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

Distribution, Abundance, and Breeding Activities of the Least Bell's Vireo at Marine Corps Base Camp Pendleton, California—2020 Annual Report

Open-File Report 2024–1009

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

Cover. Least Bell's Vireo (*Vireo bellii pusillus)* adult incubating a nest on Marine Corps Base Camp Pendleton. Photograph by Michelle Treadwell, U.S. Geological Survey, 2020.

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By Suellen Lynn, Michelle Treadwell, and Barbara E. Kus

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
meter (m)	1.094	yard (yd)
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
hectare (ha)	0.003861	square mile (mi^2)
	Flow	
liters per minute (l/min)	0.2642	gallons per minute (g/min)

Datum

Horizontal coordinate information 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

±	plus or minus
AIC_c	Akaike's Information Criterion for small sample sizes
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, and Breeding Activities of the Least Bell's Vireo at Marine Corps Base Camp Pendleton, California—2020 Annual Report

By Suellen Lynn, Michelle Treadwell, 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 (MCBCP, or Base). Surveys for the Least Bell's Vireo were conducted at MCBCP, California, between April 1 and July 10, 2020. Core survey areas and a subset of non-core areas in drainages containing riparian habitat suitable for vireos were surveyed 3–4 times. We detected 669 territorial male vireos and 16 transient vireos in core survey areas. An additional 156 territorial male vireos were detected in non-core survey areas. Territorial vireos were detected on all 10 drainages/sites surveyed (core and non-core areas). Of the vireo territories in core areas, 88 percent were on the 4 most populated drainages, with the Santa Margarita River containing 69 percent of all territories. In core areas, 79 percent of male vireos were confirmed as paired; 83 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 (669) increased 39 percent from 2019 to 2020. The number of territories in all core survey area drainages increased by one or more between 2019 and 2020. The substantial increase in vireo numbers on MCBCP (39 percent) was consistent with population changes in surrounding areas, including the lower San Luis Rey River (26 percent), Marine Corps Air Station, Camp Pendleton (58 percent), and the middle San Luis Rey River (7 percent).

Most core-area vireo territories (69 percent of males) occurred in willow (*Salix* spp.) riparian habitat. An additional 4 percent of birds occupied willow habitat co-dominated by Western sycamores (*Platanus racemosa*) or Fremont cottonwoods (*Populus fremontii*). Eighteen percent of territories were found in riparian scrub dominated by mule fat (*Baccharis salicifolia*) or sandbar willow (*S. exigua*). Upland scrub was used by 7 percent or fewer vireos; 1 percent of territories occurred in non-native vegetation, and less than 1 percent of vireo territories occurred in habitat co-dominated by coast live oak (*Quercus agrifolia*) and sycamore.

In 2019, MCBCP began operating an artificial seep along the Santa Margarita River. The artificial seep pumped water to the surface from March through August each year during daylight hours and was designed to increase the amount of surface water present to enhance Southwestern Willow Flycatcher (*Empidonax traillii extimus;* flycatcher) breeding habitat. Although this enhancement was designed to benefit flycatchers, few flycatchers have inhabited the seep and proposed 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 preliminary analyses of vireo and vegetation response to the existing artificial seep.

We sampled vegetation in the Seep site and three Reference sites to determine the effects of a new water diversion dam that was completed in 2019 and a surface water enhancement seep pump installed along the Santa Margarita River. We found minor differences in non-native vegetation cover between Reference sites and the Seep site. However, soil moisture was higher at the Reference sites compared to the Seep site. The effect of the seep pump may have been masked by high precipitation in the bio-year (July 1–June 30) before 2020, limited time for the water diversion to have an effect, well-draining soil, and the non-operation of two to three of the six seep outlets.

We color banded and resighted color banded Least Bell's Vireos to evaluate adult site fidelity, between-year movement, and the effect of surface water enhancement on vireo site fidelity and between-year movement. We banded 146 Least Bell's Vireos for the first time during the 2020 season. Birds banded included 27 adult vireos and 119 juvenile vireos. All adult vireos were banded with unique color combinations. The juvenile vireos (all nestlings) were banded with a single gold numbered federal band on the left leg.

We resighted and identified 85 Least Bell's Vireos banded before the 2020 breeding season on Base in 2020. Of the 85, 13 vireos were originally banded on the San Luis Rey River, 2 were banded in Baja California Sur, 1 was banded at Marine Corps Air Station, Camp Pendleton, and the remaining birds were banded at MCBCP. Adult birds of known age ranged from 1 to 8 years old.

Most returning adult vireos showed strong between-year site fidelity. Of the adults present in 2019 and 2020, 74 percent, (79 percent of males; 40 percent of females) returned to within 100 m of their previous territory. The average between-year movement for returning adult vireos was 0.3 plus or minus (±) 0.8 kilometer (km). The average movement of first-year vireos detected in 2020 that fledged from a known nest on MCBCP in 2019 was 4.7±7.0 km. One first-year vireo that originated at MCBCP moved off Base and was detected at Murrieta Creek, 23.0 km from his natal territory.

We monitored Least Bell's Vireo pairs to evaluate the effects of surface water enhancement on nest success and breeding productivity. Vireos were monitored at one Seep site and three Reference sites. Base personnel plan to install a second seep pump at one of the Reference sites in the future, at which time the status of the monitoring site will change from Reference to Seep.

Nesting activity was monitored between March 31 and July 28 in 52 territories within the Seep and Reference sites (12 at the Seep site and 40 at Reference sites). All territories were occupied by pairs, and all but one territory was fully monitored, meaning all nesting attempts were monitored at these territories. One vireo territory within a Reference site was partially monitored. During the monitoring period, 94 nests (25 in the Seep site and 69 in Reference sites) were monitored.

Breeding productivity was similar at the Seep site and Reference sites (3.7 and 2.9 young per pair, respectively), with 75 percent of Seep pairs and 79 percent of Reference pairs successfully fledging at least 1 young in 2020. Compared to Reference sites, the Seep site had a higher proportion of all eggs that hatched and also a higher proportion of nests with eggs that hatched. Conversely, a lower proportion of hatchlings and nests that had hatchlings fledged at the Seep site than at Reference sites. According to the best model, nest survival in 2020 was not affected by treatment (Seep versus Reference), although the second best model that included treatment was also well supported.

Completed nests at the Seep site were likely to be as successful as nests at Reference sites in 2020 (57 percent and 59 percent, respectively). Predation was believed to be the primary source of nest failure at both sites. Predation accounted for 90 percent and 73 percent of nest failures at Seep and Reference sites, respectively. Failure of the remaining eight nests was attributed to the collapse of the nesting substrate, exposure to rain and flooding, and other unknown reasons.

Fourteen plant species were used as hosts for vireo nests in 2020. In 2020, we found that at the Seep site, successful nests were placed in taller host plants and further from the edge of host plants (closer to the center) than unsuccessful nests. We found no difference in nest placement between the Seep site and the Reference sites.

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 (vireo) is a small, migratory songbird that breeds in southern California and northwestern Baja California, Mexico, from April through July. Historically abundant within lowland riparian ecosystems, vireo populations began declining in the late 1900s as a result of habitat loss and alteration associated with urbanization and conversion of land adjacent to rivers to agriculture (Franzreb, 1989, U.S. Fish and Wildlife Service, 1998, Riparian Habitat Joint Venture, 2004). Two additional factors that contributed to the vireo's decline are (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 was thought to number about 300 territorial males (U.S. Fish and Wildlife Service,1986).

In response to the dramatic reduction in numbers of Least Bell's 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 occurred on Marine Corps Base Camp Pendleton (MCBCP, or Base).

Male Least Bell's 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 re-nest 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 hectares (ha) and maintain territory boundaries through vocal interactions with neighboring pairs. Territories remain stable throughout the breeding season, although silent males occasionally will venture beyond their territory boundaries. Females will 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).

In 2019, MCBCP began operating an artificial seep along the Santa Margarita River. The artificial seep pumped water to the surface from March through August each year during daylight hours and was designed to increase the amount of surface water present to enhance Southwestern Willow Flycatcher (*Empidonax traillii extimus*; flycatcher) breeding habitat. Two additional seeps are planned within the Santa Margarita River drainage below a water diversion dam constructed in 2019 (U.S. Fish and Wildlife Service, 2016). Although the enhancements were designed to benefit Southwestern Willow Flycatchers, few flycatchers have inhabited the seep and proposed seep areas within the past several years (Howell and Kus, 2015, 2016, 2017; Howell and others, 2018, 2020). However, Least Bell's 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 brushy understory. Vireos and flycatchers have similar territory size, similar territorial behavior (singing from high perches to advertise territory boundaries), and share similarities in nest placement (nests are placed in the understory vegetation). 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 existing artificial seep.

The purpose of this study was to document the status of the Least Bell's Vireo at Marine Corps Base Camp Pendleton in San Diego County, California. Specifically, our goals were to (1) determine the size and composition of the vireo population at the Base; (2) characterize habitat used by vireos; (3) band a subset of vireos to facilitate the estimation of annual vireo survival and movements; (4) document the vegetation structure and plant composition within the areas influenced by artificial seeps (Seep sites) compared to similar areas without artificial seeps (Reference sites); and (5) assess the effects of the artificial seeps on vireos by measuring annual survival, inter-annual movement, nest success, and breeding productivity of vireos in sites surrounding artificial seeps compared to Reference sites.

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. This work was funded by and performed in cooperation with the Assistant Chief of Staff, Environmental Security Resources Management Division, Marine Corps Base Camp Pendleton, California. All activities were covered under 10(a)1(A) Recovery Permit #TE-829554-18.

Study Areas and Methods

Population Size and Distribution

Most of the MCBCP's primary drainages, and several minor ones supporting riparian habitat, were surveyed for vireos between April 1 and July 10, 2020 (fig. 1). Field work was completed by U.S. Geological Survey biologists Lisa Allen, Armand Amico, Alex Bartolo, Kim Geissler, Rachel Guinea, Scarlett Howell, Suellen Lynn, Rachelle McLaughlin, Shannon Mendia, Molly Morrissey, Ryan Pottinger, Ben Stubbs, Michelle Treadwell, and Stéphane Vernhet.

In 2020, we implemented a new, reduced vireo survey plan, which involved surveying a core area plus a subset of all riparian habitat on Camp Pendleton each year. Selection criteria for surveys within the core areas included (1) primary drainages (Santa Margarita River, Las Flores Creek, San Onofre Creek, and San Mateo Creek), (2) historic 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 units with the highest average count of flycatchers from 2005 to 2014 in drainages where no historic flycatcher breeding or nest monitoring

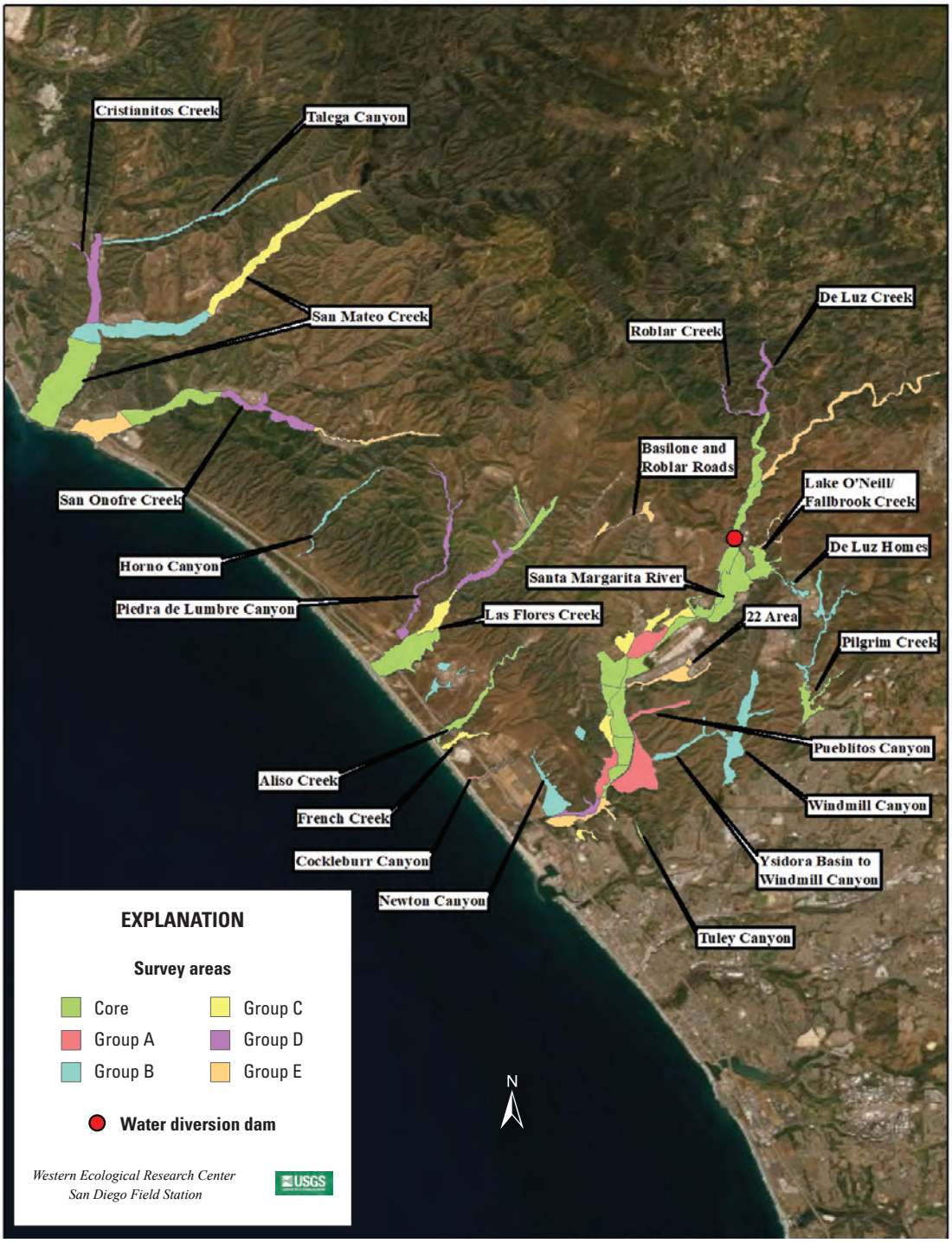

Figure 1. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2020.

has occurred. Core survey areas were surveyed 4 times per year at least 10 days apart, every year. Non-core areas were divided into 5 groups (fig. 1, Groups A–E), each to be surveyed on a rotational schedule once every 5 years. Group A non-core areas were surveyed in 2020. All non-core areas were surveyed four times in 2020 except Pueblitos Canyon, which was surveyed three times. The specific areas surveyed are listed in the Core Areas and Rotating Non-Core Areas: Group A sections below.

Core Areas

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

Rotating Non-Core Areas: Group A

1. Cockleburr Canyon, between the Pacific Ocean and a point 0.25 km east of Interstate 5 (appendix 1; fig. 1.2).
2. Santa Margarita River:
   (a) From the Rifle Range along Stagecoach Road to a point approximately 1.9 km upstream on the west side of the Santa Margarita River (appendix 1; fig. 1.1).
   (b) From a point 1.4 km upstream from Stuart Mesa Road to a point 3.5 km upstream of Stuart Mesa Road on the west side of the Santa Margarita River (appendix 1; fig. 1.2).
   (c) All riparian habitat within Ysidora Basin east of Vandegrift Road (appendix 1; fig. 1.2).
3. Pueblitos Canyon, between Vandegrift Road and a point approximately 2.5 km upstream (appendix 1; fig. 1.2).

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 and river side 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 Least Bell's Vireos were detected and confirmed audibly by hearing their diagnostic song. Attempts were made to observe males visually to note banding status, but visual observations were not required to confirm the identity of the species as 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, breeding behavior such as a food carry, or the presence of dependent fledglings. For each bird detected, investigators recorded age (adult or juvenile), sex, breeding status (paired, unpaired, undetermined, or transient), and if the bird was banded. Birds were considered transients if they were not detected on two or more consecutive surveys after an initial detection. Vireo locations were mapped on 1:12,000 aerial photographs as well as 1:24,000 U.S. Geological Survey topographic maps, using 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).

Habitat Characteristics

Dominant native and non-native plants were recorded and the 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 ramosissima*).

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 (Vernadero Group Inc., unpub. data, 2018). The purpose of the Conjunctive Use Project is to provide additional water for MCBCP and the Fallbrook Public Utility District (Vernadero Group Inc., unpub. data, 2018). In January 2019, MCBCP began operating an artificial seep along the Santa Margarita River to compensate for groundwater withdrawal upstream (fig. 2; U.S. Fish and Wildlife Service, 2016). A low-volume (20–40 liters per minute), shallow groundwater irrigation pumping well was installed to draw water to the surface. The pump was solar-powered and directed water to six outlet pipes arranged within an area approximately 1,500 square meters (m^2). Water was pumped during daylight hours from March through August each year. Two other seeps were planned but had not been installed by 2020. 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 seep 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. Although the intent was to enhance historic Willow Flycatcher breeding habitat, few Willow Flycatchers have occupied these areas over the past 5 years (Howell and Kus, 2015, 2016, 2017; Howell and others, 2018, 2020). Least Bell's Vireos were selected as surrogates for Willow Flycatchers because they were well represented in the areas, and their habitat affinities are similar to those of Willow Flycatchers.

We established two types of study plots, Seep and Reference sites (fig. 2). Two Seep sites were selected to surround and extend downstream from (1) an existing seep (in the Old Treatment Ponds area) and (2) a planned seep (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 in 2020. We anticipate the Reference sites will become drier relative to the Seep sites as the upstream water diversion effects are manifested. Only one of the two Seep sites had an operating seep pump in 2020. Therefore, we considered the Seep site without an operating pump to be a third Reference site in 2020.

Vegetation Structure and Plant Composition

We sampled vegetation at three Reference sites and one Seep site (fig. 2) to examine the response of riparian habitat to locally augmented surface water. We collected vegetation data at 12 vireo territories per site (36 territories at Reference sites and 12 territories at the Seep site), centered on a single vireo nest per territory, for a total of 48 vegetation sampling locations (appendix 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 was visually estimated within 5 m of the center of the plot at 7 height intervals: 0–1 m, 1–2 m, 2–3 m, 3–4 m, 4–5 m, 5–6 m, and greater than 6 m. Overall foliage cover was recorded as the percentage of volume (percentage cover) occupied by all foliage in the plot per 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 per height interval. Estimates of both overall foliage and non-native cover were measured using a modified Daubenmire (1959) scale with cover classes less than 1 percent, 1–10 percent, 11–25 percent, 26–50 percent, 51–75 percent, 76–90 percent, and greater than 90 percent. Cover classes were further refined using + and − to indicate whether the estimate was in the upper or lower range of the cover class.

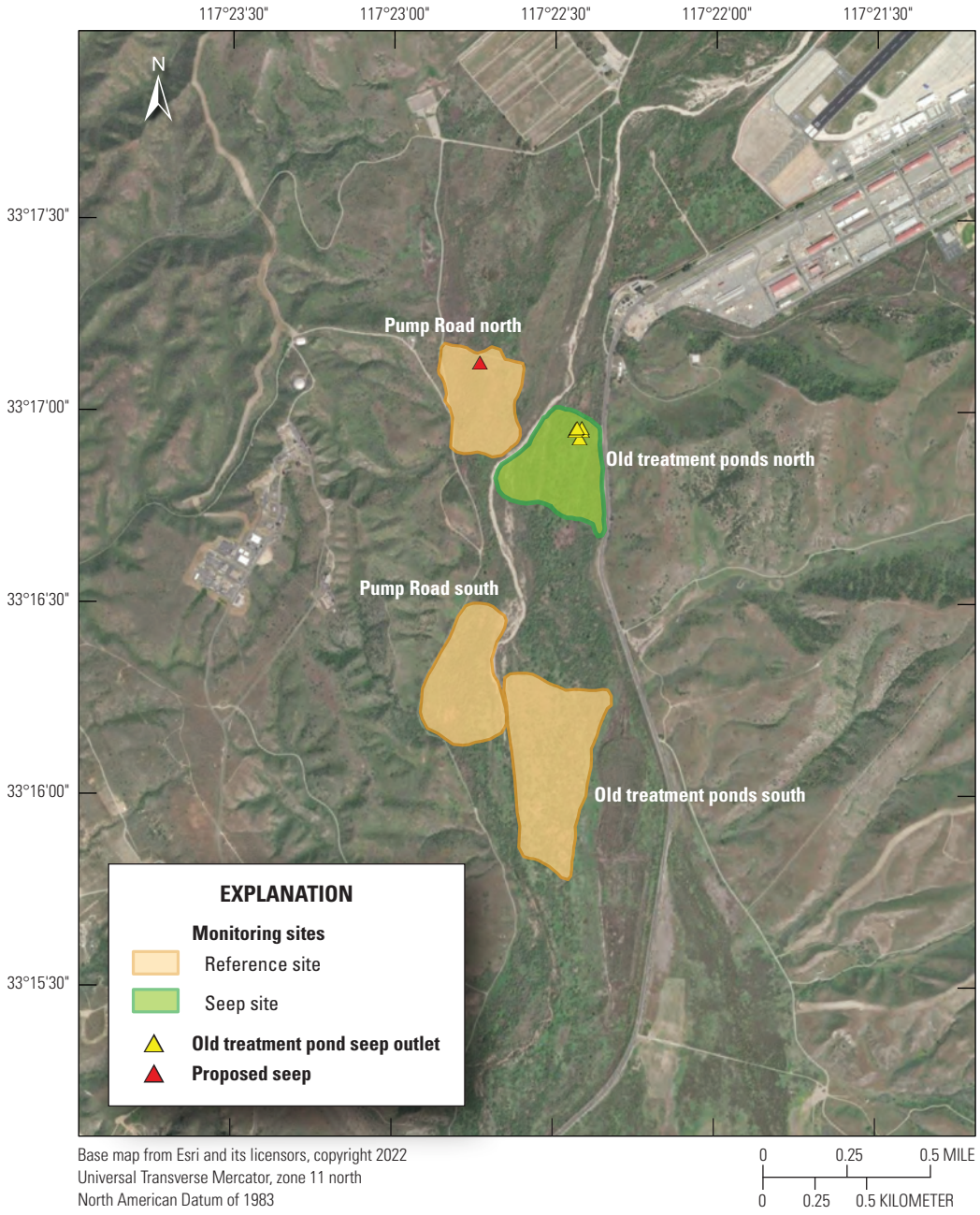

Figure 2. Location of Least Bell's Vireo Seep and Reference sites at Marine Corps Base Camp Pendleton, 2020.

A 7.5-m-tall fiberglass telescoping pole, demarcated in 1-m intervals, was used to determine height class and canopy height. Overall foliage cover was further divided by identifying the three plant species with the highest foliage volume (Species 1, 2, and 3) at each plot and estimating their contribution and the contribution of all other species combined (All other) to overall foliage cover, adding up to a total of 100 percent of the overall foliage cover. 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 (kelinstruments.com/kelway-hb-2, Teaneck, New Jersey). Soil moisture was measured to assess the effect of surface water augmentation beyond the immediate vicinity of the seep pumps.

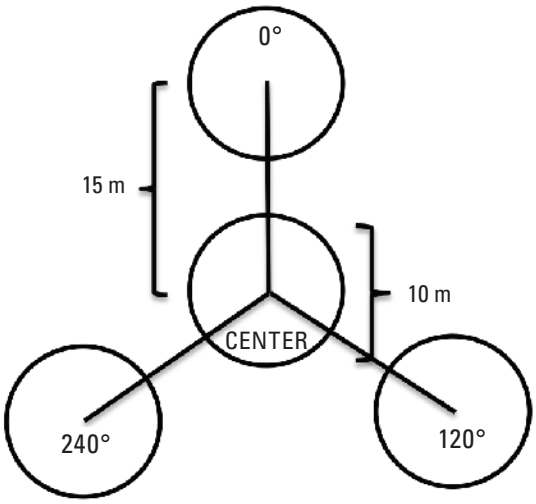

Figure 3. Diagram of vegetation sampling plot configuration. Abbreviation: m, meter.

Vireo Survival, Site Fidelity, and Movements

The primary goals of banding Least Bell's Vireos on MCBCP were (1) to evaluate adult vireo site fidelity within a potential source population, (2) to investigate natal dispersal on Base and the role MCBCP young play in potentially supporting vireo populations off Base, and (3) to evaluate how artificial seeps affected vireo site fidelity, dispersal, and survival. The regional Least Bell's 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 left leg. Adult vireos within Seep 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 to enable identification of individuals.

In 2020, we noticed an unusually high number of banded vireos that appeared to have injured legs. The suspected predominant cause of leg injuries was accumulated vegetation forming a constricting "bracelet" underneath the leg band. After in-house consultation, we stopped banding nestlings and unbanded adult vireos as of June 19 to minimize the chance of causing more injuries. Although we intended to continue to target net returning adults with single numbered federal bands to determine their identity, no more adults were captured after June 19.

Site Fidelity and Movements

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 to determine the 2020 locations of known individuals. In future reports, we will also use these data to calculate annual survival, or the proportion of birds that survived from one year to the next.

Site fidelity and movements of vireos were determined by measuring the distance between the center of a vireo's breeding or natal territory in 2019 and the center of the same vireo's breeding territory in 2020. Vireos demonstrated site fidelity if they returned to within 100 m of their 2019 territory (Kus and others, 2020).

Site fidelity and movement were calculated for (1) adults Base-wide and (2) first-year vireos that were banded as nestlings or juveniles Base-wide (in other words, first-year adults). Only individuals with known territory locations during the last year detected before 2020 were included; for example, juveniles banded after fledging were excluded because their natal territories could not be confirmed in light of their capacity for substantial movement; vireos captured at one of the two Monitoring Avian Productivity and Survivorship (MAPS) stations on Base were excluded unless their territory locations were known from surveys.

Nest Success and Breeding Productivity

Our purpose for monitoring Least Bell's Vireo nests was to evaluate how vireo nest success and breeding productivity were affected by alteration of vireo habitat by the artificial seep compared to Reference sites with no augmented surface water. We monitored vireo nests at the Seep site and three Reference sites to compare differences between the two groups. We monitored vireo nesting activity at 12 territories in the active Seep site and 40 territories in Reference sites between March 31 and July 28, 2020. Territories were chosen in order of the vireos' arrival. 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 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, nests found empty or destroyed before the estimated fledge date and where the adult vireos were not found tending fledgling(s);

(2) Parasitized, 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, nests failing 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, nests that appeared intact and undisturbed, but were abandoned with vireo eggs or nestlings. Characteristics of nests were recorded following abandonment or fledging of young from nests. These characteristics included nest height, host species, host height, and the distance nests were placed from the edge of the host plant and to the edge of the vegetation clump in which they were placed.

To determine if the artificial seeps affected vireo productivity, we compared vireo nest success (the percentage of vireo nests that successfully fledged at least one young) and breeding productivity (the number of eggs, nestlings, and fledglings produced) between Seep and Reference sites in 2020. 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, the proportion of eggs that produced fledglings, 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 characteristics to explore vireo response to potential differences in vegetation structure between Seep and Reference sites.

Marine Corps Base Camp Pendleton implements an intensive annual cowbird control program on Base, and parasitism of Least Bell's 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 new core plus rotating non-core survey procedure in 2020, we limited our examination of annual differences to vireo territories that were located within the core survey areas. We also 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 examined annual differences in the dates vireos arrived and established breeding territories by compiling the total number of vireo territories established by the end of each month (April, May, June, and July) within core survey areas, all of which were surveyed at least 4 times annually for the past 16 years. We also calculated the projected Base-wide vireo population size in 2020 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 2020 to arrive at a range of projected number of vireo territories Base-wide in 2020.

Vegetation Structure and Plant Composition

At each height category, the estimates of Species 1, 2, and 3 and All Other were converted to the percentage cover values of the sampling plot area. We averaged the percentage cover of each plant species, total plant species, non-native plant species, canopy height, and soil moisture across each sampling location (center and three satellite plots) to obtain means for each territory. We also identified the maximum canopy height at each sampling location. We used Student's *t*-tests to determine if there were differences between Seep and Reference sites in (1) average canopy height, (2) maximum canopy height, (3) soil moisture, (4) vegetation volume (percent cover) of all plant species (overall foliage cover), (5) cover of non-native species (including herbaceous and woody vegetation), (6) cover of native herbaceous species, and (7) cover of woody species at each height category by sampling location. We used Pearson's correlation to examine the relationship between soil moisture at Seep site plots and the distance of the plot from the seep outlets at the sampling plot scale, and also between soil moisture at all locations and (1) canopy height, (2) percentage overall foliage cover at each height category, and (3) percentage of herbaceous cover (including non-native herbaceous species) at all height categories at the sampling location scale.

Nest Success and Breeding Productivity

We used chi-square or Fisher's exact tests to determine if there were differences between Seep and Reference sites in (1) the likelihood of vireos re-nesting after a first nesting attempt, (2) the likelihood of re-nesting 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 category contained fewer than five samples.

We used *t*-tests to determine if there were differences between Seep and References sites in the (1) number of nesting attempts, (2) clutch size, and (3) number of fledglings per pair. 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 Pendleton vireo population.

Data were analyzed using Program R (R Core Team, 2020). 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 2020 used in comparisons with 2020 data 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). Data from before 2005 was extracted from unpublished reports by 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 found 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 is 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) if the nest was in the Seep site or a Reference site; and (5) the year. 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. We used an information-theoretic approach (Akaike's Information Criteria for small sample sizes; AIC_c; Burnham and Anderson, 2002) to evaluate support for nest survival models reflecting a priori hypotheses regarding the effect of seeps on DSR. We hypothesized that DSR would be higher in the Seep site than in Reference sites, and that DSR would decrease annually in Reference sites as the habitat became drier relative to the Seep 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 versus Reference) on DSR. We then created models with treatment, year, the combined effect of treatment and year (treatment+year), and the interaction of treatment and year (treatment*year) and evaluated support for the models in relation to the constant survival model. Models were ranked from lowest to highest AIC_c. Models were considered well supported if they were within 2 AIC_c of the highest-ranked (top, lowest AIC_c) model (difference in AIC_c [ΔAIC_c] less than 2). We further examined the well-supported models by calculating the odds ratio for each covariate in the model (the odds that the covariate had an effect on 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.

Nest Characteristics

We used *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 between Seep and Reference sites and between successful and failed nests within Seep and Reference sites.

Results

Population Size and Distribution

Core Survey Areas

A total of 685 male Least Bell's Vireos were detected in core survey areas during Base-wide surveys (table 1; fig. 4; appendix 3, figs. 3.1–3.12). Of these, 669 were territorial males, 79 percent of which were confirmed as paired, and 16 were transients. One banded male was detected at two different territories, paired at one territory and transient at the second. This vireo was only included once in the total count of territorial vireos. The 2020 total represents a 39 percent increase in territorial males from the same areas surveyed in 2019 (480). Transient vireos were observed on 4 of the 10 (40 percent) drainages or sites surveyed. Eighty-eight percent of vireo territories occurred on the 4 most populated drainages/sites (Santa Margarita River, Las Flores Creek, San Mateo Creek, and Pilgrim Creek), and most vireo territories (69 percent, 460 territories) occurred along the Santa Margarita River, the largest expanse of riparian vegetation on Base (tables 1, 2). The remaining 4 drainages/sites each contained fewer than 25 territories.

From 2005 to 2019, 54–65 percent of resident males detected on MCBCP were within the core areas surveyed in 2020 (average 57±3 percent). Assuming the vireo population on the rest of MCBCP in 2020 did not vary from the 2005 to 2019 distribution, we estimated between 1,029 and 1,239 resident vireos on MCBCP in 2020.

The distribution of Least Bell's Vireo territories documented on Base in 2020 remained very similar to 2019 (table 2). From 2019 to 2020, the proportion of vireo territories in each drainage (the number of vireo territories detected in the drainage divided by the total number of vireo territories in core survey areas) changed by less than 0.01 in every drainage except at San Onofre Creek (proportion increased by 0.012) and San Mateo Creek (proportion of territories dropped by 0.019). The absolute number of vireo territories increased in every drainage. The Santa Margarita River continued to support the most vireo territories, increasing by 38 percent (127 territories). Las Flores Creek, the second most populated drainage, increased 31 percent (15 territories). San Onofre Creek increased 120 percent (12 territories), Pilgrim Creek increased 50 percent (11 territories), De Luz Creek increased 53 percent (8 territories), Aliso Creek increased 89 percent (8 territories), Fallbrook Creek (Lake O'Neill section) increased 88 percent (7 territories), and San Mateo Creek increased 3 percent (1 territory).

Least Bell's Vireos began arriving on Base during the last week of March 2020, with 68 percent of territories established by the end of April (fig. 5). This number represented the fourth lowest proportion of territories established by the end of April since 2005. By the end of May, 87 percent of territories had been established. The first vireo detected on MCBCP in 2020 was found on March 24, 3 days later than the earliest documented arrival date for vireos in 2013 and 2019. The earliest arrival dates for other years were April 4, 2005; March 31, 2006; April 2, 2007; March 31, 2008; March 23, 2009; March 29, 2010; April 4, 2011; March 22, 2012; March 27, 2014, March 23, 2015, March 23, 2016, March 24, 2017, March 23, 2018. Note that these dates represent anecdotal observations; standardized vireo surveys began April 1 in 2020, but vireo presence before surveys was noted when observed.

Non-Core Survey Areas

A total of 156 male vireos were detected in non-core survey areas in 2020 (table 3). Eighty-three percent of territorial males were confirmed as paired, and no transients were detected.

Habitat Characteristics

Core Survey Areas

Vireos used several different habitat types ranging from willow-dominated thickets along stream courses to non-native vegetation and upland scrub (table 4). Most vireo locations in core survey areas occurred in habitat characterized as mixed willow riparian, with 69 percent of males in the study area found in this habitat. An additional 4 percent of birds occupied willow habitat co-dominated by cottonwoods or sycamores. Eighteen percent of territories were found in riparian scrub, dominated by mule fat or sandbar willow. Seven percent of vireos occupied upland scrub, 1 percent occupied non-native habitat, and less than 1 percent occupied drier habitats characterized by a mix of sycamore and oak.

The proportion of vireo territories documented in non-native vegetation in core survey areas increased from 2019 to 2020, the highest level recorded since 2005 (tables 5, 6). Seventeen percent (118/685) of vireo territories in 2020 were in areas where non-native species comprised at least 50 percent of the habitat. Eighty-one percent of territories dominated by non-native vegetation contained predominantly poison hemlock (*Conium maculatum*), and 12 percent contained predominantly black mustard (*Brassica nigra*). All eight drainages in 2020 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 number of territories dominated or co-dominated by non-native vegetation.

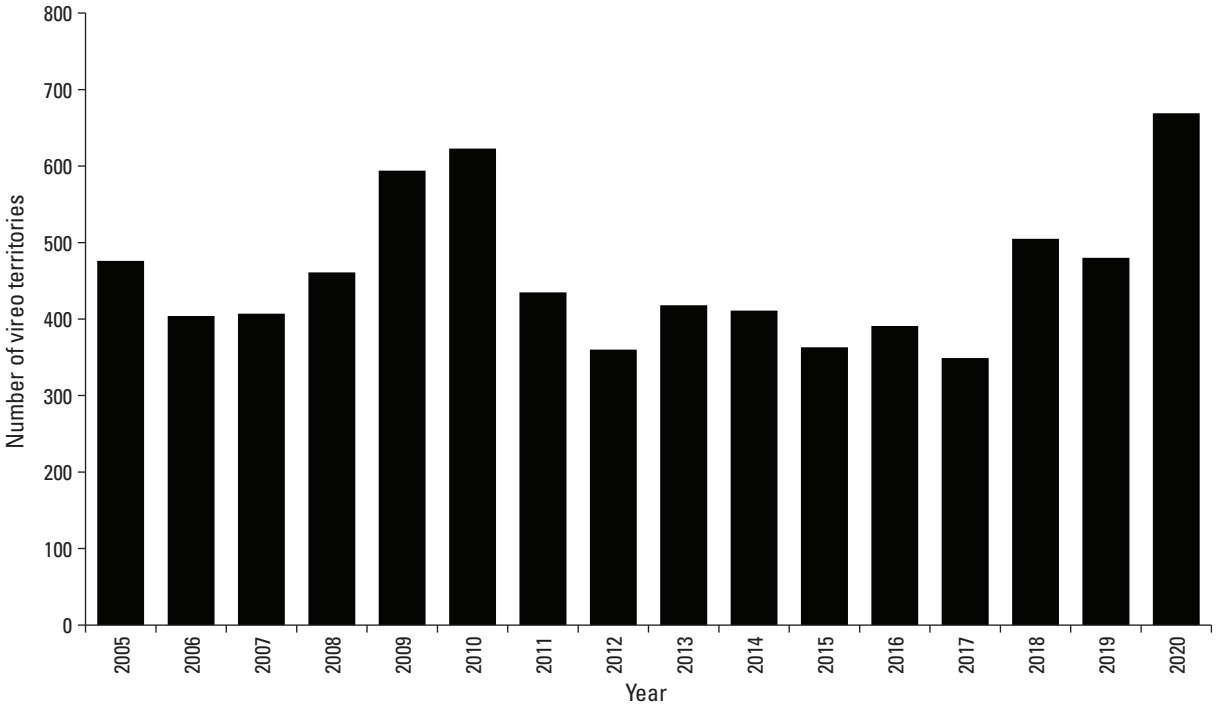

Figure 4. Number of Least Bell's Vireo territories in core survey areas at Marine Corps Base Camp Pendleton, 2005–20.

Table 1. Number and distribution of Least Bell's Vireos in core survey areas at Marine Corps Base Camp Pendleton, 2020.

[ha, hectare; rd, road]

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]	357	103	460	10	964
De Luz Creek South	20	3	23	0	95
Lake O'Neill section of Fallbrook Creek	15	0	15	0	98
Aliso Creek	14	3	17	1	94
Las Flores Creek—Pacific Ocean to Stuart Mesa Rd	0	3	3	0	124
Las Flores Creek—Stuart Mesa Rd to eastern edge of lower core area	19	15	34	2	138
Las Flores Creek—Western edge of upper core area to Zulu Impact Area	23	4	27	1	83
San Onofre Creek, lower east core area	15	7	22	2	191
San Mateo Creek, lower bottom core area	33	2	35	0	492
Pilgrim Creek, Base boundary upstream to Vandegrift Boulevard	30	3	33	0	78
Total	**526**	**143**	**669**	**16**	**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.

Table 2. Number of territorial male Least Bell's Vireos in core survey areas 2020 at Marine Corps Base Camp Pendleton, by drainage, 2005–20.

[The number includes only singing males determined to hold territories. Numeric change is the positive or negative change in the number of vireo territories between 2019 and 2020]

Drainage	Number of territorial males																Numeric change
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Santa Margarita River	314	277	281	327	402	435	293	252	291	294	259	283	253	365	333	460	127
De Luz Creek	11	19	17	19	24	23	17	19	21	15	12	12	7	9	15	23	8
Fallbrook Creek	15	5	7	10	8	10	5	4	5	7	3	3	5	13	8	15	7
Aliso Creek	21	11	9	11	21	16	9	8	9	6	4	6	5	9	9	17	8
Las Flores Creek	50	43	46	42	61	64	48	27	32	38	31	29	23	47	49	64	15
San Onofre Creek	12	10	11	7	16	13	14	16	16	12	9	10	16	11	10	22	12
San Mateo Creek	25	23	19	29	47	44	29	22	25	23	29	35	25	30	34	35	1
Pilgrim Creek	28	16	17	16	15	18	20	12	19	16	16	13	15	21	22	33	11
Total	**476**	**404**	**407**	**461**	**594**	**623**	**435**	**360**	**418**	**411**	**363**	**391**	**349**	**505**	**480**	**669**	**189**

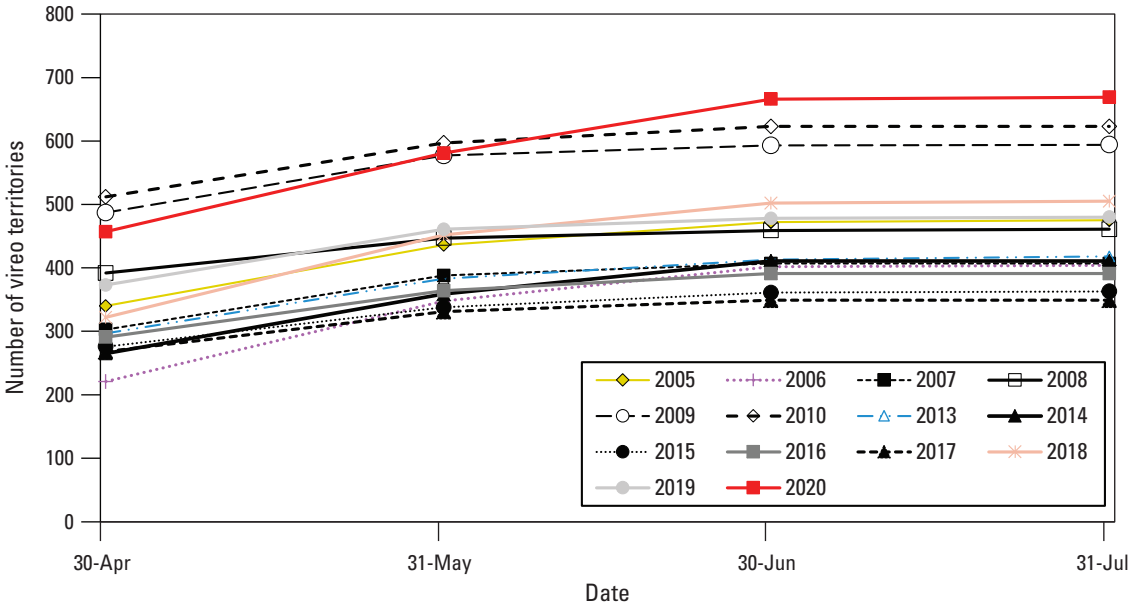

Figure 5. Territory establishment of Least Bell's Vireos in core survey areas at Marine Corps Base Camp Pendleton, 2005–20. Dates represent survey period end points. Surveys began late in 2011 and 2012; therefore, arrival dates for these years are not included.

Table 3. Number and distribution of Least Bell's Vireos in non-core survey areas at Marine Corps Base Camp Pendleton, 2020.

[ha, hectare]

Drainage/survey site	Territories		Total territories	Transients	Total area surveyed (ha)
	Known pairs	Single/status undetermined			
Non-core survey areas group A					
Santa Margarita River, I-5 to De Luz Creek	124	25	149	0	402
Pueblitos Canyon	2	2	4	0	42
Cockleburr Canyon	3	0	3	0	14
Total	**129**	**27**	**156**	**0**	**458**

Table 4. Habitat types used by Least Bell's Vireos in core survey areas at Marine Corps Base Camp Pendleton, 2020.

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

Habitat type	Number of locations			Percentage of total
	>50 percent native	>50 percent non-native	Total	
Mixed willow	400	74	473	69
Riparian scrub	101	24	125	18
Upland scrub	40	10	50	7
Willow-sycamore	19	3	22	3
Non-native	0	7	7	1
Willow-cottonwood	4	0	4	1
Oak-sycamore	3	0	3	<1
Total	**567**	**118**	**685**	**100**

Table 5. Proportion of all Least Bell's Vireo territories dominated or co-dominated by non-native vegetation, by drainage, 2005–12.

Drainage	Proportion of all territories (number of territories within the drainage)													
	2005		2006		2007		2008		2009		2010		2011		2012	
Aliso Creek	0.09	(23)	0.00	(14)	0.09	(11)	0.00	(12)	0.00	(23)	0.11	(18)	0.00	(9)	0.18	(11)
De Luz Creek	0.08	(12)	0.05	(20)	0.00	(17)	0.00	(21)	0.00	(22)	0.00	(23)	0.00	(17)	0.00	(20)
Fallbrook Creek	0.16	(19)	0.00	(6)	0.14	(7)	0.00	(10)	0.00	(8)	0.00	(10)	0.00	(5)	0.17	(6)
Las Flores Creek	0.00	(49)	0.07	(45)	0.00	(47)	0.24	(45)	0.09	(65)	0.12	(67)	0.04	(48)	0.00	(28)
Pilgrim Creek	0.00	(28)	0.00	(16)	0.00	(18)	0.00	(17)	0.30	(20)	0.05	(20)	0.05	(22)	0.00	(12)
San Mateo Creek	0.62	(26)	0.16	(25)	0.00	(19)	0.11	(27)	0.10	(52)	0.27	(49)	0.03	(30)	0.00	(21)
San Onofre Creek	0.45	(11)	0.00	(12)	0.00	(12)	0.43	(7)	0.30	(20)	0.13	(16)	0.25	(16)	0.00	(16)
Santa Margarita River	0.19	(319)	0.07	(291)	0.03	(290)	0.03	(328)	0.07	(422)	0.05	(439)	0.11	(298)	0.07	(258)
Total	0.18	(487)	0.06	(429)	0.03	(421)	0.06	(467)	0.08	(632)	0.07	(642)	0.09	(445)	0.06	(372)

Table 6. Proportion of all Least Bell's Vireo territories dominated or co-dominated by non-native vegetation, by drainage, 2013–20.

Drainage	Proportion of all territories (number of territories within the drainage)													
	2013		2014		2015		2016		2017		2018		2019		2020	
Aliso Creek	0.00	(12)	0.00	(6)	0.00	(5)	0.00	(6)	0.20	(5)	0.00	(9)	0.08	(12)	0.11	(18)
De Luz Creek	0.00	(21)	0.25	(16)	0.19	(16)	0.19	(16)	0.71	(7)	0.00	(10)	0.13	(16)	0.43	(23)
Fallbrook Creek	0.00	(6)	0.00	(7)	0.00	(5)	0.00	(4)	0.00	(6)	0.13	(15)	0.13	(8)	0.27	(15)
Las Flores Creek	0.00	(34)	0.00	(39)	0.03	(33)	0.10	(30)	0.04	(23)	0.15	(55)	0.24	(49)	0.07	(67)
Pilgrim Creek	0.00	(19)	0.00	(18)	0.00	(17)	0.00	(13)	0.06	(16)	0.05	(21)	0.00	(22)	0.09	(33)
San Mateo Creek	0.00	(28)	0.00	(28)	0.17	(30)	0.00	(39)	0.40	(25)	0.00	(33)	0.29	(35)	0.23	(35)
San Onofre Creek	0.00	(16)	0.06	(16)	0.44	(9)	0.00	(11)	0.19	(16)	0.00	(11)	0.20	(10)	0.13	(24)
Santa Margarita River	0.05	(300)	0.04	(308)	0.08	(280)	0.03	(292)	0.04	(268)	0.06	(375)	0.13	(342)	0.18	(470)
Total	0.04	(436)	0.04	(438)	0.09	(395)	0.04	(411)	0.09	(366)	0.06	(529)	0.15	(494)	0.17	(685)

Non-Core Survey Areas

Most vireo locations in non-core survey areas occurred in habitat characterized as mixed willow riparian, with 54 percent of males in the study area found in this habitat (table 7). An additional 1 percent of birds occupied willow habitat co-dominated by sycamores. Seventeen percent of territories were found in riparian scrub, dominated by mule fat or sandbar willow. Seventeen percent of vireos occupied upland scrub and 11 percent occupied non-native habitat.

Vegetation Sampling

There were no significant differences in overall foliage cover or percent cover of native herbaceous vegetation at any height category between the Seep site and the Reference sites (table 8; fig. 6). Non-native vegetation cover was significantly higher at Reference sites than at the Seep site below 1 m and above 4 m, although there was very little non-native cover above 4 m. There was no non-native cover above 5 m at the Seep site. Woody vegetation cover was significantly greater at the Seep site than at Reference sites below 1 m, but there were no other differences in woody vegetation cover between the Seep and Reference sites. We also did not find differences in maximum canopy height (20 m at the Seep site and 17 m at Reference sites) or average canopy height (7.5±1.6 m at the Seep site and 7.4±2.0 m at Reference sites; t=0.8, P=0.40 and t=0.3, P=0.80, respectively).

Table 7. Habitat types used by Least Bell's Vireos in non-core survey areas at Marine Corps Base Camp Pendleton, 2020.

[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 A				
Mixed willow	72	13	85	54
Riparian scrub	19	8	27	17
Upland scrub	20	6	26	17
Non-native	0	17	17	11
Willow-sycamore	1	0	1	1
Total	**112**	**44**	**156**	**100**

Soil moisture was significantly lower at the Seep site (36±29 percent) than at Reference sites (57±32 percent; t=−2.1, P=0.04; fig. 7). Soil moisture was not correlated with the distance from the nearest seep outlet (r=−0.03, P=0.85) or with canopy height (r=0.06, P=0.68). There was also no correlation between soil moisture and overall foliage cover at any height category (table 9). However, soil moisture was negatively correlated with percent herbaceous cover (higher soil moisture=lower percent herbaceous cover) between 2 and 3 m, and between 4 and 6 m (table 9), although there was very little herbaceous cover above 4 m.

Soil moisture varied geographically across all four monitoring sites. The western edge of the Seep site was dry, despite being close to the main river channel (fig. 7). The highest soil moisture in the Seep site was in the southeastern area, just west of an ephemeral drainage. Soil moisture was high on the eastern edge of the Old Treatment Ponds Reference site and the western side of the southern Pump Road Reference site. A dirt road defined the western border of both Pump Road Reference sites; the southern section of this road was flooded for the entire breeding season. All but one sampling location at the northern Pump Road Reference site had high soil moisture (above 65 percent), and 4 of the 12 sampling locations were 100 percent saturated. High soil moisture in the Reference sites was indicated by the rapid growth of annual vegetation until late June/early July. Except for a small portion of the northwest edge of the southern Pump Road Reference site, the soil type across all monitoring sites was uniformly high-draining river wash or Greenfield sandy loam (U.S. Department of Agriculture Natural Resources Conservation Science, 2020).

Table 8. Results of Student's t-tests for differences in vegetation cover between the Seep site and Reference sites at Marine Corps Base Camp Pendleton, 2020.

[m, meter; t, Student's t statistic; P, probability; >, greater than]

Height interval (m)	Overall foliage cover		Native herbaceous cover		Non-native vegetation cover		Woody vegetation cover	
	t	P	t	P	t	P	t	P
0–1	−0.4	0.69	0.5	0.63	−1.8	[1]**0.08**	1.7	[1]**0.10**
>1–2	0.5	0.62	−0.2	0.83	−1.1	0.29	1.5	0.14
>2–3	0.8	0.41	0.3	0.74	−0.2	0.82	1.2	0.24
>3–4	0.5	0.59	0.2	0.81	−0.7	0.51	0.8	0.44
>4–5	0.6	0.56	0.4	0.67	−1.8	[1]**0.09**	0.7	0.49
>5–6	0.4	0.70	−0.7	0.49	−1.7	[1]**0.10**	0.6	0.58
>6	0.6	0.53	−0.7	0.52	−2.0	[1]**0.06**	0.7	0.50

[1]Significant difference.

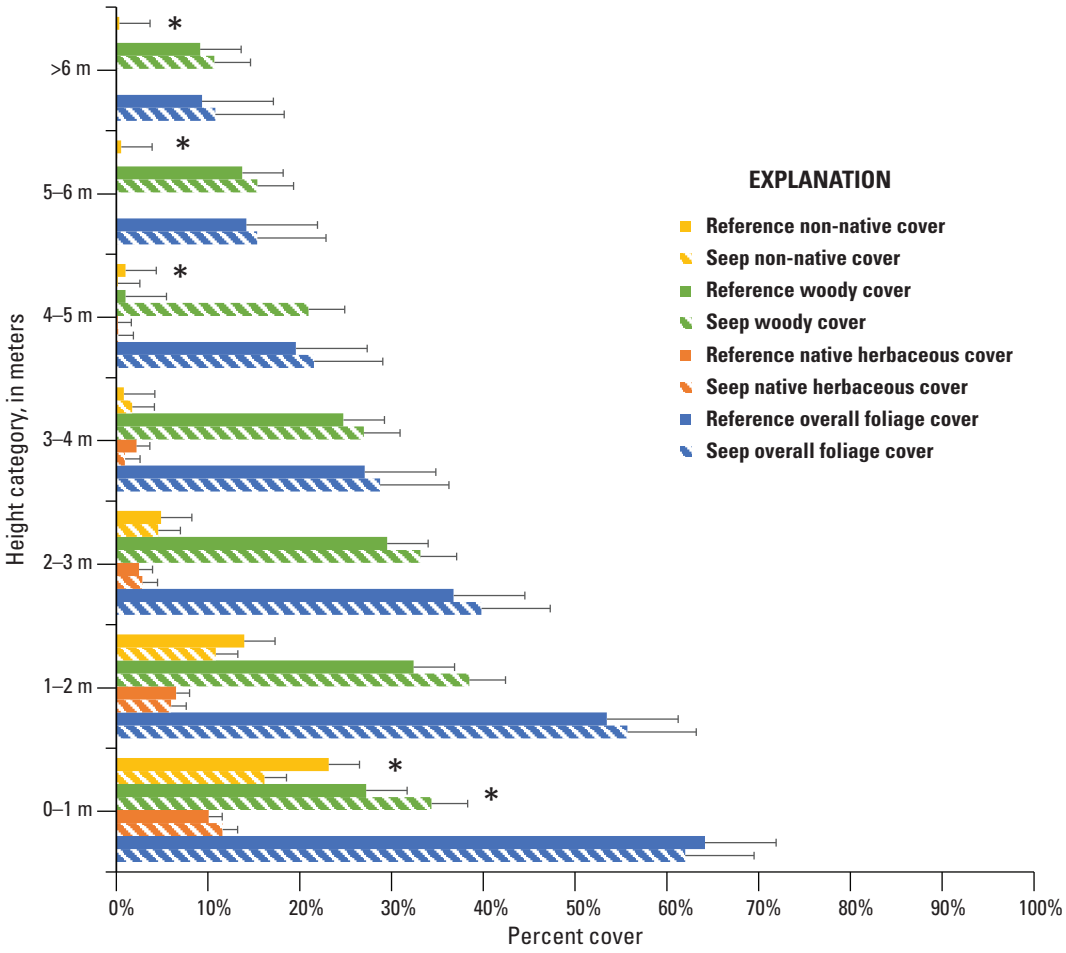

Figure 6. Average total percentage cover by height class and plant type at Seep and Reference sites, Santa Margarita River, 2020, Marine Corps Base Camp Pendleton. Error bars represent 1 standard deviation. Asterisk indicates a significant difference. Abbreviations: >, greater than; m, meter; %, percent.

Vireo Movements

Returning Banded Birds

We were able to observe 1,526 adult Least Bell's Vireos (848 males, 99 percent of all males, and 413 females, 62 percent of all females) on Base well enough to determine banding status in 2020, although not all banded vireos were observed well enough to conclusively identify the individual. Ninety-nine vireos had been banded before the 2020 breeding season, 14 of which we could not identify because the vireos were banded with only a single numbered metal federal band as nestlings and not recaptured (12 natals) or had incomplete resights and were therefore not identified (2 incomplete resights; table 10). Therefore, we were able to identify 85 vireos on Base that had unique color band combinations in 2020 (table 10; appendix 4, table 4.1). Of the 85 identified banded vireos, 69 vireos had been banded on Base, and 16 vireos were originally banded off Base (13 on the San Luis Rey River, 1 at Marine Corps Air Station, Camp Pendleton, [MCAS] and 2 in Baja California Sur; B. Kus, U.S. Geological Survey, unpub. data, 2012, 2015, 2016, 2017, 2018, 2019; table 11). Adult birds of known age ranged from 1 to 8 years old. Twenty-one percent of adult banded birds were 1 year old in 2020.

Twelve natal vireos (6 males and 6 females) were resighted on MCBCP in 2020 (table 10). Based on the color of the metal leg bands, six were banded as nestlings on Base before 2020 or at MCAS before 2016, three were banded as nestlings at MCAS in 2018 or 2019, two were banded as nestlings on the San Luis Rey River, and one may have been banded off Base or at MCAS in 2018. Efforts to recapture and identify these vireos were unsuccessful.

One male and one female vireo that were last detected on MCBCP were detected off Base in 2020 (table 10). The male was observed on Murrieta Creek and had been banded as a nestling on MCBCP in 2019. The female was observed on the San Luis Rey River and was originally banded on MCBCP before 2020.

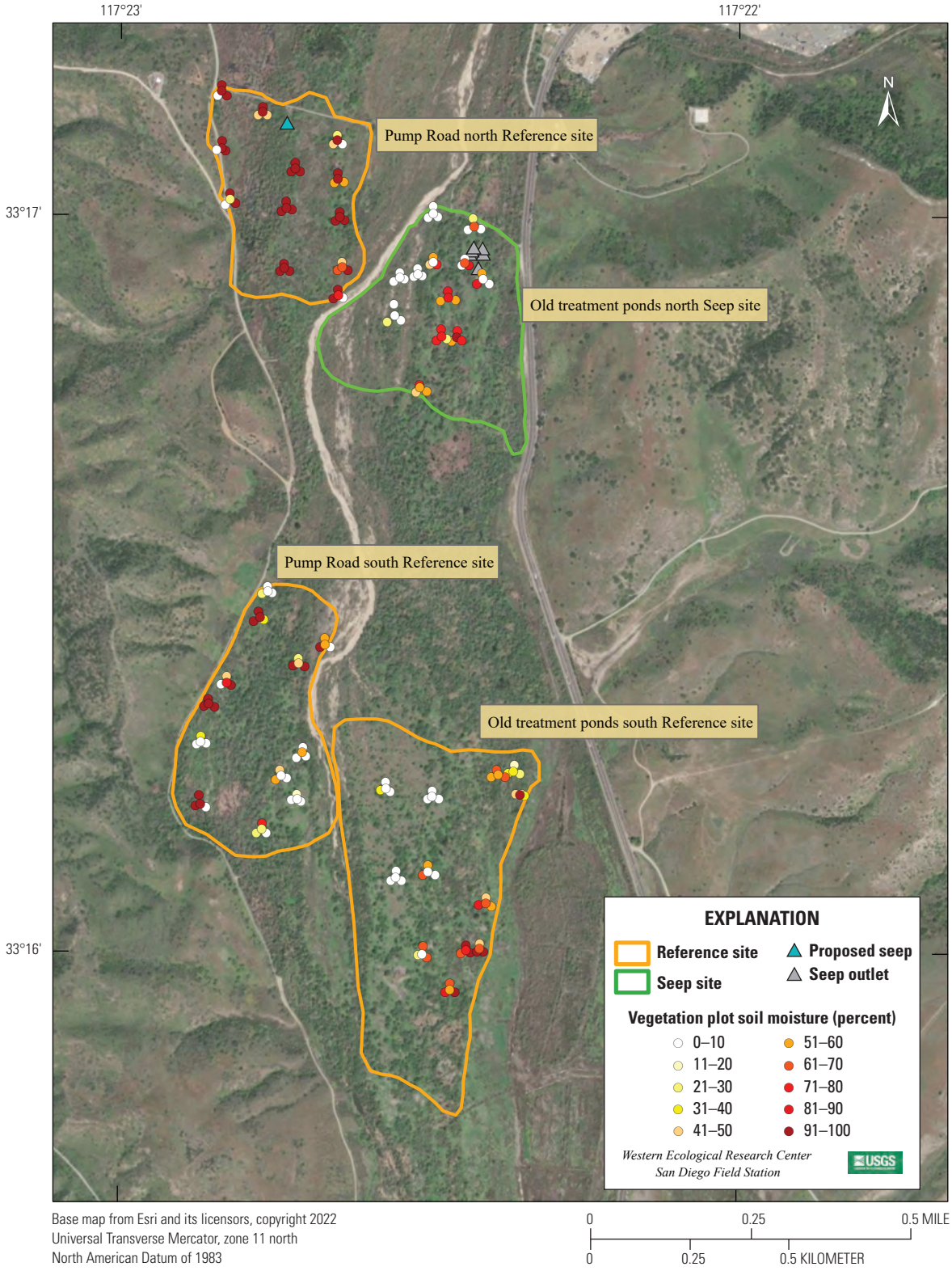

Figure 7. Percentage soil moisture at vegetation sampling plots, Marine Corps Base Camp Pendleton, 2020.

Table 9. Results of Pearson's correlation tests between percentage soil moisture and overall foliage cover and percentage herbaceous cover at each height category, Marine Corps Base Camp Pendleton, 2020.

[m, meter; *r*, Pearson's correlation coefficient; *P*, probability, >, greater than]

Height interval (m)	Overall foliage cover		Percentage herbaceous cover	
	r	*P*	*r*	*P*
0–1	0.10	0.50	−0.09	0.56
>1–2	0.02	0.90	−0.16	0.29
>2–3	0.05	0.76	−0.28	[1]**0.06**
>3–4	0.07	0.63	−0.23	0.11
>4–5	−0.03	0.85	−0.25	[1]**0.09**
>5–6	−0.02	0.91	−0.25	[1]**0.09**
>6	0.00	0.99	−0.19	0.19

[1]Significant relationship.

Table 10. Banding status of Least Bell's Vireos detected on Marine Corps Base Camp Pendleton (MCBCP) and those that emigrated off Base, 2020.

[Birds detected on MCBCP include immigrants. Natal vireos were originally banded as nestlings with a single numbered federal band. **Abbreviation**: —, no data]

Banding status	Detected on MCBCP		Total on MCBCP	Emigrants		Total
	Male	Female		Male	Female	
Uniquely banded before 2020	57	10	67	—	—	67
Natal recaptured in 2020	11	7	18	[1]1	—	19
Subtotal of known identity vireos	**68**	**17**	**85**	**1**	**—**	**88**
Natal, not recaptured	6	6	12	—	[2]1	13
Incomplete resight	1	1	2	—	—	2
Grand total	**75**	**24**	**99**	**1**	**1**	**101**

[1]Found on Murrieta Creek in 2020.

[2]Found on the San Luis Rey River in 2020.

Table 11. Number of banded adult Least Bell's Vireos by original year banded, age, original banding location, and sex at Marine Corps Base Camp Pendleton, 2020.

[Vireos originally banded in Baja California Sur were captured on the wintering grounds so the natal site was unknown. **Abbreviations:** —, no data; ≥, greater than or equal to]

Year originally banded	Age, in years, 2020	Number of vireos observed by origin								Total
		Marine Corps Base Camp Pendleton		San Luis Rey River		Marine Corps Air Station, Camp Pendleton	Baja California Sur	Unknown		
		Male	Female	Male	Female	Male	Male	Male	Female	
2012	8	1	—	1	—	—	—	—	—	2
2013	7	1	—	—	—	—	—	—	—	1
2015	≥6	[1]4	—	—	—	—	—	—	—	4
	5	[1]3	1	—	—	1	—	—	—	5
2016	≥5	1	1	—	—	—	—	—	—	2
	4	1	—	1	1	—	—	—	—	3
2017	≥4	6	1	—	—	—	1	—	—	8
	3	9	1	1	2	—	—	—	—	13
2018	≥3	3	2	—	—	—	—	—	—	5
	3	2	—	—	—	—	—	—	—	2
	2	4	1	1	1	—	—	—	—	7
2019	≥2	9	2	—	—	—	1	—	—	12
	2	3	—	—	—	—	—	—	—	3
	1	11	2	3	2	—	—	—	—	18
Subtotal		58	11	7	6	1	2	—	—	85
Unknown	≥1	3	4	—	[2]2	[3]3	—	[4]1	[5]1	14
Total		**61**	**15**	**7**	**8**	**4**	**2**	**1**	**1**	**99**

[1]Vireos were seen with a metal gold numbered banding, indicating that they were originally banded at Marine Corps Base, Camp Pendleton, before 2016.

[2]Vireos were seen with a metal dark blue numbered band, indicating that they were originally banded on the San Luis Rey River.

[3]Vireos were seen with a metal silver numbered band on the left leg and assumed to be 1- or 2-year-old vireos banded by the San Diego Natural History Museum at Marine Corps Air Station, Camp Pendleton in 2018 or 2019 (Ferree and Clark, 2018, 2019).

[4]Vireo seen with a single metal silver numbered band on the right leg, could have been banded off Base or at Marine Corps Air Station, Camp Pendleton.

[5]Vireo with incomplete resight of the bands, but metal silver seen in combination with plastic bands. Identity and origin not determinable.

New Banded Birds

A total of 146 Least Bell's Vireos were captured and banded for the first time in 2020 (table 12). Newly banded birds included 27 adult vireos caught for the first time and banded with a unique color combination and 119 juvenile birds which were banded as nestlings with a single gold numbered federal band. These newly banded vireos are not included in site fidelity or movement analyses.

Site Fidelity and Movement

Resighting banded birds allowed us to identify individuals that either returned to the same site they used in a previous year (within 100 m) or moved to a different location (appendix 5, table 5.1). Fifty-two adult vireos (45 males and 7 females) that were identified at MCBCP in 2019 were resighted in 2020, 47 of which occupied known territories both years (2 females and 3 males were banded or recaptured at a MAPS station in 2019 or 2020 and did not have known territories that year). Most returning adult vireos showed strong between-year site fidelity. Of the 47 returning territorial adults, 35 (74 percent of territorial adults; 33 males, 79 percent of males; 2 females, 40 percent of females) occupied a breeding site in 2020 that they had defended in 2019 (within 100 m). Seven additional vireos (15 percent of all vireos; 7 males, 17 percent of males; no females) returned to sites adjacent to their previous territories (within 300 m). The average distance moved by returning adult vireos was 0.3±0.8 km (range 0.0–4.7 km; 0.3±0.8 km, range 0.0–4.7 km for males; 0.4±0.4 km, range 0.0–0.9 km for females).

Table 12. Summary of new Least Bell's Vireos captured and banded on Marine Corps Base Camp Pendleton, 2020.

[—, no data]

Age banded	Males	Females	Unknown sex	Total
Adult	22	5	—	27
Nestling	—	—	119	119
Total	**22**	**5**	**119**	**146**

Nine first-year vireos that were banded as nestlings in 2019 on MCBCP were resighted in 2020 and occupied known territories (seven males and two females; table 13). Five additional first-year vireos that were detected in 2020 were originally captured at a MAPS station in 2019 and therefore did not have a known natal territory. The average distance that first-year vireos moved from their natal territories to their breeding territories was 4.7±7.0 km (range 0.6–23.0 km; males moved 5.4±7.9 km, range 0.6–23.0 km; females moved 2.4±1.2 km, range 1.5–3.3 km). One first-year male vireo that was banded as a nestling on MCBCP in 2019 was detected off Base in 2020 at Murrieta Creek, 23.0 km from his natal territory. Five other first-year vireos that were originally banded as nestlings along the San Luis Rey River (three males and two females) in 2019 dispersed 7.2±4.1 km to MCBCP.

Nest Success and Breeding Productivity

Nesting activity was monitored at 12 territories in the Seep site and 40 territories in Reference sites (table 14; figs. 8–11; appendix 6, table 6.1). All of the territories in the Seep site and all but one of the territories in the Reference sites were considered fully monitored, meaning that all nests within the territory were found and documented during the breeding season. One territory in a Reference site was partially monitored and was not included in all analyses. Fifty-two pairs built 94 nests; 7 of these were not completed (INC or FAL in appendix 6, table 6.1) and have been excluded from calculations of nest success and productivity.

Nesting Attempts

Pairs at the Seep site and Reference sites had a similar number of nesting attempts (including incomplete nests) over the course of the 2020 breeding season (table 14; t=1.5, P=0.15). Seep pairs (11/12; 92 percent) were more likely to re-nest after an initial attempt than Reference pairs (22/39; 56 percent; Fisher's Exact P=0.04). The number of re-nests after a failed first nesting attempt did not differ between Seep pairs (7/8; 88 percent) and Reference pairs (15/18; 83 percent; Fisher's Exact P>0.99). However, pairs at the Seep site (4/4; 100 percent) were more likely to re-nest after a successful first nesting attempt than were pairs at Reference sites (7/21; 33 percent; Fisher's Exact P=0.03). Pairs at Reference sites were more likely to re-nest after a failed first nesting attempt than after a successful first nesting attempt in 2020 (Fisher's Exact P=0.003), although pairs at the Seep site were equally likely to re-nest after a failed or successful first nesting attempt (Fisher's Exact P>0.99). When both monitoring site types were combined, pairs were more likely to re-nest after a failed nesting attempt than they were after a successful nesting attempt in 2020 (Fisher's Exact P=0.007). Overall, 85 percent (22/26) of vireo pairs attempted to re-nest after a failed first nesting attempt and 44 percent (11/25) of pairs attempted to re-nest after a successful first nesting attempt in 2020. Two pairs at the Seep site and seven pairs at Reference sites attempted three nests in 2020.

Nest Success

Completed nests in the Seep site were as likely to be successful as completed nests in Reference sites (chi-square=0.06, P=0.81); 57 percent (13/23) of nests in the Seep site successfully fledged young and 59 percent (38/64) of those in Reference sites successfully fledged young (table 15). First nesting attempts also were as likely to be successful at the Seep site (67 percent) as at Reference sites (46 percent; Fisher's Exact P=0.32) in 2020 (appendix 6, table 6.1). Overall, 59 percent of all nesting attempts were successful and 51 percent of first nesting attempts were successful in 2020.

Causes of failure were similar at Seep and Reference sites. Most nest failures at both Seep and Reference sites were caused by predation, although no confirmed predation events were witnessed (table 15). Predation accounted for 90 percent (9/10) of nest failures at the Seep site and 73 percent (19/26) of nest failures at Reference sites. We documented eight nests that failed for other reasons, known and unknown, at our monitoring sites (appendix 6, table 6.1). Two nests were abandoned with no eggs ever confirmed. Two nests were abandoned with eggs for unknown reasons. Rain and flooding caused three nests to fail. One nest failed when the supporting branch broke. Overall, 43 percent and 41 percent of completed vireo nests at Seep and Reference sites were lost to predation or other causes, respectively.

Cowbird Parasitism

No Least Bell's Vireo nests within monitoring sites were parasitized by Brown-headed Cowbirds in 2020.

Table 13. Between-year dispersal into, within, or out of Marine Corps Base Camp Pendleton by Least Bell's Vireos banded as juveniles in 2019 and detected in 2020.

[**Drainage codes**: SMR, Santa Margarita River; FC, Fallbrook Creek; MU, Murrieta Creek; SLR, San Luis Rey River; PU, Pueblitos Creek; PL, Pilgrim Creek; LF, Las Flores Creek. **Band colors**: ORPU, plastic orange-purple split; pupu, metal purple; Mgo, gold numbered federal band; YEYE, plastic yellow; ORDG, plastic orange-dark green split; DGOR, plastic dark green-orange split; DPDP, plastic dark pink; BPST, plastic black-pink striped; WHDP, plastic white-dark pink split; DPWH, plastic dark pink-white split; PUYE, plastic purple-yellow split; BKBK, plastic black; WHPU, plastic white-purple split; PUWH, plastic purple-white split; YEBK, plastic yellow-black split; Mdb, dark blue numbered federal band; BWST, plastic blue-white striped; PUPU, plastic purple; BKYE, plastic black-yellow split; DBWH, plastic dark blue-white split. **Sex**: M, male; F, female. **Abbreviation:** km, kilometer]

Drainage/territory		Dispersal distance (km)	Band combination		Sex
2019	2020		Left leg	Right leg	
SMR/MER	SMR/HE51	0.6	ORPU pupu	Mgo	M
SMR/DRO	SMR/HW63	1.2	ORPU	Mgo	M
SMR/FUR	SMR/HW23	1.5	YEYE pupu	Mgo	F
SMR/HTI	SMR/HW23	1.8	ORDG	DGOR Mgo	M
SMR/HDX	FC/OL10	2.0	DPDP	BPST Mgo	M
SMR/GEN	SMR/HW62	3.3	WHDP	BPST Mgo	F
SMR/TEN	SMR/HW66	4.3	DPWH	ORDG Mgo	M
SMR/LEM	SMR/HE40	4.7	PUYE	BKBK Mgo	M
SMR/WOM	MU/MSC01	23.0	WHPU	DPDP Mgo	M
SLR/FAQU[1]	SMR/YB63	3.4	PUWH	YEBK Mdb	M
SLR/DDOL[1]	PU/PU03	4.8	BPST	BWST Mdb	M
SLR/CMET[1]	PL/PS05	5.1	BPST	PUPU Mdb	M
SLR/CFOR[1]	SMR/HE38	9.2	DPWH	BKYE Mdb	F
SLR/WMON[1]	LF/UL18	13.5	BPST	DBWH Mdb	F

[1]Immigrant to Marine Corps Base Camp Pendleton from the San Luis Rey River.

Table 14. Number of Least Bell's Vireo territories and nests monitored at Seep and Reference sites on Marine Corps Base Camp Pendleton, 2020.

[±, plus or minus]

Nests/territories	Nest monitoring area type	
	Seep	Reference
Territories	12	40
Nests (number complete)	25 (23)	69 (64)
Completed nests per pair[1]	1.9±0.7	1.6±0.6
Total number of nests per pair[1] (includes incomplete nests)	2.1±0.5	1.7±0.8

[1]Does not include one territory at a Reference site that was partially monitored (one nest monitored).

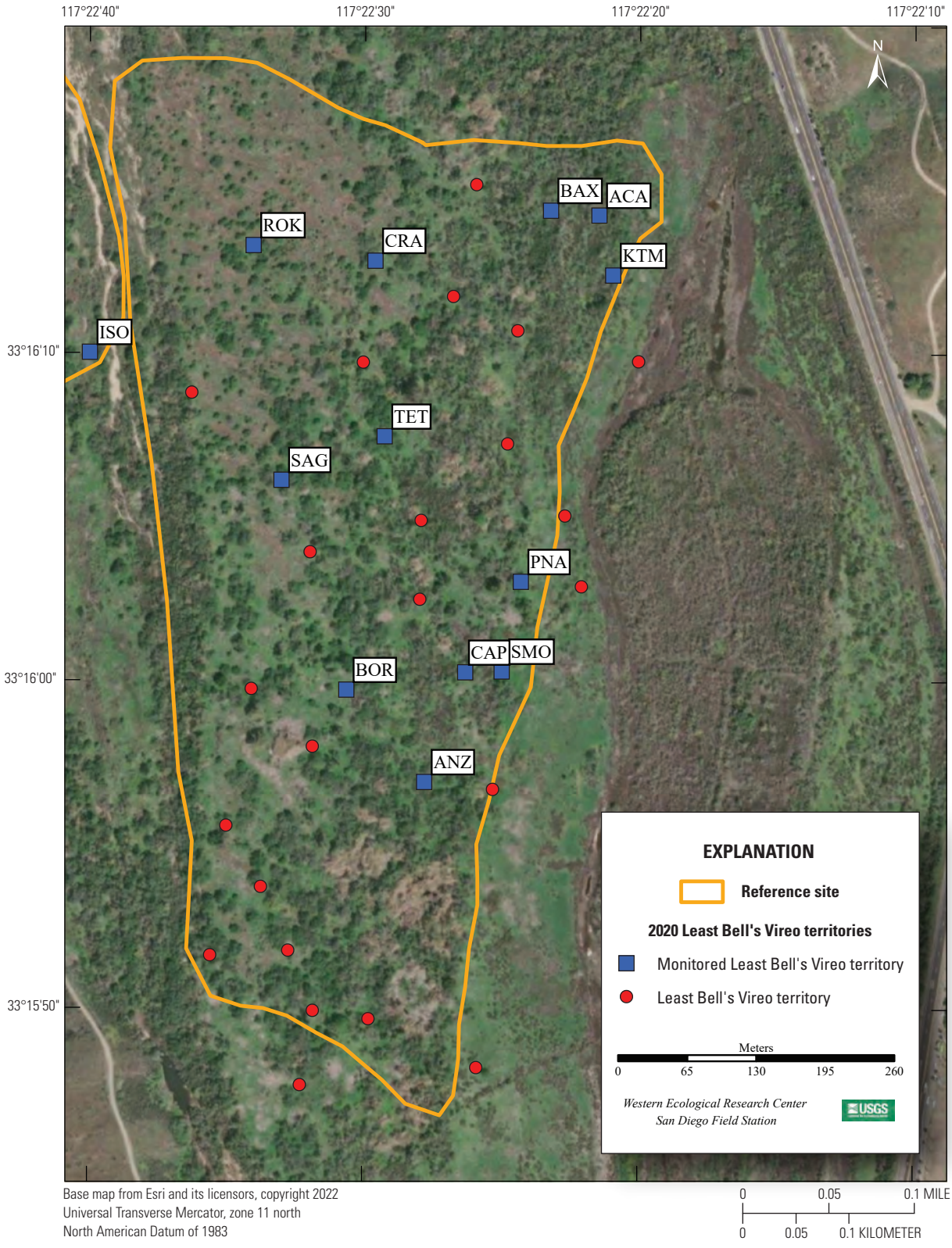

Figure 8. Locations of monitored Least Bell's Vireo territories at the Old Treatment Ponds Reference site, Marine Corps Base Camp Pendleton, 2020.

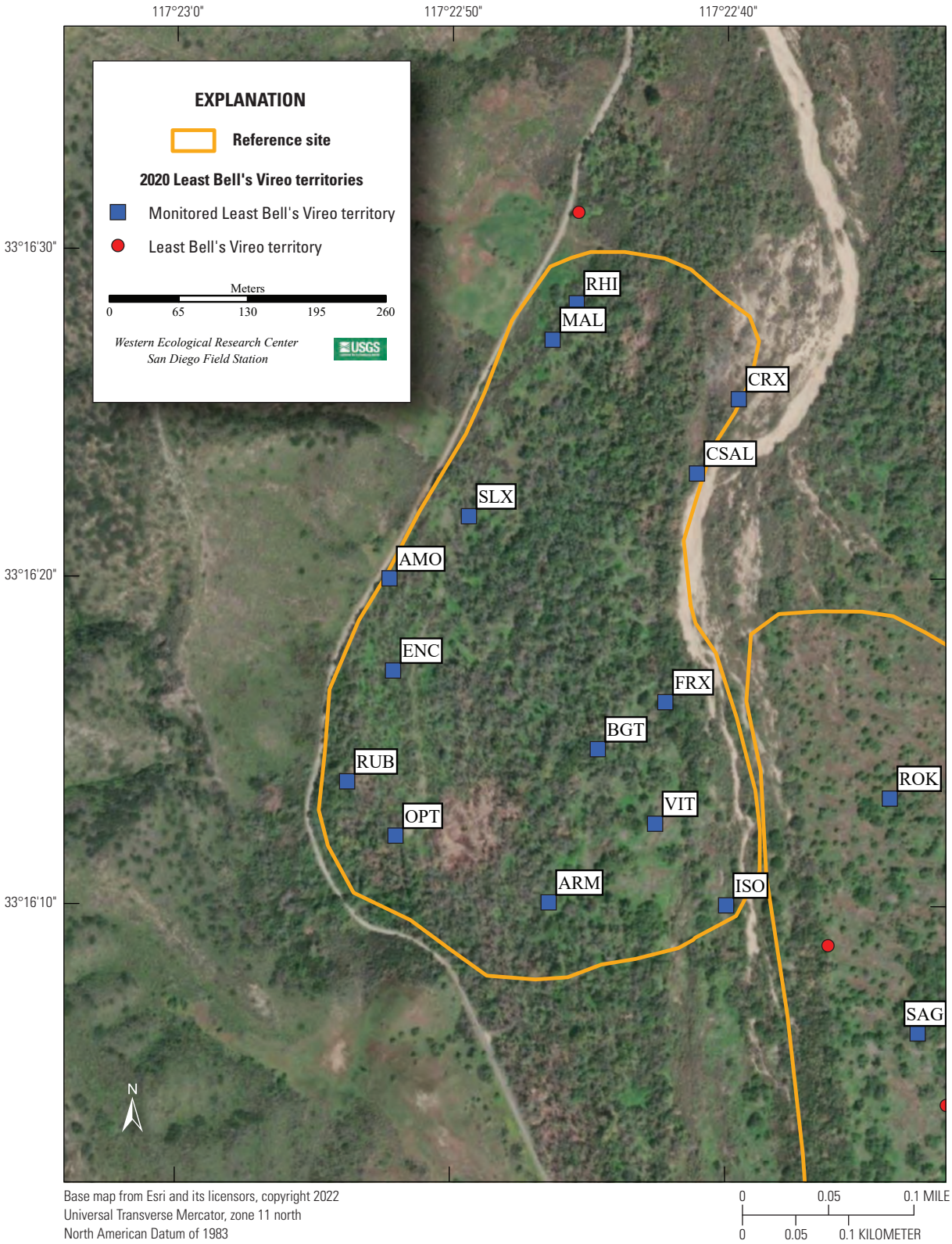

Figure 9. Locations of monitored Least Bell's Vireo territories at the Pump Road Reference site, Marine Corps Base Camp Pendleton, 2020.

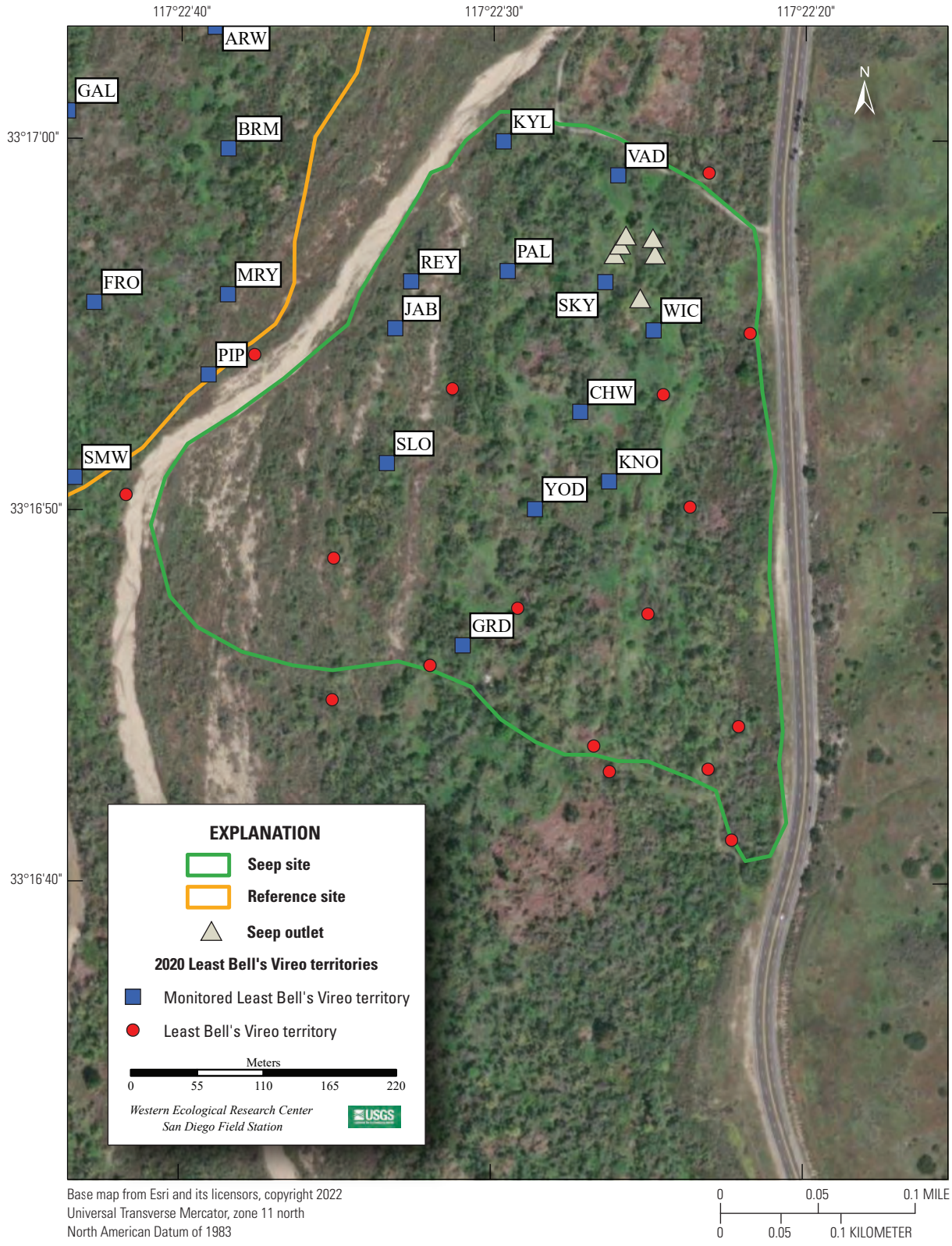

Figure 10. Locations of monitored Least Bell's Vireo territories at the Old Treatment Pond Seep site, Marine Corps Base Camp Pendleton, 2020.

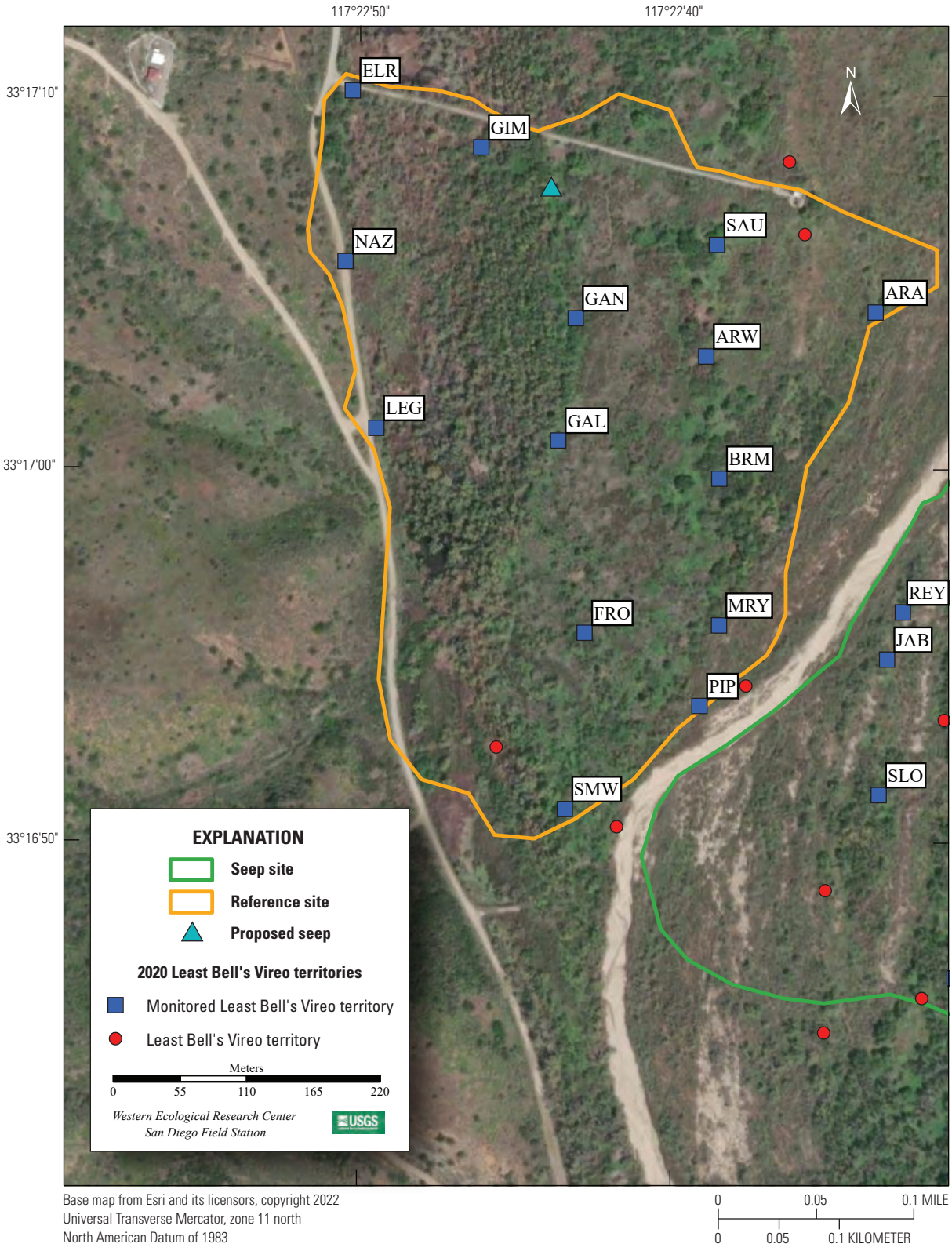

Figure 11. Locations of monitored Least Bell's Vireo territories at the Pump Road Seep site, treated as a Reference site in 2020, Marine Corps Base Camp Pendleton, 2020.

Table 15. Fate of completed Least Bell's Vireo nests in fully monitored territories at Seep and Reference sites, Marine Corps Base Camp Pendleton, 2020.

[Numbers in parentheses are proportions of total nests found]

Nest fate	Number of nests		
	Seep	Reference	Total
Successful	13	38	51 (0.59)
Failed			
Predation	9	19	28 (0.32)
Parasitism	0	0	0 (0.00)
Other/unknown	1	7	8 (0.09)
Total completed nests	23	64	87 (1.00)

Productivity

Clutch size did not differ between the Seep site and Reference sites (table 16). However, the Seep site had a higher percentage of eggs that hatched and a higher percentage of nests with hatchlings than Reference sites. The percentage of hatchlings that fledged and the percentage of nests with hatchlings that ultimately fledged young was significantly higher at Reference sites than at the Seep site. However, pairs at Seep and Reference sites were equally likely to fledge young. Four vireo pairs at the Seep site (25 percent) and six pairs at Reference sites (15 percent) successfully double-brooded during the 2020 breeding season (appendix 6, table 6.1). Vireo pairs at Seep and Reference sites combined fledged 3.1 vireo young per pair, and 78 percent of monitored pairs were successful in fledging at least 1 young in 2020.

Daily Nest Survival

Analysis of DSR showed that the model that included treatment did not improve the estimate obtained from the constant model for predicting vireo nest survival (table 17). In other words, nests at the Seep site and Reference sites in 2020 had similar daily survival rates (table 18). The second-ranked model, which included treatment (Seep) was within 2 AIC_c of the constant model and carried an AIC_c weight of 0.28, which indicated some support; however, treatment (Seep) was not considered a significant contributor to the model when examining odds ratios (95-percent confidence interval of the odds ratio included 1).

Nest Characteristics

Least Bell's Vireos used 14 plant species for nesting at Seep and Reference sites in 2020, although not all were used within each treatment (table 19). Vireos used 7 species at the Seep site and 13 species at Reference sites. Seventy-six percent of all nests (80 percent at the Seep site and 75 percent at Reference sites) were placed in arroyo willow, mule fat, or sandbar willow. At the Seep site, no vireo nests were placed in herbaceous vegetation, and 25 nests (100 percent) were placed in woody vegetation or perennial vines. At Reference sites, 5 vireo nests (7 percent) were placed in herbaceous vegetation, and 63 nests (93 percent) were placed in woody vegetation or perennial vines. Three vireo nests were built in non-native plant species (one in black mustard and two in poison hemlock) at Reference sites.

In 2020, we found that successful vireo nests were in taller host plants and further from the edge (closer to the center) of host plants than unsuccessful nests at the Seep site. We found no other differences in nest placement between successful and unsuccessful nests at either the Seep site or at Reference sites (table 20). We found no difference between vireo nest placement at the Seep site versus Reference sites (table 21).

Table 16. Reproductive success and productivity of nesting Least Bell's Vireos at Seep and Reference sites, Marine Corps Base Camp Pendleton, 2020.

[±, plus or minus; %, percent; ≥, greater than or equal to; *t*, t-statistic; *P*, probability; <, less than]

Parameter	Seep site	Reference sites	Total
Nests with eggs	23	60	83
Eggs laid	80	199	279
Average clutch size[1]	3.6±0.6	3.5±0.6	3.6±0.6
Hatchlings	73	129	202
Nests with hatchlings	22	42	64
Hatching success			
Eggs[2]	91%	65%	72%
Nests[3]	96%	70%	77%
Fledglings	44	115	159
Nests with fledglings	13	38	51
Fledging success			
Hatchlings[4]	60%	89%	79%
Nests[5]	59%	90%	80%
Fledglings per egg	0.6	0.6	0.6
Average number of young fledged per pair[6]	3.7±2.7	2.9±2.0	3.1±2.1
Pairs fledging ≥1 young[7]	9, 75%	31, 79%	40, 78%

[1]Based on 21 Seep and 51 Reference non-parasitized nests with a full clutch (*t*=0.02; *P*=0.89).

[2]Percentage of all eggs that hatched (Chi-squared=18.6, *P*<0.001).

[3]Percentage of all nests with eggs in which at least one egg hatched (Fisher's Exact *P*=0.02).

[4]Percentage of all hatchlings that fledged (Chi-squared=9.8, *P*=0.002).

[5]Percentage of all nests with hatchlings in which at least one young fledged (Fisher's Exact *P*=0.01).

[6]Based on 12 Seep and 39 Reference pairs (*t*=1.1, *P*=.30).

[7]Based on 12 Seep and 39 Reference pairs (Fisher's Exact *P*=0.71).

Table 17. Logistic regression models for the effect of treatment (whether a nest was in a Seep or Reference site) on nest survival of Least Bell's Vireos on Marine Corps Base Camp Pendleton, 2020.

[Models are ranked from best to worst based on Akaike's Information Criteria for small samples (AIC_c), change in AIC_c (ΔAIC_c), and Akaike weights. AIC_c is based on $-2\times\log_e$ likelihood and the number of parameters in the model. The constant model is the null model, which does not include covariates. **Abbreviation:** no., number]

Model	AIC_c	ΔAIC_c	AIC_c weight	No. parameters	Deviance
Constant	183.7	0.0	0.72	1	181.7
Treatment	185.6	1.9	0.28	2	181.6

Table 18. Parameter estimate (β), standard error (SE), odds ratios and 95-percent confidence intervals for models explaining daily survival rate of Least Bell's Vireos at Seep and Reference sites on Marine Corps Base Camp Pendleton, 2020.

[Models are in order of best-supported to least-supported]

Model	Effect	β	SE	Odds ratio	95-percent confidence interval
Constant	Constant	3.92	0.18	50.56	32.22–72.59
Treatment	Constant	3.97	0.23	52.95	34.01–82.44
	Treatment	−0.15	0.39	0.86	0.40–1.86

Table 19. Host plant species used by Least Bell's Vireos at Seep and Reference sites, Marine Corps Base Camp Pendleton, 2020.

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

Host species	Number of nests		
	Seep	Reference	Total
Arroyo or red willow	8 (0.32)	32 (0.47)	40 (0.43)
Mule fat	2 (0.08)	14 (0.21)	16 (0.17)
Sandbar willow	10 (0.40)	5 (0.07)	15 (0.16)
Blue elderberry (*Sambucus nigra* ssp. *caerulea*)	2 (0.08)	7 (0.10)	9 (0.10)
Poison hemlock	—	2 (0.03)	2 (0.02)
Poison oak (*Toxicodendron diversilobum*)	1 (0.04)	1 (0.01)	2 (0.02)
Black willow	1 (0.04)	1 (0.01)	2 (0.02)
Dead herb	—	1 (0.01)	1 (0.01)
California blackberry (*Rubus ursinus*)	1 (0.04)	—	1 (0.01)
Wild grape (*Vitus* sp.)	—	1 (0.01)	1 (0.01)
Mugwort (*Artemisia douglasiana*)	—	1 (0.01)	1 (0.01)
Black mustard	—	1 (0.01)	1 (0.01)
Wild rose (*Rosa californica*)	—	1 (0.01)	1 (0.01)
Black walnut (*Juglans californica*)	—	1 (0.01)	1 (0.01)

Table 20. Least Bell's Vireo nest characteristics and results of student's *t*-tests of successful versus unsuccessful nesting attempts at Seep and Reference sites, Marine Corps Base Camp Pendleton, 2020.

[*n*, number of nests in sample (successful, unsuccessful); *t*, Student's *t* statistic; *P*, *P*-value; m, meter]

Nest characteristic	Nest fate		*n*	*t*	*P*
	Successful	Unsuccessful			
Seep site					
Average nest height (m)	1.0	0.9	13, 12	1.2	0.29
Average host height (m)	4.5	3.0	13, 12	4.4	0.05
Average distance to edge of host (m)	0.9	0.6	13, 12	3.2	0.09
Average distance to edge of clump (m)	1.7	1.3	13, 12	1.7	0.21
Reference site					
Average nest height (m)	1.1	1.0	37, 28	2.1	0.16
Average host height (m)	4.8	4.2	38, 30	0.8	0.38
Average distance to edge of host (m)	0.6	0.6	38, 29	0.3	0.58
Average distance to edge of clump (m)	1.8	1.5	38, 29	1.1	0.30

Table 21. Least Bell's Vireo nest characteristics and results of Student's *t*-tests of all nesting attempts at Seep versus Reference sites, Marine Corps Base Camp Pendleton, 2020.

[*n*, number of nests in sample (Seep site, Reference site); *t*, Student's *t* statistic; *P*, *P*-value; m, meter]

Seep and Reference sites	Seep	Reference	*n*	*t*	*P*
Average nest height (m)	1.0	1.0	25, 65	0.7	0.42
Average host height (m)	3.8	4.6	25, 68	1.6	0.21
Average distance to edge of host (m)	0.7	0.6	25, 67	1.2	0.28
Average distance to edge of clump (m)	1.5	1.7	25, 67	0.7	0.39

Discussion

Least Bell's Vireo numbers have fluctuated over the past several years, manifested relatively consistently 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 through 2012. The population then fluctuated between 60 percent and 70 percent of peak numbers through 2017 before increasing in 2018, remaining high in 2019, and increasing again in 2020 (B. Jones, Sweetwater Environmental Biologists, Inc., unpub. data, 1985; Kus 1989a, 1989b, 1991a, 1991b, 1993, 1995; Kus and Beck, 1998; B. Kus, U.S. Geological Survey, unpub. data, 2007–19; Allen and others, 2017, 2018; Ferree and Clark, 2018, 2019, 2020; Allen and Kus, 2019, 2020, 2021; Houston and others, 2021).

Between 2016 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 and on the lower San Luis Rey River and remaining stable on the middle San Luis Rey River (B. Kus, U.S. Geological Survey, unpub. data, 2016). In 2017, there also was a discrepancy between 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 re-converged (Ferree and Clark, 2018; B. Kus, U.S. Geological Survey, unpub. data, 2018). From 2019 to 2020, these sites increased by 39 percent (MCBCP), 26 percent (lower San Luis Rey River; Houston and others, 2021), 7 percent (middle San Luis Rey River; B. Kus, Allen and Kus, 2021), and 58 percent (MCAS; Ferree and Clark, 2020).

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. Low precipitation compromises primary productivity, resulting in decreased annual plant and foliage growth. Consequently, foraging substrate and nesting cover for vireos was likely compromised, as was arthropod abundance, and ultimately, the wildlife (including vireos) that depend on these resources. Rainfall during 3 of the 4 bio-years between 2016 and 2020 was 12–51 percent above the 2002–11 average (Office of Water Resources, 2020), likely positively affecting breeding productivity in 2017, 2019, and 2020 and driving an increase in the vireo populations in 2018 and 2020, and possibly in 2021.

One year after the installation of the artificial seep, few differences in vegetation cover were found between the Seep site and the Reference sites; only the non-native species cover differed between sites. Non-native cover under 1 m and above 4 m was higher at the Reference sites where it was composed mostly of herbaceous annuals, giant reed, and woody species, such as salt cedar and eucalyptus (*Eucalyptus* sp). In contrast, non-native species cover at the Seep site was lower and composed only of herbaceous species.

We expected that soil moisture at the Seep site would be higher than at the Reference sites, which have not received surface water augmentation. However, average soil moisture at the Seep site was lower than at the Reference sites, and soil moisture at vegetation sampling locations near the seep outlets was similar to the average soil moisture for the entire Seep site, rather than being wetter as expected.

Similarly, soil moisture did not extend far from the surface water pools created by the seep pumps within the Seep site. Whereas soil moisture 1 m from the seep pools ranged from 15 to 55 percent, at 3 m from the pools, soil moisture dropped to 0 percent at over half of the measurement locations. This steep drop in soil moisture can be attributed to the soil type, which was a high-draining sandy loam, unlikely to retain moisture at the surface without a water source. Two of the six seep pump outlets did not produce water all season (blocked or turned off), and one other outlet only began operating after June 15. Surface water was present for most of the season at three of the seep outlets and for the last part of the season at one other seep outlet.

Soil moisture in the Seep site was highest in the southeastern section where flycatchers nested in 2020 (Howell and Kus, 2024). Soil moisture was also particularly high in the northern Pump Road Reference site where a potential new seep pump will be installed and where flycatchers have nested in past years. Precipitation in the 2019–20 bio-year was higher than average, and over half of this precipitation accumulated in April. The timing and amount of precipitation likely kept soil naturally wet throughout the season so that any effects from the diversion dam were not obvious. Additionally, the Conjuctive Use Project dam is designed to divert water under high-flow conditions and was only recently implemented; therefore, there likely has not been significant water diversion from the Santa Margarita River yet, adding to the persistence of natural surface water downstream. Surface water in the Santa Margarita River did not recede until early July. As a result, the increased water provided by the seep pump did not noticeably improve the availability of surface water over naturally available water. Similarly, the relative uniformity of vegetation structure, soil moisture, and vireo breeding success and productivity across monitoring sites suggests that comparisons between Seep and Reference sites were less meaningful than comparisons of these parameters from year to year, or of future potential divergence in these parameters among sites with changing weather conditions.

In 2020, we continued to see vireos that originated outside of MCBCP moving on to Base and holding territories. Five first-year vireos moved to MCBCP from the San Luis Rey River, where they hatched in 2019. Two 3-year old vireos and one 4-year-old vireo were detected on MCBCP in 2020 for the first time after they were banded on the San Luis Rey River in 2018 and 2016. Conversely, one vireo that hatched on MCBCP in 2019 was detected off Base. In 2020, we resighted two vireos on MCBCP that were originally banded in Baja California Sur, on the wintering grounds; one of these Baja vireos was also detected on Base in 2019. These movements demonstrate the ability of vireos to disperse well beyond their natal drainages. Incidental observations of vireos in areas that typically have not been thoroughly surveyed help to enhance our understanding of movements of both adult and dispersing juvenile vireos. Further banding and resighting of vireos within southern California and Baja California Sur continues to increase our understanding of the extent of movement between populations and during migration 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 possibly sex-related patterns in life history characteristics that affect population size, productivity, and genetic structure.

Conclusions

Until 2011, the vireo population on Marine Corps Base Camp Pendleton (MCBCP) tracked the overall increase in Least Bell's Vireos in southern California since the late 1970s (U.S. Fish and Wildlife Service, 2006). Since its peak in 2010, the vireo population on Camp Pendleton reached a 21-year low in 2015 and then rebounded in 2018 to the fifth highest count recorded. Extrapolating the number of vireos counted in core areas on MCBCP in 2020 to the entire Base, the Base-wide vireo population in 2020 was likely the highest on record. High productivity in 2017 and 2019 had a strong effect on the number of vireos that returned in 2018 and 2020.

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. On MCBCP, annual Brown-headed Cowbird control has reduced cowbird parasitism to a negligible level since the mid-1990s, releasing a major limit on vireo breeding productivity. Although two vireo nests were parasitized by cowbirds in 2018, no cowbird parasitism was recorded on MCBCP in 2019 or 2020. Cowbird control has a demonstrably positive effect on vireo productivity (Kus, 1999, Kus and Whitfield, 2005), but must be consistently practiced to maintain the desired reduction in parasitism.

The recent fluctuations in the vireo population may be a consequence of a variety of interacting factors including wildfire (affecting apparent population size, distribution, and habitat-related nesting productivity and predation), drought (affecting breeding productivity and survival), high floodwaters, and the inherent carrying capacity of the current habitat (whether breeding, migratory, or wintering). These factors are difficult to parse and are subject to change as a result of natural (for example, weather) and anthropogenic (for example, habitat alteration or restoration) processes, making future population trends difficult to predict.

The seep pump at the Old Treatment Ponds did not have a noticeable effect on vegetation or vireo breeding and productivity in 2020, likely at least partially as a result of high precipitation in the preceding bio-year, soil type in the vicinity of the seep outlets, non-operation of two or three of the six seep outlets, and the short time since completion of the water diversion dam. Non-operation of the seep outlets will need to be corrected to provide full utility to the currently installed pump. Other factors, such as precipitation and operation of the water diversion dam, were temporal and will likely change in the future, allowing determination of whether or not the seep pumps can compensate for a lowered water table and less precipitation. It is also possible that the seep pumps were not installed in an ideal location, and it is worth considering moving the pump to a more water-receptive location (topographic depression or dry drainage, less well-draining soil type) that might maintain surface water and soil moisture in a larger area. Alternatively, if the seep pumps only affect a small area, more seep pumps or more outlets would allow surface water augmentation over a larger area.

Whereas we did not document catastrophic wildfires on Base in 2020, it is worth continued vigilance surrounding military and civilian activities on Base to avoid causing wildfires during the frequent high-wildfire-risk weather conditions in southern California. The wildfires that occurred in October 2013 and May 2014 were sparked by a combination of circumstances, including the on-going drought, strong east winds that carried dry, hot air from the deserts, human activity (for example, vehicles with hot engines parked on dry grass), and electrical infrastructure failure as a result of strong winds (S. Sullivan, Marine Corps Base Camp Pendleton, written commun., 2014). Other smaller fires on Base also have been ignited by military training involving the use of equipment that can ignite fires (for example, gunfire, vehicles with hot engines parked on dry grass; S. Sullivan, Marine Corps Base Camp Pendleton, written commun., 2014). 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 activities. 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.

Direct human impacts on vireo habitat were not documented in 2020, although continued attention to other potential activities (for example, weed control, off-road vehicle traffic) would provide documentation to assist in developing management actions to preserve and enhance vireo habitat. Closing high-speed roads in vireo habitat during vireo breeding season and prohibiting the use of firearms during dry, windy weather could minimize the chances of human-caused wildfires that damage and destroy vireo breeding habitat. Communication among personnel may reduce the instances of human-related impacts to vireos and occupied vireo habitat by allowing all participants to understand needs and flexibilities and adjust their activities accordingly. For instance, impacts to vireos and vireo habitat can be minimized when military training exercises and maintenance activities, such as clearing vegetation, are limited to outside the vireo breeding season or to areas not occupied by vireos. Improved understanding of factors influencing vireos and vireo habitat will provide managers with the improved scientific knowledge 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, 2020

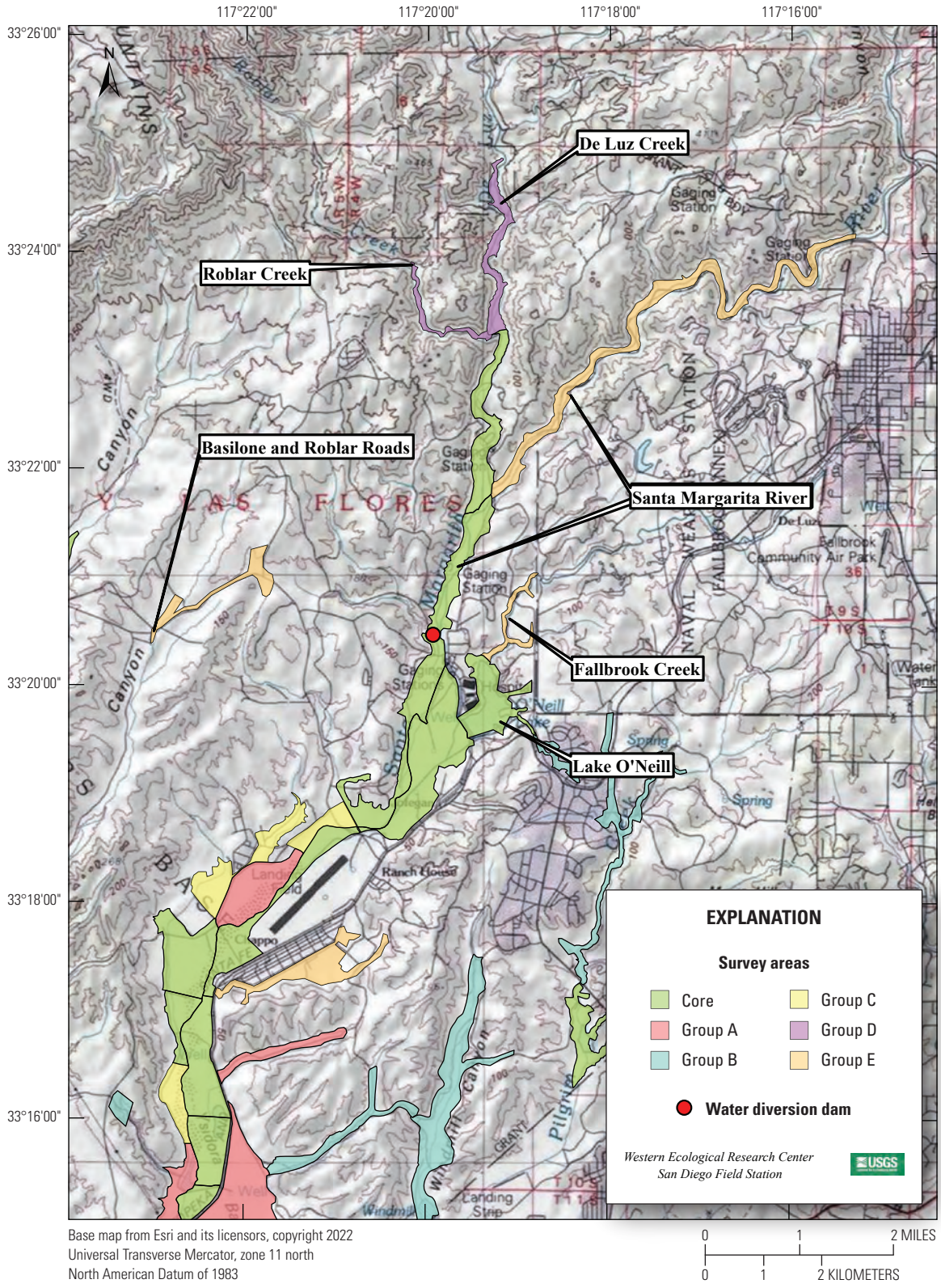

Figure 1.1. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2020: Upper Santa Margarita River, Fallbrook Creek, Lake O'Neill, De Luz Creek, Roblar Creek, and Basilone and Roblar Roads. Core areas and Group A areas were surveyed in 2020.

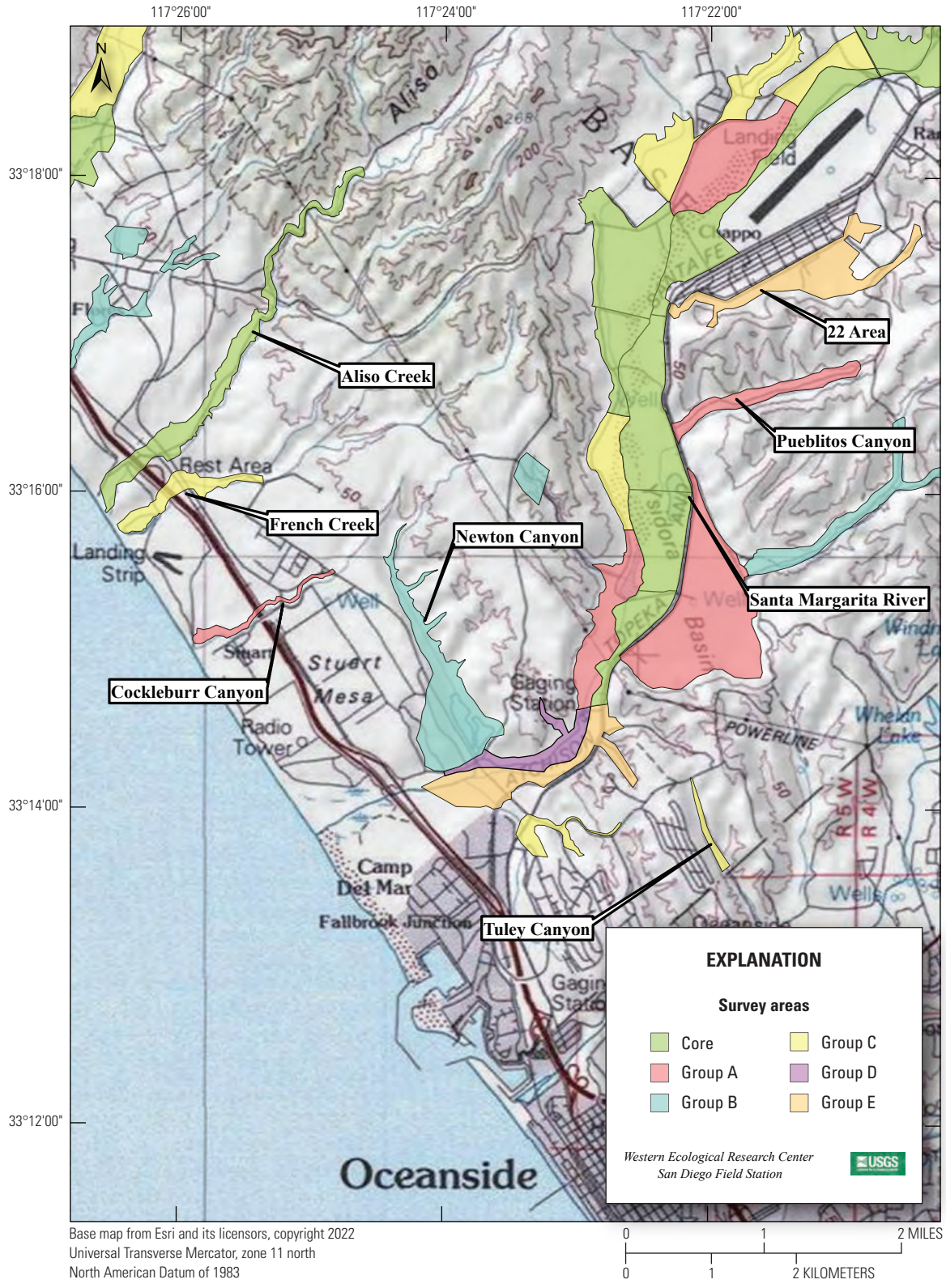

Figure 1.2. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2020: Lower Santa Margarita River, 22 Area, Pueblitos Canyon, Tuley Canyon, Newton Canyon, Cockleburr Canyon, French Creek, and Aliso Creek.

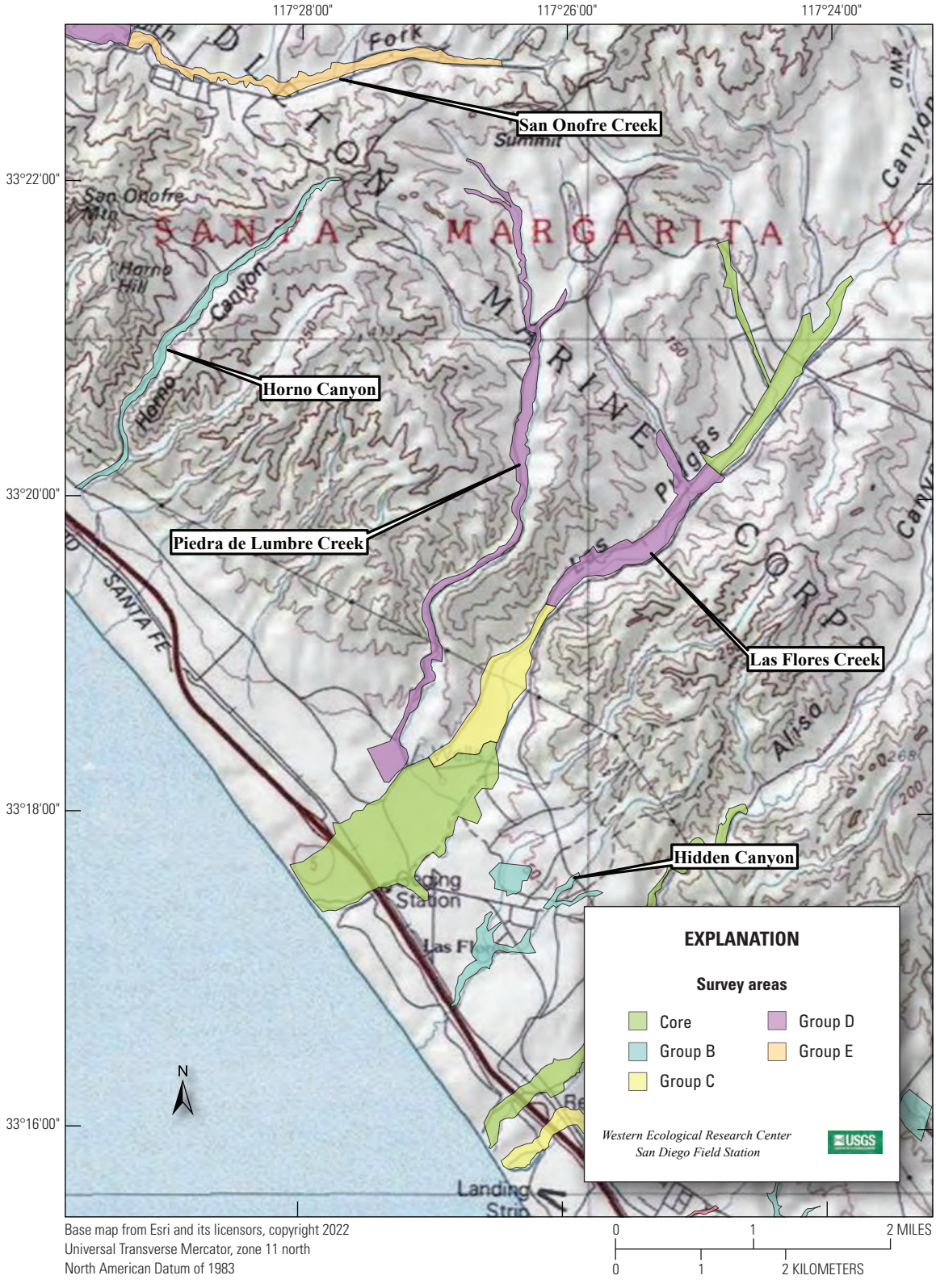

Figure 1.3. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2020: San Onofre Creek South Fork, Ammunition Supply Point, Horno Canyon, Piedra de Lumbre Canyon, Las Flores Creek, and Hidden Canyon.

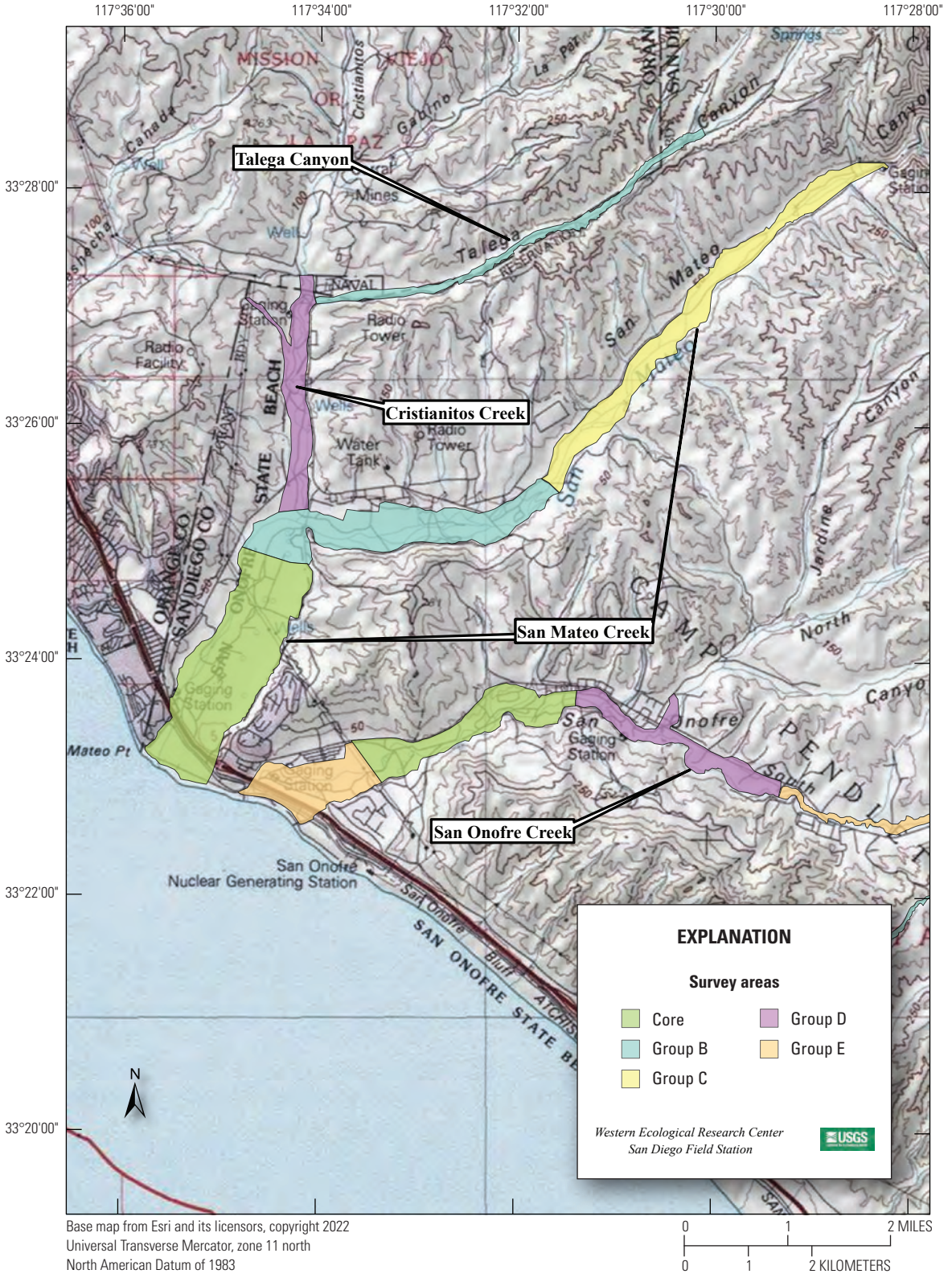

Figure 1.4. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2020: Talega Canyon, Cristianitos Creek, San Mateo Creek, and San Onofre Creek.

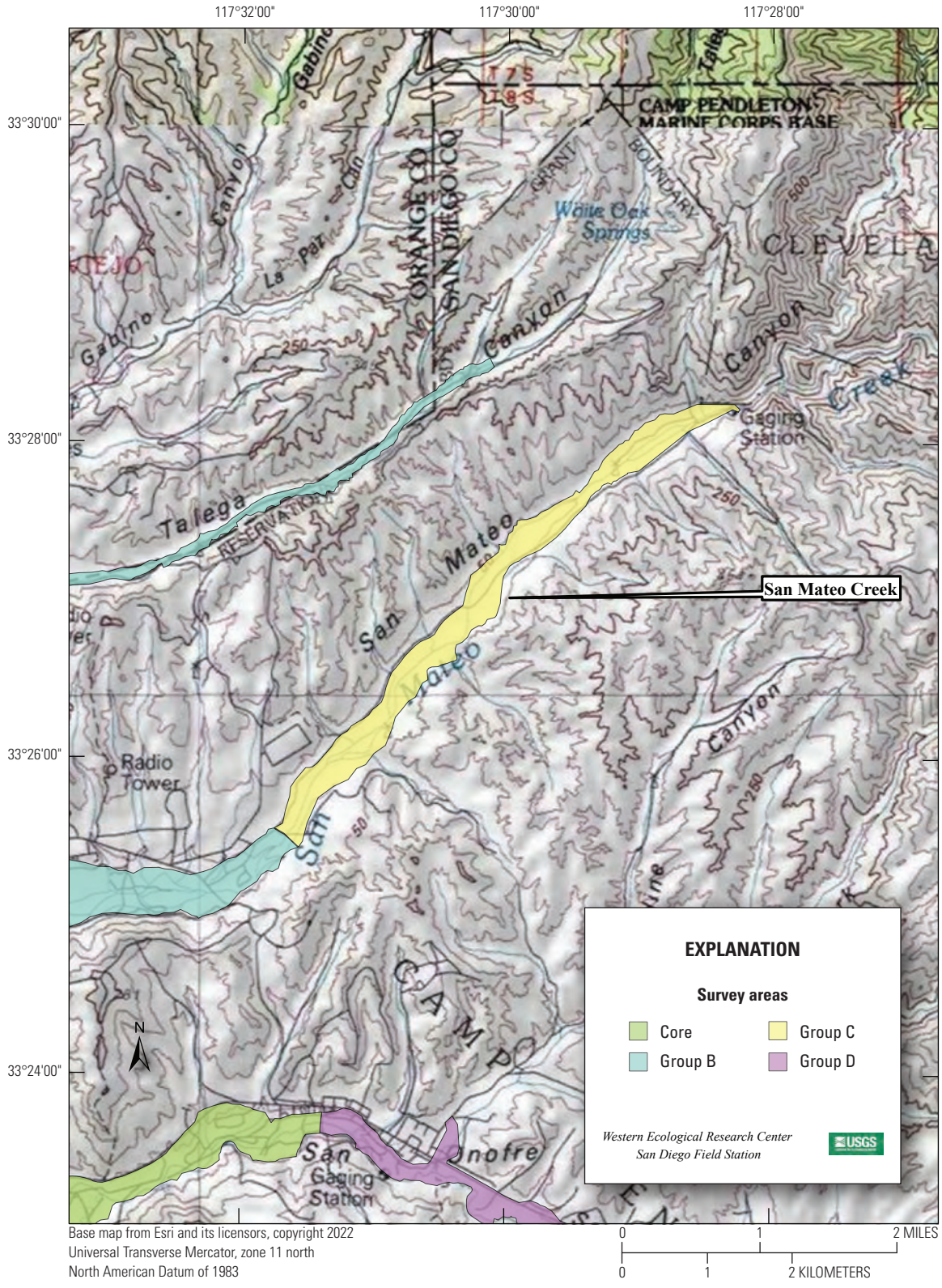

Figure 1.5. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2020: Upper San Mateo Creek.

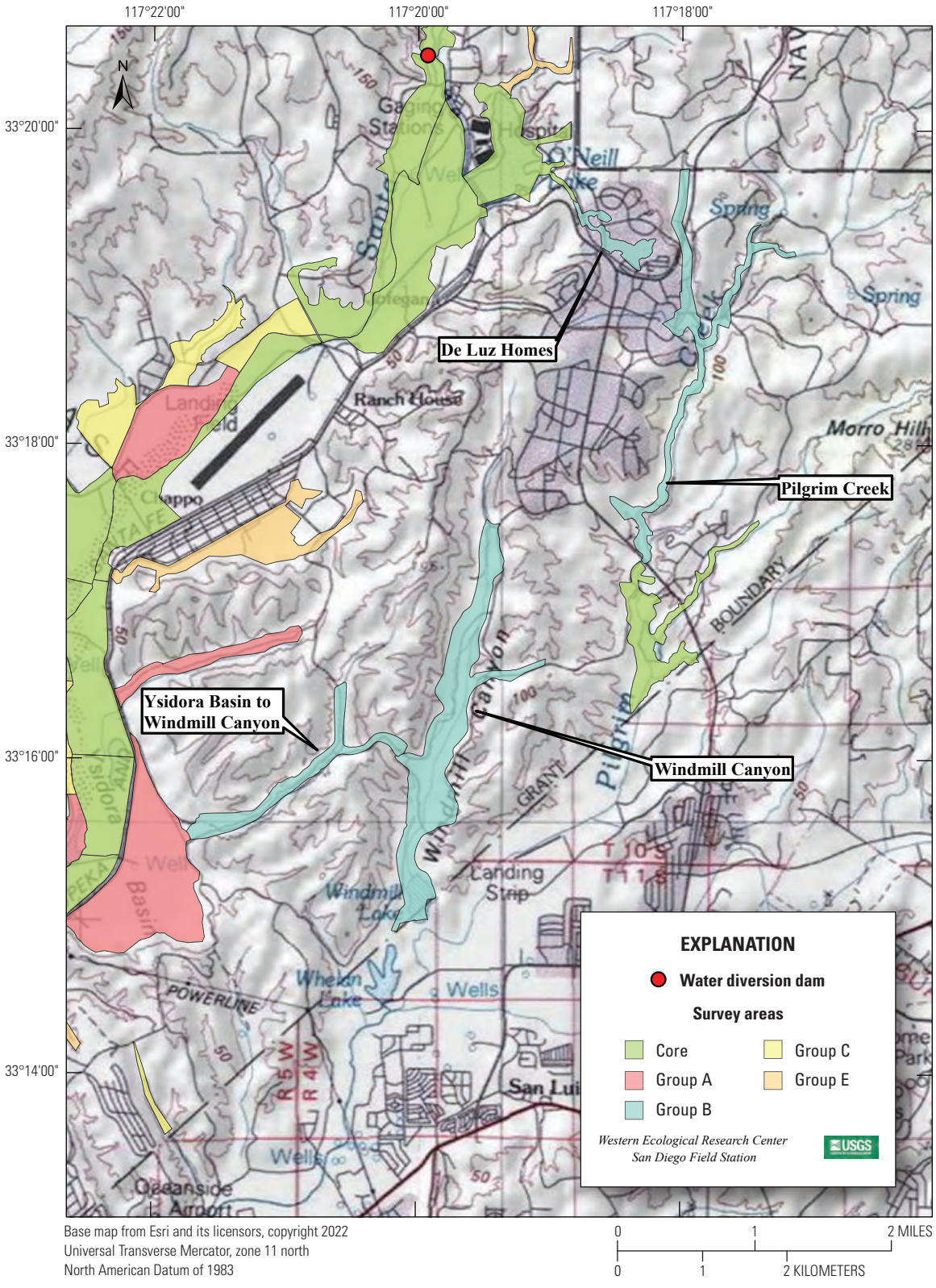

Figure 1.6. Least Bell's Vireo survey areas at Marine Corps Base Camp Pendleton, 2020: Windmill Canyon, Ysidora Basin to Windmill Canyon, Pilgrim Creek, and De Luz Homes Habitat.

Appendix 2. Vegetation Sampling Locations, Marine Corps Base Camp Pendleton, 2020

Table 2.1. Vegetation sampling locations, Marine Corps Base Camp Pendleton, 2020.

[WGS 84, World Geodic System of 1984]

Territory	Site	Longitude	Latitude	Datum
ACA	Reference	−117.37270	33.27076	WGS 84
AMO	Reference	−117.38093	33.27226	WGS 84
ANZ	Reference	−117.37439	33.26583	WGS 84
ARM	Reference	−117.37962	33.26943	WGS 84
ARW	Reference	−117.37748	33.28417	WGS 84
BGT	Reference	−117.37900	33.27067	WGS 84
BAX	Reference	−117.37310	33.27069	WGS 84
BRM	Reference	−117.37743	33.28330	WGS 84
BOR	Reference	−117.37515	33.26664	WGS 84
CAP	Reference	−117.37401	33.26671	WGS 84
CRX	Reference	−117.37779	33.27363	WGS 84
CHW	Seep	−117.37450	33.28148	WGS 84
CRA	Reference	−117.37489	33.27019	WGS 84
ELR	Reference	−117.38063	33.28614	WGS 84
ENC	Reference	−117.38119	33.27141	WGS 84
FRX	Reference	−117.37845	33.27105	WGS 84
FRO	Reference	−117.37900	33.28217	WGS 84
GAL	Reference	−117.37887	33.28350	WGS 84
GAN	Reference	−117.37868	33.28435	WGS 84
GIM	Reference	−117.37950	33.28569	WGS 84
GRD	Seep	−117.37526	33.27944	WGS 84
JAB	Seep	−117.37580	33.28194	WGS 84
KTM	Reference	−117.37252	33.27024	WGS 84
KNO	Seep	−117.37427	33.28058	WGS 84

Table 2.1. Vegetation sampling locations, Marine Corps Base Camp Pendleton, 2020.—Continued

[WGS 84, World Geodic System of 1984]

Territory	Site	Longitude	Latitude	Datum
KYL	Seep	−117.37491	33.28338	WGS 84
LEG	Reference	−117.38041	33.28372	WGS 84
MAL	Reference	−117.37954	33.27425	WGS 84
MRY	Reference	−117.37736	33.28217	WGS 84
NAZ	Reference	−117.38062	33.28485	WGS 84
OPT	Reference	−117.38113	33.27002	WGS 84
PAL	Seep	−117.37490	33.28229	WGS 84
PNA	Reference	−117.37343	33.26779	WGS 84
PIP	Reference	−117.37748	33.28150	WGS 84
Rey	Seep	−117.37532	33.28202	WGS 84
RHI	Reference	−117.37928	33.27482	WGS 84
ROK	Reference	−117.37613	33.27038	WGS 84
SAG	Reference	−117.37586	33.26837	WGS 84
SLX	Reference	−117.38044	33.27277	WGS 84
CSAL	Reference	−117.37839	33.27313	WGS 84
SAU	Reference	−117.37750	33.28504	WGS 84
SKY	Seep	−117.37400	33.28227	WGS 84
SMO	Reference	−117.37364	33.26673	WGS 84
SLO	Seep	−117.37587	33.28104	WGS 84
TET	Reference	−117.37494	33.26848	WGS 84
VAD	Seep	−117.37380	33.28310	WGS 84
VIT	Reference	−117.37852	33.27013	WGS 84
WIC	Seep	−117.37356	33.28191	WGS 84
YOD	Seep	−117.37467	33.28060	WGS 84

Pendleton Seep Vegetation Data Form — 2020

Observer(s): _____ Date: _____2020 Drainage: _____ Plot ID: _____

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

Center Plot										
Height	Overall Foliage Cover	Exotics 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	Exotics 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. Pendleton Seep Vegetation Data Form—2020.

Pendleton Seep Vegetation Data Form —2020

Observer(s): _____ Date: 2020 Drainage: _____ Plot ID: _____

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

120 Degrees Plot

Height	Overall Foliage Cover	Exotics 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	Exotics		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, 2020

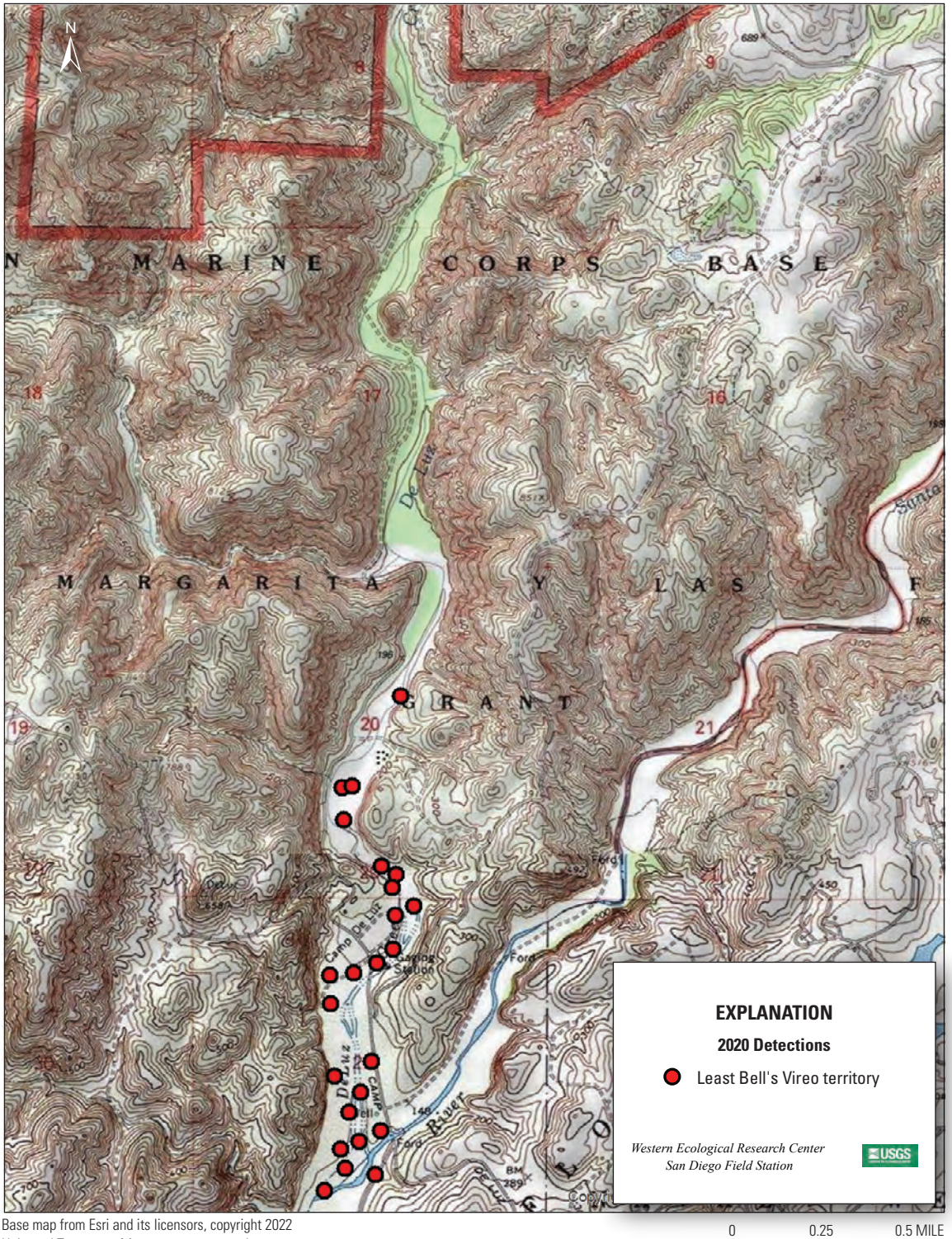

Figure 3.1. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020: De Luz Creek.

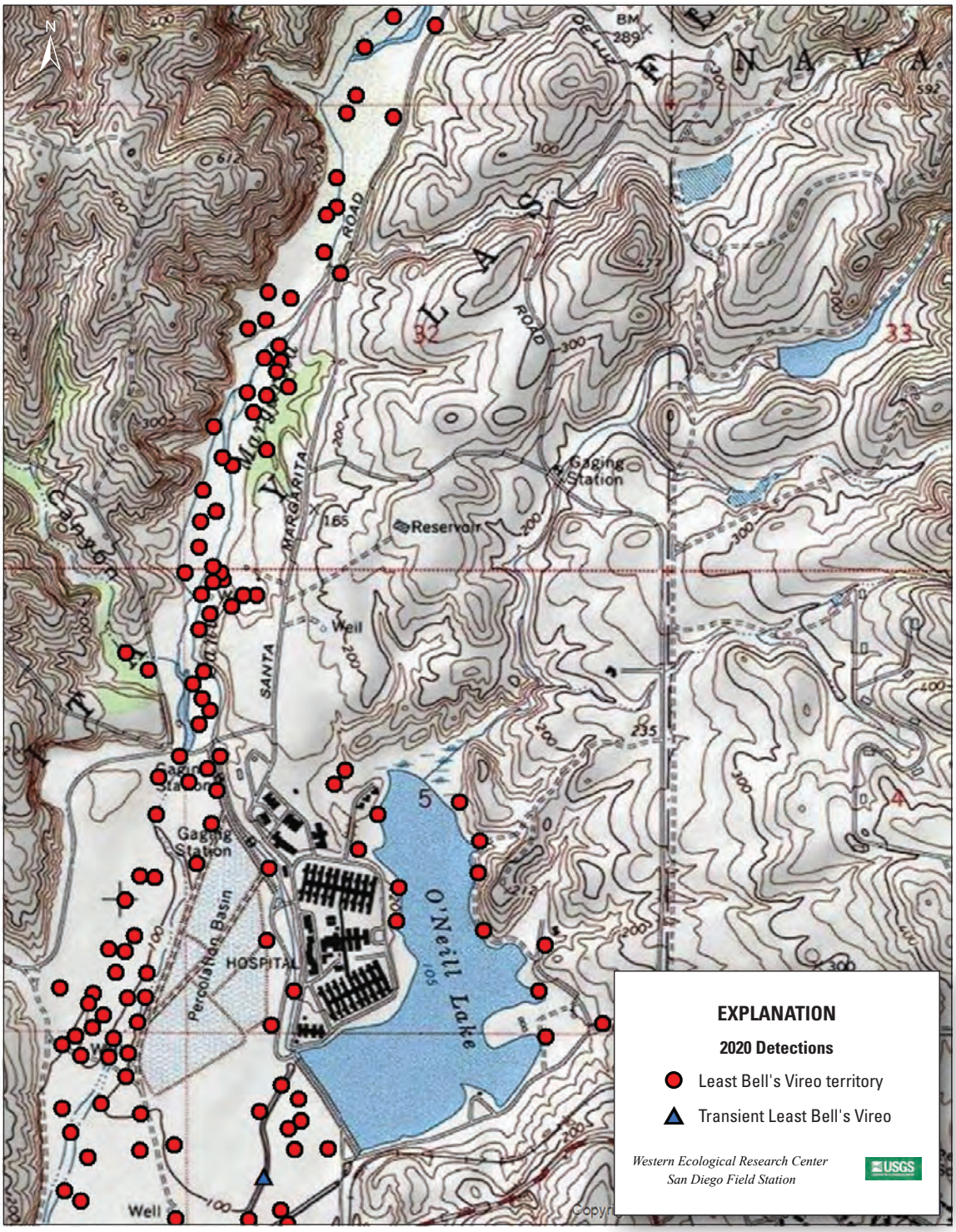

Figure 3.2. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020: Santa Margarita River and Lake O'Neill.

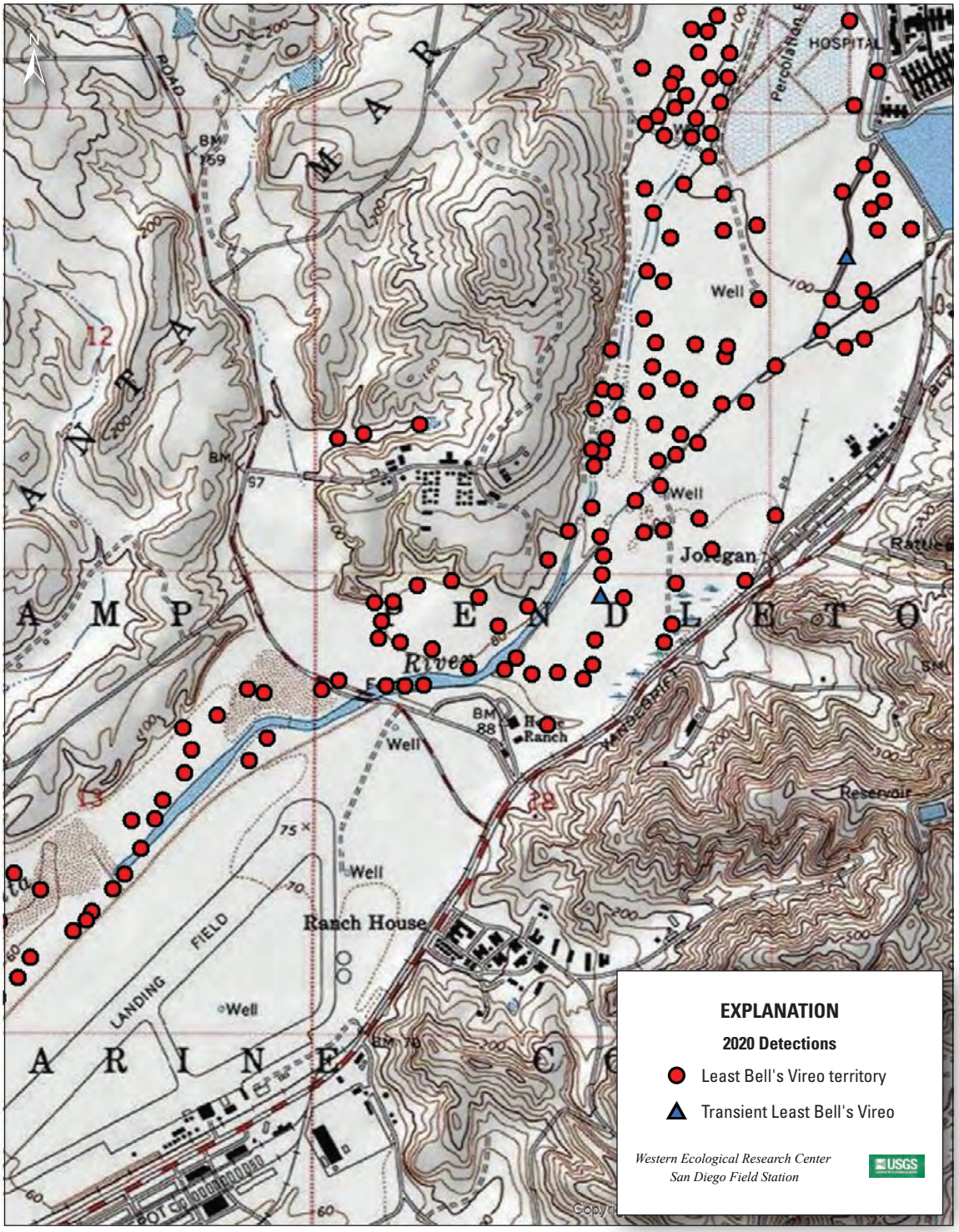

Figure 3.3. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020: Santa Margarita River.

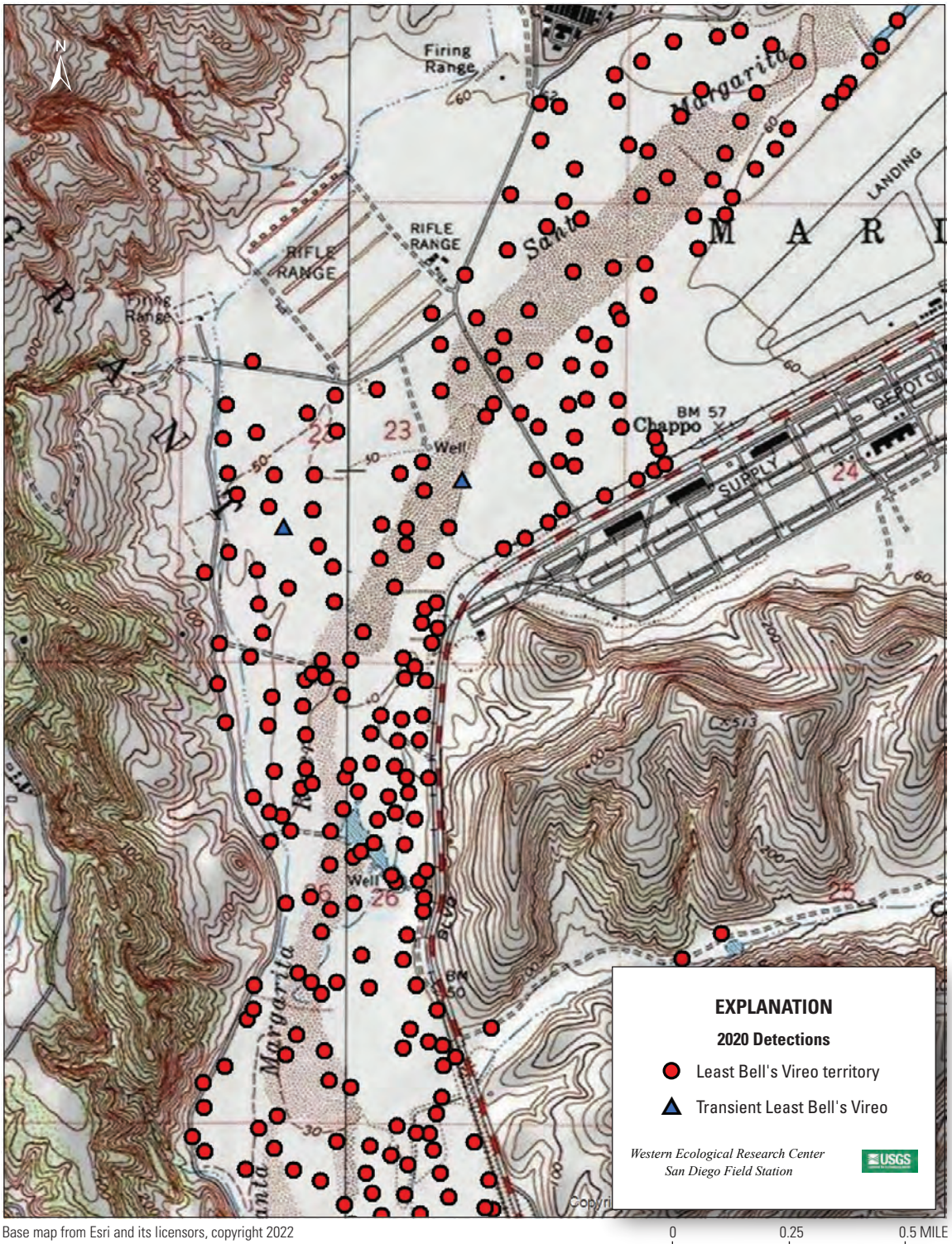

Figure 3.4. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020: Santa Margarita River and Pueblitos Canyon.

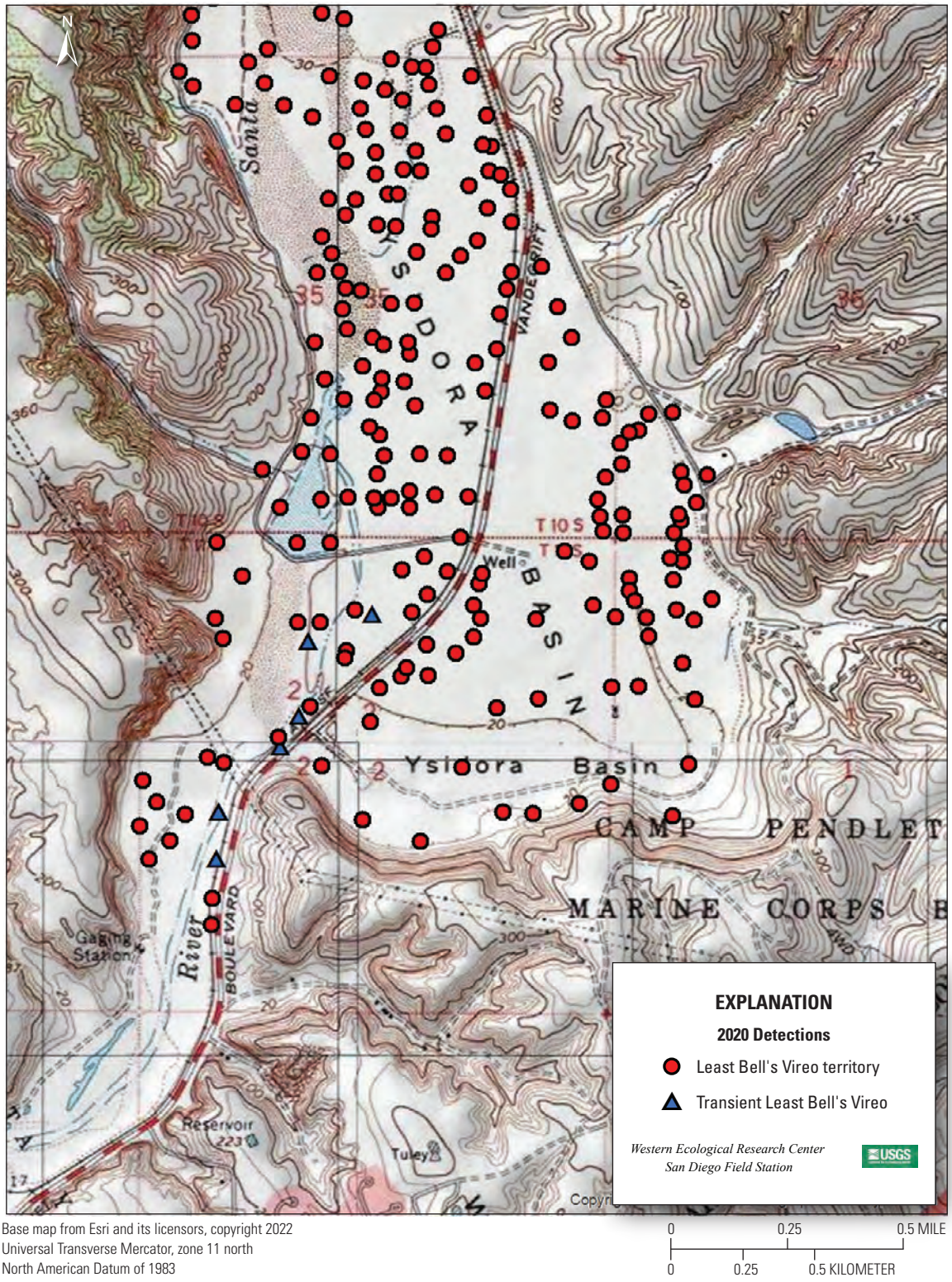

Figure 3.5. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020: Santa Margarita River and Ysidora Basin.

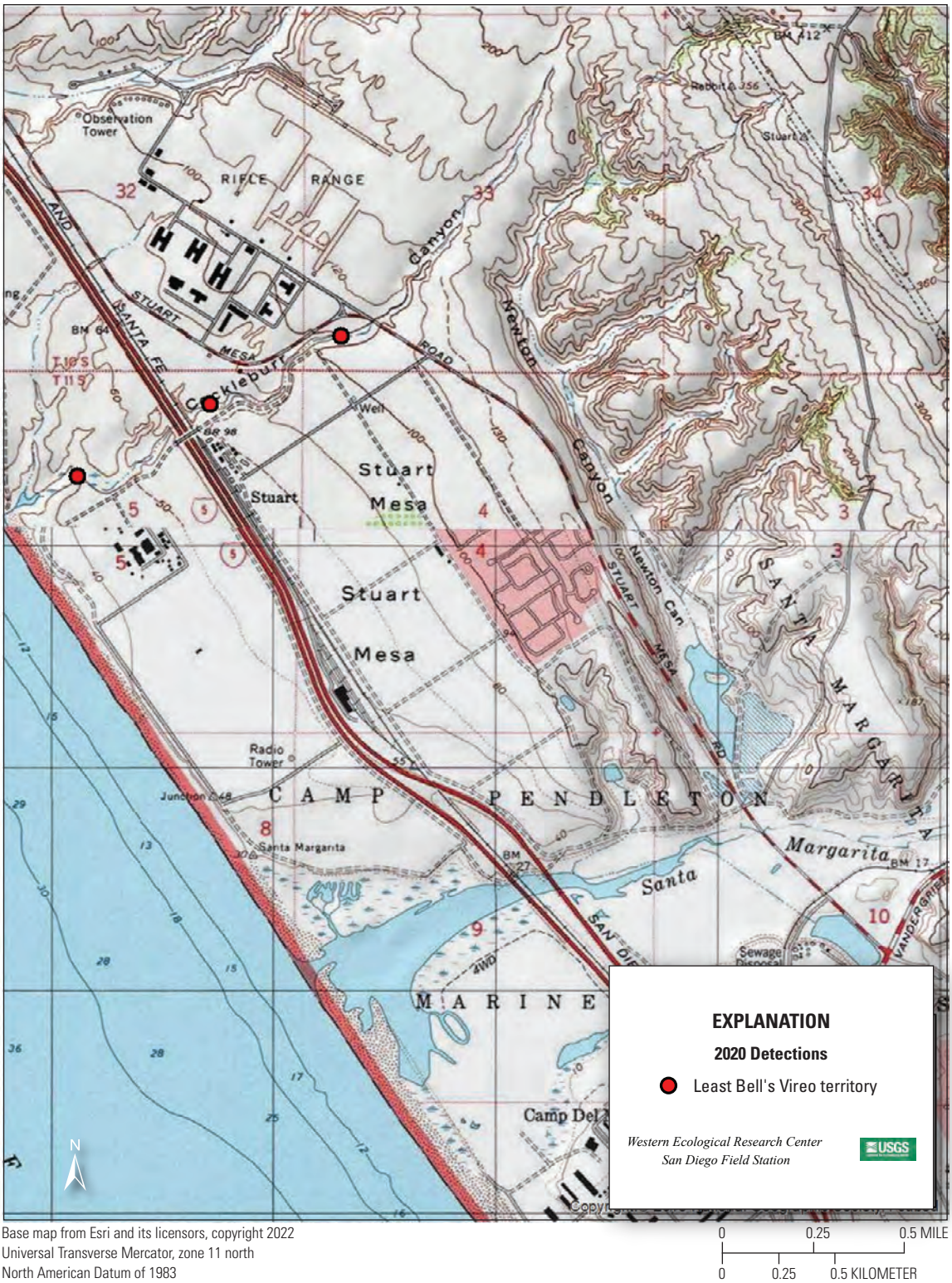

Figure 3.6. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020: Cockleburr Canyon.

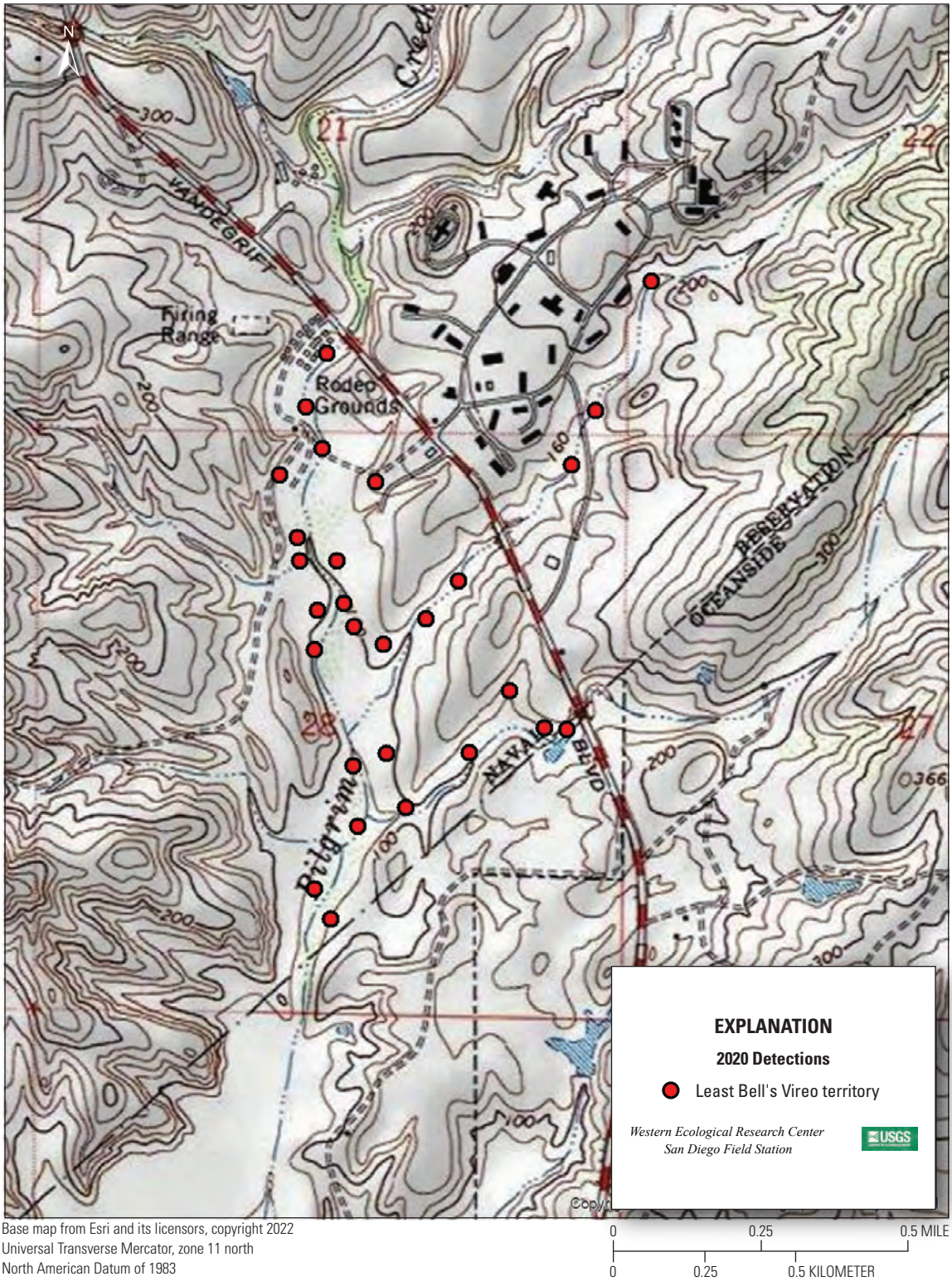

Figure 3.7. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020: Lower Pilgrim Creek.

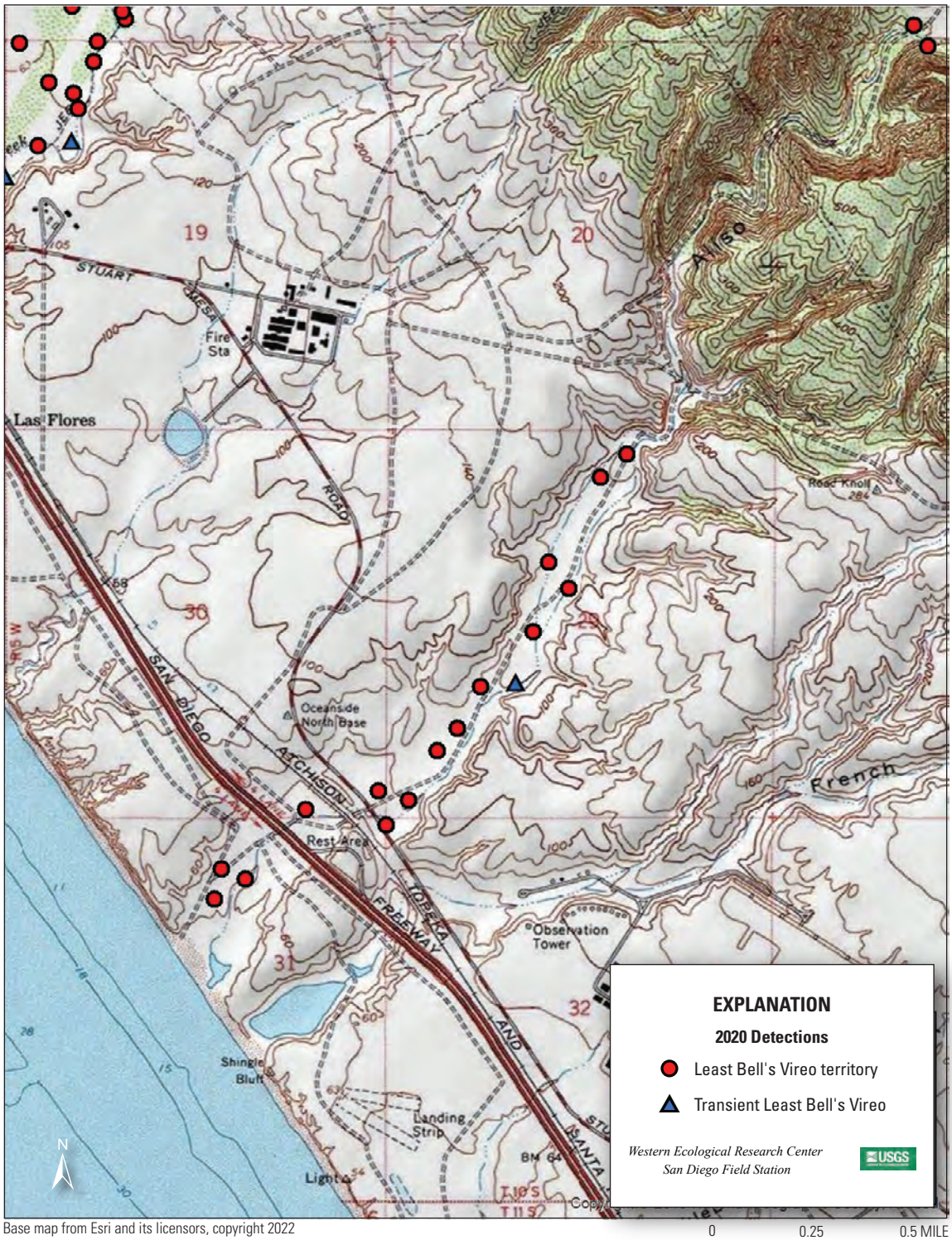

Figure 3.8. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020: Aliso Creek.

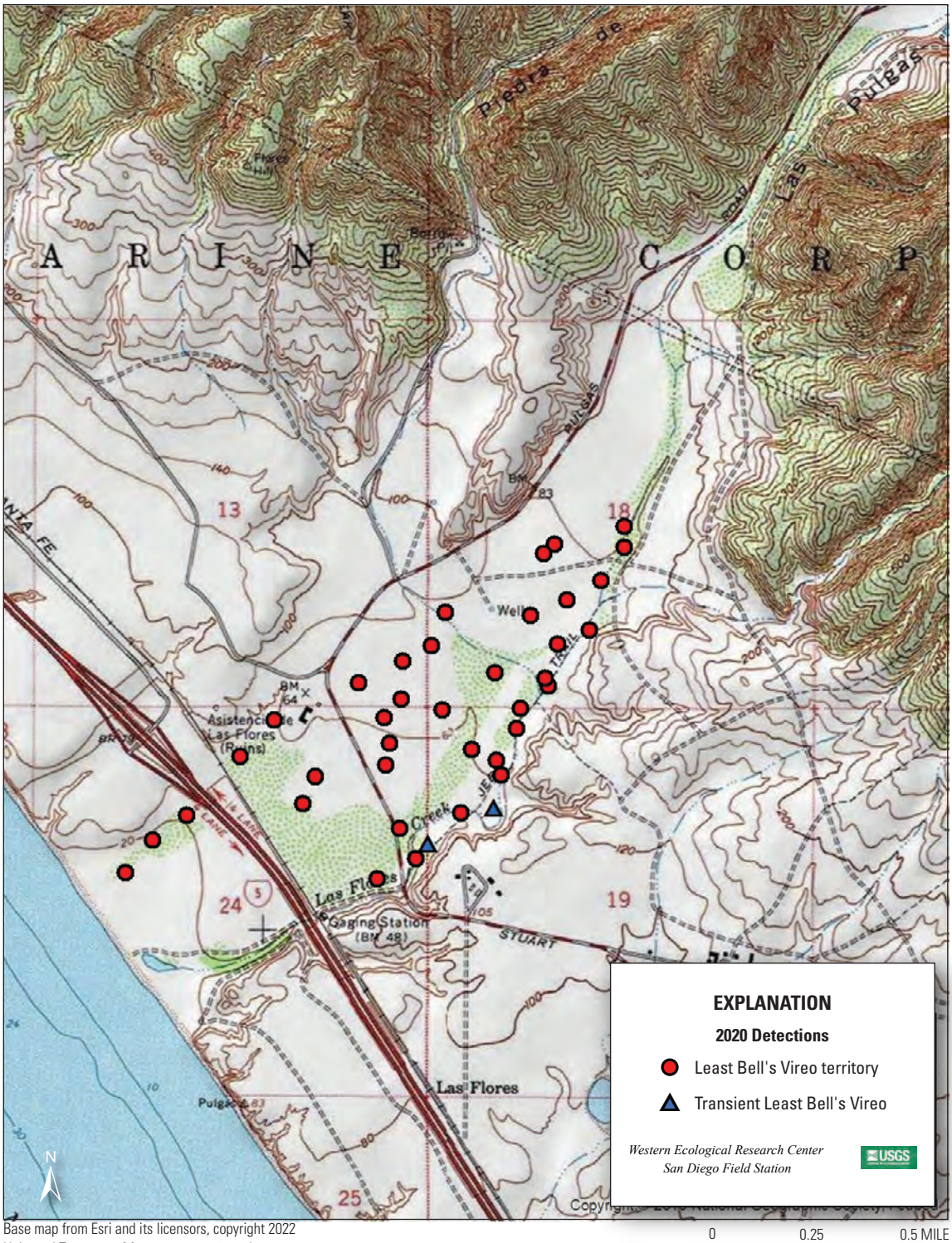

Figure 3.9. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020: Lower Las Flores Creek.

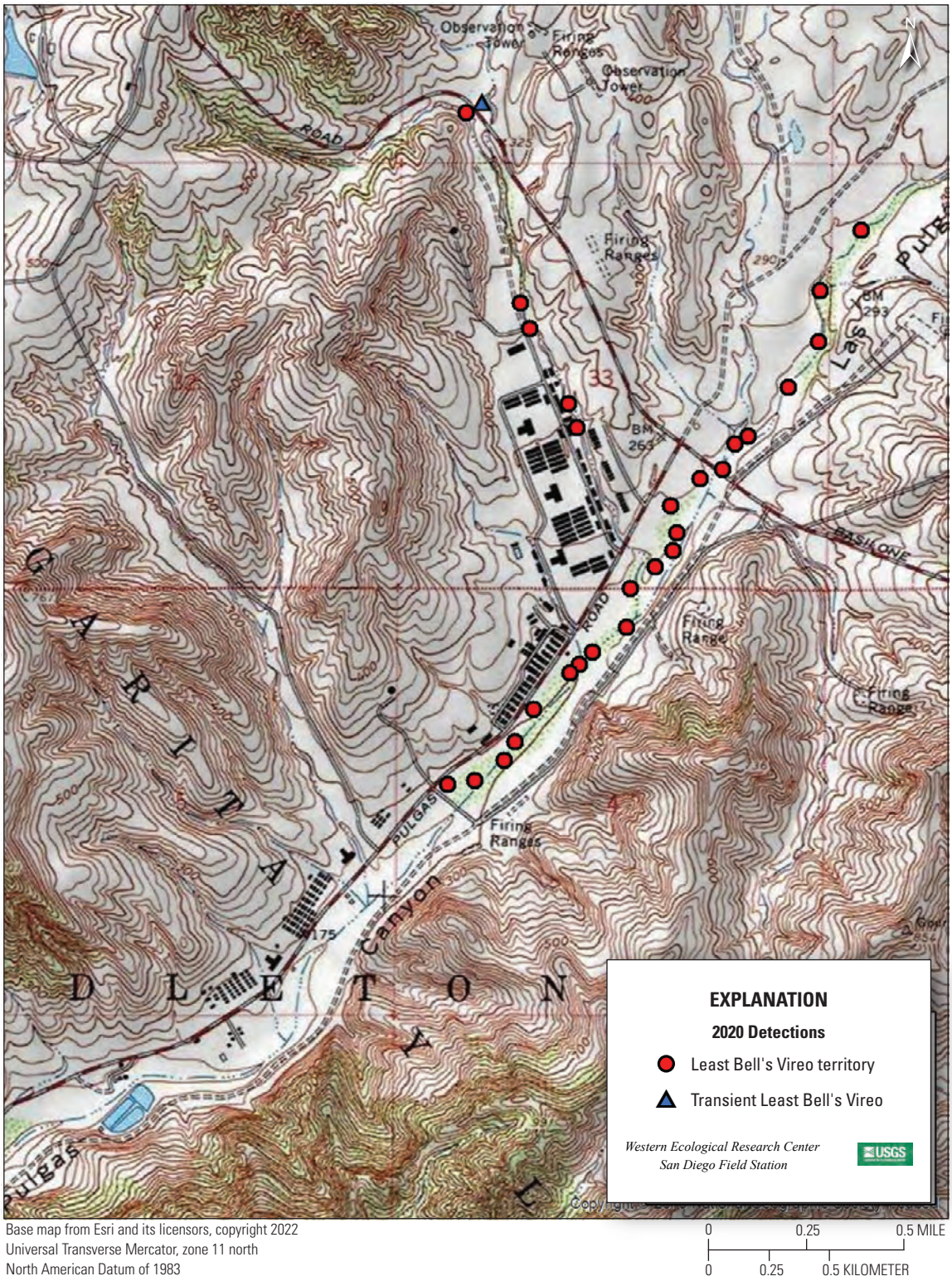

Figure 3.10. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020: Upper Las Flores Creek.

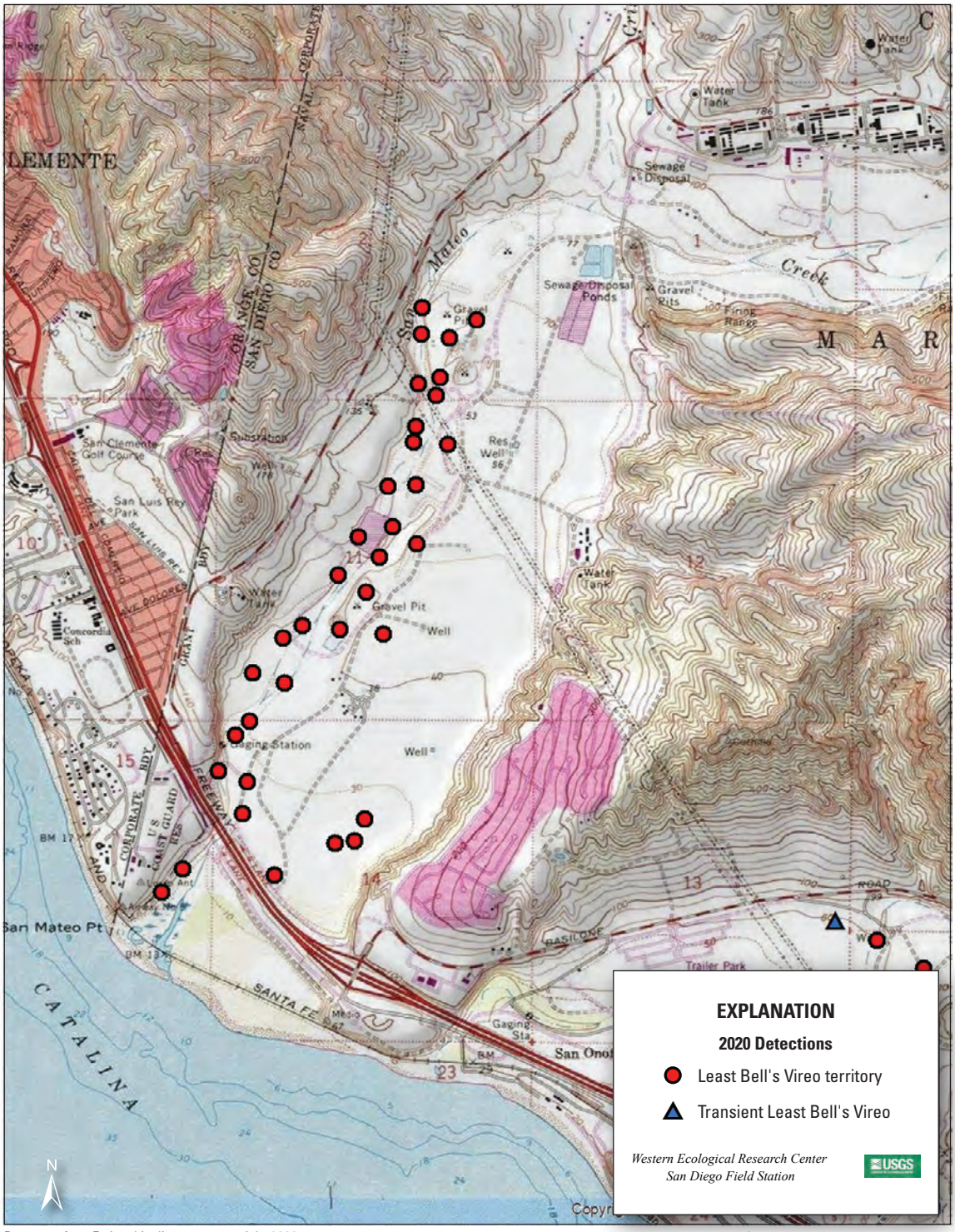

Figure 3.11. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020: Lower San Onofre Creek and Lower San Mateo Creek.

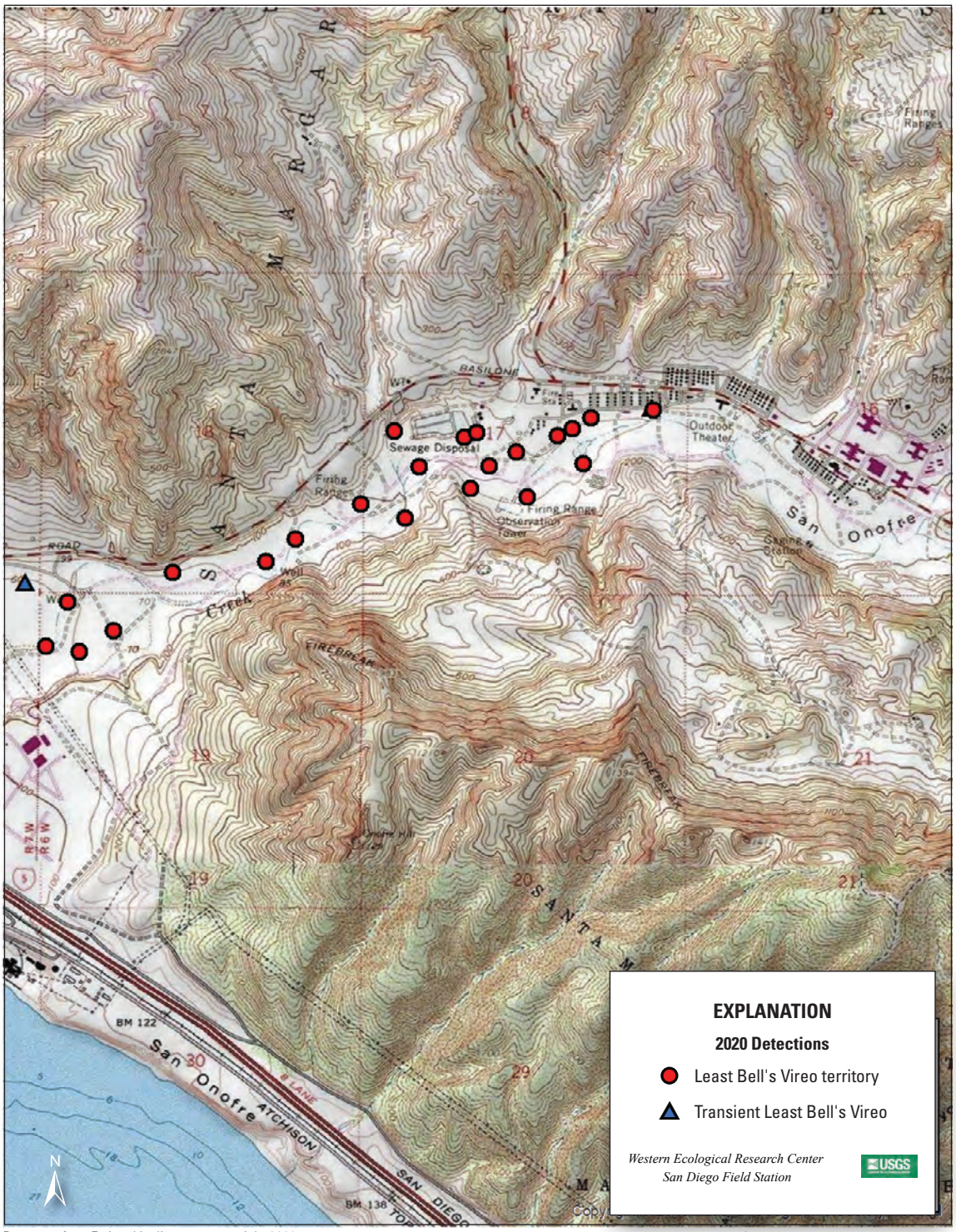

Figure 3.12. Locations of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020: San Onofre Creek (West).

Appendix 4. Banded Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020

Table 4.1. Banded Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020.

[**Band colors**: OROR, plastic orange; PUOR, plastic purple-orange split; Mgo, gold numbered federal band; DPWH, plastic dark pink-white split; BPST, plastic black-pink striped; ORDG, plastic orange-dark green split; BKYE, plastic black-yellow split; PUWH, plastic purple-white split; BKBK, plastic black; PUYE, plastic purple-yellow split; WHDP, plastic white-dark pink split; DGOR, plastic dark green-orange split; DPDP, plastic dark pink; DBWH, plastic dark blue-white split; YEBK, plastic yellow-black split; DBDP, plastic dark blue-dark pink split; Mdb, dark blue numbered federal band; WHPU, plastic white-purple split; PUPU, plastic purple; BWST, plastic dark blue-white striped; YEYE, plastic yellow; YEPU, plastic yellow-purple split; ORPU, plastic orange-purple split; BYST, plastic black-yellow striped; gogo, metal gold; Mye, yellow numbered metal band; WHDB, plastic white-dark blue split; pupu, metal purple; WHWH, plastic white; Msi, silver numbered federal band. **Sex**: M, male; F, female. **Location codes** in comments: DL MAPS, De Luz MAPS; SMR, Santa Margarita River; SM MAPS, Santa Margarita MAPS Station; SLR, San Luis Rey River; MCAS, Marine Corps Air Station, Camp Pendleton. All other 3-letter codes are territory designations. **Abbreviations:** ≥, greater than or equal to; —, no bands observed; ?, band status unknown]

Sex	Band combination		Age, in years	Comments
	Left leg	Right leg		
			De Luz Creek	
M	OROR	PUOR Mgo	≥4	Banded as an adult at LEM in 2017.
F	DPWH Mgo	BPST	≥3	Banded as an adult at DL MAPS in 2018.
M	ORDG	BKYE Mgo	≥3	Banded as an adult at WOM in 2018.
M	PUWH Mgo	BKBK	3	Banded as an adult at AH01 in 2018.
M	PUWH Mgo	BPST	≥2	Banded as an adult at ERM in 2019.
M	PUYE	WHDP Mgo	≥2	Banded as an adult at IMP in 2019.
F	—	Mgo	≥1	Banded as a nestling on the SMR before 2020.
M	—	Mgo	≥1	Banded as a nestling on the SMR before 2020.
			Fallbrook Creek	
M	DGOR	BPST Mgo	3	Banded as a nestling at KHA in 2017.
M	DPDP	BPST Mgo	1	Banded as a nestling at HDX in 2019.
			Las Flores Creek	
F	BPST	DBWH Mdb	1	Banded as a nestling on the SLR in 2019.
M	YEBK	BKBK Mgo	1	Banded as a juvenile at SM MAPS in 2019.
			Pilgrim Creek	
F	BKBK	DBDP Mdb	3	Banded as a nestling on the SLR in 2017.
M	WHPU Mdb	DPWH	2	Banded as a nestling on the SLR in 2018.
F	—	Mdb	≥1	Banded as a nestling on the SLR before 2020.
M	BPST	PUPU Mdb	1	Banded as a nestling on the SLR in 2019.
			Pueblitos Creek	
M	BPST	BWST Mdb	1	Banded as a nestling on the SLR in 2019.
			Santa Margarita River	
M	ORDG Mgo	YEYE	8	Banded as a nestling at ONX in 2012.
M	YEPU Mdb	YEYE	8	Banded as a nestling on the SLR in 2012.
M	WHDP	WHDP Mgo	7	Banded as a nestling at CKI in 2013.
M	ORDG	PUOR Mgo	≥6	Banded as an adult at UNI in 2015.
M	ORPU Mgo	ORPU	≥6	Banded as an adult at DRO in 2015.
M	WHDP	ORDG Mgo	≥6	Banded as an adult at SM MAPS in 2015.
M	WHPU Mgo	—	≥6	Banded as an adult at HOL in 2015.
F	YEPU	ORDG Mgo	≥5	Banded as an adult at SM MAPS in 2016.
M	ORDG Mgo	WHPU	≥5	Banded as an adult at LNS in 2016.

Table 4.1. Banded Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020.—Continued

[**Band colors**: OROR, plastic orange; PUOR, plastic purple-orange split; Mgo, gold numbered federal band; DPWH, plastic dark pink-white split; BPST, plastic black-pink striped; ORDG, plastic orange-dark green split; BKYE, plastic black-yellow split; PUWH, plastic purple-white split; BKBK, plastic black; PUYE, plastic purple-yellow split; WHDP, plastic white-dark pink split; DGOR, plastic dark green-orange split; DPDP, plastic dark pink; DBWH, plastic dark blue-white split; YEBK, plastic yellow-black split; DBDP, plastic dark blue-dark pink split; Mdb, dark blue numbered federal band; WHPU, plastic white-purple split; PUPU, plastic purple; BWST, plastic dark blue-white striped; YEYE, plastic yellow; YEPU, plastic yellow-purple split; ORPU, plastic orange-purple split; BYST, plastic black-yellow striped; gogo, metal gold; Mye, yellow numbered metal band; WHDB, plastic white-dark blue split; pupu, metal purple; WHWH, plastic white; Msi, silver numbered federal band. **Sex**: M, male; F, female. **Location codes** in comments: DL MAPS, De Luz MAPS; SMR, Santa Margarita River; SM MAPS, Santa Margarita MAPS Station; SLR, San Luis Rey River; MCAS, Marine Corps Air Station, Camp Pendleton. All other 3-letter codes are territory designations. **Abbreviations:** ≥, greater than or equal to; —, no bands observed; ?, band status unknown]

Sex	Band combination		Age, in years	Comments
	Left leg	Right leg		
			Santa Margarita River—Continued	
F	BPST	DPDP Mgo	5	Banded as a nestling at ARI in 2015.
M	ORDG	BKBK Mgo	5	Banded as a nestling at KNG in 2015.
M	ORDG	YEYE Mgo	5	Banded as a nestling at KOA in 2015.
M	WHDP	ORPU Mgo	5	Banded as a nestling at HDX in 2015.
M	YEPU	DPWH Mgo	5	Banded as a nestling at MCAS in 2015.
F	OROR	DPDP Mgo	≥4	Banded as an adult at SM MAPS in 2017.
M	BYST	PUOR Mgo	≥4	Banded as an adult at ARY in 2017.
M	OROR	ORPU Mgo	≥4	Banded as an adult at SM MAPS in 2017.
M	PUWH gogo	Mye	≥4	Banded as an adult in Miraflores, Baja California Sur in 2017.
M	WHDP	—	≥4	Banded as an adult at MOR in 2017.
M	WHPU Mgo	ORDG	≥4	Banded as an adult at PEP in 2017.
M	YEYE	Mgo	≥4	Banded as an adult at SM MAPS in 2017.
F	WHDB Mdb	WHDB	4	Banded as a nestling on the SLR in 2016.
M	DPWH Mgo	DGOR	4	Banded as a nestling at UNI in 2016.
M	YEYE Mdb	pupu	4	Banded as a nestling on the SLR in 2016.
F	YEYE	YEPU Mgo	≥3	Banded as an adult at SM MAPS in 2018.
M	—	BPST	≥3	Banded as an adult at CED in 2018.
M	PUWH Mgo	BYST	≥3	Banded as an adult at FAU in 2018.
F	BKBK	WHPU Mdb	3	Banded as a nestling on the SLR in 2017.
F	BKYE	YEYE Mgo	3	Banded as a nestling at MOR in 2017.
M	—	WHPU	3	Banded as an adult at SM MAPS in 2018.
M	BPST	ORDG Mgo	3	Banded as a nestling at BAD in 2017.
M	BPST	OROR Mgo	3	Banded as a nestling at ZYL in 2017.
M	BPST	WHWH Mdb	3	Banded as a nestling on the SLR in 2017.
M	BYST	PUWH Mgo	3	Banded as a nestling at ZAM in 2017.
M	ORDG	BPST Mgo	3	Banded as a nestling at MOU in 2017.
M	ORDG	ORPU Mgo	3	Banded as a nestling at KOA in 2017.
M	ORDG	YEBK Mgo	3	Banded as a nestling at KNG in 2017.
M	OROR	YEPU Mgo	3	Banded as a nestling at DAQ in 2017.
M	YEYE	PUOR Mgo	3	Banded as a nestling at BRU in 2017.
F	BKBK	ORPU Msi	≥2	Banded as an adult at SM MAPS in 2019.
F	BKYE Mgo	DPDP	≥2	Banded as an adult at SM MAPS in 2019.
M	BKBK	ORDG Msi	≥2	Banded as an adult at SM MAPS in 2019.
M	BKYE	WHWH Mgo	≥2	Banded as an adult at BAE in 2019.
M	BPST	BKYE Mye	≥2	Banded as an adult in Miraflores, Baja California Sur in 2019.

Table 4.1. Banded Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020.—Continued

[**Band colors**: OROR, plastic orange; PUOR, plastic purple-orange split; Mgo, gold numbered federal band; DPWH, plastic dark pink-white split; BPST, plastic black-pink striped; ORDG, plastic orange-dark green split; BKYE, plastic black-yellow split; PUWH, plastic purple-white split; BKBK, plastic black; PUYE, plastic purple-yellow split; WHDP, plastic white-dark pink split; DGOR, plastic dark green-orange split; DPDP, plastic dark pink; DBWH, plastic dark blue-white split; YEBK, plastic yellow-black split; DBDP, plastic dark blue-dark pink split; Mdb, dark blue numbered federal band; WHPU, plastic white-purple split; PUPU, plastic purple; BWST, plastic dark blue-white striped; YEYE, plastic yellow; YEPU, plastic yellow-purple split; ORPU, plastic orange-purple split; BYST, plastic black-yellow striped; gogo, metal gold; Mye, yellow numbered metal band; WHDB, plastic white-dark blue split; pupu, metal purple; WHWH, plastic white; Msi, silver numbered federal band. **Sex**: M, male; F, female. **Location codes** in comments: DL MAPS, De Luz MAPS; SMR, Santa Margarita River; SM MAPS, Santa Margarita MAPS Station; SLR, San Luis Rey River; MCAS, Marine Corps Air Station, Camp Pendleton. All other 3-letter codes are territory designations. **Abbreviations:** ≥, greater than or equal to; —, no bands observed; ?, band status unknown]

Sex	Band combination		Age, in years	Comments
	Left leg	Right leg		
			Santa Margarita River—Continued	
M	BPST	PUOR Mgo	≥2	Banded as an adult at MER in 2019.
M	DPWH Mgo	PUOR	≥2	Banded as an adult at SM MAPS in 2019.
M	pupu	BKYE Mgo	≥2	Banded as an adult at RNR in 2019.
M	WHPU	WHPU Mgo	≥2	Banded as an adult at HLD in 2019.
M	WHPU	WHWH Mgo	≥2	Banded as an adult at ZUS in 2019.
F	BKBK Mgo	BPST	2	Banded as a nestling at DRO in 2018.
F	DPDP Mdb	BPST	2	Banded as a nestling on the SLR in 2018.
M	—	BPST	2	Banded as a nestling at LEM in 2018.
M	DPWH	BPST Mgo	2	Banded as an adult at MOU in 2019.
M	PUOR	BKYE Mgo	2	Banded as an adult at SM MAPS in 2019.
M	WHPU	YEBK Mgo	2	Banded as an adult at ARL in 2019.
M	WHPU Mgo	WHPU	2	Banded as a nestling at DAQ in 2018.
M	WHPU Mgo	YEPU	2	Banded as a nestling at ARY in 2018.
M	YEPU Mgo	DPWH	2	Banded as a nestling at BIL in 2018.
F	—	Mdb	≥1	Banded as a nestling on the SLR before 2020.
F	—	Mgo	≥1	Banded as a nestling at MCBCP before 2020.
F	BPST	Mgo	≥1	Banded as an adult at ARW in 2020.
F	BPST Mgo	WHPU	≥1	Banded as an adult at RHI in 2020.
F	BPST Mgo	YEYE	≥1	Banded as an adult at BRM in 2020.
F	Mgo	—	≥1	Banded as a nestling on the SMR before 2020.
F	Mgo	—	≥1	Banded as a nestling on the SMR before 2020.
F	Mgo	YEYE pupu	≥1	Banded as an adult at FRO in 2020.
F	pupu	BKYE Mgo	≥1	Banded as an adult at MRY in 2020.
F	PUWH Msi	—	≥1	Banded at age unknown at an unknown location before 2020.
M	—	Mgo	≥1	Banded as a nestling on the SMR before 2020.
M	—	Msi	≥1	Banded as a juvenile at an unknown location before 2020.
M	?	ORDG Mgo	≥1	Banded at age unknown on the SMR before 2020.
M	BKBK	Mgo	≥1	Banded as an adult at FRO in 2020.
M	DGOR	Mgo	≥1	Banded as an adult at SMW in 2020.
M	DGOR Mgo	YEYE	≥1	Banded as an adult at SAU in 2020.
M	DPWH Mgo	BYST	≥1	Banded as an adult at SHD in 2020.
M	Mgo	DPWH	≥1	Banded as an adult at CAP in 2020.
M	Mgo	ORPU	≥1	Banded as an adult at CRA in 2020.

Table 4.1. Banded Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020.—Continued

[**Band colors**: OROR, plastic orange; PUOR, plastic purple-orange split; Mgo, gold numbered federal band; DPWH, plastic dark pink-white split; BPST, plastic black-pink striped; ORDG, plastic orange-dark green split; BKYE, plastic black-yellow split; PUWH, plastic purple-white split; BKBK, plastic black; PUYE, plastic purple-yellow split; WHDP, plastic white-dark pink split; DGOR, plastic dark green-orange split; DPDP, plastic dark pink; DBWH, plastic dark blue-white split; YEBK, plastic yellow-black split; DBDP, plastic dark blue-dark pink split; Mdb, dark blue numbered federal band; WHPU, plastic white-purple split; PUPU, plastic purple; BWST, plastic dark blue-white striped; YEYE, plastic yellow; YEPU, plastic yellow-purple split; ORPU, plastic orange-purple split; BYST, plastic black-yellow striped; gogo, metal gold; Mye, yellow numbered metal band; WHDB, plastic white-dark blue split; pupu, metal purple; WHWH, plastic white; Msi, silver numbered federal band. **Sex**: M, male; F, female. **Location codes** in comments: DL MAPS, De Luz MAPS; SMR, Santa Margarita River; SM MAPS, Santa Margarita MAPS Station; SLR, San Luis Rey River; MCAS, Marine Corps Air Station, Camp Pendleton. All other 3-letter codes are territory designations. **Abbreviations:** ≥, greater than or equal to; —, no bands observed; ?, band status unknown]

Sex	Band combination		Age, in years	Comments
	Left leg	Right leg		
			Santa Margarita River—Continued	
M	Mgo	PUPU	≥1	Banded as an adult at GAN in 2020.
M	Mgo	PUWH	≥1	Banded as an adult at SKY in 2020.
M	Msi	—	≥1	Banded as a nestling at MCAS before 2020.
M	Msi	—	≥1	Banded as a nestling at MCAS before 2020.
M	ORDG Mgo	ORDG	≥1	Banded as an adult at KTM in 2020.
M	ORDG Mgo	YEPU	≥1	Banded as an adult at MAL in 2020.
M	ORDG Mgo	BPST	≥1	Banded as an adult at KNO in 2020.
M	PUOR Mgo	YEPU	≥1	Banded as an adult at GAL in 2020.
M	PUOR Mgo	YEYE	≥1	Banded as an adult at RHI in 2020.
M	pupu	PUOR Mgo	≥1	Banded as an adult at AMO in 2020.
M	PUWH Mgo	BKYE	≥1	Banded as an adult at SLO in 2020.
M	PUYE	ORDG Mgo	≥1	Banded as an adult at TET in 2020.
M	PUYE Mgo	WHPU	≥1	Banded as an adult at SLX in 2020.
M	WHDP Mgo	WHPU	≥1	Banded as an adult at PIP in 2020.
M	WHWH Mgo	pupu	≥1	Banded as an adult at ACA in 2020.
M	WHWH Mgo	WHDP	≥1	Banded as an adult at CHW in 2020.
M	YEBK Mgo	ORDG	≥1	Banded as an adult at VAD in 2020.
M	YEYE Mgo	pupu	≥1	Banded as an adult at KYL in 2020.
F	DPWH	BKYE Mdb	1	Banded as a nestling on the SLR in 2019.
F	WHDP	BPST Mgo	1	Banded as a nestling at GEN in 2019.
F	YEYE pupu	Mgo	1	Banded as a nestling at FUR in 2019.
M	—	Msi	1	Banded as an adult at SM MAPS in 2020.
M	BPST	WHPU Mgo	1	Banded as a juvenile at SM MAPS in 2019.
M	DPWH	ORDG Mgo	1	Banded as a nestling at TEN in 2019.
M	ORDG	DGOR Mgo	1	Banded as a nestling at HTI in 2019.
M	ORPU	Mgo	1	Banded as a nestling at DRO in 2019.
M	ORPU pupu	Mgo	1	Banded as a nestling at MER in 2019.
M	PUWH	YEBK Mdb	1	Banded as a nestling on the SLR in 2019.
M	PUYE	BKBK Mgo	1	Banded as a nestling at LEM in 2019.
M	PUYE	DPWH Mgo	1	Banded as a juvenile at SM MAPS in 2019.
M	PUYE	WHPU Mgo	1	Banded as a juvenile at SM MAPS in 2019.
M	WHPU Mgo	YEBK	1	Banded as a juvenile at SM MAPS in 2019.

Appendix 5. Between-Year Movement of Adult Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020

Table 5.1. Between-year movement of adult Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020.

[**Drainage codes**: SMR, Santa Margarita River; DL, De Luz Creek; SM MAPS, Santa Margarita MAPS Station; FC, Fallbrook Creek; SLR, San Luis Rey River; PL, Pilgrim Creek. **Band colors**: PUYE, plastic purple-yellow split; WHDP, plastic white-dark pink split; Mgo, gold numbered federal band; ORPU, plastic orange-purple split; DPWH, plastic dark pink-white split; PUOR, plastic purple-orange split; BPST, plastic black-pink striped; WHPU, plastic white-purple split; ORDG, plastic orange-dark green split; pupu, metal purple; BKYE, plastic black-yellow split; PUWH, plastic purple-white split; gogo, metal gold; Mye, yellow numbered metal band; BKBK, plastic black; Msi, silver numbered federal band; DGOR, plastic dark green-orange split; BYST, plastic black-yellow striped; OROR, plastic orange; YEPU, plastic yellow-purple split; YEBK, plastic yellow-black split; DPDP, plastic dark pink; YEYE, plastic yellow; Mdb, dark blue numbered federal band; WHWH, plastic white; DBDP, plastic dark blue-dark pink split; WHDB, plastic white-dark blue split;. **Sex**: M, male; F, female. **Abbreviations:** km, kilometer, ≥, greater than or equal to; —, no bands observed]

Drainage/territory		Distance moved (km)	Band combination		Age, in years, 2020	Sex
Last seen	2020		Left leg	Right leg		
Last seen in 2019						
SMR/IMP	DL/DS13	0	PUYE	WHDP Mgo	≥2	M
SMR/DRO	SMR/HW14	0	ORPU Mgo	ORPU	≥6	M
SMR/SM MAPS	SMR/ES28	0	DPWH Mgo	PUOR	≥2	M
SMR/VLE	SMR/AH27	0	—	BPST	≥3	M
SMR/PEP	SMR/AH09	0	WHPU Mgo	ORDG	≥4	M
SMR/RNR	SMR/AH10	0	pupu	BKYE Mgo	≥2	M
SMR/DAQ	SMR/HE41	0	WHPU Mgo	—	≥6	M
SMR/ES16	SMR/ES32	0	WHDP	ORDG Mgo	≥6	M
SMR/RR06	SMR/RR37	0	PUWH gogo	Mye	≥4	M
SMR/ES13	SMR/REY	0	ORDG	BKBK Mgo	5	M
SMR/ES19	SMR/ES05	0	WHDP	WHDP Mgo	7	M
SMR/BOW	SMR/HE05	0	OROR	YEPU Mgo	3	M
SMR/HE21	SMR/HE08	0	—	BPST	2	M
SMR/ARL	SMR/AH08	0	WHPU	YEBK Mgo	2	M
SMR/BN11	SMR/BN20	0	OROR	ORPU Mgo	≥4	M
SMR/ES30	SMR/ES28	0	OROR	DPDP Mgo	≥4	F
SMR/HE18	SMR/HE19	0	BPST	OROR Mgo	3	M
SMR/ATL	SMR/AH19	0	ORDG	PUOR Mgo	≥6	M
SMR/MER	SMR/HE06	0	BPST	PUOR Mgo	≥2	M
SMR/BN10	SMR/BN18	0	YEYE	Mgo	≥4	M
SMR/ES28	SMR/ES30	0	BPST	WHWH Mdb	3	M
SMR/HW13	SMR/HW20	0	ORDG	BPST Mgo	3	M
SMR/RR24	SMR/RR30	0	ORDG	YEBK Mgo	3	M
SMR/ERM	DL/DS14	0.1	PUWH Mgo	BPST	≥2	M
SMR/BN10	SMR/SM MAPS	0.1	BKBK	ORPU Msi	≥2	F
FC/OL04	FC/OL13	0.1	DGOR	BPST Mgo	3	M
SMR/FAU	SMR/AH07	0.1	PUWH Mgo	BYST	≥3	M
SMR/ZUS	SMR/AH04	0.1	WHPU	WHWH Mgo	≥2	M
SMR/BN21	SMR/BN19	0.1	—	WHPU	3	M
SMR/HDS	SMR/AH38	0.1	DPWH Mgo	DGOR	4	M
SMR/MOU	SMR/AH18	0.1	DPWH	BPST Mgo	2	M
SMR/WOM	DL/DS16	0.1	ORDG	BKYE Mgo	≥3	M
SMR/MOR	SMR/HE13	0.1	WHDP	—	≥4	M
SMR/SM MAPS	SMR/PNA	0.1	PUOR	BKYE Mgo	2	M

Table 5.1. Between-year movement of adult Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020.—Continued

[**Drainage codes**: SMR, Santa Margarita River; DL, De Luz Creek; SM MAPS, Santa Margarita MAPS Station; FC, Fallbrook Creek; SLR, San Luis Rey River; PL, Pilgrim Creek. **Band colors**: PUYE, plastic purple-yellow split; WHDP, plastic white-dark pink split; Mgo, gold numbered federal band; ORPU, plastic orange-purple split; DPWH, plastic dark pink-white split; PUOR, plastic purple-orange split; BPST, plastic black-pink striped; WHPU, plastic white-purple split; ORDG, plastic orange-dark green split; pupu, metal purple; BKYE, plastic black-yellow split; PUWH, plastic purple-white split; gogo, metal gold; Mye, yellow numbered metal band; BKBK, plastic black; Msi, silver numbered federal band; DGOR, plastic dark green-orange split; BYST, plastic black-yellow striped; OROR, plastic orange; YEPU, plastic yellow-purple split; YEBK, plastic yellow-black split; DPDP, plastic dark pink; YEYE, plastic yellow; Mdb, dark blue numbered federal band; WHWH, plastic white; DBDP, plastic dark blue-dark pink split; WHDB, plastic white-dark blue split;. **Sex**: M, male; F, female. **Abbreviations:** km, kilometer, ≥, greater than or equal to; —, no bands observed]

Drainage/territory		Distance moved (km)	Band combination		Age, in years, 2020	Sex
Last seen	2020		Left leg	Right leg		
Last seen in 2019—Continued						
SMR/RR27	SMR/RR18	0.1	YEPU Mgo	DPWH	2	M
SMR/BRA	SMR/HW08	0.1	WHPU Mgo	WHPU	2	M
SMR/JAG	SMR/AH14	0.1	BKBK	WHPU Mdb	3	F
SMR/HLD	SMR/HE03	0.1	WHPU	WHPU Mgo	≥2	M
SMR/ARY	SMR/HW58	0.1	BYST	PUOR Mgo	≥4	M
SMR/HW07	SMR/HW45	0.1	ORDG	YEYE Mgo	5	M
SMR/ZAM	SMR/HW27	0.1	WHDP	ORPU Mgo	5	M
DL/MRT	DL/DS15	0.1	OROR	PUOR Mgo	≥4	M
SMR/ES07	SMR/PAL	0.1	YEPU	ORDG Mgo	≥5	F
SMR/BAE	SMR/HW04	0.1	BKYE	WHWH Mgo	≥2	M
SMR/FRAS	SMR/ES25	0.2	BKBK	ORDG Msi	≥2	M
SMR/FKI	SMR/HE59	0.2	BPST	ORDG Mgo	3	M
SMR/SM MAPS	SMR/CON	0.3	BKYE Mgo	DPDP	≥2	F
SMR/HE35	SMR/HE57	0.3	BYST	PUWH Mgo	3	M
DL/DS02	DL/DS20	0.6	DPWH Mgo	BPST	≥3	F
SMR/GEN	SMR/AE54	0.9	BKBK Mgo	BPST	2	F
SMR/APO	DL/DS09	2.7	PUWH Mgo	BKBK	3	M
SMR/IBX	SMR/HE39	4.7	ORDG	ORPU Mgo	3	M
SLR/FRAS	PL/PS15	8.1	BKBK	DBDP Mdb	3	F
Last seen in 2018						
SMR/ZAM	SMR/HW38	0	YEYE	PUOR Mgo	3	M
SMR/HE47	SMR/HE17	0.1	ORDG Mgo	YEYE	8	M
SMR/RR11	SMR/RR15	0.1	YEPU	DPWH Mgo	5	M
SMR/HE07	SMR/HE72	0.1	BPST	DPDP Mgo	5	F
SMR/BN48	SMR/BOR	0.2	YEYE	YEPU Mgo	≥3	F
SMR/BN34	SMR/CAN	0.4	YEYE Mdb	pupu	4	M
SMR/ARY	SMR/HE23	1.8	WHPU Mgo	YEPU	2	M
SLR/WMON	SMR/BN18	4.2	DPDP Mdb	BPST	2	F
SLR/WFIR	PL/PS30	6.9	WHPU Mdb	DPWH	2	M
Last seen in 2017						
SMR/ES25	SMR/PAL	0	YEPU Mdb	YEYE	8	M
SMR/MOR	SMR/CHW	4.3	BKYE	YEYE Mgo	3	F
Last seen in 2016						
SMR/LNS	SMR/HW03	0.8	ORDG Mgo	WHPU	≥5	M
SLR/BRAT	SMR/JAB	7.5	WHDB Mdb	WHDB	4	F

Appendix 6. Status and Nesting Activities of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020

Table 6.1. Status and nesting activities of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020.

[**Monitoring**: F, fully monitored territory, P, partially monitored territory. **Nest fate**: SUC, fledged at least one Least Bell's Vireo young; INC, nest not completed; PRE, nest failure caused by predation; UNK, reason for nest failure/abandonment unknown; FAL, false nest, built by male; OTH, nest failed with known cause other than predation or parasitism. **Abbreviation:** No., number; —, no data]

Territory	Nest	Monitoring	Nest fate	No. fledged	Comments
			Seep site		
CHW	1	F	SUC	4	—
CHW	2	F	SUC	3	—
GRD	1	F	SUC	4	—
GRD	2	F	SUC	3	—
JAB	1	F	INC	—	—
JAB	2	F	SUC	3	—
KNO	1	F	INC	—	—
KNO	2	F	SUC	2	—
KYL	1	F	PRE	—	Failed with nestlings, one egg or nestling disappeared after hatching and before nest was depredated.
KYL	2	F	SUC	4	—
PAL	1	F	PRE	—	Failed with nestlings.
PAL	2	F	SUC	4	—
REY	1	F	PRE	—	Failed with nestlings.
REY	2	F	PRE	—	Failed with nestlings, two eggs or nestlings disappeared after hatching and before nest was depredated.
REY	3	F	PRE	—	Failed with nestlings.
SKY	1	F	PRE	—	Failed with nestlings.
SLO	1	F	PRE	—	Failed with nestlings.
SLO	2	F	PRE	—	Failed with eggs.
VAD	1	F	SUC	4	—
VAD	2	F	SUC	3	—
WIC	1	F	SUC	4	—
WIC	2	F	PRE	—	Failed with nestlings.
YOD	1	F	UNK	—	Abandoned with eggs after rain.
YOD	2	F	SUC	3	—
YOD	3	F	SUC	3	—
			Reference sites		
ACA	1	F	SUC	2	—
ACA	2	F	INC	—	—
ACA	3	F	UNK	—	Abandoned with fully developed eggs.
AMO	1	F	SUC	4	—
ANZ	1	F	PRE	—	Failed with nestlings.
ANZ	2	F	INC	—	—
ANZ	3	F	SUC	3	—
ARA	1	F	PRE	—	Failed with eggs.

Table 6.1. Status and nesting activities of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020.—Continued

[**Monitoring**: F, fully monitored territory, P, partially monitored territory. **Nest fate**: SUC, fledged at least one Least Bell's Vireo young; INC, nest not completed; PRE, nest failure caused by predation; UNK, reason for nest failure/abandonment unknown; FAL, false nest, built by male; OTH, nest failed with known cause other than predation or parasitism. **Abbreviation:** No., number; —, no data]

Territory	Nest	Monitoring	Nest fate	No. fledged	Comments
Reference sites—Continued					
ARA	2	F	SUC	4	—
ARM	1	F	SUC	3	—
ARW	1	F	INC	—	—
ARW	2	F	PRE	—	Failed with eggs.
ARW	3	F	SUC	3	—
BAX	1	F	SUC	3	—
BGT	1	F	SUC	1	—
BOR	1	F	PRE	—	Failed before hatching confirmed.
BOR	2	F	SUC	3	—
BRM	1	F	PRE	—	Failed with eggs.
BRM	2	F	UNK	—	Abandoned, no eggs observed.
CAP	1	F	SUC	3	—
CRA	1	F	INC	—	—
CRA	2	F	SUC	4	—
CRX	1	F	FAL	—	—
CRX	2	F	PRE	—	Eggs not observed.
CRX	3	F	PRE	—	Failed with eggs.
CSAL	1	F	OTH	—	Rain destroyed nest.
CSAL	2	F	PRE	—	Failed with eggs.
CSAL	3	F	SUC	4	—
ELR	1	F	SUC	4	—
ELR	2	F	SUC	3	—
ENC	1	F	SUC	4	—
FRO	1	F	SUC	3	—
FRO	2	F	SUC	3	—
FRX	1	F	SUC	4	—
GAL	1	F	PRE	—	Failed before hatching confirmed.
GAN	1	F	SUC	3	—
GIM	1	F	PRE	—	Failed before hatching confirmed.
ISO	1	P	SUC	2	—
KTM	1	F	SUC	3	—
KTM	2	F	SUC	4	—
LEG	1	F	PRE	—	Failed with eggs.
LEG	2	F	PRE	—	Failed with eggs.
LEG	3	F	SUC	2	—
MAL	1	F	SUC	2	—
MRY	1	F	SUC	3	—
MRY	2	F	SUC	1	—
NAZ	1	F	SUC	3	—
OPT	1	F	PRE	—	Failed with eggs.

Table 6.1. Status and nesting activities of Least Bell's Vireos at Marine Corps Base Camp Pendleton, 2020.—Continued

[**Monitoring**: F, fully monitored territory, P, partially monitored territory. **Nest fate**: SUC, fledged at least one Least Bell's Vireo young; INC, nest not completed; PRE, nest failure caused by predation; UNK, reason for nest failure/abandonment unknown; FAL, false nest, built by male; OTH, nest failed with known cause other than predation or parasitism. **Abbreviation:** No., number; —, no data]

Territory	Nest	Monitoring	Nest fate	No. fledged	Comments
			Reference sites—Continued		
OPT	2	F	SUC	3	—
PIP	1	F	SUC	4	—
PNA	1	F	SUC	3	—
PNA	2	F	SUC	2	—
RHI	1	F	UNK	—	Supporting branch broke.
RHI	2	F	SUC	2	—
ROK	1	F	PRE	—	Failed with nestlings.
ROK	2	F	PRE	—	Failed with nestlings.
RUB	1	F	PRE	—	Failed with eggs.
RUB	2	F	PRE	—	Failed with nestlings.
SAG	1	F	UNK	—	Abandoned with eggs.
SAG	2	F	SUC	1	—
SAG	3	F	PRE	—	Failed before hatching confirmed.
SAU	1	F	OTH	—	Abandoned with eggs after rain.
SAU	2	F	UNK	—	Abandoned, no eggs observed.
SLX	1	F	SUC	4	—
SMO	1	F	PRE	—	Failed with eggs.
SMW	1	F	SUC	4	—
TET	1	F	SUC	3	—
TET	2	F	SUC	4	—
VIT	1	F	SUC	4	—

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

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