Least Bell's Vireo Response to Kuroshio Shot Hole Borer/Fusarium Dieback at the Tijuana River, California

2017 Data Summary

Prepared for:

San Diego Association of Governments
San Diego, California

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

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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 1900s 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 2,500 territories (USFWS 2006).

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 averages 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 can be more common during some years when breeding conditions are favorable (early initiation, high early fledging success; Ferree and Kus 2008, Ferree et al. 2010, Lynn and Kus 2009, 2010). 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.

A newly emerging threat to riparian woodlands, Kuroshio Shot Hole Borer-Fusarium Dieback (KSHB/FD), has resulted in extensive damage to riparian habitat throughout San Diego County (Boland 2017). The exotic invasive Kuroshio shot hole borer beetle (*Euwallacea* sp.) is an introduced pest native to Asia. It was first encountered in urban and agricultural settings in San Diego County in 2012 and first detected in a riparian forest in late summer 2015 at the Tijuana River (Boland 2016). Pregnant female beetles bore into tree trunks and branches, creating galleries in which they lay their eggs, and cultivate a pathogenic fungus (*Fusarium* spp.) used as a food source by developing larvae. Damage to the tree's vascular system and disruption of water and nutrient flow can kill trees in as little as 6 months after initial infestation. Of the sites where KSHB/FD has been documented, the Tijuana River has been most affected, and the once dense willow-dominated woodland that supported a large vireo population was reduced to a

stand of dead trees within the span of 1-2 years. The impact of such dramatic habitat degradation on the Tijuana River vireo population is of concern. This report presents preliminary analysis of vireo response to habitat changes related to KSHB/FD.

The purpose of this study was to document the status of Least Bell's Vireo at the Tijuana River 2 years after KSHB/FD infestation and compare it to historic vireo abundance and distribution. Specifically, our goals were to (1) determine the size and distribution of the Least Bell's Vireo population at the Tijuana River in 2017, (2) compare the 2017 population to pre-infestation populations using historical datasets for all or parts of the drainage, (3) document changes in vireo distribution related to level of KSHB/FD infestation, and (4) compare vireo numbers and recent trends at the Tijuana River to those at non-infested areas on other drainages to determine the extent to which trends at the Tijuana River were attributable to KSHB/FD as opposed to other, regional factors. These data will be used to develop specific goals and practices for managing riparian habitat and associated species threatened by KSHB/FD.

This work was funded by the San Diego Association of Governments (SANDAG), San Diego County, California. All activities were conducted under 10(a)1(A) Recovery Permit #TE-829554-17.4.

STUDY AREA AND METHODS

Study Area

The Tijuana River Valley is located in the southwestern corner of San Diego County, approximately 0.6 km north of the United States-Mexico border (Fig. 1). The valley contains a varied mix of habitats including coastal salt marsh, southern willow riparian forest, and riparian scrub. The majority of the Tijuana River Valley is conserved and managed by the Tijuana River Valley Regional Park (TRVRP), Border Field State Park (BFSP), Tijuana River National Estuarine Reserve, Tijuana Slough National Wildlife Refuge, and the U.S. Navy.

Field Surveys

We conducted four surveys for Least Bell's Vireo in the Tijuana River Valley from 12 April to 20 July 2017. Field work was conducted by USGS biologists Annabelle Bernabe and Jonathan Gunther. 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 riparian habitat while searching and listening for vireos. Observers walked along the edge(s) of the riparian corridor on the upland and/or river side where habitat was narrow enough to detect a bird on the opposite edge. In wider stands, observers traversed the habitat to detect all birds throughout its extent. Surveys were conducted between dawn and early afternoon, depending on wind and weather conditions.

All male Least Bell's Vireos were detected and confirmed audibly by hearing their diagnostic song. The presence of a female vireo within a territory was confirmed audibly through the detection of the "pair call", a unique call elicited between mated birds, visually when observed traveling quietly with the male, or was inferred by observing a nest, breeding behavior such as a

food carry, or the presence of dependent fledglings. For each bird encountered, investigators recorded age (adult or juvenile), sex, breeding status (paired, unpaired, undetermined, or transient), and whether the bird had leg bands. Birds were considered transients if they were not detected on two or more consecutive surveys after an initial detection. Vireo locations were collected using a Trimble Juno SB (Sunnyvale, CA) unit with 1-15 m positioning accuracy to determine geographic coordinates (WGS84).

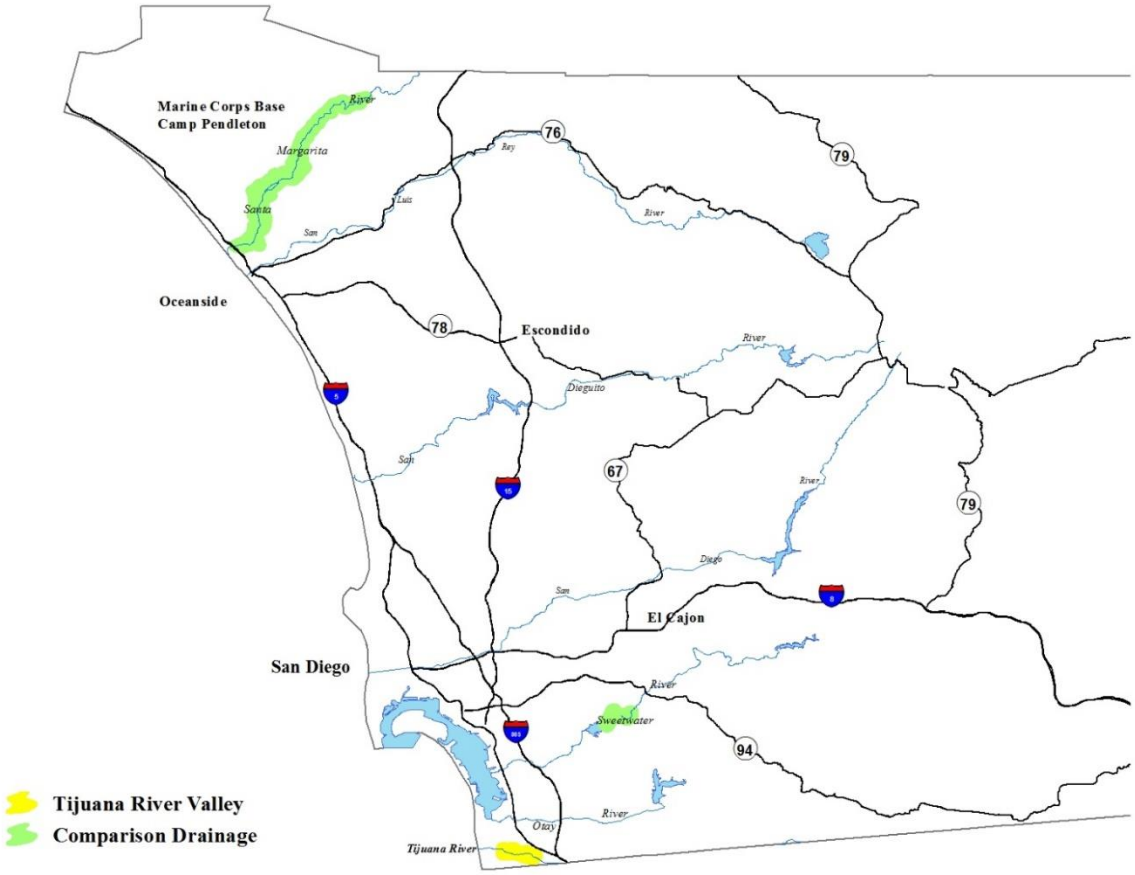

Fig. 1. Least Bell's Vireo survey area at the Tijuana River Valley in 2017 and other drainages used for historical comparison.

Comparisons with Historical Data

We searched for and compiled data on past vireo surveys at the Tijuana River Valley to compare the size and distribution of the 2017 population to pre-infestation populations (Appendix A, Table 1; Appendix B, Figs. 9-16). For reports where electronic data were not available, we scanned and ortho-rectified the report maps, digitized the survey data, and then summarized the data in a manner consistent with our 2017 survey results (e.g. number of vireo territories, number of transient vireos, etc.). We used the survey area descriptions presented in TW Biological (1997) to categorize birds into SW, West, Central, East, and ED survey sections to facilitate more fine-grained comparisons across years in survey extent and results (Appendix A, Table 1; Appendix B, Fig. 7).

Survey effort for vireos at the Tijuana River Valley has been variable over the past 20 years, leading us to create several subsets of the historical data for comparison to 2017. Drainage-wide surveys such as ours in 2017 were conducted from 1992-1998 and used for comparison with 2017. Since 1998, no drainage-wide surveys have been performed, although a survey in 2004 (ERA 2004; Appendix B, Fig. 16) covered the majority of the drainage and was used in comparisons with 2017. Otherwise, surveys since 1998 covered smaller sections of the drainage and were variable in extent and location, with minimal usefulness for trend analysis.

To maximize use of the historical data, we identified the largest common area surveyed among the 1992-1998, 2004 and 2017 surveys (hereafter "largest common survey area", Appendix B, Fig. 7) to standardize comparisons across years. This area took into account (i.e., excluded) several areas of interior riparian habitat that we were unable to access in 2017 because of widespread flooding. We used ArcGIS (ArcMAP 10.4.1, Redlands, CA) to create a 100-m buffer around the 2017 survey route and designated any habitat farther than 100 m from the route as "unsurveyed" (Appendix A, Fig.7).

To make use of the most recent pre-KSHB/FD data available, we selected three sections within the Tijuana River Valley where surveys had taken place 1-3 years prior to KSHB/FD infestation (Appendix A, Fig.18): BFSP (2014), NOLF IB (2012; Naval Outlying Landing Field Imperial Beach; excluding the 2017 unsurveyed area), and TRVRP Trails (2013/2014). In a few instances where sections of more than one survey area overlapped, we chose the area most recently surveyed and assigned territory locations accordingly. We compared vireo trends pre- and post-KSHB/FD infestation at each of these three sections to provide a more recent, albeit smaller scale, comparison than that possible with the older drainage-wide survey data.

Least Bell's Vireo Distribution Pre- and Post-KSHB/FD

Boland (2016) evaluated and characterized the majority of the riparian habitat in the Tijuana River Valley during the KSHB/FD infestation, separating it into 29 distinct survey units based on vegetation type and categorizing each unit by KSHB/FD infestation level; 23 of these units fell completely or partially within the largest common survey area (Appendix A, Fig. 7). We compared the proportion of vireos each year in High Infestation (willow riparian forest, 18) units and Low Infestation (riparian scrub, 5) units to evaluate whether bird distribution shifted in association with KSHB/FD infestation. We performed these comparisons across years within the largest common survey area as well as for the three recently surveyed sections, predicting a shift in distribution towards the Low Infestation habitat post-KSHB/FD. Chi-square tests were used when sample sizes were sufficient; Fisher's Exact tests were used when one or more categories contained fewer than five samples. Data were analyzed using GraphPad QuickCalcs Web site: https://www.graphpad.com/quickcalcs/contingency2/ (accessed August 2018). Two-tailed tests were considered significant if $P \leq 0.05$.

Comparison to Regional Drainages Unaffected by KSHB/FD

We compared the overall vireo trend at the Tijuana River Valley in the largest common survey area to those at other regional drainages with no KSHB/FD infestations to help determine to what extent trends were attributable to KSHB/FD as opposed to other, regional factors. For comparison drainages, we selected the Santa Margarita River located on Marine Corps Base

Camp Pendleton in northern San Diego County, approximately 85 km north of the Tijuana River (Lynn and Kus 2017), and a section of the Sweetwater River (P. Famalaro, pers. comm.) located approximately 18 km northeast of the Tijuana River (Fig. 1). The comparison drainages were selected because they were consistently surveyed between 1992 and 2017, and there was no evidence of KSHB/FD detected as of 2017 at either drainage.

RESULTS

2017 Survey Results

A total of 114 male Least Bell's Vireos were detected during drainage-wide surveys in 2017. Of these, 109 were territorial males (Fig. 2; Appendix A, Table 1; Appendix B, Fig. 8), 43% (47/109) of which were confirmed as paired, and 5 were transients. We observed bands on 10 Least Bell's Vireos, including 9 males and 1 female (Appendix A, Table 2).

Historical Population Trends

The vireo population within the largest common survey area in 1992-1998, 2004, and 2017 increased every survey year before declining by 22% from 2004 (113) to 2017 (88; Fig. 2; Appendix A, Table 1).

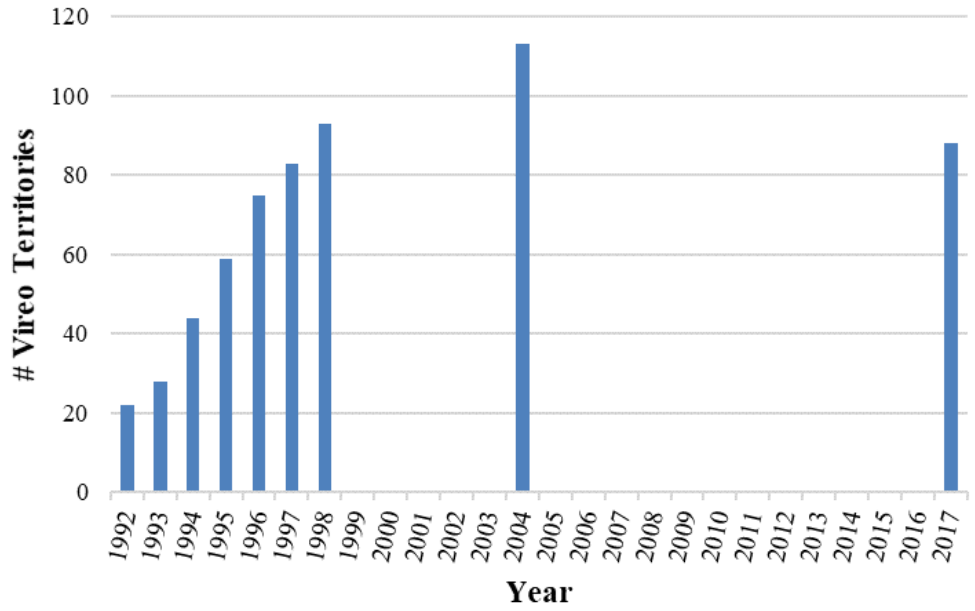

Fig. 2. Least Bell's Vireo population estimates for the Tijuana River Valley, largest common survey area, 1992-1998, 2004 and 2017.

More recently, the number of vireo territories increased in three river sections from pre-KSHB/FD infestation to 2017. At the NOLF IB section, the number of vireo territories in 2017 (7) increased by 133% from 2012 (3; Fig. 3; Appendix B, Fig. 18). The number of vireo territories in the TRVRP Trails section increased by 41% between 2013/2014 (37) and 2017

(52). The smallest increase occurred at the BFSP section, where vireo numbers increased by 9% from 2014 (11) to 2017 (12).

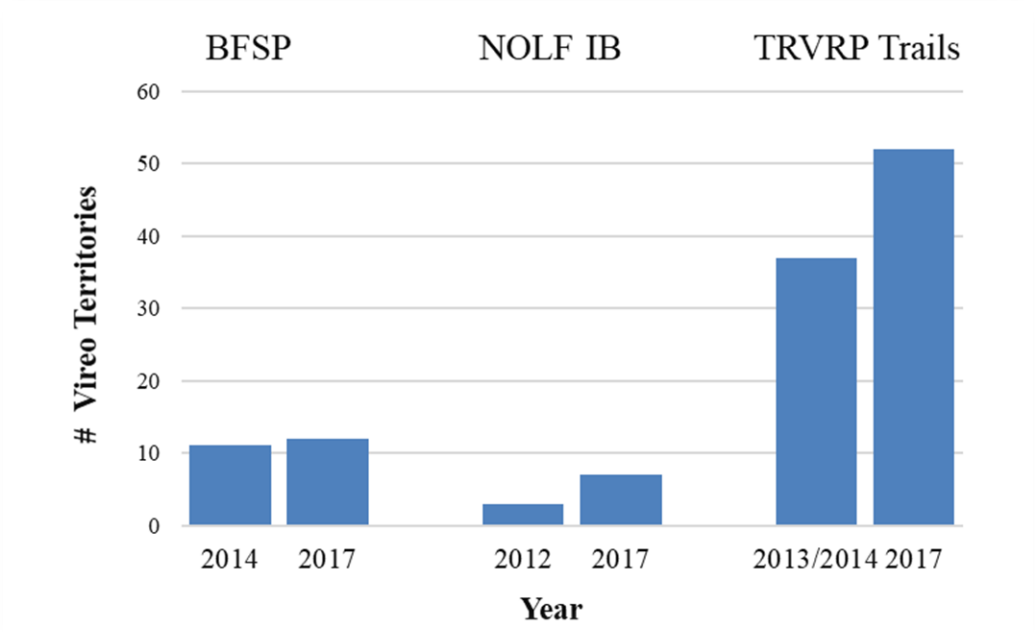

Fig. 3. Number of Least Bell's Vireo territories at three sections of the Tijuana River Valley surveyed shortly before and after infestation by KSHB/FD.

Least Bell's Vireo Distribution Pre- and Post-KSHB/FD

Of the 88 vireo territories located within the largest common survey area in 2017, 74 occurred within 23 survey units characterized by Boland (2016; Appendix A, Table 3; Appendix B, Fig. 17). In 2004 (pre-KSHB/FD), 83% (15/18) of High Infestation/willow riparian forest units were occupied by at least one vireo territory, compared to 50% (9/18) in 2017 (post-KSHB/FD); one of the 18 High Infestation/willow riparian forest units (unit 7) within the largest common survey area was never historically occupied by vireos (Appendix B, Fig.17). All Low Infestation/riparian scrub units (n=5) were occupied by at least one vireo territory pre- and post-KSHB/FD. A net loss of 32 territories occurred in High Infestation units from 2004 to 2017 (55% of 2004 territories), in contrast to a net gain of 12 territories (33% of 2004 numbers) in Low Infestation units during the same period. In 2004, 62% (58/94) of vireos occupied High Infestation units, compared to 35% (26/74) in 2017 (Fig. 4). Low Infestation units were occupied by 38% (36/94) of vireos in 2004, compared to 65% (48/74) in 2017. Relative to 2004, the proportion of vireos decreased significantly in High Infestation units and increased significantly in Low infestation units after colonization by KSHB/FD ($\chi^2 = 11.69$, $P < 0.01$).

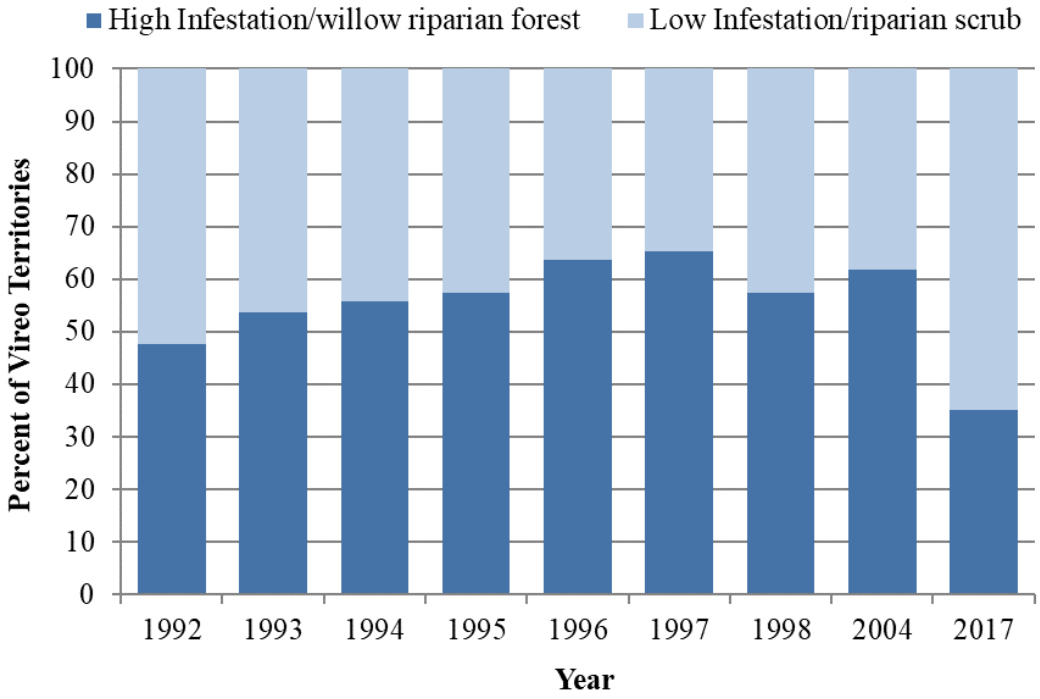

Fig. 4. Percent of Least Bell's Vireo territories in High Infestation/willow riparian forest units and Low Infestation/riparian scrub units (Boland 2016), largest common survey area, 1992-1998, 2004, and 2017.

A significant shift in vireo numbers relative to KSHB/FD infestation level was detected in one of the three river sections surveyed shortly before and after infestation (Fig. 5). The proportion of vireos at BFSP in High versus Low Infestation units decreased significantly from 2014 to 2017 (Fisher's Exact $P = 0.04$). In 2017, 100% (12/12) of vireo territories at BFSP were in Low Infestation compared to 64% (7/11) in 2014 (Fig. 5; Appendix B, Fig. 18). A similar, but statistically non-significant, shift occurred at NOLF IB, with the majority (86%; 6/7) of vireos in 2017 occupying Low Infestation units, compared to 50% (1/2; the third vireo territory was not located in a Boland survey unit) in 2012 (Fisher's Exact $P = 0.42$). The distribution of vireo territories relative to infestation level did not change pre- and post-KSHB/FD at TRVRP Trails ($\chi^2 = 0.003$, $P = 0.96$). Of the 37 Least Bell's Vireo territories in the TRVRP Trails section in 2013/2014, 31 were in Boland survey units; 42% of these (13/31) occupied High Infestation units and 58% (18/31) occupied Low Infestation units (Fig. 5; Appendix B, Fig. 18). Of the 52 vireo territories in this section in 2017, 46 were in Boland survey units; 41% (19/46) in High Infestation units and 59% (27/46) in Low Infestation units.

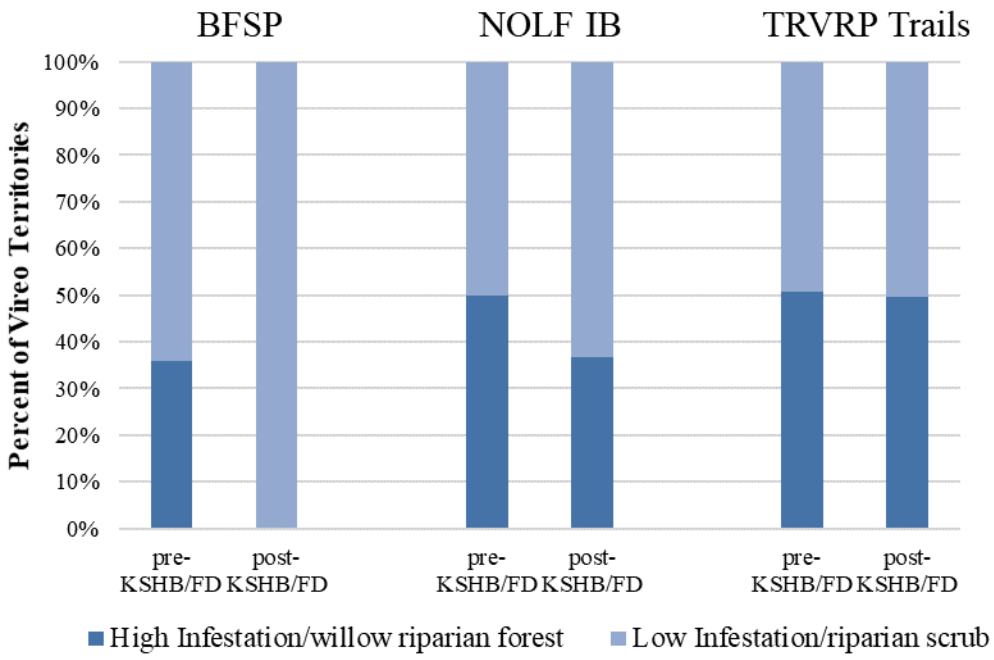

Fig. 5. Percent of Least Bell's Vireo territories in High Infestation/willow riparian forest units and Low Infestation/riparian scrub units (Boland 2016) for three river sections, pre- and post-KSHB/FD.

Comparison to Regional Drainages Unaffected by KSHB/FD

We compared the overall trend at the Tijuana River in the largest common survey area to those at the Santa Margarita and Sweetwater Rivers (Fig. 6). All three drainages showed a decline between 2004 and 2017; however, the decline was much steeper at the Tijuana River (22%) in comparison to the Santa Margarita River (6%) and Sweetwater River (16%).

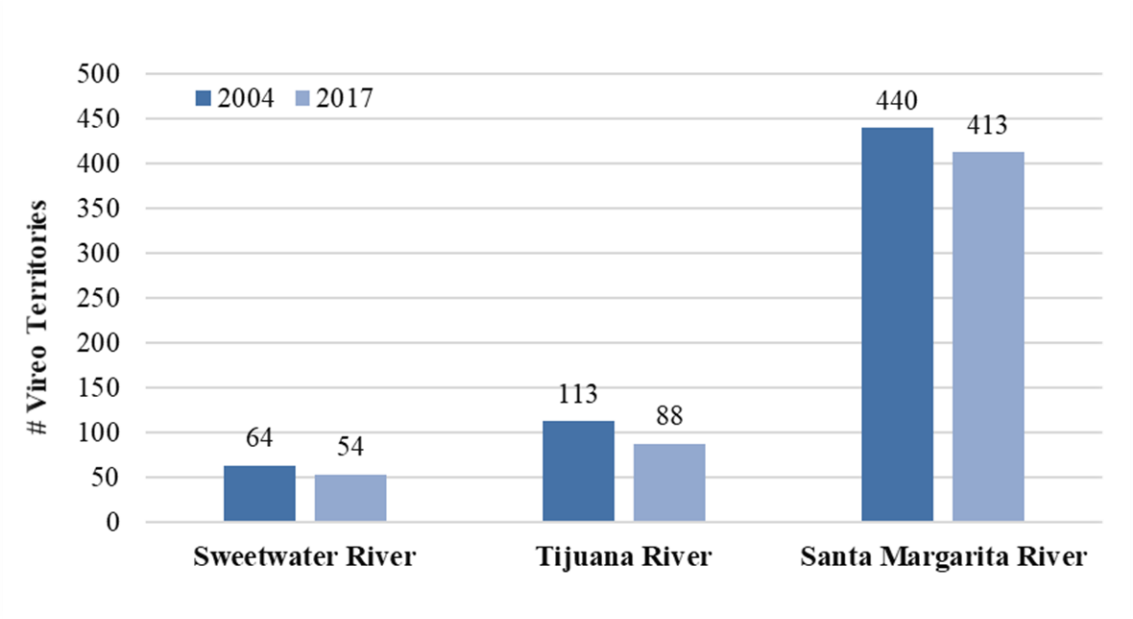

Fig. 6. Number of Least Bell's Vireo territories at the Tijuana River, Santa Margarita River, and Sweetwater River, 2004 and 2017.

DISCUSSION

Overall, Least Bell's Vireo abundance in the Tijuana River Valley in 2017 was comparable to the peak observed in 1998 following nearly a decade of systematic annual monitoring documenting establishment of the vireo population at this site. The lack of drainage-wide survey data since 1998 makes it impossible to know how the population might have fluctuated prior to KSHB/FD infestation and deprives us of the recent context needed to assess the impact of the infestation on vireo numbers. Data from a near-drainage-wide survey in 2004 indicate a 22% decline in vireo abundance by 2017. This downward trend was mirrored at two other drainages with systematic annual monitoring, although the steeper decline at the Tijuana River suggests that at least part of the decline is likely attributable to habitat destruction associated with KSHB/FD.

In contrast to the population decline indicated by the limited available drainage-wide data, our analysis of more recent data from three sections of the river suggests that at least some sections have experienced increases in vireo abundance despite the KSHB/FD infestation. Whether these sections are representative of increases that took place throughout the drainage, or reflect a shift in distribution of the vireo population, is unknown. Nevertheless, it is clear that KSHB/FD did not reduce the population to levels warranting concern about rapid local extirpation of Least Bell's Vireo from this site.

Two factors appear to have contributed to the vireos' persistence in the Tijuana River Valley post-KSHB/FD. First, previously unoccupied riparian scrub habitat was available for

some vireos to move into, as the number of vireo territories in riparian scrub within the largest common survey area increased by 33% from 2004 to 2017. According to Boland (2017), the riparian scrub habitat had low KSHB/FD infestation rates with very little damage. Second, although the southern willow forest which contained the majority of vireo territories pre-KSHB/FD was hardest hit by KSHB/FD, with the highest infestation levels and higher occurrences of tree damage (Boland 2017), some of the damaged willows began stump sprouting by 2016 and 2017, creating an early successional shrub layer that provided nesting and foraging habitat for vireos.

Examination of the three river sections with more recent pre-and post-KSHB/FD data reveals some of the complexity in the impacts of KSHB/FD on vegetation and the consequent effect on vireo abundance and distribution. Vireos in the TRVRP section underwent substantial population growth following infestation but did not display a shift in habitat use. Population growth in this section occurred in both habitat types, southern willow forest and riparian scrub. The growth in the willow forest was probably attributable to extensive stump sprouting which enhanced the suitability for vireos despite the higher levels of damage it received. In contrast, vireos in the BFSP section displayed a strong shift in habitat use but only modest population growth post-KSHB/FD. Here, stump sprouting in the willow forest had not yet begun by the 2017 vireo breeding season (Boland 2018), and birds responded with a wholesale shift to the riparian scrub. Evidence suggestive of a shift was seen at NOLF IB, although pre-KSHB/FD vireo numbers were too low for statistical significance. At NOLF IB, all of the population increase since 2014 occurred in the riparian scrub, widening the gap between occupancy in riparian scrub versus willow forest.

While it is encouraging that the Least Bell's Vireo population was able to persist in the Tijuana River Valley, primarily by shifting distribution, further monitoring is warranted to document future occupancy changes, especially in the willow riparian forest habitat that sustained the highest level of damage and has subsequently demonstrated promising regrowth (Boland 2017).

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APPENDIX A

Supporting Tables

Table 1. Least Bell's Vireo survey results at the Tijuana River Valley, 1986-2017.

Year	# Vireo Territories					Total # Vireo Territories	# Vireos Largest Common Survey Area	Source
	Historical Survey Sections							
	SW	West	Central	East	ED			
1992	4	6	7	13	0	30	22	Kus 1992a, b
1993	2	12	13	20	1	48	28	Kus 1993
1994	1	19	21	29	0	70	44	Kus 1994
1995	0	30	24	41	2	97	59	Kus 1995
1996	2	32	30	53	2	119	75	Kus 1996
1997	2	35	42	54	9	142	83	TW Biological 1997
1998	1	22	38	64	10	135	93	TW Biological 1998
2004	3[a]	15[b]	46	71	7[c]	142	113	ERA 2004
2017	12	12[d]	35[d]	47[d]	3	109	88	Kus
Partial-Drainage Surveys								
1986		1	2	2		5		Recon 1989[e]
1987			4	4		8		Recon 1989[e]
1989			3	2		5		MBA 1989
1990			6	5		11		Kus 1990
1991		2	8	12	1	23		Kus 1991
2000	7					7		Varanus 2000
2001	9					9		Varanus 2001
2003	7					7		Varanus 2003
2006	9					9		EDAW 2008
2007	9					9		EDAW 2008
2008	10					10		EDAW 2008
2009	6					6		URS 2009
2009		16	6			22		Clark Biological Services 2010
2012		12	2			14		Arnold and Clune 2012[f]
2013			9	14		23		AECOM 2013[g]
2014	1		7	10		18		AECOM 2014[g]
2014	11					11		California State Parks 2014[h]
2015		10	2			12		Arnold and Clune 2015
2015	11					11		ECM 2015
2016	10					10		Alfaro 2016

[a] Only section North of Monument Road surveyed.
[b] NOLF IB not surveyed.
[c] Easternmost habitat in ED not surveyed.
[d] Interior portions of Western, Central, and Eastern sections inundated, unable to access.
[e] Survey extent could not be determined, unclear if area South of Monument Road surveyed.
[f] NOLF IB; portion of survey used in pre- and post-KSHB/FD trend analysis.
[g] TRVRP Trails; portion of survey used in pre-and post-KSHB/FD trend analysis. Survey included existing trails plus 30 m buffer; combined Northern (2013) and Southern (2014) trails for analysis.
[h] BFSP; survey section used in pre- and post-KSHB/FD trend analysis.

Table 2. Banded Least Bell's Vireos detected at the Tijuana River Valley, 2017.

Territory	Band Combination[a]	Sex	Age at Banding	Banding Location	Year Banded
TJ11	DPDP : WHDP Mdb	Male	Nestling	San Luis Rey River	2015
TJ40	WHPU : Msi	Male	Adult	NOLF IB MAPS[b]	2017
TJ43	PUWH pupu : Msi	Male	Adult	NOLF IB MAPS	2015
TJ48	BKBK Msi : pupu	Male	Adult	NOLF IB MAPS	2015
TJ57	YEPU : Msi	Male	Adult	NOLF IB MAPS	2015
TJ57	Mdb : PUYE	Female	Nestling	San Luis Rey River	2016
TJ59	DPWH : Msi	Male	Adult	NOLF IB MAPS	2017
TJ60	Msi : BKLP	Male	Adult	NOLF IB MAPS	2017
TJ104	pupu : BKLB Mlb	Male	Nestling	San Diego River	2011
TJ123	DPWH : DGOR Mgo	Male	Hatch-Year	Santa Margarita River	2012

[a] Left Leg: Right Leg, colors read top to bottom. **Metal Bands:** Mdb = numbered dark blue band; Mgo = numbered gold band; Mlb = numbered light blue band; Msi = numbered silver band; pupu = purple band; **Plastic Bands:** BKBK = black; BKLB = black-light blue split; BKLP = black-light pink split; DGOR = dark green-orange split; DPDP = dark pink; DPWH = dark pink-white split; PUWH = purple-white split; PUYE = purple-yellow split; WHDP = white-dark pink split; WHPU = white-purple split; YEPU = yellow-purple split. [b] Monitoring Avian Productivity and Survivorship bird banding station.

Table 3. Least Bell's Vireo territories located within Boland survey units (Boland 2016), Tijuana River Valley, largest common survey area, 1992-1998, 2004, and 2017.

		# Vireo Territories									
Survey Unit[a]	KSHB/FD Infestation Level/habitat type[a]	1992	1993	1994	1995	1996	1997	1998	2004	2017	Numeric Change[b]
1	High /willow riparian	0	1	3	3	3	4	4	5	5	0
3	High /willow riparian	0	0	0	0	0	0	0	1	1	0
4	High /willow riparian	0	1	0	0	1	1	1	2	1	-1
5	High /willow riparian	0	1	2	2	3	2	2	1	0	-1
6	High /willow riparian	0	0	0	0	1	1	0	3	0	-3
7	High /willow riparian	0	0	0	0	0	0	0	0	0	0
8	High /willow riparian	0	0	0	0	0	0	1	2	0	-2
9	High /willow riparian	0	0	0	1	2	0	1	0	0	0
10	High /willow riparian	1	1	2	4	6	6	4	5	6	1
11	High /willow riparian	1	1	1	1	2	2	2	3	1	-2
12	High /willow riparian	0	0	0	0	0	1	1	2	0	-2
13	High /willow riparian	0	0	0	0	0	5	3	9	0	-9
14	High /willow riparian	0	0	0	0	0	0	0	1	0	-1
15	High /willow riparian	3	4	7	8	13	9	13	11	5	-6
16	High /willow riparian	0	1	2	3	5	7	8	8	3	-5
17	High /willow riparian	3	3	2	4	6	3	3	4	3	-1
19	High /willow riparian	1	2	3	2	0	4	2	1	1	0
21	High /willow riparian	1	0	2	3	2	2	2	0	0	0
Total # Territories/High Infestation		10	15	24	31	44	47	47	58	26	-32
23	Low/ riparian scrub	9	11	17	18	18	15	22	19	19	0
24	Low/ riparian scrub	1	0	2	4	5	7	11	11	14	3
25	Low/ riparian scrub	0	0	0	0	0	0	0	1	11	10
27	Low/ riparian scrub	1	2	0	0	0	1	0	3	3	0
29	Low/ riparian scrub	0	0	0	1	2	2	2	2	1	-1
Total # Territories/Low Infestation		11	13	19	23	25	25	35	36	48	12
Total # Vireo Territories		**21**	**28**	**43**	**54**	**69**	**72**	**82**	**94**	**74**	**-20**

[a] From Boland (2016). See Appendix B, Fig. 6 for survey unit locations.

[b] Numeric change is the positive or negative change in the number of vireo territories between 2004 and 2017.

APPENDIX B

Supporting Figures

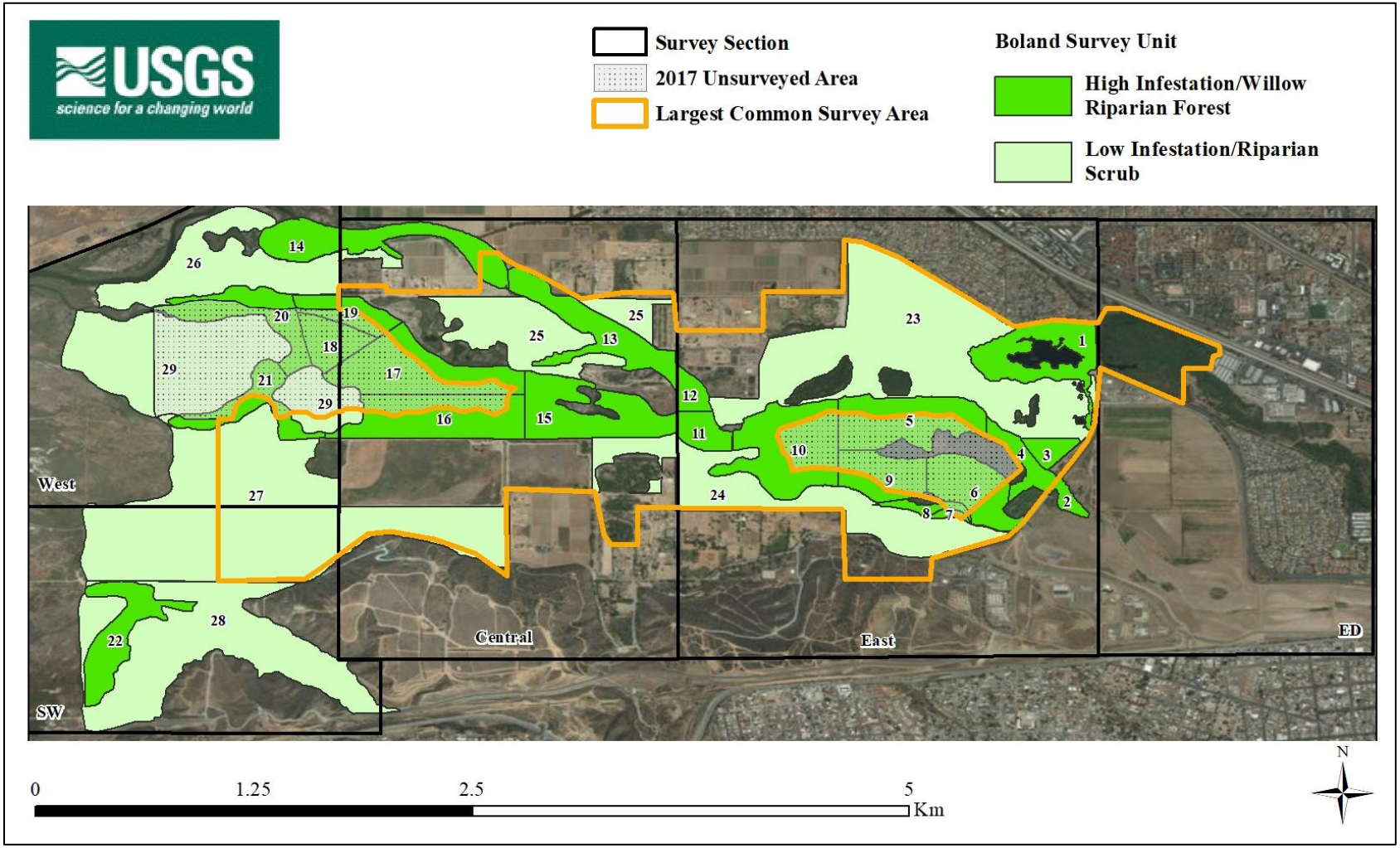

Fig. 7. Least Bell's Vireo survey sections, 2017 unsurveyed area, largest common survey area, and numbered Boland survey units used to characterize vegetation type and Kuroshio shot hole borer/Fusarium dieback infestation level (Boland 2016).

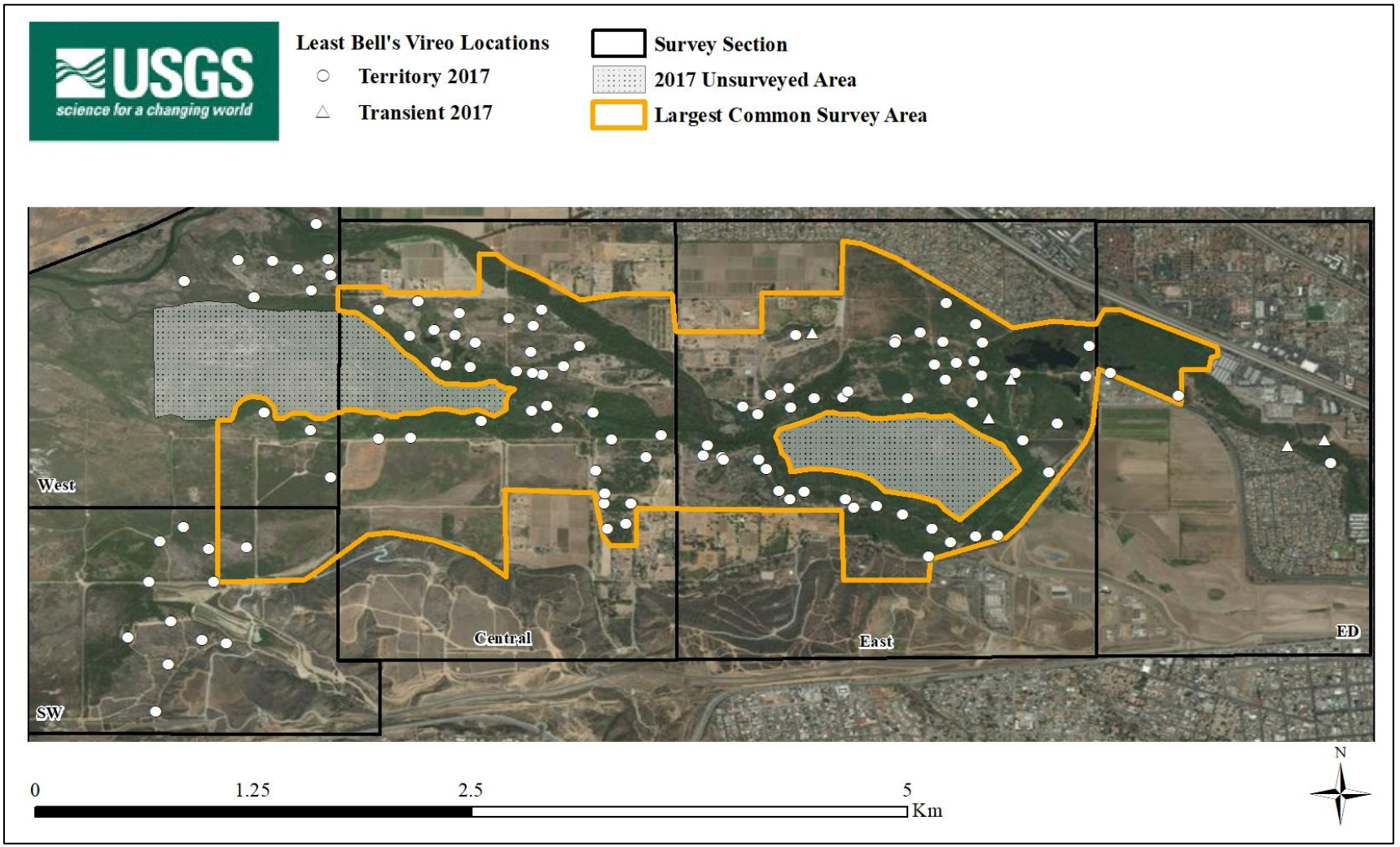

Fig. 8. Least Bell's Vireo locations at the Tijuana River Valley, 2017.

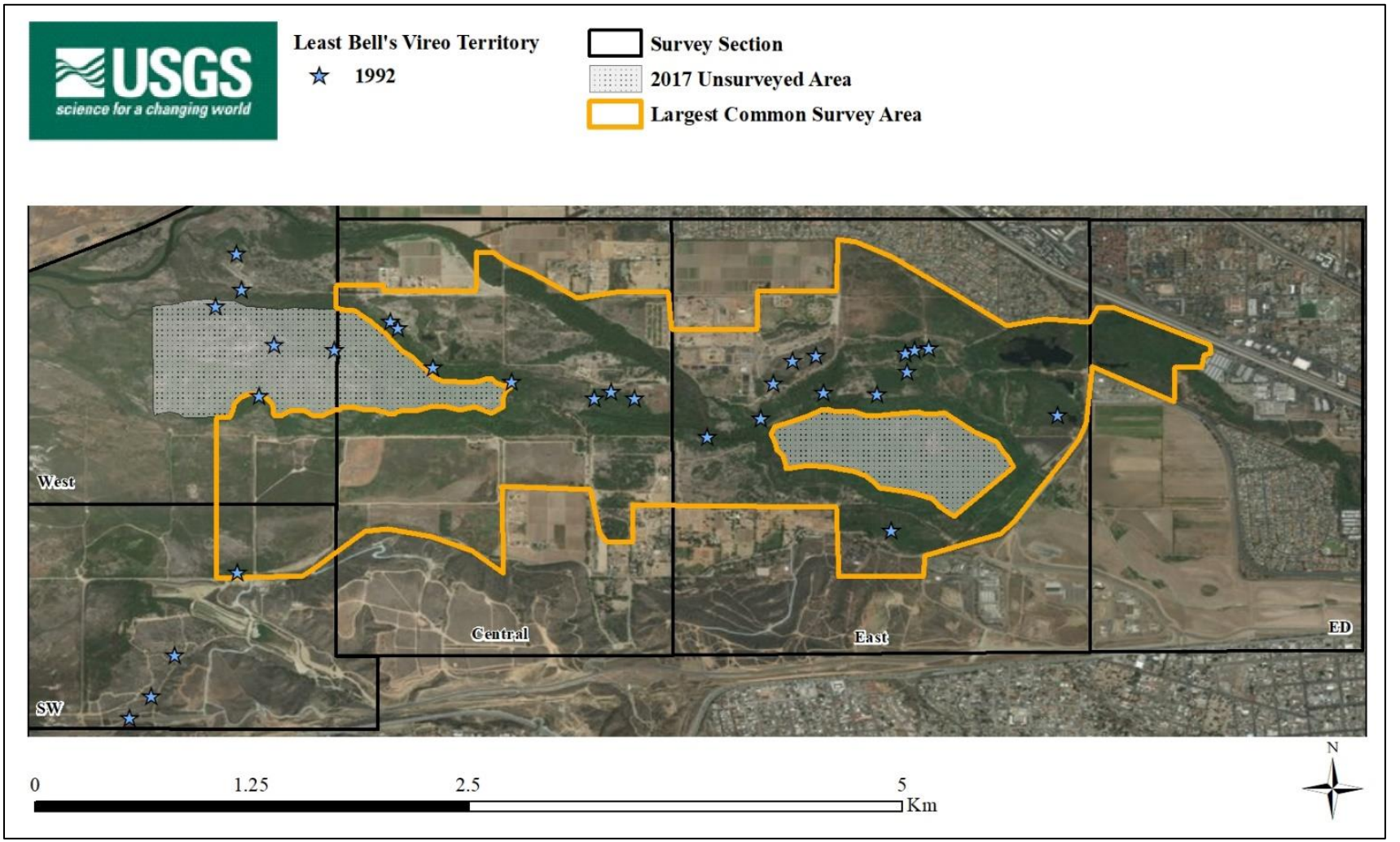

Fig. 9. Least Bell's Vireo territory locations at the Tijuana River Valley, 1992 (Kus 1992a, b).

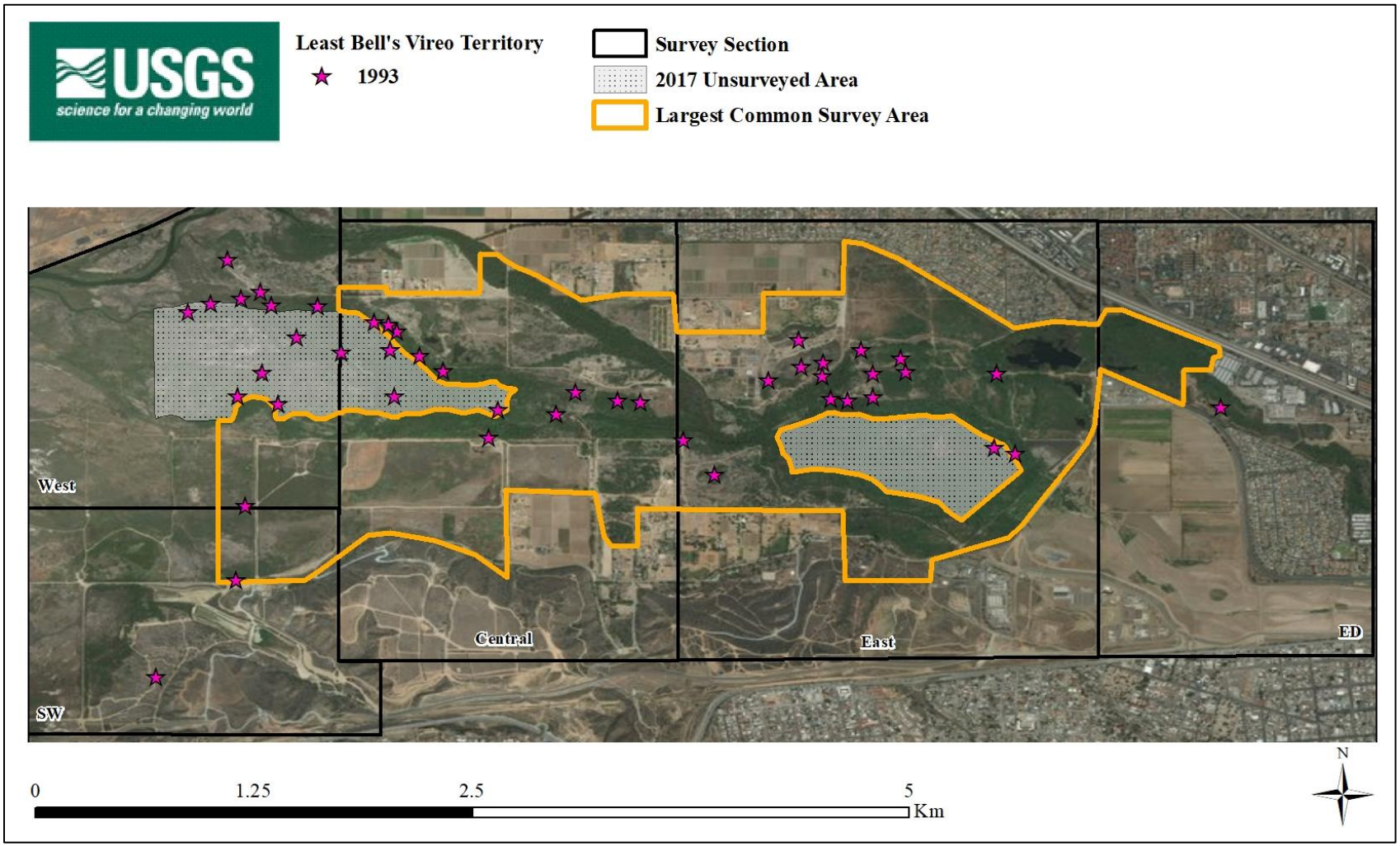

Fig. 10. Least Bell's Vireo territory locations at the Tijuana River Valley, 1993 (Kus 1993).

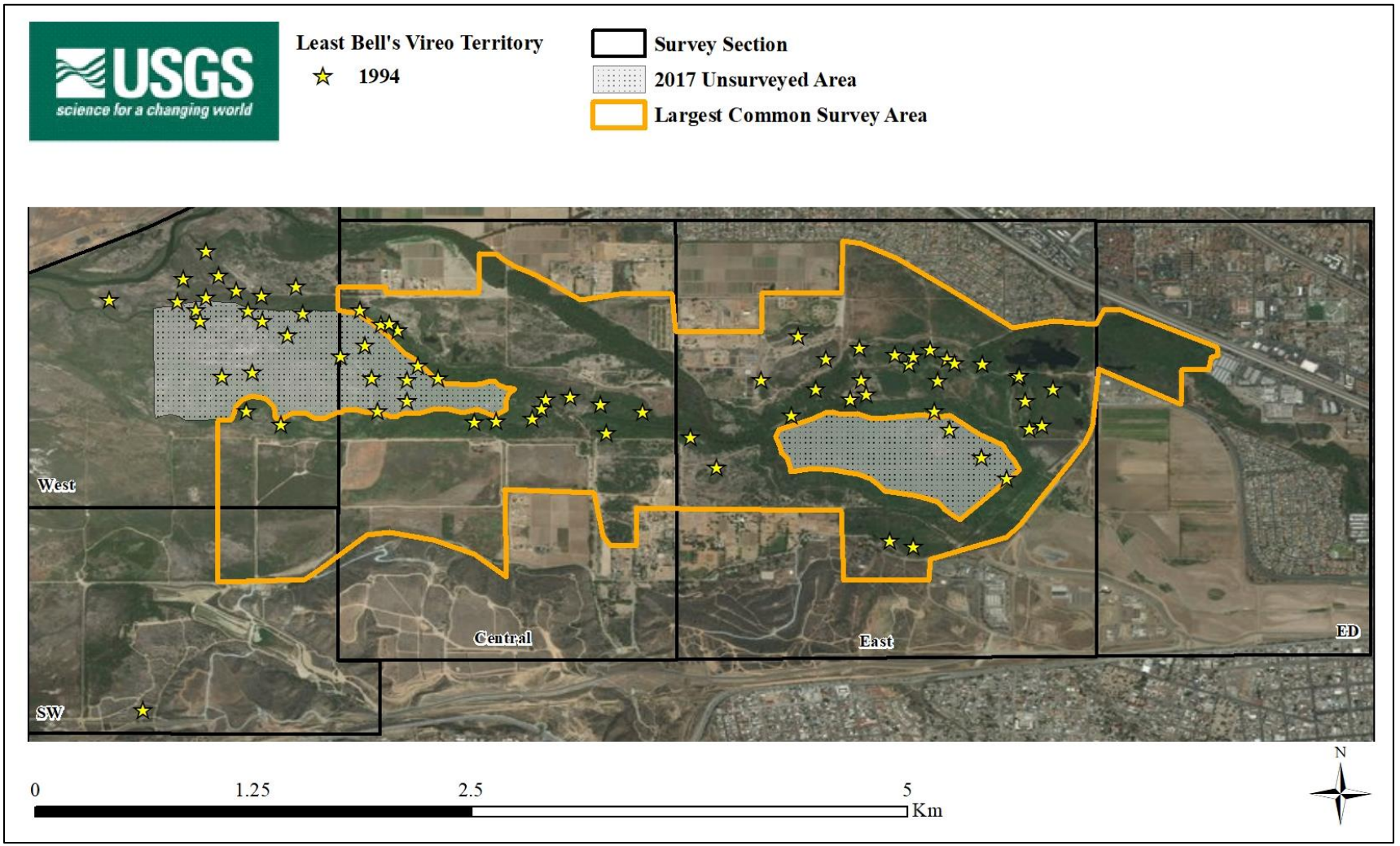

Fig. 11. Least Bell's Vireo territory locations at the Tijuana River Valley, 1994 (Kus 1994).

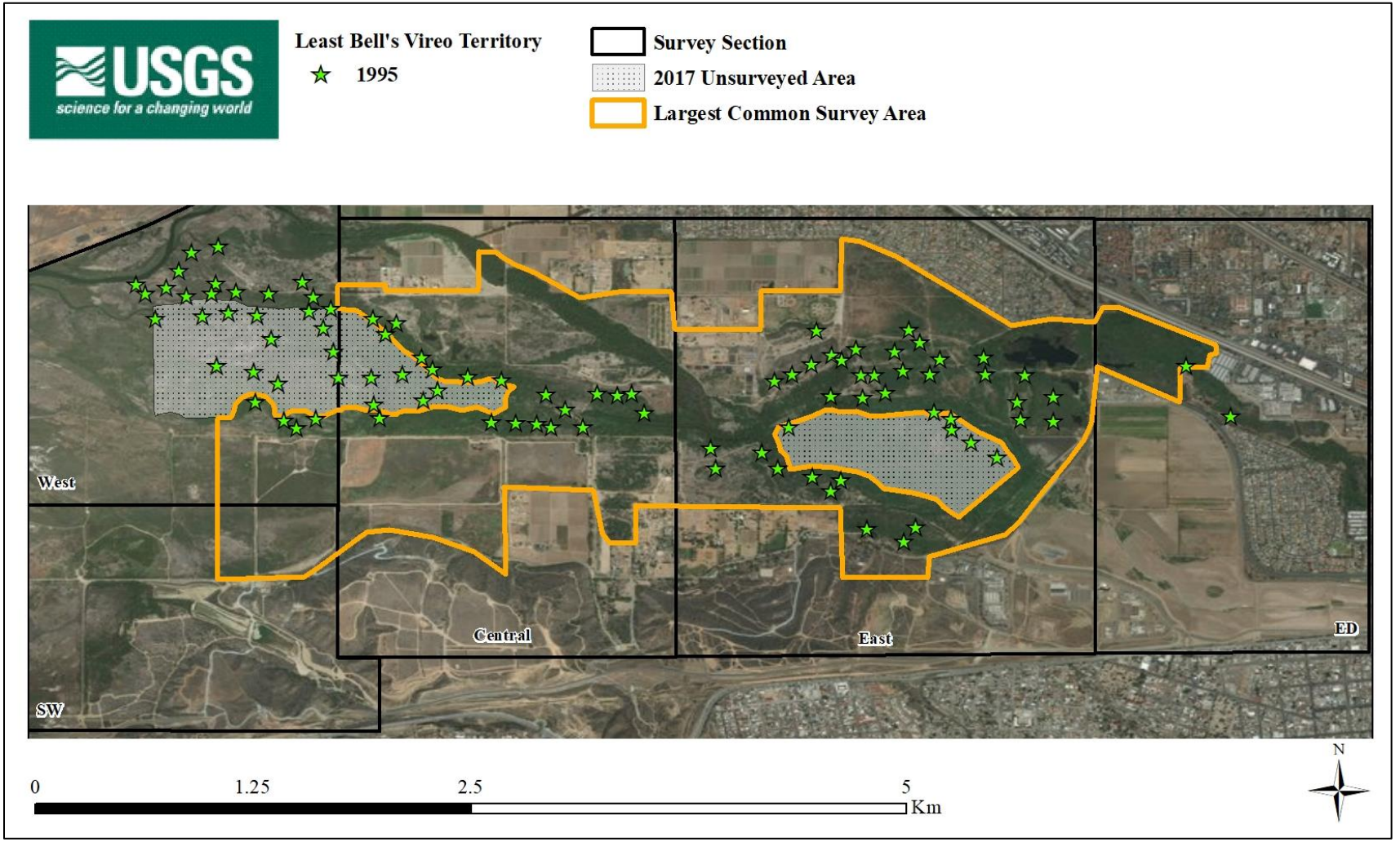

Fig. 12. Least Bell's Vireo territory locations at the Tijuana River Valley, 1995 (Kus 1995).

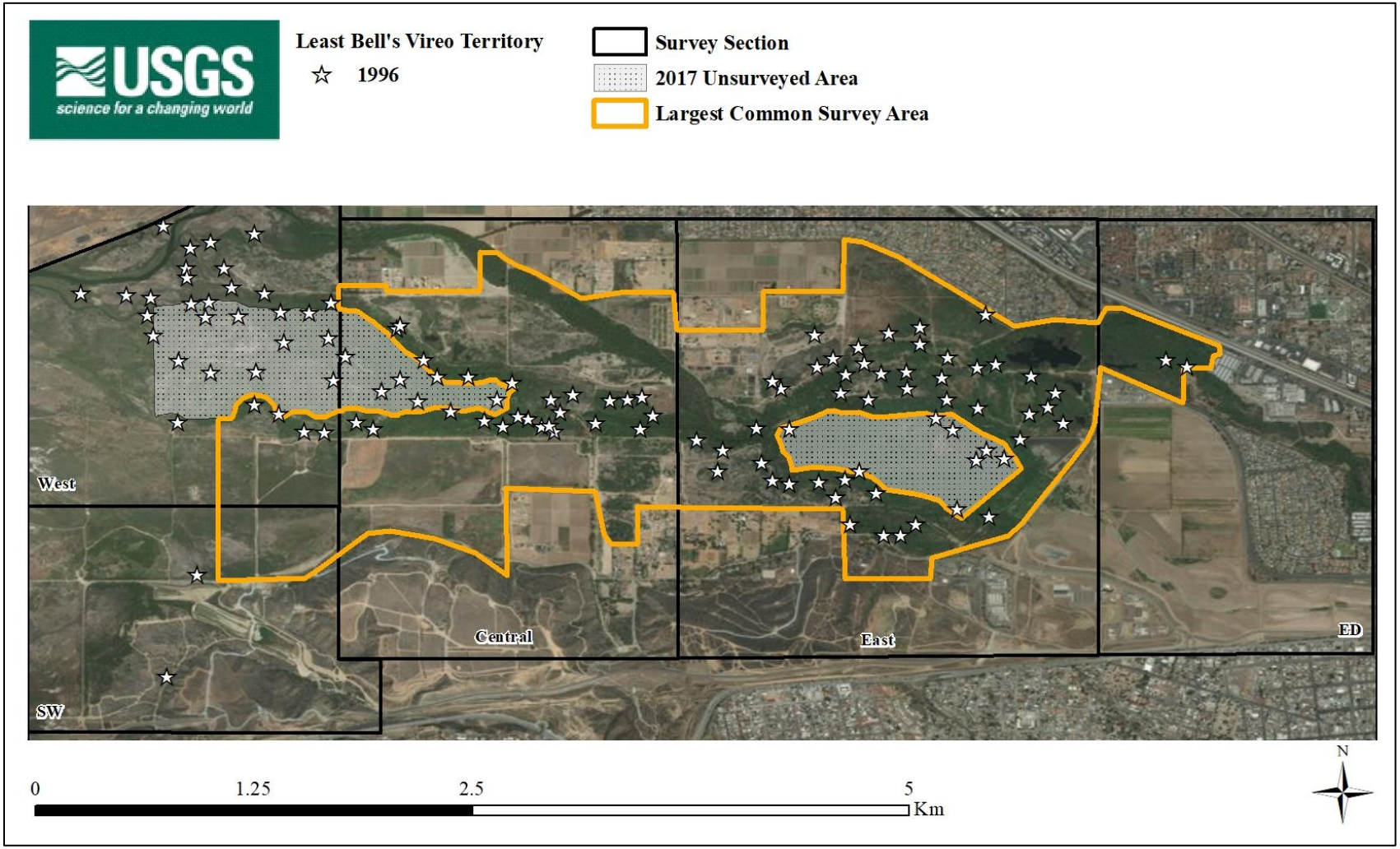

Fig. 13. Least Bell's Vireo territory locations at the Tijuana River Valley, 1996 (Kus 1996).

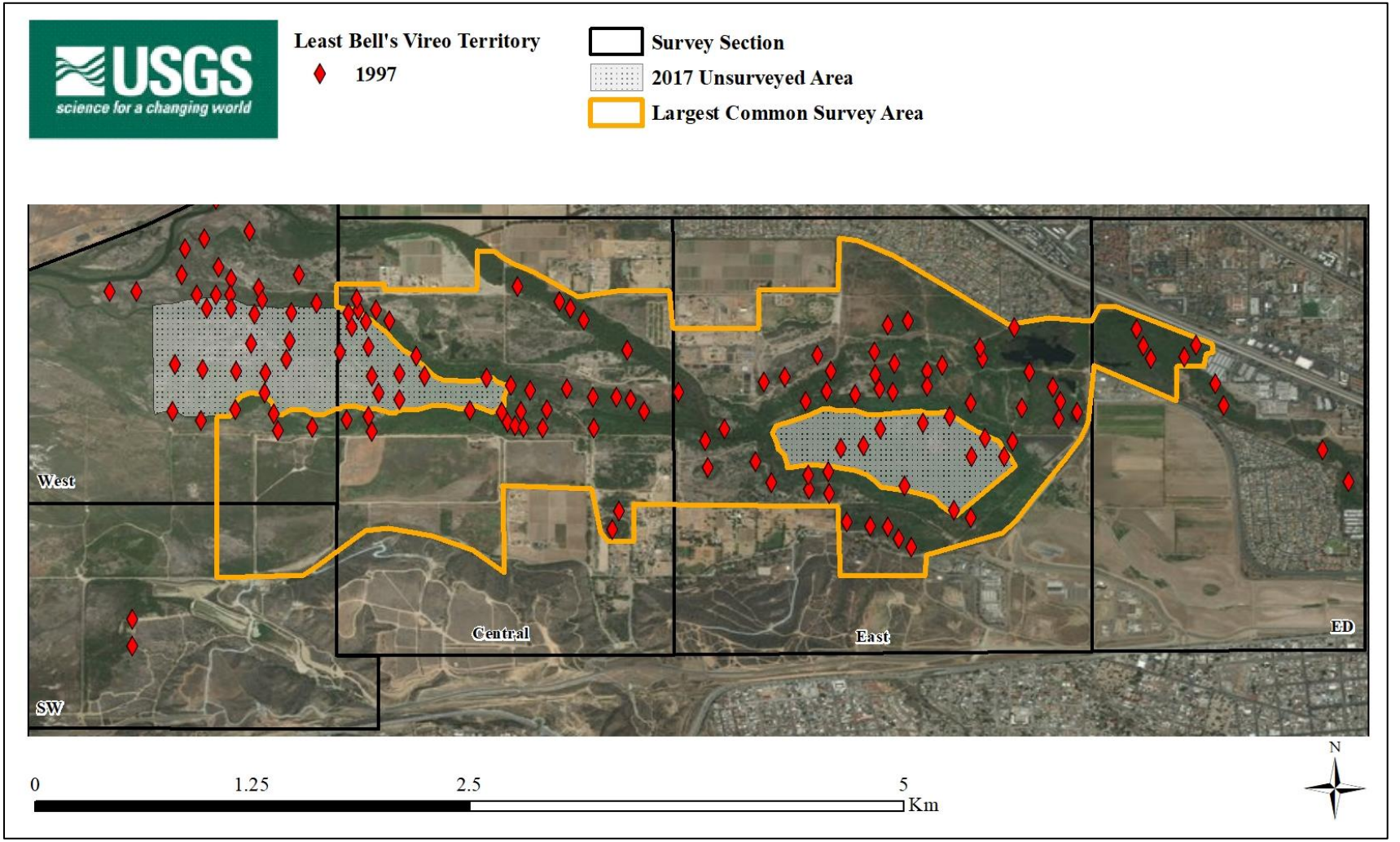

Fig. 14. Least Bell's Vireo territory locations at the Tijuana River Valley, 1997 (TW Biological 1997).

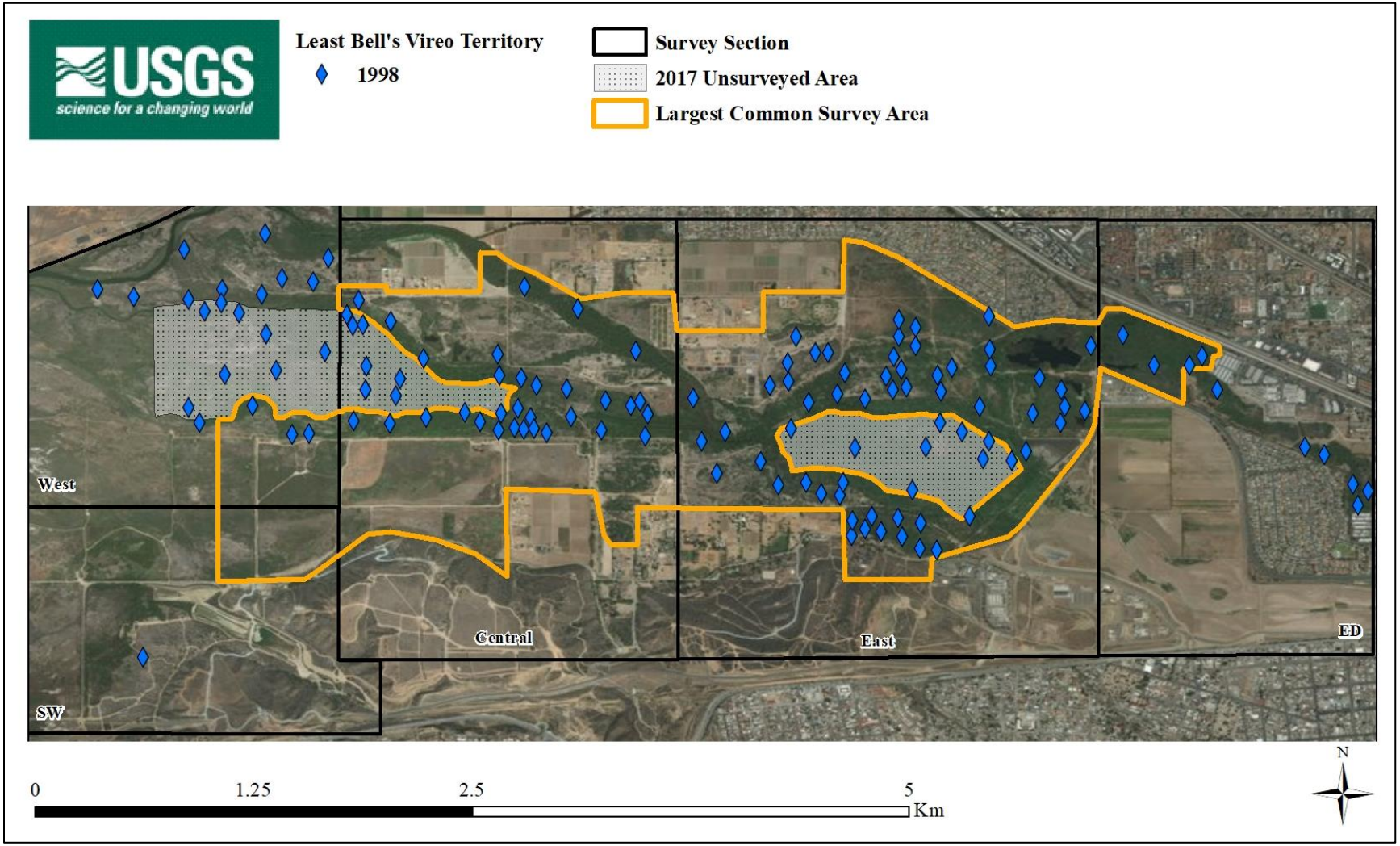

Fig. 15. Least Bell's Vireo territory locations at the Tijuana River Valley, 1998 (TW Biological 1998).

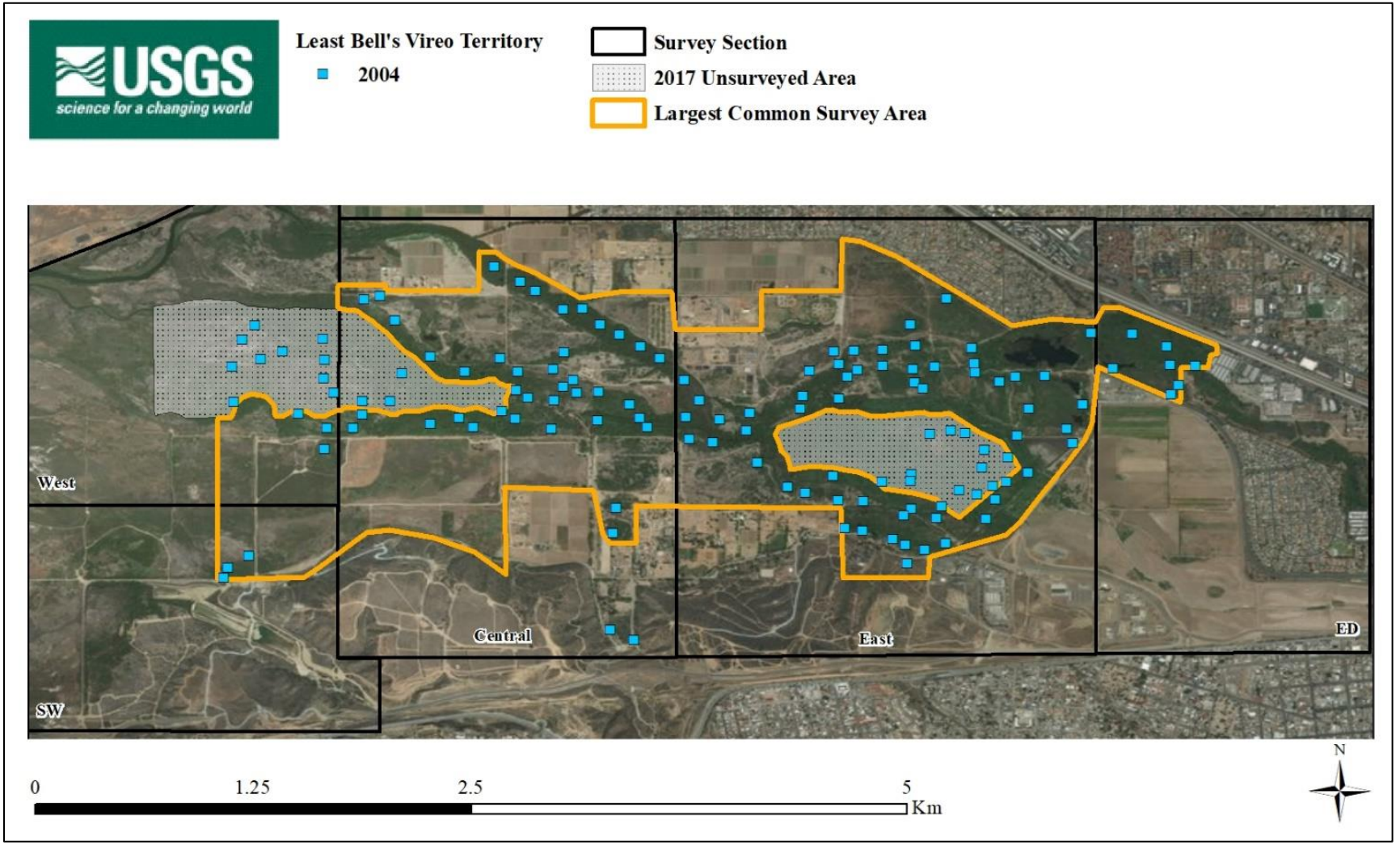

Fig. 16. Least Bell's Vireo territory locations at the Tijuana River Valley, 2004 (ERA 2004).

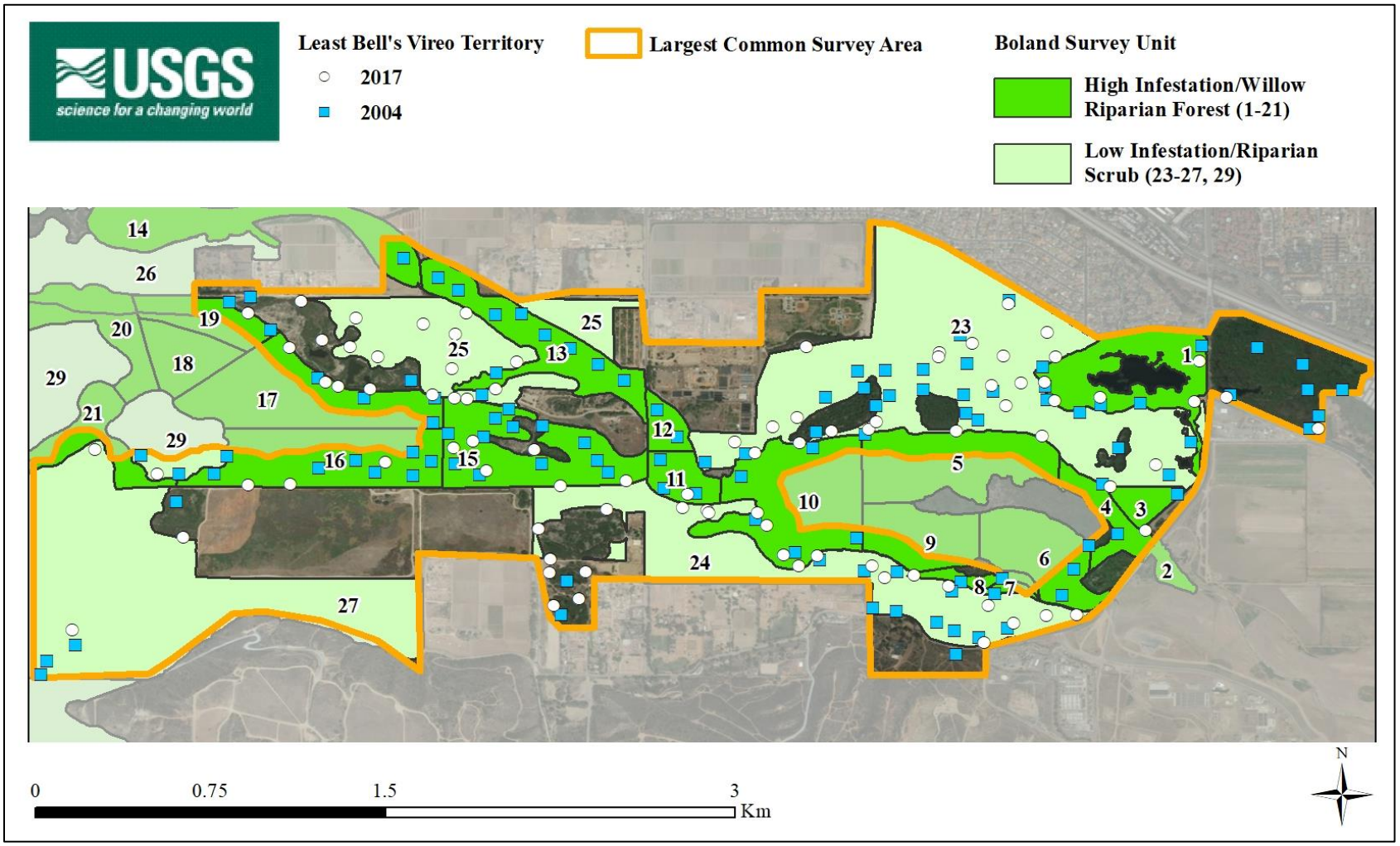

Fig. 17. Least Bell's Vireo territory locations at the Tijuana River Valley in 2004 and 2017 in the largest common survey area, and numbered Boland survey units used to characterize vegetation type and Kuroshio shot hole borer/Fusarium dieback infestation level (Boland 2016).

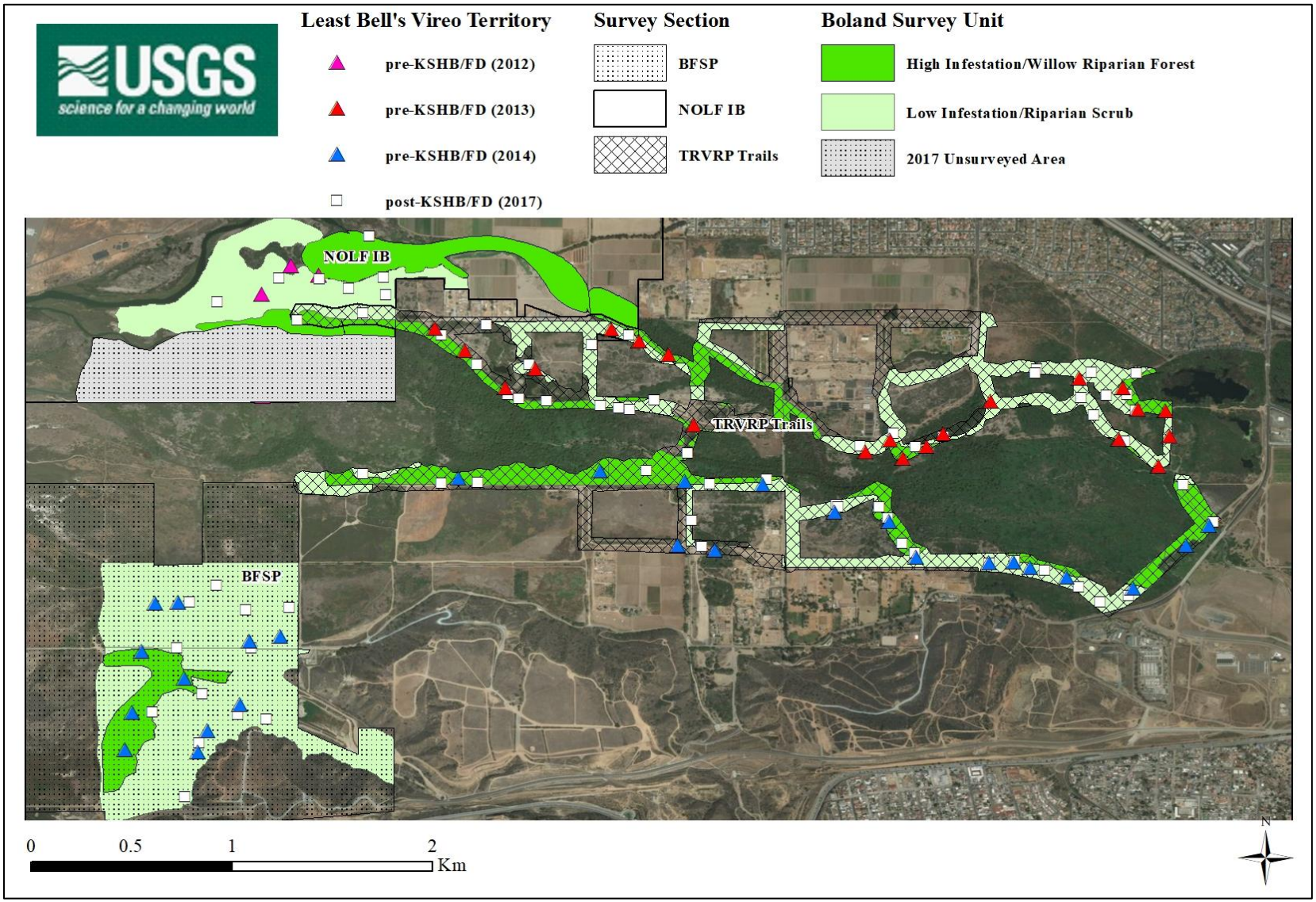

Fig. 18. Least Bell's Vireo Territories at three recently surveyed sections of the Tijuana River Valley pre- and post- Kuroshio shot hole borer/Fusarium dieback infestation, 2017 unsurveyed area, and Boland survey units used to characterize vegetation type and infestation level (Boland 2016).