



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

2006 Annual Data Summary



Prepared for:

**Assistant Chief of Staff, Environmental Security
U.S. Marine Corps Base Camp Pendleton**

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
WESTERN ECOLOGICAL RESEARCH CENTER

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EXECUTIVE SUMMARY

Surveys for the endangered least Bell's vireo (*Vireo bellii pusillus*) were conducted at Marine Corps Base Camp Pendleton, California, between 3 April and 7 July 2006. All drainages containing riparian habitat suitable for vireos were surveyed three to seven times. A small number of other sites containing more marginal habitat were periodically checked throughout the season for vireos. Seven hundred and eighteen territorial male vireos were detected on 19 out of the 23 drainages surveyed. Ninety-one percent of all vireo territories occurred on the eight most populated drainages, with the Santa Margarita River containing 56% of all territories on Base. Two thirds of all male vireos were confirmed as paired.

The majority of vireo territories (75%) occurred in habitat characterized as Willow Riparian. An additional 9% of birds occupied willow habitat co-dominated by cottonwoods (*Populus fremontii*) or sycamores (*Platanus racemosa*). Nine percent of territories were found in Riparian Scrub, dominated by *Baccharis salicifolia* and/or *Salix exigua*. Habitat characterized by upland vegetation was used by 6% of vireos. Four territories (1%) were placed in habitat dominated by white alder (*Alnus rhombifolia*), while less than 1% of vireo territories were placed in habitat composed entirely of non-native vegetation. Invasive exotic plants were found to be dominant or co-dominant in approximately 6% of all vireo territories. The primary exotic plants found in vireo territories were poison hemlock (*Conium maculatum*), black mustard (*Brassica nigra*), giant reed (*Arundo donax*), and tamarisk (*Tamarix ramosissima*).

Nesting activity was monitored in 47 territories within two *A. donax* Removal and two Reference monitoring areas. Nest success of pairs breeding in Removal sites was higher than pairs at Reference sites. More pairs at Removal sites (85%) were successful in fledging young from at least one nest than pairs at Reference sites (73%). However, pairs at Reference sites fledged more young per successful nest than pairs at Removal sites, resulting in no statistical difference in the average number of young fledged per pair between treatments. Successful and unsuccessful nests within Reference and Removal sites did not differ statistically in average nest height, height of the host plant, or the distance the nest was placed from the edge of the host plant. Sixty-two to 64% of nests were placed in *S. lasiolepis* or *S. exigua*. An additional 10% of all monitored nests were placed in two exotic species, *C. maculatum* and *B. nigra*, reflecting the disturbed nature of many of the nest sites. Predation was believed to be the primary source of nest failure at both sites. One nest (1%) was parasitized during the nestling stage, with no effect on the nest's fate.

One hundred and forty least Bell's vireos were banded during the 2006 season. These included 25 adult vireos that were target netted and banded with a unique color combination, and 115 hatch-year birds, 113 of which were banded as nestlings and 2 of which were incidentally caught while attempting to target net an adult vireo in a territory. Thirty percent (11/37) of previously banded adult vireos present in 2005 returned in 2006; 64% of those returned to the breeding area they occupied in 2005. Dispersal distances of returning adults whose locations were known in 2005 ranged from zero to 2.8 km. Ten percent (9/89) of hatch-year birds banded in 2005 that survived to fledge were documented during Base-wide surveys in 2006. Least Bell's vireos of known age ranged from 1-8 years old.

INTRODUCTION

The least Bell's vireo (*Vireo bellii pusillus*; hereafter "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 1900's as a result of habitat loss and alteration associated with urbanization and conversion of land adjacent to rivers to agriculture (Franzreb 1989, USFWS 1998, RHJV 2004). Additional factors contributing to the vireo's decline have been the expansion in range of the brown-headed cowbird (*Molothrus ater*), a brood parasite, to include the Pacific coast (USFWS 1986; Franzreb 1989; Brown 1993; Kus 1998, 1999), and the introduction of invasive exotic plant species, such as giant reed (*Arundo donax*), into riparian systems. By 1986, the vireo population in California numbered just 300 territorial males (USFWS 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, with the U.S. Fish and Wildlife Service following suit in 1986. Since listing, the vireo population in southern California has rebounded, largely in response to cowbird control, and habitat restoration and preservation (Kus and Whitfield 2005). As of 2005, the statewide vireo population was estimated to be approximately 2,500 territories (USGS, unpublished data), roughly a third of which occurred on Camp Pendleton.

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 throughout the breeding season from exposed perches. Females arrive approximately 1-2 weeks after males and are more secretive, but are often seen early in the season traveling through habitat with the male. The female, with the male's help, builds an open cup nest in dense vegetation approximately 1 m above the ground. Typical clutch size for least Bell's vireos average 3-4 eggs. Typically, the female and male incubate the eggs for 14 days, with young fledging from the nest at 11-12 days of age. It is not unusual for vireos to re-nest after a failed attempt provided ample time remains within the breeding season. Vireos rarely fledge more than one brood in a season. Nesting lasts from early April through July, but adults and juvenile birds remain on the breeding grounds into late September/early October before migrating to their wintering grounds in southern Baja California, Mexico.

The purpose of this study was to document the status of 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 Bell's vireo population at the Base, (2) characterize habitat used by vireos, (3) band a subset of vireos to facilitate the estimation of vireo survivorship and movement, and (4) assess the short-term effects of *A. donax* removal on vireo fecundity, nest success, and productivity by intensively monitoring vireos within established nest monitoring plots that had recently undergone *A. donax* removal and at reference sites in which *A. donax* had been removed 6-9 years earlier, between 1997 and 2000. These data, when combined with data from other years, will inform natural resource managers about the status of this endangered species at Camp Pendleton, and guide modification of land use and management practices as appropriate to ensure the species' continued existence.

This work was funded by the Assistant Chief of Staff, Environmental Security, Resources Management Division, Marine Corps Base Camp Pendleton, California.

STUDY AREAS AND METHODS

Field Surveys

All of Camp Pendleton's major drainages, and several minor ones supporting riparian habitat, were surveyed for vireos between 3 April and 7 July 2006 (Figure 1). Field work was conducted by Luke Caldwell, Tara Conkling, Matt Dresser, David Hadersbeck, Scarlett Howell, Dana Kamada, Kerry Kenwood, Barbara Kus, Todd Martin, Eric Nolte, Michelle Rogne, James Rourke, and Michael Wellik. The specific areas surveyed are as follows:

1. ***Santa Margarita River:***
 - a. Between Interstate 5 upstream to the confluence with De Luz Creek, including all riparian habitat within Stagecoach Canyon and Ysidora Basin east of Vandegrift Road (Appendix A, Figures 9, 10).
 - b. From the confluence with De Luz Creek upstream to the Base boundary (Appendix A, Figure 10).
2. ***De Luz Creek***, between the confluence with the Santa Margarita River and the Base boundary (Appendix A, Figure 9).
3. ***Roblar Creek***, between the confluence with De Luz Creek and a point approximately 1 km upstream (Appendix A, Figure 9).
4. ***Lake O'Neill/Fallbrook Creek:***
 - a. All riparian habitat around Lake O'Neill (Appendix A, Figure 9).
 - b. Between Lake O'Neill and the Base boundary with the Fallbrook Naval Weapons Station (Appendix A, Figure 9).
5. ***Basilone and Roblar Roads***, a small patch of habitat straddling Basilone Road at the intersection of Basilone and Roblar Roads (Appendix A, Figure 9).
6. ***22 Area***, all riparian habitat within the 22 Area, east of Vandegrift Road and the Supply Depot (Appendix A, Figure 10).
7. ***Pueblitos Canyon***, between Vandegrift Road and a point approximately 2.5 km upstream (Appendix A, Figure 10).
8. ***Tuley Canyon***, between the Base boundary and a point approximately 1.1 km upstream (Appendix A, Figure 10).
9. ***Newton Canyon***, between the confluence with the Santa Margarita River and the upstream limit of riparian habitat (Appendix A, Figure 10).

10. **Cocklebur Canyon**, between the Pacific Ocean and a point 0.25 km east of Interstate 5 (Appendix A, Figure 10).
11. **French Creek**, between the Pacific Ocean and the Edson Range Impact Area (Appendix A, Figure 10).
12. **Aliso Creek**, between the Pacific Ocean and 0.5 km upstream of the electrical transmission lines (Appendix A, Figure 10).
13. **Hidden Canyon**, between Interstate 5 and Stuart Mesa Road (Appendix A, Figure 11).
14. **Las Flores Creek (within Las Pulgas Canyon)**:
 - a. Between Stuart Mesa Road and the high voltage electrical transmission lines (Appendix A, Figure 11).
 - b. Between the Pacific Ocean and Stuart Mesa Road, and from the high voltage electrical transmission lines upstream to the Zulu Impact Area, approximately 0.75 km upstream of Basilone Road (Appendix A, Figure 11).
15. **Piedra de Lumbre Canyon**, between the confluence with Las Flores Creek and the upstream limit of riparian habitat (Appendix A, Figure 11).
16. **Horno Canyon**, between Old Highway 101 and the upstream limit of riparian habitat (Appendix A, Figure 11).
17. **San Onofre Creek**:
 - a. From the Pacific Ocean to the south fork/north fork confluence, and upstream on the south fork to Basilone Road (Appendix A, Figures 11, 12).
 - b. From Basilone Road upstream to the access road to Range 219 (Appendix A, Figure 12).
18. **San Mateo Creek**:
 - a. From the Pacific Ocean upstream to San Mateo Road, including habitat south of the creek and south and east of the agricultural fields (Appendix A, Figures 12).
 - b. From San Mateo Road upstream to the Base boundary (Appendix A, Figure 12, 13).
19. **Cristianitos Creek**, between the confluence with San Mateo Creek and the Base boundary (Appendix A, Figure 12).
20. **Talega Canyon**, between the confluence with Cristianitos Creek and a point approximately 6.5 km upstream (Appendix A, Figure 12).
21. **Pilgrim Creek**:
 - a. Between the southern Base boundary and Vandegrift Boulevard, including the two side drainages east of Pilgrim Creek (Appendix A, Figure 14).
 - b. From Vandegrift Boulevard upstream to the limit of riparian habitat (Appendix A, Figure 14).

22. **Windmill Canyon**, from the Base boundary past the golf course to the upstream extent of habitat (includes both of the 2004 Windmill Canyon and Horse Pasture sites) (Appendix A, Figure 14).
23. **Ysidora Basin to Windmill Canyon**, between Upper Ysidora Basin and Windmill Canyon/Pueblitos Canyon (Appendix A, Figure 14).
24. **De Luz Homes Habitat**, patches of habitat adjacent to the De Luz Homes development (Appendix A, Figure 14).

The majority of drainages were surveyed from 3-7 times at least 10 days apart. Sites surveyed seven times throughout the breeding season were: Santa Margarita River (1a), Lake O'Neill/Fallbrook Creek (4a), Las Flores Creek (14a), and Pilgrim Creek (21a). Sites surveyed six times included: De Luz Creek, Aliso Creek, Las Flores Creek (14b), San Onofre Creek (17a), San Mateo Creek (18b), and Cristianitos Creek. Sites surveyed three times were: Santa Margarita River (1b), Lake O'Neill/Fallbrook Creek (4b), Basilone and Roblar Roads, 22 Area, Pueblitos Canyon, Newton Canyon, French Creek, Hidden Canyon, Piedra de Lumbre Canyon, San Onofre Creek (17b), San Mateo Creek (18b), Pilgrim Creek (21b), Windmill Canyon, Ysidora Basin to Windmill Canyon, and De Luz Homes Habitat. Tuley Canyon was surveyed once for vireos.

Biologists followed standard survey techniques described in the USFWS least Bell's vireo survey guidelines (USFWS 2001). Observers moved slowly (1-2 km per hour) through the riparian habitat while searching and listening for vireos. Observers walked along the edge(s) of the riparian corridor on the upland and/or 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 were conducted between dawn and early afternoon, depending on wind and weather conditions.

All male least Bell's vireos were detected and confirmed audibly by hearing their diagnostic song. The presence of a female vireo within a territory was confirmed either audibly through the detection of the "pair call" elicited between mated birds, or visually when observed traveling quietly with the male. For each bird encountered, investigators recorded age (adult or juvenile), sex, breeding status (paired, unpaired, undetermined, or transient), and whether 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 USGS topographic maps, using a Garmin 12 Global Positioning System (GPS) unit with 1-15 m positioning accuracy to determine geographic coordinates (WGS84). Dominant native and exotic plants were recorded, and percent cover of exotic vegetation was estimated using cover categories of <5, 5-50, 51-95 and >95%. The overall habitat type within the territory was specified according to the following categories:

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

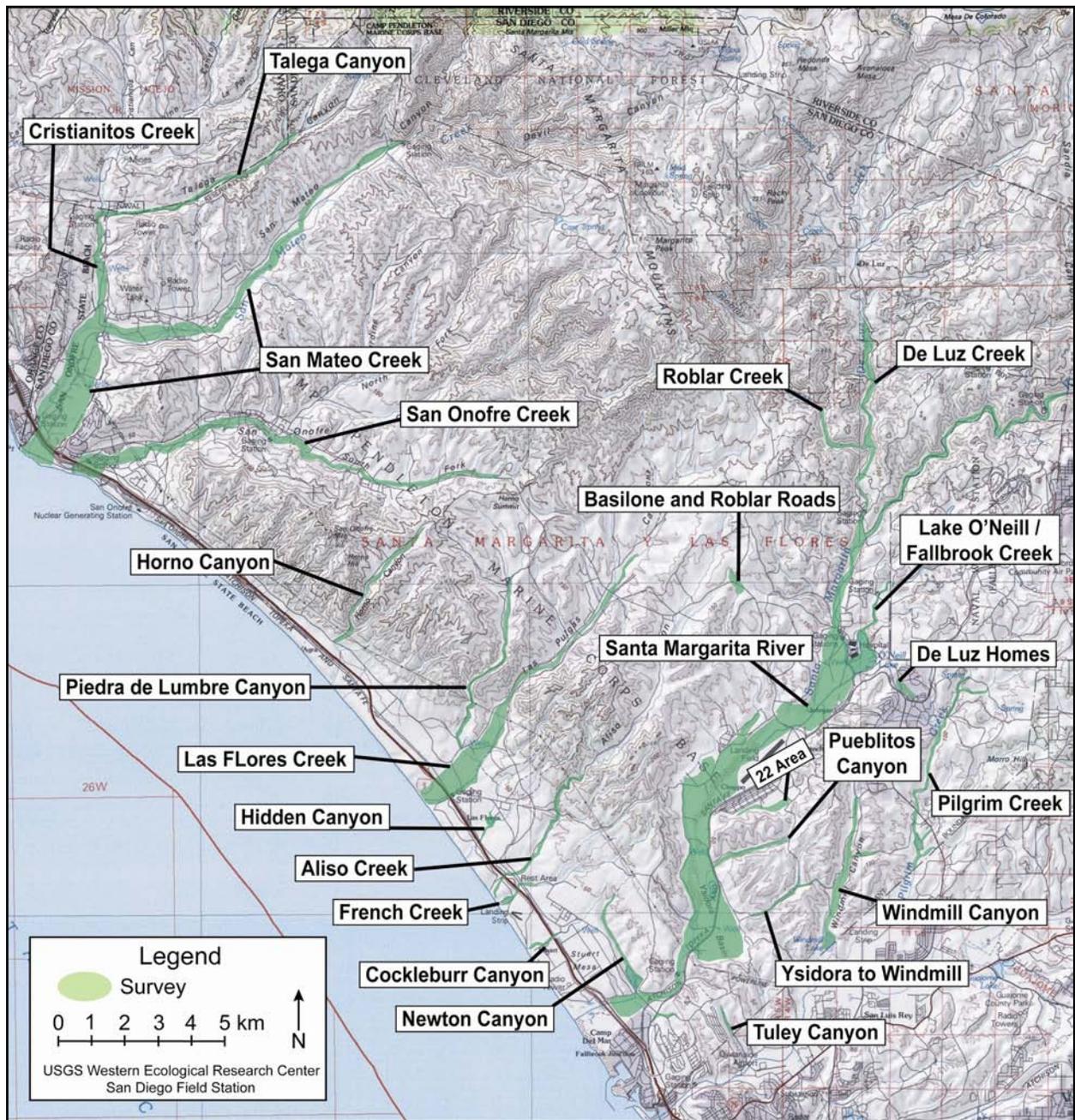


Figure 1. Least Bell's vireo survey areas at Marine Corps Base Camp Pendleton, 2006.

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

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

Sycamore-oak: Woodlands in which *P. racemosa* and *Quercus agrifolia* occur as co-dominants.

Riparian scrub: Dry and/or sandy habitat dominated by *S. exigua* or *B. salicifolia*, 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 *A. donax* and *Tamarix ramosissima*.

Nest Monitoring

We monitored least Bell's vireo nests to evaluate the effects of *A. donax* removal on nest success and productivity. *A. donax* is a highly invasive, non-native plant within riparian systems in southern California. Originally introduced for bank stabilization in the 1800's, *A. donax* has become a major component of many riparian systems, becoming the dominant vegetation within streams and rivers. As part of a riparian restoration effort, Marine Corps Base Camp Pendleton has been removing large quantities of *A. donax* on the Santa Margarita River. Areas that have recently undergone *A. donax* removal tend to consist of small patches of native woody plants surrounded by large areas of bare earth. These open areas are typically populated by native and non-native herbaceous plants until the appropriate conditions arise that allow for the establishment of native woody species, such as *B. salicifolia*, *S. exigua*, *S. gooddingii*, *S. lasiolepis*, and *S. laevigata*. We monitored vireos within four established monitoring areas: two sites within locations in which *A. donax* was removed historically and the native vegetation recovered (hereafter referred to as "Reference" sites), and two sites in areas where *A. donax* had been removed within the previous 3-4 years (hereafter "Removal" sites) (Figure 2).

Twenty-two pairs in Reference sites and 25 pairs in Removal sites were monitored throughout the season and all nesting activity was documented. Pairs were observed for evidence of nesting, and their nests were located. Nests were visited as infrequently as possible to minimize the chance of leading predators or brown-headed cowbirds to nest sites; typically, there were 3-5 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 (SUC). Unsuccessful nests were placed into one of four nest fate categories. Nests found empty or destroyed prior to the estimated fledge date and where the adult vireos were not found tending fledgling(s) were considered depredated (PRE). Previously active nests that were subsequently abandoned by adult vireos after one or more brown-headed cowbird eggs were laid in the nest were considered to have failed because of nest parasitism (PAR). Any nest that fledged cowbird young without fledging vireo young was also considered to have failed because of nest parasitism (PAR). Nests failing for reasons such as poor nest construction or the collapse of a host plant that caused a nest's contents to be dumped onto the ground, or the presence of a

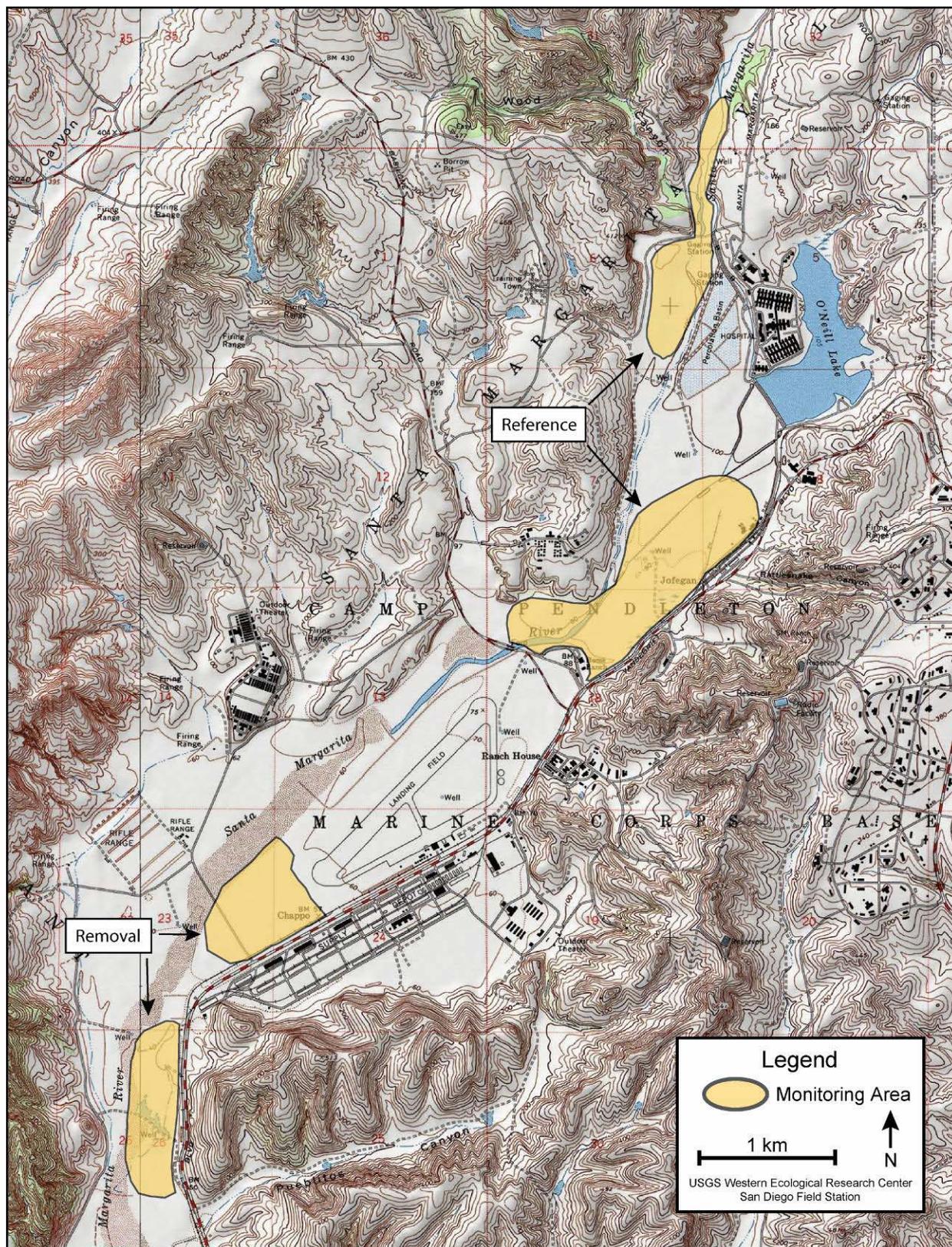


Figure 2. Location of least Bell's vireo nest monitoring areas at Marine Corps Base Camp Pendleton, 2006.

clutch of infertile eggs, were classified as failing because of other causes that were known (OTH). Nests that appeared intact and undisturbed, but were abandoned with vireo eggs and/or nestlings were classified as having failed because of unknown causes (UNK). Characteristics of nests, including 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 were recorded following abandonment or fledging of young from nests.

Camp Pendleton implements an intensive annual cowbird control program on Base, and parasitism of least Bell's vireo nests is extremely rare. Nevertheless, we were prepared to follow 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 are removed no sooner than the seventh day of incubation to minimize the possibility of nest abandonment in response to the removal. Cowbird eggs are removed from nests containing three or more vireo eggs as they are found. Cowbird nestlings are removed immediately from nests.

Banding

The primary goals of banding least Bell's vireos on Camp Pendleton are: 1) to better understand adult vireo site fidelity within a potential source population, 2) to investigate natal dispersal on Base, and the role Camp Pendleton young play in potentially supporting vireo populations off Base, and 3) to understand how *A. donax* removal affects vireo demography. Nestlings from monitored nests were banded at 6-7 days of age with a single anodized gold numbered federal band on the left leg. A subset of adult vireos within monitoring and prospective *A. donax* removal sites were captured in mist nets and banded with a unique combination of colored plastic and anodized metal bands. Adults previously banded with a single numbered federal band were target netted to determine their identity, and their original band was supplemented with other bands to generate a unique color combination. If the adult was originally banded on Base, either an anodized gold or orange plastic band was incorporated into the combination to designate Camp Pendleton as the bird's site of origin.

Data Analyses

We conducted statistical tests to determine whether there were differences in nest success, productivity, or vegetation characteristics between pairs nesting at Reference and *A. donax* Removal sites. Chi-square analysis was used to test for differences in nest success between sites. Depending on the dispersion of the data, either equal or unequal variance two-sample *t*-tests were used to test for differences in average clutch size, average brood size, and the number of young fledged per pair. Unequal variance two-sample *t*-tests were also used to test for differences in nest vegetation characteristics between successful and unsuccessful nests within and between Reference and Removal sites. If nests were parasitized by brown-headed cowbirds, rescued by removing a cowbird egg(s) and/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 impact(s) of cowbird parasitism on the Pendleton vireo population. Data were analyzed using SYSTAT statistical software (SYSTAT Software, Inc. 2005).

RESULTS

Population Size and Distribution

Although least Bell's vireos had begun arriving on Base by the first week in April, migration of the majority of vireos was delayed by approximately two weeks in 2006 compared to 2005 (Figure 3). Surveys during the first week of April detected only 3 territories in 2006 compared to 50 in 2005. By 15 April, 46 territories had been established in 2006 while there had been 352 established in 2005. This lag in territory establishment continued throughout the 2006 breeding season.

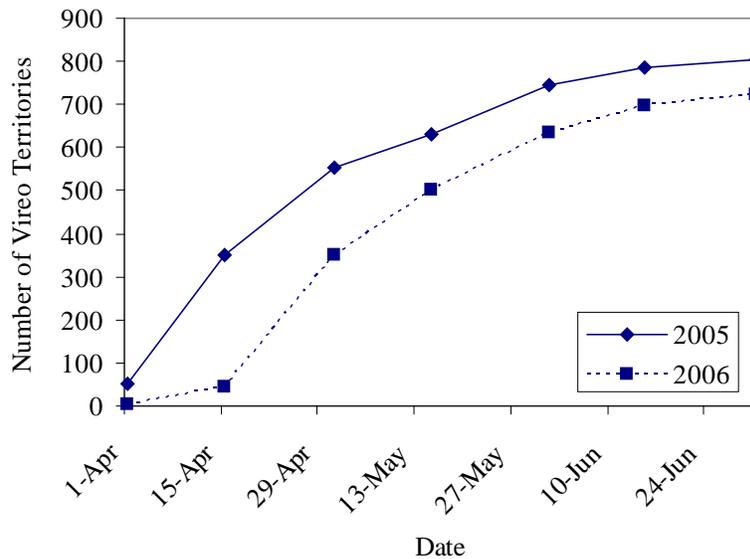


Figure 3. Territory establishment of least Bell's vireos at Marine Corps Base Camp Pendleton in 2005 and 2006.

Seven hundred and eighty-three least Bell's vireo sites were identified during Base-wide surveys (Table 1, Appendix B, Figures 15-34). This included 718 territorial male vireos, 66% of which were confirmed as paired, and 65 transients. Transient vireos were observed on 14 of the 24 (58%) drainages/sites surveyed. Ninety-one percent of all vireo territories occurred on the eight most populated drainages/sites (i.e., Santa Margarita River, Las Flores Creek, San Mateo Creek, San Onofre Creek, De Luz Creek, Pilgrim Creek, the 22 Area, and Aliso Creek), with the majority of vireo territories occurring along the Santa Margarita River, the largest expanse of riparian vegetation on Base (Tables 1, 2). The remaining 16 drainages/sites each contained 10 or fewer territories.

The number of least Bell's vireo territories documented on Base declined by 13% in 2006 compared to 2005 (Table 2, Figure 4). Declines were documented on 14 of 23 (61%) drainages/sites surveyed, and ranged from 1-55 territories lost. The drainages with the largest numeric loss in vireo numbers were the Santa Margarita River (55 territories), Pilgrim Creek (13

Table 1. Number and distribution of least Bell's vireos at Camp Pendleton, 2006.

Drainage/Survey Site	Known Pairs	Single/ Status Undetermined	Transient	Total Territories
Santa Margarita River:				
I-5 to De Luz Creek	283	95	31	378
De Luz Creek to Base Boundary	13	14	0	27
De Luz Creek	19	6	1	25
Roblar Creek	0	0	0	0
Lake O'Neill/Fallbrook Creek	8	2	3	10
Basilone-Roblar Roads	0	0	1	0
22 Area	2	10	0	12
Pueblitos Canyon	2	1	2	3
Newton Canyon	6	2	1	8
Cockleburr Creek	2	0	0	2
French Canyon	3	1	0	4
Aliso Creek	9	2	3	11
Hidden Canyon	5	0	0	5
Las Flores Creek:				
Pacific Ocean to Stuart Mesa Road	6	4	1	10
Stuart Mesa Road to Power Lines	20	10	1	30
Power Lines to Zulu Impact Area	24	12	1	36
Piedra de Lumbre Canyon	5	4	1	9
Horno Canyon	0	0	0	0
San Onofre Creek:				
Pacific Ocean to Basilone Road	12	25	7	37
Basilone Road to Access Road to Range 219	2	4	0	6
San Mateo Creek				
Pacific Ocean to San Mateo Road	27	24	5	51
San Mateo Road to Yankee Training Area	3	5	0	8
Cristianitos Creek	2	6	6	8
Talega Canyon	0	0	0	0
Tuley Canyon	0	0	0	0
Pilgrim Creek:				
Base Boundary upstream to Vandegrift Boulevard	6	10	0	16
Vandegrift Boulevard to upstream riparian limit	3	4	0	7
Windmill Canyon	6	1	1	7
Ysidora Basin to Windmill Canyon	4	2	0	6
De Luz Homes	1	1	0	2
Total	473	245	65	718

territories), Aliso Creek (10 territories), and Lake O'Neill/Fallbrook Creek (10 territories). The loss of so many vireo territories from Pilgrim Creek, Aliso Creek and Lake O'Neill/Fallbrook Creek caused vireo populations at those sites to decline by 36, 48, and 50%, respectively, compared to 2005 numbers. Five drainages/sites increased in vireo abundance. The drainage with the largest numeric increase in vireo numbers was De Luz Creek, which gained seven territories (39%), bringing the 2006 total within one territory of the number found on De Luz Creek in 2004. Vireo numbers on the remaining three drainages, Cockleburr Creek, Newton Canyon, and Roblar Creek, did not differ between 2005 and 2006.

Table 2. Number of territorial males at Marine Corps Base Camp Pendleton, by drainage, in 2004-2006. Numeric change is the positive or negative change in the number of vireo territories between 2006 and 2005.

Drainage	Number of Territorial Males			Numeric Change
	2006	2005	2004 ^a	
Santa Margarita River ^b	417	472	440	-55
De Luz Creek	25	18	26	7
Roblar Creek	0	0	1	0
Lake O'Neill/Fallbrook Creek	10	20	16	-10
Pueblitos Canyon	3	5	3	-2
Newton Canyon	8	8	9	0
Cockleburr Creek	2	2	0	0
French Canyon	4	6	5	-2
Aliso Creek	11	21	21	-10
Hidden Canyon	5	8	5	-3
Las Flores Creek	76	85	84	-9
Piedra de Lumbre Canyon	9	8	5	1
Horno Canyon	0	1	0	-1
San Onofre Creek	43	52	56	-9
San Mateo Creek	59	56	68	3
Cristianitos Creek	8	6	8	2
Talega Canyon	0	1	0	-1
Pilgrim Creek	23	36	37	-13
Windmill Canyon	7	12	20	-5
Ysidora Basin to Windmill Canyon	6	4	8	2
De Luz Homes	2	4	5	-2
Basilone-Roblar Roads	0	2	-	-2
Tuley Canyon	0	-	2	-
Total	718	827	819	-109%

^a 2004 sites not listed: Vandegrift Hills (1), Kilo 1/ Kilo 2 Hills (2); 2004 total = 822 territories

^b Includes vireo territories detected within the 22 Area.

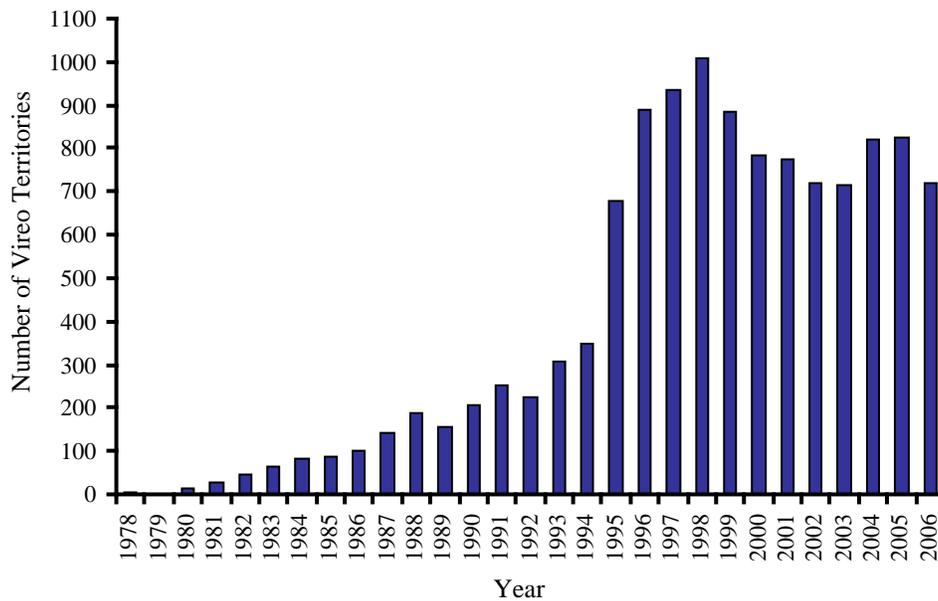


Figure 4. Number of least Bell's vireo territories at Marine Corps Base Camp Pendleton, 1978–2006. (Source: Griffith Wildlife Biology 2004, Rourke and Kus 2006).

Habitat Characteristics

Vireos used a number of different habitat types ranging from willow-dominated thickets along stream courses to upland vegetation along roads and channel margins (Table 3). The majority of vireo territories occurred in habitat characterized as Willow Riparian, with 75% of the males in the study area found in this habitat. An additional 9% of birds occupied willow habitat co-dominated by cottonwoods or sycamores. Nine percent of territories were found in Riparian Scrub, dominated by *B. salicifolia* and/or *S. exigua*. Six percent of the vireos used more

Table 3. Habitat types used by least Bell's vireos at Marine Corps Base Camp Pendleton, 2006.

Habitat Type	Number of Territories			% of Total
	>50% Native	>50% Exotic	Total	
Mixed Willow	515	23	538	75
Willow/Cottonwood	6	0	6	1
Willow/Sycamore	57	3	60	8
Riparian Scrub	56	11	67	9
Sycamore/Oak	18	0	18	3
Upland Scrub	17	7	24	3
Alder	4	0	4	1
Non-native	0	1	1	< 1
Total	673	45	718	100

upland habitats including areas dominated by a mix of sycamores and oaks (3% of total) or other upland vegetation (3%). Four territories (1%) were placed in habitat dominated by white alder (*Alnus rhombifolia*), while less than 1% of vireo territories were placed in habitat dominated by solely non-native vegetation.

Fewer vireo territories were documented in exotic vegetation in 2006 compared to 2005 (Table 4). Six percent of vireo territories (45/718) in 2006 were in areas where exotic species such as *A. donax*, *Conium maculatum*, *Brassica nigra*, and *T. ramosissima* made up 50% or more of the habitat versus 19% (160/827) the previous year. Moreover, in 2006 fewer drainages contained territories dominated by non-native vegetation compared to 2005, and when present, exotic plants were found within fewer territories. Exotic vegetation dominated at least 1 territory on 8 drainages in 2006 compared to 13 drainages in 2005. On only one drainage/site in 2006 were 50% or more of the territories dominated by non-native vegetation, compared to six such drainages/sites in 2005.

Table 4. Proportion of least Bell's vireo territories dominated or co-dominated by exotic vegetation in 2006 vs. 2005, by drainage. Numbers in parentheses are the number of territories on the drainage.

Drainage	Proportion of territories			
	2006		2005	
Ysidora Basin to Windmill Canyon	0.50	(6)	0.25	(4)
Las Flores Creek	0.14	(76)	0.02	(85)
Windmill Creek	0.14	(7)	0.67	(12)
Cristianitos Creek	0.13	(8)	0.50	(6)
Newton Canyon	0.13	(8)	0.63	(8)
San Mateo Creek	0.12	(59)	0.66	(56)
Santa Margarita River ¹	0.05	(417)	0.17	(472)
De Luz Creek	0.04	(25)	0.06	(18)
Aliso Creek	0.00	(11)	0.05	(21)
Horno Canyon	0.00	(0)	1.00	(1)
Lake O'Neill/Fallbrook Creek	0.00	(10)	0.15	(20)
Piedra de Lumbre Canyon	0.00	(9)	1.00	(8)
San Onofre Creek	0.00	(43)	0.23	(52)
Total	0.06	(718)	0.19	(827)

¹ Includes vireo territories detected within the 22 Area.

Banded Birds

Thirty-three least Bell's vireos banded prior to the 2006 breeding season were resighted on Base in 2006 (Table 5). Eighteen vireos banded on Base in 2005 returned to established territories in 2006. Of these, eight were returning adult vireos, nine were banded as nestlings in 2005, and one was of indeterminable age (juvenile or adult) when banded. Six additional vireos originally banded off Base, three on Pilgrim Creek (Kus *et al.* 2004) and three on the San Luis Rey River (Kus unpubl. data), were resighted in established territories. Two vireos originally banded at the Santa Margarita River Monitoring Avian Productivity and Survivorship (MAPS) Station (Kus and Beck 1998, Kus and Falcone 2006), and seven others that were not recaptured,

Table 5. Banded least Bell's vireos at Camp Pendleton, 2006.

<u>Drainage</u>	<u>Band Combination^a</u>		<u>Age^b</u>	<u>Comments</u>
<u>Sex</u>	<u>Left Leg</u>	<u>Right Leg</u>		
<u>De Luz Creek</u>				
M	gogo	YEYE/Msi	AHY	Banded at the De Luz Creek MAPS Station in 2006 as an adult.
M	-	Mgo	1 yr	Banded as a nestling in 2005 at Camp Pendleton.
<u>Lake O'Neill</u>				
F	Mbk	-	AHY	Banded off Base on Pilgrim Creek as a nestling in or before 2003.
<u>Pilgrim Creek</u>				
M	Mbk	YEYE	3 yrs	Banded off Base on Pilgrim Creek as a nestling in 2003.
<u>Pueblitos Canyon</u>				
M	-	Mgo	1 yr	Banded as a nestling in 2005 at Camp Pendleton.
<u>Santa Margarita River</u>				
F	-	Mgo	1 yr	Banded as a nestling in 2005 at Camp Pendleton.
F	-	Msi	AHY	Resighted close to the Santa Margarita MAPS Station.
F	BKYE	Mdb	≥ 3 yrs	Banded off Base on the San Luis Rey River in 2004 as an adult.
F	DPWH/Mgo	-	AHY	Banded as an adult in 2006 – VEG territory.
F	LPLP/gogo	Msi	AHY	Banded as an adult in 2006 at the Santa Margarita River MAPS station.
F	Mdb	-	AHY	Resighted southwest of Lake O'Neill. Originally banded as a nestling off Base on the San Luis Rey River.
M	-	BWST/Mgo	AHY	Banded as an adult in 2006 – HTI territory.
M	-	BYST/Mgo	AHY	Banded as an adult in 2006 – ALC territory.
M	-	DGOR/Mgo	8 yrs	Banded at the Santa Margarita MAPS Station in 1998 as an adult.
M	-	DPDP/Mgo	1 yr	Banded as a nestling in 2005 at the Santa Margarita River.
M	-	Mgo	1 yr	Banded as a nestling in 2005 at Camp Pendleton.
M	-	Msi	AHY	Resighted close to the Santa Margarita MAPS Station.
M	-	Msi	AHY	Resighted close to the Santa Margarita MAPS Station.
M	-	Msi	AHY	Resighted close to the Santa Margarita MAPS Station.
M	-	Msi	AHY	Resighted close to the Santa Margarita MAPS Station.
M	-	OROR/Mgo	AHY	Banded as an adult in 2006 – ORN territory.
M	-	YEPU/Mgo	AHY	Banded as an adult in 2006 – ARS territory.
M	BKBK	Mgo	≥ 2 yrs	Banded as an adult in 2005 at the Santa Margarita River.
M	BKBK/pupu	Mgo	AHY	Banded as an adult in 2006 – HRN territory.
M	BYST	Mgo	1 yr	Banded as a nestling in 2005 at the Santa Margarita River.
M	BYST/pupu	Mgo	1 yr	Banded as a nestling in 2005 at the Santa Margarita River.
M	DGOR	Mgo	AHY	Banded as an adult in 2006 – BIL territory.
M	DGOR/Mgo	pupu	≥ 2 yrs	Banded as an adult in 2005 at the Santa Margarita River.
M	DPDP/gogo	Msi	≥ 3 yrs	Banded at the Santa Margarita MAPS Station in 2004 as an adult.
M	DPDP/pupu	Mgo	AHY	Banded as an adult in 2006 – BEK territory.
M	gogo	WHWH/Msi	1 yr	Banded as a nestling in 2005 at the Santa Margarita River.
M	LPLP/Mgo	-	AHY	Banded as an adult in 2006 – VIC territory.

Table 5 (continued). Banded least Bell's vireos at Camp Pendleton, 2006.

Drainage	Band Combination ^a		Age ^b	Comments
	Sex	Left Leg		
M	Mdb	BK BK/pupu	2 yrs	Banded off Base as a nestling in 2004 at the San Luis Rey River.
M	Mgo	BK BK/pupu	AHY	Banded as an adult in 2005 at the Santa Margarita River.
M	Mgo	DGOR/pupu	≥ 2 yrs	Banded as an adult in 2005 at the Santa Margarita River.
M	Mgo	DPWH/pupu	≥ 2 yrs	Banded as an adult in 2005 at the Santa Margarita River.
M	Mgo	OROR	AHY	Banded as an adult in 2006 – HDX territory.
M	Mgo	PUPU/pupu	AHY	Banded as an adult in 2006 – ALA territory.
M	Mgo	WHWH	AHY	Banded as an adult in 2006 – FNR territory.
M	Msi	-	AHY	Resighted close to the Santa Margarita MAPS Station.
M	Msi	-	AHY	Resighted approximately 320 m north of Stuart Mesa Road, adjacent to Vandegrift Boulevard.
M	OROR/Msi	pupu	≥ 2 yrs	Banded as an adult in 2005 at the Santa Margarita River.
M	OROR/pupu	Mgo	1 yr	Banded as a nestling in 2005 at the Santa Margarita River.
M	ORPU	Mgo	AHY	Banded as an adult in 2006 – DEU territory.
M	ORPU/Msi	pupu	≥ 2 yrs	Banded as an adult in 2005 at the Santa Margarita River.
M	pupu	BYST/Mgo	AHY	Banded as an adult in 2006 – APO territory.
M	pupu	DPDP/Mgo	AHY	Banded as an adult in 2006 – ALP territory.
M	pupu	DPWH/Mgo	AHY	Banded as an adult in 2006 – HNK territory.
M	pupu	LPBK/Mgo	AHY	Banded as an adult in 2006 – DAT territory.
M	pupu	PUWH/Mgo	AHY	Banded as an adult in 2006 – LIA territory.
M	pupu	WHWH/Mgo	AHY	Banded as an adult in 2006 – SG01 territory.
M	pupu	YEYE/Mgo	AHY	Banded as an adult in 2006 – HRB territory.
M	PUPU/pupu	Mgo	AHY	Banded as an adult in 2006 – VEG territory.
M	PUWH/Mgo	pupu	≥ 2 yrs	Banded as an adult in 2005 at the Santa Margarita River.
M	YEPU/Mgo	-	≥ 2 yrs	Banded as an adult in 2005 at the Santa Margarita River.
M	YEYE/Mgo	-	AHY	Banded as an adult in 2006 – SGE territory.
M	YEYE/pupu	Mgo	AHY	Banded as an adult in 2006 – BER territory.
U	-	DPWH/Mgo	HY	2006 juvenile, caught while target netting adult in SGE territory.
<u>Windmill Canyon</u>				
M	PUWH/Mbk	-	3 yrs	Banded off Base on Pilgrim Creek as a nestling in 2003.
U	Mgo	LPLP	HY	2006 juvenile, caught while target netting adult in WC03 territory.

^a Band colors: Mbk = black numbered federal band; Mdb = dark blue numbered federal band; Msi = silver numbered federal band; Mgo = gold numbered federal band; gogo = metal gold; BK BK = plastic black; BKYE = plastic black-yellow split; BWST = plastic blue-white striped; BYST = plastic black-yellow striped; DGOR = plastic dark green-orange split; DPDP = plastic dark pink; DPWH = plastic dark pink-white split; LPBK = plastic light pink-black split; LPLP = plastic light pink; OROR = plastic orange; ORPU = plastic orange-purple split; PUPU = plastic purple; pupu = metal purple; PUWH = plastic purple-white split; WHWH = plastic white; YEPU = plastic yellow-purple split; YEYE = plastic yellow.

^b Age: AHY = after hatch-year, HY = hatch-year.

but were most likely banded at the same MAPS station because of their proximity to the MAPS area, were also resighted. Adult birds of known age ranged from 1-8 years old.

A total of 140 least Bell's vireos were banded during the 2006 season. These included 25 adult vireos that were target netted and banded with a unique color combination and 115 hatch-year birds, 113 of which were banded as nestlings with a single gold numbered federal band and two that were incidentally caught while attempting to target net an adult vireo.

Survivorship, Fidelity, and Movement

The recapture and resighting of banded birds allowed us to determine the rate at which vireos previously documented on Base returned to hold territories in 2006. Although this is the minimum number of vireos known to survive, and does not include birds that dispersed off Base or we failed to detect/resight, it can be used as an inference to calculate minimum annual survivorship for the vireo population on Base. Of 37 uniquely color banded adult vireos present during the 2005 breeding season, 30% (11/37) returned to Camp Pendleton in 2006.

Resighting banded birds allowed us to identify individuals that returned to the same area they used the previous year or moved to a different location. In 2006, all banded returning adults whose locations in 2005 were known were male (Table 6). Seven of the 11 adults (64%) returned to the breeding area they occupied in 2005. Two additional males returned to areas adjacent to their previous territories (within 150 m). In 2006, the areas these birds had occupied the previous year were occupied in 2006, but by different males. The remaining two banded returning adults held territories within the same drainage as their 2005 territories, but dispersed 2.1 and 2.8 km from their 2005 territory locations. The average distance dispersed by returning adult male vireos was 0.5 ± 1.0 km (std). One additional adult male vireo appears to have held the same territory since 2004; however, it was not observed in 2005 so its location during the 2005 field season is unknown. This bird was originally banded at the Santa Margarita River MAPS station in 2004 and was recaptured in the same location in 2006. When this bird is included in the calculations, overall vireo territory fidelity between 2005 and 2006 was 67% (8/12).

Two additional adult male vireos banded off Base prior to 2005 were recaptured in 2006. One bird was originally banded as a nestling on the San Luis Rey River in 2004. In 2006, this bird was recaptured on the upper Santa Margarita River and banded with a unique color combination. The distance between its natal site and 2006 location was over 13 km. Its 2005 location is unknown. The other adult male was originally banded as a nestling on Pilgrim Creek in 2003. In 2006, it defended a territory in Windmill Canyon, adjacent to the golf course, approximately 2 km from its natal site. The location of this bird in 2004 and 2005 is not known.

Three female vireos that had been banded off Base were resighted in 2006. Two of the females were banded with a single numbered federal band indicating that they were originally banded as nestlings. One female was banded with a black numbered federal band (Mbk), indicating its natal site was located on Pilgrim Creek. The second female possessed a dark blue numbered federal band (Mdb) identifying its natal drainage as the San Luis Rey River. The closest monitored territories on Pilgrim Creek and the San Luis Rey River, where these birds

could have been banded, are 6.7 and 8.0 km distant, respectively. Monitoring of vireos on Pilgrim Creek was last conducted in 2003, indicating this female was a minimum of three years old. The age of the female originally banded on the San Luis Rey River is unknown as banding has been conducted annually on this drainage since 1989. The third female detected on Base was originally banded as an adult on the San Luis Rey River in 2004. The distance between its banding location and 2006 location was 11.5 km. Its 2005 location is unknown.

Table 6. Between-year movement of least Bell's vireos at Marine Corps Base Camp Pendleton in 2006.

Year Last Detected	Drainage ^a / Territory	Drainage / Territory in 2006	Dispersal Distance (km)	Band Combination ^b		Age in 2006	Sex
				Left Leg	Right Leg		
2005	SMR / ES10	SMR / SNP	1.5	OROR/pupu	Mgo	1 yr	M
2005	SMR / HW05	SMR / AE102	1.4	-	DPDP/Mgo	1 yr	M
2005	SMR / ES05	SMR / AER	1.4	BYST	Mgo	1 yr	M
2005	SMR / AE07	SMR / AW22	0.9	BYST/pupu	Mgo	1 yr	M
2005	SMR / ES03	SMR / ES25	1.5	gogo	WHWH/Msi	1 yr	M
2004	SLR / PCK	SMR / UM105	13.2	Mdb	BK BK/pupu	2 yrs	M
2005	SMR / PO06	SMR / PO07	0.0	BK BK	Mgo	≥ 2 yrs	M
2005	SMR / AH25	SMR / DRK	0.0	DGOR/Mgo	pupu	≥ 2 yrs	M
2005	SMR / PR04	SMR / PO05	2.1	Mgo	DGOR/pupu	≥ 2 yrs	M
2005	SMR / ES05	SMR / LAP	0.0	Mgo	DPWH/pupu	≥ 2 yrs	M
2005	SMR / AE33	SMR / ATK	0.1	OROR/Msi	pupu	≥ 2 yrs	M
2005	SMR / AE05	SMR / ALI	0.0	ORPU/Msi	pupu	≥ 2 yrs	M
2005	SMR / HE16	SMR / HLD	0.0	PUWH/Mgo	pupu	≥ 2 yrs	M
2005	SMR / PO08	SMR / PO14	0.1	YEPU/Mgo	-	≥ 2 yrs	M
2005	PC / PS04	PC / PS17	0.0	Mbk	YEYE	3 yrs	M
2003	PC / INL3	WC / WC03	2.2	PUWH/Mbk	-	3 yrs	M
2004	SMR / MAPS	SMR / ES19	0.0	DPDP/gogo	Msi	≥ 3 yrs	M
2004	SLR / U2	SMR / HW09	11.5	BKYE	Mdb	≥ 3 yrs	F
2005	SMR / BN10	SMR / BN03	0.0	-	DGOR/Mgo	8 yrs	M
2005	SMR / PR09	SMR / PO12	2.8	Mgo	BK BK/pupu	AHY	M
≤ 2003	Unknown	FC / OL05	> 6.7	Mbk	-	AHY	F
Unknown	Unknown	SMR / HDX	> 8.0	Mdb	-	AHY	F

^a Drainage Codes: SMR = Santa Margarita River; SLR = San Luis Rey River; PC = Pilgrim Creek; WC = Windmill Canyon; FC = Fallbrook Creek/Lake O'Neill.

^b Band colors: Mbk = black numbered federal band; Mdb = dark blue numbered federal band; Msi = silver numbered federal band; Mgo = gold numbered federal band; gogo = metal gold; BK BK = plastic black; BKYE = plastic black-yellow split; BYST = plastic black-yellow striped; DGOR = plastic dark green-orange split; DPDP = plastic dark pink; DPWH = plastic dark pink-white split; OROR = plastic orange; ORPU = plastic orange-purple split; pupu = metal purple; PUWH = plastic purple-white split; WHWH = plastic white; YEPU = plastic yellow-purple split; YEYE = plastic yellow.

Nine of the 89 hatch-year vireos banded in 2005 that survived to fledge were resighted at Camp Pendleton in 2006, yielding an estimated first year survivorship of 10%. Since female vireos are elusive and difficult to resight, this estimate is most likely conservative. Eight of the nine first year birds detected were male. Assuming an even sex ratio of nestlings, a more

accurate estimate of first year survivorship of male vireos, and possibly first year vireos in general, is 18% (8/44.5). Five of the nine returning first year birds were recaptured and banded with a unique color combination. All five were male, and originally fledged from, and dispersed to, territories located within the Santa Margarita River. Dispersal distance of first year vireos ranged from 0.9-1.5 km, and averaged 1.3 ± 0.3 km (std).

Nest Monitoring

Nesting activity was monitored in a total of 47 territories within the *A. donax* Removal and Reference monitoring areas (Table 7, Figures 5-8, Appendix C). Of these, 42 territories were "fully" monitored, meaning that all nests within the territory were found and documented during the breeding season. Pairs within the remaining five territories were documented nesting; however, only a subset of nests by a pair were found and monitored (= "partially monitored"). A total of 87 nests were monitored during the breeding season; however, 8 of these were not completed (coded as "INC" in Appendix C) and have been excluded from nest success and productivity calculations. Of the remaining 79 nests, 74 were in fully monitored territories.

Table 7. Number of least Bell's vireo territories and nests monitored at Marine Corps Base Camp Pendleton, 2006.

	<u>Nest Monitoring Area Type</u>	
	Reference	Removal
Territories fully monitored	22	20
Nests in fully monitored territories	45	29
Completed nests per pair (fully monitored territories)	2.0 ± 0.7 (std)	1.4 ± 0.7 (std)
Territories partially monitored	0	5
Nests in partially monitored territories	0	5
Total # of nests monitored	45	34

Within fully monitored territories, pairs in the Reference sites averaged significantly more nesting attempts (2.0 nests/pair) than pairs at Removal sites (1.4 nests/pair) ($t_{0.05, 40} = 2.02$, $P = 0.009$) over the course of the 2006 breeding season. Fully monitored pairs at Reference sites were more likely to re-nest after their initial attempt compared to pairs at Removal sites, as 82% of Reference pairs initiated a second attempt compared to 35% of Removal pairs. Nest fate influenced the likelihood that pairs would re-nest. Ninety-four percent of Reference and 67% of Removal pairs whose initial nests failed attempted second nests, compared to only 50% of Reference and 9% of Removal pairs re-nesting after a successful first attempt. Four Reference and two Removal pairs initiated three nesting attempts, and one Reference pair initiated four nesting attempts in 2006.

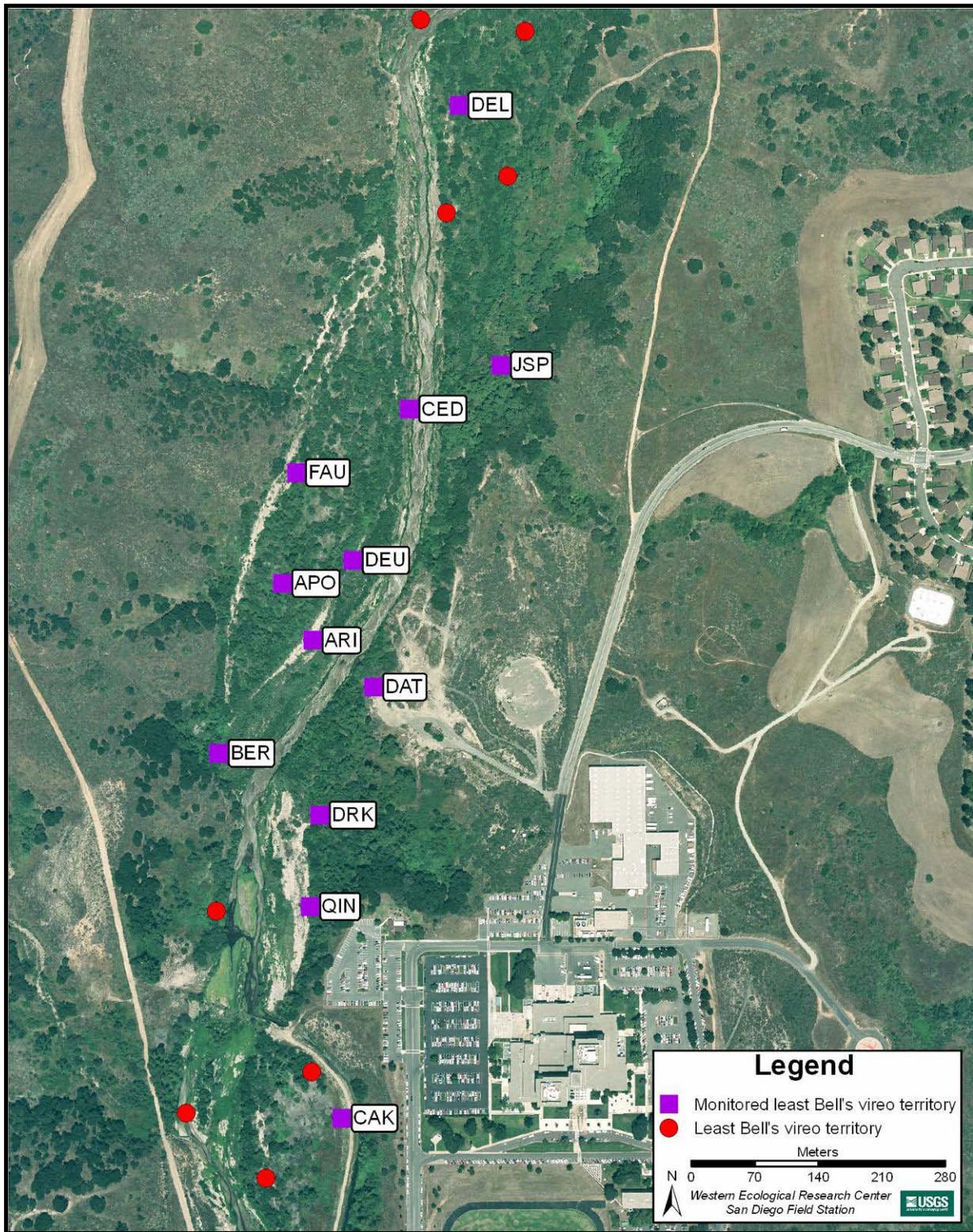


Figure 5. Locations of monitored least Bell's vireo territories at the Above Hospital Reference site, Marine Corps Base Camp Pendleton, 2006.

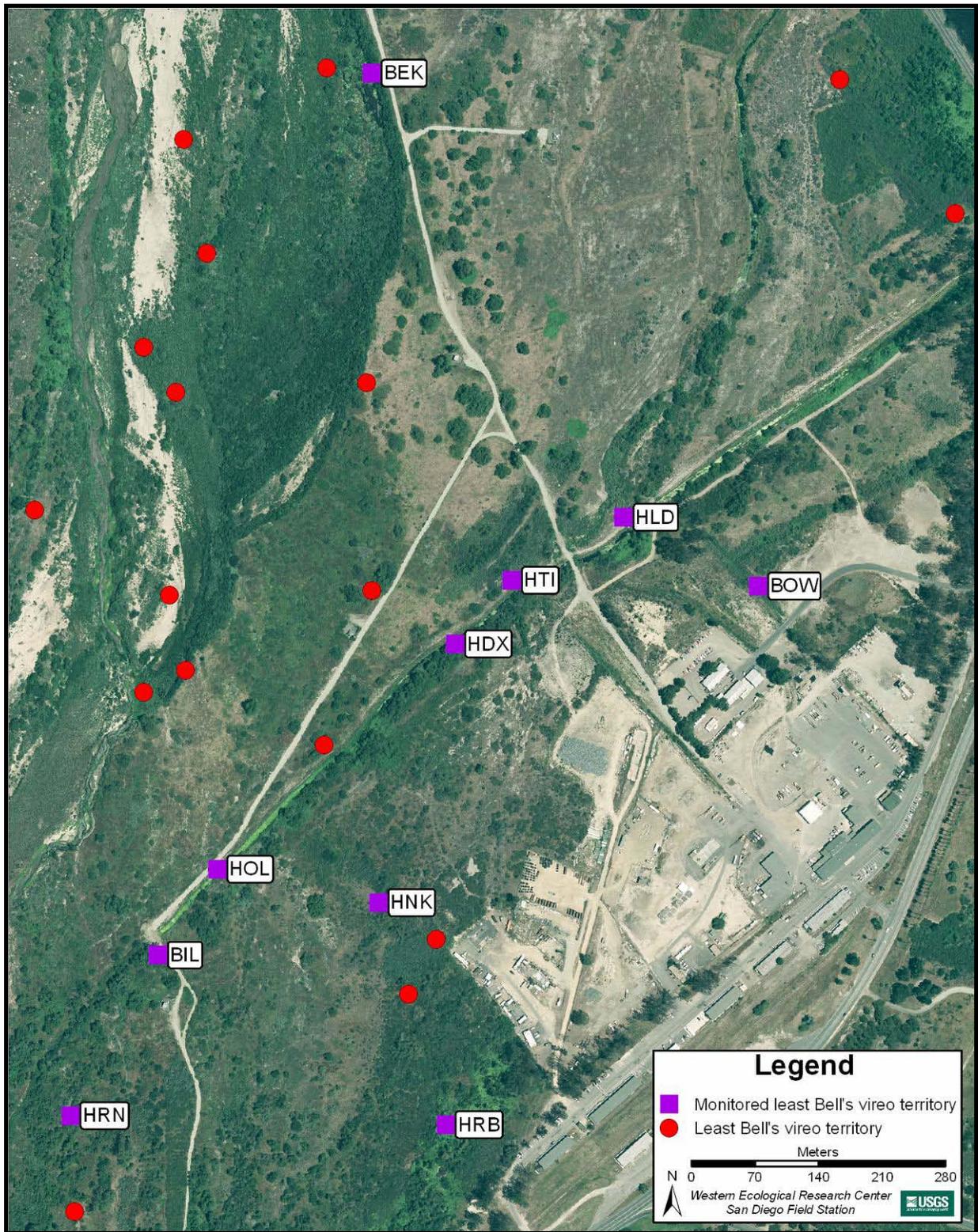


Figure 6. Locations of monitored least Bell's vireo territories at the Below Hospital Reference site, Marine Corps Base Camp Pendleton, 2006.

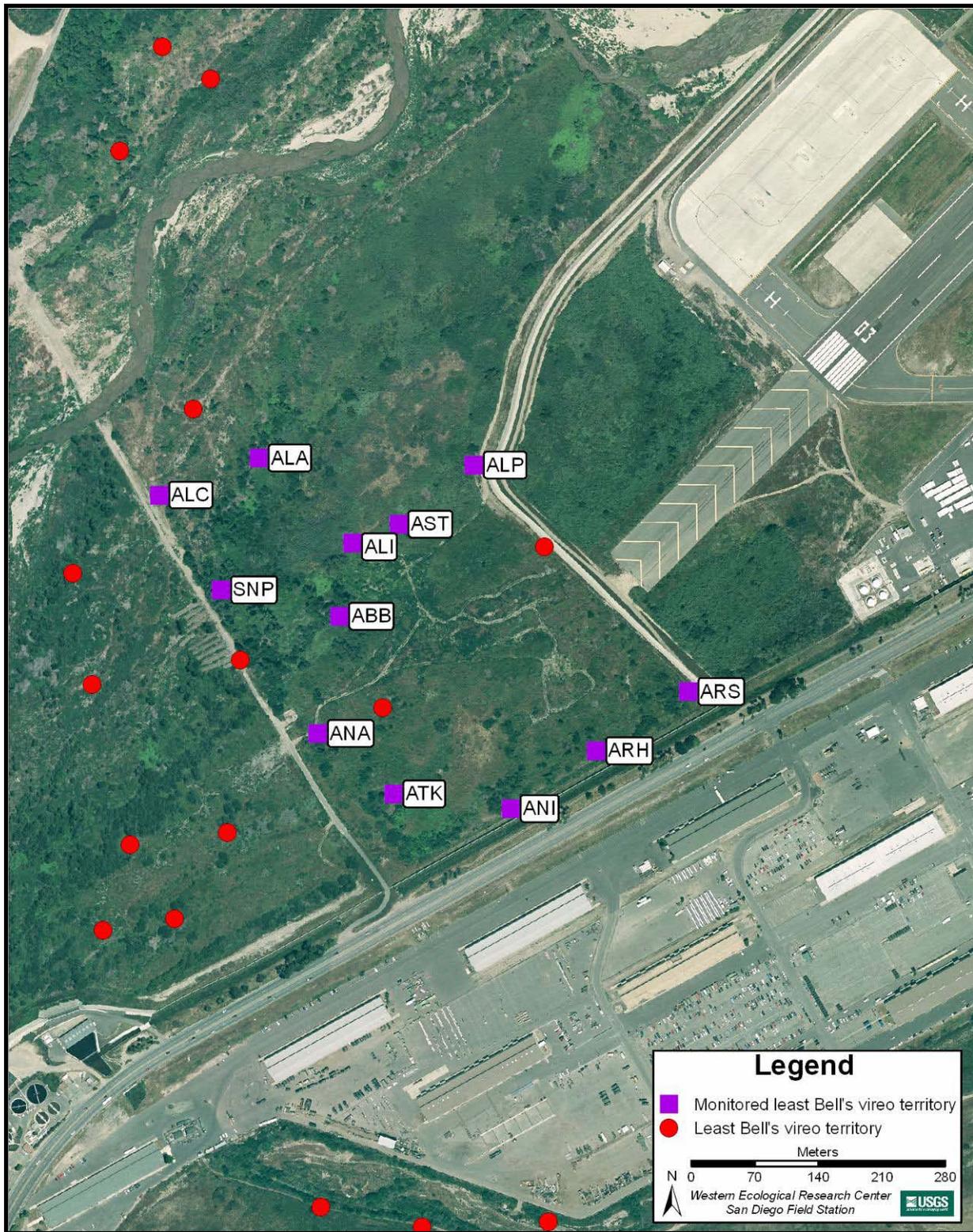


Figure 7. Locations of monitored least Bell's vireo territories at the Air Station *A. donax* Removal site, Marine Corps Base Camp Pendleton, 2006.

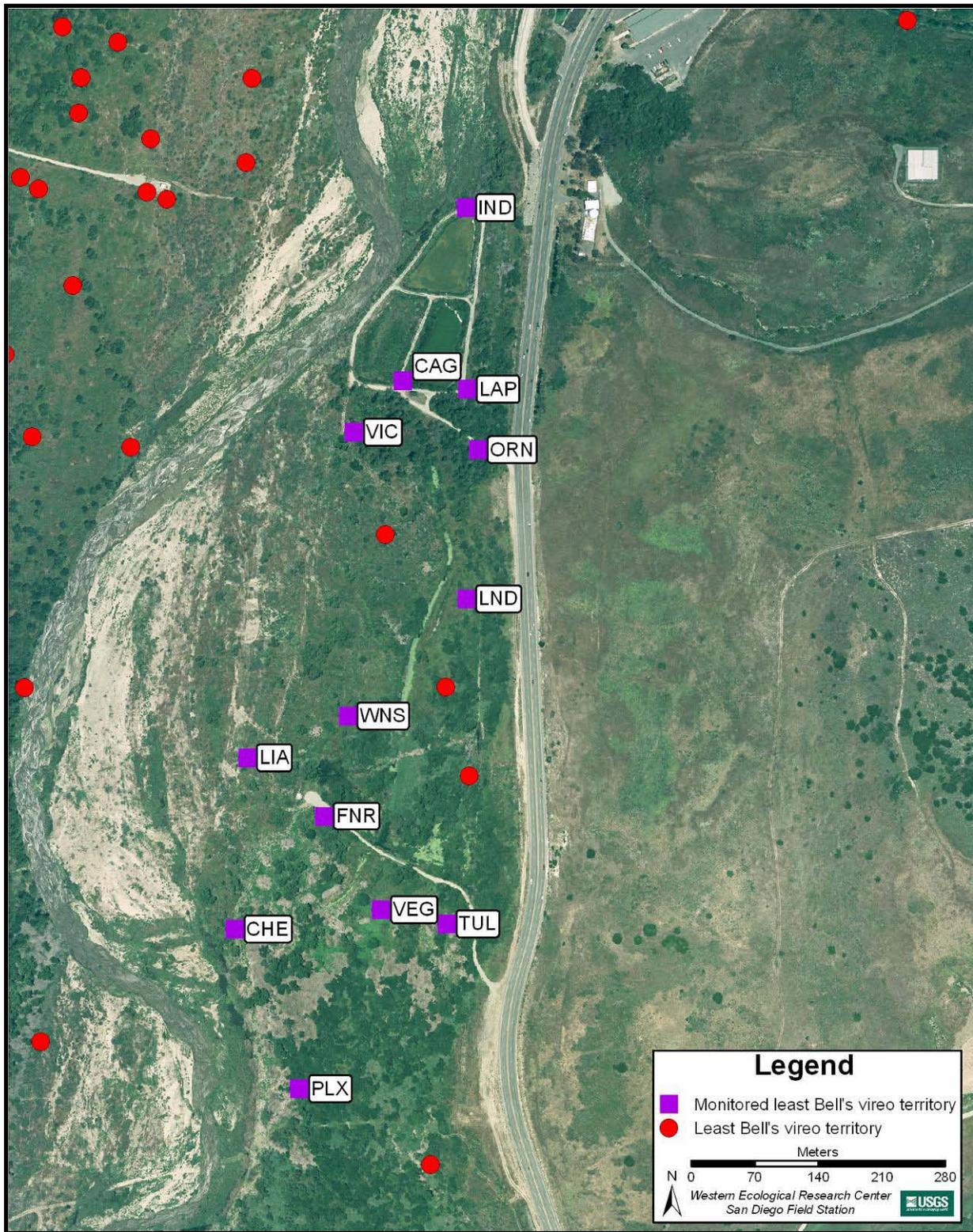


Figure 8. Locations of monitored least Bell's vireo territories at the Seep *A. donax* Removal site, Marine Corps Base Camp Pendleton, 2006.

Nest Success

Nest success of pairs breeding in Removal sites was higher than that of pairs at Reference sites ($\chi^2_{0.05,1} = 3.67, P = 0.06$), as 62% (21/34) of Removal nests and 40% (18/45) of Reference nests successfully fledged young. Causes of nest failure were similar between Reference and Removal sites. Predation was believed to be the primary source of nest failure at both sites, although no predation events were witnessed (Table 8). Predation accounted for 81% (22/27) and 77% (10/13) of nest failures at Reference and Removal sites, respectively. Overall, 49 and 29%, respectively, of completed vireo nests were lost to predation. Two nests apparently failed because of exposure when the herbaceous plant shading the nest died, exposing the nestlings to extended periods of direct sunlight. Two nests, both from the same pair, contained infertile eggs and were abandoned after 17 and 19 days of incubation. One nest built in *C. maculatum* failed when the branch supporting the nest collapsed, dumping its contents of three eggs on the ground. Finally, the cause of failure of three nests was unknown. It is possible that they were depredated in the egg stage or abandoned prior to egg laying, as they failed during the time eggs should have been laid but no eggs were observed in the nest.

Table 8. Cause of failure of least Bell's vireo nests, Camp Pendleton, 2006.

Cause of nest failure	Number of Nests		
	Reference	Removal	Total
Predation	22	10	31
Parasitism	0	0	0
Other/Unknown	5	3	8
Total Failed Nests	27	13	40
Total Completed Nests	45	34	79

Cowbird Parasitism

No nests were directly lost to parasitism; however one nest (LAP, Figure 8, Appendix C) was parasitized by a brown-headed cowbird during the nestling stage. This nest was the third attempt by the LAP pair, and was located approximately 30 m from a cowbird trap. The nest was found on 21 June and contained three least Bell's vireo eggs. The nest was monitored regularly and 12 days later on 3 July still contained 3 vireo eggs. When checked on 7 July, the nest contained two, three-day-old vireo nestlings and one cowbird egg. The nestlings were banded on 10 July, when six days old, at which time the cowbird egg was removed. On 13 July the nestlings were found dead in the nest. They were intact, possessing no lacerations or contusions suggestive of cowbird predation. The definitive cause of nest failure was unknown; however, the herbaceous plant (*C. maculatum*) that shaded the nest had died, exposing the nest to direct sunlight. It is possible that the young were not able to thermoregulate and died from heat stress. It is unlikely that the nest was abandoned for reasons associated with the removal of the cowbird egg or banding of the vireo young. Adult vireos are extremely faithful to nests with nestlings and do not readily abandon nests in which they have invested so much time and effort, particularly nests within days of fledging.

Productivity

Reproductive success did not differ between pairs occupying Reference or *A. donax* Removal sites (Table 9). Measures of productivity did not vary at the egg or nestling stage as average clutch size and average brood size were not statistically different between Reference and Removal sites. Pairs at Reference sites exhibited a lower hatching rate of eggs (59% vs. 70%) and possessed a lower percentage of nests in which at least one egg hatched (60% vs. 85%) than did pairs at Removal sites. However, this did not translate into a statistically different brood size between Reference and Removal pairs, largely because of a greater incidence of infertile eggs at

Table 9. Reproductive success and productivity of nesting least Bell's vireos at Reference and *A. donax* Removal sites, Camp Pendleton, 2006.

Parameter	Total Number	
	Reference	Removal
Nests with eggs	42	33
Eggs laid	136	111
Average clutch size ^a	3.5 ± 0.7 (std)	3.5 ± 0.6 (std)
Nests with hatchlings	25	28
Hatchlings	80	78
Average brood size ^b	3.3 ± 0.8 (std)	3.0 ± 0.8 (std)
Hatching success:		
Eggs ^c	59%	70%
Nests ^d	60%	85%
Nests with fledglings	18	21
Fledglings	58	54
Fledging success:		
Hatchlings ^e	72%	69%
Nests ^f	72%	75%
Fledglings per nest	1.3	1.6
Average number of young fledged per pair ^g	2.6 ± 2.0 (std)	2.0 ± 1.2 (std)
Pairs fledging ≥ one young ^h	16 (73%)	17 (85%)

^a Based on 32 Reference and 29 Removal non-parasitized nests with a full clutch. (Two-sample *t*-test: $t_{0.05, 59} = 0.11$, $P = 0.92$).

^b Based on 21 Reference and 22 Removal non-parasitized nests known to have a full brood. (Two-sample *t*-test: $t_{0.05, 41} = 1.75$, $P = 0.12$).

^c Percent of all eggs that hatched.

^d Percent of all nests with eggs in which at least one egg hatched.

^e Percent of all nestlings that fledged.

^f Percent of all nests with nestlings in which at least one young fledged.

^g Based on 22 Reference and 20 Removal pairs who were fully monitored. (Unequal variance two-sample *t*-test: $t_{0.05, 35} = 1.16$, $P = 0.25$).

^h Based on fully monitored pairs.

Removal sites within nests possessing four-egg clutches. Within Reference sites, 29% (4 nests) of four-egg clutches that survived to the nestling stage contained at least one infertile egg, compared to 58% (7 nests) of four-egg clutches at Removal sites. This resulted in 52% of Reference nests being comprised of four-nestling broods, compared to only 23% of nests at Removal sites. At Removal sites three-nestling broods dominated, comprising 55% of nests. This allowed nests at Reference sites to produce slightly more nestlings per nest (3.3 young/nest) than nests at Removal sites (3.0 young/nest), even though the overall hatching rate of eggs at Reference sites was less than at Removal sites.

Fledging success parameters were comparable between Reference and Removal pairs. More than 70% of nests at both sites eventually fledged young, with 72% of Reference and 69% of Removal nestlings fledging. The average number of young fledged per pair did not differ statistically between the Reference and Removal sites, but a lower proportion of pairs at Reference sites were ultimately successful in fledging young from at least one nest, 73% (16/22) compared with 85% (17/20) of the pairs at Removal sites.

Nest Characteristics

Successful and unsuccessful nests within Reference and Removal sites did not differ statistically in average nest height, height of the host plant, or the distance the nest was placed from the edge of the host (Table 10). However, differences in nest placement were observed between nests built within Reference and *A. donax* Removal sites. Vireo nests at Removal sites were placed significantly higher above ground and in taller host plants than nests at Reference sites (Table 10). There was no difference in the distance nests were placed from the edge of host plants between Reference and Removal sites.

Table 10. Least Bell's vireo nest characteristics and results of two-sample unequal variance t-tests of successful vs. unsuccessful nesting attempts at Reference and *A. donax* Removal sites, Marine Corps Base Camp Pendleton, 2006.

Nest Characteristic	Nest Fate		df ^a	<i>t</i> ^b	<i>P</i> ^c
	Successful	Unsuccessful			
Reference Site					
Average nest height (m)	0.72	0.71	32	0.03	0.97
Average host height (m)	3.57	3.14	35	0.48	0.64
Average distance to edge of host (m)	0.66	0.63	40	0.10	0.92
Removal Site					
Average nest height (m)	1.02	0.91	31	1.15	0.26
Average host height (m)	5.04	4.40	23	0.62	0.54
Average distance to edge of host (m)	0.75	0.67	22	0.33	0.74
	Overall	Reference	Removal		
Average nest height (m)	0.71	0.98	64	-4.11	< 0.001
Average host height (m)	3.16	4.79	72	-2.51	0.01
Average distance to edge of host (m)	0.64	0.72	74	-0.49	0.63

^a df = degrees of freedom

^b *t* = two-sample unequal variance t-test test statistic

^c *P* = P-value

Vireos at Reference and Removal sites were comparable in their selection of host species, with 62-64% of nests placed in *S. lasiolepis* and *S. exigua* (Table 11). Vireos at Removal sites placed 15% of nests in *C. maculatum* and 12% in *S. gooddingii*, which although present, were not used as host plants at Reference sites. The third most prevalent host plant at Reference sites was *B. salicifolia*, in which 11% of nests were constructed. An additional six plant species were used as nest support by vireos. Even though only 6% of vireo territories were in areas where exotic species made up 50% or more of the vegetation, 10% of all nests were placed in two of the exotic species, *C. maculatum* and *B. nigra*.

Table 11. Host plant species used by least Bell's vireos at Reference and A. *donax* Removal sites, Marine Corps Base Camp Pendleton, 2006. .

Host Species	Reference ^a	Removal
<i>Salix lasiolepis</i>	19 (0.42)	16 (0.47)
<i>S. exigua</i>	10 (0.22)	5 (0.15)
<i>Baccharis salicifolia</i>	5 (0.11)	1 (0.03)
<i>Vitis californica</i>	3 (0.07)	2 (0.06)
<i>Brassica nigra</i>	3 (0.07)	0 (0.00)
<i>Rubus ursinus</i>	2 (0.04)	0 (0.00)
<i>Artemisia douglasiana</i>	1 (0.02)	1 (0.03)
<i>Rosa californica</i>	1 (0.02)	0 (0.00)
<i>Toxicodendron diversilobum</i>	1 (0.02)	0 (0.00)
<i>Conium maculatum</i>	0 (0.00)	5 (0.15)
<i>S. gooddingii</i>	0 (0.00)	4 (0.12)

^a Numbers in parentheses are proportions of total nests.

DISCUSSION

One of the most striking features of the 2006 breeding season was a delay in the arrival of the majority of vireos onto breeding sites. The late arrival of vireos observed at Camp Pendleton was also documented for other nearby vireo populations including populations on the lower (Ferree and Kus 2007) and upper San Luis Rey River (Rourke and Kus 2007). Migration was delayed by at least two weeks compared to previous years. However, once vireos started arriving the rate of territory establishment was similar to other years (Figure 3). It is unclear why vireo arrival was delayed in 2006 or whether it played a role in lowering the 2006 vireo population on Base.

Despite the decrease in vireo numbers observed in 2006, the number of documented territories was within the range of approximately 700-1000 territories observed on Marine Corps Base Camp Pendleton for the past 12 years. The vireo population has fluctuated between a low of 696 territories in 1995 and a high of 1,011 territories in 1998 (Griffith Wildlife Biology 2004) (Figure 30). From 1998 to 2003, the vireo population steadily declined to 718 territories. In 2004 and 2005, the vireo population increased to 823 and 827 territories, respectively, and in 2006 was identical to the 2003 population of 718 territories. The reduction in territories in 2006 primarily occurred on 6 drainages (Santa Margarita River, Pilgrim Creek, Lake O'Neill/Fallbrook Creek, Aliso Creek, Las Flores Creek, and San Onofre Creek), which combined lost a total of 106 territories. No alteration to the habitat along any of these drainages was documented that

could explain the decline. Only 5 drainages increased in vireo abundance between 2005 and 2006, adding only 15 territories between all drainages. The largest increase in vireo numbers (39%, 7 territories) was documented on De Luz Creek. In 2005, a fire burned approximately 763 ha of habitat along the creek. Recently, habitat within the burned area has started to regenerate. Four of the seven newly established territories on De Luz Creek were within the perimeter of the burn.

The cause of the population decline in 2006 does not appear to be related to productivity as reproductive success in 2005 was high, with vireos fledging over 2.5 young per pair (Rourke and Kus 2006). It is possible that the decline was the result of dispersal/emigration of adult and/or second-year vireos off Base. One of the largest off Base drainages containing suitable vireo habitat and thus a potential destination for migrating vireos is the San Luis Rey River running along the southern border of Camp Pendleton. However, none of the 116 unaccounted-for adult and juvenile least Bell's vireos banded by 2005 were resighted along 17.5 km of the San Luis Rey River in 2006 (Ferree and Kus 2007, Rourke and Kus 2007), nor did the San Luis Rey River vireo populations increase in 2006. Three vireos originally banded on the San Luis Rey River were resighted on Base in 2006, demonstrating that dispersal between the drainages is possible. Further banding and resighting of vireos within southern California will allow a better determination of the extent of movement between populations and the role such movement plays in maintaining genetic diversity and persistence in these populations. Ten percent of hatch-year birds banded in 2005 were resighted on Base in 2006. Although this number seems low, it provides the opportunity to collect life-time reproductive data for a segment of the population, facilitating identification of age- and possibly sex-related patterns in life history characteristics that influence population size, productivity, and genetic structure.

There were numerous similarities between measures of reproductive success in 2005 and 2006 at *A. donax* Removal and Reference sites. In both years measures of productivity, such as average clutch size and average brood size, did not differ statistically. In 2005 and 2006, a higher percentage of eggs from pairs nesting at Removal sites hatched (67% vs. 58% in 2005, and 70% vs. 59% in 2006) and a higher percentage of nests in the incubation stage eventually hatched at least one egg (70% vs. 59% in 2005, and 85% vs. 60% in 2006) compared to nests at Reference sites. Four-egg clutches were most prevalent within Removal and Reference treatments. However, three-nestling broods dominated nests within Removal sites (57% in 2005 and 55% in 2006), while four-nestling broods dominated nests within Reference sites (45% in 2005 and 52% in 2006). Despite these differences, in both years, productivity at Removal and Reference sites was high, with greater than two young fledged per pair, and did not differ statistically. From these data it appears that vireo productivity within *A. donax* Removal and Reference sites does not differ. However, with only two years of data it is not possible to know whether this trend will persist through time. It is only through continued monitoring that we will determine whether vireo productivity at *A. donax* Removal sites and Reference sites are truly equal.

Exotic vegetation on Base was widespread and is a potential issue of concern since its impact(s) on least Bell's vireo abundance, distribution, and nest success are not well understood. The use of exotics as a nesting substrate declined from 15% in 2005 to 5% of all nests in 2006. Similar to 2005, 33% of nests built in *C. maculatum* failed when the host plant gave way,

dumping the nestlings on the ground. Two other nest failures may have been indirectly attributable to the presence of exotic plants as on two occasions nestlings died as a result of extended sun exposure when the exotic species shading the nest desiccated. Invasive exotic plants were less prevalent in 2006 than in 2005, but remained widespread. Exotic plants were a dominant component of at least 1 vireo territory within 8 of the 19 drainages containing vireos (compared to 100% of drainages supporting vireos in 2005) and were also a dominant component of approximately 6% (20% in 2005) of all vireo territories Base-wide. The reason for the decline in use of exotic plants by vireos is unclear. It may reflect a reduction in the availability of exotic vegetation Base-wide as a result of the removal/control programs targeting 18 exotic plant species currently implemented by Camp Pendleton (MCB Camp Pendleton 2007). Exotic vegetation on Base may have been further reduced by the low precipitation documented in southern California during the winter of 2005-2006 that may have inhibited the growth of exotic plants during the 2006 breeding season. Alternatively, because of the smaller size of the vireo population in 2006, it is possible that proportionately more high quality habitat was available during the 2006 breeding season compared to 2007, resulting in less use of exotic species. It is only through continued nest monitoring that we will be able to answer the question whether particular exotic species adversely affect least Bell's vireo nest success, productivity, and ultimately species recovery.

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APPENDIX A

**LEAST BELL'S VIREO SURVEY AREAS AT MARINE CORPS BASE CAMP
PENDLETON, 2006**

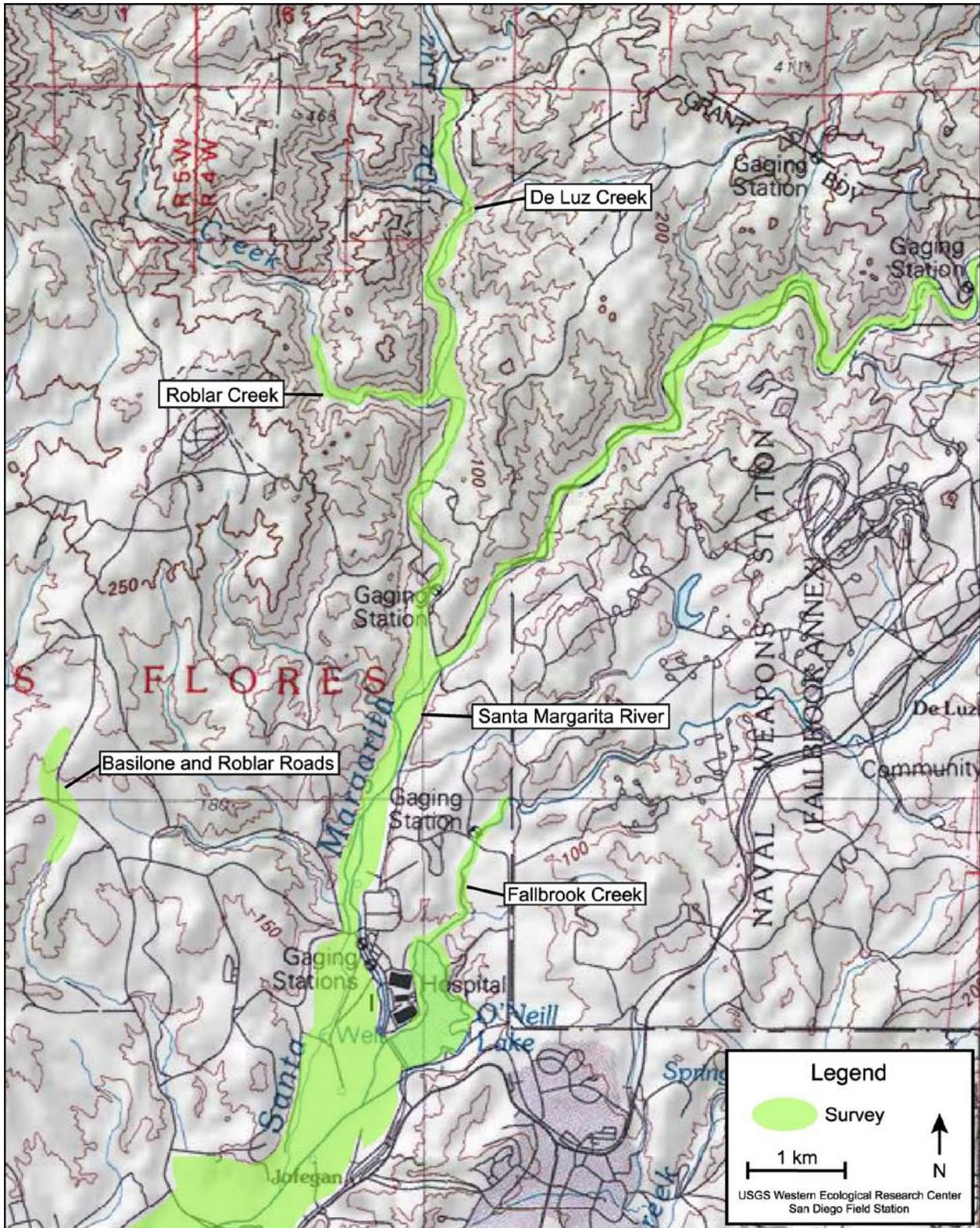


Figure 9. Least Bell's vireo survey areas at Marine Corps Base Camp Pendleton, 2006: Upper Santa Margarita River, Fallbrook Creek, De Luz Creek, Roblar Creek, and Basilone and Roblar Roads.

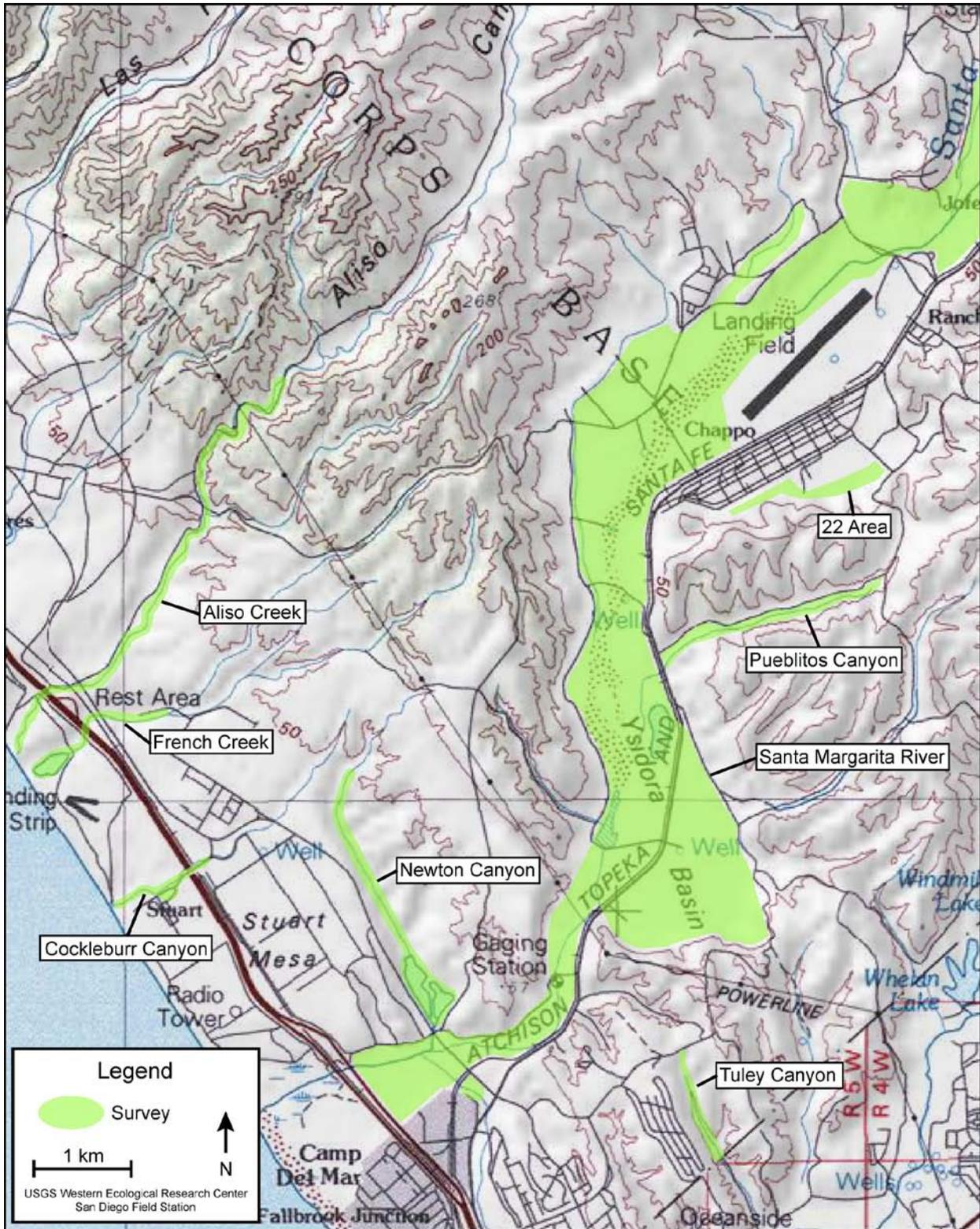


Figure 10. Least Bell's vireo survey areas at Marine Corps Base Camp Pendleton, 2006: Lower Santa Margarita River, 22 Area, Pueblitos Canyon, Tuley Canyon, Newton Canyon, Cocklebur Canyon, French Creek, and Aliso Creek.

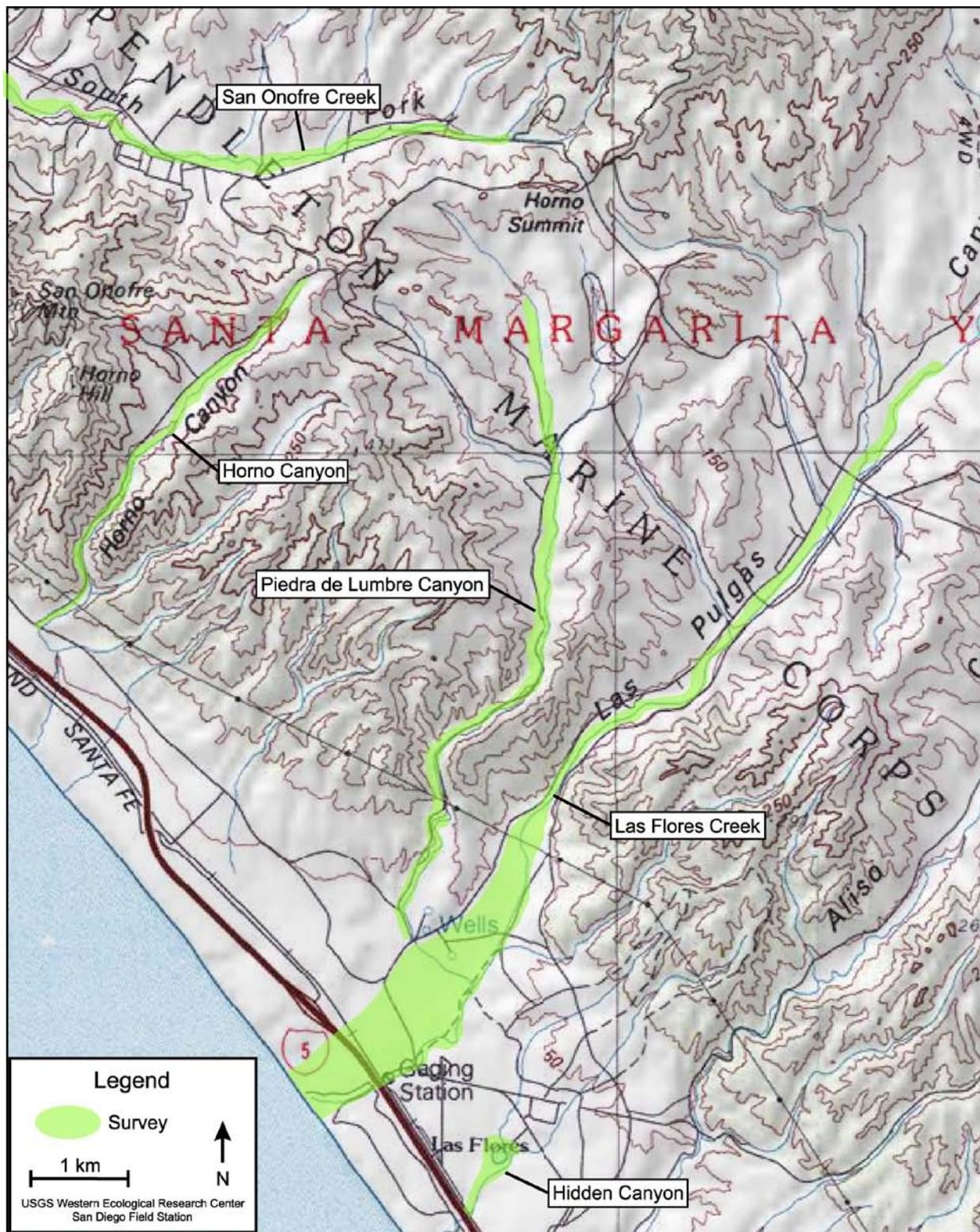


Figure 11. Least Bell's vireo survey areas at Marine Corps Base Camp Pendleton, 2006: San Onofre Creek South Fork, Horno Canyon, Piedra de Lumbre Canyon, Las Flores Creek, and Hidden Canyon.

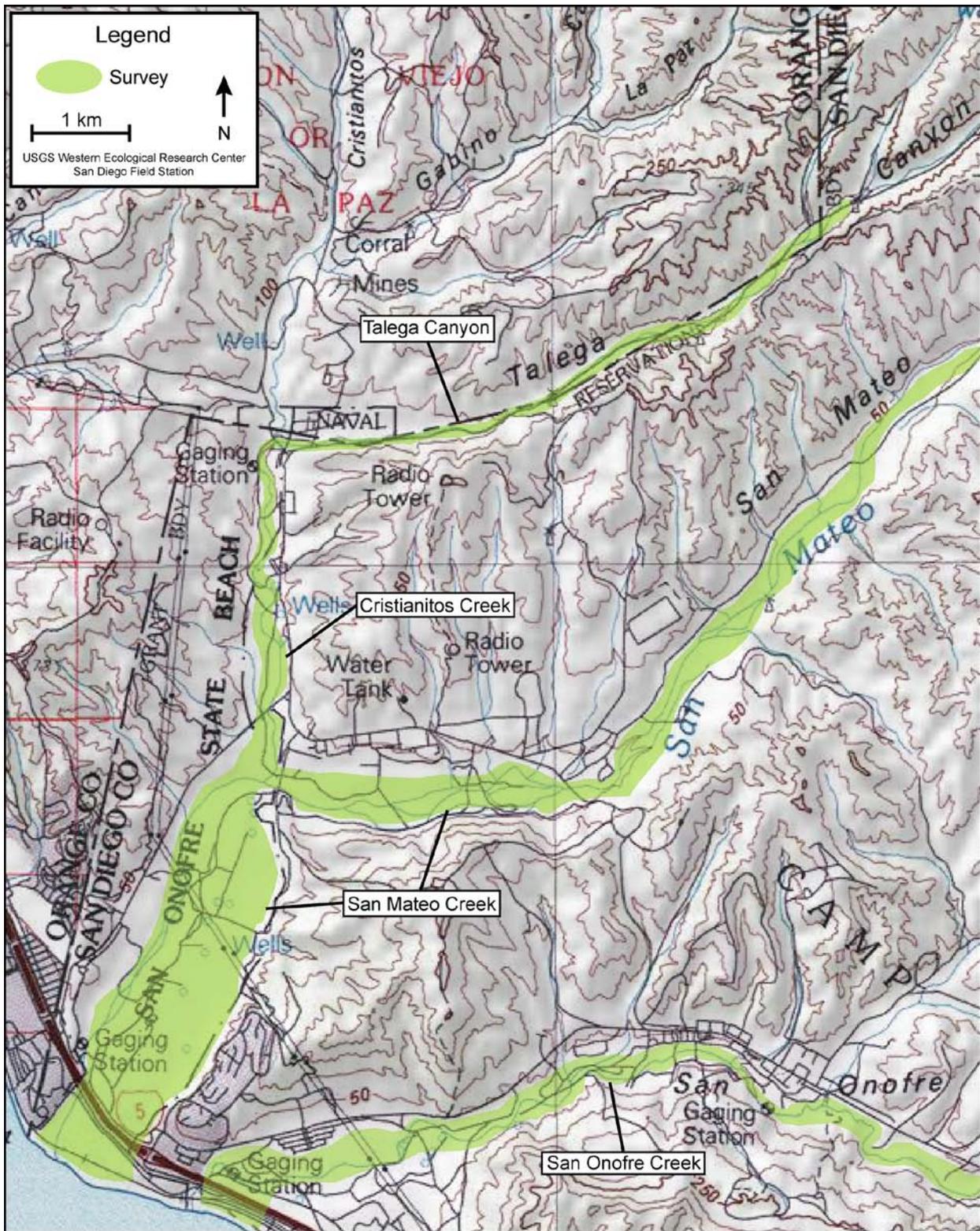


Figure 12. Least Bell's vireo survey areas at Marine Corps Base Camp Pendleton, 2006: Talega Canyon, Cristianitos Creek, San Mateo Creek, and San Onofre Creek.

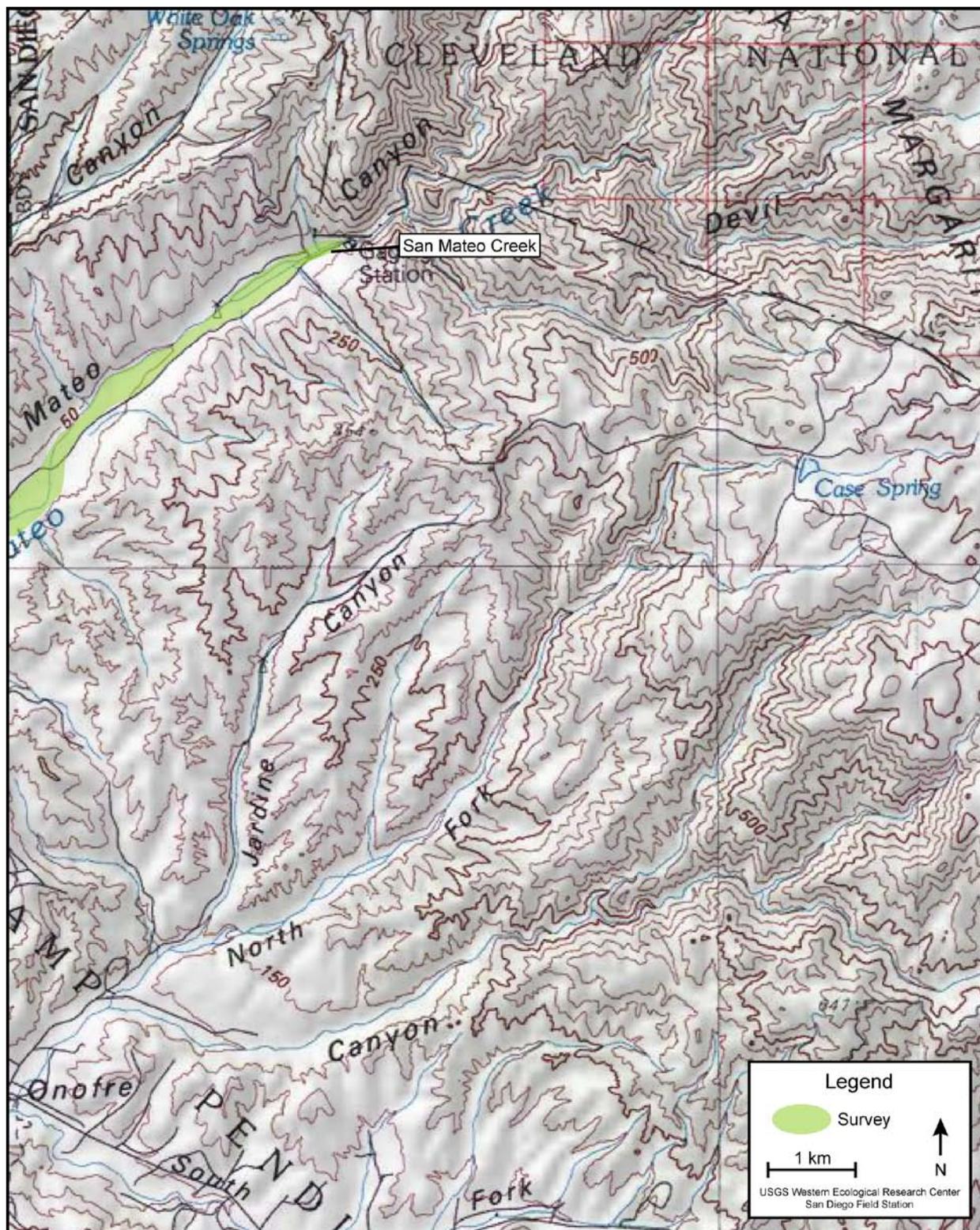


Figure 13. Least Bell's vireo survey areas at Marine Corps Base Camp Pendleton, 2006: Upper San Mateo Creek.

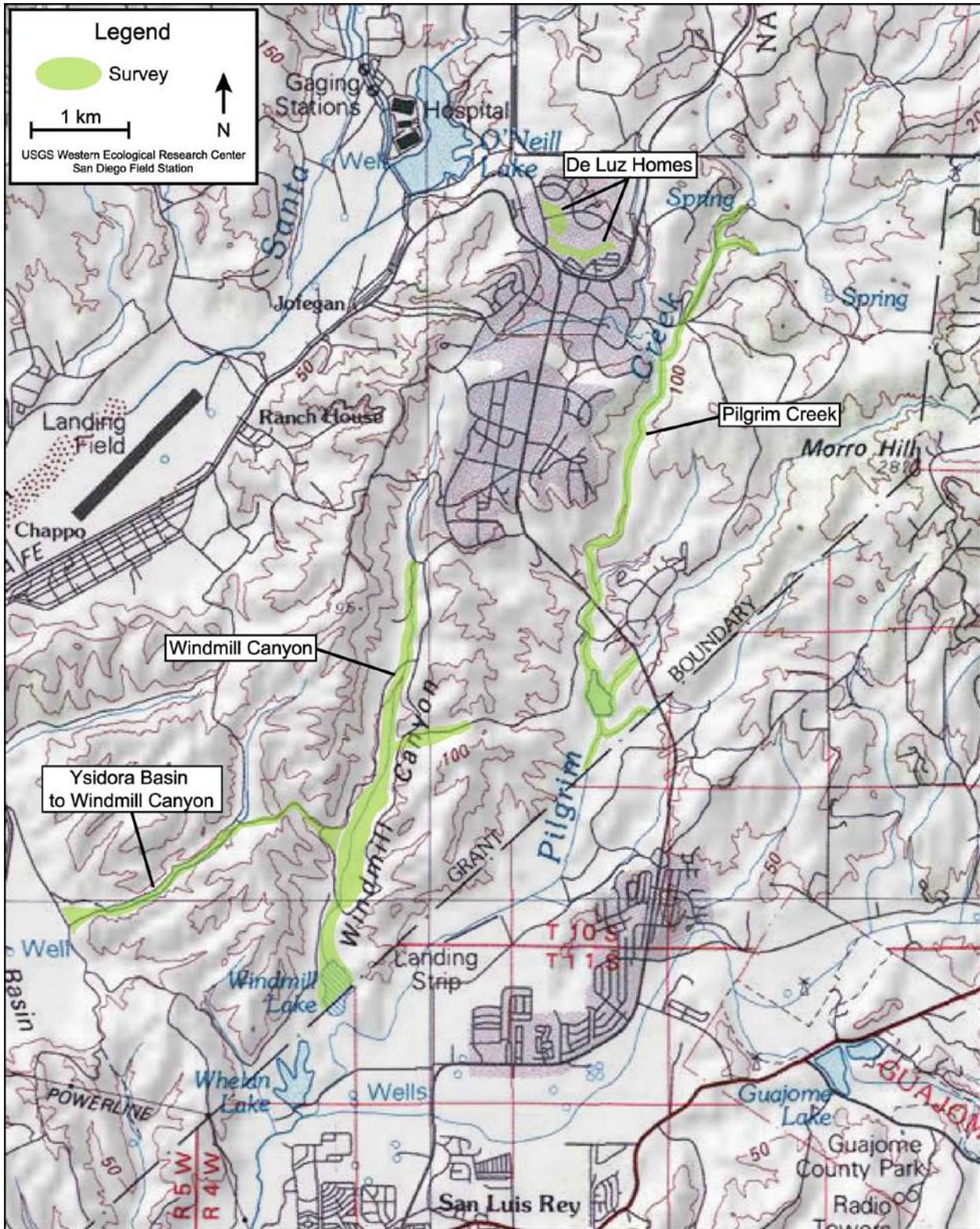


Figure 14. Least Bell's vireo survey areas at Marine Corps Base Camp Pendleton, 2006: Windmill Canyon, Ysidora Basin to Windmill Canyon, Pilgrim Creek, and De Luz Homes Habitat. .

APPENDIX B

**LOCATIONS OF LEAST BELL'S VIREOS AT MARINE CORPS BASE CAMP
PENDLETON, 2006**

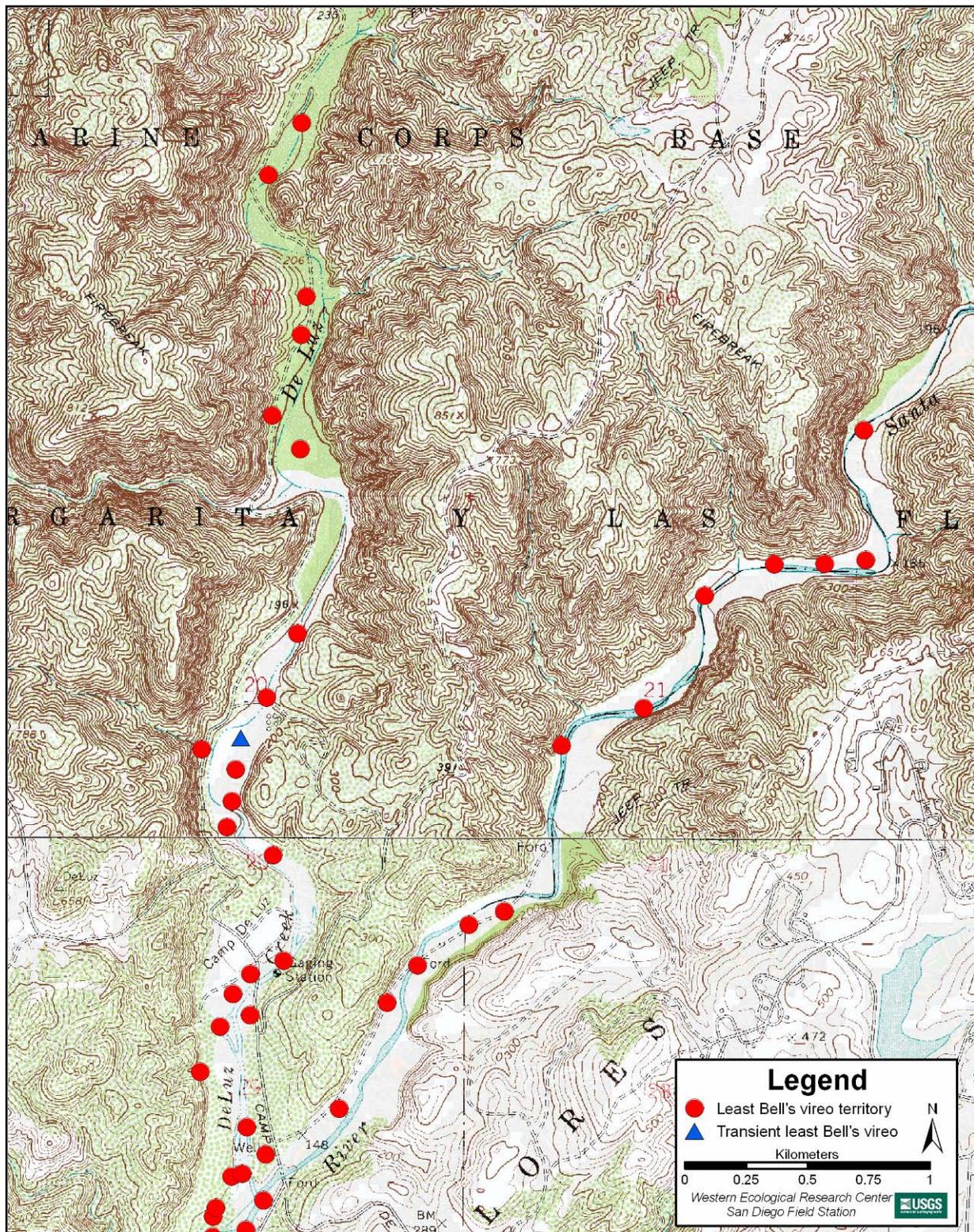


Figure 15. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Upper Santa Margarita River, De Luz Creek, and Roblar Creek.



Figure 16. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Upper Santa Margarita River.

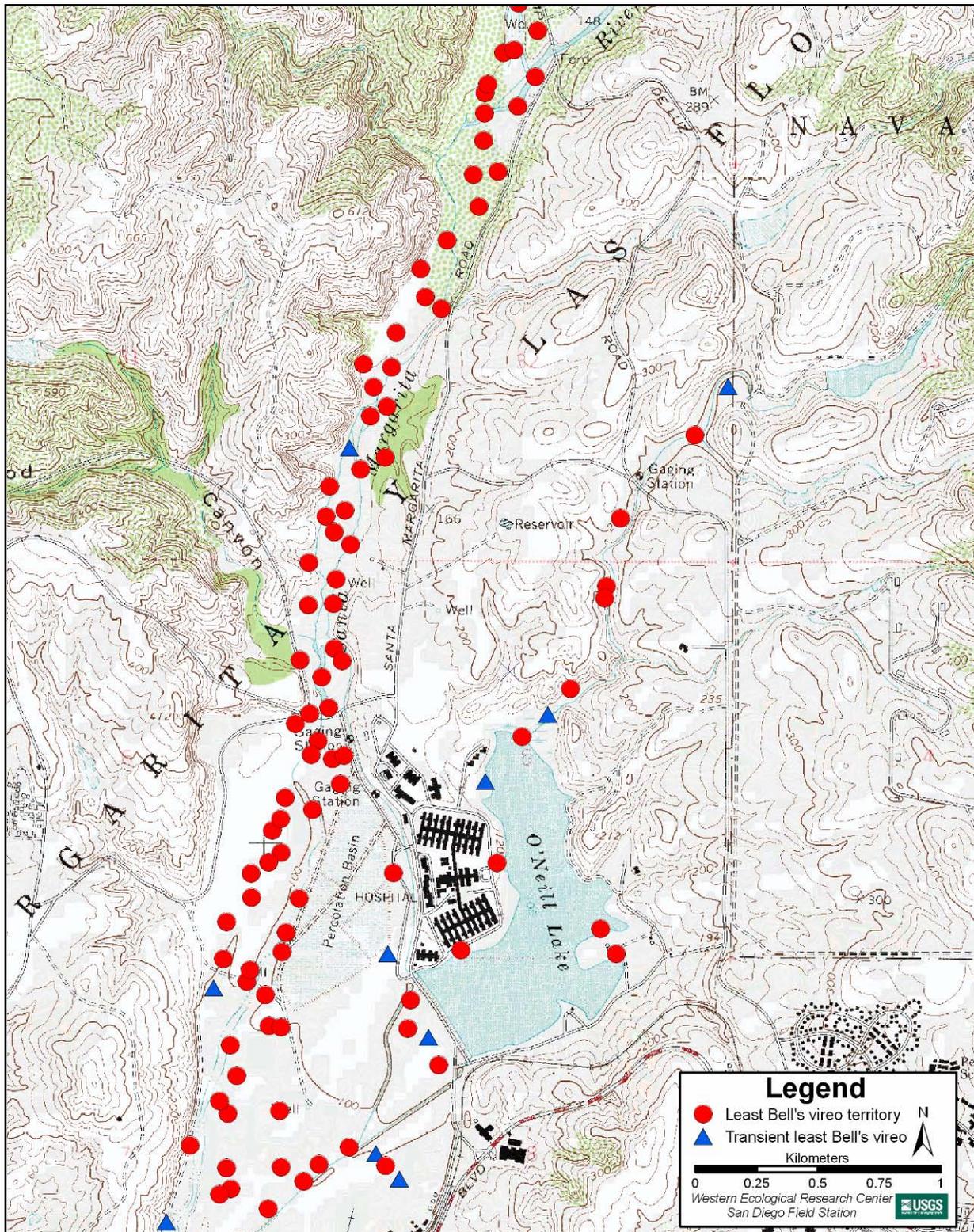


Figure 17. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Lake O'Neill, Fallbrook Creek, and Santa Margarita River.

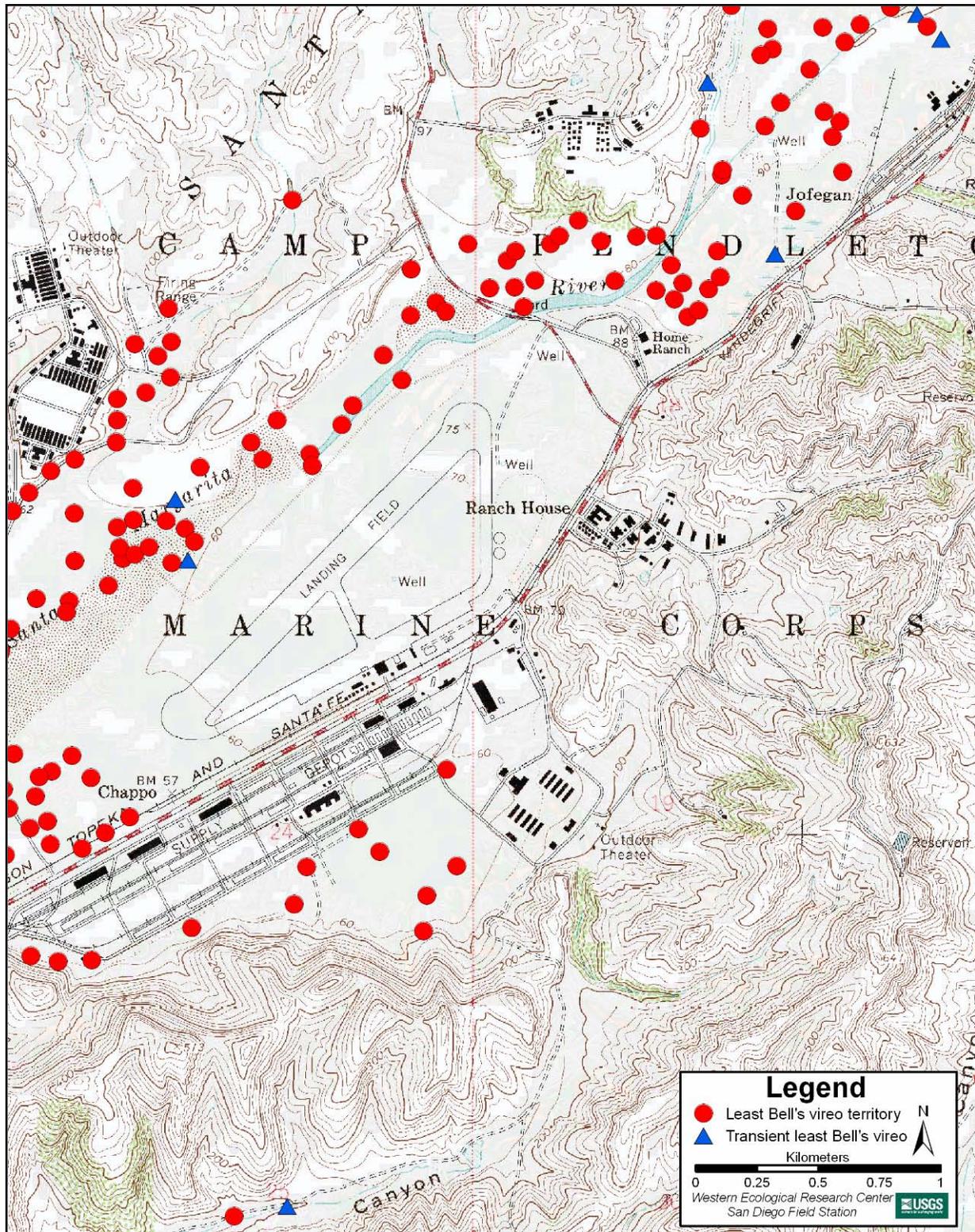


Figure 18. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Santa Margarita River and 22Area.

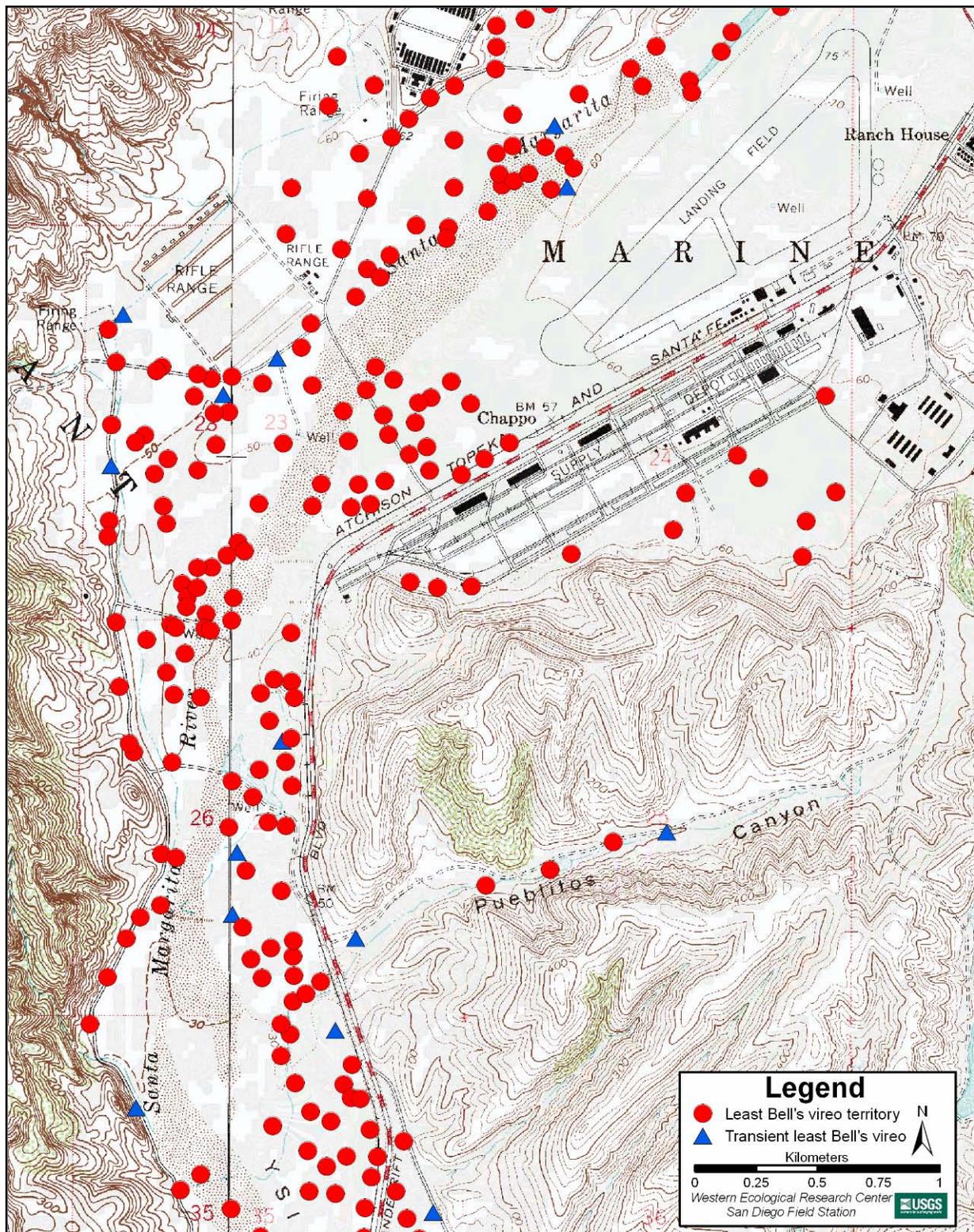


Figure 19. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Santa Margarita River and Pueblitos Canyon.

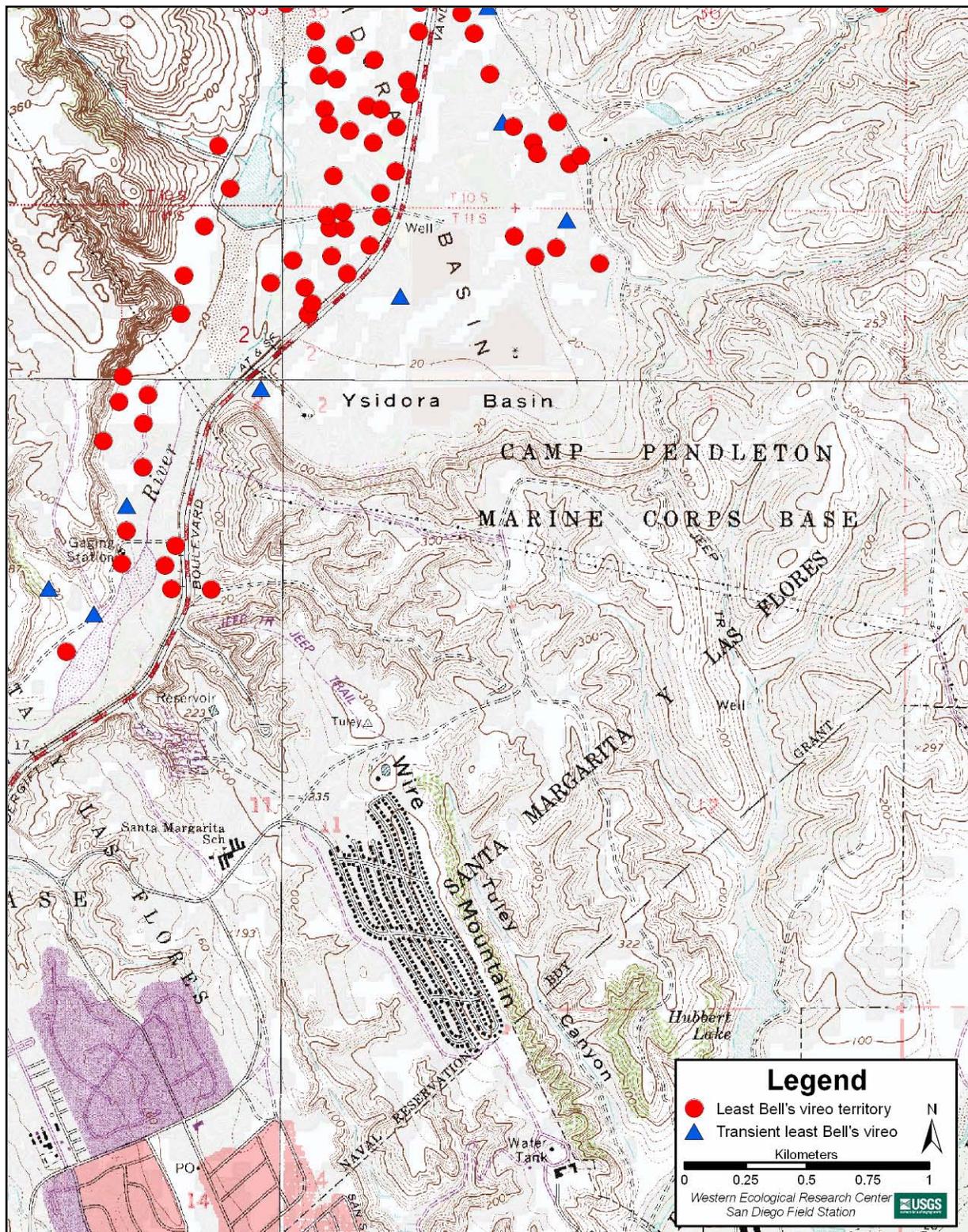


Figure 20. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Ysidora Basin, Santa Margarita River, and Ysidora Basin to Windmill Canyon.

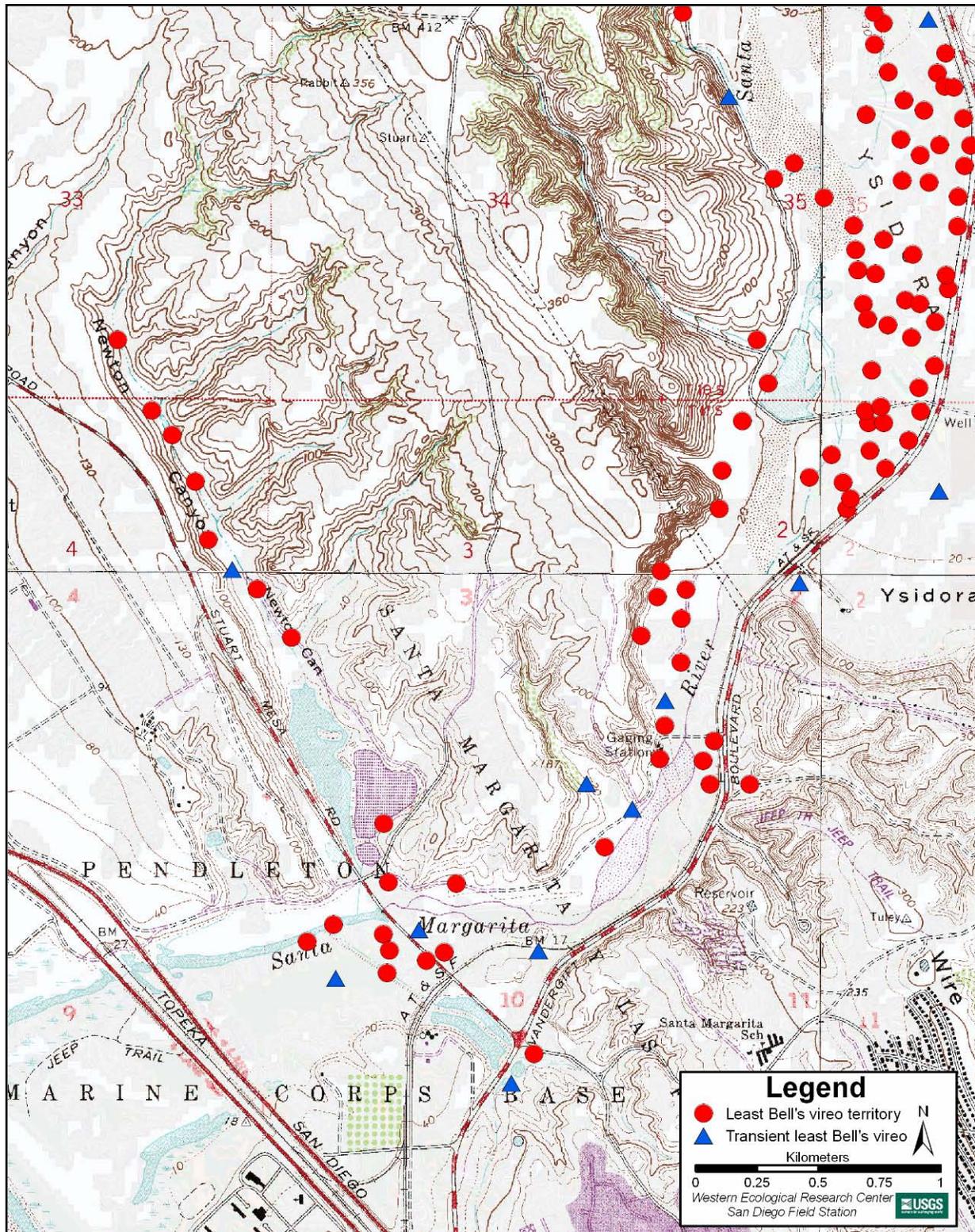


Figure 21. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Lower Santa Margarita River, Ysidora Basin, and Newton Canyon.

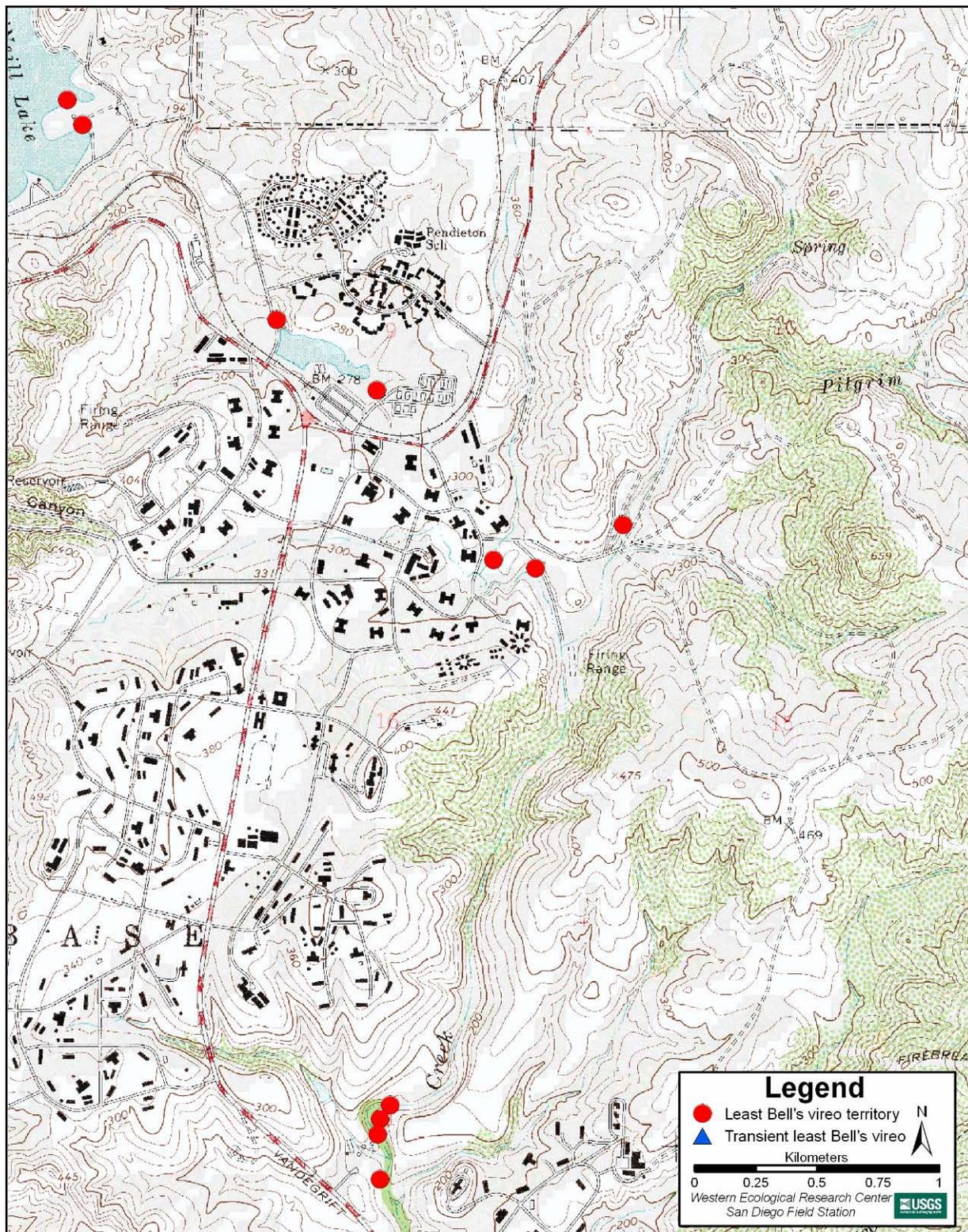


Figure 22. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Upper Pilgrim Creek, De Luz Homes Habitat, and Lake O'Neill.

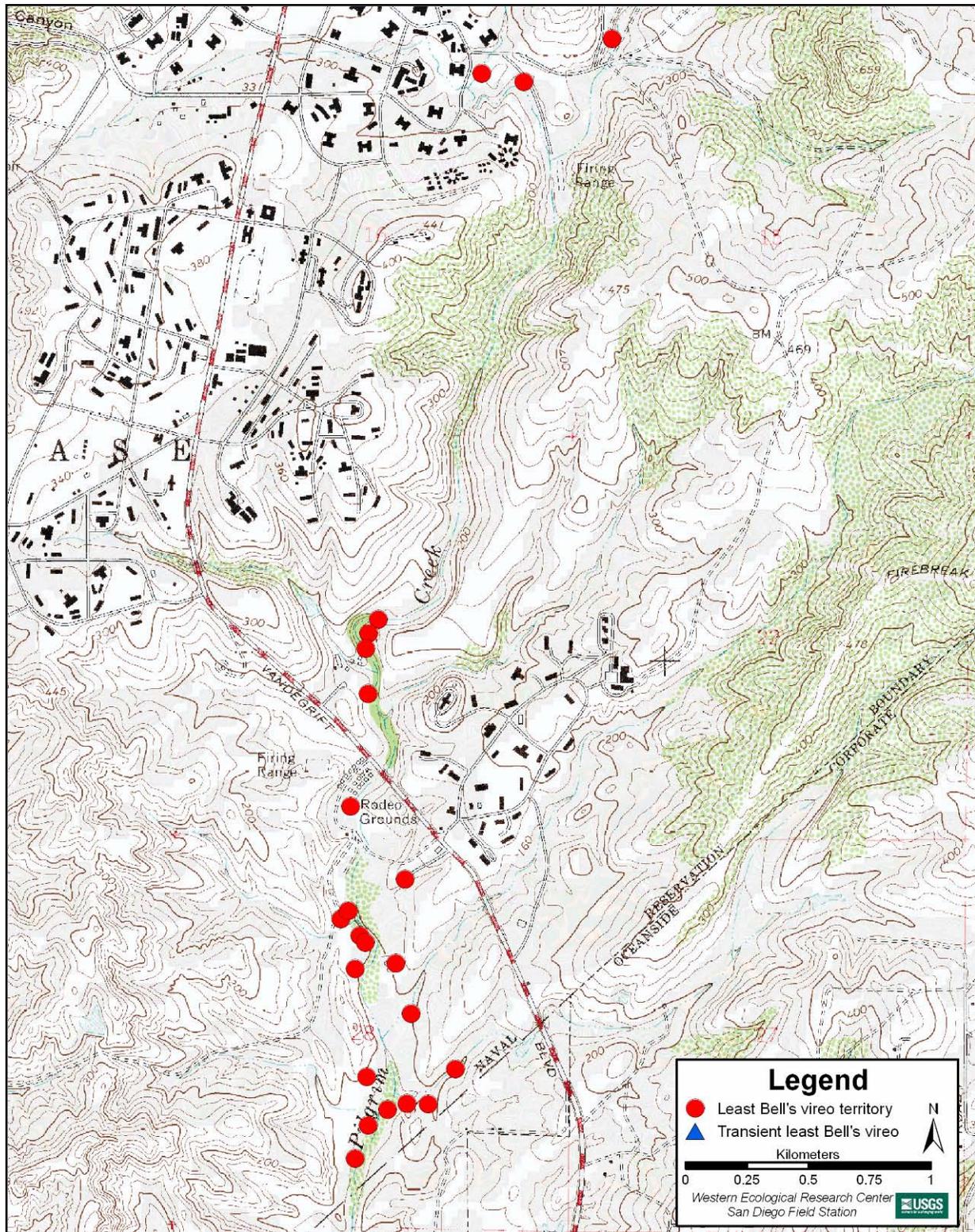


Figure 23. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Upper and Lower Pilgrim Creek.

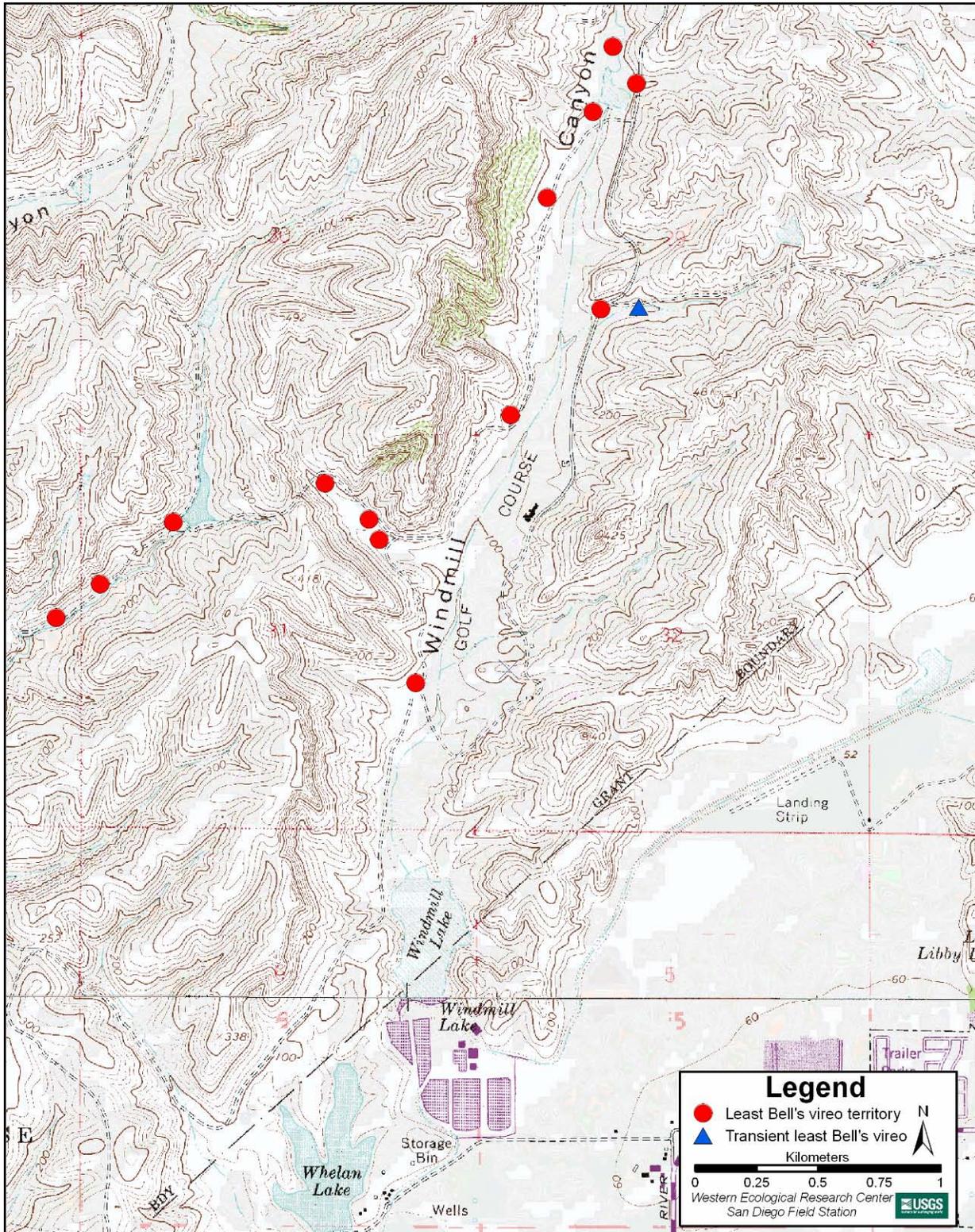


Figure 24. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Windmill Canyon, and Ysidora Basin to Windmill Canyon.

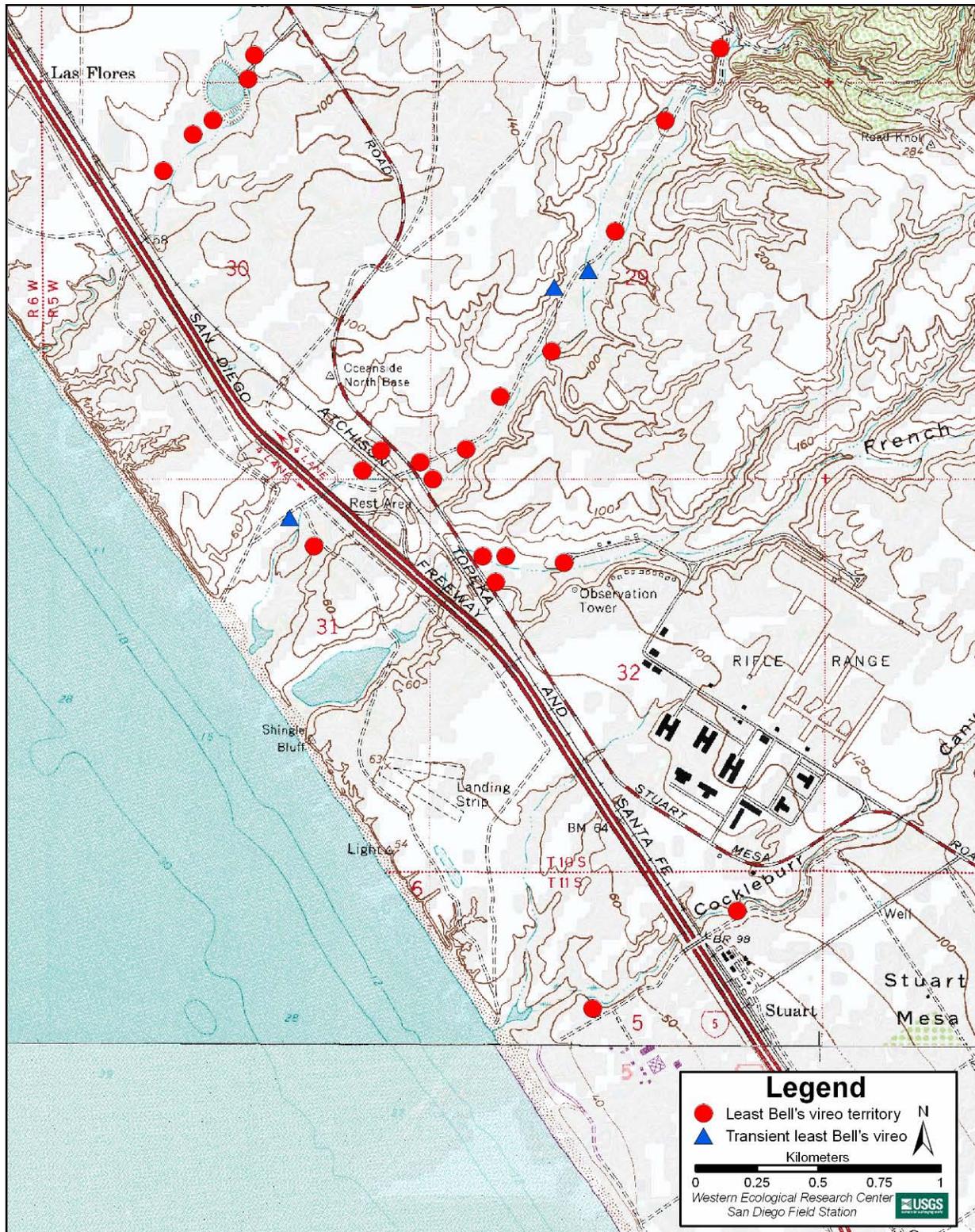


Figure 25. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Cockleburr Canyon, French Creek, Aliso Creek, and Hidden Canyon.

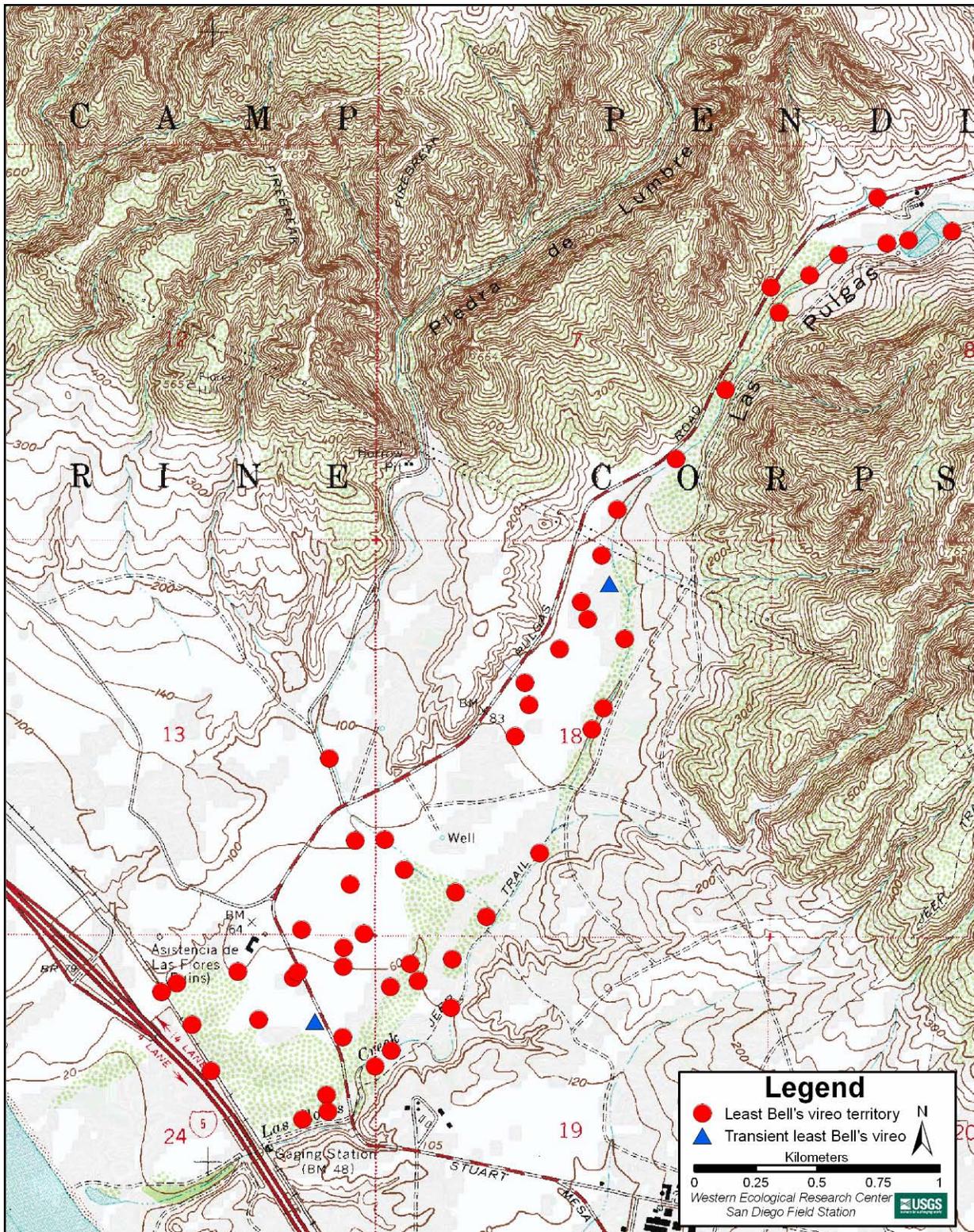


Figure 26. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Lower Las Flores Creek.

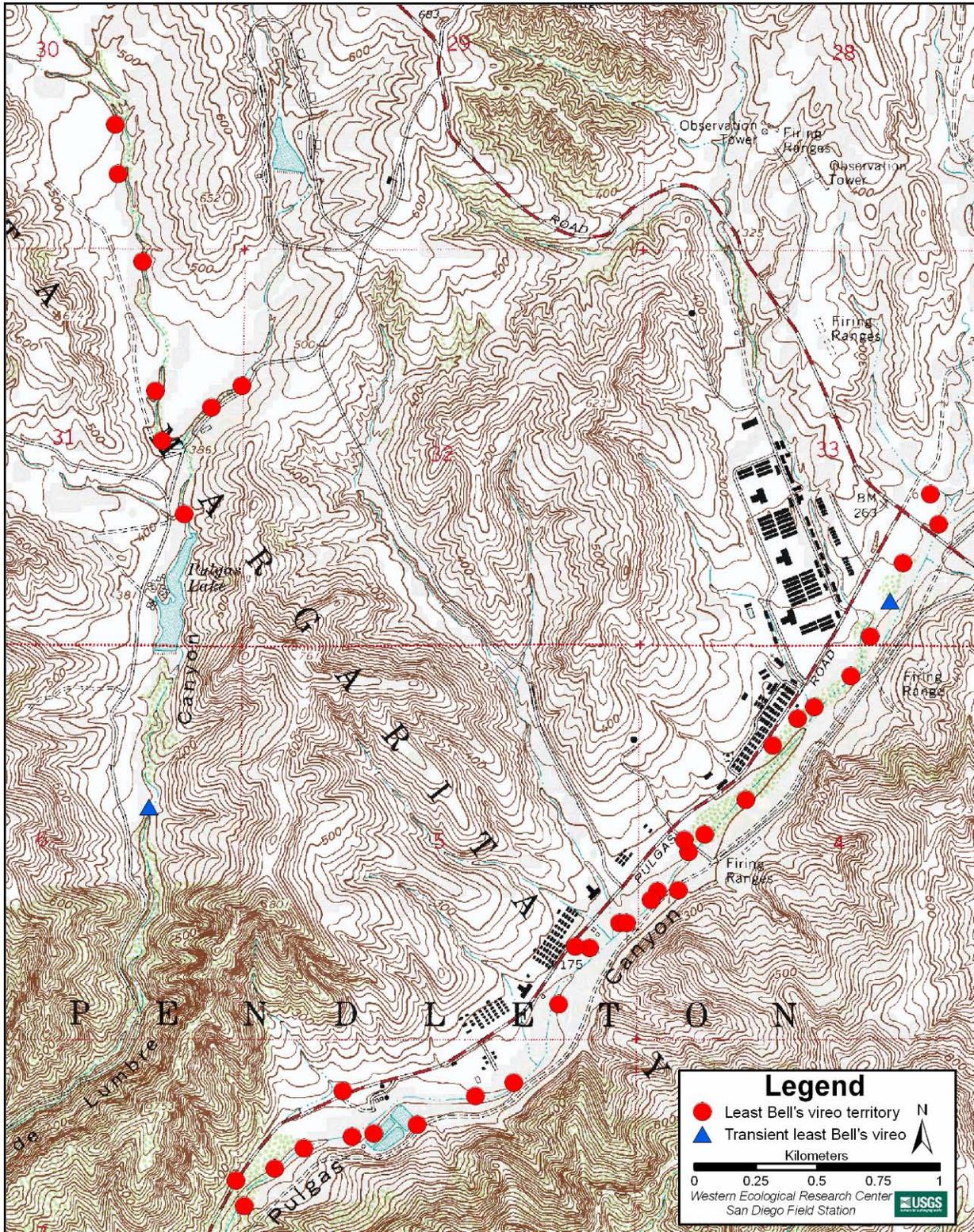


Figure 27. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Piedra de Lumbre Canyon, and Las Flores Creek.

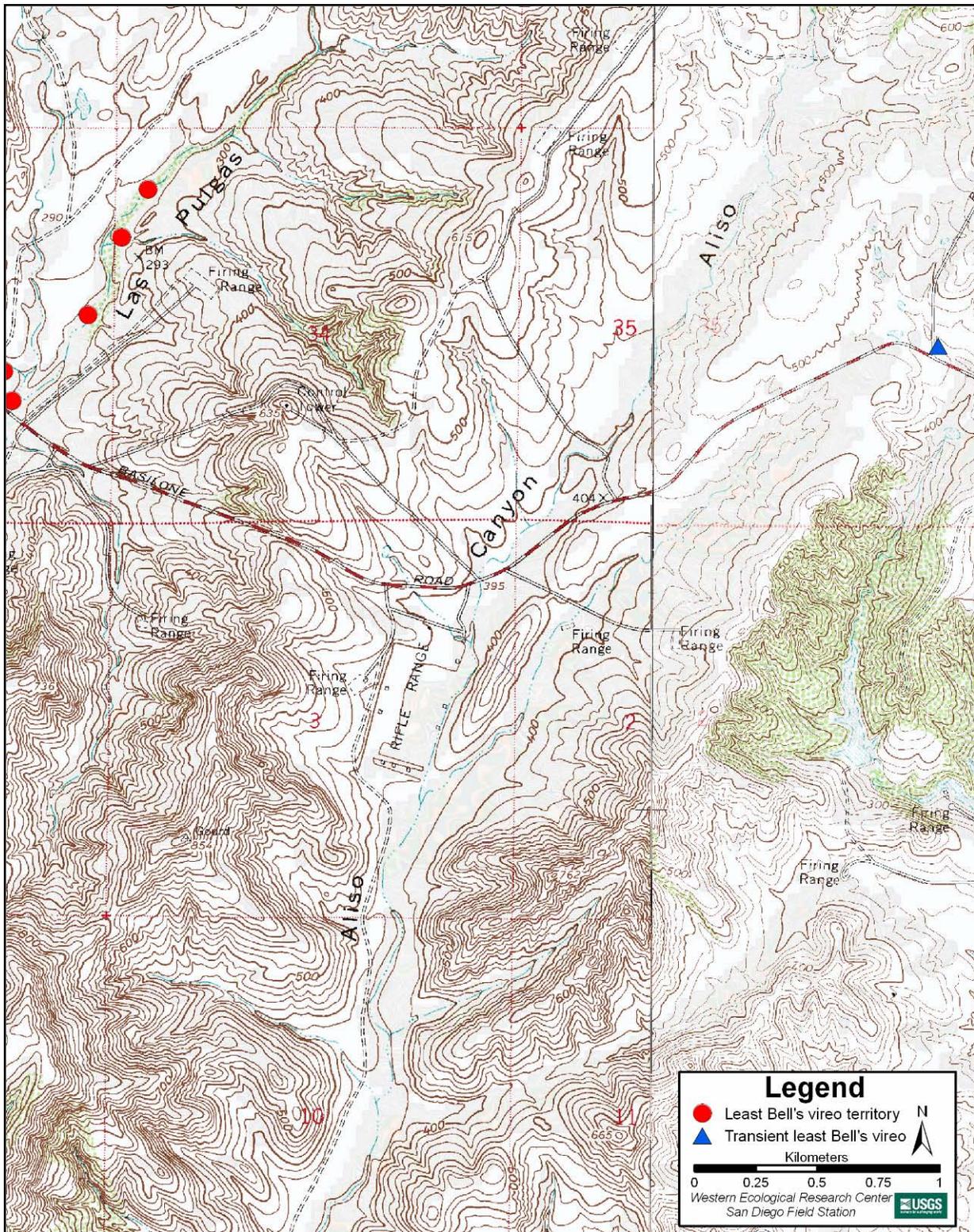


Figure 28. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Upper Las Flores Creek, and Basilone and Roblar Roads.

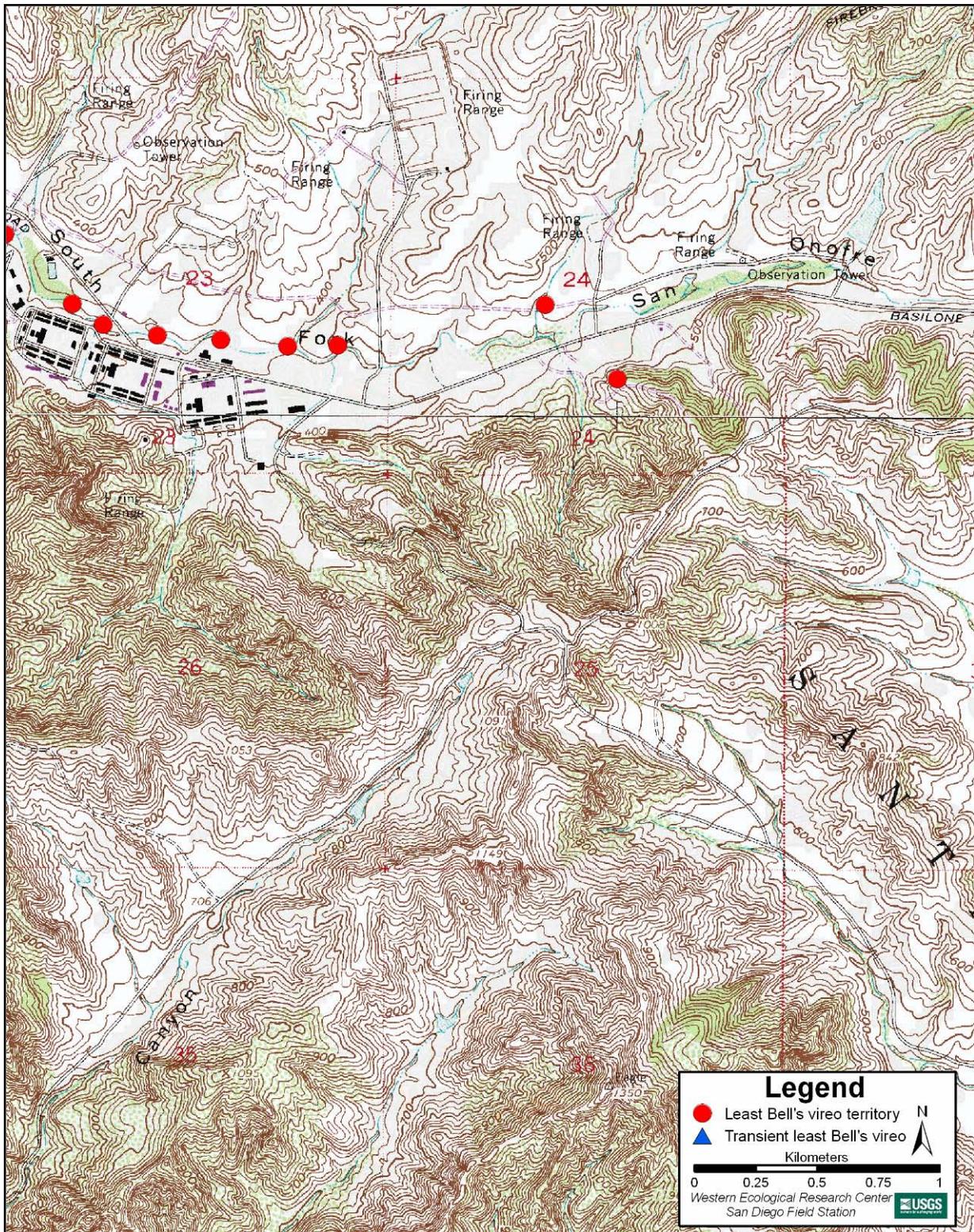


Figure 29. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Upper San Onofre Creek and Horno Canyon.

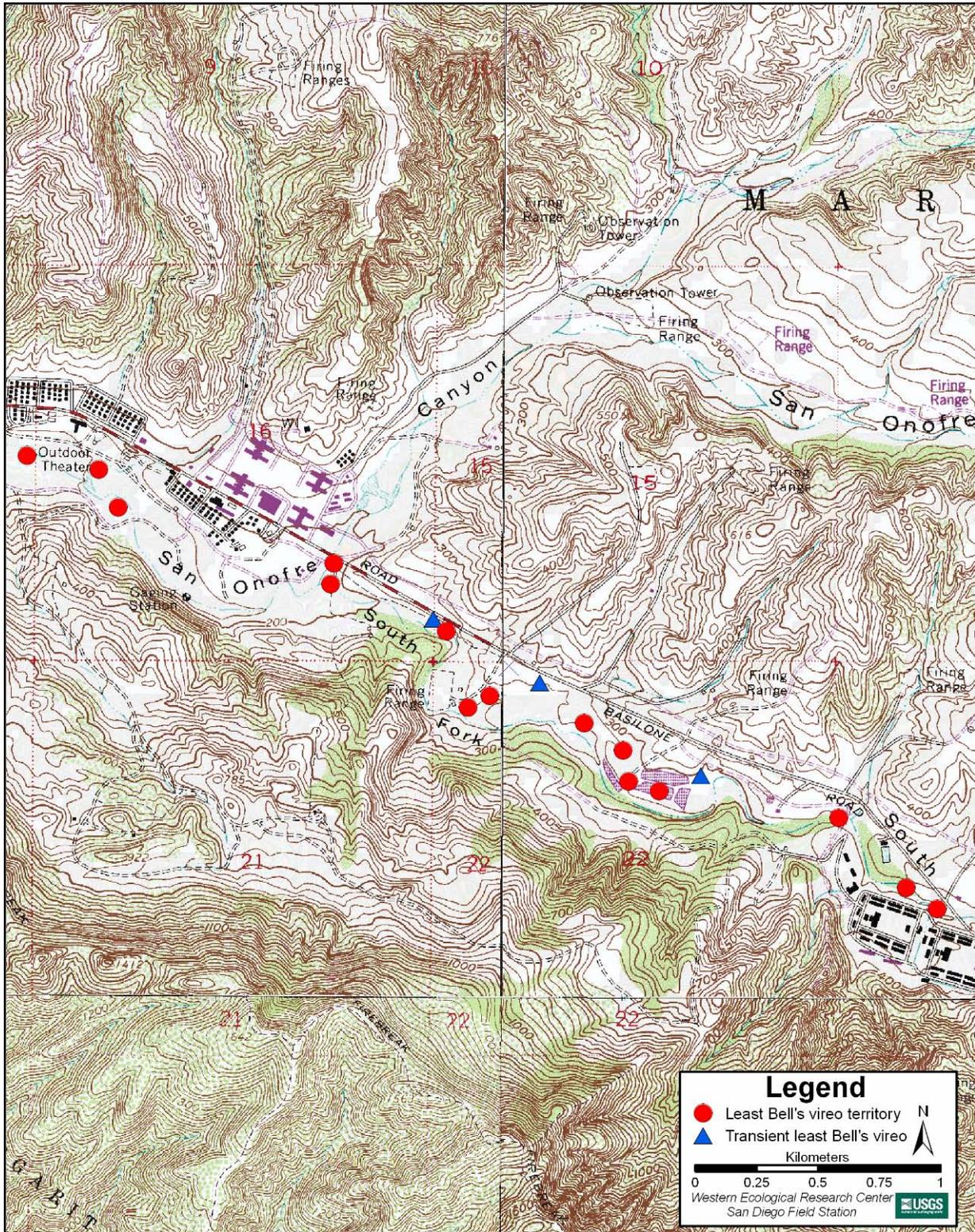


Figure 30. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: San Onofre Creek.

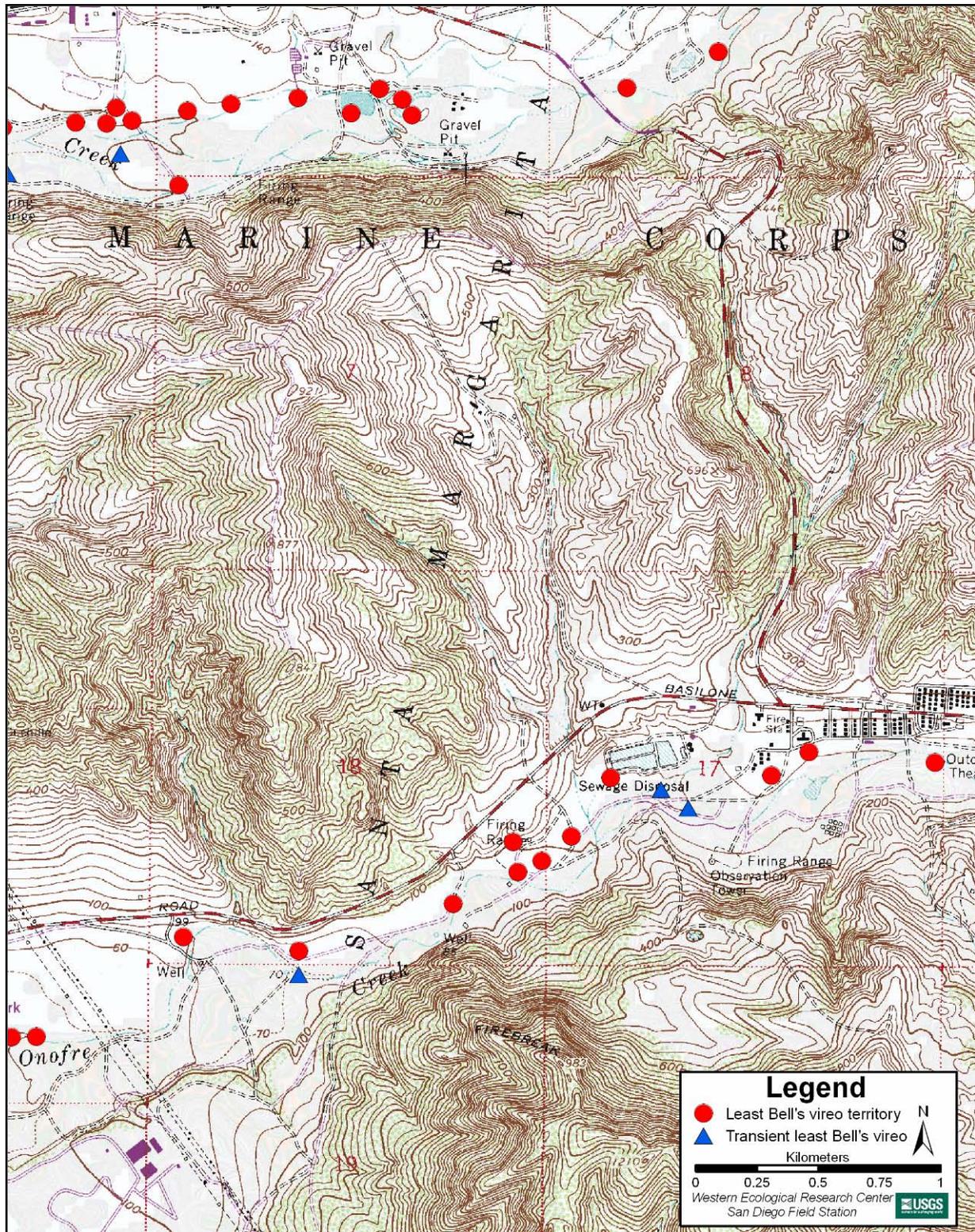


Figure 31. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: San Onofre Creek and San Mateo Creek.

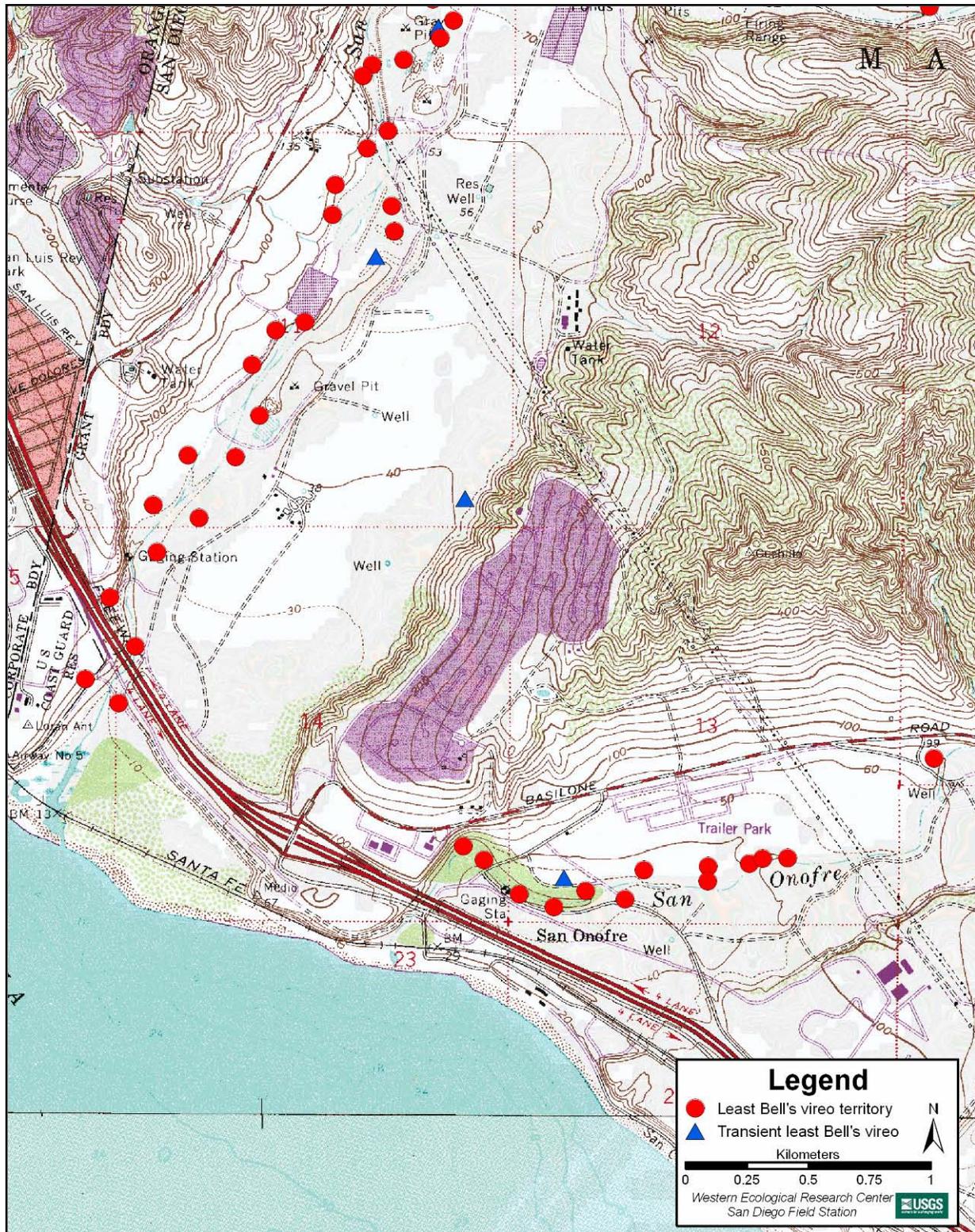


Figure 32. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Lower San Onofre Creek and Lower San Mateo Creek.

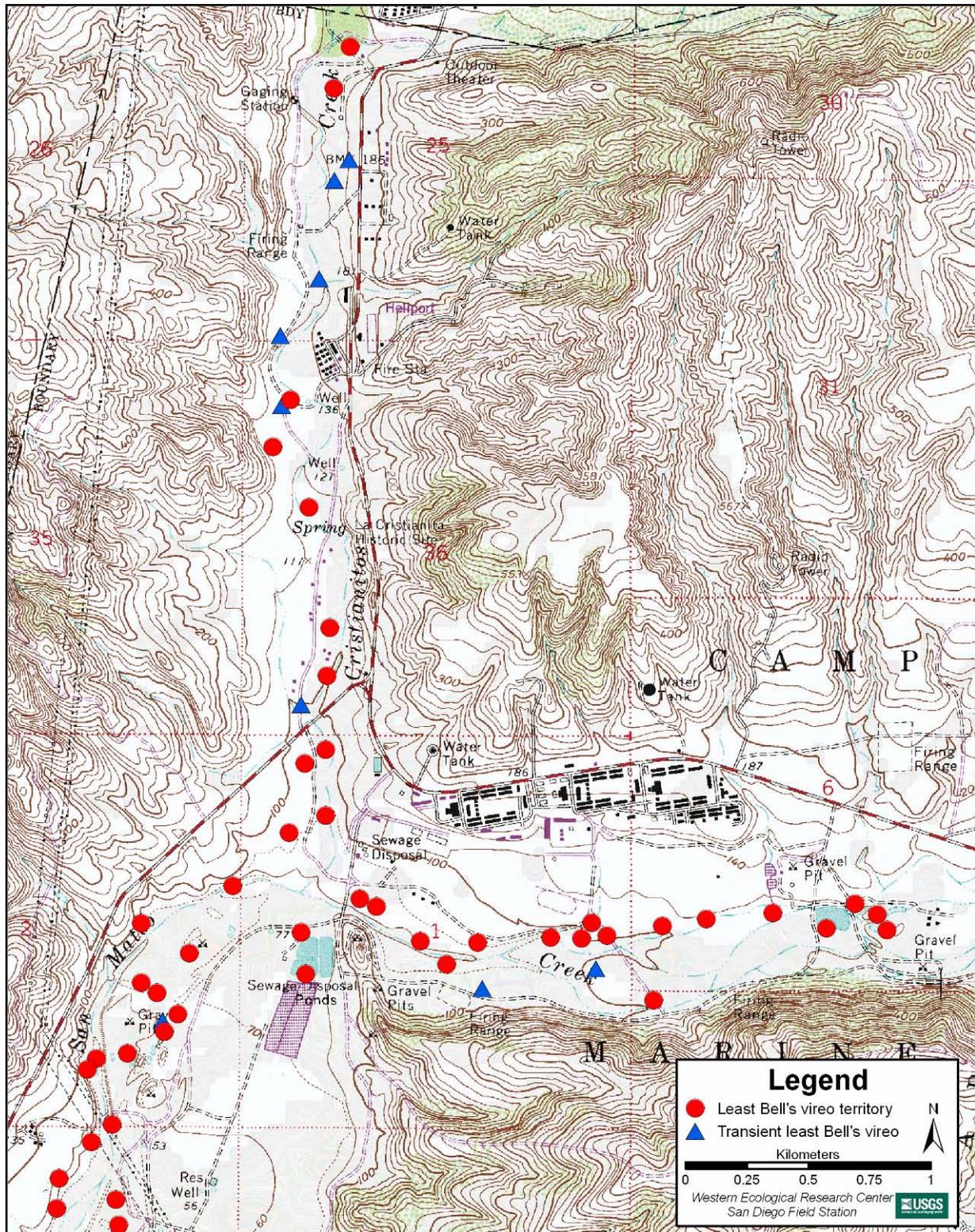


Figure 33. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: San Mateo Creek and Cristianitos Creek.

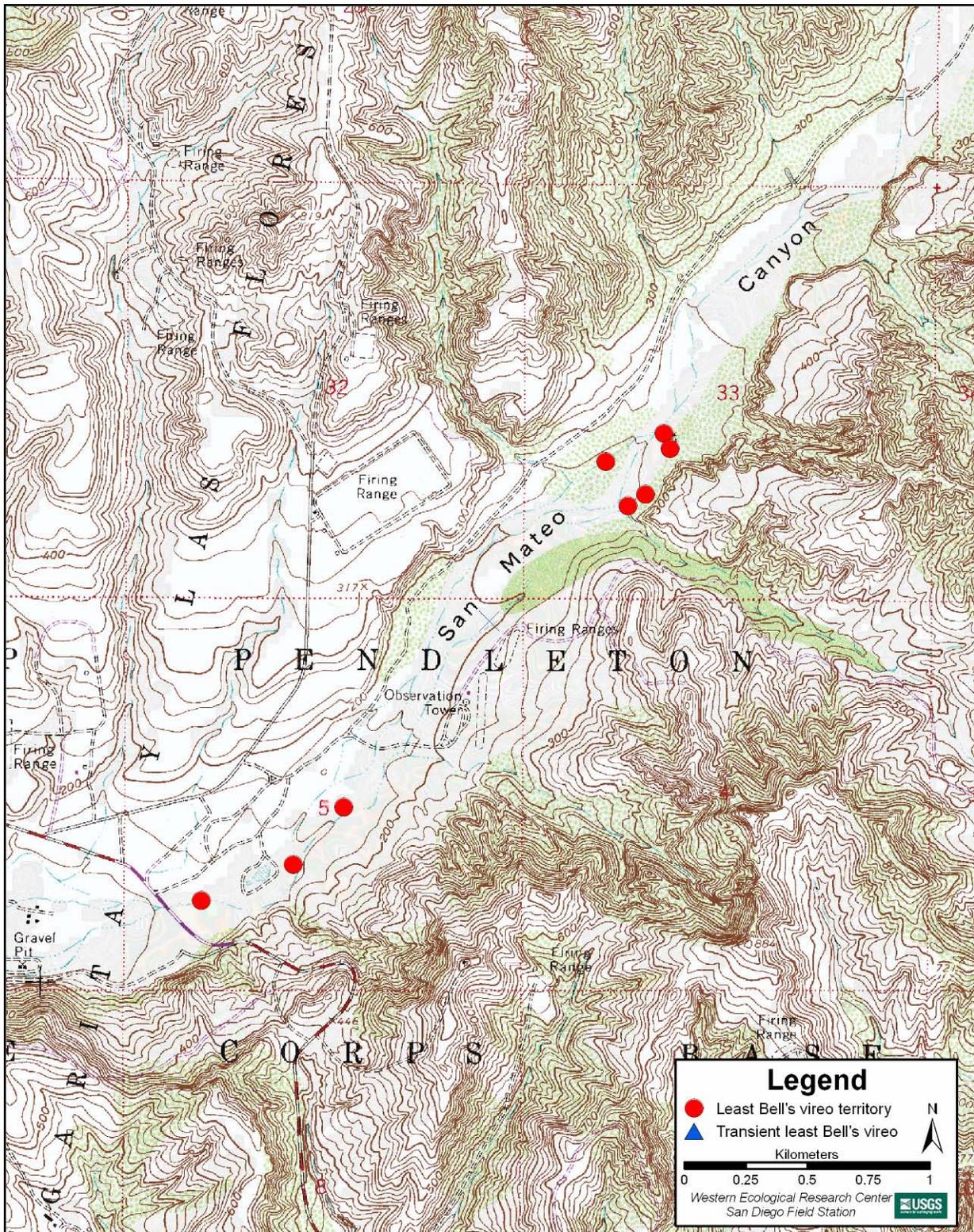


Figure 34. Locations of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006: Upper San Mateo Creek.

APPENDIX C

**STATUS AND NESTING ACTIVITIES OF LEAST BELL'S VIREOS AT MARINE
CORPS BASE CAMP PENDLETON, 2006**

Status and nesting activities of least Bell's vireos at Marine Corps Base Camp Pendleton, 2006.

Reference Site Territories					
Territory	Nest	Monitoring ^a	Nest Fate ^b	#Fledged	Comments
APO	1	F	SUC	4	
	2		SUC	2	
ARI	1	F	INC	0	Nest building was initiated, but the nest was never completed.
	2		PRE	0	
	3		OTH	0	Probable cause of nest failure: exposure to direct sunlight. Cause of failure unknown
	4		UNK	0	
	5		SUC	3	
BEK	1	F	PRE	0	
	2		SUC	4	
BER	1	F	SUC	4	
	2		SUC	3	
BIL	1	F	PRE	0	
	2		SUC	2	
BOW	1	F	PRE	0	
CAK	1	F	SUC	2	
CED	1	F	PRE	0	
	2		SUC	2	
DAT	1	F	PRE	0	
	2		PRE	0	
DEL	1	F	SUC	4	
DEU	1	F	INC	0	Nest building was initiated, but the nest was never completed.
	2		PRE	0	
	3		SUC	3	
DRK	1	F	SUC	4	
	2		PRE	0	
FAU	1	F	PRE	0	
	2		SUC	4	
HNK	1	F	INC	0	Nest building was initiated, but the nest was never completed.
	2		PRE	0	
	3		PRE	0	
	4		PRE	0	
HDX	1	F	PRE	0	
	2		PRE	0	
	3		PRE	0	
HRB	1	F	PRE	0	
	2		PRE	0	
HLD	1	F	PRE	0	
	2		SUC	3	

Status and nesting activities of least Bell's vireos at Marine Corps Base, Camp Pendleton, 2006.

Reference Site Territories					
Territory	Nest	Monitoring ^a	Nest Fate ^b	#Fledged	Comments
HOL	1	F	PRE	0	
	2		SUC	3	
HTI	1	F	OTH	0	Probable cause of nest failure: infertile eggs
	2		PRE	0	
	3		OTH	0	Probable cause of nest failure: infertile eggs
HRN	1	F	UNK	0	Cause of failure unknown
	2		SUC	3	
JSP	1	F	INC	0	Nest building was initiated, but the nest was never completed.
	2		SUC	4	
QIN	1	F	PRE	0	
	2		SUC	4	
<i>Arundo donax</i> Removal Site Territories					
ABB	1	P	SUC	4	
ARS	1	P	SUC	3	
ALA	1	P	PRE	0	
ALI	1	F	INC	0	Nest building was initiated, but the nest was never completed.
	2		SUC	4	
ALC	1	F	SUC	1	
ALP	1	P	SUC	2	
ANA	1	F	SUC	2	
ANI	1	P	SUC	4	
ARH	1	F	SUC	1	
AST	1		SUC	2	
ATK	1	F	UNK	0	Cause of failure unknown
	2		SUC	3	
CAG	1	F	SUC	3	
CHE	1	F	PRE	0	
	2		SUC	3	
FNR	1	F	SUC	3	
IND	1	F	PRE	0	
	2		SUC	3	
LAP	1	F	INC	0	Nest building was initiated, but the nest was never completed.
	2		SUC	3	
	3		UNK	0	Probable cause of nest failure: exposure to direct sunlight. Nest parasitized during the nestling stage.
LIA	1	F	PRE	0	
LND	1	F	PRE	0	
ORN	1	F	SUC	2	

Status and nesting activities of least Bell's vireos at Marine Corps Base, Camp Pendleton, 2006.

<i>Arundo donax</i> Removal Site Territories					
Territory	Nest	Monitoring ^a	Nest Fate ^b	#Fledged	Comments
PLX	1	F	PRE	0	
	2		SUC	3	
SNP	1	F	SUC	2	
TUL	1	F	PRE	0	
	2		PRE	0	
	3		SUC	3	
VEG	1	F	INC	0	Nest building was initiated, but the nest was never completed.
	2		PRE	0	
	3		PRE	0	
	4		SUC	1	
VIC	1	F	SUC	2	
WNS	1	F	INC	0	Nest building was initiated, but the nest was never completed.
	2		OTH	0	Substrate failure. Nest built in <i>C. maculatum</i> .

^a Monitoring: F = fully monitored territory; P = partially monitored territory

^b Nest Fate: Nest fate: INC = nest never completed; SUC = fledged at least one least Bell's vireo young; PRE = nest failure caused by predation; PAR = failure/abandonment caused by brown-headed cowbird parasitism; OTH = reason for nest failure known, such as substrate failure; UNK = reason for nest failure/abandonment unknown.