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Managing Water in the West

Vegetation Monitoring along the San Joaquin River

2019 Report

Middle East Side Bypass, San Joaquin River, July 2019

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

September 2019

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

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Vegetation Monitoring along the San Joaquin River

2019 Report

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Executive Summary

Vegetation transects were sampled within reaches 1A to 5 and the East Side Bypass along the San Joaquin River in 2019. The purpose of the Vegetation Monitoring Study is to evaluate the establishment and development of riparian vegetation in response to Restoration Flows. Managed flows were implemented in Water Year 2010. This study was initiated in 2011, however no data were collected in 2016 or 2018.

Vegetation sampling was conducted at 22 permanent transects in 2019, although the number of samples varied over the monitoring period. Plant cover, species composition, woody stem density, and overstory height were measured along each transect. Invasive weed species were also documented when encountered. Transect lengths were determined by the extent of the floodplain and varied from 26 to 100 meters.

River reaches experienced much different hydrological conditions with regards to flows, substrate and ground water levels, and overbank flooding. As such, vegetation varied considerably among reaches. Data is presented for individual reaches, however, due to the small sample size per reach (generally n=2) analysis was conducted across all reaches sampled. Results identified some trends among variables, including:

- Percent total cover of native understory species was highest in 2011, 2017, and 2019; total cover of native species was also higher than that of introduced species in these years. In all other years, introduced understory species were dominant relative to native species.
- Percent total cover of introduced understory species was significantly higher in 2015 than in most other years.
- Species composition within herbaceous plant communities was significantly different between years; no differences were identified between 2011, 2017, and 2019 and between 2012, 2013, 2014, and 2015.
- Average total percent overstory cover increased slightly over the monitoring period, from 16.9 percent in 2011 to 22.0 percent in 2019
- Native overstory species far outnumbered introduced overstory species
- Total stem density gradually decreased from 2011 to 2015 and increased in 2019

Many of the trends in vegetation development over the monitoring period appeared to be influenced by climatic conditions, making it difficult to determine the effect Restoration Flows may have had. San Joaquin river flows were high enough to cause overbank flooding in 2011, 2017, and 2019, with peak flows averaging between 6,500 and 9,000 cfs – but reaching as high as 22,700 cfs in 2017 – below Friant Dam and around 8,700 to 13,000 cfs within the East Side Bypass. In contrast, a severe drought was declared in California from approximately 2013 through 2015 and river flows below Friant Dam averaged around 420 cfs, ranging from 27 to 2,000 cfs; the channel in East Side Bypass was typically dry during this period.

Introduction

Background

In 2006, the Department of the Interior entered into the San Joaquin River Settlement (Settlement) in *NRDC et al., v. Kirk Rodgers et al*. The Settlement was subsequently approved by the Court in October 2006 and the San Joaquin River Restoration Settlement Act, Public Law 111-11, authorized and directed the Secretary of the Interior to implement the Settlement. The San Joaquin River Restoration Program (SJRRP) is a comprehensive long-term effort to restore flows and a self-sustaining Chinook salmon population to the San Joaquin River from Friant Dam to the confluence of Merced River, while reducing or avoiding adverse water supply impacts.

Historically, riparian vegetation in California's Central Valley was typical of a dynamic system largely driven by annual flooding and a long summer drought (Stillwater Sciences 2003). The natural hydrograph for unmanaged rivers in California is an inverted U-shape, with peak flows in the winter and spring (November through June; Griggs 2009). The slowing or reduction in magnitude of flows during late spring and early summer as rainfall tapers out is biologically important to most plants that grow in the riparian zone.

Natural vegetation recruitment and survival are maintained through annual flooding via floodplain inundation, scour, and sediment/propagule deposition. Water availability during the summer dry period is the primary factor for vegetation establishment and distribution. This cycle of flooding and drought is important to pioneer woody plant species, primarily willows (*Salix* spp.) and cottonwoods (*Populus* spp.), which have adapted timing of seed-release, dispersal, and seedling establishment to coincide with the historical annual hydrographic cycle to provide bare seed beds, water, and nutrients (Griggs 2009). These species produce rapid root growth to reach permanent water tables and a secure bank footing to resist subsequent floods (Stillwater Sciences 2003).

The frequency and duration of flood events over time shapes the physical habitat which in turn influences species composition and community structure (Griggs 2009). Riparian forests require periodic seedling recruitment and establishment to maintain populations over time (Stillwater Sciences 2003). A mature riparian zone typically consists of a mosaic of vegetation types of various ages and species. Commonly, mixed riparian forests occupy mid-elevation floodplain sites, while valley oak woodland and savannah occupy the oldest and driest floodplain sites, such as high terraces and cut banks.

Along geomorphically active streams, cottonwoods and willows are typically among the first species to colonize bare stream banks and bars. These species, which are characterized by high seed output and rapid growth rates, typically establish in bands parallel to the channel, with the youngest stands occurring closest to the active channel (Stillwater Sciences 2003). Each band of vegetation represents a separate recruitment event. Over time, pioneer vegetation traps sediment and adds litter and nutrient inputs to floodplain soils (Stillwater Sciences 2003). As the floodplain develops and the riparian stand ages, changes in microclimate (depth to groundwater, shade, temperature, and relative humidity) occur which often facilitates establishment of other riparian species such as Oregon ash (*Fraxinus latifolia*), box elder (*Acer negundo*), and valley oak (*Quercus lobata*). These "later successional" species typically produce larger seeds and are more shade-tolerant than the early pioneer species, allowing them to persist in the seedbank and germinate under the forest canopy when soil temperature and moisture conditions are adequate. Recruitment of these species is less dependent on flow and sediment conditions compared to willows and cottonwoods.

The San Joaquin River historically supported a much wider riparian corridor than is present under current conditions. Riparian vegetation between Friant Dam and the Merced River confluence has been significantly modified by agricultural development, hydrologic changes from operations of Friant Dam, and the construction and operation of the flood control levees and bypass systems. River regulation has resulted in decreased peak flows, increased summer base flows, and reduction of physical processes such as scour and sediment deposition, compared with historical conditions. Riparian pioneer tree populations that evolved with pre-regulation cycles of flooding and drought have decreased recruitment and altered topographic distributions relative to bank elevation and proximity to the channel. The reduction in riparian tree recruitment is compounded by human development on floodplains that has simultaneously removed over 90 percent of the historical riparian forests for fuel wood, agricultural and urban expansion, and floodplain mining (Stillwater Sciences 2003).

Reduced riparian vegetation along streambanks has decreased shaded riverine cover, organic inputs, water temperature control, and habitat structure (including inputs of large woody debris to aquatic habitats in the river), thus degrading aquatic habitat and fishery health. Important functions of the floodplain have also been reduced or eliminated, including flood flow retention and the ability for the channel to meander, which in turn increases both the risk of flooding and the amount of sediment deposited by flood flows.

To evaluate the establishment and development of riparian vegetation in response to Restoration Flows, Reclamation's Technical Service Center (TSC) in Denver, CO and Mid-Pacific Region in Sacramento, CA established monitoring transects in river reaches 1A through 5 and the East Side and Mariposa Bypasses. Due to the large project area (149 RM), it was feasible to locate and monitor two transects within each reach with the exception of the East Side Bypass (ESB) where four transects were placed. Monitoring began within all sites in August 2011 except for Reach 5, where transects were established and monitored beginning in 2012. Hydrologic variables, including discharge and depth to groundwater as they relate to vegetation, were also incorporated into the monitoring program in 2013. In 2013 and 2014, transects within Reach 4A and Mariposa Bypass, respectively, were discontinued due to access limitations. Remaining transects were monitored annually through 2015.

Vegetation transects within selected locations were sampled in August 2017 to inventory riparian vegetation following extended flood releases that occurred in the San Joaquin River in winter and spring of 2017 (Siegle and O'Meara 2018). The 2017 monitoring effort included transects already established in river reaches 2B and 4B2, and in the ESB, with additional transects installed in the ESB. Data from 2017 was included in this report where applicable.

Transects within the vegetation monitoring study sites that were sampled in 2015 were revisited in 2019, reincorporating transects in Reach 4A and incorporating 2 transects that were added within ESB in 2017. The Program decided that vegetation sampling would be conducted in 3 year intervals from 2019 forward. Restoration Flows were implemented in Water Year 2010; changes over the monitoring period beginning in 2011 were evaluated.

Project Area

A location map of the entire SJRRP Restoration Area is shown in Figure 1 with the vegetation monitoring transect locations and the nearest stream gauges shown in Figure 2.

Table 1 summarizes the acreages of vegetation types found within the study area. Acreages for river reaches 1A through 5 are based on riparian vegetation mapping conducted within the SJRRP Restoration Area in 2012 (SJRRP 2014). Acreages for the ESB are based on riparian vegetation mapping conducted within the Lower and Middle ESB in 2016 (SJRRP 2016).

The largest extents of two ecologically important native riparian vegetation types, 1) broadleaf forest and woodland and 2) riparian evergreen and deciduous woodland, occur in both the upstream- and downstream-most reaches (Table 1). This distribution appears, at least in part, to be a result of the numerous protected areas in Reach 1A that support native vegetation and the influence of the wide floodplain in Reach 5 with sites of suitable relative elevation and soil type to support native woody vegetation, as well as the habitat conservation and water management provided by the San Luis National Wildlife Refuge and several State Parks (SJRRP 2014). These same land- and water-use conditions also contribute to the large extents of naturalized annual and perennial grassland in Reaches 1A and 5.

The largest extents of several nonnative vegetation groups occur in the upper reaches of the Restoration Area, such as introduced riparian scrub and introduced woodland and forest (Table 1), which indicates that there is an abundant source of seeds and vegetative propagules for nonnative invasive species that can spread into downstream reaches as Interim and Restoration Flows occur (SJRRP 2014).

Several vegetation types increase notably in area in Reaches 4B2 and 5, reflecting the much wider floodplain, the relatively greater seasonal availability of water, and the influence of sloughs and more saline and finer textured (clay, clay-loam) soils (Stillwater Sciences 2003). These include both of the saline-soil associated vegetation groups—salt basin and high marsh and tidal salt and brackish meadow—as well as annual forb/grass vegetation, marsh/seep, and naturalized riparian and wetland (Table 1).

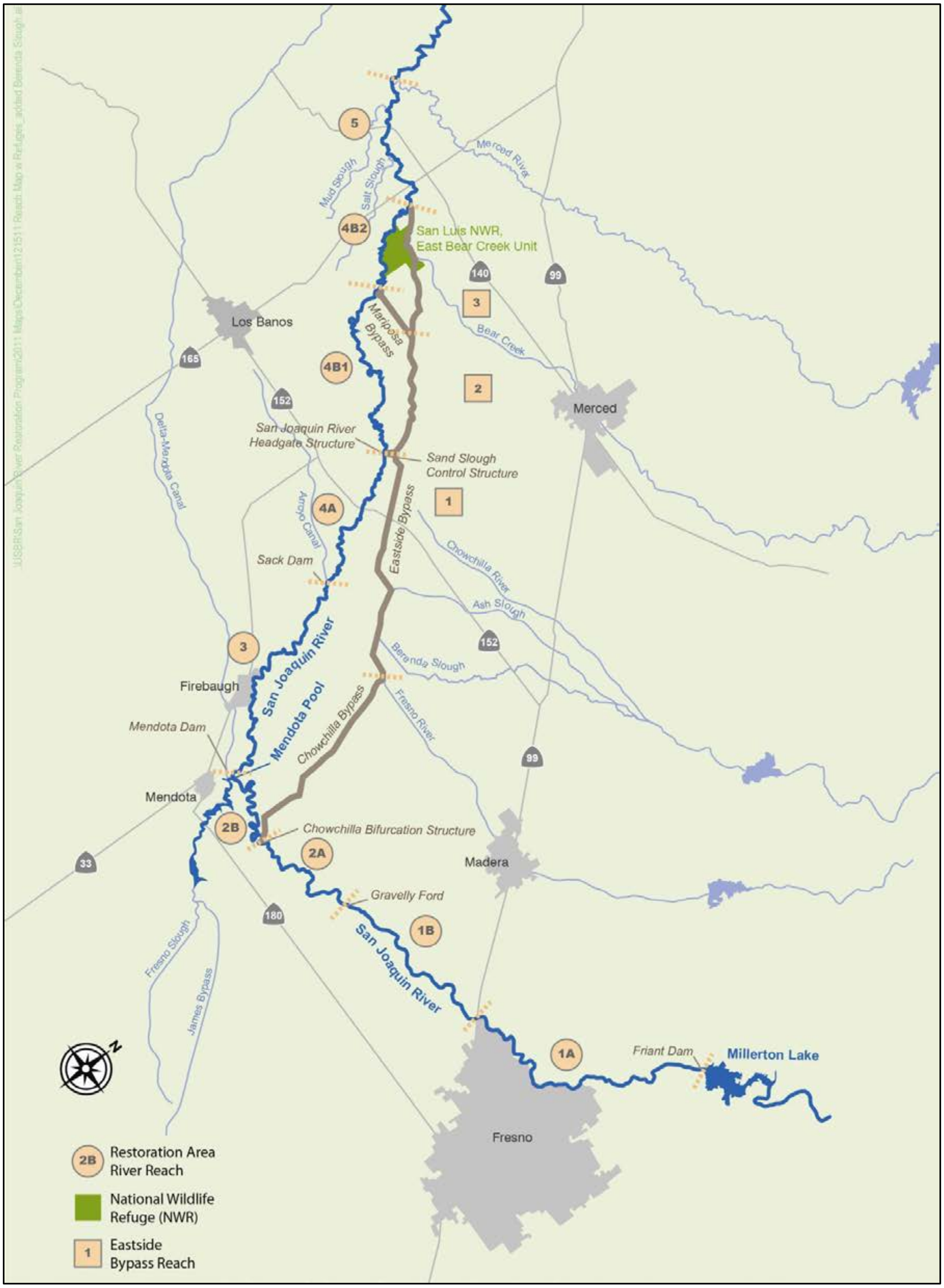


Figure 1. SJRRP Project Area.

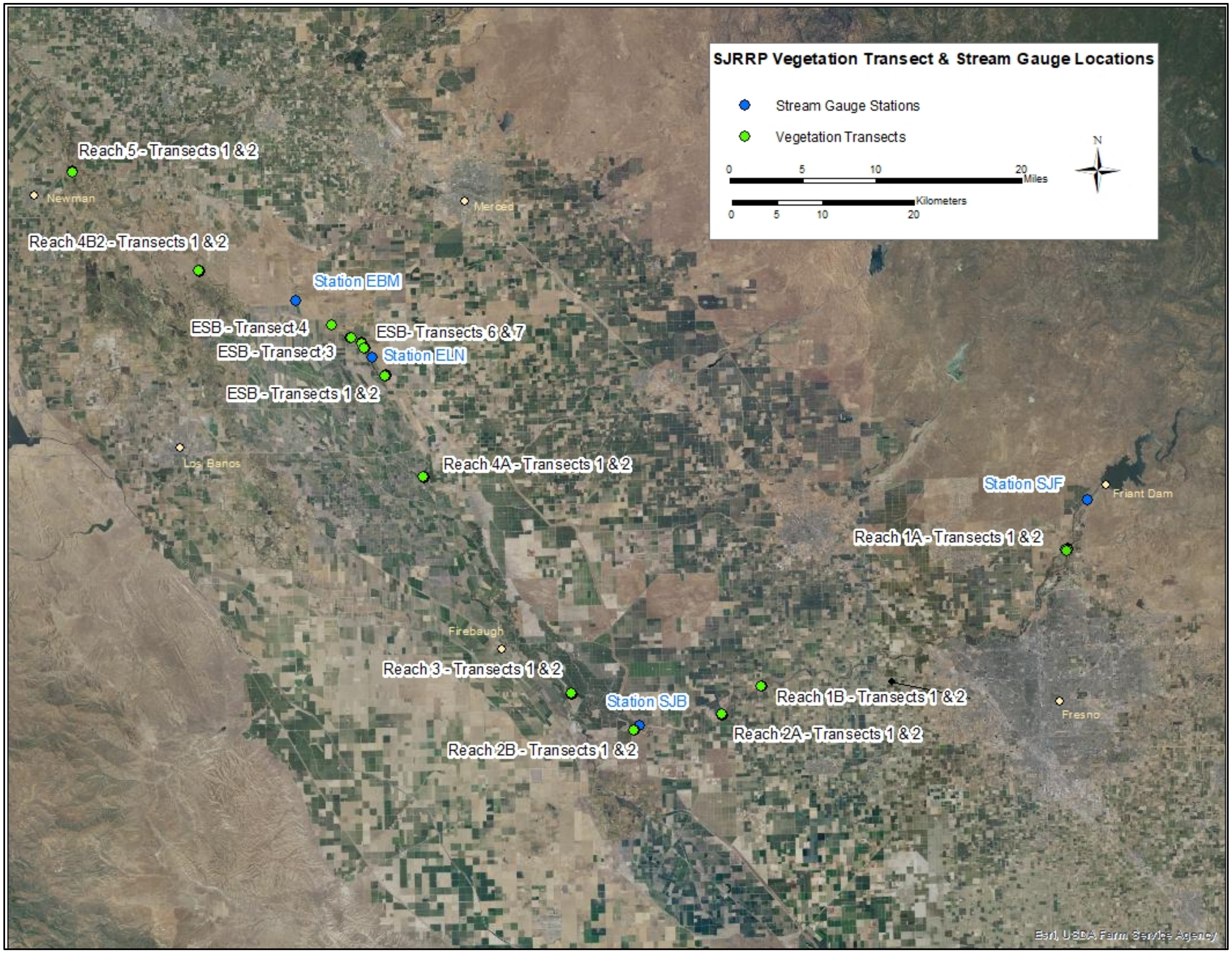


Figure 2. Vegetation monitoring transect and stream gauge station locations.

Table 1. Vegetation types and acreages in the Project Area.

VEGETATION GROUP	ACRES IN REACHES[1]								ACRES IN ESB[2]	Total
	1A	1B	2A	2B	3	4A	4B2	5		
Agriculture	80	283	62	1462	1417	124	0	131	0	**3559**
Annual forb/grass vegetation	2	2	4	0	0	2	36	47	46	**139**
Bare gravel and sand	46	142	285	67	3	73	0	4	34	**654**
Broadleaf forest and woodland	251	6	2	4	1	0	6	53	0	**323**
Deciduous scrub	0	0	0	1	0	0	0	0	0	**1**
Disturbed	120	22	5	0	39	115	77	33	15	**426**
Floating aquatic vegetation	42	0	0	4	0	0	3	5	0	**54**
Freshwater emergent marsh	6	1	7	60	10	62	27	48	44	**265**
Introduced riparian scrub	15	33	30	0	1	0	0	0	0	**79**
Introduced woodland and forest	44	54	1	0	0	0	0	9	0	**108**
Marsh/seep	1	0	0	13	0	0	19	57	163	**253**
Naturalized annual and perennial grassland	1318	387	699	209	651	199	564	1850	2200	**8077**
Naturalized nonnative deciduous scrub	9	1	0	2	10	4	0	2	0	**28**
Naturalized riparian and wetland	29	0	7	43	19	9	181	482	53	**823**
Riparian deciduous forest	24	2	5	0	0	0	0	0	0	**31**
Riparian evergreen and deciduous woodland	390	355	38	132	372	86	333	860	48	**2614**
Riparian/wash scrub	215	112	19	171	138	69	30	58	0	**812**
Salt basin and high marsh	0	0	0	3	0	0	151	2184	0	**2338**
Seral scrub	0	0	94	4	0	0	0	0	0	**98**
Tidal salt and brackish meadow	0	0	3	0	0	0	30	188	18	**239**
Water	894	205	198	247	321	63	107	356	289	**2680**
Total	**3486**	**1605**	**1459**	**2422**	**2982**	**806**	**1564**	**6367**	**2910**	**23601**

[1] SJRRP 2014

[2] SJRRP 2016

As might generally be expected, the larger reaches support a higher diversity of vegetation. Naturalized annual and perennial grassland is the predominant vegetation group in all reaches of the Restoration Area except for Reach 5, where it is surpassed by salt basin and high marsh vegetation (Table 1) After naturalized annual and perennial grassland, riparian evergreen and deciduous woodland is the next most prevalent vegetation group in all reaches. All of the Project Area reaches contain two or more nonnative vegetation groups, and the highest acreages of nonnative vegetation occur in Reaches 1A–2.

The ESB, which was mapped separately from the other reaches (SJRRP 2016), is located within the Merced NWR. Land management practices involve mowing and livestock grazing. Overall vegetation conditions are not exceptionally diverse. As in the majority of reaches, the Naturalized annual and perennial grassland vegetation group covered the most area (Table 1; SJRRP 2016).

Methods

Survey Timing

Monitoring was conducted during spring or summer months depending on flow levels, with the objective of collecting data at similar river phases and comparable stages of vegetation development each year.

Vegetation Transects

In 2019, vegetation data were collected at 22 permanent vegetation transects (mapped by river reach in Appendix A). In all reaches, 2 transects established in 2011 were sampled; in the ESB 4 existing transects and an additional 2 transects established in 2017 were sampled. In Reach 4A, sampling was resumed in 2019 after being discontinued in 2013. Transects were placed adjacent to the river channel within the historically active floodplain. These sites were subject to seasonal changes in water and nutrient input, scour, and sediment deposition. Transects were not comprehensibly representative of vegetation populations across the entirety of reaches but were located based on best potential to capture vegetation changes over time resulting from overbank flows.

Plant cover, species composition, woody stem densities, and overstory heights were collected at regular intervals along a measuring tape for each transect. Invasive weed species were also documented when encountered. The length of each transect was determined by the extent of the floodplain and varied from 26 to 100 meters (m). Waypoints for each end of the transects are listed in Appendix B; forms used to collect data are included in Appendix C.

Understory Vegetation

For understory measurements, cover and species composition were measured either every 0.5 or 1 m depending on the length of the transect. The point-intercept method was used, which entailed recording species presence by the first vertical “hit” at each sample point along the transect. This method was used for all herbaceous species and woody plants under 1 m tall. Bare soil, litter, rock, or water were recorded when no vegetation was intercepted.

Overstory Vegetation

The line-intercept method was used for measuring woody overstory cover. Overstory cover was measured along the transect by noting the point along the tape where the canopy began and the point at which it ended for each woody species over 1 m tall. Because species overlapped in some cases, the sum of the cover for all species did not necessarily reflect the actual percentage of overstory cover along the tape. The percentage of the tape covered by overstory was also calculated. The height of the tallest vegetation within each continuous stretch of the same species was measured.

Woody Stem Density

Woody stem densities were determined within one meter perpendicular to the transect on the upstream side. If any part of a stem fell within this one meter wide belt transect, it was counted and recorded by size into 4 classes for each species encountered (see Figure C-3 in Appendix C for descriptions of size classes).

Statistical Analysis

Total cover and density data were compared between sampling periods for all reaches to evaluate any statistically significant changes in vegetation over time. Individual reaches were not evaluated due to the small sample size per reach (generally n=2). Two separate analyses were conducted due to the limited number of reaches sampled in 2017. One analysis included all reaches but excluded 2017. The other analyses tested only those reaches sampled in 2017 (2B, ESB, and 4B2) but included all years.

SigmaPlot statistical software was used to run a one-way repeated measures Analysis of Variance (ANOVA) to test for differences over time when data was normally distributed, in conjunction with the Bonferroni t-test as a multiple comparison post-test to run pairwise comparisons between individual years (alpha=0.05). For non-normal data, Friedman repeated measures ANOVA on ranks test was used to compare parameters over time with the Tukey test for multiple comparisons. In some cases, a statistical difference may be identified using repeated measures ANOVA tests but is not found when comparing pairs of years. This is a result of the differences in the tests. ANOVA tests for significant variance among the set of groups (i.e., years). Significant variance can be present without any pair of groups being significantly different.

Primer (Plymouth Routines in Multivariate Ecological Research; see www.primer-e.com) statistical software was used to create a Bray-Curtis similarity matrix and Multi-dimensional Scaling (MDS) ordination to examine plant species composition between reaches and years. One-way Analysis of Similarities (ANOSIM) was used to determine similarities in plant community composition between years and between reaches.

Photo Stations

Two digital photographs were taken at each end of transects – one facing toward the transect and one facing outward. These photos provide visual documentation of vegetation height, density, species composition, and general site development for comparison over time.

Groundwater Monitoring

Reclamation installed two piezometers in 2013 to measure groundwater levels in association with vegetation transects in Reach 2B. Groundwater recession rates have been closely tied to riparian vegetation establishment and survival in the San Joaquin Valley and elsewhere (Stillwater Sciences 2003b). Causal relationships between flows, groundwater and vegetation are not analyzed in this report; these data are presented as a conceivable variable in vegetation development.

Results

Survey Timing

In order to compare vegetation data over time, sampling schedules were kept as consistent as possible from year to year. The goal was to sample in spring when flows had receded and vegetation was identifiable. Sampling was conducted in June 2012 and 2013 but was shifted to May in 2014 and 2015 when drought conditions were declared by the State of California. Water Years 2011, 2017, and 2019 were the wettest of the years within the study period. Friant Dam was in flood operations through early to mid-July in all of these years and monitoring was not feasible until late July or August due to high river levels and inundated sites.

Hydrology

River levels directly influenced survey timing. Figure 3 shows hydrographs at 4 points along the San Joaquin River and demonstrates the differences in river discharge between years. River gauge stations SJF, SJB, and ELN provide data for all years of the vegetation monitoring period (2011 to 2019); station EBM began collecting data in May 2013. Data presented in Figure 3A at Station SJF were collected downstream of Friant Dam and represents flows that were most influenced by dam operations and releases. Extreme differences in river flows in 2011 and 2017 (peak flows averaging between 8,000 and 9,000 cubic feet per second [cfs]) and in 2019 (peak flows around 6,500 cfs) compared to other years (mostly peaking between 1,000 and 2,000 cfs) were evident. However, discharge reached as high as approximately 22,000 cfs in 2017 at Station SJF. Figure 3B graphs data from Station SJB (Figure 2), located just downstream of vegetation transects in Reach 2B. Peak flows were not as high in 2011, 2017, and 2019 (between 1,700 and 2,200 cfs) as those measured at the other stations and variability between years was not as extreme. Hydrographs in Figures 3C and D show data from stream gauges EBM and ELN in the East Side Bypass (Figure 2), located just upstream and downstream of vegetation transects. Again, differences in flows were obvious between 2011 and 2017 (peak flows between 11,000 and 13,000 cfs at ELN and around 8,000 cfs at EBM in 2017 where no 2011 data is available) and 2019 (peak flows around 8,700 cfs at ELN and 5,800 cfs at EBM) as compared to the other years when the channel was typically dry.

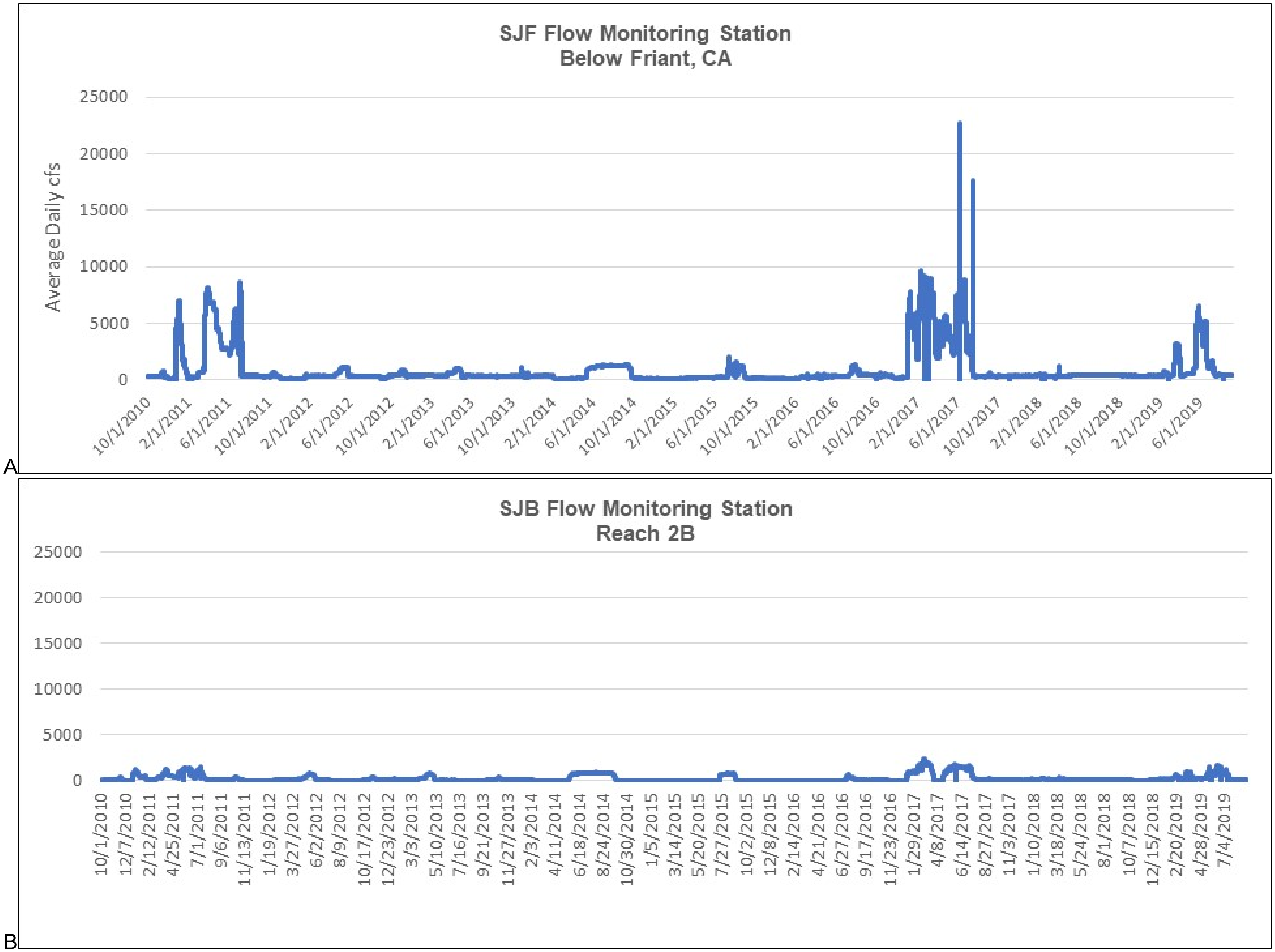


Figure 3. San Joaquin River discharge (cfs) measured at Station SJF (A) and Station SJB (B) from 2011-2019. Source: CA Dept of Water Resources.

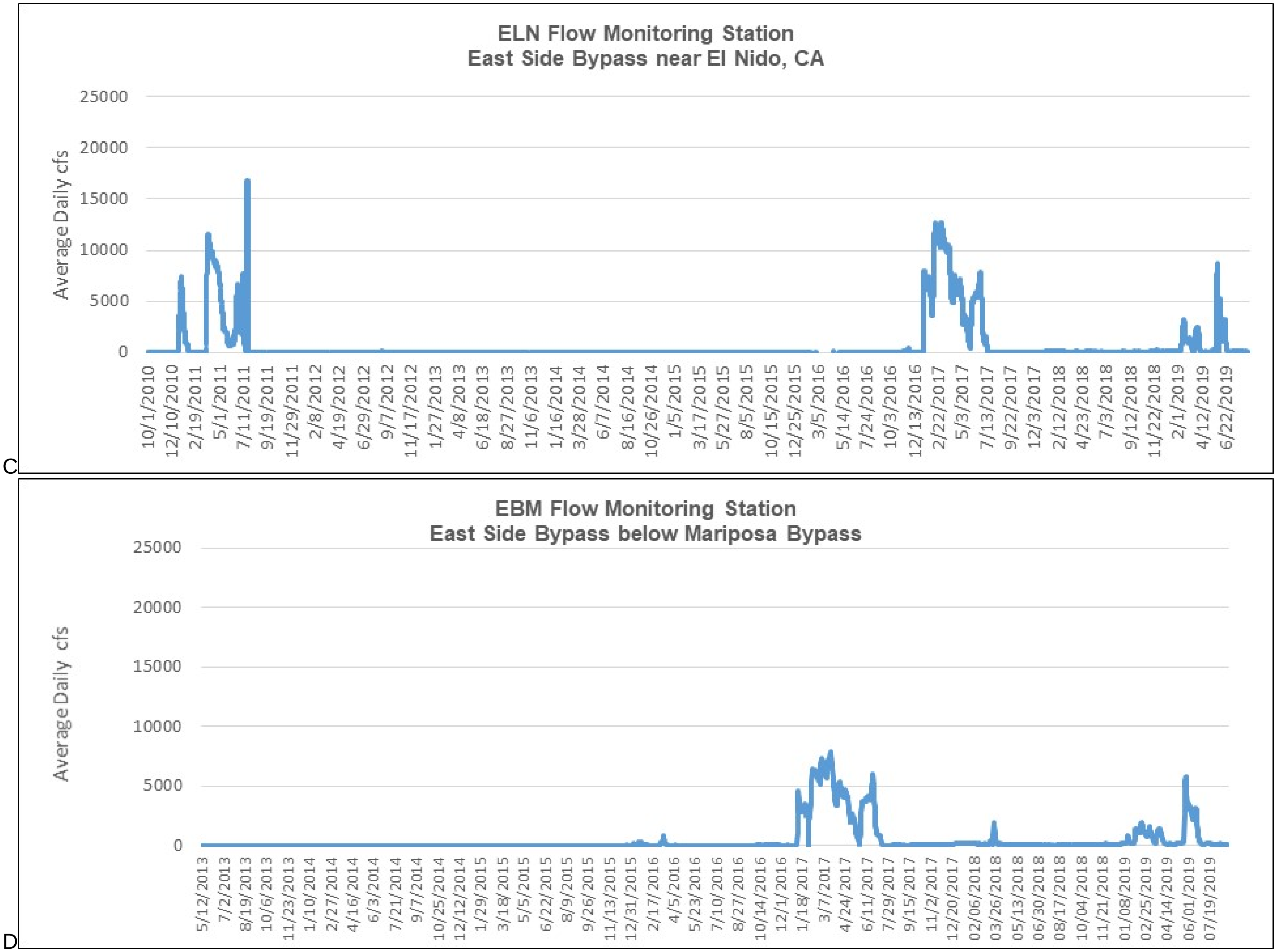


Figure 3 (cont'd). San Joaquin River discharge (cfs) measured at Station ELN (C) from 2011-2019 and Station EBM (D) from 2013-2019. Source: CA Dept of Water Resources.

Vegetation Transects

This report includes data from 2011 to 2019 (excluding 2016 and 2018), but data is limited in 2017 when only reaches 2B,4B2, and ESB were monitored. The sampling schedule for those sites monitored in 2019 is summarized in Table 2.

Table 2. Historical sampling schedule for all sites monitored in 2019.

	Years Sampled						
Sample Sites	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**
Reach 1A (n=2)	X	X	X	X	X		X
Reach 1B (n=2))	X	X	X	X	X		X
Reach 2A (n=2)	X	X	X	X	X		X
Reach 2B (n=2))	X	X	X	X	X	X	X
Reach 3 (n=2)	X	X	X	X	X		X
East Side Bypass (n=6)							
Transects 1, 3, & 4	X	X	X	X	X	X	X
Transect 2	X	X	X	X	X		X
Transects 6 & 7						X	X
Reach 4A (n=2)	X	X					X
Reach 4B2 (n=2)	X	X	X	X	X	X	X
Reach 5 (n=2)		X	X	X	X		X

When sampling was conducted in 2019, most of the sites had not been visited since 2015. Many of the t-posts marking the permanent transects were missing after 4 years. Therefore, a number of posts were replaced using GPS waypoints and photos but may not have been in the exact location where they were established, potentially causing slight differences from previous measurements. Also, in Reaches 1A, 1B, 2B, 4A, and ESB, some of the transect endpoints nearest to the river were estimated to fall within the current channel; in these cases the distance from the bank to the estimated location of the post was recorded as water.

River reaches experienced much different hydrological conditions with regards to flows, substrate and ground water levels, and overbank flooding. As such, vegetation may vary considerably among reaches. Because of these differences, data is presented by individual reach followed by a summary comparing all reaches to provide an overall assessment of vegetation development within the project area.

See Appendix D for a plant list of all herbaceous and woody species detected in transects throughout 7 years of monitoring. This table serves as a reference for scientific plant names throughout this report. Wetland indicator status is also included in this table for those plants that were on the National Wetland Plant List (USDA - NRCS 2019) and were rated Facultative or above. Codes are as follows:

OBL - Obligate wetland – Almost always occurs in wetlands
FACW – Facultative wetland - Usually occur in wetlands, but may occur in non-wetlands
FAC – Facultative - Occur in wetlands and non-wetlands

Understory Vegetation

One hundred and seventeen annual and perennial species were identified in the understory plant layer along all transects during 7 years of monitoring. The average total percent cover by individual species, life-form (*i.e.* native or introduced shrubs < 1m, grasses, and forbs) and cover type (*i.e.* plant, litter, bare ground, water) are listed in Appendix E by reach.

Reach 1A

Total understory plant cover peaked at 73.5 percent in 2015 and was lowest in 2011 at 23.0 percent (Figure 4B). From 2012 to 2015, when total cover was highest, the dominant lifeform was introduced grasses, with the major species being ripgut brome (Appendix E). In 2011 and 2019, when total cover was lowest, the dominant lifeform was native forbs, principally California mugwort and blackberry (Appendix E). Native understory species were dominant relative to introduced species in 2011 and 2019 while introduced species were dominant from 2012 to 2015 (Figure 4A).

Figure 4. Relative percent understory cover by native vs. introduced species (A) and by lifeforms with total plant cover (B) in Reach 1A along the San Joaquin River from 2011 to 2015 and 2019.

Reach 1B

Total understory plant cover peaked at 44.5 percent in 2015 and was lowest in 2019 at 11.0 percent (Figure 5B). From 2012 to 2015 and in 2019 the dominant lifeform was introduced grasses, mostly Bermuda grass and foxtail chess. In 2011, the most common lifeform was native grasses, exclusively tall flatsedge (Appendix E). 2011 was also the only year of sampling when native understory species were dominant relative to introduced species (Figure 5A).

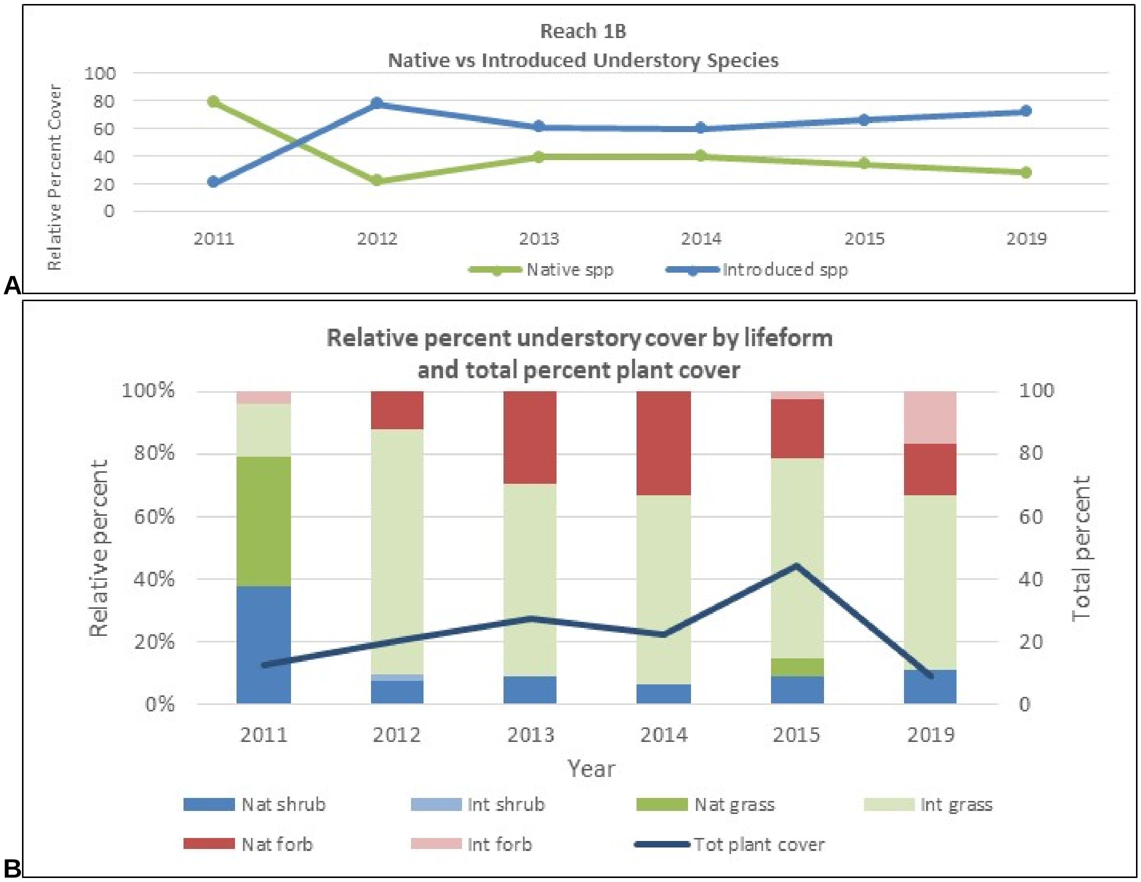


Figure 5. Relative percent understory cover by native vs. introduced species (A) and by lifeforms with total plant cover (B) in Reach 1B along the San Joaquin River from 2011 to 2015 and 2019.

Reach 2A

Total understory plant cover did not vary much over the study period and was relatively low in all years, peaking at 26.5 percent in 2013 with the lowest cover in 2013 at 15.5 percent (Figure 6B). From 2012 to 2015 and in 2019 the dominant lifeform was introduced grasses, mostly Bermuda grass and foxtail chess. In 2011, the most common lifeform was native grasses while the most common species was American birds-foot trefoil (Appendix E). Introduced understory species were dominant relative to introduced species in all years except 2011 when the proportion of native and introduced species was essentially equal (Figure 6A).

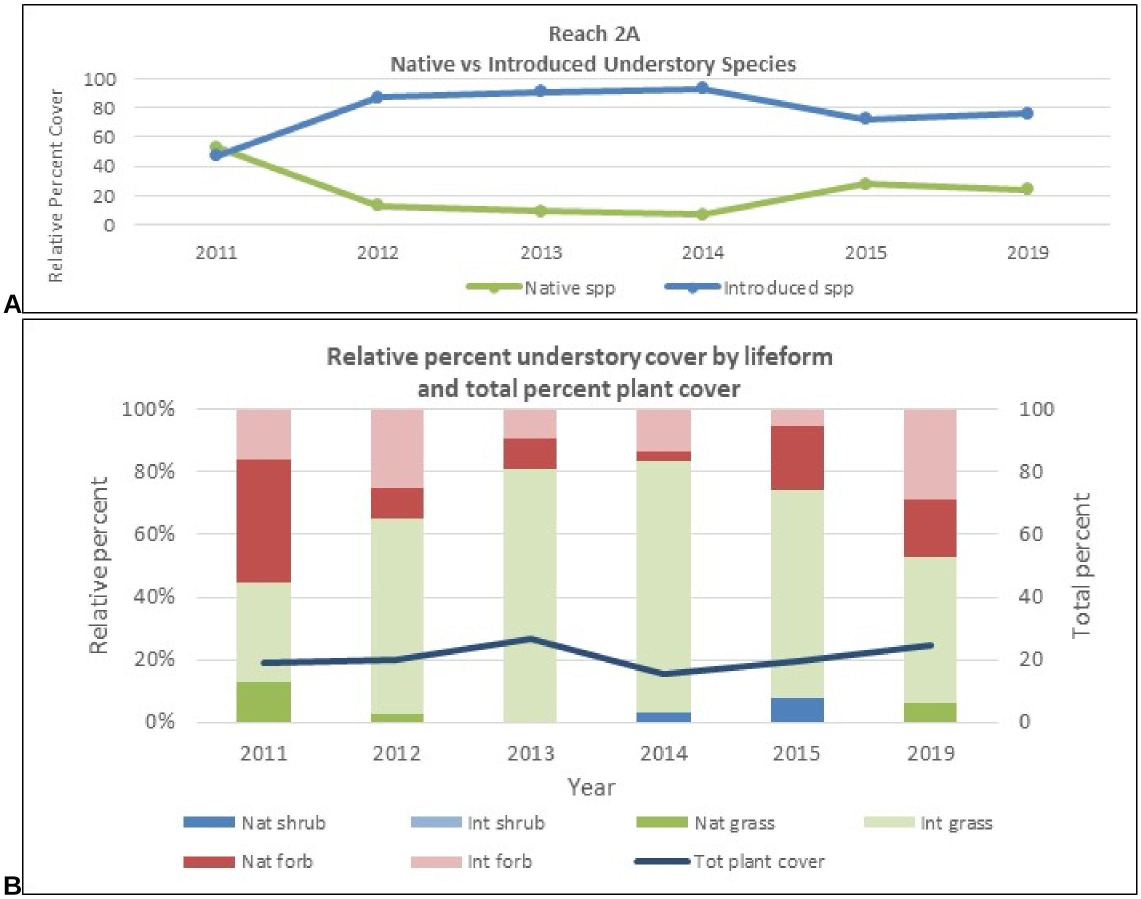


Figure 6. Relative percent understory cover by native vs. introduced species (A) and by lifeforms with total plant cover (B) in Reach 2A along the San Joaquin River from 2011 to 2015 and 2019.

Reach 2B

Total understory plant cover was highest in 2017 and 2019 at around 57 percent in both years. In 2014 and 2015 plant cover was only about 7 percent (Figure 7B). Dominant lifeforms were variable over the monitoring period in Reach 2B, which was one of three reaches sampled in 2017. In 2011 and 2019, native forbs were dominant and the most common species was American birds-foot trefoil (Appendix E). From 2012 to 2015, the dominant lifeform was introduced forbs, with the major species being black mustard (Appendix E). Finally, in 2017, redtop panicgrass, an introduced grass, composed most of the plant cover (Appendix E). There was also variability in the proportion of native to introduced understory species; native species were dominant in 2011 and 2019, introduced species were dominant in 2012, 2014,2015, and 2017 while the two were more or less equal in 2013 (Figure 7A).

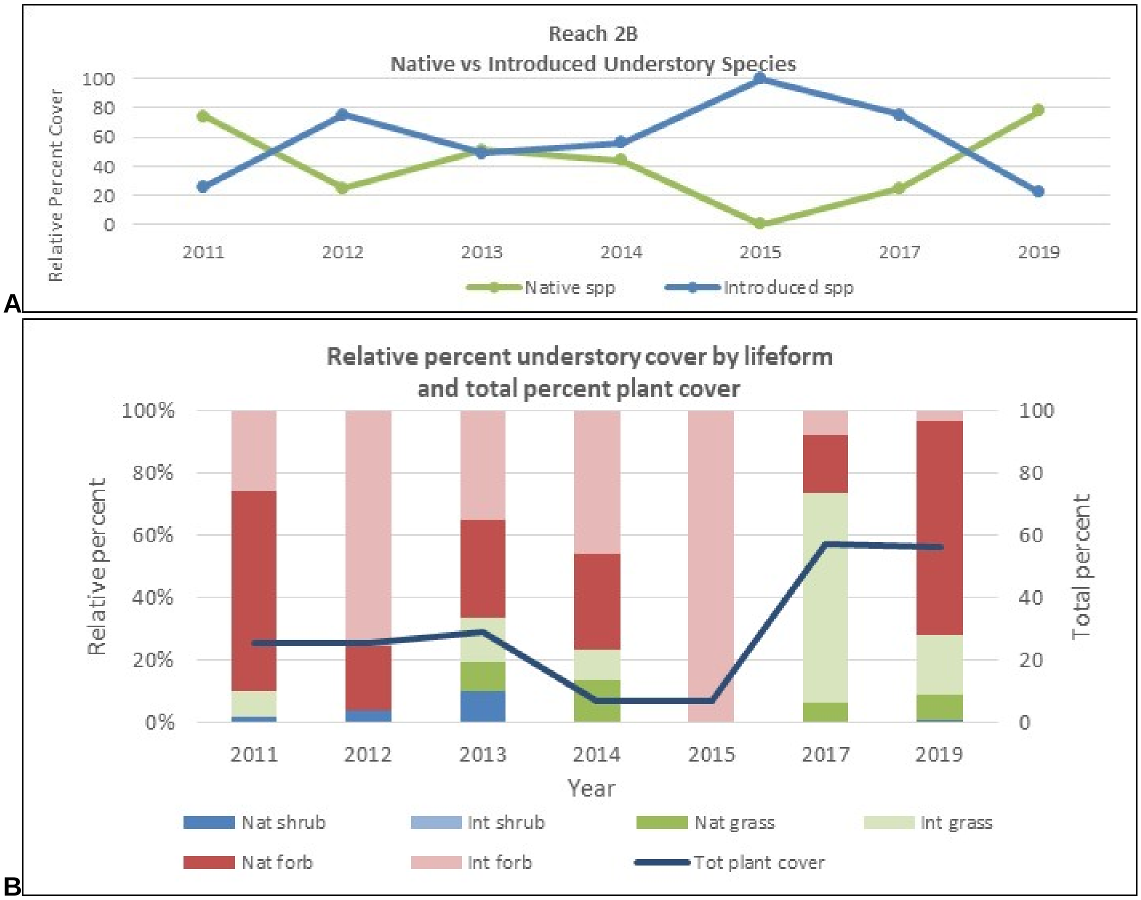


Figure 7. Relative percent understory cover by native vs. introduced species (A) and by lifeforms with total plant cover (B) in Reach 2B along the San Joaquin River from 2011 to 2015, 2017, and 2019.

Reach 3

Total understory plant cover ranged from 31.5 percent in 2012 to 73.4 percent in 2011 (Figure 8B). In 2011, native forbs were dominant and cocklebur was the most common species. From 2012 to 2015 the dominant lifeform was introduced grasses, mostly ripgut brome (Appendix E). In 2019, both introduced grasses and native forbs composed around 43 percent of relative cover, with dominant species ripgut brome and California mugwort (Appendix E). 2011 was the only year of sampling when native understory species were dominant relative to introduced species (Figure 8A).

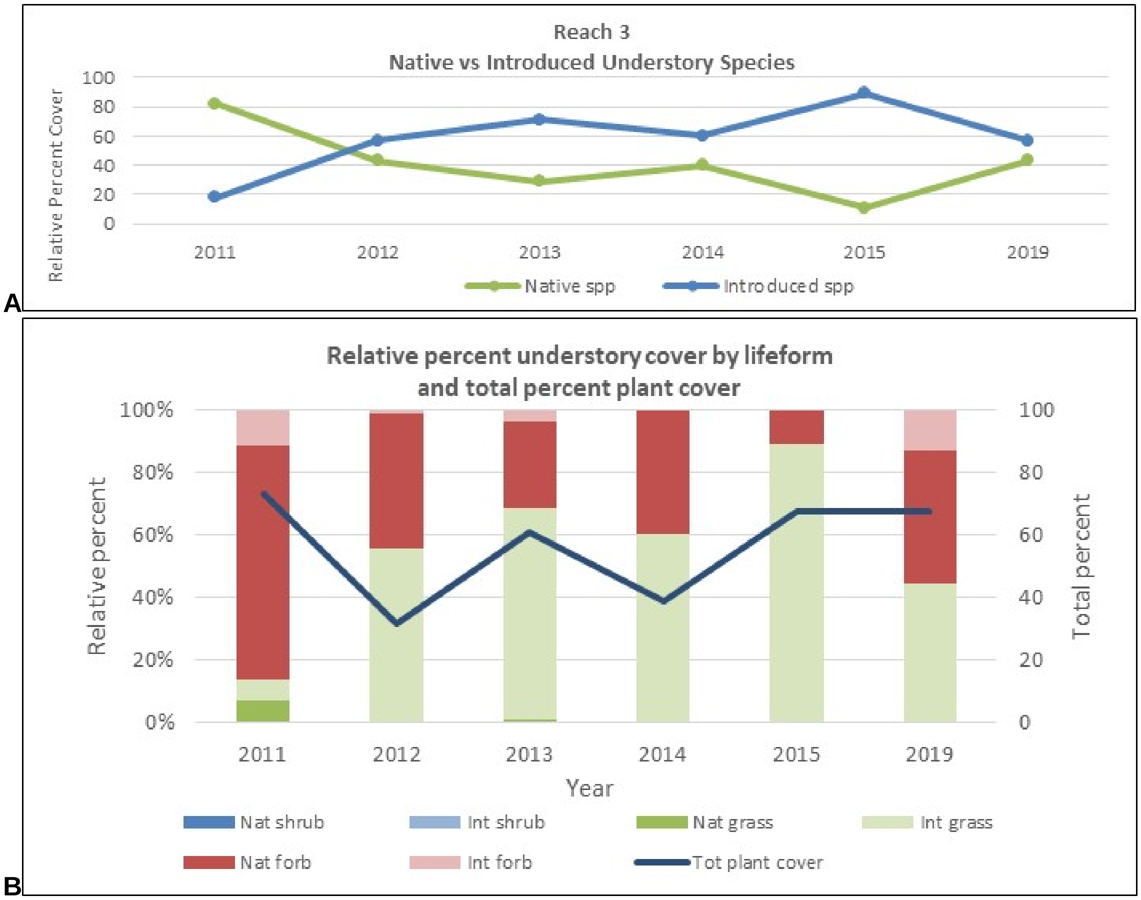


Figure 8. Relative percent understory cover by native vs. introduced species (A) and by lifeforms with total plant cover (B) in Reach 3 along the San Joaquin River from 2011 to 2015 and 2019.

East Side Bypass

The ESB was one of three reaches sampled in 2017 and the number of transects increased from 4 to 6 in 2017 and 2019. Total understory plant cover was highest in 2017 and 2019 at around 74 percent in both years. Lowest plant cover was in 2014 at 35.2 percent (Figure 9B). Native grasses were dominant lifeforms from 2011 to 2014, with saltgrass being the dominant species. Introduced grasses – including Bermuda grass, Mediterranean barley, and foxtail chess – dominated in 2015, and native forbs were dominant in 2017 (predominantly grand redstem) and 2019 (predominantly sunflower; Appendix E). Native species were dominant in all years compared to introduced species except 2015 (Figure 9A).

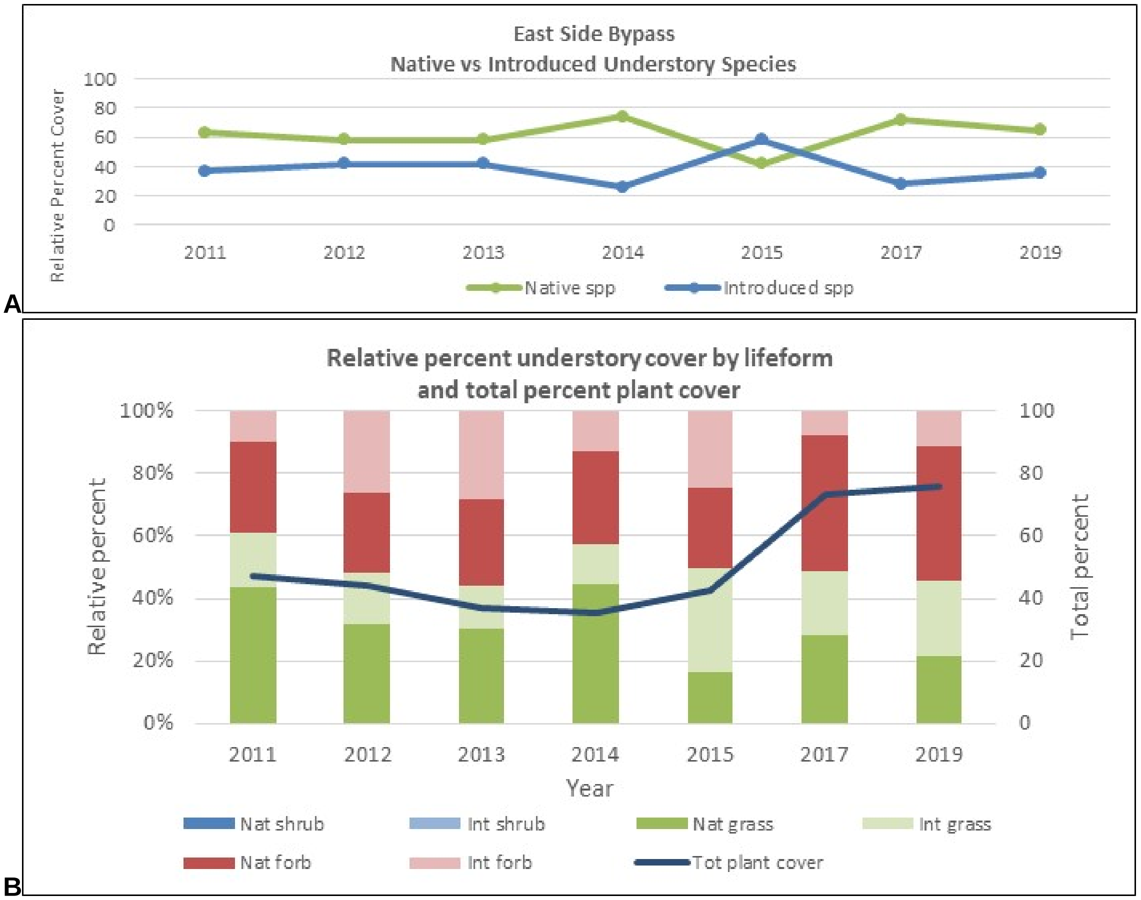


Figure 9. Relative percent understory cover by native vs. introduced species (A) and by lifeforms with total plant cover (B) in the East Side Bypass along the San Joaquin River from 2011 to 2015, 2017, and 2019.

Reach 4A

Data was only collected for three years during the study period in Reach 4A, the first two years of the study and the most recent. Total understory plant cover was highest in 2019 at 29.8 percent and lowest in 2011 at 18.3 percent (Figure 10B). Native forbs were dominant in 2011, and cocklebur was the most common species. In 2012 and 2019 the dominant lifeform was introduced forbs, although in 2019 all lifeforms (except shrubs) were close in total cover, ranging from 21 to 28 percent (Figure 10B). White sweetclover and green carpet weed were the most common introduced forbs in these years (Appendix E). 2011 was the only year of three when native understory species were dominant relative to introduced species (Figure 10A).

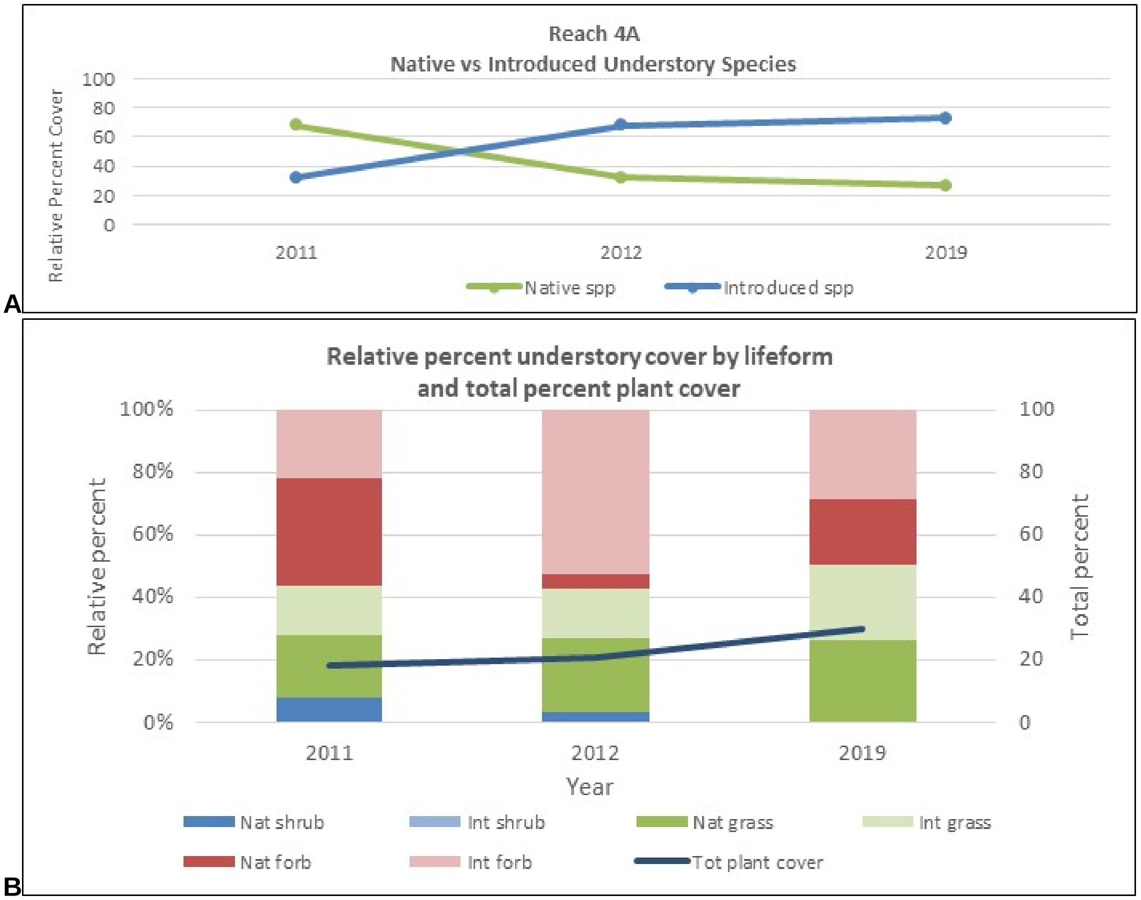


Figure 10. Relative percent understory cover by native vs. introduced species (A) and by lifeforms with total plant cover (B) in Reach 4A along the San Joaquin River in 2011, 2012, and 2019.

Reach 4B2

Reach 4B2 was one of three reaches sampled in 2017, when total understory plant cover was the highest at 90.0 percent. The lowest understory cover was recorded in 2014 at 63.5 percent (Figure 11B). Dominant lifeforms varied over the study period, though all herbaceous lifeforms were generally well represented in all years. In 2011 and 2015, introduced grasses were dominant; barnyard grass and ripgut brome were the most common species, respectively. In 2012 and 2019, introduced forbs were the dominant lifeform (predominantly black mustard) and in 2013 native grasses, mostly saltgrass, were dominant. In 2014, the proportion of the two dominant lifeforms – native and introduced grasses – was equal with saltgrass and soft chess brome as the dominant species. In 2017 native forbs were the most common lifeform and sunflower the most common species (Appendix E). The proportion of native understory species relative to introduced species was variable over the monitoring period (Figure 11A).

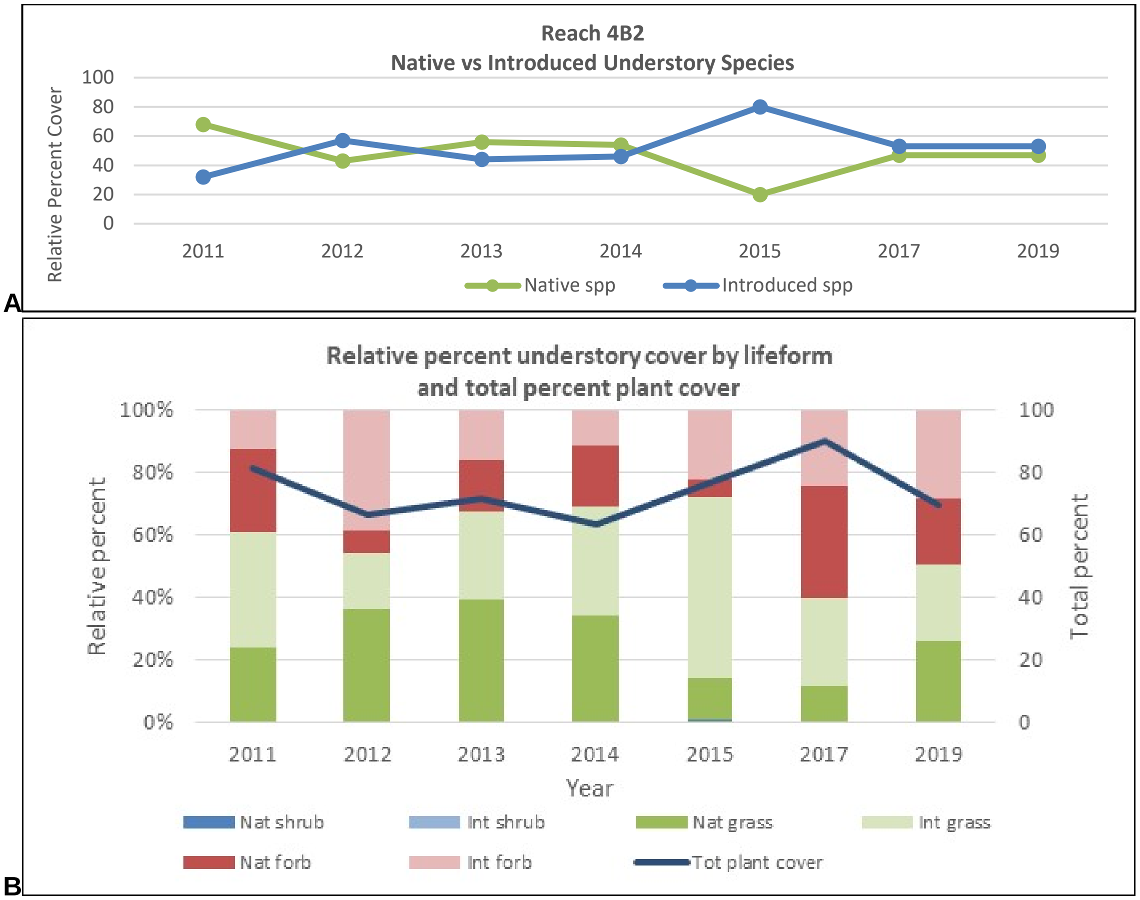


Figure 11. Relative percent understory cover by native vs. introduced species (A) and by lifeforms with total plant cover (B) in Reach 4B2 along the San Joaquin River from 2011 to 2015, 2017, and 2019.

Reach 5

Data was not collected in Reach 5 in 2011. Total understory plant cover was highest in 2015 (71.5 percent) and lowest in 2019 (20.0 percent; Figure 12B). Introduced forbs were dominant in all years except 2019, when native forbs were the dominant lifeform. White sweetclover was the dominant species in 2011 and perennial pepperweed was dominant from 2013 to 2015, reaching as high as 59.5 percent total cover in 2014. (Appendix E). In 2019, sunflower was the dominant native forb species. Introduced species were dominant relative to native species in all years except for 2019 (Figure 12A).

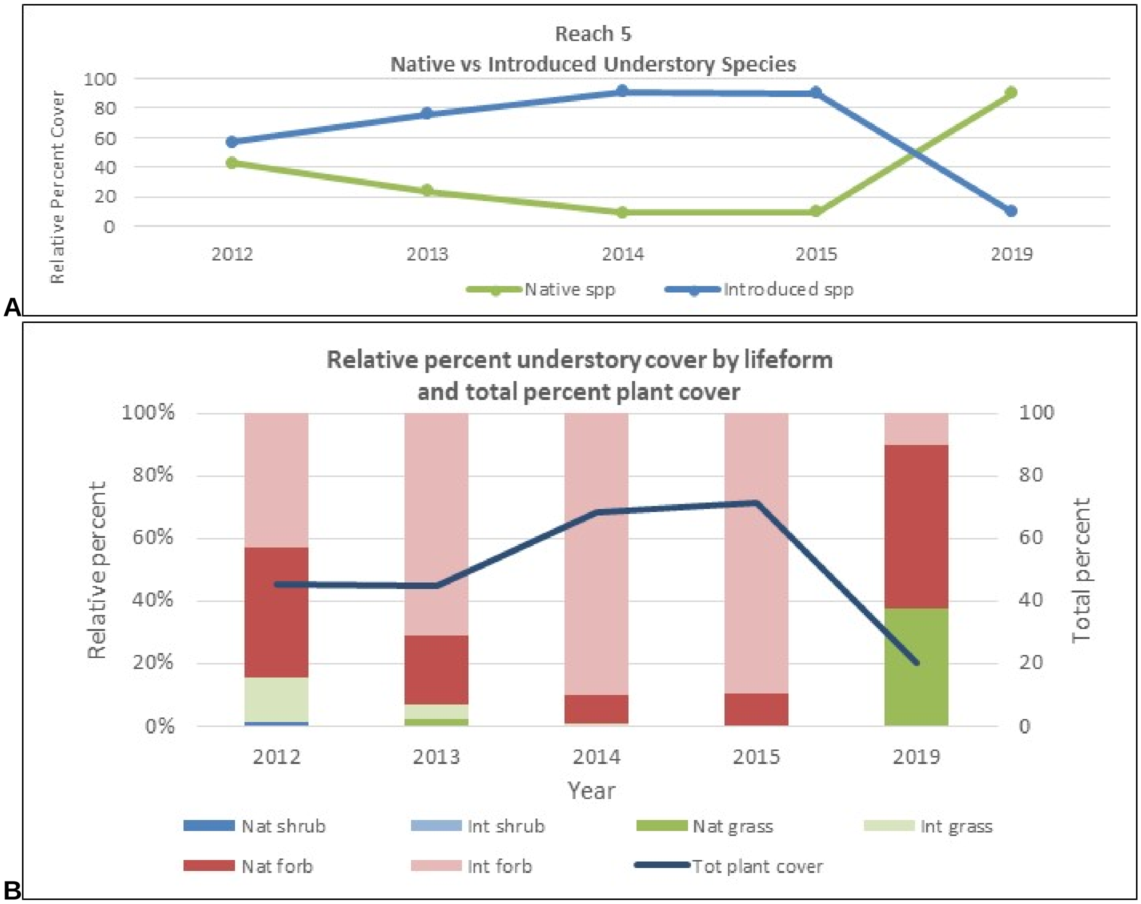


Figure 12. Relative percent understory cover by native vs. introduced species (A) and by lifeforms with total plant cover (B) in Reach 5 along the San Joaquin River from 2012 to 2015 and 2019.

All Reaches

A comparison of total understory cover by reach, including average cover of all reaches, for all years vegetation was sampled is presented in Figure 13. Downstream Reach 4B2 typically had the highest understory cover followed by Reaches 1A, 3, and 5. In contrast, upstream Reaches 1B, 2A, and 2B had the lowest cover over the years. When averaging total cover over all reaches by year, the highest percentage of understory cover was in 2017, when only three reaches were sampled. However the highest cover within these reaches was recorded in 2017 as compared to other years, which was probably a good indication of conditions throughout the project area.

The percentage of native and introduced understory species measured within the total plant coverage was averaged across all reaches to compare the type of vegetation present over the years (Figure 14). Percent total cover of native species was highest in 2011, 2017, and 2019; total cover of native species was also higher than that of introduced species in these years. In all other years, introduced species were dominant relative to native species.

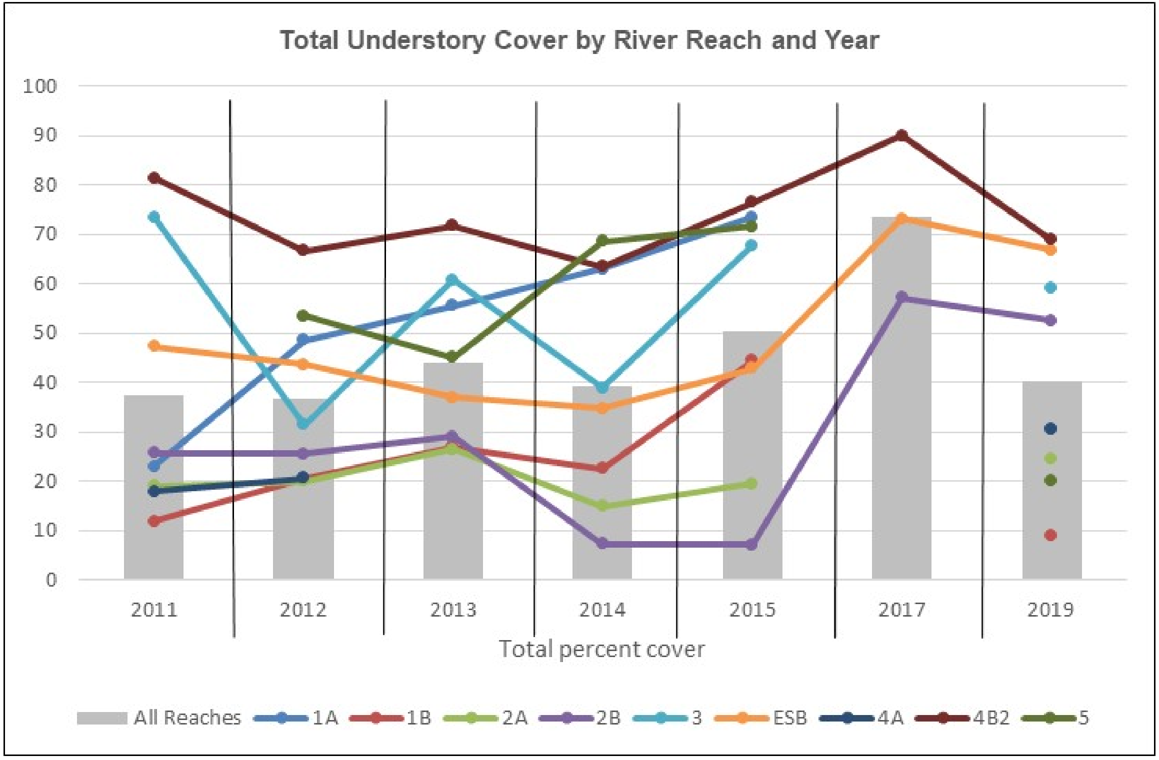


Figure 13. Total percent understory cover by river reach along the San Joaquin River from 2011 to 2015, 2017, and 2019.

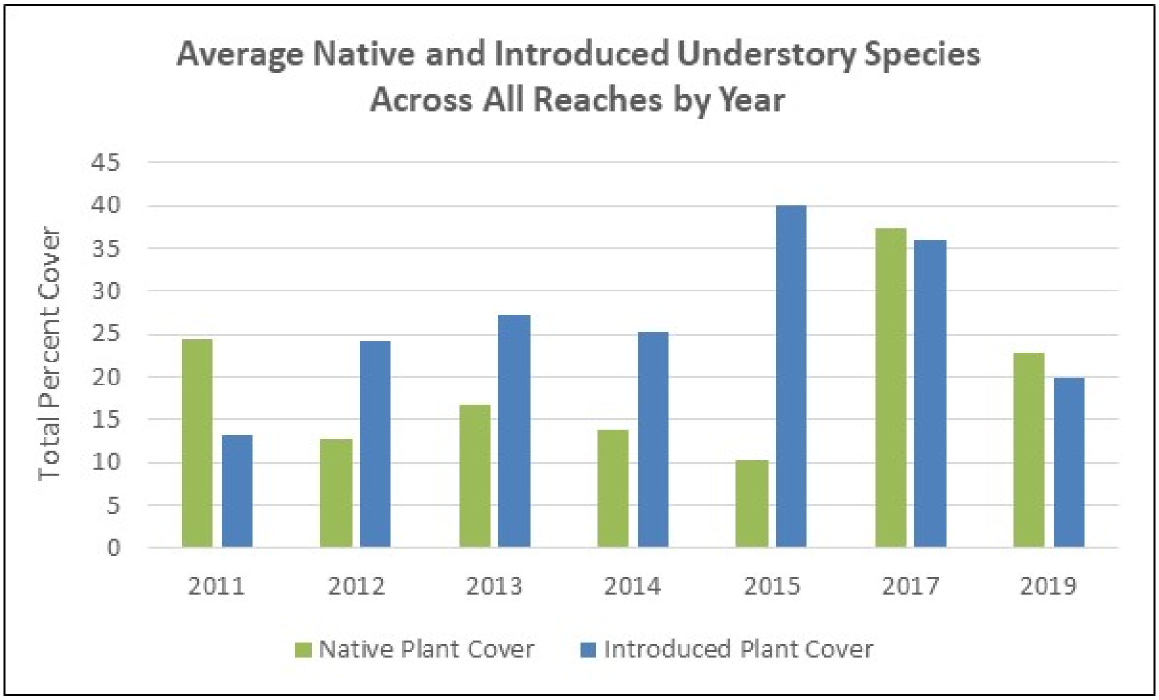


Figure 14. Total percent understory cover of native and introduced species averaged across all reaches along the San Joaquin River from 2011 to 2015, 2017 and 2019.

The average number of understory species ranked as obligate and facultative wet in the National Wetland Indicator list (USDA-NRCS 2019) per year by reach is shown in Table 3. These data are an indication of the suitability of the site for riparian wetland species. Reach 1A, the uppermost reach, had the highest number of wetland species detected (6.2). In the ESB, where herbaceous plants are dominant, the next highest number of wetland species were identified.

Table 3. The average number of understory species per year that are ranked as “obligate” or “facultative wet” on the National Wetland Indicator List by reach.

Reach	Average # of wetland species/year
1A	6.2
1B	4.3
2A	0.7
2B	3.1
3	2.0
ESB	5.4
4A	2.3
4B2	4.4
5	3.0

Species richness is the total number of species detected and is an indicator of plant diversity. Herbaceous plant species richness was often highest in the ESB, with 20 or more species recorded in 4 of 7 years (Figure 15). The higher sample size in this reach may have influenced species richness numbers since the opportunity to detect more plant species is greater with more transects. Other reaches that consistently showed relatively high herbaceous plant diversity were 1A and 4B2. The highest plant diversity was documented in 2017, taking into consideration that only 3 reaches were sampled that year. Reaches 1B, 2B, and 3 generally had low plant diversity among the reaches sampled.

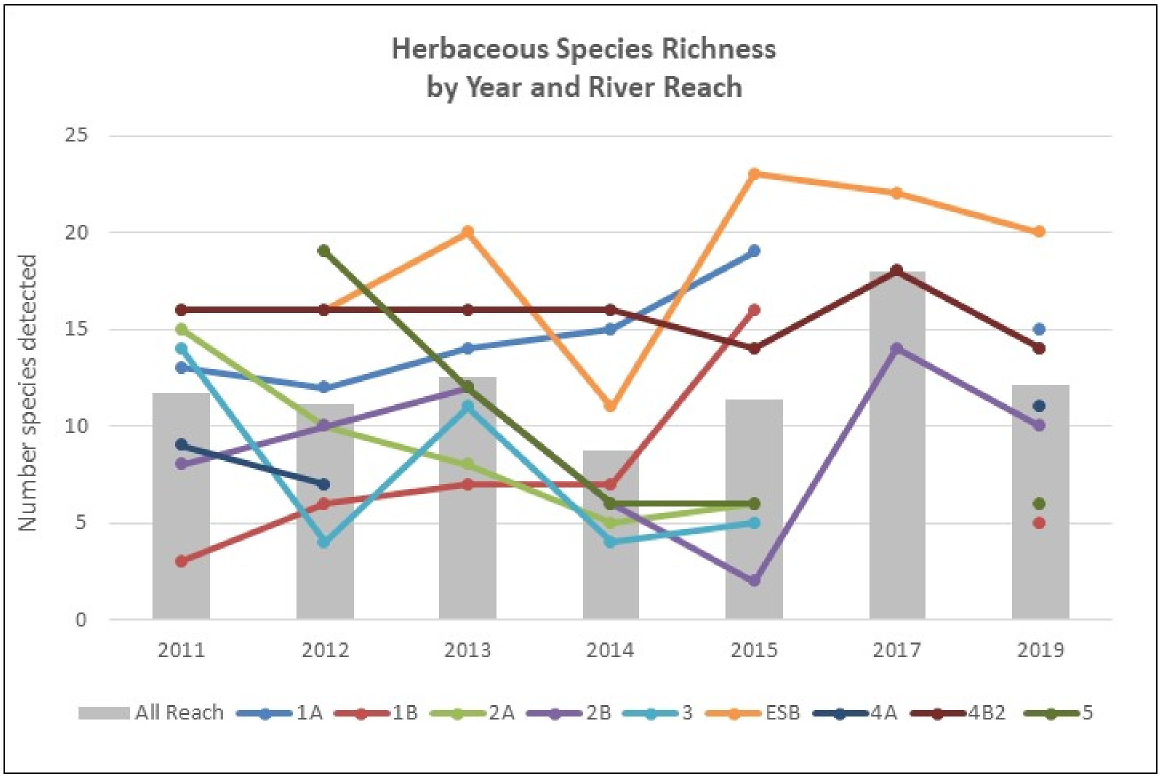


Figure 15. Number of herbaceous species detected by reach and average of all reaches in vegetation transects along the San Joaquin River from 2011 to 2015, 2017, and 2019.

Overstory Vegetation

The overstory layer as it pertains to this study includes all woody species greater than 1 m in height. Fourteen species were documented within this layer, 12 of which were native. The average total percent cover and height of individual species by reach and year are listed in Appendix F. Height was measured as the average of the tallest overstory shrubs/trees within each continuous stretch by species. No overstory species were detected in any of the 3 years that sampling was conducted in Reach 4A.

Reach 1A

Total overstory cover was greatest in 2019 at 61.7 percent (Figure 16). The lowest cover was measured in 2013 at 44.5 percent. A total of 7 woody species were detected in the overstory of transects within Reach 1A from 2011 to 2019. Valley oak was the most common species detected in all years.

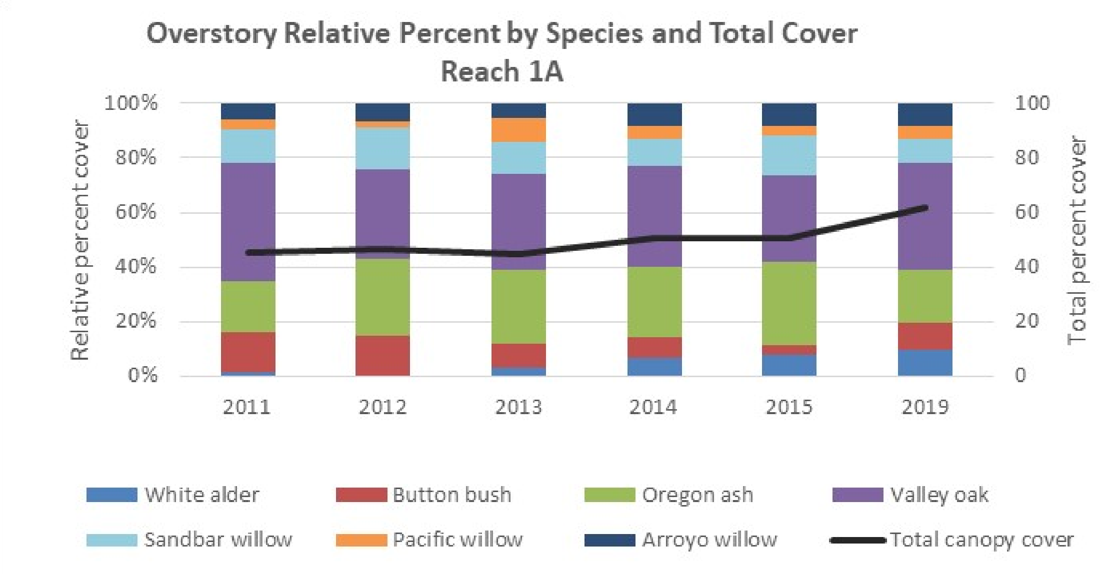


Figure 16. Relative percent overstory cover and total plant cover in Reach 1A along the San Joaquin River from 2012 to 2015 and 2019.

Reach 1B

Total overstory cover was relatively stable in Reach 1B, ranging from 48.3 percent in 2019 to 58.9 percent in 2012 (Figure 17). A total of 7 woody species were detected in the overstory of transects. This was the only reach in which introduced species were measured in the overstory layer (i.e. giant reed and scarlet wisteria). Sandbar willow was the most common species detected in all years.

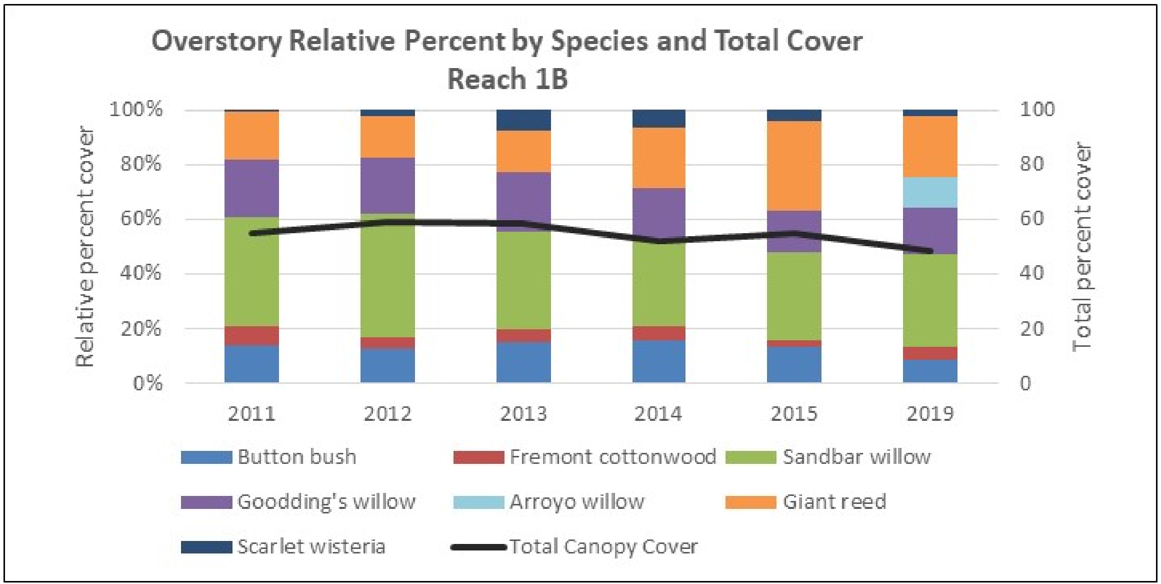


Figure 17. Relative percent overstory cover and total plant cover in Reach 1B along the San Joaquin River from 2012 to 2015 and 2019.

Reach 2A

Total overstory cover was very low in all years, ranging from 0.9 percent in 2012 to 7.2 percent in 2019 (Figure 18). A total of 3 woody species were detected in the overstory of transects, however Goodding’s willow was the only species present in all years and was also the most common species.

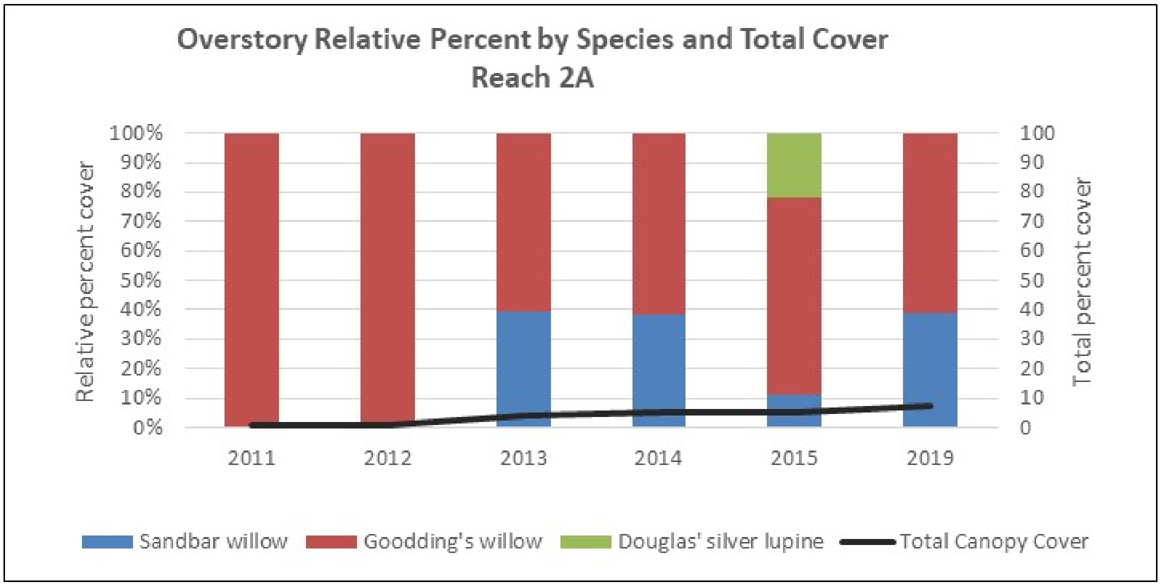


Figure 18. Total percent cover by overstory species detected in transects within Reach 2A from 2011 to 2015 and 2019.

Reach 2B

Total overstory cover increased over time, 7.2 percent in 2011 to 32.2 percent in 2019 (Figure 19). The largest increase was from 2011 to 2012 when cover increased by 12.2 percent. A total of 3 woody species were detected in the overstory of transects, however Goodding’s willow and black elderberry were the only species present in all years. Goodding’s willow was the most common species.

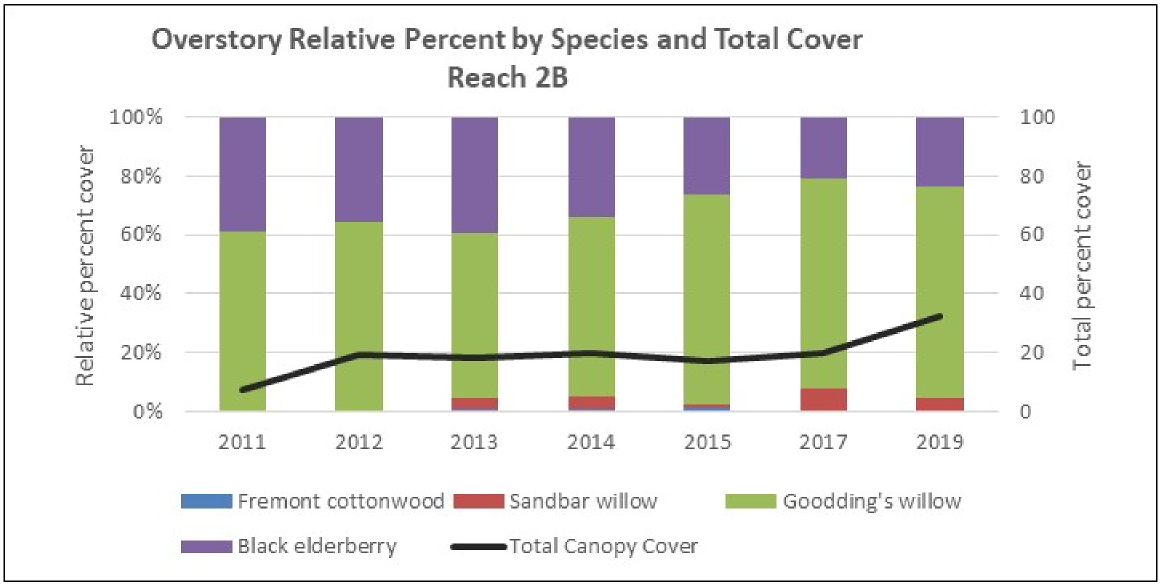


Figure 19. Total percent cover by overstory species detected in transects within Reach 2B from 2011 to 2015, 2017, and 2019.

Reach 3

Total overstory cover ranged from 14.9 percent in 2019 to 24.0 percent in 2015 (Figure 20). A total of 5 woody species were detected in the overstory layer of transects. This was the only reach in which Fremont cottonwood was detected throughout the monitoring period. This species was also dominant in all years, although by 2019 had dropped to 5.4 percent cover from 16.7 percent cover in 2011.

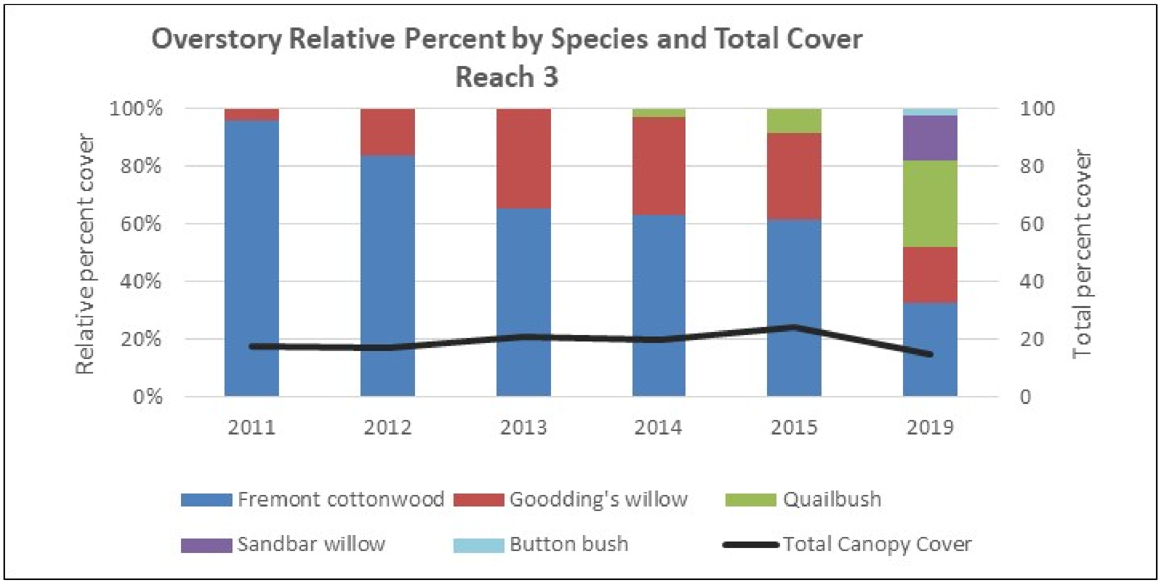


Figure 20. Total percent cover by overstory species detected in transects within Reach 3 from 2011 to 2015 and 2019.

East Side Bypass

Total overstory cover was extremely low within the bypass, ranging from 0.2 to 0.3 percent (Figure 21). No overstory species were detected from 2012 to 2015. The only species identified was Goodding's willow.

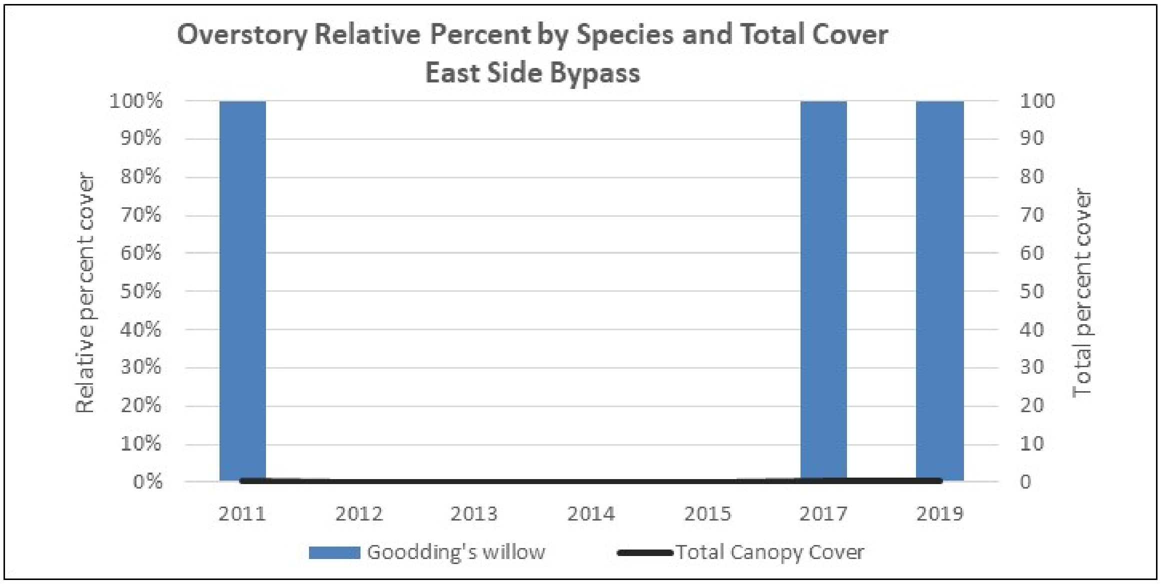


Figure 21. Total percent cover by overstory species detected in transects within the East Side Bypass from 2011 to 2015, 2017, and 2019.

Reach 4B2

Total overstory cover was relatively low, peaking at 12.7 percent in 2017 with the lowest cover measured at 8.5 percent in 2012 (Figure 22). Goodding's willow was the only species detected in all years.

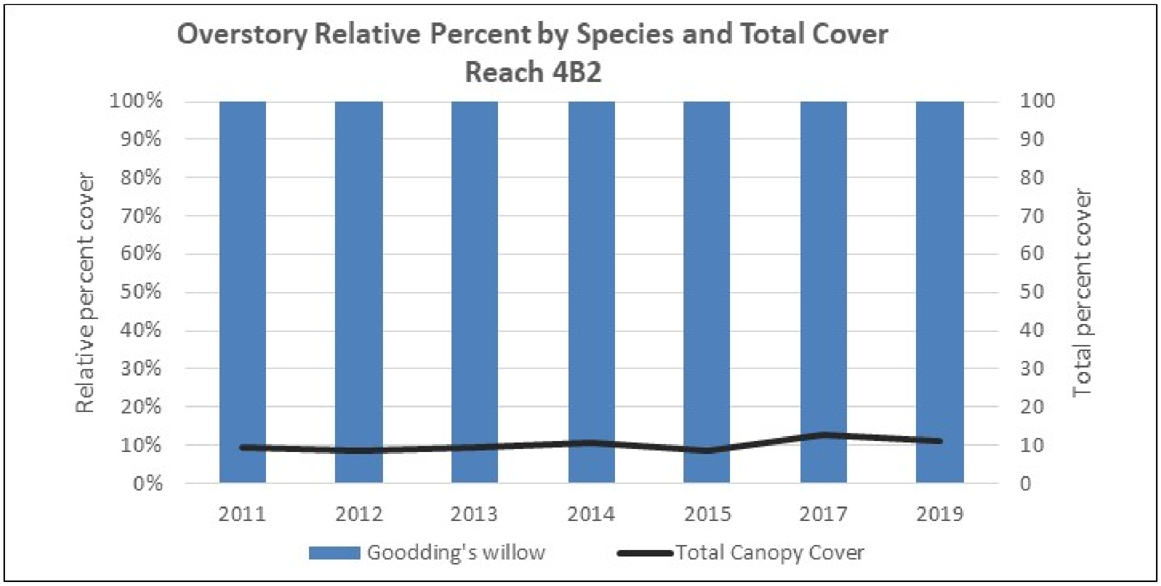


Figure 22. Total percent cover by overstory species detected in transects within Reach 4B2 from 2011 to 2015, 2017, and 2019.

Reach 5

Total overstory cover in Reach 5 was the highest of all reaches, ranging from 62.8 percent in 2012 to 70.8 percent in 2013 (Figure 22). Goodding's willow was the only species detected in all years.

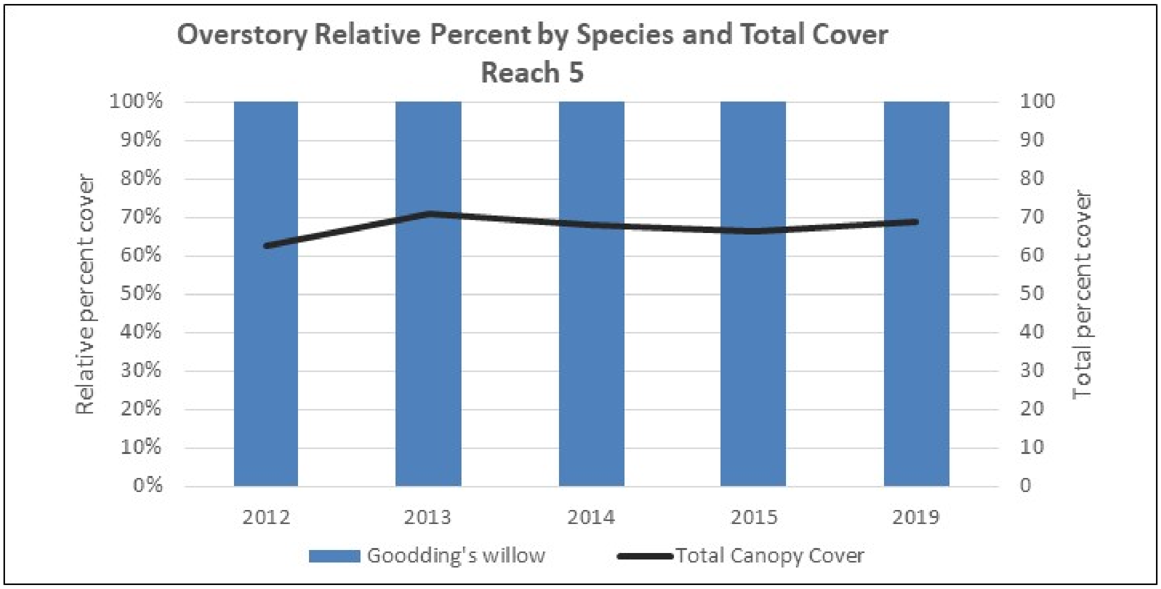


Figure 23. Total percent cover by overstory species detected in transects within Reach 5 from 2011 to 2015 and 2019.

All Reaches

A comparison of total overstory cover by reach, including average cover of all reaches, for all years vegetation was sampled is presented in Figure 24. Downstream Reach 5 had the highest overstory cover followed by Reaches 1B and 1A. In contrast, ESB and Reaches 2A and 4B2 had the lowest cover over the years; no overstory was detected in Reach 4A in any year. When averaging total cover over all reaches by year (excluding 2017, when only reaches with relatively low overstory cover were sampled), values did not vary broadly, ranging from 16.9 percent in 2011 to 23.0 percent in 2015. Nonetheless, there was a slight increase in total overstory cover across all reaches over the monitoring period.

Native overstory species were by far the most dominant as compared to introduced species. Upstream Reach 1B was the only reach in which introduced species were measured and included both giant reed and scarlet wisteria. Goodding's willow was the most commonly detected species in the overstory layer (found within 7 of 9 reaches sampled).

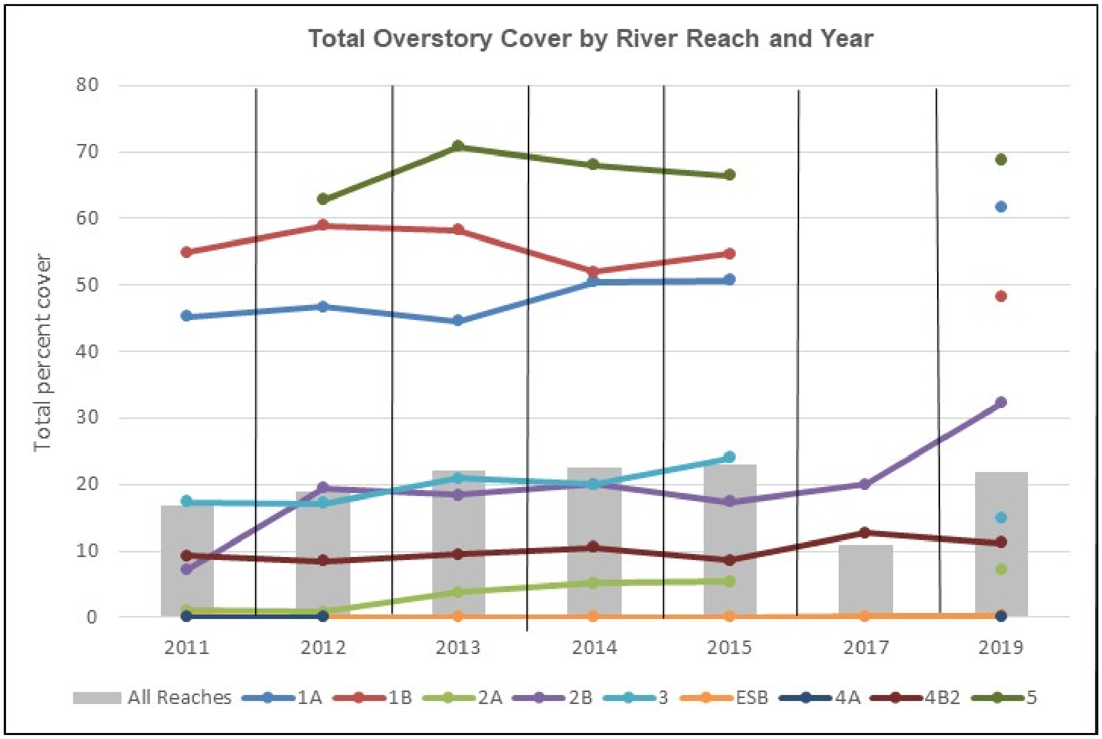


Figure 24. Total percent overstory cover by reach and across all reaches along the San Joaquin River from 2011 to 2015, 2017 and 2019.

Woody plant species richness is a measure of the number of woody species detected in all methods of sampling (i.e. understory cover, overstory cover, and stem density). The uppermost reaches 1A and 1B had the highest species richness, with 6 to 7 woody species counted each year of monitoring. Downstream reaches (ESB to Reach 5) had the lowest diversity with 0 to 1 species detected each year. The average number of species detected across all reaches remained around 3 over the monitoring period, with the exception of 2017 when only 3 reaches were sampled.

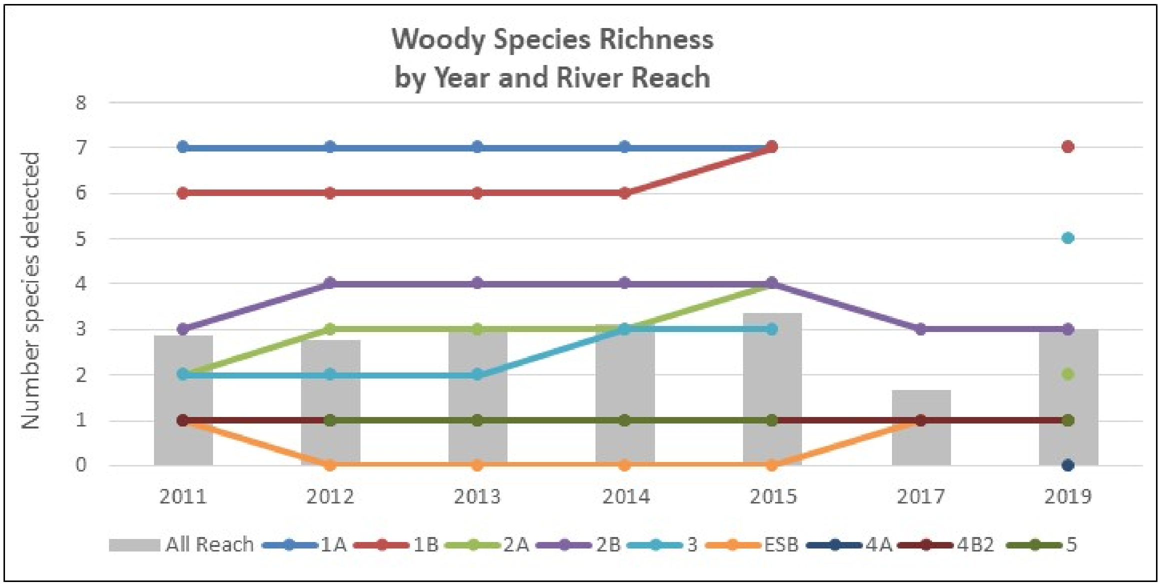


Figure 25. Number of woody species detected by reach and average of all reaches in vegetation transects along the San Joaquin River from 2011 to 2015, 2017, and 2019.

Woody Stem Density

The average woody stem densities of individual species by size class are listed by reach and year in Appendix G. No woody stems were detected in Reach 4B2 in any year. Stem size classes are described in Appendix C-3 but generally span from smallest (Class 1) to largest (Class 4).

Reach 1A

Most stems fell within size classes 2 and 3 over the years (Figure 26). Stem density peaked at 2.68 stems/m^2 in 2016 and was lowest in 2011 at 1.08 stems/m^2. Total stem densities were highest when stems were tallied in size class 1; in 2013 and 2014 a number of oak seedlings were detected while in 2019 Oregon ash seedlings were detected.

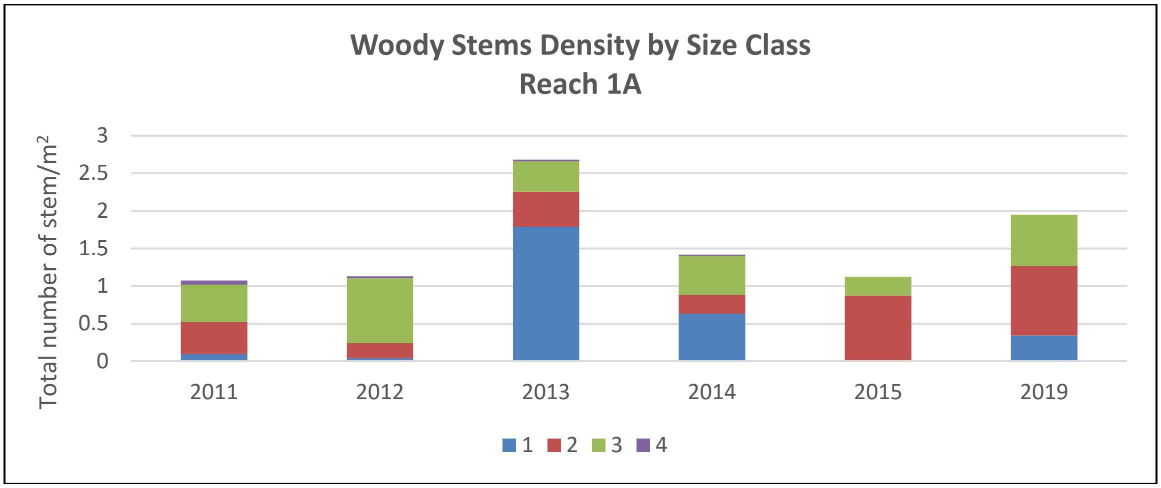


Figure 26. Average number of woody stems per meter squared by size class within Reach 1A along the San Joaquin River from 2011 to 2015 and 2019.

Reach 1B

Woody stems fell almost exclusively in size classes 2 and 3 in this reach, which generally had the highest stem density of all reaches, ranging from 1.58 stems/m^2 in 2015 to 8.59 stems/m^2 in 2019 (Figure 27). Sandbar willow was a large contributor to the high stem counts. The large increase in stem density in 2019 can be attributed to a stand of giant reed (taxonomically a grass but also categorized as a shrub; USDA - NRCS 2012). In the past, the belt transect fell adjacent to the stand and density of this species was between 0.01 and 0.22 stems/m^2; in 2019, the belt transect fell within the stand and density increased to 6.08 stems/m^2. As explained above, many transect endpoint posts were missing and replaced In Reach 1B, posts at both endpoints were replaced. Therefore, it is difficult to determine if the giant reed stand expanded over time or if the position of replaced posts was slightly different than past locations.

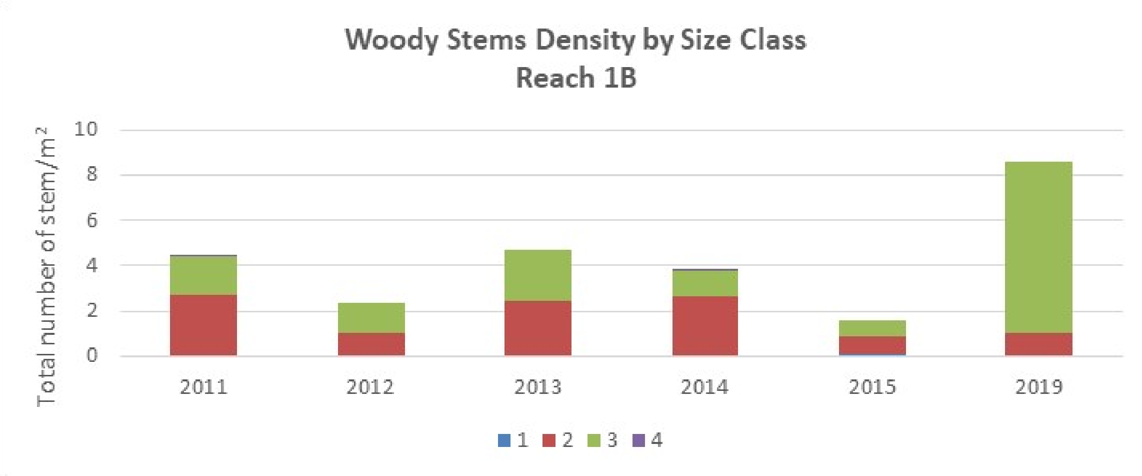


Figure 27. Average number of woody stems per meter squared by size class within Reach 1B along the San Joaquin River from 2011 to 2015 and 2019.

Reach 2A

Stem densities were very low from 2011 to 2015 (between 0.04 and 0.32 stems/m$^{2)}$ but increased to 1.26 stems/m^2 in 2019 due to an increase in class 2 sized sandbar willow stems (Figure 28).

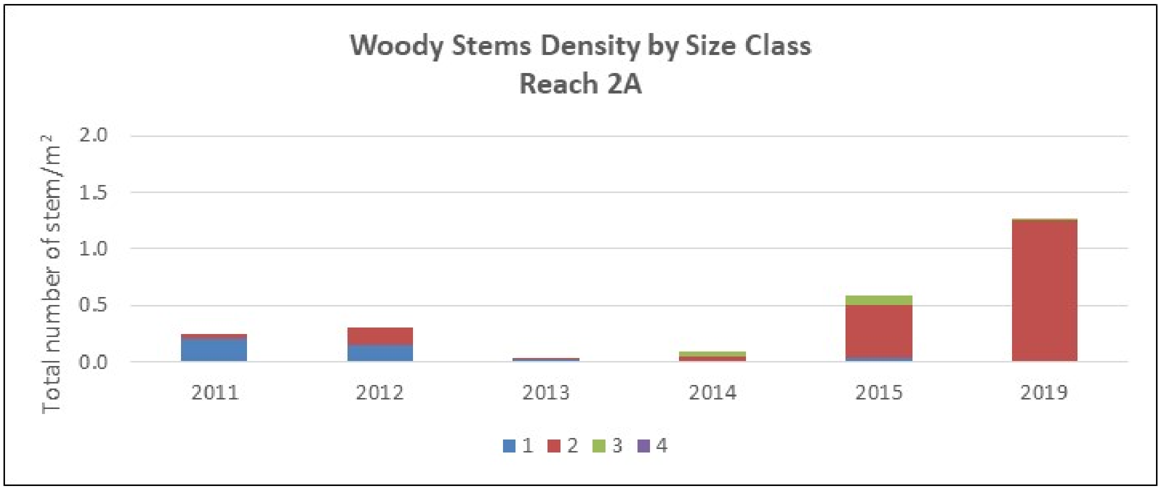


Figure 28. Average number of woody stems per meter squared by size class within Reach 2A along the San Joaquin River from 2011 to 2015 and 2019.

Reach 2B

Stem densities have been variable over the monitoring period which was related to the development of vegetation on a sandbar within this reach. Woody stems in smaller size classes 1 and 2 were counted in earlier years of the study as recruitment of willow and cottonwood occurred (Figure 29). Over time, as individual plants became larger (mostly Goodding’s willow in size Class 3) the number of stems decreased.

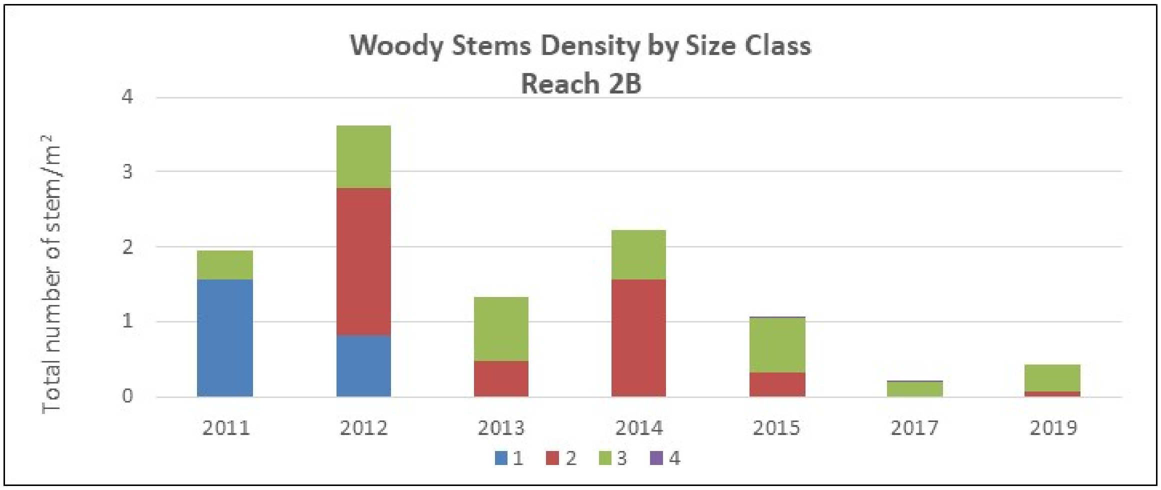


Figure 29. Average number of woody stems per meter squared by size class within Reach 2B along the San Joaquin River from 2011 to 2015, 2017, and 2019.

Reach 3

Woody stem densities were very low in all years, ranging from 0.01 to 0.11 stems/m^2 (Figure 30). Reach 3 is generally characterized by mature cottonwood which are less likely to fall within belt transects due to their large size and broad distribution. Goodding’s willow stems were most commonly counted 2011 to 2015; in 2019 quailbush and sandbar willow were the only species with stems detected.

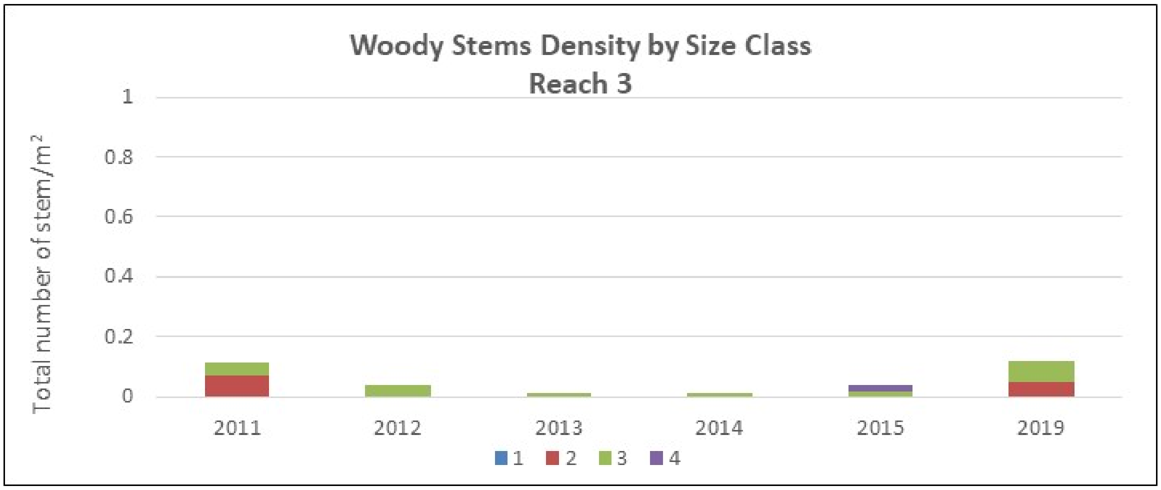


Figure 30. Average number of woody stems per meter squared by size class within Reach 3 along the San Joaquin River from 2011 to 2015 and 2019.

East Side Bypass

No woody stems were found within transects in the ESB until 2017 when Goodding's willow seedlings were recorded (Figure 31). In 2019, size Class 2 stems of both Goodding's willow and saltcedar, an introduced species that was not previously detected in the study area, were documented. Stem densities were low in both years (less than 0.2 stems/m^2).

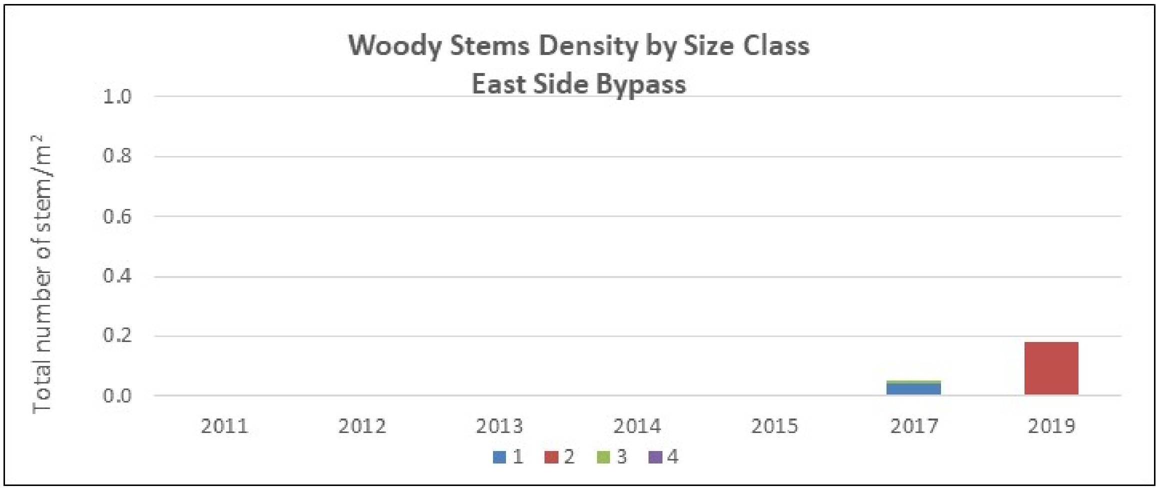


Figure 31. Average number of woody stems per meter squared by size class within East Side Bypass along the San Joaquin River from 2011 to 2015, 2017, and 2019.

Reach 4A

In 2011 and 2012, young Goodding's willow stems were detected at densities of 0.43 and 0.86 stems/m^2, respectively (Figure 32). By 2019, when Reach 4A was revisited, no stems were found.

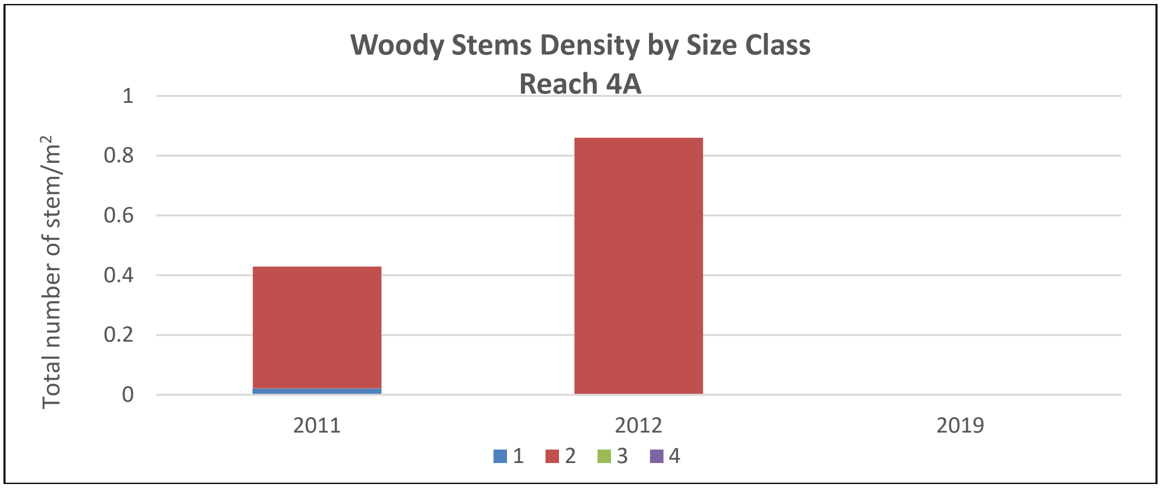


Figure 32. Average number of woody stems per meter squared by size class within Reach 4A along the San Joaquin River in 2011, 2012, and 2019.

Reach 5

Woody stem density was highest in 2012 at 1.34 stems/m^2, which were mostly within size Class 2. Since then, stem densities have generally decreased, while size classes have increased. Only Goodding's willow stems were detected within Reach 5.

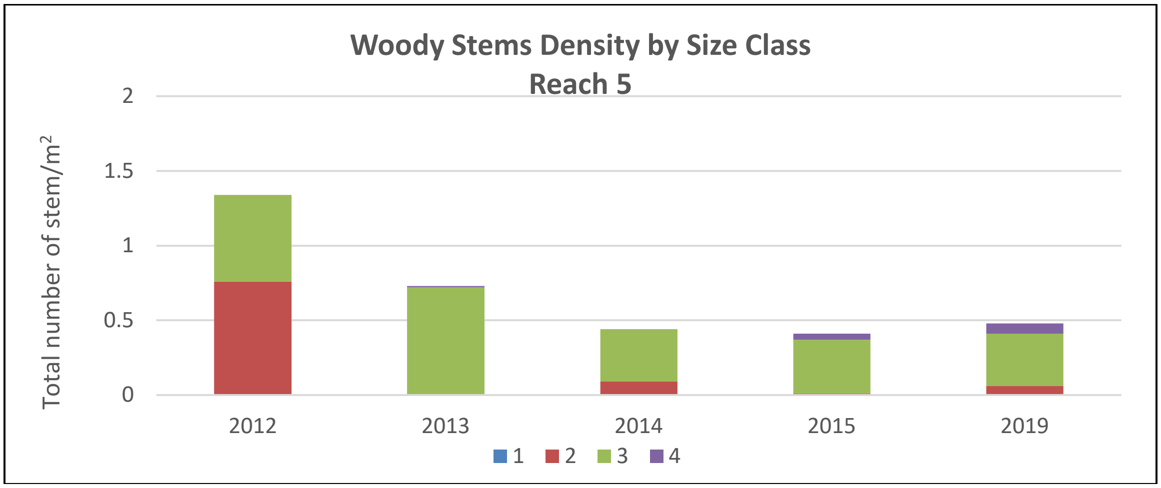


Figure 33. Average number of woody stems per meter squared by size class within Reach 5 along the San Joaquin River from 2011 to 2015 and 2019.

All Reaches

Total stem densities are graphed by reach and year in Figure 34, which also shows average stem density across all reaches for each year. Highest densities were measured in Reaches 1B, 1A and 2B over the study period. The obvious outlier in 2019 is associated with giant reed in Reach 1B and is explained above in results for Reach 1B. Aside from Reach 4B2, where no woody stems were counted, the lowest densities were measured in the ESB and Reaches 2A and 3.

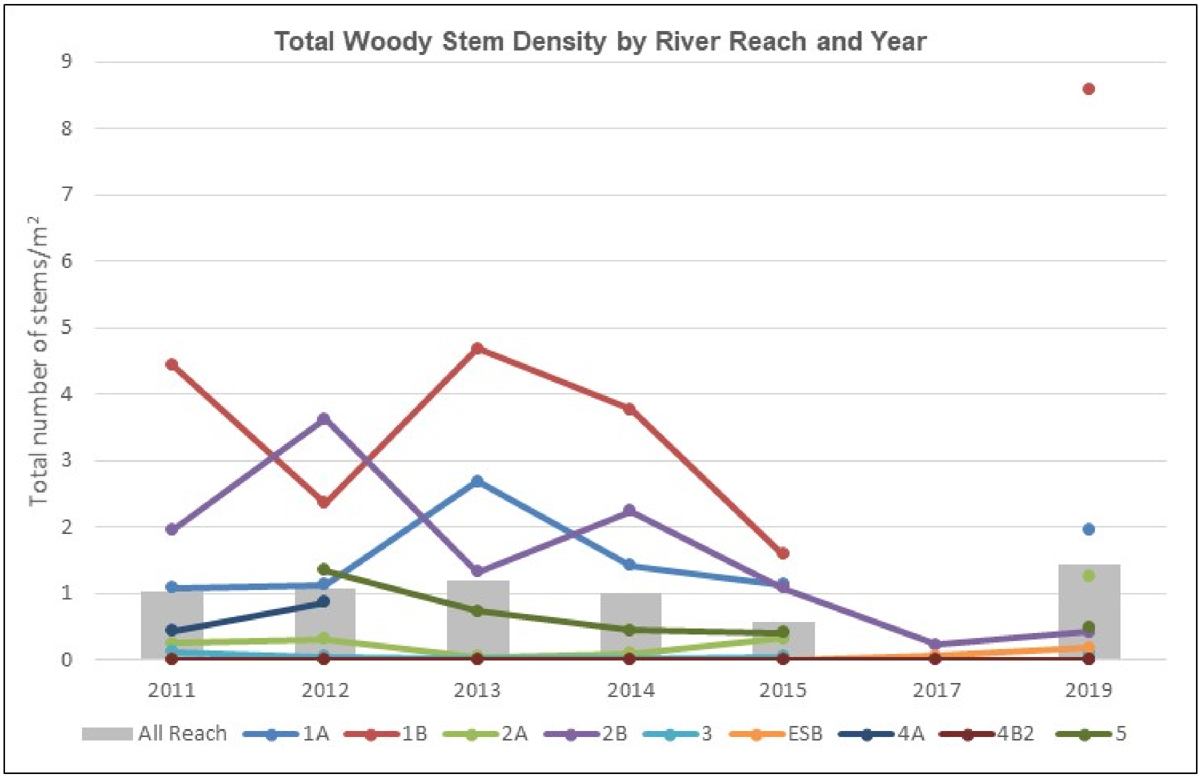
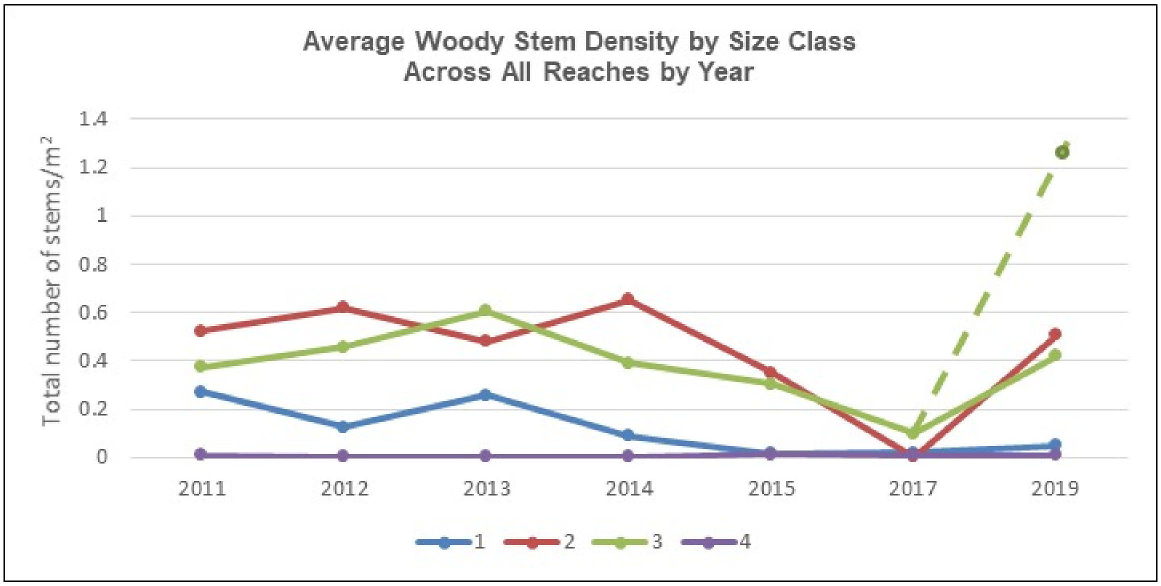


Figure 34. Total number of woody stems per meter squared by reach and averaged across all reaches along the San Joaquin River from 2011 to 2015, 2017 and 2019.

To help examine trends in woody species development, stem density averaged across all reaches by size class over time is presented in Figure 35. Stems in size Class 1 decreased over time, which can be interpreted in a few ways; seedlings have grown into larger size classes with time and recruitment of young woody species has decreased. Stem counts in size Class 2 were relatively stable over the monitoring period ranging from 0.35 to 0.65 stems/m^2 except in 2017, when stem density was 0.01 stems/m^2, which may have been affected by a smaller sample size than other years. There does appear to be somewhat of a pattern between size Class 1 and 2 stems that suggests seedlings grew into larger size classes (eg. an increase in Class 2 numbers following higher Class 1 numbers). Similar to stems densities in size Class 2, stem counts in size Class 3 were relatively stable from 2011 to 2019 , ranging from 0.31 to 0.61 stems/m^2, with the exception of 2017 when density was 0.10 stems/m^2. In 2019, Figure 35 shows 2 scenarios: one with the outlier related to giant reed in Reach 1B as discussed above, and one with the outlier removed, which is probably a better representation of this class size across the project area. Density of stems within the largest size Class 4 were low over the entire monitoring period, never reaching greater than 0.01 stems//m^2.



Size classes: 1= Seedling; 2= <1 m in ht; 3= >1 m in ht and <10 cm DBH; 4= >10 cm DBH

Figure 35. Total number of woody stems per meter squared by reach and averaged across all reaches along the San Joaquin River from 2011 to 2015, 2017 and 2019. In 2019, the dotted line represents data that includes an outlier.

Statistical Analysis

Table 4 shows statistical results comparing total plant cover over the study period. All reaches are included in Table 3, however 2017 is excluded from analysis due to the limited number of reaches sampled that year, resulting in "missing" data for the rest of the reaches, which could invalidate the repeated measures ANOVA test.

Table 4. Statistical results comparing total understory plant cover over time (excluding 2017) for various parameters in San Joaquin River Reaches. Alpha = 0.05.

	RM ANOVA[1]	Multiple comparison[2]
Vegetation Parameter	**Test stat(df), P-value**	**Significant difference between years**
Total cover		
Plant	$X^2(5)=11.77$, P=0.038	No differences
Litter	F(5)=6.25, P<0.001	11<13,14
Bare	$X^2(5)=21.34$, P<0.001	11>13,15,19
Water	$X^2(5)=12.14$, P=0.033	No differences
Native understory	$X^2(5)=10.67$, P=0.058	NA
Introduced understory	F(5)=6.55, P<0.001	15>11,12,14,19
Overstory	$X^2(5)=7.77$, P=0.169	NA
Overstory Salix species	$X^2(5)=8.08$, P=0.152	NA
Stem Density		
Total	$X^2(5)=4.94$, P=0.423	NA
Salix species	$X^2(5)=3.75$, P=0.586	NA

[1] RM ANOVA = One Way Repeated Measures ANOVA for normally distributed data (test stat=F); Friedman Repeated Measures ANOVA on Ranks for non-normal distributions (test stat=X^2)

[2] Multiple comparisons = Bonferroni t-test for normally distributed data; Tukey test for non-normal distributions

There was significant variance in total understory plant cover over the study period, however no significant differences between individual years were identified (Table 3). Total litter cover was significantly lower in 2011 than in 2013 and 2014 while bare cover was higher in 2011 than in 2013, 2015, and 2019. Although the percent of standing water showed significant variance over time, no differences were identified between individual years. Finally, although no differences were found in total native species understory cover, the total cover of introduced species was significantly greater in 2015 than in most other years.

With regards to overstory cover and stem density, no significant differences in any of the measured variables were found to change over time (Table 3)

Table 5 shows statistical results comparing total plant cover and stem density over the entire study period but includes only those reaches sampled in 2017 (i.e. 2B, 4B2, and ESB). Results were similar to those that excluded 2017 in that understory plant, litter, and bare ground showed significant change over time, although comparisons between individual years differed. Total understory plant cover within these 3 reaches was greater in 2017 and 2019 than in 2012 to 2015; litter cover was greater in 2013 and 2014 than in 2011, 2017, and 2019; and bare ground cover was lower in 2019 than in most other years (Table 4). Native understory species cover was significantly higher in 2017 than in 2015.

Table 5. Statistical results comparing total understory plant cover over time for various parameters in San Joaquin River Reaches 2B, 4B2, and East Side Bypass. Alpha = 0.05

	RM ANOVA[1]	**Multiple comparison[2]**
Vegetation Parameter	**Test stat(df), P-value**	**Significant difference between years**
Total cover		
Plant	F(6)=8.54, P<0.001	17,19 > 12-15
Litter	F(6)=12.16, P<0.001	13,14 > 11,17,19; 15 > 17
Bare	F(6)=6.06, P<0.001	19< 11,15,14,17
Water	X^2(6)=6.00, P=0.423	NA
Native understory	X^2(6)=13.77, P=0.032	17 > 15
Introduced understory	X^2(6)=12.32, P=0.055	NA
Overstory	X^2(6)=2.59, P=0.858	NA
Overstory Salix species	X^2(6)=3.48, P=0.746	NA
Density		
Total	X^2(6)=3.15, P=0.790	NA
Salix species	X^2(6)=3.15, P=0.790	NA

[1] RM ANOVA = One Way Repeated Measures ANOVA for normally distributed data (test stat=F); Friedman Repeated Measures ANOVA on Ranks for non-normal distributions (test stat=X^2)

[2] Multiple comparisons = Bonferroni t-test for normally distributed data; Tukey test for non-normal distributions

No significant differences in total overstory cover and woody stem density were identified within the 3 reaches.

Analysis comparing species composition between years based on percent plant cover of herbaceous species is illustrated in the MDS configuration in Figure 36. MDS ordination ranks species similarities between groups (in this case years) and the associated

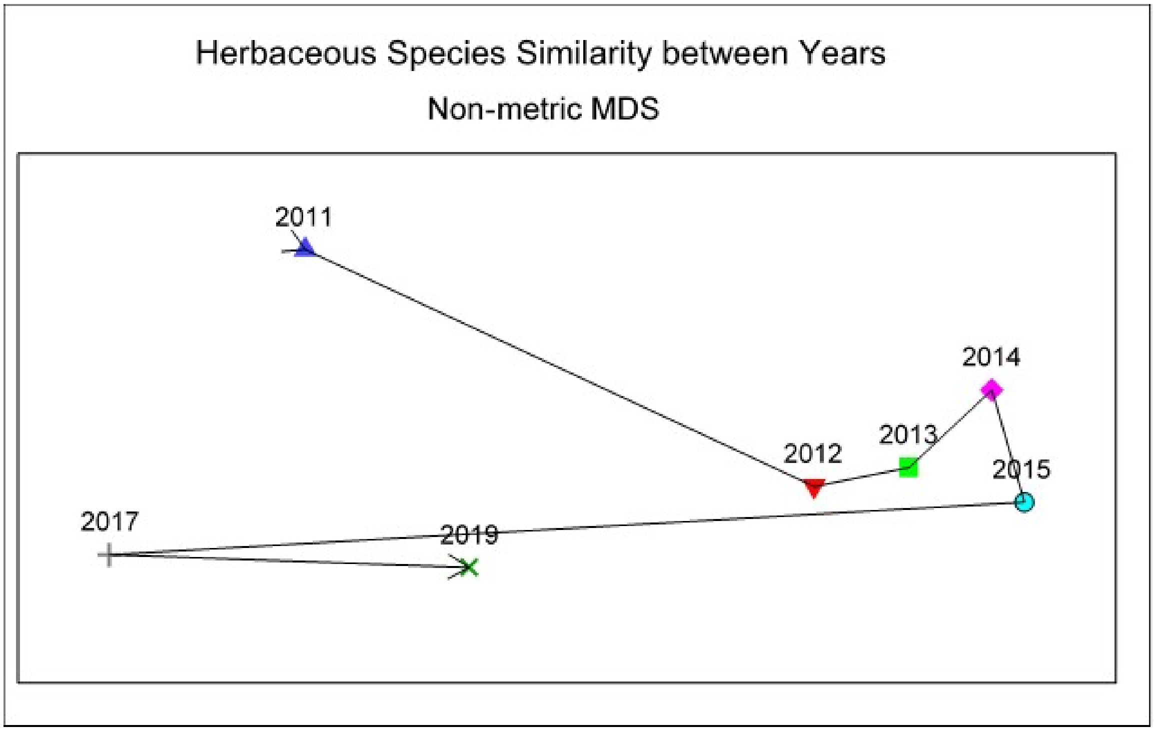


Figure 36. MDS ordination of 7 years of monitoring based on fourth root transformed herbaceous species cover data and Bray-Curtis similarities (stress=0.00).

configuration can be interpreted in terms of relative similarity of samples to each other (Clarke et al 2014). Because it is difficult to satisfy the similarity ranking perfectly there will be some distortion in the configuration. Stress is the measure of distortion between the similarity ranks and the corresponding distance ranks in the ordination. A stress factor of <0.5 gives an excellent representation of the data. MDS analysis of this data had a 2-dimensional stress of 0.0. MDS ranks show that the herbaceous plant community matrix was more similar from 2012 to 2015 than in other years (Figure 36). A one-way Analysis of Similarities test examining species composition identified a significant difference between years across all reaches (P<0.001, R=0.181). Pairwise testing identified herbaceous species composition between years 2012 to 2015 and between 2011, 2017 and 2019 to be statistically equal. Statistical analysis also indicated that the collection of herbaceous species was significantly different between reaches across all years (P<0.001, R=0.742) with none of the reaches showing similarity in community compositions.

Figure 37 shows a MDS ordination based on woody plant cover (in both understory and overstory layers) comparing species composition between years. Although the configuration suggests some variance in the woody plant species matrix between years, no significant differences were identified in one-way statistical analysis. Differences in species composition between reaches were found, however, which indicated that the woody species communities were most similar in Reaches 4A and ESB.

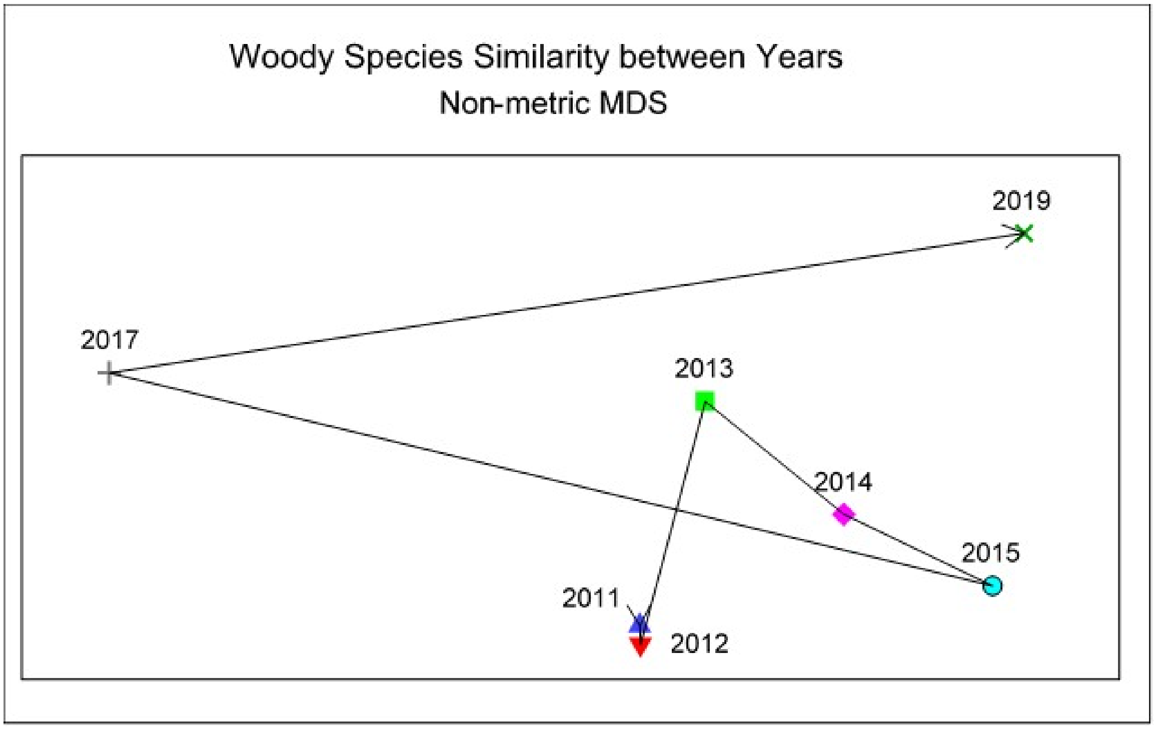


Figure 37. MDS ordination of 7 years of monitoring based on fourth root transformed woody species cover data and Bray-Curtis similarities (stress=0.00).

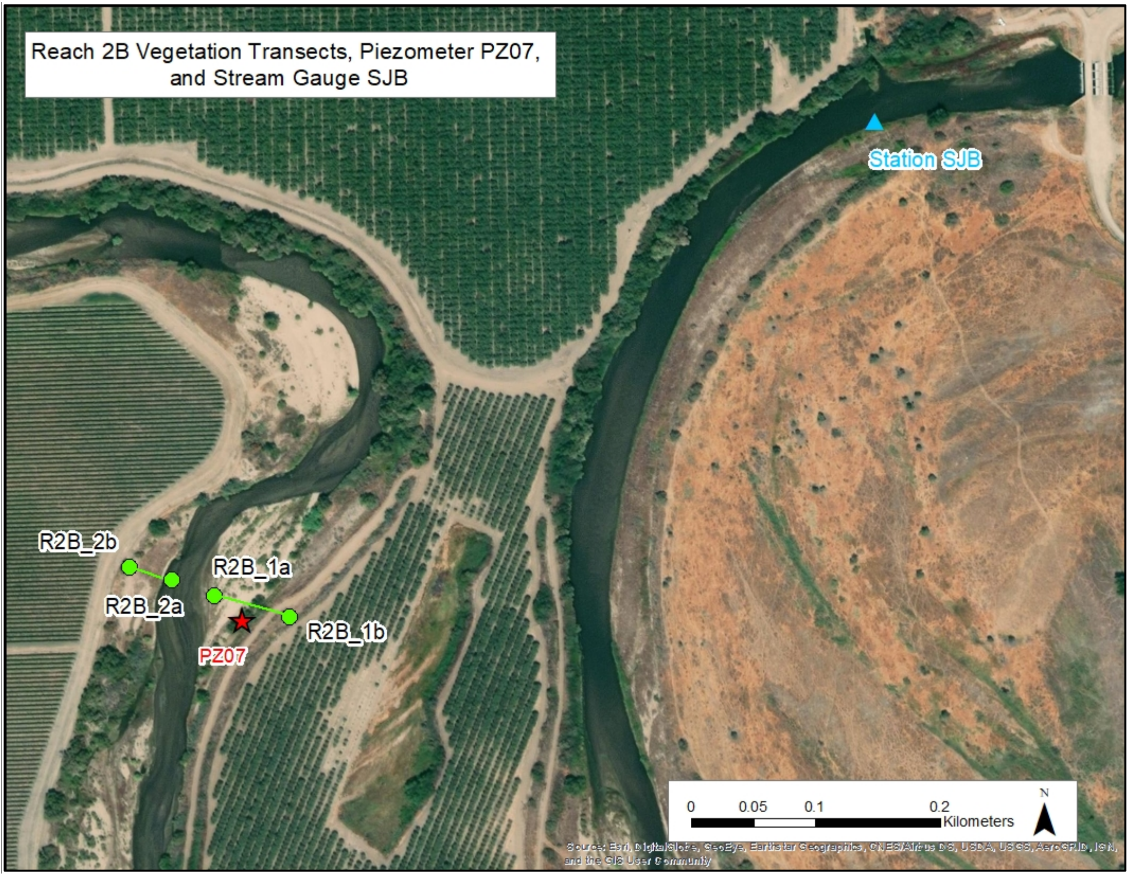
Photo Stations

Photographs taken from the end of vegetation transects since 2011 are shown in Appendix H.

Groundwater Monitoring

Groundwater well data were examined in relation to vegetation transects. Piezometer PZ07 was installed within the floodplain in association with transects in Reach 2B in February 2013 (Figure 38). The hydrograph in Figures 39 through 42 show groundwater depths at this piezometer site from March through December 2013, from and May to November 2014, from January 2016 to November 2017, and from August 2018 to September 2019, respectively. Flow data included in the hydrographs were gathered at Stations SJN (approximately 2 mi downstream and decommissioned in September 2018) and SJB (approximately 1.5 mi upstream). An association between flows and the depth of the water table is apparent, which indicates connectivity of the floodplain and river. In well PZ07 the water table remained less than 4 ft from the surface when the channel held water and <1 ft when flows reached around 500 cfs or higher.

From March to December 2013, ground water within the floodplain remained at a shallow enough depth (<4 ft) necessary to sustain established woody riparian plant species (Figure 39). In 2014, the river was completely dry in Reach 2B from mid-



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 38. Locations of well PZ-7, stream gauge station SJB, and endpoints of vegetation transects R2B-1 and R2B-2 within Reach 2B.

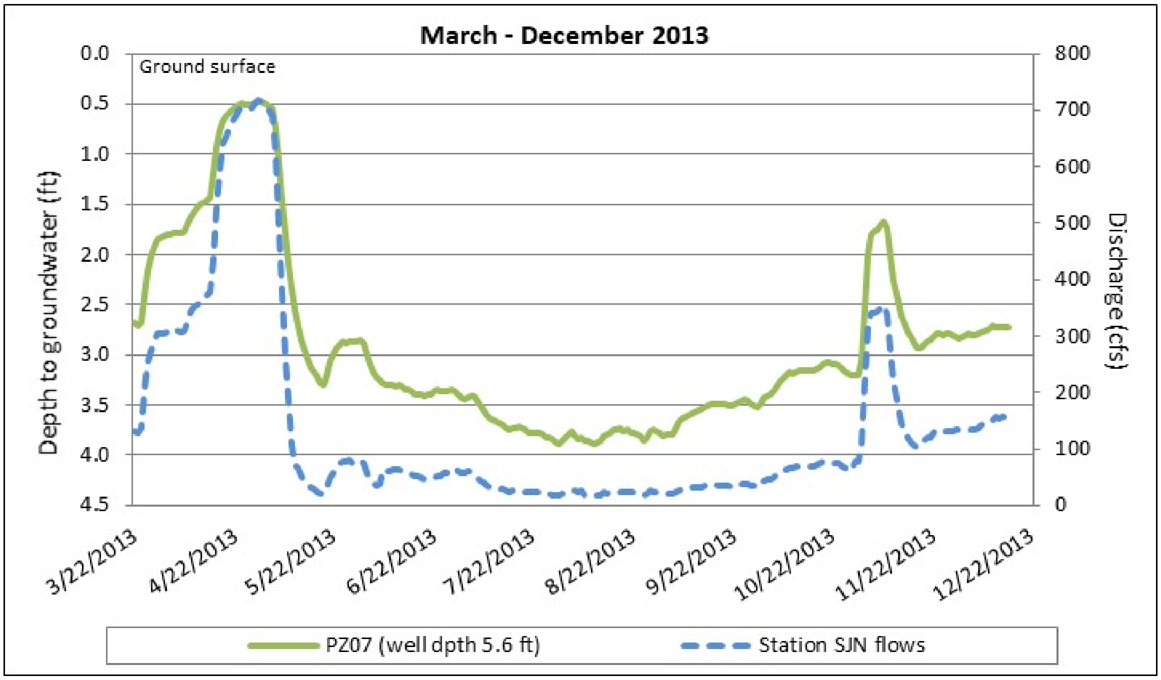


Figure 39. Depth to groundwater at well PZ-7 and San Joaquin River discharge at gauge SJN from March to December 2013 in Reach 2B.

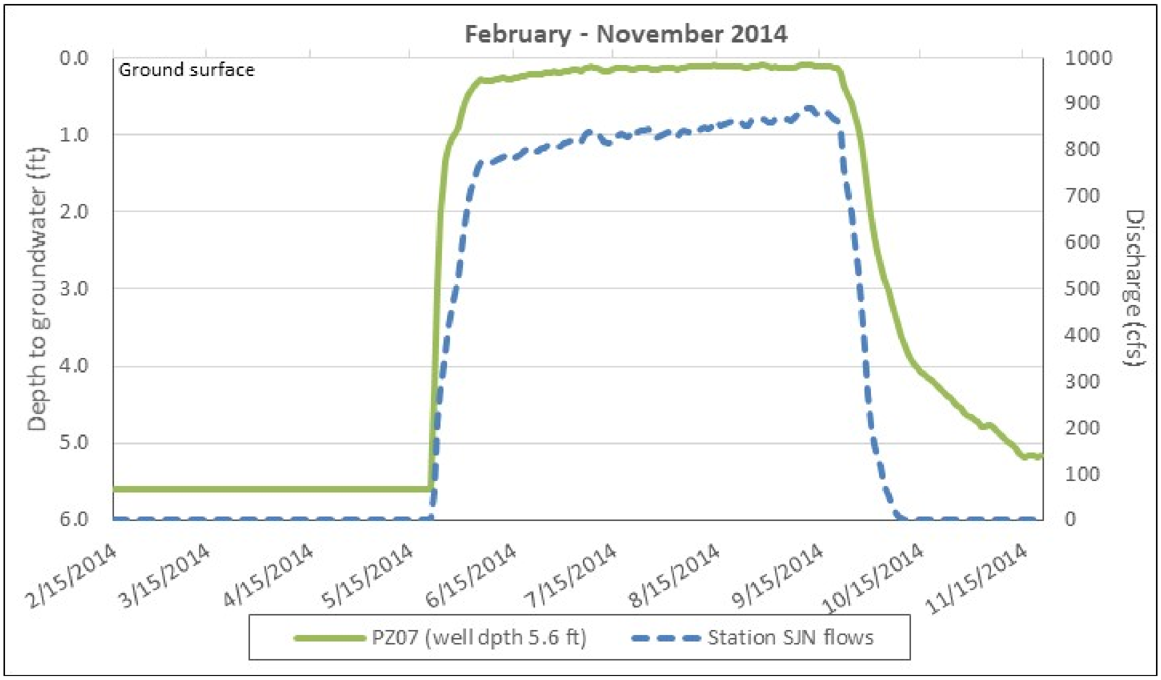


Figure 40. Depth to groundwater at well PZ-7 and San Joaquin River discharge at gauge SJN from May to November 2014 in Reach 2B.

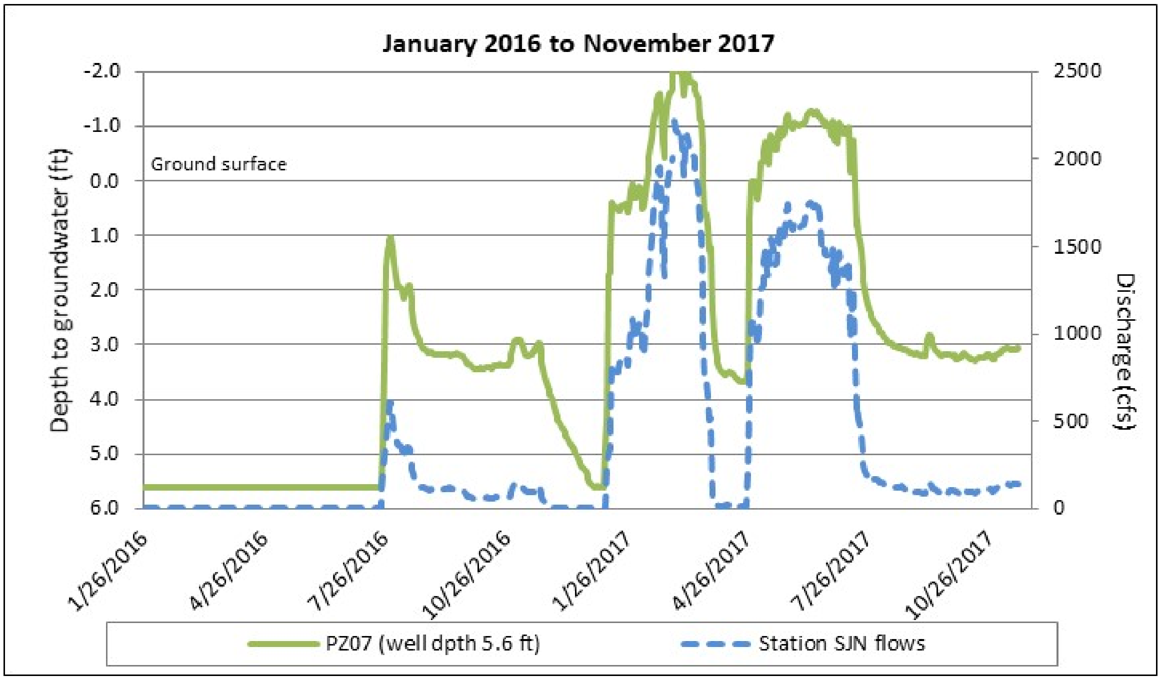


Figure 41. Depth to groundwater at well PZ-7 and San Joaquin River discharge at gauge SJN from January 2016 to November 2017 in Reach 2B.

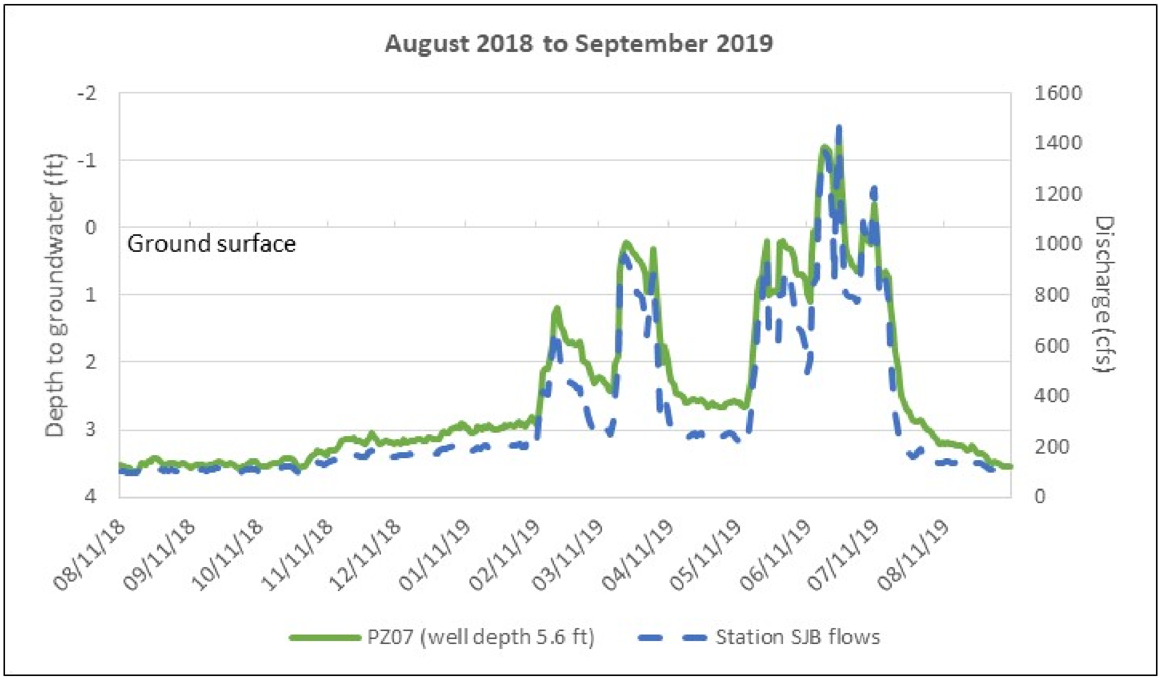


Figure 42. Depth to groundwater at well PZ-7 and San Joaquin River discharge at gauge SJB from August 2018 to September 2019 in Reach 2B.

February to late May and groundwater levels reflected this, falling below piezometer sensor levels in the wells (sensors were placed at approximately 5.6 ft below surface level; Figure 40). When irrigation flows were released in late May, discharge increased dramatically to between 750 to 900 cfs and groundwater remained at less than 1 ft until October of 2014. At that time, discharge returned to 0 cfs and groundwater again fell to near sensor levels. No data were analyzed at well PZ07 in 2015, when flow releases were minimal and these wells were dry most of the time. Monitoring resumed in January 2016; flows remained quite low that year and the water table never reached less than 1 ft from the surface (Figure 41). In 2017, however, flows were greater than approximately 600 cfs from January through March and again from late April to mid-July, bringing ground water levels within 1 ft of the surface or less. During this period, when discharge was between approximately 1800 and 2200 cfs, the flood plain was inundated.

River flows were less than around 200 cfs and groundwater levels were greater than 3 ft from the surface from August through December 2018 (Figure 42). Starting in February 2019, river discharge increased, as did groundwater. The water table was within 1 ft of the ground surface when flows were greater than 800 cfs and the site flooded when flows were around reached around 1100 cfs.

Discussion

Vegetation Transects

Many of the trends in vegetation development over the monitoring period appeared to be influenced by climatic conditions, making it difficult to determine the effect managed flows may have had. San Joaquin river flows were high enough to cause overbank flooding in 2011, 2017, and 2019, with peak flows averaging between 6,500 and 9,000 cfs, but reaching as high as 22,700 cfs in 2017, below Friant Dam and around 8,700 to 13,000 cfs within the East Side Bypass (Figure 3). In contrast, a severe drought was declared in California from approximately 2013 through 2015 and river flows below Friant Dam averaged around 420 cfs, ranging from 27 to 2,000 cfs; the channel in East Side Bypass was typically dry during this period. Cumulative annual precipitation for the years covering the study period is listed in Table 6. As would be expected, overbank flows occurred during the years when precipitation was highest.

Table 6. Annual precipitation measured as an average of 5 Precipitation Stations along the San Joaquin River basin. Source: CA Dept. of Water Resources.

Year	Annual precipitation (in)
2011	65.4
2012	24.9
2013	26.5
2014	20.4
2015	19.0
2016	40.1
2017	72.7
2018	29.7
2019	49.8

There did not appear to be observable trends with respect to the abundance of understory plants across the project area over time based on total cover (Figure 13), however understory species composition appeared to be associated with overbank flooding and a higher water table. The highest percentages of total native species cover were documented in 2011, 2017, and 2019 and these were the only years that native species were dominant relative to introduced species. Introduced understory species cover were significantly greater in 2015, the driest year recorded over the study period, than in most other years while native species were significantly greater in 2017 (wettest year recorded) than in 2015 (Tables 3 and 4). Finally, statistical analysis comparing plant communities over time indicated that species composition was most similar between years 2011, 2017, and 2019 and between years 2012 to 2015 (Figure 36).

The California State endangered delta button celery, a wetland obligate, was detected in transects within the ESB in 2011 and 2017 (Figure 43). This species was also detected in areas surrounding transects in 2011, 2012, 2017, and 2019. In 2019, there was evidence that this species had been browsed, as can be seen in Figure 43.

Figure 43. Delta button celery (*Eryngium racemosum*), a State-listed endangered plant, was detected in areas surrounding transect ESB3 within the East Side Bypass Reach, August 2019.

Understory species included on the California Department of Food and Agriculture (CDFA) Noxious Weed List were documented in transects within the study area (Appendix D) but most were found in low abundance and had decreased by 2019. Perennial pepperweed, which was first detected in transects in 2012 within Reaches 4B2 and 5, was an exception. It was especially problematic in Reach 5 in 2014 and 2015, where total cover of this species was greater than 50 percent. By 2019, no pepperweed was detected at this site, perhaps due to inundation. This species is ranked as “high” by the California Invasive Plant Council (Cal-IPC 2015), meaning it has severe ecological impacts. A few other invasive understory species that were not on the CDFA list but were given a ranking of “moderate” impact by Cal-IPC included black mustard and poison hemlock. Black mustard was identified throughout the project area but was most consistently detected in Reaches 2B and 4B2 with the highest coverage in 2012 in both reaches. Poison hemlock was consistently detected in Reach 4B2 with the highest coverage in 2012. Percent cover of both species decreased after 2012 but they were still present in 2019 (Appendix E).

With regards to overstory species, no obvious changes to canopy cover and composition were observed, which was supported by statistical analysis that found no significant difference in overstory variables over time (Figure 24, Tables 3 and 4). Any effects to a mature overstory canopy would take time to detect since woody species can generally sustain fluctuations in groundwater levels for a longer period due to deeper root systems than herbaceous species or woody seedlings and saplings. Interestingly, total overstory cover within the East Side Bypass was only documented in years when overbank flooding occurred, which may have influenced the presence of woody overstory species. This reach is mowed and grazed and land management practices could also have affected the ability to detect woody overstory species. During high flow years, surveys were conducted close to the time river levels receded and data were probably gathered prior to mowing, unlike other years.

Although no statistical differences were identified, a trend in woody stem density was observed over the study period, with total density gradually decreasing through 2015 and increasing in 2019 (Figure 34). This same pattern appears in size classes 1, 2, and 3 when separating total density out by size class (Figure 35). Not surprisingly, plants with woody stems in these size classes (less than 10 cm DBH) would show effects from varying water table levels. As explained above, younger aged riparian species rely on shallow and slowly receding groundwater levels for regeneration and survival. As such, overbank flows and high water table levels would be conducive to establishing and maintaining woody riparian species whereas declining water tables over long periods due to drought would eventually cause die-off.

Alternatively, declining river and groundwater levels related to drought can create a substrate for recruitment and establishment of woody riparian species. For example, in the East Side Bypass, photos demonstrate the establishment of willows at the edge of the channel as river levels receded over time from drought effects (see Appendix H, ESB Transect 3a). Willows first appeared in 2015 as bare ground became exposed, were still present in 2017 when river levels increased, but had died back by 2019, presumably due to a long period of inundation. This phenomenon would not be captured in data since transects were not located within the channel but is apparent in photos.

Most of the overstory species detected in vegetation transects were native. All introduced overstory species documented in the study area were on the CDFA Noxious Weed List. Giant reed and scarlet wisteria were found in Reach 1B in all years, however neither species showed considerable increases in cover over time. Scarlet wisteria was detected in stem counts in most years in Reach 2A. Saltcedar was detected for the first time in 2019, where one stem was counted in ESB.

Photo Stations

Drier conditions in 2014 and 2015 are evident in both the vegetation and the river levels, when the channel was dry in a number of reaches. In years when overbank flooding occurred (i.e. 2011, 2017, and 2019) vegetation was lusher (particularly understory) and river levels were noticeably higher (Appendix H).

Groundwater Monitoring

Piezometer PZ07, installed at the Reach 2B monitoring site in 2013 indicated that groundwater was relatively shallow (< 4 ft) within the floodplain (Figures 39 to 42). When the river was dry, the water table fell to 5.6 ft (depth of sensor) or more from the surface. Flooding potential occurred within this reach when river discharge rates were greater than 1,100 cfs.

Vegetation appeared to respond to groundwater levels at this site, where a number of willow and cottonwood stems established on a sandbar following high river flows in 2011. Stem density substantially decreased from 2012 to 2017 (Figure 29), presumably due to a declining water table caused by drought conditions. This transition was also captured in overstory cover data and is evident in photos in Appendix H, Reach 2B Transect 1a.

Maximum groundwater depths identified for cottonwood, Goodding’s willow, and coyote willow juveniles were between 4.9 and 6.6 ft from the surface (Caplan et al. 2013, Springer et al. 1999, Stromberg et al. 1996). Mature willows can eventually access deeper groundwater, with actual depth estimates varying by study. Terlep (2014) reports rooting depths of cottonwood and Goodding’s willow fluctuating between 6.6 and 9.8 ft (Glenn and Nagler 2005) and between 9.8 and 13.1 ft (Stromberg 1993). In Arizona, rooting depths of mature Goodding’s willow varied from 7 ft (Zimmerman 1969) to 10.5ft (Springer et al. 1999). Similarly, a USGS (1999) study found that where water table depth was greater than about 7 ft, or in areas where permanent water table declines were greater than about 5 ft, there was a 50 to 100 percent mortality rate in cottonwood/willow woodlands. Groundwater levels recorded in Reach 2B indicated that when the river was flowing, water table depths were within ranges that support juvenile woody riparian species. However, when the channel was dry, the water table fell below the well depth of 5.6 ft, in which case the availability of water for both juvenile and mature plants was unknown.

The frequency and duration of flood events over time determine the ability of woody riparian seedlings to establish. A water table shallow enough to sustain saturated soil conditions for approximately 6-8 weeks following seed dispersal, as well as water table declines less than about 0.1 ft/day are generally necessary for recruitment of woody riparian species in the west (Segelquist et al. 1993, Lines 1999, Taylor 2000, Shafroth et al. 2000). Accurate assessment of the suitability of groundwater conditions and timing/duration for vegetative recruitment was not possible based on the limited and irregular availability of groundwater data collected at this site and throughout the study area.

Conclusions

Data suggest that vegetation has maintained over the study period with regards to cover and density. Understory cover appeared to be associated with precipitation and river discharge, particularly in regard to species composition. Native species total percent cover was higher in the years that flows overbanked and the floodplain was inundated (i.e. 2011, 2017, and 2019), while total percent cover of introduced species was generally higher when conditions were drier. The composition of the understory plant community was also significantly different when overbank flooding occurred. Overstory cover did not change significantly, increasing slightly, over the monitoring period. Woody stem density decreased through 2015 and increased in 2019. Although this trend was not statistically significant, it did appear to be associated with severe drought conditions that prevailed through 2015.

The groundwater well data in Reach 2B indicated that groundwater levels within the floodplain were closely connected with river discharge rates. The water table was within 4 ft of the surface when the river was flowing, which is generally sufficient to support established riparian woody species. When the river was dry, groundwater was greater than well depth (5.6 ft) and therefore data could not be used to assess adequacy of groundwater levels for riparian vegetation.

For the most part, the monitoring period has experienced extremes in climatic conditions. It is difficult to evaluate the effects of Restoration Flows on vegetation when natural flow levels are exceptionally high or exceptionally low. When river discharge was high, managed flows were not necessary to provide sufficient water for plant development. When flows were low, there was simply not enough water available to provide optimum conditions for vegetation through managed flows. Although vegetation data collected from 2011 to 2019 suggest that some vegetation variables responded to precipitation patterns and overbank flooding, the role that Restoration Flows played was uncertain. An evaluation that includes data collected over a longer time period could help identify trends more accurately. From 2019 forward, vegetation sampling is scheduled to occur every three years. It is recommended that this study be continued to provide input for a more accurate assessment of the potential effects that Restoration Flows have on riparian vegetation development.

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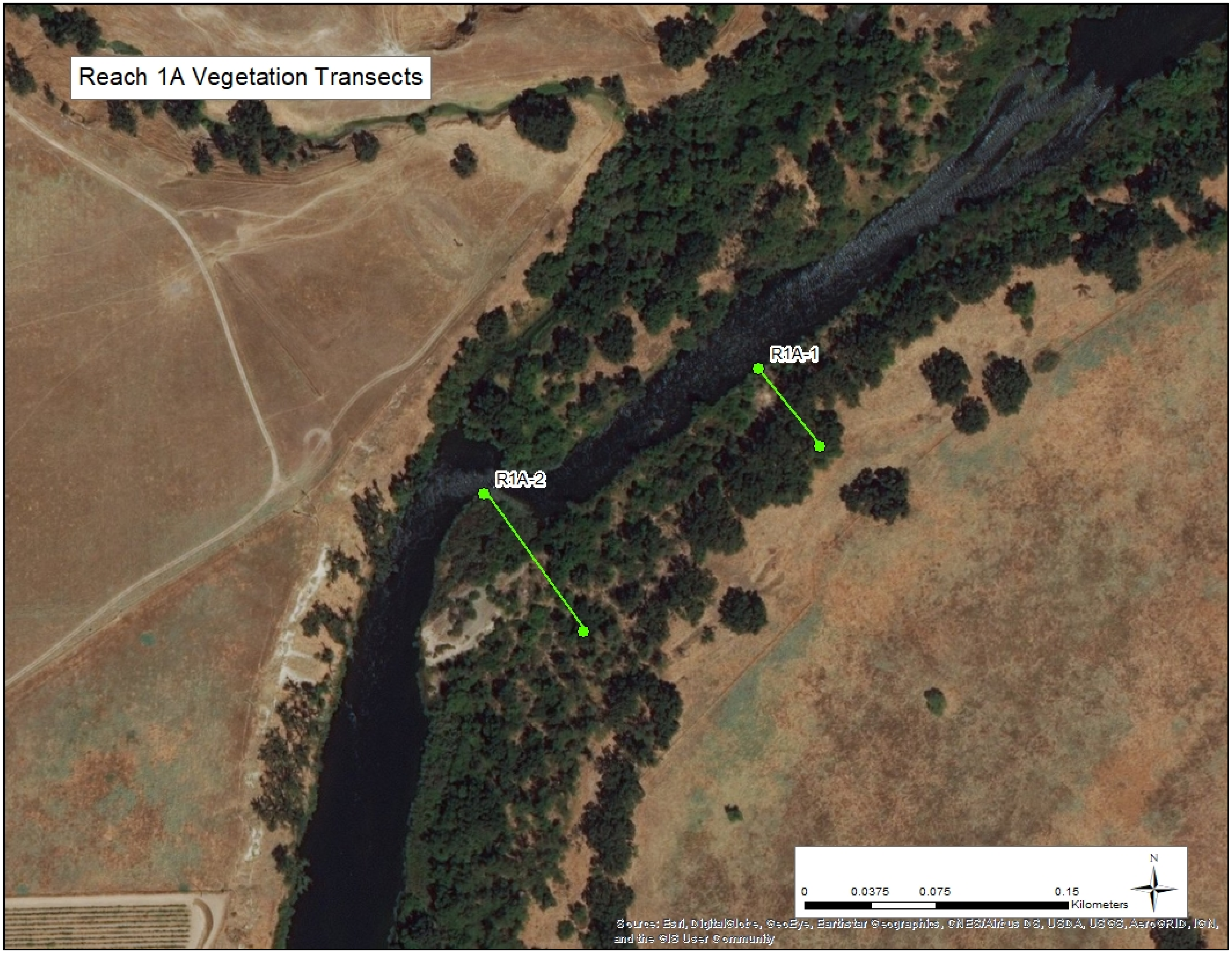
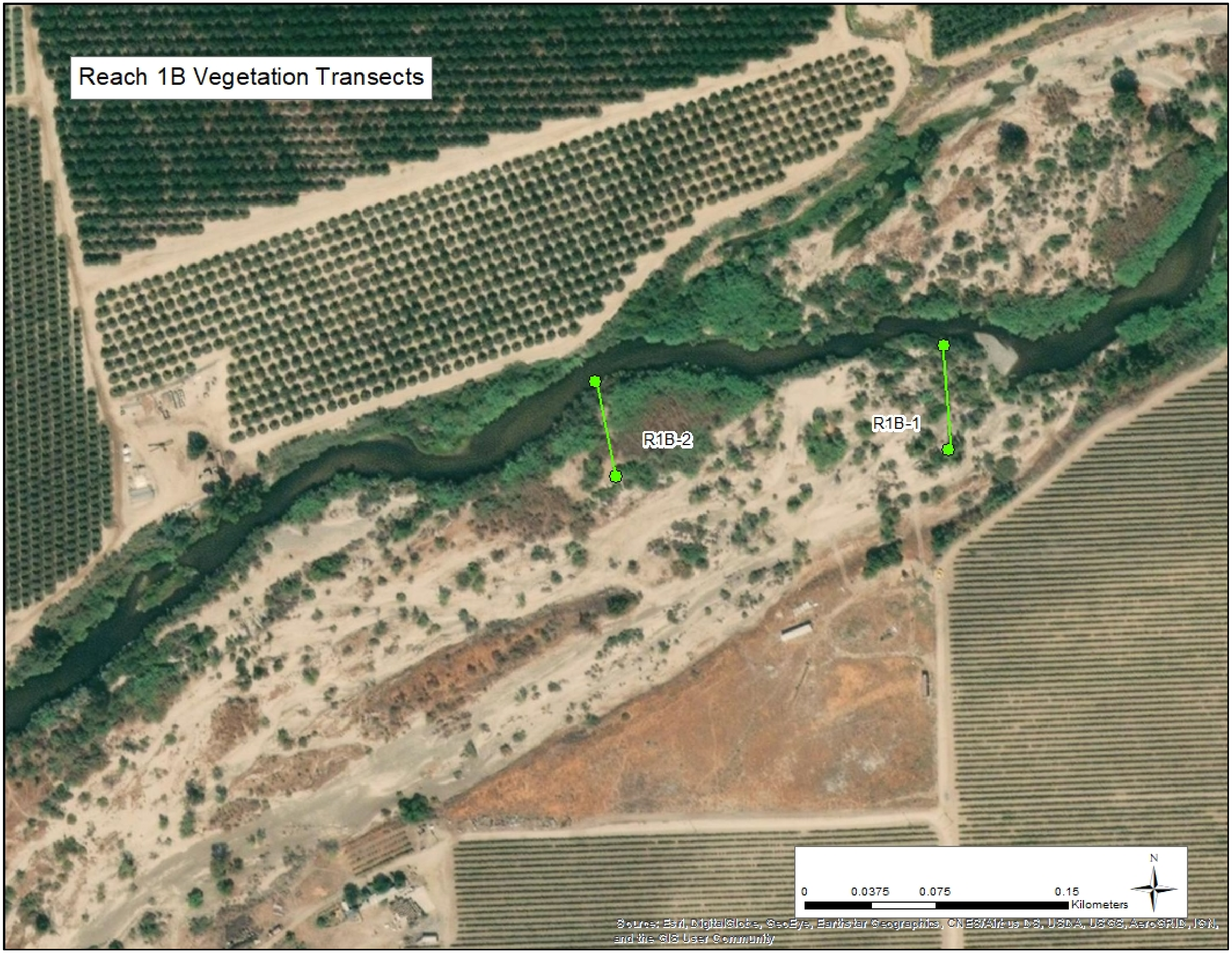
Appendix A

Vegetation Transect Locations by River Reach



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Reach 1B Vegetation Transects

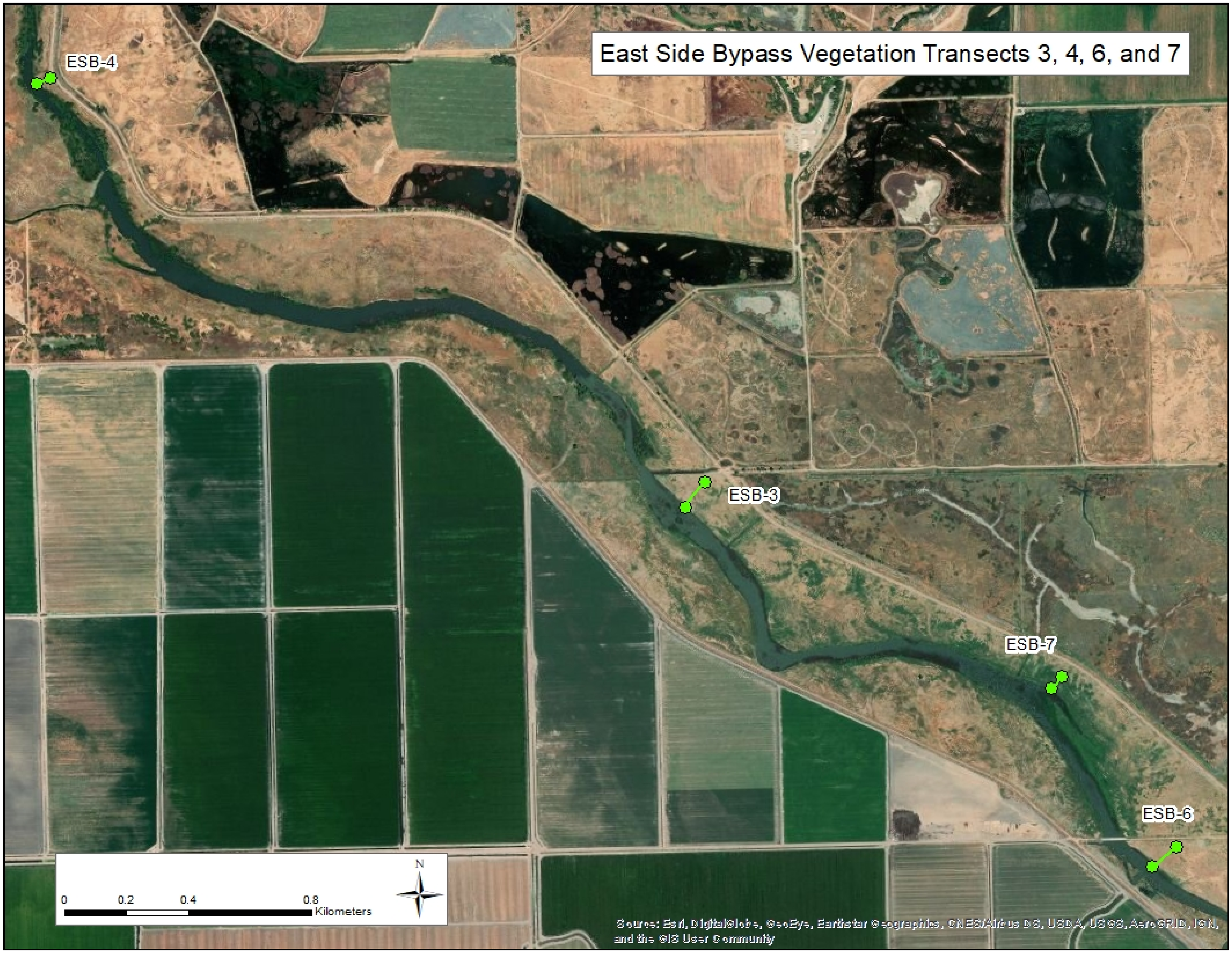
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

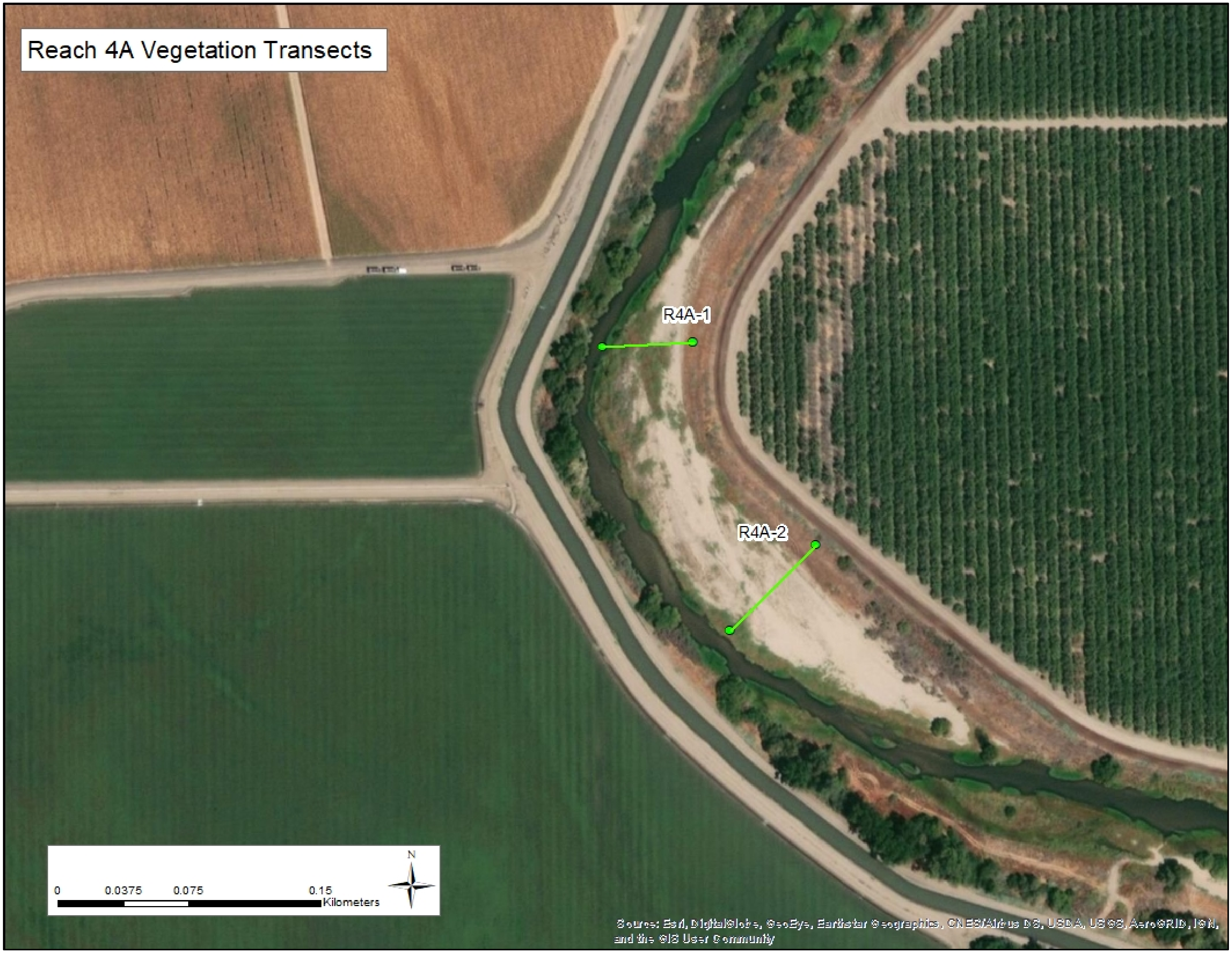
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

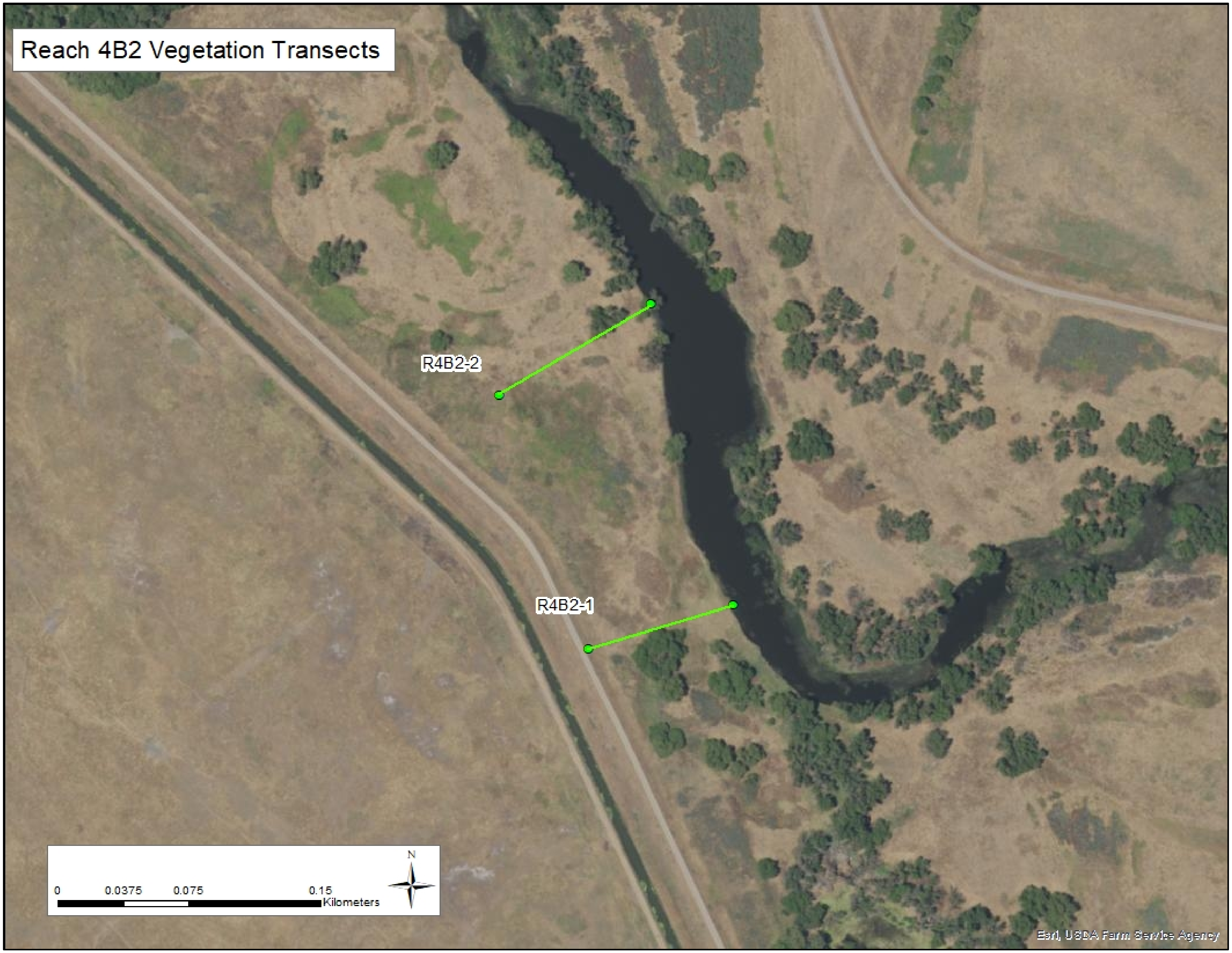
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Check waypoints


East Side Bypass Vegetation Transects 3, 4, 6, and 7
ESB-4
ESB-3
ESB-7
ESB-6
0
0.2
0.4
0.8
Kilometers
N
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Reach 4A Vegetation Transects

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Reach 4B2 Vegetation Transects
R4B2-2
R4B2-1
0
0.0375
0.075
0.15
Kilometers
N
Esri, USDA Farm Service Agency


Reach 5 Vegetation Transects
R5-1
R5-2
0
0.0375
0.075
0.15
Kilometers
N
Esri, USDA Farm Service Agency

Appendix B

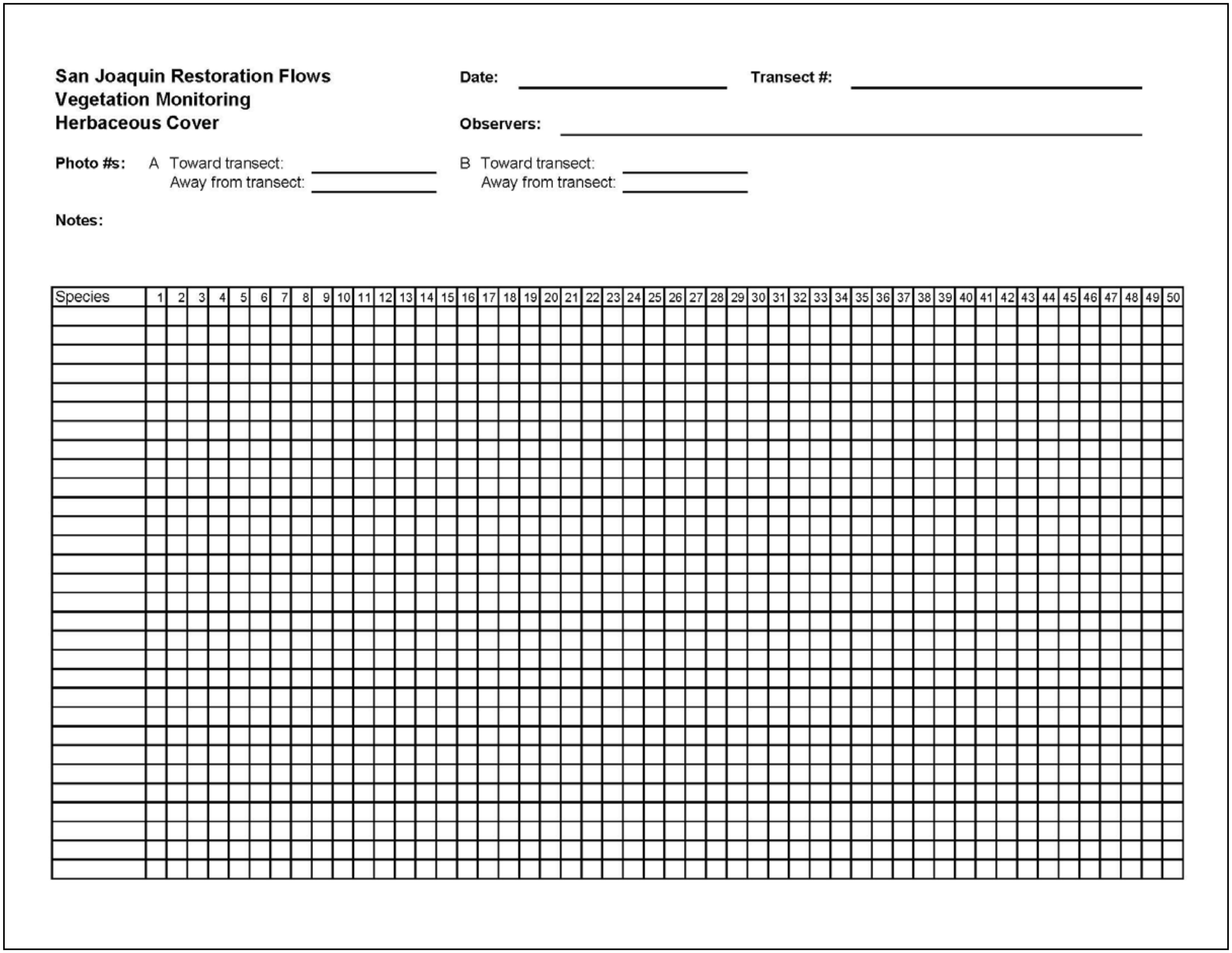
Vegetation transect waypoints

All datum in NAD83.

Reach	Transect	Endpoint A		Endpoint B		Zone
		x	y	x	y	
R1A	1	255049	4091361	255081	4091315	11S
	2	254888	4091300	254940	4091218	11S
R1B	1	755779	4077621	755782	4077561	10S
	2	755580	4077600	755592	4077546	10S
R2A	1	751417	4074422	751327	4074469	10S
	2	751327	4074470	751230	4074504	10S
R2B	1	741586	4072746	741646	4072729	10S
	2	741552	4072759	741518	4072769	10S
R3	1	734778	4076749	734732	4076729	10S
	2	734713	4076882	734652	4076833	10S
ESB	1	714230	4111882	714285	4111905	10S
	2	714194	4111872	714145	4111861	10S
	3	710325	4116027	710390	4116107	10S
	4	708217	4117404	708262	4117424	10S
	6	711844	4114860	711922	4114923	10S
	7	711516	4115437	711548	4115476	10S
R4A	1	718414	4100615	718463	4100664	10S
	2	718341	4100777	718393	4100780	10S
R4B2	1	693717	4123312	693634	4123287	10S
	2	693670	4123484	693583	4123432	10S
R5	1	679685	4134377	679699	4134329	10S
	2	679658	4134367	679694	4134336	10S

Appendix C

Data collection forms



San Joaquin Restoration Flows
Vegetation Monitoring
Herbaceous Cover

Date: ____________________ **Transect #:** ____________________

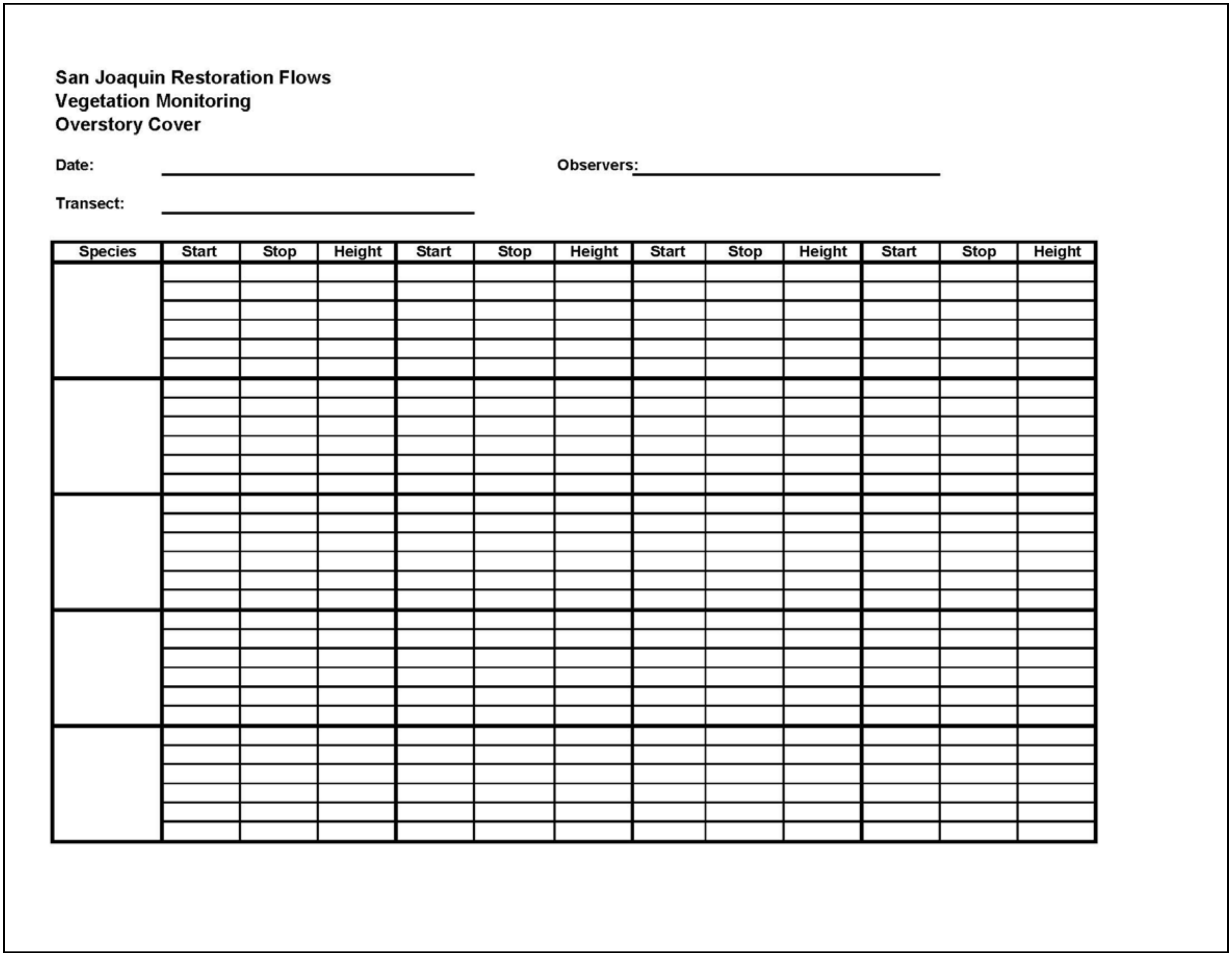
Observers: ____

Photo #s: A Toward transect: ____________ B Toward transect: ____________
Away from transect: ____________ Away from transect: ____________

Notes:

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50

Figure C-1.—Understory cover data form.



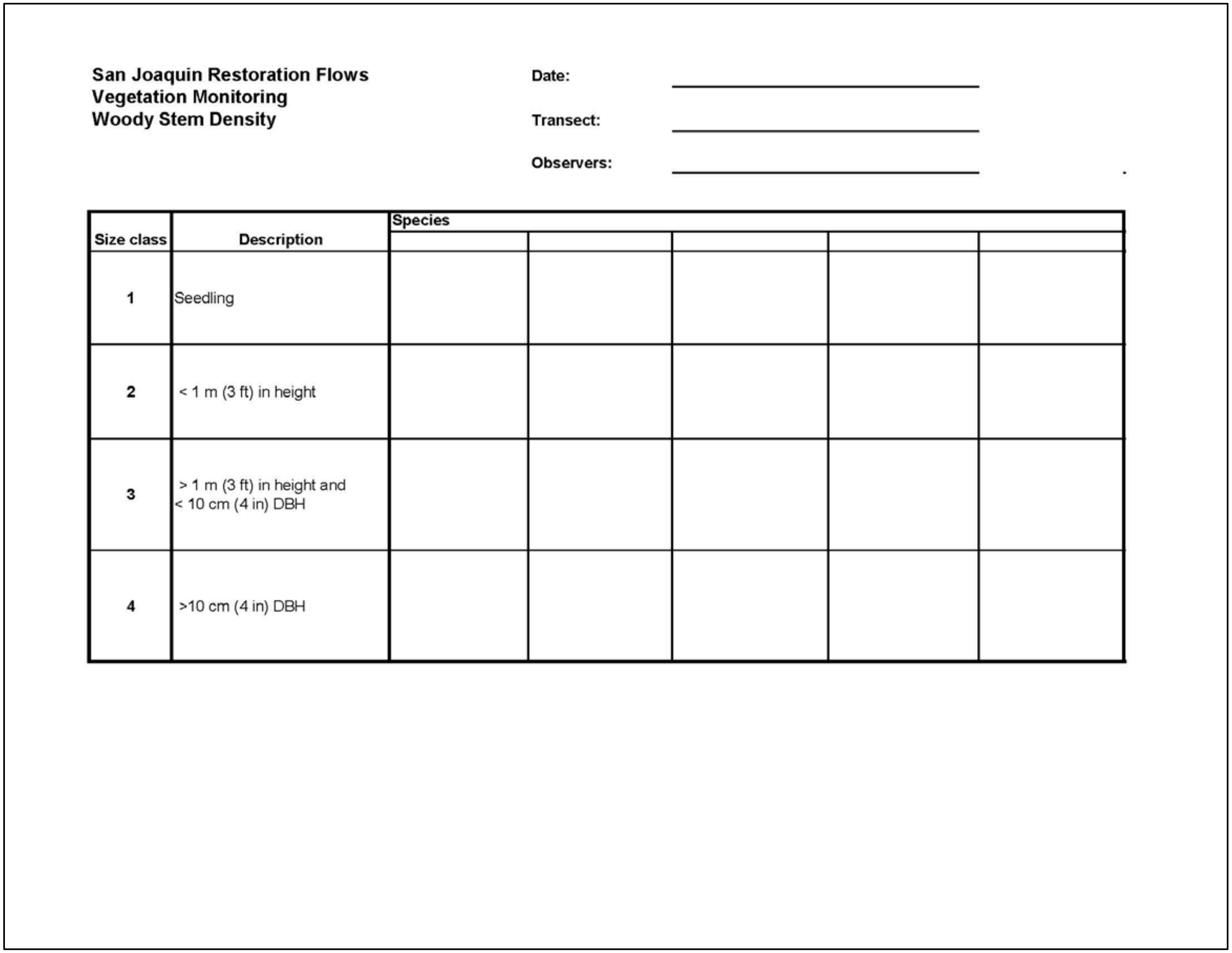
San Joaquin Restoration Flows
Vegetation Monitoring
Overstory Cover

Date: ______________________ **Observers:** ______________________

Transect: ______________________

Species	Start	Stop	Height	Start	Stop	Height	Start	Stop	Height	Start	Stop	Height

Figure C-2.—Overstory cover data form



San Joaquin Restoration Flows
Vegetation Monitoring
Woody Stem Density

Date: ______________________

Transect: ______________________

Observers: ______________________

Size class	Description	Species				
1	Seedling					
2	< 1 m (3 ft) in height					
3	> 1 m (3 ft) in height and < 10 cm (4 in) DBH					
4	>10 cm (4 in) DBH					

Figure C-3.—Woody Stem Density data form.

Appendix D

Common and Scientific Names and Locations of Plants Detected in Vegetation Transects 2011 to 2019

CODE	SCIENTIFIC NAME	COMMON NAME	LIFE FORM [1]	REACH									Wet-land [2]	Nox Weed [3]
				1A	1B	2A	2 B	3	ES B	4 A	4B 2	5		
Tree/shrub														
ALRH	*Alnus rhombifolia*	White alder	NT	X									FACW	
ATLE	*Atriplex lentiformis*	Quailbush	NS					X					FAC	
CEOC	*Cephalanthus occidentalis*	Button bush	NS	X	X								OBL	
FRLA	*Fraxinus latifolia*	Oregon ash	NT	X									FACW	
LUAL	*Lupinus albifrons* var *douglasii*	Douglas' silver lupine	NS		X	X								
POFR	*Populus fremontii*	Fremont cottonwood	NT		X		X	X						
QULO	*Quercus lobata*	Valley oak	NT	X										
SAEX	*Salix exigua*	Sandbar willow	NS	X	X		X						FACW	
SAGO	*Salix gooddingii*	Gooding's willow	NT		X	X	X	X	X	X	X	X	FACW	
SALA2	*Salix lasiandra*	Pacific willow	NT	X									FACW	
SALA	*Salix lasiolepis*	Arroyo willow	NT	X									FACW	
SANI	*Sambucus nigra*	Black elderberry	NT				X						FAC	
SEPU	*Sesbania pungens*	Scarlet wisteria	IS		X	X								Y
TASP	*Tamarix sp*	Saltcedar	IS						X				FAC	Y
Graminoid														
AGEX	*Agrostis exarata*	Spike bent grass	NG		X								FACW	
ALAE	*Alopecurus aequalis var. aequalis*	Shortawn foxtail	NG						X				OBL	
ARDO2	*Arundo donax*	Giant reed	IG		X								FACW	Y
AVFA	*Avena fatua*	Wild oat	IG	X										
BRDI	*Bromus diandrus*	Ripgut brome	IG	X		X		X		X	X			
BRHO	*Bromus hordeaceus*	Soft chess brome	IG	X							X			
BRIN	*Bromus inermis*	Smooth brome	IG					X						
BRMA	*Bromus madritensis*	Foxtail chess	IG	X	X	X	X	X	X	X				
BRSE	*Bromus secalinus*	Rye brome	IG	X						X				
CASP	*Carex* sp	Sedge	NG	X						X		X		
CRSC	*Cripsis schoenoides*	Swamp pricklegrass	IG						X		X		OBL	
CYDA	*Cynodon dactylon*	Bermuda grass	IG	X	X	X		X	X	X	X	X		
CYAC	*Cyperus acuminatus*	Tapertip flatsedge	NG				X		X				OBL	
CYER	*Cyperus eragrostis*	Tall flatsedge	NG		X	X		X	X	X			FACW	
CYST	*Cyperus strigosus*	Strawcolored flatsedge	NG						X		X		FACW	
CYSP	*Cyperus* sp.	Flatsedge	NG									X		
DISA	*Digitaria sanguinalis*	Hairy crabgrass	IG				x							
DISP	*Distichlis spicata*	Salt grass	NG	X					X	X	X	X	FACW	
ECCR	*Echinochloa crus-galli*	Barnyard grass	IG	X		X		X	X	X	X			
ELAC	*Eleocharis acicularis*	Spikesedge	NG						X				OBL	
ELMA	*Eleocharis macrostachya*	Common spikerush	NG						X					
ERPE	*Eragrostis pectinacea*	Tufted lovegrass	NG			X								
HOMA	*Hordeum marinum ssp gussoneanum*	Mediterranean barley	IG						X		X		FAC	
HOMU	*Hordeum murinem*	Mouse barley	IG			X			X				FAC	
JUAC	*Juncus acuminatus*	Tapertip rush	NG	X									OBL	
JUBA	*Juncus balticus*	Baltic rush	NG	X			X		X		X	X	FACW	
JUEN	*Juncus ensifolius*	Swordleaf rush	NG	X									FACW	
LEOR	*Leersia oryzoides*	Rice cutgrass	NG	X									FACW	
LEUN	*Leptochloa uninervia*	Mexican sprangletop	NG	X		X	X	X	X	X				
LETR	*Leymus triticoides*	Creeping wildrye	NG						X				FAC	
LUPA	*Luzula parviflora*	Smallflowered woodrush	NG	X									FAC	
ORSA	*Oryza sativa*	Rice	IG			X							OBL	
PAAC	*Panicum acuminatum*	Hairy panic grass	NG	X										
PACA	*Panicum capillare*	Witch grass	NG			X	X			X		X		
PARI	*Panicum rigidulum*	Redtop panicgrass	IG				X		X	X	X			
PADI	*Paspalum distichum*	Knotgrass	NG	X		X			X		X			

PADI2	*Paspalum dilatum*	Dallis grass	IG	X									FAC	
PANO	*Paspalum notatum*	Bahia grass	IG						X					
PHAR	*Phalaris arundinacea*	Canary reedgrass	NG	X									FACW	
POMO	*Polypogon monspeliensis*	Rabbitsfoot grass	IG						X			X	FACW	
SCAC	*Schoenplectus acutis*	Hardstemmed bullrush	NG						X		X		OBL	
SEPU2	*Setaria pumila*	Yellow foxtail	IG	X			X						FAC	
SOHA	*Sorgham halapense*	Johnsongrass	IG						X		X			Y
VUMY	*Vulpia myuros*	Rat-tail fescue	IG	X	X	X	X	X	X					
Forb														
AMRE	*Amaranthus retroflexus*	Redroot pigweed	IF					X	X	X	X			
AMRO	*Ammania robusta*	Grand redstem	NF						X		X		OBL	
ANCA	*Anthriscus caucalis*	Bur chevril	IF	X										
ANCO	*Anthemis cotula*	Dog fennel	IF						X					
ARDO	*Artemisia douglasiana*	California mugwort	NF	X	X		X	X			X	X	FACW	
ARLU	*Artemisia ludoviciana*	White sagebrush	NF	X										
ARVU	*Artemisia vulgare*	Common mugwort	IF			X				X				
ASFA	*Asclepius fascicularis*	Narrowleaf milkweed	NF								X		FAC	
BRNI	*Brassica nigra*	Black mustard	IF	X		X	X		X	X	X	X		
CESO	*Centaurea solstitialis*	Yellow starthistle	IF						X					Y
CEPA	*Centromadia parryii ssp rudis*	Pappose tarweed	NF						X		X		FAC	
CHAL	*Chenopodium album*	Lambsquarters	IF	X										
CHBE	*Chenopodium berlandii*	Pitseed goosefoot	NF					X						
CHCA	*Chenopodium californicum*	California goosefoot	NF					X			X	X		
CIVU	*Cirsium vulgare*	Bull thistle	IF						X		X			Y
COMA	*Conium maculatum*	Poison hemlock	IF								X		FAC	
COCA	*Conyza canadensis*	Horseweed	NF				X			X		X		
CRTR	*Cressa truxellensis*	Alkaliweed	NG						X				FACW	
CUSP	*Cuscuta* sp.	Dodder	IF		X		X			X				Y
DAWR	*Datura wrightii*	Jimson weed	NF			X		X				X		
DESP	*Descurainia* sp	Tansy mustard			X									
EQAR	*Equisetum arvense*	Field horsetail	NF	X									FAC	
ERSE	*Eremocarpus setigerus*	Doveweed	NF			X								
ERWR	*Eriogonum wrightii*	Wright's buckwheat	NF			X								
ERCI	*Erodium cicutarium*	Redstem storks bill	IF				X			X				
ERRA	*Eryngium racemosum*	Delta button celery	NF						X				OBL	
ESCA	*Eschscholzia californica*	California poppy	NF		X	X								
EUOC	*Euthamia occidentalis*	Western goldentop	NF	X	X		X				X	X	FACW	
FRSA	*Frankenia salina*	Alkali seaheath	NF						X		X		FACW	
GRCA	*Grindelia camporum*	Gum plant	NF						X		X	X	FACW	
HEAN	*Helianthus annuus*	Sunflower	NF			X		X	X	X	X	X		
HECU	*Heliotropium curassavicum*	Salt heliotrope	NF									X	OBL	
KOSC	*Kochia scoparia*	Kochia	IF			X	X	X	X					
LASE	*Lactuca serriola*	Prickly lettuce	IF			X		X	X		X	X		
LELA	*Lepidium latifolium*	Perennial pepperweed	IF					X			X	X	FAC	Y
LUPE	*Ludwigia peploides*	Water primrose	NF						X				OBL	
LOCO	*Lotus corniculatus*	Birdsfoot trefoil	IF						X		X		FAC	
LOUN	*Lotus unifoliolatus*	American bird's-foot trefoil	NF			X	X							
MALE	*Malvella leprosa*	Alkali mallow	IF						X		X	X		Y
MAPA	*Malva parviflora*	Cheeseweed mallow	IF						X		X			
MAVE	*Marsilea vestita*	Hairy water clover	NF						X		X		OBL	
MEAL	*Melilotus alba*	White sweetclover	IF	X					X	X		X		
MEAR	*Mentha arvensis*	Field mint	NF	X			X						FACW	
MEPU	*Mentha pulegium*	Pennyroyal	NF	X									OBL	
MOVE	*Mollugo verticillata*	Green carpetweed	IF	X			X		X	X	X	X	FAC	
MYAQ	*Myriophyllum aquaticum*	Parrotfeather	IF	X									OBL	
PELA	*Persicaria lapathifolium*	Curlytop knotweed	NF					X	X				FACW	
PHAN	*Physalis angulata*	Cutleaf groundcherry	NF								X			
PHNO	*Phyla nodiflora*	Turkey tangle fogfruit	NF						X		X		FAC	
POAV	*Polygonum aviculare*	Prostrate knotweed	IF						X		X		FAC	

PSCA	*Pseudognaphalium californicum*	California cudweed	NF	X	X	X	X		X			X		
ROPA	*Rorippa palustris*	Yellow cress	NF				X	X	X	X	X	X	OBL	
RUCR	*Rumex crispus*	Curly dock	IF					X	X	X	X		FAC	
RUDI	*Rubus discolor*	Himalayan blackberry	IF	X										
RUUR	*Rubus ursinus*	California blackberry	NF	X										
SATR	*Salsola tragus*	Russian thistle	IF			X								Y
SIMA	*Silybum marianum*	Milk thistle	IF						X					
SOAM	*Solanum americanum*	American black nightshade	NF			X	X				X	X		
SOTR	*Solanum triflorum*	Cutleaf nightshade	NF							X				
SOAS	*Sonchus asper*	Prickly sow thistle	IF				X		X					
TRSP	*Trifolium sp.*	Clover	IF				X							
URDI	*Urtica dioica*	Stinging nettle	IF				X						FAC	
VEAN	*Veronica anagallis-aquatica*	Water speedwell	IF		X								OBL	
VETH	*Verbascum thapsis*	Common mullein	IF	X										
VISP	*Vicia sp*	Vetch	IF	X										
XAST	*Xanthium strumarium*	Cocklebur	NF	X		X	X	X	X	X	X	X	FAC	

[1] NT/IT=Native or Introduced tree; NS/IS=Native or Introduced shrub; NG/IG=Native or Introduced grass or grass-like specie; NF/IF=Native or Introduced forb

[2] Wetland Indicator – OBL=Obligate; FACW=Facultative wetland; FAC=Facultative

[3] California Department of Food and Agriculture Noxious Weed List

Appendix E

Total percent cover of individual plant species detected
in the understory layer of vegetation transects
from 2011 to 2019.

Table E-1. The average total percent understory cover by individual species, life-form, and cover type in Reaches 1A – 2Afrom 2011 to 2019.

Average Total Percent Understory Cover																		
	River Reach																	
	1A						1B						2A					
	n=2						n=2						n=2					
Species	**2011**	**2012**	**2013**	**2014**	**2015**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2019**
Button bush	0	0	0	0	0	0.5	0.5	0	0	1.0	1.0	0	0	0	0	0	0	0
Sandbar willow	0.5	0	0.5	0.5	0.5	0	4.0	1.5	1.0	0.5	2.5	1.0	0	0	0	0	0	0
Goodding's willow	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0.5	0	0
Arroyo willow	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0
Douglas' silver lupine	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	1.5	0
Oregon ash	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Valley oak	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0
Native trees/shrubs	0.5	0.5	1.0	0.5	0.5	1.0	4.5	1.5	2.5	1.5	4.0	1.0	0	0	0	1.0	1.5	0
Scarlet wisteria	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0
Introduced trees/shrubs	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0
Tall flatsedge	0	0	0	0	0	0	5.0	0	0	0	0	0	0	0	0	0	0	0.5
Flatsedge	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt grass	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baltic rush	1.5	0	1.0	1.0	0.5	0	0	0	0	0	0.5	0	0	0	0	0	0	0
Mexican sprangletop	0.5	0	0	0	0	0	0	0	0	0	0	0	1.5	0.5	0	0	0	0
Canary reedgrass	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tapertip rush	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rice cutgrass	0	0	3.0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smallflowered woodrush	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spike bent grass	0	0	0	0	0	0	0	0	0	0	2.0	0	0	0	0	0	0	0
Sedge	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0
Swordleaf rush	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0
Hairy panic grass	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0
Tufted lovegrass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
Witchgrass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
Unidentified grasses*	0.5	2.5	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Native graminoids	4.0	3.0	5.0	4.0	0.5	3.0	5.0	0	0	0	2.5	0.0	1.5	0.5	0	0	0	1.5
Ripgut brome	0.5	13.0	22.5	31.5	33.5	2.0	0	0	0	0	0	0	3.0	6.0	6.0	8.0	6.0	3.5
Bermuda grass	1.0	1.5	0.5	0	1.0	3.5	2.0	10.5	4.0	5.5	10.0	5.0	0.0	0.5	1.0	1.0	1.0	1.5
Barnyard grass	0.5	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0
Rice	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0	0	0	0	0
Soft chess brome	0	3.0	1.5	2.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Foxtail chess	0	3.0	0	3.0	1.5	0	0	5.0	12.0	7.5	16.5	0	0	4.0	12.0	3.0	4.0	3.0
Dallis grass	0	0	1.0	0	0	1.5	0	0.0	0	0	0	0	1.0	0	0	0	0	0
Rat-tail fescue	0	10.0	8.5	6.5	2.5	0	0	0.5	0	0.5	0	0	1.5	2.0	2.5	0	0	2.5
Smooth brome	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rabbitsfoot grass	0	0	0	0	2.0	0	0	0	0	0	1.5	0	0	0	0	0	0	0
Giant reed	0	0	0	0	0	0	0	0	0.5	0	0.5	0	0	0	0	0	0	0
Rye brome	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0

Average Total Percent Understory Cover																		
	River Reach																	
	1A						1B						2A					
	n=2						n=2						n=2					
Species	2011	2012	2013	2014	2015	2019	2011	2012	2013	2014	2015	2019	2011	2012	2013	2014	2015	2019
Meditarrean barley	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.0	1.0
Wild oat	0	0	0	0	0.5	0	0	0	0.5	0	0	0	0	0	0	0	0	0
Yellow foxtail	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0
Introduced graminoids	2.0	30.5	34.0	44.5	42.0	8.0	2.0	16.0	17.0	13.5	28.5	5.0	7.0	12.5	21.5	12.0	13.0	11.5
California mugwort	8.0	4.5	6.5	6.5	6.5	8.5	0	0	0.5	1.5	3.0	0	0	0	0	0	0	0
Doveweed	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0
Wright's buckwheat	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0.5	0	0	0	0.5
Jimson weed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0
Sunflower	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0	0	0	0	0.5
American bird's-foot trefoil	0	0	0	0	1.5	0	0	0	0	0	0	0	3.5	0	0.5	0	0	2.5
Field mint	0.5	1.0	0	0	0.5	0.5	0	0	0	0	0.5	0	0	0	0	0	0	0
Yellow cress	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0
American black nightshade	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0
Cocklebur	1.0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0
Western goldentop	0	0.5	1.5	0.5	0	1.0	0	1.5	6.5	3.5	1.5	1.0	0	0	0	0	0	0
Pennyroyal	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
California poppy	0	0	0	0	0	0	0	0.5	0.5	2.0	0.5	0	0	1.0	2.0	0.5	4.0	0
California cudweed	0	0	1.0	1.0	0	0	0	0.5	0	0	1.0	0	0	0.5	0	0	0	0
Horseweed	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0
California blackberry	5.5	8.0	5.0	4.0	2.0	6.0	0	0	0	0	0	0	0	0	0	0	0	0
White sagebrush	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Field horsetail	0	0	0	1.0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tansy mustard	0	0	0	0	0	0	0	0	0	0.5	1.0	0	0	0	0	0	0	0
Unidentified forbs*	0.5	0	0	0	0.5	0	0	0	0.5	0	0.5	0	0	0	0	0	0	0
Native forbs	15.5	14.5	14.5	13.0	12.0	16.0	0	2.5	8.0	7.5	8.5	1.5	7.5	2.0	2.5	0.5	4.0	4.5
Black mustard	1.0	0	0	0	0	1.0	0	0	0	0	0.5	0	2.0	4.5	1.5	2.0	1.0	6.5
Prickly lettuce	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0
Russian thistle	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0
Stinging nettle	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0
Koschia	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0
Water speedwell	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0
Dodder	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0
Common mugwort	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0	0	0
Parrotfeather	0	0	1.0	0.5	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0
Bur chevril	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Vetch	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Common mullein	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Himalayan blackberry	0	0	0	0	16.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Lambsquarters	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0
White sweetclover	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0
Green carpetweed	0	0	0	0	0	0.5	0	0	0	0	0	1.0	0	0	0	0	0	0.5
Introduced forbs	1.0	0.0	1.0	1.0	18.5	2.5	1.0	0	0	0	1.0	1.5	3.0	5.0	2.5	2.0	1.0	7.0

Average Total Percent Understory Cover																		
	River Reach																	
	1A						1B						2A					
	n=2						n=2						n=2					
Species	**2011**	**2012**	**2013**	**2014**	**2015**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2019**
Total Plant Cover	23.0	48.5	55.5	63.0	73.5	30.5	12.5	20.5	27.5	22.5	44.5	9.0	19.0	20.0	26.5	15.5	19.5	24.5
Litter	33.5	39.0	39.0	31.5	22.5	42.0	20.0	40.5	41.5	51.5	31.5	52.0	16.5	17.5	15.5	23.5	19.5	23.5
Bare	43.0	11.0	5.0	5.5	4.0	23.0	67.5	39.0	30.5	26.0	24.0	34.0	64.5	62.5	58.0	61.0	61.0	52.0
Water	0.5	1.5	0.5	0	0	4.5	0	0	0	0	0	5.0	0	0	0	0	0	0
Total Cover	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

*Unidentified species may be either native or introduced

Table E-2. The average total percent understory cover by individual species, life-form, and cover type in Reaches 2B, 3 and ESB from 2011 to 2019.

Average Total Percent Understory Cover																				
	River Reach																			
	2B							3						ESB						
	n=2							n=2						n=4					n=5	n=6
Species	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**
Sandbar willow	0	0	0.5	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Gooding's willow	0.5	1.0	2.5	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0
Native trees/shrubs	0.5	1.0	3.0	0	0	0	0.5	0.3	0	0	0	0	0	0	0	0	0	0	0	0
Tapertip flatsedge	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	2.3	0.3	0	0	0	0
Salt grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10.7	9.5	13.8	4.8	11.1	7.7
Spikesedge	0	0	0	0	0	0	0	0	0	0	0	0	0	11.0	0	0	0	0	0.8	1.3
Baltic rush	0	0	1.5	1.0	0	0	0	0	0	0	0	0	0	0.7	0	0	0.8	0.5	1.9	2.0
Mexican sprangletop	2.2	0	0	0	0	0	0	1.6	0	0	0	0	0	0.2	0	0	0	0	0	0
Knotgrass	0	0	0	0	0	0	0	0	0	0	0	0	0	4.5	1.7	3.5	2.3	0.3	0	2.2
Tapertip rush	0	0	1.2	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Creeping wildrye	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	1.5	1.0	0.5	0	1.8
Shortawn foxtail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0
Spike bent grass	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strawcolored flatsedge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.0	0
Tall flatsedge	0	0	0	0	0	0	0	3.5	0	0	0	0	0	1.0	0	0	0	0	0	1.3
Witchgrass	0	0	0	0	0	0	4.7	0	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified grasses*	0	0	0	0	0	0.5	0	0	0	0	0	0	0	2.0	0	0	0	0	0	0
Native graminoids	2.2	0.0	2.7	1.0	0.0	3.9	4.7	5.1	0.0	0.0	0.0	0.0	0.0	20.4	15.7	14.8	17.9	7.3	20.8	16.3
Bermuda grass	0	0	0	0	0	0	0	4.1	1.6	0.7	0	0	0	2.7	3.0	0	0	3.7	13.8	18.0
Mouse barley	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	1.5	1.3	0	0
Barnyard grass	0	0	0	0	0	1.7	0	0.6	0	0	0	0	3.0	0.3	0	0	0	0	0	0.2
Mediterranean barley	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	3.5	0	0
Bahia grass	0	0	0	0	0	0	0	0	0	0	0	0	0	5.3	0	0	0	0	0	0
Foxtail chess	0	0	3.4	0	0	0	0	0	0	0.3	0	4.4	6.6	0	0.3	0.5	0	3.2	0	0
Soft chess brome	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	0
Rat-tail fescue	0	0	0.7	0	0	0	0	0	0	4.2	2.8	3.5	0	0	0.3	0	0	0.5	0	0
Ripgut brome	0	0	0	0	0	0	0	0	16.0	35.5	20.8	52.3	19.4	0	0.3	0	0	0	0	0

	Average Total Percent Understory Cover																				
	River Reach																				
	2B							3						ESB							
	n=2							n=2						n=4					n=5	n=6
Species	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**
Rabbitsfoot grass	0	0	0	0.7	0	0	0	0	0	0.3	0	0	0	0	1.4	0.8	0.8	0.3	0	0
Smooth brome	0	0	0	0	0	0	0	0	0	0.3	0	0	1.0	0	0	0	0	0	0	0
Johnson grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0
Swamp picklegrass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0
Rye brome	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redtop panicgrass	0	0	0	0	0	34.1	10	0	0	0.6	0	0	0	0	0	0	0	0	0.2	0
Hairy crabgrass	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow foxtail	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Introduced graminoids	0	0	4.1	0.7	0.0	38.0	10.6	4.7	17.6	41.9	23.6	60.2	30.0	8.3	5.6	1.6	2.3	14.0	15.0	18.2
California mugwort	1.4	2.9	2.1	1.7	0	3.1	7.6	10.5	13.6	14.8	13.5	6.9	18.0	0	0	0	0	0	0	0
Pappose tarweed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	1.3	0	0
Delta button celery	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0.2	0
Gumweed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	1.7	0.5	0.5	0	0
Sunflower	0	0	0	0	0	1.0	0	0	0	0.9	0	0	1.5	0	0	0	0	0	0.1	12.7
American bird's-foot trefoil	9.3	0	4.3	0	0	0	22.7	0	0	0	0	0	0	0	0	0	0	0	0	0
Field mint	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pale smartweed	0	0	0	0	0	0	1.5	12.4	0	0	0	0	0	0	0	0	0	0	1.0	0.7
Yellow cress	0	0.7	0	0	0	0	0	2.2	0	1.3	0	0	0.5	0	0	0	0	0	0	0.2
American black nightshade	4.3	0	0	0	0	1.5	0	2.8	0	0	0	0	0	0	0	0	0	0	0	0
Cocklebur	0	0	1.2	0	0	4.1	0	20.6	0	0	0	0	0	7.3	2.7	0.3	0.3	0	6.0	0
Western goldentop	0	0	0	0	0	0	3.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turkey tangle fogfruit	0	0	0	0	0	0	0	0	0	0	1.9	0.6	0	0	5.2	4.7	9.0	8.2	3.6	11.8
Jimson weed	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0
California cudweed	0	0.5	0.7	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0
Horseweed	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand redstem	0	0	0	0	0	0	0	0	0	0	0	0	0	3.0	0	0	0	0	17.2	2.2
Water primrose	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.3	0.0	0	0
Salt heliotrope	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
Alkali seaheath	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	1.0	0.8	1.3
Western marsh cudweed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
Hairy water clover	0	0	0	0	0	0	0	0	0	0.9	0	0	0	3.3	0	0	0	0	2.0	4.0
Pitseed goosefoot	0	0	0	0	0	0	0	3.3	0	0	0	0	1.3	0	0	0	0	0	0	0
Unidentified forbs*	1.4	0	0	0.5	0	0.9	3.8	0.7	0	0	0	0	7.0	3.0	2.5	0.5	0	0	0.6	0
Native forbs	16.4	5.3	9.0	2.2	0.0	10.6	38.6	52.5	13.6	17.9	15.4	7.5	28.8	17.1	11.2	10.2	10.4	11.2	31.9	32.9
Black mustard	4.1	12.4	7.2	2.6	5.1	3.6	0.9	0	0	0	0	0	0	0	1.3	2.7	1.3	4.3	0	0
Prickly lettuce	0	0	0	0	0	0	0	0.8	0	0	0	0	0.6	0	0.3	1.0	0.5	0.0	0	0
Alkali mallow	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	1.3	0.5	0.8	0.0	2.2	2.8
Stinging nettle	0.5	0.5	0.5	0	2.0	0.5	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clover sp.	2.1	4.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redstem storks bill	0	0.7	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Koschia	0	0.7	0	0	0	0	0	0	0	0.9	0	0	0	0	0	0.5	0	0	0.1	0
Prickly sowthistle	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0

	Average Total Percent Understory Cover																			
	River Reach																			
	2B							3						ESB						
	n=2							n=2						n=4					n=5	n=6
Species	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**
Prostrate knotweed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0.2	3.7
Dodder	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Curly dock	0	0	0	0	0	0	0	0	0.3	0.3	0	0	0.6	0.5	3.0	0	0	0	0	0.3
White sweetclover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0.5	0	0
Bull thistle	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	1.8	0	0	0	0
Perennial pepperweed	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0
Birdsfoot trefoil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	1.5	0	0	0	0
Dog fennel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.7	0	2.0	1.5	0	0.2
Milk thistle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	1.0	0	0
Yellow starthistle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	2.8	0	0
Green carpetweed	0	0	0	0	0	0.5	0	2.5	0	0	0	0	0	0	0	0	0	0	1.0	0
Redroot pigweed	0	0	0	0	0	0	0	7.5	0	0	0	0	6.1	0	0	0	0	0	2.2	1.5
Introduced forbs	6.7	19.3	10.2	3.3	7.1	4.6	1.9	10.8	0.3	1.2	0.0	0.0	8.6	1.5	11.5	10.5	4.6	10.3	5.7	8.5
Total Plant Cover	25.8	25.6	29.0	7.2	7.1	57.1	56.3	73.4	31.5	61.0	39.0	67.7	67.4	47.3	44.0	37.1	35.2	42.8	73.4	75.9
Litter	22.9	32.8	33.3	42.3	43.2	8.2	19.8	16.0	56.9	34.5	54.2	29.6	32.6	22.7	39.5	49.3	48.5	38.8	4.3	16.8
Bare	51.3	41.6	37.7	50.5	49.7	34.6	24.0	10.6	11.6	4.8	7.0	2.8	0.0	30.0	16.8	13.8	16.8	18.5	22.0	5.5
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	1.8
Total Cover	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table E-3. The average total percent understory cover by individual species, life-form, and cover type in Reaches 4A to 5 from 2011 to 2019.

	Average Total Percent Understory Cover - Downstream Reaches														
	River Reach														
	4A			4B2							5				
	n=2			n=2							n=2				
Species	**2011**	**2012**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**	**2012**	**2013**	**2014**	**2015**	**2019**
Goodding's willow	1.5	0.7	0	0	0	0	0	0	0	0	0.5	0	0	0	0
Seepwillow	0	0	0	0	0	0	0	0.6	0.0	0.6	0	0	0	0	0
Native trees/shrubs	1.5	0.7	0	0	0	0	0	0.6	0.0	0.6	0.5	0	0	0	0
Salt grass	0	4.9	0	14.4	19.1	22.6	12.9	4.6	7.0	16.6	0.0	0.5	0	0	0
Baltic rush	0	0	0	5.2	5.1	5.7	9.0	5.8	0	1.5	0	0.5	0	0	0
Mexican sprangletop	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hardstemmed bullrush	0	0	0	0	0	0	0	0	2.3	0	0	0	0	0	0
Strawcolored flatsedge	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0
Tall flatsedge	1.4	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0
Witchgrass	0	0	2.3	0	0	0	0	0	0	0	0	0	0	0	2.0
Sedge	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	3.0
Flatsedge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0
Unidentified grasses*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
Native graminoids	3.6	4.9	4.3	19.6	24.2	28.3	21.9	10.4	10.6	18.1	0	1.0	0	0	7.5

Average Total Percent Understory Cover - Downstream Reaches															
	River Reach														
	4A			4B2							5				
	n=2			n=2							n=2				
Species	**2011**	**2012**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**	**2012**	**2013**	**2014**	**2015**	**2019**
Bermuda grass	1.2	0	12.9	2.0	4.0	3.5	2.0	0.5	1.9	0	1.0	0	0.5	0	0
Barnyard grass	1.7	0	0	26.1	0	0	0	0	18.9	14.7	0	0	0	0	0
Mediterranean barley	0	0	0	1.0	2.5	1.0	2.5	0	0	0	0	0	0	0	0
Soft chess brome	0	0	0	0	5.5	11.2	8.5	22.0	0	0	0	0	0	0	0
Foxtail chess	0	3.2	0	0	0	0	0.7	0.6	0	0	0	0	0	0	0
Rabbitsfoot grass	0	0	0	0	0	0	0.5	0	0	0	5.5	2.0	0	0	0
Mouse barley	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0
Rat-tail fescue	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0
Ripgut brome	0	0	2.0	0	0	3.8	7.8	20.4	0	0.6	0	0	0	0	0
Redtop panicgrass	0	0	0.5	0	0	0	0	0	3.1	0	0	0	0	0	0
Johnson grass	0	0	0	0	0	0	0	0	1.5	1.5	0	0	0	0	0
Swamp picklegrass	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0
Rye brome	0	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0
Introduced graminoids	2.9	3.2	16.2	30.1	12.0	20.0	22.0	44.1	25.4	16.8	6.5	2.0	0.5	0	0
California mugwort	2.9	0	0	0	1.6	0.6	1.9	1.8	0	0	0.5	4.5	4.0	5.0	0
Pappose tarweed	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0
California goosefoot	0	0	0	3.5	1.3	4.0	1.0	0	8.8	0	0.5	0	0	0	0
Sunflower	0	0	0.5	7.1	0	0	0	0	17.4	6.5	0	0	0	0	10.5
Yellow cress	0	0.5	0	0	0.6	0	0	0	0	0	2.5	0	0	0	0
American black nightshade	0	0	0	1.9	0	0	0	0	0	0	1.5	0	0	0	0
Cocklebur	4.2	0	0	7.1	0	0	0	0	0.6	0	1.0	0	0	0	0
California cudweed	0	0	0	0	0	0	0	0	0	0	2.0	0	0	0	0
Horseweed	0	0.5	0	0	0	0	0	0	0	0	1.0	0.5	0	0	0
Gumweed	0	0	0	0	1.1	6.2	7.8	1.5	0	5.9	0	2.0	0	0	0
Turkey tangle fogfruit	0	0	0	0	0	0.5	0	0	0	0	0	0	0.5	0	0
Jimson weed	0	0	0	0	0	0	0	0	0	0	1.0	1.0	0	0	0
Western goldentop	0	0	0	0	0	0.6	0	0	0	1.3	0	1.5	2.0	1.0	0
Salt heliotrope	0	0	0	0	0	0	0	0	0	0	0	0.5	0	1.0	0
Narrowleaf milkweed	0	0	0	0	0	0	0.7	0	0.5	0	0	0	0	0	0
Alkali seaheath	0	0	0	0	0	0	0	1.0	1.0	0.5	0	0	0	0	0
Hairy water clover	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0
Cutleaf groundcherry	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0
Cutleaf nightshade	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified forbs*	2.0	0	0	0	0	0	1.0	0	0	0	9.0	0	0	0.5	0
Native forbs	9.1	1.0	4.0	20.9	4.6	11.9	12.4	4.3	29.6	14.7	19.0	10.0	6.5	7.5	10.5
Black mustard	0	4.6	0	5.8	10.3	5.8	1.0	5.5	0	9.5	1.0	3.5	2.0	6.0	0
Prickly lettuce	0	0	0	1.0	0	0	0	0	0	0	1.0	0	0	0	0
Alkali mallow	0	0	0	0.6	0	0	0	0	2.5	1.2	1.0	0	0	0	0
Prostrate knotweed	0	0	0	2.1	1.9	0	0	0	3.8	1.2	0	0	0	0	0
Curly dock	0.7	0	0	1.3	0.6	0	0	0	0	0	0	0	0	0	0
Redstem storks bill	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
White sweetclover	0	5.7	0	0	0	0	0	0	0	0	9.0	6.0	0	0	0
Bull thistle	0	0	0	0	1.3	1.3	0	0	0	0	0	0	0	0	0

Average Total Percent Understory Cover - Downstream Reaches															
	River Reach														
	4A			4B2							5				
	n=2			n=2							n=2				
Species	**2011**	**2012**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**	**2012**	**2013**	**2014**	**2015**	**2019**
Poison hemlock	0	0	0	0	9.3	1.9	3.1	5.5	0	4.0	0	0	0	0	0
Perennial pepperweed	0	0	0	0	1.9	2.5	3.1	2.5	5.6	3.7	7.5	22.5	59.5	58.0	0
Birdsfoot trefoil	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0
Milk thistle	0	0	0	0	0	0	0	3.6	0	0	0	0	0	0	0
Green carpetweed	0	0	4.3	0	0	0	0	0	8.4	0	0	0	0	0	2.0
Dodder	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0
Redroot pigweed	0.5	0	0.8	0	0	0	0	0	4.1	0	0	0	0	0	0
Introduced forbs	1.2	10.8	6.1	10.8	25.9	11.5	7.2	17.1	24.4	19.6	19.5	32.0	61.5	64.0	2.0
Total Plant Cover	18.3	20.6	30.6	81.4	66.7	71.7	63.5	76.5	90.0	69.8	45.5	45.0	68.5	71.5	20.0
Litter	7.5	26.7	54.4	11.8	32.8	28.4	36.1	22.5	4.6	30.6	42.0	49.0	30.0	23.5	64.5
Bare	74.2	52.7	10.2	6.8	0.5	0.0	0.5	1.0	5.6	0.0	12.5	6.0	1.5	5.0	15.5
Water	0	0	5.0	0	0	0	0	0	0	0	0	0	0	0	0
Total Cover	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Appendix F

Total percent cover and height of individual plant species detected
in the overstory layer of vegetation transects
from 2011 to 2019.

Table F-1. The average total percent overstory cover and height by individual species in Reaches 1A – 2A from 2011 to 2019.

		River Reach																	
		1A						1B						2A					
		2011	**2012**	**2013**	**2014**	**2015**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2019**
Native Species																			
White alder	**Tot % cov**	0.6	0	2.0	4.2	5.2	7.0	0	0	0	0	0	0	0	0	0	0	0	0
	Avg. Ht. (m)	4.3		4.3	5.3	6.1	7.8												
Button bush	**Tot % cov**	7.1	9.0	5.3	4.7	2.4	7.1	7.6	7.8	8.8	8.6	7.3	4.6	0	0	0	0	0	0
	Avg. Ht. (m)	2.2	3.4	2.9	3.6	3.0	2.9	2.4	2.7	3.2	2.5	2.9	3.0						
Oregon ash	**Tot % cov**	8.9	17.6	16.3	16.1	20.5	13.8	0	0	0	0	0	0	0	0	0	0	0	0
	Avg. Ht. (m)	10.3	15.0	10.1	9.7	9.3	6.7												
Fremont cottonwood	**Tot % cov**	0	0	0	0	0	0	4.1	2.7	2.9	2.7	1.3	2.6	0	0	0	0	0	0
	Avg. Ht. (m)							2	3.7	4.1	3.7	2.4	9.5						
Valley oak	**Tot % cov**	21.1	20.0	21.7	23.2	21.5	28.2	0	0	0	0	0	0	0	0	0	0	0	0
	Avg. Ht. (m)	12.1	21.3	14.6	17.6	19.9	10.4												
Sandbar willow	**Tot % cov**	5.7	9.4	7.1	6.3	9.6	6.0	22.05	28.3	21.0	17.8	17.6	18.2	0	0	1.5	2.0	0.6	2.8
	Avg. Ht. (m)	2.2	2.4	2.5	3.3	3.7	2.1	2.8	2.8	2.4	2.3	2.6	3.6			1.4	1.8	2.2	1.9
Gooding's willow	**Tot % cov**	0	0	0	0	0	0	11.75	12.7	12.8	9.9	8.3	9.2	1.1	0.9	2.3	3.2	3.6	4.4
	Avg. Ht. (m)							3.5	3.5	2.8	2.1	3.5	1.9	3.9	4.1	5.1	5.3	5.3	9.0
Pacific willow	**Tot % cov**	1.8	1.4	5.4	3.1	2.5	3.7	0	0	0	0	0	0	0	0	0	0	0	0
	Avg. Ht. (m)	3.6	3.1	6.0	6.2	7.0	6.4												
Arroyo willow	**Tot % cov**	2.9	4.2	3.2	5.1	5.6	5.8	0	0	0	0	0	6.0	0	0	0	0	0	0
	Avg. Ht. (m)	5.6	4.1	3.5	3.6	5.4	4.5						2.3						
Black elderberry	**Tot % cov**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Avg. Ht. (m)																		
Douglas' silver lupine	**Tot % cov**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0
	Avg. Ht. (m)																	1.2	
Total native		48.0	61.6	61.0	62.7	67.3	71.6	45.5	51.5	45.5	39.0	34.5	40.6	1.1	0.9	3.8	5.2	5.4	7.2
Introduced species																			
Giant reed	**Tot % cov**	0	0	0	0	0	0	9.8	9.5	9.1	12.4	17.8	12.0	0	0	0	0	0	0
	Avg. Ht. (m)							4.4	5.2	5.1	6.9	5.9	5.8						
Scarlet wisteria	**Tot % cov**	0	0	0	0	0	0	0.3	1.6	4.4	3.4	2.4	1.2	0	0	0	0	0	0
	Avg. Ht. (m)							1.3	1.7	1.8	2.2	2.2	2.5						
Total introduced		0	0	0	0	0	0	10.1	11.1	13.5	15.8	20.2	13.2	0	0	0	0	0	0
Total canopy*		**45.2**	**46.7**	**44.5**	**50.5**	**50.7**	**61.7**	**54.9**	**58.9**	**58.2**	**51.9**	**54.7**	**48.3**	**1.1**	**0.9**	**3.8**	**5.2**	**5.4**	**7.2**

*Due to overlap, sum of individual species may not equal total transect canopy

Table F-2. The average total percent overstory cover and height by individual species in Reaches 2B, 3, and ESB from 2011 to 2019.

		River Reach												
		2B							3					
		2011	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2019**
Native Species														
Fremont cottonwood	**Tot % cov**	0	0	0.2	0.2	0.2	0	0	16.7	14.4	13.7	12.6	14.8	5.4
	Avg. Ht. (m)				1.6	1.6			15.0	15.0	23.0	18.0	23.5	19.0
Sandbar willow	**Tot % cov**	0	0	0.7	0.9	0.2	1.5	1.4	0	0	0	0	0	2.6
	Avg. Ht. (m)				1.7	1.0	1.2	2.0						2.6
Gooding's willow	**Tot % cov**	4.4	12.5	10.3	13.0	12.6	13.3	22.8	0.8	2.8	7.2	6.8	7.1	3.3
	Avg. Ht. (m)	5.9	6.0	3.0	2.7	3.8	6.8	6.4	3.0	3.0	3.6	4.6	4.3	4.2
Quailbush	**Tot % cov**	0	0	0	0	0	0.0	0.0	0	0	0	0.6	2.1	5
	Avg. Ht. (m)											2.0	2.6	1.9
Black elderberry	**Tot % cov**	2.8	6.9	7.3	7.3	4.6	3.9	7.5	0	0	0	0	0	0
	Avg. Ht. (m)	4.2	4.8	5.7	5.5	5.1	5.1	5.1						
Button bush	**Tot % cov**	0	0	0	0	0	0	0	0	0	0	0	0	0.4
	Avg. Ht. (m)													1.4
Total native		7.2	19.4	18.5	21.4	17.6	18.7	31.7	17.4	17.2	20.9	20.0	24.0	16.7
Total canopy*		**7.2**	**19.4**	**18.4**	**20.0**	**17.4**	**20.0**	**32.2**	**17.4**	**17.2**	**20.9**	**20.0**	**24.0**	**14.9**

Table F-2. The average total percent overstory cover and height by individual species in Reaches 4B2 and 5 from 2011 to 2019.

		River Reach																	
		ESB							4B2							5			
		2011	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**	**2019**	**2012**	**2013**	**2014**	**2015**
Native Species																			
Gooding's willow	**Tot % cov**	0.2	0	0	0	0	0.2	0.3	9.3	8.5	9.5	10.5	8.6	12.7	11.2	62.8	70.8	68.0	66.4
	Avg. Ht. (m)	1.0					1.5	2.4	8.6	10.5	10.2	9.9	8.6	11.6	9.8	4.4	6.0	5.4	6.4
Total native & canopy		**0.2**	**0**	**0**	**0**	**0**	**0.2**	**0.3**	**9.3**	**8.5**	**9.5**	**10.5**	**8.6**	**12.7**	**11.2**	**62.8**	**70.8**	**68.0**	**66.4**

Appendix G

Woody stem density of individual plant species along vegetation transects from 2011 to 2019

Table G-1. Average woody stem densities of individual species by size class in Reaches 1A – 2A from 2011 to 2019.

Average # stems/m²																			
		Reach																	
	Size class*	1A						1B						2A					
Species		2011	2012	2013	2014	2015	2019	2011	2012	2013	2014	2015	2019	2011	2012	2013	2014	2015	2019
Red alder	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0
Giant Reed	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0.22	0.12	0.07	0.01	0.03	6.08	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Button bush	1	0.01	0	0	0	0	0	0.01	0	0	0	0.07	0	0	0	0	0	0	0
	2	0.07	0.14	0.01	0	0	0.40	0.22	0.16	0.02	0.16	0.10	0	0	0	0	0	0	0
	3	0.18	0.15	0.05	0	0	0.32	0.28	0.12	0.25	0.28	0.25	0.22	0	0	0	0	0	0
	4	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oregon ash	1	0.04	0	0	0	0.01	0.33	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0.05	0.03	0.05	0.08	0	0	0	0	0	0	0	0	0	0	0	0
	3	0.01	0	0.04	0.03	0.02	0.02	0	0	0	0	0	0	0	0	0	0	0	0
	4	0.01	0.02	0.01	0.01	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0
Valley oak	1	0.01	0	1.79	0.63	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0.04	0.2	0.27	0	0	0	0	0	0	0	0	0	0	0	0
	3	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0
	4	0.01	0.01	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sandbar willow	1	0.01	0.04	0	0	0	0	0	0	0	0	0	0	0.19	0	0	0	0	0
	2	0.14	0.02	0.05	0.03	0.03	0.18	2.49	0.84	0.35	0.44	0.64	0.35	0.04	0.04	0.02	0.01	0.29	1.25
	3	0.31	0.61	0.28	0.41	0.20	0.30	1.14	0.95	1.75	0.75	0.3	1.22	0	0	0	0.04	0.01	0.01
	4	0.02	0	0	0	0	0	0.01	0	0	0.01	0	0	0	0	0	0	0	0
Goodding's willow	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13	0	0	0	0
	2	0	0	0	0	0	0	0	0	2.04	2.02	0.06	0.15	0	0.12	0	0.04	0	0
	3	0	0	0	0	0	0	0.05	0.16	0.17	0.06	0.07	0.03	0	0	0	0.01	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arroyo willow	1	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0.22	0.05	0.36	0.16	0.60	0	0	0	0	0	0	0.53	0	0	0	0	0	0
	3	0	0.10	0.03	0.08	0.02	0.04	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scarlet wisteria	1	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.02	0.02	0	0	0
	2	0	0	0	0	0	0	0.02	0.01	0	0	0	0	0	0	0	0	0.01	0.01
	3	0	0	0	0	0	0	0	0	0.03	0.04	0.06	0.01	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Douglas' silver lupine	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.18	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

		Average # stems/m^2																	
		Reach																	
	Size class*	1A						1B						2A					
Species		2011	2012	2013	2014	2015	2019	2011	2012	2013	2014	2015	2019	2011	2012	2013	2014	2015	2019
Total by size class	1	0.10	0.04	1.79	0.63	0.01	0.34	0.01	0	0	0	0.07	0.00	0.21	0.15	0.02	0	0.04	0
	2	0.43	0.20	0.47	0.25	0.87	0.93	2.73	1.01	2.41	2.62	0.80	1.03	0.04	0.16	0.02	0.05	0.47	1.26
	3	0.50	0.87	0.41	0.52	0.25	0.69	1.69	1.35	2.27	1.14	0.71	1.48	0	0	0	0.05	0.09	0.01
	4	0.06	0.03	0.02	0.02	0	0	0.01	0	0	0.01	0	0	0	0	0	0	0	0
TOTAL stems/m^2		**1.08**	**1.13**	**2.68**	**1.42**	**1.13**	**1.95**	**4.44**	**2.36**	**4.68**	**3.77**	**1.58**	**8.59**	**0.25**	**0.31**	**0.04**	**0.10**	**0.32**	**1.26**

Table G-2. Average woody stem densities of individual species by size class in Reaches 1A – 2A from 2011 to 2019.

		Average # stems/m^2													
		Reach													
	Size class*	2B							3						
Species		2011	2012	2013	2014	2015	2017	2019	2011	2012	2013	2014	2015	2019
Fremont cottonwood	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0.07	0.02	0.13	0	0	0	0.07	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Sandbar willow	1	0.01	0.02	0.01	0	0.01	0	0	0	0	0	0	0	0
	2	0	0.11	0.06	0	0.12	0	0	0	0	0	0	0	0.03
	3	0	0.05	0.17	0.11	0.08	0	0.13	0	0	0	0	0	0.07
	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Goodding's willow	1	1.56	0.80	0	0	0	0	0	0	0	0	0	0	0
	2	0	1.78	0.38	1.43	0.20	0.01	0.06	0	0	0	0	0	0
	3	0.06	0.68	0.46	0.38	0.48	0.03	0.04	0.04	0.04	0.01	0.01	0.02	0
	4	0	0	0	0	0	0	0	0	0	0	0	0.02	0
Black elderberry	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0.32	0.10	0.21	0.18	0.16	0.16	0.19	0	0	0	0	0	0
	4	0	0	0	0	0.03	0.02	0	0	0	0	0	0	0
Quailbush	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0.02
	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Total by size class	1	1.57	0.82	0.01	0	0.01	0	0	0	0	0	0	0	0
	2	0.00	1.96	0.47	1.56	0.32	0.01	0.06	0.07	0	0	0	0	0.05
	3	0.38	0.83	0.84	0.67	0.72	0.19	0.36	0.04	0.04	0.01	0.01	0.02	0.07
	4	0	0	0	0	0.03	0.02	0	0	0	0	0	0.02	0
TOTAL stems/m^2		**1.95**	**3.62**	**1.32**	**2.23**	**1.08**	**0.22**	**0.42**	**0.11**	**0.04**	**0.01**	**0.01**	**0.04**	**0.10**

Table G-2. Average woody stem densities of individual species by size class in ESB and Reaches 4A and 5 from 2011 to 2019.

		Average # stems/m^2																
		Reach														
	Size class*	ESB							4A			5				
Species		2011	2012	2013	2014	2015	2017	2019	2011	2012	2019	2012	2013	2014	2015	2019
Goodding's willow	**1**	0	0	0	0	0	0.04	0	0.02	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0.16	0.41	0.86	0	0.76	0	0.09	0.01	0.06
	3	0	0	0	0	0	0.01	0	0	0	0	0.58	0.72	0.35	0.36	0.35
	4	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0.04	0.07
Saltcedar	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total by size class	**1**	0	0	0	0	0	0.04	0	0.02	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0.18	0.41	0.86	0	0.76	0	0.09	0.01	0.06
	3	0	0	0	0	0	0.01	0	0	0	0	0.58	0.72	0.35	0.36	0.35
	4	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0.04	0.07
TOTAL stems/m^2		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.05**	**0.18**	**0.43**	**0.86**	**0.00**	**1.34**	**0.73**	**0.44**	**0.41**	**0.48**

Appendix H

Photo Stations
2011 to 2019

Reach 1A, Transect 1

1a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

1a – Away from transect

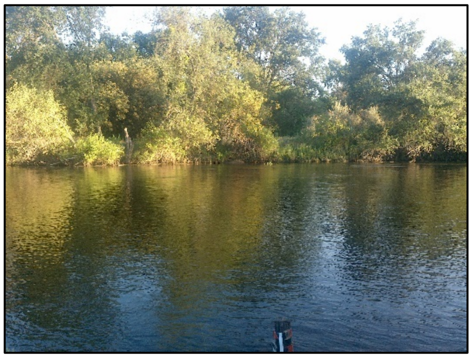

August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

1b – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

1b – Away from transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

Reach 1A, Transect 2

2a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

2a – Away from transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

2b – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

2b – Away from transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

Reach 1B, Transect 1

1a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

1a – Away from transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

1b – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

1b – Away from transect (tape continues beyond transect)


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

Reach 1B, Transect 2

2a – Toward transect


August 2011


June 2012


June 2013


May 2014

Not available
May 2015


August 2019

2a – Away from transect


August 2011


June 2012


June 2013


May 2014

Not available
May 2015


August 2019

2b – Toward transect


August 2011


June 2012


June 2013


May 2014

Not available
May 2015


August 2019

2b – Away from transect


August 2011


June 2012


June 2013


May 2014

Not available
May 2015


August 2019

Reach 2A, Transect 1

1a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

1a – Away from transect


August 2011


June 2012

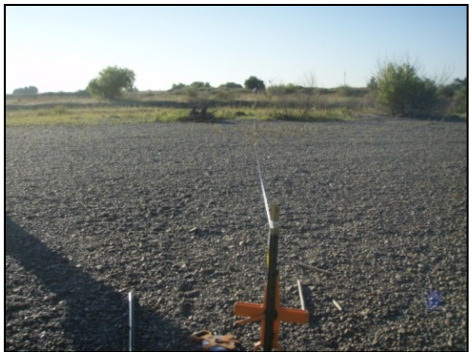

June 2013


May 2014

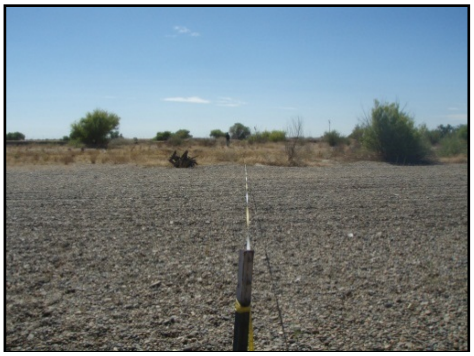

May 2015


August 2019

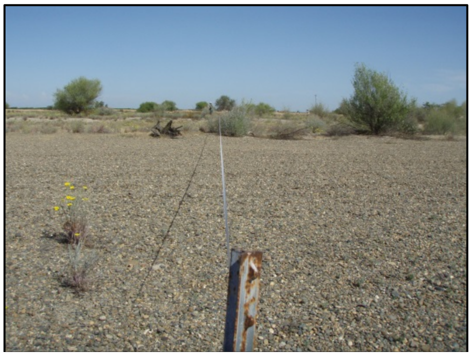
1b – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

1b – Away from transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

Reach 2A, Transect 2

2a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

2a – Away from transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

2b – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

2b – Away from transect


August 2011


June 2012


June 2013

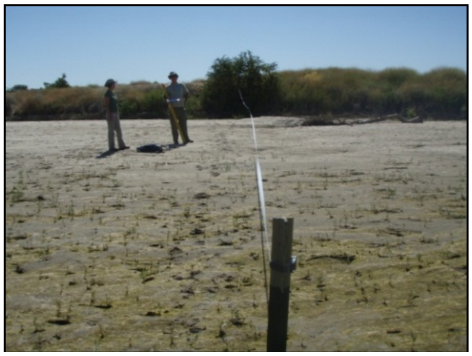

May 2014


May 2015

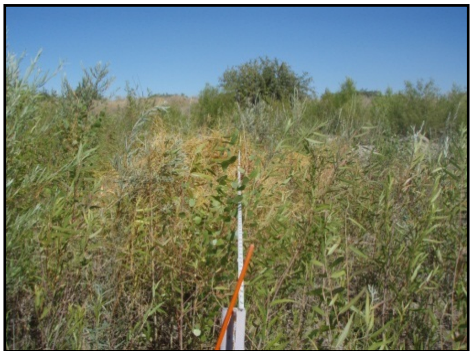

August 2019

Reach 2B, Transect 1

1a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017


August 2019

1a – Away from transect


August 2011


June 2012


June 2013


May 2014

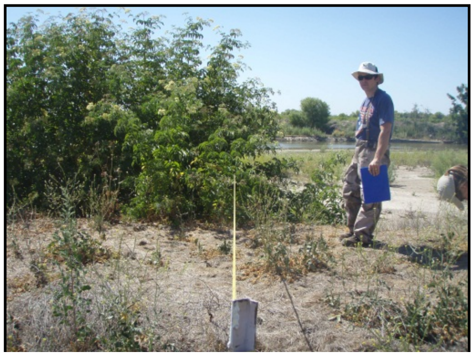

May 2015


August 2017


August 2019

1b – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017

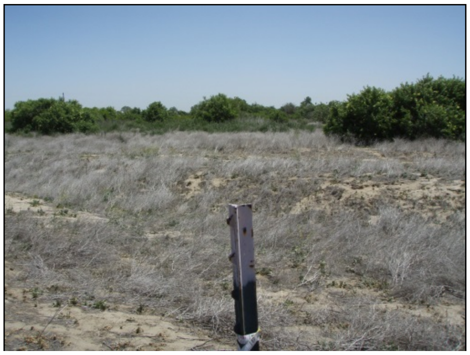

August 2019

1b – Away from transect


August 2011


June 2012


June 2013


May 2014

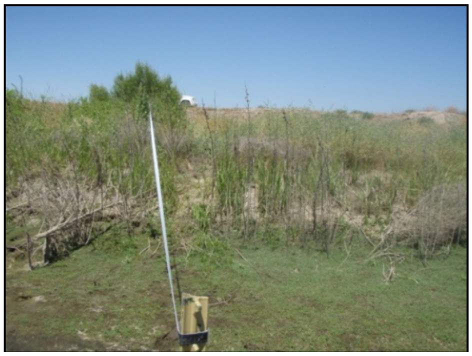

May 2015


August 2017


August 2019

Reach 2B, Transect 2

2a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017


August 2019

2a – Away from transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017


August 2019

2b – Toward transect (taken from different angle in 2011)


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017

August 2019

2b – Away from transect

August 2011

June 2012

June 2013

May 2014

May 2015

August 2017

August 2019

Reach 3, Transect 1

1a – Toward transect


August 2011


June 2012


June 2013

Not available

May 2014


May 2015


August 2019

1a – Away from transect


August 2011


June 2012


June 2013

Not available

May 2014


May 2015


August 2019

1b – Toward transect


August 2011


June 2012


June 2013

Not available

May 2014


May 2015


August 2019

1b – Away from transect


August 2011


June 2012


June 2013

Not available

May 2014


May 2015


August 2019

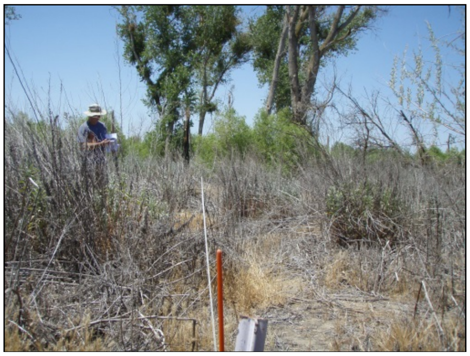
Reach 3, Transect 2

2a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

2a – Away from transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

2b – Toward transect


August 2011


June 2012


June 2013

Not available

May 2014


May 2015


August 2019

2b – Away from transect


August 2011


June 2012


June 2013

Not available

May 2014


May 2015

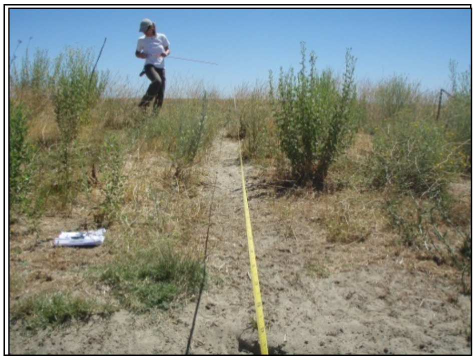

August 2019

ESB Transect 1

1a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015

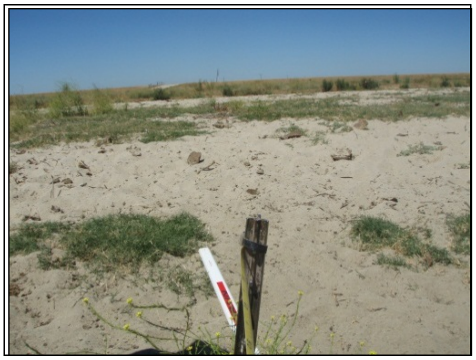

August 2017


August 2019

1a – Away from transect


August 2011


June 2012


June 2013

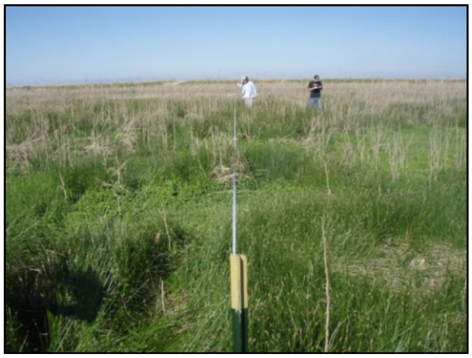

May 2014


May 2015

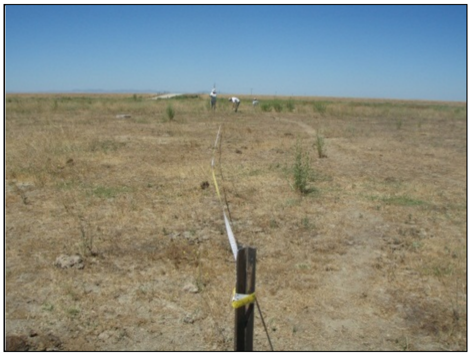

August 2017


August 2019

1b – Toward transect


August 2011


June 2012


June 2013


May 2014

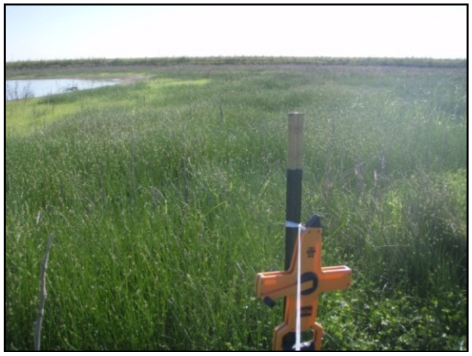

May 2015

Not Available

August 2017

August 2019

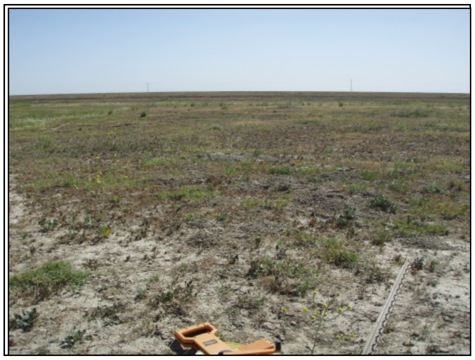
1b – Away from transect



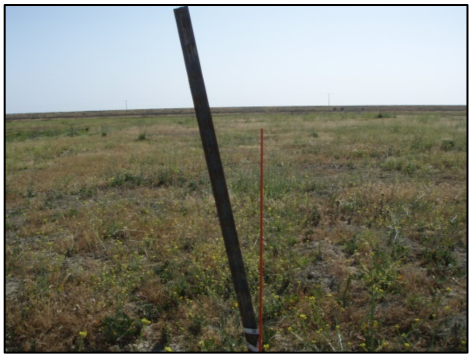
August 2011

June 2012

June 2013



May 2014



May 2015

Not Available

August 2017

August 2019

ESB Transect 2

2a – Toward transect

August 2011

June 2012

June 2013

May 2014

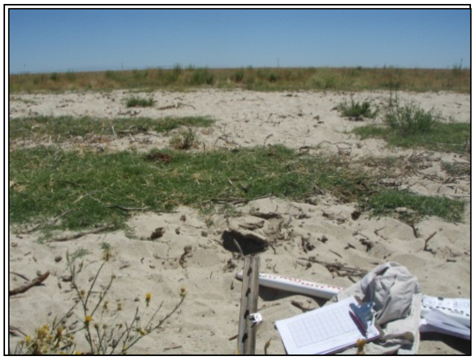
May 2015

August 2019

2a – Away from transect

August 2011

June 2012



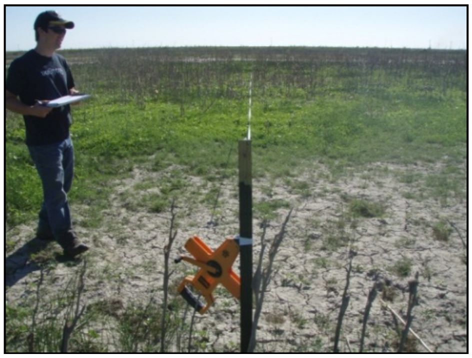
June 2013

May 2014

May 2015

August 2019

2b – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2019

2b – Away from transect


August 2011


June 2012


June 2013


May 2014

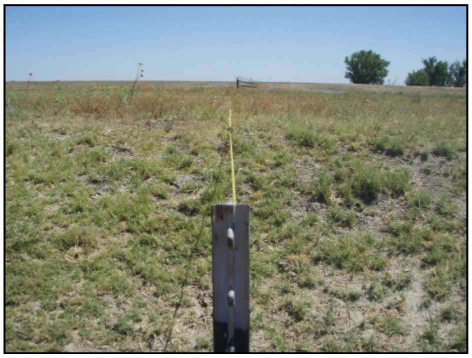

May 2015


August 2019

ESB Transect 3

3a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017


August 2019

3a – Away from transect


August 2011


June 2012


June 2013

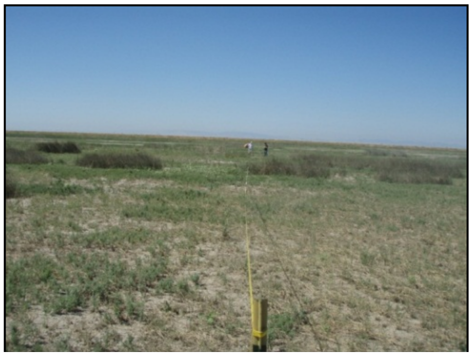

May 2014

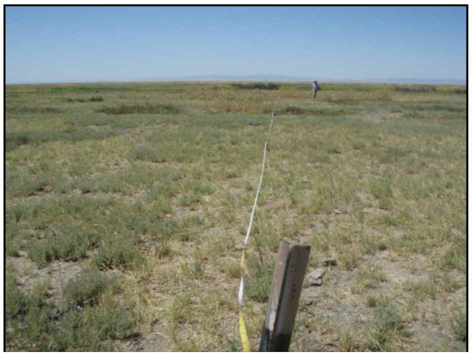

May 2015


August 2017

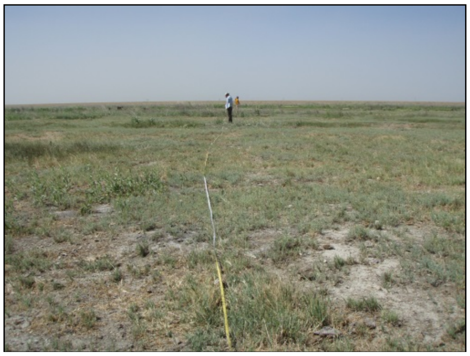

August 2019

3b – Toward transect


August 2011


June 2012


June 2013


May 2014

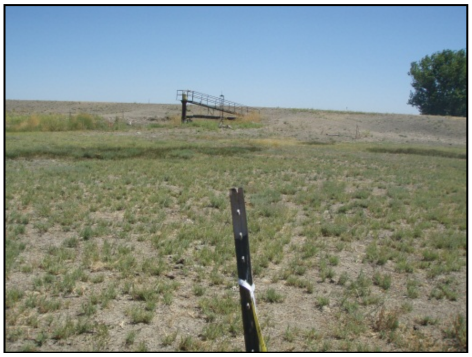

May 2015


August 2017

August 2019

3b – Away from transect

August 2011



June 2012

June 2013

May 2014

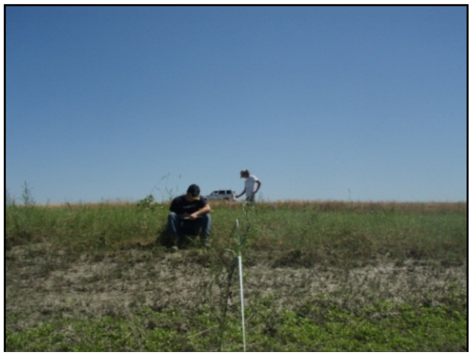
May 2015

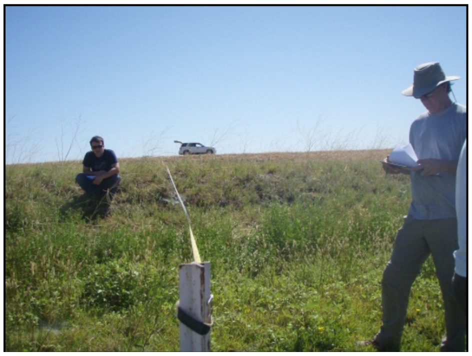
August 2017

August 2019

ESB Transect 4

4a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017


August 2019

4a – Away from transect


August 2011


June 2012


June 2013


May 2014

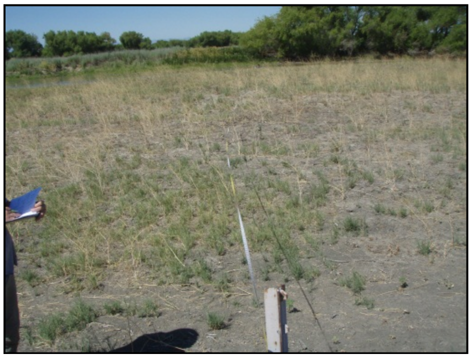

May 2015

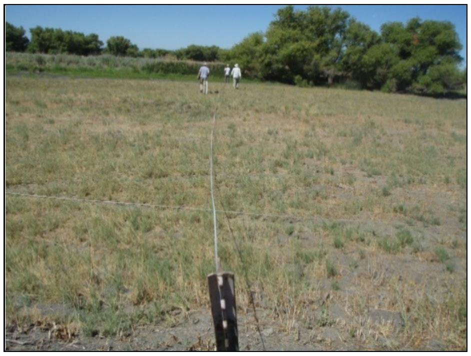

August 2017


August 2019

4b – Toward transect


August 2011


June 2012


June 2013


May 2014

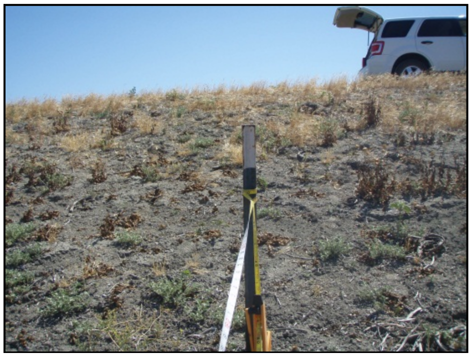

May 2015


August 2017


August 2019

4b – Away from transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017


August 2019

ESB Transect 6

6a – Toward transect


August 2017 August 2019

6a – Away from transect


August 2017 August 2019

6b – Toward transect


August 2017 August 2019

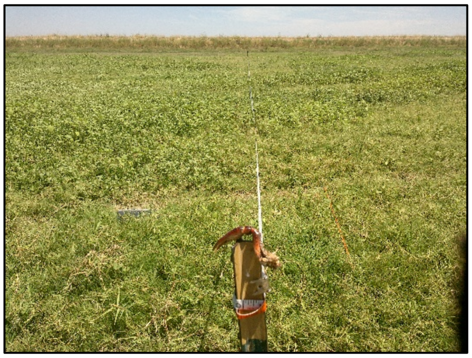
6b – Away from transect


August 2017 August 2019

ESB Transect 7

7a – Toward transect

August 2017



August 2019

7a – Away from transect

August 2017

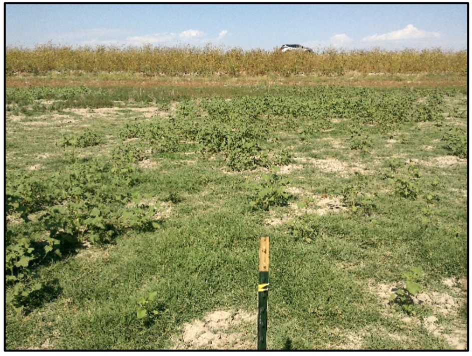
August 2019

7b – Toward transect

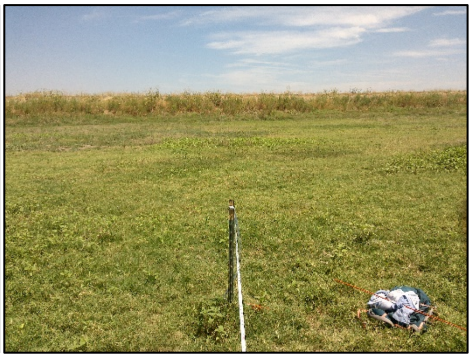
August 2017

August 2019

7b – Away from transect



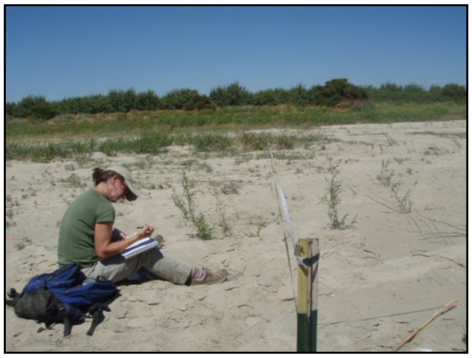
August 2017



August 2019

Reach 4A, Transect 1

1a – Toward transect



August 2011

June 2012

August 2019

1a – Away from transect

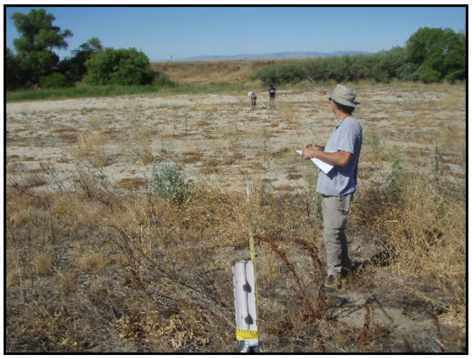
August 2011

June 2012

August 2019

1b – Toward transect

August 2011



June 2012

August 2019

1b – Away from transect

August 2011

June 2012

August 2019

Reach 4A, Transect 2

2a – Toward transect


August 2011


June 2012


August 2019

2a – Away from transect


August 2011


June 2012


August 2019

2b – Toward transect


August 2011


June 2012


August 2019

2b – Away from transect

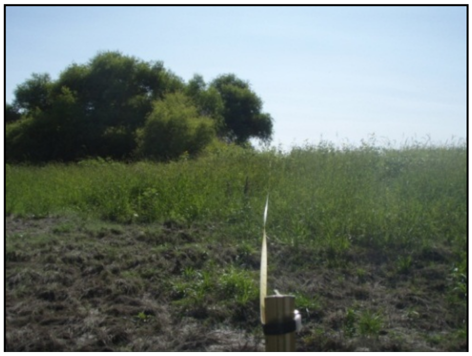

August 2011


June 2012


August 2019

Reach 4B2, Transect 1

1a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017


August 2019

1a – Away from transect


August 2011


June 2012


June 2013


May 2014


May 2015

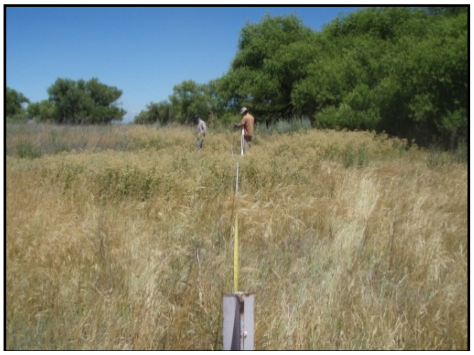

August 2017


August 2019

1b – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017

August 2019

1b – Away from transect

August 2011

June 2012

June 2013

May 2014

May 2015

August 2017 *Not Available*

August 2019

Reach 4B2, Transect 2

2a – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017


August 2019

2a – Away from transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017

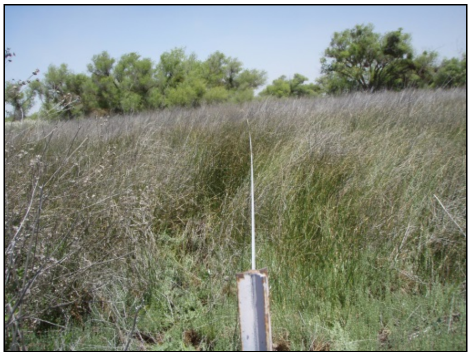

August 2019

2b – Toward transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017


August 2019

2b – Away from transect


August 2011


June 2012


June 2013


May 2014


May 2015


August 2017


August 2019

Reach 5, Transect 1

1a – Toward transect


June 2012


June 2013


May 2014


May 2015


August 2019

1a – Away from transect


June 2012


June 2013


May 2014


May 2015


August 2019

1b – Toward transect


June 2012


June 2013


May 2014


May 2015


August 2019

1b – Away from transect


June 2012


June 2013


May 2014


May 2015


August 2019

Reach 5, Transect 2

2a – Toward transect


June 2012


June 2013


May 2014


May 2015


August 2019

2a – Away from transect


June 2012


June 2013


May 2014


May 2015


August 2019

2b – Toward transect


June 2012


June 2013


May 2014


May 2015


August 2019

2b – Away from transect


June 2012


June 2013


May 2014


May 2015


August 2019

PEER REVIEW DOCUMENTATION

PROJECT AND DOCUMENT INFORMATION

Project Name San Joaquin River Restoration Project

WOID MLT19

Document Vegetation Monitoring along the San Joaquin River

Document Date September 2019

Team Leader Rebecca Siegle

Document Author(s)/Preparer(s) Rebecca Siegle, Scott O'Meara

Peer Reviewer Aaron Murphy

REVIEW CERTIFICATION

Peer Reviewer - I have reviewed the assigned Items/Section(s) noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Reclamation policy.

Reviewer: Aaron Murphy Review Date: September 2019 Signature: AARON MURPHY Digitally signed by AARON MURPHY Date: 2019.09.25 14:07:20 -06'00'

I have discussed the above document and review requirements with the Peer Reviewer and believe that this review is completed, and that the document will meet the requirements of the project.

Team Leader: Rebecca Siegle Date: 9/25/2019 Signature: REBECCA SIEGLE Digitally signed by REBECCA SIEGLE Date: 2019.09.25 13:59:14 -06'00'