Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

2019 Updates to Southwestern Willow Flycatcher (*Empidonax traillii extimus*) (SWFL) Basic Conceptual Ecological Model for the Lower Colorado River

Photos courtesy of the Bureau of Reclamation

February 2021

Work conducted under LCR MSCP Work Task G6

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2019 Updates to Southwestern Willow Flycatcher (*Empidonax traillii extimus*) (SWFL) Basic Conceptual Ecological Model for the Lower Colorado River

Prepared by:

David W. Mehlman, Ph.D., Elizabeth A. Johnson, and Robert Unnasch, Ph.D.

Sound Science, LLC

Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Basin
Boulder City, Nevada
http://www.lcrmscp.gov

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ACRONYMS AND ABBREVIATIONS

CAP	critical biological activity or process
CEM	conceptual ecological model
CF	controlling factor
cm	centimeter(s)
ha	hectare(s)
HE	habitat element
km	kilometer(s)
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
LSO	life-stage outcome
m	meter(s)
N/A	not applicable
Reclamation	Bureau of Reclamation
SWFL	southwestern willow flycatcher (*Empidonax traillii extimus*)
USFWS	U.S. Fish and Wildlife Service

Symbols

°C	degrees Celsius (*aka* Centigrade)
>	greater than
≥	greater than or equal to
<	less than
≤	less than or equal to
#	number
%	percent
±	plus or minus

Definitions

For the purposes of this document, vegetation layers are defined as follows:

Canopy – The canopy is the uppermost strata within a plant community. The canopy is exposed to the sun and captures the majority of its radiant energy.

Understory – The understory comprises plant life growing beneath the canopy without penetrating it to any extent. The understory exists in the shade of the canopy and usually has lower light and higher humidity levels. The understory includes subcanopy trees and the shrub and herbaceous layers.

Shrub layer – The shrub layer is comprised of woody plants between 0.5 and 2.0 meters in height.

Herbaceous layer – The herbaceous layer is most commonly defined as the forest stratum composed of all vascular species that are 0.5 meter or less in height.

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Attachment

1 Southwestern Willow Flycatcher (*Empidonax traillii extimus)* (SWFL) Habitat Data

Foreword

This report provides an update to the original conceptual ecological model (CEM) prepared for the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) for southwestern willow flycatcher (*Empidonax traillii extimus*) (SWFL) (McClure et al. 2016). This update incorporates information reported in publications and presentations at professional meetings since the completion of the original SWFL conceptual ecological model, and it also incorporates information from the professional experiences of LCR MSCP staff and other experts. An updated version of the CEM workbook incorporates the new information. This report constitutes an appendix to the original CEM. The full CEM report, including its life-stage diagrams, has not been updated.

The structure of the present report follows the structure of the original CEM report. Specifically, it presents and documents updates to chapters 1-6. It does not include updates to the original Executive Summary or chapters 7-8 because these sections were not updated.

The updates reported herein change the original SWFL conceptual ecological model in several ways. The terminology used has been updated and standardized in many parts of the CEM to be consistent across species as much as possible. Several changes were made to habitat elements: (1) addition of one element for consistency, (2) separation of one former combined habitat element into two separate elements to better reflect different components of habitat, and (3) combination of two formerly separated habitat elements into one for simplification. One controlling factor was added for consistency with other CEMs. These changes have created numerous edits and adjustments throughout the CEM text and workbook.

This report also provides a list of all literature cited in the updates to chapters 1–6. In addition, it provides a list of all changes made to the name of the CEM components to standardize terminology across all CEMs.

This update both explicitly and implicitly identifies possible new research and monitoring questions concerning gaps in knowledge that may bear on adaptive management of SWFL. These questions may or may not reflect the current or future goals of LCR MCSP decision making and are in no way meant as a call for the Bureau of Reclamation to undertake research to fill the identified knowledge gaps.

Updates to Chapter 1 – Introduction

The information in paragraph 3 in the initial section of chapter 1 is updated as follows:

The most widely used sources of information for the southwestern willow flycatcher (*Empidonax traillii extimus*) (SWFL) conceptual ecological model (CEM) are BIO-WEST, Inc. (2005), Dobbs et al. (2012), Ellis et al. (2008, 2009), Graber et al. (2012), Lower Colorado River Multi-Species Conservation Program (LCR MSCP) (2004, 2008), McLeod and Pellegrini (2013, 2014, 2015, 2017a, 2017b, 2019, 2020), McLeod et al. (2018), Moore (2007), Paradzick (2005), Paxton et al. (2007), Sogge et al. (2010), and U.S. Fish and Wildlife Service (USFWS) (2002, 2014).

These publications summarize and cite large bodies of earlier studies. Where appropriate and accessible, those earlier studies are directly cited. The CEM also integrates numerous additional sources, particularly reports and articles completed since the aforementioned publications; information on current research projects; and the expert knowledge of LCR MSCP avian biologists. In addition, sources of information for SWFL in other areas of the Southwest were consulted to supplement research along the lower Colorado River (LCR). The purpose of a conceptual ecological model is not to provide an updated literature review but to integrate the available information and knowledge into a CEM so it can be used for adaptive management.

Update to Southwestern Willow Flycatcher Reproductive Ecology

SWFL adults typically arrive on the breeding grounds between early May and early June. After-second-year males arrive earlier and set up territories before the females arrive (BIO-WEST, Inc. 2005; LCR MSCP 2008; Sedgwick 2020), whereas second-year males arrive at the same time as the females (Finch et al. 2002). Polygyny in SWFL is well documented, with from 3 to 50% of males pairing with multiple females, depending on the population (Pearson et al. 2006). Evidence from the Kern River Valley population in California suggests that polygynous males fledge more offspring than monogamous males (Pearson et al. 2006). Data from a declining SWFL population at Marine Corps Base Pendleton, California, showed an increasing female-biased sex ratio as the population decline, apparently due (at least partly) to female-biased nestling ratios and not from bias in emigrating or immigrating individuals (Kus et al. 2017). The proportion of males exhibiting polygyny was positively related to the ratio of females to males over the years studied.

The female will choose a territory and then build a nest within a week of pair formation (LCR MSCP 2008). SWFL build an open cup nest, about 8 centimeters (cm) high and wide, of leaves, grass, fibers, feathers, and animal hair. The nest is typically placed in a fork of several multi-diameter stems and can range from 0.6 to 18 meters (m) above the ground (Paxton et al. 2007; USFWS 2002). SWFL nests are commonly placed in native plants, such as willows (*Salix* spp.) and box elder (*Acer negundo*), and in exotics such as tamarisk (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*), with nest location apparently driven more by plant structure than by species composition (Paxton et al. 2007).

Recent observed territory sizes along the Virgin River near St. George, Utah, ranged from 0.2–0.5 hectare (ha) (Edwards 2017). Bakian and Paxton (2004) determined range sizes for SWFL at Fish Creek, Utah. The mean core area, extended home range, and total use area were significantly larger for breeding males than breeding females (0.14 versus 0.02 ha, 0.76 versus 0.21 ha, and 1.6 versus 0.50 ha, respectively). The few non-breeding birds of both sexes studied used considerably larger areas than breeding birds. The nest is generally completed over a 4- to 7-day period (Finch et al. 2002). Incubation typically lasts 12–15 days, with most of the incubation and brooding being done by the female, while the male is more active in feeding the young after fledging (Finch et al. 2002; Sogge 2000). If adults fail to attain a territory or a mate, they may become floaters (adult birds that do not breed) within the population. Floaters are usually second-year males (Paxton et al. 2007; Theimer et al. 2018a). Koronkiewicz et al. (2006) found an average of 29% of birds being unpaired, or floaters, from 2003 to 2006.

Juveniles fledge between 12–15 days (Sogge 2000), and recently fledged young remain close to the nest for 3–5 days afterward (Finch et al. 2002). Juveniles will remain in the general vicinity of the nest and of parents for a couple of weeks and are fed by the parents during this time (Finch et al. 2002; Sedgwick 2020). During fall migration, juveniles generally leave the breeding grounds 1 or 2 weeks after the adults (BIO-WEST, Inc. 2005; LCR MSCP 2008; Sedgwick 2020). Studies of juvenile survival suggest that the survival of juvenile SWFL is lower than that of adults (McLeod and Pellegrini 2013; McLeod et al. 2008b; Paxton et al. 2007). However, many juveniles may not appear, or are otherwise undetected for up to 3 years after hatching, and these may comprise many, if not most, of the floater population (Koronkiewicz et al. 2006).

SWFL overwinter offsite and will return to the same breeding territory if they were successful the previous year (McLeod and Pellegrini 2013; Paxton et al. 2007). Typical breeding habitat consists of dense riparian vegetation characterized by an overstory of Fremont cottonwoods (*Populus fremontii*) and Goodding's willows (*Salix gooddingii*) (hereafter cottonwood-willow). SWFL generally prefer patches that contain a mix of both dense areas for nest placement

and open areas for foraging. SWFL are generalist insectivores, and the abundance and condition of the food supply affects adult health as well as the growth and development of the young during the nestling and juvenile stages.

CONCEPTUAL ECOLOGICAL MODEL PURPOSES

This update does not propose any changes to this section of chapter 1; however, when the CEMs are fully updated, chapter 1 should be revised to indicate that the CEM methodology followed here is a crucial foundation for carrying out effects analyses as described by Murphy and Weiland (2011, 2014) and illustrated by Jacobson et al. (2016).

CONCEPTUAL ECOLOGICAL MODEL STRUCTURE FOR THE SWFL

No change. This will not be updated for the existing CEMs.

Updates to Chapter 2 – SWFL Life-Stage Model

This update standardizes the names of SWFL life stages by switching to the plural noun form for each name for consistency with the other LCR MSCP conceptual ecological model updates. The names of the original life-stage outcomes are standardized as follows: (1) Survivors changes to Survival for all four life stages and (2) Offspring and Reproduction change to Fertility. This update drops the word "rate" from the names of life-stage outcomes because all life-stage outcomes are rate variables by definition. Table 1 and figure 1 (at the end of this chapter) are updated accordingly.

UPDATE TO INTRODUCTION TO THE SWFL LIFE CYCLE

Several demographic studies have resulted in the development of stage-based models of the life cycle of SWFL (McLeod and Pellegrini 2013; McLeod et al. 2008b; Noon and Farnsworth 2000; Paxton et al. 2007; Stoleson et al. 2000). Some of these demographic studies modeled the life cycle of SWFL based on two stages—hatch year and after hatch year (Noon and Farnsworth 2000; Stoleson et al. 2000). Other models used equations to estimate adult and juvenile survival as well as seasonal reproduction (McLeod and Pellegrini 2013; McLeod et al. 2008b; Paxton et al. 2007). During the development of the CEM of the life cycle of SWFL presented here, we drew heavily from the past models developed for SWFL while also considering what would be most useful to management. We therefore considered both the need to understand our model in the context of past work and the need to present the ecological information necessary to effectively manage habitats to support the critical biological activities and processes necessary to sustain SWFL populations.

In many studies of avian demography, nest survival is considered integral in the reproduction of adults because adults are heavily invested in the care of eggs and nestlings (Etterson et al. 2011), and SWFL are no exception (McLeod and Pellegrini 2013; McLeod et al. 2008b; Noon and Farnsworth 2000; Paxton et al. 2007; Stoleson et al. 2000). However, we treat the nest stage as separate from adult reproduction because nest success of SWFL has been the subject of intense study, and the wealth of information learned from studies of SWFL nest success is best presented separately.

Further, we do not follow the framework of Noon and Farnsworth (2000) or Stoleson et al. (2000) by presenting hatch-year and after-hatch-year stages. Instead, we examine the juvenile and breeding adult life stages of SWFL

following Paxton et al. (2007), McLeod and Pellegrini (2013), and McLeod et al. (2008b) because those stages more closely fit our definition of a life stage. We also note that in a past version of this model we treated the egg and nestling stages as separate because they undergo different processes—e.g., eggs do not need to eat or molt. We have here combined the egg and nestling stages into an eggs/nestlings life stage because the both eggs and nestlings occupy the same nest; therefore, management focused on the nest will cover eggs and nestlings. Further, most research conducted on SWFL breeding has focused on the number of young fledged and not on the number of eggs hatched—meaning that most of the available information is on the habitat characteristics and management actions associated with success of the nest through both incubation and brooding periods.

The migratory nature of SWFL complicates its management. The LCR MSCP is mainly responsible for management of created habitat along the LCR where the species breeds, and we therefore focus on three life stages occurring within LCR MSCP lands—eggs/nestlings, juveniles, and breeding adults. SWFL management during migration and winter are certainly important but are outside of the scope of the LCR MSCP's responsibilities. It should be noted, however, that repeated surveys show that the LCR appears to be a major spring flyway for migrating willow flycatchers (*Empidonax traillii*), though its use specifically for migrating SWFL is not well known (Koronkiewicz et al. 2006).

UPDATE TO SWFL LIFE STAGE 1 – EGGS/ NESTLINGS

We consider the eggs/nestlings life stage to be the first in the life cycle of SWFL. It begins when the egg is laid and ends either when the young fledge or the nest fails. Eggs are usually laid in early to mid-June, and incubation lasts around 12 days, with all eggs in a clutch hatching within 2 days of each other (Finch et al. 2002; LCR MSCP 2008). Nestlings are generally present from mid-May through early August (LCR MSCP 2008), and fledging usually occurs 12–15 days after hatching (Finch et al. 2002; LCR MSCP 2008). Overall, sex ratios of SWFL appear close to 50:50, though male- or female-biased ratios occur at some specific sites (Paxton et al. 2002). Green et al. (2003) suggest that nest predation might be the most important factor affecting populations of the willow flycatcher in the Sierra Nevada, an assertion that, if true, makes the eggs/nestlings life stage an especially important time in the life cycle of SWFL. Further, Noon and Farnsworth (2000) found that reproduction—of which nest success is a huge factor—was the parameter that most affected the probability of population extinction. The life-stage outcome from the eggs/nestlings life stage is the survival of eggs and associated nestlings until fledging. It is important to note that the outcome of the eggs/nestlings life stage is inherently tied to the behavior

and condition of the parents. Female SWFL are known to have multiple nests in a breeding season. Of 48 females studied by Koronkiewicz et al. (2006), 18 nested once, 23 twice, 4 nested 3 times, and 3 nested 4 times; of the multiple nesting females, 26 (87%) renested after previous nest failure.

UPDATE TO SWFL LIFE STAGE 2 – JUVENILES

The juveniles life stage begins at fledging and ends when the bird returns to the breeding grounds the next year. For 3 to 5 days after fledging, juveniles will remain close to the nest, perhaps returning to and leaving the nest often (Finch et al. 2002). Juveniles will remain in the general vicinity of the nest and of parents for several weeks and are fed by the parents during this time (Finch et al. 2002; Sedgwick 2020). During fall migration, juveniles generally leave the breeding grounds 1 or 2 weeks after the adults (BIO-WEST, Inc. 2005; LCR MSCP 2008; Sedgwick 2020). The life-stage outcome from the juveniles life stage is the survival of the bird from fledging until returning to the breeding grounds the next calendar year. Paxton et al. (2007) studied SWFL at two sites in Arizona from 1996 to 2005 and found that of 122 juveniles recaptured, the overall juvenile return rate was 24%, with 69% of those found in their second year (year after hatching), 26% in their third year, and 5% in their third or fourth year.

Studies of adult and juvenile survival repeatedly show that the survival of juvenile SWFL is lower than that of adults (Koronkiewicz et al. 2002, 2006; McLeod and Pellegrini 2013, 2015, 2017a, 2017b; McLeod et al. 2008b, 2018; Newell et al. 2005; Paxton et al. 2007;). Noon and Farnsworth (2000) found that survival of the first year of life was the second most influential parameter regarding population persistence.

Estimates of juvenile return rates/survival:

- First year (juvenile) observed return rate at LCR: 27% (13/48) in 2013–14, 22% (13/61) in 2014–15, 15% (11/75) in 2015–16, and 23% (11/48) in 2016–17 (McLeod and Pellegrini 2015, 2017a, 2017b; McLeod et al. 2018).

- Median juvenile annual survivorship (= return rate) at LCR: 22% (range = 13–29%) in 2009–16 (McLeod and Pellegrini 2017a; McLeod et al. 2018).

- First year (juvenile) observed return rate (what the authors call survival) at Roosevelt Lake, Arizona: 17.8% (19/107) in 2001–02, 32% from 2000 to 2002, and 22% from 1999 to 2002 (Koronkiewicz et al. 2002).

- First year (juvenile) observed return rate at Roosevelt Lake, Arizona: 20% (25/124) in 2003–04 (Newell et al. 2005). Additional birds from previous years increased the absolute juvenile survivorship from 2001 to 2004 from 27 to 29%.

- Calculated first year (juvenile) survivorship at Roosevelt Lake, Arizona: 40% in 2003–04 (Newell et al. 2005).

- First year (juvenile) observed return rate at Roosevelt Lake and the Gila/San Pedro River confluence, Arizona: overall 24.5% (122/498; annual range = 10–50%) from 1996 to 2005 (Paxton et al. 2007).

- First year (juvenile) apparent annual survivorship at Roosevelt Lake and the Gila/San Pedro River confluence, Arizona: mean 34% (range = 13–57%) from 1996 to 2005 (Paxton et al. 2007).

Koronkiewicz et al. (2006) found that of 82 juvenile SWFL marked in 2005, only 4 (5%) were found in 2005 at two primary study areas. Across all areas, the median distance moved of dispersing juveniles was 193 kilometers (km) (range = 30–440 km). Across multiple years, of 78 total juvenile SWFL marked, 61.5% (48) returned to the natal area, and 38.5% (30) dispersed.

McLeod and Pellegrini (2017a, 2017b) found juvenile return rates around 53% in 2015 and 55% in 2016. When returning in 2015, 47% of returning juveniles dispersed an average of 3.8 km away from their natal areas (McLeod and Pellegrini 2017b). In 2016, 45% of juveniles moved up to 1.3 km away from their 2015 natal areas (McLeod and Pellegrini 2017a). These rates were consistent with long-term data from 1998 to 2015, where 50% of juvenile returns were to the natal area (McLeod and Pellegrini 2017b).

UPDATE TO SWFL LIFE STAGE 3 – BREEDING ADULTS

The breeding adults life stage begins when the bird returns to the breeding grounds after its first winter and ends when it departs the breeding grounds during fall migration. Note that we are considering all breeding individuals as adults, whereas some other studies separate between-second-year and after-second-year birds (Noon and Farnsworth 2000; Stoleson et al. 2000). Generally, adults arrive on the breeding grounds between early May and early June, with after-second-year males arriving earlier—and setting up territories before females arrive (BIO-WEST, Inc. 2005; LCR MSCP 2008; Sedgwick 2020). Second-year males generally arrive at the same time as females (Finch et al. 2002).

The female will choose a territory and then build a nest within a week of pair formation (LCR MSCP 2008). The nest is generally completed over a 4- to 7-day period (Finch et al. 2002). Most of the incubation and brooding is done by the female, although the male is more active in feeding the young after fledging (Finch et al. 2002). A pair may renest after a failed attempt, but clutch size decreases with each new nesting attempt (Finch et al. 2002). If an adult fails to attain a territory or a mate, it may become a floater within the population. Floaters are usually second-year males (Paxton et al. 2007; Theimer et al. 2018a).

The life-stage outcomes for breeding adults are survival and fertility—here defined as the production of eggs. As noted earlier, most studies of bird demography define fertility—or the reproductive rates of adults—as the number of offspring fledged (Etterson et al. 2011). We have separated the eggs/nestlings life stage from adult fertility to display the information more clearly regarding nest success so that it can be better assessed by management. Therefore, the fertility of adults involves the acts of pairing, site selection, nest building, and the production of eggs. As noted above, Noon and Farnsworth (2000) found that fecundity was the parameter that most influenced population persistence, although their estimates of fecundity included the nest stage.

Despite our definition, the research data only discusses fecundity. In McLeod et al. (2018), mean fecundity was estimated to be 1.55 (0.16 standard error) in 2017 across all sites. Graber et al. (2012) measured a fecundity of 1.26 (fledglings/ female) in 2011 along the Gila River, Arizona, though this was lower than the 10-year mean of 1.96 and much lower than measures of 2.82, 2.40, and 2.80 in 2010, 2009, and 2007, respectively.

It is important to note that the post-breeding period—after breeding but before migration—is a significant part of a bird's life cycle. During the post-breeding period, adults may prospect for potential future breeding areas or move into habitat types that differ from breeding areas and provide good conditions for migratory staging (Paxton et al. 2007; Vega Rivera et al. 2003). Although males, females, and post-breeding individuals have different goals and responsibilities on the breeding grounds, we have included them all within the breeding adults life stage because their habitat use is similar (Paxton et al. 2007), and thus, management directed at breeding adults will likely benefit all demographics present on the breeding grounds.

A comprehensive life cycle analysis of survivorship was conducted by Paxton et al. (2017). Apparent annual survival averaged 66% (range = 56–73%) between 1996–2005. Partitioning among seasons, average annual breeding season survival (3 months) was 97% (range = 88–99%), average between-season annual survival (fall migration, wintering, and spring migration combined was 68% (range = 64–73%), and average annual wintering season survival (6 months) was 65%

(range = 59–70%). Calculated migration season annual survival estimates were 78% for fall (breeding to wintering) and 77% for spring (wintering to breeding). Cumulatively, the migration seasons accounted for 62% of annual mortality.

Estimates of adult return rates/survival:

- Adult observed return rate at the LCR: 74% (42/57)in 2013–14, 49% (49/100) in 2014–2015, 56% (49/88) in 2015–16, and 45% (29/65) in 2016–17 (McLeod and Pellegrini 2015, 2017a, 2017b; McLeod et al. 2018).

- Median adult annual survivorship (= return rate): 55% (range = 39–74%) in 2004–15 (McLeod and Pellegrini 2017a).

- Median adult annual survivorship (= return rate): 55% (range = 39–74%) in 2004–16 (McLeod et al. 2018).

- Adult observed return rate (what the authors call survival) at Roosevelt Lake, Arizona: 45.9% (90/196) from 2001 2002 and 68% from 2000 2002 (Koronkiewicz et al. 2002).

- Adult observed return rate at Roosevelt Lake, Arizona: 55.5% (111/200) in 2003–04 (Newell et al. (2005). Sightings of birds from previous years increased the absolute adult 2001–04 return rate from 63 to 66% and the 2002–2004 return rate from 53 to 61%.

- Calculated adult survivorship, Roosevelt Lake, Arizona: 63% in 2003–04 (Newell et al. 2005). Over six between-year periods, Newell et al. (2005) calculated survivorship to be 65%, which is 5% higher than the observed return rate of 60%.

- Adult observed return rate at Roosevelt Lake and the Gila/San Pedro River confluence, Arizona: overall 55% (annual range = 43–61%) from 1996 to 2005 (Paxton et al. 2007).

- Adult apparent annual survivorship at Roosevelt Lake and the Gila/San Pedro River confluence, Arizona: mean 64% (range = 53–73%) from 1996 to 2005 (Paxton et al. 2007).

Newell et al. (2005) found that patch fidelity was 54% (percent of birds that returned that were found again in the exact same habitat patch) from 2003 and 2004, and site fidelity was 92% (percent of birds that returned that were found again in the same site, consisting of multiple patches). Site fidelity was 70% in 2002 for birds at Roosevelt Lake, Arizona (Koronkiewicz et al. 2002). Koronkiewicz et al. (2006) found 39% of adult birds known to be present in 2004

the following year at various lower Colorado study sites. Of these returning birds, 88% returned to the same site, and the remainder dispersed a median of 24 km (range = 21–67 km). From 2003 to 2005, the percent returning to the same site was 93%. McLeod and Pellegrini (2017a, 2017b) report that 90 and 94% of recaptured adult birds returned to the same study site in 2015 (2014–15) and 2016 (2015–16), respectively. These rates were consistent with long-term data from 1998 to 2015, when 90% of adult returns were to the same study area (McLeod and Pellegrini 2017b).

UPDATE TO LIFE-STAGE MODEL SUMMARY

Table 1.—(Revision of original table 1) SWFL life stages and life-stage outcomes in the LCR ecosystem

Life stage	Life-stage outcome(s)
1. Eggs/nestlings	• Eggs/nestlings survival
2. Juveniles	• Juveniles survival
3. Breeding adults	• Breeding adults survival • Breeding adults fertility

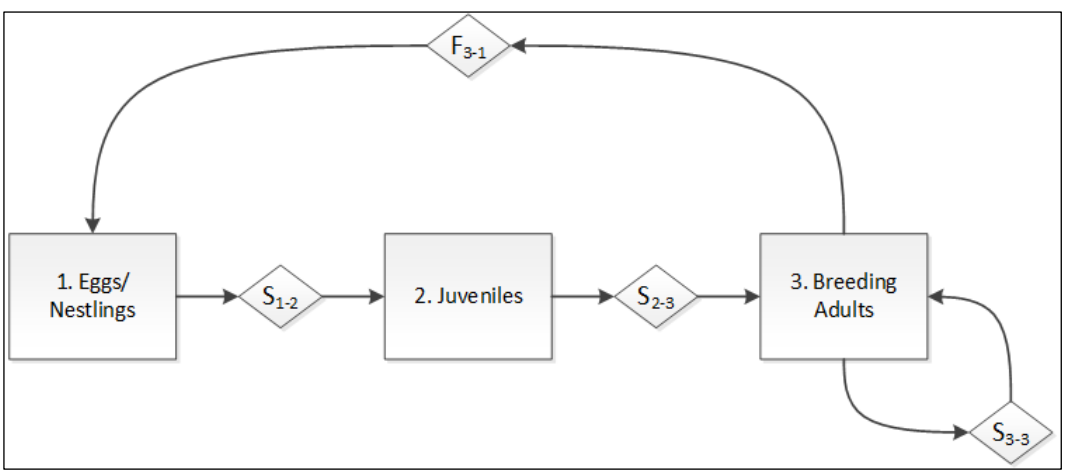

Figure 1.—(Revision of original figure 1) Proposed SWFL life history model. Squares indicate life stages and diamonds indicate life-stage outcomes. S_{1-2} = survival, eggs/nestlings, S_{2-3} = survival, juveniles, S_{3-3} = survival, breeding adults, and F_{3-1} = fertility, breeding adults.

Updates to Chapter 3 – Critical Biological Activities and Processes

This update identifies nine critical biological activities and processes that affect one or more SWFL life stages. The original SWFL conceptual ecological model (McClure et al. 2016) also identified nine. This update changes the names of two critical biological activities and processes, Molt and Temperature Regulation, and replaces them with Molting and Thermal Stress, for consistency with the other LCR MSCP conceptual ecological model updates and updates the discussion of five critical biological activities and processes. Table 2 lists the nine critical biological activities and processes in this update and their distribution across life stages, and it also indicates which are new to this update or renamed from the original SWFL conceptual ecological model.

Table 2.—(Revision of original table 2) Distribution of SWFL critical biological activities and processes among life stages

(Xs indicate that the critical biological activity or process is applicable to that life stage.)

Life stage ➔ **Critical biological activity or process 🡻**	Eggs/nestlings	Juveniles	Breeding adults
Disease	**X**	**X**	**X**
Eating	**X**		
Foraging		**X**	**X**
Molting (*replaces molt*)	**X**		
Nest attendance			**X**
Nest predation & brood parasitism	**X**		
Nest site selection			**X**
Predation		**X**	**X**
Thermal stress (*replaces temperature regulation*)	**X**	**X**	**X**

DISEASE

The definition of this critical biological activity or process remains unchanged. No new information was located on disease patterns or consequences among SWFL in the Lower Colorado River Valley or elsewhere.

EATING

The discussion of this critical biological activity or process is updated as follows:

This process only applies to the eggs/nestlings life stage because nestlings must eat to stay alive and develop but do not actively forage within their environment in the same way as juveniles and breeding adults. A nestling's ability to eat is determined by the foraging and provisioning rate of its parents (see chapter 4, "Parental Care").

FORAGING

The definition of this critical biological activity or process remains unchanged. No new information was located on foraging among SWFL in the Lower Colorado River Valley or elsewhere.

MOLTING

This critical biological process, formerly named Molt, is renamed Molting for consistency with other CEMs. Further, the discussion of this critical biological activity or process is updated as follows:

Molting is one of the most significant biological activities and processes undertaken by bird species, and successful completion of various molts during a birds' lifetime is critical to all life stages (Howell 2010). Since little specific information exists on molt in SWFL, we follow Pyle (1997) and assume that molt strategies are similar to those of other western subspecies such as *brewsteri*. Nestling SWFL undergo a molt from natal down into juvenal plumage while in the nest. The success of this molt is dependent upon the adult provisioning rate (Howell 2010). Molting is an energetically costly process that may make nestlings more susceptible to death when resources are scarce (Gill et al. 2019; Howell 2010). Juveniles then undergo a partial pre-basic (pre-formative) molt

in the wintering geographic range from September to November (Pyle 1997). Adults undergo an incomplete to complete pre-basic molt on the wintering grounds from August to November every subsequent year of their lives (Pyle 1997). Adult SWFL undergo a partial to incomplete pre-alternate molt (depending on whether the bird is in its second calendar year or older) from March to May on the wintering grounds (Pyle 1997). Since all molts (except for pre-juvenal) take place on the wintering grounds (and not on LCR lands), this activity is not included in the juveniles or breeding adults life stage but only applies to the eggs/nestlings life stage (Pyle 1997; Unitt 1987).

NEST ATTENDANCE

The discussion of this critical biological activity or process is updated as follows:

The female does most of the incubating and brooding, but the male helps with feeding of the young (Sedgwick 2020). Nest attendance is performed by breeding adults (and is dependent in part on their survivorship) and affects the eggs/nestlings life stage (egg hatching and provisioning rate to nestlings).

NEST PREDATION & BROOD PARASITISM

The discussion of this critical biological activity or process is updated as follows:

Nest predation and brood parasitism certainly affect the success of nests (McLeod and Pellegrini 2013; Sedgewick and Iko 1999; Whitfield and Sogge 1999). In fact, nest predation is the primary cause of reproductive failure at Elephant Butte Reservoir, New Mexico; the Key Pittman, Meadow Valley Wash, Morman Mesa, Muddy River, and Pahranagat National Wildlife Refuge, Nevada; and along the Gila River and the LCR in Arizona (Ahlers and Moore 2009; Ellis et al. 2008; Graber and Koronkiewicz 2009; Graber et al. 2007, 2012; McLeod and Pellegrini 2013, 2017a). Koronkiewicz et al. (2006) report depredation as the cause of nest failure for 64% of nests in 2005 along the LCR. Stumpf et al. (2012) found that overall nest survival due to predation was lower in parasitized than unparasitized nests along the LCR and Virgin River in Arizona and Nevada.

Regarding brood parasitism, McLeod and Pellegrini (2017b) report that over the years 2003–15, the average success rate for parasitized nests was only 16% as compared with 50% for unparasitized nests at their study sites. As McLeod and Pellegrini (2013) discuss, continuous parasitism over the years can reduce the lifetime productivity of female SWFL. Koronkiewicz et al. (2006) found no significant difference in proportion of SWFL nests parasitized between 5 years without cowbird (*Molothrus ater*) trapping and 3 years with cowbird trapping,

although parasitism rates actually increased during the trapping period. Therefore, despite the widespread prevalence and variability of brood parasitism across the range of SWFL (Rothstein et al. 2003; Sedgwick and Iko 1999; Whitfield and Sogge 1999), it is not at all clear that brood parasitism itself is a direct threat to SWFL in most places (Kus and Whitfield 2005; Rothstein et al. 2003; Sedgwick and Iko 1999), though it may be in some populations (Uyehara et al. 2000).

Brood parasitism is influenced by patch size and the relative proximity of the nest to a vegetation edge (Brodhead et al. 2007). These two processes have been combined for the eggs/nestlings life stage because (1) cowbirds are both nest predators and brood parasites (Stumpf et al. 2012; Theimer et al. 2011; Woodward and Stoleson 2002) and (2) habitat characteristics (distance to edge, patch width, etc.) affect both processes similarly.

Examples of documented SWFL nest predators include: reptiles (western king snakes [*Lampropeltis getula*], birds (e.g., American crows [*Corvus brachyrhynchos*], Bewick's wrens [*Thryomanes bewickii*], yellow-breasted chats [*Icteria virens*], sharp-shinned hawks [*Accipiter striatus*], gray catbirds [*Dumetella carolinensis*], owls, and passerine birds), and mammals (e.g., short-tailed weasels [*Mustela frenata*]) and skunks) (Ellis et al. 2008; Stumpf et al. 2012; Theimer et al. 2011). Nesting Cooper's hawks (*Accipiter cooperii*) may have been responsible for SWFL nest failures at the Key Pittman Wildlife Management Area in 2013, 2014, and 2016 as well as at the Pahranagat National Wildlife Refuge, Nevada (McLeod and Pellegrini 2015, 2017a).

NEST SITE SELECTION

The discussion of this critical biological activity or process is updated as follows:

Both breeding males and females select a nest site, with males selecting territories and females selecting the actual nest site within that territory (LCR MSCP 2008; Sedgwick 2020). Key attributes of nesting habitat include dense tree or shrub cover ≥ 3 m tall, dense twig structure, high levels of live, green foliage, and often dense midstory vegetation from 2 to 5 m (Paxton et al. 2007; Sogge et al. 2010). Nest site selection is important for reproductive success because nest success varies spatially as a result of vegetation characteristics, food availability, predator types and densities, hydrology, or unique events such as flooding (McLeod and Pellegrini 2013; Paxton et al. 2007).

PREDATION

The definition of this critical biological activity or process remains unchanged. No new information was located on predation among SWFL in the Lower Colorado River Valley or elsewhere.

THERMAL STRESS

This critical biological activity or process formerly named Temperature Regulation is renamed Thermal Stress for consistency with other CEMs and to clarify its meaning. Further, the discussion of this critical activity is revised as follows:

Avoiding thermal stress is important for any organism inhabiting a region with temperatures as high as that along the LCR. Although overheating is possible during all life stages, most of the concern has been directed toward eggs and nestlings (Hunter et al. 1987a, 1987b; Rosenberg 1991). The optimal temperature for egg development is 37–38 degrees Celsius (ºC,) with exposure to temperatures > 40.5 ºC potentially lethal (Gill et al. 2019). Adults can influence the thermal stress of eggs and nestlings (during the eggs/nestlings life stage) through their own behavior (incubating, brooding, or shading) and through nest placement.

Updates to Chapter 4 – Habitat Elements

This update identifies 23 habitat elements that affect 1 or more critical biological activities or processes across 1 or more SWFL life stages. The original SWFL conceptual ecological model (McClure et al. 2016) identified 22 habitat elements. This update standardizes the names of three habitat elements, with Brood Size becoming Brood/Litter Size, Community Type becoming Vegetation Community Type, and Predator Density becoming Predators; adds one new habitat element (Soil Salinity); splits one habitat element (Genetic Diversity & Infectious Agents) into two separate elements; combines two habitat elements (Parental Feeding Behavior and Parental Nest Attendance) into one (Parental Care); and updates the discussions of 20 habitat elements. Table 3 lists the 23 habitat elements in this update, indicates the critical biological activities or processes they *directly* affect across all SWFL life stages, and indicates which habitat elements are new to this update or renamed from the original SWFL conceptual ecological model.

Table 3.—(Revision of original table 3) Distribution of SWFL habitat elements and the critical biological activities and processes they directly affect across all life stages
(Xs indicate that the habitat element is applicable to that critical biological activity or process.)

Critical biological activity or process ➔ / **Habitat element ⬇**	Disease	Eating	Foraging	Molting	Nest attendance	Nest predation & brood parasitism	Nest site	Predation	Thermal stress
Anthropogenic disturbance		X	X		X	X			
Brood/litter size (*replaces brood size*)		X	X		X				
Canopy closure		X	X			X	X		X
Conspecific attraction							X		
Distance to occupied patch							X		
Diversity of vegetation		X	X				X		
Food availability		X	X		X				
Genetic diversity (*replaces genetic diversity and infectious agents*)	X								
Humidity					X		X		X
Infectious agents	X								
Intermediate structure						X	X		X
Linear width of patch						X	X	X	
Local hydrology							X		
Matrix community		X	X				X		
Nest predators & cowbird density (*replaces nest predator and cowbird density*)						X			
Parental care (*replaces parental feeding behavior and parental nest attendance*)		X	X			X		X	X
Patch size						X	X	X	
Predators (*replaces predator density*)					X		X	X	
Previous year's use							X		
Soil salinity (*new*)		N/A							
Temperature					X		X		X
Tree density						X	X		
Vegetation community type (*replaces community type*)		X	X			X	X		

Note: There are no habitat elements that *directly* affect molting. Local hydrology affects critical biological activities and processes *indirectly* through other habitat elements of vegetation community type, food availability, humidity, and temperature. Similarly, soil salinity does not have a direct effect on any critical biological activity or process.

ANTHROPOGENIC DISTURBANCE

The definition and discussion of this habitat element is updated as follows:

Full name: **Human activity within or surrounding a given habitat patch, including noise, pollution, and other disturbances associated with human activity**. Whether due to recreational, land management, or scientific research activities, the presence of humans can disturb SWFL, causing changes in behavior that might ultimately affect survival. Anthropogenic disturbance can affect both breeding success and the survival of birds (reviewed by Barber et al. 2010; Francis and Barber 2013). Noise might mask conspecific cues such as songs or calls, making it more difficult for SWFL to attract or find mates or defend territories. Further, noise might mask cues used in conspecific attraction, making it difficult for SWFL to find appropriate habitat. Noise can shift the foraging/vigilence tradeoff—either putting an individual at higher risk due to starvation or to predation (Ware et al. 2015). Noise can cause behavioral changes, physiological changes, and species diversity changes within an area.

The effect of disturbance, including noise, by the presence of humans is better described for other species but has also been suggested for SWFL (USFWS 2002). However, SWFL may have some tolerance for human disturbance. SWFL have successfully nested near a golf course in Mesquite, Nevada, for years. Their numbers fluctuate with changing water levels, but they do not seem to be affected by the presense of golfers. Similarly, the SWFL population nesting along the hiking trail behind a strip mall in St. George, Utah, has been successfully using the same site for 15–20 years (C. Dodge 2018, personal communication). Anthropogenic disturbance is considered to be a habitat element, as it is an environmental characteristic or background condition with which a nesting or foraging flycatcher must contend.

BROOD/LITTER SIZE

This habitat element replaces the original, Brood Size, with a slightly updated definition as follows:

Full name: **The number of young in the nest**. This element refers to the number of young that the parents must rear per nest. Brood/litter size is a life-stage outcome for breeding adults (fertility) that acts as a habitat element for eggs/nestlings and juveniles. Clutch size is related to maternal health, and the well-being of both parents depends in part on the availability of sufficient food resources in close proximity to the breeding territory (see Gill et al. 2019 and references therein), as well as other factors such as predator density (see below,

"Nest Predators & Cowbird Density"). Clutch size is also negatively correlated with distance to water (Peterson et al. 2015). Brood/litter size represents a background environmental condition with which a breeding adult or offspring must contend. A survey of 95 SWFL nests from 4 sites in Arizona showed a mean clutch size of 2.7, with a range from 1 to 4 (Paxton et al. 2002).

CANOPY CLOSURE

The definition and discussion of this habitat element is updated as follows:

Full name: **The percentage of ground area shaded by overhead foliage in the vicinity of the nest** (Daubenmire 1959). Canopy closure can be measured as the angular canopy closure with a field-of-view instrument, such as a camera or spherical densiometer, or as vertical canopy closure by using lidar. Both measures are related (Korhonen et al. 2011). This element refers to the percent canopy closure of canopy vegetation in the vicinity of the nest site. Canopy closure of riparian vegetation, especially higher density in the upper canopy, has been shown to be important to SWFL. Dense vegetation around the nest may provide more optimal microclimate for thermoregulation (see Balluff 2012 for additional discussion; Rosenberg 1991) and concealment from nest predators, although heterogeneity in canopy cover within a given patch or landscape may also be desirable (see below, "Diversity of Vegetation"). Canopy cover is often related to tree density (James 1971; Rudnicki et al. 2004). Moore (2007) concludes that canopy cover is not an important factor in SWFL breeding habitat because < 5% of SWFL sites contain trees in the upper canopy. Graf et al. (2002) state that SWFL prefer an open canopy. At Roosevelt Lake, 2004 pre-inundation canopy cover of productive SWFL habitat was 95.1% (Ellis et al. 2009). The USFWS (2002, 2013) lists a dense canopy as important for SWFL, citing several studies demonstrating higher canopy cover at occupied sites when compared to unoccupied sites (see attachment 1 for more details).

Canopy closure may also affect the availability of food (Smith et al. 2006). Koronkiewicz et al. (2006) found canopy closure to be significantly higher at several sites at the nest and within territories than at unused sites. Along the LCR, the median canopy closure at sites occupied by SWFL was 94% (McLeod and Pellegrini 2013). McCleod and Pellegrini (2017a) consider canopy closure of ≥ 85% to be optimal.

CONSPECIFIC ATTRACTION

The definition and discussion of this habitat element is updated as follows:

Full name: **The propensity to nest near conspecifics**. SWFL display an aggregated nesting distribution, leading some to suggest that they prefer to nest near each other (Brodhead 2005; USFWS 2002). The best evidence for conspecific attraction in SWFL comes from Brodhead (2005), who shows that an autocovariate, accounting for a clumped distribution, outperformed other aspects of habitat in describing the presence or absence of breeding SWFL. The propensity for SWFL to nest near each other might explain the myriad of observations of apparently suitable habitat going unoccupied (see citations in Brodhead 2005).

Playback of conspecific songs during settlement has been used as an effective tool to induce settlement by other species of songbirds to nesting areas selected by land managers (Schlossberg and Ward 2004; Ward and Schlossberg 2004). Willow flycatchers (subspecies *adastus* and *brewsteri*) in meadow habitats of the Sierra Nevada did respond to conspecific playback used as a restoration tool, with territorial flycatchers occurring at 33.7% of sites with playback and only 5.3% of sites without playback (Schofield et al. 2018). However, playback alone was not sufficient to explain meadow colonization and other factors, such as patch size influence, on the probability of a flycatcher colonizing unoccupied habitat. Therefore, playback of SWFL songs during early spring might be considered as a tool to induce settlement within the restoration areas along the LCR currently unused by SWFL.

DISTANCE TO OCCUPIED PATCH

The definition and discussion of this habitat element is updated as follows:

Full name: **The linear distance of a given patch of riparian forest to the nearest occupied patch**. As a generalization, the probability that a given patch of riparian forest will be colonized by SWFL is influenced by its proximity to occupied habitat in current and previous years. Nevertheless, movements of breeding adults and juveniles are well documented at various scales both within and between seasons in the LCR, in Arizona at Roosevelt Lake, at the San Pedro/Gila River confluence (see attachment 1), in other locations, and even between more widely separated sites. Data on the propensity of breeding adult and juvenile birds to return to the same or different sites are contained below in the “Previous Year’s Use” section.

LCR data suggest that limited number of individual breeding adults conduct within-season movements with a mean of approximately 37 km (range = 11.2–131.7 km) (McLeod and Pellegrini 2013, 2015, 2017b). Breeding adults also conduct between-season movements, with a documented mean distance of 30 km for three individuals (McLeod and Pellegrini 2017b). Juveniles in the LCR that conducted between-season movements to a different study area moved a mean of 28.15 km (McLeod and Pellegrini 2017b).

Paxton et al. (2007) provide an extensive description of movements of SWFL within and between patches in their study sites at Roosevelt Lake and the San Pedro/Gila River confluence, Arizona. In Arizona, most within-season movements of breeding adults were between patches (mean = 8.8 km), fewer within patches (mean = 0.3 km), and a very small number between drainages (mean = 84.7 km). Paxton et al. (2007) also showed that females moved longer distances within seasons (mean = 12.0 km) than males (mean = 5.5 km). Between-season distances moved for breeding adults averaged 9.5 km (range = 0.1–214 km), which was significantly less than natal dispersal distances (mean = 20.5 km; range = 0.03–444 km).

McLeod and Pellegrini (2020) document two known long-distance, between-season dispersals of SWFL. One was of a bird last detected in 2013 on the Virgin River in southern Nevada, which was refound in 2019 at Alamo Lake, a distance of 268.1 km. The other was of a bird last detected in 2009 on the Muddy River in Nevada and also re-found in 2019 at Alamo Lake, a distance of 259.4 km. These data, plus work done elsewhere at Rock House on the Salt River and along the Middle Rio Grande, indicate that extensive movements can and do occur at various distances, leading to the conclusion that colonization of newly restored areas is highly likely.

DIVERSITY OF VEGETATION

The definition and discussion of this habitat element is updated as follows:

Full name: **Either horizontal or vertical diversity of the vegetation structure at the patch or microhabitat scales or diversity of community types or ages at the landscape scale**. The diversity of vegetation affects site use by many animals (Erdelen 1984; MacArthur and MacArthur 1961; Wiens et al. 1993). SWFL prefer nest sites with dense shrub (predominantly native willows) and canopy cover, which likely have high foliage height diversity.

Horizontal heterogeneity of vegetation within a territory or patch is also important for site use by SWFL (Hatten and Paradzick 2003; Paxton et al. 2007). Horizontal variation in the density of vegetation is important for SWFL because

they require access to both dense and open areas during the breeding season. Dense areas provide vegetation to conceal nests and provide microclimate needed for egg and nestling development. Open areas facilitate foraging because SWFL are saltating flycatchers–they generally sit and wait at the edge of an opening and fly out to catch insects on the wing (Brodhead 2005; USFWS 2013). Ellis et al. (2008) determined the average distance from nests to canopy gaps at Roosevelt Lake to be approximately 8.4 m in 2004 (prior to lake inundation). Therefore, although dense foliage is a classic characteristic of SWFL habitat, SWFL generally prefer patches that contain a mix of both dense areas for nest placement and open areas for foraging.

We note here also that, because of the ephemeral nature of riparian habitat, a mosaic of patches of riparian forest of varying ages might be needed to ensure the persistence of SWFL within a given landscape (USFWS 2002, 2013). A mosaic of varying ages of riparian forest would ensure that if some patches succeed into unsuitable seral or structural stages or become unusable due to fire, inundation, lack of water, or changes in soil salinity, other nearby suitable patches still would be available.

FOOD AVAILABILITY

The definition of this habitat element is updated as follows:

Full name: **The abundance of food available for adults and their young**. This element refers to the taxonomic and size composition of the invertebrates that an individual SWFL will encounter during each life stage as well as the density and spatial distribution of the food supply in proximity to the nest. SWFL are primarily insectivorous during the breeding season (Sedgwick 2020; Sogge et al. 2010; Wiesenborn and Heydon 2007). The abundance and condition of the food supply affects adult health as well as the growth and development of the young during the nestling and juvenile stages. In fact, in 2002, a drought at Roosevelt Lake, Arizona, reduced the SWFL prey base, causing almost complete reproductive failure (Durst et al. 2008). However, SWFL are generalist insectivores (Wiesenborn and Heydon 2007) and, therefore, may be able to adapt their diet to a variety of conditions—meaning that arthropod abundance and not diversity or the presence of specific taxa is most important for SWFL foraging (Durst et al. 2008). Rubin et al. (2019) reported fewer aquatic invertebrates at restoration sites located farther away from the Colorado River floodplain, suggesting reduced food availability in these sites. However, since these restoration sites are managed as moist soil sites, there should be sufficient invertebrate food to support nesting SWFL (C. Dodge and B. Raulston 2018, personal communications). Numbers of other breeding riparian bird species have been found at these locations (SWCA Environmental Consultants 2019).

GENETIC DIVERSITY

The original habitat element, Genetic Diversity & Infectious Agents, has been separated into two distinct habitat elements. The definition and discussion of Genetic Diversity is updated as follows:

Full name: **The genetic diversity within SWFL populations**. This element refers to the genetic homogeneity versus heterogeneity of a population during each life stage. The greater the heterogeneity, the greater the possibility that individuals of a given life stage will have genetically encoded abilities to survive their encounters with the diverse stresses presented by their environment and/or take advantage of the opportunities presented (Allendorf and Leary 1986). SWFL exist as a complex of metapopulations that require periodic transfer of genetic material between them (Finch et al. 2002). A range-wide study of SWFL showed slight, but significant, genetic variation in and among individuals from widely distributed sites (Busch et al. 2000). However, Busch et al. (2000) felt that this variation was not biologically significant and, in fact, suggested that the sites functioned as a metapopulation with regular exchange of genetic material. The USFWS (2013) recommends that habitat patches be 30–40 km apart at most to facilitate population exchange.

There has been some recent discussion about the status of SWFL as a distinct subspecies, with Zink (2015) arguing against that hypothesis (based on genetic and other measures) and Theimer et al. (2016) finding evidence for differentiation between the subspecies *extimus*, *adastus*, and *brewsteri*. USFWS (2017) concluded, in their review of this issue in response to a petition for delisting, that the subspecies *extimus* was a valid subspecies. Irrespective of this discussion, it is important to note that SWFL would still be protected by the Endangered Species Act as a distinct population segment if it is not a subspecies.

HUMIDITY

The definition of this habitat element remains unchanged. No new information was located on humidity among SWFL in the Lower Colorado River Valley or elsewhere.

INFECTIOUS AGENTS

The original habitat element, Genetic Diversity & Infectious Agents, has been separated into two distinct habitat elements. The definition of Infectious Agents is updated as follows:

Full name: **The types, abundance, and distribution of infectious agents and their vectors**. The infectious agents habitat element refers to the spectrum of viruses, bacteria, fungi, and parasites that individual SWFL are likely to encounter during each life stage. The effects of disease and other infectious agents are poorly understood. Although the more common avian diseases and parasites of North American birds are generally known (Morishita et al. 1999), some are often difficult to detect (Jarvi et al. 2002), and they can have differing effects on different species (Palinauskas et al. 2008). However, although there are many infectious agents associated with SWFL, the effects of disease and other infectious agents are poorly understood (see USFWS 2002 and references therein).

INTERMEDIATE STRUCTURE

The definition and discussion of this habitat element is updated as follows:

Full name: **The concealment provided by the vegetation structure between the canopy and the herbaceous (= ground) layer**. This element refers to the visual density of vegetation (i.e., concealment) below the uppermost canopy layer to the ground. Dense intermediate level vegetation is a common characteristic of SWFL nesting habitat (McLeod and Pellegrini 2013; Paxton et al. 2007) and is perhaps one of the most often-listed characteristics of SWFL habitat. The USFWS (2002, 2013) states that SWFL are most often found in areas with dense vegetation 4 m above the ground. Moore (2007) found that shrub stem density did not differ between the nest and random plots in the Elephant Butte Reservoir Delta (mean = 3.64 per square meter), although nest plots had higher cover from 3 to 6 m above the ground. A more dense intermediate structure may support a more diverse and abundant invertebrate food supply as well as provide protection or concealment from predators (see attachment 1 for more details).

SWFL, like other species that colonize patches of new habitat, appear to exhibit a strong response to vegetation patch dynamics. The only study to have looked at this in any detail is Theimer et al. (2018b). They studied SWFL use of habitat patches of varying age at Roosevelt Lake, Arizona, from 1995 to 2004. Mean territory density (# territories/ha) increased steadily in the immediate years since a habitat patch was established, peaking at 3–4 years since establishment and then

declining. This result was independent of an overall effect of there being more territories in larger patches. The mean age of birds occupying territories increased linearly over time; however, there was no relationship between the number of fledglings per female and patch age. Birds colonizing newly established patches were mostly (46%) second-year birds; the remainder were split between successful and unsuccessful birds from previous years. Birds in intermediate (peak) aged stands and in declining age stands were mostly site-faithful, successful adults. Most nestling SWFL were produced in the peak-age stands; of these, 50% moved into new habitat patches, and 46% moved into peak-age patches. Similarly, most dispersing adults came from peak-age patches, with most of those moving to other peak-age patches. These findings indicate some aspects of changing intermediate structure (or factors associated with such changes, such as prey quantity and composition) may change with time and that these changes should be studied with respect to aging restored stands.

LINEAR WIDTH OF PATCH

The definition of this habitat element is updated as follows:

Full name: **The width of a patch of riparian habitat**. This element refers to the width of riparian habitat along a corridor. Flycatchers rarely breed in isolated habitat patches less than 10 m in width (Sogge et al. 2010). Patch width may also affect the presence of nest parasites and other predators. The rates of nest parasitism were negatively related to distance from habitat edge in a nearly linear fashion, with the odds of parasitism decreasing about 1% with every additional meter from an edge (Stumpf et al. 2012).

LOCAL HYDROLOGY

The definition and discussion of this habitat element is updated as follows:

Full name: **Aspects such as the distance to standing water or the presence of adjacent water bodies, timing and volume of floods, depth to the water table, and soil moisture levels**. This element refers to anything that affects soil moisture, such as the proximity of water to the nesting habitat, elevation, irrigation practices, and soil texture. The local hydrological conditions affect other aspects of habitat such as vegetation structure and abundance of arthropods. Wetter conditions might also provide cooler temperatures and more humid conditions necessary for egg and chick survival in desert systems (Rosenberg 1991).

The local hydrological conditions of a given patch might be the single most important determinant of SWFL habitat quality because if affects other aspects of habitat such as vegetation structure and abundance of arthropods (Ahlers and Moore 2009; Graber et al. 2012; McLeod and Pellegrini 2013a; Moore and Ahlers 2018; Reclamation 2009; USFWS 2013). Wetter conditions might also provide cooler temperatures and more humid conditions necessary for egg and chick survival in these desert systems (McLeod and Pellegrini 2013; Rosenberg 1991). Being riparian obligates (Sogge et al. 2010), the distance to water is a strong predictor of the presence of nesting SWFL (Hatten and Paradzick 2003; Hatten et al. 2010) and is negatively correlated with SWFL clutch size (Peterson et al. 2015).

The presence of surface water seems to be a strong driver of—or possibly a cue for—SWFL site selection (Ahlers and Moore 2009; McLeod and Pellegrini 2013; Paradzick 2005; Sogge et al. 2010; USFWS 2013), making local hydrological conditions during territory establishment especially important. For example, at LCR sites, large percentages of nests have been found within 5 m (42–83%) and 30 m (52–90%) of wet soils (for nests with known soil moisture conditions at nest selection) (McLeod and Pellegrini 2015, 2017a, 2017b; McLeod et al. 2018). In the conservation pool of Elephant Butte Reservoir, 87% of the nests were found within 50 m of surface water (Moore and Ahlers 2006). From 2004 to 2017 along the Middle Rio Grande, 91% of nests were within 100 m of surface water and 79% within 50 m (Moore and Ahlers 2018). The same dataset, when analyzed for nest success and productivity, only showed significantly higher productivity (2.60 young fledged/nest) < 50 m from water as compared to > 50 m from water. Moore and Ahlers (2018), across the years 2004–17, found highest nest success, and lowest depredation and parasitism rates, when the hydrology under the nest was flooded all of the nesting period compared to dry all period, saturated/ flooded then dry, or saturated/flooded all period. The average distance to water at Roosevelt Lake (in 2004, pre-inundation) was 187.6 m (Ellis et al. 2008). Nesting SWFL selected the Salt River restoration project fields that retained water the longest. Fields are flood irrigated every 7–10 days throughout the breeding season (Salt River Project 2014). Therefore, the timing and duration of certain hydrological events (e.g., flooding) is important for site selection. Graber et al. (2012) found the mean simple nest success to be 73% along the Gila River, Arizona, from 2008 to 2010 when there was ankle- to waist-deep water in breeding habitat; however, nest success dropped to 31% in 2011, when the habitat was dry.

While proximity to surface water is important, too much water for too long can negatively affect breeding habitat. Inundation of Roosevelt Lake in 2005–06 displaced SWFL and resulted in a 47% decrease in the number of nesting territories (Ellis et al. 2009).

Conversely, lake dewatering also affects SWFL site use. At first, SWFL select young, new vegetation on recently exposed sediment but will abandon sites as water recedes and soil dries out (McLeod and Pellegrini 2017a). Likewise, drought has a major effect on SWFL population persistence. The lack of water at Mesquite, Nevada, resulted in fewer SWFL females and reduced fecundity (McLeod and Pellegrini 2014). Fluctuations in the level of Lake Mead in the mid-2000s caused some habitat to die but also led to the creation of new habitat (Koronkiewicz et al. 2006). Fluctuating riverflows also affect SWFL; Graber et al. (2012) found significant positive correlations between Gila River annual streamflow (May – April) and April – June streamflow from the prior year and number of SWFL territories from 1998 to 2011. Moore and Ahlers (2018) examined data from 2004 to 2017 from the Middle Rio Grande and found that SWFL nests in areas that were dry the entire nesting cycle were significantly less successful and less productive than sites that were flooded the entire cycle or a mix of saturated, flooded, and then dry. Consistent with this, nest depredation and parasitism rates were higher in drier than wetter sites.

The potential effects of drought on SWFL are reviewed by Paxton et al. (2007), Theimer et al. (2018a), and USFWS (2014). A severe drought in 2002 at Roosevelt Lake, Arizona, decreased the number of territorial SWFL and increased the proportion of individuals capable of breeding that did not do so (i.e., floaters; Theimer et al. 2018a). Interestingly, male SWFL that floated during the drought had higher apparent annual survival in subsequent years. Drought conditions at Alamo Lake may also have contributed to lower nest success in 2014, possibly due to higher depredation rates related to lack of vegetative cover or greater ease of access for terrestrial predators without surface water to impede movement (McLeod and Pellegrini 2015). Similarly, extended drought along the Lower Rio Grande has resulted in a rapid reduction in the quality and quantity of SWFL habitat between 2012–16 (Moore and Ahlers 2017) and in the Bosque del Apache Reach of the Rio Grande between 2012–17 (Moore and Ahlers 2018). SWFL territories declined from 46 to 26 to 14 along the Gila River, Arizona, in response to decreased releases from Coolidge Dam that resulted in river drying (Munzer et al. 2005). Bullard et al. (2018)'s analysis of 2013–17 SWFL nesting data on the Lower Rio Grande showed no significant differences in nest success or productivity based on hydrology characterized as saturated, flooded, or dry.

MATRIX COMMUNITY

The definition of this habitat element remains unchanged. No new information was located on the matrix community among SWFL in the Lower Colorado River Valley or elsewhere.

NEST PREDATORS & COWBIRD DENSITY

The definition and discussion of this habitat element is updated as follows:

Full name: **The abundance and distribution of nest predators and brood parasites**. This element refers to a set of closely related variables that affect the likelihood that different kinds of predators will encounter and successfully prey on SWFL during the eggs/nestlings life stage or that cowbirds will lay eggs in the nest. The variables of this element include the species and size of the fauna that prey on SWFL during different life stages, the density and spatial distribution of these fauna in the riparian habitat used by flycatchers, and the ways in which predator activity may vary in relation to other factors (e.g., intermediate structure, matrix community type, patch size and width, time of day, vegetation diversity) (Thompson, III 2007). Nest depredation was the major cause of nest failure at LCR study sites between 2013–17, accounting for 46% of 242 of all failed nests and 58% of 193 nests that failed after egg laying (McLeod et al. 2019). Parasitism at LCR study sites between 2013–17 was observed in 14% of 359 nests with eggs and known parasitism status (range = 0–50% between sites) and caused nest failure at 5% of 193 nests that failed after egg laying (McLeod et al. 2019). Unparasitized nests were significantly more likely to fledge SWFL than parasitized nests (53 versus 2%, respectively, $P < 0.001$; McLeod et al. 2019).

The effect of predator and cowbird density can have impacts more subtle than survival by altering breeding behavior, foraging behavior, nest site selection, and prey behavior (Lima 1998, 2009).

Examples of SWFL nest predators include reptiles (western king snakes), birds (e.g., American crows, Bewick's wrens, yellow-breasted chats, sharp-shinned hawks, gray catbirds, owls, and passerine birds), and mammals (e.g., short-tailed weasels and skunks) (Ellis et al. 2008; Stumpf et al. 2012; Theimer et al. 2011). Nesting Cooper's hawks were likely responsible for SWFL nest failures at the Key Pittman Wildlife Management Area and Pahranagat National Wildlife Refuge, Nevada, in several years (McLeod and Pellegrini 2015, 2017a; McLeod et al. 2019).

PARENTAL CARE

This habitat element replaces the former elements, Parental Feeding Behavior and Parental Nest Attendance, with a slightly updated definition as follows:

Full name: **The ability and behavior of parents to provide care to nests, eggs, nestlings, and juveniles after they fledge from the nest**. This element refers to

the capacity of both parents to share nesting and brood-rearing responsibilities until fledging and to provision food for recently fledged birds. The care provided by one or both parents can include providing shelter and warmth, providing food, warding off predators, and teaching the young necessary life skills. The better the quality of the parental care, the healthier the condition and, therefore, the higher the rate of survival of the offspring, other things being equal. Parental care is affected by food availability, the presence of predators and competitors, and the ability to thermoregulate. Juveniles continue to be fed by the parents for several weeks after fledging. The feeding rate is dependent upon food availability and the number of young in the brood. This rate influences the amount of food and time spent foraging by juvenile birds.

PATCH SIZE

The definition of this habitat element is updated as follows:

Full name: **The size of riparian habitat patches**. This element refers to the areal extent of a given patch of riparian vegetation. Although the average patch size may differ between riverine and reservoir systems (Paxton et al. 2007), the patch size affects the number of breeding pairs that an area can support as well as the density of brood parasites, competitors, and predators. Brodhead (2005) found that SWFL are more likely to occupy larger patches. However, in general, patch size is not a limiting factor in SWFL habitat selection as long as riparian patches are at least 10 m in width—SWFL have been observed breeding in patches ranging in size from 0.1–70 ha (USFWS 2002).

PREDATORS

This habitat element replaces the original, Predator Density, for clarity and consistency among models, and the definition and discussion are updated as follows:

Full name: **The abundance and distribution of species that depredate SWFL during the juveniles and breeding adults stages**. This element refers to a set of closely related variables that affect the likelihood that different kinds of predators will encounter and successfully prey on SWFL during the juveniles or breeding adults life stages. The variables of this element include the species and size of the fauna that prey on SWFL during different life stages, the density and spatial distribution of these fauna in the riparian habitat used by flycatchers, and the ways in which predator activity may vary in relation to other factors (e.g., intermediate structure, matrix community type, patch size and width, time of day, vegetation

diversity) (Thompson, III 2007). There is little information about predators of adults or juveniles, although nesting Cooper's hawks may have contributed to reduced fledgling survival at LCR study sites (McLeod and Pellegrini 2015; McLeod et al. 2019).

The effect of predator density can have impacts more subtle than survival by altering breeding behavior, foraging behavior, nest site selection, and prey behavior (Lima 1998, 2009).

PREVIOUS YEAR'S USE

The definition of this habitat element is updated as follows:

Full name: **The location of the previous year's breeding attempt and whether or not that attempt was successful**. SWFL are more likely to return to the same territory after a successful breeding attempt (McLeod and Pellegrini 2013; Paxton et al. 2007). Individuals that return to a successful territory tend to do well, and those that abandon an unsuccessful territory are more successful in a new location the next year (Paxton et al. 2007). A multi-year study at Roosevelt Lake, Arizona, found that 67% of successful birds returned to the same patch but that only 35% of unsuccessful ones did (Theimer et al. 2018b).

SOIL SALINITY

This habitat element is a new addition to the CEM, and it is defined as follows:

Full name: **The salt content within the root zone of the soil (0–30 inches) as measured by electrical conductivity of the saturation extract value in decisiemens per meter at 25 °C** (San Joaquin River Restoration Program 2014). Rising soil salinity is a serious environmental issue throughout the entire Colorado River Basin, with concentrations increasing dramatically from the headwaters to the LCR at the international Boundary with Mexico (LaHue 2017; USGS 2000), and is a deterrent to successful habitat restoration (Raulston 2003). Contributors to salinity include natural sources (atmospheric deposition, erosion of geological formations), agriculture, municipal water use, and development of energy resources (LaHue 2017). Soil salinity is affected by the amount of water reaching the soil and the salinity of the water (San Joaquin River Restoration Program 2014), and it has been modified by historical changes in flooding regimes due to dam construction on the Colorado River (Briggs 1996; Raulston 2003). Soil salinity can impact the vigor of various plant species to different degrees and

can ultimately influence plant community type and structure (Raulston 2003; San Joaquin River Restoration Program 2014; Shafroth et al. 1995, 2008; Stromberg 2001).

TEMPERATURE

The definition and discussion of this habitat element is updated as follows:

Full name: **The maximum temperature in a habitat patch or nest site**. This element refers to the maximum temperature in the nesting habitat around the nest site (or during the nesting season). Thermoregulation is necessary for survival of chicks and adults, and flycatchers nest in areas with moderated temperature ranges (McLeod et al. 2008a). High temperatures typical of the LCR region in the summer can kill eggs and stress young in the nest (Hunter et al. 1987b; Rosenberg 1991). Koronkiewicz et al. (2006) found significantly higher temperatures at non-nest sites than nest sites and territory sites along the LCR and that nest sites exhibited fewer extreme temperatures.

TREE DENSITY

The definition of this habitat element is updated as follows:

Full name: **The stem density of trees reported as the number of trees per acre**. The greater the tree and/or shrub density, the greater the likelihood of denser vegetative cover. Moore (2007) found that tree stem density was higher in nest versus random plots in the Elephant Butte Reservoir Delta. Koronkiewicz et al. (2006), however, found mixed results depending on the site in the LCR. The shrub/sapling stem count was higher at a nest than at unused sites in some areas and lower at others. Tree stem count was higher at a nest than unused sites in one case, but no differences were found in others. Tree density is likely highly correlated with canopy closure and total vegetation density (see above, "Diversity of Vegetation").

VEGETATION COMMUNITY TYPE

This habitat element replaces the original, Community Type, with a slightly updated definition as follows:

Full name: **The species composition of the riparian forest patch**. This element refers to the species composition of riparian habitat used for breeding by SWFL. Research shows that flycatchers are adaptable, able to use various types of native and non-native broadleaf deciduous habitats at different elevations (McLeod and Pellegrini 2013). Further, both native and exotic community types seem to be ecologically equivalent regarding the quality of SWFL breeding habitat (Bullard et al. 2018; Paxton et al. 2007, 2011; USFWS 2013). SWFL regularly use tamarisk (*Tamarix* spp.), in fact, at least 50% of nests monitored from 2014 through 2019 were near or in tamarisk (McCleod and Pellegrini 2015, 2017a, 2017b, 2019, 2020; McLeod et al. 2018). Moore and Ahlers (2018, table 10) analyzed data from 1999 to 2017 from the Middle Rio Grande and found that SWFL preferentially (and significantly) used native-species dominated stands (over tamarisk-dominated and mixed dominance) for territories. However, they found that across all stands, SWFL used tamarisk as the actual nest tree 51% of the time. The success of nests in native stands (46%) was also significantly higher than success in mixed stands (38%); exotic stands had a success rate of 43%.

Updates to Chapter 5 – Controlling Factors

This update identifies 10 controlling factors that affect 1 or more habitat elements and/or critical biological activities or processes across the 3 SWFL life stages. The original SWFL conceptual ecological model (McClure et al. 2016) identified nine controlling factors. This update standardizes the name of one controlling factor (Pesticide/Herbicide Application) and replaces it with Pesticide Application, adds one new controlling factor (Irrigation), and updates the discussion of eight controlling factors. Table 4 lists the 10 controlling factors in this update, indicates which habitat elements they *directly* affect, and which controlling factors are new to this update or renamed from the original SWFL conceptual ecological model.

Table 4.—(Revision of original table 4) Habitat elements directly affected by controlling factors (Xs indicate that the habitat element is applicable to that controlling factor.)

Controlling factor ➔ / **Habitat element ⬇**	Fire management	Grazing	Irrigation (*new*)	Mechanical thinning	Natural thinning	Nuisance species introduction & management	Pesticide application (*replaces pesticide/herbicide application*)	Planting regime	Recreational activities	Water storage-delivery system design & operation
Anthropogenic disturbance				X					X	
Brood/litter size	N/A									
Canopy closure	X			X	X	X		X	X	
Conspecific attraction	N/A									
Distance to occupied patch	N/A									
Diversity of vegetation	N/A									
Food availability						X	X			
Genetic diversity	N/A									
Humidity	N/A									
Infectious agents	N/A									
Intermediate structure	X	X		X		X		X	X	
Linear width of patch	X	X						X	X	
Local hydrology			X							X
Matrix community	X	X						X		
Nest predators & cowbird density		X				X			X	
Parental care	N/A									
Patch size	X	X						X	X	
Predators						X			X	
Previous year's use	N/A									
Soil salinity			X							X
Temperature	N/A									
Tree density	X			X	X	X		X	X	
Vegetation community type	X	X				X		X	X	X

N/A = not applicable.

FIRE MANAGEMENT

The updated discussion of this controlling factor is as follows:

This factor addresses any fire management (whether prescribed fire or fire suppression) that could affect SWFL or their habitat. Effects may include creation of habitat that supports or excludes SWFL, a reduction in the food supply of invertebrates, or support of species that pose threats to SWFL such as predators, competitors, or carriers of infectious agents. Although typically not a major threat in most riparian habitats, severe wildfires have affected SWFL breeding sites in the past decade (Ellis et al. 2008; Graber et al. 2007; USFWS 2002). In fact, small, contained fires have recently occurred in a few LCR restoration sites (Hunters Hole and Yuma East Wetlands), and a severe fire occurred in 2015 in riparian habitat at the Havasu National Wildlife Refuge (C. Dodge 2018, personal communication), consuming all or most of each survey site within the burned area containing occupied SWFL breeding habitat right before nestlings fledged, and it is believed to have resulted in mortality of those nestlings.

However, the increased predominance of tamarisk (*Tamarix* spp.) in the LCR and adjacent areas has changed the fire regime, specifically increasing fire area and frequency (Drus et al. 2012; Webb et al. 2019). Invasive species such as tamarisk (*Tamarix* spp) and Russian olive have contributed to increased fuel loads and ladder fuels in southern Nevada riparian areas, which lead to more frequent and higher intensity fires (Brooks et al. 2013). Defoliation from tamarisk beetles (*Diorhabda carinulata*) (see chapter 5, "Nuisance Species Introduction & Management") should also increase fire extent, frequency, and severity (C. Dodge 2020, personal communication). Fire in tamarisk-influenced or dominated ecosystems also facilitates the expansion in area and dominance of such ecosystems in a self-perpetuating feedback cycle (Webb et al. 2019).

The USFWS (2013) specifically recommends fire management for the recovery of SWFL populations. Climate change is also projected to affect fire frequency along the LCR (USFWS 2013), in part, by altering rainfall patterns. Brooks et al. (2013) recommend a variety of specific fire management actions in riparian areas with non-native species, including fuel reduction through cutting, herbicide treatment, or prescribed fire; fire suppression in wildland-urban interface areas or where native and non-native vegetation are intermixed; and replanting of native vegetation in treated areas. The use of prescribed fire as a management tool, however, is complicated due to the potential for high-intensity fires, variability of effectiveness, and need for continued followup management (Webb et al. 2019).

GRAZING

The updated discussion of this controlling factor is as follows:

This factor addresses the grazing activity on riparian habitats along the LCR and in surrounding areas that could affect SWFL or their habitat. Grazing by cattle (Bovidae), burros (*Equus asinus*), or mule deer (*Odocoileus hemionus*) across the arid Southwestern United States has substantially degraded riparian habitat (see Appendix G in USFWS 2002). (*Note*: Mule deer have been observed by Reclamation staff and researchers on some LCR sites, and their browsing may affect vegetation communities if deer populations change). McLeod et al. (2019) found no nest failures attributable to cattle in the period 2013–17 at their LCR study sites.

Grazing may thin the understory or even prevent the establishment of cottonwood and willow seedlings (Kauffman et al. 1997). In particular, overgrazing has been an identified as a management issue along the San Pedro River and the Verde River (S. Kokos 2014, personal communication). Krueper (1993) and Krueper et al. (2003) report that fencing cattle out of sensitive riparian habitats in the San Pedro Riparian National Conservation Area led to improved habitat quality and increased riparian bird density within 4 years; SWFL were not one of the species monitored during this study. Whether grazers should be permanently excluded from critical habitats or whether periodic or temporary restrictions are sufficient requires further study (Sayre 2005). Better grazing management in SWFL habit can lead to habitat improvement, at least in some areas (USFWS 2014). Livestock grazing was documented at the Gila River, Arizona, study area (Graber et al. 2012).

Grazing activity may also influence other controlling factors, such as nuisance species introduction & management, by increasing cowbird presence or by spreading non-native grass seeds into riparian habitat (Bartuszevige and Endress 2008; Goguen and Mathews 2001).

IRRIGATION

This is a new controlling factor.

This factor addresses the human activities of artificially introducing water to the landscape to influence habitat. In many cases, this may be implemented to simulate more natural riparian processes or to manage soil salinity levels. The amount of water provided through irrigation affects the species composition and density of the riparian vegetation plant community required by SWFL. The

amount of water available is also affected by management actions to reduce or terminate water applications at a site (e.g., to reallocate water to other areas within the limits of Reclamation's or other agencies' water rights).

The LCR MSCP and USFWS irrigate portions of several conservation areas along the LCR valley to create and manage habitat for general wildlife, LCR MSCP covered species, and associated wetland habitat. However, SWFL use of these areas is complicated by the widespread occurrence of migrant willow flycatchers in the same habitats (McLeod and Pellegrini; 2020Sogge et al. 2010). Willow flycatchers are found in the LCR in areas, including restoration sites (e.g., CVCA1, CVCA2, CVCA3, and the Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail), which show no signs of territoriality, breeding, or residency and are therefore presumably migrants that are not covered by either the Endangered Species Act or the LCR MSCP (McLeod and Pellegrini 2013, 2019, 2020).

MECHANICAL THINNING

The discussion of this controlling factor has been slightly updated as follows:

This factor addresses the active removal of vegetation from areas within the LCR region. Effects may include the creation of habitat that supports or excludes SWFL or supports or excludes species that pose threats to SWFL such as predators, nest parasites, competitors, or carriers of infectious agents. This factor includes the thinning of vegetation within both riparian and matrix communities. Thinning can be implemented on a small, local scale, resembling natural thinning, or it can be implemented on a broad scale, with larger and more complete transition. Mechanical thinning always increases the level of anthropogenic disturbance, especially noise, within a habitat.

NATURAL THINNING

The discussion of this controlling factor has been updated as follows:

This factor addresses the natural death of entire or parts of trees within a patch of riparian forest or the surrounding matrix. As overstory trees or their limbs die, they leave openings in the canopy, thereby allowing light to reach lower vegetation layers and creating the horizontal and vertical foliage profile needed by SWFL.

NUISANCE SPECIES INTRODUCTION & MANAGEMENT

The discussion of this controlling factor has been updated as follows:

This factor addresses the intentional or unintentional introduction of nuisance species (animals and plants) and their control that affects SWFL survival and reproduction. Nuisance species may infect, prey on, compete with, or present alternative food resources for SWFL during one or more life stages, cause other alterations to the riparian food web that affect SWFL, or affect physical habitat features such as intermediate structure and canopy or shrub cover. For example, although SWFL successfully nest in sites dominated by invasive tamarisk, larger monocultures of tamarisk may negatively affect habitat in other ways (e.g., by altering soil chemistry, habitat structure, the arthropod community, etc.) (Di Tomaso 1998; Tamarisk Coalition 2009). Tamarisk can provide habitat structure preferred by SWFL, when mixed with native vegetation, if other habitat conditions are suitable (Edwards 2017; van Riper, III et al. 2008), yet larger monocultures may also be more susceptible to fire, as tamarisk burns hot, especially after defoliation (see above, "Fire Management" and discussion of tamarisk beetle defoliation, below). Habitat suitability mapping along the Middle Rio Grande, New Mexico, has shown an increase in the number of occupied SWFL territories containing tamarisk, from 43% in 2006–09 to 74% in 2013–16 and an increase in territories with tamarisk as the dominant plant species, from 6 to 20% in the same time periods (Siegle and Ahlers 2017). Siegle and Ahlers (2017) speculate that this is at least partially due to an increase in tamarisk overall in the region, facilitated by drought conditions.

The complicated nature of the relationship between tamarisk and SWFL is highlighted by another introduced species—the tamarisk beetle. The beetle was introduced to the region in St. George, Utah, on the Virgin River to control invasive tamarisk (Bateman et al. 2013; Hatten 2016; McLeod 2018; McLeod and Pellegrini 2013), and the beetle has since spread. Hatten (2016) estimated habitat suitability changes in several areas of the SWFL range between pre- and post-beetle phases. Calculated reductions were 90.7% loss along the Virgin River (Nevada, Arizona), 53.1% loss along the Upper Gila River (Arizona), and 33.5% loss along the LCR (California, Arizona). Although tamarisk control is an important management activity, defoliation of tamarisk due to beetle infestation causes decreases in humidity and cover along with increases in temperature (Bateman et al. 2013; Dillon and Ahlers 2018), thereby degrading areas dominated by tamarisk as habitat for SWFL (McLeod and Pellegrini 2013). Hypothesized effects of tamarisk beetle defoliation include altered insect prey abundance and composition, increased nest abandonment and/or depredation from loss of cover, and overall loss of quantity of useable riparian habitat (Paxton et al.

2011). The USFWS (2014) considered the beetle to be an emerging, potentially significant threat to SWFL because about 50% of known SWFL territories contain tamarisk as a component, and the beetles are anticipated to spread across the Southwestern United States.

A study conducted along the Dolores River, Colorado, of the response of riparian birds to tamarisk defoliation by the beetle showed three of six species declining (yellow warblers [*Setophaga petechia*], yellow-breasted chats [*Icteria virens*], blue grosbeaks [*Passerina caerulea*]); these responses were consistent with known habitat relationships (Darrah and van Riper, III 2017). Unfortunately, SWFL were too rare at this site to determine a response, and it was not known whether SWFL occurred there prior to defoliation. Van Riper, III et al. (2018) investigated whether birds preferentially used defoliated sites or consumed tamarisk beetle at a study site along the Dolores River, Colorado. Although SWFL were not a species studied, numerous co-occurring riparian passerines did occur there. When foraging, riparian birds avoided tamarisk with brown leaves. Although the beetle was found to have been consumed by four species (yellow-breasted chats, yellow warblers, common yellowthroats [*Geothlypis trichas*], Cordilleran flycatchers [*Empidonax occidentalis*]), the occurrence of the beetle by both numbers and biomass was far less than their availability in the environment. This study, Mahoney et al. (2017), who studied bird diets on the Virgin River, Utah, and Uhey et al. (2020), who studied arthropod abundance on the Dolores River, Colorado, strongly suggest that the tamarisk beetle does not provide an additional prey base for insectivorous, riparian songbirds and that tamarisk alters arthropod species composition but not necessarily richness or abundance.

Defoliation patterns—whether complete and lasting or patchy and temporarily variable—also affect nesting success. Because SWFL exhibit high site fidelity, they will return to nest in tamarisk sites used in past years, but the timing of defoliation may cause nest abandonment, without opportunities for renesting (C. Dodge 2018, personal communication). In 2017 along the LCR, McLeod et al. (2018) observed that no nesting attempts at several study sites in tamarisk-dominated areas were successful during periods of defoliation. McLeod et al. (2018) speculated that increased temperatures around nests or more visibility to predators in defoliated areas may have contributed to this failure. It has been suggested that control measures to remove tamarisk-dominated habitat used for nesting by flycatchers should assume potential negative effects on SWFL and its habitat and should include rapid replacement with other dense, preferably native, vegetation (Darrah and van Riper, III 2017; McLeod 2018; Paxton et al. 2007, 2011). An alternative could be to provide additional, nearby sites of breeding habitat close to defoliated areas that can be used by SWFL until such time as native vegetation has recovered to a suitable state (McLeod 2018).

Shot hole borer beetles (*Euwallaecea* spp.) are invasive species from Asia that have been found in southern California. The beetles feed on a wide variety of trees, including cottonwood and willow, each important riparian species on which SWFL depend (Boland 2016). To date, the beetles have not been found outside of California, and they may require cooler temperatures, which would prevent or slow their spread into LCR habitats (B. Raulston 2018, personal communication; University of California, Agriculture and Natural Resources 2019). However, Boland (2016) reported that damage to riparian habitat in California occurred rapidly once the beetles arrived, with willows and cottonwoods having the highest infestation rates. The presence of surface water was also a factor contributing to higher infestation rates.

Pesticide Application

The discussion of this controlling factor has been slightly updated as follows:

This factor addresses biocide applications that may occur on or adjacent to riparian habitat of the LCR region. The use of pesticides, including herbicides, was listed as a potential threat to SWFL by the USFWS (2002). Effects may include sublethal or lethal poisoning of SWFL via ingestion of treated insects, pollution of runoff into wetland habitats that are toxic to prey of SWFL, and a reduced or modified invertebrate food supply.

Planting Regime

The discussion of this controlling factor remains unchanged. No new information was located on the planting regime among SWFL in the Lower Colorado River Valley or elsewhere.

Recreational Activities

The discussion of this controlling factor has been updated as follows:

This factor addresses the disturbance to SWFL from recreational or research activities. Even non-consumptive human activity can have negative effects on wildlife (reviewed by Boyle and Samson [1985]). This is a broad category that encompasses the types of recreational activities (e.g., boating, fishing, wildlife viewing, horseback riding, camping) as well as the frequency and intensity of those activities. The impacts may consist of direct disturbance of SWFL and

habitat alteration. Recreational activities can influence nest predator densities by either increasing nest predator success rates through interfering with or distracting prey or by decreasing nest predator success rates through interfering with or distracting the predator (Mason 2015; Ware et al. 2015). The USFWS (2002, 2013) lists recreational activities as being a threat to SWFL and suggests that it be addressed by management.

Additionally, intensive research and monitoring that regularly disturbs nesting birds may adversely affect nest success. The impacts will depend on the tolerance of the bird species in question; nest predators and brood parasites present in the habitat; the frequency and type of nest disturbance; and other factors. However, precautionary measures should be included in the design of monitoring protocols until more is known about the potential effects of research-related disturbance on nesting SWFL.

WATER STORAGE-DELIVERY SYSTEM DESIGN & OPERATION

The discussion of this controlling factor is updated as follows:

Much of the habitat currently used by SWFL is along regulated waterways. The water moving through this system is highly regulated for storage and delivery (diversion) to numerous international, Federal, State, Tribal, and municipal users and for hydropower generation.

It is important to note that both riverine and palustrine areas provide habitat for SWFL. The dynamic nature of a free-flowing river creates a mosaic of riparian habitats, and thus, a natural flow regime might be beneficial to the SWFL (Graber et al. 2007; Graf et al. 2002; USFWS 2002, 2013). Although alteration of the natural flow of rivers is generally considered detrimental to SWFL habitat, currently some of the largest SWFL populations are within the drawdown zones of reservoirs (C. Dodge 2018, personal communication; Sogge et al. 2010). Roosevelt Lake, for example, has supported one of the largest SWFL populations in Arizona. Unfortunately, inundation of SWFL nesting habitat displaced SWFL and resulted in a reduction in productivity (as measured by number of territories) by 47% over a 2-year period (2004–06) (Ellis et al. 2009). In addition, due to inundation, canopy cover was reduced, and intermediate structure became much less dense.

However, with careful water management, it may be possible to create short-term fluctuations in water levels within reservoirs that can mimic—to some extent—the natural destruction and regeneration of riparian vegetation associated with

natural flowing systems (Paxton et al. 2007; Reclamation 2009). For example, Alamo Lake water levels have fluctuated in recent years (with accompanying changes in SWFL numbers); however, SWFL numbers rebounded with the recent flooding in 2017 (McLeod et al. 2018). SWFL will also use riparian vegetation created by sewage and agricultural drainages as well as irrigation canals (USFWS 2002).

Updates to Chapter 6 – Conceptual Ecological Model by Life Stage

The following sections identify all changes made to the SWFL conceptual ecological model workbook other than changes that involve only updates to names. These latter changes are listed separately in table 5 (see below, "Summary of Standardization of Terms"). The items in each section of this chapter are arranged alphabetically. The abbreviations, CF for controlling factor, HE for habitat element, CAP for critical activity or process, and LSO for life-stage outcome are provided to identify component types where needed. Each item also identifies the life stage(s) to which the item applies.

New Links with Controlling Factors as Causal Agents

- Grazing to Anthropogenic Disturbance (HE): This link has been added for compatibility with other CEMs. *Applies to all life stages*.

- Grazing to Intermediate Structure (HE): This link has been added based on new information and analysis. *Applies to the eggs/nestlings life stage.*

- Grazing to Linear Width of Patch (HE): This link has been added based on new information and analysis. *Applies to the eggs/nestlings life stage.*

- Grazing to Nuisance Species Introduction & Management (CF): This link has been added based on new information and analysis. *Applies to the eggs/nestlings life stage.*

- Grazing to Patch Size (HE): This link has been added based on new information and analysis. *Applies to the eggs/nestlings life stage.*

- Grazing to Vegetation Community Type (HE): This link has been added based on new information and analysis. *Applies to the eggs/nestlings life stage.*

- Irrigation to Canopy Closure (HE): This link has been added for compatibility with other CEMs. *Applies to all life stages*.

- Irrigation to Intermediate Structure (HE): This link has been added for compatibility with other CEMs. *Applies to all life stages*.

- Irrigation to Local Hydrology (HE): The amount and frequency of irrigation will directly influence local hydrology, including both groundwater and soil moisture, and the presence and length of stay of surface water. However, effects may be short term and/or small scale depending on soil conditions, the irrigation system, climate, and the exact nature of irrigation regime. The link is hypothesized to be complex and unidirectional, with proposed high intensity, low spatial scale, and low temporal scale; medium predictability; and high understanding. *Applies to all life stages*.

- Irrigation to Soil Salinity (HE): Depending upon the source of the water and nature of soils, irrigation can increase or decrease soil salinity. Without careful consideration of irrigation regimes in relation to water origin and soil type, it is well established that soil salinity can increase, although the exact response of salinity depends on the precise details of the irrigation regime. The link is hypothesized to be complex and unidirectional, with proposed high intensity, low spatial scale, and low temporal scale; medium predictability; and medium understanding. *Applies to all life stages*.

- Irrigation to Tree Density (HE): This link has been added for compatibility with other CEMs. *Applies to all life stages*.

- Irrigation to Vegetation Community Type (HE): This link has been added for compatibility with other CEMs. *Applies to all life stages*.

- Pesticide Application to Fertility (LSO): This link has been updated based on new information and analysis. *Applies to the breeding adults life stage*.

- Pesticide Application to Survival (LSO): This link has been updated based on new information and analysis. *Applies to all life stages*.

- Water Storage Delivery System Design & Operation to Soil Salinity (HE): Main stem flooding generally decreases soil salinity, but it can affect soil salinity positively or negatively, depending on soil type and operations. The link is hypothesized to be complex and unidirectional, with proposed high intensity, high spatial scale, and medium temporal scale; medium predictability; and medium understanding. *Applies to all life stages*.

- Water Storage Delivery System Design & Operation to Irrigation (CF): Irrigation is only possible with appropriate water storage delivery and operation. While irrigation is critically dependent on water delivery, the exact irrigation regime that results is difficult to predict well in advance. The link is hypothesized to be complex and bi-directional, with proposed medium intensity, medium spatial scale, and medium temporal scale; medium predictability; and high understanding. *Applies to all life stages*.

DELETED LINKS WITH CONTROLLING FACTORS AS CAUSAL AGENTS

- Water Storage Delivery System Design & Operation to Vegetation Community Type (HE): This link was deleted because there is no direct link between water storage delivery system design & operation and habitat elements such as vegetation community type; rather, water storage delivery system design & operation is linked to irrigation, which affects vegetation community type. *Applies to the juveniles and breeding adults life stages*.

UPDATED LINKS WITH CONTROLLING FACTORS AS CAUSAL AGENTS

- Grazing to Intermediate Structure (HE): The original link was considered to be complex and unidirectional, with high intensity, high spatial scale, and low temporal scale, as grazing can have great effects on understory structure by trampling and removal of vegetation and is often implemented over large and long scales. However, grazing is not a concern on LCR sites being used or managed for SWFL. Therefore, the values have been modified in this update. The link remains complex and unidirectional; however, link intensity is low, spatial scale is low, and temporal scale is low. Link predictability remains medium, and link understanding remains high. *Applies to the juveniles and breeding adults life stages.*

- Grazing to Linear Width of Patch (HE): This link has been updated based on new information and analysis. *Applies to the juveniles and breeding adults life stages.*

- Grazing to Matrix Community (HE): The original link was considered to be complex and unidirectional, with high intensity, high spatial scale, and low temporal scale, as grazing can have great effects on the surrounding community composition and is often implemented over large and long scales. However, grazing is not a concern on LCR sites being used by or managed for SWFL. Therefore, the values have been modified in this update. The link remains complex and unidirectional; however, link intensity is low, spatial scale is low, and temporal scale is low. Link predictability remains medium, and link understanding remains high. *Applies to all life stages.*

- Grazing to Nuisance Species Introduction & Management (CF): This link has been updated based on new information and analysis. *Applies to the juveniles and breeding adults life stages.*

- Grazing to Patch Size (HE): The original link was considered to be complex and unidirectional, with high intensity, high spatial scale, and low temporal scale, as grazing can have great effects on community composition and is often implemented over large and long scales. However, grazing is not a concern on LCR sites being used or managed for SWFL. Therefore, the values have been modified in this update. The link remains complex and unidirectional; however, link intensity is low, spatial scale is low, and temporal scale is low. Link predictability remains medium, and link understanding remains high. *Applies to the juveniles and breeding adults life stages.*

- Grazing to Vegetation Community Type (HE): The original link was considered to be complex and unidirectional, with high link intensity, high spatial scale, and low temporal scale, as grazing can have great effects on community composition and is often implemented over large and long scales. However, grazing is not a concern on LCR sites being used by or managed for SWFL. Therefore, the values have been modified in this update. The link remains complex and unidirectional; however, link intensity is low, spatial scale is low, and temporal scale is low. Link predictability remains medium, and link understanding remains high. *Applies to the juveniles and breeding adults life stages.*

New Links with Habitat Elements as Causal Agents

- Infectious Agents to Disease (CAP): This new link has been added due to the separation of the formerly combined Genetic Diversity & Infectious Agents into two new habitat elements. Infectious agents such as pathogens and vectors in an environment affect transmission risk, and fewer infectious agents mean less likelihood of disease transmission. The link is hypothesized to be negative, with no or an unknown threshold, and unidirectional, with proposed low intensity, low spatial scale, and low temporal scale; high predictability; and medium understanding. *Applies to all life stages*.

- Infectious Agents to Survival (LSO): This link has been updated based on new information and analysis. *Applies to all life stages*.

- Soil Salinity to Diversity of Vegetation (HE): Soil salinity generally affects plant vigor negatively, but the exact effects vary depending on plant species and salinity levels. The link is hypothesized to be complex, with no or an unknown threshold, and unidirectional, with proposed medium intensity, medium spatial scale, and medium temporal scale; low predictability; and medium understanding. *Applies to all life stages*.

- Soil Salinity to Vegetation Community type (HE): Some plant species grow better at different salinity levels; generally, desirable vegetation types for SWFL are not found at high salinity levels. The link is hypothesized to be complex and unidirectional, with proposed high intensity, medium spatial scale, and medium temporal scale; medium predictability; and medium understanding. *Applies to all life stages*.

- Temperature to Parental Care (HE): This link has been added to reflect new information and analysis. *Applies to the eggs/nestlings life stage*.

- Temperature to Thermal Stress (HE): This link has been added to reflect new information and analysis. *Applies to the eggs/nestlings life stage*.

Deleted Links with Habitat Elements as Causal Agents

No change.

Updated Links with Habitat Elements as Causal Agents

- Genetic Diversity to Disease (CAP): This link has been updated to reflect the separation of the formerly combined habitat element, Genetic Diversity & Infectious Agents, into two new habitat elements. The link is hypothesized to be complex and unidirectional, with proposed low intensity, spatial, and temporal scale; low predictability; and low understanding. *Applies to all life stages*.

New Links with Critical Activities/ Processes as Causal Agents

- Disease to Survival (LSO): This link has been added based on new information and analysis. *Applies to the eggs/nestlings life stage*.

- Eating to Survival (LSO): This link has been added based on new information and analysis. *Applies to the eggs/nestlings life stage*.

- Nest Predation & Brood Parasitism to Survival (LSO): This link has been added based on new information and analysis. *Applies to the eggs/nestlings life stage*.

- Thermal Stress to Survival (LSO): This link has been updated based on new information and analysis. *Applies to the eggs/nestlings adults life stage*.

Deleted Links with Critical Activities/ Processes as Causal Agents

No change.

Updated Links with Critical Activities/ Processes as Causal Agents

- Disease to Survival (LSO): This link has been updated based on new information and analysis. *Applies to the juveniles and breeding adults life stages*.

- Foraging to Nest Attendance (CAP): This link has been updated based on new information and analysis. *Applies to the breeding adults life stage*.

- Thermal Stress to Survival (LSO): This link has been updated based on new information and analysis. *Applies to the juveniles and breeding adults life stages*.

New Links with Life-Stage Outcomes as Causal Agents

No change.

SUMMARY OF STANDARDIZATION OF TERMS

Table 5.—(New table for this update) Updated CEM component names
(Blue indicates new or revised items; orange indicates replaced items.)

SWFL conceptual ecological model, updated terms, 2019	**SWFL conceptual ecological model, original terms, 2015–16**
Life stages	
Eggs/Nestlings *(renamed)*	Nest
Juveniles *(renamed)*	Juvenile
Breeding Adults *(renamed)*	Breeding Adult
Life-stage outcomes	
Survival	Survival
Fertility *(renamed)*	Reproduction
Critical biological activities and processes	
Disease	Disease
Eating	Eating
Foraging	Foraging
Molting *(renamed)*	Molt
Nest Attendance	Nest Attendance
Nest Predation & Brood Parasitism	Nest Predation and Brood Parasitism
Nest Site Selection	Nest Site Selection
Predation	Predation
Thermal Stress *(renamed)*	Temperature Regulation
Habitat elements	
Anthropogenic Disturbance	Anthropogenic Disturbance
Brood/Litter Size *(renamed)*	Brood Size
Canopy Closure	Canopy Closure
Conspecific Attraction	Conspecific Attraction
Distance to Occupied Patch	Distance to Occupied Patch
Diversity of Vegetation	Diversity of Vegetation
Food Availability	Food Availability
Genetic Diversity *(new)*	Genetic Diversity and Infectious Agents *(see Genetic Diversity)*
Humidity	Humidity
Infectious Agents	Genetic Diversity and Infectious Agents *(see Infectious Agents)*
Intermediate Structure	Intermediate Structure
Linear Width of Patch	Linear Width of Patch
Local Hydrology	Local Hydrology
Matrix Community	Matrix Community
Nest Predators & Cowbird Density *(renamed)*	Nest Predator and Cowbird Density
Parental Care *(renamed & updated)*	Parental Feeding Behavior *(see Parental Care)*
	Parental Nest Attendance *(see Parental Care)*
Patch Size	Patch Size
Predators *(renamed & updated)*	Predator Density *(see Predators)*
Previous Year's Use	Previous Year's Use
Soil Salinity	
Temperature	Temperature
Tree Density	Tree Density
Vegetation Community Type *(renamed & updated)*	Community Type *(see Vegetation Community Type)*
Controlling factors	
Fire Management	Fire Management
Grazing	Grazing
Irrigation *(new)*	
Mechanical Thinning	Mechanical Thinning
Natural Thinning	Natural Thinning
Nuisance Species Introduction & Management	Nuisance Species Introduction and Management
Pesticide Application *(renamed)*	Pesticide/Herbicide Application
Planting Regime	Planting Regime
Recreational Activities	Recreational Activities
Water Storage-Delivery System Design & Operation	Water Storage-Delivery System Design and Operation

LITERATURE CITED IN UPDATE

Ahlers, D. and D. Moore. 2009. A Review of Vegetation and Hydrologic Parameters Associated with the Southwestern Willow Flycatcher – 2002 to 2008. Elephant Butte Reservoir Delta NM. U.S. Department of the Interior, Bureau of Reclamation, Fisheries and Wildlife Resources, Technical Service Center, Denver, Colorado.

Allendorf, F.W. and R.F. Leary. 1986. Heterozygosity and fitness in animals *in* M.E. Soule (editor). Conservation Biology. Sinauer, Sunderland, Massachusetts. pp. 57–76.

Bakian, A.V. and E.H. Paxton. 2004. Home Range, Movement, and Habitat Use of Willow Flycatchers, Fish Creek, Utah – 2003. U.S. Geological Survey report to the Bureau of Reclamation, Salt Lake City, Utah. 24 p.

Balluff, T. 2012. Soil Hydrology and Microclimate Conditions in Occupied Southwestern Willow Flycatcher and Yellow-billed Cuckoo Habitat. U.S. Department of the Interior, Bureau of Reclamation, Boulder City, Nevada.

Barber, J.R., K.R. Crooks, and K.M. Fristrup. 2010. The costs of chronic noise exposure for terrestrial organisms. Trends in Ecology & Evolution 25:180–189.

Bartuszevige, A.M. and B.A. Endress. 2008. Do ungulates facilitate native and exotic plant spread? Journal of Arid Environments 72:904–913.

Bateman, H.L., P.L. Nagler, and E.P. Glenn. 2013. 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 89:16–20.

BIO-WEST, Inc. 2005. Colorado River Backwaters Enhancement Species Profile Report. Submitted to the Bureau of Reclamation, Boulder City, Nevada.

Boland, J.M. 2016. The impact of an invasive ambrosia beetle on the riparian habitats of the Tijuana River Valley, California. PeerJ 4:e2141. DOI https://doi.org/10.7717/peerj.2141

Boyle, S.A. and F.B. Samson. 1985. Effects of nonconsumptive recreation on wildlife: a review. Wildlife Society Bulletin 13:110–116.

Briggs, M.K. 1996. Riparian Ecosystem Recovery in Arid Lands: Strategies and References. University of Arizona Press, Tucson, Arizona.

Brodhead, K.M. 2005. The influence of riparian-canopy structure and coverage on the breeding distribution of the southwestern willow flycatcher. Master's thesis. Montana State University, Bozeman, Montana.

Brodhead, K.M., S.H. Stoleson, and D.M. Finch. 2007. Southwestern willow flycatchers (*Empidonax traillii extimus*) in a grazed landscape: factors influencing brood parasitism. The Auk 124(4):1213–1228.

Brooks, M., J. Chambers, and R. McKinley. 2013. Fire history, effects, and management in southern Nevada. Pages 75–96 *in* J.C. Chambers, M.L. Brooks, B.K. Pendleton, and C.B. Raish (editors). The Southern Nevada Agency Partnership Science and Research Synthesis: Science to Support Land Management in Southern Nevada. General Technical Report RMRS-GTR-303. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.

Bullard, M., K.G. Dillon, and D. Moore. 2018. 2017 Lower Rio Grande Southwestern Willow Flycatcher Study Results: Selected Sites Within the Rio Grande Basin from Elephant Butte Dam, NM to El Paso, TX. Bureau of Reclamation, Technical Service Center, Fisheries and Wildlife Resources, Denver, Colorado.

_____. 2009. Elephant Butte Reservoir Five-Year Operational Plan – Biological Assessment. U.S. Department of the Interior, Bureau of Reclamation, Albuquerque Area Office, Albuquerque, New Mexico.

Busch, J.D., M.P. Miller, E.H. Paxton, M.K. Sogge, and P. Keim. 2000. Genetic variation in the endangered southwestern willow flycatcher. The Auk 117(3):586–595.

Darrah, A.J. and C. van Riper, III. 2017. Riparian bird density decline in response to biocontrol of *Tamarix* from riparian ecosystems along the Dolores River in SW Colorado, USA. Biological Invasions 20:709–720. https://doi.org/10.1007/s10530-017-1569-z

Daubenmire, R. 1959. A canopy-coverage method of vegetation analysis. Northwest Science 33:43–64.

Dillon, K.G. and D. Ahlers. 2018. Photographic Monitoring of Defoliation by the Tamarisk Beetle: Middle Rio Grande from Belen to Elephant Butte Reservoir, New Mexico. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Fisheries and Wildlife Resources, Denver, Colorado.

Di Tomaso, J.M. 1998. Impact, biology, and ecology of saltcedar (*Tamarix* spp.) in the southwestern United States. Weed Technology 12:326–336.

Dobbs, R.C., M. Huizinga, C.N. Edwards, and R.A. Fridell. 2012. Status, Reproductive Success, and Habitat Use of Southwestern Willow Flycatchers on the Virgin River, Utah, 2008–2011. Publication Number 12–36. Utah Division of Wildlife Resources, Salt Lake City, Utah.

Dodge, C. 2018. Lower Colorador River Multi-Species Conservation Program, Boulder City, Nevada, personal communication.

Dodge C. and B. Raulston. 2018. Lower Colorador River Multi-Species Conservation Program, Boulder City, Nevada, personal communications.

Drus, G.M., T.L. Dudley, M.L. Brooks, and J.R. Matchett. 2012. The effect of leaf beetle herbivory on the fire behaviour of tamarisk (*Tamarix ramosissima* Lebed.). International Journal of Wildland Fire 22:446–458.

Durst, S.L., T.C. Theimer, E.H. Paxton, and M.K. Sogge. 2008. Age, habitat, and yearly variation in the diet of a generalist insectivore, the southwestern willow flycatcher. The Condor 110:514–525.

Edwards, C. 2017. Southwestern willow flycatcher status and habitat restoration efforts on the Virgin River in St. George, Utah. Presentation CRTR17-16. Washington County Field Office, Utah Division of Wildlife Resources.

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 2008, Research Technical Guidance Bulletin. Arizona Game and Fish Department, Phoenix, Arizona.

Ellis, L.A., S.D. Stump, and D.M. Weddle. 2009. Southwestern willow flycatcher population and habitat response to reservoir inundation. Journal of Wildlife Management 73(6):946–954.

Erdelen, M. 1984. Bird communities and vegetation structure: I. Correlations and comparisons of simple and diversity indices. Oecologia 61:277–284.

Etterson, M.A., S.N. Ellis-Felege, D. Evers, G. Gauthier, J.A. Grzybowski, B.J. Mattsson, L.R. Nagy, B.J. Olsen, C.M. Pease, M. Post van der Burg, and A. Potvien. 2011. Modeling fecundity in birds: conceptual overview, current models, and considerations for future developments. Ecological Modelling 222:2178–2190.

Finch, D.M., S.I. Rothstein, J.C. Boren, W.L. Graf, J.L. Holechek, B.E. Kus, R.M. Marshall, M.M. Pohl, S.J., Sferra, M.K. Sogge, J.C. Stromberg, B.A. Valentine, M.J. Whitfield, and S.O. Williams. 2002. Final Recovery Plan of the Southwestern Willow Flycatcher (*Empidonax traillii extimus*). U.S. Fish and Wildlife Service, Region 2, Albuquerque, New Mexico.

Francis, C.D. and J.R. Barber. 2013. A framework for understanding noise impacts on wildlife: combining ethology, ecology and bioacoustics to address an urgent conservation priority. Frontiers in Ecology and Evolution 11:305–313.

Gill, F.B., R.O. Prum, and S.K. Robinson. 2019. Ornithology, Fourth edition. W. H. Freeman Macmillan Learning, New York, New York. 666 p.

Goguen, C.B. and N.E. Mathews. 2001. Brown-headed cowbird behavior and movements in relation to livestock grazing. Ecological Applications 111(5):1533–1544.

Graber, A.E., D.M. Weddle, H.C. English, S.D. Stump, H.E. Telle, and L.A. Ellis. 2007. Southwestern Willow Flycatcher 2006 Survey and Nest Monitoring Report. Technical Report 249. Nongame and Endangered Wildlife Program, Arizona Game and Fish Department, Phoenix.

Graber, A.E. and T.J. Koronkiewicz. 2009. Southwestern Willow Flycatcher Surveys and Nest Monitoring along the Gila River between Coolidge Dam and South Butte, 2009. Final 2009 summary report submitted to the Bureau of Reclamation, Phoenix, Arizona, by SWCA Environmental Consultants, Flagstaff, Arizona.

Graber, A.E., T.J. Koronkiewicz, and J.L. Granger. 2012. Southwestern Willow Flycatcher Surveys and Nest Monitoring along the Gila River between Coolidge Dam and South Butte, 2011. Annual summary report submitted to U.S. Bureau of Reclamation, Glendale, Arizona. SWCA Environmental Consultants, Flagstaff, Arizona.

Graf, W.L., J. Stromberg, and B. Valentine. 2002. Rivers, dams, and willow flycatchers: a summary of their science and policy connections. Geomorphology 47:169–188.

Green, G., H. Bombay, and M. Morrison. 2003. Conservation Assessment of the Willow Flycatcher in the Sierra Nevada. U.S. Department of Agriculture, Forest Service, Region 5, Sacramento, California.

Hatten, J.R. 2016. A Satellite Model of Southwestern Willow Flycatcher (*Empidonax traillii extimus*) Breeding Habitat and a Simulation of Potential Effects of Tamarisk Leaf Beetles (*Diorhabda* spp.), Southwestern United States: U.S. Geological Survey Open-File Report 2016–1120. 88 p. http://dx.doi.org/10.3133/ofr20161120

Hatten, J.R. and C.E. Paradzick. 2003. A multiscaled model of southwestern willow flycatcher breeding habitat. The Journal of Wildlife Management: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 Modelling 221:1674–1686.

Howell, S.N.G. 2010. Peterson reference guide to molt in North American birds. Houghton Mifflin Harcourt, New York, New York.

Hunter, W.C., B.W. Anderson, and R.D. Ohmart. 1987a. Avian community structure changes in a mature floodplain forest after extensive flooding. The Journal of Wildlife Management 51:495–502.

_____. 1987b. Status of breeding riparian-obligate birds in southwestern riverine systems. Western Birds 18:10–18.

Jacobson, R.B., M.L. Annis, M.E. Colvin, D.A. James, T.L. Welker, and M.J. Parsley. 2016. Missouri River *Scaphirhynchus albus* (Pallid Sturgeon) Effects Analysis—Integrative Report 2016. Scientific Investigations Report 2016–5064. U.S. Geological Survey, Reston, Virginia.

James, F.C. 1971. Ordinations of habitat relationships among breeding birds. The Wilson Bulletin 83:215–236.

Jarvi, S.I., J.J. Schultz, and C.T. Atkinson. 2002. PCR diagnostics underestimate the prevalence of avian malaria (*Plasmodium relictum*) in experimentally-infected passerines. The Journal of Parasitology 88:153–159.

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An ecological perspective of riparian and stream restoration in the western United States. Fisheries 22:12–24.

Kokos, S. 2014. Lower Colorador River Multi-Species Conservation Program, Boulder City, Nevada, personal communication.

Korhonen, L., I. Korpela, J. Heiskanen, and M. Maltamo. 2011. Airborne discrete-return LIDAR data in the estimation of vertical canopy cover, angular canopy closure and leaf area index. Remote Sensing of Environment 115(4):1065–1080. https://doi.org/10.1016/j.rse.2010.12.011

Koronkiewicz, T.J., S.N. Cardinal, M.K. Sogge, and E.H. Paxton. 2002. Survivorship and Movements of Southwestern Willow Flycatchers at Roosevelt Lake, Arizona – 2002. Submitted to the Bureau of Reclamation, Phoenix, Arizona, by the U.S. Geological Survey Southwest Science Center, Colorado Plateau Field Station, Flagstaff, Arizona. 43 p.

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 the Bureau of Reclamation, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona. 176 p.

Krueper, D.J. 1993. Effects of land use practices on western riparian ecosystems. Pages 321–330 *in* D. Finch and P. Stangel (editors). Status and Management of Neotropical Migratory Birds. General Technical Report RM-229. U.S. Department of Agriculture, Forest Service, Rocky Mountain Range and Experiment Station, Fort Collins, Colorado. 422 p.

Krueper, D.J., J. Bart, and T.D. Rich. 2003. Response of vegetation and breeding birds to the removal of cattle on the San Pedro River, Arizona. Conservation Biology 17:607–615.

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

Kus, B.E., S.L. Howell, and D.A. Wood. 2017. Female-biased sex ratio, polygyny, and persistence in the endangered southwestern willow flycatcher (*Empidonax traillii extimus*). The Condor 119:17–25.

LaHue, G. 2017. Saline soils and water quality in the Colorado River Basin: Natural and anthropogenic causes. University of California Davis, River Ecogeomorphology, Winter 2017.

LCR MSCP (see Lower Colorado River Multi-Species Conservation Program).

Lima, S.L. 1998. Nonlethal effects in the ecology of predator-prey interactions. BioScience 48:25–34.

_____. 2009. Predators and the breeding bird: behavioral and reproductive flexibility under the risk of predation. Biological Reviews of the Cambridge Philosophical Society 84:485–513.

Lower Colorado River Multi-Species Conservation Program. 2004. Lower Colorado River Multi-Species Conservation Program, Volume II: Habitat Conservation Plan, Final. Sacramento, California.

_____. 2008. Species Accounts for the Lower Colorado River Multi-Species Conservation Program. Bureau of Reclamation, Boulder City, Nevada.

MacArthur, R.H. and J.W. MacArthur. 1961. On bird species diversity. Ecology 42:594–598.

Mahoney, S.M., T.C. Theimer, M.J. Johnson, and J.T. Foster. 2017. Similar dietary but different numerical responses to nonnative tamarisk (*Tamarix* spp.) by two native warblers. Biological Invasions 19:1935–1950. https://doi.org/10.1007/s10530-017-1408-2

Mason, J.T. 2015. The impact of anthropogenic noise on northern saw-whet owl (*Aegolius acadius*) hunting behavior. Master's thesis. Boise State University, Boise, Idaho. http://scholarworks.boisestate.edu/td/892

McClure, C.J.W., E.A. Johnson, and R. Unnasch. 2016. Southwestern Willow Flycatcher (*Empidonax traillii extimus*) (SWFL) Basic Conceptual Ecological Model for the Lower Colorado River. Submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada, by Sound Science, LLC, Boise, Idaho, under Contract No. R13PC30272.

McLeod, M.A. 2018. Unintended Consequences: Tamarisk Control and Increasing Threats to the Southwestern Willow Flycatcher. Pages 62–84 *in* R.R. Johnson, S.W. Carothers, D.M. Finch, K.J. Kingsley, and J.T. Stanley (editors). Riparian Research and Management: Past, Present, Future. Volume 1. General Technical Report RMRS-GTR-377. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado. https://www.fs.usda.gov/treesearch/pubs/57370

McLeod, M.A. and A.R. Pellegrini. 2013. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2008–2012. Summary report submitted to the Bureau of Reclamation, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona. 341 p.

_____. 2014. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2013. Annual report submitted to the Bureau of Reclamation, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona. 143 p.

_____. 2015. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the lower Colorado River and Tributaries, 2014. Annual report submitted to the Bureau of Reclamation, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona. 147 p.

_____. 2017a. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2016. Annual report submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona, under contract No. R13PD30017.

_____. 2017b. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2015. Annual report submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona, under contract No. R13PD30017.

_____. 2019. Southwestern Willow Flycatcher Monitoring Along the Lower Colorado River and Tributaries, 2018 Annual Report. Submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona, under contract No. 140R3018C0010.

_____. 2020. Southwestern Willow Flycatcher Surveys and Monitoring Along the Lower Colorado River and Tributaries, 2019 Annual Report. Submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona, under contract No. 140R3018C0010.

McLeod, M.A., T.J. Koronkiewicz, S.R. Nichols, B.T. Brown, and S.W. Carothers. 2008a. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2007. Annual report submitted to the Bureau of Reclamation, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona, under contract No. 03-CS-30-0093.

McLeod, M.A., T.J. Koronkiewicz, B.T. Brown, W.J. Langeberg, and S.W. Carothers. 2008b. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2003–2007. Five-year summary report submitted to the Bureau of Reclamation, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona, under contract No. 03-CS-30-0093.

McLeod, M.A., S. Nichols, and A. Pellegrini. 2018. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2017. Annual report submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona, under contract No. R13PD30017.

McLeod, M.A., A. Pellegrini, and G. Cummins. 2019. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries – 2013–2017. Summary report submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona, under contract No. R13PD30017.

Moore, D. 2007. Vegetation Quantification of Southwestern Willow Flycatcher Nest Sites. Rio Grande from La Joya to Elephant Butte Reservoir Delta, New Mexico – 2004–2006. Bureau of Reclamation, Albuquerque, New Mexico.

Moore, D. and D. Ahlers. 2006. 2006 Southwestern Willow Flycatcher Study Results: Selected Sites Along the Rio Grande from Velarde to Elephant Butte Reservoir, New Mexico. Bureau of Reclamation, Fisheries and Wildlife Resources, Technical Service Center, Denver, Colorado.

_____. 2017. Southwestern Willow Flycatcher Surveys Habitat Classification: Lower Rio Grande from Elephant Butte Dam, NM to El Paso, TX. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Fisheries and Wildlife Resources, Denver, Colorado.

_____. 2018. 2017 Middle Rio Grande Southwestern Willow Flycatcher Study Results: Selected Sites Along the Rio Grande from Bandelier National Monument to Elephant Butte Reservoir, New Mexico. Bureau of Reclamation, Technical Service Center, Fisheries and Wildlife Resources, Denver, Colorado.

Morishita, T.Y., P.P. Aye, E.C. Ley, and B.S. Harr. 1999. Survey of pathogens and blood parasites in free-living passerines. Avian Diseases 43:549–552.

Munzer, O.M., H.C. English, A.B. Smith, and A.A. Tudor. 2005. Southwestern Willow Flycatcher 2004 Survey and Nest Monitoring Report. Technical Report 244. Nongame and Endangered Wildlife Program, Arizona Game and Fish Department, Phoenix, Arizona.

Murphy, D.D. and P.S. Weiland. 2011. The route to best science in implementation of the Endangered Species Act's consultation mandate: the benefits of structured effects analysis. Environmental Management 47(2):161–172.

_____. 2014. Science and structured decision making: fulfilling the promise of adaptive management for imperiled species. Journal of Environmental Studies and Sciences 4(3):200–207.

Newell, P.J., C. Causey, M. Pollock, E.H. Paxton, and M. Sogge. 2005. Survivorship and Movements of Southwestern Willow Flycatchers at Roosevelt Lake, Arizona – 2004. U.S. Geological Survey report to the Bureau of Reclamation, Phoenix, Arizona.

Noon, B.R. and M. Farnsworth. 2000. Demographic Analysis of the Southwestern Willow Flycatcher: Kern River Population. Submitted to the Bureau of Reclamation, Phoenix, Arizona, by Colorado State University.

Palinauskas, V., G. Valkiūnas, C.V. Bolshakov, and S. Bensch. 2008. *Plasmodium relictum* (lineage P-SGS1): effects on experimentally infected passerine birds. Experimental Parasitology 120:372–80.

Paradzick, C.E. 2005. Southwestern Willow Flycatcher Habitat Selection Along the Gila and Lower San Pedro Rivers, Arizona: Vegetation and Hydrogeomorphic Considerations. Arizona State University, Tempe, Arizona.

Paxton, E.H., M.K. Sogge, T.D. McCarthey, and P. Keim. 2002. Nestling sex ratio in the southwestern willow flycatcher. The Condor 104:877–881.

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. U.S. Geological Survey, Reston, Virginia.

Paxton, E.H., T.C. Theimer, and M.K. Sogge. 2011. Tamarisk biocontrol using tamarisk beetles: potential consequences for riparian birds in the southwestern United States. The Condor 113(2):255–265.

Paxton, E.H., S.L. Durst, M.K. Sogge, T.J. Koronkiewicz, and K.L. Paxton. 2017. Survivorship across the annual cycle of a migratory passerine, the willow flycatcher. Journal of Avian Biology 48(8):1126–1131. https://doi.org/10.1111/jav.01371

Pearson, T., M.J. Whitfield, T.C. Theimer, and P. Keim. 2006. Polygyny and extra-pair paternity in a population of southwestern willow flycatchers. The Condor 108:571–578.

Peterson, D., A.R. Pellegrini, M.A. McLeod, and T.C. Theimer. 2015. Distance to standing water is negatively correlated with invertebrate biomass, nestling feeding rate, and productivity in southwestern willow flycatchers (*Empidonax traillii extimus*). Pages 262–270 *in* The Colorado Plateau VI: Science and Management at the Landscape Scale. University of Arizona Press, Tucson, Arizona.

Pyle, P. 1997. Identification Guide to North American Birds, Part I. Columbidae to Ploceidae. Slate Creek Press, Bolinas, California.

Raulston, B.E. 2003. Habitat Restoration on the Lower Colorado River, Demonstration Projects: 1995–2002. Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada.

_____. 2018. Lower Colorador River Multi-Species Conservation Program, Boulder City, Nevada, personal communication.

Reclamation (see Bureau of Reclamation).

Rosenberg, K.V. 1991. Birds of the Lower Colorado River Valley. University of Arizona Press, Tucson, Arizona.

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.

Rubin, Z., B. Rios-Touma, G.M. Kondolf, M.E. Power, P. Saffarinia, and J. Natali. 2019. Using prey availability to evaluate lower Colorado River riparian restoration. Restoration Ecology 27(1):46–53.

Rudnicki, M., U. Silins, and V.J. Lieffers. 2004. Crown cover is correlated with relative density, tree slenderness, and tree height in lodgepole pine. Forest Science 50:356–363.

Salt River Project. 2014. Southwestern Willow Flycatcher and Yellow-Billed Cuckoo Surveys at the Rockhouse Demonstration Site, River, Gila County, Arizona, 2014 Summary Report. Environmental Services Department, Siting and Studies, Phoenix, Arizona.

San Joaquin River Restoration Program. 2014. Seepage Management Plan (Draft September 2014). http://www.restoresjr.net/restoration-flows/seepage-projects/

Sayre, N.F. 2005. Interacting effects of landownership, land use, and endangered species on conservation of southwestern US rangelands. Conservation Biology 19(3):783–792.

Schlossberg, S.R. and M.P. Ward. 2004. Using conspecific attraction to conserve endangered birds. Endangered Species Update 21:132–138.

Schofield, L.N., H.L. Loffland, R.B. Siegel, C. Stermer, and H.A. Mathewson. 2018. Using conspecific broadcast for willow flycatcher restoration. Avian Conservation and Ecology 13(1):23. http://www.ace-eco.org/vol13/iss1/art23/

Sedgwick, J.A. 2020. Willow Flycatcher (*Empidonax traillii*), version 1.0 *in* A.F. Poole and F.B. Gill (editors). Birds of the World. Cornell Lab of Ornithology, Ithaca, New York. https://doi.org/10.2173/bow.wilfly.01

Sedgwick, J.A. and W.M. Iko. 1999. Costs of brown-headed cowbird parasitism to willow flycatchers. Pages 167–181 *in* M.L. Morrison, L.S. Hall, S.K. Robinson, S.I. Rothstein, D.C. Hahn, and T.D. Rich (editors). Research and Management of the Brown-headed Cowbird in Western Landscapes. Studies in Avian Biology No. 18. Cooper Ornithological Society.

Shafroth, P.B., J.M. Friedman, and L.S. Ischinger. 1995. Effects of salinity on establishment of *Populus fremontii* (cottonwood) and *Tamarix ramosissima* (saltcedar) in southwestern United States. Great Basin Naturalist 55(1):58–65.

Shafroth, P.B., V.B. Beauchamp, M.K. Briggs, K. Lair, M.L. Scott, and A.A. Sher. 2008. Planning riparian restoration in the context of *Tamarix* control in western North America. Restoration Ecology 16(1):97–112.

Siegle, R. and D. Ahlers. 2017. Southwestern Willow Flycatcher Habitat Suitability 2016: Middle Rio Grande, New Mexico. Bureau of Reclamation, Technical Service Center, Denver, Colorado.

Smith, D.M., J.F. Kelly, and D.M. Finch. 2006. Cicada emergence in southwestern riparian forest: influences of wildfire and vegetation composition. Ecological Applications 16:1608–1618.

Sogge, M.K. 2000. Breeding season ecology. Pages 57–70 *in* D.M. Finch and S.H. Stoleson (editors). Status, Ecology, and Conservation of the Southwestern Willow Flycatcher. General Technical Report RMRS-GTR-60. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah.

Sogge, M.K., D. Ahlers, and S.J. Sferra. 2010. A Natural History Summary and Survey Protocol for the Southwestern Willow Flycatcher. U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia.

Stoleson, S.H., M.J. Whitfield, and M.K. Sogge. 2000. Demographic characteristics and population modeling. Pages 83–94 *in* D.M. Finch and S.H. Stoleson (editors). Status, Ecology, and Conservation of the Southwestern Willow Flycatcher. General Technical Report RMRS-GTR-60. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah.

Stromberg, J.C. 2001. Restoration of riparian vegetation in the south-western United States: importance of flow regimes and fluvial dynamism. Journal of Arid Environments 49:17–34.

Stumpf, K.J., T.C. Theimer, M.A. McLeod, and T.J. Koronkiewicz. 2012. Distance from riparian edge reduces brood parasitism of southwestern willow flycatchers, whereas parasitism increases nest predation risk. Journal of Wildlife Management 76(2):269–277.

SWCA Environmental Consultants (SWCA). 2019. Riparian Bird Surveys at Conservation Areas in the Lower Colorado River Region, 2018. Submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona, under contract No. R17PC00026.

Tamarisk Coalition. 2009. Colorado River Basin Tamarisk and Russian Olive Assessment. December 2009. Grand Junction, Colorado.

Theimer, T., D. Peterson, A. Pellegrini, M.A. McLeod, and T. Koronkiewicz. 2011. Real and Artificial Nest Predation and Parental Nest Attendance Along the Lower Colorado River and Southern Nevada. U.S. Department of the Interior, Bureau of Reclamation, Boulder City, Nevada.

Theimer, T.C., A.D. Smith, S.M. Mahoney, and K.E. Ironside. 2016. Available data support protection of the southwestern willow flycatcher under the Endangered Species Act. The Condor 118(2):289–299.

Theimer, T.C., M.K. Sogge, S.N. Cardinal, S.L. Durst, and E.H. Paxton. 2018a. Extreme drought alters frequency and reproductive success of floaters in willow flycatchers. The Auk 135:647–656.

Theimer, T.C., M.K. Sogge, and E.H. Paxton. 2018b. Patch age since disturbance drives patch dynamics for flycatchers breeding in both reservoir and riverine habitat. Ecosphere 9(9):e02425. https://doi.org/10.1002/ecs2.2425

Thompson, III, F.R. 2007. Factors affecting nest predation on forest songbirds in North America. Ibis 149(Suppl.2):98–109.

Uhey, D.A., A.K. Rowe, and D. Kendall. 2020. Tamarisk alters arthropod composition, but has little negative effect on richness and abundance in southwestern Colorado. Southwestern Entomologist 45(3):585–600.

U.S. Fish and Wildlife Service (USFWS). 2002. Southwestern Willow Flycatcher Recovery Plan, Albuquerque, New Mexico. U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

_____. 2013. Designation of Critical Habitat for Southwestern Willow Flycatcher; Final Rule. Federal Register 78(2):344–534.

_____. 2014. Southwestern Willow Flycatcher *(Empidonax traillii extimus)* 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Arizona Ecological Services, Phoenix, Arizona.

_____. 2017. Endangered and Threatened Wildlife and Plants; 12-Month Findings on Petitions To List a Species and Remove a Species From the Federal Lists of Endangered and Threatened Wildlife and Plants. Federal Register 82(249):61725–61727.

U.S. Geological Survey (USGS). 2000. Monitoring the water quality of the nation's large rivers: Colorado River NASQAN program. U.S. Department of the Interior. https://pubs.usgs.gov/fs/fs-014-00/pdf/fs-014-00.pdf

Unitt, P. 1987. *Empidonax traillii extimus*: an endangered subspecies. Western Birds 18(3):137–162.

USFWS (see U.S. Fish and Wildlife Service).

USGS (see U.S. Geological Survey).

University of California, Agriculture and Natural Resources. 2019. Invasive shot hole borers: Distribution of ISHB/FD and KSHB/FC in California. https://ucanr.edu/sites/pshb/Map/

Uyehara, J.C., M.J. Whitfield, and L. Goldwasser. 2000. The ecology of Brown-headed cowbirds and their effects on southwestern willow flycatchers. Pages 95–106 *in* D.M. Finch and S.H. Stoleson (editors). Status, Ecology, and Conservation of the Southwestern Willow Flycatcher. General Technical Report, RMRS-GTR-60. U.S. Forest Service, Rocky Mountain Research Station, Ogden, Utah.

van Riper, III, C., K.L. Paxton, C. O'Brien, P.B. Shafroth, and L.J McGrath. 2008. Rethinking avian response to Tamarix on the lower Colorado River: a threshold hypothesis. Restoration Ecology 16(1):155–167.

van Riper, III, C., S.L. Puckett, and A.J. Darrah. 2018. Influences of the invasive tamarisk leaf beetle (*Diorhabda carinulata*) on avian diets along the Dolores River in Southwestern Colorado USA. Biological Invasions 20(11):3145–3159. https://doi.org/10.1007/s10530-018-1764-6

Vega Rivera, J.H., W.J. McShea, J.H. Rappole, and S.J. Hackett. 2003. Comparison of breeding and postbreeding movements and habitat requirements for the scarlet tanager (*Piranga olivacea*) in Virginia. The Auk 120:632–644.

Ward, M.P. and S. Schlossberg. 2004. Conspecific attraction and the conservation of territorial songbirds. Conservation Biology 18:519–525.

Ware, H.E., C.J.W. McClure, J.D. Carlisle, and J.R. Barber. 2015. A phantom road experiment reveals traffic noise is an invisible source of habitat degradation. Proceedings of the National Academy of Sciences 112:12105–12109.

Webb, A.D., D.A. Falk, and D.M. Finch. 2019. Fire Ecology and Management in Lowland Riparian Ecosystems of the Southwestern United States and Northern Mexico. General Technical Report RMRS-GTR-401. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado. 132 p.

Whitfield, M.J. and M.K. Sogge. 1999. Range-wide impact of brown-headed cowbird parasitism on the southwestern willow flycatcher (*Empidonax trailii extimus*). Studies in Avian Biology 18:182–190.

Wiens, J.A., N.C. Stenseth, B. Van Horne, and R.A. Ims. 1993. Ecological mechanisms and landscape ecology. Oikos:369–380.

Wiesenborn, W.D. and S.L. Heydon. 2007. Diets of breeding southwestern willow flycatchers in different habitats. The Wilson Journal of Ornithology 119:547–557.

Woodward, H.D. and S.H. Stoleson. 2002. Brown-headed cowbird attacks on southwestern willow flycatcher nestlings. The Southwestern Naturalist 47(4):626–628.

Zink, R.M. 2015. Genetics, morphology, and ecological niche modeling do not support the subspecies status of the endangered southwestern willow flycatcher (*Empidonax traillii extimus*). The Condor 117(1):76–86.

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ATTACHMENT 1

Southwestern Willow Flycatcher (*Empidonax traillii extimus)* (SWFL) Habitat Data

Table 1-1.—Southwestern willow flycatcher (*Empidonax traillii extimus)* (SWFL) habitat data
(Note: This is an update of Table 2.1 found in Attachment 2 of the original SWFL conceptual ecological model document.

Habitat element	Range	Location	Citation
Anthropogenic disturbance	No quantifiable values found in the literature		
Brood/litter size	No quantifiable values found in the literature		
Canopy closure	94%	Lower Colorado River (LCR)	McLeod and Pellegrini 2013
	92.30%	LCR	McLeod et al. 2007
	88.00%	Gila and Lower San Pedro Rivers, Arizona	Paradzick 2005
	95.10%	Roosevelt Lake, Arizona	Ellis et al. 2008
	91.5%, 92.4%, 93.8%	Virgin River, Utah	Dobbs et al. 2012
	93%	Kern River, California	Whitfield and Enos 1996 *in* Craig and Williams 1998
	89–97% coyote willows (*Salix exigua*) or Goodding's willows (*Salix gooddingii*)–recommended	LCR	McLeod and Pellegrini 2013
	88.6%, 92.4%	Ash Valley, Pahranagat Valley Wildlife Management Areas, Nevada	Klinger and Furtek 2008
Conspecific attraction	No quantifiable values found in the literature		

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Habitat element	Range	Location	Citation
Distance to occupied patch	Habitats within 30–40 kilometers (km) have higher connectivity and colonization probability	Roosevelt Lake and San Pedro/ Gila confluence, Arizona	Paxton et al. 2007; U.S/ Fish and Wildlife Service (USFWS) 2014
	Up to 75 km	LCR	McLeod and Pellegrini 2013
	30.0 km mean between-season movement (three breeding adult birds)	LCR (2014–15)	McLeod and Pellegrini 2017b
	13.9 km mean between season movement (eight juvenile birds to different study area)	LCR (2013–15)	McLeod and Pellegrini 2017b
	1.2 km mean between-season movement (nine juvenile birds to same study area)	LCR (2013–15)	McLeod and Pellegrini 2017b
	28.15 km mean between-season movement (eight juvenile birds to different study area)	LCR (2013–15)	McLeod and Pellegrini 2017b
	31.7 km within-season movement (one breeding adult bird)	LCR (2015)	McLeod and Pellegrini 2017b
	30.6 km mean (29.5, 31.7 km) within-season movements (two breeding adult birds)	LCR (2014)	McLeod and Pellegrini 2015
	32.9 km mean (range = 11.2–131.7 km) within-season movements (23 breeding adult birds)	LCR (2003–12)	McLeod and Pellegrini 2013
	20.5 km mean between-season movement for juveniles; range = 0.03–444 km	Roosevelt Lake and San Pedro/ Gila confluence, Arizona	Paxton et al. 2007
	9.5 km mean between-season movement for breeding adults; range = 0.1–214 km	Roosevelt Lake and San Pedro/ Gila confluence, Arizona	Paxton et al. 2007
	0.3 km mean within patch, within-season movements (37 of 130 breeding adult birds)	Roosevelt Lake and San Pedro/ Gila confluence, Arizona	Paxton et al. 2007
	8.8 km mean between patch, within-season movements (91 of 130 breeding adult birds)	Roosevelt Lake and San Pedro/ Gila confluence, Arizona	Paxton et al. 2007
	84.7 km mean between drainage, within-season movements (2 of 130 breeding adult birds)	Roosevelt Lake and San Pedro/ Gila confluence, Arizona	Paxton et al. 2007
	Mean female within-season movement (12.0 km) greater than male within-season movement (5.5 km)	Roosevelt Lake and San Pedro/ Gila confluence, Arizona	Paxton et al. 2007

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Habitat element	Range	Location	Citation
Diversity of vegetation	No quantifiable values found in the literature		
Food availability	No quantifiable values found in the literature		
Genetic diversity	No quantifiable values found in the literature		
Humidity	2,019 Pascals mean diurnal vapor pressure; 1,866.6 Pascals mean nocturnal vapor pressure	LCR	McLeod and Pellegrini 2013
Infectious agents	No quantifiable values found in the literature		
Intermediate structure	Dense, no number provided	LCR	Sogge et al. 2010
	3.64 shrub stems/square meter – Dense vegetation in mid-canopy between 3–6 meters (m) in height	Middle Rio Grande, New Mexico	Moore 2007
	502.1 shrub stems/5-m plot, < 8-centimeter (cm) diameter at breast height	Virgin River, Utah	Dobbs et al. 2012
	Territory density at maximum 3–4 years post-colonization; lower before and after	Roosevelt Lake, Arizona	Theimer et al. 2018
Linear width of patch	≥ 10 m	LCR	Sogge et al. 2010; Sogge and Marshall 2000
	Nests > 100 m from edge 50% less likely to be parasitized	LCR, Virgin River, Arizona and Nevada	Stumpf et al. 2012
	Nests > 200 m from edge 75% less likely to be parasitized	LCR, Virgin River, Arizona and Nevada	Stumpf et al. 2012
	Odds of parasitism 1% less for every 1 m away from edge	LCR, Virgin River, Arizona and Nevada	Stumpf et al. 2012

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(Note: This is an update of Table 2.1 found in Attachment 2 of the original SWFL conceptual ecological model document.

Habitat element	Range	Location	Citation
Local hydrology	Within 10 m at beginning of season for > 50% sites; most average distances ≤ 20 m	LCR	McLeod and Pellegrini 2013
	Mean distance to surface water 21.6 m 80% < 50 m from surface water 85% < 100 m from surface water	Elephant Butte Reservoir Delta, New Mexico	Moore 2007
	93% nests within 100 m of water; 87% sites within 50 m of surface water	Elephant Butte Reservoir, New Mexico	Moore and Ahlers 2006
	Most sites < 1 m from water (farthest 198 m but in old river channel)	LCR	Paradzick 2005
	3.3 m	Virgin River, Utah	Dobbs et al. 2012
	Mean monthly stream flow > 300 cubic feet. Higher and more consistent annual streamflow and previous year's flow between April – June is linked to a greater number of SWFL territories.	Gila River, Arizona	Graber et al. 2012
	57% ≤ 5 m of wet soil; 64% ≤ 35 of m wet soil	LCR (2014)	McLeod and Pellegrini 2015
	42% ≤ 5 m standing water or saturated soil; 52% ≤ 30 of m water	LCR (2015)	McLeod and Pellegrini 2017b
	51% of nests ≤ 5 m from moist soils or standing water; 57% ≤ 30 m of water	LCR (2016)	McLeod and Pellegrini 2017a
	83% of nests ≤ 5 m from moist soils; 90% ≤ 30 m	LCR (2017)	McLeod et al. 2018
	79% of nests < 50 m from surface water; 91% < 100 m	Middle Rio Grande	Moore and Ahlers 2018
	Significantly higher productivity (2.60 young fledged/nest) < 50 m from surface water	Middle Rio Grande	Moore and Ahlers 2018
	92% of nests ≤ 50 m from water	Arizona	Paradzick and Woodward 2003
	SWFL nested close to water's edge, moving territories accordingly in response to water levels fluctuating year to year. 2004: 187.6 ± 4.9 m (pre-inundation) 2006: 3.5 ± 3.0 m (post-inundation)	Roosevelt Lake, Arizona	Ellis et al. 2009

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(Note: This is an update of Table 2.1 found in Attachment 2 of the original SWFL conceptual ecological model document.

Habitat element	Range	Location	Citation
Matrix community	No quantifiable values found in the literature		
Nest predators & cowbird density	No quantifiable values found in the literature		
Parental care	No quantifiable values found in the literature		
Patch size	0.1–70 hectares (ha)	Rio Grande; Upper Gila River, New Mexico	USFWS 2002, p. 17
	4,000 square meters–1.72 ha	LCR	Sedgewick 2020
	0.8 ha–several hundred ha	LCR	Sogge et al. 2010
	0.6 ha	Grand Canyon	Sogge et al. 1997
	100 ha	Lake Mead	McKernan 1997
	2.0–25.5 ha	Virgin River, Utah	Dobbs et al. 2012
	1.1 ha per flycatcher territory	Range-wide	USFWS 2014
Predators	No quantifiable values found in the literature		
Previous year's use	Survival probability 0.73 for successful breeders, 0.59 for unsuccessful breeders	Roosevelt Lake, San Pedro/Gila confluence, Arizona	Paxton et al. 2007
	Same patch return rate 67% for successful breeders, 35% for unsuccessful breeders	Roosevelt Lake, San Pedro/Gila confluence, Arizona	Theimer et al. 2018
	High adult between-year site fidelity	LCR (2014)	McLeod and Pellegrini 2017b
	21.3% juvenile next-year return rate to same study area	LCR (2014–15)	McLeod and Pellegrini 2017b
	Juvenile return rates: 92.7% (114/123) to different patch, same drainage; 5.7% (7/123) to different patch, different drainage; 1.6% (2/123) to same patch, same drainage	Roosevelt Lake, San Pedro/Gila confluence, Arizona	Paxton et al. 2007
	Adult return rates: 65.3% (465/712) to different patch, same drainage; 18.3% (130/712) to same patch, same drainage; 2.4% (17/712) to different patch, different drainage	Roosevelt Lake, San Pedro/Gila confluence, Arizona	Paxton et al. 2007
Soil salinity	No quantifiable values found in the literature		
Temperature	40.4 degrees Celsius mean maximum; 20.9 degrees Celsius mean minimum	LCR	McLeod and Pellegrini 2013

Table 1-1.—Southwestern willow flycatcher (*Empidonax traillii extimus)* (SWFL) habitat data
(Note: This is an update of Table 2.1 found in Attachment 2 of the original SWFL conceptual ecological model document.

Habitat element	Range	Location	Citation
Tree density	High densities of small/medium stems	LCR	McLeod and Pellegrini 2013
	500–1,300 stems/ha young trees	LCR	Paradzick 2005
	8,349.1 ± 246 2.5–8 cm diameter at breast height stems/ha	LCR	McLeod et al. 2007
	2,829 stems/ha–tree stem density greater in nest plots than random plots	Middle Rio Grande, New Mexico	Moore 2007
Vegetation community type	Mostly willow (*Salix* spp) species, some tamarisk (*Tamarix* spp) (shrubs and trees)	Middle Rio Grande, New Mexico	Moore 2007
	58% nests in willow-dominated territories; 28% mixed; 14% tamarisk-dominated	Middle Rio Grande, New Mexico	Moore and Ahlers 2018
	51% of nests in tamarisk; 48% in willow; 1% Russian olive (*Elaeagnus angustifolia*)	Middle Rio Grande, New Mexico	Moore and Ahlers 2018
	Nest success 46% in willow-dominated territories; 43% tamarisk-dominated; 38% mixed dominance	Middle Rio Grande, New Mexico	Moore and Ahlers 2018
	71% nests in box elder (*Acer negundo*)	Gila River, Arizona	Skaggs 1996 *in* Sogge 2000
	Goodding's willow and tamarisk	LCR	Paradzick 2005
	Mix of native and exotic vegetation	Virgin River, Utah	Dobbs et al. 2012
	Most nests in tamarisk. Goodding's willow and Fremont cottonwood (*Populus fremontii*) present	Gila River, Coolidge Dam–South Butte, Arizona	Graber et al. 2012
	57% of nests ≤ 5 m from tamarisk; 29% of nests in tamarisk	LCR (2014)	McLeod and Pellegrini 2015
	54% of nests ≤ 5 m from tamarisk; 28% of nests in tamarisk	LCR (2015)	McLeod and Pellegrini 2017b
	50% of nests ≤ 5 m from tamarisk; 33% of nests in tamarisk	LCR (2016)	McLeod and Pellegrini 2017a
	51% of nests ≤ 5 m from tamarisk; 25% of nests in tamarisk	LCR (2017)	McLeod et al. 2018
	Fremont cottonwood, Goodding's willow, and dense coyote willow understory–planted	Rockhouse, Salt River, Arizona	Salt River Project 2014

Note: The data presented in this table reflect those available in the literature at the time this model was updated. These data have not been validated.

LITERATURE CITED IN ATTACHMENT 1

Craig, D. and P.L. Williams. 1998. Willow Flycatcher (*Empidonax traillii*) in The Riparian Bird Conservation Plan: A Strategy for Reversing the Decline of Riparian-Associated Birds in California. California Partners in Flight.

Dobbs, R.C., M. Huizinga, C.N. Edwards, and R.A. Fridell. 2012. Status, Reproductive Success, and Habitat Use of Southwestern Willow Flycatchers on the Virgin River, Utah, 2008–2011. Publication Number 12–36. Utah Division of Wildlife Resources, Salt Lake City, Utah.

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 2008, Research Technical Guidance Bulletin. Arizona Game and Fish Department, Phoenix, Arizona.

Ellis, L.A., S.D. Stump, and D.M. Weddle. 2009. Southwestern willow flycatcher population and habitat response to reservoir inundation. Journal of Wildlife Management 73(6):946–954.

Graber, A.E., T.J. Koronkiewicz, and J.L. Granger. 2012. Southwestern Willow Flycatcher Surveys and Nest Monitoring Along the Gila River Between Coolidge Dam and South Butte, 2011. Annual summary report submitted to the Bureau of Reclamation, Glendale, Arizona, by SWCA Environmental Consultants, Flagstaff, Arizona.

Klinger, C. and B. Furtek. 2008. Southwestern Willow Flycatcher and Yellow-billed Cuckoo Survey and Monitoring at Select Sites in Southern Nevada, 2007 Annual Report. Nevada Department of Wildlife, Wildlife Diversity Program, Job Progress Report.

McKernan, R.L. 1997. Status, Distribution, and Habitat Affinities of the Southwestern Willow Flycatcher Along the Lower Colorado River: Year 1 – 1996. Report prepared for the Bureau of Reclamation, Boulder City, Nevada.

McLeod, M.A. and A.R. Pellegrini. 2013. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2008–2012. Submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada.

_____. 2015. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2014. Submitted to the Bureau of Reclamation, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona. 147 p.

_____. 2017a. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2016 Annual Report. Submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona, under contract No. R13PD30017.

_____. 2017b. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2015 Annual Report. Submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona, under contract No. R13PD30017.

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. Submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada.

McLeod, M.A., S. Nichols, and A. Pellegrini. 2018. Southwestern Willow Flycatcher Surveys, Demography, and Ecology Along the Lower Colorado River and Tributaries, 2017. Annual report submitted to the Lower Colorado River Multi-Species Conservation Program, Boulder City, Nevada, by SWCA Environmental Consultants, Flagstaff, Arizona, under contract No. R13PD30017.

Moore, D. 2007. Vegetation Quantification of Southwestern Willow Flycatcher Nest Sites, Rio Grande from La Joya to Elephant Butte Reservoir Delta, New Mexico – 2004–2006. Bureau of Reclamation, Albuquerque, New Mexico.

Moore, D. and D. Ahlers. 2006. 2006 Southwestern Willow Flycatcher Study Results: Selected Sites Along the Rio Grande from Velarde to Elephant Butte Reservoir, New Mexico. Bureau of Reclamation, Technical Service Center, Fisheries and Wildlife Resources, Denver, Colorado.

_____. 2018. 2017 Middle Rio Grande Southwestern Willow Flycatcher Study Results: Selected Sites Along the Rio Grande from Bandelier National Monument to Elephant Butte Reservoir, New Mexico. Bureau of Reclamation, Technical Service Center, Fisheries and Wildlife Resources, Denver, Colorado.

Paradzick, C.E. 2005. Southwestern Willow Flycatcher Habitat Selection Along the Gila and Lower San Pedro Rivers, Arizona: Vegetation and Hydrogeomorphic Considerations. Arizona State University, Tempe, Arizona.

Paradzick, C.E. and A.A. Woodward. 2003. Distribution, abundance, and habitat characteristics of southwestern willow flycatchers in Arizona, 1993–2000. Studies in Avian Biology 26:22–29.

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. U.S. Geological Survey, Reston, Virginia.

Salt River Project. 2014. Southwestern Willow Flycatcher and Yellow-Billed Cuckoo Surveys at the Rockhouse Demonstration Site, River, Gila County, Arizona. 2014 Summary Report. Environmental Services Department, Siting and Studies, Phoenix, Arizona.

Sedgwick, J.A. 2020. Willow Flycatcher (*Empidonax traillii*), version 1.0 *in* A.F. Poole and F.B. Gill (editors). Birds of the World. Cornell Lab of Ornithology, Ithaca, New York. https://doi.org/10.2173/bow.wilfly.01

Sogge, M.K. 2000. Breeding season ecology. Pages 57–70 *in* D.M. Finch and S.H. Stoleson (editors). Status, Ecology, and Conservation of the Southwestern Willow Flycatcher. General Technical Report RMRS-GTR-60. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah.

Sogge, M.K. and R.M. Marshall. 2000. A survey of current breeding habitats. Pages 43–56 *in* D.M. Finch and S.H. Stoleson (editors). Status, Ecology, and Conservation of the Southwestern Willow Flycatcher. General Technical Report RMRS-GTR-60. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah.

Sogge, M.K., R.M. Marshall, S.J. Sferra, and T.J. Tibbitts. 1997. A Southwestern Willow Flycatcher Natural History Summary and Survey Protocol. Technical Report NPS/NAUCPRS/NRTR-97/12. U.S. Department of the Interior, National Park Service, Colorado Plateau Research Station at Northern Arizona University, Flagstaff, Arizona.

Sogge, M.K., D. Ahlers, and S.J. Sferra. 2010. A Natural History Summary and Survey Protocol for the Southwestern Willow Flycatcher. U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia.

Stumpf, K.J., T.C. Theimer, M.A. McLeod, and T.J. Koronkiewicz. 2012. Distance from riparian edge reduces brood parasitism of southwestern willow flycatchers, whereas parasitism increases nest predation risk. Journal of Wildlife Management 76(2):269–277.

Theimer, T.C., M.K. Sogge, and E.H. Paxton. 2018. Patch age since disturbance drives patch dynamics for flycatchers breeding in both reservoir and riverine habitat. Ecosphere 9(9):e02425. https://doi.org/10.1002/ecs2.2425

U.S. Fish and Wildlife Service (USFWS). 2002. Southwestern Willow Flycatcher Recovery Plan. U.S. Fish and Wildlife Service Region 2, Albuquerque, New Mexico.

_____. 2014. Southwestern Willow Flycatcher *(Empidonax traillii extimus)* 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Arizona Ecological Services, Phoenix, Arizona.