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

2011 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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EXECUTIVE SUMMARY

Surveys for the endangered Least Bell's Vireo (*Vireo bellii pusillus*) were conducted along the San Diego River between 4 April and 14 June 2011. Riparian habitat suitable for vireos from Interstate 5 to the El Capitan Reservoir was surveyed three times. Sixty-seven territorial male vireos were detected, 42 (63%) of which were confirmed as paired. Five transient vireos were also detected.

Most (94%) vireo territories occurred in four of six sections surveyed: Santee (27%), Park (27%), Gorge (22%), and Lakeside (18%). The Valley survey section contained four vireo territories (6%) and no vireo territories were detected in the El Capitan survey section. The number of territorial Least Bell's Vireos detected in 2011 decreased 26% from 2010. Vireo numbers decreased in all six survey sections, with the smallest decrease in the Park area (14%).

The majority of vireo territories (57%) occurred in habitat characterized as mixed willow (*Salix* spp.) riparian. Thirty-nine 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 upland scrub.

Of the 117 vireos (males and females) detected in 2011, 18 were color banded prior to 2011, 4 with single numbered bands were recaptured and given color combinations in 2011, and twelve unbanded adult vireos were captured and given color combinations. One other adult vireo was banded with a single numbered light blue metal band indicating that she had been banded as a nestling in the study are in 2008, 2009, or 2010 but we were unable to capture her to determine her identity or give her a color combination. Fifty nestlings were banded in 2011 for the first time with a single numbered federal band.

Forty-one percent (43% of males and 33% of females) of adult vireos banded prior to 2011 returned to the San Diego River in 2011. Four additional adult vireos that were not detected in 2010 were observed in 2011. Three were originally banded on the San Diego River in 2008, one male as a nestling, one male as an adult, and one female as an adult. The fourth vireo, a male, was banded as an adult on the San Diego River in 2006. The detection of these adult vireos increased first-year survivorship for 2008-2009 from 17% to 19% and adult survivorship for the same years to 84%. Four of the 38 hatch-year banded vireos that survived to fledge in 2010 returned in 2011 for a first-year survivorship of 11% (11% for males and 11% for females). Survival rate for adults at the Treatment site was 47% (46% for males and 50% for females) and at the Reference site was 31% (36% for males and 0% for females).

All of the returning adults occupied the same territory that they had occupied in 2010 or the territory adjacent to their 2010 territory. The average distance first-year vireos dispersed from the San Diego River to all sites was 3.9 ± 5.9 km (SD) (n = 4).

A single Willow Flycatcher (*Empidonax traillii*) was detected in the Valley survey area in early June. This bird was only seen once and we were unable to determine whether or not it was banded.

Nesting activity was monitored in 22 territories, 11 within the Treatment site where Brown-headed Cowbirds (*Molothrus ater*) have been trapped for 3 years and 11 within the Reference site, where cowbird trapping began this year. Cowbird traps were open from 1 April through 31 May. A total of 38 nests were monitored during the breeding season; however, four of these were not completed and were excluded from calculations of nest success and productivity. Twenty-four percent of pairs had initiated their first nest by the end of April and two pairs did not initiate nesting until June. No pairs successfully fledged two broods in 2011.

Only one instance of parasitism by Brown-headed Cowbirds was observed in the study area in 2011, in a nest at the Reference site. The rate of cowbird parasitism in the study area has decreased each year from 2008 to 2011 but has been consistently higher at the Reference site than at the Treatment site, where cowbird trapping has occurred annually since 2009. No nests failed as a result of cowbird parasitism. One parasitized nest fledged two young after removal of cowbird eggs by nest monitors.

Forty-four percent of all completed vireo nests in our monitoring sites successfully produced at least one vireo fledgling. If cowbird eggs had not been removed from nests, the nest success rate would have been 41%. Nest success did not differ significantly between Treatment and Reference sites (29% and 15%, respectively). Fifty-six percent of nests were not successful. Predation was believed to be the primary source of nest failure at all sites, accounting for 78% of nest failures. Other causes of nest failure included abandonment after rain, poor nest construction, and unknown reasons. Average clutch size was relatively high across all sites and was not reduced in nests that experienced cowbird parasitism. The number of vireo young fledged per pair was significantly higher at the Treatment site than at the Reference site.

In 2011, successful and unsuccessful nests within Treatment and Reference sites did not differ statistically in nest placement characteristics. There were few differences in nest placement between nests at Treatment and Reference sites, with Treatment site nests placed lower and closer to the edge of the nest clump than Reference site nests. Ten plant species were used as hosts for vireo nests in 2011. Sixty-five percent of all nests were placed in mule fat (*Baccharis salicifolia*), red or arroyo willow (*S. laevigata* or *S. lasiolepis*), or black willow (*S. gooddingii*).

INTRODUCTION

The Least Bell's Vireo (*Vireo bellii pusillus*; "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; Kus 1998, 1999; Kus et al 2010), 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 3,000 territories (USFWS 2006).

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).

Natural resource managers on the San Diego River have identified two management activities, giant reed removal and cowbird control, that have been effective in enhancing vireo numbers elsewhere and in the past on the San Diego River (Jones 1985, Kus and Whitfield 2005). Both of these management activities have the potential to be expensive in terms of money (e.g., cost of operating cowbird traps annually in perpetuity) and collateral impacts (e.g., short-term reduction of vegetation cover in vireo habitat). Therefore, our project was designed to allow an experimental determination of the most cost- and biologically-effective means to implement these management activities.

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. 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 (*Baccharis salicifolia*), sandbar willow (*Salix exigua*), black willow (*S. gooddingii*), arroyo willow (*S. lasiolepis*), and red willow (*S. laevigata*).

As part of our project, giant reed was removed from the eastern reach of the Valley section of the survey area and the western reach of the Santee section along Carlton Oaks Golf Course in late 2008/early 2009. We surveyed for vireos along the San Diego River drainage from Interstate 5 to El Capitan Dam before and after the giant reed removal to determine how vireo distribution and abundance responded to this management activity.

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, unpubl. 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.

To determine the effectiveness of various potential cowbird trapping regimes, we monitored vireo nesting activity at two monitoring plots according to the following plan: (year 1 - 2008) no cowbird trapping (baseline with no management); (year 2 - 2009) cowbird traps operated at one of two monitoring plots from 25 April through 30 July (contracting constraints delayed intended start date of 1 April); (year 3 - 2010) cowbird traps operated at the same monitoring plot for a shorter period, from 1 April through 31 May; (year 4 – current year) cowbird traps operated at both monitoring plots from 1 April through 31 May; and (year 5) no cowbird trapping but vireo nesting activity will be monitored at both plots. Data from year 2 allowed us to document the effectiveness of cowbird trapping by comparing parasitism in trapped and non-trapped monitoring plots. Year 3 allowed us to explore the efficacy of a shortened trapping period relative to the traditional period employed in year 2. Year 4 demonstrated the response to site-wide cowbird management under the shortened trapping timeframe, while year 5 will allow us to investigate the potential for biannual cowbird control as an effective alternative to the current practice of annual cowbird trapping.

Our objectives in this study were to (1) determine abundance and distribution of vireos along the San Diego River to facilitate population trend analyses and response to management activities, (2) band a subset of vireos to estimate vireo survivorship and movement for the population as a whole and in response to management activities, (3) assess the effect of giant reed removal on vireo abundance and distribution, and (4) assess the short-term effects of varied Brown-headed Cowbird control regimes 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

Natural History

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 although double-brooding is not uncommon when conditions are favorable (Lynn and Kus 2009, Ferree and Kus 2008). 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.

Field Surveys

Riparian habitat along the San Diego River from Interstate 5 to El Capitan Reservoir was surveyed for vireos between 4 April and 14 June 2011 (Fig. 1). Field work was conducted by Aaron Gallagher, PJ Falatek, Michael Hague, Alex Houston, Suellen Lynn, Ryan Pottinger, and Sonya Steckler. 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 (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 approximately 3.6 km, and from El Capitan Dam downstream approximately 1.2 km. In 2011, we were not able to gain access to the remaining section of this survey area (Fig. 1; Appendix A, Fig. 12).

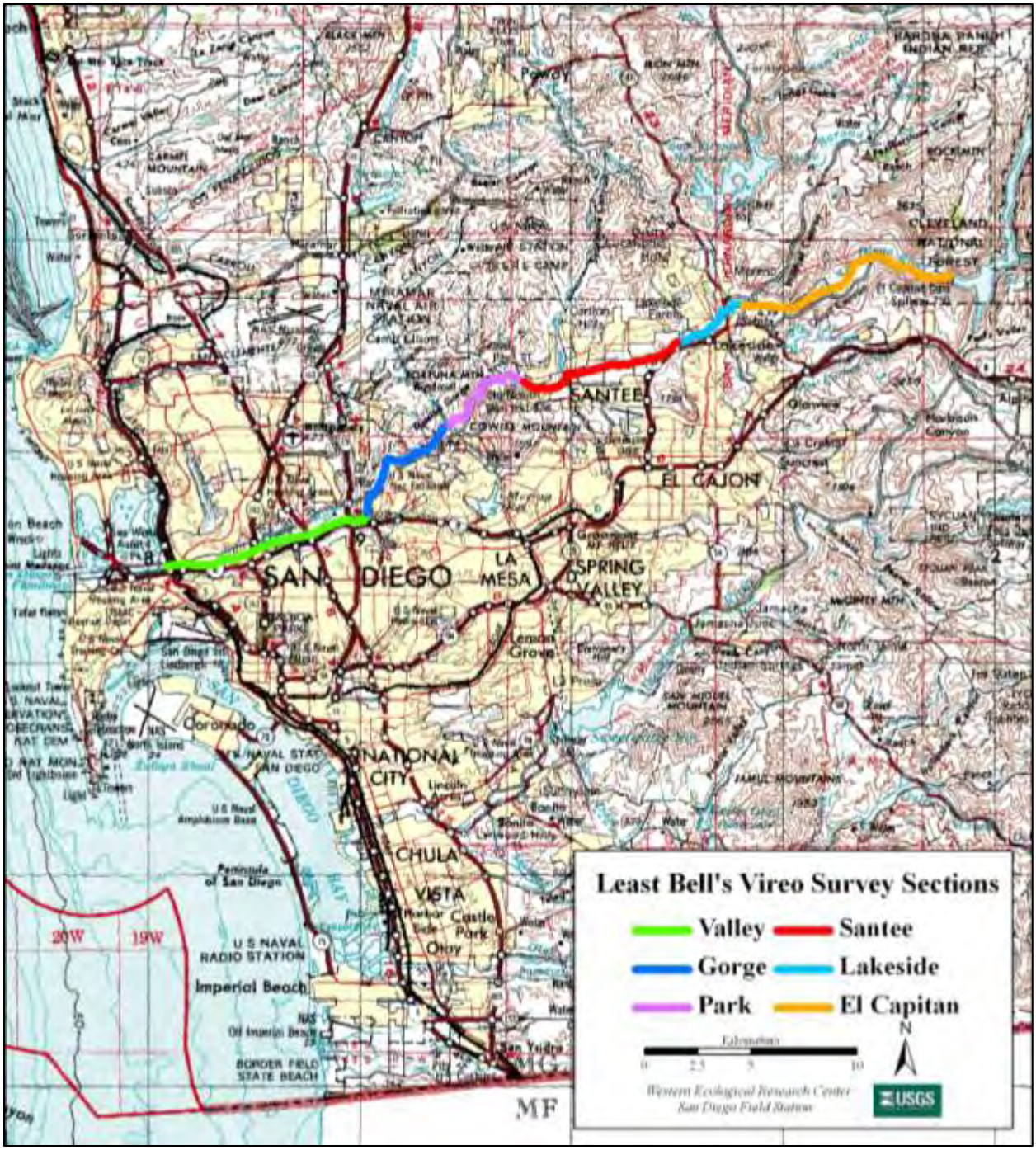

Fig. 1. Least Bell's Vireo survey sections along the San Diego River, 2011.

Giant reed was removed from the eastern part of the Valley survey section beginning in late 2008 and from the western part of the Santee survey section beginning in late 2009 (Fig. 2).

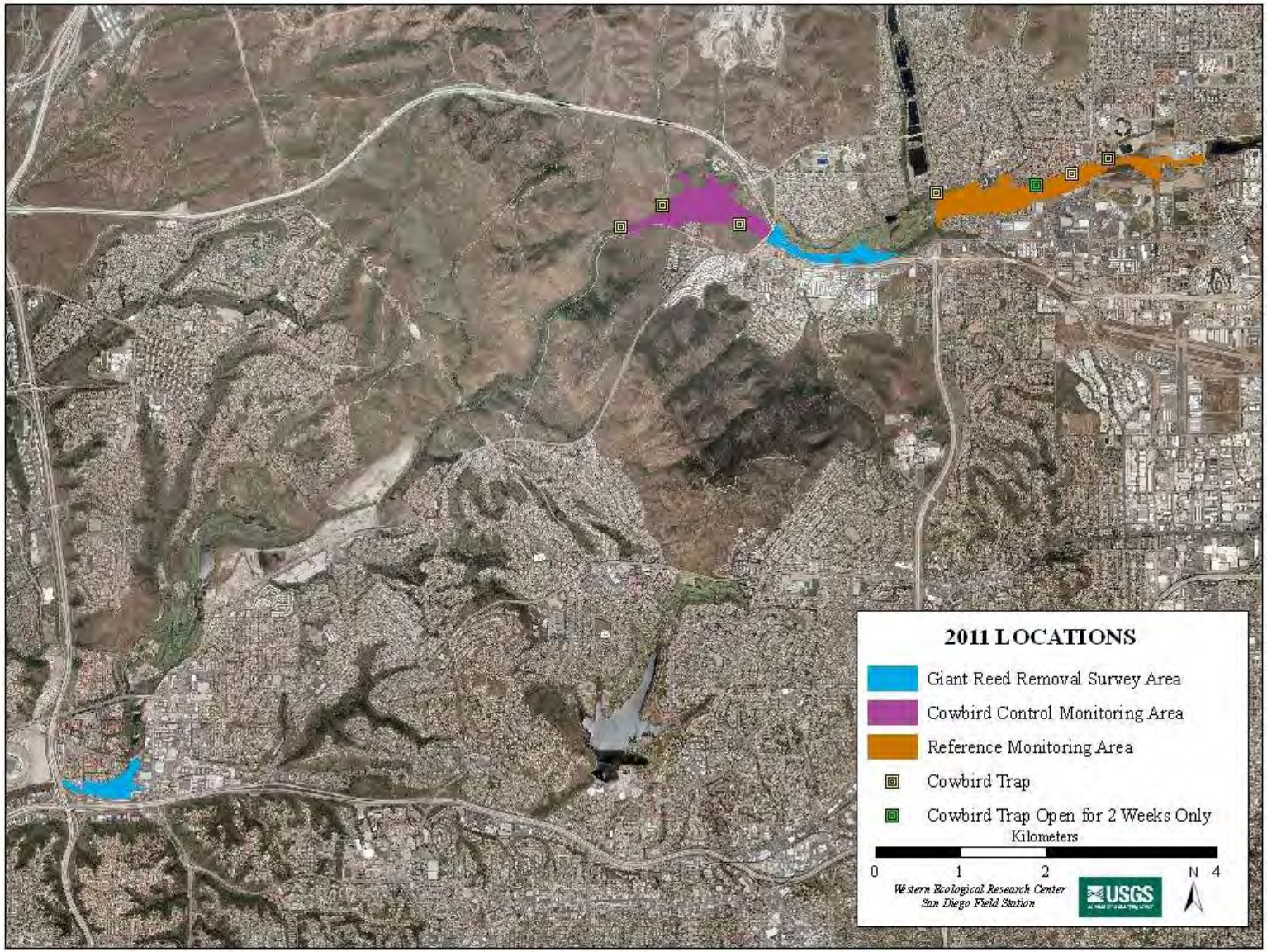

Fig. 2. Location of Least Bell's Vireo nest monitoring areas along the San Diego River, 2011.

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 visual identification was 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 again on subsequent surveys after an initial detection. Vireo locations were mapped using a Garmin 12 Global Positioning System (GPS) unit or Garmin GPS 60 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, arroyo willow, and red willow, with mule fat 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 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 vireos from 4 April through 27 July within two areas, one in which cowbird trapping occurred from 2009 through 2011 (hereafter referred to as "Treatment" site, in the Park survey section) and a paired site in which cowbird trapping began in 2011 (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, and attempts were made to monitor the same territories that had been monitored in previous years.

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 were recorded following abandonment or fledging of young from nests. These data included nest 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.

In 2011, three cowbird traps were operated from 1 April through 31 May in the Treatment site at the same locations they were operated in 2009 and 2010 (Sexton 2009, 2010, 2011; Fig. 2). In addition, three new cowbird traps were established in the Reference site and operated for the same dates (1 April through 31 May). 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 5-7 days of age with a single anodized light blue numbered federal band on the right (or, rarely, left) leg. 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, including either an anodized light blue or light blue plastic band to designate the San Diego River as the bird's site of origin. Returning adults previously banded as nestlings with a single numbered federal band were target netted to determine their identity, and their original band was supplemented with other bands to generate a unique color combination.

During surveys and nest monitoring activities, we attempted to resight all vireos to determine whether or not they were banded, and if so, to confirm the vireo's identity by reading the unique color band combination or by recapturing birds with single federal bands. We used resighting and recapture data to calculate annual survivorship, or the fraction of all individuals known to be present on the San Diego River in one year that returned the following year. Individuals "known to be present" in a given year included birds observed directly as well as individuals not observed but whose presence was inferred retroactively by their detection in a subsequent year. Imperfect detectability of banded individuals is typical of mark-recapture studies and occurs for various reasons (e.g., females are more cryptic and may be missed on surveys, birds are detected as banded but their full color combinations (and thus identities) are not obtained; birds with single federal bands are not recaptured and thus their identities not determined). Our previous estimates of annual survivorship therefore require adjustment each year to incorporate data for individuals not "seen" previously but known to have been alive.

Survivorship from 2010-2011 was calculated for known individuals that were: (1) adults in 2010 on the San Diego River and were resighted anywhere in 2011; (2) adult vireos that held territories in Treatment or Reference sites in 2010 and were resighted anywhere in 2011; (3) first-year vireos that were banded as nestlings or juveniles anywhere on the San Diego River in 2010 and were resighted anywhere in 2011; and (4) first-year vireos that were banded as nestlings or juveniles in Treatment or Reference sites in 2010 and were resighted anywhere in 2011. Unlike for estimates of overall survivorship of adults and juveniles (i.e., (1) and (3)), we did not adjust survivorship (see above) for analyses involving Treatment and Reference sites because we could not confirm the presence of birds in those specific sites during years that they were not detected.

Site fidelity and movements of vireos were determined by measuring the distance between the center of a vireo's breeding or natal territory in 2010 and the center of the same vireo's breeding territory in 2011. Vireos exhibited site fidelity if they returned to within 100 m of their 2010 territory. Site fidelity and movement were calculated for the same four categories analyzed for survivorship (see above), except that only individuals with known territory locations during the last year they were detected prior to 2011 were included (e.g., juveniles

banded after fledging were excluded because their natal territories could not be confirmed in light of their capacity for substantial movement).

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 survivorship, 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 Student's *t*-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 adult survivorship and nest fate between monitoring sites and between years. We used Pearson's correlation to determine if annual changes in cowbird parasitism were similar between Treatment and Reference 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

Drainage-wide

A total of 72 male Least Bell's Vireos were identified during surveys (Table 1, Appendix B, Figs. 13-18). This included 67 territorial male vireos, 42 (63%) of which were confirmed as paired, and five transients. Transient vireos were observed at two of the six sections surveyed. Four survey sections contained 94% of all male vireos (27% in Park, 27% in Santee, 22% in Gorge, and 18% in Lakeside; Table 1). Four territorial vireos (6%) were detected in the Valley survey section and no territorial vireos were detected in the El Capitan survey section.

Table 1. Number and distribution of Least Bell's Vireo males along the San Diego River, 2011.

Survey Section	Known Pairs	Single/ Status Undetermined	Total Territorial Males	Transient
Valley	1	3	4	0
Gorge	7	8	15	0
Park	12	6	18	3
Santee	16	2	18	2
Lakeside	6	6	12	0
El Capitan	0	0	0	0
Total	42	25	67	5

The distribution of vireo territories on the San Diego River in 2011 remained similar to the distribution in 2010, with the percent of territories that occur in each section changing by < 5% (Table 2). Overall, the vireo population on the San Diego River decreased by 26% from 2010-2011 (Fig. 3).

Table 2. Number of territorial male vireos and percent of total number that year on the San Diego River, by survey area and year, 2010-2011.

	Number of Territorial Males				Numeric/Percent Change	
Survey Area	2010		2011		2010-2011	
Valley	6	7%	4	6%	-2	-33%
Gorge	20	22%	15	22%	-5	-25%
Park	21	23%	18	27%	-3	-14%
Santee	26	29%	18	27%	-8	-31%
Lakeside	16	18%	12	18%	-4	-25%
El Capitan	1	1%	0	0%	-1	-100%
Total	90		67		-23	-26%

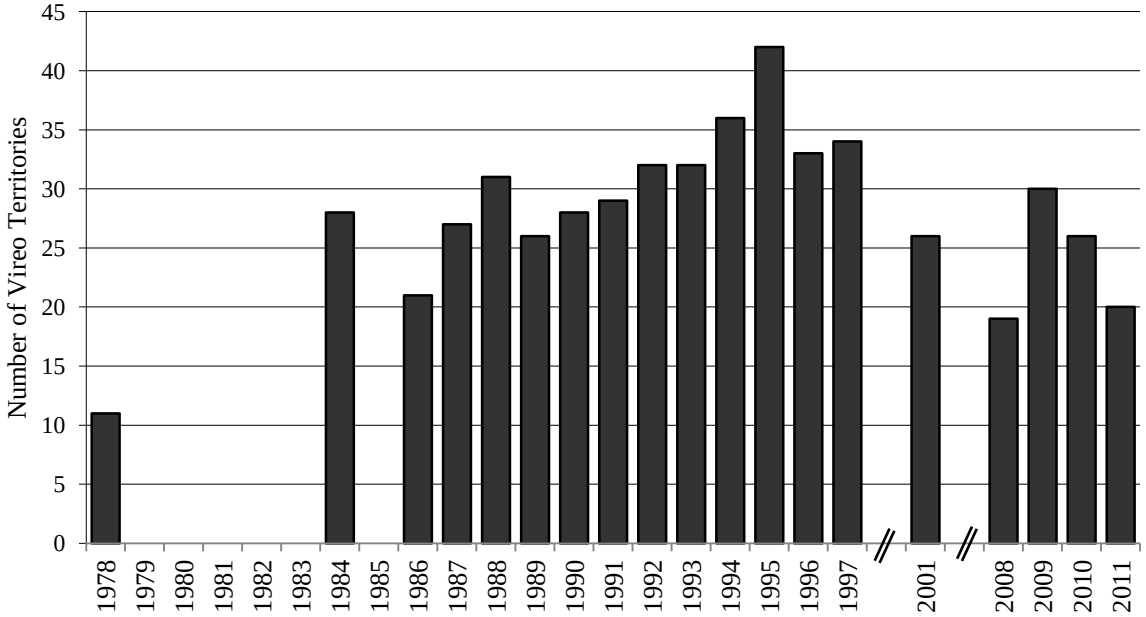

Fig. 3. Number of Least Bell's Vireo territories between Mission Dam and Santee, San Diego River, 1978-2011. Data compiled from Goldwasser 1978; Jones 1985; Kus 1989, 1992, 1994, 1995; Kus and Beck 1998; Wellik et al. 2009; USGS unpubl. data.

Giant Reed Removal Sites

No vireos were detected in the Valley giant reed removal site the year prior to giant reed removal or the first breeding season following weed control (Table 3). However, one vireo and one Willow Flycatcher (*Empidonax traillii*; see Incidental Detections below) were detected using the Valley site during the second breeding season following giant reed removal. During the third breeding season after giant reed removal (2011), once again no vireos were detected using the Valley giant reed removal site.

In the year prior to giant reed removal at the Santee site, three vireos were detected. During the breeding season following giant reed removal at the Santee site, two vireos were present, and during the second breeding season after weed control (2011), three vireos were present.

Table 3. Number of Least Bell's Vireo territories within giant reed removal sites, San Diego River.

Location of Giant Reed Removal	Breeding Season Relative to When Giant Reed Removal Occurred			
	Immediately Prior	One Year After	Two Years After	Three Years After
Valley	0	0	1	0
Santee	3	2	3	-

Habitat Characteristics

Vireos occupied five habitat types along the San Diego River (Table 4). The majority of vireo territories (57%) occurred in habitat characterized as mixed willow riparian, followed by willow habitat co-dominated by cottonwoods (39%). One vireo territory each occurred in riparian scrub, willow habitat co-dominated by sycamore, and upland scrub. Similar to 2008 and 2009, few vireo territories in 2011 contained a large proportion of exotic vegetation (Table 5). These territories contained abundant giant reed, and black mustard (*Brassica nigra*).

Table 4. Habitat types used by Least Bell's Vireos along the San Diego River, 2011.

	Number of Territories			
Habitat Type	**> 50% Native**	**> 50% Exotic**	**Total**	**Percent of Total**
Mixed Willow	36	2	38	57%
Willow/Cottonwood	26	0	26	39%
Riparian Scrub	1	0	1	1%
Willow/Sycamore	1	0	1	1%
Upland Scrub	1	0	1	1%
Total	65	2	67	100%

Table 5. Percent of Least Bell's Vireo territories dominated or co-dominated by exotic vegetation, by survey area, 2008-2011. Numbers in parentheses are the number of territories in the survey area.

	Percent of Territories							
Survey Area	**2008**		**2009**		**2010**		**2011**	
Lakeside	9%	(11)	0%	(14)	19%	(16)	8%	(12)
Gorge	0%	(9)	0%	(12)	15%	(20)	7%	(15)
Park	0%	(18)	0%	(24)	0%	(21)	0%	(18)
Santee	0%	(20)	3%	(30)	12%	(26)	0%	(18)
Valley	0%	(1)	67%	(3)	17%	(6)	0%	(4)
El Capitan	0%	(0)	0%	(0)	100%	(1)	0%	(0)
Total	2%	(59)	4%	(83)	12%	(90)	3%	(67)

Banded Birds

We observed 72 male and 45 female vireos on the San Diego River in 2011, including transients and individuals that were detected in more than one location. We were able to observe 107 adult vireos (71 males, 99% of all males, and 36 females, 80% of all females) well enough to determine banding status in 2011. Twenty-three of these had been banded prior to the 2011 breeding season, 18 of which already had unique color band combinations prior to 2011, 4 of which were "natal" birds, recaptured with a single federal band and given a unique color band combination, and 1 of which was natal and not recaptured (Table 6). The one natal vireo that was not recaptured had a light blue numbered federal band on the left leg indicating that she had been banded as a nestling on the San Diego River during the past 3 years (Tables 5 and 6). Of the 23 known-identity banded birds, 22 were originally banded on the San Diego River and 1 was originally banded on the San Luis Rey River as nestlings (Table 7; Appendix C). One other

vireo that was banded as a nestling on the San Diego River in 2010 was recaptured and banded on the Sweetwater River in 2011 (Table 6). Adult birds of known age ranged from 1-6 years old (Table 7).

Table 6. Banding status of Least Bell's Vireos detected on the San Diego River and those that emigrated to other drainages, 2011.

	Detected on the San Diego River			Emigrants		
Banding Status	**Male**	**Female**	**Subtotal**	**Male**	**Female**	**Total**
Uniquely banded prior to 2011	15	3	18	0	0	18
Natal recaptured in 2011	2	2	4	1[a]	0	5
Natal (Single numbered metal band)	0	1	1	0	0	1
Total	17	6	23	1	0	24

[a] Captured on the Sweetwater River in 2011.

Table 7. Number of banded adult Least Bell's Vireos on the San Diego River in 2011, by original year banded, age, original banding location, and sex.

Year Originally Banded	**Age in 2011**	**Number of Vireos Observed by Origin**				
		San Diego River		**San Luis Rey River**		
		Male	**Female**	**Male**	**Female**	**Total**
2006	≥7 yrs.	1	-	-	-	1
2008	≥4 yrs.	3	1	-	-	4
	3 yrs.	3	-	-	1	4
2009	≥3 yrs.	6	-	-	-	6
	2 yrs.	1	1	-	-	2
2010	≥2 yrs.	1	-	-	-	1
	1 yr.	2	2	-	-	4
Subtotal		17	4	0	1	22
Unknown	≥1 yrs.	-	1	-	-	1
Total		17	5	0	1	23

A total of 62 vireos were newly banded along the San Diego River in 2011. Twelve unbanded adult vireos were captured at their breeding territories in 2011 and given full band combinations (Table 8; Appendix C). Fifty nestlings were banded with a single light blue metal numbered federal band on the right leg.

Table 8. Summary of new Least Bell's Vireos captured and banded along the San Diego River in 2011.

Age Banded	Males	Females	Unknown Sex	Total
Adult	11	1	0	12
Nestling			50	50
Total	11	1	50	62

Survivorship, Fidelity, and Movement

Drainage-wide Survivorship

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 2011. 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. However, this baseline number can be used to calculate minimum annual survivorship for the vireo population along the river and can be adjusted annually to add in individuals that were not identified in a particular year but were detected in subsequent years (see Methods: Banding).

Adult Survivorship from 2010-2011

Of 34 uniquely color banded adult vireos present along the San Diego River during the 2010 breeding season, 41% (14/34) returned to the San Diego River in 2011 (Table 9). Two of the six banded adult female vireos present in 2010 were resighted in 2011, an over-winter survivorship rate of 33%. Twelve of the 28 banded adult male vireos present in 2010 were resighted in 2011, an over-winter survivorship rate of 43%. The remaining 20 vireos that had full color band combinations in 2010 were not resighted in 2011.

Four other vireos (three males and one female) were detected in 2011 that were not detected in 2010, requiring that we adjust our estimates of survivorship to account for these birds (see Methods). Adding these four vireos increased overall survivorship from 2010 to 2011 to 47% (18/38), male survivorship to 48% (15/31), and female survivorship to 43% (3/7). Generally, there is a discrepancy in estimates of sex-related over-winter survivorship 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.

Table 9. Number of banded adult Least Bell's Vireos detected in 2010 at Treatment sites, Reference sites, and other areas on the San Diego River, and those that were detected in 2011. Numbers in parentheses include the adjustments resulting from vireos that were identified in 2011 but not in 2010.

Year/Sex	Treatment Site	Reference Site	Other Areas	Total
2010				
Male	13	11	4	28 (31)
Female	4	2	0	6 (7)
Total	17	13	4	34 (38)
2011				
Male	6	4	2	12 (15)
Female	2	0	0	2 (3)
Total	8[a]	4[b]	2	14 (18)

[a] All occupied a territory at the Treatment site in 2010.
[b] All occupied a territory at the Reference site in 2010.

First-year Survivorship from 2010-2011

Four of the 38 hatch-year vireos banded in 2010 that survived to fledge were captured and given unique color band combinations on the San Diego River or elsewhere in 2011 (Table 10) yielding a conservative first-year survivorship of 11%. Assuming an equal sex ratio of banded nestlings, first-year survivorship of males was 11% (2/19) and females was 11% (2/19). Because female vireos are elusive and difficult to recapture, the first-year survivorship estimate may be conservative.

Table 10. Number of Least Bell's Vireos banded as nestlings or fledglings at Treatment sites, Reference sites, and other areas along the San Diego River in 2010, and where those that returned were detected in 2011.

Year/Sex	Treatment Site	Reference Site	Other Areas	Total
2010				
Unknown	29	9	0	38
2011				
Male	1[a]	0	1[b]	2
Female	1[a]	0	1[a]	2
Total	2	0	2	4

[a] Banded as a nestling at the Treatment site in 2010, found in 2011 on the San Diego River.
[b] Banded as a nestling at the Reference site in 2010, found in 2011 on the Sweetwater River.

Adjusted Annual Survivorship for Previous Years

Four banded adult vireos were identified in 2011 that were not detected in 2010. Three were originally banded on the San Diego River in 2008, one male as a nestling, one male as an adult, and one female as an adult. The fourth vireo, a male, was banded as an adult on the San Diego River in 2006 (K. Moore, pers. comm.). These detections increase first-year survivorship

for 2008-2009 from 17% to 19%, adult survivorship for the same years from 80% to 84%, and adult survivorship for 2009-2010 from 69% to 73% (Table 11).

Table 11. Adjustments to first-year and adult Least Bell's Vireo survivorship on the San Diego River, 2011. These numbers update survivorship estimates presented in Wellik et al. 2009, Lynn et al. 2010, Lynn and Kus 2010b.

	First-year Survivorship			Adult Survivorship		
Years	Original	Last Year	New	Original	Last Year	New
2008-2009	15%	17%	19%	72%	80%	84%
2009-2010	-	9%	9%	-	69%	73%
2010-2011	-	-	11%	-	-	47%

Survivorship at Treatment and Reference Sites

Of the 17 vireos of known sex (13 males and 4 females) that were detected within the Treatment site in 2010, eight (six males and two females) were resighted in 2011 for a 47% survival rate (46% for males, 50% for females; Table 9). Of the 13 banded adult vireos of known sex (11 males and 2 females) that were detected within the Reference site in 2010, four (all males) were resighted in 2011 for a 31% survival rate (36% for males, 0% for females). Survivorship for adults was not significantly different between the Treatment and Reference sites (Fisher's Exact $P = 0.47$). No adult vireos moved between Treatment and Reference sites between 2010 and 2011. All 38 banded juveniles that were known to fledge in 2010 were banded at Treatment or Reference sites. Four (one male and two females from the Treatment site and one male from the Reference site) were recaptured in 2011 for a first-year survivorship rate of 10% for fledglings from the Treatment site and 11% for fledglings from the Reference site (Table 10).

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. Fourteen adult vireos that were identified in 2010 were resighted in 2011, all of which occupied known territories both years (Table 12). Ten adult vireos (71%; all males) that returned in 2011 occupied the same breeding territory that they did in 2010. The remaining four vireos (29%; two males and two females) returned to occupy territories adjacent to their 2010 territories (within 300 m).

Four other vireos were not detected in 2010 but were observed in 2009 and detected on the San Diego River in 2011. One male was banded as a nestling on the San Diego River in 2008 and was detected in 2011 occupying a territory 1.8 km from his natal territory. One female and one male were banded as adults in 2008; the female was detected in 2011 0.2 km from her 2008 territory, and the male was detected in 2011 0.1 km from his 2009 territory. The fourth vireo was a male banded as an adult on the San Diego River and detected in 2011 0.1 km from his 2009 territory (Table 12).

Three of the four first-year vireos that had been banded as nestlings along the San Diego River in 2010 were resighted on the San Diego River 2011 and dispersed an average of 1.0 ± 1.0 km from their natal sites (0.7 km for the one male and 0.2-2.1 km for females; Table 12). The fourth first-year vireo detected in 2011 was found on the Sweetwater River, 12.7 km from his natal territory. Overall, first-year vireos were detected 3.9 ± 5.9 km from their 2010 natal territories.

Table 12. Between-year movement of Least Bell's Vireos along the San Diego River.

Year Last	Drainage[a] / Territory / Treatment		Distance Moved	Band Combination[b]		Age in	
Detected	Last Seen	2011	km	Left Leg	Right Leg	2011	Sex[c]
2010	SDR / SGPP / TMT	SDR / SGPP / TMT	0.02	Mlb	BKBK/pupu	≥ 4	M
2010	SDR / WMB2 / TMT	SDR / WMB2 / TMT	0.02	DPWH/Mlb		≥ 4	M
2010	SDR / JOY / REF	SDR / JOY / REF	0.01	Mlb	BKLB/pupu	≥ 3	M
2010	SDR / SGCA / REF	SDR / SGCA / REF	0.02	BKLB/pupu	Mlb	≥ 3	M
2010	SDR / FJS2 / TMT	SDR / FJS2 / TMT	0.05		BKLB/Mlb	≥ 3	M
2010	SDR / POR / REF	SDR / POR / REF	0.08	YEYE/Mlb		≥ 3	M
2010	SDR / ALT / REF	SDR / MER / REF	0.09		LBBK/Mlb	≥ 3	M
2010	SDR / CCO / TMT	SDR / CCO / TMT	0.20	LBLB/Mlb		≥ 3	M
2010	SDR / EDD / TMT	SDR / EDD / TMT	0.06		DPWH/Mlb	3	M
2010	SDR / PA07	SDR / ORD / TMT	0.06	YEPU/Mlb	pupu	3	M
2010	SDR / TOW / TMT	SDR / HTS / TMT	0.19		BKLP/Mlb	≥ 2	M
2010	SDR / VA03	SDR / VA03	0.01		PUYE/Mlb	2	M
2010	SDR / SGPN / TMT	SDR / PA08 / TMT	0.67	Mlb	WHDP/pupu	1	M
2010	SDR / POR / REF	SWR / SN15	12.71	LPBK/Mlb	pupu	1	M
2010	SDR / HTS / TMT	SDR / ORD / TMT	0.19	BKLB/Mlb	pupu	1	F
2010	SDR / WMB2 / TMT	SDR / PA07	2.10	DPWH/Mlb	pupu	1	F
2010	SDR / SGPN / TMT	SDR / SGPP / TMT	0.11	WHWH/Mdb	LPBK	3	F
2010	SDR / CCO / TMT	SDR / CCO / TMT	0.20		WHDP/Mlb	2	F
2009	SDR / GO01	SDR / GO17	0.05		LPBK/Mlb	≥ 4	M
2009	SDR / SIG	SDR / LA07	0.13		Msi	≥ 6	M
2008	SDR / WMB2 / TMT	SDR / BHV / TMT	1.79	PUPU/Mlb	pupu	3	M
2008	SDR / SGSA / REF	SDR / SGFU[d] / REF	0.21	PUPU/pupu	Mlb	≥ 4	F

[a] Drainage Codes: SDR = San Diego River; SWR = Sweetwater River; Treatment codes: TMT = Treatment site; REF = Reference site.

[b] Band Colors: Mdb = dark blue numbered federal band; Mlb = light blue numbered federal band; Msi = silver numbered federal band; pupu = metal purple; BKBK = plastic black; BKLB = plastic black-light blue split; BKLP = plastic black-light pink split; DPWH = plastic dark pink-white split; LBBK = plastic light blue-black split; LBLB = plastic light blue; LPBK = plastic light pink-black split; PUPU = plastic purple; PUYE = plastic purple-yellow split; WHDP = plastic white-dark pink split; WHWH = plastic white; YEPU = plastic yellow-purple split; YEYE = plastic yellow.

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

[d] This female bred at two locations in 2011.

Site Fidelity and Movement at Treatment and Reference Sites

Eight adult vireos (six males and two females) that were identified at Treatment sites in 2010 were resighted in 2011 (Table 12). Four of these (all males) returned in 2011 to occupy the same territory that they did in 2010. The remaining four (two males and two females) returned in 2011 to occupy a territory adjacent to their 2010 territory. All four adult vireos that were

identified at Reference sites in 2010 and were resighted in 2011 returned to occupy the same territory that they did in 2010 (Table 12).

Incidental Detections

On 1 June, during a vireo survey, we detected a single Willow Flycatcher in the Valley survey area (Fig. 12). The flycatcher was not found during subsequent attempts to detect it to determine banding, status, breeding status, or subspecies.

Nest Monitoring

A total of 22 territories were monitored for nesting activity within the Treatment and Reference monitoring sites (Table 13; Figs. 4 and 5; Appendix D). All of territories were "fully" monitored, meaning that all nests within the territory were found and documented during the breeding season. At one fully monitored territory in the Reference monitoring site, the male remained single throughout the 2011 breeding season and therefore no nests were completed in this territory. This territory was excluded from nest monitoring analyses. A total of 38 nests were monitored during the breeding season; however, four of these were not completed (coded as "INC" of "FAL" in Appendix D) and have been excluded from calculations of nest success and productivity.

Table 13. Number of Least Bell's Vireo territories and nests monitored at Treatment and Reference sites on the San Diego River, 2011. Averages presented as mean ± standard deviation.

	Nest Monitoring Site/Type		
	Treatment	**Reference**	**Total**
Territories fully monitored	11	11[a]	22
Nests in monitored territories[b]	23	15	38
Completed nests per pair	1.9 ± 0.7	1.3 ± 0.5	1.6 ± 0.7

[a] Includes one territory with a single male.
[b] Includes incomplete nests (two at the Treatment site and two at the Reference site).

Fig. 4. Locations of monitored Least Bell's Vireo territories at the Park Brown-headed Cowbird removal (Treatment) site, San Diego River, 2011.

Fig. 5. Locations of monitored Least Bell's Vireo territories at the Santee Reference site, San Diego River, 2011. Trap labeled 5a was only operated for 2 weeks at the beginning of the field season.

Nest Initiation

Nesting activity started in mid-April and continued until early July (Fig. 6). Excluding the one territory with a single male, 24% (5/21) of the pairs had attempted nesting by the end of April, and 90% (19/21) by the end of May. Two pairs did not initiate nesting until June.

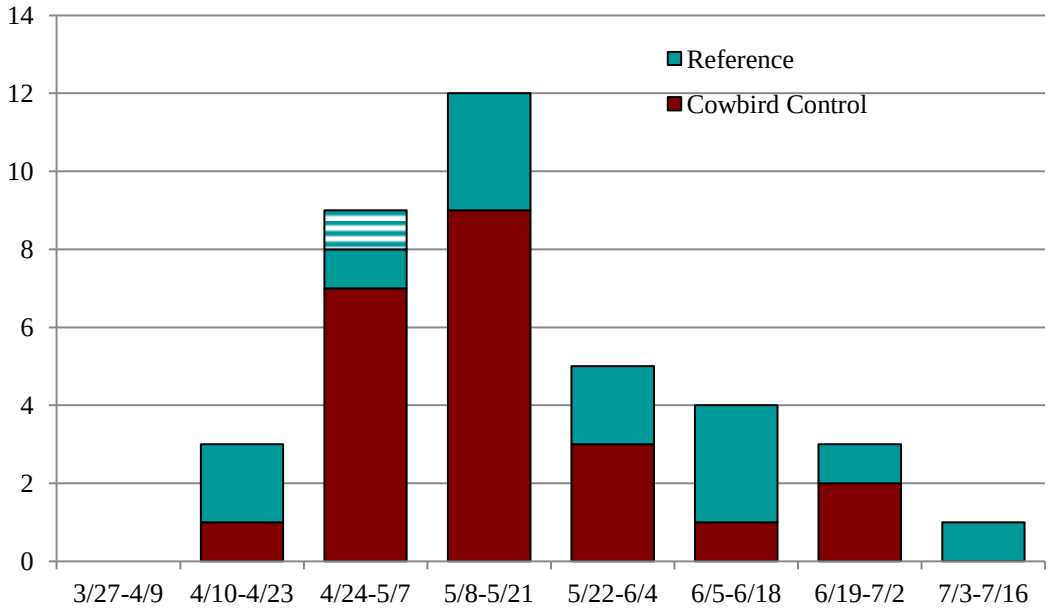

Fig. 6. Number of Least Bell's Vireo nests and those that were parasitized by Brown-headed Cowbirds by 2-week intervals, San Diego River, 2011. Parasitized nests represented by horizontal hatching.

Every fully monitored pair initiated at least one nest in 2011. Of paired males, 11 (52%) re-nested after first attempts. Two pairs (18%) re-nested after a successful first nest, and nine pairs (82%) initiated a second nest after a failed first attempt. Three of the 11 pairs that re-nested after a first attempt (27%) had successful second nests (all after failed first attempts). Four of the 11 pairs (36%) initiated a third nesting attempt, two of which were successful. One pair attempted a fourth nest, successfully fledging young on their fourth attempt. No pairs successfully fledged two broods in 2011. Pairs at the Treatment site completed more nests than pairs at the Reference site (Table 13; $t = 2.30$, $P = 0.03$).

Cowbird Parasitism

A total of 30 cowbirds were captured and removed from the Treatment site (20 males and 10 females) and 21 from the Reference site (11 males and 10 females) in 2011 (Sexton 2011; Fig. 3). No juvenile cowbirds were captured in 2011.

Only one (3%) of all completed vireo nests was parasitized by cowbirds in 2011, a nest at the Reference site initiated during the first week of May (4 May). The cowbird egg was removed on the date it was discovered; one intact vireo egg was found under the nest and a second vireo egg was missing. Parasitism did not cause the nest to fail, and the successful nest was responsible for the production of 5% (2/41) of all vireo young fledged among our monitored pairs. No monitored nests contained cowbird nestlings or fledged cowbird young.

Parasitism at the Treatment site, where trapping began in year 2, was consistently lower than at the Reference site across all four years (Fig. 7). In 2011, cowbird parasitism reached a project-wide low of 3% (1/34 completed nests) when trapping was implemented throughout the entire study site. Parasitism at both the Treatment and Reference sites has declined consistently since 2008, and the decreases at the two sites are highly correlated (Pearson's $R = 0.95$; Fig. 7).

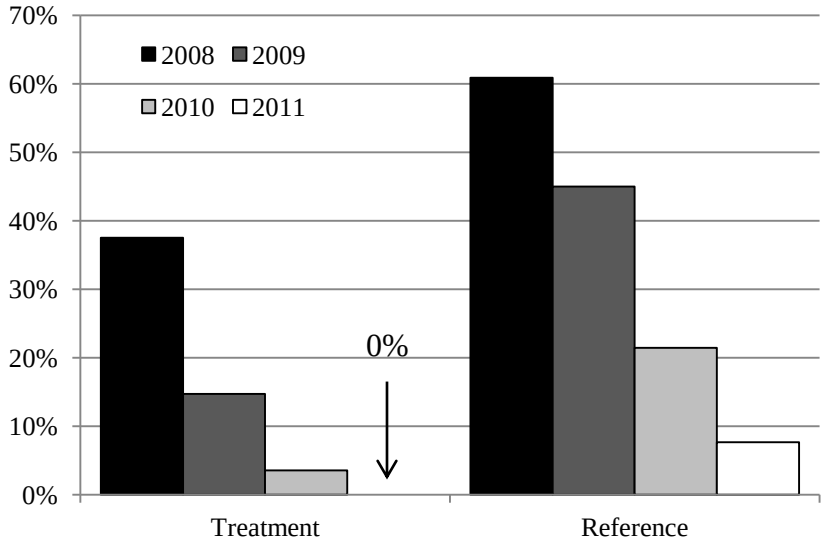

Figure 7. Percent of Least Bell's Vireo nests that were parasitized by Brown-headed Cowbirds at Treatment and Reference sites, 2008-2011, San Diego River, CA.

Fate of Nests

Forty-four percent of the completed nests among our monitored pairs were successful, producing at least one vireo fledgling (Table 14). One 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 2010 would have been reduced by 3%. Nest success did not differ significantly by site (Fisher's Exact $P = 0.73$). Counting all parasitized nests as failed, nest success still did not significantly differ by site (Fisher's Exact $P = 0.48$).

Table 14. Fate of Least Bell's Vireo nests in fully monitored territories, San Diego River, 2011. Numbers in parentheses are percent of total nests.

	Number of Nests					
Nest Fate	**Treatment**		**Reference**		**Total**	
Successful	10	(48%)	5	(39%)	15	(44%)
Failed						
Predation	9	(43%)	6	(46%)	15	(44%)
Parasitism	0	(0%)	0	(0%)	0	(0%)
Other/Unknown	2	(10%)	2	(15%)	4	(12%)
Total Completed Nests	21		13		34	

Fifty-six percent of nests observed were unsuccessful in fledging vireo young (Table 14). Nest failure throughout the monitoring sites was primarily attributed to predation (79% of all nests that failed), although predation events were 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. Cooper's Hawks (*Accipiter cooperii*) and Red-shouldered Hawks (*Buteo lineatus*) were active in two territories where nests failed as a result of predation. Other potential predators include snakes (Clark 2009), birds such as Western Scrub-jays (*Aphelocoma californica*), 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. No eggs were seen in one nest at the Treatment site which may have been depredated or abandoned between nest-building and egg-laying. One nest at the Treatment site was abandoned with two cold, wet eggs after a night-time rainstorm. One nest at the Reference site was abandoned with nestlings after the nest came loose from the supporting branch and tilted sideways. One nest at the Reference site was abandoned with vireo eggs for unknown reasons.

Productivity

Reproductive indices for vireos differed between the Treatment and Reference nest monitoring sites. Average clutch size was significantly larger at the Reference site than at the Treatment site (Table 15). Hatching success was high and was similar between sites. We documented at least 41 fledglings in 2011, most of which (68%) came from nests in the Treatment site. The total number of fledglings in 2011 would be reduced by two if parasitized nests had been allowed to fail. The number of fledglings per pair was significantly higher at the Treatment site than at the Reference site, whether or not we assumed that the nest that had been parasitized would have failed if not rescued by removing the cowbird egg (Table 15).

Table 15. Reproductive success and productivity of nesting Least Bell's Vireos, San Diego River, 2011. Averages presented as mean ± standard deviation.

	Total Number		
Parameter	**Treatment**	**Reference**	**Total**
Nests with eggs	20	13	33
Eggs laid	58	46	104
Average clutch size			
Non-Parasitized[a]	3.3 ± 0.8	3.7 ± 0.5	3.5 ± 0.7
Parasitized[b]	0	4	4
Hatchlings	36	31	67
Nests with hatchlings	13	10	23
Hatching success:			
Eggs[c]	62%	67%	64%
Nests[d]	65%	77%	70%
Fledglings	28 (28)[e]	13 (11)[e]	41 (39)[e]
Nests with fledglings	10 (10)[e]	5 (4)[e]	15 (14)[e]
Fledging success:			
Hatchlings[f]	78% (78%)[e]	42% (35%)[e]	62% (58%)[e]
Nests[g]	77% (77%)[e]	50% (40%)[e]	65% (61%)[e]
Fledglings per egg	0.5 (0.5)[e]	0.3 (0.2)[e]	0.4 (0.4)[e]
Fledglings per nest	1.4 (1.4)[e]	1.0 (0.8)[e]	1.2 (1.2)[e]
Average number of young fledged per pair[h]	2.5 ± 1.2 (2.5 ± 1.2)[e]	1.3 ± 1.5 (1.2 ± 1.6)[e]	2.0 ± 1.5 (2.0 ± 2.0)[e]
Pairs fledging ≥1 young	10 / 91% (10 / 91%)[e]	5 / 50% (4 / 40%)[e]	15 / 71% (14 / 67%)[e]

[a] Based on 15 Treatment and 11 Reference non-parasitized nests with a full clutch. t = -1.84, P = 0.08.
[b] Based on one Reference parasitized nest.
[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 11 Treatment and 10 Reference pairs. t = 2.08, P = 0.05. If parasitized nests were allowed to fail, t = 2.39, P = 0.03.

Nest Characteristics

In 2011, successful and unsuccessful nests within monitoring sites had similar nest placement characteristics, except successful nests were higher than unsuccessful nests at Reference sites (Table 16). Combining successful and unsuccessful nests within sites, we found

that nests in the Treatment site were significantly lower and closer to the edge of the nest clump than nests in the Reference site (Table 17).

Table 16. 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, 2011. 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)	0.61	0.71	9, 13	47.5	0.46
Average host height (m)	3.15	3.58	10, 13	60.5	0.78
Average distance to edge of host (m)	0.73	0.65	10, 13	58.0	0.66
Average distance to edge of clump (m)	1.46	0.96	10, 13	81.5	0.30
Average distance to edge of riparian vegetation (m)	19.10	20.12	10, 13	57.0	0.62
Reference Site					
Average nest height (m)	1.41 (1.20)	0.86 (1.00)	5, 9 (4, 10)	36.5 (27.5)	**0.06** (0.29)
Average host height (m)	5.00 (4.13)	3.86 (4.33)	5, 9 (4, 10)	30.5 (21.5)	0.28 (0.83)
Average distance to edge of host (m)	0.95 (1.05)	0.75 (0.75)	5, 9 (4, 10)	22.5 (18.0)	> 0.99 (0.78)
Average distance to edge of clump (m)	4.74 (4.93)	2.98 (3.08)	5, 9 (4, 10)	23.0 (16.5)	0.95 (0.62)
Average distance to edge of riparian vegetation (m)	27.00 (28.90)	23.38 (22.98)	5, 9 (4, 10)	26.0 (23.0)	0.64 (0.67)

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

Table 17. Least Bell's Vireo nest characteristics and results of Mann-Whitney *U*-tests between monitoring sites along the San Diego River, 2011.

Nest Placement Characteristic	**Treatment**	**Reference**	***U*[a]**	***P*[b]**
Average nest height (m)	0.67	1.05	76.0	**0.01**
Average host height (m)	3.39	4.27	122.0	0.22
Average distance to edge of host (m)	0.68	0.82	151.0	0.75
Average distance to edge of clump (m)	1.18	3.61	35.0	< **0.01**
Average distance to edge of riparian vegetation (m)	19.67	24.67	135.0	0.42

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

Ten plant species were used as hosts for vireo nests at monitoring sites in 2011, although not all were used within each site (Table 18). Vireos used eight of the ten at the Treatment site and six of the ten species at the Reference site. Host species selection differed between sites, with only four species used at both sites. At the Treatment site, 64% of vireo nests were placed in willows and mule fat while 78% of the vireo nests at the Reference site were placed in willows and mule fat. Three vireo nests at the Treatment site were built in exotic plant species (two in black mustard and one in thistle; *Cirsium* sp.) and one of these nests was unsuccessful (in black

mustard). One vireo nest at the Reference site was built in an exotic host species (poison hemlock; *Conium maculatum*) and it was successful.

Table 18. Host plant species used by Least Bell's Vireos at monitoring sites along the San Diego River, 2011. Numbers in parentheses are proportions of total nests at that site.

	Number of Nests	
Host Species	**Treatment**	**Reference**
Mule fat	7 (0.30)	5 (0.36)
Arroyo or red willow	7 (0.30)	3 (0.21)
Black willow	1 (0.04)	3 (0.21)
Coast live oak	3 (0.13)	1 (0.07)
Black mustard	2 (0.09)	-
Elderberry (*Sambucus nigra*)	1 (0.04)	-
Thistle	1 (0.04)	-
Toyon (*Heteromeles arbutifolia*)	1 (0.04)	-
Poison hemlock	-	1 (0.07)
California Sycamore	-	1 (0.07)

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) in 25 of the past 34 years and increased from 11 territories in 1978 to a high of 42 territorial males in 1995 (Fig. 3). By 2008, this number dropped to its lowest point since 1978 (19), then nearly doubled in 2009, then dropped in 2010 and again, to near its lowest point, in 2011.

The number of vireo territories along the San Diego River follows the general trend in vireo numbers throughout southern California, where the vireo population increased dramatically since the mid-1980s (Lynn and Kus 2010a, Ferree et al. 2010). Similar to Marine Corps Base Camp Pendleton and the lower San Luis Rey River, vireo populations peaked in 2009/2010 and then dropped in 2011 (Ferree et al. 2011; Lynn and Kus 2011). The peak and subsequent declines in vireo numbers rangewide appear to be a response to exceptionally high productivity in 2008 and to a lesser extent 2009, followed by years of more typical productivity. Much of the population growth at the San Diego River in 2009 was likely attributable to immigration coupled with high over-wintering survival of both juveniles and adults, as productivity at our study site has differed little over the last 4 years. Since 2009, juvenile and adult survivorship has declined at the San Diego River, consistent with the declining population size.

In addition to providing estimates of juvenile and adult survivorship, our banding studies have allowed us to document immigration and emigration, two important demographic parameters influencing population size. Twenty-three banded vireos were resighted along the San Diego River in 2011. One of these vireos had dispersed from her natal drainage (the San

Luis Rey River; Ferree et al. 2008) to the San Diego River, demonstrating the potential for vireos to move far beyond their natal drainages. Similarly, one male vireo that was banded as a nestling on the San Diego River in 2010 was detected on the Sweetwater River in 2011 (Pottinger and Kus 2011). Vireos in other years have moved from the San Diego River to Marine Corps Base Camp Pendleton (Lynn et al. 2010, Lynn and Kus 2010a,), in further support of the vireos' ability to move between drainages. On the other hand, many of the adult vireos that returned to the San Diego River in 2011 occupied the same territories that they had in 2010, demonstrating strong fidelity to breeding sites once established. 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.

The degradation 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 present in sections of the river in 2008 and 2009, and removal had begun in the eastern extent of the Valley survey section in late 2008/early 2009. Removal of giant reed also occurred in the Santee section, along the Carlton Oaks Golf Course, starting in November 2009. To date, we have not seen a significant increase in vireo or flycatcher use of areas where giant reed has been removed, however, vireos are beginning to use these areas. In 2010, we detected a pair of vireos using the periphery of the Valley clearing and a single Willow Flycatcher within the clearing using dead stalks of giant reed as foraging perches (Lynn and Kus 2010b). However, in 2011, no vireos or flycatchers were observed using the Valley cleared area. No new vireo territories were detected in the giant reed removal area in the Santee section in 2010. In 2011, a vireo territory at the eastern edge of this clearing shifted westward to include a larger proportion of the removal area. Colonization of restored riparian vegetation by vireos is dependent on the proximity to mature, occupied habitat and the development of suitable nesting habitat structure within the site, which may take 3-5 years, depending on rainfall and other conditions (Kus 1998). Although we have seen little response to giant reed removal thus far, we expect that vireos and flycatchers will begin using these areas as the native vegetation recovers and the habitat becomes more suitable.

We did not sample vegetation in areas unoccupied by vireos to quantify the extent of exotic vegetation throughout the drainage; however, vireos may expand into these areas when population numbers are high. In 2010, when the vireo population peaked, 12% of vireo territories were placed in non-native vegetation, while only 2-4% of territories were placed in non-native vegetation in 2008, 2009, and 2011, when the vireo population was smaller. The Valley survey section continued to contain extensive patches of giant reed which were not occupied in 2008, 2009, 2010, or 2011, although vireos continued to occupy more suitable habitat in 2011.

In addition to habitat loss and degradation, cowbird parasitism is a major determinant of vireo productivity and abundance (Kus and Whitfield 2005). Cowbird trapping has been shown

to decrease the incidence of cowbird nest parasitism; for example, at Marine Corps Base Camp Pendleton and the lower San Luis Rey River, intensive programs to control Brown-headed Cowbirds have virtually eliminated cowbird parasitism of Least Bell's Vireo nests and facilitated vireo population growth. Parasitism was relatively high at the San Diego River in the absence of trapping during the first year of our study (2008), when over half the vireo nests (34/65) were parasitized. Since this baseline year, experimentally controlled trapping in a portion of the study area has allowed us to document consistently lower rates of parasitism of vireo nests in the Treatment area relative to the untrapped Reference area. Shortening the trapping period by 2 months did not diminish the effectiveness of trapping, and there has been no parasitism in the Treatment site since 2010. In 2011, we deployed traps in the Reference site, and although one instance of parasitism was observed there, our prediction that parasitism rates would decline relative to previous untrapped years was upheld. Our observations that parasitism rates have declined over the course of the study at both sites suggests that the radius of effectiveness of Treatment site traps may extend into the Reference site; this warrants further examination through spatial modeling of parasitized nests relative to distance from traps.

Although cowbird trapping in 2011 reduced parasitism and associated failure of vireo nests in the Reference site, it did not result in an increase in productivity of Reference pairs to match that of Treatment pairs. Treatment pairs fledged over twice as many young on average as did Reference pairs (2.5 versus 1.2 young per pair, respectively), as has been the case during previous years of the study. Because most nest site characteristics did not differ between Treatment and Reference sites, or between successful and unsuccessful nests either at the Reference site or at the Treatment site, 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. Human disturbance in the Reference site may be contributing to damage and abandonment of vireo nests and may represent an additional source of nest failure not common in the Treatment site; this possibility warrants further examination.

In 2011, we detected a single Willow Flycatcher on the San Diego River. This bird was only observed once and we were unable to ascertain whether it was banded or what subspecies it was. In 2010, a banded Southwestern Willow Flycatcher was detected 8 km upstream and remained in the same area for approximately 3 weeks, although it was not paired. In 2009, a different banded single flycatcher was detected on the San Diego River, approximately midway between the 2010 flycatcher and the 2011 flycatcher. The movement of the 2009 and 2010 birds, both of which had been banded as nestlings at Marine Corps Base Camp Pendleton (Howell and Kus 2009, 2010), and the discovery of another flycatcher in the same general area in 2011 demonstrate the ability of this species to colonize new areas, and further suggest 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 2011, 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 flycatchers that we found in 2009, 2010, and 2011, 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 recent detections represent the re-establishment (or new establishment) of a population of this species on the San Diego River.

FUTURE DIRECTIONS

In 2012 (year 5 of our study), following our experimental design, cowbird traps will not be operated along the San Diego River but we will continue to monitor vireo nests to assess the effect of intermittent trapping on parasitism rates, and to determine whether vireo population goals can be maintained with trapping every other year. Future aspects of the study will also include adjusting the number and placement of cowbird traps based on spatial analysis of cowbird parasitism and cowbird abundance in prior years. 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, 2011

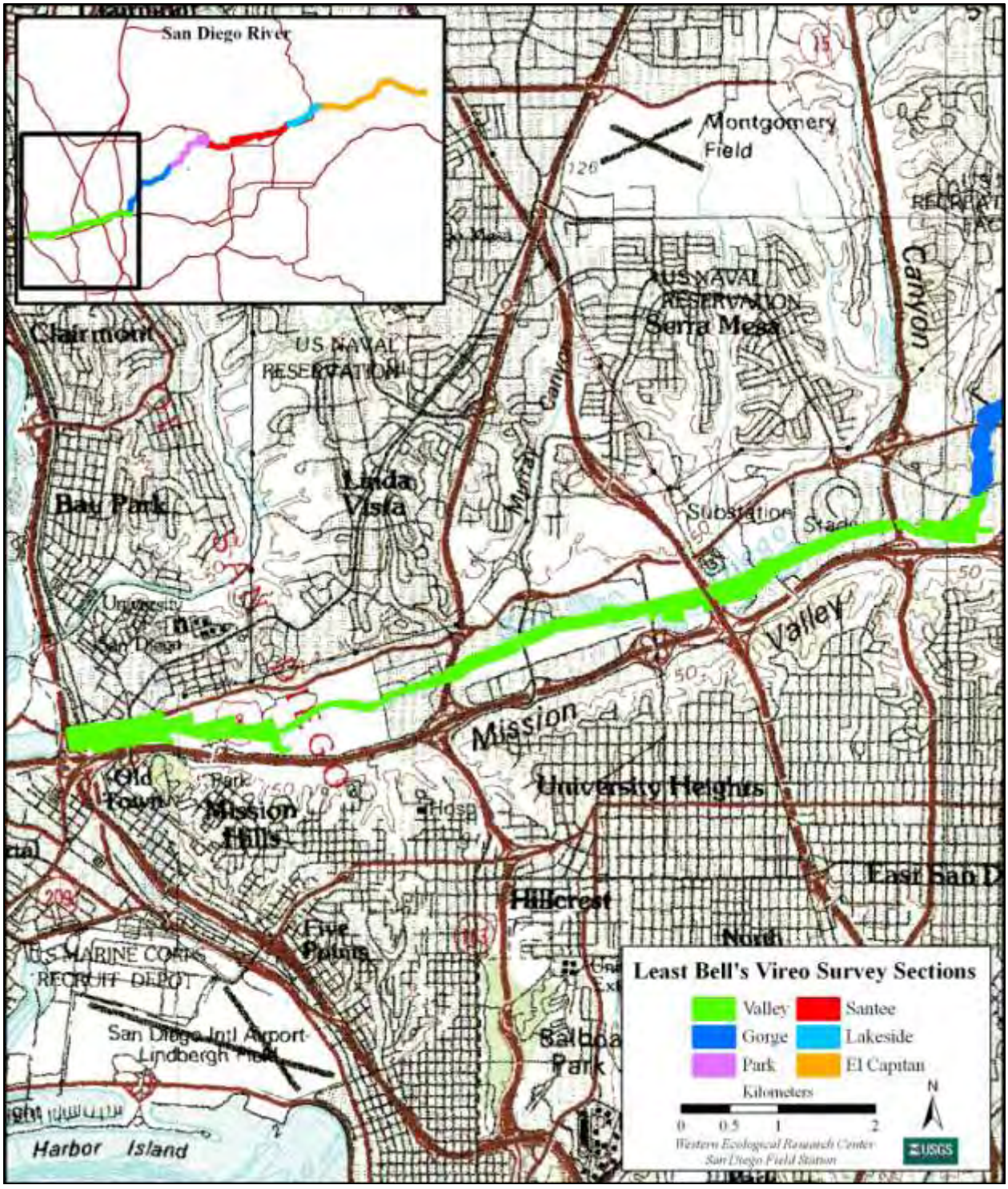

Fig. 8. Least Bell's Vireo survey areas along the San Diego River, 2011: Valley.

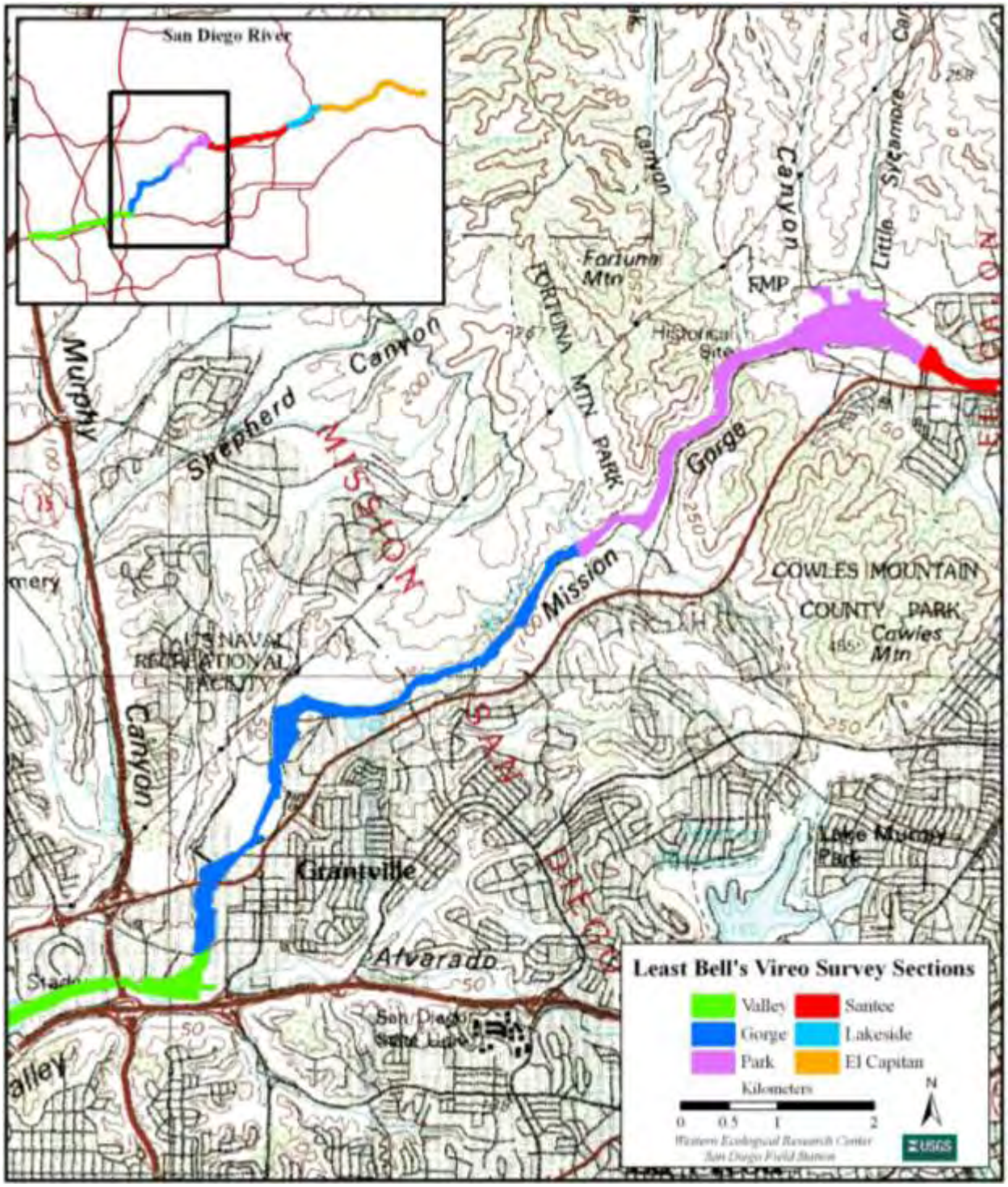

Fig. 9. Least Bell's Vireo survey areas along the San Diego River, 2011: Gorge and Park.

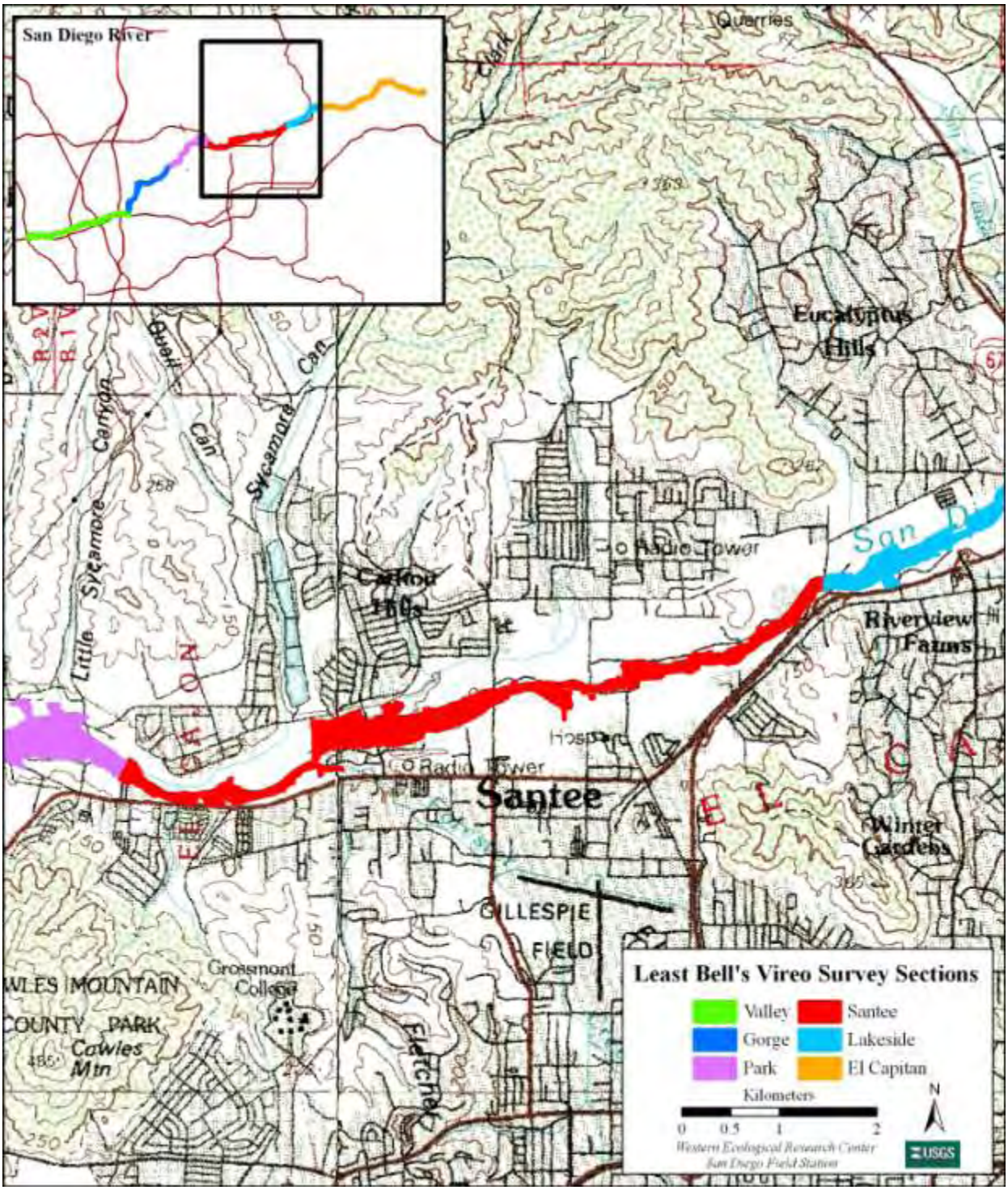

Fig. 10. Least Bell's Vireo survey areas along the San Diego River, 2011: Santee.

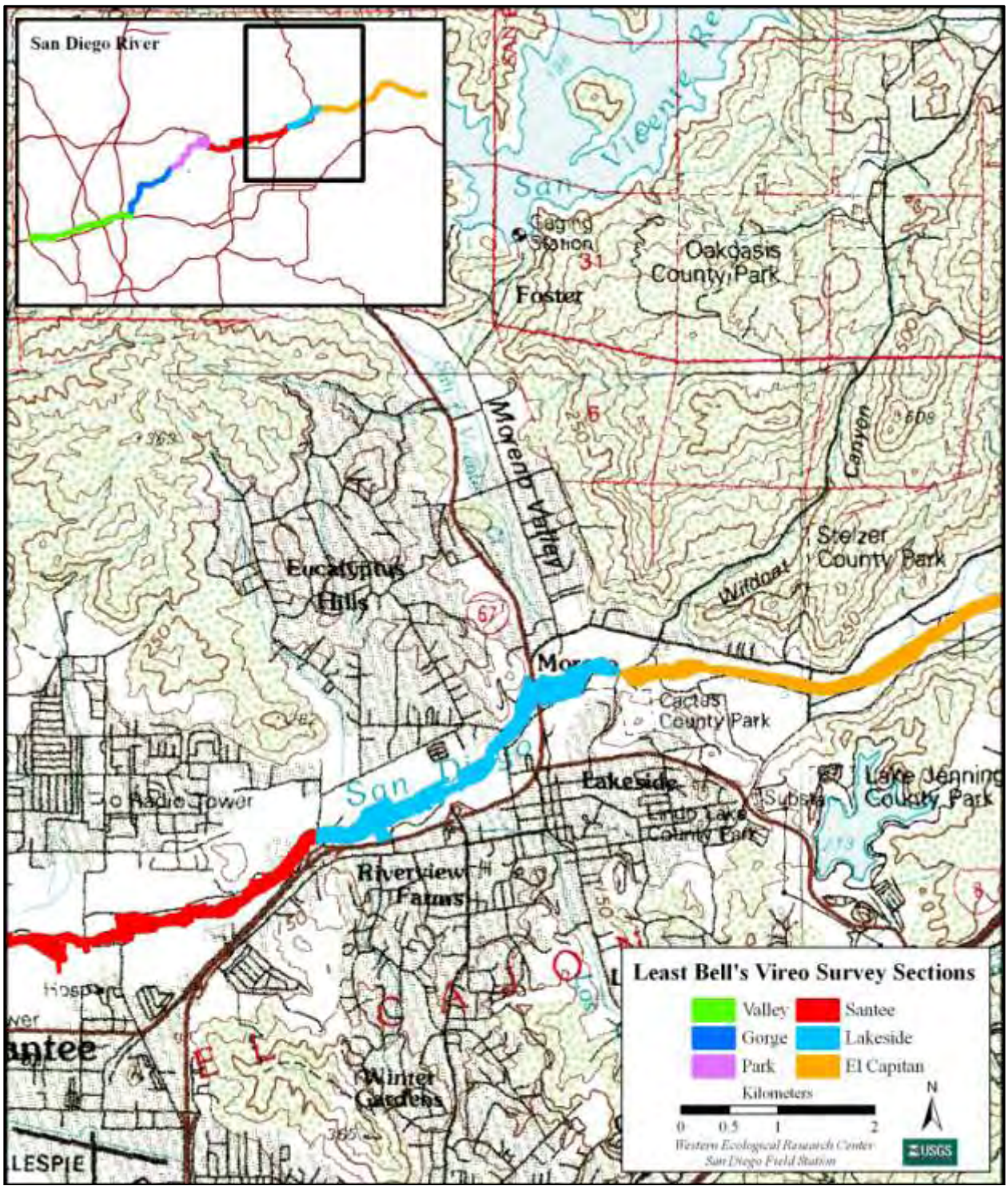

Fig. 11. Least Bell's Vireo survey areas along the San Diego River, 2011: Lakeside.

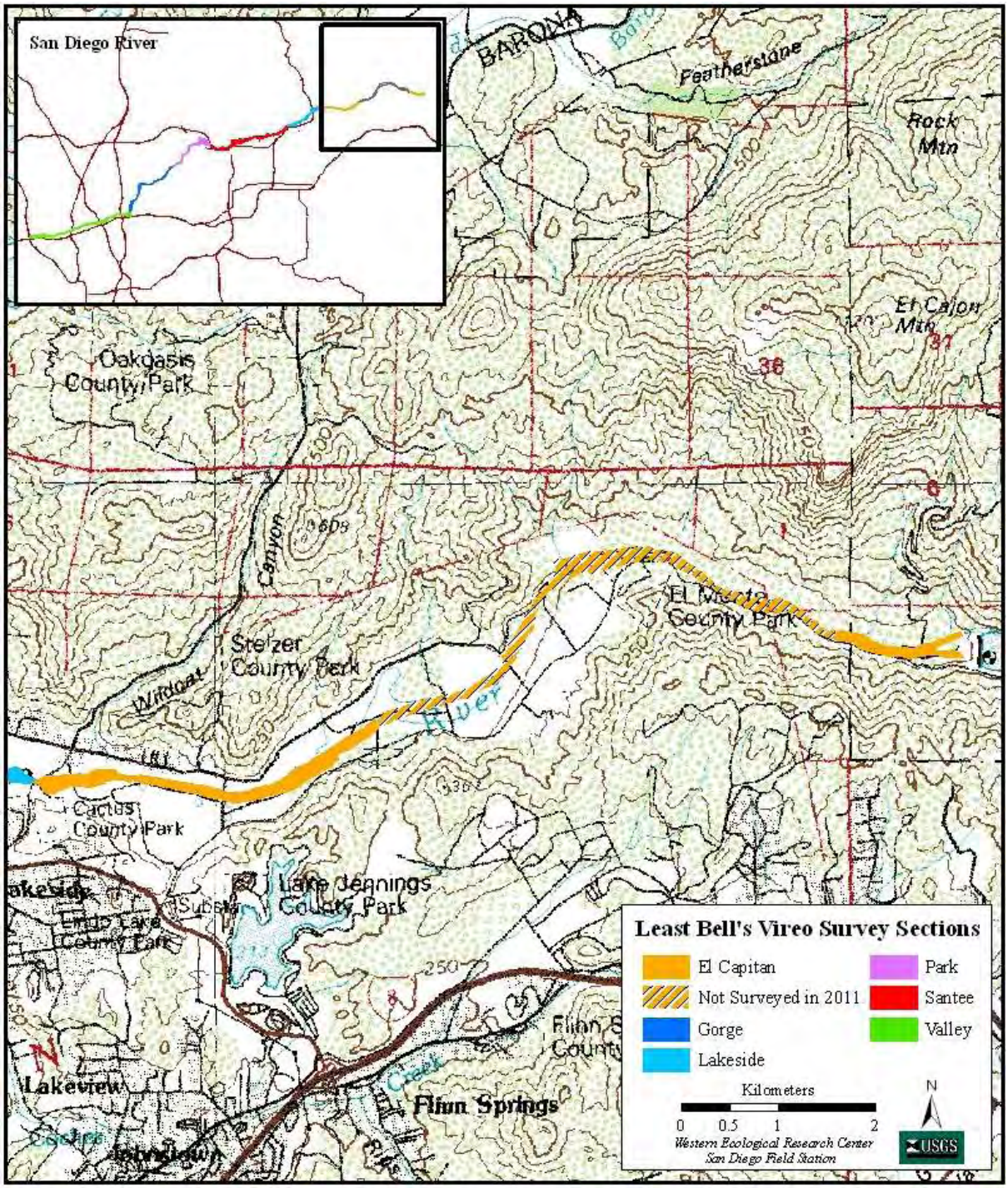

Fig. 12. Least Bell's Vireo survey areas along the San Diego River, 2011: El Capitan.

APPENDIX B

LOCATIONS OF LEAST BELL'S VIREOS ALONG THE SAN DIEGO RIVER, 2011

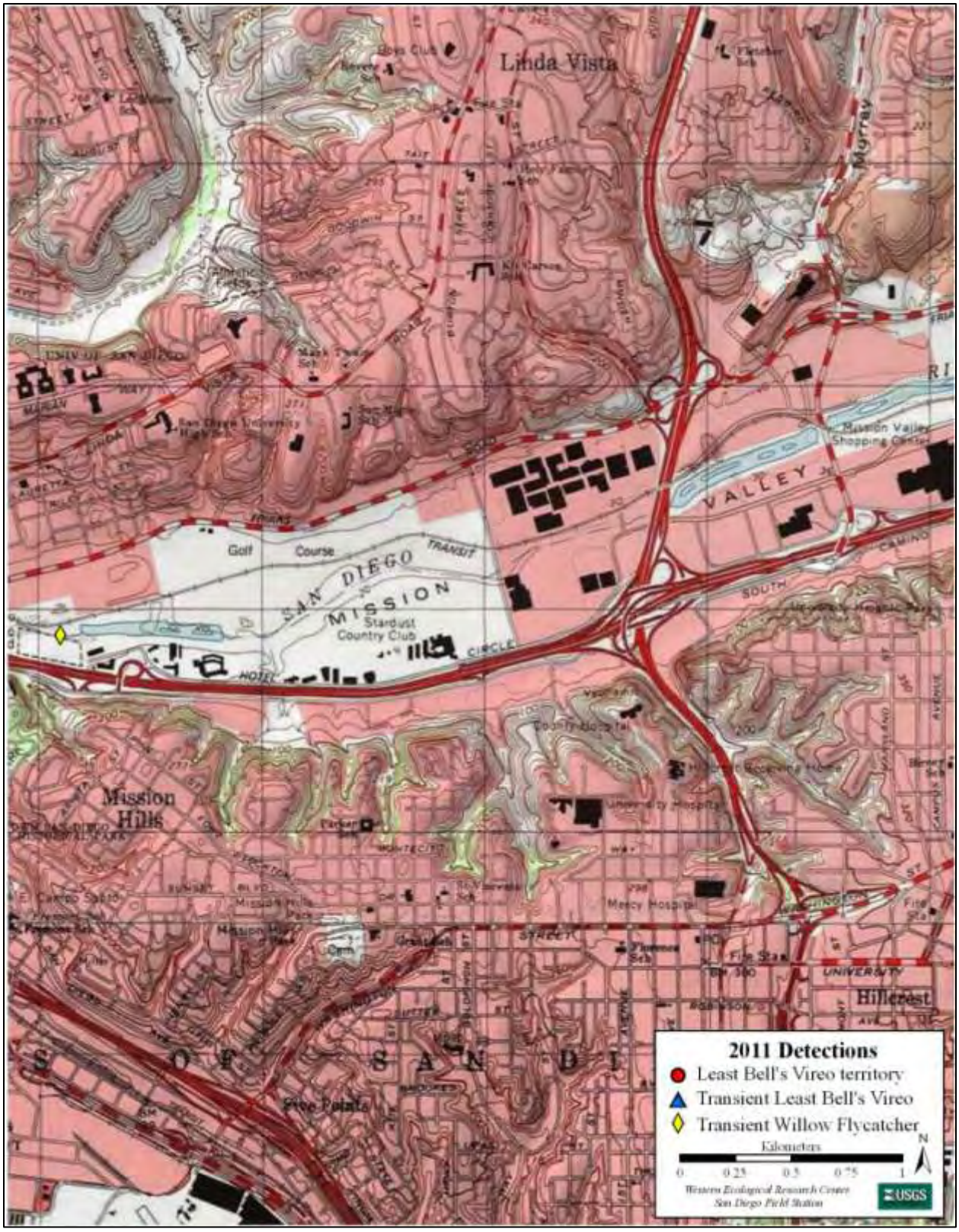

Fig. 13. Locations of Least Bell's Vireos along the San Diego River, 2011: middle section of Valley.

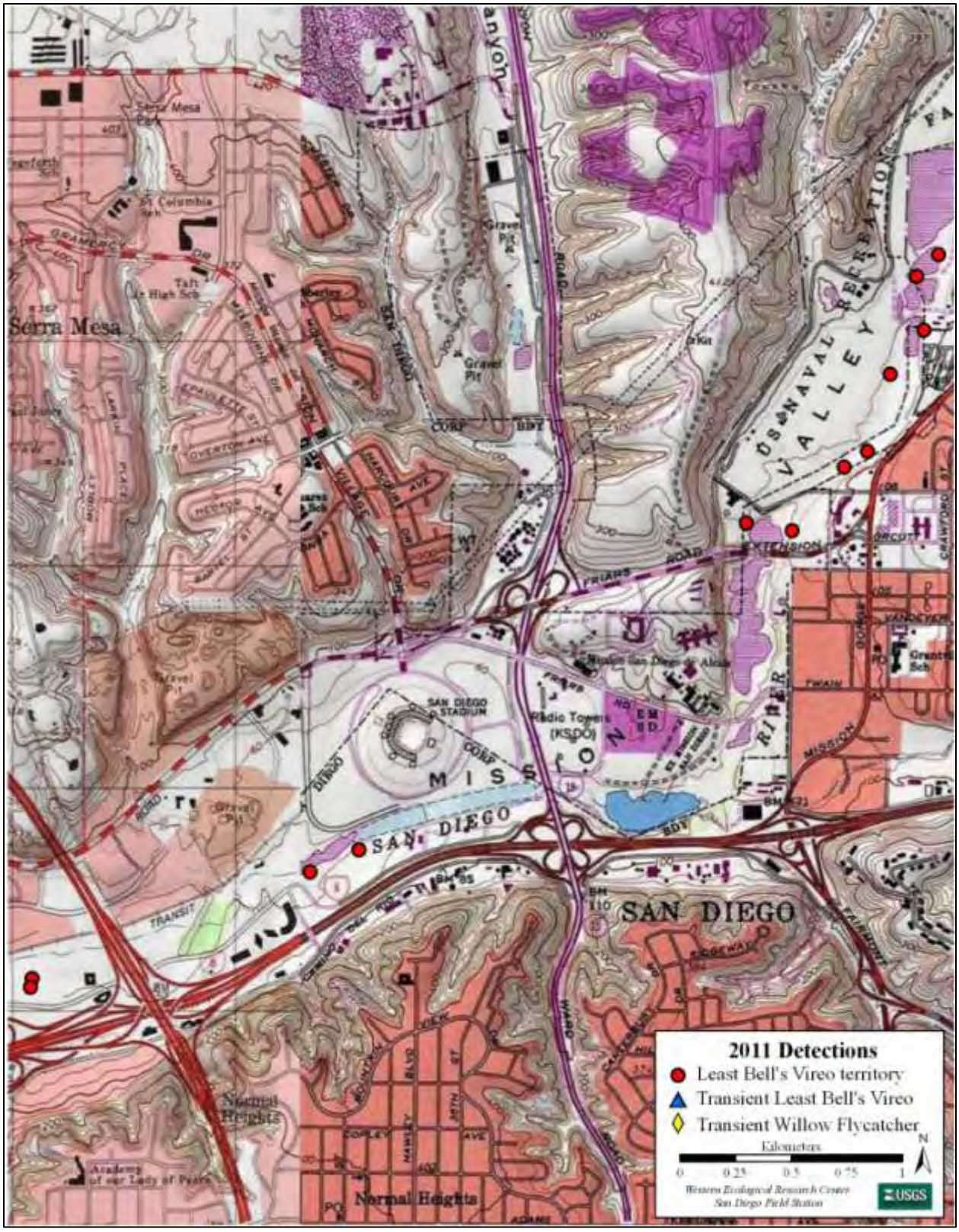

Fig. 14. Locations of Least Bell's Vireos along the San Diego River, 2011: east Valley and west Gorge.

Fig. 15. Locations of Least Bell's Vireos along the San Diego River, 2011: middle Gorge.

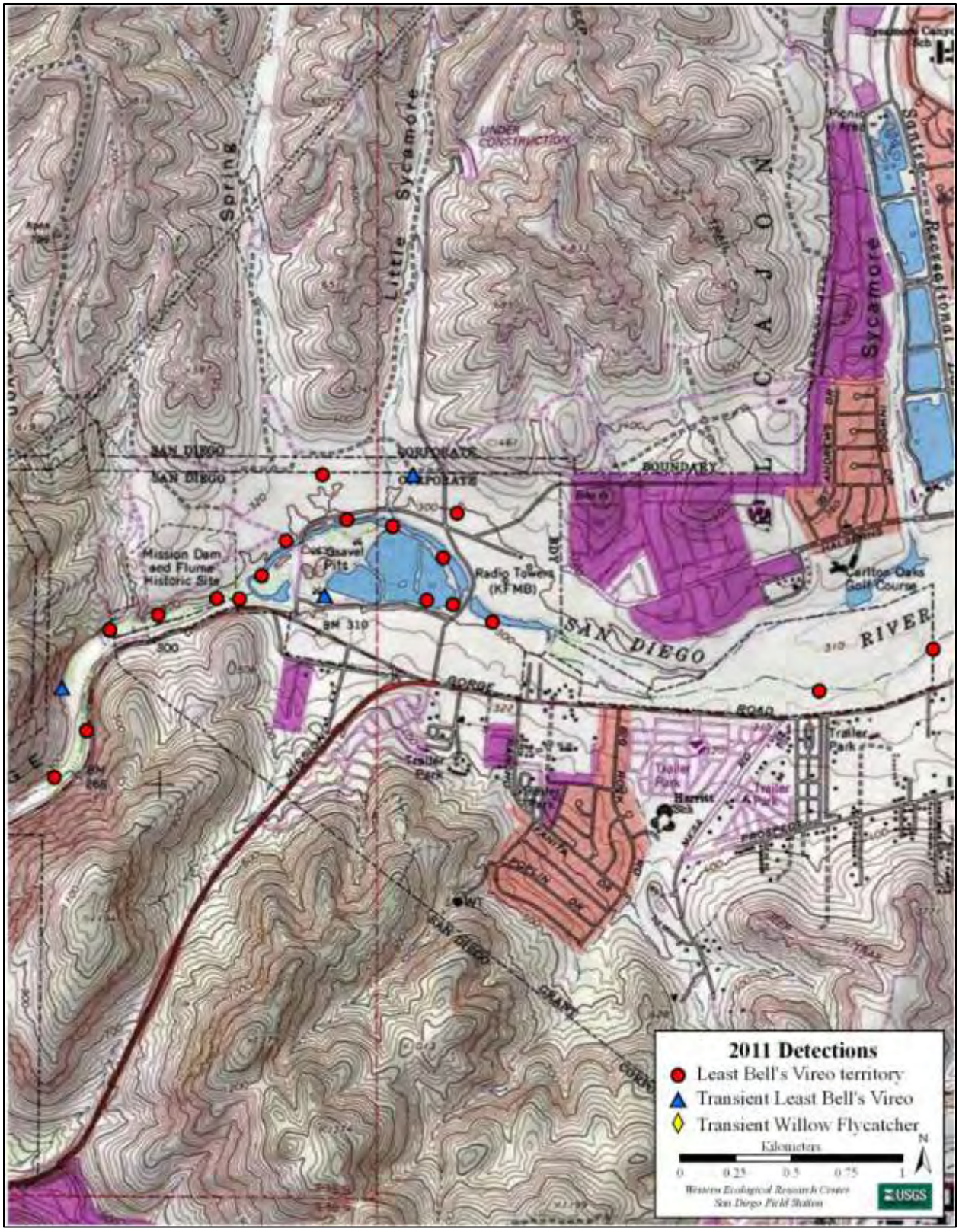

Fig. 16. Locations of Least Bell's Vireos along the San Diego River, 2011: Park and west Santee.

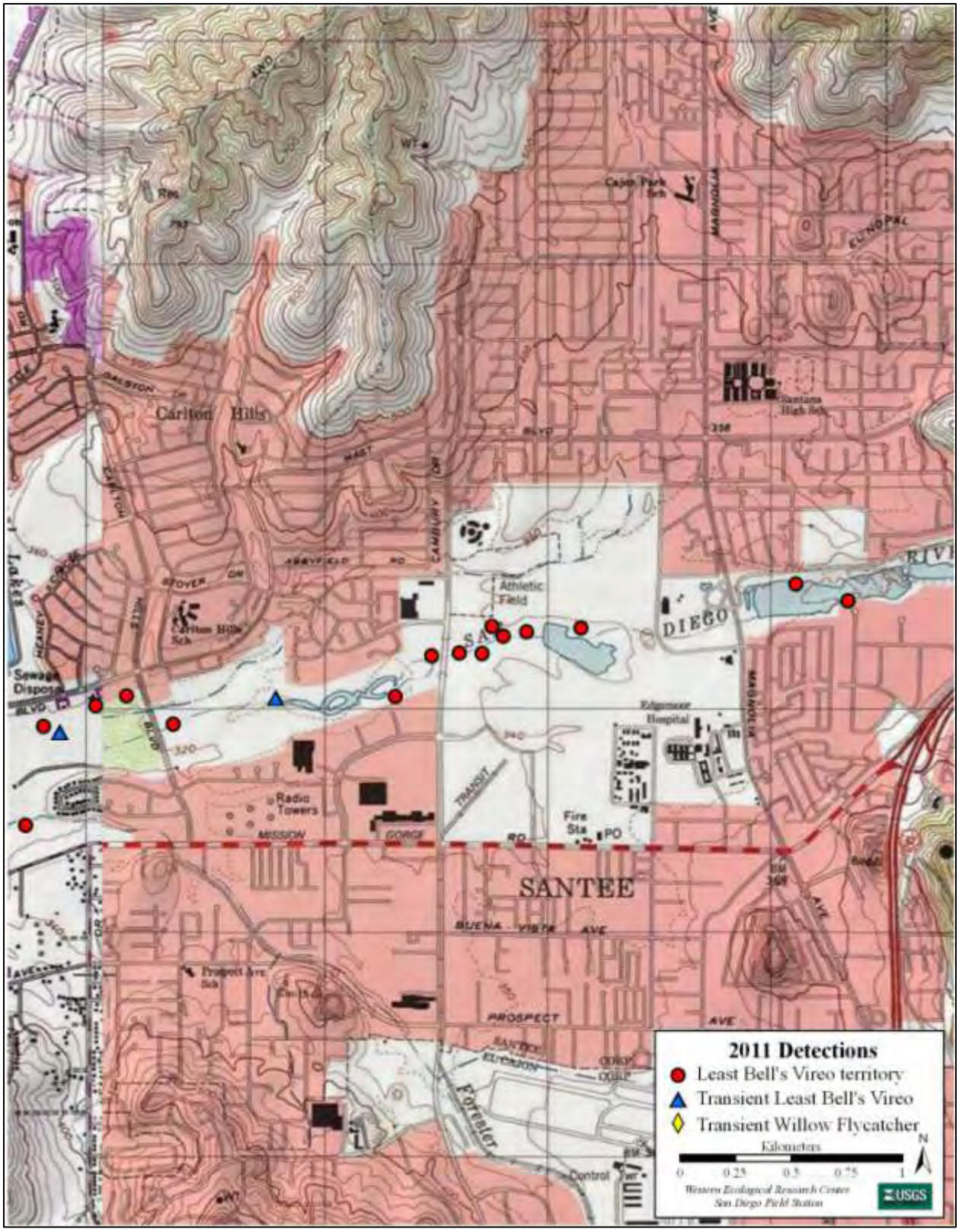

Fig. 17. Locations of Least Bell's Vireos along the San Diego River, 2011: Santee.

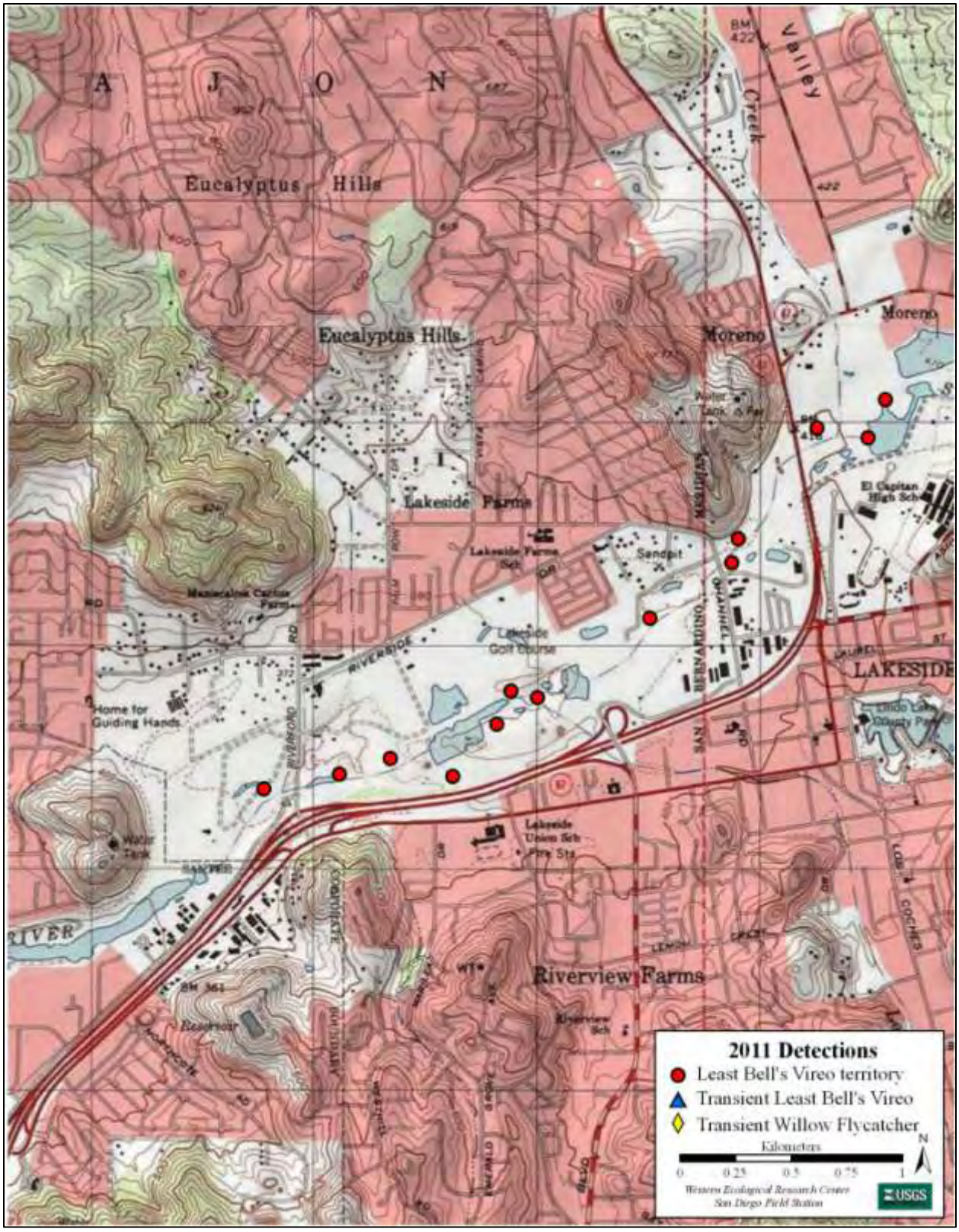

Fig. 18. Locations of Least Bell's Vireos along the San Diego River, 2011: Lakeside..

APPENDIX C

BANDED LEAST BELL'S VIREOS ON THE SAN DIEGO RIVER, 2011

Yr. Last Seen	Drainage / Terr. in 2011 / Treatment	Band Combination[a]		Age in 2011 (yrs.)	Sex[b]	Comments[c]
		Left Leg	Right Leg			
2011	SDR / SGMD / TMT	pupu	YEYE/Mlb	≥ 1	M	Banded as an adult at SGMD in 2011.
2011	SDR / CL6 / TMT	pupu	LBLB/Mlb	≥ 1	M	Banded as an adult at CL6 in 2011.
2011	SDR / SGSA / REF	WHWH/gogo	Mlb	≥ 1	M	Banded as an adult at SGSA in 2011.
2011	SDR / OSA / REF	DPDP/gogo	Mlb	≥ 1	M	Banded as an adult at OSA in 2011.
2011	SDR / FUZ / REF	Mlb	PUWH/pupu	≥ 1	M	Banded as an adult at FUZ in 2011.
2011	SDR / ALT / REF	Mlb	BYST/gogo	≥ 1	M	Banded as an adult at ALT in 2011.
2011	SDR / SPT / REF	pupu	WHDP/Mlb	≥ 1	M	Banded as an adult at SPT in 2011.
2011	SDR / PA07	YEPU/pupu	Mlb	≥ 1	M	Banded as an adult at PA07 in 2011.
2011	SDR / SGFU / REF	Mlb	LPBK/pupu	≥ 1	M	Banded as an adult at SGFU in 2011.
2011	SDR / SGBT / TMT	BYST/pupu	Mlb	≥ 1	M	Banded as an adult at SGBT in 2011.
2011	SDR / SGPP / TMT	BKBK/gogo	Mlb	≥ 1	M	Banded as an adult at SGPP in 2011.
2011	SDR / SGPP / TMT	LBBK/Mlb	pupu	≥ 1	F	Banded as an adult at SGPP in 2011.
2011	SDR / EDD / TMT	Mlb		≥ 1	F	Banded as a nestling on the SDR before 2011. This female also paired with FJS2 in 2011.
2010	SDR / VA03		PUYE/Mlb	2	M	Banded as a nestling on the SDR in 2009.
2010	SDR / JOY / REF	Mlb	BKLB/pupu	≥ 3	M	Banded as an adult on the SDR in 2009.
2010	SDR / SGPP / TMT	Mlb	BKBK/pupu	≥ 4	M	Banded as an adult on the SDR in 2008.
2010	SDR / WMB2 / TMT	DPWH/Mlb		≥ 4	M	Banded as an adult on the SDR in 2008.
2010	SDR / SGCA / REF	BKLB/pupu	Mlb	≥ 3	M	Banded as an adult on the SDR in 2009.
2010	SDR / FJS2 / TMT		BKLB/Mlb	≥ 3	M	Banded as an adult on the SDR in 2009.
2010	SDR / EDD / TMT		DPWH/Mlb	3	M	Banded as a nestling on the SDR in 2008.
2010	SDR / ORD / TMT	YEPU/Mlb	pupu	3	M	Banded as a nestling on the SDR in 2008.
2010	SDR / POR / REF	YEYE/Mlb		≥ 3	M	Banded as an adult on the SDR in 2009.
2010	SDR / MER / REF		LBBK/Mlb	≥ 3	M	Banded as an adult on the SDR in 2009.
2010	SDR / HTS / TMT		BKLP/Mlb	≥ 2	M	Banded as an adult on the SDR in 2010.
2010	SDR / CCO / TMT	LBLB/Mlb		≥ 3	M	Banded as an adult on the SDR in 2009.
2010	SDR / PA08 / TMT	Mlb	WHDP/pupu	1	M	Banded as a nestling at SGPN in 2010.
2010	SDR / SGPP / TMT	WHWH/Mdb	LPBK	3	F	Banded as a nestling on the SLR in 2008.
2010	SDR / ORD / TMT	BKLB/Mlb	pupu	1	F	Banded as a nestling at HTS in 2010.
2010	SDR / CCO / TMT		WHDP/Mlb	2	F	Banded as a nestling on the SDR in 2009.
2010	SDR / PA07	DPWH/Mlb	pupu	1	F	Banded as a nestling at WMB2 in 2010.
2009	SDR / GO17		LPBK/Mlb	≥ 4	M	Banded as an adult on the SDR in 2008.
2009	SDR / LA07		Msi	≥ 7	M	Banded as an adult on the SDR in 2006.
2008	SDR / BHV / TMT	PUPU/Mlb	pupu	3	M	Banded as a nestling on the SDR in 2008.
2008	SDR / SGFU / REF	PUPU/pupu	Mlb	≥ 4	F	Banded as an adult on the SDR in 2008. This female also paired with SGCA in 2011.

[b] Band colors: Mdb = dark blue numbered federal band; Mlb = light blue numbered federal band; gogo = metal gold; pupu = metal purple; BKBK = plastic black; BKLB = plastic black-light blue split; BKLP = plastic black-light pink split; BYST = plastic black-yellow striped; DPDP = plastic dark pink; DPWH = plastic dark pink-white split; LBBK = plastic light blue-black split; LBLB = plastic light blue; LPBK = plastic light pink-black split; PUPU = plastic purple; PUWH = plastic purple-white split; PUYE = plastic purple-yellow split; WHDP = plastic white-dark pink split; WHWH = plastic white; YEPU = plastic yellow-purple split; YEYE = plastic yellow.

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

[d] SDR = San Diego River, SLR = San Luis Rey River.

APPENDIX D

STATUS AND NESTING ACTIVITIES OF LEAST BELL'S VIREOS ALONG THE SAN DIEGO RIVER, 2011

TREATMENT SITE TERRITORIES

Territory	Nest	Nest Fate[a]	# Cowbird Eggs	# Fledged	Comments
BHV	1	UNK			Nest abandoned, no eggs observed.
BHV	2	SUC		4	
BTN	1	SUC		3	
CCO	1	SUC		4	
CL6	1	SUC		3	
EDD	1	PRE			
EDD	2	SUC		3	
FJS2	1	PRE			
FJS2	2	INC			Nest not completed.
FJS2	3	SUC		3	
HTS	1	PRE			
HTS	2	PRE			
SGMD	1	PRE			
SGMD	2	INC			Nest not completed.
SGMD	3	PRE			
SGMD	4	SUC		2	Same location as Nest 2.
ORD	1	PRE			
ORD	2	SUC		1	
SGPP	1	PRE			
SGPP	2	UNK			Nest abandoned with wet, cold eggs after rainfall.
SGPP	3	SUC		2	
WMB2	1	SUC		3	
WMB2	2	PRE			

REFERENCE SITE TERRITORIES

Territory	Nest	Nest Fate[a]	# Cowbird Eggs	# Fledged	Comments
ALT	1	FAL			Bachelor male building nest, not completed.
ALT	2	PRE			
SGCA	1	SUC		4	
SGCA	2	OTH			Nest came loose from support branches. Nestlings died from a combination of starvation/abandonment and ant depredation.
SGFU	1	PRE			
SGFU	2	PRE			
GOL	1	PRE			
JOY	1	SUC		2	
MER	1	PRE			
MER	2	INC			Nest not completed.
MER	3	UNK			Nest abandoned with eggs. Female missing.
OSA	1	SUC	1	2	
POR	1	SUC		3	
SGSA	1	SUC		2	
SPT	1	PRE			

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