Vegetation Response to Interim Flows in the San Joaquin River

Annual Report 2014

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

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Vegetation Response to Interim Flows in the San Joaquin River

Annual Report 2014

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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 (Act), Public Law 111-11, authorizes and directs 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 (Thompson 1961 as cited in Stillwater Sciences 2003a). Vegetation recruitment and survival were maintained through annual flooding via floodplain inundation, scour, and sediment deposition. Water availability during summer drought was the primary factor structuring vegetation establishment and distribution. This cycle of flooding and drought was – and still is – important to pioneer woody plant species, primarily willows (*Salix* spp.) and cottonwoods (*Populus* spp.), which rely on floods for bare seed beds, water, and nutrients, and which grow roots quickly to reach permanent water tables and a secure bank footing to resist subsequent floods (Braatne et al. 1996 as cited in Stillwater Sciences 2003a).

Riparian forests require periodic seedling recruitment and subsequent establishment to maintain the stand through time (Stillwater Sciences 2003a). 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, and valley oak woodland and savannah occupy the oldest and driest floodplain sites such as high terraces and cut banks. Riparian vegetation dynamics are tightly coupled with river processes. Along geomorphically active streams, cottonwoods and willows are typically among the first species to colonize bare stream banks and bars. These species, with traits such as high seed output and rapid growth rates, tend to establish in bands parallel to the channel, with the youngest stands occurring closest to the active channel (Gregory et al. 1991, McBride and Strahan 1984, Walker and Chapin 1986 as cited in Stillwater Sciences 2003a). Each band of vegetation represents a separate recruitment event. Over time, pioneer vegetation traps sediment and adds litter and nutrient inputs to floodplain soils (Walker and Chapin 1986 as cited in Stillwater Sciences 2003a). As the floodplain develops and the riparian stand ages, changes in microclimate (depth to groundwater, shade, temperature, 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 pioneers, 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 not as dependent on flow and sediment conditions as willows and cottonwoods.

Riparian vegetation along the San Joaquin 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 system. River regulation has created artificial hydrologic conditions, resulting in decreased peak flows, increased summer base flows, and reduction of physical processes such as scour and sediment deposition compared with historical conditions (Stillwater Sciences 2003a). 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 (Strahan 1984, McBain and Trush 2000, Stillwater Sciences 2001 as cited in Stillwater Sciences 2003a). 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 (Katibah 1984 as cited in Stillwater Sciences 2003a). The San Joaquin River historically supported a much wider riparian corridor than is present under current conditions.

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.

In order to evaluate the establishment and development of riparian vegetation in response to Interim 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 including the East Side and Mariposa Bypasses. Monitoring began within all sites in August 2011with the exception of Reach 5, where transects were established and monitored beginning in 2012. In 2014, transects within Reach 4A and Mariposa Bypass were removed from the study due to access limitations. Remaining transects were monitored annually. Hydrologic variables, including discharge and depth to groundwater as they relate to vegetation, were also incorporated in the monitoring program in 2013. Interim Flows were implemented in Water Year 2010; changes over the monitoring period beginning in 2011 were evaluated.

Project Area

Vegetation transects were located in several reaches of the SJRRP Restoration Area (reach descriptions from CDWR 2002):

Reach 1A – River mile (RM) 267-243; Friant Dam to Highway 99 bridge at Herndon. This reach has the greatest diversity of vegetation types (as defined by CDWR 2002) and the highest overall diversity of plant species. It is also the most urbanized region of the project area, and has more gravel extraction and the least number of confining levees of any of the reaches. Riparian oak forest and mixed riparian forest are more commonly encountered in Reach 1A than downstream. Herbaceous and exotic vegetation types account for two-thirds (66.8 percent) of the total natural vegetation mapped, while approximately one-quarter (26.8 percent) is riparian forest. Woody scrub makes up less than seven percent (6.5 percent) of the total natural vegetation. The most common natural habitat types found here are: herbaceous (2701 acres), mixed riparian forest (526 acres), riparian oak forest (289 acres), willow scrub (290 acres), wetland/marsh (247 acres), and willow riparian (233 acres). The ratio of habitat per river mile is 194.2 acres/mi. (In these reach descriptions, CDWR (2002) describes "habitat" as naturally occurring vegetation, which excludes agricultural fields, open water, anthropologically disturbed areas, or urban areas). In addition to woody exotic trees and giant reed (*Arundo donax*), scarlet wisteria (*Sesbania punicea*) is widespread in portions of Reach 1A. It has invaded wide areas of the floodplain in this and the subsequent Reach 1B, displacing willow scrub along the edge of the low-flow channel.

Reach 1B – RM 243-229; Highway 99 bridge to Gravelly Ford. This reach is more narrowly confined by levees than the upper section. The proportion of herbaceous and exotic vegetation is closer to one half of the total natural vegetation (55 percent), while the proportion of woody riparian vegetation is closer to one-third (30.6 percent) of the total and occurs mainly in narrow strips immediately adjacent to the river channel. Willow scrub is more abundant (14.3 percent) than in Reach 1A. Outside the levees and steep bluffs, the land use is nearly all agricultural. Scarlet wisteria was observed as far downstream as river mile 240. Giant reed patches are commonly encountered. The most abundant habitat types are herbaceous (300 acres) and mixed riparian (280 acres), followed by cottonwood riparian (193 acres), willow scrub (155 acres) and willow riparian (120 acres). This reach has the second lowest ratio of natural vegetation per mile—in 14 miles of channel, there is a little over one square mile of natural habitat (48 acres/mile).

Reach 2 (2A and 2B) – RM 229-205; Gravelly Ford to Mendota Pool. This reach is characterized by seasonal drying in the late summer and fall. The water table recedes into the porous substrate, creating a pronounced riparian drought nearly every year. There is about half as much riparian forest, proportionally, as in Reach 1 (15 percent of natural and naturalized vegetation), about the same proportion of woody scrub communities (13.5 percent) as Reach 1B, and more herbaceous vegetation (71 percent) than in Reach 1 overall. The most abundant habitat type by far is herbaceous (718.7 acres), followed by riparian scrub (302.8 acres), willow scrub (254.2 acres), riverwash (173.8 acres), willow riparian (165.4 acres), and cottonwood riparian forest (124.5 acres). The ratio of natural vegetation/river mile is 79.0 acres/mi., about 60 percent higher than in Reach 1B, but 40 percent of that in Reach 1A. Cultivated lands occupy nearly all the lands outside the river bottom. The character of the reach changes somewhat near Mendota Pool (RM 216-204). Downstream of the bifurcation structure at RM 216 (SW of which is found the large elderberry savanna), the riparian zone is very narrowly confined to a thin strip 3-10 meters wide bordering the channel. The herbaceous understory is however, very rich in native species and a high proportion of the total vegetative cover is native plants, possibly due to the exclusion of cattle and other domestic stock from these thin habitat strips.

Reach 3 – RM 205-182; Mendota Pool to Sack Dam. The reach is characterized by a continuous flow within a very confined channel, seasonally low water (although not as dry as Reach 2), and narrow strips of riparian habitat along the river's edge. Adjacent lands are mostly under cultivation, although the city of Firebaugh borders the river's west edge for 3 miles. This reach has the smallest proportion of herbaceous habitat (25.2 percent) and the highest proportion of riparian forest (53.7 percent). Willow scrub occupies 21 percent of the total extent of natural vegetation. The most common habitats are cottonwood riparian (460.8 acres), willow scrub (230.5 acres), herbaceous (174.4 acres), and willow riparian (124.8 acres). Forty-seven and one-half acres of natural vegetation were mapped for every river mile in this reach, equivalent to the ratio found for Reach 1B.

Reach 4B – RM 136 to 148; continues through public lands to the confluence with Bear Creek. Cultivated fields border approximately nine miles of the river's eastern bank. The floodplain is broad between widely spaced levees and the water table is nearer the surface than in some of the other reaches. These factors, along with a much lower level of disturbance to the native landscape on the public lands, create vast areas of natural habitat, compared to the upstream reaches. The ratio of natural habitat per river mile increases thirty-five-fold over that of Reach 4A (512.8 acres/mi.). The most common vegetation type by far in this reach is herbaceous vegetation (4175 acres), followed by willow riparian forest (701.2 acres), wetland/marsh (377.7 acres), and willow scrub (132.1 acres). Giant reed was not seen in this reach.

Reach 5 – RM 118 to 136; confluence with Bear Creek to the confluence with the Merced River. Eight miles of this reach are adjacent to cultivated lands on the eastern bank, while the rest is bordered by relatively undisturbed natural habitat of private duck clubs and State and federal lands designated as refuges and parks. The natural habitat mapped per mile is similar to that of Reach 4B: 508 acres/mi. The characteristic habitat type of this reach is herbaceous vegetation, with 7,239 acres spreading over the wide floodplains of the San Luis Wildlife Refuge and the North Grasslands Wildlife Area. Following in predominance are willow riparian (972.6 acres), wetland/marsh (532.02 acres), and willow scrub (86 acres). The amount of wetlands encountered in the 30 river miles of Reach 4B and Reach 5 total more than twice that contained in the 119 miles of Reaches 1 through 4A.

Methods

Vegetation Transects

In 2014, vegetation data was collected at eighteen permanent vegetation transects within river reaches 1A, 1B, 2A, 2B, 3, 4B2 (*i.e.* San Luis National Wildlife Refuge (NWR)), and the East Side Bypass (Figures 1 and 2). Due to the large project area (over 150 RM), it was feasible to locate and monitor two transects within each reach with the exception of the East Side Bypass, where four transects were placed, two of which were in the Merced NWR. Transects were placed in areas adjacent to the river channel within the historically active floodplain. These sites are subsequently subject to seasonal changes in water and nutrient input and scour and sediment deposition. These transects are not representative of vegetation types across entire reaches, but were chosen to identify potential vegetation change over time resulting from Interim Flows. Aerial photos of vegetation transects by river reach are shown in Appendix A.

Plant cover, composition, stem density, and overstory height were collected along each transect. Habitat variable ratings were determined for the area encompassing the transect. The length of each transect was determined by the extent of the floodplain and varied from 35 to 100 meters (m). Waypoints for each end of transects are listed in Appendix B. Forms used to collect data are included in Appendix C.

Timing

Monitoring was conducted annually 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.

Understory Vegetation

For understory measurements, cover and species composition were measured either every 0.5 or 1 m along the transect depending on the length of the transect. The point-intercept method was used, which entailed recording the first “hit” for herbaceous plants and for woody plants under 1 m tall by species (Figure 3). If a plant was not intercepted, then bare soil, litter, rock, or water were recorded. The location and extent of invasive weed species were documented when encountered.

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 (Figure 4). 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.

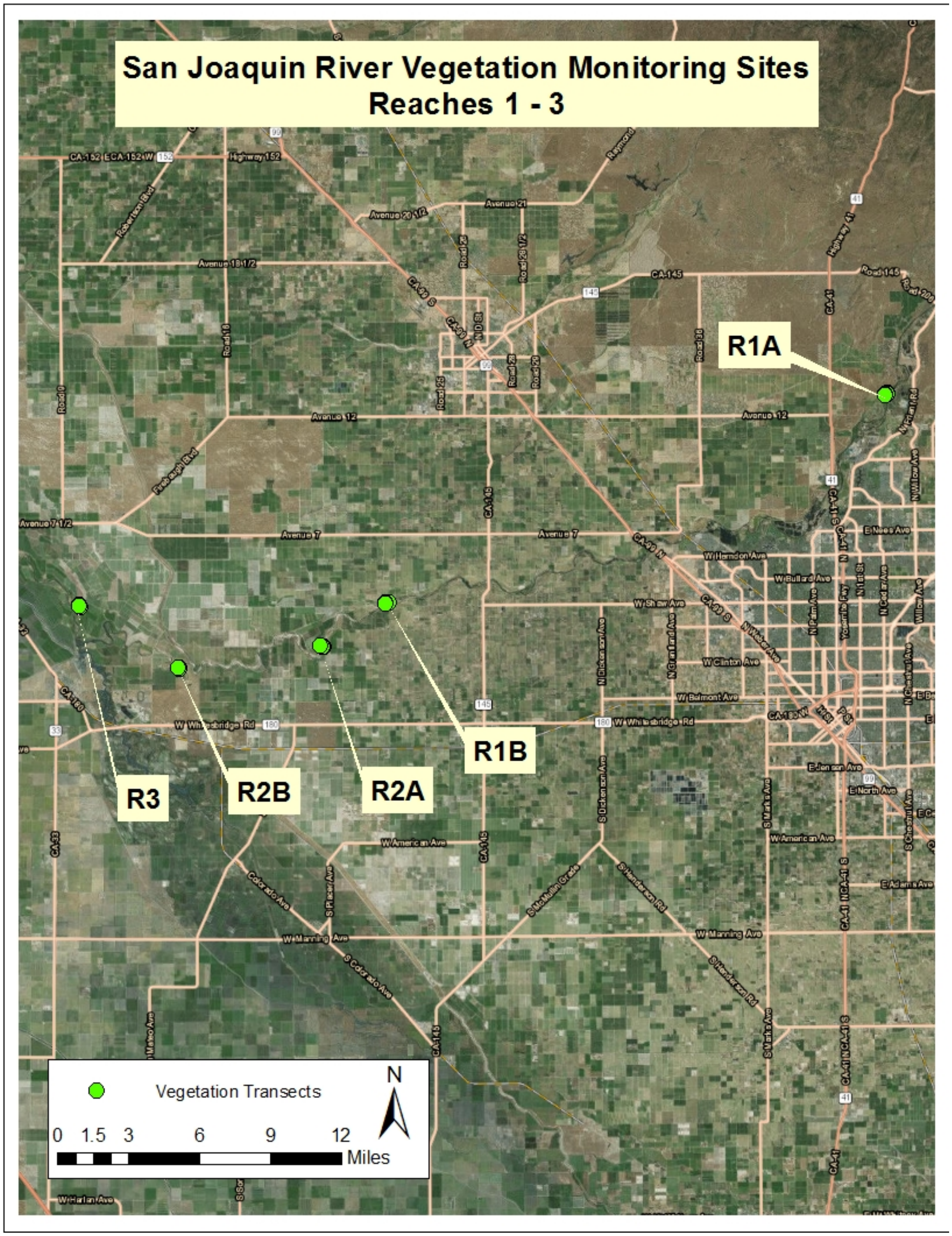

Figure 1.—Location of upstream vegetation transects in Reaches 1, 2, and 3 along the San Joaquin River.

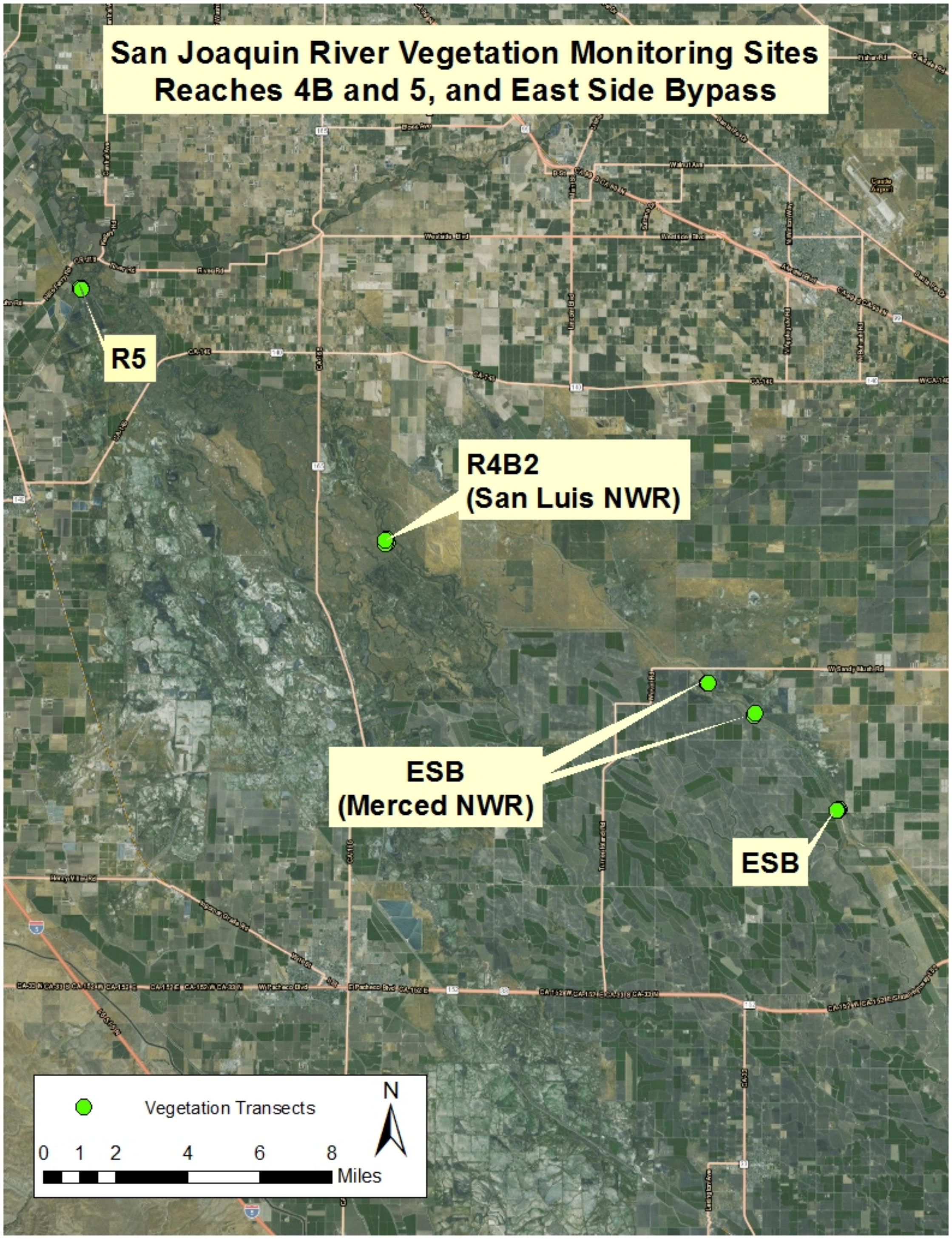

Figure 2.—Location of downstream vegetation transects in Reaches 4B2 and 5, and the East Side Bypass (ESB) along the San Joaquin River.

Figure 3—Measuring understory cover along transect.

Figure 4—Measuring overstory cover along transect.

Stem Density

Woody stem density was determined by using a meter stick to measure one meter outward on the upstream side of the transect. All woody stems within the one meter belt transect were counted and recorded by size into 4 classes by species (see Figure C-3 in Appendix C for descriptions of size classes).

Habitat Variables

A riparian systems model (Stein et al. 2000) was used to rank riparian condition. This qualitative model (riparian rank) includes spatial and structural diversity of native woody plants, contiguity of dominant vegetation, invasive woody vegetation, hydrology, topographic complexity, characteristics of flood-prone areas, and biogeochemical processing. These criteria consider the interaction between geology, hydrology, and organic and inorganic inputs to the system. Each criterion is scored between 0 and 1.0 and scores are added so that the "best" rank is an 8. See Figure C-4 in Appendix C for a listing of the variables and descriptions.

Statistical Analysis

Total cover and density data were compared between sampling periods for upstream reaches (Reaches 1 to 3) and downstream reaches (Reaches 4, 5, and Bypasses) to evaluate any statistically significant changes in vegetation over time. The repeated measures ANOVA was applied to test for relationships between cover or density and year, while Fisher's least significant difference (LSD) procedure was used as a multiple comparison test to evaluate statistically significant differences between years (alpha=0.05) utilizing StatGraphics statistical software. The Fisher's LSD analysis is a post-test to the repeated measures ANOVA and provides a more focused analysis of individual years. Primer (Plymouth Routines in Multivariate Ecological Research; see www.primer-e.com) statistical software was used to create a Bray-Curtis similarity matrix and MDS ordination to examine plant species composition between reaches and years.

Photo Stations

Two digital photographs were taken at each end of the transect – one 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 piezometers to measure groundwater levels in association with vegetation transects in Reach 2B following the 2012 vegetation monitoring season. Groundwater recession rates have been closely tied to riparian vegetation establishment and survival in the San Joaquin Valley and elsewhere (Stillwater Sciences 2003b). Groundwater data from wells installed near transects will be used to determine if any correlations are observed between growth and development of vegetation and water table levels.

Results

Vegetation Transects

See Appendix D for a plant list of all herbaceous and woody species detected in transects within all reaches over 4 years of monitoring.

Timing

Vegetation transects were sampled June 11-14, 2012 and June 24-27, 2013 approximately 5-7 weeks earlier than the August 1-4 sampling in 2011. In 2011, Friant Dam was in flood operations through mid-July and monitoring was not feasible until relatively late in the summer due to high river levels and inundated sites. In 2014, vegetation monitoring took place from May 9-13 – much earlier than all other years – due to drought conditions.

The extreme differences in river discharges between years can be seen in Figure 5, which shows the hydrograph for Water Year 2011 to 2014 along the San Joaquin River approximately 3.7 kilometers (2.3 miles) downstream of Friant Dam. Despite temporal differences in discharge, river levels were similar in August of 2011 and June of 2012 and 2013. River discharge was extremely low from February through May in 2014 before dam releases for irrigation flows at the end of May.

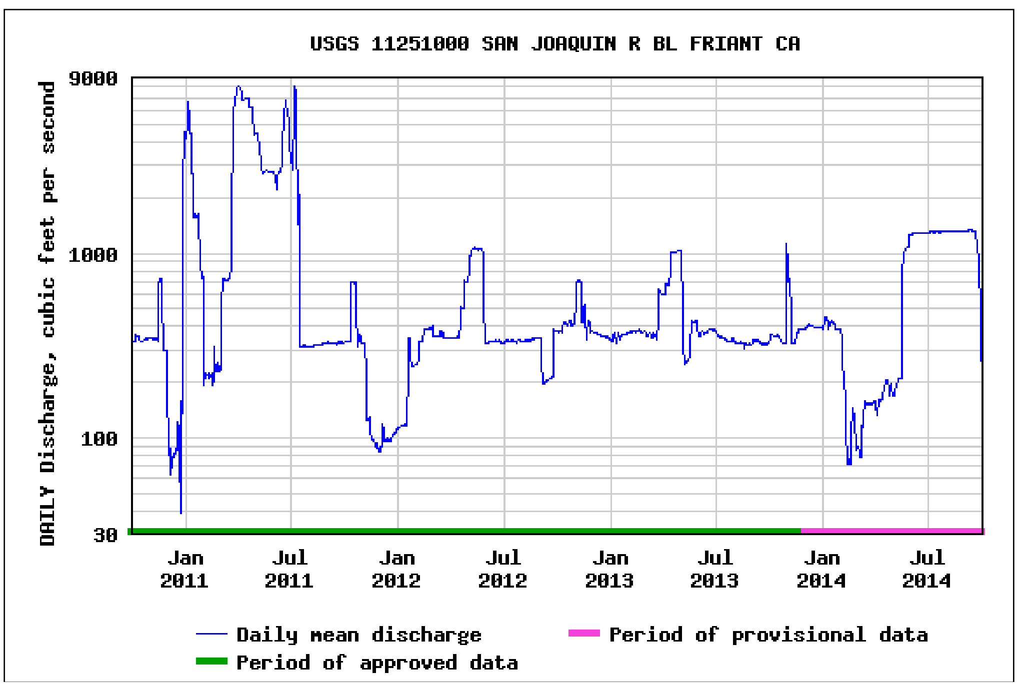

Figure 5.—San Joaquin River discharge (cfs) measured at USGS gage 11251000 below Friant, California for Water Years 2011 to 2014. Source: United States Geological Survey.

Understory Vegetation

Ninety annual and perennial species were identified while measuring understory vegetation along transects in all river reaches combined over 4 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, rock, water) found in the understory layer are shown for upstream Reaches 1A, 1B, 2A, 2B, and 3 in Table E-1, Appendix E and for downstream Reaches ESB, 4B2, and 5 in Table E-2, Appendix E. A summary of total percent cover in the understory layer by cover type is shown in Table 1 for each reach.

Trends in understory cover were variable among reaches over the monitoring period from 2011 to 2014. Total plant cover increased in association with an increase in introduced species cover in Reaches 1A, 1B, and 5. Total plant cover decreased in association with decreasing native plant cover in Reaches 2B, 3, and 4B2 and in association with decreasing introduced plant cover in ESB. There was essentially no change in total plant cover in Reach 2A. Litter either changed little or increased except in Reach 5, while bare ground either changed little or decreased except in Reach 2A.

Species richness – or the number of species detected along the transect incorporating all measurement methods – was highest in Reach 4B2 in 2014, where 16 different herbaceous plant species were detected, followed by Reach 1A where 15 herbaceous species were detected (Table 2). Species richness was consistently at 16 in Reach 4B2 over the 4 years, although most species identified were introduced.

Relative percent understory cover of lifeforms by reach is shown in Figure 6. In 2011, native forbs were generally the most common lifeforms detected. Dominant lifeforms shifted to primarily introduced grasses in the upper reaches from 2012 to 2014 with the exception of Reach 2B, where introduced forbs were most common. In lower Reaches 4B2 and ESB, native grasses were typically dominant while introduced forbs comprised the largest proportion of lifeforms documented in Reach 5. Native species were dominant relative to introduced species among understory plants in all reaches in 2011; however this trend shifted in 2012, when relative cover of introduced species was higher than native species in all reaches with the exception of the East Side Bypass and 4B2, where relative cover of native species typically remained dominant over the monitoring period (Table 3).

Table 1.—Average total percent cover by type in the understory layer of vegetation transects along the San Joaquin River from 2011 to 2014.

Average Total Percent Understory Cover	River Reach															
	1A				1B				2A				2B			
	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014
Native Plant Cover	14.5	7.5	15.5	16.5	9.5	4.0	10.5	9.0	9.0	2.5	2.5	1.0	19.1	6.3	14.8	3.2
Introduced Plant Cover	8.5	41.0	40.0	46.5	2.5	16.5	16.5	13.5	10.0	17.5	24.0	14.0	6.7	19.3	14.2	4.1
Total Plant Cover	23.0	48.5	55.5	63.0	12.0	20.5	27.0	22.5	19.0	20.0	26.5	15.0	25.8	25.6	29.0	7.3
Litter	33.5	39.0	39.0	31.5	20.0	40.5	42.5	51.5	16.5	17.5	15.5	23.5	22.9	32.8	33.3	42.3
Bare	37.0	6.0	2.5	2.5	55.0	32.5	30.5	26.0	45.0	43.0	58.0	61.5	51.3	41.6	37.8	50.4
Rock	6.0	5.0	2.5	3.0	13.0	6.5	0.0	0.0	19.5	19.5	0.0	0.0	0.0	0.0	0.0	0.0
Water	0.5	1.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Cover	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	3				ESB				4B2				5			
	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014	2012	2013	2014	
Native Plant Cover	60.4	13.6	17.7	15.4	29.8	25.2	21.5	25.8	41.5	28.8	40.3	34.1	19.5	11.0	6.5	
Introduced Plant Cover	13.0	17.9	43.1	23.5	17.5	18.5	15.5	9.0	39.9	37.9	31.4	29.3	26.0	34.0	62.0	
Total Plant Cover	73.4	31.5	60.8	38.9	47.3	43.7	37.0	34.8	81.4	66.7	71.7	63.4	45.5	45.0	68.5	
Litter	16.0	56.9	34.5	54.1	22.7	39.5	49.3	48.5	11.8	32.8	28.4	36.1	42.0	49.0	30.0	
Bare	10.6	11.6	4.8	7.0	30.0	16.8	13.8	16.8	6.8	0.5	0.0	0.5	12.5	6.0	1.5	
Total Cover	100.0	100.0	100.0	100.0	100.0	100.0	100.1	100.1	100.0	100.0	100.1	100.0	100.0	100.0	100.0	

Table 2.—Species richness (number of species detected) for herbaceous and woody plants by reach along the San Joaquin River from 2011 to 2014.

Species Richness																								
	Number of herbaceous species detected												Number of woody species detected											
	Total				Native				Introduced				Total				Native				Introduced			
Reach	**2011**	**2012**	**2013**	**2014**	**2011**	**2012**	**2013**	**2014**	**2011**	**2012**	**2013**	**2014**	**2011**	**2012**	**2013**	**2014**	**2011**	**2012**	**2013**	**2014**	**2011**	**2012**	**2013**	**2014**
1A	13	12	14	15*	8	6	7	8	5	6	7	6	6	6	6	6	6	6	6	6	0	0	0	0
1B	3	6	7*	7	1	3	3	4	2	3	3	3	6	6	6	6	4	4	4	4	2	2	2	2
2A	15	10	8	5	7	4	2	1	8	6	6	4	2	3	3	2	1	2	2	2	1	1	1	0
2B	8	10	12	6*	5	4	7	2	3	6	5	3	3	4	4	4	3	4	4	4	0	0	0	0
3	14	4	11	4	10	1	4	2	4	3	8	2	2	2	2	3	2	2	2	3	0	0	0	0
ESB	16	16*	20*	11	9	7	8	8	7	6	11	3	1	0	0	0	1	0	0	0	0	0	0	0
4B2	16	16	16	16*	8	6	7	6	8	10	9	9	1	1	1	1	1	1	1	1	0	0	0	0
5	na	19*	12	6	na	8	8	3	na	7	4	3	na	1	1	1	na	1	1	1	na	0	0	0

*Includes unidentified plants; native/introduced status not determined

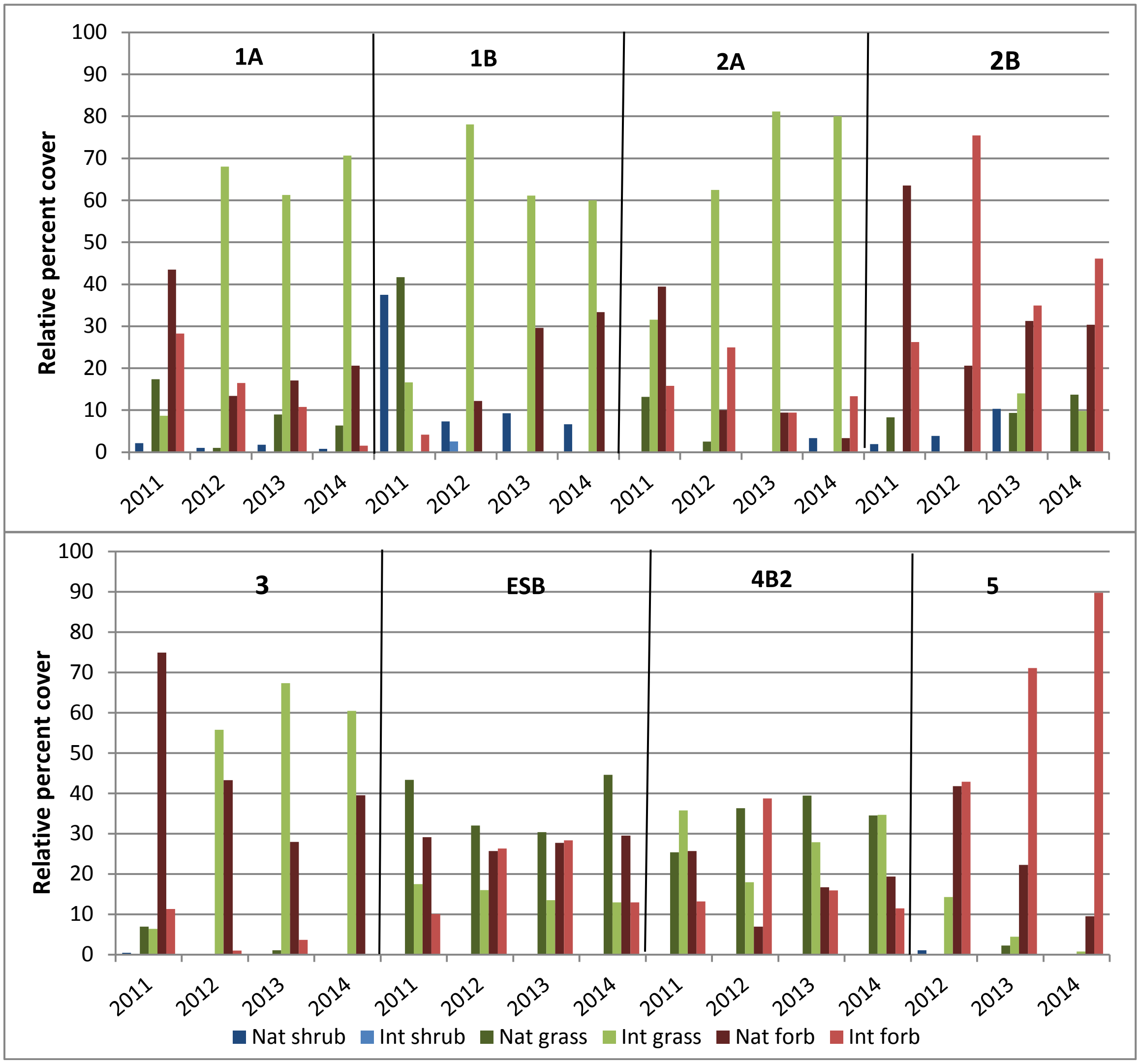

Figure 6.—Relative percent understory cover of lifeforms in vegetation transects by reach along the San Joaquin River from 2011 to 2014.

Table 3.— Proportion of native and introduced species in the understory and overstory layers by reach along the San Joaquin River from 2011 to 2014.

Relative Percent Cover																
	Understory layer								Overstory layer							
	Native spp				Introduced spp				Native spp				Introduced spp			
Reach	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014
1A	63	16	28	28	37	84	72	72	100	100	100	100	0	0	0	0
1B	79	22	39	40	21	78	61	60	82	82	77	70	18	18	23	30
2A	53	13	9	7	47	87	91	93	100	100	100	100	0	0	0	0
2B	74	25	51	44	26	75	49	56	100	100	100	100	0	0	0	0
3	82	43	29	40	18	57	71	60	100	100	100	100	0	0	0	0
ESB	51	58	58	74	49	42	42	26	100	no overstory			0	no overstory		
4B2	68	43	56	54	32	57	44	46	100	100	100	100	0	0	0	0
5	NA	43	24	9	NA	57	76	91	NA	100	100	100	NA	0	0	0

Overstory Vegetation

There were 12 woody species detected in the overstory layer (woody species > 1m in height) of all transects combined (Table 4). There was little change in total overstory cover from 2011 to 2014 in any reach except 2B, where cover increased from 7.2 to 21.4 percent (Table 4). In 2014, total percent overstory cover was highest in the most downstream reach 5 (68.0 percent) followed by the uppermost reaches 1A and 1B, with estimates of 50.5 and 51.9 percent, respectively. The average height of the tallest overstory shrubs/trees within each stretch by species is also shown in Table 4.

In general, woody species richness was directly related to proximity to Friant Dam, with only upstream Reaches 1A, 1B, and 2B having more than 2 woody species in the plant composition (Table 2).

The vast majority of overstory trees and shrubs were comprised of native species relative to introduced (Table 3). The only overstory introduced species recorded were giant reed (technically a grass but also categorized as a shrub; USDA - NRCS 2012) and scarlet wisteria. Both were documented in overstory measurements in Reach 1B; scarlet wisteria was also noted in density measurements in Reach 2A.

Stem Density

Density of woody plants by size class and species is listed in Table 5. No stems were detected in the one meter belt associated with transects in Reach 4B2 and the East Side Bypass. Highest densities were found in upstream Reaches 1A, 1B, and 2B in all years. Of these, Reach 1B had the highest density in 2013 and 2014 (4.68 and 3.77 stems / m^2, respectively), after a decrease in 2012. The relatively high number of stems in 2013 and 2014 were mostly due to beaver browse of Goodding’s willow that resulted in numerous resprouts. Within this reach, most stems were willow of size classes 2 and 3. Densities in Reach 2B decreased somewhat substantially in 2013 from 3.62 to 1.32 stems/m^2 (mostly reductions in the number of Goodding’s willow stems), although densities increased to 2.23 stems/m^2 in 2014 (mostly related to increases in size class 2 Goodding’s willow). The greatest contributor to the relatively high stem densities in Reach 1A in 2013 and 2014 were oak seedlings (size class 1).

Habitat Variables

The highest ranking habitat variables (>7.0) were found in the uppermost Reaches 1A and 1B, and in the lowermost Reach 5 in 2014 (Table 6). These sites were rated relatively close to the highest possible ranking of 8.0, which indicates excellent riparian condition. Reaches with a moderate ranking (between 5.0 and 7.0) were 2B and 4B2. All other reaches ranked between 3.4 and 4.65. These sites typically ranked relatively low in variables “Coverage and Spatial Diversity”, “Structural Diversity”, “Micro- and Macrotopographic Complexity”, and “Biogeochemical Processes”. Changes in habitat variables from 2011 to 2014 differed among reaches with the greatest difference in Reach 3 (decrease of 1.2); no reach had an increase in habitat variable ranking except Reach 5, which was considered to improve by 0.3 over the monitoring period.

Table 4.— Total percent cover and average height of woody overstory species (>1 m) detected in vegetation transects within reaches along the San Joaquin River from 2011 to 2014.

	Reach	1A				1B				2A				2B				3			
Species	**Year**	**2011**	**2012**	**2013**	**2014**	**2011**	**2012**	**2013**	**2014**	**2011**	**2012**	**2013**	**2014**	**2011**	**2012**	**2013**	**2014**	**2011**	**2012**	**2013**	**2014**
Native Species																					
White alder	**Tot % cov**	0.6	0	2.0	4.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Avg. Ht. (m)	4.3		4.3	5.3																
Button bush	**Tot % cov**	7.1	9.0	5.3	4.7	7.6	7.8	8.8	8.6	0	0	0	0	0	0	0	0	0	0	0	0
	Avg. Ht. (m)	2.2	3.4	2.9	3.6	2.4	2.7	3.2	2.5												
Oregon ash	**Tot % cov**	8.9	17.6	16.3	16.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Avg. Ht. (m)	10.3	15.0	10.1	9.7																
Fremont cottonwood	**Tot % cov**	0	0	0	0	4.1	2.7	2.9	2.7	0	0	0	0	0	0	0.2	0.2	16.7	14.4	13.7	12.6
	Avg. Ht. (m)					2	3.7	4.1	3.7								1.6	15.0	15.0	23.0	18.0
Valley oak	**Tot % cov**	21.1	20.0	21.7	23.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Avg. Ht. (m)	12.1	21.3	14.6	17.6																
Sandbar willow	**Tot % cov**	5.7	9.4	6.3	6.3	22.1	28.3	21.0	17.8	0	0	1.5	2	0	0	0.7	0.9	0	0	0	0
	Avg. Ht. (m)	2.2	2.4	2.7	3.3	2.8	2.8	2.4	2.3			1.4	1.8				1.7				
Gooding's willow	**Tot % cov**	0	0	0	0	11.8	12.7	12.8	9.9	1.1	0.9	2.3	3.2	4.4	12.5	10.3	13.0	0.8	2.8	7.2	6.8
	Avg. Ht. (m)					3.5	3.5	2.8	2.1	3.9	4.1	5.1	5.3	5.9	6.0	3.0	2.7	3.0	3.0	3.6	4.6
Arroyo willow	**Tot % cov**	4.7	5.5	8.6	7.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Avg. Ht. (m)	4.9	3.8	4.1	4.0																
Black elderberry	**Tot % cov**	0	0	0	0	0	0	0	0	0	0	0	0	2.8	6.9	7.3	7.3	0	0	0	0
	Avg. Ht. (m)													4.2	4.8	5.7	5.5				
Quailbush	**Tot % cov**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6
	Avg. Ht. (m)																				2.0
	Total native	48.0	61.5	60.2	61.8	45.5	51.5	45.5	39.0	1.1	0.9	3.8	5.2	7.2	19.4	18.5	21.4	17.4	17.2	20.9	20.0
Introduced species																					
Giant reed	**Tot % cov**	0	0	0	0	9.8	9.5	9.1	12.4	0	0	0	0	0	0	0	0	0	0	0	0
	Avg. Ht. (m)					4.4	5.2	5.1	6.9												
Scarlet wisteria	**Tot % cov**	0	0	0	0	0.3	1.6	4.4	3.4	0	0	0	0	0	0	0	0	0	0	0	0
	Avg. Ht. (m)					1.3	1.7	1.8	2.2												
	Total introduced	0	0	0	0	10.1	11.1	13.5	15.8	0	0	0	0	0	0	0	0	0	0	0	0
	Total canopy*	**45.2**	**46.7**	**44.5**	**50.5**	**54.9**	**58.9**	**58.2**	**51.9**	**1.1**	**0.9**	**3.8**	**5.2**	**7.2**	**19.4**	**18.4**	**20**	**17.4**	**16.1**	**18.3**	**42.2**

	Reach	ESB				4B2				5		
Species	**Year**	**2011**	**2012**	**2013**	**2014**	**2011**	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
Native Species												
Gooding's willow	**Tot % cov**	0.2	0	0	0	9.3	8.5	9.5	10.5	62.8	70.8	68.0
	Avg. Ht. (m)	na				8.6	10.5	10.2	9.9	4.4	6.0	5.4
	Total native & total canopy	**0.2**	**0.0**	**0.0**	**0.0**	**9.3**	**8.5**	**9.5**	**10.5**	**62.8**	**70.8**	**68.0**

*Total canopy may not equal sum of all species due to overlap

Table 5.—Density of woody plant species by size class and species in river reaches along the San Joaquin River from 2011 to 2014.

Average # stems/m^2

		Reach											
	Size	1A				1B				2A			
Species	class*	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014
Giant reed	1	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
	3	0	0	0	0	0.22	0.12	0.07	0.01	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0
Button bush	1	0.01	0	0	0	0.01	0	0	0	0	0	0	0
	2	0.07	0.14	0.01	0	0.22	0.16	0.02	0.16	0	0	0	0
	3	0.18	0.15	0.05	0	0.28	0.12	0.25	0.28	0	0	0	0
	4	0.02	0	0	0	0	0	0	0	0	0	0	0
Oregon ash	1	0.04	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0.05	0.03	0	0	0	0	0	0	0	0
	3	0.01	0	0.04	0.03	0	0	0	0	0	0	0	0
	4	0.01	0.02	0.01	0.01	0	0	0	0	0	0	0	0
Valley oak	1	0.01	0	1.79	0.63	0	0	0	0	0	0	0	0
	2	0	0	0	0.04	0	0	0	0	0	0	0	0
	3	0.01	0.01	0.01	0.01	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
Sandbar willow	1	0.01	0.04	0	0	0	0	0	0	0.19	0	0	0
	2	0.14	0.02	0.05	0.03	2.49	0.84	0.35	0.44	0.04	0.04	0.02	0.01
	3	0.31	0.61	0.28	0.41	1.14	0.95	1.75	0.75	0	0	0	0.04
	4	0.02	0	0	0	0.01	0	0	0.01	0	0	0	0
Gooding's willow	1	0	0	0	0	0	0	0	0	0	0.13	0	0
	2	0	0	0	0	0	0	2.04	2.02	0	0.12	0	0.04
	3	0	0	0	0	0.05	0.16	0.17	0.06	0	0	0	0.01
	4	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
	2	0.22	0.05	0.36	0.16	0	0	0	0	0	0	0	0
	3	0	0.10	0.03	0.08	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0
Scarlet wisteria	1	0	0	0	0	0	0	0	0	0.02	0.02	0.02	0
	2	0	0	0	0	0.02	0.01	0	0	0	0	0	0
	3	0	0	0	0	0	0	0.03	0.04	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0
Total by size class	1	0.10	0.04	1.79	0.63	0.01	0.00	0.00	0.00	0.21	0.15	0.02	0.00
	2	0.43	0.20	0.47	0.25	2.73	1.01	2.41	2.62	0.04	0.16	0.02	0.05
	3	0.50	0.87	0.41	0.52	1.69	1.35	2.27	1.14	0.00	0.00	0.00	0.05
	4	0.06	0.03	0.02	0.02	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00
TOTAL stems/m^2		**1.08**	**1.13**	**2.68**	**1.42**	**4.44**	**2.36**	**4.68**	**3.77**	**0.25**	**0.31**	**0.04**	**0.10**

		Reach										
	Size	2B				3				5		
Species	class*	2011	2012	2013	2014	2011	2012	2013	2014	2012	2013	2014
Fremont cottonwood	1	0	0	0	0	0	0	0	0	0	0	0
	2	0	0.07	0.02	0.13	0.07	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0
Sandbar willow	1	0.01	0.02	0.01	0	0	0	0	0	0	0	0
	2	0	0.11	0.06	0	0	0	0	0	0	0	0
	3	0	0.05	0.17	0.11	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0
Gooding's willow	1	1.56	0.80	0	0	0	0	0	0	0	0	0
	2	0	1.78	0.38	1.43	0	0	0	0	0.76	0	0.09
	3	0.06	0.68	0.46	0.38	0.04	0.04	0.01	0.01	0.58	0.72	0.35
	4	0	0	0	0	0	0	0	0	0	0.01	0
Black elderberry	1	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0
	3	0.32	0.10	0.21	0.18	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0
Total by size class	1	1.57	0.82	0.01	0.00	0	0	0	0	0	0	0
	2	0.00	1.96	0.47	1.56	0.07	0	0	0	0.76	0	0.09
	3	0.38	0.83	0.84	0.67	0.04	0.04	0.01	0.01	0.58	0.72	0.35
	4	0.00	0.00	0.00	0.00	0	0	0	0	0	0.01	0
TOTAL stems/m^2		**1.95**	**3.62**	**1.32**	**2.23**	**0.11**	**0.04**	**0.01**	**0.01**	**1.34**	**0.73**	**0.44**

*Size class:

1= current year's seedling; 2= <1 m in ht; 3= >1 m in ht and <10 cm DBH; 4= >10 cm DBH

Table 6.—Ranking of habitat variables as an indicator of riparian condition by reach along the San Joaquin River from 2011 to 2014.

Reach	Year	Coverage & Spatial Diversity	Structural Diversity	Contiguity of Habitats	% Invasive Woody Vegetation	Hydrology	Micro- & Macrotopographic Complexity	Characteristics of Flood-prone Area	Biogeochemical Processes	**Total Score***
1A	**2011**	1.00	0.70	1.00	1.00	1.00	1.00	1.00	0.90	**7.60**
	2012	0.90	0.65	1.00	1.00	1.00	0.80	1.00	0.90	**7.25**
	2013	0.95	0.75	0.95	1.00	1.00	0.90	1.00	0.90	**7.45**
	2014	1.00	0.70	0.90	1.00	0.90	0.90	0.80	1.00	**7.20**
1B	**2011**	1.00	0.75	0.80	0.90	1.00	0.85	1.00	0.80	**7.10**
	2012	1.00	0.85	1.00	0.90	1.00	0.90	1.00	0.95	**7.60**
	2013	1.00	0.80	0.90	1.00	1.00	1.00	1.00	0.95	**7.65**
	2014	1.00	0.70	0.80	0.80	0.90	0.90	1.00	1.00	**7.10**
2A	**2011**	0.25	0.25	0.80	1.00	1.00	0.80	0.90	0.35	**5.35**
	2012	0.40	0.40	0.90	1.00	1.00	0.50	1.00	0.30	**5.50**
	2013	0.35	0.40	0.80	1.00	1.00	0.95	1.00	0.40	**5.90**
	2014	0.45	0.40	0.80	1.00	0.60	0.20	0.70	0.50	**4.65**
2B	**2011**	0.25	0.40	0.90	1.00	1.00	0.35	0.90	0.30	**5.10**
	2012	0.40	0.40	0.90	1.00	1.00	0.70	0.90	0.50	**5.80**
	2013	0.75	0.40	0.80	1.00	1.00	0.95	1.00	0.70	**6.55**
	2014	0.55	0.60	0.70	1.00	0.55	0.50	0.80	0.60	**5.30**
3	**2011**	0.45	0.60	0.65	1.00	0.80	0.70	0.80	0.60	**5.60**
	2012	0.55	0.50	0.80	1.00	0.90	0.25	0.70	0.50	**5.20**
	2013	0.40	0.40	0.80	1.00	0.60	0.35	0.45	0.50	**4.50**
	2014	0.35	0.40	1.00	1.00	0.60	0.25	0.30	0.50	**4.40**
ESB	**2011**	0.18	0.18	0.90	1.00	0.50	0.28	0.83	0.40	**4.25**
	2012	0.23	0.25	0.90	1.00	0.30	0.28	0.33	0.28	**3.55**
	2013	0.25	0.18	0.80	1.00	0.30	0.20	0.40	0.30	**4.53**
	2014	0.23	0.25	0.80	1.00	0.28	0.28	0.28	0.30	**3.40**
4B2	**2011**	0.40	0.40	0.80	1.00	0.70	0.50	0.80	0.60	**5.20**
	2012	0.40	0.40	0.90	1.00	0.60	0.45	0.80	0.40	**4.95**
	2013	0.30	0.40	1.00	1.00	0.60	0.50	0.45	0.45	**4.70**
	2014	0.50	0.40	0.80	1.00	0.70	0.60	0.80	0.50	**5.30**
5	**2012**	0.50	0.70	1.00	1.00	1.00	0.90	1.00	1.00	**7.10**
	2013	0.40	0.80	1.00	1.00	0.95	0.90	0.80	1.00	**6.85**
	2014	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	**7.40**

* Possible score 0 (Poor) to 8 (Excellent)

Statistical Analysis

Statistical comparisons of total cover and stem density between years were performed on upstream reaches (Reaches 1A to 3) and downstream reaches (Reaches 4B2, 5, and East Side Bypass) separately. This division of areas was based on MDS ordination of species composition similarities between reaches (Figure 7). MDS ordination ranks similarities and the associated configuration can be interpreted in terms of relative similarity of samples to each other (Clarke et al 2014). For example, in this case it can be interpreted that species composition in Reach 2A was more similar to 2B and 3 than to 1A or ESB, while ESB is very different from 1B. Stress is the measure of distortion in the configuration. A stress factor of <0.5 gives an excellent representation; MDS

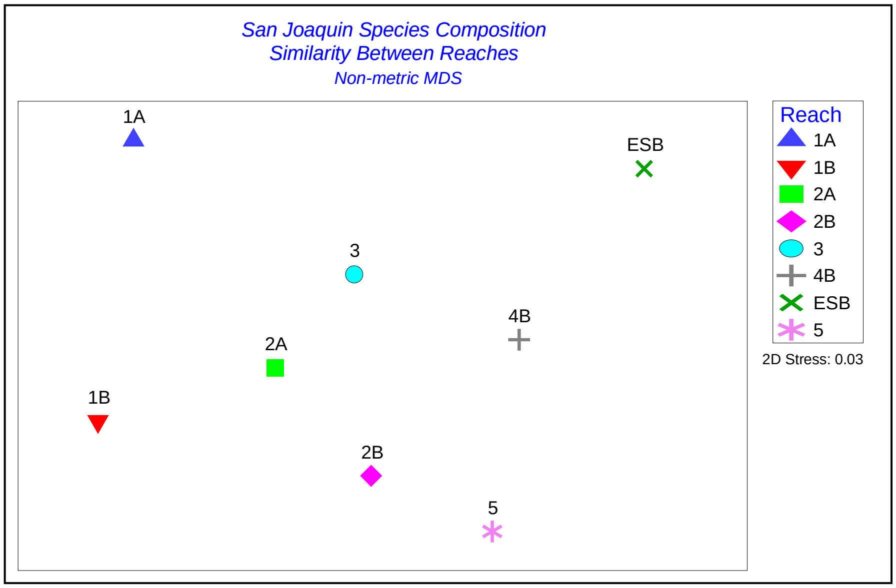

Figure 7.— MDS ordination of sample sites (i.e. reaches) using Bray-Curtis similarities of plant species based on fourth root transformation of total percent cover data along the San Joaquin River in years 2011 to 2014.

analysis of this data had a 2-dimensional stress of 0.03. There is a general division between the upper reaches (to the left on the graph in Figure 7) and lower reaches (to the right).

In the upstream reaches, repeated measures ANOVA identified statistical differences in total cover of litter (significantly less in 2011 than 2012 and 2014) and in total cover of introduced understory species (significantly less in 2011 than in both 2012 and 2013; Table 7). Fisher's LSD test also indicated that native understory was significantly greater in 2011 than in 2012 and 2014. The only statistical difference identified in downstream reaches using repeated measures ANOVA was significantly less litter cover in 2011 than in other years. Fisher's LSD also found that bare ground was greater in 2011 than in 2013 and 2014.

Analysis using a Bray-Curtis similarity matrix found that species composition among all reaches was statistically different across all years ($P<0.001$). Statistical comparisons of species composition between years across all reaches indicated that 2011 was significantly different than all other years ($P=0.005$).

MDS ordination of species similarity including all monitoring areas by year is shown in Figure 8. This perspective demonstrates the relationship of species similarity between reaches and over time. All reaches are clearly distinct from another (with some overlap in Reaches 2B and 5 but at different times) and year 2011 is more distant from other years within each reach. The 2- dimensional stress in this ordination is 0.2, which provides an excellent representation.

Table 7.— Statistical results comparing total plant cover and density over time for various parameters in upstream and downstream reaches of the San Joaquin River. Alpha = 0.05.

Upstream Reaches (1-3) n=10		
	Repeated measures ANOVA	**LSD**
Parameter	**P-value**	**Significant difference (P<0.05)**
Total cover		
Plant	P=0.624	No difference
Litter	P=0.018	11<12 and 14
Bare	P=0.558	No difference
Native understory	P=0.063	11>12 and 14
Introduced understory	P=0.048	11<12 and 13
Overstory	P=0.859	No difference
Salix spp	P=0.923	No difference
Density		
Total	P=0.993	No difference
Salix spp	P=1.00	No difference
Downstream Reaches (4B2, 5 and ESB) n=8		
	Repeated measures ANOVA	**LSD**
Parameter	**P-value**	**Significant difference (P<0.05)**
Total cover		
Plant	P=0.684	No difference
Litter	P<0.008	11< All other years
Bare	P=0.092	11>13 and 14
Native understory	P=0.421	No difference
Introduced understory	P=0.983	No difference
Overstory	P=0.646	No difference
Salix spp	P=0.691	No difference
Density		
Total	P=0.437	No difference
Salix spp	P=0.437	No difference

Highlighted boxes = significant difference at the 95% confidence level

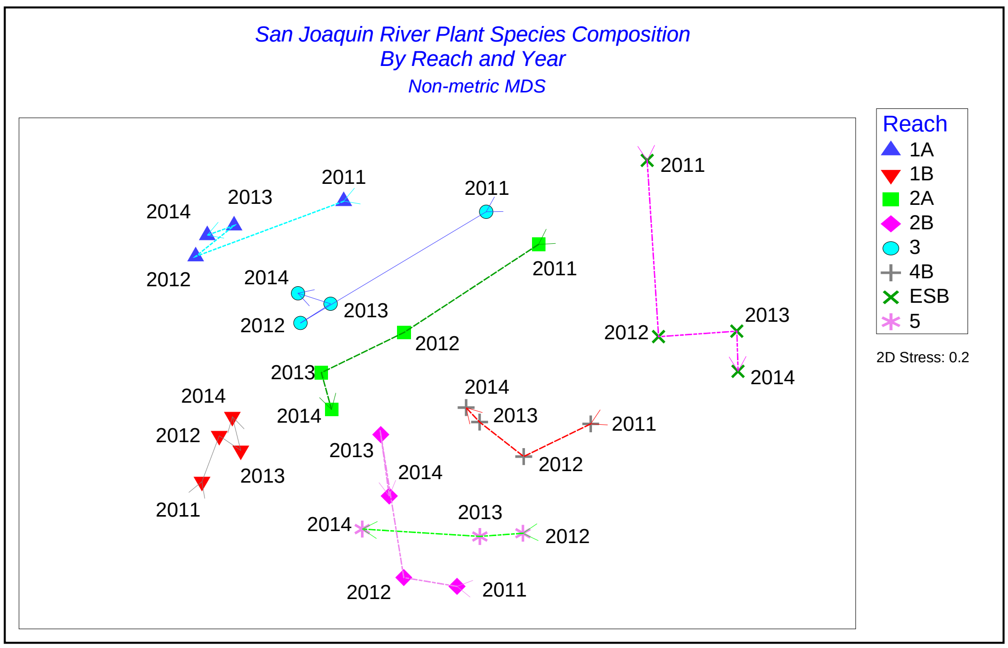

Figure 8.— MDS ordination of sample sites (i.e. reaches) by year using Bray-Curtis similarities of plant species based on fourth root transformation of total percent cover data along the San Joaquin River in years 2011 to 2014.

Photo Stations

Photographs taken from the end of vegetation transects the first four years of monitoring are shown in Appendix F. Differences in vegetation along transects within many of the reaches are evident when comparing the photos from 2011 (a very wet year) to photos from the other 3 years. In 2014, a very dry year, foliage on overstory species appears to show signs of stress.

Groundwater Monitoring

Groundwater wells from 2 locations were examined in relation to vegetation transects. Piezometers were installed in association with transects in Reach 2B in February 2013 (PZ-7 and PZ-8 in Figure 9). The hydrograph in Figure 10 shows groundwater depths at these wells from March through December 2013 and May to November 2014 and uses flow data gathered at Station SJB (approximately 1.5 mi upstream) and Station SJN (approximately 2 mi downstream). A correlation between flows and the depth of the water table is apparent, which indicates connectivity of the floodplain and river. In well PZ7, which is located in the floodplain, the water table remained less than 4 ft from the surface when the channel held water and <1 ft when flows reached around 700 cfs or higher. From March to December 2013, ground water within the floodplain (PZ7) remained at a shallow enough depth (<4 ft) necessary to sustain woody riparian plant species (Figure 10). In 2014, the river was completely dry in Reach 2b from mid-February to late May and groundwater levels reflected this, falling below piezometer sensor levels in the wells (sensors were placed at approximately 5.3 and 8.5 ft below surface level in wells PZ07 and PZ08, respectively). 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

Figure 9.—Locations of wells PZ-7 (floodplain), PZ-8 (upper terrace) and 13-3 (floodplain); staff gauges SJN and SJB; and vegetation transects 1 and 2 within Reaches 2A and 2B. Google Earth imagery April 2014.

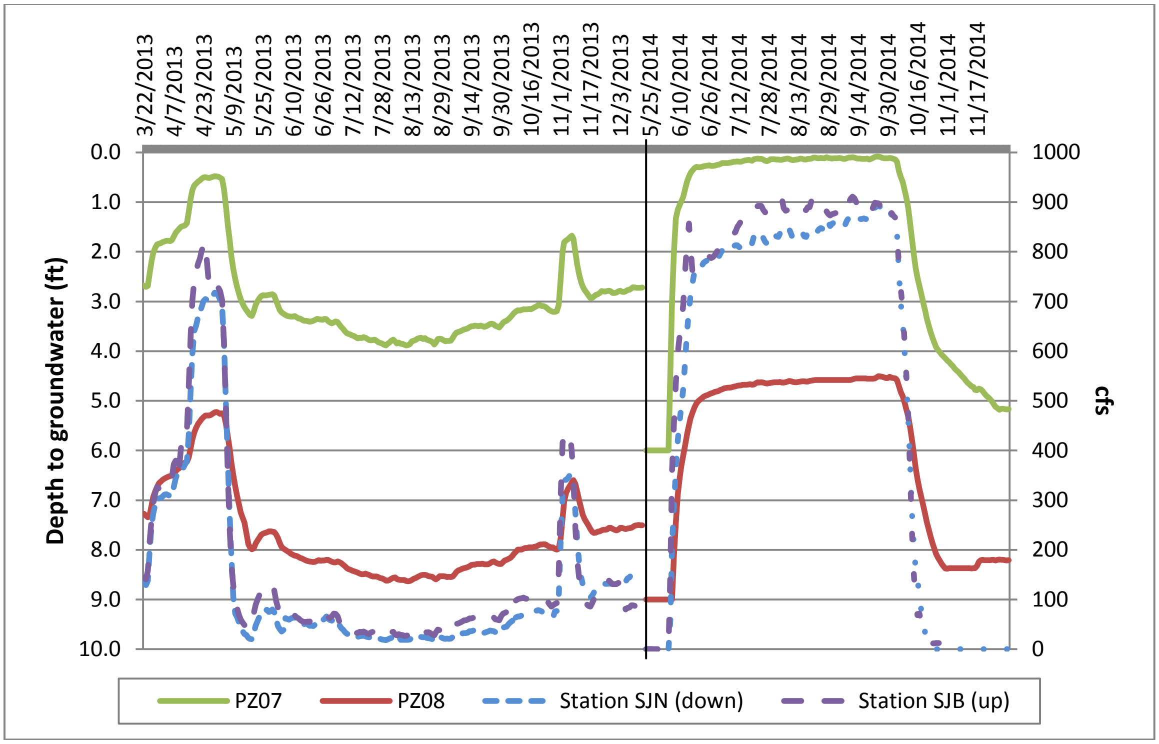

Figure 10. —Depth to groundwater at wells PZ-7 and -8 and San Joaquin River discharge at gauges SJN and SJB from March to December 2013 and May to November 2014 in Reach 2B.

and groundwater again fell to near sensor levels. Vegetation was observed to be stressed within transects at Reach 2b, most likely due to the very dry conditions prior to monitoring in May. Any effects from the shallower water table that occurred after the 2014 monitoring period may be observed with monitoring in 2015; however if drought conditions continue, the temporary increase in available water may not have been sufficient to benefit riparian species at this site.

Data from 2011 to 2014 associated with an existing Reclamation groundwater well (Transect 13-3) was also examined. This well is located at the downstream end of Reach 2A, approximately 6.5 miles downstream of Transects 2A, and approximately 3.2 miles upstream of Transects 2B (Figure 9). Although Well 13-3 is not closely associated with vegetation transects, it provides supplemental information about groundwater levels in floodplain areas of Reach 2. There is also a correlation between flows and the depth of groundwater at this site, however the water table seldom reaches less than 4 ft from the ground surface and is more commonly 5 to 6 ft deep (Figure 11), which is generally not shallow enough to support riparian plant seedlings. Recruitment and establishment of woody riparian vegetation depends on plant available water for prolonged periods so that young plants can develop a deeper root system, at which point a deeper water table should suffice. Because this data tracks time over a longer and continuous period in comparison to PZ-7 data, the extremely low river and associated groundwater levels are more apparent beginning in February 2014.

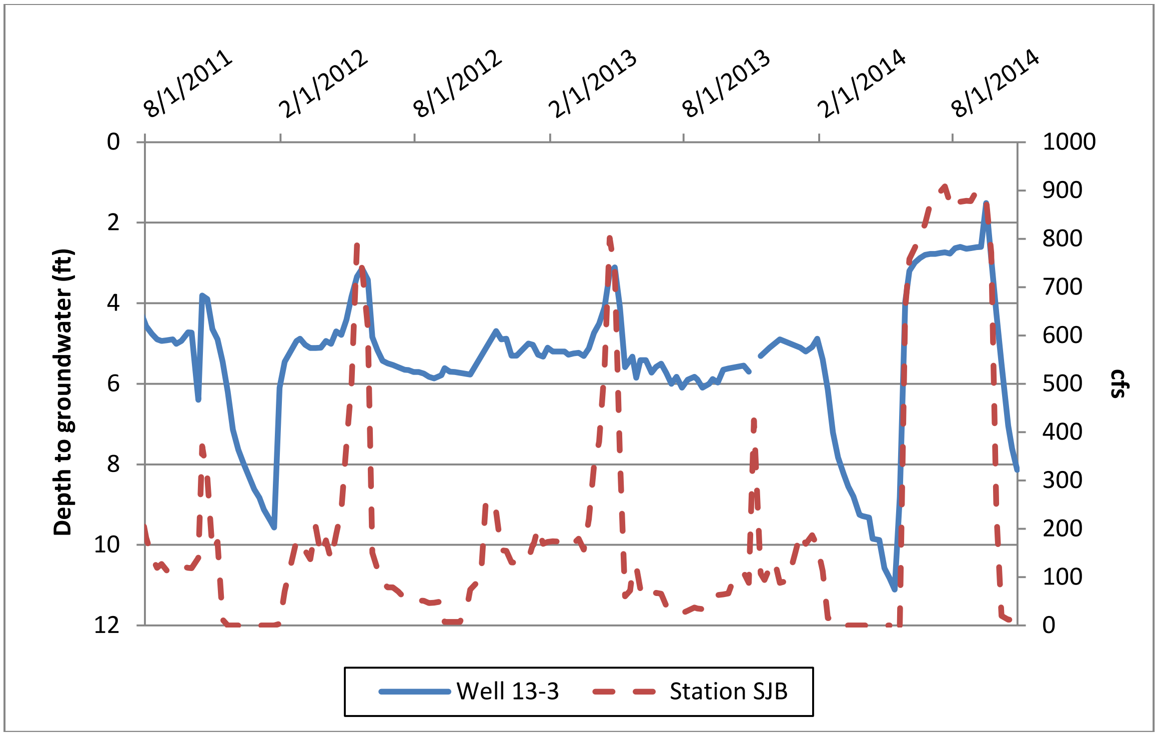

Figure 11. —Depth to groundwater at Well 13-3 and San Joaquin River discharge at gauge SJB from July 2011 through October 2014 in the lower Reach 2A.

Discussion

Following is a descriptive analysis comparing vegetation parameters from 2011 to 2014 by reach. The 2011 Water Year was very different hydrologically from 2012 through 2014 (Figure 4), which was likely a cause for many of the changes observed. In 2014, the region suffered severe drought conditions, with the river dry in the mid reaches during the monitoring period.

Reach 1A

This reach was the only one to show an appreciable increase in understory plant cover from 2011 to 2014, increasing from 23.0 to 63.0 percent in total cover (Table 1). This rise was due to a substantial increase in introduced species which were almost exclusively introduced grasses (Table E-1, Appendix E). This change is evident in photos from 2011 to 2014 (Appendix F; Reach 1A, Transect 1; 1A-Toward transect and Transect 2; 2B-Toward transect). Low river banks at this site allow for overbank flooding, a condition that was prolonged in 2011 and likely deterred the establishment of introduced grasses, which are not as adaptable to inundation as native riparian species. From 2012 to 2014, conditions were drier and upland introduced grass species detected at the site (i.e. ripgut brome, softchess brome, foxtail chess, and rattail fescue) were able to thrive. The total bare cover decreased from 37.0 in 2011 to 2.5 percent in 2014, which was likely due to high flows and major flooding that caused scouring in 2011 and was not a factor in the other 3 years. The increase in understory introduced species resulted in a shift in dominance of native species at the site, with relative cover of understory native species decreasing from 63 percent in 2011 to 28 percent in 2014 (Table 3). Understory species richness increased slightly over the course of monitoring, with the number of native species unchanged (Table 2). Total cover of overstory species within this reach remained essentially the same although the cover of native species increased by about 13 percent (Table 4), indicating that although total canopy (i.e. the amount of overstory covering the transect) did not spread into open areas, native species canopy became more dense. This reach continued to have one of the highest diversity of woody species, with species richness remaining at 6 (Table 2). Stem density in Reach 1A increased a bit over the monitoring period, peaking in 2013 (Table 5). The large increase in 2013 was due to the detection of numerous oak seedlings (size class 1). Recruitment of this species most likely indicates drier conditions since valley oak is more tolerant of drought and is less dependent on flow and sediment conditions than willows and cottonwoods. In 2014, the number of oak seedlings decreased, which may indicate that severe drought conditions did have an impact on survivability of the species. Finally, based on the habitat variable rating, this reach still remained among the top in riparian health (with a rating of 7.2 out of 8). This reach, being the most upstream of all monitoring sites, has perennial river flows combined with a more natural channel and floodplain structure, despite controlled flows.

Reach 1B

This reach showed an increase in total understory cover of about 10 percent from 2011 to 2014 (Table 1). There was a notable increase in total percent litter, while bare cover decreased. These results were presumably related to flows and flooding – high river discharge in 2011 caused scouring (higher bare cover) and lower flows in 2012 through 2014 led to the accumulation of litter. Total cover of introduced species increased linked to an increase in introduced grasses (Table E-1, Appendix E). A dominance of native herbaceous species in 2011 shifted to a dominance of introduced species through 2014 (Table 3). Species richness in Reach 1B increased over the monitoring period, and despite dominance of introduced species, native species richness increased from 1 to 4 (Table 2). Total overstory cover showed a negligible decrease, with total cover of the introduced species scarlet wisteria and giant reed increasing slightly from 2011 to 2014 (Table 4). Based on cover, the site was dominated by sandbar willow. Stem density remained the highest relative to other reaches in 2013 and 2014 (Table 5), which was associated with Goodding’s willow that had been browsed by beaver resulting in several resprouted stems. Habitat variable rating of 7.1 was among the highest in 2014. This site has the advantage of relatively consistent river flows; however the area is heavily used by recreational motorists, which appears to affect potential vegetation development. It is also the only site where introduced overstory species are consistently documented. Both species – giant reed and scarlet wisteria - are classified as a noxious weed in the “high” category, which indicates severe ecological impacts (Cal-IPC 2015).

Reach 2A

Total understory cover decreased only slightly from 2011 to 2014, although native understory cover decreased from 9.0 to 1.0 percent due to a drop in native forbs. As a result, relative percent cover of native species decreased from 53 to 7 percent (Table 3). Herbaceous species richness dropped from 15 in 2011 to 5 in 2014, with native species richness decreasing from 7 to 1 (Table 2). Total overstory cover was only around 1.0 percent in 2011 and 2012 (Table 4). In 2013, overstory cover increased to 5.2 percent due to the development of young willow in the lowermost portion of transects. Woody species richness varied between 2 and 3, with 2 of the species native. This was one of two reaches in which the noxious weed scarlet wisteria was documented, although the species was not detected in 2014. Like overstory cover, stem density remained low (Table 5). Riparian condition was ranked relatively low (4.65) in 2014 (Table 6), with lowest scores in the variables coverage and spatial diversity (i.e. cover and diversity of native riparian species), structural diversity (i.e. different size- and age- classes of riparian vegetation), and biogeochemical processes (i.e. vegetation with woody debris, leaf litter, detritus in channel). This site has very low vegetative cover (15 percent understory and 5 percent overstory in 2014) and coarse soils (sand and gravel). Higher flows would need to be maintained through this reach to increase vegetation development, the potential of which is indicated by recruitment of young willow.

Reach 2B

There was a drop of approximately 20 percent in total understory cover in 2014 (Table 1) within this reach. Relative cover of native and introduced species have been fairly equivalent in the last 2 years following a higher percentage of natives in 2011 (Table 3, Figure 6). Species richness decreased over the study period in association with a decrease in the number of natives detected (Table 2). This reach showed the largest increase in total overstory cover (7.2 to 20.0 percent; Table 4). There was also a large increase in stem density from 2011 to 2012; however this number decreased by 2014 (Table 5). The majority of stems shifted from size class 1 in 2011 to size classes 2 and 3 which could explain the decrease in overall stem density; as plants grow, their numbers decrease due to competition. Dodder, a parasitic plant, was documented at the site in 2013, and may have been a factor in decreasing willow density; there also appeared to be a slight reduction in overstory cover that year as well. Woody species richness increased from 3 to 4 (all native species). Reach 2B showed the most potential for identifying change over time and effects from Interim Flows as a healthy riparian community began to develop. Young willow and cottonwood seedlings became established over the monitoring period, increasing in cover, size and richness. Severe drought conditions in 2014 appeared to impact this site, however. Although overstory cover and density slightly increased from 2013, overall health of plants was observed to be poor (see comparison photos in Appendix F; Reach 2B, Transect 1; 1A). Shallow-rooted understory species had a relatively large decrease in cover, as well. Piezometers installed at the site in 2013 indicated that hydrology was favorable for sustaining riparian vegetation when there were flows in the river, with a relatively shallow water table (< 4 ft) within the floodplain

(Figure 9). When the river is dry, however, as it was from February to May and again in October in 2014, the water table fell to 5.3 ft (depth of sensor) or more from the surface, which is not conducive to establishment of young riparian vegetation. Riparian condition remained moderate with a ranking of 5.3 in 2014 (Table 6), with lowest scores in the variables coverage and spatial diversity (i.e. cover and diversity of native riparian species), structural diversity (i.e. different size- and age- classes of riparian vegetation), and biogeochemical processes (i.e. vegetation with woody debris, leaf litter, detritus in channel).

Reach 3

This reach showed substantial changes following 2011 floods. Total understory cover decreased from 73.4 percent to 38.9 over the monitoring period, associated with a major drop in native species cover (Table 1). Dominance in native herbaceous species relative to introduced species shifted in 2012 and introduced species have remained dominant (Table 3). This shift was related to an increase in introduced grasses (predominantly ripgut brome) at the site. Herbaceous species richness fell from 14 to 4 from 2011 to 2014 (Table 2), mostly due to a drop in native species richness. Total overstory cover remained stable (around 20 percent; Table 4), as did woody species richness (2 species detected; Table 2). Stem density was consistently low within this reach (0.01 stems/m^2 in 2014), with stems detected only in size class 3 from 2012 and 2014, indicating no recruitment of woody seedlings (Table 5). The difference in hydrologic conditions between the first and last 3 years of the study appeared to have large effects on herbaceous understory species within this reach, with drier conditions from 2012 and 2014 presumably causing cover, species richness and the native species component to decrease considerably. This site has high cutbanks that prevented overbank flows – which occurred in 2011 – from happening in later years. Reach 3 dropped from a moderate ranking to low in riparian condition (from 5.6 to 4.4) with a relatively large drop in the micro- and macrotopographic complexity (mixture of topographic features) and characteristics of flood-prone area variable ratings.

East Side Bypass

Total understory cover within this reach dropped about 12 percent during the study period, with litter cover increasing while bare cover decreased. Unlike other reaches, native herbaceous species remained dominant relative to introduced species throughout the entire monitoring period (Table 3), with native grasses the most common life form. Herbaceous species richness decreased from 20 to 11 in 2014, although this decrease was almost entirely introduced species (Table 2). From 2012 to 2014, transects in this reach fell within exclusively herbaceous habitat; in 2011, 0.2 percent overstory cover was documented (Table 4) but no woody species were detected in understory or stem density measurements. The East Side Bypass has always received low scores in riparian condition. Rankings were relatively low in all but 2 variables, which were contiguity of habitats and % invasive woody vegetation (only because there were no woody species). Two of four transects (3 and 4) were located within the Merced NWR where an existing year-round water supply could make it difficult to identify changes in vegetation from Interim Flows. There has never been water in the channel adjacent to the other transects (1 and 2) during monitoring. Delta button celery, which is a State-listed endangered plant, was detected in the Merced NWR within this reach (Figure 12). This plant was documented in transect monitoring in 2011 (Table E-2, Appendix E). Although it was not intercepted in transect cover measurements in 2012, it was observed in the area surrounding transect 3. It was not observed at all during 2013 and 2014 sampling when the area was heavily grazed by cattle.

Figure 12.—Delta button celery (*Eryngium racemosum*), a State-listed endangered plant, was detected in transects within the Merced NWR in the East Side Bypass Reach, June 2012.

Reach 4B2

Reach 4B2 had the highest total understory cover of all reaches in all years (between 63 and 81 percent; Table 1). There was an increase in litter cover over the study period. Native species have typically dominated (except in 2012; Table 3) and composition has been predominantly native grasses (i.e. saltgrass and Baltic rush; Table E-2 in Appendix E). Herbaceous species richness remained high at 16 in all years (Table 2), although less than half of species detected were native. Black mustard and poison hemlock, invasive species that are both given a ranking of “moderate” by the California Invasive Plant Council (Cal-IPC 2015), had relatively high coverage in Reach 4B2 in 2012. Although these species are still present, percent cover has decreased (Table E-2 in Appendix E). The invasive perennial pepperweed, on the other hand, was first detected in transects in 2012 and has increased slightly during monitoring. This species is ranked as “high” by Cal-IPC, meaning it has severe ecological impacts. While mature Goodding’s willow was measured in total overstory cover all years (around 9 percent), no woody species were detected in understory cover or stem density measurements, indicating that recruitment is potentially low. Reach 4B2 has consistently received a moderately low ranking in riparian condition over the monitoring period. Lowest scores were given for the coverage and spatial diversity (i.e. cover and diversity of native riparian species), structural diversity (i.e. different size- and age- classes of riparian vegetation), and biogeochemical processes (i.e. vegetation with woody debris, leaf litter, detritus in channel) variables. This reach is located in the San Luis NWR and, like the Merced NWR in the East Side Bypass, has been supplied with year-round water; therefore hydrologic conditions may not change considerably and effects from Interim Flows may be difficult to determine.

Reach 5

Transects in this reach were first established and monitored in 2012; total understory has increased by about 23 percent since then, with a decrease in native cover and a major increase in introduced species cover (approximately 40 percent). The noxious weed perennial pepperweed dominated understory species cover at 59.5 percent in 2014, increasing from 7.5 percent in 2012. When monitoring began, Reach 5 was quite diverse, with 19 herbaceous species detected and about half of those native. Herbaceous species richness has dropped to 6 with the invasion of pepperweed. This site had the highest total overstory cover in 2014 at 68.0 percent, although Goodding’s willow was the only woody species detected. Stem density has decreased over time, also probably related to competition from pepperweed in the understory. Riparian condition was given the highest ranking among reaches at 7.4, indicating relatively good habitat quality in Reach 5 despite an invasive weed problem; the habitat variable model does not account for herbaceous invasive weeds in its ranking system.

Conclusions

Many of the vegetation parameters measured showed similar trends among reaches from 2011 to 2012, which was most likely a result of extreme differences in hydrologic conditions during the 2 water years. Exceptionally high flows (approximately 3,000 to 9,000 cfs) in January and April through July of 2011 created prolonged flooding (Figure 5). Water Years 2012 and 2013 were very similar to each other, with river discharge lower (approximately 1,000 cfs) throughout the year, prohibiting typical overbank flows. Water Year 2014 was exceptionally dry and severe drought conditions were declared in the state of California. Dam releases for irrigation flows towards the end of May (post vegetation monitoring) increased flow levels. Most changes in vegetation that were observed were likely due to differences in precipitation patterns and hydrology over the monitoring period, although some of the changes could probably be linked to Interim Flow implementation over the study period.

Total understory native cover decreased, as did herbaceous native species richness, in all reaches from 2011 to 2012. In 2013, most reaches showed increases in native cover and richness from 2012, but generally not to levels of 2011. By 2014, native cover had either maintained (Reaches 1A, 1B, 3, ESB, and 4B2) or decreased (Reaches 2A, 2B, and 5) in comparison to the previous 2 years. Fisher's LSD test found native species cover to be significantly greater in 2011 than in 2012 and 2014 in upper reaches (1A – 3). Understory cover was composed of principally native species in 2011. This condition generally shifted to dominance of introduced species in the understory layer with the exception of Reaches 4B2 and ESB, where native grasses were the dominant lifeform. Prolonged flooding in 2011 appeared to affect composition and cover of native understory species along the river and likely deterred the establishment of introduced species, which are generally not as adaptable to inundation as native riparian species. The dominance of native species in 2011 was presumably because they are tolerant of anaerobic conditions and because of less competition from exotic species. The predominance of introduced species from 2012 through 2014 could be attributed to drier conditions. Understory cover was closely linked to discharge, with abundance of these shallow-rooted plant species dependent upon the amount of available water near the surface. Statistically, the percentage of introduced species was significantly greater in 2012 and 2013 than in 2011 in upper reaches (Reach 1A to 3; Table 7).

Total litter cover increased in all reaches, which was a statistically significant change. In some cases, total bare cover decreased, which was likely due to high flows and major flooding that caused scouring in 2011 and was not a factor in 2012 or 2013. Statistically, Fisher's LSD test identified greater bare cover in 2011 than in 2013 and 2014 in the lower reaches (4B2, ESB, and 5).

Deeper rooted woody species in the overstory layer did not appear to be affected by lower flows, with total cover showing little change over the monitoring period. The exception was in Reach 2B, where overstory cover increased over the study period and where numerous willow seedlings were documented in 2011. Apparently these plants were established enough to withstand drier conditions in 2012 and 2013 and expand in cover. Groundwater monitoring has also shown that there is a relatively shallow water table associated with vegetation transects as long as the river is flowing, which is conducive to successful restoration. Riparian recruitment sustained throughout monitoring at the Reach 2B site is likely related to implementation of Interim Flows. Willow recruitment was documented after the 2011 flood year and these new plants were maintained by Interim Flows and a relatively shallow water table (according to data collected in 2013). There was a slight increase in overstory cover and stem density at this site in 2014; however vegetation was observed to be much less vigorous than in previous years (see photos in Appendix F). The river was dry from February to late May prior to vegetation sampling, and subsequently there was a large drop in water table levels (Figure 9). Monitoring in 2015 should determine if dam releases that occurred after monitoring in 2014 benefited young woody species.

Stem density was variable, increasing or decreasing among reaches, and no statistically significant changes were identified. In general, there was a decrease in stem density in

Size Class 1 (i.e. current year's growth), indicating little recruitment of new seedlings beyond 2011. This was most likely due to a lack of flooding from 2012 to 2014, a condition that is conducive to regeneration of willow and cottonwood species. The exception was in Reach 1A, where numerous valley oak seedlings were observed in 2013 and 2014. This species is able to tolerate drier conditions than willow and cottonwood.

In general, the most upstream Reaches 1A and 1B exhibited healthier riparian condition than downstream reaches, with greater cover, diversity, and density of woody species and higher habitat variable rankings. Subsequently, reaches further downstream – with the exception of the wildlife refuges that sustain a year-round water supply – are likely to have a greater potential for showing effects from interim flows. Reach 5 (the furthermost downstream reach in the study) was comparable to upstream reaches in that relatively high values were recorded for cover of woody species and habitat variable rankings. Reach 5 is being impacted by the invasive species perennial pepperweed, however, which has rapidly become the dominant understory species, affecting species diversity and potential recruitment of more desirable under- and overstory species. Weed control at this site is warranted. Continued monitoring will determine if vegetative conditions have improved in transects along all reaches of the San Joaquin River included in this study.

Summary

The SJRRP Vegetation Monitoring Study evaluates the response of riparian vegetation to Interim Flows through comparison of transect data over time. Changes in vegetation may have implications for Friant Dam flow scheduling, habitat establishment supporting fish, and maintenance needs to convey flows. In 2011 SJRRP established transects, collected the first year of data, and ranked transects for riparian condition. This monitoring effort was continued in 2012 - when 2 new transects added to the study further downstream – through 2014. SJRRP will continue monitoring vegetation transects in 2015.

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Appendix A

Aerial Photos of Vegetation Transects by River Reach
Upstream to Downstream
Google Earth Imagery 2014

Reach 1A

Reach 1B

Reach 2A

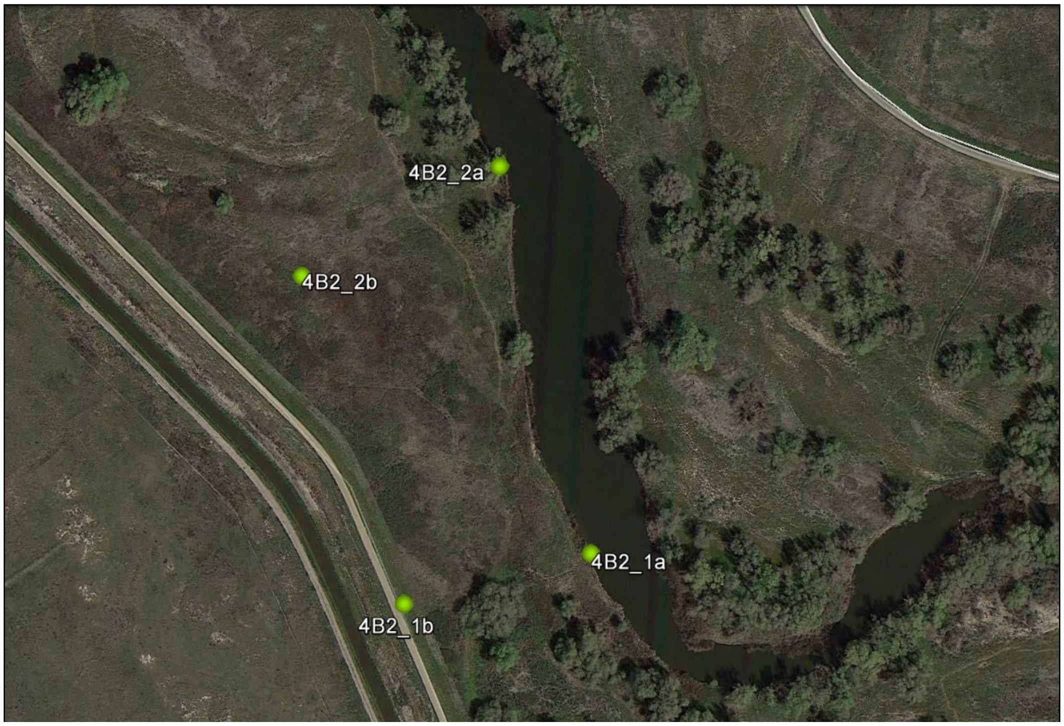
Reach 2B

Reach 3

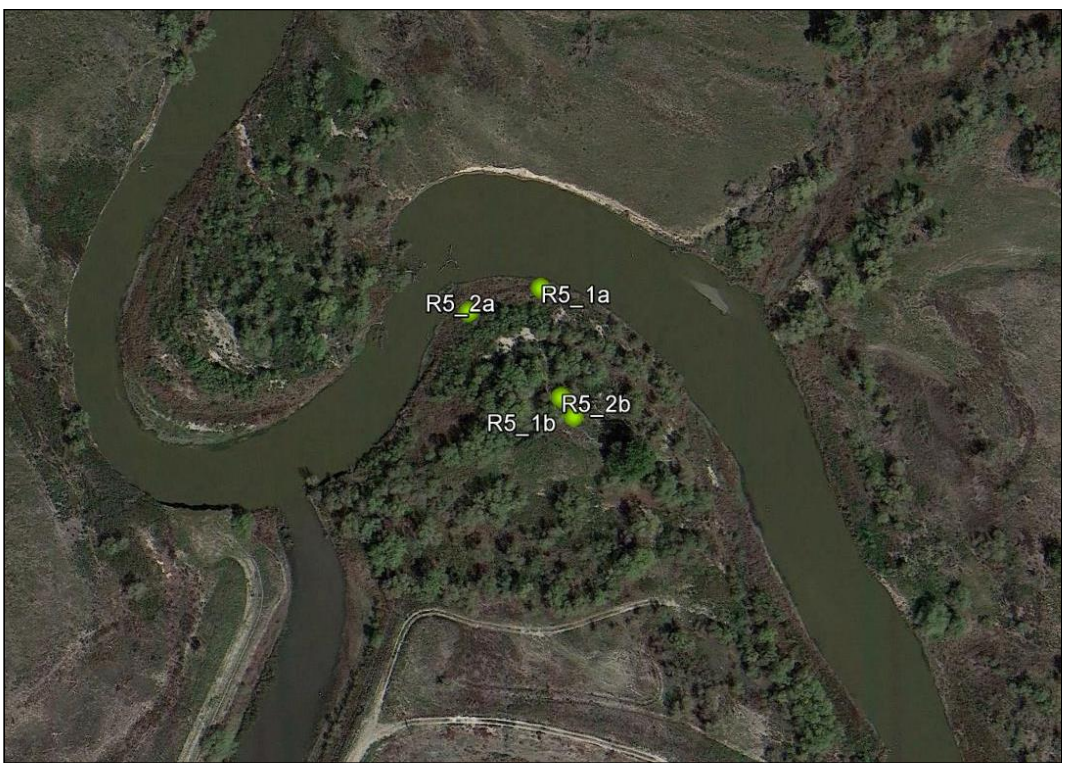
East Side Bypass

East Side Bypass (Merced NWR), Transect 3

East Side Bypass (Merced NWR), Transect 4



Reach 4B2 (San Luis NWR)



Reach 5

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
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
Tree Density
Site Characterization

Date: ______________________

Transect: ______________________

Observers: ______________________

Density

Size class	Description	Species				
1	Current year 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					

Site Characterization

Elevational differences along transect (e.g. terraces, gradual change):

General composition of bed material in river:

Multiple channels or single channel:

Active erosion or protection on banks:

Figure C-3.—Density and Site Characterization data form

Variable	Rankings-written description and numeric score											
	Poor ===== ===Excellent											
Coverage and Spatial Diversity	Site permanently converted to land use not able to support native riparian vegetation, such as housing, agriculture, or concrete channel	0	No existing riparian vegetation (e.g., covered with grasses and scrub, bare ground).	0.2	Patches of monotypic woody riparian vegetation covering up to 50% of the site, interspersed among herbaceous species or bare ground.	0.4	Patches of diverse riparian vegetation (e.g., at least two different genera of woody riparian vegetation present) covering up to 30% of the site, interspersed among grasses, invasive plants, or bare ground; and/or greater than 50% of the site covered with monotypic patches of riparian vegetation, interspersed among herbaceous species or bare ground.	0.6	Diverse woody riparian vegetation (at least three genera) covering between 30% and 75% of the site, e.g., strips or islands of riparian habitat interspersed in open space.	0.8	Diverse riparian vegetation (e.g., at least three different genera of native riparian vegetation present) covering between 75% and 100% of the site, interspersed in open space or herbaceous plant communities.	1.0
Structural Diversity	Site permanently converted to land use not able to support native riparian vegetation, such as housing, agriculture, or concrete channel	0	No existing riparian vegetation (e.g., covered with grasses and scrub, bare ground).	0.2	Vegetated areas of the site contain sparse, scattered, patchy, or remnant riparian vegetation that is immature and/or lacks structural (vertical) diversity.	0.4	Patches of riparian vegetation contain riparian trees and/or saplings(i.e., perennial dicots), but contain none or poorly developed shrub understory.	0.6	Riparian vegetation patches contain cottonwood trees and saplings, with well-developed native shrub understory, or shrub understory, but few riparian trees.	0.8	Patches of diverse riparian vegetation. They contain cottonwood trees, saplings, and seedlings (or evidence of seedling establishment), as well as developed native shrub understory and herbaceous layer.	1.0

Contiguity of Habitats	No linear contiguity or transitional upland habitat; surrounded by or isolated within an anthropogenic modified setting.	0	No linear contiguity upstream or downstream, but isolated within upland open space habitat.	0.2	Contiguous with comparable habitat on one end of the site, but surrounded with urban/suburban or other non-open space lands adjacent (lateral to) to the site on at least one side.	0.4	Contiguous with comparable habitat on one end of the site and surrounded by transitional upland habitat which is at least twice the width of the riparian zone.	0.6	Contiguous with comparable habitat on both ends of the site, but surrounded with anthropogenically modified lands adjacent (lateral to) to the site on at least one side.	0.8	Contiguous with comparable habitat on both ends of the site and surrounded by transitional upland habitat on both sides which is at least twice the width of the riparian zones.	1.0
Percent of Invasive Woody Vegetation (please note other invasive herbaceous vegetation)	Site is covered by pure stands of invasive vegetation or lacks any riparian vegetation	0	70-99% invasive vegetation.	0.2	40-69% invasive vegetation.	0.4	10-39% invasive vegetation.	0.6	4-9% invasive vegetation	0.8	Site is covered by less than 5% invasive vegetation.	1.0
Hydrology	No regular supply of water to the site. Site not associated with any water source, surface drainage, impoundment, or groundwater discharge.	0	Water supply to the site is solely from artificial irrigation. No natural supply.	0.2	Site is sustained by source of water not associated with water way. For example, the site is sustained by groundwater or urban runoff. There is no evidence of riparian processes.	0.4	Site is sustained by natural source, but no evidence of riparian processes, such as overbank flow or scour or deposition. Cut banks.	0.6	Site is within or adjacent to an impoundment on a natural waterway which is subject to fluctuations in flow or hydroperiod.	0.8	Site is within or adjacent to a waterway that provides the primary source of water to the site. The site contains evidence of riparian processes where water flows into the riparian vegetation zone.	1.0
Micro- and Macrotopographic Complexity	Flood-prone area contained in a concrete-lined channel.	0	Flood-prone area is characterized by a homogenous, flat earthen surface with little to no micro- and	0.2	Flood-prone area contains micro- and/or macro-topographic features such as pits, ponds, hummocks,	0.5	Flood plain mostly hetero-geneous, characterized by micro-topo-graphic features ie pits, ponds, hummocks,bars.	0.8	Flood-prone area is characterized by micro- and macro-topographic complexity, such as	1.0		

			macro-topographic features.		bars, but is predominantly homogenous or flat surface		However, there are no macro-topographic features, such as braiding, 2° channels, backwaters.		meanders, bars, braiding, 2°channels, backwaters, terraces, pits, ponds, hummocks, etc.			
Characteristics of Flood-prone Area	All flows are contained in a concrete-lined channel, culvert, etc.	0	Channel has an earthen bottom; however, it is structurally confined (e.g., riprap or concrete sideslopes) such that the flood-prone area is wholly contained within the channel, except in extreme events.	0.2	Channel has an earthen bottom and earthen sideslopes; however, it is incised or confined such that the flood-prone area is wholly contained within the channel and there is no opportunity for overbank flow, except in extreme events.	0.3	Site is part of a flood plain, which provides an opportunity for overbank flow during moderate flow events (i.e., during a 2- to 10-year-flood event). However, the flood-prone area is confined by levees, berms, dikes, cut banks, or other obstructions or barriers such that the area available for overbank flow is less than twice the width of the channel at bankful conditions.	0.6	Site is part of a flood plain, which provides an opportunity for overbank flow during moderate flow events. The flood-prone area is confined by levees, berms, dikes, cut banks, or other obstructions or barriers; however, the area available for overbank flow is equal to or greater than twice the width of the channel at bankfull conditions.	0.8	Site is part of an unconfined natural floodplain at least twice the width of the channel at bankfull conditions and there is evidence of overbank flow.	1.0
Biogeochemical Processes	Flood-prone area contained in a concrete-lined channel, culvert, etc., with little to no vegetation or detritus.	0	Site can support grasses, forbs, or other herbaceous vegetation, and there is woody debris, leaf litter, or detritus present in the channel.	0.2	Site supports at least 25% relative cover of grasses, forbs, herbaceous, or riparian vegetation, and there is at least 10% relative cover of woody debris, leaf litter, or detritus in the channel.	0.4	Site contains between 25% and 50% relative cover of any strata of riparian vegetation and between 10% and 40% relative cover with woody debris, leaf litter, or detritus.	0.6	Site contains between 50% and 75% relative cover of any strata of riparian vegetation and between 40% and 60% relative cover with woody debris, leaf litter, or detritus.	0.8	Site contains greater than 75% relative cover of any strata of riparian vegetation (native or non-native) and greater than 60% relative cover with woody debris, leaf litter, or detritus.	1.0

Figure C-4.—Habitat variables data form.

Appendix D

Scientific Names and Locations of Plants Detected in Vegetation Transects
2011 to 2014

CODE	SCIENTIFIC NAME	COMMON NAME	LIFE FORM*	REACH							
				1A	1B	2A	2B	3	ESB	4B2	5
Tree/shrub											
ALRH	*Alnus rhombifolia*	White alder	NT	X							
ATLE	*Atriplex lentiformis*	Quailbush	NS					X			
CEOC	*Cephalanthus occidentalis*	Button bush	NS	X	X						
FRLA	*Fraxinus latifolia*	Oregon ash	NT	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				
SAGO	*Salix gooddingii*	Gooding's willow	NT		X			X	X	X	X
SALA	*Salix lasiolepis*	Arroyo willow	NT	X							
SALU	*Salix lucida*	Shining willow	NT	X							
SANI	*Sambucus nigra*	Black elderberry	NT				X				
SEPU	*Sesbania pungens*	Scarlet wisteria	IS		X						
Graminoid											
ALSA	*Alopecurus saccatus*	Pacific foxtail	NG							X	
ARDO2	*Arundo donax*	Giant reed	IG		X						
BRDI	*Bromus diandrus*	Ripgut brome	IG	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		
CYAC	*Cyperus acuminatus*	Tapertip flatsedge	NG				X		X		
CYDA	*Cynodon dactylon*	Bermuda grass	IG	X	X	X		X	X	X	X
CYES	*Cyperus esculentus*	Yellow nutgrass	NG		X			X	X		
CYSP	*Cyperus sp.*	Flatsedge		X							
DISP	*Distichlis spicata*	Salt grass	NG	X					X	X	X
ECCR	*Echinochloa crus-galli*	Barnyard grass	IG	X		X		X	X	X	
ELMA	*Eleocharis macrostachya*	Common spikerush	NG						X		
HOMA	*Hordeum marinum ssp gussoneanum*	Mediterranean barley	IG						X	X	
HOMU	*Hordeum murinem*	Mouse barley	IG						X		
JUAC	*Juncus acuminatus*	Tapertip rush	NG	X							
JUBA	*Juncus balticus*	Baltic rush	NG	X			X		X	X	X
LEOR	*Leersia oryzoides*	Rice cutgrass	NG	X							
LEUN	*Leptochloa uninervia*	Mexican sprangletop	NG	X		X	X	X	X		
LETR	*Leymus triticoides*	Creeping wildrye	NG						X		
LUPA	*Luzula parviflora*	Smallflowered woodrush	NG	X							
MUAS	*Muhlenbergia asperifolia*	Scratchgrass	NG					X			
ORSA	*Oryza sativa*	Rice	IG			X					
PADI	*Paspalum dilatum*	Dallis grass	IG	X		X			X		
PANO	*Paspalum notatum*	Bahia grass	IG						X		
PHAR	*Phalaris arundinacea*	Canary reedgrass	NG	X							
POMO	*Polypogon monspeliensis*	Rabbitsfoot grass	IG						X		X
VUMY	*Vulpia myuros*	Rat-tail fescue	IG	X	X	X	X	X	X		
Forb											
AMRO	*Ammania robusta*	Grand redstem	NF						X	X	
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
ARLU	*Artemisia ludoviciana*	White sagebrush	NF	X							
ARVU	*Artemisia vulgare*	Common mugwort	IF			X					
ASSP	*Asclepius sp*	Milkweed	NF							X	
BRNI	*Brassica nigra*	Black mustard	IF	X		X	X		X	X	X
CESO	*Centaurea solstitialis*	Yellow starthistle	IF						X		
CEPA	*Centromadia parryii ssp rudis*	Pappose tarweed	NF						X	X	
CHCA	*Chenopodium californicum*	California goosefoot	NF					X		X	X
EUOC	*Euthamia occidentalis*	Western goldentop	NF	X	X					X	X
CIVU	*Cirsium vulgare*	Bull thistle	IF						X	X	
COMA	*Conium maculatum*	Poison hemlock	IF							X	
COCA	*Conyza canadensis*	Horseweed	NF				X				X
CUSP	*Cuscuta* sp.	Dodder	NF				X				
DAWR	*Datura wrightii*	Jimson weed	NF								X
DESP	*Descurainia* sp	Tansy mustard			X						
EQAR	*Equisetum arvense*	Field horsetail	NF	X							
ERSE	*Eremocarpus setigerus*	Doveweed	NF			X					
ERWR	*Eriogonum wrightii*	Wright's buckwheat	NF			X					
ERCI	*Erodium cicutarium*	Redstem storks bill	IF				X				
ERRA	*Eryngium racemosum*	Delta button celery	NF						X		
ESCA	*Eschscholzia californica*	California poppy	NF		X	X					

CODE	SCIENTIFIC NAME	COMMON NAME	LIFE FORM*	REACH							
				1A	1B	2A	2B	3	ESB	4B2	5
FRSA	*Frankenia salina*	Alkali seaheath	NF						X		
GATR	*Gallium trifudum*	Threepetal bedstraw	NF					X			
GRCA	*Grindelia camporum*	Gum plant	NF						X	X	X
HEAN	*Helianthus annuus*	Sunflower	NF			X		X		X	
HECU	*Heliotropium curassavicum*	Salt heliotrope	NF								X
KOSC	*Kochia scoparia*	Kochia	IF			X	X	X	X		
LASE	*Lactuca serriola*	Prickly lettuce	IF			X		X	X	X	X
LELA	*Lepidium latifolium*	Perennial peppergrass	IF							X	X
LUPE	*Ludwigia peploides*	Water primrose	NF						X		
LOCO	*Lotus corniculatus*	Birdsfoot trefoil	IF						X	X	
LOUN	*Lotus unifoliolatus*	American bird's-foot trefoil	NF			X	X				
MALE	*Malvella leprosa*	Alkali mallow	IF						X	X	X
MEAL	*Melilotus alba*	White sweetclover	IF						X		X
MEAR	*Mentha arvensis*	Field mint	NF	X			X				
MEPU	*Mentha pulegium*	Pennyroyal	NF	X							
MYAQ	*Myriophyllum aquaticum*	Parrotfeather	IF	X							
PHNO	*Phyla nodiflora*	Turkey tangle fogfruit	NF						X	X	
POAR	*Polygonum arenastrum*	Common knotweed	IF						X	X	
POLA	*Polygonum lapathifolium*	Pale smartweed	NF					X			
PSCA	*Pseudognaphalium californicum*	California cudweed	NF	X	X	X	X		X		X
ROPA	*Rorippa palustris*	Yellow cress	NF				X	X		X	X
RUCR	*Rumex crispus*	Curly dock	IF					X	X	X	
RUUR	*Rubus ursinus*	California blackberry	NF	X							
SATR	*Salsola tragus*	Russian thistle	IF			X					
SASP	*Salsola sp.*	Saltwort	IF					X	X		
SIMA	*Silybum marianum*	Milk thistle	IF						X		
SOAM	*Solanum americanum*	American black nightshade	NF			X	X			X	X
SOAS	*Sonchus asper*	Prickly sow thistle	IF				X		X		
TRSP	*Trifolium sp.*	Clover					X	X	X		
URDI	*Urtica dioica*	Stinging nettle	IF				X				
VEAN	*Veronica anagallis-aquatica*	Water speedwell	IF		X						
XAST	*Xanthium strumarium*	Cocklebur	NF	X		X	X	X	X	X	X

*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

Appendix E

Total percent cover of individual plant species detected
in the understory layer of vegetation transects
from 2011 to 2014.

Table E-1—Total percent cover of individual plant species detected in transects in Upstream Reaches 1-3.

Average Total Percent Understory Cover – Upstream Reaches																				
	River Reach																			
Species	1A				1B				2A				2B				3			
	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014
Button bush	0	0	0	0	0.5	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0
Sandbar willow	0.5	0	0.5	0.5	4.0	1.5	1.0	0.5	0	0	0	0.5	0	0	0.5	0	0	0	0	0
Goodding's willow	0	0	0	0	0	0	1.5	0	0	0	0	0	0.5	1.0	2.5	0	0.3	0	0	0
Arroyo willow	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oregon ash	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Native trees/shrubs	0.5	0.5	1.0	0.5	4.5	1.5	2.5	1.5	0	0	0	0.5	0.5	1.0	3.0	0	0.3	0	0	0
Scarlet wisteria	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Introduced trees/shrubs	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow nutgrass	0	0	0	0	5.0	0	0	0	0	0	0	0	0	0	0	0	3.5	0	0	0
Flatsedge	1.0	0	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	0	0
Baltic rush	1.5	0	1.0	1.0	0	0	0	0	0	0	0	0	0	0	1.5	1.0	0	0	0	0
Mexican sprangletop	0.5	0	0	0	0	0	0	0	1.5	0.5	0	0	2.2	0	0	0	1.6	0	0	0
Canary reedgrass	0	0.5	0	0	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	1.2	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	0	0
Scratchgrass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0
Smallflowered woodrush	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified grasses*	0.5	2.5	0	1.0	0	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	5.0	0	0	0	1.5	0.5	0	0	2.2	0	2.7	1.0	5.1	0	0.6	0.0
Ripgut brome	0.5	13.0	22.5	31.5	0	0	0	0	3.0	6.0	6.0	8.0	0	0	0	0	0	16.0	35.5	20.8
Bermuda grass	1.0	1.5	0.5	0	2.0	10.5	4.0	5.5	0.0	0.5	1.0	1.0	0	0	0	0	4.1	1.6	0.7	0
Barnyard grass	0.5	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0.6	0	0	0
Rice	0	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0
Soft chess brome	0	3.0	1.5	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Foxtail chess	0	3.0	0	3.0	0	5.0	12.0	7.5	0	4.0	12.0	3.0	0	0	3.4	0	0	0	0.3	0
Dallis grass	0	0	1.0	0	0	0.0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0
Rat-tail fescue	0	10.0	8.5	6.5	0	0.5	0	0.5	1.5	2.0	2.5	0	0	0	0.7	0	0	0	4.2	2.8
Smooth brome	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0
Rabbitsfoot grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0.3	0
Giant reed	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Introduced graminoids	2.0	30.5	34.0	44.5	2.0	16.0	16.5	13.5	7.0	12.5	21.5	12.0	0.0	0.0	4.1	0.7	4.7	17.6	41.3	23.6
California mugwort	8.0	4.5	6.5	6.5	0	0	0.5	1.5	0	0	0	0	1.4	2.9	2.1	1.7	10.5	13.6	14.8	13.5
California goosefoot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0
Doveweed	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0
Wright's buckwheat	0	0	0	0	0	0	0	0	1.5	0.5	0	0	0	0	0	0	0	0	0	0
Threepetal bedstraw	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	0	0
Sunflower	0	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0.9	0
American bird's-foot trefoil	0	0	0	0	0	0	0	0	3.5	0	0.5	0	9.3	0	4.3	0	0	0	0	0
Field mint	0.5	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0
Pale smartweed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.4	0	0	0
Yellow cress	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	2.2	0	1.3	0
American black nightshade	0	0	0	0	0	0	0	0	0.5	0	0	0	4.3	0	0	0	2.8	0	0	0
Cocklebur	1.0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	1.2	0	20.6	0	0	0
Western goldentop	0	0.5	1.5	0.5	0	1.5	6.5	3.5	0	0	0	0	0	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	0	0
California poppy	0	0	0	0	0	0.5	0.5	2.0	0	1.0	2.0	0.5	0	0	0	0	0	0	0	0
California cudweed	0	0	1.0	1.0	0	0.5	0	0	0	0.5	0	0	0	0.5	0.7	0	0	0	0	0
Horseweed	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0
California blackberry	5.5	8.0	5.0	4.0	0	0	0	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	0	0
Field horsetail	0	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tansy mustard	0	0	0	0	0	0	0	0.5	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	0	0	0	0	0	0	0	0	0	1.9

Average Total Percent Understory Cover – Upstream Reaches																				
	River Reach																			
Species	1A				1B				2A				2B				3			
	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014
Unidentified forbs*	0.5	0	0	0	0	0	0.5	0	0	0	0	0	1.4	0	0	0.5	0.7	0	0	0
Native forbs	15.5	14.5	14.5	13.0	0	2.5	8.0	7.5	7.5	2.0	2.5	0.5	16.4	5.3	9.0	2.2	55.0	13.6	17.0	15.4
Black mustard	1.0	0	0	0	0	0	0	0	2.0	4.5	1.5	2.0	4.1	12.4	7.2	2.6	0	0	0	0
Prickly lettuce	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0.8	0	0	0
Curly dock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3	0
Russian thistle	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0
Saltwort	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.5	0	0	0
Clover	0	0	0	0	0	0	0	0	0	0	0	0	2.1	4.3	0	0	0	0	0.9	0
Stinging nettle	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0	0	0	0	0
Redstem storks bill	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0.7	0	0	0	0
Koschia	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0.7	0	0	0	0	0.9	0
Prickly sowthistle	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0
Water speedwell	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dodder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	0	0	0	0
Common mugwort	0	0	0	0	0	0	0	0	0	0	1.0	0	0	0	0	0	0	0	0	0
Parrotfeather	0	0	1.0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bur chevril	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Introduced forbs	1.0	0.0	1.0	1.0	1.0	0	0	0	3.0	5.0	2.5	2.0	6.7	19.3	10.2	3.3	8.3	0.3	2.1	0
Total Plant Cover	23.0	48.5	55.5	63.0	12.5	20.5	27.0	22.5	19.0	20.0	26.5	15.0	25.8	25.6	29.0	7.2	73.4	31.5	61.0	39.0
Litter	33.5	39.0	39.0	31.5	20.0	40.5	42.5	51.5	16.5	17.5	15.5	23.5	22.9	32.8	33.3	42.3	16.0	56.9	34.5	54.2
Bare	37.0	6.0	2.5	2.5	55.0	32.5	30.5	26.0	45.0	43.0	58.0	61.5	51.3	41.6	37.8	50.5	10.6	11.6	4.8	7.0
Rock	6.0	5.0	2.5	3.0	13.0	6.5	0	0	19.5	19.5	0	0	0	0	0	0	0	0	0	0
Water	0.5	1.5	0.5	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Cover	100.0	100.0	100.0	100.0	100.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.1	100.0	100.0	100.0	100.3	100.2

*Unidentified species may be either native or introduced

Table E-1—Total percent cover of individual plant species detected in transects in Downstream Reaches 4, 5, and ESB.

Average Total Percent Understory Cover - Downstream Reaches											
	River Reach										
	ESB				4B2				5		
Species	2011	2012	2013	2014	2011	2012	2013	2014	2012	2013	2014
Goodding's willow	0	0	0	0	0	0	0	0	0.5	0	0
Native trees/shrubs	0	0	0	0	0	0	0	0	0.5	0	0
Pacific foxtail	0	0	0	0	1.0	0	0	0	0	0	0
Tapertip flatsedge	1.0	2.3	0.3	0	0	0	0	0	0	0	0
Yellow nutgrass	1.0	0	0	0	0	0	0	0	0	0	0
Salt grass	0	10.7	9.5	13.8	14.4	19.1	22.6	12.9	0.0	0.5	0
Common spikerush	11.0	0	0	0	0	0	0	0	0	0	0
Baltic rush	0.7	0	0	0.8	5.2	5.1	5.7	9.0	0	0.5	0
Mexican sprangletop	0.2	0	0	0	0	0	0	0	0	0	0
Creeping wildrye	0	1.0	1.5	1.0	0	0	0	0	0	0	0
Unidentified grasses*	2.0	0	0	0	0	0	0	0	0	0	0
Native graminoids	15.9	14.0	11.3	15.6	20.6	24.2	28.3	21.9	0.0	1.0	0.0
Bermuda grass	2.7	3.0	0	0	2.0	4.0	3.5	2.0	1.0	0	0.5
Barnyard grass	0.3	0	0	0	26.1	0	0	0	0	0	0
Mediterranean barley	0	0	0.3	0	1.0	2.5	1.0	2.5	0	0	0
Bahia grass	5.3	0	0	0	0	0	0	0	0	0	0
Soft chess brome	0	0	0	0	0	5.5	11.2	8.5	0	0	0
Foxtail chess	0	0.3	0.5	0	0	0	0	0.7	0	0	0
Rabbitsfoot grass	0	1.4	0.8	0.8	0	0	0	0.5	5.5	2.0	0
Mouse barley	0	0.3	0	1.5	0	0	0	0	0	0	0
Dallis grass	4.5	1.7	3.5	2.3	0	0	0	0	0	0	0
Rat-tail fescue	0	0.3	0	0	0	0	0.5	0	0	0	0
Ripgut brome	0	0.3	0	0	0	0	3.8	7.8	0	0	0

Average Total Percent Understory Cover - Downstream Reaches											
	River Reach										
	ESB				4B2				5		
Species	2011	2012	2013	2014	2011	2012	2013	2014	2012	2013	2014
Introduced graminoids	12.8	7.3	5.1	4.6	29.1	12.0	20.0	22.0	6.5	2.0	0.5
California mugwort	0	0	0	0	0	1.6	0.6	1.9	0.5	4.5	4.0
Pappose tarweed	0	0	2.5	0	1.3	0	0	0	0	0	0
California goosefoot	0	0	0	0	3.5	1.3	4.0	1.0	0.5	0	0
Delta button celery	0.5	0	0	0	0	0	0	0	0	0	0
Sunflower	0	0	0	0	7.1	0	0	0	0	0	0
Yellow cress	0	0	0	0	0	0.6	0	0	2.5	0	0
American black nightshade	0	0	0	0	1.9	0	0	0	1.5	0	0
Cocklebur	7.3	2.7	0.3	0.3	7.1	0	0	0	1.0	0	0
California cudweed	0	0.5	0	0	0	0	0	0	2.0	0	0
Horseweed	0	0	0	0	0	0	0	0	1.0	0.5	0
Gumweed	0	0.3	1.7	0.5	0	1.1	6.2	7.8	0	2.0	0
Turkey tangle fogfruit	0	5.2	4.7	9.0	0	0	0.5	0	0	0	0
Jimson weed	0	0	0	0	0	0	0	0	1.0	1.0	0.5
Grand redstem	3.0	0	0	0	0	0	0	0	0	0	0
Western goldentop	0	0	0	0	0	0	0.6	0	0	1.5	2.0
Water primrose	0	0	0.5	0.3	0	0	0	0	0	0	0
Salt heliotrope	0	0	0	0	0	0	0	0	0	0.5	0
Milkweed	0	0	0	0	0	0	0	0.7	0	0	0
Alkali seaheath	0	0	0	0.3	0	0	0	0	0	0	0
Unidentified forbs*	3.0	2.5	0.5	0	0	0	0	1.0	9.0	0	0
Native forbs	13.8	11.2	10.2	10.4	20.9	4.6	11.9	12.4	19.0	10.0	6.5
Black mustard	0	1.3	2.7	1.3	5.8	10.3	5.8	1.0	1.0	3.5	2.0
Prickly lettuce	0	0.3	1.0	0.5	1.0	0	0	0	1.0	0	0
Alkali mallow	1.0	1.3	0.5	0.8	0.6	0	0	0	1.0	0	0
Common knotweed	0	0.5	0	0	2.1	1.9	0	0	0	0	0
Curly dock	0.5	3.0	0	0	1.3	0.6	0	0	0	0	0
Clover	3.3	0	0	0	0	0	0	0	0	0	0
Prickly sowthistle	0	0.7	0	0	0	0	0	0	0	0	0
White sweetclover	0	0.5	0	0	0	0	0	0	9.0	6.0	0
Bull thistle	0	0	1.8	0	0	1.3	1.3	0	0	0	0
Poison hemlock	0	0	0.0	0	0	9.3	1.9	3.1	0	0	0
Perennial pepperweed	0	0	0.0	0	0	1.9	2.5	3.1	7.5	22.5	59.5
Birdsfoot trefoil	0	0.5	1.5	0	0	0.6	0	0	0	0	0
Dog fennel	0	2.7	0	2.0	0	0	0	0	0	0	0
Milk thistle	0	0.7	0	0	0	0	0	0	0	0	0
Kochia	0	0	0.5	0	0	0	0	0	0	0	0
Yellow starthistle	0	0	2.5	0	0	0	0	0	0	0	0
Introduced forbs	4.8	11.5	10.5	4.6	10.8	25.9	11.5	7.2	19.5	32.0	61.5
Total Plant Cover	47.3	44.0	37.1	35.2	81.4	66.7	71.7	63.5	45.5	45.0	68.5
Litter	22.7	39.5	49.3	48.5	11.8	32.8	28.4	36.1	42.0	49.0	30.0
Bare	30.0	16.8	13.8	16.8	6.8	0.5	0.0	0.5	12.5	6.0	1.5
Total Cover	100.0	100.3	100.2	100.5	100.0	100.0	100.1	100.1	100.0	100.0	100.0

Appendix F

Photo Stations
August 2011 and May 2014

Reach 1A, Transect 1

1a – Toward transect


August 2011


June 2012


June 2013


May 2014

1a – Away from transect


August 2011


June 2012


June 2013


May 2014

1b – Toward transect


August 2011


June 2012


June 2013


May 2014

1b – Away from transect


August 2011


June 2012


June 2013

Reach 1A, Transect 2

2a – Toward transect


August 2011


June 2012


June 2013


May 2014

2a – Away from transect


August 2011


June 2012


June 2013


May 2014

2b – Toward transect


August 2011


June 2012


June 2013


May 2014

2b – Away from transect


August 2011


June 2012


June 2013


May 2014

Reach 1B, Transect 1

1a – Toward transect


August 2011


June 2012


June 2013


May 2014

1a – Away from transect


August 2011


June 2012


June 2013


May 2014

1b – Toward transect


August 2011


June 2012


June 2013


May 2014

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


August 2011


June 2012


June 2013


May 2014

Reach 1B, Transect 2

2a – Toward transect


August 2011


June 2012


June 2013


May 2014

2a – Away from transect


August 2011


June 2012


June 2013


May 2014

2b – Toward transect


August 2011


June 2012


June 2013


May 2014

2b – Away from transect


August 2011


June 2012


June 2013


May 2014

Reach 2A, Transect 1

1a – Toward transect


August 2011


June 2012


June 2013


May 2014

1a – Away from transect

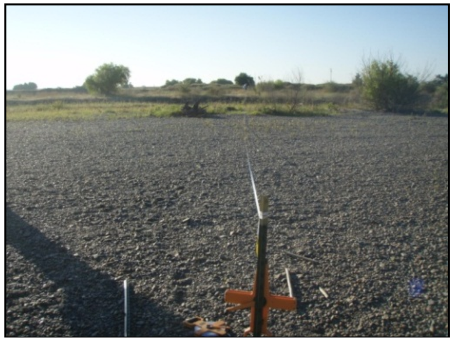

August 2011


June 2012

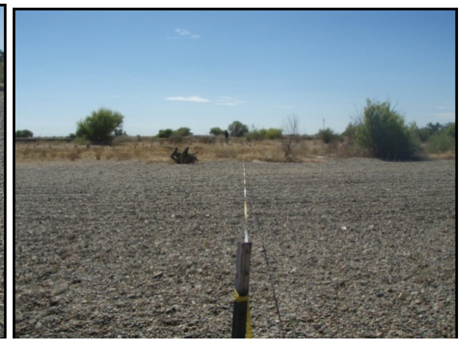

June 2013


May 2013

1b – Toward transect


August 2011


June 2012


June 2013


May 2014

1b – Away from transect


August 2011

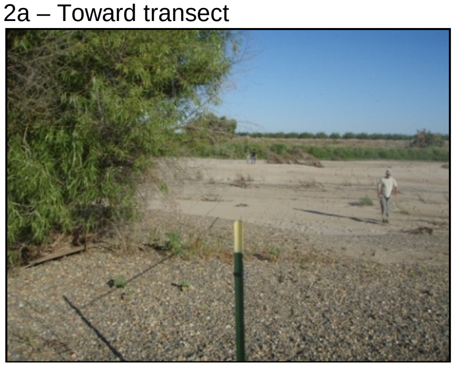

June 2012


June 2013


May 2014

Reach 2A, Transect 2

2a – Toward transect


August 2011


June 2012


June 2013


May 2014

2a – Away from transect


August 2011


June 2012


June 2013


May 2014

2b – Toward transect


August 2011


June 2012


June 2013


May 2014

2b – Away from transect


August 2011

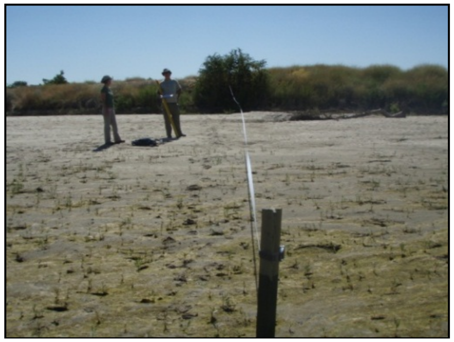

June 2012


June 2013

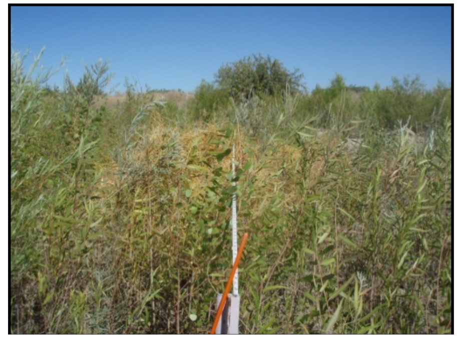

May 2014

Reach 2B, Transect 1

1a – Toward transect


August 2011


June 2012


June 2013


May 2014

1a – Away from transect


August 2011


June 2012


June 2013


May 2014

1b – Toward transect


August 2011


June 2012


June 2013

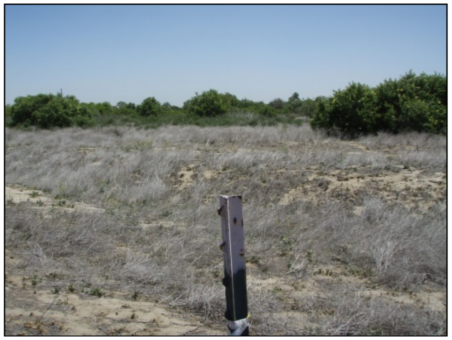

May 2014

1b – Away from transect


August 2011

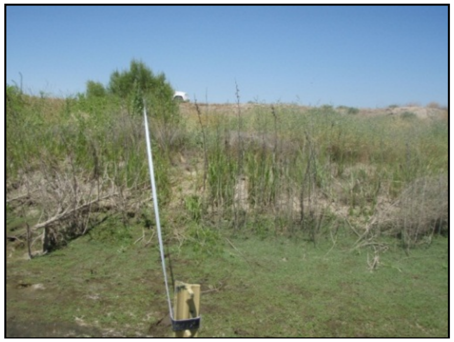

June 2012


June 2013


May 2014

Reach 2B, Transect 2

2a – Toward transect


August 2011


June 2012


June 2013


May 2014

2a – Away from transect


August 2011


June 2012


June 2013


May 2014

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


August 2011


June 2012


June 2013


May 2014

2b – Away from transect


August 2011


June 2012


June 2013


May 2014

Reach 3, Transect 1

1a – Toward transect


August 2011


June 2012


June 2013

Not available
May 2014

1a – Away from transect

August 2011

June 2012

June 2013

Not available
May 2014

1b – Toward transect

August 2011

June 2012

June 2013

Not available
May 2014

1b – Away from transect

August 2011

June 2012

June 2013

Not available
May 2014

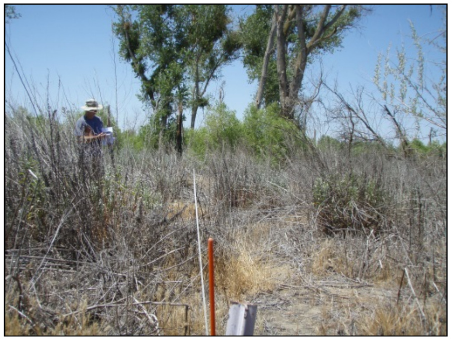
Reach 3, Transect 2

2a – Toward transect


August 2011


June 2012


June 2013


May 2014

2a – Away from transect


August 2011


June 2012


June 2013


May 2014

2b – Toward transect


August 2011


June 2012


June 2013

Not available
May 2014

2b – Away from transect


August 2011


June 2012


June 2013

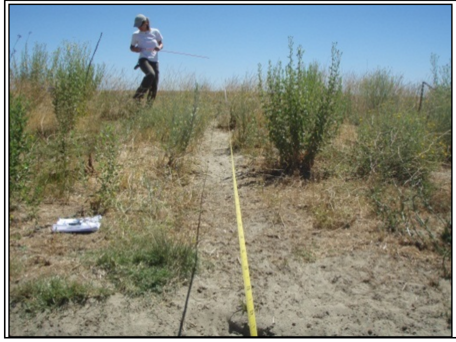
Not available
May 2014

East Side Bypass, Transect 1

1a – Toward transect


August 2011


June 2012


June 2013


May 2014

1a – Away from transect

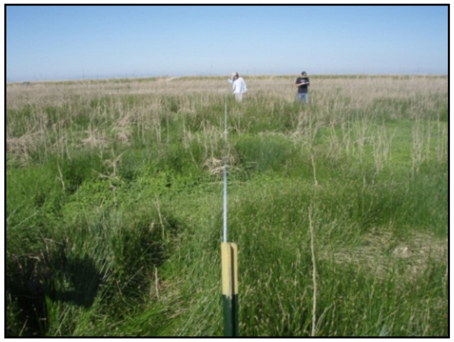

August 2011

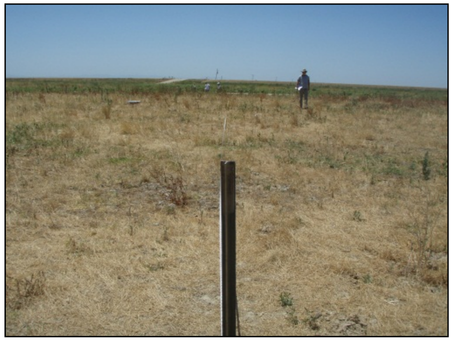

June 2012

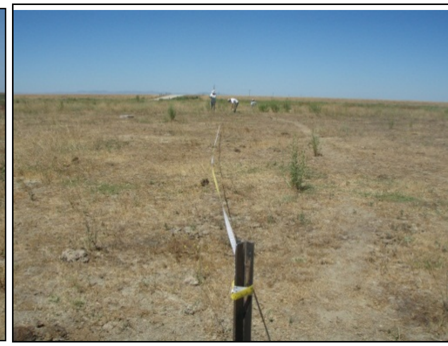

June 2013


May 2014

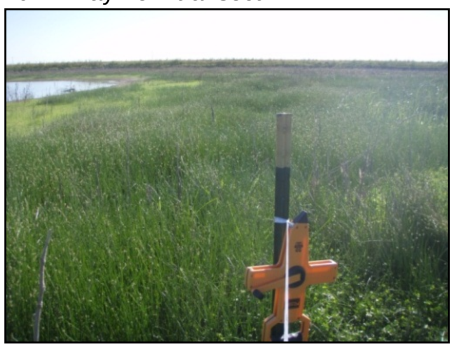
1b – Toward transect


August 2011

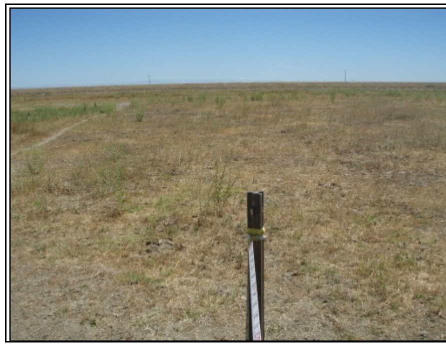

June 2012

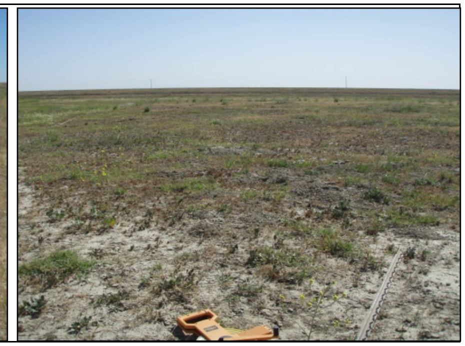

June 2013

1b – Away from transect


August 2011


June 2012


June 2013


May 2014

East Side Bypass, Transect 2

2a – Toward transect


August 2011


June 2012

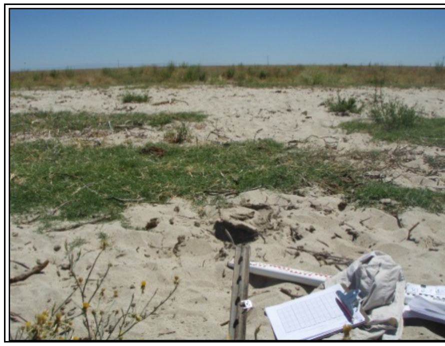

June 2013


May 2014

2a – Away from transect

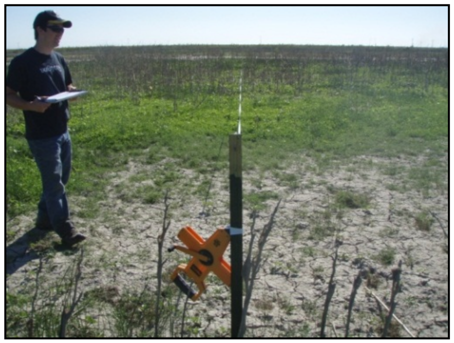

August 2011


June 2012


June 2013

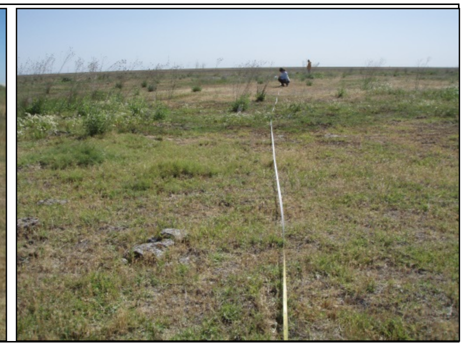

May 2014

2b – Toward transect


August 2011


June 2012

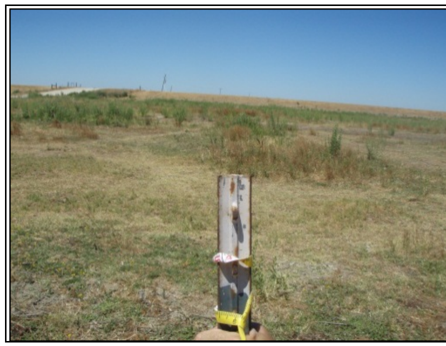

June 2013


May 2014

2b – Away from transect


August 2011


June 2012

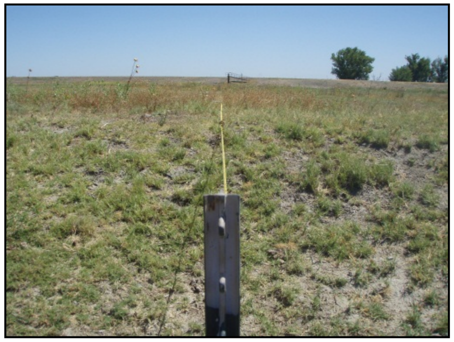

June 2013

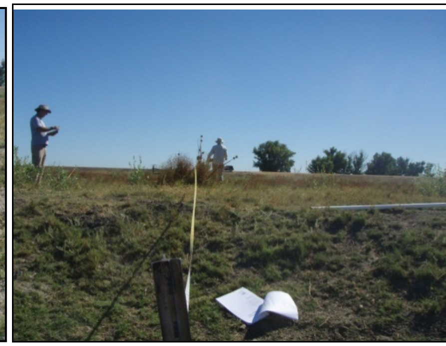

May 2014

East Side Bypass (Merced NWR), Transect 3

3a – Toward transect


August 2011


June 2012


June 2013


May 2014

3a – Away from transect

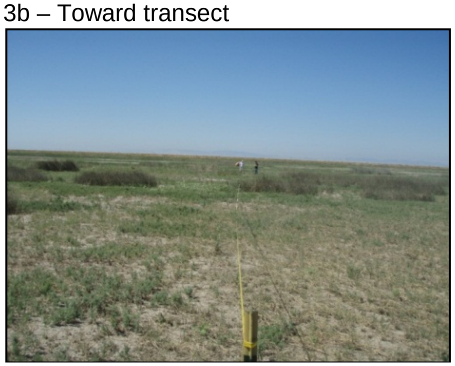

August 2011

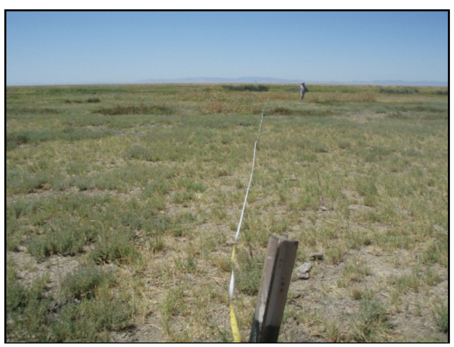

June 2012


June 2013

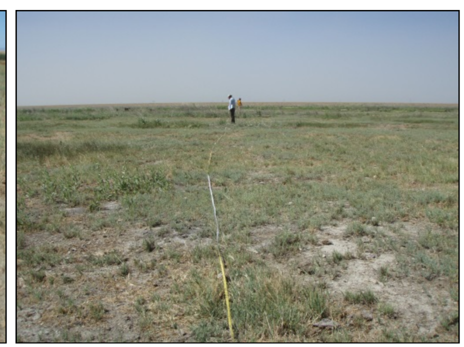

May 2013

3b – Toward transect

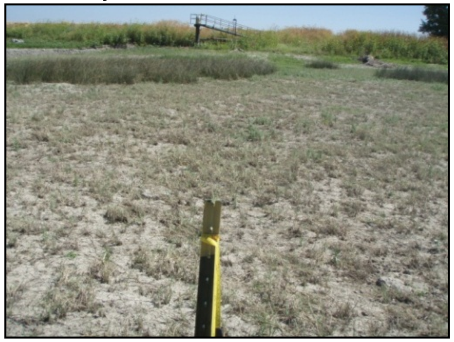

August 2011

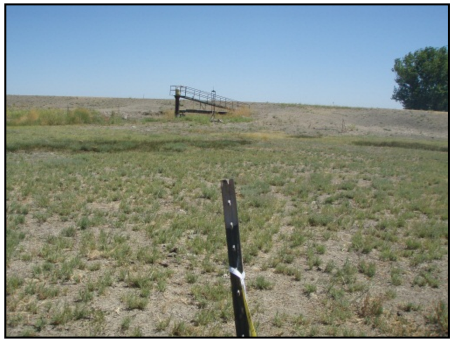

June 2012


June 2013


May 2014

3b – Away from transect


August 2011


June 2012


June 2013


May 2014

East Side Bypass (Merced NWR), Transect 4

4a – Toward transect


August 2011


June 2012


June 2013


May 2014

4a – Away from transect


August 2011

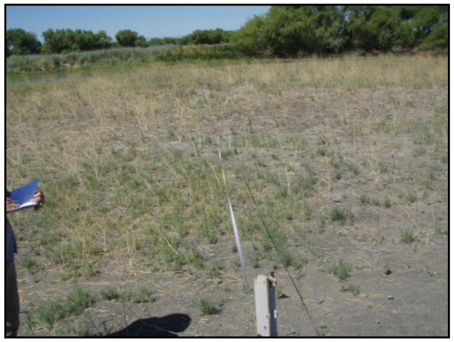

June 2012

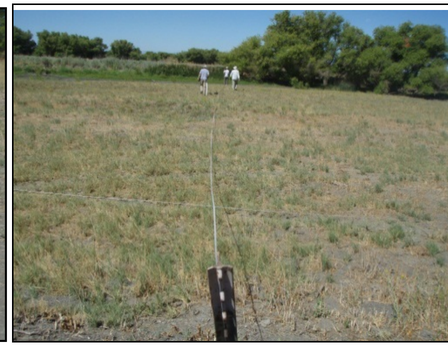

June 2013


May 2014

4b – Toward transect


August 2011

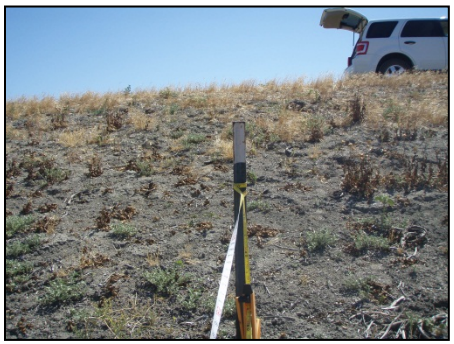

June 2012


June 2013


May 2014

4b – Away from transect


August 2011

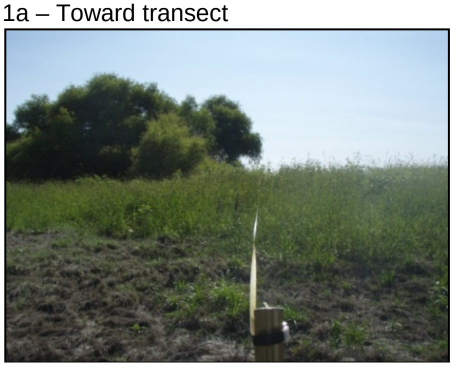

June 2012


June 2013

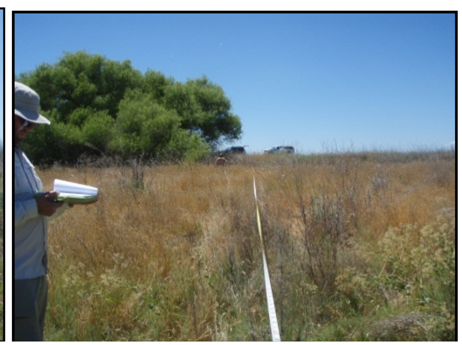

May 2014

Reach 4B2 (San Luis NWR), Transect 1

1a – Toward transect


August 2011


June 2012


June 2013


May 2014

1a – Away from transect


August 2011


June 2012

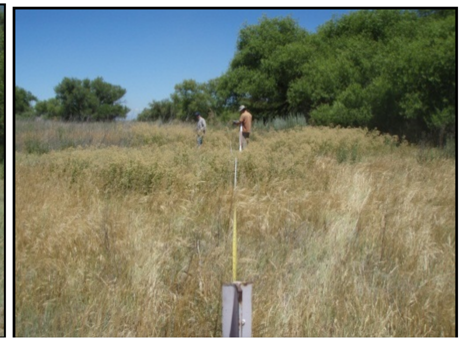

June 2013


May 2014

1b – Toward transect


August 2011


June 2012


June 2013


May 2014

1b – Away from transect


August 2011


June 2012


June 2013


May 2014

Reach 4B2 (San Luis NWR), Transect 2

2a – Toward transect


August 2011


June 2012


June 2013


May 2014

2a – Away from transect

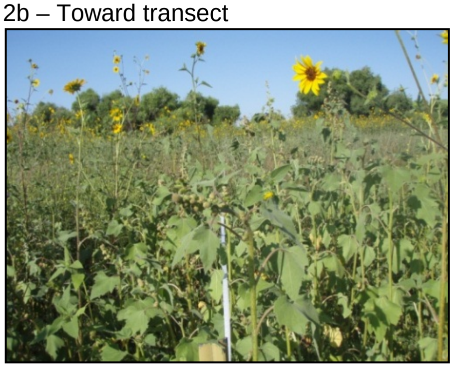

August 2011


June 2012


June 2013


May 2014

2b – Toward transect


August 2011


June 2012


June 2013


May 2014

2b – Away from transect


August 2011


June 2012


June 2013


May 2014

Reach 5, Transect 1

1a – Toward transect


June 2012


June 2013


May 2014

1a – Away from transect


June 2012


June 2013


May 2014

1b – Toward transect


June 2012


June 2013


May 2014

1b – Away from transect

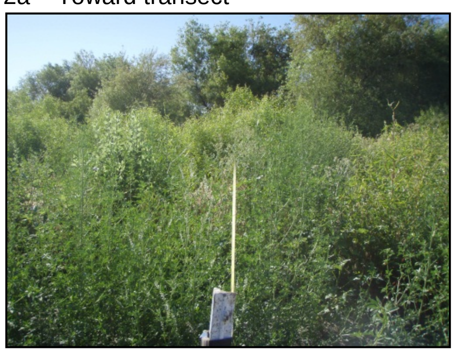

June 2012


June 2013


May 2014

Reach 5, Transect 2

2a – Toward transect


June 2012


June 2013


May 2014

2a – Away from transect


June 2012


June 2013


May 2014

2b – Toward transect


June 2012


June 2013


May 2014

2b – Away from transect


June 2012


June 2013


May 2014

PEER REVIEW DOCUMENTATION

PROJECT AND DOCUMENT INFORMATION

Project Name San Joaquin River Restoration Project

WOID A207F

Document Vegetation Response to Interim Flows in the San Joaquin River

Document Date March 2015

Team Leader Gregory Reed

Document Author(s)/Preparer(s) Rebecca Siegle, Gregory Reed, S.Mark Nelson

Peer Reviewer Gregory Reed

Peer Reviewer S. Mark Nelson

REVIEW REQUIREMENT

Part A: Document Does Not Require Peer Review

Explain

Part B: Document Requires Peer Review: SCOPE OF PEER REVIEW

Peer Review restricted to the following Items/Section(s): Reviewer:

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: Gregory Reed Review Date: 3/23/15 Signature: [signature]

Reviewer: S. Mark Nelson Review Date: 3/23/15 Signature: [signature]

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: Gregory Reed Date: 3/23/15 Signature: [signature]