San Diego Association of Governments:
Transnet EMP Program

Arundo Re-treatments- Santa Margarita, San Luis Rey and San Dieguito Watersheds

Final Project Report

Grant Number: **50044732**

Dates: **September 28th 2015 to September 28th 2018**

Submitted: **August 20th, 2018**

To: **Sarah Pierce and Kim Smith**
SANDAG
401 B Street, Suite 800
San Diego CA 92101

Executive Summary

Arundo donax once severely degraded riparian systems in north San Diego County watersheds (Santa Margarita, San Luis Rey, and San Dieguito). Arundo impacts include: fire, flooding, water use, and degradation of habitat functions critical to supporting listed species. Watershed based (top/down) control programs funded through state and federal programs have completed initial treatments on the majority of Arundo stands on north county watersheds. SANDAG EMP funding is being used to implement the long-term re-treatments to achieve the goal of watershed based eradication of Arundo. Significant progress in reducing Arundo regrowth has occurred, with a drastic reduction in the density of re-sprouts and the gradual decline of re-treatment points (more portions of creeks and rivers are Arundo free). Time series aerial and ground based photography visually demonstrate project progress (Appendix A), and detailed mapping of re-treatments show progress over time in eliminating Arundo from watersheds (Tables and Figures).

Contents

Project Overview & Background

The primary tasks of this EMP project were to: 1) re-treat *Arundo* stands that were previously treated under Mission RCD projects on the Santa Margarita and San Luis Rey watersheds, 2) re-treat *Arundo* stands that were previously treated under San Dieguito JPA projects on the San Dieguito watershed and 3) maintain Right of Entry Agreements (ROEs) and permits for the programs to allow re-treatments to occur. This was the 'third' EMP funded *Arundo* re-treatment project running from Fall 2015 through Spring 2018. It follows two previous EMP re-treatment projects running from Fall 2009 to Spring 2015. A fourth EMP *Arundo* re-treatment project has also been awarded to continue work in Fall 2018 through Fall 2020 (three more re-treatment years). This new grant cycle will also expand work to include Carlsbad HU, so the entire North County will now have active *Arundo* re-treatments.

The goal of the watershed based control program is to achieve eradication of *Arundo* within riparian areas on watersheds where *Arundo* is being controlled (Figure 1). This will 'protect' the substantial investment that has been made in controlling over 1,200 acres of *Arundo* on the two watersheds. The *Arundo* control program for the San Luis Rey and Santa Margarita watersheds has been operating since 1994 and has completed initial treatments on over 99% of the Santa Margarita and 95% of the San Luis Rey using predominantly State and Federal grant funds (Figure 1). Over $10 million has been invested in controlling *Arundo* through Federal, State, and local funding. Most of the work has been managed by Mission RCD (upper Santa Margarita and San Luis Rey watersheds) and USMCB Camp Pendleton (lower Santa Margarita River). There are numerous additional groups that have also carried out *Arundo* control, typically as mitigation, including: ACOE, CalTrans, City of Oceanside, and other private entities including both agricultural (Vine Ripe Tomato and SRF) and development groups (Granite Construction, Vista High School, Lake Rancho Viejo LLC, and West Lilac). Although *Arundo* eradication is a difficult task to achieve, the goal is obtainable as demonstrated by a near absence of *Arundo* on the Santa Margarita River between the County line and Camp Pendleton (the result of twenty years of control work).

Work on San Dieguito Watershed follows a similar pattern, with work starting in the mid 2000's to an area just below Lake Hodges Dam. This work has been mostly on City of San Diego lands and funded by the State (IRWM), NRCS, and SANDAG/Transnet.

The watershed based *Arundo* control programs have active regulatory permits (FWS, ACOE, DFW, and CEQA compliance) and right of entry agreements (ROEs) for over 350 properties. The programs also continue to secure other funding to complete remaining initial treatments on the last scattered *Arundo* stands on the San Luis Rey (used as match: IRWM and WCB) and to continue work downstream on San Dieguito (FWS Partners). State and Federal funders infrequently fund long term re-treatments (viewed as O&M), even though this is a critical component of the long term eradication program and one that is vital for the EMP program to support. The SANDAG Managers Group recently received the report 'Management Priorities for Invasive Non-native Plants' which specifically recommends funding support for watershed based *Arundo* control programs that occur on high value watersheds and which have already achieved

significant progress in eradication. In this report, north county watersheds are ranked as the highest priority watersheds for funding support to implement re-treatments.

There are many invasive, non-native species that occur across the region. *Arundo* is nearly unique in the severity of its impacts (San Diego Regional PAF score of 8.9, the highest of any invasive non-native plant). These impacts occur predominantly due to the size and density of *Arundo* stands that develop over time. Human disturbances, such as modification of fire and flood regimes and mechanical disturbance, promote the spread and growth of the species. Dense stands of *Arundo* modify fluvial processes on large river systems, like the Santa Margarita and San Luis Rey. *Arundo* stands form along the banks of low flow channels, converting the systems into a single stable, deep channel versus the multiple, laterally unstable channels that were historically present. Control and eradication of *Arundo* helps restore active channel width and instability, which is critical to maintaining riverine features that endangered species utilize. Arroyo southwestern toads are particularly impacted by changes to channel morphology as they require pools and sandy fluvial material for aestivation and completion of their life cycles. Significant downstream impacts also occur to estuarine and beach/foredune habitats due to the accumulation of *Arundo* biomass. *Arundo* also uses significantly more water than native vegetation, consuming up to an estimated 30 ac-ft of water per year per acre if water is available. This is drastically higher than the estimated water use of 4 ac-ft yr/ per acre of the mixed vegetation and open substrate that replaces *Arundo* once it is controlled.

Arundo's greatest impact may be on the alteration of fire regime cycles in both riparian and upland areas. *Arundo* stands are highly flammable, and when combined with their attractiveness for harboring encampments (an ignition source), a new class of wildland fires is created that starts in riparian areas (Cal-IPC 2011). Riparian areas that once interrupted the conveyance of upland fires, are now frequently the ignition source. *Arundo* fires also function as a fire conveyance corridor. *Arundo* stands on the Santa Clara River clearly allowed an upland fire on the northern mountain range to cross one mile of *Arundo* invaded riverine habitat and then ignite the southern mountain range, where 107,560 acres of upland habitat then burned (Cal-IPC 2011). These abiotic fire and fluvial/hydrologic impacts result in severe degradation of critical habitat and even direct mortality of listed riparian/wetland species (arroyo toad, Southwestern willow flycatcher, least Bell's vireo, and *Ambrosia pumila,* Figure 2). These impacts even extend into upland terrestrial communities (including listed species that reside there) through *Arundo*'s ability to move fire across landscapes.

Project Goals:

The project goal is achieve 100% Arundo control within project areas (areas with active Arundo control). The ultimate project goal is Arundo eradication, which requires both 100% control and all populations of the plant being eliminated on the creek, river, or watershed.

Administration Task 'n'

Budget: $15,000
Spent: $15,000
Match for Task: $18,288.06

The Project agreement with SANDAG and the selection of and contracting with field contractors were completed. EMP Quarterly Reports (1 - 11) were completed, documenting: 1) re-treatments of target plants from Fall 2015 to Spring 2018, 2) work on the Right of Entry Database (ROEs), and 3) annual regulatory permit reporting. Quarterly invoice sets were prepared and submitted. Invoices were paid to contractors and consultants. This final EMP Report summarizes annual work as well as providing an overall project summary.

Arundo Re-treatment Tasks:

Task 1: Santa Margarita and San Luis Rey Right of Entry work, MRCD Staff

Budget: $30,854.20
Spent: $30,854.20
Match for Task: $24,173.56

District staff worked to maintain and expand the 'right of entry' (ROE) database. This database was developed using two GIS data layers, *Arundo* mapping and parcel data, to identify all properties where permission is needed to treat *Arundo* stands. Identified properties were contacted and a signed permission slip obtained (the ROE). Two separate datasets are maintained: 1) a GIS dataset and 2) an Excel workbook with twelve worksheets covering portions of the two watersheds. Contacting property owners, renewing ROEs, and maintaining the databases are time consuming, but critical, tasks.

Work areas are selected each year and maps are prepared to assist treatment crews. Specific information on logistics (gate codes, work date or time requirements, access issues, etc.) are noted.

Staff periodically checked on work crews to assure permitting compliance, that work was being completed (including an assessment of thoroughness and quality), and that the correct areas and plants were being treated. Interaction with the treatment contractor assured that crews were searching areas adequately, that adequate coverage (>90%) was occurring, that minimal cutting or breaking of *Arundo* was occurring, and that no damaging herbicide drift onto non-target vegetation was happening.

Treatment crews are self-directed based on treatment areas selected for re-treatment. However, both RCD staff and consultants monitor quality of work completed and regulatory compliance. Of particular concern is inadequate searching and/or detection of *Arundo* re-sprouts. The District determined that a specific contractor had better detection ability and that continuity of treatment crews was important factor in work performance.

Task 2: San Diguito Right of Entry work, San Dieguito JPA and Conservancy Staff

Budget: $2,305.00
Spent: $2,305.00
Match for Task: $3,736.25

JPA staff worked to maintain and expand the 'right of entry' (ROE) database and contacted the City and leases where needed. JPA staff also completed needed monitoring and reporting to maintain their permits. San Dieguito River Conservancy Staff assisted crews on the ground with logistics.

Task 3: Regulatory Permit Monitoring and Reporting, San Luis Rey, Consultants
Budget: $18,573.62
Spent: $18,567.50
Match for Task: $18,573.62

Consultants assisted with several tasks including: GIS data management and map generation, biological monitoring and permit reporting, project reporting, and quality control.

Biological monitoring (before, during and after work is carried out) included review of permit conditions with crews at the start of each season and monitoring to assure conditions are being followed. Photos, notes and GIS data collection occurred. Each year annual reports were prepared for CADFW, USFWS and ACOE (2016, 2017, and 2018). These reports outline work completed and as well work planned for the next year. GIS data, project photos and a description of work completed were included in the annual reports. This same information was used to prepare quarterly and this final EMP report.

Task 4: Arundo re-treatments, Contractor
Budget: $233,267.18
Spent: $233,267.18
Match for Task: $236,761.64

A contractor with licensed applicators were used to carryout re-treatments. The contractor has extensive experience re-treating *Arundo*. *Arundo* was re-treated with backpacks using aquatic approved formulation of glyphosate and surfactant. Surfactant was added to assure both spreading and sticking of the applied herbicide. Blue dye is also used to assist in assessing adequate coverage and detecting drift. Adequate coverage is also important - typically over 90% of the leaf surface should be covered. It is important not to cut *Arundo* re-sprouts when possible, as this drastically reduces control success. Trimming of natives may occur (as specified in permits), but crews can usually 'bend and spray' *Arundo* canes to achieve adequate treatment. Drift and overspray are monitored and have not been found to cause mortality of established native vegetation. If overspray is detected on non-target plants during treatment, which is uncommon, it is usually trimmed off to assure that no lasting damage occurs to the non-target plant.

GIS mapping of re-treatments was the responsibility of the treatment contractor, with review of data by RCD staff and the consultant. For the fall 2015-2017 seasons the treatment crews uniformly collected treatment location data. This was efficient and made the data comparable year to year. Collection of GPS data by crews is important for the project as it allows the program to track both work areas and treatment success. This in turn effects re-treatment area selection as well as the need to maintain ROEs (if a property is clear of *Arundo* for several years, renewal of the ROE is not needed). Although the GPS data collection is important, it cannot take up too much field time. A balance was struck between achieving the data quality needed and the time required to collect that data. The project has settled on the following procedure, which has been used from Fall 2010 through Fall 2017, and will continue for the Fall 2018 to 2020 treatments.

Each applicator is fitted with a small simple GPS unit. They collect a point at each treatment location (a separate 'patch' of *Arundo*, this could vary from a single cane to hundreds of canes, but is typically 5 to 50 canes). The unit must be small and simple in order not to slow the applicator down (they are doing multiple things: searching, treating with a backpack, pumping the pack occasionally, untangling or separating the *Arundo* and native vegetation, etc.). The unit only records points, no attribute data. This allows the project to get detailed location data on the re-treatment target (*Arundo*). Having the crew's record the data is much more practical than having a separate mapper in the crew, as they cannot keep up with multiple people in the crew.

Results:

This EMP *Arundo* re-treatment project treated three field seasons: fall 2015, 2016 and 2017 (with some spring 2018 work after a fire on the San Luis Rey).

For the San Luis Rey and Santa Margarita Watersheds:

The 2015 re-treatment effort covered 27.3 miles of streams and rivers with 1,922 treatment points on the two watersheds (Table 1, Figure 3). The entire Santa Margarita watershed was re-treated, except for upper Rainbow Creek. The San Luis Rey watershed re-treatment effort focused on the main stem of the river above College Ave to North River Road and from County lands by I-15 to Pala, as well as Moosa and Castle Creeks (Figure 3).

The 2016 re-treatment effort covered 22.8 miles of streams and rivers with 4,678 treatment points on San Luis Rey Watershed (Table 1, Figure 4). On the San Luis Rey watershed re-treatments covered the main stem of the river from College Ave all the way to I-15, as well as Moosa, Live Oaks, Guajome, and Keys Creeks (Figure 4).

The 2017 re-treatment effort covered 29.7 miles of streams and rivers with 3,475 treatment points on San Luis Rey Watershed and Santa Margarita Watersheds (Table 1, Figure 5). The entire Santa Margarita watershed was re-treated, including all of Rainbow Creek. On the San Luis Rey watershed re-treatments covered the main stem of the river from Bonsall Bridge to Pala, as well as Ostrich, Keys, Castle, Olive Hill, and Stewart Canyon Creeks (Figure 4).

Trends of several treatment areas are presented in Table 2. All of the sites show a similar pattern, higher re-sprout counts that typically drop by over 50% after the first few cycles, followed by persistent re-sprouting that slowly declines, but has yet to reach zero. It is important to remember that these treatment areas were covered with large dense stands of *Arundo* initially and that the number of canes was in the hundreds of thousands (Appendix A). And at each of these 'points' cane density is dropping, from hundreds of canes to only a few at each point. But the goal is eradication, and Santa Margarita is in year 22 and Live Oak is in year 18. To address this, future work will use a mix of herbicides to try and boost efficacy (discussed further in recommendations). Santa Margarita re-treatment work shows a steady decline, but not an elimination of *Arundo* re-sprouts (Table 3, Figure 8). Driving by this site and viewing the river would give you the impression that there is no *Arundo* in this area. But traces of *Arundo* remain. The San Luis Rey from College Ave to River Road also has shown a drastic reduction, especially considering that the initial 5 year phase of work ended in 2008 (Table 3, Figure 9). Ostrich Creek *Arundo* re-sprouts have declined a bit, but have been frustratingly persistent in areas (Table 3, Figure 10). Part of this Creek burned, which will trigger more re-sprouts for 2018, but may allow a better re-treatment. Live Oak Creek has persistent pockets of re-sprouts as well and Olive Hill actually increased in re-sprout number. Olive Hill burned in the December 2017 fire, so all areas will have re-treatments. The San Luis Rey from Bonsall Bridge to Camino Del Rey Bridge has seen a significant decline, similar to the College area (Table 3). It seems that the main river channel may have better control. This may be due to tributaries receiving more runoff (irrigation) which may be making these *Arundo* stands more resilient. The main stem has gone dry in many areas, particularly during the drought (2012 to 2016). Castle Creek seems to on a declining trend, although treatments in 2017 were of only part of the area due to Golf Course non-response to access requests (groundskeeper staff changes).

<u>For the San Dieguito Watershed:</u>

No work occurred in 2015 as IRWM funding was still active for most of the treatment area.

The 2016 re-treatment effort covered 10.7 river miles with 2,028 treatment points (Table 2, Figure 6). The work are started at I-15 and ended at Clevenger Canyon (aside from one re-treatment on the lower Lake).

The 2017 re-treatment effort covered 17.4 river miles with 4,668 treatment points (Table 2, Figure 7). The work are started at Lake Hodges and ended at Clevenger Canyon.

As this is only the second year of re-treatments trends are difficult to assess. The high rainfall in 2017 clearly increased re-sprouting (519 points in 2017 versus 115 points in 2016) in the drier portions of San Pasqual Valley (Figures 12 & 13). The strong expression of re-sprouts following good rains after five years of drought, allowing a thorough re-treatment, should help turn the corner on re-sprouts. A steady decline is expected to occur from 2018 onward.

Conclusions/Recommendations:

Obviously faster *Arundo* control is desirable. The program is expending ongoing resources to maintain permits, Right of Entry Agreements, and program activities. A drastic reduction in *Arundo* is occurring throughout the program area (Appendix A). But the program desires faster attainment of 100% control. Most entities in the State will have difficulty achieving success with a 20 year commitment for a control program. A 10 year program would be far more desirable. To improve treatment efficacy a revised herbicide formulation will be used. Herbicides are restricted to those approved for use in wetlands, as most work is in riparian habitat. To date re-treatments have been with glyphosate (5%), an aromatic amino acid inhibitor affecting three amino acids. Glyphosate is non-mobile and has high efficacy, but is obviously not killing all rhizomes. Another aquatic approved herbicide is also available for use in wetlands, Imazapyr. This herbicide also is an amino acid inhibitor, it effects three different amino acids. Imazapyr is very mobile, is slow acting, and has long soil residual effects. Initial treatments (high volume) applications were used in 2008 on the San Luis Rey. The program was not happy with the slow succession of native vegetation as well as some migration of the herbicide to non-target native vegetation. However, re-treatments are very low volume applications (few canes, not much herbicide). For the next three years an herbicide mix will be used, a lower concentration of glyphosate (3%) and a low concentration of Imazapyr (1%). This should result in higher rates of *Arundo* control, as six amino acids will be affected, and better movement of the herbicide throughout the remaining live rhizomes may occur as the mix will be slower acting. These low volume applications should have no effect on native vegetation.

Table 1. San Luis Rey and Santa Margarita Watersheds *Arundo* re-treatment (2015, 2016, & 2017) and past (2009 – 2014). *Arundo* points/locations treated (may be multiple canes).

Re-treatment Year	Miles treated	*Arundo* re-treatment locations[+]	Average re-treatments per mile	Notes:
Spring 2009	16	741	NA	Abbreviated treatments
Fall 2009	19.9	272*	NA	
Fall 2010	31	5,749	185.5	
Fall 2011	29	4,658	199.1	
Fall 2012	23.4	4,642	198.4	
Fall 2013	31.7	4,972	156.8	
Fall 2014	39.6	4,808	121.4	
Fall 2015	27.3	1,922	70.4	See figure 3
Fall 2016	22.8	4,678	205.2	See figure 4
Fall 2017	29.7	3,475	117.0	See figure 5, high rainfall

[+]Re-treatment locations have variable *Arundo* cane density, from one to several hundred canes.
*Large areas mapped as polygons, not comparable to other years.

Table 2. San Dieguito Watershed Arundo re-treatments (2016 & 2017). *Arundo* points/locations treated (may be multiple canes).

Re-treatment Year	Miles treated	*Arundo* re-treatment locations[+]	Average re-treatments per mile	Notes:
Fall 2016	10.7	2,028		See figure 6
Fall 2017	17.4	4,668		See figure 7

[+]Re-treatment locations have variable *Arundo* cane density, from one to several hundred canes.

Table 3. EMP re-treatment grant (first grant 2009-2012, second 2013-14). *Arundo* points/locations treated (may be multiple canes).

Re-treatment Year	**Santa Marg** Initial work ended: 1996	**San Luis Rey River: College** Initial work end: 2008	**Ostrich Creek** Initial work ended: 2002	**Live Oak Creek** Initial work ended: 2000	**Olive Hill Creek** Initial work ended: 2004	**San Luis Rey River: B-Br to CDR Br*** Initial work ended: 2010	**Castle Creek** Initial work ended: 2006
2009	504	-	196 (part)	-	-		-
Fall 2010		1,932	273	297	121		568
Fall 2011		1,517	84	46	15		268
Fall 2012		472	101	47	11	2,853	169
Fall 2013	168	689	-	55	-	2,533	95
Fall 2014	-	586	100	37	28	1,346	104
Fall 2015	159	203				1,163	40
Fall 2016		195		33			
Fall 2017	143		79		44	729 (part)	20 (part)

B Br: Bonsall Bridge Highway 76
CDR Br: Camino Del Rey Bridge

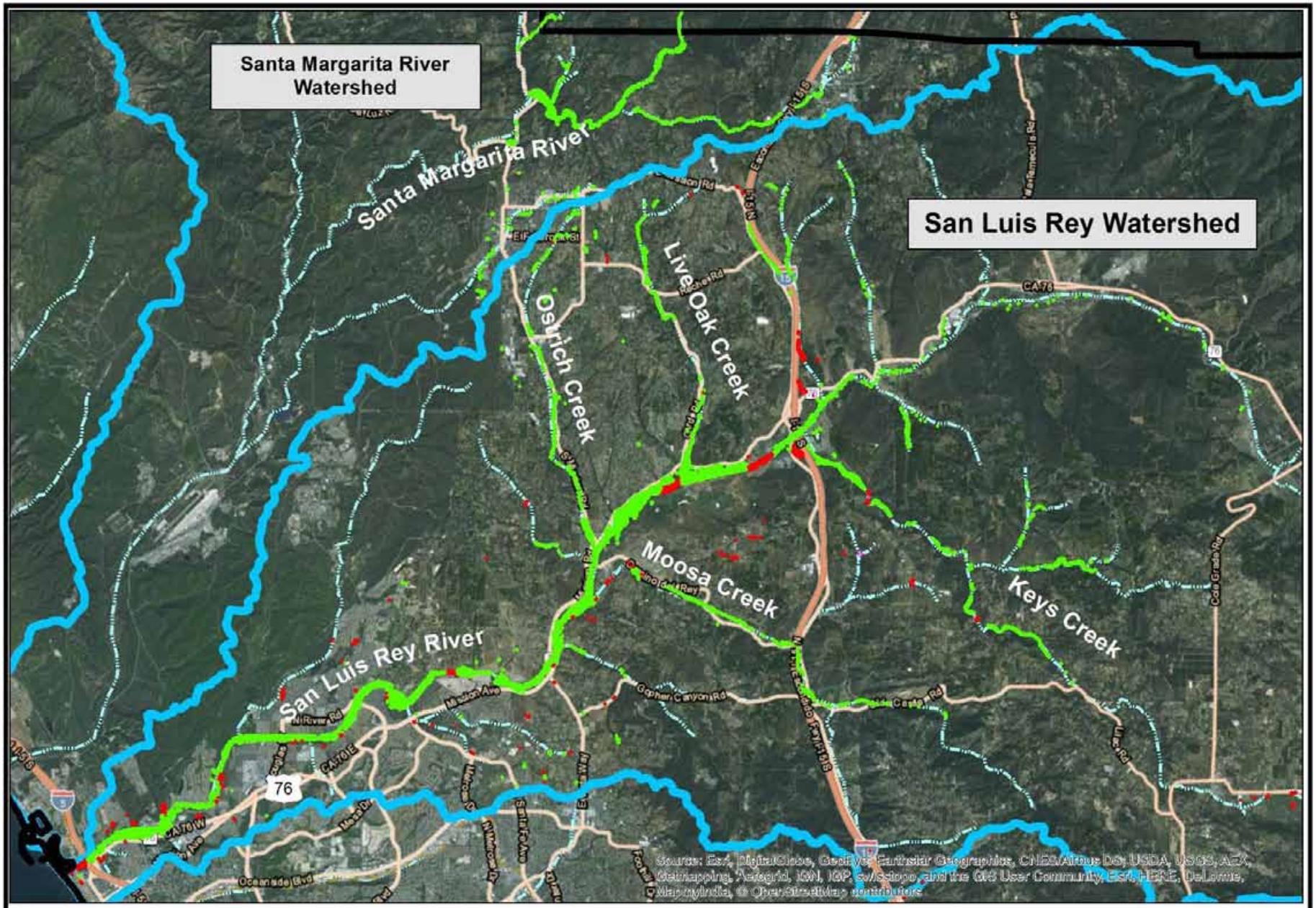
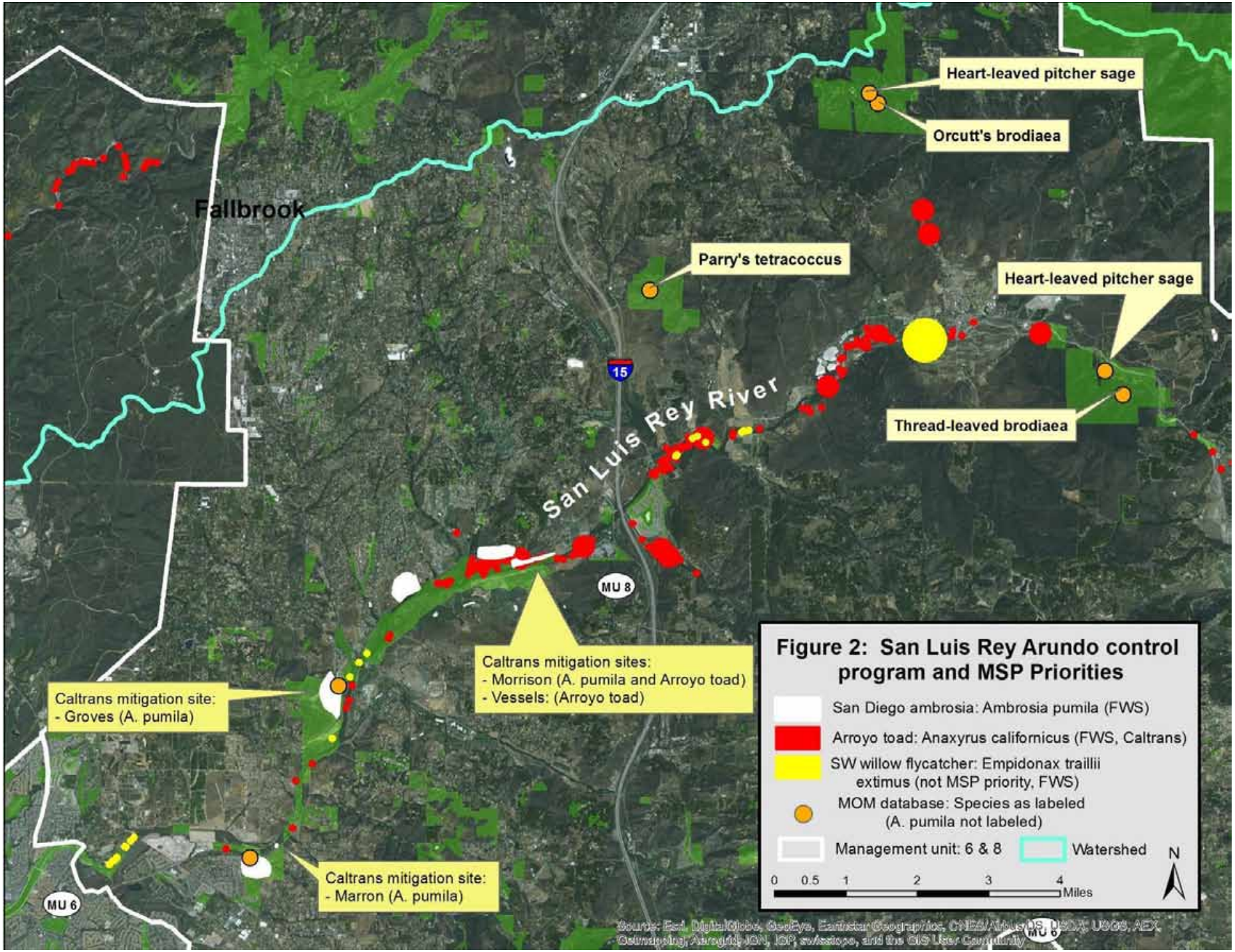


Figure 1. Treatment status of Arundo on the Santa Margarita and San Luis Rey Watersheds.

Arundo stands have been treated in the past


Heart-leaved pitcher sage
Orcutt's brodiaea
Fallbrook
Parry's tetracoccus
Heart-leaved pitcher sage
15
San Luis Rey River
Thread-leaved brodiaea
MU 8
Caltrans mitigation sites:
- Morrison (A. pumila and Arroyo toad)
- Vessels: (Arroyo toad)
Caltrans mitigation site:
- Groves (A. pumila)
Caltrans mitigation site:
- Marron (A. pumila)
MU 6
Figure 2: San Luis Rey Arundo control program and MSP Priorities
San Diego ambrosia: Ambrosia pumila (FWS)
Arroyo toad: Anaxyrus californicus (FWS, Caltrans)
SW willow flycatcher: Empidonax traillii extimus (not MSP priority, FWS)
MOM database: Species as labeled (A. pumila not labeled)
Management unit: 6 & 8
Watershed
N
0 0.5 1 2 3 4
Miles

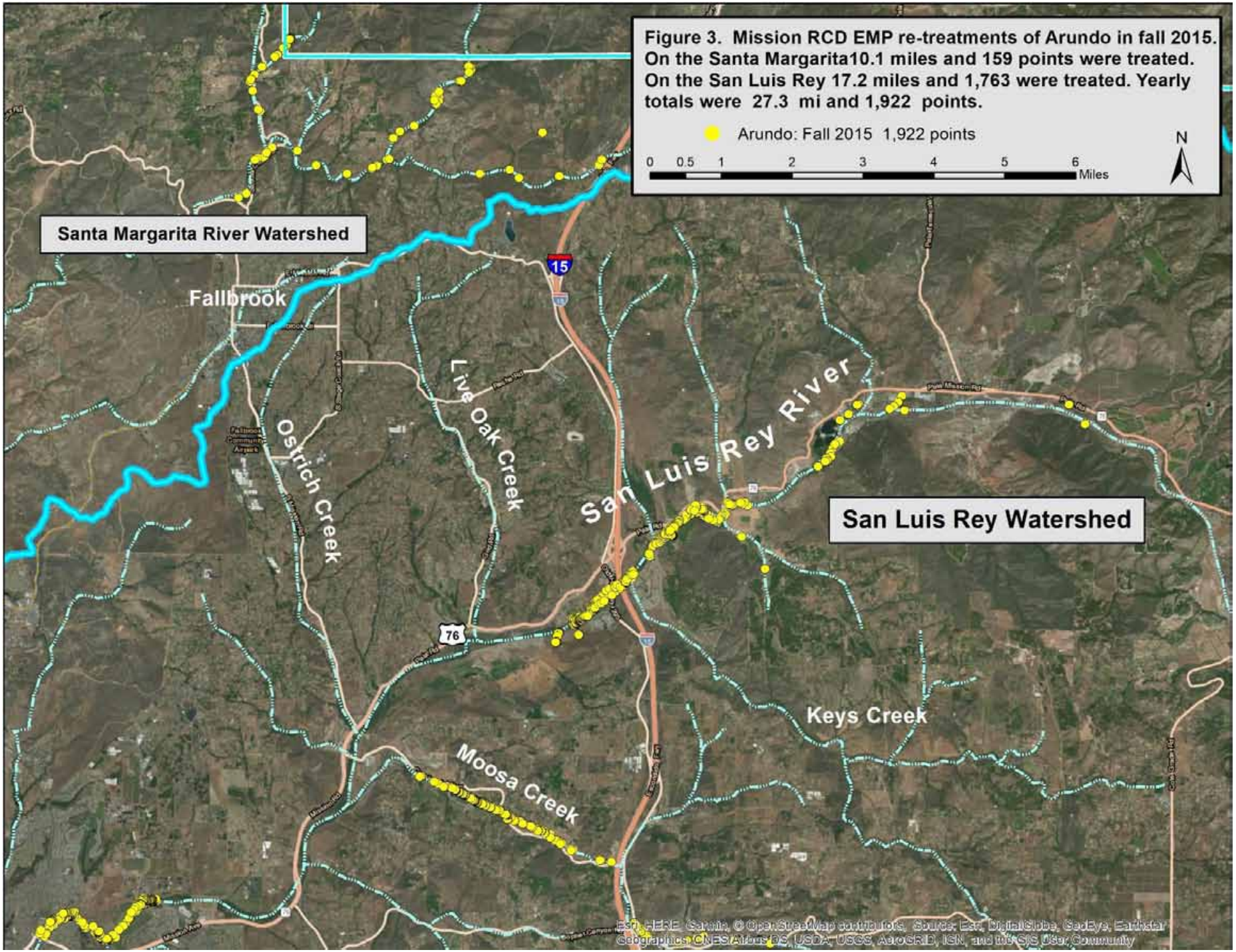


Figure 3. Mission RCD EMP re-treatments of Arundo in fall 2015.
On the Santa Margarita10.1 miles and 159 points were treated.
On the San Luis Rey 17.2 miles and 1,763 were treated. Yearly totals were 27.3 mi and 1,922 points.
Arundo: Fall 2015 1,922 points
0 0.5 1 2 3 4 5 6 Miles
N
Santa Margarita River Watershed
Fallbrook
15
Live Oak Creek
Ostrich Creek
San Luis Rey River
San Luis Rey Watershed
76
Keys Creek
Moosa Creek
Esri, HERE, Garmin, © OpenStreetMap contributors, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

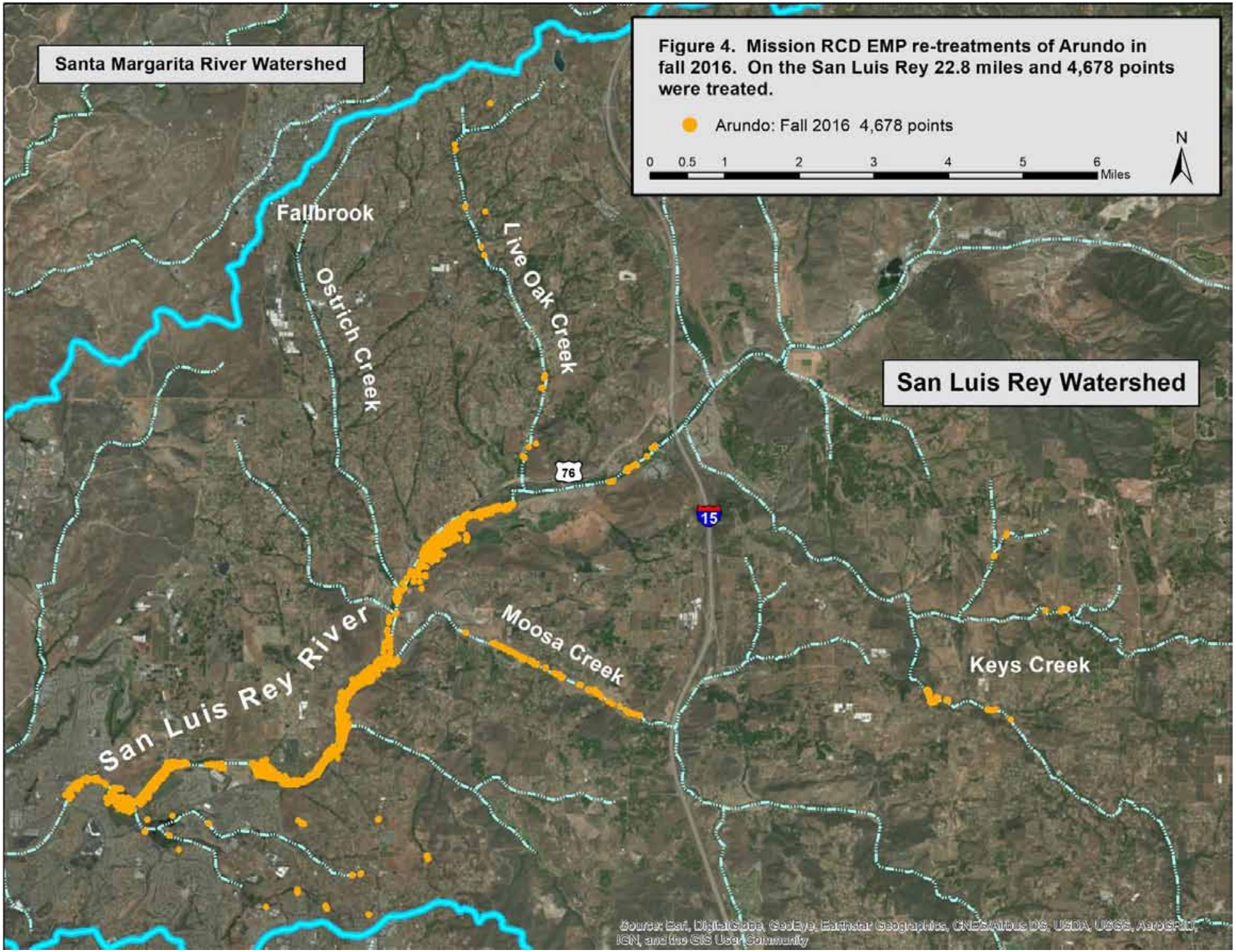


Figure 4. Mission RCD EMP re-treatments of Arundo in fall 2016. On the San Luis Rey 22.8 miles and 4,678 points were treated.
Arundo: Fall 2016 4,678 points
0 0.5 1 2 3 4 5 6 Miles
N
Santa Margarita River Watershed
San Luis Rey Watershed
Fallbrook
Ostrich Creek
Live Oak Creek
76
15
Moosa Creek
Keys Creek
San Luis Rey River
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

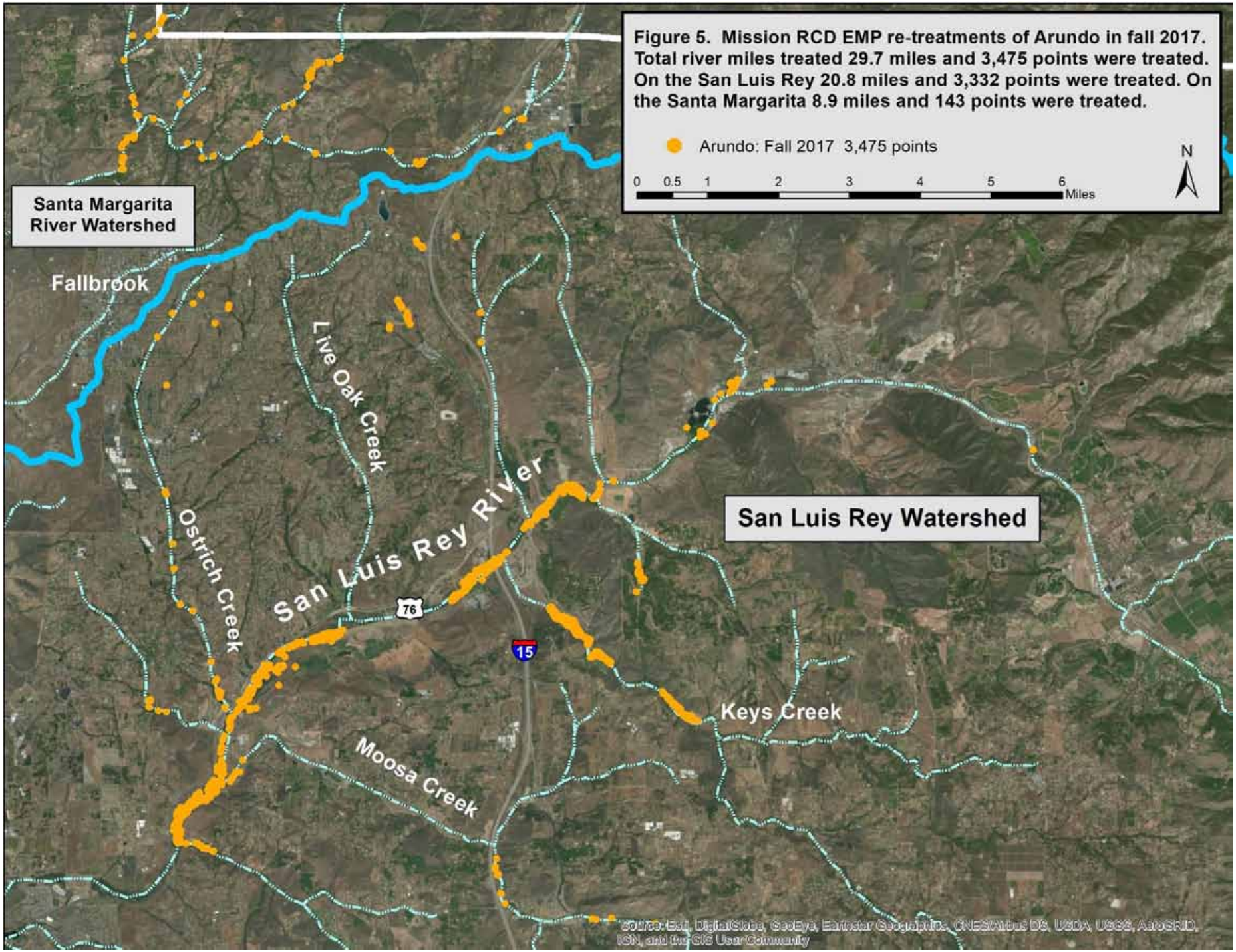


Figure 5. Mission RCD EMP re-treatments of Arundo in fall 2017. Total river miles treated 29.7 miles and 3,475 points were treated. On the San Luis Rey 20.8 miles and 3,332 points were treated. On the Santa Margarita 8.9 miles and 143 points were treated.
Arundo: Fall 2017 3,475 points
0 0.5 1 2 3 4 5 6 Miles
N
Santa Margarita River Watershed
Fallbrook
Live Oak Creek
Ostrich Creek
San Luis Rey River
San Luis Rey Watershed
76
15
Keys Creek
Moosa Creek
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

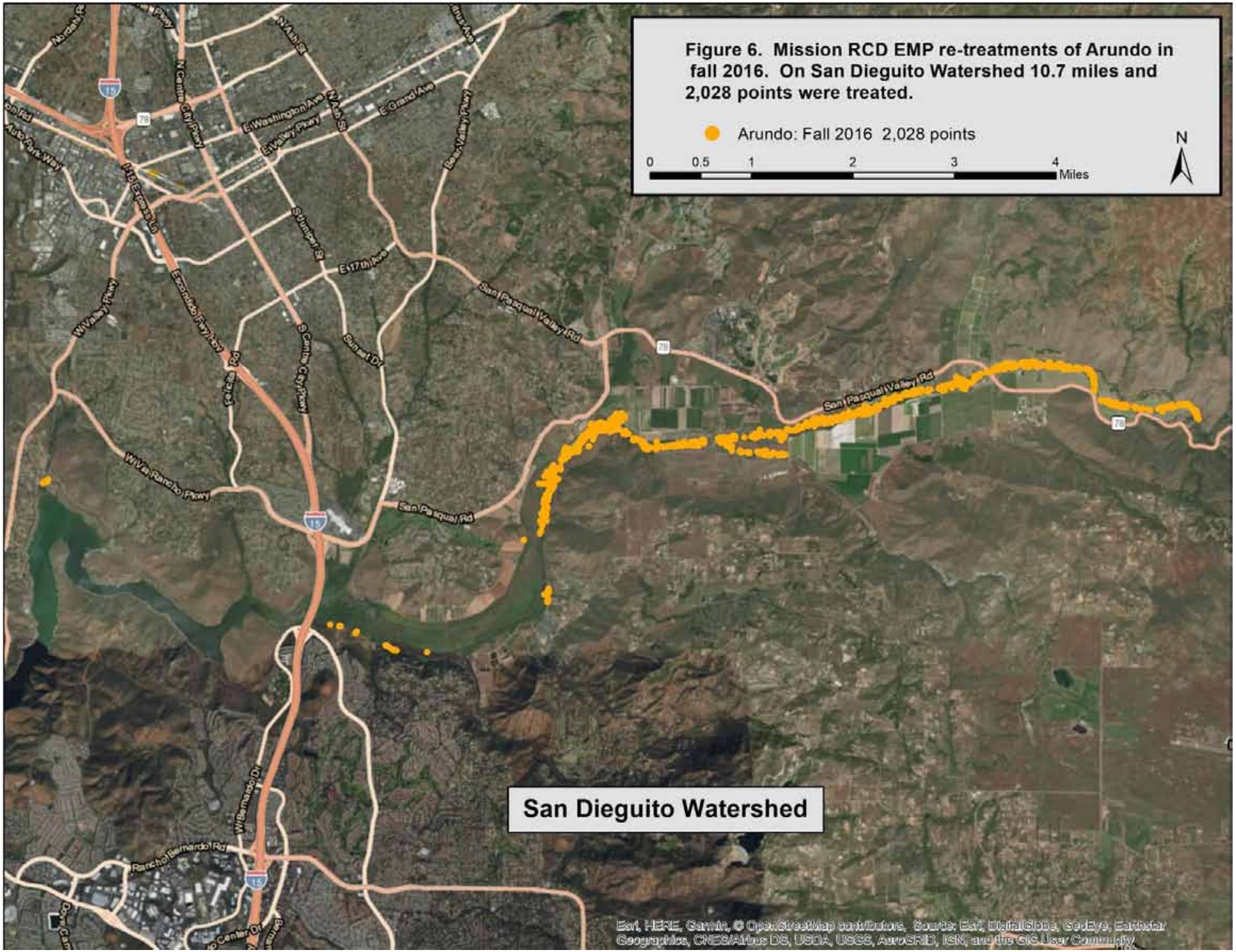


Figure 6. Mission RCD EMP re-treatments of Arundo in fall 2016. On San Dieguito Watershed 10.7 miles and 2,028 points were treated.
Arundo: Fall 2016 2,028 points
0 0.5 1 2 3 4
Miles
N
San Dieguito Watershed
San Pasqual Valley Rd
San Pasqual Rd
W Valley Pkwy
E Valley Pkwy
E Washington Ave
E Grand Ave
E 17th Ave
Sunset Dr
W Via Rancho Pkwy
Rancho Bernardo Rd
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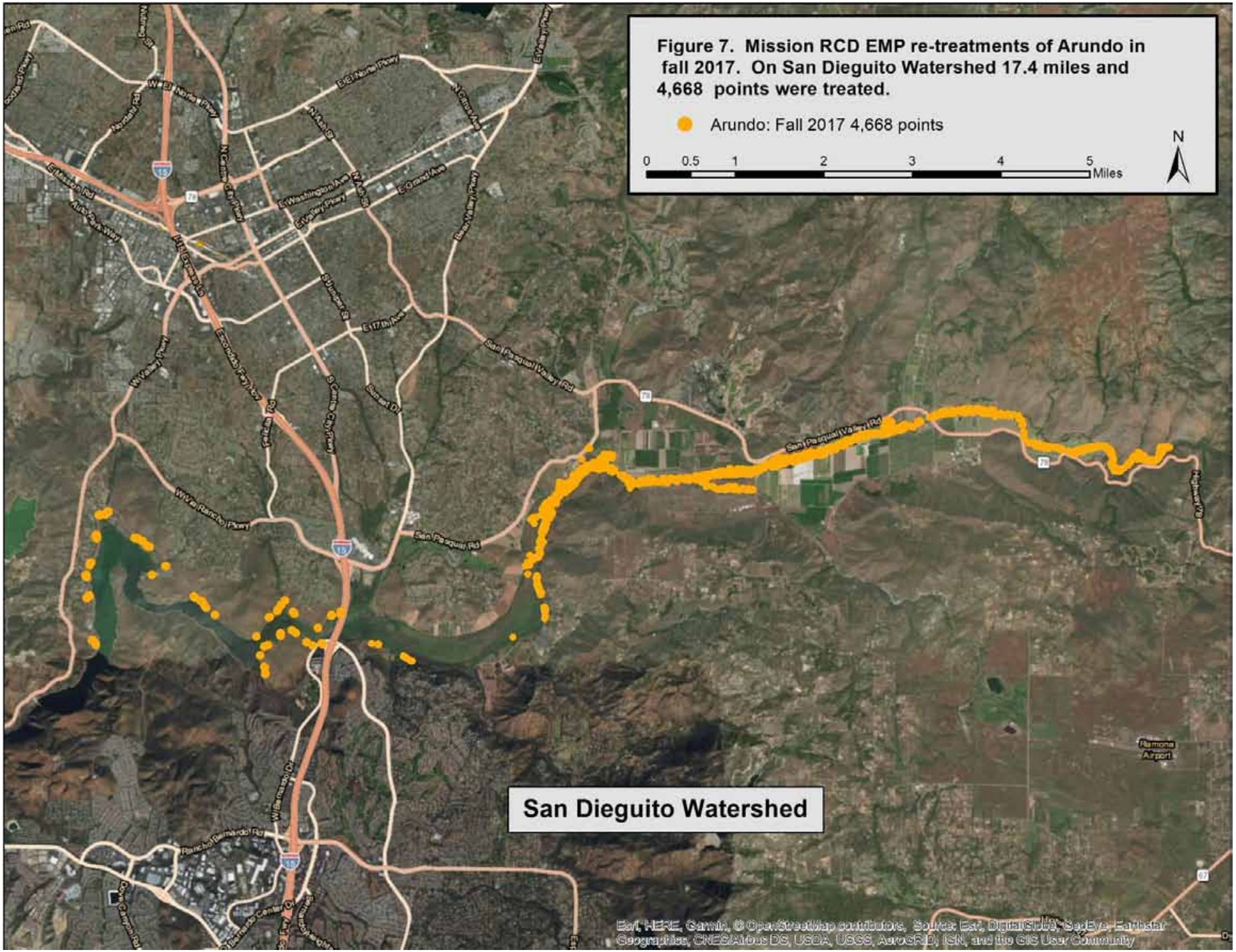


Figure 7. Mission RCD EMP re-treatments of Arundo in fall 2017. On San Dieguito Watershed 17.4 miles and 4,668 points were treated.
Arundo: Fall 2017 4,668 points
0 0.5 1 2 3 4 5 Miles
N
San Dieguito Watershed
Ramona Airport
Esri, HERE, Garmin, © OpenStreetMap contributors, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

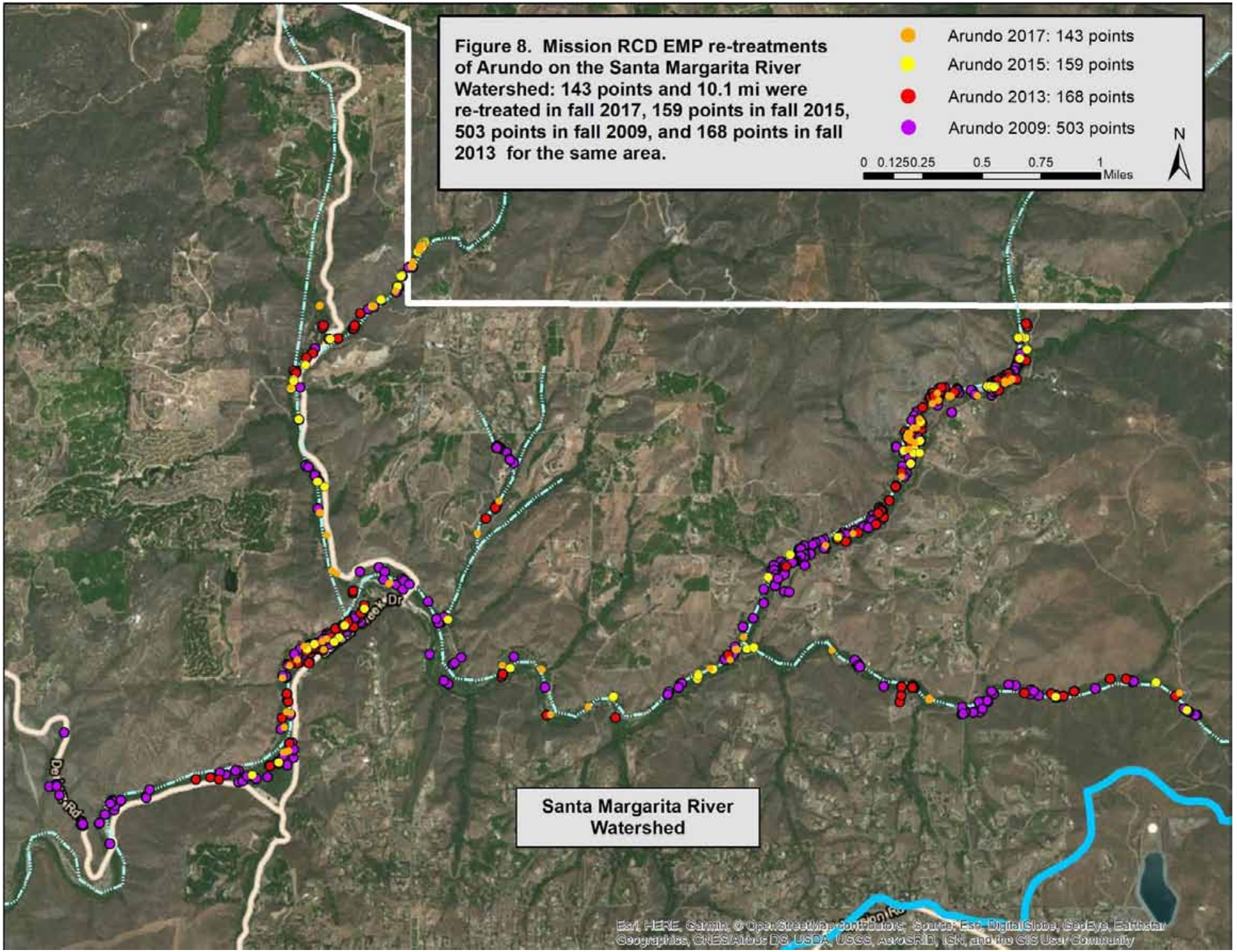


Figure 8. Mission RCD EMP re-treatments of Arundo on the Santa Margarita River Watershed: 143 points and 10.1 mi were re-treated in fall 2017, 159 points in fall 2015, 503 points in fall 2009, and 168 points in fall 2013 for the same area.

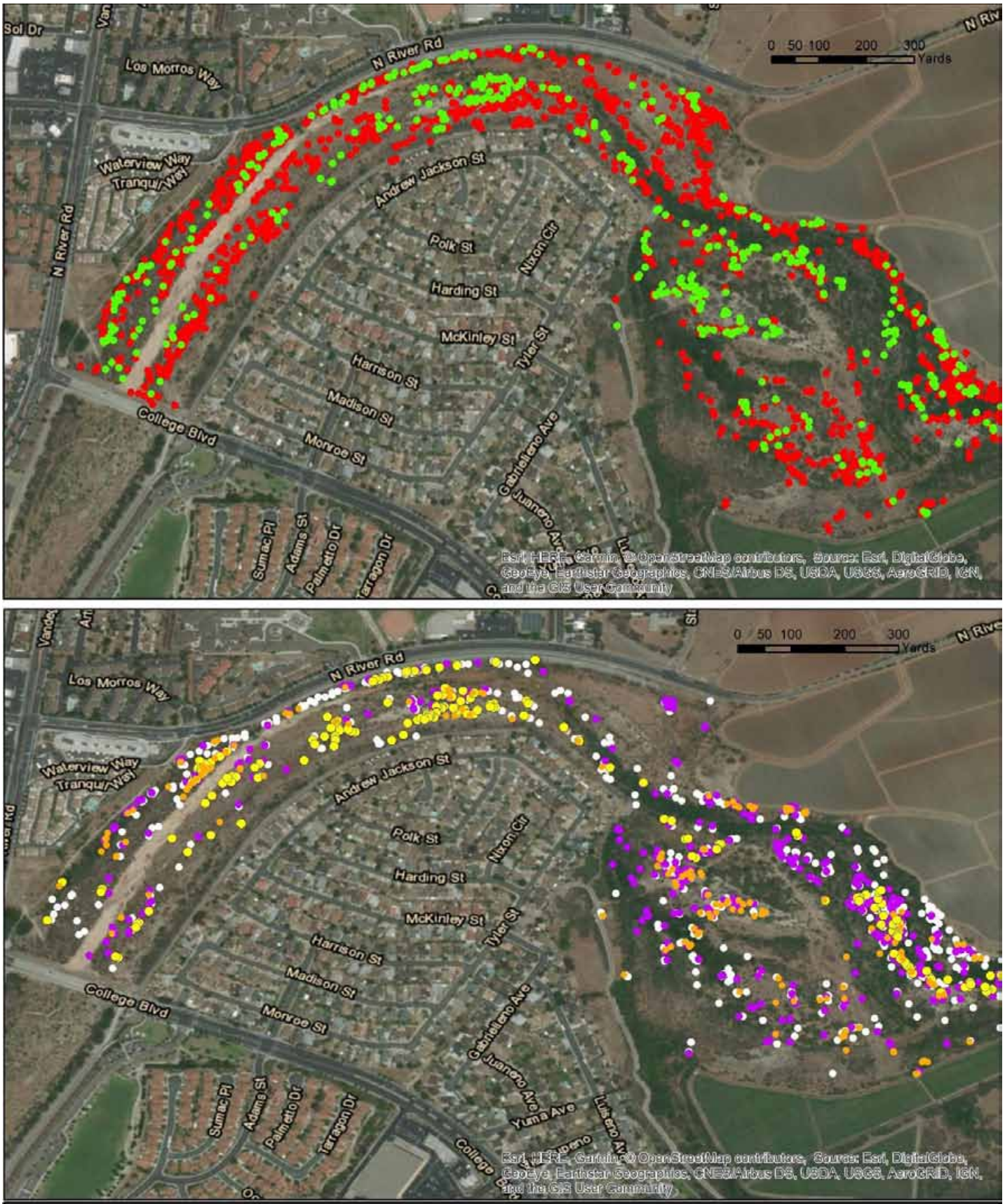


Figure 9. San Luis Rey River EMP re-treatments of Arundo above College Blvd in: 2010 & 2012 (top) and 2013, 2014, 2015 & 2016 (below).

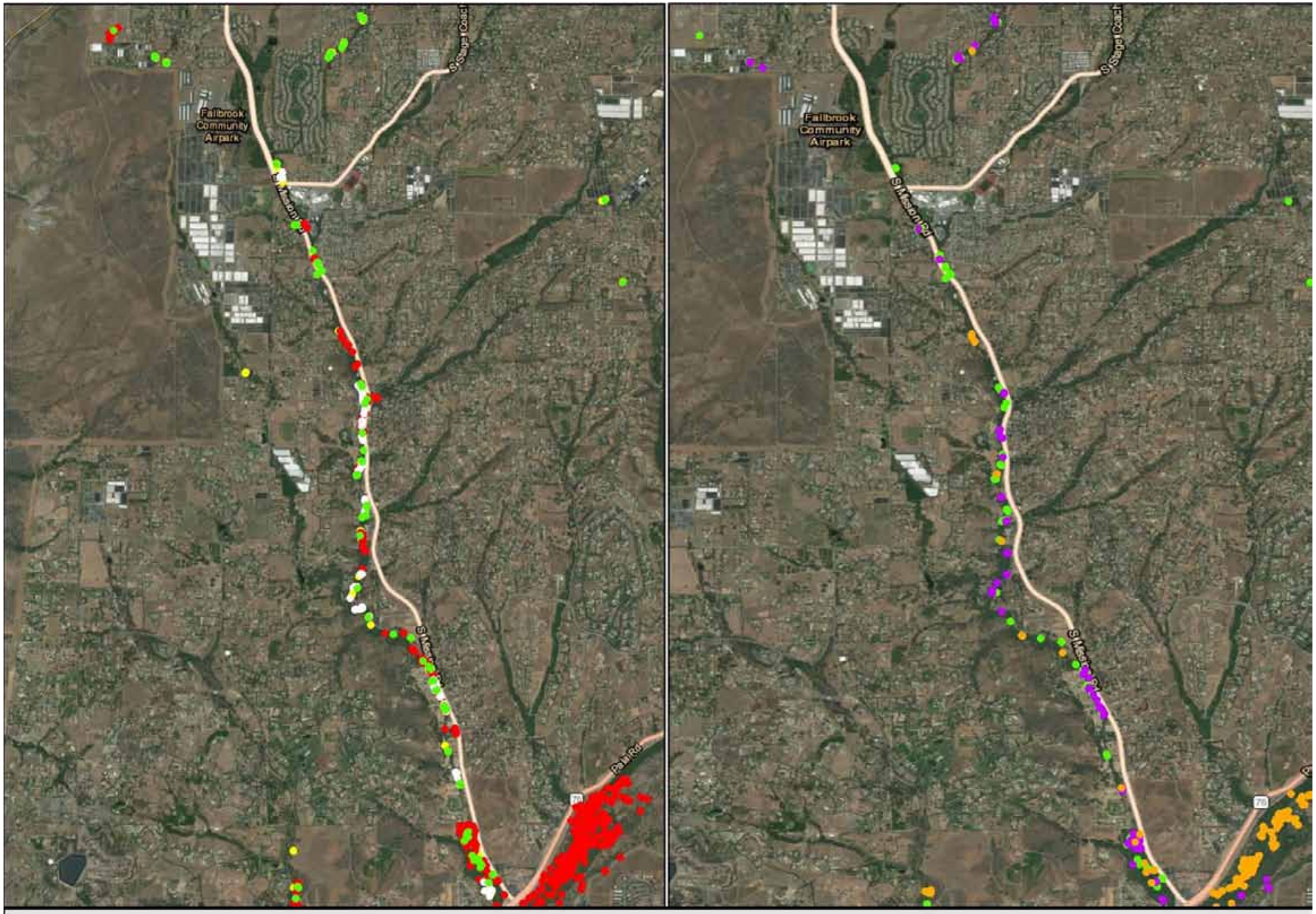


Figure 10. San Luis Rey River EMP re-treatments of Arundo on Ostrich Creek: 2009, 2010 & 2011 (top) and 2012, 2014 & 2017 (below).

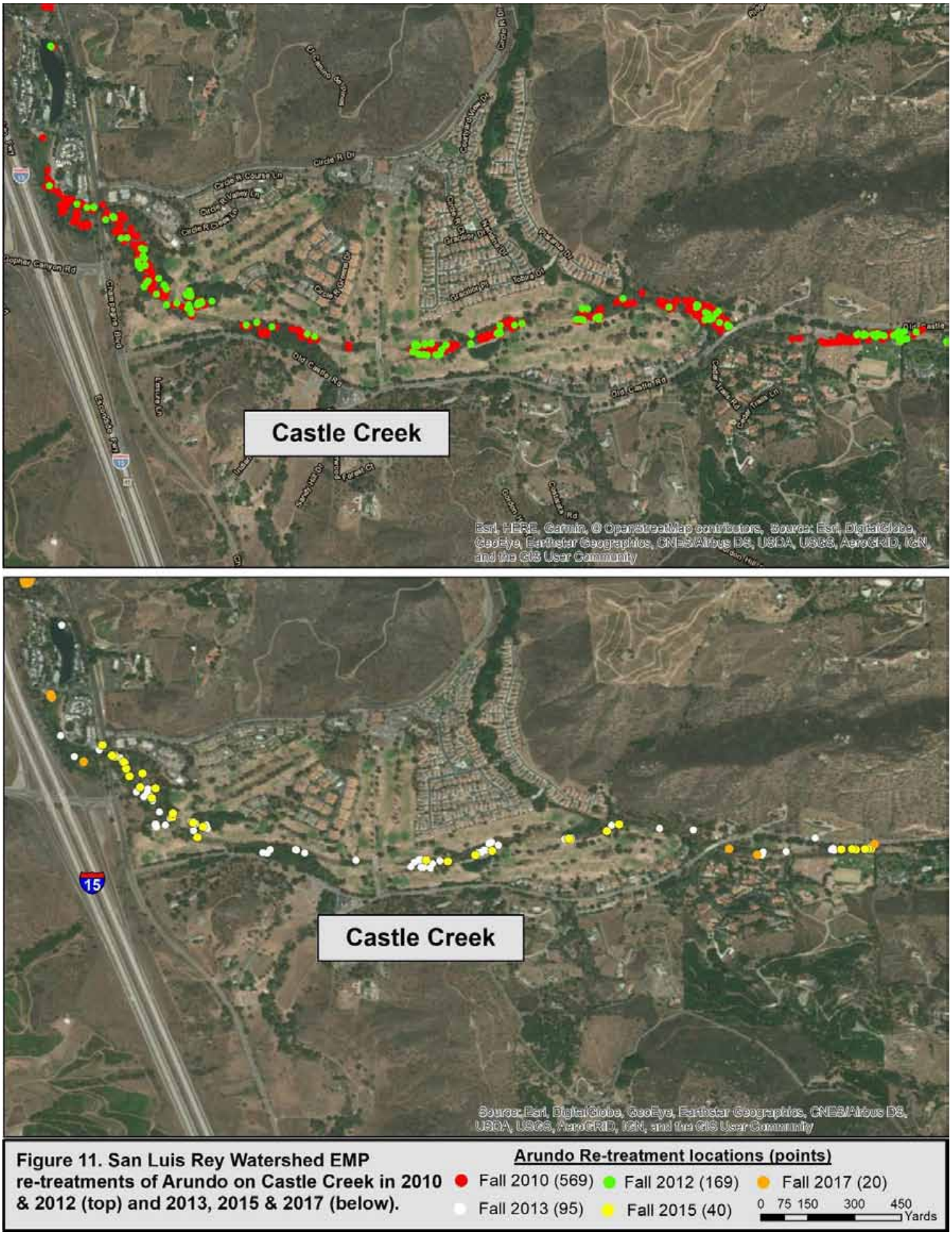


Figure 11. San Luis Rey Watershed EMP re-treatments of Arundo on Castle Creek in 2010 & 2012 (top) and 2013, 2015 & 2017 (below).

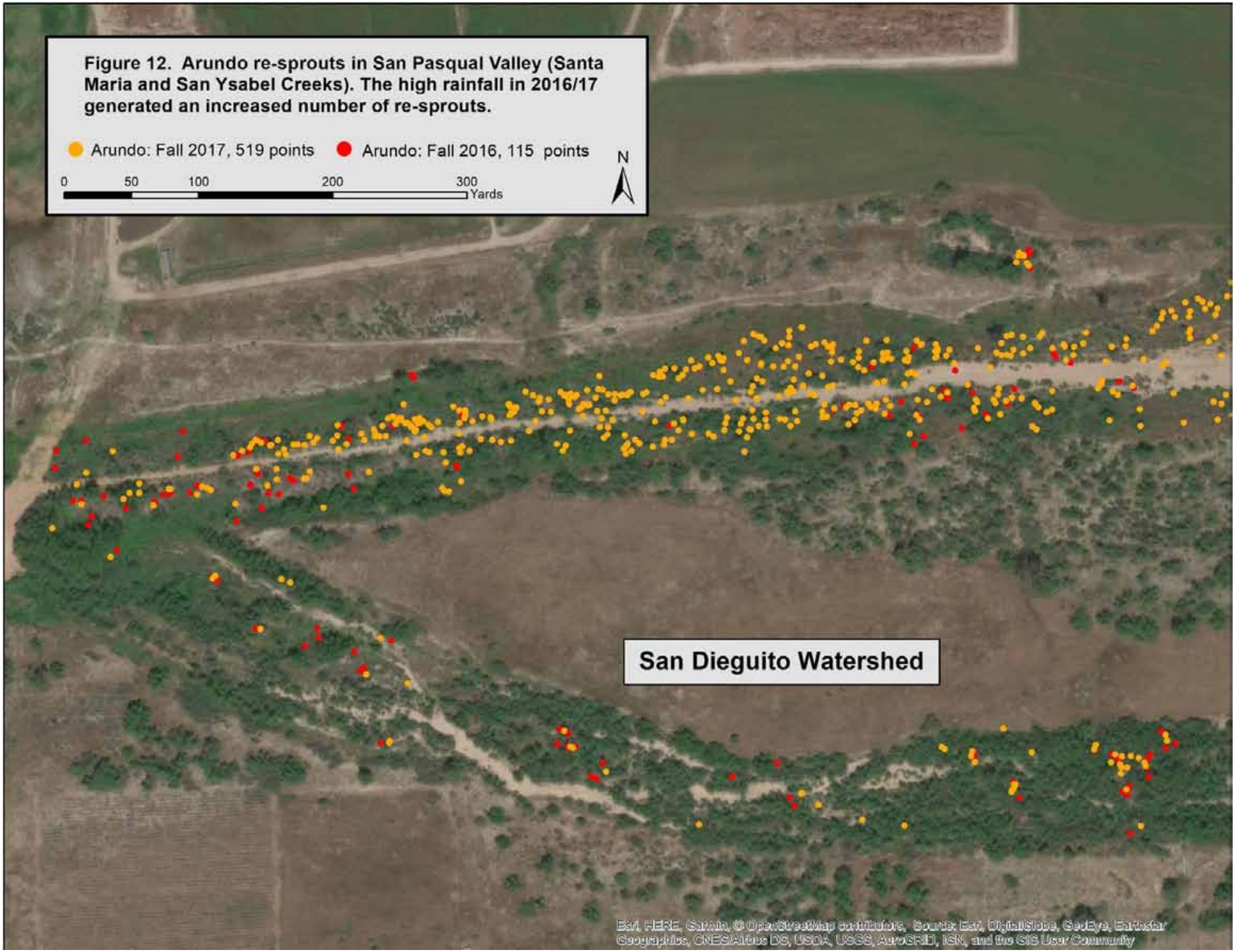


Figure 12. Arundo re-sprouts in San Pasqual Valley (Santa Maria and San Ysabel Creeks). The high rainfall in 2016/17 generated an increased number of re-sprouts.
Arundo: Fall 2017, 519 points
Arundo: Fall 2016, 115 points
0
50
100
200
300
Yards
N
San Dieguito Watershed
Esri, HERE, Garmin, © OpenStreetMap contributors, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

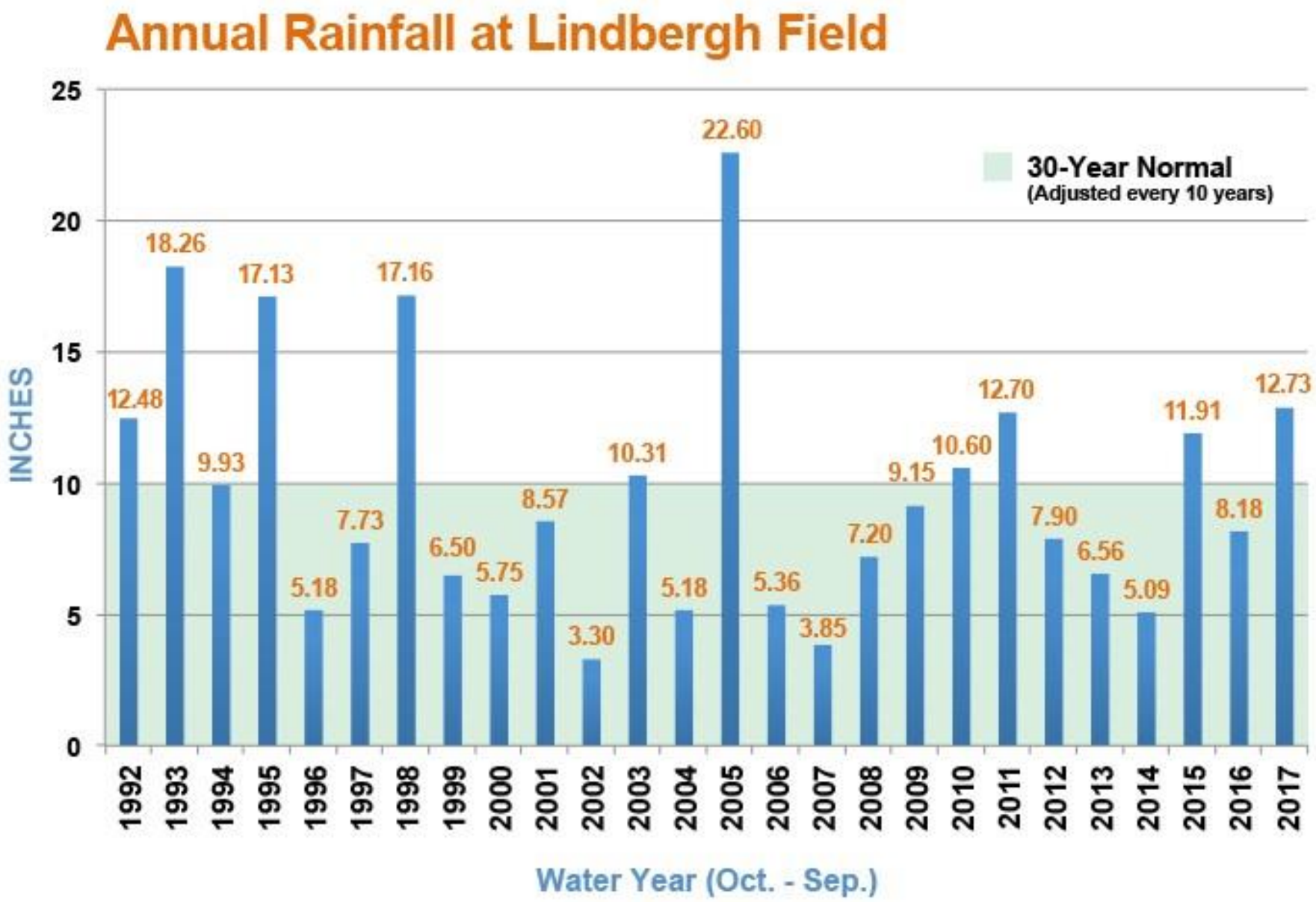
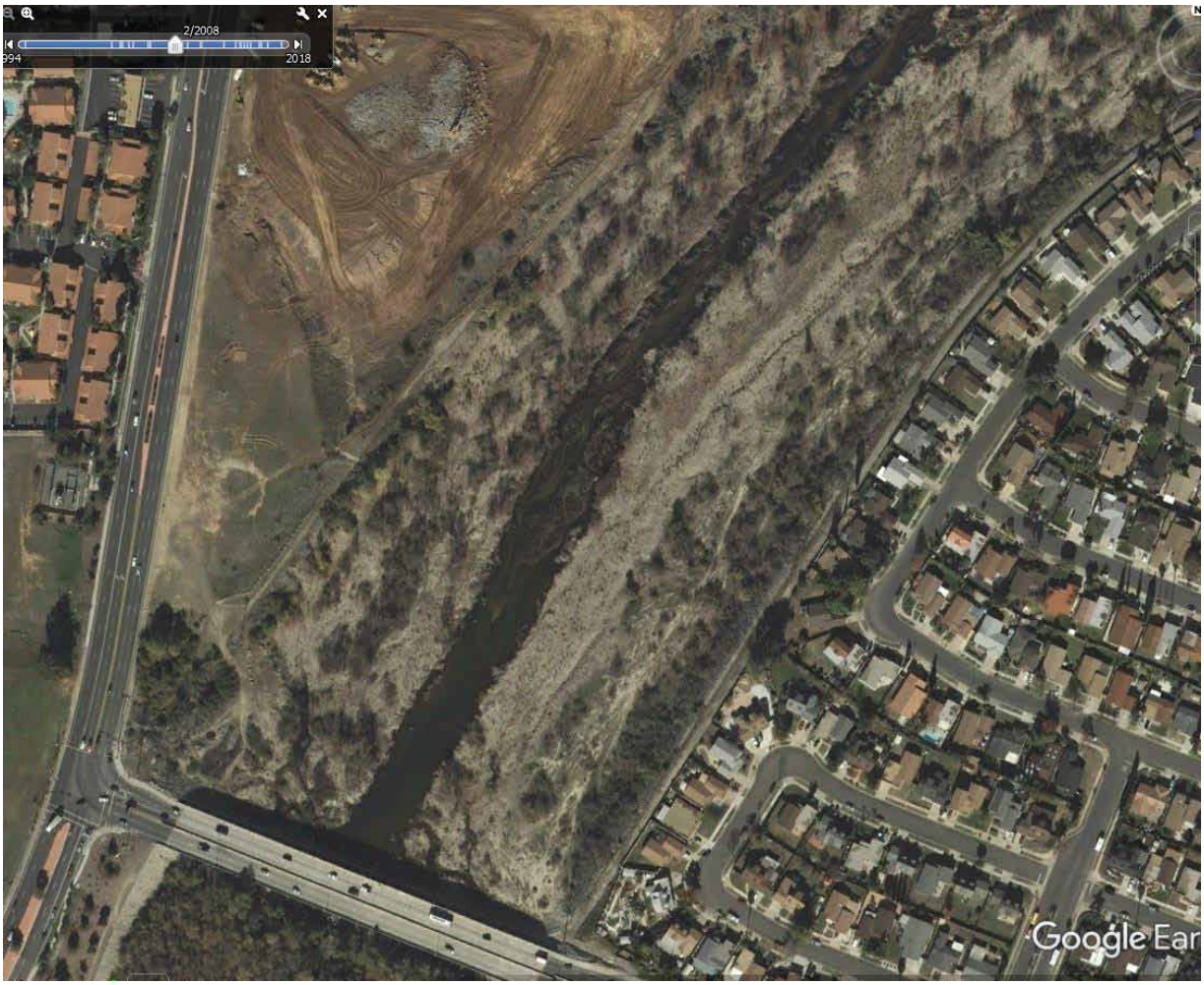


Figure 13. Rainfall San Diego https://www.sdcwa.org/rainfall

San Luis Rey River: College Ave Bridge

2006



2008

2017

2007

2018

2007

2018

2008

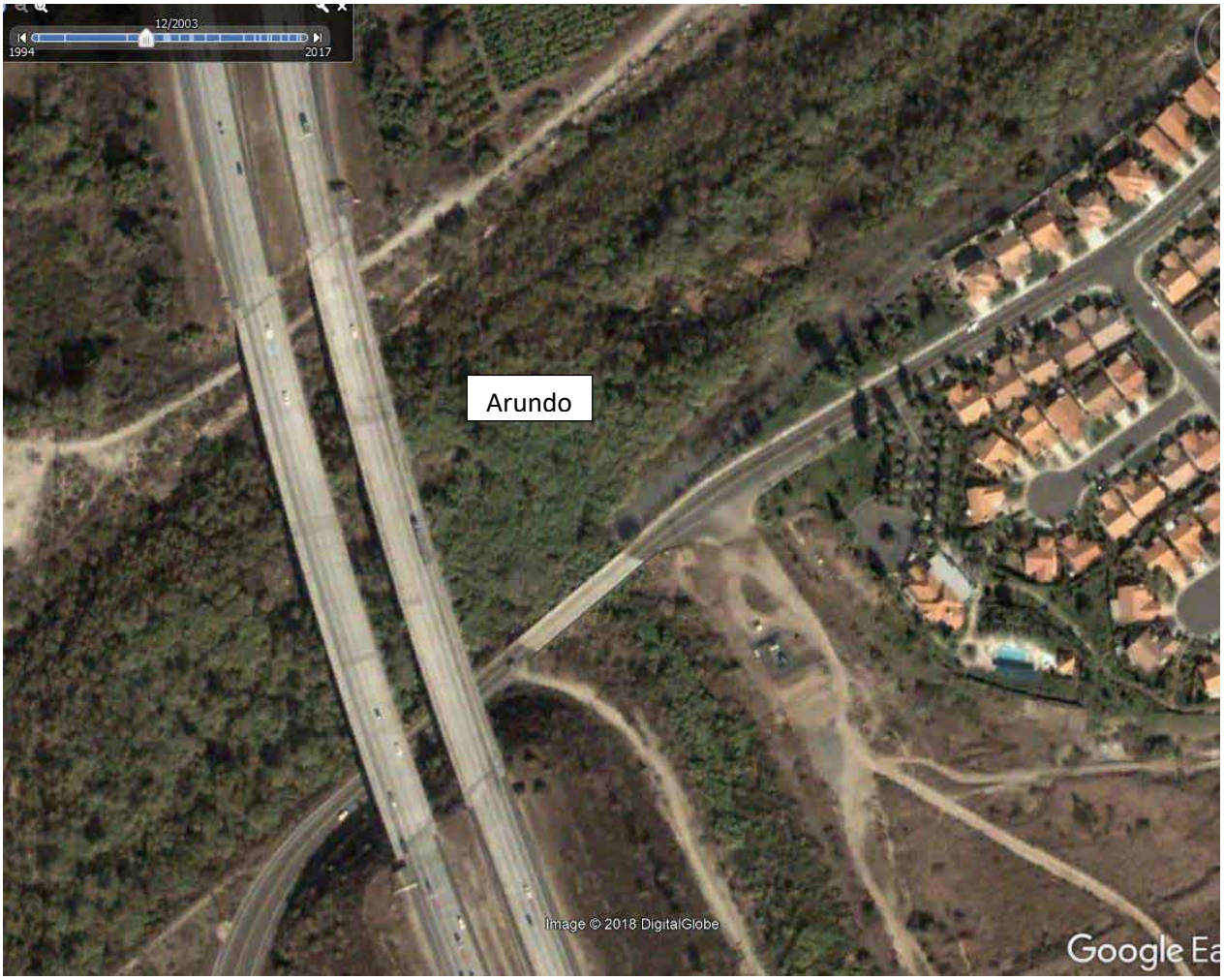
2018

Weak roots

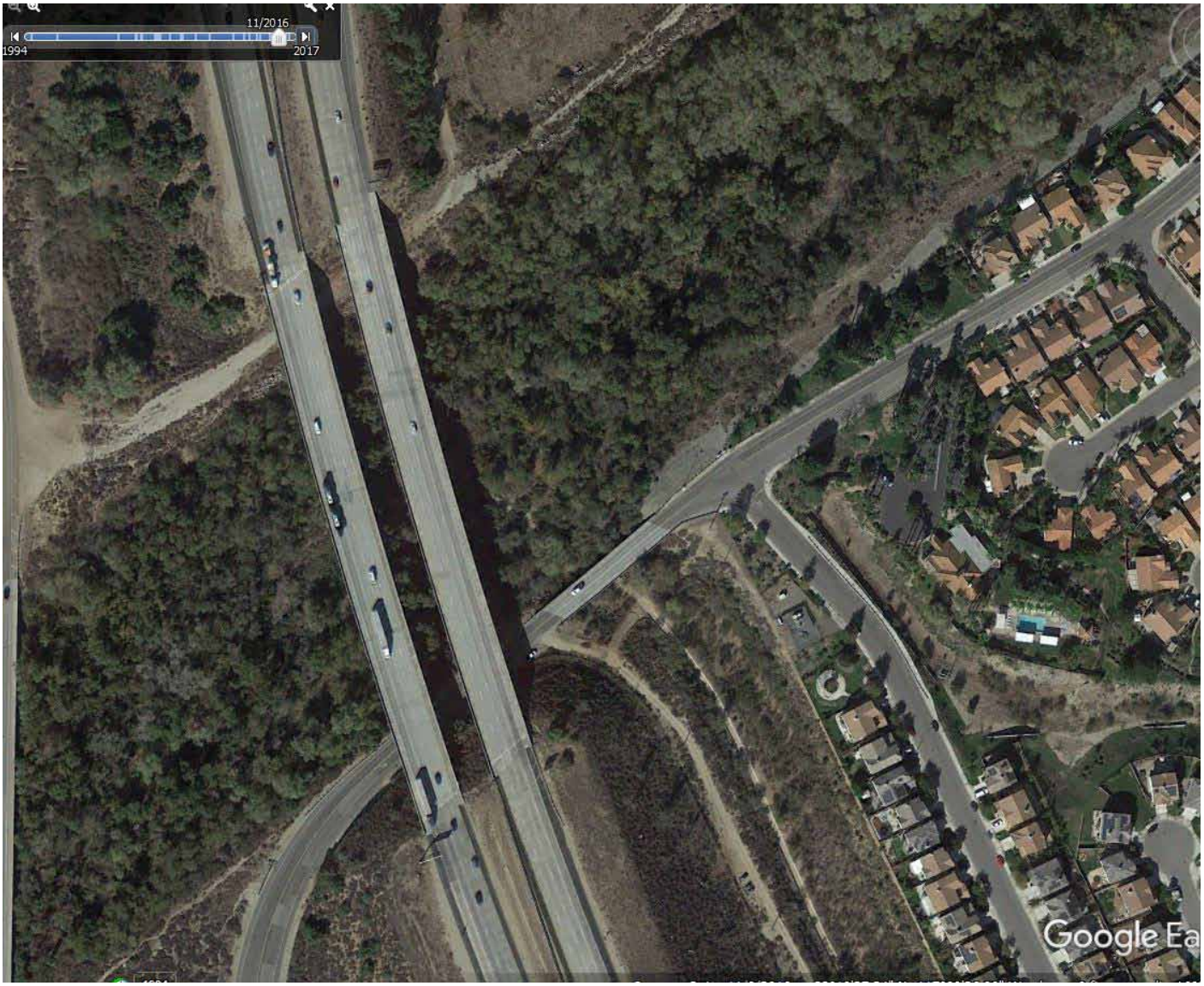
San Luis Rey River: I-15

2003

2009


12/2003
1994
2017
Arundo
Image © 2018 DigitalGlobe
Google Ea
2003


8/2005
Image USDA Farm Service Agency
Google Ear
2004

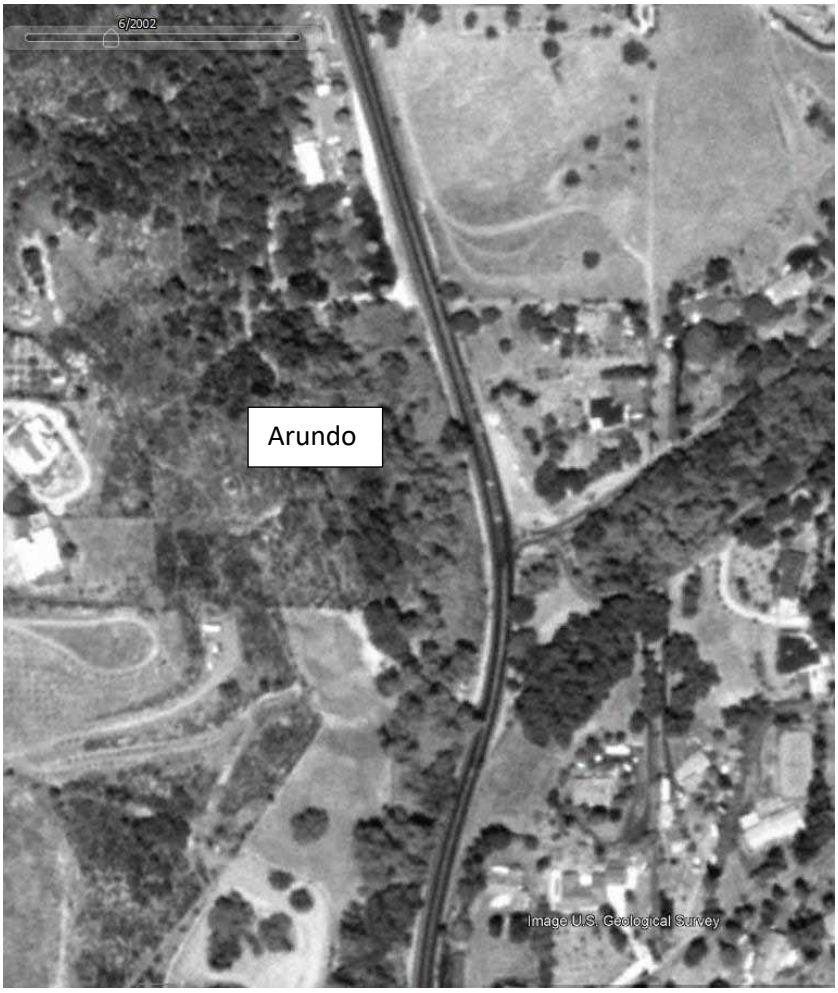


2016

San Luis Rey: Ostrich Creek along Mission Road

2000

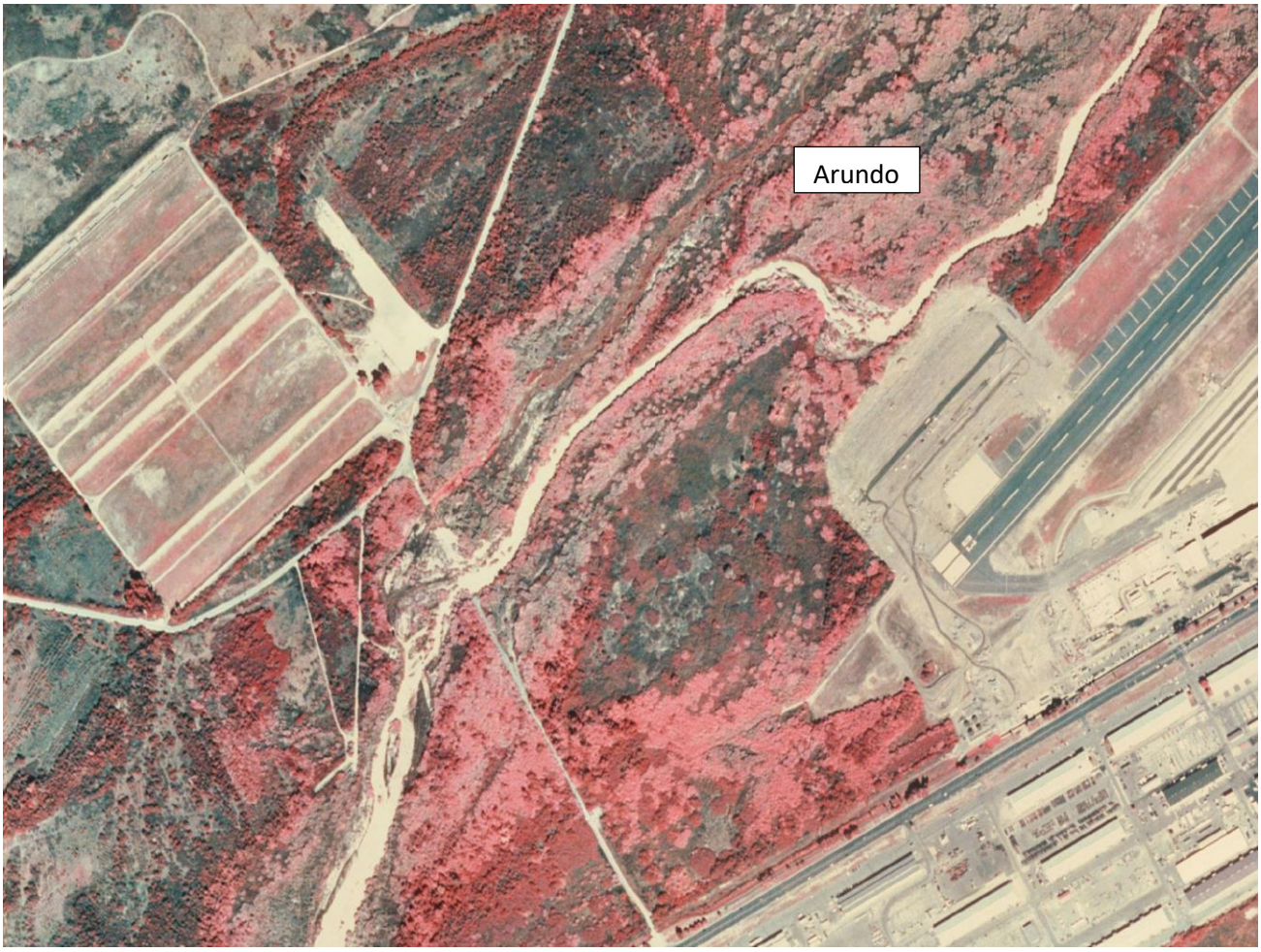
2005


6/2002
Arundo
Image U.S. Geological Survey
2002


6/2003
Image © 2013 DigitalGlobe
2003

2016

Santa Margarita River: Camp Pendleton



1997

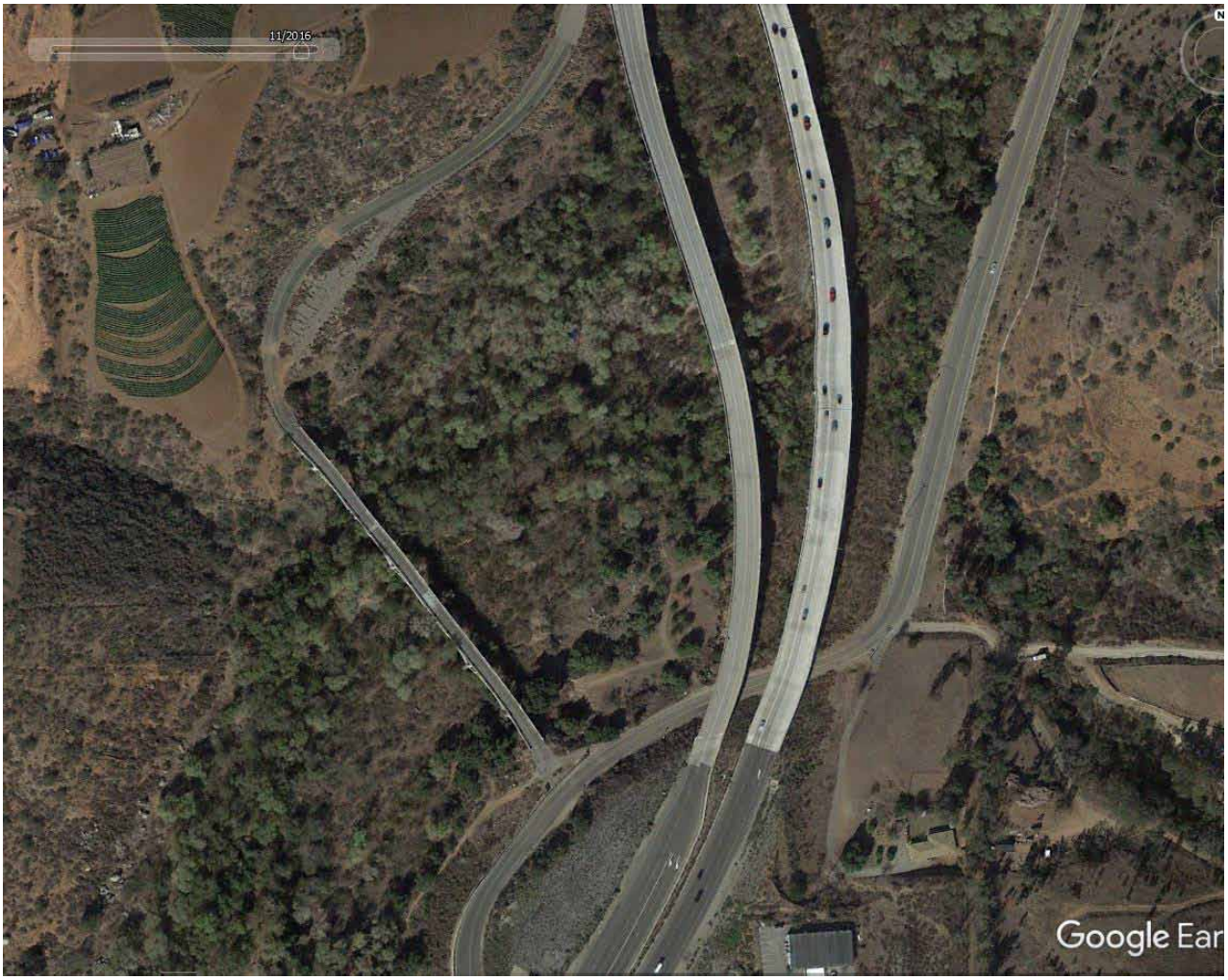
2002


10/2016
N
Stagecoach Rd
Vandegrift Blvd
A Ave
Main St
5th St
Google Earth
2016

San Luis Rey River: Bonsall Bridge Highway 76

1997

2009



2016

2008

2018