest failure at 18 nests. Brood parasitism at the four life history study areas, Muddy River Delta, and Bill Williams ranged from 0 to 39%, with Mesquite, Muddy River, and Topock all having parasitism rates above 30%. Across all study areas, nests that contained flycatcher eggs and were brood parasitized were less likely to be successful ($\chi^2 = 40.12$, $P < 0.001$).

MAYFIELD NEST SUCCESS AND NEST PRODUCTIVITY

Mayfield survival probability (MSP) at the four life history study areas, Littlefield, Muddy River Delta, Grand Canyon, and Bill Williams ranged from 0.002 at Grand Canyon to 0.684 at Pahranagat and was 0.444 for all sites combined (Table 4.4). Daily survival rates (DSR) during egg laying were significantly higher at Pahranagat than at Mesquite or Topock. Daily survival rate during incubation was lower at Topock than at either Mesquite or Pahranagat, and DSR at Mormon Mesa was also lower than that at Pahranagat. Daily survival rate during the nestling period was lower at Mormon Mesa than at Pahranagat. Littlefield and Grand Canyon were excluded from the comparisons because of small sample sizes. Across all study areas, DSR during the nestling period was higher than during incubation or laying. Mayfield survival probabilities did not differ substantially from apparent nest success (number of successful nests divided by total number of nests; Table 4.5).

[1] Table 4.1 shows a total of 350 nests known to contain at least one flycatcher egg. When calculating brood parasitism rates, however, 25 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).

Table 4.2. Summary of Causes of Willow Flycatcher Nest Failure at All Study Areas Where Nesting Was Documented, 2003–2007*

Study Area[1]	Year	Total # Nests	All Failed Nests	Abandoned	Deserted	Depredated	Parasitized	Addled	Tree fell	Unknown
PAHR	2003	12	2	1	1	0	0	0	0	0
	2004	17	4	0	0	3	0	0	0	1
	2005	21	10	2	0	7	0	0	0	1
	2006	18	9	3	3	2	0	1	0	0
	2007	12	4	0	1	1	0	0	0	2
	All Years	80	29	6 (21)	5 (17)	13 (45)	0	1 (3)	0	4 (14)
LIFI	2004	3	2	1 (50)	0	1 (50)	0	0	0	0
MESQ	2003	19	11	1	2	7	0	1	0	0
	2004	20	16	3	4	4	5	0	0	0
	2005	13	6	1	0	4	1	0	0	0
	2006	21	10	1	2	5	2	0	0	0
	2007	16	8	2	1	4	1	0	0	0
	All Years	89	51	8 (16)	9 (17)	24 (47)	9 (18)	1 (2)	0	0
MOME	2003	13	13	3	4	4	0	0	0	2
	2004	7	4	1	0	3	0	0	0	0
	2005	6	4	0	0	1	1	2	0	0
	2006	9	5	1	1	1	0	2	0	0
	2007	12	9	1	4	2	0	1	0	1
	All Years	47	35	6 (17)	9 (26)	11 (31)	1 (3)	5 (14)	0	3 (9)
MUDD	2005	8	5	0	1	2	2	0	0	0
	2006	9	5	0	2	3	0	0	0	0
	2007	12	12	6	1	4	1	0	0	0
	All Years	29	22	6 (27)	4 (18)	9 (41)	3 (14)	0	0	0
GRCA	2004	1	0	0	0	0	0	0	0	0
	2006	3	3	0	1	2	0	0	0	0
	2007	1	1	0	1	0	0	0	0	0
	All Years	5	4	0	2 (50)	2 (50)	0	0	0	0
TOPO	2003	12	4	2	2	0	0	0	0	0
	2004	43	25	5	1	14	4	0	0	1
	2005	38	30	4	4	20	1	0	1	0
	2006	17	10	0	3	5	0	1	0	1
	2007	8	2	0	1	1	0	0	0	0
	All Years	118	71	11 (15)	11 (15)	40 (56)	5 (7)	1 (2)	1 (2)	2 (3)
BIWI	2003	2	0	0	0	0	0	0	0	0
	2005	2	0	0	0	0	0	0	0	0
	2006	5	4	0	1	3	0	0	0	0
	2007	9	7	1	2	3	0	0	0	1
	All Years	18	11	1 (9)	3 (27)	6 (55)	0	0	0	1 (9)
Total		**389**	**225**	**39[2] (17)**	**43[3] (19)**	**106 (47)**	**18 (8)**	**8 (4)**	**1 (1)**	**10 (4)**

* 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 National Wildlife Refuge.

[2] 9 nests abandoned after being parasitized.

[3] 8 nests deserted after >14 d incubation, 7 deserted immediately after being parasitized, 13 deserted after partial depredation, no obvious cause of desertion for remainder.

Table 4.3. Summary of Fates of Willow Flycatcher Nests Parasitized by Brown-Headed Cowbirds at All Study Areas Where Nesting Was Documented, 2003–2007*

Study Area[1]	Total # Nests	Abandoned	Deserted	Depredated	Parasitized	Tree fell	Fledged	Unknown
MESQ	27	2	5	5	9	0	5	1
MOME	7	2	3	0	1	0	1	0
MUDD	10	1	1	4	3	0	1	0
TOPO	39	4	4	15	5	1	8	2
BIWI	1	0	1	0	0	0	0	0
Total	**84**	**9**	**14**	**24**	**18**	**1**	**15**[2]	**3**[3]

* All nesting attempts (those with and without flycatcher eggs) are included.
[1] MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River Delta, TOPO = Topock Marsh, BIWI = Bill Williams River NWR.
[2] 5 nests fledged a cowbird as well as at least one flycatcher.
[3] These nests suspected to have fledged flycatchers, but fledges not visually confirmed.

Table 4.4. 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 Littlefield, Grand Canyon and Bill Williams, AZ, 2003–2007*

Study Area	Nest Stage[1]	Nest Losses/ Observation Days	Daily Survival Rate	Mayfield Survival Probability
Pahranagat	1	2/147	0.986 (0.968–1.000)	0.971 (0.932–1.000)
	2	14/772	0.982 (0.972–0.991)	0.790 (0.698–0.893)
	3	6/724	0.992 (0.985–0.998)	0.892 (0.814–0.977)
	MSP all stages = 0.684			
Littlefield	1	0/5	1.000	1.000
	2	1/16	0.938 (0.819–1.000)	0.436 (0.077–1.000)
	3	0/11	1.000	1.000
	MSP all stages = 0.436			
Mesquite	1	10/131	0.924 (0.878–0.969)	0.845 (0.759–0.936)
	2	21/791	0.973 (0.962–0.985)	0.707 (0.609–0.820)
	3	11/526	0.979 (0.967–0.991)	0.748 (0.629–0.887)
	MSP all stages = 0.447			
Mormon Mesa	1	3/55	0.945 (0.885–1.000)	0.888 (0.773–1.000)
	2	18/437	0.959 (0.940–0.977)	0.582 (0.452–0.746)
	3	8/194	0.959 (0.931–0.987)	0.559 (0.372–0.832)
	MSP all stages = 0.289			
Muddy River	1	3/31.5	0.905 (0.802–1.000)	0.809 (0.627–1.000)
	2	7/239	0.971 (0.949–0.992)	0.682 (0.5112–0.903)
	3	5/113	0.956 (0.918–0.994)	0.537 (0.308–0.916)
	MSP all stages = 0.296			
Grand Canyon	1	0/8	1.000	1.000
	2	3/60	0.950 (0.895–1.000)	0.517 (0.240–1.000)
	3	1/3	0.667 (0.133–1.000)	0.004 (0.000–1.000)
	MSP all stages = 0.002			

Table 4.4. 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 Littlefield, Grand Canyon and Bill Williams, AZ, 2003–2007,* continued

Study Area	Nest Stage[1]	Nest Losses/ Observation Days	Daily Survival Rate	Mayfield Survival Probability
Topock	1	9/134	0.933 (0.890–0.975)	0.863 (0.782–0.948)
	2	39/830	0.953 (0.939–0.967)	0.539 (0.443–0.653)
	3	10/617	0.984 (0.974–0.994)	0.799 (0.694–0.917)
	MSP all stages = 0.371			
Bill Williams	1	2/16.5	0.879 (0.721–1.000)	0.761 (0.500–1.000)
	2	6/146	0.959 (0.926–0.991)	0.582 (0.374–0.891)
	3	2/111	0.982 (0.957–1.000)	0.779 (0.548–1.000)
	MSP all stages = 0.345			
TOTAL	1	29/527.5	0.945 (0.926–0.964)	0.887 (0.849–0.926)
	2	109/3289	0.967 (0.961–0.973)	0.648 (0.5970.703)
	3	43/2298.5	0.981 (0.976–0.987)	0.771 (0.714–0.833)
	MSP all stages = 0.444			

* Mayfield survival probability was calculated using 2.12-day egg laying, 12.86-day incubation, and 13.75-day nestling stages. 95% confidence intervals are shown in parentheses.

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

Table 4.5. Mayfield Nest Success and Apparent Nest Success, 2003–2007

Study Area	Mayfield Nest Success	Apparent Nest Success
Pahranagat	0.684	0.689
Littlefield	0.436	0.500
Mesquite	0.447	0.444
Mormon Mesa	0.289	0.268
Muddy River	0.296	0.304
Grand Canyon	0.002	0.000
Topock	0.371	0.402
Bill Williams	0.345	0.412
Overall	0.444	0.446

At all sites, 324 nestlings were confirmed to have fledged from 342 nests of known outcome (mean number of nestlings/nest = 0.95, SE = 0.07; Table 4.6). Productivity did not vary significantly across years but did vary between study areas, with Pahranagat have significantly higher productivity than any of the other study areas, which did not differ from each other ($F_{5,330} = 14.20$, $P < 0.001$). Grand Canyon and Littlefield were excluded from the analysis because of small sample size. Fecundity (number of young fledged per female) ranged from 0.0 at Grand Canyon to 2.40 at Pahranagat (Table 4.6) and averaged 1.22 (SE = 0.09). Fecundity at Pahranagat was significantly higher ($F_{5,2559} = 15.41$, $P < 0.001$) than at the other study areas, which did not differ from one another.

Table 4.6. Willow Flycatcher Nest Productivity (Young Fledged per Nest) and Fecundity (Young Fledged per Female) at All Study Areas Where Nesting Was Documented, 2003–2007*

Study Area	Year	# Young Fledged (# Nests)	Productivity Mean (SE)	Fecundity Mean (SE)
Pahranagat	2003	24 (11)	2.18 (0.35)	3.00 (0.42)
	2004	35 (17)	2.06 (0.34)	2.50 (0.47)
	2005	33 (19)	1.74 (0.39)	3.00 (0.30)
	2006	24 (15)	1.60 (0.38)	1.60 (0.38)
	2007	23 (12)	1.92 (0.43)	2.30 (0.42)
	All Years	139 (74)	1.88 (0.17)	2.40 (0.19)
Littlefield	2004	2 (2)	1.00	2.00
Mesquite	2003	17 (18)	0.94 (0.30)	1.31 (0.50)
	2004	11 (17)	0.65 (0.30)	0.92 (0.40)
	2005	6 (10)	0.60 (0.22)	1.20 (0.49)
	2006	23 (20)	1.15 (0.28)	1.53 (0.45)
	2007	15 (14)	1.07 (0.32)	1.25 (0.35)
	All Years	72 (79)	0.91 (0.13)	1.26 (0.20)
Mormon Mesa	2003	0 (10)	0.00 (0.00)	0.00 (0.00)
	2004	6 (6)	1.00 (0.52)	0.86 (0.46)
	2005	1 (5)	0.20 (0.20)	0.25 (0.25)
	2006	8 (8)	1.00 (0.42)	1.14 (0.46)
	2007	3 (11)	0.27 (0.14)	0.27 (0.14)
	All Years	18 (40)	0.45 (0.13)	0.50 (0.15)
Muddy River	2005	3 (8)	0.38 (0.18)	0.50 (0.22)
	2006	7 (9)	0.78 (0.36)	1.00 (0.44)
	2007	0 (6)	0.00 (0.00)	0.00 (0.00)
	All Years	10 (23)	0.43 (0.16)	0.48 (0.18)
Grand Canyon	2006	0 (3)	0.00 (0.00)	0.00 (0.00)
	2007	0 (1)	0.00 (0.00)	0.00 (0.00)
	All Years	0(4)	0.00 (0.00)	0.00 (0.00)
Topock	2003	15 (10)	1.50 (0.31)	1.67 (0.44)
	2004	25 (37)	0.38 (0.14)	0.89 (0.17)
	2005	13 (34)	0.38 (0.13)	0.72 (0.29)
	2006	5 (14)	0.36 (0.17)	0.45 (0.21)
	2007	12 (8)	1.50 (0.46)	1.50 (0.46)
	All Years	70 (103)	0.68 (0.09)	0.95 (0.13)
Bill Williams	2003	3 (2)	1.50 (0.50)	1.00 (0.58)
	2005	5 (2)	2.50 (0.50)	2.50 (0.50)
	2006	2 (5)	0.40 (0.40)	0.67 (0.67)
	2007	3 (8)	0.38 (0.26)	0.43 (0.30)
	All Years	13 (17)	0.76 (0.25)	0.87 (0.27)
Total		**324 (342)**	**0.95 (0.07)**	**1.22 (0.09)**

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

DISCUSSION

Willow flycatcher nesting was documented every year from 2003–2007 at the four life history study areas. Breeding was documented in some years at Littlefield, Muddy River Delta, lower Grand Canyon, and Bill Williams. 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 some sites in one year but not in another.

NEST FAILURE

Depredation was the major cause of willow flycatcher nest failure, accounting for 47% of all failed nests. These results are consistent with those reported 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). Direct observations of nest depredation events are rare to nonexistent during nest monitoring, and the identity of nest predators and factors influencing nest depredation along the Virgin and lower Colorado Rivers remain undetermined.

BROOD PARASITISM

Brood parasitism by Brown-headed Cowbirds across all study areas ranged from 0 to 39% and averaged 23%. 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 five consecutive years of no brood parasitism at Pahranagat. Cowbird trapping and removal studies were initiated at all the life history study areas in 2003, and we discuss trends in brood parasitism rates in detail in Chapter 5.

We observed several 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, 16 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 (Paxton et al. 2007; 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.

NEST SUCCESS AND NEST PRODUCTIVITY

Overall, Pahranagat exhibited the highest nest success, nest productivity, and fecundity of the four life history study areas, Muddy River, and Bill Williams. Nest success at all study areas exhibited yearly fluctuations, illustrating that the demographic patterns of passerine populations often vary year to year, and sometimes to a very large degree (Wiens 1989a). The variable patterns of nest success observed at the study areas over many years demonstrate the need for long-term data. Fecundity estimates are incorporated into calculations of per capita growth rate (see Chapter 3).

Mayfield nest success did not differ substantially from apparent nest success, suggesting that the majority of nesting attempts were located. Indeed, 80% of all documented nesting attempts were located during the building or laying stages, and another 5% were located during the first two days of incubation. With a high proportion of nests located early in the nesting cycle, it is not surprising that apparent nesting success mirrors Mayfield success, which is designed to adjust for nests that fail before they are found. If intensive nest searching results in the discovery of most nests early in the nesting cycle, Mayfield estimates may be unnecessary for obtaining accurate nest success estimates. Calculating Mayfield estimates requires frequent visits to the nest around transition dates (e.g., hatch date); if Mayfield estimates were not necessary, fewer visits could be made to the nest and nest disturbance could be reduced with no loss of nest success information.

CHAPTER 5

BROWN-HEADED COWBIRD TRAPPING

INTRODUCTION

From 1997 to 2002, willow flycatcher breeding data (brood parasitism rates, nest success, and productivity) were documented at the four life history study areas (McKernan and Braden unpubl. data), with no cowbird trapping conducted in the proximity of the breeding sites.[1] In this study we compare five successive years (2003–2007) of willow flycatcher breeding data under the influence of cowbird trapping (trapping period) with data gathered at the life history study areas from 1997 to 2002 (pre-trapping period). Our objectives were to determine if cowbird trapping and removal affects willow flycatcher brood parasitism rates, flycatcher nest success, or flycatcher productivity.

METHODS

From 2003 to 2007, we conducted cowbird trapping following methods outlined in Griffith Wildlife Biology (1994). To minimize the number of parasitism days (the number of days a host population is exposed to each female cowbird), cowbird traps were deployed at least two weeks prior to the initiation of flycatcher nesting (mid-May) and continually operated until all nests at the study area were at least past the egg laying and incubation stages (late July or early August).

TRAP DESIGN

In 2003 and 2004, we used a variation of the Australian crow trap (per the design of Ahlers and Tisdale 1999) to capture Brown-headed Cowbirds (Figure 5.1). These flat-topped, portable, wood-framed traps were 1.2 m high, 1.2 m wide, and 2.4 m long, with a door located on one end. The panels consisted of 5 × 5–cm wood supports covered with 1.3-cm wire mesh, and included a bottom panel. A piece of plywood, with two 3.5-cm-wide slots down the middle, was attached to the top of each trap for cowbird entry.

In 2005, we experimented with two different trap designs: the flat-topped trap (described above), which we had used in 2003 and 2004, and a trap with a funnel-shaped top. The funnel-shaped traps were 1.8 m high, 1.8 m wide, and 2.4 m long, and had a funnel-shaped top (Figure 5.2). The slots on the funnel-topped traps used in 2005 were 3.2 cm wide. All panels consisted of 5 × 5–cm wood supports covered with 1.3-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.

[1] Limited cowbird trapping occurred at Topock in 1998 (White et al. 1998), but no traps were deployed within 400 m of flycatcher breeding areas.

Figure 5.1. Flat-topped Brown-headed Cowbird trap used at life history study areas, 2003–2005

Figure 5.2. Funnel-shaped top Brown-headed Cowbird trap used at life history study areas, 2005–2007

The width of the entrance slot in cowbird traps varies from project to project, ranging from 3.1 cm (2.2 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 and 2007, we experimented with slots of two different widths to determine if slight variations in slot size had any effect on capture rates of cowbirds or non-target species. Three of the six traps at Topock had 3.8-cm-wide slots and three had 3.2-cm-wide slots. The 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.

During this study, signs were posted on all trap doors to inform the public of the nature and relevance of the trapping program. The signs were clearly marked and laminated to maintain legibility over the season. Padlocks were used on the doors of traps in public locations to discourage vandalism. Each trap was situated in an accessible location and was visible from above with some natural tree cover.

To attract cowbirds, at least two male and three female live-decoy cowbirds were maintained in each trap whenever possible. Each trap was leveled, and the wire mesh floor covered with a thin layer of soil to encourage natural foraging and social behavior among the decoy birds. Six or more horizontal perches were provided in the trap corners, and shadecloth was attached to sections of the outside of each trap to provide adequate shade.

TRAP MAINTENANCE

An abundant supply of wild birdseed (not containing sunflower seeds, which attract non-target species) and a 1-gallon guzzler of water were kept in each trap and replenished daily. Each trap was checked every 24 hours, and findings were recorded on a daily data sheet. Upon entering a trap, field personnel carefully flushed out any non-target birds, recording the number of each species, and, when possible, sex and age. Each day we recorded the number, sex, and age of newly trapped cowbirds, and we clipped the wings of all cowbirds at the edge of the secondary and primary feathers, thus lowering the probability of injury in the trap and the likelihood that any escaped bird would be able to survive. We also recorded any cowbirds that were missing, dead, or removed from the trap as well as any pertinent notes. The disposition (transferred to another trap or euthanized) of all removed cowbirds was noted. Excess numbers of cowbirds were removed periodically, placed in a small holding cage, and euthanized off-site using carbon monoxide.

NON-TARGET SPECIES BANDING

During the first four years of cowbird trapping, we noted that a number of non-target 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. 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). Field personnel banded as many non-target individuals as possible, recording the federal band number, species, and, when possible, sex and age before releasing them. Recaptured individuals were released after their federal band number was recorded. Any injuries or mortalities were also noted.

TRAP NUMBER AND LOCATION

We attempted to deploy traps in sufficient numbers and locations such that all flycatcher nests were within 400 m (the effective trapping radius; John Griffith, GWB, pers. comm., March 2002) of a cowbird trap.

DATA ANALYSIS

We used SPSS® Version 15.0 (SPSS Inc.) software for statistical analyses. A statistical significance level of $P \leq 0.05$ was chosen to reject null hypotheses. Mormon Mesa was excluded from all analyses regarding the effects of trapping because trapping was ineffective or not completed in most trapping years. Although we attempted to trap at Mesquite in 2003, trapping was ineffective and no cowbirds were removed. Thus, data from 2003 at Mesquite were included in the pre-trapping period.

Analysis of trap design – Because capture rate data were not normally distributed, we used Mann-Whitney U tests to compare capture rates (number of cowbirds newly captured per trap-day) and escape rates (number of cowbirds reported to have escaped per trap-day) of the two trap designs used at Topock in 2005 and the two different slot widths used at Topock in 2006 and 2007.

Analysis of brood parasitism rates: pre-trapping vs. trapping periods – We could not use logistic regression models to analyze potential interactions between study area and trapping on parasitism because there were no parasitized nests at Pahranagat during trapping, creating quasi-complete separation in the data. Therefore, we examined data from each study area separately and used Pearson chi-square tests to compare the likelihood of a nest being parasitized during the pre-trapping and trapping periods.

Analysis of willow flycatcher nest success: pre-trapping vs. trapping periods – We used logistic regression models to explore the relationship between trapping and whether or not a nest fledged flycatcher young. We also used Pearson chi-square tests to compare nest success rates during pre-trapping and trapping periods at individual study areas.

Analysis of willow flycatcher nest productivity: pre-trapping vs. trapping periods – We used ANOVA to compare the number of fledges produced per nest and the number of fledges produced per female during pre-trapping versus trapping years. Because recent studies have shown that the most important predictor of survivorship for juvenile willow flycatchers was fledge date, with nestlings fledging later in the breeding season having lower survivorship than those fledged early in the breeding season (Paxton et al. 2007, this document), we used ANOVA to compare nestling fledge date between trapping and pre-trapping periods.

RESULTS

TRAP OPERATION

From 2003 to 2007, we operated two traps at Pahranagat and six at Topock, all of which remained in essentially the same locations across years. Two traps were operated at Mesquite in 2003, and three traps were operated in 2004–2007. Because few cowbirds were captured at

Mesquite in 2003, traps were placed in different locations in 2004. Trap locations were essentially unchanged between 2004 and 2005. In 2006, one of two traps at Mesquite East was moved to Mesquite West. The remaining trap location at Mesquite East was moved between 2006 and 2007 from the west end to the center of the site. At Mormon Mesa, we operated four traps in 2003–2005. Over-winter flooding and changes in the location of flycatcher breeding areas at Mormon Mesa required us to relocate traps between years. We discontinued trapping at Mormon Mesa in 2006 because we were unable to place traps within 400 m of areas occupied by breeding flycatchers. For details on trap locations from 2003 to 2007 see orthophotos presented in Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007, and McLeod et al. 2008.

We operated all traps from approximately mid-May to late July or early August each year. In 2003–2007, we captured and removed 544, 266, 43, and 872 Brown-headed Cowbirds at Pahranagat, Mesquite, Mormon Mesa, and Topock, respectively (Table 5.1). Approximately 1% of cowbirds captured at Pahranagat were juveniles, compared to 6% at Mesquite and 9% at Topock.

Table 5.1. Summary of Brown-headed Cowbirds Trapped and Removed at Pahranagat NWR, Mesquite, and Mormon Mesa, NV, and Topock Marsh, AZ, 2003–2007

Study Area	Year	# Males	# Females	# Juveniles	Total # Brown-headed Cowbirds
Pahranagat	2003	65	85	2	**152**
	2004	100	59	3	**162**
	2005	32	24	0	**56**
	2006	45	25	0	**70**
	2007	55	48	1	**104**
	Total	**297**	**241**	**6**	**544**
Mesquite	2003	-4	-4	1	**-7**
	2004	8	6	2	**16**
	2005	34	24	3	**61**
	2006	73	44	8	**125**
	2007	41	29	1	**71**
	Total	**152**	**99**	**15**	**266**
Mormon Mesa	2003	6	2	1	**9**
	2004	8	17	4	**29**
	2005	1	0	4	**5**
	Total	**15**	**19**	**9**	**43**
Topock	2003	38	30	22	**90**
	2004	24	15	4	**43**
	2005	133	77	33	**243**
	2006	195	108	20	**323**
	2007	88	82	3	**173**
	Total	**478**	**312**	**82**	**872**

TRAP DESIGN

In 2005, funnel-topped traps captured on average 0.50 male and 0.27 female cowbirds per trap-day, while flat-topped traps captured 0.10 male and 0.09 female cowbirds per trap-day. Capture rates were significantly higher at the funnel-topped traps for each gender (P < 0.001) and for juveniles (P = 0.048). Funnel-topped traps also had a lower escape rate (0.02 cowbirds per trap-day) compared to flat-topped traps (0.07 cowbirds per trap day; P = 0.029). In addition to capturing more cowbirds, the funnel-topped traps also captured more non-target individuals (0.69 individuals per trap-day) than did the flat-topped traps (0.02 individuals per trap day; P < 0.001).

In 2006, traps with the wider slots had a tendency to capture more cowbirds than the narrower slots (daily capture rate of 0.86 and 0.61 cowbirds per trap-day, respectively, P = 0.063). The escape rate of cowbirds did not differ significantly (P = 0.34) between the wide slots (0.04 cowbirds per trap-day) and the narrow slots (0.02 cowbirds per trap-day). We detected the same pattern in 2007 of wider slots having a higher capture rate (0.49 cowbirds per trap-day) than narrower slots (0.39 cowbirds per trap-day), but the difference was not significant (P = 0.44). Only one cowbird escaped during 2007, so escape rates were not analyzed. Wider slots had a higher capture rate of non-target individuals in 2006 (P = 0.033), but no significant differences were seen in 2007 (P = 0.188). When data from both years were combined, wider slots had a tendency to capture more cowbirds than narrower slots (P = 0.07), and this difference was significant for female cowbirds (P = 0.039). There were no significant differences in escape rates or capture rates for non-target individuals.

BROOD PARASITISM RATES

The proportion of nests parasitized did not differ between pre-trapping and trapping periods at Mesquite and Topock (χ^2 = 0.0, P = 1.00 and χ^2 = 2.06, P = 0.15, respectively). The proportion of nests parasitized at Pahranagat was significantly lower during trapping compared to pre-trapping (χ^2 = 12.93, P < 0.001).

WILLOW FLYCATCHER NEST SUCCESS

Nest success differed between trapping and pre-trapping periods only at Pahranagat (χ^2 = 4.3, P = 0.039), with a higher proportion of successful nests recorded during trapping years. The proportion of successful nests recorded at Mesquite and Topock did not differ between pre-trapping and trapping periods (χ^2 = 0.09, P = 0.77 and χ^2 = 0.01, P = 0.91, respectively).

WILLOW FLYCATCHER PRODUCTIVITY

The ANOVA examining the effects of trapping, study area, and their interaction on mean number of flycatcher young fledged per successful nest showed that mean number of young fledged varied by study area ($F_{2,504}$ = 18.02, P < 0.001), but not by trapping period ($F_{1,504}$ = 3.22, P = 0.13), with Pahranagat fledging more young per successful nest than either Topock or Mesquite; Topock and Mesquite did not differ from each other. The interaction between study area and trapping period was significant ($F_{2,504}$ = 9.02, P = 0.002), with mean number of fledges per successful nest being higher at Pahranagat during trapping versus pre-trapping but not differing at the other study areas between trapping periods (Figure 5.3). Mean number of young produced per female flycatcher also differed between study areas ($F_{2,322}$ = 37.8, P < 0.001) but did not differ by trapping period, and there was no significant interaction between trapping period and study area (Figure 5.3). When data from Pahranagat were analyzed separately, mean number of fledges produced per female was higher during the trapping than pre-trapping period ($F_{1,108}$ = 8.3, P = 0.038). Mean fledge date did not differ significantly by study area ($F_{2,216}$ = 1.4, P = 0.26) or trapping period ($F_{1,216}$ = 3.0, P = 0.085), and there was no significant interaction between study area and trapping period ($F_{2,216}$ = 2.7, P = 0.066). However, when data from Pahranagat were analyzed separately, average fledge date was earlier at Pahranagat during the trapping compared to the pre-trapping period (Figure 5.3; $F_{1,90}$ = 8.3, P = 0.005).

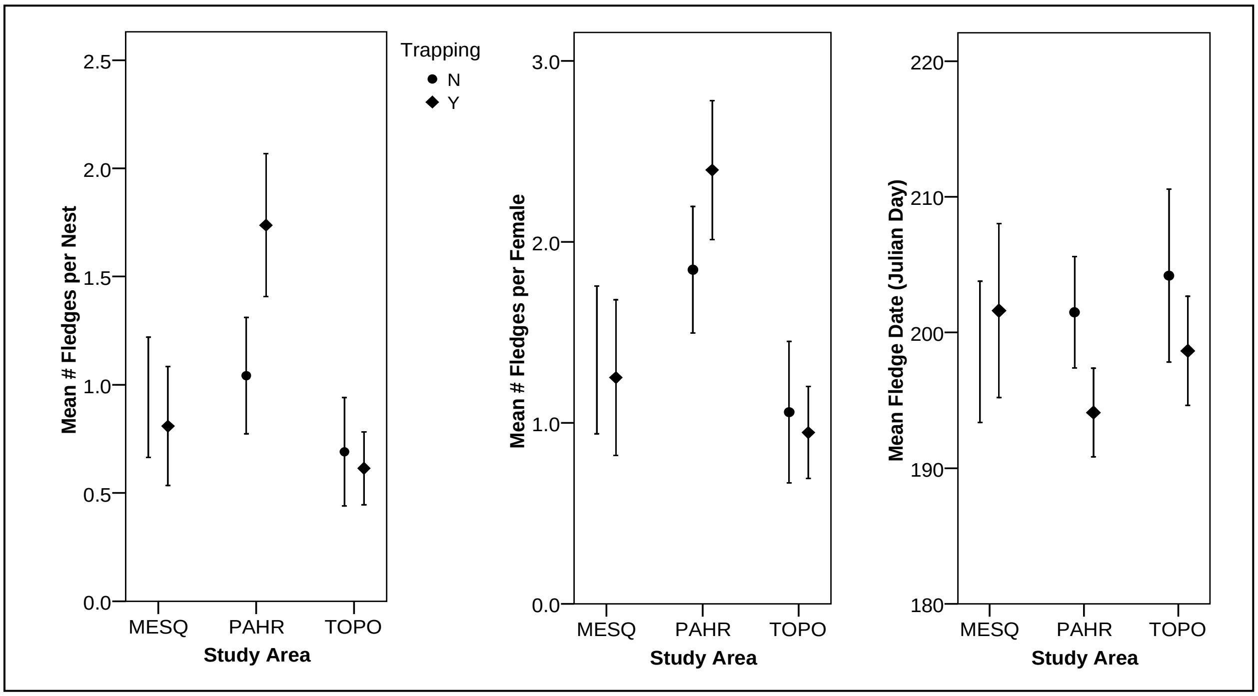

Figure 5.3. Mean number of fledges produced per nest and per female and mean fledge date during pre-trapping and trapping periods at each study area. Error bars indicate 95% confidence intervals.

NON-TARGET SPECIES

Thirty-two non-target species were captured and identified at the four study areas during cowbird trapping in 2003–2007. Non-target species captured included Abert's Towhee (*Pipilo aberti*), Bewick's Wren (*Thryomanes bewickii*), Black-headed Grosbeak (*Pheucticus melanocephalus*), Black-tailed Gnatcatcher (*Polioptila melanura*), Blue Grosbeak (*Guiraca caerulea*), Bronzed Cowbird (*Molothrus aeneus*), Bullock's Oriole (*Icterus galbula*), California Towhee (*Pipilo* crissalis), Canyon Wren (*Catherpes mexicanus*), Common Yellowthroat (*Geothlypis trichas*), Gambel's Quail (*Callipepla gambelii*), Gila Woodpecker (*Melanerpes uropygialis*), Gray Catbird (*Dumetella carolinensis*), Great-tailed Grackle (*Quiscalus mexicanus*), Hooded Oriole (*Icterus cucullatus*), House Finch (*Carpodacus mexicanus*), House Sparrow (*Passer domesticus*),

Table 5.2. Brown-Headed Cowbird Brood Parasitism Rates, Nest Success, Number of Fledges, and Fecundity at Pahranagat, Mesquite, and Topock, 1997–2007*

	Year	Pahranagat					Mesquite[1]					Topock				
		# Nests	% Parasitism	% Nest Success	# Fledges	Fecundity	# Nests	% Parasitism	% Nest Success	# Fledges	Fecundity	# Nests	% Parasitism	% Nest Success	# Fledges	Fecundity
Pre-trapping	1997	Nm[2]					3	66.7	66.7	0.7	0.7	INA[3]				
	1998	22	0.0	47.4	0.9	2.0	7	83.3	0.0	0.0	0.0	19	31.6	53.3	0.9	1.4
	1999	16	8.3	60.0	1.4	2.2	Nd[4]					20	30.0	37.5	0.6	0.7
	2000	19	13.3	62.5	1.4	2.1	8	25.0	50.0	1.0	1.0	19	15.8	36.3	0.4	0.6
	2001	21	16.7	50.0	1.0	1.6	18	29.4	52.9	1.2	1.8	19	27.8	35.7	0.6	1.2
	2002	18	47.1	33.3	0.5	1.0	17	28.6	58.8	1.1	1.5	8	12.5	50.0	1.1	1.8
Trapping[5]	2003	12	0.0	90.9	2.0	3.0	19	21.1[5]	44.4	0.9	1.3	12	18.2	80.0	1.3	1.7
	2004	17	0.0	76.5	2.1	2.5	20	45.0	23.5	0.6	0.9	43	31.7	44.7	0.6	0.9
	2005	21	0.0	57.9	1.6	3.0	7	28.6	41.7	0.6	1.2	38	51.4	23.5	0.3	0.7
	2006	18	0.0	60.0	1.3	1.6	21	23.8	55.0	1.1	1.5	17	31.2	23.5	0.4	0.5
	2007	12	0.0	66.7	1.9	2.3	19	40.0	57.1	0.9	1.3	8	0.0	75.0	1.5	1.5
Pre-trapping period mean (SE)			17.1 (8.0)	50.6 (5.2)	1.0 (0.2)	1.8 (0.2)		42.3 (12.0)	45.5 (9.6)	0.8 (0.2)	1.1 (0.3)		23.5 (3.9)	42.6 (3.8)	0.7 (0.1)	1.2 (0.2)
Trapping period mean (SE)			0.0 (0.0)	70.4 (6.1)	1.8 (0.1)	2.5 (0.3)		34.4 (4.9)	44.3 (7.7)	0.8 (0.1)	1.2 (0.1)		26.5 (8.5)	49.4 (12.2)	0.8 (0.2)	1.1 (0.2)

* Number of nests includes all nesting attempts. Percent parasitism is calculated using only nests for which contents could be determined. Percent nest success is calculated using only nests in which at least one flycatcher egg was laid. Number of fledges indicates the average number of confirmed fledges per successful nests, and fecundity indicates number of young fledged per female. Data for pre-trapping periods (1997–2002) are from Braden and McKernan (unpubl. data); these numbers have been verified with the raw data and may differ from those presented in annual reports.

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

[2] Study area not monitored.

[3] Unpublished data were not available.

[4] Study area monitored, no breeding documented.

[5] Data for Mesquite in 2003 were included in pre-trapping years because although cowbird trapping was attempted, no cowbirds were removed.

House Wren (*Troglodytes aedon*), Indigo Bunting (*Passerina cyanea*), Ladder-backed Woodpecker (*Picoides scalaris*), Lark Sparrow (*Chondestes grammacus*), Loggerhead Shrike (*Lanius ludovicianus*), Lucy's Warbler (*Vermivora luciae*), Marsh Wren (*Cistothorus palustris*), Mourning Dove (*Zenaida macroura*), Northern Mockingbird (*Mimus polyglottos*), Red-winged Blackbird (*Agelaius phoeniceus*), Song Sparrow (*Melospiza melodia*), Western Kingbird (*Tyrannus verticalis*), White-crowned Sparrow (*Zonotrichia leucophrys*), White-winged Dove (*Zenaida asiatica*), and Yellow-breasted Chat (*Icteria virens*).

During the cowbird trapping period, a total of 37, 608, 12, and 547 non-target captures were recorded at Pahranagat, Mesquite, Mormon Mesa, and Topock, respectively. The number of different non-target species captured in each year ranged from 8 to 15. Abert's Towhee and House Finch accounted for the vast majority of captures at the four study areas. Mortalities consisted of eight House Finches, six Abert's Towhees, two Lucy's Warblers, two Northern Mockingbirds, one Bewick's Wren, one Blue Grosbeak, one Loggerhead Shrike, and one Yellow-breasted Chat. Injuries to five Abert's Towhees, three House Finches, one Blue Grosbeak, and one Common Yellowthroat were also noted. For details on species, capture instances and occurrences, mortalities, and injuries at the four study areas from 2003 to 2007, see Koronkiewicz et al. 2004, McLeod et al. 2005, Koronkiewicz et al. 2006a, McLeod et al. 2007 and 2008.

NON-TARGET SPECIES BANDING

We banded 72 non-target individuals in 2007. 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, the minimum and maximum numbers of captured non-target individuals of all species were 108 and 164, respectively (Table 5.3).

DISCUSSION

Cowbird brood parasitism of *E. t. extimus* is of particular concern because brood parasitism usually results in reduced reproductive output (Sedgwick and Knopf 1988, Harris 1991, Whitfield and Sogge 1999, Rothstein et al. 2003, this document). Brown-headed Cowbird management issues are complicated because it is still unclear how brood parasitism rates affect willow flycatcher population sizes (Rothstein et al. 2003), and cowbird control methods are costly. The frequency of cowbird brood parasitism of the willow flycatcher across its range is known to be highly variable, ranging from less than 5% at some sites to over 60% at others (Sedgwick 2000). Furthermore, the effectiveness of cowbird control in reducing parasitism in the willow flycatcher varies across studies or cannot be assessed because flycatcher productivity data were not collected before cowbird control began (Rothstein et al. 2003).

Table 5.3. 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 Placement and Operation

Deploying an additional trap and relocating the traps at Mesquite in 2004 resulted in the capture of more cowbirds in 2004. The results of this field manipulation were similar to that of Ahlers and Tisdale-Hein (2001), who had shown that for cowbird trapping sites along the Rio Grande, relocating traps that captured few to no cowbirds increased the number of captures. Cowbird control efforts should deploy traps at alternative locations if cowbird trapping success at established trap locations appears low. Also, the effectiveness of other cowbird control measures in lowering parasitism rates should be evaluated for sites like Mormon Mesa where parasitism is a concern and trapping is impracticable. For example, as part of cowbird control methods to decrease brood parasitism of the Black-capped Vireo (*Vireo atricapilla*) in central Texas (Kostecke et al. 2005), researchers shot cowbirds within vireo breeding areas.

Parasitism Rates of Flycatcher Nests

At Mesquite and Topock, the proportion of nests parasitized did not differ between pre-trapping and trapping periods; however, parasitism at Pahranagat was significantly lower during trapping compared to pre-trapping, with no brood parasitism recorded since trapping began in 2003. Riparian habitat and surrounding landscape characteristics at Pahranagat have experienced practically no change in hydrology or vegetation over the last 10 years. In the absence of site-specific habitat or environmental change that could affect cowbird numbers or behavior, it seems likely that cowbird trapping at Pahranagat decreased brood parasitism rates. The low proportion of juvenile cowbirds to the total number of cowbirds captured also suggests that parasitism rates of all host species at Pahranagat were low.

The landscape characteristics at Pahranagat may facilitate the effectiveness of trapping. Pahranagat consists of small, relatively isolated patches of mature riparian forest surrounded by upland desertscrub. Because of Pahranagat's isolation from other riparian corridors, as cowbirds are removed during any given season the likelihood of cowbirds recolonizing the area is low. In contrast, 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. Ahlers et al. (2001) found that the Rio Grande serves as a migratory corridor for cowbirds, and as cowbirds are removed, local individuals prospecting for home ranges quickly fill unoccupied habitat. The riparian corridors along lower Colorado and Virgin Rivers probably also serve as similar migratory corridors for cowbirds, and cowbirds removed in any given year are probably replaced by other individuals. Pahranagat's relatively small size may also make it more likely that the female cowbirds caught in the traps are the ones that would be likely to parasitize flycatcher nests.

Flycatcher Nest Success

Willow flycatcher nest success differed between trapping and pre-trapping periods only at Pahranagat, with a 20% increase in the percentage of successful nests during the trapping period. Nests parasitized by Brown-headed Cowbirds during this study were less likely to fledge young than nests that were not parasitized, and this result is consistent with observations in other studies (Sedgwick and Iko 1999, Whitfield 2000 as cited in Rothstein et al. 2003). In addition to the effects of brood parasitism itself, cowbirds may affect host nest success in other ways by ejecting host eggs and removing host young (as reviewed by Rothstein et al. 2003). Kostecke et al. (2005) found that cowbird control efforts in Texas steadily reduced brood parasitism and increased Black-capped Vireo nesting success over time. Whitfield et al. (1999) also found nest success to increase in the willow flycatcher with cowbird control along the South Fork of the Kern River. However, both Kostecke et al. (2005) and Whitfield et al. (1999) used combinations of intensive cowbird control measures (shooting cowbirds, cattle removal, addling cowbird eggs, removing cowbird nestlings) in addition to trapping; therefore, the effect of trapping alone in increasing host nest success cannot not be determined for those studies.

The proportion of successful nests recorded at Mesquite and Topock did not differ between pre-trapping and trapping periods. This might be expected given that brood parasitism rates did not differ between the pre-trapping and trapping periods. This finding is similar to that of Ahlers et al. (2001) who reported that four years (1997–2000) of cowbird trapping along the Rio Grande did not increase nest success for Neotropical migrant songbirds, including the willow flycatcher. As noted above, the efficacy of trapping at sites that are part of larger, contiguous riparian corridors like those found on the Rio Grande and Colorado and Virgin Rivers may be lower than that at smaller, isolated sites.

FLYCATCHER PRODUCTIVITY

At Pahranagat, not only were nests more likely to fledge during the trapping period, but the mean number of young fledged from each successful nest was also higher during the trapping compared to the pre-trapping period. This suggests cowbirds may affect flycatcher production by decreasing the number of young produced from each successful nest as well as decreasing the likelihood that a nest fledges young. Cowbirds are suspected to depredate host eggs and nestlings even in nests that are not parasitized, thereby reducing the number of host eggs or nestlings through partial depredation of the clutch or brood (reviewed by Rothstein et al. 2003). Flycatchers will often renest following a failed nesting attempt, and cowbirds may cause a delay in the production of a successful brood by parasitizing nests (resulting in abandonment, desertion, or fledging of a cowbird) or by depredating the entire contents of a nest. Successive flycatcher nest attempts contain, on average, fewer eggs (Holcomb 1974, SWCA unpubl. data), so an overall delay in fledge dates would be associated with a smaller brood size. Indeed, fledge dates at Pahranagat tended to be earlier during cowbird trapping than in the pre-trapping period.

The mean number of young fledged per female at Pahranagat was also higher during the trapping than pre-trapping period. This is the logical result of each successful nest producing more young, and is also influenced by the number of females who successfully fledged multiple broods during a single season (four during the trapping period, zero during the pre-trapping period). Whitfield et al. (1999) reported that cowbird control along the South Fork of the Kern River was successful in increasing the mean number of young each female flycatcher fledged per season from 1.04 before control to 1.72 afterwards, but the researchers used combinations of intensive cowbird control measures in addition to trapping.

The average fledge date was significantly earlier at Pahranagat during the trapping compared to the pre-trapping period. Fledge date affects the survival probability of juveniles, with those fledging earlier in the season having a greater chance of survival (Paxton et al. 2007, this document). Therefore, it is possible that trapping at Pahranagat not only lowered brood parasitism and increased nest success and productivity, but also increased juvenile flycatcher survivorship.

NON-TARGET SPECIES CAPTURES

Results of the non-target banding study in 2007 showed that a minimum of 24% of the non-target birds captured were recaptures of birds previously captured that season. Given the tendency for birds at our sites to return to traps multiple times over a season, the total number of non-target captures we recorded in any given year of trapping since 2003 is probably much higher than the number of individuals captured. These results may be applicable when interpreting non-target capture data from other cowbird trapping studies.

From 2003 to 2007, 22 individuals of eight species died in the cowbird traps and 10 individuals of four species were injured. 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, particularly at desert sites where temperatures can reach 115° F during the trapping season.

TRAP DESIGN EXPERIMENTS

Our comparison of the trapping and escape rates of two different trap designs suggests that to maximize the capture rates of cowbirds and decrease escape rates, traps should have funnel-shaped rather than flat tops. However, the funnel-topped traps also captured significantly more non-target species than did the flat-topped traps, so traps should be checked daily.

Our comparison between two different slot sizes also suggests that funnel-topped traps with a slot width of 3.8 cm capture more cowbirds than the same trap design with a slot width of 3.2 cm. This difference was not nearly as dramatic, however, as the difference in capture rates between the two styles (funnel vs. flat tops) of traps. Non-target species captured in traps with wider slots tended to be of larger species. If an area has a large non-target species that researchers particularly wish to avoid capturing, a funnel-topped trap with a 3.2-cm-wide slot might provide a compromise between catching the maximum number of cowbirds and avoiding captures of particular non-target species.

CHAPTER 6

VEGETATION AND HABITAT CHARACTERISTICS

INTRODUCTION

During the 2003–2007 field seasons, 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 during each year at the four life history study areas in 2003–2007, and at Muddy River Delta in 2005–2007. We also measured vegetation and habitat characteristics at flycatcher nest sites at Bill Williams and Grand Canyon in years when nests were located in those study areas. Field methods during vegetation sampling were identical across years. 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 are 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.

METHODS

We described and measured vegetation and habitat features following a modification of the methods of James and Shugart (1970). These methods were refined over several seasons by the Arizona Game and Fish Department. 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. In addition, in 2006 and 2007 we measured distance to standing water or saturated soil from each nest and corresponding non-use point (see below) at the time the nest was found to contain flycatcher eggs.

We measured habitat characteristics at 30 plots annually 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, 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. In cases where life history study areas consisted of several sites, 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 a GIS 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. Study area boundaries varied between years as study areas were refined, via acquisition of higher resolution aerial photographs or ground reconnaissance, to include areas of dense, riparian vegetation and exclude areas with sparse vegetation. The Mesquite study area was expanded in 2005 to include Mesquite East and Bunker Farm in addition to Mesquite West, and habitat block points in 2005–2007 included Mesquite East and Bunker Farm.

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 greater than 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 (NS), 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 (WT) plots located at a randomly selected distance 5–10 m from the nest in a randomly selected compass direction. The plot was centered at the location used for the HOBO temperature/humidity data logger (see Chapter 7). We sampled approximately 10 WT locations annual in 2005–2007 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, 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 (NU) plots located 50–200 m from any willow flycatcher nest or territory center. In most years, 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. In 2005 at Topock, after a minimum sample size of 15 non-use plots was obtained, we assigned corresponding non-use sites to a subsample of nest sites. 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 a GIS 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 the location used for the HOBO temperature/humidity data logger (see Chapter 7). 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 2003–2006), 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.

We aggregated stem counts into the following categories for analysis: <2.5 cm dbh, 2.5–8.0 cm dbh, and >8.0 cm dbh. Although stems were tallied only within the vegetation plot, stem counts are presented below in per hectare units. We calculated basal area within the 5-m circle based on the stem counts tallied in each of the original six size categories and dbh measurements of stems >15 cm dbh. To obtain basal area, we multiplied the number of stems in the size class by the average basal area of a stem in that class, given an even distribution of stems within each size class. We calculated basal area separately for each species and then calculated the ratio of basal area of native species to the total basal area of all live stems.

Analyses of habitat blocks – We used ANOVA followed by Tukey's multiple comparison tests to determine if there were differences between years at a given study area in canopy closure, canopy height, percent woody ground cover, stem counts by size categories, and tree counts in the 5- to 11-m-radius circle. We graphed the means and 95% confidence intervals (CI) of these variables for each study area in each year from 2003 to 2007. We added a regression trend line across time for each variable in each study area to identify consistent changes.

In 2003 and 2004, measures of distance to water included categorical measures (>30 m). After 2004, when we obtained high-resolution aerial photographs for all the study areas, we used only continuous measures for distance to water. Therefore, data analyses of distance to water are restricted to 2005–2007.

Measures of distance to canopy gap and distance to nearest broadleaf contained both continuous and categorical (>30 m) data. Greater than 5% of the measurements were categorical, so we categorized all data as less than 15 m, between 15 and 30 m, or greater than 30 m and analyzed the data for each study area across time using 5 × 3 contingency tables. If differences were indicated across years, we examined the expected and observed counts to determine which years differed.

The habitat block area at Mesquite included only Mesquite West in 2003 and 2004 and was expanded in 2005 and subsequent years to include Bunker Farm and Mesquite East. Expansion of the study area to include additional sites may obscure any trends in vegetation that were occurring at Mesquite West; therefore, the habitat block analysis here includes only Mesquite West.

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. We used ANOVA and Tukey's multiple comparison tests to compare total foliage density at each meter interval across years at each study area.

Analyses of nest characteristics – Characteristics specific to the nest (nest height, nest substrate height, and nest substrate dbh) were compared between study areas and years using ANOVA.

Analyses of nest vs. within-territory and non-use sites – We used repeated measures ANOVA to compare NS, WT, and NU plots, examining the same variables as used in the habitat block analysis. We aggregated vertical foliage density counts into three categories: below the nest, the interval containing the nest, and above the nest. These analyses were done for each study area and then overall, taking into account the matched relationship between NS, WT, and NU. Because Pahranagat differs markedly from the other study areas in its vegetation structure, we also ran an overall analysis excluding Pahranagat. Because we did not measure vegetation at within-territory locations until 2005, the analysis is restricted to 2005–2007. To determine if we were losing information by eliminating the first two years of data and matching NS and NU locations although they are not spatially paired in the same way as NS/WT locations, we also used ANOVA to examine the complete set of NS and NU data.

We used conditional logistic regression to test the association of NS versus WT and NU sites with vegetation variables. This was done to determine if a minimum set of variables could distinguish the NS sites versus randomly chosen sites. All continuous variables with significant single effects in the overall models were included in the logistic regression models, and backward selection was used to create the most parsimonious model. Because vegetation data for WT locations were not collected until 2005, data used for the comparison of NS to WT sites were restricted to 2005–2007. Distance to water during nesting was not included in any models because data were available only for 2006–2007.

Analyses of vegetation characteristics as related to nest success – We used logistic regression to determine whether any vegetation characteristics were associated with nest success. Each nest was categorized as either successful (at least one fledgling produced) or failed. Nests with unknown fates were excluded. All vegetation variables were included in the logistic regression model, and a categorical variable designating study area was also included. We used backward selection to create to most parsimonious model.

RESULTS

At the four life history study areas, Littlefield, Muddy River, Grand Canyon, and Bill Williams, we gathered data on vegetation and habitat characteristics at 339 nest plots, 307 non-use plots, and 134 within-territory plots. We gathered data at an additional 229 habitat block plots at the life history study areas. Sample sizes at Littlefield (2 NS), Grand Canyon (4 NS), and Bill Williams (16 NS, 2 NU) did not allow for comparisons between nest and unused locations, and data from these study areas were excluded from NS vs. WT and NS vs. NU comparisons. Data from Littlefield and Grand Canyon were also excluded from between-study area comparisons of nest site characteristics.

HABITAT BLOCK MEASUREMENTS

Canopy closure at Mesquite, Mormon Mesa, and Topock did not differ between years. Canopy closure at Pahranagat was lower in 2005 than in 2003 or 2004, but no consistent trend through time is apparent. Though years did not differ from one another at Mormon Mesa, average canopy closure at the habitat block points has been increasing through the years (Figure 6.1).

Canopy height did not differ between years at any study area, and there were no significant trends in canopy height through time (Figure 6.2).

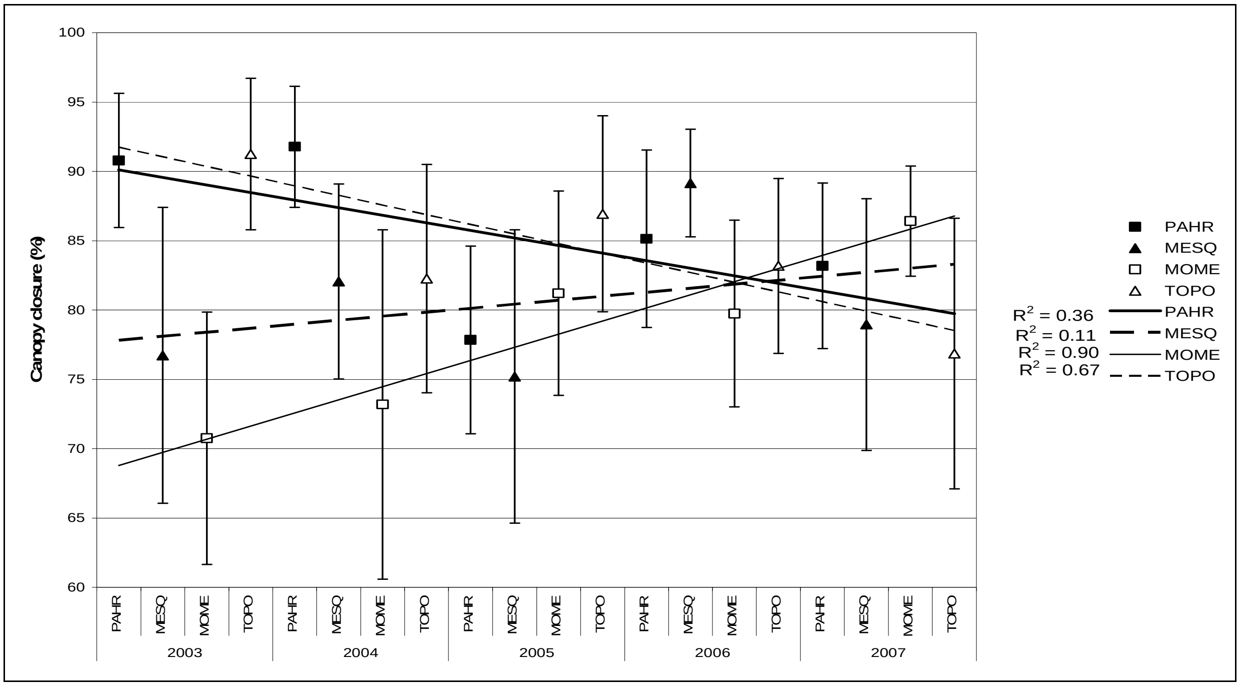

Figure 6.1. Mean and 95% CI of percent canopy closure at habitat block points at Pahranagat (PAHR), Mesquite (MESQ), Mormon Mesa (MOME), and Topock Marsh (TOPO) in each year from 2003 to 2007. Lines show linear regression trends.

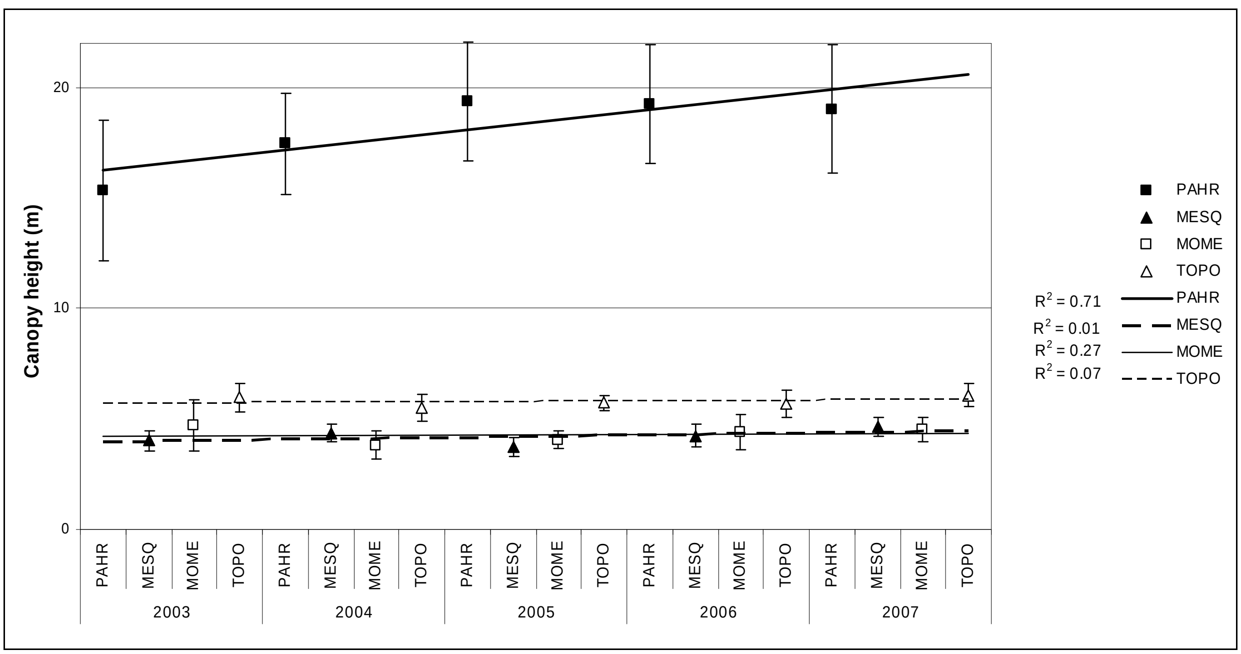

Figure 6.2. Mean and 95% CI of canopy height at habitat block points at Pahranagat (PAHR), Mesquite (MESQ), Mormon Mesa (MOME), and Topock Marsh (TOPO) in each year from 2003 to 2007. Lines show linear regression trends.

Woody ground cover differed between years at Pahranagat, being higher in 2007 than in any other year, but there was no consistent trend (Figure 6.3). Woody ground cover did not differ between years at Mesquite or Topock, but showed an increasing trend at Mormon Mesa, with there being significantly more woody ground cover in 2006 and 2007 than in previous years.

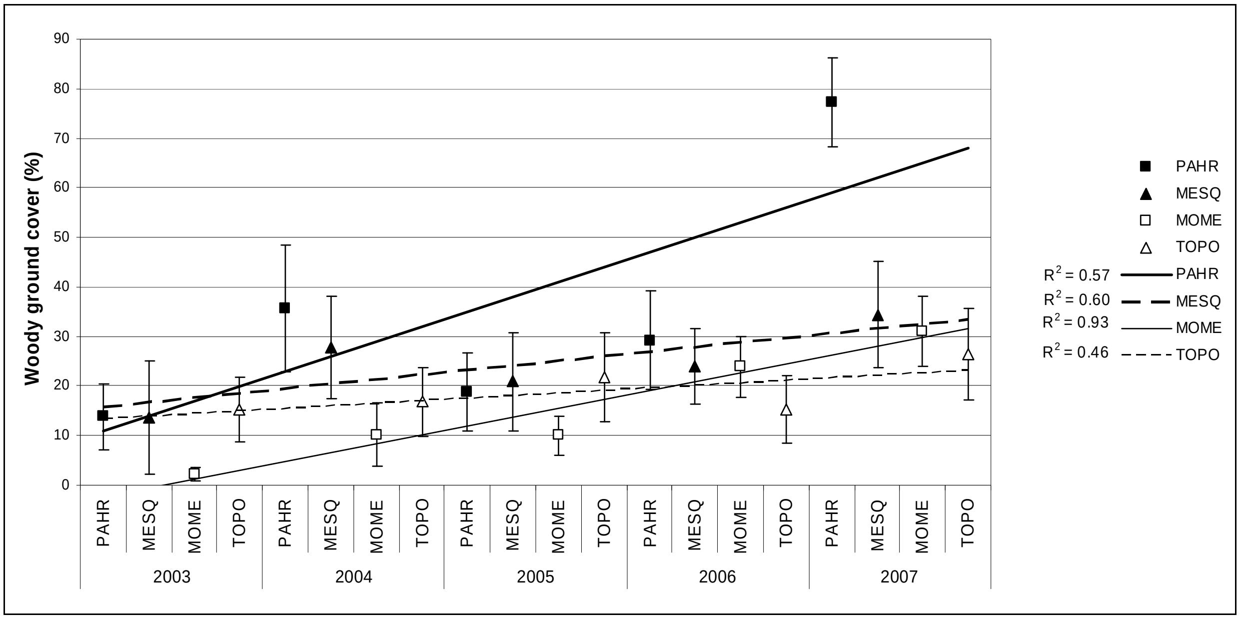

Figure 6.3. Mean and 95% CI of woody ground cover at habitat block points at Pahranagat (PAHR), Mesquite (MESQ), Mormon Mesa (MOME), and Topock Marsh (TOPO) in each year from 2003 to 2007. Lines show linear regression trends.

Distance to water did not differ significantly between years at either Pahranagat or Mesquite (Figure 6.4). At Mormon Mesa, distance to water increased over time, with 2007 differing significantly from 2005. Distance to water at Topock was less in 2007 than in the two prior years.

The number of stems less than 2.5 cm dbh showed no trend at any of the study areas (Figure 6.5). Stem counts in this size class did not differ between years at Pahranagat. At both Mesquite and Mormon Mesa, counts of small stems were greater in 2003 than in 2005, while at Topock, stem counts were higher in 2005 than 2006.

There were no trends in the number of stems 2.5–8 cm dbh at any of the study areas (Figure 6.6). Stem counts did not differ between years at Pahranagat or Mesquite. At Mormon Mesa, stem counts in 2005 and 2007 were higher than those recorded in 2004. Stem counts in 2005 at Topock were higher than those in 2006 or 2007.

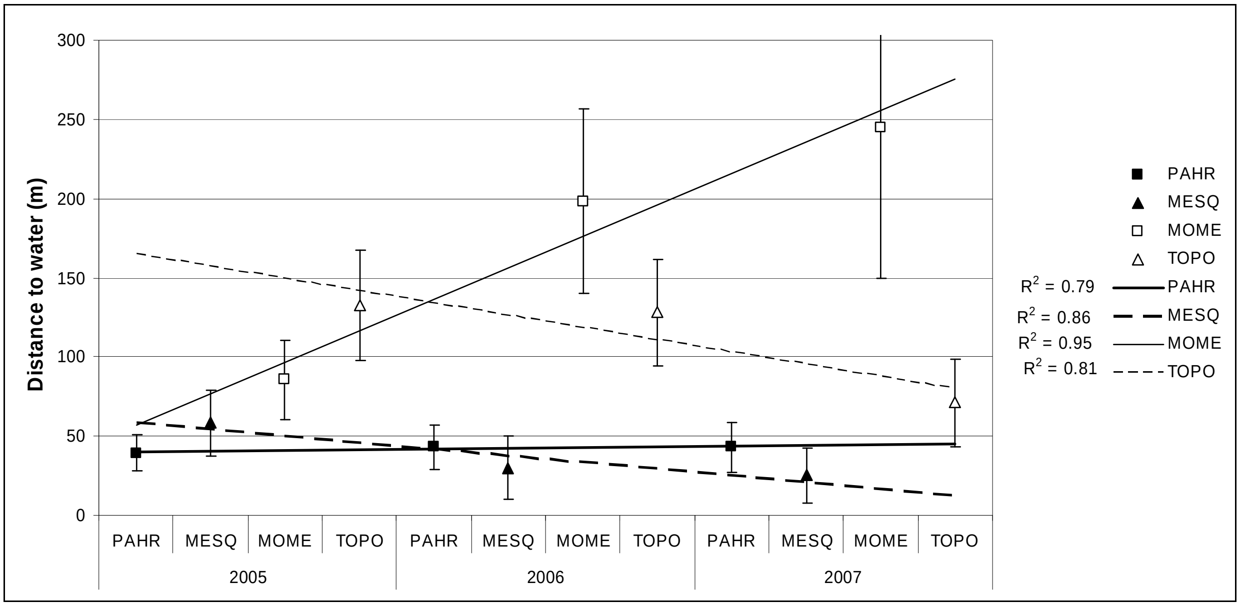

Figure 6.4. Mean and 95% CI of distance to water at habitat block points at Pahranagat (PAHR), Mesquite (MESQ), Mormon Mesa (MOME), and Topock Marsh (TOPO) in each year from 2005 to 2007. Lines show linear regression trends.

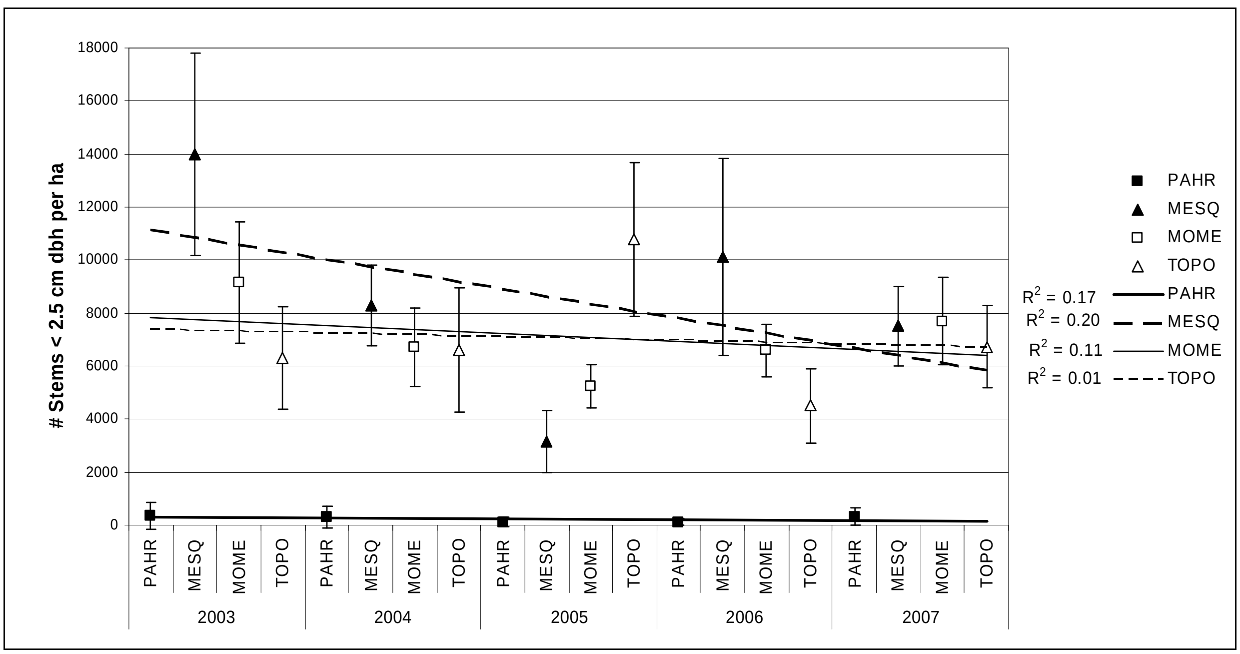

Figure 6.5. Mean and 95% CI of number of stems <2.5 cm dbh per ha at habitat block points at Pahranagat (PAHR), Mesquite (MESQ), Mormon Mesa (MOME), and Topock Marsh (TOPO) in each year from 2003 to 2007. Lines show linear regression trends.

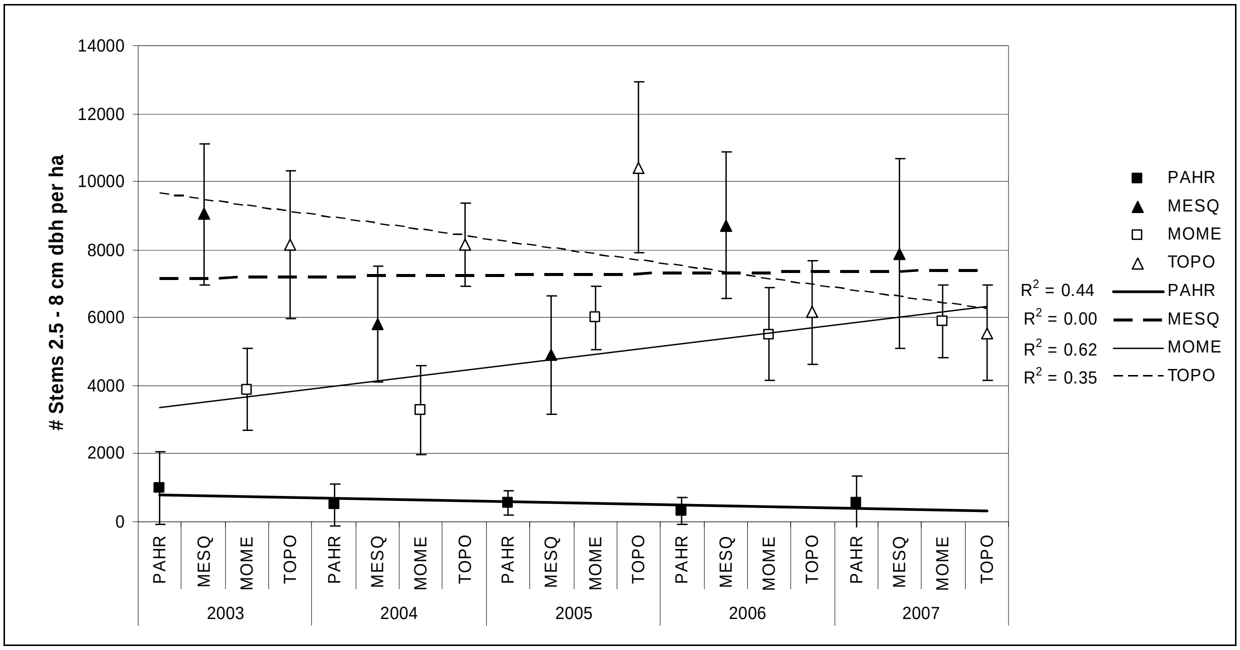

Figure 6.6. Mean and 95% CI of number of stems 2.5–8 cm dbh per ha at habitat block points at Pahranagat (PAHR), Mesquite (MESQ), Mormon Mesa (MOME), and Topock Marsh (TOPO) in each year from 2003 to 2007. Lines show linear regression trends.

Counts of stems >8 cm dbh within 5 m of plot center did not differ between years at any of the study areas (Figure 6.7). There was a trend for stem counts in this size class to increase through time at Topock. Counts of stems >8 cm dbh in the 5- to 11-m-radius circle did not differ between years at either Pahranagat or Mesquite (Figure 6.8). Stem counts at Mormon Mesa were higher in 2003 than in 2004 or 2005, and counts at Topock were higher in 2004 than in 2003. There were no clear trends in stem counts in the 5- to 11-m-radius circle at any of the study areas.

Distance to canopy gap did not differ among years at Pahranagat or Mesquite. Chi-square analyses indicated between-year differences at both Mormon Mesa and Topock, although expected cell counts in the 15–30 m and >30 m categories were <5, making these results hard to interpret. Visual inspection of the expected and observed counts at both study areas suggested that in 2005 a greater proportion of plots had distances to canopy gap of 15–30 m or >30 m, and when 2005 was removed from the analysis, no between-year differences were indicated. Distance to the nearest broadleaf did not differ among years at any study area.

Vertical foliage density differed between years in several intervals at all study areas (Tables 6.1–6.4). The following patterns were apparent: 1) Vertical foliage density at Pahranagat in the 12–21 m range was less in 2004 than in 2006; 2) vertical foliage density in most intervals was lowest at Mesquite in 2005; 3) vertical foliage density at Mormon Mesa in the first 2-m intervals was lower in 2005 and 2006 than in other years, and both years differed significantly from 2003; and 4) vertical foliage density in the first 5-m intervals at Topock was generally significantly lower in 2006 than in 2003 or 2004. Intermediate vertical foliage values were recorded in 2005 and 2007.

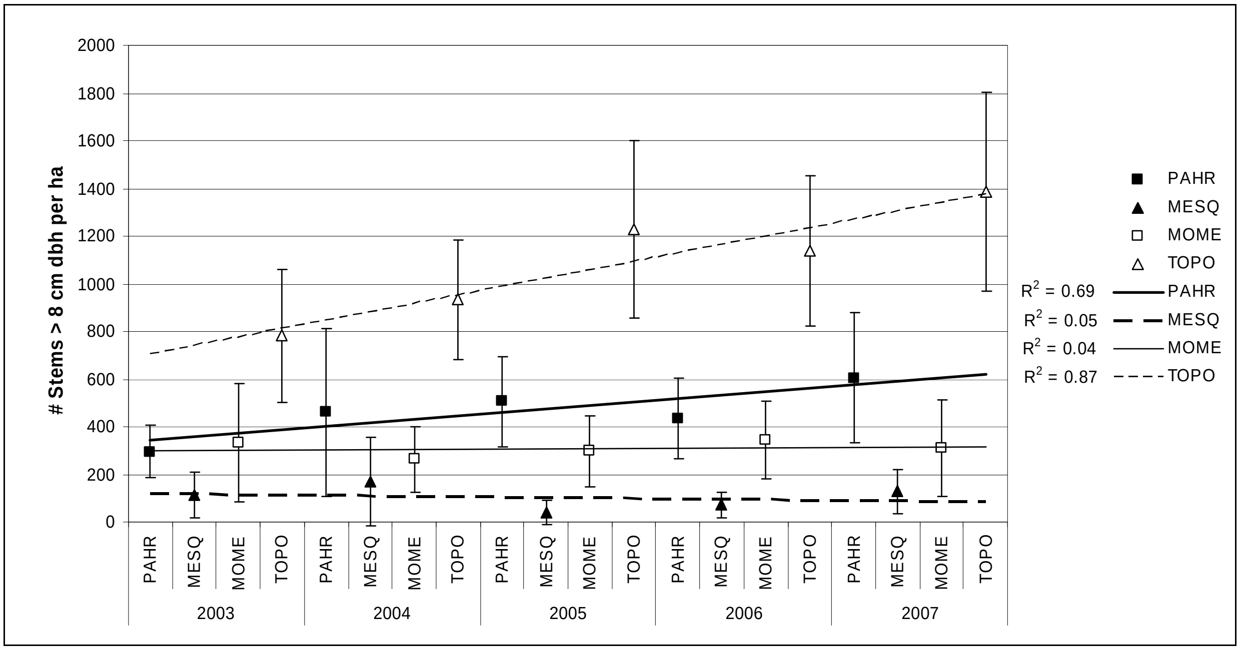

Figure 6.7. Mean and 95% CI of number of stems >8 cm dbh per ha at habitat block points at Pahranagat (PAHR), Mesquite (MESQ), Mormon Mesa (MOME), and Topock Marsh (TOPO) in each year from 2003 to 2007. Lines show linear regression trends.

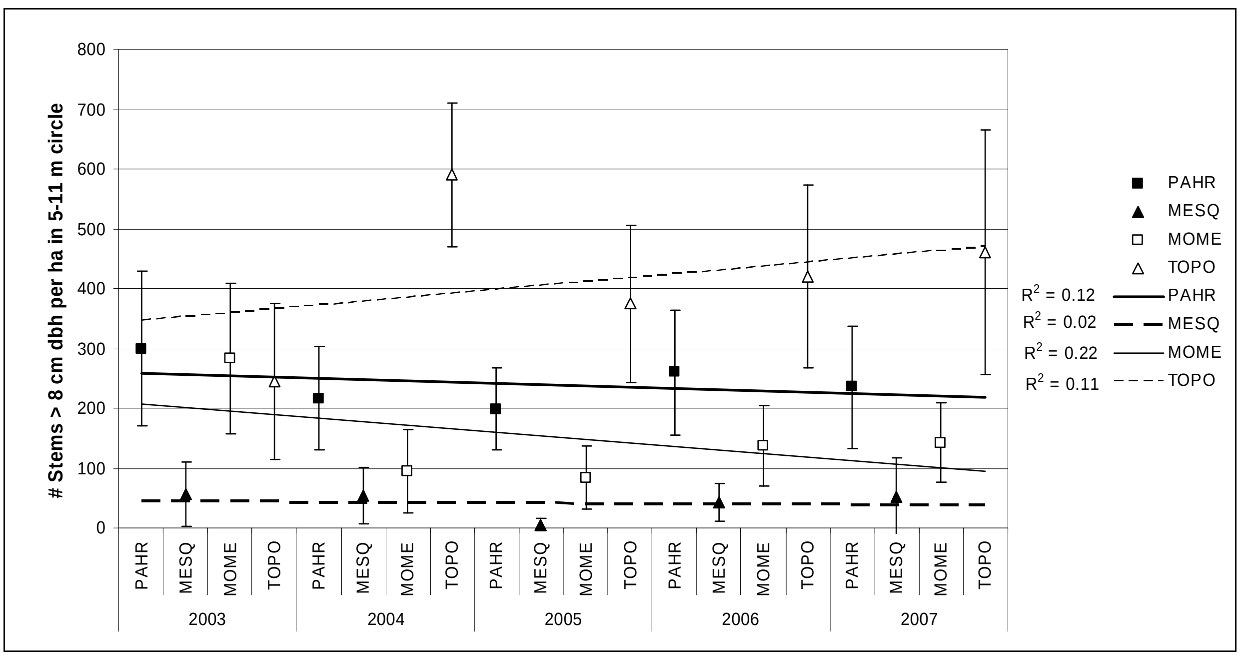

Figure 6.8. Mean and 95% CI of number of stems >8 cm dbh per ha in the 5- to 11-m-radius circle at habitat block points at Pahranagat (PAHR), Mesquite (MESQ), Mormon Mesa (MOME), and Topock Marsh (TOPO) in each year from 2003 to 2007. Lines show linear regression trends.

Table 6.1. Between-year Comparisons of Vertical Foliage Density in Each Meter Interval at Pahranagat, 2003–2007*

Meter Interval	Year				
	2003	2004	2005	2006	2007
1	7.4 (2.2)	11.1 (1.9)	6.3 (1.6)	13 (2.5)	10.9 (1.7)
2	12.7 (2.2)	9.1 (1.6)	7.6 (1.3)	11.9 (2)	13.3 (2)
3	19 (2.5) B	11.4 (1.8) A,B	10.4 (1.2) A	10.7 (1.9) A	15.4 (2.2) A,B
4	21.2 (2.8) B	11.8 (1.8) A	11.1 (1.3) A	12.8 (2) A	12.3 (2.1) A
5	18 (2.3)	12.3 (2)	11 (1.4)	12.5 (1.7)	11.7 (1.8)
6	11.9 (2.5)	10.8 (1.8)	9.8 (1.3)	8.6 (1.6)	9.6 (1.4)
7	10.1 (2.4)	10.7 (1.7)	8.4 (1.2)	9.9 (1.6)	10.7 (1.3)
8	11.1 (2.4)	13 (2.2)	10.8 (1.6)	10 (1.6)	10.4 (1.8)
9	11.9 (2.5)	14.6 (2.2)	12.1 (1.9)	8.6 (1.5)	9.1 (1.5)
10	9.8 (2.4)	12.9 (2.4)	13.1 (1.8)	8.2 (1.4)	8 (1.5)
11	8.1 (2.3)	10.7 (2.1)	13.4 (2.1)	7.5 (1.4)	9.3 (1.5)
12	8.3 (2.0)	10.3 (2.0)	13 (2.1)	10 (1.9)	8.2 (1.5)
13	9.6 (2.1)	5.2 (1.3)	11.3 (1.8)	10.9 (2.1)	7.9 (1.5)
14	9.6 (2.4)	2.8 (1.2)	9.7 (2)	9.8 (1.8)	6.9 (1.4)
15	7.1 (2.2) A,B	1.8 (1) A	7 (1.8) A,B	8.9 (1.7) B	5.8 (1.4) A,B
16	5.7 (1.9) A,B	0.6 (0.5) A	5.2 (1.6) A,B	8.8 (2) B	5.1 (1.4) A,B
17	5.1 (1.7) A,B	0 (0) A	3.6 (1.3) A,B	7.6 (1.8) B	4.9 (1.6) A,B
18	5.8 (2.1) A,B	0 (0) A	1.8 (1.1) A,B	7.6 (1.8) B	6.4 (2.0) B
19	4.7 (2.1) A,B	0 (0) A	2.8 (1.2) A,B	7.2 (1.9) B	3.8 (1.3) A,B
20	3.4 (1.8) A,B	0 (0) A	3.2 (1.3) A,B	6.8 (1.9) B	3.9 (1.3) A,B
21	2.4 (1.7) A,B	0 (0) A	2.8 (1.2) A,B	5.7 (1.6) B	3.5 (1.4) A,B
22	2.3 (1.7)	0 (0)	1.8 (1.1)	4.2 (1.5)	3.6 (1.5)
23	2.3 (1.7)	0 (0)	1.2 (0.7)	3.3 (1.4)	3 (1.4)
24	2.3 (1.7)	0 (0)	0.3 (0.3)	2.3 (1)	2.6 (1.4)
25	2.3 (1.7)	0 (0)	0.3 (0.3)	0.7 (0.4)	1.4 (1.0)

*Significant differences (Tukey's test, α=0.05) between years for a given meter interval are indicated by alpha codes; years with different letters differed from one another, while years with the same letter did not. No alpha codes are given for meter intervals that did not differ among years. Vertical foliage counts are total hits summed across all species. Data are presented as mean (SE).

Table 6.2. Between-year Comparisons of Vertical Foliage Density in Each Meter Interval at Mesquite, 2003–2007*

Meter interval	Year				
	2003	2004	2005	2006	2007
1	13.2 (2.4) A,B	27.6 (3) C	10.8 (1.6) A	12.8 (2.8) A	22.9 (2.3) B,C
2	23.6 (2.7) A,B	32.8 (2.7) B	18.8 (1.7) A	21 (3.4) A	33.1 (2.9) B
3	28.1 (2.8) B	25.6 (2) B	15.8 (2.1) A	30.5 (1.0) B	28.3 (1.9) B
4	20.4 (2.5) B	20.2 (2.5) B	8.8 (2) A	18.3 (1.3) B	21.2 (2.3) B
5	10.3 (2.1) A,B	12.6 (2.3) B	3.3 (1) A	15.3 (7.5) B	14.1 (2.5) B
6	3.6 (1.2)	4.5 (1.5)	0.7 (0.3)	1.0 (1.0)	5 (1.6)
7	0.1 (0.1)	1 (0.7)	0 (0)	0 (0)	0.1 (0.1)

*Significant differences (Tukey's test, α=0.05) between years for a given meter interval are indicated by alpha codes; years with different letters differed from one another, while years with the same letter did not. No alpha codes are given for meter intervals that did not differ among years. Vertical foliage counts are total hits summed across all species. Data are presented as mean (SE).

Table 6.3. Between-year Comparisons of Vertical Foliage Density in Each Meter Interval at Mormon Mesa, 2003–2007*

Meter interval	Year				
	2003	2004	2005	2006	2007
1	19.3 (2.5) B	17.2 (2.1) A,B	10.3 (1.3) A	10.9 (1.2) A	14.4 (1.3) A,B
2	28.9 (2.6) B	22.7 (2.7) A,B	18.6 (1.5) A	19.8 (1.7) A	24.7 (2.1) A,B
3	27.2 (2.9)	22.5 (3)	22.2 (2)	21.3 (2)	29.3 (2.3)
4	18.4 (3)	14.6 (2.6)	11.9 (1.4)	13 (1.7)	18.4 (2.4)
5	9.6 (2.3)	5.9 (1.7)	6.2 (1.6)	6.8 (1.6)	11.4 (2)
6	5.9 (1.8)	5.5 (2.2)	3.3 (1.1)	3.7 (1.1)	4.3 (1.4)
7	5.1 (1.9)	5.8 (2.5)	1.1 (0.4)	1.8 (0.9)	1.4 (0.9)
8	3 (1.4)	3.8 (1.8)	0.3 (0.3)	1.1 (0.8)	0.2 (0.2)
9	2.6 (1.4)	2.2 (1.3)	0.1 (0.1)	0.9 (0.9)	0 (0)
10	2.3 (1.4)	0 (0)	0 (0)	0.9 (0.9)	0 (0)
11	1.4 (1)	0 (0)	0 (0)	0.8 (0.8)	0 (0)
12	0.9 (0.6)	0 (0)	0 (0)	0.3 (0.3)	0 (0)
13	0.3 (0.2)	0 (0)	0 (0)	0.1 (0.1)	0 (0)

*Significant differences (Tukey's test, α=0.05) between years for a given meter interval are indicated by alpha codes; years with different letters differed from one another, while years with the same letter did not. No alpha codes are given for meter intervals that did not differ among years. Vertical foliage counts are total hits summed across all species. Data are presented as mean (SE).

Table 6.4. Between-year Comparisons of Vertical Foliage Density in Each Meter Interval at Topock, 2003–2007*

Meter interval	Year				
	2003	2004	2005	2006	2007
1	21.7 (2.6) B	16.8 (2.3) A,B	13.4 (2.4) A,B	9.3 (2.1) A	12.7 (1.8) A
2	28.9 (2.4) B	29.6 (2.5) B	21.5 (2) A,B	17.7 (1.8) A	16.4 (1.7) A
3	28 (2.2) A,B	34.7 (2.9) B	29.1 (2.7) A,B	22.6 (1.6) A	22.5 (1.9) A
4	27.6 (2.8) B	28.7 (2.5) B	25.3 (2.8) A,B	17 (1.8) A	19.2 (2.1) A,B
5	23.1 (3) B	22.6 (2.5) B	21.2 (2.6) A,B	13.1 (1.5) A	16.7 (1.9) A,B
6	17.3 (2.8)	17.4 (2.6)	14 (2.3)	9.3 (1.7)	13.4 (2)
7	12.4 (2.9)	11.2 (2.6)	6.9 (1.7)	5.7 (1.4)	6.6 (1.4)
8	5.3 (1.7)	4.1 (1.3)	1.9 (0.9)	2.3 (0.8)	1.9 (0.9)
9	1.4 (0.8)	1.4 (0.7)	0.1 (0.1)	0.1 (0.1)	0.8 (0.4)
10	1.3 (1.1)	1 (0.7)	0 (0)	0 (0)	0.2 (0.2)
11	0.3 (0.2)	0.8 (0.6)	0 (0)	0 (0)	0.1 (0.1)
12	0 (0)	0.7 (0.5)	0 (0)	0 (0)	0 (0)
13	0 (0)	0.4 (0.3)	0 (0)	0 (0)	0 (0)
14	0 (0)	0.3 (0.3)	0 (0)	0 (0)	0 (0)

*Significant differences (Tukey's test, α=0.05) between years for a given meter interval are indicated by alpha codes; years with different letters differed from one another, while years with the same letter did not. No alpha codes are given for meter intervals that did not differ among years. Vertical foliage counts are total hits summed across all species. Data are presented as mean (SE).

VEGETATION MEASUREMENTS AT THE NEST

Nest substrate included five woody species of trees, one exotic and four native, as well as dead trees. Flycatchers placed 63% of all nests in tamarisk, 23% in Goodding willow, 10% in coyote willow, 1% in Fremont cottonwood, 0.3% in screwbean mesquite, and 3% in snags. Nest height, substrate height, and substrate dbh did not differ across time at any study area, and there was no interaction between year and study area; therefore, data from each study area were pooled across years. Nest substrate height, substrate dbh, and nest height differed across study areas (Table 6.5). Nest height at Mesquite, Mormon Mesa, and Muddy River was lower than that at Topock or Pahranagat. Nest substrate height and dbh was higher at Pahranagat than at any of the other study areas. Nest substrate height at Bill Williams was also significantly taller than at Mesquite, Mormon Mesa, Muddy River, or Topock. Overall, willow flycatcher nest height ranged from 1.0 to 15.0 m, with a mean nest height of 3.2 m (SE = 0.1). Nest substrate height ranged from 1.7 to 27.8 m, with a mean nest substrate height of 6.0 m (SE = 0.2). Nest substrate dbh was highly variable, ranging from 0.9 to 235.0 cm, with a mean nest substrate dbh of 12.3 cm (SE = 1.2).

Table 6.5. Summary of Nest Measurements at All Study Areas Where Nests Were Located, 2003–2007*

Parameter	Pahranagat (n = 72)	Littlefield (n = 2)	Mesquite (n = 79)	Mormon Mesa (n = 40)	Muddy River (n = 23)	Grand Canyon (n = 4)	Topock (n = 103)	Bill Williams (n = 16)
Nest height (m)	3.8 (0.3) 1.2–15.0 B	2.2 (0.2) 2.0–2.4	2.1 (0.1) 1.0–3.4 A	2.6 (0.2) 1.4–9.3 A	2.4 (0.1) 1.4–3.5 A	2.4 (0.2) 2.0–2.8	3.7 (0.1) 1.3–6.7 B	4.6 (0.4) 1.7–7.6 B
Nest substrate[1]	4% POFR 3% SAEX 90% SAGO 3% TASP	100% SAEX	30% SAEX 66% TASP 4% SNAG	5% SAEX 5% SAGO 75% TASP 15% SNAG	17% SAEX 17% SAGO 61% TASP 4% SNAG	100% SAGO	1% PRSP 99% TASP	19% SAGO 81% TASP
Nest substrate height (m)	11.5 (0.7) 2.5–27.8 C	3.3 (0.5) 2.8–3.7	3.4 (0.1) 1.7–6.0 A	4.4 (0.3) 2.3–13.8 A	4.4 (0.4) 1.9–10.0 A	5.0 (1.7) 2.8-10.0	5.3 (0.1) 2.3–9.0 A	7.4 (0.8) 3.1–16.0 B
Nest substrate dbh (cm)	39.8 (4.1) 1.5–235.0 B	1.8 (0.5) 1.3–2.2	2.5 (0.1) 0.9–6.9 A	4.2 (0.5) 1.0–17.4 A	4.4 (0.9) 0.9–16.0 A	5.0 (2.7) 1.5–13.0	5.9 (0.3) 1.7–21.8 A	11.2 (2.8) 2.5–38.8 A

* Numerical data presented are means, (standard error), and range. Significant differences (Tukey's test, α = 0.05) between study areas for a given continuous variable are indicated by alpha codes; study areas with different letters differed from one another, while those with the same letter did not. Study areas were not included in statistical comparisons if sample size was less than five.
[1] TASP = ***Tamarix*** sp**.** (tamarisk), SAEX = ***Salix exigua*** (coyote willow), SAGO = ***Salix gooddingii*** (Goodding willow), PRSP = mesquite (***Prosopis***) species, POFR = ***Populus fremontii*** (Fremont cottonwood), SNAG = standing dead tree.

Vegetation Measurements at Nest, Within-Territory, and Non-Use Plots

The ANOVA results from the NS/NU comparison using the complete data set did not differ from the repeated measures ANOVA results; therefore, only the repeated measures results are presented here.

A total of 393 vegetation plots associated with corresponding NS, WT, and NU sites were available from the four life history study areas and Muddy River from 2005–2007. The number of matched sets of three vegetation plots (1 NS, 1 WT, and 1 NU) that could be used in the matched analysis was 131 (393 ÷ 3 = 131).

Canopy height was significantly greater at NS compared to NU plots at Mesquite, Muddy River, Mormon Mesa, and Topock, and canopy height was also greater at NS compared to WT plots at Mesquite and Muddy River (Tables 6.6 to 6.10). At Pahranagat, NU plots exhibited greater canopy height than either NS or WT. Canopy closure was significantly greater at NS vs. NU plots at Pahranagat, Mesquite, Muddy River, and Topock. Canopy closure at NS plots did not differ from that at WT plots at any study area.

Woody ground cover was less at NS and WT plots than at NU plots at Mesquite and Mormon Mesa. Woody ground cover did not differ among locations at any of the other study areas.

The number of shrub stems <2.5 cm dbh differed between NS and NU locations only at Topock, where nest sites had fewer stems in the <2.5 cm dbh category. NS sites did not differ from WT locations in this category at any study area. Numbers of shrub stems from 2.5 to 8.0 cm dbh

Table 6.6. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Vegetation Measures: **Pahranagat NWR**, 2005–2007*

Response Variable	Nest Site (n = 28)	Within Territory (n = 28)	Non-Use (n = 28)	P	Significant Pairwise Differences
Canopy height (m)	18.5 (1.4)	18.0 (1.3)	23.1 (1.4)	0.002	NS & WT < NU
Canopy closure (%)	92.8 (1.3)	90.9 (1.4)	79.3 (3.6)	<0.001	NS & WT > NU
Woody ground cover (%)	47.6 (5.8)	40.6 (5.8)	40.1 (6.7)	0.437	N/A
No. stems <2.5 cm dbh per ha	122.8 (92.7)	50.0 (33.0)	105.6 (56.4)	0.702	N/A
No. stems 2.5–8 cm dbh per ha	418.4 (191.7)	268.3 (126.0)	231.9 (72.9)	0.332	N/A
No. stems >8 cm dbh per ha	418.4 (96.0)	472.9 (81.8)	645.8 (134.4)	0.331	N/A
No. stems >8 cm dbh per ha in 5- to 11-m-radius circle	205.9 (32.3)	261.3 (35.0)	177.1 (30.8)	0.181	N/A
Distance (m) to water during nesting**	7.9 (3.1)	--	18.9 (4.2)	0.021	NS < NU
Percent of basal area native	95.9 (4.0)	95.8 (4.2)	96.0 (4.0)	1.000	N/A
Vertical foliage (hits) below nest	39.3 (6.9)	38.8 (7.3)	36.9 (11.0)	0.941	N/A
Vertical foliage (hits) at nest	22.6 (1.6)	11.9 (1.6)	12.3 (1.8)	<0.001	NS > WT & NU
Vertical foliage (hits) above nest	167 (16.2)	111.8 (14.5)	166.5 (16.6)	0.016	NS & NU > WT
Distance (m) to canopy gap					
<15 m	26	26	28	0.264	N/A
15–30m	2	2	0		
>30 m	0	0	0		
Distance (m) to broadleaf					
<15 m	27	27	28	0.368	N/A
15–30m	1	1	0		
>30 m	0	0	0		

*Nest, within territory, and non-use areas are matched within study area. Standard errors in parentheses. N/A = data not available or not applicable.

** Data on distance to water during nesting were collected only at NS and NU locations during 2006 and 2007.

were greater at NS compared to NU locations at Mesquite and Mormon Mesa, while NU plots had higher shrub counts in this category than NS plots at Topock. NS plots had greater stem counts in this category than WT plots only at Mormon Mesa. Numbers of stems >8 cm dbh differed between NS and NU plots at Mesquite, Mormon Mesa, and Topock; in all cases NS plots had higher stem counts in this category. Numbers of stems >8 cm dbh in the 5- to 11-m-radius circle were greater at NS vs. NU plots at both Mormon Mesa and Topock. NS, WT, and NU plots did not differ in any stem count categories at Pahranagat or Muddy River.

Distance to water during nesting was significantly less at NS plots compared to NU plots at Pahranagat, Mesquite, Mormon Mesa, and Muddy River. There was a trend at Topock for NS sites to be closer to water than NU locations ($P = 0.056$). The percent basal area that was native was greater at NS vs. NU plots at Mesquite and Muddy River, and Mormon Mesa exhibited the same trend ($P = 0.06$).

Table 6.7. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Vegetation Measures: **Mesquite**, 2005–2007*

Response Variable	Nest Site (n = 31)	Within Territory (n = 31)	Non-Use (n = 31)	P	Significant Pairwise Differences
Canopy height (m)	5.4 (0.1)	5.1 (0.1)	3.6 (0.2)	<0.001	NS > WT > NU
Canopy closure (%)	92.3 (0.7)	91.5 (1.1)	71.0 (4.1)	<0.001	NS & WT > NU
Woody ground cover (%)	22.7 (3.5)	19.8 (3.1)	36.5 (4.7)	0.006	NS & WT < NU
No. stems <2.5 cm dbh per ha	7097.6 (822.7)	7036.0 (766.6)	5261.6 (1287.6)	0.264	N/A
No. stems 2.5–8 cm dbh per ha	11274.9 (923.9)	10067.3 (764.2)	4370.3 (790.0)	<0.001	NS & WT > NU
No. stems >8 cm dbh per ha	316.3 (73.3)	271.1 (75.6)	32.9 (13.2)	0.001	NS & WT > NU
No. stems >8 cm dbh per ha in 5- to 11-m-radius circle	63.0 (23.8)	94.0 (30.0)	47.0 (22.6)	0.321	N/A
Distance (m) to water during nesting	8.6 (2.6)	--	44.5 (7.7)	<0.001	NS < NU
Percent of basal area native	78.2 (3.4)	72.2 (4.7)	58.9 (7.0)	0.017	NS > NU
Vertical foliage (hits) below nest	28.2 (3.1)	30.6 (3.3)	30.7 (3.1)	0.714	N/A
Vertical foliage (hits) at nest	24.8 (1.7)	26.1 (1.7)	20.4 (1.9)	0.034	WT > NU
Vertical foliage (hits) above nest	56.7 (4.8)	52.2 (4.3)	22.7 (3.1)	<0.001	NS & WT > NU
Distance (m) to canopy gap					
<15 m	24	25	29	0.174	N/A
15–30m	5	5	1		
>30 m	2	1	1		
Distance (m) to broadleaf					
<15 m	31	31	30	0.368	N/A
15–30m	0	0	1		
>30 m	0	0	0		

*Nest, within territory, and non-use areas are matched within study area. Standard errors in parentheses. N/A = data not available or not applicable.

** Data on distance to water during nesting were collected only at NS and NU locations during 2006 and 2007.

Vertical foliage density below the nest layer exhibited no significant difference between NS, WT, and NU plots at any of the study areas. Vertical foliage density at the nest layer was significantly greater at NS vs. NU plots at Pahranagat and Topock and was also greater at NS vs. WT plots at Pahranagat. Vertical foliage density above the nest layer was significantly greater at NS vs. NU plots at Mesquite, Mormon Mesa, Muddy River, and Topock. Vertical foliage density above the nest was greater at NS vs. WT plots at Mormon Mesa.

Distance to the nearest canopy gap did not differ among NS, WT, and NU locations at any of the five study areas. NS and WT plots were significantly closer than NU plots to broadleaf vegetation at Mormon Mesa, Muddy River, and Topock.

Table 6.8. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Vegetation Measures: **Mormon Mesa**, 2005–2007*

Response Variable	Nest Site (n = 23)	Within Territory (n = 23)	Non-Use (n = 23)	P	Significant Pairwise Differences
Canopy height (m)	5.7 (0.2)	5.7 (0.2)	4.1 (0.2)	<0.001	NS & WT > NU
Canopy closure (%)	89.2 (1.3)	90.3 (1.2)	82.8 (3.2)	0.024	WT > NU
Woody ground cover (%)	18.6 (2.3)	18.7 (2.6)	32.7 (4.7)	0.001	NS & WT < NU
No. stems <2.5 cm dbh per ha	5425.4 (378.9)	5115.3 (399.0)	7263.4 (905.3)	0.013	WT < NU
No. stems 2.5–8 cm dbh per ha	7805.9 (728.8)	6715.3 (544.1)	4882.8 (501.6)	0.001	NS > WT > NU
No. stems >8 cm dbh per ha	592.4 (134.6)	525.9 (129.7)	299.0 (86.4)	0.082	NS > NU
No. stems >8 cm dbh per ha in 5- to 11-m-radius circle	277.7 (44.1)	234.5 (51.3)	124.0 (37.8)	0.033	NS > NU
Distance (m) to water during nesting	110.8 (53.9)	--	342.3 (91.1)	0.014	NS < NU
Percent of basal area native	21.2 (7.2)	18.4 (5.8)	4.8 (3.3)	0.060	N/A
Vertical foliage (hits) below nest	32.6 (3.9)	33.0 (3.4)	38.6 (5.1)	0.160	N/A
Vertical foliage (hits) at nest	23.7 (2.2)	24.6 (1.8)	25.1 (2.6)	0.883	N/A
Vertical foliage (hits) above nest	63.6 (5.7)	42.3 (3.1)	27.7 (5.2)	<0.001	NS > WT > NU
Distance (m) to canopy gap					
<15 m	19	14	18		
15–30m	4	5	1	0.191	N/A
>30 m	0	4	0		
Distance (m) to broadleaf					
<15 m	21	21	10		
15–30m	1	1	1	<0.001	NS & WT - NU
>30 m	1	1	12		

*Nest, within territory, and non-use areas are matched within study area. Standard errors in parentheses. N/A = data not available or not applicable.

** Data on distance to water during nesting were collected only at NS and NU locations during 2006 and 2007.

Table 6.9. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Vegetation Measures: **Muddy River**, 2005–2007*

Response Variable	Nest Site (n = 23)	Within Territory (n = 23)	Non-Use (n = 23)	P	Significant Pairwise Differences
Canopy height (m)	6.8 (0.3)	6.6 (0.3)	4.9 (0.3)	<0.001	NS > WT > NU
Canopy closure (%)	93.0 (1.0)	92.9 (0.9)	84.9 (4.3)	0.025	NS > NU
Woody ground cover (%)	27.8 (4.9)	26.9 (4.4)	28.0 (5.2)	0.965	N/A
No. stems <2.5 cm dbh per ha	5048.9 (694.9)	4976.9 (875.1)	4960.3 (731.0)	0.993	N/A
No. stems 2.5–8 cm dbh per ha	8204.5 (777.7)	6482.8 (790.2)	7994.1 (1164.8)	0.245	N/A
No. stems >8 cm dbh per ha	1096.2 (179.5)	1085.1 (136.5)	841.5 (226.7)	0.404	N/A
No. stems >8 cm dbh per ha in 5- to 11-m-radius circle	440.7 (66.1)	459.6 (88.9)	237.2 (63.6)	0.054	N/A
Distance (m) to water during nesting	13.3 (4.1)		38.4 (7.5)	0.006	NS < NU
Percent of basal area native	59.2 (7.6)	57.3 (8.3)	3.1 (2.4)	<0.001	NS & WT > NU
Vertical foliage (hits) below nest	30.4 (5.1)	32.6 (3.4)	31.0 (4.9)	0.864	N/A
Vertical foliage (hits) at nest	19.6 (1.2)	21.6 (1.9)	22.8 (1.8)	0.364	N/A
Vertical foliage (hits) above nest	76.6 (6.4)	74.3 (6.3)	42.4 (7.1)	0.001	NS & WT > NU
Distance (m) to canopy gap					
<15 m	20	18	17	0.336	N/A
15–30m	3	5	1		
>30 m	0	0	0		
Distance (m) to broadleaf					
<15 m	22	22	4	<0.001	NS & WT - NU
15–30m	1	1	2		
>30 m	0	0	17		

*Nest, within territory, and non-use areas are matched within study area. Standard errors in parentheses. N/A = data not available or not applicable.

** Data on distance to water during nesting were collected only at NS and NU locations during 2006 and 2007.

Table 6.10. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Vegetation Measures: **Topock**, 2005–2007*

Response Variable	Nest Site (n = 26)	Within Territory (n = 26)	Non-Use (n = 26)	P	Significant Pairwise Differences
Canopy height (m)	6.8 (0.2)	6.5 (0.3)	5.4 (0.2)	0.001	NS & WT > NU
Canopy closure (%)	95.9 (0.6)	94.7 (0.8)	88.3 (2.0)	<0.001	NS & WT > NU
Woody ground cover (%)	20.4 (4.5)	21.1 (4.7)	21.7 (4.6)	0.814	N/A
No. stems <2.5 cm dbh per ha	4686.7 (787.8)	4935.9 (646.5)	9779.9 (1704.0)	0.001	NS & WT < NU
No. stems 2.5–8 cm dbh per ha	5083.4 (585.0)	4935.3 (568.9)	7605.5 (862.9)	0.002	NS & WT < NU
No. stems >8 cm dbh per ha	1346.8 (154.6)	1395.5 (178.2)	773.8 (109.6)	0.002	NS & WT > NU
No. stems >8 cm dbh per ha in 5- to 11-m-radius circle	478.1 (94.4)	457.6 (102.2)	231.3 (49.3)	0.061	NS > NU
Distance (m) to water during nesting	53.6 (17.8)	--	104.4 (19.4)	0.056	N/A
Percent of basal area native	2.2 (1.5)	3.8 (2.2)	5.6 (4.1)	0.525	N/A
Vertical foliage (hits) below nest	62.8 (6.6)	59.7 (7.0)	70.7 (7.9)	0.265	N/A
Vertical foliage (hits) at nest	24.8 (1.7)	26.0 (2.4)	19.2 (2.3)	0.020	NS & WT > NU
Vertical foliage (hits) above nest	62.9 (6.0)	51.3 (7.7)	30.8 (5.9)	<0.001	NS & WT > NU
Distance (m) to canopy gap					
<15 m	24	22	20	0.068	N/A
15–30m	0	2	0		
>30 m	1	1	5		
Distance (m) to broadleaf					
<15 m	10	8	3	0.005	NS & WT - NU
15–30m	2	4	1		
>30 m	13	13	21		

*Nest, within territory, and non-use areas are matched within study area. Standard errors in parentheses. N/A = data not available or not applicable.

** Data on distance to water during nesting were collected only at NS and NU locations during 2006 and 2007.

Data from all five study areas were combined (Table 6.11) to demonstrate which vegetation variables exhibited significant differences between NS, WT, and NU plots at a regional level. Five of the 14 vegetation variables exhibited no significant differences between nest and either within-territory or non-use locations: canopy height, percent woody ground cover, number of shrub stems <2.5 cm dbh, vertical foliage density below the nest layer, and distance to canopy gap. Nest sites exhibited greater canopy closure, number of stems 2.5–8.0 cm dbh, number of stems >8.0 cm dbh in the 5-m-radius circle, number of stems >8.0 cm dbh in the 5- to 11.3-m-radius circle, percent basal area that was native, and vertical foliage density at and above the nest layer when compared to non-use sites. NS locations were also closer to broadleaf vegetation and water than NU locations. NS differed from WT locations only in having a greater number of stems 2.5–8.0 cm dbh and greater vertical foliage density above the nest layer.

Table 6.11. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Vegetation Measures: **All Study Areas**, 2005–2007*

Response Variable	Nest Site (n = 131)	Within Territory (n = 131)	Non-Use (n = 131)	P	Significant Pairwise Differences
Canopy height (m)	8.7 (0.5)	8.5 (0.5)	8.5 (0.7)	0.734	N/A
Canopy closure (%)	92.7 (0.5)	92.0 (0.5)	80.6 (1.7)	<0.001	NS & WT > NU
Woody ground cover (%)	27.9 (2.2)	25.6 (2.0)	32.1 (2.4)	0.008	WT < NU
No. stems <2.5 cm dbh per ha	4475.0 (353.6)	4429.0 (348.7)	5354.7 (567.5)	0.105	N/A
No. stems 2.5–8 cm dbh per ha	6577.4 (454.6)	5742.6 (400.1)	4854.1 (410.7)	0.001	NS > WT & NU
No. stems >8 cm dbh per ha	728.0 (66.1)	719.9 (64.9)	499.6 (61.5)	0.001	NS & WT > NU
No. stems >8 cm dbh per ha in 5- to 11-m-radius circle	280.0 (28.2)	289.5 (30.9)	158.3 (19.2)	<0.001	NS & WT > NU
Distance (m) to water during nesting	33.8 (9.3)	--	94.8 (17.1)	<0.001	NS < NU
Percent of basal area native	52.6 (3.8)	50.6 (3.8)	35.5 (3.9)	<0.001	NS & WT > NU
Vertical foliage (hits) below nest	38.8 (2.6)	38.9 (2.5)	41.4 (3.4)	0.462	N/A
Vertical foliage (hits) at nest	23.2 (0.8)	22.0 (1.0)	19.7 (1.0)	0.005	NS & WT > NU
Vertical foliage (hits) above nest	86.2 (5.5)	66.9 (4.4)	59.4 (6.4)	<0.001	NS > WT & NU
Distance (m) to canopy gap					
<15 m	113	105	112	0.397	N/A
15–30m	10	19	3		
>30 m	7	6	15		
Distance (m) to broadleaf					
<15 m	111	109	75	<0.001	NS & WT - NU
15–30m	5	6	5		
>30 m	14	15	50		

*Nest, within territory, and non-use areas are matched within study area. Standard errors in parentheses. N/A = data not available or not applicable.

** Data on distance to water during nesting were collected only at NS and NU locations during 2006 and 2007.

When Pahranagat was removed from the analysis, two additional vegetation variables exhibited significant differences between NS and NU plots: canopy height was significantly greater at NS vs. NU plots, and woody ground cover was less at NS compared to NU locations (Table 6.12). When Pahranagat was removed from the analysis, vertical foliage density at the nest layer no longer differed between NS and NU sites, but NS differed from NU and from WT in all other variables that were significant in the overall analysis.

Conditional Logistic Regression Model. All continuous measures of vegetation were included in the initial multivariate models except for number of stems <2.5 cm dbh and vertical foliage density below the nest. The two variables distinguishing NS from WT locations in models both with and without Pahranagat were number of stems 2.5–8.0 cm dbh and vertical foliage density above the nest layer (Tables 6.13 and 6.14). Increases in these variables increased the likelihood

Table 6.12. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Vegetation Measures: **All Study Areas without Pahranagat**, 2005–2007*

Response Variable	Nest Site (n = 131)	Within Territory (n = 131)	Non-Use (n = 131)	P	Significant Pairwise Differences
Canopy height (m)	6.1 (0.1)	5.9 (0.1)	4.5 (0.1)	<0.001	NS & WT > NU
Canopy closure (%)	92.7 (0.5)	92.3 (0.5)	81.0 (1.9)	<0.001	NS & WT > NU
Woody ground cover (%)	22.4 (2.0)	21.5 (1.9)	30.0 (2.4)	0.001	NS & WT < NU
No. stems <2.5 cm dbh per ha	5658.2 (371.3)	5631.2 (362.5)	6781.9 (654.6)	0.107	N/A
No. stems 2.5–8 cm dbh per ha	8251.8 (451.3)	7245.3 (394.5)	6110.6 (447.8)	0.001	NS > WT & NU
No. stems >8 cm dbh per ha	812.2 (78.1)	787.7 (78.5)	459.9 (68.9)	<0.001	NS & WT > NU
No. stems >8 cm dbh per ha in 5- to 11-m-radius circle	300.1 (34.6)	297.2 (38.2)	153.2 (22.9)	<0.001	NS & WT > NU
Distance (m) to water during nesting	40.3 (11.5)	--	113.9 (20.9)	<0.001	NS < NU
Percent of basal area native	42.1 (4.0)	40.0 (3.9)	20.8 (3.5)	<0.001	NS & WT > NU
Vertical foliage (hits) below nest	38.6 (2.8)	38.9 (2.6)	42.6 (3.1)	0.167	N/A
Vertical foliage (hits) at nest	23.4 (0.9)	24.7 (1.0)	21.7 (1.1)	0.048	WT > NU
Vertical foliage (hits) above nest	64.2 (2.9)	54.7 (3.0)	30.2 (2.7)	<0.001	NS > WT > NU
Distance (m) to canopy gap					
<15 m	87	79	84	0.349	N/A
15–30m	8	17	3		
>30 m	7	6	15		
Distance (m) to broadleaf					
<15 m	84	82	47	<0.001	NS & WT - NU
15–30m	4	5	5		
>30 m	14	15	50		

*Nest, within territory, and non-use areas are matched within study area. Standard errors in parentheses. N/A = data not available or not applicable.

** Data on distance to water during nesting were collected only at NS and NU locations during 2006 and 2007.

of a location being a nest site. Canopy height, canopy closure, proportion of basal area that was native, and vertical foliage density above the nest layer distinguished NS from NU sites in models both with and without Pahranagat. Number of tree stems in the 5- to 11-m-radius circle was also a significant predictor in the model including Pahranagat. Increases in canopy closure, proportion of basal area that was native, vertical foliage density above the nest layer, and number of tree stems in the 5- to 11-m-radius circle increases the likelihood of a location being a nest site. In the model including Pahranagat, an increase in canopy height decreased the likelihood of the location being a nest site, while in the model excluding Pahranagat, an increase in canopy height made the location more likely to be a nest.

Table 6.13. Relative Importance of Vegetation Measures in Southwestern Willow Flycatcher Nest Site Selection for **All Study Areas**, 2003–2007*

Explanatory Variables	Coefficient	Wald	P	Odds Ratio	95% CI
NS versus WT					
Canopy height (m)	0.03	0.05	0.826	1.03	0.80–1.32
Canopy closure (%)	0.03	0.74	0.388	1.03	0.97–1.09
Woody ground cover (%)	0.01	1.20	0.273	1.01	0.99–1.03
No. shrub stems (2.5–8.0 cm dbh) per ha	**0.00**	**7.36**	**0.007**	**1.00**	**1.00–1.00**
No. tree stems (>8.0 cm dbh) per ha	0.00	0.05	0.823	1.00	1.00–1.00
No. tree stems (>8.0 cm dbh) per ha in 5- to 11-m radius circle	-0.00	0.79	0.376	1.00	1.00–1.00
Proportion basal area that is native	0.85	0.61	0.437	2.35	0.27–20.25
Vertical foliage at nest layer	0.00	0.00	0.980	1.00	0.96–1.04
Vertical foliage above nest layer	**0.02**	**9.61**	**0.002**	**1.02**	**1.01–1.03**
NS versus NU					
Canopy height (m)	**-0.12**	**5.34**	**0.021**	**0.89**	**0.81–0.98**
Canopy closure (%)	**0.09**	**27.69**	**<0.001**	**1.09**	**1.03–1.13**
Woody ground cover (%)	0.00	0.10	0.757	1.00	0.99–1.01
No. shrub stems (2.5–8.0 cm dbh) per ha	0.00	0.51	0.477	1.00	1.00–1.00
No. tree stems (>8.0 cm dbh) per ha	0.00	0.05	0.817	1.00	1.00–1.00
No. tree stems (>8.0 cm dbh) per ha in 5- to 11-m radius circle	**0.00**	**10.11**	**0.001**	**1.00**	**1.00–1.00**
Proportion basal area that is native	**2.87**	**20.30**	**<0.001**	**17.61**	**5.06–61.36**
Vertical foliage at nest layer	0.02	2.73	0.098	1.02	1.00–1.04
Vertical foliage above nest layer	**0.01**	**8.93**	**0.003**	**1.01**	**1.00–1.01**

* Variables remaining in the final model are shown in bold; for these variables, their corresponding statistical values from the final model have been presented. For variables removed through backward selection, corresponding statistical values have been presented for the time when the variable was removed. The odds ratio is the probability of nest selection given a one unit of change in that variable when the other variables are equal. This conditional logistic regression model accounts for the matching of corresponding NS/WT/NU sites by life history study areas and year. NS vs. WT model uses data from 2005 to 2007. CI = confidence interval.

Table 6.14. Relative Importance of Vegetation Measures in Southwestern Willow Flycatcher Nest Site Selection for **All Study Areas without Pahranagat**, 2003–2007*

Explanatory Variables	Coefficient	Wald	P	Odds Ratio	95% CI
NS versus WT					
Canopy height (m)	-0.06	0.08	0.783	0.94	0.60–1.48
Canopy closure (%)	0.01	0.06	0.808	1.01	0.94–1.09
Woody ground cover (%)	0.01	0.97	0.324	1.01	0.99–1.04
No. shrub stems (2.5–8.0 cm dbh) per ha	**0.00**	**7.01**	**0.008**	**1.00**	**1.00–1.00**
No. tree stems (>8.0 cm dbh) per ha	0.00	0.13	0.720	1.00	1.00–1.00
No. tree stems (>8.0 cm dbh) per ha in 5- to 11-m radius circle	0.00	0.00	0.986	1.00	1.00–1.00
Proportion basal area that is native	0.89	0.62	0.432	2.44	0.26–22.76
Vertical foliage at nest layer	-0.04	3.17	0.075	0.96	0.92–1.00
Vertical foliage above nest layer	**0.02**	**8.75**	**0.003**	**1.02**	**1.01–1.04**
NS versus NU					
Canopy height (m)	**0.50**	**5.52**	**0.019**	**1.64**	**1.09–2.49**
Canopy closure (%)	**0.08**	**8.59**	**0.003**	**1.08**	**1.03–1.14**
Woody ground cover (%)	0.00	0.00	1.000	1.00	0.98–1.02
No. shrub stems (2.5–8.0 cm dbh) per ha	0.00	0.54	0.462	1.00	1.00–1.00
No. tree stems (>8.0 cm dbh) per ha	0.00	0.00	0.999	1.00	1.00–1.00
No. tree stems (>8.0 cm dbh) per ha in 5- to 11-m radius circle	0.00	1.10	0.295	1.00	1.00–1.00
Proportion basal area that is native	**2.88**	**11.66**	**0.001**	**17.87**	**3.42–93.45**
Vertical foliage at nest layer	-0.01	0.39	0.532	0.99	0.95–1.02
Vertical foliage above nest layer	**0.04**	**13.08**	**<0.001**	**1.04**	**1.02–1.06**

* Variables remaining in the final model are shown in bold; for these variables, their corresponding statistical values from the final model have been presented. For variables removed through backward selection, corresponding statistical values have been presented for the time when the variable was removed. The odds ratio is the probability of nest selection given a one unit of change in that variable when the other variables are equal. This conditional logistic regression model accounts for the matching of corresponding NS/WT/NU sites by life history study areas and year. NS vs. WT model uses data from 2005 to 2007. CI = confidence interval.

EFFECT OF VEGETATION CHARACTERISTICS ON NEST SUCCESS

The proportion of basal area that was native was the only vegetation variable that was a significant predictor of nest success (Table 6.15). Study area also remained in the model as a predictor of nest success.

Table 6.15. Relative Importance of Vegetation Measures in Southwestern Willow Flycatcher Nest Success, 2003–2007*

Explanatory Variables	Coefficient	Wald	P	Odds Ratio
Canopy height (m)	0.03	0.39	0.53	1.03
Canopy closure (%)	-0.01	0.26	0.91	0.99
Woody ground cover (%)	0.00	0.00	0.98	1.00
No. shrub stems (<2.5 cm dbh) per ha	0.00	0.78	0.38	1.00
No. shrub stems (2.5–8.0 cm dbh) per ha	0.00	1.42	0.23	1.00
No. tree stems (>8.0 cm dbh) per ha	0.00	0.01	0.93	1.00
No. tree stems (>8.0 cm dbh) per ha in 5- to 11-m radius circle	0.00	0.04	0.85	1.00
Proportion basal area that is native	**-1.393**	**5.47**	**0.019**	**0.25**
Vertical foliage below nest layer	0.00	0.72	0.40	1.00
Vertical foliage at nest layer	-0.00	0.08	0.78	1.00
Vertical foliage above nest layer	-0.00	1.70	0.192	1.00
Nest height	-0.04	0.11	0.74	0.96

* Variables remaining in the final model are shown in bold; for these variables, their corresponding statistical values from the final model have been presented. For variables removed through backward selection, corresponding statistical values have been presented for the time when the variable was removed. The odds ratio is the probability of nest success given a one unit of change in that variable when the other variables are equal.

DISCUSSION

HABITAT BLOCK MEASUREMENTS

No consistent trends through time were evident at Pahranagat or Mesquite in any of the vegetation variables we measured. At Mormon Mesa, percent canopy closure and percent woody ground cover showed increasing trends through time. Mormon Mesa encompasses a large block of riparian vegetation, and over the course of the five-year study we have been refining our survey areas to exclude short, sparse habitat and include taller, denser habitat. Therefore, changes in vegetation characteristics may be a reflection of a shift in the areas selected for surveys, rather than overall changes in vegetation. The number of stems >8.0 cm dbh increased over time at habitat block points at Topock. Survey areas have changed little over the years at Topock, so this may be the result of vegetation maturing over time. However, no changes in stem counts in other categories were recorded.

Differences in vertical foliage density observed between years at Mesquite and Mormon Mesa may be the result of widespread flooding that occurred at both study areas during the 2004–2005 winter. Flooding at Mesquite resulted in sediment deposition in many areas, and we noted in 2005 that willows in areas that had been inundated were yellowing or dead. This reduction in foliage density was evident in the vertical foliage density measurements, which were lowest in 2005 in most meter intervals at Mesquite. Vertical foliage density measurements in the first two meter intervals at Mormon Mesa were lowest in 2005 and 2006, and this could also have been the result of the severe flooding that occurred throughout large portions of the study area, where flood debris was visible on the trees up to 2 m above the ground.

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

Both the single effects and conditional logistic regression models showed that only two vegetation variables differed between NS and WT locations, with flycatchers placing their nests at locations within their territories that had more stems 2.5–8 cm dbh and greater foliage density above nest height. Selection of locations within the territory that have denser vegetation may afford protection from predation or a more favorable microclimate (see Chapter 7).

Although canopy height differed between NS and NU locations at every study area, at Pahranagat NU plots had taller canopy height than NS plots, while the relationship was reversed at all other study areas. This is because the NU locations at Pahranagat were typically in a stringer of tall cottonwoods on the periphery of the sites, while nests were located in shorter willows. Thus, inclusion of Pahranagat in the analysis of all study areas combined obscures the difference between canopy height at NS and NU plots that occurs at all other study areas. The conditional logistic regression model excluding Pahranagat showed that an increase of 1.0 m in canopy height resulted in the location being 1.6 times more likely to be a nest site. Allison et al. (2003) also reported that Southwestern Willow Flycatcher nest sites had a taller canopy than non-use sites, with a 1-m increase in canopy height resulting in an odds ratio of approximately 3.2.

Canopy closure and vertical foliage density above the nest layer also consistently differentiated nest sites from non-use sites. Allison et al. (2003) reported a trend for Southwestern Willow Flycatcher nest sites to have a higher percentage canopy closure, and Paradzick (2005) also found occupied willow flycatcher sites in Arizona to have higher canopy cover and denser foliage in the upper (7–9 m) strata of the canopy than unoccupied sites.

Number of stems <2.5 cm dbh, vertical foliage density below the nest, and distance to canopy gap did not differ between nest and non-use sites in the single effects analyses, suggesting that these characteristics are not important in nest site selection. Although woody ground cover and number of stems (2.5–8.0 cm dbh and >8.0 cm dbh) differed between nest and non-use locations in the single effects models, these variables dropped out of the conditional logistic regression models, suggesting that other vegetation variables were more important in distinguishing nest from non-use 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 (see Chapter 7). 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.

It is clear that willow flycatchers nest in both predominantly native (e.g., Pahranagat) and predominantly exotic (e.g., Topock) habitats, and at these study areas, where vegetation was monotypic (either native or exotic), there was no difference in percent basal area that was native between nest and non-use locations. At other study areas that did have variability in available habitats, NS sites had a higher proportion of basal area that was native than did NU sites.

Flycatchers are not necessarily selecting nest sites because they have a larger component of native vegetation; native vegetation may be associated with other habitat characteristics such as greater soil moisture.

Nest sites that had a higher proportion of basal area that was native were more likely to produce successful nests. It is not clear whether the presence of native vegetation has a direct effect on nest success or if both native vegetation and nest success are affected by another factor.

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). Nest sites were significantly closer to surface water or saturated soil during nesting than were non-use sites at Pahranagat, Mesquite, Mormon Mesa, and Muddy River, while Topock showed a strong trend for nest sites to be closer to water. We were unable to assess the importance of distance to water in distinguishing nest sites from non-use locations in relation to other vegetation variables because data on distance to water during nesting were collected only in 2006 and 2007.

CHAPTER 7

MICROCLIMATE

INTRODUCTION

AVIAN MICROCLIMATE STUDIES

Sympatric bird species are typically segregated along gradients of microclimate and vegetation, factors that are strongly co-dependent (Martin 2001). 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), terns and skimmers (Grant et al. 1984), hummingbirds (Calder 1973), and cavity-nesting species such as woodpeckers (Connor 1975, Inouye 1976, Inouye et al. 1981, Wiebe 2001), Tree Swallows (*Tachycineta bicolor*; Dawson et al. 2005), and Elf Owls (*Micrathene whitneyi*; Hardy and Morrison 2001) 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 and the Elf Owl excavate or use 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 those nesting in artificial nest boxes (e.g., Prothonotary Warblers [*Protonotaria citrea*]; Blem and Blem 1994), ground-nesters, or species 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).

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).

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).

HYDROGEOMORPHOLOGY, VEGETATION, AND MICROCLIMATE: CONNECTIVITY IN A DESERT RIPARIAN SYSTEM

Contemporary scientific findings have demonstrated that hydrogeomorphic conditions (soil moisture, water table, surface water, flooding, etc.) and the resulting vegetation are strongly correlated in lowland riparian systems in the Southwest (see Busch et al. 1992, Shafroth et al 2000, Elmore et al. 2003, Baird et al. 2005, Paradzick 2005). The development of riparian vegetation is controlled partly by surface flow and partly by groundwater whose influence extends far beyond the edge of surface water (Appendix J in USFWS 2002). Paradzick (2005) demonstrated that riparian vegetation was strongly associated with water availability and inundation rates. Foliage density on the Gila and San Pedro Rivers, for example, increased with higher water tables and low annual water table fluctuations in both cottonwood-willow and tamarisk-dominated vegetation. Small changes in hydrogeomorphic conditions can modify riparian vegetation at the patch scale, altering habitat suitability for Southwestern Willow Flycatchers (Paradzick 2005). Our working hypothesis is that hydrogeomorphic factors influence riparian vegetation development and then these work in concert to influence microclimate.

RIPARIAN HABITAT CREATION AND RESTORATION

Southwestern Willow Flycatchers along the Lower Colorado River are currently dependent upon riparian habitat dominated primarily by tamarisk and willow. The creation and persistence of this riparian vegetation is dependent upon the ability of river systems to provide appropriate hydrogeomorphic conditions. Since the widespread loss and degradation of riparian habitat has been identified as the main cause of population decline in the flycatcher (USFWS 1995), recovery of the species is primarily dependent on the protection, restoration, and creation of suitable riparian habitat. These are accepted management techniques to promote the recovery of rare and endangered species (Reclamation n.d.; Appendix K in USFWS 2002). The restoration of full ecosystem integrity to riparian habitats along the Lower Colorado River system is not possible due to economic, political, and social constraints. A responsible alternative is to protect existing flycatcher habitat, restore degraded habitat, and create "new" habitat in areas that may have once exhibited suitable habitat but currently do not (e.g., agricultural fields).

Meyer et al. (2001) demonstrated that habitat restoration efforts modify microclimate. Further, changes in microclimate resulting from habitat restoration have been shown to influence wildlife distribution (Meyer and Sisk 2001). A thorough search of the relevant literature, however, did not identify any habitat restoration effort with the specific goal of restoring a particular microclimate for the benefit of a target wildlife species.

Study Design Overview

The research design for this microclimate study examined climatic predictor variables (temperature, relative humidity, vapor pressure, and soil moisture) at three levels of habitat use relative to flycatcher nest locations. 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 these four variables were substantially interrelated.

Because vegetation likely influences microclimate, microclimate and vegetation data were combined to determine which vegetation parameters (as reported in the previous chapter), if any, were associated with microclimate. We tested the null hypothesis that there was no significant association between microclimate and vegetation.

Methods

Overview

We located active flycatcher nests at four life history study areas (Pahranagat, Mesquite, Mormon Mesa, and Topock) between May and August from 2003 to 2007, and at Muddy River Delta (May–August, 2005–2007). We selected eleven microclimate variables for evaluation because (1) available literature on avian microclimate use emphasized the utility of some, and (2) our combined professional experience suggested the potential utility of others given that Southwestern Willow Flycatchers in our study areas nest in dense riparian habitat along lowland rivers in a hot desert environment. 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 to nesting birds 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), 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. Subsequent renests 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.

TEMPERATURE AND RELATIVE HUMIDITY (T/RH) MEASUREMENTS

Measurements of 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, as follows:

(1) Seasonal-variation riparian (SVR) sensor arrays: When field personnel arrived at the four life history study areas in early May, they placed SVR sensor arrays at randomly selected locations within known flycatcher breeding areas. The SVR arrays 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. Seasonal variation sensor arrays were removed after the last NS, WT, and NU sensor arrays were removed.

(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 when possible, preferably hanging directly below it. When nests were too high to reach (above approximately 6 m), sensor arrays were hung as high as possible below the nest. 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 2003–2004, the random numbers were equally distributed through the known range of nest heights. In 2005–2007, 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 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.

SOIL MOISTURE (SM) MEASUREMENTS

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) was used to gather soil moisture data in 2004–2007.[1] 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 NS, WT, and NU site at the time the T/RH sensor array was placed, and at the time the T/RH sensor array was removed 14 days later. In addition, SM readings were taken at SVR locations at least twice a week throughout the season.[2] To take a soil moisture reading, we cleared away any duff or leaf litter and inserted the probe vertically into the soil until the metal rods (6 cm long) were completely buried. Soil moisture (SM) was recorded both as voltage (mV) and as volumetric water content (%).[3] 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.

VEGETATION MEASUREMENTS

We measured vegetation at flycatcher nests at the four life history study areas (Pahranagat, Mesquite, Mormon Mesa, and Topock) from 2003 to 2007, and at Muddy River Delta (2005–2007). As with microclimate, vegetation variables were measured at three locations (NS, WT, and NU) relative to each nest for the purpose of examining vegetation at three levels of potentially increasing differences in flycatcher nesting habitat use. See Chapter 6 for details of vegetation sampling methods.

ASSUMPTIONS

This study made the following assumptions in study design and analysis:

- Microclimate was adequately estimated with the variables chosen for investigation; resulting patterns provided a reasonable index to microclimate selection.
- Microclimate variables as measured by the sensor arrays provided a suitable index to microclimate conditions experienced by flycatchers.
- Placement of temperature/humidity arrays within 1 m of a vacated nest was appropriate to estimate microclimate at the nest.

[1] The hand-held equipment used to collect soil moisture data in 2003 proved to be unsuitable for use in dense, clay soils, and those data are not included here.

[2] In 2003–2004, soil moisture readings were collected once per hour by data loggers left in place throughout the season. The sensors associated with these loggers were difficult to install in dense soils and were susceptible to animal damage; therefore, we switched to hand-held units in 2005–2007. SVR data collected in 2003–2004 are not included here.

[3] 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.

- Microclimatic data from NS, WT, and SVR locations (from within occupied flycatcher territories) were appropriate for summarizing overall conditions in occupied flycatcher habitat.

STATISTICAL ANALYSES

We downloaded data from the T/RH sensor arrays at SVR, NS, WT, and NU sites into databases at the end of each field season; SM data were manually entered into the database from field forms. We merged data from all study years to create one dataset for analysis. We then calculated the following variables for each sensor array by overall study period:

- Mean soil moisture (mV) from plot center to 2.0 m from plot center
- Mean maximum diurnal temperature (°C)
- Mean diurnal temperature (°C)
- Mean number of 15-minute intervals above 41°C each day[4]
- Mean minimum nocturnal temperature (°C)
- Mean nocturnal temperature (°C)
- Mean daily temperature range (diurnal maximum minus nocturnal minimum) (°C)
- Mean diurnal relative humidity (%)
- Mean diurnal vapor pressure (Pa)[5]
- Mean nocturnal relative humidity (%)
- Mean nocturnal vapor pressure (Pa)

The overall study period constituted the entire season for SVR 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 (2003–2007).

We created a separate dataset that included SVR sensors in occupied habitat and NS and WT data over all years of study to show microclimate conditions at occupied territories. The Pahranagat study area was excluded from the category of 'all study areas combined' because it is at a much higher elevation and exhibits atypical vegetation structure and composition when contrasted with the other four study areas. Overall soil moisture was presented on a weekly basis because daily soil moisture data were not available.

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. At a given study area, any consecutive weeks that were significantly different would be an indication that

---

[4] 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).

[5] 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.

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 2005–2007, as we were confident in the validity of measuring nest microclimate after nests were vacated.

Descriptive Statistics and Single Effects ANOVA. We used repeated measures analysis of variance (ANOVA) to determine the association between location type (NS, WT, NU) and microclimate variables. This was done for each study area and then overall. Repeated measures ANOVA takes into account the matched relationship between NS, WT, and NU, which are matched in time and space within study year and study area. 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. If significant differences were found between NS, WT, and/or NU sites, paired t-tests were used to determine significant pairwise differences.

Multiple Effects Models. Conditional multiple logistic regression was used to test the association of NS versus WT and NU sites with microclimate and vegetation variables. This was done to determine the relative importance of variables in distinguishing nest from non-nest sites. All variables with significant single effects in the overall model were included in the models unless they were >80% correlated with another variable, and stepwise selection was used to create the most parsimonious model. Because vegetation data for WT locations were not collected until 2005, data used for the conditional logistic regression models were restricted to 2005–2007.

Each microclimate variable found to be statistically associated with NS sites from this analysis was then used as the dependent variable in a multiple linear regression model, using the vegetation variables as the predictors. Stepwise selection was used to create the most parsimonious set of vegetation variables that predicts each microclimate measure.

All analyses were conducted using SAS® version 9.1.3 (SAS Institute 2003). Statistical significance was accepted at $P<0.05$. Numerical values in tables were not rounded.

RESULTS

LOCATION TYPES: DESCRIPTIVE STATISTICS AND SINGLE EFFECTS

The final dataset for analysis consisted of 639 NS, WT, and NU sensor arrays for temperature and humidity from 2003 to 2007. These arrays formed 213 sets (639 ÷ 3 = 213) of matched arrays (one NS, one WT, and one NU). Of the 639 arrays, 387 had corresponding soil moisture measurements.

Substantial microclimate differences existed between NS and WT sites. NS sites differed significantly from WT sites for all four measures of diurnal temperature (mean maximum diurnal temperature, mean diurnal temperature, mean number of 15-min. intervals >41° C, and mean daily temperature range) at four study areas (Tables 7.1–7.5) and when all study areas were combined (Table 7.6), with NS being cooler than WT. The only exception was at Topock where NS and WT were similar for measures of diurnal temperature (see Table 7.4).

Table 7.1. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Microclimate Measures: **Pahranagat NWR**, June–August, 2003–2007*

Response Variable	Nest Site (n = 53)	Within Territory (n = 53)	Non-Use (n = 53)	*P*	Significant Pairwise Differences
Soil Moisture					
Mean soil moisture (mV), 2005–2007**	855.4 (23.1)	849.8 (23.5)	623.1 (40.1)	<0.001	NU<NS,WT
Temperature					
Mean maximum diurnal temperature (°C)	36.8 (0.3)	39.3 (0.6)	41.5 (0.6)	<0.001	NU>WT>NS
Mean diurnal temperature (°C)	26.6 (0.2)	27.2 (0.2)	29.2 (0.2)	<0.001	NU>WT>NS
Mean no. of 15-min. intervals above 41°C each day	0.1 (0.0)	1.0 (0.3)	1.5 (0.3)	<0.001	NU,WT>NS
Mean minimum nocturnal temperature (°C)	13.8 (0.3)	13.8 (0.3)	14.3 (0.4)	0.003	NU>NS,WT
Mean nocturnal temperature (°C)	22.7 (0.2)	22.8 (0.2)	23.8 (0.3)	<0.001	NU>NS,WT
Mean daily temperature range (°C)	16.3 (0.4)	18.4 (0.6)	19.3 (0.5)	<0.001	NU,WT>NS
Humidity					
Mean diurnal relative humidity (%)	44.9 (1.4)	46.6 (1.4)	34.3 (1.6)	<0.001	NU<NS<WT
Mean diurnal vapor pressure (Pa)	1481.5 (47.5)	1462.9 (45.5)	1260.6 (53.6)	<0.001	NU<NS,WT
Mean nocturnal relative humidity (%)	47.5 (1.5)	46.7 (1.4)	41.6 (1.8)	<0.001	NU<NS,WT
Mean nocturnal vapor pressure (Pa)	1295.5 (46.4)	1274.7 (44.6)	1180.5 (49.5)	<0.001	NU<NS,WT

*Nest, within territory, and non-use areas are matched within study area each year. Standard errors in parentheses.

** Soil moisture data are from 2005 to 2007 only, when mV soil moisture was measured; percent soil moisture was measured in 2003–2004.

Table 7.2. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Microclimate Measures: **Mesquite**, June–August, 2003–2007*

Response Variable	Nest Site (n = 59)	Within Territory (n = 59)	Non-Use (n = 59)	*P*	Significant Pairwise Differences
Soil Moisture					
Mean soil moisture (mV), 2005–2007**	776.9 (41.7)	759.7 (44.2)	482.9 (49.6)	<0.001	NU<NS, WT
Temperature					
Mean maximum diurnal temperature (°C)	40.9 (0.4)	43.6 (0.6)	50.0 (0.7)	<0.001	NU>WT>NS
Mean diurnal temperature (°C)	30.0 (0.2)	31.1 (0.2)	34.4 (0.3)	<0.001	NU>WT>NS
Mean no. of 15-min. intervals above 41°C each day	2.4 (0.6)	5.7 (1.0)	16.6 (1.3)	<0.001	NU>WT>NS
Mean minimum nocturnal temperature (°C)	16.0 (0.2)	15.6 (0.3)	14.4 (0.3)	<0.001	NU<NS<WT
Mean nocturnal temperature (°C)	24.0 (0.2)	23.9 (0.2)	24.0 (0.3)	0.448	N/A
Mean daily temperature range (°C)	18.4 (0.5)	21.1 (0.6)	27.3 (0.7)	<0.001	NU>WT>NS
Humidity					
Mean diurnal relative humidity (%)	55.9 (1.4)	52.5 (1.3)	43.0 (1.2)	<0.001	NU<WT<NS
Mean diurnal vapor pressure (Pa)	2185.7 (58.5)	2138.8 (58.3)	1924.7 (56.7)	<0.001	NU<WT<NS
Mean nocturnal relative humidity (%)	65.6 (1.3)	64.6 (1.2)	62.0 (1.2)	0.065	NU<NS
Mean nocturnal vapor pressure (Pa)	1910.7 (44.6)	1866.5 (44.1)	1761.1 (40.8)	<0.001	NU<WT<NS

*Nest, within territory, and non-use areas are matched within study area each year. Standard errors in parentheses. N/A = data not available or not applicable.

** Soil moisture data are from 2005 to 2007 only, when mV soil moisture was measured; percent soil moisture was measured in 2003–2004.

Table 7.3. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Microclimate Measures: **Mormon Mesa**, June–August, 2003–2007*

Response Variable	Nest Site (n = 21)	Within Territory (n = 21)	Non-Use (n = 21)	*P*	Significant Pairwise Differences
Soil Moisture					
Mean soil moisture (mV), 2005–2007**	755.8 (52.2)	724.4 (61.4)	604.5 (81.3)	0.296	N/A
Temperature					
Mean maximum diurnal temperature (°C)	44.3 (0.7)	47.7 (1.0)	50.8 (1.2)	<0.001	NU>WT>NS
Mean diurnal temperature (°C)	32.1 (0.3)	33.4 (0.5)	35.1 (0.6)	<0.001	NU>WT>NS
Mean no. of 15-min. intervals above 41°C each day	5.8 (1.3)	10.4 (1.6)	18.6 (2.1)	<0.001	NU>WT>NS
Mean minimum nocturnal temperature (°C)	17.4 (0.5)	17.0 (0.4)	15.5 (0.5)	<0.001	NU<WT<NS
Mean nocturnal temperature (°C)	25.1 (0.5)	24.9 (0.5)	24.3 (0.6)	0.001	NU<NS,WT
Mean daily temperature range (°C)	19.9 (0.9)	23.2 (1.0)	27.0 (1.1)	<0.001	NU>WT>NS
Humidity					
Mean diurnal relative humidity (%)	44.3 (2.2)	41.4 (2.2)	38.0 (2.0)	<0.001	NU,WT<NS
Mean diurnal vapor pressure (Pa)	1872.6 (92.9)	1834.6 (92.3)	1748.9 (92.0)	0.032	NU<NS
Mean nocturnal relative humidity (%)	59.9 (2.0)	59.5 (1.9)	60.0 (2.1)	0.746	N/A
Mean nocturnal vapor pressure (Pa)	1881.5 (79.6)	1847.6 (79.0)	1774.9 (82.6)	0.048	NU<NS

*Nest, within territory, and non-use areas are matched within study area each year. Standard errors in parentheses. N/A = data not available or not applicable.

** Soil moisture data are from 2005 to 2007 only, when mV soil moisture was measured; percent soil moisture was measured in 2003–2004.

Table 7.4. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Microclimate Measures: **Topock**, June–August, 2003–2007*

Response Variable	Nest Site (n = 53)	Within Territory (n = 53)	Non-Use (n = 53)	*P*	Significant Pairwise Differences
Soil Moisture					
Mean soil moisture (mV), 2005–2007**	812.5 (34.1)	813.3 (33.1)	660.1 (53.3)	0.085	NU<NS,WT
Temperature					
Mean maximum diurnal temperature (°C)	42.3 (0.6)	43.1 (0.5)	46.5 (0.9)	0.001	NU>NS,WT
Mean diurnal temperature (°C)	31.0 (0.3)	31.3 (0.2)	33.0 (0.5)	<0.001	NU>NS,WT
Mean no. of 15-min. intervals above 41°C each day	3.3 (0.7)	4.2 (0.8)	11.7 (1.5)	<0.001	NU>NS,WT
Mean minimum nocturnal temperature (°C)	16.7 (0.4)	16.6 (0.4)	15.5 (0.4)	<0.001	NU<NS,WT
Mean nocturnal temperature (°C)	24.6 (0.3)	24.6 (0.3)	24.3 (0.3)	0.151	N/A
Mean daily temperature range (°C)	19.0 (0.5)	19.9 (0.5)	23.5 (0.9)	<0.001	NU>WT,NS
Humidity					
Mean diurnal relative humidity (%)	56.8 (1.1)	56.0 (1.1)	51.3 (1.7)	0.014	NU<NS,WT
Mean diurnal vapor pressure (Pa)	2411.8 (60.3)	2402.2 (58.8)	2286.6 (68.3)	0.070	NU<NS,WT
Mean nocturnal relative humidity (%)	68.4 (0.9)	68.3 (1.0)	67.6 (1.3)	0.874	N/A
Mean nocturnal vapor pressure (Pa)	2118.7 (46.9)	2107.1 (48.2)	2047.8 (49.9)	0.062	NU<NS,WT

*Nest, within territory, and non-use areas are matched within study area each year. Standard errors in parentheses. N/A = data not available or not applicable.

** Soil moisture data are from 2005 to 2007 only, when mV soil moisture was measured; percent soil moisture was measured in 2003–2004.

Table 7.5. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Microclimate Measures: **Muddy River**, June–August, 2005–2007*

Response Variable	Nest Site (n = 23)	Within Territory (n = 23)	Non-Use (n = 23)	*P*	Significant Pairwise Differences
Soil Moisture					
Mean soil moisture (mV), 2005–2007**	641.8 (38.9)	675.3 (44.9)	528.4 (42.7)	0.097	NU<WT
Temperature					
Mean maximum diurnal temperature (°C)	40.8 (0.7)	44.3 (1.0)	47.3 (1.2)	<0.001	NU,WT>NS
Mean diurnal temperature (°C)	30.5 (0.4)	31.3 (0.4)	33.7 (0.6)	<0.001	NU>WT>NS
Mean no. of 15-min. intervals above 41°C each day	2.4 (0.8)	4.8 (1.3)	13.4 (2.2)	<0.001	NU>WT>NS
Mean minimum nocturnal temperature (°C)	17.0 (0.5)	16.7 (0.5)	16.2 (0.7)	0.023	WT<NS
Mean nocturnal temperature (°C)	25.6 (0.4)	25.6 (0.4)	2.9 (0.4)	0.589	N/A
Mean daily temperature range (°C)	16.3 (0.7)	19.5 (0.9)	22.3 (1.5)	<0.001	NU,WT>NS
Humidity					
Mean diurnal relative humidity (%)	52.7 (2.3)	50.6 (1.4)	43.6 (1.9)	<0.001	NU<NS,WT
Mean diurnal vapor pressure (Pa)	2132.8 (80.0)	2141.4 (71.1)	1939.2 (82.0)	<0.001	NU<NS,WT
Mean nocturnal relative humidity (%)	59.5 (2.4)	58.9 (2.0)	55.0 (1.7)	0.100	NU<NS,WT
Mean nocturnal vapor pressure (Pa)	1923.7 (84.4)	1896.1 (75.1)	1785.6 (75.7)	0.007	NU<NS,WT

*Nest, within territory, and non-use areas are matched within study area each year. Standard errors in parentheses. N/A = data not available or not applicable.

** Soil moisture data are from 2005 to 2007 only, when mV soil moisture was measured; percent soil moisture was measured in 2003–2004.

Table 7.6. Descriptive Statistics and Single Effects for Southwestern Willow Flycatcher Microclimate Measures: **All Life History Areas Combined**, June–August, 2003–2007*

Response Variable	Nest Site (n = 209)	Within Territory (n = 209)	Non-Use (n = 209)	*P*	Significant Pairwise Differences
Soil Moisture					
Mean soil moisture (mV), 2005–2007**	778.4 (17.5)	776.4 (18.2)	576.9 (23.1)	<0.001	NU<NS,WT
Temperature					
Mean maximum diurnal temperature (°C)	40.5 (0.3)	42.9 (0.3)	46.8 (0.4)	<0.001	NU>WT>NS
Mean diurnal temperature (°C)	29.6 (0.1)	30.4 (0.2)	32.7 (0.2)	<0.001	NU>WT>NS
Mean no. of 15-min. intervals above 41°C each day	2.4 (0.3)	4.5 (0.4)	11.4 (0.7)	<0.001	NU>WT>NS
Mean minimum nocturnal temperature (°C)	15.9 (0.1)	15.7 (0.2)	15.0 (0.2)	<0.001	NU<WT<NS
Mean nocturnal temperature (°C)	24.1 (0.1)	24.1 (0.1)	24.3 (0.1)	0.260	N/A
Mean daily temperature range (°C)	17.9 (0.2)	20.1 (0.3)	23.7 (0.4)	<0.001	NU>WT>NS
Humidity					
Mean diurnal relative humidity (%)	51.8 (0.7)	49.7 (0.7)	42.4 (0.8)	<0.001	NU<WT<NS
Mean diurnal vapor pressure (Pa)	2027.2 (37.3)	2003.9 (36.8)	1832.0 (39.5)	<0.001	NU<WT<NS
Mean nocturnal relative humidity (%)	60.5 (0.8)	59.8 (0.8)	57.3 (0.9)	<0.001	NU<NS,WT
Mean nocturnal vapor pressure (Pa)	1805.9 (32.2)	1778.8 (31.8)	1690.8 (32.6)	<0.001	NU<WT<NS

*Nest, within territory, and non-use areas are matched within study area each year. Standard errors in parentheses. N/A = data not available or not applicable.

** Soil moisture data are from 2005 to 2007 only, when mV soil moisture was measured; percent soil moisture was measured in 2003–2004.

Mean minimum nocturnal temperature was significantly higher at NS than at WT at Mesquite, Muddy River, and when all study areas were combined. There was no significant difference between NS and WT sites for mean nocturnal temperature. Mean diurnal relative humidity was significantly higher at NS than at WT at Mesquite, Mormon Mesa, and overall, and significantly lower at NS than at WT at Pahranagat; otherwise, the humidity variables did not significantly differ except at Mesquite and when all life history areas were combined. Soil moisture did not differ significantly between NS and WT.

The microclimate differences between NS and NU sites were more pronounced. NS sites differed significantly from NU sites for almost all microclimate variables at each of the five study areas, with nest sites being cooler, more thermally stable, and more humid. The exceptions were as follows: mean nocturnal temperature did not differ significantly between NS and NU at Mesquite, Topock, and Muddy River; mean soil moisture did not differ significantly between NS and NU at Mormon Mesa or Muddy River; and mean nocturnal relative humidity did not differ significantly between NS and NU at Mormon Mesa and Topock (see Tables 7.1–7.5).

Virtually all response variables exhibited significant differences between NS, WT, and/or NU when all life history areas were combined and the full sample size of 213 matched pairs was analyzed (Table 7.6). Mean nocturnal temperature was the only response variable analyzed for which there was no significant difference between NS, WT, and/or NU. In general, occupied habitat (NS and WT) was significantly cooler during the day, warmer at night, more humid overall, exhibited greater soil moisture, and experienced a smaller daily temperature range than unoccupied (NU) habitat. Table 7.6 also demonstrates that the relationship between NS, WT, and NU sites was typically a predictably tiered one; that is, microclimate was warmest (or drier or more variable) at NU sites, less so at WT sites, and coolest, most humid, and least variable at NS sites.

SEASONAL VARIATION BY STUDY AREA

Soil moisture, maximum diurnal temperature, diurnal temperature, daily temperature range, and diurnal relative humidity have been shown graphically to compare occupied flycatcher habitat between study areas over the season (Figures 7.1–7.5). Soil moisture in occupied habitat at Pahranagat was consistently higher than at other study areas (see Figure 7.1). When all study areas were combined (excluding Pahranagat), mean soil moisture ranged from 600 to 800 mV. Substantial differences existed between study areas for the three measures of diurnal temperature: Pahranagat was consistently the coolest with the smallest temperature range of the five study areas, while Mormon Mesa was consistently the warmest with the largest temperature range of the five study areas. Mean diurnal relative humidity values between study areas exhibited less consistent differences than diurnal temperature variables. Mormon Mesa and Pahranagat were typically less humid during daytime than other sites, while Topock and Muddy River were usually more humid.

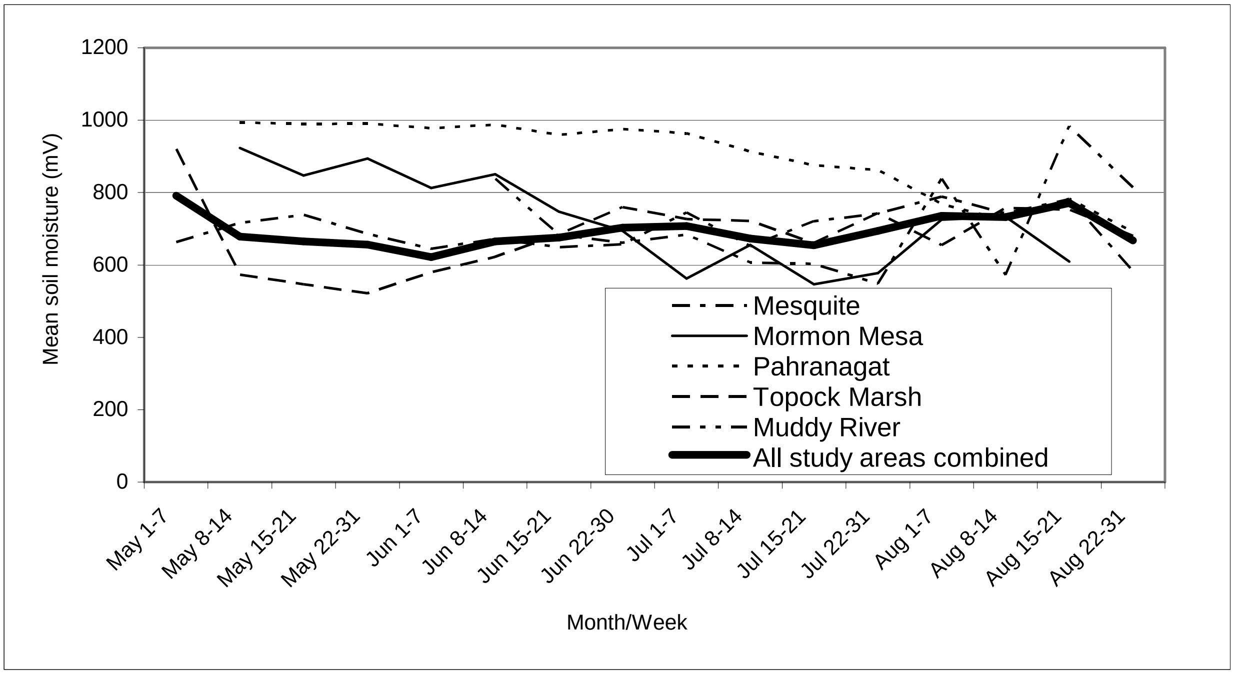

Figure 7.1. Weekly mean soil moisture at Southwestern Willow Flycatcher territories by study area, 2005–2007. Flycatcher territories include nest, within-territory, and seasonal variation sites. "All study areas combined" does not include Pahranagat.

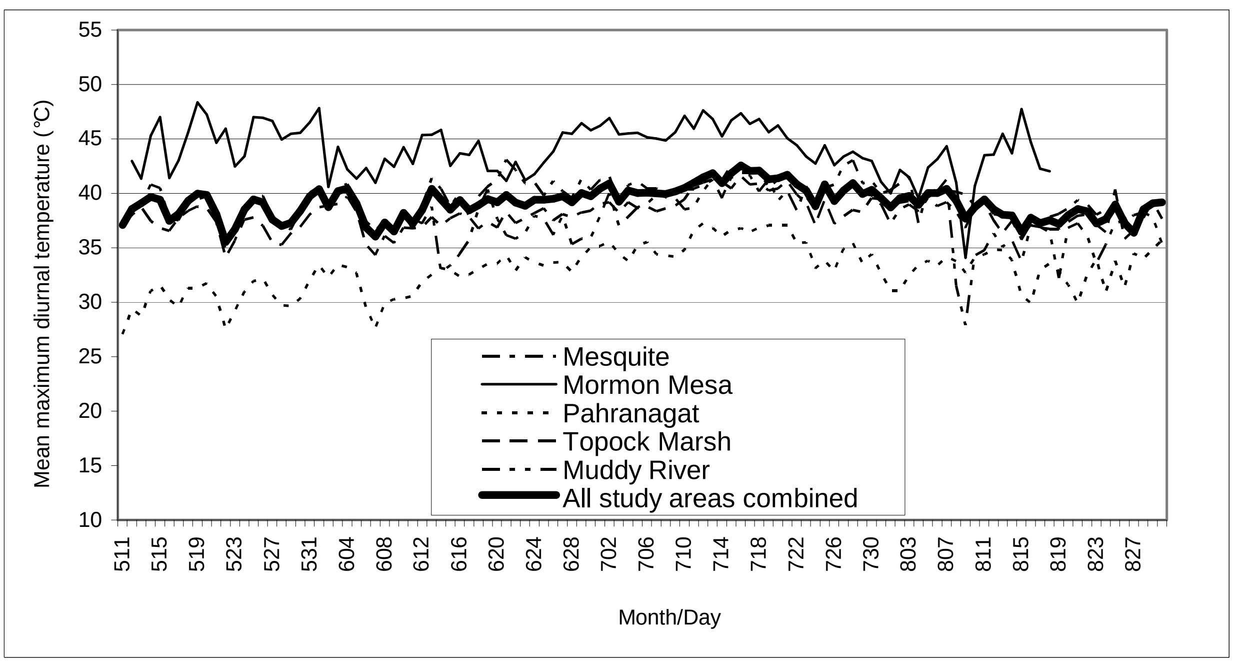

Figure 7.2. Mean maximum diurnal temperature at Southwestern Willow Flycatcher territories by study area, 2003–2007. Flycatcher territories include nest, within-territory, and seasonal variation sites. "All study areas combined" does not include Pahranagat.

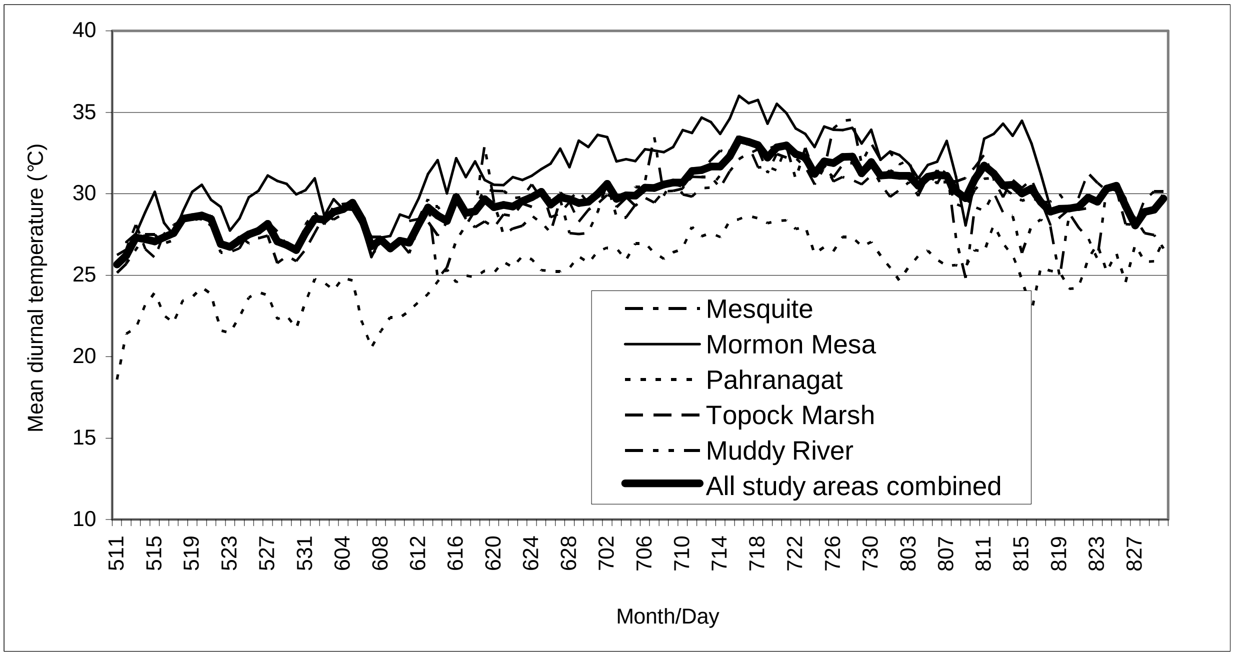

Figure 7.3. Mean diurnal temperature at Southwestern Willow Flycatcher territories by study area, 2003–2007. Flycatcher territories include nest, within-territory, and seasonal variation sites. "All study areas combined" does not include Pahranagat.

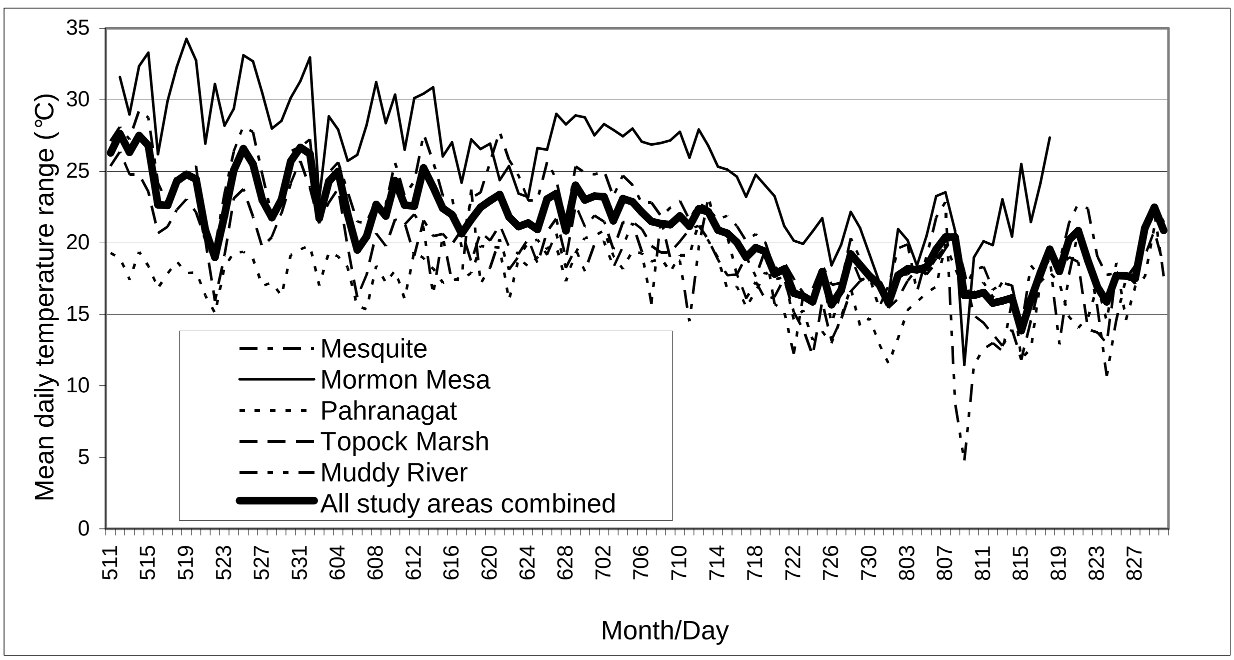

Figure 7.4. Mean daily temperature range at Southwestern Willow Flycatcher territories by study area, 2003–2007. Flycatcher territories include nest, within-territory, and seasonal variation sites. "All study areas combined" does not include Pahranagat.

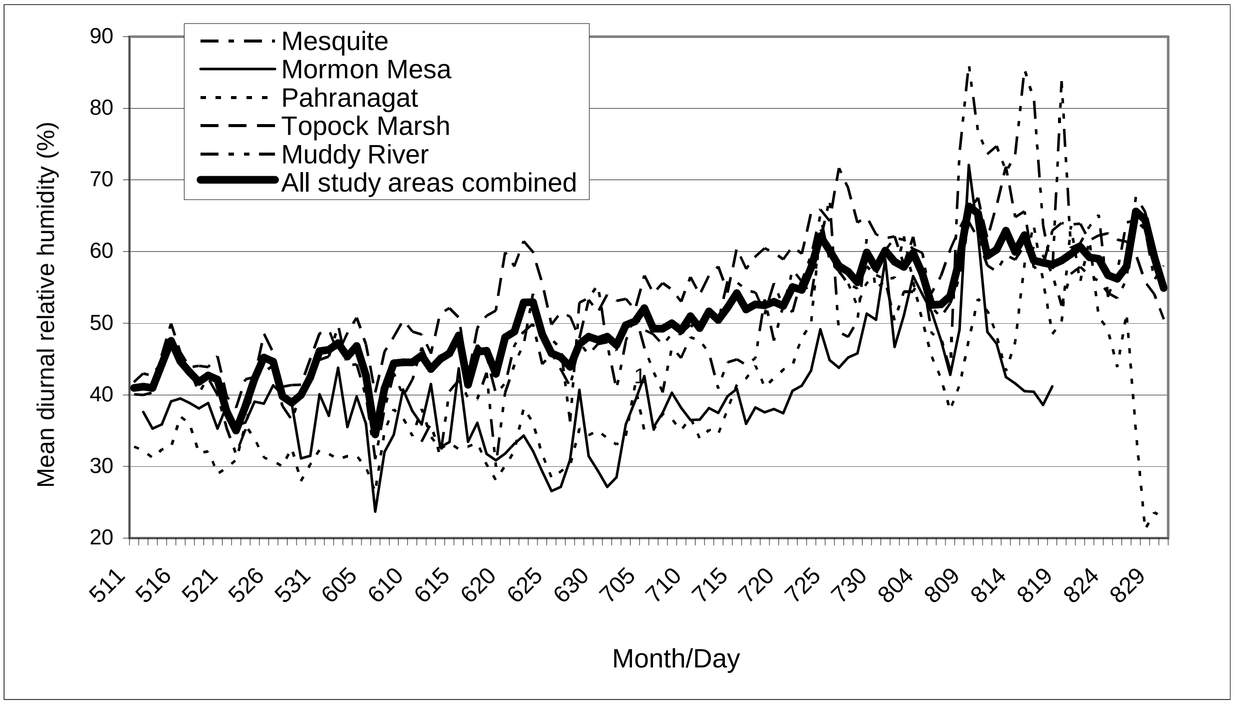

Figure 7.5. Mean diurnal relative humidity at Southwestern Willow Flycatcher territories by study area, 2003–2007. Flycatcher territories include nest, within-territory, and seasonal variation sites. "All study areas combined" does not include Pahranagat.

SEASONAL VARIATION BETWEEN NEST, WITHIN TERRITORY, AND NON-USE SITES

Soil moisture, maximum diurnal temperature, diurnal temperature, daily temperature range, and diurnal relative humidity have been shown graphically to compare NS, WT, and NU sites over the combined nesting seasons (Figures 7.6–7.10). Mean soil moisture was consistently greater at NS and WT sites compared to NU sites throughout the study seasons (see Figure 7.6). The three measures of diurnal temperature were also predictably tiered: NU sites were the warmest with the largest temperature range, NS sites were the coolest and exhibited the lowest temperature range, and WT sites were in between (Figures 7.7–7.9). Mean diurnal relative humidity was greater at NS and WT sites compared to NU sites throughout the season (Figure 7.10).

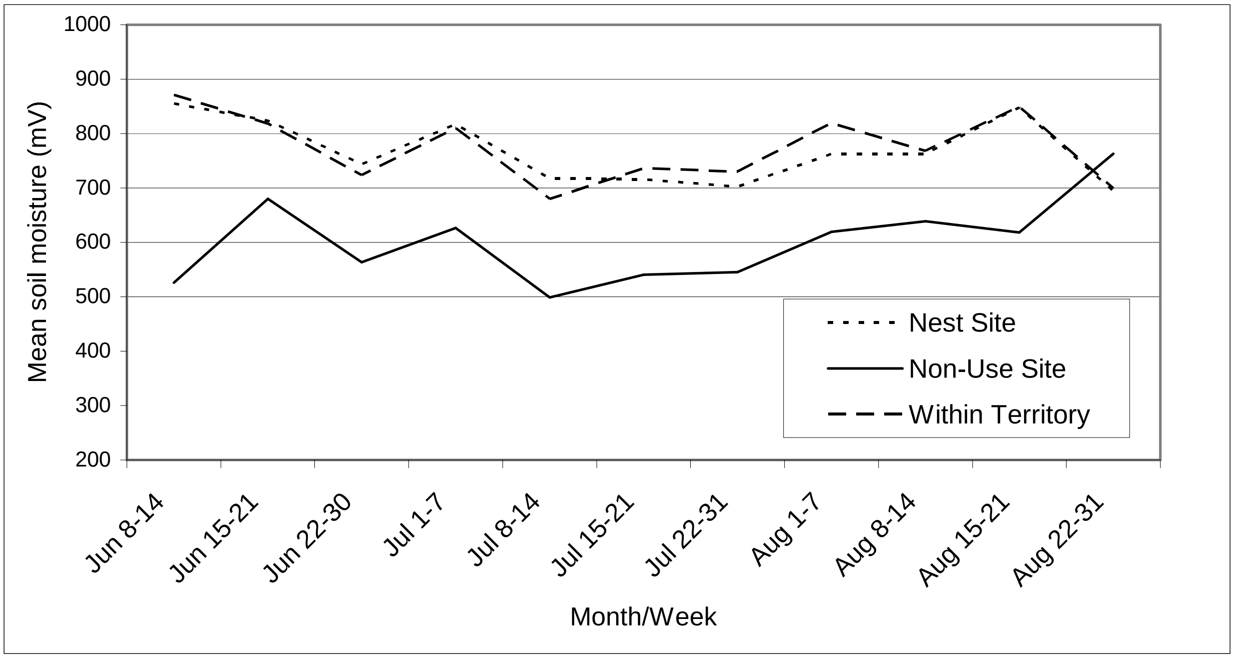

Figure 7.6. Seasonal mean weekly soil moisture at nest, within-territory, and non-use sites at all study areas combined, excluding Pahranagat, 2005–2007.

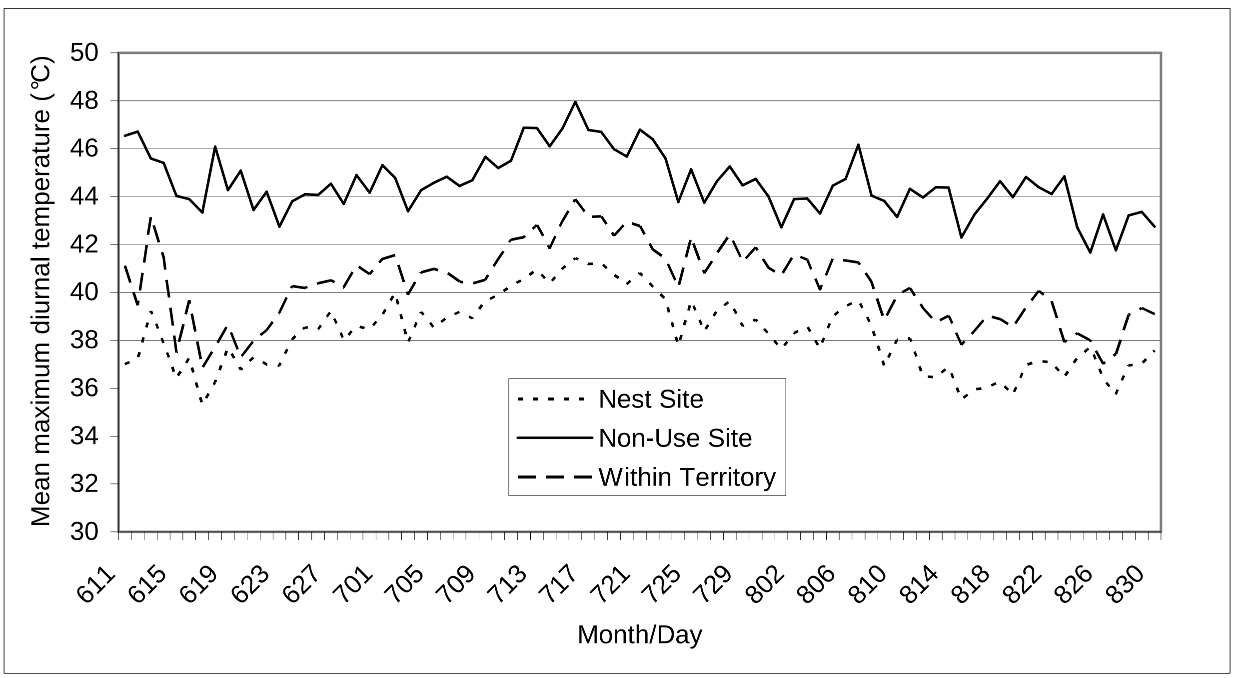

Figure 7.7. Seasonal mean daily maximum diurnal temperature at nest, within-territory, and non-use sites at all study areas combined, excluding Pahranagat, 2003–2007.

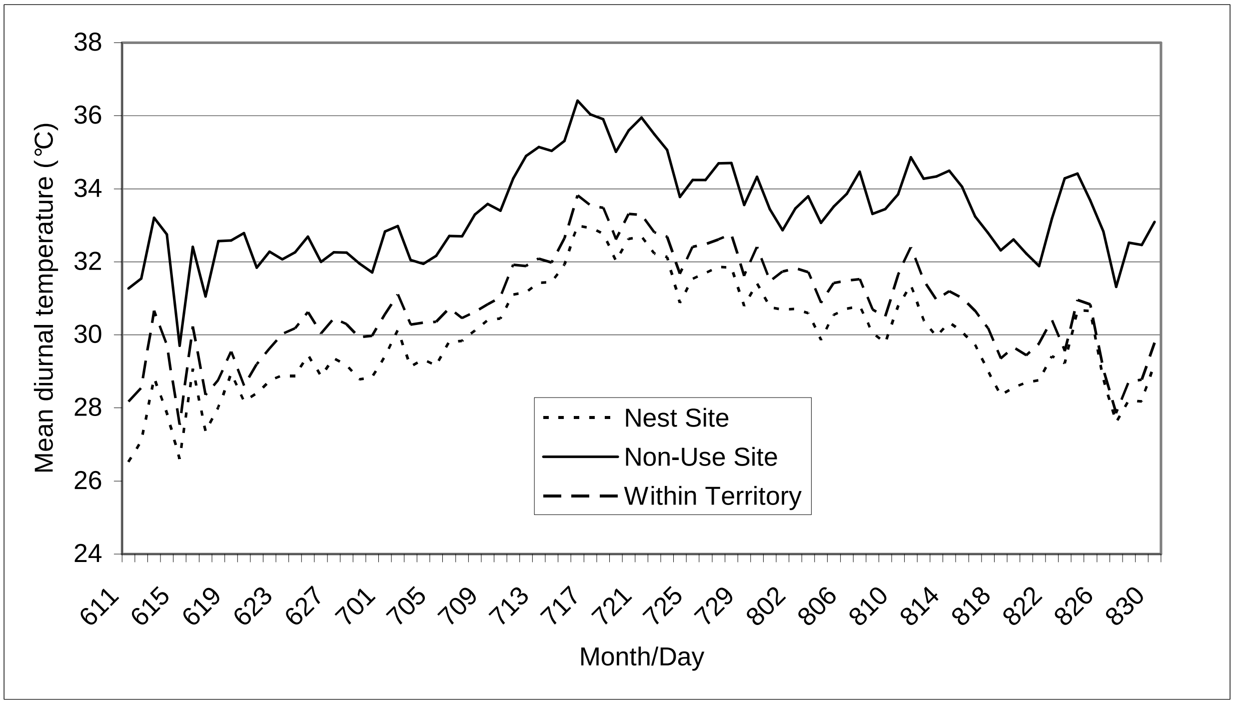

Figure 7.8. Seasonal mean diurnal temperature at nest, within-territory, and non-use sites at all study areas combined, excluding Pahranagat, 2003–2007.

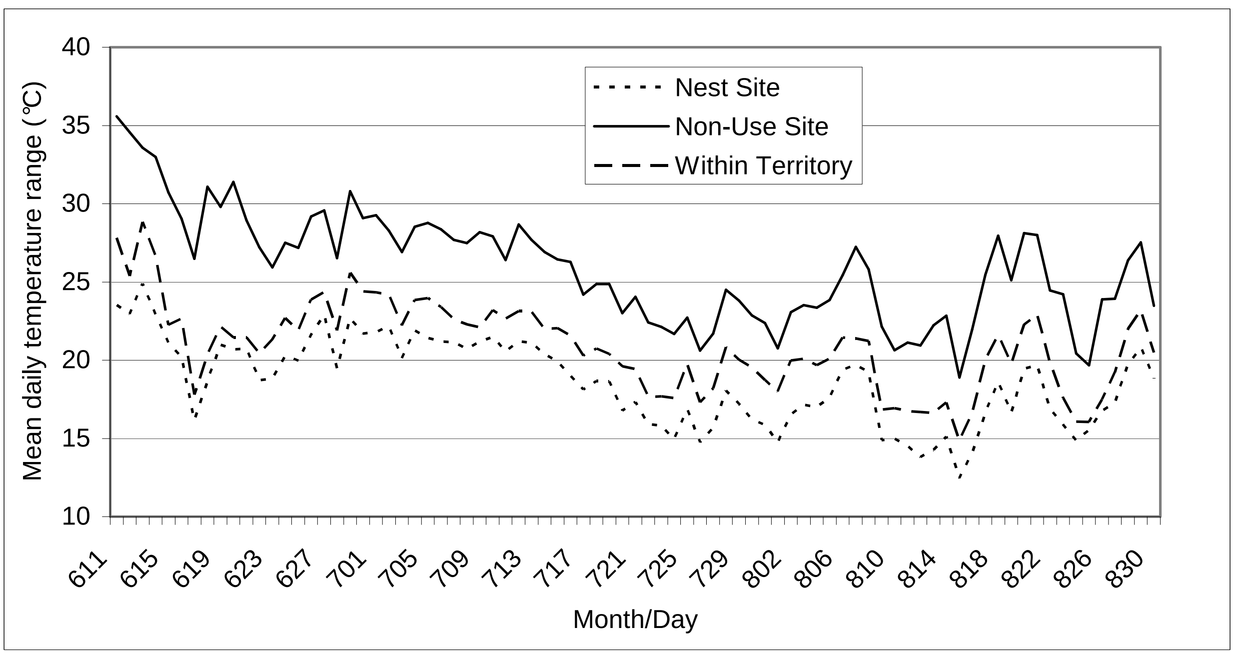

Figure 7.9. Seasonal mean daily temperature range at nest, within-territory, and non-use sites at all study areas combined, excluding Pahranagat, 2003–2007.

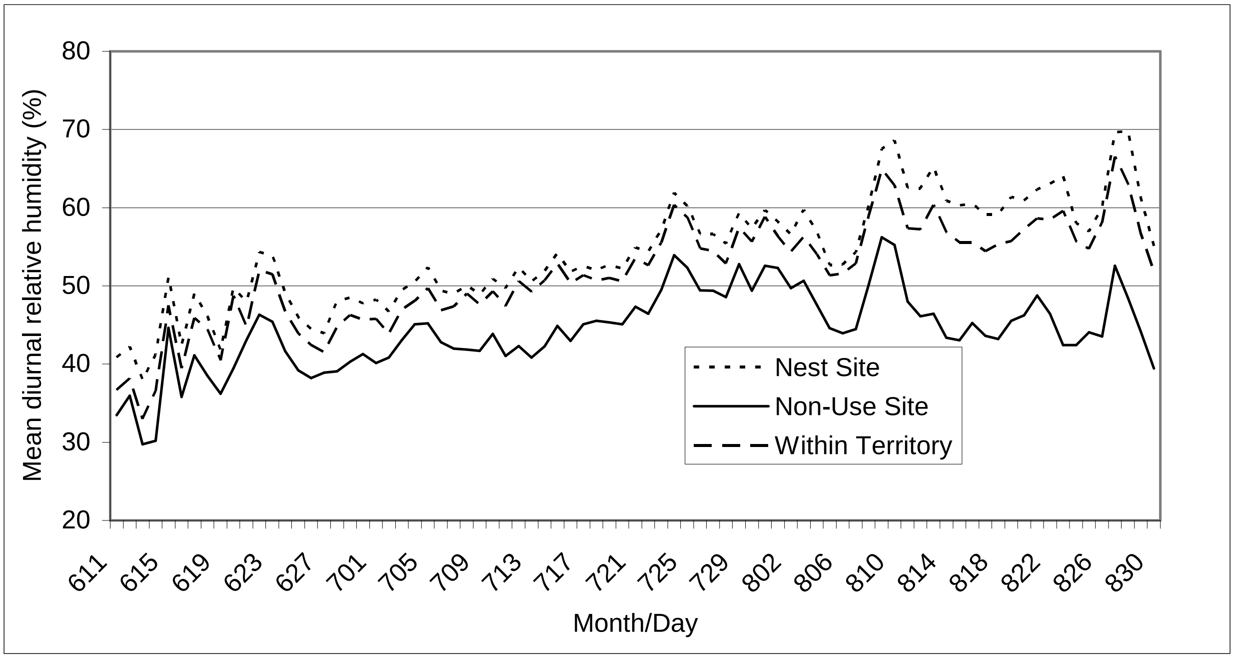

Figure 7.10. Seasonal mean diurnal relative humidity at nest, within-territory, and non-use sites at all study areas combined, excluding Pahranagat, 2003–2007.

MULTIPLE EFFECTS MODELS

Conditional Logistic Regression Model: Identifying Significant Microclimate and Vegetation Variables in Nest Site Selection. All measures of microclimate and select measures of vegetation were included in the initial multivariate models except for the following:

- Distance to water. A large number of distance to water measurements were missing.
- Diurnal temperature, maximum diurnal temperature, and number of 15-minute intervals above 41°C each day. These variables were highly correlated with each other and with daily temperature range. The models were initially fit using maximum diurnal temperature because this was most highly correlated with the other diurnal temperature variables. After the final model was formed, we replaced maximum temperature with the other variables. The estimates did not change substantially; however, mean daily temperature range had the largest odds ratio, and therefore represented a larger relative importance in predicting a nest site.
- Diurnal and nocturnal relative humidity, and diurnal vapor pressure. These variables were also highly correlated with each other and with nocturnal vapor pressure. The models were initially fit using diurnal vapor pressure because this was most highly correlated with the other humidity variables. After the final model was formed, we replaced diurnal vapor pressure with the other variables. The estimates did not change substantially; however, nocturnal vapor pressure had the largest odds ratio, and therefore represented a larger relative importance in predicting a nest site.

The relative importance of the remaining microclimate and vegetation variables is shown in Table 7.7 for all areas combined and in Table 7.8 for all areas except Pahranagat. Variables that remained in the models after stepwise selection are shown in the two columns on the far right of each table. For all study areas combined, an increase of 3° in the mean daily temperature range translated to a 66% decrease in the odds of a site being an NS site versus a WT site, and a 46% decrease in the odds of a site being an NS site versus an NU site. An increase of 215 PA in the mean nocturnal vapor pressure translated to more than double the odds of a site being an NS site versus a WT or NU site. An increase of 5768 shrub stems <2.5 cm dbh per ha translated to an 86% decrease in the odds of a site being an NS site versus an NU site. A 10% increase in the proportion of the basal area that was native meant a site was 49% more likely to be NS versus NU. An increase of seven hits in combined vertical foliage density at the nest layer doubled the odds a site was NS versus NU. And an increase of 25 hits in combined vertical foliage density below the nest layer decreased the odds by 70% that a site was NS versus NU.

Stepwise regression retained mean daily temperature range, mean nocturnal vapor pressure, and combined vertical foliage density at the nest in models comparing NS to WT and NS to NU for all study areas combined. Number of shrub stems 2.5–8.0 cm dbh also remained in the model comparing NS to WT, and proportion of the basal area that is native, number of stems <2.5 cm dbh, and vertical foliage density below the nest remained in the model comparing NS to NU. When Pahranagat was excluded, mean daily temperature range, mean nocturnal vapor pressure, and number of shrub stems <2.5 cm dbh remained in the model differentiating NS and WT. Mean daily temperature range, mean minimum nocturnal temperature, mean nocturnal vapor pressure, canopy closure, number of stems <2.5 cm dbh, number of stems >8.0 cm dbh, and proportion of basal area that was native remained in the model comparing NS to NU. Soil moisture and canopy height were not included in the model comparing NS to NU because collinearity of the variables prevented model convergence.

Linear Regression Model: Identifying Significant Associations between Microclimate and Vegetation. As shown in Table 7.9, most of the vegetation variables were associated with daily temperature range. An increase in canopy height, canopy closure, number of shrub stems 2.5–8.0 or >8.0 cm dbh, and proportion basal area that is native significantly decreased mean daily temperature range, while an increase in number of shrub stems <2.5 cm dbh significantly increased mean daily temperature range. An increase in canopy height and proportion basal area that is native significantly decreased mean nocturnal vapor pressure, whereas an increase in number of shrub stems 2.5–8.0 cm significantly increased mean nocturnal vapor pressure. The models run without Pahranagat produced similar results (Table 7.10).

Table 7.7. Relative Importance of Microclimate and Vegetation Measures in Southwestern Willow Flycatcher Nest Site Selection for All Study Areas Combined, June–August, 2005–2007

Variable	Definition of unit increase	Full model NS vs WT			Full model NS vs NU			Reduced models in which the variable remained	
		Odds Ratio	95% CI	*P*	Odds Ratio	95% CI	*P*	NS vs WT	NS vs NU
Mean soil moisture (mV)	90 mV	0.89	0.471–1.683	0.721	1.24	0.935–1.664	0.131		
Mean daily temperature range (°C)	3°	0.34	0.196–0.684	**0.003**	0.54	0.320–0.916	**0.022**	✓	✓
Mean minimum nocturnal temperature (°C)	2°	0.58	0.102–3.338	0.547	1.43	0.601–3.435	0.414		
Mean nocturnal vapor pressure (Pa)	215 Pa	2.42	0.906–6.466	0.078	3.40	1.158–10.005	**0.026**	✓	✓
Canopy height (m)	4 m	0.95	0.394–2.315	0.919	0.55	0.221–1.406	0.216		
Canopy closure (%)	9%	1.17	0.461–2.999	0.734	1.48	0.939–2.349	0.090		
No. shrub stems (<2.5 cm dbh) per ha	5768 stems per ha	2.26	0.704–7.293	0.170	0.14	0.028–0.729	**0.019**		✓
No. shrub stems (2.5–8.0 cm dbh) per ha	2789 stems per ha	1.94	0.991–3.824	0.053	1.57	0.876–2.842	0.129	✓	
No. tree stems (>8.0 cm dbh) per ha	497 stems per ha	1.20	0.692–2.112	0.505	1.23	0.802–1.914	0.333		
Percent basal area that is native	10%	1.42	0.780–2.608	0.249	1.49	1.097–2.032	**0.011**		✓
Vertical foliage density above nest (hits)	70 hits	1.54	0.743–3.197	0.245	1.57	0.578–4.313	0.372		
Vertical foliage density at nest (hits)	7 hits	1.39	0.846–2.295	0.192	2.08	1.132–3.845	**0.018**	✓	✓
Vertical foliage density below nest (hits)	25 hits	1.57	0.680–3.638	0.289	0.30	0.664–0.131	**0.041**		✓

Table 7.8. Relative Importance of Microclimate and Vegetation Measures in Southwestern Willow Flycatcher Nest Site Selection for All Study Areas Combined except Pahranagat, June–August, 2005–2007

Variable	Definition of unit increase	Full model NS vs WT			Full model NS vs NU*			Reduced models in which the variable remained	
		Odds Ratio	95% CI	*P*	Odds Ratio	95% CI	*P*	NS vs WT	NS vs NU
Mean soil moisture (mV)	90 mV	1.17	0.595–2.304	0.646	--	--	--		
Mean daily temperature range (°C)	3°	0.19	0.064–0.594	**0.004**	0.64	0.421–0.991	**0.045**	✓	✓
Mean minimum nocturnal temperature (°C)	2°	0.20	0.024–1.684	0.140	2.59	1.087–6.205	**0.032**		✓
Mean nocturnal vapor pressure (Pa)	215 Pa	2.51	0.775–8.154	0.124	3.84	1.443–10.265	**0.007**	✓	✓
Canopy height (m)	4 m	0.50	0.056–4.473	0.536	--	--	--		
Canopy closure (%)	9%	0.71	0.224–2.279	0.571	2.75	1.180–6.418	**0.019**		✓
No. shrub stems (<2.5 cm dbh) per ha	5768 stems per ha	1.95	0.584–6.516	0.277	0.20	0.063–0.636	**0.006**		✓
No. shrub stems (2.5–8.0 cm dbh) per ha	2789 stems per ha	2.07	0.946–4.567	0.068	1.40	0.978–2.019	0.065	✓	
No. tree stems (>8.0 cm dbh) per ha	497 stems per ha	1.32	0.721–2.431	0.364	1.39	0.944–2.071	0.094		✓
Percent basal area that is native	10%	1.16	0.616–2.210	0.636	1.55	1.186–2.041	**0.001**		✓
Vertical foliage density above nest (hits)	70 hits	1.47	0.434–5.020	0.532	1.83	0.561–5.998	0.315		
Vertical foliage density at nest (hits)	7 hits	0.82	0.452–1.498	0.524	1.07	1.693–1.661	0.750		
Vertical foliage density below nest (hits)	25 hits	1.96	0.713–5.390	0.192	0.50	0.233–1.081	**0.079**		

* Soil moisture and canopy height were not included in the model comparing NS to NU because collinearity of the variables prevented model convergence.

Table 7.9. Vegetation Variables That Predict the Significant Microclimate Measures for Southwestern Willow Flycatcher Nest Site Selection at All Study Areas Combined, 2003–2007*

Variable	Definition of unit increase	Mean daily temperature range (°C)			Mean nocturnal vapor pressure (Pa)		
		Co-efficient	95% CI	*P*	Co-efficient	95% CI	*P*
Canopy height (m)	4 m	-0.71	-(1.110–0.328)	**<0.001**	-92.47	-(121.964–62.982)	**<0.001**
Canopy closure (%)	9%	-1.01	-(1.313–0.714)	**<0.001**	8.48	-14.138–31.112	0.461
No. shrub stems (<2.5 cm dbh) per ha	5768 stems per ha	0.94	0.457–1.437	**<0.001**	-24.79	-61.816–12.226	0.189
No. shrub stems (2.5–8.0 cm dbh) per ha	2789 stems per ha	-0.57	-(0.870–272)	**<0.001**	54.47	31.919–77.030	**<0.001**
No. tree stems (>8.0 cm dbh) per ha	497 stems per ha	-0.58	-(0.926–0.247)	**0.001**	18.53	-7.079–44.157	0.156
Percent basal area that is native	10%	-0.21	-(0.348–0.084)	**0.001**	-21.78	-(31.762–11.813)	**<0.001**
Vertical foliage density above nest (hits)	70 hits	-0.58	-1.182–0.014	**0.056**	-2.44	-47.633–42.746	0.915
Vertical foliage density at nest (hits)	7 hits	-0.30	-0.614–0.009	0.058	19.92	-3.633–43.492	0.097
Vertical foliage density below nest (hits)	25 hits	0.34	0.002–0.687	0.052	-26.63	-(52.659–0.602)	0.045

* Vegetation variables remaining in the reduced model as predictors of the microclimate measure are shown in bold.

Table 7.10. Vegetation Variables That Predict the Significant Microclimate Measures for Southwestern Willow Flycatcher Nest Site Selection at All Study Areas Combined Except Pahranagat, 2003–2007*

Variable	Definition of unit increase	Mean daily temperature range (°C)			Mean nocturnal vapor pressure (Pa)		
		Co-efficient	95% CI	*P*	Co-efficient	95% CI	*P*
Canopy height (m)	4 m	-2.53	-(3.765–1.299)	**<0.001**	21.50	-64.799–107.809	0.624
Canopy closure (%)	9%	-0.83	-(1.199–0.477)	**<0.001**	8.99	-16.280–34.261	0.485
No. shrub stems (<2.5 cm dbh) per ha	5768 stems per ha	0.80	0.287–1.312	**0.002**	-28.60	-64.508–7.293	0.118
No. shrub stems (2.5–8.0 cm dbh) per ha	2789 stems per ha	-0.56	-(0.896–0.233)	**0.001**	27.02	3.822–50.235	**0.023**
No. tree stems (>8.0 cm dbh) per ha	497 stems per ha	-0.45	-(0.856–0.054)	**0.026**	19.06	-9.002–47.137	0.182
Percent basal area that is native	10%	-0.16	-(0.311–0.014)	**0.032**	-9.82	-20.246–0.603	**0.065**
Vertical foliage density above nest (hits)	70 hits	-1.75	-(2.789–0.713)	**0.001**	-50.35	-22.287–122.996	**0.174**
Vertical foliage density at nest (hits)	7 hits	-0.26	-0.629–0.092	0.145	9.51	-15.776–34.814	0.460
Vertical foliage density below nest (hits)	25 hits	0.36	-0.038–0.773	0.076	-3.67	-32.120–24.769	0.800

* Vegetation variables remaining in the reduced model predicting the microclimate measure are shown in bold.

DISCUSSION

Variation in overall microclimate characteristics did occur among study areas, likely due to differences in elevation, dominant vegetation, and availability of water. Pahranagat differed from the other study areas in that it exhibited markedly lower mean diurnal temperature, mean maximum diurnal temperature, and mean daily temperature range, as well as the greatest soil moisture. Mormon Mesa was generally the hottest of the study areas, exhibiting a higher mean diurnal temperature, mean maximum diurnal temperature, and mean daily temperature range, as well as generally lower humidity.

When all study areas were combined, Southwestern Willow Flycatchers exhibited nest-site selection for habitat that was cooler during the day, more humid overall, exhibited greater soil moisture, and experienced a smaller daily temperature range than unoccupied riparian habitat. This general pattern was consistent throughout the nesting season. The most important microclimate variables separating nest site and unoccupied habitat were mean daily temperature range and mean nocturnal vapor pressure when all study areas were combined, with NS habitat associated with a more moderate thermal regime. In our study areas, Southwestern Willow Flycatchers select nesting habitat that buffers diurnal heat gain and nocturnal heat loss. These findings are consistent with previous investigations of avian microclimate, which demonstrated that vegetation structure at the nest can moderate potentially harmful climatic extremes (e.g., Walsberg 1981, 1985).

Of particular interest was our finding that NS and WT sites differed significantly within the same occupied flycatcher territory for most microclimate variables, especially those aspects of microclimate associated with diurnal temperature. Virtually all measures of daily temperature at nest-site locations were cooler, more moderate, and less variable than at corresponding sites within the same flycatcher territory. This distinction between NS sites and adjacent habitat within 10 m of the nest illustrates the strong degree to which nest-site selection is occurring in this desert riparian species. Since a more moderate microclimate for nest placement can positively influence energy conservation (Warkentin and West 1990), any energy saved through beneficial nest-site selection has the potential to increase productivity and improve fitness (Gloutney and Clark 1997).

The most important vegetation variables responsible for the separation between NS and NU habitat were mean daily temperature range, mean nocturnal vapor pressure, shrub stems <2.5 cm dbh, native basal area, and vertical foliage at and below the nest. Mean daily temperature range was the most important predictor of NS versus WT locations. This confirms our previous finding that flycatchers nesting in hot desert environments avoid temperature extremes in favor of more moderate and less variable microclimates. Therefore, we suggest that at our sites Southwestern Willow Flycatchers are selecting nest sites that lessen energy expenditure via a moderate microclimate.

The strong relationship between occupied flycatcher sites and standing water and soil moisture has been emphasized by many investigators (e.g., Finch and Stoleson 2000, Sogge et al. 2003). However, soil moisture was not a significant factor separating occupied and unoccupied habitat in the multiple effects models, although it differed between occupied and unoccupied habitat at several study areas. In the multiple effects models, soil moisture may have been overshadowed by other, more statistically important factors. It is also possible that our measurements of soil moisture were made at an inappropriate depth or at an inappropriate temporal scale. Depth to groundwater before and during the flycatcher breeding season may differ between occupied and unoccupied areas.

If a suitable microclimate is important both to flycatcher site occupancy and also possibly to nesting success, providing a site with a suitable microclimate is of concern in habitat creation, restoration, and management. Microclimate can not be manipulated directly, but can be indirectly influenced through manipulation of vegetation characteristics and possibly soil moisture. Vegetation structure and species composition appeared to influence microclimate variables that were good predictors of whether a location was occupied by flycatchers.

Vegetation variables tested in the model but not included below were ones that appeared to make no positive contribution to suitable flycatcher microclimate. To decrease daily temperature range and/or increase nocturnal vapor pressure:

- Increase canopy height.
- Increase canopy closure.
- Decrease numbers of shrubs stems <2.5 cm dbh.
- Increase numbers of shrub stems 2.5–8.0 cm dbh.
- Increase numbers of shrub stems >8.0 cm dbh.

Increases in the proportion of basal area that is native and in vertical foliage density above nest height were associated with decreasing daily temperature range but also with decreasing nocturnal vapor pressure.

CHAPTER 8

MANAGEMENT RECOMMENDATIONS

PRESENCE/ABSENCE SURVEYS

Most survey sites along the lower Colorado River change little from one year to the next, with the exception of sites that have been altered by fire or hydrological events (e.g., floods or changes in reservoir levels). Surveys over the last 10 years have not revealed any resident flycatchers at currently surveyed sites south of Parker Dam, and we feel annual surveys are not necessary at these static, unoccupied sites. Adult flycatchers exhibit a high degree of site fidelity, and if flycatchers are present at a site in one year, they are likely to be present the following year, unless vegetation or hydrology of the site has been altered. Thus, biannual surveys are likely to detect any colonization of sites. Any marked changes in sites, such as growth of new vegetation, would be noted during annual reconnaissance (see Site Selection below), and survey schedules could be altered accordingly to include sites where conditions have changed. Therefore, we recommend biannual surveys for sites that exhibit little inter-annual change and have no history of flycatcher residency. We recommend continuing annual surveys and monitoring for sites with a history of flycatcher residency (see Demography, below).

SITE SELECTION

The selection of survey sites should be reevaluated depending on the goal of the surveys (i.e., to detect resident flycatchers or to document use by migrants). Some sites that are currently surveyed (e.g., Three Fingers Lake) are used heavily by migrants but do not contain the vegetation characteristics and/or hydrologic conditions that are found at breeding sites.

Current, high-resolution aerial photographs are essential for guiding site selection in extensive riparian corridors, and current aerial photography should be maintained for all potential survey areas. Ground reconnaissance of large areas in riparian habitat is often prohibitively difficult and time consuming. Areas containing dense vegetation can often be distinguished from surrounding habitat on high-resolution aerial photographs, and these areas can be prioritized for ground habitat reconnaissance and surveys. This type of prioritization was instrumental in the discovery in 2005 of breeding flycatchers in Virgin River #2 at Mormon Mesa. Annual helicopter overflights are also essential for identifying recent changes in vegetation and surface water conditions. Previously unknown breeding areas on the Lake Mead delta (RM 285.3), Muddy River delta (south end of Overton WMA), and in Mormon Mesa (south of the previously existing Virgin River #2 area) were identified via helicopter reconnaissance.

DEMOGRAPHY

Because the willow flycatcher is a successional habitat specialist and riparian vegetation and hydrology can change rapidly, flycatcher populations can be lost or colonize suitable habitat quickly. Therefore, population monitoring utilizing color-banding and resighting throughout the LCR MSCP area should be continued. Known, marked individuals are essential for determining many demographic parameters. Accurate estimates of the number of breeding flycatchers would be difficult without marked individuals. Flycatchers may shift territory locations within a site, or even move between sites, during a breeding season, and such individuals would be counted multiple times if they were not individually identifiable. Similarly, turnover of individuals at a given territory location occurs during a given breeding season, and in these cases multiple individuals would be recorded as a single bird. Observing marked individuals who are feeding fledglings is also useful in determining the success or failure of nests. A marked population is also essential to quantifying dispersal patterns, identifying source populations, and estimating, through mark-recapture modeling, population parameters such as annual survival. Differential survival between sites or changes in survival over time can be identified only through long-term monitoring of marked individuals.

This study has shown that a portion of the willow flycatcher population within the LCR MSCP area consists of floaters (non-territorial individuals). Many floater or non-breeding individuals would go undetected if large portions of the population were not individually marked. Non-breeding birds often do not exhibit observable, territorial behaviors (e.g., song and calls from exposed perches) and thus would go undetected, even with broadcast surveys, if they were not incidentally resighted or captured during passive or target netting. These non-territorial and non-breeding individuals should be included in any population estimates of the willow flycatcher because these individuals consistently make up a substantial part of the relatively small, local populations that occur on the lower Virgin, Muddy, and Colorado Rivers. These individuals likely serve as population reservoirs and replace other individuals that move or die.

BANDING TECHNIQUES

Metal, pin-striped color-bands result in fewer leg injuries than celluloid-plastic bands and experience less color fading, making them easier to resight in the field. Therefore, all banding studies of willow flycatchers should use metal, pin-striped bands. In study areas where recapture of adult individuals is difficult because of dense vegetation, full color combinations, rather than a single federal band, should be placed on all nestlings, allowing individual identification of any returning nestlings without requiring recapture of the individual.

NEST MONITORING

Depredation has consistently been the leading cause of Southwestern Willow Flycatcher nest failure at the Virgin/lower Colorado River sites since nest monitoring studies were initiated in 1996. However, direct observations of nest depredation events are rare to nonexistent during nest monitoring, and the identity of nest predators and factors influencing nest depredation along the Virgin and lower Colorado Rivers remain undetermined. Future studies should identify nest predator assemblages as a necessary first step in addressing factors that influence depredation rates. Results of these studies would guide restoration planning and design and would be applicable to other species addressed in the LCR MSCP.

Intensive nest-searching efforts employed during this study resulted in the discovery of the majority of nests during the building, laying, or early incubation stages. Discovery of most nests early in the nesting cycle results in apparent nest success not differing substantially from

Mayfield nest success. Therefore, calculation of Mayfield estimates may be unnecessary if most nests are found early in the nesting cycle, and nests could be visited fewer times, resulting in less nest disturbance but no loss of nest success information.

BROWN-HEADED COWBIRD TRAPPING

Our studies have shown that cowbird trapping can lower brood parasitism, increase flycatcher nest success and productivity, and potentially increase juvenile flycatcher survivorship. However, our data suggest Brown-headed Cowbird trapping may be more effective in reducing willow flycatcher brood parasitism and increasing nest success at small, isolated sites than within large, contiguous stretches of riparian habitat such as those found on the Virgin and lower Colorado Rivers. In addition, cowbird trapping at some sites is impractical because of remoteness of the sites and difficulty in placing traps close to flycatcher breeding areas. Other cowbird control measures (shooting cowbirds within flycatcher territories, addling cowbird eggs, removing cowbird nestlings) have been shown to be effective in lowering parasitism rates and increasing nest success, and these methods should be considered at sites where parasitism is a concern and trapping is ineffective or impractical.

In areas where cowbird trapping is implemented, traps should be of the funnel-top design and have entrance slots 3.8 cm wide. Our studies showed that traps with funnel-shaped tops were more effective in capturing and retaining cowbirds than the more portable, flat-topped design. Traps with entrance slots 3.8 cm wide were also more effective in trapping cowbirds than traps with narrower 3.2-cm-wide slots, and escape rates between the two slot dimensions did not differ significantly.

MIGRATION AND HABITAT USE STUDIES

Although much funding and effort is currently being focused on creating and restoring riparian habitat along the lower Colorado River for *E. t. extimus*, the degree to which the subspecies uses the river corridor as a migratory flyway and/or prospects in existing habitat is unknown and should be investigated. Determining if, how, and where *extimus* prospects in existing habitat along the lower Colorado River may provide insight as to where restoration sites should be located to best facilitate colonization.

SITE RESTORATION, MAINTENANCE, AND ENHANCEMENT

The selection, design, and management of riparian restoration sites for land birds as part of the LCR MSCP should include recommendations from experts in the fields of avian ecology, population biology, and landscape ecology. Although the life history traits and habitat requirements of riparian land birds along the lower Colorado River are inherently complex and are difficult to quantify, a vast knowledge of species' habitat requirements does exist as result of many years of bird research throughout the Southwest. Recommendations from species experts would ensure restoration sites contain the habitat characteristics that best facilitate colonization by bird species of concern.

HYDROLOGICAL CONDITIONS

Overbank flooding into adjacent riparian vegetation does not occur along the majority of the Colorado River south of the Bill Williams River, and the general lack of standing water under the vegetation may be a factor in why no willow flycatcher nests have been recorded in the area in almost 70 years. A riparian restoration program on the Gila River in southwestern New Mexico (see Boucher et al. 2003) demonstrated that mechanically removing, or sloping, river cutbanks to expose the water table adjacent to the main river channel created hydrogeomorphological characteristics resembling a natural oxbow, or backwater area. This in combination with pole-planting native trees in and adjacent to the newly created backwater areas resulted in the colonization of Southwestern Willow Flycatchers into the project area in two years. Facilitating, or simulating, overbank flooding events into existing riparian stands or restoration sites within the LCR MSCP area may create the hydrological conditions required by the Southwestern Willow Flycatcher. Several current flycatcher survey sites within the LCR MSCP area may be suited for this application because of their proximity to mainstem rivers or existing backwater areas and riparian habitat. These sites include Ehrenberg, Hoge Ranch, Walker Lake, Paradise, and the Gila River sites. If mechanical manipulation of mainstem riverbanks at sites is not practicable, overbank flooding into riparian stands may also be simulated from adjacent uplands via runoff from agricultural fields or other similar means. Historically and currently occupied Southwestern Willow Flycatcher sites that are dependent upon upland human controlled runoff are located along the Gila River near Gila and Cliff, New Mexico; the San Pedro River near Winkleman, Arizona; and along the Virgin River at Mesquite West, Mesquite East, and Bunker Farm, Nevada.

Manipulative experiments at restoration sites that attempt to duplicate hydrological conditions at breeding sites may provide managers information regarding the amount and duration of standing water needed to create and maintain the structural characteristics of vegetation found at occupied flycatcher habitat. Experiments should include different types of water impoundment structures and materials to identify those that are best suited for riparian ecosystem replication.

LANDSCAPE CONFIGURATION

Habitat use by unpaired residents and non-territorial floaters (including returning juveniles) remains largely unknown, and future studies (e.g., using radio telemetry) should document habitat use for unpaired resident and non-territorial floater willow flycatchers. These data may help guide restoration efforts and promote recovery of the species by providing quantitative information regarding how the spatial patterning of habitats within the greater landscape best facilitates flycatcher immigration and establishment of new populations.

Demographic data collected as part of these studies and those of the U.S. Geological Survey in south-central Arizona (Paxton et al. 2007) indicate that willow flycatcher juvenile dispersal among local populations is largely limited to within river drainages, and most dispersal distances are 30 km or less. Therefore, the willow flycatchers in the Havasu area (Topock Marsh and possibly Bill Williams) would likely be the main source population for LCR MSCP riparian restoration sites being created along the lower Colorado River.[1] Restoration areas should be established close to existing flycatcher populations to increase the likelihood of these areas being colonized by flycatchers.

Efforts must be initiated to ensure Topock Marsh continues to remain suitable for breeding willow flycatchers. In particular, the site must receive an adequate amount of standing water under the vegetation annually. Fluctuations in the amount of standing water under the vegetation at Topock have been recorded, with a markedly reduced amount in 2005 compared to 2003–2004 and 2006–2007. It is noted consistently in the literature that breeding willow flycatchers are associated with surface water; therefore, an increase in the amount of surface water within the habitat at Topock Marsh may result in a greater number of breeding flycatchers at this site. Furthermore, because of the ever-present danger of fire at Topock Marsh, buffer zones and/or firebreaks are needed around flycatcher breeding areas. Because much of the habitat that surrounds the flycatcher breeding areas at Topock Marsh is unsuitable for willow flycatchers, firebreaks could be established to protect breeding areas.

QUANTITATIVE HABITAT AND MICROCLIMATE RECOMMENDATIONS

The analyses presented in Chapters 6 and 7 provide strong evidence that vegetation and microclimate influence habitat selection by the Southwestern Willow Flycatcher. Manipulation of vegetation structure and composition is the most practical means for a resource manager to create or restore the preferred microclimate for flycatcher nesting habitat. Therefore, our recommendations for the creation and/or restoration of flycatcher nesting habitat emphasize vegetation parameters (Table 8.1). The recommended direction in which to manipulate each vegetation characteristic is derived from the observed differences between occupied and unoccupied habitat and also the observed associations between vegetation and microclimate. Important microclimate variables and their values are also identified, as a guide to monitoring the success of restoration efforts in duplicating microclimate conditions of occupied flycatcher habitat (Table 8.2).

Although it may be possible to increase some vegetation variables (e.g., canopy height or number of tree stems) to a point where the habitat is no longer suitable for flycatchers, we did not observe this situation. Table 8.3 shows the minimum, 25th percentile, median, 75th percentile, and maximum values observed for each of the vegetation and microclimate variables at occupied (NS and WT) and unoccupied (NU) sites to illustrate this and to provide further details on the conditions observed at occupied vs. unoccupied sites.

The management recommendations that follow have been designed to apply to riparian areas within the LCR MSCP management area. For this reason, findings from the Pahranagat study area have been excluded. Not only is Pahranagat an anomaly in terms of elevation, vegetation structure and composition, and ecological connectedness when compared to the other study areas, it is also unlikely that riparian habitat similar to that at Pahranagat could be duplicated within the area encompassed by the LCR MSCP.

[1] Although a flycatcher population exists within lower Grand Canyon/Lake Mead National Recreation Area, demographic data have shown this population is more strongly connected with populations that occur within the Virgin and Muddy River drainages (see Chapter 3).

Table 8.1. Vegetation Variables, Management Actions, Microclimate Response, and Recommended Ranges for the Creation of Suitable Nesting Habitat for Southwestern Willow Flycatchers in the Lower Colorado River Multi-Species Conservation Program Area.*

Vegetation Variables	Recommended Management Action[1]	Recommended Statistical Range of Variable (mean ± standard error)
Canopy height (m)	increase	6.1 ± 0.1
Canopy closure (%)	increase	92.8 ± 0.3
No. shrub stems (<2.5 cm dbh) per ha	decrease or minimize	<6714.9
No. shrub stems (2.5–8.0 cm dbh) per ha	increase	8349.1 ± 246.1
No. shrub stems (>8.0 cm dbh) per ha	increase	893.1 ± 60.0
Percent basal area that is native	increase	41.4 ± 2.2
Vertical foliage density (hits) above nest	increase	69.0 ± 2.1
Vertical foliage density (hits) at nest	ignore	N/A
Vertical foliage density(hits) below nest	decrease or minimize	<48.2

* These recommendations are based on findings from single- and multiple-effects models that do not include data from the Pahranagat study area. Data from both NS and WT sites from the other four study areas (Mesquite, Mormon Mesa, Muddy River, and Topock) and all years combined (total sample size = 350) provided the basis for these recommendations, including the recommended statistical range for each vegetation variable. Vegetation variables show in bold are those that were significant predictors of flycatcher nest locations in models combining vegetation and microclimate variables (see Table 7.8). N/A = not applicable.

[1] Vegetation variables should be managed simultaneously, not separately, to meet the recommended range for each.

Table 8.2. Recommended Microclimate Goals for Southwestern Willow Flycatcher Microclimate Measures*

Microclimate Variable	Recommended Statistical Range of Variable (mean ± standard error)
Soil Moisture	
Mean soil moisture (mV), 2005–2007**	751.9 ± 15.5
Temperature	
Mean maximum diurnal temperature (°C)	43.0 ± 0.2
Mean diurnal temperature (°C)	31.1 ± 0.1
Mean no. of 15-min. intervals above 41°C each day	4.5 ± 0.3
Mean minimum nocturnal temperature (°C)	16.4 ± 0.1
Mean nocturnal temperature (°C)	24.6 ± 0.1
Mean daily temperature range (°C)	**19.6 ± 0.2**
Humidity	
Mean diurnal relative humidity (%)	53.0 ± 0.6
Mean diurnal vapor pressure (Pa)	2,200.2 ± 26.0
Mean nocturnal relative humidity (%)	64.6 ± 0.5
Mean nocturnal vapor pressure (Pa)	**1,964.7 ± 20.6**

* These measures are the mean and standard errors for occupied territory (NS and WT combined) for all life history areas combined, except Pahranagat, across study years. The variation for several of these measures by life history area and through the season is provided in the graphs in Chapter 7. Bold indicates the microclimate variables that were significant in regression models comparing occupied to unoccupied flycatcher habitat.

Table 8.3. Minimum, 25^{th} Percentile, Median, 75th Percentile, and Maximum Values for Occupied and Unoccupied Sites for All Study Areas Combined Except Pahranagat.

Variable	Within-Territory (NS and WT combined)					Unoccupied (NU)				
	Minimum	25%	Median	75%	Maximum	Minimum	25%	Median	75%	Maximum
Soil moisture (mV)	128.5	649.0	819.5	911.3	994.0	94.5	334.3	597.2	807.1	955.4
Diurnal temperature (°C)	26.1	29.5	30.9	32.4	39.7	25.2	31.6	33.7	36.2	41.4
Nocturnal temperature (°C)	19.2	23.2	24.9	26.1	29.3	18.0	23.2	24.8	26.1	29.4
Diurnal relative humidity (%)	24.7	46.1	53.7	59.9	87.4	18.4	36.8	44.6	51.9	72.6
Diurnal vapor pressure (Pa)	996.0	1,899.9	2,235.3	2,529.6	3,307.5	883.0	1,696.4	1,973.4	2,385.8	3,157.9
Nocturnal relative humidity (%)	36.7	58.8	65.3	71.3	95.6	36.3	56.9	63.3	69.3	91.2
Nocturnal vapor pressure (Pa)	1,016.0	1,758.9	2,024.3	2,215.8	2,730.8	981.8	1,625.5	1,891.9	2,156.9	2,523.5
Canopy height (m)	2.8	5.0	6.0	7.0	13.4	1.0	3.5	4.5	5.5	11.0
Canopy closure (%)	55.7	90.0	94.2	97.0	100.0	4.2	73.0	88.0	94.8	100.0
No. shrub stems (<2.5 cm dbh) per ha	0.0	3,437.9	5,602.5	9,040.4	29,158.5	127.3	3,947.2	6,748.5	10,441.1	57,680.4
No. shrub stems (2.5–8.0 cm dbh) per ha	254.6	5,093.2	7,767.1	11,205.0	29,413.2	0.0	2,801.3	6,239.2	10,059.1	24,829.3
No. tree stems (> 8.0 cm dbh) per ha	0.0	127.3	636.6	1,400.6	14,643.0	0.0	0.0	254.6	891.3	3,947.2
Percent basal area that is native	0.0	0.0	29.7	88.4	100.0	0.0	0.0	0.0	44.0	100.0
Vertical foliage density above nest (hits)	5.0	42.0	61.3	93.0	266.0	0.0	9.0	25.0	54.0	152.0
Vertical foliage density at nest (hits)	5.0	19.0	25.0	33.0	60.0	0.0	15.0	24.0	34.0	76.0
Vertical foliage density below nest (hits)	0.0	23.0	38.0	66.0	198.0	4.0	26.0	45.0	82.0	213.0
Distance to water (m)	0.0	1.0	5.0	27.0	675.0	0.0	7.0	38.0	80.0	740.0

Mean nest height must be known in order to manage for combined vertical foliage density above or below the nest layer. The nest height at all four study areas (Mesquite, Mormon Mesa, Muddy River, and Topock) during the five years of study ranged from 1.0 to 9.3 m (n = 244; see Chapter 6) and the mean was 2.9 ± 0.1 m. Therefore, we recommend that approximately 3.0 m be considered the lower limit for management of the 'combined vertical foliage density above nest layer' vegetation variable. Conversely, we recommend that approximately 2.0 m be considered the upper limit for management of the 'combined vertical foliage density below nest layer' vegetation variable.

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.

Ahlers, D. and R. Tisdale. 2001. Brown-headed cowbird control Middle Rio Grande, New Mexico 2001 study results. U.S. Department of the Interior, Bureau of Reclamation, Albuquerque Area Office and Technical Service Center, Ecological Planning and Assessment, Denver, Colorado. 39 pp.

Ahlers, D. and R. Tisdale-Hein. 2001. Preliminary assessment of the effectiveness of the cowbird control program Middle Rio Grande, New Mexico 2000. U.S. Department of the Interior, Bureau of Reclamation, Albuquerque Area Office and Technical Service Center, Ecological Planning and Assessment, Denver, Colorado. 38 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.

Baird, K.J., J.C. Stromberg, and T. Maddock III. 2005. Linking riparian dynamics and groundwater: An ecohydrologic approach to modeling groundwater and riparian vegetation. Environmental Management 36:551–564.

Bekoff, M., A.C. Scott, and D.A. Conner. 1987. Nonrandom nest-site selection in Evening Grosbeaks. Condor 89:819–829.

Blem, C.R., and L.B. Blem. 1994. Composition and microclimate of Prothonotary Warbler nests. Auk 111:197–200.

Boucher, P.F., S.H. Stoleson, R.S. Shook, R.D. Pope, and J. Monzingo. 2003. Riparian restoration on the Gila River, New Mexico, creates breeding habitat for Southwestern Willow Flycatchers. Pages 135–142 ***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.

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, 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, D.E., N.L. Ingraham, and S.D. Smith. 1992. Water uptake in woody riparian phreatophytes of the southwestern United States: A stable isotope study. Ecological Applications 2:450-459.

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.

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.

Dawson, R.D., C.C. Lawrie, and E.L. O'Brien. 2005. The importance of microclimate variation in determining size, growth and survival of avian offspring: Experimental evidence from a cavity nesting passerine. Oecologia 144:499–507.

Elmore, A.J., J.F. Mustard, and S.J. Manning. 2003. Regional patterns of plant community responses to changes in water: Owens Valley, California. Ecological Applications 13:443–460.

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., and S.H. Stoleson (eds.). 2000. 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.

Garrett, K., and J. Dunn. 1981. Birds of Southern California. Los Angeles Audubon Society, Los Angeles, California.

Gill, F.B. 1995. Ornithology, Second Edition. W.H. Freeman and Company, New York.

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.

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.

Grant, G.C., C.V. Paganelli, and H. Rahn. 1984. Microclimate of gull-billed tern and black skimmer nests. Condor 86:337–338.

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.

Hardy, P.C., and M.L. Morrison. 2001. Nest site selection by Elf Owls in the Sonoran Desert. Wilson Bulletin 113:23–32.

Harris, J.H. 1991. Effects of Brown-headed Cowbirds on willow flycatcher nesting success along the Kern River, California. Western Birds 22:13–26.

Hartman, C.A., and L.W. Oring. 2003. Orientation and microclimate of Horned Lark nests: The importance of shade. Condor 105:158–163.

Holcomb, L.C. 1974. The influence of nest building and egg laying behavior on clutch size in renests of the willow flycatcher. Bird-Banding 45(4):320–325.

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, 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., E.H. Paxton, and M.K. Sogge. 2005. A technique to produce aluminum color-bands for avian research. Journal of Field Ornithology 76(1):94–97.

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.

Kostecke, R.M., S.G. Summers, G.H. Eckrich, and D. A. Cimprich. 2005. Effects of Brown-headed Cowbird (*Molothrus ater*) removal on Black-capped Vireo (*Vireo atricapilla*) nest success and population growth at Fort Hood, Texas. Ornithological Monographs No. 57. The American Ornithologists' Union.

Lindsey, G.D., K.A. Wilson, and C. Herrmann. 1995. Color change in Hughes's Celluloid Leg Bands. Journal of Field Ornithology 66(2):289–295.

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.

Manolis, J.C., D.E. Andersen, and F.J. Cuthbert. 2000. Uncertain nest fates in songbird studies and variation in Mayfield estimation. The Auk 117(3): 615–626.

Marshall, R.M., and S.H. Stoleson. 2000. Threats. Pages 13–24 *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.

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. 2001. Abiotic vs. biotic influences on habitat selection of coexisting species: Climate change impacts? Ecology 82:175–188.

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 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.

McLeod, MA., T.J. Koronkiewicz, S.R. Nichols, B.T. Brown, and S.W. Carothers. 2008. Southwestern Willow Flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2007. Annual report submitted to Bureau of Reclamation, Boulder City, NV by SWCA Environmental Consultants, Flagstaff, AZ. 182 pp.

Meyer, C.L., and T.D. Sisk. 2001. Butterfly response to microclimatic conditions following ponderosa pine restoration. Restoration Ecology 9:453–461.

Meyer, C.L., T.D. Sisk, and W.W. Covington. 2001. Microclimatic changes induced by ecological restoration of ponderosa pine forests in northern Arizona. Restoration Ecology 9:443–452.

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., 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.

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 sythesis report. USGS Open-File Report 2007-1381.

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.

Pulliam, H.R. 1988. Sources, sinks, and population regulation. American Naturalist 132:652–661.

Pyle, P. 1997. Identification guide to North American birds. Part 1. Slate Creek Press, Bolinas, California. 730 pp.

Pyle, P. 1998. Eccentric first-year molt patterns in certain Tyrannid flycatchers. Western Birds 29:29–35.

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.

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.

Sedgwick, J.A., and W.M. Iko. 1999. Costs of Brown-headed Cowbird parasitism to Willow Flycatchers, Studies in Avian Biology 18:167–181.

Sedgwick, J.A., and R.J. Klus. 1997. Injury due to leg bands in willow flycatchers. Journal of Filed Ornithology 68(4):622–629.

Shafroth, P.B., J.C. Stromberg, and D.T. Patten. 2000. Woody riparian vegetation response to different alluvial water table regimes. Western North American Naturalist 60:66-76.

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.

Sogge, M.K, T.J. Koronkiewicz, C. Van Riper III, and S.L. Durst. 2007. Nonbreeding Territory Defense Behavior in the Willow Flycatcher (*Empidonax traillii*). Condor 109:475–480.

Stiles, F.G., and A.F. Skutch. 1989. A guide to the birds of Costa Rica. Cornell University Press, New York.

SWCA Environmental Consultants. 2004. Southwestern Willow Flycatcher surveys along the Virgin River near Mesquite, Nevada, 2004. Final report to the Bureau of Land Management, Las Vegas, Nevada, submitted by SWCA Environmental Consultants, Salt Lake City, Utah. 25 pp.

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. n.d. Long-term restoration program for the historical Southwestern Willow Flycatcher (*Empidonax traillii extimus*) habitat along the Lower Colorado River. Unpublished Report, Lower Colorado Region, Bureau of Reclamation, Boulder City, Nevada. 70 pp.

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 BR Lower Colorado Region to Lower Colorado Multi-Species Conservation Program. BR: Boulder City, Nevada. 70 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). 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., K.M., Enos, and S. P. Rowe. 1999. Is Brown-headed Cowbird trapping effective for managing populations of the endangered Southwestern Willow Flycatcher. Pages 260–266 *in* Morrison, M.L., L.S. Hall, S.K. Robinson, S.I. Rothstein, D. Caldwell Hahn, and T.D. Rich (eds.). Research and management of the Brown-headed Cowbird in western landscapes. Studies in Avian Biology No. 18. Cooper Ornithological Society.

Whitfield, M.J. 2000. Results of a Brown-headed Cowbird control program for the Southwestern Willow Flycatcher. Pp. 371–377 *in* J. N. M. Smith, T. L. Cook, S.I. Rothstein, S.K. Robinson, and S.G. Sealy (editors). Ecology and management of cowbirds and their hosts. University of Texas Press, Austin, TX.

Whitfield, M.J., and M.K. Sogge. 1999. Range-wide impacts of Brown-headed Cowbird parasitism on the Southwestern Willow Flycatcher (*Empidonax trailli extimus*). Studies in Avian Biology 18:182–190.

Wiebe, K.L. 2001. Microclimate of tree cavity nests: Is it important for reproductive success in Northern Flickers? Auk 118:412–421.

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.

Winker, K. 1998. The concept of floater. Ornitologia Neotropical 9: 111–119.

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.

ACKNOWLEDGEMENTS

This five-year project was made possible by the support of many persons, agencies, private landowners, and our dedicated staff and crew. Work was conducted under the auspices of Federal Fish and Wildlife Threatened and Endangered Species Permit TE-028605-1 and Master Banding Permit #23258. Funding was provided by the Bureau of Reclamation (Contract No. 03-CS-30-0093). The U.S. Fish and Wildlife Service, Ecological Services Field Office, Phoenix, provided funding for flycatcher color-banding and sub-species studies. Theresa Olson, John Swett, and Joe Kahl from Reclamation in Boulder City provided background information and guidance, and Mark Santee piloted the helicopter for site tours.

Many thanks to the following national wildlife refuges and personnel for all their assistance and for providing housing: Eddy Pausch, Merry Maxwell, and Jim Doctor at Pahranagat NWR; Greg Wolf, John Earl, Jack Allen, Aimee Haskew, and Ty Bennali at Havasu NWR; Dr. Kathleen Blair, Dick Gilbert, and Stan Culling at Bill Williams River NWR; Tom Alexander, John Earl, Geary Hund, and Bill Seese at Cibola NWR; and Ken Edwards, Jackie Ferrier, Guy Walker, Tina Lynsky, and Juliette Gutierrez at Imperial NWR. Also, we would like to thank Cris Tomlinson, Christy Klinger, Bob Furtek, and Keith Brose with Nevada Division of Wildlife for their support at Key Pittman and Overton Wildlife Management Areas.

Thanks to the following agencies and personnel for assistance with obtaining permits: Greg Beatty, Daniel Marquez, Sandy Marquez, Jeri Krueger, Christiana Manville, Luela Roberts, and Sarah Quamme with the U.S. Fish and Wildlife Service; Florence Soehnlein, Mary Gustafson, and Danny Bystrak with the federal Bird Banding Laboratory; Melissa Swain with the Arizona Game and Fish Department; Gloria Shaw and Jeanne Sealove with Lake Mead National Recreation Area; Emma Benenati, Bette Anne Domilici, and Kristin Heins with Grand Canyon National Park; Dr. John Gustafson with the California Department of Fish and Game; Cris Tomlinson, Maureen Hullinger, and Julie Meadows with the Nevada Division of Wildlife; Kerry Christensen with the Hualapai Department of Natural Resources; Gary White with the Cocopah Tribe; Arlene Kingery and Juliana Comet with Fort Yuma-Quechan Tribe Environmental Department; and Michael Herder with the Bureau of Land Management, St. George. Phillip, Betty, and Angela Reber and Robert Bunker granted access to their property.

A very special thanks to April Tudor, Patrick Dockens, Alex Smith, and Heather English with the Arizona Game and Fish Department and to Eben Paxton, Scott Durst, Mark Sogge, Patti Newell, and Suzanne Cardinal with the U.S. Geological Survey, Southwest Biological Science Center for support and assistance in all phases of the project. Thanks to Scott Rogers, Mike Tam, and Bill Burris for constructing cowbird traps, and to Johnny and Kathy at Monte Vista Marine for assisting with boating logistics. Thanks also to Susan Sferra with Reclamation, Phoenix. We would also like to thank Cloyd at Anotech Corp. and David Kraft at Anacote for producing color-anodized leg bands.

This project would not be a success without our dedicated staff and field personnel. Many, many thanks to Lisa Baca, Jessica Maggio, Karen Epperly, Casey Wyatt, Beth Moser, and Kimberly MacMillan who went beyond their administrative duties and coordinated housing, permitting, payroll, vehicles, computers, and telecommunications and handled all manner of crises with cheerful aplomb. Cooper Carothers, Yael Bernstein, and Bobby Jenson served as river guides, and Valerie Stein and Suzanne Rhodes made color-bands. A very special thanks to Glenn Dunno and Ashley Jenkins for their GIS talents. Thanks also to Terri Patrick for administrative and accounting support. Thanks to Andy Forde and Jeff Sakowicz for volunteering their time surveying. And sincere thanks to the 2003–2007 field crews for their hard work, dedication, and sweat.