

Ecosystems Mission Area—Species Management Research Program

Prepared in cooperation with the U.S. Army Corps of Engineers, Los Angeles District

Least Bell's Vireos and Southwestern Willow Flycatchers at the San Luis Rey Flood Risk Management Project Area in San Diego County, California: Breeding Activities and Habitat Use—2021 Annual Report



Open-File Report 2022–1012

Cover: Photograph showing Least Bell's Vireo (*Vireo bellii pusillus*) nest hatching at the lower San Luis Rey River. Photograph by Ryan Pottinger, U.S. Geological Survey, 2021.

Least Bell's Vireos and Southwestern Willow Flycatchers at the San Luis Rey Flood Risk Management Project Area in San Diego County, California: Breeding Activities and Habitat Use—2021 Annual Report

By Alexandra Houston, Lisa D. Allen, Ryan E. Pottinger, and Barbara E. Kus

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
Length		
centimeter (cm)	0.394	inch (in)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
Area		
hectare (ha)	2.471	acre (ac)
Flow		
cubic meter per second (m ³ /s)	35.315	cubic foot per second (ft ³ /s)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8.$$

Datum

Horizontal coordinate information is referenced to the World Geographic System of 1984 (WGS 84).

Abbreviations

AIC	Akaike's Information Criterion
DSR	daily survival rate
GLM	generalized linear model
GPS	Global Positioning System
MCBCP	Marine Corps Base Camp Pendleton
USFWS	U.S. Fish and Wildlife Service

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Executive Summary

Surveys and monitoring for the endangered Least Bell's Vireo (*Vireo bellii pusillus*; vireo) were done at the San Luis Rey Flood Risk Management Project Area (Project Area) in the city of Oceanside, San Diego County, California, between April 4 and August 4, 2021. We completed four protocol surveys during the breeding season, supplemented by weekly territory monitoring visits. We identified a total of 122 territorial male vireos; 111 were confirmed as paired and 8 were confirmed as single males. For the remaining three territories, we were unable to confirm pair status. Five transient vireos were detected in 2021. The vireo population in the Project Area decreased by 24 percent from 2020 to 2021. Vireo populations decreased across San Diego County, with a 14-percent decrease documented at Marine Corps Base Camp Pendleton (MCBCP); a 5-percent decrease on the Otay River; a 6-percent decrease on the middle San Luis Rey River; and a 44-percent decrease at Marine Corps Air Station (although this decrease was likely exaggerated by large-scale vegetation clearing that occurred prior to the 2021 breeding season).

We used an index of treatment (Treatment Index) to evaluate the impact of on-going vegetation clearing on the Project Area vireo population. The Treatment Index measures the cumulative effect of vegetation treatment within a territory (since 2005) by using the percent area treated weighted by the number of years since treatment. We found that the Treatment Index for unoccupied habitat was more than two times that of occupied habitat, indicating that vireos selected less treated habitat in which to settle.

We monitored vireo nests at three general site types: (1) within the flood channel where exotic and native vegetation removal has occurred regularly (Channel), (2) three sites next to the flood channel where limited exotic and native vegetation removal has occurred (Off-channel), and (3) three

sites that have been actively restored by planting native vegetation (Restoration). Nesting activity was monitored in 85 territories, 8 of which were occupied by single males. Of the completed nests, 39 percent were successful, and nest success did not differ among the three sites. Clutch size was greater in the Channel than the Off-channel sites, and the proportion of hatchlings that fledged was greater in Off-channel sites than Channel and Restoration sites. There were no other nest-level differences detected among site types, nor were there any differences in territory-level measures of productivity (young fledged per pair, double-brooding) among the sites. Overall, breeding success and productivity were slightly lower in 2021 than in 2020, with 66 percent of pairs fledgling at least one young and pairs fledging an average of 1.9 ± 1.7 young.

To investigate if the cumulative years of treatment had an impact on vireo reproductive effort, we looked at the effects of the Treatment Index on reproductive parameters. Results from generalized linear models indicated that treatment did not have an effect on vireo nesting effort or the number of vireo fledglings per pair produced in 2021. Similarly, our analysis of nest survival for 2021 revealed no effect of Treatment Index on daily survival rate.

Analysis of vegetation data collected at vireo nests from 2006 to 2021 did not indicate an effect of vegetation at the nest on daily survival rate. We also found no differences in nest-placement characteristics among site types or successful/unsuccessful nests.

Red/arroyo willow (*Salix laevigata* or *Salix lasiolepis*) was the species most commonly selected for nesting by vireos in all three site types. Black willow (*Salix gooddingii*) and mule fat (*Baccharis salicifolia*) also were commonly used. Vireos used a wider variety of species for nesting in Channel and Off-channel sites (seven and eight species, respectively) compared with Restoration sites (three species).

Sixty-six vireos banded prior to the 2021 breeding season were resighted and identified at the Project Area in 2021. One of these vireos was originally banded outside of the Project Area, at the Santa Margarita River on MCBCP. Adult birds of known age ranged from 1 to 6 years old. A total of 133 vireos were newly banded in 2021. Three adult vireos were banded with a unique color combination, and 130 nestlings were banded with a single dark blue numbered federal band on the right leg. Between 2006 and 2021, survivorship of males (65 ± 12 percent) was consistently higher than females (51 ± 12 percent). First-year birds from 2006 to 2021 had an average annual survivorship of 18 ± 6 percent.

First-year dispersal in 2021 averaged 2.8 ± 2.9 kilometers (km), with the longest dispersal (11.2 km) by a male that was recaptured at the middle San Luis Rey River, upstream from the Project Area. From 2007 to 2011, most returning first-year vireos returned to the Project Area, whereas from 2014 to 2016, the majority of returning birds dispersed to areas outside of the Project Area. In 2018, the trend shifted, and more first-year vireos returned to the Project area. This trend continued in 2021; 63 percent of all re-encountered first-year birds returned to the Project Area and 37 percent dispersed to areas outside of the Project Area (upstream to the middle San Luis Rey River and to drainages on MCBCP).

Most of the returning adult male vireos showed strong between-year site fidelity to their previous territories. Seventy percent of males (32/46) occupied a territory in 2021 that they had defended in 2020 (within 100 meters [m]). Twenty-five percent of females (1/4) detected in 2021 returned to a territory that they occupied in 2020. The average between-year movement for returning adult vireos was 0.2 ± 0.3 km. The amount of treatment at adults' 2020 territories did not affect the distance adults moved to their 2021 territories.

We completed four protocol surveys for the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*; flycatcher) at the Project Area between May 17 and July 22, 2021. There were 12 transient Willow Flycatchers detected in the Project Area in 2021. Four transients were detected in Reach 1, two in Reach 2, one in Tuley Canyon, two in Whelan Mitigation, two in Reach 3a, and one in Upper Pond. No resident flycatchers were documented in the Project Area in 2021.

A total of 46 vegetation transects (516 points) were sampled at the San Luis Rey Flood Risk Management Project Area in 2021. Seventy-one percent (366/516) of points were in the Channel and 22 percent (115/516) were at Upper Pond. The remaining 7 percent (35/516) were at the Whelan Restoration site. Foliage cover below 1 m was higher at the Channel points compared to Upper Pond and Whelan Restoration. Higher foliage cover in the Channel was attributed to the greater herbaceous component associated with mowing. Above 1 m, foliage cover was similar at the Channel and Whelan Restoration sites and was higher than

at Upper Pond. Average canopy height was higher in the Channel (5.1 ± 2.9 m) compared to Upper Pond (4.2 ± 2.4 m) and Whelan Restoration (4.2 ± 1.7 m). From 2006 to 2021, total foliage cover above 2 m declined in the Channel, in contrast to Upper Pond and Whelan Restoration, where little directional change in vegetation cover has occurred. Within the Channel, the steepest declines occurred between 2009 and 2013 and between 2014 and 2016. Since 2016, we observed an increase in foliage cover, largely herbaceous, between 0 and 2 m within the Channel, but for other height classes, percent cover remained below levels detected prior to 2009.

Following the 2021 breeding season, we sampled vegetation at 45 vireo nests and 45 random plots ("territory" plots) within territories in the Channel and Upper Pond. Vireos in the Channel selected territories with significantly more cover above 8 m but less cover below 2 m relative to the available habitat. In addition, Channel vireos selected nest sites within their territories with significantly less foliage below 1 m. Vireos at Upper Pond selected territories with significantly more foliage cover from 2 to 5 m and above 8 m relative to available habitat. Vireos were generally less selective regarding nest sites but selected nest sites within their territories with less foliage cover from 2 to 3 m.

Introduction

Bird surveys, nest monitoring, and vegetation sampling were done in collaboration with the U.S. Army Corps of Engineers, Los Angeles District.

Least Bell's Vireo

The Least Bell's Vireo (*Vireo bellii pusillus*; vireo) is a small, migratory, songbird that breeds in southern California and northwestern Baja California, Mexico, from April through July. Historically abundant within lowland riparian ecosystems, vireo populations began declining in the late 1900s as a result of habitat loss and alteration associated with urbanization and conversion of land adjacent to rivers to agriculture (Franzreb, 1989; U.S. Fish and Wildlife Service, 1998; Riparian Habitat Joint Venture, 2004). Additional factors contributing to the vireo's decline have been the expansion in range of the brood-parasitic Brown-headed Cowbird (*Molothrus ater*; cowbird), to include the Pacific Coast (U.S. Fish and Wildlife Service, 1986; Franzreb, 1989; Kus, 1998, 1999; Kus and others, 2020), and the introduction of invasive exotic plant species such as giant reed (*Arundo donax*) into riparian systems. By 1986, the vireo population in California numbered just 300 territorial males (U.S. Fish and Wildlife Service, 1986).

In response to the dramatic reduction in numbers of vireos in California, the California Fish and Game Commission listed the species as endangered in 1980, with the U.S. Fish and Wildlife Service (USFWS) following suit in 1986. Since listing, the vireo population in southern California has rebounded, largely in response to cowbird control and habitat restoration and preservation (Kus, 1999; Kus and Whitfield, 2005). As of 2006, the statewide vireo population was estimated to be approximately 2,500 to 3,000 territories (U.S. Fish and Wildlife Service, 2006a), of which approximately 10 percent occurred along the San Luis Rey River between Interstate 15 and Interstate 5.

Male vireos arrive on breeding grounds in southern California in mid-March. Male vireos are vocally conspicuous and frequently sing their diagnostic primary song from exposed perches throughout the breeding season. Females arrive approximately 1–2 weeks after males and are more secretive. They often are seen early in the season traveling through habitat with the male. The female, with the male's help, builds an open cup nest in dense vegetation approximately 1 meter (m) above the ground. Clutch size for vireos averages three to four eggs. Typically, the female and male incubate the eggs for 14 days and young fledge from the nest at 11–12 days of age. It is not unusual for vireos to re-nest after a failed attempt provided ample time remains within the breeding season. Vireos rarely fledge more than one brood in a season, although double-brooding can be more common during years when breeding conditions are favorable (early initiation, high early fledging success; Ferree and Kus, 2008b; Houston and others, 2017, 2019). Nesting lasts from early April through July, but adults and juvenile birds remain on the breeding grounds into late September through early October before migrating to their wintering grounds in southern Baja California, Mexico (Kus and others, 2020).

Southwestern Willow Flycatcher

The Southwestern Willow Flycatcher (*Empidonax traillii extimus*; flycatcher) is one of four subspecies of Willow Flycatcher in the United States, with a breeding range including southern California, Arizona, New Mexico, extreme southern portions of Nevada and Utah, and western Texas (Hubbard, 1987; Unitt, 1987). Restricted to riparian habitat for breeding, the flycatcher has declined in recent decades in response to widespread habitat loss throughout its range and, possibly, cowbird parasitism (Wheelock, 1912; Willett, 1933; Grinnell and Miller, 1944; Remsen, 1978; Garrett and Dunn, 1981; Unitt, 1984, 1987; Gaines, 1988; Schlorff, 1990; Whitfield and Sogge, 1999; Kus and Whitfield, 2005). By 1993, the species was believed to number approximately 70 pairs in California (U.S. Fish and Wildlife Service, 1993)

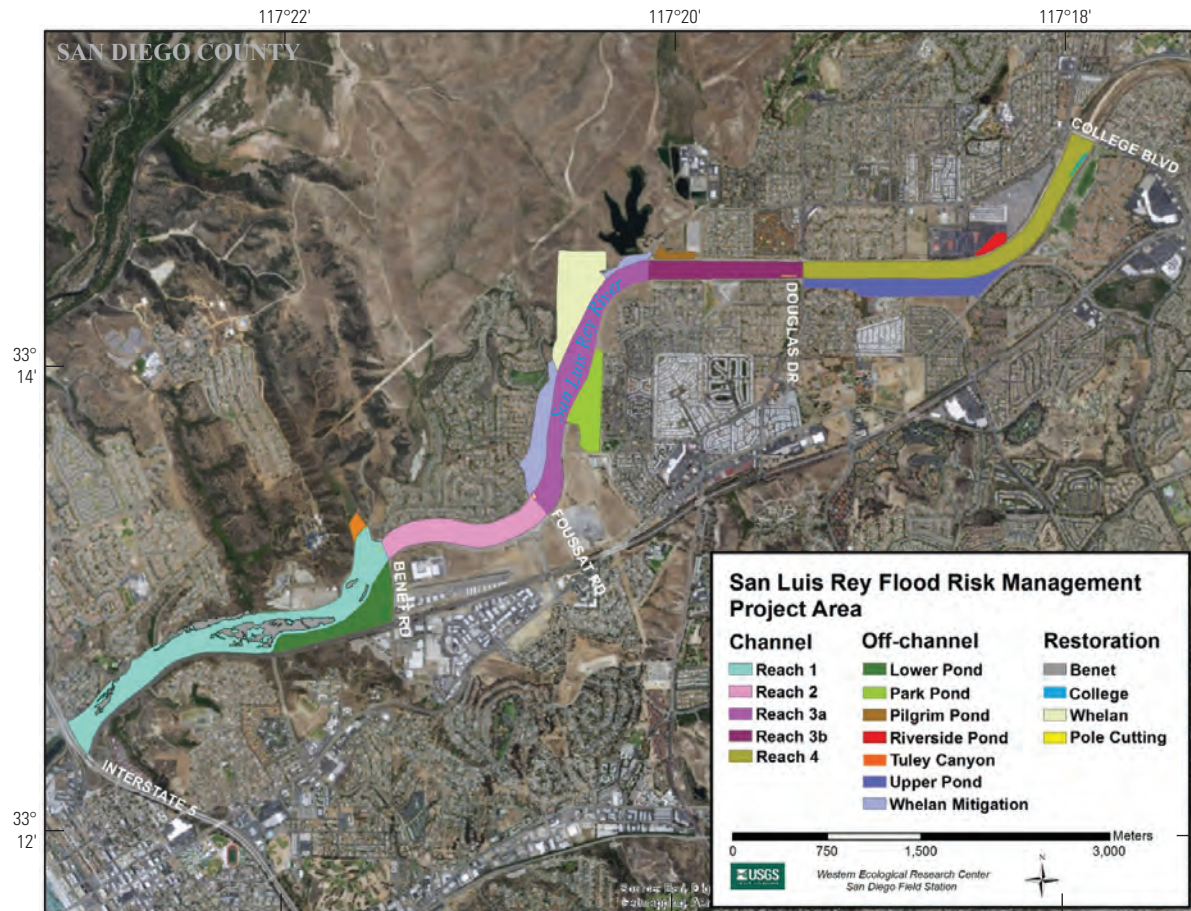
in small, disjunct populations. The flycatcher was listed as endangered by the state of California in 1992 and by the USFWS in 1995.

Willow Flycatchers in southern California co-occur with the vireo. However, unlike the vireo, which has increased tenfold since the mid-1980s in response to management efforts, Willow Flycatcher numbers have remained low. Currently, most flycatchers in California are concentrated at one site, the upper San Luis Rey River, near Lake Henshaw, in San Diego County (Howell and Kus, 2021). Outside of this site, flycatchers occur as small, isolated populations of one to six pairs. Data on the distribution and demography of the flycatcher, as well as identification of factors limiting the species, are critical information needs during the current stage of recovery planning (Kus and others, 2003; Kus and Whitfield, 2005).

Male flycatchers typically arrive in southern California at the end of April, whereas females arrive approximately 1 week later. While on the breeding grounds, males sing repeatedly from exposed perches. Once the pair bond is established, the female builds an open cup nest that usually is placed in a branch fork of a willow (*Salix* spp.) or plant with a similar branching structure approximately 1–3 m above the ground. The typical clutch of three to four eggs is laid in May–June. Females incubate for approximately 12 days and nestlings fledge within 12–15 days, in early July. Adults usually depart from their breeding territory in mid-August through early September to their wintering grounds in central Mexico and northern South America (U.S. Fish and Wildlife Service, 2002).

San Luis Rey Flood Risk Management Project Area

The San Luis Rey Flood Risk Management Project Area (Project Area) spans approximately 233 hectares (ha; 576 acres) of the lower San Luis Rey River in northwestern San Diego County, California (fig. 1; table 1). Authorized in 1970 and constructed during the late 1980s and early 1990s, the flood control Project Area includes single- and double-levee reaches and six off-channel detention ponds, five of which also serve as mitigation sites for impacts to biological resources within the channel. Operation and maintenance of the flood control project includes periodic vegetation clearing, exotic plant removal, and sediment removal to ensure that sufficient water conveyance capacity is maintained (U.S. Fish and Wildlife Service, 2006b). Management of the off-channel ponds involves adaptive habitat management such as vegetation clearing, exotic plant removal, and planting native vegetation.



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Figure 1. Least Bell's Vireo and Southwestern Willow Flycatcher survey and monitoring sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

Table 1. Least Bell's Vireo and Southwestern Willow Flycatcher survey sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

Survey site	Description
Channel sites	
Reach 1	From Interstate 5 to Benet Road.
Benet Restoration	Active restoration begun in 2012.
Reach 2	From Benet Road to Foussat Road.
Reach 3a	From Foussat Road to Whelan canal.
Reach 3b	From Whelan canal to Douglas Drive.
Reach 4	From Douglas Drive to College Boulevard.
College Restoration	Active restoration begun in 2014.
Off-channel sites	
Lower Pond	Detention pond with historic restored habitat, west of Benet Road and south of the levee.
Park Pond	Detention pond with historic restored habitat, located south of the levee, between Douglas Drive and Foussat Road. Adaptive habitat management (mowing in 2015 and planting in 2017).
Pilgrim Pond	Detention pond with historic restored habitat, north of Reach 4.
Riverside Pond	Detention pond with historic restored habitat, north of Reach 3b.
Tuley Canyon	Detention pond with historic restored habitat, west of Benet Road and north of the levee.
Upper Pond	Detention pond with historic restored habitat located south of levee between College Boulevard and Douglas Drive. Adaptive habitat management (mowing in 2015 and planting in 2017).
Whelan Mitigation	Historic restored habitat north of levee, between Whelan canal and Foussat Road.
Whelan Restoration	Active restoration begun in 2014.

Riparian vegetation communities at the Project Area include willow-dominated riparian, mixed mule fat (*Baccharis salicifolia*) and sandbar willow (*Salix exigua*) riparian scrub, freshwater marsh, and areas dominated by non-native giant reed. Dominant plants include red/arroyo willow (*Salix laevigata*/*Salix lasiolepis*; we did not distinguish between these species), black willow (*Salix gooddingii*), Fremont cottonwood (*Populus fremontii*), sandbar willow, mule fat, and giant reed. Neighboring habitat and land-use types include coastal sage scrub, non-native grassland, and urban housing and commercial developments. Human disturbances such as homeless camps, recreation, illegal dumping, introduction of invasive exotic plants and feral animals, and use by pets from neighboring houses are pervasive throughout the Project Area (table 2).

The Project Area includes a channelized 10.7-kilometer (km; 6.6-mile) section of the lower San Luis Rey River from Interstate 5 to College Boulevard and six detention ponds outside of the channel in Oceanside, California (table 1). The Project Area is divided into 12 survey sites, 5 of which are primarily within the flood control channel (hereafter “Channel”) and 7 that are outside of the channel (hereafter “Off-channel”; table 1). The seven Off-channel sites include one historic restored site north of the levee and west of Whelan Lake and six in the detention ponds. There are two large restoration sites, one in Reach 1 (Benet Restoration) and one in Whelan Mitigation (Whelan Restoration). One smaller restoration site is located in Reach 4 (College Restoration).

Before the 2006 vireo breeding season, the U.S. Army Corps of Engineers began two flood risk management activities for the San Luis Rey Flood Risk Management

Project: (1) exotic species eradication and (2) flood risk management of river channel vegetation. Exotic species eradication primarily included removal and control of giant reed, but other exotic species such as pepperweed (*Lepidium latifolium*), tamarisk (*Tamarix ramosissima*), and other non-native tree species also were targeted for removal. Exotic species were physically removed or treated with herbicide. The purpose of the flood risk management was to remove vegetation from the San Luis Rey flood control channel to provide a level of flood conveyance of 2,016 cubic meter per second (m³/s; equivalent to a 150-year flood; U.S. Fish and Wildlife Service, 2006b). In addition, a one-time mowing and mulching task was done in 2005 to reduce the risk of flooding during the 2006 rainy season. Ongoing flood risk management of river channel vegetation includes rotational and annual vegetation mowing in phases. Phase 1 includes vegetation clearing in Reaches 1–4 to achieve a minimum flow conveyance of 1,500 m³/s (equivalent to a 100-year flood). Phase 2 includes mowing associated with maintaining the Phase 1 mowing area as well as restoration or creation of habitat for vireos and flycatchers. Phase 3 includes mowing associated with maintaining the Phase 1 mowing area as well as small sections of vegetation mowing in Reach 1 and Reach 3a. Rotational mowing is done every 5 years, alternating between two 18–23-m-wide strips of vegetation (Rotations 1 and 2) such that each strip is mowed every 10 years. There was no mowing in fall of 2020. For a detailed description of the timeline and vegetation treatments and management, see appendix 1.

Table 2. Site attributes of the Channel, Off-channel and Restoration monitoring sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[Channel = Reach 1, Reach 2, Reach 3a, Reach 3b, and Reach 4 survey sites.]

Attribute	Channel	Off-channel			Restoration		
		Park Pond	Upper Pond	Whelan Mitigation	Benet Restoration	Whelan Restoration	College Restoration
Size: ha (acres)	148 (365)	11 (28)	19 (49)	22 (55)	12 (30)	10.5 (26)	0.4 (1)
Habitat type¹	Mixed willow	Riparian scrub	Riparian scrub/ mixed willow	Mixed willow/ riparian scrub	Mixed willow	Mixed willow/ riparian scrub	Mixed willow
Dominant canopy species	Red/arroyo willow, black willow	Sandbar willow, mule fat	Sandbar willow, mule fat, red/arroyo willow, black willow	Black willow, mule fat, red/arroyo willow	Red/arroyo willow, black willow	Sandbar willow, mule fat, red/arroyo willow, black willow	Black willow, mule fat, red/arroyo willow
Dominant exotic species	Exotic herbaceous cover	Exotic herbaceous cover	Exotic herbaceous cover	Exotic herbaceous cover	Exotic herbaceous cover	Exotic herbaceous cover	Exotic herbaceous cover
Disturbance	Homeless camps; moderate-heavy human use	Homeless camps, pets, recreation; heavy human use	Homeless camps, pets, recreation; heavy human use	Homeless camps; moderate-heavy human use	Exotic plant control; moderate homeless use	Exotic plant control; some homeless use	Exotic plant control; some homeless use

There were three Restoration areas within the Project Area: an exotic plant removal program in Reach 1 (Benet Restoration) that began in October 2012 and two projects that started in March 2014 (appendix 2, figs. 2.1–2.4). The largest project, focused on providing flycatcher habitat, was on the north side of the river channel in the eastern section of the Whelan Mitigation site (Whelan Restoration). A rock levee was removed and graded to below ground level, allowing flooding from the main channel to mimic more natural river flows. A second, smaller project occurred on the south side of Reach 4 near the College Boulevard bridge (College Restoration). Restoration activities included planting, bi-monthly watering, and spraying weeds with herbicide through 2015. Since 2016, there has been no watering or herbicide treatment, but we continued to classify these areas as Restoration sites and evaluate them separately. In addition to the three Restoration sites, in spring 2014, several small areas of the river were planted with pole cuttings, and in 2017, two of the Off-channel ponds were planted as a part of adaptive habitat management. These areas were considered passive restoration and were not included with our Restoration sites or included in any of our analyses of Treatment Index.

The purpose of this study was to document the status of vireos and flycatchers at the Project Area and characterize habitat structure and composition within the Project Area (fig. 1). Specifically, our goals for vireos were to (1) determine the size and composition of the vireo population; (2) characterize habitat used by vireos; (3) band vireos and resight banded vireos to estimate vireo survivorship, site fidelity, and dispersal; and (4) assess the effects of vegetation removal on vireo reproductive success and productivity by monitoring established nest monitoring plots in the Channel and Off-channel sites. Our goals for flycatchers were to (1) determine the size and composition of the Willow Flycatcher population at the Project Area, (2) document and monitor nesting activities of resident flycatchers, and (3) band and resight all flycatchers to facilitate the estimation of flycatcher survivorship and movement. The purpose of the habitat component of the study was to (1) provide post-treatment data on the habitat composition and structure of the Project Area, including areas that underwent vegetation removal in 2005, 2007–12, 2014–15, and 2017–19 and (2) characterize habitat use by vireos in response to

vegetation management at the Project Area. These data, when combined with data from other years, will inform natural resource managers about the status of these endangered species at the Project Area and guide modification of land use and management practices as appropriate to ensure the species' persistence.

Methods

Surveys

Vireo and flycatcher surveys have been done at the Project Area every year since 2006. In 2021, four protocol surveys were conducted between April 12 and July 21, 2021, and followed standard survey techniques developed and recommended by the California Least Bell's Vireo Working Group (now known as the California Riparian Birds Working Group) and USFWS Least Bell's Vireo survey guidelines (U.S. Fish and Wildlife Service, unpub. data, 2001). We supplemented these protocol surveys with weekly territory monitoring visits; therefore, most survey sites were visited more than 10 times throughout the breeding season, resulting in complete coverage of the Project Area. We used recorded callbacks, as needed, during surveys and monitoring to confirm absence of vireos in areas in which no birds were detected and to attract males to check leg bands. Vireo field work was done by Armand Amico, Aaron Gallagher, Alexandra Houston, Suellen Lynn, Shannon Mendia, Ryan Pottinger, and Devin Taylor (all under USFWS permit ESPER0004080_0), with assistance provided by Annabelle Bernabe, Jessica Medina, Rachelle McLaughlin, and Benjamin Stubbs.

We completed four protocol flycatcher surveys of the Project Area between May 17 and July 22, 2021, completing one survey during each of four survey periods (U.S. Fish and Wildlife Service, 2000; Sogge and others, 2010). Flycatcher field work was done by Armand Amico, Aaron Gallagher, Alexandra Houston, Suellen Lynn, Shannon Mendia, Ryan Pottinger, and Devin Taylor (all under USFWS permit ESPER0004080_0), with assistance provided by Annabelle Bernabe, Jessica Medina, Rachelle McLaughlin, and Benjamin Stubbs.

For both species, observers moved slowly (1–2 kilometers per hour [0.6–1.2 miles per hour]) through the riparian habitat while searching and listening for vireos or flycatchers. Observers walked along the north and south levees to survey the flood control channel. In wider stands, observers traversed the habitat to detect all birds throughout its extent. Surveys were done between dawn and early afternoon, depending on wind and weather conditions. For each bird encountered, investigators recorded age (adult or juvenile), sex, breeding status (paired, single, unknown, or transient), and if the bird was banded. Birds were considered transients if they were not detected on two or more consecutive surveys after an initial detection. Vireo locations were mapped using ArcGIS Collector and Survey 123 on Samsung Galaxy S7 and S8 and LG G5 mobile phones with Android operating systems and built in Global Positioning System (GPS) to determine geographic coordinates (World Geographic System of 1984, WGS 84). Distance to the nearest surface water was recorded for each flycatcher location. Dominant native and exotic plants were recorded within each vireo and flycatcher territory, and percent cover of native vegetation was estimated using cover categories of less than 5 percent, 5–50 percent, 51–95 percent, and greater than 95 percent. Overall habitat type was specified according to the following categories:

Mixed willow riparian: Habitat dominated by one or more willow species, including black willow, arroyo willow, and red willow, with mule fat as a frequent co-dominant.

Willow-cottonwood: Willow riparian habitat in which cottonwood is a co-dominant.

Willow-sycamore: Willow riparian habitat in which California sycamore (*Platanus racemosa*) is a co-dominant.

Sycamore-oak: Woodlands in which California sycamore and coastal live oak (*Quercus agrifolia*) occur as co-dominants.

Riparian scrub: Dry or sandy habitat dominated by sandbar willow or mule fat, with few other woody species.

Upland scrub: Coastal sage scrub next to riparian habitat.

Non-native: Areas vegetated exclusively with non-native species, such as giant reed and tamarisk.

Nest Monitoring

We monitored vireo nests to evaluate the effects of native and exotic vegetation removal on nest success and productivity. Nest monitoring was done from April 5 until the last nest fledged on August 4, 2021. We performed work at three general site types: (1) within the flood channel where exotic and native vegetation removal has occurred regularly (Channel); (2) at three sites next to the flood channel (Upper Pond, Park Pond, and Whelan Mitigation; Off-channel); and (3) at three sites that have been restored (Restoration), two of which were within the Channel (Benet Restoration in Reach 1 and College Restoration in Reach 4) and one situated Off-channel (Whelan Restoration within Whelan Mitigation).

Territory boundaries were delineated by biologists in the field by circumscribing vireos' nesting, singing, and foraging locations. In 2017, we began excluding areas in a vireo's territory that were obviously avoided (for example, the vireo used the edges of the river channel but avoided the center) by creating two unconnected polygons, as opposed to a single large one spanning the area. We classified territories quantitatively by site type in ArcGIS (version 10.5, ESRI, 2016) using territory boundaries and the boundaries of the three site types (Channel, Off-channel, and Restoration). If a territory straddled more than one site type, we assigned it to the site type that comprised more than 50 percent of the territory. There were 55 Channel vireo pairs and 4 single males, 19 Off-channel pairs and 4 single males, and 3 Restoration pairs monitored during the 2021 breeding season.

Pairs were observed for evidence of nesting, and their nests were located. We visited nests as infrequently as possible to minimize the chances of leading predators or Brown-headed Cowbirds to nests; typically, there were three to four visits per nest. The first visit was timed to determine the number of eggs laid, the next visits to determine hatching and age of young, and the last to band nestlings (see [next section](#)). We removed cowbird eggs from nests depending on when they were found. In nests with fewer than three vireo eggs, cowbird eggs were removed no sooner than the seventh day of incubation to minimize the possibility of nest abandonment in response to the removal. We removed cowbird eggs from nests containing three or more vireo eggs as they were found. Cowbird nestlings were removed immediately from nests. Fledging was determined through direct observation of fledglings in the territory or, in some rare cases, inferred from an accumulation of feather dust and fecal material in the nest, indicative of vireo fledging. We recorded characteristics of nests, including nest height, host plant species, host height, distance to edge of host plant, and distance to edge of host clump following abandonment or fledging of nests.

Banding

The primary goals of banding vireos at the San Luis Rey Flood Risk Management Project Area were (1) to assess vireo site fidelity in response to vegetation management, (2) to examine natal dispersal within and outside of the Project Area in response to vegetation management, and (3) to understand how vegetation removal and alteration affected vireo demography. We banded nestlings from monitored nests at 6–7 days of age with a single dark blue anodized numbered federal band on the right leg. We captured unbanded adult vireos in mist nets at monitoring sites, as needed, to clarify identity among neighbors and banded them with a unique combination of colored plastic and anodized metal federal bands, including an anodized dark blue band to designate the San Luis Rey River as the bird's site of origin. Adults previously banded as nestlings with a single numbered metal federal band (natal birds) were target netted to determine their identity, and their original band was supplemented with other bands to generate a unique color combination. These data will supplement banding data currently being gathered by the U.S. Geological Survey (USGS) and other investigators on nearby vireo populations on the upper San Luis Rey River and the Santa Margarita River on Marine Corps Base Camp Pendleton (MCBCP).

Survivorship Estimates

During surveys and nest monitoring activities, we attempted to resight all vireos to determine whether or not they were banded, and if so, to confirm the vireos' identity by reading the unique color band combination or by recapturing birds with single federal bands. We used resighting and recapture data to calculate annual survivorship or the fraction of all individuals present at the Project Area in 1 year that returned the following year.

Imperfect detectability of banded individuals is typical of mark-recapture studies and occurs for various reasons (for example, females are more cryptic and may be missed on surveys, birds were detected as banded but their full color combinations [and thus identities] were not obtained; birds with single federal bands were not recaptured and thus their identities were not determined). To account for individuals that were present but not detected, we used RMark (Laake, 2013), which uses Program MARK (White and Burnham, 1999) to model annual survivorship. Annual survivorship was calculated from 2006 to 2021 by creating an encounter history matrix of all individual vireos ever detected in the Project Area and whether or not they were observed in each year from 2006 to 2021. Vireos were grouped by age (originally encountered as a juvenile [usually nestling but sometimes fledglings] versus originally encountered as an adult) and sex (female versus male). Survivorship was assumed to be constant for

adults once they survived their first year. We created two sets of models. The first set included only adult captures, in which we modeled the influence of sex, year, and precipitation over the previous bio-year (July 1–June 30; National Oceanic and Atmospheric Administration [National Oceanographic and Atmospheric Administration], 2021) on vireo survivorship and the influence of sex on detection probability. The second model set included both adult and first-year vireos and modeled the influence of age, year, and precipitation on survivorship, and year on detection probability. This model set did not include sex because we were unable to determine sex of vireos banded as juveniles unless they returned and were recaptured and identified as adults. Therefore, only the juveniles that survived their first winter were retroactively classified as male or female, which would severely bias the estimate of sex-related survivorship of first-year vireos.

Models created for survivorship in RMark included only detections from sites at which survey effort has been consistent from 2006 through 2021 (for example, lower San Luis Rey River Project Area, middle San Luis Rey River, MCBCP). Incidental resights outside of these survey sites were excluded from analysis. We excluded one adult of unknown sex from our first model set analysis because we were not interested in defining characteristics of this group.

We used an information-theoretic approach (Akaike's Information Criterion for small sample sizes or AIC_c ; Burnham and Anderson, 2002) to evaluate support for the models. To evaluate the influence of sex and year on detection probability, we compared models holding survivorship constant. For the adults-only models we found that detection probability was influenced by sex, so it was included in all models of vireo survivorship. For models with adults and nestlings, we evaluated the effects of year on detection probability by comparing models with survivorship varying by age. We found that detection probability differed by year, so we included it in all of our models to evaluate survivorship. We used logistic regression with a logit link to build and rank models by AIC_c and present annual real estimates from the top model. If there was support for multiple models (change in AIC_c [ΔAIC_c] less than 2), we averaged all models using AIC_c weights to obtain annual real estimates of survivorship for adult females, adult males, all adults, and all first-year vireos. We also evaluated the effect of covariates within our top models by calculating the odds ratio for each covariate (the odds that the covariate had an effect on survivorship where "no effect" equals 1, negative effect is less than 1, and positive effect is greater than 1). We then calculated the 95-percent confidence interval of the odds ratio to determine the likelihood that the effect was significant. Where the confidence interval was greater than or less than 1, we concluded that we had 95-percent confidence that the covariate had a positive or negative effect on survivorship relative to the reference.

Site Fidelity and Movement

We determined site fidelity of adult banded vireos by measuring the distance between the center of an individual's breeding territory in 2020 and the center of the same individual's breeding territory in 2021. We considered vireos to have exhibited site fidelity if they returned to within 100 m of their 2020 territory. Site fidelity was calculated for the same categories analyzed for survivorship (see [previous section](#)), except that only individuals with known territory locations during the last year they were detected, prior to 2021, were included (for example, juvenile birds banded after fledging were excluded because their natal territories could not be confirmed in light of their capacity for substantial movement). We examined site fidelity to identify patterns indicative of relaxation of site fidelity in response to habitat alteration associated with vegetation clearing. To do this, we analyzed the distance moved by territorial males, hypothesizing that movement would be greater (site fidelity weaker) in years following vegetation treatment than in years where vegetation was undisturbed. We investigated the effect of a Treatment Index (see the [“Effects of Treatment”](#) section) on the movement of birds between 2020 and 2021. We focused on banded males because sample sizes for banded females were low, and females, in general, tend to exhibit lower site fidelity than males.

We examined first-year dispersal in 2021 and compared it to dispersal in previous years. We compared the proportion of first-year vireos that originated at the Project Area and returned to the Project Area to the proportion of first-year vireos that returned to nearby areas outside of the Project Area. Because some natal vireos were not detected or identified during their first year of dispersal, but were recaptured in subsequent years, our initial estimates were adjusted to include vireos that were not detected during their first year of dispersal. Although we were unable to determine their exact territory location during their first year, we can conclude that birds recaptured outside of the Project site were not likely present at the Project Area because of our high success in recapturing and resighting vireos within the Project Area.

Analysis of Nesting Data

We used Pearson's chi-square analysis and Fisher's exact tests to determine if there were differences in nest success, hatching rates, and fledging rates between Channel, Off-channel, and Restoration pairs. We included a “Mixed” category for instances where (1) a territory was categorized as one site type, but the vireos placed at least one nest in another site type or (2) vireos nested in two different site types within the same territory. For example, we had territories that were categorized as “Restoration” (50 percent or more of the total territory area fell within the boundaries of the restoration), but the vireos placed their nest(s) within the Channel, avoiding areas of active restoration. In total, four territories were

considered “Mixed” in 2021. For analyses involving the nest as the unit of analysis, we used the location of the nest (for example, a territory categorized as Channel could have a nest in a Restoration site). For any analyses of reproductive success or productivity that involved a measure of success per pair or territory, we analyzed Mixed territories separately. Chi-square tests were used when sample sizes were sufficient; Fisher's exact tests were used when one or more categories contained fewer than five samples. We used two-sample *t*-tests, Mann-Whitney *U*-tests (two groups), and Kruskal-Wallis tests (three or more groups) to determine if there were differences in nest site characteristics between successful and unsuccessful nests within and between the Channel, Off-channel, and Restoration sites. *T*-tests were used when distributions were normal and variances were similar; Mann-Whitney *U*-tests or Kruskal-Wallis tests were used when the data violated these assumptions. We used analysis of variance and Tukey's post-hoc pair-wise comparisons to determine if there were differences between Channel, Off-channel, and Restoration sites in average clutch size and average number of young per pair in 2021.

Effects of Treatment

We created an index of treatment (Treatment Index) to evaluate the cumulative effects of vegetation removal over time for 2020 and 2021 vireo territories. We restricted treatment type for this index to the vegetation removal that occurred from 2005, 2007–12, 2014–15 or 2017–19, in which vegetation (native or exotic) was cleared to the ground. We did not include any restoration or herbicide treatments because these treatments were distinct from vegetation removal and analysis of them was beyond the scope of this project. We limited our analysis of Treatment Index to territories located in the Channel because Off-channel adaptive habitat management activities mitigated the impact of the vegetation removal, making the Treatment Index for those territories unsuitable for our analyses. We calculated the percent of each territory area that was treated in each year (2005, 2007–12, 2014–15, and 2017–19) by overlaying the 2020 and 2021 territory boundaries with the treatment areas in ArcGIS. Territory boundaries were created to include the bird location points collected using GPS throughout the field season. Treatment boundaries were generated from the location data collected using GPS in the field by a RECON Environmental, Inc. (<https://www.recon-us.com/>) biologist who walked the entire treatment boundary during vegetation removal activities. Because treatments have been occurring since 2005, it was possible to have multiple years of treatments and overlap among treatments within a single territory. Because early successional vegetation can recover quickly following disturbance, we assumed that the influence of the vegetation removal diminished over time; therefore, when there was overlap in treated areas among years, we used the most recent treatment year to calculate the Treatment Index ([fig. 2](#)).

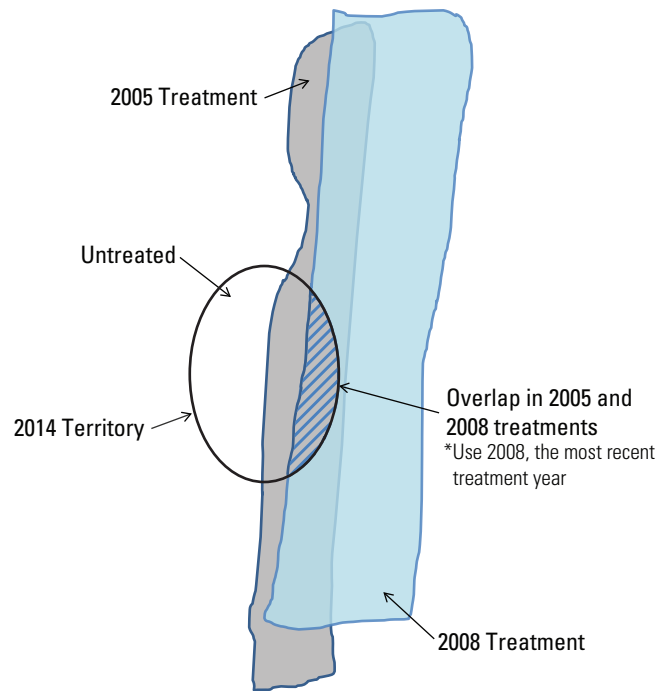


Figure 2. Least Bell's Vireo territory boundary with two treatments (2005 and 2008 vegetation removal) and a section of overlap between the two treatments.

To calculate the Treatment Index, we used the percent of the territory area treated weighted by the squared inverse of the time (t^2) since treatment summed across all treatment years. We chose t^2 , rather than t because we wanted to capture the effect of the treatment diminishing quickly over time. We used the following formula:

$$\text{Treatment Index} = \sum_{t=2005}^{2019} \text{percent Territory Area Treated}_t \times 1/n_t^2 \quad (1)$$

where

- t is the year of treatment,
- n is the years since treatment, and
- $n=1$ is the first breeding season following treatment.

Note that there was no treatment in 2006, 2013, 2016, or 2020, so values for these years =0 and drop out of the equation.

To calculate the Treatment Index, calculate the percent area that intersects with the territory for (1) 2005 Treatment and (2) overlap in 2005 and 2008 treatments.

We performed three sets of analyses using the Treatment Index. For all analyses of the Treatment Index, we excluded territories that overlapped with areas of active restoration.

1. We compared the Treatment Index between occupied (monitored and non-monitored) territories and unoccupied vireo habitat within the Channel using a two-sample t -test. To generate a Treatment Index for unoccupied habitat, we used historic territory boundaries from 2006 to 2020 as a guide and subdivided habitat that was unoccupied in 2021 into units approximating vireo territories in size. We calculated the Treatment Index for the unoccupied historical territories within the Channel that did not overlap with restoration, creating a distribution of Treatment Indices for unoccupied habitat that allowed statistical comparisons with occupied territories. Habitat never occupied by vireos (for example, marsh, open water) during this study and unoccupied patches too small (less than or equal to 0.2 ha [0.5 acres]) for a territory were excluded from analysis. We hypothesized that the Treatment Index in occupied habitat would be lower than that of the unoccupied habitat, indicating that vireos were preferentially selecting habitat that was less treated or was treated less recently.

2. We used generalized linear models (GLM) in Program R (R Core Team, 2018) to evaluate if treatment (Treatment Index) had an effect on vireo reproductive parameters for monitored territories within the Channel including the total number of (1) nests, (2) completed nests, and (3) fledglings per territory in 2021. We limited our analysis to Channel territories since 2018 because, in 2017, passive restoration including some planting, weeding and watering occurred at two of our Off-channel sites, confounding the effect of the vegetation removal. We hypothesized that there would be an inverse relationship between the reproductive parameters and the Treatment Index (for example, the number of fledglings would decrease as the Treatment Index increased) and a positive relationship between the Treatment Index and the number of nests, as we might expect to see higher levels of nest failure in the lower quality (more treated) habitat. Treatment Index was a continuous, fixed effect. We assumed a Poisson distributed response to the reproductive parameters.
3. Finally, we used a GLM to test for the effect of the expected Treatment Index for 2020 territories on the distances that banded vireos moved between 2020 and 2021. We hypothesized that birds whose previous territories were heavily treated (had high Treatment Indices) would shift their territories a greater distance than those whose territories were less affected by, or were temporally further removed from, the treatment.

Nest Survival Analysis

We used RMark to model the effects of vegetation treatment on daily survival rate (DSR) of vireo nests or the probability that a nest survived from one day to the next (Dinsmore and others, 2002). We used RMark to run program MARK to calculate DSR, which accounts for the variability in exposure days across nests found at different stages of the nesting cycle and allows for the analysis of the effects of covariates on DSR. In this study, we evaluated the effects of Treatment Index (for Channel territories only) on DSR in 2021 and if habitat structure at the nest (2006–21) was correlated with DSR by analyzing the relationship between total vegetation cover at each height category (see the “[Vegetation Study Design](#)” section) and DSR.

We calculated nest survival across a 32-day cycle (2 days nest complete and rest before the first egg is laid, 4 days egg-laying, 14 days incubation, 12 days nestling period) in which incubation begins with the penultimate egg. We calculated age of nests at the time they were discovered by forward- or backward-dating of nests in relation to known dates of nest building, laying, or hatching. We used an information-theoretic approach (Burnham and Anderson,

2002) to evaluate support for statistical models reflecting a priori hypotheses regarding the effect of treatment and habitat variables on DSR. We hypothesized that DSR would be inversely related to the Treatment Index and would increase with increasing foliage cover at nest sites, particularly understory cover within 2 m (6.6 feet) of the ground, where vireos place their nests. We used logistic regression with a logit link to build models. First, we generated a constant survival model to serve as a reference for the effect of treatment and habitat variables on DSR. We then modeled the treatment and habitat covariates individually and evaluated support for each model in relation to the constant survival model and each other.

Vegetation Study Design

We sampled vegetation along permanent linear transects within three of the vireo monitoring sites (Channel and two Off-channel sites: Upper Pond and Whelan Restoration). Sampling points consisted of 2- by 2-m quadrats at 10-m intervals along each transect; the number of points sampled varied with the length of each transect ([fig. 3](#)). Transects were originally established in 2006 by using a systematic sampling design. To capture the range of variability of riparian vegetation structure and composition, we positioned transects perpendicular to the river channel. To provide uniform coverage, we placed transects at fixed distances from each other; distances varied with the size of the site. In the Channel, transects were placed at 200- or 400-m intervals, depending on the width of the river. In Upper Pond, transects were placed every 100 m. In addition, we sampled two 350-m transects at Whelan Mitigation (Whelan Restoration) that were initially surveyed from 1991 to 1993 to monitor riparian restoration by the U.S. Army Corps of Engineers (Kus, 1998). The Whelan Restoration transects were 75 m apart and oriented approximately parallel (320 degrees) to the flood control channel. Before 2014, this site was sampled and used as an Off-channel site in analyses. However, in 2014, it became a Restoration site and has been analyzed separately from the Channel and the Upper Pond sites since then.

We used a number of permanent and semi-permanent methods to ensure that transects could be re-sampled in future years. First, a 1.5-m metal rebar was driven into the ground, leaving 75 centimeters above ground to mark the start of each transect. We spray-painted the rebar pink or orange and placed them at the intersection of the south levee and the riverbed. From the rebar, using a compass and tape measure, two field personnel measured the distances between sampling points. A numbered wooden stake, spray-painted pink or orange, was placed in the ground and colored plastic flagging was tied nearby to aid in locating the points. Finally, we obtained geographic coordinates for each rebar and wooden stake using a GPS unit (Garmin GPS 12).

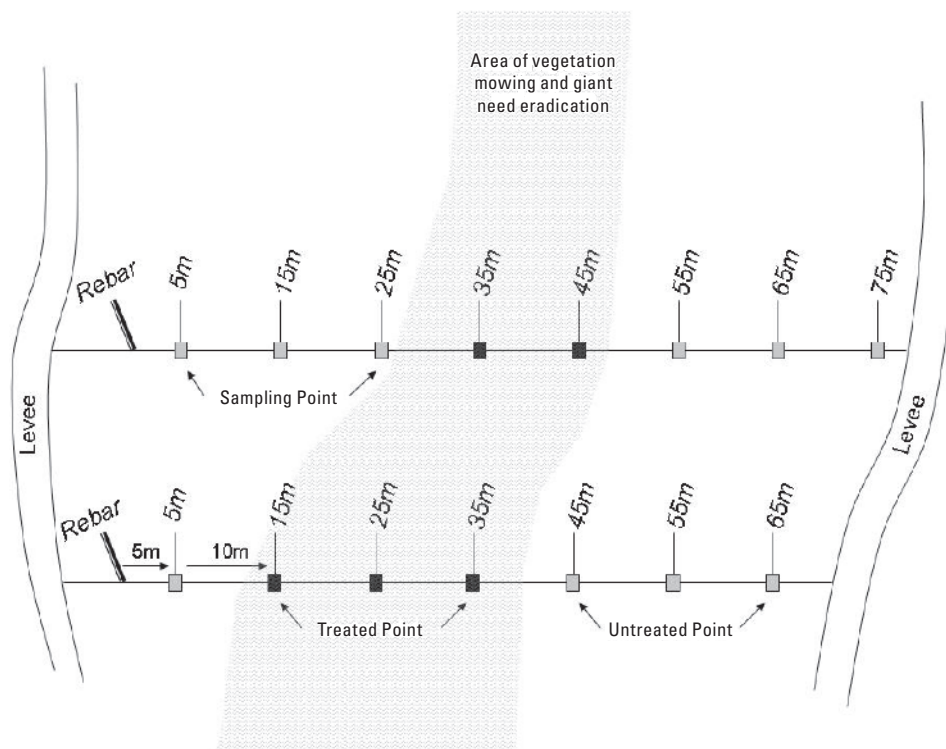


Figure 3. Vegetation transects in the Channel at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

Vireo Habitat Use Study Design

In addition to sampling vegetation along transects, we collected vegetation data at 45 randomly selected vireo territories. We sampled one nest and one paired random plot within each territory (hereafter “nest plots” and “territory plots,” respectively) in the Channel and at Upper Pond. We did not sample vegetation at Restoration site nests because the sample was small, and our focus was determining the response of vireos to treatments (measured by the Treatment Index) rather than their response to restoration activities. Nest and territory plots consisted of four 2- by 2-m quadrats; one quadrat centered on the nest (or center for random plots) and the remaining three quadrats located 10 m from the nest/center and oriented at 0, 120, and 240 degrees from it (fig. 4). Territory plot locations were constrained using the “Buffer” tool in ArcGIS to create a 10-m negative buffer on the territory boundaries. This negative buffer ensured that the random sampling point for the quadrats at 0, 120, or 240 degrees would not fall outside of the territory boundaries. A positive 2-m buffer was created around nest locations and vegetation transect points to exclude these locations and prevent duplicating vegetation sampling. We then used the “Create Random Points” tool on the territory boundary buffer to select one random point between the buffered areas to serve as the center quadrat. Territories were excluded from analysis if they were too narrow to allow a 10-m negative buffer, were in the “mixed” type category, or overlapped with Restoration.

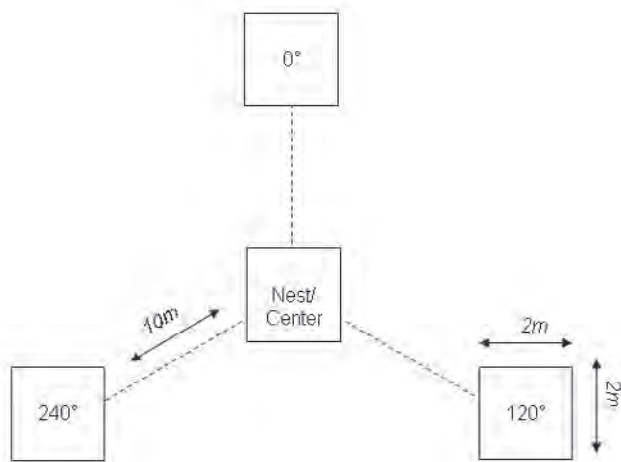


Figure 4. Nest-centered and territory vegetation plots sampled at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

Vegetation Sampling

Foliage cover at 1-m height intervals was estimated using the “stacked cube” method, developed specifically to characterize canopy architecture in structurally diverse riparian habitat (Kus, 1998). At each sampling point along a vegetation transect or in a nest or territory plot, we recorded canopy height and percent cover of vegetation, by species, within 1-m height intervals, using a modified Daubenmire (1959) scale with cover classes: less than 1, 1–10, 11–25, 26–50, 51–75, 76–90, and greater than 90 percent. The sampling units were 2- by 2- by 1-m high “cubes,” which were “stacked” vertically between the ground and the top of the canopy. Four 2-m length PVC pipes were placed on the ground to define quadrat boundaries, and a 7.5-m tall fiberglass telescoping pole, demarcated in 1-m intervals, was used to determine height class and canopy height. Vegetation data were collected by USGS biologists Lisa Allen, Armand Amico, Annabelle Bernabe, Aaron Gallagher, Rachelle McLaughlin, Jessica Medina, Shannon Mendia, Ryan Pottinger, Benjamin Stubbs, Devin Taylor, Michelle Treadwell, and Stéphane Vernhet.

Vegetation Data Analysis

For analysis, we converted cover codes to class midpoints, which were then used to quantify foliage cover at each sampling point for nine height classes: 0–1 m, greater than 1–2 m, greater than 2–3 m, greater than 3–4 m, greater than 4–5 m, greater than 5–6 m, greater 6–7 m, greater 7–8 m, and greater than 8 m. We examined percent cover for species that occurred at greater than 5 percent of the sampling points (more than 25 points). Species that were less common (less than 5 percent of the sampling points) were grouped together by plant life form, including tree, shrub, dead woody species, and freshwater marsh. Herbaceous species also were grouped together and included annual and perennial species (native and exotic), with the exception of nine exotic species: poison hemlock (*Conium maculatum*), pepperweed, fennel (*Foeniculum vulgare*), white sweet clover (*Melilotus alba*), black mustard (*Brassica nigra*), wild radish (*Raphanus sativus*), thistle (*Cirsium* sp.), ivy (*Hedera* sp.), and all grass species. These nine exotic species were combined and analyzed as exotics. We calculated average foliage cover across all height classes separately for the Channel, Upper Pond, and Whelan Restoration sites, separately. We used linear regression to examine the cumulative effects of vegetation management activities at these sites over time (2006–21) and to investigate any temporal trends that existed in percent cover at all height classes for each site. We focused on a cumulative approach because it allowed us to analyze the long-term effects of vegetation management within the Project Area. Comparisons between the intensively managed Channel sites and the less-managed Off-channel sites provided insight into how annual vegetation management has affected the structure of the vegetation in the Channel through time.

We used data from the vegetation transects, nest plots, and territory plots to examine vireo habitat selection at two spatial scales. First, we compared vegetation structure at nest plots to that at territory plots to assess if vireos were selecting nest sites non-randomly, relative to the vegetation available in the territory. Next, we compared territory plot data to transect data to evaluate if vireos were establishing territories non-randomly with regard to the habitat available to them throughout the site. We performed these comparisons separately for the Channel and Upper Pond to evaluate the effect of vegetation treatment on vireo nest and territory placement. We used *t*-tests to test for differences in foliage cover between nest sites and the territory and between territories and the available habitat.

Averages are presented with standard deviations. We considered *P* less than or equal to 0.10 to be significant for all statistical tests to avoid overlooking potentially important biological relationships relevant to the recovery of these endangered birds. Data were analyzed using Program R.

Data from the Project Area from 2006 to 2021, used in comparisons with current data, can be found in Ferree and Kus, 2007, 2008a, b; Ferree and others, 2010a, 2010b, 2011, 2012, 2014, 2015; and Houston and others, 2015, 2016, 2017, 2018, 2019, 2021.

Results

Least Bell's Vireo

In this section, we present the results from surveys and nest monitoring on Least Bell's Vireo population size and demographic parameters.

Population Size and Distribution

We identified a total of 122 vireo territories during surveys and weekly territory monitoring (table 3; appendix 2, figs. 2.1–2.4). The number of vireo territories decreased from 161 in 2020, which is a 24-percent decrease (table 4; fig. 5). Of the 122 territorial males, 111 (91 percent) were confirmed as paired and 8 (7 percent) were confirmed as single males. For the remaining three territories, we were unable to confirm pair status. We detected five transient vireos during surveys in 2021 (table 3).

Table 3. Number and breeding status of Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[—, no data]

Survey site	Known pairs	Unknown status	Single males	Total territories	Total transients
Channel sites					
Reach 1	20	1	—	21	1
Benet Restoration	4	1	—	5	—
Reach 2	10	—	2	12	—
Reach 3a	10	—	—	10	3
Reach 3b	12	—	—	12	—
Reach 4	24	—	2	26	—
College Restoration	—	—	—	—	—
Off-channel sites					
Lower Pond	7	—	—	7	—
Tuley Canyon	1	—	—	1	—
Whelan Mitigation	5	—	2	7	—
Whelan Restoration	3	—	—	3	—
Park Pond	4	1	—	5	—
Pilgrim Pond	—	—	1	1	—
Upper Pond	11	—	1	12	1
Riverside Pond	—	—	—	—	—
Total	111	3	8	122	5

Table 4. Number and distribution of Least Bell's Vireo territories at the San Luis Rey Flood Risk Management Project Area, California, in 2006–21.

[—, no data]

Survey site	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Channel sites																
Reach 1	13	7	10	23	23	17	10	13	14	22	15	22	27	17	26	21
Benet Restoration	—	—	—	—	—	—	—	6	6	2	4	4	5	6	6	5
Reach 2	15	14	16	18	22	16	6	6	6	3	6	7	12	13	12	12
Reach 3a	14	19	23	28	26	17	14	18	16	12	8	10	15	16	17	10
Reach 3b	13	14	13	17	16	18	5	4	6	5	4	7	11	10	16	12
Reach 4	21	21	25	32	24	18	10	14	15	16	12	10	20	22	27	26
College Restoration	—	—	—	—	—	—	—	—	2	0	0	0	0	0	1	0
Total	76	75	87	118	111	86	45	61	65	60	49	60	90	84	105	86
Off-channel sites																
Lower Pond	3	2	3	7	7	4	1	7	7	7	6	7	9	8	7	7
Tuley Canyon	1	1	1	1	1	0	0	0	1	2	2	1	1	1	2	1
Whelan Mitigation	14	9	12	15	16	12	11	13	6	6	4	6	8	13	15	7
Whelan Restoration	—	—	—	—	—	—	—	—	4	3	3	3	5	3	5	3
Park Pond	3	2	4	4	4	6	3	5	5	4	3	4	6	6	6	5
Pilgrim Pond	1	1	1	1	0	2	0	2	0	0	0	1	1	1	1	1
Upper Pond	20	17	21	24	17	19	15	14	11	12	11	11	10	12	18	12
Riverside Pond	1	1	1	1	1	1	1	1	1	1	0	0	0	0	2	0
Total	43	33	43	53	46	44	31	42	35	35	29	33	40	44	56	36
Grand total	119	108	130	171	157	130	76	103	100	95	78	93	130	128	161	122

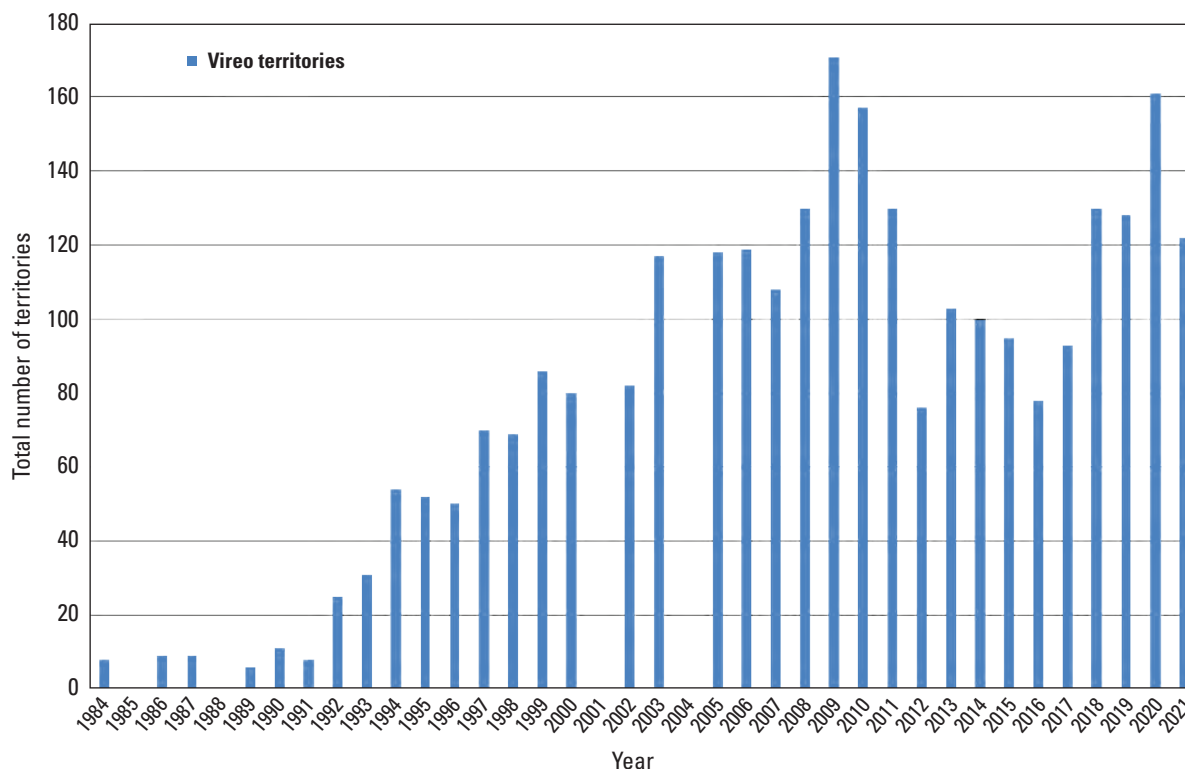


Figure 5. Number of Least Bell's Vireo territories from 1984 to 2021, at the San Luis Rey Flood Risk Management Project Area, California. Surveys were not conducted during 1985, 1988, 2001, or 2004.

Seventy percent of the territories (86/122) were within the Channel. The remaining 30 percent of the territories (36/122) were located Off-channel. There were 5 Channel territories in Benet Restoration, and the remaining 81 Channel territories were outside of Restoration areas. There were 3 Off-channel territories within Whelan Restoration, 7 were within Whelan Mitigation, but outside of the Restoration area, and 26 were in other retention ponds (tables 3, 4; appendix 2, figs. 2.1–2.4).

From 2020 to 2021, the number of vireo territories in the Channel decreased by 18 percent (from 105 to 86) and decreased by 36 percent (from 56 to 36) within Off-channel sites (table 4). Vireo territory numbers decreased for all Channel sites, with the exception of Reach 2, which remained stable. The largest decreases were in Reach 3a (seven territories, 41-percent decrease), Reach 3b (four territories, 25-percent decrease), and in Reach 1 (five territories, 19-percent decrease). The majority of Off-channel sites also decreased from 2020 to 2021. Only two sites, Lower Pond and Pilgrim Pond, remained stable, with seven and one territories respectively. The largest decreases occurred at Whelan Mitigation (eight territories, 53-percent decrease) and Upper Pond (six territories, 33-percent decrease). Other sites decreased by 1–2 territories (table 4).

Effects of Treatment on Habitat Use

To investigate if vireos were selecting territories in habitat that was less impacted by vegetation removal, we compared the Treatment Index of occupied vireo territories in the Channel to the Treatment Index of territories previously occupied, but unused, in 2021. Within the Channel, the average Treatment Index of unoccupied habitat (0.07 ± 0.07 , $n=79$) was 2.6 times that of habitat occupied by vireos in 2021 (0.03 ± 0.04 , $n=68$; $t = -4.8$, $df = 130$, $P < 0.01$), indicating that vireos avoided the more heavily treated sections of the river channel.

Nest Monitoring

We monitored nesting activity in 85 territories within the San Luis Rey River Flood Risk Management Project Area monitoring areas (table 5; appendix 2, figs. 2.1–2.4; appendix 3). These territories were fully monitored, meaning that all nests within the territory were found and monitored during the breeding season. Of the 85 monitored territories, 8 were occupied by single males and therefore were excluded from nesting analyses. A total of 165 nests were monitored during the breeding season. Seventeen of these nests were not completed and were subsequently excluded from calculations of nest success and productivity unless otherwise noted.

Table 5. Number of Least Bell's Vireo territories and nests monitored at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[Mixed territories had a territory classification that differed from one or more nest classifications (two territories were classified as Channel but had a nest located Off-channel, one territory was classified as Off-channel, but nested in the channel, and one territory was classified as Restoration, but had nests in the channel). Incomplete nests were partially built, but not completed. False nests were partially built by the male only. **Abbreviations:** —, no data; ±, plus or minus]

Territories and nests monitored	Channel	Off-channel	Restoration	Mixed	Total
Territories	57	22	2	4	85
Total number of pairs	53	18	2	4	77
Total number of nests monitored	123	36	¹ 6	—	165
Incomplete nests	14	2	0	—	16
False nests	0	1	0	—	1
Total number of completed nests	109	33	6	—	148
Completed nests/pair	2.0±1.1	1.6±0.6	1.5±0.7	3.3±1.7	1.9±1.1
Total number of nest attempts/pair	2.2±1.3	1.7±0.7	1.5±0.7	3.8±1.0	2.1±1.2

¹All nests were in Whelan Restoration.

Nesting Attempts

The average number of nesting attempts per territory (including incomplete nests) over the course of the 2021 breeding season was 2.1 ± 1.2 (table 5). Sixty-eight percent (52/77) of pairs re-nested after their first nest attempt, and 44 percent (23/52) of these pairs initiated at least a third nesting attempt. A total of 13 successful pairs (25 percent, 13/51) attempted a re-nest after a successful nest. Of these, 6 pairs (46 percent, 6/13) successfully fledged 2 broods.

The majority of first nesting attempts in 2021 were initiated during late April and early May (fig. 6). The peak of nest initiation was during the weeks of April 25 and May 2, 2021, when 37 percent (28/75) of first nests were initiated. Nesting was similarly timed in 2021 (median Julian day 126; May 6 in 2021) compared with 2020 (median Julian day 125; May 4 in 2020) but was later than the 15-year average (mean median Julian day 113.6 2006–20; fig. 7).

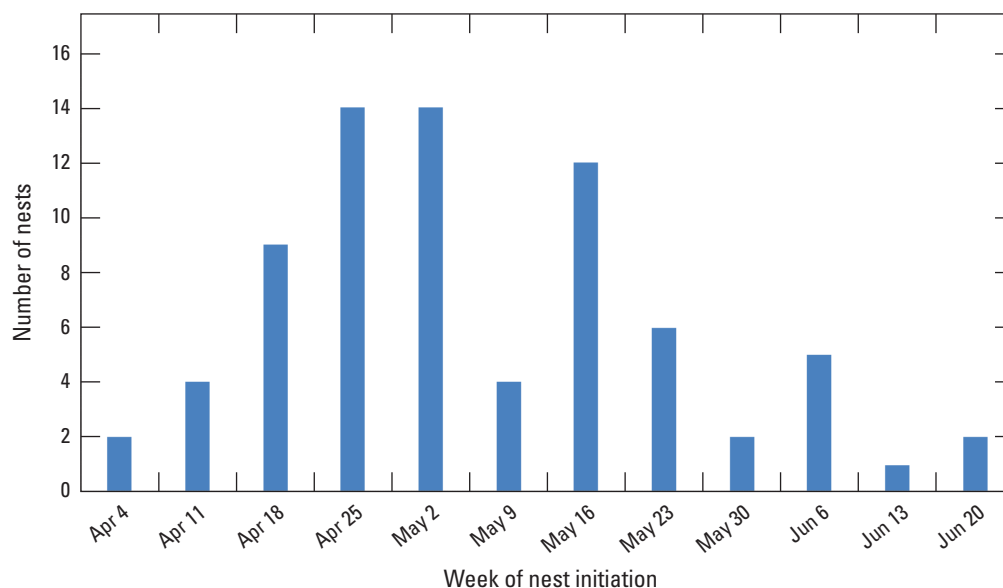


Figure 6. Number of first Least Bell's Vireo nests initiated (date first egg laid) by week at the San Luis Rey Flood Risk Management Project Area, California, 2021.

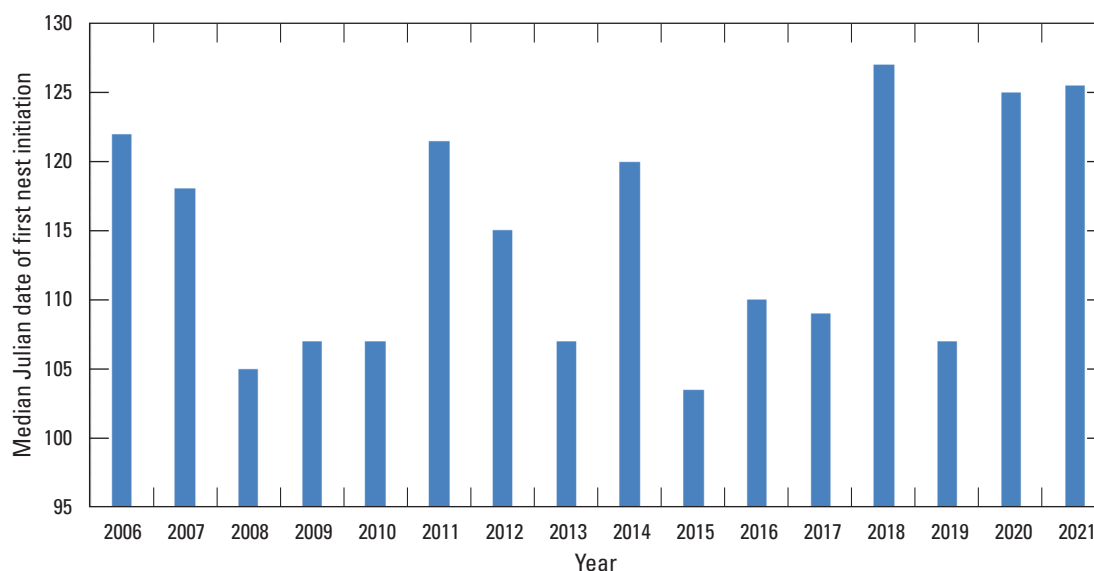


Figure 7. Nest initiation of first nests (renests excluded) at the San Luis Rey Flood Risk Management Project Area, California, 2006–21.

Apparent Nest Success

Overall, 39 percent (57/148) of completed nests were successful (table 6). Thirty-six percent (39/109) of nests in the Channel, 52 percent (17/33) of Off-channel nests, and 17 percent (1/6) of Restoration nests fledged young. Nest success did not differ among the three site types ($P=0.19$, Fisher’s Exact test).

Causes of nest failure were similar among the Channel, Off-channel, and Restoration site nests. Predation was the primary source of nest failure for all sites (table 6). Predation accounted for 69 percent (48/70), 75 percent (12/16), and 40 percent (2/5) of nest failures in the Channel, Off-channel, and Restoration sites, respectively. Most predators were believed to be birds, mammals, or snakes. Overall, 44 percent (48/109) of Channel nests, 36 percent (12/33) of Off-channel nests, and 33 percent (2/6) of Restoration nests were lost to predation.

Although we could attribute most nest failures to predation in 2021, there were 19 nests that failed for other or unknown reasons. Of these, one nest failed with infertile eggs, 2 nests failed as a result of Brown-headed Cowbird “predation” (they were found abandoned with a cowbird egg in the nest and with vireo eggs ejected or punctured), 4 were abandoned with eggs, and 12 nests failed for unknown reasons before eggs were documented.

Table 6. Fate of Least Bell’s Vireo nests at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[Proportion of total completed nests shown in parentheses]

Nest fate	Number of nests			
	Channel	Off-channel	Restoration	Total
Successful	39	17	1	57 (0.39)
Failed				
Predation	48	12	2	62 (0.42)
Parasitism	8	2	0	10 (0.07)
Other/unknown	14	2	3	19 (0.13)
Failed total	70	16	5	91 (0.61)
Total completed nests	109	33	6	148 (1.00)

Brown-headed Cowbird Parasitism

We documented 35 incidents of Brown-headed Cowbird parasitism in 2021, which is a 400-percent increase from 2020 (7 incidents). In total, 35 nests (24 percent of completed nests) in 28 territories (36 percent of territories) were parasitized with 36 eggs (table 7). Ten nests failed as a result of parasitism (abandoned). We removed cowbird eggs from 25 nests, of which 15 (60 percent) were ultimately successful. Of the remaining parasitized nests, seven were depredated, two failed as a result of cowbird “predation,” and one failed with infertile vireo eggs.

Parasitism was first observed during the third week of nesting (April 18), when 44 percent of completed nests were parasitized. The average weekly parasitism rate for completed nests from April 4 to July 4, 2021, was 24 percent (range 0–60 percent; fig. 8).

Table 7. Number and fate of Least Bell’s Vireo nests parasitized by Brown-headed Cowbirds at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

Number and fate	Channel	Off-channel	Restoration	Total
Nests parasitized	25	9	1	35
Total cowbird eggs laid	26	9	1	36
Fate of parasitized nests				
Abandoned	8	2	0	¹ 10
Not abandoned:				
Successful	8	6	1	15
Unsuccessful	9	1	0	² 10

¹Cowbird eggs removed from three nests before failure was confirmed.

²Three nests failed before cowbird eggs could be removed.

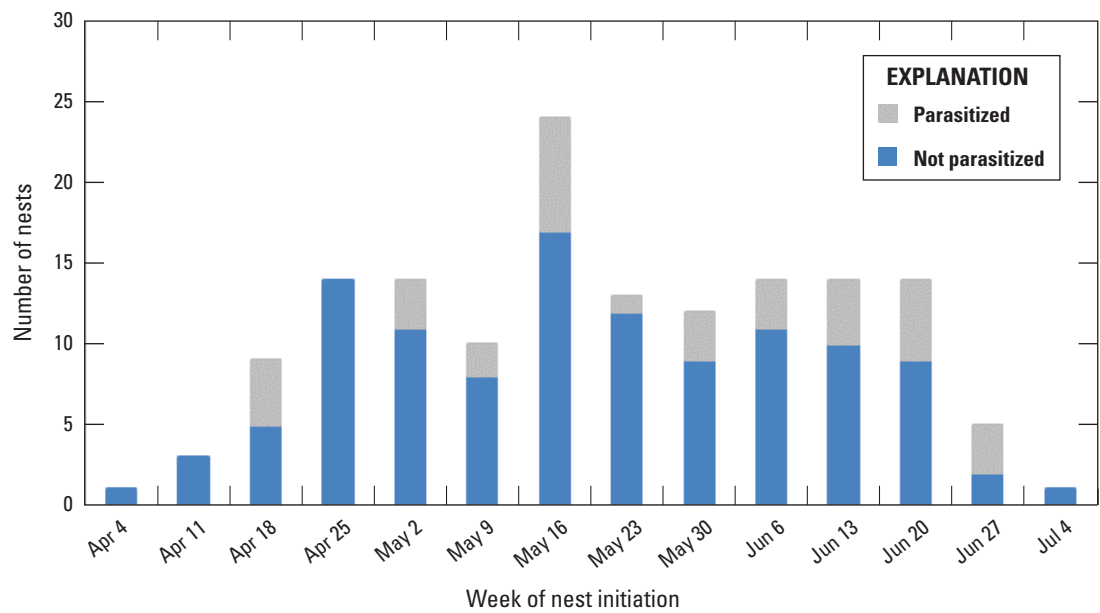


Figure 8. Number of completed Least Bell's Vireo nests initiated and those that were parasitized by Brown-headed Cowbirds by week at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

Reproductive Success and Productivity

Hatching and fledging success were similar, but slightly lower in 2021 compared to 2020. Overall, 64 percent of nests with eggs hatched at least one egg and 74 percent of nests with nestlings fledged at least one young (table 8), compared to 69 and 81 percent in 2020. Overall, clutch size of non-parasitized nests (3.3 ± 0.6) was slightly lower than in 2020 (3.5 ± 0.6) and compared to the 15-year average (2006–20; 3.4). In 2021, clutch size was greater in the Channel (3.4 ± 0.6) compared with the Off-channel sites (2.9 ± 0.6). Fledging success differed by site type in 2021, with more hatchlings fledging in Off-channel sites than in either Channel or Restoration sites, but there were no other differences for any other measures of reproductive success or productivity among Channel, Off-channel and Restoration nests (table 8).

In 2021, Project Area vireos fledged 1.9 ± 1.7 young per pair, similar to productivity in 2020 (2.1 ± 1.7 young per pair), but lower than the 15-year average (2.5 ± 0.8 , table 9; fig. 9).

There was no difference in productivity (the number of young fledged per pair) or in the proportion of pairs fledgling one or more young between site types. Overall, 66 percent (51/77) of pairs fledged at least one young in 2021, which was similar to productivity in 2020 (67 percent), but lower than in any other year since 2006, with the exception of 2014 when only 30 percent of pairs successfully fledged young. In 2021, 8 percent of pairs (6/77) successfully fledged 2 broods, which was slightly higher than the 5 percent observed in 2020, but still below the 15-year average of 13 percent. Without the “rescue effect” of removing Brown-headed Cowbird eggs from parasitized nests, thus allowing them to potentially fledge, productivity and nest success would have been lower. The number of fledglings per pair without the removal of cowbird eggs would have been only 1.5 ± 1.7 young per pair, with only 49 percent of pairs successfully fledgling at least one young.

Table 8. Reproductive parameters for nesting Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[Nests were categorized based on their locations within Channel, Off-channel, and Restoration sites rather than based on the pair's territory site category. Standard deviations presented with means. Asterisks (*) signify significant differences between site types. Channel includes Reaches 1, 2, 3a, 3b, and 4, excluding restoration sites. Off-channel includes Upper Pond and Whelan Mitigation, excluding restoration sites. Restoration includes Benet Restoration, College Restoration, and Whelan Restoration. **Abbreviations:** \pm , plus or minus; %, percent]

Parameter	Channel	Off-channel	Restoration	Overall	
Nests with eggs	100	32	3	135	
Eggs laid	294	87	10	391	
Average clutch size¹	3.4 ± 0.6	2.9 ± 0.6	3.5 ± 0.7	3.3 ± 0.6	*
Hatchlings	156	55	4	215	
Nests with hatchlings	61	23	2	86	
Hatching success					
Eggs ²	53%	63%	40%	55%	
Nests ³	61%	72%	67%	64%	
Fledglings	101	44	1	146	
Nests with fledglings	45	18	1	64	
Fledging success					
Hatchlings⁴	65%	80%	25%	68%	*
Nests ⁵	74%	78%	50%	74%	

¹Based on 55 Channel, 17 Off-channel, and 2 Restoration non-parasitized nests with a full clutch (One-way ANOVA: F-ratio=4.4, P=0.02; Channel versus Off-channel P=0.01, Tukey test, all other comparisons not significant).

²Percent of all eggs that hatched, among all three sites: P=0.15, Fisher's Exact test.

³Percent of all nests with eggs in which at least one egg hatched, among all three sites: P=0.60, Fisher's Exact test.

⁴Percent of all hatchlings that fledged, among all three sites: P=0.02, Fisher's Exact test; Channel versus Off-channel $\chi^2=3.7$, df=1, P=0.05; Channel versus Restoration P=0.14, Fisher's Exact test; Off-channel versus Restoration P=0.04, Fisher's Exact test.

⁵Percent of all nests with hatchlings in which at least one young fledged, among all three sites: P=0.52, Fisher's Exact test.

Table 9. Productivity per pair for nesting Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[±, plus or minus; %, percent]

Parameter	Channel	Off-channel	Restoration	Mixed	Overall
Number of pairs	53	18	2	4	77
Average number of young fledged per pair ¹	1.8±1.8	2.3±1.7	0.5±0.7	2.0±1.4	1.9±1.7
Pairs fledging at least one young ²	33 (62%)	14 (78%)	1 (50%)	3 (75%)	51 (66%)
Pairs fledging two broods ³	4 (8%)	2 (11%)	0 (0%)	0 (0%)	6 (8%)

¹One-way ANOVA: F-ratio = 0.76, P=0.52.

²P=0.57, Fisher's Exact test.

³P=0.78, Fisher's Exact test.

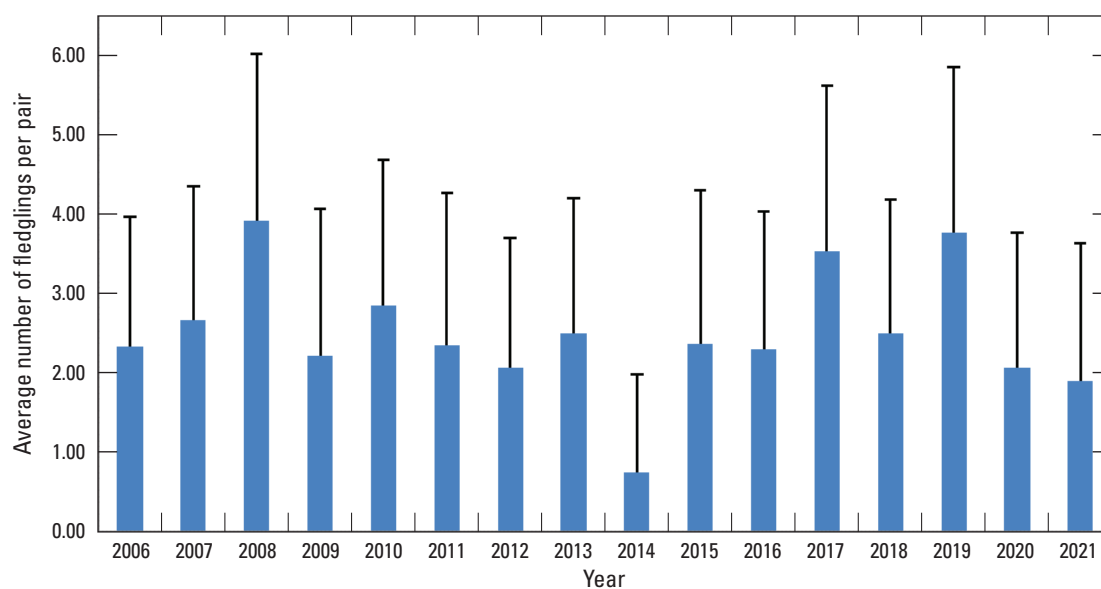


Figure 9. Average number of fledglings per pair by year at the San Luis Rey Flood Risk Management Project Area, California, 2006–21. Bars are standard deviations.

Effects of Treatment on Vireo Reproduction

The Treatment Index for fully monitored 2021 vireo territories within the Channel that did not overlap with active restoration averaged 0.03 ± 0.04 ($n=55$, range=0–0.21; [fig. 10](#)). In 2021, there were 5 fully monitored vireo territories (9 percent, 5/55) within the Channel that had no treatment. There was no effect of Treatment Index on any measures of nesting effort or productivity (number of nests, number of completed nests, or number of fledglings per pair; [table 10](#); [fig. 11](#)).

We analyzed 2021 nest survival to determine if there was an effect of Treatment Index on DSR (within the Channel only). The best model for daily survival rate was the constant DSR model ([table 11](#)). There was some support for the model that included Treatment Index (ΔAIC_c less than or equal to 2). However, an analysis of the odds ratio revealed that the 95 percent for Treatment Index included 1, indicating that it was not a significant contributor to the model ($\beta=0.04$, $SE=0.03$, odds ratio=1.04, 95-percent confidence interval=0.98–1.10).

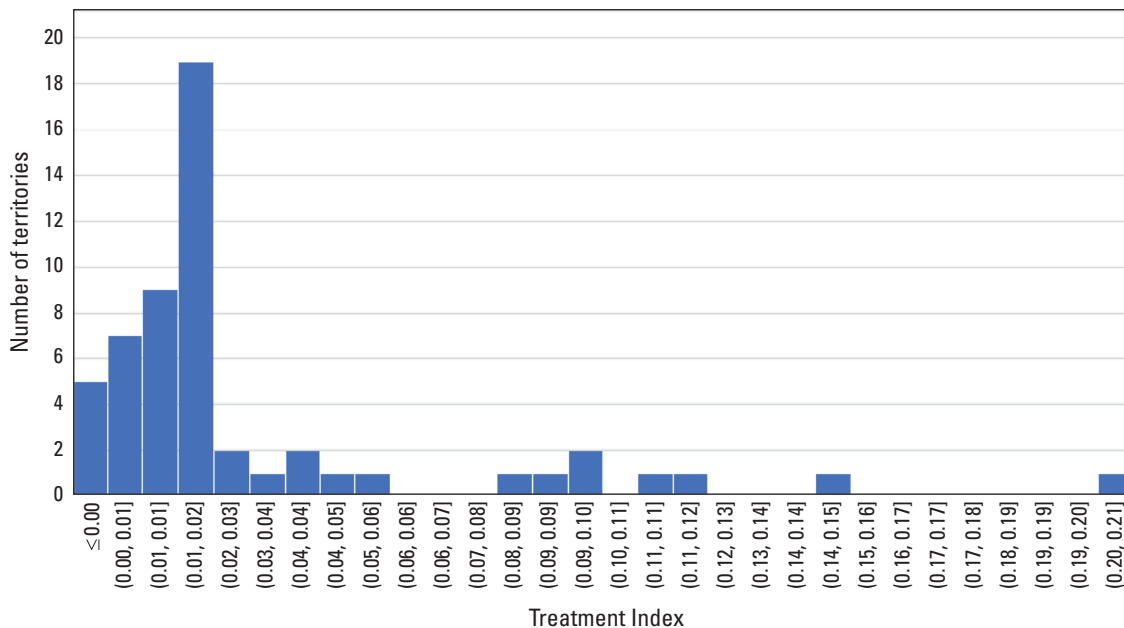


Figure 10. Number of monitored vireo territories by Treatment Index within the Channel at the San Luis Rey Flood Risk Management Project Area, California, 2021. Territories overlapping with active restoration are not included.

Table 10. Generalized linear model results, parameter estimate, standard error (SE), Z statistic and *P*-values for Least Bell's Vireo reproductive parameters per pair as a function of Treatment Index within the Channel at the San Luis Rey Flood Risk Management Project Area, California, 2021.

[<, less than]

Variable	Estimate	SE	Z-value	<i>P</i>
Number of nests				
Intercept	0.9	0.1	7.9	<0.01
Treatment Index	-3.1	2.6	-1.2	0.24
Number of completed nests				
Intercept	0.8	0.1	6.4	<0.01
Treatment Index	-2.1	2.6	-0.8	0.43
Number of fledglings				
Intercept	0.5	0.1	4.0	<0.01
Treatment Index	1.9	2.3	0.8	0.40

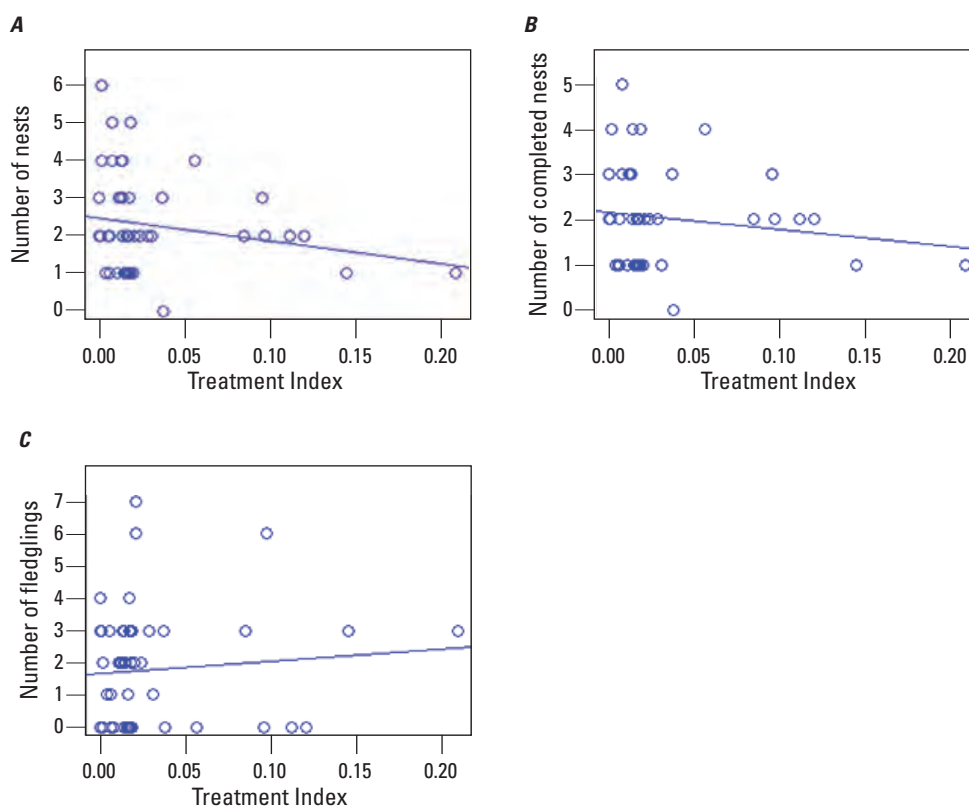


Figure 11. Effect of Treatment Index on Least Bell's Vireo reproductive parameters (per pair) at the San Luis Rey Flood Risk Management Project Area, California, 2021. *A*, Number of nests; *B*, number of completed nests; and *C*, number of fledglings per pair. Lines represent linear regression.

Table 11. Logistic regression models for the effects of Treatment Index (within the Channel only) on daily nest survival of Least Bell’s Vireos at the San Luis Rey Flood Risk Management Project Area, California, 2021.

[Models are ranked from best to worst based on Akaike’s Information Criterion for small samples (AIC_c), ΔAIC_c , and Akaike weights. AIC_c is based on $-2 \times \log_e$ likelihood, the number of parameters in the model, and sample size]

Model	Deviance	Number of parameters	AIC_c	ΔAIC_c	AIC_c weight
Constant	307.4	1	309.4	0.0	0.58
Treatment Index	306.1	2	310.1	0.7	0.42

Nest Survival and Habitat Use

We investigated the effect of habitat structure at vireo nest sites on nest survival by constructing a series of models relating the vegetation cover variables to the daily nest survival rate (table 12). The best model was the constant DSR model; however, there was support for several of the other models (ΔAIC_c less than or equal to 2). We looked at the beta

estimates for the first two of these, the model that included percent cover 0–1 m+1–2 m and the model that included percent cover 1–2 m. For both of these models, the beta values for the percent cover estimates were low (0–0.01) with the confidence interval for the odds ratio spanning one, so we can conclude that percent cover 0–1 m and 1–2 m were not significant contributors to the models (table 13).

Table 12. Logistic regression models for the effects of habitat structure on daily nest survival of Least Bell's Vireos at the San Luis Rey Flood Risk Project Area, California, 2006–21.

[Models are ranked from best to worst based on Akaike's Information Criterion for small samples (AIC_c), ΔAIC_c , and Akaike weights. AIC_c is based on $-2 \times \log_e$ likelihood, the number of parameters in the model, and sample size. **Abbreviations:** DSR, daily survival rate; +, plus; m, meter]

Model	Deviance	Number of parameters	AIC_c	ΔAIC_c	AIC_c weight
Constant DSR	2,135.2	1	2,137.2	0.0	0.17
Percent cover 0–1 m + 1–2 m	2,131.9	3	2,137.9	0.7	0.12
Percent cover 1–2 m	2,134.1	2	2,138.1	0.8	0.11
Percent cover 5–6 m	2,134.3	2	2,138.3	1.1	0.10
Percent cover 4–5 m	2,134.5	2	2,138.5	1.3	0.09
Percent cover 3–4 m	2,134.6	2	2,138.6	1.3	0.09
Percent cover 6–7 m	2,134.7	2	2,138.7	1.4	0.08
Canopy height	2,135.1	2	2,139.1	1.8	0.07
Percent cover 7–8 m	2,135.2	2	2,139.2	1.9	0.06
Percent cover 0–1 m	2,135.2	2	2,139.2	2.0	0.06
Percent cover 2–3 m	2,135.2	2	2,139.2	2.0	0.06
Percent cover 2–3 m + 3–4 m + 4–5 m + 5–6 m + 6–7 m + 7–8 m	2,132.6	7	2,146.6	9.3	0.00

Table 13. Parameter estimate (β), standard error (SE), odds ratios, and 95-percent confidence intervals (CI) for models explaining the effect of habitat structure on the daily survival rate of Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, 2006–21.

[Models are in order of best-supported to least-supported. Bold indicates a significant effect. **Abbreviations:** m, meter; + plus]

Effect	β	SE	Odds ratio	95-percent CI
Percent cover 0–1 m + 1–2 m				
Intercept	3.80	0.15	44.49	32.88–60.19
0–1 m	–0.01	0.01	0.99	0.98–1.00
1–2 m	0.01	0.01	1.01	1.00–1.03
Percent cover 1–2 m				
Intercept	3.72	0.15	35.70	27.20–46.87
1–2 m	0.00	0.00	1.00	1.00–1.01

Nest Characteristics

There were no differences in nest placement among Channel, Off-channel, and Restoration nests for any of the four measures ([table 14](#)). Nest height, host height, distance to edge of host, and distance from edge of clump were similar in all site types. Within sites, we also found no differences between successful and unsuccessful nests.

Red/arroyo willow was the species most commonly selected for nesting by vireos in all three site types (50 percent of nests in the Channel, 42 percent in Off-channel sites, and 50 percent in Restoration sites; [table 15](#)). Other species commonly used by vireos (greater than 10 percent of all nests) included black willow and mule fat. Vireos used a wider variety of species for nesting in Channel and Off-channel sites (seven and eight species, respectively) compared with Restoration sites (three species). Two nests were placed in exotic species in 2021.

Table 14. Least Bell's Vireo nest characteristics and results of Kruskal-Wallis and Mann-Whitney U-tests comparing Channel, Off-channel, and Restoration nests, and successful versus failed nests, at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[Standard deviation presented in parentheses. Asterisks indicate a significant difference. **Abbreviations:** N, sample size; H, Kruskal-Wallis H statistic; P, P-value; U, Mann-Whitney U statistic; m, meter]

Overall						Channel						Off-channel						Restoration							
Channel	N	Off-channel	N	Resto- ration	N	H	P	Suc- cessful	N	Unsuc- cessful	N	U	P	Suc- cessful	N	Unsuc- cessful	N	U	P	Suc- cessful	N	U	P		
Average nest height (m)																									
1.0 (0.4)	105	0.9 (0.3)	33 (0.3)	0.8 (0.3)	6	2.9	0.23	1.0 (0.4)	38	1.0 (0.4)	67	1,375.0	0.50	0.9 (0.4)	17	0.9 (0.3)	16	130.5	0.86	0.7 (NA)	1	0.8 (0.4)	5	1.0	1.00
Average host height (m)																									
5.7 (3.1)	105	4.9 (2.8)	33 (4.6)	5.9 (4.6)	6	1.4	0.49	5.6 (3.2)	38	5.8 (3.1)	67	1,317.5	0.77	5.3 (3.2)	17	4.4 (2.3)	16	115.0	0.46	3.0 (NA)	1	6.4 (4.9)	5	4.0	0.55
Average distance to edge of host (m)																									
1.0 (1.1)	107	0.7 (0.7)	33 (0.2)	0.3 (0.2)	6	2.6	0.27	1.1 (1.3)	38	1.0 (1.1)	69	1,219.0	0.55	0.7 (0.9)	17	0.6 (0.5)	16	140.0	0.90	0.6 (NA)	1	0.3 (0.1)	5	0.0	0.33
Average distance to edge of clump (m) ¹																									
1.5 (1.2)	106	1.4 (1.1)	33 (1.6)	2.3 (1.6)	6	2.0	0.36	1.6 (1.4)	37	1.5 (1.1)	69	1,240.5	0.81	1.2 (0.9)	17	1.5 (1.3)	16	143.0	0.81	3.0 (NA)	1	2.2 (1.8)	5	1.0	0.67

¹Clump boundaries were defined where leaves or branches of neighboring plants no longer overlapped.

Table 15. Host plant species used by Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[Numbers in parentheses are proportions of total nests. **Abbreviation:** —, no data]

Host species	Channel				Off-channel				Restoration			
	Successful	Unsuccessful	Total		Successful	Unsuccessful	Total		Successful	Unsuccessful	Total	
Red/arroyo willow	16	37	53 (0.50)		9	5	14 (0.42)		0	3	3 (0.50)	
Black willow	8	17	25 (0.23)		1	2	3 (0.09)		—	—	—	
Poison oak (<i>Toxicodendron diversilobum</i>)	5	6	11 (0.10)		0	1	1 (0.03)		—	—	—	
Mule fat	6	4	10 (0.09)		2	4	6 (0.18)		—	—	—	
Sandbar willow	2	2	4 (0.04)		3	3	6 (0.18)		1	1	2 (0.33)	
Fremont cottonwood	1	2	3 (0.03)		0	1	1 (0.03)		—	—	—	
Giant reed	0	1	1 (0.01)		—	—	—		—	—	—	
Mugwort (<i>Artemisia douglasiana</i>)	—	—	—		—	—	—		0	1	1 (0.17)	
Evening primrose (<i>Oenothera elata</i>)	—	—	—		1	0	1 (0.03)		—	—	—	
Common fig (<i>Ficus carica</i>)	—	—	—		1	0	1 (0.03)		—	—	—	

Banded Birds

We determined banding status for 96 percent (229/239) of adult vireos (127 males, 100 percent of all males and 102 females, 91 percent of all females) observed at the San Luis Rey Flood Risk Management Project Area in 2021. Sixty-six of these had been banded prior to the 2021 breeding season, and their identities were verified through resighting or recapture. There were six vireos (one male and five females) that could not be identified because they were

banded with only a single numbered metal federal band as a nestling (natal), and we were unable to recapture them in 2021 (table 16; appendix 4).

Of the 66 returning adults with a known identity, 50 were banded with full color band combinations prior to 2021 and 16 were natal vireos recaptured and color banded in 2021. With the exception of one vireo, originally banded on the Santa Margarita River, all adults (65) were originally banded at the Project Area (table 16). Adult birds of known age ranged from 1 to 6 years old (table 17).

Table 16. Banding status of Least Bell’s Vireos detected at the San Luis Rey Flood Risk Management Project Area, California, in 2021, and those that emigrated from the Project Area in 2021.

[Project Area includes one immigrant vireo. Natal: natal vireos were originally banded as nestlings with a single numbered federal band. **Abbreviation:** —, no data]

Banding status	Project area			Emigrants			Total
	Male	Female	Subtotal	Male	Female	Subtotal	
Known-identity vireos							
Banded prior to 2021	45	5	50	—	1	1	51
Natal, recaptured in 2021	14	2	16	10	5	15	31
Subtotal	59	7	66	10	6	16	82
Unidentified vireos							
Natal, not recaptured	1	5	6	1	2	3	9
Grand total	60	12	72	11	8	19	91

Table 17. Number of banded adult Least Bell’s Vireos, by original year banded, age, and sex, at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[Year originally banded: Year banded with a single numbered metal federal band as a nestling or with a unique color band combination as an adult; Age in 2021: Exact ages determined from single numbered metal federal band observed during recapture; estimated age applies to a bird captured as an unbanded adult; Unknown: Natal vireos banded with single numbered metal federal band, so natal year is not known. Six natal vireos were seen with a single metal blue numbered band, indicating that they were originally banded at the Project Area. **Abbreviations:** yr, year; ≥, greater than or equal to; —, not applicable]

Year originally banded	Age in 2021	San Luis Rey River		Santa Margarita River	Total
		Male	Female	Male	
2015	6 yrs	1	0	0	1
2016	5 yrs	1	0	1	2
2017	4 yrs	8	0	0	8
2018	≥4 yrs	3	1	0	4
	3 yrs	3	2	0	5
2019	≥3 yrs	13	0	0	13
	2 yrs	6	1	0	7
2020	≥2 yrs	14	2	0	16
	1 yr	9	1	0	10
Subtotal	—	58	7	1	66
Unknown	≥1 yr	1	5	0	6
Total	—	59	12	1	72

Emigrants

Nineteen vireos that were originally banded in the San Luis Rey River Project Area as nestlings or adults were detected in areas outside of the Project Area in 2021 (tables 16, 18; appendix 5). Fifteen of these vireos were recaptured in 2021 and banded with unique color band combinations at three drainages within MCBCP, at the middle San Luis Rey River (upstream from the Project Area), and at Whelan Lake, within the San Luis Rey River watershed (U.S. Geological Survey, unpub. data, 2021). One adult vireo that was originally resighted with a unique color band combination at the San Luis Rey River Project Area, in 2019, was resighted at Whelan Lake in 2021.

Three unidentified natal vireos were detected outside the San Luis Rey River Project Area in 2021. Two natal vireos were detected at the Santa Margarita River within MCBCP

(U.S. Geological Survey, unpub. data, 2021), and one was detected at the middle San Luis Rey River, (U.S. Geological Survey, unpub. data, 2021). Efforts to recapture and identify these individuals were unsuccessful.

New Captures

A total of 133 vireos were banded for the first time during 2021 (table 19). These newly banded birds included 3 adults that were captured and banded with a unique color combination and 130 nestlings that were banded with a single numbered dark blue metal federal band. These newly banded vireos were not included in survivorship, fidelity, or movement analyses.

Table 18. Number of emigrant Least Bell's Vireos detected outside of the Project Area that originated in the San Luis Rey Flood Risk Management Project Area, California, by original year banded, age, 2021 location, and sex.

[Year originally banded: Year banded with a single numbered metal federal band as a nestling or with a unique color band combination as an adult; MCBCP: Marine Corps Base Camp Pendleton; Middle San Luis Rey River: Upstream from the Project Area, between College Boulevard and Interstate 15. **Abbreviations:** MCBCP, Marine Corps Base Camp Pendleton; ≥, greater than or equal to; yr, year; —, no data]

Year originally banded	Age in 2021	2021 Location drainage					Total
		MCBCP drainages		Middle San Luis Rey River		Other drainages	
		Male	Female	Male	Female	Female	
2019	≥3 yrs	—	—	—	—	¹ 1	1
2019	2 yrs	² 2	³ 1	3	2	—	8
2020	1 yr	⁴ 1	—	4	1	¹ 1	7
Subtotal	—	3	1	7	3	2	16
Unknown	≥1 yr	—	³ 2	1	—	—	3
Total	—	3	3	8	3	2	19

¹Detected at Whelan Lake, San Diego County.

²One detected at French Creek and one detected at Santa Margarita River.

³Detected at Santa Margarita River.

⁴Detected at Pilgrim Creek.

Table 19. Total number of new Least Bell's Vireos captured and banded at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[Adult: banded with unique color combinations; Nestling: Nestlings banded with a single numbered dark blue metal federal band on the right leg. **Abbreviation:** —, no data]

Age banded	Males	Unknown sex	Total
Adult	3	0	3
Nestling	—	130	130
Total	3	130	133

Survivorship, Fidelity, and Movement

Survivorship Models—Adults-Only

The best model explaining adult annual survivorship included effects of sex and year on adult survival (table 20). Male survivorship was higher than female survivorship and survivorship varied by year (95-percent confidence interval of the odds ratio did not include 1; table 21). We found little support for models that included bio-year (July–June) precipitation (National Oceanic and Atmospheric Administration, 2021), suggesting that precipitation on the breeding grounds was not the primary driver of annual fluctuations in survivorship in this system (table 20).

We used the top model to calculate annual survivorship and the detection probabilities for adult males and adult females (table 22). Annual survival for females was consistently lower than for males, averaging 51±12 percent (range of 35–71 percent). For males, annual survivorship averaged 65±12 percent (range of 43–78 percent). Detection probability was somewhat higher for males (0.90) than for females (0.79) but was high for both sexes.

Table 20. Survivorship models for the effects of sex, year, and precipitation on adult survival for Least Bell's Vireos at the San Luis Rey Flood Risk Project Area, California, 2006–21.

[The effect of sex on detection probability was included in all models. Models are ranked from best to worst based on Akaike's Information Criterion for small samples (AIC_c), ΔAIC_c, and Akaike weights. AIC_c is based on -2 x log_e likelihood, the number of parameters in the model, and sample size. **Abbreviation:** +, plus]

Model	Deviance	Number of parameters	AIC _c	ΔAIC _c	AIC _c weight
Sex+year	494.1	18	3,139.2	0.0	0.94
Year	501.9	17	3,145.0	5.8	0.05
Sex+precipitation	531.9	5	3,150.7	11.5	0.00
Precipitation	541.1	4	3,157.9	18.7	0.00
Sex	588.9	4	3,205.7	66.5	0.00
Constant	598.0	3	3,212.8	73.6	0.00

Table 21. Parameter estimate (β), standard error (SE), odds ratios and 95-percent confidence intervals (CI) for the top model explaining annual survivorship (Phi) of adult Least Bell's Vireos at the San Luis Rey Flood Risk Project Area, California, 2006–21.

[The Intercept (reference) represents female vireos, 2006–07. All other effects values are the difference between that parameter and the Intercept. **Bold** (*) indicates a significant effect. **Abbreviation:** +, plus]

Effect	β	SE	Odds ratio	95-percent CI
Sex+year				
Intercept	0.83	0.34	2.29	1.18–4.47
Male*	0.36	0.13	1.43	1.11–1.82
2007–08	−0.07	0.46	0.93	0.38–2.28
2008–09	0.06	0.39	1.06	0.49–2.29
2009–10	−0.29	0.37	0.75	0.37–1.54
2010–11*	−1.01	0.35	0.36	0.18–0.73
2011–12*	−1.22	0.36	0.30	0.15–0.60
2012–13	−0.15	0.39	0.86	0.40–1.86
2013–14	−0.19	0.38	0.82	0.39–1.75
2014–15	−0.13	0.38	0.88	0.41–1.87
2015–16	−0.62	0.37	0.54	0.26–1.12
2016–17	−0.17	0.39	0.84	0.39–1.82
2017–18*	−0.85	0.37	0.43	0.21–0.88
2018–19	−0.46	0.37	0.63	0.31–1.29
2019–20*	−1.17	0.36	0.31	0.15–0.63
2020–21*	−1.47	0.37	0.23	0.11–0.48

Table 22. Annual survivorship for adult female and adult male Least Bell's Vireos at the San Luis Rey Flood Risk Project Area, California, 2006–21.

[Survivorship and estimates were derived from the top model]

Years	Adult female survivorship	Adult male survivorship
2006–07	0.70	0.77
2007–08	0.68	0.75
2008–09	0.71	0.78
2009–10	0.63	0.71
2010–11	0.46	0.54
2011–12	0.40	0.49
2012–13	0.66	0.74
2013–14	0.65	0.73
2014–15	0.67	0.74
2015–16	0.55	0.64
2016–17	0.66	0.73
2017–18	0.49	0.58
2018–19	0.59	0.67
2019–20	0.42	0.50
2020–21	0.35	0.43

Survivorship Models—Adults and First-year Vireos

The best model for vireo survival was the model that included the effects of age and year on survival and an effect of year on detection probability (table 23). Analysis of the odds ratio showed that survival of adult vireos was significantly higher than that of first-year vireos and that survival varied by year for both age classes (95-percent confidence interval of the odds ratio did not include 1; table 24).

Survival estimates for 2020–21 were high relative to previous years. Adult survival was 83 percent and first-year survival was 30 percent. Average annual survival across all years for adults was 70 ± 9 percent (range of 51–83 percent) and for first-year birds, it was 18 ± 6 percent (range of 8–30 percent; table 25).

Table 23. Survivorship models for the effect of age, year and precipitation on survival of Least Bell's Vireos at the San Luis Rey Flood Risk Project Area, California, 2006–21.

[The effect of year on detection probability was included in all models. Models are ranked from best to worst based on Akaike's Information Criterion for small samples (AIC_c), ΔAIC_c , and Akaike weights. AIC_c is based on $-2 \times \log_e$ likelihood, the number of parameters in the model, and sample size. Abbreviation: +, plus]

Model	Deviance	Number of parameters	AIC_c	ΔAIC_c	AIC_c weight
Age+year	3,604.5	31	6,677.9	0.0	1.00
Age+precipitation	3,688.3	18	6,735.5	57.6	0.00
Age	3,696.2	17	6,741.3	63.4	0.00
Year	4,647.8	30	7,719.2	1,041.3	0.00

Table 24. Parameter estimate (β), standard error (SE), odds ratios and 95-percent confidence intervals (CI) for the top model explaining annual survivorship of Least Bell's Vireos at the San Luis Rey Flood Risk Project Area, California, 2006–21.

[The Intercept (reference) represents first-year vireos, 2006–07. All other effects values are the difference between that parameter and the Intercept. Bold (*) indicates a significant effect. Abbreviation: +, plus]

Effect	β	SE	Odds ratio	95-percent CI
Age+year				
Intercept	−1.35	0.18	0.26	0.18–0.37
Adults*	2.46	0.08	11.67	9.93–13.71
2007–08	−0.30	0.26	0.74	0.45–1.22
2008–09	0.39	0.22	1.48	0.96–2.28
2009–10	−0.25	0.24	0.78	0.49–1.24
2010–11*	−0.84	0.24	0.43	0.27–0.69
2011–12*	−1.05	0.24	0.35	0.22–0.56
2012–13	0.11	0.26	1.12	0.67–1.86
2013–14	−0.44	0.23	0.64	0.41–1.02
2014–15	−0.11	0.26	0.90	0.54–1.50
2015–16	−0.31	0.24	0.73	0.46–1.16
2016–17	−0.22	0.24	0.80	0.50–1.29
2017–18	0.19	0.24	1.21	0.75–1.93
2018–19	−0.48	0.24	0.62	0.38–1.00
2019–20*	−0.55	0.27	0.57	0.34–0.97
2020–21	0.51	0.53	1.66	0.59–4.67

Table 25. Annual survivorship for adult and first-year Least Bell's Vireos at the San Luis Rey Flood Risk Project Area, California, 2006–21.

[Estimates were calculated from the top model]

Years	Adult survivorship (percent)	First-year survivorship (percent)
2006–07	75	21
2007–08	69	16
2008–09	82	28
2009–10	70	17
2010–11	57	10
2011–12	51	8
2012–13	77	22
2013–14	66	14
2014–15	73	19
2015–16	69	16
2016–17	71	17
2017–18	78	24
2018–19	65	14
2019–20	63	13
2020–21	83	30

First-year Dispersal 2007–21

We examined the return locations of first-year vireos in 2021 and compared them to dispersal observed in previous years. From 2007 to 2011, the majority (67–86 percent) of returning first-year vireos returned to the Project Area (table 26). As habitat in the Project Area became more limited following the commencement of mowing in 2012,

proportionately more birds dispersed to sites outside of the Project Area, a trend that continued until about 2017. Since 2018, the proportion of first-year vireos returning to the Project Area has been generally increasing, although, as of 2021, it was still below the proportions observed prior to vegetation mowing.

Table 26. Number of first-year Least Bell's Vireos that originated at the San Luis Rey Flood Risk Management Project Area and returned to the Project Area or returned to areas outside of the Project Area, 2007–21, by year and sex.

[Numbers in parentheses indicate the percent of returning first-year vireos that returned to that area. Middle San Luis Rey River is upstream from the Project Area, between College Boulevard and Interstate 15. **Abbreviations:** %, percent; —, no data]

Return year	Drainage location									
	San Luis Rey Project Area			Marine Corps Base Camp Pendleton		Middle San Luis Rey River		Other drainages		Outside Project Area total
	Male	Female	Project Area total	Male	Female	Male	Female	Male	Female	
2007	9	9	18 (75%)	—	3	1	1	¹ 1	—	6 (25%)
2008	16	4	20 (67%)	7	1	1	1	—	—	10 (33%)
2009	40	19	59 (79%)	8	1	3	—	² 3	³ 1	16 (21%)
2010	10	8	18 (69%)	4	1	2	—	⁴ 1	—	8 (31%)
2011	11	7	18 (86%)	1	—	1	—	⁵ 1	—	3 (14%)
2012	6	5	11 (61%)	5	1	—	—	⁶ 1	—	7 (39%)
2013	9	4	13 (57%)	2	2	3	—	⁷ 3	—	10 (43%)
2014	4	1	5 (31%)	4	3	2	1	⁸ 1	—	11 (69%)
2015	3	2	5 (50%)	4	—	—	1	—	—	5 (50%)
2016	9	5	14 (41%)	7	5	4	2	⁹ 2	—	20 (59%)
2017	9	4	13 (57%)	4	3	1	1	—	¹⁰ 1	10 (43%)
2018	35	14	49 (68%)	11	6	2	2	³ 1	¹¹ 1	23 (32%)
2019	5	5	10 (56%)	1	2	4	—	¹² 1	—	8 (44%)
2020	16	8	24 (62%)	5	3	3	4	—	—	15 (38%)
2021	9	1	10 (63%)	1	—	4	—	—	¹² 1	6 (37%)
Total	191	96	287 (64%)	64	31	31	13	15	4	158 (36%)

¹Detected at Elanus Creek, San Diego County.

²One detected at the Santa Ana River in Orange County, one detected at San Dieguito River, and one detected at Agua Hedionda, San Diego County.

³Detected at the San Diego River, San Diego County.

⁴Detected at Chollas Creek, San Diego County.

⁵Detected at Bonita Creek, Orange County.

⁶Detected at the San Dieguito River, San Diego County.

⁷One detected at the San Gabriel River, Los Angeles County, one detected at the Sweetwater River, and one detected at Moody Creek, San Diego County.

⁸Detected at Escondido Creek, San Diego County.

⁹One detected at the Tijuana River and one detected at Otay River, San Diego County.

¹⁰Detected at the Tijuana River, San Diego County.

¹¹Detected at the upper Santa Margarita River, upstream (12 kilometers) from MCBCP.

¹²Detected at Whelan Lake, San Diego County.

Adult Site Fidelity 2021

Resighting banded birds allowed us to identify individuals that either returned to the same territory they used in a previous year (within 100 m) or moved to a different location. Fifty adult vireos (46 males and 4 females) that were identified in 2020 at the Project Area were resighted in 2021 (appendix 7). Of the 50 returning adults, 33 (66 percent of all adults; 32 males, 70 percent of males; 1 female, 25 percent of females) occupied a territory in 2021 that they had defended in 2020 (within 100 m; appendix 7). Seven vireos (14 percent of all adults; 6 males, 13 percent of males; 1 female, 25 percent of females) detected in 2021 returned to areas next to their previous territories (within 300 m). The remaining 10 vireos (20 percent of all adults; 8 males, 17 percent of males; 2 females, 50 percent of females) detected in 2021 returned to areas more than 300 m from their previous territories. The average distance moved by returning 2021 adult vireos was 0.2 ± 0.3 km, range 0.0–1.6 km (0.2 ± 0.3 km, range 0.0–1.6 km for males; 0.4 ± 0.3 km, range 0.0–0.9 km for females).

Effect of Treatment on Adult Site Fidelity

Because we are interested in the cumulative effect of vegetation treatment over the years on the movement of returning banded vireos, we performed a linear regression

on the distance moved by banded vireos as a function of the expected Treatment Index for the vireos' 2020 territories (that is, the Treatment Index in 2021 if the bird had occupied exactly the same territory boundaries as in 2020). The residuals were skewed, so we log-transformed the data for analysis. We restricted our analysis to birds nesting in the Channel to avoid the confounding effects of passive habitat restoration that occurred Off-channel in 2017.

We found no effect of expected Treatment Index on distance moved between 2020 and 2021 ($P=0.84$, table 27).

Table 27. Generalized linear model results, parameter estimate, standard error (SE), *t* statistic and *P*-values for banded Least Bell's Vireo movement (log-transformed) as a function of the expected Treatment Index for 2020 territories at the San Luis Rey Flood Risk Management Project Area, California, 2021.

[<, less than]

Variable	Estimate	SE	<i>t</i> -value	<i>P</i>
Intercept	4.8	0.4	12.5	<0.01
Expected Treatment Index	4.3	21.6	0.2	0.84

Southwestern Willow Flycatcher

Population Size and Distribution

Twelve transient Willow Flycatchers of unknown subspecies were detected within the Project Area between May 17 and June 4, 2021. Four transients were detected in Reach 1, two in Reach 2, one in Tuley Canyon, two in Whelan Mitigation, two in Reach 3a, and one in Upper Pond (appendix 8, figs. 8.1–8.4). No flycatcher pairs were detected within the Project Area in 2021.

Habitat Characteristics

All 12 transient flycatchers used mixed willow riparian habitat in 2021 (table 28). The dominant native species in 10 of the flycatcher locations was red/arroyo willow. Two flycatchers were found in habitat dominated by sandbar willow. Eight flycatchers were located in habitat with 5–50 percent exotic vegetation and four were in habitat with less than 5-percent exotic vegetation. Poison hemlock and black mustard were the most common exotic species at flycatcher locations. Flycatchers were detected between 0 and 2.5 km away from surface water.

Table 28. Habitat characteristics of transient Willow Flycatchers at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[ID, identification; km, kilometer; <, less than]

Bird ID	Date first detected	Habitat type	Dominant species	Percent cover exotics	Dominant exotics	Distance to surface water (km)
BT01F	May 17	Mixed willow	Red/arroyo willow	5–50	Poison hemlock	2.5
BT02F	May 17	Mixed willow	Red/arroyo willow	5–50	Poison hemlock	0.6
BT03F	May 17	Mixed willow	Red/arroyo willow	5–50	Poison hemlock	0.0
BT04F	May 17	Mixed willow	Red/arroyo willow	5–50	Poison hemlock	1.0
BT05F	May 17	Mixed willow	Red/arroyo willow	5–50	Black mustard	0.2
CB01F	May 25	Mixed willow	Red/arroyo willow	<5	Black mustard	1.5
FO01F	May 24	Mixed willow	Sandbar willow	<5	Sweet clover	0.0
FO02F	May 24	Mixed willow	Sandbar willow	<5	Sweet clover	0.0
WH01F	May 20	Mixed willow	Red/arroyo willow	5–50	Giant reed	0.8
WH02F	May 24	Mixed willow	Red/arroyo willow	<5	Pepperweed	1.1
WH98F	June 4	Mixed willow	Red/arroyo willow	5–50	Black mustard	0.0
WH99F	June 4	Mixed willow	Red/arroyo willow	5–50	Black mustard	0.0

Vegetation Study

A total of 46 transects (516 sampling points) were sampled in the Project Area in 2021 (table 29; appendix 9, figs. 9.1–9.4). Seventy-one percent (366/516) of points were in the Channel and 22 percent (115/516) were Off-channel in Upper Pond. The remaining 7 percent (35/516) were located in the Whelan Restoration site. The number of points per transect varied between 4 and 18. Ten points were in homeless camps and were not sampled in 2021. Global Positioning System coordinates for the start and end point of each transect are provided in appendix 10.

Table 29. Number of vegetation transects and sampling points at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

Site type	Transects	Sampling points
Channel	31	366
Upper Pond	13	115
Whelan Restoration	2	35
Total	46	516

Vegetation Structure and Composition

There was more foliage cover below 1 m in the Channel than in Upper Pond and Whelan Restoration (fig. 12). Above 1 m, foliage cover was similar at the Channel and Whelan Restoration and was greater than at Upper Pond. Overall, foliage cover was low above 6 m and was highest in the Channel. Average live canopy height and maximum canopy height (including live and dead vegetation) was higher in the Channel (5.1 ± 2.9 m) compared to Upper Pond (4.2 ± 2.4 m) and Whelan Restoration (4.2 ± 1.7 m).

Vegetation composition in the Channel differed from that in Upper Pond and Whelan Restoration (fig. 13). Tree cover, dominated by red/arroyo willow, was higher in the Channel (40 percent) and Whelan Restoration (39 percent) compared to Upper Pond (23 percent). In contrast, shrub cover was substantially lower in the Channel (10 percent) than in Upper Pond (38 percent) and Whelan Restoration (34 percent). Mule fat was the dominant shrub species at all three site types. Herbaceous cover was nearly 3 times greater in the Channel (29 percent) and Upper Pond (26 percent) than in Whelan Restoration (9 percent). Marsh species such as bulrush (*Scirpus* sp.), sedge (*Carex* sp.), and cattail (*Typha latifolia*) comprised 59 percent of the total herbaceous cover in the Channel. Exotic species cover also was higher in the Channel (19 percent) than at Whelan Restoration (10 percent) and Upper Pond (5 percent). Dead, woody cover was highest in Upper Pond (8 percent) and Whelan Restoration (8 percent), compared to the Channel (2 percent). Dead vegetation in Upper Pond and Whelan Restoration was primarily red/arroyo willow, whereas most dead species in the Channel could not be identified or consisted of large debris piles from prior flooding.

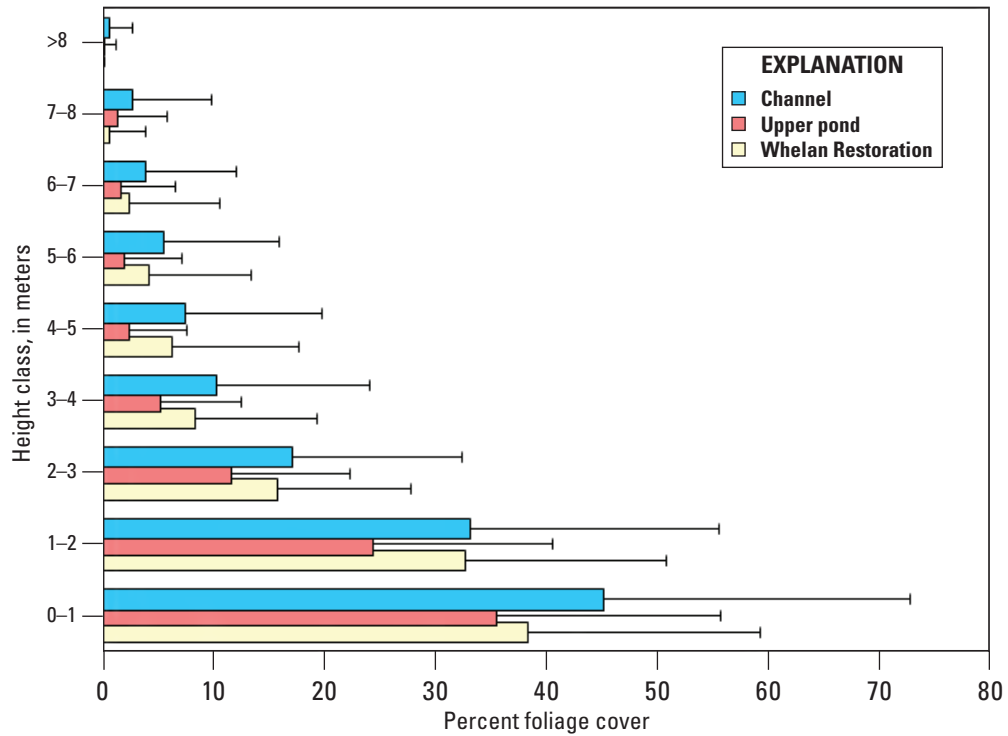


Figure 12. Average percent foliage cover by height class (meters) at the San Luis Rey Flood Risk Management Project Area, California, in 2021. Bars are standard deviations.

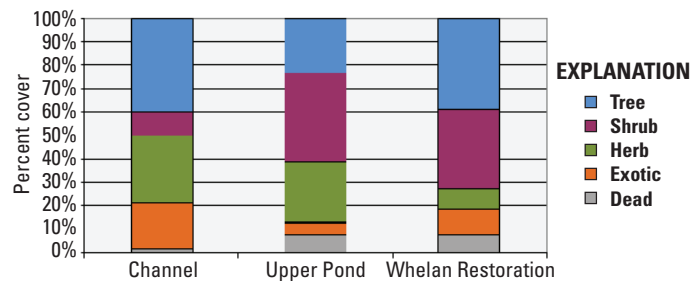


Figure 13. Percent of total cover by vegetation type at Channel, Upper Pond, and Whelan Restoration sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

Vegetation Changes 2006–21

When we examined the cumulative effects of management activities on vegetation structure over time at the Project Area, and we found significant changes from 2006 to 2021 in the Channel, Upper Pond, and Whelan Restoration (figs. 14–16). In the Channel, we found significant negative trends for all height classes above 2 m (2–3 m: $R^2=0.28$, $P=0.02$, 3–4 m: $R^2=0.20$, $P=0.05$, 4–5 m: $R^2=0.22$, $P=0.04$, 5–6 m: $R^2=0.33$, $P=0.01$, 6–7 m: $R^2=0.44$, $P=0.00$, 7–8 m: $R^2=0.48$, $P=0.00$, greater than 8 m: $R^2=0.64$, $P=0.00$ [fig. 13]). Decreases were steeper from 2008 to 13 and 2014 to 16 than from 2006 to 2008. Since 2016, percent foliage cover increased for the lowest height classes (0–2 m), as herbaceous cover doubled between 2016 (13 percent) and 2020 (28 percent), and has remained high through 2021

(29 percent). Although some increases were observed above 2 m after 2016, overall percent foliage cover remained lower than levels detected prior to 2009.

At Upper Pond, we found a significant negative trend from 2006 to 2021 at the 4–5 m height class only (4–5 m: $R^2=0.30$, $P=0.02$ [fig. 15]). Foliage cover steadily decreased from 2013 to 2021 (from 6 percent to 2 percent) at the 4–5 m class. No other significant trends were detected at Upper Pond.

At Whelan Restoration, we found a significant negative trend for the highest height class (above 8 m) only ($R^2=0.33$, $P=0.01$). From 2006 to 2009, before active restoration was initiated in 2014, foliage cover above 8 m was low (2 percent), and since 2009, foliage cover above 8 m has been almost absent (fig. 16). Below 8 m, there were no significant increasing or decreasing trends in foliage cover at Whelan Restoration.

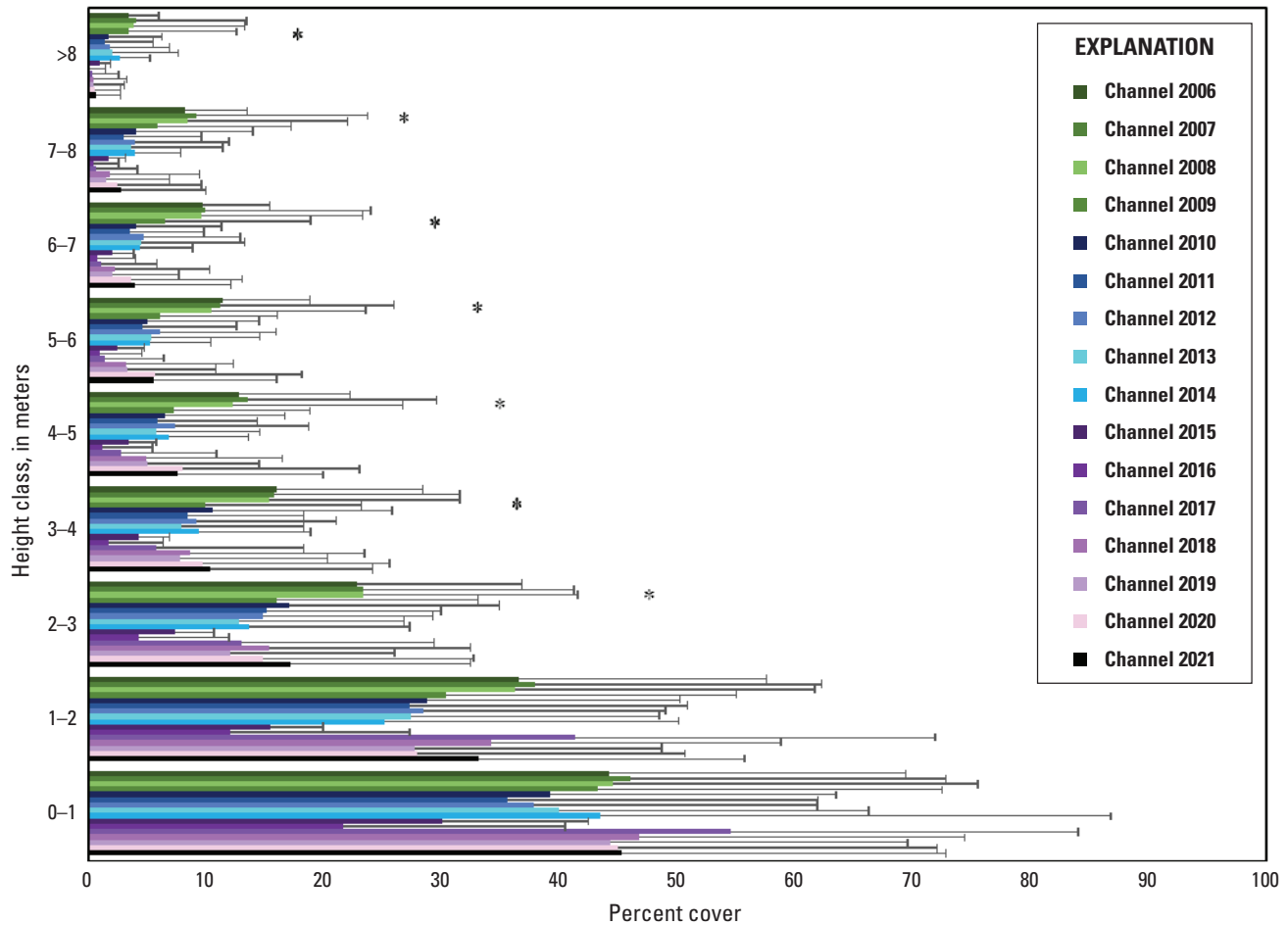


Figure 14. Average percent foliage cover by height class (meters) for the Channel at the San Luis Rey Flood Risk Management Project Area 2006–21. Bars are standard deviations. Asterisks (*) indicate statistically significant trends 2006–21 ($P \leq 0.10$, linear regression).

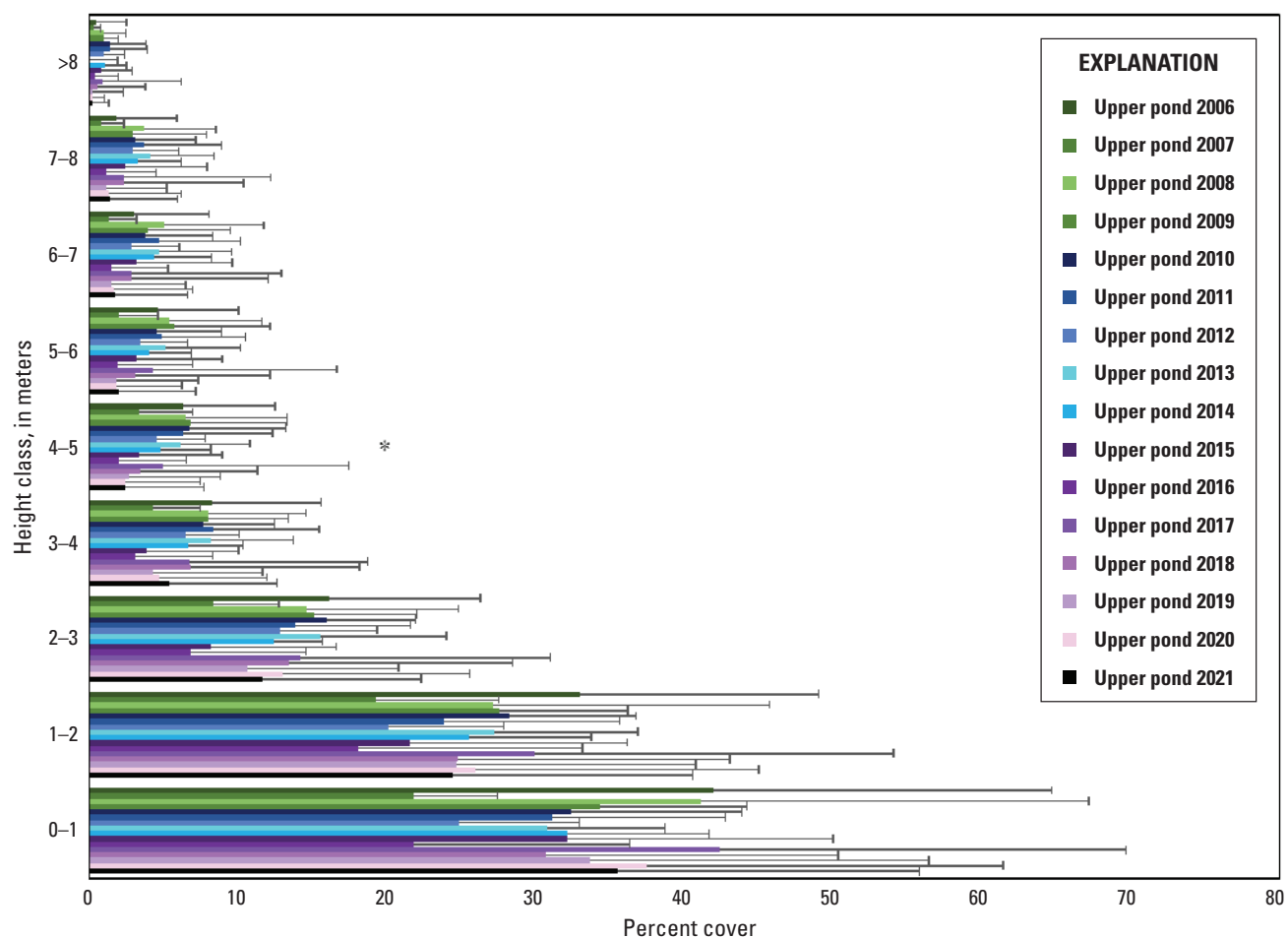


Figure 15. Average percent foliage cover by height class (meters) for Upper Pond at the San Luis Rey Flood Risk Management Project Area 2006–21. Bars are standard deviations. Asterisks (*) indicate statistically significant trends 2006–21 ($P \leq 0.10$, linear regression).

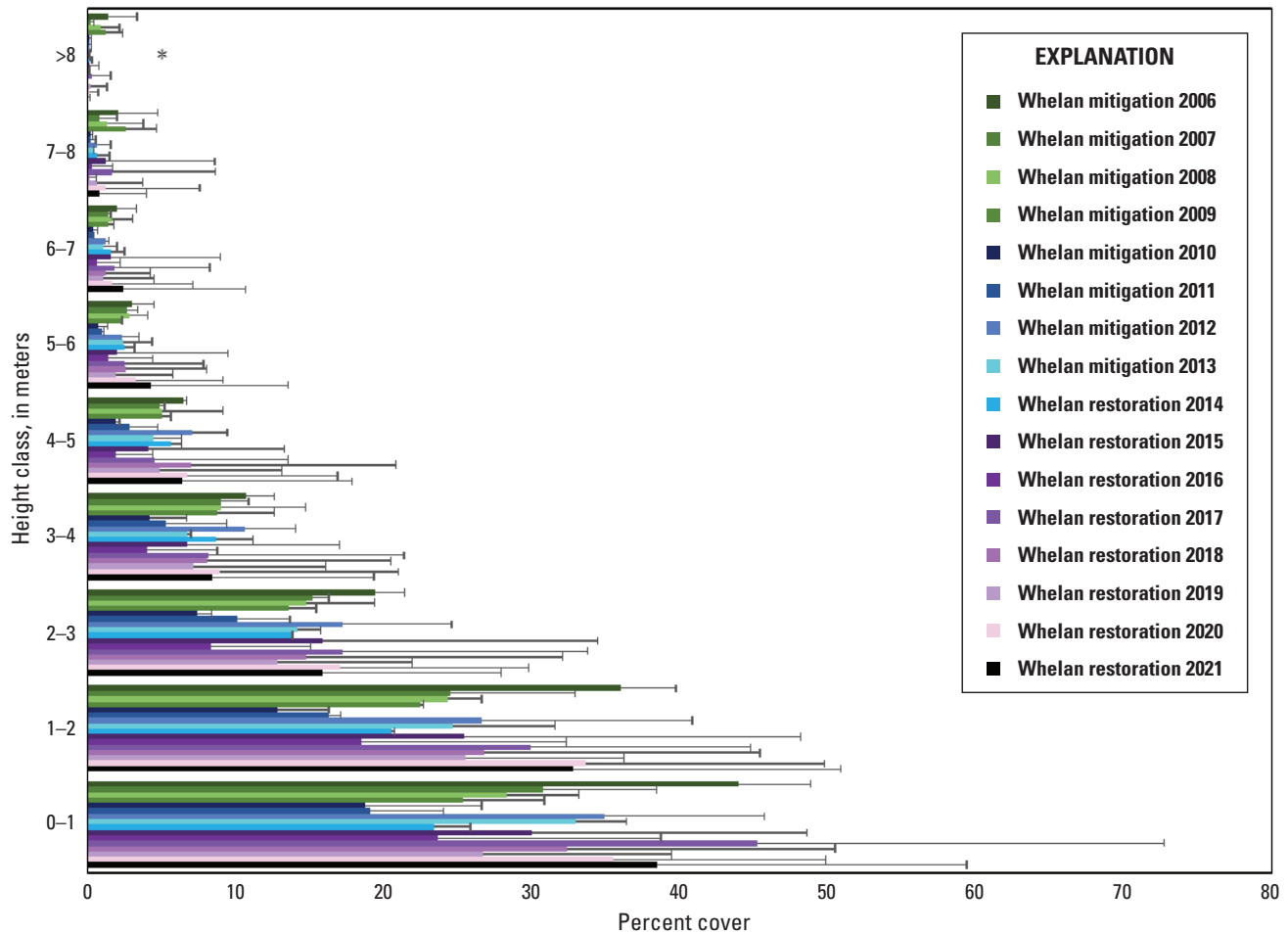


Figure 16. Average percent foliage cover by height class (meters) for Whelan Restoration and Whelan Mitigation at the San Luis Rey Flood Risk Management Project Area 2006–21. Vegetation points are the same throughout; however, Whelan Restoration was referred to as Whelan Mitigation prior to 2014. Bars are standard deviations. Asterisks (*) indicate statistically significant trends 2006–21 ($P \leq 0.10$, linear regression).

Vireo Habitat Use

We measured vegetation characteristics at 35 nest plots and 35 territory plots (280 sampling points) within the Channel and 10 nest and 10 territory plots (80 sampling points) at Upper Pond. In the Channel, foliage cover between 0 and 2 m in territory plots was significantly lower than what was available, indicating that vireos established territories in areas with less foliage in the low understory. Vireos did not appear to be selective regarding vegetation cover above 2 m, although cover above 8 m was significantly higher than what

was available in the Channel. When comparing vegetation at the nest to that in the territory, we found that vireos selected nest sites randomly, with regard to foliage cover at most height classes, except below 1 m where they selected nest sites with lower foliage cover (fig. 17). In contrast to the Channel, vireos in Upper Pond established territories in habitat with greater cover in the mid-canopy than what was available but were similar to Channel birds in siting nests generally at random with regard to available habitat within the territory (fig. 18).

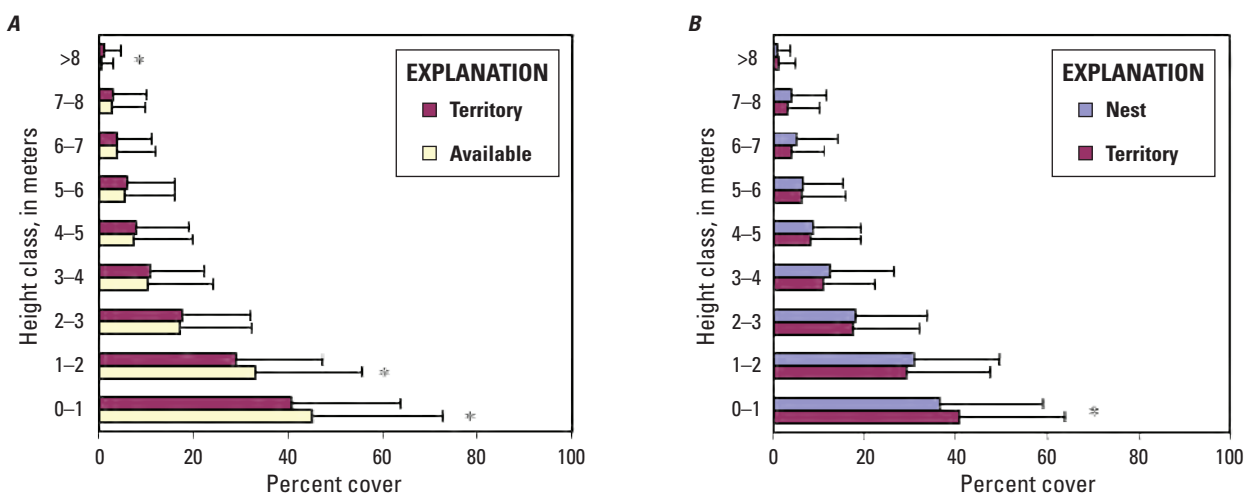


Figure 17. A, Average percent foliage cover for territory plots ($n=35$) compared to vegetation transects ($n=31$, shown as “available”); and B, nest plots ($n=35$) compared to territory plots ($n=35$) by height class in the Channel at the San Luis Rey Flood Risk Management Project Area, California, in 2021. Bars are standard deviations. Asterisks denote significant differences between plots by height class ($P \leq 0.10$).

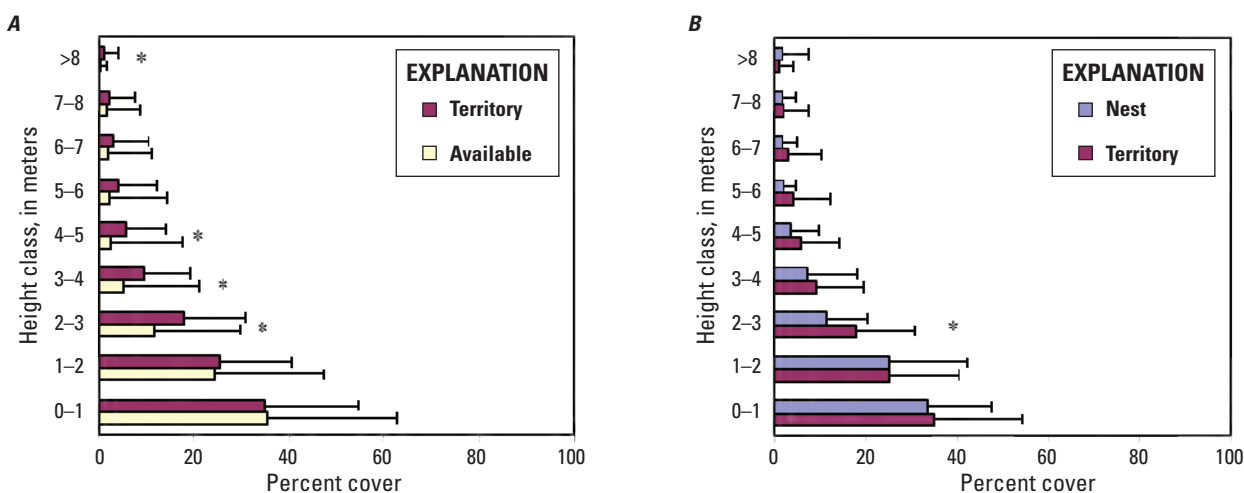


Figure 18. A, Average percent foliage cover for territory plots ($n=10$) compared to vegetation transects ($n=13$, shown as “available”); and B, nest plots ($n=10$) compared to territory plots ($n=10$) by height class in the Upper Pond at the San Luis Rey Flood Risk Management Project Area, California, in 2021. Bars are standard deviations. Asterisks denote significant differences between plots by height class ($P \leq 0.10$).

Discussion

The Least Bell's Vireo population (122 territories) at the San Luis Rey Flood Risk Management Project Area decreased by 24 percent between 2020 and 2021 but was similar to the number of territories observed in other recent years (130 in 2018 and 128 in 2019). From the time surveys were initiated in 1984, the population grew steadily until it peaked in 2009, likely the result of an increase in suitable riparian habitat during the 1990s, cowbird control, and high productivity of nesting pairs (Kus and Whitfield, 2005). Following the 2009 peak, the population experienced several years of declines before reaching a low of 76 territories in 2012, after which it stabilized, hovering between 78 and 103 territories. In 2018, the population increased and has remained higher (greater than 120 territories) since that time, including a population spike in 2020, likely in response to high productivity in 2019. Over the past 4 years, the vireo population in the Project Area has largely tracked regional trends, with the population stable or increasing in 2018 (Ferree and Clark, 2018; U.S. Geological Survey, unpub. data, 2018; Allen and Kus, 2019), decreasing in 2019 (Ferree and Clark, 2019; U.S. Geological Survey, unpub. data 2019), and increasing again in 2020 (Ferree and Clark, 2020; U.S. Geological Survey, unpub. data, 2020; Allen and Kus, 2021; Ferree and Clark, 2021). In 2021, we observed a region-wide decrease in the vireo population, with an 18-percent drop at MCBP (U.S. Geological Survey, unpub. data, 2021), a 6 percent drop on the middle San Luis Rey River (U.S. Geological Survey, unpub. data, 2021), and a 5 percent drop on the Otay River (K. Ferree, San Diego Natural History Museum, written commun., 2021). There also was a 44-percent decrease documented at Marine Corps Air Station Camp Pendleton (K. Ferree, San Diego Natural History Museum, written commun., 2021), although this decrease was exaggerated in response to large-scale clearing of riparian vegetation that occurred at the Air Station prior to the breeding season in 2020.

Using the Treatment Index to create a quantitative snapshot in time of the vegetation removal from 2006 through the present incorporates spatial and temporal variability in vegetation structure and provides a useful approach for explaining vireos' reproductive and behavioral responses to habitat alteration. In 2021, as in 2015–20, our analyses did not reveal a relationship between the Treatment Index and reproductive parameters such as the number of fledglings produced per pair. Vireo territory selection, however, continued to respond to vegetation removal as represented by the Treatment Index. Since 2015, we have found that vireos have selected territories in less treated habitat and moved to avoid heavily treated areas. In 2021, the average Treatment Index of unoccupied habitat was more than double that of

occupied habitat, even in a year with no mowing, indicating an avoidance of more recently treated habitat, as vireos selected territories along the Channel edges that have been less affected by mowing. However, unlike in 2016 and 2017, but similar to 2018–20, we did not find an effect of territory treatment on the movement of individual banded birds between 2020 and 2021, which is not surprising given that there was no mowing in the fall of 2020.

Our analysis of vireo habitat supported the finding that vireos tend to avoid more recently and heavily treated sections of the river when selecting their territories. In the Channel, most of the herbaceous and exotic growth occurred in the middle where vegetation has been mowed. Vireos tended to avoid the middle of the Channel and instead limited their territories to the edges, where more mature, woody vegetation persisted. Our analysis of vireo habitat showed that vireo territories in the Channel had less total cover below 2 m and more cover above 8 m compared to what was available, which describes the strips of mature habitat along the edges of the Channel. Within territories, however, Channel vireos placed nests largely at random, selecting nest sites that had slightly less cover below 1 m but were otherwise similar to the rest of the territory in vegetation structure. In Upper Pond, which has not been subject to widespread mowing, we found that vireos were more selective with regard to territory selection in 2021 compared to previous years. Vireos selected territories with greater cover in the mid- and upper canopy (between 2 and 5 m and more than 8 m). In previous years, vireos were less selective with regard to territory but more selective with regard to nest site. This year the trend was reversed, perhaps, because of a steady decline in habitat quality in Upper Pond as trees have been dying during the drought, resulting in vireos selecting territories where the shrub and tree layers were beginning to recover.

Since mowing of the Channel began in 2005, we have documented a steady decline in total percent foliage cover at all height classes above 2 m. Steeper annual declines in percent cover, not surprisingly, coincided with large mowing events. Herbaceous (native and exotic) cover recovered quickly after mowing and made up the bulk of the vegetation in the Channel in 2021, in contrast to Upper Pond and Whelan Restoration, which had a greater proportion of shrub cover. In general, shrub cover has not recovered in the Channel (and was limited to the Channel edges), as significant negative trends were found for all height classes over 2 m. Not surprisingly, we found fewer significant negative trends from 2006 to 2021 in percent foliage cover at Upper Pond and Whelan Restoration, and instead documented annual fluctuations in both directions, likely primarily in response to environmental conditions such as variations in annual precipitation.

Nest success was lower in 2021 (39 percent of completed nests successful) compared with 2020 (50 percent of completed nests successful) and did not differ by site type. Vireo breeding productivity also was slightly lower in 2021 compared with 2020 and was lower than the 15-year average. Double-brooding, although slightly higher in 2021 compared with 2020, was low compared to long-term averages. This 2-year decline in nest success and breeding productivity across the Project Area was likely in response to lower-than-average precipitation during the preceding year coupled with increased cowbird parasitism. In 2021, parasitism by Brown-headed Cowbirds was 400 percent higher than in 2020. This large spike in cowbird parasitism likely was caused, in part, by a delay in opening cowbird traps in 2021. In most years, cowbird traps begin operation on April 1, but in 2021, cowbird trapping did not commence until April 28. Historically, the majority of cowbirds have been captured and removed from the population during the month of April. Having the traps closed for most of the month, allowing birds to become established on the river during this time, may have had a significant impact on the population of cowbirds, resulting in the high parasitism rates observed this year. Additionally, one trap was vandalized in June, resulting in six lost trapping days and the release of bait birds (J. Sexton, T.W. Biological Services, written commun., 2021). In contrast, there were no incidents of Brown-headed Cowbird parasitism on MCBCP in 2021 (U.S. Geological Survey, unpub. data, 2021) where traps were opened on schedule and remained open throughout the breeding season.

Banding of vireos with unique color combinations (starting in 2006) has allowed us to estimate adult and first-year survival rates as well as examine adult and first-year movement between and within years at the Project Area and across drainages throughout southern California. In 2021, we had fewer banded birds overall in the Project Area (the lowest number since 2008), and more specifically, fewer banded birds in the older age classes. Between 2015 (the year in which the cohort of 2006 nestlings would have reached nine years of age) and 2020, on average 12 percent (range 6–18 percent) of banded vireos were age 7 years or older. In 2021, we had no birds over the age of 6 years. There has been a steady decline in the oldest age classes since 2017. Seemingly, in contrast to the low number of banded adults returning to the Project Area in 2021, were the high estimates of adult and first-year survival derived from MARK. Our top model, which included an effect of year and age on survival and year on detection probability, estimated adult survival at 83 percent between 2020 and 2021, which was considerably higher than the estimates of adult male and adult female survival from the adults-only model (43 and 35 percent, respectively). We suspect the estimate of 2020–21 survival is inflated as a result of the apparent lower rate of return for banded adults in 2021, which is reflected in the low detection probability (0.42) for this interval. In the adults-only model, detection probability

varied only by sex (0.90 for males and 0.79 for females), not by year, likely resulting in the contrasting results of the two models. Adult vireos continued to show relatively strong site fidelity in 2021, with 66 percent of vireos returning to within 100 m of their 2020 territory.

Beginning in 2012, and especially between 2014 and 2016, we detected a shift in the proportion of first-year vireos returning to the Project Area to breed, with more birds dispersing to areas outside of the Project Area. This may be attributed to a decrease in available habitat within the Project Area, likely a result of increased vegetation removal in 2014 and 2015 coupled with drought conditions. However, since 2017, first-year vireos have been more likely to return to the Project Area for breeding. This return has coincided with increased precipitation in 3 out of the last 5 years, along with more moderate mowing, which has likely contributed to an increase in habitat available for new breeders in the Project Area. In 2021, 63 percent of first-year birds returned to the Project Area, which is similar to the 15-year average of 64 percent.

Southwestern Willow Flycatcher

No breeding pairs of flycatchers were detected in 2021. This was the 15th year that the Project Area has not been occupied by Willow Flycatchers since it was colonized, and monitoring began in 2000 (Kus and Rourke, 2005). It is unknown why flycatchers did not breed in the Project Area, although conditions in the historical flycatcher territories have been gradually changing since 2006 when three pairs occupied the Project Area. At Whelan Restoration, in particular, large canopy trees such as red/arroyo willows and black willows have been dying, and restoration efforts are still in early phases, so this historic breeding site is likely still too sparse and open for flycatchers.

Vegetation clearing does not appear to have played a role in the decline of the flycatcher in the San Luis Rey Flood Risk Management Project Area population. More likely explanations, in addition to habitat change, include other life history factors, such as first-year or adult mortality experienced during migration or on the wintering grounds. At nearby Marine Corps Base Camp Pendleton, the resident population of flycatchers also declined for 10 years, from 26 individuals in 2007 to 0 individuals in 2017 (S. Howell, U.S. Geological Survey, unpub. data, 2017). In 2018, a social attraction study commenced at Camp Pendleton. In 2018–19, three resident breeders were documented; in 2020, two resident breeders were documented; and in 2021, one breeding female was documented (S. Howell, U.S. Geological Survey, unpub. data, 2018, 2019, 2020, 2021). Collection of more data on the distribution and demographics of this declining species is warranted.

Conclusion

The vireo population decreased in 2021, from a population spike in 2020, to levels comparable to what we observed in 2018 and 2019. Nest success and productivity, however, remained low in 2021, likely in response to lower-than-average precipitation in the preceding winter and increased levels of Brown-headed Cowbird parasitism. Although we continue to find no effect of vegetation treatment on measures of reproductive success, we do find a strong effect of treatment on vireo territory selection. For the past 7 years, we have documented an avoidance of recently treated habitat, even in years in which there was no treatment, suggesting that vireos require more than 1 year of habitat recovery between mowing events for territory selection. Mowing of the channel has resulted in two distinct habitat types, neither of which is ideal for vireos. The herbaceous middle of the Channel is too dense in the lower height classes, lacks canopy cover, and has less woody substrate that vireos prefer for nesting. The edges of the Channel are possibly becoming too mature, lacking cover diversity in the lower height classes. A gradient in habitat successional stages within the Project Area and continued and consistent Brown-headed Cowbird trapping would be ideal and help to ensure that vireos will be able to continue breeding successfully in the Project Area.

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Appendix 1. Timeline and Description of Vegetation Treatments at the San Luis Rey Flood Risk Management Project Area, California, 2005–21

This appendix describes the type, extent, and location of all of the vegetation treatment that has occurred in the Project Area from 2005 through 2021.

Table 1.1. Timeline and description of vegetation treatments at the San Luis Rey Flood Risk Management Project Area, California, 2005–21.

[ha, hectare; m, meter; ft, foot; km, kilometer; —, no data; GPS, Global Positioning System; GIS, geographic information system]

Date	Vegetation treatment	Vegetation management	Treatment location	Area [ha (acres)]	Comments
December 2005	Giant reed removal	First phase of risk reduction ¹ was to remove large stands of giant reed.	Reaches 2–4	9.4 (23.2)	Giant reed was mowed using a large mower with biomass chipped or shredded in situ.
March 2006	Vegetation removal	Second phase of risk reduction was to mow/mulch vegetation 30 m (100 ft) wide.	Reaches 2–4	18.0 (44.5)	30-m (100-ft) swath of vegetation in the river channel from Benet Road to College Boulevard (7.5 km [4.6 miles]) was mowed and mulched, overlapping when possible with the giant reed eradication areas.
2006 Least Bell's Vireo breeding season (April–July)					
October 2006	Herbicide treatment	Giant reed sprayed with herbicide.	Reach 4 (below College Boulevard)	0.4 (1.0)	This spraying was an experimental effort to see if the herbicide after mowing approach would be effective.
2007 Least Bell's Vireo breeding season (April–July)					
November–December 2007	Herbicide treatment	Giant reed sprayed with herbicide.	Reach 1 (Benet Road to 1–5 and south of main river channel)	11.9 (29.4)	—
February–March 2008	Vegetation removal	First Phase 1 ² mowing, not completed.	Reach 1	6.5 (16.1)	Only 7 days of mowing completed before rains and vireo breeding season began.
2008 Least Bell's Vireo breeding season (April–July)					
July 2008	Herbicide treatment	Pepperweed sprayed.	Reach 1 (downstream from Benet Road)	0.08 (0.2)	—
September–December 2008	Vegetation removal	First Phase 1 mowing.	Reaches 2–4	37.9 (93.7)	Phase 1 mowing continued after vireo breeding season.
September–October 2008	Giant reed removal and herbicide treatment	Re-treatment of giant reed sprayed in 2005.	Reaches 2–4	2.3 (5.7)	Extensive mowing and chemical re-treatment of some giant reed areas that had been targeted in 2005 was conducted from Benet Road to College Boulevard. This completed the initial clearing of Phase 1.
March 2009	Herbicide treatment	Re-treatment of giant reed sprayed in 2005.	Reaches 3b and 4	3.2 (7.9)	—
2009 Least Bell's Vireo breeding season (April–July)					

Table 1.1. Timeline and description of vegetation treatments at the San Luis Rey Flood Risk Management Project Area, California, 2005–21.—Continued

[ha, hectare; m, meter; ft, foot; km, kilometer; —, no data; GPS, Global Positioning System; GIS, geographic information system]

Date	Vegetation treatment	Vegetation management	Treatment location	Area [ha (acres)]	Comments
October–November 2009	Vegetation removal	Mowing with material hand-removed.	Reach 1	5.1 (12.6)	—
October–December 2010	Herbicide treatment	Giant reed sprayed.	Reach 1	8.2 (20.3)	—
December 2010	Vegetation removal	Second Phase 1 mowing not completed.	Reaches 3a and 3b	8.8 (21.7)	Phase 1 mowing by the city of Oceanside. Mowing not completed because of rains.
February 2011	Herbicide treatment	Giant reed sprayed with herbicide.	Reach 1	5.0 (12.4)	Resprouted giant reed was sprayed with herbicide within the area of Reach 1 that was mowed in 2009.
August–December 2011	Herbicide treatment	Weed eradication throughout Project Area, except annually mowed area.	Reaches 1–4	34.4 (85.0)	Benet Road to I-5 and College Boulevard to 152 m (500 ft) downstream from Fousat Road were treated before stopping for the season. Lower Pond, Tuley Canyon, and Park Pond also treated.
September–October 2011	Vegetation removal	Third Phase 1 mowing completed.	Reaches 1, 2, and 4	32.8 (81.1)	Phase 1 mowing by the city of Oceanside.
July–September 2012	Herbicide treatment	Giant reed sprayed in Phase 1 mowed area.	Reaches 2–4	— ³	—
October–November 2012	Herbicide treatment	Giant reed sprayed.	Reach 1 (west of Benet Road, north side of the river channel)	— ³	—
November–December 2012	Vegetation removal	First Phase 2 ⁴ mowing completed; all reaches.	Reaches 1–4	18.1 (44.7)	—
October 2012	Active restoration	Planting started.	Reach 1	11.9 (29.4)	—
September 2013–January 2014	Exotic vegetation removal	Exotic plant and tree removal throughout Project Area.	Reaches 1–4, Upper Pond, Whelan Mitigation	— ³	No GPS data recorded so exact location and acreage affected is not available.
March–April 2014	Pole cuttings	Remedial planting.	Reaches 1, Reach 2, Reach 3a and Reach 3b	0.2 (0.5)	—

Table 1.1. Timeline and description of vegetation treatments at the San Luis Rey Flood Risk Management Project Area, California, 2005–21.—Continued

[ha, hectare; m, meter; ft, foot; km, kilometer; —, no data; GPS, Global Positioning System; GIS, geographic information system]

Date	Vegetation treatment	Vegetation management	Treatment location	Area [ha (acres)]	Comments
2014 Least Bell's Vireo breeding season (April–July)					
October 2014	Vegetation removal	Phase 1, Phase 2, Rotation 1	Reaches 1–4	56.0 (138.4)	—
September–November 2014	Active restoration	Planting early March; Bi-monthly watering, herbicide treatment and weed control.	Reach 1	11.9 (29.4)	—
March–November 2014	Active restoration	Planting early March; Bi-monthly watering, herbicide treatment and weed control.	Reach 4	0.4 (1.0)	—
March–November 2014	Active restoration	Earthwork March 6–April 20, 2014; Planting May–June 2014; Bi-weekly watering May–November 2014.	Whelan Mitigation	10.5 (25.9)	—
2015 Least Bell's Vireo breeding season (April–July)					
November–December 2015	Vegetation removal	Annual mowing Phase 1, Phase 2, and Phase 3; Rotational mowing Rotation 1 and Rotation 2.	Reaches 1–4	65.8 (162.6)	—
December 2015–January 2016	Restoration enhancement	Manual trimming and mowing.	Upper Pond	2.5 (6.2)	—
December 2015–January 2016	Restoration enhancement	Manual trimming and mowing.	Park Pond	4.0 (9.9)	—
December 2015–January 2016	Restoration enhancement	Manual trimming and mowing.	Reach 3a	0.1 (0.2)	—
2016 Least Bell's Vireo breeding season (April–July)					
October–November 2016	Herbicide treatment	Spraying	Project-wide	18.3 (45.1)	Hand spraying of exotic weeds throughout Project Area.
2017 Least Bell's Vireo breeding season (April–July)					
September–October 2017	Vegetation removal	Annual mowing Phase 1 and boundary mowing.	Reach 1, 3, 4	28.2 (69.7)	Boundary mowing occurred in Reach 1 in preparation for sediment removal.
November 2017	Restoration enhancement	Herbicide spraying.	Upper Pond and Park Pond	— ³	Spraying and cutting of exotic weeds in Upper Pond and Park Pond. No GIS data collected to calculate area.
February 2018	Vegetation removal	Giant reed cut and removed.	Upper Pond and Park Pond	— ³	Giant reed was cut and removed from Upper Pond and Park Pond. No GIS data collected to calculate area.

Table 1.1. Timeline and description of vegetation treatments at the San Luis Rey Flood Risk Management Project Area, California, 2005–21.—Continued

[ha, hectare; m, meter; ft, foot; km, kilometer; —, no data; GPS, Global Positioning System; GIS, geographic information system]

Date	Vegetation treatment	Vegetation management	Treatment location	Area [ha (acres)]	Comments
2018 Least Bell's Vireo breeding season (April–July)					
Fall 2018	Vegetation removal	Annual mowing Phase 1 and Phase 2.	Reach 2	16.2 (40.1)	—
April 2018	Herbicide spraying	Weed eradication.	Upper Pond and Park Pond	— ³	Herbicide applied to exotic weeds around pole plantings in Upper Pond and Park Pond. No GIS data collected to calculate area.
2019 Least Bell's Vireo breeding season (April–July)					
November–December 2019	Vegetation removal	Annual mowing Phase 1 and Phase 2.	Reaches 1–4	31.2 (77.2)	—
2020 Least Bell's Vireo breeding season (April–July)					
November–December 2020	Herbicide spraying	Herbicide Spraying.	Reach 1 and Whelan restoration	— ³	Spraying of exotic weeds in restoration areas. No GPS data recorded so exact location and acreage affected is not available.
2021 Least Bell's Vireo breeding season (April–July)					

¹Risk Reduction was implemented in 2005 to reduce the risk of flooding during the 2006 rainy season.

²Phase 1 mowing was the first phase of the San Luis Rey Flood Risk Management Project to remove vegetation from the San Luis Rey River flood control channel to reduce the risk of flooding.

³Acreage not available.

⁴Phase 2 mowing includes mowing associated with maintaining the Phase 1 mowed area.

Appendix 2. Locations of Least Bell's Vireo Territories and Completed Nests at the San Luis Rey Flood Risk Management Project Area, California, 2021

This appendix includes maps showing the location of all Least Bell's Vireo territories and completed nests within the Project Area.

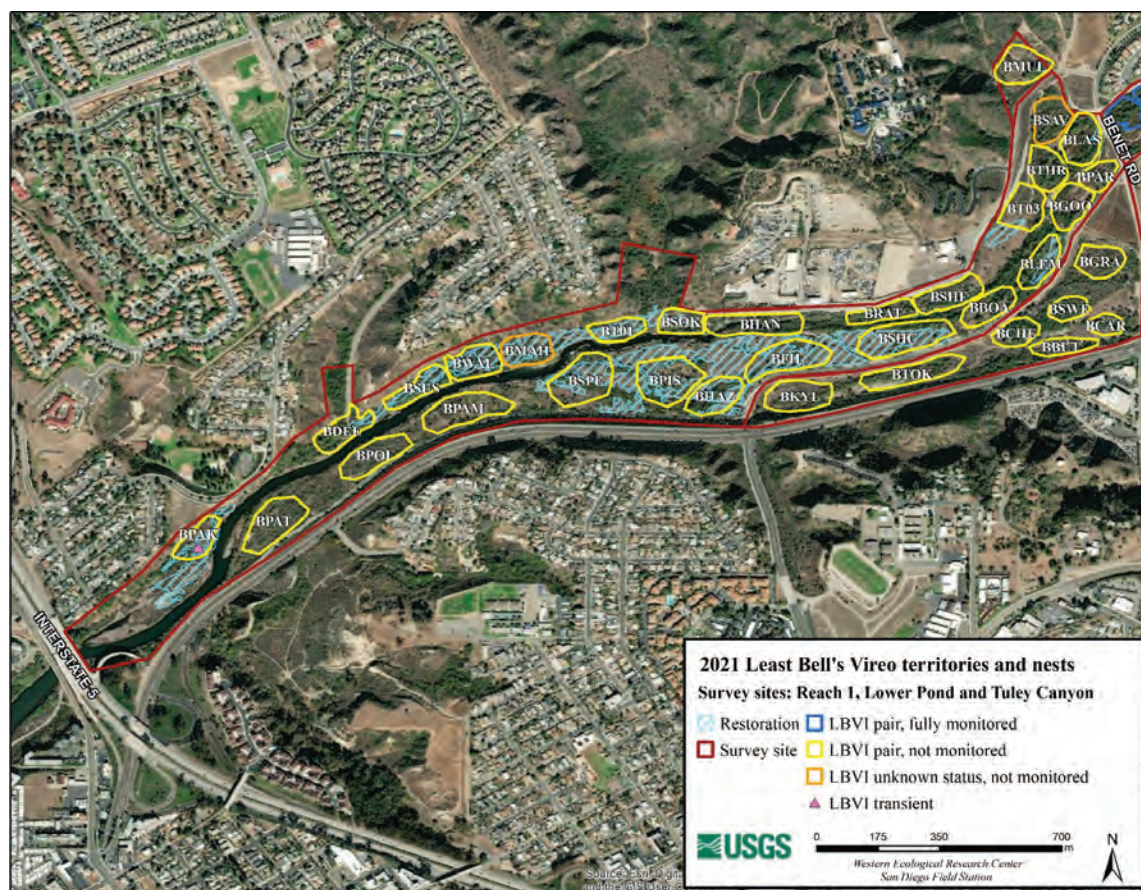


Figure 2.1. Locations of Least Bell's Vireo territories in Reach 1, Lower Pond, and Tuley Canyon survey sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.



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Figure 2.2. Locations of Least Bell's Vireo territories and nests in Reach 2 survey site at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

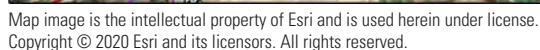


Figure 2.3. Locations of Least Bell's Vireo territories and nests in Reach 3a, Reach 3b, Park Pond, Pilgrim Pond, and Whelan Mitigation survey sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

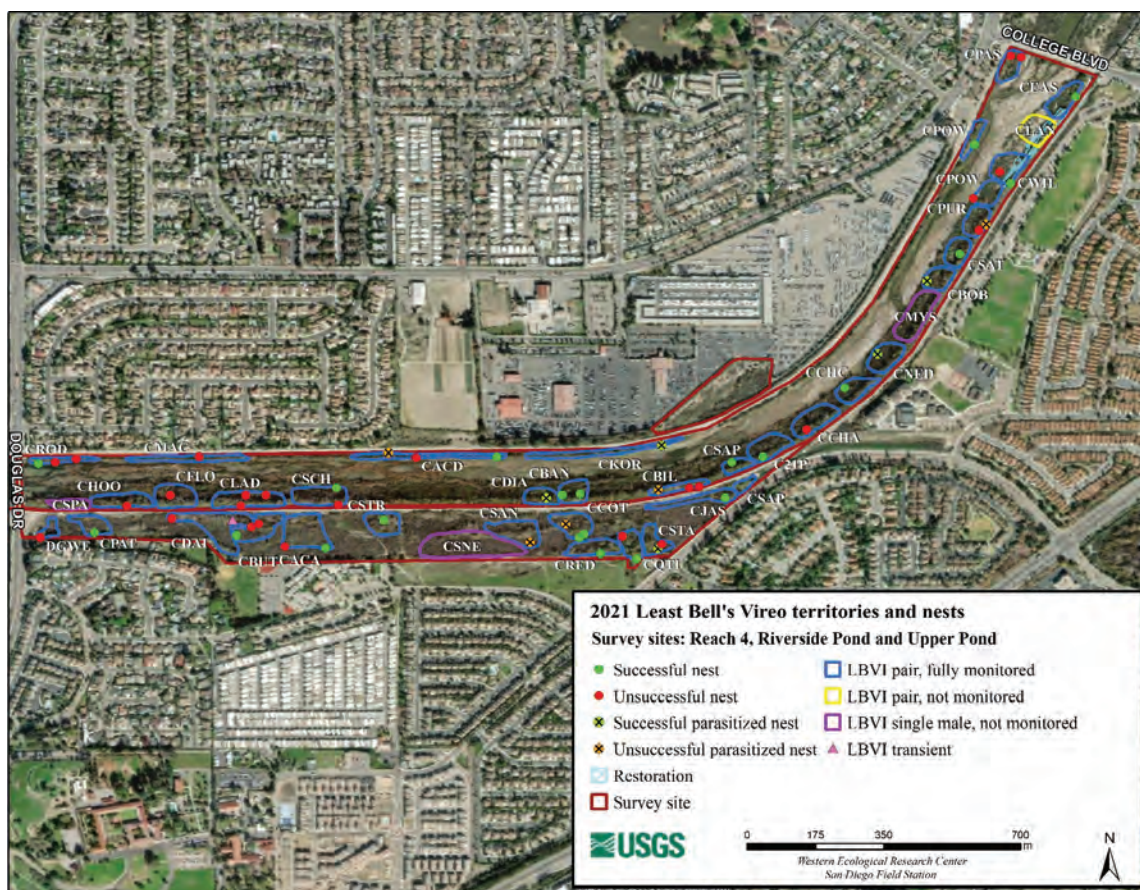


Figure 2.4. Locations of Least Bell's Vireo territories and nests in Reach 4, Riverside Pond, and Upper Pond survey sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

Appendix 3. Status and Nesting Activities of Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021

This is an appendix of all monitored vireo nests with the nest location, nest fate, number of young fledged, and any relevant comments.

Table 3.1. Status and nesting activities of Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[**Nest Fate:** FAL, nest built by unpaired male; INC, nest never completed; OTH, reason for nest failure known, such as substrate failure; PAR, failed as a result of Brown-headed Cowbird parasitism; PRE, nest failure caused by predation event; SUC, fledged at least one Least Bell's Vireo young; UNK, reason for nest failure/abandonment unknown. **Abbreviation:** —, no data]

Survey site	Territory	Nest	Nest fate	Number fledged	Comments
Channel					
Reach 2	FAQU	1	SUC	1	—
Reach 2	FBRI	1	PRE	0	—
Reach 2	FO1	1	PRE	0	—
Reach 2	FO6	1	SUC	3	—
Reach 2	FO8	1	SUC	3	—
Reach 2	FGOO	1	SUC	2	—
Reach 2	FMAV	1	PRE	0	—
Reach 2	FNER	1	SUC	3	Cowbird egg removed.
Reach 2	FRAS	1	PRE	0	—
Reach 2	FAQU	2	SUC	3	Reused the same nest.
Reach 2	FBRI	2	PRE	0	—
Reach 2	FO1	2	SUC	3	—
Reach 2	FO6	2	PRE	0	—
Reach 2	FGOO	2	PRE	0	—
Reach 2	FMAV	2	SUC	4	—
Reach 2	FNER	2	SUC	4	—
Reach 2	FRAS	2	PRE	0	—
Reach 2	FBRI	3	PRE	0	—
Reach 2	FBRI	4	OTH	0	Continued to incubate after the removal of cowbird egg; eggs inviable and never hatched.
Reach 3a	WANI	1	SUC	1	Cowbird egg removed.
Reach 3a	WBON	1	SUC	2	—
Reach 3a	WDID	1	UNK	0	Nest completed, but eggs not observed.
Reach 3a	WDOC	1	PRE	0	—
Reach 3a	WKEL	1	UNK	0	Abandoned with one egg.
Reach 3a	WOUT	1	PRE	0	Cowbird egg removed.
Reach 3a	WSHA	1	PRE	0	—
Reach 3a	WH21	1	SUC	2	—
Reach 3a	WH26	1	SUC	3	—
Reach 3a	WDID	2	SUC	3	—
Reach 3a	WDOC	2	SUC	2	—
Reach 3a	WKEL	2	SUC	2	—
Reach 3a	WOUT	2	SUC	3	—

Table 3.1. Status and nesting activities of Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021.—Continued

[**Nest Fate:** FAL, nest built by unpaired male; INC, nest never completed; OTH, reason for nest failure known, such as substrate failure; PAR, failed as a result of Brown-headed Cowbird parasitism; PRE, nest failure caused by predation event; SUC, fledged at least one Least Bell's Vireo young; UNK, reason for nest failure/abandonment unknown. **Abbreviation:** —, no data]

Survey site	Territory	Nest	Nest fate	Number fledged	Comments
Channel—Continued					
Reach 3a	WSHA	2	PRE	0	—
Reach 3a	WH21	2	SUC	4	—
Reach 3a	WSHA	3	SUC	2	Cowbird egg removed.
Reach 3a	WFID	3	PAR	0	Abandoned with one cowbird egg and three vireo eggs.
Reach 3a	WSTA	4	PRE	0	Parasitized after depredation; cowbird egg not removed.
Reach 3a	WSTA	5	SUC	3	—
Reach 3b	DBOW	1	PRE	0	—
Reach 3b	DBRU	1	PRE	0	—
Reach 3b	DCAL	1	UNK	0	Nest completed, but eggs not observed.
Reach 3b	DCHE	1	PAR	0	Abandoned with one cowbird egg and two vireo eggs.
Reach 3b	DGAF	1	PRE	0	—
Reach 3b	DJOU	1	UNK	0	Nest completed, but eggs not observed.
Reach 3b	DMAD	1	PRE	0	—
Reach 3b	DMES	1	SUC	3	—
Reach 3b	DNIC	1	PRE	0	—
Reach 3b	DSIM	1	PRE	0	—
Reach 3b	DWIL	1	PRE	0	Cowbird egg removed.
Reach 3b	DGWE	1	INC	0	—
Reach 3b	DBOW	2	PAR	0	Abandoned with one cowbird egg.
Reach 3b	DBRU	2	PRE	0	Cowbird egg removed.
Reach 3b	DCAL	2	PRE	0	—
Reach 3b	DCHE	2	PRE	0	—
Reach 3b	WGAR	2	SUC	2	—
Reach 3b	DJOU	2	PRE	0	—
Reach 3b	DMAD	2	PAR	0	Abandoned with one cowbird egg and one vireo egg.
Reach 3b	DMES	2	INC	0	—
Reach 3b	DNIC	2	PRE	0	Cowbird egg removed.
Reach 3b	DSIM	2	PRE	0	—
Reach 3b	DWIL	2	UNK	0	Nest completed, but eggs not observed.
Reach 3b	DBRU	3	INC	0	—
Reach 3b	DCAL	3	PRE	0	—
Reach 3b	DCHE	3	INC	0	—
Reach 3b	DJOU	3	PRE	0	—
Reach 3b	DNIC	3	PAR	0	Abandoned with two cowbird eggs and one vireo egg.
Reach 3b	DSIM	3	PRE	0	—
Reach 3b	DWIL	3	PRE	0	Cowbird egg removed.
Reach 3b	DBRU	4	PRE	0	—
Reach 3b	DCAL	4	PAR	0	Abandoned with one cowbird egg.
Reach 3b	DCHE	4	PRE	0	—

Table 3.1. Status and nesting activities of Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021.—Continued

[**Nest Fate:** FAL, nest built by unpaired male; INC, nest never completed; OTH, reason for nest failure known, such as substrate failure; PAR, failed as a result of Brown-headed Cowbird parasitism; PRE, nest failure caused by predation event; SUC, fledged at least one Least Bell's Vireo young; UNK, reason for nest failure/abandonment unknown. **Abbreviation:** —, no data]

Survey site	Territory	Nest	Nest fate	Number fledged	Comments
Channel—Continued					
Reach 3b	DNIC	4	UNK	0	Nest completed, but eggs not observed.
Reach 3b	DWIL	4	SUC	2	Cowbird egg removed.
Reach 3b	DBRU	5	PRE	0	—
Reach 3b	DCHE	5	INC	0	—
Reach 3b	DNIC	5	OTH	0	Cowbird predation—failed with one cowbird egg in nest; vireo eggs punctured in nest and on ground.
Reach 3b	DCHE	6	PRE	0	—
Reach 4	CACD	1	INC	0	—
Reach 4	CBAN	1	SUC	3	—
Reach 4	CBIL	1	PRE	0	—
Reach 4	CBOB	1	SUC	2	Cowbird egg removed.
Reach 4	CCHC	1	SUC	3	—
Reach 4	CCHC	1	PRE	0	—
Reach 4	CDIA	1	SUC	2	Cowbird egg removed.
Reach 4	CEAS	1	SUC	4	—
Reach 4	CFLO	1	INC	0	—
Reach 4	CHOO	1	UNK	0	Nest abandoned with three vireo eggs.
Reach 4	CKOR	1	INC	0	—
Reach 4	CLAD	1	INC	0	—
Reach 4	CMAC	1	PRE	0	—
Reach 4	CNED	1	SUC	1	Cowbird egg removed.
Reach 4	CPAS	1	PRE	0	—
Reach 4	CPOW	1	PRE	0	—
Reach 4	CPUR	1	PRE	0	—
Reach 4	CJIM	1	PRE	0	—
Reach 4	CSAP	1	SUC	1	—
Reach 4	CSAT	1	SUC	3	—
Reach 4	CSCH	1	UNK	0	Nest completed, but eggs not observed.
Reach 4	C21P	1	INC	0	—
Reach 4	CWIL	1	PRE	0	—
Reach 4	CACD	2	OTH	0	Cowbird predation: vireo egg ejected after the removal of cowbird egg.
Reach 4	CBAN	2	SUC	3	—
Reach 4	CBIL	2	UNK	0	Nest completed, but eggs not observed.
Reach 4	CFLO	2	PRE	0	—
Reach 4	CKOR	2	SUC	1	Cowbird egg removed.
Reach 4	CLAD	2	PRE	0	—
Reach 4	CPAS	2	PRE	0	—
Reach 4	CPOW	2	SUC	3	—
Reach 4	CPUR	2	PAR	0	Abandoned with one cowbird egg and two vireo eggs.

Table 3.1. Status and nesting activities of Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021.—Continued

[**Nest Fate:** FAL, nest built by unpaired male; INC, nest never completed; OTH, reason for nest failure known, such as substrate failure; PAR, failed as a result of Brown-headed Cowbird parasitism; PRE, nest failure caused by predation event; SUC, fledged at least one Least Bell's Vireo young; UNK, reason for nest failure/abandonment unknown. **Abbreviation:** —, no data]

Survey site	Territory	Nest	Nest fate	Number fledged	Comments
Channel—Continued					
Reach 4	CJIM	2	PRE	0	—
Reach 4	CSCH	2	INC	0	—
Reach 4	C21P	2	INC	0	—
Reach 4	CWIL	2	INC	0	—
Reach 4	CACD	3	UNK	0	Abandoned with one vireo egg.
Reach 4	CBIL	3	PAR	0	Abandoned with one cowbird egg.
Reach 4	CLAD	3	PRE	0	—
Reach 4	CPUR	3	INC	0	—
Reach 4	CJIM	3	SUC	3	—
Reach 4	CSCH	3	SUC	3	—
Reach 4	C21P	3	SUC	3	—
Reach 4	CWIL	3	SUC	3	—
Reach 4	CACD	4	SUC	3	—
Reach 4	CLAD	4	UNK	0	Abandoned with two vireo eggs.
Off-channel					
Park Pond	W154	1	SUC	3	Cowbird egg removed.
Park Pond	W155	1	PRE	0	—
Park Pond	WH29	1	PRE	0	—
Pilgrim Pond	DGAF	3	PRE	0	—
Upper Pond	DGWE	2	INC	0	—
Upper Pond	DGWE	3	PRE	0	—
Upper Pond	CACA	1	PRE	0	—
Upper Pond	CBUT	1	SUC	3	—
Upper Pond	COT	1	PAR	0	Abandoned with four vireo eggs and one cowbird egg.
Upper Pond	CDAI	1	PRE	0	—
Upper Pond	CJAS	1	SUC	3	—
Upper Pond	CPAT	1	SUC	3	—
Upper Pond	CQTI	1	PRE	0	—
Upper Pond	CRED	1	FAL	0	—
Upper Pond	CSAN	1	PAR	0	Abandoned with one cowbird egg and two vireo eggs.
Upper Pond	CSTA	1	PRE	0	—
Upper Pond	CSTR	1	SUC	3	—
Upper Pond	CACA	2	SUC	3	—
Upper Pond	CBUT	2	PRE	0	—
Upper Pond	COT	2	SUC	1	—
Upper Pond	CDAI	2	UNK	0	Nest completed, but eggs not observed.
Upper Pond	CQTI	2	SUC	3	—
Upper Pond	CRED	2	SUC	3	—
Upper Pond	CSTA	2	SUC	2	Cowbird egg removed.

Table 3.1. Status and nesting activities of Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021.—Continued

[**Nest Fate:** FAL, nest built by unpaired male; INC, nest never completed; OTH, reason for nest failure known, such as substrate failure; PAR, failed as a result of Brown-headed Cowbird parasitism; PRE, nest failure caused by predation event; SUC, fledged at least one Least Bell's Vireo young; UNK, reason for nest failure/abandonment unknown. **Abbreviation:** —, no data]

Survey site	Territory	Nest	Nest fate	Number fledged	Comments
Off-channel—Continued					
Upper Pond	COT	3	SUC	1	—
Upper Pond	CSTA	3	INC	0	—
Whelan Mitigation	WFID	1	UNK	0	Nest completed, but eggs not observed.
Whelan Mitigation	WJEF	1	SUC	3	Cowbird egg removed.
Whelan Mitigation	WMIL	1	SUC	3	—
Whelan Mitigation	WH22	1	PRE	0	—
Whelan Mitigation	WH33	1	PRE	0	—
Whelan Mitigation	WFID	2	SUC	3	Cowbird egg removed.
Whelan Mitigation	WJEF	2	SUC	4	Cowbird egg removed.
Whelan Mitigation	WH22	2	SUC	1	Cowbird egg removed.
Whelan Mitigation	WH33	2	SUC	2	—
Whelan Mitigation	WFID	4	PRE	0	Nest torn down with one cowbird egg and one vireo egg.
Restoration					
Whelan Mitigation	WEMI	1	PRE	0	—
Whelan Mitigation	WGRI	1	UNK	0	Nest completed, but eggs not observed.
Whelan Mitigation	WSTA	1	PRE	0	—
Whelan Mitigation	WGRI	2	SUC	1	One cowbird egg removed.
Whelan Mitigation	WSTA	2	UNK	0	Nest completed, but eggs not observed.
Whelan Mitigation	WSTA	3	UNK	0	Nest completed, but eggs not observed.

Appendix 4. Banded adult Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021

This is an appendix of all banded adult vireos identified in the Project Area in 2021. The band combinations are listed along with the age and sex of the bird.

Table 4.1. Banded adult Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

[Band combo orientation on leg: left leg : right leg. **Band colors:** BKBK, plastic black; BKYE, plastic black-yellow split; BPST, plastic black-pink striped; BWST, plastic blue-white striped; BYST, plastic black-yellow striped; DBDP, plastic dark blue-dark pink split; DBWH, plastic dark blue-white split; DGOR, plastic dark green-orange split; DPDB, plastic dark pink-dark blue split; DPDP, plastic dark pink; DPWH, plastic dark pink-white split; gogo, metal gold; Mdb, dark blue numbered federal band; Mgo, gold numbered federal band; pupu, metal purple; PUPU, plastic purple; PUWH, plastic purple-white split; PUYE, plastic purple-yellow split; WHDB, plastic white-dark blue split; WHDP, plastic white-dark pink split; WHPU, plastic white-purple split; WHWH, plastic white; YEBK, plastic yellow-black split; YEPU, plastic yellow-purple split; YEYE, plastic yellow. **Age:** Exact age determined from uniquely numbered metal band observed during recapture; estimated age applies to an unbanded bird captured as an after-hatch-year. **Sex:** M, male, F, female. **Abbreviations:** yr, year; ≥, greater than or equal to]

Territory	Band combination (left leg : right leg)	Age	Sex	Comments
BBOA	DBWH Mdb : PUYE	1 yr	M	Banded as a nestling in FO12 territory in 2020. Color banded in BBOA territory in 2021.
BBUT	WHPU Mdb : PUYE	1 yr	M	Banded as a nestling in FGOO territory in 2020. Color banded in BBUT territory in 2021.
BFIL	PUWH Mdb : PUYE	1 yr	M	Banded as a nestling in FNER territory in 2020. Color banded in BFIL territory in 2021.
BHAZ	YEBK Mgo : DGOR	5 yrs	M	Banded as a nestling in Silas territory on MCBP in 2016. Color banded in BHAZ territory in 2021.
BMUL	WHDP : PUYE Mdb	4 yrs	M	Banded as a nestling in BKEN territory in 2017. Color banded in BFAT territory in 2020.
BPAM	DBDP : PUYE Mdb	4 yrs	M	Banded as a nestling in BKYL territory in 2017. Color banded in BPEA territory in 2018.
BSHE	BKKB : BPST Mdb	4 yrs	M	Banded as a nestling in BSUS territory in 2017. Color banded in BJUK territory in 2020.
BTHR	DPDP pupu : Mdb	≥2 yrs	M	Banded as AHY in WALE territory in 2020.
B TOK	BYST Mdb : PUYE	1 yr	M	Banded as a nestling in FO12 territory in 2020. Color banded in BBOA territory in 2021.
CBAN	PUWH Mdb : DBDP	≥3 yrs	M	Banded as AHY in CDIA territory in 2019.
CBIL	DBWH Mdb : BPST	≥2 yrs	M	Banded as AHY in CBAN territory in 2020.
CBUT	YEBK Mdb : gogo	3 yrs	M	Banded as a nestling in CBOB territory in 2018. Color banded in CACA territory in 2019.
CCHC	Mdb :	≥1 yr	M	Banded as a nestling at the San Luis Rey River before 2021.
CCOT	YEPU : BKKB Mdb	6 yrs	M	Banded as a nestling in CSCH territory in 2015. Color banded in CCOT territory in 2016.
CCOT	BKKB Mdb : BPST	3 yrs	F	Banded as a nestling in WEEB territory in 2018. Color banded in CCOT territory in 2020.
CDIA	Mdb :	≥1 yr	F	Banded as a nestling at the San Luis Rey River before 2021.
CEAS	BPST Mdb : YEBK	3 yrs	M	Banded as a nestling in CFLO territory in 2018. Color banded in MSL161 territory in 2019.
CHOO	: DBWH Mdb	≥4 yrs	M	Banded as AHY in CMAK territory in 2018.
CJAS	WHDP Mdb : WHDP	1 yr	M	Banded as a nestling in CSCH territory in 2020. Color banded in CJAS territory in 2021.
CLAD	DBWH : PUWH Mdb	≥3 yrs	M	Banded as AHY in CLAD territory in 2019.
CNED	PUPU Mdb : YEBK	1 yr	M	Banded as a nestling in DBOW territory in 2020. Color banded in CNED territory in 2021.
CPAS	WHDP Mdb : YEPU	≥2 yrs	M	Banded as AHY in CPAS territory in 2020.

Table 4.1. Banded adult Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021.—Continued

[Band combo orientation on leg: left leg : right leg. **Band colors:** BKBK, plastic black; BKYE, plastic black-yellow split; BPST, plastic black-pink striped; BWST, plastic blue-white striped; BYST, plastic black-yellow striped; DBDP, plastic dark blue-dark pink split; DBWH, plastic dark blue-white split; DGOR, plastic dark green-orange split; DPDB, plastic dark pink-dark blue split; DPDP, plastic dark pink; DPWH, plastic dark pink-white split; gogo, metal gold; Mdb, dark blue numbered federal band; Mgo, gold numbered federal band; pupu, metal purple; PUPU, plastic purple; PUWH, plastic purple-white split; PUYE, plastic purple-yellow split; WHDB, plastic white-dark blue split; WHDP, plastic white-dark pink split; WHPU, plastic white-purple split; WHWH, plastic white-black split; YEPU, plastic yellow-purple split; YEYE, plastic yellow. **Age:** Exact age determined from uniquely numbered metal band observed during recapture; estimated age applies to an unbanded bird captured as an after-hatch-year. **Sex:** M, male, F, female. **Abbreviations:** yr, year; ≥, greater than or equal to]

Territory	Band combination (left leg : right leg)	Age	Sex	Comments
CPOW	Mdb : BPST	1 yr	F	Banded as a nestling in CNED territory in 2020. Color banded in CPOW territory in 2021.
CRED	DPDB pupu : Mdb	2 yrs	F	Banded as a nestling in CFLO territory in 2019. Color banded in CRED territory in 2021.
CRED	DPDP : PUYE Mdb	2 yrs	M	Banded as a nestling in WOUT territory in 2019. Color banded in CTRO territory in 2020.
CROD	PUYE : WHDB Mdb	≥3 yrs	M	Banded as AHY in CSCR territory in 2019.
CSAN	BPST : WHDB Mdb	≥3 yrs	M	Banded as AHY in CDIS territory in 2019.
CSCR	YEBK : BWST Mdb	≥3 yrs	M	Banded as AHY in CBUT territory in 2019.
CSPA	WHDB Mdb : YEPU	≥2 yrs	M	Banded as AHY in CSPA territory in 2020.
CSTA	pupu : BPST Mdb	4 yrs	M	Banded as a nestling in WKEL territory in 2017. Color banded in CACE territory in 2018.
CSTA	DPDB Mdb : PUWH	≥4 yrs	M	Banded as AHY in CSTA territory in 2018.
CWIL	DBDP Mdb : PUWH	≥3 yrs	M	Banded as AHY in CSOC territory in 2019.
DBOW	BPST Mdb : PUWH	3 yrs	F	Banded as a nestling in DWIL territory in 2018. Color banded in CIAS territory in 2019.
DBOW	BPST Mdb : gogo	≥2 yrs	M	Banded as AHY in DBOW territory in 2020.
DBRU	BPST Mdb : DBDP	≥2 yrs	M	Banded as AHY in DBRU territory in 2020.
DCAL	: Mdb	≥1 yr	F	Banded as a nestling at the San Luis Rey River before 2021.
DCHE	DBWH Mdb : PUWH	≥2 yrs	M	Banded as AHY in DCHE territory in 2020.
DCHE	: Mdb	≥1 yr	F	Banded as a nestling at the San Luis Rey River before 2021.
DGWE	PUWH Mdb : YEBK	≥3 yrs	M	Banded as AHY in CFOR territory in 2019.
DJOU	WHDB Mdb : BPST	≥3 yrs	M	Banded as AHY in WMRG territory in 2019.
DJOU	Mdb :	≥1 yr	F	Banded as a nestling at the San Luis Rey River before 2021.
DMES	pupu : BKBK Mdb	≥2 yrs	M	Banded as AHY in WSHA territory in 2020.
DNIC	YEBK : WHDP Mdb	2 yrs	M	Banded as a nestling in CJET territory in 2019. Color banded in DNIC territory in 2021.
DO01	BYST Mdb : PUWH	≥2 yrs	M	Banded as AHY in DGAF territory in 2020.
DWIL	YEPU Mdb : WHDB	5 yrs	M	Banded as a nestling in BSAV territory in 2016. Color banded in DWIL territory in 2017.
FAQU	WHPU Mdb : BKYE	≥2 yrs	M	Banded as AHY in FAQU territory in 2020.
FBRI	PUYE Mdb : DPDP	≥3 yrs	M	Banded as AHY in FBRI territory in 2019.
FGOO	BKYE : DPDP Mdb	4 yrs	M	Banded as a nestling in BGRA territory in 2017. Color banded in FO 1 territory in 2018.
FMAV	BKYE : PUWH Mdb	4 yrs	M	Banded as a nestling in DWIL territory in 2017. Color banded in FO40 territory in 2018.
FNER	DBDP Mdb : gogo	≥3 yrs	M	Banded as AHY in FNER territory in 2019.

Table 4.1. Banded adult Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, California, in 2021.—Continued

[Band combo orientation on leg: left leg : right leg. **Band colors:** BKBK, plastic black; BKYE, plastic black-yellow split; BPST, plastic black-pink striped; BWST, plastic blue-white striped; BYST, plastic black-yellow striped; DBDP, plastic dark blue-dark pink split; DBWH, plastic dark blue-white split; DGOR, plastic dark green-orange split; DPDB, plastic dark pink-dark blue split; DPDP, plastic dark pink; DPWH, plastic dark pink-white split; gogo, metal gold; Mdb, dark blue numbered federal band; Mgo, gold numbered federal band; pupu, metal purple; PUPU, plastic purple; PUPU, plastic purple-white split; PUYE, plastic purple-yellow split; WHDB, plastic white-dark blue split; WHDP, plastic white-dark pink split; WHPU, plastic white-purple split; WHWH, plastic white-black split; YEPU, plastic yellow-purple split; YEYE, plastic yellow. **Age:** Exact age determined from uniquely numbered metal band observed during recapture; estimated age applies to an unbanded bird captured as an after-hatch-year. **Sex:** M, male, F, female. **Abbreviations:** yr, year; ≥, greater than or equal to]

Territory	Band combination (left leg : right leg)	Age	Sex	Comments
FO2	BKBK Mdb : YEBK	1 yr	M	Banded as a nestling in DCHE territory in 2020. Color banded in FO2 territory in 2021.
FO4	BWST Mdb : BPST	≥1 yr	M	Banded as AHY in FO4 territory in 2021.
FO6	DBWH Mdb : WHDP	≥4 yrs	M	Banded as AHY in FO41 territory in 2018.
FO7	DBDP Mdb : BPST	≥1 yr	M	Banded as AHY in FO7 territory in 2021.
FO8	DPWH : YEBK Mdb	≥1 yr	M	Banded as AHY in FO8 territory in 2021.
W154	pupu : DPDB Mdb	2 yrs	M	Banded as a nestling in DDOL territory in 2019. Color banded in W153 territory in 2020.
W155	YEPU : BKYE Mdb	4 yrs	M	Banded as a nestling in FNER territory in 2017. Color banded in WTHA territory in 2018.
W155	Mdb :	≥1 yr	F	Banded as a nestling at the San Luis Rey River before 2021.
WANI	YEBK : WHPU Mdb	2 yrs	M	Banded as a nestling in FO4 territory in 2019. Color banded in WANI territory in 2021.
WANI	DBDP : YEBK Mdb	≥2 yrs	M	Banded as AHY in WEAR territory in 2020.
WEMI	PUPH Mdb : PUPH	≥2 yrs	M	Banded as AHY in WEMI territory in 2020.
WFID	DPWH : BPST Mdb	≥3 yrs	M	Banded as AHY in WFID territory in 2019.
WFID	BPST Mdb : PUPU	≥2 yrs	F	Banded as AHY in WKEL territory in 2020.
WGAR	DPDB : YEYE Mdb	2 yrs	M	Banded as a nestling in WGAR territory in 2019. Color banded in WGAF territory in 2021.
WH21	DPDB Mdb : WHPU	3 yrs	M	Banded as a nestling in DBEL territory in 2018. Color banded in WH25 territory in 2019.
WH22	PUPH Mdb : WHDP	1 yr	M	Banded as a nestling in DSAN territory in 2020. Color banded in WH22 territory in 2021.
WH26	DBWH Mdb : BKYE	≥2 yrs	M	Banded as AHY in WH01 territory in 2020.
WH29	DBDP : WHWH Mdb	2 yrs	M	Banded as a nestling in CCHA territory in 2019. Color banded in WH29 territory in 2020.
WH33	DPDB Mdb : DBDP	1 yr	M	Banded as a nestling in CCOT territory in 2020. Color banded in WH33 territory in 2021.
WJEF	DPWH Mdb : WHDP	≥4 yrs	F	Banded as AHY in WRAD territory in 2018.
WJEF	BKYE Mdb : gogo	≥3 yrs	M	Banded as AHY in WRUS territory in 2019.
WKEL	BKYE Mdb : WHDP	≥2 yrs	F	Banded as AHY in WMAN territory in 2020.
WMAN	YEBK : DBDP Mdb	4 yrs	M	Banded as a nestling in BMAL territory in 2017. Color banded in WMAN territory in 2021.
WSHA	WHDP : DPDB Mdb	≥2 yrs	M	Banded as AHY in WN24 territory in 2020.
WSTA	DPDP : YEBK Mdb	≥3 yrs	M	Banded as AHY in WGEE territory in 2019.

Appendix 5. Between-year Movement of Emigrant Least Bell's Vireos from the San Luis Rey Flood Risk Management Project Area to Other Areas Outside of the Project Area in California, 2021

The table in this appendix lists Least Bell's Vireos that emigrated from the Project Area to areas outside of the Project Area in 2021. The table includes the original territory, 2021 territory, dispersal distance, age, and sex of the bird.

Table 5.1. Between-year movement of emigrant Least Bell's Vireos from the San Luis Rey Flood Risk Management Project Area to other areas outside of the Project Area in California, 2021.

[**Location:** MCBCP, Marine Corps Base Camp Pendleton. **Band colors:** BKYE, plastic black-yellow split; BPST, plastic black-pink striped; BWST, plastic blue-white striped; BYST, plastic black-yellow striped; DPDB, plastic dark pink-dark blue split; DPDP, plastic dark pink; DPWH, plastic dark pink-white split; Mdb, dark blue numbered federal band; Msi, silver numbered federal band; pupu, metal purple; PUPU, plastic purple; PUWH, plastic purple-white split; PUYE, plastic purple-yellow split; WHDB, plastic white-dark blue split; WHDP, plastic white-dark pink split; WHPU, white-purple split; YEBK, plastic yellow-black split; YEYE, plastic yellow. **Age:** Exact age determined from uniquely numbered metal band observed during recapture; estimated age applies to an unbanded bird captured as an adult. **Sex:** M, male, F, female. **Abbreviations:** km, kilometer; yr, year; ≥, greater than or equal to]

Drainage / natal territory	2021 Drainage / territory / location	Dispersal distance (km)	Band combination (left leg : right leg)	Age in 2021	Sex
San Luis Rey River / WMON	Whelan Lake / Windmill	0.29	DPDP : BPST Mdb	≥3 yrs	F
San Luis Rey River / CACE	Middle San Luis Rey River / MSL110	2.95	YEBK pupu : Mdb	2 yrs	M
San Luis Rey River / CLAD	Middle San Luis Rey River / MSL230	7.07	WHPU : WHDB Mdb	2 yrs	M
San Luis Rey River / DDOL	Santa Margarita River / HE63 / MCBCP	7.99	WHPU : WHDP Mdb	2 yrs	M
San Luis Rey River / DGAR	Middle San Luis Rey River / MSL142	3.48	DPDB : Mdb	2 yrs	M
San Luis Rey River / FO1	French Creek / FR01 / MCBCP	0.34	BKYE Msi :	2 yrs	M
San Luis Rey River / CSNE	Middle San Luis Rey River / MSL118	2.59	PUYE : BYST Mdb	2 yrs	F
San Luis Rey River / WANI	Santa Margarita River / Rhus / MCBCP	5.68	WHDP pupu : Mdb	2 yrs	F
San Luis Rey River / WCAR	Middle San Luis Rey River / MSL132	6.45	PUWH : BPST Mdb	2 yrs	F
San Luis Rey River / CSTR	Middle San Luis Rey River / MSL109	2.88	PUYE : WHPU Mdb	2 yrs	F
San Luis Rey River / Unknown	Middle San Luis Rey River / MSL114	6.06	: Mdb	≥1 yr	M
San Luis Rey River / Unknown	Santa Margarita River / AE24 / MCBCP	8.39	: Mdb	≥1 yr	F
San Luis Rey River / Unknown	Santa Margarita River / AE39 / MCBCP	8.19	: Mdb	≥1 yr	F
San Luis Rey River / CCOT	Middle San Luis Rey River / MSL155	1.80	DPWH Mdb : PUWH	1 yr	M
San Luis Rey River / CKES	Middle San Luis Rey River / BO15	11.15	YEYE Mdb : DPWH	1 yr	M
San Luis Rey River / CNED	Middle San Luis Rey River / MSL147	1.51	Mdb : DPWH pupu	1 yr	M
San Luis Rey River / CSCH	Pilgrim Creek / PS11 / MCBCP	4.71	PUPU Mdb : BWST	1 yr	M
San Luis Rey River / DMAD	Middle San Luis Rey River / MSL227	7.76	DPDP Mdb : pupu	1 yr	M
San Luis Rey River / DBRU	Whelan Lake / WH101	1.13	BPST Mdb :	1 yr	F

Appendix 6. Between-year Movement of Least Bell's Vireos Banded as Juveniles in 2020 at the San Luis Flood Risk Program Area; Redetected in 2021

The table in this appendix lists all Least Bell's Vireos that were banded in 2020 as nestlings in the Project Area that were detected as breeding adults in 2021. The table includes the location of the 2020 natal territory and 2021 territory, dispersal distance, band combo, and sex of the bird.

Table 6.1. Between-year movement of Least Bell's Vireos banded as juveniles in 2020 at the San Luis Flood Risk Program Area; redetected in 2021.

[MCBCP, Marine Corps Base Camp Pendleton. **Band colors:** BKBK, plastic black; BPST, plastic black-pink striped; BWST, plastic blue-white striped; BYST, plastic black-yellow striped; DBDP, plastic dark blue-dark pink split; DBWH, plastic dark blue-white split; DPDB, dark pink-dark blue split; DPDP, plastic dark pink; DPWH, plastic dark pink-white split; Mdb, dark blue numbered federal band; PUPU, plastic purple; pupu, metal purple; PUWH, plastic purple-white split; PUYE, plastic purple-yellow split; WHDP, plastic white-dark pink split; WHPU, plastic white-purple split; YEBK, plastic yellow-black split; YEYE, plastic yellow. **Sex:** M, male, F, female. **Abbreviation:** km, kilometer]

2020 Drainage / natal territory	2021 Drainage / territory	Dispersal distance (km)	Band combination (left leg : right leg)	Sex
San Luis Rey River / DSAN	San Luis Rey River / WH22	1.65	PUWH Mdb : WHDP	M
San Luis Rey River / DMAD	Middle San Luis Rey River / MSL227	7.76	DPDP Mdb : pupu	M
San Luis Rey River / FGOO	San Luis Rey River / BTOK	1.52	BYST Mdb : PUYE	M
San Luis Rey River / FGOO	San Luis Rey River / BBUT	1.18	WHPU Mdb : PUYE	M
San Luis Rey River / DCHE	San Luis Rey River / FO2	2.91	BKBK Mdb : YEBK	M
San Luis Rey River / FO12	San Luis Rey River / BBOA	0.98	DBWH Mdb : PUYE	M
San Luis Rey River / FNER	San Luis Rey River / BFIL	1.07	PUWH Mdb : PUYE	M
San Luis Rey River / DBOW	San Luis Rey River / CNED	2.21	PUPU Mdb : YEBK	M
San Luis Rey River / DBRU	Whelan Lake / WH101	1.13	BPST Mdb :	F
San Luis Rey River / CSCH	Pilgrim Creek / PS11 / MCBCP	4.71	PUPU Mdb : BWST	M
San Luis Rey River / CSCH	San Luis Rey River / CJAS	0.68	WHDP Mdb : WHDP	M
San Luis Rey River / CNED	Middle San Luis Rey River / MSL147	1.51	Mdb : DPWH pupu	M
San Luis Rey River / CNED	San Luis Rey River / CPOW	0.51	Mdb : BPST	F
San Luis Rey River / CCOT	Middle San Luis Rey River / MSL155	1.80	DPWH Mdb : PUWH	M
San Luis Rey River / CCOT	San Luis Rey River / WH33	3.54	DPDB Mdb : DBDP	M
San Luis Rey River / CKES	Middle San Luis Rey River / BO15	11.15	YEYE Mdb : DPWH	M

Appendix 7. Between-year Movement of Adult Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, 2021

The table in this appendix lists all banded vireos identified in 2021 with their previous known territories, band combination, distance moved, age, and sex of the bird.

Table 7.1. Between-year movement of adult Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, 2021.

[**Drainage Codes:** SLR, San Luis Rey River. **Band colors:** BKBK, plastic black; BKYE, plastic black-yellow split; BPST, plastic black-pink striped; BWST, plastic blue-white striped; BYST, plastic black-yellow striped; DBDP, plastic dark blue-dark pink split; DBWH, plastic dark blue-white split; DPDB, plastic dark-pink dark-blue split; DPDP, plastic dark pink; DPWH, plastic dark pink-white split; gogo, metal gold; Mdb, dark blue numbered federal band; PUPU, plastic purple; pupu, metal purple; PUWH, plastic purple-white split; PUYE, plastic purple-yellow split; WHDB, plastic white-dark blue split; WHDP, plastic white-dark pink split; WHPU, plastic white-purple split; WHWH, plastic white; YEBK, plastic yellow-black split; YEPU, plastic yellow-purple split. **Age:** Exact age determined from uniquely numbered metal band observed during recapture; estimated age applies to an unbanded bird captured as an after-hatch-year. **Sex:** M, male, F, female. **Abbreviations:** km, kilometer; yr, year; ≥, greater than or equal to]

Year last detected	Return to territory (within 0.1 km)	Last year detected drainage / territory	2021 drainage / territory	Distance moved (km)	Band combination (left leg : right leg)	Age in 2021	Sex
2020	Yes	SLR / DWIL	SLR / DWIL	0.01	YEPU Mdb : WHDB	5 yrs	M
2020	Yes	SLR / W155	SLR / W155	0.01	YEPU : BKYE Mdb	4 yrs	M
2020	Yes	SLR / CCOT	SLR / CCOT	0.01	YEPU : BKBK Mdb	6 yrs	M
2020	Yes	SLR / CCOT	SLR / CCOT	0.01	BKBK Mdb : BPST	3 yrs	F
2020	Yes	SLR / FNER	SLR / FNER	0.01	DBDP Mdb : gogo	≥3 yrs	M
2020	Yes	SLR / DBOW	SLR / DBOW	0.01	BPST Mdb : gogo	≥2 yrs	M
2020	Yes	SLR / CPAS	SLR / CPAS	0.01	WHDP Mdb : YEPU	≥2 yrs	M
2020	Yes	SLR / FAQU	SLR / FAQU	0.01	WHPU Mdb : BKYE	≥2 yrs	M
2020	Yes	SLR / CPAT	SLR / DGWE	0.01	PUWH Mdb : YEBK	≥3 yrs	M
2020	Yes	SLR / CEAS	SLR / CEAS	0.02	BPST Mdb : YEBK	3 yrs	M
2020	Yes	SLR / CSPA	SLR / CSPA	0.02	WHDB Mdb : YEPU	≥2 yrs	M
2020	Yes	SLR / WH21	SLR / WH21	0.02	DPDB Mdb : WHPU	3 yrs	M
2020	Yes	SLR / FBRI	SLR / FBRI	0.02	PUYE Mdb : DPDP	≥3 yrs	M
2020	Yes	SLR / CSAN	SLR / CSAN	0.02	BPST : WHDB Mdb	≥3 yrs	M
2020	Yes	SLR / CBAN	SLR / CBIL	0.02	DBWH Mdb : BPST	≥2 yrs	M
2020	Yes	SLR / CSTA	SLR / CSTA	0.03	DPDB Mdb : PUWH	≥4 yrs	M
2020	Yes	SLR / CHOO	SLR / CHOO	0.03	WHPU Mdb : DPDP	≥4 yrs	M
2020	Yes	SLR / BJUK	SLR / BSHE	0.03	BKBK : BPST Mdb	4 yrs	M
2020	Yes	SLR / BFAT	SLR / BMUL	0.03	WHDP : PUYE Mdb	4 yrs	M
2020	Yes	SLR / BPEA	SLR / BPAM	0.04	DBDP : PUYE Mdb	4 yrs	M
2020	Yes	SLR / CACE	SLR / CSTR	0.04	pupu : BPST Mdb	4 yrs	M
2020	Yes	SLR / WBLU	SLR / WFID	0.04	DPWH : BPST Mdb	≥3 yrs	M
2020	Yes	SLR / CPAN	SLR / CBAN	0.05	PUWH Mdb : DBDP	≥3 yrs	M
2020	Yes	SLR / FMAV	SLR / FMAV	0.05	BKYE : PUWH Mdb	4 yrs	M
2020	Yes	SLR / WSTA	SLR / WSTA	0.05	DPDP : YEBK Mdb	≥3 yrs	M
2020	Yes	SLR / WEMI	SLR / WEMI	0.05	PUWH Mdb : PUWH	≥2 yrs	M
2020	Yes	SLR / W153	SLR / W154	0.06	pupu : DPDB Mdb	2 yrs	M
2020	Yes	SLR / WH29	SLR / WH29	0.07	DBDP : WHWH Mdb	2 yrs	M
2020	Yes	SLR / DCHE	SLR / DCHE	0.07	DBWH Mdb : PUWH	≥2 yrs	M
2020	Yes	SLR / DBRU	SLR / DBRU	0.08	BPST Mdb : DBDP	≥2 yrs	M

Table 7.1. Between-year movement of adult Least Bell's Vireos at the San Luis Rey Flood Risk Management Project Area, 2021.—Continued

[**Drainage Codes:** SLR, San Luis Rey River. **Band colors:** BKBK, plastic black; BKYE, plastic black-yellow split; BPST, plastic black-pink striped; BWST, plastic blue-white striped; BYST, plastic black-yellow striped; DBDP, plastic dark blue-dark pink split; DBWH, plastic dark blue-white split; DPDB, plastic dark-pink dark-blue split; DPDP, plastic dark pink; DPWH, plastic dark pink-white split; gogo, metal gold; Mdb, dark blue numbered federal band; PUPU, plastic purple; pupu, metal purple; PUWH, plastic purple-white split; PUYE, plastic purple-yellow split; WHDB, plastic white-dark blue split; WHDP, plastic white-dark pink split; WHPU, plastic white-purple split; WHWH, plastic white; YEBK, plastic yellow-black split; YEPU, plastic yellow-purple split. **Age:** Exact age determined from uniquely numbered metal band observed during recapture; estimated age applies to an unbanded bird captured as an after-hatch-year. **Sex:** M, male, F, female. **Abbreviations:** km, kilometer; yr, year; \geq , greater than or equal to]

Year last detected	Return to territory (within 0.1 km)	Last year detected drainage / territory	2021 drainage / territory	Distance moved (km)	Band combination (left leg : right leg)	Age in 2021	Sex
2020	Yes	SLR / CBUT	SLR / CSCR	0.08	YEBK : BWST Mdb	≥ 3 yrs	M
2020	Yes	SLR / CACA	SLR / CBUT	0.09	YEBK Mdb : gogo	3 yrs	M
2020	Yes	SLR / CLAD	SLR / CLAD	0.09	DBWH : PUWH Mdb	≥ 3 yrs	M
2020	No	SLR / CWIL	SLR / CWIL	0.11	DBDP Mdb : PUWH	≥ 3 yrs	M
2020	No	SLR / CTRO	SLR / CRED	0.12	DPDP : PUYE Mdb	2 yrs	M
2020	No	SLR / WBAN	SLR / WJEF	0.13	BKYE Mdb : gogo	≥ 3 yrs	M
2020	No	SLR / FO6	SLR / FO6	0.14	DBWH Mdb : WHDP	≥ 4 yrs	M
2020	No	SLR / CKES	SLR / CROD	0.18	PUYE : WHDB Mdb	≥ 3 yrs	M
2020	No	SLR / WFID	SLR / WJEF	0.21	DPWH Mdb : WHDP	≥ 4 yrs	F
2020	No	SLR / DGAF	SLR / DO01	0.26	BYST Mdb : PUWH	≥ 2 yrs	M
2020	No	SLR / WH01	SLR / WH26	0.32	DBWH Mdb : BKYE	≥ 2 yrs	M
2020	No	SLR / DDOL	SLR / DBRU	0.34	BPST Mdb : PUWH	3 yrs	F
2020	No	SLR / FRAN	SLR / FGOO	0.35	BKYE : DPDP Mdb	4 yrs	M
2020	No	SLR / WSHA	SLR / DMES	0.40	pupu : BKBK Mdb	≥ 2 yrs	M
2020	No	SLR / WMON	SLR / WKEL	0.54	BKYE Mdb : WHDP	≥ 2 yrs	M
2020	No	SLR / WN24	SLR / WSHA	0.80	WHDP : DPDB Mdb	≥ 2 yrs	M
2020	No	SLR / WEAR	SLR / WANI	0.80	DBDP : YEBK Mdb	≥ 2 yrs	M
2020	No	SLR / WKEL	SLR / WFID	0.88	BPST Mdb : PUPU	≥ 2 yrs	F
2020	No	SLR / WMRG	SLR / DJOU	1.00	WHDB Mdb : BPST	≥ 3 yrs	M
2020	No	SLR / WALE	SLR / BTHR	1.57	DPDP pupu : Mdb	≥ 2 yrs	M

Appendix 8. Locations of Transient Willow Flycatchers at the San Luis Rey Flood Risk Management Project Area, 2021

This appendix includes maps showing the location of all transient Willow Flycatchers detected in 2021 within the Project Area.



Figure 8.1. Locations of transient Willow Flycatchers in Reach 1, Lower Pond, and Tuley Canyon survey sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.



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Figure 8.2. Locations of transient Willow Flycatchers in Reach 2 survey site at the San Luis Rey Flood Risk Management Project Area, California, in 2021.



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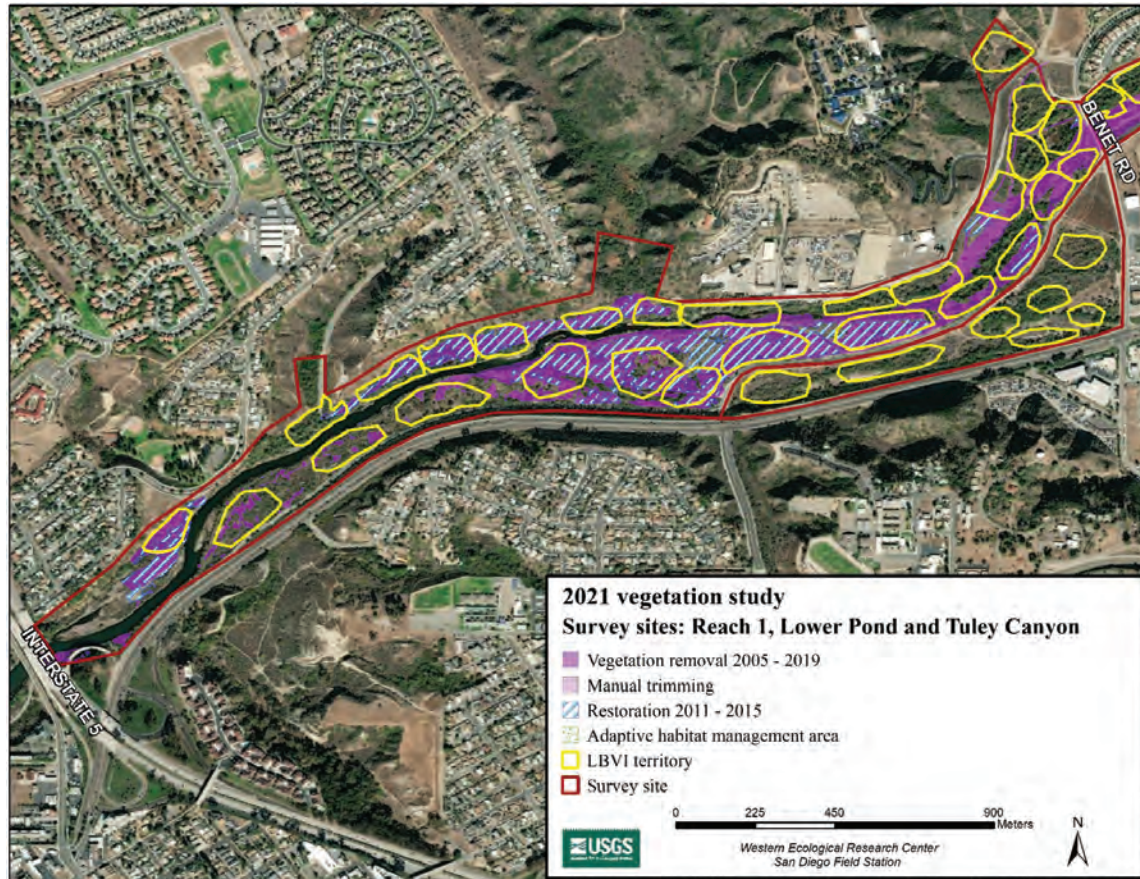
Figure 8.3. Locations of transient Willow Flycatchers in Reach 3a, Reach 3b, Park Pond, Pilgrim Pond, and Whelan Mitigation survey sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.



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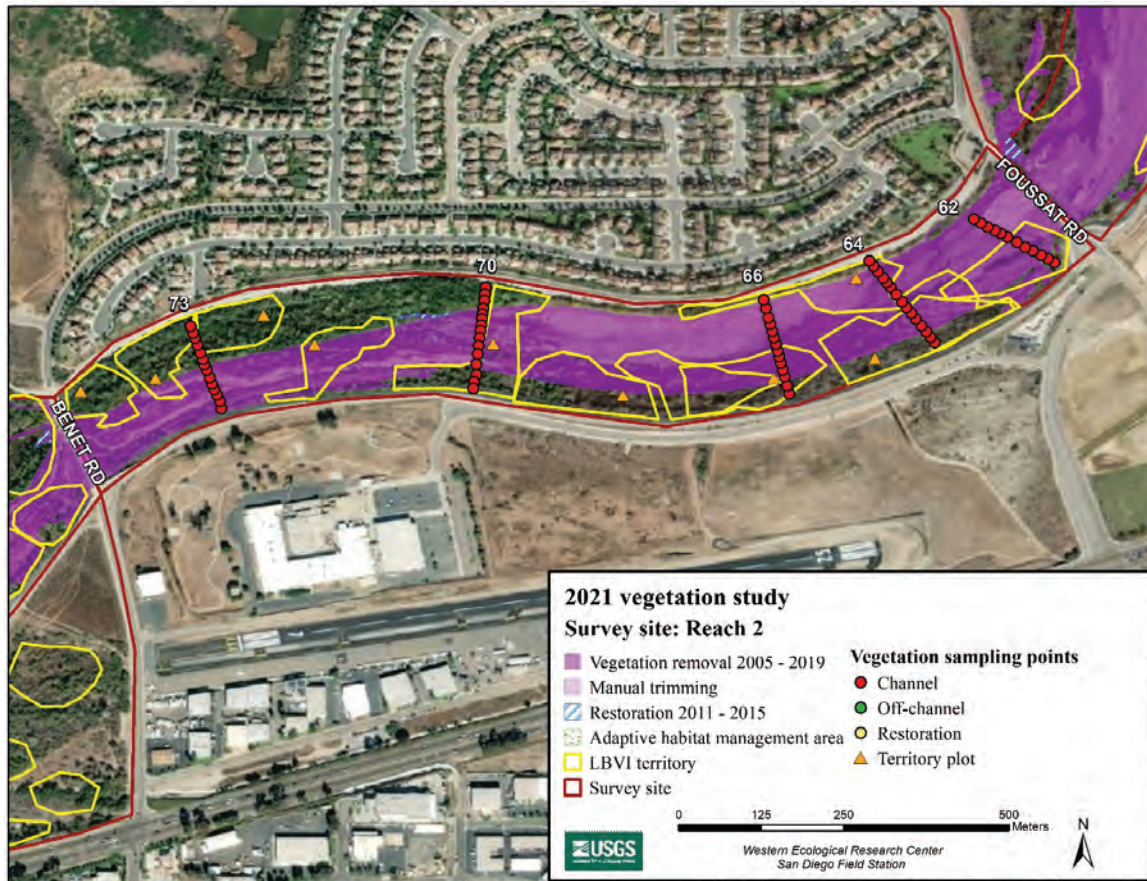
Figure 8.4. Locations of transient Willow Flycatcher in Reach 4, Riverside Pond, and Upper Pond survey sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

Appendix 9. Locations of Vegetation Transects, Nest-centered Vegetation Plots, and Vegetation Treatments at the San Luis Rey Flood Risk Management Project Area, 2021



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Figure 9.1. Locations of vegetation treatments in Reach 1, Lower Pond, and Tuley Canyon survey sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.



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Figure 9.2. Locations of vegetation transects and territory plots in Reach 2 survey site at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

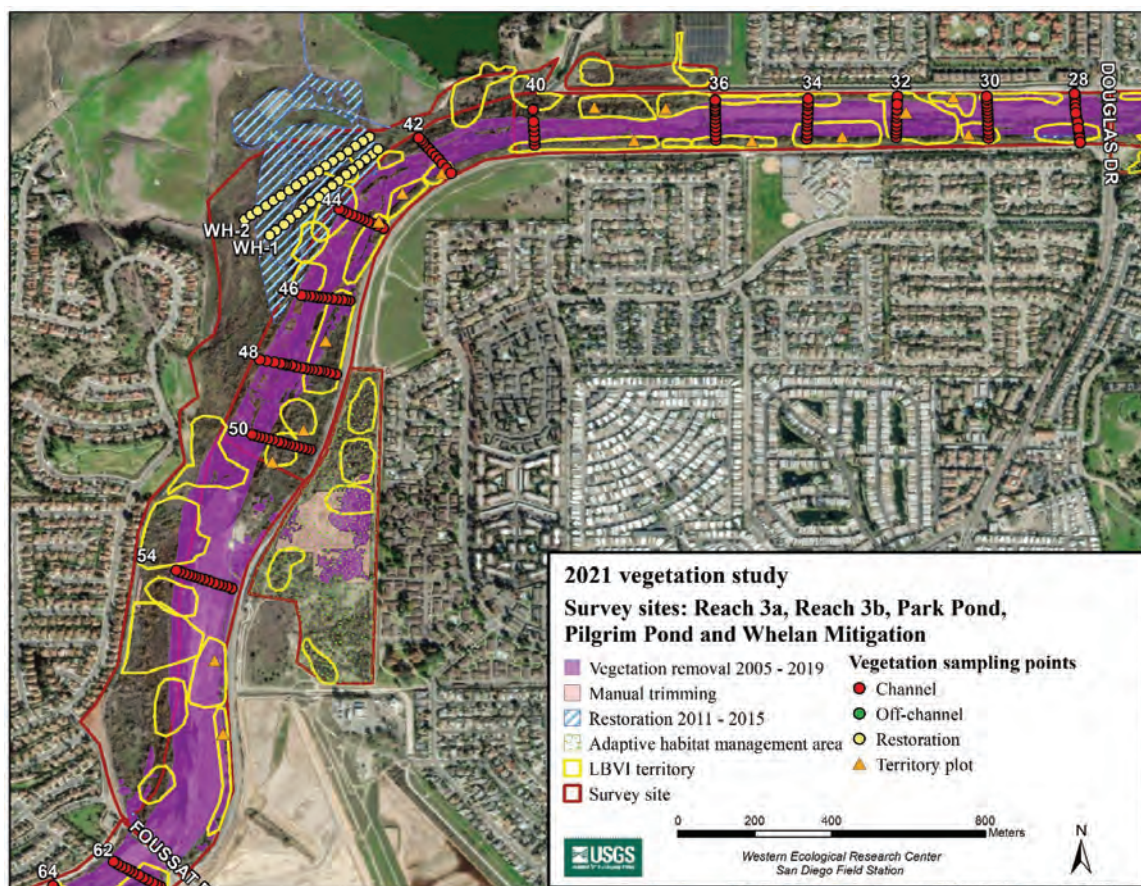
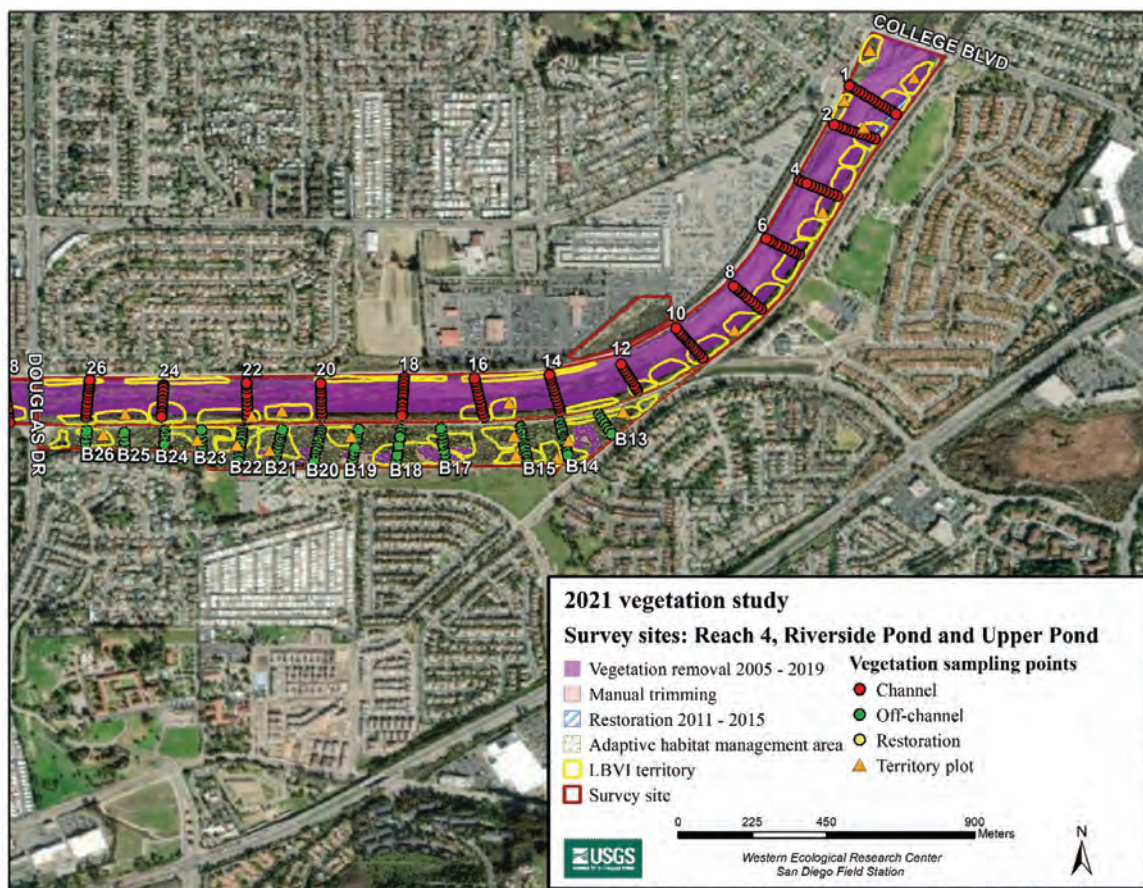


Figure 9.3. Locations of vegetation transects and territory plots in Reach 3a, Reach 3b, Park Pond, Pilgrim Pond, and Whelan Mitigation survey sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.



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Figure 9.4. Locations of vegetation transects and territory plots in Reach 4, Riverside Pond, and Upper Pond survey sites at the San Luis Rey Flood Risk Management Project Area, California, in 2021.

Appendix 10. Global Positioning System Coordinates for the Start and End Points of Each Vegetation Transect Sampled at the San Luis Rey Flood Risk Management Project Area, in 2006–21

The table in this appendix lists the location and the Global Positioning System coordinates for the start and end point for all vegetation transects in the Project Area.

Table 10.1. Global Positioning System coordinates (Decimal Degrees; World Geographic System of 1984 [WGS84]) for the start and end points (Quadrat) of each vegetation transect sampled at the San Luis Rey Flood Risk Management Project Area in 2006–21.

[Quad indicates the distance in m along a transect. **Abbreviations:** ID, identification; =, equals; —, not applicable]

Site	Transect ID	Quad	X-West	Y-North	Transect bearing
Reach 4	1	5	-117.29912	33.24834	Bearing = 304 degrees
Reach 4	1	145	-117.30033	33.24907	—
Reach 4	2	5	-117.29964	33.24763	Bearing = 310 degrees
Reach 4	2	115	-117.30074	33.24805	—
Reach 4	4	5	-117.30067	33.24607	Bearing = 300 degrees
Reach 4	4	105	-117.30170	33.24649	—
Reach 4	6	5	-117.30167	33.24445	Bearing = 300 degrees
Reach 4	6	105	-117.30260	33.24490	—
Reach 4	8	5	-117.30274	33.24299	Bearing = 314 degrees
Reach 4	8	105	-117.30349	33.24361	—
Reach 4	10	5	-117.30434	33.24167	Bearing = 330 degrees
Reach 4	10	115	-117.30506	33.24246	—
Reach 4	12	5	-117.30612	33.24078	Bearing = 330 degrees
Reach 4	12	95	-117.30656	33.24148	—
Reach 4	14	5	-117.30823	33.24023	Bearing = 352 degrees
Reach 4	14	115	-117.30851	33.24111	—
Reach 4	16	5	-117.31030	33.24005	Bearing = 358 degrees
Reach 4	16	115	-117.31056	33.24110	—
Reach 4	18	5	-117.31255	33.23992	Bearing = 358 degrees
Reach 4	18	115	-117.31248	33.24111	—
Reach 4	20	5	-117.31473	33.24009	Bearing = 2 degrees
Reach 4	20	115	-117.31476	33.24105	—
Reach 4	22	5	-117.31675	33.23999	Bearing = 2 degrees
Reach 4	22	105	-117.31678	33.24098	—
Reach 4	24	5	-117.31910	33.24006	Bearing = 2 degrees
Reach 4	24	105	-117.31904	33.24093	—
Reach 4	26	5	-117.32116	33.24006	Bearing = 2 degrees
Reach 4	26	115	-117.32106	33.24105	—
Reach 3b	28	5	-117.32325	33.23991	Bearing = 0 degrees
Reach 3b	28	105	-117.32339	33.24101	—
Reach 3b	30	5	-117.32537	33.24037	Bearing = 0 degrees

Table 10.1. Global Positioning System coordinates (Decimal Degrees; World Geographic System of 1984 [WGS84]) for the start and end points (Quadrat) of each vegetation transect sampled at the San Luis Rey Flood Risk Management Project Area in 2006–21.—Continued

[Quad indicates the distance in m along a transect. **Abbreviations:** ID, identification; =, equals; —, not applicable]

Site	Transect ID	Quad	X-West	Y-North	Transect bearing
Reach 3b	30	115	-117.32544	33.24099	—
Reach 3b	32	5	-117.32756	33.24004	Bearing = 0 degrees
Reach 3b	32	105	-117.32753	33.24099	—
Reach 3b	34	5	-117.32965	33.24000	Bearing = 0 degrees
Reach 3b	34	105	-117.32968	33.24073	—
Reach 3b	36	5	-117.33178	33.23997	Bearing = 0 degrees
Reach 3b	36	115	-117.33180	33.24090	—
Reach 3a	40	5	-117.33602	33.23986	Bearing = 0 degrees
Reach 3a	40	95	-117.33606	33.24068	—
Reach 3a	42	5	-117.33802	33.23924	Bearing = 332 degrees
Reach 3a	42	115	-117.33872	33.24006	—
Reach 3a	44	5	-117.33963	33.23798	Bearing = 296 degrees
Reach 3a	44	105	-117.34059	33.23835	—
Reach 3a	46	5	-117.34036	33.23622	Bearing = 278 degrees
Reach 3a	46	115	-117.34148	33.23634	—
Reach 3a	48	5	-117.34067	33.23450	Bearing = 284 degrees
Reach 3a	48	165	-117.34229	33.23481	—
Reach 3a	50	5	-117.34127	33.23273	Bearing = 286 degrees
Reach 3a	50	145	-117.34264	33.23309	—
Reach 3a	54	5	-117.34311	33.22950	Bearing = 286 degrees
Reach 3a	54	135	-117.34445	33.22993	—
Reach 2	62	5	-117.34478	33.22253	Bearing = 304 degrees
Reach 2	62	125	-117.34586	33.22306	—
Reach 2	64	5	-117.34641	33.22144	Bearing = 326 degrees
Reach 2	64	145	-117.34730	33.22255	—
Reach 2	66	5	-117.34839	33.22074	Bearing = 346 degrees
Reach 2	66	135	-117.34877	33.22220	—
Reach 2	70	5	-117.35272	33.22096	Bearing = 6 degrees
Reach 2	70	145	-117.35252	33.22219	—
Reach 2	73	5	-117.35612	33.22054	Bearing = 347 degrees
Reach 2	73	135	-117.35654	33.22166	—
Upper Pond	B13	5	-117.30713	33.24002	Bearing = 172 degrees
Upper Pond	B13	65	-117.30683	33.23959	—
Upper Pond	B14	5	-117.30823	33.23991	Bearing = 172 degrees
Upper Pond	B14	115	-117.30807	33.23901	—
Upper Pond	B15	5	-117.30930	33.23978	Bearing = 172 degrees
Upper Pond	B15	115	-117.30912	33.23880	—
Upper Pond	B17	5	-117.31148	33.23974	Bearing = 172 degrees
Upper Pond	B17	105	-117.31135	33.23885	—

Table 10.1. Global Positioning System coordinates (Decimal Degrees; World Geographic System of 1984 [WGS84]) for the start and end points (Quadrat) of each vegetation transect sampled at the San Luis Rey Flood Risk Management Project Area in 2006–21.—Continued

[Quad indicates the distance in m along a transect. **Abbreviations:** ID, identification; =, equals; —, not applicable]

Site	Transect ID	Quad	X-West	Y-North	Transect bearing
Upper Pond	B18	5	-117.31256	33.23971	Bearing = 182 degrees
Upper Pond	B18	105	-117.31270	33.23883	—
Upper Pond	B19	5	-117.31372	33.23972	Bearing = 182 degrees
Upper Pond	B19	105	-117.31391	33.23874	—
Upper Pond	B20	5	-117.31475	33.23970	Bearing = 182 degrees
Upper Pond	B20	105	-117.31495	33.23881	—
Upper Pond	B21	5	-117.31580	33.23972	Bearing = 182 degrees
Upper Pond	B21	105	-117.31602	33.23880	—
Upper Pond	B22	5	-117.31689	33.23969	Bearing = 182 degrees
Upper Pond	B22	95	-117.31699	33.23885	—
Upper Pond	B23	5	-117.31802	33.23968	Bearing = 182 degrees
Upper Pond	B23	55	-117.31800	33.23920	—
Upper Pond	B24	5	-117.31901	33.23964	Bearing = 182 degrees
Upper Pond	B24	45	-117.31902	33.23930	—
Upper Pond	B25	5	-117.32011	33.23963	Bearing = 182 degrees
Upper Pond	B25	35	-117.32010	33.23927	—
Upper Pond	B26	5	-117.32110	33.23955	Bearing = 182 degrees
Upper Pond	B26	35	-117.32118	33.23925	—
Whelan Mitigation	WH-1	5	-117.33969	33.23975	Bearing = 345 degrees
Whelan Mitigation	WH-1	325	-117.34222	33.23774	—
Whelan Mitigation	WH-2	5	-117.33989	33.24004	Bearing = 345 degrees
Whelan Mitigation	WH-2	345	-117.34281	33.23811	—

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