Ecosystems Mission Area—Species Management Research Program

Prepared in cooperation with Assistant Chief of Staff, Environmental Security, U.S. Marine Corps Base Camp Pendleton

Distribution, Abundance, Breeding Activities, and Habitat Use of the Least Bell's Vireo at Marine Corps Base Camp Pendleton, California—2023 Annual Report

Open-File Report 2024–1065

U.S. Department of the Interior
U.S. Geological Survey

Cover. Least Bell's Vireo (*Vireo bellii pusillus*) nestlings in nest. Photograph by Devin Taylor, U.S. Geological Survey, July 3, 2023.

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By Suellen Lynn and Barbara E. Kus

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Figures

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
hectare (ha)	0.003861	square mile (mi^2)
	Flow rate	
liters per minute (l/min)	15.85	gallon per minute (gal/min)

Datum

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

Horizontal coordinate information in mapped figures is referenced to the North American Datum of 1983 (NAD 83).

Abbreviations

AIC_c	Akaike's Information Criterion for small sample sizes
ANOVA	analysis of variance
DSR	daily survival rate
GPS	global positioning system
MAPS	monitoring avian productivity and survivorship
MCAS	Marine Corps Air Station, Camp Pendleton
MCBCP	Marine Corps Base Camp Pendleton

Distribution, Abundance, Breeding Activities, and Habitat Use of the Least Bell's Vireo at Marine Corps Base Camp Pendleton, California—2023 Annual Report

By Suellen Lynn and Barbara E. Kus

Executive Summary

The purpose of this report is to provide the Marine Corps with an annual summary of abundance, breeding activity, demography, and habitat use of endangered Least Bell’s Vireos (*Vireo bellii pusillus*) at Marine Corps Base Camp Pendleton, California (MCBCP or Base). Surveys for the Least Bell's Vireo were completed at MCBCP between April 11 and July 20, 2023. Core survey areas and a subset of non-core areas in drainages containing riparian habitat suitable for vireos were surveyed two to four times. We detected 561 territorial male vireos and 28 transient vireos in core survey areas. An additional 103 territorial male vireos and 15 transients were detected in non-core survey areas. Transient vireos were detected on 10 of the 15 drainages/sites surveyed (core and non-core areas). In core survey areas, 90 percent of vireo territories were on the four most populated drainages, with the Santa Margarita River containing 72 percent of all territories in core areas surveyed on Base. In core areas, 79 percent of male vireos were confirmed as paired; 69 percent of male vireos in non-core areas were confirmed as paired.

The number of documented Least Bell’s Vireo territories in core survey areas on MCBCP decreased 2 percent from 2022. In two core survey area drainages, the number of territories increased by at least three, and in two core survey area drainages, the number of vireo territories decreased by at least four between 2022 and 2023. The number of vireo territories at the lower San Luis Rey River increased 2 percent from 2022, in contrast to the decrease at MCBCP; however, this change was negligible overall. Although the 10-percent decrease at Marine Corps Air Station, Camp Pendleton from 2022 to 2023 was superficially less trivial, this 10-percent decrease represented the loss of a single territory. The proportion of surveys during which Brown-headed Cowbirds (*Molothrus ater*) were detected decreased to 0.20 from a peak of 0.45 in 2022. Cowbirds were detected from April through July in 2023.

Most core-area vireos (62 percent, including transients) used mixed willow (*Salix* spp.) riparian habitat. An additional 7 percent of birds occupied willow habitat co-dominated by Western sycamores (*Platanus racemosa*) or Fremont cottonwoods (*Populus fremontii*). Riparian scrub dominated by mule fat (*Baccharis salicifolia*), sandbar willow (*S. exigua*), or blue elderberry (*Sambucus mexicana*) was used by 29 percent of vireos. Habitat dominated by coast live oak (*Quercus agrifolia*) and sycamore or non-native habitat was used by 1 percent of vireos; fewer than 1 percent of vireo territories were in upland scrub and habitat dominated by white alder (*Alnus rhombifolia*).

In 2019, MCBCP began operating an artificial seep along the Santa Margarita River; then in 2021, two additional artificial seeps became operational. The artificial seeps pumped water to the surface starting in March and ending in August each year during daylight hours and were designed to increase the amount of surface water present to enhance Southwestern Willow Flycatcher (*Empidonax traillii extimus*) breeding habitat. Although this enhancement was designed to benefit flycatchers, few flycatchers have inhabited MCBCP, including the seep areas, within the past several years; therefore, vireos were selected as a surrogate species to determine effects of the habitat enhancement. This report presents the fourth year of analyses of vireo and vegetation response to the artificial seeps.

In 2020, we established four study sites along the Santa Margarita River, two surrounding and extending downstream of seep pumps at the Old Treatment Ponds and along Pump Road, and two Reference sites in similar habitat but further downstream of the Seep sites. In 2023, seep pumps at one Seep site did not function, and we recategorized that study site as Intermediate. Soil moisture was higher at sites that had surface water augmentation (Seep and Intermediate sites) than at the Reference site, and soil moisture also decreased with increasing distance from the seep pumps. We sampled vegetation at these sites to determine the effects of surface water enhancement by seep pumps. Soil moisture was positively related to total foliage cover, woody cover, and native herbaceous cover below 1 meter (m), and also positively related to native herbaceous cover between 1 and 2 m. The Seep site had greater total vegetation cover in the understory (71–79 percent) than the Intermediate (52–66 percent) and Reference (61–69 percent) sites. Total herbaceous cover below 3 m was higher at the Seep site than at the Intermediate site; total herbaceous cover between 1 and 3 m was higher at the Seep site than at the Reference sites. Native herbaceous cover below 3 m was greater at the Seep site than at the Reference sites; native herbaceous cover between 2 and 3 m was also greater at the Seep site than at

the Intermediate site. Non-native cover below 3 m was greater at Seep and Reference sites than at the Intermediate site. We found no difference in woody cover among site types at any height.

Vireo territory density among the Seep, Intermediate, and Reference sites was similar before the seep pumps were installed. However, vireo territory density at Seep and Intermediate sites combined was significantly higher than at Reference sites after the seep pumps were installed.

The U.S. Geological Survey has been color banding Least Bell's Vireos on Marine Corps Base Camp Pendleton since 1995. By the end of 2022, over 1,000 Least Bell's Vireos had been color banded on Base. In 2023, we continued to color band and resight color banded Least Bell's Vireos to evaluate adult survival, site fidelity, between-year movement, and the effect of surface water enhancement on vireo return rate, site fidelity, and between-year movement. We banded 180 Least Bell's Vireos for the first time during the 2023 season, including 1 adult vireo and 179 nestlings. Adult vireos were banded with unique color combinations, whereas nestlings were banded with a single gold numbered federal band on the right leg.

We resighted 57 Least Bell's Vireos on Base in 2023 that had been banded before the 2023 breeding season, 20 of which we were unable to identify. Of the 37 that we could identify, 34 were banded on Base, 2 were originally banded on the San Luis Rey River, and 1 was banded at Marine Corps Air Station, Camp Pendleton. Adult birds of known age ranged from 1 to 8 years old.

Base-wide survival of vireos was affected by sex, age, and year. Males had significantly higher annual survival than females. Adults had higher annual survival than first-year vireos. Survival for adults and first-year birds was lowest from 2020 to 2021 and highest from 2007 to 2008 and from 2012 to 2013. The return rate of adult vireos to Seep, Intermediate, or Reference sites was not affected by the original banding site (Seep versus Intermediate versus Reference).

Most returning adult vireos, predominantly males, showed strong between-year site fidelity. Of the adults present in 2022, 88 percent (96 percent of males; 25 percent of females) returned in 2023 to within 100 m of their previous territory. The discrepancy between male and female return rates follows the pattern observed in previous years. The average between-year movement for returning adult vireos was 0.4±1.9 kilometers (km). The average movement of first-year vireos detected in 2023 that fledged from a known nest on MCBCP in 2022 was 0.9±0.5 km.

We monitored Least Bell's Vireo pairs to evaluate the effects of surface water enhancement on nest success and breeding productivity. We monitored vireo nesting activity at 13 territories in the Seep site, 12 territories at the Intermediate site, and 25 territories in the Reference sites between April 8 and July 26. All territories except one at a Seep site and one at a Reference site were occupied by pairs, and all were fully monitored, meaning that all nesting attempts were monitored at these territories. During the monitoring period, 99 nests (26 in the Seep site, 28 at the Intermediate site, and 45 in Reference sites) were monitored.

Breeding productivity was similar among Seep, Intermediate, and Reference sites (2.9, 3.6, and 3.0 young fledged per pair, respectively), and a similar percentage of pairs at Seep, Intermediate, and Reference sites fledged at least 1 young (83, 83, and 96 percent, respectively). Other measures of breeding productivity were also similar among Seep, Intermediate, and Reference site pairs. According to the best model, daily nest survival in 2023 was not related to site. Fledging success appeared lower at Intermediate and Seep sites than at the Reference sites in 2023 (48, 46, and 67 percent, respectively), although the difference was not statistically significant. Predation was believed to be the primary source of nest failure at all sites. Predation accounted for 85, 77, and 71 percent of nest failures at Seep, Intermediate, and Reference sites, respectively. Failure of the remaining nests was attributed to infertile eggs, collapse of the vegetation supporting the nest, and other unknown causes. We found no relationships between vireo productivity and understory (below 3 m) vegetation cover.

Vireos placed their nests in 15 plant species in 2023. We found few differences in nest placement between successful and unsuccessful vireo nests. At Reference sites, successful vireo nests were placed slightly but significantly higher in the vegetation than unsuccessful nests, and at Intermediate sites, successful nests were placed significantly closer to the edge of the nest plant than unsuccessful nests. We did not find differences in nest placement among Seep, Intermediate, and Reference sites.

We found that as bio-year precipitation increased, the number of fledglings produced per vireo pair also increased. We did not find a link between bio-year precipitation and adult survival.

Introduction

The purpose of this report is to provide the Marine Corps with an annual summary of abundance, breeding activity, demography, and habitat use of endangered Least Bell's Vireos (*Vireo bellii pusillus*) at Marine Corps Base Camp Pendleton (MCBCP or Base). The results are intended to provide the Base with biological information during each year to assist with appropriate management of the federally listed Least Bell's Vireo and maintain compliant actions supporting military training on MCBCP in accordance with the Base Integrated Natural Resources Management Plan and U.S. Fish and Wildlife Service Programmatic Biological Opinion (U.S. Fish and Wildlife Service, 1995).

The Least Bell's Vireo (hereafter referred to as "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 and agriculture (Franzreb, 1989; U.S. Fish and Wildlife Service, 1998; Riparian Habitat Joint Venture, 2004). Additional factors that contributed to the vireo's decline were (1) the expansion in range of the Brown-headed Cowbird (*Molothrus ater*), a brood parasite, to include the Pacific coast (U.S. Fish and Wildlife Service, 1986; Franzreb, 1989; Kus, 1998, 1999; Kus and others, 2020) and (2) the introduction of invasive non-native 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, and the U.S. Fish and Wildlife Service followed 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 and Whitfield, 2005). As of 2006, the statewide vireo population was estimated to be approximately 2,500 territories (U.S. Fish and Wildlife Service, 2006), roughly a third of which were on MCBCP.

Male vireos arrive on breeding grounds in southern California in mid-March. Male vireos are conspicuous and frequently sing their diagnostic primary song from exposed perches throughout the breeding season (Kus and others, 2020). Females arrive approximately 1–2 weeks after males and are more secretive. Females often are seen early in the season traveling through the habitat with males. 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 Least Bell's 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 renest after a failed attempt, provided ample time remains within the breeding season (Kus and others, 2020). Vireos rarely fledge more than one brood in a season, although double-brooding can be more common during years when breeding conditions are favorable (for example, early nest initiation, high early fledging success; Lynn and Kus, 2009, 2010a). Nesting lasts from early April through July, but adults and juvenile birds remain on the breeding grounds into late September or early October before migrating to their wintering grounds in southern Baja California, Mexico.

Vireo pairs hold territories of approximately 0.5–1.0 hectare (ha) and maintain territory boundaries through vocal interactions with neighboring pairs. Territories remain stable throughout the breeding season, although silent males occasionally venture beyond their territory boundaries. Females sometimes leave their original territory to begin a new breeding attempt with a different male after completing an earlier nesting attempt (either successful or failed). Territory boundaries relax near the end of the breeding season as fledglings explore surrounding habitat. Territory fidelity between years is high for males, with typically 70–90 percent of males returning to within 100 m of their previous breeding territory (Rourke and Kus, 2006, 2007, 2008; Lynn and Kus, 2009, 2010a, 2010b, 2011, 2012, 2013; Lynn and others, 2014, 2015, 2016, 2017, 2018, 2020, 2024a, 2024b, 2024c).

In 2019, MCBCP began operating an artificial seep along the Santa Margarita River as part of a Conjunctive Use Project. Two additional seeps were installed and activated in early 2021. In 2023, one seep failed to operate for the entire season. The artificial seeps pump water to the surface beginning in March and ending in August each year during daylight hours and were designed to increase the amount of surface water present to enhance Southwestern Willow Flycatcher (*Empidonax traillii extimus*) breeding habitat. Although these enhancements were designed to benefit Southwestern Willow Flycatchers, few flycatchers have inhabited MCBCP, including the seep areas, within the past several years (Howell and Kus, 2015, 2016, 2017, 2024a, 2024b, 2024c; Howell and others, 2018, 2020; B. Kus, U.S. Geological Survey, unpub. data, 2023). However, vireos are abundant in the enhancement areas and were selected as a surrogate species to determine the effects of the habitat enhancement. Vireos frequently co-occur with flycatchers in riparian habitat and have similar habitat requirements, such as the presence of riparian obligate trees (typically willows and cottonwoods) with a shrubby understory. Vireos and flycatchers have similar territory size and similar territorial behavior (singing from high perches to advertise territory boundaries), and they share some similarities in nest placement. Both species' nests are placed in the understory vegetation, although vireo nests are usually placed about 1 m above the ground, whereas flycatcher nest heights range from 1 to 3 m (Howell and Kus, 2024c). Although there are some differences in habitat requirements between these two species (flycatchers prefer more mesic conditions that include surface water or elevated soil moisture during at least part of the breeding season; vireos are more tolerant of drier, brushier vegetation sometimes lacking an overstory), vireos were considered sufficiently similar to flycatchers to serve as a surrogate species to evaluate the response of habitat to surface water enhancement and the effect of these habitat changes on vireo breeding productivity. This report presents preliminary analyses of vireo and vegetation response to the artificial seeps.

Specific goals of this study were to (1) determine the size and composition of the vireo population on Base; (2) characterize habitat used by vireos; (3) band a subset of vireos to facilitate the estimation of vireo annual survival and movement; (4) document the vegetation structure and plant composition within the areas affected by artificial seeps (Seep or Intermediate sites) compared to similar areas without artificial seeps (Reference sites); and (5) assess the effects of the artificial seeps on vireos by measuring territory density, annual survival, inter-annual movement, nest success, and breeding productivity of vireos in sites surrounding artificial seeps compared to Reference sites in which no additional surface water was provided.

Data collected from this study are critical to inform natural resource managers about the status of this endangered species at MCBCP and guide modification of land use and management practices as appropriate to ensure the species' continued existence. All activities were covered under 10(a)1(A) Recovery Permit #ESPER0004080-0.2.

Study Areas and Methods

Population Size and Distribution

Most of the MCBCP's major drainages, and several minor ones supporting riparian habitat (fig. 1), were surveyed for vireos between April 11 and July 20, 2023. Field work was completed by U.S. Geological Survey biologists Lisa Allen, Annabelle Bernabe, Ynez Diaz, Alexandra Houston, Scarlett Howell, Megan Logsdon, Suellen Lynn, Jessica Medina, Maia Nguyen, Samuel Rapp, Aaron Spiller, and Devin Taylor.

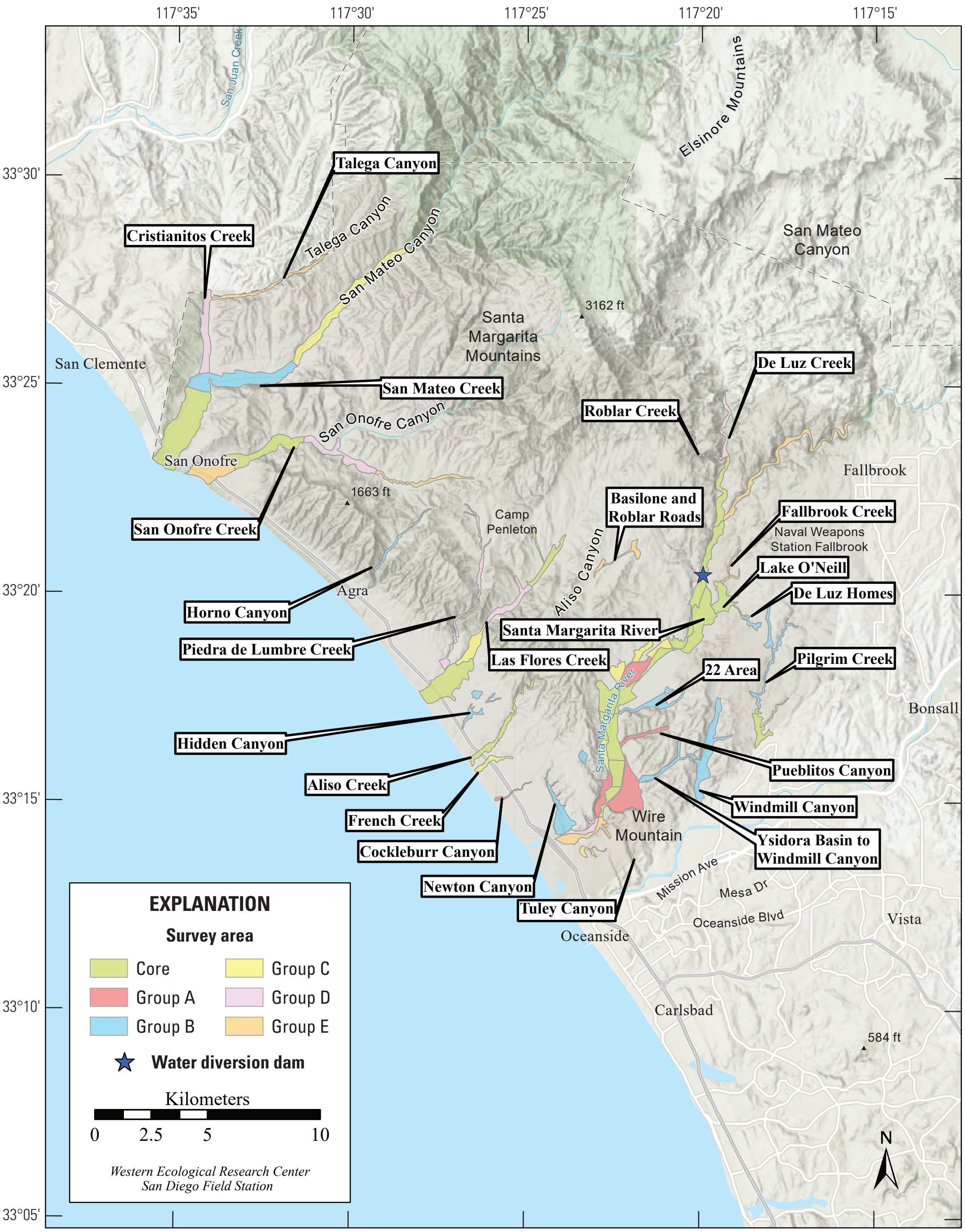
In 2020, we began a new program for surveying for vireos on MCBCP. The new design involved surveying a core area plus a rotating subset of non-core riparian habitat each year rather than surveying the entire Base every year. Selection criteria for surveys within the core area included (1) primary drainages (Santa Margarita River, Las Flores Creek, San Onofre Creek, and San Mateo Creek); (2) historic Southwestern Willow Flycatcher territories; (3) vireo nest monitoring areas from a previous post-fire study (Lynn and others, 2014, 2015, 2016, 2017, 2018, 2020); and (4) the survey unit with the highest average count of flycatchers from 2005 to 2014 in drainages where no historic flycatcher breeding or nest monitoring has occurred (C. Lee, U.S. Marine Corps Base Camp Pendleton, written commun., 2019). Core survey areas were surveyed 4 times per year at least 10 days apart every year except for a section of the upper Santa Margarita River that was surveyed 3 times in 2023 because range access was denied for the first survey period. Non-core areas were divided into five groups (A–E; fig. 1), each to be surveyed on a rotational schedule once every 5 years. Group B non-core areas were surveyed in 2023. The number of surveys per year in non-core areas varied depending on the amount of suitable habitat, the likelihood of vireo occupation of the area based on previous surveys at MCBCP, and logistical restrictions (for example, denial of range access). All non-core areas were surveyed three times in 2023, except De Luz Homes habitat, which was surveyed four times. The specific areas surveyed were as follows:

Core Survey Areas

1. De Luz Creek South, between the confluence of the Santa Margarita River and the confluence with Roblar Creek (app. 1, fig. 1.1).
2. Santa Margarita River:
    (a) Air Station East, Effluent Seep, Bell North, and Bell South from Basilone Road to a point approximately 8.5 kilometers (km) downstream on the east side of the Santa Margarita River (app. 1, figs. 1.1, 1.2).
    (b) Rifle Range, Pump Road (excluding Pump Road monitoring area), from the Rifle Range along Stagecoach Road to a point approximately 2.5 km downstream on the west side of the Santa Margarita River (app. 1, figs. 1.1, 1.2).
    (c) Above Hospital, Below Hospital East, Below Hospital West, from the confluence with De Luz Creek to Basilone Road (app. 1, fig. 1.1).
3. Lake O'Neill section of Fallbrook Creek, all riparian habitat surrounding Lake O'Neill (app. 1, fig. 1.1).
4. Aliso Creek, between the Pacific Ocean and 0.5 km upstream from the electrical transmission lines (app. 1, fig. 1.2).
5. Las Flores Creek (within Las Pulgas Canyon):
    (a) Lower Las Flores South, between the Pacific Ocean and a point approximately 2 km upstream from Stuart Mesa Road (app. 1, fig. 1.3).
    (b) Upper Las Flores North, between a point 1.6 km downstream of Basilone Road to the Zulu Impact Area, approximately 0.75 km upstream from Basilone Road (app. 1, fig. 1.3).
6. San Mateo Creek, Lower San Mateo Bottom, from the Pacific Ocean to a point 3.7 km upstream, including habitat south and east of the abandoned agricultural fields (app. 1, fig. 1.4).
7. San Onofre Creek, Lower San Onofre East, from a point 1.5 km upstream from the Pacific Ocean to a point approximately 5 km upstream from the Pacific Ocean (app. 1, figs. 1.3, 1.4).
8. Pilgrim Creek, Pilgrim South: between the southern Base boundary and Vandegrift Boulevard, including the two side drainages east of Pilgrim Creek (app. 1, fig. 1.5).

Rotating Non-Core Survey Areas: Group B

1. 22 Area, all riparian habitat within the 22 Area, east of Vandegrift Road and the Supply Depot (app. 1, fig. 1.2).
2. Newton Canyon, between the confluence with the Santa Margarita River and the upstream limit of riparian habitat (app. 1, fig. 1.2).
3. Hidden Canyon, between Interstate 5 and Stuart Mesa Road (app. 1, fig. 1.3).
4. Horno Canyon, between Old Highway 101 and the upstream limit of riparian habitat (app. 1, fig. 1.3).



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Universal Transverse Mercator, zone 11 north
North American Datum of 1983

Figure 1. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2023.

5. San Mateo Creek, from San Mateo Road downstream approximately 4.6 km to the confluence with Cristianitos Creek (app. 1, fig. 1.4).
6. Pilgrim Creek, from Vandegrift Boulevard upstream to the limit of riparian habitat (app. 1, fig. 1.5).
7. Windmill Canyon, from the Base boundary past the golf course to the upstream extent of habitat (includes both 2004 Windmill Canyon and Horse Pasture sites; app. 1, fig. 1.5).
8. Ysidora Basin to Windmill Canyon, between Upper Ysidora Basin and Windmill Canyon/ Pueblitos Canyon (app. 1, fig. 1.5).
9. De Luz Homes Habitat, patches of habitat adjacent to the De Luz Homes development (app. 1, fig. 1.5).

Biologists followed standard survey techniques described in the U.S. Fish and Wildlife Service Least Bell's Vireo survey guidelines (U.S. Fish and Wildlife Service, 2001). Observers moved slowly (1–2 km per hour) through riparian habitat while searching and listening for vireos. Observers walked along the edge(s) of the riparian corridor on the upland or riverside where habitat was narrow enough to detect a bird on the opposite edge. In wider stands, observers traversed the habitat to detect all birds throughout its extent. Surveys typically began at sunrise and were completed by early afternoon, avoiding conditions of high winds and extreme heat that can reduce bird activity and detectability.

All male vireos were detected and confirmed audibly by hearing their diagnostic song. Attempts were made to observe males visually to note banding status, but direct observation was not required to confirm the identity of the species because the song was considered the most diagnostic field characteristic. The presence of a female vireo within a territory was confirmed audibly through the detection of the pair call, a unique call elicited between mated birds, or visually when observed traveling quietly with the male. Alternatively, female presence was inferred by observing a nest, the presence of dependent fledglings, or breeding behavior such as a food carry. For each bird encountered, investigators recorded age (adult or juvenile), sex, breeding status (paired, unpaired, undetermined, or transient), and if the bird was banded. Birds were only considered unpaired if their territories were visited weekly and no female was ever detected (for example, territories in nest monitoring plots). Birds were considered transients if they were detected only once, or if detected more than once, all detections were within a short period of time (maximum of 2 weeks). Vireo locations were mapped using Environmental Systems Research Institute (ESRI) field maps (Environmental Systems Research Institute, 2022) on Samsung Galaxy S7 and S8 and LG G5 mobile phones that use Android operating systems with a built-in Global Positioning System (GPS) to determine geographic coordinates (World Geodetic System of 1984 [WGS 84]).

Habitat Characteristics

Dominant native and non-native plants were recorded, and percentage cover of non-native vegetation was estimated using cover categories of less than 5, 5–50, 51–95, and greater than 95 percent within the area used by each vireo detected. The overall habitat type within each territory was specified according to the following categories:

Mixed willow riparian: Habitat dominated by one or more willow species, including black willow (*Salix gooddingii*), arroyo willow (*S. lasiolepis*), and red willow (*S. laevigata*), with mule fat (*Baccharis salicifolia*) as a frequent co-dominant.

Willow-cottonwood: Willow riparian habitat in which Fremont cottonwood (*Populus fremontii*) is a co-dominant.

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

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

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

Upland scrub: Coastal sage scrub adjacent to riparian habitat.

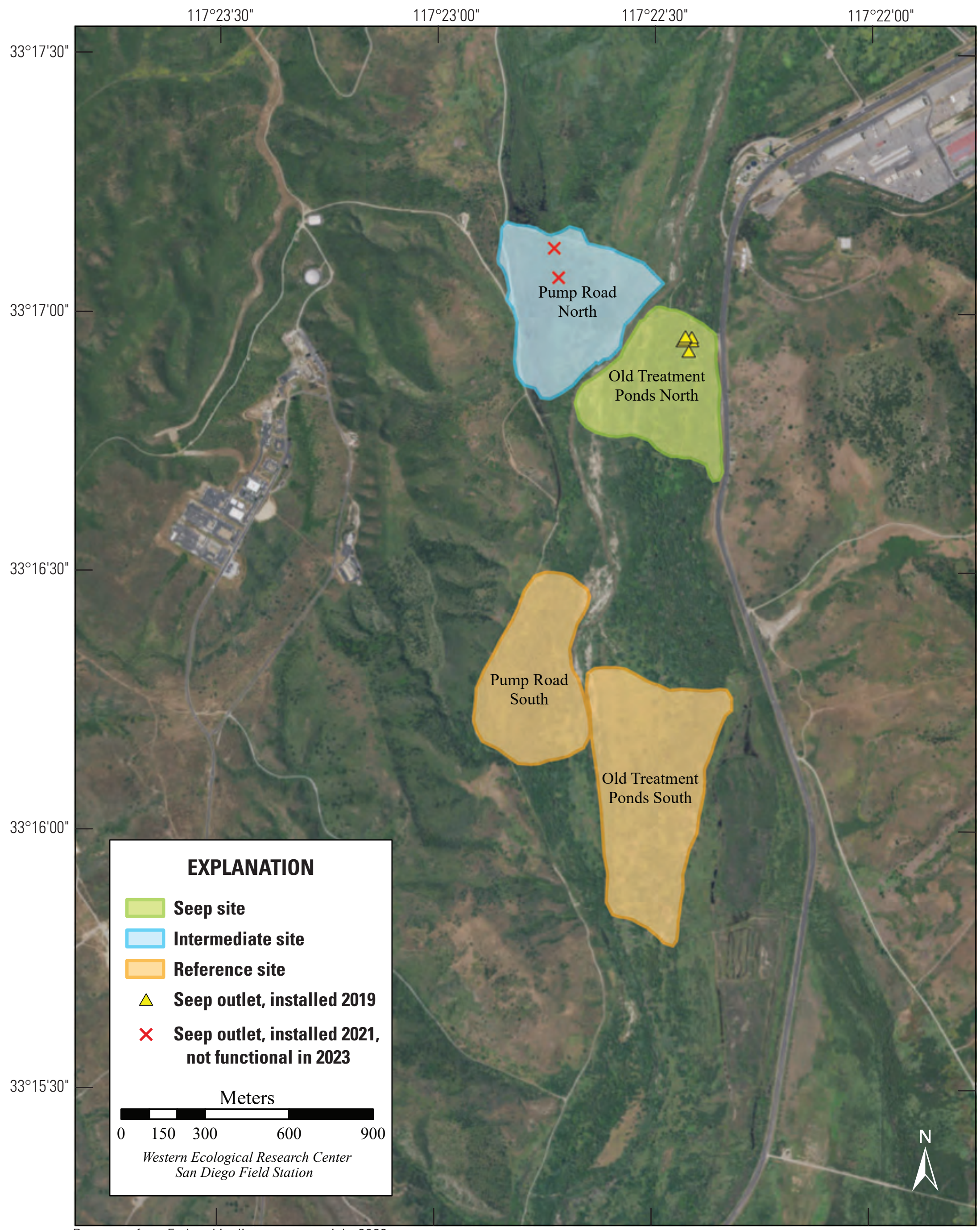
Non-native: Sites vegetated exclusively with non-native species, such as giant reed and salt cedar (*Tamarix* spp.).

Artificial Seep Study

In April 2019, MCBCP completed construction of a weir system designed to divert water from the Santa Margarita River to Lake O'Neill and several recharging ponds for the Conjunctive Use Project (P. McConnell, Vernadero Group, unpub. data, 2018). The purpose of the Conjunctive Use Project is to provide additional water for MCBCP and the Fallbrook Public Utility District (P. McConnell, Vernadero Group, unpub. data, 2018). In January 2019, MCBCP began operating an artificial seep along the Santa Margarita River to compensate for groundwater withdrawal upstream associated with the weir system (fig. 2; U.S. Fish and Wildlife Service, 2016). Two more artificial seeps were installed in early 2021. One of the pumps installed in 2021 was non-functional for the entire 2023 field season.

A low-volume (20–40 liters per minute), shallow groundwater irrigation pumping well was installed at each artificial seep location to draw water to the surface. The pumps were solar-powered and directed water to as many as six outlet pipes at each seep arranged within an area of approximately

1,500 square meters (m^2). Water was pumped to the surface when there was sufficient sunlight for solar panels to operate beginning in March and ending in August each year. Shallow pools created by the seep pumps were small (8–44 m^2) and limited to the immediate vicinity of the outlet pipes. The purpose of our study was to measure the effects of the artificial seeps on vegetation and vireo breeding, movements, and survival compared to areas where seeps were not operating, beginning in 2020, the first breeding season after the Conjunctive Use Project was implemented. Data collection and analyses were focused on vireo habitat affinities that are shared with Southwestern Willow Flycatchers.



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North American Datum of 1983

Figure 2. Location of Least Bell's Vireo Seep, Intermediate, and Reference sites at Marine Corps Base Camp Pendleton, 2023.

We established two types of study plots, Seep and Reference sites, and later added a third category, Intermediate sites, to incorporate unanticipated disruptions to the operation of the seep pumps (fig. 2). Originally, two Seep sites were selected. The Seep sites surrounded and extended downstream of (1) the seep installed in 2019 northwest of the Old Treatment Ponds area and (2) the seep installed in 2021 in the Pump Road area. A Reference site was selected 0.5–0.8 km from each Seep site. Reference sites were on the same side of the Santa Margarita River as their corresponding Seep sites and encompassed similar vegetation as the corresponding Seep site. Because the seep pump at Pump Road was not installed until 2021, and then failed to function in 2023, we redefined that site as Intermediate in 2023. We anticipate that the Seep site, and likely the Intermediate site, will become wetter relative to the Reference sites as the upstream water diversion effects are manifested and surface water is augmented near the seep pumps.

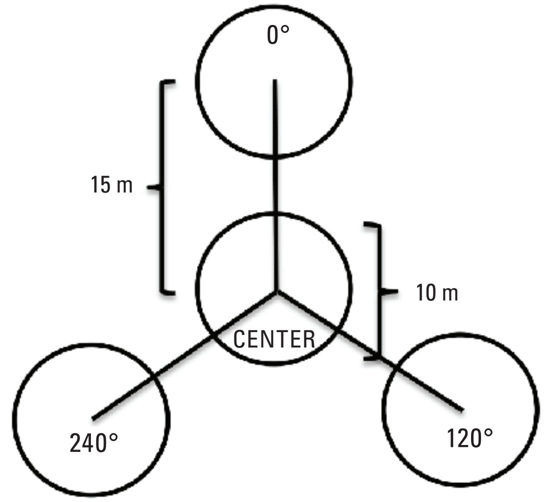


Figure 3. Vegetation sampling plot configuration. Abbreviation: m, meter.

Vegetation Structure and Plant Composition

We sampled vegetation at one Seep site, one Intermediate site, and two Reference sites (fig. 2) to examine the response of riparian habitat to locally augmented surface water. We collected vegetation data at 12 vireo territories at the Seep site, 12 territories at the Intermediate site, and 24 territories at Reference sites, centered on the nest closest to the center of each vireo territory, for a total of 48 vegetation sampling locations (app. 2). Vegetation data were collected using a protocol that combined aspects of flycatcher vegetation sampling in 2001 and 2002 (Rourke and others, 2004) and the stacked cube method developed to characterize canopy architecture in structurally diverse riparian habitat for vireos (Kus, 1998). Each sampling location consisted of a center plot (nest location) and 3 satellite plots (fig. 3), totaling 192 sampling plots. Satellite plots were located 15 m from the center plot at 0, 120, and 240 degrees. We collected a GPS point at the center of each plot.

Vegetation cover within 5 m of the center of the plot was visually estimated at seven height intervals: 0–1, 1–2, 2–3, 3–4, 4–5, 5–6, and greater than 6 m. A 7.5-m tall fiberglass telescoping pole (Hastings non-conductive fiberglass telescoping measuring rod, model M-25, https://www.hfgp.com, Hastings, Michigan), demarcated in 1-m intervals, was used to determine height class and canopy height. Overall (or total) foliage cover was recorded as the percentage of volume (percentage cover) occupied by all foliage in the plot at each height interval, lumping all species together. Overall non-native foliage cover was measured as the percentage cover of all non-native species (herbaceous and woody) within the plot at each height interval. Both overall foliage and non-native cover were estimated 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. Cover classes were further refined using + and − to indicate if the estimate was in the upper or lower range of the cover class. We described the composition of vegetation at each height by recording the percentage of the overall foliage cover made up by each of the three species (Species 1, 2 and 3) contributing the most cover, as well as a fourth category called "All Other" species, with the four cover estimates summing to 100 percent. We also measured canopy height (estimated if above 7.5 m) and recorded soil moisture (percentage of relative saturation) at the center of each plot using a Kelway model HB-2 soil pH and moisture meter (Kel Instruments Co., Inc., https://www.kelinstruments.com/kelway-hb-2, Teaneck, New Jersey).

Vireo Survival, Site Fidelity, and Movements

We began color banding vireos on MCBCP in 1995, and by the end of 2022, over 1,000 vireos had been color banded. The primary goals of banding vireos were to (1) evaluate adult and first-year annual survival; (2) evaluate vireo site fidelity within a potential source population; (3) investigate natal dispersal on Base and the role MCBCP young play in potentially supporting vireo populations off Base; and, (4) starting in 2020, evaluate how artificial seeps affected vireo site fidelity, dispersal, and annual survival. The regional vireo color banding convention designates orange or gold as the color representing MCBCP; therefore, nestlings from monitored nests were banded at 6–7 days of age with a single anodized gold numbered federal band on the right leg. When identification of neighboring territories was in question, adult vireos within Seep, Intermediate, and Reference sites were captured in mist nets and banded with a unique combination of colored plastic and anodized metal bands, including either an anodized gold or orange plastic band or both, depending on the available color combinations (to designate MCBCP as the bird's site of origin). Returning adults previously banded as nestlings with a single numbered federal band were target netted to determine their identity, and their original band was supplemented with other bands to generate unique color combinations.

Survival Estimates

During surveys and nest monitoring activities, we attempted to resight all vireos to determine if they were banded, and if so, to confirm their identity by reading their unique color band combination or by recapturing birds with single federal bands. We used resighting and recapture data from core survey areas and nest monitoring areas to calculate annual survival.

Annual survival was calculated for (1) adults Base-wide; (2) first-year vireos that were banded as nestlings or juveniles Base-wide (in other words, first-year survival); (3) adults that were initially detected at Seep, Intermediate, or Reference sites and returned to Seep, Intermediate, or Reference sites; and (4) first-year vireos that were banded as nestlings or juveniles at Seep, Intermediate, or Reference sites and were redetected anywhere that we performed regular surveys. We examined the effects of precipitation, sex, age, and year on annual survival. Precipitation data were collected from Lake O’Neill on MCBCP (Office of Water Resources, 2023) and were grouped into bio-year (July 1 through June 30). Most of the annual precipitation accumulates during the winter months in southern California (fig. 4). Using bio-year to group annual precipitation allows us to examine the effects of the wet season as a whole, rather than breaking up the wet months into separate periods.

Site Fidelity and Movement

Site fidelity and movement of vireos were determined by measuring the distance between the center of a vireo’s breeding or natal territory in 2022 and the center of the same vireo’s breeding territory in 2023. Vireos demonstrated site fidelity if they returned to within 100 m of their 2022 territory (Kus and others, 2020).

Site fidelity and movement were calculated for the same four categories analyzed for annual survival (see the “Survival Estimates” section), except we excluded individuals that did not have a known territory location before 2023 (for example, juveniles banded after fledging were excluded because their natal territories could not be confirmed because of their capacity for substantial movement; vireos captured at either of the Monitoring Avian Productivity and Survivorship [MAPS] stations on Base were excluded unless their territory locations were known from surveys).

Nest Success and Breeding Productivity

We monitored vireo nests to evaluate how vireo nest success and productivity were affected by alteration of vireo habitat by the artificial seeps compared to reference sites with no augmented surface water. We monitored vireo nests at one Seep site, one Intermediate site, and two Reference sites to compare measures of nest success and productivity among the groups. Nesting activity was monitored at 13 territories in the Seep site, 12 territories in the Intermediate site, and 25 territories in Reference sites between April 8 and July 26, 2023. Territories were chosen in order of the vireos’ arrival, with priority given to territories occupied by banded vireos or territories that had been monitored in previous years. Vireos were observed for evidence of nesting, and their nests were located. Nests were visited as infrequently as possible to minimize the chances of leading predators or Brown-headed Cowbirds to nest sites; typically, there were three to five visits per nest. The first visit was timed to determine the number of eggs laid, the next few visits to determine hatching and age of young, and the last visit to band nestlings. Fledging was confirmed through detection of young outside the nest, or rarely, the presence of feather dust in the nest. Unsuccessful nests were placed into one of four nest fate categories: (1) Depredated, meaning nests found empty or destroyed before the estimated fledge date and where the adult vireos were not found tending fledgling(s); (2) Parasitized, meaning previously active nests that were subsequently abandoned by adult vireos after one or more Brown-headed Cowbird eggs were laid in the nest or any nests that fledged cowbird young without fledging vireo young; (3) Other, meaning nests that failed for reasons such as poor nest construction, the collapse of a host plant that caused a nest’s contents to be dumped onto the ground, the presence of a clutch of infertile eggs, or other causes that were known; and (4) Unknown, meaning nests that appeared intact and undisturbed but were abandoned with vireo eggs or nestlings. Characteristics of nests were recorded

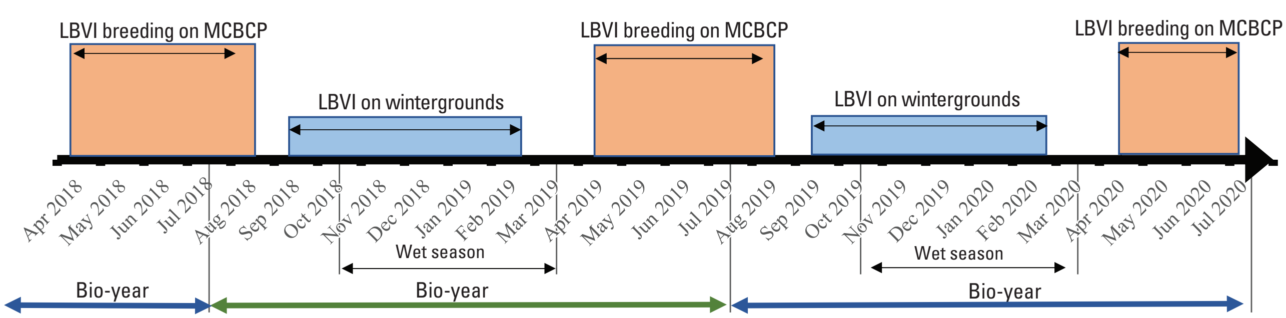


Figure 4. Timeline relating Least Bell’s Vireo (LBVI) life cycle stages, bio-year, and seasonality of annual precipitation (wet season on breeding grounds), represented for April 2018 through July 2020. Abbreviation: MCBCP, Marine Corps Base Camp Pendleton.

after abandonment or fledging of young from nests. These characteristics included nest height, host species, host height, the distance nests were placed from the edge of the host plant, and the distance nests were placed from the edge of the vegetation clump in which they were located.

To determine if the artificial seeps affected vireo productivity, we compared vireo breeding productivity among Seep, Intermediate, and Reference sites in 2023 using several metrics. We examined nest success and the proportion of nests that were depredated or parasitized by cowbirds, and the likelihood of re-nesting after a first nesting attempt (successful or failed), to associate the effects altered habitat may have on the vulnerability of vireo nests to predators and brood parasites. We also examined clutch size (the maximum number of vireo eggs known to be laid in the nest), the proportion of eggs that hatched, the proportion of nestlings that fledged, number of fledglings produced per egg, the proportion of nests that successfully fledged young, the total number of fledglings per pair, and the proportion of pairs that had at least one successful nest. We examined vireo nest placement to explore vireo response to potential differences in vegetation structure among Seep, Intermediate, and Reference sites.

Marine Corps Base Camp Pendleton implements an intensive annual cowbird control program on Base, and parasitism of vireo nests is extremely rare. Nevertheless, when necessary, we followed our standard protocol for manipulating nest contents in the event cowbird eggs or nestlings were detected in vireo nests. 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. Cowbird eggs were removed from nests containing three or more vireo eggs as they were found. Cowbird nestlings were removed immediately from nests.

Data Analyses

Population Size and Distribution

Because we began a core plus rotating non-core survey design in 2020, we limited our examination of annual differences in population size to vireo territories that were located within the core survey areas. In this report, we present summaries of vireo territories in non-core survey areas without annual comparisons. Non-core survey results will be summarized every fifth year (for example, in 2024, 2029, and so on) when a round of non-core surveys has been completed. We calculated the projected Base-wide vireo population size in 2023 based on the proportion of all vireo territories that were counted within core survey areas from 2005 to 2019. First, for each year from 2005 to 2019, we calculated the proportion of all vireo territories on Base that were counted within the core survey areas (core/total); then, we multiplied these proportions by the number of vireo territories that were counted within core survey areas in 2023 to arrive at a range of projected numbers of vireo territories Base-wide in 2023.

Vegetation Structure and Plant Composition

At each height category, the estimates of the top three species contributing the most cover and the fourth category representing All Other were converted to percentage cover values of the sampling plot area (n=192) by dividing the estimate by the overall foliage cover at that height. We then calculated the average percentages of cover of each plant species, overall cover, cover of non-native plant species, canopy height, and soil moisture across the center and three satellite plots at each sampling location to obtain means for each territory (n=48). For the three top species, we further classified plant species into native herbaceous vegetation, woody vegetation (including both native and non-native species), and all herbaceous vegetation to calculate percentage cover of each of these three groups at each height category and sampling location. We also identified the maximum canopy height among the center and three satellite plots at each sampling location. We used analysis of variance tests (ANOVA) to determine if there were differences among Seep, Intermediate, and Reference sites in (1) average canopy height, (2) maximum canopy height, (3) soil moisture, (4) vegetation volume (percentage cover) of all plant species (overall cover), (5) vegetation volume of woody species, (6) vegetation volume of all herbaceous species, (7) vegetation volume of native herbaceous species, and (8) vegetation volume of non-native species (including herbaceous and woody species) at each height. If ANOVA tests indicated differences among sites, we used Tukey's post-hoc pair-wise tests to determine where differences occurred (Seep versus Intermediate, Intermediate versus Reference, or Seep versus Reference sites). We used Pearson's correlation to examine the relationship between soil moisture and the distance of the plot from the seep outlets at the sampling plot scale. We also used Pearson's correlation to examine the relationship between soil moisture at all locations and (1) canopy height, (2) percentage overall foliage cover in the understory (below 3 m), and (3) percentage herbaceous cover (including non-native herbaceous species) in the understory at the sampling location scale. Although we compared vegetation cover among site types at all height categories, the bulk of the vegetation was below 3 m, which is where vireos and flycatchers typically place their nests. Therefore, our primary focus was evaluation of vegetation cover among sites below 3 m, and then the presentation of differences above 3 m, when significant. Data were analyzed using Program R (R Core Team, 2022). Two-tailed tests were considered significant if $P \leq 0.10$. Means are presented with standard deviations.

Vireo Territory Density at Seep, Intermediate, and Reference Sites

To determine if vireo territory density changed after seep pumps were installed, we counted the total number of vireo territories detected within each monitoring site from 2015 to 2023. We chose this time span because it encompasses the expected project length (5 years) before the first seep was installed and all years after the first seep pump was installed. We divided the number of territories by the area (in ha) within the boundaries of each of the four monitoring sites to obtain the territory density within each site. We calculated the average territory density at the Reference sites and compared that to the average territory density of the Seep and Intermediate sites (combined because both sites had had some surface water augmentation). We used paired Student's *t*-tests (paired by year) to compare territory density in the 3 years preceding seep pump installation (2017–19) with the 3 years after seep pumps were installed at both sites (2021–23).

Annual Survival

Base-Wide Survival

We analyzed annual survival of banded vireos on MCBCP in Program MARK (White and Burnham, 1999) using the RMark package (Laake, 2013) in R (R Core Team, 2022). Imperfect detectability of banded individuals is typical of mark-recapture studies and happens for various reasons (for example, females are more cryptic and may be missed on surveys, birds are detected as banded but their full color combinations [and thus identities] are not obtained; birds with single federal bands are not recaptured and thus their identities not determined). Survival analysis in Program MARK accounts for individuals that were present but not captured (detected) by modeling both survival and detection probabilities. RMark uses program MARK to create models with or without covariates (user-designated) and produces metrics for evaluating the validity of each model or how well the model fits the data relative to the other models. Annual survival models were built for 2005–23 by creating an encounter history matrix of all individual vireos ever detected in MCBCP core survey areas, as well as the Pump Road Monitoring Area, and if they were observed in each year from 2005 to 2023. In the encounter history, a 1 is used if the bird was detected and a 0 if the bird was not detected. We included the Pump Road Monitoring Area because, although it is not a core survey area, we resight for banded birds there every year in the course of our demographic monitoring activities. Although nest monitoring sites were visited more frequently than core survey areas, we assumed detectability was the same between these two areas because we used broadcasted songs to enhance detectability of vireos. We rarely detected banded birds for the first time after the second survey, indicating that we were able to resight and identify almost all vireos by the end of May, regardless of their location.

Vireos were grouped by sex (female or male) and age: first-year (birds that were first detected and banded as nestlings or juveniles) or adult (birds that were first detected and banded as adults and any first-year bird that survived to adulthood). Survival was assumed to be constant for adults once they survived their first year. We created two sets of models. In the first set, which included only survival of adults past their first year (n=802), we instructed MARK to use the encounter history containing all birds but excluding the first year interval for any bird first encountered as a juvenile (in other words, we removed the first-year to adult time interval). For this adults-only model set, we modeled the effects of sex, year, and precipitation over the bio-year preceding the survival year. For instance, precipitation data from July 1, 2004, to June 30, 2005, (Office of Water Resources, 2023) were used for the 2005–06 survival year. We allowed detection probability to vary by sex and year. Detection probability accounted for sex because of sex-related behaviors (males are more obvious than females) and year because of annual differences in observers, number of surveys, and survey conditions (for example, surveys started late in 2011). When allowing detection probability to vary by year, any model that also includes year as a survival parameter cannot separate the estimate of survival from detection probability for the last time interval (2022–23; Cooch and White, 2022). Therefore, to provide a conservative estimate of survival for the last time interval, we fixed the detection probability to 1 for 2022–23. The survival estimate for this time interval will likely increase in the future with subsequent opportunities to recapture and resight birds. We created six adults-only models: (1) the constant model (no covariates, describing survival when none of our covariates was allowed to account for variability); (2) sex (describing the effect of sex on survival); (3) precipitation (describing the effect of precipitation on survival); (4) year (describing annual differences in survival); (5) sex plus precipitation (describing the additive effects of sex and precipitation); and (6) sex plus year (describing the additive effects of sex and year).

The second set of models included both adults and first-year birds (n=2,917) and examined the effect of age, year, and bio-year precipitation on annual survival. We allowed detection probability to vary by year to account for annual differences as described in the first set of models. This model set did not include a sex covariate because we were unable to determine sex of vireos banded as nestlings unless they returned and were recaptured and identified as adults. Therefore, only the nestlings that survived their first winter could be classified retroactively as male or female, which severely biases the estimate of sex-related survival of first-year vireos. As with the adults-only models, we fixed detection probability to 1 for 2022–23. We created six age-related models: (1) the constant model (no covariates, describing survival when none of our covariates was allowed to account for variability); (2) age (describing the difference between first-year and adult survival); (3) precipitation (describing the effect of precipitation on survival); (4) year (describing annual differences in survival); (5) age plus precipitation (describing the additive effects of age group and precipitation); and (6) age plus year (describing the additive effects of age group and year). Survival estimates were derived from the top model. Models created for survival in RMark only included detections from sites at which survey effort has been consistent from 2005 to 2023 (including MCBCP core survey areas, artificial seep study nest monitoring areas, and the lower San Luis Rey River). Incidental resights outside of these survey sites were excluded from analysis. Additionally, we did not include detections from MAPS captures because MAPS effort was considered different from survey effort. We excluded adults with unknown sex from our first model set analysis because we were not interested in defining characteristics of this group.

Vireo Survival and Return Rates Associated with Seeps

We used RMark (White and Burnham, 1999; Laake, 2013) to model the return rate of banded adult vireos to Seep, Intermediate, and Reference sites between 2020 and 2023. For the adults-only set of models, we were most interested in potential differences in return rates to Seep, Intermediate, and Reference sites rather than annual survival, so we excluded all detections outside of Seep, Intermediate, and Reference sites. We grouped adult vireos by sex and treatment (if they were originally detected at a Seep site, an Intermediate site, or a Reference site) and created a set of models similar to the Base-wide analysis for adults. We held detectability constant because all monitored birds at these sites were identified each year, and there were no sex-related or year-related differences in detectability.

We used RMark (White and Burnham, 1999; Laake, 2013) to model first-year survival for vireos that had been banded as nestlings at Seep, Intermediate, or Reference sites from 2020 to 2023. For first-year vireos, we were interested in survival within and beyond monitoring sites, so calculations included all nestlings from successful nests that were banded in 2020–22 and were re-detected anywhere in monitoring areas, core survey areas, and in regularly surveyed areas on the San Luis Rey River from 2021 to 2023 (see the "Base-wide Survival" section). We grouped vireos by age and treatment. All models included age because we were most interested in first-year survival, which would not be described in models that did not include age differences. We created a set of models similar to the Base-wide analysis for adults versus first-year birds, including age, treatment, and year. As with the adults-only models, we held detectability constant because all monitored birds at these sites were identified each year, and there were no year-related differences in detectability.

Model Evaluation

We used an information-theoretic approach (Akaike's Information Criterion for small sample sizes [AIC_c]; Burnham and Anderson, 2002) to evaluate support for models regarding the effects of sex, age, year, precipitation, and original location at a Seep, Intermediate, or Reference site (treatment) on vireo survival and return rates. For the adults-only model sets, we hypothesized that females would have a lower survival and return rate than males and that the return rate would be highest for birds that originated at the Seep site, followed by the Intermediate site, and finally, the Reference sites, although this difference might not be apparent within the first few years after seep installation. We used logistic regression with a logit link to build and rank the constant model plus five models with combinations of sex, year, and bio-year precipitation (for Base-wide, adults-only survival) and the constant model plus eight models with combinations of sex, year, and treatment (for treatment, adults-only return rate) by AIC_c, where the model with the lowest AIC_c in each model set was the highest ranked model. Models were considered well supported if they were within 2 AIC_c of the highest-ranked (top) model (difference in AIC_c [ΔAIC_c] less than 2). We examined the contributions that covariates made to the well supported models by calculating the odds ratio for each covariate in the model (the odds that the covariate affected survival such that no effect equaled 1, negative effect was less than 1, positive effect was greater than 1) and then examining the 95-percent confidence interval of the odds ratio. For example, if the 95-percent confidence interval of the odds ratio was greater than 1 and did not include 1, we had 95-percent confidence that the covariate had a positive effect on survival relative to the reference; therefore, we considered that the covariate significantly contributed to the model. We used the top model to obtain estimates of annual survival for adult females and adult males for Base-wide survival.

For the model sets that included first-year vireos, we hypothesized that first-year survival would be lower than adult survival, and that survival would be highest for first-year vireos that originated at the Seep site, followed by the Intermediate site, and lowest for vireos that hatched from nests at the Reference sites. We used logistic regression with a logit link to build and rank the constant model plus five models with combinations of age, year, and bio-year precipitation (for Base-wide survival) and age plus four models with combinations of age, year, and treatment (for treatment survival). Then, we ranked these models from lowest to highest AIC_c. We used the top model to obtain estimates of survival for adults and first-year birds.

Nest Success and Breeding Productivity

We used chi-square or Fisher's exact tests to determine if there were differences among Seep, Intermediate, and Reference sites in (1) the likelihood of vireos renesting after a first nesting attempt, (2) the likelihood of renesting if the first nesting attempt failed or was successful, (3) the proportion of nests that successfully fledged young, (4) the proportion of nests that were depredated, (5) whether or not the first nest attempt was successful, (6) the proportion of eggs that hatched, (7) the proportion of nestlings that fledged, (8) the proportion of eggs that produced fledglings, (9) the proportion of nests that produced fledglings, and (10) the number of pairs that had at least one successful nest. 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 ANOVA to determine if there were differences among Seep, Intermediate, and Reference sites in (1) the number of nesting attempts per pair, (2) clutch size, and (3) number of fledglings per pair. For nest success and breeding productivity analyses, bio-year precipitation was calculated from July 1 of the year before breeding through June 30 of the breeding season year (for example, precipitation from July 1, 2022, to June 30, 2023, was related to breeding parameters in 2023). We used Pearson's correlation to determine if there was a relationship between precipitation during the bio-year immediately preceding the breeding season and (1) the number of fledglings produced per pair, (2) the number of fledglings produced per egg, and (3) the proportion of all nests that successfully fledged young by year from 2005 to 2023. If nests were parasitized by Brown-headed Cowbirds, rescued by removing the cowbird egg(s) or nestling(s), and subsequently fledged vireo young, all success and productivity calculations were rerun treating successful rescued nests as failed nests to estimate the potential effect(s) of cowbird parasitism on the MCBCP vireo population.

Data were analyzed using Program R (R Core Team, 2022). Two-tailed tests were considered significant if $P \leq 0.10$. Means are presented with standard deviations. All data from the MCBCP from 2005 to 2022 used in comparisons with data collected for this report can be found in Rourke and Kus (2006, 2007, 2008), Lynn and Kus (2009, 2010a, 2010b, 2011, 2012, 2013), and Lynn and others (2014, 2015, 2016, 2017, 2018, 2020, 2024a, 2024b, 2024c). Data from before 2005 were extracted from unpublished reports by Griffith Wildlife Biology (J.C. Griffith and J.T. Griffith, Griffith Wildlife Biology, unpub. data, 2004).

Daily Nest Survival

We used RMark (White and Burnham, 1999; Laake, 2013) in program MARK to calculate daily survival rate (DSR) of vireo nests, which accounts for the variability in exposure days across nests discovered at different stages of the nesting cycle and allows for the analysis of the effects of covariates on DSR (Dinsmore and others, 2002). Using RMark, we modelled the effects of the seeps on DSR. Nest survival was calculated across a 32-day cycle length: 2 days for the last day of nest construction and a day of rest before the first egg was laid, 4 days for egg-laying, 14 days for incubation, and 12 days for the nestling period. Age of nests at the time they were discovered was calculated in days by forward- or backward-dating of nests in relation to known dates of nest-building, egg-laying, or hatching. Data compiled for each nest included (1) the Julian dates for when the nest was first found, last active, and last checked; (2) the nest fate (successful or unsuccessful); (3) the age of the nest (in days) when it was initiated, relative to the first nest found that year; (4) location of the nest (Seep, Intermediate, or Reference site); and (5) the year. We used AIC_c (see the "Annual Survival" section) to evaluate support for nest survival models reflecting a priori hypotheses regarding the effect of seeps on DSR. We hypothesized that DSR would be highest in the Seep site, followed by the Intermediate site and then the Reference sites; we further hypothesized that the difference in DSR among site types would increase as the soil and habitat at the Seep and Intermediate sites became wetter relative to the Reference sites. 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 (Seep, Intermediate, or Reference site) on DSR. We then created models with treatment, year, the combined effect of treatment and year (treatment plus year), and the interaction of treatment and year (treatment*year) and evaluated support for the models in relation to the constant survival model. We examined the well supported models further by calculating the odds ratio for each covariate in the model (see the "Annual Survival" section).

Nest Characteristics

We summarized the total number of nests that were placed in each host plant species by site type (Seep versus Intermediate versus Reference). We used ANOVA and Student's *t*-tests to determine if there were differences in (1) nest height, (2) host plant height, (3) distance to the edge of the host plant, and (4) distance to the edge of the vegetation clump in which the nest was located among Seep, Intermediate, and Reference sites (ANOVA). We used Student's *t*-tests to determine if there were differences in nest placement characteristics between successful and failed nests within Seep, Intermediate, and Reference sites.

Results

Population Size and Distribution

Core Survey Areas

We detected 589 male vireos in core survey areas during Base-wide surveys (fig. 5; app. 3). Of these vireos, 561 were territorial males (79 percent of which were confirmed as paired) and 28 were transients (table 1). This total represents a 2-percent decrease in territorial males (10/571) from the same areas surveyed in 2022 (table 4.1). Transient vireos were observed on six of the eight drainages and sites surveyed (75 percent). Most vireo territories (91 percent) were on the four most populated drainages/sites (Santa Margarita River, Las Flores Creek, San Mateo Creek, and Pilgrim Creek), and 72 percent were along the Santa Margarita River, which is the largest expanse of riparian vegetation on Base (tables 1, 4.1; fig. 6). The remaining 4 drainages and sites each contained fewer than 20 territories.

From 2005 to 2019, 55–62 percent of resident males detected on MCBCP were within the core areas (average 57±2 percent). Assuming the distribution of the vireo population on the rest of MCBCP in 2023 did not vary from the 2005 to 2019 distribution, we estimated between 902 and 1,029 resident vireos on MCBCP in 2023.

The distribution of vireo territories documented on Base in 2023 was similar to 2022 across all core survey areas (fig. 6; app. 4). From 2022 to 2023, the percentage of vireo territories in each drainage (number of vireo territories detected in the drainage/total number of vireo territories in core survey areas) changed by 1 percent or less in every drainage except at the Santa Margarita River (decreased by 1.2 percent). The number of vireo territories increased in four drainages and decreased in four drainages. The Santa Margarita River continued to support the most vireo territories although it decreased by 3 percent (14 territories; app. 4). Las Flores Creek, the second most populated drainage, increased by 10 percent (5 territories). The number of territories in San Mateo Creek, De Luz Creek, and Aliso Creek increased by 8–10 percent (3, 1, and 1 territories, respectively). The number of territories decreased in Fallbrook Creek by 27 percent (4 territories), in San Onofre Creek by 6 percent (1 territory), and in Pilgrim Creek by 5 percent (1 territory).

In 2023, the proportion of surveys during which Brown-headed Cowbirds were detected dropped to 0.20 from a peak of 0.45 in 2022 (table 2; app. 5). The second highest proportion of surveys where cowbirds were detected was in 2010 (0.37), followed by 2005 (0.23). No cowbirds were detected on De Luz, Aliso, San Onofre, or San Mateo Creeks in 2023. In 2023, cowbirds were detected on the Santa Margarita River in May, June, and July; on Fallbrook Creek in April and June; on Las Flores Creek in July; and on Pilgrim Creek in April, May, and June.

Non-Core Survey Areas

A total of 118 male vireos, including 103 territorial males and 15 transients, were detected in non-core survey areas in 2023 (table 3). Most of the territorial males (70 percent) were confirmed as paired.

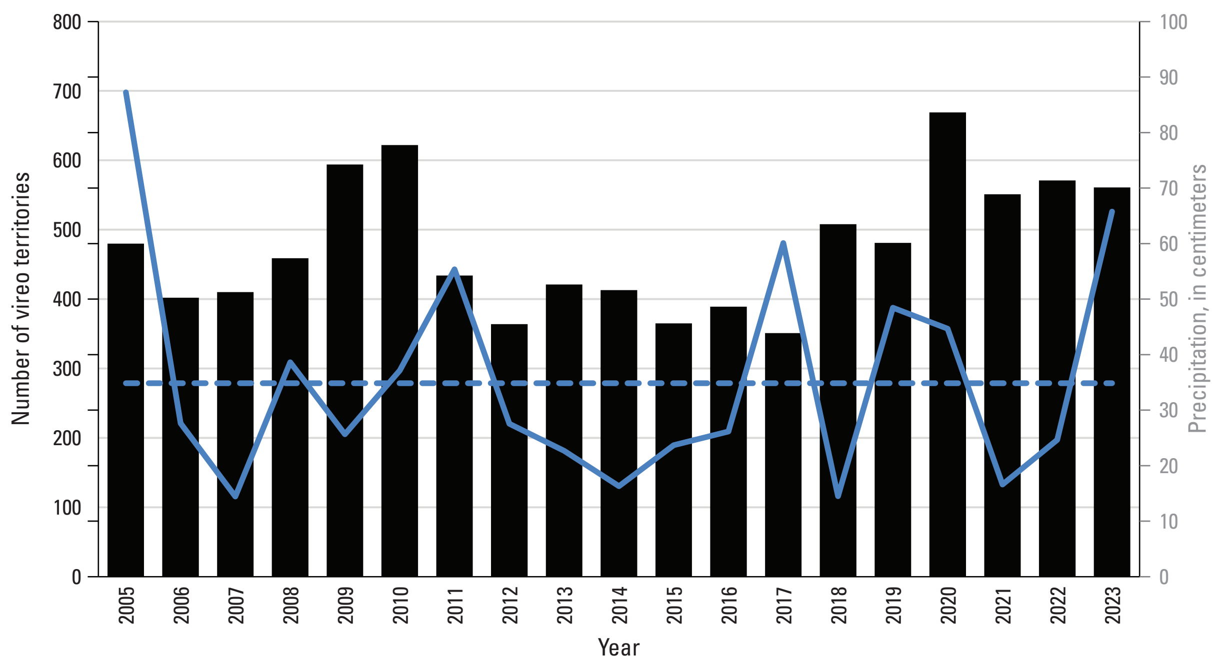


Figure 5. Number of Least Bell's Vireo territories in core survey areas (black bars) and bio-year precipitation (solid blue line; July 1–June 30, ending in the survey year; Office of Water Resources, 2023) at Marine Corps Base Camp Pendleton, 2005–23. Dotted blue line is average bio-year precipitation from 1950 to 2000 at Lake O'Neill.

Table 1. Number and distribution of Least Bell's Vireos in core survey areas at Marine Corps Base Camp Pendleton, 2023.

[Las Flores Creek was divided into specific sections for reporting in this table as requested by Marine Corps Base Camp Pendleton. **Abbreviations:** ha, hectare; Rd., road; Blvd., boulevard]

Drainage/survey site	Territories		Total territories	Transients	Total area surveyed (ha)
	Known pairs	Single/status undetermined			
Santa Margarita River, I-5 to De Luz Creek[1]	322	80	402	17	964
De Luz Creek South	9	2	11	0	95
Lake O'Neill section of Fallbrook Creek	8	3	11	3	98
Aliso Creek	10	3	13	0	94
Las Flores Creek, Pacific Ocean to Stuart Mesa Rd.	7	3	10	1	124
Las Flores Creek, Stuart Mesa Rd to eastern edge of lower core area	18	7	25	2	138
Las Flores Creek, Western edge of upper core area to Zulu Impact Area	17	2	19	0	83
San Onofre Creek, lower east core area	11	6	17	1	191
San Mateo Creek, lower bottom core area	23	11	34	1	492
Pilgrim Creek, Base boundary upstream to Vandegrift Blvd.	18	1	19	3	78
Total	**443**	**118**	**561**	**28**	**2,359**

[1]Core areas in the Santa Margarita River are the east section of Air Station, Effluent Seep, Bell, Rifle Range, Pump Road excluding Pump Road monitoring area, Above Hospital, and Below Hospital.

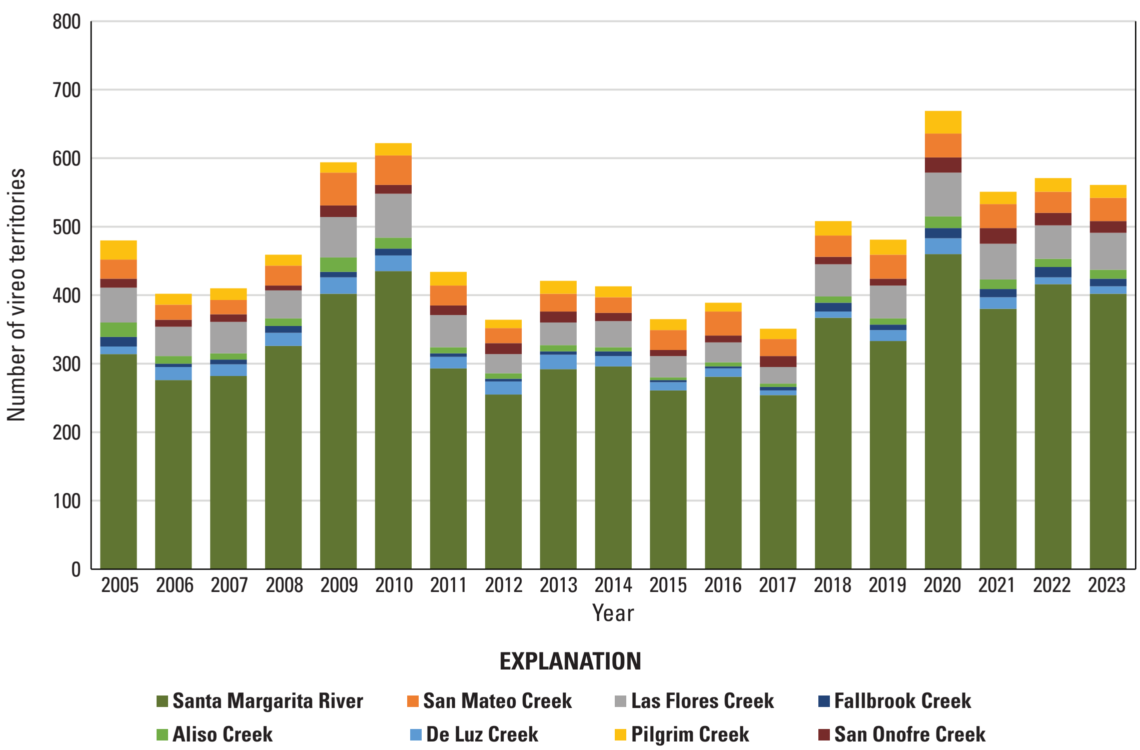


Figure 6. Number of Least Bell's Vireo territories found in each drainage in core areas on Marine Corps Base Camp Pendleton, by year, 2005–23.

Table 2. Proportion of all surveys during which Brown-headed Cowbirds were detected in core survey areas at Marine Corps Base Camp Pendleton, by drainage, 2005–23.

[Number of survey areas is the number of distinct survey units that were surveyed multiple times per year within the drainage. **Abbreviation**: —, no data]

Drainage	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Number of survey areas
Santa Margarita River	0.21	0.24	0.10	0.03	0.19	0.30	0.07	0.11	0.09	0.09	0.07	0.06	0.19	0.03	0.06	0.10	0.13	0.48	0.21	9
De Luz Creek	1.00	0	0.33	0.33	0	0.33	0	0.67	0	0	0	0	0.67	0	0	0.25	0.25	0	0	1
Fallbrook Creek	0	0	0	0.25	0.75	1.00	0	0.67	0.25	0.33	0	0	0.25	0	0	0.67	0	1.00	0.50	1
Aliso Creek	0.25	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	1
Las Flores Creek	0	0	0.43	0.29	0.29	0.50	0	0.20	0.29	0.14	0	0	0	0.14	0	0	0.13	0.63	0.13	2
San Onofre Creek	0	0.67	0	0.25	0	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	1
San Mateo Creek	1.00	0	0.33	0	0.33	0.67	1.00	0.67	—	0.50	0	0	0	0	0	0	0.25	0	0	1
Pilgrim Creek	0.25	1.00	0.33	0.25	0	0.67	0	0	—	0.25	0.33	0	0.75	0.33	0	0.50	0	0.75	0.75	1
Total	**0.23**	**0.20**	**0.16**	**0.12**	**0.21**	**0.37**	**0.15**	**0.20**	**0.11**	**0.13**	**0.06**	**0.03**	**0.21**	**0.05**	**0.03**	**0.14**	**0.11**	**0.45**	**0.20**	**20**

Habitat Characteristics

Core Survey Areas

Vireos used several habitat types ranging from willow-dominated thickets along stream courses to upland scrub (table 4). Most vireo locations in core survey areas were in habitat characterized as mixed willow riparian, with 62 percent of males in the study area found in this habitat. An additional 7 percent of birds occupied willow habitat co-dominated by cottonwoods or sycamores. Riparian scrub, dominated by mule fat, sandbar willow, or blue elderberry (*Sambucus mexicana*), was prevalent at 29 percent of vireo territories. One percent of vireos occupied drier habitat characterized by a mix of sycamore and oak or non-native vegetation, and less than 1 percent occupied upland scrub and vegetation dominated by white alder (*Alnus rhombifolia*).

The proportion of vireos documented in non-native vegetation in core survey areas decreased slightly from 2022 to 2023 (table 5; app. 6); 9 percent (53/589) of vireos in 2023 were in areas where non-native species comprised at least 50 percent of the habitat. Of territories dominated by non-native vegetation, 68 percent contained predominantly black mustard (*Brassica nigra*), 19 percent contained predominantly poison hemlock (*Conium maculatum*), and 4 percent contained predominantly salt cedar. Six of the eight drainages in 2023 contained territories dominated by non-native vegetation. Two of these drainages (the Santa Margarita River and Las Flores Creek) also contained territories dominated by non-native vegetation every year since 2015. Overall, 2005 remained the year with the highest proportion of territories dominated or co-dominated by non-native vegetation.

Non-Core Survey Areas

Most vireo locations in non-core survey areas were in habitat characterized as riparian scrub, with 54 percent of males in the study area occupying this habitat (table 6). The second most commonly used habitat type was mixed willow (36 percent of vireos), with an additional 4 percent of birds using willow habitat co-dominated by sycamore. Six percent of territories were found in upland scrub, habitat co-dominated by oaks and sycamore, and non-native vegetation.

Vegetation at Artificial Seep, Intermediate, and Reference Sites

Overall vegetation cover was highest near the ground and decreased with increasing height (fig. 7). Woody vegetation made up most of the cover at all height categories with cover ranging from 5 to 40 percent. Total and native herbaceous cover was concentrated near the ground with very little cover (less than 3 percent) above 3 m. Non-native vegetation was present at all height categories, tapering from 33 percent below 1 m to 5 percent or less above 3 m.

Soil moisture varied across the monitoring sites, but was higher in the Seep and Intermediate sites than in the Reference sites (figs. 8, 9). Most of the plots (89 percent) in the Seep site (Old Treatment Ponds) had greater than 50 percent soil moisture, with a concentration of plots with 100 percent saturated soil near the seep outlets (fig. 8). Although the seep pumps in the Intermediate site (Pump Road) were not operating in 2023, most of the plots were saturated (77 percent of plots), and almost all of the plots (98 percent) had at least 50 percent soil moisture (fig. 8). Only 23 percent of Reference site plots were 100 percent saturated, although 53 percent of plots had at least 50 percent

Table 3. Number and distribution of Least Bell's Vireos in non-core survey areas at Marine Corps Base Camp Pendleton, 2023.

[ha, hectare]

Drainage/survey site	Territories: Known pairs	Territories: Single/status undetermined	Total territories	Transients	Total area surveyed (ha)
Non-core survey areas group B					
22 Area	13	3	16	3	94
Newton Canyon	5	5	10	6	119
Hidden Canyon	5	1	6	3	48
Horno Canyon	1	0	1	0	46
San Mateo Creek, Cristianitos Creek to San Mateo Road	19	14	33	0	323
Pilgrim Creek, north of Vandegrift Boulevard	8	3	11	1	95
Windmill Creek	10	2	12	2	207
Ysidora Basin to Windmill Canyon	8	1	9	0	62
Habitat around De Luz Homes	3	2	5	0	23
Total	**72**	**31**	**103**	**15**	**1,017**

Table 4. Habitat types used by Least Bell's Vireos in core survey areas at Marine Corps Base Camp Pendleton, 2023.

[Habitat types are included for resident and transient Least Bell's Vireo locations. **Abbreviations**: >, greater than; <, less than]

Habitat type	Number of locations: >50 percent native	Number of locations: >50 percent non-native	Number of locations: Total	Percentage of total
Mixed willow	350	17	367	62
Riparian scrub	140	32	172	29
Willow-sycamore	38	0	38	6
Non-native	0	4	4	1
Oak-sycamore	3	0	3	1
Willow-cottonwood	2	0	2	<1
Upland scrub	2	0	2	<1
Alder	1	0	1	<1
Total	**536**	**53**	**589**	**100**

Table 5. Proportion of Least Bell's Vireo territories, including areas occupied by transients, dominated or co-dominated by non-native vegetation, by drainage, 2005–23.

Year	Proportion of all territories (number of territories within the drainage)								
	Aliso Creek	De Luz Creek	Fallbrook Creek	Las Flores Creek	Pilgrim Creek	San Mateo Creek	San Onofre Creek	Santa Margarita River	Total
2005	0.09 (23)	0.08 (12)	0.16 (19)	0 (49)	0 (28)	0.62 (26)	0.45 (11)	0.19 (319)	**0.18 (487)**
2006	0 (14)	0.05 (20)	0 (6)	0.07 (45)	0 (16)	0.16 (25)	0 (12)	0.07 (291)	**0.06 (429)**
2007	0.09 (11)	0 (17)	0.14 (7)	0 (47)	0 (18)	0 (19)	0 (12)	0.03 (291)	**0.03 (422)**
2008	0 (12)	0 (21)	0 (10)	0.24 (45)	0 (17)	0.11 (27)	0.43 (7)	0.03 (328)	**0.06 (467)**
2009	0 (23)	0 (22)	0 (8)	0.09 (65)	0.30 (20)	0.10 (52)	0.30 (20)	0.07 (422)	**0.08 (632)**
2010	0.11 (18)	0 (23)	0 (10)	0.12 (67)	0.05 (20)	0.27 (49)	0.13 (16)	0.05 (439)	**0.07 (642)**
2011	0 (9)	0 (17)	0 (5)	0.04 (48)	0.05 (22)	0.03 (30)	0.25 (16)	0.11 (297)	**0.09 (444)**
2012	0.18 (11)	0 (20)	0.17 (6)	0 (28)	0 (12)	0 (21)	0 (16)	0.07 (258)	**0.06 (372)**
2013	0 (12)	0 (21)	0 (6)	0 (34)	0 (19)	0 (28)	0 (16)	0.05 (300)	**0.04 (436)**
2014	0 (6)	0.25 (16)	0 (7)	0 (39)	0 (18)	0 (28)	0.06 (16)	0.04 (308)	**0.04 (438)**
2015	0 (5)	0.19 (16)	0 (5)	0.03 (33)	0 (17)	0.17 (30)	0.44 (9)	0.08 (280)	**0.09 (395)**
2016	0 (6)	0.19 (16)	0 (4)	0.10 (30)	0 (13)	0 (39)	0 (11)	0.03 (292)	**0.04 (411)**
2017	0.20 (5)	0.71 (7)	0 (6)	0.04 (23)	0.06 (16)	0.40 (25)	0.19 (16)	0.04 (268)	**0.09 (366)**
2018	0 (9)	0 (10)	0.13 (15)	0.15 (55)	0.05 (21)	0 (33)	0 (11)	0.06 (376)	**0.06 (530)**
2019	0.08 (12)	0.13 (16)	0.13 (8)	0.24 (49)	0 (22)	0.29 (35)	0.2 (10)	0.13 (342)	**0.15 (494)**
2020	0.11 (18)	0.43 (23)	0.27 (15)	0.07 (67)	0.09 (33)	0.23 (35)	0.13 (24)	0.18 (470)	**0.17 (685)**
2021	0.13 (16)	0 (19)	0.07 (14)	0.11 (53)	0 (20)	0 (36)	0.38 (26)	0.10 (393)	**0.10 (577)**
2022	0.07 (14)	0 (10)	0 (15)	0.22 (51)	0.10 (21)	0.15 (34)	0.16 (19)	0.10 (421)	**0.11 (585)**
2023	0.08 (13)	0 (11)	0.36 (14)	0.18 (57)	0.09 (22)	0.23 (35)	0 (18)	0.06 (419)	**0.09 (589)**

Table 6. Habitat types used by Least Bell's Vireos in non-core survey areas at Marine Corps Base Camp Pendleton, 2023.

[Habitat types are included for resident and transient Least Bell's Vireo locations. **Abbreviation**: >, greater than]

Habitat type	Number of locations			Percentage of total
	>50 percent native	>50 percent non-native	Total	
Non-core survey areas group B				
Riparian scrub	35	29	64	54
Mixed willow	35	7	42	36
Willow-sycamore	5	0	5	4
Upland scrub	3	1	4	3
Oak-sycamore	2	0	2	2
Non-native	0	1	1	1
Total	**80**	**38**	**118**	**100**

soil moisture. In the Pump Road Reference site, wet plots were located in the center and north end, and in the Old Treatment Ponds Reference site, wet plots were prevalent in the eastern section (further from the river channel; fig. 9). Soil moisture was significantly higher at the Seep (78±17 percent) and Intermediate sites (94±7 percent) than at Reference sites (51±23 percent; F=11.98, P<0.001; Tukey's post-hoc tests: Seep versus Intermediate P=0.27; Intermediate versus Reference P<0.001; Seep versus Reference P=0.02). Soil moisture decreased significantly with increasing distance from the nearest seep outlet (r=−0.48, P<0.001).

Overall cover and woody cover below 1 m significantly increased with increasing soil moisture, and native herbaceous cover below 2 m increased with increasing soil moisture (table 7). We did not find significant correlations between soil moisture and non-native cover or total herbaceous cover in 2023. We also did not find a significant correlation between soil moisture and canopy height (r=0.16, P=0.26).

Total cover was significantly greater below 2 m at the Seep site than at both Intermediate and Reference sites (fig. 7; table 8). The Seep site had greater total herbaceous cover below 3 m than the Intermediate site and greater total herbaceous cover between 1 and 3 m than the Reference sites. Native herbaceous cover below 3 m was greater at the Seep site than at the Reference sites, and between 2 and 3 m, native herbaceous cover was also greater at the Seep site than at the Intermediate site. Non-native cover below 3 m was significantly higher at Seep and Reference sites than at the Intermediate site. We did not find differences in woody cover among sites at any height category. The average canopy height did not differ significantly among plots at Seep, Intermediate, and Reference sites (6.5±1.5 m versus 7.1±1.6 m versus 7.2±1.9 m, respectively; F=0.77, P=0.47). There was also no significant difference in maximum canopy height among plots at Seep, Intermediate, and Reference sites (Seep=8.9±2.7 m; Intermediate=9.4±1.9 m; Reference=9.2±2.6 m; F=−0.12, P=0.89).

Vireo Territory Density at Seep, Intermediate, and Reference Sites

For the 5 years before seep pumps were installed at Seep and Intermediate sites, vireo territory density varied among Seep, Intermediate, and Reference sites, with density higher at the Seep and at Reference sites than at the Intermediate site in 2015 and 2016 and higher at the Seep site than at the Reference and the Intermediate sites in 2017 and 2018 (fig. 10). Territory density remained slightly higher at the Seep site than the other sites through 2023. For the 3 years before the seep pumps were installed (2017–19), the difference in territory density between the Reference sites and the Seep and Intermediate sites combined was not significant (t=1.71, P=0.23). However, the territory density at the Seep and Intermediate sites combined was significantly higher than at Reference sites during the 3 years after seep pumps were installed (2021–23; t=3.87, p=0.06).

Vireo Survival, Site Fidelity, and Movements

Returning Banded Birds

We were able to observe 1,043 adult vireos (males: 717/729, 98 percent of all males; females: 326/534, 61 percent of all females) on Base well enough to determine banding status in 2023, although not all banded vireos were observed well enough to conclusively identify the individual. Of the 1,043 vireos, 57 had been banded before the 2023 breeding season, 20 of which we could not identify because they were banded with a single numbered silver metal federal band. Birds with a single silver band were either banded within the past 4 years at local MAPS stations (two stations at MCBCP that were operated in 2020 and 2021 [B. Kus, U.S. Geological Survey, unpub. data, 2020; Mendia and Kus, 2024] and

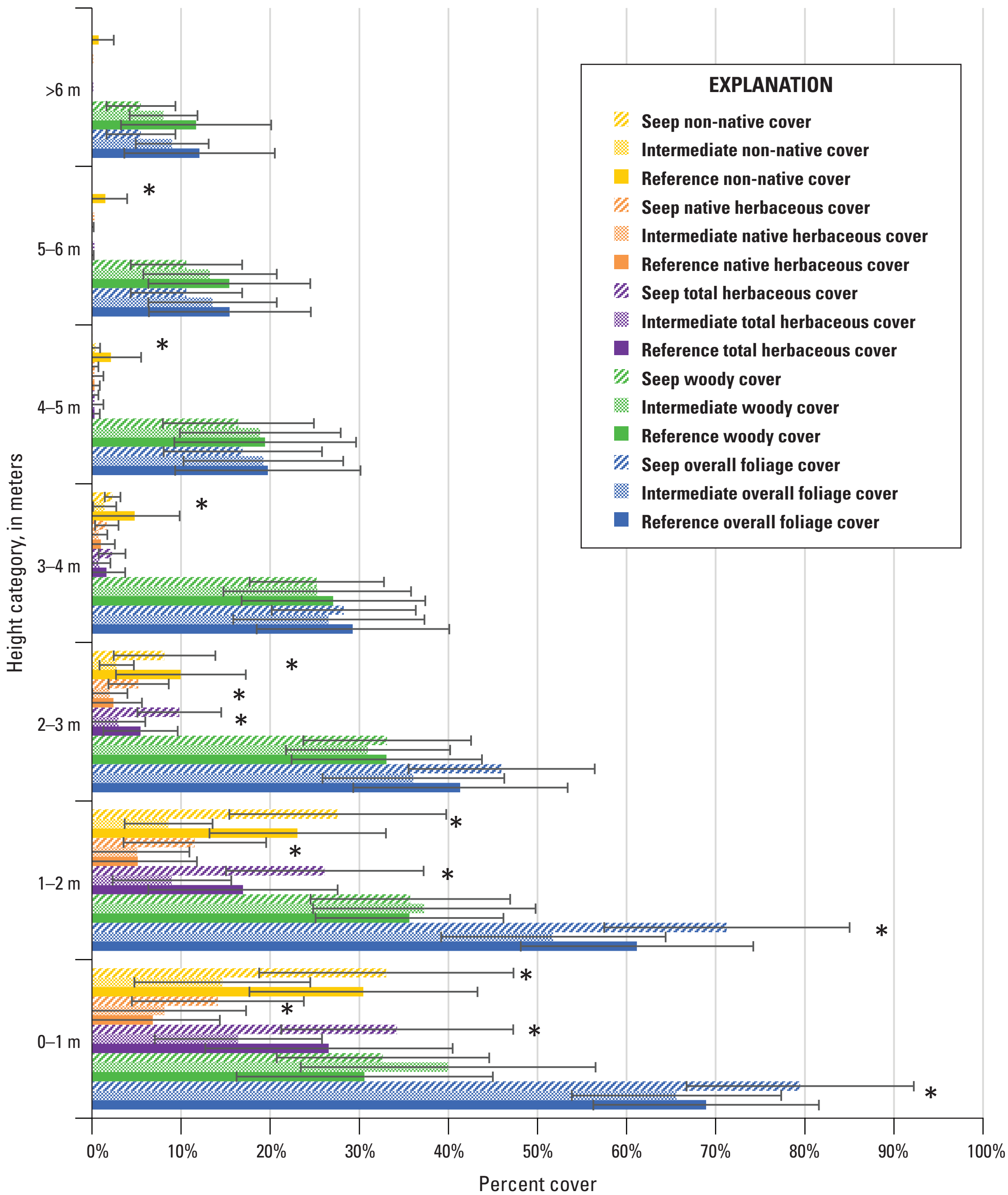


Figure 7. Average total percentage cover by height class and plant type at Seep, Intermediate, and Reference sites, Santa Margarita River, Marine Corps Base Camp Pendleton, 2023. Error bars represent 1 standard deviation. Asterisk indicates a significant difference (analysis of variance, $P \leq 0.10$). Abbreviations: ≤, less than or equal to; >, greater than.

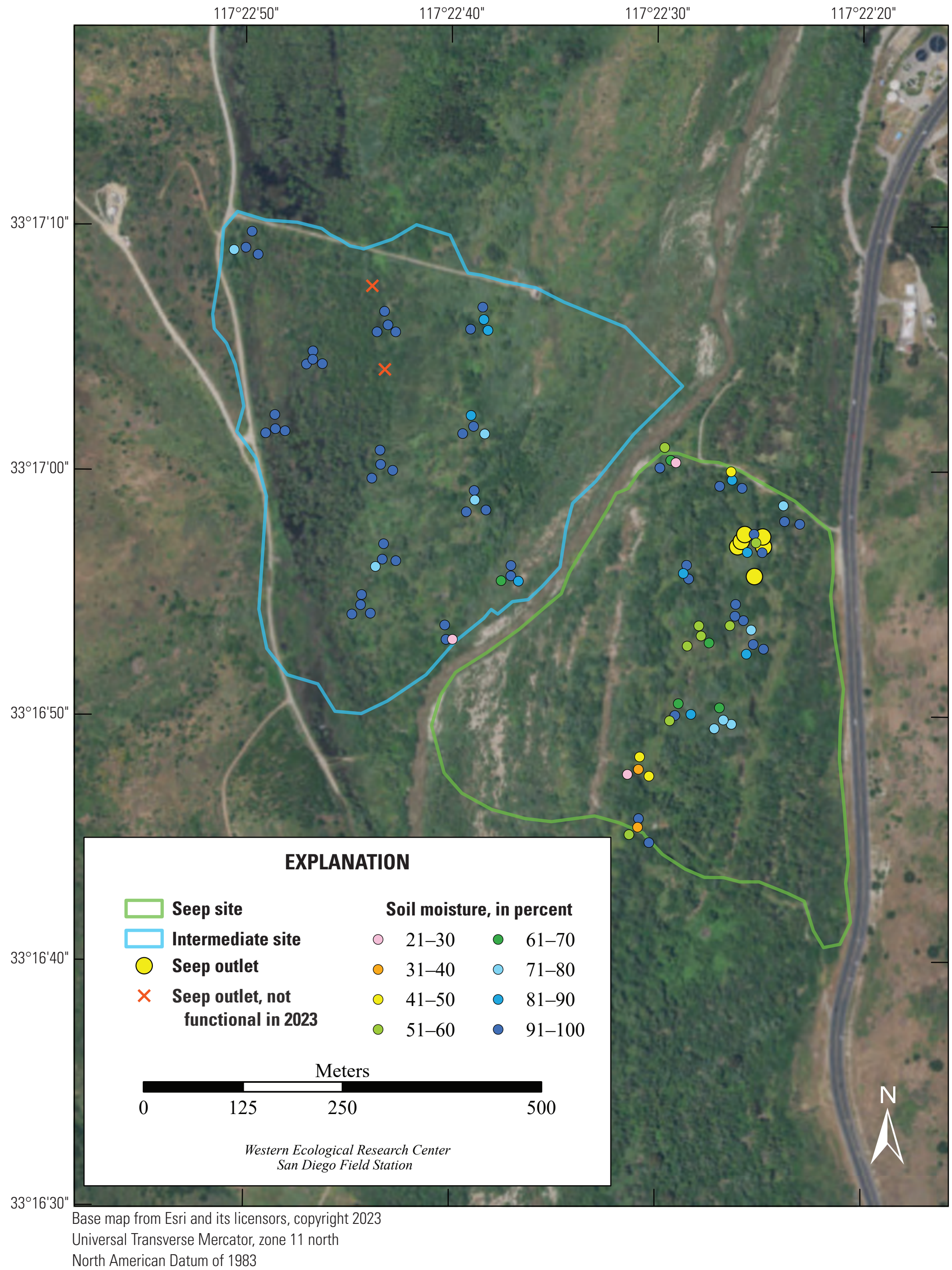
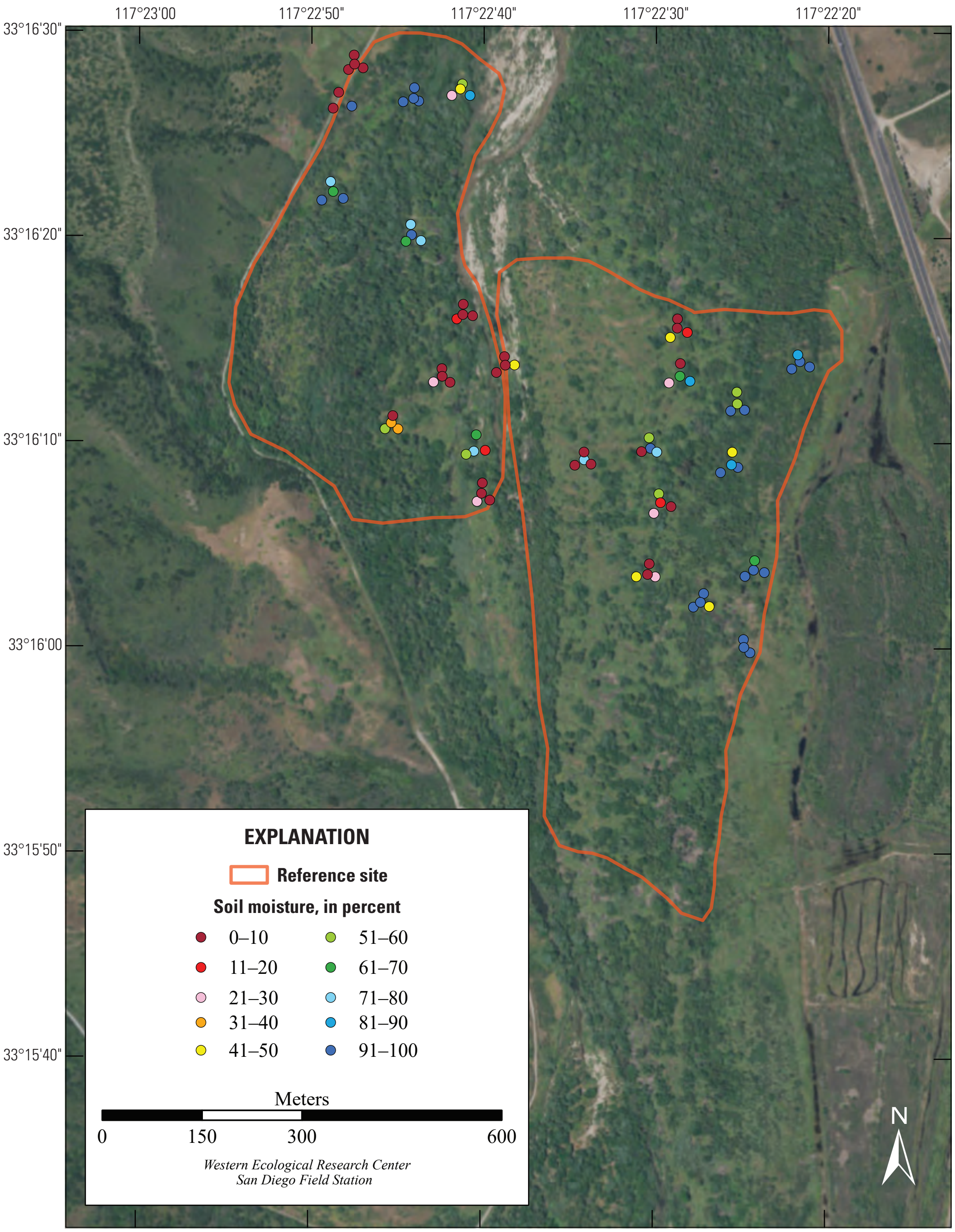


Figure 8. Percentage soil moisture at Seep and Intermediate site vegetation sampling plots, Marine Corps Base Camp Pendleton, 2023. Soil moisture was not collected at some plots. See figure 2 for overview map.



Base map from Esri and its licensors, copyright 2023
Universal Transverse Mercator, zone 11 north
North American Datum of 1983

Figure 9. Percentage soil moisture at Reference site vegetation sampling plots, Marine Corps Base Camp Pendleton, 2023. Soil moisture was not collected at some plots. See figure 2 for overview map.

Table 7. Pearson's correlations between soil moisture and vegetation cover by height category.

[*r*, correlation coefficient; *P*, probability that the statistical test result was not significant; m, meter; >, greater than]

Height category	Overall cover		Woody cover		Total herbaceous cover		Native herbaceous cover		Non-native cover	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
0–1 m	**0.34**	[1]**0.02**	**0.30**	[1]**0.04**	0.00	0.99	**0.35**	[1]**0.02**	−0.16	0.27
1–2 m	0.24	0.11	0.20	0.17	0.07	0.63	**0.33**	[1]**0.02**	−0.12	0.41
2–3 m	0.19	0.21	0.14	0.35	0.07	0.63	0.23	0.12	−0.11	0.47
3–4 m	0.18	0.23	0.15	0.32	0.16	0.29	0.24	0.10	−0.13	0.38
4–5 m	0.19	0.21	0.18	0.22	0.12	0.40	0.12	0.41	−0.08	0.59
5–6 m	0.19	0.19	0.19	0.21	0.11	0.47	0.11	0.47	−0.03	0.86
>6 m	0.14	0.34	0.16	0.29	0.12	0.42	0.12	0.42	0.06	0.66

[1]Significant correlation.

Table 8. Results of Tukey's post-hoc tests (*P*-values) examining differences among Seep, Intermediate, and Reference sites when analysis of variance test results showed significant differences in foliage cover among site types, Marine Corps Base Camp Pendleton, 2023.

[Results not shown for non-significant analysis of variance tests. Bold indicates significant results. **Abbreviations**: m, meter; <, less than]

Height category	Seep versus Intermediate	Intermediate versus Reference	Seep versus Reference
Overall foliage cover			
0–1 m	[1]**0.02**	0.73	[1]**0.05**
1–2 m	[1]**0.002**	0.12	[1]**0.09**
Total herbaceous cover			
0–1 m	[1]**0.004**	[1]**0.07**	0.21
1–2 m	[1]**<0.001**	[1]**0.07**	[1]**0.03**
2–3 m	[1]**<0.001**	0.21	[1]**0.01**
Native herbaceous cover			
0–1 m	0.21	0.90	[1]**0.05**
1–2 m	[1]**0.06**	1.00	[1]**0.03**
2–3 m	[1]**0.03**	0.92	[1]**0.03**
Non-native cover			
0–1 m	[1]**0.002**	[1]**0.002**	0.83
1–2 m	[1]**<0.001**	[1]**<0.001**	0.39
2–3 m	[1]**0.08**	[1]**0.004**	0.66
3–4 m	0.82	[1]**0.03**	0.14
4–5 m	0.94	0.12	[1]**0.05**
5–6 m	1.00	[1]**0.06**	[1]**0.06**

[1]Significant result.

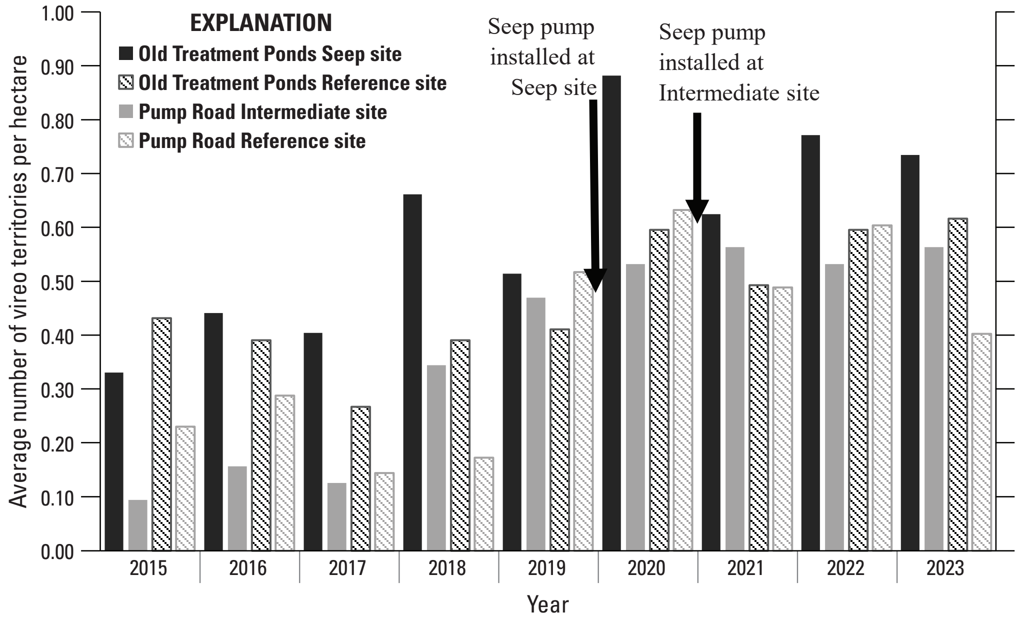


Figure 10. Least Bell's Vireo territory density (average number of territories per hectare) at Seep, Intermediate, and Reference sites before and after seep pumps were installed, 2015–23.

one station in the Tijuana River Valley that was operated from 2019 to 2022 [B. Kus, U.S. Geological Survey, unpub. data, 2021, 2022; Lynn and others, 2023]) or were nestlings banded at Marine Corps Air Station, Camp Pendleton (MCAS) from 2018 to 2023 (Ferree and Clark, 2018, 2019, 2020, 2021, 2023; K. Ferree, San Diego Natural History Museum, written commun., 2023). We were not able to determine the year or location where these 20 birds were banded. In total, we were able to identify 37 vireos that had unique color band combinations on Base in 2023 (table 9; app. 7). Of the 37 identified banded vireos, 34 vireos were originally banded on Base, and 3 vireos were originally banded off Base (2 on the San Luis Rey River and 1 at MCAS; app. 7, tables 9, 10; B. Kus, U.S. Geological Survey, unpub. data, 2015, 2018; Houston and others, 2023). Adult birds of known age ranged from 1 to 8 years old. Of the known-age adult banded birds, 5 percent were 1 year old in 2023.

All four natal vireos that were resighted on MCBCP in 2023 were captured and given a complete color combination (table 9). Three natal vireos from MCBCP were detected off Base in 2023. Two females that were originally banded as nestlings on MCBCP in 2020 and 2021 were detected on the lower San Luis Rey River, and one male that was originally banded as a nestling on MCBCP in 2021 was detected on the middle San Luis Rey River in 2023 (B. Kus, U.S. Geological Survey, unpub. data, 2023).

Table 9. Banding status of Least Bell's Vireos detected on Marine Corps Base Camp Pendleton (MCBCP) and those that emigrated off Base in 2023.

[Birds detected on MCBCP include immigrants; natal vireos were originally banded as nestlings with a single numbered federal band]

Banding status	Detected on MCBCP		Total on MCBCP	Emigrants		Total
	Male	Female		Male	Female	
Uniquely banded before 2023	[1]28	[2]5	33	0	0	33
Natal recaptured in 2023	[3]3	1	4	1	2	7
Subtotal of known identity vireos	**31**	**6**	**37**	**1**	**2**	**40**
Silver metal federal band	11	9	20	0	0	20
Grand total	**42**	**15**	**57**	**1**	**2**	**60**

[1]One vireo was originally banded at Marine Corps Air Station, Camp Pendleton, in 2015. It was first detected on MCBCP in 2016.

[2]One vireo was originally banded on the San Luis Rey River in 2018. It was first detected on MCBCP in 2022.

[3]One vireo was originally banded on the San Luis Rey River in 2021. It was first detected on MCBCP in 2023.

Table 10. Number of banded adult Least Bell's Vireos by original year banded, age, original banding location, and sex at Marine Corps Base Camp Pendleton (MCBCP) in 2023.

[Year originally banded unknown: Vireos banded with single numbered silver metal federal band so original year banded (and therefore age) and location were not known. **Abbreviations**: SLR, San Luis Rey River; MCAS, Marine Corps Air Station, Camp Pendleton; yr(s), year(s); ≥, greater than or equal to]

Year originally banded	Age in 2023	Number of vireos observed by origin							Total
		MCBCP		SLR		MCAS	Unknown		
		Male	Female	Male	Female	Male	Male	Female	
2015	8 yrs	0	1	0	0	[1]1	0	0	2
2017	≥7 yrs	1	0	0	0	0	0	0	1
	6 yrs	2	0	0	0	0	0	0	2
2018	5 yrs	0	0	0	[2]1	0	0	0	1
2019	≥5 yrs	1	0	0	0	0	0	0	1
	5 yrs	2	0	0	0	0	0	0	2
	4 yrs	2	1	0	0	0	0	0	3
2020	≥4 yrs	8	2	0	0	0	0	0	10
	3 yrs	1	0	0	0	0	0	0	1
2021	≥3 yrs	2	0	0	0	0	0	0	2
	2 yrs	6	0	[3]1	0	0	0	0	7
2022	≥2 yrs	3	0	0	0	0	0	0	3
	1 yr	1	1	0	0	0	0	0	2
Subtotal		**29**	**5**	**1**	**1**	**1**	**0**	**0**	37
Unknown	≥1 yr	0	0	0	0	0	11	9	20
Total		**29**	**5**	**1**	**1**	**1**	**11**	**9**	**57**

[1]B. Kus, U.S. Geological Survey, unpub. Data, 2015.

[2]B. Kus, U.S. Geological Survey, unpub. Data, 2018.

[3]Houston and others, 2022.

Newly Banded Birds

A total of 180 vireos were captured and banded for the first time during 2023. These newly banded birds included 1 adult male vireo caught for the first time and banded with a unique color combination and 179 nestlings that were banded with a single gold numbered federal band.

Adult Survival

The most important variables predicting adult survival were sex and year. The top model including sex and year had more support than any other model (AIC_c weight=0.75), and no other models had AIC_c within 2 of the top model (table 11). Sex and year (in particular, the 2012–13 time interval) significantly contributed to the model (table 12). Although the second-ranked model included precipitation, this model was not strongly supported (AIC_c weight=0.16), and therefore, precipitation did not appear to be a significant predictor of adult survival. In the top model, male annual survival (62±10 percent) was higher than female annual survival (49±11 percent), and adult vireo survival was higher from 2012 to 2013 than other years (tables 12, 13).

Adult Versus First-Year Vireo Survival

Of the six models we created to examine the effects of age, year, and precipitation on vireo survival, the model that included age and year ranked highest (table 14). The top model with age plus year had an AIC_c weight of 1.00, which is well above any other model in the model set. No other models had measurable weight. Age, survival from 2007 to 2008, and survival from 2012 to 2013 significantly contributed to the top model (table 15).

According to the top model, adults had higher survival than first-year birds during the entire time span (2005–23), and survival of all birds from 2007 to 2008 and from 2012 to 2013 was higher than other years (table 15). Annual survival of adult vireos averaged 62±11 percent (range 42–77 percent), with highest survival from 2007 to 2008 and 2012 to 2013 and lowest survival from 2020 to 2021 (table 16). Annual survival of first-year vireos averaged 15±6 percent (range: 7–25 percent), with highest survival from 2007 to 2008 and lowest survival from 2020 to 2021 and 2010 to 2011.

Table 11. Logistic regression models for the effect of sex (male versus female), year, and bio-year precipitation on survival of adult Least Bell's Vireos on Marine Corps Base Camp Pendleton, 2005–23.

[Bio-year precipitation was calculated from July 1 to June 30 of the year preceding the survival year. The effect of sex and year on detection probability was included in all models. Detection probability for 2022–23 was fixed equal to 1. Models are ranked from best to worst based on Akaike's Information Criterion for small samples (AIC_c), change in AIC_c (ΔAIC_c), and AIC_c weights. AIC_c is based on $-2x\log_e$ likelihood and the number of parameters in the model. **Abbreviation:** +, plus]

Model	AIC_c	ΔAIC_c	AIC_c weight	Number of parameters	Deviance
Sex+year	248,900.3	0.0	0.75	37	246,357.5
Sex+precipitation	248,903.4	3.0	0.16	21	246,393.6
Sex	248,905.0	4.7	0.07	20	246,397.3
Year	248,909.1	8.8	0.01	36	246,368.4
Precipitation	248,912.3	12.0	0.00	20	246,404.6
Constant	248,913.9	13.5	0.00	19	246,408.2

Table 12. Parameter estimate (β), standard error (SE), odds ratios, and 95-percent confidence intervals (CI) of the odds ratios for the top model explaining annual survival of adult Least Bell's Vireos on Marine Corps Base Camp Pendleton, 2005–23.

[Reference represents female survival, 2005–06. All other effects values are the difference between that parameter and the reference. **Abbreviation:** +, plus]

Effect	β	SE	Odds ratio	95-percent CI
		Sex+year model		
Reference	−0.60	0.49	0.55	0.21–1.42
Males[1]	0.53	0.16	1.69	**[1]1.24–2.32**
2006–07	1.18	0.70	3.27	0.84–12.76
2007–08	1.04	0.63	2.84	0.82–9.80
2008–09	0.59	0.53	1.80	0.64–5.12
2009–10	0.25	0.52	1.28	0.46–3.56
2010–11	0.27	0.57	1.31	0.43–4.00
2011–12	0.28	0.54	1.32	0.46–3.79
2012–13[1]	1.46	0.56	4.32	**[1]1.44–12.96**
2013–14	0.45	0.52	1.57	0.57–4.38
2014–15	0.70	0.52	2.01	0.72–5.63
2015–16	0.31	0.52	1.36	0.49–3.77
2016–17	0.44	0.52	1.56	0.56–4.31
2017–18	0.86	0.54	2.37	0.82–6.82
2018–19	0.95	0.54	2.59	0.90–7.46
2019–20	0.28	0.52	1.32	0.47–3.69
2020–21	−0.26	0.51	0.77	0.28–2.11
2021–22	0.45	0.56	1.57	0.52–4.68
2022–23	0.95	0.59	2.58	0.81–8.23

[1]The 95-percent confidence interval off the odds ratio does not include 1, indicating that this effect is a significant contributor to the model.

Table 13. Annual survival for male and female Least Bell's Vireos on Marine Corps Base Camp Pendleton, 2005–23.

[Estimates were calculated from the top model. **Abbreviations**: ±, plus or minus; SD, standard deviation]

Survival interval	Male survival (percentage)	Female survival (percentage)
2005–06	48	35
2006–07	75	64
2007–08	72	61
2008–09	63	50
2009–10	54	41
2010–11	55	42
2011–12	55	42
2012–13	80	70
2013–14	59	46
2014–15	65	52
2015–16	56	43
2016–17	59	46
2017–18	69	56
2018–19	71	59
2019–20	55	42
2020–21	42	30
2021–22	59	46
2022–23[1]	71	59
Mean±SD	**62±10**	**49±11**

[1]Survival for 2022–23 may be inaccurate because of the inability to separate detection probability from survival probability in the final time interval.

Table 14. Logistic regression models for the effect of age (first-year versus adult), year, and bio-year precipitation on survival of Least Bell's Vireos on Marine Corps Base Camp Pendleton, 2005–23.

[Bio-year precipitation was calculated from July 1 to June 30 of the year preceding the survival year. The effect of year on detection probability was included in all models. Detection probability for 2022–23 was fixed equal to 1. Models are ranked from best to worst based on Akaike's Information Criterion for small samples (AIC_c), change in AIC_c (ΔAIC_c), and AIC_c weights. AIC_c is based on $-2x\log_e$ likelihood and the number of parameters in the model. **Abbreviation**: +, plus]

Model	AIC_c	ΔAIC_c	AIC_c weight	Number of parameters	Deviance
Age+year	5,149.0	0.0	1.00	36	923.5
Age	5,197.8	48.8	0.00	19	1,006.8
Age+precipitation	5,199.4	50.4	0.00	20	1,006.4
Year	5,842.5	693.5	0.00	35	1,619.0
Constant	5,898.4	749.4	0.00	18	1,709.4
Precipitation	5,900.3	751.3	0.00	19	1,709.3

Table 15. Parameter estimates (β), standard errors (SE), odds ratios, and 95-percent confidence intervals (CI) of the odds ratios for the top model explaining annual survival of Least Bell's Vireos on Marine Corps Base Camp Pendleton, 2005–23.

[Reference represents first-year vireos, 2005–06. All other effects values are the difference between that parameter and the reference. **Abbreviation**: +, plus]

Effect	β	SE	Odds ratio	95-percent CI
		Age+year model		
Reference	−2.07	0.35	0.13	0.06–0.25
Adults[1]	2.34	0.09	10.36	**[1]8.63–12.43**
2006–07	0.71	0.45	2.04	0.84–4.97
2007–08[1]	0.95	0.42	2.60	**[1]1.14–5.91**
2008–09	0.50	0.39	1.64	0.76–3.56
2009–10	0.13	0.41	1.14	0.51–2.53
2010–11	−0.47	0.42	0.63	0.28–1.42
2011–12	0.37	0.46	1.45	0.59–3.57
2012–13[1]	0.92	0.41	2.51	**[1]1.13–5.59**
2013–14	0.54	0.41	1.71	0.77–3.79
2014–15	−0.13	0.39	0.88	0.41–1.90
2015–16	0.57	0.41	1.76	0.79–3.95
2016–17	−0.12	0.39	0.89	0.41–1.91
2017–18	0.71	0.39	2.03	0.95–4.34
2018–19	0.70	0.42	2.01	0.89–4.54
2019–20	0.10	0.41	1.11	0.50–2.46
2020–21	−0.58	0.40	0.56	0.25–1.24
2021–22	−0.09	0.41	0.91	0.41–2.04
2022–23	−0.13	0.41	0.88	0.39–1.97

[1]The 95-percent confidence interval off the odds ratio does not include 1, indicating that this effect is a significant contributor to the model.

Table 16. Annual survival for adult and first-year Least Bell's Vireos on Marine Corps Base Camp Pendleton, 2005–23.

[Estimates were calculated from the top model. **Abbreviations**: ±, plus or minus; SD, standard deviation]

Survival interval	Adult survival (percentage)	First-year survival (percentage)
2005–06	57	11
2006–07	73	20
2007–08	77	25
2008–09	68	17
2009–10	60	13
2010–11	45	7
2011–12	65	15
2012–13	77	24
2013–14	69	18
2014–15	54	10
2015–16	70	18
2016–17	54	10
2017–18	73	20
2018–19	72	20
2019–20	59	12
2020–21	42	7
2021–22	54	10
[1]2022–23	54	10
Mean±SD	**62±11**	**15±6**

[1]Survival for 2022–23 may be inaccurate because of the inability to separate detection probability from survival probability in the final time interval.

Vireo Survival and Return Rates at Seep, Intermediate, and Reference Sites

Artificial seeps did not appear to affect the return rate of adult vireos: treatment was not included in the well supported models describing adult vireo return rate to Seep, Intermediate, and Reference sites (table 17). The most important factor affecting return rate for adult vireos to Seep, Intermediate, and Reference sites was sex, although the 95-percent confidence interval of the odds ratio for sex included 1, indicating that sex did not have a significant effect on return rate. The top two models were well supported, with weights of 0.35 and 0.32, and no other models were within 2 AIC_c of the top model.

The most well supported model describing age-related survival at Seep, Intermediate, and Reference sites included only age (table 18). Age significantly contributed to the top model (95-percent confidence interval of the odds ratio did not include 1). Adult annual survival was 73 percent, and first-year survival was 7 percent. Although treatment was included in the second of the two well supported models, the addition of treatment to the age-only model did not significantly improve survival estimates, and the 95-percent confidence interval of the odds ratio for treatment included 1, indicating that it is likely that treatment did not have a significant effect on survival of first-year vireos. The two top models were well supported, with weights of 0.58 and 0.27, and no other models were within 2 AIC_c of the top model.

Table 17. Logistic regression models for the effect of sex (male versus female), year, and treatment (Seep versus Intermediate versus Reference site) on return rate of adult Least Bell's Vireos on Marine Corps Base Camp Pendleton, 2020–23.

[Models are ranked from best to worst based on Akaike's Information Criterion for small samples (AIC_c), change in AIC_c (ΔAIC_c), and AIC_c weights. AIC_c is based on $-2x\log_e$ likelihood and the number of parameters in the model. **Abbreviations**: +, plus; *, interacting with]

Model	AIC_c	ΔAIC_c	AIC_c weight	Number of parameters	Deviance
Sex	144.64	0.00	0.35	3	32.70
Constant	144.82	0.18	0.32	2	35.02
Year	147.08	2.44	0.10	4	32.96
Treatment	147.37	2.74	0.09	4	33.26
Sex+year	147.41	2.77	0.09	5	31.06
Treatment+year	150.15	5.51	0.02	6	31.51
Treatment+sex+year	150.79	6.15	0.02	7	29.82
Treatment*year	155.00	10.36	0.00	10	26.68
Treatment*year+sex	156.36	11.72	0.00	11	25.47

Table 18. Logistic regression models for the effect of age (adults versus first-year birds), year, and treatment (Seep versus Intermediate versus Reference site) on survival of Least Bell's Vireos on Marine Corps Base Camp Pendleton, 2020–23.

[Models are ranked from best to worst based on Akaike's Information Criterion for small samples (AIC_c), change in AIC_c (ΔAIC_c), and AIC_c weights. AIC_c is based on $-2x\log_e$ likelihood and the number of parameters in the model. **Abbreviations**: +, plus; *, interacting with]

Model	AIC_c	ΔAIC_c	AIC_c weight	Number of parameters	Deviance
Age	307.98	0.00	0.58	3	48.59
Age+treatment	309.49	1.51	0.27	5	46.02
Age+year	311.69	3.71	0.09	5	48.21
Age+treatment+year	312.62	4.64	0.06	7	45.02
Age+treatment*year	320.74	12.76	0.00	11	44.75

Base-Wide Site Fidelity and Movement

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 (app. 8). There were 32 adult vireos (28 males and 4 females) identified at MCBCP in 2022 that were resighted in 2023, all of which occupied known territories both years. Most of the returning adult vireos showed strong between-year site fidelity, with males returning at a higher rate than females, as observed in previous years. Of the 32 returning territorial adults, 28 (88 percent of territorial adults: 27 males, 96 percent of males; 1 female, 25 percent of females) occupied a breeding site in 2023 that they had defended in 2022. An additional 3 vireos (9 percent of all vireos: 1 male, 4 percent of males; 2 females, 50 percent of females) returned to sites adjacent to their previous territories (within 300 m). The average distance moved by returning adult vireos was 0.4±1.9 km (range: 0.0–10.8 km; males: 0.0±0.0 km, range: 0.0–0.1 km; females: 2.8±5.3 km, range: 0.1–10.8 km).

Two first-year vireos that were banded as nestlings in 2022 on MCBCP were resighted in 2023 and occupied known territories (one male and one female; app. 8). The average distance that first-year vireos moved from their natal territories to their breeding territories was 0.9±0.5 km (range: 0.5–1.3 km; the male moved 1.3 km; the female moved 0.5 km). No first-year vireos that were banded as nestlings in 2022 on MCBCP were resighted off Base, and no first-year vireos from off Base were resighted on MCBCP in 2023.

Site Fidelity and Movement at Seep, Intermediate, and Reference Sites

Adult fidelity to Seep, Intermediate, and Reference sites was high. Of adult vireos detected in 2022 and 2023, three vireos that held territories at the Seep site in 2022 returned to the Seep site in 2023 (100 percent). Similarly, the five vireos identified at the Intermediate site in 2022 returned to the Intermediate site in 2023 (100 percent), and eight vireos that held territories at Reference sites in 2022 returned to Reference sites in 2023 (100 percent). In 2023, one first-year vireo that fledged from the Seep site in 2022 returned to the Intermediate site, and one first-year vireo that fledged from a Reference site in 2022 was redetected at a Seep site.

Nest Success and Breeding Productivity

Nesting activity was monitored at 13 of the 20 territories in the Seep site, 12 of the 18 territories in the Intermediate site, and 25 of the 44 territories in Reference sites (table 19; figs. 11–14; app. 9). All of the territories were fully monitored, meaning that all nests within the territory were found and documented during the breeding season. One territory at the Seep site and one territory at a Reference site were occupied by single males and were not included in productivity analyses. The remaining 48 pairs built 99 nests; 7 of these were not completed (INC, meaning nest not completed; table 9.1 in app. 9) and have been excluded from calculations of nest success and productivity.

Nesting Attempts

Pairs at Seep, Intermediate, and Reference sites built a similar number of nests (including incomplete nests) during the 2023 breeding season (F=1.99, P=0.15; table 19). Pairs at the Seep site (10/12; 83 percent), the Intermediate site (12/12; 100 percent), and Reference sites (17/24; 71 percent) were all likely to renest after an initial nesting attempt (Fisher's Exact test, P=0.12). The number of renests after a failed first nesting attempt did not differ among Seep pairs (6/7; 86 percent), Intermediate pairs (9/9; 100 percent), and Reference pairs (10/10; 100 percent; Fisher's exact test, P=0.27). Similarly, pairs at the Seep site (4/5; 80 percent), the Intermediate site (3/3; 100 percent), and Reference sites (7/14; 50 percent) were equally likely to renest after a successful first nesting attempt (Fisher's exact test, P=0.23). Pairs at the Seep and Intermediate sites were as likely to renest after a failed first nesting attempt as after a successful first nesting attempt in 2023 (Fisher's exact test, P>0.99 and P>0.99, respectively), but pairs at the Reference site were more likely to renest after a failed first nesting attempt than after a successful first nesting attempt (Fisher's exact test, P=0.02). When all monitoring site types were combined, pairs were more likely to renest after a failed nesting attempt than they were after a successful nesting attempt in 2023 (Fisher's exact test, P=0.01). Overall, in 2023, 64 percent (14/22) of vireo pairs attempted to renest after a successful first nesting attempt, and 96 percent (25/26) of pairs attempted to renest after a failed first nesting attempt. In 2023, four pairs at the Seep site, four pairs at the Intermediate site, and three at Reference sites attempted to nest three times, and one pair at Reference sites attempted to nest four times.

Nest Success

Although fledging success of completed nests in the Seep (46 percent; 11/24) and Intermediate sites (48 percent; 12/25) appeared less than in the Reference sites (67 percent; 29/43), the difference was not statistically significant (chi-square=3.94, P=0.14; table 20). Similarly, although it appeared that fewer first nesting attempts at the Seep (42 percent; 5/12) and Intermediate (25 percent; 3/12) sites were successful than first nesting attempts at Reference sites (58 percent; 14/24), the difference was not statistically significant (Fisher's Exact test, P=0.16; app. 9). Overall, 57 percent of all nesting attempts were successful, and 46 percent of first nesting attempts were successful in 2023.

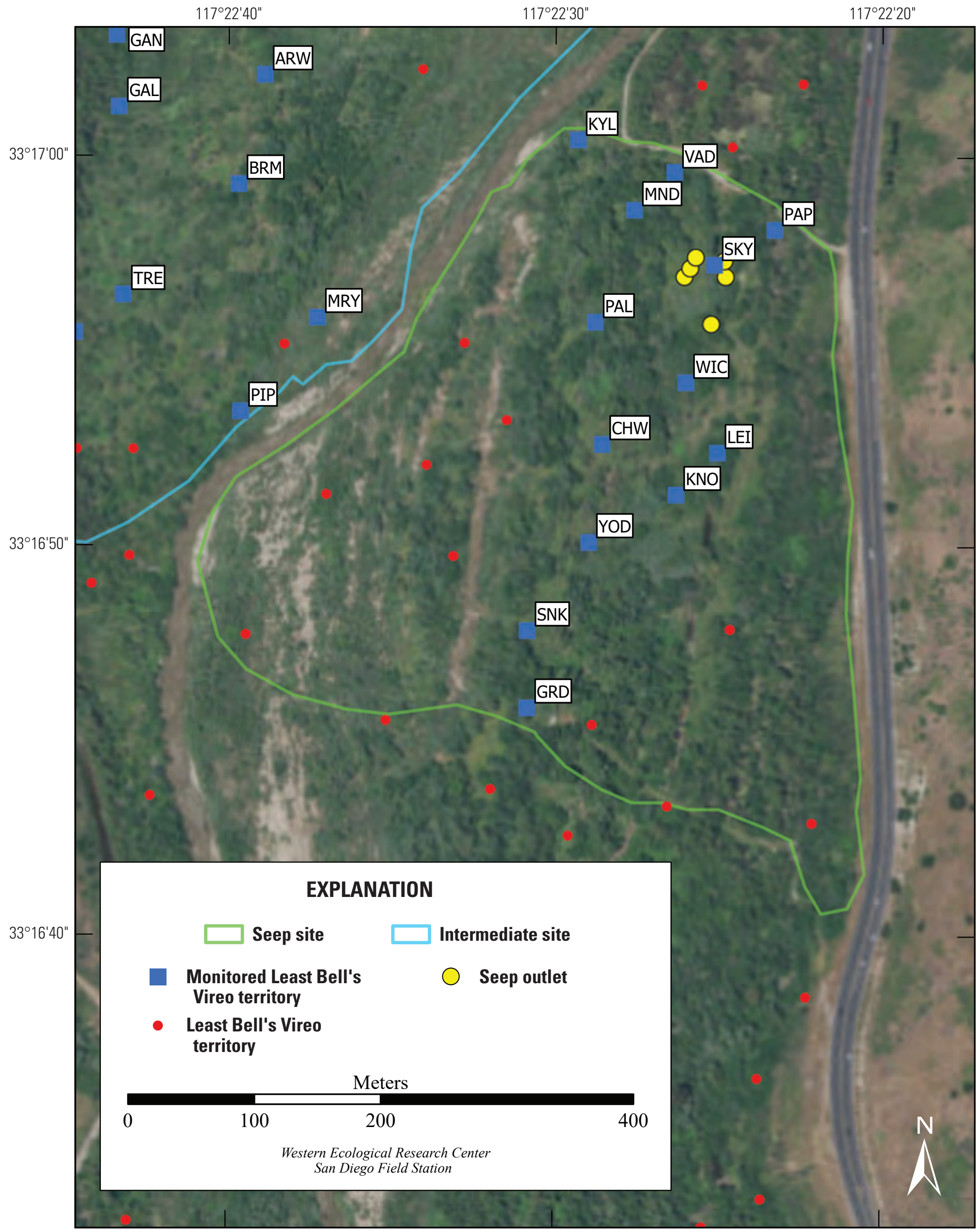
Causes of failure were similar at all sites. Most nest failures were caused by predation (table 20), although confirmed predation events were not witnessed. Predation accounted for 85 percent (11/13) of nest failures at the Seep site, 77 percent (10/13) of nest failures at the Intermediate site, and 71 percent (10/14) of nest failures at Reference sites. We documented two nests at the Seep site, three nests at the Intermediate site, and four nests at Reference sites that failed for other reasons, known and unknown (app. 9); five nests were abandoned with no eggs ever confirmed,

Table 19. Number of Least Bell's Vireo territories and nests monitored at Seep, Intermediate, and Reference sites on Marine Corps Base Camp Pendleton, 2023.

[±, plus or minus]

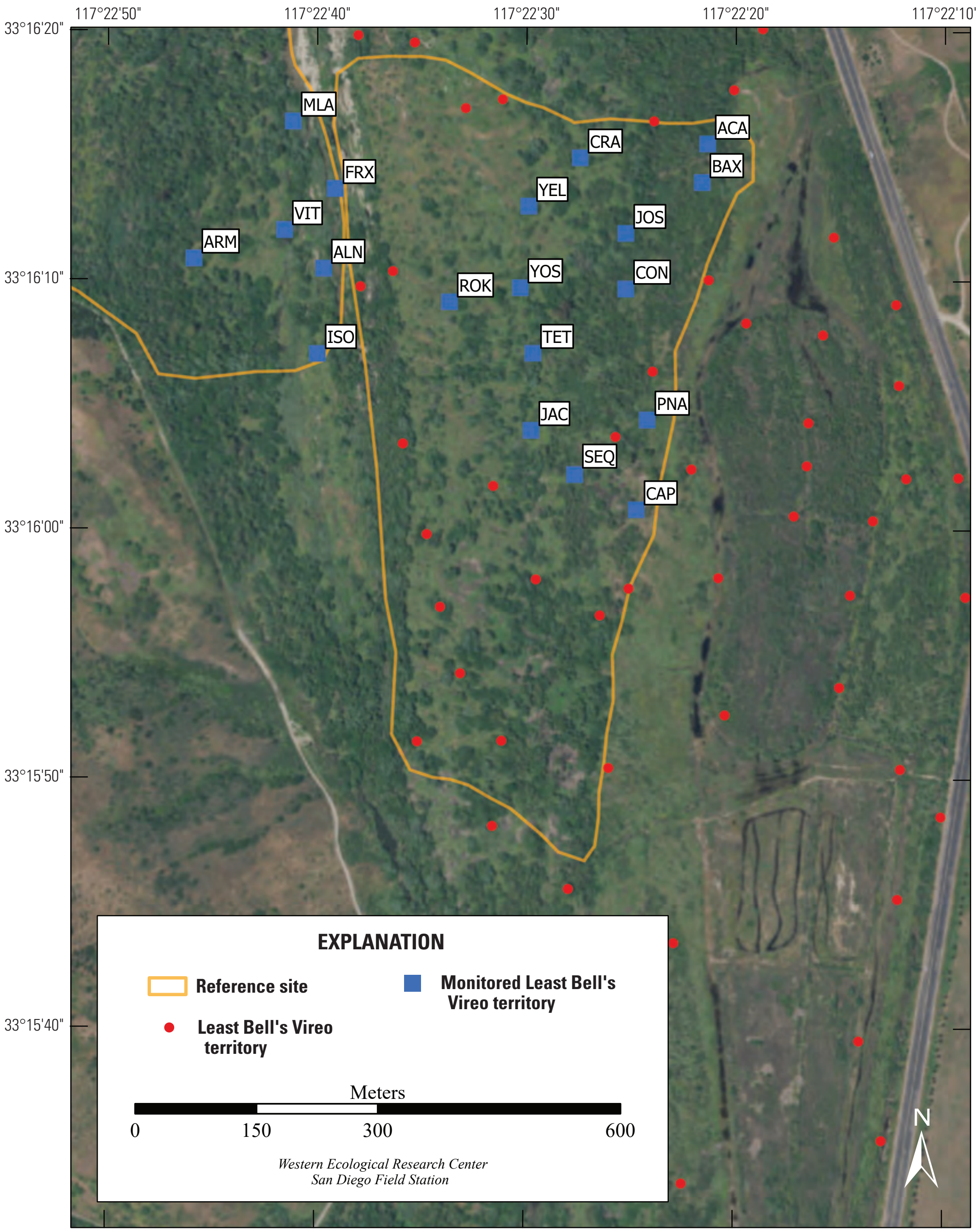
Parameter	Nest monitoring area type		
	Seep	Intermediate	Reference
Monitored territories	[1]13	12	[1]25
All territories, including those not monitored	20	18	44
Nests (number completed nests)	26 (24)	28 (25)	45 (43)
Completed nests per pair	2.0±0.6	2.1±0.3	1.8±0.7
Total number of completed and incomplete nests per pair	2.2±0.7	2.3±0.5	1.9±0.7

[1]One territory was occupied by a single male that did not build a nest.



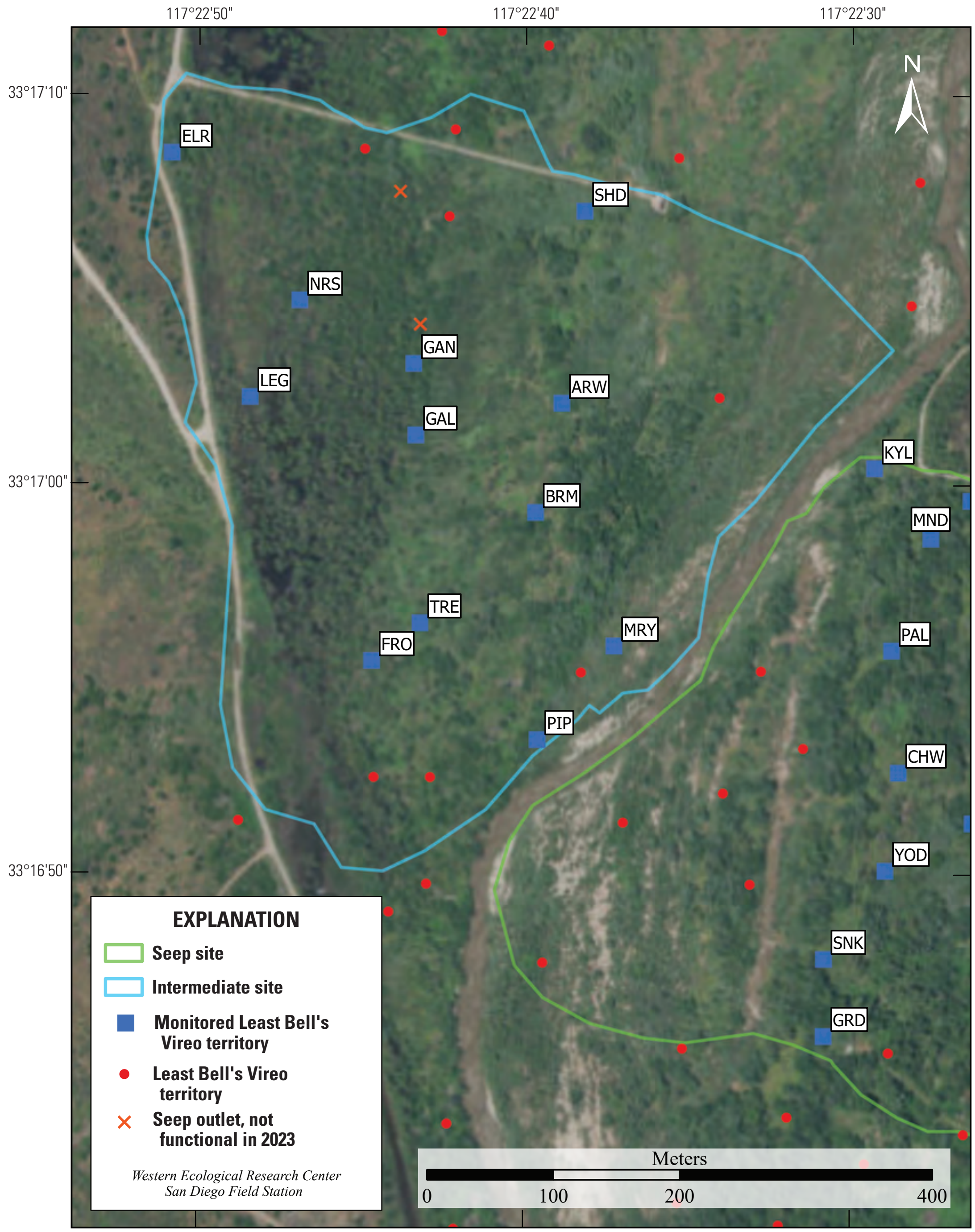
Base map from Esri and its licensors, copyright 2023
Universal Transverse Mercator, zone 11 north
North American Datum of 1983

Figure 11. Locations of monitored Least Bell's Vireo territories at the Old Treatment Ponds Seep site, Marine Corps Base Camp Pendleton, 2023.



Base map from Esri and its licensors, copyright 2023
Universal Transverse Mercator, zone 11 north
North American Datum of 1983

Figure 12. Locations of monitored Least Bell's Vireo territories at the Old Treatment Ponds Reference site, Marine Corps Base Camp Pendleton, 2023.



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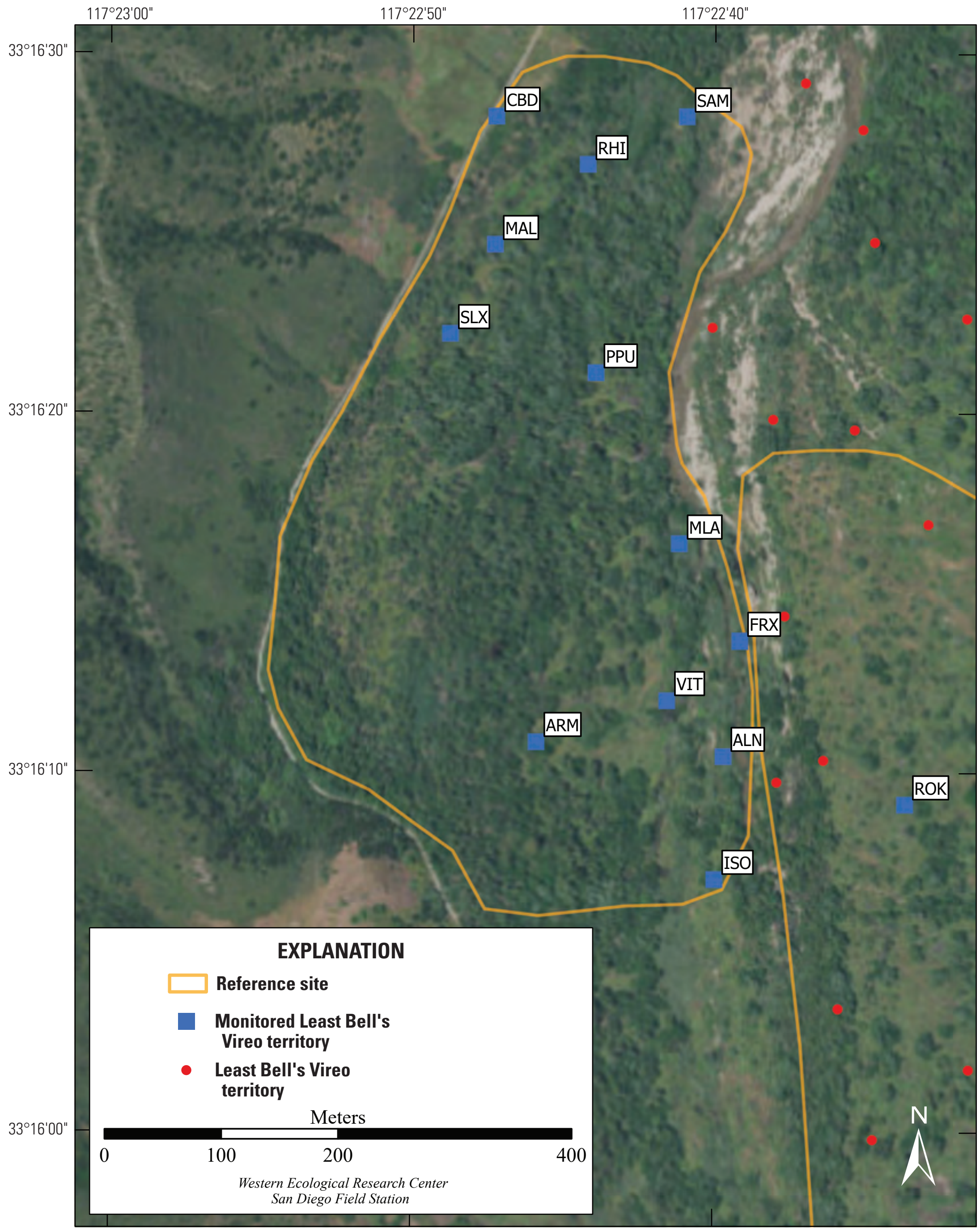
Universal Transverse Mercator, zone 11 north
North American Datum of 1983

Figure 13. Locations of monitored Least Bell's Vireo territories at the Pump Road Intermediate site, Marine Corps Base Camp Pendleton, 2023.



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North American Datum of 1983

Figure 14. Locations of monitored Least Bell's Vireo territories at the Pump Road Reference site, Marine Corps Base Camp Pendleton, 2023.

Table 20. Fate of completed Least Bell’s Vireo nests in fully monitored territories at Seep, Intermediate, and Reference sites, Marine Corps Base Camp Pendleton, 2023.

[Numbers in parentheses are proportions of total nests]

Nest fate	Number of nests			
	Seep	Intermediate	Reference	Total
Successful	11	12	29	52 (0.57)
Failed: predation	11	10	10	31 (0.34)
Failed: parasitism	0	0	0	0 (0.00)
Failed: other/unknown	2	3	4	9 (0.10)
Total completed nests	**24**	**25**	**43**	**92 (1.00)**

one nest was abandoned with eggs when the nest support structure failed, one nest with mite-covered eggs failed to hatch, one nest failed when the eggs were punctured, and one nest was abandoned with nestlings. Overall, 54 percent, 52 percent, and 33 percent of completed vireo nests at Seep, Intermediate, and Reference sites, respectively, were lost to predation or other causes.

Cowbird Parasitism

None of the monitored vireo nests were parasitized by Brown-headed Cowbirds in 2023.

Productivity

Clutch size did not differ among Seep, Intermediate, and Reference sites (table 21). Seep, Intermediate, and Reference sites also had similar percentages of eggs that hatched and nests with hatchlings. The percentage of hatchlings that fledged, the percentage of nests with hatchlings that ultimately fledged young, and the number of fledglings per egg did not differ among Seep, Intermediate, and Reference sites. Seep, Intermediate, and Reference pairs fledged similar numbers of young, and pairs at the three categories of sites had similar likelihood of fledging at least one young. One pair at the Seep site (8 percent), two pairs at the Intermediate site (17 percent), and five pairs at Reference sites (21 percent) each successfully fledged two broods in 2023 (app. 9). No pairs successfully fledged three broods. Vireo pairs at Seep, Intermediate, and Reference sites combined fledged an average of 3.3 vireo young per pair, and 90 percent of monitored pairs were successful in fledging at least 1 young in 2023 (table 21).

We did not find a significant relationship between precipitation and the number of fledglings produced per egg across all monitoring sites (Pearson’s r=−0.02, P=0.95). The number of fledglings produced per pair appeared to be correlated with the amount of precipitation during the previous bio-year, but the relationship was not quite significant (Pearson’s r=0.49, P=0.11). However, higher precipitation was significantly related to a higher proportion of pairs that successfully fledged at least one young (Pearson’s r=0.61, P=0.04). We did not find any significant relationships between vireo nest productivity and percentage of foliage cover of any type below 3 m (table 22).

Daily Nest Survival

Using treatment (Seep versus Intermediate versus Reference site) and year as covariates, we built five models with potential to predict the probability that a nest would survive from 1 day to the next (table 23). The constant model was generated first and remained the best supported model. Adding treatment, year, and the interaction of treatment and year did not improve upon the constant model, and no other model was within 2 AIC_c of the top model.

Nest Characteristics

Vireos used 15 plant species for nesting at Seep, Intermediate, and Reference sites in 2023, although not all were used within each site category (table 24). Vireos used 9 species at the Seep site, 8 species at the Intermediate site, and 12 species at Reference sites. Vireos placed 54 percent of all nests in arroyo or red willow, sandbar willow, or black willow (54 percent at the Seep site, 46 percent at the Intermediate site, and 58 percent at Reference sites). At Seep sites, 20 vireo nests (83 percent) were placed in woody vegetation, and 4 nests (17 percent) were placed in herbaceous vegetation. At Intermediate sites, 27 vireo nests (96 percent) were placed in woody vegetation, and 1 vireo nest (4 percent) was placed in herbaceous vegetation. At Reference sites, 40 vireo nests (93 percent) were placed in woody vegetation, and 3 nests (7 percent) were placed in herbaceous vegetation. Of the eight vireo nests placed in herbaceous vegetation, four were built in non-native plant species (poison hemlock and giant reed).

In 2023, we found that successful nests were placed 0.1 m higher in the host plant than unsuccessful nests at Reference sites, a difference that was statistically significant but not biologically meaningful. Unsuccessful nests were placed significantly further from the edge of the host plant (closer to the center) than successful nests at the Intermediate site (table 25). We did not find any differences in nest placement characteristics among all nests at Seep, Intermediate, and Reference sites (table 26).

Table 21. Reproductive success and productivity of nesting Least Bell's Vireos at Seep, Intermediate, and Reference sites, Marine Corps Base Camp Pendleton, 2023.

[*P*, probability that a difference was not significant, —, no data; ±, plus or minus; *F*, *F*-statistic from analysis of variance test; %, percent]

Parameter	Seep sites	Intermediate sites	Reference sites	Total	Test statistic	*P*
Nests with eggs	23	24	40	87	—	—
Eggs laid	81	88	140	309	—	—
Average clutch size[1]	3.5±0.5	3.7±0.5	3.6±0.6	3.6±0.5	F=0.45	0.64
Hatchlings	62	48	114	224	—	—
Nests with hatchlings	19	16	35	70	—	—
Hatching success						
Eggs[2]	77%	55%	81%	72%	chi-square=3.48	0.18
Nests[3]	83%	67%	88%	80%	chi-square=0.48	0.79
Fledglings	35	36	86	157	—	—
Nests with fledglings	11	12	30	53	—	—
Fledging success						
Hatchlings[4]	56%	75%	75%	70%	chi-square=1.41	0.49
Nests[5]	58%	75%	86%	76%	chi-square=0.75	0.69
Fledglings per egg[6]	0.4	0.4	0.6	0.5	chi-square=3.77	0.15
Average number of young fledged per pair[7]	2.9±1.6	3.0±1.5	3.6±1.7	3.3±1.6	F=0.90	0.42
Pairs fledging at least 1 young[7]	10 (83%)	10 (83%)	23 (96%)	43 (90%)	Fisher's exact test	0.27

[1]These figures are based on 23 Seep, 24 Intermediate, and 35 Reference site non-parasitized nests with a full clutch.

[2]Percentage of all eggs that hatched.

[3]Percentage of all nests with eggs in which at least one egg hatched.

[4]Percentage of all hatchlings that fledged.

[5]Percentage of all nests with hatchlings in which at least one young fledged.

[6]Proportion of all eggs that fledged.

[7]These figures are based on 12 Seep, 12 Intermediate, and 24 Reference site pairs. Numbers in parentheses are percentage of pairs that fledged at least 1 young.

Table 22. Pearson's correlations between two measures of Least Bell's Vireo nest productivity and percentage of foliage cover at height categories below 3 meters.

[*r*, correlation coefficient; *P*, probability that the statistical test result was not significant; m, meter]

Height category	Fledglings per pair		Fledglings per egg	
	r	*P*	*r*	*P*
Overall cover				
0–1 m	−0.10	0.49	−0.11	0.46
1–2 m	0.06	0.69	0.07	0.62
2–3 m	0.05	0.74	−0.11	0.44
Total herbaceous cover				
0–1 m	0.04	0.77	0.04	0.77
1–2 m	0.08	0.61	0.12	0.43
2–3 m	−0.08	0.57	−0.07	0.64
Native herbaceous cover				
0–1 m	0.10	0.52	0.05	0.72
1–2 m	0.09	0.53	0.07	0.62
2–3 m	−0.02	0.87	−0.02	0.89
Woody cover				
0–1 m	−0.12	0.41	−0.14	0.35
1–2 m	−0.02	0.90	−0.07	0.63
2–3 m	0.09	0.56	−0.11	0.46
Non-native cover				
0–1 m	−0.01	0.97	0.05	0.73
1–2 m	0.08	0.60	0.17	0.24
2–3 m	−0.01	0.94	0.01	0.93

Table 23. Logistic regression models for the effect of year and treatment (if a nest was in a Seep, Intermediate, or Reference site) on Least Bell's Vireo nest survival on Marine Corps Base Camp Pendleton, 2023.

[Models are ranked from best to worst based on Akaike's Information Criterion for small samples (AIC_c), change in AIC_c, (ΔAIC_c), and Akaike weights. AIC_c is based on $-2x\log_e$ likelihood (L) and the number of parameters (K) in the model. **Abbreviations**: +, plus; *, interacting with]

Model	AIC_c	ΔAIC_c	AIC_c weight	Number of parameters	Deviance
Constant	887.7	0.0	0.8	1	885.7
Treatment	891.2	3.5	0.1	3	885.2
Year	892.5	4.8	0.1	4	884.5
Treatment+year	896.0	8.3	0.0	6	884.0
Treatment*year	898.9	11.1	0.0	12	874.8

Table 24. Host plant species used by Least Bell's Vireos at Seep, Intermediate, and Reference sites, Marine Corps Base Camp Pendleton, 2023.

[Numbers in parentheses are proportions of total nests within treatment types. **Abbreviation**: —, no nests were found in the plant species]

Host species	Number of nests			
	Seep	Intermediate	Reference	Total
Arroyo or red willow	8 (0.33)	7 (0.25)	21 (0.49)	36 (0.38)
Mule fat	3 (0.13)	10 (0.36)	4 (0.09)	17 (0.18)
Sandbar willow	4 (0.17)	4 (0.14)	2 (0.05)	10 (0.11)
Blue elderberry	3 (0.13)	—	6 (0.14)	9 (0.09)
Black willow	1 (0.04)	2 (0.07)	2 (0.05)	5 (0.05)
Poison oak (*Toxicodendron diversilobum*)	—	2 (0.07)	2 (0.05)	4 (0.04)
Poison hemlock	2 (0.08)	—	1 (0.02)	3 (0.03)
California blackberry (*Rubus ursinus*)	1 (0.04)	—	1 (0.02)	2 (0.02)
Wild grape (*Vitis girdiana*)	1 (0.04)	1 (0.04)	—	2 (0.02)
California wild rose (*Rosa californica*)	—	1 (0.04)	1 (0.02)	2 (0.02)
Coyote brush (*Baccharis pilularis*)	—	—	1 (0.02)	1 (0.01)
Giant reed	—	—	1 (0.02)	1 (0.01)
Stinging nettle (*Urtica dioica*)	1 (0.04)	—	—	1 (0.01)
Thistle species (*Circium* spp.)	—	1 (0.04)	—	1 (0.01)
Toyon (*Heteromeles arbutifolia*)	—	—	1 (0.02)	1 (0.01)

Table 25. Least Bell's Vireo nest characteristics and results of Student's *t*-tests of successful versus unsuccessful nesting attempts at Seep, Intermediate, and Reference sites, Marine Corps Base Camp Pendleton, 2023.

[*n*, number of nests in sample (successful, unsuccessful); *t*, Student's *t* statistic; *P*, probability that the difference was not significant; m, meter]

Nest characteristic	Nest fate		*n*	*t*	*P*
	Successful	Unsuccessful			
Seep site					
Average nest height (m)	0.8	0.9	11, 13	0.4	0.67
Average host height (m)	4.5	2.9	11, 13	−1.4	0.19
Average distance to edge of host (m)	1.0	0.7	11, 13	−0.9	0.36
Average distance to edge of clump (m)	2.0	2.3	11, 13	0.5	0.65
Intermediate site					
Average nest height (m)	0.9	0.9	11, 16	−0.3	0.74
Average host height (m)	3.9	5.2	12, 16	1.1	0.29
Average distance to edge of host (m)	0.8	1.4	12, 16	2.6	[1]**0.02**
Average distance to edge of clump (m)	1.6	2.4	12, 16	0.9	0.38
Reference site					
Average nest height (m)	1.0	0.9	27, 15	−2.1	[1]**0.04**
Average host height (m)	5.0	4.4	27, 15	−0.7	0.52
Average distance to edge of host (m)	1.2	1.1	27, 15	−0.4	0.71
Average distance to edge of clump (m)	1.9	1.6	27, 15	−1.1	0.29

[1]Significant result.

Table 26. Least Bell's Vireo nest characteristics and results of analysis of variance tests of all nesting attempts among Seep, Intermediate, and Reference sites, Marine Corps Base Camp Pendleton, 2023.

[*n*, number of nests in sample (Seep, Intermediate, Reference); *F*, analysis of variance statistic; *P*, probability that the difference was not significant; m, meter]

Nest characteristic	Site type			*n*	*F*	*P*
	Seep	Intermediate	Reference			
Average nest height (m)	0.8	0.9	1.0	24, 27, 42	1.8	0.17
Average host height (m)	3.6	4.7	4.8	24, 28, 42	1.2	0.31
Average distance to edge of host (m)	0.9	1.2	1.1	24, 28, 42	1.5	0.23
Average distance to edge of clump (m)	2.2	2.1	1.8	24, 28, 42	0.3	0.71

Discussion

Least Bell's Vireo numbers have fluctuated over the past several years with relative consistency across several study areas in San Diego County, including MCBCP, the San Luis Rey River, the San Diego River, MCAS, and the Sweetwater Reservoir. The range-wide vireo population gradually increased through the 1980s and 1990s, reaching a peak in 2009–10 before declining to between 50 and 60 percent of this peak by 2017, then dramatically increasing in 2018, and again in 2020 to a new peak, then declining in 2021 and remaining stable through 2023 (B. Jones, unpub. data, 1985; Kus, 1989a, 1989b, 1991a, 1991b, 1993, 1995; Kus and Beck, 1998; Allen and others, 2017, 2018; Ferree and Clark, 2018, 2019, 2020, 2021, 2023; Allen and Kus, 2019, 2020, 2021, 2022; Houston and others, 2021, 2022, 2023; K. Ferree, San Diego Natural History Museum, written commun., 2023; B. Kus, U.S. Geological Survey, unpub. data, 2023).

Between 2015 and 2018, the population trends at different study areas within the vireo's range diverged, with vireos increasing on MCBCP from 2015 to 2016 but decreasing on MCAS (likely a result of large-scale vegetation removal in 2014 and 2015, B. Kus, U.S. Geological Survey, unpub. data, 2016) and on the lower San Luis Rey River (also likely a result of habitat modification; Houston and others, 2022) while remaining stable on the middle San Luis Rey River (Allen and others, 2017). In 2017, there was a discrepancy among sites, although in the opposite direction. By 2018, trends in vireo populations on MCBCP, the lower San Luis Rey River, the middle San Luis Rey (in areas not burned during a December 2017 fire), and at MCAS reconverged with a slight drop in 2019 and then a dramatic increase in 2020. Vireo populations in these sites decreased again from 2020 to 2021 (Ferree and Clark, 2021; Allen and Kus, 2022; Houston and others, 2022), then rebounded slightly from 2021 to 2022, increasing by 4 percent on MCBCP and 9 percent on the lower San Luis Rey River, although there was a 10-percent decrease at MCAS (Ferree and Clark, 2023; Houston and others, 2023). In 2023, vireo populations on MCBCP and the lower San Luis Rey River changed by 2 percent or less (decreased on MCBCP, increased on the lower San Luis Rey River; B. Kus, U.S. Geological Survey, unpub. data, 2023) and decreased by 10 percent at MCAS, although the decrease at MCAS was from the loss of a single territory (K. Ferree, San Diego Natural History Museum, written commun., 2023).

There was a general decrease in vireo numbers region-wide from 2010 to 2017 that can largely be attributed to drought conditions on the breeding grounds before and during that timeframe. Average bio-year precipitation from 1990 to 1999 at Lake O'Neill was 43 centimeters (cm), the highest 10-year average since measurement began in 1887 (range of 29–43 cm; Office of Water Resources, 2023). From 2000 to 2009, the average precipitation dropped to 34 cm, and from 2010 to 2019, average precipitation dropped again to 33 cm. Several years of low precipitation likely compromised primary productivity, resulting in decreased annual plant and foliage growth. Consequently, foraging substrate and nesting cover for vireos likely decreased in extent and quality, affecting arthropod abundance and ultimately higher trophic level wildlife (vireos) that depend on these resources. Precipitation was 30–92 percent above the 2000–09 average in 2017, 2019, 2020, and 2023, likely positively affecting breeding productivity those years. Breeding productivity on MCBCP is strongly and positively related to the number of vireo territories on Base: high breeding productivity in 1 year has translated into increased population size the next year. Increases in precipitation in recent years has led to increases in breeding productivity and consequently a generally higher vireo population than during the recent drought years (2011–17).

We expected that precipitation at MCBCP also would affect annual survival of vireos, affecting vireo fitness on the breeding grounds before migration from MCBCP, but this expectation was not supported. Although vireo survival varied significantly by year, other factors that may have affected survival inconsistently across years include habitat degradation (for example, destruction of trees as a result of shothole borer [*Euwallacea* spp.] infestation) and rehabilitation, wildfire, flooding, or other habitat disturbance, and weather events, such as excessive rainfall or temperature extremes on breeding, migratory stop-over, and wintering grounds, disease, parasites, or other factors outside of our knowledge.

The increasing trend in the vireo population in the 1980s and 1990s can largely be attributed to management actions, including control of Brown-headed Cowbirds and protection and restoration of riparian habitat (Kus and Whitfield, 2005). On MCBCP, Brown-headed Cowbird control has reduced cowbird parasitism to a negligible level since the mid-1990s, releasing a major limit on vireo breeding productivity. In recent years, nest parasitism by Brown-headed Cowbirds has become more common on nearby drainages south of MCBCP. Cowbird parasitism on the lower San Luis Rey River jumped from 0 to 2 nests between 2015 and 2019, increased to 7 nests (5 percent of completed nests) in 2020, to 35 nests (24 percent of completed nests) in 2021, to 40 nests (27 percent of completed nests) in 2022, and to 16 nests (10 percent of completed nests) in 2023 (Houston and others, 2021, 2022, 2023; B. Kus, U.S. Geological Survey, unpub. data, 2023). The increases in cowbird nest parasitism happened during years when cowbird traps were opened late on the San Luis Rey River and on Base (J. Sexton, T.W. Biological Services, written commun., 2021; B. Leatherman, Leatherman BioConsulting, Inc., written commun., 2022). No cowbird parasitism was documented during these years at our nest monitoring plots on MCBCP; however, in 2022 a male vireo was observed feeding a cowbird fledgling during a survey outside of the nest monitoring plots. Cowbirds were detected on 45 percent of surveys on Base in 2022, the highest detection rate since 2005. In 2023, the cowbird detection rate dropped to 20 percent; however, detections persisted throughout the breeding season (April through July). It is likely that cowbirds parasitized nests of birds (vireo and non-vireo) that were not monitored, contributing to the persistence of the cowbird population.

After 2 years of lower-than-average accumulation, precipitation in the 2022–23 bio-year rebounded to the highest level since 2005. Although all monitoring sites experienced the same level of precipitation, by the end of the breeding season, both the Seep and Intermediate sites, which had received varying amounts of supplemental surface water since 2020, had higher soil moisture than the Reference sites. The difference in soil moisture among sites was not observed in 2020 or 2021, but was observed in 2022, even though 2022 was a drier than average year. This change in 2022 and 2023 was likely a result of the additive effect of multiple years of surface water augmentation. Cumulative supplementation of surface water at the Seep and Intermediate sites following dry and wet winters appears to have maintained moist conditions at these sites throughout the year that were not maintained at the Reference sites and also supported a gradient of decreasing moisture with increasing distance from the seep pump outlets. If climate conditions continue to become warmer and drier, the seep pumps likely will continue to maintain the desired conditions at these sites.

We expected higher soil moisture at Seep and Intermediate sites to translate into higher foliage cover than at Reference sites, and we found evidence to support this expectation in the understory at the Seep site but not at the Intermediate site. The Seep site had greater total foliage cover than Intermediate and Reference sites below 2 m. Considering that we also found a positive relationship between soil moisture and total cover below 1 m, the significantly wetter conditions at the Seep and Intermediate sites likely lead to more low-canopy foliage cover than at Reference sites. Unlike in 2022, we did not find that soil moisture was related to foliage cover in the middle height categories, although we did find greater vegetation cover in the understory at the Seep site. In 2023, we found the lowest foliage cover was in the Intermediate site.

In 2023, the amount of foliage cover above 3 m did not differ among Seep, Intermediate, and Reference sites, nor did the Seep and Intermediate sites have higher non-native cover below 3 m than the Reference sites. Woody cover was similar among all sites. The Willow Flycatcher habitat models developed on MCBCP from vegetation data collected in 2001 and 2002 predicted that flycatchers would occupy areas with high total vegetation cover between 3 and 6 m and high poison hemlock and black willow cover below 3 m (Howell and others, 2018). Stinging nettle (*Urtica dioica*) below 3 m and black willow above 6 m were also considered important, although less compelling, components of the habitat models (Howell and others, 2018). Poison hemlock and stinging nettle are structurally similar and likely provide similar ecological roles for flycatchers; therefore, it is likely that the higher importance of poison hemlock in flycatcher habitat models was a result of the predominance of hemlock among herbaceous vegetation in the area. A more in-depth comparison of vegetation structure and composition associated with seep pumps and the Willow Flycatcher habitat model warrants further analysis and will be presented in the 5-year synthesis report.

Average canopy height differences among Seep, Intermediate, and Reference sites, with differences in soil moisture, have varied each year. These inconsistencies can be attributed to annual differences in vegetation plot locations. Vegetation sampling plots were centered on vireo nests each year rather than distributed evenly throughout the monitoring plots, and locations changed each year depending on where vireos placed their nests; therefore, some sampling variability is expected. We anticipate clarification with a more robust dataset may be provided by continued sampling in future years.

Aside from greater foliage cover at lower height categories at Seep sites, there were few other differences among sites in 2023. Survival of adults and first-year vireos and adult site fidelity were similar among sites. Pairs at

Seep, Intermediate, and Reference sites had similar numbers of nests, hatching success, and fledging success, and they fledged similar numbers of young per pair. We did not find any differences among Seep, Intermediate, and Reference sites in nest placement characteristics.

In 2023, we continued to find vireos that originated outside of MCBCP moving onto Base and holding territories. One adult male vireo was detected on MCBCP in 2023 for the first time after it was banded as a nestling on the San Luis Rey River in 2021. Conversely, three vireos that hatched on MCBCP in 2020 and 2021 were detected off Base. On the other hand, as in 2022, we did not find any first-year birds that had immigrated to MCBCP from the San Luis Rey River. Lower productivity in surrounding vireo populations, regardless of the cause, is likely to have an effect on the regional population because of the interconnected nature of local populations. Incidental observations of vireos in areas that typically have not been thoroughly surveyed help to enhance our understanding of movement of both adult and dispersing first-year vireos. Further banding and resighting of vireos within southern California continues to increase our understanding of the extent of movement among populations and the role such movements play in maintaining genetic diversity and persistence in these populations. Continued monitoring of cohorts banded as nestlings provides the opportunity to collect lifetime reproductive data for a segment of the population, facilitating identification of age- and sex-related patterns in life history characteristics that affect population size, productivity, and genetic structure.

Conclusions

The Least Bell's vireo (*Vireo bellii pusillus*) population on Marine Corps Base Camp Pendleton, California (MCBCP or Base) has largely tracked the regional, southern California vireo population, with minor exceptions. Continued surveys of vireos on MCBCP will enhance understanding of movements among populations and regional population trends.

Long-term, annual Brown-headed Cowbird (*Molothrus ater*) control has had a lasting effect, even in occasional years when applied imperfectly. Cowbird control has a demonstrably positive effect on vireo productivity (Kus, 1999; Kus and Whitfield, 2005), and when practiced consistently, it can effectively maintain the desired reduction in parasitism.

Our study to determine the effects of increased surface water provided by seep pumps in vireo and flycatcher habitat has allowed us to detect differences in soil moisture, vegetation cover, and vireo breeding productivity and survival among plots on an annual basis. Our original study design, comparing sites with and without seep pumps, was altered in 2023 when the pump at one Seep site failed, requiring the creation of a new, Intermediate site category. In the 2024 report, we will provide an analysis and discussion of 5 years of data collected to examine the effects of the seep pumps and increased soil moisture on vireo habitat, breeding productivity, and survival.

Although we did not document catastrophic wildfires on Base in 2022 or 2023, a fire in 2021 affected some vireo habitat along the Santa Margarita River. Continued vigilance surrounding military and civilian activities on Base will minimize the ignition of wildfires that affect large sections of vireo habitat during the frequent high-wildfire-risk weather conditions in southern California. The wildfires that have occurred on MCBCP were sparked by a combination of circumstances, including drought, strong east winds that carried dry, hot air from the deserts, human activity (for example, vehicles with hot engines parked on dry grass, military training involving sources of ignition), and electrical infrastructure failure as a result of strong winds. Although most of these circumstances were beyond immediate human control, catastrophic events like wildfires highlight the delicate tipping point that can easily be upset by normally innocuous human actions. These events can adversely affect vireo populations in the short-term and potentially long-term, causing direct mortality during the breeding season, destroying habitat during any time of the year, and possibly causing long-term changes in vegetation structure and composition and consequently a reduction in high quality breeding habitat for vireos.

Evidence of invasive shothole borer beetles was observed on MCBCP during surveys, including dead and dying willows and cottonwoods (B. Kus, U.S. Geological Survey, unpub. data, 2023). Confirming the presence and status of shothole borer beetles on Base and evaluating their effect on vegetation structure would help in understanding the urgency of controlling this invasive species and developing restoration scenarios for vireo and flycatcher habitat.

Aside from prescribed management actions, direct human effects on vireo habitat were not documented in 2023, although continued attention to human activities (for example, weed control, off-road vehicle traffic) would provide documentation to assist in developing management actions to preserve and enhance vireo habitat. Communication among personnel may reduce the instances of human-related effects on vireos and occupied vireo habitat by allowing all participants to understand needs and flexibilities and adjust their activities accordingly. Improved understanding of factors influencing vireos and vireo habitat will provide managers with the tools necessary to maintain a balance between the sometimes competing land uses on Base, including military activities, recreation, habitat protection, and endangered species management.

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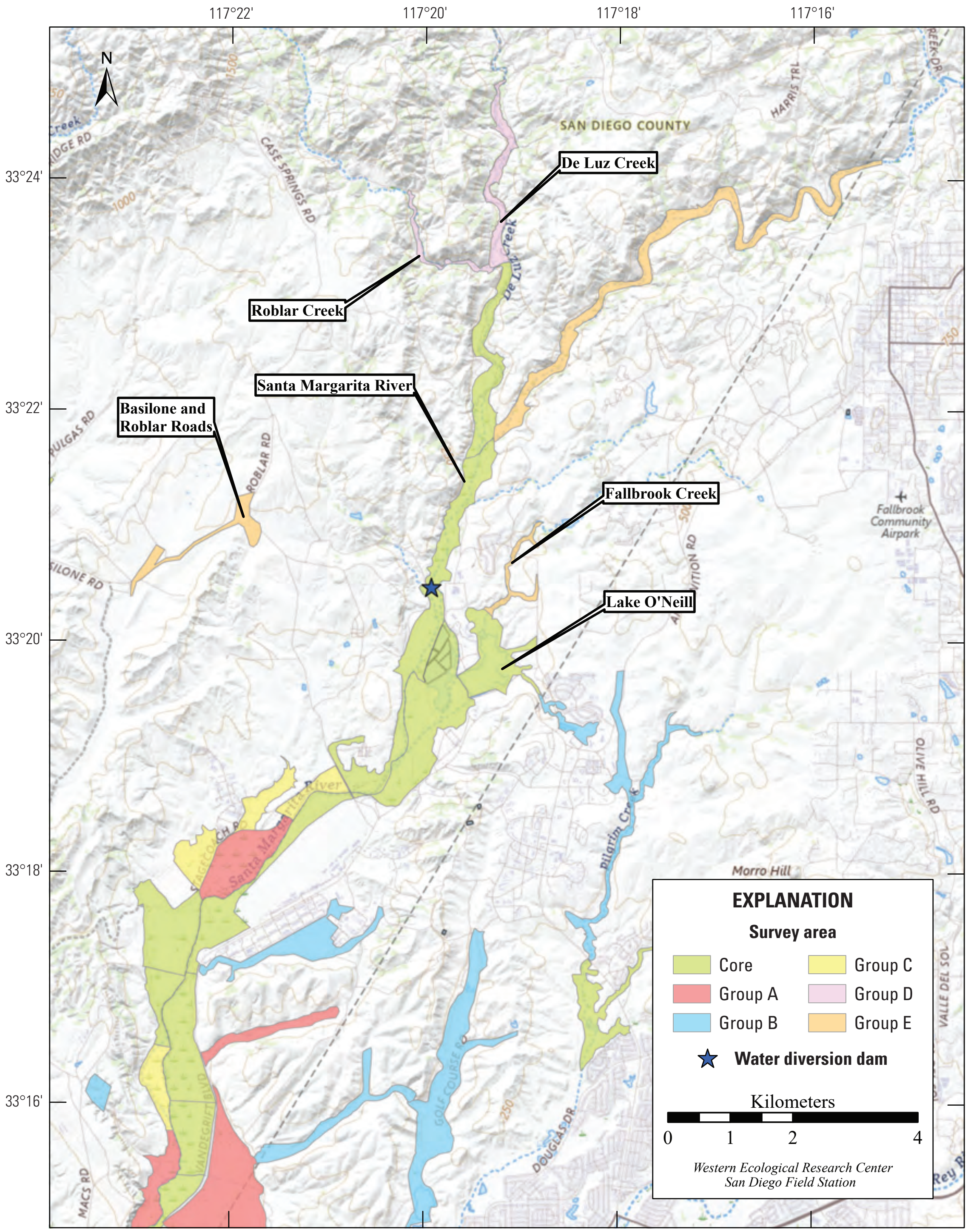
Appendix 1. Least Bell's Vireo Survey Areas at Marine Corps Base Camp Pendleton, 2023



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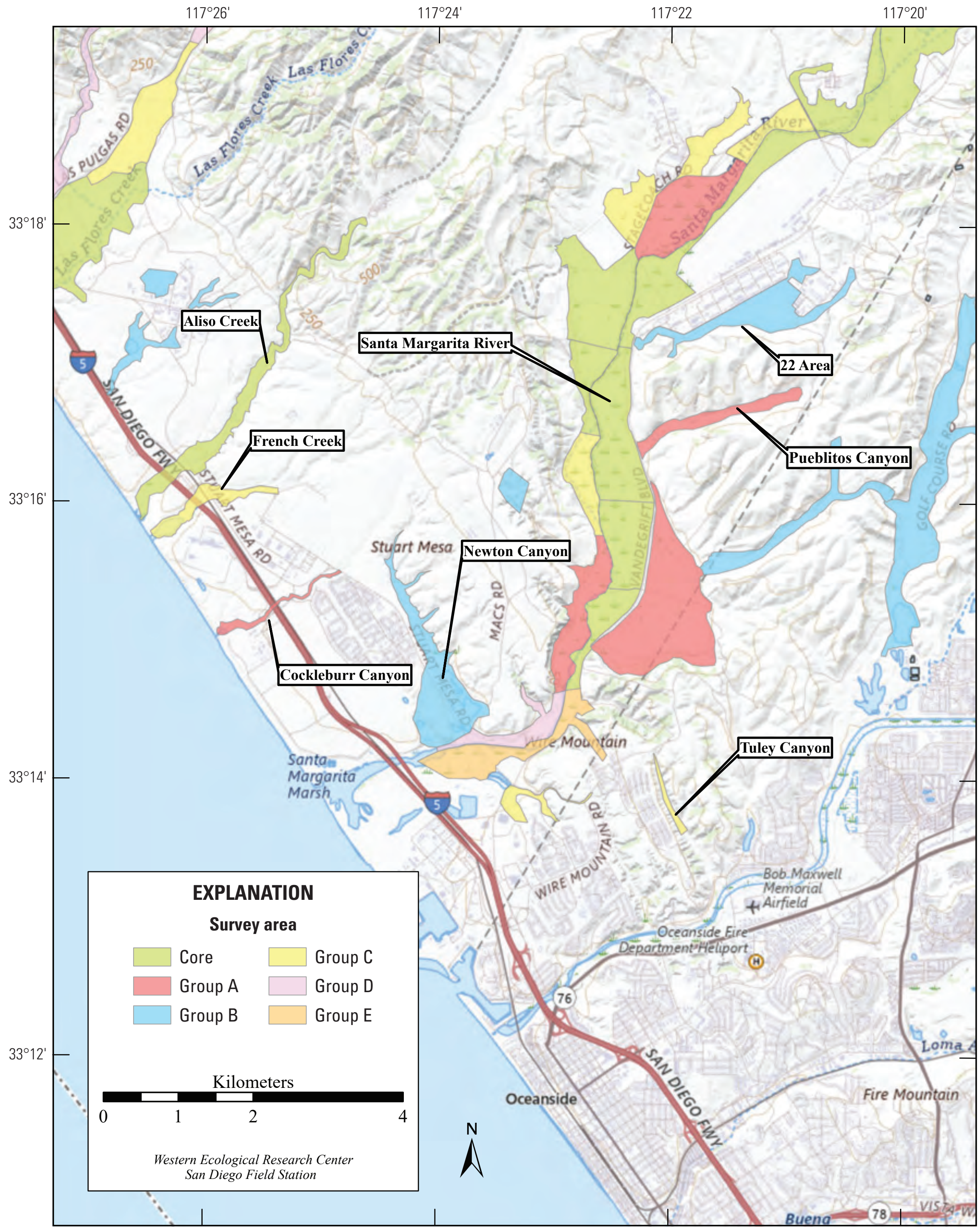
Universal Transverse Mercator, zone 11 north
North American Datum of 1983

Figure 1.1. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2023: upper Santa Margarita River, Fallbrook Creek, Lake O'Neill, De Luz Creek, Roblar Creek, and Basilone and Roblar Roads. Core areas and Group B areas were surveyed in 2023.



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North American Datum of 1983

Figure 1.2. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2023: lower Santa Margarita River, 22 Area, Pueblitos Canyon, Tuley Canyon, Newton Canyon, Cockleburr Canyon, French Creek, and Aliso Creek.

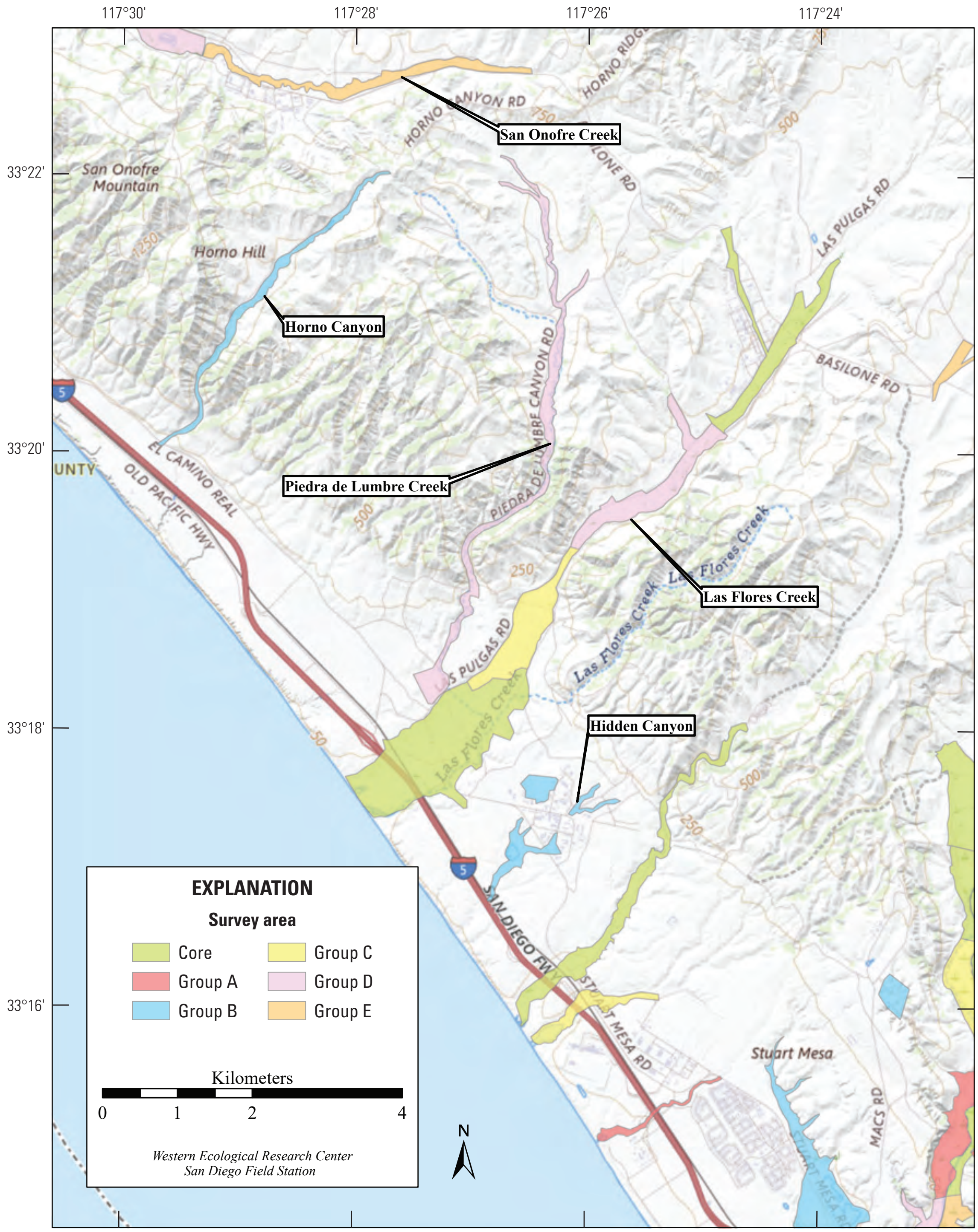

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Figure 1.3. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2023: San Onofre Creek South Fork, Horno Canyon, Piedra de Lumbre Creek, Las Flores Creek, and Hidden Canyon.

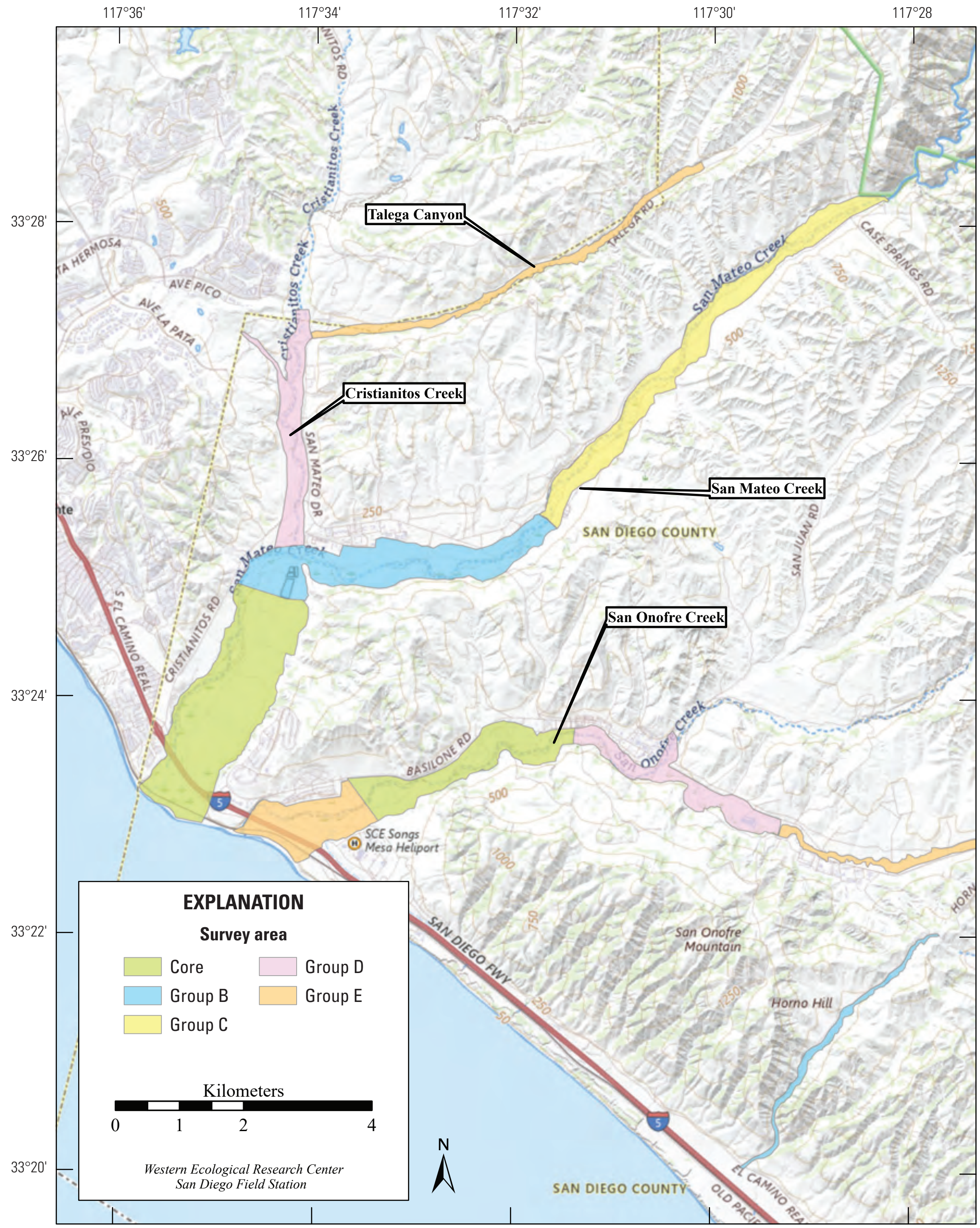

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Figure 1.4. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2023: Talega Canyon, Cristianitos Creek, San Mateo Creek, and San Onofre Creek.

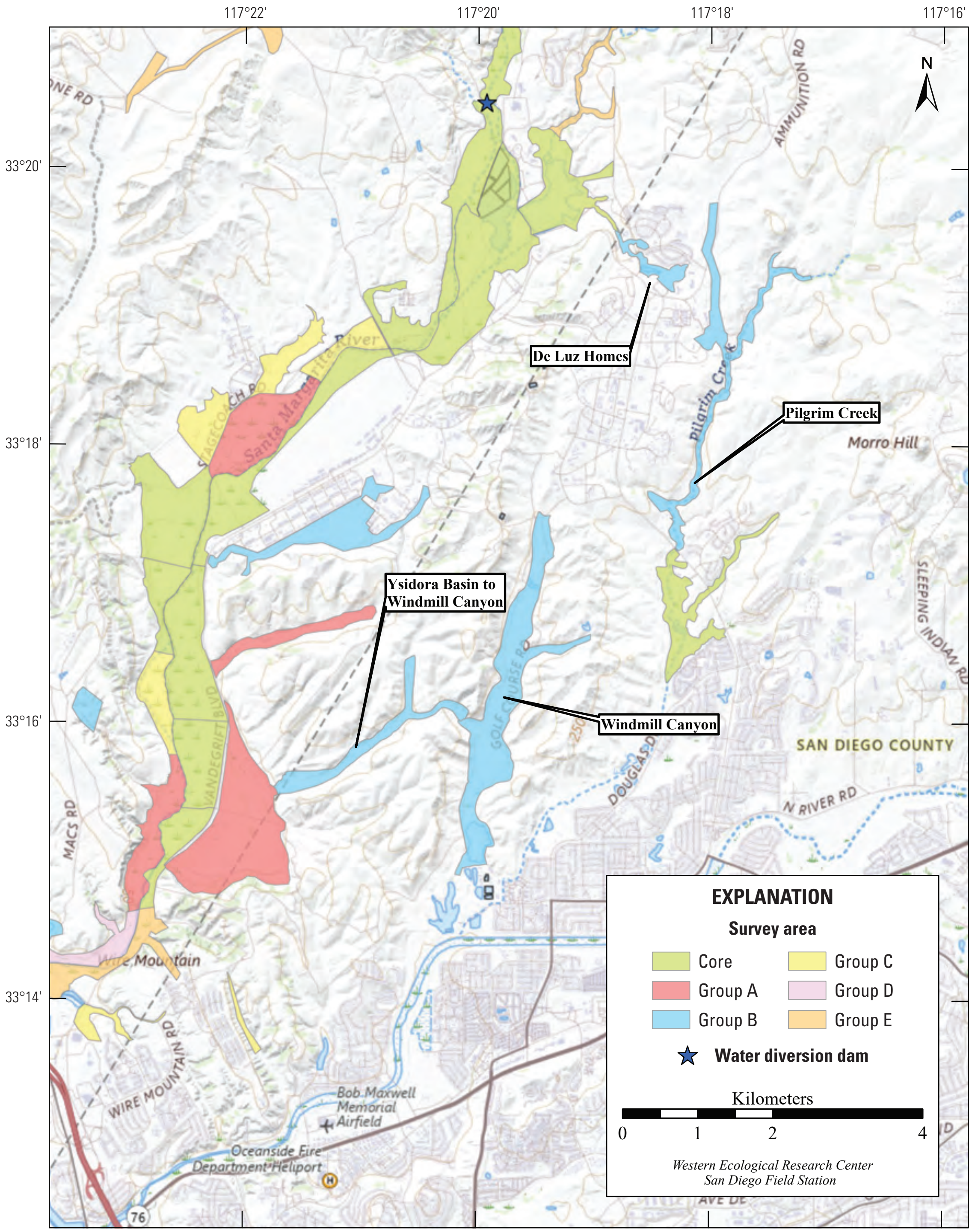

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Figure 1.5. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2023: Windmill Canyon, Ysidora Basin to Windmill Canyon, Pilgrim Creek, and De Luz Homes Habitat.

Appendix 2. Vegetation Sampling Locations and Vegetation Sampling Data Sheet, Marine Corps Base Camp Pendleton, 2023

Table 2.1. Vegetation sampling locations and vegetation sampling data sheet, Marine Corps Base Camp Pendleton, 2023.

[Datum: World Geodetic System of 1984]

Territory	Site	Latitude	Longitude
CHW	Seep	33.28147	−117.37440
GRD	Seep	33.27930	−117.37525
KNO	Seep	33.28052	−117.37410
KYL	Seep	33.28346	−117.37482
LEI	Seep	33.28138	−117.37370
PAL	Seep	33.28218	−117.37465
PAP	Seep	33.28277	−117.37328
SKY	Seep	33.28253	−117.37367
SNK	Seep	33.27996	−117.37524
VAD	Seep	33.28323	−117.37300
WIC	Seep	33.28170	−117.37395
YOD	Seep	33.28057	−117.37475
ARW	Intermediate	33.28384	−117.37749
BRM	Intermediate	33.28300	−117.37747
ELR	Intermediate	33.28586	−117.38057
FRO	Intermediate	33.28181	−117.37900
GAL	Intermediate	33.28340	−117.37874
GAN	Intermediate	33.28499	−117.37865
LEG	Intermediate	33.28380	−117.38016
MRY	Intermediate	33.28215	−117.37698
NRS	Intermediate	33.28458	−117.37969
PIP	Intermediate	33.28142	−117.37785
SHD	Intermediate	33.28505	−117.37735
TRE	Intermediate	33.28233	−117.37871

Table 2.1. Vegetation sampling locations and vegetation sampling data sheet, Marine Corps Base Camp Pendleton, 2023.—Continued

[Datum: World Geodetic System of 1984]

Territory	Site	Latitude	Longitude
ALN	Reference	33.26933	−117.37793
ARM	Reference	33.26971	−117.37927
BAX	Reference	33.27055	−117.37268
CBD	Reference	33.27447	−117.37783
CAP	Reference	33.26668	−117.37357
CON	Reference	33.26915	−117.37378
CRA	Reference	33.27100	−117.37466
FRX	Reference	33.27049	−117.37743
ISO	Reference	33.26876	−117.37781
JAC	Reference	33.26767	−117.37513
JOS	Reference	33.26998	−117.37369
MLA	Reference	33.27118	−117.37812
MAL	Reference	33.27401	−117.38012
PNA	Reference	33.26773	−117.37342
PPU	Reference	33.27225	−117.37895
RHI	Reference	33.27410	−117.37892
ROK	Reference	33.26921	−117.37603
SLX	Reference	33.27284	−117.38021
SAM	Reference	33.27423	−117.37817
SEQ	Reference	33.26729	−117.37427
TET	Reference	33.26864	−117.37492
VIT	Reference	33.27027	−117.37844
YEL	Reference	33.27035	−117.37438
YOS	Reference	33.26937	−117.37509

Marine Corps Base Camp Pendleton Seep Vegetation Data Form – 2023

Observer(s): _____________ Date: __________2023 Drainage: ______________ Plot ID: _______________

% Cover **CODE**	<1% T	1-10% **1**	11-25% **2**	26-50% **3**	51-75% **4**	76-90% **5**	>90% **6**

Center Plot										
Height	Overall Foliage Cover	Non-native Cover		Species 1	Sp. 1 % Cover	Species 2	Sp. 2 % Cover	Species 3	Sp. 3 % Cover	All Other
0-1 m										
1-2 m										
2-3 m										
3-4 m										
4-5 m										
5-6 m										
>6 m										
GPS Coordinates		**N:**				**W:**			**Canopy Height:**	
Soil Moisture:										
Comments:										

Satellite Plots (15m from Center Plot)

0 Degrees Plot										
Height	Overall Foliage Cover	Non-native Cover		Species 1	Sp. 1 % Cover	Species 2	Sp. 2 % Cover	Species 3	Sp. 3 % Cover	All Other
0-1 m										
1-2 m										
2-3 m										
3-4 m										
4-5 m										
5-6 m										
>6 m										
GPS Coordinates		**N:**				**W:**			**Canopy Height:**	
Soil Moisture:										
Comments:										

Figure 2.1. Marine Corps Base Camp Pendleton Seep Vegetation Data Form, 2023.

Marine Corps Base Camp Pendleton Seep Vegetation Data Form – 2023

Observer(s): _____________ Date: __________2023 Drainage: ______________ Plot ID: _____________

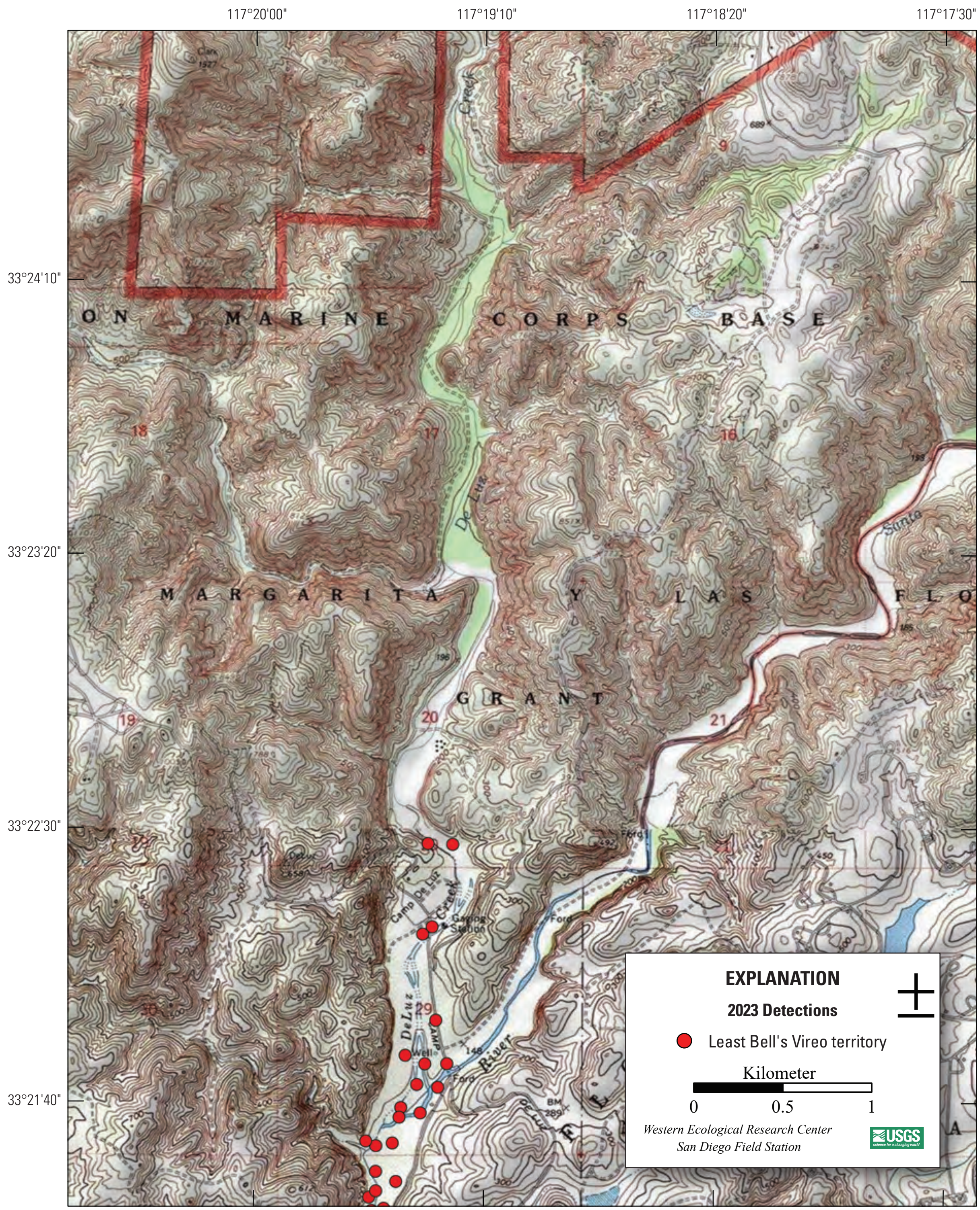
% Cover	<1%	1-10%	11-25%	26-50%	51-75%	76-90%	>90%
CODE	T	**1**	**2**	**3**	**4**	**5**	**6**

120 Degrees Plot										
Height	Overall Foliage Cover	Non-native Cover		Species 1	Sp. 1 % Cover	Species 2	Sp. 2 % Cover	Species 3	Sp. 3 % Cover	All Other
0-1 m										
1-2 m										
2-3 m										
3-4 m										
4-5 m										
5-6 m										
>6 m										
GPS Coordinates	**N:**				**W:**				**Canopy Height:**	
Soil Moisture:										
Comments:										

240 Degrees Plot										
Height	Overall Foliage Cover	Non-native Cover		Species 1	Sp. 1 % Cover	Species 2	Sp. 2 % Cover	Species 3	Sp. 3 % Cover	All Other
0-1 m										
1-2 m										
2-3 m										
3-4 m										
4-5 m										
5-6 m										
>6 m										
GPS Coordinates	**N:**				**W:**				**Canopy Height:**	
Soil Moisture:										
Comments:										

Figure 2.1.—Continued

Appendix 3. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023



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Universal Transverse Mercator, zone 11 north
North American Datum of 1983

Figure 3.1. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: De Luz Creek.

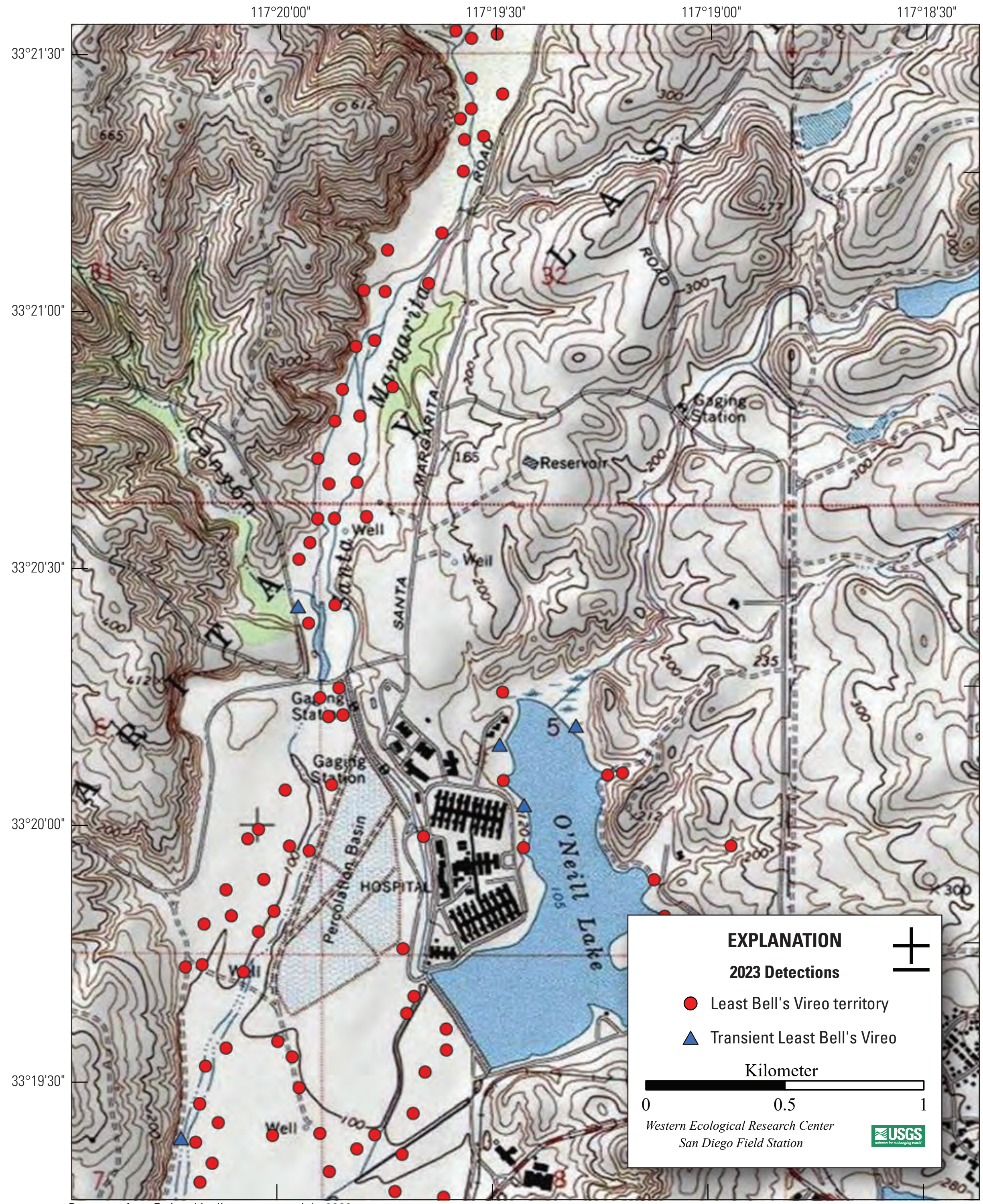

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Figure 3.2. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: Santa Margarita River and Lake O'Neill.

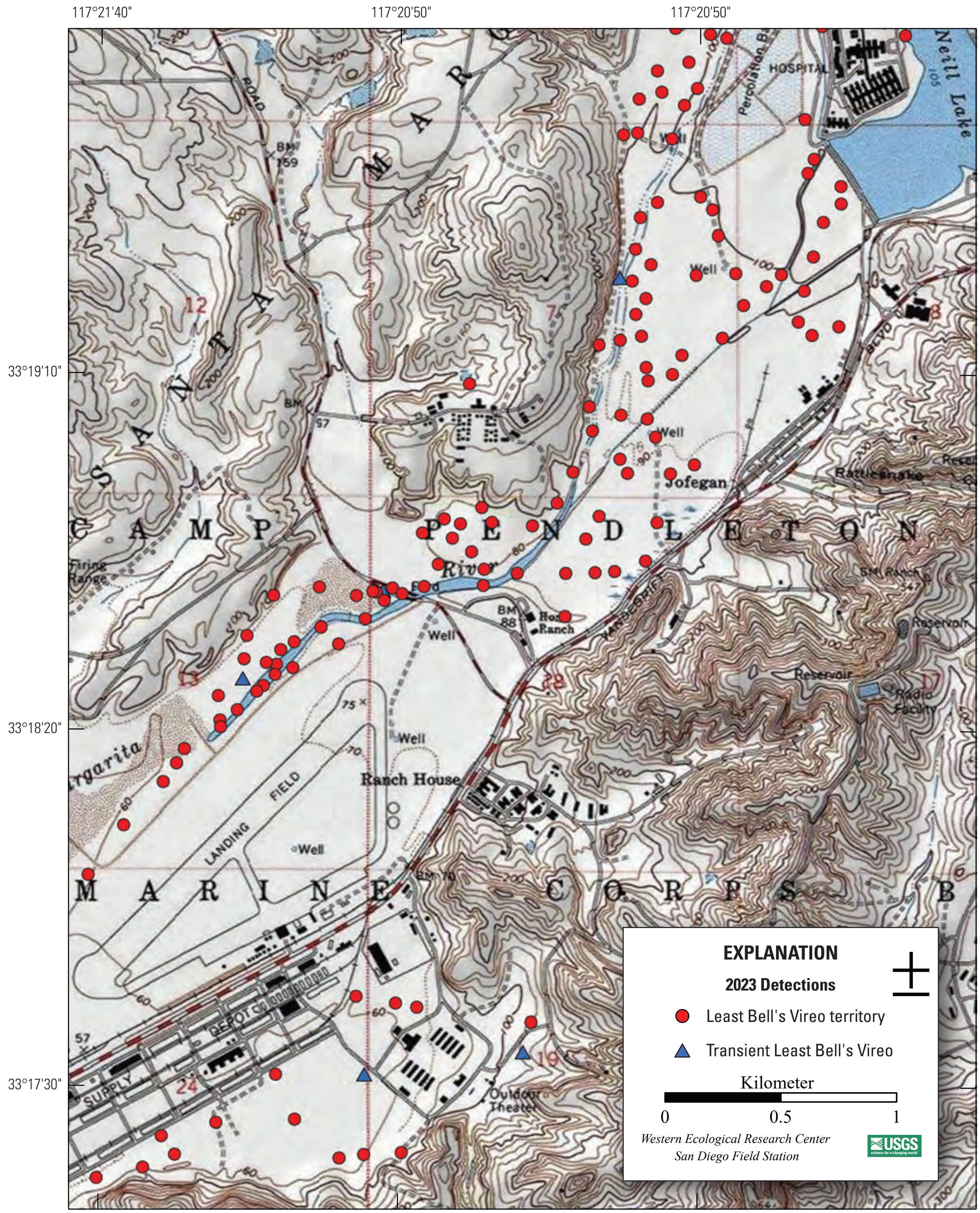

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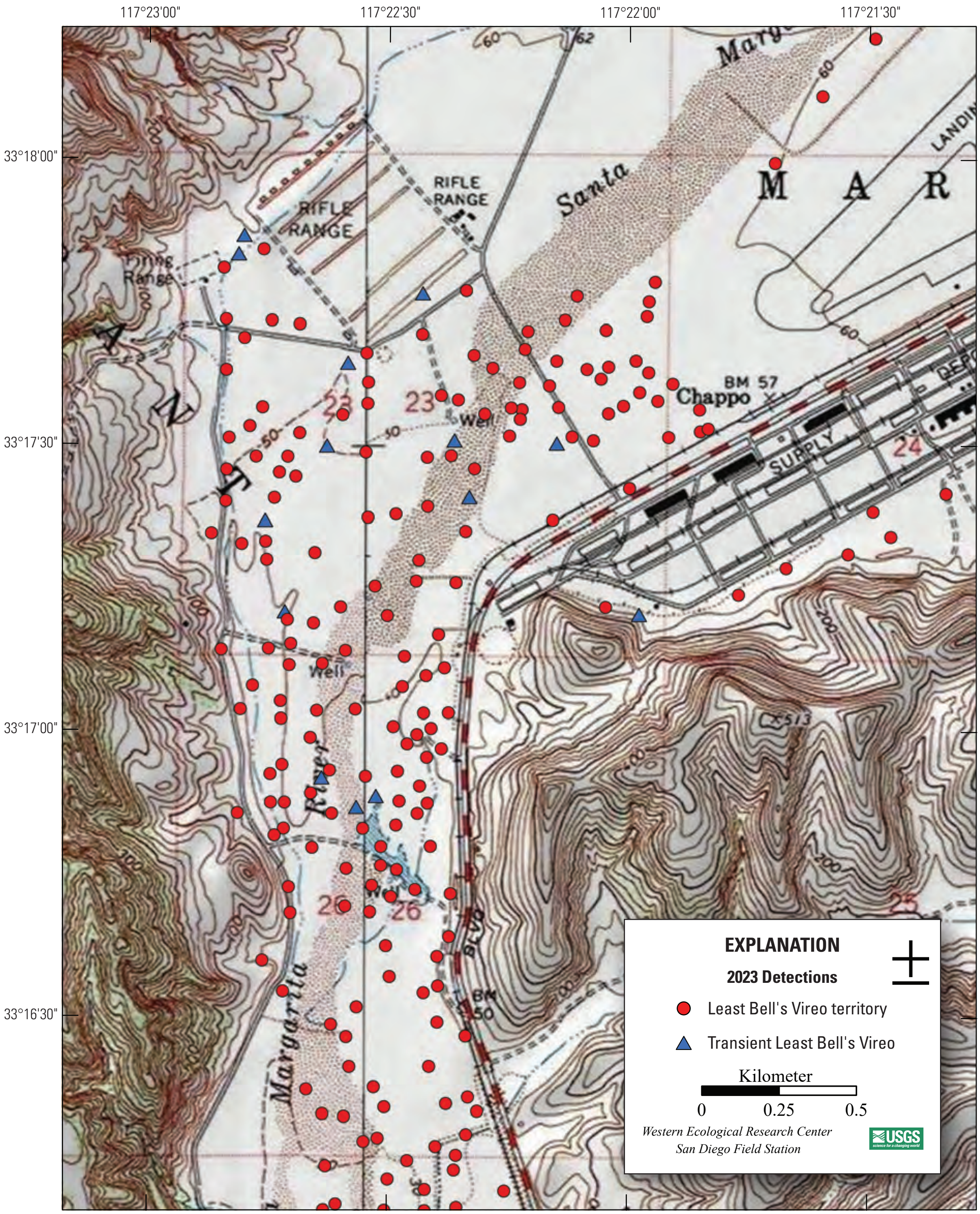
Figure 3.3. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: Santa Margarita River.



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North American Datum of 1983

Figure 3.4. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: Santa Margarita River.

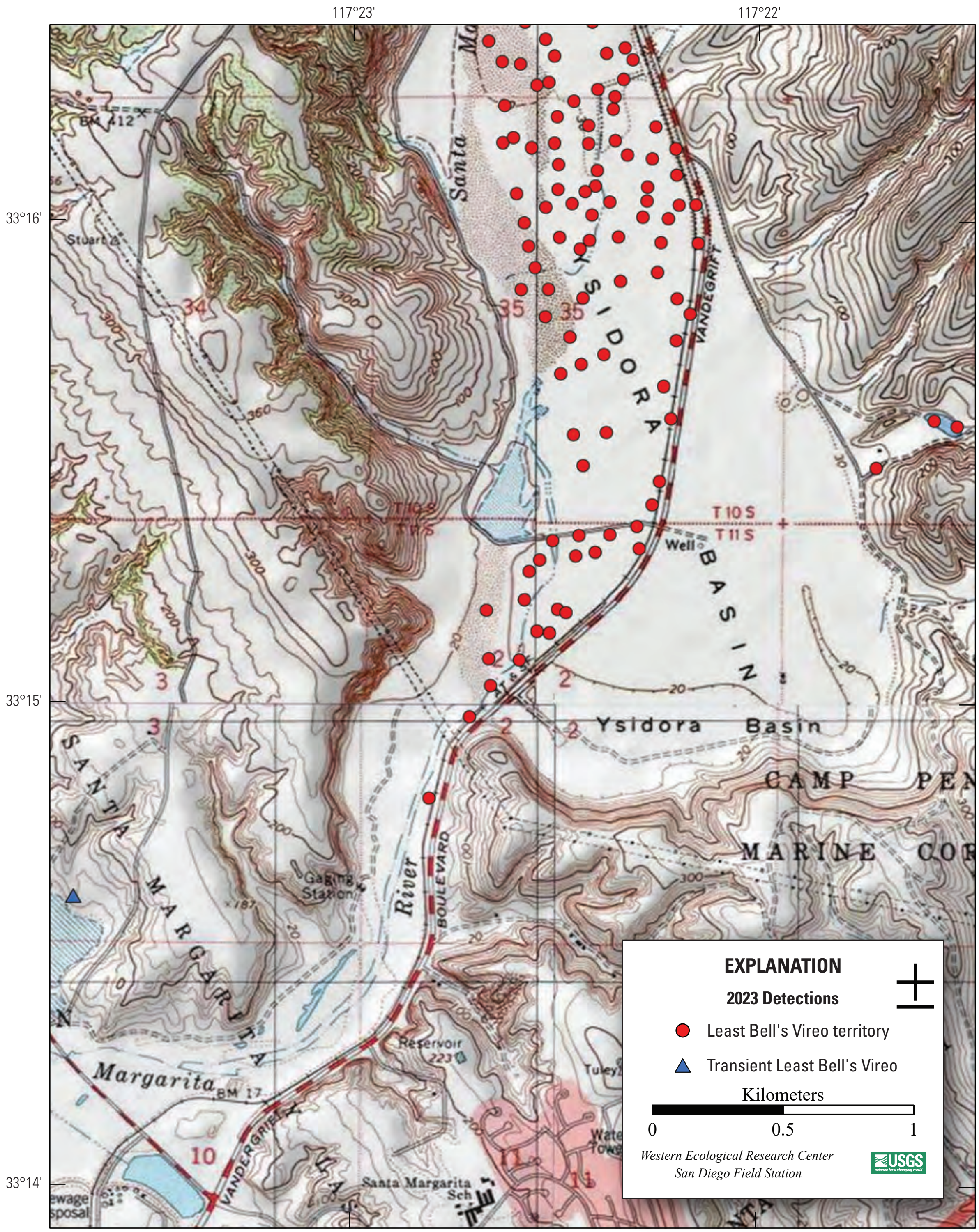

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Figure 3.5. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: Santa Margarita River and Tuley Canyon.

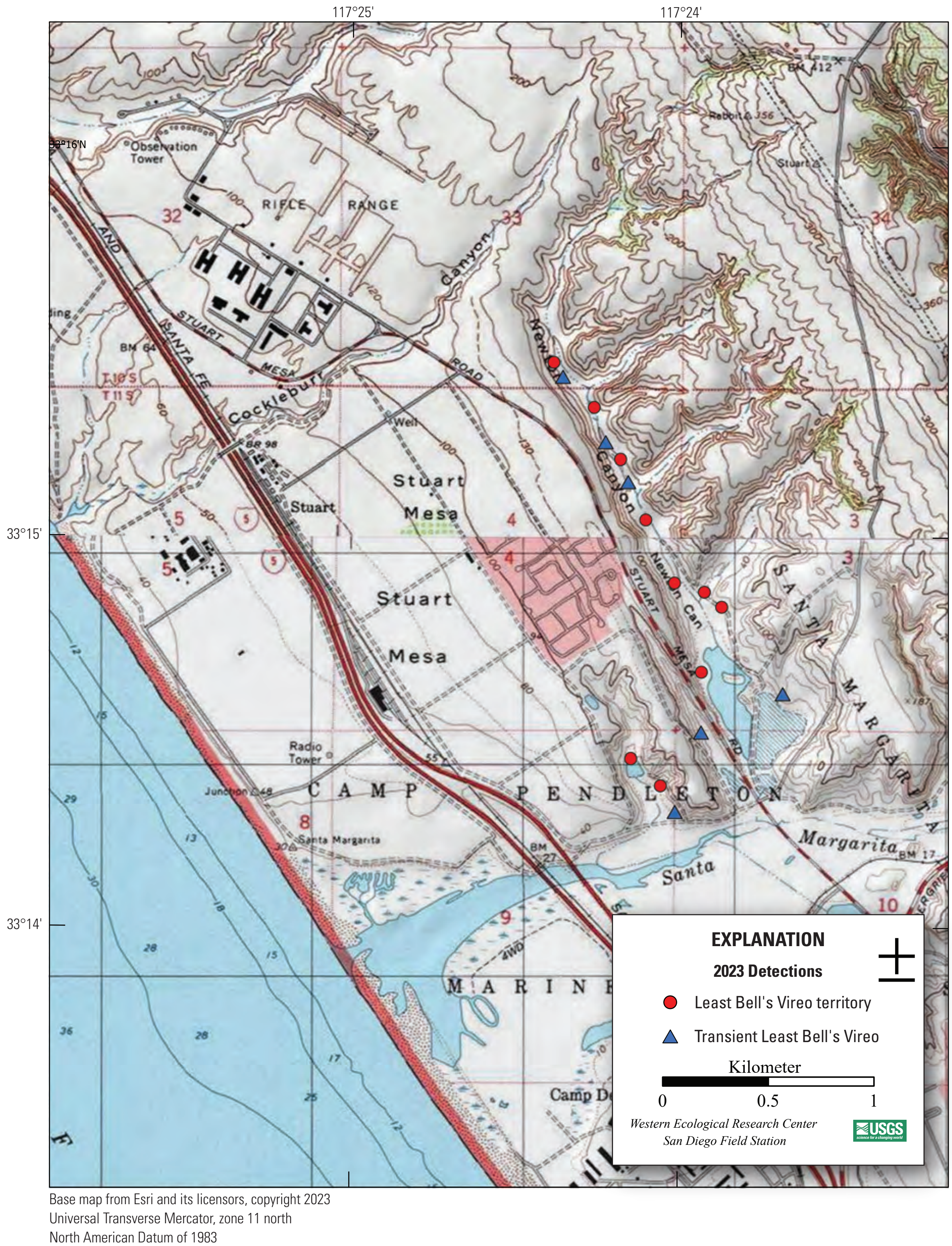

Figure 3.6. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: lower Santa Margarita River, Newton Canyon, and Cockleburr Canyon.

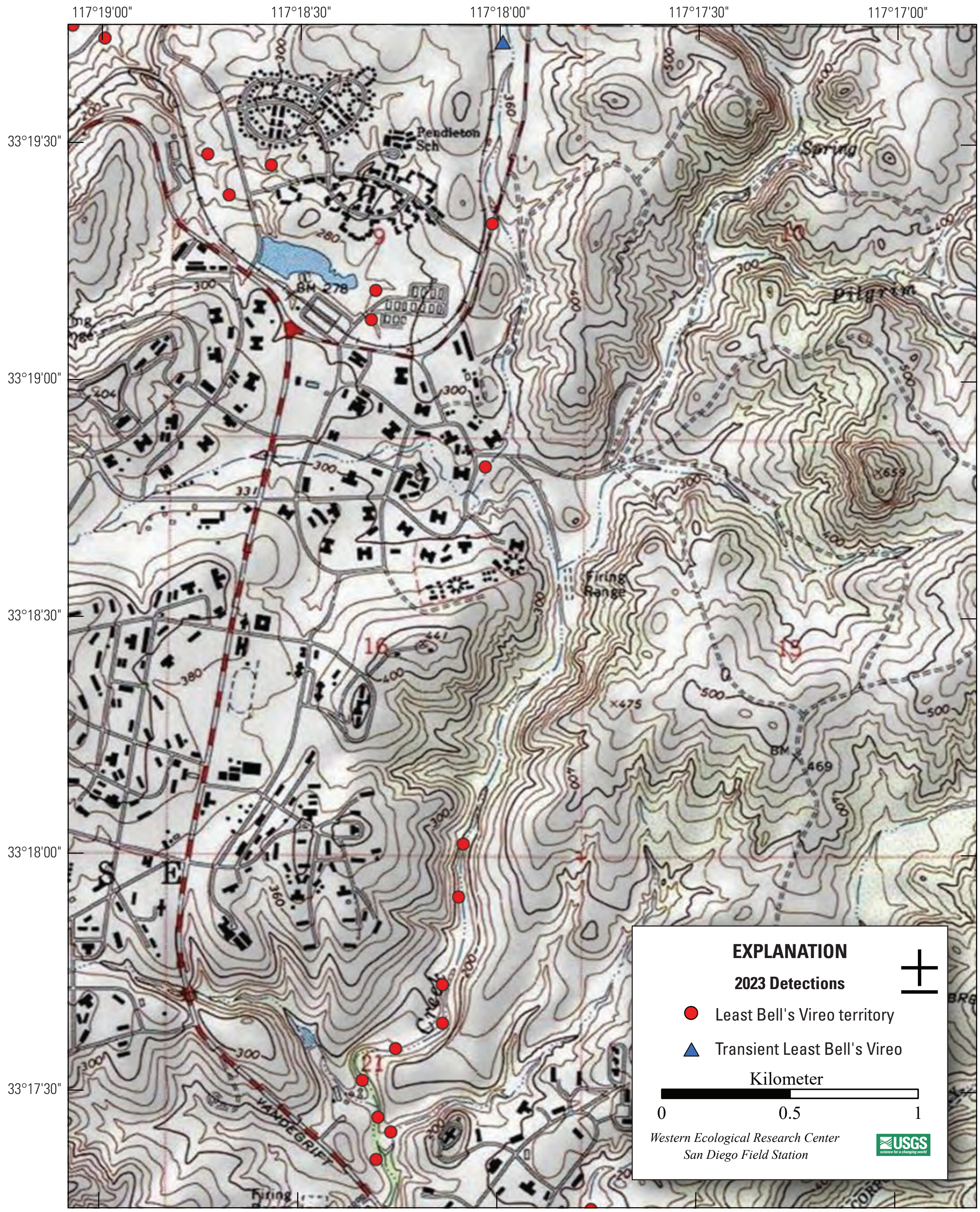

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Figure 3.7. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: upper Pilgrim Creek and De Luz Homes Habitat.

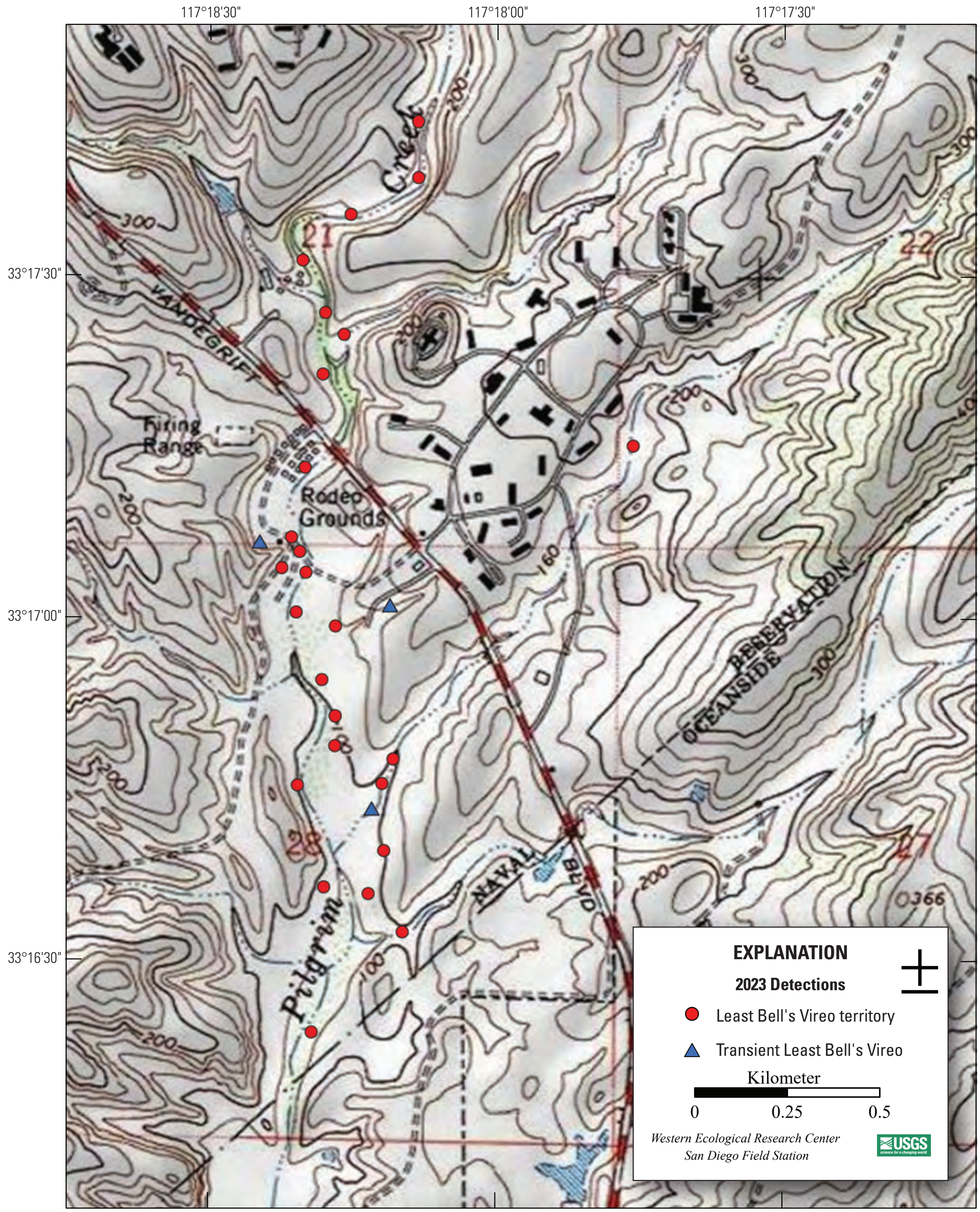

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Figure 3.8. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: lower Pilgrim Creek.

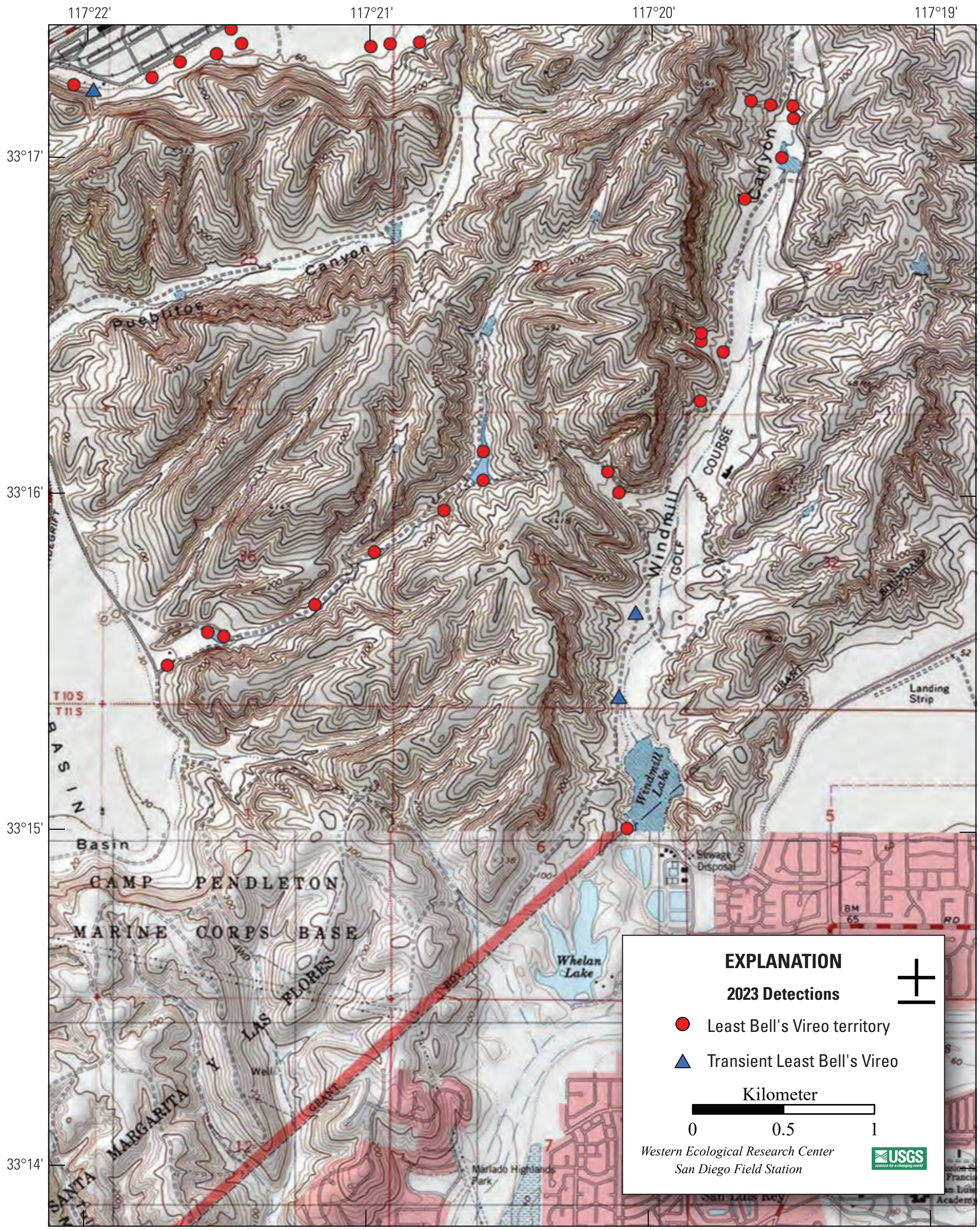

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Figure 3.9. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: Windmill Canyon and Ysidora Basin to Windmill Canyon.

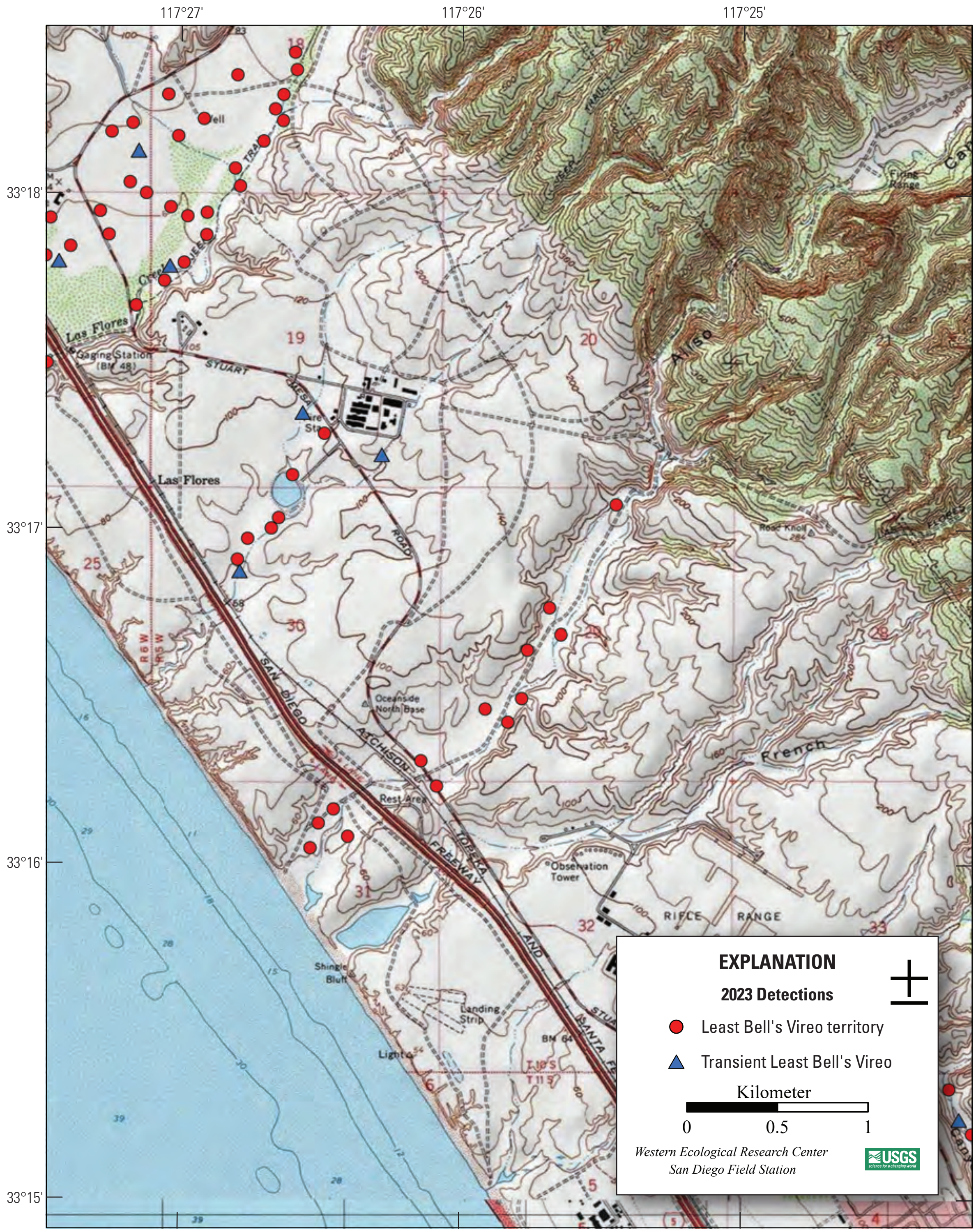

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Figure 3.10. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: Aliso Creek.

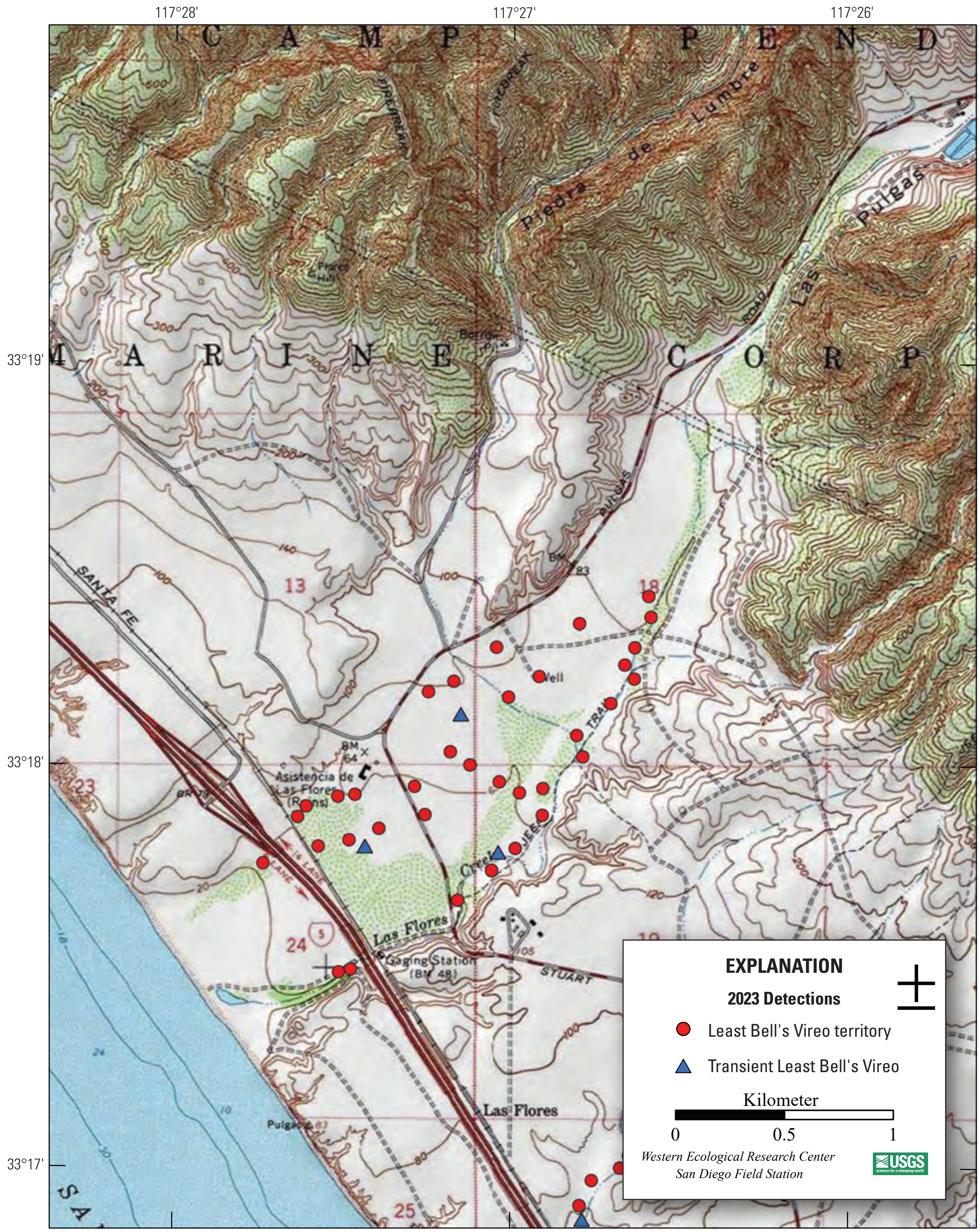

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Figure 3.11. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: lower Las Flores Creek and lower Piedra de Lumbre Canyon.

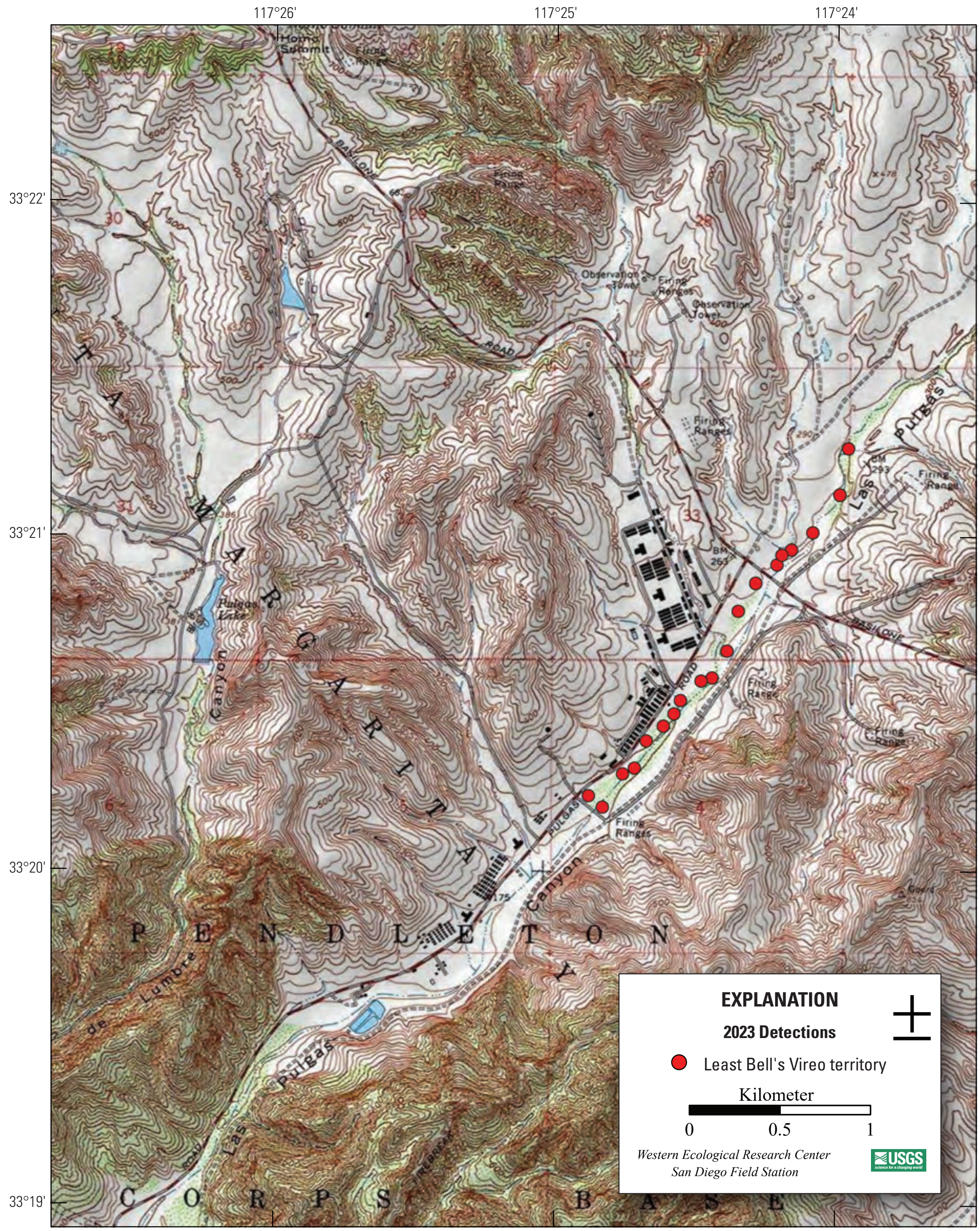

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Figure 3.12. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: upper Las Flores Creek and upper Piedra de Lumbre Canyon.

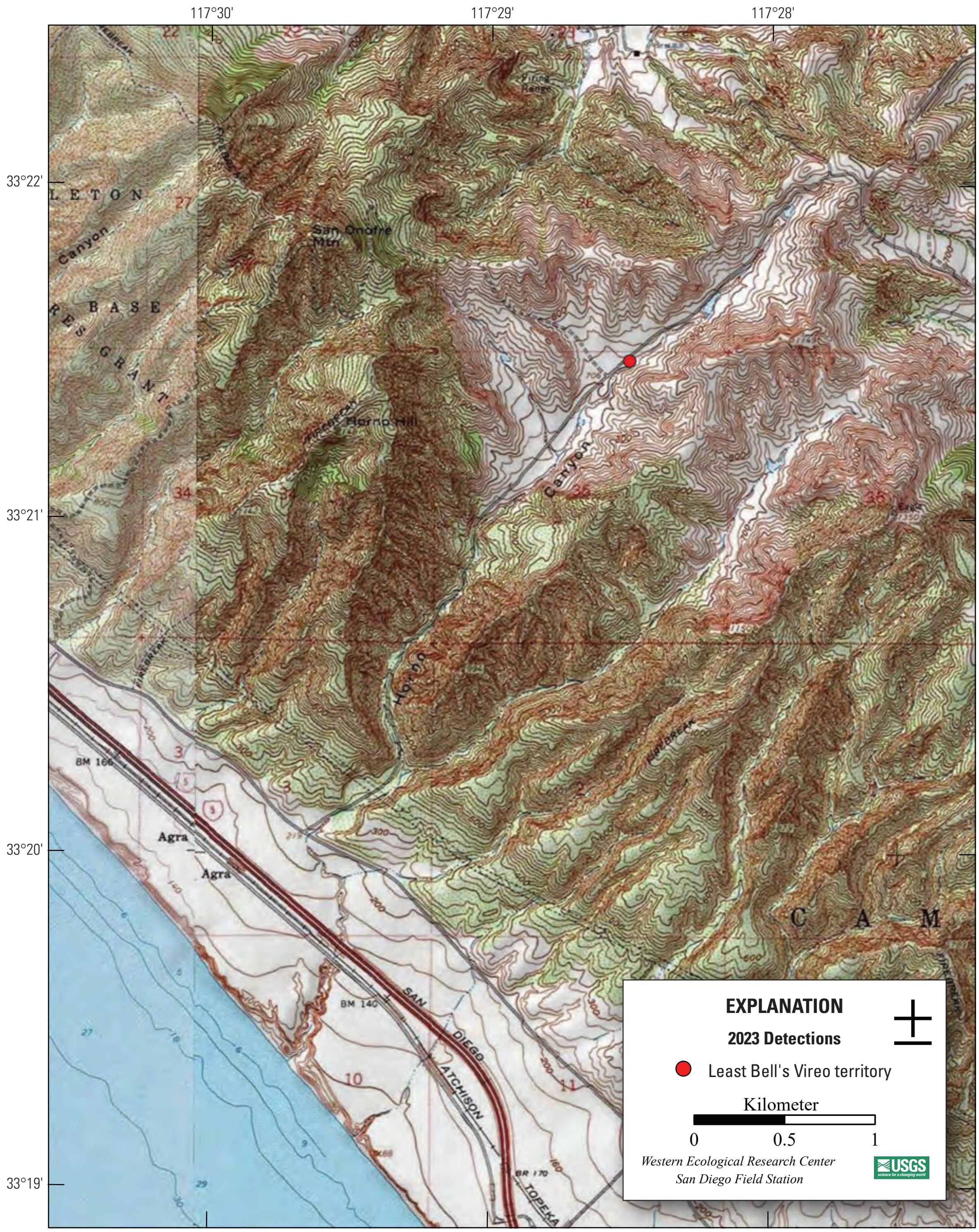

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Figure 3.13. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: Horno Canyon.

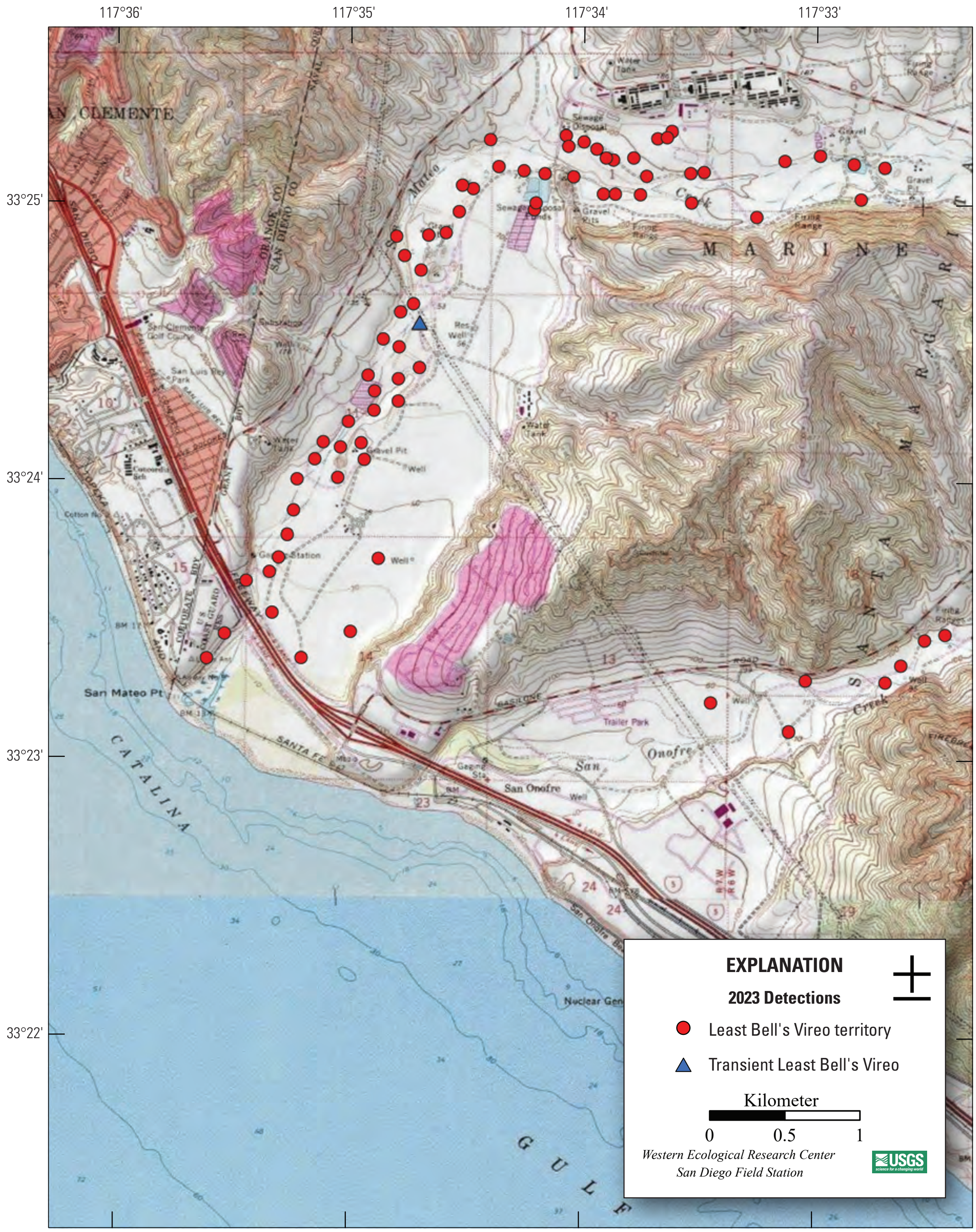

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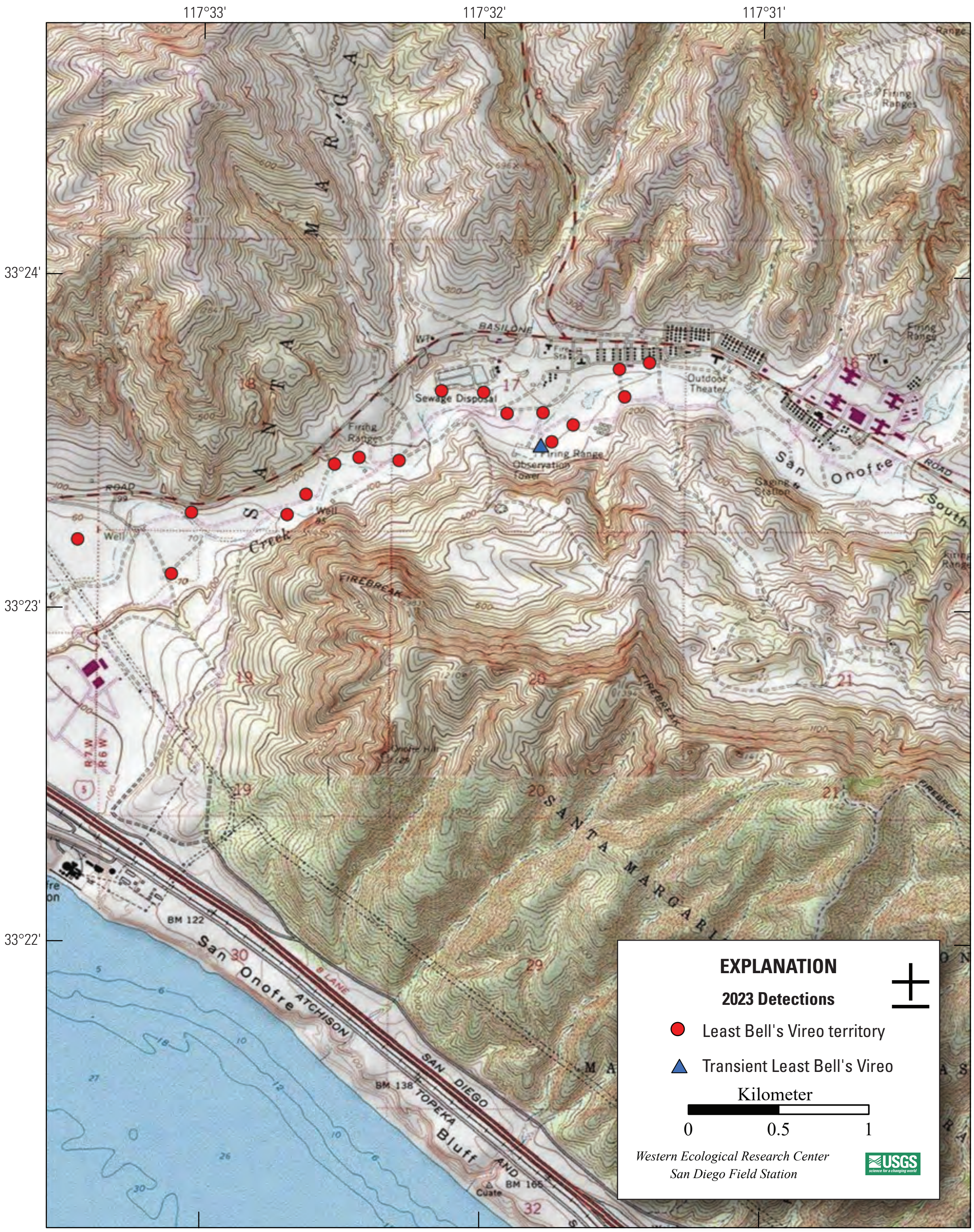
Figure 3.14. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: lower San Mateo Creek and lower San Onofre Creek.



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North American Datum of 1983

Figure 3.15. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023: San Onofre Creek (West).

Appendix 4. Number of Territorial Male Least Bell Vireos in Core Survey Areas at Marine Corps Base Camp Pendleton, by Drainage, 2005–23

Table 4.1. Number of territorial male Least Bell's Vireos in core survey areas at Marine Corps Base Camp Pendleton, by drainage, 2005–23.

[Number includes only singing males determined to hold territories. Numeric change is the positive or negative change in the number of vireo territories between 2022 and 2023. Percentage change is the positive or negative percentage change in vireo territories within that drainage from 2022 to 2023]

Drainage	Number of territorial males																			Numeric change	Percentage change
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023		
Santa Margarita River	314	276	282	326	402	435	293	255	292	296	261	281	254	367	333	460	380	416	402	−14	−3
De Luz Creek	11	19	17	19	24	23	17	19	21	15	12	12	7	9	16	23	17	10	11	1	10
Fallbrook Creek	14	5	7	10	8	10	5	4	5	7	3	3	5	13	8	15	12	15	11	−4	−27
Aliso Creek	21	11	9	11	21	16	9	8	9	6	4	6	5	9	9	17	14	12	13	1	8
Las Flores Creek	51	43	46	41	59	64	47	28	33	38	31	29	24	47	48	64	52	49	54	5	10
San Onofre Creek	13	10	11	7	17	13	14	16	16	12	9	10	16	11	10	22	23	18	17	−1	−6
San Mateo Creek	28	22	21	29	48	43	29	22	26	23	29	35	25	31	35	35	35	31	34	3	10
Pilgrim Creek	28	16	17	16	15	18	20	12	19	16	16	13	15	21	22	33	18	20	19	−1	−5
Total	**480**	**402**	**410**	**459**	**594**	**622**	**434**	**364**	**421**	**413**	**365**	**389**	**351**	**508**	**481**	**669**	**551**	**571**	**561**	**−10**	**−2**

Appendix 5. Proportion of All Surveys during which Brown-headed Cowbirds Were Detected in Core Survey Areas at Marine Corps Base Camp Pendleton, by Drainage, 2005–23

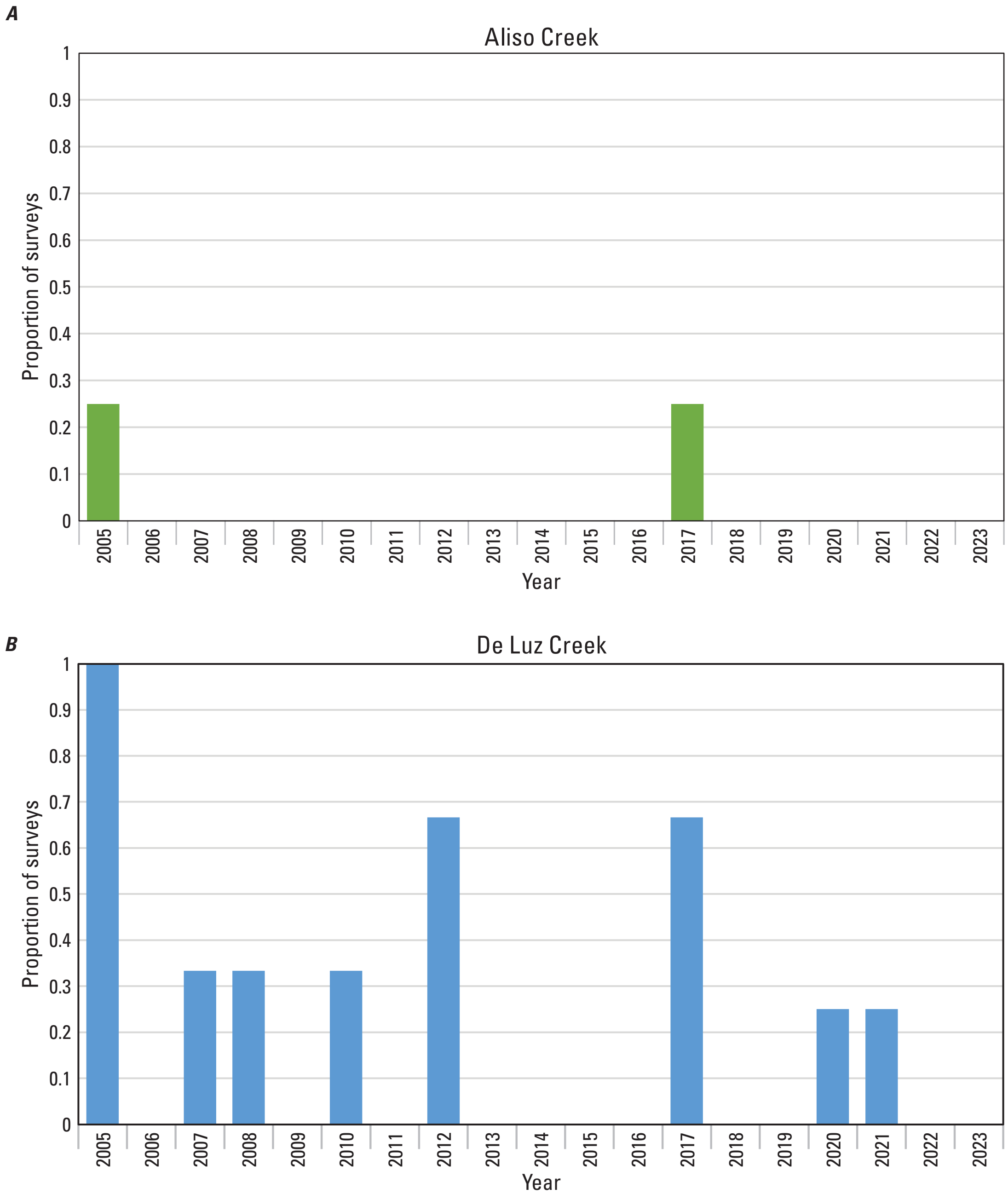
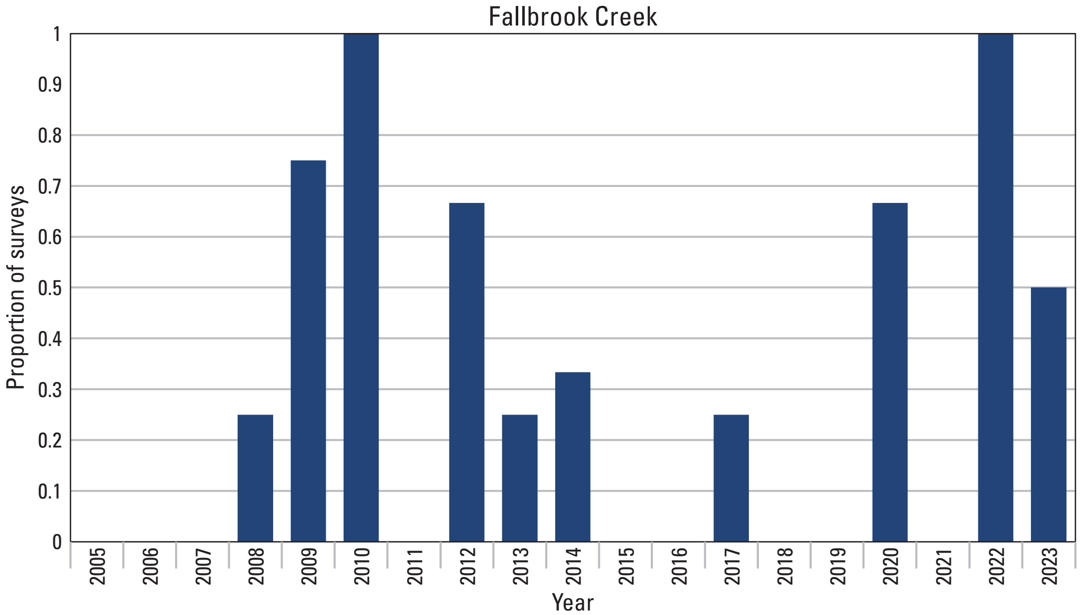


Figure 5.1. Proportion of all surveys during which Brown-headed Cowbirds were detected in core survey areas at Marine Corps Base Camp Pendleton, by drainage, 2005–23.

C



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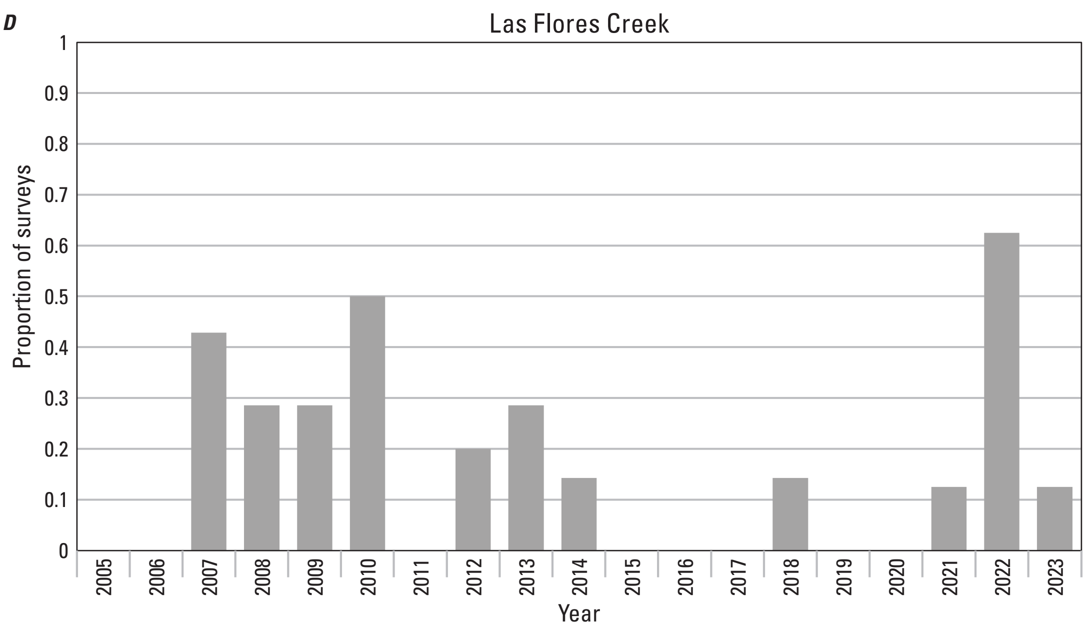

Figure 5.1.—Continued

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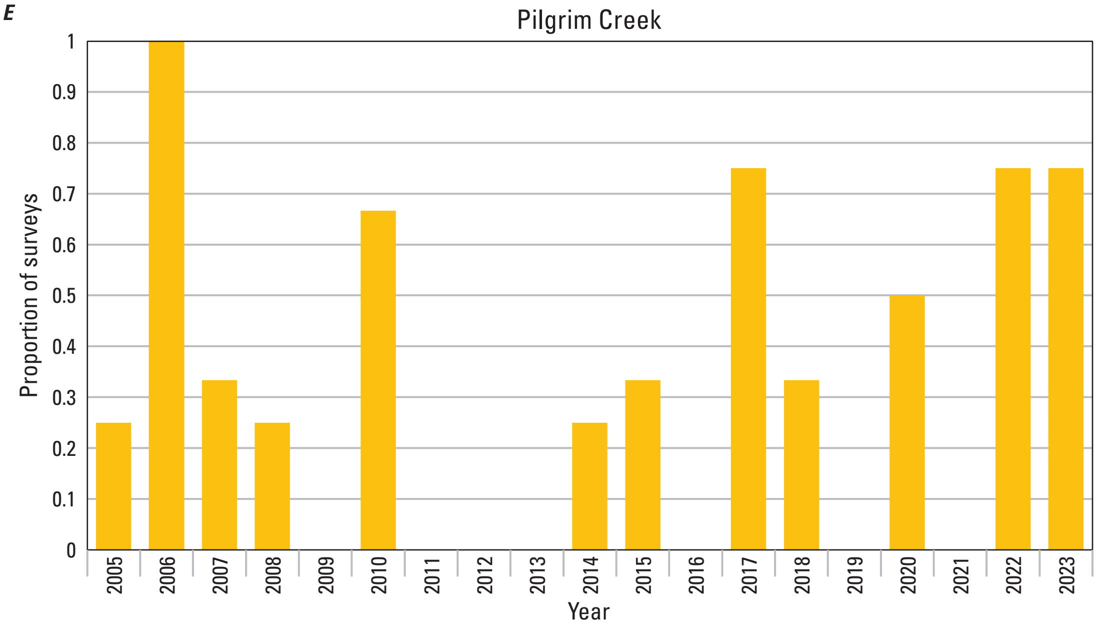

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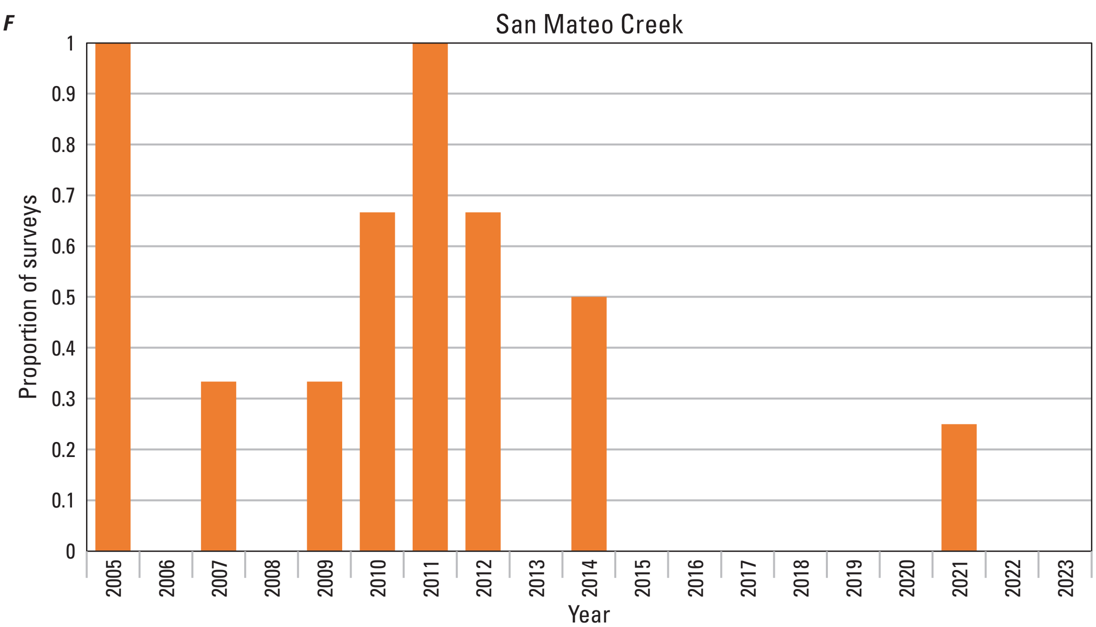
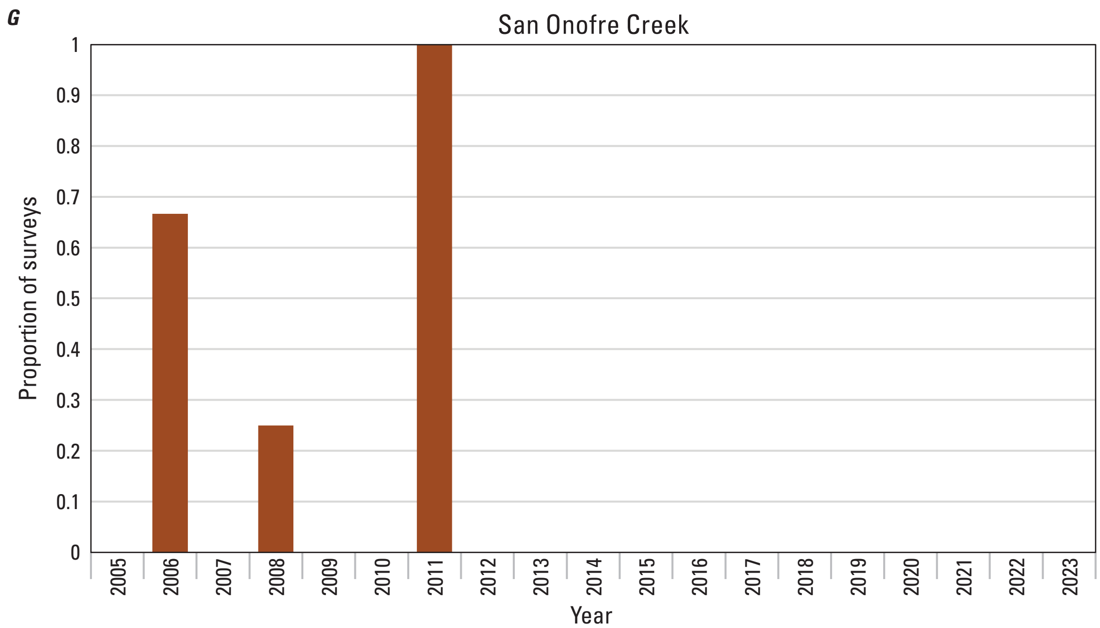


Figure 5.1.—Continued



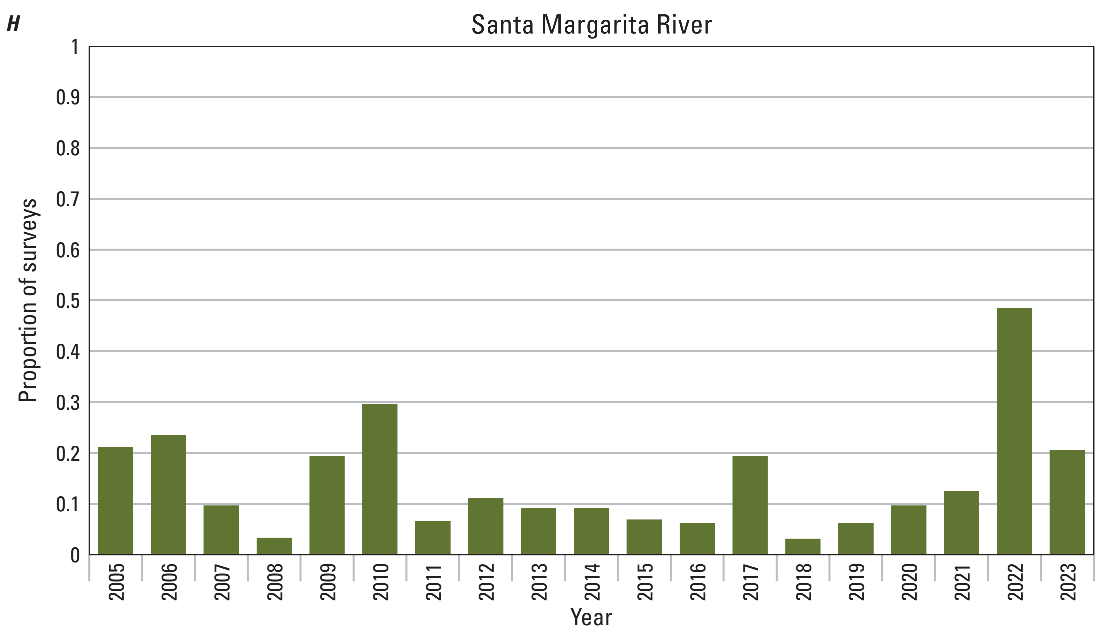


Figure 5.1.—Continued

Appendix 6. Proportion of Least Bell's Vireo Territories, Including Areas Occupied by Transients, Dominated or Co-Dominated by Non-Native Vegetation, by Drainage, 2005–23

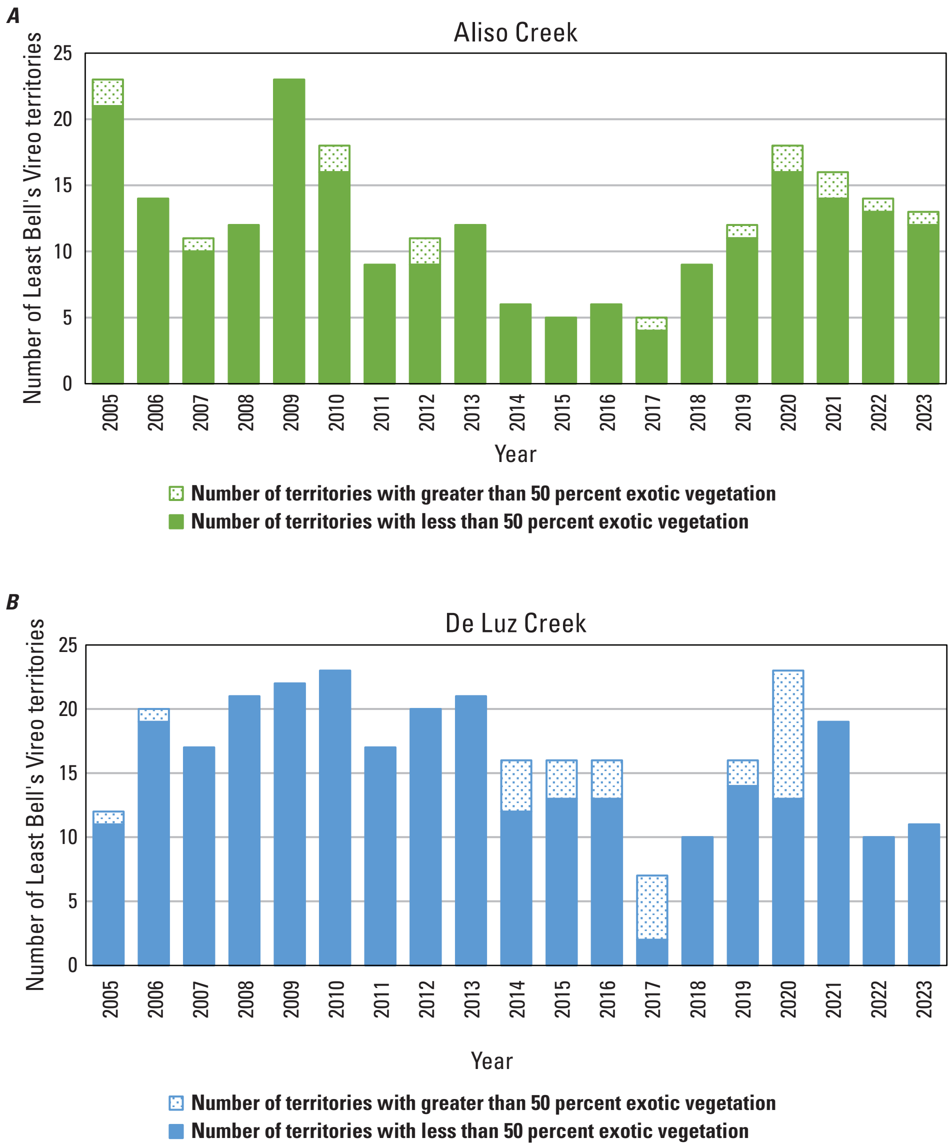
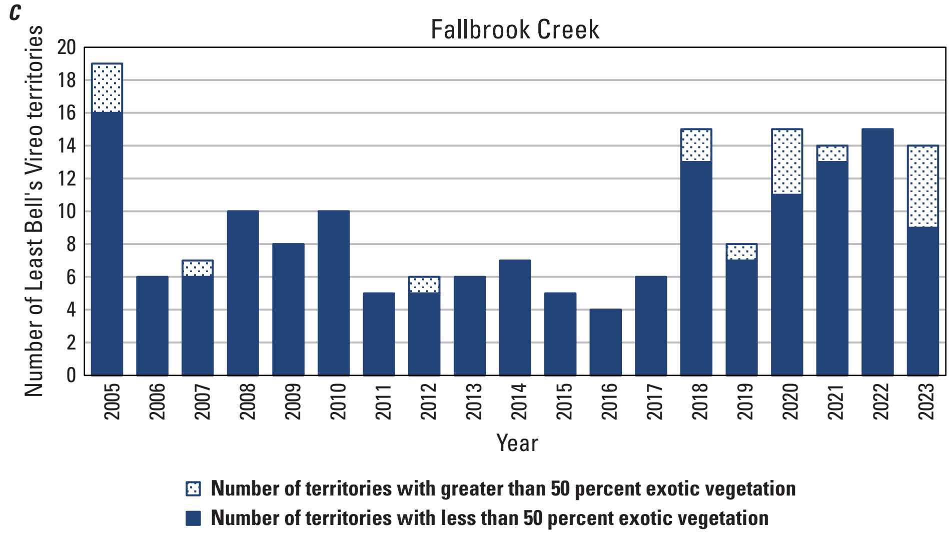


Figure 6.1. Number of Least Bell's Vireo territories, including areas occupied by transients, dominated or co-dominated by non-native vegetation, by drainage, 2005–23.



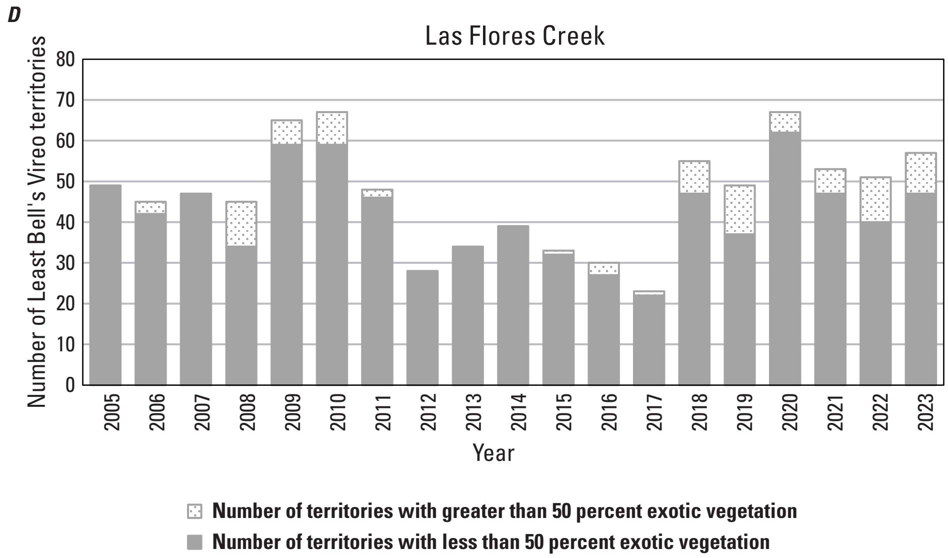
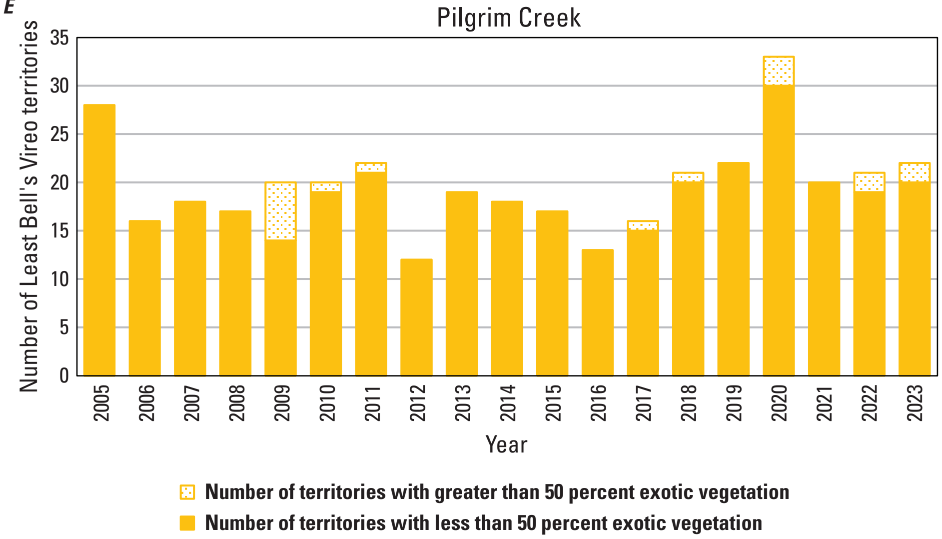


Figure 6.1.—Continued

E



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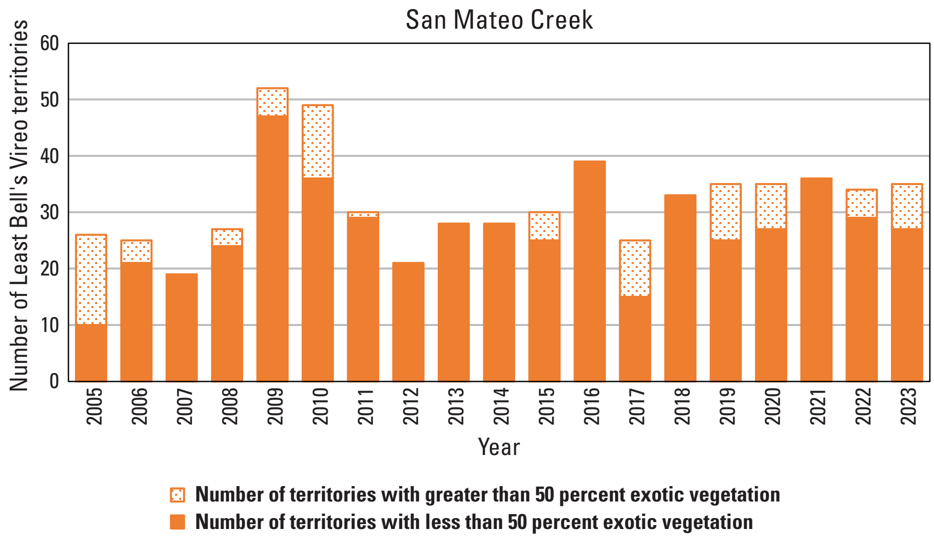
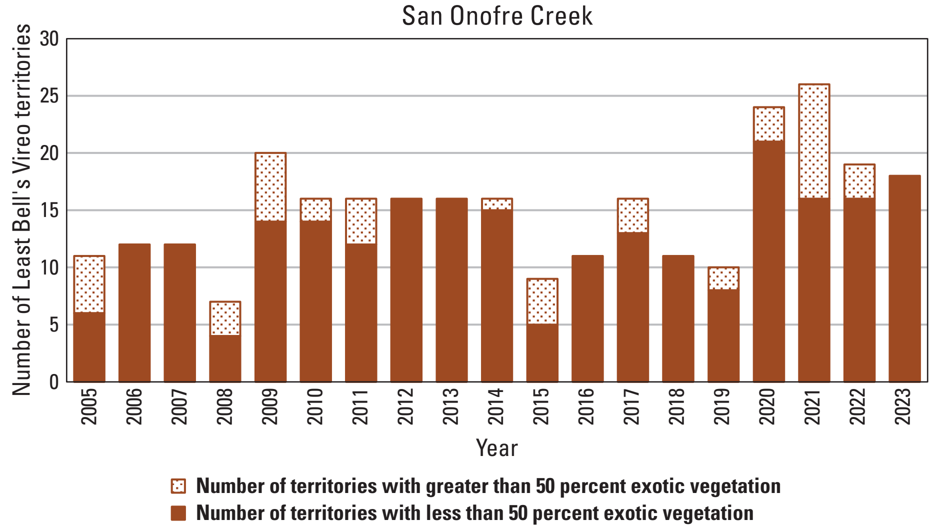


Figure 6.1.—Continued

G



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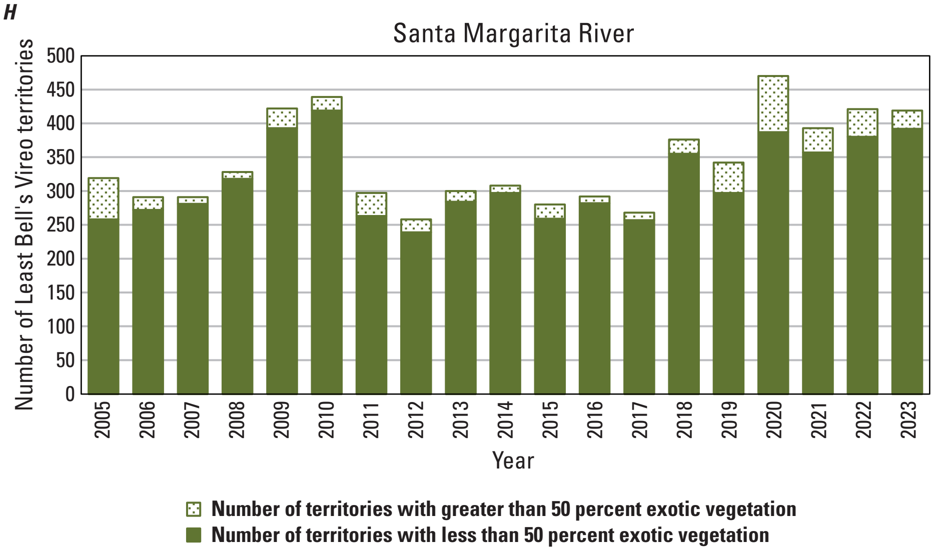

Figure 6.1.—Continued

Appendix 7. Banded Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023.

Table 7.1. Banded Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023.

[**Band colors**: PUWH, plastic purple-white split; PUPU, plastic purple; Mgo, gold numbered federal band; OROR, plastic orange; PUOR, plastic purple-orange split; BPST, plastic black-pink striped; YEYE, plastic yellow; Msi, silver numbered federal band; YEPU, plastic yellow-purple split; DPWH, plastic dark pink-white split; DPDP, plastic dark pink; BYST, plastic black-yellow striped; Mdb, dark blue numbered federal band; BKBK, plastic black; WHPU, plastic white-purple split; YEBK, plastic yellow-black split; BKYE, plastic black-yellow split; WHDP, plastic white-dark pink split; pupu, metal purple; ORDG, plastic orange-dark green split; YEPU, plastic yellow-purple split; PUYE, plastic purple-yellow split; DGOR, plastic dark green-orange split; gogo, metal gold. **Location codes in comments**: MCBCP, Marine Corps Base Camp Pendleton; MAPS, De Luz or Santa Margarita Monitoring Avian Productivity Station; MCAS, Marine Corps Air Station, Camp Pendleton; SLR, San Luis Rey River. **Abbreviations**: ≥, greater than or equal to; —, no bands]

Sex	Band combination		Age	Comments
	Left leg	Right leg		
2023 drainage: Aliso Creek				
Male	PUWH	PUPU Mgo	2 years	Banded as a nestling on MCBCP in 2021.
2023 drainage: De Luz Creek				
Male	OROR	PUOR Mgo	≥7 years	Banded as an adult on MCBCP in 2017.
Male	BPST	YEYE Mgo	6 years	Banded as a nestling on MCBCP in 2017.
2023 drainage: Las Flores Creek				
Male	Msi	—	≥1 year	Banded at MAPS or MCAS, year and age unknown.
2023 drainage: Newton Canyon				
Male	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
2023 drainage: Santa Margarita River				
Male	YEPU	DPWH Mgo	8 years	Banded as a nestling on MCBCP in 2015.
Female	BPST	DPDP Mgo	8 years	Banded as a nestling on MCAS in 2015.
Male	BYST	PUWH Mgo	6 years	Banded as a nestling on MCBCP in 2017.
Female	BPST Mdb	BKBK	5 years	Banded as a nestling on the LSLR in 2018.
Male	WHPU	YEBK Mgo	5 years	Banded as an adult on MCBCP in 2019.
Male	PUPU	BKYE Mgo	≥5 years	Banded as an adult on MCBCP in 2019.
Male	PUOR	BKYE Mgo	5 years	Banded as an adult on MCBCP in 2019.
Male	—	WHDP	≥4 years	Banded as an adult on MCBCP in 2020.
Male	PUWH Mgo	BKYE	≥4 years	Banded as an adult on MCBCP in 2020.
Male	OROR Mgo	BPST	≥4 years	Banded as an adult on MCBCP in 2020.
Female	Mgo	YEYE pupu	≥4 years	Banded as an adult on MCBCP in 2020.
Male	ORDG Mgo	YEPU	≥4 years	Banded as an adult on MCBCP in 2020.
Male	PUYE Mgo	WHPU	≥4 years	Banded as an adult on MCBCP in 2020.
Male	PUOR Mgo	YEPU	≥4 years	Banded as an adult on MCBCP in 2020.
Female	BPST	Mgo	≥4 years	Banded as an adult on MCBCP in 2020.
Male	DGOR	Mgo	≥4 years	Banded as an adult on MCBCP in 2020.
Male	—	YEPU Mgo	≥4 years	Banded as an adult on MCBCP in 2020.
Male	PUYE	DPWH Mgo	4 years	Banded as a juvenile on MCBCP in 2019.
Female	BPST gogo	Mgo	4 years	Banded as a nestling on MCBCP in 2019.
Male	DPWH	ORDG Mgo	4 years	Banded as a nestling on MCBCP in 2019.
Male	DPDP pupu	Mgo	≥3 years	Banded as an adult on MCBCP in 2021.
Male	BKBK Mgo	pupu	≥3 years	Banded as an adult on MCBCP in 2021.
Male	ORDG Mgo	PUOR	3 years	Banded as a nestling on MCBCP in 2020.
Male	PUPU Mgo	pupu	≥2 years	Banded as an adult on MCBCP in 2022.

Table 7.1. Banded Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023.—Continued

[**Band colors**: PUWH, plastic purple-white split; PUPU, plastic purple; Mgo, gold numbered federal band; OROR, plastic orange; PUOR, plastic purple-orange split; BPST, plastic black-pink striped; YEYE, plastic yellow; Msi, silver numbered federal band; YEPU, plastic yellow-purple split; DPWH, plastic dark pink-white split; DPDP, plastic dark pink; BYST, plastic black-yellow striped; Mdb, dark blue numbered federal band; BKBK, plastic black; WHPU, plastic white-purple split; YEBK, plastic yellow-black split; BKYE, plastic black-yellow split; WHDP, plastic white-dark pink split; pupu, metal purple; ORDG, plastic orange-dark green split; YEPU, plastic yellow-purple split; PUYE, plastic purple-yellow split; DGOR, plastic dark green-orange split; gogo, metal gold. **Location codes in comments**: MCBCP, Marine Corps Base Camp Pendleton; MAPS, De Luz or Santa Margarita Monitoring Avian Productivity Station; MCAS, Marine Corps Air Station, Camp Pendleton; SLR, San Luis Rey River. **Abbreviations**: ≥, greater than or equal to; —, no bands]

Sex	Band combination		Age	Comments
	Left leg	Right leg		
2023 drainage: Santa Margarita River—Continued				
Male	Mgo	BKBK	≥2 years	Banded as an adult on MCBCP in 2022.
Male	WHPU	YEYE Mgo	≥2 years	Banded as an adult on MCBCP in 2022.
Male	PUPU	YEYE Mgo	≥1 year	Banded as an adult on MCBCP in 2023.
Male	pupu	DGOR Mgo	2 years	Banded as a nestling on MCBCP in 2021.
Male	BYST	Mgo	2 years	Banded as a nestling on MCBCP in 2021.
Male	DGOR	DPWH Mgo	2 years	Banded as a nestling on MCBCP in 2021.
Male	DGOR	DPDP Mgo	2 years	Banded as a nestling on MCBCP in 2021.
Male	PUOR	YEPU Mgo	2 years	Banded as a nestling on MCBCP in 2021.
Male	gogo	YEYE Mdb	2 years	Banded as a nestling on the SLR in 2021.
Male	BPST Mgo	DGOR	1 year	Banded as a nestling on MCBCP in 2022.
Female	BKBK Mgo	BYST	1 year	Banded as a nestling on MCBCP in 2022.
Female	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Female	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Female	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Female	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Female	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Female	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Female	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Female	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Female	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Male	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Male	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Male	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Male	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Male	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Male	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Male	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Male	Msi	—	≥1 year	Banded at MAPS or MCAS, year and age unknown.
Male	—	Msi	≥1 year	Banded at MAPS or MCAS, year and age unknown.

Appendix 8. Between-Year Movement of Adult and Juvenile Least Bell's Vireos Detected at Marine Corps Base Camp Pendleton, 2023

Table 8.1. Between-year movement of adult and juvenile Least Bell's Vireos detected at Marine Corps Base Camp Pendleton, 2023.

[**Drainage codes**: AL, Aliso Canyon; DL, De Luz Creek; SLR, San Luis Rey River; SMR, Santa Margarita River. **Abbreviation**: km, kilometer; yr(s), year(s); ≥; greater than or equal to]

Drainage/territory		Distance moved (km)	Age, in years, 2023	Sex
Location last seen	Location in 2023			
Last seen in 2022				
AL/AL02	SMR/HE42	10.79	5	Female
SMR/PNA	SMR/JAW	1.30	1	Male
SMR/PAP	SMR/GAL	0.53	1	Female
SMR/LEG	SMR/ARW	0.25	≥4	Female
SMR/HE06	SMR/HE05	0.21	8	Female
SMR/ES17	SMR/ES23	0.11	2	Male
SMR/PR08	SMR/PRN02	0.09	≥4	Male
SMR/ENT	SMR/GAL	0.09	2	Male
SMR/AH21	SMR/AH19	0.08	≥5	Male
SMR/HE35	SMR/HE23	0.07	4	Female
SMR/MLA	SMR/BGT	0.07	≥3	Male
SMR/GIM	SMR/GIM	0.06	≥3	Male
SMR/VIT	SMR/VIT	0.05	≥2	Male
SMR/AH19	SMR/AH21	0.05	5	Male
AL/AL13	AL/AL10	0.05	2	Male
SMR/RHI	SMR/CBD	0.04	≥4	Male
SMR/RR45	SMR/RR33	0.04	8	Male
SMR/HW18	SMR/HW14	0.04	4	Male
DL/DS06	DL/DS09	0.04	≥7	Male
SMR/CHW	SMR/CHW	0.04	≥4	Male
SMR/PNA	SMR/PNA	0.04	5	Male
SMR/AE14	SMR/AE01	0.03	4	Male
SMR/PPU	SMR/PPU	0.03	≥2	Male
SMR/HE07	SMR/HE06	0.03	6	Male
SMR/CRZ	SMR/CRZ	0.03	2	Male
SMR/PIP	SMR/PIP	0.02	≥4	Male
SMR/BN23	SMR/BN12	0.02	3	Male
SMR/TRE	SMR/TRE	0.02	≥4	Male
SMR/FRX	SMR/FRX	0.02	≥2	Male
SMR/SLO	SMR/SLO	0.02	≥4	Male
SMR/KNO	SMR/KNO	0.01	≥4	Male
SMR/SLX	SMR/SLX	0.01	≥4	Male
DL/DS07	DL/DS11	0.00	6	Male
SMR/ES103	SMR/ES100	0.00	2	Male
Last seen in 2021				
SMR/LEG	SLR/MSL01	10.09	2	Male
SLR/WJEF	SMR/AE37	8.89	2	Male
SMR/BGT	SLR/WDOB	5.90	2	Female
SMR/LEI	SMR/AE23	1.29	2	Male
Last seen in 2020				
SMR/CRA	SLR/FO05	6.03	3	Female
SMR/ARW	SMR/NARI	0.21	≥4	Female

Appendix 9. Status and Nesting Activities of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023

Table 9.1. Status and Nesting Activities of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023.

[All territories were fully monitored. **Nest Fate**: INC, nest not completed; OTH, nest failed with known cause other than predation or parasitism; PRE, nest failure caused by predation; SUC, fledged at least one Least Bell's Vireo young; UNK, reason for nest failure/abandonment unknown. **Abbreviation**: —, no data]

Territory	Nest	Nest fate	Number fledged	Comments
		Seep site		
CHW	1	SUC	4	—
GRD	1	INC	—	—
GRD	2	SUC	3	1 egg or nestling disappeared
GRD	3	SUC	3	—
KNO	1	SUC	3	1 nestling disappeared
KNO	2	PRE	—	Failed with nestlings
KYL	1	PRE	—	Failed with nestlings
KYL	2	PRE	—	Failed with nestlings
LEI	1	UNK	—	Failed before eggs confirmed
LEI	2	INC	—	Only male seen building nest
LEI	3	SUC	3	—
PAL	1	SUC	3	—
PAL	2	PRE	—	Failed with nestlings
PAL	3	PRE	—	Failed before hatching confirmed
PAP	1	PRE	—	Failed with eggs
PAP	2	UNK	—	Abandoned with eggs
PAP	3	SUC	4	—
SKY	1	PRE	—	Failed with nestlings
SKY	2	SUC	3	—
SNK	1	SUC	3	—
SNK	2	PRE	—	Failed with nestlings
VAD	1	PRE	—	Failed before hatching confirmed
WIC	1	PRE	—	Failed with nestlings
WIC	2	SUC	3	—
YOD	1	SUC	3	1 nestling disappeared
YOD	2	PRE	—	Failed with nestlings
		Intermediate site		
ARW	1	INC	—	—
ARW	2	PRE	—	Failed with eggs
ARW	3	OTH	—	Failed with eggs
BRM	1	SUC	2	1 nestling disappeared
BRM	2	SUC	2	1 nestling dead in nest
ELR	1	SUC	2	—
ELR	2	SUC	3	—
FRO	1	PRE	—	Failed with nestlings

Table 9.1. Status and Nesting Activities of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023.—Continued

[All territories were fully monitored. **Nest Fate**: INC, nest not completed; OTH, nest failed with known cause other than predation or parasitism; PRE, nest failure caused by predation; SUC, fledged at least one Least Bell's Vireo young; UNK, reason for nest failure/abandonment unknown. **Abbreviation**: —, no data]

Territory	Nest	Nest fate	Number fledged	Comments
		Intermediate site—Continued		
FRO	2	PRE	—	Failed with egg
GAL	1	INC	—	—
GAL	2	PRE	—	Failed with nestlings
GAL	3	SUC	3	—
GAN	1	PRE	—	Failed with eggs
GAN	2	SUC	4	—
LEG	1	UNK	—	Failed before eggs confirmed
LEG	2	SUC	4	—
MRY	1	PRE	—	Failed with eggs
MRY	2	SUC	3	—
NRS	1	PRE	—	Failed with eggs
NRS	2	OTH	—	Failed with punctured eggs
NRS	3	SUC	4	—
PIP	1	SUC	3	—
PIP	2	PRE	—	Failed with nestlings
SHD	1	PRE	—	Failed before hatching confirmed
SHD	2	SUC	3	1 nestling disappeared
TRE	1	INC	—	—
TRE	2	SUC	3	—
TRE	3	PRE	—	Failed with nestlings
		Reference sites		
ALN	1	SUC	3	—
ARM	1	PRE	—	Failed with eggs
ARM	2	PRE	—	Failed with nestlings
BAX	1	SUC	2	—
BAX	2	SUC	4	—
CAP	1	SUC	2	1 egg or nestling disappeared
CAP	2	PRE	3	Failed with nestlings
CBD	1	SUC	3	—
CON	1	SUC	4	—
CRA	1	SUC	2	2 eggs or nestlings disappeared
CRA	2	SUC	3	—
FRX	1	UNK	—	Nest abandoned with nestlings
FRX	2	SUC	3	—
ISO	1	SUC	3	1 nestling disappeared
ISO	2	PRE	—	Failed with nestlings
JAC	1	INC	—	Same nest used for nest 3
JAC	2	UNK	—	Failed before eggs confirmed
JAC	3	PRE	—	Failed with nestlings

Table 9.1. Status and Nesting Activities of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2023.—Continued

[All territories were fully monitored. **Nest Fate**: INC, nest not completed; OTH, nest failed with known cause other than predation or parasitism; PRE, nest failure caused by predation; SUC, fledged at least one Least Bell's Vireo young; UNK, reason for nest failure/abandonment unknown. **Abbreviation**: —, no data]

Territory	Nest	Nest fate	Number fledged	Comments
Reference sites—Continued				
JAC	4	SUC	4	—
JOS	1	UNK	—	Failed before eggs confirmed
JOS	2	SUC	2	1 egg or nestling disappeared
MAL	1	INC	—	—
MAL	2	SUC	4	—
MLA	1	SUC	4	—
PNA	1	PRE	—	Failed with eggs
PNA	2	SUC	3	—
PNA	3	SUC	1	1 nestling died and 1 nestling disappeared
PPU	1	SUC	3	—
PPU	2	SUC	3	1 nestling dead in nest
RHI	1	PRE	—	Failed with eggs
RHI	2	SUC	3	—
ROK	1	SUC	3	—
SAM	1	SUC	3	1 egg or nestling disappeared
SEQ	1	PRE	—	Failed with eggs
SEQ	2	SUC	1	—
SLX	1	SUC	3	—
TET	1	UNK	—	Failed before eggs confirmed
TET	2	SUC	2	1 nestling dead in nest
TET	3	PRE	—	Failed with nestlings
VIT	1	SUC	3	1 egg or nestling disappeared
VIT	2	SUC	3	—
YEL	1	PRE	—	Failed with eggs
YEL	2	SUC	2	2 eggs or nestlings disappeared
YOS	1	SUC	4	—
YOS	2	SUC	3	1 egg or nestling disappeared

For more information concerning the research in this report, contact the
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