Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Soil Hydrology and Microclimate Conditions in Occupied Southwestern Willow Flycatcher and Yellow-Billed Cuckoo Habitat

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Lower Colorado River Multi-Species Conservation Program

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EXECUTIVE SUMMARY

The endangered Southwestern willow flycatcher (SWFL) and the candidate Western yellow-billed cuckoo (YBCU) are two key avian riparian species included in the Lower Colorado River (LCR) Multi-Species Conservation Plan (MSCP). The LCR MSCP was developed to avoid jeopardy, support the conservation of listed species, and reduce the potential for future listings of additional species as a result of ongoing water delivery and power systems operations along the LCR. The Bureau of Reclamation (Reclamation) was interested in collecting information on the characteristics of habitats used by SWFLs and YBCUs to inform habitat creation or restoration efforts along the LCR. SWFL and YBCU breeding habitats have been studied in terms of canopy density, canopy height, patch size, plant species composition, and other vegetation characteristics. However, there was less information available on the underlying soil hydrology and microclimate conditions that characterize breeding habitats for these species.

The objective of this study was to identify and describe the range of soil hydrology and microclimate conditions in riparian habitats occupied by SWFLs and YBCUs along the LCR. The intent was to collect additional information that may aid in the creation and/or restoration of breeding habitat for these species.

This study was based on sites occupied by SWFLs and YBCUs and examined multiple variables over a two-year period. Study sites were selected using information from SWFL and YBCU surveys conducted in 2009 and 2010, associated vegetation surveys, and through consultation with Reclamation and its biological consultants. Nineteen sites were selected for each species per year, for a total of 38 sites per species. Identical data sampling methods were employed at all SWFL and YBCU sites and included measurements of organic matter, soil moisture, air temperature, relative humidity, soil texture, extent of standing water, depth to ground water, distance to flowing water, and stream discharge.

Results of this study documented a range of soil hydrology and microclimate conditions and indicated that there were significant differences in conditions between SWFL and YBCU occupied habitats. Two sample t-tests indicated that YBCU sites had lower percent soil moisture, sandier soil texture, less area of standing water, greater depth to ground water, and greater distance to flowing water compared with SWFL sites. Logistic regression identified depth to ground water, soil texture, and distance to flowing water as the most important variables distinguishing SWFL from YBCU habitats.

These results suggest that creation or restoration of habitat for SWFLs should occur under different soil hydrology and microclimate conditions and in different locations than creation or restoration of habitat for YBCUs. It is recommended that soil texture be analyzed when evaluating potential creation or restoration sites for these species. Additional study that compares soil hydrology and microclimate conditions between occupied and unoccupied habitat for these species may aid in determining which variables are most important to consider in efforts to create or restore habitat.

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1.0 INTRODUCTION

The Endangered Species Act (ESA) of 1973 provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. Federal and non-Federal actions related to the operations of the Lower Colorado River (LCR) water delivery and power systems have been determined to affect species listed as threatened or endangered and their critical habitat.

The LCR Multi-Species Conservation Program (MSCP) was created to address the needs of listed species and to comply with the ESA. The LCR MSCP intends to avoid jeopardy, support the conservation of listed species, and reduce the potential for future listing of additional species as a result of ongoing operations. Two key avian species included in the LCR MSCP are the endangered Southwestern willow flycatcher (SWFL) *(Empidonax traillii extimus)* and the candidate Western yellow-billed cuckoo (YBCU) *(Coccyzus americanus occidentalis).* These species use riparian habitat along perennial stretches of water for nesting.

Riparian areas are the transition zones between an aquatic system and the surrounding uplands. As such, riparian zones occupy a relatively small area in the natural landscape but are highly productive, provide unique communities, and are key habitat for many species of wildlife (Bechtold and Naiman 2006, Kelsey and West 1998, Naiman et al. 1993, Naiman et al. 2000, Pase and Layser 1977). Riparian habitat has decreased or become degraded in many areas in the southwestern United States due to various factors, including urban development, water diversion and impoundment, overgrazing by livestock, and increasing numbers of decadent riparian stands due to lack of natural succession (Brinson et al. 1981, Busch and Smith 1995). Decadent stands have resulted from increased fire suppression activities over the past 100 years and the construction of dams that change the historic hydrologic regime of the area (U.S. Forest Service 2000).

Historically, riparian systems in the southwestern United States were dynamic and subject to frequent change due to annual periods of spring/summer flooding and, as a result, supported plant species adapted to this particular hydrologic regime. These flooding events cleared decadent vegetation, added soil nutrients, created space, and carried seed for new growth (U.S. Forest Service 2000). Many common riparian tree species adapted to this hydrologic regime, including various willow (*Salix* spp.) and cottonwood (*Populus* spp.) species. For example, Goodding's willow *(Salix gooddingii)* has the ability to withstand long periods of inundation without long-term injury, which aided its survival during these historic annual floods (Green and Balluff 2005). In addition, Goodding's willow seed release occurred as these flood flows started to recede and expose sediment, therefore providing the seeds with moist, bare soil on which to germinate (Roelle and Gladwin 1999, Sprenger et al. 2002, Tallent-Halsell and Walker 2002). With flows becoming increasingly regulated, many rivers in the Southwest no longer accommodate the historic hydrologic regime to which native riparian tree species are adapted.

Regulation of flows has contributed to the alteration of the plant species composition of riparian areas and has complicated efforts to restore historic conditions. Historic stands of cottonwoods and willows have become dominated in many areas by exotic species such as saltcedar (*Tamarix* spp.) and Russian olive *(Elaeagnus angustifolia).* These invasive plant species are promoted by

the regulated nature of most rivers in the Southwest. For example, saltcedar cannot withstand long periods of inundation; therefore, the historic hydrologic regime would likely have made establishment of saltcedar more challenging (Tallent-Halsell and Walker 2002). Furthermore, regulated flows favor saltcedar, which has a longer seeding period than native riparian species such as cottonwoods and willows (Siegel and Brock 1990, Sprenger et al. 2002).

Efforts to mimic the historic hydrologic regime are highly dependent on precipitation levels, reservoir capacity, and careful timing. If one of these variables is missing, success is far from assured. For example, efforts to mimic historic hydrology in cottonwood and willow stands along the Verde River above Horseshoe Dam were stymied by too much water, resulting in full reservoirs in the system. With full reservoirs downstream of Horseshoe Dam and elsewhere in the system, the water in Horseshoe Reservoir could not be released before seedfall. The cottonwoods and willows therefore dropped their seeds into the water rather than on recently exposed substrate. The result was poor natural recruitment of willow and cottonwood in that area that year (Balluff 2007).

In addition to plant species composition and other vegetation characteristics, soil hydrologic conditions such as soil texture, moisture, depth to ground water, and the amount of standing water and microclimate conditions such as relative humidity and temperature may influence habitat selection by breeding birds, including SWFLs and YBCUs. These conditions can rapidly change temporally and spatially in the semi-arid Southwest, creating a range of soil hydrology through the course of one season, from year to year, and from the river channel toward the uplands (Paxton et al. 2007, U.S. Forest Service 2000). This results in varying habitat conditions available for breeding birds across temporal and spatial scales.

1.1 Southwestern Willow Flycatcher (SWFL)

The willow flycatcher is widely distributed across the United States with various subspecies (Ellis et al. 2008). The Southwestern subspecies of interest in this study (Figure 1.1) has breeding grounds along the LCR and its tributaries, arrives in late April or early May, and departs in September (Ellis et al. 2008, Paxton et al. 2007, USFWS 2010).

As noted previously, SWFLs select breeding habitat with a variety of vegetation characteristics. Plant species composition of SWFL breeding habitat can consist of native, nonnative, and mixed tree and shrub communities (Ellis et al. 2008, Paxton et al. 2007, U.S. Forest Service 2000). In addition to plant species composition, breeding habitat selected by SWFLs varies in canopy height and structure as well as in size and shape of breeding patch. It can range from monotypic to diverse stands of vegetation and from single-canopy to multiple-canopy strata (U.S. Forest Service 2000).

Credit: Jim Rorabaugh/USFWS

Figure 1.1. Southwestern willow flycatcher.

The Arizona Game and Fish Department (AGFD) found that areas with dense riparian vegetation showed greater breeding activity and nest density for SWFLs than areas with sparse riparian

vegetation (AGFD 2004). Breeding SWFLs have been observed to use patch sizes ranging from 0.6 hectare up to 100 hectares or more (Sogge et al. 1997, Spencer et al. 1996). Generally, preferred breeding habitat consists of dense stands with high or midstory canopy closure with multiple small openings (AGFD 2004, Ellis et al. 2008, Paxton et al. 2007, U.S. Forest Service 2000). The U.S. Forest Service (2000) noted that no long-term data are available to determine optimal breeding habitat, though SWFLs do not appear to use cottonwood/willow galleries that lack understory and are not known to use riparian patches less than 10 meters (m) wide for breeding purposes.

Few data exist in the literature regarding soil hydrology and microclimate conditions in SWFL breeding habitat beyond noting that the species is an obligate riparian breeder that requires surface water or saturated soil conditions to breed (Ellis et al. 2008, McLeod and Koronkiewicz 2010, McLeod and Pellegrini 2011, Paxton et al. 2007, Sogge and Marshall 2000, U.S. Forest Service 2000, USFWS 2010). A report by the U.S. Forest Service (2000) noted that because of diverse temporal hydrologic conditions in the semi-arid Southwest, breeding habitat may be saturated for the entire breeding season one year but may be several hundred meters from water in dry years. The report noted that nesting SWFLs may persist in the same area for several years even with these varying conditions, but it is not known how long they would persist given continuing dry conditions. SWCA Environmental Consultants (SWCA) has conducted SWFL surveys along the LCR and its tributaries and has noted sites to which SWFLs consistently return through varying conditions over several years (McLeod and Koronkiewicz 2010, McLeod and Pellegrini 2011).

1.2 Western Yellow-billed Cuckoo (YBCU)

The yellow-billed cuckoo occurs as two subspecies whose combined range extends across the continental United States from southern Canada to northern Mexico. The only currently known breeding populations of the western subspecies are in California, Arizona, and New Mexico (Figure 1.2) (U.S. Geological Survey [USGS] 2010a). The YBCU breeds along the LCR and its tributaries, arriving in mid- to late May and departing in September, with the peak breeding activity occurring in mid-July to early August (Corman and Magill 2000, USGS 2010a).

Credit: www.fws.gov/USFWS

Figure 1.2. Western yellow-billed cuckoo.

Characteristics of YBCU breeding habitat vary in plant species composition across its geographic range. The YBCU breeds in large blocks of dense, mature cottonwood/willow stands along streams and in stands with varying concentrations of cottonwood, willow, velvet ash, Arizona walnut, mesquite, and saltcedar (USFWS 2010, USGS 2010a). The stands selected for breeding tend to have multilayer canopy structure, with tall trees and dense understory (USGS 2010a). YBCUs are more likely to use saltcedar stands for foraging rather than breeding (USGS 2010a), and the Johnson et al. (2006) study found that YBCUs had a low occupancy rate in stands with 75 percent saltcedar cover. Other studies suggest that use of saltcedar stands by

YBCUs varies by geographic region, likely due to temperature changes (Howe 1986, Hunter 1987). YBCUs have been observed nesting in saltcedar in New Mexico but do not appear to use monotypic saltcedar stands along the LCR (Howe 1986, Hunter 1987). Surveys for YBCUs within the LCR MSCP area found that the average size of occupied sites was 33.9 hectares (Halterman et al. 2009). In 2010, surveys indicated that the average home range for YBCUs at restoration sites in the LCR MSCP was 21.7 ±10.4 hectares (McNeil et al. 2011).

A few studies have investigated the importance of hydrologic and microclimate features in YBCU habitat. These studies found that distance to water and high humidity near the nest are important habitat elements (Gaines 1974, Hamilton and Hamilton 1965). Standing water in cottonwood/willow stands may positively influence the microclimate of the breeding habitat and protect eggs from extreme temperatures (USGS 2010a).

1.3 Study Purpose

Though there is quite a bit of information regarding the vegetation characteristics for SWFL and YBCU breeding habitat in terms of canopy density, patch size, and species composition, there is less information available for the underlying soil hydrology and microclimate conditions. The purpose of this study was to identify and describe the range of soil hydrology and microclimate conditions that are present in occupied SWFL and YBCU habitat along the LCR. This information may contribute to future efforts by the Bureau of Reclamation (Reclamation) to create or restore habitat for these species along the LCR.

2.0 METHODS

2.1 Field Methods

Study sites were selected based on previously recorded occurrences of SWFLs and YBCUs and measured vegetation characteristics. Soil hydrology and microclimate data were collected in 2010 and 2011 at sites where SWFL and YBCU surveys and associated vegetation surveys were completed by researchers contracted by Reclamation in 2009 and 2010. Site selection for this study involved a four-step process conducted each year. First, Reclamation and its biological contractors were consulted to determine which general areas (e.g., Bill Williams River National Wildlife Refuge [NWR], Havasu NWR) would be most appropriate to use for the study. Because the purpose of this study was to identify the range of soil hydrologic and microclimate conditions in habitat used by these two species, the second step was to identify habitat patches in these general areas that had bird or nest sightings in 2009 and 2010. The third step narrowed the list of possible study sites further by selecting sites that also had vegetation survey plots, to minimize the spatial disparity between the soil hydrology/microclimate and vegetation measurements. Though many sites selected had vegetation data, a few sites without vegetation plots were included to increase sample size. Fourth, from this final list of appropriate habitat patches, study sites were randomly selected. In 2011, the number of sites selected that were also measured in 2010 was minimized to maximize the total range of sites sampled.

Figure 2.1. Litter depth measurement.

Nineteen sites were selected per year for each species, for a total of 38 sample sites per species per year. The final locations of the SWFL sites are listed in Table 2.1. The YBCU sites are listed in Table 2.2. Variables selected for measurement were those considered to be indicative of soil hydrology and microclimate conditions that may influence use of sites by SWFLs and YBCUs. These variables were distance to surface flows, surface flow levels (stream discharge), soil texture, litter depth at the soil surface (i.e., organic matter; Figure 2.1), soil moisture, extent of surface water, depth to ground water, air temperature, and relative humidity.

The same soil hydrology and microclimate variables were measured at all SWFL and YBCU sites. At each site, a site center was identified using the vegetation plot locations. For those sites without associated vegetation plot data, a site center was randomly determined. From each site center, four 20-m transects were laid out, one in each cardinal direction. Measurements of organic matter depth, soil moisture, air temperature, relative humidity (RH), and soil texture were taken at 12 approximately 0.25 m^2 subplots located at 5 m, 12 m, and 20 m along each of the four transects. The total surface area and average depth of standing water crossing transects were also measured.

Table 2.1. Final site locations for SWFLs for the 2010 and 2011 field seasons.

SWFL Site Name	Year	Nearest Water Body	Landowner/ Manager	Latitude/Longitude (decimal degrees)	Associated Bird Survey Area
WF01	2010	Beaver Dam Wash	Private	36.90286N/113.93580W	2010 Littlefield Poles
WF02	2010	Beaver Dam Wash	Private	36.90250N/113.93473W	2010 Littlefield Poles
WF03	2010	Virgin River	Nevada Department of Wildlife	36.61676N/114.32585W	2010 Virgin River #1 South
WF04	2010	Virgin River	Nevada Department of Wildlife	36.61720N/114.32645W	2010 Virgin River #1 South
WF05	2010	Virgin River	Nevada Department of Wildlife	36.61833N/114.32644W	2010Virgin River #1 South
WF06	2010	Virgin River	Nevada Department of Wildlife	36.61928N/114.32620W	2010 Virgin River #1 North
WF07	2010/ 2011	Topock Marsh	Havasu NWR	34.82466N/114.51699W	2010/2011 Topock Pipes #3
WF08	2010/ 2011	Topock Marsh	Havasu NWR	34.82246N/114.51577W	2010/2011 Topock Wallows
WF09	2010	Topock Marsh	Havasu NWR	34.81261N/114.51883W	2010 Topock 800M
WF10	2010/ 2011	Topock Marsh	Havasu NWR	34.81229N/114.52247W	2010/2011 Topock Pierced Egg
WF11	2010	Topock Marsh	Havasu NWR	34.80599N/114.53029W	2010 Topock MAM
WF12	2010	Topock Marsh	Havasu NWR	34.79899N/114.53097W	2010 Topock Platform
WF13	2010	Topock Marsh	Havasu NWR	34.79447N/114.53382W	2010 Topock Glory Hole
WF14	2010	Bill Williams River	Bill Williams River NWR	34.25795N/113.97449W	2010 BIWI upstream from Site 8
WF16*	2010	Bill Williams River	Bill Williams River NWR	34.28081N/114.06678W	2010 BIWI Site 3
WF17	2010/ 2011	Bill Williams River	Bill Williams River NWR	34.28081N/114.06752W	2010/2011 BIWI Site 3
WF19*	2010	Bill Williams River	Bill Williams River NWR	34.28210N/114.06733W	2010 BIWI Site 3
WF20	2010	Bill Williams River	Bill Williams River NWR	34.28181N/114.06814W	2010 BIWI Site 3
WF21	2010	Bill Williams River	Bill Williams River NWR	34.28279N/114.06980W	2010 BIWI Site 4
WF22	2011	Virgin River	Private	36.79042N/114.10878W	2011 Mesquite West
WF23	2011	Virgin River	Private	36.79082N/114.10876W	2011 Mesquite West
WF24	2011	Virgin River	Private	36.79034N/114.10812W	2011 Mesquite West

Table 2.1. Final site locations for SWFLs for the 2010 and 2011 field seasons.

SWFL Site Name	Year	Nearest Water Body	Landowner/ Manager	Latitude/Longitude (decimal degrees)	Associated Bird Survey Area
WF25	2011	Virgin River	Private	36.78995N/114.10997W	2011 Mesquite West
WF26	2011	Virgin River	Private	36.78856N/114.11233W	2011 Mesquite West
WF27	2011	Virgin River	Nevada Department of Wildlife	36.61817N/114.32635W	2011 Virgin River 1 South
WF28	2011	Virgin River	Nevada Department of Wildlife	36.61831N/114.32677W	2011 Virgin River 1 South
WF29	2011	Virgin River	Nevada Department of Wildlife	36.61795N/114.32677W	2011 Virgin River 1 South
WF30	2011	Virgin River	Nevada Department of Wildlife	36.61924N/114.32626W	2011 Virgin River 1 North
WF31	2011	Virgin River	Nevada Department of Wildlife	36.61783N/114.32628W	2011 Virgin River 1 South
WF32	2011	Topock Marsh	Havasu NWR	34.82512N/114.51725W	2011 Topock Pipes 3
WF33	2011	Topock Marsh	Havasu NWR	34.80132N/114.53134W	2011 Topock Platform
WF34	2011	Topock Marsh	Havasu NWR	34.77751N/114.53462W	2011 Topock Beal Lake
WF35	2011	Bill Williams River	Bill Williams River NWR	34.28071N/114.06717W	2011 BIWI Site 3
WF36	2011	Bill Williams River	Bill Williams River NWR	34.25383N/113.96693W	2011 BIWI Planet Ranch Road

NWR = National Wildlife Refuge, SWFL = Southwestern willow flycatcher.

* WF15 and WF18 were dropped from the study during the March 2010 field visit. These two sites overlapped sites WF14 and WF17, respectively.

Table 2.2. Final site locations for YBCUs for the 2010 and 2011 field seasons.

YBCU Site Name	Year	Nearest Water Body	Landowner/ Manager	Latitude/Longitude (decimal degrees)	Associated Bird Survey Area
YB01	2010	Topock Marsh	Havasu NWR	34.83775N/114.52580W	2009 Havasu NWR North Dike
YB02	2010	Topock Marsh	Havasu NWR	34.78732N/114.55590W	2009 Havasu NWR Topock Platform
YB03	2010	Bill Williams River	Planet Ranch (City of Scottsdale)	34.25368N/113.95785W	2009 Bill Williams River NWR Cottonwood Patch
YB04	2010	Bill Williams River	Planet Ranch (City of Scottsdale)	34.25459N/113.96634W	2009 Bill Williams River NWR Cave Wash

Table 2.2. Final site locations for YBCUs for the 2010 and 2011 field seasons.

YBCU Site Name	Year	Nearest Water Body	Landowner/ Manager	Latitude/Longitude (decimal degrees)	Associated Bird Survey Area
YB05	2010	Bill Williams River	Bill Williams River NWR	34.25460N/113.98517W	2009 Bill Williams River NWR Honeycomb Bend
YB06	2010	Bill Williams River	Bill Williams River NWR	34.25409N/114.00124W	2010 Bill Williams River NWR Mineral Wash
YB07	2010	Bill Williams River	Bill Williams River NWR	34.25993N/114.01771W	2009 Bill Williams River NWR Esquerra Ranch
YB08	2010	Bill Williams River	Bill Williams River NWR	34.26307N/114.02626W	2010 Bill Williams River NWR BWPT
YB09	2010	Bill Williams River	Bill Williams River NWR	34.25966N/114.03259W	2009 Bill Williams River NWR Kohen Cliff
YB10	2010	Bill Williams River	Bill Williams River NWR	34.26011N/114.03635W	2009 Bill Williams River NWR Gibraltar Rock
YB11	2010	Bill Williams River	Bill Williams River NWR	34.27584N/114.05034W	2009 Bill Williams River NWR Sandy Wash
YB12	2010	Bill Williams River	Bill Williams River NWR	34.27644N/114.05551W	2009 Bill Williams River NWR Borrow Pit
YB13	2010	Bill Williams River	Bill Williams River NWR	34.27988N/114.06429W	2009 Bill Williams River NWR Mosquito Flats
YB16*	2010/ 2011	Colorado River	Cibola Valley Conservation Area	33.41016N/114.65888W	2010 Cibola Valley Conservation Area 1
YB17†	2010	Colorado River	Cibola Valley Conservation Area	33.40530N/114.66013W	2010 Cibola Valley Conservation Area 2
YB18	2010	Colorado River	Cibola Valley Conservation Area	33.40378N/114.69425W	2009 Cibola Valley Conservation Area 3
YB19	2010	Colorado River	Cibola NWR	33.37434N/114.67970W	2009 Cibola NWR North Plantation
YB20	2010	Colorado River	Cibola NWR	33.36716N/114.67690W	2010 Cibola NWR Nature Trail
YB21	2010	Colorado River	Cibola NWR	33.27972N/114.68617W	2009 Cibola NWR South Restoration
YB22	2011	Topock Marsh	Havasu NWR	34.77556N/114.53149W	2011 Havasu NWR Beal Restoration
YB23	2011	Topock Marsh	Havasu NWR	34.84268N/114.52461W	2011 Havasu NWR HAVPS
YB24	2011	Bill Williams River	Bill Williams River NWR	34.25396N/113.97092W	2011 Bill Williams NWR BWCW
YB25	2011	Bill Williams River	Bill Williams River NWR	34.25794N/113.97780W	2011 Bill Williams NWR BWHB
YB26	2011	Bill Williams River	Bill Williams River NWR	34.26448N/114.02665W	2011 Bill Williams NWR BWPT

Table 2.2. Final site locations for YBCUs for the 2010 and 2011 field seasons.

YBCU Site Name	Year	Nearest Water Body	Landowner/ Manager	Latitude/Longitude (decimal degrees)	Associated Bird Survey Area
YB27	2011	Bill Williams River	Bill Williams River NWR	34.27208N/114.05265W	2011 Bill Williams NWR Sandy Wash
YB28	2011	Colorado River	California Department of Fish and Game	33.69195N/114.52015W	2011 PVER 4
YB29	2011	Colorado River	California Department of Fish and Game	33.68749N/114.53415W	2011 PVER 2
YB30	2011	Colorado River	California Department of Fish and Game	33.68569N/114.53293W	2011 PVER 3
YB31	2011	Colorado River	Cibola Valley Conservation Area	33.41032N/114.65790W	2010 CVCA 1
YB32	2011	Colorado River	Cibola Valley Conservation Area	33.40987N/114.66022W	2010 CVCA 1
YB33	2011	Colorado River	Cibola Valley Conservation Area	33.41073N/114.66338W	2010 CVCA 1
YB34	2011	Colorado River	Cibola Valley Conservation Area	33.40596N/114.66109W	2011 CVCA 2
YB35	2011	Colorado River	Cibola Valley Conservation Area	33.40681N/114.66211W	2011 CVCA 2
YB36	2011	Colorado River	Cibola Valley Conservation Area	33.40580N/114.66292W	2011 CVCA 2
YB37	2011	Colorado River	Cibola NWR	33.36583N/114.67740W	2011 Cibola NWR Nature Trail
YB38	2011	Colorado River	Cibola NWR	33.36468N/114.68775W	2011 Cibola NWR CIBCR
YB39	2011	Colorado River	Cibola NWR	33.36467N/114.69189W	2011 Cibola NWR CIBCR

NWR = National Wildlife Refuge, YBCU = Western yellow-billed cuckoo.

[*] YB14 and YB15 were dropped from the study during the March 2010 field visit. These sites were inaccessible.

[†] YB17 did not have any YBCU observations in 2009. However, YB16 and YB18 (both of which are restoration sites in the same general area) had YBCU observations. YB17 was included in the study because it was expected that YBCUs would be present in 2010.

At a subgroup of sites in 2011, HOBO® permanent data loggers were installed to collect frequent measurements (every 10 minutes) of surficial soil moisture. These sites were selected in discussion with Reclamation. At select sites in 2010 and 2011, piezometers were installed to measure depth to ground water (Table 2.3). These sites were selected to be representative of multiple other sites a similar distance from the same body of water. No piezometers were installed along the Bill Williams River because previously installed piezometers were available for measurement. In 2011, GeoSystems Analysis, Inc. (GSA) installed piezometers for a separate project at or near eight of the study sites for this project and provided information on water table depth. This report used these data sources for applicable sites, as identified in Table 2.3.

Table 2.3. Location of piezometers used to measure depth to ground water in 2010 and 2011.

Piezometer Name	Year	Existing or New	Landowner	Latitude/Longitude (decimal degrees)
PZ WF02	2010	New	Private	36.90254N/113.93474W
PZ WF04	2010/ 2011	New	Nevada Department of Wildlife	36.61715N/114.32644W
PZ WF08	2010/ 2011	New	Havasu National Wildlife Refuge	34.82245N/114.51577W
PZ WF12	2010/ 2011	New	Havasu National Wildlife Refuge	34.79896N/114.53102W
PZ WF22	2011	New	Private	36.79039N/114.10880W
PZ YB01	2010/ 2011	New	Havasu National Wildlife Refuge	34.83778N/114.52586W
PZ YB02	2010	New	Havasu National Wildlife Refuge	34.78741N/114.55599W
PZ BW225	2010/ 2011	Existing	Bill Williams River National Wildlife Refuge	34.25732N/113.97834W
PZ BW230	2010	Existing	Bill Williams River National Wildlife Refuge	34.25349N/114.00617W
PZ BW233	2010	Existing	Bill Williams River National Wildlife Refuge	34.25990N/114.01834W
PZ BW240	2010/ 2011	Existing	Bill Williams River National Wildlife Refuge	34.26040N/114.03123W
PZ BW248	2010	Existing	Bill Williams River National Wildlife Refuge	34.27542N/114.05100W
PZ BW249	2011	Existing	Bill Williams River National Wildlife Refuge	34.27482N/114.05213W
PZ BW250	2010/ 2011	Existing	Bill Williams River National Wildlife Refuge	34.27962N/114.06563W
PZ PR3B	2010	Existing	Planet Ranch	34.25376N/113.96306W
PZ PR3C	2010/ 2011	Existing	Planet Ranch	34.25399N/113.96606W
PZ YB16	2010/ 2011	New	Cibola Valley Conservation Area	33.41020N/114.65892W
PZ YB19	2010	New	Cibola National Wildlife Refuge	33.37433N/114.67964W
PZ YB21	2010	New	Cibola National Wildlife Refuge	33.27972N/114.68617W
PZ YB36	2011	New	Cibola Valley Conservation Area	33.40587N/114.66303W
GA PZ2BL	2011	GSA*	Havasu National Wildlife Refuge–Beal Lake	34.77519N/114.53277W
GA PZ2PVER	2011	GSA*	California Department of Fish and Game	33.68604N/114.53336W
GA PZ4PVER	2011	GSA*	California Department of Fish and Game	33.68604N/114.53611W
GA PZ6PVER	2011	GSA*	California Department of Fish and Game	33.68939N/114.52949W
GA PZ3C	2011	GSA*	Cibola National Wildlife Refuge	33.36469N/114.68542W
GA PZ6C	2011	GSA*	Cibola National Wildlife Refuge	33.36477N/114.69279W
GA PZ9C	2011	GSA*	Cibola National Wildlife Refuge	33.36504N/114.67666W

* Well installed and water depth measured by GeoSystems Analysis, Inc.

Distance to flowing water was determined by overlaying the sites on 2005–2007 aerial photographs. Due to the extremely thick vegetation along the Bill Williams River, it was not always possible to see the river channel on aerial photographs. A 2005 Geographic Information System (GIS) map of the Bill Williams River channel, marsh area, and river bars obtained from the U.S. Fish and Wildlife Service (USFWS) was used to determine the distance of sites to the nearest braid of the Bill Williams River. Though this map was the most detailed available, it may not be representative of flowing water conditions along the Bill Williams River in March and April 2010 due to the high releases of water from Alamo Dam in March 2010.

Stream discharge data were obtained from the online record of the closest upstream USGS station on the same body of water on which the study sites were located (USGS 2010b and USGS 2011). Data from the following USGS stream discharge stations were used for analysis purposes: Beaver Dam Wash at Beaver Dam, Arizona (USGS 09414900), Virgin River at Littlefield, Arizona (USGS 09415000), Virgin River Above Lake Mead Near Overton, Nevada (USGS 09415250), Topock Marsh Inlet Near Needles, California (USGS 09423550), Bill Williams River Below Alamo Dam, Arizona (USGS 09426000), and Colorado River Below Palo Verde Dam, Arizona–California (USGS 09429100).

Soil samples to a depth of approximately 8 inches were collected for texture analysis in April 2010 and 2011. Soil texture samples were only collected once during each field season because soil texture would not be expected to change over the course of one season. One soil sample was collected at each subplot, and a 200-gram subsample of each was transported to Olsen Laboratories for texture analysis. The results for the 12 subplots were averaged to obtain an overall average soil texture per site.

The depth of organic matter (litter depth or thickness of the decomposing organic matter layer at the soil surface) was measured using a metric ruler directly adjacent to the transect line at each of the 12 subplots.

Percent soil moisture was measured using two different methods over the course of the 2010 field season. Soil moisture was recorded below the surface rather than at the soil surface. Collecting deeper soil moisture measurements would be expected to provide more useful information because it is indicative of conditions closer to the tree root zone.

Initially, soil moisture data were obtained via direct measurement in the field at a 0.6 m depth using an AquaTerr M300 Soil Moisture Meter, which measures the ratio of water to air in the soil, at each of the 12 subplots. Unfortunately, the M300 was not robust when exposed to field conditions. After 17 days in the field, it stopped taking readings. AquaTerr was contacted, and it was discovered that the equipment is sensitive to wet field conditions—not ideal for this study, given the habitat conditions present. A replacement was ordered, but constant recalibration was necessary due to unusual readings, which brought the accuracy of the measurements into question. After one month in the field, the replacement M300 also stopped working. The original M300 had been repaired in the meantime and, after only a few days back in the field, it again stopped taking measurements. After discussions with Reclamation, it was determined that, given the cost of the equipment and its short life cycle, an alternate method of measuring soil moisture was needed. Soil moisture was subsequently measured gravimetrically by collecting and oven-drying soil samples from the same 0.6 m depth at each of the 12 subplots.

Soil samples for gravimetric soil moisture determination were collected at all but two sites in April 2010, at five sites in May 2010, and at all sites in June through August 2010. The M300 was used exclusively in March 2010, part of April 2010, and almost entirely in May 2010. In 2011, soil moisture was measured solely using the gravimetric soil moisture method. These two methods of soil moisture measurement were not directly comparable and, according to a regression analysis, were only weakly correlated ($R^2 = 0.461$, $p = 0.054$). Because of this lack of a predictive relationship, the multiple problems with the M300, and because the majority of data were collected using the gravimetric method, the M300 data were dropped from the overall

statistical analysis. As a result, no percent soil moisture data were analyzed for the months with only M300 data available, including all sites in March 2010 and all sites in May 2010. Though two months of data were not included in the quantitative analysis, this was the appropriate course to take to ensure that the analyses were valid and to use comparable data. Only gravimetric data were carried forward in quantitative analyses.

Figure 2.2. HOBO® data logger.

In 2011 only, data loggers (Figure 2.2) were installed, at a depth of approximately 6 inches, at a subgroup of 10 sites to collect measurements of surficial soil moisture every 10 minutes starting in late April through August. The data loggers measured volumetric soil moisture (the fraction of the total volume of soil that is occupied by the water contained in the soil, in m^3 of water per m^3 of soil). One data logger was old and did not work upon installation, and a second data logger was cut and the soil moisture meter stolen, leaving eight active data loggers in place. This report included the measurements taken at the remaining eight devices. Data loggers were used at the following SWFL study sites (sample size [n] = 8): WF23, WF29, WF33, and WF35; and at the following YBCU study sites: YB24, YB30, YB31, and YB34. This surficial soil moisture data was a supplement to gravimetric soil moisture measured at a 2-foot depth at all sites (n = 76) during both years of the study.

Standing water was measured using a variation of the line intercept method. Whenever a pool of standing water crossed one of the 20-m transects, the width, length, and average depth of the pool were noted. These measurements did not include the depth or width of water in a flowing river or in areas inundated by flood irrigation and included only the dimensions of standing water within the limits of the site (e.g., the 40 m by 40 m or 1,600 m^2 area determined by the lateral extent of the four transects). The areas of each pool of standing water at one site were summed to acquire the total square meters of standing water in each site. Where the site was completely inundated, the total area of the site (e.g., 1,600 m^2) was recorded.

Depth to ground water was measured once per month at piezometer locations, as identified in Table 2.3. Existing piezometers installed by the USFWS for long-term monitoring were used to measure depth to ground water at sample sites along the Bill Williams River in 2010 and 2011. In addition, three-quarter-inch-diameter piezometers were installed to a depth of 15 feet at nine sites in March 2010 and two additional sites in March 2011 (Figure 2.3). In 2011, GSA installed piezometers near several of the soil hydrology study sites, and continuous data from seven of these were used to supplement the other depth to water information collected.

Figure 2.3. Three-quarter-inch piezometer near site center.

Following installation of the new piezometers in 2010 and 2011, the wells were allowed to fill and the depth to ground water was measured using a battery-operated Solinst water level meter. The wells were then hand-bailed and allowed to refill to ensure that no clogging or blockage due to piezometer installation had occurred. Depth to ground water was then measured again to ensure that the measurement was consistent and not skewed by the recent installation. For each piezometer, the height of the piezometer above ground level was measured and subtracted from the total depth to water (from the top of the piezometer) to obtain a depth to ground water from ground level. The distance of each to the nearest flowing water was determined using 2005–2007 aerial photography, with the exception of those along the Bill Williams River, where this distance was determined using the 2005 GIS map provided by the USFWS. Not all piezometers were within a soil hydrology site. Piezometers were assigned to one or more study sites based on similar distances to the nearest flowing water. Therefore, a piezometer assigned to a site may have been some distance from the site but was a similar distance from flowing water.

Air temperature and RH were collected during the time of each field visit using a handheld digital thermo-hygrometer. Measurements were collected at approximately 1.5 m above the soil surface at each of the 12 subplots and were averaged for each site. The air temperature and relative humidity measurements recorded on-site were taken at varying times of day. Analysis of the data was hindered by the potential for error created by the disparity in measurement time.

Additional hourly temperature data were provided for some sites by Reclamation for use in estimating potential evapotranspiration. Evapotranspiration is difficult to measure directly, but it can be correlated to atmospheric temperature, net radiation, and soil heat flux using the Priestley-Taylor estimation method (Fisher et al. 2005, Nichols et al. 2004). Samani et al. (2007) found that variables in the Priestley-Taylor method can be estimated using remote sensing. Measurements such as albedo (or reflectivity of the land surface) and land surface temperature were acquired from remote sensing data available from NASA (2011).

Other calculations were used to find atmospheric pressure and the psychometric constant to complete the Priestley-Taylor equation (Natural Resources Management and Environment Department 1998). Combined with the hourly temperature data from permanent data loggers placed by researchers contracted by Reclamation, potential evapotranspiration (PET) was estimated for a subgroup of study sites. Hourly data collected throughout the day are preferable to a single data point to estimate PET because it provides a good average daily temperature in addition to minimum and maximum daily temperature.

Vegetation data, including canopy height, percent canopy closure, and percent ground cover, were collected by SWCA in 2010 and 2011 at approximately the same location as some of the SWFL study sites. Percent canopy closure was collected in 2010 and canopy closure class data were collected in 2011 by the Southern Sierra Research Station (SSRS) at approximately the same location as some of the YBCU hydrology sites. The vegetation measurement plots were smaller than our study sites, but they were encompassed in the area measured for soil hydrology and microclimate conditions. All references to canopy height, percent canopy closure, canopy closure class, and percent ground cover in this report refer to the 2010 or 2011 data from SSRS or SWCA (SSRS 2010, SSRS 2011, SWCA 2010, SWCA 2011).

2.2 Analysis Methods

The data were compiled and combined for the 2010 and 2011 field seasons. Statistical analyses were completed for the combined two-year dataset and for a series of subgrouped data and included descriptive statistics, correlation analysis, and logistic regression. Unless otherwise noted, statistical analyses were conducted using MiniTab 15, and significance was inferred at a p-value less than 0.05.

2.2.1 Descriptive Statistics

Basic descriptive statistics were obtained for each measured variable (e.g., soil moisture, area of standing water) per site. These statistics included information on the mean, range, variance, and standard error of the mean.

2.2.2 Correlation Analysis

Correlation analyses were performed separately for SWFL and YBCU datasets to identify significant relationships between soil hydrology or microclimate variables present at the sites. Correlation analyses included the primary soil hydrology and microclimate variables (percent soil moisture, depth of organic matter, RH, air temperature, area of standing water, percent sand as the representative of soil texture, stream discharge, depth to the water table, and distance to nearest flowing water). Correlation analysis identifies positive linear relationships (e.g., depth to ground water increasing as distance to flowing water increases) and negative linear relationships (e.g., soil moisture decreasing as percent sand increases). Identifying the relationships between variables may provide valuable information when determining what conditions may be important for breeding habitat. It is important to note that a significant correlation between variables does not imply causation. Significant correlations between variables suggests that they are interdependent and that one variable may only be a proxy for another that is more important to site selection by SWFLs or YBCUs.

2.2.3 Logistic Regression

Key multivariate assumptions were not met for the comparison of SWFL and YBCU soil hydrology and microclimate data (i.e., equal covariances and multivariate normality). Logistic regression is robust in spite of the violation of these assumptions and was used to compare data from SWFL and YBCU sites. Prior to running the logistic regression, two sample t-tests were run to identify significant differences for individual variables between SWFL and YBCU sites. Percent sand was used as a representative of soil texture. Significant variables were then carried forward into the logistic regression, which was performed using SPSS for Windows, Version 11.0.0.

Most of the significant variables identified through the individual t-tests, except for stream discharge and area of standing water, were carried forward into the logistic regression. Stream discharge was not included because the distance to the river at sites associated with the highest discharge (i.e., YBCU sites associated with the Colorado River) was up to 2,000 m; these discharge rates would therefore have minimal impact on soil hydrology properties at these sites. A preliminary logistic regression analysis was run, and the Wald statistic (which indicates the level of influence one variable has on the overall model) indicated that standing water did not greatly influence the model (Wald = 2.24). Because of the low importance of the area of standing water

variable in the logistic regression and the problems due to the extreme non-normality of the data (even following data transformations), this variable was dropped from the final logistic regression.

Due to non-normality of the data, all variables except depth to the water table and air temperature were square root transformed to bring individual variables closer to normality. The square root transformed data were then used, where applicable, in the logistic regression. The 365 cases were dummy-coded as "1" for the 177 SWFL cases (sites x months of data) and "2" for the 188 YBCU cases (sites x months of data).

2.2.4 Analysis of Data Subgroups

Varying levels of statistical analysis were performed on selected subgroups of the larger dataset. In all cases, the subgroups had small sample sizes, which reduced the power of the analyses.

The first subgroup consisted of sites (n = 8) that had data loggers installed in 2011 to measure volumetric surficial soil moisture. Four data loggers were placed in SWFL sites and four in YBCU sites. The full suite of correlation analyses were performed for this subgroup.

The second subgroup consisted of sites in which bird presence and soil hydrology data were spatially and temporally concurrent (i.e., sites where SWFLs were recorded in the same location and year that soil hydrology and microclimate data were recorded). This SWFL subgroup (n = 18) also had the full suite of correlation analyses performed—identical to those performed on the full dataset.

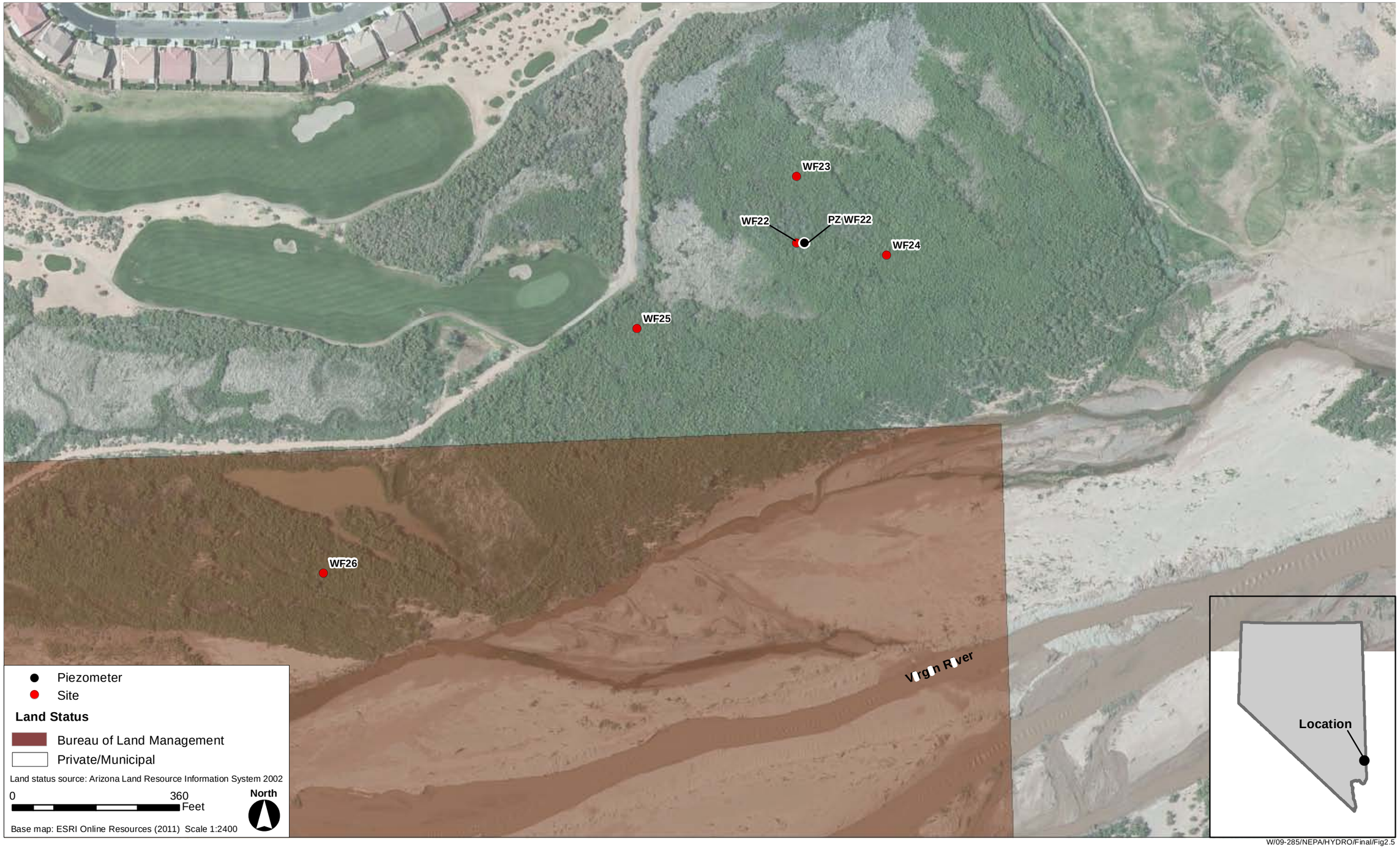
The third subgroup consisted of sites where vegetation data were collected in the same location and year that soil hydrology and microclimate data were collected. For this subgroup, only correlation analyses between the vegetation data and the soil hydrology/microclimate data were completed. Seven SWFL study sites in 2010 and four in 2011 overlapped vegetation sample plots measured by SWCA (SWCA 2010, SWCA 2011). Vegetation characteristics of interest at these sites were average percent canopy closure, tree height (m), and average percent ground cover. Seventeen YBCU study sites in 2010 and nine in 2011 overlapped vegetation sample plots measured by SSRS. Vegetation data collected changed between 2010 and 2011. In 2010, percent canopy closure was collected and in 2011, canopy closure class was collected (SSRS 2010, SSRS 2011). Therefore, 2010 percent canopy closure and 2011 canopy closure class were compared individually with YBCU 2010 and 2011 soil hydrology and microclimate data.

The fourth subgroup consisted of study sites where hourly temperature or daily minimum/ maximum temperature data were available (SSRS 2010, SSRS 2011, SWCA 2011). Nineteen sites were used to calculate PET for YBCUs, and 11 sites were used to calculate PET for SWFLs. Only sites with hourly or daily minimum/maximum temperature data were included in these calculations. Hourly temperature data were available for YBCUs for late June through August, and daily minimum/maximum temperature data were available for SWFLs for May through July; therefore, the PET calculations for each species were restricted to the available months. The YBCU subgroup ranged across the geography of the study sites from Havasu NWR to Cibola NWR. The SWFL subgroup included sites in Havasu NWR and Bill Williams River NWR.

The final locations of the SWFL sites are shown in Figures 2.4 through 2.8. The YBCU sites are shown in Figures 2.7 through 2.10.

W/09-285/NEPA/HYDRO/Final/Fig2.4

Figure 2.4. Site locations along Beaver Dam Wash in Littlefield, Arizona.



W/09-285/NEPA/HYDRO/Final/Fig2.5

Figure 2.5. Site locations along the Virgin River near Mesquite, Nevada.

W/09-285/NEPA/HYDRO/Final/Fig2.6

Figure 2.6. Site locations along the Virgin River near Overton, Nevada.

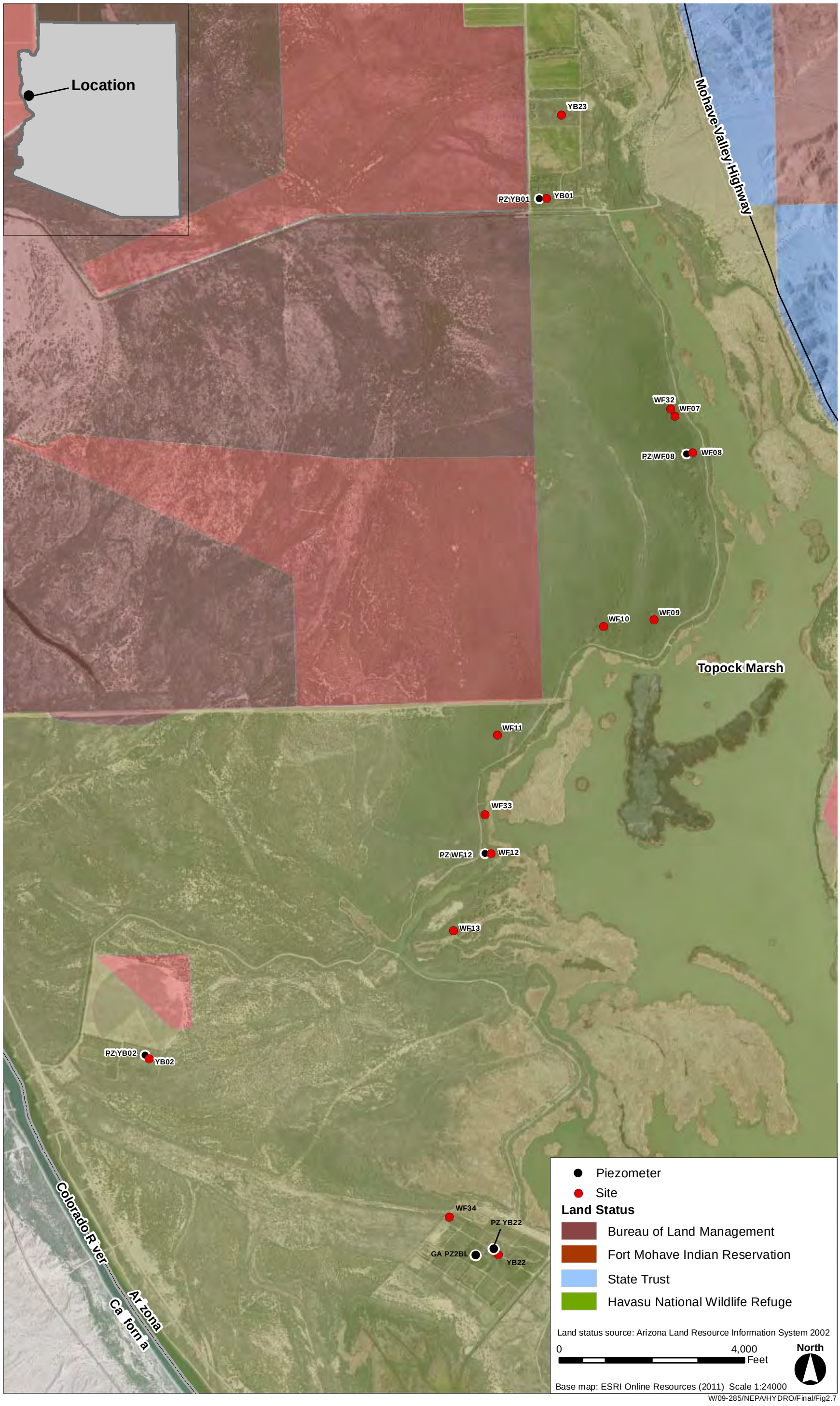
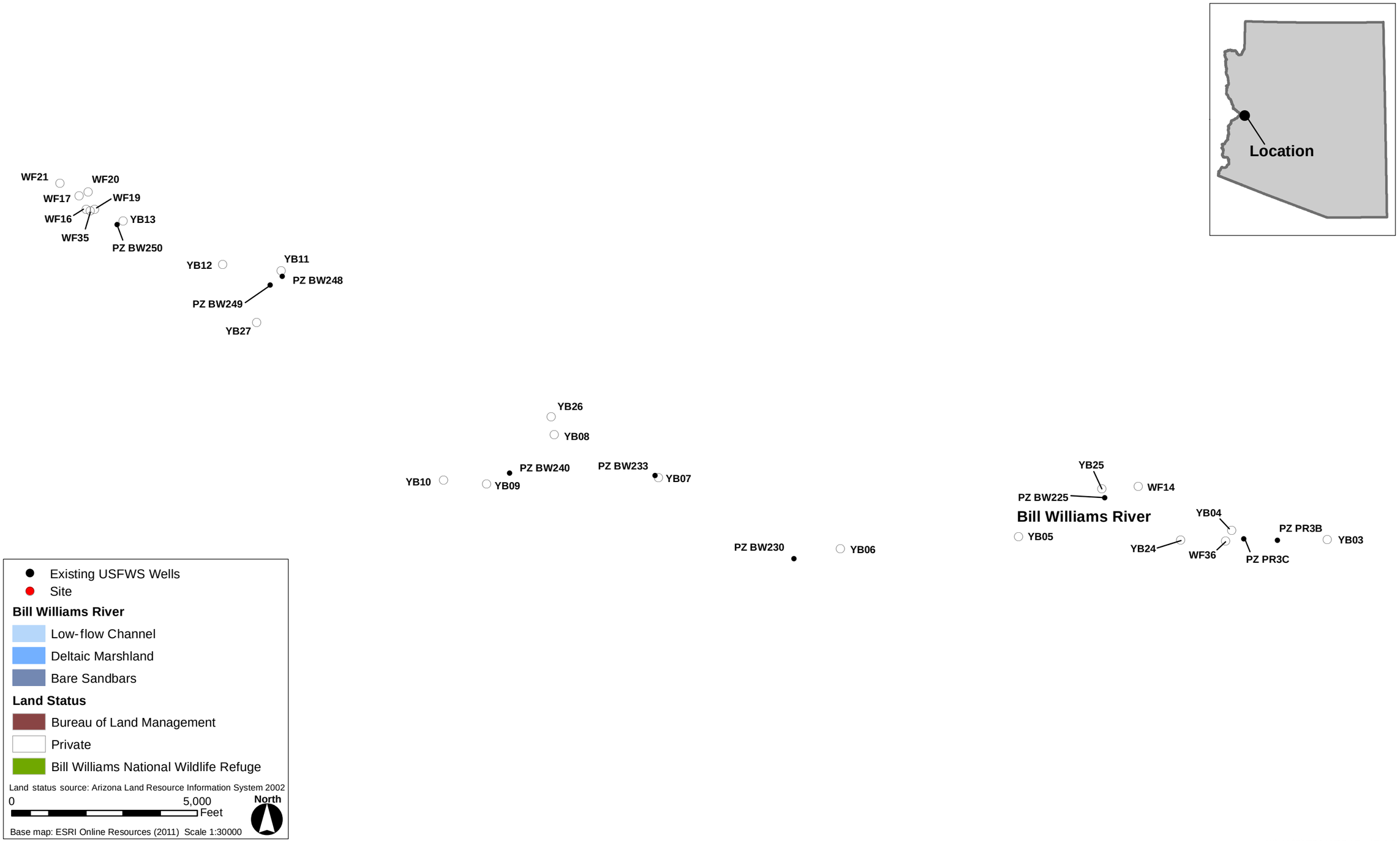


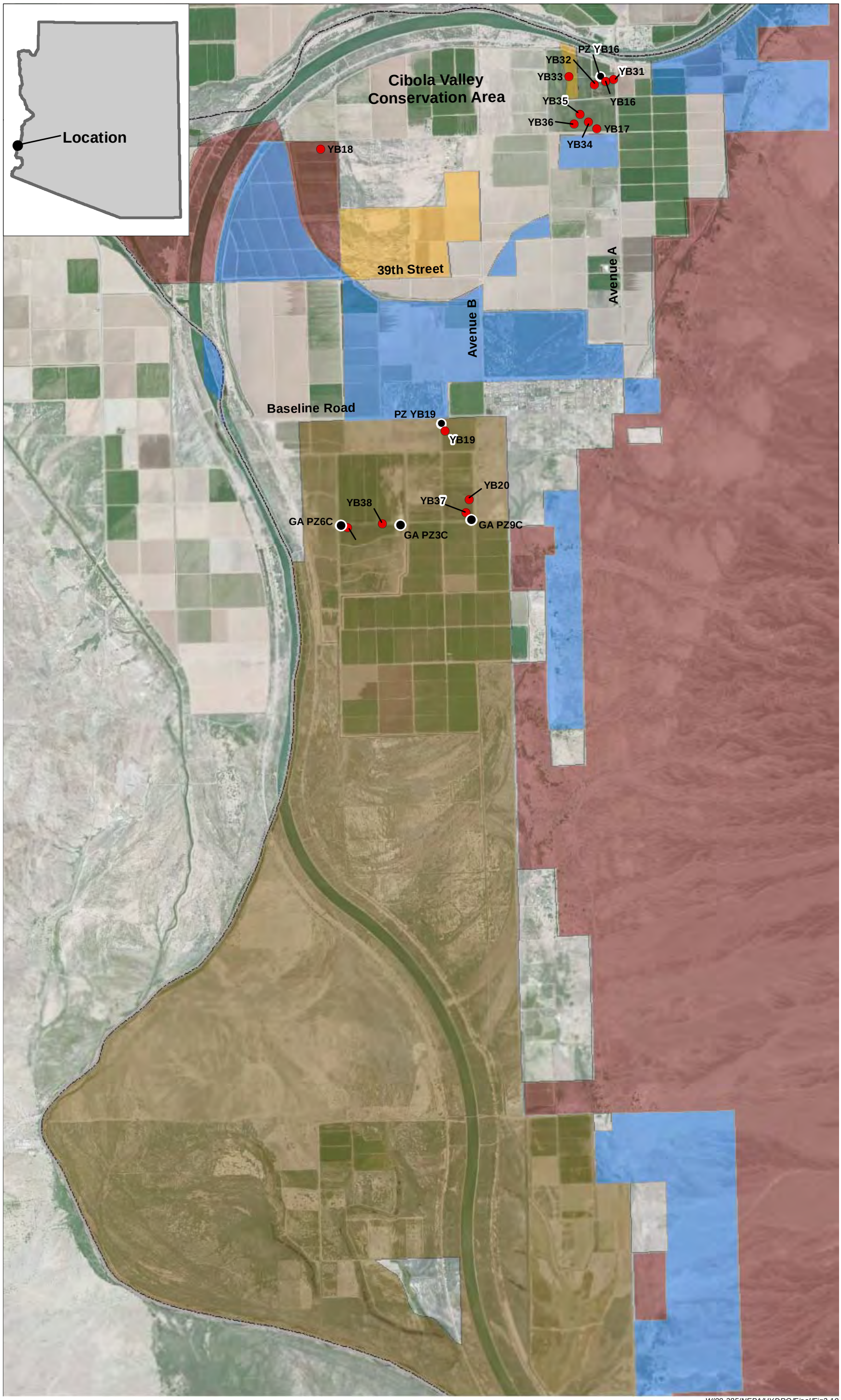
Figure 2.7. Site locations near Topock Marsh in Havasu National Wildlife Refuge, Arizona.



W/09-285/NEPA/HYDRO/Final/Fig2.8

Figure 2.8. Site locations along the Bill Williams River downstream of Alamo Dam, Arizona.

Figure 2.9. Site locations near the Colorado River at the Palo Verde Ecological Reserve, California.



W/09-285/NEPA/HYDRO/Final/Fig2.10

Figure 2.10. Site locations at restoration sites near the Colorado River at the Cibola Valley Conservation Area and the Cibola National Wildlife Refuge, Arizona.

3.0 RESULTS

The results of this study are discussed in three main sections: SWFL results, YBCU results, and a comparison between SWFL and YBCU sites. Within the SWFL and YBCU sections, results are further discussed by study site, for all study sites combined, and for data subgroups. Results of statistical analyses are discussed in each of the respective cumulative sections and in data subgroup sections, as appropriate.

3.1 SWFL Results

3.1.1 SWFL Individual Site Results

Tables 3.1 and 3.2 list the range of soil hydrology and microclimate conditions measured during the 2010 and 2011 field seasons at each SWFL site. Appendix A contains charts showing the discharge at the nearest USGS (2010b) stream gauge compared with depth to ground water at each piezometer.

Table 3.1. Soil hydrology results for individual SWFL sites across the 2010–2011 field seasons (March through August).

Site Name	Average Distance to Flowing Water (m)	Range of Area of Standing Water (m^2)/Depth of Standing Water (m)	Range of Depth to Ground Water (m)/ Piezometer Used	Range of Soil Moisture (%)*	Range of Organic Matter Depth (cm)	Soil Texture Classes Present	Months Standing/ Flowing Water Present
WF01	0	0.0/0.0	0.69–0.46/ WF02	4–35	0.0–6.0	Sandy loam	March through August
WF02	0	0.0/0.0	0.69–0.46/ WF02	23–28	0.0–8.5	Sand, sandy loam, loamy sand	March through August
WF03	348	283–1,150/ 0.04–0.07	0.2–0.0/ WF04	37–50	0.0–4.2	Silt loam	March through June
WF04	170	33–1,600/ 0.0–0.13	0.2–0.0/ WF04	29–44	0.0–1.5	Silt loam	March through June, August
WF05	289	1.46–286/ 0.01–0.04	0.2–0.0/ WF04	38–43	0.0–5.0	Silt loam	March, May, June†
WF06	240	34–51.75/ 0.02–0.04	0.2–0.0/ WF04	32–36	0.0–5.0	Silt loam, sandy loam	March and May†
WF07 2010	96	3.7–9/ 0.21	1.21–0.85/ WF12	31–46	0.0–9.0	Loam	March and April
WF07 2011	96	0.0/0.0	0.63–0.0/ WF08	4–68	0.0–6.0	Sand, silt loam, loam	NA
WF08 2010	111	7.6–107/ 0.05	0.28–0.0/ WF08	38–57	0.0–12.0	Silt loam, clay loam, loam	April and May
WF08 2011	111	0.0/0.0	0.63–0.0/ WF08	9–73	0.5–6.0	Sandy loam, silt loam, loamy sand, loam	NA
WF09	226	77–180/ 0.05	0.28–0.0/ WF08	29–36	0.0–8.0	Sandy loam and loam	March and April
WF10 2010	165	28.2–150.8/ 0.04	0.28–0.0/ WF08	33–42	0.0–4.0	Sandy loam, loam	March and April

Table 3.1. Soil hydrology results for individual SWFL sites across the 2010–2011 field seasons (March through August).

Site Name	Average Distance to Flowing Water (m)	Range of Area of Standing Water (m^2)/Depth of Standing Water (m)	Range of Depth to Ground Water (m)/ Piezometer Used	Range of Soil Moisture (%)*	Range of Organic Matter Depth (cm)	Soil Texture Classes Present	Months Standing/ Flowing Water Present
WF10 2011	165	0.0/0.0	0.63–0.0/ WF08	14–75	0.0–4.0	Silt loam, loam	NA
WF11	202	0.0/0.0	0.28–0.0/ WF08	24–32	0.0–12.5	Loam, sandy loam, silt loam	NA
WF12	61	0.0/0.0	1.21–0.85/ WF12	20–24	0.0–17.0	Loamy sand	NA
WF13	214	0.0/0.0	1.21–0.85/ WF12	4.9–9.8	0.0–7.5	Sand, loamy sand	NA
WF14	8	10–550/ 0.04–0.14	2.08–1.73/ BW225	33.7–40.2	0.0–13.0	Silt loam, sandy loam, loam	April through August‡
WF16**	446	15–520/ 0.04–0.21	2.8–1.1/ BW250	39.6–50.3	0.0–14.0	Silt loam	March through June
WF17 2010	331	180–755/ 0.15	2.8–1.1/ BW250	30.5–42.6	0.0–4.0	Silt loam	March through June
WF17 2011	331	150–409/0.10–0.11	3.1–1.66/ BW250	14–57	0.0–5.0	Sandy loam, silt loam, silty clay loam	March through May
WF19**	430	34–64/ 0.04	2.8–1.1/ BW250	34.7–51.0	0.0–17.0	Silt loam	March through May
WF20	290	20–27.5/ 0.02	2.8–1.1/ BW250	31.2–47.5	0.0–7.0	Silt loam	March through June
WF21	250	63.5/0.04	2.8–1.1/ BW250	32.8–47.3	0.0–9.0	Silt loam	March
WF22	170	40–1600/0.03–0.09	1.36–0.0/ WF22	5–88	0.0–2.5	Sandy loam, silt loam, loam	March through May
WF23	200	460/0.05	1.36–0.0/ WF22	0.9–76	0.0–6.0	Sandy loam, silt loam	April
WF24	128	17–800/0.06–0.11	1.36–0.0/ WF22	1–62	0.0–2.0	Silt loam, loam	March and April
WF25	209	468–1600/0.09–0.22	1.36–0.0/ WF22	3–65	0.0–2.0	Silt loam	March and April
WF26	100	69.5–355/0.16–0.28	1.36–0.0/ WF22	3–60	0.0–2.0	Silt, silt loam, loam, clay loam	March through May
WF27	260	395–479/0.07–0.08	0.0–0.0/ WF04	35–97	0.0–1.0	Silt loam	March, May, and August

Table 3.1. Soil hydrology results for individual SWFL sites across the 2010–2011 field seasons (March through August).

Site Name	Average Distance to Flowing Water (m)	Range of Area of Standing Water (m^2)/Depth of Standing Water (m)	Range of Depth to Ground Water (m)/ Piezometer Used	Range of Soil Moisture (%)*	Range of Organic Matter Depth (cm)	Soil Texture Classes Present	Months Standing/ Flowing Water Present
WF28	195	644–1600/0.08–0.1	0.0–0.0/ WF04	41–79	0.0–0.5	Silt loam	March, May, June, and August
WF29	215	16–980/0.08–0.18	0.0–0.0/ WF04	48–100	0.0–0.5	Silt loam	March, May through August
WF30	220	109/0.08	0.0–0.0/ WF04	18–61	0.0–3.0	Sandy loam, silt loam, silt	March
WF31	197	448–805/0.05–0.09	0.0–0.0/ WF04	44–100	0.0–1.0	Silt loam	March, May, August
WF32	130	0.0/0.0	0.63–0.0/ WF08	19–58	0.0–5.5	Loamy sand, silt loam, loam	NA
WF33	30	0.0/0.0	1.48–0.9/ WF12	3–25	0.5–7.5	Sand, loamy sand	NA
WF34	542	0.0/0.0	1.86–1.23/ GA PZ2BL	1–23	0.0–4.0	Sand, sandy loam, loamy sand	NA
WF35	330	180–1375/0.11–0.34	3.1–1.66/ BW250	21–75	0.0–1.5	Silt loam, silty clay loam, loam	March through May
WF36	5	4.8–326.4/0.29–0.58	0.84–0.57/ PR3C	8–45	0.0–6.0	Sand, sandy loam, loamy sand	March through August

cm = centimeter, m = meter, NA = not applicable, SWFL = Southwestern willow flycatcher.

* Represents gravimetric soil moisture measurements collected in April and June–August 2010.

† Due to rising water in the Virgin River (in response to precipitation), no data were collected at this site in April 2010.

‡ Due to high water levels, this site was inaccessible in March 2010, and no measurements were taken.

** WF15 and WF18 were dropped from the study during the March 2010 field visit. These two sites overlapped sites WF14 and WF17, respectively.

3.1.2 Cumulative SWFL Results

The collective range of conditions measured at the SWFL sites in 2010 and 2011 are detailed in Table 3.2. As discussed previously, the range of soil moisture conditions only reflect gravimetric measurements and do not include measurements in inundated soils. Twenty-nine of 38 SWFL sites had inundated/saturated soil conditions in at least part of the site for one or more months, and these had higher levels of soil moisture than actually measured. Therefore, the range of percent soil moisture listed in Table 3.2 is an underestimation of approximately 10 percent, but it gives an idea of the range of conditions when combined with the area of standing water (saturated soil conditions).

Table 3.2. Total range of conditions measured at all SWFL sites in 2010 and 2011.

Measurement	Mean	Median	Range (minimum/ maximum)	Standard Error/Standard Deviation	Notes
2010 and 2011 Soil Hydrology Measurements					
Percent soil moisture	34.7	35.8	2.3/85.1	1.1/15.2	Does not include measurements in inundated soils
Soil texture (% sand)	40.7	33.3	16.4/89.4	3.7/22.6	Soil textures ranged from sand to silty clay loam; samples taken at all 38 sites
Organic matter depth (cm)	1.4	1.1	0.0–9.8	0.1/1.4	
Standing/flowing water area (m^2)	573	397.5	0.0/1600	63.4/614.8	29 of 38 sites had standing or flowing water at least one month of the field season and 27 sites had standing water for two or more months
Standing/flowing water depth (m)	0.1	0.1	0.0/0.6	0.01/0.1	
Depth to ground water (m)	1.0	0.9	0.0/3.1	0.09/0.8	
Distance to flowing water (m)	197.7	198.5	0.0/542.0	20.5/126.7	Per aerial measurements and 2005 Bill Williams River GIS map
Air temperature ºCelsius (within site)	25.1	25.7	8.7/37.0	0.4/5.3	Measurements were not continuous across the field season
Percent relative humidity (within site)	50.0	50.6	15.0/93.1	1.4/20.7	Measurements were not continuous across the field season

cm = centimeter, m = meter, SWFL = Southwestern willow flycatcher.

Appendix B contains the full results of correlation analysis performed to determine significant relationships between soil hydrology and microclimate variables (distance to flowing water, stream discharge, soil texture, depth of organic matter, percent soil moisture, standing water extent, depth to ground water, air temperature, and RH).

This analysis identified several significant relationships between soil hydrology and microclimate variables at SWFL sites. Correlation analysis identified a significant negative relationship between percent sand and percent soil moisture ($r = -0.63$, $p<0.01$) with percent soil moisture decreasing with increasing sand levels. This result was expected since sand allows water to infiltrate more rapidly, resulting in lower soil moistures in sandy soils. The correlation analysis also identified a significant linear relationship between the distance to flowing water and depth to the water table ($r = 0.433$, $p<0.01$) Distance to flowing water was positively correlated with the depth to the water table, verifying the expectation that as a site was removed farther from the nearest perennial water source, the water table deepened. The measure of distance to flowing water used in the analysis was acquired for the average stream discharge over the course of the field season and did not reflect extreme flow events.

Significant correlations with varying coefficient strengths were identified between many other soil hydrology and microclimate variables (see Appendix B), indicating a high level of interdependence between variables. Therefore, the apparent significance of one particular variable may be due to one or more other, but interdependent, variables.

3.1.3 SWFL Data Subgroup Results

Subgroup of Sites with Data Loggers

A range of surficial soil moisture measurements was recorded at the sites (n = 4) included in this subgroup (Table 3.3). The data loggers measured volumetric surficial soil moisture (the fraction of the total volume of soil that is occupied by the water contained in the soil, in m^3 of water per m^3 of soil).

Table 3.3 Range of surficial soil moisture (m^3 water/m^3 soil) measured at SWFL data logger subgroup in 2011.

SWFL Study Site	Mean	Median	Range (minimum/ maximum)	Standard Error of the Mean
WF23	0.178	0.139	0.077–0.426	0.0007
WF29	0.464	0.466	0.003–0.470	0.0002
WF33	0.021	0.057	-0.107–0.070	0.0006
WF35	0.190	0.208	0.071–0.264	0.0004

SWFL = Southwestern willow flycatcher.

The negative number observed at the low end of the range at WF33 is likely an indication that an air pocket was next to the sensor and affected the observations. It is important to note that the small sample size increases the potential for error and reduces the power of the analysis.

Correlation analyses of data in this subgroup identified several significant relationships between variables. As anticipated, a positive correlation was found between the volumetric surficial soil moisture and gravimetric soil moisture at a 2-foot depth ($r = 0.887$, $p<0.01$). A significant negative correlation was found between percent sand and surficial soil moisture, which was consistent with the larger dataset ($r = -0.606$, $p = 0.01$). Significant negative correlations were also identified between surficial soil moisture and depth to ground water ($r = -0.513$, $p = 0.03$) and surficial soil moisture and organic matter (OM) depth ($r = -598$, $p = 0.01$). Other significant but weaker correlations were also identified, indicating that many soil hydrology and microclimate variables were interdependent (Appendix B).

Bird Presence Data Subgroup

In 2010, seven of the 19 study sites spatially overlapped SWFL nest or territory center locations identified in the same year. In 2011, 11 of the 19 study sites spatially overlapped SWFL nest locations identified in the same year. The resulting total sample size of 18 sites where SWFLs nested or had established territories and soil hydrology/microclimate data were spatially and temporally consistent was small.

Correlation analysis identified significant relationships between several variables in this subgroup. Depth to the water table and distance to flowing water were positively correlated ($r = 0.552$, $p<0.01$) while percent sand and percent soil moisture were negatively correlated ($r = -0.466$, $p<0.01$). Percent sand was also negatively correlated with distance to flowing water ($r = -0.688$, $p<0.01$). These results were similar to those identified in the correlation analysis of the complete SWFL soil hydrology and microclimate dataset. Significant correlations with varying coefficient strengths were identified between other soil hydrology and microclimate variables, indicating interdependence between variables (Appendix B).

Vegetation Data Subgroup

Generally, significant relationships occurred between soil hydrology and microclimate variables and percent ground cover in this subgroup (n = 11). Figure 3.1 provides a representative photo of a SWFL site in 2011. Only the area of standing water was not significantly correlated with percent ground cover (-0.087, p = 0.531). Only stream discharge and distance to flowing water were correlated with tree height, though the correlation coefficients were low (-0.275, p = 0.04 and -0.342, p = 0.011, respectively). Results of all correlation analyses are included in Appendix B.

Figure 3.1. WF22 June 2011 along the Virgin River near Overton, Nevada.

Potential Evapotranspiration Data Subgroup

Estimated PET varied between SWFL sites (n = 11) included in the study (Appendix C). PET at SWFL sites in Havasu NWR ranged from 3.4 mm/day in July 2011 to 6.9 mm/day in May 2011 (note that only three soil hydrology sites had temporally and spatially corresponding hourly temperature data available in Havasu NWR). PET at sites along the Bill Williams River ranged from 0.1 mm/day in July 2010 to 3.5 mm/day in May 2011. No hourly temperature data were available for the other SWFL soil hydrology study areas. These results are generally within the normal range for the dominant vegetation types and location.

3.2 YBCU Results

3.2.1 YBCU Individual Site Results

Table 3.4 shows the range of soil hydrology conditions measured during the 2010 and 2011 field seasons at YBCU study sites. Appendix A contains the charts showing the discharge at the nearest USGS (2010b) stream gauge compared with depth to ground water at each piezometer.

Table 3.4. Soil hydrology results for individual YBCU sites across the 2010 and 2011 field seasons (March through August).

Site Name	Average Distance to Flowing Water (m)	Range of Area of Standing Water (m^2)/Depth of Standing Water (m)	Range of Depth to Ground Water (m)/ Piezometer Used	Range of Soil Moisture (%)*	Range of Organic Matter (cm)	Soil Texture Classes Present	Months Standing/Flowing Water Present
YB01	450	0.0/0.0	1.32–0.88/ YB01	16–24	0.0–10.0	Loam, sand, silt loam	NA
YB02	700	0.0/0.0	2.4–1.9/ YB02	0.47–3	0.0–7.0	Sand, loamy sand	NA

Table 3.4. Soil hydrology results for individual YBCU sites across the 2010 and 2011 field seasons (March through August).

Site Name	Average Distance to Flowing Water (m)	Range of Area of Standing Water (m^2)/Depth of Standing Water (m)	Range of Depth to Ground Water (m)/ Piezometer Used	Range of Soil Moisture (%)*	Range of Organic Matter (cm)	Soil Texture Classes Present	Months Standing/Flowing Water Present
YB03	144	0.0/0.0	0.94–0.0/ PZ PR3C	3.9–14.8	0.0–8.0	Sand	NA
YB04	28	0.0/0.0	1.4–0.9/ PZ PR3B	3.5–6.1	0.0–6.6	Sand	NA
YB05	5	0.0/0.0	2.08–1.73/ PZ BW225	4.6–9.2	0.0–11.5	Sand	NA†
YB06	5	0.0/0.0	2.43–2.21/ PZ BW233	9.6–16.7	0.0–11.5	Loam, sandy loam, loamy sand	March through August (flowing water)
YB07	11	0.0/0.0	2.43–2.21/ PZ BW233	12.9–15.1	0.0–15.0	Sand, loamy sand, sandy loam	March through August (flowing water)
YB08	49	0.0/0.0	1.96–1.37/ PZ BW230	4.5–12.3	0.0–4.0	Sand	NA†
YB09	32	0.0/0.0	1.81–1.52/ PZ BW240	1.6–7.2	0.0–12.0	Sand	NA†
YB10	30	0.0/0.0	1.81–1.52/ PZ BW240	9.0–19.2	0.0–2.0	Sand	NA†
YB11	207	0.0/0.0	2.2–0.9/ PZ BW248	2.3–8.7	0.0–10.0	Sand, loam, loamy sand, sandy loam	NA
YB12	215	0.0/0.0	2.2–0.9/ PZ BW248	1.2–3.9	0.0–7.8	Sand, loamy sand, sandy loam	March and April (flowing water)
YB13	433	0.96–700/ 0.03–0.07	2.08–1.73/ PZ BW250	38.9–53.5	0.0–25.0	Sand, loamy sand, silt loam	March through June
YB16 2010‡	254	0.0/0.0	4.71–4.18/ YB16	4.2–11.6	1.0–11.5	Sandy loam, loam	NA (flood irrigated
YB16 2011	254	0.0/0.0	4.45–3.72/ YB16	2.6–25.3	1.0–17.0	Silt loam, loam	NA (flood irrigated
YB17	754	0.0/0.0	4.71–4.18/ YB16	9.7–23.8	0.0–12.5	Silt loam, loam	NA (flood irrigated
YB18	680	0.0/0.0	4.71–4.18/ YB16	7.9–29.8	0.0–6.0	Silt loam	NA (flood irrigated
YB19	2100	0.0/0.0	2.91–1.02/ YB19	3.6–26.6	0.5–10.0	Loam, sandy loam	NA (flood irrigated

Table 3.4. Soil hydrology results for individual YBCU sites across the 2010 and 2011 field seasons (March through August).

Site Name	Average Distance to Flowing Water (m)	Range of Area of Standing Water (m^2)/Depth of Standing Water (m)	Range of Depth to Ground Water (m)/ Piezometer Used	Range of Soil Moisture (%)*	Range of Organic Matter (cm)	Soil Texture Classes Present	Months Standing/Flowing Water Present
YB20	2000	0.0/0.0	2.91–1.02/ YB19	17.8–29.0	0.5–15.5	Loam, sandy loam, silt loam	NA (flood irrigated
YB21	200	0.0/0.0	1.45–0.89/ YB21	26.9–33.1	0.0–2.0	Sandy loam, loam	NA (flood irrigated
YB22	393	0.0/0.0	1.86–1.23/ GA PZ2BL	0.6–8.2	0.0–6.0	Sand	NA
YB23	703	0.0/0.0	1.98–1.12/ YB01	3.4–25.0	0.0–11.0	Sandy loam, silt loam, loam	NA
YB24	11	0.0–240/ 0.04–1.0	0.84–0.57/ PR3C	1.4–56.7	0.0–6.0	Sand, sandy loam, silt loam, loam	March through August
YB25	15	30–300/ 0.07–0.6	1.92–1.76/ BW225	4.4–72.2	0.0–10.5	Silt loam	March through August
YB26	9	320–600/ 0.3–0.7	2.4–1.48/ BW240	2.5–62.7	0.0–12.0	Sand, loamy sand, sandy loam, loam	March through August
YB27	117	0.0/0.0	3.55–0.7/ BW249	0.8–21.8	0.0–12.5	Sand, loamy sand	NA
YB28	214	0.0/0.0	4.52–3.72/ GA PZ6PVER	6.5–26.4	0.0–20.0	Sandy loam, silt loam, loam	NA (flood irrigated)
YB29	660	0.0/0.0	4.08–1.34/ GA PZ4PVER	2.1–20.0	0.0–11.0	Loamy sand, sandy loam	NA (flood irrigated)
YB30	440	0.0/0.0	4.26–1.73/ GA PZ2PVER	5.6–27.0	0.0–20.0	Sandy loam, loam	NA (flood irrigated)
YB31	234	0.0/0.0	4.45–3.72/ YB16	3.7–27.5	0.0–11.0	Sandy loam, silt loam, loam	NA
YB32	343	0.0/0.0	4.45–3.72/ YB16	2.9–26.2	0.0–13.5	Silt loam, loam	NA
YB33	363	0.0/0.0	4.45–3.72/ YB16	4.9–28.1	0.5–15.8	Silt loam, loam	NA
YB34	770	0.0/0.0	3.56–2.99/ YB36	1.6–87.2	0.0–10.5	Sandy loam, silt loam, loam	NA
YB35	713	0.0/0.0	3.56–2.99/ YB36	2.7–87.9	0.0–10.0	Silt loam, loam	NA
YB36	842	0.0/0.0	3.56–2.99/ YB36	6.5–34.8	0.0–7.0	Silt loam, loam	NA

Table 3.4. Soil hydrology results for individual YBCU sites across the 2010 and 2011 field seasons (March through August).

Site Name	Average Distance to Flowing Water (m)	Range of Area of Standing Water (m^2)/Depth of Standing Water (m)	Range of Depth to Ground Water (m)/ Piezometer Used	Range of Soil Moisture (%)*	Range of Organic Matter (cm)	Soil Texture Classes Present	Months Standing/Flowing Water Present
YB37	2,032	0.0/0.0	2.35–1.77/ GA PZ9C	8.5–37.3	0.0–8.0	Silt loam, loam	NA
YB38	1,049	0.0/0.0	2.72–2.59/ GA PZ3C	1.1–28.4	0.0–12.0	Sandy loam, silt loam, loam	NA
YB39	684	0.0/0.0	2.75–2.41/ GA PZ6C	2.3–30.7	0.0–6.0	Sandy loam, silt loam, loam	NA

cm = centimeter, m = meter, NA = not applicable, YBCU = Western yellow-billed cuckoo.

* Represents gravimetric soil moisture measurements collected in April and June–August 2010.

† Site was inaccessible in March 2010 due to high flows. No measurements taken.

‡ YB14 and YB15 were inaccessible and were dropped from the study during the March 2010 field visit.

3.2.2 Cumulative YBCU Results

The range of soil hydrology and microclimate conditions measured at the YBCU sites in 2010 and 2011 are detailed in Table 3.5. As noted previously, the range of soil moisture conditions only reflect gravimetric measurements. As with the SWFL sites, the percent soil moisture does not include measurements in saturated soils, which may lead to an underestimation of soil moisture. However, this effect was less in the YBCU sites because few sites had saturated soil conditions, and those that had saturated soil on at least part of the site did not have those conditions for the entire field season.

Appendix B contains the full results of correlation analysis performed to determine significant relationships between soil hydrology and microclimate variables (distance to flowing water, stream discharge, soil texture, depth of organic matter, percent soil moisture, standing water extent, depth to ground water, air temperature, and RH).

A positive correlation was found between stream discharge and depth to the water table ($r = 0.702$, $p<0.01$). Though counterintuitive, this correlation was simply a relict of the high number of irrigated restoration sites chosen for this study. These sites (19 in total) were farther away from the nearest flowing water than non-restoration sites, resulting in a deeper water table, and all but one were associated with the Colorado River, which had a much higher rate of discharge than any of the other perennial streams included in this study. Therefore, this relationship should not be considered indicative of an important habitat characteristic for species use.

A significant negative correlation was found between percent sand and percent soil moisture ($r = -0.610$, $p<0.01$). This was a reflection of the reduced moisture retention capacity of sandy soils and was also found in the SWFL data. Percent sand was also negatively correlated with depth to water table ($r = -0.490$, $p<0.01$), indicating that the water table was shallower at sandier

sites. As previously established, sandier sites were associated with sites near flowing water, which would feed the shallow water table.

Table 3.5. Total range of conditions measured at all YBCU sites in 2010 and 2011.

Measurement	Mean	Median	Range (minimum/ maximum)	Standard Error/Standard Deviation	Notes
2010 and 2011 Soil Hydrology Measurements					
Percent soil moisture	15.1	14.5	0.5/53.5	0.7/9.8	Does not include measurements in inundated soils
Soil texture (% sand)	58.5	51.7	23.5/94.9	3.7/22.9	Soil textures ranged from sand to silt loam
Organic matter depth (cm)	2.6	2.1	0.0/12.3	0.1/2.0	
Standing/flowing water area (m^2)	454.5	320.0	0.0/700	72.5/422.5	Four of 38 sites had standing or flowing water at least one month of the field season (not including flood irrigation)
Standing/flowing water depth (m)	0.2	0.2	0.0/0.7	0.03/0.2	
Depth to ground water (m)	2.2	2.1	0.0/4.7	0.09/1.1	
Distance to flowing water (m)	477.4	298.5	5.0/2100.0	88.8/547.5	Per aerial measurements and 2005 Bill Williams River GIS map
Air temperature ºC (within site)	26.9	26.6	7.8/47.4	0.5/6.7	Measurements not continuous across the field season
Percent relative humidity (within site)	46.8	43.9	13/96	1.5/22.4	Measurements not continuous across the field season

YBCU = Western yellow-billed cuckoo.

Significant correlations with varying coefficient strengths were identified between other soil hydrology and microclimate variables, indicating interdependence between variables (Appendix B).

3.2.3 YBCU Data Subgroup Results

Subgroup of Sites with Data Loggers

A range of surficial soil moisture measurements were recorded at the sites (n = 4) included in this subgroup (Table 3.6). The data loggers measured volumetric surficial soil moisture (the fraction of the total volume of soil that is occupied by the water contained in the soil, in m^3 of water per m^3 of soil).

Table 3.6. Range of surficial soil moisture (m^3 water/m^3 soil) measured at YBCU data logger subgroup in 2011.

YBCU Study Site	Mean	Median	Range (minimum/ maximum)	Standard Error of the Mean
YB24	0.059	0.05	-0.29–0.083	0.0003
YB30	0.167	0.142	0.03–0.38	0.0007

Table 3.6. Range of surficial soil moisture (m^3 water/m^3 soil) measured at YBCU data logger subgroup in 2011.

YBCU Study Site	Mean	Median	Range (minimum/ maximum)	Standard Error of the Mean
YB31	0.167	0.163	0.05–0.41	0.0005
YB34	0.152	0.162	-0.0009–0.39	0.0007

YBCU = Western yellow-billed cuckoo.

In general, the YBCU measurements showed more negative data than SWFL measurements. This was a potential source of error as negative measurements usually indicated a data collection issue.

Correlation analysis of data in this subgroup identified significant relationships between some variables. RH and area of standing water showed significant correlations to surficial soil moisture ($r = 0.621$, $p<0.01$ and $r = -0.511$, $p = 0.03$, respectively). The latter was an unexpected result because it implies that as the area of standing water decreased, surficial soil moisture increased. This relationship was likely a relic of the small subsample size of four sites and the presence of negative values at the only site with standing water. Therefore, this result was probably due to sampling error. No significant correlations were found between surficial soil moisture and gravimetric soil moisture, air temperature, depth of organic matter, depth to the water table, distance to flowing water, soil texture, or stream discharge. Full results of the correlation analyses can be found in Appendix B.

Bird Presence Data Subgroup

This data subgroup was not analyzed for YBCU soil hydrology and microclimate data. YBCU nests are notoriously hard to pinpoint. Unlike the SWFL bird location data, which had specific nest locations identified, most of the YBCU location data identified an area of use rather than a nest. It was not possible to narrow the parameters to an extent where we could ensure that soil hydrology sites spatially overlapped with YBCU nests. Therefore, this was not a reliable subgroup for analysis of YBCU data and was not expected to yield any more refined data compared with the full YBCU soil hydrology and microclimate dataset.

Figure 3.2. YB18 July 2010 in Cibola Valley Conservation Area.

Vegetation Data Subgroup

Appendix B summarizes the results of the correlation analysis performed for this data subgroup. Figure 3.2 provides a representative photo of a 2010 YBCU site. The correlation analysis for the 2010 data did not yield any significant results between air temperature and canopy closure or RH and canopy closure ($r = -0.165$, $p = 0.17$ and $r = -0.062$, $p = 0.61$, respectively). The analysis for the 2011 data also did not yield any significant

results between air temperature and canopy closure class (r = -0.237, p = 0.09) or RH and canopy closure class (r = 0.198, p = 0.15). It was expected that canopy density would be correlated with the microclimate under the canopy through shading and evapotranspiration and thereby influence microclimate conditions that may be important in breeding habitat selection. The lack of a significant correlation from this data subgroup may be attributable to small sample size (n = 26).

Potential Evapotranspiration Data Subgroup

Estimated PET varied between YBCU sites (n = 19) included in the study (Appendix C). PET at YBCU sites in Havasu NWR ranged from 0.9 mm/day to 8.9 mm/day (note that only one soil hydrology site had temporally and spatially corresponding hourly temperature data available in Havasu NWR). PET at sites along the Bill Williams River ranged from 0.2 mm/day to 4.3 mm/day. PET at sites in PVER ranged from 0.9 mm/day to 4.3 mm/day (note that only one soil hydrology site had spatially and temporally corresponding hourly temperature data at PVER). PET at sites in CVCA ranged from 2.7 mm/day to 7.8 mm/day. PET at sites in Cibola NWR ranged from 3.0 mm/day to 8.9 mm/day. These results are generally within the normal range for the dominant vegetation types and location.

3.3 Results of SWFL and YBCU Site Conditions Comparison

Two Sample T-tests

Results of two sample t-tests to identify significant differences between SWFL and YBCU sites are listed in Table 3.7.

Table 3.7. Results of two sample t-tests comparing SWFL sites with YBCU sites.

Environmental Variable	SWFL and YBCU T-test Results				
	Sites	Mean	Standard Error of the Mean	T-value	P-value
Soil moisture (%)	SWFL	34.7	1.1	14.59	<0.01
	YBCU	15.2	0.71		
Soil texture (% sand)	SWFL	41.4	1.7	6.88	<0.01
	YBCU	57.5	1.6		
Depth to ground water (m)	SWFL	0.87	0.07	15.38	<0.01
	YBCU	2.53	0.09		
Distance to water (m)	SWFL	192	9.4	7.21	<0.01
	YBCU	473	38		
Area of standing water on-site (m^2)	SWFL	195	29	4.53	<0.01
	YBCU	53	11		
Air temperature (C)	SWFL	25.59	0.38	3.24	<0.01
	YBCU	27.53	0.46		
Relative humidity (%)	SWFL	51.6	1.6	1.57	0.12
	YBCU	48.0	1.7		
Organic matter depth (cm)	SWFL	1.38	0.10	6.75	<0.01
	YBCU	2.55	0.14		
Stream discharge (cfs)	SWFL	157	20	13.65	<0.01
	YBCU	4750	336		
Canopy Closure (%) (2010 data only)	SWFL	88.39	1.7	1.69	0.09
	YBCU	84.4	1.7		

m = meter, C = Celsius, cfs = cubic feet per second, cm = centimeter, SWFL = Southwestern willow flycatcher, YBCU = Western yellow-billed cuckoo.

Results of this analysis indicated that, compared with YBCU sites, SWFL sites had higher soil moisture, lower percent sand, and shallower depth to ground water; were closer to flowing water; and had more area of standing water, lower average temperature, less organic matter (litter) depth, and lower stream discharge. There were no significant differences in RH or canopy closure between SWFL and YBCU sites.

Average percent soil moisture was more than twice as high at SWFL sites compared with YBCU sites. Soils at YBCU sites generally had more sandy textures than SWFL sites, which may have factored into lower soil moisture content. Depth of organic matter was greater at YBCU sites than at SWFL sites. The number of sites with standing water at least one month of the field season was higher in SWFL sites than in YBCU sites. Twenty-nine SWFL sites had standing water at least one month of the year (and tended to have standing water for a minimum of two or three months), whereas only four YBCU sites had standing water present at least one month of the field season. For those sites with standing water, a larger portion of the SWFL sites were covered by standing water than on YBCU sites.

In line with these observations of standing water, depth to ground water was generally shallower at SWFL sites than at YBCU sites, and the mean distance to flowing water was greater for YBCU sites than for SWFL sites. The distance to water was higher for YBCU sites due to the location of many YBCU study sites in restoration areas at Palo Verde Ecological Reserve, Cibola Valley Conservation Area, and Cibola NWR, some of which were more than 2 kilometers away from the nearest flowing water.

In the study area, our results did not support previous research that suggested YBCUs need close proximity to flowing water to nest (Gaines 1974, Hamilton and Hamilton 1965). The results were consistent with other research that suggested SWFLs prefer stands close to flowing water and with standing water on site (Ellis et al. 2008, McLeod and Koronkiewicz 2010, McLeod and Pellegrini 2011, Paxton et al. 2007, Sogge and Marshall 2000, U.S. Forest Service 2000, USFWS 2010).

Logistic Regression

The logistic regression correctly distinguished SWFL sites from YBCU sites in 86.8 percent of the cases. Tables 3.8 and 3.9 detail the relevant statistics. Results of the logistic regression are shown in full in Appendix D.

Table 3.8. Logistic regression results.

Category	Result
% of correct classification	86.8
Nagelkerke R-squared	0.711
Implied R-squared*	0.843
Hosmer and Lemeshow test	Chi-square = 8.642, df = 8, p = 0.373†

* Based on the square root of the Nagelkerke R-squared.

† A low p-value would suggest that the data fit the model poorly.

Table 3.9. Variable coefficients.

Variable*	Logit Coefficient (B)	Standard Error	Wald Statistic	Significance
tMoist (percent soil moisture)	-0.324	0.182	3.177	0.075
Temp (air temperature)	0.042	0.032	1.760	0.185
tOM (depth of organic matter)	0.184	0.332	0.308	0.579
Depth (depth to water table)	1.539	0.228	45.361	0.000
tDistance (distance to flowing water)	0.065	0.021	9.709	0.002
tSand (percent sand)	0.715	0.199	12.975	0.000
Constant	-8.297	2.586	10.290	0.001

* "t" denotes that the variable has been quasi-normalized with a square root transformation.

The results of the logistic regression were strong, with an implied multiple correlation coefficient (R^2) of 0.843. A standard normal test of significance led us to reject the null hypothesis that the observed results could have occurred by chance ($z = 14.07$, $p<0.001$). The Wald statistic, which indicates the level of influence one variable has on the overall model, indicated that depth to ground water was the most important variable of influence in this regression. Soil texture followed at a distant second, and then distance to flowing water was the third most influential variable. The results suggested that air temperature and depth of organic matter had little influence and could be dropped from the regression without significantly changing the model.

The 86.8 percent correct classification indicated that the regression could predict whether a site is SWFL or YBCU based on the variables included, which indicated significant differences between the two types of sites. Figure 3.3 shows a graphical representation of these results.

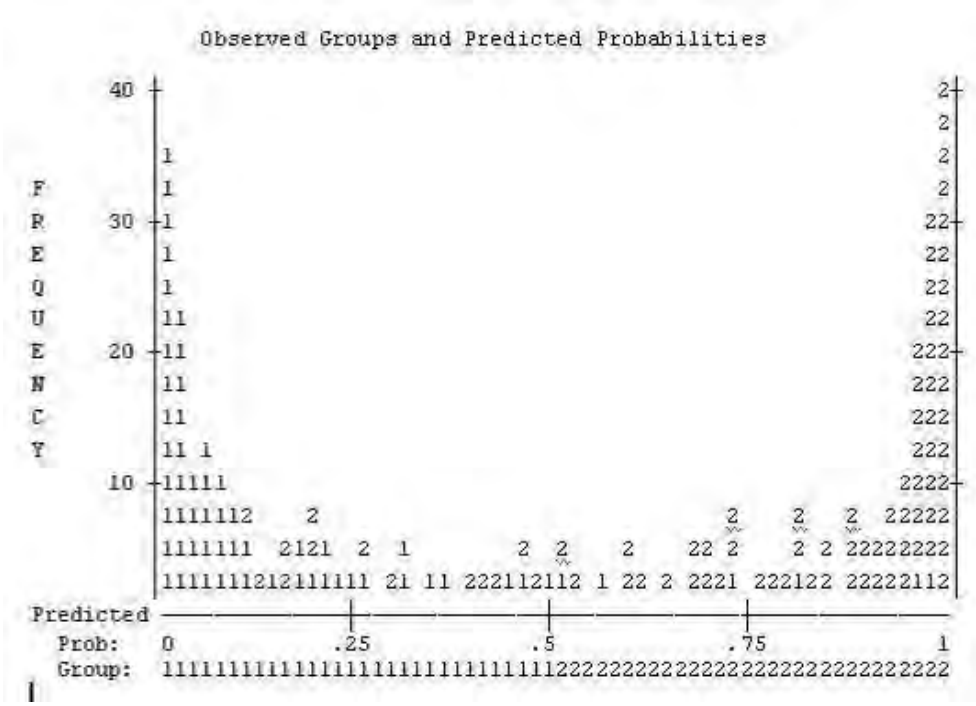


Figure 3.3. Logistic regression predicted probability chart. Each symbol represents 2.5 cases. The 1s represent SWFLs and the 2s represent YBCUs.

4.0 DISCUSSION

SWFL Sites

The SWFL sites showed a wide range of soil hydrology and microclimate conditions over the two years of this study. The study sites in Mesquite, Nevada, and Havasu NWR tended to have the lowest percent soil moisture, though the maximum end of the range could also be quite high, as identified in Table 3.1. At the beginning of the 2011 field season, the Mesquite, Nevada, sites were receiving supplemental water from an adjacent golf course, resulting in highly saturated conditions across many of the sites. Drainage improvements undertaken by the golf course during the field season resulted in these sites drying up completely in the later months of the field season. These factors helped explain the extreme low and high soil moisture numbers recorded at these sites.

The SWFL sites at Havasu NWR that had standing water present had moderate to high percent soil moisture. Comparatively, the SWFL sites at Havasu NWR that had no recorded standing water present at any time during the field season had low soil moisture percentages. In fact, Havasu NWR had the highest number of sites without any standing water present compared with any other area included in the study, particularly in 2011. This doesn't seem to have greatly impacted depth to ground water. Most of the sites at Havasu NWR had a depth to ground water of less than 1 m. A decrease in successful SWFL nesting at Havasu NWR over the course of several years has been documented (McLeod and Pellegrini 2011), and this may be related to decreases in the amount and/or duration of standing water at these sites.

Figure 4.1. WF20 July 2010 in Bill Williams River National Wildlife Refuge.

The SWFL study sites along the Bill Williams River had the greatest depth to ground water, ranging from the shallowest at 0.57 m at Planet Ranch to a maximum depth of 3.1 m at BW250 toward the western extent of the Bill Williams study sites. The Bill Williams River is a highly braided channel with a main low-flow channel. Many of the wells and sites were near dry braids, sometimes hundreds of meters from the main low-flow channel. Figure 4.1 is a representative photo showing SWFL habitat in the Bill Williams River NWR. The figures charting depth to ground water near SWFL sites against stream discharge (Appendix A) generally show that as stream discharge increased, depth to ground water decreased (became more shallow). The strength of this relationship varies but was generally more obvious at wells closer to the flowing water than farther away. This suggested that the range of depths to ground water along the Bill Williams River was a reflection of the varying distances to the main channel. This was also supported by a significant positive correlation between distance to flowing water and depth to ground water, which indicated that as distance to flowing water increased, the depth to the ground water also increased.

Generally speaking, the range of soil hydrology and microclimate variables measured at all 2010 and 2011 SWFL sites was fairly wide, particularly with soil moisture (at 0.6 m depth), soil texture, area of standing water, depth to ground water, and distance to flowing water. However, the average values for sites used tended to be less sandy, with moderate soil moisture, large areas of standing water, and within 200 m of flowing water. This was consistent with the conclusions of previous research that indicate SWFLs require surface water or saturated soil conditions to breed (Ellis et al, 2008, Paxton et al. 2007, Sogge and Marshall 2000, U.S. Forest Service 2000, USFWS 2010).

The preceding discussion applies to the entire 2010–2011 SWFL soil hydrology dataset. Because study sites were selected prior to the nesting period, SWFL presence from the previous year was used to select soil hydrology study sites (i.e., 2009 SWFL presence data was used to select 2010 soil hydrology sites). Though there is a certain amount of fidelity to nesting sites, it is more on a stand level than on a nest level, and varying conditions across the years may result in different nest location choices. Therefore, though best efforts were made to choose sites likely to be used again, this was subject to some error.

The subgroup analysis that examined study sites spatially and temporally consistent with SWFL nesting (i.e., where SWFL nests were present and soil hydrology/microclimate data were collected in the same year) was useful in validating significant relationships against those identified in the larger dataset. The small sample size (only 18 sites were spatially and temporally correlated) limited the predictive power of this analysis. However, several of the significant results obtained in the full dataset were validated in this smaller dataset. This subgroup of sites covered the entire range of SWFL study sites, from Littlefield to the sites near Overton to the Bill Williams River, and included the widest-ranging soil moisture levels and depths to ground water, including the lowest soil moisture percent identified at the Mesquite, Nevada, sites. Interestingly, though there were nine sites in the larger dataset without standing water present, only one of those fell into this subgroup. The remaining 17 sites in this subgroup had multiple months of standing water recorded. Again, this supported the conclusions reached by previous research regarding the importance of standing water to nesting SWFLs.

Soil hydrology is important when considering the creation and maintenance of favorable habitat. Vegetation density, ground cover, the type of vegetation, and tree height are all impacted by soil hydrology variables. Historically favored vegetation for SWFLs (cottonwoods and willows) generally requires shallow ground water found near perennial streams. Saltcedar, which has been used in recent years by nesting SWFLs, shows a preference for these same conditions but does not rely on it for survival as much as the native cottonwoods and willows. The correlation analysis for the subgroup comparing vegetation characteristics with the soil hydrology and microclimate data verified the strong relationship between certain vegetation and soil hydrology characteristics, particularly the negative correlation between distance to flowing water with tree height and ground cover and depth to ground water with ground cover.

PET values were mostly within the normal range expected with the vegetation present (Water Resources Research Center 2011). PET was generally higher in May and at the sites in Havasu NWR, dipping to lower levels in June and July during the stressful summer months with higher temperatures and lower water supply. Because the results were mostly within the normal range

of evapotranspiration for this habitat, this variable was not considered predictive of SWFL habitat in this study.

YBCU Sites

The range of measured variables at YBCU sites provided insight into the wide range of soil hydrology and microclimate conditions associated with YBCU sites. Distance to flowing water had a particularly wide range, with sites within 5 m of flowing water and as far away as 2,100 m.

Percent soil moisture for YBCU sites was generally low to moderate. Only six YBCU sites had soil moisture percentages above 50 percent. The lowest percent soil moisture observed was at Havasu NWR, but it was quite common to see soil moisture percentages of only 1 to 5 percent across the range of YBCU sites. This was likely associated with the sandy soil texture at many of these sites, though even the silt loam YBCU sites had low soil moisture percentages.

The YBCU sites selected for this study included many restoration sites along the Colorado River. These sites were sometimes far from flowing water but were used for at least two years by nesting YBCUs. The sites were flood-irrigated and were mostly populated with Fremont cottonwood trees as the dominant overstory species. These sites appeared to be having success in attracting YBCU use.

Figure 4.2. YB07 July 2010 in Bill Williams River National Wildlife Refuge.

Depth to ground water was generally around 2 m, extending as deep as 4.7 m at some of the restoration sites. The shallowest ground water associated with YBCU sites in this study was along the Bill Williams River. Figure 4.2 provides a representative photo of YBCU habitat at a site in the Bill Williams River NWR. Only four sites had standing water on-site other than sites that were flood-irrigated. Many of the restoration sites, including sites at Cibola NWR, CVCA, PVER, and Beal Lake, had flood irrigation across the sites periodically over the course of the 2010 and 2011 field seasons. Flood irrigation schedules are included in Appendix E for reference.

As with the SWFL sites, the correlation analyses noted a significant relationship between percent sand and percent soil moisture. As discussed previously, sand allows water to infiltrate more rapidly, resulting in lower soil moistures in sandy soils. Other significant correlations found (i.e., distance to flowing water and percent soil moisture, stream discharge and area of standing water, stream discharge and distance to flowing water) appeared to be the result of the high number of restoration sites included in the study. Soil hydrology characteristics could also reasonably be assumed to influence the vegetation present in sites used by YBCUs. For YBCU sites, only canopy closure in 2010 and canopy closure class in 2011 were available. Only weak correlations were identified between these vegetation measurements and soil hydrology variables. Because 2010 and 2011 data had to be analyzed separately, the sample sizes involved were extremely

small and presented a potential source of error. The results of this analysis were therefore limited but could be used to recommend an avenue of additional study.

Microclimate conditions were generally not reliable predictors of vegetation conditions. PET rates were mostly within the normal range expected with the vegetation present (Water Resources Research Center 2011). The calculations for YBCU sites used hourly data from other Reclamation consultants and were therefore a more reliable estimate of PET than the calculations at SWFL sites. The low of 0.2 mm/day was low for the normal range of PET expected for the area, but most of the results were well within the normal range for the vegetation and location. These numbers were estimations and were not based on direct measurements of evapotranspiration in the field. These PET measurements at YBCU sites were lower than the measurements at SWFL sites, but that was likely because YBCU data were only available for the latter half of June, and July and August, the three lowest months for evapotranspiration, whereas SWFL PET used data from March through August. Because the results were within the normal range of evapotranspiration for this habitat, these data were not considered strongly predictive of sites used by YBCUs.

SWFL and YBCU Comparison

When SWFL results were compared to YBCU results, significant differences in soil hydrology and microclimate conditions were found. The two sample t-tests and the multivariate logistic regression identified significant differences between the two types of sites, with the latter identifying the level of influence of each variable.

The logistic regression model correctly categorized SWFL and YBCU habitat 86.8 percent of the time. Depth to the water table was by far the most influential variable in the model. YBCU sites had an average depth to ground water almost three times deeper than the average depth to ground water at SWFL sites. As noted earlier, depth to ground water was strongly correlated with distance to flowing water. Though not nearly as predictive as depth to ground water, distance to flowing water was also an influential variable in the regression model. YBCU sites were generally farther from flowing water, sometimes more than 2,000 m from the nearest river. The farthest soil hydrology SWFL site, by contrast, was 542 m from the nearest river. This result should be considered when selecting placement of habitat creation or restoration sites for SWFL. Though YBCU sites were located very close and relatively far away from flowing water, indicating that YBCUs have a broader selection range for this variable, results of this study suggested that SWFL sites were more likely to be closer to flowing water.

Percent sand was also a highly influential variable in the logistic regression, indicating that it was a key difference between YBCU and SWFL sites. YBCU sites were, on average, sandier than SWFL sites. Following soil texture, the remaining variables had minimal influence on the model, including percent soil moisture. Given the significant relationship between soil texture and percent soil moisture, it was expected that soil moisture would have more strongly influenced the regression model. The water holding capacity of soil in an area is dictated in large part by soil texture. The YBCU sites had a significant number of sites that were sandier than SWFL sites (as evidenced by the t-test). Water infiltrates through sandy soils more quickly than in silt or clay soils, thereby resulting in lower soil moisture. The majority of the sandy YBCU sites occurred along the Bill Williams River—almost twice as many as SWFL sites. However, it is unlikely that the difference observed in soil texture was simply a result of this difference in site frequency.

Though 13 YBCU sites along the Bill Williams River had sandy soil, only one of the nine SWFL sites had soil classified as sand. Therefore, this appeared to be a genuine difference in soil texture between SWFL and YBCU sites rather than a difference based on the sample size at one river. It may be that SWFLs select sites with less sandy soil because the soil retains more moisture, thereby creating a preferred microclimate. On the other hand, YBCUs did not appear to select for sandy soil because 21 YBCU sites had soil textures of sandy loam, loam, or silt loam.

5.0 CONCLUSION AND RECOMMENDATIONS

The purpose of this study was to provide data on the range of soil hydrology and microclimate conditions in habitat used for breeding by SWFLs and YBCUs. It is important to note that the scope of this study did not include a comparison of occupied versus unoccupied sites, but was limited to a description of conditions in sites occupied by these two species. Recommendations on which habitat variables may be important are therefore limited by the scope of the study. Furthermore, significant positive or negative correlations found between measured variables indicate various degrees of interdependence. This should be considered since a particular variable or condition may be acting as a proxy for another (interdependent) variable that may be more important in habitat selection by SWFLs and YBCUs. For example, at YBCU sites, depth to ground water was significantly correlated with OM depth ($r = 0.421$, $p<0.01$). This does not mean that depth of OM should be considered a key habitat variable because of this correlation. It is more likely an indicator of another variable, such as vegetation density and health.

Though conditions overlap in some cases, logistic regression clearly distinguished sites used by SWFLs from those used by YBCUs based on soil hydrology and microclimate. This suggested that creation/restoration of habitat for SWFLs should occur under different conditions and in different locations than creation/restoration of habitat for YBCUs. Even when SWFL and YBCU sites were along the same river (i.e., Bill Williams River), they appeared to use generally different habitat based on soil hydrology (e.g., SWFLs used sites along the Bill Williams River with less sandy soils and more standing water). This may reflect differences in vegetation types used for nesting by these species. Where YBCUs show a preference for cottonwoods growing in a range of soil conditions, including sandy overbank areas farther from flow channels, SWFLs nest predominantly in saltcedar thickets near flow channels that lack deeper sand deposits and more frequently have standing water. Some of the key results from this study are noted below:

- SWFL and YBCU correlations identified a negative relationship between percent sand (soil texture) and percent soil moisture
- No correlation was identified in SWFL and YBCU sites between canopy closure (or class) and air temperature or RH (Note: this analysis had a small sample size)
- SWFL correlations identified a positive relationship between distance to flowing water and tree height and between stream discharge and tree height
- The two sample t-tests did not identify a significant difference in RH or canopy closure between SWFL and YBCU sites
- SWFL sites had an average percent soil moisture more than twice as high as YBCU sites
- YBCU sites had sandier sites than SWFL but also utilized less sandy sites
- SWFLs had a higher number of sites with standing water present (29) than YBCUs (4)
- SWFL sites had shallower depths to ground water than YBCU sites
- YBCUs utilized sites much farther from the nearest flowing water (up to 2,100 m) than SWFLs (up to 542 m)
- The logistic regression indicated that depth to ground water was the variable with the highest influence in predicting SWFL versus YBCU sites, followed by soil texture and distance to flowing water

Recommendations on habitat and future study needs are as follows:

- SWFL creation or restoration sites should be located near flowing perennial water, preferably within 200 m and preferably outside the active channel but on a floodplain. Such sites would be more likely to have a shallow depth to ground water, would be more likely to be inundated during high flows, therefore providing a source of standing water, and would be more likely to sustain the vegetation density preferred by SWFLs.
- If YBCU creation/restoration sites are located away from flowing perennial water, planting and maintenance methods (including irrigation) should be undertaken to ensure a mature, healthy stand of native riparian trees for YBCU use.
- Soil texture analysis is recommended when evaluating potential creation/restoration sites. In consideration of other variables, sites with higher moisture content (lower percent sand) would be more suitable for SWFLs. YBCUs are more tolerant than SWFLs of sites with low soil moisture.
- Further study comparing occupied and unoccupied habitat is recommended. This study provides information on soil hydrology and microclimate conditions at sites occupied by SWFLs and YBCUs, but it is not known which soil hydrology, microclimate, or other habitat characteristics are also present in unoccupied habitat. Comparison of occupied and unoccupied habitat is needed to determine which variables are truly important to SWFLs and YBCUs in selection of breeding habitat.

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APPENDIX A
Ground Water Depth and Discharge Graphs

Depth to ground water at wells associated with Southwestern willow flycatcher sites and discharge at the nearest US Geological Survey (USGS) gaging station

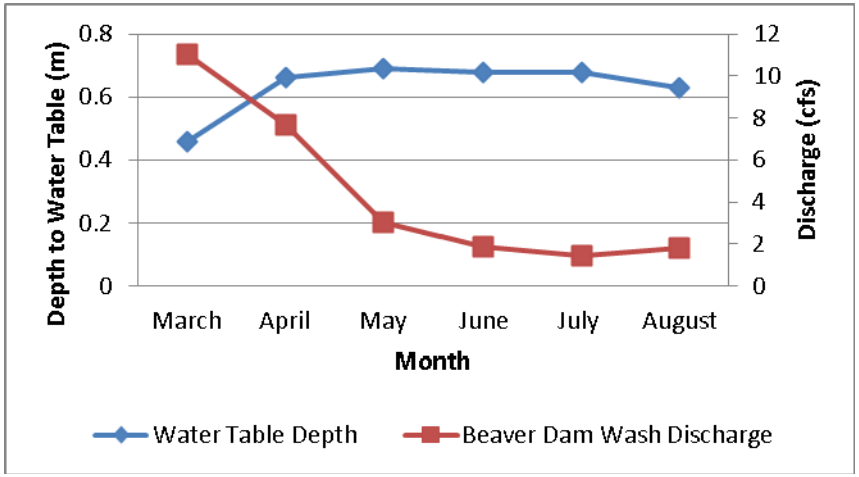


Figure A.1. Depth to ground water at WF02 piezometer and discharge at Beaver Dam USGS station (2010).

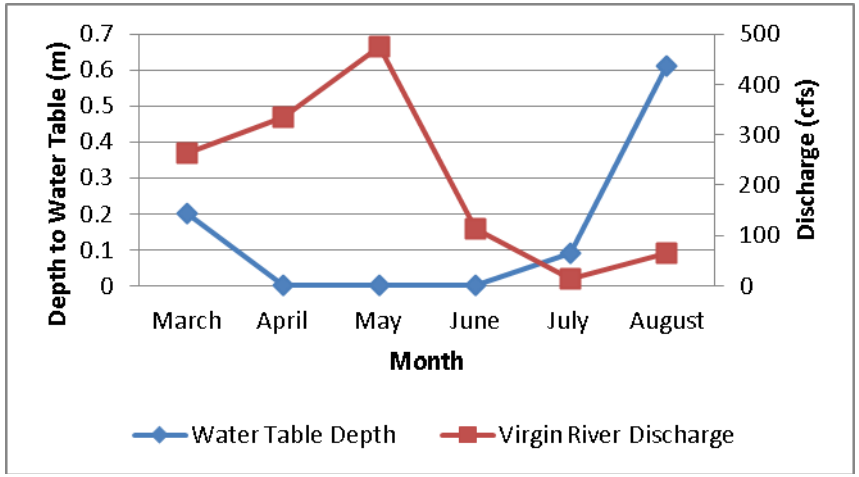


Figure A.2. Depth to ground water at WF04 piezometer and discharge at Virgin River near Overton USGS station (2010).

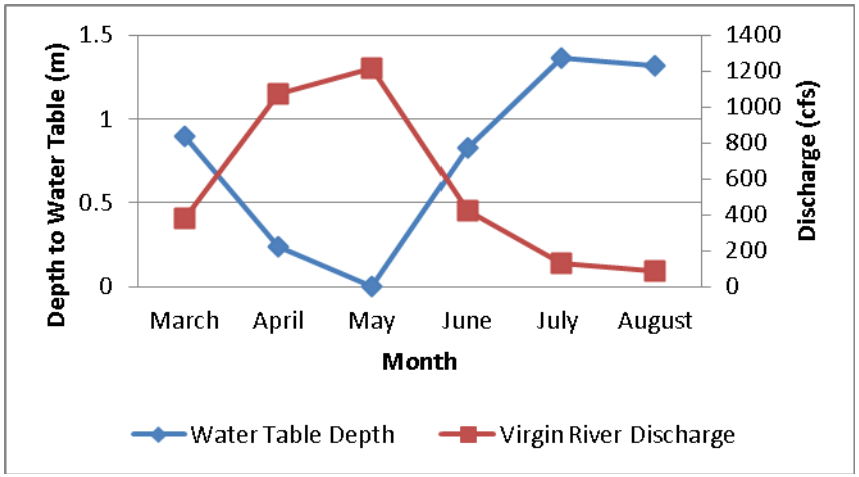


Figure A.3. Depth to ground water at WF22 piezometer and discharge at Virgin River near Littlefield USGS station (2011).

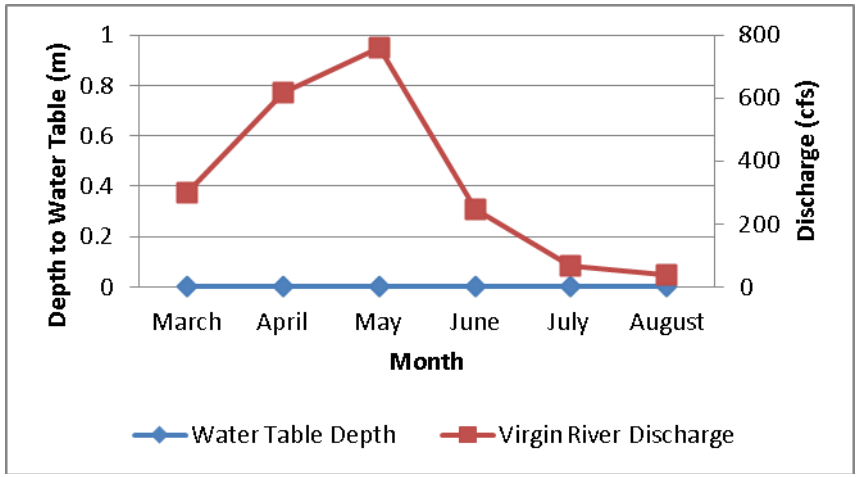


Figure A.4. Depth to ground water at WF04 piezometer and discharge at Virgin River near Overton USGS station (2011).

Depth to ground water at wells associated with Southwestern willow flycatcher sites and discharge at the nearest US Geological Survey (USGS) gaging station

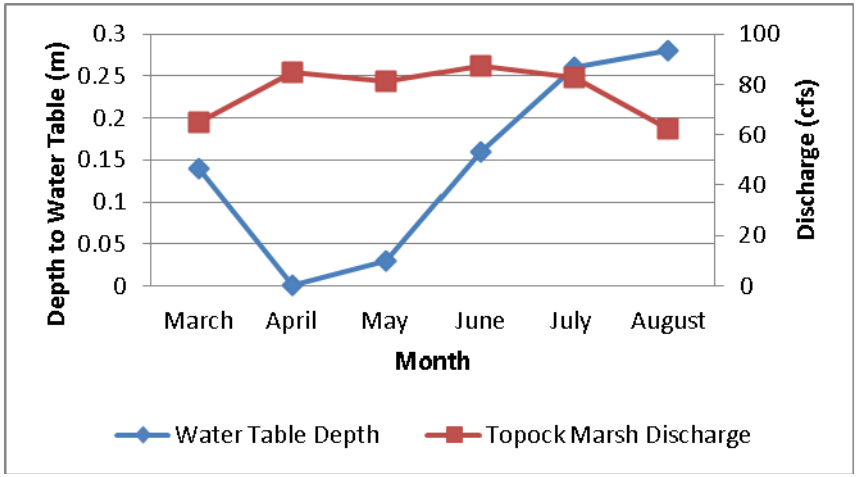


Figure A.5. Depth to ground water at WF08 piezometer and discharge at Topock Marsh Inlet USGS station (2010).

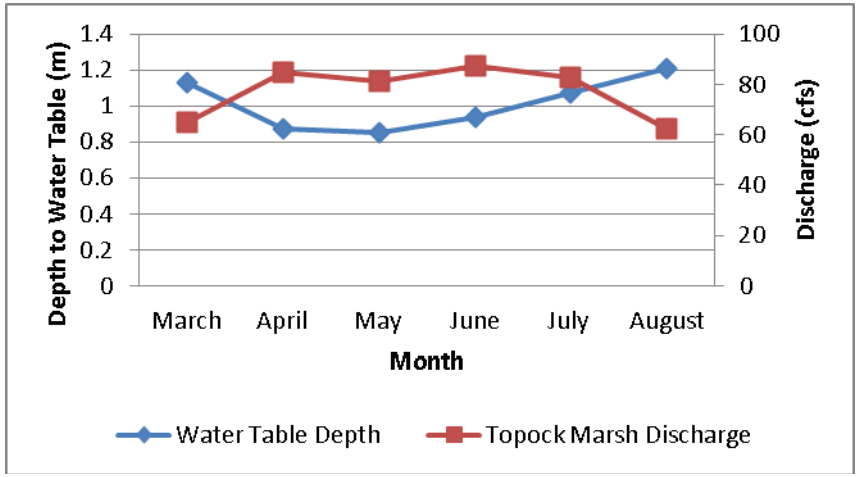


Figure A.6. Depth to ground water at WF12 piezometer and discharge at Topock Marsh Inlet USGS station (2010).

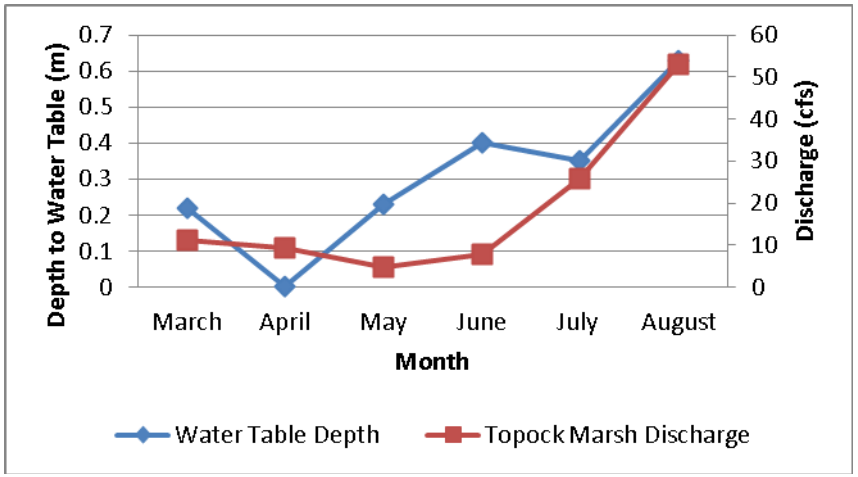


Figure A.7. Depth to ground water at WF08 piezometer and discharge at Topock Marsh Inlet USGS station (2011).

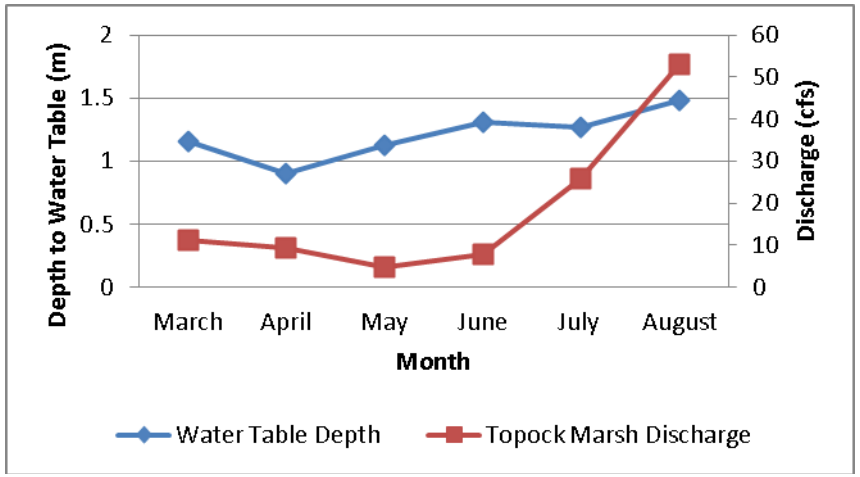


Figure A.8. Depth to ground water at WF12 piezometer and discharge at Topock Marsh Inlet USGS station (2011).

Depth to ground water at wells associated with Southwestern willow flycatcher sites and discharge at the nearest US Geological Survey (USGS) gaging station

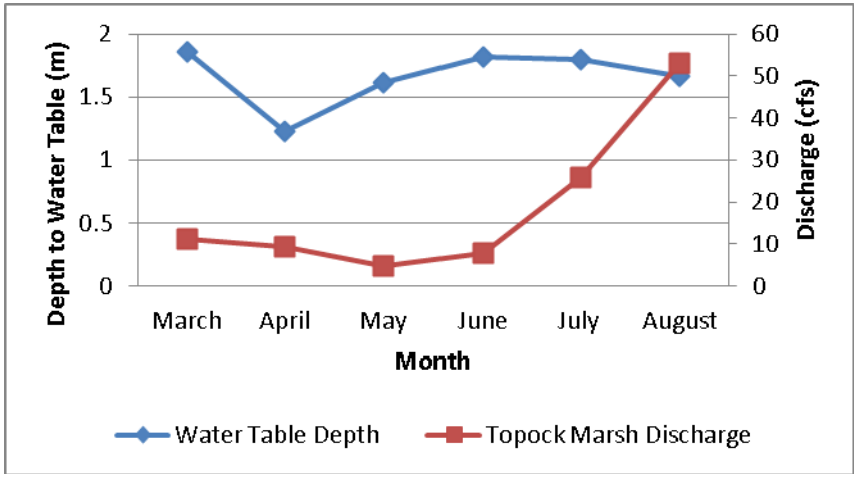


Figure A.9. Depth to ground water at GA PZ2BL (Beal Lake) and discharge at Topock Marsh Inlet USGS station (2011).

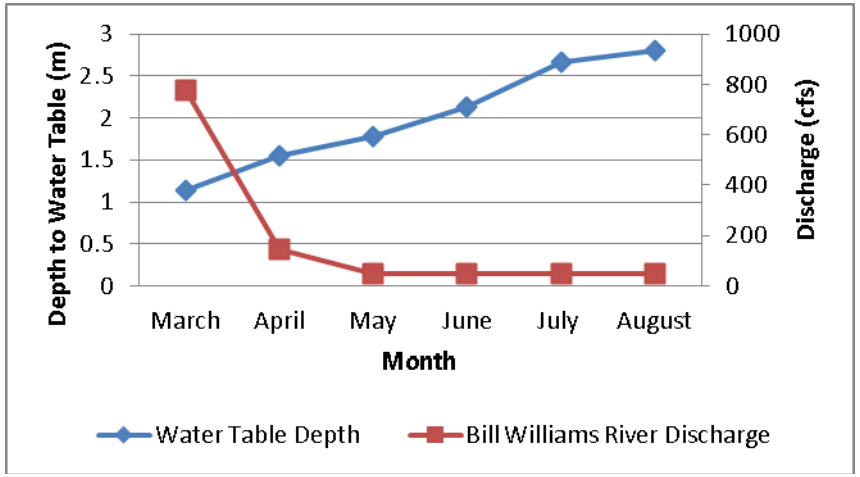


Figure A.10. Depth to ground water at PZ BW250 and discharge at Bill Williams River below Alamo Dam USGS station (2010).

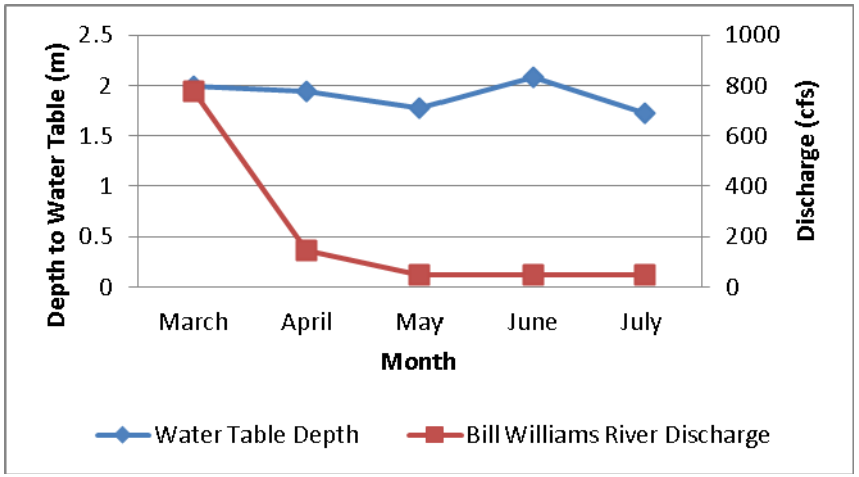


Figure A.11. Depth to ground water at PZ BW225 and discharge at Bill Williams River below Alamo Dam USGS station (2010).

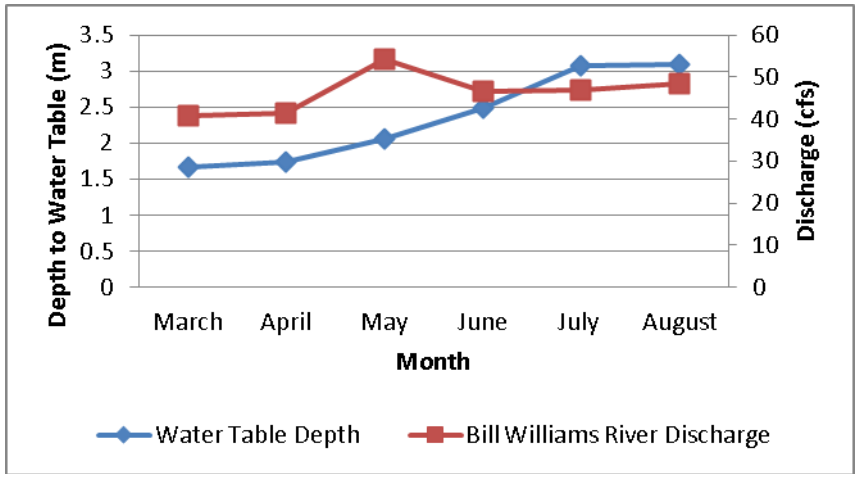


Figure A.12. Depth to ground water at PZ BW250 and discharge at Bill Williams River below Alamo Dam USGS station (2011).

Depth to ground water at wells associated with Southwestern willow flycatcher sites and discharge at the nearest US Geological Survey (USGS) gaging station

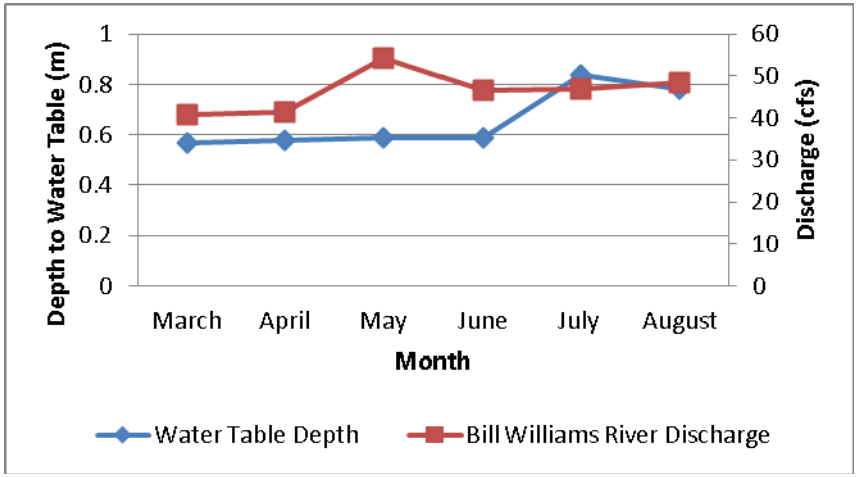


Figure A.13. Depth to ground water at PZ PR3C and discharge at Bill Williams River below Alamo Dam USGS station (2011).

Depth to ground water at wells associated with yellow-billed cuckoo sites and discharge at the nearest US Geological Survey (USGS) gaging station

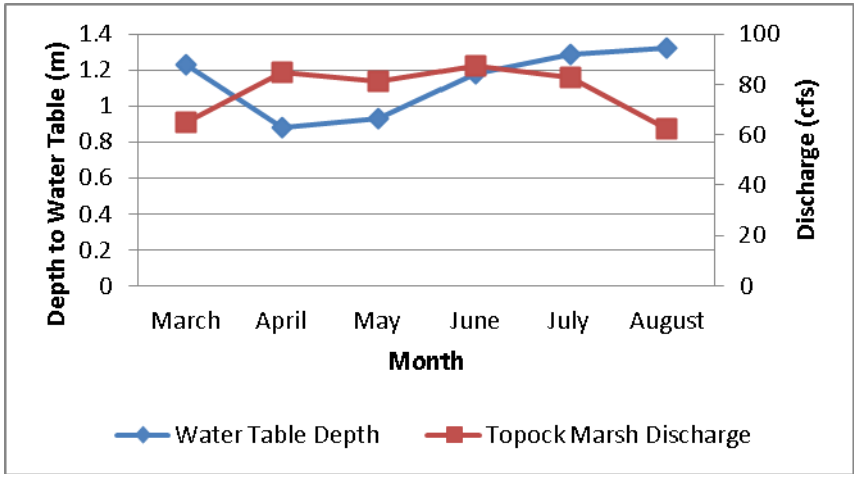


Figure A.14. Depth to ground water at YB01 piezometer and discharge at Topock Marsh Inlet USGS station (2010).

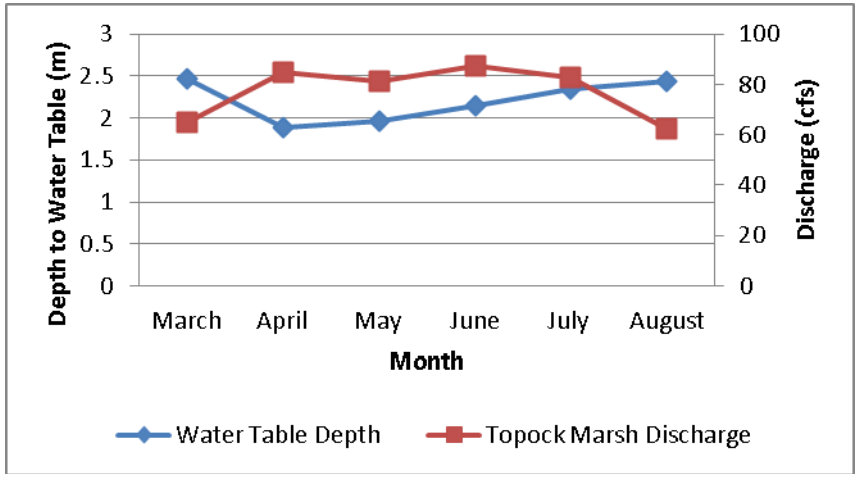


Figure A.15. Depth to ground water at YB02 piezometer and discharge at Topock Marsh Inlet USGS station (2010).

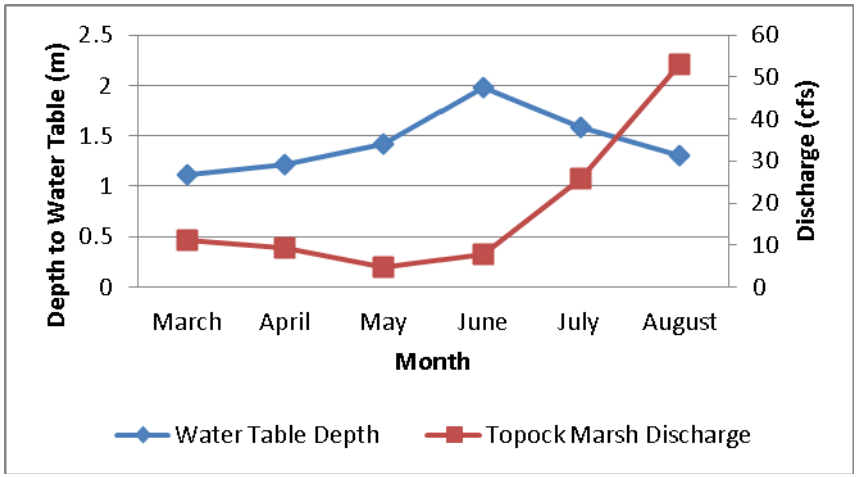


Figure A.16. Depth to ground water at YB01 piezometer and discharge at Topock Marsh Inlet USGS station (2011).

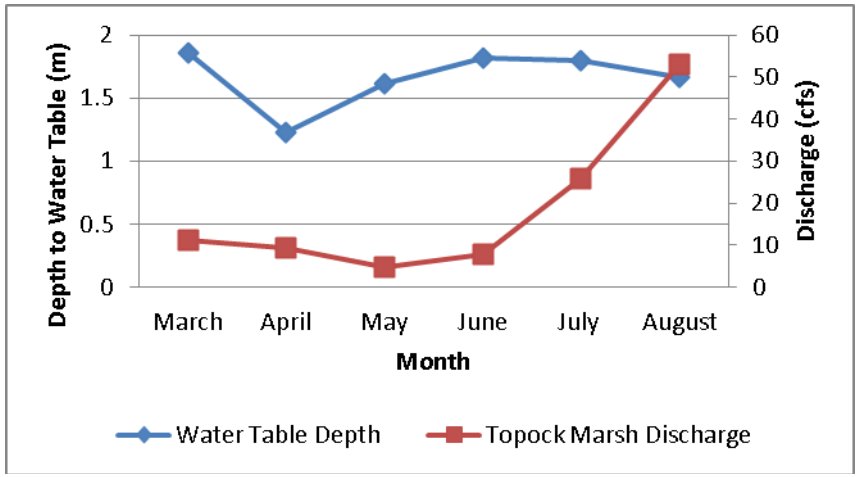


Figure A.17. Depth to ground water at GA PZ2BL and discharge at Topock Marsh Inlet USGS station (2011).

Depth to ground water at wells associated with yellow-billed cuckoo sites and discharge at the nearest US Geological Survey (USGS) gaging station

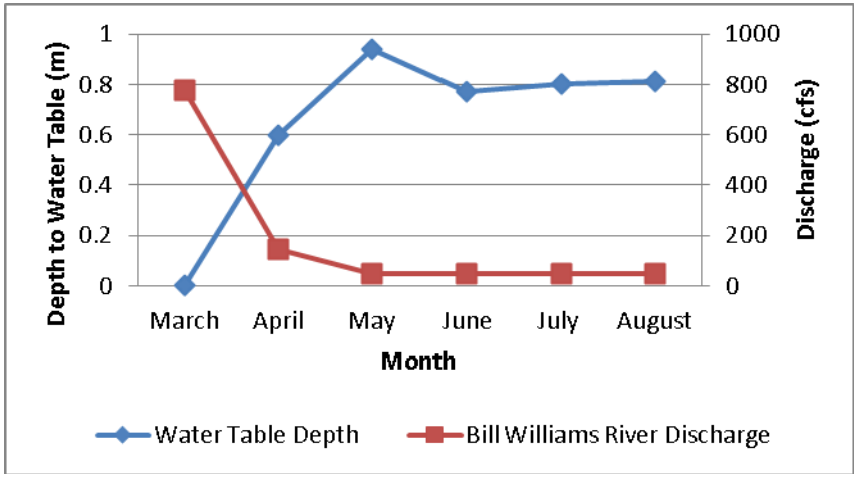


Figure A.18. Depth to ground water at PR3C and discharge at Bill Williams River below Alamo Dam USGS station (2010).

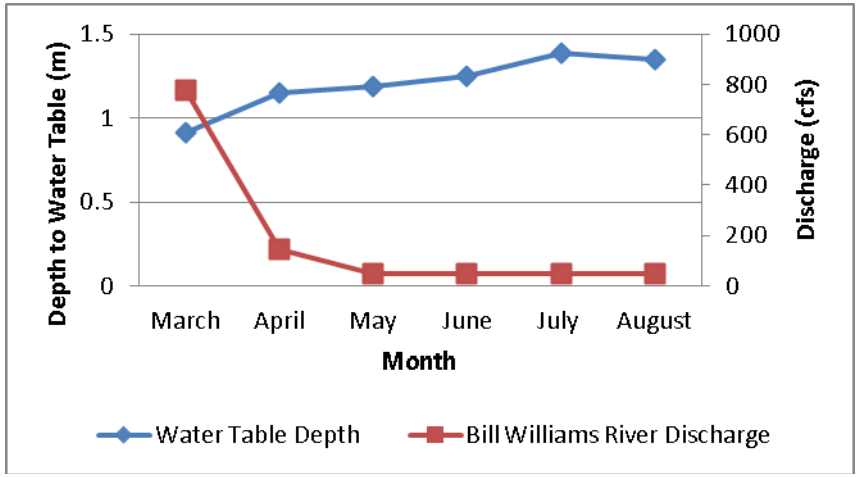


Figure A.19. Depth to ground water at PR3B and discharge at Bill Williams River below Alamo Dam USGS station (2010).

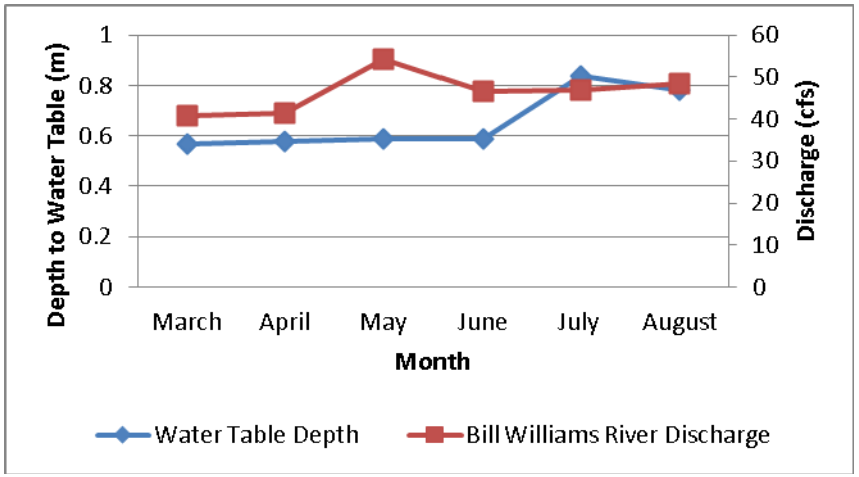


Figure A.20. Depth to ground water at PR3C and discharge at Bill Williams River below Alamo Dam USGS Station (2011).

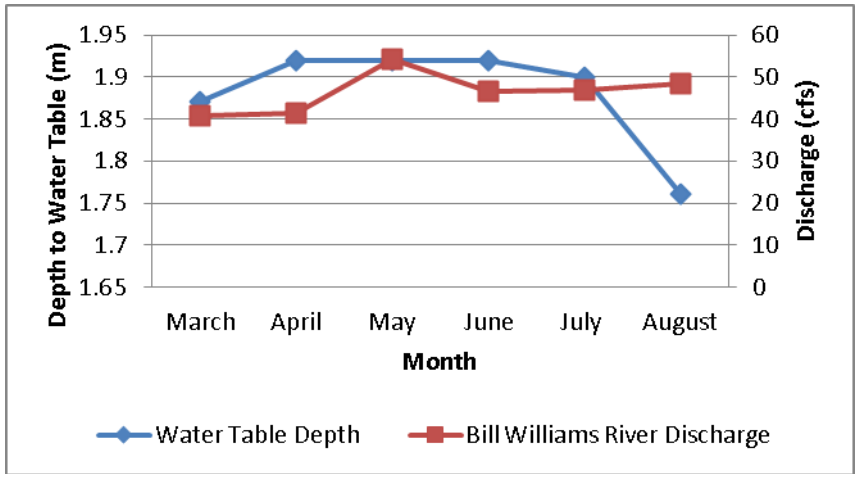


Figure A.21. Depth to ground water at BW225 and discharge at Bill Williams River below Alamo Dam USGS station (2011).

Depth to ground water at wells associated with yellow-billed cuckoo sites and discharge at the nearest US Geological Survey (USGS) gaging station

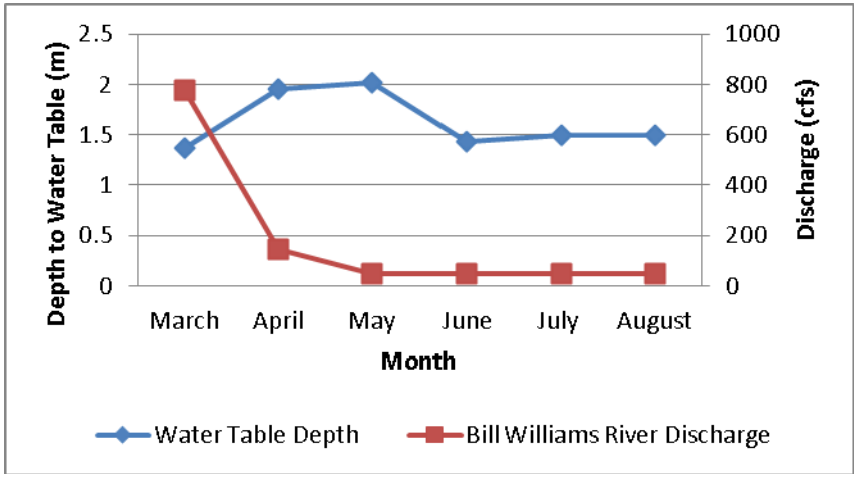


Figure A.22. Depth to ground water at BW230 and discharge at Bill Williams River below Alamo Dam USGS station (2010).

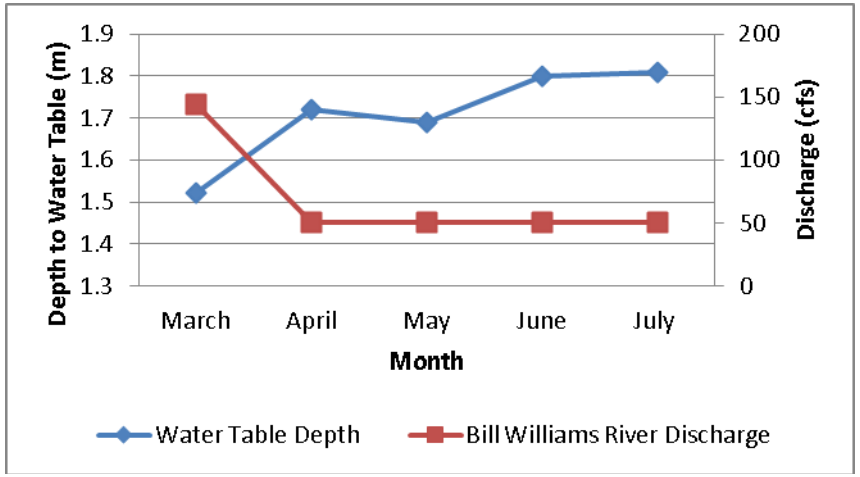


Figure A.23. Depth to ground water at BW240 and discharge at Bill Williams River below Alamo Dam USGS station (2010).

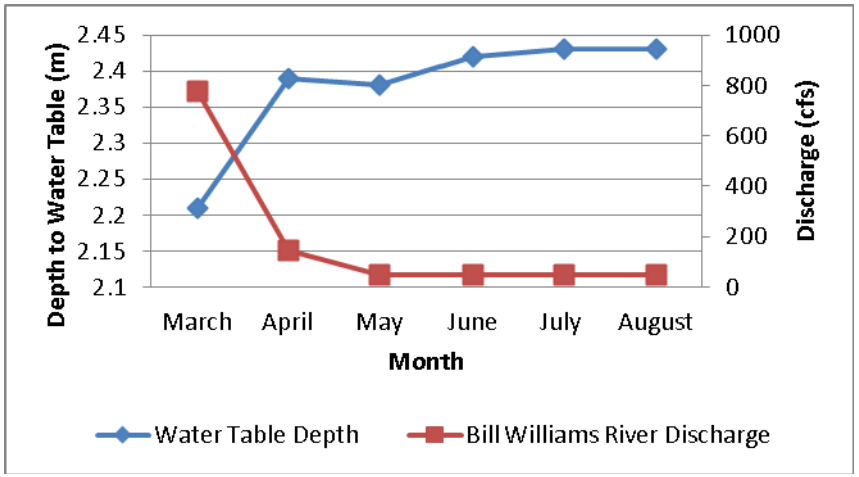


Figure A.24. Depth to ground water at BW233 and discharge at Bill Williams River below Alamo Dam USGS station (2010).

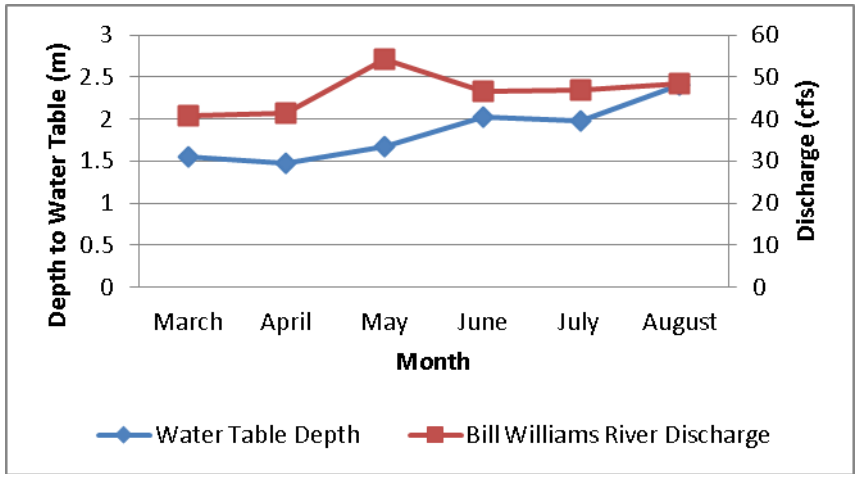


Figure A.25. Depth to ground water at BW240 and discharge at Bill Williams River below Alamo Dam USGS station (2011).

Depth to ground water at wells associated with yellow-billed cuckoo sites and discharge at the nearest US Geological Survey (USGS) gaging station

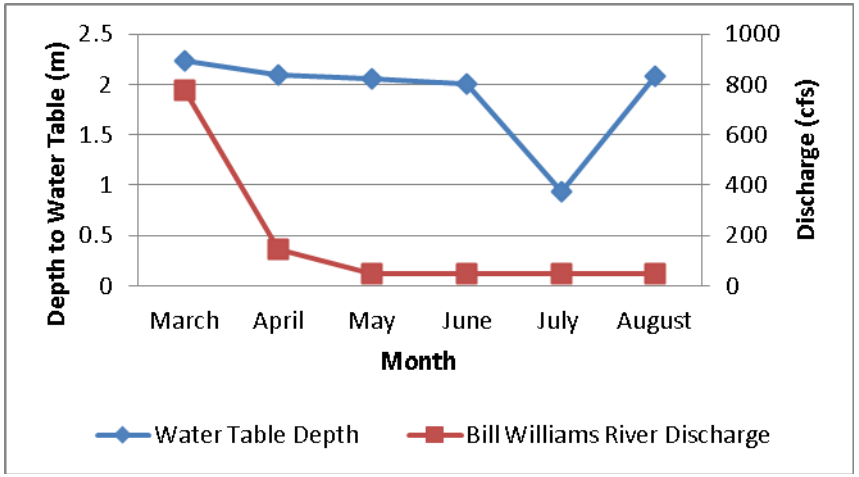


Figure A.26. Depth to ground water at BW248 and discharge at Bill Williams River below Alamo Dam USGS station (2010).

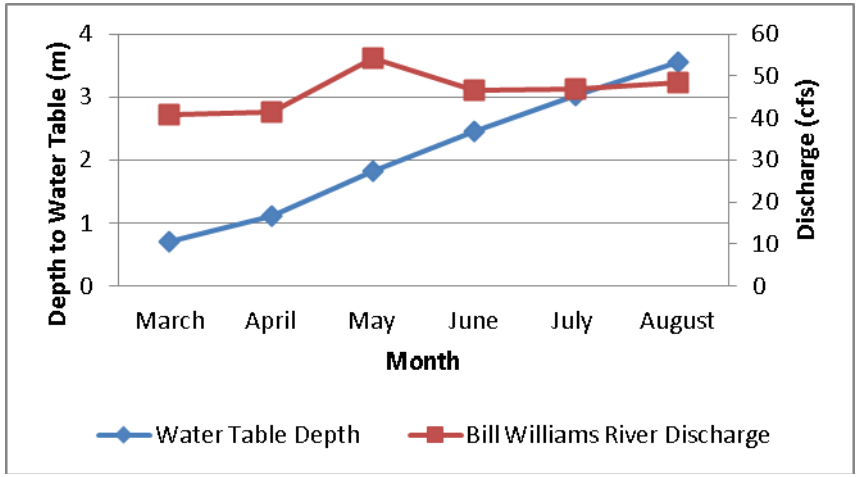


Figure A.27. Depth to ground water at BW249 and discharge at Bill Williams River below Alamo Dam USGS station (2011).

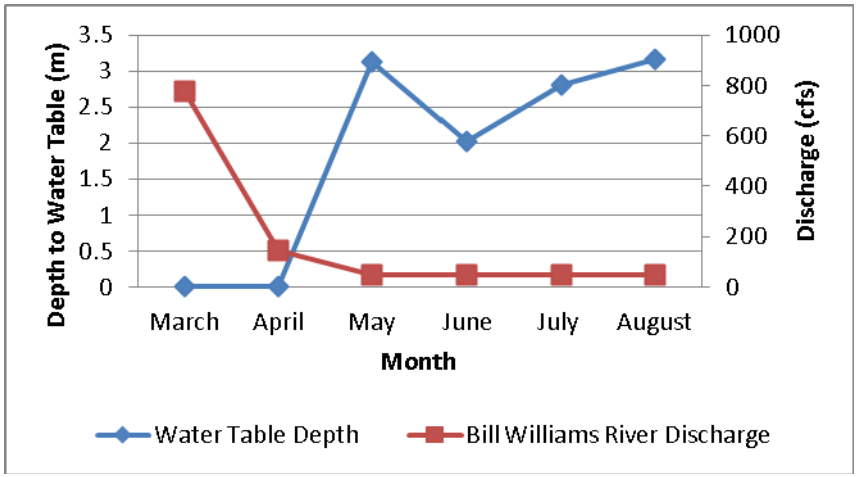


Figure A.28. Depth to ground water at BW249 and discharge at Bill Williams River below Alamo Dam USGS station (2010).

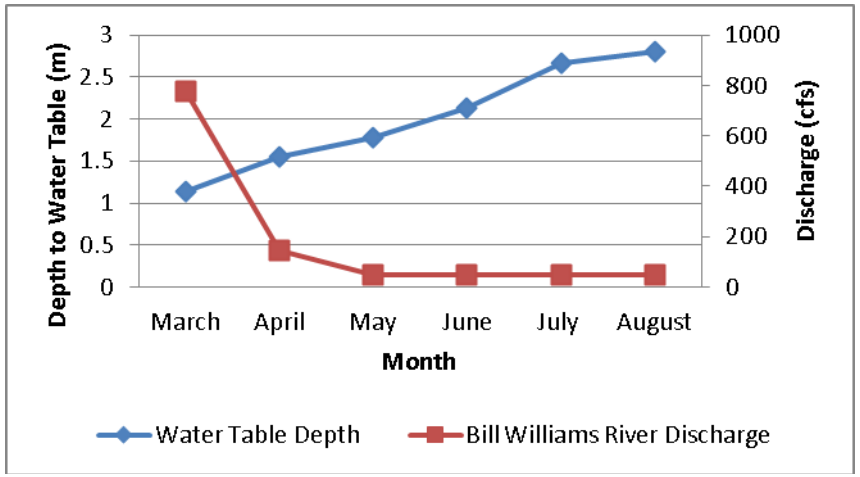


Figure A.29. Depth to ground water at BW250 and discharge at Bill Williams River below Alamo Dam USGS station (2010).

Depth to ground water at wells associated with yellow-billed cuckoo sites and discharge at the nearest US Geological Survey (USGS) gaging station

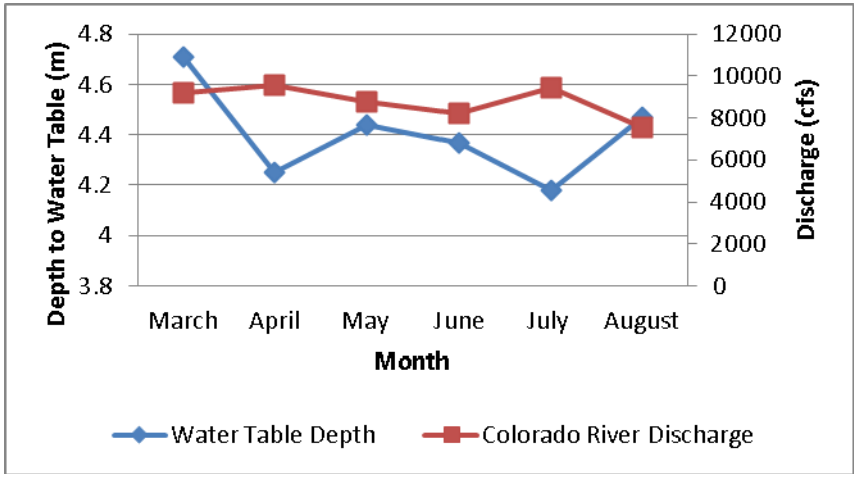


Figure A.30. Depth to ground water at YB16 piezometer and discharge at Colorado River below Palo Verde Dam USGS station (2010).

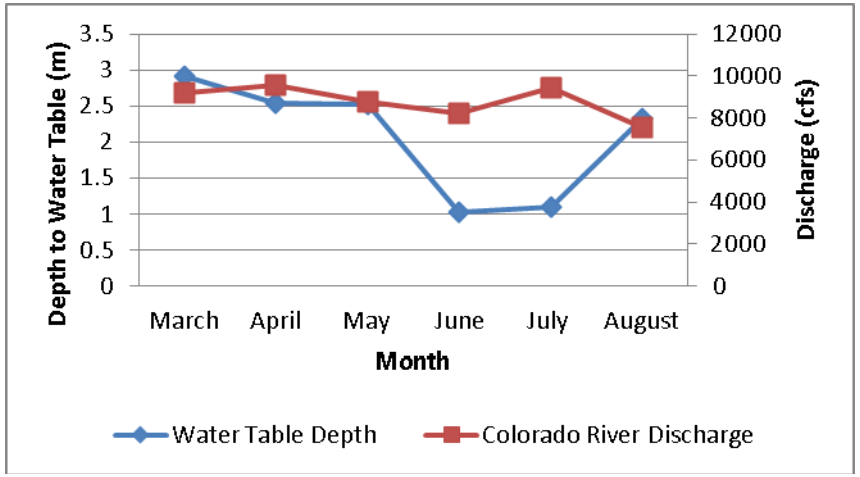


Figure A.31. Depth to ground water at YB19 piezometer and discharge at Colorado River below Palo Verde Dam USGS station (2010).

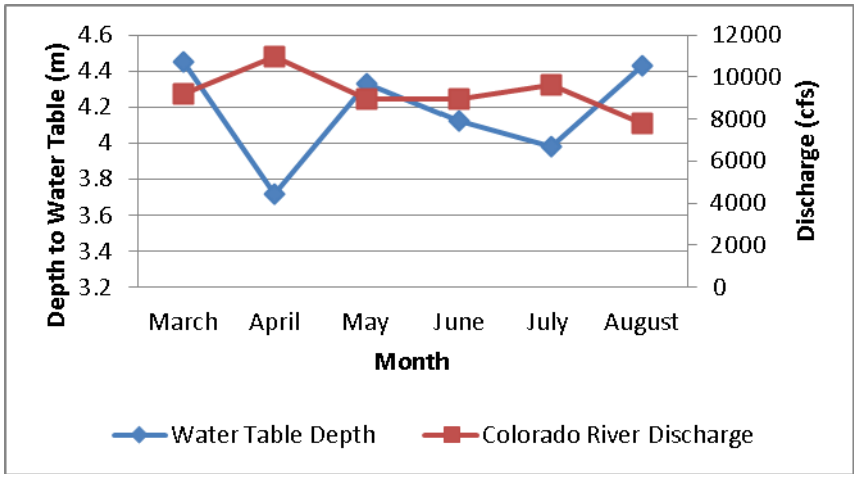


Figure A.32. Depth to ground water at YB16 piezometer and discharge at Colorado River below Palo Verde Dam USGS station (2011).

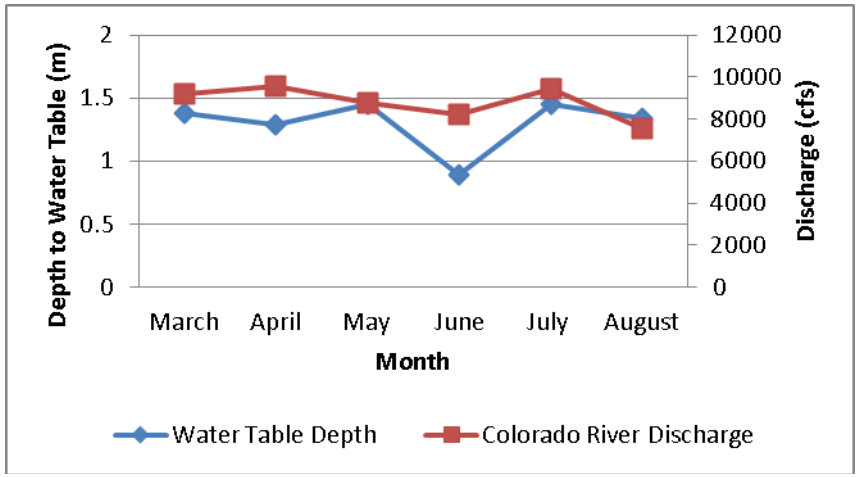


Figure A.33. Depth to ground water at YB21 piezometer and discharge at Colorado River below Palo Verde Dam USGS station (2010).

Depth to ground water at wells associated with yellow-billed cuckoo sites and discharge at the nearest US Geological Survey (USGS) gaging station

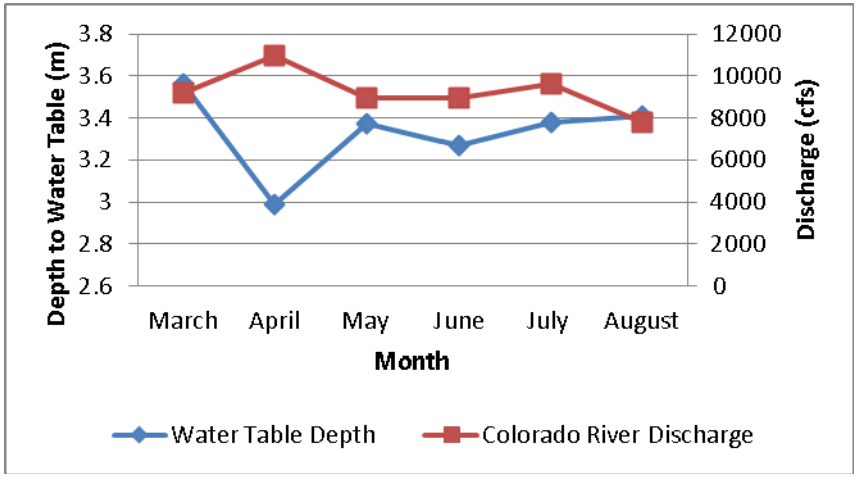


Figure A.34. Depth to ground water at YB36 piezometer and discharge at Colorado River below Palo Verde Dam USGS station (2011).

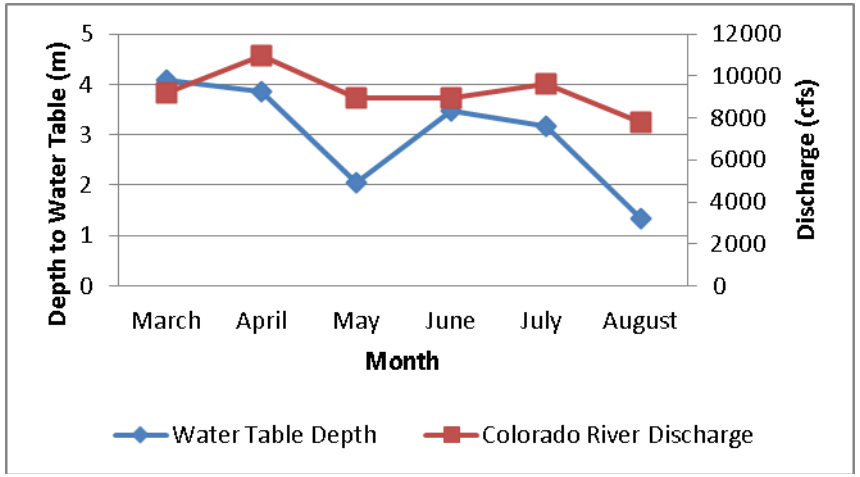


Figure A.35. Depth to ground water at GA PZ4PVER piezometer and discharge at Colorado River below Palo Verde Dam USGS station (2011).

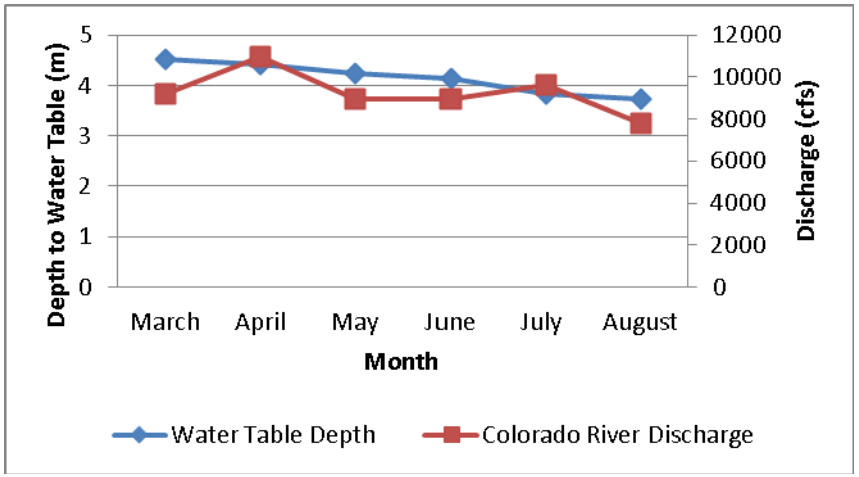


Figure A.36. Depth to ground water at GA PZ6PVER piezometer and discharge at Colorado River below Palo Verde Dam USGS station (2011).

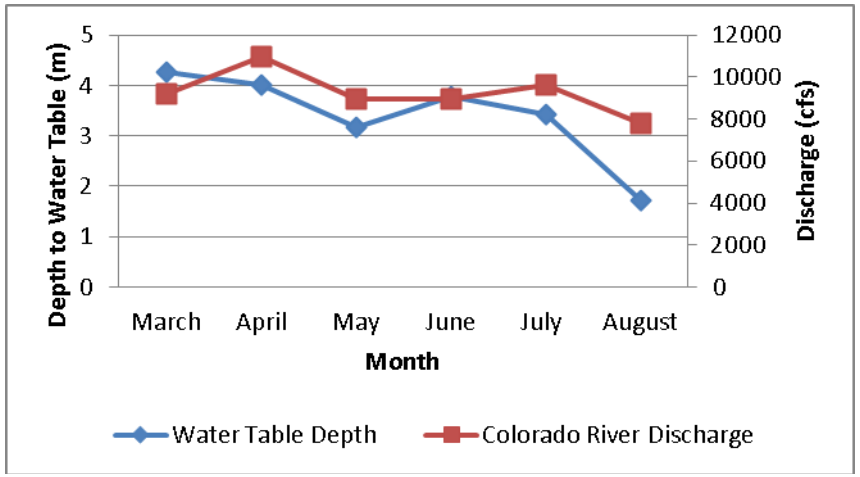


Figure A.37. Depth to ground water at GA PZ2PVER piezometer and discharge at Colorado River below Palo Verde Dam USGS station (2011).

Depth to ground water at wells associated with yellow-billed cuckoo sites and discharge at the nearest US Geological Survey (USGS) gaging station

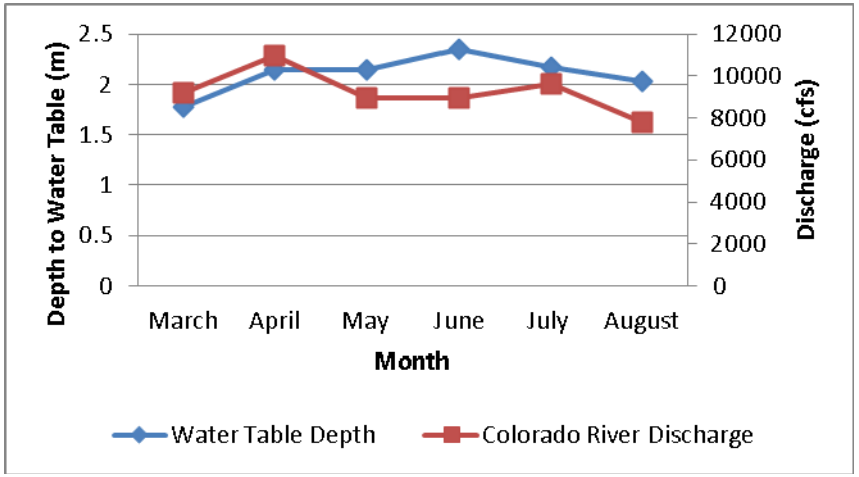


Figure A.38. Depth to ground water at GA PZ9C piezometer and discharge at Colorado River below Palo Verde Dam USGS station (2011).

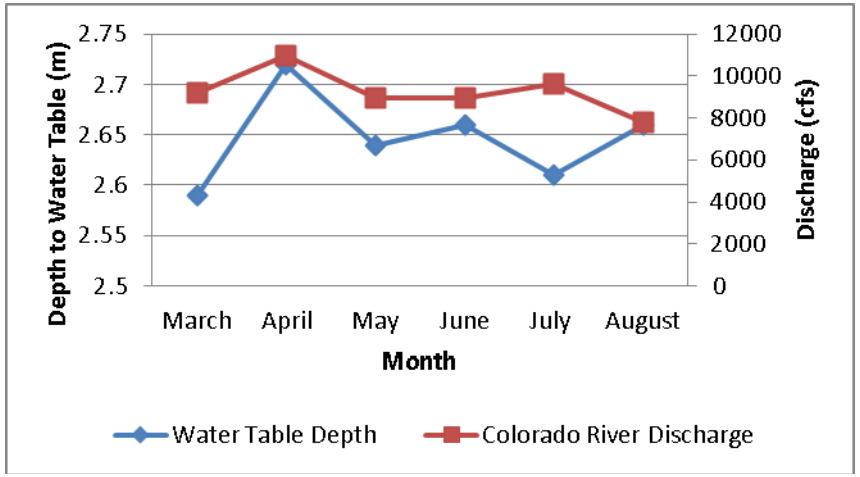


Figure A.39. Depth to ground water at GA PZ3C piezometer and discharge at Colorado River below Palo Verde Dam USGS station (2011).

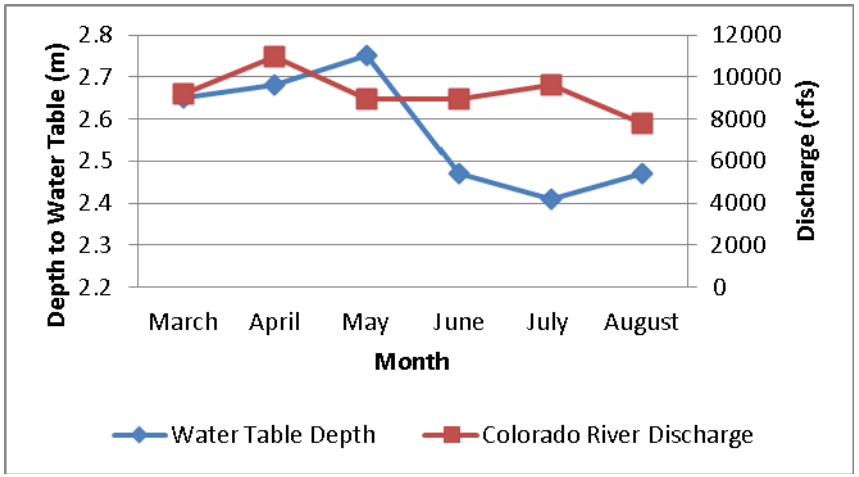


Figure A.40. Depth to ground water at GA PZ6C piezometer and discharge at Colorado River below Palo Verde Dam USGS station (2011).

APPENDIX B
Correlation Analysis Results

Table B.1. Southwestern willow flycatcher (SWFL) correlations: Full dataset SWFL soil hydrology variables.

	Percent Soil Moisture	Average Organic Matter Depth (centimeters)	Average Relative Humidity	Average Temperature (degrees Celsius)	Total Area of Standing Water	Average Percent Sand	Discharge (cubic feet per second)	Depth to Ground Water
Average Organic Matter Depth (centimeters)								
Pearson correlation	-0.260							
P-value	0.000							
Average Relative Humidity								
Pearson correlation	-0.216	0.009						
P-value	0.004	0.906						
Average Temperature (degrees Celsius)								
Pearson correlation	0.040	0.078	-0.057					
P-value	0.595	0.301	0.450					
Total Area of Standing Water								
Pearson correlation	0.088	-0.257	-0.265	-0.239				
P-value	0.245	0.001	0.000	0.001				
Average Percent Sand								
Pearson correlation	-0.630	0.442	0.053	-0.141	-0.064			
P-value	0.000	0.000	0.487	0.062	0.394			
Discharge (cubic feet per second)								
Pearson correlation	0.202	-0.217	-0.312	-0.066	0.316	-0.287		
P-value	0.007	0.004	0.000	0.385	0.000	0.000		
Depth to Ground Water								
Pearson correlation	-0.233	-0.033	0.331	0.205	-0.206	-0.076	-0.289	
P-value	0.002	0.659	0.000	0.006	0.006	0.314	0.000	
Distance to Flowing Water								
Pearson correlation	0.197	-0.179	0.049	0.212	-0.105	-0.384	-0.024	0.433
P-value	0.009	0.017	0.518	0.005	0.166	0.000	0.753	0.000

Table B.2. SWFL HOBO® data correlations: SWFL soil hydrology variables and HOBO® data.

	Surficial Moisture
Average Percent Soil Moisture	
Pearson correlation	0.887
P-value	0.000
Average Organic Matter Depth (centimeters)	
Pearson correlation	-0.598
P-value	0.011
Average Relative Humidity	
Pearson correlation	0.072
P-value	0.782
Average Temperature (degrees Celsius)	
Pearson correlation	-0.284
P-value	0.269
Total Area of Standing Water	
Pearson correlation	0.515
P-value	0.035
Average Percent Sand	
Pearson correlation	-0.606
P-value	0.010
Discharge (cubic feet per second)	
Pearson correlation	0.482
P-value	0.050
Depth to Ground Water	
Pearson correlation	-0.513
P-value	0.035
Distance to Flowing Water	
Pearson correlation	0.407
P-value	0.105

Table B.3. SWFL bird presence correlations: SWFL soil hydrology variables at the subset of sites with SWFL present in the same year.

	Average Soil Moisture	Average Organic Matter Depth (centimeters)	Average Relative Humidity	Average Temperature (degrees Celsius)	Total Area of Standing Water	Average Percent Sand	Discharge (cubic feet per second)	Depth to Ground Water
Average Organic Matter Depth (centimeters)								
Pearson correlation	-0.202							
P-value	0.068							
Average Relative Humidity								
Pearson correlation	-0.361	0.254						
P-value	0.001	0.021						
Average Temperature (degrees Celsius)								
Pearson correlation	-0.033	-0.047	-0.004					
P-value	0.770	0.673	0.971					
Total Area of Standing Water								
Pearson correlation	-0.100	-0.293	-0.330	-0.260				
P-value	0.368	0.007	0.002	0.018				
Average Percent Sand								
Pearson correlation	-0.466	0.502	0.316	-0.222	0.066			
P-value	0.000	0.000	0.004	0.043	0.555			
Discharge (cubic feet per second)								
Pearson correlation	0.264	-0.204	-0.410	0.000	0.351	-0.265		
P-value	0.016	0.065	0.000	0.997	0.001	0.015		
Depth to Ground Water								
Pearson correlation	-0.237	-0.248	0.232	0.279	-0.174	-0.281	-0.303	
P-value	0.031	0.024	0.034	0.011	0.115	0.010	0.005	
Distance to Flowing Water								
Pearson correlation	0.372	-0.337	-0.062	0.277	-0.177	-0.688	-0.044	0.552
P-value	0.001	0.002	0.578	0.011	0.108	0.000	0.696	0.000

Table B.4. SWFL vegetation data correlations: SWFL soil hydrology variables and vegetation variables at the subset of sites with both measured in the same year.

	Average Soil Moisture	Average Relative Humidity	Average Temperature (degrees Celsius)	Total Area of Standing Water	Canopy Closure	Tree Height	Ground Cover
Canopy Closure							
Pearson correlation	-0.087	-0.124	0.186	0.217			
P-value	0.531	0.372	0.179	0.115			
Tree Height							
Pearson correlation	-0.231	-0.125	-0.259	-0.100	-0.006		
P-value	0.093	0.368	0.059	0.471	0.966		
Ground Cover							
Pearson correlation	-0.303	-0.161	-0.323	-0.087	-0.014	0.656	
P-value	0.026	0.244	0.017	0.531	0.918	0.000	
Average Percent Sand							
Pearson correlation					0.215	0.267	0.479
P-value					0.118	0.051	0.000
Discharge (cubic feet per second)							
Pearson correlation					-0.055	-0.275	-0.432
P-value					0.694	0.044	0.001
Depth to Ground Water							
Pearson correlation					-0.118	-0.231	-0.478
P-value					0.396	0.093	0.000
Distance to Flowing Water							
Pearson correlation					0.099	-0.342	-0.584
P-value					0.474	0.011	0.000

Table B.5. Yellow-billed cuckoo (YBCU) correlations: Full dataset YBCU soil hydrology variables.

	Average Percent Soil Moisture	Average Relative Humidity	Average Temperature (degrees Celsius)	Average Organic Matter Depth (centimeters)	Total Area of Standing Water	Depth to Ground Water	Distance to Flowing Water	Average Percent Sand
Average Relative Humidity								
Pearson correlation	0.051							
P-value	0.485							
Average Temperature (degrees Celsius)								
Pearson correlation	-0.117	-0.372						
P-value	0.109	0.000						
Average Organic Matter Depth (centimeters)								
Pearson correlation	0.006	-0.178	0.023					
P-value	0.940	0.015	0.754					
Total Area of Standing Water								
Pearson correlation	0.340	-0.020	-0.059	-0.137				
P-value	0.000	0.785	0.419	0.060				
Depth to Ground Water								
Pearson correlation	-0.012	0.066	0.027	0.421	-0.232			
P-value	0.875	0.368	0.710	0.000	0.001			
Distance to Flowing Water								
Pearson correlation	0.179	-0.085	0.036	0.154	-0.273	0.092		
P-value	0.014	0.246	0.626	0.035	0.000	0.210		
Average Percent Sand								
Pearson correlation	-0.610	0.031	-0.009	-0.235	-0.042	-0.490	-0.495	
P-value	0.000	0.675	0.904	0.001	0.565	0.000	0.000	
Discharge (cubic feet per second)								
Pearson correlation	0.184	-0.020	-0.063	0.397	-0.350	0.702	0.520	-0.646
P-value	0.011	0.788	0.392	0.000	0.000	0.000	0.000	0.000

Table B.6. YBCU HOBO® data correlations: YBCU soil hydrology variables and HOBO® data.

	Surficial Moisture
Average Percent Soil Moisture	
Pearson correlation	-0.095
P-value	0.717
Average Relative Humidity	
Pearson correlation	0.621
P-value	0.008
Average Temperature (degrees Celsius)	
Pearson correlation	0.138
P-value	0.599
Average Organic Matter Depth (centimeters)	
Pearson correlation	0.070
P-value	0.791
Total Area of Standing Water	
Pearson correlation	-0.511
P-value	0.036
Depth to Ground Water	
Pearson correlation	0.297
P-value	0.247
Distance to Flowing Water	
Pearson correlation	0.111
P-value	0.673
Average Percent Sand	
Pearson correlation	-0.168
P-value	0.519
Discharge (cubic feet per second)	
Pearson correlation	0.183
P-value	0.481

Table B.7. 2010 YBCU vegetation data correlations: YBCU soil hydrology variables and canopy closure data at the subset of sites with both measured in the same year.

	Average Percent Soil Moisture	Average Relative Humidity	Average Temperature (degrees Celsius)	Total Area of Standing Water	Canopy Closure	Depth to Ground Water	Distance to Flowing Water	Average Percent Sand
Average Relative Humidity								
Pearson correlation	0.072							
P-value	0.552							
Average Temperature (degrees Celsius)								
Pearson correlation	-0.102	-0.450						
P-value	0.400	0.000						
Total Area of Standing Water								
Pearson correlation	0.303	0.003	-0.136					
P-value	0.011	0.982	0.262					
Canopy Closure								
Pearson correlation	-0.062	0.217	-0.165	-0.199				
P-value	0.610	0.071	0.171	0.099				
Depth to Ground Water								
Pearson correlation	-0.038	-0.061	0.266	-0.019	0.266			
P-value	0.753	0.618	0.026	0.878	0.026			
Distance to Flowing Water								
Pearson correlation	0.312	-0.167	0.244	-0.106	-0.041	0.113		
P-value	0.009	0.166	0.042	0.385	0.734	0.351		
Average Percent Sand								
Pearson correlation	-0.700	0.094	-0.138	-0.164	-0.036	-0.380	-0.550	
P-value	0.000	0.440	0.256	0.176	0.768	0.001	0.000	
Discharge (cubic feet per second)								
Pearson correlation	0.274	-0.141	0.151	-0.156	0.332	0.460	0.534	-0.588
P-value	0.022	0.244	0.213	0.196	0.005	0.000	0.000	0.000

Table B.8. 2011 YBCU vegetation data correlations: YBCU soil hydrology variables and canopy closure data at the subset of sites with both measured in the same year.

	Average Percent Soil Moisture	Average Relative Humidity	Average Temperature (degrees Celsius)	Total Area of Standing Water	Canopy Class	Depth to Ground Water	Distance to Flowing Water	Average Percent Sand
Average Relative Humidity								
Pearson correlation	-0.061							
P-value	0.663							
Average Temperature (degrees Celsius)								
Pearson correlation	-0.059	-0.406						
P-value	0.672	0.003						
Total Area of Standing Water								
Pearson correlation	0.450	-0.133	0.043					
P-value	0.001	0.344	0.760					
Canopy Class								
Pearson correlation	0.198	0.144	-0.237	0.059				
P-value	0.155	0.305	0.088	0.675				
Depth to Ground Water								
Pearson correlation	-0.500	0.144	0.032	-0.773	-0.163			
P-value	0.000	0.303	0.820	0.000	0.243			
Distance to Flowing Water								
Pearson correlation	-0.203	0.089	-0.115	-0.629	0.134	0.151		
P-value	0.146	0.525	0.412	0.000	0.339	0.280		
Average Percent Sand								
Pearson correlation	-0.232	0.026	-0.147	0.157	0.353	-0.201	-0.048	
P-value	0.094	0.853	0.292	0.261	0.009	0.148	0.731	
Discharge (cubic feet per second)								
Pearson correlation	-0.468	0.024	-0.054	-0.928	-0.046	0.771	0.645	-0.142
P-value	0.000	0.863	0.700	0.000	0.745	0.000	0.000	0.311

APPENDIX C
Potential Evapotranspiration Results

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
YB02	7/1/2010	41.50	8.96	
	7/2/2010	33.00	6.34	
	7/3/2010	30.40	5.58	
	7/4/2010	30.20	5.48	
	7/5/2010	30.67	5.59	
	7/6/2010	30.97	5.66	
	7/7/2010	30.96	5.63	
	7/8/2010	32.23	5.95	
	7/9/2010	32.94	6.14	
	7/10/2010	34.77	6.65	
	7/11/2010	36.02	6.97	
	7/12/2010	36.07	6.95	
	7/13/2010	36.23	6.96	
	7/14/2010	35.40	6.70	
	7/15/2010	37.97	7.43	
	7/16/2010	38.43	7.55	
	7/17/2010	37.83	7.33	
	7/18/2010	37.79	7.28	
	7/19/2010	37.98	7.30	
	7/20/2010	38.02	7.27	
	7/21/2010	36.81	6.88	
	7/22/2010	35.80	6.54	
	7/23/2010	35.80	6.51	
	7/24/2010	35.09	6.25	
	7/25/2010	37.14	6.82	
	7/26/2010	36.94	6.73	
	7/27/2010	35.09	6.14	
	7/28/2010	34.96	6.07	
	7/29/2010	35.82	6.29	
	7/30/2010	36.67	6.49	
	7/31/2010	34.09	5.70	6.59
	8/1/2010	33.20	2.87	
	8/2/2010	32.30	2.67	
	8/3/2010	33.86	2.96	
	8/4/2010	34.29	3.01	
	8/5/2010	34.75	3.08	
	8/6/2010	34.42	3.00	
	8/7/2010	33.95	2.88	
	8/8/2010	30.89	2.27	
	8/9/2010	28.40	1.79	
	8/10/2010	31.13	2.26	
	8/11/2010	31.40	2.29	
	8/12/2010	29.51	1.92	
	8/13/2010	30.07	1.99	
	8/14/2010	31.50	2.24	
	8/15/2010	33.13	2.53	
	8/16/2010	37.11	3.31	
	8/17/2010	35.59	2.98	
	8/18/2010	34.28	2.68	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	8/19/2010	34.90	2.80	
	8/20/2010	34.98	2.79	
	8/21/2010	35.15	2.80	
	8/22/2010	35.13	2.78	
	8/23/2010	35.27	2.78	
	8/24/2010	37.13	3.15	
	8/25/2010	36.77	3.07	
	8/26/2010	34.46	2.58	
	8/27/2010	33.55	2.38	
	8/28/2010	32.22	2.11	
	8/29/2010	27.99	1.34	
	8/30/2010	25.97	1.00	
	8/31/2010	25.63	0.93	2.49
YB03	7/3/2010	33.62	1.74	
	7/4/2010	30.13	0.90	
	7/5/2010	29.43	0.73	
	7/6/2010	31.37	1.16	
	7/7/2010	29.62	0.75	
	7/8/2010	31.26	1.12	
	7/9/2010	33.63	1.68	
	7/10/2010	34.54	1.90	
	7/11/2010	36.24	2.33	
	7/12/2010	35.78	2.20	
	7/13/2010	36.35	2.36	
	7/14/2010	36.16	2.30	
	7/15/2010	36.47	2.38	
	7/16/2010	36.22	2.31	
	7/17/2010	36.83	2.46	
	7/18/2010	37.12	2.55	
	7/19/2010	37.04	2.53	
	7/20/2010	36.58	2.40	
	7/21/2010	35.11	2.02	
	7/22/2010	35.19	2.05	
	7/23/2010	33.14	1.54	
	7/24/2010	31.75	1.21	
	7/25/2010	34.98	2.02	
	7/26/2010	34.88	2.00	
	7/27/2010	32.38	1.39	
	7/28/2010	33.39	1.65	
	7/29/2010	32.68	1.49	
	7/30/2010	33.49	1.71	
	7/31/2010	31.35	1.21	1.80
	8/1/2010	29.19	0.42	
	8/2/2010	30.30	0.23	
	8/3/2010	32.62	0.17	
	8/4/2010	32.71	0.20	
	8/5/2010	33.06	0.28	
	8/6/2010	32.64	0.22	
	8/7/2010	33.12	0.32	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	8/8/2010	31.70	0.10	
	8/9/2010	28.35	0.41	
	8/10/2010	30.16	0.10	
	8/11/2010	30.65	0.00	
	8/12/2010	28.71	0.28	
	8/13/2010	27.99	0.37	
	8/14/2010	29.30	0.14	
	8/15/2010	32.33	0.39	
	8/16/2010	36.16	1.11	
	8/17/2010	30.32	0.12	
	8/18/2010	31.22	0.30	
	8/19/2010	34.01	0.82	
	8/20/2010	33.00	0.68	
	8/21/2010	35.55	1.18	
	8/22/2010	32.55	0.67	
	8/23/2010	34.10	0.99	
	8/24/2010	34.56	1.11	
	8/25/2010	35.65	1.36	
	8/26/2010	33.91	1.08	
	8/27/2010	31.77	0.75	
	8/28/2010	32.27	0.88	
	8/29/2010	28.51	0.30	
	8/30/2010	25.84	0.07	
	8/31/2010	25.34	0.09	0.49
YB04	7/3/2010	34.26	1.90	
	7/4/2010	28.74	0.59	
	7/5/2010	27.89	0.40	
	7/6/2010	30.02	0.85	
	7/7/2010	28.18	0.44	
	7/8/2010	29.42	0.70	
	7/9/2010	32.34	1.37	
	7/10/2010	33.04	1.53	
	7/11/2010	35.33	2.09	
	7/12/2010	34.39	1.85	
	7/13/2010	34.91	1.98	
	7/14/2010	34.53	1.88	
	7/15/2010	35.47	2.12	
	7/16/2010	34.74	1.93	
	7/17/2010	35.25	2.05	
	7/18/2010	35.98	2.25	
	7/19/2010	35.63	2.15	
	7/20/2010	35.35	2.09	
	7/21/2010	34.01	1.75	
	7/22/2010	34.45	1.86	
	7/23/2010	32.12	1.29	
	7/24/2010	30.13	0.84	
	7/25/2010	33.33	1.60	
	7/26/2010	33.34	1.61	
	7/27/2010	30.99	1.06	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/28/2010	31.24	1.13	
	7/29/2010	31.51	1.21	
	7/30/2010	31.81	1.30	
	7/31/2010	30.46	1.00	1.48
	8/1/2010	28.68	0.50	
	8/2/2010	28.59	0.50	
	8/3/2010	30.65	0.16	
	8/4/2010	31.00	0.09	
	8/5/2010	32.01	0.10	
	8/6/2010	30.92	0.07	
	8/7/2010	32.02	0.14	
	8/8/2010	30.12	0.15	
	8/9/2010	27.28	0.56	
	8/10/2010	28.69	0.33	
	8/11/2010	28.79	0.30	
	8/12/2010	27.43	0.48	
	8/13/2010	26.20	0.62	
	8/14/2010	27.66	0.39	
	8/15/2010	30.39	0.06	
	8/16/2010	34.87	0.88	
	8/17/2010	29.89	0.05	
	8/18/2010	29.70	0.05	
	8/19/2010	32.71	0.59	
	8/20/2010	31.63	0.44	
	8/21/2010	34.32	0.95	
	8/22/2010	31.51	0.49	
	8/23/2010	32.16	0.64	
	8/24/2010	32.16	0.68	
	8/25/2010	34.03	1.07	
	8/26/2010	32.66	0.86	
	8/27/2010	31.13	0.64	
	8/28/2010	31.49	0.74	
	8/29/2010	28.06	0.22	
	8/30/2010	25.06	0.18	
	8/31/2010	23.98	0.28	0.43
YB05	6/27/2010	33.14	2.18	
	6/28/2010	29.97	1.40	
	6/29/2010	32.21	1.92	
	6/30/2010	31.58	1.76	1.81
	7/1/2010	31.87	1.34	
	7/2/2010	30.26	0.95	
	7/3/2010	28.84	0.62	
	7/4/2010	28.48	0.53	
	7/5/2010	27.71	0.36	
	7/6/2010	29.20	0.67	
	7/7/2010	27.87	0.37	
	7/8/2010	28.80	0.56	
	7/9/2010	30.72	0.98	
	7/10/2010	32.04	1.29	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/11/2010	33.64	1.67	
	7/12/2010	33.62	1.66	
	7/13/2010	33.64	1.65	
	7/14/2010	33.22	1.55	
	7/15/2010	34.26	1.81	
	7/16/2010	33.89	1.70	
	7/17/2010	33.76	1.67	
	7/18/2010	34.66	1.90	
	7/19/2010	34.51	1.86	
	7/20/2010	33.74	1.67	
	7/21/2010	33.03	1.50	
	7/22/2010	32.67	1.42	
	7/23/2010	31.17	1.06	
	7/24/2010	29.09	0.60	
	7/25/2010	32.36	1.36	
	7/26/2010	32.13	1.32	
	7/27/2010	29.66	0.75	
	7/28/2010	30.18	0.88	
	7/29/2010	29.87	0.82	
	7/30/2010	29.43	0.74	
	7/31/2010	28.13	0.48	1.15
	8/1/2010	27.50	0.67	
	8/2/2010	27.08	0.72	
	8/3/2010	29.09	0.41	
	8/4/2010	30.09	0.24	
	8/5/2010	30.39	0.17	
	8/6/2010	29.91	0.23	
	8/7/2010	30.43	0.13	
	8/8/2010	29.29	0.29	
	8/9/2010	26.39	0.69	
	8/10/2010	28.15	0.42	
	8/11/2010	27.92	0.43	
	8/12/2010	26.76	0.57	
	8/13/2010	25.76	0.69	
	8/14/2010	26.78	0.52	
	8/15/2010	29.15	0.14	
	8/16/2010	33.18	0.56	
	8/17/2010	29.13	0.08	
	8/18/2010	28.36	0.17	
	8/19/2010	31.04	0.30	
	8/20/2010	30.77	0.28	
	8/21/2010	32.99	0.70	
	8/22/2010	30.35	0.29	
	8/23/2010	30.68	0.38	
	8/24/2010	30.68	0.42	
	8/25/2010	32.51	0.78	
	8/26/2010	31.39	0.63	
	8/27/2010	28.67	0.22	
	8/28/2010	29.93	0.47	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	8/29/2010	26.70	0.01	
	8/31/2010	23.45	0.36	0.40
YB07	7/13/2010	35.34	2.10	
	7/14/2010	31.41	1.13	
	7/15/2010	32.28	1.34	
	7/16/2010	32.60	1.41	
	7/17/2010	33.29	1.57	
	7/18/2010	34.73	1.93	
	7/19/2010	32.77	1.45	
	7/20/2010	33.12	1.54	
	7/21/2010	31.78	1.21	
	7/22/2010	31.43	1.14	
	7/23/2010	29.00	0.59	
	7/24/2010	27.69	0.32	
	7/25/2010	31.16	1.09	
	7/26/2010	31.22	1.11	
	7/27/2010	27.98	0.40	
	7/28/2010	28.36	0.49	
	7/29/2010	28.44	0.52	
	7/30/2010	29.57	0.79	1.12
	8/1/2010	26.62	0.80	
	8/2/2010	25.83	0.90	
	8/3/2010	27.33	0.68	
	8/4/2010	28.04	0.56	
	8/5/2010	27.89	0.57	
	8/6/2010	28.37	0.48	
	8/7/2010	27.85	0.54	
	8/8/2010	27.33	0.60	
	8/9/2010	24.07	1.02	
	8/10/2010	25.74	0.78	
	8/11/2010	26.35	0.68	
	8/12/2010	24.67	0.88	
	8/13/2010	23.75	0.97	
	8/14/2010	24.15	0.90	
	8/15/2010	27.06	0.48	
	8/16/2010	30.66	0.10	
	8/17/2010	28.19	0.26	
	8/18/2010	27.79	0.29	
	8/19/2010	30.65	0.20	
	8/20/2010	29.09	0.02	
	8/21/2010	32.52	0.58	
	8/22/2010	28.71	0.01	
	8/23/2010	29.09	0.08	
	8/24/2010	28.44	0.02	
	8/25/2010	29.30	0.19	
	8/26/2010	28.65	0.13	
	8/27/2010	27.77	0.03	
	8/28/2010	29.40	0.33	
	8/29/2010	27.02	0.01	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	8/30/2010	22.96	0.52	
	8/31/2010	21.22	0.69	0.46
YB08	7/4/2010	29.34	0.74	
	7/5/2010	26.65	0.16	
	7/6/2010	27.52	0.34	
	7/7/2010	26.83	0.18	
	7/8/2010	27.63	0.34	
	7/9/2010	28.75	0.57	
	7/10/2010	30.33	0.91	
	7/11/2010	32.62	1.44	
	7/12/2010	32.23	1.34	
	7/13/2010	32.00	1.28	
	7/14/2010	31.46	1.15	
	7/15/2010	32.33	1.35	
	7/16/2010	31.58	1.17	
	7/17/2010	31.92	1.25	
	7/18/2010	33.25	1.57	
	7/19/2010	32.50	1.39	
	7/20/2010	31.71	1.20	
	7/21/2010	30.92	1.01	
	7/22/2010	30.79	0.99	
	7/23/2010	29.61	0.72	
	7/24/2010	27.96	0.37	
	7/25/2010	30.90	1.03	
	7/26/2010	30.67	0.99	
	7/27/2010	27.88	0.38	
	7/28/2010	28.48	0.52	
	7/29/2010	28.94	0.63	
	7/30/2010	28.36	0.52	
	7/31/2010	26.90	0.23	0.85
	8/1/2010	26.65	0.79	
	8/2/2010	26.07	0.86	
	8/3/2010	27.83	0.59	
	8/4/2010	28.13	0.53	
	8/5/2010	28.40	0.48	
	8/6/2010	28.44	0.45	
	8/7/2010	28.67	0.40	
	8/8/2010	27.71	0.53	
	8/9/2010	24.73	0.92	
	8/10/2010	26.15	0.71	
	8/11/2010	26.83	0.59	
	8/12/2010	25.29	0.78	
	8/13/2010	25.37	0.74	
	8/14/2010	25.58	0.69	
	8/15/2010	28.21	0.29	
	8/16/2010	31.40	0.25	
	8/17/2010	29.36	0.05	
	8/18/2010	28.73	0.12	
	8/19/2010	30.27	0.16	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	8/20/2010	29.56	0.08	
	8/21/2010	31.73	0.47	
	8/22/2010	29.42	0.13	
	8/23/2010	30.23	0.30	
	8/24/2010	29.67	0.24	
	8/25/2010	30.04	0.35	
	8/26/2010	28.19	0.09	
	8/27/2010	27.59	0.04	
	8/28/2010	28.79	0.27	
	8/29/2010	26.04	0.10	
	8/30/2010	23.52	0.41	
	8/31/2010	22.77	0.46	0.42
YB10	6/29/2010	38.14	3.48	
	6/30/2010	32.32	1.94	2.71
	7/1/2010	32.63	1.53	
	7/2/2010	32.32	1.44	
	7/3/2010	30.76	1.06	
	7/4/2010	29.99	0.88	
	7/5/2010	28.80	0.60	
	7/6/2010	29.97	0.85	
	7/7/2010	29.01	0.63	
	7/8/2010	29.76	0.78	
	7/9/2010	32.36	1.37	
	7/10/2010	33.50	1.65	
	7/11/2010	35.67	2.19	
	7/12/2010	35.36	2.10	
	7/13/2010	35.25	2.07	
	7/14/2010	34.42	1.85	
	7/15/2010	35.04	2.01	
	7/16/2010	34.75	1.93	
	7/17/2010	36.17	2.29	
	7/18/2010	36.71	2.43	
	7/19/2010	34.96	1.97	
	7/20/2010	35.13	2.03	
	7/21/2010	34.07	1.77	
	7/22/2010	34.59	1.89	
	7/23/2010	31.66	1.18	
	7/24/2010	28.68	0.51	
	7/25/2010	33.17	1.56	
	7/26/2010	34.90	2.00	
	7/27/2010	30.30	0.90	
	7/28/2010	30.76	1.01	
	7/29/2010	31.18	1.12	
	7/30/2010	30.20	0.91	
	7/31/2010	29.37	0.74	1.46
	8/1/2010	27.43	0.68	
	8/2/2010	27.02	0.73	
	8/3/2010	29.68	0.32	
	8/4/2010	30.51	0.17	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	8/5/2010	31.44	0.01	
	8/6/2010	30.61	0.12	
	8/7/2010	31.20	0.01	
	8/8/2010	29.37	0.28	
	8/9/2010	26.80	0.64	
	8/10/2010	29.34	0.24	
	8/11/2010	28.76	0.31	
	8/12/2010	28.92	0.26	
	8/13/2010	26.01	0.66	
	8/14/2010	26.53	0.56	
	8/15/2010	29.63	0.07	
	8/16/2010	33.32	0.58	
	8/17/2010	30.10	0.06	
	8/18/2010	29.51	0.00	
	8/19/2010	33.78	0.76	
	8/20/2010	32.18	0.51	
	8/21/2010	35.13	1.08	
	8/22/2010	30.22	0.26	
	8/23/2010	31.41	0.49	
	8/24/2010	31.09	0.48	
	8/25/2010	28.48	0.09	0.37
YB11	6/25/2010	31.60	1.91	
	6/26/2010	25.94	0.62	
	6/27/2010	25.19	0.46	
	6/28/2010	26.61	0.74	
	6/29/2010	27.23	0.85	
	6/30/2010	27.85	0.98	0.93
	7/1/2010	27.81	0.50	
	7/2/2010	26.85	0.29	
	7/3/2010	25.44	0.01	
	7/4/2010	26.29	0.15	
	7/5/2010	24.44	0.22	
	7/6/2010	24.67	0.19	
	7/7/2010	24.25	0.28	
	7/8/2010	25.04	0.14	
	7/9/2010	26.33	0.11	
	7/10/2010	27.42	0.32	
	7/11/2010	30.17	0.91	
	7/12/2010	30.56	1.00	
	7/13/2010	30.06	0.88	
	7/14/2010	29.04	0.64	
	7/15/2010	30.31	0.92	
	7/16/2010	30.00	0.85	
	7/17/2010	30.38	0.93	
	7/18/2010	31.02	1.08	
	7/19/2010	30.08	0.86	
	7/20/2010	29.59	0.75	
	7/21/2010	28.81	0.58	
	7/22/2010	29.11	0.65	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/23/2010	28.63	0.55	
	7/24/2010	26.76	0.16	
	7/25/2010	28.77	0.59	
	7/26/2010	29.23	0.69	
	7/27/2010	26.07	0.04	
	7/28/2010	26.67	0.17	
	7/29/2010	27.94	0.44	
	7/30/2010	27.32	0.32	
	7/31/2010	25.01	0.13	0.49
	8/1/2010	25.63	0.91	
	8/2/2010	25.05	0.98	
	8/3/2010	26.29	0.80	
	8/4/2010	26.48	0.76	
	8/5/2010	26.60	0.73	
	8/6/2010	27.23	0.62	
	8/7/2010	28.42	0.43	
	8/8/2010	26.59	0.68	
	8/9/2010	23.79	1.03	
	8/10/2010	24.71	0.90	
	8/11/2010	24.73	0.87	
	8/12/2010	23.08	1.06	
	8/13/2010	23.83	0.94	
	8/14/2010	24.42	0.84	
	8/15/2010	26.71	0.51	
	8/16/2010	29.59	0.05	
	8/17/2010	28.57	0.18	
	8/18/2010	27.84	0.26	
	8/19/2010	29.13	0.03	
	8/20/2010	28.54	0.09	
	8/21/2010	29.61	0.11	
	8/22/2010	28.75	0.01	
	8/23/2010	28.96	0.08	
	8/24/2010	27.59	0.10	
	8/25/2010	28.67	0.11	
	8/26/2010	27.77	0.01	
	8/27/2010	25.69	0.26	
	8/28/2010	25.01	0.32	
	8/29/2010	21.31	0.75	
	8/30/2010	21.04	0.75	0.51
YB13	7/2/2010	32.31	1.53	
	7/3/2010	26.77	0.28	
	7/4/2010	26.19	0.15	
	7/5/2010	23.96	0.29	
	7/6/2010	24.03	0.29	
	7/7/2010	23.94	0.32	
	7/8/2010	24.45	0.23	
	7/9/2010	26.50	0.16	
	7/10/2010	27.17	0.29	
	7/11/2010	32.48	1.47	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/12/2010	30.97	1.10	
	7/13/2010	31.72	1.28	
	7/14/2010	29.63	0.79	
	7/15/2010	31.14	1.13	
	7/16/2010	31.01	1.10	
	7/17/2010	32.37	1.41	
	7/18/2010	31.91	1.30	
	7/19/2010	30.38	0.94	
	7/20/2010	30.19	0.90	
	7/21/2010	29.90	0.83	
	7/22/2010	31.72	1.26	
	7/23/2010	30.49	0.97	
	7/24/2010	27.37	0.29	
	7/25/2010	30.26	0.93	
	7/26/2010	30.80	1.06	
	7/27/2010	26.67	0.17	
	7/28/2010	27.03	0.25	
	7/29/2010	29.15	0.71	
	7/30/2010	30.03	0.92	
	7/31/2010	28.98	0.70	0.77
	8/1/2010	27.32	0.67	
	8/2/2010	26.19	0.82	
	8/3/2010	26.71	0.73	
	8/4/2010	26.80	0.71	
	8/5/2010	27.89	0.54	
	8/6/2010	27.53	0.58	
	8/7/2010	29.48	0.26	
	8/8/2010	28.45	0.41	
	8/9/2010	23.88	1.01	
	8/10/2010	24.64	0.90	
	8/11/2010	24.38	0.91	
	8/12/2010	22.60	1.12	
	8/13/2010	23.08	1.04	
	8/14/2010	23.59	0.95	
	8/15/2010	26.40	0.55	
	8/16/2010	29.38	0.08	
	8/17/2010	28.96	0.12	
	8/18/2010	28.02	0.23	
	8/19/2010	31.26	0.32	
	8/20/2010	29.27	0.02	
	8/21/2010	30.87	0.32	
	8/22/2010	28.88	0.03	
	8/23/2010	29.27	0.13	
	8/24/2010	27.89	0.05	
	8/25/2010	29.94	0.31	
	8/26/2010	29.96	0.35	
	8/27/2010	27.78	0.05	
	8/28/2010	24.01	0.46	0.49
YB16	6/15/2010	31.00	5.24	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	6/16/2010	26.18	3.95	
	6/17/2010	24.47	3.49	
	6/18/2010	25.72	3.80	
	6/19/2010	25.82	3.81	
	6/20/2010	25.13	3.64	
	6/21/2010	25.55	3.73	
	6/22/2010	25.68	3.75	
	6/23/2010	25.93	3.80	
	6/24/2010	27.13	4.11	
	6/25/2010	28.34	4.41	
	6/26/2010	27.34	4.16	
	6/27/2010	28.13	4.37	
	6/28/2010	28.11	4.38	
	6/29/2010	27.32	4.17	
	6/30/2010	28.09	4.39	4.07
	7/1/2010	28.78	4.21	
	7/2/2010	28.26	4.09	
	7/3/2010	27.45	3.89	
	7/4/2010	27.20	3.86	
	7/5/2010	26.80	3.78	
	7/6/2010	25.82	3.56	
	7/7/2010	26.22	3.69	
	7/8/2010	27.03	3.93	
	7/9/2010	28.45	4.33	
	7/10/2010	29.86	4.71	
	7/11/2010	30.76	4.99	
	7/12/2010	30.30	4.91	
	7/13/2010	30.38	4.97	
	7/14/2010	30.80	5.13	
	7/15/2010	29.91	4.92	
	7/16/2010	31.42	5.39	
	7/17/2010	31.72	5.53	
	7/18/2010	31.78	5.60	
	7/19/2010	31.76	5.65	
	7/20/2010	30.86	5.45	
	7/21/2010	30.24	5.34	
	7/22/2010	30.59	5.51	
	7/23/2010	29.45	5.27	
	7/24/2010	29.84	5.42	
	7/25/2010	31.42	5.93	
	7/26/2010	29.41	5.46	
	7/27/2010	28.74	5.33	
	7/28/2010	29.43	5.61	
	7/29/2010	29.47	5.70	
	7/30/2010	30.20	5.96	
	7/31/2010	29.70	5.90	4.97
	8/1/2010	26.84	2.74	
	8/2/2010	26.97	2.81	
	8/3/2010	28.16	3.11	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	8/4/2010	28.41	3.20	
	8/5/2010	28.36	3.26	
	8/6/2010	28.47	3.36	
	8/7/2010	28.51	3.43	
	8/8/2010	25.74	2.96	
	8/9/2010	25.74	3.02	
	8/10/2010	25.97	3.12	
	8/11/2010	26.64	3.32	
	8/12/2010	26.18	3.30	
	8/13/2010	26.24	3.38	
	8/14/2010	27.09	3.62	
	8/15/2010	29.80	4.22	
	8/16/2010	31.13	4.58	
	8/17/2010	30.61	4.55	
	8/18/2010	30.01	4.50	
	8/19/2010	30.82	4.73	
	8/20/2010	30.36	4.71	
	8/21/2010	33.05	5.39	
	8/22/2010	30.68	4.94	
	8/23/2010	31.03	5.11	
	8/24/2010	32.05	5.41	
	8/25/2010	31.94	5.44	
	8/26/2010	31.65	5.47	
	8/27/2010	31.87	5.59	
	8/28/2010	29.61	5.19	
	8/29/2010	24.59	4.22	
	8/30/2010	23.14	4.01	
	8/31/2010	24.45	4.35	4.10
YB18	7/2/2010	34.90	5.97	
	7/3/2010	31.33	4.99	
	7/4/2010	30.06	4.68	
	7/5/2010	31.00	4.96	
	7/6/2010	30.62	4.87	
	7/7/2010	30.12	4.77	
	7/8/2010	31.45	5.14	
	7/9/2010	33.83	5.85	
	7/10/2010	34.39	6.07	
	7/11/2010	34.45	6.10	
	7/12/2010	34.39	6.15	
	7/13/2010	35.08	6.38	
	7/14/2010	35.85	6.64	
	7/15/2010	34.20	6.24	
	7/16/2010	35.51	6.66	
	7/17/2010	35.60	6.73	
	7/18/2010	35.12	6.65	
	7/19/2010	35.80	6.89	
	7/20/2010	34.79	6.65	
	7/21/2010	34.49	6.65	
	7/22/2010	33.85	6.50	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/23/2010	32.54	6.20	
	7/24/2010	32.48	6.23	
	7/25/2010	36.03	7.38	
	7/26/2010	33.04	6.56	
	7/27/2010	32.10	6.36	
	7/28/2010	32.87	6.64	
	7/29/2010	32.69	6.67	
	7/30/2010	32.98	6.82	
	7/31/2010	32.04	6.66	6.17
	8/1/2010	31.52	3.71	
	8/2/2010	30.46	3.55	
	8/3/2010	32.04	3.93	
	8/4/2010	32.89	4.16	
	8/5/2010	33.08	4.27	
	8/6/2010	33.45	4.40	
	8/7/2010	32.66	4.31	
	8/8/2010	29.25	3.68	
	8/9/2010	29.25	3.74	
	8/10/2010	30.35	4.05	
	8/11/2010	30.89	4.21	
	8/12/2010	29.06	3.92	
	8/13/2010	29.60	4.10	
	8/14/2010	30.85	4.41	
	8/15/2010	34.04	5.21	
	8/16/2010	34.56	5.38	
	8/17/2010	34.12	5.38	
	8/18/2010	33.35	5.25	
	8/19/2010	34.43	5.59	
	8/20/2010	34.29	5.65	
	8/21/2010	34.62	5.78	
	8/22/2010	33.27	5.55	
	8/23/2010	32.91	5.55	
	8/24/2010	33.29	5.72	
	8/25/2010	33.35	5.81	
	8/26/2010	32.93	5.79	
	8/27/2010	32.10	5.71	
	8/28/2010	31.92	5.73	
	8/29/2010	26.59	4.68	
	8/30/2010	25.19	4.46	
	8/31/2010	26.23	4.75	4.79
YB20	8/4/2010	29.96	3.85	
	8/5/2010	26.26	3.20	
	8/6/2010	25.95	3.19	
	8/7/2010	27.03	3.48	
	8/8/2010	24.41	3.03	
	8/9/2010	24.03	3.03	
	8/10/2010	24.59	3.20	
	8/11/2010	25.57	3.45	
	8/12/2010	24.80	3.36	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	8/13/2010	25.01	3.48	
	8/14/2010	25.53	3.64	
	8/15/2010	28.84	4.36	
	8/16/2010	30.72	4.83	
	8/17/2010	30.49	4.86	
	8/18/2010	29.93	4.80	
	8/19/2010	30.53	5.02	
	8/20/2010	29.57	4.89	
	8/21/2010	32.16	5.52	
	8/22/2010	30.61	5.26	
	8/23/2010	29.72	5.14	
	8/24/2010	30.13	5.31	
	8/25/2010	29.80	5.30	
	8/26/2010	30.11	5.46	
	8/27/2010	29.66	5.43	
	8/28/2010	29.76	5.52	
	8/29/2010	24.28	4.44	
	8/30/2010	22.07	4.08	4.34
YB21	6/24/2010	30.82	6.52	
	6/25/2010	32.28	6.96	
	6/26/2010	30.78	6.52	
	6/27/2010	31.07	6.63	
	6/28/2010	31.95	6.86	
	6/29/2010	30.19	6.38	
	6/30/2010	32.75	7.14	6.72
	7/1/2010	33.98	6.35	
	7/2/2010	32.55	6.78	
	7/3/2010	31.18	6.40	
	7/4/2010	29.97	6.09	
	7/5/2010	29.91	6.10	
	7/6/2010	29.28	5.92	
	7/7/2010	29.41	6.01	
	7/8/2010	31.19	6.54	
	7/9/2010	33.11	7.13	
	7/10/2010	35.10	7.77	
	7/11/2010	34.78	7.70	
	7/12/2010	34.86	7.76	
	7/13/2010	34.69	7.76	
	7/14/2010	36.10	8.25	
	7/15/2010	33.55	7.52	
	7/16/2010	35.60	8.20	
	7/17/2010	35.86	8.31	
	7/18/2010	35.69	8.33	
	7/19/2010	36.73	8.71	
	7/20/2010	35.52	8.41	
	7/21/2010	35.03	8.32	
	7/22/2010	34.74	8.27	
	7/23/2010	33.51	7.98	
	7/24/2010	34.86	8.44	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/25/2010	36.35	8.98	
	7/26/2010	33.99	8.30	
	7/27/2010	32.91	8.04	
	7/28/2010	33.53	8.34	
	7/29/2010	33.45	8.36	
	7/30/2010	33.84	8.57	
	7/31/2010	32.95	8.36	7.68
	8/1/2010	31.85	4.78	
	8/2/2010	31.62	4.80	
	8/3/2010	33.11	5.18	
	8/4/2010	33.57	5.35	
	8/5/2010	33.67	5.42	
	8/6/2010	33.25	5.39	
	8/7/2010	33.20	5.45	
	8/8/2010	29.39	4.67	
	8/9/2010	29.82	4.83	
	8/10/2010	30.47	5.05	
	8/11/2010	31.55	5.35	
	8/12/2010	30.65	5.22	
	8/13/2010	31.03	5.37	
	8/14/2010	31.57	5.56	
	8/15/2010	34.80	6.34	
	8/16/2010	35.34	6.51	
	8/17/2010	35.19	6.59	
	8/18/2010	35.07	6.64	
	8/19/2010	36.66	7.08	
	8/20/2010	34.84	6.71	
	8/21/2010	35.42	6.89	
	8/22/2010	34.80	6.85	
	8/23/2010	34.65	6.90	
	8/24/2010	35.54	7.19	
	8/25/2010	35.32	7.20	
	8/26/2010	34.21	7.05	
	8/27/2010	33.09	6.83	
	8/28/2010	33.28	6.94	
	8/29/2010	27.43	5.66	
	8/30/2010	25.58	5.35	
	8/31/2010	26.49	5.59	5.96
YB25	7/24/2011	23.10	1.31	
	7/25/2011	23.24	1.28	
	7/26/2011	23.51	1.25	
	7/27/2011	29.74	0.38	
	7/28/2011	28.61	0.54	
	7/29/2011	28.43	0.56	
	7/30/2011	29.78	0.34	
	7/31/2011	27.99	0.60	0.78
	8/1/2011	29.32	0.39	
	8/2/2011	29.42	0.36	
	8/3/2011	30.79	0.13	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	8/4/2011	30.46	0.17	
	8/5/2011	27.30	0.64	
	8/6/2011	25.07	0.93	
	8/7/2011	26.98	0.64	
	8/8/2011	30.07	0.16	
	8/9/2011	30.22	0.12	
	8/10/2011	30.11	0.11	
	8/11/2011	29.11	0.25	
	8/12/2011	29.63	0.14	
	8/13/2011	28.32	0.32	
	8/14/2011	28.88	0.20	
	8/15/2011	30.75	0.12	
	8/16/2011	30.42	0.10	
	8/17/2011	29.26	0.06	
	8/18/2011	29.84	0.07	
	8/19/2011	30.86	0.27	
	8/20/2011	27.65	0.21	
	8/21/2011	26.19	0.39	
	8/22/2011	27.07	0.22	
	8/23/2011	27.86	0.07	
	8/24/2011	28.48	0.07	
	8/25/2011	31.46	0.60	
	8/26/2011	30.25	0.44	
	8/27/2011	30.80	0.57	
	8/28/2011	30.34	0.54	
	8/29/2011	29.38	0.43	
	8/30/2011	29.36	0.47	
	8/31/2011	28.42	0.37	0.31
YB26	7/21/2011	32.44	0.04	
	7/22/2011	29.20	0.48	
	7/23/2011	30.45	0.28	
	7/24/2011	32.02	0.02	
	7/25/2011	29.62	0.40	
	7/26/2011	30.56	0.25	
	7/27/2011	30.43	0.27	
	7/28/2011	29.81	0.36	
	7/29/2011	30.06	0.31	
	7/30/2011	30.77	0.19	
	7/31/2011	28.52	0.53	0.28
	8/1/2011	29.79	0.32	
	8/2/2011	30.47	0.20	
	8/3/2011	31.43	0.03	
	8/4/2011	30.78	0.12	
	8/5/2011	29.03	0.38	
	8/6/2011	26.74	0.70	
	8/7/2011	28.12	0.48	
	8/8/2011	32.06	0.16	
	8/9/2011	31.16	0.03	
	8/10/2011	31.83	0.17	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	8/11/2011	30.18	0.08	
	8/12/2011	30.56	0.00	
	8/13/2011	29.71	0.11	
	8/14/2011	29.12	0.17	
	8/15/2011	30.33	0.05	
	8/16/2011	30.56	0.11	
	8/17/2011	29.93	0.04	
	8/18/2011	30.74	0.20	
	8/19/2011	32.24	0.49	
	8/20/2011	29.33	0.04	
	8/21/2011	27.56	0.20	
	8/22/2011	28.49	0.02	
	8/23/2011	29.45	0.17	
	8/24/2011	29.99	0.30	
	8/25/2011	32.22	0.71	
	8/26/2011	31.91	0.70	
	8/27/2011	32.24	0.80	
	8/28/2011	30.85	0.61	
	8/29/2011	30.56	0.60	
	8/30/2011	30.99	0.72	
	8/31/2011	29.68	0.55	0.30
YB30	7/9/2011	32.77	2.71	
	7/10/2011	29.91	2.04	
	7/11/2011	29.06	1.87	
	7/12/2011	26.16	1.25	
	7/13/2011	25.27	1.08	
	7/14/2011	24.39	0.93	
	7/15/2011	24.62	1.02	
	7/16/2011	24.62	1.05	
	7/17/2011	24.66	1.10	
	7/18/2011	26.79	1.59	
	7/19/2011	28.24	1.97	
	7/20/2011	28.22	2.01	
	7/21/2011	25.68	1.49	
	7/22/2011	26.66	1.75	
	7/23/2011	29.10	2.37	
	7/24/2011	28.60	2.31	
	7/25/2011	27.41	2.08	
	7/26/2011	29.02	2.52	
	7/27/2011	28.18	2.38	
	7/28/2011	28.58	2.54	
	7/29/2011	29.04	2.72	
	7/30/2011	29.08	2.80	
	7/31/2011	30.85	3.30	1.95
	8/1/2011	30.01	1.76	
	8/2/2011	29.16	1.63	
	8/3/2011	29.08	1.68	
	8/4/2011	27.31	1.36	
	8/5/2011	25.10	0.96	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	8/6/2011	25.05	1.03	
	8/7/2011	28.64	1.89	
	8/8/2011	28.39	1.91	
	8/9/2011	27.93	1.89	
	8/10/2011	28.20	2.04	
	8/11/2011	27.87	2.05	
	8/12/2011	26.89	1.91	
	8/13/2011	26.87	2.00	
	8/14/2011	27.33	2.20	
	8/15/2011	27.16	2.25	
	8/16/2011	27.64	2.46	
	8/17/2011	28.45	2.76	
	8/18/2011	28.12	2.77	
	8/19/2011	28.95	3.07	
	8/20/2011	26.54	2.60	
	8/21/2011	25.20	2.39	
	8/22/2011	25.72	2.61	
	8/23/2011	25.95	2.76	
	8/24/2011	26.99	3.11	
	8/25/2011	29.64	3.89	
	8/26/2011	29.58	3.99	
	8/27/2011	30.26	4.27	
	8/28/2011	28.68	3.98	
	8/29/2011	28.35	4.00	
	8/30/2011	28.02	4.05	
	8/31/2011	24.66	3.33	2.54
YB31	8/9/2011	32.35	5.83	
	8/10/2011	29.78	5.21	
	8/11/2011	29.82	5.32	
	8/12/2011	28.02	4.94	
	8/13/2011	28.80	5.23	
	8/14/2011	28.76	5.32	
	8/15/2011	29.34	5.56	
	8/16/2011	29.66	5.76	
	8/17/2011	30.05	5.98	
	8/18/2011	30.97	6.31	
	8/19/2011	30.05	6.18	
	8/20/2011	28.46	5.85	
	8/21/2011	27.90	5.77	
	8/22/2011	29.45	6.33	
	8/23/2011	29.78	6.51	
	8/24/2011	30.60	6.86	
	8/25/2011	31.89	7.33	
	8/26/2011	32.00	7.50	
	8/27/2011	32.37	7.70	
	8/28/2011	30.85	7.35	
	8/29/2011	30.18	7.27	
	8/30/2011	30.22	7.39	
	8/31/2011	29.26	7.21	6.29

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
YB32	7/17/2011	30.55	5.22	
	7/18/2011	28.83	4.80	
	7/19/2011	29.94	5.17	
	7/20/2011	29.44	5.09	
	7/21/2011	28.61	4.92	
	7/22/2011	29.48	5.22	
	7/23/2011	30.90	5.65	
	7/24/2011	29.17	5.25	
	7/25/2011	29.36	5.36	
	7/26/2011	30.92	5.85	
	7/27/2011	29.42	5.54	
	7/28/2011	29.25	5.55	
	7/29/2011	31.56	6.28	
	7/30/2011	30.21	5.97	
	7/31/2011	30.71	6.19	5.47
	8/1/2011	30.62	4.68	
	8/2/2011	31.00	4.87	
	8/3/2011	31.62	5.12	
	8/4/2011	30.23	4.82	
	8/5/2011	28.27	4.38	
	8/6/2011	27.23	4.20	
	8/7/2011	30.67	5.20	
	8/8/2011	30.65	5.28	
	8/9/2011	29.94	5.19	
	8/10/2011	30.02	5.30	
	8/11/2011	29.86	5.36	
	8/12/2011	28.29	5.00	
	8/13/2011	28.86	5.25	
	8/14/2011	29.02	5.40	
	8/15/2011	29.69	5.68	
	8/16/2011	29.83	5.81	
	8/17/2011	30.19	6.01	
	8/18/2011	31.19	6.40	
	8/19/2011	30.19	6.22	
	8/20/2011	28.63	5.89	
	8/21/2011	27.86	5.76	
	8/22/2011	28.17	5.96	
	8/23/2011	28.44	6.12	
	8/24/2011	30.25	6.75	
	8/25/2011	31.96	7.35	
	8/26/2011	31.79	7.42	
	8/27/2011	32.56	7.78	
	8/28/2011	30.02	7.13	
	8/29/2011	30.73	7.43	
	8/30/2011	30.23	7.39	
	8/31/2011	29.17	7.19	5.88
YB34	6/30/2011	28.35	4.12	
	7/1/2011	25.70	3.48	
	7/2/2011	27.34	3.90	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/3/2011	31.90	5.12	
	7/4/2011	29.86	4.59	
	7/5/2011	30.49	4.79	
	7/6/2011	27.16	3.94	
	7/7/2011	29.55	4.59	
	7/8/2011	29.97	4.74	
	7/9/2011	30.30	4.84	
	7/10/2011	30.76	5.00	
	7/11/2011	30.07	4.86	
	7/12/2011	26.57	3.99	
	7/13/2011	26.14	3.92	
	7/14/2011	25.84	3.88	
	7/15/2011	25.91	3.94	
	7/16/2011	26.11	4.05	
	7/17/2011	25.38	3.90	
	7/18/2011	28.80	4.83	
	7/19/2011	29.45	5.08	
	7/20/2011	29.11	5.03	
	7/21/2011	28.09	4.82	
	7/22/2011	29.24	5.18	
	7/23/2011	30.86	5.68	
	7/24/2011	29.01	5.26	
	7/25/2011	28.97	5.29	
	7/26/2011	30.47	5.80	
	7/27/2011	29.36	5.54	
	7/28/2011	29.26	5.59	
	7/29/2011	30.92	6.12	
	7/30/2011	30.01	5.97	
	7/31/2011	30.01	6.05	4.83
	8/1/2011	30.26	4.62	
	8/2/2011	30.90	4.87	
	8/3/2011	31.61	5.16	
	8/4/2011	29.92	4.79	
	8/5/2011	28.49	4.49	
	8/6/2011	27.57	4.34	
	8/7/2011	30.85	5.28	
	8/8/2011	30.92	5.38	
	8/9/2011	30.30	5.31	
	8/10/2011	30.19	5.38	
	8/11/2011	30.55	5.58	
	8/12/2011	29.09	5.27	
	8/13/2011	28.97	5.31	
	8/14/2011	29.28	5.50	
	8/15/2011	29.36	5.61	
	8/16/2011	29.78	5.83	
	8/17/2011	30.26	6.07	
	8/18/2011	30.97	6.36	
	8/19/2011	30.11	6.24	
	8/20/2011	28.36	5.84	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	8/21/2011	27.61	5.75	
	8/22/2011	28.32	6.03	
	8/23/2011	28.43	6.16	
	8/24/2011	29.86	6.67	
	8/25/2011	30.88	7.07	
	8/26/2011	31.32	7.32	
	8/27/2011	31.99	7.61	
	8/28/2011	29.72	7.07	
	8/29/2011	30.07	7.29	
	8/30/2011	29.80	7.34	
	8/31/2011	28.65	7.09	5.89
WF09	5/1/2010	16.50	3.51	
	5/2/2010	18.50	4.01	
	5/3/2010	17.10	3.71	
	5/4/2010	20.50	4.58	
	5/5/2010	21.90	4.93	
	5/6/2010	21.40	4.85	
	5/7/2010	20.10	4.57	
	5/8/2010	20.50	4.72	
	5/9/2010	21.20	4.92	
	5/10/2010	19.60	4.56	
	5/11/2010	17.50	4.07	
	5/12/2010	18.90	4.40	
	5/13/2010	18.70	4.40	
	5/14/2010	22.00	5.29	
	5/15/2010	21.30	5.10	
	5/16/2010	21.30	5.13	
	5/17/2010	22.40	5.43	
	5/18/2010	22.20	5.42	
	5/19/2010	21.60	5.31	
	5/20/2010	22.40	5.51	
	5/21/2010	23.00	5.73	
	5/22/2010	21.60	5.36	
	5/23/2010	16.40	4.04	
	5/24/2010	16.30	4.05	
	5/25/2010	16.70	4.16	
	5/26/2010	19.90	4.95	
	5/27/2010	23.50	5.96	
	5/28/2010	20.20	5.08	
	5/29/2010	19.10	4.81	
	5/30/2010	22.30	5.63	
	5/31/2010	22.30	5.64	4.83
	6/1/2010	23.60	4.64	
	6/2/2010	24.50	4.90	
	6/3/2010	24.20	4.80	
	6/4/2010	26.10	5.33	
	6/5/2010	26.50	5.45	
	6/6/2010	28.10	5.87	
	6/7/2010	29.30	6.18	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	6/8/2010	28.50	5.99	
	6/9/2010	28.40	5.94	
	6/10/2010	27.40	5.67	
	6/11/2010	25.20	5.09	
	6/12/2010	24.10	4.79	
	6/13/2010	22.80	4.44	
	6/14/2010	23.40	4.59	
	6/15/2010	25.00	5.03	
	6/16/2010	25.80	5.20	
	6/17/2010	22.00	4.25	
	6/18/2010	23.70	4.64	
	6/19/2010	24.20	4.77	
	6/20/2010	23.20	4.50	
	6/21/2010	23.60	4.59	
	6/22/2010	23.00	4.44	
	6/23/2010	22.70	4.32	
	6/24/2010	24.10	4.68	
	6/25/2010	25.20	4.95	
	6/26/2010	25.20	4.92	
	6/27/2010	24.20	4.65	
	6/28/2010	25.40	4.93	
	6/29/2010	27.70	5.55	
	6/30/2010	26.60	5.23	5.01
	7/1/2010	26.00	4.73	
	7/2/2010	26.40	4.78	
	7/3/2010	24.40	4.25	
	7/4/2010	25.50	4.52	
	7/5/2010	24.60	4.26	
	7/6/2010	25.10	4.38	
	7/7/2010	24.20	4.11	
	7/8/2010	24.40	4.12	
	7/9/2010	25.90	4.48	
	7/10/2010	26.90	4.70	
	7/11/2010	28.50	5.12	
	7/12/2010	29.80	5.43	
	7/13/2010	29.40	5.29	
	7/14/2010	28.10	4.92	
	7/15/2010	28.70	5.04	
	7/16/2010	30.80	5.58	
	7/17/2010	31.40	5.71	
	7/18/2010	30.80	5.51	
	7/19/2010	31.40	5.65	
	7/20/2010	30.60	5.40	
	7/21/2010	31.00	5.49	
	7/22/2010	29.60	5.05	
	7/23/2010	30.10	5.17	
	7/24/2010	29.60	4.99	
	7/25/2010	29.50	4.92	
	7/26/2010	28.80	4.69	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/27/2010	27.80	4.40	
	7/28/2010	29.00	4.68	
	7/29/2010	30.00	4.92	
	7/30/2010	31.80	5.36	
	7/31/2010	30.20	4.88	4.92
WF10	5/1/2010	20.10	4.36	
	5/2/2010	21.10	4.64	
	5/3/2010	21.30	4.71	
	5/4/2010	24.10	5.49	
	5/5/2010	23.90	5.45	
	5/6/2010	25.10	5.84	
	5/7/2010	22.60	5.20	
	5/8/2010	23.60	5.50	
	5/9/2010	24.50	5.79	
	5/10/2010	22.90	5.37	
	5/11/2010	20.10	4.70	
	5/12/2010	21.70	5.14	
	5/13/2010	21.90	5.21	
	5/14/2010	24.40	5.90	
	5/15/2010	23.90	5.79	
	5/16/2010	24.20	5.90	
	5/17/2010	23.40	5.71	
	5/18/2010	24.30	5.97	
	5/19/2010	24.00	5.95	
	5/20/2010	24.60	6.13	
	5/21/2010	25.30	6.32	
	5/22/2010	23.50	5.87	
	5/23/2010	16.70	4.13	
	5/24/2010	17.70	4.38	
	5/25/2010	19.10	4.76	
	5/26/2010	21.80	5.45	
	5/27/2010	24.50	6.22	
	5/28/2010	21.70	5.46	
	5/29/2010	20.30	5.11	
	5/30/2010	24.50	6.26	
	5/31/2010	23.90	6.06	5.44
	6/1/2010	24.10	4.77	
	6/2/2010	26.10	5.31	
	6/3/2010	25.50	5.17	
	6/4/2010	27.70	5.75	
	6/5/2010	28.40	5.92	
	6/6/2010	29.70	6.32	
	6/7/2010	30.50	6.55	
	6/8/2010	29.50	6.26	
	6/9/2010	29.20	6.16	
	6/10/2010	28.00	5.84	
	6/11/2010	25.90	5.25	
	6/12/2010	26.30	5.37	
	6/13/2010	24.70	4.93	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	6/14/2010	25.40	5.10	
	6/15/2010	25.40	5.09	
	6/16/2010	26.10	5.30	
	6/17/2010	23.10	4.51	
	6/18/2010	24.20	4.77	
	6/19/2010	24.90	4.94	
	6/20/2010	24.30	4.77	
	6/21/2010	24.30	4.76	
	6/22/2010	24.30	4.75	
	6/23/2010	23.40	4.49	
	6/24/2010	24.80	4.85	
	6/25/2010	25.50	5.04	
	6/26/2010	25.70	5.05	
	6/27/2010	25.70	5.05	
	6/28/2010	26.60	5.26	
	6/29/2010	27.60	5.52	
	6/30/2010	26.50	5.21	5.27
	7/1/2010	26.30	4.78	
	7/2/2010	26.70	4.88	
	7/3/2010	24.90	4.38	
	7/4/2010	26.20	4.69	
	7/5/2010	25.30	4.42	
	7/6/2010	25.60	4.50	
	7/7/2010	24.90	4.27	
	7/8/2010	24.70	4.20	
	7/9/2010	26.60	4.67	
	7/10/2010	27.50	4.90	
	7/11/2010	29.20	5.29	
	7/12/2010	30.10	5.52	
	7/13/2010	29.50	5.34	
	7/14/2010	28.80	5.11	
	7/15/2010	29.60	5.30	
	7/16/2010	30.70	5.55	
	7/17/2010	31.70	5.80	
	7/18/2010	30.90	5.54	
	7/19/2010	31.10	5.57	
	7/20/2010	30.20	5.29	
	7/21/2010	30.30	5.27	
	7/22/2010	29.50	5.02	
	7/23/2010	30.20	5.18	
	7/24/2010	30.90	5.33	
	7/25/2010	30.70	5.23	
	7/26/2010	29.00	4.77	
	7/27/2010	27.40	4.29	
	7/28/2010	29.00	4.69	
	7/29/2010	30.90	5.15	
	7/30/2010	32.70	5.62	
	7/31/2010	30.20	4.89	5.01
WF14	6/3/2010	33.20	2.61	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	6/4/2010	34.20	2.86	
	6/5/2010	34.40	2.88	
	6/6/2010	35.30	3.11	
	6/7/2010	35.00	3.01	
	6/8/2010	34.50	2.86	
	6/9/2010	34.30	2.79	
	6/10/2010	35.00	2.95	
	6/11/2010	29.20	1.52	
	6/12/2010	27.20	1.04	
	6/13/2010	30.50	1.78	
	6/14/2010	32.00	2.12	
	6/15/2010	32.90	2.33	
	6/16/2010	34.60	2.75	
	6/17/2010	32.20	2.12	
	6/18/2010	30.70	1.75	
	6/19/2010	34.20	2.59	
	6/20/2010	32.20	2.07	
	6/21/2010	31.40	1.86	
	6/22/2010	32.60	2.13	
	6/23/2010	31.10	1.30	
	6/24/2010	31.90	1.43	
	6/25/2010	33.80	1.77	
	6/26/2010	34.80	1.94	
	6/27/2010	33.70	1.73	
	6/28/2010	34.30	1.83	
	6/29/2010	35.60	2.08	
	6/30/2010	34.70	1.88	2.18
	7/1/2010	34.70	1.51	
	7/2/2010	35.30	1.63	
	7/3/2010	32.70	1.13	
	7/4/2010	33.70	1.30	
	7/5/2010	33.20	1.21	
	7/6/2010	35.90	1.70	
	7/7/2010	32.80	1.12	
	7/8/2010	32.90	1.13	
	7/9/2010	33.60	1.25	
	7/10/2010	36.60	1.81	
	7/11/2010	37.80	2.05	
	7/12/2010	39.30	2.34	
	7/13/2010	39.10	2.30	
	7/14/2010	39.30	2.33	
	7/15/2010	38.80	2.23	
	7/16/2010	36.20	1.72	
	7/17/2010	38.10	2.09	
	7/18/2010	40.70	2.63	
	7/19/2010	38.00	2.07	
	7/20/2010	36.20	1.71	
	7/21/2010	37.30	1.92	
	7/22/2010	36.80	1.83	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/23/2010	36.60	1.79	
	7/24/2010	32.40	1.01	
	7/25/2010	37.70	2.03	
	7/26/2010	35.30	1.56	
	7/27/2010	30.70	0.73	
	7/28/2010	32.80	1.12	
	7/29/2010	37.90	2.10	
	7/30/2010	34.50	1.44	
	7/31/2010	27.70	0.29	1.65
WF16	5/14/2010	22.60	1.90	
	5/15/2010	21.40	1.64	
	5/16/2010	23.00	1.98	
	5/17/2010	23.00	1.95	
	5/18/2010	22.90	1.91	
	5/19/2010	22.20	1.75	
	5/20/2010	23.40	1.99	
	5/21/2010	25.50	2.46	
	5/22/2010	23.70	2.03	
	5/23/2010	17.70	0.84	
	5/24/2010	17.50	0.79	
	5/25/2010	18.70	0.99	
	5/26/2010	21.30	1.47	
	5/27/2010	24.70	2.18	
	5/28/2010	21.40	1.47	
	5/29/2010	19.90	1.15	
	5/30/2010	21.00	1.38	
	5/31/2010	23.50	1.86	1.65
	6/1/2010	23.40	0.51	
	6/2/2010	24.00	0.61	
	6/3/2010	24.60	0.72	
	6/4/2010	24.90	0.77	
	6/5/2010	25.90	0.96	
	6/6/2010	27.10	1.21	
	6/7/2010	28.10	1.41	
	6/8/2010	28.70	1.52	
	6/9/2010	27.30	1.19	
	6/10/2010	29.60	1.69	
	6/11/2010	23.70	0.42	
	6/12/2010	23.50	0.37	
	6/13/2010	23.30	0.32	
	6/14/2010	23.80	0.39	
	6/15/2010	25.40	0.70	
	6/16/2010	27.00	1.02	
	6/17/2010	24.80	0.54	
	6/18/2010	23.80	0.34	
	6/19/2010	25.20	0.59	
	6/20/2010	24.80	0.50	
	6/21/2010	24.80	0.48	
	6/22/2010	24.60	0.42	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	6/23/2010	23.60	0.23	
	6/24/2010	24.80	0.45	
	6/25/2010	25.80	0.62	
	6/26/2010	26.50	0.77	
	6/27/2010	26.20	0.68	
	6/28/2010	27.50	0.96	
	6/29/2010	28.00	1.05	
	6/30/2010	27.60	0.94	0.75
	7/1/2010	27.60	0.48	
	7/2/2010	27.60	0.46	
	7/3/2010	26.20	0.16	
	7/4/2010	26.90	0.29	
	7/5/2010	26.00	0.09	
	7/6/2010	26.10	0.12	
	7/7/2010	25.80	0.03	
	7/8/2010	26.20	0.10	
	7/9/2010	27.30	0.34	
	7/10/2010	28.60	0.59	
	7/11/2010	30.10	0.92	
	7/12/2010	30.80	1.07	
	7/13/2010	30.50	0.99	
	7/14/2010	30.30	0.94	
	7/15/2010	30.30	0.94	
	7/16/2010	30.90	0.79	
	7/17/2010	30.90	0.79	
	7/18/2010	31.50	0.89	
	7/19/2010	31.30	0.85	
	7/20/2010	30.90	0.78	
	7/21/2010	30.00	0.63	
	7/22/2010	29.90	0.62	
	7/23/2010	30.40	0.71	
	7/24/2010	28.00	0.31	
	7/25/2010	29.50	0.57	
	7/26/2010	30.30	0.70	
	7/27/2010	27.40	0.24	
	7/28/2010	28.20	0.37	
	7/29/2010	30.80	0.81	
	7/30/2010	25.40	0.04	0.55
WF17	5/14/2010	24.40	2.30	
	5/15/2010	23.90	2.17	
	5/16/2010	24.50	2.29	
	5/17/2010	24.00	2.16	
	5/18/2010	24.70	2.31	
	5/19/2010	24.60	2.28	
	5/20/2010	25.50	2.46	
	5/21/2010	27.00	2.81	
	5/22/2010	24.10	2.12	
	5/23/2010	20.40	1.34	
	5/24/2010	18.50	0.97	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	5/25/2010	21.60	1.55	
	5/26/2010	23.00	1.84	
	5/27/2010	26.70	2.64	
	5/28/2010	23.80	1.96	
	5/29/2010	21.80	1.53	
	5/30/2010	24.10	2.01	
	5/31/2010	25.20	2.23	2.05
	6/1/2010	25.30	0.89	
	6/2/2010	26.30	1.08	
	6/3/2010	26.50	1.12	
	6/4/2010	27.30	1.27	
	6/5/2010	28.30	1.48	
	6/6/2010	29.20	1.68	
	6/7/2010	29.80	1.78	
	6/8/2010	30.50	1.94	
	6/9/2010	28.80	1.53	
	6/10/2010	30.30	1.87	
	6/11/2010	25.40	0.77	
	6/12/2010	25.70	0.80	
	6/13/2010	25.50	0.76	
	6/14/2010	25.80	0.80	
	6/15/2010	27.70	1.19	
	6/16/2010	28.40	1.32	
	6/17/2010	26.10	0.82	
	6/18/2010	25.70	0.72	
	6/19/2010	27.00	0.97	
	6/20/2010	26.10	0.77	
	6/21/2010	25.70	0.67	
	6/22/2010	26.00	0.73	
	6/23/2010	25.80	0.65	
	6/24/2010	26.30	0.75	
	6/25/2010	26.90	0.86	
	6/26/2010	27.90	1.06	
	6/27/2010	27.30	0.92	
	6/28/2010	28.30	1.13	
	6/29/2010	29.20	1.31	
	6/30/2010	28.30	1.09	1.10
	7/1/2010	28.50	0.67	
	7/2/2010	28.10	0.57	
	7/3/2010	27.20	0.37	
	7/4/2010	28.40	0.61	
	7/5/2010	27.20	0.35	
	7/6/2010	27.20	0.34	
	7/7/2010	27.00	0.29	
	7/8/2010	27.50	0.37	
	7/9/2010	28.40	0.57	
	7/10/2010	29.70	0.83	
	7/11/2010	30.90	1.10	
	7/12/2010	31.70	1.27	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/13/2010	32.00	1.35	
	7/14/2010	31.30	1.18	
	7/15/2010	31.50	1.23	
	7/16/2010	32.60	1.47	
	7/17/2010	31.90	1.30	
	7/18/2010	32.70	1.48	
	7/19/2010	32.50	1.44	
	7/20/2010	31.70	1.25	
	7/21/2010	30.30	0.93	
	7/22/2010	30.20	0.91	
	7/23/2010	30.70	1.01	
	7/24/2010	28.60	0.57	
	7/25/2010	31.40	1.20	
	7/26/2010	31.30	1.17	
	7/27/2010	27.90	0.43	
	7/28/2010	28.10	0.47	
	7/29/2010	32.00	1.38	
	7/30/2010	30.70	1.07	0.91
WF20	5/14/2010	26.20	2.71	
	5/15/2010	26.40	2.73	
	5/16/2010	27.30	2.93	
	5/17/2010	24.40	2.25	
	5/18/2010	26.20	2.66	
	5/19/2010	26.90	2.80	
	5/20/2010	27.80	3.01	
	5/21/2010	29.00	3.30	
	5/22/2010	26.50	2.68	
	5/23/2010	22.50	1.78	
	5/24/2010	20.10	0.95	
	5/25/2010	24.50	1.62	
	5/26/2010	25.60	1.78	
	5/27/2010	28.20	2.22	
	5/28/2010	26.30	1.87	
	5/29/2010	24.20	1.52	
	5/30/2010	27.00	1.98	
	5/31/2010	27.10	1.98	2.27
	6/1/2010	26.90	1.24	
	6/2/2010	28.90	1.67	
	6/3/2010	28.70	1.60	
	6/4/2010	30.20	1.94	
	6/5/2010	31.50	2.25	
	6/6/2010	31.50	2.23	
	6/7/2010	31.20	2.14	
	6/8/2010	32.20	2.37	
	6/9/2010	30.90	2.03	
	6/10/2010	31.60	2.19	
	6/11/2010	27.70	1.25	
	6/12/2010	28.30	1.38	
	6/13/2010	26.20	0.90	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	6/14/2010	27.80	1.24	
	6/15/2010	29.40	1.57	
	6/16/2010	28.60	1.38	
	6/17/2010	27.50	1.12	
	6/18/2010	26.20	0.82	
	6/19/2010	27.20	1.02	
	6/20/2010	26.30	0.81	
	6/21/2010	25.90	0.72	
	6/22/2010	26.80	0.88	
	6/23/2010	26.90	0.89	
	6/24/2010	27.00	0.90	
	6/25/2010	27.60	1.01	
	6/26/2010	27.90	1.06	
	6/27/2010	28.70	1.23	
	6/28/2010	28.80	1.24	
	6/29/2010	29.40	1.36	
	6/30/2010	29.00	1.25	1.39
	7/1/2010	29.90	0.98	
	7/2/2010	28.10	0.59	
	7/3/2010	26.50	0.23	
	7/4/2010	28.00	0.52	
	7/5/2010	27.30	0.36	
	7/6/2010	27.70	0.44	
	7/7/2010	27.80	0.45	
	7/8/2010	27.50	0.38	
	7/9/2010	29.70	0.84	
	7/10/2010	29.70	0.84	
	7/11/2010	31.20	0.87	
	7/12/2010	32.70	1.12	
	7/13/2010	32.80	1.14	
	7/14/2010	32.80	1.13	
	7/15/2010	33.00	1.17	
	7/16/2010	32.60	1.10	
	7/17/2010	33.10	1.18	
	7/18/2010	33.60	1.28	
	7/19/2010	33.00	1.17	
	7/20/2010	31.70	0.93	
	7/21/2010	30.10	0.66	
	7/22/2010	30.30	0.69	
	7/23/2010	29.90	0.62	
	7/24/2010	28.50	0.39	
	7/25/2010	31.20	0.86	
	7/26/2010	30.40	0.72	
	7/27/2010	27.70	0.29	
	7/28/2010	28.70	0.45	
	7/29/2010	32.10	1.03	
	7/30/2010	25.60	0.01	0.75
WF21	5/14/2010	26.80	2.85	
	5/15/2010	27.00	2.90	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	5/16/2010	27.40	2.96	
	5/17/2010	25.90	2.59	
	5/18/2010	26.60	2.76	
	5/19/2010	27.10	2.86	
	5/20/2010	28.50	3.19	
	5/21/2010	28.90	3.26	
	5/22/2010	26.90	2.76	
	5/23/2010	22.30	1.73	
	5/24/2010	21.60	1.57	
	5/25/2010	25.60	2.43	
	5/26/2010	26.00	2.51	
	5/27/2010	28.80	3.14	
	5/28/2010	26.80	2.66	
	5/29/2010	23.70	1.94	
	5/30/2010	27.90	2.88	
	5/31/2010	28.00	2.91	2.66
	6/1/2010	26.80	1.23	
	6/2/2010	29.50	1.83	
	6/3/2010	29.30	1.75	
	6/4/2010	30.80	2.09	
	6/5/2010	32.40	2.47	
	6/6/2010	32.40	2.45	
	6/7/2010	32.60	2.49	
	6/8/2010	33.00	2.57	
	6/9/2010	31.80	2.26	
	6/10/2010	32.50	2.41	
	6/11/2010	28.30	1.39	
	6/12/2010	29.70	1.69	
	6/13/2010	28.00	1.30	
	6/14/2010	29.20	1.56	
	6/15/2010	30.30	1.79	
	6/16/2010	30.50	1.83	
	6/17/2010	29.20	1.50	
	6/18/2010	28.20	1.27	
	6/19/2010	29.20	1.48	
	6/20/2010	28.80	1.37	
	6/21/2010	28.00	1.17	
	6/22/2010	28.80	1.33	
	6/23/2010	29.50	1.48	
	6/24/2010	29.50	1.48	
	6/25/2010	30.10	1.59	
	6/26/2010	30.00	1.54	
	6/27/2010	31.10	1.79	
	6/28/2010	31.40	1.86	
	6/29/2010	31.80	1.94	
	6/30/2010	31.30	1.80	1.76
	7/1/2010	32.50	1.60	
	7/2/2010	30.40	1.10	
	7/3/2010	29.00	0.77	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/4/2010	31.20	1.24	
	7/5/2010	30.30	1.02	
	7/6/2010	30.40	1.05	
	7/7/2010	30.60	1.07	
	7/8/2010	30.50	1.05	
	7/9/2010	32.10	1.41	
	7/10/2010	32.50	1.51	
	7/11/2010	33.70	1.79	
	7/12/2010	34.80	2.06	
	7/13/2010	34.70	2.02	
	7/14/2010	35.10	2.11	
	7/15/2010	35.50	2.21	
	7/16/2010	35.80	1.69	
	7/17/2010	35.30	1.59	
	7/18/2010	35.80	1.69	
	7/19/2010	35.90	1.71	
	7/20/2010	34.80	1.50	
	7/21/2010	32.40	1.06	
	7/22/2010	32.90	1.14	
	7/23/2010	31.80	0.96	
	7/24/2010	30.60	0.75	
	7/25/2010	33.60	1.29	
	7/26/2010	32.90	1.16	
	7/27/2010	30.10	0.68	
	7/28/2010	31.10	0.86	
	7/29/2010	35.60	1.69	
	7/30/2010	35.10	1.60	
	7/31/2010	31.50	0.95	1.37
WF10	5/1/2011	17.60	3.76	
	5/2/2011	19.50	4.26	
	5/3/2011	22.40	4.99	
	5/4/2011	23.50	5.34	
	5/5/2011	27.10	6.35	
	5/6/2011	26.70	6.28	
	5/7/2011	27.70	6.60	
	5/8/2011	26.60	6.34	
	5/9/2011	23.30	5.45	
	5/10/2011	20.10	4.67	
	5/11/2011	21.80	5.12	
	5/12/2011	23.50	5.62	
	5/13/2011	25.20	6.10	
	5/14/2011	25.20	6.14	
	5/15/2011	25.00	6.07	
	5/16/2011	20.50	4.95	
	5/17/2011	22.00	5.37	
	5/18/2011	17.30	4.18	
	5/19/2011	19.90	4.83	
	5/20/2011	22.50	5.56	
	5/21/2011	23.90	5.93	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	5/22/2011	24.60	6.16	
	5/23/2011	25.40	6.39	
	5/24/2011	22.70	5.67	
	5/25/2011	23.00	5.79	
	5/26/2011	24.90	6.29	
	5/27/2011	25.60	6.53	
	5/28/2011	26.90	6.90	
	5/29/2011	21.00	5.31	
	5/30/2011	20.70	5.22	
	5/31/2011	20.30	5.13	5.59
	6/1/2011	21.60	4.15	
	6/2/2011	22.90	4.45	
	6/3/2011	22.10	4.29	
	6/4/2011	22.40	4.34	
	6/5/2011	23.40	4.60	
	6/6/2011	24.10	4.80	
	6/7/2011	22.00	4.27	
	6/8/2011	23.70	4.70	
	6/9/2011	24.40	4.85	
	6/10/2011	25.20	5.08	
	6/11/2011	25.50	5.18	
	6/12/2011	25.30	5.09	
	6/13/2011	25.80	5.22	
	6/14/2011	27.00	5.56	
	6/15/2011	27.20	5.60	
	6/16/2011	30.10	6.40	
	6/17/2011	27.20	5.58	
	6/18/2011	27.10	5.55	
	6/19/2011	27.30	5.58	
	6/20/2011	26.80	5.43	
	6/21/2011	28.50	5.91	
	6/22/2011	27.90	5.70	
	6/23/2011	31.00	6.59	
	6/24/2011	29.40	6.07	
	6/25/2011	28.00	5.69	
	6/26/2011	27.40	5.49	
	6/27/2011	27.20	5.43	
	6/28/2011	28.20	5.69	
	6/29/2011	31.20	6.52	
	6/30/2011	26.50	5.20	5.30
	7/1/2011	26.00	4.73	
	7/2/2011	26.80	4.89	
	7/3/2011	29.10	5.49	
	7/4/2011	26.40	4.73	
	7/5/2011	28.90	5.38	
	7/6/2011	27.20	4.91	
	7/7/2011	30.80	5.85	
	7/8/2011	30.80	5.83	
	7/9/2011	30.70	5.76	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/10/2011	31.20	5.89	
	7/11/2011	30.80	5.73	
	7/12/2011	28.90	5.18	
	7/13/2011	26.80	4.59	
	7/14/2011	26.40	4.45	
	7/15/2011	27.00	4.60	
	7/16/2011	26.60	4.47	
	7/17/2011	25.40	4.12	
	7/18/2011	28.90	4.98	
	7/19/2011	32.30	5.91	
	7/20/2011	31.00	5.52	
	7/21/2011	28.40	4.76	
	7/22/2011	27.10	4.39	
	7/23/2011	31.70	5.59	
	7/24/2011	23.40	3.41	5.05
WF17	5/13/2011	29.40	3.48	
	5/14/2011	25.50	2.55	
	5/15/2011	24.40	2.27	
	5/16/2011	19.70	1.29	
	5/17/2011	19.80	1.31	
	5/18/2011	20.00	1.34	
	5/19/2011	19.50	1.22	
	5/20/2011	23.20	1.96	
	5/21/2011	24.00	2.12	
	5/22/2011	24.10	2.13	
	5/23/2011	26.30	2.60	
	5/24/2011	22.40	1.73	
	5/25/2011	23.10	1.87	
	5/26/2011	25.10	2.28	
	5/27/2011	24.90	2.22	
	5/28/2011	25.00	2.25	
	5/29/2011	23.10	1.81	
	5/30/2011	21.00	1.38	
	5/31/2011	21.90	1.53	1.96
	6/1/2011	22.60	0.36	
	6/2/2011	21.80	0.20	
	6/3/2011	21.70	0.16	
	6/4/2011	22.90	0.37	
	6/5/2011	23.90	0.55	
	6/6/2011	24.00	0.55	
	6/7/2011	22.10	0.18	
	6/8/2011	23.20	0.38	
	6/9/2011	24.10	0.53	
	6/10/2011	24.50	0.59	
	6/11/2011	25.60	0.81	
	6/12/2011	24.40	0.54	
	6/13/2011	24.90	0.62	
	6/14/2011	25.50	0.73	
	6/15/2011	26.50	0.93	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	6/16/2011	29.50	1.59	
	6/17/2011	29.00	1.45	
	6/18/2011	26.60	0.91	
	6/19/2011	27.40	1.05	
	6/20/2011	26.80	0.91	
	6/21/2011	26.90	0.93	
	6/22/2011	27.30	1.00	
	6/23/2011	29.50	1.48	
	6/24/2011	28.40	1.20	
	6/25/2011	27.10	0.90	
	6/26/2011	26.30	0.71	
	6/27/2011	26.90	0.83	
	6/28/2011	27.00	0.85	
	6/29/2011	30.40	1.58	
	6/30/2011	27.00	0.82	0.79
	7/1/2011	26.90	0.33	
	7/2/2011	27.10	0.36	
	7/3/2011	29.20	0.81	
	7/4/2011	30.10	0.99	
	7/5/2011	30.60	1.09	
	7/6/2011	28.50	0.60	
	7/7/2011	29.50	0.82	
	7/8/2011	30.60	1.05	
	7/9/2011	30.50	1.04	
	7/10/2011	30.50	1.02	
	7/11/2011	29.70	0.83	
	7/12/2011	27.30	0.31	
	7/13/2011	27.00	0.24	
	7/14/2011	25.80	-0.01	
	7/15/2011	27.00	0.22	
	7/16/2011	25.80	-0.02	
	7/17/2011	24.80	-0.22	
	7/18/2011	27.50	0.32	
	7/19/2011	29.80	0.81	
	7/20/2011	31.20	1.13	
	7/21/2011	27.90	0.41	
	7/22/2011	26.00	0.01	
	7/23/2011	29.10	0.67	
	7/24/2011	30.70	1.02	
	7/25/2011	30.40	0.97	
	7/26/2011	30.30	0.95	
	7/27/2011	28.80	0.62	
	7/28/2011	29.50	0.79	
	7/29/2011	30.40	0.99	
	7/30/2011	31.30	1.22	
	7/31/2011	30.30	0.99	0.67
WF35	5/13/2011	27.90	3.13	
	5/14/2011	24.10	2.23	
	5/15/2011	25.90	2.61	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	5/16/2011	19.90	1.32	
	5/17/2011	18.70	1.09	
	5/18/2011	20.80	1.48	
	5/19/2011	19.30	1.17	
	5/20/2011	21.90	1.67	
	5/21/2011	22.80	1.86	
	5/22/2011	22.70	1.82	
	5/23/2011	25.90	2.51	
	5/24/2011	21.00	1.46	
	5/25/2011	21.90	1.61	
	5/26/2011	23.90	2.01	
	5/27/2011	23.50	1.92	
	5/28/2011	24.70	2.16	
	5/29/2011	23.40	1.86	
	5/30/2011	19.50	1.07	
	5/31/2011	20.90	1.33	1.81
	6/1/2011	23.30	0.49	
	6/2/2011	21.90	0.21	
	6/3/2011	20.90	0.02	
	6/4/2011	22.60	0.31	
	6/5/2011	22.50	0.29	
	6/6/2011	24.70	0.70	
	6/7/2011	21.70	0.11	
	6/8/2011	23.30	0.39	
	6/9/2011	22.90	0.30	
	6/10/2011	23.70	0.44	
	6/11/2011	25.30	0.74	
	6/12/2011	24.50	0.56	
	6/13/2011	24.10	0.47	
	6/14/2011	24.50	0.53	
	6/15/2011	25.30	0.68	
	6/16/2011	28.10	1.26	
	6/17/2011	28.00	1.23	
	6/18/2011	25.50	0.67	
	6/19/2011	25.20	0.59	
	6/20/2011	24.10	0.36	
	6/21/2011	24.70	0.47	
	6/22/2011	25.70	0.66	
	6/23/2011	28.80	1.30	
	6/24/2011	27.20	0.95	
	6/25/2011	26.10	0.70	
	6/26/2011	24.50	0.35	
	6/27/2011	25.30	0.50	
	6/28/2011	26.50	0.74	
	6/29/2011	29.40	1.36	
	6/30/2011	25.20	0.44	0.59
	7/1/2011	24.90	0.06	
	7/2/2011	26.00	0.13	
	7/3/2011	28.20	0.59	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/4/2011	28.20	0.57	
	7/5/2011	28.90	0.71	
	7/6/2011	27.20	0.34	
	7/7/2011	29.50	0.83	
	7/8/2011	30.00	0.92	
	7/9/2011	30.20	0.95	
	7/10/2011	30.40	0.99	
	7/11/2011	29.50	0.79	
	7/12/2011	27.20	0.28	
	7/13/2011	26.30	0.08	
	7/14/2011	25.30	0.12	
	7/15/2011	25.80	0.02	
	7/16/2011	24.90	0.21	
	7/17/2011	24.50	0.29	
	7/18/2011	26.10	0.03	
	7/19/2011	29.40	0.73	
	7/20/2011	29.70	0.80	
	7/21/2011	27.60	0.35	
	7/22/2011	25.50	0.09	
	7/23/2011	28.80	0.59	
	7/24/2011	29.50	0.75	
	7/25/2011	29.40	0.74	
	7/26/2011	29.50	0.78	
	7/27/2011	28.70	0.59	
	7/28/2011	28.70	0.61	
	7/29/2011	30.00	0.91	
	7/30/2011	30.90	1.13	
	7/31/2011	30.70	1.09	0.55
WF36	5/15/2011	24.70	2.29	
	5/16/2011	19.40	1.19	
	5/17/2011	20.20	1.33	
	5/18/2011	19.80	1.24	
	5/19/2011	17.50	0.80	
	5/20/2011	23.70	2.00	
	5/21/2011	23.90	2.02	
	5/22/2011	22.70	1.75	
	5/23/2011	25.90	2.43	
	5/24/2011	22.80	1.73	
	5/25/2011	21.30	1.42	
	5/26/2011	26.10	2.45	
	5/27/2011	23.20	1.78	
	5/28/2011	25.80	2.34	
	5/29/2011	22.10	1.53	
	5/30/2011	20.40	1.18	
	5/31/2011	20.30	1.14	1.68
	6/1/2011	21.00	0.01	
	6/2/2011	22.00	0.15	
	6/3/2011	20.10	0.20	
	6/4/2011	22.70	0.26	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	6/5/2011	23.80	0.44	
	6/6/2011	23.20	0.31	
	6/7/2011	20.90	0.13	
	6/8/2011	22.00	0.07	
	6/9/2011	22.00	0.05	
	6/10/2011	23.60	0.33	
	6/11/2011	27.30	1.08	
	6/12/2011	24.50	0.48	
	6/13/2011	24.10	0.37	
	6/14/2011	24.20	0.38	
	6/15/2011	25.60	0.65	
	6/16/2011	29.20	1.40	
	6/17/2011	29.70	1.51	
	6/18/2011	26.70	0.83	
	6/19/2011	25.10	0.48	
	6/20/2011	23.60	0.17	
	6/21/2011	24.20	0.28	
	6/22/2011	25.60	0.54	
	6/23/2011	28.60	1.16	
	6/24/2011	29.40	1.33	
	6/25/2011	26.80	0.74	
	6/26/2011	26.40	0.63	
	6/27/2011	27.00	0.76	
	6/28/2011	26.80	0.70	
	6/29/2011	32.70	2.04	
	6/30/2011	25.30	0.37	0.59
	7/1/2011	24.50	0.25	
	7/2/2011	24.10	0.33	
	7/3/2011	29.30	0.73	
	7/4/2011	28.60	0.56	
	7/5/2011	29.20	0.69	
	7/6/2011	26.20	0.03	
	7/7/2011	28.40	0.49	
	7/8/2011	29.40	0.70	
	7/9/2011	29.90	0.79	
	7/10/2011	31.50	1.16	
	7/11/2011	30.10	0.82	
	7/12/2011	28.20	0.40	
	7/13/2011	27.40	0.23	
	7/14/2011	26.30	0.00	
	7/15/2011	26.80	0.09	
	7/16/2011	25.20	0.21	
	7/17/2011	22.80	0.66	
	7/18/2011	26.20	0.02	
	7/19/2011	30.40	0.88	
	7/20/2011	32.60	1.40	
	7/21/2011	30.20	0.83	
	7/22/2011	27.20	0.20	
	7/23/2011	30.50	0.92	

Table C.1. Yellow-billed cuckoo and Southwestern willow flycatcher potential evapotranspiration (PET) results.

Site Name	Date	Average air temperature (degrees Celsius)	PET (millimeters/day)	Daily Average Per Month (millimeters/day)
	7/24/2011	31.50	1.14	
	7/25/2011	28.50	0.49	
	7/26/2011	30.30	0.89	
	7/27/2011	30.30	0.90	
	7/28/2011	28.60	0.54	
	7/29/2011	29.20	0.69	
	7/30/2011	29.80	0.83	
	7/31/2011	28.20	0.49	0.59

APPENDIX D
Logistic Regression Results

Logistic Regression

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	365	100.0
	Missing Cases	0	.0
	Total	365	100.0
Unselected Cases		0	.0
Total		365	100.0

a. If weight is in effect, see classification table for the total number of cases.

Dependent Variable Encoding

Original Value	Internal Value
1.00	0
2.00	1

Block 0: Beginning Block

Iteration History[a,b,c]

Iteration		-2 Log likelihood	Coefficients Constant
Step 0	1	505.666	.060
	2	505.666	.060

a. Constant is included in the model.

b. Initial -2 Log Likelihood: 505.666

c. Estimation terminated at iteration number 2 because parameter estimates changed by less than .001.

Classification Table[a,b]

Observed			Predicted SPECIES 1.00	Predicted SPECIES 2.00	Percentage Correct
Step 0	SPECIES	1.00	0	177	.0
		2.00	0	188	100.0
	Overall Percentage				51.5

a. Constant is included in the model.

b. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	.060	.105	.331	1	.565	1.062

Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	TMOIST	130.144	1	.000
		TEMP	10.135	1	.001
		TOM	49.062	1	.000
		DEPTH	142.529	1	.000
		TDISTANC	32.532	1	.000
		TSAND	48.116	1	.000
	Overall Statistics		210.685	6	.000

Block 1: Method = Enter

Iteration History[a,b,c,d]

Iteration		-2 Log likelihood	Coefficients						
			Constant	TMOIST	TEMP	TOM	DEPTH	TDISTANC	TSAND
Step 1	1	266.990	-3.922	-.185	.010	-.067	.717	.047	.394
	2	234.019	-6.267	-.273	.026	.022	1.128	.062	.582
	3	228.041	-7.777	-.312	.038	.132	1.422	.065	.683
	4	227.643	-8.257	-.323	.042	.179	1.529	.065	.713
	5	227.640	-8.297	-.324	.042	.184	1.539	.065	.715

a. Method: Enter

b. Constant is included in the model.

c. Initial -2 Log Likelihood: 505.666

d. Estimation terminated at iteration number 5 because log-likelihood decreased by less than .010 percent.

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	278.026	6	.000
	Block	278.026	6	.000
	Model	278.026	6	.000

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	227.640	.533	.711

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	8.642	8	.373

Contingency Table for Hosmer and Lemeshow Test

		SPECIES = 1.00		SPECIES = 2.00		Total
		Observed	Expected	Observed	Expected	
Step 1	1	37	36.688	0	.312	37
	2	37	35.771	0	1.229	37
	3	33	33.671	4	3.329	37
	4	26	29.135	11	7.865	37
	5	25	20.855	12	16.145	37
	6	10	12.224	27	24.776	37
	7	4	5.571	33	31.429	37
	8	3	1.971	34	35.029	37
	9	2	.872	35	36.128	37
	10	0	.244	32	31.756	32

Classification Table[a]

			Predicted		
			SPECIES		Percentage Correct
	Observed		1.00	2.00	
Step 1	SPECIES	1.00	153	24	86.4
		2.00	24	164	87.2
	Overall Percentage				86.8

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	TMOIST	-.324	.182	3.177	1	.075	.724	.507	1.033
	TEMP	.042	.032	1.760	1	.185	1.043	.980	1.109
	TOM	.184	.332	.308	1	.579	1.202	.627	2.303
	DEPTH	1.539	.228	45.361	1	.000	4.659	2.977	7.292
	TDISTANC	.065	.021	9.709	1	.002	1.068	1.025	1.112
	TSAND	.715	.199	12.975	1	.000	2.045	1.386	3.018
	Constant	-8.297	2.586	10.290	1	.001	.000		

a. Variable(s) entered on step 1: TMOIST, TEMP, TOM, DEPTH, TDISTANC, TSAND.

Correlation Matrix

		Constant	TMOIST	TEMP	TOM	DEPTH	TDISTANC	TSAND
Step 1	Constant	1.000	-.804	-.402	.093	-.470	-.452	-.913
	TMOIST	-.804	1.000	.038	-.113	.280	.312	.746
	TEMP	-.402	.038	1.000	-.082	.041	-.036	.141
	TOM	.093	-.113	-.082	1.000	-.007	-.291	-.284
	DEPTH	-.470	.280	.041	-.007	1.000	-.038	.422
	TDISTANC	-.452	.312	-.036	-.291	-.038	1.000	.544
	TSAND	-.913	.746	.141	-.284	.422	.544	1.000

```
Step number: 1

Observed Groups and Predicted Probabilities
```

```
      40 ⇧                                                          2⇧
         ⇔                                                           2⇔
         ⇔1                                                          2⇔
F        ⇔1                                                          2⇔
R     30 ⇧1                                                         22⇧
E        ⇔1                                                          22⇔
Q        ⇔1                                                          22⇔
U        ⇔11                                                         22⇔
E     20 ⇧11                                                        222⇧
N        ⇔11                                                         222⇔
C        ⇔11                                                         222⇔
Y        ⇔11 1                                                       222⇔
      10 ⇧11111                                                     2222⇧
         ⇔1111112    2                                 2    2   2  22222⇔
         ⇔1111111  2121  2  1        2  2    2    22 2    2 2 22222222⇔
         ⇔1111111212111111 21 11 222112112 1 22 2 2221 222122 22222112⇔
Predicted
⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇧⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇧⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇧⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩
⇩⇩⇩
  Prob:   0            .25            .5             .75             1
  Group:  1111111111111111111111111111112222222222222222222222222222222

          Predicted Probability is of Membership for 2.00
          The Cut Value is .50
          Symbols: 1 - 1.00
                   2 - 2.00
          Each Symbol Represents 2.5 Cases.
```

APPENDIX E
Irrigation Schedules of Restoration Sites

Beal 2010-2011 Irrigation Schedule

2010 Beal Irrigation Schedule

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
AF applied			127*	143	156	149	158	179	169	154	78*	

* Irrigation did not occur through the entire month

Calculated Total Water Use for 2010 (acre-feet)	1313
Average Water Use/Wk (acre-feet)	37.5

2011 Beal Irrigation Schedule

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
AF applied			31*	174	117	134	140	180	143			

*Irrigation did not occur through the entire month

Calculated Total Water Use for 2011 (acre-feet)	888
Average Water Use/Wk (acre-feet)	32.9

Palo Verde Ecological Reserve 2011 Irrigation Schedule

Field 15	20 acres	Field 16	10 acres	Field 17	72 acres	Field 18	73 acres	Field 12	70 acres	Field 13	9 acres
Date	Hours	Date	Hours	Date	Hours	Date	Hours	Date		Date	Hours
23-Jan	8	26-Jan	8	26-Jan	22	6-Mar	15	26-Jan	15	23-Jan	5
3-Mar	2			29-Jan	10	28-Mar	10	27-Jan	15	3-Mar	4
4-Mar	1			5-Mar	19	29-Mar	24	5-Mar	9	26-Mar	3
27-Mar	7					30-Mar	2	6-Mar	16		
								24-Mar	9		
								25-Mar	16		
sub total	18		8		51		51		80		12
af appplied	1.875		1.66		1.45		1.45		2.38		1.3
18-Apr	7	18-May	9	18-Apr	10	19-Apr	8	15-Apr	24	17-Apr	5
4-May	4			19-Apr	16	20-Apr	24	26-Apr	2	4-May	5
5-May	5			6-May	12	21-Apr	19	30-Apr	5	17-May	5
18-May	8			7-May	24	8-May	24	1-May	22	28-May	8
29-May	15			18-May	5	9-May	24	14-May	16	10-Jun	6
10-Jun	5			19-May	15	11-May	3	15-May	18	22-Jun	4
11-Jun	4.00			31-May	13	19-May	3	27-May	18	23-Jun	2
23-Jun	9			1-Jun	24	20-May	24	28-May	17		
				2-Jun	16	21-May	24	7-Jun	13		
				13-Jun	3	22-May	5	8-Jun	20		
				14-Jun	24	2-Jun	8	18-Jun	24		
				15-Jun	24	3-Jun	24	19-Jun	18		
				16-Jun	10	4-Jun	12	27-Jun	12		
				25-Jun	18	16-Jun	14	28-Jun	24		
				26-Jun	24	17-Jun	24	29-Jun	5		
				27-Jun	18	18-Jun	24				
						19-Jun	7				
						27-Jun	6				
						28-Jun	24				
						29-Jun	24				
						30-Jun	5				
sub-total	57		9		256		330		238		35
af applied	5.9		1.875		7.4		9		7.08		8.1
af applied to date	7.775		3.535		8.85		11		9.46		9.4

Formula based on the following 1 cfs=2 af/day, Ditch capacity 25cfs = 50af/day. 50af/day x hours irrigated/24 hours.
AF/acreage = water applied. This is based on the ditch running at capacity.

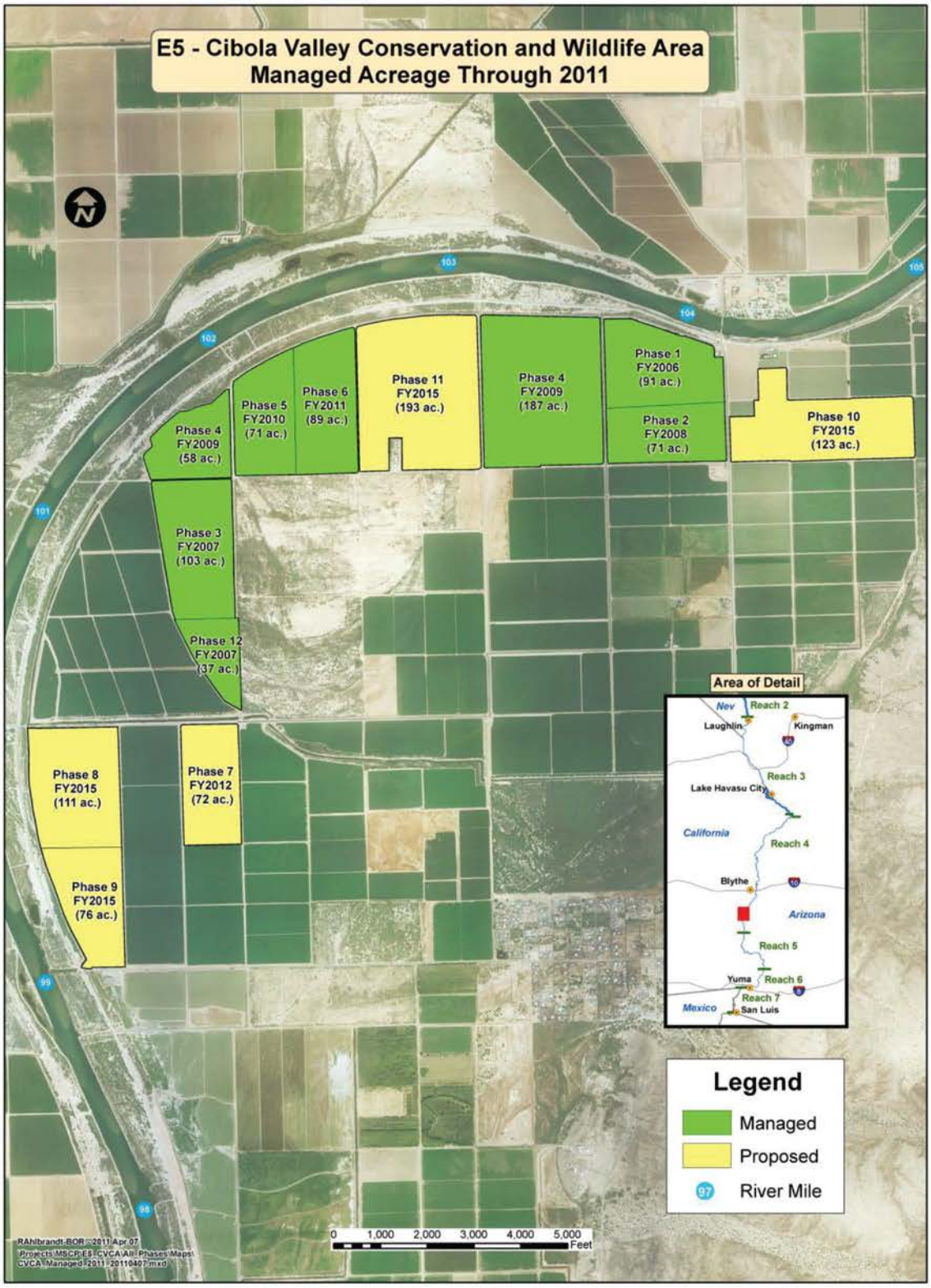
Field 14	19 acres	Field 11	62 acres	Field 10	69 acres	Field 9	78 acres	Field 7	111 acres	Field 8	99 acres
Date	Hours	Date	Hours	Date	Hours	Date	Hours	Date	Hours	Date	
23-Jan	5	25-Jan	8	25-Jan	10	25-Jan	5	28-Mar	5	2-Mar	11
3-Mar	4	1-Mar	9	1-Mar	9	26-Jan	9	29-Mar	5		
26-Mar	4	23-Mar	11	23-Mar	6	2-Mar	11	30-Mar	5		
				24-Mar	2	24-Mar	11	31-Mar	5		
	9		28		27		36		20		11
	0.98		0.94		0.72		0.96		0.37		0.23
18-Apr	5	14-Apr	7	17-Apr	11	13-Apr	9	1-Apr	5	2-Apr	3
4-May	5	30-Apr	8	30-Apr	11	14-Apr	6	2-Apr	3	4-Apr	2
17-May	5	13-May	8	12-May	8	29-Apr	12	4-Apr	4	5-Apr	6
29-May	4	24-May	10	13-May	5	13-May	10	6-Apr	3	6-Apr	5
10-Jun	6	6-Jun	9	24-May	8	14-May	8	7-Apr	5	7-Apr	5
23-Jun	6	17-Jun	6	25-May	5	27-May	4	8-Apr	3	8-Apr	5
		26-Jun	10	5-Jun	2	28-May	15	9-Apr	3	13-Apr	11
				6-Jun	1.5	6-Jun	22	11-Apr	2	19-Apr	2
				17-Jun	11	16-Jun	16	16-Apr	12	20-Apr	7
				25-Jun	11	17-Jun	7	25-Apr	13	29-Apr	12
				25-Jun	10	26-Jun	4	3-May	17	8-May	14
						27-Jun	12	4-May	1	16-May	17
								11-May	2	17-May	3
								12-May	16	25-May	16
								19-May	5	3-Jun	12
								20-May	13	4-Jun	7
								27-May	14	14-Jun	14
								4-Jun	17	15-Jun	6
								13-Jun	11	23-Jun	12
								14-Jun	10	26-Jun	12
								22-Jun	14		
								23-Jun	12		
	31		58		83.5		125		185		171
	3.39		1.94		2.52		3.33		3.47		3.59
	4.37		2.88		3.24		4.29		3.84		3.82

Cibola Valley Conservation Area 2010 Irrigation Schedule

	2010						
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	GS
March	47	40	75	0	19	46	0
April	122	0	40	40	24	81	102
May	113	45	106	19	22	32	0
June	134	83	89	17	30	0	161
July	166	55	104	48	15	0	234
August	35	0	109	0	0	0	53
September	37	0	0	0	0	0	38
October							
November							
Totals	653	224	523	123	110	159	587

Cibola Valley Conservation Area 2011 Irrigation Schedule

Phase Number	1	2	4	3	5	TOTAL
Mar 3 2011	34					
Mar 2 2011			30.30			
Mar 4 2011		6.90				
Mar 7 2011		10.00				
Mar 8 2011				7.80	21.10	
						110.10
April 5 2011			21.00			
April 18 2011			25.40	16.50	16.90	
April 25 2011	30.90	20.60	17.30			
						148.60
May 16 2011	38.60		17.80		23.70	
May 23 2011		14.30	25.90	9.40		
June 13 2011	44.90				22.70	
June 20 2011	17.00	16.40	27.10	7.50		
						135.60
July 11 2011		27.30		13.70		
July 9 2011	23.40					
July 7 2011			23.70			
Jluy 8 2011			26.00		11.90	
						126.00
Aug 2 2011	33.30					
Aug 3 2011		20.00	37.40	13.40		
Aug 4 2011					19.40	
						123.50
Sub Totals	222.10	115.50	251.90	68.30	115.70	643.80
Grand Total						773.50


E5 - Cibola Valley Conservation and Wildlife Area
Managed Acreage Through 2011
N
103
105
104
102
101
99
98
Phase 1
FY2006
(91 ac.)
Phase 2
FY2008
(71 ac.)
Phase 10
FY2015
(123 ac.)
Phase 11
FY2015
(193 ac.)
Phase 4
FY2009
(187 ac.)
Phase 5
FY2010
(71 ac.)
Phase 6
FY2011
(89 ac.)
Phase 4
FY2009
(58 ac.)
Phase 3
FY2007
(103 ac.)
Phase 12
FY2007
(37 ac.)
Phase 8
FY2015
(111 ac.)
Phase 7
FY2012
(72 ac.)
Phase 9
FY2015
(76 ac.)
Area of Detail
Nev
Reach 2
Laughlin
Kingman
Reach 3
Lake Havasu City
California
Reach 4
Blythe
Arizona
Reach 5
Yuma
Reach 6
Reach 7
Mexico
San Luis
Legend
Managed
Proposed
97
River Mile
0 1,000 2,000 3,000 4,000 5,000
Feet
RAhlbrandt-BOR - 2011 Apr 07
Projects\MSCP\E5_CVCA\All Phases\Maps\
CVCA Managed 2011 20110407.mxd