Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Southwestern Willow Flycatcher Surveys, Demography, and Ecology along the Lower Colorado River and Tributaries, 2008. Annual Report

U.S. DEPARTMENT OF THE INTERIOR
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February 2009

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Lower Colorado River Multi-Species Conservation Program

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EXECUTIVE SUMMARY

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

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

Reclamation and USFWS completed a separate consultation on the potential effects to threatened and endangered species from implementation of surplus guidelines through 2016 and an annual change in the point of diversion for up to 400,000 acre-feet of California apportionment water for 75 years. The point of diversion, previously located below Parker Dam, would change to a point above Parker Dam. These changes in water regulation could cause a drop in floodplain groundwater levels of 1.55 feet (0.47 m) or less and have the potential to modify riparian habitats below Parker Dam. A Biological Opinion for Interim Surplus Criteria, Secretarial Implementation Agreements, and Conservation Measures was issued in January 2001 and required monitoring of 150.5 ha of existing, occupied Southwestern Willow Flycatcher habitat between Parker and Imperial Dams. In 2004, Reclamation biologists initiated studies of the microclimate within potentially affected areas. In 2005, these studies were continued and expanded by SWCA Environmental Consultants (SWCA) to address how the hydrological changes might affect riparian habitats along the Parker to Imperial reach.

From 1997 to 2008, breeding populations of Southwestern Willow Flycatchers were documented along the Virgin and lower Colorado Rivers and tributaries at eight study areas from Pahranagat National Wildlife Refuge, Nevada, south to the Bill Williams River in Arizona. Willow flycatchers also have been detected during the breeding season at many sites along the Colorado River south of the Bill Williams River to the Mexico border. Behavioral observations and timing of detections strongly suggest this section of the river corridor is a major flyway for migrant willow flycatchers in spring. The degree to which migrant Southwestern Willow Flycatchers use the lower Colorado River corridor is unknown.

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 2008. Approximately 100 sites are included in the study, but a portion of them are surveyed on a biennial basis. We completed presence/absence surveys and site descriptions at 77 sites in 16 study areas from the Pahranagat National Wildlife Refuge (NWR), Nevada, south to Yuma, Arizona. We also conducted more intensive studies at the eight study areas where territorial flycatchers were detected: Pahranagat NWR, Mesquite, Mormon Mesa, and Muddy River Nevada; and Grand Canyon, Topock Marsh, Bill Williams River NWR, and Ahakhav Tribal Preserve, Arizona. At these study areas, we searched for nests in all areas occupied by territorial

flycatchers, monitored willow flycatcher nests to document nest fate, brood parasitism, and causes of nest failure; color-banded and resighted as many willow flycatchers as possible to determine the breeding status of territorial flycatchers and document movement and recruitment; and measured characteristics of vegetation and microclimate in occupied territories and at old flycatcher nests in abandoned areas where we had collected similar data when the nest was active.

We used recorded broadcasts of willow flycatcher song and calls to elicit responses from willow flycatchers at 77 sites, ranging in size from 1 to 92 ha, along the Virgin and lower Colorado Rivers and tributaries between 12 May and 28 July 2008, following a 5-survey protocol. We detected willow flycatchers on at least one occasion at 42 of these sites. Resident, breeding flycatchers were detected at nine sites within the following six study areas: Pahranagat NWR, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams. Resident flycatchers were also detected at Grand Canyon and Ahakhav, Arizona. South of Ahakhav, 90 willow flycatcher detections were recorded between 15 May and 22 June; no flycatcher detections were recorded at any of these sites after 22 June. Monitoring results suggest these flycatchers were not resident, breeding individuals and were most likely spring migrants.

We used targeted mist-net and passive netting techniques to capture and uniquely color-band adult and fledgling willow flycatchers at all survey sites where resident willow flycatchers were detected. Nestlings were banded between 8 and 10 days of age. We banded each willow flycatcher with a single, numbered U.S. federal aluminum band on one leg and one pin-striped, aluminum band on the other. We used binoculars to determine the identity of previously color-banded flycatchers by observing, from a distance, the unique color combinations on their legs.

We color-banded 18 new adult flycatchers and recaptured 6 individuals previously banded as adults. An additional 50 adults were identified to individual via resighting, while 4 individuals were resighted but did not have their color combinations confirmed, and 1 individual had federal band on one leg and an injury on the other leg. We detected 14 individuals identified as returning nestlings by the presence of a single federal band, with 4 (29%) identified to individual via recapture. Twenty-five adult flycatchers remained unbanded, and banding status was undetermined (i.e., we were unable to determine if these individuals were banded) for 17 adults. We banded 74 nestlings from 29 nests. We banded flycatchers opportunistically at Key Pittman Wildlife Management Area, Seegmiller Marsh, and Las Vegas Wash, capturing and color-banding 10 new adults and recapturing 3 returning nestlings. Eleven nestlings from four nests were banded.

We recorded 72 territories at all monitored sites. Of these, 50 (69%) consisted of paired flycatchers and 22 (31%) consisted of unpaired individuals. Ten breeding males were polygynous; nine were paired with two females, and one was paired with three females. One female mated consecutively with two different males.

Of the 95 adult willow flycatchers identified to individual in 2007, 54 (57%) returned in 2008; 3 (6%) were detected at a different study area from where they were detected in 2007. We detected two within-year, between-study area movements in 2008. One male moved from Pahrangat North to Key Pittman, and one female moved from Mormon Mesa Virgin River #2 to Muddy River Overton WMA.

Of the 50 juveniles banded in 2007, 2 (4%) were recaptured or resighted and identified in 2008. Both were detected at a different study area from where originally banded. Two individuals originally banded as nestlings in 2005 and two banded in 2006 were also recaptured; of these, three returned to a different study area than where originally banded. The median dispersal distance for all returning juvenile flycatchers in 2008 was 30 km.

We documented 62 willow flycatcher nesting attempts, 55 of which contained eggs and were used in calculating nest success and productivity. Thirty (55%) nests were successful and fledged young; 23 (42%) failed, and fate was unknown for 2 (3%). Mayfield survival probability ranged from 0.194 to 0.705 and was 0.461 for all sites combined. Depredation was the major cause of nest failure, accounting for 40% of all failed nests and 52% of nests that failed after flycatcher eggs were laid.

Eight of 48 nests (17%) with flycatcher eggs and known contents were brood parasitized by Brown-headed Cowbirds. Brood parasitism at all study areas ranged from 0 to 57% and was highest at Muddy River. We observed the sixth consecutive year of no brood parasitism at Pahranagat. Nests that contained flycatcher eggs and were brood parasitized were not less likely to fledge flycatcher young than nests that were not parasitized.

At Mesquite, Mormon Mesa, Muddy River, Topock Marsh, Bill Williams, and Ahakhav, we gathered data on vegetation and microclimate characteristics at one location for each of 41 territorial male flycatchers we identified, regardless of the length of time the male was resident and whether or not he obtained a mate. We delineated the following habitat types: 1) coyote willow, 2) tamarisk with coyote willow, 3) Goodding willow, 4) Goodding willow with tamarisk understory, 5) tamarisk with scattered Goodding willow, 6) tamarisk, and 7) tamarisk with mesquite. Coyote willow and Goodding willow are the only habitat types likely to be created at restoration areas, but we summarize vegetation and microclimate characteristics for all habitat types. Sample sizes in 2008 are likely too small to provide an accurate representation of the range and variance in vegetation and microclimate characteristics in each habitat type.

Territories within all vegetation types exhibited moist or inundated soil conditions throughout the breeding season. Several habitat types showed a general drying trend in soil conditions as the breeding season progressed. Daily maximum temperatures spanned a range of approximately 15°C among habitat types while daily minimum temperatures spanned only 5°C. Habitat types with high daily maximum temperatures also tended to have low daily minimum temperatures and thus had the largest temperature ranges. In general, habitats with a significant native component tended to be cooler and more thermally moderate than those dominated by tamarisk.

In addition to collecting vegetation and microclimate data at occupied territories, we investigated whether changes in vegetation and microclimate might have contributed to the abandonment of some areas by flycatchers. We identified several areas that had been occupied by nesting flycatchers in at least one previous year from 2003 to 2007 but were unoccupied in 2008, and we relocated old nests at which we had collected vegetation and microclimate information in the year the nest was active. We resampled microclimate and vegetation at these nests in 2008. At Mesquite and Mormon Mesa, areas that had been abandoned were affected by flooding over the 2004–2005 winter, and we had noted the loss of native vegetation in these areas. These qualitative observations were supported by the vegetation data collected in 2008, which showed shorter canopy height, less canopy closure, and less native vegetation than when the nests were active. We observed corresponding changes in microclimate, with generally higher temperatures recorded in 2008.

We had not noted qualitative changes in vegetation in abandoned areas at Muddy River or Topock, though vegetation data showed a decrease in live stems <2.5 cm dbh, an increase in dead foliage density at nest height, and a decrease in the percent of native vegetation at Muddy River. There were no statistically significant changes in microclimate at Muddy River, though the direction of interannual change was consistent with what we observed at Mesquite. Bulldozing activities in the vicinity of the nests at Muddy River could have contributed to abandonment of the area, or the site could have been unoccupied in 2008 as the result of interannual variation in site occupancy. Monitoring of the site in future years will help determine whether abandonment of the site was a temporary or long-term phenomenon.

We detected a decrease in the number of live stems 2.5–8 cm dbh and a decrease in dead foliage below the nest at Topock. A decrease in the number of live stems at Topock could reduce suitability of the sites for flycatchers. The microclimate changes observed at Topock were in a direction opposite to what we anticipated, with old nest sites being generally cooler and more humid in 2008 than when they were active. The number of territories at Topock has varied widely over the years, and the abandonment of certain sites may simply reflect a lower overall number of territorial flycatchers rather than a change in habitat suitability.

In 2005, we selected 11 sites between Parker and Imperial Dams for inclusion in the habitat monitoring study addressing how changes in water transfer actions might affect riparian habitat. We also selected two control sites above Parker Dam and two below Imperial Dam. At each site we installed 3–5 temperature/humidity data loggers and one groundwater observation well (piezometer). All logger and piezometer locations selected in 2005 were retained in 2006. Two loggers and one piezometer were damaged or destroyed in a fire in December 2006 and were replaced in 2007, and one piezometer that was destroyed by a bulldozer in 2007 was replaced in 2008. Soil moisture measurements were collected at each data logger location during each of approximately five flycatcher surveys between 15 May and 25 July. Vegetation measurements were also collected at each data logger location after surveys were completed.

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

Analyses of groundwater data indicate a strong correlation between piezometer water levels and releases from Parker Dam. Data did not show strong correlations between piezometer water level and soil moisture within the habitat monitoring sites. Most microclimatic variables at the combined habitat monitoring sites differed significantly from those at Topock Marsh. Topock was cooler and exhibited lower diurnal/nocturnal relative humidity and lower diurnal/nocturnal vapor pressure than habitat monitoring sites.

Comparisons of microclimate characteristics among 2005, 2006, 2007, and 2008 at the habitat monitoring sites indicated generally hotter and more humid conditions in 2006 than in the other years. The interannual changes were generally similar between test and control sites, suggesting that changes in temperature and humidity conditions may have been regional, rather than being influenced by changes in river operations. Soil moisture was lower in 2006 than in 2005 or 2007, and while this pattern was exhibited at both test and control sites, the interannual change was greater at control than at test sites. In 2008, soil moisture at test sites increased while it remained the same at control sites. This suggests that local conditions, in addition to regional climatic conditions, influenced soil moisture.

We noted between-year differences at the habitat monitoring sites for canopy closure, woody ground cover, and number of dead stems 2.5–8 cm dbh. There was no evidence that the differences in canopy closure and number of dead stems 2.5–8 cm dbh occurred exclusively at control sites or at test sites; rather, the differences occurred across all sites. Across all sites, canopy closure decreased between 2005 and 2006 and then increased in 2007 and 2008 to values higher than those recorded in 2005. The number of dead stems 2.5–8 cm dbh was lower in 2006 and 2007 than in 2005 or 2008. Percent woody ground cover was higher in 2008 than in previous years. There was a significant interaction between year and location for woody ground cover, with woody ground cover increasing at control plots between 2005 and 2006 and then decreasing in 2007 while it did not change at test plots across those years.

There were no between-year differences for live vertical foliage density in any meter interval, but there were between-year differences for the first, second, third, and fourth meter intervals above the ground for dead vegetation. In all cases, density of dead vegetation was higher in 2008 than in 2007. There was a significant interaction between live vertical foliage density and location for the fourth meter interval, but there was no clear pattern. There was also a significant interaction between dead vertical foliage density and location for the first meter interval, with the density of dead vegetation increasing more in 2007 and 2008 at control plots relative to test plots.

Chapter 1

INTRODUCTION

PROJECT HISTORY

In 1995, the U.S. Bureau of Reclamation (Reclamation), other federal, state, and tribal agencies, and environmental and recreational interests agreed to form a partnership to develop and implement a Multi-Species Conservation Program (MSCP) for long-term endangered species compliance and management in the historical floodplain of the lower Colorado River (LCR). As a step to developing the LCR MSCP, Reclamation prepared a Biological Assessment (BA) in August 1996, evaluating the effects of dam operations and maintenance activities on threatened, endangered, and sensitive (TES) species. These species included the Southwestern Willow Flycatcher (***Empidonax traillii extimus***), which was listed by the U.S. Fish and Wildlife Service (USFWS) as endangered in 1995 (60 FR 10694–10715). In response to the BA, the USFWS issued a Biological Opinion (BO) in April 1997 outlining several terms and conditions Reclamation must implement in order not to jeopardize the species. Among these terms and conditions was the requirement to survey and monitor occupied and potential habitat for Southwestern Willow Flycatchers along the lower Colorado River for a period of five years. The studies were intended to determine the number of willow flycatcher territories, status of breeding pairs, flycatcher nest success, the biotic and abiotic characteristics of occupied willow flycatcher sites, and Brown-headed Cowbird (***Molothrus ater***) brood parasitism rates. In 2002, Reclamation reinitiated consultation with USFWS on the effects of continued dam operations and maintenance on TES species along the lower Colorado River. The USFWS responded with a BO in April 2002 requiring continued Southwestern Willow Flycatcher studies along the lower Colorado River through April 2005. The BO also required implementation of a study to evaluate the effectiveness of Brown-headed Cowbird trapping for conservation of the flycatcher.

Reclamation and USFWS completed a separate consultation on the potential effects to threatened and endangered species from implementation of surplus guidelines through 2016 and an annual change in the point of diversion for up to 400,000 acre-feet for 75 years. A Biological Opinion for Interim Surplus Criteria, Secretarial Implementation Agreements, and Conservation Measures was issued in January 2001 and required monitoring of 150.5 ha of existing, occupied Southwestern Willow Flycatcher habitat between Parker and Imperial Dams.

The LCR MSCP is a 50-year program that seeks to protect 26 TES species and their habitats along the lower Colorado River while maintaining river regulation and water management required by law. The LCR MSCP was approved in April 2005 with the signing of a Record of Decision by the Secretary of the Department of the Interior, and implementation of the program began in October 2005. Documentation for the LCR MSCP includes a Habitat Conservation Plan (HCP), BA/BO, and an Environmental Impact Statement. The HCP specifies monitoring and research measures that call for surveys and research to better define habitat requirements for the Southwestern Willow Flycatcher and studies to determine the effects of cowbird nest parasitism on flycatcher reproduction.

Reclamation initiated willow flycatcher studies along the lower Colorado River in 1996, in anticipation of the requirements outlined in the BOs that were part of LCR MSCP development. These studies have been conducted annually since 1996. In compliance with the consultation on Interim Surplus Criteria and Secretarial Implementation Agreements, Reclamation biologists deployed temperature/humidity data loggers in 2004 at a subset of sites currently monitored for Southwestern Willow Flycatcher along the Colorado River in California and Arizona. These studies were expanded in 2005 to include annual monitoring of groundwater levels, vegetation, and soil moisture in addition to temperature and humidity.

SPECIES INTRODUCTION

The Southwestern Willow Flycatcher is one of four subspecies of willow flycatcher currently recognized (Unitt 1987), although Browning (1993) posits a fifth subspecies (*E. t. campestris*) occurring in the central portions of the United States (Figure 1.1). The Southwestern Willow Flycatcher breeds in dense, mesic riparian habitats at scattered, isolated sites in New Mexico, Arizona, southern California, southern Nevada, southern Utah, southwestern Colorado, and, at least historically, extreme northwestern Mexico and western Texas (Unitt 1987).

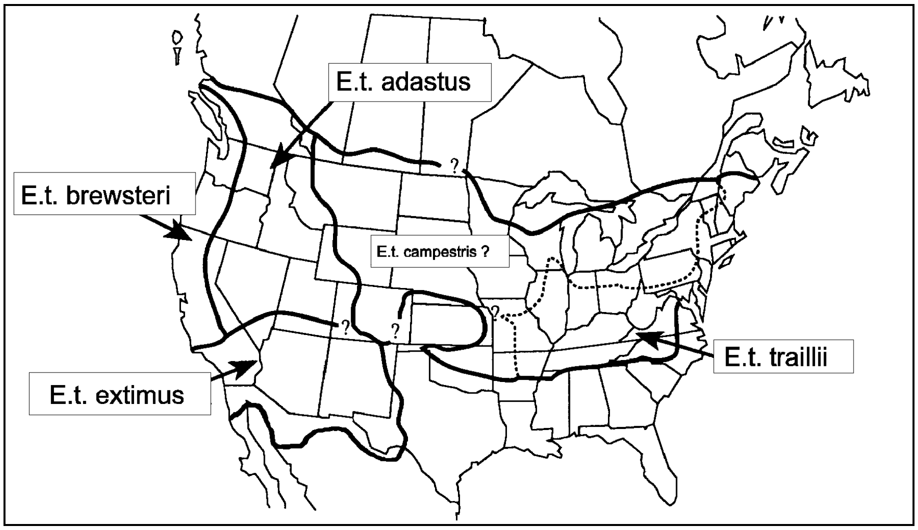

Figure 1.1. Breeding range distribution of the subspecies of the willow flycatcher (***Empidonax traillii***). Adapted from Unitt (1987), Browning (1993), and Sogge et al. (1997).

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

Historical breeding records and museum collections indicate that a sizable population of Southwestern Willow Flycatchers may have existed along the extreme southern stretches of the lower Colorado River region (Unitt 1987). However, no nests have been located south of the Bill Williams River, Arizona, in over 65 years (Unitt 1987), though northbound and southbound migrant willow flycatchers use the riparian corridor (Phillips et al. 1964, Brown et al. 1987, McKernan and Braden 2002, McLeod et al. 2008a, 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 2008,[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 (WMA) along the Muddy River, Nevada; (6) Grand Canyon, Arizona; (7) Topock Marsh on the Colorado River, Havasu NWR, Arizona; and (8) Bill Williams River NWR (Bill Williams), Arizona (McLeod et al. 2008a, Braden and McKernan unpubl. data). Willow flycatchers, including one banded migrant Southwestern Willow Flycatcher (Koronkiewicz et al. 2006a), were detected during the breeding season at several sites along the Colorado River south of the Bill Williams River to the Mexico border, but no nesting activity was confirmed.

PURPOSE AND DESCRIPTION OF STUDY

The purpose of the 2008 study is to continue surveys, monitoring, and demographic and ecological studies of the Southwestern Willow Flycatcher in suitable and/or historical riparian and wetland habitats throughout the lower Colorado and Virgin River region. This project encompasses three types of studies: (1) presence/absence surveys, including site descriptions, at pre-selected sites along the lower Colorado and Virgin Rivers and tributaries, including the lower Grand Canyon and Bill Williams River; (2) intensive life history studies at all study areas where breeding flycatchers are located to assess Southwestern Willow Flycatcher demographics and ecology, habitat selection, and the effects of Brown-headed Cowbird brood parasitism; and (3) monitoring of microclimate, vegetation, and groundwater conditions of currently occupied[2] Southwestern Willow Flycatcher habitat between Parker and Imperial Dams. SWCA's contract specifies the following field tasks:

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

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

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

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

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

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

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

[2] As per Reclamation (1999), we defined occupied Southwestern Willow Flycatcher habitat as patches of vegetation that are similar to and contiguous with areas where willow flycatchers were detected after 15 June in any year, 1996–2007.

Each distinct aspect of the 2008 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.

Chapter 3 – Color-banding and Resighting. Details of banding activities in 2008 and resighting of previously banded flycatchers are presented in this chapter. Also included are discussions of within- and between-year movement of individual flycatchers.

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

Chapter 5 – Vegetation Sampling. Vegetation sampling methods are described, and vegetation characteristics are summarized for territories in different habitat types. We also compare vegetation characteristics at nest sites when the nest was active vs. vegetation at the same location after the area had been abandoned by flycatchers.

Chapter 6 – Microclimate. The methodology of monitoring temperature, humidity, and soil moisture is described, and microclimate characteristics are summarized for flycatcher territories in different habitat types. We also compare microclimate characteristics at nest sites when the nest was active vs. microclimate at the same location after the area had been abandoned by flycatchers.

Chapter 7 – Habitat Monitoring. The methodology and results of monitoring microclimate, vegetation, and groundwater conditions at occupied sites between Parker and Imperial Dams are presented.

Chapter 2

PRESENCE/ABSENCE SURVEYS AND SITE DESCRIPTIONS

INTRODUCTION

Broadcasts of recorded conspecific vocalizations are useful in eliciting responses from nearby willow flycatchers, and multiple broadcast surveys conducted throughout the breeding season are the standard technique for determining the presence or absence of *E. t. extimus* (Sogge et al. 1997). According to Sogge et al. (1997) and USFWS (2002), willow flycatchers detected between approximately 15 June and 20 July in the breeding range of *E. t. extimus* probably belong to the southwestern subspecies. However, because northbound individuals of all western subspecies of the willow flycatcher migrate through areas where *E. t. extimus* are actively nesting, and southbound migrants occur where *E. t. extimus* are still breeding (Sogge et al. 1997, USFWS 2002), field confirmation of the southwestern subspecies is problematic.[1] For example, the northwestern ***E. t. brewsteri***, far more numerous than ***E. t. extimus***, has been documented migrating north in southern California as late as 20 June (Garrett and Dunn 1981 as cited in Unitt 1987), and Phillips et al. (1964 as cited in Unitt 1987) documented ***E. t. brewsteri*** collected in southern Arizona on 23 June. An understanding of willow flycatcher migration ecology in combination with multiple broadcast surveys conducted throughout the breeding season is therefore needed to assess the presence and residency of Southwestern Willow Flycatchers.

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

In 2008, 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 willow flycatchers (Figure 2.1).

Special Concern Species

The Yuma Clapper Rail (*Rallus longirostris yumanensis*) is listed as federally endangered by the USFWS, and the Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*) is a candidate for federal listing. Both species occur along the lower Colorado River and its tributaries and are of concern to managing agencies. Nine additional avian species [California Black Rail (*Laterallus jamaicensis coturniculus*), Western Least Bittern (*Ixobrychus exilis*), Elf Owl (*Micrathene whitneyi*), Gila Woodpecker (*Melanerpes uropygialis*), Gilded Northern Flicker (*Colaptes auratus chrysoides*), Vermilion Flycatcher (*Pyrocephalus rubinus*),

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

[2] Study areas consist of 1–20 survey sites that are grouped geographically (see Table 2.2).

Figure 2.1. Locations of Southwestern Willow Flycatcher study areas along the lower Colorado River and tributaries, 2008. (Note, study area labels represent the approximate center of multiple sites within that region; see Table 2.2)

Arizona Bell's Vireo (*Vireo bellii arizonae*), Yellow Warbler (*Dendroica petechia*), and Summer Tanager (*Piranga rubra*)] are considered to be special-concern species under the LCR MSCP. The Yellow-breasted Chat (*Icteria virens*) is also considered a special concern species in California. We did not survey specifically for these species but recorded all incidental detections.

METHODS

Site Selection

Survey sites were selected based on locations surveyed during previous years of willow flycatcher studies on the lower Colorado River (McKernan 1997; McKernan and Braden 1998, 1999, 2001a, 2001b, 2002; McLeod et al. 2008a) and reconnaissance by helicopter, by boat, and on foot prior to the start of the 2008 survey period. Sites consisting of mature native or exotic woody riparian vegetation with high canopy closure (>50%) and standing water or saturated soil under or adjacent to the vegetation were considered the most suitable habitats for flycatchers. Early successional stands of young riparian vegetation >3 m in height in proximity to surface water or saturated soil were also considered suitable flycatcher habitat. Riparian vegetation contiguous with suitable habitat was often included as part of survey areas. Reclamation biologist Theresa Olson guided and approved site selection. For sites surveyed in previous years, we retained original site names.

In 2008 we implemented a biennial survey schedule at selected sites in study areas where resident flycatchers have not been documented in the last 10 years of surveys. Sites were selected for biennial surveys based on the absence of damp or wet soils within the site and/or the relative absence of dense vegetation that might provide suitable nesting habitat for flycatchers (Table 2.1). The survey schedule is subject to revision based on conditions observed during the 2008 survey season and in future years.

Table 2.1. Proposed Survey Schedule for Sites Where No Resident Flycatchers Have Been Detected since 1996

Study Area[1]	Site	Habitat Comments	Proposed Survey Schedule		
			Annual	2008, 2010, 2012	2009, 2011
TOGO	Pulpit Rock	Tiny. Wet soil adjacent to river; upland edge dry.			X
	Picture Rock	Wet soil adjacent to river, interior dry.			X
	Blankenship Bend North	Stand of Goodding willow adjacent to marsh.	X		
	Blankenship Bend South	Mosaic of cattail, bulrush, willow. Areas with water under vegetation.	X		
	Havasu NE	Mature vegetation; most of interior of site is very dry, willows near lakeshore – need to evaluate soil conditions in area with willows. Annual survey unless evaluation reveals no suitable habitat.	X		
BIHO	Big Hole Slough	Marshy, new willows coming in.	X		
EHRE	Ehrenberg	Decent structure; needs more water.	X		

Table 2.1. Proposed Survey Schedule for Sites Where No Resident Flycatchers Have Been Detected since 1996 (Continued)

Study Area[1]	Site	Habitat Comments	Proposed Survey Schedule		
			Annual	2008, 2010, 2012	2009, 2011
CIBO	CVCA	New restoration area.	X		
	Cibola Nature Trail	Generally dry and sparse, restoration area. Habitat improvements taking place, may improve.	X		
	Cibola Island	Only surveyed in 2007, need to evaluate. Annual schedule, pending results of evaluation.	X		
	Cibola Site 2	No dense canopy. Mostly tamarisk with some emergent willow. Cattail marshes in parts of the site, but dry soil under the tamarisk.			X
	Cibola Site 1	No dense canopy. Mostly tamarisk with some emergent willow. Cattail marshes in parts of the site, but dry soil under the tamarisk.			X
	Hart Mine Marsh	Mostly tamarisk, with linear stretches of marsh vegetation. Dry soil under the tamarisk.			X
	Three Fingers Lake	Very dry and hot in interior, vegetation short.		X	
	Cibola Lake #1 (North)	Patchy vegetation, hot and dry in interior.		X	
	Cibola Lake #2 (East)	Patchy vegetation, hot and dry in interior.			X
	Cibola Lake #3 (West)	Patchy vegetation, hot and dry in interior.		X	
	Walker Lake	Large willows and water under vegetation along lake edge.	X		
IMPE	Draper Lake	Recovering from fire. Need to evaluate. Annual survey, pending results of evaluation.	X		
	Paradise	Some big willows with tamarisk understory, sometimes has water in marshes.	X		
	Hoge Ranch	Mosaic of tamarisk, willow, and marshes. Sometimes wet.	X		
	Adobe Lake	Perched above river, very dry, dense tamarisk with many dead branches in understory.		X	
	Rattlesnake	Dense willows, wet soils.	X		
	Norton South	Very small, old plantation. Sometimes contains water.			X
	Milemarker 65	Very narrow strip (<50m) of tamarisk adjacent to bulrush marsh. Understory of ***Phragmites*** creates extremely dense vegetation within 3 m of ground.			X
	Clear Lake/The Alley	Mature tamarisk, very dense understory. Very dry except immediately next to backwater channel.		X	
	Nursery NW	Dense tamarisk interspersed with marsh areas.	X		
	Imperial Nursery	Plantation. No understory.		X	
	Ferguson Lake	Mix of willow and tamarisk with water under vegetation on west side of site. East side is dry and scrubby.	X		

Table 2.1. Proposed Survey Schedule for Sites Where No Resident Flycatchers Have Been Detected since 1996 (Continued)

Study Area[1]	Site	Habitat Comments	Proposed Survey Schedule		
			Annual	2008, 2010, 2012	2009, 2011
IMPE	Ferguson Wash	Mature tamarisk with emergent willow. Very dry in interior of site. Borders backwater channel and Ferguson Lake. Need to determine whether there are any moist soils under the mature vegetation. Annual survey pending results of evaluation.	X		
	Great Blue Heron	Good structure, moist soils.	X		
	Powerline	Very small, stringer of trees around cattail marsh that sometimes contains water. Sparse canopy.			X
	Martinez Lake	Scattered willows, tamarisk and arrowweed understory, sparse canopy closure.			X
MITT	Mittry West	Willow overstory, tamarisk understory, 80% canopy closure, sometimes wet.	X		
	Mittry South	Monotypic tamarisk, lots of deadfall. Interior is dry. Adjacent to lake.		X	
YUMA	Gila Confluence North	Patchy. A few small stands of mature willows around cattail marshes. Marshes sometimes contain water. Half of site burned in 2006. Overall canopy closure 50%.		X	
	Gila River Site #1	Recovering from fire. Still very sparse.			X
	Gila River Site #2	Cottonwood/willow overstory, tamarisk and arrowweed understory, dry soils in interior, canopy closure 50%.			X
	Fortuna Site #1	Narrow (30m) strip of cottonwood/willow. Patchy understory of tamarisk and arrowweed on periphery, no understory within cottonwood/willow. Interior is dry.			X
	Fortuna North	Mature tamarisk, 80% canopy closure. Interior very dry. Adjacent to Gila River.			X
	Morelos Dam	Recovering from fire, canopy closure less than 50%, widely spaced willow and cottonwood, dense patch of tamarisk on northern end of site.			X

[1] TOGO = Topock Gorge, BIHO = Big Hole Slough, EHRE = Ehrenberg, CIBO = Cibola NWR, IMPE = Imperial NWR, MITT = Mittry Lake, YUMA = Yuma.

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

Additional Site Evaluation

During the survey season, we conducted on-the-ground habitat reconnaissance and evaluation to locate additional potentially suitable willow flycatcher habitat and to reevaluate areas we had visited in previous years and had noted as potentially suitable. Field personnel were provided high-resolution aerial photographs overlain with a UTM grid to aide with navigation and the identification of potentially suitable flycatcher habitat. We focused habitat reconnaissance and evaluation in areas that contained or were adjacent to standing water or saturated soils, and that had vegetation characteristics similar to that of flycatcher breeding sites (i.e., dense vegetation within 2–4 m of the ground and high canopy closure). Broadcast surveys were conducted opportunistically during ground reconnaissance. Field personnel formulated qualitative site descriptions of all evaluated areas.

Broadcast Surveys

To elicit responses from nearby willow flycatchers, we broadcast conspecific vocalizations previously recorded throughout the Southwest from 1996 to 1998. All flycatcher surveys were conducted according to methods described in Sogge et al. (1997), and we followed a 5-survey protocol, as recommended by the U.S. Fish and Wildlife Service (USFWS 2000). We completed at least one survey between 15 and 31 May, at least one survey between 1 and 15 June, and three additional surveys between 16 June and 25 July. Surveys were separated by a minimum of five days whenever logistically possible. Field personnel surveyed within the habitat wherever possible, using a portable CD or MP3 player (various models were used) coupled to a Radio Shack 277-1008C mini amplified speaker. Surveyors stopped every 30–40 m and broadcast willow flycatcher primary song (*fitz-bew*) and calls (*breets*). Field personnel watched for flycatchers and listened for vocal responses for approximately one to two minutes before proceeding to the next survey station. Wherever territorial flycatchers were detected, broadcast surveys were discontinued within a radius of 50 m of territories, and territory and nest monitoring commenced (see Chapter 4). If a willow flycatcher was observed but did not respond with song to the initial broadcast, we broadcast other conspecific vocalizations including *creets/breets*, *wee-oos*, *whitts*, *churr/kitters*, and a set of interaction calls given by a mated pair of flycatchers (per Lynn et al. 2003). These calls were frequently effective in eliciting a *fitz-bew* song, thereby enabling surveyors to positively identify willow flycatchers. To produce a spatial representation of all survey areas, field personnel recorded survey start and stop UTM coordinates as well as the UTM coordinates of intermediate survey points. Observers recorded start and stop times and the location(s) and behavior of all willow flycatchers detected (see survey form, Appendix A). Field personnel also recorded the presence of Brown-headed Cowbirds (hereafter cowbirds) and livestock, as requested by the Arizona Game and Fish Department. Cowbirds may affect flycatcher populations by decreasing flycatcher productivity (see Chapter 4), while livestock may substantially alter the vegetation in an area (USFWS 2002).

Site Description

Because vegetation structure and hydrology within riparian habitats are seasonally dynamic, field personnel completed site description forms (Appendix A) for each survey site at least three times throughout the survey season: early season (mid-May), mid-season (mid-June), and late season (mid-July). Vegetation composition (native vs. exotic) at survey sites followed the definitions of Sogge et al. (1997) and the Southwestern Willow Flycatcher Range-wide Database. Vegetation composition was defined as (1) native: >90% of the vegetation at a site was native; (2) exotic: >90% of the vegetation at a site was exotic/introduced; (3) mixed-native: 50 to 90% of the vegetation at a site was native; or (4) mixed-exotic: 50 to 90% of the vegetation at a site was exotic/introduced. Information from site description forms was used in conjunction with habitat photographs and comments in field notebooks and on survey forms to formulate qualitative site descriptions.

RESULTS

Field personnel spent 680.7 observer-hours conducting willow flycatcher broadcast surveys at 77 sites along the Virgin and lower Colorado Rivers and tributaries.[3] Willow flycatcher survey results are summarized in Table 2.2 and are presented below along with site descriptions. The boundaries of survey sites and occupancy in 2008 are shown on orthophotos in Appendix B, along with historically occupied habitat.[4] Each site that was not occupied by territorial flycatchers was formally surveyed between four and six times. Field personnel spent an additional 53.9 observer-hours completing habitat reconnaissance and evaluation and opportunistic surveys. The results of reconnaissance for each study area are presented below following the results for the regularly surveyed sites. Because subspecies identification of willow flycatchers detected between approximately 15 June and 20 July in the breeding range of *E. t. extimus* is problematic (Sogge et al. 1997, USFWS 2002), flycatcher detections after 15 June at sites where breeding or residency was not confirmed are summarized in Table 2.3. Yellow-billed Cuckoo and Yuma Clapper Rail detections are listed in Tables 2.4 and 2.5, respectively, and overall numbers of detections of all special concern species are listed in Appendix C. Hydrologic characteristics of each site are summarized in Table 2.6.

Table 2.2. Willow Flycatcher Detections at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2008*

Study Area[1]	Survey Site	Area (ha)	Number Detected (Date(s) of Detection)[2,3]
PAHR	North	4.6	26 (14 May–12 Aug)
	West	1.5	ND
	MAPS	2.7	ND
	South	2.5	ND
LIFI	Poles	2.6	1 (22 Jul)
MESQ	East	4.4	1 (22 Jul)
	West	11.5	25 (10 May–12 Aug)
	Electric Avenue North[4]	1.8	ND
	Electric Avenue South[4]	3.9	ND
	Bunker Farm	1.9	1 (5 Jun)
MOME	Mormon Mesa North	8.2	ND
	Hedgerow	1.1	ND
	Mormon Mesa South	19.9	2 (12 Jun)
	Virgin River #1	41.4	21 (12 May–5 Aug)
	Virgin River #2	36.9	7 (12 May–2 Aug)
MUDD	Overton WMA Pond	0.7	1 (10 Jun)
	Overton WMA	14.9	10 (11 May–11 Aug)

[3] We started the survey season with 76 sites scheduled for surveys in 2008. We discontinued surveys at three sites because of poor habitat quality and added one site mid-season as the result of habitat reconnaissance.

[4] As per Reclamation (1999), we defined occupied Southwestern Willow Flycatcher habitat as patches of vegetation that are similar to and contiguous with areas where willow flycatchers were detected after 15 June.

Table 2.2. Willow Flycatcher Detections at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2008* (Continued)

Study Area[1]	Survey Site	Area (ha)	Number Detected (Date(s) of Detection)[2,3]
GRCA	Burnt Springs	11.0	ND
	RM 274.5N	18.3	ND
	RM 285.3N	8.6	ND
	Iceberg Canyon	3.1	1 (5–19 Jun)
TOPO	Pipes #1	5.2	ND
	Pipes #3	5.7	2 (14 May–29 Jul)
	The Wallows	0.4	1 (17 Jun)
	PC6-1	4.8	ND
	Pig Hole	2.4	ND
	In Between	7.7	1 (27 May–8 Jun)
	800M	6.1	ND
	Pierced Egg	6.7	12 (8 May–14 Jul)
	Swine Paradise	2.4	ND
	Barbed Wire	2.6	ND
	IRFB03	1.0	ND
	IRFB04	1.5	1 (27 May)
	Platform	1.3	ND
	250M	2.3	1 (18 Jun)
	Hell Bird	3.7	ND
	Glory Hole	5.0	8 (8 May–29 Jul)
	Beal Lake	13.9	2 (5 Jun), 1 (11 Jun)
	Lost Slough	1.5	ND
	Lost Pond	1.2	ND
	Lost Lake	3.3	ND
TOGO	Blankenship Bend North	26.7	ND
	Blankenship Bend South	25.9	ND
	Havasu NE	12.6	ND
BIWI	Site #2	3.1	ND
	Site #11	6.3	ND
	Site #4	9.9	1 (29–30 Jun)
	Site #3	9.5	7 (11 May–26 Jul)
	Site #5	9.0	ND
	Mineral Wash Complex	18.8	ND
	Beaver Pond	21.7	ND
	Site #8	10.3	ND
AHAK	Willow Beach[5]	2.0	ND
	Deer Island	91.6	2 (21 May–6 Jun)

Table 2.2. Willow Flycatcher Detections at Survey Sites along the Virgin and Colorado Rivers and Tributaries, 2008* (Continued)

Study Area[1]	Survey Site	Area (ha)	Number Detected (Date(s) of Detection)[2,3]
BIHO	Big Hole Slough	16.6	1 (9 Jun)
EHRE	Ehrenberg	4.7	ND
CIBO	CVCA	26.2	2 (18 Jun)
	Cibola Nature Trail	13.7	1 (6 Jun)
	Cibola Island	4.2	1 (15 May), 2 (6 Jun), 2 (18 Jun)
	Three Fingers Lake	67.9	1 (18 May), 2 (7 Jun), 4 (19 Jun)
	Cibola Lake #1 (North)	8.5	1 (8 Jun), 1 (18 Jun)
	Cibola Lake #3 (West)	6.8	1 (20 May), 2 (9 Jun), 2 (18 Jun)
	Walker Lake	11.4	2 (7 Jun)
IMPE	Draper Lake[4]	4.6	1 (27 May)
	Paradise	7.8	2 (27 May)
	Hoge Ranch	20.7	2 (31 May), 4 (13 Jun), 1 (22 Jun)
	Adobe Lake	7.6	10 (31 May), 2 (15 Jun)
	Rattlesnake	7.6	3 (30 May), 1 (13 Jun)
	Clear Lake/The Alley	8.3	6 (1 June)
	Nursery NW	7.0	ND
	Imperial Nursery	1.4	ND
	Ferguson Lake	21.1	12 (29 May)
	Ferguson Wash	6.8	2 (29 May)
	Great Blue Heron	7.1	2 (23 May), 1 (14 Jun)
MITT	Mittry West	4.4	2 (28 May)
	Mittry South	15.2	2 (28 May)
YUMA	Gila Confluence North	2.2	5 (2 Jun), 5 (16 Jun), 2 (21 Jun)

* This table includes only sites where regular surveys were scheduled and does not include sites where habitat reconnaissance and opportunistic surveys were conducted.

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

2 ND = No willow flycatchers were detected.

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

4 Surveys discontinued because of poor quality habitat.

5 Surveys started 18 June.

Table 2.3. Detections of Willow Flycatchers Recorded after 15 June 2008 at Sites Where Breeding or Residency Was Not Confirmed

Study Area[1]	Site	Date	Comments
LIFI	Poles	22 Jul	Lone flycatcher responded vigorously to broadcast with primary song ***(fitz-bew)*** and ***wheeos***
MESQ	East	22 Jul	Lone flycatcher responded briefly to broadcast with primary song ***(fitz-bew)***
TOPO	The Wallows	17 Jun	Lone flycatcher, gave primary song (***fitz-bew***) spontaneously after survey was finished
	250M	18 Jun	Lone flycatcher responded briefly to broadcast with primary song (***fitz-bew***)
BIWI	Site #4	29–30 Jun	Flycatcher singing spontaneously
CIBO	CVCA	18 Jun	Two flycatchers. One responded briefly to broadcast with primary song ***(fitz-bew)*** and ***wheeos***; the other gave primary song spontaneously
	Cibola Island	18 Jun	Two flycatchers responded briefly to playback with primary song ***(fitz-bew)***
	Three Fingers Lake	19 Jun	Four flycatchers. Three responded to playback with primary song ***(fitz-bew)***, one gave primary song spontaneously
	Cibola Lake North	18 Jun	Lone flycatcher responded briefly to broadcast with primary song (***fitz-bew***)
	Cibola Lake West	18 Jun	Two flycatchers responded to broadcast with primary song ***(fitz-bew***) and ***brrr-kitters***
IMPE	Hoge Ranch	22 Jun	Lone flycatcher responded to broadcast with primary song ***(fitz-bew***)
YUMA	Gila Confluence North	16 Jun	Five flycatchers responded to broadcast with primary song ***(fitz-bew***)
		21 Jun	Two flycatchers responded to broadcast with primary song ***(fitz-bew***)

[1] LIFI = Littlefield, MESQ = Mesquite, TOPO = Topock Marsh, BIWI = Bill Williams River NWR, CIBO = Cibola NWR, IMPE = Imperial NWR, YUMA = Yuma.

Table 2.4. Yellow-Billed Cuckoo Detections along the Virgin, Bill Williams, and Lower Colorado Rivers, 2008*

Study Area[1]	Site	Date	Behavioral Observations
KEPI	Key Pittman	26 Jun	One individual observed visually
PAHR	North	13 Jun	One individual observed visually
MOME	Virgin River #1 North	9 Jul	One individual seen and heard calling in northwestern corner of site
TOPO	Beal Lake	21 Jun	One individual observed visually
BIWI	Site #5	7 Jul	No notes taken
	Site #8	8 Jul	No notes taken
CIBO	Cibola Lake North	18 Jul	Individual heard calling

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

[1] KEPI = Key=Pittman, PAHR = Pahranagat NWR, MOME = Mormon Mesa, TOPO = Topock Marsh, BIWI = Bill Williams River NWR, CIBO = Cibola NWR.

Table 2.5. Yuma Clapper Rail Detections along the Bill Williams and Lower Colorado Rivers, 2008

Study Area[1]	Site	Date(s)	Behavioral Observations
TOPO	Swine Paradise	3 Jun	One individual heard calling
	IRFB03	12 May	One individual heard calling
	Platform	5 July	One individual heard calling
	Lost Lake	14 May	One individual heard calling
BIWI	Site #2	15 May	Two detections recorded, no notes taken
CIBO	Three Fingers Lake	18 May	One individual heard calling
		3 Jul	One individual heard calling
	Cibola Lake North	19 May	One individual heard calling
	Walker Lake	18 May	One individual heard calling
IMPE	Draper Lake	27 May	Pair heard calling
	Nursery NW	1 Jun	Four detections recorded, no notes taken
		14 Jun	One detection recorded, no notes taken
	Imperial Nursery	1 Jun	One individual heard calling
	Ferguson Lake	15 Jul	One detection recorded, no notes taken
MITT	Mittry South	28 Jun	One individual heard calling

TOPO = Topock Marsh, BIWI = Bill Williams River NWR, CIBO = Cibola NWR, IMPE = Imperial NWR, MITT = Mittry Lake.

Table 2.6. Summary of Hydrologic Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2008*

Study Area[1]	Survey Site	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
PAHR	North	8/5/0	5/10/0	20/10/0	0/0/0
	West	0/0/0	0/0/0	0/0/0	20/20/250
	MAPS	0/0/0	0/0/0	0/0/0	30/30/70
	South	10/10/10	25/25/10	0/0/0	0/0/0
LIFI	Poles[4]	10/10/10	20/20/20	10/10/10	0/0/0
MESQ	East[4]	1/1/1	35/5/--	0/0/1	0/0/0
	West[5]	65/35/65	25/25/15	10/10/20	0/0/0
	Bunker Farm	0/0/0	0/0/0	0/0/0	50/50/50
MOME	Mormon Mesa North[4]	0/0/0	0/0/0	0/0/0	0/0/200
	Hedgerow	0/0/0	0/0/0	0/0/0	100/100/100
	Mormon Mesa South[4]	0/0/0	0/0/0	1/0/0	--/10/10
	Virgin River #1[4]	10/10/0	10/10/0	5/5/0	0/0/2
	Virgin River #2[4]	0/0/0	0/0/0	0/0/0	10/10/650
MUDD	Overton WMA Pond	5/5/5	25/5/10	3/3/5	0/0//0
	Overton WMA	30/25/35	50/30/30[6]	1/10/10	0/0/0

Table 2.6. Summary of Hydrologic Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2008* (Continued)

Study Area[1]	Survey Site	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
GRCA	Burnt Springs[4]	10/10/0	10/10/0	5/10/0	0/0/15
	RM 274.5N[4]	70/70/60	30/30/30	10/10/15	0/0/0
	RM 285.3N[4]	0/0/0	0/0/0	10/15/3	0/0/0
	Iceberg Canyon[4]	--/10/5	--/10/--	--/20/30	--/0/0
TOPO	Pipes #1	0/0/0	0/0/0	0/0/0	50/50/50
	Pipes #3	80/10/1[7]	10/10/25	10/20/5	0/0/0
	The Wallows	40/10/10	25/3/10	15/10/10	0/0/0
	PC6-1	80/30/10	10/3/3	5/20/40	0/0/0
	Pig Hole	25/25/0	10/3/0	50/30/5	0/0/0
	In Between	10/5/5	3/3/5	5/10/5	0/0/0
	800M	35/3/0	10/10/0	15/20/0	0/0/55
	Pierced Egg	20/15/2[7]	10/10/10	15/50/3	0/0/0
	Swine Paradise[8]	10/10/10	25/25/25	2/0/3	0/0/0
	Barbed Wire	1[7]/0/0	10/0/0	5/0/0	0/100/100
	IRFB03	0/0/0	0/0/0	0/0/0	150/150/150
	IRFB04	0/0/0	0/0/0	0/0/0	75/75/75
	Platform[8]	--/--/--	--/--/--	--/--/--	0/0/0
	250M[8]	0/3/5	0/10/5	10/10/5	0/0/0
	Hell Bird	55/55/60	50/50/25	10/10/10	0/0/0
	Glory Hole	35/40/15	70/25/70	5/15/2	0/0/0
	Beal Lake[9]	0/0/0	0/0/0	0/0/0	10/100/100
	Lost Slough	30/3/10	25/3/10	10/3/10	0/0/0
	Lost Pond[4]	40/40/30	>100/>100/>100	5/3/5	0/0/0
	Lost Lake[8]	10/5/0	10/25/0	20/3/0	0/0/0
TOGO	Blankenship Bend North[4]	20/15/15	100/100/30	3/3/10	0/0/0
	Blankenship Bend South[4]	60/60/25	50/50/30	20/20/15	0/0/0
	Havasu NE[4]	0/0/0	0/0/0	0/0/0	0/0/0
BIWI	Site #2[4]	0/2/0	0/10/0	0/0/0	0/0/0
	Site #11[4]	0/0/0	0/0/0	0/0/0	0/0/0
	Site #4[4]	15/3/3	10/25/25	20/3/3	0/0/0
	Site #3[4]	30/3/3	10/25/3	10/8/3	0/0/0
	Site #5	--/3/3	--/>100/>100	--/3/3	0/0/0
	Mineral Wash Complex[4]	30/10/10	25/25/25	15/13/0	0/0/0
	Beaver Pond[4]	30/10/20	25/25/25	10/10/5	0/0/0
	Site #8[4]	10/10/15	25/50/30	0/5/3	0/0/0

Table 2.6. Summary of Hydrologic Conditions at Each Survey Site along the Virgin and Lower Colorado Rivers and Tributaries, 2008* (Continued)

Study Area[1]	Survey Site	% Site Inundated[2]	Depth (cm) of Surface Water[2]	% Site with Saturated Soil[2,3]	Distance (m) to Surface Water or Saturated Soil[2]
AHAK	Willow Beach[4]	--/--/1	--/--/10	--/--/0	0/0/0
	Deer Island[4]	60/60/60	>100/>100/>100	10/10/10	0/0/0
BIHO	Big Hole Slough	40/30/25	30/10/50	15/10/20	0/0/0
EHRE	Ehrenberg	--/0/5	3/0/3	5/10/10	0/--/0
CIBO	CVCA[9]	10/1/5	10/3/3	50/0/20	0/0/0
	Cibola Nature Trail[9]	65/0/0	10/0/0	15/0/5	0/0/0
	Cibola Island	0/50/50	0/40/50	--/1/10	--/0/0
	Three Fingers Lake[4]	20/20/20	>100/>100/>100	5/5/5	0/0/0
	Cibola Lake #1 (North)[4]	3/3/3	10/3/10	0/0/0	0/0/0
	Cibola Lake #3 (West)[4]	3/3/3	3/3/3	3/3/3	0/0/0
	Walker Lake[4]	3/0/0	10/0/0	5/1/2	0/0/0
IMPE	Draper Lake[8]	0/--/--	0/--/--	0/--/--	0/0/0
	Paradise[4]	--/10/5	10/10/--	--/10/5	0/0/0
	Hoge Ranch[4]	--/--/--	--/--/--	--/--/--	0/0/0
	Adobe Lake[4]	--/--/--	--/--/--	--/--/--	0/0/0
	Rattlesnake[8]	5/5/5	3/3/10	80/10/20	0/0/0
	Clear Lake/The Alley[4]	2/2/2	50/50/50	0/2/2	0/0/0
	Nursery NW[7]	3/0/0	--/0/0	5/5/5	0/0/0
	Imperial Nursery[9]	0/0/40	0/0/0	0/20/20	30/0/0
	Ferguson Lake[4]	3/3/10	25/3/10	0/1/10	0/0/0
	Ferguson Wash[4]	1/1/5	--/3/3	5/0/10	0/0/0
	Great Blue Heron[4]	5/0/0	3/0/0	10/10/5	0/0/0
MITT	Mittry West	20/15/0	3/3/0	55/40/30	0/0/0
	Mittry South[4]	0/0/0	0/0/0	0/0/0	0/0/0
YUMA	Gila Confluence North[4]	1/1/5	3/3/3	10/5/20	0/0/0

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

[1] PAHR = Pahranagat NWR, LIFI = Littlefield, MESQ = Mesquite West, MOME = Mormon Mesa, MUDD = Muddy River, GRCA = Grand Canyon, TOPO = Topock Marsh, TOGO = Topock Gorge, AHAK = Ahakhav Tribal Preserve, 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] Percent of site with saturated soil does not include inundated areas.

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

[7] Saturated soil or water was present in pig wallows.

[8] Site borders marsh.

[9] Site is irrigated as part of restoration efforts; amount of standing 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 native vegetation exist at the inflow and outflow of Upper Pahranagat Lake. Prior to the 2008 survey season, the majority of the riparian vegetation along the north side of the upper lake (Pahranagat North) was inundated annually with up to 1 m of water, with the highest water levels occurring in May. Major structural problems with the levee that impounds the upper lake resulted in the upper lake being drained in early 2008, and the riparian vegetation at the north end of the lake was not flooded during the 2008 breeding season as it had been in previous years.

Pahranagat North

Area: 4.6 ha Elevation: 1,026 m

Pahranagat North is a stand of large-diameter Goodding willow (*Salix gooddingii*) at the inflow of Upper Pahranagat Lake. Fremont cottonwood (*Populus fremontii*; hereafter cottonwood) lines the northern, upland edge of the site and extends in narrow stringers around the edge of the lakebed. Canopy height within the patch is 15–18 m, and canopy closure is approximately 70%. During the survey season, standing water and saturated soils were present only in an inflow channel that runs along the northern side of the site and drains into the lakebed at the southeastern corner of the site. The water channel is vegetated with bulrush (*Schoenoplectus californicus*) where it enters the lakebed. Saturated soils were also present within patches of bulrush that border the southern edges of the site.

We detected 16 breeding willow flycatchers, as well as 8 resident, unpaired males. In addition to resident adults, we detected two individuals for which residency and/or breeding status could not be confirmed. Details of occupancy, pairing, color-banding, and breeding are presented in Chapters 3 and 4. Areas of Pahranagat North not known to be occupied by willow flycatchers were surveyed five times, totaling 6.9 observer-hours. The site lies immediately adjacent to a cattle pasture, but livestock have access only to the cottonwood stringer on the northwestern corner of the lake, which is separated from the survey site by a fence. Individual cows made incursions into the site on two known occasions but were removed within 24 hours. Cowbirds were detected during one survey.

Pahranagat West

Area: 1.5 ha Elevation: 1,026 m

This native site consists of a stringer of cottonwood, one to three trees wide and 20 m in height, on the western edge of Upper Pahranagat Lake. A few Goodding willow 2–4 m in height are also present, but the site has no significant understory vegetation. The eastern edge of the site is vegetated with bulrush, which extends into the lakebed to the east. During the survey season, the upland edge of the site was dry, while the bulrush along the lakebed edge had saturated soils until mid-June.

We detected no willow flycatchers. We surveyed the site five times, totaling 2.8 observer-hours. Cowbirds were detected on one survey, and there was no sign of livestock use.

Pahranagat MAPS

Area: 2.7 ha Elevation: 1,026 m

Pahranagat MAPS is a stringer of cottonwood on the western edge of the bed of Upper Pahranagat Lake. Canopy height is 15–20 m, and canopy closure is approximately 60%. There is no woody vegetation in the understory, and cattail (*Typha* sp.) and bulrush line the eastern edge of the tree line. The site was dry throughout the survey season, with the nearest water or saturated soil being at least 25 m away in the lakebed.

No willow flycatchers were detected. We surveyed the site five times, totaling 4.8 observer-hours. No cowbirds were detected and there was no evidence of livestock use.

Pahranagat South

Area: 2.5 ha Elevation: 1,023 m

Pahranagat South consists of a relatively small stringer of Goodding willow, coyote willow (*Salix exigua*), and 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. In 2005, we noted that dense coyote willow was increasing on the western side of the patch; this area of willow had very sparse canopy in 2006 and 2007, and the coyote willow was almost completely dead in 2008. The site is bordered to the west by an open marsh and to the east by upland scrub. Tamarisk (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*) form a sparse understory. Overall canopy closure at this site is approximately 50%. The channel held varying amounts of water throughout the survey season.

We did not detect any willow flycatchers. We surveyed the site seven times, totaling 4.0 observer-hours. Cowbirds were detected during one survey, and no sign of livestock was observed.

Littlefield, Arizona

In 2007, our survey and monitoring activities focused on an area along Beaver Dam Wash immediately upstream of the Highway 91 Bridge. We expanded the survey area in 2008 to include young Goodding and coyote willow stringers downstream of the bridge.

Littlefield Poles

Area: 2.6 ha Elevation: 565 m

Littlefield Poles consists of two relatively small patches of mixed-native vegetation located on Beaver Dam Wash, immediately upstream and downstream of the Highway 91 Bridge. Vegetation upstream of the bridge consists of a scattered overstory of cottonwood averaging 25 m in height. 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. Cattail is present along the southern edge of the patch, and the vegetation is bordered to the south by a stream. Downstream of the bridge, young stringers of Goodding and coyote willow reach 5 m in height and form linear patches 10–15 m wide on the edges of multiple stream channels. Larger Goodding willow is present on the edge of the golf course that borders the southwestern edge of the site. Canopy closure in the densest areas of Goodding and coyote willow is >90%, though overall canopy closure ranges from 50 to 70%. Surface water was present in stream channels throughout the survey season.

We detected one willow flycatcher for which residency could not be confirmed. Three subsequent territory monitoring visits failed to detect the flycatcher again. Details of occupancy and color-banding are presented in Chapter 3. We surveyed Littlefield Poles five times, totaling 5.5 observer-hours. Cowbirds were detected on all surveys. Cattle were observed in the site on two occasions, and cattle scat and trails were observed on all visits.

Mesquite, Nevada

The Mesquite study area is in the floodplain of the Virgin River near Mesquite and Bunkerville, Nevada. The entire area experience flooding, and some areas were scoured, during the 2004–2005 winter floods.

Mesquite East

Area: 4.4 ha Elevation: 468 m

This mixed-native site lies on several terraces within the floodplain of the Virgin River in Mesquite, Nevada. Vegetation on the lowest terrace, on the northern edge of the site adjacent to the river, consists of 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 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. The western half of the upper terrace burned over the 2004–2005 winter and has grown back with thick stands of coyote willow and cottonwood. A small drainage pond at the end of an irrigation ditch held standing water throughout the survey season.

We detected one willow flycatcher. Three subsequent territory monitoring visits failed to detect the flycatcher again. Details of occupancy and color-banding information are presented in Chapter 3. We surveyed Mesquite East five times throughout the flycatcher breeding season, totaling 8.8 observer-hours. Cowbirds were detected on all but one survey, and cattle trails and scat were observed on all surveys.

Mesquite West

Area: 11.5 ha Elevation: 470 m

This mixed-native site lies within the floodplain of the Virgin River in Mesquite, Nevada. Golf courses and housing developments border the site to the north, and the Virgin River borders the site to the south. This large site is primarily a mosaic of cattail and bulrush marshes separated by narrow (40–50 m) strips of dense coyote willow with interspersed tamarisk. The coyote willows are generally 5 m in height, and canopy closure varies from 50 to >90%. Hydrology at the site is influenced by irrigation runoff from the two adjacent golf courses, and the amount of surface water present under the vegetation varied daily and throughout the season. The site contained standing water and muddy soils throughout the survey season, and the irrigation runoff supports much of the vegetation within the site.

We detected 21 breeding willow flycatchers and 3 resident, unpaired males. In addition to resident adults, we detected three individuals for which residency and/or breeding status could not be determined. Details of occupancy, pairing, color-banding, and breeding are presented in Chapters 3 and 4. Areas of Mesquite West not known to be occupied by flycatchers were surveyed five times throughout the flycatcher breeding season, totaling 23.2 observer-hours. Cowbirds were detected on all but one survey. Evidence of livestock was observed on the last three surveys, and cattle were observed on the banks of the Virgin River immediately adjacent to the southern edge of the site. Cattle were observed within the site on at least one territory monitoring visit.

Electric Avenue North

Area: 1.8 ha Elevation: 460 m

This mixed-exotic site lies adjacent to an agricultural field within the floodplain of the Virgin River in Bunkerville, Nevada. During the summer of 2007, an area running northwest to southeast was bulldozed through the center of the site, removing approximately 20% of the vegetation present in previous years and creating a drainage ditch. Vegetation at the site consists of an overstory of cottonwood, Goodding willow, and tall coyote willow averaging 10 m in height. Shorter coyote willow and tamarisk averaging 8 m in height make up the understory. Most of the willows are dead, and the cottonwoods have sparse leaves, creating canopy closure less than 50%. A cattail marsh on the northwestern edge of the site is lined with narrow (<5 m wide) stringers of young coyote willow. The vegetation around the marsh is not currently mature or extensive enough to provide flycatcher habitat but should be evaluated in future years. The marsh held surface water in May.

We did not detect any flycatchers at this site. We surveyed the site one time, totaling 1.5 observer-hours. Cowbirds were detected, and evidence of livestock use was observed. Surveys were discontinued because most of the vegetation at the site is dead.

Electric Avenue South

Area: 3.9 ha Elevation: 460 m

This mixed-exotic site lies adjacent to an agricultural field within the floodplain of the Virgin River in Bunkerville, Nevada. Vegetation at the site consists of a scattered overstory of cottonwood and Goodding willow averaging 12 m in height with a predominantly tamarisk understory. Some coyote willow is scattered throughout the site, and arrowweed (*Pluchea sericea*) and mesquite (*Prosopis* sp.) trees mix with the tamarisk in some areas. A cluster of cottonwood is located at the northern end of the site. The cottonwoods have sparse leaves, many of the willows are dead, and approximately 50% of the tamarisk understory is dead. Canopy closure is less than 50%. The interior of the site was dry in May, though water was present in a marshy area along the southeastern edge of the site. A high embankment prevents water in the marsh from flowing into the site.

We did not detect any flycatchers at this site. We surveyed the site one time, totaling 1.6 observer-hours. Cowbirds were detected, but no evidence of livestock use was observed. Surveys were discontinued because most of the vegetation at the site is dead.

Bunker Farm

Area: 1.9 ha Elevation: 457 m

This exotic site lies within the floodplain of the Virgin River in Bunkerville, Nevada, approximately 3 km downstream of Mesquite West. The site is between an agricultural field to the southeast and the Virgin River to the northwest. Most of the southwestern third of the site was bulldozed prior to the start of surveys in 2008. Vegetation at the site consists of tamarisk 4–7 m in height and of varying density, with canopy closure not exceeding 60%. Many of the emergent Goodding willow are dead or dying. The coyote willow that had formed dense stands within the site in previous years was completely dead in 2008. The site was dry throughout the survey season. This is the fourth consecutive year that the agricultural field adjacent to the site was fallow, and the site did not receive agricultural runoff.

We detected one willow flycatcher for which residency could not be confirmed. Three territory monitoring visits as well as three subsequent surveys failed to detect the flycatcher again. Details of occupancy and color-banding are presented in Chapter 3. Although initial visits to the site revealed that the vegetation is no longer suitable for resident flycatchers, we visited the site regularly as part of our microclimate studies (see Chapter 6) and continued to survey the site. We surveyed the site five times, totaling 8.0 observer-hours. Cowbirds were detected only on the first survey. Evidence of livestock use was observed on all visits.

Mormon Mesa, Nevada

For approximately 15 km upstream of 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. All the areas surveyed at Mormon Mesa are at least 10 km upstream of Lake Mead, though we did complete habitat reconnaissance along the Virgin River near its mouth at the Overton Arm of Lake Mead.

Mormon Mesa North

Area: 8.2 ha Elevation: 390 m

This mixed-exotic site consists primarily of tamarisk 3–5 m in height with areas of emergent Goodding willow. Overall canopy closure is around 50%. The willows in the central and eastern portions of the site are primarily dead, while the northern end of the site has clumps of live Goodding willow 10–12 m in height with a 3-m tamarisk understory. The western edge of the site has a 100 x 50 m patch of Goodding willow, 8 m in height, with up to 75% canopy closure and dead cattails in the understory. The center of the site consists of dead coyote willow and was not surveyed. No standing water or saturated soils were present within the site during the survey season. Surface water was adjacent to the site throughout the survey season in a marsh to the west and in the river channel to the south. The site is perched up to 2 m above the water level.

We did not detect any flycatchers. We surveyed the site six times, totaling 18.2 observer-hours. Cowbirds were detected on all surveys as was evidence of livestock use. Cattle were observed in or adjacent to the site on at least four occasions.

Hedgerow

Area: 1.1 ha Elevation: 390 m

This mixed-exotic site is east of Mormon Mesa North, on the eastern side of the Virgin River. The site consists of a continuous understory of tamarisk 4–5 m in height with scattered emergent Goodding willow up to 12 m in height. The site is surrounded by tamarisk and arrowweed 2–3 m in height. Canopy closure at the site varies from about 50% on the edges of the site up to 80% in the denser areas. Soils within the site were dry throughout the survey season.

We did not detect any flycatchers. We surveyed the site five times, totaling 3.9 observer-hours. Cowbirds were not observed, but evidence of cattle was observed on each visit.

Mormon Mesa South

North half: Area: 12.9 ha Elevation: 385 m
South half: Area: 7.0 ha Elevation: 385 m

This mixed-exotic site was split into two contiguous areas to facilitate tracking of survey activity. Mormon Mesa South consists of a mosaic of tamarisk 4 m in height and patches of Goodding willow up to 12 m in height. A long stringer of willow runs north to south through the site. Canopy height of the willows is up to 12 m. Canopy closure varies throughout the site, averaging around 70%. There was no surface water within the site, but damp soils were noted in May and June.

We detected two willow flycatchers. Subsequent visits, including three territory monitoring visits, yielded no further detections. Details of banding and occupancy are presented in Chapter 3. We surveyed the northern half of the site five times, totaling 23.3 hours. The southern half was also surveyed five times, for a total of 18.3 observer-hours. Cowbirds were detected on all but one survey. Evidence of livestock was documented on all visits, and cattle were observed in the site on several occasions.

Virgin River #1

North half: Area: 16.5 ha Elevation: 380 m
South half: Area: 24.9 ha Elevation: 380 m

Virgin River #1 was also divided into two areas, Virgin River #1 North and Virgin River #1 South, to facilitate streamlining of field logistics. Virgin River #1 North is primarily tamarisk 4–5 m in height with areas of emergent Goodding willow and patches of coyote willow. Canopy closure throughout the site is 50–70%. The emergent willows in the northeastern portion of the site, which supported breeding flycatchers in 2003 and 2004, are now completely dead and many have fallen. The soil in most of the site is sandy, though during the surveys the center of the site had areas of damp, slippery clay, and standing water was present on cattle trails early in the season. The southwestern corner of the site also contained surface water in May and June.

We detected one breeding pair of willow flycatchers in the southwestern corner of Virgin River #1 North. Details of occupancy, color-banding, and breeding are presented in Chapters 3 and 4. Areas of this site not known to be occupied by flycatchers were surveyed five times, totaling 37.3 observer-hours. Cowbirds were detected on all but one survey. Evidence of livestock and/or live cattle were observed on all visits.

Virgin River #1 South is primarily dense tamarisk approximately 4–5 m in height. The northwestern portion of the site is a marsh, where coyote and Goodding willows are interspersed with the tamarisk. Goodding and coyote willows in the site average 8 and 5 m in height, respectively. The southern third of the site consists of dense tamarisk with a few emergent Goodding willows, while the middle third of the site consists of sparser tamarisk with dry, open areas. Canopy closure in vegetated areas is approximately 90%. Standing water was present through June both in the marsh and in a stream channel in the southern third of the site.

We detected 15 breeding willow flycatchers and 3 unpaired, resident males in the northwestern portion of Virgin River #1 South. One additional willow flycatcher was detected for which residency could not be confirmed. Details of occupancy, color-banding, and nesting are presented in Chapters 3 and 4. Areas of the site not known to be occupied by willow flycatchers were surveyed five times, totaling 38.8 observer-hours. Cowbirds were observed on all but one survey as were cattle and/or evidence of cattle.

Virgin River #2

Area: 36.9 ha Elevation: 380 m

This site is primarily a monotypic stand of tamarisk 6 m in height with 70–90% canopy closure. Patches of emergent Goodding willow up to 10 m in height are also present. Most of the willows occur in a clump halfway down the eastern edge of the site, with widely scattered willows extending to the southern end of the site. The site contained no surface water during the breeding season, though about 10% of the site contained damp soils. The Virgin River, about 10 m from the eastern edge of the site, had surface water in May and June.

We detected five breeding willow flycatchers and one unpaired, resident male. We also detected one individual for which residency was not confirmed. Details of occupancy, color-banding, and nesting are presented in Chapters 3 and 4. Portions of the site not known to be occupied by flycatchers were surveyed five times, totaling 35.3 observer-hours. Cowbirds were observed on all surveys as were live cattle and/or evidence of cattle.

Ground Reconnaissance Results

"STILLWATER FLAT"

We explored this mixed-exotic area, northwest of Mormon Mesa North, because emergent willows were visible from the bluff overlooking the floodplain. The area is primarily sparse tamarisk 4 m in height with a few emergent Goodding willow up to 10 m in height. The southeastern corner of the site contains a few willows 3 m in height and dense tamarisk. Overall canopy closure is <50%, and soils throughout the site were very dry. Because vegetation was generally sparse and soils were dry, this area does not represent suitable flycatcher habitat and we do not recommend surveying it in future years.

No willow flycatchers were observed. The site was surveyed once, totaling 11.5 observer-hours. No cowbirds were detected, but evidence of livestock use was observed.

"RIVER MILE 30"

This mixed-exotic area is along the Virgin River approximately 5 km upstream of the confluence of the Virgin River and the Overton Arm of Lake Mead (Figure 2.2). We had not noted this area during helicopter reconnaissance, but aerial photographs taken after the 2004–2005 winter flood showed side channels bisecting dense vegetation. The area consists of tamarisk 3 m in height and arrowweed 2 m in height, and canopy closure is <50%. The only water present during the site visit in early June was in the main channel of the Virgin River. All vegetated areas were perched approximately 2 m above the riverbed, and the side channels that contained water at the time the aerial photograph was taken were dry and sandy. The vegetation is too short and dry to provide suitable flycatcher habitat, and we do not recommend surveys of this area in future years.

"VIRGIN NARROWS NORTH"

This native area is on the Virgin River approximately 3 km upstream of the confluence of the Virgin River and the Overton Arm of Lake Mead (Figure 2.2). We noted this area during helicopter reconnaissance in April 2008. It consists of a band of Goodding willow approximately 30 m wide and 100 m long paralleling the river on a dry terrace 1–1.5 m above the water. The willows are 4–6 m in height and are densest close to the river, becoming mixed with arrowweed away from the river. Foliage on the willows is not very dense, and canopy closure is 70–90%. Of the areas explored at Mormon Mesa, this one most closely resembled suitable flycatcher habitat, though the vegetation was too sparse and the soils too dry to warrant further surveys. Given that the site is perched well above the water table, habitat conditions in the area seem unlikely to improve in future years. We do not recommend surveys of this area in future years.

“VIRGIN NARROWS EAST”

This mixed-native area is on the Virgin River approximately 2.8 km upstream of the confluence of the Virgin River and the Overton Arm of Lake Mead (Figure 2.2). We noted this area during helicopter reconnaissance in April 2008. The area consists of a series of dry terraces adjacent to the river, with the lowest terrace perched approximately 2 m above the riverbed. Vegetation consists primarily of a mix of arrowweed and tamarisk 3 m in height with scattered clumps and bands of emergent Goodding willow. Canopy closure is <50%. The site is too dry and sparsely vegetated to provide suitable flycatcher habitat, and we do not recommend surveys of this area in future years.

“VIRGIN NARROWS WEST”

This mixed-native area is on the Virgin River approximately 2.5 km upstream of the confluence of the Virgin River and the Overton Arm of Lake Mead (Figure 2.2). We noted this area during helicopter reconnaissance in April 2008. Vegetation consists of a 10-m-wide band of Goodding willow, approximately 8 m in height, on a narrow terrace perched 2 m above the riverbed. Arrowweed forms an understory 2 m in height. Leaves on the willows are sparse, and overall canopy closure is 70–90%. This area has the vegetation structure of suitable flycatcher habitat but lacks the foliage density, areal extent, and damp soils typical of flycatcher habitat. We do not recommend surveys in future years.

Muddy River, Nevada

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

Overton WMA Pond

Area: 0.7 ha Elevation: 378 m

This site consists of a patch of mixed-native vegetation approximately 150 m long and 150 m wide at the north end of Overton WMA just south of Honeybee Reservoir. The dominant vegetation consists of 10-m-tall Goodding willow with a sparse 5-m-tall tamarisk understory. Cattail and sedges are also present on the edges of the site. Canopy closure is variable, ranging up to 90%. A small stream channel runs through the site, and it held surface water in May and June. The marshy edges of the site had standing water throughout the survey season.

We detected one willow flycatcher. Three territory monitoring visits as well as subsequent surveys failed to detect the individual again. Details of occupancy and banding are presented in Chapter 3. Overton WMA Pond was surveyed six times for a total of 5.1 observer-hours. Cowbirds were detected at the site on all but one survey. No sign of livestock use was observed.

Overton WMA

Area: 14.9 ha Elevation: 378 m

This site consists of a 150-m-wide strip of riparian vegetation spanning both sides of the Muddy River. The site is bordered to the southwest by open agricultural fields and to the northeast by sparser areas of riparian vegetation. The site flooded heavily during the 2004–2005 winter, but vegetation at the site was relatively unchanged. The northern portion of the site is dominated by very dense tamarisk up to 7 m in height with canopy closure of 70–90%. The southern portion of the site consists primarily of a stand of Goodding willow 10–12 m in height with an understory of tamarisk and cattail and canopy closure up to 90%. Flowing water was present in the channel of the Muddy River throughout the survey season, and extensive beaver activity resulted in the southern portion of the site being flooded with approximately 30 cm of water throughout the survey season. 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. Two stretches of the channel of the Muddy River within the site were dredged with heavy equipment over the 2007–2008 winter, resulting in a cleared swath 10–15 m wide on the western bank of the river. The more upstream of the two dredged and cleared areas extended from the northern end of the site southward for approximately 350 m, ending approximately 10 m upstream of the most upstream flycatcher nest recorded in 2005–2007. Dredging resumed less than 5 m downstream of the most downstream nest in that portion of the site and continued southwest along the river channel for approximately 400 m, ending over 100 m from the flycatcher nesting area at the southern end of the site.

We located six breeding willow flycatchers and two unpaired, resident males. We also detected two males for which residency could not be confirmed. Details of occupancy, color-banding, and nesting are presented in Chapters 3 and 4. Portions of the site not known to be occupied by flycatchers were surveyed five times, totaling 26.3 observer-hours. We observed no signs of livestock but detected cowbirds on all surveys.

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 eight years as the result of a 33.8-m drop in the level of Lake Mead from 2000 to July 2008.[5] 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 unsuitable for flycatchers. New areas of willow and tamarisk developed along the Colorado River in Lake Mead National Recreation Area on newly exposed sediments over the last several years, and the vegetation in many of these areas subsequently died as the lake continued to drop.

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.

[5] 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.

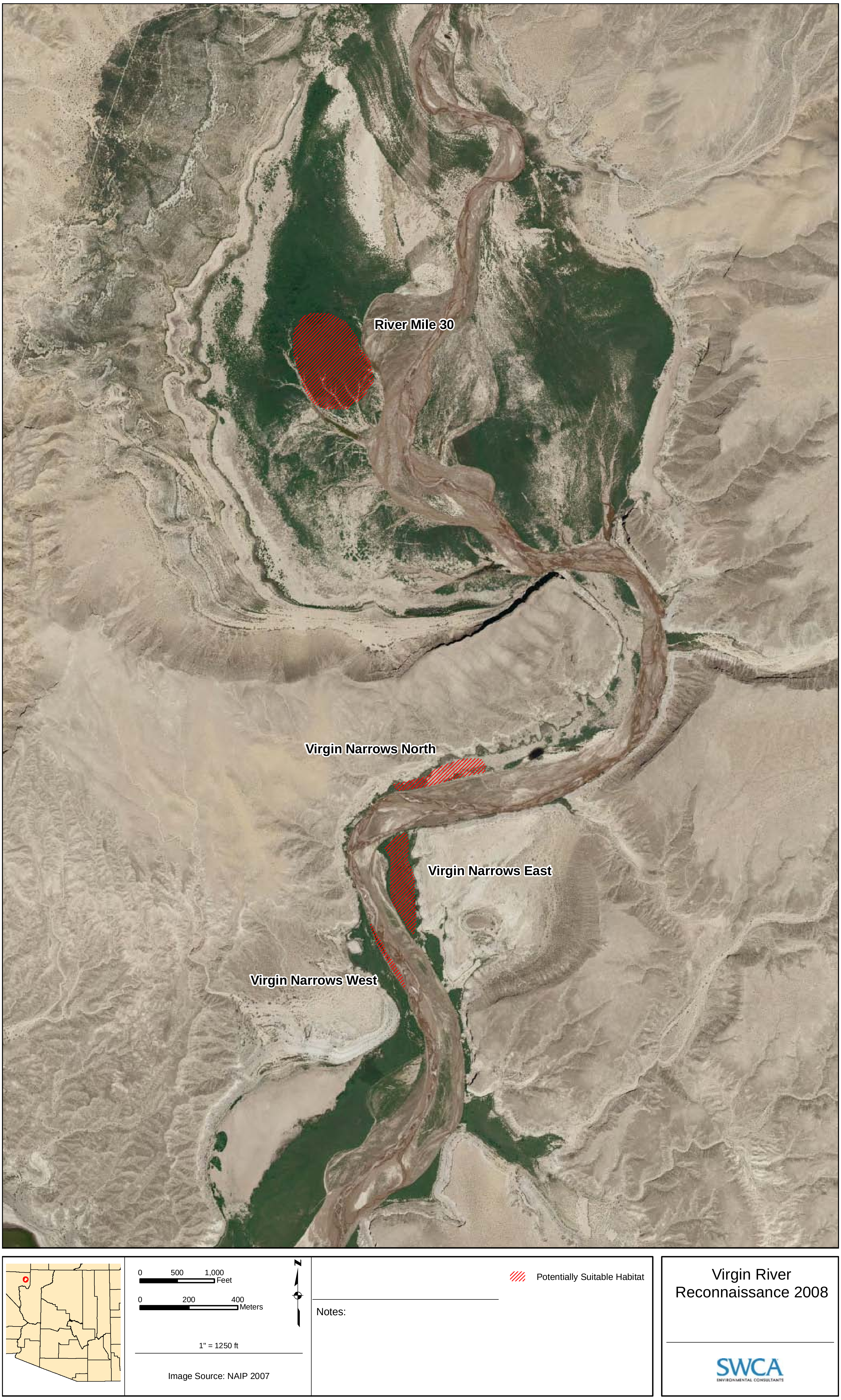

Figure 2.2. Reconnaissance areas near the mouth of the Virgin River, 2008.

Burnt Springs (RM 259.5N)

Area: 11.0 ha Elevation: 363 m

Vegetation within the first 200 m of Burnt Springs Canyon upstream from the Colorado River consists of extremely dense monotypic tamarisk approximately 5 m in height. The next 150 m of the canyon is vegetated by smaller tamarisk 3–4 m in height. 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%. Water was present in the streambed in the downstream half of the site through June.

We detected no willow flycatchers. We surveyed this site four times, totaling 3.5 observer-hours. Cowbirds were detected during two surveys, and no sign of livestock use was recorded.

RM 274.5N

Area: 18.3 ha Elevation: 354 m

This mixed-native site lies immediately adjacent to the Colorado River and contains several perennial springs, which feed small creeks, flooded willow and tamarisk forest, beaver ponds, and cattail marshes. Perennial creeks lined with coyote and Goodding willow connect the wetlands to the Colorado River. Throughout the survey season, deep pools of clear, standing water were present at springs, and large areas of the site contained muddy soils and standing water. Although the site has contained large areas of standing water since 2003, continued beaver activity has expanded the areas of standing water in the site compared to previous years. Vegetation at the site is a mosaic of well developed, mature Goodding willow forest, willow forest with tamarisk understory, and cattail marsh. Some cottonwoods are also present. Canopy height of the tamarisk is around 5 m, while the willows reach approximately 10 m. Canopy height and relative proportions of willow and tamarisk vary throughout the site. Canopy closure is highly variable but averages approximately 70%.

We detected no willow flycatchers. We surveyed this site four times, totaling 13.5 observer-hours. Cowbirds were detected on two surveys, and no sign of livestock use was observed.

RM 285.3N

Area: 8.6 ha Elevation: 343 m

This mixed-exotic site lies between the Colorado River and Grand Wash Bay, which was isolated from the Colorado River when the water level dropped in Lake Mead. Goodding willow and tamarisk developed on newly exposed soils, but the willows died as water levels continued to drop. The site has a steep, high bank adjacent to the river and slopes downward toward the bay. New vegetation continues to develop on the edge of the bay as additional soils are exposed. In 2008, the only dense vegetation at the site consisted of 3–4-m-tall willows in a narrow band on the edge of Grand Wash Bay. Vegetation in the rest of the site consisted of tamarisk 3 m in height with patches of dead willows. Canopy closure ranged from 25 to 70%. No standing water was present under the vegetation during the survey season, and saturated soils were present only in areas immediately adjacent to Grand Wash Bay.

No willow flycatchers were detected. We surveyed this site four times, totaling 2.6 observer-hours. Cowbirds were detected on one survey, and no evidence of livestock use was observed.

Iceberg Canyon

Area: 3.1 ha Elevation: 340 m

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

We detected one resident, unpaired male. Details of occupancy and color-banding are presented in Chapter 3. The site was surveyed three times, totaling 5.0 observer-hours. Cowbirds were detected on one survey, and no sign of livestock use was observed.

Topock Marsh, Arizona

Topock Marsh lies within Havasu NWR and encompasses over 3,000 ha of open water, cattail and bulrush marsh, and riparian vegetation. A large expanse (over 2,000 ha) of riparian vegetation occupies the Colorado River floodplain between the Colorado River on the western edge of the floodplain and the open water of Topock Marsh on the eastern edge of the floodplain. The vegetation is primarily monotypic tamarisk with isolated patches of tall Goodding willow. Seasonally wet, low-lying areas are interspersed throughout the riparian area.

Pipes #1

Area: 5.2 ha Elevation: 140 m

This exotic site is bordered to the east by the refuge road and consists primarily of monotypic tamarisk 5–7 m in height. Arrowweed occurs in dense patches within 50 m of the refuge road. The tamarisk is densest within 100 m of the refuge road and becomes more open toward the western edge of the site. The northern edge of the site has the tallest canopy, and there is relatively little deadfall in this area compared to the rest of the site. The central and southern portions of the site have many dead stems and clusters of fallen trees. Canopy closure is 50–70%. The site contained no standing water during the survey season but did contain damp soils through June.

No willow flycatchers were detected. We surveyed the site five times, totaling 9.5 observer-hours. Cowbirds were detected on all surveys, and evidence of feral pigs was observed.

Pipes #3

Area: 5.7 ha Elevation: 140 m

This site is bordered to the east by the refuge road. Arrowweed occurs in dense patches within 50 m of the road. Most of the site is vegetated by tamarisk 4–6 m in height. The southeastern portion of the site has two large Goodding willows and open, marshy areas. Canopy closure generally exceeds 70%. Most of the site was inundated in May. The site progressively dried out through the season but still contained damp soils and small areas of standing water in July.

Two breeding willow flycatchers were detected at Pipes #3. Details of occupancy, color-banding, and nesting are presented in Chapters 3 and 4. Portions of Pipes #3 not known to be occupied by flycatchers were surveyed five times, totaling 6.0 observer-hours. Cowbirds were detected and on three surveys, and evidence of feral pigs was observed on all surveys.

The Wallows

Area: 0.4 ha Elevation: 140 m

The Wallows is located between Pipes #3 and PC6-1 and is primarily vegetated by tamarisk 5–6 m in height with emergent Goodding willow on the western side of the site. Overall canopy closure ranges from 50 to 70%. The northwestern edge of the site borders an open cattail marsh. The Wallows contained standing water and saturated soils throughout the survey season.

One willow flycatcher was detected for which residency was not confirmed. Details of occupancy and color-banding are presented in Chapter 3. The site was surveyed six times, totaling 1.8 hours. Evidence of feral pigs was observed on all surveys. Cowbirds were not detected.

PC6-1

Area: 4.8 ha Elevation: 140 m

PC6-1 is a mixed-exotic site consisting primarily of tamarisk 6–7 m in height, with a few patches of arrowweed and cattails present in the understory. A scattered overstory of Goodding willow approximately 10–15 m in height is present in the southwestern corner of the site. Arrowweed 1–2 m in height is present under the willow. A portion of the site within approximately 50 m of the refuge road contains thick stands of arrowweed. Canopy closure in the interior of the site is approximately 90%, while canopy closure on the periphery of the site near the refuge road is approximately 50%. PC6-1 contained standing water and saturated soils throughout the survey season, though the percentage of the site inundated declined from over 50% in May to 10% in July.

No willow flycatchers were detected. The site was surveyed six times, totaling 11.4 observer-hours. Evidence of feral pigs was found on all surveys as were cowbirds.

Pig Hole

Area: 2.4 ha Elevation: 140 m

Pig Hole consists of monotypic tamarisk 6–7 m in height, with canopy closure ranging from 70 to 90%. The northern edge of the site has smaller-diameter tamarisk, with many wispy branches, than the remainder of the site. Approximately 5% of the site consists of dense patches of arrowweed. Approximately 25% of the site had standing water in May, and another 50% of the site had saturated soils. By mid-July, the standing water had disappeared and only 5% of the site contained saturated soils.

No willow flycatchers were detected. The site was surveyed six times, totaling 4.8 observer-hours. Cowbirds were detected on all but one survey. Evidence of feral pigs was observed on all surveys.

In Between

Area: 7.7 ha Elevation: 140 m

In Between consists of approximately 50-m-wide linear patches of monotypic tamarisk separated by swampy areas. 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 areas is 70–90%. The western edge of the site borders an open marsh and contained standing water and damp soil throughout the survey season.

We located one unpaired, resident male at In Between. Details of occupancy and color-banding are presented in Chapter 3. Portions of In Between not known to be occupied by flycatchers were surveyed six times, totaling 11.5 observer-hours. Cowbirds were recorded on five surveys, and evidence of feral pigs was observed on all surveys.

800M

Area: 6.1 ha Elevation: 140 m

800M adjoins the western edge of In Between, and the eastern half of the site consists of an open marsh. The remainder of the site is vegetated by tamarisk 4–7 m in height. Canopy closure in the tamarisk stands varies between 70 and 90%. Standing water and/or saturated soil were present in and along small areas of marsh and in pig wallows through the survey season.

We did not detect any willow flycatchers. We surveyed the site six times, totaling 5.8 observer-hours. Cowbirds and evidence of feral pigs were observed on all surveys.

Pierced Egg

Area: 6.7 ha Elevation: 140 m

This mixed-exotic site borders the western edge of 800M and consists of dense tamarisk 7 m in height, with a scattered overstory of Goodding willow 15 m in height. Areas with willows tend to have a more open understory and contain patches of cattails. Overall canopy closure is approximately 80%. Standing water and saturated soils persisted in portions of the site throughout the season.

We located nine breeding willow flycatchers and three additional flycatchers for which occupancy could not be confirmed. Details of occupancy, color-banding, and nesting are presented in Chapters 3 and 4. We surveyed the site one time for a total of 2.25 observer-hours. Cowbirds and evidence of pigs were observed. After the initial survey, Pierced Egg was visited as part of territory monitoring.

Swine Paradise

Area: 2.4 ha Elevation: 140 m

This mixed-exotic site borders the open water of Topock Marsh. Near the marsh, vegetation at the site is dominated by Goodding willow up to 15 m in height, with some coyote willow and an understory of 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%. Standing water and saturated soils persisted throughout the season in a cattail marsh on the eastern edge of the site.

No willow flycatchers were detected. We surveyed the site five times, totaling 3.0 observer-hours. Cowbirds were detected on all visits as was evidence of use by pigs.

Barbed Wire

Area: 2.6 ha Elevation: 140 m

This site is contiguous with Swine Paradise. One large, emergent Goodding willow occurs at the site; otherwise, the site is vegetated by tamarisk 5–8 m in height and of varying density. The northeastern portion of the site contains taller stems, less dead wood in the understory, and fewer large canopy openings than the southwestern portion of the site. Canopy closure is approximately 90%. Standing water was present in pig wallows in May.

No willow flycatchers were detected. We surveyed the site five times, totaling 4.5 observer-hours. Cowbirds were detected on three visits. Evidence of pig use was observed on all visits.

IRFB03 and IRFB04

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

These two contiguous sites are separated from the Barbed Wire site by a firebreak road. They are vegetated by a monotypic stand of tamarisk 7 m in height, which forms a dense canopy and relatively open understory. There is little deadfall, although many standing stems are dead, leaving dense areas of dead branches in the understory. Canopy closure is >90%. Soils within these sites were completely dry throughout the survey season. Soils within these sites have been completely dry throughout all survey seasons from 2003 to 2008, and the sites thus do not represent typical breeding habitat for flycatchers. Therefore, we recommend discontinuing surveys at these sites.

One willow flycatcher was detected at IRFB04 on 27 May. This individual was likely a migrant and was not detected on subsequent visits to the site. We surveyed these sites five times each, totaling 3.8 observer-hours. Cowbirds were detected on one survey at both sites. Evidence of pigs was observed on all surveys.

Platform

Area: 1.3 ha Elevation: 140 m

This site forms a narrow strip of vegetation between the main refuge road and the open marsh. Vegetation at the site consists of tamarisk 7 m in height with a few isolated, emergent Goodding willow. Overall canopy closure is approximately 80%. Bulrush and cattail line the eastern edge of the site adjacent to the marsh. Hydrologic conditions in the interior of the site were not recorded.

No willow flycatchers were detected. We surveyed the site five times, totaling 1.3 observer-hours. Cowbirds were not detected at this site, but evidence of pigs was observed on four surveys.

250M

Area: 2.3 ha Elevation: 140 m

This site lies between the main refuge road and the open marsh. Vegetation composition and structure varies with distance from the marsh. Closest to the refuge road the site is dominated by mesquite trees with an understory of arrowweed. The center of the site is dominated by tamarisk approximately 7 m in height. Closest to the marsh, the site contains patches of coyote willow and one large Goodding willow. Canopy closure within the site is approximately 70%. Small patches of saturated soil were present adjacent to the marsh throughout the flycatcher breeding season.

We detected one willow flycatcher on 18 June for which residency was not confirmed. The site was surveyed five times, totaling 4.0 observer-hours. Cowbirds were detected on three surveys, and we observed evidence of pigs on all surveys.

Hell Bird and Glory Hole

Hell Bird: Area: 3.7 ha Elevation: 140 m
Glory Hole: Area: 5.0 ha Elevation: 140 m

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

No willow flycatchers were found at Hell Bird. We detected six breeding flycatchers and two unpaired, resident males at Glory Hole. Details of occupancy, color-banding, and nesting activity are presented in Chapters 3 and 4. Hell Bird was surveyed five times, totaling 5.5 observer-hours. Portions of Glory Hole not known to be occupied by flycatchers were surveyed twice, totaling 5.0 observer-hours. Cowbirds and evidence of pigs were observed on all surveys at both sites.

Beal Lake

Area: 13.9 ha Elevation: 140 m

This mixed-native restoration site consists of a mosaic of relatively young cottonwood, Goodding willow, coyote willow, and arrowweed, with some tamarisk and mesquite scattered throughout the site. Canopy height is highly variable and averages approximately 5 m; canopy closure is sparse, averaging 35%. The amount of standing water and saturated soil at the site is highly variable because it is flood irrigated.

We detected two willow flycatchers on 5 June and one on 11 June. These individuals likely were migrants and were not detected on subsequent visits to the site. We surveyed this site five times, totaling 5.0 observer-hours. Cowbirds were detected on two surveys, and evidence of pigs was observed on three visits.

Lost Slough

Area: 1.5 ha Elevation: 140 m

Lost Slough is located approximately 4 km south of Glory Hole and Hell Bird. The site runs north-south for approximately 250 m, and measures 100 m wide at the broadest point. There is a marshy area in the center of the site that runs southwest to northeast; a small area of bulrush is present in the marsh, along with stands of coyote willow 6 m in height. Vegetation around the marsh is composed mainly of 6- to 8-m-tall tamarisk with a few emergent Goodding willow and mesquite scattered throughout.

Arrowweed up to 2 m in height makes up the understory vegetation. Canopy closure at the site is variable, with open areas toward the edges of the site and over 70% closure in areas with thick vegetation. Some surface water and saturated soils were present throughout the survey season.

We did not detect any willow flycatchers. We surveyed Lost Slough five times, totaling 4.5 observer-hours. Cowbirds were detected during one survey, and evidence of pigs was observed on four visits.

Lost Pond

Area: 1.2 ha Elevation: 140 m

This mixed-exotic site is located approximately 700 m southeast of Lost Slough. The site is approximately 200 m long and 125 m wide, with a small pond at the southern end of the site. The edges of the pond are vegetated with a 30-m-wide border of cattail, bulrush, and sedges. The pond is surrounded by tamarisk 4 to 7 m in height. Canopy closure in the tamarisk is approximately 90%. The area surrounding the site consists of arrowweed, 3-m tamarisk, and screwbean mesquite (*Prosopis pubescens*). Water remained in the pond throughout the flycatcher breeding season, and saturated soils and water were present under the tamarisk on the northeastern side of the pond.

No willow flycatchers were detected. We surveyed the site five times, totaling 2.1 observer-hours. Cowbirds were detected during one survey, and pig trails were present in the site.

Lost Lake

Area: 3.3 ha Elevation: 140 m

This site lies approximately 850 m southeast of Lost Pond. It is a narrow (<100-m-wide) strip of riparian vegetation separated from the Colorado River to the southwest by a low ridge of barren sand dunes and bordered to the northeast 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 10–15 m in height, with an understory of tamarisk 5 m in height, on the edge of a cattail marsh. South of the cottonwoods, the site is primarily tamarisk, 5–8 m in height, with small openings vegetated by arrowweed. In previous years, the southeastern end of the site was dominated by dense stands of coyote willow. These willows are now all dead, dramatically reducing the suitability of the site for breeding flycatchers. Overall canopy closure is approximately 80%. Areas adjacent to the marsh edges held some standing water through mid-June.

No willow flycatchers were detected. We surveyed the site five times, totaling 4.0 observer-hours. Cowbirds and evidence of pigs were detected on all surveys.

Ground Reconnaissance Results

"NW OF PIPES #1"

We explored the area immediately northwest of Pipes #1 to determine whether the tall, dense tamarisk with relatively little deadfall that is present at the north end of Pipes #1 extends outside the area we currently survey. We encountered extremely dense tamarisk 8 m in height mixed with arrowweed. Canopy closure at the site is >90%. Soils within the site were completely dry. We abandoned attempts to explore this area because the dense vegetation made access very difficult.

No willow flycatchers were detected. We surveyed the site one time, totaling 3.8 observer-hours. Cowbirds and evidence of pigs were detected.

Topock Gorge, Arizona and California

Between Topock Marsh and Lake Havasu, the Colorado River winds through Topock Gorge. Throughout the Gorge, the river is confined between steep cliffs and high bluffs, and little vegetation grows along the river. We surveyed backwater areas that support marsh and riparian vegetation.

Blankenship Bend

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

Blankenship Bend is a 2-km-long strip of riparian and marsh vegetation that lies along the 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. Because of the proximity to the Colorado River, both sites contained standing water and saturated soils throughout the survey season.

No willow flycatchers were detected at either site at Blankenship Bend. We surveyed each site five times, totaling 7.5 observer-hours at Blankenship Bend North and 5.8 observer-hours at Blankenship Bend South. Cowbirds were detected on four surveys at North and on three surveys at South. Evidence of feral pigs and burros was observed at both locations.

Havasu NE

Area: 12.6 ha Elevation: 136 m

This mixed-native site consists of a 1.3-km-long and <100-m-wide strip of riparian vegetation along the northeastern shore of Lake Havasu. Vegetation at the site grades from cattails along the lakeshore to Goodding willow and tamarisk in the center of the site and a mix of tamarisk and mesquite on the upland edge. Canopy closure is approximately 80%. Many Goodding willows at the site are mature and stand 5 m above the 10-m-tall tamarisk and mesquite. Soils in the interior of the site were extremely dry throughout the survey season, and water from the lake does not extend under the vegetation. Based on our determination that no moist soils exist beneath the vegetation, we recommend biennial surveys for this site.

We did not detect any willow flycatchers. We surveyed the site five times, totaling 8.0 observer-hours. Cowbirds were detected on all visits as was evidence of use by pigs.

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 addition to the regularly scheduled surveys, we revisited sites located in previous years that were determined to be potentially suitable flycatcher habitat. Results of this habitat evaluation and opportunistic surveys are presented below following the survey results.

Bill Williams Site #2

Area: 3.1 ha Elevation: 140 m

This mixed-native site has an overstory of large Goodding willow and cottonwood up to 15 m in height and an understory of tamarisk 5 m in height. Overall canopy closure is approximately 70%. The northern portion of the site contains open cattail marshes. These cattails were dead in 2008, and the site contains much dead, woody vegetation in the understory. 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, and vegetation is densest near this channel. The site is separated from the channel by a steep, high bank. There was a small amount of standing water in the cattail marsh in June, but soils under the woody vegetation were complete dry throughout the survey season. Because of dry soils within the site and the presence of large quantities of deadfall, this site does not represent typical occupied flycatcher habitat, and no resident willow flycatchers have been detected at this site since 2003. We recommend biennial surveys unless floods occur that have the potential to alter the hydrology of the area.

No willow flycatchers were detected. We surveyed the site six times, totaling 4.0 observer-hours. Cowbirds were detected on all visits, and no evidence of livestock use was observed.

Bill Williams Site #11

Area: 6.3 ha Elevation: 140 m

This mixed-native site has an overstory of Goodding willow and cottonwood trees up to 20 m in height. Tamarisk ranging from 3 to 5 m in height is the dominant species in the understory, and the ground is covered by thick deadfall. Canopy closure is approximately 75%. Large areas of standing water are present within the survey site because an arm of Lake Havasu follows the channel of the Bill Williams River through the center of the site. However, soils under the vegetation were very dry during the survey season. Because of dry soils within the site and the presence of large quantities of deadfall, this site does not represent typical occupied flycatcher habitat, and no resident willow flycatchers have been detected at this site since 2003. We recommend biennial surveys unless floods occur that have the potential to alter the hydrology of the area.

No willow flycatchers were observed. We surveyed the site five times, totaling 4.3 observer-hours. Cowbirds were detected on all visits, and no evidence of livestock was observed.

Bill Williams Site #4 and Site #3

Site #4: Area: 9.9 ha Elevation: 140 m
Site #3: Area: 9.5 ha Elevation: 140 m

These two sites are contiguous and together are known as Mosquito Flats. Vegetation is mixed-native, with an overstory of Goodding willow 15–20 m in height and patches of monotypic tamarisk up to 8 m in height. Patches of coyote willow are also present. Overall canopy closure is approximately 50%. Stands of cattails and marshy areas occupy approximately 10% of the sites. The understory in some areas is very open, and the ground in these areas is covered with herbaceous vegetation. Many large willows and cottonwoods have fallen over the past several years, leaving large gaps in the canopy and creating patches of thick, dead, fallen woody vegetation. Mosquito Flats had a network of small, flowing streams in May, but these had largely dried to damp soil by July with only small puddles remaining.

We detected one willow flycatcher in Site #4 for which residency was not confirmed. Seven breeding flycatchers were detected in Site #3. Details of color-banding, occupancy, and nesting are presented in Chapters 3 and 4. Portions of the sites not known to be occupied by flycatchers were visited five times, totaling 7.2 observer-hours at Site #4 and 11.9 observer-hours at Site #3. Cowbirds were detected on all visits to Mosquito Flats, and no evidence of livestock was observed.

Bill Williams Site #5

Area: 9.0 ha Elevation: 143 m

Site #5 is located on the eastern edge of the Bill Williams River floodplain and is bordered to the east by upland desert. The survey site was expanded in 2008 approximately 350 m upstream. Vegetation in the site is mixed-native, with Goodding willow and cottonwood 15 m in height in the overstory. The understory consists of tamarisk 7 m in height as well as some young Goodding willow and cottonwood. Ground cover in portions of the site consists of thick, dead, fallen woody vegetation. Canopy closure in the site is variable, averaging 70%. Soils under the vegetation were mostly dry, with a couple of small ponds and small marshy areas containing water through July.

No willow flycatchers were detected. We visited the site five times, totaling 10.8 observer-hours. Cowbirds were detected on all visits, and no evidence of livestock use was observed.

Mineral Wash Complex

Area: 18.8 ha Elevation: 162 m

This mixed-native site is approximately 3 km upstream of Site #5. The northern third of the site is a sparse mix of tamarisk, honey mesquite (*Prosopis glandulosa*), and arrowweed with a few emergent cottonwood. The remainder of the site has an overstory of cottonwood and Goodding willow up to 20 m in height and an understory of tamarisk averaging 5 m in height. The site contains two channels of the Bill Williams River, one along the southwestern edge of the site and the other through the center of the site. Areas of bulrush and cattail are present in both channels, and patches of young Goodding willow and cottonwood are growing in sandy areas along the channel that runs along the southwestern edge of the site. Overall canopy closure is <50%. Both channels of the Bill Williams River contained surface water through July, but soils away from the channels were dry and sandy. Sparse canopy closure and lack of surface water or damp soils underneath the vegetation make this site unlikely to support resident flycatchers. No resident willow flycatchers have been detected at this site since 2003, and we recommend biennial surveys unless floods occur that have the potential to alter the hydrology or vegetation of the area.

No willow flycatchers were detected. We surveyed the site five times, totaling 8.0 observer-hours. Cowbirds were detected on all but one visit, and no evidence of livestock use was observed.

Beaver Pond

Area: 21.7 ha Elevation: 165 m

This mixed-native site consists of cottonwood and Goodding willow averaging 15 m in height with an understory of tamarisk along the Bill Williams River. Areas not immediately adjacent to the river channel are vegetated by tamarisk and honey mesquite 5–7 m in height. Cattail and bulrush are present along most of the river channel. Overall canopy closure at the site is <50%. A channel of the Bill Williams River was flowing along the edge of the site throughout the flycatcher breeding season, and an old channel in the center of the site contained small pools of water. Soils under the vegetation, however, were completely dry. Sparse canopy closure and lack of surface water or damp soils underneath the vegetation make this site unlikely to support resident flycatchers. No resident willow flycatchers have been detected at this site since 2003, and we recommend biennial surveys unless floods occur that have the potential to alter the hydrology or vegetation of the area.

No willow flycatchers were detected. We surveyed the site five times, totaling 5.0 observer-hours. Cowbirds were detected on all visits. No signs of livestock were observed.

Bill Williams Site #8

Area: 10.3 ha Elevation: 168 m

This narrow, linear site encompasses the river channel approximately 3 km upstream from the Mineral Wash Complex, at the confluence of Mohave Wash and the Bill Williams River. This section of the river is confined between high cliffs on both banks. Cottonwood and willow trees 18 m in height line a flowing river channel, with clumps of tamarisk also present in the understory throughout the site. Overall canopy closure is 25–50%. This site had flowing water in the river channel throughout the flycatcher breeding season, but soils beneath the vegetation were very dry. Sparse canopy closure and lack of surface water or damp soils underneath the vegetation make this site unlikely to support resident flycatchers. No resident willow flycatchers have been detected at this site since 2003, and we recommend biennial surveys unless floods occur that have the potential to alter the hydrology or vegetation of the area.

No willow flycatchers were detected. We surveyed the site five times, totaling 4.5 observer-hours. Cowbirds were detected on all but one visit and no evidence of livestock use was observed.

Ground Reconnaissance Results

Field personnel spent a total of 27.4 person-hours conducting habitat reconnaissance and/or habitat evaluation and opportunistic broadcast surveys along the Bill Williams River corridor. We revisited seven areas that had been identified in 2006 or 2007 and visited four new areas (Cliff Pond, Downstream of Site #8, New River, and East of Planet Ranch; see Figures 2.3 and 2.4). The following descriptions are organized from downstream to upstream along the Bill Williams River.

"BURN EDGE"

Burn Edge consists of two areas of riparian vegetation northeast of where an arm of Lake Havasu follows a channel of the Bill Williams River. The eastern patch is located approximately 100 m north of Site #2 and consists of tamarisk 8–10 m in height, with 14 m Goodding willow scattered throughout the site. Ground cover in portions of the site consists of thick, dead, fallen woody vegetation. Canopy closure averages 80%. Although no standing water or saturated soils were present under the vegetation, a small arm of Lake Havasu follows a channel of the Bill Williams River through the site.

The western patch of Burn Edge is located approximately 300 m northeast of Site #11. The northwestern end of the site is on the edge of an area that burned in 2006, and scattered 3-m-tall Goodding willow and tamarisk have sprouted in this area. The burned area ends at a small, grassy opening with a pond on the western end. To the southeast of the pond, the overstory comprises Goodding willow and cottonwood 12–15 m in height, and tamarisk 3–5 m in height forms the understory. An understory of 3–5 m tamarisk is present throughout the site, and ground cover in portions of the site consists of thick, dead, fallen woody vegetation. Canopy closure is highly variable, and ranges from 20% to 90%, depending on the density of the tamarisk. The pond held standing water during site visits in late May and mid-June. Although soils under the vegetation were dry, there was evidence that water had been present under the vegetation at one time. This site should be visited in future years to assess any changes in hydrology that might increase the suitability of the area for flycatchers.

No willow flycatchers were detected at Burn Edge. We surveyed the eastern patch once and the western patch twice, totaling 5.0 observer-hours. Cowbirds were detected on all visits, and no evidence of livestock use was observed.

"LAST GASP"

Last Gasp is depicted as a wetland on the U.S. Geological Survey (USGS) Monkey's Head 7.5-min topographic map. The area consists of an overstory of cottonwood and Goodding willow up to 15 m in height and a tamarisk understory 5 m in height. Canopy closure is highly variable. Stagnant surface water was present in small pools along a muddy channel during site visits in May and June. Soils under the vegetation and away from the muddy channels were dry. This site should be visited in future years to assess any changes in hydrology that might increase the suitability of the area for flycatchers.

No willow flycatchers were detected at Last Gasp. We surveyed the site twice, totaling 2.3 observer-hours. Cowbirds were detected on both visits, and no evidence of livestock use was observed.

"RIVER END"

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

No willow flycatchers were detected. We surveyed the site twice, totaling 2.0 observer-hours. Cowbirds were detected on both visits, and no evidence of livestock use was observed.

"FLOODED REFUGE ROAD"

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

No willow flycatchers were detected. We surveyed the site twice, totaling 4.5 observer-hours. Cowbirds were detected on both visits, and no evidence of livestock use was observed.

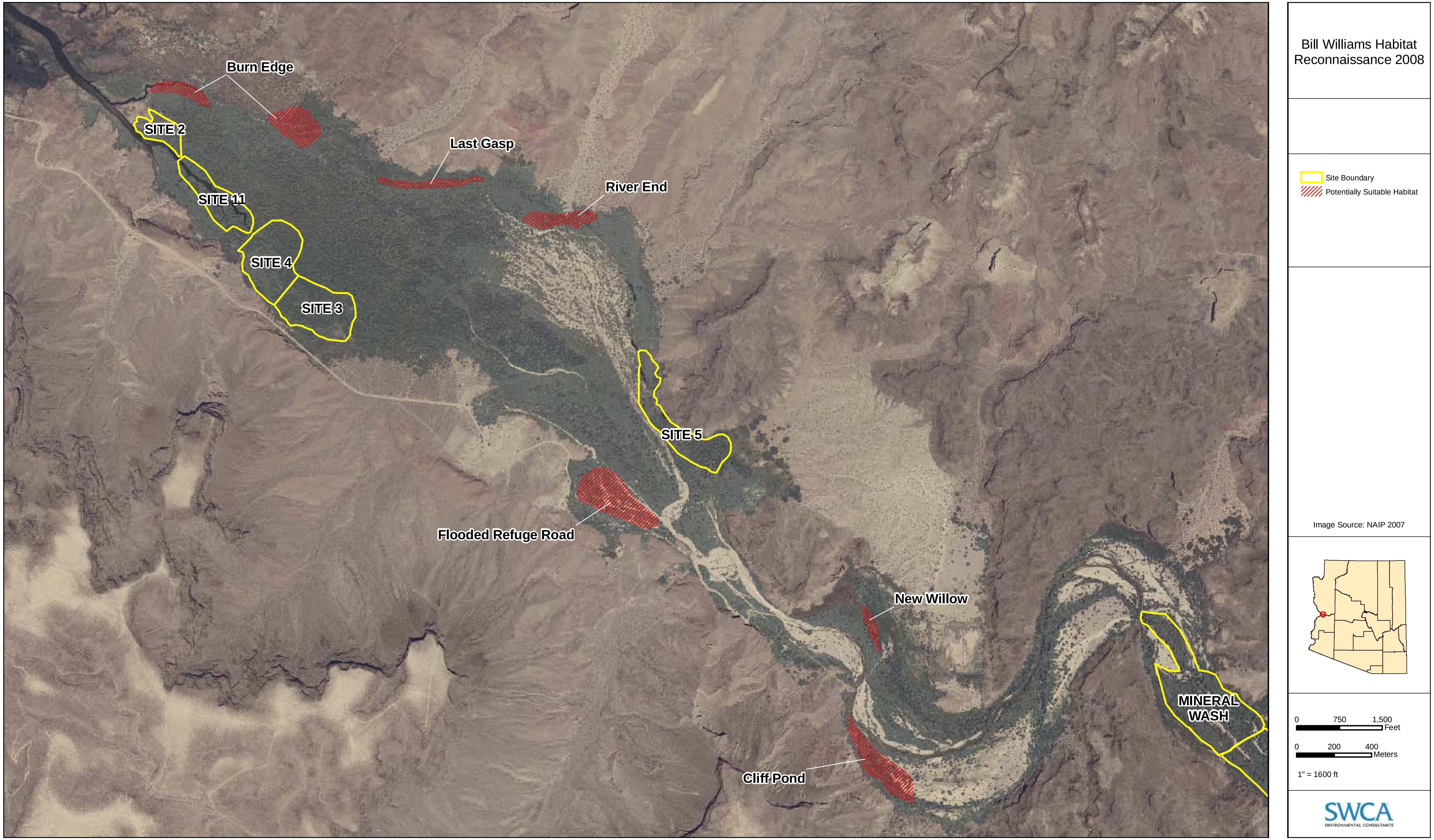

Figure 2.3. Bill Williams River NWR habitat evaluation 2008.

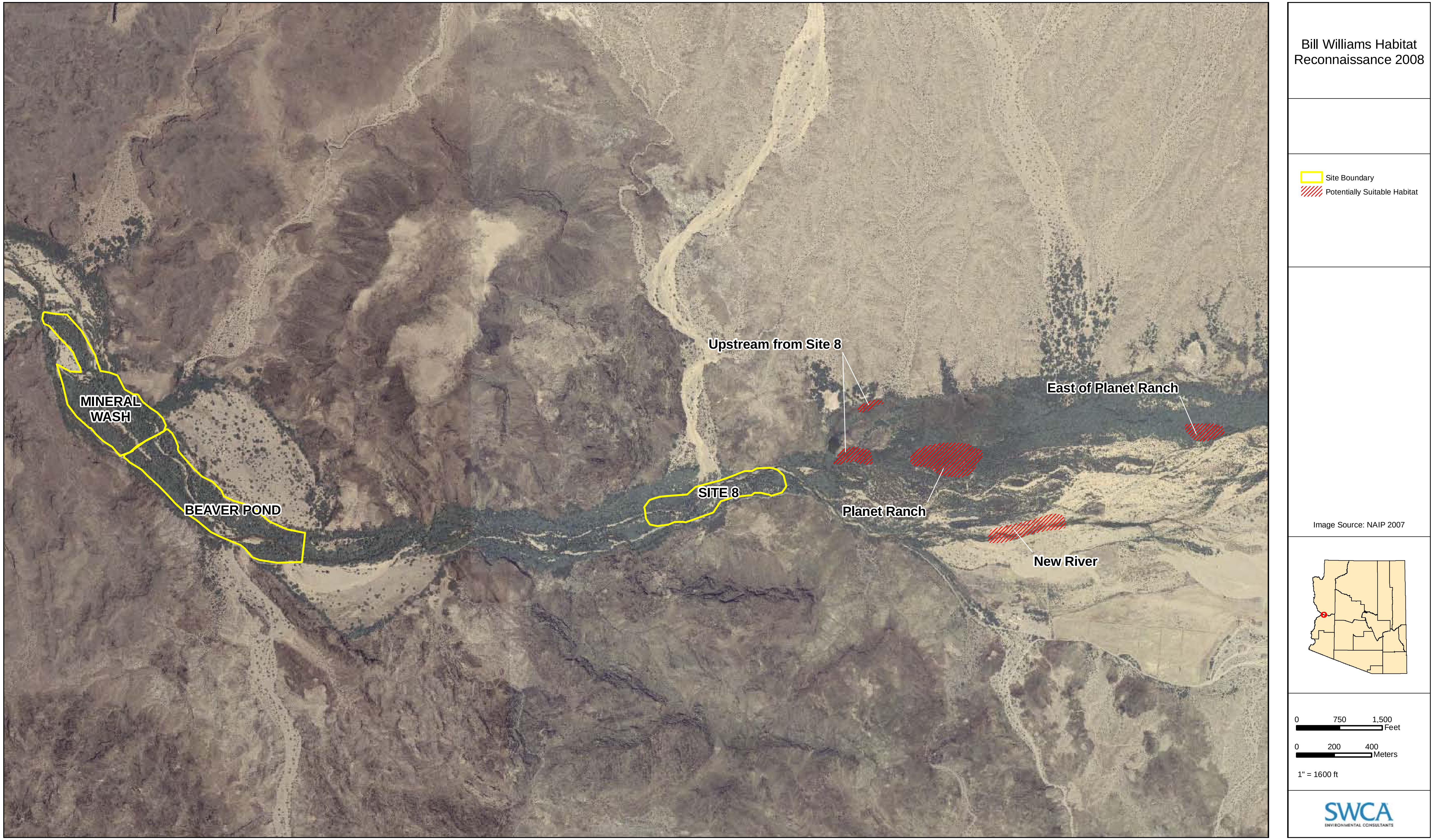

Figure 2.4. Bill Williams River NWR habitat evaluation 2008, continued.

"NEW WILLOW"

This area is approximately 1.4 km southeast of Site #5. Goodding willow and cottonwood to heights of 10 m compose a patchy overstory in this area. Understory vegetation is primarily tamarisk of varying height, and canopy closure is around 70%. Cattail and honey mesquite are also present, and areas of young cottonwood and Goodding willow occur to the east of the site. Soils under the vegetation were dry to damp during site visits in late May and late June, with the nearest surface water approximately 200 m away. The areas of young vegetation should be reevaluated in future years.

No willow flycatchers were detected. We surveyed the site twice, totaling 2.5 observer-hours. Cowbirds were detected on both visits, and no evidence of livestock use was observed.

"CLIFF POND"

Cliff Pond is located approximately 350 m south of New Willow and consists of a stand of Goodding willow and cottonwood 10–15 m in height with a dense, tamarisk understory. The site is bordered to the west by rocky cliffs and desert upland, and to the east by a dry wash. Standing water that was observed during helicopter reconnaissance in mid-April was not confirmed because dense vegetation prohibited access of the entire area. During the site visit, small areas of saturated soils were present in cattail stands along the wash. This area should be reevaluated in future years to determine the vegetation and hydrological characteristics of the interior of the site.

No willow flycatchers were detected. We surveyed the site once, totaling 0.8 observer-hours. Cowbirds were detected, and no evidence of livestock use was observed.

"DOWNSTREAM FROM SITE #8"

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

No willow flycatchers were detected. We surveyed the site once, totaling 0.3 observer-hours. Cowbirds were detected, and no evidence of livestock use was observed.

"UPSTREAM FROM SITE #8"

We evaluated two relatively small areas upstream of Site #8. The first is approximately 300 m east of Site #8 and is bordered by an open pond to the northwest and a marsh to the north. Vegetation in this area consists of an overstory of cottonwood up to 17 m in height and an understory of tamarisk. Arrowweed also occurs in the understory in areas with little canopy cover. Canopy cover is patchy and ranges from 50 to 70%. Surface water and saturated soils were limited to the marshy areas on the edge of the site, and soils in the remainder of the site were damp during the site visit in mid-May. Canopy closure in this area is generally too low to provide suitable flycatcher habitat.

The second area we evaluated is approximately 200 m north of the first and is bordered to the north by desert uplands. The overstory consists of scattered Goodding willow and cottonwood, while the understory consists of tamarisk up to 2 m in height and dead cattails. Canopy closure is <50%. Approximately 40% of the site was inundated during the site visit in early June, with another 30% having saturated or damp soils. This area could become suitable flycatcher habitat if the tamarisk matures, and it should be evaluated in future years.

No willow flycatchers were detected. We surveyed the site twice, totaling 2.5 observer-hours. Cowbirds were detected on both visits, and no evidence of livestock use was observed.

"PLANET RANCH"

We started our habitat evaluation approximately 200 m east of the southern portion of Upstream from Site #8, and evaluated an area extending 400 m east of the starting point. Goodding willow and cottonwood up to 20 m in height make up a scattered overstory, while tamarisk up to 7 m in height form a relatively continuous understory. The southern edge of the site is more sparsely vegetated than the center and has many fallen cottonwoods. The center of the site has small channels lined with dead sedges and cattails. No standing water or saturated soils were present in mid-May, though soils were damp in approximately 75% of the site. The central portion of the site has the structure typical of flycatcher habitat, and this area should be evaluated in future years to determine hydrologic conditions.

No willow flycatchers were detected. We surveyed the site once, totaling 2.3 observer-hours. Cowbirds were detected, and no evidence of livestock use was observed.

"NEW RIVER"

New River is located approximately 300 m south of Planet Ranch and consists of a stringer of young Goodding willow and cottonwood 3–6 m in height along the Bill Williams River. The stringer varies from 10 to 30 m wide. We evaluated a section 500 m long, and the habitat continues upstream beyond the area we evaluated. The stringer is surrounded by open, sandy areas. Cattail and bulrush are present along the river, which contained flowing water during the visit in mid-May. This area is currently too young and narrow to provide suitable flycatcher habitat but should be monitored in future years.

"EAST OF PLANET RANCH"

This area is approximately 1 km upstream from Planet Ranch. We evaluated this area because large trees are visible on the aerial photograph. The large trees are a scattered stringer of cottonwood approximately 25 m in height. The understory consists of dense tamarisk up to 10 m in height. The area was extremely dry during the site visit and does not resemble suitable flycatcher habitat.

Ahakhav Tribal Preserve, Arizona

The Ahakhav Tribal Preserve encompasses backwater areas along the Colorado River near Parker, Arizona, and includes restoration sites. We initially surveyed Deer Island and then added Willow Beach as a survey area midway through the season. We also visited the CRIT 9 restoration area.

Willow Beach

Area: 2.0 ha Elevation: 104 m

This site consists of an area of planted cottonwood bordering a backwater channel. The interior of the site consists of an understory of arrowweed and an overstory of cottonwoods up to 10 m in height. Many of the cottonwoods have sparse leaves, and overall canopy closure is <25%. The backwater channel is lined with seep willow (*Baccharis* sp.), and the edges of the restoration site have areas of tamarisk and mesquite. Surface water was present in the backwater channel and in a small pond during site visits in

June and July. This site does not resemble suitable flycatcher habitat and further surveys are not recommended.

No willow flycatchers were detected. We surveyed the site three times, totaling 1.5 observer-hours. Cowbirds were detected on two surveys, and no evidence of livestock use was present.

Deer Island

Area: 91.6 ha Elevation: 104 m

This site consists of a narrow strip of mixed-native vegetation on the edge of a long backwater slough with extensive areas of cattails. The only dense, woody vegetation occurs in a strip approximately 5 m wide on the edge of the slough and consists of tamarisk and screwbean mesquite up to 6 m in height and an understory of arrowweed. More than 5 m from the water, vegetation is primarily arrowweed with widely scattered tamarisk and mesquite. Canopy closure is <50%. The southern side of the slough has a steep, high bank, and woody vegetation is perched several meters above the water level. The north bank is not as high, with woody vegetation approximately 1 m above the water level. Although extensive areas of inundated and saturated soils existed in the slough and the adjacent cattails, water did not extend into the woody vegetation at any time during the survey season.

One unpaired, resident flycatcher was detected. One additional willow flycatcher was detected for which residency was not confirmed. Details of color-banding and occupancy are presented in Chapter 3. Five surveys were completed at the site, totaling 14.5 observer-hours. Cowbirds were detected on all visits. No evidence of livestock use was observed.

Ground Reconnaissance Results

"RESTORATION"

This site consists of planted stands of cottonwood and Goodding willow up to 15 m in height. The site also contains patches of honey mesquite 4–7 m tall. The edges of the site have coyote willow up to 3 m in height. Understory is minimal and consists of young willows and cottonwoods. Overall canopy closure is <50%. Soils within the site were dry and sandy during the site visit in mid-June. This restoration area does not currently provide suitable habitat for flycatchers, and we do not recommend further surveys unless additional management actions create a denser understory and greater canopy closure.

No willow flycatchers were detected. We surveyed the site once for a total of 0.8 observer-hours.

Big Hole Slough, California

Big Hole Slough

Area: 16.6 ha Elevation: 82 m

This mixed-native site consists of a cattail marsh edged with narrow bands of coyote willow 5 m in height. 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 cottonwood are present at the site. Overall canopy closure is approximately 50%. The marsh contained standing water throughout the survey season.

We detected one willow flycatcher on 9 June. The site was surveyed five times, totaling 9.8 observer-hours. Cowbirds were detected on all visits, often in large flocks. No livestock use was observed.

Ehrenberg, Arizona

Ehrenberg

Area: 4.7 ha Elevation: 78 m

This mixed-native site consists primarily of a canopy of cottonwood and Goodding willow 15 m in height with an understory of arrowweed. Approximately 5% of the site contains a cattail marsh surrounded by stands of coyote willow. Most of the coyote willows were leafless and dead by the end of the survey season. The periphery of the site is vegetated with a mix of tamarisk and mesquite. Canopy closure at the site is approximately 50%. The cattail marsh contained saturated soils in May and July, and the site is separated from the Colorado River by a levee. The coyote willows were the only dense understory taller than 3 m, and the death of the willow stands makes this site less suitable for flycatchers.

No willow flycatchers were detected. The site was surveyed five times, totaling 7.3 observer-hours. Cowbirds were detected on all surveys, and no evidence of livestock use was observed.

Cibola National Wildlife Refuge, Arizona and California

CVCA

Area: 26.2 ha Elevation: 73 m

This restoration area consists of a mosaic of rectangular cells of cottonwood, Goodding willow, and coyote willow of varying size and density. Each cell generally contains a single species and age class. The tallest cottonwoods and willows are around 8 m in height, and canopy closure in the densest areas is 80–90%. The site is flood irrigated and contained varying amounts of surface water through the season.

Two willow flycatchers were detected on 18 June. The site was surveyed five times, totaling 8.3 observer-hours. Large flocks of cowbirds were detected on all visits, and no evidence of livestock use was observed.

Cibola Nature Trail

Area: 13.7 ha Elevation: 70 m

This restoration site consists of a mosaic of cottonwood, Goodding willow, and mesquite. Approximately half the site consists of scattered screwbean and honey mesquite up to 5 m in height with a thick understory of seep willow. The northern half of the site contains an extensive stand of Goodding willow 8 m in height. The northern edge of the willow stand has canopy closure <25% and many of the willow are dead. The southern half of the willow stand has canopy closure around 70%. The southwestern corner of the site has a small stand of cottonwoods, and stringers of cottonwoods up to 18 m in height occur throughout the site. The site is flood irrigated and contained varying amounts of surface water through the season.

We detected one willow flycatcher on 6 June. The site was surveyed five times, totaling 4.0 observer-hours. Cowbirds were detected on all surveys, and no evidence of livestock use was observed.

Cibola Island

Area: 4.2 ha Elevation: 70 m

This mixed-native site is approximately 9.5 km southwest of Cibola Nature Trail. The site runs north to south, extending approximately 500 m lengthwise, with a width of 100 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. An irrigation canal empties into the northern end of the site, creating an open, marshy area down the center of the site. Between this marshy area and the western road, vegetation consists of an overstory of Goodding willow 10–12 m in height with an understory of tamarisk 5–7 m in height. Canopy closure within the willows is 80%. A narrow strip had been bulldozed along the western road and planted with Goodding willow and cottonwood poles that had barely sprouted in mid-June. The eastern edge of the marsh is lined with a narrow strip of tamarisk 5–6 m in height with a few emergent Goodding willows on the marsh edge. Between the tamarisk strip and the eastern road, vegetation consists of honey mesquite and bushy arrowweed. The marsh was dry in May but contained up to 50 cm of water in June and July.

We detected one willow flycatcher on 15 May, two on 6 June, and two on 18 June. The site was surveyed five times, totaling 5.7 observer-hours. Cowbirds were detected on all surveys, and no evidence of livestock use was observed.

Three Fingers Lake

Area: 67.9 ha Elevation: 65 m

This mixed-exotic site consists of the area immediately surrounding a dredged backwater channel of the Colorado River. The edges of the channel are vegetated by cattail and bulrush. The dominant woody vegetation is tamarisk, which is densest immediately adjacent to the channel and reaches heights of 6 m. A few large Goodding willow are also present. Away from the channel, the tamarisk is shorter and sparser and is mixed with honey and screwbean mesquite with an understory of arrowweed. Canopy closure along the shore is approximately 50%. Water was present in the backwater channel throughout the season, but there was no water under the woody vegetation.

We detected one willow flycatcher on 18 May, two on 7 June, and four on 19 June. The site was surveyed five times, totaling 13.0 observer-hours. Large numbers of cowbirds were detected on all visits, and no evidence of livestock use was observed.

Cibola Lake North and West

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

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

We detected one willow flycatcher on 8 June and one on 18 June at Cibola Lake North. At Cibola Lake West we detected one flycatcher on 20 May, two on 9 June, and two on 18 June. Each site was surveyed five times, totaling 11.0 observer-hours for Cibola Lake North and 11.5 observer-hours for Cibola Lake West. Cowbirds were detected on all visits to both sites, and no evidence of livestock use was observed.

Walker Lake

Area: 11.4 ha Elevation: 64 m

This mixed-exotic site is located along the northeastern edge of Walker Lake. The majority of the site consists of very dense tamarisk approximately 5 m in height. The southeastern end of the site contains scattered emergent Goodding willow up to 20 m in height, as well as a couple of emergent cottonwoods. This portion of the site also contains a small opening with dead cattails and a small patch of half-dead coyote willow. Walker Lake contained standing water and saturated soil throughout the survey season. Areas of the site adjacent to Walker Lake had standing water and saturated soils in May, though these soils were only damp in June and July. Soils in the interior of the site were dry throughout the survey season.

We detected two willow flycatchers on 7 June. The site was visited five times, totaling 13.0 observer-hours. Cowbirds were detected on all surveys, and no evidence of livestock use was observed.

Imperial National Wildlife Refuge, Arizona and California

Draper Lake

Area: 4.6 ha Elevation: 63 m

This site is on the northern edge of Draper Lake, which lies approximately 200 m west of the Colorado River and is surrounded by extensive areas of cattail marsh. This site burned prior to the 2003 survey season and was first surveyed again in 2006. Vegetation immediately adjacent to the cattail marsh consists of a narrow (5–10 m) strip of young, dense tamarisk up to 7 m in height with over 90% canopy closure. The central portion of the site consists of a stand of coyote willow approximately 100 m x 50 m. Many of these willows are dead, and canopy cover is around 70%. The northern end of the site consists of scattered tamarisk clumps up to 5 m in height, an understory of arrowweed, and many open areas. Canopy closure in this portion of the site is <25%. Standing water was present in Draper Lake during the site visit in May. Surveys at this site were discontinued because the stands of coyote willow are dying, and the site does not provide habitat suitable for resident flycatchers.

One willow flycatcher was detected on 27 May. The site was surveyed once, totaling 1.5 observer-hours. Cowbirds were detected, and there was no evidence of livestock use.

Paradise

Area: 7.8 ha Elevation: 62 m

This site is mixed-native habitat, with stringers of cottonwood and Goodding willow, 15–20 m in height, bordering a small cattail marsh. Tamarisk (5 m in height) and arrowweed (3 m in height) make up the understory. The cottonwoods and willows are separated from the Colorado River by a narrow (50-m-wide) strip of dense tamarisk. A cattail marsh borders the site to the south. Overall canopy closure is approximately 25%. Standing water was present within the marsh throughout the survey season.

We detected two willow flycatchers on 27 May. The site was surveyed five times, totaling 10.9 observer-hours. Cowbirds were detected on every visit, and no evidence of livestock use was observed.

Hoge Ranch

Area: 20.7 ha Elevation: 61 m

This mixed-exotic site is dominated by tamarisk 4–6 m in height, with a few emergent cottonwoods and Goodding willows (15 to 18 m in height) at the southern end of the site near the old ranch. Linear marshes with cattail, bulrush, and common reed (*Phragmites* sp.) occupy less than 20% of the interior of the site, and there are a few patches of coyote willow. Canopy closure is approximately 50%. The marshes in the interior of the site contained fluctuating amounts of standing water and saturated soil throughout the survey season, but the interior of the site was not explored sufficiently to determine the percentage of the site that was inundated. The site also borders the Colorado River.

We detected two willow flycatchers on 31 May, four on 13 June, and one on 22 June. The site was surveyed five times, totaling 9.8 observer-hours. Cowbirds were detected on all surveys, and there was evidence of burros using the site.

Adobe Lake

Area: 7.6 ha Elevation: 60 m

This mixed-exotic site consists primarily of dense tamarisk (5 to 7 m in height) with many dead branches in the understory. There are scattered Goodding willows up to 10 m in height. Canopy closure within the site is 70–90%. The site is adjacent to the Colorado River, but hydrological conditions in the interior of the site were undetermined.

We detected 10 willow flycatchers on 31 May and 2 on 15 June. One of the flycatchers detected on 31 May was banded on at least one leg. The site was surveyed five times, totaling 5.5 observer-hours. Cowbirds were detected on three visits, and no evidence of livestock use was observed.

Rattlesnake

Area: 7.6 ha Elevation: 60 m

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

We detected three willow flycatchers on 30 May and one on 13 June. The site was surveyed five times, totaling 8.9 observer-hours. Cowbirds were detected on all surveys, and there was no evidence of livestock use.

Clear Lake/The Alley

Area: 8.3 ha Elevation: 59 m

Vegetation at this site is primarily exotic, consisting of monotypic tamarisk 8–10 m in height. Emergent Goodding willows, up to 13 m in height, are scattered throughout the site. The tamarisk is mature, with large amounts of deadfall ground cover, and canopy closure is approximately 90%. The site is surrounded on the east, north, and west by upland desert and is bordered on the south by cattail marshes and common reed. A narrow, backwater channel runs northward from the Colorado River into the center of the site, and soils immediately adjacent to the channel were inundated or saturated. Soils in the interior of the site, however, were dry throughout the survey season.

We detected six willow flycatchers on 1 June. We surveyed the site five times for a total of 11.6 observer-hours. Cowbirds were detected on all visits, and no evidence of livestock use was observed.

Nursery NW

Area: 7.0 ha Elevation: 58 m

This mixed-exotic site lies between the Colorado River and a cattail marsh. The dominant vegetation is tamarisk approximately 5 m in height with an understory of common reed. Mesquite trees are scattered along the western edge of the site. The eastern edge of the site, adjacent to the cattail marsh, has a stand of Goodding willow 9 m in height. Overall canopy closure is around 70%. Surface water was present under the willows in May.

No willow flycatchers were detected. The site was surveyed five times, totaling 3.1 observer-hours. Cowbirds were detected on all visits, and there was no evidence of livestock use.

Imperial Nursery

Area: 1.4 ha Elevation: 58 m

This site is a cottonwood planting managed by the Imperial NWR. The cottonwoods are approximately 12 m in height. The edges of the site are vegetated by arrowweed and seep willow, with a few honey mesquite in the northwestern corner of the site. The understory is very sparse, and canopy closure is approximately 90%. The site is bordered to the north by a patchwork of cattails, common reed, and tamarisk. This site is flood irrigated.

No willow flycatchers were detected. The site was surveyed five times, totaling 2.2 observer-hours. Cowbirds were detected on all visits, and no evidence of livestock use was observed.

Ferguson Lake

Area: 21.1 ha Elevation: 57 m

The Ferguson Lake site is on a strip of land between Ferguson Lake and the Colorado River. Vegetation is mixed-native, with scattered, emergent Goodding willow 10 m in height along the western edge of the site bordering Ferguson Lake. Tamarisk 5–6 m in height is the dominant understory species, and it forms a continuous canopy in portions of the site. The site also contains patches of arrowweed with scattered screwbean mesquite and little canopy cover. The northwestern corner of the site up to 50 m from the lakeshore had damp soils in May and June and standing water in July. A cattail marsh is present in the southwestern corner of this site; it had standing water when it was visited in late May.

We detected 12 willow flycatchers on 29 May. The site was surveyed five times, totaling 6.8 observer-hours. Cowbirds were detected on all but one visit, and no signs of livestock use were observed.

Ferguson Wash

Area: 6.8 ha Elevation: 58 m

This mixed-exotic site, at the outflow of Ferguson Wash into Ferguson Lake, is dominated by dense, mature tamarisk approximately 7 m in height, with dense deadfall in the understory. A few scattered, emergent Goodding willows are present near the lake, and canopy closure is around 70%. 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, although the banks along the channel are abrupt and do not allow water to flow under the vegetation in this area. Another backwater channel runs along the southeastern edge of the site. The banks along this channel are less abrupt, allowing water to penetrate a few meters into the woody vegetation in a few places along the channel edge. Soils in the interior of the site were dry throughout the survey season. Because the site contains so little water under mature vegetation, and soils in the majority of the site are completely dry, we recommend biennial surveys at this site.

We detected two willow flycatchers on 29 May. The site was surveyed five times, totaling 9.2 observer-hours. Cowbirds were recorded on all visits, and evidence of burros was present in the site.

Great Blue Heron

Area: 7.1 ha Elevation: 58 m

This site, on the eastern shore of Martinez Lake, consists of mixed-exotic vegetation. Near the shore of Martinez Lake, Goodding willows form an overstory 15 m in height, with an understory of tamarisk, common reed, and giant reed (*Arundo* sp.). Canopy closure in this area is 80%. The center of the site has several fallen willows. Farther from the lake, the site is vegetated by scattered arrowweed and tamarisk 6 m in height, with canopy closure <50%. Standing water was present in May, and saturated soils were noted within the site throughout the survey season near Martinez Lake.

We detected two willow flycatchers on 23 May and one on 14 June. The site was surveyed five times, totaling 13.8 observer-hours. Cowbirds were detected on all visits, and no evidence of livestock use was observed.

Mittry Lake, Arizona and California

Mittry West

Area: 4.4 ha Elevation: 48 m

The center of this mixed-native site is dominated by Goodding willow 12 m in height with a dense understory of arrowweed and tamarisk. Canopy closure is approximately 80%. Honey and screwbean mesquite are scattered throughout the site but are more common near the periphery. There are patches of cattail within the site. Surface water was present in the site during May and June, with saturated soils present until July.

We detected two willow flycatchers on 28 May. The site was visited five times, totaling 10.5 observer-hours. Cowbirds were detected during all surveys, and no evidence of livestock use was observed.

Mittry South

Area: 15.2 ha Elevation: 46 m

This monotypic tamarisk site lies immediately adjacent to Mittry Lake. Vegetation at the site is very dense, with abundant dead branches and deadfall in the understory. Canopy closure within the tamarisk is >90%, and canopy height is approximately 8 m. The site is bordered to the south by Mittry Lake, and the edge of the lake is vegetated by cattail, bulrush, and common reed. Water from the lake does not extend under the woody vegetation, and soils in the site were very dry throughout the survey season.

We detected two willow flycatchers on 28 May. The site was visited five times, totaling 6.5 observer-hours. Cowbirds were detected during all surveys, and no evidence of livestock use was observed.

Yuma, Arizona

Gila Confluence North

Area: 2.2 ha Elevation: 40 m

This mixed-native site borders the northern side of the Colorado River at the confluence of the Gila and Colorado Rivers. Overstory vegetation at the site is a combination of Goodding willow and cottonwood 9 m in height. Dense stands of these trees surround a cattail marsh near the center of the site. Cattail marsh is also present along the river, and there is an open area of common reed in the center of the site. Canopy closure is variable and averages around 50%. Arrowweed, tamarisk, and seep willow are common in the understory. Surface water was present in the marshy areas along the edge of the river throughout the survey season, and shallow pools of water were also present in the common reed patch in July.

We detected five willow flycatchers on 2 June, five on 16 June, and two on 21 June. The site was surveyed five times, totaling 10.25 observer-hours. Cowbirds were detected on all visits, and no evidence of livestock use was observed.

DISCUSSION

The areas occupied in 2008 by breeding flycatchers (Pahranagat NWR, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams River NWR) consistently held resident and breeding flycatchers in previous years (McKernan and Braden 2002, McLeod et al. 2008a; details of residency and breeding in 2008 are presented in Chapters 3 and 4 of this document). We detected unpaired, resident flycatchers in two new areas. One resident flycatcher was detected at Iceberg Canyon on the Lake Mead Delta. This site consists of newly developed vegetation and had not been previously surveyed. The development and persistence of vegetation at this site will likely be influenced by the level of Lake Mead. A resident flycatcher was also detected on the Ahakhav Tribal Preserve at Deer Island, which we had not surveyed prior to 2008. This was the first detection of a resident willow flycatcher south of Bill Williams since 2003, although we did not survey any areas between Bill Williams and Big Hole Slough in 2003–2007. Deer Island does not resemble typical occupied flycatcher habitat. Dense vegetation occurs only in a narrow strip on the edge of a long backwater slough, overall canopy closure is very sparse, and canopy height is low. Future surveys will reveal whether this area is typically occupied by flycatchers or if flycatcher occupancy at Deer Island was an anomalous occurrence.

The association between surface water and flycatcher occupancy and breeding is noted consistently in the literature, and we observed an association between the presence of breeding flycatchers and surface water at Bill Williams, with flycatchers breeding only in years when sites contained standing water (McLeod et al. 2008b, this document). Factors in addition to the presence of standing water during the breeding season appear to be influencing the presence and numbers of flycatchers at Topock Marsh. The amount of standing water throughout the entire Topock study area was markedly reduced in 2005 compared to 2003–2004 and 2006–2008, and sites in 2008 were as wet or wetter than in any previous year. The number of flycatchers recorded at Topock since 2003 does not appear to be related to the amount of standing water present during the breeding season, with 25, 67, 41, 37, 31, and 30 adults recorded in 2003–2008, respectively. Factors such as reproductive rates, survival, or other abiotic conditions may be influencing the demographics of this local population. Hydrologic conditions within the sites at Topock prior to mid-May of each year are unknown; conditions prior to flycatcher arrival could influence habitat conditions and flycatcher occupancy.

In an effort to locate all potentially suitable willow flycatcher habitat within the Bill Williams River NWR, we continued habitat reconnaissance and opportunistic surveys initiated in 2006 and 2007. We revisited most sites that had been identified in 2006 or 2007 as warranting further investigation and evaluated four additional areas. Although the Bill Williams River NWR contains the largest expanse of native cottonwood-willow forest on the lower Colorado River, at this time vegetation structure and hydrological conditions along most of the river corridor are not characteristic of willow flycatcher breeding habitat. We determined that several of the areas we revisited are unlikely to support flycatchers unless the Bill Williams River experiences floods that might alter hydrological conditions.

We continued to observe habitat changes in lower Grand Canyon and on the Lake Mead Delta as water levels in Lake Mead continued to decline between 2007 and 2008. Several sites that were occupied in 2006 but were dead or dying by the end of the 2007 survey season were not surveyed in 2008 because of the lack of live vegetation. Only one new site, at the mouth of Iceberg Canyon, had emerged between 2007 and 2008; this site had the only flycatcher detected in Grand Canyon in 2008. If Lake Mead continues to decline, we expect this pattern to continue, with once-suitable habitat becoming elevated above the water table and vegetation emerging on newly exposed sediments.

Although many flycatchers were recorded at sites surveyed south of the Colorado River Indian Reservation until 15 June, and 23 detections were recorded post 15 June, monitoring results at these sites suggest these flycatchers were not resident or breeding individuals. Based upon the variation in total numbers of flycatchers detected at a particular site over the survey period (e.g., 10 flycatcher detections at Adobe Lake on 31 May, 2 on 15 June, and 0 on three subsequent surveys), and the overall lack of territorial, aggressive behaviors exhibited toward conspecific broadcasts, willow flycatchers detected these sites were most likely migrants. These results are consistent with those recorded in 2003–2007 (McLeod et al. 2008a). One banded flycatcher was detected at Adobe Lake on 31 May, but the observer was unable to determine the color combination. We banded migrant willow flycatchers at sites on the extreme southern stretches of the Colorado River near Yuma in 2003–2007, and without confirmation of the color combination, we cannot determine whether the flycatcher was banded as a resident Southwestern Willow Flycatcher or whether it was banded during migration and might belong to a different subspecies.

In 2008 we implemented a biennial survey schedule at selected sites in study areas where resident flycatchers have not been documented in the last 10 years of surveys. Sites were selected for biennial surveys based on the absence of damp or wet soils within the site and/or the relative absence of dense vegetation that might provide suitable nesting habitat for flycatchers. Ground reconnaissance completed during the 2008 field season revealed that Havasu NE and Ferguson Wash do not contain wet soils within the vegetation, and we recommend that these sites be added to the biennial schedule. In addition, we identified several sites at Bill Williams where no resident flycatchers have been detected since 2003 and where surface water exists only in river channels and not within the vegetation. We recommend that these sites (Site #2, Site #11, Beaver Pond, Mineral Wash, and Site #8) be surveyed on a biennial basis as well.

Chapter 3

COLOR-BANDING AND RESIGHTING

INTRODUCTION

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

METHODS

Color-banding

From early May through mid-August, we captured, uniquely color-banded, and subsequently monitored adult and nestling willow flycatchers at all study areas where resident willow flycatchers were detected. The color-banding effort also included opportunistic banding at Key Pittman Wildlife Management Area in Nevada (in cooperation with Nevada Division of Wildlife), along Las Vegas Wash (in cooperation with Southern Nevada Water Authority), and in St. George, Utah (in cooperation with Utah Division of Wildlife Resources).

Adult flycatchers were captured with mist-nets, which provide the most effective technique for live-capture of adult songbirds (Ralph et al. 1993). We used a targeted capture technique (per Sogge et al. 2001), whereby a variety of conspecific vocalizations were broadcast from a CD player and remote speakers to lure territorial flycatchers into the nets. In addition, we used “passive netting,” whereby several mist-nets were erected and periodically checked, with no broadcast of conspecific vocalizations. We banded each adult willow flycatcher with a single, numbered U.S. federal aluminum band on one leg and a colored metal band on the other. We coordinated all color combinations with the Federal Bird Banding Laboratory and all other Southwestern Willow Flycatcher banding projects to minimize replication of color combinations. For each color-banded bird recaptured, we visually inspected the legs and noted any evidence of irritation or injury that may be related to the presence of leg bands.

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

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

Resighting

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

Inactive territories were visited at least three times (each visit four days apart) before territory visits stopped. All territories were assigned a unique alphanumeric code and were plotted onto high-resolution aerial photographs, thus producing a spatial representation of the flycatcher population at each study location. Flycatchers were determined to be unpaired if none of the following breeding behaviors were observed: presence of another unchallenged flycatcher in the immediate vicinity, counter calling (*whitts*) with a nearby flycatcher, interaction twitter calls (*churr/kitters*) with a nearby flycatcher, a flycatcher in the immediate vicinity carrying nesting material, a flycatcher in the immediate vicinity carrying food or fecal sac, or adult flycatchers feeding young (per Sogge et al. 1997).

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

RESULTS

All Monitoring Sites

Color-Banding and Resighting – Field personnel color-banded 18 new adult flycatchers and recaptured 6 individuals previously captured as adults. An additional 50 adults were identified to individual via resighting, while 4 individuals were resighted but did not have their color combinations confirmed, and 1 individual had federal band on one leg and an injury on the other leg. We detected 14 individuals identified as returning nestlings by the presence of a single federal band, with 4 (29%) identified to individual via recapture. Twenty-five adult flycatchers remained unbanded, and banding status was undetermined (i.e., we were unable to determine if these individuals were banded) for 17 adults. Overall, 69% of the adult flycatchers detected at the monitoring sites were known to be color-banded by the end of the breeding season (Table 3.1). We banded 74 nestlings from 29 nests. Of the 74 nestlings banded, 4 were known or suspected to have died before fledging. For details on all banded flycatchers detected at the study areas from 2003 to 2008, see Appendix D.

Site-by-Site Color-Banding and Resighting

Monitoring Sites

Pahranagat – We detected 24 resident, adult willow flycatchers from 17 territories at Pahranagat. In addition to resident adults, we detected two individuals for which residency and/or breeding status could not be confirmed (Table 3.2). Of the 17 territories recorded at Pahranagat, 9 consisted of breeding pairs and 8 consisted of unpaired males. Of the breeding individuals, two males were polygynous with two females.

Field personnel captured and color-banded three new adults and recaptured one flycatcher previously captured as an adult. We resighted and confirmed band combinations for an additional 16 adults. We recaptured two individuals originally banded as nestlings in 2005; both were unpaired males (see Table 3.6 for juvenile dispersal data). Two adults had bands but the combination could not be confirmed, and the presence of bands could not be determined for one adult. Of all the adults detected, one, for which residency and/or breeding status could not be confirmed, remained unbanded. We banded 19 nestlings from six nests. Of the banded nestlings, one was suspected to have died before fledging. We resighted four unbanded fledglings from two additional nests.

Littlefield – We detected one willow flycatcher at Littlefield. This individual was unbanded, and residency and breeding status could not be confirmed (Table 3.2).

Mesquite – We detected 24 resident, adult willow flycatchers from 14 territories at Mesquite. In addition to resident adults, we detected three individuals for which residency and/or breeding status could not be determined. Of the 14 territories recorded at Mesquite, 11 consisted of paired individuals and 3 consisted of unpaired males (Table 3.2). Of the breeding individuals, one male was polygynous with two females.

Field personnel captured and color-banded one new adult flycatcher and recaptured one flycatcher previously captured as an adult. We confirmed the identities of an additional 15 adults via resighting. One additional adult had a federal band on one leg and an injury on the opposite leg. We captured one returning nestling that was originally banded as a juvenile in 2006 and resighted another returning nestling for which study area and year banded could not be determined because we were unable to recapture this individual. Three additional resident adults remained unbanded, and band status could not be determined for two. Band status could also not be determined for two individuals for which residency and/or breeding status could not be confirmed. We banded 20 nestlings from eight nests; two of these nestlings were suspected to have died before fledging. We resighted one unbanded fledgling from a ninth nest.

Mormon Mesa – We detected 26 resident, adult willow flycatchers from 17 territories at Mormon Mesa. In addition to resident adults, we detected four individuals for which residency could not be confirmed (Table 3.2). Of the 17 territories recorded at Mormon Mesa, 13 consisted of breeding individuals and 4 consisted of unpaired males. Of the resident individuals, one female nested at Virgin River #2 and then moved to Muddy River where she had a second nesting attempt. Of the breeding individuals, four males were each polygynous with two females.

Field personnel captured and color-banded four new adults and recaptured two flycatchers previously captured as adults. We resighted and identified 13 additional returning adults. We captured one returning nestling originally banded as a juvenile in 2007 and resighted an additional three returning nestlings that we were unable to recapture Six adults remained unbanded, and the band status of one individual, for which residency could not be confirmed, was undetermined. We banded 23 nestlings from nine nests. One of these nestlings was known to have died before fledging.

Muddy River – We detected eight resident, adult willow flycatchers from six territories at Muddy River. In addition to resident adults, we detected three individuals for which residency could not be confirmed. Of the six territories recorded, four consisted of breeding individuals and two consisted of unpaired males (Table 3.2). Of the resident individuals, one female nested at Mormon Mesa earlier in the season. Of the breeding individuals, one male was polygynous with three females.

Field personnel captured and color-banded two new adults and recaptured two individuals previously captured as adults. We resighted and identified two other adults and resighted one adult for which band combination could not be confirmed. We resighted one returning nestling but could not capture this individual to determine year and study area of origin. Three adults remained unbanded. We banded three nestlings from one nest and resighted one unbanded fledgling from another nest.

Grand Canyon – We detected one resident, adult willow flycatcher at Iceberg Canyon on the Lake Mead Delta (Table 3.2). Field personnel captured and color-banded this new adult.

Topock – We detected 20 resident, adult willow flycatchers from 12 territories at Topock. In addition to resident adults, we detected 10 individuals for which residency and/or breeding status could not be confirmed (Table 3.2). Five of these individuals were detected for only one day in mid- to late May or early June and were suspected to be migrants. Of the 12 territories recorded at Topock, 9 consisted of paired individuals and 3 consisted of unpaired males. Of the breeding individuals, one male was consecutively polygynous with two females.

Field personnel captured and color-banded three new adults. We resighted and identified four other banded adults. We resighted five returning nestlings but were unable to capture these individuals to determine their identity. The band status of one resident individual could not be determined, and seven resident individuals remained unbanded. Eight of the ten individuals for which residency and/or breeding status could not be confirmed were of unknown band status and two were unbanded. We banded three nestlings from two nests.

Table 3.1. Summary of Willow Flycatchers Detected at Monitored Sites during the 2008 Breeding Season*

Study Area	Site	Adults									Nestlings Banded (# nests)	Fledglings Captured	% of All Adults Banded
				Recaptured		Resighted							
						Color combination confirmed							
		Total Adults Detected	New Captured	Previously Captured as Adults	Returning Nestlings	Individual Identified	Individual Not Identified	Unbanded	Band Status Undetermined	Banded (color combinations unconfirmed)			
Pahranagat	North	26	3	1	2	16	0	1	1	2	19(6)	0	**96**
	Study Area Total	**26**	**3**	**1**	**2**	**16**	**0**	**1**	**1**	**2**	**19(6)**	**0**	**96**
Littlefield	Poles	1	0	0	0	0	0	1	0	0	0	0	0
	Study Area Total	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
Mesquite	East	1	0	0	0	0	0	0	1	0	0	0	0
	West	25	1	1	1	15	2[1]	3	2	0	20(8)	0	80
	Bunker Farm	1	0	0	0	0	0	0	1	0	0	0	0
	Study Area Total	**27**	**1**	**1**	**1**	**15**	**2**	**3**	**4**	**0**	**20(8)**	**0**	**74**
Mormon Mesa	Mormon Mesa South (North)	2	0	0	0	0	0	1	1	0	0	0	0
	Virgin River #1 (North)	2	1	0	0	1	0	0	0	0	3(1)	0	100
	Virgin River #1 (South)	19	2	2	1	9	2[2]	3	0	0	19(7)	0	84
	Virgin River #2	7	1	0	0	3[3]	1[2]	2	0	0	1(1)	0	71
	Study Area Total	**30**	**4**	**2**	**1**	**13**	**3**	**6**	**1**	**0**	**23(9)**	**0**	**77**
Muddy River	Overton WMA Pond	1	0	0	0	0	0	1	0	0	0	0	0
	Overton WMA	10	2	2	0	2[3]	1[2]	2	0	1	3(1)	0	80
	Study Area Total	**11**	**2**	**2**	**0**	**2**	**1**	**3**	**0**	**1**	**3(1)**	**0**	**73**
Grand Canyon	Iceberg Canyon	1	1	0	0	0	0	0	0	0	0	0	100
	Study Area Total	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**100**
Topock	Pipes #3	2	1	0	0	0	1[2]	0	0	0	2(1)	0	100
	The Wallows	1	0	0	0	0	0	0	1	0	0	0	0
	In Between	1	0	0	0	0	0	0	1	0	0	0	0
	Pierced Egg	12	2	0	0	1	3[2]	5	1	0	0	0	50
	IRFB04	1	0	0	0	0	0	0	1	0	0	0	0
	250M	1	0	0	0	0	0	0	1	0	0	0	0
	Channel[5]	1	0	0	0	0	0	0	1	0	0	0	0
	Glory Hole	8	0	0	0	3	1[2]	4	0	0	1(1)	0	50
	Beal Lake	3	0	0	0	0	0	0	3	0	0	0	0
	Study Area Total	**30**	**3**	**0**	**0**	**4**	**5**	**9**	**9**	**0**	**3(2)**	**0**	**40**
Bill Williams	Site #4	1	0	0	0	0	0	0	1	0	0	0	0
	Site #3	7	4	0	0	1	0	1	0	1	6(3)	0	86
	Study Area Total	**8**	**4**	**0**	**0**	**1**	**0**	**1**	**1**	**1**	**6(3)**	**0**	**75**
Ahakhav	Deer Island	2	0	0	0	0	0	1	1	0	0	0	0
	Study Area Total	**2**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**
Total		**135[4]**	**18**	**6**	**4**	**50[4]**	**11**	**25**	**17**	**4**	**74(29)**	**0**	**69**

* Individuals are identified as new captures (previously unbanded), recaptures of previously banded birds, resightings of previously banded birds for which band combinations were confirmed, birds known to be unbanded, birds for which band status could not be determined, and resighting of previously banded birds for which band combinations were undetermined. Included are total numbers of adults detected and percent of all adults banded. For breeding and/or residency status of adults see Tables 3.2–3.16.

[1] One individual had silver federal band only and had a visible injury on the unbanded left leg; a male with silver federal band number 2390-92434 and a visible injury on the unbanded left leg was captured at Mesquite in 2005, and this is likely the same individual. Other individual was a returning nestling.

[2] Returning nestling(s).

[3] One individual moved from Mormon Mesa Virgin River #2 to Muddy River Overton WMA.

[4] The individual that moved between study areas is tallied only once in the total.

[5] Not a formal survey site. Flycatchers detected en route.

Table 3.2. Willow Flycatchers Detected at All Monitored Study Areas with Resident Flycatchers, 2008

Study Area[1]	Site	Date Banded	Federal Band #[2]	Color Combination[3]	Old Color Combination[2,3,4]	Age[5]	Sex[6]	Territory or Location[7]	Observation Status[8]
PAHR	North	20-Jun-04	2320-31657	WO(M):EE	N/A	A6Y	F	1	RS
	North	4-Jun-02	2370-40015	PU:WG(M)	N/A	A8Y	M	1	RS
	North	1-Jul-08	2430-61114	WR(M):XX	N/A	L	U	1	N
	North	1-Jul-08	2430-61113	XX:OO(M)	N/A	L	U	1	N
	North	1-Jul-08	2430-61112	BD(M):XX	N/A	L	U	1	N
	North	INA	INA	undetermined	N/A	AHY	F	2	
	North	6-Aug-01	2320-31592	GO(M):EE	N/A	8Y	M	2	RS
	North	30-Jun-08	2430-61107	WY(M):XX	N/A	L	U	2	N[9]
	North	30-Jun-08	2430-61108	XX:OD(M)	N/A	L	U	2	N[9]
	North	30-Jun-08	2430-61106	XX:KV(M)	N/A	L	U	2	N[9]
	North	30-Jun-08	2430-61115	XX:GV(M)	N/A	L	U	2	N[9]
	North	26-Jul-07	2370-40168	PU:KOK(M)	N/A	3Y	F	4	RS
	North	15-May-04	2320-31590	GR(M):EE	N/A	A6Y	M	4, 26	RS
	North	1-Jul-08	2430-61118	XX:KK(M)	N/A	L	U	4	N
	North	1-Jul-08	2430-61117	VY(M):XX	N/A	L	U	4	N
	North	3-Jul-08	2430-61197	XX:VY(M)	N/A	L	U	4	N
	North	19-Jun-07	2370-40195	YWY(M):PU	N/A	3Y	F	5	RS
	North	23-Jul-02	2370-39952	BB(M):PU	N/A	A8Y	M	5	RS
	North	6-Jul-08	2430-61198	XX:KR(M)	N/A	L	U	5	N
	North	6-Jul-08	2430-61199	RW(M):XX	N/A	L	U	5	N
	North	6-Jul-08	2430-61200	XX:WW(M)	N/A	L	U	5	N
	North	18-Jun-04	none	RR(M):no foot	N/A	A6Y	F	24	R 29 Jun
	North	19-Jul-08	2430-61080	YY(M):XX	N/A	SY	M	24, 27	N
	North	N/A	N/A	UB:UB	N/A	HY	U	24	RS

Table 3.2. Willow Flycatchers Detected at All Monitored Study Areas with Resident Flycatchers, 2008 (Continued)

Study Area[1]	Site	Date Banded	Federal Band #[2]	Color Combination[3]	Old Color Combination[2,3,4]	Age[5]	Sex[6]	Territory or Location[7]	Observation Status[8]
PAHR	North	30-Jun-05	2320-31698	RB(M):EE	N/A	4Y	F	26	RS
	North	15-Jul-08	2430-61124	OY(M):XX	N/A	L	U	26	N
	North	15-Jul-08	2430-61123	XX:VK(M)	N/A	L	U	26	N
	North	15-Jul-08	2430-61122	YW(M):XX	N/A	L	U	26	N
	North	17-Jun-07	2370-40194	PU:BR(M)	N/A	3Y	F	27	RS
	North	N/A	N/A	UB:UB	N/A	HY	U	27	RS
	North	N/A	N/A	UB:UB	N/A	HY	U	27	RS
	North	N/A	N/A	UB:UB	N/A	HY	U	27	RS
	North	1-Jul-06	2370-40047	PU:DD(M)	N/A	A4Y	F	85	RS
	North	2-Jun-05	2370-39953	OB(M):PU	N/A	A5Y	M	85	RS
	North	1-Jul-08	2430-61111	WV(M):XX	N/A	L	U	85	N
	North	1-Jul-08	2430-61120	XX:KO(M)	N/A	L	U	85	N
	North	1-Jul-08	2430-61119	WK(M):XX	N/A	L	U	85	N
	North	17-Jun-04	None[10]	no foot:DW(M)	EE:DW(M)	6Y	F	86	RS
	North	21-Jun-06	2370-40060	YG(M):PU	N/A	A4Y	M	86	RS
	North	6-Jul-05	2360-59711	KB(M):EE	UB:EE	4Y	M	T3	R 20 May and 28 Jun; detected 19 May–25 Jul
	North	25-Jul-05	2370-39915	PU:RZ(M)	N/A	A5Y	M	T23	RS; detected 19 May–11 Jul
	North	INA	INA	banded	N/A	AHY	M	T25	RS; detected 13 Jun–6 Jul
	North	3-Aug-08	2430-61127	XX:WG(M)	N/A	AHY	M	T28	N; detected 23 Jul–3 Aug
	North	24-Jul-08	2430-61083	XX:RW(M)	N/A	SY	M	T61	N; detected 21–31 Jul
	North	1-Jun-05	2370-39951	PU:OZ(M)	N/A	A5Y	M	T83	RS; detected 14 May–13 Jul
	North	6-Jul-05	2360-59712	EE:GKG	EE:UB	4Y	M	T84	R 6 Jun; detected 29 May–19 Jul
	North	18-May-04	2320-31595	WKW(M):EE	N/A	A6Y	M	T99	RS; detected 19 May–12 Jul
	North	INA	INA	banded	N/A	AHY	U	F23	RS; detected 23 Jul

Table 3.2. Willow Flycatchers Detected at All Monitored Study Areas with Resident Flycatchers, 2008 (Continued)

Study Area[1]	Site	Date Banded	Federal Band #[2]	Color Combination[3]	Old Color Combination[2,3,4]	Age[5]	Sex[6]	Territory or Location[7]	Observation Status[8]
PAHR	North	N/A	N/A	UB:UB	N/A	AHY	M	F88	RS; detected 16 Jul
LIFI	Poles	N/A	N/A	UB:UB	N/A	AHY	M	F89	RS; detected 22 Jul
MESQ	West	5-Jul-07	2370-40193	GY(M):PU	N/A	A3Y	F	2	RS
	West	8-Jun-05	2370-39954	BO(M):PU	N/A	A5Y	M	2	RS
	West	N/A	N/A	UB:UB	N/A	HY	U	2	RS
	West	27-Jun-07	2370-40170	RG(M):PU	N/A	A3Y	F	3	RS
	West	3-Jun-04	2320-31490	EE:OO(M)	N/A	A6Y	M	3, 97	RS
	West	28-Jun-08	2430-61184	GV(M):XX	N/A	L	U	3	N
	West	28-Jun-08	2430-61186	KO(M):XX	N/A	L	U	3	N
	West	28-Jun-08	2430-61185	DB(M):XX	N/A	L	U	3	N
	West	1-Aug-03	2320-31445	EE:WK(M)	N/A	A7Y	F	20	RS
	West	26-Jul-01	2390-92475	XX:WY(M)	N/A	8Y	M	20	RS
	West	28-Jun-08	2430-61187	KV(M):XX	N/A	L	U	20	N[11]
	West	28-Jun-08	2430-61188	BG(M):XX	N/A	L	U	20	N[11]
	West	28-Jun-08	2430-61189	KB(M):XX	N/A	L	U	20	N[11]
	West	6-Jul-04	2320-31573	WY(M):EE	N/A	A6Y	F	21	RS
	West	15-Jul-05	2320-31688	EE:BG(M)	N/A	4Y	M	21	RS
	West	1-Jul-08	2430-61190	XX:DB(M)	N/A	L	U	21	N[6]
	West	1-Jul-08	2430-61165	XX:RY(M)	N/A	L	U	21	N[6]
	West	INA	INA	undetermined	N/A	AHY	F	22	
	West	18-May-06	2370-39937	KK(M):PU	N/A	4Y	M	22	RS
	West	INA	INA	UB:EE	N/A	AHY	F	40	RS
	West	30-May-08	2430-61105	XX:YY(M)	N/A	AHY	M	40	N
	West	18-Jul-08	2430-61121	YO(M):XX	N/A	L	U	40	N

Table 3.2. Willow Flycatchers Detected at All Monitored Study Areas with Resident Flycatchers, 2008 (Continued)

Study Area[1]	Site	Date Banded	Federal Band #[2]	Color Combination[3]	Old Color Combination[2,3,4]	Age[5]	Sex[6]	Territory or Location[7]	Observation Status[8]
MESQ	West	18-Jul-08	2430-61078	BY(M):XX	N/A	L	U	40	N
	West	23-Jun-04	2320-31498	KW(M):EE	N/A	5Y	F	82	RS
	West	4-Jul-01	2390-92434[12]	UB:XX	N/A	8Y	M	82	RS
	West	8-Jul-08	2430-61130	VK(M):XX	N/A	L	U	82	N
	West	8-Jul-08	2430-61129	XX:KD(M)	N/A	L	U	82	N
	West	N/A	N/A	UB:UB	N/A	AHY	F	84	RS
	West	7-Jun-06	2370-39967	KO(M):PU	N/A	A4Y	M	84	R 20 Jun
	West	24-Jun-08	2430-61175	BR(M):XX	N/A	L	U	84	N
	West	24-Jun-08	2430-61176	DK(M):XX	N/A	L	U	84	N
	West	24-Jun-08	2430-61177	XX:OW(M)	N/A	L	U	84	N
	West	20-Jul-06	2370-40066	YO(M):PU	N/A	4Y	F	85	RS
	West	6-Jul-06	2360-59751	OG(M):EE	N/A	3Y	M	85	RS
	West	2-Jul-08	2430-61194	VB(M):XX	N/A	L	U	85	N
	West	2-Jul-08	2430-61195	RY(M):XX	N/A	L	U	85	N
	West	2-Jul-08	2430-61196	XX:WV(M)	N/A	L	U	85	N
	West	N/A	N/A	UB:UB	N/A	AHY	F	88	RS
	West	INA	INA	undetermined	N/A	AHY	M	88	
	West	25-Jul-08	2430-61082	XX:VG(M)	N/A	L	U	88	N
	West	25-Jul-08	2430-61084	XX:BO(M)	N/A	L	U	88	N
	West	26-Jul-07	2370-40087	PU:BZ(M)	N/A	A3Y	F	97	RS
	West	N/A	N/A	UB:UB	N/A	AHY	M	T23	RS; detected 10 Jul–1 Aug
	West	3-Jun-07	2370-40197	OG(M):PU	N/A	A3Y	M	T86	RS; detected 30 May–12 Jul
	West	7-Jul-06	2360-59754	OR(M):EE	N/A	3Y	M	T87	RS; detected 30 May–8 Jul
	Bunker Farm	INA	INA	undetermined	N/A	AHY	U	F41	Detected 5 Jun

Table 3.2. Willow Flycatchers Detected at All Monitored Study Areas with Resident Flycatchers, 2008 (Continued)

Study Area[1]	Site	Date Banded	Federal Band #[2]	Color Combination[3]	Old Color Combination[2,3,4]	Age[5]	Sex[6]	Territory or Location[7]	Observation Status[8]
MESQ	West	7-Jul-06	2360-59752	DRD(M):EE	UB:EE	3Y	M	F43	R 27 Jul; detected 25–27 Jul
	East	INA	INA	undetermined	N/A	AHY	U	F90	Detected 22 Jul
MOME	Virgin River #1 South	N/A	N/A	UB:UB	N/A	AHY	F	1	RS
	Virgin River #1 South	29-Jun-06	2360-59749	BG(M):EE	N/A	3Y	M	1	RS
	Virgin River #1 South	23-Jun-08	2430-61206	XX:BW(M)	N/A	L	U	1	N
	Virgin River #1 South	23-Jun-08	2430-61207	GO(M):XX	N/A	L	U	1	N
	Virgin River #1 South	N/A	N/A	UB:UB	N/A	AHY	F	3	RS
	Virgin River #1 South	14-Jun-06	2370-40046	PU:DK(M)	N/A	4Y	M	3, 87	R 24 Jul
	Virgin River #1 South	17-Jul-08	2430-61132	OR(M):XX	N/A	L	U	3	N
	Virgin River #1 South	17-Jul-08	2430-61131	VW(M):XX	N/A	L	U	3	N
	Virgin River #1 South	17-Jul-08	2430-61128	XX:WO(M)	N/A	L	U	3	N
	Virgin River #2	N/A	N/A	UB:UB	N/A	AHY	F	25	RS
	Virgin River #2	19-Jun-08	2430-61167	XX:KW(M)	N/A	AHY	M	25	N
	Virgin River #2	13-Jul-08	2430-61133	WD(M):XX	N/A	L	U	25	N
	Virgin River #1 South	23-Jul-03	2320-31486	YV(M):EE	N/A	6Y	F	28	RS
	Virgin River #1 South	6-Jul-06	2360-59799	EE:OZ(M)	N/A	3Y	M	28, 30	RS
	Virgin River #1 South	28-Jun-08	2430-61168	XX:YW(M)	N/A	L	U	28	N
	Virgin River #1 South	28-Jun-08	2430-61169	XX:YV(M)	N/A	L	U	28	N
	Virgin River #1 South	28-Jun-08	2430-61170	XX:YO(M)	N/A	L	U	28	N
	Virgin River #1 South	28-Jun-08	2430-61171	XX:YG(M)	N/A	L	U	28	N
	Virgin River #1 South	20-Jul-08	2430-61079	RR(M):XX	N/A	SY	F	30	N
	Virgin River #1 South	20-Jul-08	2430-61077	GB(M):XX	N/A	L	U	30	N
	Virgin River #1 South	20-Jul-08	2430-61081	UB:XX	N/A	L	U	30	N
	Virgin River #1 North	2-Jul-08	2430-61116	VV(M):XX	N/A	AHY	F	40	N

Table 3.2. Willow Flycatchers Detected at All Monitored Study Areas with Resident Flycatchers, 2008 (Continued)

Study Area[1]	Site	Date Banded	Federal Band #[2]	Color Combination[3]	Old Color Combination[2,3,4]	Age[5]	Sex[6]	Territory or Location[7]	Observation Status[8]
MOME	Virgin River #1 North	15-May-07	2370-40161	PU:DY(M)	N/A	A3Y	M	40	RS
	Virgin River #1 North	1-Jul-08	2430-61193	VG(M):XX	N/A	L	U	40	N
	Virgin River #1 North	1-Jul-08	2430-61191	XX:BD(M)	N/A	L	U	40	N
	Virgin River #1 North	1-Jul-08	2430-61192	XX:OB(M)	N/A	L	U	40	N
	Virgin River #1 South	21-Jun-07	2370-40191	PU:RYR(M)	N/A	A3Y	F	63	RS
	Virgin River #1 South	22-Jul-02	2140-66709	Bs:GW(M)	N/A	A8Y	M	63, 96	RS
	Virgin River #1 South	23-Jun-08	2430-61203	XX:GB(M)	N/A	L	U	63	N
	Virgin River #1 South	23-Jun-08	2430-61204	XX:YB(M)	N/A	L	U	63	N
	Virgin River #1 South	23-Jun-08	2430-61202	DR(M):XX	N/A	L	U	63	N
	Virgin River #1 South	23-Jun-08	2430-61205	DY(M):XX	N/A	L	U	63	N
	Virgin River #1 South	N/A	N/A	UB:UB	N/A	AHY	F	64	RS
	Virgin River #1 South	8-Jun-06	2370-39938	KG(M):PU	N/A	4Y	M	64	RS
	Virgin River #1 South	INA	INA	EE:UB	N/A	AHY	F	65	RS
	Virgin River #1 South	12-Jun-07	2370-40172[13]	RK(M):UB	PU:RO(M)	A3Y	M	65	R 24 Jul
	Virgin River #1 South	27-Jul-08	2430-61212	KG(M):XX	N/A	L	U	65	N[14]
	Virgin River #2	16-Jul-04	2320-31632	RZ(M):EE	N/A	6Y	F	86	RS; moved to Muddy River
	Virgin River #2	23-Jun-03	2370-39940	GY(M):PU	N/A	A4Y	M	86, 88	RS
	Virgin River #1 South	6-Aug-05	2360-59788	BO(M):EE	N/A	4Y	F	87	RS
	Virgin River #1 South	23-Jun-08	2430-61172	XX:GR(M)	N/A	L	U	87	N
	Virgin River #1 South	23-Jun-08	2430-61173	XX:GY(M)	N/A	L	U	87	N
	Virgin River #1 South	23-Jun-08	2430-61174	XX:KG(M)	N/A	L	U	87	N
	Virgin River #2	N/A	N/A	UB:UB	N/A	AHY	F	88	RS
	Virgin River #1 South	30-Jun-04	2320-31485	EE:WO(M)	N/A	A6Y	F	96	RS
	Virgin River #1 South	12-Jun-08	2340-61104	YD(M):XX	N/A	SY	M	T2	N; detected 2–21 Jun

Table 3.2. Willow Flycatchers Detected at All Monitored Study Areas with Resident Flycatchers, 2008 (Continued)

Study Area[1]	Site	Date Banded	Federal Band #[2]	Color Combination[3]	Old Color Combination[2,3,4]	Age[5]	Sex[6]	Territory or Location[7]	Observation Status[8]
MOME	Virgin River #2	21-Jun-06	2370-39988	DW(M):PU	N/A	4Y	M	T61	RS; detected 12 May–25 Jun
	Virgin River #1 South	12-Jun-03	2320-31428	EE:DB(M)	N/A	6Y	M	T97	RS; detected 12–29 May
	Virgin River #1 South	INA	INA	PU:UB	N/A	AHY	M	T98	RS; detected 23 Jun–1 Jul
	Mormon Mesa South (North)	INA	INA	undetermined	N/A	AHY	M	F4	Detected 12 Jun
	Mormon Mesa South (North)	N/A	N/A	UB:UB	N/A	AHY	M	F5	RS; detected 12 Jun
	Virgin River #2	INA	INA	PU:UB	N/A	AHY	U	F29	RS; detected 17 Jun
	Virgin River #1 South	26-Jul-07	2370-40086	WRW(M):PU	UB:PU	SY	U	F95	R 19 Jun; not detected pre- or post-capture
MUDD	Overton WMA	INA	INA	banded	N/A	AHY	F	1	RS
	Overton WMA	N/A	N/A	UB:UB	N/A	AHY	M	1, 80, 94	RS
	Overton WMA	N/A	N/A	UB:UB	N/A	HY	U	1	RS
	Overton WMA	14-Jun-06	2370-40059	PU:BY(M)	N/A	A4Y	F	20	R 29 Jul
	Overton WMA	26-Jun-03	2370-39955[13]	BV(M):no foot	BV(M):PU	6Y	M	20	R 29 Jul
	Overton WMA	26-Jul-08	2430-61223	XX:YD(M)	N/A	L	U	20	N
	Overton WMA	26-Jul-08	2430-61224	XX:YK(M)	N/A	L	U	20	N
	Overton WMA	26-Jul-08	2430-61225	WG(M):XX	N/A	L	U	20	N
	Overton WMA	INA	INA	PU:UB	N/A	AHY	F	80	RS
	Overton WMA	16-Jun-04	2320-31632	RZ(M):EE	N/A	6Y	F	94	RS; at Mormon Mesa until 29 Jun
	Overton WMA	24-Jun-08	2430-61103	XX:DR(M)	N/A	SY	M	T40	N; detected 14–24 Jun
	Overton WMA	N/A	N/A	UB:UB	N/A	AHY	M	T95	RS; detected 14 Jul–5 Aug
	Overton WMA	21-Jun-04	2320-31615	EE:OY(M)	N/A	5Y	M	F60	RS; detected 11 May
	Overton Pond	N/A	N/A	UB:UB	N/A	AHY	U	F61	RS; detected 10 Jun
	Overton WMA	24-Jun-08	2430-61208	XX:BV(M)	N/A	SY	M	F62	N; detected 22–24 Jun
GRCA	Iceberg Canyon	12-Jun-08	2430-61072	XX:RK(M)	N/A	SY	M	T22	N, unpaired, detected 6 May–19 Jun

Table 3.2. Willow Flycatchers Detected at All Monitored Study Areas with Resident Flycatchers, 2008 (Continued)

Study Area[1]	Site	Date Banded	Federal Band #[2]	Color Combination[3]	Old Color Combination[2,3,4]	Age[5]	Sex[6]	Territory or Location[7]	Observation Status[8]
TOPO	Pierced Egg	N/A	N/A	UB:UB	N/A	AHY	F	1	RS
	Pierced Egg	INA	INA	UB:EE	N/A	AHY	M	1	RS
	Pipes #3	INA	INA	PU:UB	N/A	AHY	F	2	RS
	Pipes #3	20-May-08	2430-61134	XX:OG(M)	N/A	AHY	M	2	N
	Pipes #3	10-Jul-08	2430-61143	XX:VB(M)	N/A	L	U	2	N
	Pipes #3	10-Jul-08	2430-61144	GR(M):XX	N/A	L	U	2	N
	Glory Hole	N/A	N/A	UB:UB	N/A	AHY	F	9	RS
	Glory Hole	22-Jul-04	2320-31562	KY(M):EE	N/A	5Y	M	9	RS
	Glory Hole	N/A	N/A	UB:UB	N/A	AHY	F	10	RS
	Glory Hole	N/A	N/A	UB:UB	N/A	AHY	M	10	RS
	Glory Hole	N/A	N/A	UB:UB	N/A	AHY	F	11	RS
	Glory Hole	25-Jul-04	2320-31560	EE:GY(M)	N/A	6Y	M	11	RS
	Glory Hole	10-Jul-08	2430-61145	GW(M):XX	N/A	L	U	11	N
	Pierced Egg	INA	INA	EE:UB	N/A	AHY	F	21	RS
	Pierced Egg	INA	INA	UB:EE	N/A	AHY	M	21,22	RS
	Pierced Egg	N/A	N/A	UB:UB	N/A	AHY	F	22	RS
	Pierced Egg	N/A	N/A	UB:UB	N/A	AHY	F	30	RS
	Pierced Egg	1-Jun-06	2370-39916	PU:YD	N/A	A4Y	M	30	RS
	Pierced Egg	26-Jun-08	2430-61139	XX:BY(M)	N/A	SY	F	32	N
	Pierced Egg	22-May-08	2430-61135	XX:OY(M)	N/A	SY	M	32	N
	In Between	INA	INA	undetermined	N/A	AHY	M	T6	Detected 27 May–4 Jun
	Glory Hole	17-May-07	2370-40139	PU:ZB(M)	N/A	A3Y	M	T13	RS; detected 11 Jun–13 Jul
	Glory Hole	INA	INA	UB:PU	N/A	AHY	M	T84	RS; detected 5–17 Jun
	IRFB04	INA	INA	undetermined	N/A	AHY	U	F5	Detected 27 May, probable migrant

Table 3.2. Willow Flycatchers Detected at All Monitored Study Areas with Resident Flycatchers, 2008 (Continued)

Study Area[1]	Site	Date Banded	Federal Band #[2]	Color Combination[3]	Old Color Combination[2,3,4]	Age[5]	Sex[6]	Territory or Location[7]	Observation Status[8]
TOPO	Pierced Egg	N/A	N/A	UB:UB	N/A	AHY	U	F7	RS; detected 6-11 Jun
	Pierced Egg	N/A	N/A	UB:UB	N/A	AHY	U	F8	RS; detected 21 Jun
	Pierced Egg	INA	INA	undetermined	N/A	AHY	U	F12	Detected 21 Jun
	The Wallows	INA	INA	undetermined	N/A	AHY	M	F23	Detected 17–18 Jun
	250M	INA	INA	undetermined	N/A	AHY	U	F36	Detected 18 Jun
	Channel[15]	INA	INA	undetermined	N/A	AHY	M	F56	Detected 9 Jun, probable migrant
	Beal Lake	INA	INA	undetermined	N/A	AHY	U	F100	Detected 5 Jun, probable migrant
	Beal Lake	INA	INA	undetermined	N/A	AHY	U	F101	Detected 5 Jun, probable migrant
	Beal Lake	INA	INA	undetermined	N/A	AHY	U	F102	Detected 11 Jun, probable migrant
BIWI	Site #3	18-Jun-08	2430-61138	XX:BK(M)	N/A	SY	F	8	N
	Site #3	6-Jun-08	2430-61136	XX:BG(M)	N/A	SY	M	8	N
	Site #3	1-Jul-08	2430-61075	XX:DK(M)	N/A	L	U	8	N
	Site #3	1-Jul-08	2430-61076	XX:RG(M)	N/A	L	U	8	N
	Site #3	N/A	N/A	UB:UB	N/A	AHY	F	12	RS
	Site #3	24-May-05	2370-40052	KV(M):PU	N/A	A5Y	M	12, 66	RS
	Site #3	6-Jun-08	2430-61137	XX:BR(M)	N/A	SY	F	31	N
	Site #3	14-Jun-08	2430-61073	XX:DO(M)	N/A	SY	M	31	N
	Site #3	29-Jun-08	2430-61074	KY(M):XX	N/A	L	U	31	N
	Site #3	INA	INA	banded	N/A	AHY	F	66	RS
	Site #3	6-Jul-08	2430-61140	XX:WB(M)	N/A	L	U	66	N
	Site #3	6-Jul-08	2430-61141	XX:BB(M)	N/A	L	U	66	N
	Site #3	6-Jul-08	2430-61142	XX:RO(M)	N/A	L	U	66	N
	Site #4	INA	INA	undetermined	N/A	AHY	M	F24	Detected 29–30 Jun

Table 3.2. Willow Flycatchers Detected at All Monitored Study Areas with Resident Flycatchers, 2008 (Continued)

Study Area[1]	Site	Date Banded	Federal Band #[2]	Color Combination[3]	Old Color Combination[2,3,4]	Age[5]	Sex[6]	Territory or Location[7]	Observation Status[8]
AHAK	Deer Island	N/A	N/A	UB:UB	N/A	AHY	U	T4	RS; detected 21 May–6 Jun
	Deer Island	INA	INA	undetermined	N/A	AHY	U	F3	Detected 21–24 May

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

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

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

[4] Old combination included only if rebanded in 2008.

[5] **Age in 2008**: L = nestling, HY = hatch year, SY = 2 years, AHY = 2 years or older, 3Y = 3 years, A3Y = 3 years or older, 4Y = 4 years, A4Y = 4 years or older, etc.

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

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

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

[9] One of these four nestlings suspected to have died before fledging.

[10] This female was resighted missing her left foot. Former band combination is EE:DW(M), federal band number 2320-31661.

[11] One of the nestlings suspected to have died before fledging.

[12] Band number likely 2390-92434 but cannot be confirmed because bird was not captured in 2008. Bird had a visible injury on left leg.

[13] This band was removed.

[14] Nestling died before fledging.

[15] Not a formal survey site.

Bill Williams – We detected seven resident willow flycatchers from four territories at Bill Williams. In addition to resident adults, we detected one individual for which residency and/or breeding status could not be determined (Table 3.2). All four territories recorded at Bill Williams consisted of paired individuals. Of the breeding individuals, one male was polygynous with two females.

Field personnel captured and color-banded four new adults. We resighted and identified one returning banded adult, and resighted one additional banded adult but could not confirm the color combination. One resident adult remained unbanded, and band status could not be determined for one adult for which residency status could not be determined. We banded six nestlings from three nests.

Ahakhav Tribal Preserve – We detected one resident willow flycatcher and one individual for which residency could not be determined (Table 3.2). The resident flycatcher was unbanded, and band status could not be determined for the other adult.

Non-Monitoring Sites

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

Key Pittman Wildlife Management Area – Field personnel captured and color-banded nine new adults (Table 3.3). An additional adult was captured with a single federal band; this individual had been captured but not rebanded previously as an adult. We resighted and identified four returning banded adults. We recaptured two returning nestlings, one each from 2006 and 2007 (see Table 3.6 for juvenile dispersal data). We banded six nestlings from two nests.

St. George – Field personnel resighted and identified one adult flycatcher. A second adult was identified as a returning nestling, but we were unable to capture this individual to determine year and study area of origin. We banded five nestlings from two nests (Table 3.3).

Las Vegas Wash – Field personnel captured and color-banded one adult (Table 3.3).

Table 3.3. Willow Flycatchers Color-Banded and Resighted, Non-Monitoring Sites, 2008

Study Area[1]	Site	Date Banded	Federal Band #	Color Combination[2]	Old Color Combination[2,3]	Age[4]	Sex[5]	Observation Status[6]
KEPI	Patch 1	30-Jul-05	2370-39980	WO(M):PU	N/A	4Y	M	RS
	Patch 3	25-Jun-08	2430-61178	DO(M):XX	N/A	AHY	M	N; R 26 Jun
	Patch 4	25-Jun-08	2430-61179	XX:KB(M)	N/A	AHY	M	N; R 26 Jun
	Patch 5	26-Jul-08	2430-61210	OD(M):XX	N/A	AHY	U	N
	Patch 6	30-Jun-08	2430-61109	WW(M):XX	N/A	AHY	F	N
	Patch 6	3-Jul-05	2320-31694	EE:BK(M)	N/A	4Y	M	RS
	Patch 6	3-Aug-08	2370-40098	PU:KD(M)	N/A	L	U	N
	Patch 6	3-Aug-08	2370-40097	PU:GY(M)	N/A	L	U	N
	Patch 6	3-Aug-08	2370-40096	PU:WY(M)	N/A	L	U	N
	Patch 7	27-Jun-06	2320-31674	BW(M):EE	UB:EE	3Y	M	R 26 Jun
	Patch 8	27-Jun-03	2320-31468	EE:RO(M)	N/A	6Y	M	RS
	Patch 8	30-Jun-08	2430-61110	XX:OK(M)	N/A	L	U	N
	Patch 8	30-Jun-08	2430-61101	XX:GW(M)	N/A	L	U	N
	Patch 8	30-Jun-08	2430-61102	YG(M):XX	N/A	L	U	N
	Patch 9	26-Jun-08	2430-61180	RD(M):XX	N/A	SY	M	N
	Patch 9	23-Jun-04	2320-31484	YB(M):EE	UB:EE	5Y	M	R 26 Jun
	Patch 10	25-Jul-05	2370-39915	PU:RZ(M)	N/A	A5Y	M	RS; at PAHR through 11 Jul
	Patch 10	26-Jun-08	2430-61181	XX:RD(M)	N/A	AHY	F	N
	Patch 10	26-Jun-08	2430-61182	XX:OR(M)	N/A	SY	M	N
	Patch 11	29-Jun-07	2360-59743	EE:GRG(M)	EE:UB	SY	F	R 15 Jul
	Patch 11	26-Jun-08	2430-61183	XX:RB(M)	N/A	AHY	M	N; R 15 Jul
	Patch 12	15-Jul-08	2430-61125	XX:WK(M)	N/A	AHY	M	N
STGE	Seegmiller Marsh	INA	INA	UB:PU	N/A	AHY	M	RS
	Seegmiller Marsh	21-Jun-04	2320-31660	BZ(M):EE	N/A	5Y	F	RS
	Seegmiller Marsh	27-Jul-08	2370-40149	PU:KK(M)	N/A	L	U	N
	Seegmiller Marsh	27-Jul-08	2370-40148	PU:KR(M)	N/A	L	U	N
	Seegmiller Marsh	27-Jul-08	2370-40147	OR(M):PU	N/A	L	U	N
	Seegmiller Marsh	31-Jul-08	2430-61126	XX:VW(M)	N/A	L	U	N
	Seegmiller Marsh	31-Jul-08	2430-61211	BK(M):XX	N/A	L	U	N
LVWA	Upstream Pabco South Lower Plateau	25-Jun-08	2430-61209	GY(M):XX	N/A	AHY	M	N; detected 28 May–30 Jun

[1] KEPI = Key Pittman Wildlife Management Area, STGE = St. George, LVWA = Las Vegas Wash.

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

[3] Old combination included only if rebanded in 2008.

[4] **Age in 2008:** L = nestling, SY = 2 years, AHY = 2 years or older, 3Y = 3 years, A3Y = 3 years or older, 4Y = 4 years, A4Y = 4 years or older, etc.

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

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

Adult Between-Year Return and Dispersal

In 2007 we identified 95 adult, resident willow flycatchers at our monitored study areas, of which 54 (57%) were detected in 2008 (Table 3.4). Of the returning adults, three (6%) were detected at a different study area than where they were last detected in 2007, and two of those were detected at study areas (Key Pittman and St. George) monitored by other agencies (Table 3.5). Two additional adults, one of which was last detected in 2005 and the other in 2006, exhibited between-year movement in 2008. The median dispersal distance for all returning adult flycatchers exhibiting between-year movements in 2008 was 32 km (min = 13 km, max = 61 km).

Table 3.4. Resident Adult Willow Flycatcher Annual Return from 2007 to 2008

Study Area	# Identified in 2007	# of 2007 Birds Detected in 2008	% Return	% Return to Same Study Area
Pahranagat	23	15	65	100
Mesquite	21	16	76	100
Mormon Mesa	22	15	68	88
Muddy River	10	4	40	75
Grand Canyon	3	0	0	--
Topock	8	3	38	100
Bill Williams	8	1	13	100
Total	**95**	**54**	**57**	**94**

Table 3.5. Summary of Adult Willow Flycatcher Between-Year Movements for All Individuals Identified in a Previous Year and Recaptured or Resighted at a Different Study Area in 2008

Study Area/Site/Year Detected [1]	Study Area/Site Detected 2008[1]	Distance Moved (km)	Federal Band #	Color Combination[2]	Sex[3]
PAHR/MAPS/2005	KEPI/Patch 9	32	2320-31484	YB(M):EE	M
PAHR/South/2006	KEPI/Patch 8	33	2320-31468	EE:RO(M)	M
MOME/VR#2/2007	STGE/Seegmiller Marsh	61	2320-31660	BZ(M):EE	F
MOME/VR#2/2007	MESQ/West	29	2370-40197	OG(M):PU	M
MUDD/Overton Pond/2007	MOME/VR #1S	13	2360-59799	EE:OZ(M)	M

[1] PAHR = Pahranagat NWR, KEPI = Key Pittman WMA, STGE = St. George, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River.
[2] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, (M) = metal pin striped band, B = light blue, G = green, O = orange, R = red, Z = gold, Y = yellow. Color combinations are read as the bird's left leg and right leg, top to bottom; two letters designate every band; color-band designations for right and left legs are separated with a colon.
[3] **Sex codes**: F = female, M = male.

Juvenile Between-Year Return and Dispersal

In 2007, we banded 55 nestlings and 1 fledgling at the monitored study areas. Six of these nestlings were known to have died before fledging. Of the 50 remaining juveniles, 2 (4%) were recaptured and identified in 2008. Both were detected at a different study area from where originally banded. Two individuals originally banded as nestlings in 2005 and two banded in 2006 were also recaptured for the first time; of these, three returned to a different study area than where originally banded (Table 3.6). The median dispersal distance for all returning juvenile flycatchers in 2008 was 30 km (min = 0.15 km, max = 30 km).

Table 3.6. Summary of Juvenile Flycatchers Banded as Hatch Year Birds in 2005, 2006, or 2007 and Recaptured for the First Time in 2008

Study Area/ Site Banded	Year Hatched	Study Area/Site Detected 2008	Distance Moved (km)	Federal Band #	Color Combination[2]	Sex[3]
PAHR/North	2006	KEPI/Patch 7	30	2320-31674	BW(M):EE	M
KEPI	2005	PAHR/North	30	2360-59711	KB(M):EE	M
KEPI	2005	PAHR/North	30	2360-59712	EE:GKG(M)	M
MESQ/West	2006	MESQ/West	0.15	2360-59752	DRD(M):EE	M
MESQ/West	2007	MOME/Virgin River #1 South	28	2370-40086	WRW(M):PU	U
PAHR/North	2007	KEPI/Patch 11	30	2360-59743	EE:GRG(M)	F

[1] KEPI = Key Pittman WMA, PAHR = Pahranagat NWR, MESQ = Mesquite, MOME = Mormon Mesa.
[2] **Color-band codes**: EE = electric yellow federal band, PU = pumpkin federal band, (M) = metal pin striped band, B = light blue, D = dark blue, G = green, R = red, W = white, K = black. Color combinations are read as the bird's left leg and right leg, top to bottom; two or three letters designate every band; color-band designations for right and left legs are separated with a colon.
[3] **Sex codes**: F = female, M = male, U = unknown.

Ten additional returning nestlings from 2003–2007 were resighted in 2008 (one each at Mesquite and Muddy River, three at Mormon Mesa, and five at Topock), but the identity of these individuals was undetermined because we were unable to recapture them.

Within-Year, Between-Study Area Movements

We detected two within-year, between study area movements in 2008. One male held a territory at Pahranagat North from 19 May to 11 July and then was detected at Key Pittman on 26 July. A female had an unsuccessful nesting attempt at Mormon Mesa Virgin River #2 (25 May–29 June) and then moved to Muddy River Overton WMA where she had another unsuccessful nesting attempt (14–19 July).

DISCUSSION

Color-Banding Effort

Overall, 69% of the adult flycatchers detected at the monitoring sites during 2008 were banded by the end of the breeding season. This compares to 55, 57, 75, 70, and 73% in 2003–2007, respectively. Unbanded migrant willow flycatchers are included in calculating these percentages; therefore, in most cases, these numbers under-represent the actual proportion of resident banded flycatchers at a given site. We have maintained high overall percentages of banded birds annually over the five years, which has enabled us to detect movements, generate dispersal data, and determine survival and detection probabilities across study areas (McLeod et al. 2008a). Differences between study areas in the percentage of banded individuals are directly related to vegetation density and overall structure, which affect our ability to erect mist-nets in the habitat. Topock Marsh typically has the lowest percentage of color-banded flycatchers because dense vegetation limits the number and size of possible net locations.

Prior to 2008, we banded all nestlings with a single anodized federal band, identifying the bird as a returning nestling in the event it was sighted in a subsequent year. The individual would then have to be recaptured to determine its individual identity and to apply a unique color combination so the bird could be individually identified via resighting. Returning nestlings were particularly difficult to recapture at Topock. To eliminate the need to recapture returning nestlings, in 2008 we applied unique color combinations to all nestlings. These nestlings will not need to be recaptured in subsequent years, and the use of full color combinations on nestlings should increase the proportion of adults that can be individually identified and yield more information on juvenile dispersal and survivorship.

Adult and Juvenile Between-Year Dispersal

Ninety-four percent of all adults detected in both 2007 and 2008 were detected at the same study area in both years. From 1998 to 2007, 92% of all between-year adult returns were to the same study area. Of the six individuals that were banded as juveniles in 2005–2007 and detected for the first time in 2008, 50% returned to the same study area where originally banded. From 1997 to 2007, 41% of all returning juveniles dispersed away from the natal area (McKernan and Braden unpubl. data, McLeod et al. 2008a). Adult and juvenile dispersal data show high site fidelity exhibited by adult flycatchers and lower natal site fidelity exhibited by juveniles, with juveniles dispersing among study areas annually. These dispersal data are consistent with range-wide data (Paxton et al. 2007), with adult flycatchers exhibiting high site fidelity to breeding areas. Juvenile dispersal within the Virgin/lower Colorado River population(s) is largely limited to this region, and while reciprocal juvenile movements among geographically isolated flycatcher populations of the greater Southwest do occur, they are rare. Only three instances of willow flycatcher immigration from sites outside the Virgin/lower Colorado River region have been recorded since 1997 (McKernan and Braden unpubl. data, McLeod et al. 2008a), with two males originally banded as nestlings in 2003 at Roosevelt Lake recaptured in 2005 at Muddy River and Topock, and one male banded as a nestling in 1999 at Roosevelt Lake recaptured in 2002 in Grand Canyon. Although movements of this magnitude are infrequent, other instances of dispersal distances greater than 140 km have been reported for the Southwestern Willow Flycatcher (Paxton et al. 2007).

The observed dispersal patterns 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.

Adult and Juvenile Survivorship

Annual survivorship is defined as the number of individuals that survive from one year to the next, and accurate estimates depend on year-to-year detection of uniquely marked birds. Fifty-seven percent of the adult, resident willow flycatchers identified in 2007 were detected again in 2008, while of the 50 juveniles banded in 2007, only 2 (4%) were identified in 2008. Thus, minimum estimated adult and juvenile survival from 2007 to 2008 was 57 and 4%, respectively. These simple annual percent survivorship calculations assume that all living flycatchers are detected in a given year, and individuals not detected are assumed to have died, unless detected elsewhere. This is the lowest juvenile return rate recorded since 2004, with an average return rate of 13% recorded in 2004–2007 for the juveniles from the previous year. Flycatchers sometimes go undetected for up to three years after being banded as juveniles, and banding data collected in future years will determine if low survival rates, low detection rates, or both contributed to the low number of juveniles from 2007 identified in 2008.

Chapter 4

NEST MONITORING

INTRODUCTION

Documentation of nest success and productivity is critical to understanding local population status and demographic patterns of the Southwestern Willow Flycatcher. In 2008, at all sites where willow flycatcher breeding activity was suspected, we conducted intensive nest searches and nest monitoring. Specific objectives of nest monitoring included identifying breeding individuals (see Chapter 3, Color-banding and Resighting), calculating nest success and failure, documenting causes of nest failure (e.g., abandonment, desertion, depredation, and brood parasitism), and calculating nest productivity. Nest monitoring results from 2008 were compared with those at the study areas from 1996 to 2007 (Braden and McKernan unpubl. data, McLeod et al. 2008a). Although aspects of willow flycatcher breeding ecology can vary widely across its broad geographical and elevational ranges throughout the Southwest (Whitfield et al. 2003), we compared monitoring results with range-wide data to identify specific variables that may contribute to the characterization of flycatcher breeding ecology throughout the lower Colorado and Virgin River riparian systems.

METHODS

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

Nests were located primarily by observing adult flycatchers return to a nest or by systematically searching suspected nest sites. Nests were monitored every two to four days after nest building was complete and incubation was confirmed. 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.

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

We considered a nest to have failed if (1) the nest was abandoned prior to egg laying (abandoned); (2) the nest was deserted with flycatcher eggs or young remaining (deserted); (3) the nest was found empty or destroyed more than two days prior to the estimated fledge date (depredated); (4) the nest was destroyed due to weather (weather); or (5) the entire clutch was incubated for an excess of 20 days (infertile/addled). For nests containing flycatcher eggs, parasitism was considered the cause of nest failure if (1) cowbird young outlived any flycatcher eggs or young, or (2) the nest was parasitized during egg laying and the disappearance of flycatcher eggs coincided with the appearance of cowbird eggs.

During each nest check, we recorded date and time of the visit, observer initials, monitoring method (observation via binoculars or mirror pole), nesting stage, nest contents, and number and behavior of adults and/or fledges present onto standardized data forms (Appendix A) that included the nest or territory number and UTM coordinates. We calculated flycatcher nest success using both simple nesting success (number of successful nests/total number of nests containing at least one flycatcher egg) and the Mayfield method (Mayfield 1961, 1975), which calculates daily nest survival to account for nests that failed before they were found. We assumed one egg was laid per day, and incubation was considered to start the day the last egg was laid (per Martin et al. 1997). The nestling period was considered to start the day the first egg hatched and end the day the first nestling fledged. If exact transition dates or dates of depredation events were unknown, we estimated the transition date as halfway between observations. For nests where fate was unknown, we used the last known date of activity to determine the number of observation days. To calculate Mayfield survival probabilities (MSP), we used the average length of each nest stage (2.12, 12.90, and 13.71 days for laying, incubation, and nestling stages, respectively) as observed in this study in 2003–2008 for nests where transition dates were known. Nest productivity was calculated as the number of young fledged per nesting attempt that produced at least one flycatcher egg. Fecundity was calculated as number of young produced per female over the breeding season. Parasitism rates were calculated as the number of nests that contained at least one cowbird egg/number of nests containing at least one flycatcher egg and having known contents.

RESULTS

Nest Monitoring

We documented 62 willow flycatcher nesting attempts at Pahranagat, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams; 55 of these nests were known to contain flycatcher eggs and were used in calculating nest success and productivity. Thirty (55%) nests were successful and fledged young, 23 (42%) failed, and fate was unknown for 2 (3%). Nest success ranged from 13% at Topock Marsh to 82% at Mesquite (Table 4.1). For a comparison of nest success at all monitoring sites from 1997 to 2008, see Table 4.2.

Table 4.1. Summary of Willow Flycatcher Nest Monitoring Results at Pahranagat, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams Study Areas, 2008

Study Area[1]	Site	Pairs	Nests	Nests with 1+ WE[2]	Successful Nests[3]	Failed Nests[3]	Nests with Unknown Fate[3]	Parasitized Nests[4]
PAHR	North	9	12	10	8 (80)	2 (20)	0	0
	Total	*9*	*12*	*10*	*8 (80)*	*2 (20)*	*0*	*0*
MESQ	West	11	11	11	9 (82)	2 (18)	0	1 (10)
	Total	*11*	*11*	*11*	*9 (82)*	*2 (18)*	*0*	*1 (10)*

Table 4.1. Summary of Willow Flycatcher Nest Monitoring Results at Pahranagat, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams Study Areas, 2008 (Continued)

Study Area[1]	Site	Pairs	Nests	Nests with 1+ WE[2]	Successful Nests[3]	Failed Nests[3]	Nests with Unknown Fate[3]	Parasitized Nests[4]
MOME	Virgin River #1 North	1	1	1	1 (100)	0	0	0
	Virgin River #1 South	9	10	9	6 (67)	3 (33)	0	1 (11)
	Virgin River #2	3	3	3	1 (33)	2 (67)	0	0
	Total	*13*	*14*	*13*	*8 (62)*	*5 (38)*	*0*	*1 (8)*
MUDD	Overton WMA	4	8	8	2 (25)	6 (75)	0	4 (57)
	Total	*4*	*8*	*8*	*2 (25)*	*6 (75)*	*0*	*4 (57)*
TOPO	Pipes #3	1	1	1	0	0	1 (100)	0
	Pierced Egg	5	5	4	0	4 (100)	0	0
	Glory Hole	3	6	3	1 (33)	2 (67)	0	1 (33)
	Total	*9*	*12*	*8*	*1 (13)*	*6 (75)*	*1 (13)*	*1 (13)*
BIWI	Site 3	4	5	5	2 (40)	2 (40)	1 (20)	1 (25)
	Total	*4*	*5*	*5*	*2 (40)*	*2 (40)*	*1 (20)*	*1 (25)*
Overall Total		**50**	**62**	**55**	**30 (55)**	**23 (42)**	**2 (3)**	**8 (17)**

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

[2] WE = willow flycatcher egg.

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

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

Forty-eight nesting females, of which all but three were known to have produced at least one egg, were followed through all of their nesting attempts. One additional female was detected for which no nesting attempt could be confirmed. Of the 48 nesting females, 36 had one nesting attempt, 10 had two nesting attempts, and 2 had three nesting attempts. All 12 females who had multiple nesting attempts renested after unsuccessful nests.

Table 4.2. Willow Flycatcher Percent Nest Success Recorded at Breeding Sites along the Virgin and Lower Colorado Rivers and Tributaries from 1996 to 2008*

Year	Pahranagat	Littlefield	Mesquite[1]	Mormon Mesa[2]	Muddy River	Grand Canyon	Topock	Bill Williams
1996	Nm[3]	Nm[3]	Nm[3]	Nm[3]	Nm[3]	Nc[7]	Nc[6]	Nm[3]
1997	Nm[3]	Nd[4]	67 (3)	42 (12)	Bc[9]	Nc[7]	Nc[6]	Nd[4]
1998	47 (19)	Nd[4]	0 (7)	70 (10)	Nm[3]	Nd[4]	53 (15)	Nd[4]
1999	60 (15)	Nm[3]	Nm[3]	45 (11)	Nm[3]	Nc[5]	38 (16)	100 (1)
2000	63 (16)	Nd[4]	50 (8)	38 (13)	100 (1)	Nc[5]	36 (11)	100 (1)
2001	50 (18)	Nd[4]	53 (17)	54 (13)	Nc[6]	Nc[6]	36 (14)	50 (4)
2002	33 (12)	Nd[4]	59 (17)	0 (9)	Nd[4]	Nd[4]	50 (6)	78 (9)
2003	91 (11)	Nd[4]	44 (18)	0 (10)	Nd[4]	Nd[4]	78 (9)	100 (2)
2004	76 (17)	50 (2)	24 (17)	50 (6)	Nd[4]	Bc[7]	45 (38)	Nd[4]
2005	58 (19)	Nd[4]	42 (12)	17 (6)	38 (8)	Nd[4]	24 (34)	100 (2)
2006	60 (15)	Nd[4]	55 (20)	50 (8)	44 (9)	0 (3)	23 (17)[8]	20 (5)

Table 4.2. Willow Flycatcher Percent Nest Success Recorded at Breeding Sites along the Virgin and Lower Colorado Rivers and Tributaries from 1996 to 2008* (Continued)

Year	Pahranagat	Littlefield	Mesquite[1]	Mormon Mesa[2]	Muddy River	Grand Canyon	Topock	Bill Williams
2007	67 (12)	Nd[4]	57 (14)	27 (11)	0 (6)	0 (1)	75 (8)	25 (8)
2008	80 (10)	Nd[4]	82 (11)	62 (13)	25 (8)	Nd[4]	13 (8)[9]	40 (5)[9]

* Data from 1997 to 2002 are from Braden and McKernan (unpubl. data); these numbers have been verified with the raw data and may differ from those presented in earlier annual reports. Data from 2003 to 2007 are from McLeod et al. 2008a, and data from 2008 can be found in this document. Total number of nests containing at least one flycatcher egg is indicated in parentheses.
1 Study area includes the Mesquite East, Mesquite West, and Bunker Farm sites.
2 Study area includes the Virgin River Delta at Lake Mead.
3 Study area not monitored.
4 Study area surveyed, no breeding documented.
5 Breeding suspected, nest success not calculated.
6 Breeding confirmed, nest success not calculated.
7 Breeding confirmed, undetermined if nestlings from a single nest fledged.
8 An additional three nests (18%) were suspected to have fledged but fledglings were not visually confirmed.
9 Fate of one nest was unknown.

Nest Failure

Depredation was the major cause of nest failure, accounting for 40% (12 of 30) of all failed nests (Table 4.3) and 52% (15 of 23) of nests that failed after flycatcher eggs were laid. Seven nesting attempts (23% of all failed nests) were abandoned prior to willow flycatcher eggs being laid and nine nests (30%) were deserted. Two nests (7%) failed because of Brown-headed Cowbird parasitism (see below for more details on parasitism).

Table 4.3. Summary of Causes of Willow Flycatcher Nest Failure at Pahranagat, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams Study Areas, 2008*

Study Area[1]	Total # Nests	All Failed Nests	Abandoned	Deserted	Depredated	Parasitized
PAHR	12	4	2 (50)	0	2 (50)	0
MESQ	11	2	0	1 (50)[2]	1 (50)	0
MOME	14	6	1 (17)	3 (50)[3]	1 (17)	1 (17)
MUDD	8	6	0	1 (17)[4]	4 (67)	1 (17)
TOPO	12	10	4 (10)	2 (20)[5]	4 (40)	0
BIWI	5	2	0	2 (100)[6]	0	0
Total	**62**	**30**	**7 (23)**	**9 (30)**	**12 (40)**	**2 (7)**

* 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 NWR, MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, TOPO = Topock Marsh, BIWI = Bill Williams River NWR.
2 Nest deserted during incubation.
3 One nest deserted after 18 days incubation, one nest already deserted when found, one nest deserted during laying.
4 Nest deserted after being parasitized.
5 One nest deserted during laying, one nest deserted after at least 20 days incubation.
6 One nest deserted after video camera was set up at nest, one nest deserted during incubation.

Brood Parasitism

Eight of 48[1] nests (17%) with flycatcher eggs and known contents were brood parasitized by Brown-headed Cowbirds (Table 4.4). For nests containing flycatcher eggs, parasitism caused nest failure at two nests. In one case, the nest was parasitized during laying, and appearance of the cowbird egg coincided with disappearance of the flycatcher egg. In the other case, the nest fledged a cowbird and the severely underdeveloped flycatcher nestling was found dead under the nest. One parasitized nest fledged a flycatcher but no cowbirds, and two nests fledged both a cowbird and a flycatcher. Two parasitized nests were depredated during incubation, and one nest was deserted after at least 20 days incubation. Brood parasitism ranged from 0 to 57% and was highest at Muddy River (see Table 4.1). In 2008, three of eight (38%) parasitized nests successfully fledged flycatchers, and nests that contained flycatcher eggs and were brood parasitized were not less likely to fledge flycatcher young than nests that were not parasitized (Chi-square = 1.10, $P = 0.293$). However, when data were pooled for all years from 2003 to 2008 to obtain a larger sample size and greater statistical power, parasitized nests were less likely to fledge flycatcher young, with 18 of 80 (23%) parasitized nests fledging flycatcher young vs. 148 of 284 (52%) non-parasitized nests (Chi-square = 22.06, . $P < 0.001$). In addition, parasitized nests that did succeed in fledging flycatcher young produced on average fewer fledges (1.2 per nest) than non-parasitized nests (2.2 fledges per nest; $F_{1,164} = 19.0$, $P < 0.001$). From 2003 to 2008, 7 of 17 nests that fledged cowbirds also fledged flycatcher young.

Table 4.4. Fates of Willow Flycatcher Nests Parasitized by Brown-Headed Cowbirds, 2008*

Study Area[1]	Nest ID Code	Outcome[2]
MESQ	21A	Fledged one cowbird and one flycatcher
MOME	65B	Parasitized during laying; fledged one cowbird; flycatcher nestling found dead under nest
MUDD	1A	Fledged one cowbird and one flycatcher
	1B	Nest depredated during incubation
	1C	Nest depredated during incubation
	20A	Parasitized during laying; WE disappeared and CE appeared; nest abandoned
TOPO	9A	Parasitized after at least 6 days incubation; nest deserted after at least 20 days incubation; no eggs hatched
BIWI	31B	Fledged one flycatcher; CE did not hatch

* All nesting attempts are included.
[1] MESQ = Mesquite, MOME = Mormon Mesa, MUDD = Muddy River, TOPO = Topock Marsh, BIWI = Bill Williams River NWR.
[2] WE = willow flycatcher egg, CE = cowbird egg.

Mayfield Nest Success and Nest Productivity

Mayfield survival probability (MSP) ranged from 0.194 at Muddy River to 0.705 at Mesquite and was 0.461 for all sites combined (Table 4.5). At all sites, 66 nestlings were confirmed to have fledged from 53 nests of known outcome (mean number of nestlings/nest = 1.25, SE = 0.17). Fecundity across study areas ranged from 0.13 to 2.33 young per female and averaged 1.40 (SE = 0.18) (Table 4.6).

[1] Table 4.1 shows a total of 55 nests known to contain at least one flycatcher egg. When calculating brood parasitism rates, however, seven 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 4.5. Daily Survival Rates and Mayfield Survival Probabilities (MSP) for Willow Flycatcher Nest Stages at Pahranagat, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams Study Areas, 2008*

Study Area	Nest Stage[1]	Nest Losses/ Observation Days	Daily Survival Rate	Mayfield Survival Probability
Pahranagat	1	1/9	0.889	0.779
	2	1/52	0.981	0.778
	3	0/84	1.000	1.000
	MSP all stages = 0.606			
Mesquite	1	1/11	0.909	0.817
	2	1/88	0.989	0.863
	3	0/110	1.000	1.000
	MSP all stages = 0.705			
Mormon Mesa	1	1/13	0.923	0.844
	2	1/125	0.992	0.902
	3	2/124	0.984	0.800
	MSP all stages = 0.609			
Muddy River	1	1/8	0.875	0.753
	2	5/50	0.900	0.257
	3	0/24	1.000	1.000
	MSP all stages = 0.194			
Topock	1	2/14.5	0.62	0.730
	2	4/50	0.920	0.341
	3	0/13.5	1.000	1.000
	MSP all stages = 0.249			
Bill Williams	1	0/1	1.000	1.000
	2	2/41.5	0.952	0.529
	3	0/26	1.000	1.000
	MSP all stages = 0.529			
Total	**1**	**6/56.5**	**0.894**	**0.788**
	2	**14/406.5**	**0.966**	**0.628**
	3	**2/381.5**	**0.995**	**0.932**
	MSP all stages = 0.461			

* Mayfield survival probability was calculated using 2.12-day egg laying, 12.90-day incubation, and 13.71-day nestling stages.
[1] 1 = egg laying, 2 = incubation, 3 = nestling.

Table 4.6. Willow Flycatcher Nest Productivity (Young Fledged per Nest) and Fecundity (Young Fledged per Female) at Pahranagat, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams Study Areas, 2008*

Study Area	Young Fledged (# Nests)	Productivity Mean (SE)	Fecundity Mean (SE)
Pahranagat	21 (10)	2.10 (0.41)	2.33 (0.37)
Mesquite	18 (11)	1.64 (0.34)	1.64 (0.34)
Mormon Mesa	19 (13)	1.46 (0.37)	1.46 (0.37)
Muddy River	3 (8)	0.38 (0.26)	0.75 (0.48)
Topock	1 (7)	0.14 (0.14)	0.13 (0.13)
Bill Williams	4 (4)	1.00 (0.71)	1.33 (0.88)
Total	**66 (53)**	**1.25 (0.17)**	**1.40 (0.18)**[1]

* Productivity calculations include nests that contained flycatcher eggs and had a known outcome.
[1] The female that moved from Mormon Mesa to Muddy River is counted only once in the total.

DISCUSSION

In 2008, willow flycatcher nesting was documented at Pahranagat, Mesquite, Mormon Mesa, Muddy River, Topock Marsh, and Bill Williams. The number of breeding pairs recorded at Pahranagat, Mesquite, Mormon Mesa, and Topock Marsh were consistent with those recorded in 2007. The number of breeding pairs at Bill Williams in 2008 (3) was identical to that recorded in 2006 but less than half the number observed in 2007 (7). Muddy River had the lowest number of breeding pairs recorded since 2005; this decline in breeding activity could be related to recent habitat modifications within the site (see Chapter 2), which may have affected occupancy in the northern portion of the site in 2008. Given that southwestern riparian ecosystems experience dynamic change and are not ecologically static (Periman and Kelly 2000), willow flycatcher occupancy and nesting are likely to be affected by changes in habitat suitability, with breeding flycatchers detected at a given site in one year and not in another.

Nest Success

As in 2003–2007, Pahranagat continued to exhibit high nest success. Nest success at Mesquite was the highest observed since monitoring began in 1997, and nest success at Mormon Mesa was the highest recorded since 1998. Nest success at Topock Marsh, however, was the lowest ever recorded. Nest success at the remaining study areas continued to exhibit the yearly fluctuations observed since nest monitoring began in 1996. Nest success results again illustrate that the demographic patterns of passerine populations often vary year to year, and sometimes to a very large degree (Wiens 1989a). The variable patterns of nest success observed at the study areas over many years further demonstrate the need for long-term data.

Nest Failure

As in 2003–2007, depredation was the major cause of willow flycatcher nest failure, accounting for 40% of all failed nests in 2008 (see Table 4.3). These results are consistent with those reported at the life history study areas from 1998 to 2007 (Braden and McKernan unpubl. data, McLeod et al. 2008a) and at monitored sites across Arizona from 2000 to 2006 (Paradzick et al. 2001; Smith et al. 2002, 2003, 2004; Munzer et al. 2005; English et al. 2006; Graber et al. 2007; Ellis et al. 2008), 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).

In 2008, Northern Arizona University (NAU) initiated a nest camera study in cooperation with SWCA on open-cup nesting passerines at selected study areas along the lower Colorado River and tributaries. The study used video and still cameras on real and artificial nests to identify depredation rates and nest predators. Problems with both video and still cameras affected the detection of depredation events and the identification of nest predators, but both Brown-headed Cowbirds and Yellow-breasted Chats were identified by still cameras as depredating artificial nests (NAU unpubl. data). Ellis et al. (2008) also identified Yellow-breasted Chats depredating flycatcher nests at sites in Arizona. The camera study will be continued in 2009 and may provide additional information on the identity and relative importance of nest predators.

Brood Parasitism

Brood parasitism by Brown-headed Cowbirds across all study areas ranged from 0 to 57% and averaged 17% (see Table 4.1). These results are consistent with those reported at the study areas from 1998 to 2007 (Braden and McKernan unpubl. data, McLeod et al. 2008a), but these parasitism rates are higher than those reported at monitored sites across Arizona, which averaged 4, 5, 11, 2, 6, 7, and 13% in 2000, 2001, 2002, 2003, 2004, 2005, and 2006, respectively (Paradzick et al. 2001; Smith et al. 2002, 2003, 2004; Munzer et al. 2005; English et al. 2006; Graber et al. 2007). We observed the sixth consecutive year of no brood parasitism at Pahranagat, and Mesquite experienced the lowest parasitism rate recorded since 2003. Muddy River continued to have high parasitism rates.

Cowbird trapping and removal studies were initiated at Pahranagat, Mesquite, and Topock Marsh in 2003 and continued through 2007. Results of these studies showed that cowbird trapping appeared to lower parasitism rates in comparison to the pre-trapping period of 1998–2002 only at Pahranagat, with no parasitism detected during trapping years (McLeod et al. 2008a). No cowbird trapping was completed in 2008, the first year of a planned five-year post-trapping monitoring period. Even in the absence of cowbird trapping, no parasitism events were detected at Pahranagat in 2008. This suggests that cowbird trapping may have lingering effects beyond the years in which trapping is completed, though a single year of data at one study area is insufficient to draw strong conclusions.

We observed one occasion in which the disappearance of flycatcher eggs coincided with the parasitism event. In this case, 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), and cowbirds were photographed removing eggs from artificial nests during the 2008 camera study. Therefore, it is likely that some depredation events on eggs and nestlings are attributable to cowbirds.

Parasitism does not invariably cause nest failure, but the success rate for parasitized nests in 2003–2008 was less than half that of unparasitized nests. A similar result was recorded for willow flycatchers in Oregon, with parasitism resulting in a 50% decrease in success rates compared to unparasitized nests (Sedgwick and Iko 1999). Parasitized nests that do succeed in fledging flycatcher young produced on average fewer young than unparasitized nests; cowbirds may eject flycatcher eggs during the parasitism event, thus reducing clutch size, and cowbird young also cause interspecific nestling competition, as evidenced by the presence of severely underdeveloped nestlings in parasitized nests. For all nests monitored from 2003 to 2008, 41% of nests that fledged a cowbird also fledged flycatcher young. This is a higher rate of success than that observed in other Southwestern Willow Flycatcher populations, with 9% and 0% reported for the Kern River, California, and various Arizona sites, respectively (Whitfield and Sogge 1999).

Female flycatchers may desert their nests after parasitism events and thus expend energy renesting and laying additional eggs. Given that adult flycatchers exhibit high site fidelity to breeding areas (Braden and McKernan unpubl. data, McLeod et al. 2008a, 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, McLeod et al. 2008a), suggesting additional hidden effects of parasitism and subsequent renesting on flycatcher demography.

Mayfield Nest Success and Nest Productivity

Overall MSP in 2008 (0.461) was nearly identical to that recorded in 2007 (0.459), though the relative contributions of various study areas to overall MSP differed between years. MSP alone, however, is an incomplete measure of the production of young. Successful nests produce from one to four young, and variations in nest productivity are not reflected in MSP. In addition, although every failed nest attempt lowers percent nest success and MSP, success of a subsequent nesting attempt may result in the same number of young produced as if the initial nesting attempt had been successful. Thus, nest productivity (young produced per nesting attempt) and fecundity (young produced per female), in conjunction with nest success, provide additional information on the success of a given breeding season. Overall fecundity in 2008 (1.40) did not differ statistically from that recorded in 2003–2007 ($F_{5,308} = 0.916$, $P = 0.47$).

Chapter 5

VEGETATION AND HABITAT CHARACTERISTICS

INTRODUCTION

Our objective for vegetation sampling is to provide a quantitative summary of the floristic and structural conditions within occupied territories in various vegetation types. These descriptive summaries will provide guidance for managers working to restore and create riparian habitat to meet the obligations of the LCR MSCP and will provide a means to evaluate habitats to determine if they resemble occupied flycatcher territories. The Pahranagat study area was excluded from the characterization of occupied territories because the vegetation consists primarily of very large and widely spaces trees, and these characteristics are unique to the site and not likely to be replicated in restoration areas.

In addition, we investigated whether changes in vegetation characteristics might have contributed to the abandonment of some areas by flycatchers. We identified several areas that had been occupied by nesting flycatchers in at least one previous year from 2003 to 2007 but were unoccupied in 2008, and we relocated old nest sites at which we had collected vegetation information in the year the nest was active. We resampled the vegetation at these nests and compared the vegetation data collected in 2008 to that collected when the nest site was active to elucidate how changes in vegetation through time may influence flycatcher occupancy. These results will provide additional quantitative information on the characteristics of vegetation within flycatcher nesting territories.

METHODS

Currently Occupied Territories

We described and measured vegetation and habitat features following a modification of the methods of James and Shugart (1970). Vegetation characteristics were measured within a 5-m-radius circle.
To avoid disrupting flycatcher breeding activities, we measured vegetation late in the summer when the nest, territory, and adjacent flycatcher territories were inactive.

We measured vegetation and habitat characteristics at one plot for each resident (i.e., detected for at least one week) male flycatcher we identified, regardless of whether or not he obtained a mate. Plot center locations were determined as soon as territories were identified. We estimated the center of the male's activity by observing his use of singing perches and selecting a location that was approximately equidistant from the perches at the perimeter of his use area. We then proceeded in a randomly selected compass direction for a randomly selected distance between 0 and 20 m. We used additional random numbers to select the exact location in which to hang a temperature/humidity data logger (see Chapter 6) and used that location as plot center. This process resulted in the random selection of a point that was still within the male's territory.

At each plot, we laid out four 5-m-long ropes from plot center, one in each of the four cardinal directions. Each rope was marked at 1 m and 5 m from the center of the plot. At plot center and at 1 m and 5 m from the center of the plot in each cardinal direction, we measured vertical foliage density using a 7.5-m-tall survey rod. Working our way up the rod, we recorded the presence of vegetation, by species, within a 10-cm radius of the rod in 0.1-m intervals (presence of the species within the 0.1-m interval equaled one "hit" on the rod), and summed all hits in 1-m intervals. Presence of dead vegetation (snags) was recorded in the same manner, but not identified to species. If canopy vegetation continued above 8.0 m, we estimated the number of hits as zero, greater than five, or less than five hits per 1-m interval until the canopy vegetation stopped (modified from Rotenberry 1985).

We measured total canopy closure using a Model-A spherical densiometer at 1 m north and south of the center of each plot and averaged these measurements to obtain a single canopy closure value for each plot. We measured average canopy height within each plot by selecting a representative tree and using a survey rod or a clinometer and measuring tape to measure the height of the selected tree. We estimated percent woody ground cover, alive and dead, within 0.5 m of the ground using a Daubenmire-type frame with the lower edge of the frame centered at 1 m north, south, east, and west of plot center. These percentages were averaged to obtain a single measure of percent woody ground cover for each plot.

We tallied the number of live stems for each species within 5 m of the center of the plot. Stems were tallied if they were at least 1.4-m tall and >2.5 cm in diameter at 10 cm above the ground. Stems were tallied by the following diameter at breast height (dbh) categories: <1 cm, 1–2.5 cm, 2.6–5.5 cm, 5.6–8 cm, 8.1–10.5 cm, and 10.5–15 cm. Any stems >15 cm dbh were measured and the exact dbh was recorded. Dead stems were also tallied in these categories, but not identified to species. In previous years of vegetation sampling, if a stem branched above 10 cm but below 1.4 m above the ground, only the largest stem was tallied. In habitats (e.g., tamarisk) where stems frequently branch in this height interval, this method of counting stems may underestimate the density of stems that form an important part of the habitat structure. Therefore, in 2008 we tallied stems as we had in previous years and then for each stem that branched between 10 cm and 1.4 m from the ground, we tallied the number of additional stems that were at least 2.5 cm in diameter at 10 cm above the point where it branched from the main stem.

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

Several habitat variables that were measured in previous years were not measured in 2008 because they were not useful in differentiating habitats or because logistical difficulties precluded accurate data collection. These variables were distance to canopy gap, distance to broadleaf tree, distance to water, and number of stems >8 cm dbh between 5 and 11.3 m of plot center.

Nests in Formerly Occupied Areas

The same measurements that were completed at occupied territories were also taken at old nest sites. We used the UTM coordinates of the nest, nest tree species, nest height, and nest flags that remained in the field to locate the old nests. Vegetation plots were centered on the nest location.

Data Analyses

We used high-resolution aerial photography and field knowledge of each study area to delineate clusters of territories that occur within habitat patches of similar floristics and canopy height. Vegetation characteristics were then summarized for each habitat type. We used SPSS® Version 16.0 (SPSS Inc.) software for statistical analyses. Data presented are means ± standard error (SE) unless otherwise stated.

Stem counts were grouped into the following size categories for analysis: <2.5 cm dbh, 2.5–8 cm dbh, and >8 cm dbh. For each size category, stem counts are reported separately for live and dead stems; the sum of these is the equivalent of the stem counts per size category that were reported in the 2003–2007 summary report (McLeod et al. 2008a). Vertical foliage density measurements above 8.0 m that were recorded as < or >5 hits per meter were converted to 2.5 and 7.5 hits, respectively, to allow analyses of these data as continuous rather than categorical. Vertical foliage density was calculated for each meter interval as the mean of the number of hits recorded within the interval at the nine locations in the plot. In previous years, we had measured vertical foliage density only at plot center and 1 m from plot center in each cardinal direction, and foliage density measures per meter interval were presented as the sum of the hits recorded at the five locations in the plot. Thus, vertical foliage data presented in previous reports should be divided by 5 to be comparable to data presented here. In the five-year summary report (McLeod et al. 2008a), vertical foliage data were grouped into three categories of above, at, and below the nest. Vegetation data were not collected at nest sites in 2008, so we used average nest height as measured in 2003–2007 in each vegetation type to demarcate vertical foliage categories. As with stem counts, vertical foliage data are reported separately for live and dead vegetation.

Percent native vegetation was calculated as the average of the percent basal area that was native and the percent native vertical foliage hits. For data collected in 2003–2007 and reported in McLeod et al. 2008a), we did not use vertical foliage data to calculate percent native because all vertical foliage data were collected within 1 m of plot center and represented only a small portion of the plot. We included vertical foliage data in the percent native calculations in 2008 to account for the influence of stems that were too small to be tallied or were rooted outside the 5-m-radius circle but overhung the plot. All exotic vegetation consisted of tamarisk.

We used non-parametric Wilcoxon signed rank tests for related samples to compare vegetation measurements collected at old nests to the measurements collected during the year the nest was active. We chose non-parametric tests because several parameters had non-normal distributions. Vertical foliage data used in these comparisons were restricted to data collected within 1 m of plot center so as to be directly comparable to data collected prior to 2008. A statistical significance level of $P \leq 0.05$ was chosen to reject null hypotheses.

RESULTS

Currently Occupied Territories

We measured vegetation at 41 occupied territories at Mesquite, Mormon Mesa, Muddy River, Topock Marsh, Bill Williams, and Ahakhav. We delineated the following habitat types: 1) coyote willow, 2) tamarisk/coyote willow mix, 3) Goodding willow, 4) Goodding willow with tamarisk understory, 5) tamarisk with scattered Goodding willow, 6) tamarisk, and 7) tamarisk/mesquite mix. Coyote willow and tamarisk/coyote willow mix occurred only at Mesquite, with coyote willow dominating the eastern half of the site while tamarisk and coyote willow were mixed in the western half of the site. Goodding willow occurred in the southern portion of Muddy River, in a small stand readily discernible on high-resolution aerial photographs. Large Goodding willow with tamarisk understory occurred at Bill Williams. Tamarisk with scattered, emergent Goodding willow occurred both at Mormon Mesa and Topock; these two study areas were summarized separately because several variables, including canopy height and canopy closure, differed between the two areas. Tamarisk habitats lacking emergent willows occurred both at Muddy River and Topock, while tamarisk with mesquite occurred at Ahakhav. Average nest height recorded in 2003–2007 and used to assign vertical foliage strata for each vegetation category were 2.0, 2.4, 2.4, 4.5, 2.6, 3.4, and 4.0 m for coyote willow, tamarisk/coyote willow mix, Goodding willow, Goodding willow with tamarisk understory, tamarisk with scattered Goodding willow at Mormon Mesa, tamarisk with scattered Goodding willow at Topock, and tamarisk, respectively. No nests were known from tamarisk/mesquite habitat, so the overall mean nest height of 3.2 m was used to assign vertical foliage categories for that vegetation type.

Vegetation characteristics of each habitat type are summarized in Table 5.1. Habitat types varied widely in many characteristics, and plots within each habitat type also showed a wide range in most habitat variables.

The proportion of stems omitted from stem counts by counting only the largest stem of a cluster that branched between 10 cm and 1.4 m above the ground varied both by size and species of the main stem (Table 5.2). Tamarisk had the highest proportion of omitted stems, and larger stems had more branches that were omitted.

Including vertical foliage data in the calculation of percent native had, overall, little effect when compared to percent native as calculated solely from basal area. For plots that were <25% native by basal area (21 of 41 plots), including vertical foliage in the calculations increased percent native by an average of 5.5% (median 1.0%). This was generally because for some plots, vertical foliage data included large Goodding willow that were rooted outside but overhung the vegetation plot. For plots that were >75% native by basal area (15 of 41 plots), including vertical foliage decreased the percent native by an average of 3.6% (median 1.5%).

Vertical foliage profiles for each habitat type are shown in Figures 5.1–5.8. Average nest height in each habitat type, as recorded in 2003–2007, is also shown on each graph. No nests were recorded in tamarisk-mesquite habitat, so average nest height across all habitat types is shown on this graph. In all habitat types, the proportion of dead vegetation in the vertical profile was highest immediately above the ground and declined with increasing height. With the exception of the Goodding willow and tamarisk-mesquite habitats, the densest live foliage occurred between 3 and 4 m above the ground and was at or immediately above average nest height. In Goodding willow, the densest foliage occurred above 7 m above the ground, approximately 5 m above average nest height. In tamarisk-mesquite, the densest foliage was below 2 m above the ground; this was the only habitat type where the densest foliage was below average nest height.

Nests in Formerly Occupied Areas

We gathered vegetation data at 44 old nests at Mesquite, Mormon Mesa, Muddy River, and Topock. We were able to locate the exact nest fork in 28 cases and located the nest tree but were unsure of the correct fork in 12 additional cases. In three cases we located the nest vicinity (within 5 m of the nest location) but were unable to verify that we had located the exact nest tree, and in one case the nest tree was clearly no longer there, and we centered the vegetation plot on the nearest adjacent tree.

Vegetation at nest sites differed between occupied and unoccupied periods in more than one variable at each study area; however, the characteristics that differed were not consistent among sites (Tables 5.3 and 5.4). At Mesquite, nest sites had greater canopy closure, more live stems <2.5 cm dbh, fewer dead stems 2.5–8 cm dbh, more live foliage at nest level, and less dead foliage at and below nest level when they were active compared to when the area was abandoned. Vegetation at nest sites at Mesquite also consisted of a larger proportion of native vegetation when the territory was occupied than when it was abandoned. At Mormon Mesa, nest sites had greater canopy closure, more live stems <2.5 cm dbh, more live foliage above the nest, and more dead foliage at nest level when they were occupied versus when territories had been abandoned. At Muddy River, nest sites had more live stems <2.5 cm dbh, less dead foliage at nest level, and a greater percentage of native vegetation when they were occupied, while at Topock Marsh, nests had more live stems 2.5–8 cm dbh and more dead foliage below nest level when they were occupied. When all study areas were combined (Table 5.5), nest sites had greater canopy closure, more live stems <2.5 cm dbh, fewer dead stems 2.5–8 cm dbh, more live foliage at and below nest level, and a greater percentage of native vegetation when they were active versus when the territory was abandoned.

Table 5.1. Summary of Vegetation Characteristics at Occupied Southwestern Willow Flycatcher Territories in Varying Habitat Types, Lower Colorado River and Tributaries, 2008*

Parameter	SAEX (n=8)	TASP and SAEX (n=4)	SAGO (n=2)	SAGO with TASP understory (n=3)	TASP with scattered SAGO (MOME) (n=11)	TASP with scattered SAGO (TOPO) (n=9)	TASP (n=3)	TASP and PRSP (n=1)
Average canopy height (m)	5.0 (0.3)	4.7 (0.4)	8.0 (0.2)	10.8 (1.6)	4.4 (0.2)	6.5 (31.4)	4.8 (0.2)	5.2
	3.9–6.2	3.9–5.5	7.8–8.2	7.7–12.5	3.3–6.2	6.0–6.9	4.6–5.2	
% total canopy closure	86.7 (4.3)	82.2 (8.9)	90.1 (1.6)	97.6 (1.0)	79.8 (3.5)	93.7 (1.6)	63.7 (15.8)	56.8
	59.4–94.3	57.8–95.8	88.5–91.7	96.4–99.5	57.3–92.7	83.3–98.4	41.1–94.3	
% woody ground cover	18.3 (6.5)	18.6 (8.1)	13.9 (12.4)	30.8 (9.1)	34.6 (7.7)	31.4 (7.9)	25.6 (16.0)	100
	5.0–58.8	3.0–41.2	1.5–26.2	13.0–42.8	3.5–77.8	2.8–78.8	8.0–57.5	
# live stems <2.5 cm dbh per ha	4647 (930)	2324 (500)	1846 (1719)	934 (571)	1181 (180)	2023 (359)	1995 (810)	2165
	891–9677	1019–3438	127–3565	127–2037	637–2419	127–3820	382–2928	
# live stems 2.5–8 cm dbh per ha	7974 (414)	5539 (782)	1082 (955)	2165 (641)	2905 (577)	4202 (690)	2504 (1213)	1019
	6112–9423	3692–7130	127–2037	1401–3438	509–5857	1401–7385	382–4584	
# live stems >8 cm dbh per ha	477 (275)	255 (116)	955 (64)	1146 (515)	208 (88)	1287 (337)	509 (509)	127
	0–2292	0–509	891–1019	255–2037	0–764	0–2928	0–1528	
# dead stems <2.5 cm dbh per ha	5268 (1678)	1146 (172)	2737 (64)	3735 (1587)	1898 (423)	2957 (969)	2462 (473)	12478
	891–12732	891–1655	2674–2801	1146–6621	382–4711	1146–10441	1528–3056	
# dead stems 2.5–8 cm dbh per ha	2913 (743)	2769 (326)	2483 (1464)	1570 (297)	2141 (591)	2207 (417)	1825 (695)	2292
	127–7385	1910 3438	1019–3947	1019–2037	255–6239	764–5220	891–3183	
# dead stems >8 cm dbh per ha	16 (16)	0 (0)	127 (127)	0 (0)	93 (60)	156 (82)	42 (42)	127
	0–127	0–0	0–255	0–0	0–637	0–637	0–127	
Percent native	92.9 (2.3)	36.1 (6.5)	93.8 (3.7)	50.4 (28.3)	32.7 (10.0)	4.3 (3.0)	6.1 (3.6)	62.1
	81.7–98.0	16.6–43.0	90.0–97.5	0–98.0	0–96.6	0–27.5	0–12.5	
Live vertical foliage (hits) below nest	3.7 (0.6)	4.4 (1.2)	0.2 (0.2)	14.0 (6.0)	1.4 (0.4)	3.4 (0.7)	0.7 (0.2)	17.8
	1.9–7.3	0.9–6.4	0–0.4	3.8–24.6	0–3.6	1.0–7.0	0.40–1.0	
Live vertical foliage (hits) at nest	4.3 (0.6)	4.4 (0.7)	0.8 (0.2)	3.8 (1.8)	2.5 (0.4)	3.7 (0.6)	3.0 (0.2)	2.2
	1.9–7.7	2.6–5.8	0.6–1.0)	0.2–60	1.1–4.8	1.8–7.3	2.7–3.2	
Live vertical foliage (hits) above nest	9.8 (0.9)	8.0 (0.5)	19.7 (4.3)	12.7 (3.9)	7.4 (1.2)	6.8 (1.3)	7.3 (3.0)	0.8
	6.3–13.8	6.8–9.1	15.4–23.9	5.1–17.8	2.6–13.9	1.4–11.9	1.7–12.1	
Dead vertical foliage (hits) below nest	4.8 (0.7)	5.7 (0.4)	4.1 (0.9)	12.8 (2.7)	4.8 (0.7)	10.9 (1.7)	6.9 (1.6)	10.7
	2.6–7.7	4.87–6.7	3.2–5.0	7.4–16.1	1.7–9.8	5.4–17.8	4.4–9.8	
Dead vertical foliage (hits) at nest	2.1 (0.2)	2.7 (0.7)	3.3 (1.1)	0.7 (0.6)	2.6 (0.4)	1.4 (0.4)	2.8 (0.8)	0.4
	1.3–2.9	0.8–4.2	2.2–4.3	0–1.9	0.4–5.2	0.6–4.0	1.2–3.8	
Dead vertical foliage (hits) above nest	1.1 (0.3)	0.9 (0.4)	2.9 (0.3)	0.6 (0.6)	1.2 (0.3)	0.9 (0.3)	0.6 (0.2)	0.3
	0.2–2.8	0–1.7	2.6–3.2	0–1.9	0–3.0	0.1–2.8	0.3–0.9	

* Data are presented as mean, standard error, and range. Stem counts include only the largest stem of any cluster that branched above 10 cm above the ground. SAEX = coyote willow, SAGO = Goodding willow, TASP = tamarisk, PRSP = mesquite.

Table 5.2. Proportion of Stems Omitted from Stem Counts

Size category[1]	Species			
	Tamarisk	Coyote willow	Goodding willow	Dead stems
<2.5 cm dbh	0.16	0.03	0.00	0.08
2.5–8 cm dbh	0.44	0.17	0.00	0.25
>8 cm dbh	1.70	0.48	0.12	0.27

[1] Size category indicates the size of the main stem that was tallied. All stems that were omitted from the stem count are equal to or smaller than the size of the main stem.

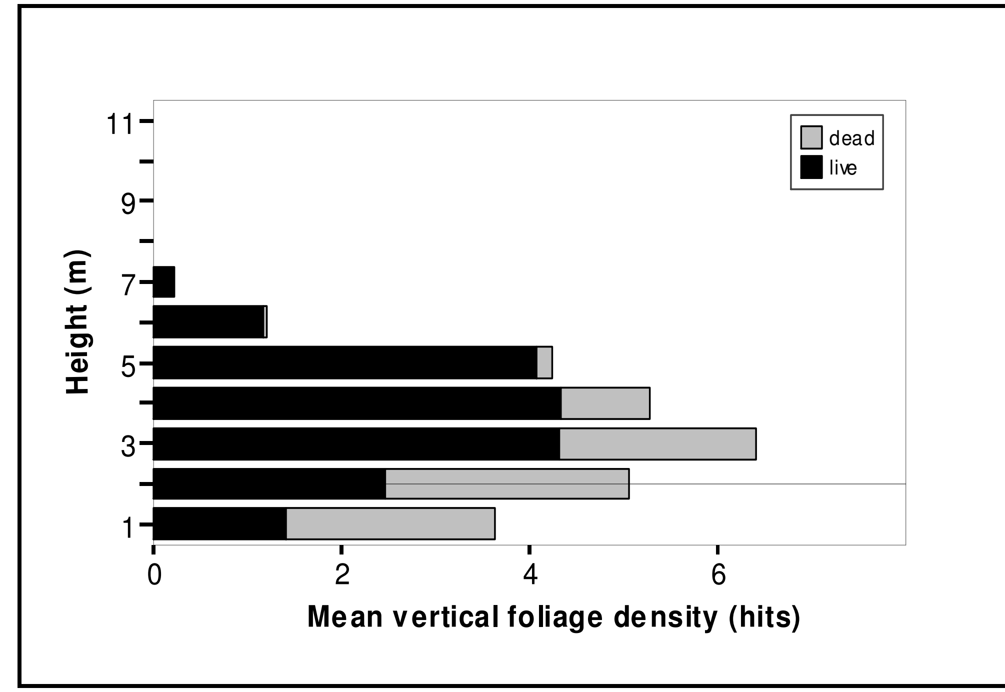

Figure 5.1. Vertical foliage density at occupied willow flycatcher territories in coyote willow habitat type, 2008. Horizontal line shows average nest height in this habitat type in 2003–2007.

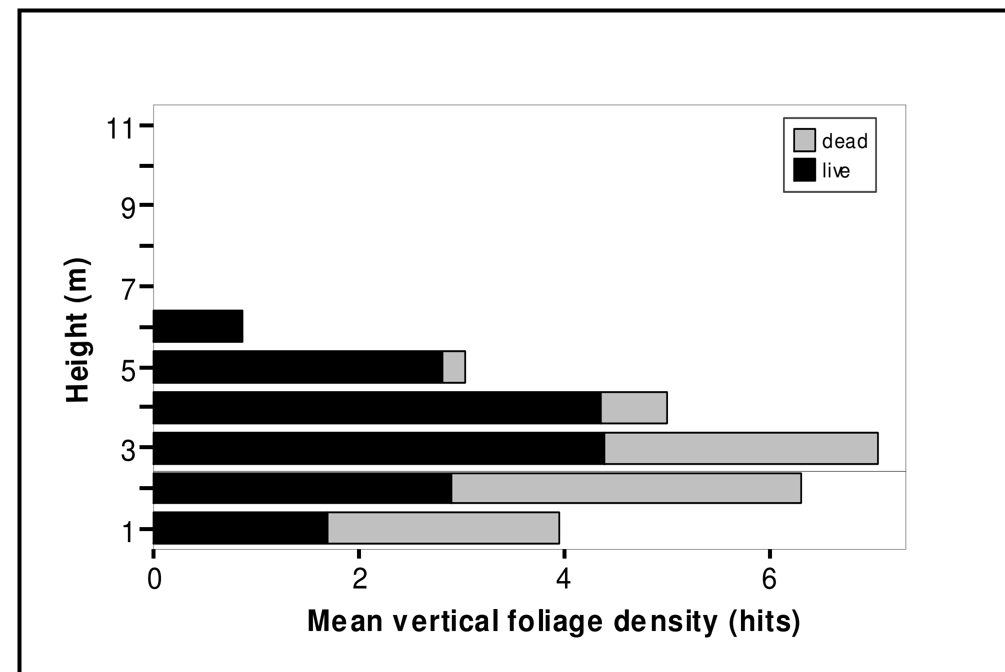

Figure 5.2. Vertical foliage density at occupied willow flycatcher territories in tamarisk/coyote willow habitat type, 2008. Horizontal line shows average nest height in this habitat type in 2003–2007.

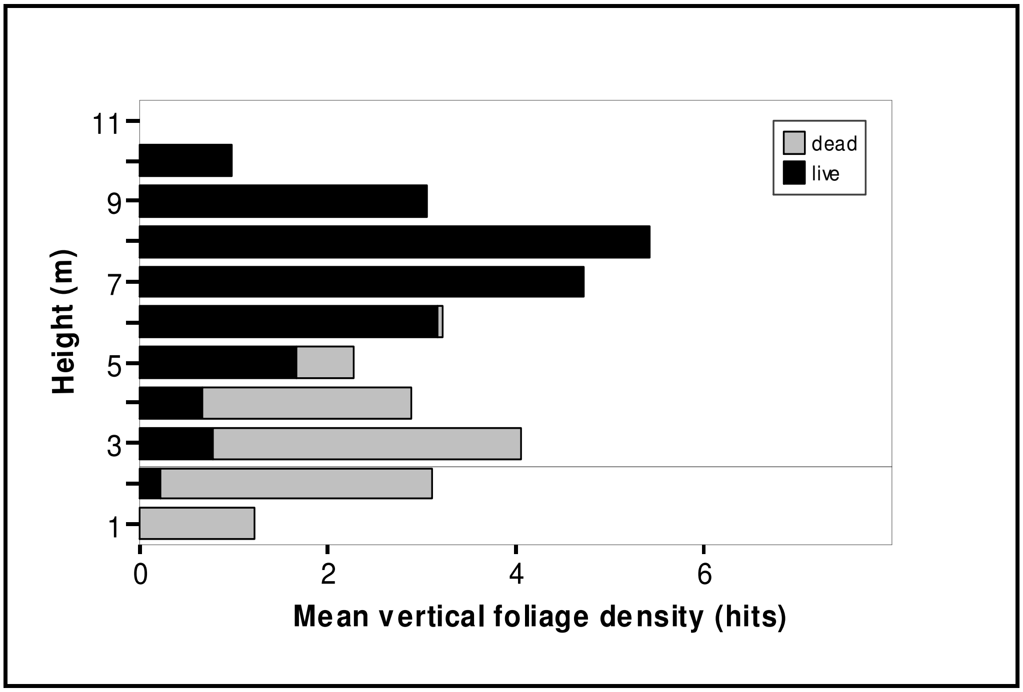

Figure 5.3. Vertical foliage density at occupied willow flycatcher territories in Goodding willow habitat type, 2008. Horizontal line shows average nest height in this habitat type in 2003–2007.

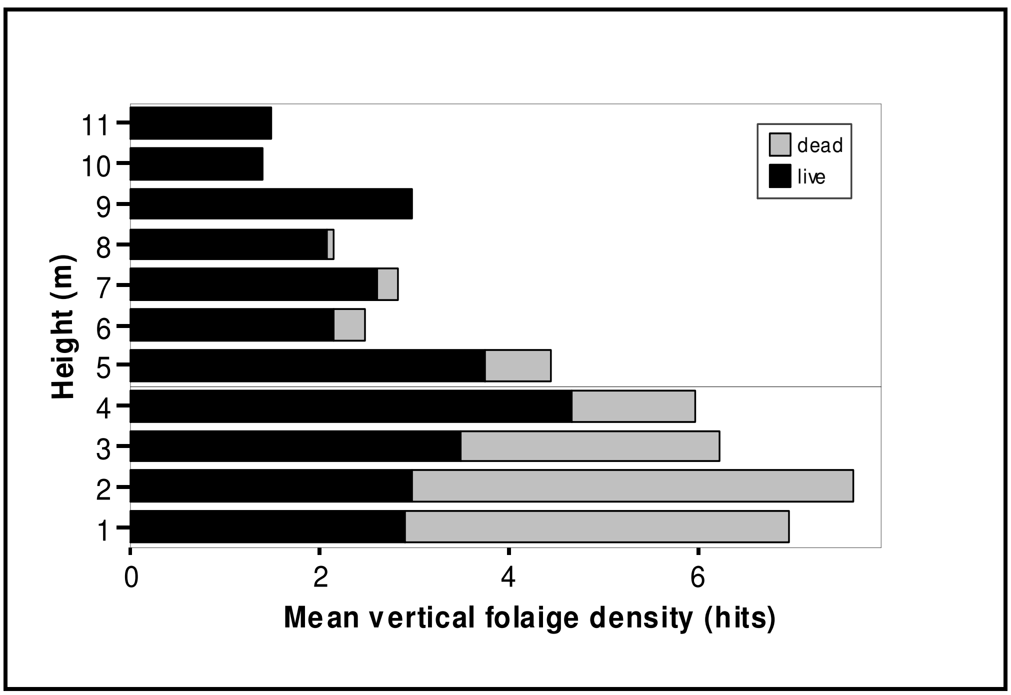

Figure 5.4. Vertical foliage density at occupied willow flycatcher territories in Goodding willow with tamarisk understory habitat type, 2008. Horizontal line shows average nest height in this habitat type in 2003–2007.

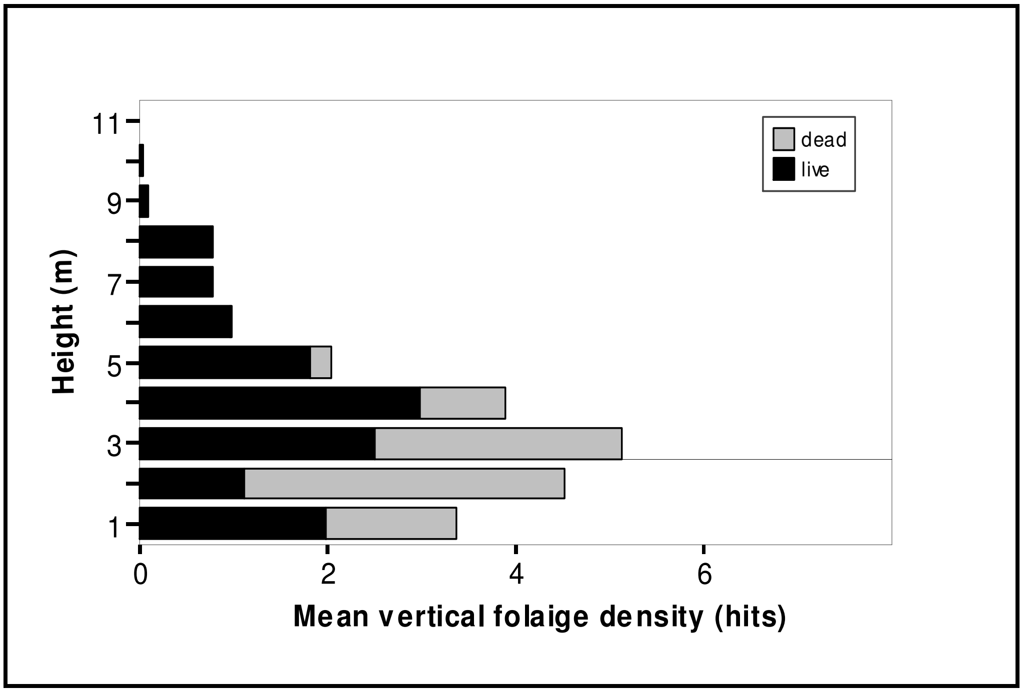

Figure 5.5. Vertical foliage density at occupied willow flycatcher territories in tamarisk with scattered Goodding willow habitat type, Mormon Mesa, 2008. Horizontal line shows average nest height in this habitat type in 2003–2007.

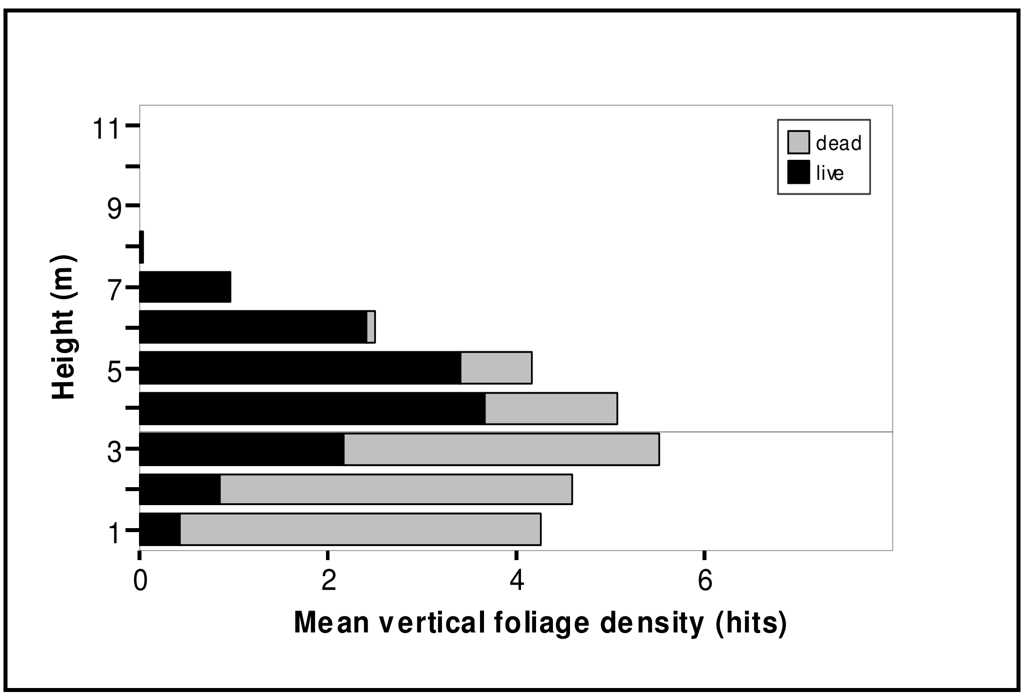

Figure 5.6. Vertical foliage density at occupied willow flycatcher territories in tamarisk with scattered Goodding willow habitat type, Topock Marsh, 2008. Horizontal line shows average nest height in this habitat type in 2003–2007.

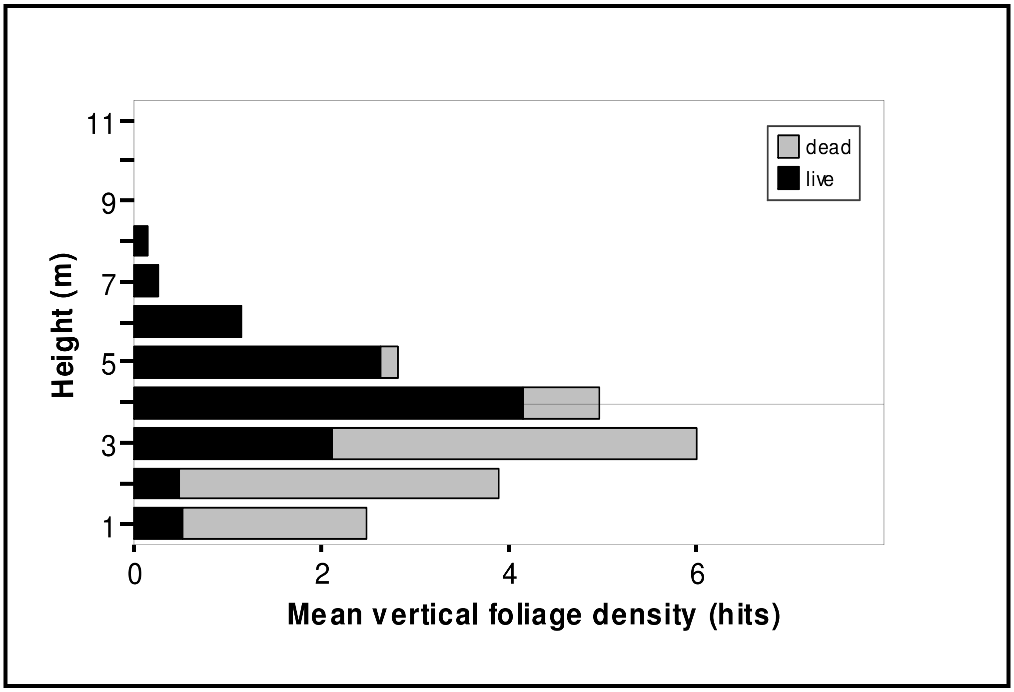

Figure 5.7. Vertical foliage density at occupied willow flycatcher territories in tamarisk habitat type, 2008. Horizontal line shows average nest height in this habitat type in 2003–2007.

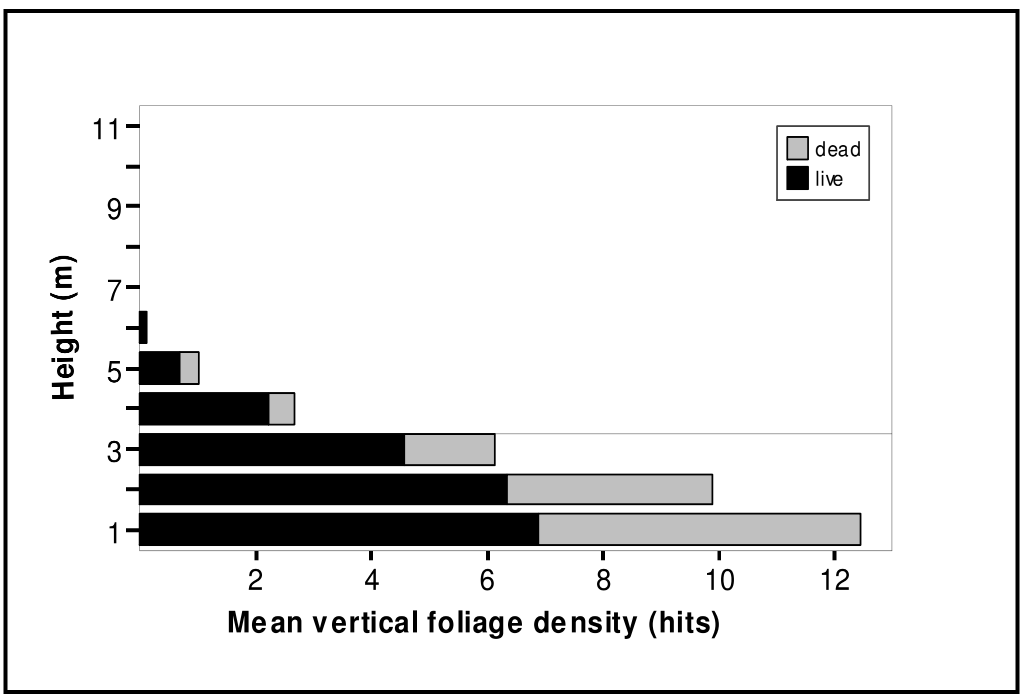

Figure 5.8. Vertical foliage density at occupied willow flycatcher territories in tamarisk/mesquite habitat type, 2008. Horizontal line shows average nest height across all habitat types in 2003–2007.

Table 5.3. Wilcoxon Signed Rank Test Results Comparing Vegetation Characteristics at Willow Flycatcher Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, Mesquite and Mormon Mesa*

Variable	Mesquite (n = 15)				Mormon Mesa (n = 8)			
	Occupied	Unoccupied	Difference	*P*	Occupied	Unoccupied	Difference	*P*
Canopy height (m)	5.3 (0.2)	4.9 (0.2)	-0.3 (0.2)	0.096	8.0 (1.4)	4.9 (0.4)	-3.1 (1.6)	0.080
% canopy closure	95.2 (0.9)	71.3 (6.5)	-23.9 (6.5)	**0.001**	95.5 (2.8)	58.5 (10.7)	-37.0 (11.9)	**0.017**
% woody ground cover	14.6 (3.9)	16.4 (2.7)	1.8 (2.5)	0.426	8.3 (3.3)	13.9 (2.5)	5.6 (4.0)	0.123
# live stems <2.5 cm dbh per ha	4100 (1136)	2071 (387)	-2029 (1134)	**0.027**	2944 (1259)	493 (171)	-2451 (1157)	**0.028**
# live stems 2.5–8 cm dbh per ha	6816 (726)	6451 (810)	-365 (929)	0.530	3454 (1666)	1591 (451)	-1862 (1556)	0.327
# live stems >8 cm dbh per ha	178 (61)	475 (157)	297 (146)	0.062	653 (141)	414 (146)	-239 (121)	0.114
# dead stems <2.5 cm dbh per ha	2283 (731)	4524 (734)	2241 (1213)	0.112	3884 (582)	2960 (895)	-923 (1293)	0.484
# dead stems 2.5–8 cm dbh per ha	2343 (508)	9719 (1299)	7376 (1438)	**0.001**	1607 (683)	2260 (1090)	652 (1330)	0.674
# dead stems > 8cm dbh per ha	110 (51)	255 (120)	144 (139)	0.395	0 (0)	143 (81)	143 (81)	0.102
Live vertical foliage density (hits) below nest	3.0 (1.1)	0.6 (0.2)	-2.4 (1.2)	0.059	2.9 (1.5)	1.2 (0.7)	-1.7 (1.8)	0.465
Live vertical foliage density (hits) at nest	3.2 (0.6)	1.7 (0.6)	-1.5 (0.4)	**0.005**	2.1 (0.8)	1.9 (0.8)	-0.2 (0.7)	0.345
Live vertical foliage density (hits) above nest	11.9 (1.3)	10.0 (1.0)	-1.9 (1.2)	0.167	16.6 (4.4)	5.8 (2.6)	-10.8 (4.3)	**0.050**
Dead vertical foliage density (hits) below nest	1.8 (0.5)	3.3 (0.7)	1.5 (0.6)	**0.011**	7.1 (1.3)	4.8 (1.0)	-2.4 (1.5)	0.161
Dead vertical foliage density (hits) at nest	1.4 (0.3)	3.0 (0.4)	1.6 (0.5)	**0.013**	3.6 (0.7)	1.8 (0.6)	-1.9 (0.4)	**0.017**
Dead vertical foliage density (hits) above nest	1.9 (0.7)	3.4 (0.6)	1.5 (1.0)	0.069	1.7 (0.8)	2.1 (0.8)	0.4 (1.2)	0.866
Percent native	73.5 (5.5)	49.7 (9.4	-23.7 (6.9)	**0.006**	68.0 (13.3)	47.5 (16.8)	-20.6 (12.5)	0.091

* Data are presented as means (standard error).

Table 5.4 Wilcoxon Signed Rank Test Results Comparing Vegetation Characteristics at Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, Muddy River and Topock Marsh*

Variable	Muddy River (n = 11)				Topock Marsh (n = 10)			
	Occupied	Unoccupied	Difference	P	Occupied	Unoccupied	Difference	P
Canopy height (m)	6.1 (0.3)	6.0 (0.3)	-0.1 (0.4)	0.959	6.1 (0.3)	5.9 (0.4)	-0.1 (0.6)	0.878
% canopy closure	92.1 (1.7)	83.1 (6.1)	-9.0 (6.3)	0.075	90.2 (2.1)	92.7 (1.2)	2.5 (2.3)	0.445
% woody ground cover	26.3 (7.9)	19.5 (5.1)	-6.8 (7.3)	0.534	19.8 (6.4)	20.0 (4.5)	0.2 (5.0)	0.799
# live stems <2.5 cm dbh per ha	2558 (438)	1701 (327)	-856 (350)	**0.038**	2470 (482)	2572 (272)	102 (605)	0.859
# live stems 2.5–8 cm dbh per ha	4572 (615)	5197 (576)	625 (583)	0.350	7168 (647)	4201 (455)	-2967 (780)	**0.009**
# live stems >8 cm dbh per ha	799 (226)	1215 (168)	417 (277)	0.110	1006 (190)	968 (197)	-38 (304)	0.959
# dead stems <2.5 cm dbh per ha	1123 (302)	1181 (172)	57.9 (278)	0.964	3450 (605)	2050 (353)	-1401 (814)	0.202
# dead stems 2.5–8 cm dbh per ha	2280 (480)	2014 (272)	-266 (609)	1.000	1337 (315)	1859 (339)	522 (391)	0.153
# dead stems >8 cm dbh per ha	150 (78)	69 (26)	-81 (69)	0.339	25 (25)	25 (17)	0 (19)	1.000
Live vertical foliage density (hits) below nest	2.0 (0.7)	2.5 (0.5)	0.5 (0.6)	0.475	7.1 (2.3)	3.4 (0.6)	-3.7 (2.1)	0.083
Live vertical foliage density (hits) at nest	2.0 (0.4)	1.7 (0.5)	-0.2 (0.4)	0.406	3.1 (0.6)	2.0 (0.5)	-1.1 (0.6)	0.102
Live vertical foliage density (hits) above nest	10.4 (1.6)	14.8 (1.8)	4.3 (2.0)	0.066	12.1 (2.2)	7.0 (5.8)	-5.1 (2.7)	0.093
Dead vertical foliage density (hits) below nest	4.3 (0.7)	5.4 (0.5)	1.1 (1.0)	0.398	10.8 (1.3)	8.0 (0.9)	-2.8 (1.2)	**0.047**
Dead vertical foliage density (hits) at nest	2.3 (0.5)	4.0 (0.6)	1.7 (0.5)	**0.016**	3.1 (0.7)	2.1 (0.6)	-1.1 (0.5)	0.075
Dead vertical foliage density (hits) above nest	2.8 (0.7)	3.2 (0.9)	0.4 (0.4)	0.357	1.5 (0.7)	1.5 (0.5)	-0.1 (0.4)	0.726
Percent native	38.1 (7.9)	26.1 (7.5)	-12.0 (4.6)	**0.028**	4.7 (3.0)	10.4 (4.9)	5.8 (4.7)	0.345

* Data are presented as means (standard error).

Table 5.5. Wilcoxon Signed Rank Test Results Comparing Vegetation Characteristics at Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, All Sites Combined*

Variable	All Sites (n = 44)				Direction and Magnitude of Change[1]			
	Occupied	Unoccupied	Difference	P	MESQ	MOME	MUDD	TOPO
Canopy height (m)	6.1 (0.2)	5.4 (0.2)	-0.6 (0.3)	0.080	↓ (blue)	↓ (blue)	↓	↓
% canopy closure	93.4 (0.9)	76.8 (3.7)	-16.6 (4.0)	**<0.001**	↓ (red)	↓ (red)	↓ (blue)	↑
% woody ground cover	17.6 (2.9)	17.5 (1.9)	-0.0 (2.4)	0.363	↑	↑	↓	↑
# live stems <2.5 cm dbh per ha	3134 (474)	1806 (196)	-1328 (478)	**0.002**	↓ (red)	↓ (red)	↓ (red)	↑
# live stems 2.5–8 cm dbh per ha	5724 (482)	4743 (419)	-981 (508)	0.071	↓	↓	↑	↓ (red)
# live stems >8 cm dbh per ha	608 (91)	761 (97)	153 (114)	0.151	↑ (blue)	↓	↑	↓
# dead stems <2.5 cm dbh per ha	2549 (341)	2842 (365)	292 (548)	0.674	↑	↓	↑	↓
# dead stems 2.5–8 cm dbh per ha	1965 (255)	4650 (736)	2685 (760)	**0.001**	↑ (red)	↑	↓	↑
# dead stems >8 cm dbh per ha	81 (27)	136 (45)	55 (54)	0.412	↑	↑	↓	--
Live vertical foliage density (hits) below nest	3.7 (0.8)	1.8 (0.3)	-1.8 (0.7)	**0.029**	↓ (blue)	↓	↑	↓ (blue)
Live vertical foliage density (hits) at nest	2.7 (0.3)	1.8 (0.3)	-0.9 (0.3)	**0.001**	↓ (red)	↓	↓	↓
Live vertical foliage density (hits) above nest	12.4 (1.1)	9.7 (0.9)	-22.7 (1.4)	0.090	↓	↓ (red)	↑ (blue)	↓ (blue)
Dead vertical foliage density (hits) below nest	5.4 (0.7)	5.2 (0.5)	-0.3 (0.6)	0.777	↑ (red)	↓	↑	↓ (red)
Dead vertical foliage density (hits) at nest	2.4 (0.3)	2.8 (0.3)	0.4 (0.3)	0.334	↑ (red)	↓ (red)	↑ (red)	↓ (blue)
Dead vertical foliage density (hits) above nest	2.0 (0.4)	2.7 (0.4)	0.7 (0.4)	0.065	↑ (blue)	↑	↑	↓
Percent native	48.0 (5.5)	34.5 (5.4)	-13.5 (3.9)	**0.001**	↓ (red)	↓ (blue)	↓ (red)	↑

* Data are presented as means (standard error).

[1] Arrows indicate the direction of change of the variable between occupied and unoccupied periods for each study area (MESQ = Mesquite, MOME = Mormon Mesa,
MUDD = Muddy River, TOPO = Topock Marsh, while color indicates the statistical significance of the change as follows: red is P <0.05, blue is 0.05< P <0.10, black is P >0.10.

DISCUSSION

Currently Occupied Territories

The purpose of vegetation measurements of occupied habitat is to provide quantitative guidelines for restoration efforts. Coyote willow and Goodding willow are the two habitat types that are most likely to be replicated in restoration areas. Mesquite West contains the only extensive stand of coyote willow known to be occupied by territorial willow flycatchers along the lower Colorado River and tributaries in any year since 2003. Occupied coyote willow habitat at Mesquite encompasses approximately 3 ha in the eastern and central portions of Mesquite West and is surrounded by cattail marsh and mixed coyote willow and tamarisk. Occupied even-age Goodding willow habitat occurred in 2008 on less than 1 ha on the southern end of the Overton WMA site at Muddy River and at Iceberg Canyon in Grand Canyon; however, vegetation data were not collected at Iceberg Canyon. Occupied Goodding willow habitat also occurred in previous years at RM 274.5 and RM 285.3 in Grand Canyon.

Sample sizes for the coyote willow and Goodding willow habitat types in 2008 are small (eight and two, respectively) and likely do not provide an accurate representation of the range and variance in vegetation characteristics in each habitat type. In future reports, data from 2008 will be combined with data collected in future years as well as data collected within active territories between 2003 and 2005 to provide a more comprehensive description of each habitat type.

Although other vegetation types occupied by willow flycatchers are not likely to be created in restoration areas, descriptive data are provided for these habitats to assist in the evaluation of areas to determine their suitability as flycatcher breeding habitat. Data from these other vegetation types may also be useful in illustrating structural similarities between occupied areas in different habitat types. Small sample sizes preclude meaningful comparisons of the 2008 data across habitat types.

Nests in Formerly Occupied Areas

The areas of Mesquite and Mormon Mesa that contained flycatcher nests in previous years but were abandoned in 2008 primarily consisted of areas that were affected by the winter floods of 2004–2005. The eastern edge of Mesquite West experienced flooding and deposition, which appeared to change the flow of water such that the area was no longer inundated. In 2005 we noted that this portion of Mesquite West had reduced foliage density and many of the willows were yellow and dying (Koronkiewicz et al. 2006a). The vegetation did not recover in subsequent years, and this area has not been occupied by flycatchers since 2005. The vegetation at Bunker Farm has also changed noticeably since it was last occupied by breeding flycatchers in 2005. The adjacent agricultural field, which supplied runoff to the site, has been fallow since 2005, and the stands of coyote willow and many of the Goodding willow at Bunker Farm were dead by 2008.

Areas of Mormon Mesa containing most of the old nests were also affected by the 2004–2005 winter floods, which deposited sediment and changed water flow patterns such that nesting areas were no longer inundated. We sampled old nests in Mormon Mesa North and the eastern half of Virgin River #1 North, both of which experienced progressive death of native vegetation since the flood and have not been occupied by flycatchers since 2005. We also sampled one nest from 2006 in the southern end of Virgin River #2; this area was unoccupied in 2007–2008, though no obvious changes in vegetation were noted.

The changes in vegetation that were noted in qualitative site descriptions were also apparent in the vegetation data, with both Mesquite and Mormon Mesa showing less canopy closure, fewer live stems, less live foliage, and more dead foliage in 2008 than when the nests were occupied. Both sites also showed a trend toward decreased canopy height. Nest sites at Mesquite had also lost a significant percentage of their native vegetation, while nest sites at Mormon Mesa showed a trend in this same direction. Canopy closure, canopy height, and the percent native vegetation were all found to be important in differentiating nest sites from non-use areas (McLeod et al. 2008a), and it is likely that decreases in canopy cover and canopy height and the death of native vegetation at Mesquite and Mormon Mesa made portions of those sites unsuitable for nesting flycatchers.

Flycatcher nests at Muddy River have occurred primarily in two areas, one in the northern half of Overton WMA and the other at the southern tip of Overton WMA. The northern portion was occupied each year from 2004 to 2007 but was abandoned in 2008, and the majority of the old nests occurred in this area. We sampled one additional nest at Overton Pond, which was occupied in 2007 but not 2008.

Areas adjacent to the old nests sites at Overton WMA were bulldozed prior to the 2008 breeding season (see Chapter 2), but no obvious habitat changes were noted at the old nest sites themselves. However, vegetation data showed a decrease in live stems <2.5 cm dbh, an increase in dead foliage density at nest height, and a decrease in the percent of native vegetation. There was also a trend toward decreased canopy closure. It is possible that vegetation in the area has changed, although this was not obvious from qualitative descriptions of the site, decreasing the suitability of the area for flycatchers. Bulldozing activities in the vicinity of old nests could also have contributed to abandonment of the area, or the site could have been unoccupied in 2008 as the result of interannual variation in site occupancy. Monitoring of the site in future years will help determine whether abandonment of the site was a temporary or long-term phenomenon.

Old nests at Topock occurred in PC6-1, Pig Hole, and 250M all of which were occupied in 2004 and/or 2005. No obvious changes in vegetation have been noted in any of these sites, though vegetation measurements showed a decrease in the number of live stems 2.5–8 cm dbh and a decrease in dead foliage below the nest. There were also trends toward decreased live foliage below the nest and decreased dead foliage at nest height. A decrease in the number of live stems and decreases in foliage density could reduce suitability of the sites for flycatchers. The number of territories at Topock has varied widely over the years, and the abandonment of certain sites may also reflect a lower overall number of territorial flycatchers. Territorial individuals would be expected to occupy optimal habitats first, and the areas that have not been occupied since 2005 may represent sub-optimal habitat.

The overall habitat changes between occupied and unoccupied periods for all study areas combined, along with an examination of which habitat variables changed in a consistent direction across study areas, lend further insight into which vegetation characteristics seem to be important to flycatcher occupancy. Live foliage density below, at, and above nest height; canopy height; canopy closure; number of live stems <2.5 cm dbh and 2.5–8 cm dbh; and percent native decreased in three or four study areas between occupied and unoccupied periods. Number of dead stems 2.5–8 cm dbh, dead vertical foliage density above nest height, and percent woody ground cover increased in three or four study areas between occupied and unoccupied periods. These trends are all consistent with abandoned areas having experienced a temporal decrease in the density of live vegetation, particularly of native species. McLeod et al. (2008a) reported similar differences between occupied and unoccupied areas when habitat patches were sampled to identify spatial habitat variation that affected flycatcher occupancy. Flycatchers typically occupied areas that had greater canopy height, canopy closure, foliage density, stem density, and percent native vegetation than unoccupied areas.

Chapter 6

MICROCLIMATE

INTRODUCTION

Our objective for microclimate sampling is to provide a quantitative summary of microclimate conditions within occupied territories in various vegetation types. These descriptive summaries will provide guidance for managers working to restore and create riparian habitat to meet the obligations of the LCR MSCP and will provide a means to evaluate habitats to determine if the microclimate resembles that in occupied flycatcher territories. The Pahranagat study area was excluded from the characterization of occupied territories because the study area is approximately 650 m higher in elevation and experiences a cooler climate than the LCR MSCP study area.

In addition, we investigated whether changes in microclimate characteristics might have contributed to the abandonment of some areas by flycatchers. We identified several areas that had been occupied by nesting flycatchers in at least one previous year from 2003 to 2007 but were unoccupied in 2008, and we relocated old nest sites at which we had collected microclimate information in the year the nest was active. We resampled the microclimate at these nests to see whether microclimate characteristics had changed. Comparison of microclimate data collected when a nest site was active versus when the area was abandoned may elucidate how changes in microclimate through time may influence flycatcher occupancy. These results will provide additional quantitative information on the characteristics of microclimate within flycatcher nesting territories.

METHODS

Currently Occupied Territories

We collected microclimate measurements at one location for each territorial male flycatcher we identified, regardless of the length of time the male was resident and whether or not he obtained a mate.

Temperature and Relative Humidity (T/RH) Measurements

Measurements of temperature and relative humidity (T/RH) were recorded automatically every 15 minutes using a HOBO H8 Pro (Onset Computer Corporation, Pocasset, MA) that combines a thermometer (degrees Celsius), relative humidity monitor, and digital data logger. We camouflaged all HOBO units by placing them in an inverted small, plastic container coated with spray adhesive and local vegetation. The opening at the bottom was covered with shadecloth, allowing free air circulation around the unit. One HOBO unit was placed within each active flycatcher territory. We estimated the center of the male's territory (see Chapter 5) and then determined the location of the HOBO unit by means of the following instructions and the use of random number sequences:

(1) The compass direction to walk from the territory center, given in degrees from north, was determined from a random number sequence.

(2) The distance (between 0 and 20 m) to walk in the designated direction was determined from a random number sequence. Once that distance was traveled, the closest woody tree or shrub was selected for data logger placement.

(3) The HOBO unit was placed at a randomly selected height within the range of flycatcher nest heights documented at that study area in 2003–2007 (McLeod et al. 2008a). The distribution of random numbers followed the distribution of nest heights. If the chosen tree or shrub was of insufficient height to accept the height from the random number sequence, then field personnel placed the HOBO unit at the first height in the sequence that was less than the height of the tree or shrub. If no nests had been previously recorded at that study area, field personnel used the height sequences from the nearest study area with known nests.

(4) The distance (0–2 m) at which the HOBO was placed from the bole of the tree or center of the shrub was determined from a random number sequence. If the tree or shrub was of insufficient radius to accept the distance from the random number sequence, then field personnel placed the unit at the first number in the sequence that was less than the radius of the tree or shrub.

(5) The compass direction, given in degrees from north, at which the unit was placed from the bole of the tree or center of the shrub was determined from a random number sequence. If there was no branch in this compass direction that would support the data logger at the height and distance specified in (3) and (4), field personnel proceeded clockwise around the tree or shrub until a suitable branch was located.

If, as presented in (3) and (4), 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 territory center and used the next sequence of random numbers.

HOBO data loggers were deployed as soon as the male was confirmed as being resident and were left in place throughout the breeding season. The logger was downloaded when vegetation measurements were collected at the end of the breeding season, and the logger was left in place to collect data until the start of the 2009 breeding season.

Soil Moisture (SM) Measurements

A ThetaProbe ML2x coupled to an HH2 Moisture Meter Readout (Macaulay Land Use Research Institute, Aberdeen, UK, and Delta-T Devices, Cambridge, UK, respectively) was used to gather soil moisture (SM) data. The SM readings (nine per site) were recorded directly beneath the HOBO logger (plot center) and at 1.0 and 2.0 m from plot center in each cardinal direction. Soil moisture readings were collected when the HOBO logger was deployed and at two-week intervals throughout the breeding season until the HOBO logger was downloaded. Soil moisture was recorded both as voltage (mV) and as volumetric water content (%).[1] Soil type on the HH2 was set to mineral soil. For any SM measurement point that was underwater, we recorded the depth of standing water and assigned a value of 994 mV, which is equivalent to 50% volumetric water content, or fully saturated soil. All mV values greater than 994 were also reassigned as 994 mV, because this reading represents fully saturated soil and because the mV to percent relationship becomes excessively nonlinear for mV readings above this point. Each time we collected soil moisture data, we also recorded the distance to the nearest standing water or saturated soil and recorded the approximate percentage, as estimated in the field, of the site within 20 and 50 m of the data logger that contained inundated or saturated soil.

[1] The soil moisture logger measures the dielectric constant of moist soil via a direct current voltage, which is converted to volumetric soil moisture with conversion tables. For very high (above ~1000 mV) or low (below ~90 mV) voltage readings, the HH2 reports volumetric soil moisture as "above" or "below" the table, respectively. To eliminate these qualitative readings, we recorded both mV and volumetric soil moisture.

A soil sample was collected from beneath each HOBO data logger. Samples were approximately the size of a medium apple, collected from the surface down to and including a depth of 5 cm, and placed in a heavy zip-lock plastic bag labeled with the site designation. These samples will contribute to an ongoing analysis of soil texture, which strongly influences capillary action and therefore overall SM (Sumner 2000).

Statistical Analyses

Soil moisture data were entered into a database as they were collected during the field season. We downloaded data from the HOBO data loggers into databases at the end of the field season. We merged all data to create one dataset for further analysis. We summarized the following variables for each HOBO location:

- Mean soil moisture from plot center to 2.0 m from plot center
- Distance to nearest standing water or saturated soil
- % of the site within 20 m that was inundated or saturated
- % of the site within 50 m that was inundated or saturated
- Maximum diurnal temperature
- Minimum nocturnal temperature
- Daily temperature range (diurnal maximum minus nocturnal minimum)
- Mean diurnal vapor pressure[2]
- Mean nocturnal vapor pressure

Soil moisture variables were summarized per visit, and temperature/humidity variables were summarized on a daily basis. We determined diurnal and nocturnal periods by using the actual daily sunrise and sunset times reported for the region by the National Weather Service (2008). We selected the above measures of temperature and humidity for analysis because they were the most highly correlated with other variables or were the most useful in distinguishing use areas from non-use locations (McLeod et al. 2008a). Territories were grouped according to vegetation type (see Chapter 5), and microclimate variables were averaged for each vegetation type over the following two-week periods to show how microclimate conditions changed throughout the breeding season: 12–31 May, 1–15 June, 15–30 June, 1–15 July, 16–31 July, and 1–15 August.

Analyses were conducted using SAS® v.9.1.3 (SAS Institute 2003) and Stata® v.9.2 (StataCorp 2006). Data are presented as mean (standard error) unless otherwise noted.

Nests in Formerly Occupied Areas

We used the UTM coordinates of the nest, nest tree species, nest height, and nest flags that remained in the field to locate old nests. We hung a HOBO logger at the old nest location in May, and the logger remained in place until the end of the breeding season. Soil moisture measurements were taken at two-week intervals as described above.

[2] 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.

Statistical Analyses

During the year when each nest was active, microclimate data were collected for a two-week period immediately following the nest being vacated. We selected data from the same two-week period for each nest in 2008. We summarized the following variables for each HOBO location:

- Mean soil moisture from plot center to 2.0 m from plot center
- Maximum diurnal temperature
- Minimum nocturnal temperature
- Daily temperature range (diurnal maximum minus nocturnal minimum)
- Mean diurnal vapor pressure[3]
- Mean nocturnal vapor pressure

We used paired t-tests to compare measures of microclimate at old nests to the measurements collected during the year the nest was active. P-values were similar to those obtained when a non-parametric test (Wilcoxon signed rank sum) was used to compare matched sites. Analyses were conducted using SAS® v.9.1.3 (SAS Institute 2003) and Stata® v.9.2 (StataCorp 2006). Missing data were excluded test-wise. Data are presented as mean (standard error) unless otherwise noted.

To address whether any observed changes in microclimate between occupied and unoccupied periods could be the result of overall changes in regional climate, we obtained weather station data from the National Climate Data Center (www.ncdc.noaa.gov/oa/ncdc.html) for Overton, Nevada (Station ID #265846) and Needles, California (Station ID #723805) for 2003–2008. Maximum and minimum daily temperature data were available for both weather stations, and dew point data were available for Needles. We used one-way ANOVA to test whether temperature and dew point variables differed between years for the June–August period. We used SPSS® Version 16.0 (SPSS Inc.) software for statistical analyses.

RESULTS

Currently Occupied Territories

We deployed HOBO data loggers and collected soil moisture data at 41 active territories. HOBO loggers failed to collect data at three locations, and soil moisture data could not be collected at one location because thick piles of arrowweed and bulrush prevented access to the soil. Microclimate variables are summarized by two-week periods for each vegetation type in Tables 6.1–6.8. These same variables are plotted in Figures 6.1–6.9 to facilitate comparisons between vegetation types.

All vegetation types exhibited moist soil conditions throughout the breeding season. Goodding willow had the wettest conditions, with fully saturated soil throughout the season and a minimum of 60% of the surrounding area within 50 m having surface water at each visit through the end of July. Soil conditions showed a general drying trend, with the inundated percentage of the surrounding area declining through the season, in Goodding willow with tamarisk understory, tamarisk with scattered Goodding willow at Mormon Mesa, and tamarisk with scattered Goodding willow at Topock.

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[3] 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.

Table 6.1. Microclimate Measures in Southwestern Willow Flycatcher Territories in Coyote Willow (n = 7), 2008

Microclimate measure	May 12-31	June 1-15	June 16-30	July 1-15	July 16-31	August 1-15
Soil Moisture						
Mean soil moisture (mV)	790.9 (51.9)	914.7 (25.0)	781.6 (39.8)	757.3 (68.2)	662.8 (51.2)	757.5 (61.2)
Mean distance to nearest standing water	36.3 (13.3)	0.2 (0.2)	17.2 (6.9)	27.8 (10.9)	36.2 (9.6)	95.8 (31.0)
% of the site within 20 m that was inundated	28.9 (11.9)	55.0 (10.0)	46.7 (8.2)	21.6 (11.5)	8.2 (3.5)	10.6 (6.7)
% of the site within 50 m that was inundated	35.1 (12.2)	40.0 (7.6)	50.0 (7.6)	25.8 (11.3)	10.1 (4.0)	11.3 (6.0)
Temperature						
Mean maximum diurnal temperature (°C)	49.0 (0.1)	42.9 (0.1)	42.9 (0.1)	44.9 (0.1)	44.4 (0.1)	44.9 (0.1)
Mean minimum nocturnal temperature (°C)	6.2 (0.1)	7.0 (0.1)	11.0 (0.1)	14.9 (0.1)	16.0 (0.0)	14.9 (0.0)
Mean daily temperature range (°C)	35.4 (1.7)	31.0 (1.1)	28.6 (0.9)	25.1 (0.9)	24.3 (1.0)	25.6 (0.9)
Humidity						
Mean diurnal vapor pressure (Pa)	1276.7 (6.6)	1359.9 (5.5)	1811.0 (6.8)	2441.4 (6.1)	2383.2 (6.3)	2640.7 (8.4)
Mean nocturnal vapor pressure (Pa)	1131.4 (4.9)	1128.3 (4.8)	1401.2 (4.6)	1926.0 (4.7)	1972.5 (4.5)	2205.8 (6.2)

Table 6.2. Microclimate Measures in Southwestern Willow Flycatcher Territories in Tamarisk with Coyote Willow (n = 4), 2008

Microclimate measure	May 12-31	June 1-15	June 16-30	July 1-15	July 16-31	August 1-15
Soil Moisture						
Mean soil moisture (mV)	885.8 (49.8)	963.0 (26.0)	842.8 (61.9)	941.2 (14.9)	908.4 (21.2)	932.7 (21.6)
Mean distance to nearest standing water	1.4 (0.5)	1.0 (1.0)	1.0 (0.6)	1.3 (0.8)	1.6 (0.3)	1.5 (0.5)
% of the site within 20 m that was inundated	42.0 (18.7)	67.5 (7.5)	40.0 (20.9)	31.3 (4.3)	24.2 (6.2)	31.0 (4.3)
% of the site within 50 m that was inundated	39.0 (14.1)	57.5 (2.5)	35.0 (18.9)	28.8 (4.3)	28.3 (5.3)	30.0 (4.7)
Temperature						
Mean maximum diurnal temperature (°C)	48.0 (0.2)	43.4 (0.1)	45.9 (0.2)	44.9 (0.1)	44.4 (0.1)	44.4 (0.1)
Mean minimum nocturnal temperature (°C)	8.6 (0.1)	8.2 (0.1)	12.2 (0.1)	16.0 (0.1)	17.1 (0.1)	15.6 (0.1)
Mean daily temperature range (°C)	36.8 (1.8)	32.0 (2.0)	29.5 (1.9)	25.6 (2.3)	22.5 (2.4)	24.9 (2.5)
Humidity						
Mean diurnal vapor pressure (Pa)	1124.1 (9.3)	1140.6 (7.8)	1565.6 (10.9)	2257.0 (11.6)	2210.7 (11.0)	2428.9 (13.3)
Mean nocturnal vapor pressure (Pa)	1101.9 (7.9)	1092.2 (7.8)	1376.0 (8.6)	1952.5 (9.4)	1965.8 (9.1)	2165.3 (9.7)

Table 6.3. Microclimate Measures in Southwestern Willow Flycatcher Territories in Goodding Willow (n = 2), 2008

Microclimate measure	May 12-31	June 1-15	June 16-30	July 1-15	July 16-31	August 1-15
Soil Moisture						
Mean soil moisture (mV)	994.0 (0.0)	994.0 (0.0)	956.0 (0.0)	994.0 (0.0)	994.0 (0.0)	925.0 (16.5)
Mean distance to nearest standing water	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	2.1 (2.0)
% of the site within 20 m that was inundated	85.0 (0.0)	95.0 (0.0)	90.0 (0.0)	70.0 (0.0)	100.0 (0.0)	57.0 (13.8)
% of the site within 50 m that was inundated	70.0 (0.0)	75.0 (0.0)	85.0 (0.0)	60.0 (0.0)	80.0 (0.0)	46.0 (12.0)
Temperature						
Mean maximum diurnal temperature (°C)	32.8 (0.4)	39.2 (0.2)	39.7 (0.2)	40.1 (0.2)	41.5 (0.2)	42.0 (0.1)
Mean minimum nocturnal temperature (°C)	12.9 (0.3)	12.6 (0.2)	16.0 (0.1)	17.5 (0.1)	19.0 (0.1)	17.1 (0.1)
Mean daily temperature range (°C)	19.8 (0.0)	26.7 (0.0)	23.7 (0.0)	22.6 (0.0)	17.1 (5.4)	22.5 (0.9)
Humidity						
Mean diurnal vapor pressure (Pa)	984.8 (12.4)	1058.4 (9.8)	1464.1 (12.0)	2125.7 (16.2)	2128.5 (13.5)	2068.6 (12.2)
Mean nocturnal vapor pressure (Pa)	1242.3 (18.1)	1221.6 (16.6)	1751.5 (14.3)	2172.9 (18.1)	2228.8 (15.4)	2137.4 (12.3)

Table 6.4. Microclimate Measures in Southwestern Willow Flycatcher Territories in Goodding Willow with Tamarisk Understory (n = 2), 2008

Microclimate measure	May 12-31	June 1-15	June 16-30	July 1-15	July 16-31	August 1-15
Soil Moisture						
Mean soil moisture (mV)	920.6 (15.7)	887.1 (34.6)	887.4 (7.3)	920.5 (5.7)	853.7 (27.5)	N/A
Mean distance to nearest standing water	14.0 (4.0)	10.0 (0.0)	10.0 (0.0)	225.0 (25.0)	225.0 (25.0)	N/A
% of the site within 20 m that was inundated	7.5 (7.5)	10.0 (5.0)	5.0 (0.0)	4.0 (0.0)	0.0 (0.0)	N/A
% of the site within 50 m that was inundated	10.0 (10.0)	15.0 (5.0)	8.5 (1.5)	4.0 (0.0)	0.0 (0.0)	N/A
Temperature						
Mean maximum diurnal temperature (°C)	39.7 (0.2)	43.4 (0.2)	41.5 (0.2)	38.8 (0.1)	38.8 (0.4)	N/A
Mean minimum nocturnal temperature (°C)	9.0 (0.1)	10.6 (0.2)	14.1 (0.1)	18.3 (0.1)	19.8 (0.2)	N/A
Mean daily temperature range (°C)	28.9 (1.7)	30.6 (0.6)	25.2 (1.4)	18.6 (1.2)	16.8 (1.8)	N/A
Humidity						
Mean diurnal vapor pressure (Pa)	1417.1 (12.0)	1642.4 (13.7)	2398.3 (15.1)	3020.6 (11.2)	3004.1 (37.9)	N/A
Mean nocturnal vapor pressure (Pa)	1326.6 (7.8)	1406.4 (10.2)	1852.7 (8.8)	2513.4 (8.9)	2459.8 (15.4)	N/A

Table 6.5. Microclimate Measures in Southwestern Willow Flycatcher Territories in Tamarisk with Scattered Goodding Willow – Mormon Mesa (n = 11), 2008

Microclimate measure	May 12-31	June 1-15	June 16-30	July 1-15	July 16-31	August 1-15
Soil Moisture						
Mean soil moisture (mV)	902.9 (34.9)	886.8 (25.3)	843.7 (40.8)	779.1 (31.4)	752.5 (47.4)	791.4 (54.0)
Mean distance to nearest standing water	29.8 (18.6)	23.3 (8.5)	131.4 (68.4)	795.8 (197.5)	40.4 (10.4)	50.2 (14.3)
% of the site within 20 m that was inundated	50.0 (17.9)	50.3 (9.9)	34.2 (12.1)	0.0 (0.0)	6.3 (4.2)	4.8 (1.8)
% of the site within 50 m that was inundated	42.5 (16.6)	49.3 (8.8)	32.5 (11.6)	1.9 (1.6)	6.7 (3.7)	6.1 (2.8)
Temperature						
Mean maximum diurnal temperature (°C)	49.0 (0.1)	53.5 (0.1)	56.0 (0.1)	57.2 (0.1)	54.1 (0.1)	53.0 (0.1)
Mean minimum nocturnal temperature (°C)	6.6 (0.1)	7.0 (0.1)	10.6 (0.1)	13.7 (0.1)	14.5 (0.1)	13.7 (0.1)
Mean daily temperature range (°C)	34.0 (2.5)	36.9 (1.6)	35.0 (1.9)	33.0 (1.7)	30.4 (1.5)	30.5 (1.5)
Humidity						
Mean diurnal vapor pressure (Pa)	975.3 (4.9)	859.9 (3.7)	1324.8 (6.2)	1716.2 (5.3)	1744.2 (5.6)	1950.3 (8.0)
Mean nocturnal vapor pressure (Pa)	1100.6 (6.1)	1026.0 (5.3)	1449.7 (5.0)	1753.1 (4.9)	1809.5 (4.4)	1988.4 (6.1)

Table 6.6. Microclimate Measures in Southwestern Willow Flycatcher Territories in Tamarisk with Scattered Goodding Willow – Topock Marsh (n = 8), 2008

Microclimate measure	May 12-31	June 1-15	June 16-30	July 1-15	July 16-31	August 1-15
Soil Moisture						
Mean soil moisture (mV)	766.6 (111.9)	794.3 (105.5)	725.0 (113.3)	781.7 (72.2)	653.7 (85.1)	N/A
Mean distance to nearest standing water	7.7 (2.8)	12.5 (3.1)	15.5 (5.4)	26.8 (5.8)	18.0 (1.9)	N/A
% of the site within 20 m that was inundated	38.0 (10.4)	20.0 (11.1)	12.4 (3.3)	6.8 (1.7)	6.3 (1.5)	N/A
% of the site within 50 m that was inundated	44.5 (9.6)	30.0 (8.1)	28.1 (5.3)	15.0 (3.4)	14.0 (3.6)	N/A
Temperature						
Mean maximum diurnal temperature (°C)	52.4 (0.1)	50.7 (0.1)	51.8 (0.1)	46.9 (0.1)	45.9 (0.1)	N/A
Mean minimum nocturnal temperature (°C)	6.6 (0.1)	7.4 (0.1)	12.2 (0.1)	16.4 (0.0)	17.5 (0.0)	N/A
Mean daily temperature range (°C)	37.6 (1.6)	33.9 (1.5)	31.1 (1.6)	23.8 (1.4)	20.9 (1.5)	N/A
Humidity						
Mean diurnal vapor pressure (Pa)	1142.3 (5.2)	1481.9 (7.7)	2245.9 (8.8)	2950.9 (6.9)	2869.7 (9.1)	N/A
Mean nocturnal vapor pressure (Pa)	1092.2 (4.3)	1299.3 (5.7)	1757.5 (5.4)	2380.4 (5.1)	2450.2 (6.1)	N/A

Table 6.7. Microclimate Measures in Southwestern Willow Flycatcher Territories in Tamarisk (n = 3), 2008

Microclimate measure	May 12-31	June 1-15	June 16-30	July 1-15	July 16-31	August 1-15
Soil Moisture						
Mean soil moisture (mV)	908.7 (0.0)	899.9 (10.2)	907.8 (26.9)	902.4 (25.9)	936.4 (19.3)	853.0 (53.8)
Mean distance to nearest standing water	23.0 (0.0)	20.3 (6.5)	13.3 (4.7)	10.3 (4.1)	8.8 (4.3)	15.7 (7.5)
% of the site within 20 m that was inundated	0.0 (0.0)	15.0 (5.0)	23.8 (19.1)	10.0 (3.5)	34.5 (22.1)	13.3 (8.8)
% of the site within 50 m that was inundated	20.0 (0.0)	23.3 (6.0)	28.8 (12.8)	23.8 (4.3)	40.0 (17.8)	30.0 (10.0)
Temperature						
Mean maximum diurnal temperature (°C)	38.3 (1.1)	41.5 (0.2)	50.7 (0.2)	51.2 (0.1)	51.8 (0.2)	50.7 (0.2)
Mean minimum nocturnal temperature (°C)	16.0 (0.8)	9.0 (0.2)	12.6 (0.1)	15.2 (0.1)	17.1 (0.1)	16.4 (0.1)
Mean daily temperature range (°C)	22.3 (0.0)	32.1 (0.0)	32.6 (2.6)	28.5 (3.5)	27.4 (3.8)	30.7 (3.6)
Humidity						
Mean diurnal vapor pressure (Pa)	1359.1 (31.4)	1251.4 (13.2)	1781.5 (12.4)	2339.2 (12.6)	2196.0 (13.7)	2045.6 (14.2)
Mean nocturnal vapor pressure (Pa)	1405.5 (23.4)	1201.2 (11.1)	1567.1 (8.0)	2030.4 (9.9)	2046.5 (9.5)	2021.3 (9.9)

Table 6.8. Microclimate Measures in Southwestern Willow Flycatcher Territories in Tamarisk with Mesquite (n = 1), 2008*

Microclimate measure	May 12-31	June 1-15	June 16-30	July 1-15	July 16-31	August 1-15
Soil Moisture						
Mean soil moisture (mV)[1]	N/A	N/A	N/A	N/A	N/A	N/A
Mean distance to nearest standing water	N/A	15 (0.0)	15 (0.0)	N/A	15 (0.0)	N/A
% of the site within 20 m that was inundated	N/A	5 (0.0)	5 (0.0)	N/A	5 (0.0)	N/A
% of the site within 50 m that was inundated	N/A	20 (0.0)	15 (0.0)	N/A	15 (0.0)	N/A
Temperature						
Mean maximum diurnal temperature (°C)	N/A	54.7 (0.6)	57.2 (0.4)	57.9 (0.3)	54.7 (1.4)	N/A
Mean minimum nocturnal temperature (°C)	N/A	9.8 (0.4)	13.3 (0.2)	19.0 (0.1)	22.5 (0.4)	N/A
Mean daily temperature range (°C)	N/A	44.9 (0.0)	43.9 (0.0)	38.9 (0.0)	32.3 (0.0)	N/A
Humidity						
Mean diurnal vapor pressure (Pa)	N/A	1376.2 (32.8)	1733.0 (16.1)	2659.1 (14.7)	2180.2 (42.2)	N/A
Mean nocturnal vapor pressure (Pa)	N/A	1252.3 (16.6)	1540.1 (13.1)	2264.9 (11.9)	2059.6 (9.1)	N/A

N/A = data not available or not applicable.

[1] Soil moisture data were not collected for this location because thick piles of arrowweed and bulrush prevented access to the soil.

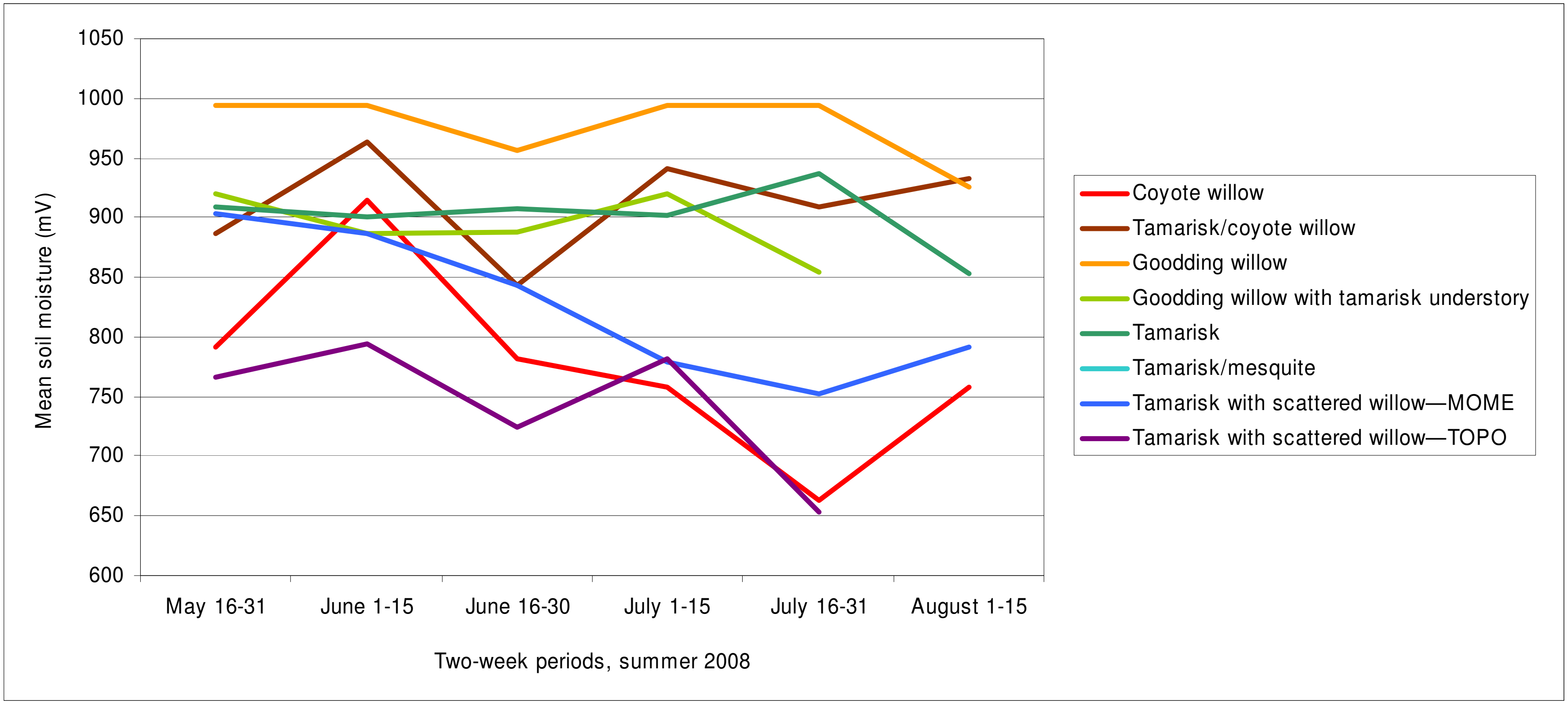

Figure 6.1. Mean soil moisture (mV) in Southwestern Willow Flycatcher territories in various vegetation types, Lower Colorado River and tributaries, 2008. No soil moisture data are available for the tamarisk/mesquite habitat type because dense arrowweed and bulrush prevented access to the soil.

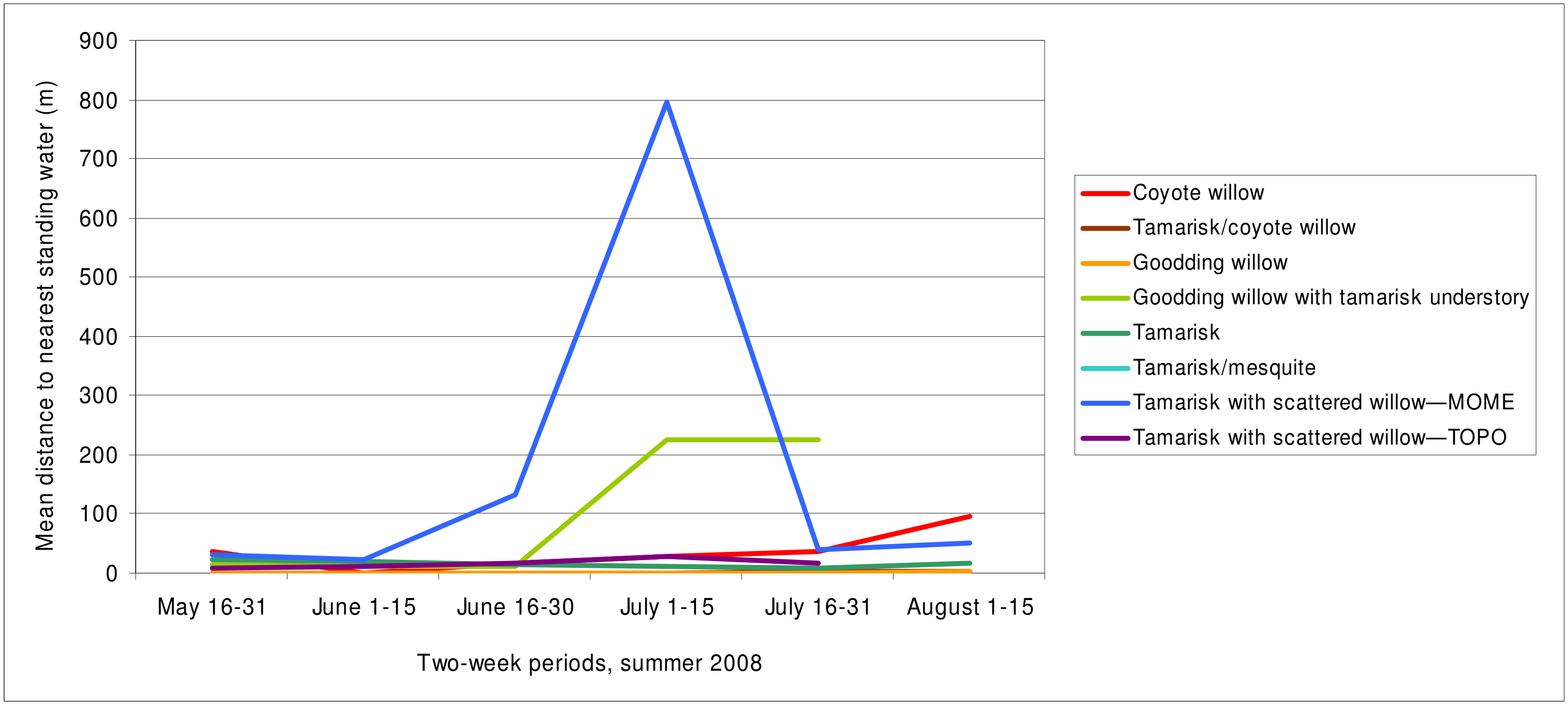

Figure 6.2. Mean distance (m) to standing water or saturated soil from Southwestern Willow Flycatcher territories in various vegetation types, Lower Colorado River and tributaries, 2008.

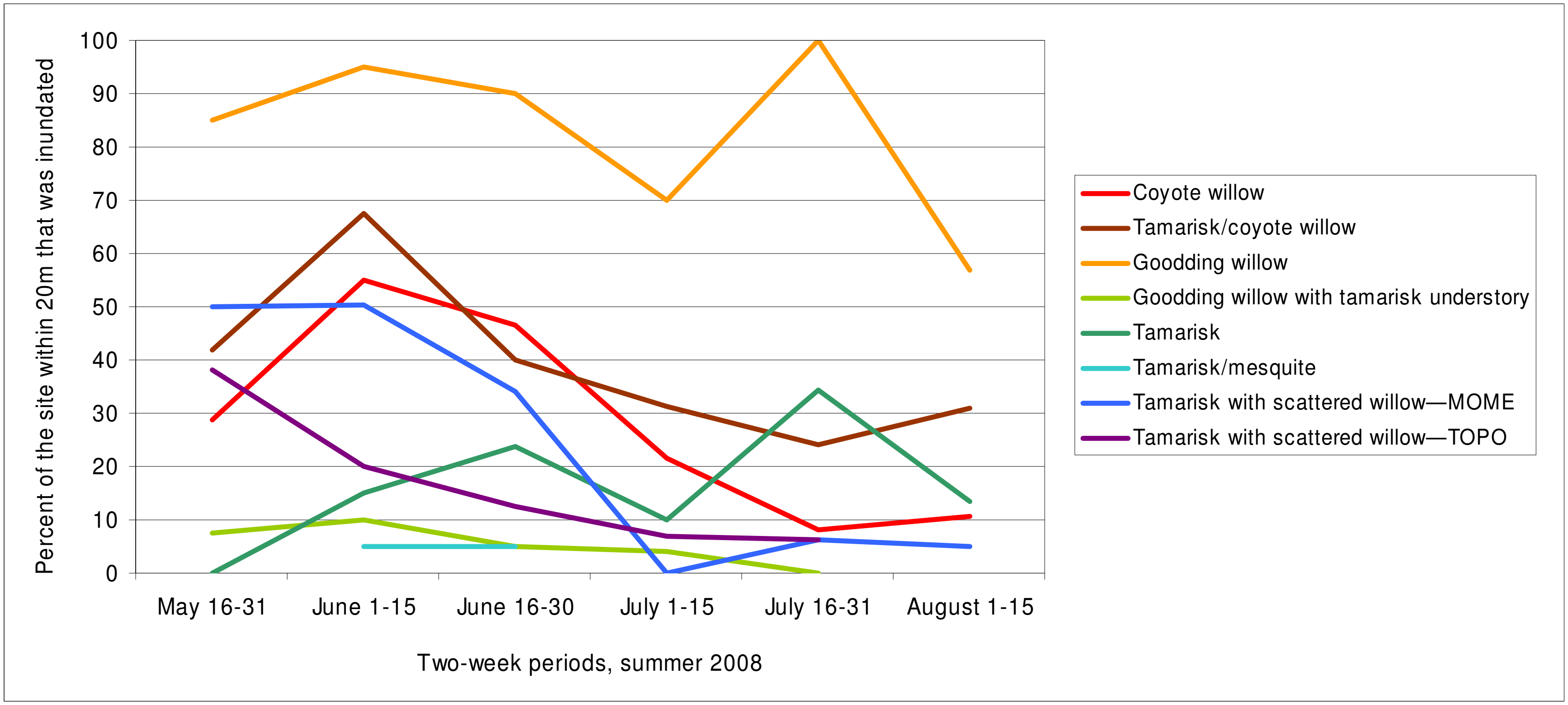

Figure 6.3. Mean percent of the area within 20 m of Southwestern Willow Flycatcher territories that contained standing water or saturated soil in various vegetation types, Lower Colorado River and tributaries, 2008.

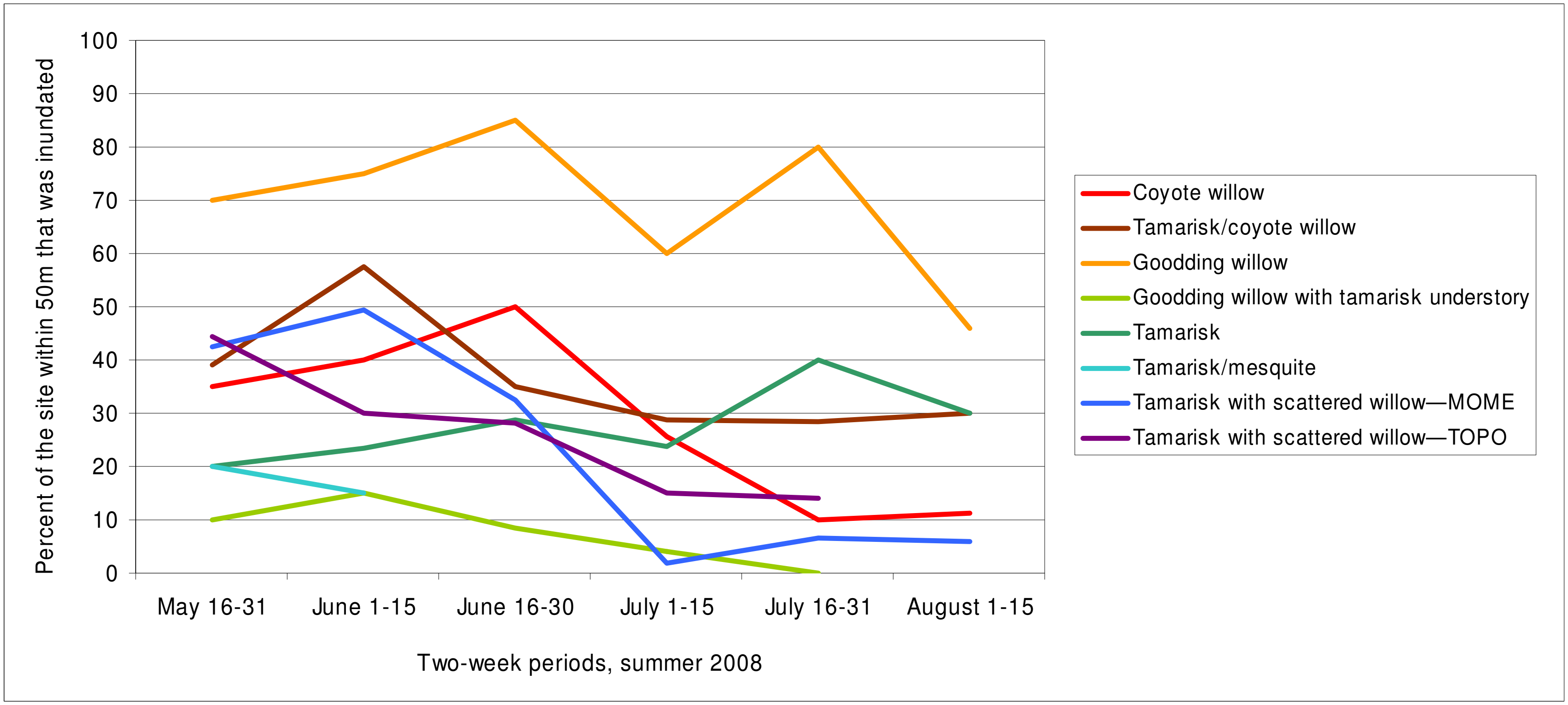

Figure 6.4. Mean percent of the area within 50 m of Southwestern Willow Flycatcher territories that contained standing water or saturated soil in various vegetation types, Lower Colorado River and tributaries, 2008. Data are summarized by two-week periods.

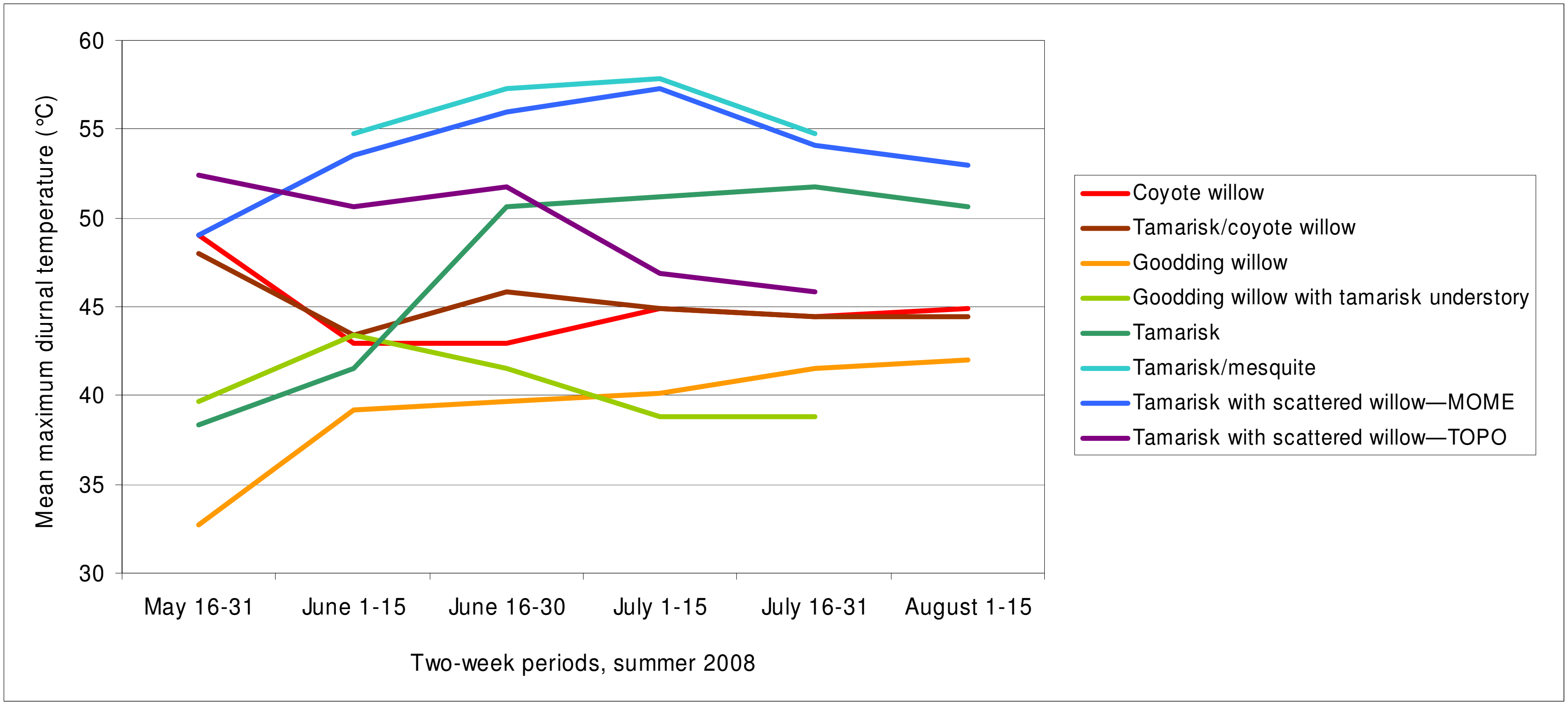

Figure 6.5. Mean maximum diurnal temperature at Southwestern Willow Flycatcher territories in various vegetation types, Lower Colorado River and tributaries, 2008.

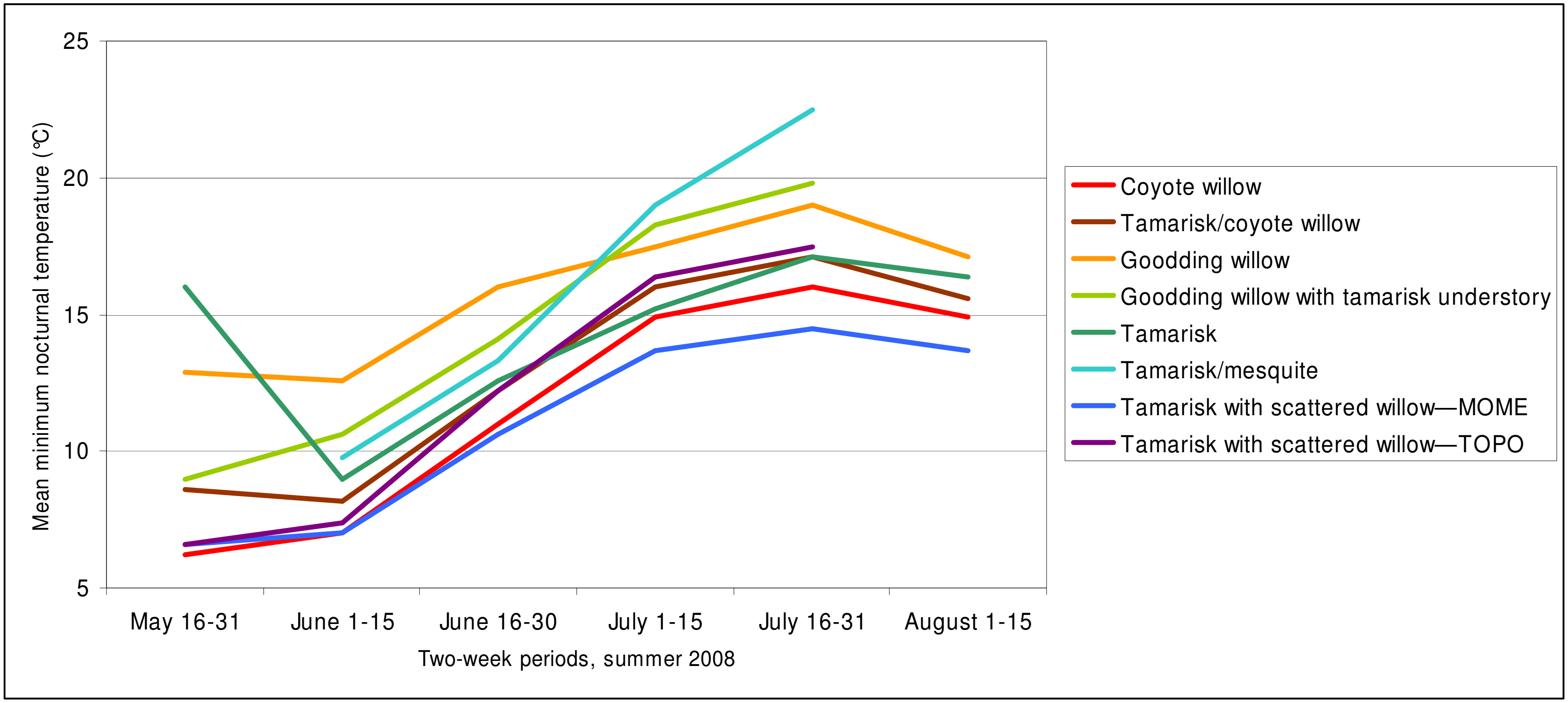

Figure 6.6. Mean minimum diurnal temperature at Southwestern Willow Flycatcher territories in various vegetation types, Lower Colorado River and tributaries, 2008.

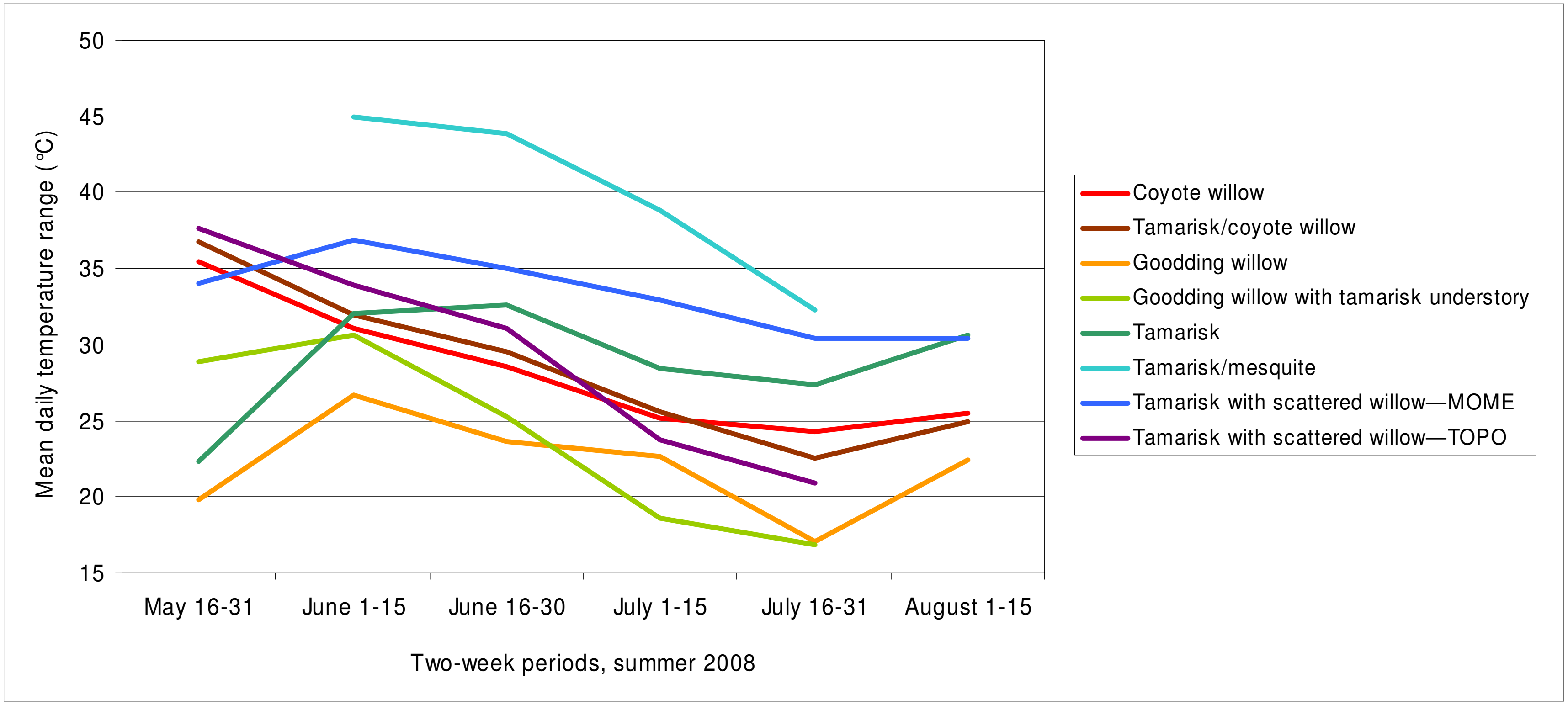

Figure 6.7. Mean daily temperature range at Southwestern Willow Flycatcher territories in various vegetation types, Lower Colorado River and tributaries, 2008.

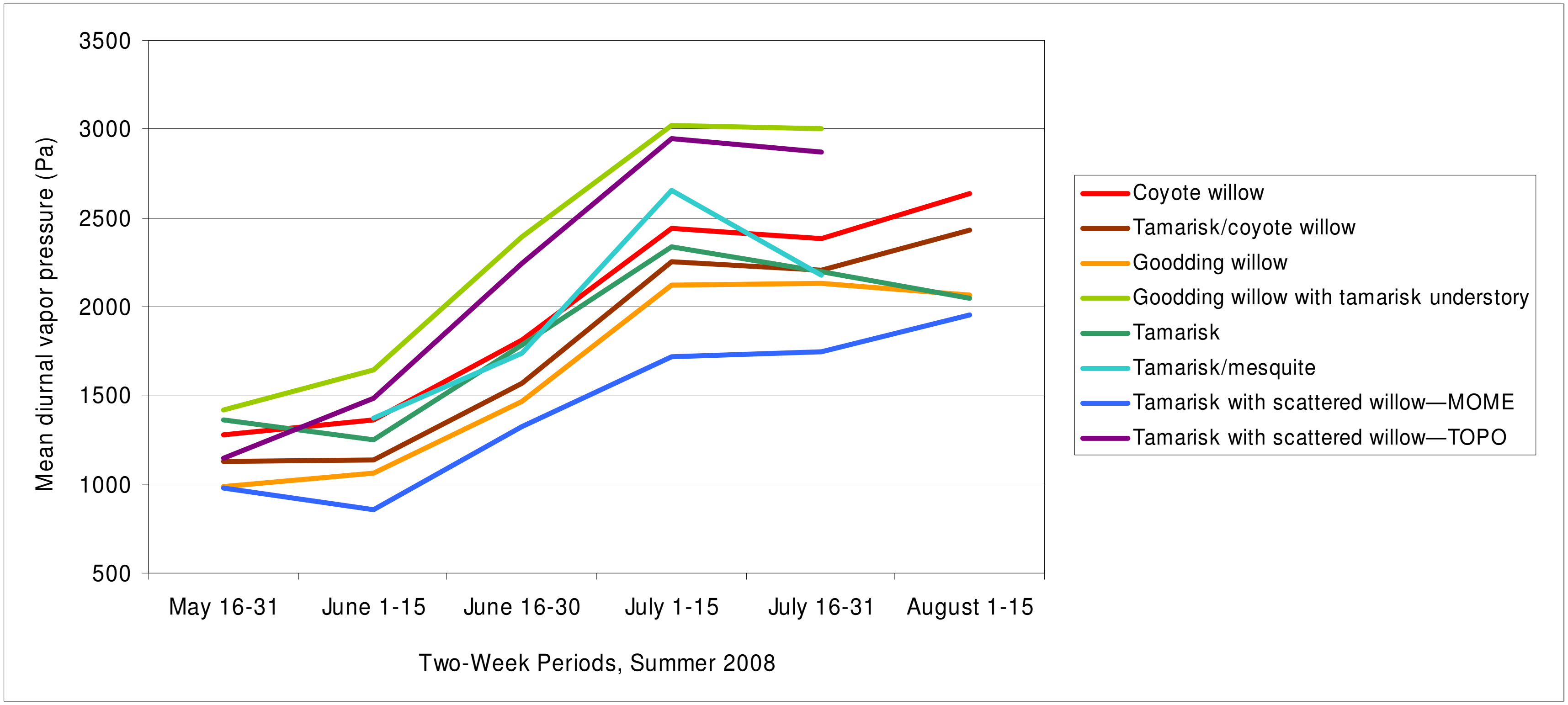

Figure 6.8. Mean diurnal vapor pressure at Southwestern Willow Flycatcher territories in various vegetation types, Lower Colorado River and tributaries, 2008.

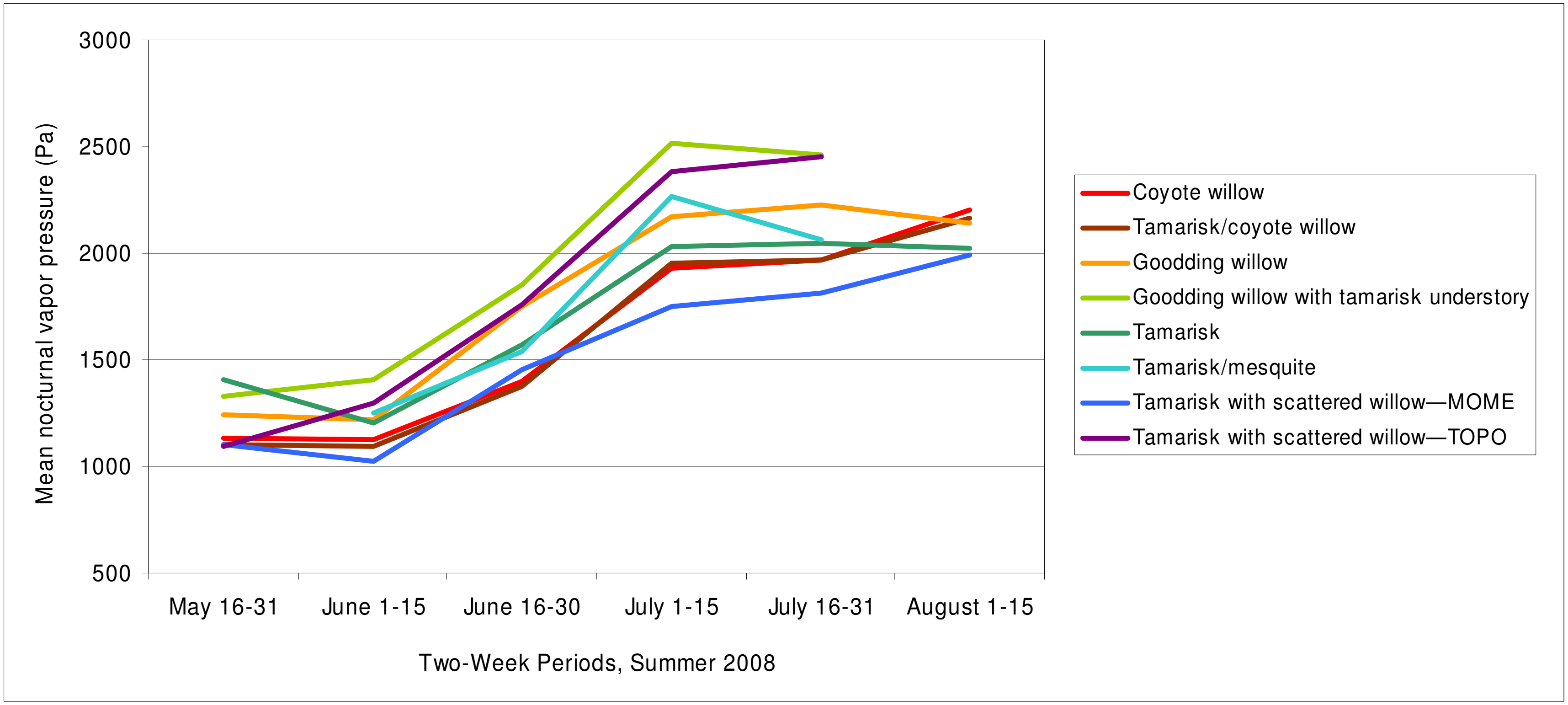

Figure 6.9. Mean nocturnal vapor pressure at Southwestern Willow Flycatcher territories in various vegetation types, Lower Colorado River and tributaries, 2008.

Daily maximum temperatures spanned a range of approximately 15°C among habitat types. Daily minimum temperatures showed a much smaller range, spanning only 5°C. Habitat types with high daily maximum temperatures also tended to have low daily minimum temperatures and thus had the largest temperature ranges. Tamarisk/mesquite and tamarisk with scattered Goodding willow at Mormon Mesa showed the highest daily temperature ranges, while Goodding willow and Goodding willow with tamarisk understory had the most moderate temperature ranges.

Vapor pressure increased throughout the season for all habitat types. Vapor pressure was highest in Goodding willow with tamarisk understory and in tamarisk with emergent Goodding willow at Topock. Vapor pressure was lowest in tamarisk with emergent Goodding willow at Mormon Mesa.

Nests in Formerly Occupied Areas

We located 44 old nests at Mesquite, Mormon Mesa, Muddy River, and Topock Marsh. We were able to locate the exact nest fork in 28 cases and located the nest tree but were unsure of the correct fork in 12 additional cases. In three cases we located the nest vicinity (within 5 m of the nest location) but were unable to verify that we had located the exact nest tree, and in one case the nest tree was clearly no longer there, and we placed the data logger on the nearest adjacent tree. Five of the 44 HOBO data loggers failed to collect data, while two data loggers collected temperature but no humidity data. Soil moisture data from the occupied period were unavailable for the three nests that were active in 2003.

Microclimate at old nests sites differed between occupied and unoccupied periods in at least one variable at both Mesquite (Table 6.9) and Mormon Mesa (Table 6.10). At Mesquite, nest sites had higher soil moisture when they were occupied versus when they were abandoned, while at Mormon Mesa nest sites had wetter soils in 2008 versus when the nest was occupied. Mean maximum diurnal temperature and mean daily temperature range were greater during the unoccupied period at Mormon Mesa. No statistically significant differences in microclimate variables were detected at Muddy River (Table 6.11) or Topock (Table 6.12) between occupied and unoccupied periods, but general trends were evident when data from all sites were examined together (Table 6.13). At three of the four study areas, nest sites had higher measures of all three temperature variables and lower measures of both humidity variables when the sites were unoccupied versus when they were occupied. Topock was the study area that generally countered these trends, with lower temperatures and higher humidity during the unoccupied period. When all sites were considered together, mean maximum diurnal temperature was significantly higher during the unoccupied period. Soil moisture, daily temperature range, and diurnal humidity all showed trends (P-values <0.1), with nest sites having more extreme temperatures and lower soil moisture and humidity during the unoccupied period.

Mean daily maximum and minimum temperature recorded at the Overton weather station did not differ between 2008 and any of the preceding five years for the June–August period. At the Needles weather station, mean maximum daily temperature was higher ($F_{5,537} = 7.6$, $P < 0.001$) in June–August 2008 (109.3 °F) than during the same period in 2004 (106.9 °F), while mean minimum daily temperature in 2008 (83.2 °F) was lower than in 2006 (86.2 °F) and higher than in 2004 (81.4 °F; $F_{5,537} = 7.8$, $P < 0.001$). Average dew point at Needles was lower ($F_{5,537} = 11.4$, $P < 0.001$) in 2008 (42.6 °F) than in 2003 (55.3 °F) or 2004 (48.6 °F).

Table 6.9. Paired T-test Results Comparing Microclimate Characteristics at Willow Flycatcher Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, Mesquite, NV

Microclimate measure	**Occupied**	**Unoccupied**	**Difference**	***P***
Soil Moisture (n = 14)				
Mean soil moisture (mV)	656.6 (82.7)	319.4 (37.8)	-326.2	**<0.01**
Temperature (n = 13)				
Mean maximum diurnal temperature (°C)	42.5 (1.7)	45.8 (1.0)	3.3	0.09
Mean minimum nocturnal temperature (°C)	15.6 (0.6)	16.1 (0.6)	0.5	0.35
Mean daily temperature range (°C)	19.7 (1.2)	22.0 (0.9)	2.2	0.12
Humidity (n = 13)				
Mean diurnal vapor pressure (Pa)	1916.4 (113.7)	1803.6 (60.7)	-112.9	0.15
Mean nocturnal vapor pressure (Pa)	1681.8 (97.7)	1609.9 (56.7)	-71.9	0.21

Table 6.10. Paired T-test Results Comparing Microclimate Characteristics at Willow Flycatcher Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, Mormon Mesa, NV

Microclimate measure	**Occupied**	**Unoccupied**	**Difference**	***P***
Soil Moisture (n = 5)				
Mean soil moisture (mV)	454.1 (135.6)	602.8 (91.1)	148.7	**0.04**
Temperature (n = 8)				
Mean maximum diurnal temperature (°C)	45.7 (1.6)	53.3 (2.7)	7.6	**0.01**
Mean minimum nocturnal temperature (°C)	16.8 (0.7)	14.9 (0.9)	-1.9	0.05
Mean daily temperature range (°C)	22.2 (1.6)	30.1 (3.7)	7.9	**0.02**
Humidity (n = 7)				
Mean diurnal vapor pressure (Pa)	1606.9 (131.9)	1587.3 (78.5)	-83.6	0.35
Mean nocturnal vapor pressure (Pa)	1671.3 (131.6)	1627.7 (101.4)	-93.5	0.20

Table 6.11. Paired T-test Results Comparing Microclimate Characteristics at Willow Flycatcher Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, Muddy River, NV

Microclimate measure	**Occupied**	**Unoccupied**	**Difference**	***P***
Soil Moisture (n = 10)				
Mean soil moisture (mV)	687.1 (42.5)	586.4 (49.9)	-90.1	0.30
Temperature (n = 9)				
Mean maximum diurnal temperature (°C)	41.1 (0.6)	42.2 (1.1)	1.1	0.33
Mean minimum nocturnal temperature (°C)	17.8 (1.1)	18.0 (1.0)	0.3	0.73
Mean daily temperature range (°C)	16.4 (1.2)	17.4 (1.5)	1.0	0.37
Humidity (n = 9)				
Mean diurnal vapor pressure (Pa)	2095.7 (133.6)	1882.9 (98.7)	-212.8	0.13
Mean nocturnal vapor pressure (Pa)	1854.8 (144.9)	1703.9 (86.0)	-151.0	0.27

Table 6.12. Paired T-test Results Comparing Microclimate Characteristics at Willow Flycatcher Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, Topock Marsh, AZ

Microclimate measure	Occupied	Unoccupied	Difference	*P*
Soil Moisture (n = 10)				
Mean soil moisture (mV)	798.1 (81.3)	915.3 (20.7)	132.7	0.11
Temperature (n = 6)				
Mean maximum diurnal temperature (°C)	40.8 (1.4)	38.0 (0.8)	-2.8	0.13
Mean minimum nocturnal temperature (°C)	15.4 (1.2)	17.8 (1.2)	2.4	0.10
Mean daily temperature range (°C)	19.4 (1.6)	13.8 (1.3)	-5.7	**0.04**
Humidity (n = 5)				
Mean diurnal vapor pressure (Pa)	2342.4 (262.4)	2603.4 (183.4)	81.9	0.74
Mean nocturnal vapor pressure (Pa)	2033.2 (183.8)	2328.7 (98.8)	170.4	0.36

Table 6.13. Paired T-test Results Comparing Microclimate Characteristics at Willow Flycatcher Nest Sites When the Nest Was Occupied Versus When the Nest Area Was Abandoned, All Sites Combined

Microclimate measure	Occupied	Unoccupied	Difference	*P*	Direction and Magnitude of Change			
					MESQ	MOME	MUDD	TOPO
Soil Moisture (n = 39)								
Mean soil moisture (mV)	674.7 (43.2)	536.4 (42.6)	-93.1	0.09	↓	↑	↓	↑
Temperature (n = 36)								
Mean maximum diurnal temperature (°C)	42.6 (0.8)	45.3 (1.1)	2.7	**0.01**	↑	↑	↑	↓
Mean minimum nocturnal temperature (°C)	16.4 (0.4)	16.6 (0.5)	0.2	0.60	↑	↓	↑	↑
Mean daily temperature range (°C)	19.4 (0.7)	21.3 (1.3)	1.9	0.09	↑	↑	↑	↓
Humidity (n = 34)								
Mean diurnal vapor pressure (Pa)	1963.5 (81.7)	1897.7 (69.9)	-104.7	0.07	↓	↓	↓	↑
Mean nocturnal vapor pressure (Pa)	1781.3 (66.9)	1744.1 (57.5)	-61.6	0.22	↓	↓	↓	↑

DISCUSSION

Currently Occupied Territories

The hydrological conditions recorded in occupied territories in 2008 showed that flycatcher territories contained damp or wet soils, with the distance to surface water generally being less than 30 m, and in most cases between 10 and 50% of the surrounding area within 50 m containing saturated or inundated soils during each visit to the site. The soil moisture conditions observed in occupied territories generally mirrored those observed at the same sites in previous years.

Tamarisk with scattered Goodding willow at Topock Marsh had the wettest conditions in May and became progressively drier through the rest of the season. Soils within the Goodding willow with tamarisk understory vegetation type also showed a general drying trend through the season, with distance to water increasing and the percentage of inundated soils decreasing. Tamarisk with scattered Goodding willow at Mormon Mesa was the only vegetation type that was influenced by an undammed river, and soil moisture conditions showed a steady drying trend until the arrival of monsoon storms in late July. In early July, prior to monsoon storms, the river went subsurface in much of the Mormon Mesa study area and there was virtually no surface water within 50 m of the active territories. After the arrival of monsoons, surface flow was restored in the river and the inundated percentage around the territories increased, though both soil moisture and inundated percentages were markedly lower than in May and June.

Coyote willow and tamarisk with coyote willow showed fluctuating soil moisture levels throughout the flycatcher breeding season, with soil moisture levels being the highest in early June and lowest in the second half of July. These habitat types are influenced by irrigation runoff, and in previous years we observed highly variable water levels within the site, with fluctuations sometimes occurring on a daily basis.

Goodding willow habitat at Overton WMA was wetter than in some previous years because of recent beaver activity that resulted in the flooding of most of the site.

Temperature and humidity varied across habitat types but followed the same patterns we had observed in some of the habitat types in previous years, with tamarisk with emergent willow at Mormon Mesa being hot and dry relative to other habitat types, and tamarisk with emergent willow at Topock being relatively humid. In general, habitats with a significant native component tended to be cooler and more thermally moderate than those dominated by tamarisk.

Nests in Formerly Occupied Territories

Willow flycatchers along the lower Colorado River and tributaries selected nest sites that were cooler, wetter, and more thermally moderate than unused sites in the adjacent landscape (McLeod et al. 2008a), and we anticipated seeing similar differences when we examined temporal, rather than spatial, variation in habitat use. We observed changes in microclimate in the direction we anticipated at Mesquite, with abandoned nest sites having drier soils and a trend toward higher maximum daily temperatures than they had when they were occupied. The change in soil moisture was likely caused by flood deposition, which altered water flow patterns in the area. These hydrological changes contributed to changes in the vegetation (see Chapter 5), with nest sites having taller canopy height, greater canopy closure, and a higher percentage of native vegetation when they were occupied. Changes in both hydrology and vegetation likely influenced microclimate; canopy height, canopy closure, and percent native vegetation are all inversely related to maximum daily temperature (McLeod et al. 2008a). There were no differences in average maximum or minimum temperature between 2008 and any of the five preceding years as recorded at the weather station in Overton; therefore, temporal differences observed at old nests in the Virgin and Muddy River area are unlikely to be the result of overall changes in regional climate.

We observed similar vegetation and temperature changes at Mormon Mesa, with abandoned nest sites having less canopy closure and more extreme temperatures than when they were occupied. We did not observe the same shift in soil moisture conditions, however, with abandoned nest sites actually having higher soil moisture than when they were occupied. Soil moisture in 2008 was likely influenced by a rain storm immediately prior to collecting soil moisture readings in late July. Soil moisture at the nests at Mormon Mesa when they were occupied was lower than in any of the other study areas. It is possible that these areas at Mormon Mesa were already dry and in decline when they were occupied in 2003 and 2004.

We did not observe any statistically significant changes in microclimate at old nests at Muddy River, although the direction of change of all variables was consistent with what we observed at Mesquite. As discussed in Chapter 5, occupancy at Muddy River may have been influenced by bulldozing activity in the vicinity, rather than by changes at the nest sites themselves.

Temporal changes in microclimate at Topock were opposite those we would have expected, with old nest sites having a smaller temperature range when unoccupied. The direction of change in soil moisture and humidity was also counter to what would be anticipated, with nest sites having higher soil moisture and higher humidity when unoccupied. These changes are also counter to what was observed at the Needles weather station, which had higher maximum temperature and lower dew point in 2008 than in 2004; thus, regional climate is unlikely to have influenced the changes we observed at the old nests. The data from Topock show no evidence that nest sites were abandoned because of changes in moisture or temperature that led to less suitable microclimate conditions. As discussed in Chapter 5, changes in occupancy patterns at Topock may be related to varying numbers of territorial individuals rather than to temporal changes in habitat suitability.

Chapter 7

HABITAT MONITORING: PARKER TO IMPERIAL DAMS

INTRODUCTION

Southwestern Willow Flycatcher nests and breeding territories are typically located near rivers, streams, and open water (Sogge and Marshall 2000) or over wet soil (Flett and Sanders 1987, Harris et al. 1987, Harris 1991). Nest substrate plants are often rooted in or overhang standing water. Although the association between breeding flycatchers and open water or wet soil is widely recognized by managers and scientists alike, the exact nature of the association is poorly quantified. Water may be a direct environmental cue for flycatcher nesting behavior or it may be the ultimate cause of proximate factors such as vegetation composition and structure, prey base, and microclimate.

Anthropogenic or natural modifications to surface water resources (i.e., fluvial hydrology and geomorphology) can modify existing and potential flycatcher breeding habitat and therefore have the potential to modify flycatcher abundance, distribution, and nesting success (Graf et al. 2002). For example, nine flycatcher territories at San Marcial on the middle Rio Grande in New Mexico exhibited a near absence of nesting attempts in 1996 when a combination of drought, upstream dam operations, and upstream withdrawals for irrigation removed all surface water (Johnson et al. 1999). This was in contrast to previous (1994, 1995) and subsequent (1997) years when active nests were documented at the site, with the river flowing in those years. A nearby control site that contained water exhibited multiple nesting attempts during all four years, leading Johnson et al. (1999) to suggest that the presence of water was a fundamental requirement for nesting. A similar pattern was observed along the Gila River in Arizona when decreased streamflow from 2002 to 2004 coincided with the number of flycatcher territories declining by nearly half each year (Munzer et al. 2005). Since 2004, flows within the Gila River have been greater and more consistent, and correspond with a continuing increase in flycatcher territories (14 to 62) from 2004 to 2008 (Graber and Koronkiewicz 2008). The high degree to which willow flycatchers are associated with standing water can also be seen by correlating flycatcher habitat occupancy and breeding patterns with the presence/absence of standing water in areas like Bill Williams, with flycatchers breeding only in years when sites contained standing water (this document Chapter 2).

Flow characteristics of the lower Colorado River have been modified by numerous dams and irrigation withdrawals (Rosenberg et al. 1991). The river reach between Parker Dam and Imperial Dam is regulated by releases from Parker Dam, which has been in operation since 1939. Existing riparian habitat in the Parker to Imperial reach has likely adjusted to historical water release patterns from Parker Dam and appears to be in a stable or declining condition (Lower Colorado River Multi-Species Conservation Program 2004). Implementation of the Secretarial Implementation Agreements/California 4.4 Plan (hereafter SIAs) by Reclamation would change the point of diversion for up to 400,000 acre-feet of California apportionment water for up to 75 years (USFWS 2001). The point of diversion, previously located below Parker Dam at Imperial Dam, would change to a point above Parker Dam, resulting in lower water levels in the river between Parker and Imperial. The change in point of diversion was scheduled to begin in 2002.

River flow changes related to the change in point of diversion have the potential to further modify riparian habitats below Parker Dam, habitats that are presently considered potentially suitable for willow flycatcher (USFWS 2001:47). Reclamation (2000) estimated that implementation of the SIAs will cause a drop in floodplain groundwater levels of 1.55 feet (0.47 m) or less. As a result, 372 acres (151 ha) of occupied[1] Southwestern Willow Flycatcher habitat could lose their moist soils. This loss could influence plant species composition (loss of cottonwood and willow) and structure (loss of vegetation volume) over an undetermined length of time. In addition, Reclamation estimated that 5,404 acres (2,187 ha) of potential flycatcher habitat could be influenced by the drop in groundwater level. These changes may affect the distribution, abundance, occupancy, and prey base of Southwestern Willow Flycatchers in the Parker to Imperial reach.

In 2004, Reclamation completed a pilot year of habitat monitoring by deploying temperature/ humidity data loggers at several sites in the Parker to Imperial reach. Reclamation then initiated a more comprehensive, long-term study in 2005 for the purpose of addressing how the above hydrological changes might affect riparian habitats along the Parker to Imperial reach. The objective is to monitor 372 acres (151 ha) of occupied Southwestern Willow Flycatcher habitat between Parker and Imperial Dams for 10–15 years to determine how microclimate, vegetation, and groundwater conditions might be affected by the SIAs water transfer actions. Monitoring did not commence until after diversions started; therefore, antecedent conditions are unknown and monitoring analyses focus on detecting change through time rather than comparing current conditions to a baseline. An additional objective was to compare microclimate characteristics of sites in the Parker to Imperial reach with those at flycatcher breeding areas. This chapter reports the results of this study to date.

METHODS

In 2005, we selected a subset of sites that are currently surveyed for the presence of willow flycatchers for inclusion in the habitat monitoring study. We chose 11 sites distributed along the Parker to Imperial reach that are reasonably accessible, and where we believed groundwater levels were influenced primarily by river levels and not by outside sources such as irrigation return flows. Chosen sites equated to at least 75.3 ha (186 acres) on the California side of the lower Colorado River and at least 75.3 ha (186 acres) on the Arizona side. We also chose four control sites, two above Parker Dam and two below Imperial Dam, to distinguish any changes in microclimate, groundwater, or vegetation caused by water transfer actions from those caused by fluctuations in climate or rainfall. We monitored these same 15 sites from 2005 to 2008. In August of 2006, we initiated habitat monitoring within a consistently occupied breeding site at Topock Marsh to obtain groundwater levels and patterns with which we can compare results obtained at the habitat monitoring sites.

Temperature/Humidity (T/RH) Loggers

In 2005, we deployed HOBO H8 Pro (Onset Computer Corporation, Pocasset, MA) temperature/humidity data loggers at several locations within each site selected for habitat monitoring. All loggers collected data at 15-minute intervals and were placed in inverted plastic containers and camouflaged as described in Chapter 6. All 60 logger locations selected in 2005 were retained in 2006. Two additional data loggers were installed in the Topock Marsh monitoring site in August 2006. A portion of Gila Confluence North, one of the control sites below Imperial Dam, burned in December 2006. As a result of the fire, all vegetation at one HOBO location at the site was killed, and vegetation at another HOBO location was dramatically reduced. These two HOBOs were replaced in May 2007 with HOBOs at new locations within unburned portions of the site.

[1] As per the USFWS, occupied Southwestern Willow Flycatcher habitat is defined as patches of vegetation that are similar to and contiguous with areas where willow flycatchers were detected after 15 June in any year since surveys began in 1996.

Soil Moisture (SM) Measurements

Soil moisture beneath each HOBO logger was measured and recorded using a hand-held ThetaProbe ML2x coupled to an HH2 Moisture Meter Readout (Macaulay Land Use Research Institute, Aberdeen, UK, and Delta-T Devices, Cambridge, UK, respectively). Soil moisture measurements were collected during each presence/absence survey between 15 May and 25 July and when HOBO data were downloaded. Soil moisture measurements, percent of the area containing inundated or saturated soil, and distance to water were recorded as described in Chapter 6.

Vegetation Measurements

We completed vegetation measurements, following the methods described in Chapter 5, at each HOBO location after flycatcher surveys were completed in late July. All HOBO loggers were also downloaded at this time. Vegetation measurements were completed at the same locations as in 2005–2007, with the exception of Gila Confluence North, where vegetation measurements were collected at the two new HOBO locations established in 2007.

Groundwater Measurements

A small-diameter shallow well, or piezometer, was installed in May–August 2005 near each of the 15 sites selected for habitat monitoring to monitor groundwater levels. These 15 piezometers are described in Koronkiewicz et al. (2006a) and were initially downloaded in August–September 2005. One additional piezometer was installed at Topock Marsh in 2006. The piezometer at the Gila Confluence North monitoring site was moved to a new location in July 2007 because the original station was damaged in the brush fire referred to above. In March 2008, a new piezometer was installed at the Cibola Lake monitoring site to replace the original station, which was bulldozed sometime during the summer of 2007.

Piezometer Installation

Installation of the Cibola Lake replacement piezometer employed the same installation process as described in previous reports. The specific model of pressure transducer installed in the original 16 piezometers (In-Situ MiniTroll 500) is no longer manufactured. The Cibola Lake piezometer now makes use of the newest generation of pressure transducer (In-Situ LevelTroll 500), as will any replacement equipment in the future.

Data Collection

A pressure transducer/data logger (15 mini-Troll Standard-P, 5psi and one level-troll 500, 5psi, manufactured by In-Situ Corporation) collected data at each piezometer. These devices measure and record pressure of the water column present in the well, and these pressure measurements are then converted into water levels (in distance below top of casing). Vented cables with data-transfer ports were also used for each data logger. With these cables there is no need to correct measurements for atmospheric pressure changes, and the data can be downloaded at the wellhead without disturbing the pressure transducer in the well.

During the initial installation of the pressure transducers, as well as at each data download thereafter, water levels were manually measured in the piezometers using an electric water level sounder (Solinst-brand). These known water levels were then used to program the pressure transducer with a baseline measurement from which all other automatically recorded water levels were calculated. The pressure transducers recorded water levels in the piezometers every hour.

Because the pressure transducer is almost the same diameter as the inside of the piezometer, inserting the pressure transducers tends to change the water levels in the piezometer temporarily but drastically. This disturbance persists until the water levels in the piezometer come back into equilibrium with water levels in the aquifer. In areas where there are tight, clayey soils, there can be a slight discrepancy between the pressure transducer measurement of water levels and actual water levels. This discrepancy can be adjusted with a simple correction.

We obtained additional hydrologic data from the U.S. Geological Survey (USGS) regarding streamflow and stage height in the Colorado River at several gages: Colorado River below Parker Dam (09427520) and Colorado River below Imperial Dam (09429500). Lake water levels were also obtained from the USGS for Lake Havasu. In addition, daily water releases were obtained from the Bureau of Reclamation for Parker Dam.[2] Our goal was to define the relationship between the water levels in the piezometers and operation of the reservoirs on the Colorado River.

Statistical Analyses

Microclimate

The following values were calculated for all 15 habitat monitoring sites:

- Mean soil moisture from plot center to 2.0 m from plot center
- Mean distance to saturated/inundated soil
- Mean diurnal temperature
- Mean number of 15-minute intervals above 41°C each day
- Mean nocturnal temperature
- Mean daily temperature range (diurnal maximum minus nocturnal minimum)
- Mean diurnal relative humidity
- Mean diurnal vapor pressure
- Mean nocturnal relative humidity
- Mean nocturnal vapor pressure

The diurnal and nocturnal periods were determined from the daily sunrise and sunset times reported for the region by the National Weather Service (2008).

These values were then calculated for all sites combined and compared to the same values for territory locations at Topock Marsh combined with two sensors placed near the piezometer at Topock Marsh, which was within 50 m of a territory center. These analyses were restricted to 6 May–31 July 2008, the dates during which microclimate data were collected both within territories at Topock and at habitat monitoring locations. One-way ANOVA tests were used to test the difference in means for the T/RH and SM values.

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

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

Vegetation

We analyzed the between-year differences among the test sites compared to the control sites using one-way repeated measures ANOVA. These analyses and all descriptive statistics were produced using SPSS® Version 16.0 (SPSS Inc.) software. We excluded vertical foliage density measurements at 5 m from plot center from the analysis so as to have comparable data across years.

Groundwater Levels

We examined the following correlations between piezometer levels and reservoir operations:
1) correlation of the Havasu NE piezometer (control site) with Lake Havasu water levels; and
2) correlation of nine test site piezometers between Parker and Imperial Dams (Ehrenberg, Three Fingers Lake, Walker Lake, Hoge Ranch, Rattlesnake, Clear Lake, Ferguson Wash, Ferguson Lake, and Great Blue Heron) with releases (in cubic feet per second, or cfs) from Parker Dam, which largely regulates streamflow in the lower Colorado River between Parker and Imperial Dams.

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

We examined monthly river flow data from below Parker Dam from 2000 to 2008 to determine whether there has been a decrease in water levels since the scheduled implementation of the change in point of diversion from Imperial Dam to above Parker Dam, which began in early 2001.

Reclamation (2000) estimated the expected change in river stage between Parker and Imperial Dams that would result from a 400,000 acre-foot reduction in releases from Parker Dam. In previous reports (McLeod et al. 2007), this expected reduction in river stage was extended using regression equations developed from the piezometer measurements to predict the corresponding change in groundwater level below each habitat polygon. This analysis was not repeated for this report.

In addition to correlating piezometer levels with reservoir operations, we used linear regression to examine potential relationships between average daily piezometer level and average daily soil moisture. These analyses were conducted using the built-in analysis functions of Microsoft Excel. Piezometer water levels were also compared to ground surface to determine whether any inundation or standing water was observed at the piezometer locations.

Groundwater fluctuations are the reflection of various inflows or outflows from the shallow aquifer system below the habitat. Longer-term fluctuations, on the weekly or seasonal scale, are mostly linked to variation in reservoir releases and flow in the Colorado River. Shorter-term fluctuations, those that take place over the course of a single day, are the result of the removal of water from the shallow aquifer through evapotranspiration by riparian habitat. The magnitude of these fluctuations can potentially be used to estimate changes in vegetation density or vegetation cover over time. The magnitude of the daily evapotranspiration signature was calculated from the difference between the minimum and maximum water levels that occurred during each day, and the median of the daily results was calculated for each month during 2006 (the first full season of data) and 2007. Changes in the magnitude of the evapotranspiration signature over time will be correlated to actual field measurements of vegetation density or cover.

RESULTS

HOBO Logger Maintenance

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

Piezometer Installation and Maintenance

Table 7.1 lists details on installation parameters for all piezometers. Data from all piezometers were downloaded in December 2005; June and September 2006; February, July, and August of 2007; and February and September of 2008. All pressure transducers except those at Three Fingers Lake and Walker Lake have experienced some data breaks over their lifetime, primarily due to battery failure (Table 7.1). Isolated incidents of battery failure are expected in field equipment, and battery voltage is routinely monitored at the time of each download. However, such widespread and consistent failure appears to be systemic and is currently being addressed with the equipment manufacturer.

Table 7.1. Summary of Piezometer Construction and Data Collection at Habitat Monitoring Sites, Lower Colorado River, 2005–2008*

Site	Depth (ft)	Stickup height (ft)	Date installed	Data breaks	Distance (ft) from habitat
Topock Marsh	INA	2.5	13-Aug-06	16 Dec 2007–27 Feb 2008 After 24 Jun 2008	Within
Blankenship Bend	7.2	3.4	28-Aug-05	After 12 Aug 2007	Within
Havasu NE	6.1	2.2	09-May-05	26 Dec 2007–26 Feb 2008	Within
Ehrenburg	7.4	2.6	29-Aug-05	5 Jul–28 Aug 2007	Within
Three Fingers Lake	7.7	4.1	31-May-05	N/A	540
Cibola Lake	7.2	3.4	30-May-05[1]	29 Sep–13 Dec 2005 After 15 Feb 2007	Within
Walker Lake	7.4	2.9	30-May-05	N/A	230
Paradise	11.7	0.6	11-May-05	7 May–12 Jun 2006 3–29 Aug 2007 15 Sep 2007–28 Feb 2008 After 5 Mar 2008	Within
Hoge Ranch	8.7	2.8	11-May-05	10 Sep 2007–21 Feb 2008 After 17 Jun 2008	Within
Rattlesnake	7.0	2.8	10-May-05	After 15 Apr 2008	1,080

Table 7.1. Summary of Piezometer Construction and Data Collection at Habitat Monitoring Sites, Lower Colorado River, 2005–2008* (Continued)

Site	Depth (ft)	Stickup height (ft)	Date installed	Data breaks	Distance (ft) from habitat
Clear Lake	8.7	2.4	10-May-05	After 17 Apr 2008	Within
Ferguson Lake	7.6	2.7	10-May-05	After 7 Apr 2008	Within
Ferguson Wash	INA	2.2	10-May-05	24 Jan–20 Feb 2008 After 7 Aug 2008	Within
Great Blue Heron	7.3	1.7	31-May-05	30 Aug–15 Dec 2005 After 28 Jul 2008	60
Mittry West	5.0	3.0	29-Aug-05	4–19 Feb 2008	270
Gila Confluence North	7.9	2.7	29-Aug-05[2]	After fire 5 Jul 2007	50

* INA = information not available, N/A = not applicable.

[1] Piezometer destroyed by clearing activity between February and July 2007; replaced 27 March 2008.

[2] Location of original piezometer burned in December 2006; piezometer replaced on 5 July 2007.

In addition to the battery failure incidents that resulted in complete failure of the unit to collect data, some periods of data from Blankenship and Paradise are suspect. The Blankenship pressure transducer began to return anomalous data and stopped collecting data altogether shortly after the August 2007 download. Batteries were changed during the February 2008 download and the unit was restarted. During the September 2008 download, the pressure transducer failed to communicate with the Rugged Reader and after numerous attempts the download process was abandoned. The Paradise pressure transducer stopped collecting data shortly after both the August 2007 download and the February 2008 download; fresh batteries were installed at each download. For the purposes of analysis, all data after August 2007 were disregarded for both Blankenship and Paradise.

In July 2007, a replacement piezometer at the Gila Confluence North station was installed approximately 0.1 mile north of the original location. This station used the original pressure transducer, which was not damaged in the fire; however, a replacement cable was installed. The pressure transducer appears to have been malfunctioning since reinstallation; it is collecting data but there are no fluctuations in the data, and the data do not match the manual measurements. For the purposes of analysis, all post-fire data have been disregarded.

During the 2007 field season, the Cibola Lake piezometer had been cleared and bulldozed, and no trace of the piezometer could be located. On 27 March 2008, a replacement piezometer was installed on an island within Cibola Lake, adjacent to one of the HOBO monitoring sites. As of this report, the station is operational but no data has been downloaded from the site. One attempt was made in October 2008, but there was a hardware compatibility issue with the driver for the serial cable adapter that connects the field laptop to the pressure transducer, thus impeding any download attempts.

Microclimate

2008 Microclimate Descriptive Statistics

Soil moisture, temperature, relative humidity, and vapor pressure parameters from the 15 study sites monitored in 2008 exhibited substantial variation among sites (Table 7.2). Soil moisture varied by a factor of six among the 2008 study sites, from a low of 194.7 mV at Havasu NE to a high of 951.3 at Great Blue Heron.

Mean diurnal temperatures ranged from a low of 28.3°C at Rattlesnake and a high of 37.4°C at Cibola Lake. Mean nocturnal temperatures ranged from a low of 20.2°C again at Rattlesnake and a high of 26.0°C at Ferguson Wash. Mean number of 15-minute intervals above 41°C each day varied from 1.8 at Rattlesnake to 24.7 at Cibola Lake. Mean daily temperature range varied from 21.3°C at Ferguson Lake to 33.3°C at Three Fingers Lake.

Mean diurnal relative humidity ranged from 23.5% at Cibola Lake to 52.6% at Rattlesnake. Mean diurnal vapor pressure was lowest at Cibola Lake (1,047.6 Pa) and highest at Rattlesnake (1,900.9 Pa). Mean nocturnal vapor pressure was lowest at Havasu NE (974.4 Pa) and highest at Rattlesnake (1,683.7 Pa).

Between-year Comparisons of Microclimate Characteristics

Microclimatic characteristics at habitat monitoring sites varied significantly over time at test sites (Cibola Lake, Clear Lake, Ehrenberg, Ferguson Lake, Ferguson Wash, Great Blue Heron, Hoge Ranch, Paradise, Rattlesnake, Three Fingers Lake, and Walker Lake; Table 7.3). At control sites (Blankenship Bend, Gila Confluence North, Havasu NE, Mittry West), only mean nocturnal temperature and nocturnal vapor pressure varied significantly over time. In 2007 and 2008, mean soil moisture increased at both test and control sites. Mean diurnal temperature, mean number of 15 minute intervals above 41°C each day, and mean nocturnal temperature all decreased slightly in 2008 for control sites, but remained about the same as in 2007 for test sites. For both test and control sites, all measures of humidity and vapor pressure decreased in 2007 compared to 2006, but increased in 2008. Except for soil moisture, the changes over time were the same for test sites and controls (right-most column of Table 7.3).

Table 7.2. Microclimatic Data Summaries Collected From Habitat Monitoring Sites, Lower Colorado River, May–July 2008*

Descriptive Statistics	Blankenship Bend	Havasu NE	Ehrenberg	Three Fingers Lake	Cibola Lake	Walker Lake	Paradise	Hoge Ranch	Rattlesnake	Clear Lake	Ferguson Lake	Ferguson Wash	Great Blue Heron	Mittry West	Gila Confluence North
Soil Moisture															
Mean soil moisture (mV)	795.3 (72.1)	194.7 (34.1)	642.3 (46.6)	672.1 (36.2)	458.3 (47.8)	928.6 (14.9)	791.1 (69.5)	868.2 (9.4)	867.7 (11.0)	453.3 (78.9)	936.2 (11.0)	213.1 (16.6)	951.3 (2.5)	914.2 (6.2)	498.4 (57.1)
Temperature/Humidity															
Mean diurnal temperature (°C)	32.9 (0.3)	31.4 (0.3)	36.2 (0.3)	34.6 (0.3)	37.4 (0.3)	30.1 (0.2)	32.9 (0.3)	32.2 (0.3)	28.3 (0.2)	29.4 (0.2)	31.6 (0.2)	31.9 (0.2)	30.2 (0.2)	32.1 (0.2)	33.5 (0.3)
Mean no. of 15-min. intervals above 41°C each day	13.3 (0.8)	7.9 (0.6)	19.2 (0.7)	21.6 (0.6)	24.7 (0.7)	7.5 (0.4)	13.4 (0.8)	12.4 (0.5)	1.8 (0.2)	3.6 (0.3)	9.0 (0.5)	11.2 (0.6)	5.2 (0.3)	9.6 (0.6)	13.6 (0.7)
Mean nocturnal temperature (°C)	23.1 (0.3)	23.6 (0.3)	23.3 (0.3)	23.0 (0.3)	23.3 (0.3)	22.3 (0.3)	24.1 (0.3)	23.2 (0.3)	20.2 (0.2)	23.0 (0.3)	24.7 (0.3)	26.0 (0.3)	21.9 (0.2)	22.9 (0.3)	22.0 (0.3)
Mean daily temperature range (°C)	25.8 (0.4)	22.6 (0.5)	29.0 (0.4)	33.3 (0.4)	30.6 (0.3)	24.7 (0.4)	26.0 (0.5)	28.0 (0.4)	22.2 (0.3)	22.4 (0.4)	21.3 (0.3)	22.3 (0.4)	23.9 (0.3)	25.0 (0.4)	28.7 (0.4)
Mean diurnal relative humidity (%)	32.1 (0.8)	26.5 (0.6)	23.6 (0.5)	28.3 (0.6)	23.5 (0.5)	43.5 (0.7)	35.9 (0.6)	39.8 (0.7)	52.6 (0.8)	47.4 (0.9)	39.2 (0.6)	39.5 (0.7)	45.1 (0.7)	39.6 (0.6)	35.8 (0.6)
Mean diurnal vapor pressure (Pa)	1316.9 (38.0)	1079.8 (29.2)	1175.1 (29.3)	1116.1 (30.0)	1047.6 (26.5)	1606.9 (37.8)	1495.5 (31.1)	1596.4 (29.2)	1900.9 (43.1)	1832.4 (45.5)	1555.1 (31.8)	1601.4 (32.3)	1772.3 (38.9)	1632.8 (35.8)	1503.2 (36.8)
Mean nocturnal relative humidity (%)	46.6 (0.9)	33.4 (0.7)	45.9 (0.8)	47.8 (0.6)	46.6 (0.7)	55.9 (0.7)	48.5 (0.6)	53.3 (0.7)	68.9 (0.7)	54.3 (0.8)	50.8 (0.6)	42.5 (0.7)	58.8 (0.6)	53.5 (0.6)	57.2 (0.6)
Mean nocturnal vapor pressure (Pa)	1299.3 (34.1)	974.4 (25.7)	1287.8 (29.5)	1228.1 (26.2)	1284.8 (24.6)	1475.6 (30.8)	1432.1 (28.9)	1476.1 (26.0)	1683.7 (32.8)	1555.1 (36.5)	1542.7 (27.2)	1378.9 (28.8)	1583.2 (30.3)	1494.2 (28.1)	1509.3 (33.3)

* Soil moisture and temperature/humidity values are means (standard error in parentheses).

Table 7.3. Change in Microclimatic Variables at Habitat Monitoring Sites from 2005 to 2008*

Parameter	Test (n=45)								Control (n=15)								P-value for difference between years among test sites compared to control sites
	2005	2006	2007	2008	Change 2005 to 2006	Change 2006 to 2007	Change 2007 to 2008	P-value for the difference between years	2005	2006	2007	2008	Change 2005 to 2006	Change 2006 to 2007	Change 2007 to 2008	P-value for the difference between years	
Soil Moisture																	
Mean soil moisture (mV)	645.7	634.4	662.9	702.2	-11.3	28.5	39.3	<0.001	694.4	582.9	635.3	638.8	-111.5	52.4	3.5	0.175	<0.001
Temperature/Humidity																	
Mean diurnal temperature (°C)	33.8	36.2	34.3	34.7	2.4	-1.9	0.4	<0.001	33.9	36.8	34.6	34.3	2.9	-2.2	-0.3	0.073	0.344
Mean no. of 15 min. intervals above 41°C each day	14.9	17.1	16.1	16.4	2.2	-1	0.3	0.002	15.0	19.8	16.5	13.7	4.8	-3.3	-2.8	0.406	0.253
Mean nocturnal temperature (°C)	25.9	28.8	25.3	26.1	2.9	-3.5	0.8	<0.001	24.8	28.2	25.0	25.7	3.4	-3.2	0.7	<0.001	0.734
Mean daily temperature range (°C)	24.4	21.5	25.6	25.7	-2.9	4.1	0.1	<0.001	25.2	24.0	26.9	24.7	-1.2	2.9	-2.2	0.153	0.237
Mean diurnal relative humidity (%)	40.0	45.3	37.5	39.6	5.3	-7.8	2.1	<0.001	37.0	39.7	35.1	36.8	2.7	-4.6	1.7	0.151	0.451
Mean diurnal vapor pressure (Pa)	1,745.0	2,304.4	1,620.3	1765.5	559.4	-684.1	145.2	<0.001	1,654.9	2,083.5	1,593.2	1676.3	428.6	-490.3	83.1	0.131	0.485
Mean nocturnal relative humidity (%)	50.8	55.4	49.4	51.7	4.6	-6	2.3	<0.001	51.5	51.5	46.9	48.2	0	-4.6	1.3	0.490	0.796
Mean nocturnal vapor pressure (Pa)	1,634.4	2,100.5	1,540.4	1675.5	466.1	-560.1	135.1	<0.001	1,576.0	1,898.8	1,452.3	1559.4	322.8	-446.5	107.1	0.015	0.514

* The analysis was restricted to 1 June–1 August each year.

Comparison of Parker/Imperial to Topock: Microclimate

All microclimate parameters except for mean soil moisture were significantly different between Topock Marsh and the habitat monitoring sites (Table 7.4). Topock was cooler and exhibited higher relative humidity and vapor pressure than habitat monitoring sites.

Table 7.4. Comparison of Microclimatic Variables at Habitat Monitoring Sites to Territories at Topock Marsh, 2008*

Response Variable	Habitat Monitoring Sites	Topock Marsh	*P*
N (Temp./Humidity Sensor Arrays)	57	11[1]	N/A
Soil Moisture			
Mean soil moisture (mV)	683.6 (39.7)	783.3 (73.9)	0.301
Temperature/Humidity			
Mean diurnal temperature (°C)	32.9 (0.4)	29.0 (0.6)	<0.001
Mean no. of 15 min. intervals above 41°C each day	13.0 (1.2)	3.1 (1.2)	0.001
Mean nocturnal temperature (°C)	23.6 (0.3)	21.7 (0.5)	0.005
Mean daily temperature range (°C)	25.9 (0.8)	21.6 (0.9)	0.019
Mean diurnal relative humidity (%)	36.8 (1.3)	55.7 (2.5)	<0.001
Mean diurnal vapor pressure (Pa)	1500.4 (46.2)	2,101.1 (73.2)	<0.001
Mean nocturnal relative humidity (%)	50.9 (1.2)	67.2 (2.6)	<0.001
Mean nocturnal vapor pressure (Pa)	1,441.1 (28.9)	1,760.4 (48.0)	<0.001

* Soil moisture and temperature/humidity values are means (standard error in parentheses). N/A = data not available or not applicable. The analysis was restricted to 6 May–31 July 2008.

[1] This includes nine territory locations and two HOBOs placed near the piezometer.

Vegetation Measurements

Vegetation characteristics varied widely both between and within the selected habitat monitoring sites (Table 7.5). Average canopy height ranged from 3.5 m (Three Fingers Lake) to 10.4 m (Ehrenberg), and average canopy closure ranged from 69.9% (Ehrenberg) to 98.0% (Ferguson Lake). Measures of other habitat characteristics were similarly variable. Vertical foliage profiles for each site are shown in Figure 7.1. Sites typically exhibited the densest foliage within 4–5 m of the ground, and the majority of vegetation within 2–3 m of the ground typically consisted of dead branches.

Between-year Comparisons of Vegetation Characteristics

Average values of canopy height, canopy closure, woody ground cover, percent of the basal area in each plot that consisted of native vegetation, and live and dead stems in <2.5 cm, 2.5–8.0 cm, and >8 cm dbh size categories for both test and control sites by year are shown in Table 7.6. Repeated measures ANOVA comparing these variables between years showed an overall between-year difference in canopy closure ($P = 0.001$), woody ground cover ($P < 0.001$), and number of dead stems 2.5–8 cm dbh ($P = 0.003$) for all plots combined. There were no significant interactions between canopy closure or number of dead stems 2.5–8 cm dbh and location (test vs. control sites), meaning the change in these variables between years among test sites was not significantly different from the change at control sites. Across all sites, canopy closure decreased between 2005 and 2006 and then increased in 2007 and 2008 to values higher than those recorded in 2005. The number of dead stems 2.5–8 cm dbh was lower in 2006 and 2007 than in 2005 or 2008. Percent woody ground cover was higher in 2008 than in previous years.

Table 7.5. Summary of Vegetation Characteristics at Habitat Monitoring Sites, Lower Colorado River, 2008*

Parameter	Blankenship Bend (n=4)	Havasu NE (n=4)	Ehrenberg (n=4)	Cibola Lake (n=5)	Three Fingers Lake (n=5)	Walker Lake (n=3)	Paradise (n=4)	Hoge Ranch (n=4)	Rattlesnake (n=4)	Clear Lake (n=3)	Ferguson Lake (n=5)	Ferguson Wash (n=4)	Great Blue Heron (n=4)	Mittry West (n=4)	Gila Confluence North (n=3)
Average canopy height (m)	7.8 (2.4)	5.2 (0.9)	10.4 (4.4)	5.1 (0.9)	3.5 (0.1)	4.8 (0.8)	8.4 (2.3)	6.5 (1.6)	7.5 (1.3)	7.6 (0.2)	5.6 (0.2)	6.0 (0.5)	8.3 (1.2)	10.0 (2.2)	7.8 (0.4)
	5.1–15.0	3.4–7.5	2.5–20.7	3.4–8.5	3.2–3.8	4.0–5.5	3.4–14.0	4.0–11.3	5.5–10.0	7.4–8.0	5.0–6.0	5.2–7.5	6.0–11.6	6.0–14.4	7.0–8.5
% total canopy closure	76.0 (12.5)	87.8 (2.6)	69.9 (5.2)	76.4 (10.0)	72.5 (9.7)	94.8 (0.3)	89.6 (5.3)	95.7 (0.9)	95.4 (2.7)	97.4 (0.8)	93.9 (2.9)	98.0 (0.2)	94.7 (2.5)	93.1 (2.0)	84.9 (8.1)
	39.1–92.7	82.3–93.2	60.4–83.9	37.5–90.6	43.2–94.3	94.3–95.3	74.0–97.9	94.3–97.9	87.5–99.0	96.4–99.0	84.9–99.0	97.4–98.4	87.5–97.9	89.6–96.9	68.9–94.8
% woody ground cover	78.4 (11.3)	53.8 (13.5)	22.4 (2.7)	32.9 (6.2)	14.4 (3.3)	59.9 (8.8)	73.2 (14.3)	60.3 (4.5)	65.1 (8.3)	35.4 (19.2)	23.4 (4.3)	57.2 (9.8)	29.9 (9.7)	48.2 (9.8)	24.6 (3.6)
	53.8–98.8	30.0–82.5	17.5–28.8	19.8–56.0	5.5–23.8	46.0–76.2	36.8–100.0	47.5–68.8	41.2–79.2	15.0–73.8	11.5–32.5	37.8–83.8	8.0 (47.5)	18.8–58.8	17.5–28.8
# live stems <2.5 cm dbh per ha	1178 (262)	255 (90)	1178 (272)	1019 (420)	4711 (2230)	1188 (679)	1178 (660)	2324 (1906)	159 (95)	467 (297)	738 (136)	350 (175)	764 (214)	891 (382)	1316 (699)
	509–1655	127–509	509–1782	255–2547	1146–13496	509–2546	0–3056	0–8021	0–382	0–1019	382–1146	0–764	509–1401	255–1783	127–2547
# live stems 2.5–8 cm dbh per ha	2133 (466)	828 (184)	191 (82)	5220 (1180)	10008 (2090)	1740 (667)	3565 (2455)	4361 (2226)	2515 (1011)	2037 (1528)	4304 (797)	2292 (227)	3692 (807)	2546 (1346)	3353 (1154)
	1146–2929	382–1273	0–382	764–7257	5220–15788	891–3056	127–10823	127–10186	764–4329	509–5093	1910–6366	1910–2801	1655–5602	0–6239	1783–5602
# live stems >8 cm dbh per ha	859 (131)	668 (334)	159 (61)	713 (435)	102 (102)	334 (42)	318 (152)	95 (61)	1401 (425)	1612 (542)	637 (139)	1401 (392)	923 (204)	668 (354)	722 (42)
	509–1445	255–1655	0–255	0–2419	0–509	255–383	127–764	0–255	509–2546	891–2674	382–1146	764–2546	637–1528	0–1655	637–764
# dead stems <2.5 cm dbh per ha	1241 (80)	1846 (663)	2419 (1561)	764 (255)	3743 (1094)	85 (85)	318 (184)	1814 (607)	64 (64)	170 (112)	1120 (321)	223 (80)	127 (90)	1082 (282)	1358 (478)
	1019–1401	0–2928	255–6875	0–1528	1655–7768	0–255	0–637	764–3565	0–255	0–382	127–2037	0–382	0–382	637–1910	509–2164
# dead stems 2.5–8 cm dbh per ha	1273 (375)	987 (383)	2101 (1848)	2063 (453)	4736 (1187)	478 (478)	32 (32)	2196 (772)	350 (217)	2122 (170)	2827 (959)	1528 (308)	700 (278)	2069 (516)	1188 (594)
	509–2037	0–1655	0–7639	382–3056	2928–9422	0–1655	0–127	255–3947	0–891	1783–2292	1019–6239	1019–2419	0–1146	891–3056	0–1783
# dead stems >8 cm dbh per ha	127 (90)	64 (64)	0 (0)	51 (51)	0 (0)	0 (0)	0 (0)	95 (95)	0 (0)	722 (405)	0 (0)	382 (138)	127 (90)	32 (32)	0 (0)
	0–382	0–255	0–0	0–255	0–0	0–0	0–0	0–382	0–0	0–1401	0–0	127–764	0–382	0–127	0–0
Percent basal area native	26.9 (23.9)	13.5 (10.4)	83.1 (16.8)	0.0 (0.0)	0.0 (0.0)	32.6 (32.6)	23.5 (23.2)	63.9 (18.1)	27.5 (24.3)	0.0 (0.0)	3.5 (3.5)	25.8 (17.6)	38.6 (22.9)	70.4 (23.7)	100.0 (0)
	0–98.4	0–44.0	32.8–100.0	0–0	0–0.1	0–97.8	0–93.0	29.7–98.8	0–100.0	0–0	0–17.5	0–75.5	0–95.8	0–100.0	100.0–100.0

* Data presented are means, (standard error), and range.

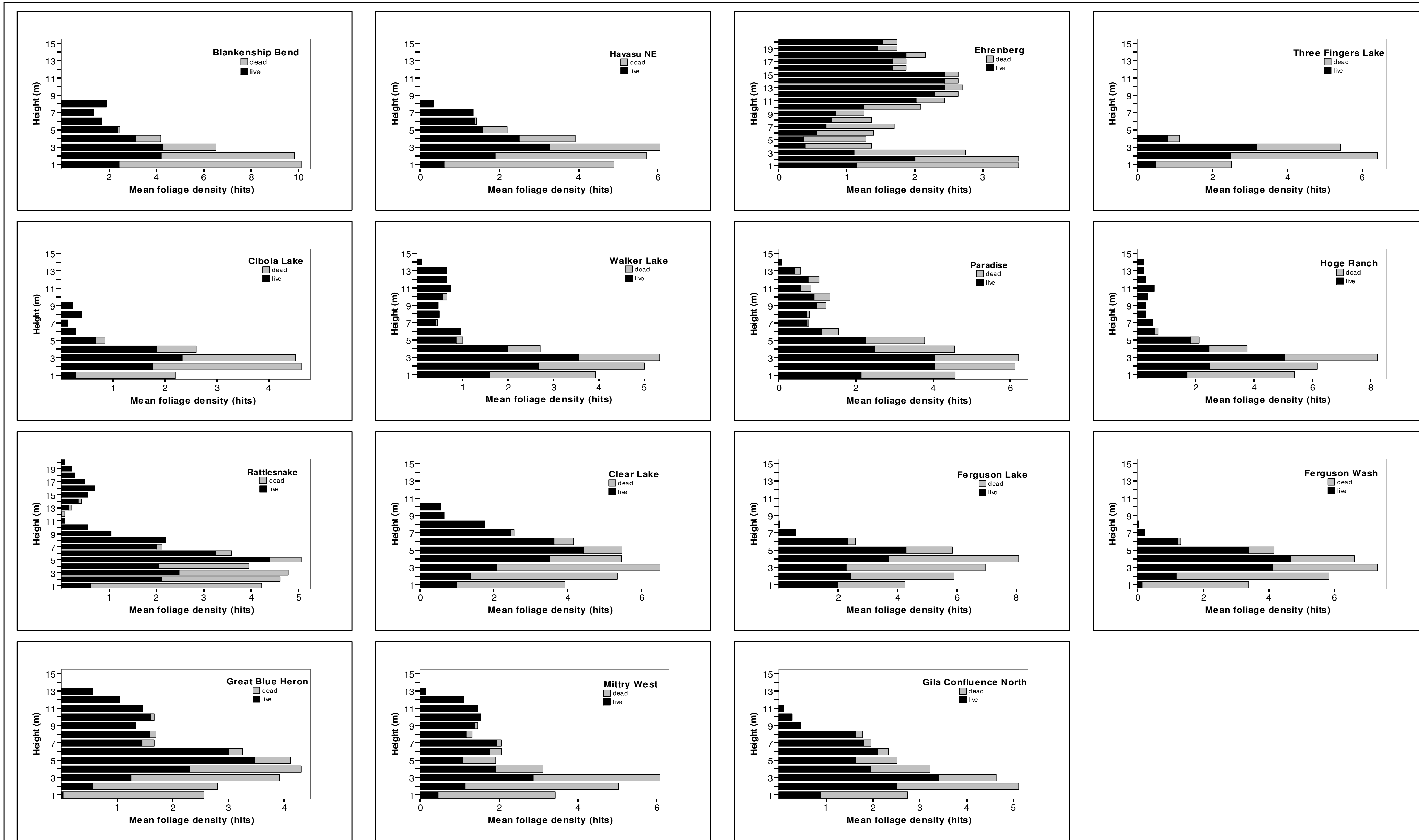

Figure 7.1. Vertical foliage profiles for each habitat monitoring site, lower Colorado River, 2008.

Table 7.6. Annual Means of Vegetation Characteristics at Plots between Parker and Imperial Dams (Test Sites) and Plots above Parker or below Imperial (Control Sites), 2005–2008

Parameter	Test				Control				P-value for overall difference in means between years	P-value for difference in means between years among test sites compared to control sites
	2005	2006	2007	2008	2005	2006	2007	2008		
Average canopy height (m)	6.4	6.8	5.7	6.6	6.3	6.6	6.9	7.1	0.666	0.545
% total canopy closure	84.7	78.3	87.9	88.1	81.1	76.1	87.1	84.3	0.001	0.869
% woody ground cover	31.1	27.2	29.8	41.6	27.3	48.8	39.3	56.8	<0.001	0.002
# live stems <2.5 cm dbh per ha	1933	2272	2515	1358	955	2186	1655	743	0.013	0.627
# live stems 2.5–8 cm dbh per ha	3107	2722	3143	3899	1613	1984	1910	1963	0.376	0.440
# live stems >8 cm dbh per ha	481	430	654	673	668	594	690	753	0.081	0.838
# dead stems <2.5 cm dbh per ha	340	1282	1259	1084	803	1305	1294	1422	0.058	0.786
# dead stems 2.5–8 cm dbh per ha	1234	821	925	1879	1284	456	711	1528	0.003	0.836
# dead stems >8 cm dbh per ha	48	59	96	108	64	95	148	74	0.243	0.526
Percent basal area native	27.2	20.3	28.9	25.9	36.7	39.5	58.1	45.2	0.017	0.148

There was a significant interaction between year and location for woody ground cover ($P = 0.002$). Average woody ground cover increased at control plots between 2005 and 2006 and then decreased in 2007, while it did not change at test plots across those years.

Repeated measures ANOVAs for vertical foliage in each meter interval showed no significant between-year differences in live vegetation but showed between-year differences for the first, second, third, and fourth meter intervals above the ground for dead vegetation. In all cases, density of dead vegetation was higher in 2008 than in 2007. There was a significant interaction ($P = 0.037$) between live vertical foliage density and location (test vs. control sites) for the fourth meter interval, but there was no clear pattern, with density increasing at control plots in years it decreased at test plots, and vice versa. There was also a significant interaction ($P < 0.001$) between dead vertical foliage density and location for the first meter interval, with the density of dead vegetation increasing more in 2007 and 2008 at control plots relative to test plots.

Groundwater Monitoring

Overview of Piezometer Groundwater Levels

More than two full years of data have been collected at 15 of the 16 piezometers (excluding Topock Marsh, which has nearly two full years of data), with the exception of the data breaks noted in Table 7.1.

The piezometer hydrographs generally exhibit some common characteristics. Two general trends, a weekly trend and a daily cycle, are apparent. Groundwater levels were lowest during the afternoon hours and on weekends, while high groundwater levels were observed in early morning hours and in the middle of the week. The weekly trend is the result of reservoir operation and changes in river water levels; the daily trend is the result of evapotranspiration of water from the aquifer. Both trends are useful for analysis.

A third general trend, a seasonal pattern, has appeared in the hydrographs as multiple years of data have been recorded. In the majority of the hydrographs, the lowest groundwater levels occurred in the winter and highest groundwater levels occurred in the spring (Table 7.7). Average monthly groundwater level ranges from inundated conditions at Mittry West to over 6 feet below ground surface at Paradise, with an average seasonal water level change of just over 2 feet. Hydrographs for all piezometers are included in Appendix E. For 2008, the data trend is very similar to that of previous years, with some sites having slightly higher and lower maximum and minimum groundwater levels.

Table 7.7. High and Low Average Monthly Water Depths Recorded at Piezometers at Habitat Monitoring Sites, August 2005–August 2008

Location	Shallowest water level (ft bgs)	Month occurred	Deepest water level (ft bgs)	Month occurred
Topock	1.52	March	2.1	September
Blankenship Bend	1.99	June	3.70	December
Havasu NE	1.55	June	2.82	February
Ehrenburg	0.72	April	3.75	December
Three Fingers Lake	2.1	April	4.81	December
Cibola Lake	2.16	April	4.59	November
Walker Lake	4.15	March	5.32	July
Paradise	4.61	April	6.66	December
Hoge Ranch	1.4	April	4.68	December
Rattlesnake	0.52	April	3.40	December
Clear Lake	1.47	April	3.81	January
Ferguson Lake	0.97	April	3.15	December
Ferguson Wash	1.14	April	3.11	December
Great Blue Heron	0.63	April	2.43	December
Mittry West	-0.22	April	2.13	January
Gila Confluence North[1]	2.94	October	4.29	August

[1] Data from two locations

Correlation of Piezometer Groundwater Levels with Reservoir Releases

Lake Havasu Water Levels – There is a strong correlation ($R^2 = 0.96$) between water levels in Lake Havasu as measured by the USGS and groundwater levels below the habitat as measured in the Havasu NE piezometer (Figure 7.2). Data prior to August 2007 (before erroneous data collection) indicated that the piezometer at Blankenship Bend appears to be too far upstream to be strongly correlated with lake levels, showing a correlation through the same period with an R^2 value of only 0.09.

Colorado River Water Levels – Data were collected between August 2005 and September 2008 in hourly intervals and averaged by the day. The “best fit” time lag varied from two days for the upstream piezometers (Hoge Ranch, Cibola, Ehrenberg, Paradise and Three Fingers Lake) to three days for the downstream piezometers (Rattlesnake, Clear Lake, Ferguson Lake, Ferguson Wash, and Great Blue Heron). The best fit R^2 statistics varied from 0.71 to 0.94 (Table 7.8). Piezometer levels at Walker Lake had no correlation ($R^2 = 0.15–0.16$) to releases from Parker Dam. Additionally, the relationship between piezometer levels at Mittry West and releases from Imperial Dam was examined for the entire time period (May 2005–September 2008). There was no correlation between releases and water levels (best $R^2 = 0.003$).

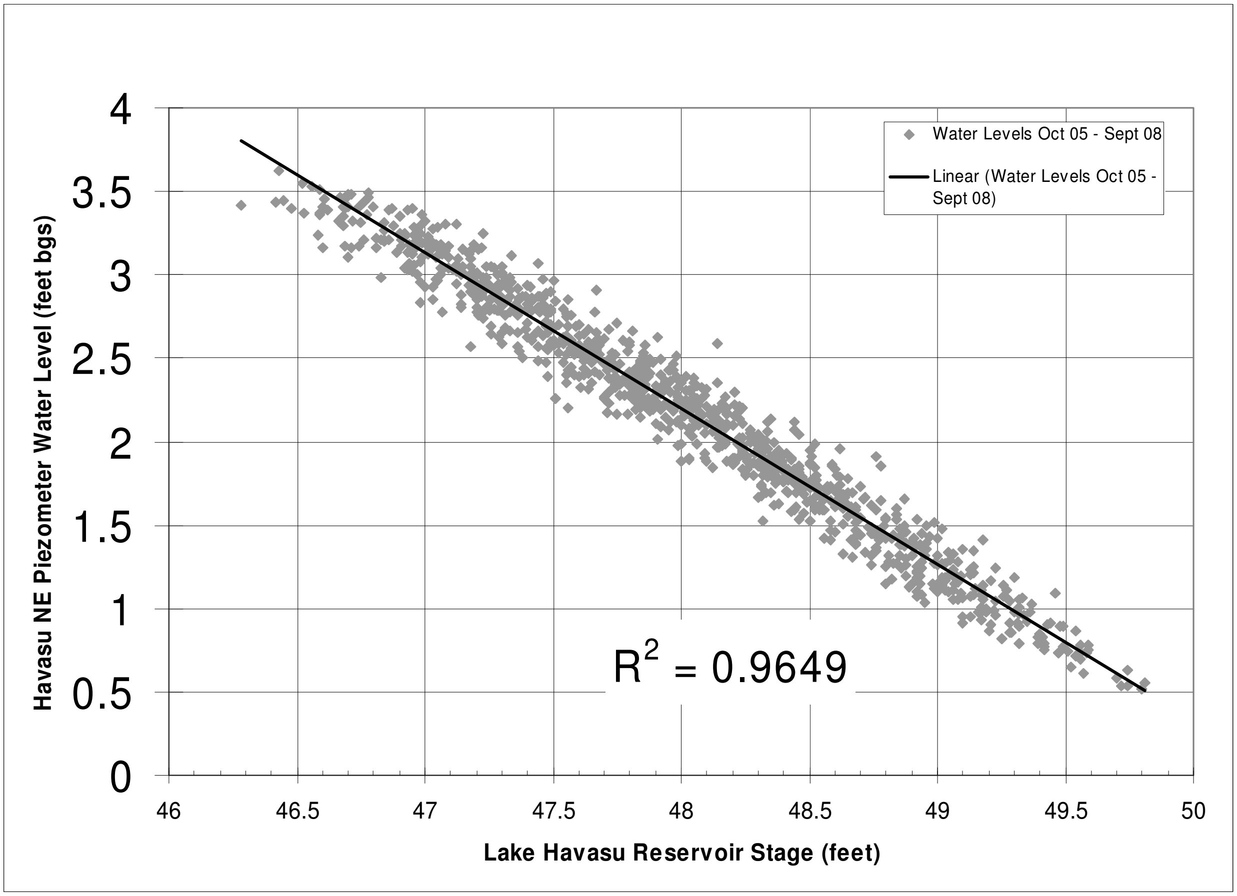

Figure 7.2. Correlation of Havasu NE piezometer and Lake Havasu water levels, October 2005–September 2008. Line shows linear regression.

Table 7.8. Correlation (R^2 Statistic) of Parker Dam Daily Releases (cfs) with Average Daily Groundwater Levels (feet bgs) of Piezometers at Habitat Monitoring Sites, September 2006–September 2008*

Site	Time Lag				
	None	1 day	2 days	3 days	4 days
Ehrenberg	0.82	0.92	0.93	0.85	0.78
Cibola Lake	0.26	0.45	0.66	0.47	0.29
Three Fingers Lake	0.78	0.87	0.94	0.84	0.77
Walker Lake	0.16	0.16	0.15	0.15	0.16
Paradise	0.69	0.79	0.91	0.82	0.72
Hoge Ranch	0.66	0.75	0.84	0.74	0.66
Rattlesnake	0.66	0.71	0.77	0.80	0.74
Clear Lake	0.77	0.81	0.89	0.92	0.87
Ferguson Lake	0.68	0.72	0.88	0.93	0.83
Ferguson Wash	0.56	0.60	0.68	0.71	0.63
Great Blue Heron	0.67	0.71	0.79	0.86	0.83

* Shaded cells indicate best correlation.

Planned Declines in Parker Releases – An examination of monthly river flows below Parker Dam from 2000 to 2008 (Table 7.9) revealed there has been a noticeable decline in reservoir releases during most months. While there is moderate variation, average monthly flow decreased from 2001 (the year prior to the scheduled change in point of diversion) to present, with the percent decrease ranging from 13.4% in January 2008 to 31.7% in December of 2007. The decreases occurred throughout the year except for February–April. March experienced an increase of average flow for 2008; releases for February and April were roughly equivalent to those in 2001.

Table 7.9. Average Monthly Flows (cfs) Below Parker Dam, 2000–2008

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**Difference (2001–present)**	**% Change (2001–present)**
January	6,820	5,599	6,478	6,327	5,536	4,166	5,842	5,945	4,850	-749	-13.4%
February	9,123	8,505	8,978	6,881	7,129	4,888	7,798	8,491	8,232	-273	-3.2%
March	11,594	10,524	11,334	12,360	11,523	9,699	9,752	11,122	12,180	1,656	15.7%
April	14,613	14,090	13,610	13,803	12,824	11,356	11,985	12,618	14,293	203	1.4%
May	14,174	14,068	12,826	11,990	12,252	11,428	11,998	11,718	11,339	-2,729	-19.4%
June	13,803	14,733	13,713	12,778	12,741	12,444	12,383	12,116	11,957	-2,776	-18.8%
July	14,210	14,974	14,439	13,100	12,331	13,842	11,688	12,180	12,226	-2,748	-18.4%
August	11,441	12,047	12,118	10,803	11,420	10,316	10,141	10,317	10,720	-1,327	-11.0%
September	11,233	10,837	10,429	11,159	9,566	9,048	7,334	9,195	9,072	-1,765	-16.3%
October	9,362	8,852	8,765	9,761	7,405	6,967	7,424	7,204	7,568	-1,284	-14.5%
November	7,437	7,357	7,049	6,153	5,163	6,335	6,094	5,420		-1,937	-26.3%
December	6,706	5,970	5,615	5,737	4,129	4,841	5,507	4,079		-1,891	-31.7%

Correlation of Piezometer Groundwater Levels with Soil Moisture Measurements

Linear regressions between the average soil moisture measurements and the average daily groundwater level in the piezometer for that site show little to no correlation between these two variables (R^2 = 0.0–0.50; Table 7.10). Analysis included all available data from 2005 to 2008.

Table 7.10. Results of Linear Regression Between Average Daily Piezometer Groundwater Levels and Soil Moisture at Habitat Monitoring Sites, Lower Colorado River, 2005–2008

Site	Number of data points	Range of soil moisture values (mV)	Median soil moisture value (mV)	R^2
Blankenship Bend	15	393–1070	960	0.24
Havasu NE	27	12–907	188	0.02
Ehrenburg	23	51–1018	624	0.00
Cibola Lake	22	11–994	296	0.04
Three Fingers Lake	40	49–1012	477	0.00
Walker Lake	36	519–1504	931	0.04
Paradise	26	45–1020	683	0.00
Hoge Ranch	34	452–1313	877	0.01
Rattlesnake	34	99–994	816	0.37
Clear Lake	29	54–1017	404	0.03
Ferguson Lake	34	437–1020	938	0.50
Ferguson Wash	39	34–643	167	0.01
Great Blue Heron	30	336–991	920	0.00
Mittry West	30	431–1018	909	0.22
Gila Confluence North	17	96–937	332	0.00
Topock	27	864–975	908	0.01

Presence of Standing Water

Data from Gila Confluence North indicate that the piezometer location was inundated from 18 to 20 October 2005 to a depth up to 1.4 feet. Data from Mittry West indicate that piezometer location was inundated four times in three different years: 22 April–2 May 2006 to a depth up to 0.2 feet; 5 April–5 May 2007; 20 March–19 May 2008; and 24–25 May 2008. Data from two other sites, Three Fingers Lake and Rattlesnake, also indicated possible inundation, but repeated differences between data logger and manual measurements suggest these data may not be accurate. Topock did not appear to have encountered standing water based on piezometer measurements.

Evapotranspiration Signature

Nearly all the sites exhibit a typical seasonal trend in evapotranspiration, with the magnitude of the daily evapotranspiration signature peaking between June and September (Tables 7.11 and 7.12). The Ehrenberg piezometer exhibited duplicate measurements occurring in a 23-hour cycle beginning in November 2005; this equipment malfunction was investigated with the manufacturer but was not able to be resolved until July 2007. Ehrenberg data are not presented here for 2006 or 2007. The difference between 2006 and 2007 is shown in Table 7.13.

Table 7.11. Magnitude of Daily Evapotranspiration Signature, January–December 2006

Site	Median of Daily Water Level Fluctuation (feet)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Blankenship Bend	0.231	0.294	0.499	0.769	0.812	0.732	0.802	0.834	0.841	0.680	0.407	0.241
Havasu NE	0.150	0.180	0.236	0.277	0.304	0.288	0.302	0.300	0.243	0.208	0.157	0.177
Cibola Lake	0.331	0.434	0.417	0.394	0.476	0.535	0.488	0.538	0.544	0.462	0.498	0.321
Three Fingers Lake	0.418	0.586	0.637	0.820	0.972	0.982	0.900	0.878	0.817	0.651	0.626	0.416
Walker Lake	0.043	0.044	0.066	0.432	0.759	0.896	0.847	0.792	0.677	0.612	0.442	0.075
Paradise	0.373	0.411	0.464	0.488	0.611	0.716	0.646	0.609	0.562	0.526	0.489	0.356
Hoge Ranch	0.587	0.707	0.725	0.702	0.895	0.903	0.800	0.889	0.839	0.786	0.666	0.529
Rattlesnake	0.224	0.215	0.202	0.256	0.272	0.327	0.239	0.285	0.319	0.273	0.237	0.261
Clear Lake	0.129	0.126	0.117	0.148	0.138	0.148	0.126	0.162	0.168	0.145	0.119	0.116
Ferguson Lake	0.221	0.202	0.218	0.236	0.247	0.279	0.182	0.257	0.253	0.201	0.226	0.183
Ferguson Wash	0.239	0.221	0.219	0.225	0.271	0.254	0.176	0.239	0.270	0.235	0.248	0.209
Great Blue Heron	0.073	0.093	0.102	0.105	0.154	0.154	0.174	0.205	0.184	0.142	0.133	0.080
Mittry West	0.014	0.023	0.041	0.042	0.077	0.108	0.131	0.140	0.122	0.083	0.058	0.019
Gila Confluence North	0.061	0.130	0.062	0.084	0.090	0.110	0.108	0.113	0.106	0.145	0.083	0.039
Topock	-	-	-	-	-	-	-	0.510	0.515	0.239	0.092	0.017

Table 7.12. Magnitude of Daily Evapotranspiration Signature, January–December 2007

Site	Median of Daily Water Level Fluctuation (feet)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Blankenship Bend	0.271	0.461	0.432	0.789	0.737	0.650	0.722	-	-	-	-	-
Havasu NE	0.173	0.184	0.186	0.311	0.310	0.305	0.308	0.313	0.231	0.187	0.145	0.135
Cibola Lake	0.316	0.335	-	-	-	-	-	-	-	-	-	-
Three Fingers Lake	0.401	0.582	0.742	0.975	1.049	1.024	0.932	1.016	0.750	0.578	0.426	0.324
Walker Lake	0.047	0.051	0.105	0.462	0.788	0.875	0.868	0.790	0.719	0.619	0.438	0.060
Paradise	0.306	0.378	0.473	0.614	0.704	0.677	0.680	-	-	-	-	-
Hoge Ranch	0.458	0.673	0.710	0.877	0.976	0.978	0.922	1.089	0.731	-	-	-
Rattlesnake	0.165	0.306	0.314	0.279	0.256	0.357	0.385	0.315	0.203	0.209	0.237	0.289
Clear Lake	0.078	0.141	0.139	0.125	0.127	0.143	0.185	0.143	0.115	0.099	0.095	0.110
Ferguson Lake	0.159	0.192	0.256	0.242	0.209	0.282	0.233	0.219	0.190	0.180	0.200	0.208
Ferguson Wash	0.161	0.210	0.240	0.231	0.194	0.263	0.232	0.242	0.201	0.183	0.215	0.287
Great Blue Heron	0.071	0.093	0.123	0.099	0.113	0.138	0.142	0.173	0.165	0.146	0.112	0.100
Mittry West	0.012	0.019	0.037	0.026	0.076	0.112	0.138	0.104	0.112	0.091	0.065	0.016
Gila Confluence North	0.050	0.035	0.448	0.070	0.115	0.067	0.085	-	-	-	-	-
Topock	0.041	0.017	0.021	0.034	0.141	0.282	0.366	0.461	0.491	0.280	0.093	0.020

Table 7.13. Difference in Magnitude of Evapotranspiration Signature from 2006 to 2007*

Site	Difference in Median Daily Water Level Fluctuation (feet)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Blankenship Bend	0.040	0.168	-0.067	0.020	-0.075	-0.082	-0.080	INA	INA	INA	INA	INA
Havasu NE	0.023	0.004	-0.050	0.034	0.006	0.017	0.006	0.013	-0.012	-0.021	-0.013	-0.042
Cibola Lake	-0.015	-0.099	INA	INA	INA	INA	INA	INA	INA	INA	INA	INA
Three Fingers Lake	-0.017	-0.005	0.105	0.155	0.077	0.041	0.032	0.138	-0.067	-0.073	-0.200	-0.092
Walker Lake	0.004	0.007	0.039	0.030	0.029	-0.020	0.021	-0.002	0.042	0.007	-0.004	-0.015
Paradise	-0.067	-0.033	0.009	0.126	0.093	-0.039	0.034	INA	INA	INA	INA	INA
Hoge Ranch	-0.129	-0.034	-0.015	0.175	0.081	0.075	0.122	0.200	-0.108	INA	INA	INA
Rattlesnake	-0.059	0.091	0.112	0.023	-0.016	0.030	0.146	0.030	-0.117	-0.064	0.000	0.028
Clear Lake	-0.051	0.015	0.022	-0.024	-0.011	-0.004	0.059	-0.019	-0.053	-0.046	-0.024	-0.006
Ferguson Lake	-0.062	-0.010	0.038	0.007	-0.038	0.003	0.051	-0.038	-0.063	-0.021	-0.026	0.025
Ferguson Wash	-0.078	-0.011	0.021	0.007	-0.077	0.009	0.056	0.003	-0.070	-0.052	-0.033	0.078
Great Blue Heron	-0.002	0.000	0.021	-0.006	-0.041	-0.016	-0.032	-0.032	-0.019	0.004	-0.021	0.020
Mittry West	-0.002	-0.004	-0.004	-0.016	-0.001	0.005	0.007	-0.036	-0.010	0.008	0.007	-0.003
Gila Confluence North	-0.011	-0.095	0.386	-0.014	0.025	-0.043	-0.023	INA	INA	INA	INA	INA
Topock	INA	INA	INA	INA	INA	INA	INA	-0.049	-0.024	0.041	0.001	0.004

* Shaded cells show a decline from 2006 to 2007; INA = information not available.

DISCUSSION

Microclimate

Comparison of Parker/Imperial to Topock

Most microclimatic variables at the combined habitat monitoring sites differed significantly from those at Topock Marsh. The habitat monitoring sites were lower in elevation and at lower latitudes than Topock and therefore were more likely to be warmer, an expectation confirmed by all measures of diurnal temperature parameters compared in Table 7.4.

Between-year Comparisons of Microclimate Characteristics

Comparisons of microclimate characteristics among 2005, 2006, 2007, and 2008 at the habitat monitoring sites indicated generally hotter and more humid conditions in 2006 than in the other years. The interannual changes were generally similar between test and control sites, suggesting that changes in temperature and humidity conditions may have been regional, rather than being influenced by changes in river operations. Soil moisture was lower in 2006 than in 2005 or 2007, and while this pattern was exhibited at both test and control sites, the interannual change was greater at control than at test sites.
In 2008, soil moisture at test sites increased while it remained the same at control sites. This suggests that local conditions, in addition to regional climate, may have influenced soil moisture. The role of river flows in influencing soil moisture within the sites is still unclear, given that no strong relationship was

found between piezometer levels and soil moisture (see Correlation of Piezometer Groundwater Levels with Soil Moisture Measurements below).

Vegetation

Between-year differences across all sites were noted for canopy closure, woody ground cover, and number of dead stems 2.5–8 cm dbh. None of these variables showed unidirectional trends from 2005 to 2008, suggesting that the differences are not indicative of long-term, regional habitat changes during that time period. Changes in canopy closure could be caused by changes in overall weather conditions between the years or could be the result of systematic observer variation.

Woody ground cover showed an overall increase in 2008; the number of dead stems 2.5–8 cm dbh was higher in 2008 and 2005 than in the intervening years; and the vertical density of dead vegetation was greater in 2008 than in 2007 within 4 m of the ground. The increases in these variables in 2008 suggest there may have been more dead vegetation in 2008. No corresponding change in the number of live stems or canopy closure was observed, and additional years of monitoring will help determine whether the changes observed in 2008 represent a real increase in the amount of dead vegetation.

Few variables showed changes that were specific to control or test sites. Ground cover did not differ between 2005 and 2007 at test locations but increased at control plots in 2006 and then decreased in 2007. It is not clear whether this represents actual changes in the amount of woody ground cover or whether it is a result of observer variation. Vertical foliage counts did not show any consistent differences between control and test locations. Measurable changes in vegetation as a response to water availability may take several years to develop, and future years of monitoring will help determine whether water diversions are affecting potential flycatcher habitat.

Groundwater Levels

Piezometer Groundwater Levels

The general daily and weekly cycles that were attributed to evapotranspiration and river operations, respectively, in the 2005 data are still visible in the 2006–2008 data. Groundwater levels drop during afternoon hours and on the weekends, while higher groundwater levels occur in early morning hours and in the middle of the week. The daily small-scale groundwater level fluctuations are caused by evapotranspiration of plants. During the day, the riparian vegetation removes water from aquifer storage, which is then replenished as evapotranspiration lessens near the end of the day. These fluctuations occur at similar times of day regardless of distance downstream from Parker Dam and are thus unlikely to be the result of daily fluctuations in releases, which would exhibit a lag effect with increasing distance downstream. In addition, similar daily fluctuations occur at the control sites both upstream and downstream of Parker Dam, and follow typical evapotranspiration patterns (White 1932, Freeze and Cherry 1979).

The seasonal cycle in groundwater levels mirrors the seasonal fluctuation in river flow. This is driven primarily by the operational decrease in releases from Parker Dam. Evapotranspiration would be expected to decrease during the winter months, which should result in higher river and groundwater levels during the winter; however, this trend is not observed. Any seasonal effect of evapotranspiration appears to be overwhelmed by operations at Parker Dam.

Several anomalous hydrograph features deserve discussion:

Walker Lake – The Walker Lake piezometer recovered slowly from two apparent inundations in the late summer of 2005 and went through a period of declining groundwater levels until the 5 December 2005 download. From the point of restart, this piezometer began to show the same general seasonal trend as seen in the other piezometers, with a seasonal high occurring in winter 2006 and seasonal low occurring in spring 2006. Groundwater levels, however, have continued to drop from the seasonal high spring levels to levels more like those first recorded before the summer 2005 inundation, suggesting this lower groundwater level is closer to the seasonal low than that recorded in the winter 2006. We speculated in the 2006 report that Walker Lake represented a backwater area that gets periodically inundated, but otherwise does not respond strongly to fluctuations in the Colorado River. However, since the spike in summer 2005, the seasonal pattern appears to match the pattern at most of the piezometer locations between Parker and Imperial dams, including Rattlesnake, Ferguson Lake, and Clear Lake. The spike, which we speculated may have been an inundation of a backwater lake, does not appear to have repeated.

Mittry West – While the hydrograph for the Mittry West piezometer was almost flat from installation through December 2005, the data now show a seasonal trend. A peak in groundwater level occurred on 29 April 2006, from which point water levels declined into the summer months. Weekly fluctuations and daily fluctuations are not as apparent on the rising leg of the 2006 seasonal curve, but reappear on the declining leg of the curve. This may be attributed to the onset of evapotranspiration with the regrowth of vegetation in the immediate area surrounding the piezometer. Because of the inexplicable flat data from the first data downloads, we considered reinstalling the Mittry West piezometer at a different location within the habitat polygon. It now appears that this piezometer is functioning properly, and the flat data likely reflect the true groundwater levels at the site. The data have remained consistent through 2008.

Havasu NE – Daily and weekly changes in groundwater level are apparent in the Havasu NE hydrograph; however, there is no seasonal trend common in the other hydrographs. This lack of a seasonal trend at the Havasu NE piezometer can be attributed to the highly regulated water level at Lake Havasu.

Gila Confluence North, Paradise, and Blankenship – These piezometers appear to be malfunctioning or inoperative. Gila Confluence North has been returning nearly flat data since its relocation in July 2007, which is drastically different from the data collected prior to reinstallation. It is unclear whether it is a hardware or installation problem. Paradise has had massive battery failure since August 2007. It will likely need to be replaced, although the systemic problems with battery life are also being investigated with the manufacturer. Blankenship, as mentioned, began returning erratic measurements in August 2007. It has not functioned properly since and will no longer communicate with our download interface. It will likely need to be replaced.

Topock – Nearly two years of data exist for Topock. Data from 2007 showed high groundwater levels in spring, followed by declining water levels through the summer. Data gaps in 2008 make it difficult to determine whether this pattern continued.

Correlation of Piezometer Groundwater Levels with Reservoir Releases

Regression analyses indicated that, as would be expected, piezometer readings were best correlated with flow release data that had been time-lagged to allow for the progression of releases downstream.

The most upstream site included in the analyses (Ehrenberg) showed a two-day lag, while the most downstream site (Great Blue Heron) showed a three-day lag.

Correlation of Piezometer Groundwater Levels with Soil Moisture Measurements

With two to three years of data at most sites, we have not found a linear relationship between piezometer water levels and soil moisture measurements at the subset of habitat monitoring sites for which we have complete data sets. The highest correlations between groundwater levels and soil moisture occurred at sites where soil moisture is relatively high and surface water is sometimes present, suggesting that soil moisture is most strongly affected by groundwater when distance to groundwater is shallow. Soil texture influences the capillary rise of groundwater from a shallow aquifer, and variability in soil texture among sites may confound the relationship between piezometer groundwater levels and soil moisture. Soil samples collected during various field activities over the last three years are currently being analyzed for soil texture. Future analyses will examine soil texture and incorporate these data into a more complex analysis of the influence of groundwater levels on soil moisture.

Presence of Standing Water

Standing water appears to be consistent at Mittry West in the spring but does not appear to be a factor at any other site. Based on anecdotal observations, Topock was considered likely to experience inundation, and we expected such inundation could show up during the piezometer monitoring. However, that has not yet occurred, despite surface water being observed less than 10 m from the piezometer during May 2008.

Evapotranspiration Signature

The usefulness of the evapotranspiration signature is in assessing the relative change in evapotranspiration, and thus vegetation density, at a given site over time. With only two years of data, it is not yet useful to look for trends at individual sites. However, the comparison of 2006 to 2007 data suggests that variations in temperature between the years may need to be incorporated into the future analysis, as these could also account for differences in evapotranspiration signature. Almost all of the sites exhibited less evapotranspiration during the latter half of 2007; such a regional change is more suggestive of climate variation than vegetation growth or decline at individual sites.

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Appendix A

FIELD DATA FORMS

Willow Flycatcher Survey and Detection Form (revised April, 2004)

Site Name_______________________________ State_____ County ___________________
USGS Quad Name ________________________ Elevation _______________ feet / meters (circle one)

Is copy of USGS map marked with survey area and WIFL sightings attached (as required)? ☐ ***Yes*** ☐ ***No***

Site Coordinates: Start: N______________ E________________ UTM Datum______ (NAD27 preferred)
Stop: N______________ E________________ UTM Zone _______

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

Survey # Observer(s) (Full Name)	Date (m/d/y) Survey time	Number of Adult WIFLs	Estimated Number of Pairs	Estimated Number of Territories	Nest(s) Found? Y or N	Cowbirds Detected? Y or N	Presence of Livestock, Recent sign, If Yes, Describe Y or N	Comments about this survey (e.g., bird behavior, evidence of pairs or breeding, number of nests, nest contents or number of fledges seen; potential threats)
1________ ________ ________ ________ ________	Date Start Stop Total hrs ____							
2________ ________ ________ ________ ________	Date Start Stop Total hrs ____							
3________ ________ ________ ________ ________	Date Start Stop Total hrs ____							
4________ ________ ________ ________ ________	Date Start Stop Total hrs ____							
5________ ________ ________ ________ ________	Date Start Stop Total hrs ____							
Overall Site Summary (Total **resident** WIFLs only) Total survey hrs________		Adults	Pairs	Territories	Nests	Were any WIFLs color-banded? Yes No If yes, report color combination(s) in the comments section on back of form		

Reporting Individual ________________________________ Date Report Completed ______________
US Fish and Wildlife Service Permit #__________ AZ Game and Fish Department (or other state) Permit # __________

***Submit original** form by August 1st. Retain a copy for your records.*

Fill in the following information completely. <u>Submit original</u> form by August 1st. Retain a copy for your records.

Reporting Individual ______________________________ Phone # ______________
Affiliation ______________________________ E-mail ______________
Site Name ______________________________ Date Report Completed ______________

Did you verify that this site name is consistent with that used in previous years? Yes / No (circle one)
If name is different, what name(s) was used in the past? ______________________________
If site was surveyed last year, did you survey the same general area this year? Yes / No If no, summarize in comments below.
Did you survey the same general area during each visit to this site this year? Yes / No If no, summarize in comments below.

Management Authority for Survey Area (circle one): Federal Municipal/County State Tribal Private
Name of Management Entity or Owner (e.g., Tonto National Forest) ______________________________

Length of area surveyed: __________ (specify units, e.g., miles = mi, kilometers = km, meters = m)

Vegetation Characteristics: Overall, are the species in tree/shrub layer at this site comprised predominantly of (check one):

☐ Native broadleaf plants (entirely or almost entirely, includes high-elevation willow)

☐ Mixed native and exotic plants (mostly native)

☐ Mixed native and exotic plants (mostly exotic)

☐ Exotic/introduced plants (entirely or almost entirely)

Identify the 2-3 predominant tree/shrub species: ______________________________

Average height of canopy (Do not put a range): ______________________________ (specify units)

Was surface water or saturated soil present at or adjacent to site? Yes / No (circle one)
Distance from the site to surface water or saturated soil: ____________ (specify units)

Did hydrological conditions change significantly among visits (did the site flood or dry out)? Yes / No (circle one)
If yes, describe in comments section below.

Remember to attach a copy of a USGS quad/topographical map (REQUIRED) of the survey area, outlining the survey site and location of WIFL detections. Also include a sketch or aerial photograph showing details of site location, patch shape, survey route in relation to patch, and location of any willow flycatchers or willow flycatcher nests detected. Such sketches or photographs are welcomed, but DO NOT substitute for the required USGS quad map. Please include photos of the interior of the patch, exterior of the patch, and overall site and describe any unique habitat features.

Comments (attach additional sheets if necessary)

____
____
____
____
____
____
____

WIFL Detection Locations:

Date Detected	N UTM	E UTM	Date Detected	N UTM	E UTM

SWFL General Site Description

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

General Info

Study Area: _________ **Survey Site:** ______________________________ **Date:** ________________

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

Vegetation

Vegetation at site: >90% native 50–90% native 50–90% exotic >90% exotic

Canopy closure: <25% 25–50% 50–70% 70–90% >90%

Overstory height (m): _______ **Dominant overstory species:** TASP SAGO SAEX POFR Other __________

Understory height (m): _______ **Dominant understory species**: TASP SAGO SAEX PLSE Other _________

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

If yes, type of vegetation: __________________________ **percentage of site:**__________

type of vegetation: __________________________ **percentage of site:**__________

type of vegetation: __________________________ **percentage of site:**__________

Hydrology

% of site inundated: ________________

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

____

Average depth of surface water:

toes (<5cm) ankles (5-15 cm) calves (15-40 cm) knees (40-60 cm)

thighs (60-80 cm) waist (100 cm) too deep to wade (>100 cm)

% of site with saturated soils (do not include inundated areas in percentage!): ____________________

% of site with damp soils (do not include inundated or saturated areas): ___________________

If not inundated or saturated, distance (m) to standing water or saturated soil:_____________________

How was distance determined? Visually estimated in field Measured in field using GPS

Measured from aerial photograph Other ___________________________________

Describe type of nearest surface water: ____

Narrative and Pictorial Description

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

____

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

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

____

____

____

____

____

____

____

____

Additional comments:____

____

____

STUDY AREA: ________ **SITE**: ____________ **BANDER**: ________ **DATE**: ________ **TIME**: ________ **TERR/NEST #**: __________

UTM: NAD_____ **Zone**______ ____________**E** ____________**N** **NBN:** ____ of ____ nestlings banded.

NOTES:____

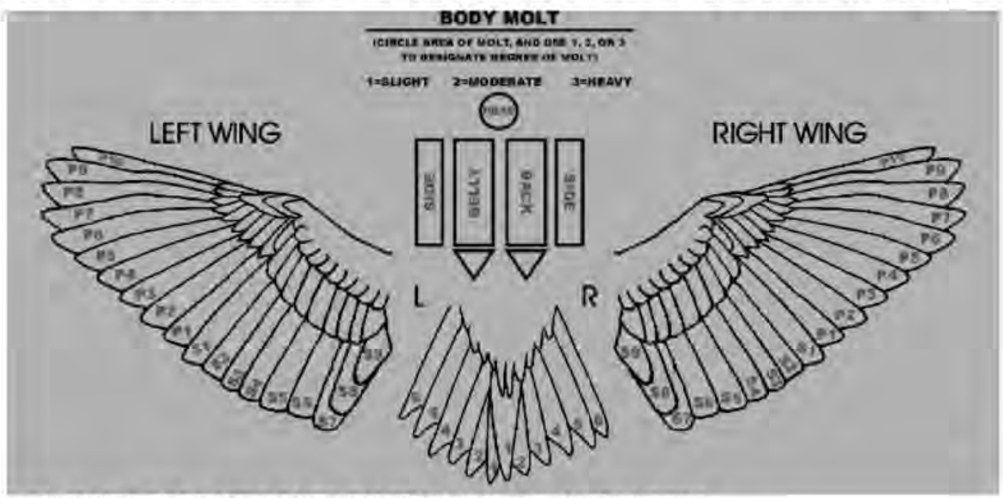
FEDERAL BAND #	COLOR COMBO		STATUS	SEX	CP	BP	AGE	FECAL SAMPLE? (Y or N)	GENETIC SAMPLE? (Y or N)	WING CHORD (mm)	TAIL (mm)	CULMEN LENGTH (mm)	CULMEN WIDTH (mm)	FAT
	L	R												

Retained Feathers Present: Yes or No (circle) – if Yes use diagram below **Colorimeter sample**: Yes or No (circle)

Active Molt: Yes or No (circle) – if Yes use diagram below

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

STATUS: NCP = new cap passive, NCT = new cap target, RCP = recap passive, RCT = recap target, NBN = nestling banded
SEX: U = unknown, F = female, M = male
CP: 0 = non-breeding, S = partial breeding, M = full breeding
BP: 0 = none, 1 = smooth, 2 = vascularized and filled with fluid, 3 = wrinkled, 4 = molting
AGE: AHY = after hatch year; SY = second year; L = nestling banded in nest; HY = hatch year/young of the year
FAT: 0 = no fat; 1 = trace of fat in furculum, deeply concave, scattered patches, less than 5 percent filled; 2 = thin layer of fat in furculum, less than a third filled, trace of thin layer of fat in abdomen; 3 = furculum is ½ filled or more; small patches, not covering some areas, on abdomen; 4 = furculum more than 2/3 filled, level with clavicles, slightly mounded on abdomen



DETAIL ALL MOLTS AND RETAINED FEATHERS ONTO DIAGRAM AND DETAIL IN NOTES

Colorimetry Data Sheet

SITE: ______________________ **DATE:** ______________________

BANDER: ______________________ **FED BAND NUMBER:** ______________________

CROWN MEASUREMENTS

PAGE: ________

	L*	a*	b*
1			
2			
3			
4			
5			
6			
7			
8			
MAX			
MIN			
AVG			
SD			

BACK MEASUREMENTS

PAGE: ________

	L*	a*	b*
1			
2			
3			
4			
5			
6			
7			
8			
MAX			
MIN			
AVG			
SD			

NOTES:

Date: ____________ Page ____ of ____

				COLOR COMBO								
OBS	STUDY AREA	TERR	NEST	LEFT LEG (Top/ Bottom)	RIGHT LEG (Top/ Bottom)	CONF LEVL	ASSOC WITH A NEST?	CAPTURE?	# WIFLS PRESENT	SEX	NBN (__of__)	OBSERVATIONS AND COMMENTS: discuss observations & activities.
												Service Band Number =
												Service Band Number =
												Service Band Number =
												Service Band Number =
												Service Band Number =
												Service Band Number =
												Service Band Number =
												Service Band Number =
												Service Band Number =
												Service Band Number =
												Service Band Number =
												Service Band Number =

Entered by: ____________ Date entered: ____________

Willow Flycatcher Territory/Nest Record Form

Study Area:________________ Survey Site:________________________________ Territory/Nest no.:__________

Territory/Nest Location:
NAD:________ Zone:________

Territory UTMs:

Easting:______________________

Northing:______________________

GPS Accuracy: __________m

Nest UTMs:

Easting:______________________

Northing:______________________

GPS Accuracy: __________m

Nest Height:________________m (approximate)

Nest Substrate:________________(e.g., TASP=tamarisk, SAGO=Goodding willow, POFR=cottonwood, SAEX = coyote willow, etc.)

Distance to standing water or saturated soil when nest found: ____________________(m)

How was distance determined?____

Date distance to water determined: ____

Depth of surface water at nest (please circle how wet you got when nest was found):

dry damp muddy toes (<5cm) ankles (5-15 cm)

calves (15-40 cm) knees (40-60 cm) thighs (60-80 cm)

waist (100 cm) too deep to wade (>100 cm)

PLEASE DO NOT FILL OUT ANYTHING BELOW

Bird 1: Color band combination:____________________________ **Band Number:**____________________________ Female

Bird 2: Color band combination:____________________________ **Band Number:**____________________________ Male

Willow Flycatcher

Trans dates	BD	(T/F)
		Found
		First egg
		Clutch completion
		Hatching
		Fledged or Failed

Willow Flycatcher

No.	Presumed	Confirmed
		Eggs
		Nestlings
		Fledglings

Cowbird

Trans dates	BD	(T/F)
		First egg
		Hatching
		Fledged

Cowbird

No.	Complete? (T/F)	
		Eggs
		Nestlings
		Fledglings

Outcome (Record code & describe)**:**______:____

____

____

____

Outcome codes:
UN= unknown; **FY**= fledged young, with at least one young seen leaving or in the vicinity of nest; **FP**= fledged young, as determined by parents behaving as if dependent fledgling(s) nearby; **FU**= suspected fledging of at least one young; **FC**= fledged at least one host young with cowbird parasitism; **FD**= Nest partially depredated with confirmed fledging of at least one young; **PO**= predation observed; **PE**= probable predation, nest empty and intact; **PD**= probable predation, damage to nest structure; **AB**= nest abandoned prior to egg(s) being laid; **DE**= deserted with egg(s) or young; **PA=** parasitized, host attempted to raise cowbird young. No host young were fledged from the nest; **WE**= failure due to weather; **AD**= failure, entire clutch addled/infertile; **OT**= failure due to other, or unknown, causes.

Mayfield Success

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

Mayfield success codes: **S**= successful; **D**= depredated; **U**= status unknown/nest occupied- fate unknown; **M**= mortality other than predation; **A**= abandoned with host egg(s) or young; **Z**= abandoned, no (zero) eggs laid.

Willow Flycatcher Territory/Nest Record Form (continued)

Study Area:______________Survey Site:___________________________Territory/Nest no.:_______

Date	Time		Obs	Mon Type	Stage	Adult pres.	# WE	# CE	# WN	# CN	#WF	Age Yng	Comments
	In	Out											

LCR SWFL – Vegetation Datasheet

Observers: ____________________

Study area	Survey site	Plot type	ID#	UTM: E N	Acc. m	Date

Canopy height	Direct measurement m	Using clinometer Top % - Bottom % × Dist m	Ground cover	N	E	S	W	Canopy closure	N	S

Stem Count By cm dbh category	Species	TASP single	TASP multi	TASP skipped	SAEX single	SAEX multi	SAEX skipped	SAGO single	SAGO multi	SAGO skipped	SNAG single	SNAG multi	SNAG skipped
	<1												
	1–2.5												
	2.6–5.5												
	5.6–8												
	8.1–10.5												
	10.5–15												
	Measured Trees >15 cm dbh												

Stem Count By cm dbh category	Species	OTSP1 single	OTSP1 multi	OTSP1 skipped	OTSP2 single	OTSP2 multi	OTSP2 skipped	OTSP3 single	OTSP3 multi	OTSP3 skipped
	<1									
	1–2.5									
	2.6–5.5									
	5.6–8									
	8.1–10.5									
	10.5–15									
	Measured Trees >15 cm dbh									

Other species (write out full name)

OTSP1 ____________________

OTSP2 ____________________

OTSP3 ____________________

If stem splits below ankle height, measure and tally each stem in "single" column. If, at ankle height or above, stem splits into multiple branches, measure and tally the biggest stem in "multi" column and record how many stems you did not measure in the "skipped" column (in the size category of the stem you measured).

If stem is not at least breast height, do not count

Vertical Foliage Sampling

CENTER PLOT							
Height (m)	Hits/Species						
	TASP	SAGO	SAEX	SNAG	OTSP1*:	OTSP2*:	OTSP3*:
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
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22							
23							
24							
25							

Record number of decimeters with hits on pole (within 10-cm radius) per 1-m interval up to 8 m; above 8 m, estimate 0, < 5, or > 5 or hits per meter interval.
***Use same OTSP (1,2,3) as listed on main record.**

Notes:

Vertical Foliage Sampling

Study Area:				Survey Site:				Plot type:				ID#		Date:	
NORTH 1m								EAST 1m							
Height (m)	Hits/Species							Height (m)	Hits/Species						
	TASP	SAGO	SAEX	SNAG	OTSP1	OTSP2	OTSP3		TASP	SAGO	SAEX	SNAG	OTSP1	OTSP2	OTSP3
1								1							
2								2							
3								3							
4								4							
5								5							
6								6							
7								7							
8								8							
9								9							
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19								19							
20								20							
21								21							
22								22							
23								23							
24								24							
25								25							

Record number of decimeters with hits on pole (within 10 cm radius) per 1-m interval up to 8 m; above 8 m, estimate 0, < 5, or > 5 or hits per meter interval.

***Use same OTSP (1,2,3) as listed on main record.**

SIDE 1

Vertical Foliage Sampling

SOUTH 1m								WEST 1m							
Height (m)	Hits/Species							Height (m)	Hits/Species						
	TASP	SAGO	SAEX	SNAG	OTSP1	OTSP2	OTSP3		TASP	SAGO	SAEX	SNAG	OTSP1	OTSP2	OTSP3
1								1							
2								2							
3								3							
4								4							
5								5							
6								6							
7								7							
8								8							
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19								19							
20								20							
21								21							
22								22							
23								23							
24								24							
25								25							

Record number of decimeters with hits on pole (within 10 cm radius) per 1-m interval up to 8 m; above 8 m, estimate 0, < 5, or > 5 or hits per meter interval.
*__Use same OTSP (1,2,3) as listed on main record.__

SIDE 2

Vertical Foliage Sampling

Study Area:			Survey Site:					Plot type:			ID#			Date:	
NORTH 5m								EAST 5m							
Height (m)	Hits/Species							Height (m)	Hits/Species						
	TASP	SAGO	SAEX	SNAG	OTSP1	OTSP2	OTSP3		TASP	SAGO	SAEX	SNAG	OTSP1	OTSP2	OTSP3
1								1							
2								2							
3								3							
4								4							
5								5							
6								6							
7								7							
8								8							
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20								20							
21								21							
22								22							
23								23							
24								24							
25								25							

Record number of decimeters with hits on pole (within 10 cm radius) per 1-m interval up to 8 m; above 8 m, estimate 0, < 5, or > 5 or hits per meter interval.
***Use same OTSP (1,2,3) as listed on main record.**

SIDE 1

Vertical Foliage Sampling

SOUTH 5m								WEST 5m							
Height (m)	Hits/Species							Height (m)	Hits/Species						
	TASP	SAGO	SAEX	SNAG	OTSP1	OTSP2	OTSP3		TASP	SAGO	SAEX	SNAG	OTSP1	OTSP2	OTSP3
1								1							
2								2							
3								3							
4								4							
5								5							
6								6							
7								7							
8								8							
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19								19							
20								20							
21								21							
22								22							
23								23							
24								24							
25								25							

Record number of decimeters with hits on pole (within 10 cm radius) per 1-m interval up to 8 m; above 8 m, estimate 0, < 5, or > 5 or hits per meter interval.
***Use same OTSP (1,2,3) as listed on main record.**

SIDE 2

Page 1 of ____

SWFL Microclimate at Currently Occupied Territories

Study Area ________ **Survey Site** ______________________ **LOCATION ID** ________–________–______
(Study area) – (Year) – (Territory #)

UTM coordinates: E 0_ _ _ _ _ _ **N** _ _ _ _ _ _ _ **GPS Accuracy**: _________ m

Temperature/Relative Humidity (T/RH)

Set-up: Date:_____________ Time:___________ Observer(s)________________

Logger 6-digit serial number (e.g., #630863):_____________ Was red LED checked at set-up? Y or N

What randomization sequence was used? Sequence #: _________

Column 1: _______ Column 2: ________ Column 3:________ Column 4:________ Column 5: _______

Est. actual height of logger _______ m Date territory first occupied ___________ Date territory vacated ___________

Download: Date:________________ Time:_____________ Observer(s):________________

Was red LED blinking at download? Y or N Did you check red LED after (re)launch? Y or N

Logger 6-digit serial number (do NOT copy from above; read the number on the logger!):______________

Did any events occur that might have interfered with accuracy of data gathered by this logger (e.g., blown out of tree, etc.)? No Yes If yes, explain:

Was logger downloaded on-site? Y or N If N, date and time of download: Date: ___________ Time: __________

Did you replace the existing logger? Y or N If Y, serial number of new logger: _______________

Comments:

Soil Moisture (SM)

Date:_____________ Time:_____________ Observer(s)________________

6-digit sensor serial number (on cord of probe): _______________ logger number (on back of HH2) : _______________

Soil sample taken? Yes No If no, why not? (put it on the calendar for the next person to collect!)___________________

Distance to saturated/inundated soil: ________ m How distance was measured: ___________________________

% of area w/in 20 m with inundated/saturated soil: _______ % of site w/in 50 m with inundated/saturated soil:_______

SM readings: Plot center ______% ______mV

N: 1.0 m ______% ______mV | 2.0 m ______% ______mV | **S:** 1.0 m _____% ______mV | 2.0 m ______% ______mV

E: 1.0 m ______% ______mV | 2.0 m ______% ______mV | **W:** 1.0 m _____% ______mV | 2.0 m ______% ______mV

Comments:

Date:_____________ Time:_________ Observer(s):________________

6-digit sensor serial number (on cord of probe): _______________ logger number (on back of HH2) : _______________

Distance to saturated/inundated soil: ________ m How distance was measured: ___________________________

% of site w/in 20 m with inundated/saturated soil: _______ % of site w/in 50 m with inundated/saturated soil:______

SM readings: Plot center ______% ______mV

N: 1.0 m ______% _______mV | 2.0 m ______% _______mV | **S:** 1.0 m _____% ______mV | 2.0 m ______% _______mV

E: 1.0 m ______% _______mV | 2.0 m ______% ______mV | **W:** 1.0 m _____% ______mV | 2.0 m ______% _______mV

Comments:

Page 1 of ____

SWFL Microclimate at Formerly Occupied Territories

Study Area _______ **Survey Site** ___________________ **LOCATION ID** _______–_______–_____
(Study area) – (Year active) – (Nest #)

UTM coordinates: E 0__ __ __ __ __ __ **N** __ __ __ __ __ __ __ **GPS Accuracy**: ________ m

Temperature/Relative Humidity (T/RH)

Set-up: Date:____________ Time:__________ Observer(s)________________

Logger 6-digit serial number (e.g., #630863):____________ Was red LED checked at set-up? Y or N

How certain are you that the logger is hanging from the fork the nest was in? (check one)

_______Nest still visible, certain of location

_______Nest gone, but found nest flag and certain of location

_______Nest gone, no nest flag, but base of nest tree flagged and nest height adequate to determine exact location

_______Nest gone, base of nest tree flagged, certain in right tree but not sure if right fork

_______Nest gone, nest tree not flagged, not certain if in right tree.

_______Other: ____

Est. actual height of logger _______ m

Comments:

Take-down: Date:_______________ Time:____________ Observer(s):________________

Logger 6-digit serial number (do NOT copy from above; read the number on the logger!):______________

Did any events occur that might have interfered with accuracy of data gathered by this logger (e.g., blown out of tree, etc.)?

No Yes If yes, explain:

Comments:

Soil Moisture (SM)

Date:______________ Time:___________ Observer(s)________________

6-digit sensor serial number (on cord of probe): _______________ logger number (on back of HH2) : _______________

Distance to saturated/inundated soil: ________ m **How distance was measured**: ______________________________

SM readings: Plot center _____% _____mV

N: 1.0 m _____% _____mV	2.0 m _____% _____mV	**S:** 1.0 m _____% _____mV	2.0 m _____% _____mV
E: 1.0 m _____% _____mV	2.0 m _____% _____mV	**W:** 1.0 m _____% _____mV	2.0 m _____% _____mV

Comments:

Date:_____________ Time:_________ Observer(s):________________

6-digit sensor serial number (on cord of probe): _______________ logger number (on back of HH2) : _______________

Distance to saturated/inundated soil: ________ m **How distance was measured**: ______________________________

SM readings: Plot center _____% _____mV

N: 1.0 m _____% _____mV	2.0 m _____% _____mV	**S:** 1.0 m _____% _____mV	2.0 m _____% _____mV
E: 1.0 m _____% _____mV	2.0 m _____% _____mV	**W:** 1.0 m _____% _____mV	2.0 m _____% _____mV

Comments:

Page 1 of ____

SWFL Microclimate
Soil Moisture Supplement

Study Area ________ **Survey Site** ______________________ **LOCATION ID** ________–________–_______

UTM coordinates: E 0__ __ __ __ __ __ **N** __ __ __ __ __ __ __

Date:_________________ Time:___________ Observer(s):________________
6-digit sensor serial number (on cord of probe): _______________ logger number (on back of HH2) : ________________
Distance to saturated/inundated soil: _______ m **How distance was measured**: ____________________________
% of area w/in 20 m with inundated/saturated soil: _______ % of site w/in 50 m with inundated/saturated soil:_______
SM readings: Plot center _______% _______mV
N: 1.0 m ______% ______mV | 2.0 m ______% ______mV | **S:** 1.0 m _____% ______mV | 2.0 m ______% ______mV
E: 1.0 m ______% ______mV | 2.0 m ______% ______mV | **W:** 1.0 m _____% ______mV | 2.0 m ______% ______mV
Comments:

Date:_________________ Time:___________ Observer(s):________________
6-digit sensor serial number (on cord of probe): _______________ logger number (on back of HH2) : ________________
Distance to saturated/inundated soil: _______ m **How distance was measured**: ____________________________
% of area w/in 20 m with inundated/saturated soil: _______ % of site w/in 50 m with inundated/saturated soil:_______
SM readings: Plot center _______% _______mV
N: 1.0 m ______% ______mV | 2.0 m ______% ______mV | **S:** 1.0 m _____% ______mV | 2.0 m ______% ______mV
E: 1.0 m ______% ______mV | 2.0 m ______% ______mV | **W:** 1.0 m _____% ______mV | 2.0 m ______% ______mV
Comments:

Date:_________________ Time:___________ Observer(s):________________
6-digit sensor serial number (on cord of probe): _______________ logger number (on back of HH2) : ________________
Distance to saturated/inundated soil: _______ m **How distance was measured**: ____________________________
% of area w/in 20 m with inundated/saturated soil: _______ % of site w/in 50 m with inundated/saturated soil:_______
SM readings: Plot center _______% _______mV
N: 1.0 m ______% ______mV | 2.0 m ______% ______mV | **S:** 1.0 m _____% ______mV | 2.0 m ______% ______mV
E: 1.0 m ______% ______mV | 2.0 m ______% ______mV | **W:** 1.0 m _____% ______mV | 2.0 m ______% ______mV
Comments:

Date:_________________ Time:___________ Observer(s):________________
6-digit sensor serial number (on cord of probe): _______________ logger number (on back of HH2) : ________________
Distance to saturated/inundated soil: _______ m **How distance was measured**: ____________________________
% of area w/in 20 m with inundated/saturated soil: _______ % of site w/in 50 m with inundated/saturated soil:_______
SM readings: Plot center _______% _______mV
N: 1.0 m ______% ______mV | 2.0 m ______% ______mV | **S:** 1.0 m _____% ______mV | 2.0 m ______% ______mV
E: 1.0 m ______% ______mV | 2.0 m ______% ______mV | **W:** 1.0 m _____% ______mV | 2.0 m ______% ______mV
Comments:

Habitat Monitoring Sites – T/RH Downloads

Study Area _______ **Survey Site** ____________________ **LOCATION ID** ________–________–______
(Study area) – (Survey site) – (Number)

UTM coordinates: E 0__ __ __ __ __ __ **N** __ __ __ __ __ __ __ **Accuracy**: ______ m

Date:__________ Time:________ Observer(s):______________ Was red LED blinking at download? Y or N

Logger 6-digit serial number (e.g., #630863):____________ Did you check red LED after (re)launch? Y or N

Did any events occur that might have interfered with accuracy of data gathered by this logger (e.g., blown out of tree, etc.)?
No Yes If yes, explain:

Was logger downloaded on-site? Y or N If N, date and time of download: Date: ___________ Time: _________

Did you replace the existing logger? Y or N If Y, serial number of new logger: _______________

Comments:

Date:__________ Time:________ Observer(s):______________ Was red LED blinking at download? Y or N

Logger 6-digit serial number (e.g., #630863):____________ Did you check red LED after (re)launch? Y or N

Did any events occur that might have interfered with accuracy of data gathered by this logger (e.g., blown out of tree, etc.)?
No Yes If yes, explain:

Was logger downloaded on-site? Y or N If N, date and time of download: Date: ___________ Time: _______

Did you replace the existing logger? Y or N If Y, serial number of new logger: _______________

Comments:

Date:__________ Time:________ Observer(s):______________ Was red LED blinking at download? Y or N

Logger 6-digit serial number (e.g., #630863):____________ Did you check red LED after (re)launch? Y or N

Did any events occur that might have interfered with accuracy of data gathered by this logger (e.g., blown out of tree, etc.)?
No Yes If yes, explain:

Was logger downloaded on-site? Y or N If N, date and time of download: Date: ___________ Time: _______

Did you replace the existing logger? Y or N If Y, serial number of new logger: _______________

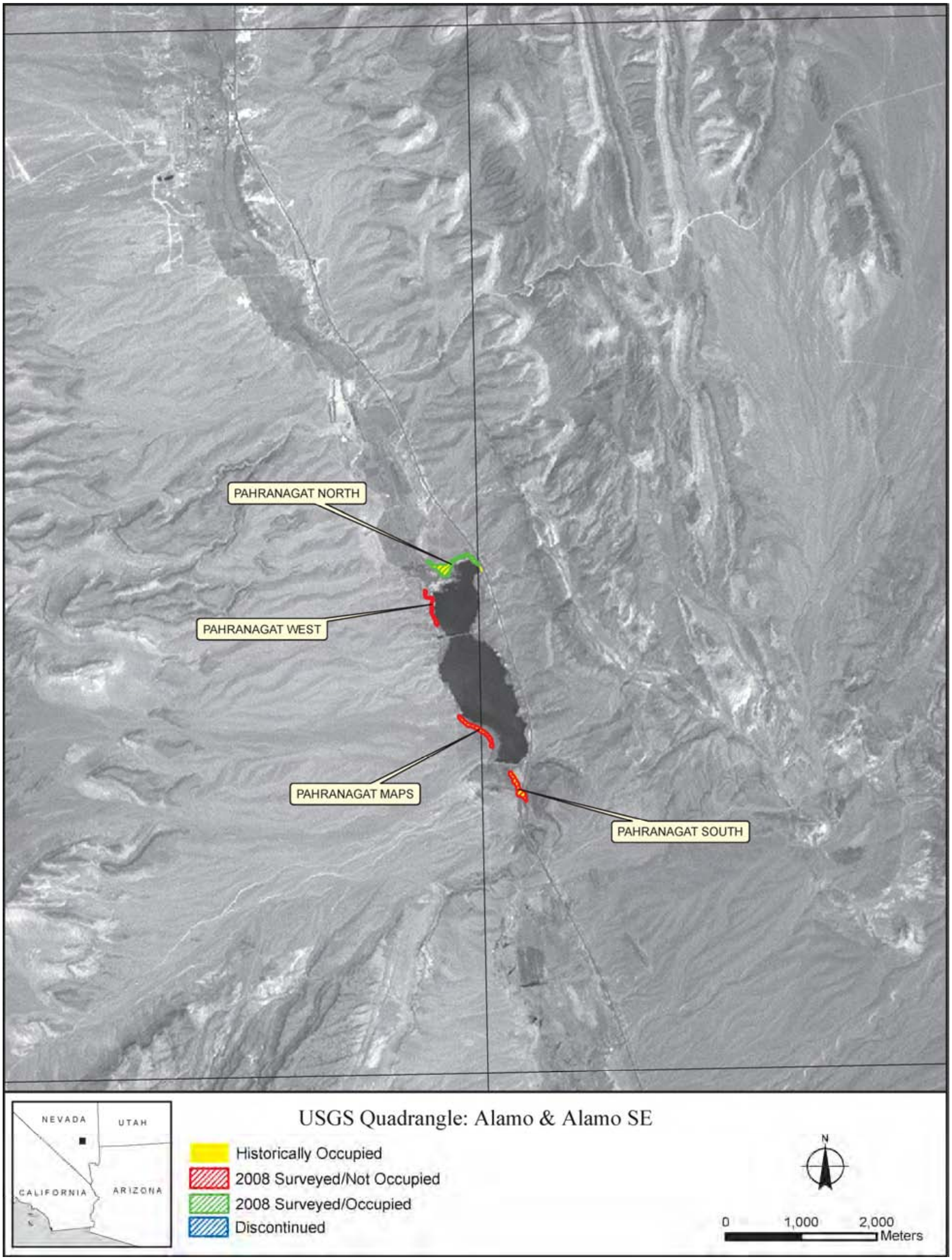
Comments:

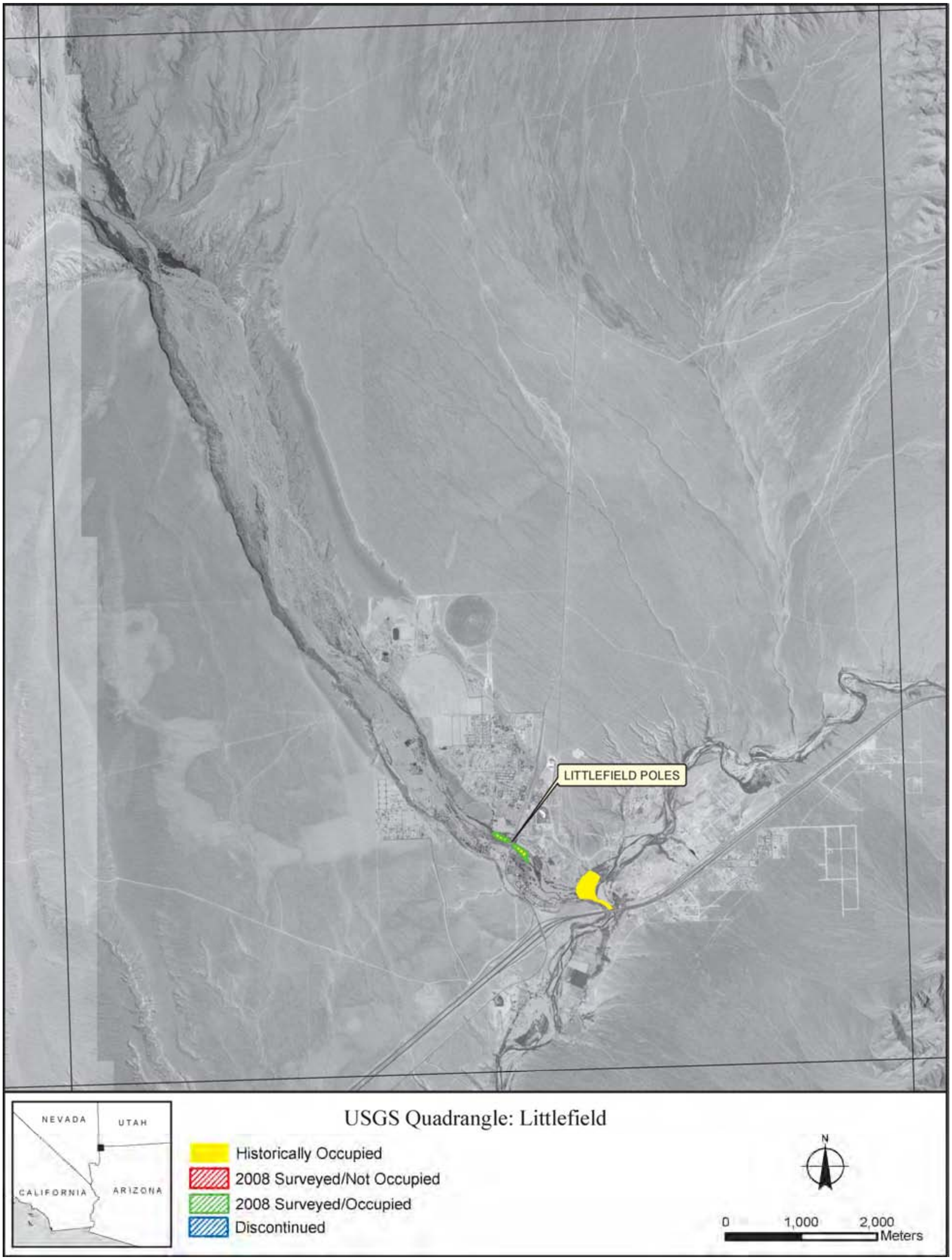
Location ID codes: Study area codes – Topock Marsh = TM, Topock Gorge = TG, Ehrenberg = EH, Cibola = CI, Imperial = IM, Mittry = MI, Yuma = YU. Survey site codes – In Between = IB, Blankenship = BK, Havasu NE = HV, Ehrenberg = EH, Three Fingers Lake = TF, Cibola Lake = CL, Walker Lake = WL, Paradise = PV, Hoge Ranch = HR, Rattlesnake = RS, Clear Lake = LK, Ferguson Lake = FL, Ferguson Wash = FW, Great Blue Heron = GB, Mittry West = MW, Gila Confluence North = GC

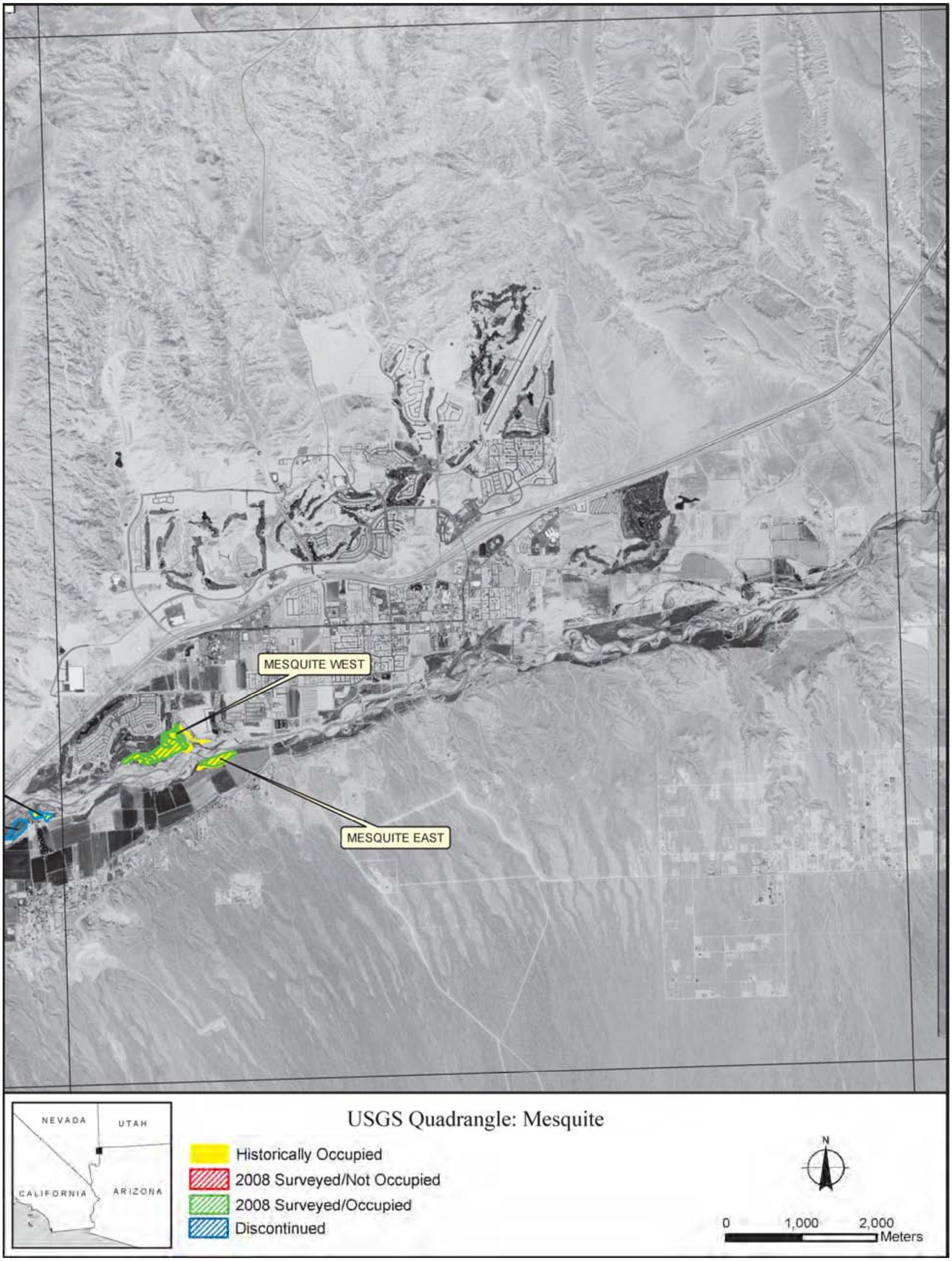
Appendix B

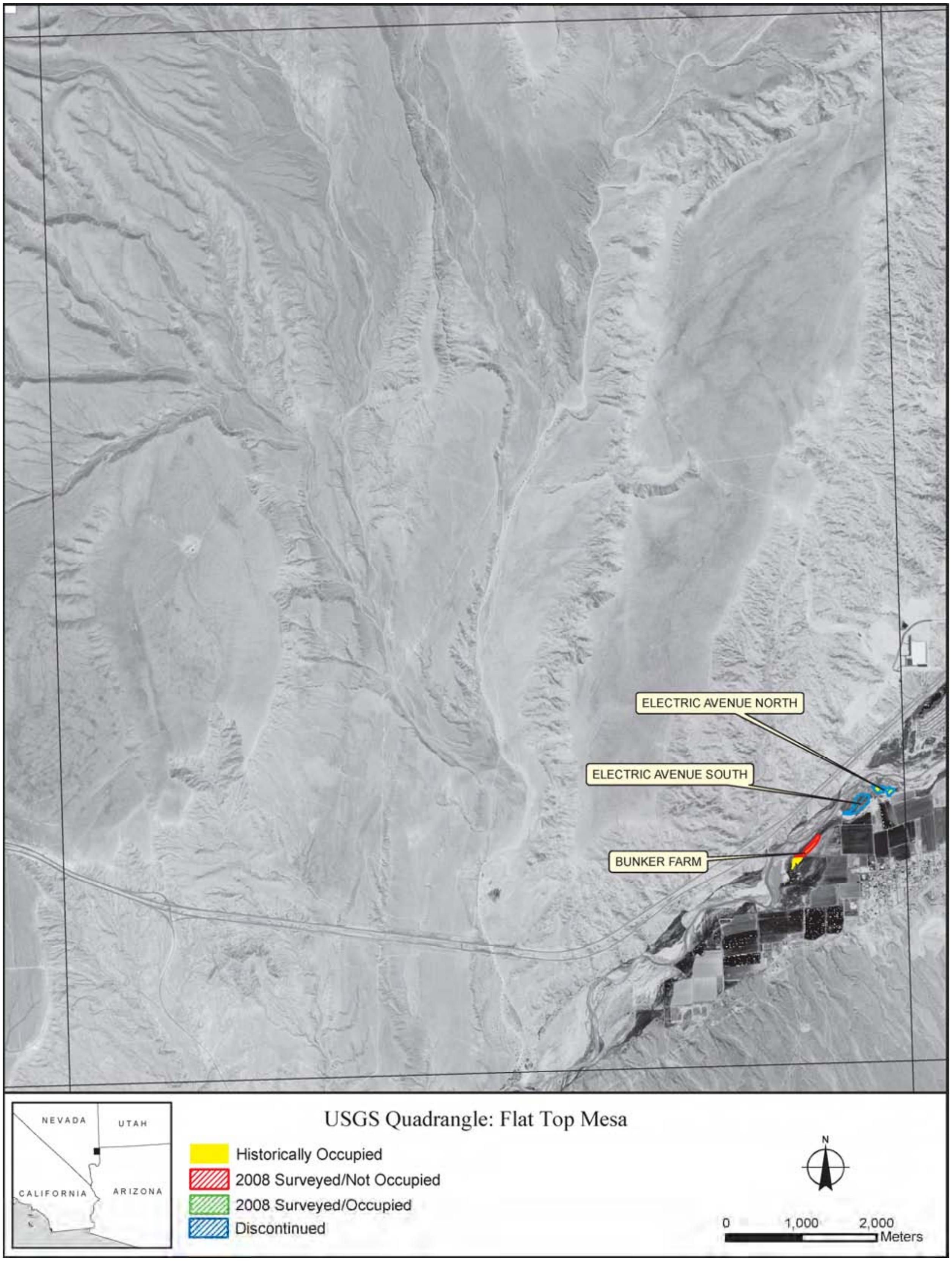
ORTHOPHOTOS SHOWING STUDY SITES

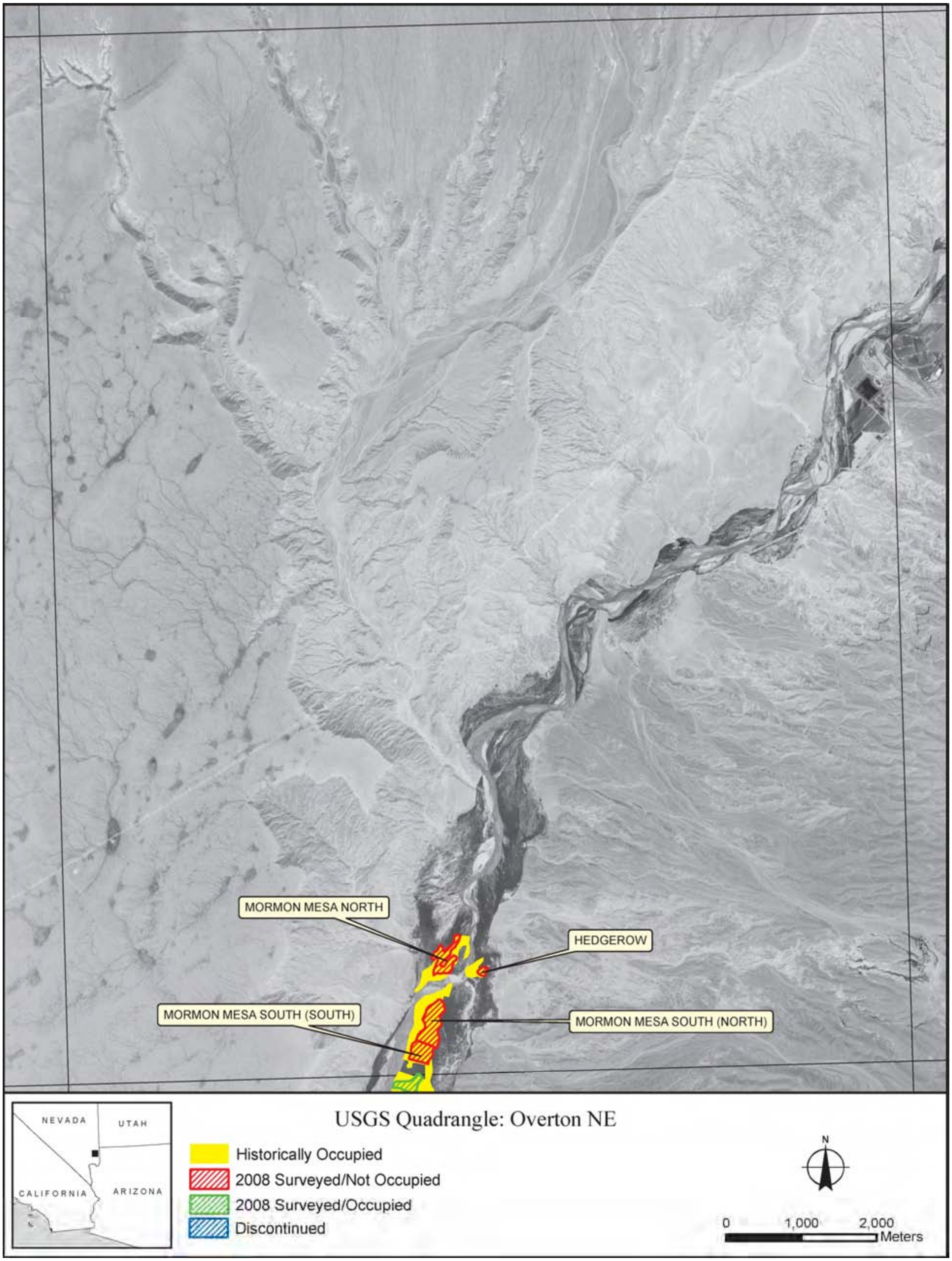

NEVADA
UTAH
CALIFORNIA
ARIZONA
MEXICO
PAHRANAGAT NWR
LITTLEFIELD
St. George
MESQUITE
Virgin River
Pahranagat Wash
MORMON MESA
MUDDY RIVER
Colorado River
Las Vegas
Lake Mead
GRAND CANYON
Lake Mohave
Kingman
Flagstaff
TOPOCK MARSH
TOPOCK GORGE
Lake Havasu
Verde River
BILL WILLIAMS RIVER NWR
Bill Williams River
AHAKHAV
Colorado River
Palm Springs
BIG HOLE SLOUGH
Quartzsite
EHRENBERG
Salton Sea
Phoenix
CIBOLA NWR
IMPERIAL NWR
MITTRY LAKE
Gila River
Yuma
YUMA
Pacific Ocean
Gulf Of California
Lower Colorado River Southwestern Willow Flycatcher Study 2008
City/Town
Study Area
Highway
N
0 25 50 75 Miles

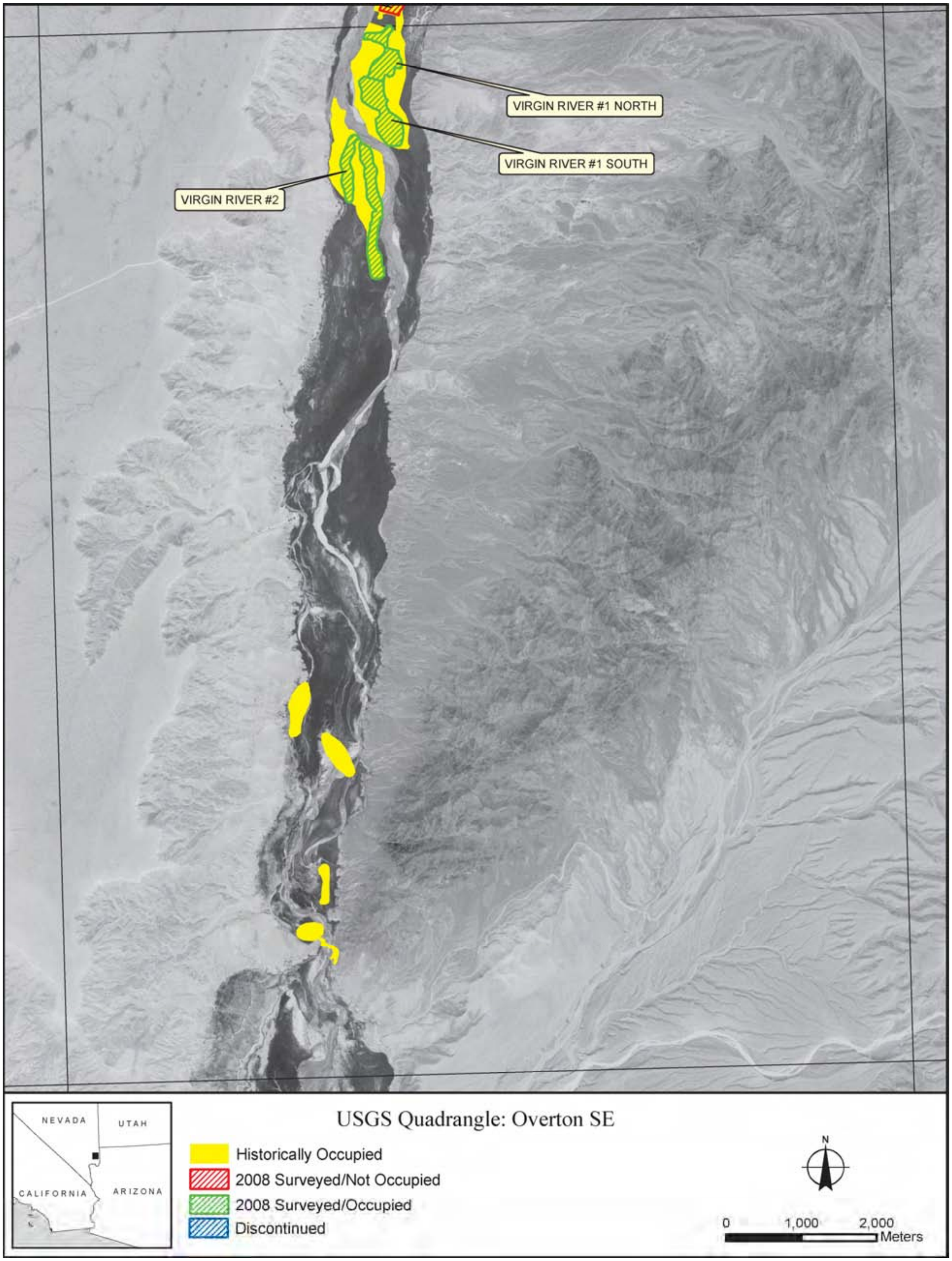

PAHRANAGAT NORTH
PAHRANAGAT WEST
PAHRANAGAT MAPS
PAHRANAGAT SOUTH
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Alamo & Alamo SE
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0 1,000 2,000
Meters

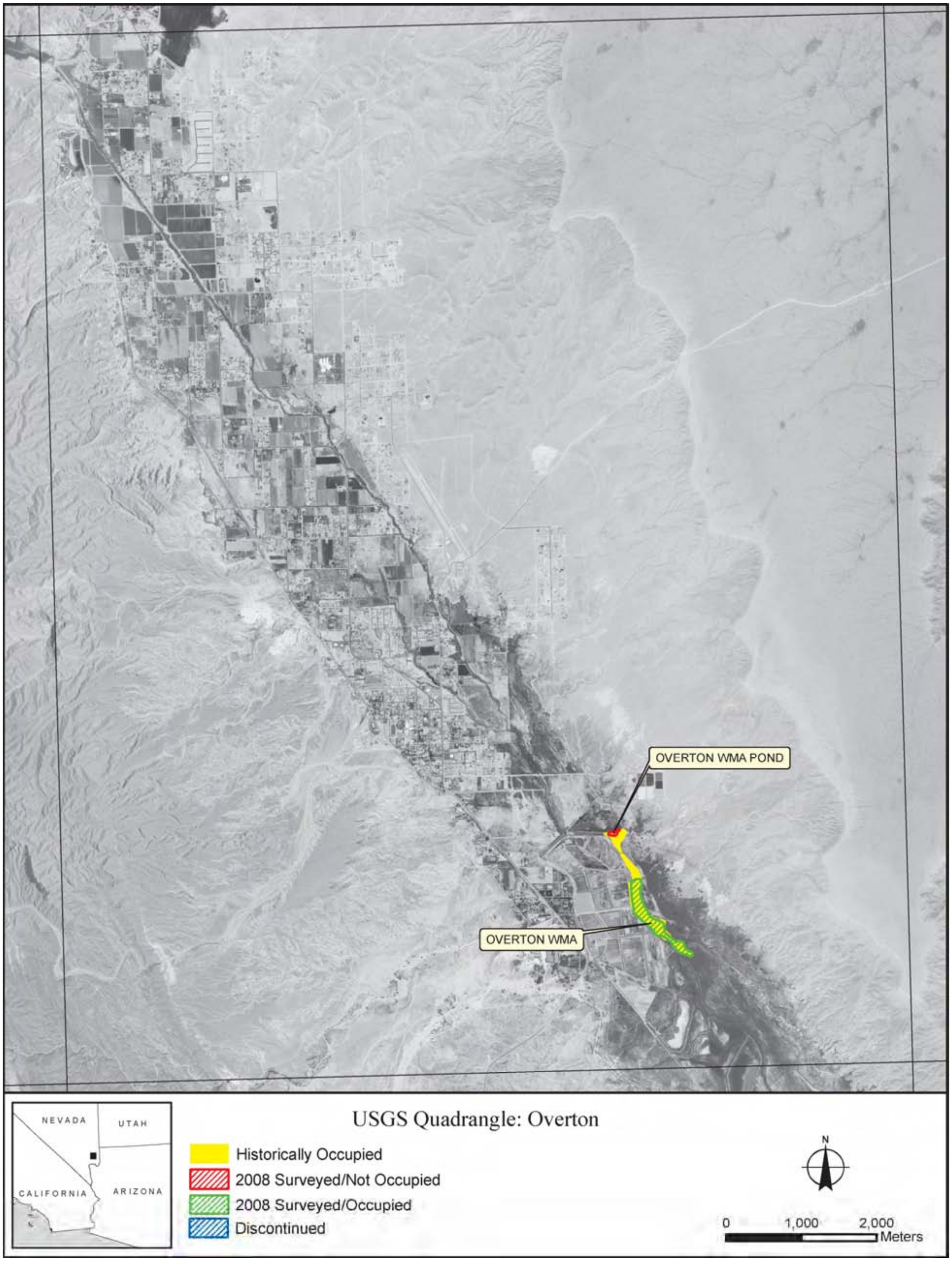

LITTLEFIELD POLES
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Littlefield
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

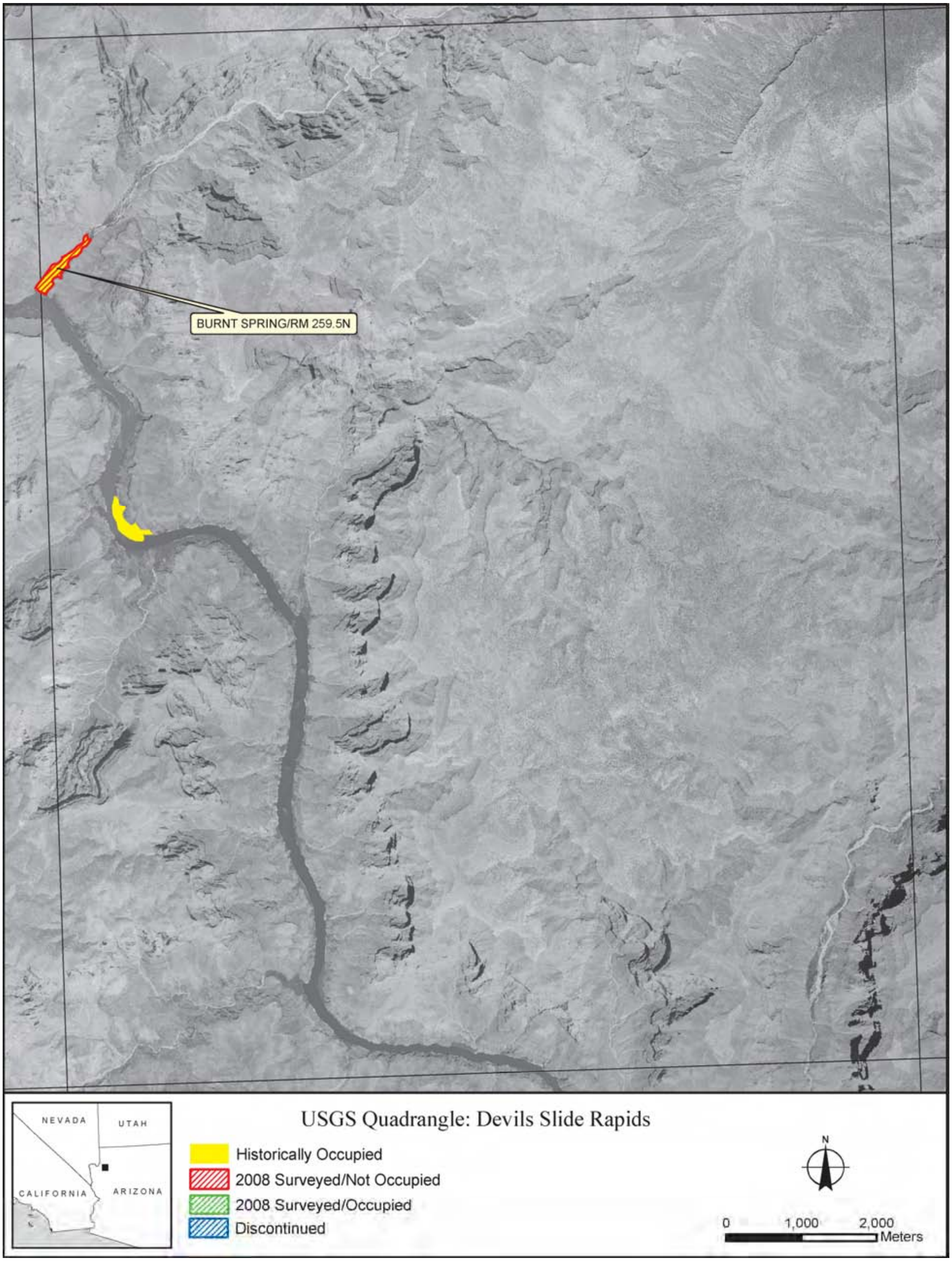

MESQUITE WEST
MESQUITE EAST
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Mesquite
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

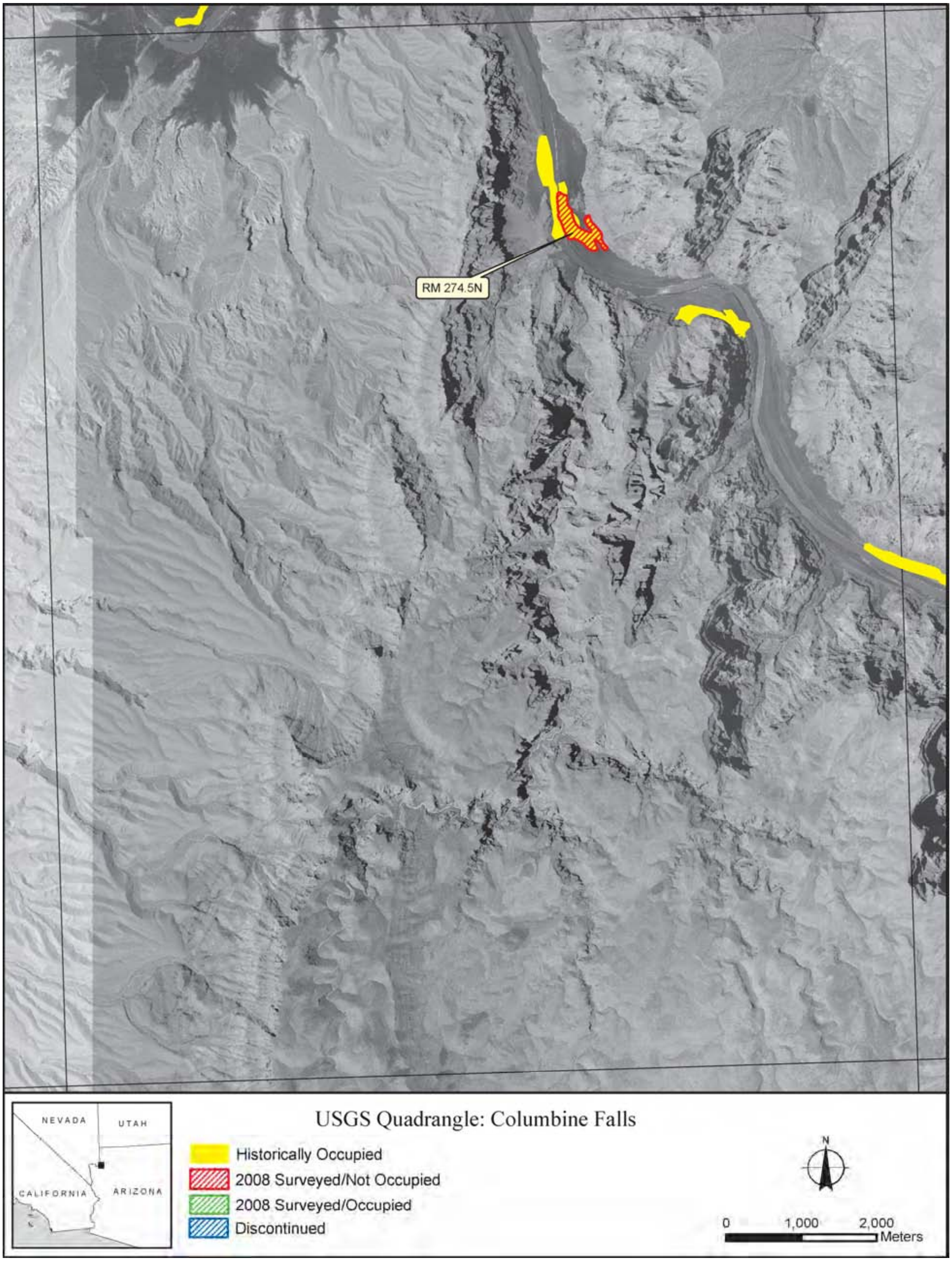

ELECTRIC AVENUE NORTH
ELECTRIC AVENUE SOUTH
BUNKER FARM
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Flat Top Mesa
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

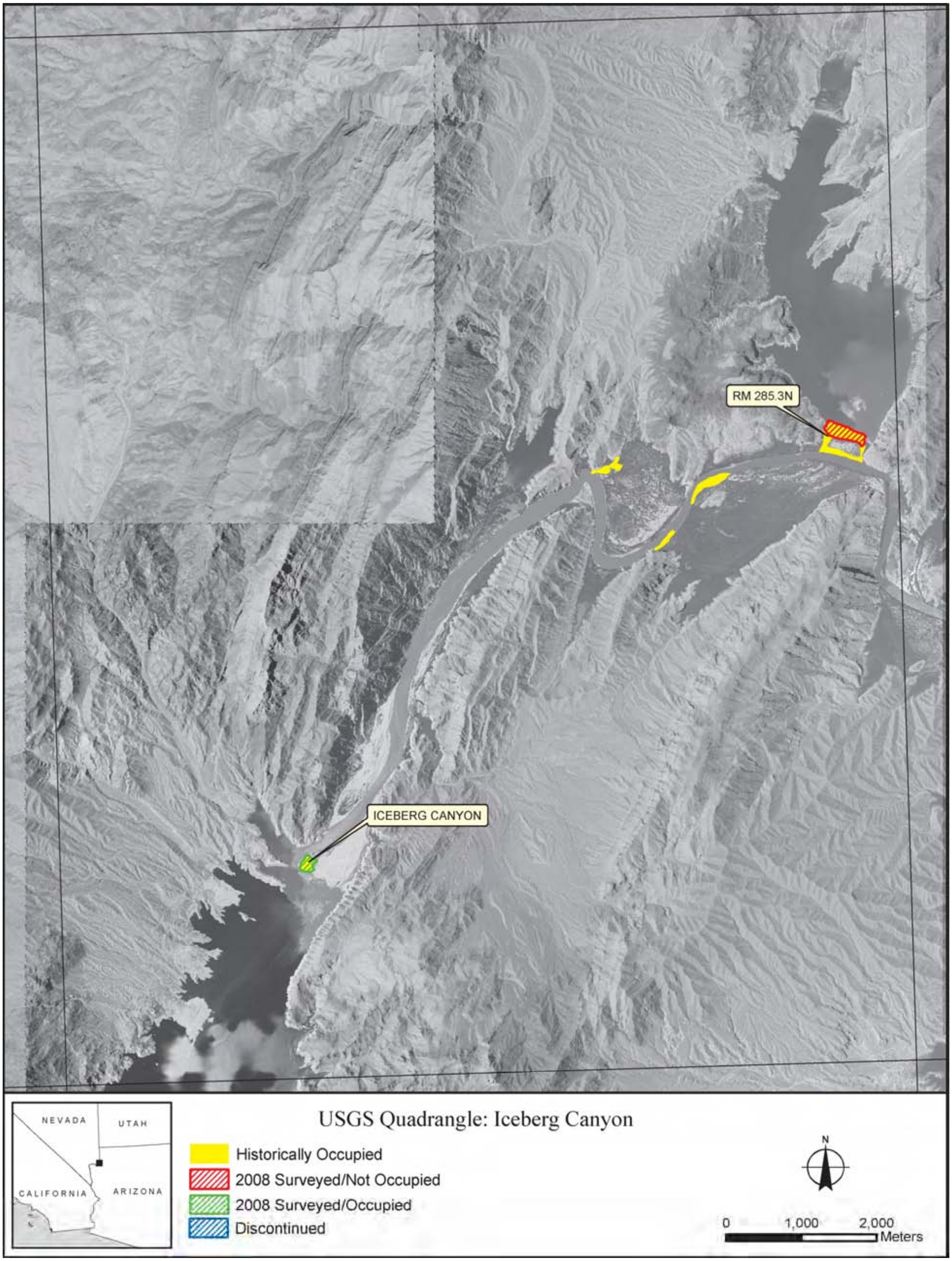

MORMON MESA NORTH
HEDGEROW
MORMON MESA SOUTH (SOUTH)
MORMON MESA SOUTH (NORTH)
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Overton NE
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

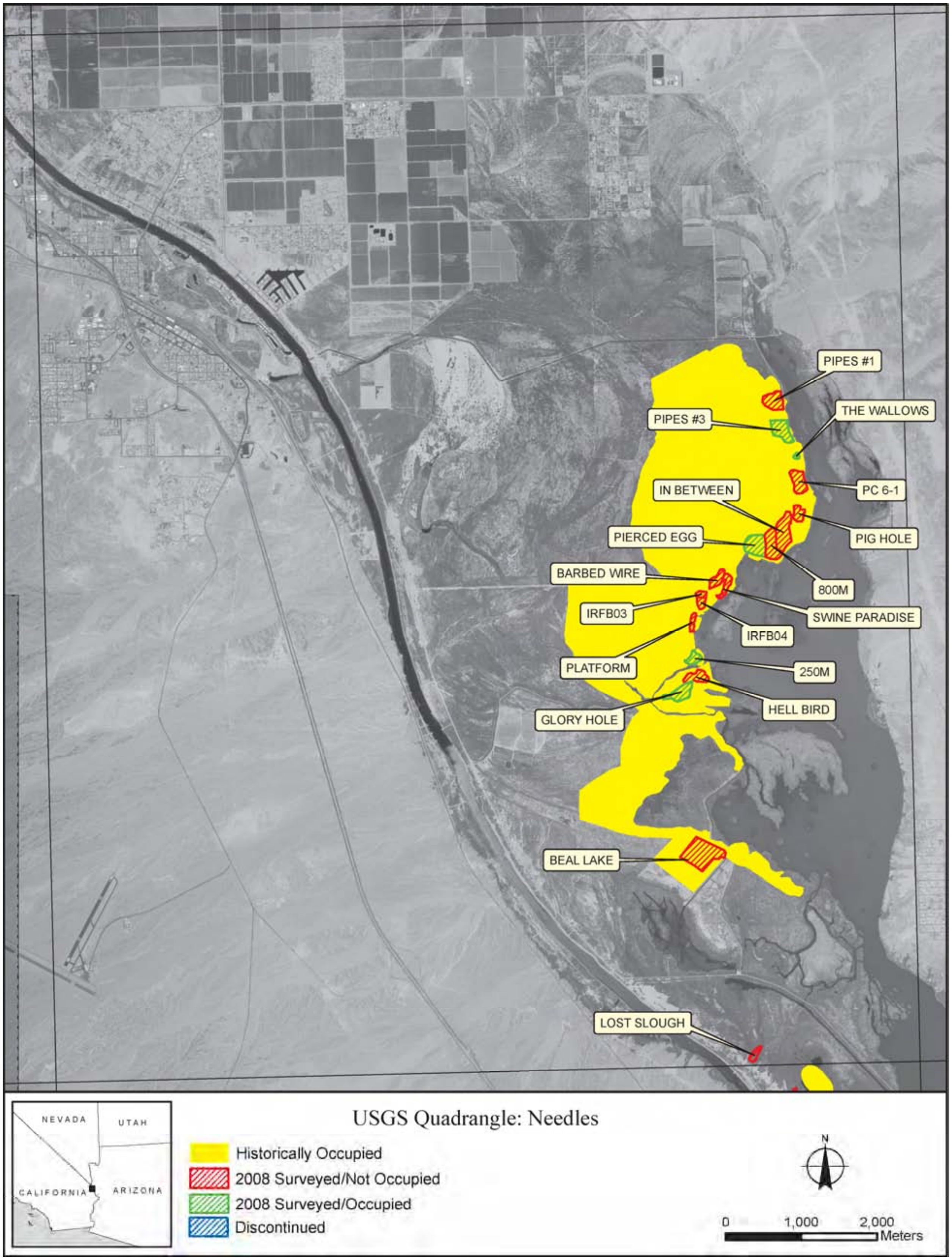

VIRGIN RIVER #1 NORTH
VIRGIN RIVER #1 SOUTH
VIRGIN RIVER #2
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Overton SE
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters


OVERTON WMA POND
OVERTON WMA
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Overton
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

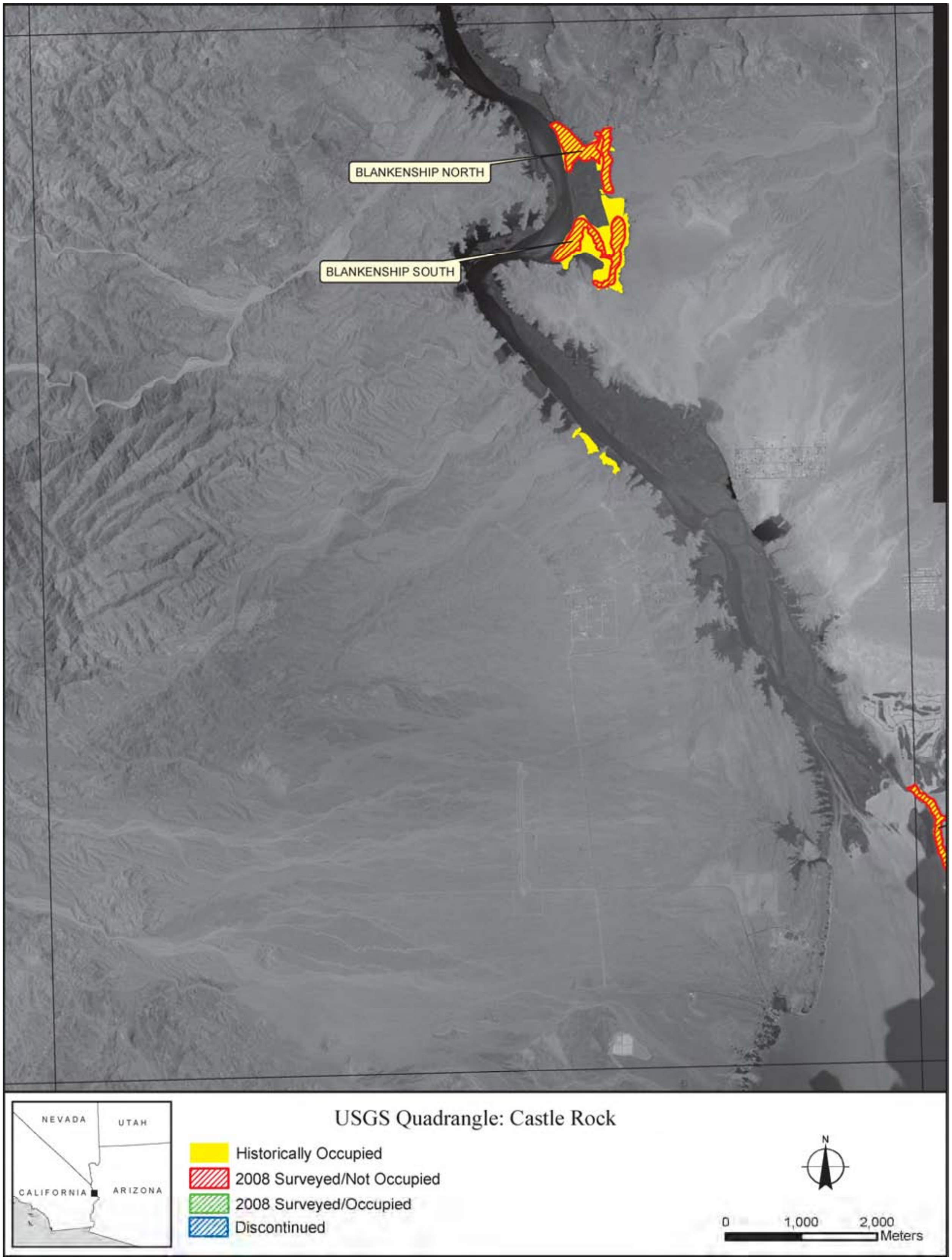

BURNT SPRING/RM 259.5N
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Devils Slide Rapids
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

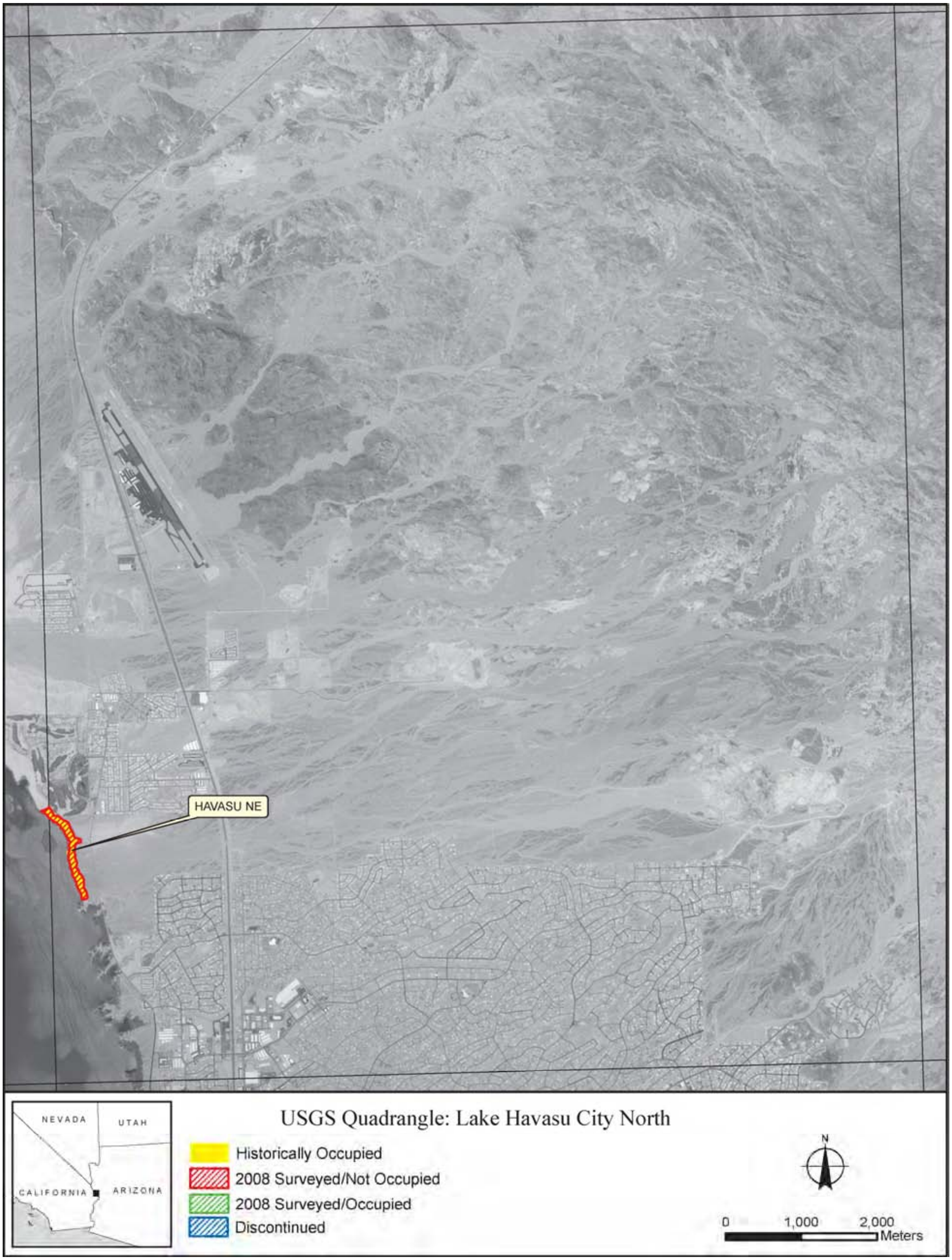

RM 274.5N
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Columbine Falls
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

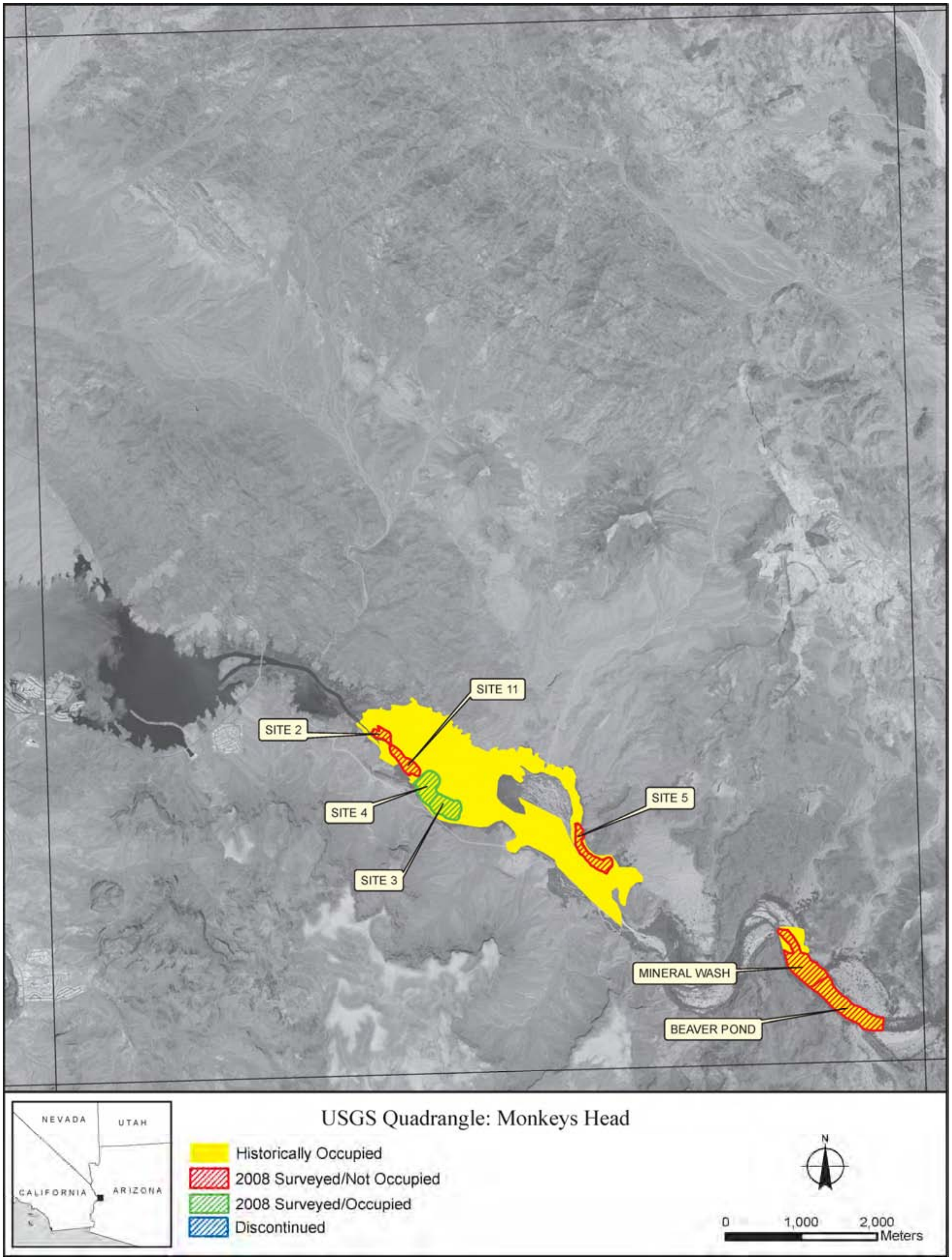

RM 285.3N
ICEBERG CANYON
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Iceberg Canyon
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

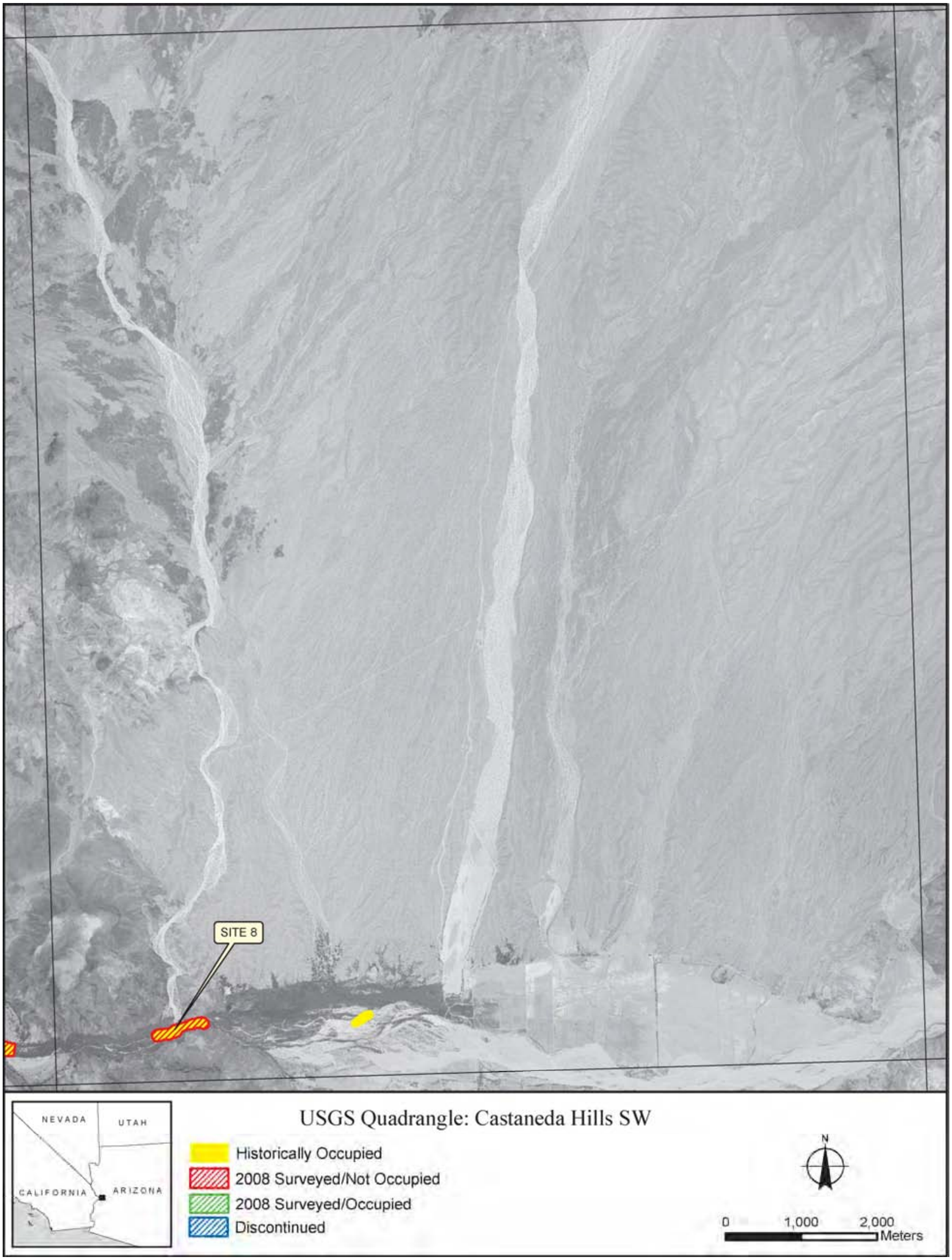

PIPES #1
PIPES #3
THE WALLOWS
IN BETWEEN
PC 6-1
PIG HOLE
PIERCED EGG
800M
BARBED WIRE
SWINE PARADISE
IRFB03
IRFB04
PLATFORM
250M
HELL BIRD
GLORY HOLE
BEAL LAKE
LOST SLOUGH
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Needles
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters


LOST POND
LOST LAKE
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Whale Mountain
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

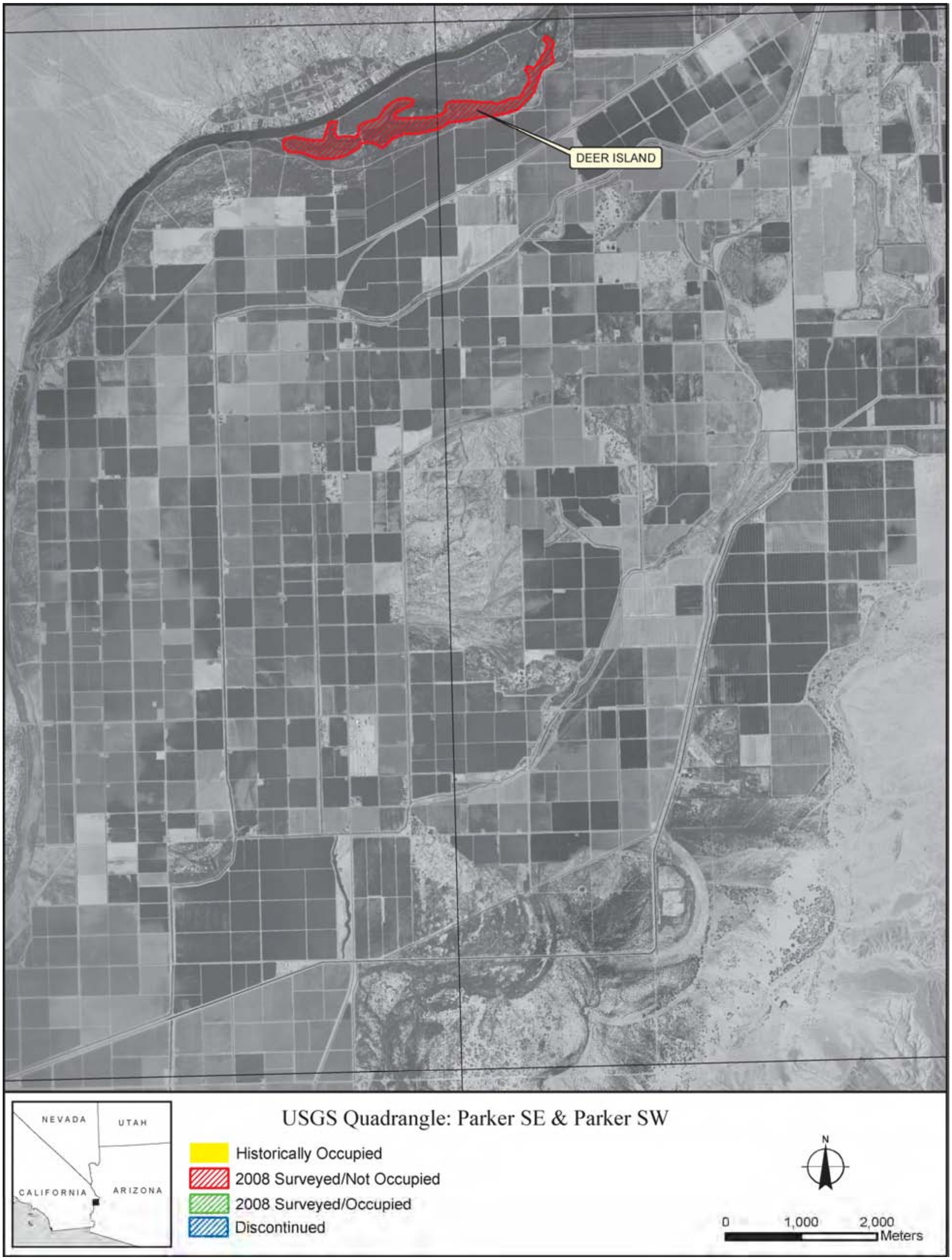

BLANKENSHIP NORTH
BLANKENSHIP SOUTH
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Castle Rock
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters


HAVASU NE
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Lake Havasu City North
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters


SITE 11
SITE 2
SITE 4
SITE 3
SITE 5
MINERAL WASH
BEAVER POND
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Monkeys Head
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters


SITE 8
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Castaneda Hills SW
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

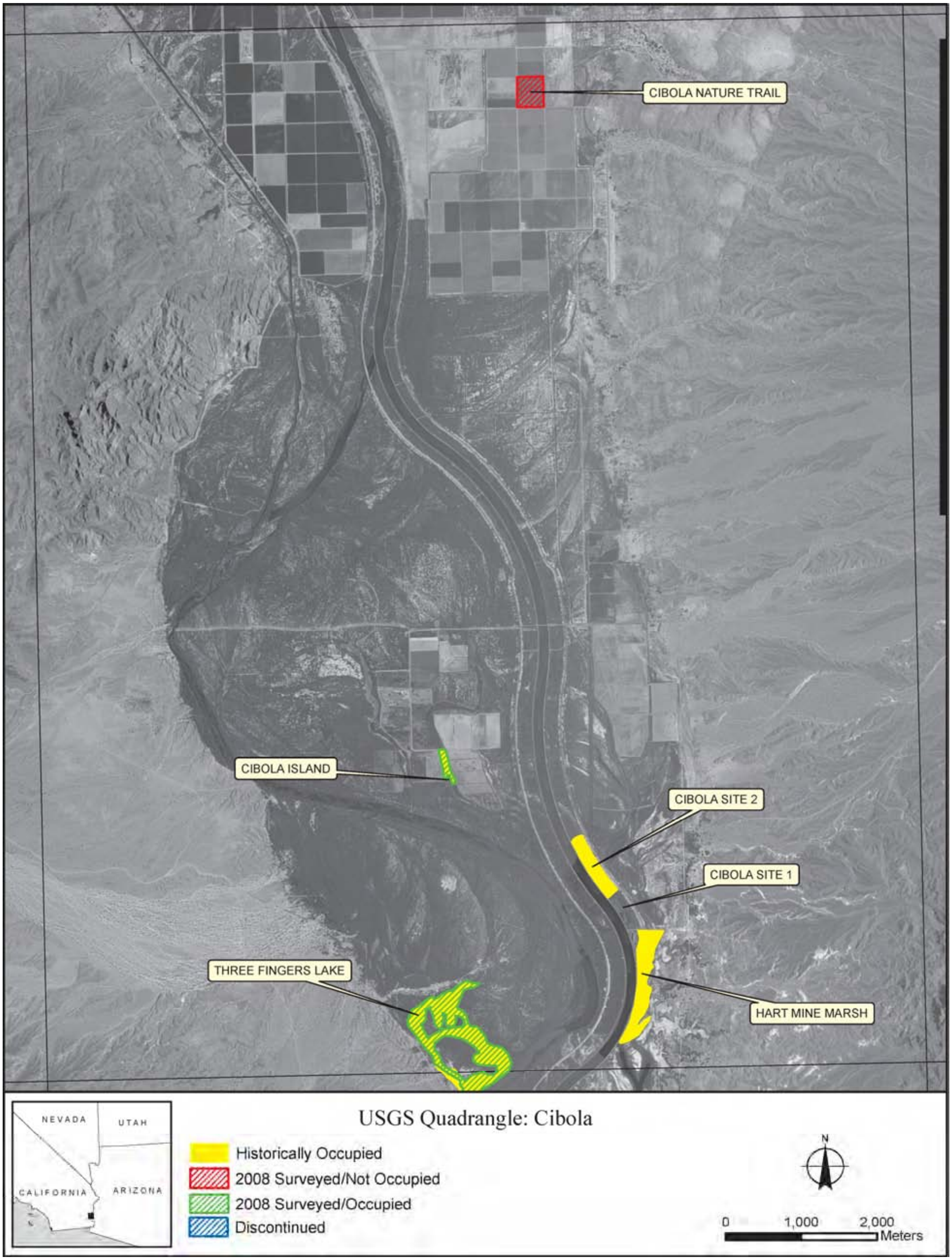

WILLOW BEACH
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Parker
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

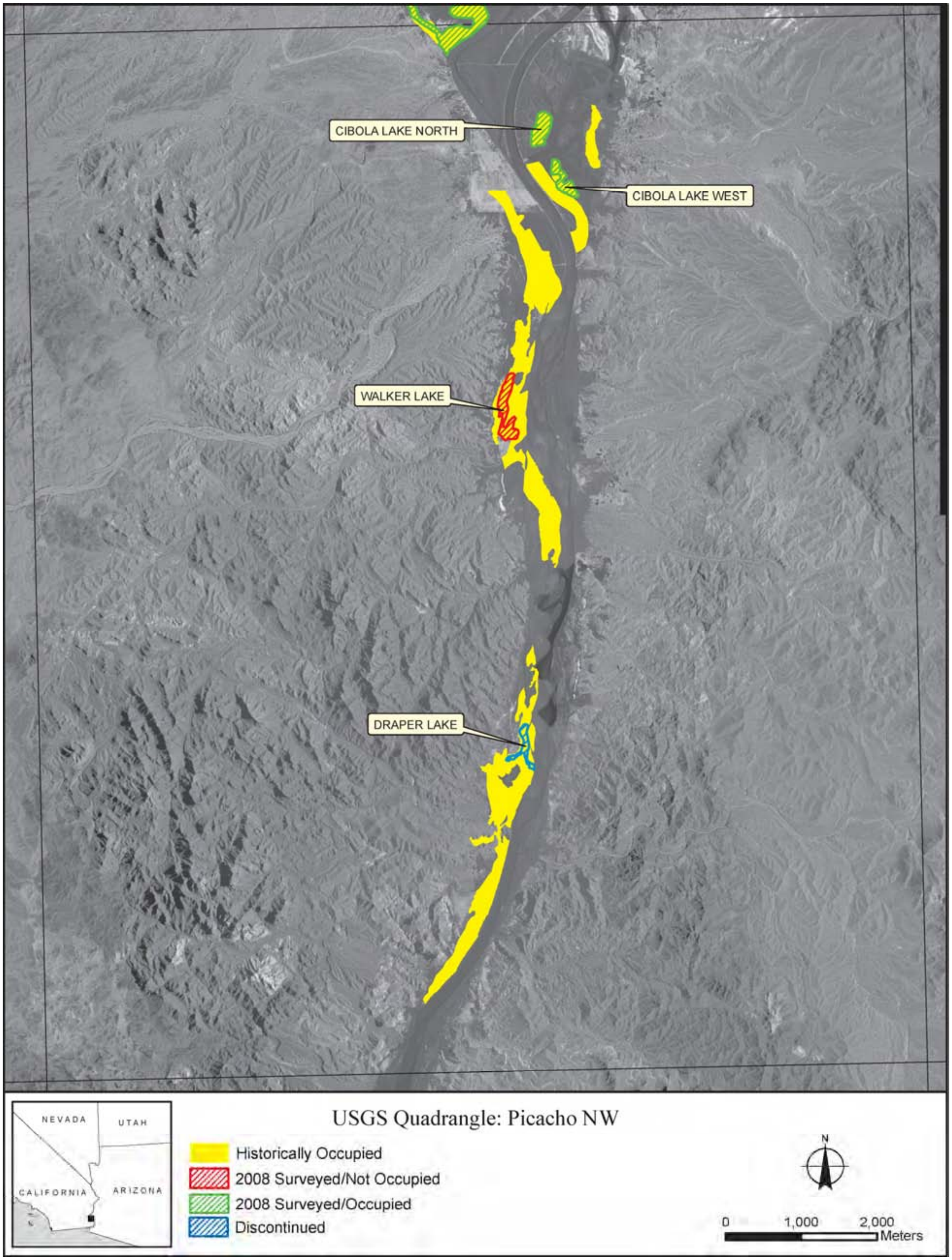

DEER ISLAND
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Parker SE & Parker SW
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

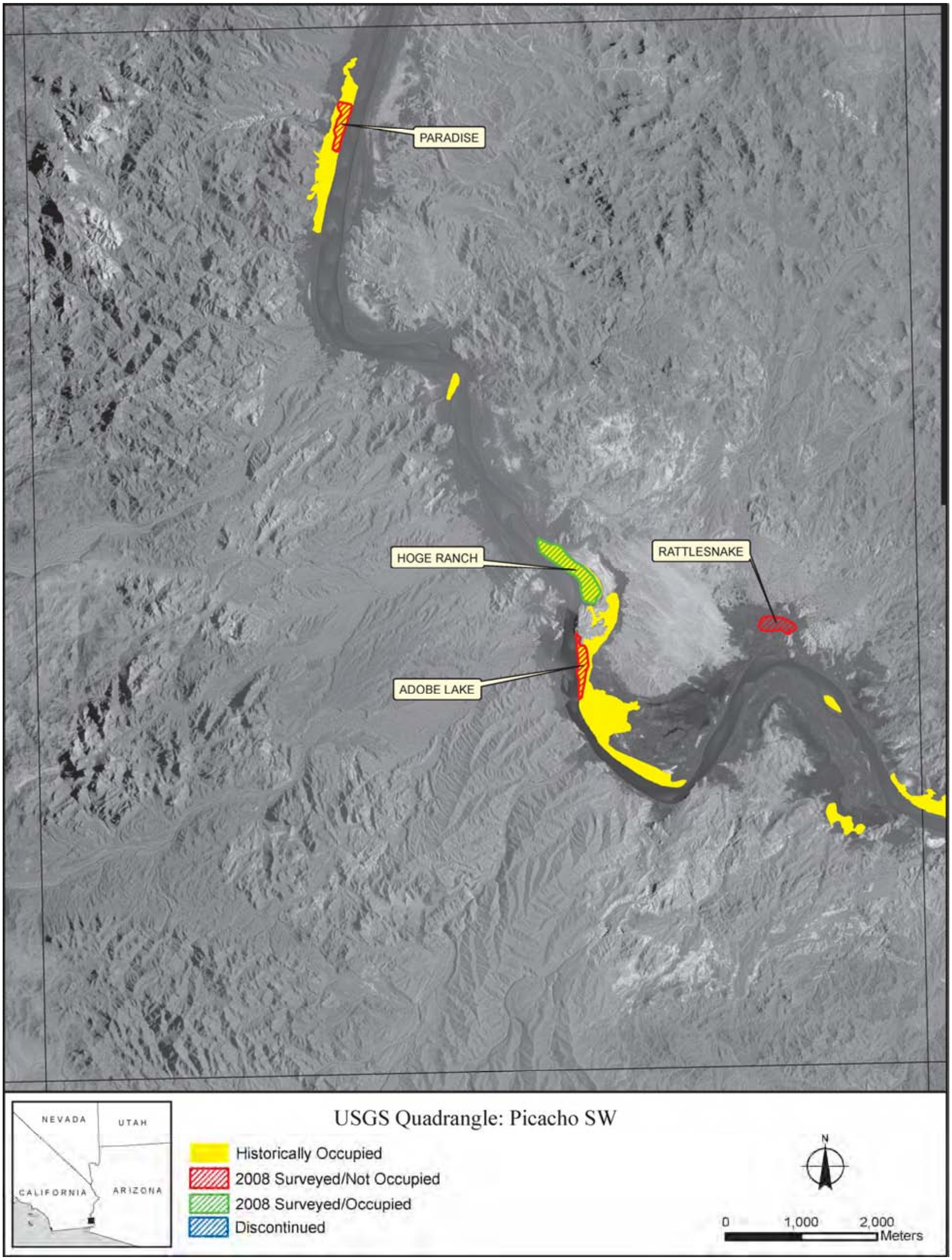

BIG HOLE SLOUGH
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Blythe NE
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

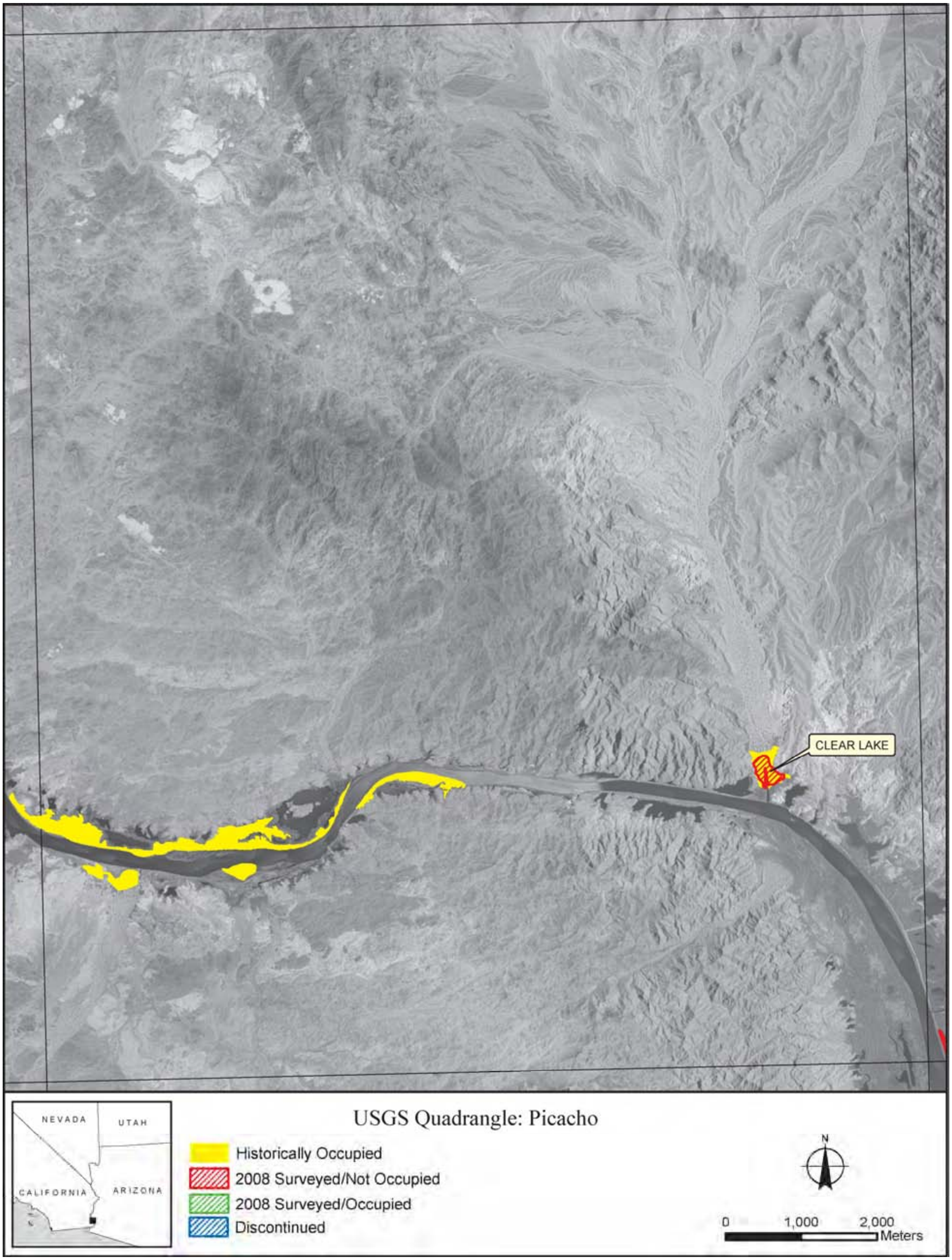

EHRENBERG
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Blythe
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

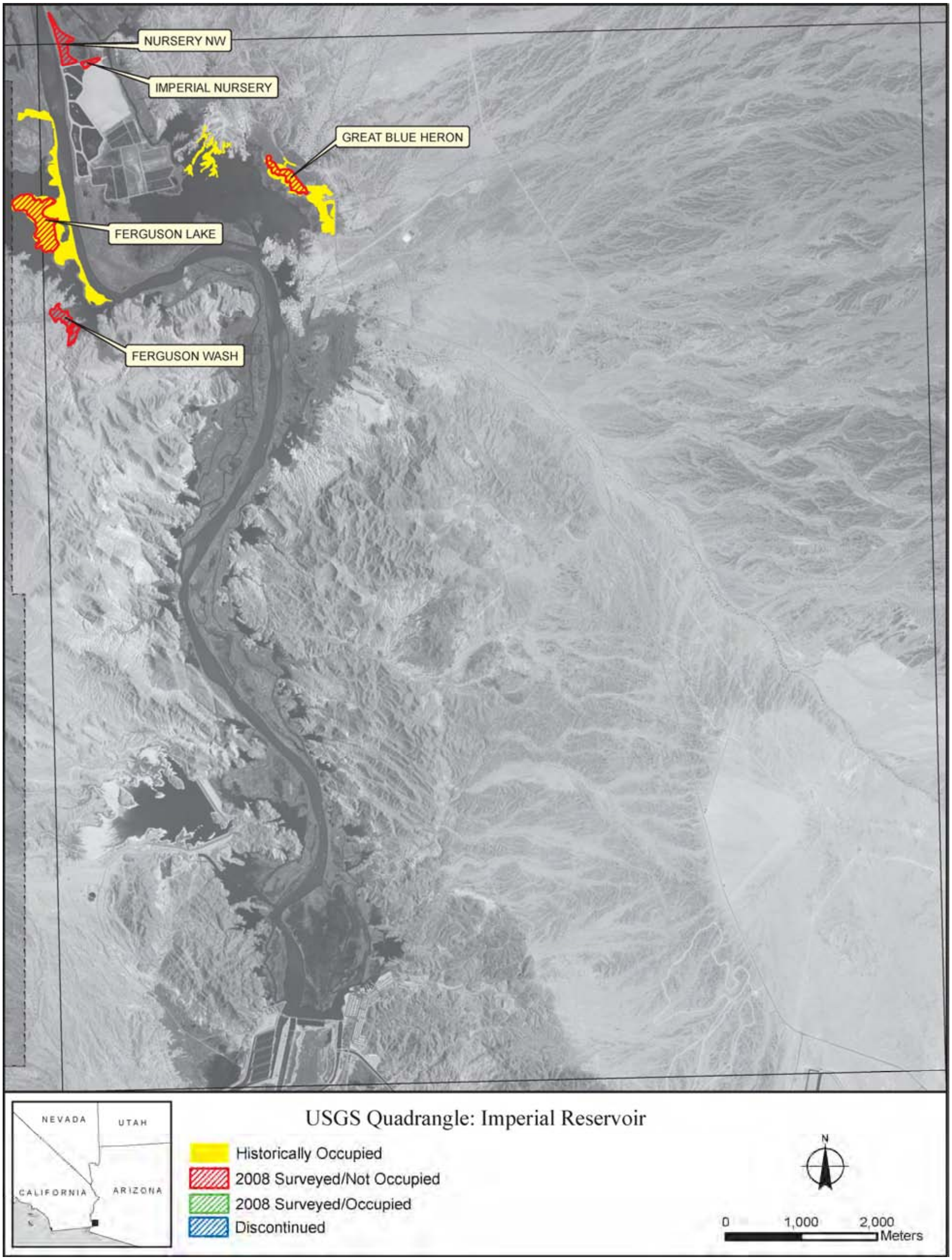

CVCA
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Palo Verde
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

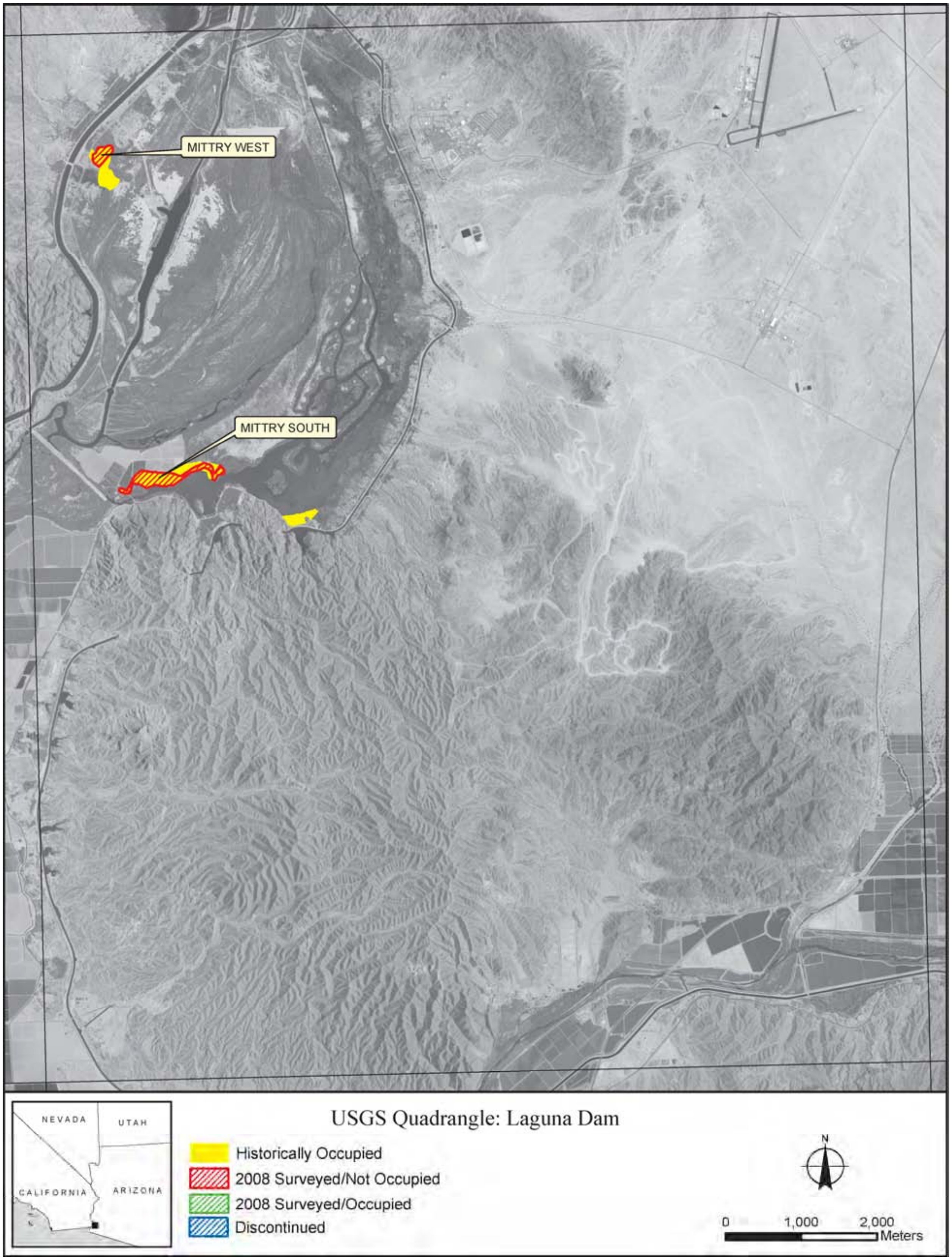

CIBOLA NATURE TRAIL
CIBOLA ISLAND
CIBOLA SITE 2
CIBOLA SITE 1
THREE FINGERS LAKE
HART MINE MARSH
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Cibola
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

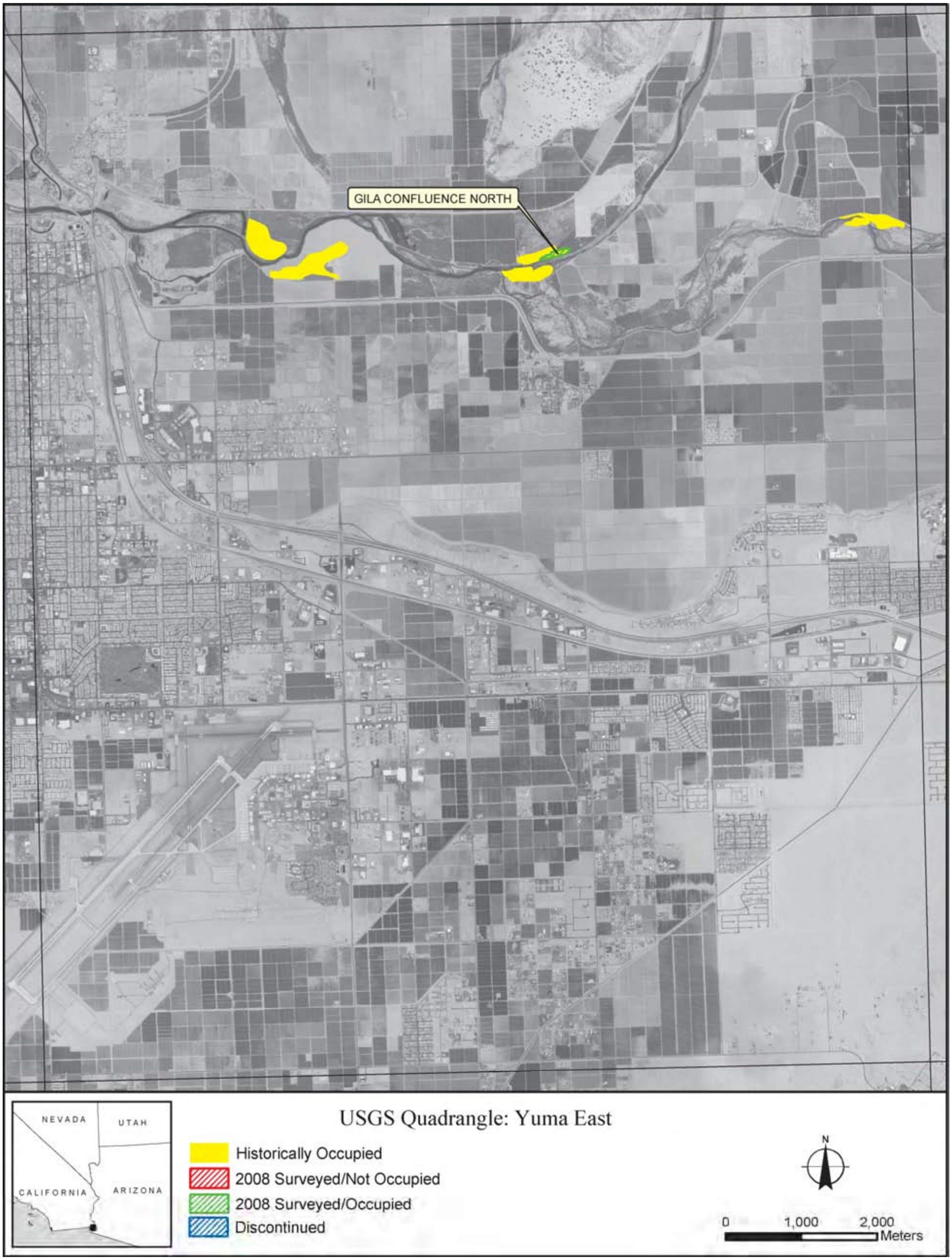

CIBOLA LAKE NORTH
CIBOLA LAKE WEST
WALKER LAKE
DRAPER LAKE
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Picacho NW
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters


PARADISE
HOGE RANCH
RATTLESNAKE
ADOBE LAKE
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Picacho SW
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters


CLEAR LAKE
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Picacho
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters


NURSERY NW
IMPERIAL NURSERY
GREAT BLUE HERON
FERGUSON LAKE
FERGUSON WASH
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Imperial Reservoir
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters


MITTRY WEST
MITTRY SOUTH
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Laguna Dam
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters


GILA CONFLUENCE NORTH
NEVADA
UTAH
CALIFORNIA
ARIZONA
USGS Quadrangle: Yuma East
Historically Occupied
2008 Surveyed/Not Occupied
2008 Surveyed/Occupied
Discontinued
N
0
1,000
2,000
Meters

Appendix C

DETECTIONS OF SPECIAL CONCERN SPECIES, 2008

Appendix C. Number of Detections of Each Special Concern Species Recorded at Each Survey Site, 2008

Study Area[1]	Survey Site	Special Concern Species[2]											
		BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
PAHR	North	0	0	0	1	0	0	0	0	0	24	0	3
	West	0	0	0	0	0	0	0	0	0	9	0	1
	MAPS	0	0	0	0	0	0	0	1	0	7	0	2
	South	0	0	0	0	0	0	0	0	1	15	1	7
LIFI	Poles	0	0	0	0	0	0	0	0	4	13	2	6
MESQ	East	0	0	0	0	0	0	0	0	2	18	2	17
	West	0	0	0	0	0	0	0	0	1	45	1	3
	Electric Avenue North	0	0	0	0	0	0	0	0	1	0	0	0
	Electric Avenue South	0	0	0	0	0	0	0	0	2	12	0	10
	Bunker Farm	0	0	0	0	0	0	0	0	1	20	2	5
MOME	Mormon Mesa North	0	0	0	0	0	0	0	0	4	63	0	42
	Hedgerow	0	0	0	0	0	0	0	0	1	18	1	10
	Mormon Mesa South	0	0	0	0	0	0	0	0	15	104	3	134
	Virgin River #1	0	0	0	0	0	0	0	0	8	117	0	100
	Virgin River #2	0	0	0	0	0	0	0	0	9	69	8	75
MUDD	Overton WMA Pond	0	0	0	0	0	0	0	0	0	21	1	3
	Overton WMA	0	0	0	0	0	0	0	0	2	60	0	37
GRCA	Burnt Springs	0	0	0	0	0	0	0	0	23	20	6	23
	RM 274.5N	1	0	2	0	0	0	0	0	33	34	2	27
	RM 285.3N	0	0	0	0	0	0	0	0	9	0	0	2
	Iceberg Canyon	0	0	0	0	0	0	0	0	2	1	0	2
TOPO	Pipes #1	0	0	0	0	0	0	0	0	3	5	0	27
	Pipes #3	0	0	0	0	0	0	0	0	4	7	4	24
	The Wallows	0	0	0	0	0	0	1	0	1	0	0	11
	PC6-1	0	0	0	0	0	0	3	0	0	8	3	29
	Pig Hole	0	0	0	0	0	0	1	0	0	4	0	11
	In Between	0	0	0	0	0	0	1	0	0	13	0	15
	800M	0	0	1	0	0	0	3	0	1	5	4	15
	Pierced Egg	0	0	0	0	0	0	2	0	1	4	5	14

Study Area[1]	Survey Site	Special Concern Species[2]											
		BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
TOPO	Swine Paradise	0	1	0	0	0	0	2	0	1	9	0	14
	Barbed Wire	0	0	0	0	0	0	1	0	2	3	0	14
	IRFB03	0	1	0	0	0	0	0	0	0	0	0	5
	IRFB04	0	0	0	0	0	0	0	0	0	0	0	5
	Platform	0	1	0	0	0	0	1	0	1	5	1	11
	250M	0	0	0	0	0	0	0	0	0	13	0	16
	Hell Bird	0	0	0	0	0	0	0	0	0	14	1	12
	Glory Hole	0	0	2	0	0	0	8	0	3	10	4	10
	Beal Lake	0	0	0	0	0	0	0	0	2	4	0	10
	Lost Slough	0	0	0	0	0	0	0	0	0	0	0	11
	Lost Pond	0	0	1	0	0	0	0	0	0	0	0	5
	Lost Lake	0	1	1	0	0	0	0	0	1	5	1	17
TOGO	Blankenship Bend North	0	0	0	0	0	0	0	0	11	3	0	18
	Blankenship Bend South	0	0	2	0	0	0	0	0	7	0	0	17
	Havasu NE	0	0	0	0	0	0	0	0	0	4	0	16
BIWI	Site #2	1	2	4	0	0	0	3	0	4	10	0	24
	Site #11	0	0	0	0	0	0	3	0	2	11	0	26
	Site #4	0	0	0	0	0	0	13	0	13	10	2	49
	Site #3	6	0	0	0	0	0	8	0	13	17	7	46
	Site #5	0	0	0	1	0	2	10	0	11	22	3	57
	Mineral Wash Complex	3	0	0	0	0	0	5	1	17	2	1	21
	Beaver Pond	3	0	0	0	0	0	3	1	18	5	0	24
	Site #8	1	0	0	1	0	0	2	0	16	11	1	20
AHAK	Willow Beach	0	0	0	0	0	0	0	0	0	3	0	2
	Deer Island	0	0	6	0	0	0	0	0	2	8	0	2
BIHO	Big Hole Slough	0	0	1	0	0	0	3	0	0	0	0	3
EHRE	Ehrenberg	0	0	0	0	0	0	1	0	1	2	1	7
CIBO	CVCA	0	0	0	0	0	0	0	0	1	4	0	2
	Cibola Nature Trail	0	0	0	0	0	0	0	0	0	0	0	2

Study Area[1]	Survey Site	Special Concern Species[2]											
		BLRA	CLRA	LEBI	YBCU	ELOW	GIFL	GIWO	VEFL	BEVI	YWAR	SUTA	YBCH
CIBO	Cibola Island	0	0	0	0	0	0	0	0	0	2	0	7
	Three Fingers Lake	0	2	15	0	0	1	1	0	8	0	1	30
	Cibola Lake #1 (North)	0	1	4	1	0	1	2	0	3	0	3	15
	Cibola Lake #3 (West)	1	0	4	0	0	2	1	0	6	0	0	18
	Walker Lake	0	1	0	0	0	0	2	0	0	0	1	9
IMPE	Draper Lake	0	2	0	0	0	0	0	0	1	0	0	2
	Paradise	2	0	0	0	0	1	10	0	1	1	1	14
	Hoge Ranch	0	0	0	0	0	1	0	0	5	2	3	21
	Adobe Lake	0	0	0	0	0	0	1	0	1	3	5	16
	Rattlesnake	0	0	0	0	0	0	3	0	3	2	10	27
	Clear Lake/The Alley	0	0	4	0	0	0	4	0	6	0	1	33
	Nursery NW	1	5	1	0	0	0	2	0	4	0	0	10
	Imperial Nursery	0	2	0	0	0	0	3	0	0	1	2	3
	Ferguson Lake	0	1	4	0	0	0	7	0	5	0	0	14
	Ferguson Wash	0	0	4	0	0	0	0	0	1	1	0	13
	Great Blue Heron	0	0	0	0	0	0	3	0	3	0	0	13
MITT	Mittry West	0	0	0	0	0	0	12	0	5	0	1	22
	Mittry South	0	1	1	0	0	0	1	0	2	0	0	3
YUMA	Gila Confluence North	0	0	0	0	0	0	2	0	0	0	2	8

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

[2] BLRA = Black Rail, CLRA = Clapper Rail, LEBI = Least Bittern, YBCU = Yellow Billed Cuckoo, ELOW = Elf Owl, GIFL = Gilded Flicker, GIWO = Gila Woodpecker, VEFL = Vermilion Flycatcher, BEVI = Bell's Vireo, YWAR = Yellow Warbler, SUTA = Summer Tanager, YBCH = Yellow-breasted Chat

Appendix D

ALL WILLOW FLYCATCHERS COLOR-BANDED AND/OR RESIGHTED, 2003–2008

Appendix D. Willow flycatchers banded and/or resighted by SWCA at sites along the Virgin and lower Colorado Rivers in 2003–2008. Table includes individuals banded at sites prior to 2003 (Braden and McKernan, unpubl. data) and recaptured or resighted by SWCA.

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1490-89889	M	J							R		D	D	D	D
1590-97338	M	A	P				P	P	P	P				
1710-20312	M	J							R		T			
1710-20638	M	A		G	M	M	M	M	M	M	M			
2090-42022	F	J		M					Q					
2110-78841	F	J						T	T	T	T			
2110-78842	M	A						Q	Q	Q				
2110-78855	M	J						T	T					
2110-78861	M	J						T	M[4]	Q				
2110-78863	M	J						T	T	T				
2140-66502	M	J						Q	Q					
2140-66503	F	J						Q		Q				
2140-66517	F	A						Q	Q	Q	D			
2140-66518	M	A						Q	Q					
2140-66561	M	A						P			P	P	P	P
2140-66564	F	J						P	P					
2140-66566	M	J						P			P			
2140-66568	M	A						P	P		P	P	P	P
2140-66606	M	J		M		Q	Q		Q					
2140-66621	F	A				P	P	P	P	P				
2140-66627	F	A				P	P	P		P				
2140-66693	M	J					M	Q	Q					
2140-66696	F	J					Q		Q					
2140-66697	M	J					Q			P	P	P	P	P
2140-66709	M	A						Q	Q	Q		Q[5]	M	M
2140-66728	M	J					T			T				
2140-66743	M	J			T					T				
2140-66775	M	J				T	M		Q	Q	Q			
2190-76604	M	A					P		P	P	P	P		
2320-31401	M	A							B					
2320-31402	M	A							B					
2320-31403	M	A							Y					
2320-31404	F	A							B					
2320-31405	F	A							B					
2320-31406	U	J							B					
2320-31407	F	J							B	T				
2320-31408	U	J							B					
2320-31409	U	J							B					
2320-31410	U	J							B					
2320-31411	U	J							B					
2320-31412	M	A							B	B				
2320-31413	U	A							Q					
2320-31414	M	A								T	T			

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2320-31415	F	A								T				
2320-31416	U	J								T				
2320-31417	U	J								T				
2320-31418	M	A								T	T			
2320-31419	U	J								T				
2320-31420	U	J								T				
2320-31421	U	J								T				
2320-31422	U	J								T				
2320-31423	U	A								T				
2320-31424	M	J								T	T			
2320-31425	U	J								T				
2320-31426	F	A							M					
2320-31427	M	A							M					
2320-31428	M	J							Q	M	Q[6]		M	M
2320-31429	U	J							Q					
2320-31430	U	J							P					
2320-31431	U	J							Q					
2320-31432	U	J							P					
2320-31433	U	J							Q					
2320-31434	U	J							Q					
2320-31435	U	J							P					
2320-31436	U	J							P					
2320-31437	U	J							P					
2320-31438	M	J							Q	Q				
2320-31439	U	J							Q					
2320-31440	F	J							Q	M				
2320-31441	U	J							M					
2320-31443	U	J							Q					
2320-31444	F	A							Q	Q	Q	Q		
2320-31445	F	A							Q	Q	Q	Q	Q	Q
2320-31446	U	J								P				
2320-31447	U	J								P				
2320-31448	U	J								P				
2320-31449	U	J								P				
2320-31450	U	J								P				
2320-31451	M	A							P	P	P	P		
2320-31452	M	A							P					
2320-31453	M	A							P	P				
2320-31454	M	A							P	P				
2320-31455	M	A							P					
2320-31456	U	J							P					
2320-31457	M	J							P	K				
2320-31458	M	J							P		P			
2320-31459	M	J							P	P				
2320-31460	U	J							P					
2320-31461	U	J							P					
2320-31462	U	J							P					

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2320-31463	F	J							P			K	K	
2320-31464	U	J							P					
2320-31465	U	J							P					
2320-31466	F	A							P					
2320-31467	M	J							P		P	P		
2320-31468	M	J							P		P	P		K
2320-31469	U	J							P					
2320-31470	U	J							P					
2320-31471	M	J							Q	Q			M	
2320-31472	U	J							Q					
2320-31473	M	J							Q	Q				
2320-31474	U	J							Q					
2320-31475	M	J							P	L				
2320-31476	F	A							Q					
2320-31477	U	J							Q					
2320-31479	F	A							Q	Q				
2320-31480	F	J							Q	Q				
2320-31481	U	J							P					
2320-31482	U	J							P					
2320-31483	U	J								Q				
2320-31484	M	J								P	P			K
2320-31485	F	A								M		M	M	M
2320-31486	F	J							Q	L	Q	M	M	M
2320-31487	U	J							Q					
2320-31488	U	J							Q					
2320-31489	U	A								M				
2320-31490	M	A								L	L[7]	Q	Q	Q
2320-31491	M	A								Q				
2320-31493	M	A								D				
2320-31494	U	A								Q				
2320-31495	M	A								T				
2320-31496	U	J								M				
2320-31497	U	J								M				
2320-31498	F	J								M		G[8]	Q	Q
2320-31499	M	A								Q				
2320-31500	U	J								Q				
2320-31501	M	A							B					
2320-31502	F	A							T	T				
2320-31503	U	A								I				
2320-31504	U	A								I				
2320-31505	M	A								T				
2320-31506	U	J								T				
2320-31507	U	J								T				
2320-31508	U	J								T				
2320-31510	U	J								T				
2320-31511	U	J								T				
2320-31512	U	J								T				

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2320-31513	U	J								T				
2320-31514	U	J								T				
2320-31515	F	A								T	T	T		
2320-31516	F	A								G				
2320-31517	M	A								G	M	M		
2320-31518	U	J								T				
2320-31519	U	J								T				
2320-31520	U	J								T				
2320-31521	F	A								T	T			
2320-31522	U	J											Q	
2320-31523	U	J											M	
2320-31524	U	J											P	
2320-31525	U	J											P	
2320-31526	F	A							T	T	T			
2320-31527	F	A								T				
2320-31528	M	A								T				
2320-31529	U	J								T				
2320-31530	U	J								T				
2320-31531	U	J								T				
2320-31532	U	J								T				
2320-31533	U	J								T				
2320-31534	U	J								T				
2320-31535	U	J								T				
2320-31536	U	J								T				
2320-31537	U	J								T				
2320-31538	M	A								T				
2320-31539	M	A								B				
2320-31540	F	A								T				
2320-31541	M	A								T	T			
2320-31542	U	J								T				
2320-31543	U	J								T				
2320-31544	U	J								T				
2320-31545	U	J											P	
2320-31546	U	J											P	
2320-31547	U	J											P	
2320-31548	U	J											P	
2320-31549	U	J											P	
2320-31550	U	J											P	
2320-31551	M	A								Q				
2320-31552	M	A								M				
2320-31553	M	A								M		M		
2320-31554	U	J								T				
2320-31555	U	J								T				
2320-31556	U	J								T				
2320-31557	U	J								T				
2320-31558	U	J								T				
2320-31559	M	A								T	T	T	T	

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2320-31560	M	A								T	T	T	T	T
2320-31561	U	J								T				
2320-31562	M	J								T		T		T
2320-31563	U	J								T				
2320-31564	U	J								T				
2320-31565	F	A								T	T			
2320-31566	U	J										T		
2320-31567	M	A								T	T			
2320-31568	F	A								P				
2320-31569	U	J								P				
2320-31570	U	J								P				
2320-31571	U	J								P				
2320-31572	M	A								M				
2320-31573	F	A								Q	Q	Q	Q	Q
2320-31574	U	J									P			
2320-31575	U	J										Q		
2320-31576	M	A							T	T				
2320-31577	F	A							T	T	T			
2320-31578	U	A							Y					
2320-31579	U	A							Y					
2320-31580	U	A							Y					
2320-31581	U	J							T					
2320-31582	U	J							T					
2320-31583	U	J							T					
2320-31584	F	A							T	T	T	T		
2320-31585	U	J							T					
2320-31586	U	J							T					
2320-31587	U	J							T					
2320-31588	U	J							T					
2320-31589	M	A								P	P	P	P	
2320-31590	M	A								P	P	P	P	P
2320-31591	M	A								P	P	P	P	
2320-31593	M	A								P	P	P		
2320-31594	M	A								P				
2320-31595	M	A								P	P	P	P	P
2320-31596	M	A								P				
2320-31598	M	A								T				
2320-31599	U	A								I				
2320-31600	U	A								I				
2320-31601	U	J								P				
2320-31602	U	J								P				
2320-31603	U	J								P				
2320-31604	M	J								P		K	K	
2320-31605	U	J								P				
2320-31606	U	J								P				
2320-31607	U	J								P				
2320-31608	U	J								P				

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2320-31609	U	J								P				
2320-31610	U	J								P				
2320-31611	U	J								Q				
2320-31612	U	J								Q				
2320-31616	F	J								Q		D		
2320-31617	U	J								Q				
2320-31618	F	J								Q	M	M	M	
2320-31619	U	J								M				
2320-31620	U	J								M				
2320-31621	F	A								M				
2320-31622	M	A								Q				
2320-31623	U	J								M				
2320-31624	U	J								M				
2320-31625	F	A								M				
2320-31627	M	A								Q				
2320-31628	U	A								M				
2320-31629	U	J								M				
2320-31630	U	J								Q				
2320-31631	F	J								Q		D	D	
2320-31632	F	A								Q		M	M	M[9]
2320-31633	U	J								Q				
2320-31634	U	J								Q				
2320-31635	M	A								K				
2320-31636	U	J								K				
2320-31637	F	J								K	P			
2320-31638	U	J								K				
2320-31639	U	J											P	
2320-31640	U	J											Q	
2320-31641	U	J											Q	
2320-31642	U	J											Q	
2320-31643	U	J											P	
2320-31644	U	J											M	
2320-31645	U	J											M	
2320-31646	U	J											P	
2320-31649	U	J											P	
2320-31650	F	J										T	T	
2320-31651	M	A								M				
2320-31652	M	A								M	Q	Q		
2320-31653	M	A								M	M	M	M	
2320-31654	M	A								Q				
2320-31655	F	A								Q	Q	Q		
2320-31656	F	A								P	P	P		
2320-31657	F	A								P	P	P	P	P
2320-31658	F	A								P				
2320-31659	M	J								Q		D	D	D
2320-31660	F	J								Q			M	S
2320-31661	F	A								P	P	P	P	P

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2320-31662	F	A								P				
2320-31663	F	A								P	P	P	P	P
2320-31664	F	A								P				
2320-31665	U	J								P				
2320-31666	U	J								P				
2320-31667	U	J								P				
2320-31668	F	A								P				
2320-31669	F	A								P				
2320-31670	U	J											Q	
2320-31671	U	J										M		
2320-31672	U	J											P	
2320-31673	U	J										T		
2320-31674	M	J										P		K
2320-31675	U	J									T			
2320-31676	U	J									T			
2320-31677	U	J										T		
2320-31678	U	J										P		
2320-31679	U	J											P	
2320-31680	U	J									T			
2320-31681	U	J									T			
2320-31682	U	J									P			
2320-31683	M	J									P		K	
2320-31684	U	J									P			
2320-31685	U	J									P			
2320-31686	M	J									P	P		
2320-31687	U	J									P			
2320-31688	M	J									Q	Q	Q	Q
2320-31689	U	J									Q			
2320-31690	U	J									Q			
2320-31691	U	J									Q			
2320-31692	M	J									P	K		
2320-31693	U	J									P			
2320-31694	M	J									P		K	K
2320-31695	F	J									P	P		
2320-31696	U	J									Q			
2320-31697	U	J									P			
2320-31698	F	J									P		P	P
2320-31699	U	J									P			
2320-31700	U	J									P			
2360-59701	F	J									Q	Q		
2360-59702	M	J									Q	D	M	
2360-59703	U	J									Q			
2360-59704	U	J									M			
2360-59705	U	J									M			
2360-59706	U	J									K			
2360-59707	F	J									P	P		
2360-59708	F	J									P	P		

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2360-59709	U	J									P			
2360-59710	U	J									P			
2360-59711	M	J									K			P
2360-59712	M	J									K			P
2360-59713	U	J									K			
2360-59714	U	J									Q			
2360-59715	U	J									Q			
2360-59716	U	J									Q			
2360-59717	M	A								Q				
2360-59718	U	J									P			
2360-59719	U	J									T			
2360-59720	U	J									T			
2360-59721	U	J								P				
2360-59722	U	J									T			
2360-59723	U	J								P				
2360-59724	F	J								P		P		
2360-59725	U	J									B			
2360-59727	M	J									B		B	
2360-59728	U	J									B			
2360-59729	U	J									T			
2360-59730	U	J									T			
2360-59731	U	J									T			
2360-59732	U	J									T			
2360-59733	U	J									T			
2360-59734	U	J									T			
2360-59735	U	J										P		
2360-59736	U	J										P		
2360-59737	U	J										D		
2360-59738	U	J										D		
2360-59739	U	J										Q		
2360-59740	U	J									P			
2360-59741	U	J									Q			
2360-59742	U	J									Q			
2360-59743	F	J											P	K
2360-59744	U	J										T		
2360-59745	U	J										P		
2360-59746	U	J								G				
2360-59747	U	J										D		
2360-59748	U	J										D		
2360-59749	M	J										D	D[10]	M
2360-59750	F	J										M	Q	
2360-59751	M	J										M	Q	Q
2360-59752	M	J										Q		Q
2360-59753	U	J										Q		
2360-59754	M	J										Q	Q	Q
2360-59755	U	J										Q		
2360-59756	U	J										P		

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2360-59757	U	J								K				
2360-59758	U	J										P		
2360-59759	U	J										P		
2360-59760	U	J								L				
2360-59761	U	J								L				
2360-59762	U	J								Q				
2360-59763	U	J								Q				
2360-59764	U	J											P	
2360-59765	U	J											P	
2360-59766	U	J								Q				
2360-59767	U	J								K				
2360-59768	U	J										T		
2360-59769	U	J										M		
2360-59770	U	J								K				
2360-59771	U	J								G				
2360-59772	F	A								K				
2360-59773	U	J											Q	
2360-59775	U	J											Q	
2360-59776	U	J											Q	
2360-59777	U	J											Q	
2360-59778	U	J											Q	
2360-59779	U	J											K	
2360-59780	U	J											K	
2360-59781	U	J											K	
2360-59782	U	J											K	
2360-59785	U	J									D			
2360-59786	U	J									D			
2360-59787	U	J									D			
2360-59788	F	J									D	D	M	M
2360-59789	U	J										Q		
2360-59790	U	J										Q		
2360-59791	U	J										P		
2360-59792	U	J										P		
2360-59793	U	J										P		
2360-59794	U	J										P		
2360-59795	U	J										P		
2360-59796	U	J										P		
2360-59797	M	J										P	P	
2360-59798	U	J										P		
2360-59799	M	J										M	D	M
2360-59800	U	J								G				
2370-39901	U	A								P				
2370-39902	U	J								P				
2370-39904	U	J								P				
2370-39911	M	A									P			
2370-39912	M	A									Q		Q	
2370-39913	M	A									G			

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2370-39914	U	J									P			
2370-39915	M	A									P	P	P	P[11]
2370-39916	M	A										T	T	T
2370-39917	U	A										Y		
2370-39918	U	A										Y		
2370-39919	U	A										Y		
2370-39920	U	A										Y		
2370-39921	U	A										Y		
2370-39922	U	A										Y		
2370-39923	U	A										Y		
2370-39924	U	A										Y		
2370-39925	U	A										Y		
2370-39926	U	A										Y		
2370-39927	U	A										Y		
2370-39928	U	A										Y		
2370-39929	M	A										G	G	
2370-39932	F	A									B	B	B	
2370-39933	U	A									Y			
2370-39934	U	A									Y			
2370-39935	U	A									Y			
2370-39937	M	A										Q	Q	Q
2370-39938	M	A										M	M	M
2370-39939	F	A										Q	Q	
2370-39940	M	A										M	M	M
2370-39941	M	J										Q	L[12]	
2370-39942	U	J										D		
2370-39943	U	J										D		
2370-39944	U	J										D		
2370-39945	U	J										P		
2370-39946	M	J										P	P	
2370-39947	U	J										P		
2370-39948	F	A										M		
2370-39949	U	J										Q		
2370-39950	U	J										Q		
2370-39951	M	A									P	P	P	P
2370-39953	M	A									P	P	P	P
2370-39954	M	A									Q	Q	Q	Q
2370-39956	F	A									D	D	D	
2370-39957	F	A									Q	Q		
2370-39958	F	A									P			
2370-39959	M	A									P		A	
2370-39960	M	A									K			
2370-39961	M	A									P			
2370-39962	F	A									P			
2370-39964	F	A									P	P	P	
2370-39965	U	A									D			
2370-39966	M	J									D		M	

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2370-39967	M	A										M	D[13]	Q
2370-39971	U	A									P			
2370-39972	U	A									I			
2370-39973	U	A									Y			
2370-39974	U	A									I			
2370-39975	M	A									D	M		
2370-39976	M	A									D			
2370-39977	U	J									P			
2370-39978	F	A									P			
2370-39979	U	J									P			
2370-39980	M	J									P	K	K	K
2370-39981	U	J									P			
2370-39982	U	A										Y		
2370-39983	U	A										Y		
2370-39984	U	A										Y		
2370-39985	U	A										Y		
2370-39986	M	A										G		
2370-39987	M	A										G		
2370-39988	M	A										G	M	M
2370-39989	M	A										G		
2370-39990	F	A										G		
2370-39992	M	A										T		
2370-39993	U	A										Y		
2370-39994	U	A										Y		
2370-39995	U	A										Y		
2370-39996	U	A										Y		
2370-39997	U	A										Y		
2370-39998	U	A										Y		
2370-40003	M	A										T		
2370-40004	F	A										B		
2370-40012	M	A									Q	Q	Q	
2370-40013	M	A									P	P		
2370-40014	F	A									P	P	P	
2370-40016	U	J									P			
2370-40017	M	A									M	M		
2370-40019	U	J									P			
2370-40020	U	J									P			
2370-40021	M	A									P	P		
2370-40032	M	A									B			
2370-40033	U	A									Y			
2370-40034	U	A									Y			
2370-40035	U	A									Y			
2370-40036	M	A										G[14]		
2370-40037	F	A										G	M	
2370-40038	M	A										G		
2370-40039	U	A										Y		
2370-40040	U	A										Y		

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2370-40041	U	A										Y		
2370-40042	U	A										Y		
2370-40043	U	A										Y		
2370-40044	U	A										Y		
2370-40045	U	A										Y		
2370-40046	M	A										G	G[15]	M
2370-40047	F	A										P	P	P
2370-40052	M	A									B	B	B	B
2370-40053	M	A									B			
2370-40054	M	A									B			
2370-40055	F	A									T			
2370-40056	M	A									T			
2370-40057	M	A										D		
2370-40058	M	A										M	B	
2370-40059	F	A										D	D	D
2370-40060	M	A										P		P
2370-40061	F	A										P		
2370-40062	F	A										P	P	
2370-40063	U	J										Q		
2370-40064	U	J										P		
2370-40065	U	J										Q		
2370-40066	F	A										Q	Q	Q
2370-40067	U	J										Q		
2370-40068	U	J										Q		
2370-40069	U	J										M		
2370-40070	U	J										M		
2370-40071	U	J										P		
2370-40080	U	J										Q		
2370-40081	M	A										K		
2370-40082	F	A										K		
2370-40083	U	J										Q		
2370-40084	U	J										Q		
2370-40085	U	J											Q	
2370-40086	U	J											Q	M
2370-40087	F	A											Q	Q
2370-40096	U	J												K
2370-40097	U	J												K
2370-40098	U	J												K
2370-40100	U	J										K		
2370-40101	U	J										K		
2370-40102	U	J										K		
2370-40103	U	J										Q		
2370-40104	U	J										Q		
2370-40105	U	J										Q		
2370-40106	U	J										Q		
2370-40107	U	J										Q		
2370-40108	U	J										Q		

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2370-40110	U	J											T	
2370-40111	U	J											T	
2370-40112	U	J											T	
2370-40113	U	J											B	
2370-40114	U	J											T	
2370-40115	U	J											T	
2370-40116	U	J											T	
2370-40117	U	J											T	
2370-40118	U	J											T	
2370-40119	U	J											T	
2370-40120	U	J											T	
2370-40121	U	J											T	
2370-40122	U	J											T	
2370-40123	U	J											T	
2370-40124	U	J											T	
2370-40125	U	J											T	
2370-40126	M	A											G	
2370-40127	M	A											G	
2370-40129	M	A											G	
2370-40132	F	A											T	
2370-40133	F	A											B	
2370-40134	U	A											B	
2370-40135	F	A											B	
2370-40136	F	A											T	
2370-40137	M	A											B	
2370-40138	M	A											T	
2370-40139	M	A											T	T
2370-40147	U	J												S
2370-40148	U	J												S
2370-40149	U	J												S
2370-40157	M	A											P	
2370-40158	U	J											B	
2370-40159	U	J											B	
2370-40160	F	A											G	
2370-40161	M	A											M	M
2370-40164	U	J											Q	
2370-40166	U	A											P	
2370-40167	U	J											P	
2370-40168	F	A											P	P
2370-40169	U	J											M	
2370-40170	F	A											Q	Q
2370-40171	F	A											D	
2370-40173	M	A											M	M
2370-40183	F	A											M	
2370-40184	M	A											D	
2370-40185	M	A											P	
2370-40186	M	A											D	

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2370-40187	M	A											K	
2370-40188	U	J											Q	
2370-40190	U	J											P	
2370-40191	F	A											M	M
2370-40192	F	A											D	
2370-40193	F	A											Q	Q
2370-40194	F	A											P	P
2370-40195	F	A											P	P
2370-40197	M	A											M	Q
2370-40199	U	J											P	
2390-92348	F	J		T						T				
2390-92350	M	A				M	Q		Q	Q				
2390-92365	M	J				D			Q	Q	Q			
2390-92410	M	A					Q		Q					
2390-92420	M	J					Q	Q	Q					
2390-92421	M	J					Q	Q	Q	Q	M	M		
2390-92427	F	J					M		Q					
2390-92433	M	J					Q		Q	Q				
2390-92434	M	J					Q	Q		Q	Q	Q	Q	Q
2390-92451	F	J			M	M		Q		Q				
2390-92470	F	J					Q			Q				
2390-92475	M	J					M	Q	Q	Q	Q	Q	Q	Q
2430-31015	U	A											Y	
2430-31017	U	A											Y	
2430-61006	U	A											Y	
2430-61007	U	A											Y	
2430-61008	U	A											Y	
2430-61009	U	A											Y	
2430-61010	U	A											Y	
2430-61011	U	A											Y	
2430-61012	U	A											Y	
2430-61013	U	A											Y	
2430-61014	U	A											Y	
2430-61016	U	A											Y	
2430-61018	U	A											Y	
2430-61019	U	A											Y	
2430-61020	U	A											Y	
2430-61021	U	A											Y	
2430-61023	U	A											Y	
2430-61024	U	A											Y	
2430-61025	U	A											Y	
2430-61026	U	A											Y	
2430-61027	U	A											Y	
2430-61028	U	A											Y	
2430-61029	U	A											Y	
2430-61030	U	A											Y	
2430-61031	U	A											Y	

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2430-61032	U	A											Y	
2430-61033	U	A											Y	
2430-61034	U	A											Y	
2430-61035	U	A											Y	
2430-61036	U	A											Y	
2430-61037	U	A											Y	
2430-61038	U	A											Y	
2430-61039	U	A											Y	
2430-61040	U	A											Y	
2430-61041	U	A											Y	
2430-61042	U	A											Y	
2430-61043	U	A											Y	
2430-61044	U	A											Y	
2430-61045	U	A											Y	
2430-61046	U	A											Y	
2430-61047	U	A											Y	
2430-61048	U	A											Y	
2430-61049	U	A											Y	
2430-61050	U	A											Y	
2430-61051	U	A											Y	
2430-61052	U	A											Y	
2430-61053	U	A											Y	
2430-61054	U	A											Y	
2430-61055	U	A											Y	
2430-61056	U	A											Y	
2430-61058	U	A											Y	
2430-61059	U	A											Y	
2430-61060	U	A											Y	
2430-61061	U	A											Y	
2430-61062	U	A											Y	
2430-61063	U	A											Y	
2430-61064	U	A											Y	
2430-61065	U	A											Y	
2430-61067	U	A											Y	
2430-61068	U	A											Y	
2430-61069	U	A											Y	
2430-61070	U	A											Y	
2430-61071	U	A											Y	
2430-61072	M	A												G
2430-61073	M	A												B
2430-61074	U	J												B
2430-61075	U	J												B
2430-61076	U	J												B
2430-61077	U	J												M
2430-61078	U	J												Q
2430-61079	F	A												M
2430-61080	M	A												P

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2430-61081	U	J												M
2430-61082	U	J												Q
2430-61083	M	A												P
2430-61084	U	J												Q
2430-61101	U	J												K
2430-61102	U	J												K
2430-61103	M	A												D
2430-61104	M	A												M
2430-61105	M	A												Q
2430-61106	U	J												P
2430-61107	U	J												P
2430-61108	U	J												P
2430-61109	F	A												K
2430-61110	U	J												K
2430-61111	U	J												P
2430-61112	U	J												P
2430-61113	U	J												P
2430-61114	U	J												P
2430-61115	U	J												P
2430-61116	F	A												M
2430-61117	U	J												P
2430-61118	U	J												P
2430-61119	U	J												P
2430-61120	U	J												P
2430-61121	U	J												Q
2430-61122	U	J												P
2430-61123	U	J												P
2430-61124	U	J												P
2430-61125	M	A												K
2430-61126	U	J												S
2430-61127	M	A												P
2430-61128	U	J												M
2430-61129	U	J												Q
2430-61130	U	J												Q
2430-61131	U	J												M
2430-61132	U	J												M
2430-61133	U	J												M
2430-61134	M	A												T
2430-61135	M	A												T
2430-61136	M	A												B
2430-61137	F	A												B
2430-61138	F	A												B
2430-61139	F	A												T
2430-61140	U	J												B
2430-61141	U	J												B
2430-61142	U	J												B
2430-61143	U	J												T

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2430-61144	U	J												T
2430-61145	U	J												T
2430-61165	U	J												Q
2430-61167	M	A												M
2430-61168	U	J												M
2430-61169	U	J												M
2430-61170	U	J												M
2430-61171	U	J												M
2430-61172	U	J												M
2430-61173	U	J												M
2430-61174	U	J												M
2430-61175	U	J												Q
2430-61176	U	J												Q
2430-61177	U	J												Q
2430-61178	M	A												K
2430-61179	M	A												K
2430-61180	M	A												K
2430-61181	F	A												K
2430-61182	M	A												K
2430-61183	M	A												K
2430-61184	U	J												Q
2430-61185	U	J												Q
2430-61186	U	J												Q
2430-61187	U	J												Q
2430-61188	U	J												Q
2430-61189	U	J												Q
2430-61190	U	J												Q
2430-61191	U	J												M
2430-61192	U	J												M
2430-61193	U	J												M
2430-61194	U	J												Q
2430-61195	U	J												Q
2430-61196	U	J												Q
2430-61197	U	J												P
2430-61198	U	J												P
2430-61199	U	J												P
2430-61200	U	J												P
2430-61202	U	J												M
2430-61203	U	J												M
2430-61204	U	J												M
2430-61205	U	J												M
2430-61206	U	J												M
2430-61207	U	J												M
2430-61208	U	J												D
2430-61209	M	A												V
2430-61210	U	A												K
2430-61211	U	J												S

Original Federal Band Number	Sex[2]	Age When Banded[3]	Study Area Detected[1]											
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2430-61212	U	J												M
2430-61223	U	J												D
2430-61224	U	J												D
2430-61225	U	J												D
3500-68963	U	J								T				
3500-68968	U	J								P				
3500-68969	U	J								P				
3500-68972	F	J								P	P	P		

1 K = Key Pittman, P = Pahranagat NWR, W = Meadow Valley Wash, L = Littlefield, Q = Mesquite, M = Mormon Mesa, D = Muddy River, G = Grand Canyon, T = Topock Marsh, B = Bill Williams River NWR, I = Imperial NWR, Y = Yuma, S = St. George, V = Las Vegas Wash, R = Roosevelt Lake, A = Ash Meadows. Study area indicated is the study area where the individual was first detected during the given season. Within-season movements are indicated with individual footnotes.

2 M = male, F = female, U = unknown.

3 A = adult, J = juvenile.

4 Within-season movement from Mormon Mesa to Mesquite.

5 Within-season movement from Mesquite to Mormon Mesa.

6 Within-season movement from Mesquite to Mormon Mesa

7 Within-season movement from Littlefield to Mesquite.

8 Within-season movement from Grand Canyon to Mesquite.

9 Within-season movement from Mormon Mesa to Muddy River.

10 Within-season movement from Muddy River to Mormon Mesa.

11 Within-season movement from Pahranagat to Key Pittman.

12 Within-season movement from Littlefield to Mesquite.

13 Within-season movement from Muddy River to Mesquite.

14 Within-season movement from Grand Canyon to Mesquite.

15 Within-season movement from Grand Canyon to Mormon Mesa.

Appendix E

HYDROGRAPHS FOR PIEZOMETERS AT HABITAT MONITORING SITES

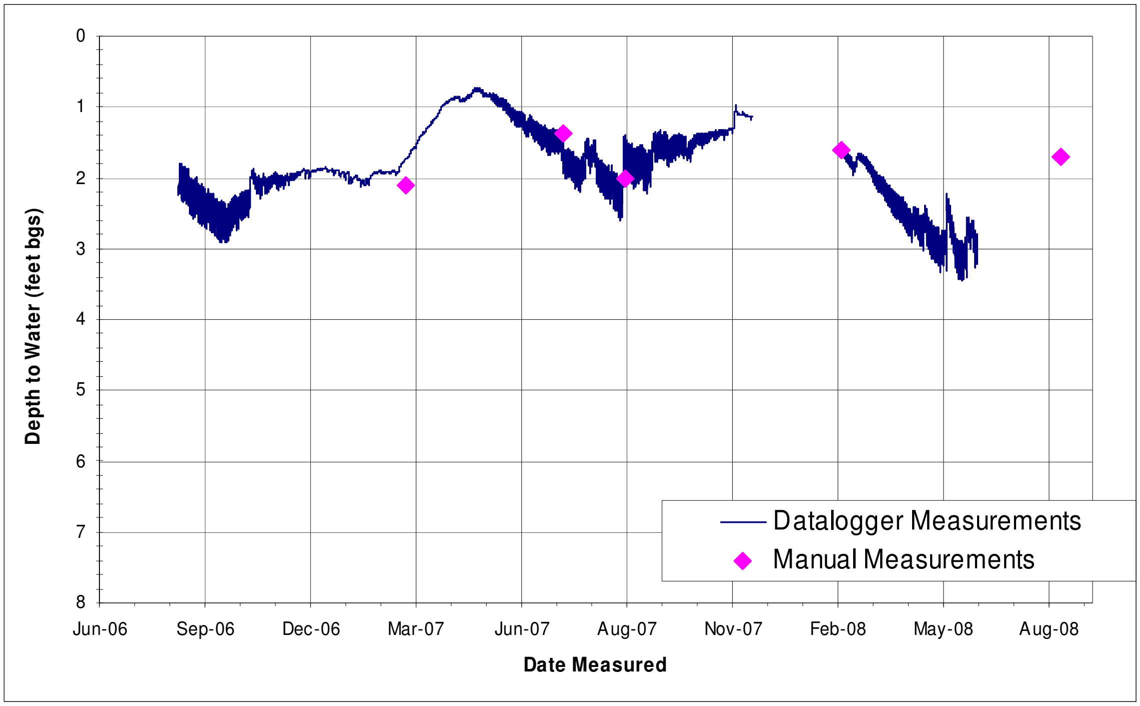


Figure E1. Hydrograph for piezometer at Topock Marsh.

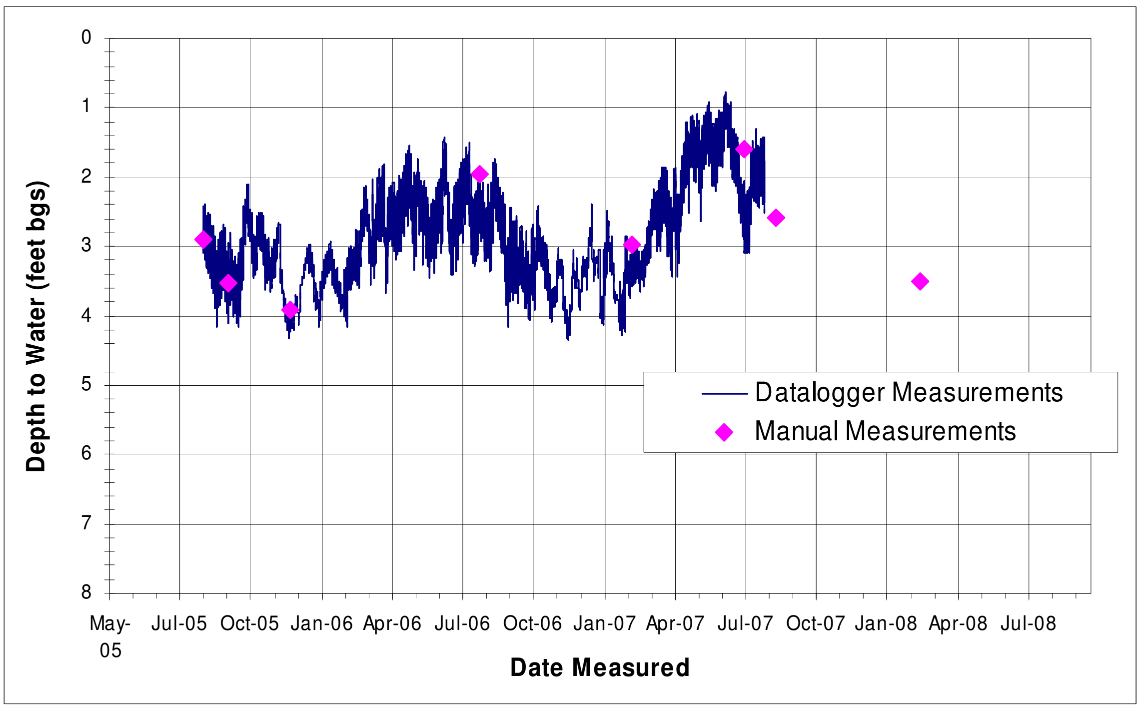


Figure E2. Hydrograph for piezometer at Blankenship Bend.

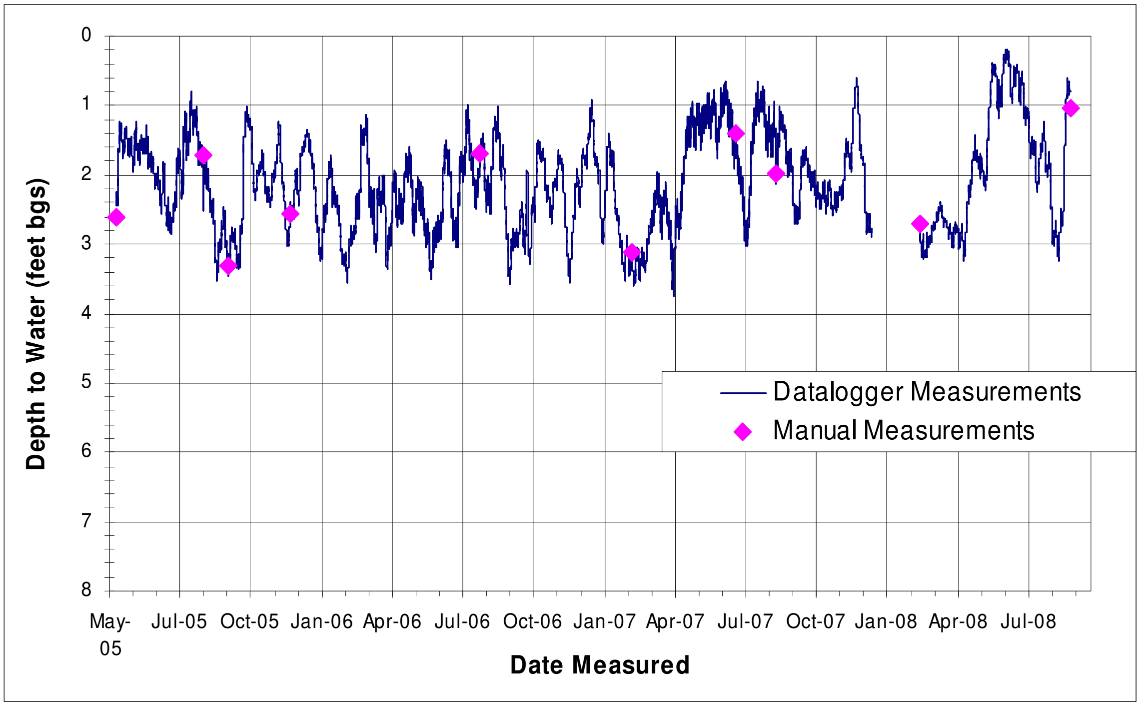


Figure E3. Hydrograph for piezometer at Havasu NE.

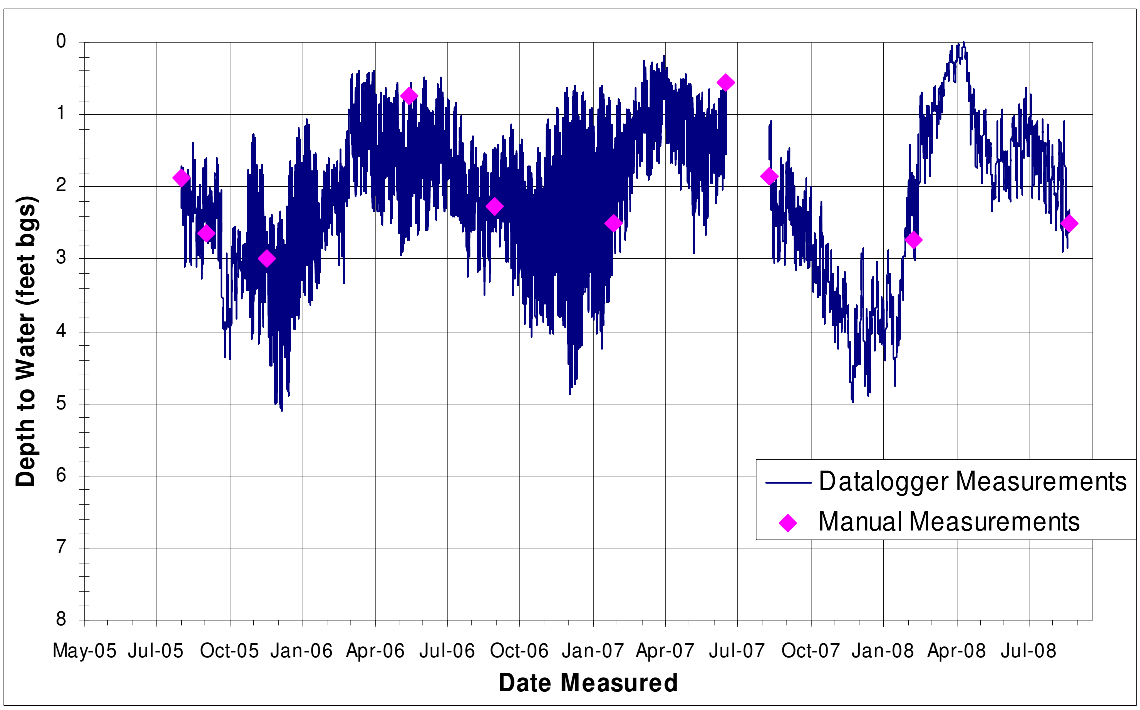


Figure E4. Hydrograph for piezometer at Ehrenberg.

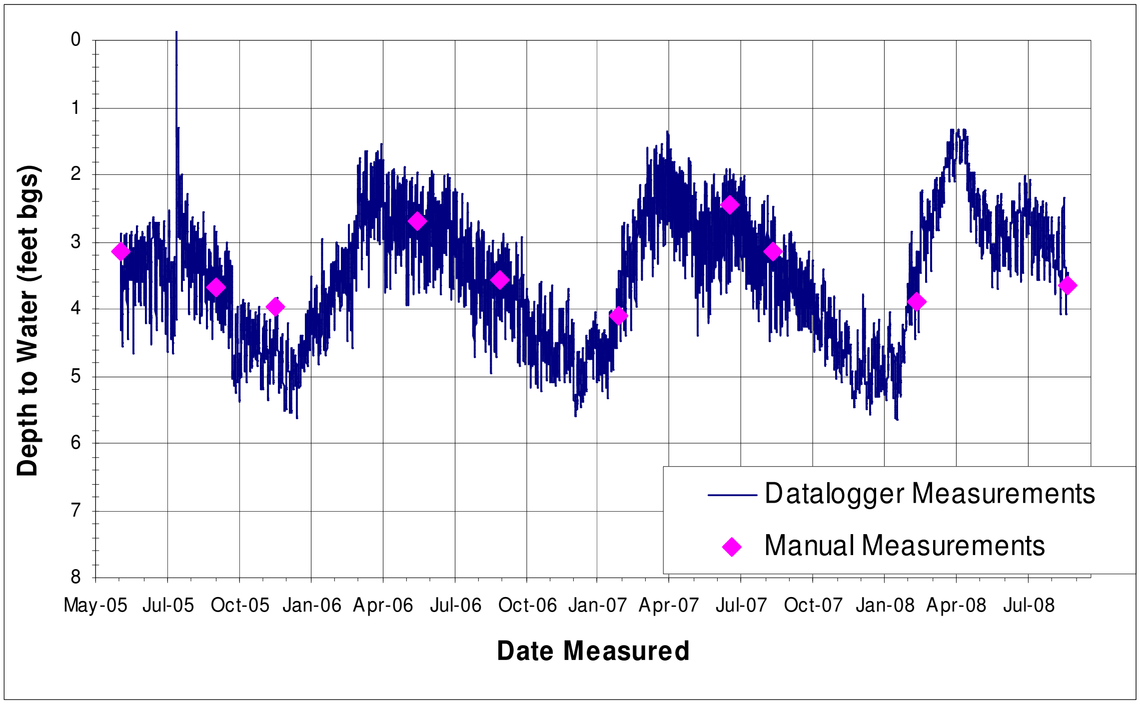


Figure E5. Hydrograph for piezometer at Three Fingers Lake.

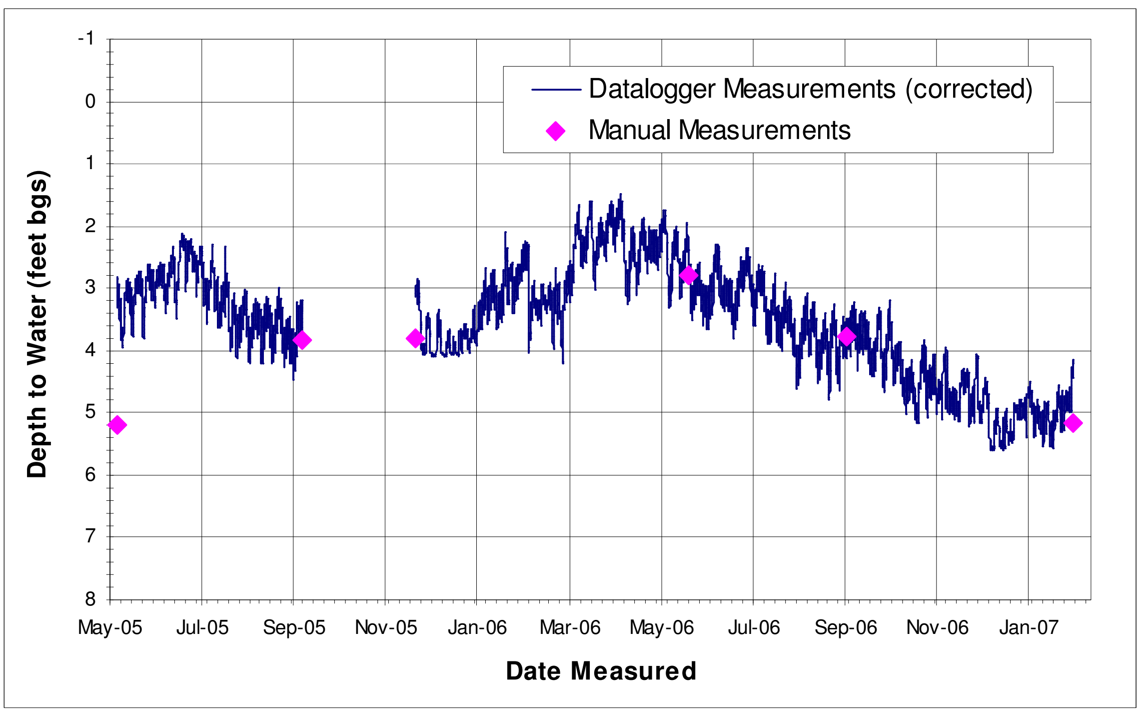


Figure E6. Hydrograph for piezometer at Cibola Lake.

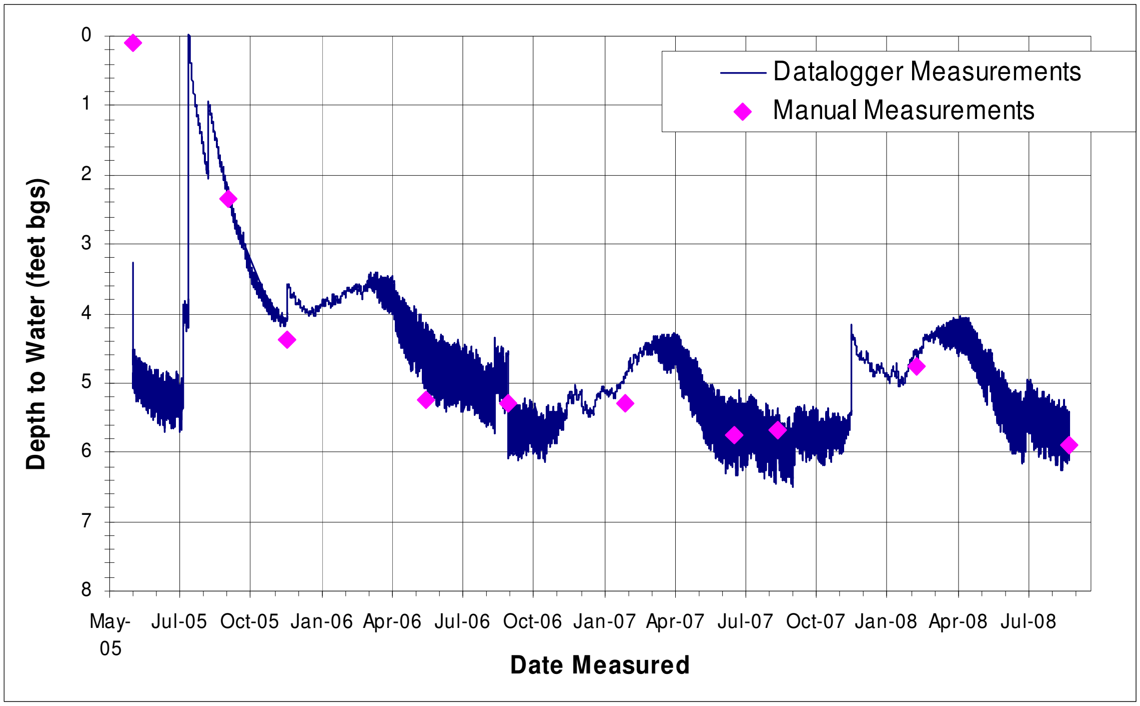


Figure E7. Hydrograph for piezometer at Walker Lake.

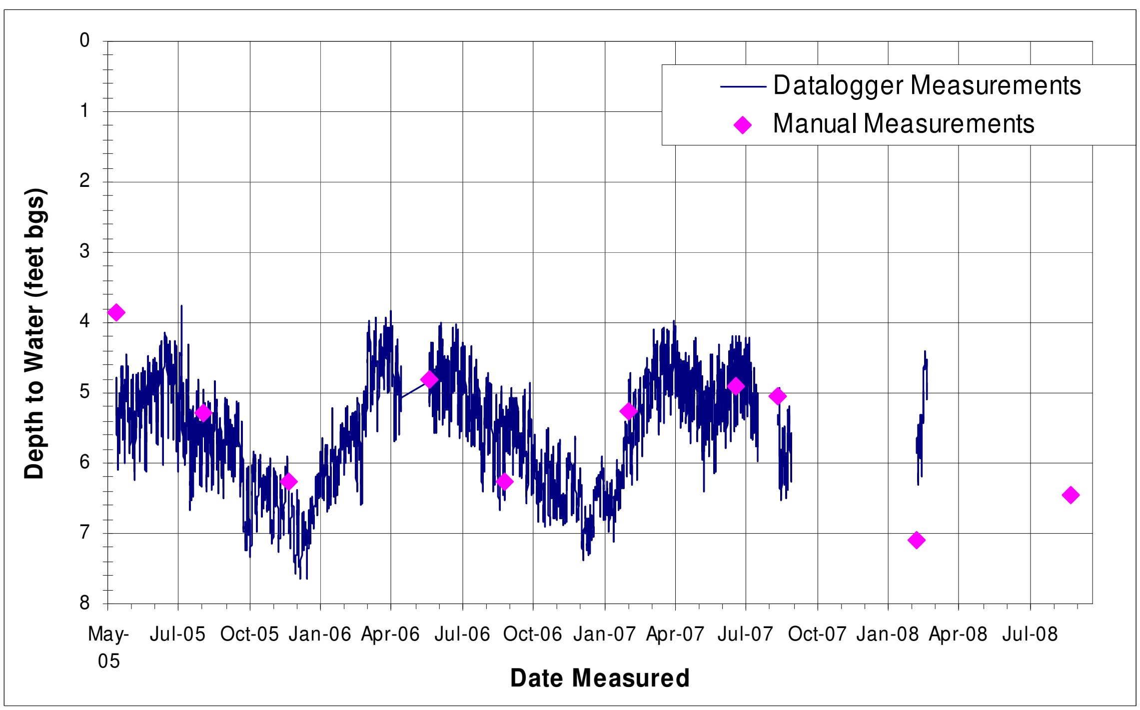


Figure E8. Hydrograph for piezometer at Paradise.

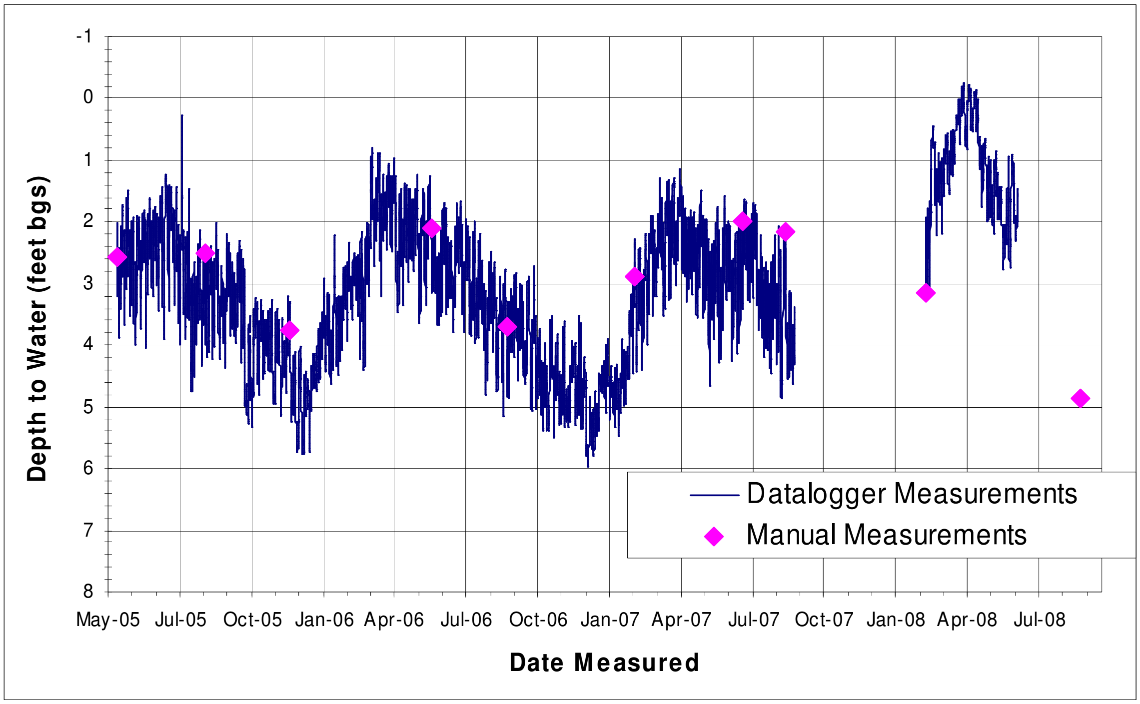


Figure E9. Hydrograph for piezometer at Hoge Ranch.

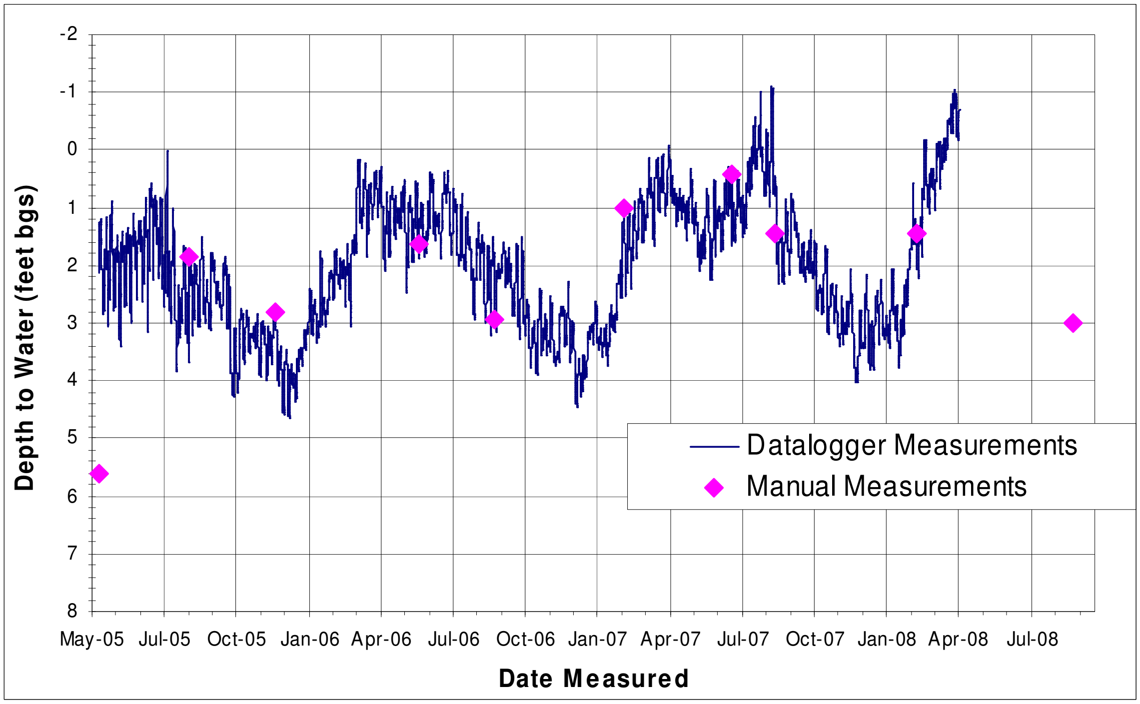


Figure E10. Hydrograph for piezometer at Rattlesnake.

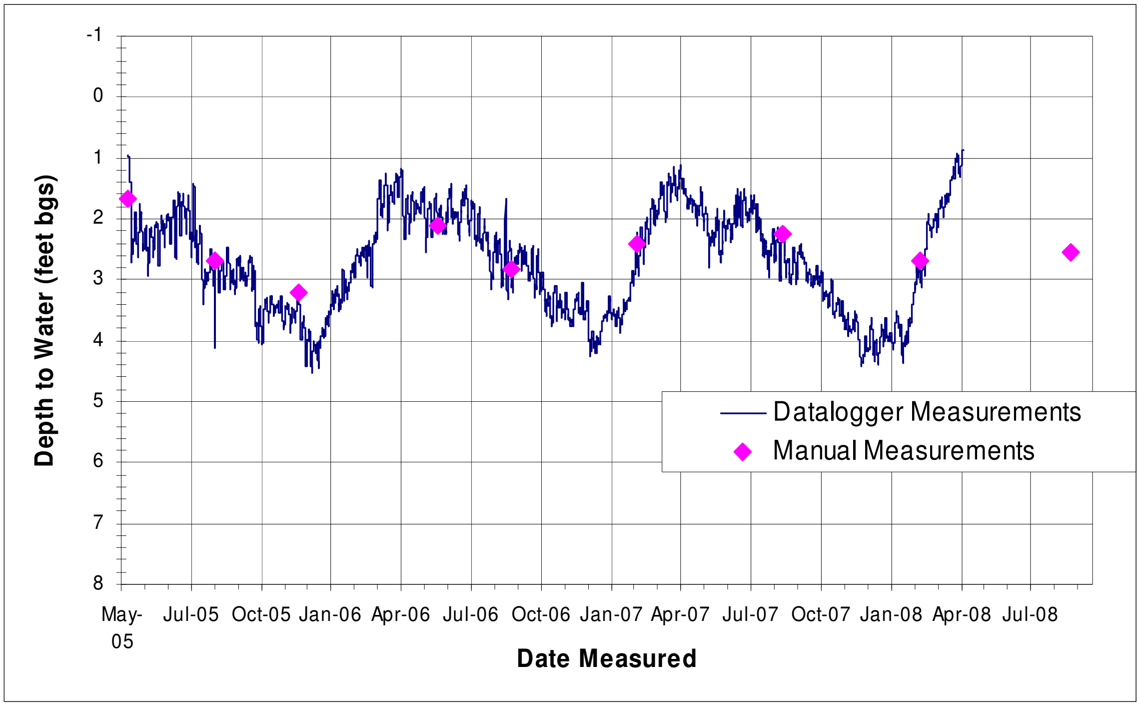


Figure E11. Hydrograph for piezometer at Clear Lake.

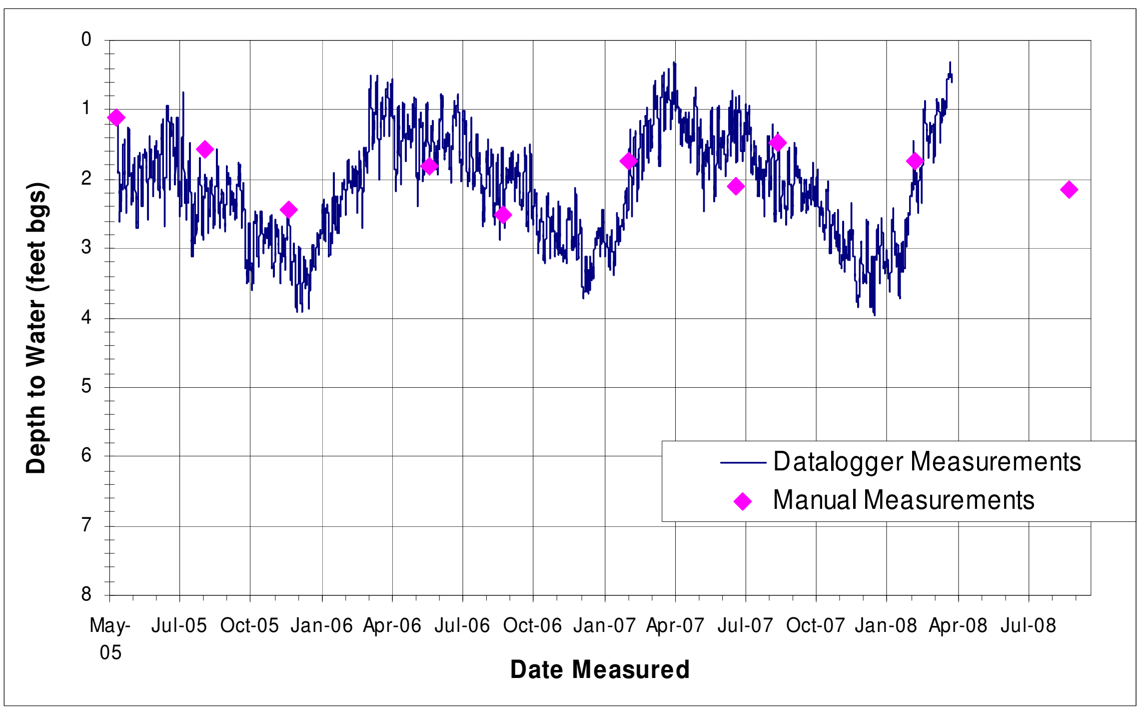


Figure E12. Hydrograph for piezometer at Ferguson Lake.

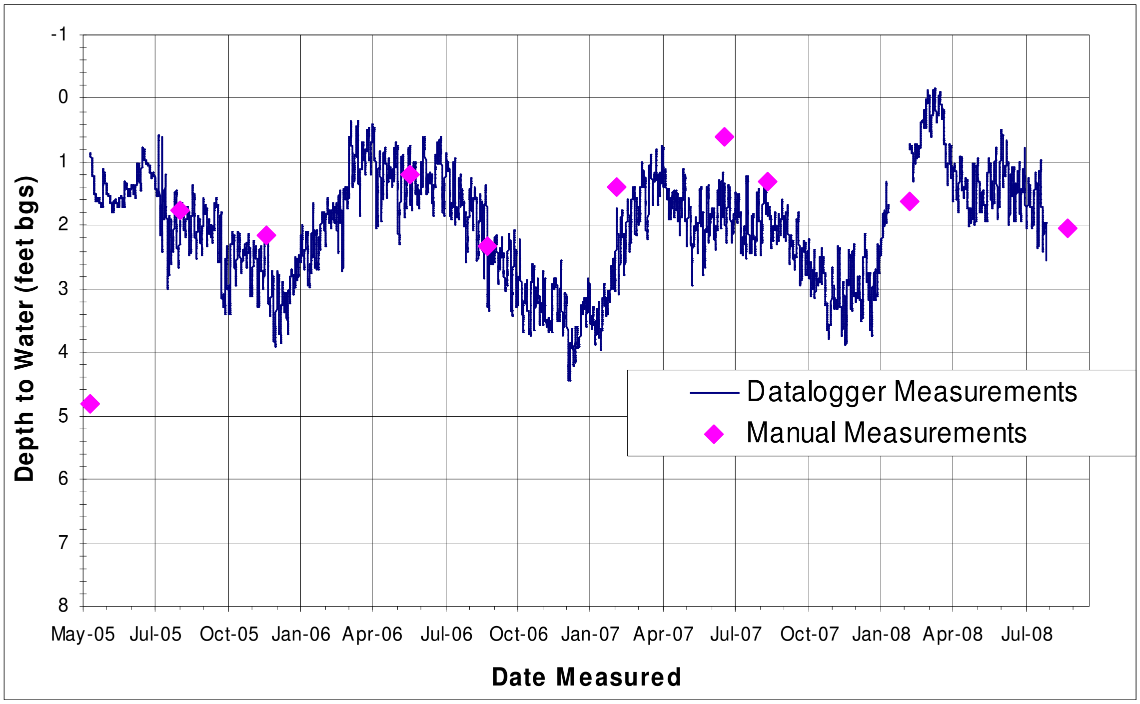


Figure E13. Hydrograph for piezometer at Ferguson Wash.

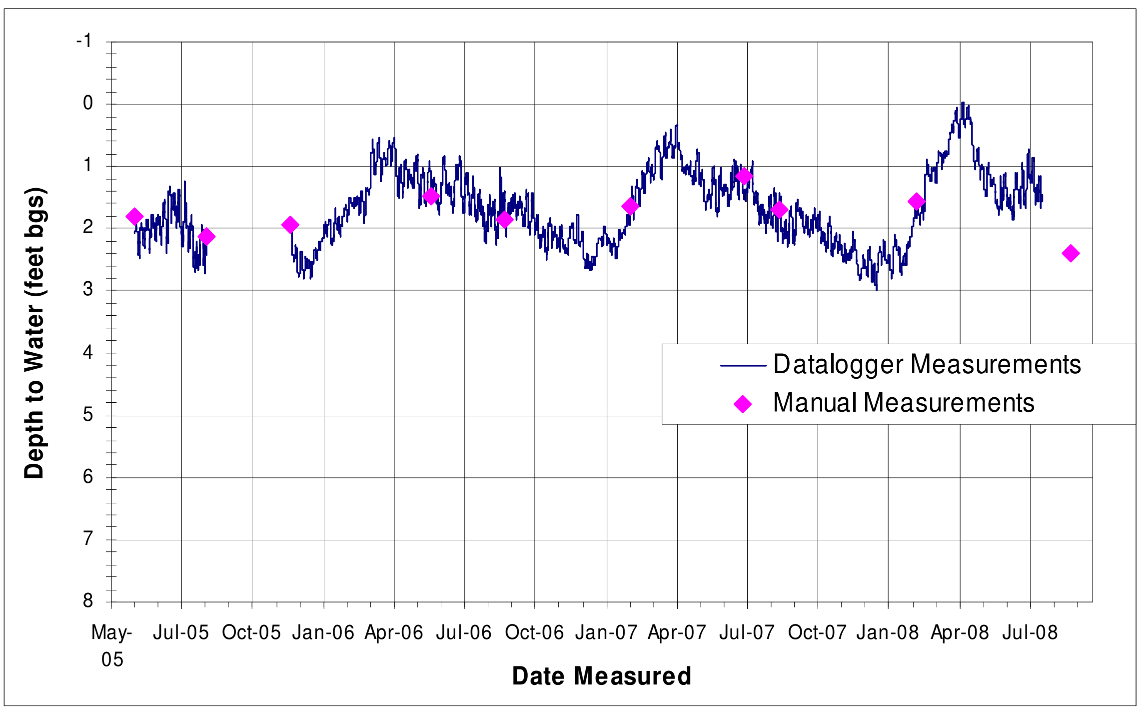


Figure E14. Hydrograph for piezometer at Great Blue Heron.

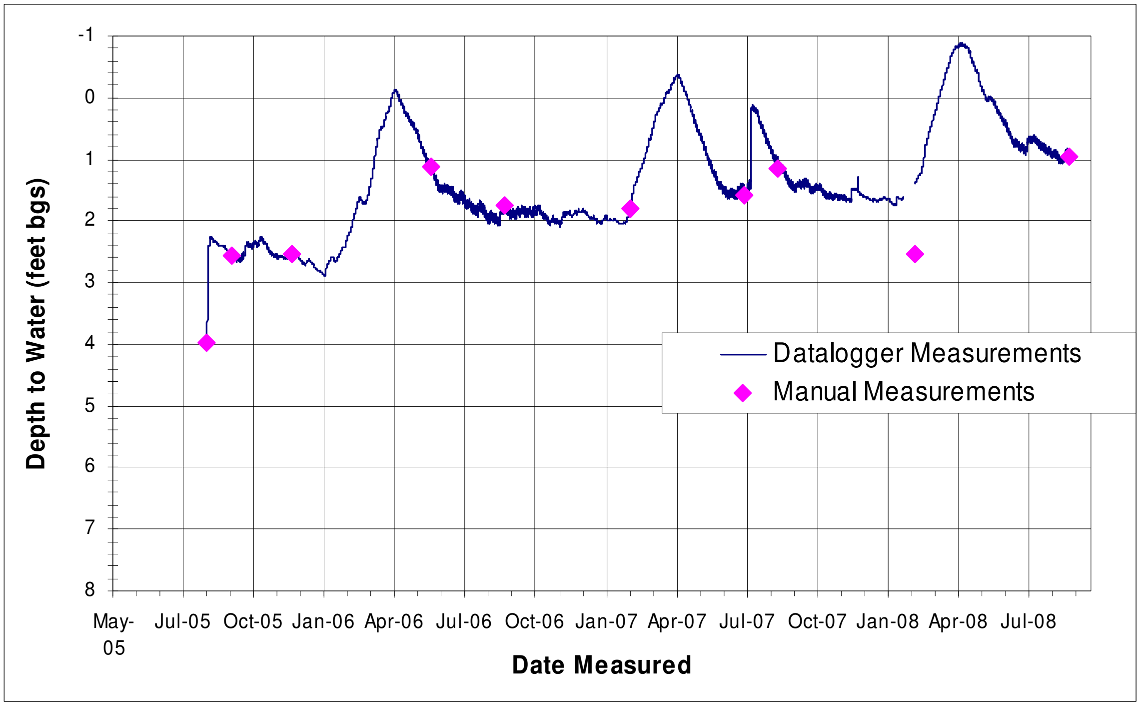


Figure E15. Hydrograph for piezometer at Mittry West.

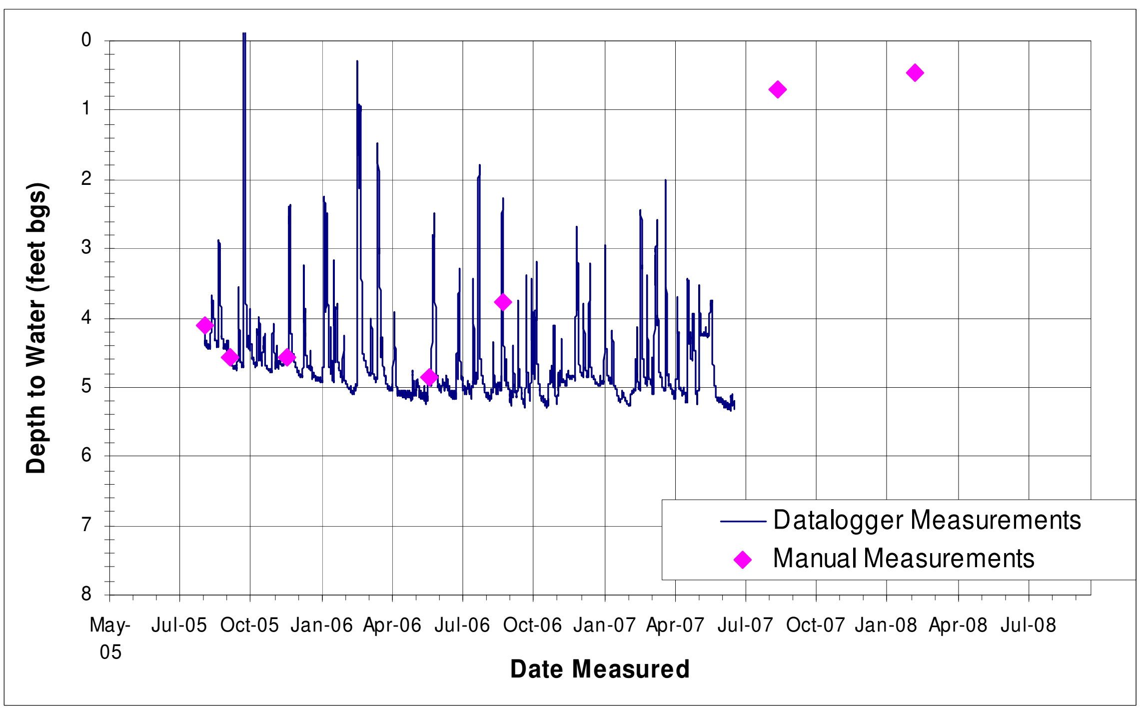


Figure E16. Hydrograph for piezometer at Gila Confluence North.

Appendix F

CONTRIBUTING PERSONNEL

Contributor	**Role**
Steven W. Carothers, Ph.D.	Principal-in-Charge
Mary Anne McLeod, M.S.	Project Manager/Scientist/Field Supervisor
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Jessica Maggio	Project Administrator/Data Entry
Kimberly MacMillan	Administrative Assistant/Data Entry
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Cheryl Schweizer.	Field Coordinator
Laura Stewart.	Field Coordinator
Emma DeLeon	Bander/Nest Monitor
Zachary Kaiser	Bander/Nest Monitor
Ryan Pottinger	Bander/Nest Monitor
Jason Thomas	Bander/Nest Monitor
Kristen Dillon	Surveyor/Nest Monitor
Angelina Robinson	Surveyor/Nest Monitor
Gregory Ainsworth	Surveyor
Corina Anderson	Surveyor
Jonathon West	Surveyor
Jeremy Doschka	Vegetation Field Assistant
Devin Keane	Piezometer Maintenance/Data Entry
Kevin Serrato	Piezometer Maintenance