National Park Service
U.S. Department of the Interior

Grand Canyon National Park

Surveying for Southwestern Willow Flycatchers in Grand Canyon National Park, 2010-2012

Final Project Report

ON THE COVER
Top left photo: Southwestern willow flycatcher
Photograph by: Bob Steele
Top right photo: Biological Technician Jean Lawrence
Photograph by: Janice Stroud-Settles
Bottom photo: Colorado River in Grand Canyon National Park
Photograph by: Grand Canyon Division of Science and Resource Management

Surveying for Southwestern Willow Flycatchers in Grand Canyon National Park, 2010-2012

Final Project Report

Janice Stroud-Settles

National Park Service
P.O. Box 129
Grand Canyon, Arizona 86023

Gregory Holm

National Park Service
P.O. Box 129
Grand Canyon, Arizona 86023

Rosa Palarino

National Park Service
P.O. Box 129
Grand Canyon, Arizona 86023

August 2013

U.S. Department of the Interior
National Park Service
Grand Canyon National Park
Grand Canyon, Arizona

Contents

Contents (continued)

Figures

Tables

Page

Acknowledgments

The authors would like to thank those who were involved in the many aspects of this project: R.V. Ward, Tim Bowden, and Rosa Palarino for initiating and securing funding for the project and leading the first year of surveys; Nate Alvord for safely guiding us down the Colorado River and providing logistical support to the project; Emily Keil (formerly Slayton) and Jean Lawrence for excellent field data collection; Joseph Monfeli for developing a recognizer sound file and analyzing two years of sound data; Tom Koronkiewicz, the US Fish and Wildlife Service, and SWCA Environmental Consultants for helping provide field training; and Lori Makarick, Levi Jamison, Christopher Holms, Maddie Tighe, Kate Peterlein, Eric Frye, and Brian Reif for providing support on and off the river and for diligently tracking the tamarisk beetle. Lastly, the authors would also like to thank the Bureau of Reclamation for providing funding for the project.

Abbreviations

BHCO	Brown-headed Cowbird
ESA	Endangered Species Act
GIS	Geographic Information Systems
GPS	Global Positioning System
GRCA	Grand Canyon National Park
GCMRC	Grand Canyon Monitoring and Research Center
HCP	Habitat Conservation Plan
Hz	Hertz
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
NHWZ	New High Water Zone
NPS	National Park Service
OHWZ	Old High Water Zone
RM	River Mile
SWFL	Southwestern Willow Flycatcher
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
UTM	Universal Transverse Mercator

Executive Summary

From 2010-2012, we conducted presence/absence surveys and breeding habitat assessments for the southwestern willow flycatcher (*Empidonax traillii extimus*), along the Colorado River in Grand Canyon National Park. We broadcasted songs and calls of willow flycatcher to elicit responses from willow flycatchers at 25 sites between Lee's Ferry and Pearce Ferry. We detected ten willow flycatchers at seven different sites. All detections were single occurrence and no nests searches were conducted. Eight brown-headed cowbirds (*Molothrus ater*), were detected at seven different survey sites. We supplemented search effort by placing sound recording equipment at 10 different sites which recorded 3,194 hours of audio data. A total of 10 positive audio detections were recorded on a sound recording device at one site.

Forty-six sites were assessed for willow flycathcer breeding habitat. Ten sites were designated as suitable habitat, 20 were designated as potential habitat, and 16 were designated as unsuitable habitat. Patch size ranged from 0.05-18.22 ha and averaged 1.5 ha. The tamarisk leaf beetle (*Diorhabda carinulata*) distribution was studied during the same time period as our study, during which the beetle rapidly expanded its range along the Colorado River. By 2012, the beetle could be found along most of the Colorado River in Grand Canyon including the stretch below Diamond Creek. Our study witnessed first-hand the rapid impacts from the beetle, which can quickly turn a potential patch of habitat to unsuitable.

The southwestern willow flycatcher, listed as a federally endangered species in 1995, breeds in dense, mesic riparian habitats in the six southwestern states of California, Nevada, Utah, Colorado, Arizona, and New Mexico. Habitat and population numbers of this riparian obligate bird have declined in recent decades, due to several factors including loss, degradation, and fragmentation of riparian habitat, invasion by nonnative plants, brood parasitism by brown-headed cowbirds and loss of wintering habitat.

Surveys for the southwestern willow flycatcher have occurred in Grand Canyon National Park, mainly along the main stem of the Colorado River, since 1982. The number of nesting willow flycatchers has declined since the 1980's and nesting flycatchers have not been confirmed in Grand Canyon National Park since 2007, although formal nest searches have not been conducted above Diamond Creek since 2004. The limited data regarding willow flycatcher numbers prior to the construction of the Glen Canyon Dam suggest that they were not common breeders along the Colorado River in Grand Canyon.

In order to compare this study's results with past studies and to decipher a general population trend, historical data had to be compiled from historical reports and publications. In doing so, all data was standardized to the best of our ability since past studies have varied in many respects including: survey effort (i.e., number of surveys per year, length of surveys), survey locations, survey protocol, and data compilation. The river stretch from Lee's Ferry to Phantom Ranch has been surveyed the most consistently since 1982 and best represents potential trend of the southwestern willow flycatcher in Grand Canyon. There has been a noticeable decrease in the detection of breeding pairs since the 1990s along this stretch of river. The river stretch from Phantom Ranch to Diamond Creek has infrequent habitat patches. Surveys did not occur along this stretch until the 1990's and have produced minimal detections. The previous studies along

the Diamond Creek – Pearce Ferry river stretch have varied considerably. A five-year boost in detections along this stretch of river that occurred from 1997- 2001 is likely due to favorable water levels of Lake Mead in combination with increased survey effort. The water level in Lake Mead over the past 20 years has drastically changed the riparian vegetation along this stretch of river, thus negatively affecting southwestern willow flycatcher breeding habitat.

The overall downward trend in both adult non-residents and breeding pairs in Grand Canyon can likely be attributed to several factors including the fluctuating and unstable hydrological conditions and the increased distribution of the tamarisk leaf beetle. Our study reinforces previous convictions that Grand Canyon does not provide extensive stands of dense riparian habitat suited for breeding willow flycatchers. The majority of habitat patches lack a consistent, dependable source of water for maintaining moist/saturated soil conditions and/or slow-moving water/ standing surface water. Unless current hydrological conditions change, the majority of flycatcher habitat in Grand Canyon will remain marginal or continue to decline, especially with the recent arrival of the tamarisk leaf beetle. The surveys over the past 31 years have established that between Lee's Ferry and Diamond Creek, the southwestern willow flycatcher exists as a very small, widely dispersed population that currently is not likely self-sustaining. Territorial adults and nesting attempts have been confined to a small number of sites, which are now experiencing inevitable and detrimental change to key habitat components. The presence of southwestern willow flycatchers in Grand Canyon will likely be at a reduced rate from previous decades. However, Grand Canyon will continue to provide essential habitat for migrating willow flycatchers, but the presence of breeding willow flycatchers will be less common.

Grand Canyon National Park should continue to manage for the conservation and recovery of the southwestern willow flycatcher. Surveys should be conducted on a periodic schedule that would allow the Park to continue to monitor the long-term status of flycatcher presence/absence and habitat quality in Grand Canyon. The suitable habitat patches below Diamond Creek should be surveyed more frequently and these sites should be at the forefront for habitat improvement and restoration work.

Introduction

Background

The southwestern willow flycatcher (SWFL) is a Neotropical migrant that nests in dense riparian habitats in the six southwestern states of California, Nevada, Utah, Colorado, Arizona, and New Mexico. This subspecies of the willow flycatcher was placed on the Endangered Species list in 1995 (USFWS 1995). Under the species recovery plan, Grand Canyon National Park (GRCA) falls within the Middle Colorado Management Unit which is delineated within the Lower Colorado Recovery Unit. (Figure 1, USFWS 2002).

Habitat and population numbers of this riparian obligate bird have declined in recent decades, due to several factors including loss, degradation, and fragmentation of riparian habitat; invasion by nonnative plants; brood parasitism by brown-headed cowbirds (BHCO; *Molothrus ater*); and loss of wintering habitat (Hunter et al. 1987, Unitt 1987, Hunter et al. 1988, Harris 1991, USFWS 1995). SWFLs are most commonly found in lower elevation habitats associated with rivers, swamps, and other wetlands, but can occur from near sea level to over 2600 m (8500 ft; Bent 1960, USFWS 2002).

Historically, the range of the SWFL in Arizona included portions of all major watersheds (Phillips 1948, Unitt 1987); however, these watersheds have changed dramatically in many cases. As a result, most of the areas where SWFL were locally abundant now support few to none (Tellman et al. 1997). Habitat loss and nest parasitism by BHCOs are believed to be the two most important factors in the declining numbers of SWFL (USFWS 2002). In the few patches SWFL have nested, BHCOs have impacted nest success, causing nest failure or lowered fledge rates of SWFL in GRCA (Ward et al. 2010). From 1982 to 2004, approximately half of the SWFL nest sites on the Colorado River between Lee's Ferry and Pearce Ferry were observed to have the presence of BHCOs (Brown 1998, 1991, Sogge and Tibbitts 1992, Sogge et al. 1995, Peterson and Sogge 1996, Sogge et al. 1997b, Paradzick et al 2001, Koronkiewicz et al. 2005, Ellis et al. 2008).

The SWFL only breeds in patchy to dense riparian vegetation near saturated soils, slow-moving water, or surface water. Breeding habitat characteristics such as canopy structure, vegetation density and height, dominant plant species, and size and shape of habitat patch vary greatly across a large elevation and geographic area (USFWS 2002). While there is much variation of vegetation characteristics among breeding sites, there are also some unifying characteristics that can be identified. Occupied sites most often have a patch interior of dense vegetation or dense patches of vegetation intermingled with openings. Most often, this dense vegetation occurs within the first 3-4 m above the ground (USFWS 2002). The structure of the patch should vary with a scattering of small openings, shorter vegetation, and open water. This dense riparian habitat associated with lentic water or saturated soils that SWFLs prefer is uncommon in the river corridor of GRCA.

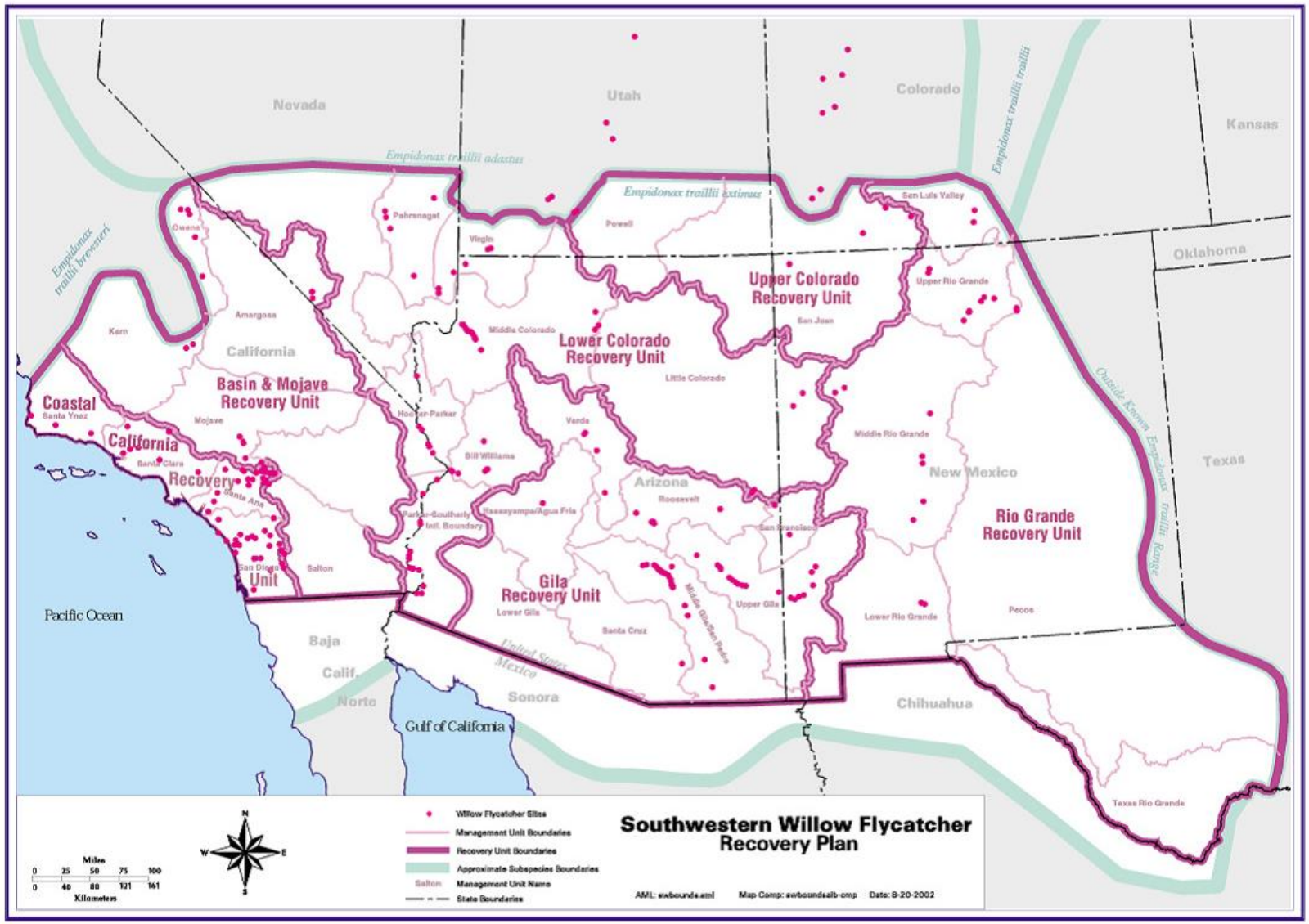


Figure 1. Recovery Area, Recovery Units, and Management Units for the southwestern willow flycatcher

SWFL have historically nested in native plants such as willows (*Salix* spp.), buttonbush (*Cephalanthus occidentalis*), boxelder (*Acer negundo*), and seepwillow (*Baccharis* spp.) (Grinnell and Miller 1944, Phillips 1948, Whitmore 1977, Unitt 1987). Currently, the SWFL will still nest in native plants when available, but will also nest in patches dominated by exotic plant species such as tamarisk (*Tamarix spp.)* and Russian olive (*Elaeagnus angustifolia;* Hubbard 1987, Brown 1988, Sogge et al. 1993, Muiznieks et al. 1994, Maynard 1995, Sferra et al. 1997, Sogge et al. 1997b, Paradzick et al. 1999). There are many flycatcher observations that have caused confusion among the most experienced flycatcher biologists when attempting to understand and define suitable breeding habitat (USFWS 2002). Dockens and Paradzick (2004) modeled SWFL breeding habitat throughout Arizona. This GIS-based model produced the first inventory of possible breeding habitat on a statewide scale and identified possible habitat in GRCA. However, one of the difficulties of modeling habitat for a riparian obligate species is that the model can quickly become obsolete since riparian habitats can change during a relatively short period of time.

In 2005 and 2013, the U.S. Fish and Wildlife Service (USFWS) finalized the second and third designation of critical habitat for the SWFL, respectively. Under both these designations, critical habitat was proposed within the Middle Colorado Management Unit, comprising the Colorado River riparian habitat between river mile (RM) 243 downstream to the upper most portion of Lake Mead (Figure 2). This area was "identified as having features essential to the flycatcher in Mohave County, AZ" (USFWS 2005, 2013). This proposed critical habitat was excluded from both the 2005 and 2013 final designation since this river stretch is incorporated into and covered under the Lower Colorado River Multi-Species Conservation Program[1] (LCR MSCP), as is defined under Section 4(b)(2) of the Endangered Species Act (ESA; USFWS 2005, 2013). The Colorado River above Lake Mead on the Hualapai Nation was also identified as having features essential to the SWFL; however the Nation developed, completed, and implemented actions in their SWFL Management Plan that in conjunction with the LCR MSCP, allowed the Hualapai Lands to also be excluded from being designated as critical habitat as is defined by Secretarial

[1] The LCR MSCP was developed and implemented in response to the 1994 designation of critical habitat along the lower Colorado River for endangered fish species. The LCR MSCP is a 50-year and 626 million dollar multi-stakeholder Federal and non-Federal partnership responding to the need to balance the use of the lower Colorado River water resources and the conservation of the native species and their habitats in compliance with the ESA. The long-term goal of the program is to conserve and work toward the recovery of State- and Federally-listed species, and protect and maintain wildlife habitat along the lower Colorado River. The program area extends over 400 miles of the lower Colorado River, from RM 235 in GRCA to the southernmost border with Mexico, and includes lakes Mead, Mohave, and Havasu, as well as the historic 100-year floodplain along the main stem of the lower Colorado River. The LCR MSCP accommodates current water diversions and power production, and will optimize opportunities for future water and power development by providing ESA compliance through the implementation of a HCP. As a step to the LCR MSCP, a Biological Assessment was prepared and in return a Biological Opinion issued by the USFWS in 1997. Among the terms and conditions of the Biological Opinion was the requirement to survey and monitor occupied and potential habitat for SWFL along the lower Colorado River. Subsequent consultations with the USFWS have resulted in the requirement to continue surveying and monitoring habitat for SWFL through 2005 and most recently required monitoring of 150.5 hectares of existing, occupied SWFL habitat between Parker and Imperial Dams. Lower Grand Canyon was one of the areas surveyed and monitored for SWFL and habitat. The Lower Grand Canyon remained a study area through 2008, after which this study area was eliminated because of the declining level of Lake Mead, which had dramatically reduced the amount of potential flycatcher habitat, and the formation of rapids at Pearce Ferry and Iceberg Canyon made access difficult (McLeod and Pellegrini 2011).

Order 3206[2] (USFWS 2005, 2103). In the LCR MSCP Habitat Conservation Plan[3] (HCP), two Conservation Area Sites were recommended for potential habitat restoration and improvement in GRCA. Both areas are on Hualapai lands and included 60 acres between RM 243-260 (restoration) and 2 acres at RM 237 (improvement). As of 2012, neither of these sites has been established as a LCR MSCP Conservation Area (LCR MSCP 2004).

In GRCA, the number of nesting SWFL detections have declined since the 1980's (Appendix A and B). There is little information on the number of SWFL along the river before the construction of the Glen Canyon Dam. However, what data are available suggests that historically, SWFLs were not common breeders along the Colorado River in GRCA (Brown 1988, Brown 1991, Sogge et al. 1997b). Studies conducted along the river from 1982-1991 and from 1992-2001, detected 14-15 breeding pairs per decade of surveys between Lee's Ferry and Phantom Ranch (Appendix B; Brown 1988, 1991; Sogge and Tibbitts 1992, 1994; Sogge et al. 1993, 1997; Sogge et al. 1995; Petterson and Sogge 1996; Sogge and Tibbitts 1994; Sferra et al. 1997, Tibbitts and Johnson 1999; Paradizick et al. 2001; Smith et al. 2002, Yard 2001; Ellis et al. 2008).

After the 2004 survey season, Grand Canyon Monitoring and Research Center (GCMRC) elected to discontinue their monitoring of known SWFL nesting habitat in the GRCA (Ward et al. 2010). Beginning in 2005, GRCA began conducting annual surveys in the upper canyon from Lee's Ferry to Phantom Ranch, but funding prevented surveying the isolated habitat patches between Phantom Ranch and Diamond Creek. From 2005 to 2009, four individuals were detected between Lee's Ferry and Phantom Ranch (Yard 2005, Haynes and Ward 2007, Northrip et al. 2008, Slayton et al. 2009). Nesting flycatchers have not been confirmed at GRCA since 2007; however, nest searches have not been conducted above Diamond Creek since 2004, the last year GCMRC conducted surveys (Appendices A, B).

[2] Secretarial Order No. 3206- American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act

[3] HCPs are planning documents required as part of an application for an incidental take permit. They describe the anticipated effects of the proposed taking; how those impacts will be minimized, or mitigated; and how the HCP is to be funded. HCPs under Section 10(a)(1)(B) of the ESA provide for partnerships with non-Federal parties to conserve the ecosystems upon which listed species depend, ultimately contributing to their recovery.

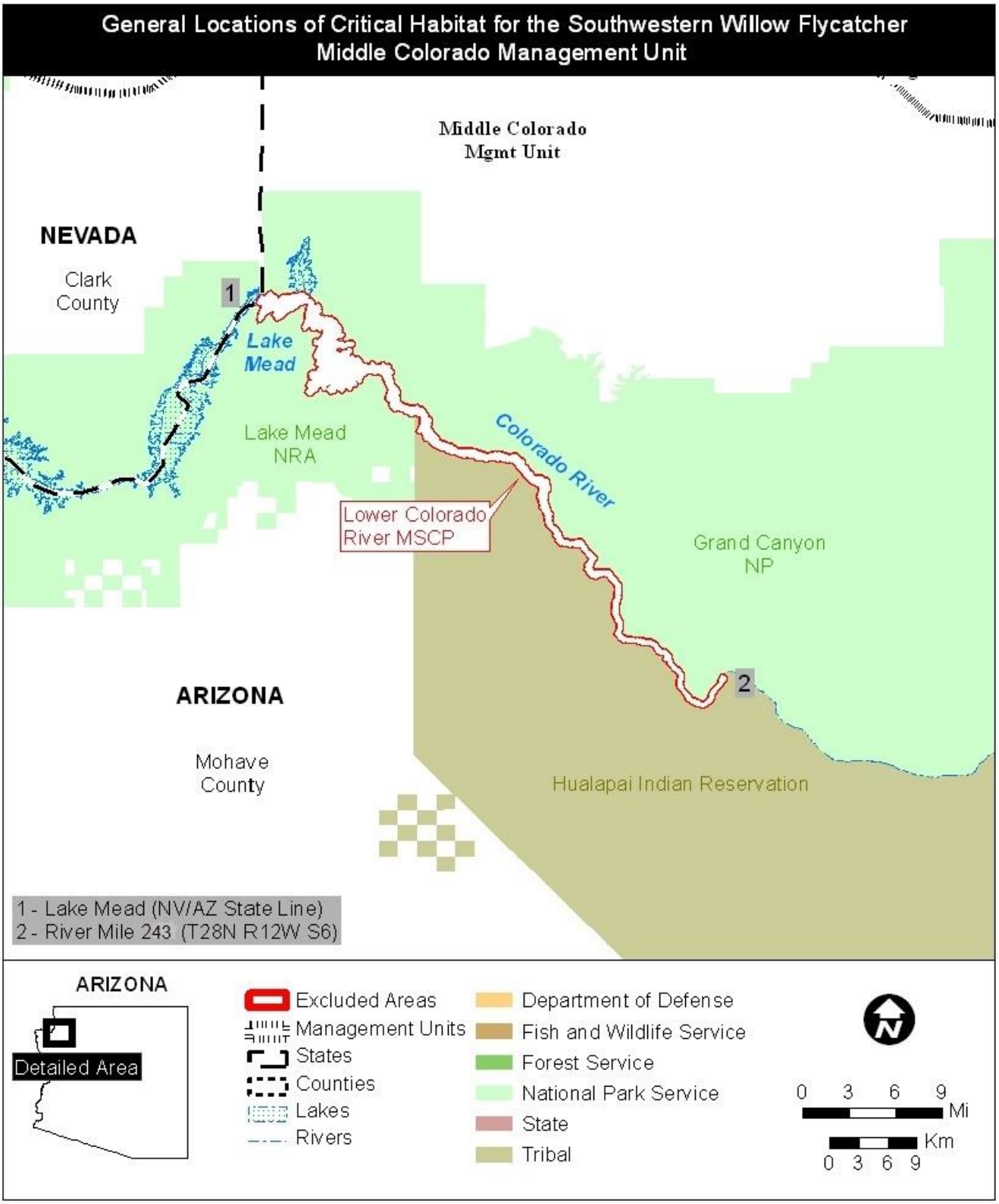


Figure 2. Proposed critical habitat for the southwestern willow flycatcher between upper Lake Mead and river mile 243. This area was excluded from both the 2005 and 2013 final critical habitat designation since this river stretch is covered under the Lower Colorado River Multi-Species Conservation Program, which covers Colorado River riparian habitat upstream to river mile 235.

Purpose and Need

As past survey efforts have proven, surveying for SWFL in GRCA is hampered by difficult access to riparian patches. Surveyors have limited windows in which to conduct their work on the multi-day river trips required to access potential use areas. Increasingly, avifauna research is changing to include automated recording devices that capture bird vocalizations, reduce observer bias, and increase survey duration (Budney and Grotke 1997, Gaunt et al. 2005, Rempel et al. 2005). From 2010-2012 GRCA completed a project that surveyed for SWFL presence, assessed breeding habitat suitability, and tested the feasibility of using supplemental sound recording devices to determine flycatcher presence. Specific project objectives for the three-year project included:

Project Objectives

1. Refine potential SWFL habitat between river miles 0 and 277 in Grand Canyon National Park and provide a habitat evaluation for each site.
2. Conduct presence/absence surveys for SWFL using the U.S. Fish and Wildlife Service three-survey protocol of 2010 in dense riparian habitat between river miles 0 and 277.
3. Establish acoustical monitoring equipment at 6-8 of the best sites and record acoustical data for $\geq$ 35 days.
4. If territorial flycatchers are located, conduct nest searches and, where possible, document predation, brood parasitism, and nesting success.
5. Collect habitat and physical measurements around each nest site.

In addition to the summary of this three-year project, this report attempts to review and compare our results to all previous SWFL surveys that have been conducted in GRCA since 1982. In doing so, GRCA will better comprehend the host of issues related to SWFLs in GRCA including: general population trend; habitat quality; changes in habitat; threats to habitat and breeding SWFLs; and extent of surveys conducted in GRCA. Such a review will allow GRCA to better manage and plan future projects concerning SWFL conservation.

Methods

Southwestern Willow Flycatcher Surveys

GRCA monitored for SWFL at historic nesting sites between Lee's Ferry and Phantom Ranch, and also surveyed new sites between Phantom Ranch and Pearce Ferry. We conducted surveys at new sites when the breeding habitat assessment resulted in a site being classified as suitable or potentially suitable habitat and the time required to survey the site suited the river trip logistics. All surveys were conducted with the use of standard audio playback of SWFL songs and calls as described in the survey protocol for the SWFL (Sogge et al. 2010). We walked through sites playing recorded SWFL vocalizations. At each calling point along survey routes, we broadcasted for 15-30 seconds, and then listened and looked quietly for a response for approximately 60 seconds. At the end of that time period we moved along the route and repeated this sequence at 20-30 meter (m) intervals. The broadcast/listening sequence was repeated several times at a single calling point if background noise or suspicions that a flycatcher was present. We performed surveys primarily between 0430 hours and 1000 hours, when SWFL song rates are greatest. We surveyed primarily on land, walking or crawling slowly through or adjacent to potential habitat. Where topography and/or dense vegetation made it necessary, we conducted surveys from a boat floating quietly adjacent to the habitat. When possible, we camped adjacent to habitat patches so that birds singing spontaneously in the pre-dawn hours could be heard. One survey was completed during each of the three survey periods (15 May-31 May, 1 June- 21 June, 22 June- 17 July). Sites were named according to their location in river miles (RM) relative to Lee's Ferry (RM 0) and reported in GCMRC measurement system; river right (R) and river left (L) refer to the side of the river as one faces downriver. All geographic coordinates were collected in the North American Datum of 1983 (NAD 83).

When we located SWFL, we monitored them non-intrusively for extended periods. Our monitoring goals were to: 1) determine the number and gender of birds in the habitat patch; 2) verify if there was a nesting pair; 3) determine their stage of nesting; 4) make observations of their use of the habitat patch; 5) make observations on interactions between BHCOs and willow flycatchers; and 6) make general observations on willow flycatcher behavior. All data for each survey site for each year was recorded on the standard USFWS willow flycatcher field data sheet (Appendix C). Nest searches were not conducted due to not having staff properly trained as required by GRCA's Section 10 permit.

Breeding Habitat Assessment

Habitat evaluations were based on the qualitative criteria specified in Appendix D of the Southwestern Willow Flycatcher Recovery Plan (USFWS 2002). We measured the following parameters at all historical and potential sites between Lee's Ferry and Pearce Ferry: 1) dominant vegetation type; 2) associated vegetation; 3) size and shape of vegetation patch; 4) density and height of vegetation; 5) distance to water; and 6) presence of saturated soil; 7) light exposure; 8) understory composition; 9) average tree height; 10) tamarisk estimate of patch composition.

Vegetation patch size was calculated in ArcGIS (ESRI, Redlands, California, USA) by drawing polygons on aerial photos around estimated habitat patches. As our most recent aerial photos were taken in 2010, adjustments were made once researchers went into the field and found that at many sites the vegetation had changed. It was also difficult in some photos to differentiate plant species such as mesquite (*Prosopis glandulaosa*) and tamarisk. Therefore, utilizing handheld GPS units (Garmin International, Inc., Olathe, Kansas, USA), we walked through and marked waypoints at the borders of the patch. All GPS data collected in the field were then used to ground truth our aerial photos to accurately reflect the current patch size (Appendix D). Soil moisture was determined at the surface level and down to four inches. We used clinometers to accurately determine tree and shrub height and used this information to calculate average height. Canopy cover and understory density was determined by taking the average of observer estimates from several locations within the patch, and placing them into categories of sparse (0-25%), low (26-50%), moderate (51-75%), and high (76-100%).

Each surveyed vegetation patch was classified into 1 of the following categories; definitions were taken from the USFWS 2002 Southwestern Willow Flycatcher Recovery Plan (USFWS 2002):

.

Suitable Habitat

- "...riparian habitats along rivers, streams, or other wetlands, where relatively dense growths of trees and shrubs are established, near or adjacent to surface water or underlain by saturated soil."

- "...occupied sites usually consist of dense vegetation in the patch interior, or an aggregate of dense patches interspersed with openings. In most cases this dense vegetation occurs within the first 3-4 m (10-13 ft) above ground. These dense patches are often interspersed with small openings, open water or marsh, or shorter/sparser vegetation, creating a mosaic that is not uniformly dense."

- "...thickets of trees and shrubs ranging in height from 2 m to 30 m (6 – 98 ft)."

- "Nest sites typically have a dense canopy." "...typically 80% or greater."

- "...nests in native vegetation where available, but also nests in thickets dominated by tamarisk and Russian olive (Hubbard 1987, Brown 1988, Sogge et al. 1993, Muiznieks et al. 1994, Maynard 1995, Sferra et al. 1997, Sogge et al. 1997b, McKernan and Braden 1999)."

Potentially Suitable Habitat (potential habitat)

- "...a riparian system that does not currently have all the components needed to provide conditions suitable for nesting flycatchers (as described above), but which could – if managed effectively – develop these components over time."

Unsuitable Habitat

- "...those riparian and upland areas which do not have the potential for developing into suitable habitat, even with extensive management."

All data was recorded on the habitat assessment form (Appendix E), which was developed based on the USFWS Southwestern Willow Flycatcher Recovery Plan's (2002) description of habitat requirements, as well as suggestions from local USFWS biologists (Austin 2009, Beaty 2009, email comm.).

Sound Monitoring

To supplement search efforts and increase duration of SWFL surveys, we placed sound recording equipment in riparian habitats to monitor bird vocalizations during the breeding season. In the 2010 field season, we used two types of automated recording devices. The first type of system continuously recorded both decibel and audio data. Two of these larger systems were deployed and used Larson-Davis 831 Sound Level Meters (Larson Davis, Gold Canyon, Arizona, USA) to monitor sound pressure levels, Edirol R-09 (Roland Corporation, Los Angeles, California, USA) to record Mp3 data, and were powered by a solar charged lithium ion battery (Figure 3). These devices were placed at RM 50.4L and 194R.

Figure 3. Larson-Davis 831 sound-recording system, powered by solar panels, river mile 50.4, river left, Grand Canyon, Arizona.

The second type of system consisted of Song Meter SM2 Platforms (Wildlife Acoustics, Inc. Concord, Massachusetts, USA; Figure 4). Each year, six of these smaller units were deployed. The units were powered by D-cell batteries, and were programmed to record a set amount of hours each morning. SM2 Platforms were secured approximately 1.5 m above ground in willow, tamarisk, or seepwillow trees. These units were serviced once per month when memory cards and batteries were replaced. In the

Figure 4. Securing a Song Meter SM2 Platform sound recorder onto a willow tree, river mile 275, river right, Grand Canyon, Arizona.

2011 and 2012 field season, just the six SM2 Platforms were deployed each year. These devices were placed at RMs 28.5L, 47R, 50.5L, 51.8L, 196.4R, 204R, 216L, 259.8R, and 275R. All data associated with site location was recorded on the sound recording data form (Appendix F).

All recording devices were placed where SWFL had been observed and/or areas that contained characteristics of their habitat. Audio data was transferred to a Maxtor 1.5 GB external hard drive and backed up on a duplicate external hard drive. Audio data was analyzed using Songscope, version 4.0.7 (Wildlife Acoustics, Inc., Concord, Massachusetts, USA). A recognizer (i.e., an algorithm used to detect certain bird vocalizations within recordings) was built in Songscope using ten low-quality SWFL vocalizations recorded in on 14 June 2010 at RM 50.4L. Adobe Audition 3 (Adobe Systems, Inc., San Jose, California, USA) was used to visualize both the recognizer and any potential SWFL vocalizations within the recordings.

Results

Southwestern Willow Flycatcher Surveys

A total of 25 sites were surveyed for SWFL presence; five historical sites and one new site between Lee's Ferry and Phantom Ranch, and four historical and 15 new sites between Phantom Ranch and Pearce Ferry (Table 1). Ninety-four hours of surveys were conducted. Completing river trips at Pearce Ferry instead of Diamond Creek allowed for five additional sites to be surveyed. There were a total of 10 detections over the course of the three-year study (Table 1; Appendix B). Six detections occurred during the first survey period (May 15-31), two occurred during the second survey period (June1-21) and two occurred during the third survey period (June 24-July 17). One detection was made via the analysis of the sound recording device placed at RM 50.4L in June 2010. All SWFL detections occurred on single occasions and birds were never detected again in subsequent surveys. No nests searches were conducted. Eight BHCOs were detected at seven different sites during SWFL surveys.

Table 1. Southwestern willow flycatcher survey site locations and detections, 2010-2012, Grand Canyon, Arizona. See Appendix D for maps of detections.

River Mile (Site Name, river R/L)	Year	SWFL Detected	Comments
RM 28.5 (L) **	2010	1	audio/visual detection (5/19/2010)
	2011	0	
	2012	NS[1]	
RM 47 (Saddle Canyon, R) **	2010	0	unknown Empid seen (5/2010)
	2011	0	
	2012	0	
RM 50.3-50.7 (L) **	2010	1	detection made from sound recording device (6/14/2010)
	2011	0	
	2012	0	
RM 51.8-52 (L)	2010	0	
	2011	1	audio/visual detection (5/19/11)
	2012	0	
RM 56 (Kwagunt Marsh, R) **	2010	0	
	2011	0	BHCO present
	2012	0	
RM 71.6 (Cardenas, L) **	2010	0	BHCO present
	2011	0	
	2012	0	
RM 137.7 (Football Field, L)	2010	0	
	2011	NS	
	2012	NS	

River Mile (Site Name, river R/L)	Year	SWFL Detected	Comments
RM 144 (Kanab Creek, L)	2010	0	*Diorhabda* spp detected at mouth of Kanab Creek
	2011	0	*Diorhabda* spp present, nearly 100% defoliation
	2012	NS	
RM 157.3 (Havasu Creek, L)	2010	0	
	2011	NS	
	2012	NS	
RM 166 (R)	2010	0	
	2011	NS	
	2012	NS	
RM 168.5 (Fern Glen, R)	2010	NS	
	2011	0	*Diorhabda* spp present, nearly 100% defoliation
	2012	NS	
RM 171.3 (L)	2010	NS	
	2011	NS	
	2012	0	
RM 183.5 (L)	2010	NS	
	2011	**1**	audio detection only *(6/18/2011); Diorhabda* spp present, nearly 100% defoliation month post detection; BHCO present
	2012	NS	*Diorhabda* spp present, nearly 100% defoliation
RM 194.7 (L)	2010	0	
	2011	0	
	2012	0	
RM 196.4 (R)	2010	**1**	audio detection only (5/28/2010)
	2011	0	
	2012	0	
RM 204.7 (R)	2010	NS	
	2011	NS	
	2012	0	
RM 214.1 (L)	2010	NS	
	2011	NS	
	2012	0	
RM 216 (Three Springs, L)	2010	NS	
	2011	NS	
	2012	0	
RM 217.6 (L)	2010	0	
	2011	**1**	audio detection only (5/28/2011)

River Mile (Site Name, river R/L)	Year	SWFL Detected	Comments
	2012	0	
RM 218 (L)	2010	2	pair seen and heard singing/ calling (5/29/2010); BHCO present
	2011	0	
	2012	0	
RM 246.2 (Spencer Canyon, L) **	2010	0	
	2011	0	
	2012	0	
RM 249.2 (Clay Tank, L)	2010	0	
	2011	NS	
	2012	NS	
RM 252.6 Reference Point (L) **	2010	0	
	2011	NS	
	2012	NS	
RM 259.8 (Burnt Springs, R) **	2010	0	
	2011	0	BHCO present
	2012	0	
RM 275 (R) **	2010	2	2 audio/visual detections. 2 territories (6/24/2010); BHCO present twice
	2011	0	BHCO present
	2012	0	

** indicates historic location
[1] NS = no survey

Breeding Habitat Assessment

Forty-six sites were assessed for SWFL breeding habitat. Ten sites were designated as suitable habitat (Figure 5), 20 were designated as potential habitat, and 16 were designated as unsuitable habitat (Figure 6; Table 2). Patch size ranged from 0.05-18.22 ha and averaged 1.5 ha. Thirty-five percent of the patches had both canopy cover and understory density that was classified as high (> 75% cover); 72% had canopy cover and understory density that was classified as moderate or high (> 50% cover). Only three sites (RM 28.5L, 169.7R, and 176.8R) had an understory density rated as sparse or low (Table 2). Seventy-four percent (*n*=34) of habitat patches surveyed consisted of dry soil moisture. Twenty-four percent (*n*=11) of the surveyed patches had moist soil, and two percent (*n*=1) maintained standing water (RM 275R; Table 2). One additional BHCO was detected that was not already detected during a SWFL survey.

Figure 5. Suitable southwestern willow flycatcher breeding habitat at river mile 275, river right, Grand Canyon, Arizona.

Figure 6. Unsuitable SWFL breeding habitat at river mile 174.2, river right, Grand Canyon, Arizona.

Table 2. Breeding habitat suitability for the southwestern willow flycatcher, Grand Canyon, Arizona. Canopy Cover: Sparse = 0-25%, Low = 26-50%, Moderate = 51-75%, High = 76-100%. Understory Density: sparse =0-25%, low = 26-50%, moderate= 51-75%, high =76-100%.

River Mile (river L/R)	Patch Size (ha)	Canopy Cover	Understory Density	Water Component/ Soil Moisture	Suitability Determination	Comments
47.0 (Triple Alcoves, R)	1.18	High	High	River/ Moist	Suitable	
56.0 (Kwagunt Marsh, R)	2.06	Moderate	High	River/ Moist	Suitable	
71.6 (Cardenas Marsh, L)	1.72	High	Moderate	River is slow moving and with potential backwaters/ Dry	Suitable	Historical site. Open areas inside patch. BHCO[1] present in 2010
168.5 (Fern Glen, R)	0.38	Moderate	High	River with backwaters/ Dry	Suitable	Tamarisk beetle found 7/2010
196.4 (R)**	0.56	Low	High	River/ Dry	Suitable	Large eddy with backwaters. Low canopy cover overall, but high canopy cover in tamarisk thickets. SWFL detected
204.7 (Spring Canyon, R)	0.81	Low	High	River/ Dry	Suitable	Low canopy cover overall, but in areas of tamarisk canopy cover is high
216 (Three Spring Canyon, L)	0.4	High	High	Stream/Moist	Suitable	
249.2 (Clay Tank, L)	1.27	Moderate	High	Stream and River/ Moist	Suitable	Standing and flowing water at center of patch
259.8 (Burnt Springs, R)	18.22	High	Moderate	Stream and River/ Moist	Suitable	Stream runs through site
275 (R)**	>17.53	High	High	Spring, Stream, and River/ Saturated and standing water	Suitable	Standing water throughout site; active beaver damn; 2 SWFLs detected. BHCO[1] present in 2010
28.5 (L)**	0.07	Low	Sparse	River/ Moist	Potential	Potential because SWFLs have been observed
50.3-50.7** (L)	4.07	Low	Moderate	River with large eddy/ Dry	Potential	Potential because SWFLs have been observed

River Mile (river L/R)	Patch Size (ha)	Canopy Cover	Understory Density	Water Component/ Soil Moisture	Suitability Determination	Comments
137.7 (Football Field, L)	0.14	High	Moderate	River with backwaters/ Dry	Potential	Small patch size
144 (Kanab Creek, R)	0.44	High	Moderate	Slow moving Stream/ moist	Potential	Tamarisk beetle found 7/2010
171.3 (L)	0.39	High	High	River/ Dry	Potential	Slow moving eddies
171.6 (R)	0.35	Moderate	High	River/ Dry	Potential	
183.5 (Beecher Springs, L)**	0.6	Moderate	High	River/ Dry	Potential	Large slow moving eddy
191.8 (R)	0.65	High	High	River/Dry	Potential	*Diorhabda* spp present
194.7 (L)	0.51	High	High	River/ Moist	Potential	Backwaters at certain river levels, slow moving eddy
197.9 (L)	0.27	High	High	River/Dry	Potential	
198.1 (L)	0.09	High	High	River/Dry	Potential	
198.2 (R)	0.49	Moderate	Moderate	River/Dry	Potential	
205.2 (L)	1.74	High	High	River/Dry	Potential	
214.1 (L)	0.28	High	High	River/Dry	Potential	
217.6 (L)**	0.62	High	High	River/ Dry Soil with Saturated beach	Potential	Saturated beach at certain river levels, otherwise dry
218 (L)**	0.33	Sparse	Moderate	River/ Moist Soil	Potential	
238.8 (L)	0.13	High	High	Stream and River/ Moist	Potential	Creek running through site
246.2 (Front Spencer Canyon, L)	1.4	High	High	Stream and River/ Dry	Potential	Slow moving stream runs through site, but no soil saturation
246.2 (Back Spencer Canyon, L)	2.7	High	High	Stream/ Dry	Potential	Slow moving stream runs through site, but no soil saturation
252.6 (Reference Point, L)	4.5	High	High	River/ Dry	Potential	Potential because SWFL's have been observed, but water component is missing. BHCO present in 2010
51.8 (L)**	0.41	Low	High	River/ Dry	Unsuitable	Very dry site, no suitable water component
93.8 (Granite Camp, L)	0.29	Low	Moderate	River/Dry	Unsuitable	
117.2 (L)	0.17	Moderate	High	River and Stream/ Dry	Unsuitable	Patchy vegetation, stream or river do not provide standing water

River Mile (river L/R)	Patch Size (ha)	Canopy Cover	Understory Density	Water Component/ Soil Moisture	Suitability Determination	Comments
166 (R)	0.15	Low	Moderate	River/ Dry	Unsuitable	No suitable water component, marginal habitat
169.7 (R)	0.39	Low	Low	River/ Dry	Unsuitable	
174.2 (R)	0.09	Low	Moderate	River/ Dry	Unsuitable	
176.8 (R)	0.14	Sparse	Low	River/ Dry	Unsuitable	
186.7 (L)	0.1	Low	High	River/Dry	Unsuitable	*Diorhabda* spp present
188 (R)	0.11	Moderate	High	River/ Dry	Unsuitable	Patch is narrow tamarisk thickets at river edge
188.2 (R)	0.19	High	High	River/ Dry	Unsuitable	Fast moving water, no slow or standing water
198.6 (L)	0.37	High	Moderate	River/Dry	Unsuitable	
213.8 (L)	0.4	Moderate	Moderate	River/Dry	Unsuitable	
268.7 (L)	0.12	High	High	River/ Moist	Unsuitable	Young and small tamarisk, no standing water
269 (L)	0.05	Moderate	Moderate	River/ Dry	Unsuitable	Small patch size
271.1 (R)	0.17	Moderate	High	River/ Dry	Unsuitable	Young, thin willows Dry and sandy site
273.6 (L)	0.12	Low	Moderate	River/ Dry	Unsuitable	No standing water throughout patch, moist soil at edge but dependent on water

** indicates SWFL detection
[1] Same BHCO detected during SWFL survey

Sound Monitoring

We placed a total of 20 recording units along the Colorado River between RM 28.5L and 275R over the course of the three-year study. These recorders captured a total of 3,194 hours of audio data. A total of 10 positive audio SWFL detections were recorded. All 10 recordings were at RM 50.4L and were recorded on 14 June 2010 around 6:00 am. In 2010, the Larson-Davis unit at RM 50.4L failed following five hours of recording. In 2012, all six units failed to record at some point during the two months they were deployed. Only one unit recorded during the first month (RM 259.8R) and four units recorded during the second month (RMs 47R, 196.4R, 216L, and 275R).

Discussion

Southwestern Willow Flycatcher Surveys

SWFL detections during this three-year study were infrequent and varied between years. Breeding attempts were difficult to verify due to all the detections being single-occurrence detections. Past studies on SWFL in GRCA vary in many respects, including: survey effort (i.e., number of surveys per year, length of surveys), survey locations, survey protocol, and data compilation. Historical SWFL data, recently compiled from reports and publications, fail to provide the specific details on survey methodology that is needed to make statistically-sound data comparison and trend analysis. Although it is difficult to determine the extent of change in SWFL abundance within GRCA over the last 31 years, inferences on the overall trend can be made. Since 1982, surveys have divided the river corridor study area into three main sections: 1) Lee's Ferry-Phantom Ranch, 2) Phantom Ranch – Diamond Creek, and 3) Diamond Creek to Pearce Ferry. Most surveys have occurred between Lee's Ferry and Phantom Ranch, with surveys having occurred every year except from 1988-1990 (Appendix B). Surveys in the remaining river corridor have been less consistent. Prior to this study, the Phantom Ranch – Diamond Creek section was surveyed a total of 10 seasons since 1982 and the Diamond Creek – Pearce Ferry section was surveyed 16 seasons since 1982 (Appendix B).

Several past study designs have made the assumption that if a singing SWFL were detected then it was a breeding male and/ or a resident (e.g., Brown 1988, 1991). Such assumptions neglect to consider other life history conditions of the detected SWFL including the potential for the bird to be a migrant, floater, unpaired male, or female, rather than a breeding male (Sogge et al. 1997b). To best eliminate these assumptions, we compiled historical data by applying the same set of rules in defining residency and reproductive status. During this process we generally lumped all detected birds into an adult SWFL category. The designation of a breeding pair was made only if the surveyor observed at least one of the following activities: a) two birds were seen at the same site, b) a nest was found, c) a bird was seen constructing a nest, d) a bird was seen on/near a nest, and/or d) juvenile SWFL(s) were observed at the site. Not all data from all years were able to be standardized in this fashion due to certain years and/ or studies having limited methodology descriptions. Appendix B provides a year-to-year overview of major data fields including total number of adult SWFLs, number of verified breeding pairs, and number of nests. Since SWFL presence or absence has the potential to vary from year to year due to extraneous variables (e.g., weather, wintering ground conditions; Norris et al. 2004, Paxton et al. 2011b), we grouped select fields of SWFL data into three-year increments starting from 1982 in order to better understand a general population trend per river corridor section (Table 3).

Lee's Ferry – Phantom Ranch

Due to the more consistent annual survey effort, the river section from Lee's Ferry to Phantom Ranch best represents potential trend of the SWFL in GRCA (Figure 7). The number of adults observed has varied from year to year, with a maximum of 24 in 1994 (Figure 7; Sogge et al. 1997b). A notable decrease in the detection of breeding pairs has occurred since the 1990's, with the last breeding pairs detected above Phantom Ranch in 2003 (RMs 28.5L and 50.6L). Prior to

2003, the breeding population of flycatchers in GRCA was small ($\bar{x}$ = 1.6 ± 1.2 pairs/year) with no clear trend. The high count of four pairs only has occurred twice (1985 and 1994; Figure 7). The majority (79%) of SWFL detections between Lee's Ferry and Phantom Ranch have occurred within three stretches of habitat patches along the river: RM 46.9-47.5, RM 50.2-52.2, and Cardenas Marsh (RM 71.6L). During our three-year study, SWFL detections were minimal within these three patches, with only two detections made within the RM 50.2-52.2 patch. The detection at RM 51.8L, which occurred in May 2011, was likely a migrant since the bird was never detected again, nor was it recorded on the sound recording device which was placed at the detection location. Migrants are known to respond strongly to recorded SWFL vocalizations, in much the same manner as territorial birds (Sogge et al. 1997b). The other detection was at RM 50.4L, which was detected in June 2010 on a sound recording device. Again, this bird was likely a migrant since the sound recorder only recorded the bird one morning and surveyors never detected the bird during any of the subsequent surveys. The remaining SWFL detection above Phantom Ranch was made in 2010 at RM 28.5L. This bird was also likely a migrant due to the habitat patch providing marginal habitat and it never being detected again in the second or third survey periods.

Table 3. Total number of observed adults, breeding pairs, and found nests of the Southwestern willow flycatcher along the Colorado River in Grand Canyon National Park in three-year increments, 1982-2012.

	Lee's Ferry-Phantom Ranch			**Phantom Ranch-Diamond Creek**			**Diamond Creek-Pearce Ferry**		
	Adult[1]	*Pair*[2]	*Nest*[3]	*Adult*	*Pair*	*Nest*	*Adult*	*Pair*	*Nest*
1982-1984	10	3	4	ns[4]	ns	ns	ns	ns	ns
1985-1987	33	9	9	ns	ns	ns	ns	ns	ns
1988-1990	ns	ns	ns	ns	ns	ns	ns	ns	ns
1991-1993	17	6	6	1	0	0	3	0	0
1994-1996	36	6	11	3	0	0	1	0	0
1997-1999	10	3	3	0	0	0	56	20	9
2000-2002	9	2	2	3	0	0	63	26	9
2003-2005	5	2	2	0	0	0	4	1	1
2006-2008	1	0	0	ns	ns	ns	11	2	2
2009-2012[5]	6	0	ns	5	1	ns	2	0	ns

[1]Total number of adult SWFL observed
[2]Total number of breeding pairs observed (1 pair = 2 adult SWFLs)
[3]Total number of nests found, includes nests that were re-nests (nest rebuild after first or second nest failed/destroyed)
[4]No survey conducted
[5]2012 surveys were lumped with the 2009-2011 three-increment; no detections were made in 2012 along the entire stretch of river.

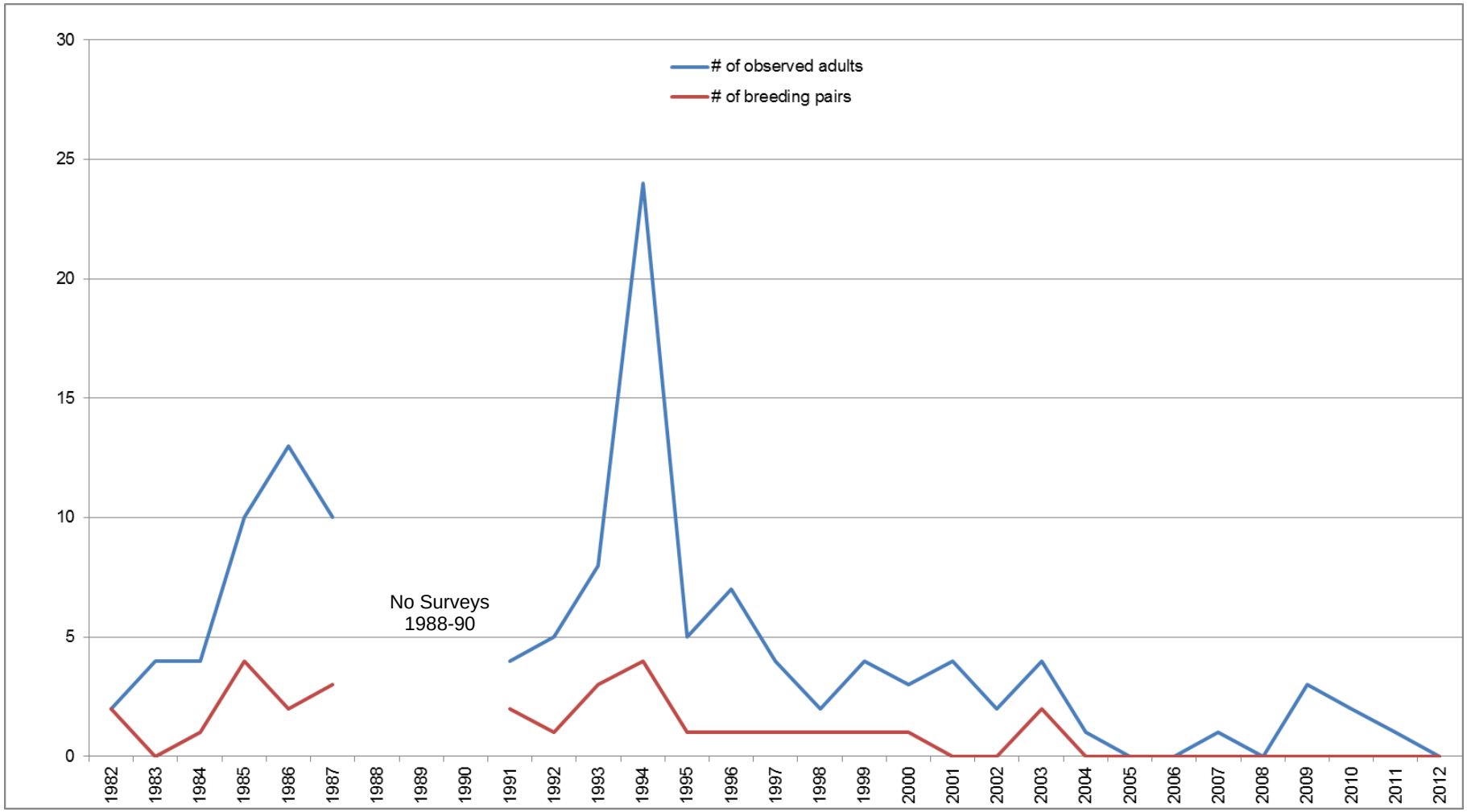


Figure 7. Total number of observed adult and breeding pairs of southwestern willow flycatchers along the Colorado River from Lee's Ferry to Phantom Ranch, 1982-2012.

Phantom Ranch – Diamond Creek

Infrequent habitat patches exist between Phantom Ranch and Diamond Creek. Surveys from 2009-2011 show a slight increase in SWFL detections compared to previous three-year survey increments (Table 3). The 2010 detection of a breeding pair at RM 218L marked the first observed breeding pair between Phantom Ranch and Diamond Creek. Nests have never been observed along this river section. The four detections that occurred in May 2010 and 2011 were likely migrants while the one detection that occurred at RM 183.5L in June may have been either a floater or breeder. This June detection occurred while a habitat survey was being conducted and the site had not been surveyed in May. The July survey did not detect the SWFL, but this may have been due to the site being 100% defoliated from the tamarisk leaf beetle (*Diorhabda carinulata*).

Diamond Creek – Pearce Ferry

The two detections made in 2010 along the Diamond Creek-Pearce Ferry section were not confirmed to be breeding pairs (i.e., nest not found, breeding partner not seen/heard), but since the two territorial individuals were detected in late June, it is likely that each were part of a breeding pair. Comparing our results against those of previous studies is difficult since survey efforts have changed considerably from study to study. From 1997- 2007, surveys were conducted by environmental consultants (San Bernardino County Museum Biological Science Section, Redlands, California from 1997-2002 and SWCA Environmental Consultants from 2003-2007) as part of the LCR MSCP. During this 10-year period, sites were mostly surveyed five times per breeding season. This increased survey effort in combination with the favorable water levels of Lake Mead during 1997- 2001, likely contributed to the five-year boost in SWFL detections (Table 3, Figure 8, Appendix B). The Colorado River in lower GRCA downstream of Separation Canyon (RM 239.7) is strongly influenced by water levels in Lake Mead thus causing a profound change in SWFL habitat in this area since 1993 (McLeod et al. 2008, USBR 2013). The mean lake level from 1993-2002 was 363.3 m ± 4.7 m while the mean lake level from 2003-2012 was 340.7 m ± 5.7 m. (Figure 8; USBR 2013). From 2000-2004, lake levels drastically decreased a total of 23.8 m.

Much of the riparian vegetation below Burnt Springs Canyon (RM 259.8), which was once inundated and potentially suitable for breeding flycatchers in the late 1990s, is now terraced well above the current river level and the existing vegetation in most of these areas is dead or unsuitable for flycatchers (Figure 9). Moreover, the remaining tamarisk-dominated patches that have survived are now being further deteriorated from the tamarisk leaf beetle (Figure 10). It is likely that most of these tamarisk patches that are terraced above the river level will die more quickly than the river-level tamarisk due to the trees being exposed to multiple environmental stressors (i.e., lack of water, beetles).

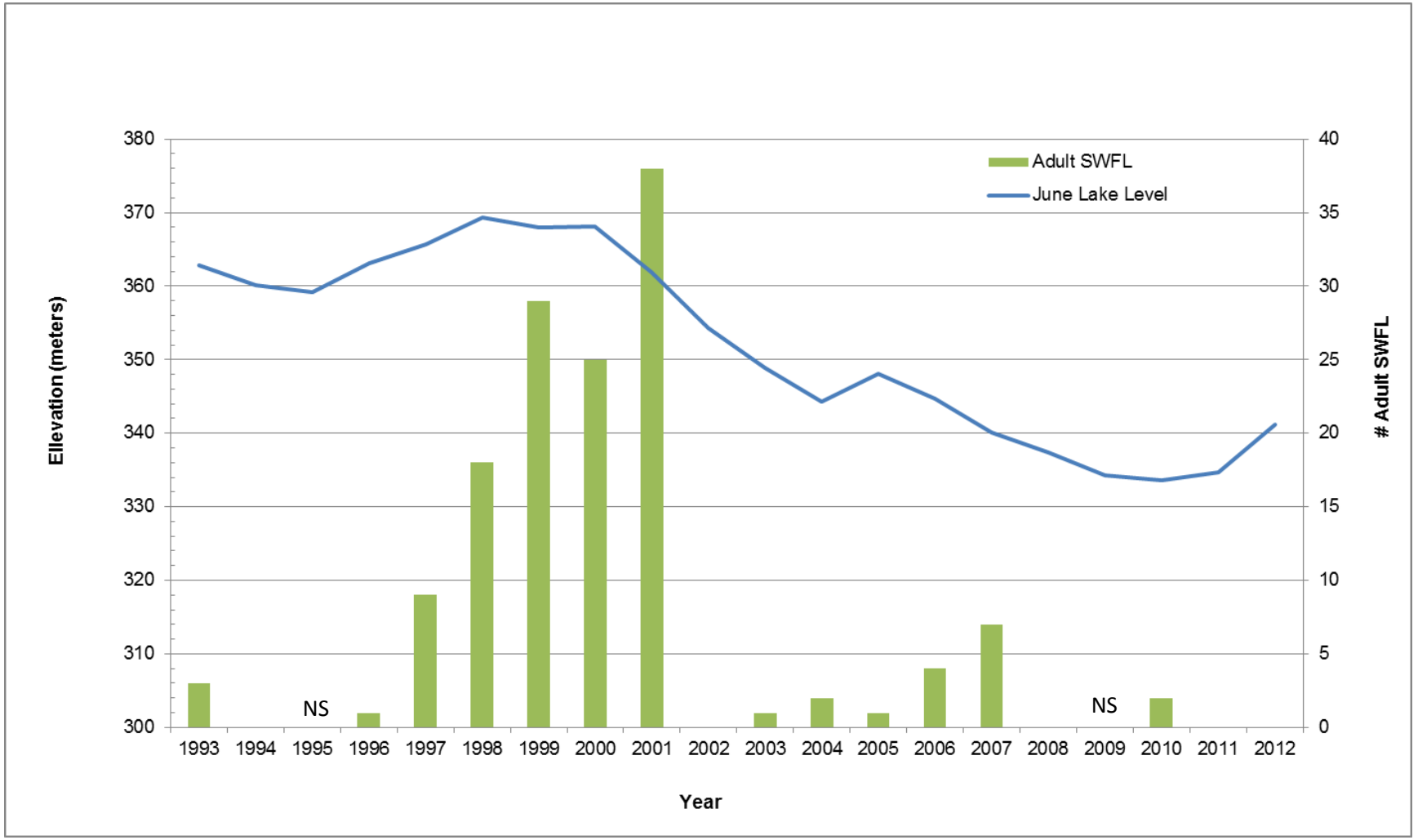


Figure 8. Annual water levels of Lake Mead at Hoover Dam during the month of June and number of adult southwestern willow flycatchers per survey season between Diamond Creek and Pearce Ferry, 1993-2012. The water level in Lake Mead Reservoir rose approximately seven meters from mid-2004 to early 2005 because of record precipitation during the winter of 2004–2005. Since mid-2005, the water level has continued to drop. NS = No Survey

Figure 9. Tamarisk trees below Burnt Springs Canyon (RM 259.8) that are terraced above the current river level and have been defoliated by the tamarisk leaf beetle.

Population Trend

The overall downward trend in both adult non-residents (i.e., migrants, floaters, and unpaired males) and breeding pairs in GRCA, especially in regards to the Lee's Ferry – Phantom Ranch river section, can likely be attributed to several direct factors including: 1) the fluctuating and unstable hydrological conditions at the majority of sites which lead to a site being either too dry or having water moving too fast through the sites; and 2) the increased distribution of the tamarisk leaf beetle, which has caused increased defoliation of tamarisk-dominated sites.

The fluctuating and unstable hydrological conditions can be attributed to several interdependent variables including: Glen Canyon Dam operations, increased establishment of water-consuming plant species (i.e., tamarisk) along the river banks, climate change, the Upper Colorado River annual snowpack, and human population growth (Jacobs 2011). The complex relationship between these variables ultimately affects the habitat quality needed by breeding SWFL. The trickle-down impacts from climate change have and will continue to affect Colorado River stream-flow and Glen Canyon Dam operations. Numerous climate modeling studies have

concluded that temperature increases in the upper Colorado River basin could result in marked reductions in stream-flow and inflows into Lake Powell (Christensen et al. 2004). This is of special concern since 90% of the Colorado River's flow is derived from snowmelt from precipitation in three upper basin states of Colorado, Utah, and Wyoming (Jacobs 2011). A review of temperature data for the entire river basin showed that "since the late 1970's, the Colorado River region has exhibited a steady upward trend in surface temperature. The most recent 11-year average exceeds any previous values in the over 100 years of instrumental records…The Colorado River basin has warmed more than any other region of the United States" (NRC 2007).

Prior to the completion of Glen Canyon Dam construction in 1963, annual floods scoured the river's edge and prevented the establishment of large patches of tamarisk/willow/cottonwood habitat (Turner and Karpiscak 1980). Since 1963, the riparian corridor in GRCA consists of two distinct vegetative communities. The old high-water zone (OHWZ) includes those habitats above the pre-dam high-water line that persisted after completion of the dam as a relict community. The new high-water zone (NHWZ) is a new riparian community that has developed since 1963 in the zone previously scoured by floods. The NHWZ is dominated by tamarisk as well as associated vegetation including coyote willow (*Salix exigua*), arrowweed (*Tessaria sericea*), seepwillow (*Baccharis spp.),* reed (*Phragmites communis*), and Goodding willow (*Salix gooddingii*). Although most of the NHWZ is too narrow to support breeding SWFLs, there are larger patches which have been or could potentially be used by breeding SWFL. The increased distribution of the tamarisk leaf beetle since 2010 is negatively altering these patches of SWFL habitat, thus further advancing the problem of diminishing breeding habitat. Our study witnessed first-hand the rapid impact from the beetle, which can quickly turn a potential patch of habitat to unsuitable.

The status, abundance, and distribution of SWFL in GRCA are poorly known pre-dam since the study area was difficult to reach. The first bird checklist for GRCA listed the SWFL as a rare migrant, with no known breeding record (Grater 1937). Only a handful of records preceded Glen Canyon Dam construction. The completion of the dam and subsequent changes in downstream riparian habitat ensured that the original abundance and distribution of SWFL in GRCA would never be known. Nonetheless, it is likely that a handful of suitable breeding habitat patches existed prior to the dam. Between Lee's Ferry and Diamond Creek 23 sites have been identified as historical (i.e., pre-dam) Goodding's willow and Fremont cottonwood gallery forests (Grand Canyon Wildlife Council 2011). Remnant evidence exists at several of these sites including surviving cottonwoods and Goodding's willows and/or former backwater channels. Post-dam vegetative and hydrological conditions at these sites deteriorated post-dam since the natural cycles of flood-induced sediment deposition, floodplain hydration and flushing, and timing of seed dispersal necessary for establishment and maintenance of native riparian habitat were inhibited. It is likely that prior to the dam, a subset of these historical cottonwood gallery forests maintained suitable SWFL breeding habitat.

Breeding Habitat Assessment

In past studies, all confirmed SWFL nests in the GRCA have been located in NHWZ plant associations (Carothers and Brown 1991) and nest plants have all been tamarisk. Tamarisk is abundant along the river corridor, but the few sites occupied by SWFL are quite distinct. As described in the Southwestern Willow Flycatcher Recovery Plan (USFWS 2002), the historic nesting sites along the Colorado River in Grand Canyon have been small dense patches (0.6 to 0.9 ha) of mature tamarisk with an average canopy height of 8-12 m extending 30 to 50 m back from the river's edge (USFWS 2002). These patches are bordered on the upslope by acacia (*Acacia greggii*) and along the river by coyote willow (*Salix exigua*) (USFWS 2002). The live foliage is dense and continuous along the edge of the patch; however the foliage within the patch does not begin until 2-4 m above the ground. Dead branches and twigs form a dense understory below the live foliage. Canopy density at nest sites in GRCA have been less than 50% up to 100% (generally 75% to 90%) on the Colorado River (McKernan and Braden 1999). These habitat components are relatively limited in the Grand Canyon with the vast majority of tamarisk thickets existing as relatively narrow strips close to the water's edge.

The majority of habitat patches surveyed in our study consisted of vegetation that was fairly dense (>50% overstory and understory cover density). The water component and soil moisture portion of the habitat surveys signified that water was the foremost limited habitat component in surveyed habitat patches. Not only were water features often lacking (e.g., saturated soil), they were often variable from year-to-year. For example, RM 50.3-50.7L was surveyed for SWFL absence/presence all three years. A habitat assessment was completed the first year and classified the soil moisture as dry. The following year, due to the river running at higher levels (~25,000 cubic feet per second), soil was moist and there was standing backwater in areas. During the last year of the study, the soil at this site was dry. Eighty percent of the surveyed habitat patches maintain the Colorado River as its only water component and soil moisture source and therefore are completely dependent on river levels (Table 2).

Tamarisk Leaf Beetle

The tamarisk leaf beetle was another ever-changing variable during our study and drastically changed the vegetation structure of habitat patches (Figure 10). Tamarisk beetle larvae feed on tamarisk foliage and can cause defoliation, dieback, or death of the plants (Lewis et al. 2003; Figure 10). Prior to defoliation by the tamarisk beetle, many habitat patches (60%) were classified as potential or suitable habitat with a soil moisture classification as dry or a water component that was solely the Colorado River. Now, with the addition of the tamarisk beetle, these sites clearly will not have the consistent, favorable habitat conditions required to support breeding SWFLs. Therefore, most of our habitat suitability classification in this study have or will become obsolete due to the quickly-changing conditions of the tamarisk-dominated patches.

Figure 10. Before (2010) and after (2011) *Diorhabda* defoliation at Kanab Creek, river mile 144, river right. Note the backflow of the Colorado River into Kanab Creek during 2011 due to higher river levels.

During our three-year study, surveys for the tamarisk leaf beetle were performed within GRCA. In 2010 and 2011, the surveys were conducted under a Cooperative Ecosystem Studies Unit project within the park, while in 2012, NPS staff, one University of Arizona graduate student, and volunteers completed the beetle sampling work. In 2010, tamarisk beetles were not detected until the July survey trip. They were most prevalent in the first 25 miles of the river, and then sporadically below the Bass area (RM 108). They were found fairly continuously downstream from Kanab Creek for approximately 30 miles (~RM 174; Figure 7).

In 2011, the beetle was monitored in GRCA once a month from May-September, with sampling every 1-3 miles from Lee's Ferry to Pearce Ferry (May, June, July trips) and Lee's Ferry to Diamond Creek (August, September trips). Results from the 2011 beetle surveys show that the beetles had defoliated the full stretch of Marble Canyon from Lee's Ferry to South Canyon (~RM 32; Figure 11). By August, defoliation had grown considerably in the lower portion of the Grand Canyon, extending as a solid swath across the river corridor from above Blacktail Canyon (~RM 120) downstream to a point just above 192 Mile Canyon (RM 192). Spotty defoliation was then found intermittently downstream as far as Parashant Wash (RM 199). By September much of the areas defoliated in June had begun to show small to medium levels of refoliation, while other areas had only intensified in defoliation. No defoliation was found downstream of Parashant Wash.

In 2012, the beetle was monitored from April-August, with sampling focused on a subset of sites and then completed opportunistically every 2-5 miles. The beetles expanded their range in the river corridor, with rapid expansion in the stretch below Diamond Creek (Figure 11). They also expanded their distribution in the Kanab Creek drainage. The tamarisk weevil (*Coniatus tamarisci*) was also present at many of the sampled sites. Heavy defoliation was most prominent in July and August again this year, with many trees showing signs of refoliation. Trees in the area around Cove Canyon (RM 174) are showing signs of mortality, which is the first documented in the park.

It is unknown the short and long-term effects of the tamarisk beetle on avian populations in riparian systems. In southwestern riparian forests, vegetation density and canopy cover may be more important to avian communities than in other forest types, since these variables play an important role in improving the microclimate at the nests (Tieleman et al. 2008, Paxton et al. 2011a). For SWFL, studies have shown that the normalized difference vegetation index (NDVI), a measure of foliage density and vigor (Avery and Berlin 1992), is instructive in predicting breeding habitat (Hatten and Paradzick 2003, Hatten et al. 2010). Paxton et al. (2007) showed that annual variation in NDVI of breeding sites is strongly correlated with variation in the SWFL's annual productivity. Even small decreases in foliar cover may render a site unsuitable for the SWFL (Allison et al. 2003). It has been documented that the tamarisk leaf beetle can cause a reduction in tamarisk NDVI values following defoliation (Dennison et al. 2009, Bateman et al. 2012). However, Nagler et al. (2012) showed that NDVI values eventually return to pre-beetle-release levels, due to regeneration of tamarisk and infill with other native and non-native species.

It is important to note that while our habitat assessments categorize suitable breeding habitat for the willow flycatcher, sites that are listed as or may become potential or unsuitable should still be considered significant use areas for the flycatcher and other avian species. *Empidonax* flycatchers rarely sing during fall migration, so distinguishing SWFL from others cannot be done with certainty. Listening for willow flycatchers during spring migration has confirmed that they utilize riparian habitats along major drainages in the southwest (Sogge et al. 1997a, Johnson and O'Brien 1998, McKernan and Braden 2001, USFWS 2002). These migration stopover areas, even those deemed potential or unsuitable, may not be used for breeding, but may be critically important for flycatcher productivity and survival.

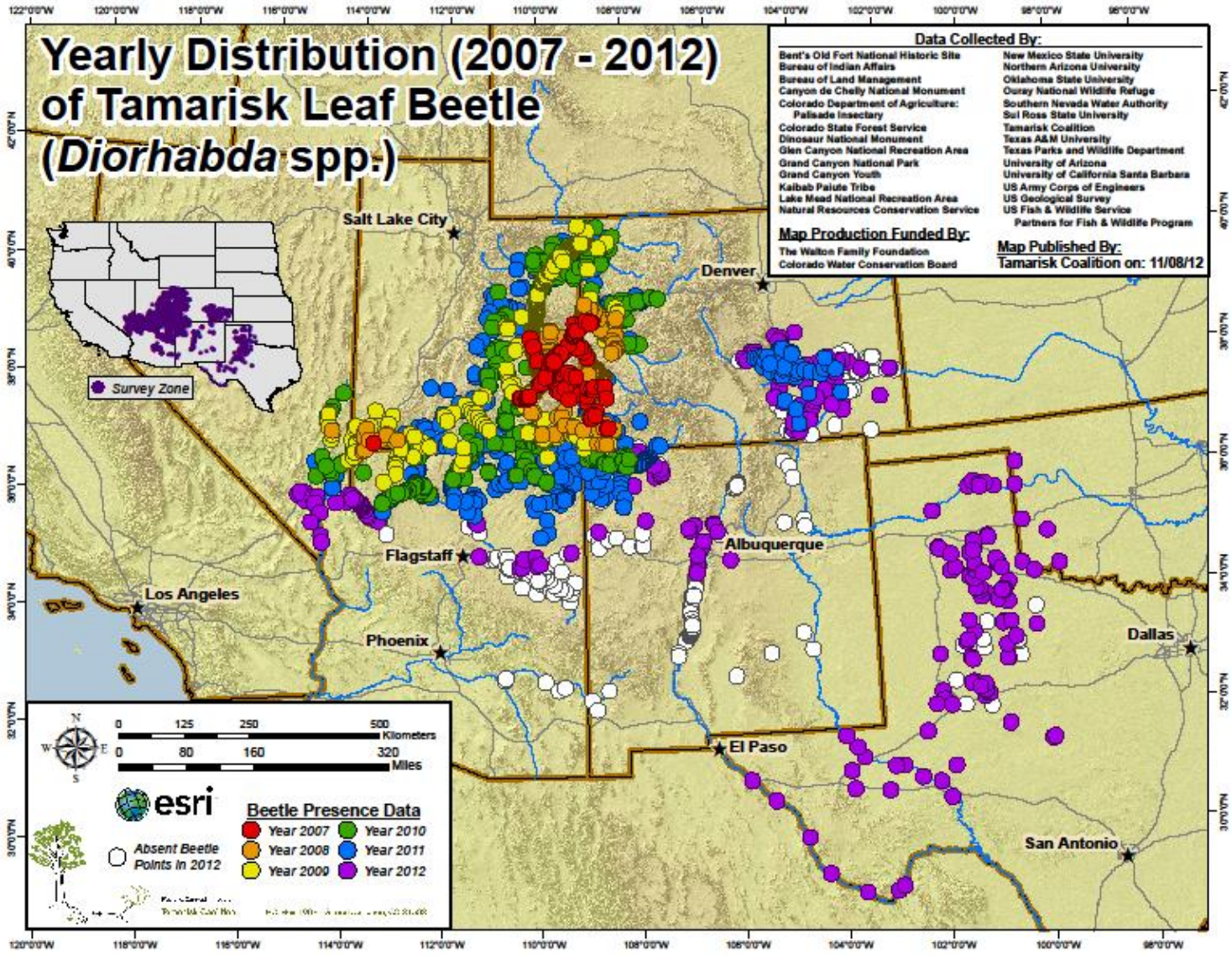


Figure 11. Yearly distribution of the tamarisk leaf beetle, 2007-2012

Brown-headed Cowbird Parasitism

Our study did not conduct nest searches or nest peeping due to not having staff properly trained as required by GRCA's Section 10 permit. We did collect data on BHCO absence/presence at both SWFL survey sites and breeding habitat assessment sites. We detected nine BHCOs over the course of the study. Three BHCO detections were at sites where SWFL(s) had been detected that year. In 2010, a BHCO was detected at RM 218L in July (SWFL detected in May) and at RM 275R a BHCO was detected both in May and June (2 SWFLs detected in June). In 2011, a BHCO was detected at RM 183.5L in June (SWFL detected in June). It is difficult to compare our BHCO absence/presence result to previous studies since many earlier studies only reported BHCO presence if there were BHCO eggs in a SWFL nest (Brown 1988, 1991, Sogge 1997, Tibbitts and Johnson 1999). Past reports have indicated that from 1982-2002 approximately half of the willow flycatcher nests on the Colorado River between Lee's Ferry and Diamond Creek were parasitized by BHCOs, thus creating a population that is not stable, but maintained only by an influx of individuals from other areas (Brown 1988, 1991, Sogge et al. 1997b, Whitfield and Sogge 1999, Kearsley et al. 2003). From 2003-2007, BHCOs were seen at 60% of the known nest sites, but no nests were determined to be parasitized (Smith et al. 2003; Koronkiewicz et al. 2004, 2006; McLeod et al. 2005, 2007, 2008).

From 1995-1996, BHCOs were studied in GRCA to determine distribution and abundance, to assess the magnitude of threat of parasitism to native bird species, and to monitor cowbird movement patterns. Cowbird movements were either local, ($\bar{x}$ = 0.53 km) or long-distance ($\bar{x}$=18.7 km), which indicated that cowbirds may move from South Rim Village locations to the Colorado River to parasitize riparian-nesting birds there (Drost 1996). From 2006-2009, GRCA conducted a BHCO control program in response to requests from the Center for Biological Diversity, a non-profit environmental organization. Trapping occurred within the South Rim Village at mule corrals and residential locations. During this 4-year project, 819 BHCOs were trapped of which 567 were euthanized and 184 were depredated in the trap (Laczek-Johnson 2006, Haynes 2007, Palarino 2008, 2009). GRCA was not able to determine the potential effects trapping efforts had on SWFL nests since nests were not found above Diamond Creek during the years of the BHCO trapping project. Similarly, it is difficult to determine the impacts BHCOs may have had on the SWFLs during our study since we did not search for nests. Although we did detect BHCO at sites where SWFLs were detected, BHCO presence does not imply that SWFLs are being parasitized at that site or that parasitism rates are high (Whitfield and Sogge 1999). Furthermore, previous studies have determined that it is impossible to predict parasitism rates based simply on the presence of cowbirds (Whitfield and Sogge 1999).

Cowbird parasitism clearly plays a role in the decline of SWFL populations, however, habitat destruction and modification are the primary causes of the decline and the high rates of BHCO parasitism is a symptom of this problem (Unitt 1987; Robinson et al. 1993; Rothstein 1994; USFWS 1993, 1995; Whitfield and Sogge 1999). The pros and cons of BHCO control programs have been evaluated both in regards to endangered species recovery and general avifauna productivity. Many studies have come to the conclusion that a cowbird control program is a mitigation measure that can be readily implemented to improve the short-term productivity of endangered host species, such as the SWFL (Rothstein and Peer 2005). Control programs are often viewed as a secondary solution to the overarching problem of habitat destruction and

reduction (Whitfield and Sogge 1999, Kus and Whitfield 2005, Rothstein and Peer 2005). In most cases, cowbird control has resulted in large increases of young SWFL but no clear increases in the number of breeding birds (Rothstein et al. 2003).

For example, Kus and Whitfield (2005) evaluated the effectiveness of a 12-year BHCO control program in Kern River, California, comparing results to the three pre-control years. SWFL numbers grew for a few years post-trapping, but then declined steeply to reach the lowest level recorded at the site, suggesting that factors other than parasitism were limiting flycatcher abundance and distribution. Although short-term cowbird control is an effective management tool in recovery of endangered hosts and may prevent extinction, long-term BHCO control should be avoided for a number of reasons including economic, political, biological, and ethical issues (Rothstein and Cook 2000, Rothstein et al. 2003, Kus and Whitfield 2005). Biological concerns of cowbird control include interference with the evolutionary processes necessary for establishment of genetically-based natural defenses that would allow for the continued existence of host species in the absence of human intervention (e.g., desertion of parasitized nests followed by successful renesting; Kus and Whitfield 2005). Sedgewick and Iko (1999) showed that cowbird parasitism appeared to wage the greatest toll on first-year birds, but older willow flycatchers may learn improved anti-parasite strategies over time.

Sound Monitoring

Analysis of the audio data has revealed several drawbacks. The "*fitz-bew*" vocalization of the SWFL is similar to the sounds of many other species when viewed in terms of its Hertz (Hz) range and audio pattern. We used a recognizer that scanned all our audio data between 1500 and 5000 Hz. This allowed us to detect key vocalizations as well as several of the fainter, lower quality vocalizations in the recordings. This produced results that were both good and bad. On average, four hours of audio data produced about 300 false positive, all of which had to be reviewed both by sight and sound in order to confirm potential SWFL detections. The SongScope program is generally designed for much more distinctive vocalizations than that of the SWFL (e.g., owls). In 2011 and 2012, there were no SWFLs detected on any of the functioning recording units. The majority of the sounds recorded were either crickets, ground squirrels, Bell's Vireos, Common Yellowthroats, House Sparrows, or Ash-Throated Flycatchers. The cost of these recording devices (e.g., unit price, deployment, audio data analysis) far outweighs the benefit. Over 3,000 hours of audio data detected one SWFL at one site during one day.

Conclusion

Our study bolsters previous convictions that GRCA does not provide extensive stands of dense riparian habitat suited for breeding SWFLs. In addition, our study clearly shows that the majority of habitat patches that do persist are lacking a consistent, dependable source of water for maintaining moist/saturated soil conditions and/or slow-moving water/ standing surface water. Unless current hydrological conditions change, the majority of SWFL habitat in GRCA will remain marginal or continue to decline. Furthermore, the recent arrival of the tamarisk leaf beetle has and will continue to transform the patches of dense tamarisk into unpredictable, diminished patches. The potential transformation of these tamarisk-dominated patches to native vegetation is unclear and uncertain; especially considering the Colorado River in GRCA is a dam-regulated riparian system. Despite differing methodologies, the surveys over the past 31 years have established that between Lee's Ferry and Diamond Creek, the SWFL exists as a very small, widely dispersed population that currently is not likely to be self-sustaining. Repeated surveys have identified and confirmed that territorial adults and all nesting attempts have been confined to a small number of sites. Most of these sites are now experiencing inevitable and detrimental change to key habitat components. The presence of SWFL in GRCA will likely follow the pattern that has been observed in recent years; SWFLs will be present in the canyon, but at a reduced rate from previous decades. GRCA will continue to provide essential habitat for migrating flycatchers, but breeding SWFL presence will likely be less common.

Recommendations

Although our predictions for SWFL in GRCA may seem bleak, the Park will continue to manage for the conservation and recovery of the SWFL. At the same time, GRCA needs to recognize the disproportionately high costs and logistics associated with surveying and monitoring presence/absence when compared to most other SWFL sites and populations. From the perspective of simple numbers of the SWFL range-wide, annual monitoring of these GRCA sites is not necessary. There are approximately 1262 territories[4] known range-wide (Durst et al. 2007). The few territories in GRCA, with their history of erratic occupancy and poor reproduction, are of small demographic consequence to the subspecies. Still, as an endangered species, all sites have importance and hence a focused-level of monitoring should be pursued.

Presence/absence surveys should be conducted at least once every five years to monitor the long-term status of SWFL presence/absence and habitat quality in the canyon. If opportunity to survey more often is present, effort should be made to perform additional surveys (i.e., if a river trip for another project were to occur during SWFL breeding season, then attempts should be made to survey for SWFL on these trips). We also recommend that prior to any future survey effort, surveyors are provided the appropriate training needed in order for nest searches to be conducted. We recommend that GRCA continue to conduct compliance surveys for SWFL prior to the initiation of projects that are in potential SWFL habitat.

Surveys should also be considered in tributary canyons that may provide patches of suitable breeding habitat including, but not limited to: Paria, Nankoweap, Little Colorado River, Bright Angel, Trancept, Shinumo, Tapeats, Deer Creek, Kanab, Havasu, National, Mohawk, Lava Falls, Three Springs, Diamond, and Surprise.

The suitable habitat patches below Diamond Creek (i.e., Spencer Canyon, Burnt Springs, and RM 275R) should be surveyed more frequently since these sites are dominated by native vegetation and have a reliable water component. These sites should also be at the forefront for habitat improvement and restoration work, which would help ensure that these sites could provide consistent, predictable breeding habitat for SWFLs. Logistically, these sites can be accessed by up-running the river from Pearce Ferry, which would reduce the amount of time and resources needed to conduct these surveys.

In regards to the tamarisk leaf beetle and habitat restoration, GRCA is conducting a pilot stewardship project at Granite Camp (RM 93.5L) within the Monument Creek Watershed. This pilot project aims to rehabilitate the native riparian plant community and wildlife habitat and will provide a better understanding of the feasibly of removing tamarisk and proactively planting native species at priority sites along the river corridor. GRCA will be initiating another habitat restoration project in 2014 at specific sites between Diamond and Pearce Ferry. This project will focus on selective tamarisk removal during the non-breeding season and installation of native species to fill its niche. The project will focus on sites where SWFL have been detected over the past decade and where suitable breeding habitat remains. This project will be serving as a pilot for expansion of restoration protocols to additional sites and directly addresses one of the

[4] An exclusive defended area within a breeding site. Although detailed monitoring studies have identified unpaired territorial males and/or polygynous males at some flycatcher breeding sites, for the purposes of this estimation, a territory is roughly equivalent to a pair of flycatchers.

primary actions required in the SWFL Recovery Plan: increase and improve occupied, suitable and potential breeding habitat. As GRCA continues to develop future riparian restoration projects, priority should continue to be given to the historical cottonwood/ Goodding's willow forests that may have once supported breeding SWFLs.

GRCA should continually seek other opportunities that could provide the monetary resources needed to restore habitat at historical sites. For example, GRCA could pursue external partnerships which would allow specific riparian sites to be used in compensatory mitigation[5] programs (Environmental Law Institute 2007). Such programs would essentially allow habitat in GRCA to be rehabilitated when activities outside the park result in habitat loss or damage.

The pros and cons of cowbird control have been well deliberated. When an endangered host species, such as the SWFL, is the target of a cowbird control program, careful consideration should be given to both the positive and negative consequences. Funds for endangered species recovery are often severely limited and hence funds expended on control programs often mean fewer funds directed at more critical management issues, such as increasing and improving habitat. GRCA maintains 277.6 miles of river corridor, surrounded by mostly dry, sparsely-vegetated canyonlands. This riparian corridor likely plays a crucial role in connecting more productive breeding habitats outside the boundaries of GRCA. Thus, GRCA should prioritize habitat restoration and improvement before BHCO control.

Beyond presence/absence surveys, the SWFLs that do utilize GRCA (i.e., for migration or breeding) may be of interest to researchers in terms of the flycatcher's population ecology (dispersal, immigration/emigration, dynamics of marginal populations). GRCA should be open to a range of potential research studies that could better define the interactions of dynamics of this small, dispersed, isolated group of sites with other flycatcher populations. Projects might include: intensive capture and banding of all individuals and tissue sampling for genetic analysis.

[5] The restoration, creation, enhancement, or preservation of natural resources to compensate for impacts pursuant to a regulatory program that: (1) prospectively issues permits or licenses for activities that affect fish and wildlife habitat or other natural resources; or (2) assesses after-the-fact damages for injury to, destruction of, or loss of habitat or natural resources.

Literature Cited

Allison, L J., C.E. Paradzick, J.W. Rourke, and T.D. McCarthey. 2003. A characterization of vegetation in nesting and non-nesting plots for Southwestern willow Flycatchers in central Arizona. Studies in Avian Biology 26:81–90.

Austin, W.J. 2009. Arizona Ecological Services Field Office, Flagstaff Suboffice, 323 Leroux, Suite 201, Flagstaff AZ 86001.

Avery, T.E., and G.L. Berlin. 1992. Fundamentals of remote sensing and aerial photo interpretation, 5th ed. MacMillan, New York. Barber, N.A., R.J. Marquis, and W.P. Tori. 2008. Invasive prey impacts the abundance and distribution of native predators. Ecology 89:2678–2683

Bateman, H.L., P.L. Nagler, E.P. Glenn. 2012. Plot- and landscape-level changes in climate and vegetation following defoliation of exotic saltcedar (*Tamarix* sp.) from the biocontrol agent *Diorhabda carinulata* along a stream in the Mojave Desert (USA). Journal of Arid Environments 89 16-29.

Beaty G. 2009. Arizona Ecological Services Field Office. 2321 West Royal Palm Road, Suite 103, Phoenix, AZ 85021-4951.

Bent, A.C. 1960. Bent's Life Histories of North American Birds. Vol. II, Land Birds. Harper & Brothers, New York. 555 pp.

Braden G.T., R.L. McKernan. 2006. Status, distribution, and habitat affinities of the Southwestern Willow Flycatcher along the lower Colorado River, Year 7 – 2002: Final report-revised. San Bernardino County Museum, Redlands, CA.

Brown, B.T. 1988. Breeding ecology of a willow flycatcher population in Grand Canyon, AZ. Western Birds 19(1):25-33.

Brown, B.T. 1991. Status of nesting willow flycatchers along the Colorado River from Glen Canyon Dam to Cardenas Creek, Arizona. Endangered Species Report No. 20 to the U.S. Fish and Wildlife Service, Phoenix, Arizona. 34 pp.

Budney G.E., and R.W. Grotke. 1997. Techniques for audio recording vocalizations of tropical birds. Ornithological Monographs, 48:147-163.

Carothers, S.W. and B.T. Brown. 1991. The Colorado River through Grand Canyon: Natural History and Human Change. The University of Arizona Press, Tucson. 235 pp.

Christensen, N., A. Wood, N. Viosin, D. Lettenmaier, and R. Palmer. 2004. The effects of climate change on the hydrology and water resources of the Colorado River Basin. Climatic Change 62(1): 337–363.

Dennison, P.E., P.L. Nagler, K.R. Hultine, E.P. Glenn, J.R. Ehleringer. 2009. Remote monitoring of tamarisk defoliation and evapotranspiration following saltcedar leaf beetle attack. Remote Sensing of Environment 133, 1462-1472.

Dockens, P.E.T. and C.E. Paradzick, editors. 2004. Mapping and monitoring southwestern willow flycatcher breeding habitat in Arizona: a remote sensing approach. Nongame and Endangered Wildlife Technical Report 223. Arizona Game and Fish Department, Phoenix, Arizona.

Drost, C. 1996. Monitoring of brown-headed cowbird impact on nesting neotropical migrantbirds in Grand Canyon National Park, 1996. Final report to the National Park Foundation.

Durst, S.L., M.K. Sogge, S.D. Stump, S.O. Williams, B.E. Kus, and S.J. Sferra. 2007, Southwestern Willow Flycatcher Breeding Site and Territory Summary – 2006: USGS Open File Report 2007-1391. [http://pubs.usgs.gov/of/2007/1391/]

Ellis, L.A., D.M. Weddle, S.D. Stump, H.C. English, and A.E. Graber. 2008. Southwestern Willow Flycatcher Final Survey and Nest Monitoring Report. Arizona Game and Fish Department Research Technical Guidance Bulletin #10.

Environmental Law Institute. 2007. Mitigation of impacts to fish and wildlife habitat: estimating costs and identifying opportunities. Environmental Law Institute project No. 0430-02, Washington, D.C.

Gaunt, S.L.L., D.A. Nelson, M.S. Dantzker, G.F. Budney, and J.W. Bradbury. 2005. New directions for bioacoustics collections. Auk 122: 984-987.

Grater, R.K. 1937. Check-list of birds of Grand Canyon National Park. Natural History Bulletin 8. Granc Anyon Natural Historical Association, Grand Canyon, AZ.

Grand Canyon Wildlands Council. 2011. Potential riparian restoration projects in Grand Canyon National Park, Arizona: report submitted to NPS 9 July 2009, minor revision 28 Aug 2011. Grand Canyon Wildlands Council, Inc., Flagstaff, AZ.

Grinnell, J. and A.H. Miller. 1944. The distribution of the birds of California. Pacific Coast Avifauna, Number 27. Cooper Ornithological Club. Berkeley, CA. 609 pp.

Harris, J.H. 1991. Effects of brood parasitism by brown-headed cowbirds on willow flycatcher nesting success along the Kern River, California. Western Birds 22(1):13-26.

Hatten, J.R., and C.E. Paradzick. 2003. A multiscaled model of Southwestern willow Flycatcher breeding habitat. Journal of Wildlife Management 67:774–788.

Hatten, J.R., E.H. Paxton, and M.K. Sogge. 2010. Modeling the dynamic habitat and breeding population of Southwestern willow flycatcher. Ecological modeling 221:1674–1686.

Haynes, D. 2007. Brown-head cowbird trapping results. Final Report. National Park Service, Grand Canyon National Park. 16 pp.

Haynes, D. and R.V. Ward. 2007. Southwestern willow flycatcher survey. Final Report. National Park Service, Grand Canyon National Park. 8 pp.

Hubbard, J.P. 1987. The Status of the Willow Flycatcher in New Mexico. Endangered Species Program, New Mexico Department of Game and Fish, Santa Fe, New Mexico. 29 pp.

Hunter, W.C., R.D. Ohmart, and B.W. Anderson. 1987. Status of breeding riparian-obligate birds in southwestern riverine systems. Western Birds 18:10-18.

Hunter, W.C., R.D. Ohmart, and B.W. Anderson. 1988. Use of exotic saltcedar (*Tamarix chinensis*) by birds in riparian systems. Condor 90:113-123.

Jacobs, J. 2011. The sustainability of water resources in the Colorado River basin. The Bridge 41(4): 6-12

Johnson, M.J. and C.O'Brien. 1998. Southwestern willow flycatcher and yellow-billed cuckoo surveys along the San Juan River, Utah (Four Corners Bridge - Mexican Hat): 1998. Final Report to the Utah Division of Wildlife Resources (Contract # 976475). Colorado Plateau Field Station/Northern Arizona University report. 45 pp.

Kearsley, M.J.C., N.S. Cobb, H. Yard, D. Lightfoot, S. Brantley, G. Carpenter, and J.. Frey. 2003. Inventory and Monitoring of terrestrial riparian resources in the Colorado River Corridor of Grand Canyon: an integrative approach. 2003 annual report to Grand Canyon Monitoring and Research Center, Flagstaff, Arizona. Cooperative Agreement 01-WRAG0034/0044.

Koronkiewicz, T.J., M.A. McLeod, B.T. Brown, and S.W. Carothers. 2004. Southwestern willow flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2003. Annual report submitted to U.S. Bureau of Reclamation, Boulder City, NV by SWCA Environmental Consultants, Flagstaff, AZ. 125 pp.

Koronkiewicz, T.J., M.A. McLeod, B.T. Brown, and S.W. Carothers. 2006. Southwestern willow flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2005. Annual report submitted to U.S. Bureau of Reclamation, Boulder City, NV by SWCA Environmental Consultants, Flagstaff, AZ. 315 pp.

Kus, B.E. and M.J. Whitfield. 2005. Parasitism, productivity, and population growth: response of least Bbell's vireos (*Vireo bellii pusillus*) and Southwestern willow flycatchers (*Empidonax traillii extimus*) to cowbird (*Molothrus* spp.) control. Ornithological Monographs 2005(57): 16-27.

Laczek-Johnson, C. 2006. Southwestern willow flycatchers survey results Grand Canyon National Park. Final Report. National Park Service, Grand Canyon National Park. 8 pp.

Lewis, P.A., C.J. DeLoach, A.E. Knutson, J.L. Tracy, and T.O. Robbins. 2003. Biology of *Diorhabda elongata deserticola* (Coleoptera: Chrysomelidae), an Asian leaf beetle for biological control of saltcedars (*Tamarix* spp.) in the United States. Biological Control 27(2): 1010-116.

Lower Colorado River Multi-Species Conservation Program [LCR MSCP] 2004. Lower Colorado River Multi-Speices Conservation Program, Volume II: Habitat Conservation Plan. Final December 17. (J$S 00450.00.) Sacramento, CA.

Maynard, W.R. 1995. Summary of 1994 survey efforts in New Mexico for southwestern willow flycatcher (*Empidonax traillii extimus*). Contract # 94-516-69. New Mexico Department of Game and Fish, Santa Fe, New Mexico. 48 pp.

McLeod, M.A., T.J. Koronkiewicz, B.T. Brown, and S.W. Carothers. 2005. Southwestern willow flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2004 Annual report submitted to U.S. Bureau of Reclamation, Boulder City, NV, by SWCA Environmental Consultants, Flagstaff, AZ. 244 pp.

McLeod, M.A., T.J. Koronkiewicz, B.T. Brown, and S.W. Carothers. 2007. Southwestern willow flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2006 Annual report submitted to U.S. Bureau of Reclamation, Boulder City, NV, by SWCA Environmental Consultants, Flagstaff, AZ. 328 pp.

McLeod, M.A., T.J. Koronkiewicz, S.r. Nicholos, B.T. Brown, and S.W. Carothers. 2008. Southwestern willow flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2007 Annual report submitted to U.S. Bureau of Reclamation, Boulder City, NV, by SWCA Environmental Consultants, Flagstaff, AZ. 206 pp.

McLeod, M.A., and A.R. Pellegrini. 2011. Southwestern willow flycatcher surveys, demography, and ecology along the lower Colorado River and tributaries, 2010. Annual report submitted to U.S. Bureau of Reclamation, Boulder City, NV, by SWCA Environmental Consultants, Flagstaff, AZ. 166pp.

McKernan, R.L. and G. Braden. 1998. Status, distribution, and habitat affinities of the southwestern willow flycatcher along the lower Colorado River: Year 2 – 1997. San Bernardino County Museum Report. Redlands, CA. 67 pp.

McKernan, R.L. and G. Braden. 1999. Status, distribution, and habitat affinities of the southwestern willow flycatcher along the lower Colorado River: Year 3 – 1998. San Bernardino County Museum Report. Redlands, CA. 71 pp.

McKernan, R.L. and G. Braden. 2000. Status, distribution, and habitat affinities of the southwestern willow flycatcher along the lower Colorado River: Year 4 – 1999. San Bernardino County Museum Report. Redlands, CA. 83 pp.

McKernan, R. L. and G. Braden. 2001. Status, distribution, and habitat affinities of the Southwestern Willow Flycatcher along the lower Colorado River, Year 5 - 2000. San Bernardino County Museum, Redlands, CA. 86 pp.

McKernan, R. L. and G. Braden. 2002. Status, distribution, and habitat affinities of the Southwestern Willow Flycatcher along the lower Colorado River, Year 6 - 2001. San Bernardino County Museum, Redlands, CA.

Muiznieks, B.D., T.E. Corman, S.J. Sferra, M.K. Sogge, and T.J. Tibbitts. 1994. Arizona Partners In Flight 1993 southwestern willow flycatcher survey. Technical Report 52. Arizona Game and Fish Department, Nongame and Endangered Wildlife Program, Phoenix, Arizona. 25 pp.

Nagler, P.J., T. Brown, K.R. Hultine, C. van Riper III, D.W. Bean, P. Dennison, R.S. Murray, E.P. Glenn. 2012. Regional scale impacts of *Tamarix* leaf beetles (*Diorhabda carinulam*) on the water availability of western U.S. rivers as determined by multi-scale remote sensing methods. Remote Sensing of Environment 118, 227-240.

National Research Council [NRC]. 2007. Colorado River basin water management: evaluating and adjusting to hydroclimatic variability. Washington, D.C.: National Academies Press.

Norris, D.R., P.P. Marra, T.K. Kyser, T.W. Sherry, and L.M. Ratcliffe. 2004. Tropical winter habitat limits reproductive success on the temperate breeding grounds in a migratory bird. Proceedings of the Royal Society of London B 271:59–64.

Northrip Q., R. Palarino, and R. V. Ward. 2008. Southwestern willow flycatchers surveys in Grand Canyon National Park. Final Report. National Park Service, Grand Canyon National Park. 8 pp.

Palarino, R. 2008. Brown-headed cowbird parasitism at Grand Canyon National Park. Final Report. National Park Service, Grand Canyon. 9 pp.

Palarino, R. 2009. Brown-headed cowbird parasitism at Grand Canyon National Park. Final Report. National Park Service, Grand Canyon. 7 pp.

Palarino, R., E. Slayton, T. Bowden, J. White, and R.V. Ward. 2010. Surveying for southwestern willow flycatchers in Grand Canyon National Park. 2010 Annual Report. National Park Service, Grand Canyon. 43 pp.

Paradzick, C. E., R. F. Davidson, J. W. Rourke, M. W. Sumner and T. D. McCarthey. 1999. Southwestern Willow Flycatcher 1998 survey and nest monitoring report. Arizona Game and Fish Department, Nongame and Endangered Wildlife Program Technical Report 141. Phoenix, AZ. 98 pp.

Paradzick, C.E., T.D. McCarthey, R.F. Davidson, J.W. Rourke, M.W. Sumner, A.B. Smith. 2001. Southwestern willow flycatcher 2000 survey and nest monitoring report. Nongame and Endangered Wildlife Program Technical Report 175. Arizona Game and Fish Department, Phoenix, Arizona.

Paxton, E.H., M.K. Sogge, S.L. Durst, T.C. Theimer, and J.R. Hatten. 2007. The ecology of the Southwestern willow flycatcher in central Arizona: a 10-year synthesis report. USGS Open File Report 2007-1381.

Paxton, E.H., T.C. Theimer, and M.K. Sogge. 2011a. Tamarisk biocontrol using tamarisk beetles: potential consequences for riparian birds in the Southwestern United States. The Condor 133(2) 255-265.

Paxton, E.H., P. Unitt, M.K. Sogge, M.J. Whitfield, and P. Keim. 2011b. Winter distribution of willow flycatcher subspecies. Condor 113:608-618.

Petterson, J.R. and M.K. Sogge. 1996. Distribution and status of the southwestern willow flycatcher along the Colorado River in the Grand Canyon - 1996. Grand Canyon

National Park and Colorado Plateau Research Station: Grand Canyon, Arizona and Flagstaff, Arizona.

Phillips, A.R. 1948. Geographic variation in *Empidonax traillii*. The Auk 65:507-514.

Rempel, R.S., K.A. Hobson, G. Holborn, S.L. Van Wilgenburg, and J. Elliott. 2005. Bioacoustic monitoring of forest songbirds: interpreter variability and effects of configuration and digital processing methods in the laboratory. Journal of Field Ornithology 76:1–11.

Robinson, S.K., J.A. Grzybowski. S.I. Rothstien, M.C. Brittingham, L.J. Petit, and F.R. Thompson. 1993. Management implications of cowbird parasitism on neotropical migrant songbirds. Pp. 93-102 In Status and management of neotropical migrant songbirds (D.M. Finch and P.W. Stangel, eds). USDA Gen. Tech. Rep. RM-229.

Rothstein, S.I. 1994. The cowbird's invasion of the far west: history, causes, and consequences experienced by host species. Stud. Avian Biol. 15:301-315.

Rothstein, S.I. and T.L. Cook. 2000. Cowbird management, host population limitation, and efforts to save endangered species: Introduction. Pages 323–332 *in* Ecology and Management of Cowbirds and Their Hosts (J. N. M. Smith, T. L. Cook, S. I. Rothstein, S. K. Robinson, and S. G. Sealy, Eds.). University of Texas Press, Austin.

Rothstein, S.I., B.E. Kus, M.J. Whitfield, and S.J. Sferra. 2003. Recommendations for cowbird management in recovery efforts for the Southwestern Willow Flycatcher. Studies in Avian Biology 26:157–167.

Rothstein, S.I. and B.D. Peer. 2005. Conservation solutions for threatened and endangered cowbird hosts: Separating fact and fiction. Ornithological Monographs 57:98-144. American Ornithologists' Union, Washington, D.C.

Sedgewick, J.A. and W.M. Iko. 1999. Cost of brown-headed cowbird parasitism to willow flycatchers. Pages 167-181 in Morrison, M.L., L.S. Hall, S.K. Robinson, S.I. Rothstein, D. Caldwell Hahn, and T.D. Rich (eds.). Research and management of the brown-headed cowbird in western landscapes. Studies in Avian Biology No. 18.

Sferra, S. J., T.E. Corman, C. E. Paradzick, J. W. Rourke, J.A. Spencer, and M.W. Sumner. 1997. Arizona Partners in Flight southwestern willow flycatcher survey 1993-1996 summary report. Technical Report. Nongame and Endangered Wildlife Program. Arizona Game and Fish Department, Phoenix, AZ. 97 pp.

Slayton, E., R. Palarino, and R.V. Ward. 2009. Southwestern willow flycatchers surveys in Grand Canyon National Park. Final Report. National Park Service, Grand Canyon National Park. 8 pp.

Smith, A.B., C.E. Paradzick, A. A. Woodward, P E. T. Dockens, and T.D. McCarthey. 2002. Southwestern Willow Flycatcher 2001 survey and nest monitoring report. Nongame and Endangered Wildlife Program Technical Report 191, Arizona Game and Fish Department, Phoenix, AZ.

Smith, A.B., A. A. Woodward, P E. T. Dockens, J.S. Martin, and T.D. McCarthey. 2003. Southwestern Willow Flycatcher 2002 survey and nest monitoring report. Nongame and Endangered Wildlife Program Technical Report 210, Arizona Game and Fish Department, Phoenix, AZ.

Sogge, M.K. 1997. Status and distribution of the southwestern willow flycatcher along the Colorado River in the Grand Canyon - 1997. USGS Colorado Plateau Field Station final report. 24 pp.

Sogge, M.K., D. Ahlers, and S.J. Sferra. 2010. A natural history summary and survey protocol for the southwestern willow flycatcher: U.S. Geological Survey Techniques and Methods 2A-10, 38 pp.

Sogge, M.K., R.M. Marshall, S.J. Sferra, and T.J. Tibbitts. 1997a. A southwestern willow flycatcher natural history summary and survey protocol. National Park Service Technical Report NPS/NAUCPRS/NRTR-97/12. 37 pp.

Sogge, M.K. and T.J. Tibbitts. 1992. Southwestern willow flycatcher (*Empidonax traillii extimus*) surveys along the Colorado River in Grand Canyon National Park and Glen Canyon National Recreation Area - 1992. National Park Service Cooperative Studies Unit/Northern Arizona University, Flagstaff. 43 pp.

Sogge, M.K. and T.J. Tibbitts. 1994. Distribution and status of the southwestern willow flycatcher along the Colorado River in the Grand Canyon - 1994. Summary Report. National Biological Service Colorado Plateau Research Station/Northern Arizona University and U.S. Fish and Wildlife Service. 37 pp.

Sogge, M.K., T.J. Tibbitts, and J. Petterson 1997b. Status and breeding ecology of the southwestern willow flycatcher in the Grand Canyon. Western Birds 28:142-157.

Sogge, M.K., T.J. Tibbitts, and S.J. Sferra. 1993. Status of the southwestern willow flycatcher along the Colorado River between Glen Canyon Dam and Lake Mead - 1993. Summary Report. National Park Service Cooperative Studies Unit/Northern Arizona University and U.S. Fish and Wildlife Service. 69 pp.

Sogge, M.K., T.J. Tibbitts, C. Van Riper III, and T. May. 1995. Status of the southwestern willow flycatcher along the Colorado River in Grand Canyon National Park - 1995. Summary Report. National Biological Service Colorado Plateau Research Station/Northern Arizona University. 26 pp.

Tellman B., R. Yarde, M.G. Wallac. 1997. Arizona's Changing Rivers: How People Have Affected the Rivers. Tucson: University of Arizona. Water Resources Research Center Issue Paper 19.

Tibbitts, T.J., M.K. Sogge, and S.J. Sferra. 1994. A survey protocol for the southwestern willow flycatcher (*Empidonax traillii extimus*). Technical Report NPS/NAUCPRS/NRTR-94/04. National Park Service Colorado Plateau Research Station, Flagstaff, Arizona.

Tibbitts, T.J. and M.J. Johnson. 1999. Southwestern willow flycatcher inventory and monitoring along the Colorado River in Grand Canyon National Park. 1998 Summary Report. USGS Biological Resources Division, Colorado Plateau Field Station, Northern Arizona University, Flagstaff. 17 pp.

Tieleman, B.I., H.J. van Noordwijk, and J.B. Williams. 2008. Nest site selection in a hot desert: trade-off between microclimate and predation risk? Condor 110:116-124.

Turner, T.M. and M.M. Karpiscak. 1980. Recent vegetation changes along the Colorado River between Glen Canyon Dam and Lake Mead, Arizona, U.S. Geological Survey Prof. Paper 1132.

Unitt, P. 1987. *Empidonax traillii extimus:* An Endangered Species. W. Birds 18:137-162.

U.S. Bureau of Reclamaion [USBR]. 2013. Historic reservoir levels for Lake Mead at Hoover Dam. http://www.usbr.gov/lc/region/g4000/hourly/mead-elv.html Accessed 28 June 2013.

U.S. Fish Wildlife Service [USFWS]. 1993. Endangered and threatened wildlife and plants; proposed rule to list the Southwestern Willow Flycatcher as Endangered with critical habitat. Federal Register 58:39495-39522.

U.S. Fish Wildlife Service [USFWS]. 1995. Final rule determining endangered status for the southwestern willow flycatcher (*Empidonax traillii extimus*). Federal Register 60:10694 (February 27, 1995).

U.S. Fish Wildlife Service [USFWS]. 2002. Southwestern Willow Flycatcher Recovery Plan. Albuquerque NM. I-IX + 210 pp, Appendices A-O.

U.S. Fish Wildlife Service [USFWS]. 2005. Final rule designating critical habitat for the southwestern willow flycatcher (*Empidonax traillii extimus*). Federal Register 70(201):60886-61009 (October 19, 2005).

U.S. Fish Wildlife Service [USFWS]. 2013. Final rule designating critical habitat for the southwestern willow flycatcher (*Empidonax traillii extimus*). Federal Register 78(2): 344- 534 (January 3, 2013).

Ward, R.V., T. Bowden, and R. Palarino 2010. Surveying for southwestern willow flycatchers (*Empidonax traillii extimus*) in Grand Canyon National Park. A Proposal. Grand Canyon National Park, Grand Canyon, Arizona 86023.

Whitfield, M.J. and M.K. Sogge. 1999. Rangewide impact of brown-headed cowbird parasitism on the Southwestern willow flycatcher *(Empidonax traillii extimus*). Pages 182–190 *in* Research and Management of the Brown-Headed Cowbird in Western Landscapes (M.L. Morrison, L.S. Hall, S.K. Robinson, S.I. Rothstein, D.C. Hahn, and T.D. Rich, Eds.). Studies in Avian Biology, no. 18. Whitmore, R.C. 1977. Habitat partitioning in a community of passerine birds. Wilson Bulletin 89:253-265.

Whitmore, R.C. 1977. Habitat partitioning in a community of passerine birds. Wilson Bulletin

89:253-265.

Yard, H.K. 2001. Southwestern willow flycatcher surveys and nest searches 2001. Summary Report to Grand Canyon Research and Monitoring Center. 2 pp.

Yard, H.K. 2005. Final report: southwestern willow flycatcher surveys results. Submitted to Grand Canyon National Park. 19 pp.

Appendix A. Documented Nest Sites of Southwestern Willow Flycatchers in Grand Canyon National Park between Lee's Ferry and Pearce Ferry, 1935-2012.

River Mile[1] (Site Name)	River L/R	Year	# of Nests[2]	Field Notes
0 (Lee's Ferry)	L	1936	1	nest collected
28.5	L	2003	1	nest successful
46.9	R	1987	1	unknown fate of nest
47.5	R	1985	1	nest parasitized; nest abandoned
50.6	L	2001	1	nest parasitized; unknown fate of nest
		2003	1	nest successful
50.7	L	1993	2	1 nest was parasitized and failed; other nest failed
		1994	4	Nests of 2 breeding pairs; both nests were parasitized and then rebuild; both second nests were parasitized second time and failed.
		1995	1	nest parasitized and failed
		1996	2	1 nest successful, 1 nest failed
		1997	1	nest parasitized and failed
		1998	1	1 nest failed
		1999	1	unknown fate of nest
50.9	L	1991	1	unknown fate of nest
		2000	1	unknown fate of nest
51.0	L	1985	1	unknown fate of nest
51.2	L	1982	1	unknown fate of nest
51.7	L	1994	4	Nests of 2 breeding pairs; both nests failed and then rebuild; both second nests abandoned and failed
51.8	L	1987	1	unknown fate of nest
52.2	L	1985	1	unknown fate of nest
71.6 (Cardenas Marsh)	L	1971	1	unknown fate of nest
		1982	1	unknown fate of nest
		1984	2	Nests of 1 breeding pair, 1st nest abandoned after it was parasitized. 2nd nest was build but also parasitized and failed.
		1985	1	nest parasitized; unknown fate of nest
		1986	2	Nests of 2 breeding pairs; unknown fates of both nests
		1987	1	unknown fate of nest
		1991	1	unknown fate of nest
		1992	1	Nest successful
		1993	1	unknown fate of nest
246 (Spencer Canyon)	L	1998	1	Nest successful
		1999	2	Nests of 2 breeding pairs; 1 nest successful, 1 nest of unknown fate
		2000	2	Nests of 1 breeding pair2 nests of unknown fate
		2001	2	2 nests successful
259.8 (Burnt Springs)	R	1999	1	Nest successful
		2007	1	Nest successful
260.8	R	2001	1	Nest successful

River Mile[1] (Site Name)	River L/R	Year	# of Nests[2]	Field Notes
264.4	L	1998	1	Nest successful
266	R	2001	1	Nest failed
267.7	L	1998	1	Nest successful
		1999	1	Nest successful
		2000	2	Both nests successful
		2001	1	Nest successful
269.8	L	1997	1	Nest successful
275	R	2004	1	Nest failed
		2006	1	Unknown fate of nest

[1] River Miles in GCMRC river mile measure.
[2] Total nest observed; includes nests that were rebuild after first nest failed

Appendix B: Southwestern Willow Flycatcher Adult, Breeding Pair, and Nest Annual Totals, 1982 - 2012

	Lee's Ferry-Phantom Ranch			Phantom Ranch-Diamond Creek			Diamond Creek- Pearce Ferry		
	Adult[1]	*Pair*[2]	*Nest*[3]	*Adult*	*Pair*	*Nest*	*Adult*	*Pair*	*Nest*
1982	2	2	2	ns[4]	ns	ns	ns	ns	ns
1983	4	0	ns	ns	ns	ns	ns	ns	ns
1984	4	1	2	ns	ns	ns	ns	ns	ns
1985	10	4	4	ns	ns	ns	ns	ns	ns
1986	13	2	2	ns	ns	ns	ns	ns	ns
1987	10	3	3	ns	ns	ns	ns	ns	ns
1991	4	2	2	ns	ns	ns	ns	ns	ns
1992	5	1	1	1	0	0	0	0	0
1993	8	3	3	0	0	0	3	0	0
1994	24	4	8	1	0	0	0	0	0
1995	5	1	1	ns	ns	ns	ns	ns	ns
1996	7	1	2	ns	ns	ns	1	0	0
1997	4	1	1	ns	ns	ns	9	3	1
1998	2	1	1	0	0	0	18	4	4
1999	4	1	1	0	0	0	29	13	4
2000	3	1	1	1	0	0	25	9	4
2001	4	1	1	1	0	ns	38	17	5
2002	2	0	0	1	0	ns	0	0	0
2003	4	2	2	0	0	0	1	0	0
2004	1	0	0	0	0	0	2	1	1
2005	0	0	0	ns	ns	ns	1	0	0
2006	0	0	0	ns	ns	ns	4	1	1
2007	1	0	ns	ns	ns	ns	7	1	1
2008	0	0	0	ns	ns	ns	0	0	0
2009	3	0	ns	ns	ns	ns	ns	ns	ns
2010	2	0	ns	3	1	ns	2	0	ns
2011	1	0	ns	2	0	ns	0	0	ns
2012	0	0	ns	0	0	ns	0	0	ns

[1]Total number of adult SWFL observed
[2]Total number of breeding pairs observed (1 pair = 2 adult SWFLs)
[3]Total number of nests found, includes nests that were re-nests (nest rebuild after first or second nest failed/destroyed)
[4]No survey conducted

Appendix C: Willow Flycatcher Survey and Detection Form, 2010

Site Name_____ State_____ County _____
USGS Quad Name _____ Elevation _____(meters)
Creek, River, Wetland, or Lake Name_____
Is copy of USGS map marked with survey area and WIFL sightings attached (as required)? Yes___ No____

Survey Coordinates: Start: E_____ N_____ UTM Datum_____(See instructions)
Stop: E_____ N_____ UTM Zone _____
If survey coordinates changed between visits, enter coordinates for each survey in comments section on back of this page.

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

Survey # / Observer(s) (Full Name)	Date (m/d/y) Survey time	Number of Adult WIFLs	Estimated Number of Pairs	Estimated Number of Territories	Nest(s) Found? Y or N / If Yes, number of nests	Comments (e.g., bird behavior; evidence of pairs or breeding; potential threats [livestock, cowbirds, *Diorhabda* spp.]). If *Diorhabda* found, contact USFWS and State WIFL coordinator	GPS Coordinates for WIFL Detections (this is an optional column for documenting individuals, pairs, or groups of birds found on each survey). Include additional sheets if necessary.			
							# Birds	Sex	UTM E	UTM N
Survey # 1 Observer(s)	Date Start Stop Total hrs ___									
Survey # 2 Observer(s)	Date Start Stop Total hrs ___									
Survey # 3 Observer(s)	Date Start Stop Total hrs ___									
Survey # 4 Observer(s)	Date Start Stop Total hrs ___									
Survey # 5 Observer(s)	Date Start Stop Total hrs ___									

Overall Site Summary Totals do not equal the sum of each column. Include only resident adults. Do not include migrants, nestlings, and fledglings. Be careful not to double count individuals. Total Survey Hrs_____	Total Adult Residents	Total Pairs	Total Territories	Total Nests	Were any Willow Flycatchers color-banded? Yes___ No ___ If yes, report color combination(s) in the comments section on back of form and report to USFWS.

Reporting Individual _____ Date Report Completed_____
US Fish and Wildlife Service Permit #_____State Wildlife Agency Permit #_____

<u>Submit</u> form to USFWS and State Wildlife Agency by September 1st. Retain a copy for your records.Fill in the following information completely. <u>Submit</u> form by September 1st. Retain a copy for your records.

Reporting Individual _____Phone # _____
Affiliation _____ E-mail _____
Site Name_____Date Report Completed _____
Was this site surveyed in a previous year? Yes___ No ___ Unknown ____
Did you verify that this site name is consistent with that used in previous years? Yes ____No ____Not Applicable_

If site name is different, what name(s) was used in the past?_____

If site was surveyed last year, did you survey the same general area this year? Yes ____ No ____ If no, summarize below.
Did you survey the same general area during each visit to this site this year? Yes ____ No ____ If no, summarize below.

Management Authority for Survey Area: Federal____ Municipal/County ____ State ____ Tribal ____ Private __
Name of Management Entity or Owner (e.g., Tonto National Forest) _____
Length of area surveyed: _____ (km)

Vegetation Characteristics: Check (only one) category that best describes the predominant tree/shrub foliar layer at this site:

_____ Native broadleaf plants (entirely or almost entirely, > 90% native)

_____ Mixed native and exotic plants (mostly native, 50 - 90% native)

_____ Mixed native and exotic plants (mostly exotic, 50 - 90% exotic)

_____ Exotic/introduced plants (entirely or almost entirely, > 90% exotic)

Identify the 2-3 predominant tree/shrub species in order of dominance. Use scientific names.
_____
_____
_____

Average height of canopy (Do not include a range): _____ (meters)

Attach the following: 1) copy of USGS quad/topographical map (REQUIRED) of survey area, outlining survey site and location of WIFL detections; 2) sketch or aerial photo showing site location, patch shape, survey route, location of any detected WIFLs or their nests; 3) photos of the interior of the patch, exterior of the patch, and overall site. Describe any unique habitat features in Comments.

Comments (such as start and end coordinates of survey area if changed among surveys, supplemental visits to sites, unique habitat features. Attach additional sheets if necessary.

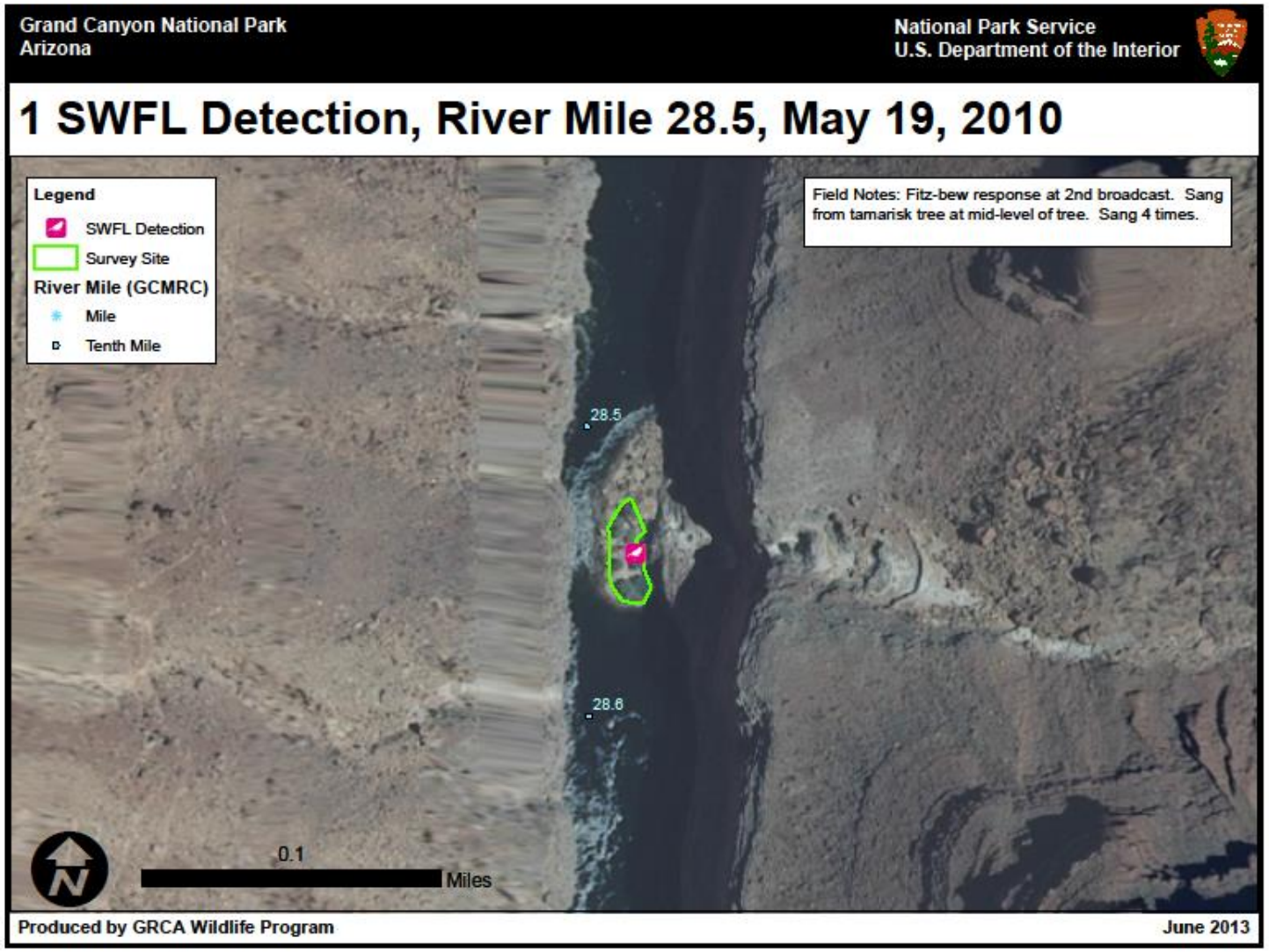
_____
_____
_____
_____
_____
_____

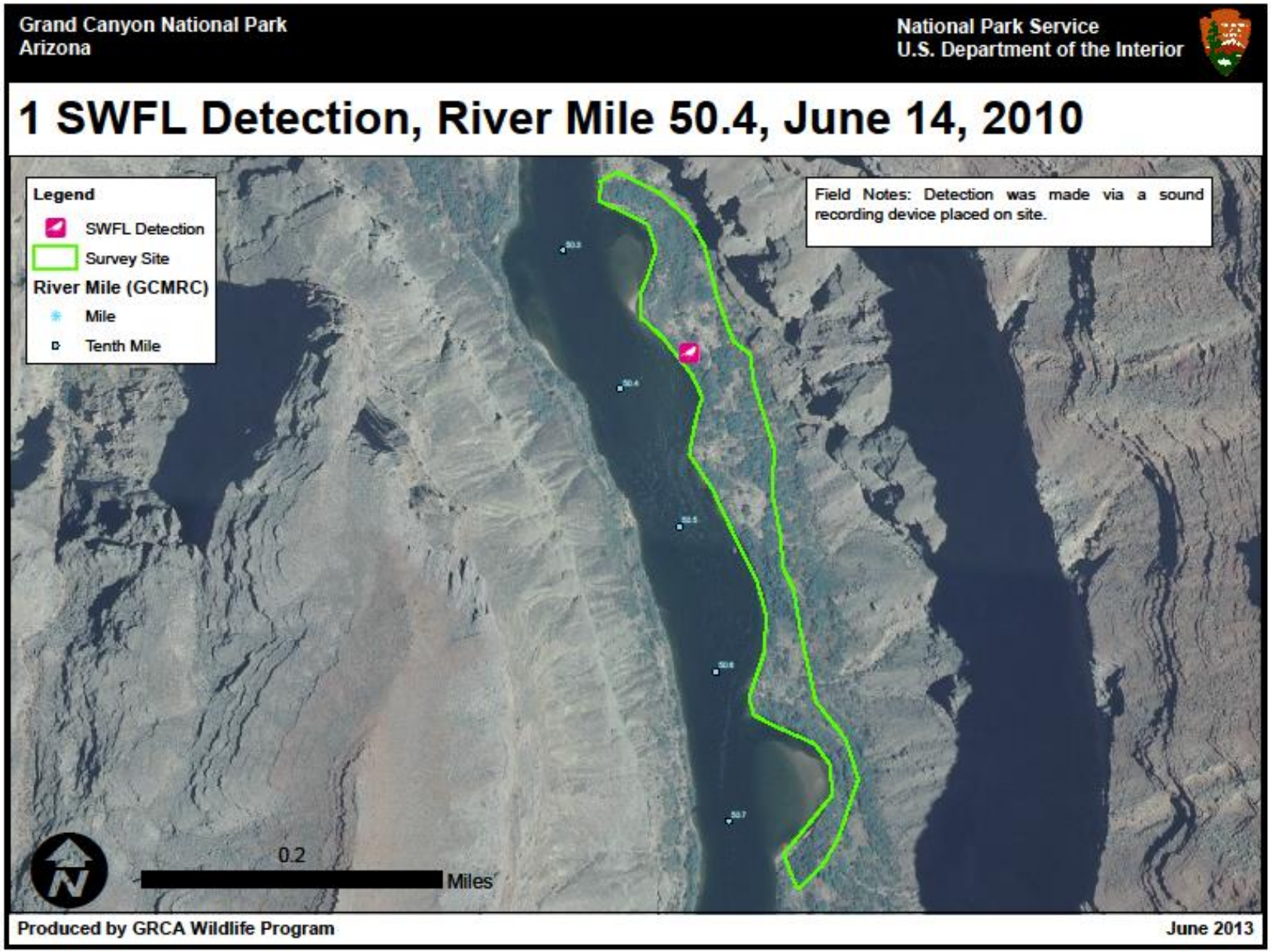
Territory Summary Table. Provide the following information for each verified territory at your site.

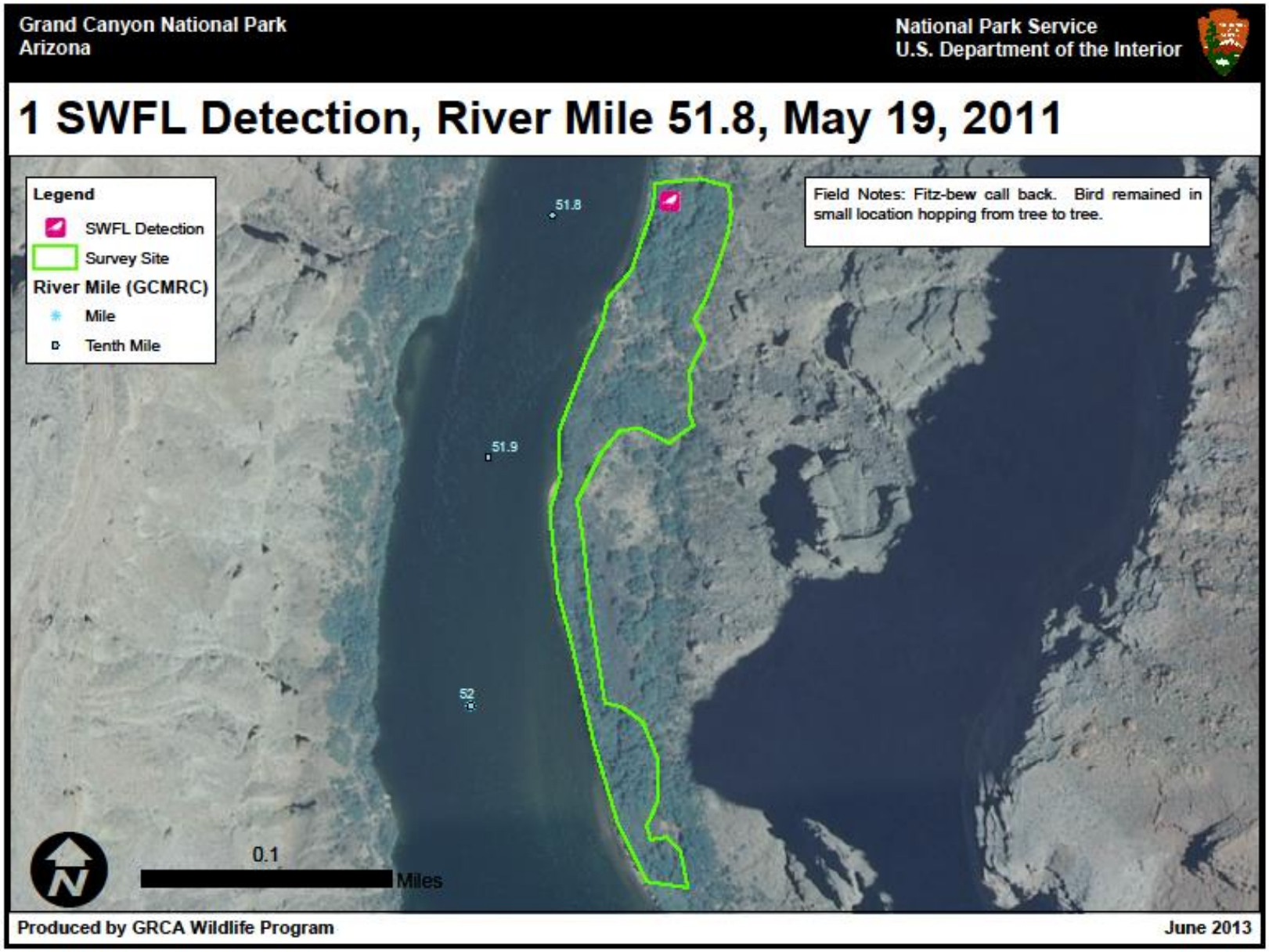
Territory Number	All Dates Detected	UTM E	UTM N	Pair Confirmed? Y or N	Nest Found? Y or N	Description of How You Confirmed Territory and Breeding Status (e.g., vocalization type, pair interactions, nesting attempts, behavior)

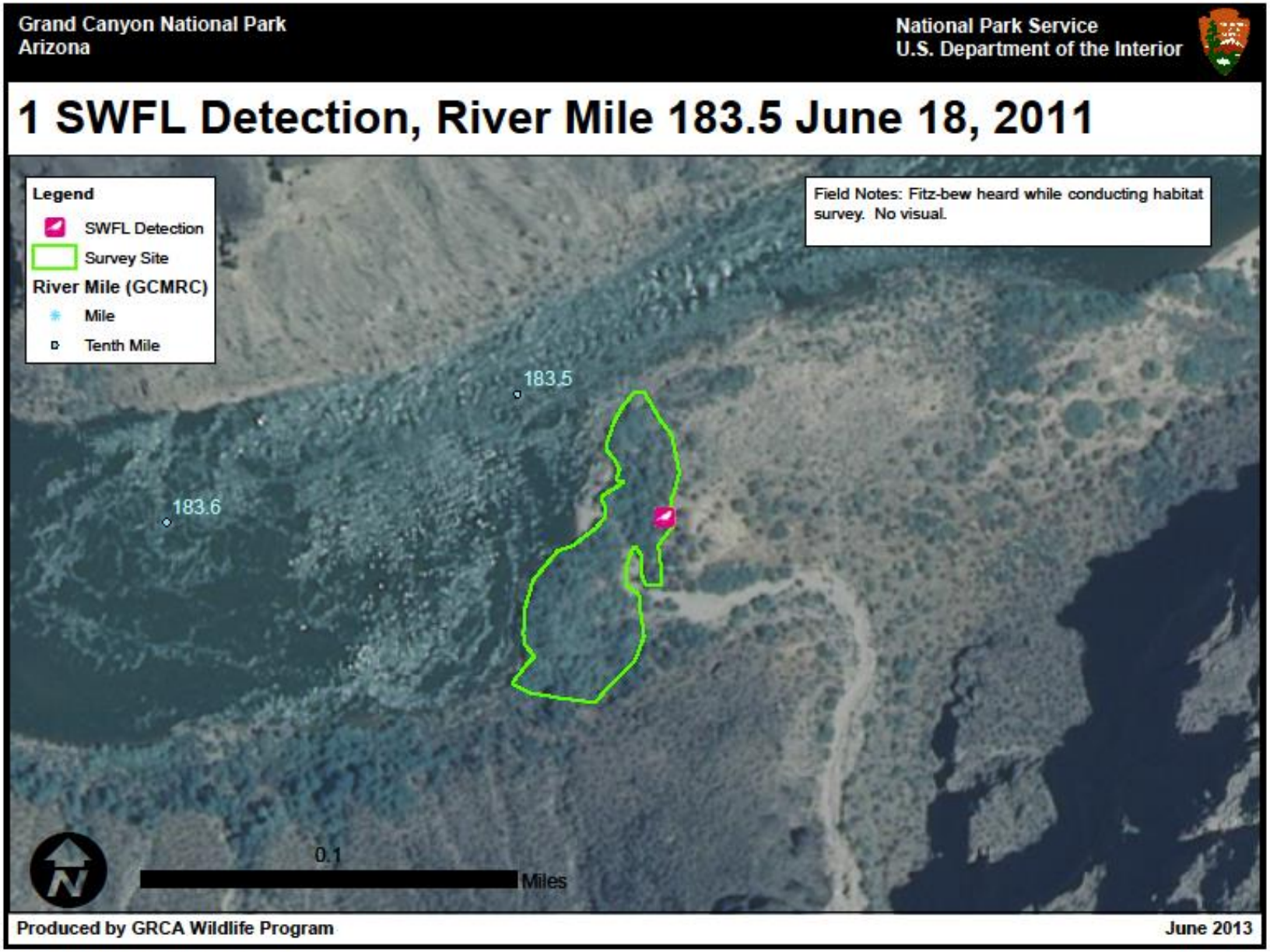
Attach additional sheets if necessary

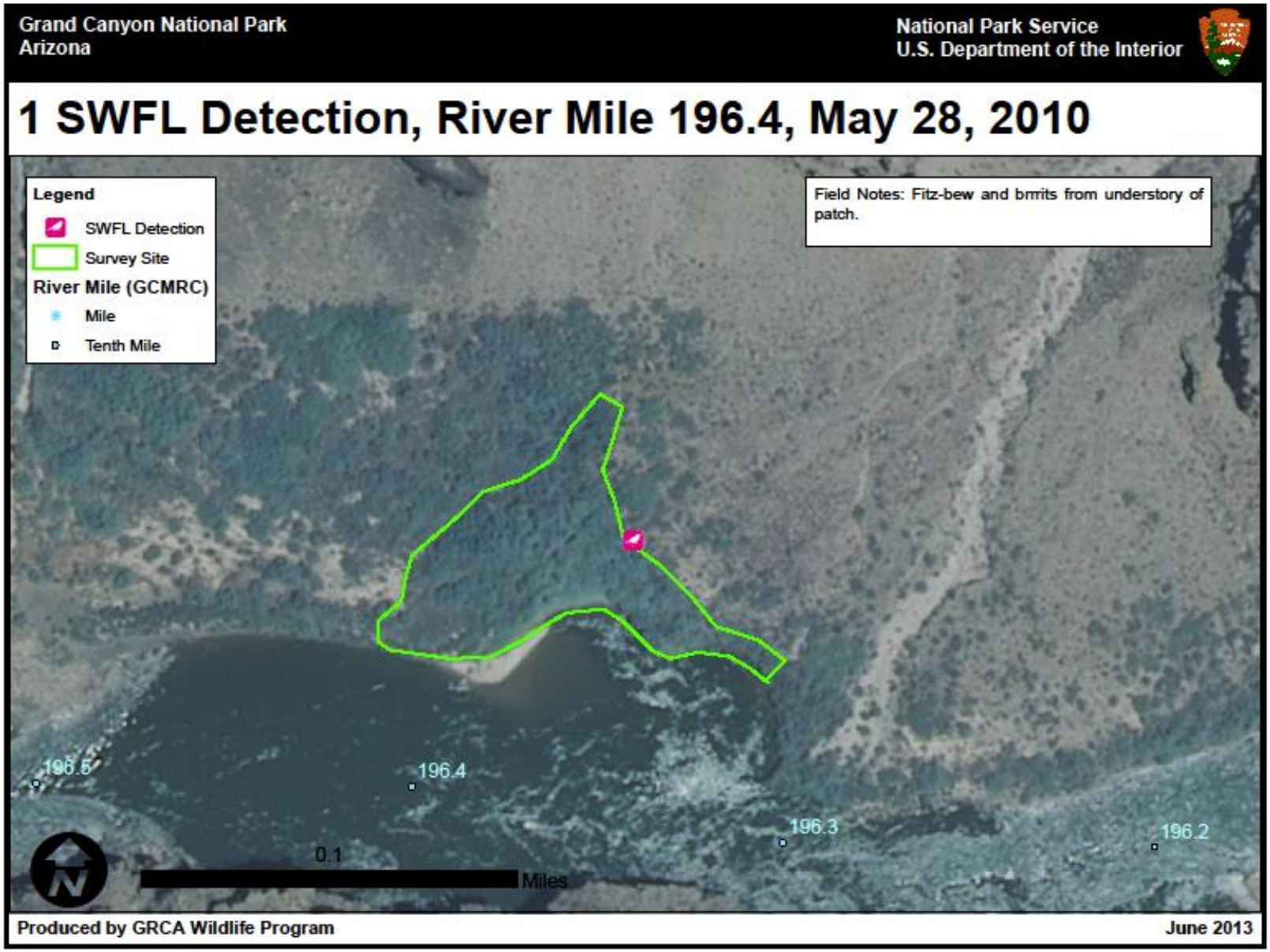
Appendix D. Maps of Southwestern Willow Flycatcher Detection Locations, 2010- 2012

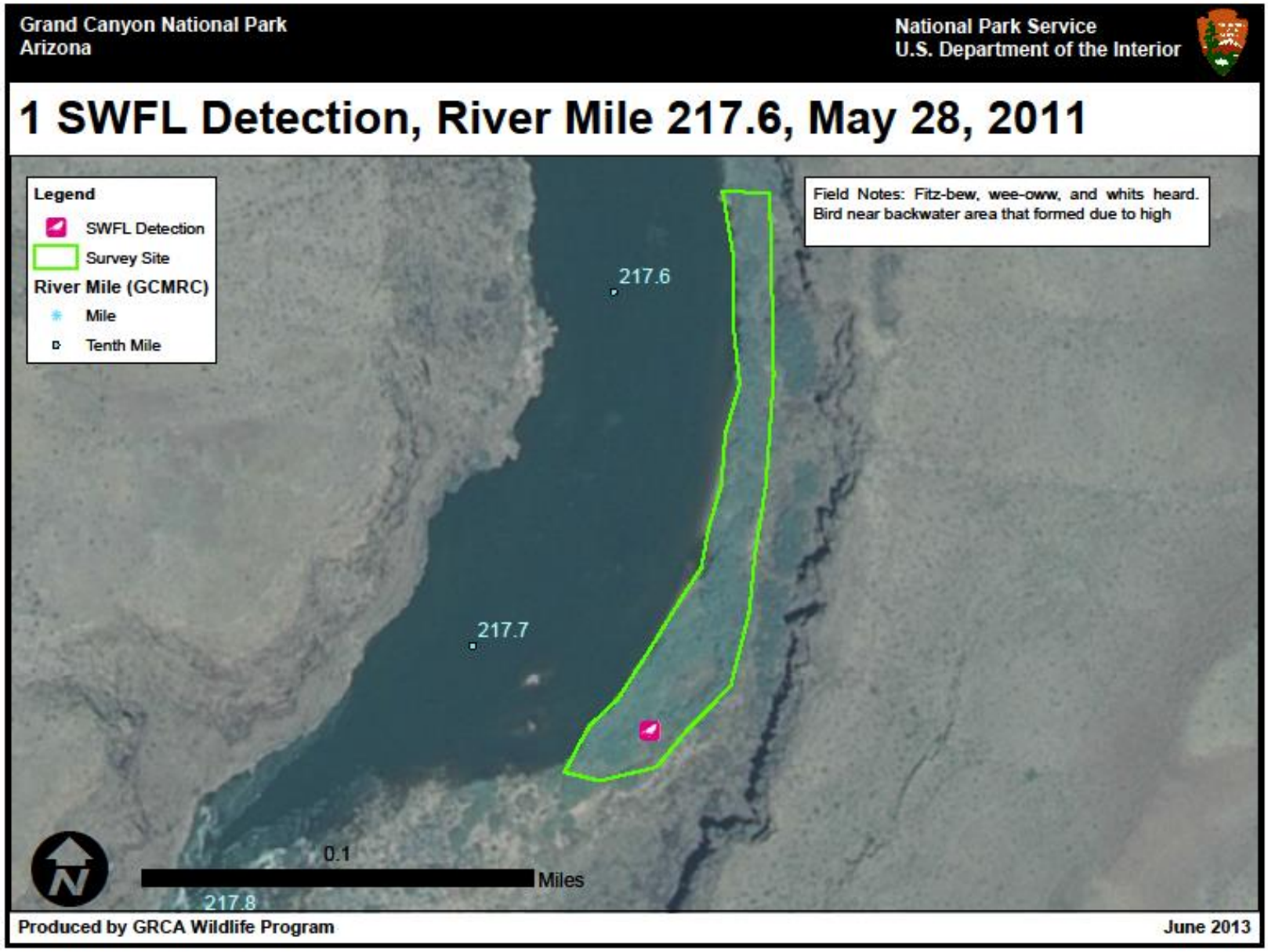


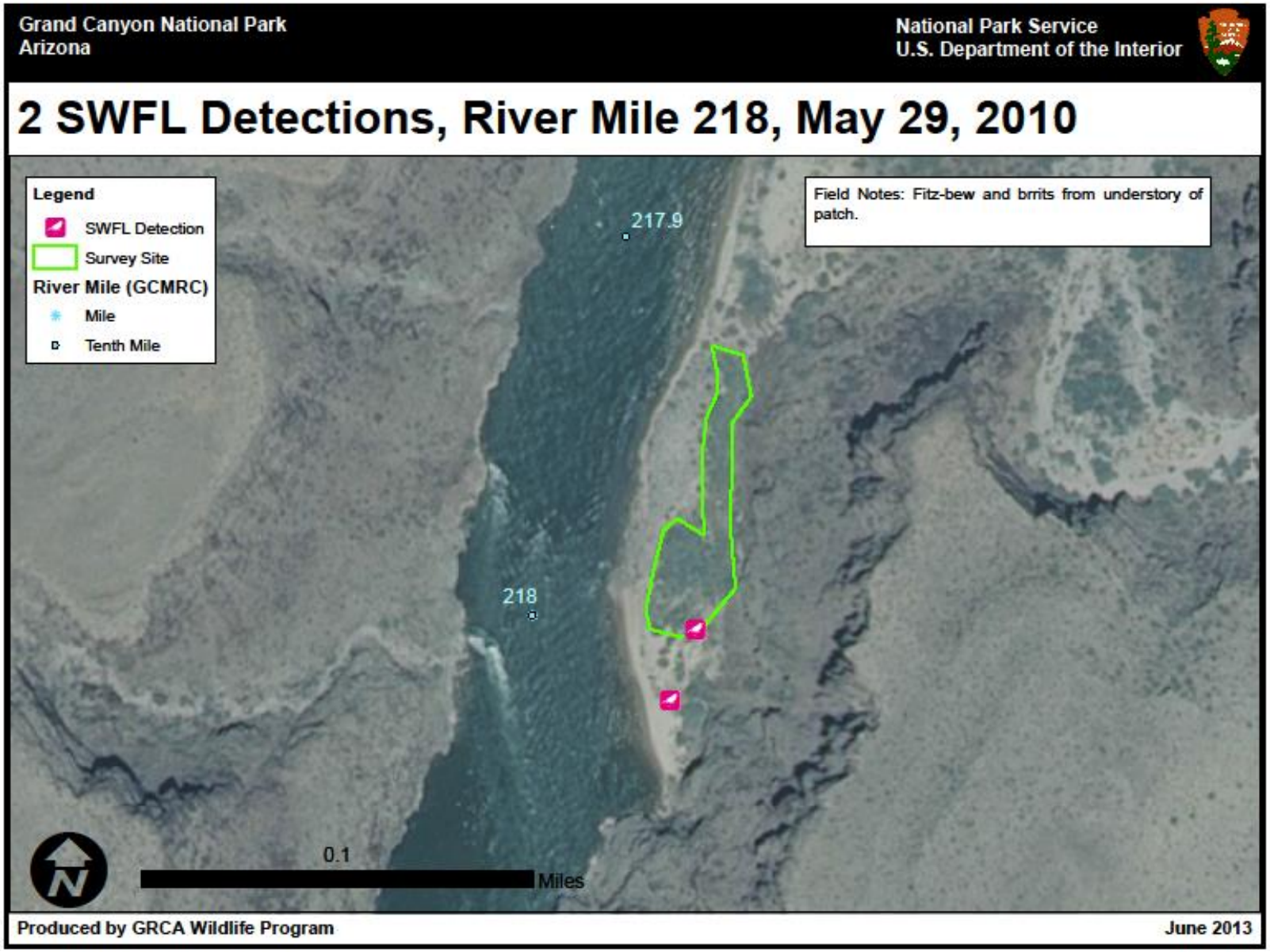

Grand Canyon National Park
Arizona
National Park Service
U.S. Department of the Interior
1 SWFL Detection, River Mile 50.4, June 14, 2010
Legend
SWFL Detection
Survey Site
River Mile (GCMRC)
Mile
Tenth Mile
Field Notes: Detection was made via a sound recording device placed on site.
0.2
Miles
Produced by GRCA Wildlife Program
June 2013

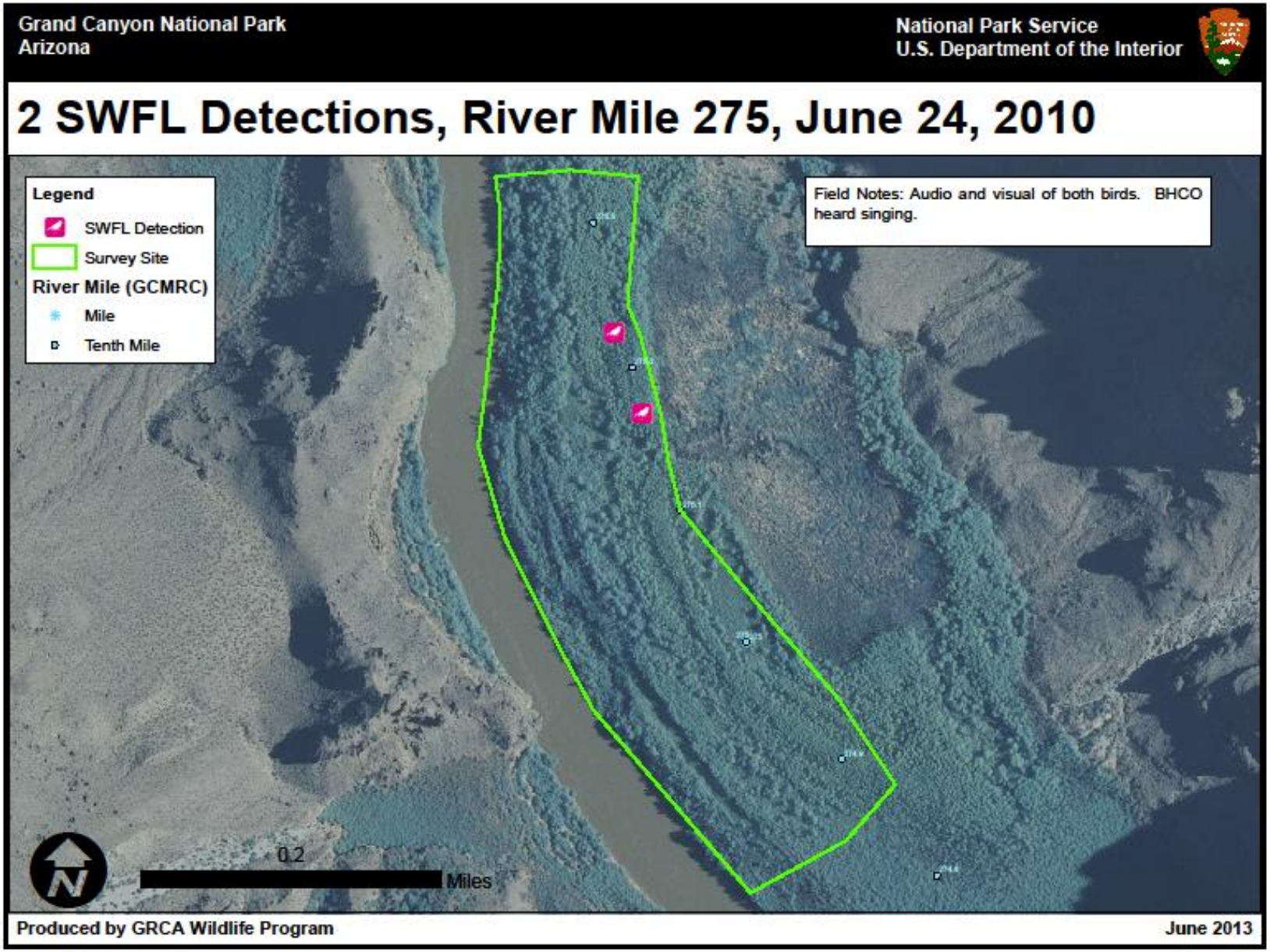

Grand Canyon National Park
Arizona
National Park Service
U.S. Department of the Interior
1 SWFL Detection, River Mile 51.8, May 19, 2011
Legend
SWFL Detection
Survey Site
River Mile (GCMRC)
Mile
Tenth Mile
Field Notes: Fitz-bew call back. Bird remained in small location hopping from tree to tree.
51.8
51.9
52
0.1
Miles
Produced by GRCA Wildlife Program
June 2013


Grand Canyon National Park
Arizona
National Park Service
U.S. Department of the Interior
1 SWFL Detection, River Mile 183.5 June 18, 2011
Legend
SWFL Detection
Survey Site
River Mile (GCMRC)
Mile
Tenth Mile
Field Notes: Fitz-bew heard while conducting habitat survey. No visual.
183.5
183.6
0.1
Miles
Produced by GRCA Wildlife Program
June 2013


Grand Canyon National Park
Arizona
National Park Service
U.S. Department of the Interior
1 SWFL Detection, River Mile 196.4, May 28, 2010
Legend
SWFL Detection
Survey Site
River Mile (GCMRC)
Mile
Tenth Mile
Field Notes: Fitz-bew and brrits from understory of patch.
196.5
196.4
196.3
196.2
0.1
Miles
Produced by GRCA Wildlife Program
June 2013


Grand Canyon National Park
Arizona
National Park Service
U.S. Department of the Interior
1 SWFL Detection, River Mile 217.6, May 28, 2011
Legend
SWFL Detection
Survey Site
River Mile (GCMRC)
Mile
Tenth Mile
Field Notes: Fitz-bew, wee-oww, and whits heard. Bird near backwater area that formed due to high
217.6
217.7
217.8
0.1
Miles
Produced by GRCA Wildlife Program
June 2013


Grand Canyon National Park
Arizona
National Park Service
U.S. Department of the Interior
2 SWFL Detections, River Mile 218, May 29, 2010
Legend
SWFL Detection
Survey Site
River Mile (GCMRC)
Mile
Tenth Mile
Field Notes: Fitz-bew and brrits from understory of patch.
217.9
218
0.1
Miles
Produced by GRCA Wildlife Program
June 2013


Grand Canyon National Park
Arizona
National Park Service
U.S. Department of the Interior
2 SWFL Detections, River Mile 275, June 24, 2010
Legend
SWFL Detection
Survey Site
River Mile (GCMRC)
Mile
Tenth Mile
Field Notes: Audio and visual of both birds. BHCO heard singing.
N
0.2
Miles
Produced by GRCA Wildlife Program
June 2013

Appendix E: Southwestern Willow Flycatcher Habitat Assessment Form

DATE:_____OBSERVER(S):_____

SITE/CANYON NAME:_____

GCMRC RIVER MILE:_____RIVER SIDE: R L

UTM START: __ __ __ __ __ __E __ __ __ __ __ __ __N ACCURACY: _____m
UTM END: __ __ __ __ __ __E __ __ __ __ __ __ __N ACCURACY: _____m

NAD27 or NAD83 (circle one)

LIGHT EXPOSURE: full-sun partial-sun full-shade

CANOPY COVER: sparse(0-25%) low(26-50%) moderate(51-75%) high(76-100%)

UNDERSTORY DENSITY: sparse(0-25%) low(26-50%) moderate(51-75%) high(76-100%)

UNDERSTORY COMPOSITION: live foliage dead branches both

DOMINANT PLANT SPECIES:_____
_____

ASSOCIATED PLANT SPECIES: _____
_____

AVERAGE TREE HEIGHT: _____m

TAMARISK ESTIMATE: none sparse(1-25%) low(26-50%) moderate(51-75%) high(76-100%)

VEGETATION PATCH SIZE: _____ Circle One: Field Est. Aerial Photo

WATER WITHIN 25m: Y N Circle One: seep spring stream pothole river

SOIL MOISTURE: dry moist saturated standing water

INCIDENTAL BIRD SPECIES: _____
_____

BHCO DETECTION: Y N How Many: ____male **____**female **____**juvenile

TAMARISK BEETLE SURVEYS CONDUCTED: Y N Beetle Detection: Y N

PHOTOS TAKEN: Y N Reference: _____

SOUTHWESTERN WILLOW FLYCATCHER DETERMINATION:

suitable potential unsuitable

COMMENTS: _____
_____
_____
_____

Appendix F: Southwestern Willow Flycatcher Sound Monitoring Set-up Form

Date			
Observer		**Site**	
Name		SiteID	
Organization	GRCA	Unit Location	
Phone		EUTM	
Email		NUTM	
Instrument		Elevation	
Song Meter (model)		Accuracy	
Microphone	SMX II	Veg1	
SD card #		Veg1%	
Battery Type	4 D Alkaline	Veg2	
	Settings	Veg2%	
SD card size (GB)		Veg3	
Recording	Stereo Mono-R Mono-L (circle)	Veg3%	
		Photos (Y/N)	