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

2008 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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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

(Continued)

LIST OF APPENDICES

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. Fifty-nine territorial male vireos were detected, 43 of which were confirmed as paired. Nine transient vireos were also detected.

Most (98%) vireo territories occurred in four of six sections surveyed: Santee (34%), Park (31%), Lakeside (19%), and Gorge (15%). The Valley and El Capitan survey sections contained one or no territories. The number of territorial least Bell's vireos detected in 2008 was similar to the number detected in 1997 and approximately double the number detected in 1987. The distribution of vireos in 2008 shifted relative to that in previous years: more vireos were detected in the Park and Lakeside survey sections and fewer vireos were detected in the Valley, Gorge, Santee, and El Capitan survey sections than in 1997.

The majority of vireo territories occurred in habitat characterized as mixed willow (*Salix* spp.) riparian, with 68% of males in the study area found in this habitat. The remaining 32% of males occupied willow habitat co-dominated by cottonwoods (*Populus fremontii*). Only one territory was dominated by exotic vegetation (salt-cedar; *Tamarix ramosissima*).

A total of 74 least Bell's vireos were banded during the 2008 season. These included 21 adult vireos and 53 nestlings that were banded for the first time in 2008. The 21 adult vireos were banded with unique color combinations. The nestlings were banded with a single light blue numbered federal band (49 on the left leg and four on the right leg). Three other vireos that had been banded prior to 2008 were resighted along the San Diego River in 2008. One was banded as an adult in 2006 near its 2008 territory. Two others were banded as nestlings in 2007, one on the Santa Margarita River on Marine Corps Base Camp Pendleton and one on the Sweetwater River. These two birds moved 39.0 $\pm$ 32.5 km from their natal sites to their 2008 breeding territories.

Nesting activity was monitored in 30 territories within two Treatment sites (one giant reed (*Arundo donax*) removal site and one cowbird control site) and two Reference sites. Treatments had not occurred by the 2008 breeding season, so these results represent a pre-treatment baseline. A total of 68 nests were monitored during the breeding season; however, three 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 68% of pairs attempted at least two nests in 2008. Five pairs successfully fledged two broods in 2008.

Parasitism by brown-headed cowbirds (*Molothrus ater*) occurred in the Gorge, Park, and Santee sites, but not in the Valley site. The rate of cowbird parasitism did not differ between the three parasitized sites. Cowbird parasitism did not occur until the middle of April, after which an average of 52% of nests were parasitized per two-week interval, peaking in late May at 88%. Seventeen percent of parasitized nests contained two cowbird eggs. Seventeen percent of nests failed as a result of cowbird parasitism, while three parasitized nests successfully fledged a total of six young after removal of cowbird eggs by nest monitors.

Nest success was highest at the Valley site, where the only pair successfully fledged young from two nests. Nest success at the Park site (cowbird control Treatment) was significantly higher than its paired Reference site (Santee). Seventy-two percent of nests were not successful. Predation was believed to be the primary source of nest failure at all sites, accounting for 45% of nest failures. Other causes of nest failure included human disturbance, host plant collapse/structural instability, 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 varied between sites and was highest at the Valley site, followed by the Park site.

In 2008, successful and unsuccessful nests within Treatment and Reference sites did not differ statistically in nest placement characteristics. Nests at Reference sites were placed closer to the edge of riparian vegetation than nests at Treatment sites. A total of 13 plants (14 species and one "dead" category, which included all dead woody species) were used as hosts for vireo nests in 2008. Sixty-two percent of Treatment nests and 87% 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 least Bell's vireos arrive on breeding grounds in southern California in mid-March. Male vireos are conspicuous, and frequently sing their diagnostic primary song from exposed perches throughout the breeding season. 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 vireo 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, and (3) collect baseline data to assess the short-term effects of habitat restoration and 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 Brent Campos, Aaron Gallagher, Scarlett Howell, and Michael Wellik. Approximately 3 km of river, on Superior Ready Mix property, was not accessible for surveys. Data from this section were collected by RECON Environmental and is incorporated herein. 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. 8).

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. 9).

3. ***Park:*** From Jackson Drive upstream 5.1 km to West Hills Parkway (Fig. 1; Appendix A, Fig. 9).

4. ***Santee:*** From West Hills Parkway upstream 8.1 km to Riverford Road (Fig. 1; Appendix A, Fig. 10).

5. ***Lakeside:*** From Riverford Road upstream 3.9 km to Ashwood Street (Fig. 1; Appendix A, Fig. 11).

6. ***El Capitan:*** From Ashwood Street upstream 11.1 km to the dam at El Capitan Reservoir (Fig. 1; Appendix A, Fig. 12).

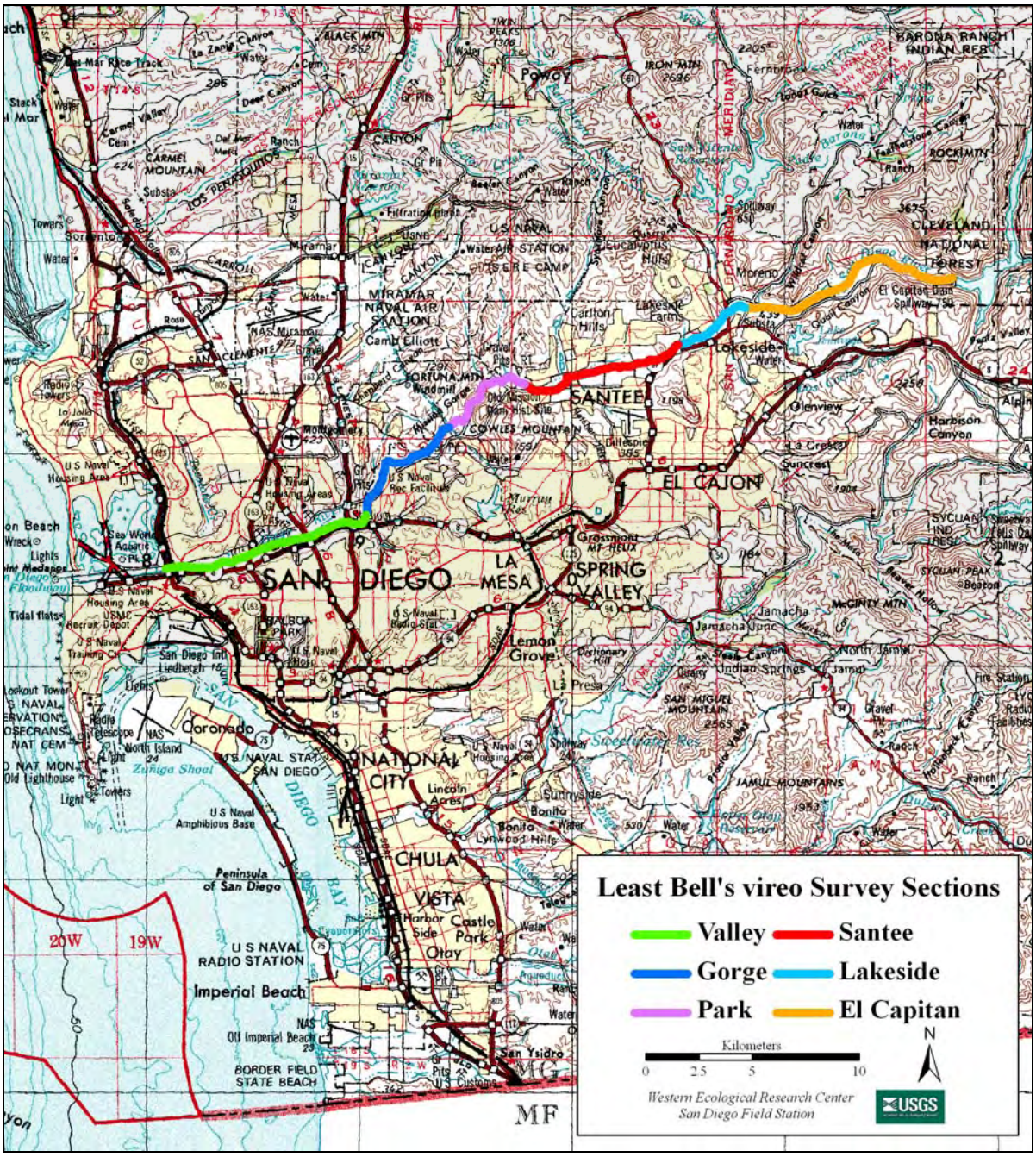

Fig. 1. Least Bell's vireo survey sections along the San Diego River, 2008.

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. 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.

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. No cowbird trapping occurred in 2008.

We monitored vireos within four areas: two sites in which management actions will occur (hereafter referred to as "Treatment" sites) and two sites in areas where no additional management action will occur (hereafter referred to as "Reference" sites; Fig. 2). Each Treatment site was paired with a similar Reference site: Valley Treatment with Gorge Reference and Park Treatment with Santee Reference. We attempted to document nesting activity for 10 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. At sites where fewer than 10 vireo territories occurred, we monitored as many pairs as possible to obtain the maximum sample size.

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 left (or, rarely, right) 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.

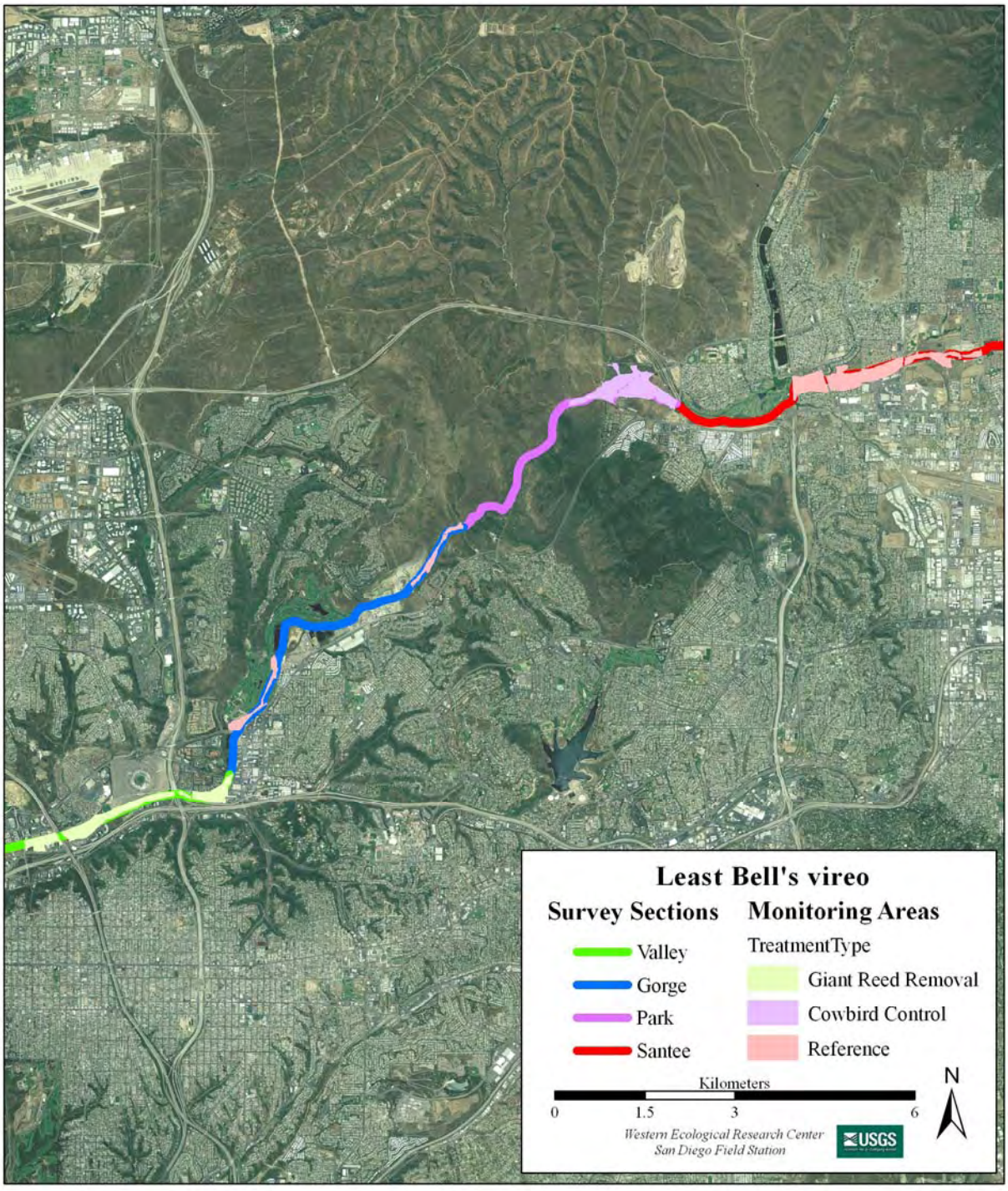

Fig. 2. Location of least Bell's vireo nest monitoring areas along the San Diego River, 2008.

Data Analyses

Although the planned management actions have not yet occurred, we summarized the monitoring sites separately to provide baseline numbers for comparison with subsequent years, after management actions have begun. For sites with a sufficient number of samples, we compared nesting parameters between all monitoring sites. If differences occurred between monitoring sites, we compared each Treatment site with its paired Reference site to determine where the differences lay. Because only one pair was detected in the Valley Treatment site, comparisons between that site and the Gorge Reference site were descriptive rather than statistical. We also present data summed across all monitoring sites to provide an overall estimation of nesting parameters for the San Diego River.

We conducted statistical tests to determine whether there were differences in vireo nest success, productivity, or vegetation characteristics between monitoring sites. We used the nonparametric Kruskal-Wallis test 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. When differences were found, we used Mann-Whitney *U*-tests to determine if there were differences between paired Treatment and Reference sites. 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 to test for differences in cowbird parasitism rate and nest fate between monitoring sites. 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

Seventy-two least Bell's vireo sites were identified during surveys (Table 1, Appendix B, Figs. 13-18). This included 63 territorial male vireos, 68% of which were confirmed as paired, and nine transients. Transient vireos were observed at four of the six (67%) sections surveyed. Ninety-eight percent of all vireo territories occurred in four survey sections (32% in Santee, 29% in Park, 21% in Gorge, and 17% in Lakeside; Table 1). One or no territories occurred in the Valley and El Capitan survey sections.

Table 1. Number and distribution of least Bell's vireos along the San Diego River, 2008.

Survey Section	Known Pairs	Single/ Status Undetermined	Transient	Total Territories
Valley	1	0	0	1
Gorge	6	7[a]	1	13
Park	15	3	5	18
Santee	17	3	2	20
Lakeside	4	7	1	11
El Capitan	0	0	0	0
Total	43	20[a]	9	63

[a] Includes four territories detected by RECON Environmental.

Habitat Characteristics

Vireos occupied two habitat types along the San Diego River (Table 2). The majority of vireo territories occurred in habitat characterized as mixed willow riparian, with 68% of males in the study area found in this habitat. The remaining 32% of males occupied willow habitat co-dominated by cottonwoods. Only one vireo territory contained a large proportion of exotic vegetation. This territory was dominated by salt-cedar.

Table 2. Habitat types used by least Bell's vireos along the San Diego River, 2008.

	Number of Territories			
Habitat Type	>50% Native	>50% Exotic	Total	Percent of Total
Mixed Willow	39	1	40	68%
Willow/Cottonwood	19	0	19	32%
Total	58	1	59[a]	100%

[a] Excludes four territories detected by RECON Environmental for which habitat data were not collected.

Banded Birds

Three least Bell's vireos banded prior to the 2008 breeding season were resighted along the San Diego River in 2008 (Table 3). 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.). The second vireo was banded as a nestling on the Sweetwater River in 2007 (Famolaro 2008) and dispersed 16 km to its 2008 breeding territory. The third vireo was banded as a nestling on the Santa Margarita River on Marine Corps Base Camp Pendleton in 2006 (Rourke and Kus 2007) and dispersed 62 km to its 2008 breeding territory. None of these three vireos had been resighted between their original banding and the 2008 resightings.

A total of 74 vireos were banded during the 2008 season. Twenty-one unbanded adult vireos were captured at their breeding territories in 2008 and given full band combinations (Table 3). Fifty-three nestlings were banded, 49 with a single light blue metal numbered federal band on the left leg and four with a single light blue metal numbered federal band on the right leg.

Table 3. Adult least Bell's vireos banded or seen along the San Diego River in 2008.

Year Last Detected	Territory / Survey Section in 2008	Band Combination[a] Left Leg	Band Combination[a] Right Leg	Age in 2008[b]	Sex[c]	Comments[d]
2006	SIG / Lakeside	-	Msi	ATY	M	Banded as an adult in 2006 at Lakeside River Conservancy.
2007	SGBT / Park	gogo	Mdg	SY	F	Banded as a nestling in 2007 on the Sweetwater River.
2006	SGMA / Santee	PUOR/Mgo	-	TY	F	Banded as a nestling in 2007 at Camp Pendleton.
2008	SGMA / Santee	WHWH/Mlb	-	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGHO / Santee	PUWH/Mlb	-	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGBT / Park	DPDP/Mlb	-	AHY	M	Banded as adult in 2008 on the SDR.
2008	WMB2 / Park	DPWH/Mlb	-	AHY	M	Banded as adult in 2008 on the SDR.
2008	WMB1 / Park	PUPU/Mlb	-	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGTS / Park	BKBK/Mlb	pupu	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGCH / Santee	-	BKBK/Mlb	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGFU / Santee	pupu	WHWH/Mlb	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGSA / Santee	PUPU/pupu	Mlb	AHY	F	Banded as adult in 2008 on the SDR.
2008	SGSA / Santee	Mlb	BYST/pupu	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGCA / Santee	WHDP/Mlb	pupu	AHY	M	Banded as adult in 2008 on the SDR.
2008	HTS / Park	-	YEPU/Mlb	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGPN / Park	-	PUPU/Mlb	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGBG / Gorge	-	LPBK/Mlb	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGGA / Park	BYST/Mlb	pupu	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGGR / Valley	pupu	PUPU/Mlb	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGBI / Gorge	LPBK/pupu	Mlb	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGPP / Park	Mlb	BKBK/pupu	AHY	M	Banded as adult in 2008 on the SDR.
2008	SGSO / Park	pupu	DPDP/Mlb	AHY	M	Banded as adult in 2008 on the SDR.
2008	MER / Santee	LPLP/Mlb	-	ASY	F	Banded as adult in 2008 on the SDR.
2008	MER / Santee	PUWH/pupu	Mlb	AHY	M	Banded as adult in 2008 on the SDR.

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

[b] Age: AHY = after hatch-year; ASY = after second-year; ATY = after third-year; SY = second-year; TY = third-year.

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

[d] SDR = San Diego River.

Nest Monitoring

Nesting activity was documented in a total of 29 territories within the Treatment and Reference monitoring sites (Table 4; Figs. 3-6; 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"). One additional territory, on the Lakeside River Conservancy property, was monitored incidentally outside of the Treatment and Reference areas (Appendix B, Fig. 18) and was included only in the total summary calculations. A total of 68 nests were monitored during the breeding season; however, 3 of these were not completed (coded as "INC" in Appendix C) and have been excluded from calculations of nest success and productivity. Of the remaining 65 nests, 62 were in fully monitored territories.

Table 4. Number of least Bell's vireo territories and nests monitored at Treatment and Reference sites on the San Diego River, 2008. Averages presented as mean ± standard deviation.

	Nest Monitoring Site/Type				
	Valley (*A. donax* removal)	**Gorge** (Reference)	**Park** (Cowbird Control)	**Santee** (Reference)	**Total**
Territories fully monitored	1	4	10	12	28[a]
Nests in fully monitored territories	2	11	24	24	65[a]
Completed nests per pair (fully monitored territories)	2.0 ± 0.0	2.3 ± 0.5	2.3 ± 1.3	1.9 ± 1.2	2.1 ± 1.1
Territories partially monitored	0	1	0	2	3
Nests in partially monitored territories	0	1	0	2	3
Total # of nests monitored	2	12	24	26	68[a]

[a] Includes an additional fully monitored territory (four nests) outside the Treatment and Reference sites

Fig. 3. Locations of monitored least Bell's vireo territories at the Valley giant reed (*Arundo donax*) removal site, San Diego River, 2008.

Fig. 4a. Locations of monitored least Bell's vireo territories at the Gorge reference site (lower section), San Diego River, 2008.

Fig. 4b. Locations of monitored least Bell's vireo territories at the Gorge reference site (upper section), San Diego River, 2008

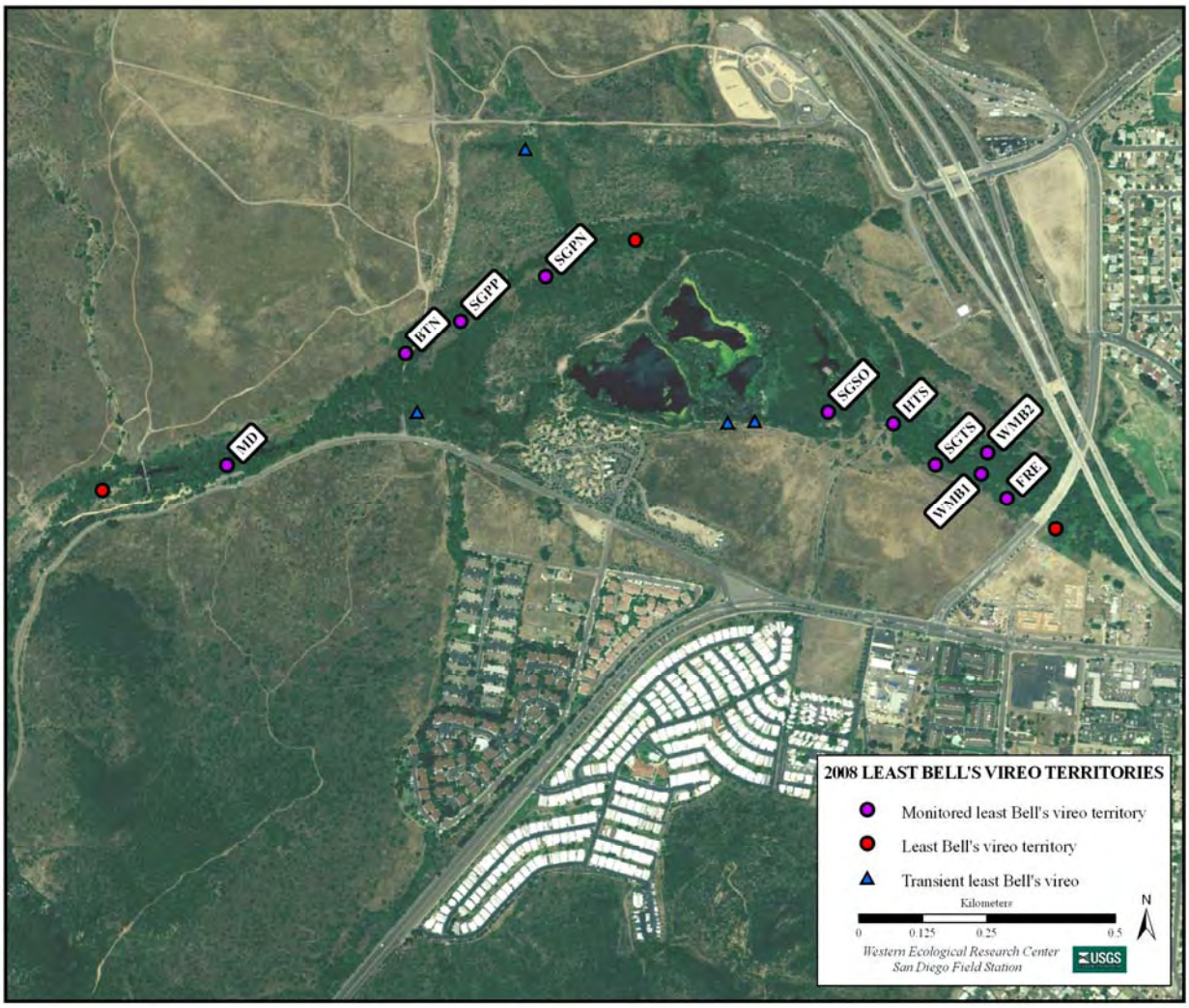

Fig. 5. Locations of monitored least Bell's vireo territories at the Park brown-headed cowbird (*Molothrus ater*) removal site, San Diego River, 2008.

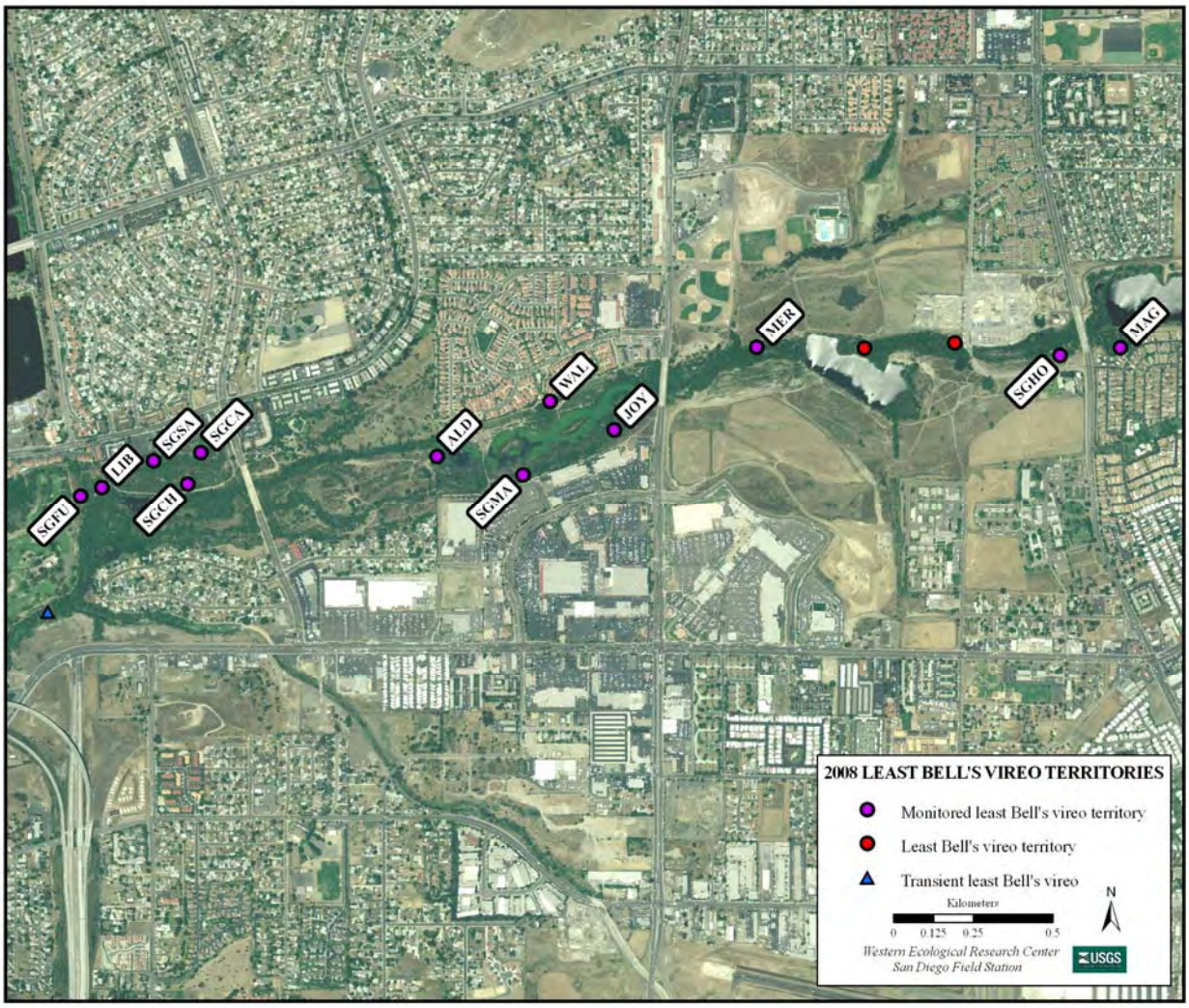

Fig. 6. Locations of monitored least Bell's vireo territories at the Santee reference site, San Diego River, 2008.

Nest Initiation

Nesting activity started in early April and continued until the end of June (Fig. 7). Seventy-eight percent (21/27) of the pairs had attempted nesting by the end of April, and 89% (24/27) by the end of May. Three pairs did not initiate nesting until June.

Every fully monitored pair initiated at least one nest in 2008, and 19 (68%) re-nested after first attempts. Eight pairs (42%) re-nested after a successful first nest, while 11 pairs (61%) initiated a second nest after a failed first attempt. Six pairs (32%) had successful second nests (four after successful first attempts and two after failed first attempts). Eight pairs initiated a third nesting attempt, only one of which was successful. Five pairs attempted a fourth nest, one of which was successful, and one pair attempted to nest six times, all of which failed. Within fully monitored territories, there was no difference in the number of completed nests among the four monitoring sites (Kruskal-Wallis statistic = 1.35, $P > 0.71$, df = 3; Table 4).

Cowbird Parasitism

Fifty-two percent (34/65 completed nests) of vireo nests were parasitized by cowbirds in 2008. Parasitism of vireo nests occurred in three of the four monitoring sites in 2008 (Fig. 7). The Valley site was not parasitized. There was no difference in the number of nests parasitized at fully monitored territories between the other three sites (Gorge = 5 [50%], Park = 9 [38%], Santee = 14 [61%]; $\chi^2 = 2.57$, $P = 0.28$, df = 2). Parasitism was not observed until the second half of April (17 April), after which parasitism rate averaged 52% of nests initiated per two week interval of the breeding season (Fig. 7). Nest parasitism was highest in May, peaking at 88% in the last two weeks of the month. At the three monitoring sites that experienced parasitism, one nest at each failed with punctured eggs; potentially punctured by cowbirds.

Sixteen percent (5/31) of parasitized nests in the monitoring sites were parasitized twice (contained two cowbird eggs). At the one fully monitored territory on the Lakeside River Conservancy property, all three completed nests were parasitized twice. No monitored nests contained cowbird nestlings or fledged cowbird young. Cowbird parasitism events were documented twice outside of the nest monitoring study during surveys, both occurring in the Park site. One nest was found with a cowbird egg, and an adult vireo at a different territory was seen feeding a cowbird fledgling. A total of 42 cowbird eggs were removed from nests found during monitoring and surveying.

Parasitism was responsible for the failure of 17% (8/34) of nests; however, not all instances of parasitism resulted in nest failure (Table 5). Seventy-six percent of the nests along the river (Gorge 83%, Park 89%, and Santee 63%) 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 11% (6/54; see below) of all young fledged along the river (Gorge 0% [0/5], Park 16% [5/31], and Santee 14% [1/7]).

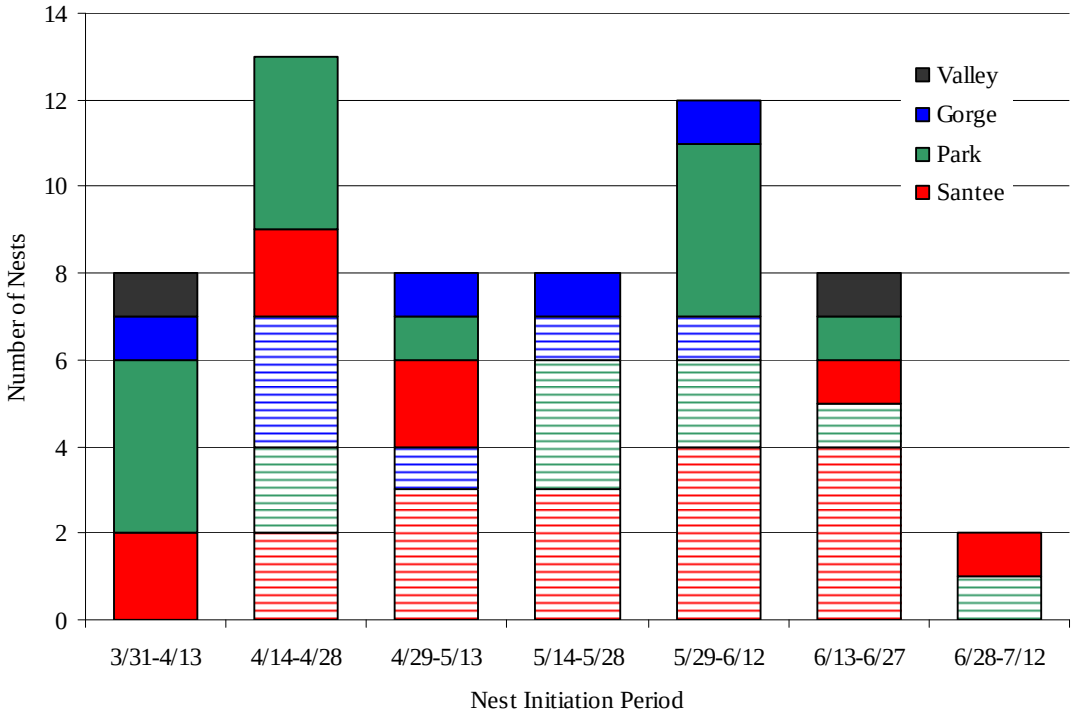

Fig. 7. Number of least Bell's vireo nests and those that were parasitized by brown-headed cowbirds by two-week intervals, San Diego River, 2008. Parasitized nests represented by horizontal hatching.

Table 5. Number and fate of least Bell's vireo nests parasitized by brown-headed cowbirds in fully and partially monitored territories, San Diego River, 2008.

	Valley	Gorge	Park	Santee	Total
Nests Parasitized	0	6	9	16	34[a]
Pairs Parasitized	0	3	4	14	22[a]
Total Cowbird Eggs Laid	0	7	9	20	42[a]
Fate of Nests:					
Abandoned		1	1	6	8
Not abandoned					
Successful		0	2	1	3
Unsuccessful		5	6	9	23[a]

[a] Includes an additional fully monitored territory (three nests) outside the Treatment and Reference sites.

Fate of Nests

Twenty-eight percent of the completed nests along the San Diego River were successful, producing at least one vireo fledgling (Table 6). Three 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 2008 would have been just 23%. The Valley site, with a single territory, had the highest success rate, fledging two nests (100%). Nest success differed significantly by site ($\chi^2 = 7.66$, $P = 0.02$, df = 2). The Park site had the second highest rate (46%), significantly higher than its paired Reference site (Santee = 12%; $\chi^2 = 6.87$, $P = 0.01$, df = 1). Counting all parasitized nests as failed, nest success would still differ significantly by monitoring site ($\chi^2 = 6.38$, $P = 0.04$, df = 2), with the Park site having significantly higher nest success than Santee ($\chi^2 = 6.12$, $P = 0.01$, df = 1).

Seventy-two percent of nests observed were unsuccessful in fledging vireo young (Table 6). 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. A western scrub-jay (*Aphelocoma coerulescens*) was seen depredating a nest with nestlings in the Park site. 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). Not all successful nests were unaffected by predation: seven successful nests were partially depredated (Valley: 1, Gorge: 1, Park: 3, and Santee: 2). Argentine ants depredated a nestling in a nest in the Valley site that eventually fledged three vireo young.

Nest failures were not limited to predation and parasitism. In the Gorge site, one nest appeared to have been knocked down by human activity along a golf course. In the Park site, one nest failed after the host plant, tree tobacco (*Nicotiana glauca*), collapsed. On the Lakeside Conservancy property, a nest containing a single vireo egg and a cowbird egg was found hanging on its side with a broken support. Three additional nests failed between nest-building and egg-laying, two of which were torn or suffered other structural damage. One nest failed as a result of unknown causes.

Table 6. Fate of least Bell's vireo nests in fully and partially monitored territories, San Diego River, 2008. Numbers in parentheses are proportion of total nests.

	Number of Nests				
Nest Fate	**Valley** (*A. donax* removal)	**Gorge** (Reference)	**Park** (Cowbird Control)	**Santee** (Reference)	**Total**
Successful	2 (1.00)	2 (0.18)	11 (0.46)	3 (0.12)	18 (0.28)
Failed					
Predation	0 (0.00)	5 (0.45)	9 (0.38)	14 (0.56)	29[a] (0.45)
Parasitism	0 (0.00)	1 (0.09)	1 (0.04)	6 (0.24)	8 (0.12)
Other/Unknown	0 (0.00)	3 (0.27)	3 (0.13)	2 (0.08)	10[b] (0.15)
Total Completed Nests	2	11	24	25	65[a,b] (1.00)

[a] Includes one nest from an additional fully monitored territory outside the Treatment and Reference sites.
[b] Includes two nests from an additional fully monitored territory outside the Treatment and Reference sites.

Productivity

Reproductive indices for least Bell's vireos nesting in different monitoring sites were varied. Average clutch size was relatively high and did not differ across sites for non-parasitized

nests or for parasitized nests (Table 7). Hatching success averaged 50% for vireo eggs and nests. We documented at least 50 fledglings in 2008, most of which came from nests in the Park site. The total number of fledglings in 2008 would be reduced by six if parasitized nests had been allowed to fail. Five fully monitored pairs successfully double brooded, fledging young from two nests. The number of fledglings per pair varied widely and significantly (0.5-7), and averaged fewer than two per pair across all nests (Table 7). This difference was no longer significant when we assumed nests that had been parasitized would have failed.

Nest Characteristics

In 2008, successful and unsuccessful nests within monitoring sites had similar nest placement characteristics. However, at the Gorge site, successful nests were placed significantly higher than unsuccessful nests, and at the Santee site, successful nests were placed significantly closer to the edge of the host plant than unsuccessful nests (Table 8; this difference did not change when parasitized nests were considered to be unsuccessful). Average host plant height and the average distance to the edge of riparian differed between monitoring sites (Table 9). On average, host plants were taller at the Santee site. Nests were placed significantly furthest from the edge of the riparian vegetation at the Park site.

Table 7. Reproductive success and productivity of nesting least Bell's vireos, San Diego River, 2008. Averages presented as mean ± standard deviation.

	Total Number				
Parameter	**Valley** (*A. donax* removal)	**Gorge** (Reference)	**Park** (Cowbird Control)	**Santee** (Reference)	**Total**
Nests with eggs	2	10	23	22	60[a]
Eggs laid	8	33	79	66	191[b]
Average clutch size					
Non-Parasitized[c]	4.0 ± 0.0	4.0 ± 0.0	3.9 ± 0.3	3.7 ± 0.5	3.9 ± 0.4
Parasitized[d]	n/a	3.2 ± 0.8	3.2 ± 1.0	2.4 ± 1.2	2.7 ± 1.1
Nests with hatchlings	2	5	15	8	30
Hatchlings	8	14	48	25	95
Hatching success:					
Eggs[d]	100%	42%	61%	40%	50%[e]
Nests[f]	100%	50%	65%	38%	50%[g]
Nests with fledglings	2	2	11 (9)[h]	3 (2)[h]	18 (15)
Fledglings	7	5	31 (26)[h]	7 (6)[h]	50 (44)
Fledging success:					
Hatchlings[i]	88%	36%	65% (54%)[h]	28% (24%)[h]	53% (46%)[h]
Nests[j]	100%	40%	73% (60%)[h]	38% (25%)[h]	60% (50%)[h]
Fledglings per egg	0.9	0.2	0.4 (0.3)[h]	0.1 (0.1)[h]	0.3 (0.2)[h]
Fledglings per nest	3.5	0.5	1.3 (1.1)[h]	0.3 (0.3)[h]	0.8 (0.7)[h]
Average number of young fledged per pair[k]	7.0 ± 0.0	1.3 ± 1.5	3.1 ± 2.9 (2.6 ± 3.2)[h]	0.6 ± 1.5 (0.5 ± 1.2)[h]	1.8 ± 2.5 (1.6 ± 2.5)[h]
Pairs fledging ≥ one young[l]	1 / 100%	2 / 50%	8 / 80% (6 / 60%)[h]	2 / 17%	13 / 46% (11 / 39%)[h]

[a] Includes three nests from an additional fully monitored territory outside the Treatment and Reference sites.
[b] Includes six eggs from an additional fully monitored territory outside the Treatment and Reference sites.
[c] Based on 2 Valley, 3 Gorge, 11 Park, 6 Santee and 22 Total non-parasitized nests with a full clutch. Kruskal-Wallis statistic = 1.82, $P = 0.40$, df = 2.
[d] Based on 0 Valley, 6 Gorge, 9 Park, 15 Santee and 33 Total (includes three nests from outside the Treatment and Reference sites) parasitized nests with a full clutch. Kruskal-Wallis statistic = 0.98, $P = 0.64$, df = 2.
[d] Percent of all eggs that hatched.
[e] Includes one hatched egg from an additional territory outside the Treatment and Reference sites.
[f] Percent of all nests with eggs in which at least one egg hatched.
[g] Includes one nest from an additional territory outside the Treatment and Reference sites.
[h] Number in parentheses is result if parasitized nests had not been manipulated but had been allowed to fail.
[i] Percent of all nestlings that fledged.
[j] Percent of all nests with nestlings in which at least one young fledged.
[k] Based on 1 Valley, 4 Gorge, 10 Park, 12 Santee and 28 Total pairs that were fully monitored. Kruskal-Wallis statistic = 7.83, $P = 0.02$, df = 2. For Park vs. Santee: Mann-Whitney $U = 98.0$, $P = 0.01$. If parasitized nests were allowed to fail, Kruskal-Wallis statistic = 4.43, $P = 0.11$, df = 2.
[l] Based on fully monitored pairs.

Table 8. 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, 2008. 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]**
Valley *A. donax* Removal Site					
Average nest height (m)	0.80	-	2, 0	-	-
Average host height (m)	3.00	-	2, 0	-	-
Average distance to edge of host (m)	0.75	-	2, 0	-	-
Average distance to edge of clump (m)	12.50	-	2, 0	-	-
Average distance to edge of riparian vegetation (m)	27.50	-	2, 0	-	-
Gorge Reference Site					
Average nest height (m)	0.55	1.12	2, 5	0.0	0.05
Average host height (m)	2.50	4.00	2, 8	5.0	0.42
Average distance to edge of host (m)	0.50	0.55	2, 8	7.0	0.79
Average distance to edge of clump (m)	4.00	2.88	2, 8	13.0	0.18
Average distance to edge of riparian vegetation (m)	11.00	11.69	2, 8	8.0	>0.99
Park Cowbird Control Site					
Average nest height (m)	0.96 (0.94)	0.86 (0.89)	10, 11 (8, 13)	71.5 (61.5)	0.24 (0.49)
Average host height (m)	4.36 (4.06)	4.29 (4.49)	11, 13 (9, 15)	87.0 (79.5)	0.37 (0.47)
Average distance to edge of host (m)	0.53 (0.57)	0.70 (0.65)	11, 13 (9, 15)	69.0 (74.0)	0.88 (0.70)
Average distance to edge of clump (m)	5.75 (5.92)	2.88 (3.16)	11, 13 (9, 15)	83.5 (80.0)	0.49 (0.45)
Average distance to edge of riparian vegetation (m)	28.70 (28.38)	26.27 (26.77)	10, 13 (8, 15)	77.0 (65.0)	0.46 (0.75)
Santee Reference Site					
Average nest height (m)	0.97 (1.00)	1.08 (1.07)	3, 19 (2, 20)	24.5 (20.0)	0.70 (>0.99)
Average host height (m)	7.77 (6.15)	5.76 (6.03)	3, 19 (2, 20)	33.0 (17.0)	0.67 (0.73)
Average distance to edge of host (m)	0.23 (0.15)	0.74 (0.73)	3, 19 (2, 20)	5.0 (1.0)	0.02 (0.03)
Average distance to edge of clump (m)	8.50 (10.75)	4.95 (4.90)	3, 19 (2, 20)	40.5 (32.0)	0.25 (0.17)
Average distance to edge of riparian vegetation (m)	8.50 (10.75)	11.92 (11.53)	3, 19 (2, 20)	25.0 (22.5)	0.74 (0.78)

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

Table 9. Least Bell's vireo nest characteristics and results of Kruskal-Wallis tests between monitoring sites along the San Diego River, 2008.

Nest Placement Characteristic	Gorge (Reference)	Park (Cowbird Control)	Santee (Reference)	*KW*[a]	*P*[b]
Average nest height (m)	0.96	0.91	1.06	2.94	0.23
Average host height (m)	3.70	4.33	6.04	5.79	0.06[c]
Average distance to edge of host (m)	0.54	0.62	0.68	0.23	0.89
Average distance to edge of clump (m)	3.10	4.20	5.43	3.28	0.19
Average distance to edge of riparian vegetation (m)	11.55	27.33	11.46	7.33	0.03[d]

[a] *KW* = Kruskal-Wallis statistic.
[b] *P* = P-value.
[c] Park vs. Santee Mann-Whitney $U = 190.0$, $P = 0.10$.
[d] Park vs. Santee Mann-Whitney $U = 364.5$, $P = 0.01$.

A total of 13 plants (12 species and one "dead" category, which included all dead woody species) were used as hosts for vireo nests at monitoring sites in 2008, although not all were used within each site (Table 10). Vireos used 11 of the 13 at the Park site and 5 or fewer of the 13 species at the remaining sites. Despite this difference, vireos at all sites were comparable in their selection of host species, as 76% of all nests were placed in mule fat, arroyo willow, and black willow (Table 10). Six vireo nests were built in exotic plant species; two in giant reed (at the Park site), two in salt-cedar (at the Santee site), one in black mustard, and one in tree tobacco (both at the Park site). Each of the nests placed in exotic species was built by a different pair.

Table 10. Host plant species used by least Bell's vireos at monitoring sites along the San Diego River, 2008. Numbers in parentheses are proportions of total nests at that site.

	Number of Nests			
Host Species	Valley (*A. donax* removal)	Gorge (Reference)	Park (Cowbird Control)	Santee (Reference)
Mule fat	1 (0.50)	4 (0.36)	6 (0.25)	7 (0.28)
Arroyo willow	1 (0.50)	3 (0.27)	5 (0.21)	13 (0.52)
Black willow		2 (0.18)	3 (0.13)	2 (0.08)
Giant reed			2 (0.08)	
Mexican elderberry (*Sambucus nigra*)			2 (0.08)	
Freemont cottonwood		1 (0.09)	1 (0.04)	1 (0.04)
Mugwort (*Artemisia douglasiana*)			1 (0.04)	
Black mustard			1 (0.04)	
Dead species			1 (0.04)	
Tree tobacco			1 (0.04)	
Coast live oak			1 (0.04)	
Salt-cedar				2 (0.08)
Poison oak (*Toxicodendron diversilobum*)		1 (0.09)		

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; USGS unpubl. data; Fig. 8). By 2008, this number had dropped to approximately half the 1994 maximum within the same area.

Surveys of other areas on the river have been conducted less frequently, but also show an increase in vireo territories through 1997, with a small increase since 1997 (Table 11; SANDAG 1990, Kus and Beck 1998). While the bulk of vireo territories remained in the central section of the river (Park and Santee survey sections), vireo numbers dropped 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.

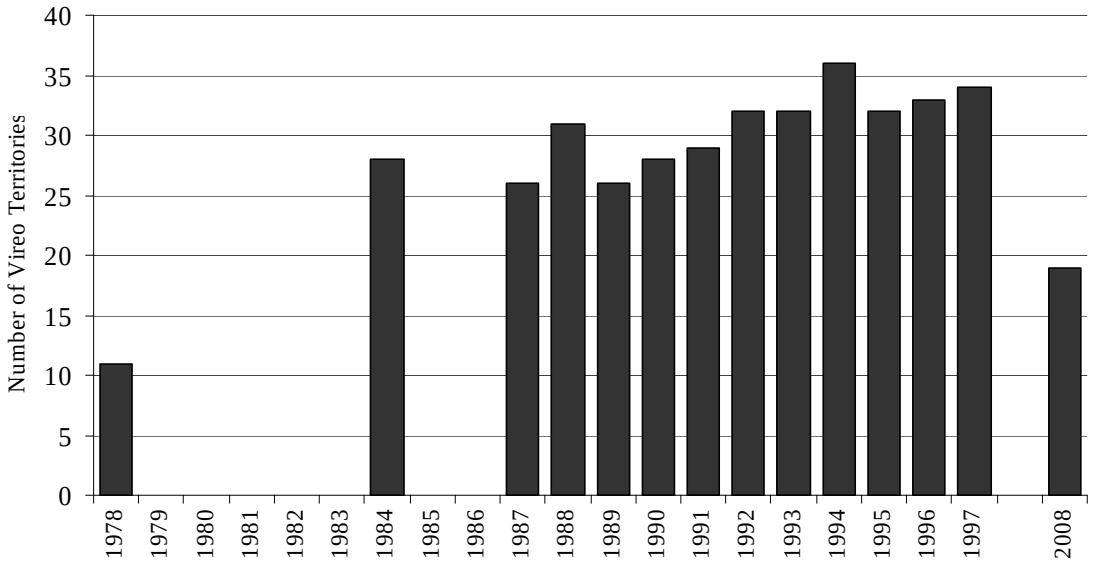

Fig. 8. Number of least Bell's vireo territories between Mission Dan and Santee, San Diego River, 1978-2008

Table 11. Number of least Bell's vireo territories occurring historically along the San Diego River. (Sources: SANDAG 1990, Kus and Beck 1998). Numeric change represents the absolute change in vireo numbers from 1997 to 2008.

	Number of Territorial Males				Numeric Change
Survey Site	**1978**	**1987**	**1997**	**2008**	
Valley	1	0	7	1	-6
Gorge	-	2	7	13	+6
Park	8	12	19	18	-1
Santee	3	12	24	20	-4
Lakeside	-	5	3	11	+7
El Capitan	-	-	2	0	-2
Total	12	31	60	63	-1

The number of vireo territories along the San Diego River follows the 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 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 and have not changed substantially since 1997. At both Camp Pendleton and the lower San Luis Rey River, intensive programs to control brown-headed cowbirds have virtually eliminated cowbird parasitism from least Bell's vireo nests. Additionally, 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. Brown-headed cowbirds were documented throughout all stretches of the San Diego River, and large stands of giant reed were also observed in sections of the river in 2008. In subsequent years of this study, vireos should respond as the management actions that have been planned for the two treatment sites along the San Diego River are implemented.

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 dominated by exotic plants (salt-cedar). The Valley survey section contained extensive patches of giant reed, which were not occupied in 2008.

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. Three banded vireos were resighted along the San Diego River in 2008. Two of these vireos had dispersed from their natal drainages to the San Diego River, demonstrating the potential for vireos to disperse far beyond their natal drainages. 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.

Cowbird parasitism did not occur during the first two weeks of the breeding season in 2008. This phenomenon is subject to annual variation, as demonstrated from 1990 through 1994 on the San Diego River (Kus 1992, 1994, and 1995), and may result from variation in dates of arrival for both cowbirds and vireos. Cowbird parasitism was prevalent in vireo nests along most of the San Diego River and affected 45% of nests. However, not all parasitized nests failed. The removal of cowbird eggs from parasitized nests potentially helped increase nest success (23% 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. 8). 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. By 2008, the vireo population had declined by 44% in the Park site.

This decline in the vireo population, 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. By implementing the current project, vireo nest monitoring simultaneous with cowbird trapping, we can 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.

The only section that did not suffer from cowbird parasitism was the Valley site, which had only one documented vireo pair. Even though only one pair occupied the Valley site, this pair was one of five that fledged two broods on the river in 2008, and therefore had high overall productivity measured as the number of young fledged per pair. Therefore, although the Valley site did not support many vireos, the causes of nest failure (brown-headed cowbirds and/or predators and/or human disturbance) may be less prevalent there. Giant reed removal is scheduled to occur at the Valley site in the near future. It is expected that this will improve vireo habitat and allow more vireos to occupy the Valley site, as they have in the past (Kus and Beck 1998), and potentially contribute to higher breeding productivity throughout the river.

Aside from the Valley site, nest success and overall productivity (number of young fledged per pair) were highest at the Park site. The Park site occurs within Mission Trails Regional Park and is set within a natural landscape, unlike the remaining sites that are mostly surrounded by urban areas and golf courses. Kus *et al*. (2008) found that nest predation risk increased with proximity to golf courses and manicured parks on the nearby San Luis Rey River, which may also apply to areas along the San Diego River.

Nest site characteristics did not differ between successful and unsuccessful nests, either at Reference sites or at Treatment sites. 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. However, we found that in 2008, vireos placed their nests closer to the edge of riparian vegetation in Reference sites, which may reflect what is available at these sites. For instance, at the Gorge site, vireo habitat consisted of a relatively thin strip of riparian vegetation

and therefore all nests must be near the edge of the riparian vegetation. This difference in nest placement should be considered when analyzing for differences in nest placement after treatment has occurred to avoid drawing a misleading conclusion and attributing it to treatment effects.

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 this baseline study year in the absence of cowbird trapping. In 2009, cowbirds will be trapped at the treatment plots in Mission Trails Regional Park (Park site) during a prescribed portion of the vireo breeding season (1 April – 30 June) to provide data on the abundance and spatial and temporal distribution of cowbirds in this site. Concurrent vireo monitoring will provide data on rates of parasitism, seasonal timing of parasitism, nest success, seasonal productivity (production of vireo young), dispersal, and recruitment of young vireos. By examining the spatial distribution of parasitized nests, we will be able to determine the zone of influence of the cowbird traps and use this information to direct future trapping activities regarding trap numbers and spacing. Comparing the seasonal productivity of vireo pairs will allow us to document changes between years and the portion attributable to the cowbird control. Determining the temporal pattern of cowbird parasitism (in conjunction with data on the seasonal abundance of cowbirds) will help us identify the critical period of the season during which control might be most effective.

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, 2008

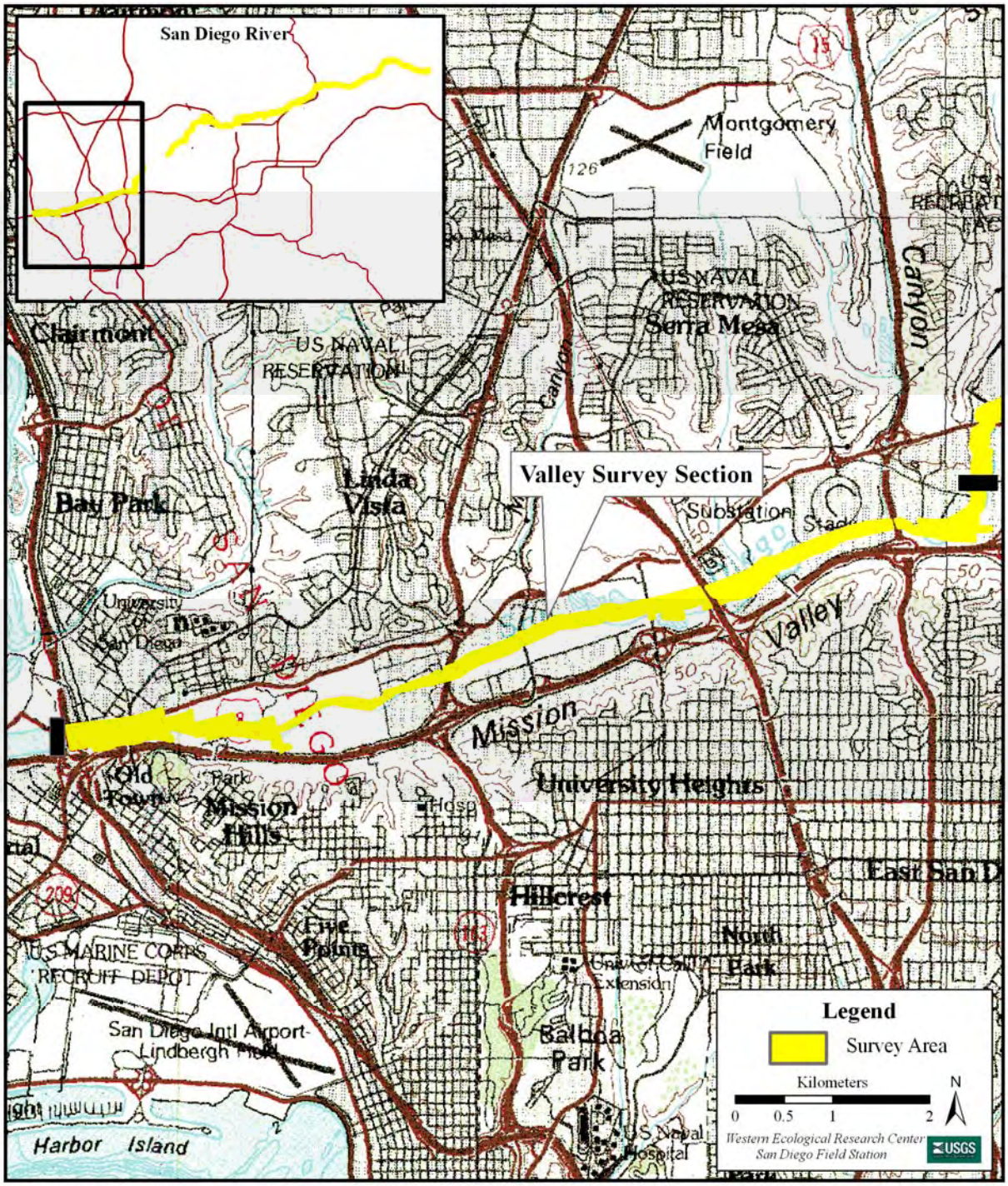

Fig. 8. Least Bell's vireo survey areas along the San Diego River, 2008: Valley.

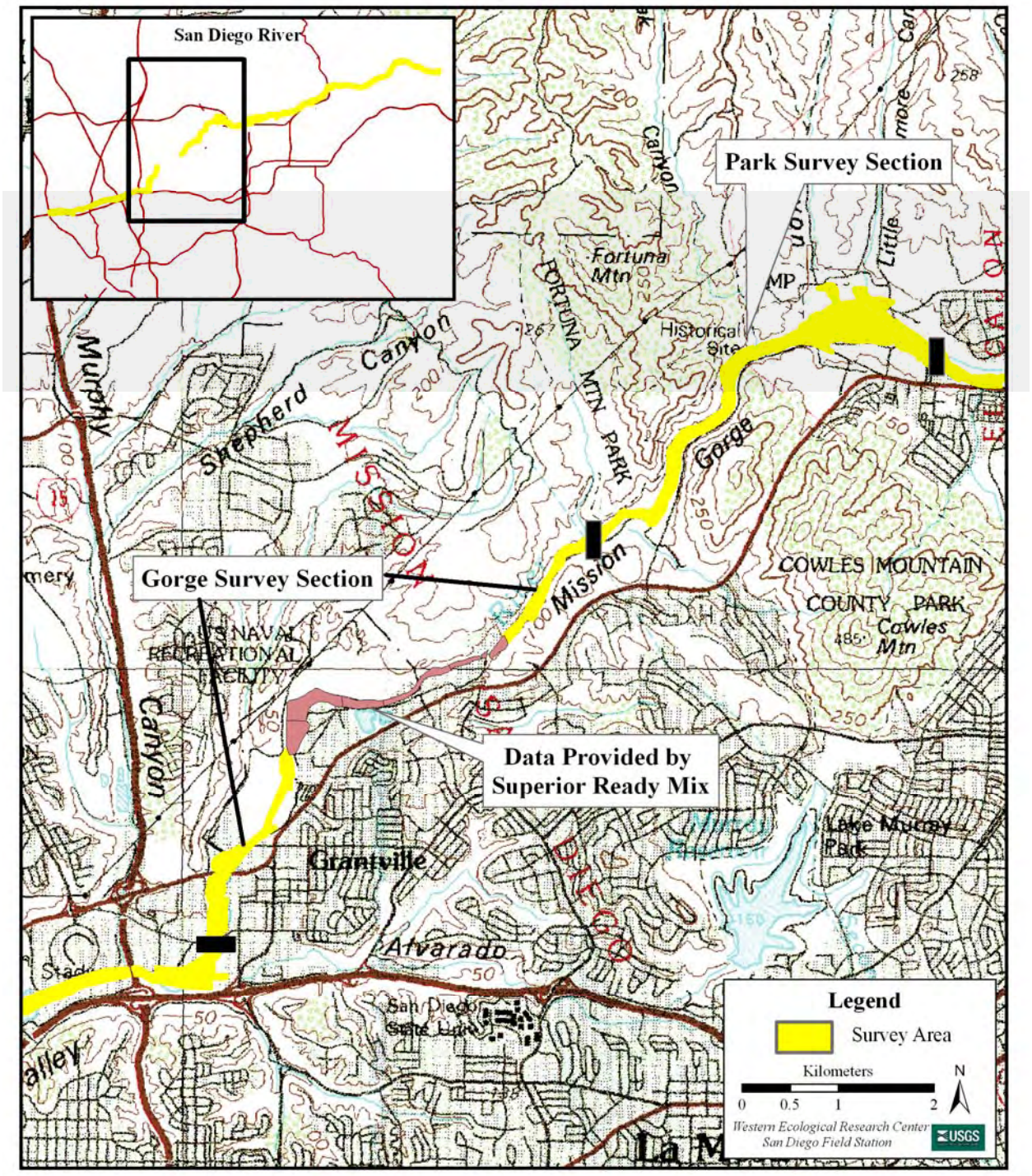

Fig. 9. Least Bell's vireo survey areas along the San Diego River, 2008: Gorge and Park.

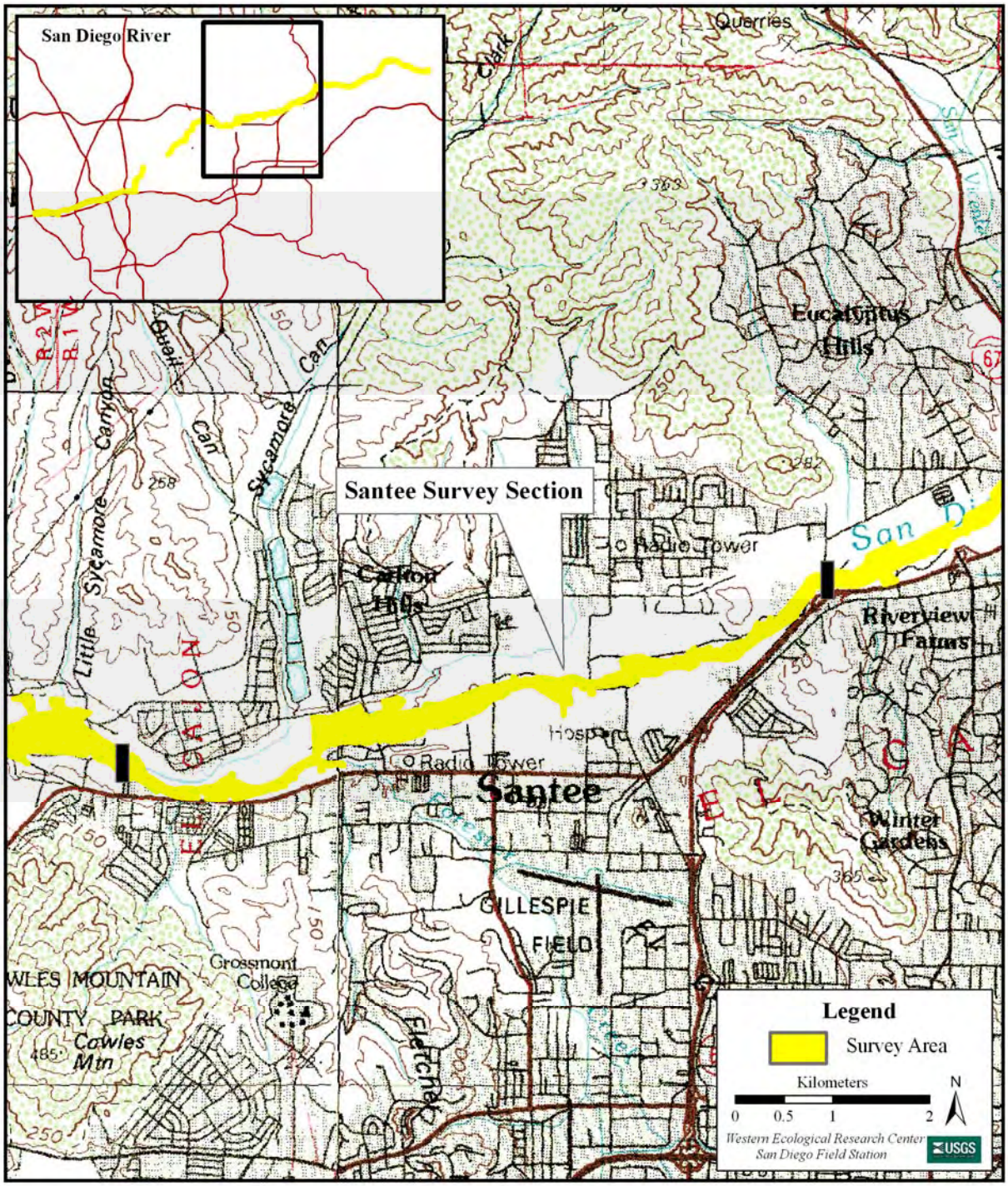

Fig. 10. Least Bell's vireo survey areas along the San Diego River, 2008: Santee.

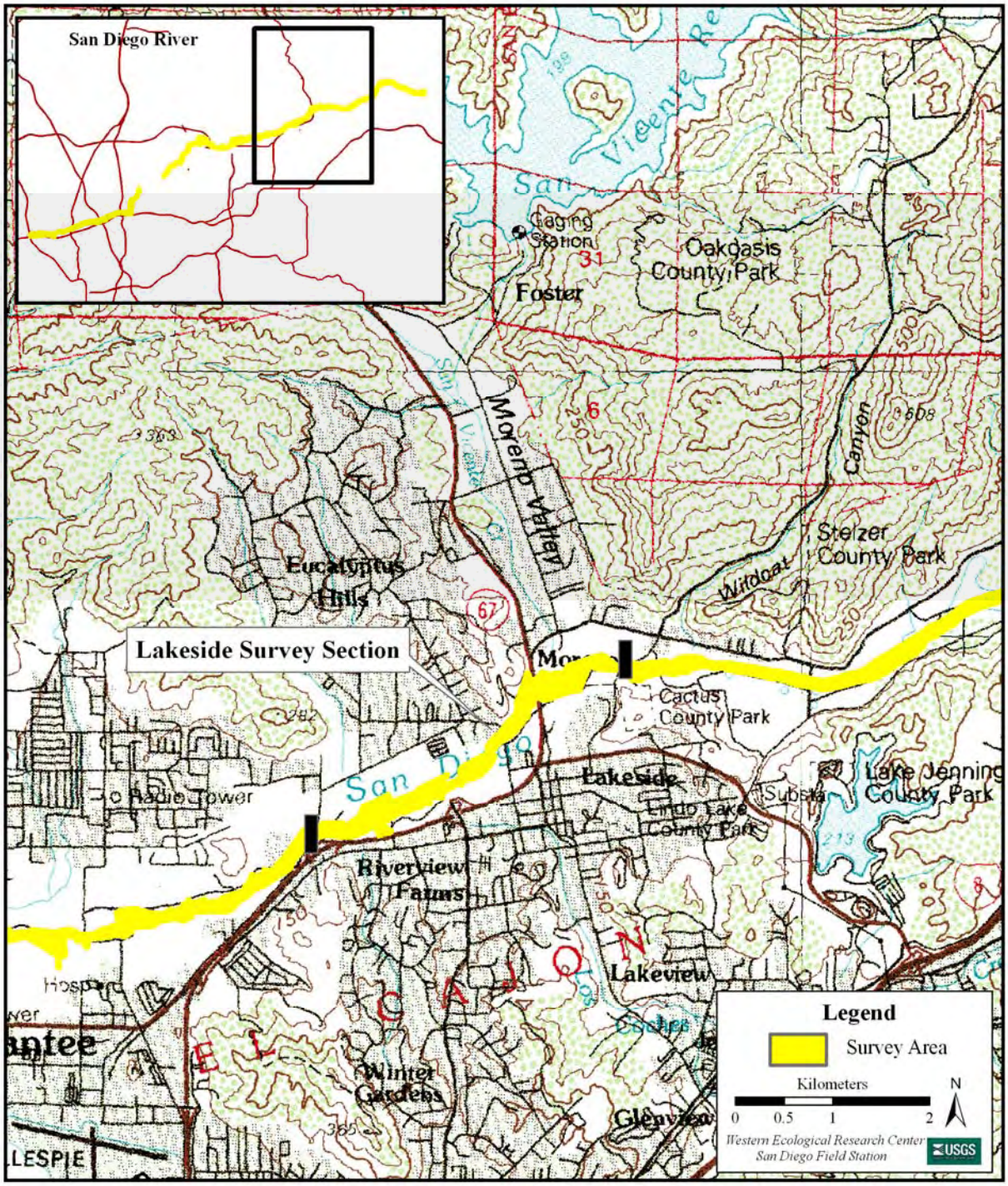

Fig. 11. Least Bell's vireo survey areas along the San Diego River, 2008: Lakeside.

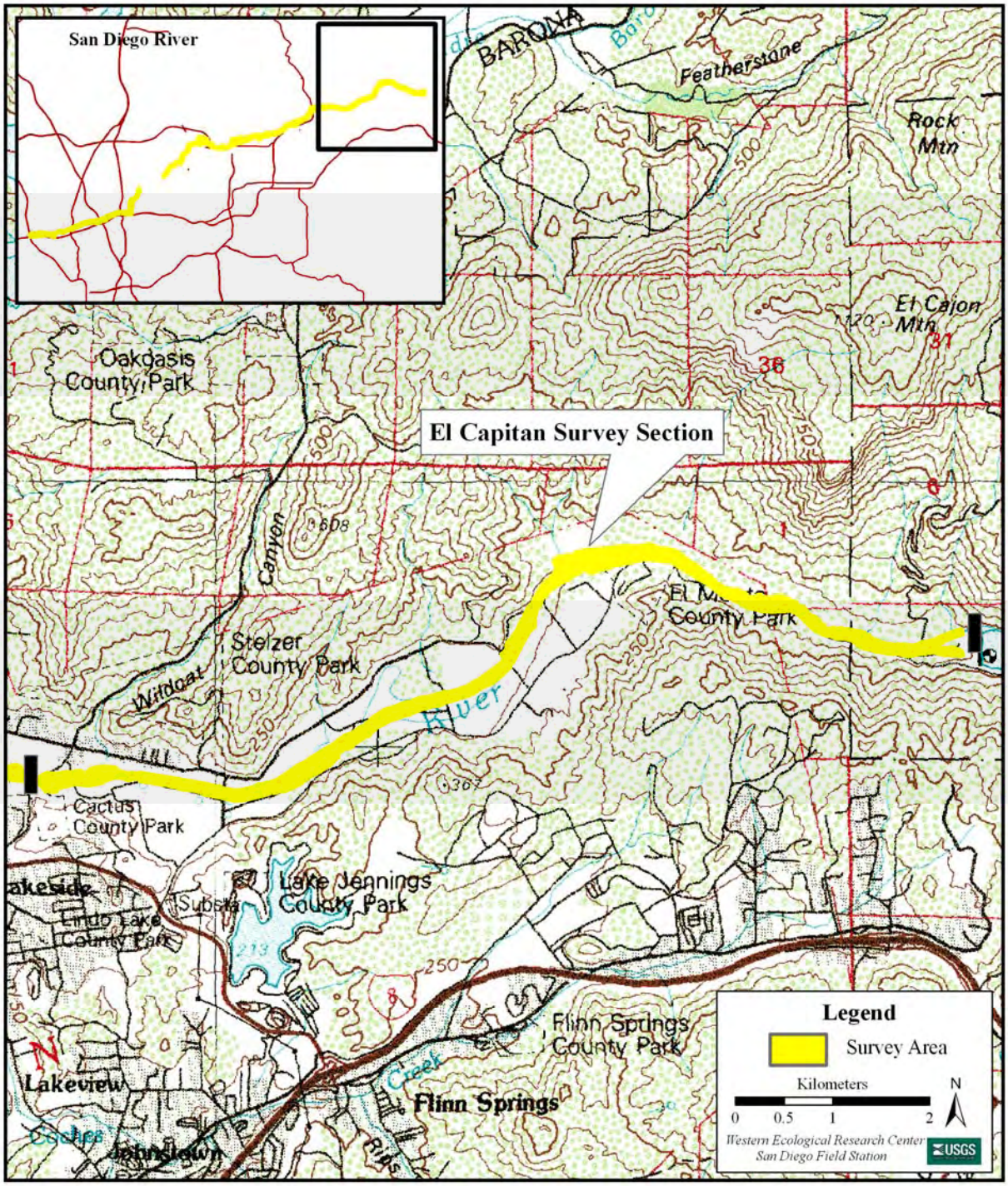

Fig. 12. Least Bell's vireo survey areas along the San Diego River, 2008: El Capitan.

APPENDIX B

LOCATIONS OF LEAST BELL'S VIREOS ALONG THE SAN DIEGO RIVER, 2008

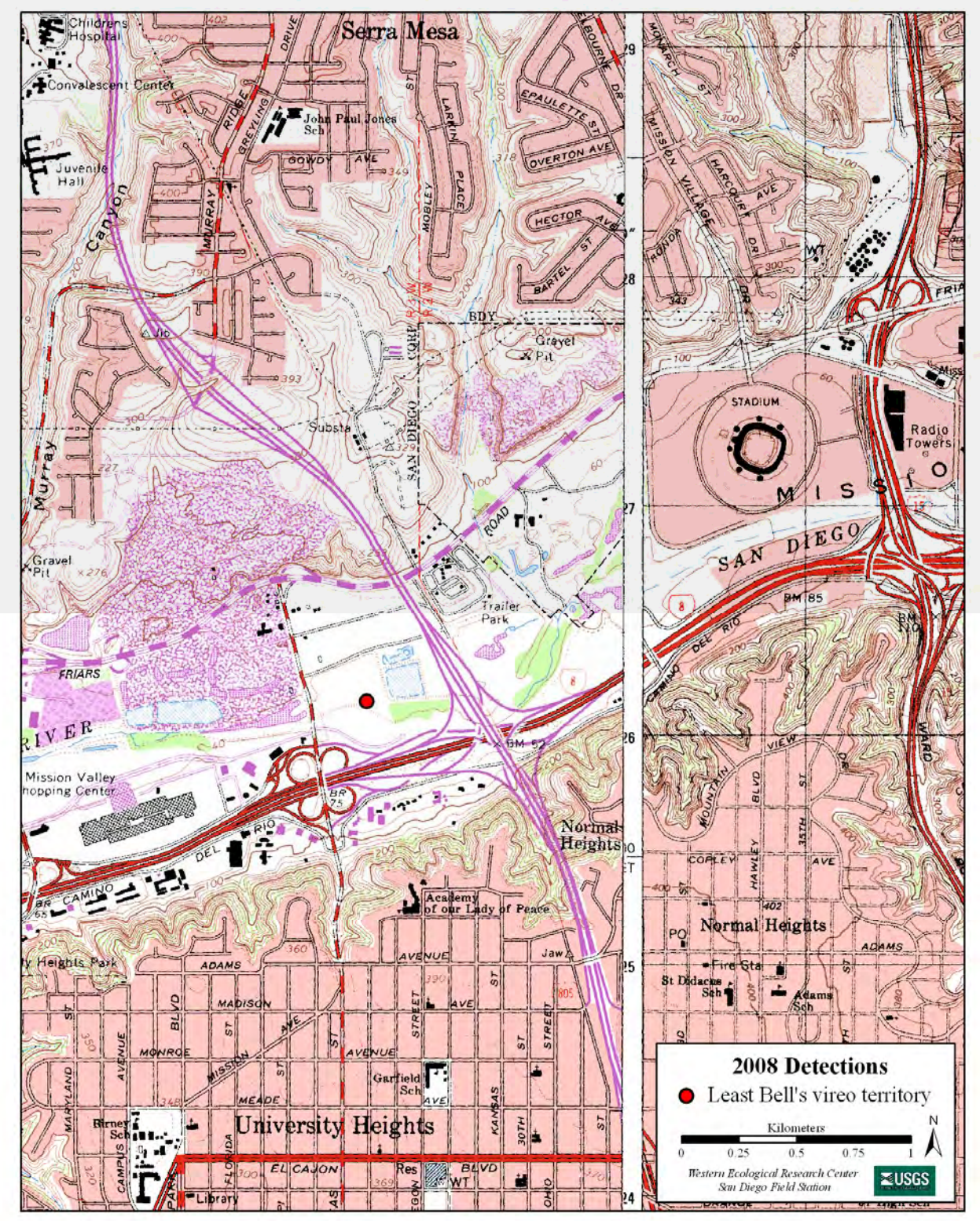

Fig. 13. Locations of least Bell's vireos along the San Diego River, 2008: Valley.

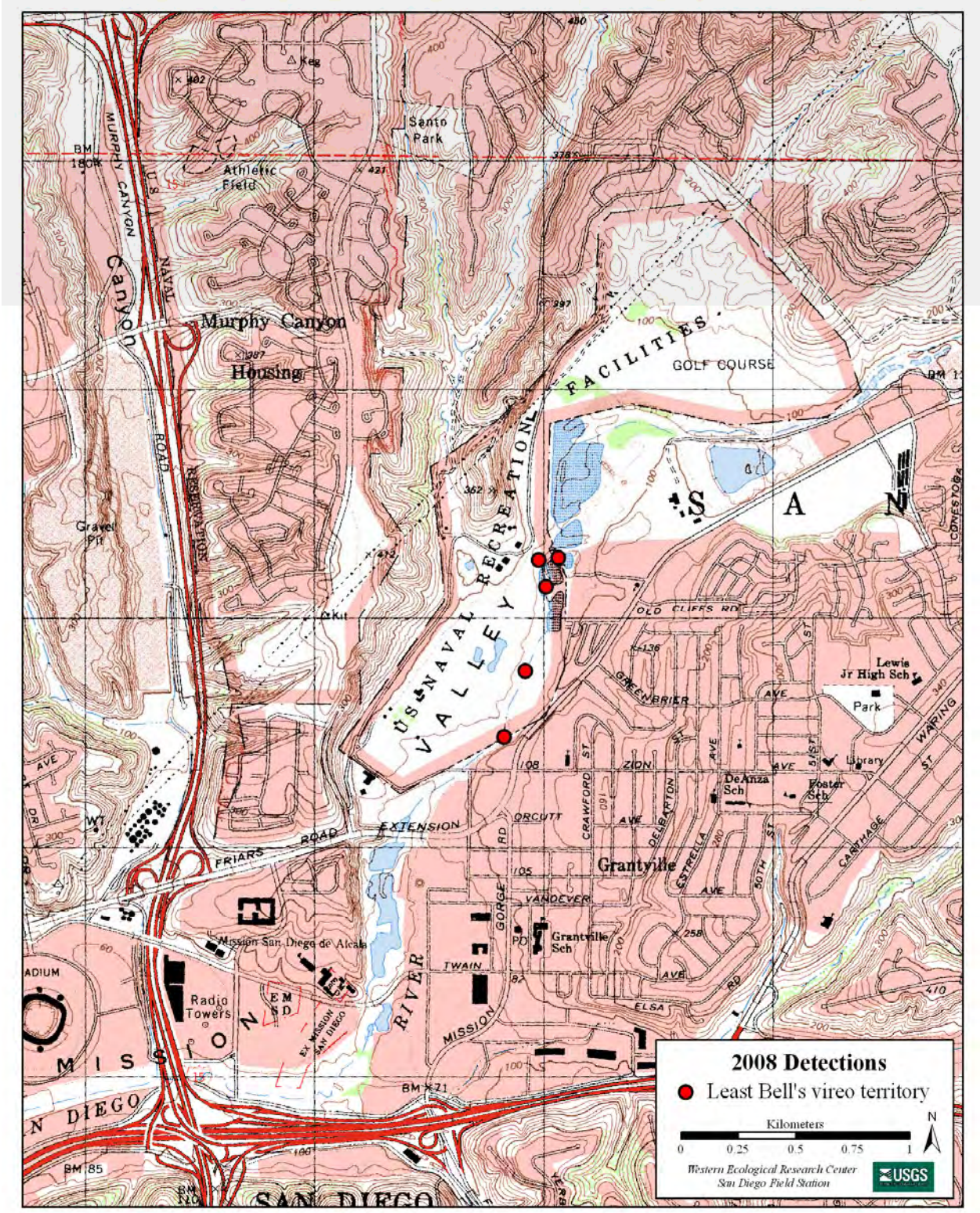

Fig. 14. Locations of least Bell's vireos along the San Diego River, 2008: lower Gorge.

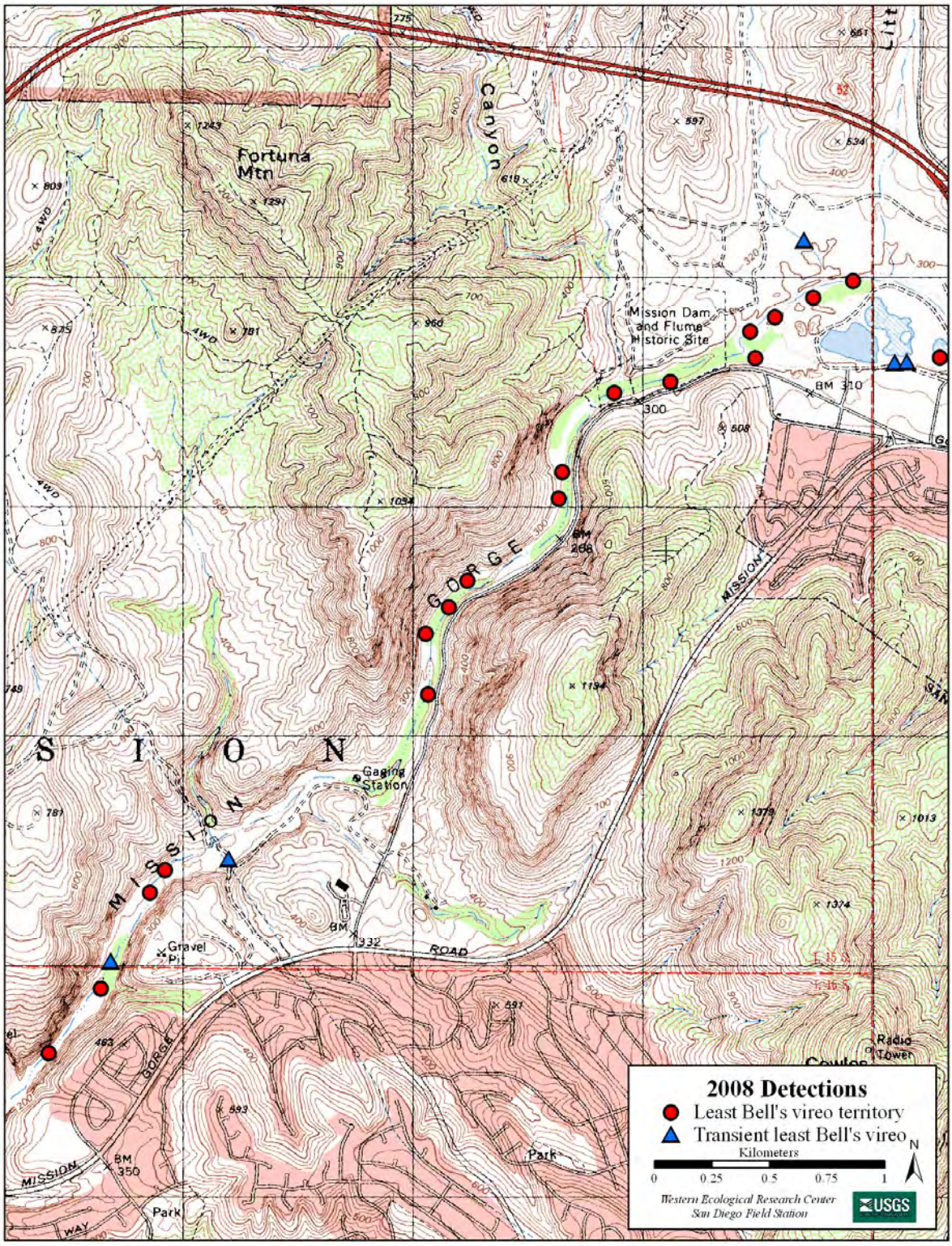

Fig. 15. Locations of least Bell's vireos along the San Diego River, 2008: upper Gorge and west Park.

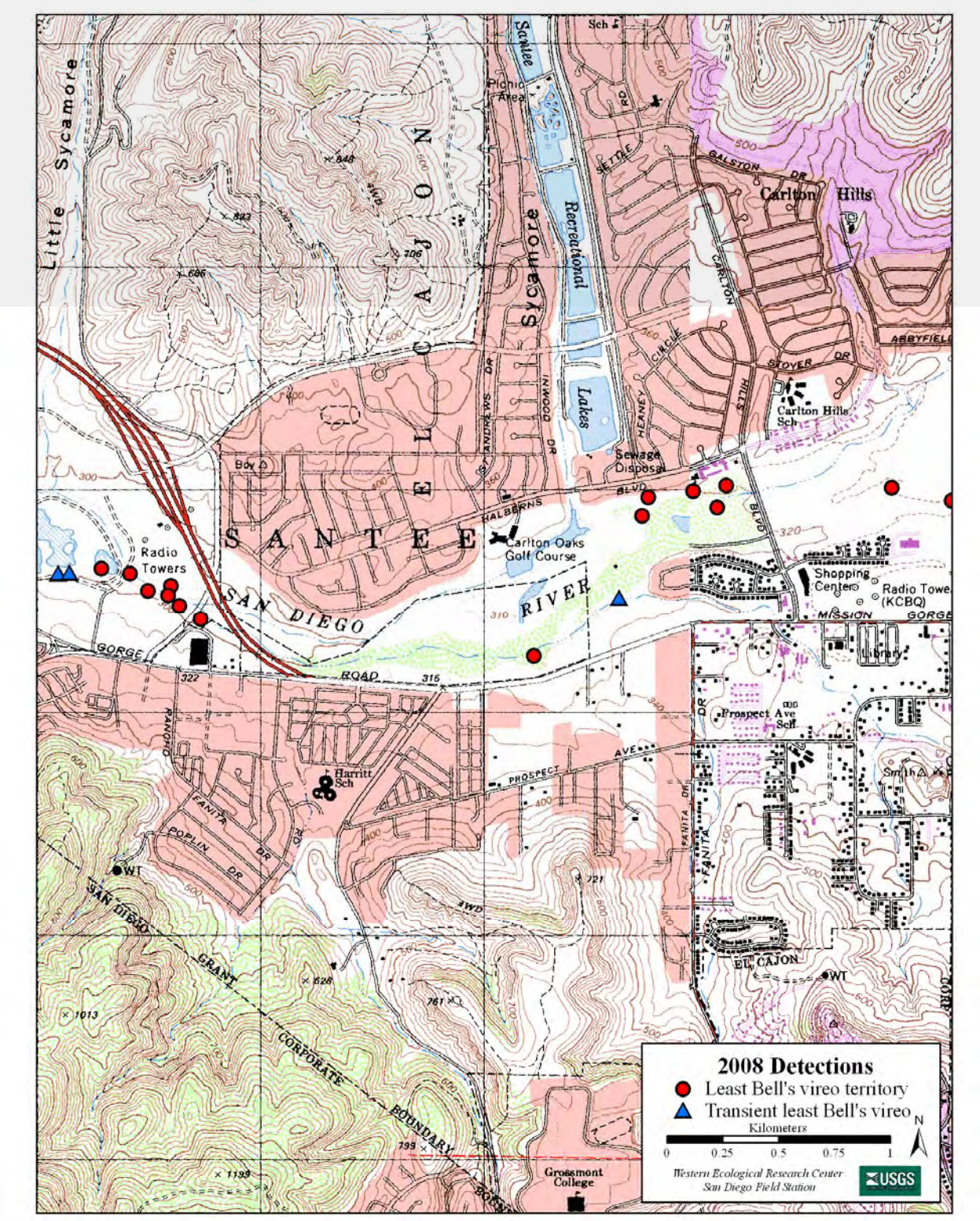

Fig. 16. Locations of least Bell's vireos along the San Diego River, 2008: east Park and west Santee.

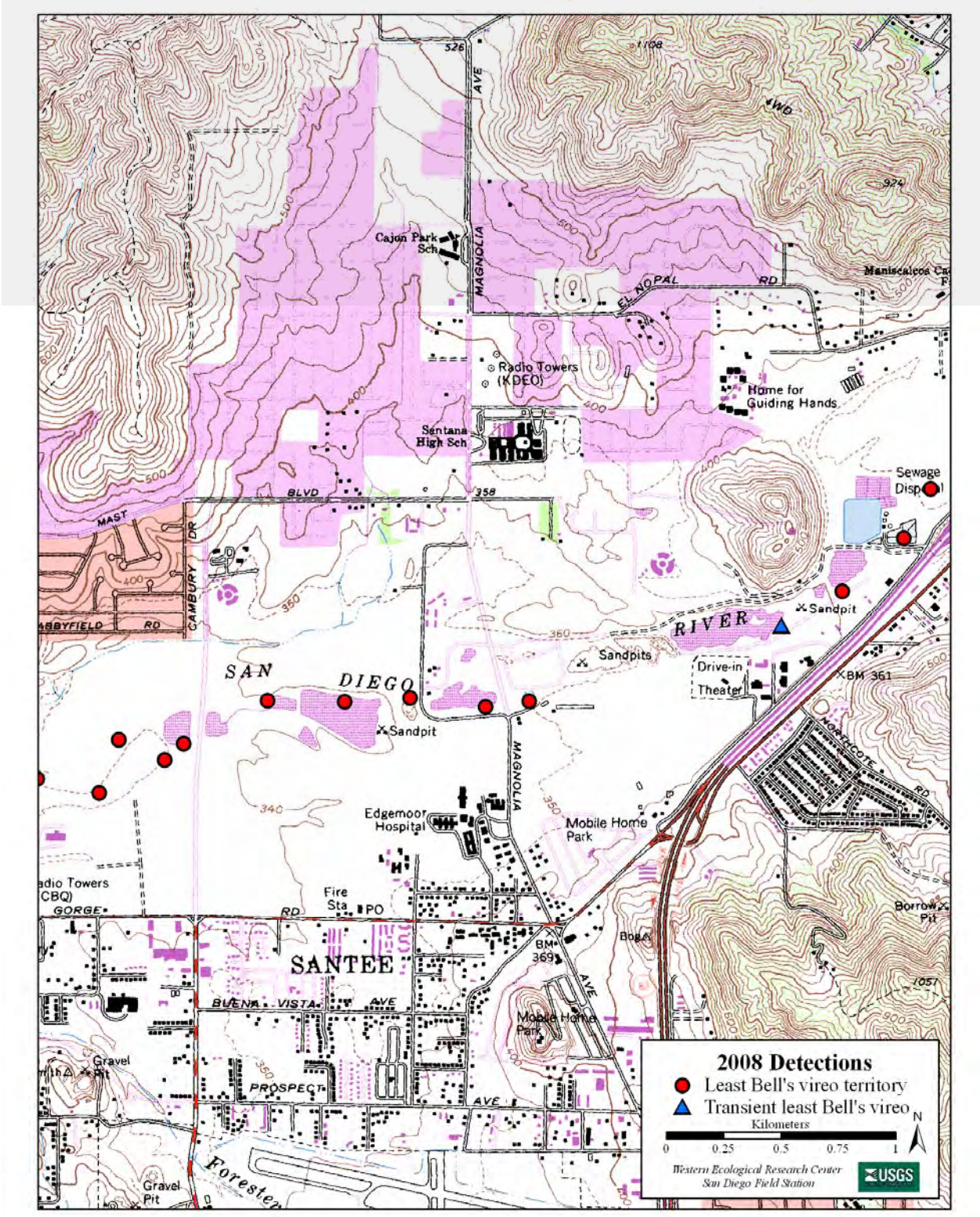

Fig. 17. Locations of least Bell's vireos along the San Diego River, 2008: Santee.

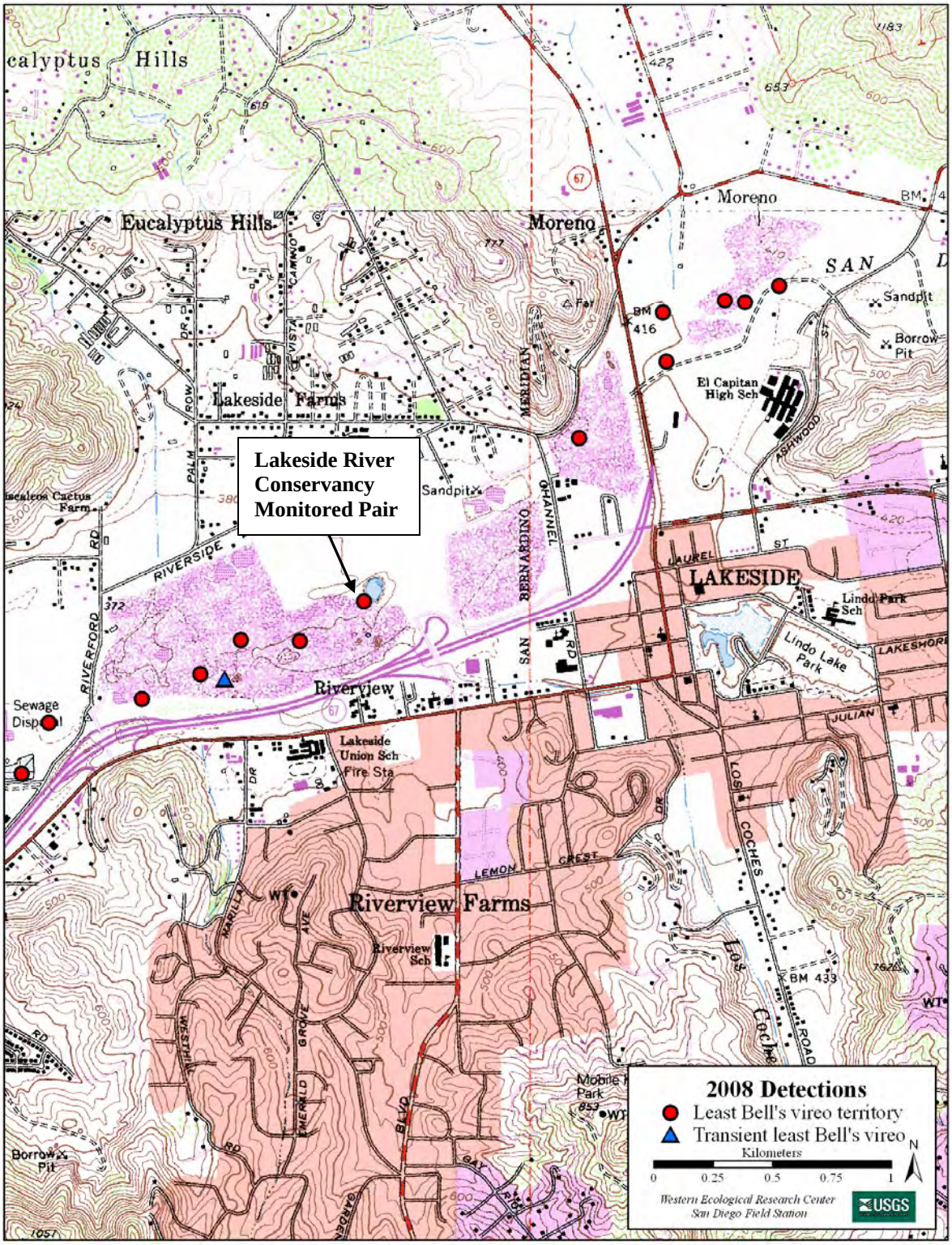

Fig. 18. Locations of least Bell's vireos along the San Diego River, 2008: Lakeside.

APPENDIX C

STATUS AND NESTING ACTIVITIES OF LEAST BELL'S VIREOS ALONG THE SAN DIEGO RIVER, 2008

Territory	Nest	Monitoring[a]	Nest Fate[b]	# Cowbird Eggs	# Fledged	Comments
REFERENCE SITE TERRITORIES - GORGE						
SGBI	1	F	OTH			Supporting branch broke.
SGBI	2	F	SUC		2	Partial nestling predation.
SGBG	1	F	OTH	1		Possible cowbird predation.
SGBG	2	F	PRE	1		
COL	1	F	PAR	1		
COL	2	F	PRE	1		
COL	3	F	INC			
COL	4	F	PRE	2		
COL	5	F	OTH			Nest found torn, possibly before eggs were laid.
SGEA	1	F	SUC		3	
SGEA	2	F	PRE			
SGGA	1	F	PRE	1		
REFERENCE SITE TERRITORIES - SANTEE						
ALD	1	F	PRE	1		
SGCA	1	F	PRE	1		
SGCH	1	F	PRE	1		
SGFU	1	F	PAR	1		
SGFU	2	F	PRE			
SGFU	3	F	PRE			
SGFU	4	F	PAR	1		
SGHO	1	F	PRE	1		
SGHO	2	F	UNK			May have failed prior to egg laying.
SGHO	3	F	PRE	1		
SGHO	4	F	OTH			Possible cowbird predation.
SGHO	5	F	INC			
JOY	1	F	PRE	2		
JOY	2	F	PRE			
LIB	1	F	PAR	2		
MAG	1	F	PAR	2		
SGMA	1	F	SUC		4	
SGMA	2	F	SUC	1	1	Partial nestling predation.
MER	1	F	PRE			
MER	2	F	PRE			Nest found on the ground.
MER	3	F	PRE	1		
SA16	1	P	PRE	1		
SGSA	1	F	SUC		2	Partial nestling predation.
SGSA	2	F	PRE	1		
STN	1	P	PAR	2		
WAL	1	F	PAR	1		

Territory	Nest	Monitoring[a]	Nest Fate[b]	# Cowbird Eggs	# Fledged	Comments
GIANT REED (*ARUNDO DONAX*) REMOVAL SITE TERRITORIES - VALLEY						
SGGR	1	F	SUC		4	
SGGR	2	F	SUC		3	Ant predation on one nestling.
BROWN-HEADED COWBIRD (*MOLOTHRUS ATER*) CONTROL SITE TERRITORIES - PARK						
BTN	1	F	PRE	1		
BTN	2	F	SUC	1	3	
FRE	1	F	PRE			
HTS	1	F	SUC		4	
HTS	2	F	SUC		4	
MD	1	F	SUC		2	Partial egg predation.
SGPN	1	F	PRE			
SGPN	2	F	OTH			Nest tilted, no nest contents observed.
SGPN	3	F	OTH			Host plant collapsed.
SGPN	4	F	PRE	1		
SGPN	5	F	PRE	1		
SGPN	6	F	PRE	1		
SGPP	1	F	PRE	1		
SGPP	2	F	PRE	1		
SGPP	3	F	SUC	1	2	1 unhatched egg.
SGSO	1	F	SUC		4	
SGSO	2	F	OTH			Possible cowbird predation.
SGSO	3	F	PAR	1		
SGSO	4	F	SUC		4	
SGTS	1	F	SUC		4	
SGTS	2	F	PRE			
WMB1	1	F	SUC		1	Partial nestling predation.
WMB2	1	F	SUC		2	Partial nestling predation.
WMB2	2	F	SUC		1	
OTHER TERRITORIES - LAKESIDE						
SIG	1	F	OTH	2		Nest tipped sideways with eggs.
SIG	2	F	PRE	2		
SIG	3	F	OTH	2		Punctured vireo eggs in nest.
SIG	4	F	INC			

[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.