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Distribution, Abundance, and Breeding Activities of the Least Bell's Vireo along the San Diego River, California

2009 Annual Data Summary

Prepared for:

San Diego River Conservancy

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

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U.S. GEOLOGICAL SURVEY
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2009

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Cover photograph by Suellen Lynn

Recommended citation:

Lynn, S., M. J. Wellik, and B. E. Kus. 2009. Distribution, abundance, and breeding activities of the Least Bell's Vireo along the San Diego River, California. 2009 Annual Data Summary. Prepared for the San Diego River Conservancy, San Diego, California.

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EXECUTIVE SUMMARY

Surveys for the endangered Least Bell's Vireo (*Vireo bellii pusillus*) were conducted along the San Diego River between 31 March and 23 June 2008. Riparian habitat suitable for vireos from Interstate 5 to the El Capitan Reservoir was surveyed three times. Eighty-two territorial male vireos were detected, forty-five of which were confirmed as paired. One transient vireo was also detected.

Most (96%) vireo territories occurred in four of six sections surveyed: Santee (37%), Park (28%), Lakeside (17%), and Gorge (15%). The Valley survey section contained two vireo territories and no vireos were detected in the El Capitan survey section. The number of territorial Least Bell's Vireos detected in 2009 increased 30% from 2008. Vireo numbers increased in four of the six survey sections, with the largest increase in the Santee area (50%).

The majority of vireo territories occurred in habitat characterized as mixed willow (*Salix* spp.) riparian, with 72% of territories in the study area found in this habitat. Twenty-four percent of territories occurred in willow habitat co-dominated by cottonwoods (*Populus fremontii*), and one territory each occurred in willow habitat co-dominated by sycamores (*Platanus racemosa*), riparian scrub, and non-native vegetation.

A total of 84 banded Least Bell's Vireos were observed during the 2009 season. These included 40 adult vireos (26 banded prior to 2009 and 14 banded in 2009) and 44 nestlings that were banded for the first time in 2009. Of the 40 adult vireos, 39 were banded with unique color combinations and 1 was observed with a single metal light blue service band, indicating it had been banded as a nestling in 2008. The nestlings were banded with a single light blue numbered federal band on the right leg. Seventy-two percent (80% of males and 50% of females) of adult vireos banded prior to 2009 returned to the San Diego River in 2009. All returning adults occupied the same territory that they had occupied in 2008. One additional adult vireo that was not detected in 2008 was captured and banded in 2009. This vireo fledged from a nest on the San Luis Rey River in 2007, 55 km from his 2009 breeding site. Twenty-six percent (40% of males and 13% of females) of vireos banded as nestlings in 2008 were resighted in 2009, one of which was captured and banded on Marine Corps Base Camp Pendleton (61.3 km from his natal territory). The average distance first-year vireos dispersed from the San Diego River to all sites was 10.2 ± 22.6 km (SD) (n = 7).

A single Southwestern Willow Flycatcher (*Empidonax traillii extimus*) was detected in the Valley survey area in early June where it remained for approximately one month. The flycatcher was recaptured and given a complete color band combination; it was originally banded 60.6 km to the north on Marine Corps Base Camp Pendleton in 2008 as a nestling.

Nesting activity was monitored in 29 territories, 15 within the Treatment site where Brown-headed Cowbirds (*Molothrus ater*) were trapped and 14 within the Reference site, where no cowbirds were trapped. Cowbird traps were open from 25 April through 30 July. A total of 62 nests were monitored during the breeding season; however, 8 of these were not completed and were excluded from calculations of nest success and productivity. Most pairs had initiated their first nest by the end of April and 63% of pairs attempted at least two nests in 2009. Two pairs successfully fledged two broods in 2009.

Parasitism by Brown-headed Cowbirds occurred at both sites. The rate of cowbird parasitism did not differ between years, although cowbird parasitism was higher at the Reference site than the Treatment site. Cowbird parasitism was first observed at the Treatment site during the first half of April, approximately two weeks before cowbird traps were opened. The rate of cowbird parasitism significantly declined at the Treatment site after cowbird traps were open. At the Reference site, cowbird parasitism averaged 65% after the first incident, in early May. Eight percent of parasitized nests contained two cowbird eggs (one nest). Thirteen percent of nests failed as a result of cowbird parasitism, while four parasitized nests successfully fledged a total of nine young after removal of cowbird eggs by nest monitors.

Twenty-eight percent of all completed vireo nests along the San Diego River successfully produced at least one vireo fledgling. If cowbird eggs had not been removed from nests, the nest success rate would have been 20%. Nest success did not differ between Treatment and Reference sites. Seventy-two percent of nests were not successful. Predation was believed to be the primary source of nest failure at all sites, accounting for 44% of nest failures. Other causes of nest failure included host plant collapse/structural instability, egg infertility, and unknown reasons. Average clutch size was relatively high across all sites and was reduced in nests that experienced cowbird parasitism. The number of vireo young fledged per pair did not differ significantly between sites.

In 2009, successful and unsuccessful nests within Treatment and Reference sites did not differ statistically in most nest placement characteristics, although successful nests at Reference sites were placed further from the edge of the vegetation clump and further from the edge of the riparian vegetation than unsuccessful nests. Nests at Reference sites were placed closer to the edge of the host plant but further from the edge of riparian vegetation than nests at Treatment sites. A total of 16 plants (15 species and 1 "dead" category, which included all dead woody species) were used as hosts for vireo nests in 2009. Fifty-three percent of Treatment nests and 62% of Reference nests were placed in mule fat (*Baccharis salicifolia*), arroyo willow (*S. lasiolepis*), or black willow (*S. gooddingii*).

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, 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 (USGS, unpublished data).

The San Diego River has been subject to a number of Least Bell's Vireo surveys and nest monitoring activities over the past 30 years. In 1978, Goldwasser (1978) found 12 vireo territories between Mission Valley and State Route 67. Jones (1985) found 33 vireo territories from just west of the Old Mission Dam to State Route 67 in 1984. Jones assumed that this increase of 21 vireo territories was not an actual increase in vireo numbers but rather an increase in survey effort. This number remained relatively stable through 1988 (SANDAG 1990), and increased to 58 territories by 1997 (Kus and Beck 1998). The increase in vireo numbers occurred concurrently with cowbird control efforts, which were initiated in the Mission Trails Park area in 1984 (Jones 1985).

Male vireos arrive on breeding grounds in southern California in mid-March. Male vireos are conspicuous, and frequently sing their diagnostic primary song from exposed perches throughout the breeding season. 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. Clutch size for Least Bell's Vireos average 3-4 eggs. Typically, the female and male incubate the eggs for 14 days and young fledge from the nest at 11-12 days of age. It is not unusual for vireos to re-nest after a failed attempt provided ample time remains within the breeding season. Vireos rarely fledge more than one brood in a season. 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 Vireos along the San Diego River in San Diego County, California. Specifically, our goals were to (1) determine abundance and distribution of vireos along the San Diego River to facilitate population trend analyses, (2) band a subset of vireos to aid in the estimation of vireo survivorship and movement for

the population as a whole and in response to management activities, (3) collect baseline data to assess the short-term effects of habitat restoration and collect the first year of data assessing the short-term effects of Brown-headed Cowbird control on vireo fecundity, nest success, and productivity by intensively monitoring vireos within nest monitoring sites. These data, when combined with data from other years, will inform natural resource managers about the status of this endangered species along the San Diego River, and guide modification of land use and management practices as appropriate to ensure the species' continued existence.

This work was funded by the San Diego River Conservancy, San Diego, California.

STUDY AREAS AND METHODS

Field Surveys

Riparian habitat along the San Diego River from Interstate 5 to El Capitan Reservoir was surveyed for vireos between 31 March and 23 June 2008 (Fig. 1). Field work was conducted by Aaron Gallagher, Suellen Lynn, Michael Wellik, and David Wilamowski. The survey area was divided into six sections:

1. ***Valley:*** From Interstate 5 upstream 10.2 km to San Diego Mission Road (Fig.1; Appendix A, Fig. 7).

2. ***Gorge:*** From San Diego Mission Road upstream 6.5 km to Jackson Drive, minus approximately 3 km from Old Cliffs Road to Mission Vista Drive (Fig. 1; Appendix A, Fig. 8).

3. ***Park:*** From Jackson Drive upstream 5.1 km to West Hills Parkway (Fig. 1; Appendix A, Fig. 8).

4. ***Santee:*** From West Hills Parkway upstream 8.1 km to Riverford Road (Fig. 1; Appendix A, Fig. 9).

5. ***Lakeside:*** From Riverford Road upstream 3.9 km to Ashwood Street (Fig. 1; Appendix A, Fig. 10).

6. ***El Capitan:*** From Ashwood Street upstream 11.1 km to the dam at El Capitan Reservoir (Fig. 1; Appendix A, Fig. 11).

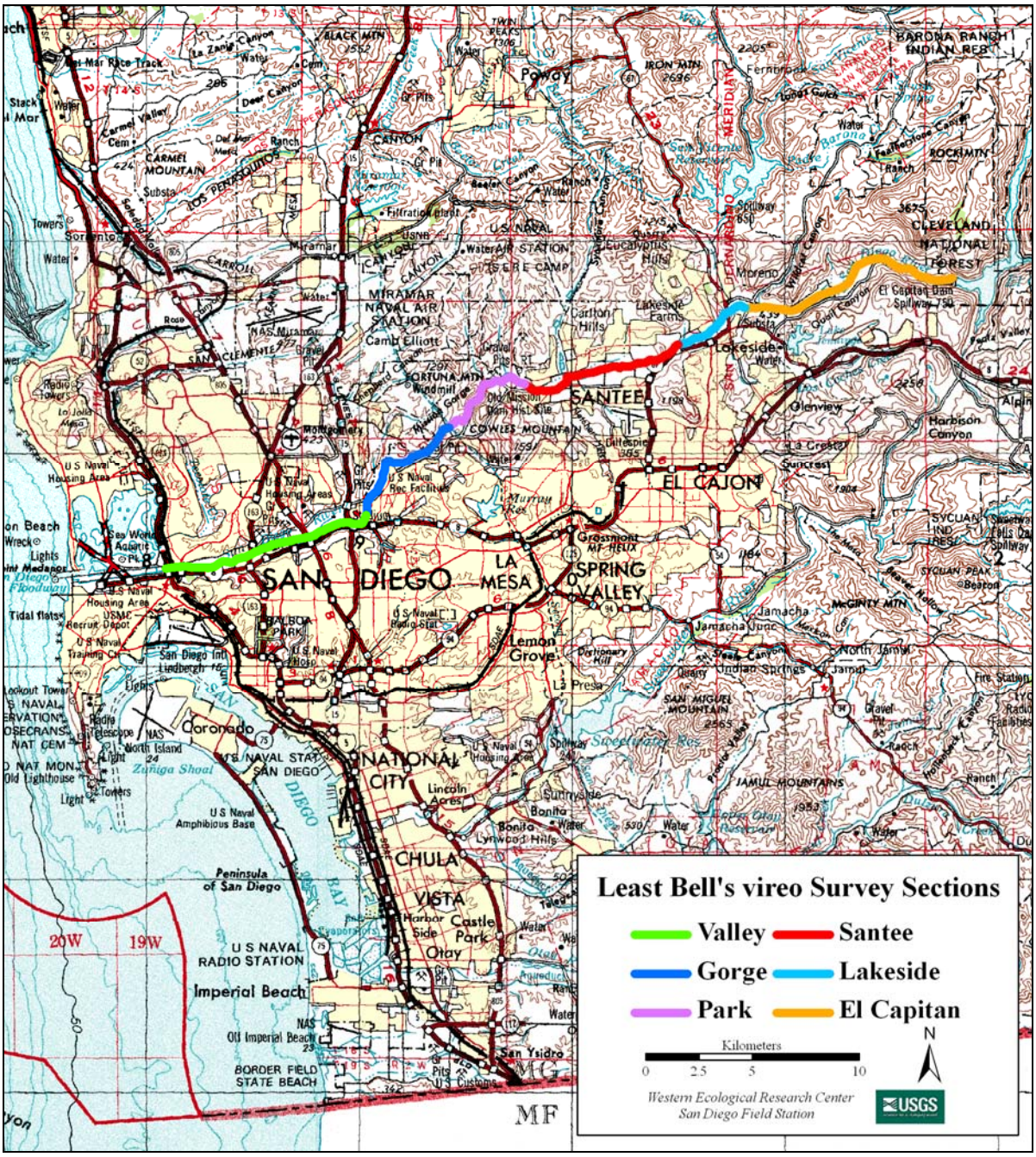

Fig. 1. Least Bell's Vireo survey sections along the San Diego River, 2009.

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 vireos were detected and confirmed audibly by hearing their diagnostic song. Attempts were made to observe males visually to note banding status but 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 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 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 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 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 cottonwood (*Populus fremontii*) is a co-dominant.

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

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

Riparian scrub: Dry and/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*).

Nest Monitoring

We monitored Least Bell's Vireo nests to collect baseline data that will be used evaluate the effects of management activities on nest success and productivity. Two management activities are

planned: 1) removal of giant reed to restore native riparian vegetation, and 2) trapping and removal of Brown-headed Cowbirds, a brood parasite. Only Brown-headed Cowbird trapping and removal was conducted in 2009.

Giant reed is a highly invasive, non-native plant within riparian systems in southern California. Originally introduced for bank stabilization in the 1800's, giant reed has become a major component of many riparian systems, becoming the dominant vegetation within streams and rivers. As part of a riparian restoration effort, large quantities of giant reed have been removed from sections of the San Diego River in the past. Removal of giant reed in the Valley section of the survey area is planned for the near future. Areas that have recently undergone giant reed removal tend to consist of patches of native woody plants surrounded by 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 mule fat, sandbar willow, black willow, arroyo willow, and red willow.

Brood parasitism by Brown-headed Cowbirds has been identified as one of the leading causes of decline in vireo populations (Kus 1999). Cowbird trapping, in addition to nest monitoring to detect and remove cowbird eggs from vireo nests, has the potential to virtually eliminate parasitism in many populations. Cowbird trapping and vireo nest monitoring were first implemented on the San Diego River in 1984 (Jones 1985), and standardized nest monitoring began in 1986 (G. Collier and B. Jones, unpublished data). Cowbird trapping was conducted annually from 1987 through at least 1996 (Kus and Whitfield 2005), and also in 2001 through 2007 (Varanus Biological Services 2001, 2003; Varanus Monitoring Services 2004, 2007) in Mission Trails Regional Park. In 2009, three cowbird traps were installed in Mission Trails Regional Park (Treatment site). Traps were opened 25 April and closed 30 July (Sexton 2009).

We monitored vireos within two areas, one in which cowbird trapping occurred (hereafter referred to as “Treatment” site, in the Park survey section) and a paired site in which no additional management action occurred (hereafter referred to as "Reference" site, in the Santee survey section; Fig. 2). We attempted to document nesting activity for ten pairs per site throughout the breeding season. Pairs were chosen in order of their detection on-site during the first vireo survey to ensure a complete record of activity within the territory.

Pairs 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 3-5 visits per nest. The first visit was timed to determine the number of eggs laid, the next few visits to document 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 nests that fledged cowbird young without fledging vireo young were 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 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, the edge of the vegetation clump in which they were placed, and the riparian/upland edge, were recorded following abandonment or fledging of young from nests.

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. Performed in this way, nest manipulation allows many parasitized nests to remain active and potentially fledge young where they would otherwise fail to fledge vireo young (Kus 1999).

Banding

The primary goals of banding Least Bell's Vireos along the San Diego River were: 1) to better understand adult and juvenile survivorship, site fidelity, and dispersal associated with management actions, and 2) to investigate natal dispersal and the interconnection of vireo populations in San Diego County. Nestlings from monitored nests were banded at 6-7 days of age with a single anodized light blue numbered federal band on the right (or, rarely, left) leg. A subset of adult vireos within Treatment and Reference 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 along the San Diego River, either an anodized light blue or light blue plastic band was incorporated into the combination to designate the San Diego River as the bird's site of origin.

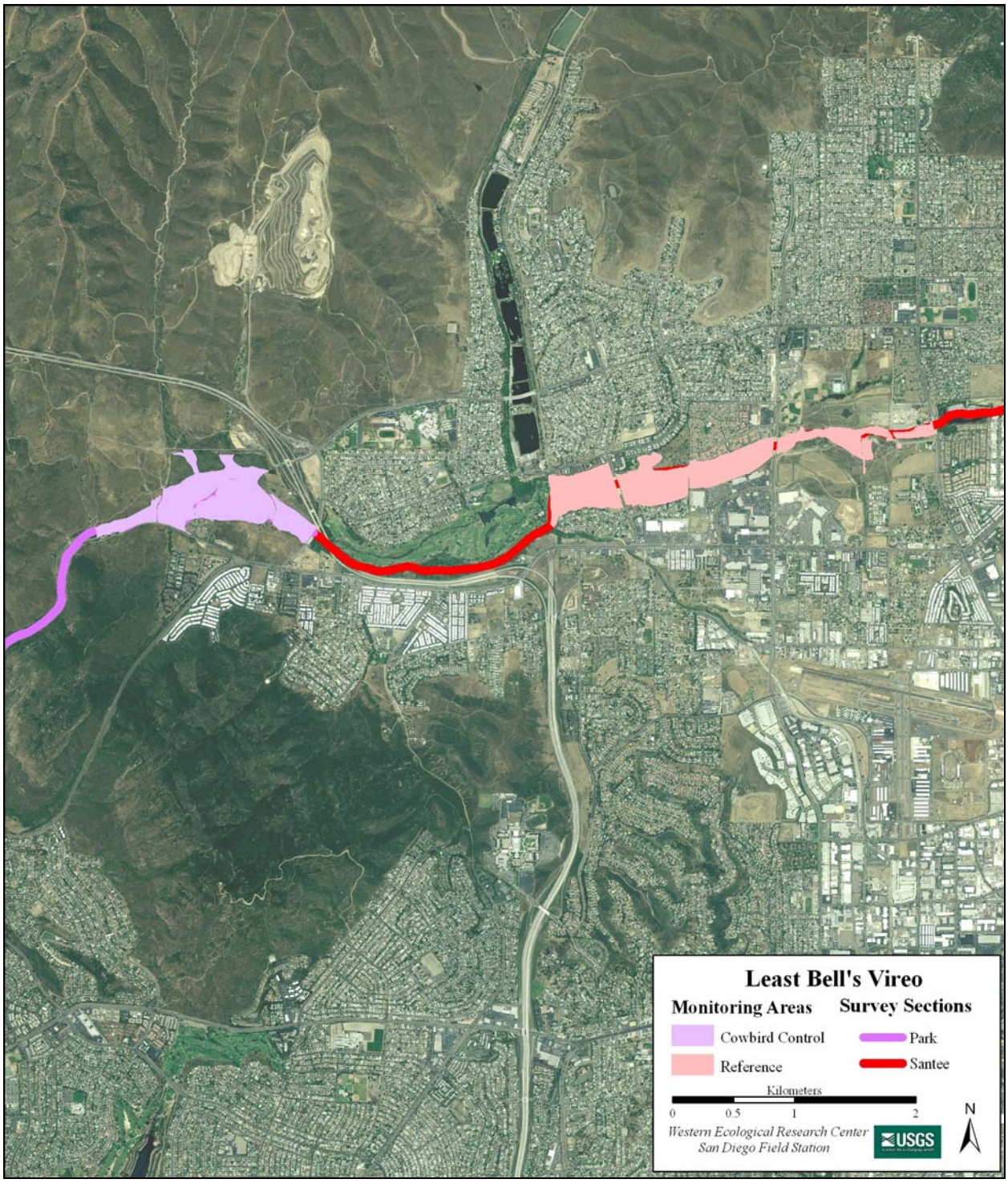

Fig. 2. Location of Least Bell's Vireo nest monitoring areas along the San Diego River, 2009.

Data Analyses

We summarized the Treatment and Reference monitoring sites separately to allow comparison between the two sites and between years at each site, before and after management actions occurred. We conducted statistical tests to determine whether there were differences in vireo nest success, productivity, or vegetation characteristics between monitoring sites. We used the Student's *t*-test (or Mann-Whitney *U*-test when data did not meet assumptions for *t*-tests) to determine if there were differences between sites in number of nests completed, clutch size (for parasitized and non-parasitized nests), number of young fledged per pair, nest height, nest host height, and distance from the nest to the edge of the nest host, the edge of the nest vegetation clump, and the edge of riparian vegetation. We also used Mann-Whitney *U*-tests to determine if there were differences between successful and unsuccessful nests in nest height, nest host height, distance from the nest to the edge of the nest host plant, the nest vegetation clump, and the edge of riparian vegetation. We used chi-square analysis (or Fisher's Exact Test when numbers weren't sufficient to perform chi-square analyses) to test for differences in cowbird parasitism rate and nest fate between monitoring sites, between years, and before and after traps were opened in 2009. To estimate the potential impact(s) of cowbird parasitism on the San Diego River vireo population, we compared two calculations of nest success and productivity: one set including manipulated nests that were eventually successful, and the other treating manipulated nests as failed (their likely fate in the absence of nest manipulation). Data were analyzed using SYSTAT statistical software (SYSTAT Software, Inc. 2005). Tests were considered significant if $P < 0.10$.

RESULTS

Population Size and Distribution

Eighty-four Least Bell's Vireo sites were identified during surveys (Table 1, Appendix B, Figs. 12-17). This included 82 territorial male vireos (1 of which held 2 different territories), 55% of which were confirmed as paired, and 1 transient. Transient vireos were observed at one of the six sections surveyed. Four survey sections contained 96% of all male vireos (37% in Santee, 28% in Park, 17% in Lakeside, and 15% in Gorge; Table 1). No vireos were detected in El Capitan survey section.

Table 1. Number and distribution of Least Bell's Vireo males along the San Diego River, 2009.

Survey Section	Known Pairs	Single/ Status Undetermined	Transient	Total Territorial Males
Valley	0	3	1	3
Gorge	5	7	0	12
Park	19	4	0	23
Santee	16	14	0	30
Lakeside	5	9	0	14
El Capitan	0	0	0	0
Total	45[a]	37	1	82

The distribution of vireo territories on the San Diego River in 2009 was similar to that in 2008, although the number of vireo territories increased in most survey areas (Table 2). In 2009, the vireo population increased in 67% of areas surveyed (4/6). The remaining two survey areas showed no change or decreased by only one territory between 2008 and 2009. The area with the largest numeric increase was Santee, increasing by 50%. Overall, the vireo population on the San Diego River increased by 30% from 2008-2009.

Table 2. Number of territorial male vireos on the San Diego River, by survey area, 2008-2009.

	Number of Territorial Males		Numeric
Survey Area	**2008**	**2009**	**Change**
Valley	1	3	+2
Gorge	13	12	-1
Park	18	23	+5
Santee	20	30	+10
Lakeside	11	14	+3
El Capitan	0	0	0
Total	63	82	+19

Habitat Characteristics

Vireos occupied five habitat types along the San Diego River (Table 3). The majority of vireo territories (72%) occurred in habitat characterized as mixed willow riparian, followed by willow habitat co-dominated by cottonwoods (24%). A single vireo territory each occurred in willow habitat co-dominated by sycamore, riparian scrub, and non-native vegetation. Similar to 2008, few vireo territories in 2009 contained a large proportion of exotic vegetation (Table 4). These territories contained abundant giant reed and castor bean (*Ricinus communis*).

Table 3. Habitat types used by Least Bell's Vireos along the San Diego River, 2009.

	Number of Territories			
Habitat Type	**>50% Native**	**>50% Exotic**	**Total**	**Percent of Total**
Mixed Willow	58	2	60[a]	72%
Willow/Cottonwood	20	0	20[a]	24%
Willow/Sycamore	1	0	1	1%
Riparian Scrub	1	0	1	1%
Non-native	0	1	1	1%
Total	80	3	83[a]	100%

[a] One male occupied two consecutive territories in different habitat types.

Table 4. Proportion of Least Bell's Vireo territories dominated or co-dominated by exotic vegetation, by survey area, 2008-2009. Numbers in parentheses are the number of territories in the survey area.

	Proportion of Territories			
Survey Area	**2008**		**2009**	
Valley	0%	(1)	67%	(3)
Santee	0%	(20)	3%	(30)
Lakeside	9%	(11)	0%	(14)
Gorge	0%	(9)	0%	(12)
Park	0%	(18)	0%	(24)
Total	2%	(59[a])	4%	(83)

Banded Birds

We were able to observe 123 adult Least Bell's Vireos (78 males, 94% of all males, and 45 females, 90% of all females) on the San Diego River well enough to determine banding status in 2009. Twenty-six of these had been banded prior to the 2009 breeding season, twenty-five of which we were able to identify by unique color band combination and one of which was banded with a single federal band indicating it had been banded in 2008 as a nestling on the San Diego River. Of the 26, 24 were originally banded on the San Diego River (1 in 2006 and 23 in 2008), 1 was originally banded on the Sweetwater River (as a nestling in 2007), and 1 was originally banded on the Upper San Luis Rey River (as a nestling in 2007). Of vireos originally banded on the San Diego River in 2008, 16 were returning adults and 7 were banded as nestlings (captured in 2009 and given color bands). Adult birds of known age ranged from 1-4 years old.

The recapture and resighting of banded birds allowed us to determine the rate at which vireos previously documented along the San Diego River returned to hold territories or were resighted in 2009. Although this is the minimum number of vireos known to survive and does not include all birds that dispersed from the San Diego River drainage or that we may have failed to detect/resight, it can be used as an inference to calculate minimum annual survivorship for the vireo population along the river.

Of 25 uniquely color banded adult vireos present along the San Diego River during the 2008 breeding season, 72% (18/25) returned to the San Diego River in 2009. Two of the four banded adult female vireos known to be alive in 2008 were resighted in 2009, an over-winter survivorship rate of 50%. Sixteen of the twenty banded adult male vireos known to be alive in 2008 were resighted in 2009, an over-winter survivorship rate of 80%. One of these banded vireos had a single silver numbered federal band on the right leg. This vireo was not recaptured but was assumed to be the adult male banded in the same area at Lakeside River Park in 2006 (K. Moore, pers. comm.). A male vireo was banded as a nestling on the San Luis Rey River in 2007 and recaptured in 2009. This vireo was not detected in 2008. The remaining six vireos that had full color band combinations in 2008 were not resighted in 2009. The discrepancy in sex-related over-winter survivorship may be attributed to difficulty in resighting females and also the low proportion of females that were banded. In any given year, the proportion of females that are resighted is lower than for males. Therefore, the chances of resighting a particular female are correspondingly smaller.

Six of the 30 hatch-year vireos banded in 2008 that survived to fledge were captured and given unique color band combinations on the San Diego River in 2009 (Table 5). One additional vireo was banded as a nestling on the San Diego River in 2008 and was recaptured and given a unique color band combination on Marine Corps Base Camp Pendleton in 2009 (Lynn and Kus in prep.) yielding a conservative first-year survivorship of 23%. Assuming an equal sex ratio of banded nestlings, first-year survivorship of males was 33% (5/15) and females was 13% (2/15). One other female vireo that was resighted in 2009 on the San Diego River with a light blue numbered federal band on her left leg was banded as a nestling in 2008. This increases the first-year survivorship estimate to 26% (33% for males and 20% for females). Because female vireos are elusive and difficult to recapture, the first-year survivorship estimate may be conservative.

Drainage-wide 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. Eighteen adult vireos that were identified in 2008 were resighted in 2009, all of which occupied known territories both years. All 18 adult vireos that returned in 2009 occupied the same breeding territory that they did in 2008. One additional male vireo that had been banded as a nestling on the San Luis Rey River in 2007 settled in a breeding territory on the San Diego River in 2009 55 km from his natal territory.

The six first-year vireos that had been banded as nestlings along the San Diego River in 2008 and were resighted on the San Diego River 2009 dispersed an average of 1.6 ± 1.1 km from their natal sites (range 1.1-3.7 km for males and 0.6-1.0 km for females). One vireo that fledged from a nest on the San Diego River in 2008 was resighted at Marine Corps Base Camp Pendleton in 2009, having dispersed 61.3 km. Overall, the average distance first-year vireos dispersed from the San Diego River to all sites was 10.2 ± 22.6 km (SD) (n = 7).

A total of 64 vireos were banded along the San Diego River during the 2009 season. Six vireos that had been banded as nestlings in 2008 and fourteen unbanded adult vireos were captured at their breeding territories in 2009 and given full band combinations (Table 5). Forty-four nestlings were banded with a single light blue metal numbered federal band on the right leg.

Table 5. Adult Least Bell's Vireos banded or seen along the San Diego River in 2009.

Year Last Detected	Territory / Survey Section in 2009	Band Combination[a]		Age in 2009	Sex[b]	Comments[c]
		Left Leg	Right Leg			
2008	Gorge / GO01	-	LPBK/Mlb	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2008	Gorge / SGBI	LPBK/pupu	Mlb	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2008	Lakeside / SIG	-	Msi	≥ 4 yrs	M	Banded as an adult in 2006 at the LRC.
2008	Park / BTN	gogo	Mdg	2 yrs	F	Banded as a nestling in 2007 on the SWR.
2009	Park / SGMD	Mlb	LBLB/pupu	≥ 1 yr	F	Banded as an adult in 2009 - SGMD territory.
2008	Park / SGPP	LPBK/Mlb	-	1 yr	F	Banded as a nestling in 2008 on the SDR.
2008	Park / FNK	LBLB/Mlb	pupu	1 yr	F	Banded as a nestling in 2008 on the SDR.
2008	Park / BTN	Mlb	-	1 yr	F	Banded as a nestling in 2008 on the SDR.
2008	Park / BTN	DPDP/Mlb	-	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2008	Park / WMB2	DPWH/Mlb	-	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2008	Park / WMB1[d]	PUPU/Mlb	-	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2008	Park / SGTS	BKBK/Mlb	pupu	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2008	Park / HTS	-	YEPU/Mlb	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2008	Park / SGPN	-	PUPU/Mlb	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2008	Park / SGPP	Mlb	BKBK/pupu	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2009	Park / FNK	BYST/Mlb	-	≥ 1 yr	M	Banded as an adult in 2009 - FNK territory.
2009	Park / FRE	WHPU/pupu	Mlb	≥ 1 yr	M	Banded as an adult in 2009 - FRE territory.
2009	Park / CCO	LBLB/Mlb	-	≥ 1 yr	M	Banded as an adult in 2009 - CCO territory.
2009	Park / SGSO	pupu	BYST/Mlb	≥ 1 yr	M	Banded as an adult in 2009 - SGSO territory.
2009	Park / FJS2	-	BKLB/Mlb	≥ 1 yr	M	Banded as an adult in 2009 - FJS2 territory.
2008	Park / EDD	-	DPWH/Mlb	1 yr	M	Banded as a nestling in 2008 on the SDR.
2008	Park / PA10	WHPU/Mlb	-	1 yr	M	Banded as a nestling in 2008 on the SDR.
2008	Santee / GOL[e]	LPLP/Mlb	-	≥ 3 yrs	F	Banded as an adult in 2008 on the SDR.
2008	Santee / SGMA	WHWH/Mlb	-	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2008	Santee / MER	PUWH/pupu	Mlb	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2008	Santee / SGHO	PUWH/Mlb	-	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2008	Santee / SGFU	pupu	WHWH/Mlb	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2008	Santee / SGSA	Mlb	BYST/pupu	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.
2007	Santee / ALD	BKBK	Mdb	2 yrs	M	Banded as a nestling in 2007 on the SLR.
2009	Santee / POR	YEYE/Mlb	-	≥ 1 yr	M	Banded as an adult in 2009 - POR territory.
2009	Santee / ALT	-	LBBK/Mlb	≥ 1 yr	M	Banded as an adult in 2009 - ALT territory.
2009	Santee / SPR	LBLB/pupu	Mlb	≥ 1 yr	M	Banded as an adult in 2009 - SPR territory.
2009	Santee / WAL	pupu	PUWH/Mlb	≥ 1 yr	M	Banded as an adult in 2009 - WAL territory.
2009	Santee / JOY	Mlb	BKLB/pupu	≥ 1 yr	M	Banded as an adult in 2009 - JOY territory.
2009	Santee / SGCA	BKLB/pupu	Mlb	≥ 1 yr	M	Banded as an adult in 2009 - SGCA territory.
2009	Santee / SGCH	BKBK/pupu	Mlb	≥ 1 yr	M	Banded as an adult in 2009 - SGCH territory.
2009	Santee / GOL	-	BYST/Mlb	≥ 1 yr	M	Banded as an adult in 2009 - GOL territory.
2008	Santee / STN	-	PUWH/Mlb	1 yr	M	Banded as a nestling in 2008 on the SDR.
2008	Santee / SA18	BKLB/Mlb	-	1 yr	M	Banded as a nestling in 2008 on the SDR.
2008	Valley / SGGR	pupu	PUPU/Mlb	≥ 2 yrs	M	Banded as an adult in 2008 on the SDR.

[a] Band colors: Msi = silver numbered federal band; gogo = metal gold; Mdg = dark green numbered federal band; Mlb = light blue numbered federal band; pupu = metal purple; BKBK = plastic black; BKLB = plastic black-light blue split; BYST = plastic black-yellow striped; DPDP = plastic dark pink; DPWH = plastic dark pink-white split; LBLB = plastic light blue; LPBK = plastic light pink-black split; LPLP = plastic light pink; PUPU = plastic purple; PUWH = plastic purple-white split; WHPU = plastic white-purple split; WHWH = plastic white; YEPU = plastic yellow-purple split; YEYE = plastic yellow.

[b] Sex: F = female; M = male.

Table 5. Continued.

[c] SDR = San Diego River, LRC = Lakeside River Conservancy; SLR = San Luis Rey River, SWR = Sweetwater River.
[d] This male bred at two sites in 2009, WMB1 and WMBB.
[e] This female bred at two sites in 2009, GOL and MER.

Incidental Detections

On 9 June, during a vireo survey, we detected a single, banded Southwestern Willow Flycatcher (*Empidonax traillii extimus*) in the Valley survey area (Fig. 12). The flycatcher was apparently unpaired and remained in the area until 7 July. This bird was recaptured on 10 June and given a full color band combination. It was originally banded as a nestling on Marine Corps Base Camp Pendleton in 2008 (Howell and Kus 2009), approximately 60.6 km to the north.

Nest Monitoring

A total of 29 territories were monitored for nesting activity within the Treatment and Reference monitoring sites (Table 6; Figs. 3 and 4; Appendix C). Of these, 27 territories were "fully" monitored, meaning that all nests within the territory were found and documented during the breeding season. Pairs within the remaining two territories were documented nesting; however, only a subset of nests by each pair was found and monitored ("partially monitored territory"). At two fully monitored territories in the Reference monitoring site, the males remained single throughout the 2009 breeding season and therefore no nests were completed in these two territories. A third male occupied two consecutive breeding territories in 2009 and is therefore considered a single territory hereafter. A total of 62 nests were monitored during the breeding season; however, 8 of these were not completed (coded as "INC" of "FAL" in Appendix C) and have been excluded from calculations of nest success and productivity. Of the remaining 54 nests, 52 were in fully monitored territories.

Table 6. Number of Least Bell's Vireo territories and nests monitored at Treatment and Reference sites on the San Diego River, 2009. Averages presented as mean ± standard deviation.

	Nest Monitoring Site/Type		
	Treatment	**Reference**	**Total**
Territories fully monitored	12	14[a]	27
Nests in fully monitored territories	35	25	60
Completed nests per pair (fully monitored territories)	2.7 ± 1.1	1.7 ± 1.2	2.2 ± 1.2
Territories partially monitored	2	0	2
Nests in partially monitored territories	2	0	2
Total # of nests monitored	37	25	62

[a] Includes two territories with single males, one of which initiated a nest which was not completed.

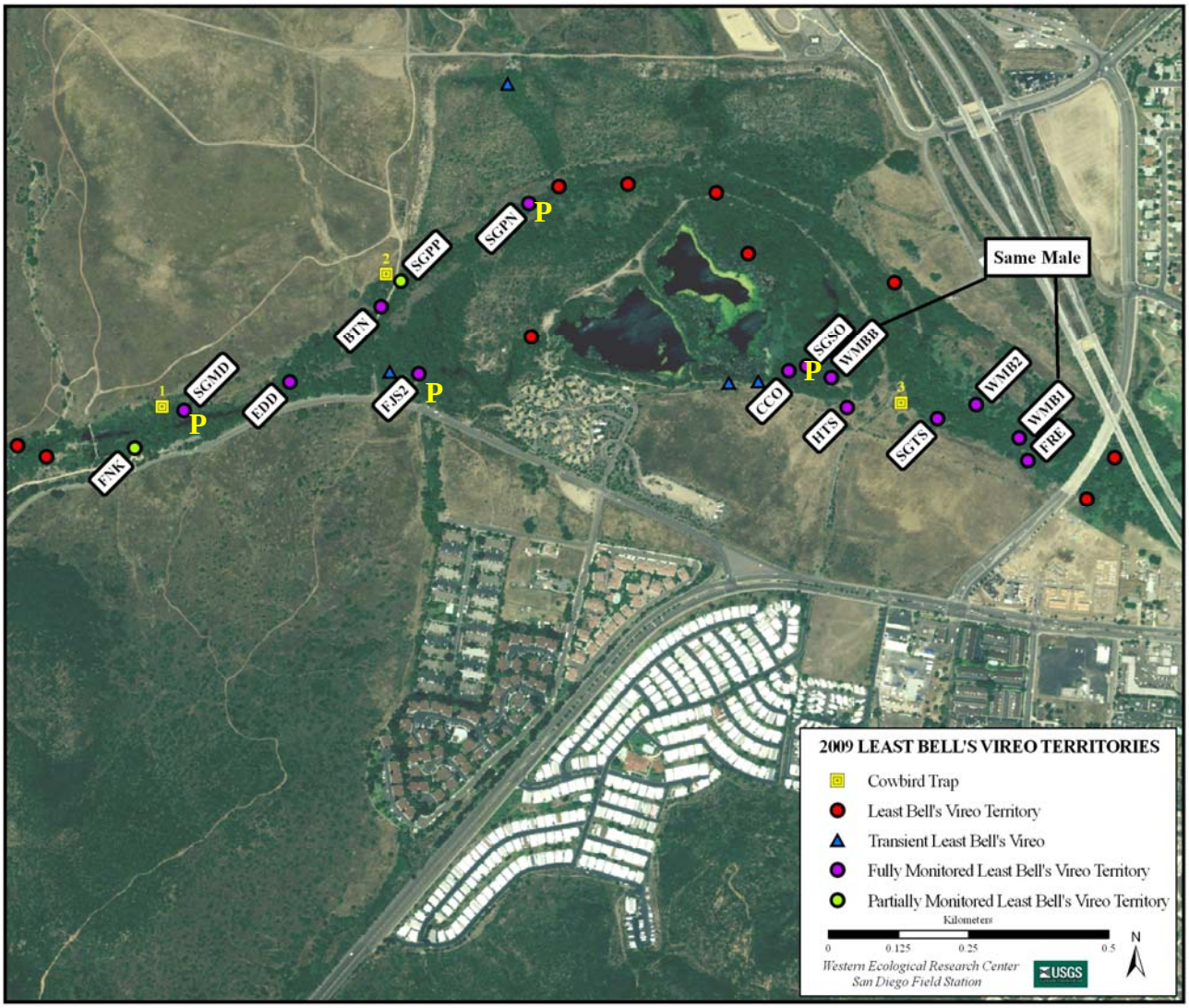

Fig. 3. Locations of monitored Least Bell's Vireo territories at the Park Brown-headed Cowbird (*Molothrus ater*) removal (Treatment) site, San Diego River, 2009. "P" indicates territory where cowbird parasitism occurred.

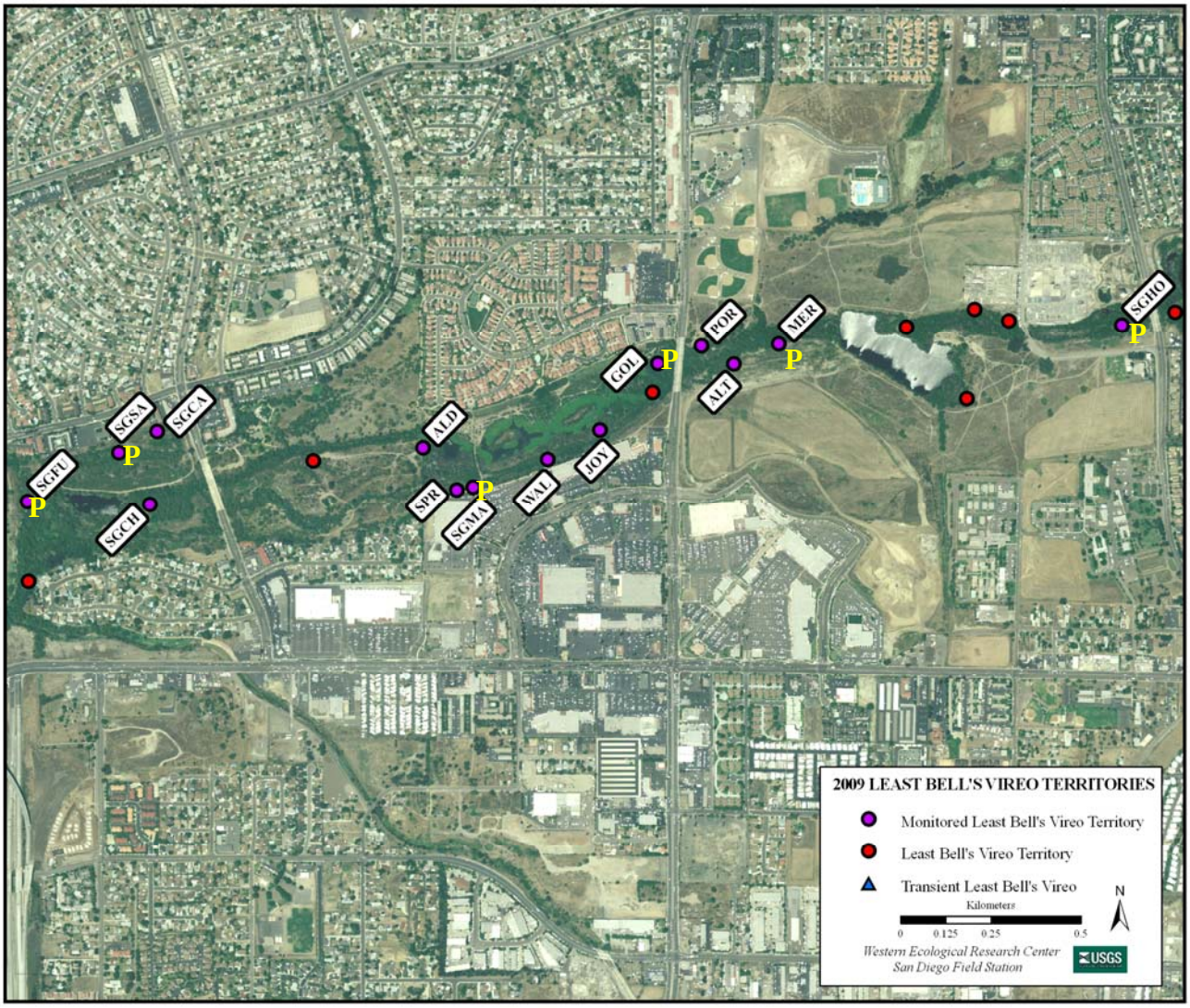

Fig. 4. Locations of monitored Least Bell's Vireo territories at the Santee Reference site, San Diego River, 2009. "P" indicates territory where cowbird parasitism occurred.

Nest Initiation

Nesting activity started in early April and continued until early July (Fig. 5). Excluding the two territories with single males and counting the male that bred at two territories as a single territory, 54% (13/24) of the pairs had attempted nesting by the end of April, and 92% (22/24) by the end of May. Two pairs did not initiate nesting until June.

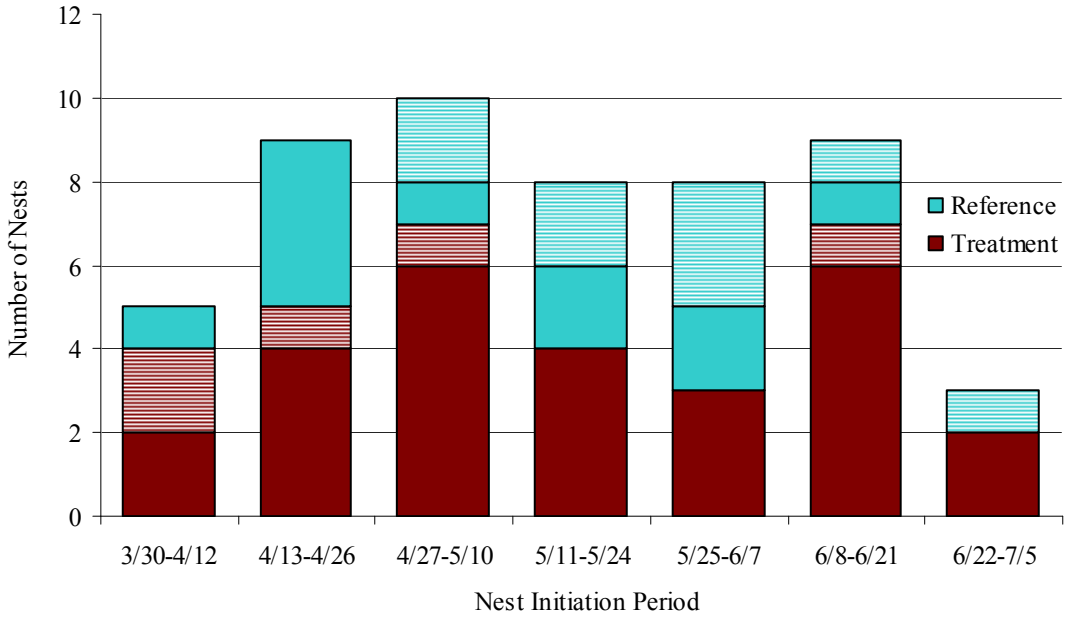

Fig. 5. Number of Least Bell's Vireo nests and those that were parasitized by Brown-headed Cowbirds by two-week intervals, San Diego River, 2009. Parasitized nests represented by horizontal hatching.

Every fully monitored pair and one of the two single males initiated at least one nest in 2009. Of paired males, 15 (63%) re-nested after first attempts. Two pairs (8%) re-nested after a successful first nest, while thirteen pairs (54%) initiated a second nest after a failed first attempt. Three pairs (13%) had successful second nests (one after a successful first attempt and two after failed first attempts). Eleven pairs initiated a third nesting attempt, two of which were successful. Seven pairs attempted a fourth nest, none of which were successful, and one pair attempted to nest six times, successfully fledging young on their sixth attempt. Within fully monitored territories, pairs at the Treatment site completed more nests than pairs at the Reference site ($t = 2.20$, $P = 0.04$; Table 6).

Cowbird Parasitism

A total of 50 cowbirds were captured and removed from the Treatment site in 2009, 14 from trap #1 (10 males and 4 females), 9 from trap #2 (7 males and 2 females), and 27 from trap #3 (21 males and 6 females; Sexton 2009; Fig. 3). No juvenile cowbirds were captured in 2009.

Twenty-six percent (14/54 completed nests) of vireo nests were parasitized by cowbirds in 2009. A lower proportion of nests in fully monitored territories were parasitized at the Treatment site (16%; 5/32) than at the Reference site (45%; 9/20; Fisher's Exact Test $P = 0.03$). There was no significant change in rate of cowbird parasitism between 2008 and 2009 at the Reference site (2008 = 64%; Fisher's Exact $P = 0.24$) although there was a marginal decrease in parasitism at the Treatment site (2008 = 38%; Fisher's Exact $P = 0.12$). Parasitism was first observed in the second week of April (13 April) at the Treatment site, approximately two weeks before cowbird traps were opened (25 April). After cowbird traps were open, two more nests were parasitized at the Treatment site, one in early May (4 May) and one in the second half of June (22 June). Significantly fewer vireo nests were parasitized after cowbird traps were opened (2/24; 8.3%) than before cowbird traps were opened (3/8; 37.5%) at the Treatment site (Fisher's Exact $P = 0.09$). Parasitism was first observed at the Reference site at the beginning of May (1 May) after which parasitism rate remained consistently high (range of 50-100%, average 65%) for nests initiated per two-week interval for the remainder of the breeding season (Fig. 5). Nests that were parasitized at the Treatment site after cowbird traps were opened were no further from cowbird trap locations (136.0 ± 64.9 m; $n = 2$) than nests that had been parasitized before traps were opened (162.4 ± 110.4 m; $n = 3$).

Only one parasitized nest in the monitoring sites (in a Reference territory) was parasitized twice (contained two cowbird eggs) in 2009 (8%), unlike 2008 when 16% of parasitized nests contained two cowbird eggs. No monitored nests contained cowbird nestlings or fledged cowbird young. A total of 11 cowbird eggs were removed from nests found during monitoring and surveying. Four other cowbird eggs were not removed because the nest failed before removal could occur.

Parasitism was responsible for the failure of 13% (7/54) of nests; however, not all instances of parasitism resulted in nest failure (Table 7). Fifty percent of the parasitized nests (Treatment 60%, Reference 44%) remained active following the removal of cowbird eggs. While some of these nests failed later, those that were successful were responsible for the production of 23% (9/39; see below) of all young fledged along the river (Treatment 21% [6/28], and Reference 27% [3/11]).

Fate of Nests

Twenty-eight percent of the completed nests along the San Diego River were successful, producing at least one vireo fledgling (Table 8). Four of these successful nests fledged young after manipulation to remove cowbird eggs. In the absence of manipulation, the success rate of completed nests along the San Diego River in 2009 would have been just 20%. Nest success did not differ significantly by site (Fisher's Exact $P > 0.99$). Counting all parasitized nests as failed, nest success would still not differ significantly by monitoring site (Fisher's Exact $P = 0.51$).

Table 7. Number and fate of Least Bell's Vireo nests parasitized by Brown-headed Cowbirds in fully and partially monitored territories, San Diego River, 2009.

	Treatment	Reference	Total
Nests Parasitized	5	9	14
Pairs Parasitized	4	6	10
Total Cowbird Eggs Laid	5	10	15
Fate of Nests:			
Abandoned	2	5	7
Not abandoned			
Successful	2	2	4
Unsuccessful	1	2	3

Table 8. Fate of Least Bell's Vireo nests in fully and partially monitored territories, San Diego River, 2009. Numbers in parentheses are percent of total nests.

	Number of Nests					
Nest Fate	**Treatment**		**Reference**		**Total**	
Successful	10	(29%)	5	(25%)	15	(28%)
Failed						
Predation	17	(50%)	7	(35%)	24	(44%)
Parasitism	2	(6%)	5	(25%)	7	(13%)
Other/Unknown	5	(15%)	3	(15%)	8	(15%)
Total Completed Nests	34		20		54	

Seventy-two percent of nests observed were unsuccessful in fledging vireo young (Table 8). Nest failure throughout the monitoring sites was primarily attributed to predation, although predation events were often not observed. Predation was determined based upon circumstantial evidence such as the loss of eggs and/or young from intact nests, partial or complete destruction of nests, and the presence of eggshell fragments in or beneath abandoned nests. Vireos were observed scolding Western Scrub-jays (*Aphelocoma californica*) immediately following nest failure at one territory. Jays were also active within at least one other territory which experienced repeated nest failures, although no depredation was observed. Other potential predators include snakes, birds such as Cooper's Hawks (*Accipiter cooperii*), small mammals, Virginia opossums (*Didelphis virginiana*), Argentine ants (*Linepithema humile*; Peterson *et al*. 2004), and alligator lizards (*Elgaria multicarinata*; D. Evans unpubl. data).

Nest failures were not limited to predation and parasitism. At both sites, nests failed after the host plant or branch collapsed (three nests at the Treatment site and three at the Reference site). Three of these nests were built in herbaceous plants (two in exotic black mustard, *Brassica nigra* and one in wild grape, *Vitis californica*) which collapsed before the nest cycle was complete. The eggs in one nest at the Treatment site failed to hatch after lengthy incubation and were probably infertile. One nest at the Treatment site was abandoned for unknown reasons.

Productivity

Reproductive indices for vireos were similar between the Treatment and Reference nest monitoring sites. Average clutch size was relatively high and did not differ between sites for non-parasitized nests ($t = 0.43$, $P = 0.68$). Parasitized nests at the Treatment site had significantly larger clutches than parasitized nests at the Reference site ($t = 3.01$, $P = 0.01$; Table 9). Hatching success was similar between sites and averaged 50% for vireo eggs and 47% for nests. We documented at least 39 fledglings in 2009, most of which (72%) came from nests in the Treatment site. The total number of fledglings in 2009 would be reduced by nine if parasitized nests had been allowed to fail. Two fully monitored pairs successfully double brooded, fledging young from two nests. The number of fledglings per pair was not statistically different between Treatment and Reference sites (likely because of low sample size) although the higher number of fledglings per pair at Treatment sites represents a strong biological response (Table 9). There was also no statistical difference between the number of young fledged per pair at Treatment and Reference sites when we assumed nests that had been parasitized would have failed, although this, again, represents a strong biological response.

Table 9. Reproductive success and productivity of nesting Least Bell's Vireos, San Diego River, 2009. Averages presented as mean ± standard deviation.

	Total Number		
Parameter	**Treatment**	**Reference**	**Total**
Nests with eggs	32	20	52
Eggs laid	106	53	159
Average clutch size			
Non-Parasitized[a]	3.5 ± 0.6	3.4 ± 0.7	3.5 ± 0.6
Parasitized[b]	3.4 ± 0.5	2.1 ± 1.1	2.6 ± 1.1
Nests with hatchlings	17	9	26
Hatchlings	50	24	74
Hatching success:			
Eggs[c]	53%	45%	50%
Nests[d]	47%	45%	47%
Nests with fledglings	10 (8)[e]	5 (3)[e]	15 (11)[e]
Fledglings	28 (22)[e]	11 (8)[e]	39 (30)[e]
Fledging success:			
Hatchlings[f]	55% (44%)[e]	46% (33%)[e]	53% (41%)[e]
Nests[g]	59% (47%)[e]	56% (33%)[e]	58% (42%)[e]
Fledglings per egg	0.3 (0.2)[e]	0.2 (0.2)[e]	0.2 (0.2)[e]
Fledglings per nest	0.9 (0.7)[e]	0.6 (0.4)[e]	0.8 (0.6)[e]
Average number of young fledged per pair[h]	2.1 ± 2.3 (1.6 ± 2.0)[e]	0.9 ± 1.4 (0.7 ± 1.4)[e]	1.5 ± 1.9 (1.1 ± 1.7)[e]
Pairs fledging ≥ one young[i]	7 / 58% (6 / 50%)[e]	5 / 42% (3 / 25%)[e]	12 / 50% (9 / 38%)[e]

[a] Based on 22 Treatment and 8 Reference non-parasitized nests with a full clutch.
[b] Based on five Treatment and nine Reference parasitized nests.
[c] Percent of all eggs that hatched.
[d] Percent of all nests with eggs in which at least one egg hatched.
[e] Number in parentheses is result if parasitized nests had not been manipulated but had been allowed to fail.
[f] Percent of all nestlings that fledged.
[g] Percent of all nests with nestlings in which at least one young fledged.
[h] Based on 12 Treatment and 12 Reference pairs that were fully monitored. Mann-Whitney U = 92.0, P = 0.21. If parasitized nests were allowed to fail, Mann-Whitney U = 91.0, P = 0.21.
[i] Based on fully monitored pairs.

Nest Characteristics

In 2009, successful and unsuccessful nests within monitoring sites had similar nest placement characteristics. However, at the Reference site, successful nests were placed significantly further from the edge of the vegetation clump and the edge of riparian vegetation than

unsuccessful nests (Table 10; this difference did not change when parasitized nests were considered to be unsuccessful). Nests at the Reference site were placed closer to the edge of the host plant but further from the edge of the vegetation clump though closer to the edge of the riparian vegetation than nests at the Treatment site (Table 11).

Table 10. Least Bell's Vireo nest characteristics and results of Mann-Whitney *U*-tests of successful vs. unsuccessful nesting attempts at nest monitoring sites along the San Diego River, 2009. Numbers in parentheses represent recalculated figures that consider all parasitized nests to be unsuccessful.

	Nest Fate				
Nest Characteristic	**Successful**	**Unsuccessful**	***n*[a]**	***U*[b]**	***P*[c]**
Treatment Site					
Average nest height (m)	1.17 (1.23)	1.17 (1.15)	10, 26 (8, 28)	161.0 (148.5)	0.27 (0.16)
Average host height (m)	2.82 (2.88)	4.52 (4.39)	10, 26 (8, 28)	101.0 (92.5)	0.30 (0.46)
Average distance to edge of host (m)	0.85 (0.85)	1.12 (1.10)	10, 26 (8, 28)	148.5 (133.0)	0.51 (0.42)
Average distance to edge of clump (m)	2.81 (3.26)	2.80 (2.67)	10, 26 (8, 28)	99.0 (93.5)	0.27 (0.48)
Average distance to edge of riparian vegetation (m)	25.10 (22.00)	25.27 (26.14)	10, 26 (8, 28)	138.0 (103.5)	0.77 (0.75)
Reference Site					
Average nest height (m)	1.00 (0.90)	1.00 (1.01)	4, 15 (2, 17)	30.0 (14.0)	>0.99 (0.69)
Average host height (m)	4.10 (4.00)	3.33 (3.44)	5, 15 (3, 17)	45.5 (31.5)	0.48 (0.52)
Average distance to edge of host (m)	0.66 (0.87)	0.45 (0.44)	5, 15 (3, 17)	45.0 (36.0)	0.51 (0.26)
Average distance to edge of clump (m)	6.40 (8.33)	3.37 (3.39)	5, 15 (3, 17)	58.5 (45.5)	0.07 (0.03)
Average distance to edge of riparian vegetation (m)	18.70 (21.67)	9.44 (10.01)	5, 15 (3, 17)	56.5 (42.0)	0.10 (0.08)

[a] *n* = number of nests in sample (Successful, Unsuccessful).
[b] *U* = Mann-Whitney *U* statistic.
[c] *P* = P-value.

Table 11. Least Bell's Vireo nest characteristics and results of Mann-Whitney *U*-tests between monitoring sites along the San Diego River, 2009.

Nest Placement Characteristic	**Treatment**	**Reference**	***U*[a]**	***P*[b]**
Average nest height (m)	1.17	1.00	368.0	0.64
Average host height (m)	4.05	3.52	359.5	0.99
Average distance to edge of host (m)	1.04	0.51	487.0	0.03
Average distance to edge of clump (m)	2.80	4.13	195.0	0.01
Average distance to edge of riparian vegetation (m)	25.22	11.76	551.5	0.01

[a] *U* = Mann-Whitney *U* statistic.
[b] *P* = P-value.

A total of 16 plants (15 species and 1 "dead" category, which included all dead woody species) were used as hosts for vireo nests at monitoring sites in 2009, although not all were used within each site (Table 12). Vireos used 11 of the 16 at the Treatment site and 9 of the 16 species at the Reference site. Host species selection differed between sites, with only four species used at both sites. At the Reference site, 62% of vireo nests were placed in willows and mule fat while 53% of the vireo nests at the Treatment site were placed in willows and mule fat. Most vireo nests at the Treatment site were placed in mule fat. Eight vireo nests at the Treatment site were built in exotic plant species (five in giant reed and three in black mustard; *Brassica nigra*) while only two

vireo nests at the Reference site were built in exotic host species, one in an ornamental fig (*Ficus* sp.) and one in a pepper tree (*Schinus* sp.).

Table 12. Host plant species used by Least Bell's Vireos at monitoring sites along the San Diego River, 2009. Numbers in parentheses are proportions of total nests at that site.

	Number of Nests	
Host Species	**Treatment**	**Reference**
Mule fat	12 (0.33)	3 (0.14)
Giant reed	5 (0.14)	
Black willow	4 (0.11)	2 (0.10)
Coast live oak	4 (0.11)	
Arroyo willow	3 (0.08)	8 (0.38)
Black mustard	3 (0.08)	
Dead species	1 (0.03)	1 (0.05)
Box elder (*Acer negundo*)	1 (0.03)	
Mugwort (*Artemisia douglasiana*)	1 (0.03)	
California rose (*Rosa californica*)	1 (0.03)	
California blackberry (*Rubus ursinus*)	1 (0.03)	
Freemont cottonwood		3 (0.14)
Fig (*Ficus* sp.)		1 (0.05)
Toyon (*Heteromeles arbutifolia*)		1 (0.05)
Pepper (*Schinus* sp.)		1 (0.05)
California wild grape (*Vitis californica*)		1 (0.05)

DISCUSSION

Surveys for Least Bell's Vireos have been conducted along the San Diego River periodically since the mid-1970s. Vireos have been documented within the same general area (Mission Dam to Santee) over a number of years and increased from 11 territories in 1978 to a high of 36 territorial males in 1994 (Goldwasser 1978; Jones 1985; Kus 1989, 1992, 1994, 1995; Kus and Beck 1998; Wellik *et al.* 2009; USGS unpubl. data; Fig. 6). In 2008, this number had dropped to approximately half the 1994 maximum, but in 2009, the numbers rebounded to slightly fewer territories than were recorded within the same area in 1997.

Surveys of other areas on the river have been conducted less frequently, but also show an increase in vireo territories through 1997, with a greater increase between 1997 and 2009 (Table 13; SANDAG 1990, Kus and Beck 1998). The bulk of vireo territories remained in the central section of the river (Park and Santee survey sections). Vireo numbers fluctuated in the lowest and upper-most sections of the river (Valley and El Capitan) and increased in the Gorge and Lakeside survey sections since 1997.

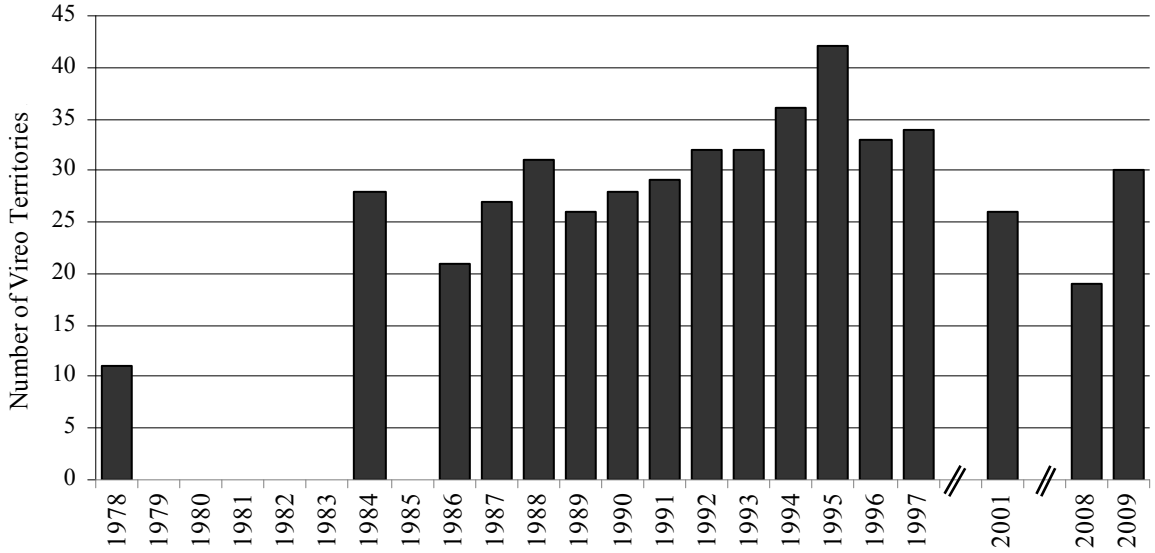

Fig. 6. Number of Least Bell's Vireo territories between Mission Dam and Santee, San Diego River, 1978-2009

Table 13. Number of Least Bell's Vireo territories occurring historically along the San Diego River. (Sources: SANDAG 1990, Kus and Beck 1998).

	Number of Territorial Males				
Survey Site	**1978**	**1987**	**1997**	**2008**	**2009**
Valley	1	0	7	1	3
Gorge	-	2	7	13	12
Park	8	12	19	18	23
Santee	3	12	24	20	30
Lakeside	-	5	3	11	14
El Capitan	-	-	2	0	0
Total	12	31	60	63	82

The number of vireo territories along the San Diego River follows the general trend in southern California, where the vireo population increased dramatically since the mid-1980s (Lynn and Kus 2009, Ferree and Kus 2009). However, whereas vireo numbers increased 6-7 times between 1987 and 1997 on Marine Corps Base Camp Pendleton (Lynn and Kus 2009), and doubled between 1997 and 2008 on the lower San Luis Rey River (Ferree and Kus 2009), vireo numbers on the San Diego River increased more slowly during that time period. On the other hand, the increase in vireo territories between 2008 and 2009 on the San Diego River was mirrored on Marine Corps Base Camp Pendleton and along the San Luis Rey River during the same time interval (Lynn and Kus in prep., Ferree and Kus in prep.).

The swamping of suitable vireo habitat by exotic giant reed has been identified as a management issue for vireos in many riparian areas in southern California. Marine Corps Base Camp Pendleton has been removing giant reed from the Santa Margarita River (the most extensive habitat for Least Bell's Vireo on Base) since 1996, and the lower San Luis Rey River is also being managed to control giant reed and protect Least Bell's Vireo habitat. Such programs have been sporadic and widely spaced along the San Diego River. Large stands of giant reed were observed in sections of the river in 2008 and 2009, and some removal had begun in the eastern extent of the Valley survey section in late 2008/early 2009. Removal of giant reed was also underway along the Carlton Oaks Golf Course as of November 2009. In subsequent years of this study, vireos should respond as the management actions that have been planned are implemented along the San Diego River.

As expected, vireos occupied territories in mixed willow and mixed willow/cottonwood riparian vegetation. We did not define vegetation in areas the vireos did not occupy to quantify the extent of exotic vegetation throughout the drainage; however, vireos may be avoiding these areas because only one vireo territory was placed in non-native vegetation. The Valley survey section contained extensive patches of giant reed which were not occupied in 2008 or 2009.

Banding of Least Bell's Vireos allows us to estimate both adult and juvenile survival rates as well as investigate annual dispersal of adult and first-year adult vireos. Twenty-six banded vireos were resighted along the San Diego River in 2009. One of these vireos had dispersed from his natal drainages (the San Luis Rey River) to the San Diego River, demonstrating the potential for vireos to move far beyond their natal drainages. Another vireo that was banded as a nestling on the San Diego River in 2008 was re-detected on Marine Corps Base Camp Pendleton in 2009, in further support of the vireos' ability to move between drainages. On the other hand, all of the adult vireos that returned to the San Diego River in 2009 occupied the same territories that they had in 2008, demonstrating strong breeding site fidelity. 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 movements play in maintaining genetic diversity and persistence in these populations. Continued monitoring of cohorts banded as nestlings 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.

In 2009, we detected a single Southwestern Willow Flycatcher on the San Diego River. This bird remained in the same area for approximately one month, although it was not paired. The movement of this bird from Marine Corps Base Camp Pendleton demonstrates the ability of this species to colonize new areas, and further suggests that areas on the San Diego River contain suitable habitat to attract this species. No formal Southwestern Willow Flycatcher surveys were conducted on the San Diego River during 2009, so it is possible that other individuals were present but undetected. Three pairs of Southwestern Willow Flycatchers were detected on the San Diego River in 2001, two above El Capitan Reservoir (Kus et al. 2003) and one at William Heise County Park near Julian, California (J. Barth, unpubl. data). While these records are well upstream of the flycatcher that we found in 2009, the San Diego River was identified as a potential drainage for establishing a flycatcher population (part of the Coastal California Recovery Unit) in the Southwestern Willow Flycatcher final recovery plan (USFWS 2002). Future surveys and

observations should determine whether or not the 2009 detection represents the re-establishment (or new establishment) of a population of this species on the San Diego River.

Cowbird trapping has been shown to decrease incidence of cowbird nest parasitism for vireos. At Marine Corps Base Camp Pendleton and the lower San Luis Rey River, intensive programs to control Brown-headed Cowbirds have dramatically reduced cowbird parasitism of Least Bell's Vireo nests, although a delay in opening cowbird traps along the lower San Luis Rey led to a substantial increase in cowbird parasitism in 2009 (Ferree and Kus in prep.). Ideally, cowbird traps are opened by the beginning of April, at the onset of the vireo breeding season. On the San Diego River, traps were opened on 25 April, and significantly fewer vireo nests were parasitized after the cowbird traps were opened on the San Diego River. Additionally, significantly fewer vireo nests were parasitized at the Treatment site, where cowbird traps were open for the majority of the vireo breeding season, than at the Reference site, where no cowbird traps were opened. The removal of adult cowbirds, coupled with the removal of cowbird eggs from vireo nests, may account for the generally higher breeding productivity of vireos at the Treatment site, which produced 28 fledglings while the Reference site produced 11 fledglings in 2009.

Cowbird parasitism affected 26% of nests along the San Diego River in 2009, a drop from the 45% documented in 2008. Not all parasitized nests failed. The removal of cowbird eggs from parasitized nests potentially helped increase nest success (20% to 28%). However, it cannot prevent reduced productivity associated with parasitism relative to areas with no cowbird parasitism because removing cowbird eggs does not replace the vireo eggs that were removed by cowbirds.

Cowbirds have been trapped almost annually along the San Diego River, specifically in the Park site, since as early as 1984. Cowbird trapping and vireo nest monitoring occurred simultaneously from 1987 through 1996, during which time nest parasitism rates significantly declined (Kus and Whitfield 2005). Kus and Whitfield (2005) also found that decreasing cowbird parasitism rates were associated with increasing vireo productivity, leading to an increasing trend in the vireo population ($r = 0.80$; $P = 0.002$; Fig. 6). While cowbird trapping occurred in the Park site from 2001–2007 (Varanus Biological Services 2001, 2003; Varanus Monitoring Services 2004, 2007), vireo monitoring did not occur simultaneous with this later cowbird trapping effort. Although the vireo population had declined by 44% in the Park site by 2008, it rebounded somewhat in 2009, likely as a result of range-wide high vireo breeding productivity in 2008, which may have supplemented breeding numbers on the San Diego River.

The decline in the vireo population prior to 2009, despite cowbird trapping, may have resulted from two factors. First, nest monitoring involves removing cowbird eggs and nestlings from parasitized nests, thereby allowing vireos to successfully fledge vireo young. Failure to remove cowbird eggs and nestlings from a vireo nest not only reduces productivity of that vireo nest (most likely no vireo young would fledge), but also prevents the vireo pair from initiating a new nest while they are occupied raising a cowbird nestling. Second, during the 2001-2007 cowbird trapping effort, only two traps were deployed during most years which may have been adequate to protect the vireos within an undetermined buffer of the traps, but may not have been sufficient to impact cowbird numbers and reduce parasitism of vireo nests throughout the drainage. While we looked at the distance of parasitized nests from the nearest cowbird trap before and after the traps were opened in 2009, our sample size was insufficient to determine what that buffer may

have been. In 2009, we monitored vireo nests simultaneous with cowbird trapping, allowing us to provide the additional protection to vireo nests (by removing cowbird eggs and nestlings) while also providing a measure of how this additional protection affects vireo productivity.

Although the difference was not statistically significant, in 2009, pairs at the Treatment site fledged more than twice as many young per pair than did pairs at the Reference site. This follows the same trend as in 2008, when the Treatment site had higher nest success and more young fledged per pair. Because most nest site characteristics did not differ between Treatment and Reference site, or between successful and unsuccessful nests either at Reference sites or at Treatment sites, it is evident that habitat characteristics alone were not responsible for differences in vireo breeding success and productivity. Similarly, Kus *et al*. (2008) found that fine-scale and intermediate-scale nest placement factors were not significantly related to nest survival along the San Luis Rey River.

Cowbird parasitism resulted in the loss of 13% of nests in 2009, although if no parasitized nests had been rescued (by the removal of cowbird eggs), the rate of nest loss would have risen to 26%. However, 44% of nests failed from predation, indicating that predation, possibly exacerbated by habitat conditions, should not be discounted as a risk to vireo nests, and may be more of a concern than previously thought.

CONCLUSIONS AND FUTURE DIRECTIONS

One of the management options for protecting and enhancing the San Diego River vireo population is cowbird control. Our project was designed to allow an experimental determination of the most cost- and biologically-effective way to achieve that control. Historically, cowbird control has been initiated with the goal of eliminating parasitism of vireo nests within a prescribed area through the annual operation of multiple traps "in perpetuity". The purpose of our project is to evaluate alternatives to this approach and to tailor a cowbird management plan specific to the San Diego River and the goals for its vireo population.

Parasitism of vireo nests was high during the baseline study year in the absence of cowbird trapping. In 2009, cowbirds traps were opened in the Treatment sites in Mission Trails Regional Park, although they were opened approximately 3-4 weeks later (25 April) than recommended (1 April). Systematic cowbird trapping is intended to provide data on the abundance and spatial and temporal distribution of cowbirds in this site. Concurrent vireo monitoring provides data on rates of parasitism, seasonal timing of parasitism, nest success, seasonal productivity (production of vireo young), dispersal, and recruitment of young vireos. With sufficient sample size over multiple years, we will be able to examine the spatial distribution of parasitized nests to determine the zone of influence of the cowbird traps and use this information to direct future trapping activities regarding trap numbers and spacing. We observed an overall decrease in cowbird parasitism between our baseline year (2008) and this year, but also observed significantly less cowbird parasitism at the Treatment site than at the Reference site, indicating that cowbird trapping is negatively influencing incidence of cowbird parasitism. A preliminary conclusion, based on one year of data (2009), is that the timing of parasitism indicates that cowbird traps should be opened by early April to ensure a minimum of parasitism during the time vireos are initiating their first nests, thereby allowing them the opportunity to increase season-long breeding productivity by nesting multiple times.

Future aspects of the study will include reducing cowbird trapping to a limited portion of the vireo breeding season based on results from prior years, adjusting the number and placement of cowbird traps based on spatial analysis of cowbird parasitism and cowbird abundance in prior years, and skipping a year of cowbird trapping while continuing to monitor vireos to determine whether vireo population goals can be maintained with trapping every other year. Ultimately, the results of this study will be useful in expanding cowbird trapping to a larger study area to identify areas that warrant cowbird control and determine the number, location, and period of operation of cowbird traps to achieve objectives of cowbird control relative to management goals of protecting and enhancing the San Diego River vireo population.

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APPENDIX A

LEAST BELL'S VIREO SURVEY AREAS ALONG THE SAN DIEGO RIVER, 2009

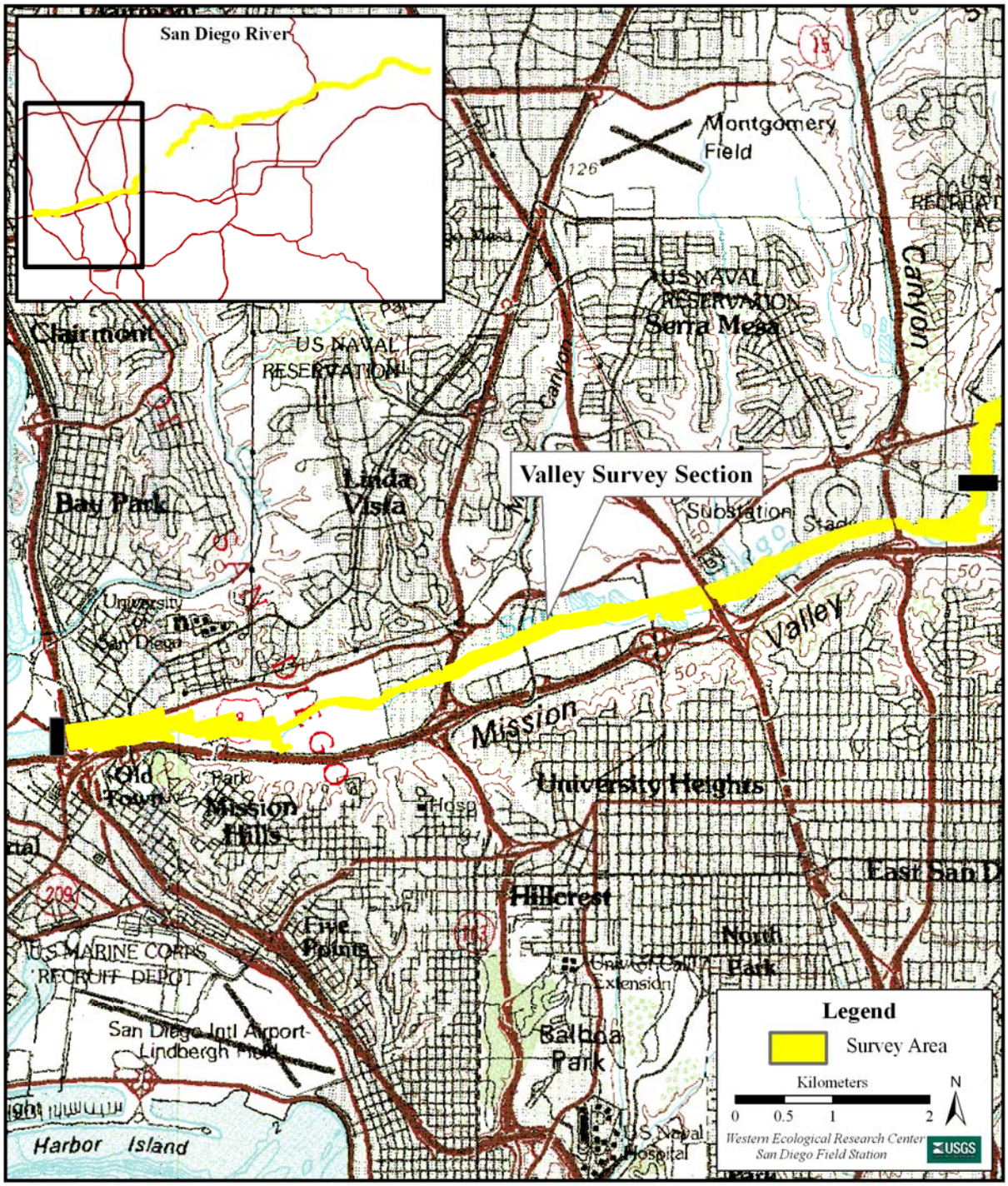

Fig. 7. Least Bell's Vireo survey areas along the San Diego River, 2009: Valley.

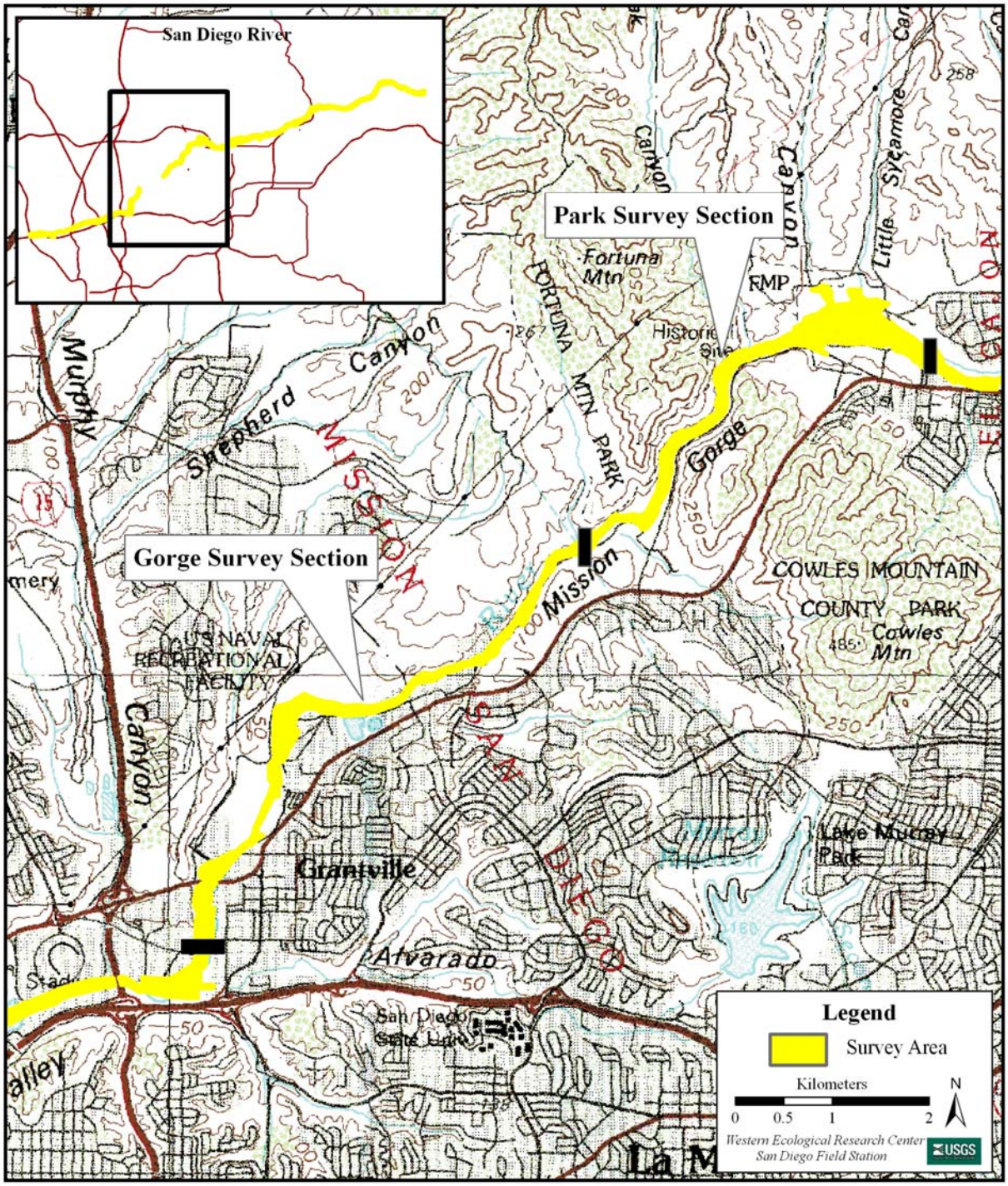

Fig. 8. Least Bell's Vireo survey areas along the San Diego River, 2009: Gorge and Park.

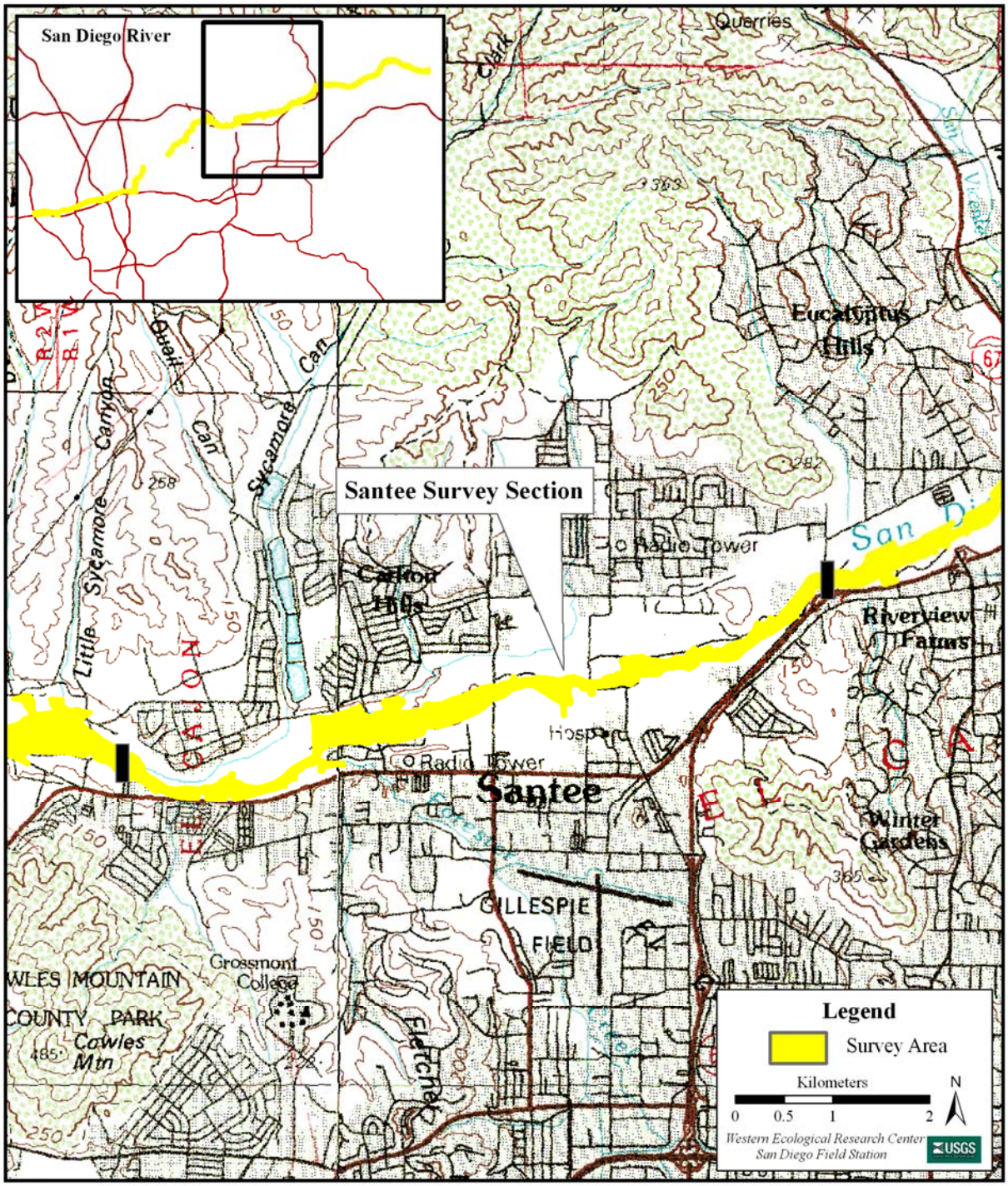

Fig. 9. Least Bell's Vireo survey areas along the San Diego River, 2009: Santee.

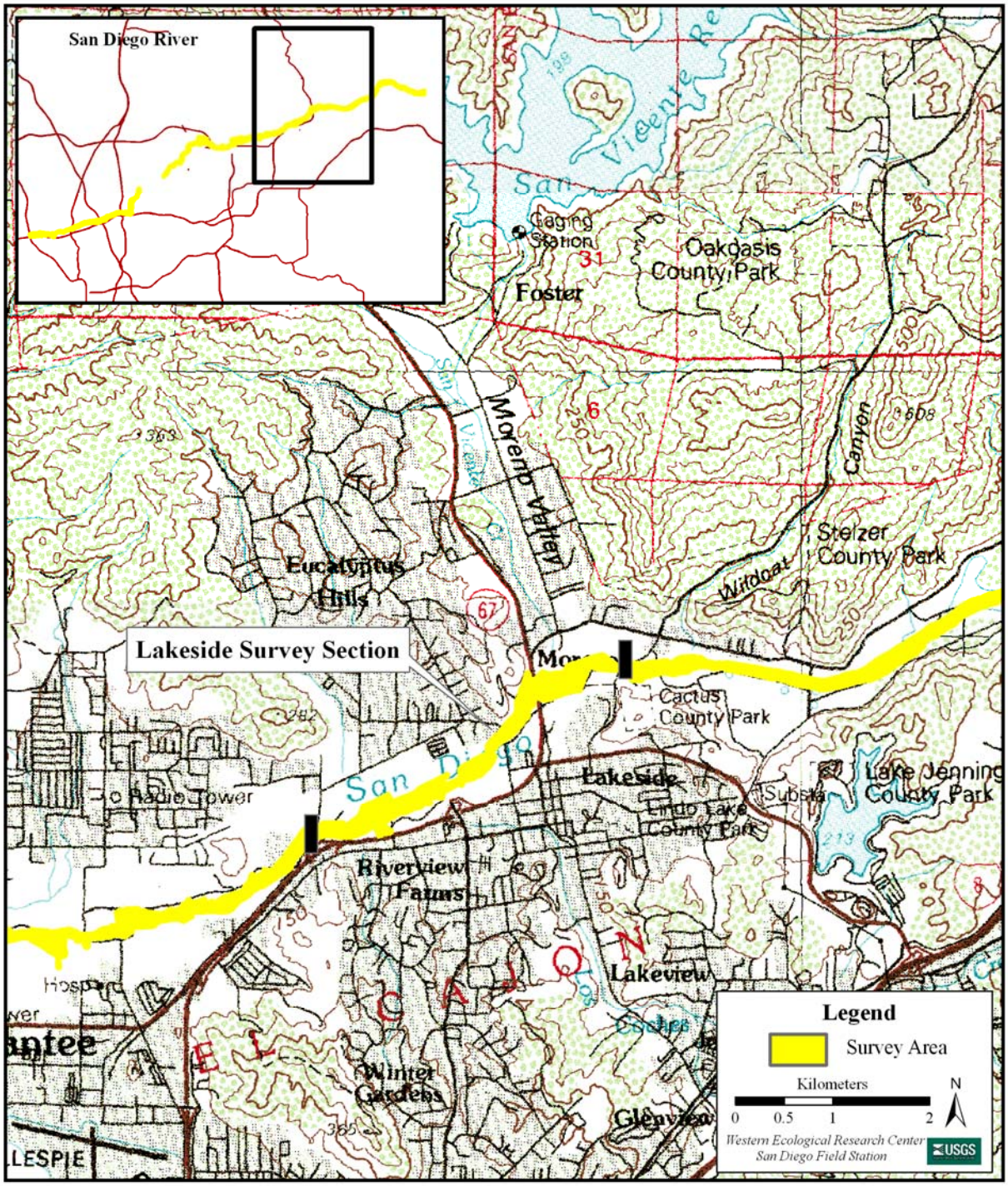

Fig. 10. Least Bell's Vireo survey areas along the San Diego River, 2009: Lakeside.

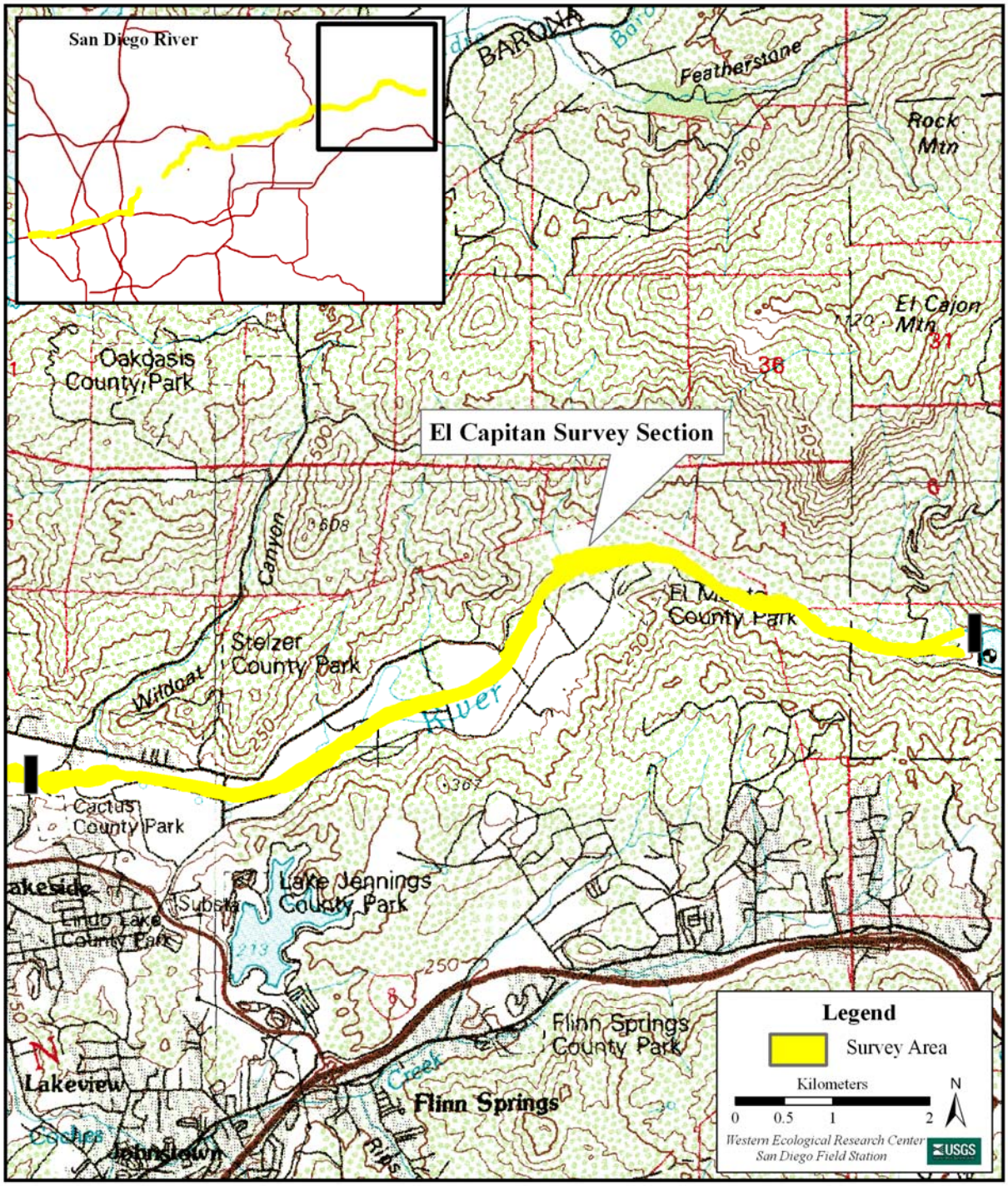

Fig. 11. Least Bell's Vireo survey areas along the San Diego River, 2009: El Capitan.

APPENDIX B

LOCATIONS OF LEAST BELL'S VIREOS ALONG THE SAN DIEGO RIVER, 2009

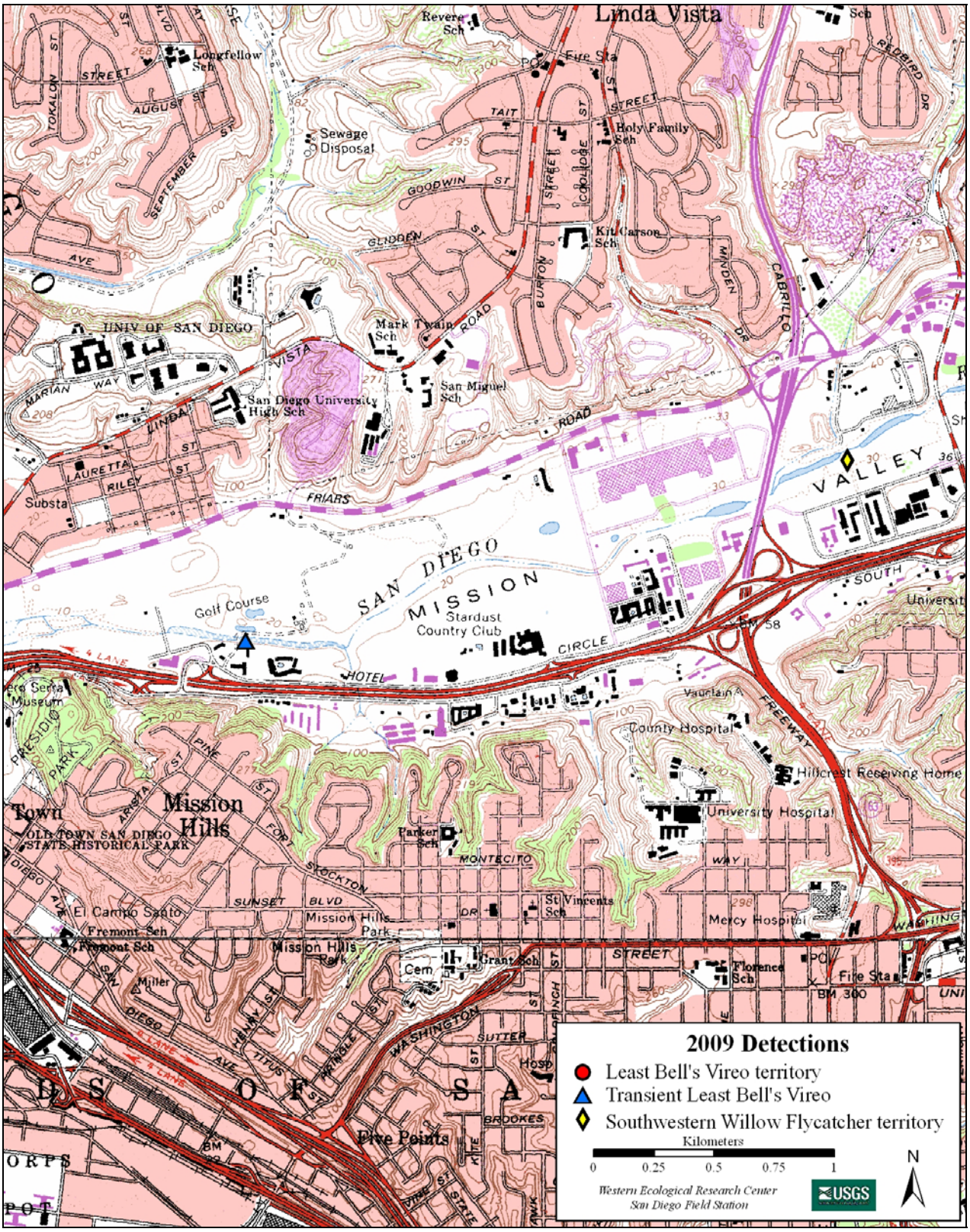

Fig. 12. Locations of Least Bell's Vireos along the San Diego River, 2009: Valley (west).

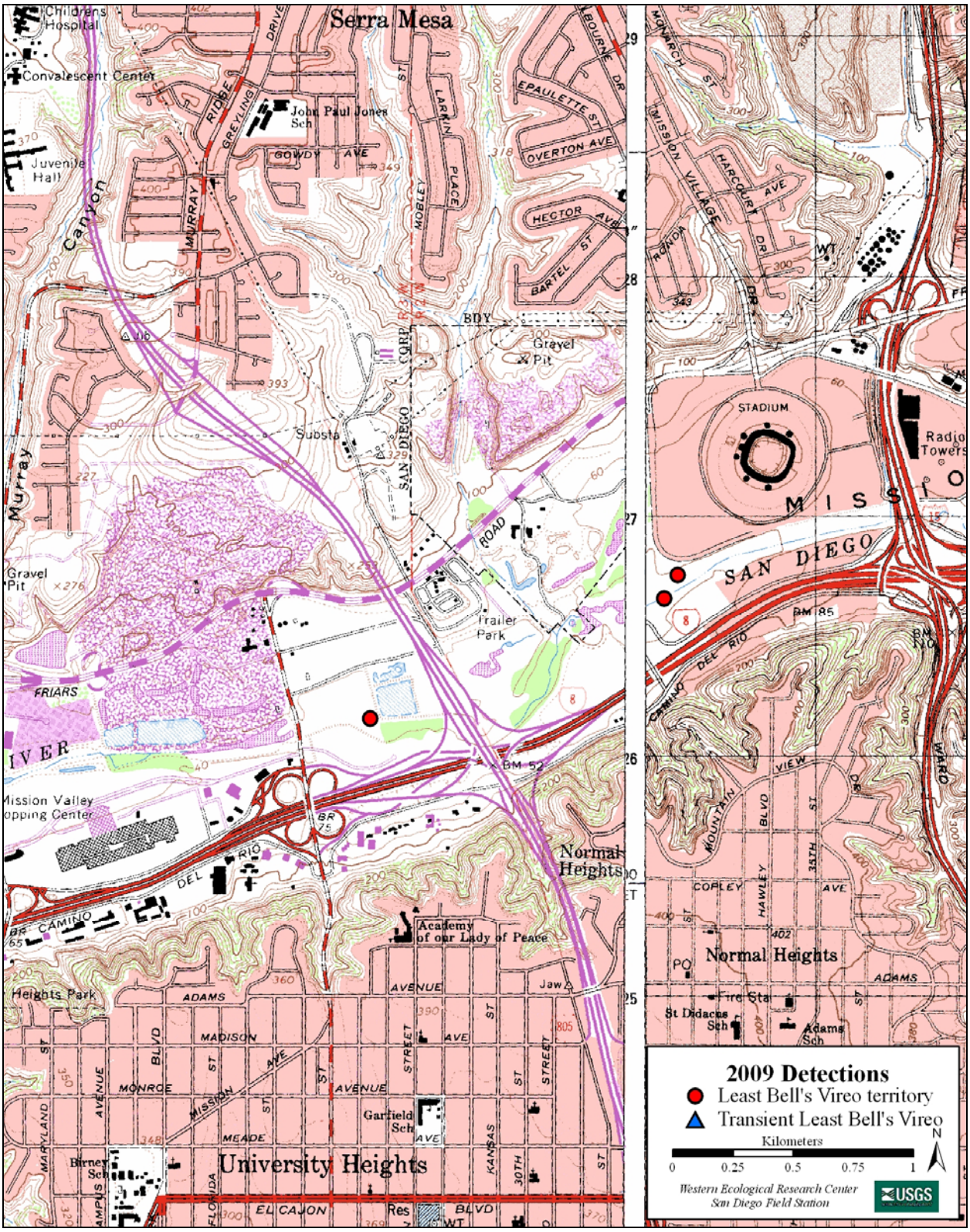

Fig. 13. Locations of Least Bell's Vireos along the San Diego River, 2009: Valley (east).

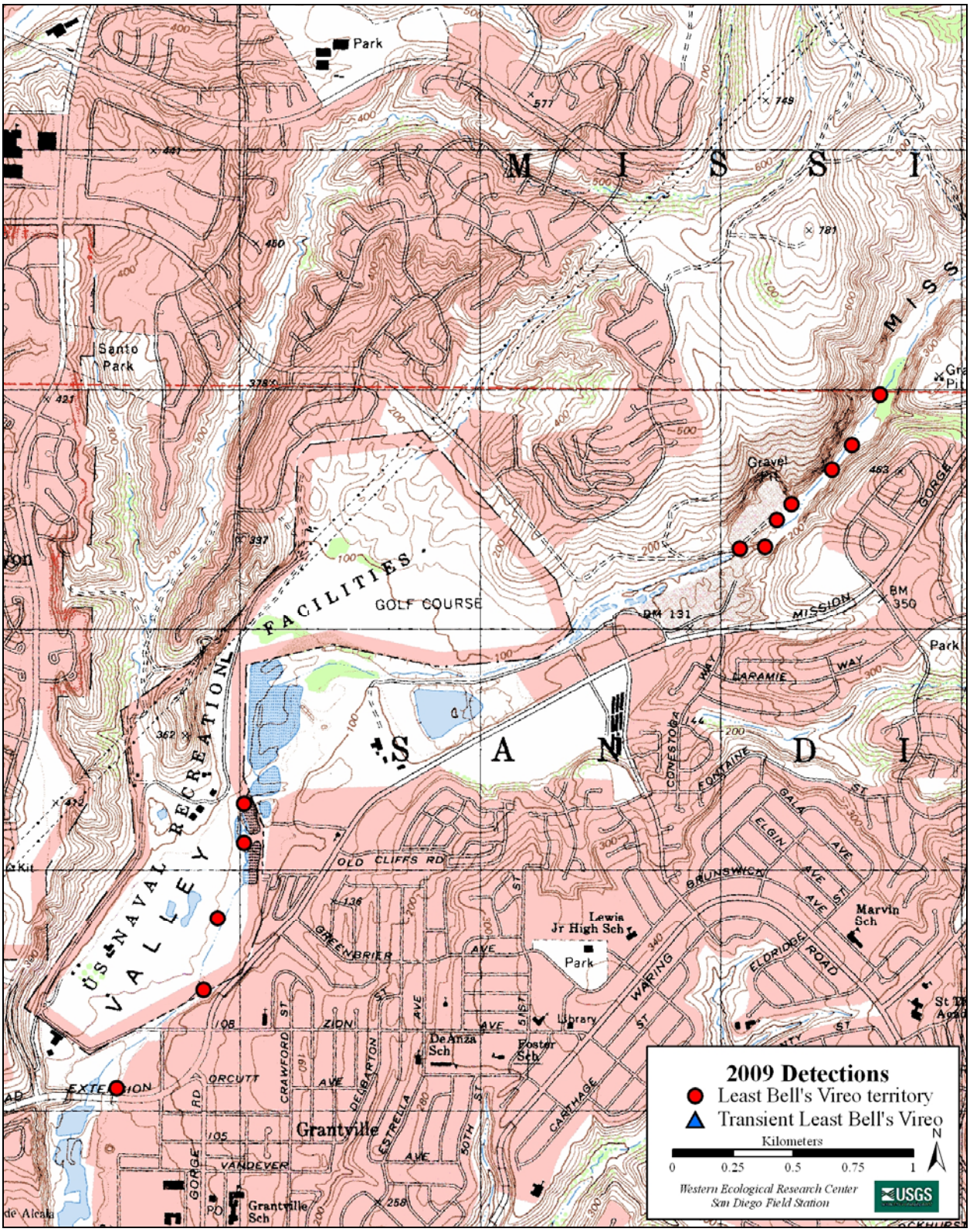

Fig. 14. Locations of Least Bell's Vireos along the San Diego River, 2009: Gorge.

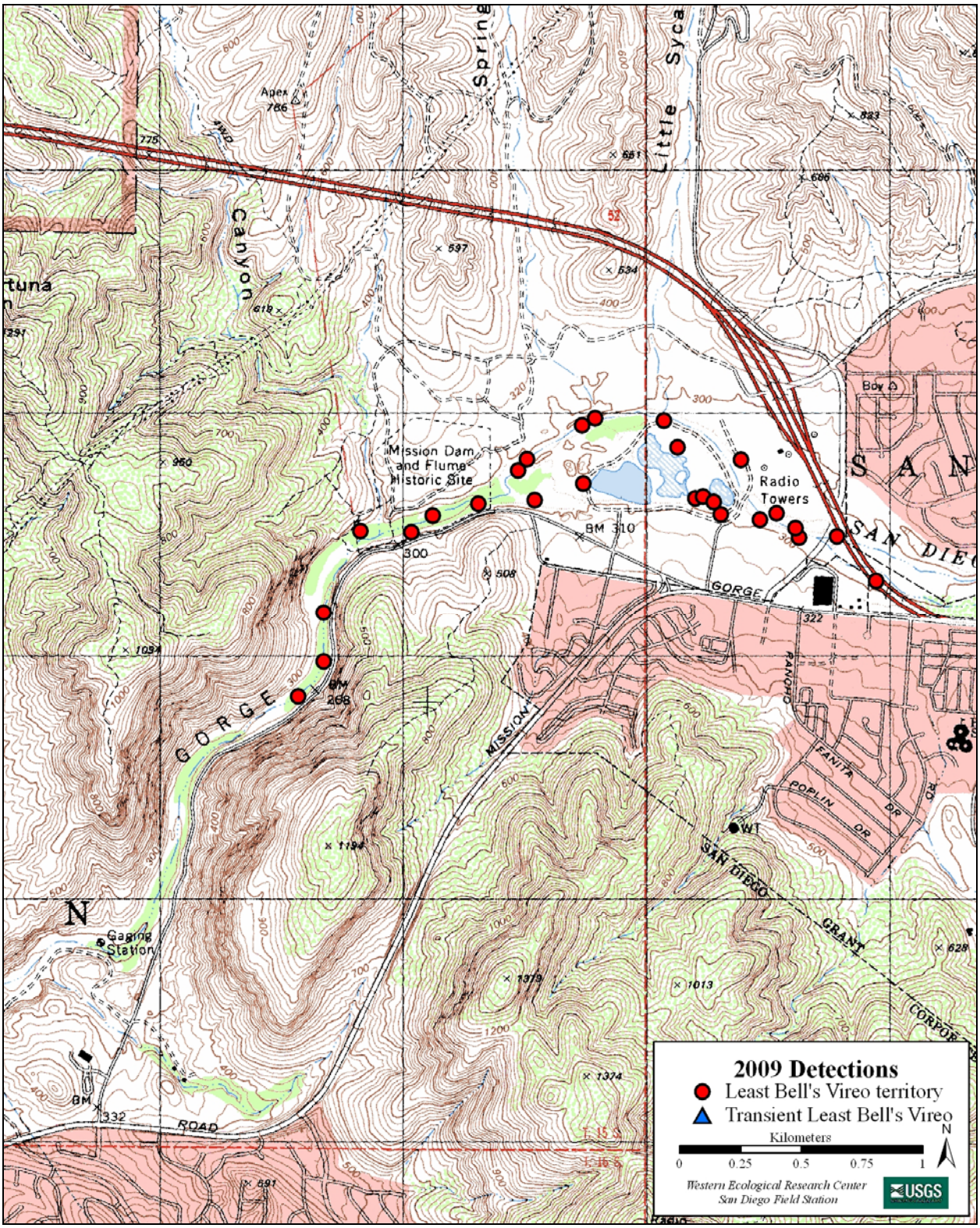

Fig. 15. Locations of Least Bell's Vireos along the San Diego River, 2009: upper Gorge and Park.

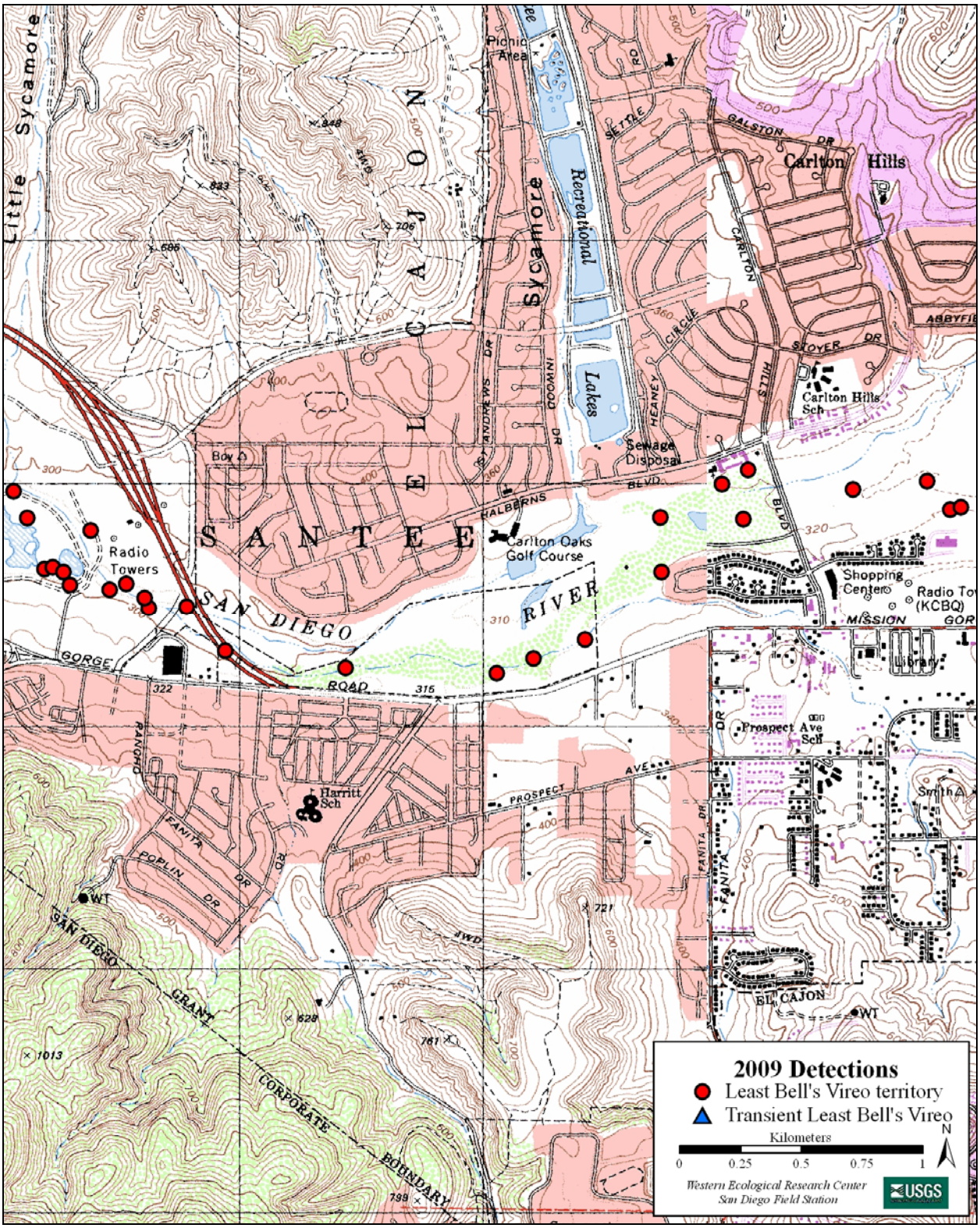

Fig. 16. Locations of Least Bell's Vireos along the San Diego River, 2009: east Park and west Santee.

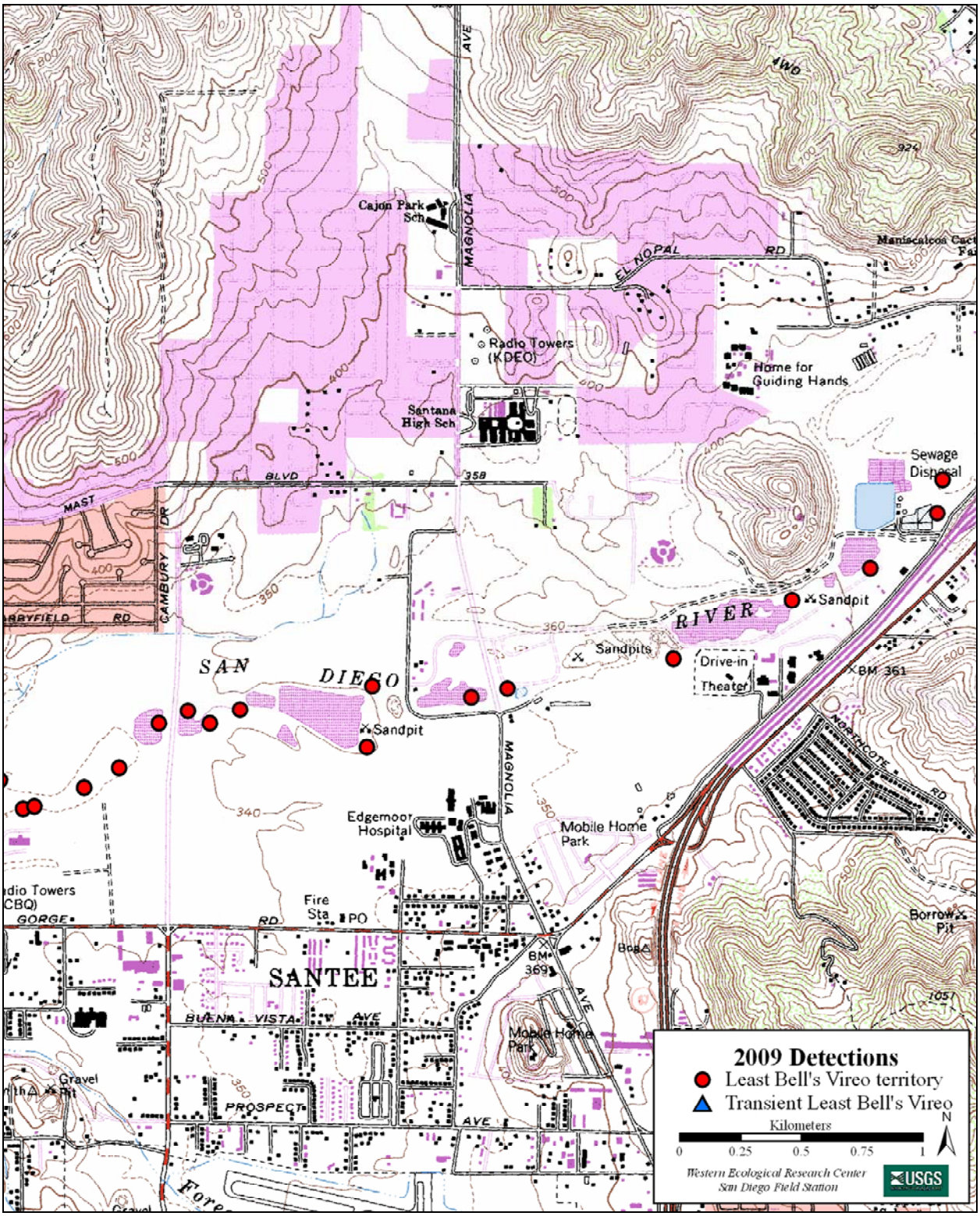

Fig. 17. Locations of Least Bell's Vireos along the San Diego River, 2009: Santee.

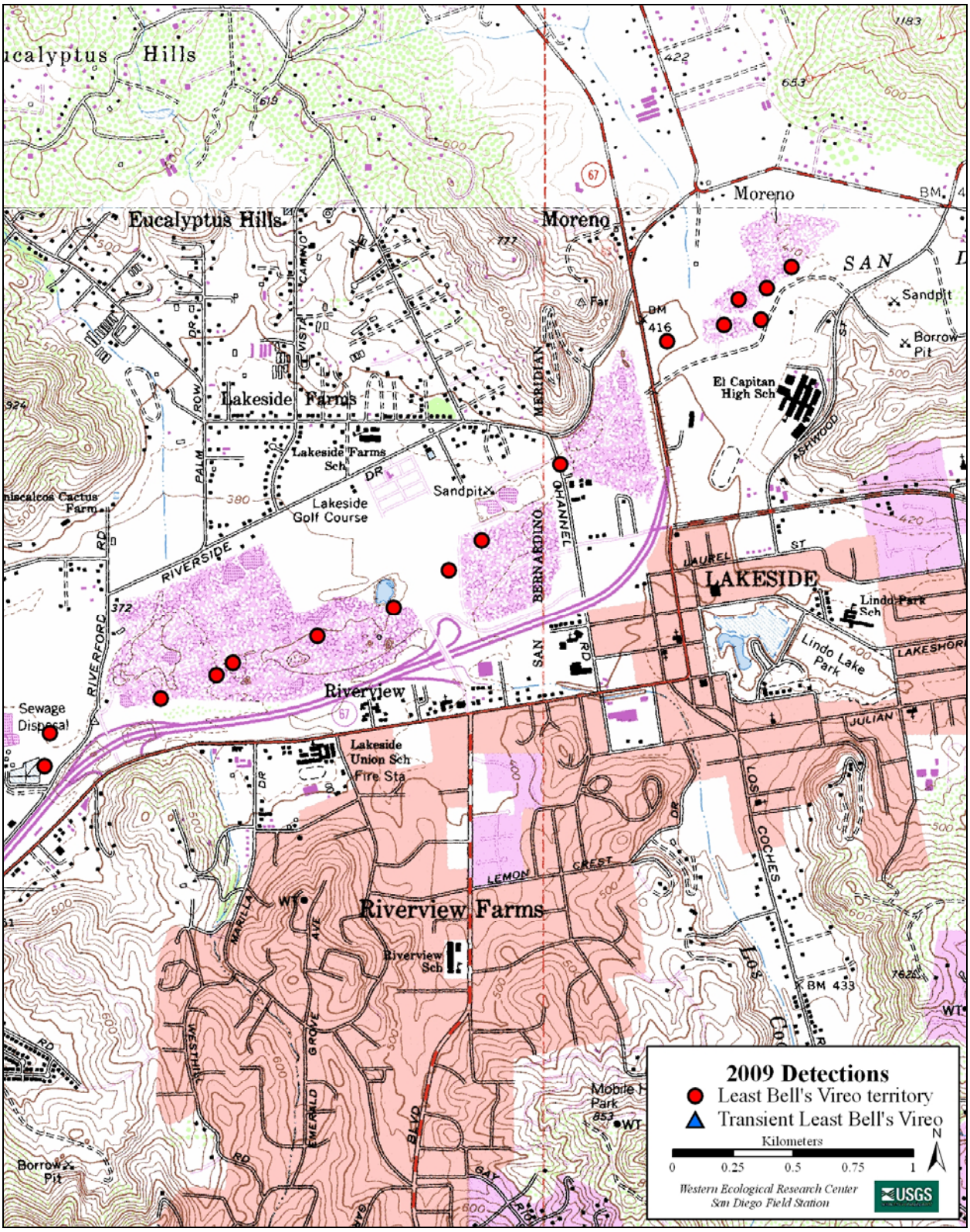

Fig. 18. Locations of Least Bell's Vireos along the San Diego River, 2009: Lakeside.

APPENDIX C

STATUS AND NESTING ACTIVITIES OF LEAST BELL'S VIREOS ALONG THE SAN DIEGO RIVER, 2009

REFERENCE SITE TERRITORIES						
Territory	**Nest**	**Monitoring[a]**	**Nest Fate[b]**	**# Cowbird Eggs**	**# Fledged**	**Comments**
ALD	1	F	PRE			
ALT	1	F	FAL			Single male with bachelor nest
SGCA	1	F	SUC		3	
SGFU	1	F	FAL			Single male with bachelor nest
SGFU	2	F	SUC	1	2	
GOL	1	F	PRE	1		
SGHO	1	F	PRE			
SGHO	2	F	PRE			
SGHO	3	F	PRE			
SGHO	4	F	PAR	2		
JOY	1	F	SUC		4	
SGMA	1	F	PAR	1		
SGMA	2	F	PAR	1		
SGMA	3	F	PAR	1		
SGMA	4	F	PAR	1		
MER	1	F	FAL			Bachelor nest, female did not help build nest.
MER	2	F	UNK			Nest support broken, may have been predator.
MER	3	F	INC			
MER	4	F	PRE	1		
POR	1	F	SUC		1	
SGSA	1	F	OTH			Nest support broken.
SGSA	2	F	FAL			Bachelor nest, female did not help build nest.
SGSA	3	F	SUC	1	1	
SPR	1	F	PRE			
WAL	1	F	UNK			Nest support broken, may have been predator.

TREATMENT SITE TERRITORIES						
Territory	**Nest**	**Monitoring[a]**	**Nest Fate[b]**	**# Cowbird Eggs**	**# Fledged**	**Comments**
BTN	1	F	INC			
BTN	2	F	UNK			Nest tilted, no nest contents observed.
BTN	3	F	UNK			Nest support broken, no sign of eggs.
BTN	4	F	PRE			
CCO	1	F	PRE			
CCO	2	F	SUC		3	
CCO	3	F	SUC		3	
EDD	1	F	PRE			
EDD	2	F	PRE			
EDD	3	F	PRE			
FJS2	1	F	SUC	1	4	
FJS2	2	F	SUC		2	

TREATMENT SITE TERRITORIES						
Territory	**Nest**	**Monitoring[a]**	**Nest Fate[b]**	**# Cowbird Eggs**	**# Fledged**	**Comments**
FRE	1	F	SUC		2	
FRE	2	F	PRE			
FNK	1	P	PRE			
HTS	1	F	SUC		4	
SGMD	1	F	OTH	1		Eggs did not hatch, probably infertile.
SGMD	2	F	PRE			
SGMD	3	F	PRE			
SGMD	4	F	PAR	1		
SGPN	1	F	FAL			Bachelor nest, female did not help build nest.
SGPN	2	F	INC			
SGPN	3	F	PAR	1		
SGPN	4	F	OTH			Nest support broken.
SGPN	5	F	PRE			
SGPN	6	F	SUC		3	
SGPP	1	P	SUC		3	
SGSO	1	F	SUC	1	2	
SGTS	1	F	UNK			Failed between eggs and nestlings.
SGTS	2	F	PRE			
SGTS	3	F	SUC		2	
WMB1	1	F	PRE			
WMB1[c]	2	F	PRE			
WMB2	1	F	UNK			Abandoned with 2 eggs.
WMB2	2	F	PRE			
WMB2	3	F	PRE			
WMB2	4	F	PRE			

[a] Monitoring: F = fully monitored territory; P = partially monitored territory.

[b] Nest Fate: INC = nest never completed; SUC = fledged at least one Least Bell's Vireo young; PRE = nest failure caused by predation; PAR = nest failure caused by Brown-headed Cowbird parasitism; OTH = reason for nest failure known, such as substrate failure; UNK = reason for nest failure/abandonment unknown.

[c] Same male nested at a different territory for his second nest.