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Vegetation Response to Interim Flows in the San Joaquin River

Annual Report 2012

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

April 2013

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Vegetation Response to Interim Flows in the San Joaquin River

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

April 2013

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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 fishery 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 (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 in August 2011 and will be conducted annually for comparison over time. In 2012, additional vegetation transects were established and monitored in river reach 5, which will also continue to be monitored annually. Hydrologic variables, including discharge and depth to groundwater as they relate to vegetation, will also be incorporated in the monitoring program. Interim Flows were implemented in Water Year 2010; changes over the monitoring period beginning in 2011 will be 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 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, 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 4A – RM 182-148; Sack Dam to southern portions of the San Luis National Wildlife Refuge. This reach begins in cultivated and ends in public lands. Access for field verification and transects was denied in about half of this stretch. Reach 4A has the fewest habitat types and the lowest ratio of natural vegetation per river mile of any of the segments—only 502 acres of vegetation in this 34-mile segment (14.8 acres/mi.). The proportion of herbaceous habitats is typical of the San Joaquin River as a whole—about two-thirds (67.7 percent), while the proportion of forest is 22.4 percent and the proportion of woody scrub is 5 percent. The most common habitats are herbaceous (177.2 acres), willow riparian forest (89.1 acres), riverwash (65.2 acres), and riparian scrub (56.7 acres).

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, with a similar ratio continuing to the Merced River confluence (512.8

acres/mi. in Reach 4B). 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 2011, twenty permanent vegetation transects were established within river reaches 1A, 1B, 2A, 2B, 3, 4A, 4B2 (*i.e.* San Luis National Wildlife Refuge (NWR)), and the East Side and Mariposa Bypasses (Figures 1 and 2). In 2012, two permanent vegetation transects were established within river reach 5 (Figure 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 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 are illustrative of vegetation change over time resulting from Interim Flows. Aerial photos of vegetation transects by river reach are shown in Figures A-1 to A-11 in Appendix A.

Plant cover, composition, and overstory height and stem density 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.

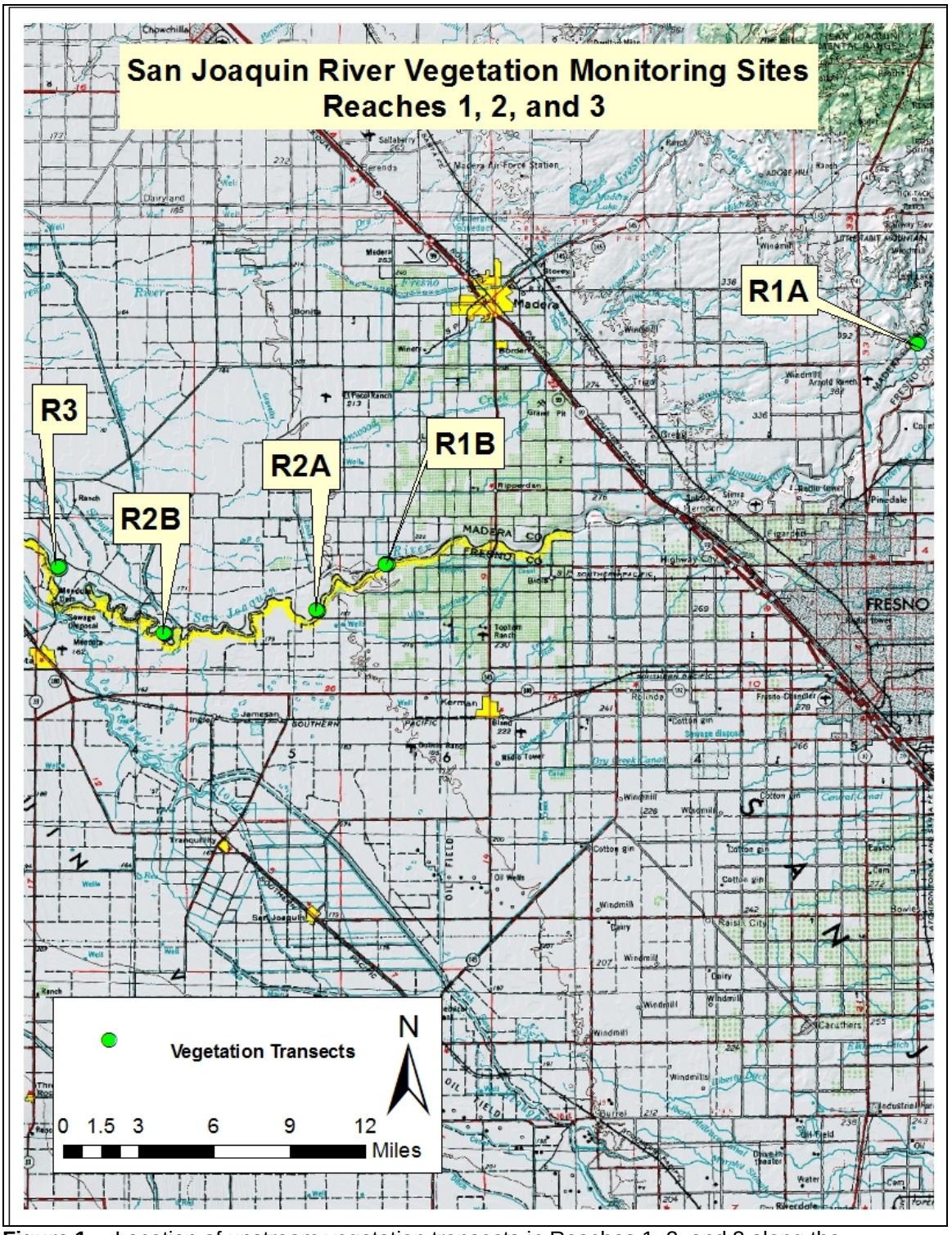


Figure 1.—Location of upstream vegetation transects in Reaches 1, 2, and 3 along the San Joaquin River.

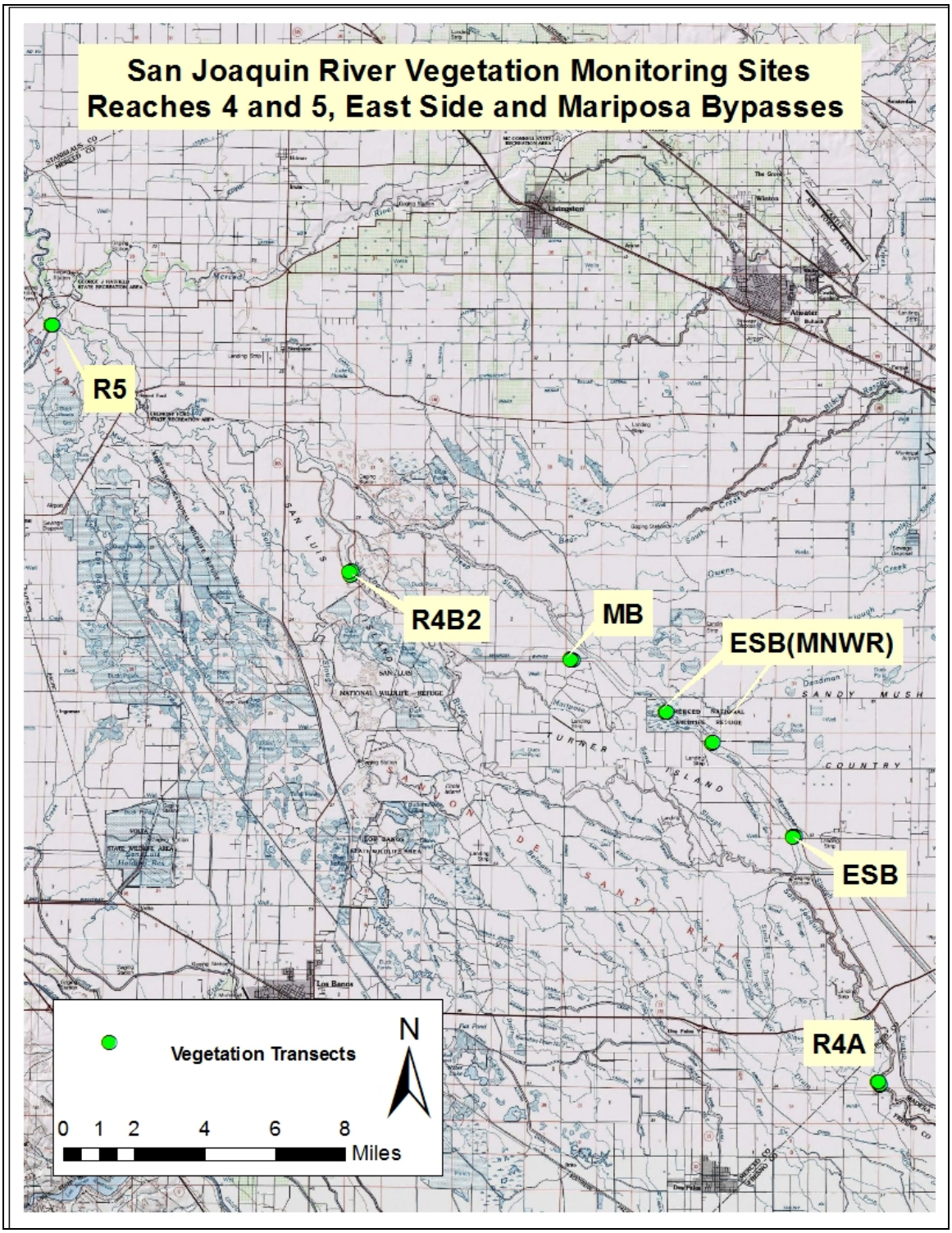


Figure 2.—Location of downstream vegetation transects in Reaches 4 and 5, East Side Bypass (ESB), and Mariposa Bypass (MB) along the San Joaquin River.

Timing

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

Herbaceous vegetation

For herbaceous 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 by species and for woody species under 1 m tall (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.

Figure 3—Measuring herbaceous cover along transect.

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 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 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

Primer (Plymouth Routines in Multivariate Ecological Research; see www.primer-e.com) statistical software was used to create a similarity matrix of plant species between reaches and between years using the Bray-Curtis measure.

Photo Stations

Two digital photographs were taken at each end of the transect – one toward the transect and one facing outward. These photos will 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 on vegetation transects in Reach 2B and 4A 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 can be used to determine if any correlations are observed between growth and development of vegetation and water table levels. No analysis was conducted for this report since ground water wells associated with transects were not yet established as of the 2012 monitoring season.

Results

Vegetation Transects

See Appendix D for a plant list of all herbaceous and woody species detected in transects within all reaches over 2 years of monitoring.

Timing

Vegetation transects were monitored June 11-14, 2012 which was almost 2 months earlier than in 2011, when monitoring was conducted August 1-4. 2011 was a wet year and Friant Dam was in flood operations through mid-July. Monitoring was not feasible until relatively late in the summer due to high river levels and inundated sites. The extreme differences in river discharges from 2011 to 2012 can be seen in Figure 5, which shows the hydrograph for Water Year 2011 and 2012 along the San Joaquin River approximately 3.7 kilometers (2.3 miles) downstream of Friant Dam. River levels were similar in August of 2011 and June of 2012.

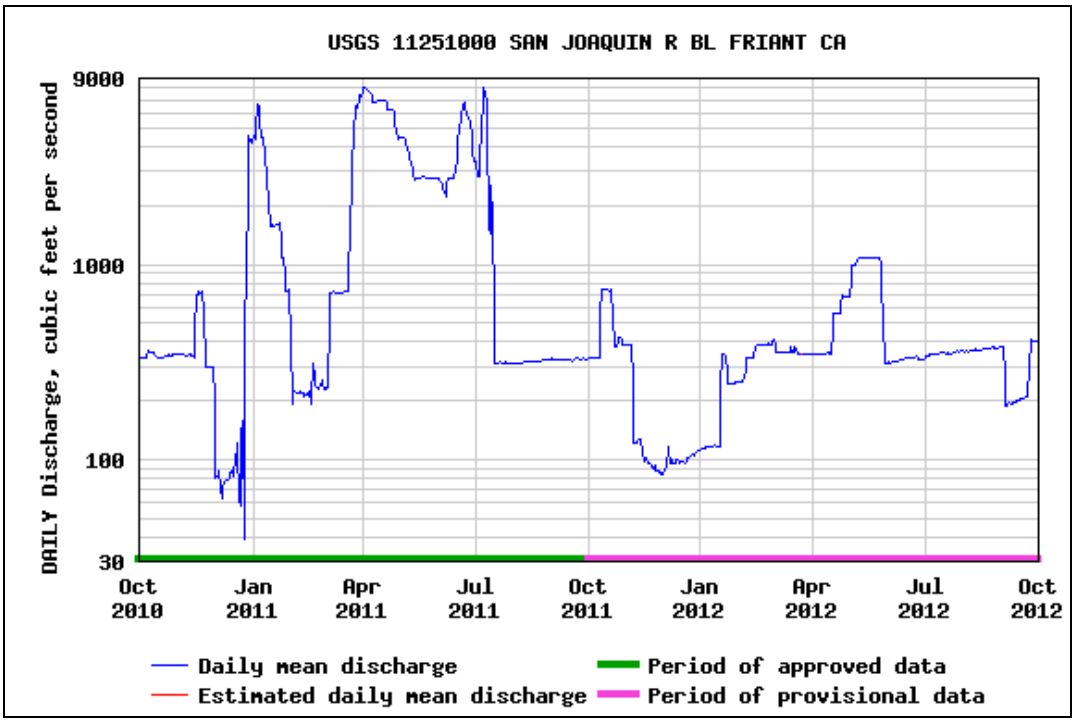


Figure 5.—San Joaquin River discharge (cfs) measured at USGS gage 11251000 below Friant, California for Water Years 2011 and 2012. Source: United States Geological Survey.

Herbaceous vegetation

Seventy-two annual and perennial species were identified while measuring herbaceous vegetation along transects in all river reaches combined over 2 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 herbaceous layer (*i.e.* understory) are shown for Reaches 1A, 1B, 2A, 2B, and 3 in Table E-1, Appendix E and for Reaches 4A, ESB, MB, 4B2, and 5 in Table E-2, Appendix E. A summary of total percent cover in the herbaceous layer by cover type is shown in Table 1.

In 2012, total herbaceous plant cover was less than 50 percent along transects within all reaches except Reach 4B2, where plant cover was 66.7 percent (Table 1) and introduced forbs were the dominant life form (Table E-2, Appendix E). Trends in total cover that were consistent throughout all reaches included a decrease in native plant cover and an increase in litter cover from 2011 to 2012.

Species richness – or the number of species detected along the transect incorporating all measurement methods – was highest in Reach 5 in 2012, where 19 different herbaceous plant species were detected (Table 2). Species richness remained among the highest in the East Side Bypass and Reach 4B2, with 16 herbaceous species detected in both 2011 and 2012. Native plant species richness

Table 1.—Average total percent cover by type in the herbaceous layer of vegetation transects along the San Joaquin River in 2011 and 2012.

Cover type	Average Total Percent Cover – Upstream Reaches									
	Reach 1A		Reach 1B		Reach 2A		Reach 2B		Reach 3	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Native Plant Cover	14.5	7.5	9.5	4.0	9.0	2.5	19.1	6.3	60.4	13.6
Introduced Plant Cover	8.5	41.0	2.5	16.5	10.0	17.5	6.7	19.3	13.0	17.9
Total Plant Cover	23.0	48.5	12.0	20.5	19.0	20.0	25.8	25.6	73.4	31.5
Litter	33.5	39.0	20.0	40.5	16.5	17.5	22.9	32.8	16.0	56.9
Bare	37.0	6.0	55.0	32.5	45.0	43.0	51.3	41.6	10.6	11.6
Rock	6.0	5.0	13.0	6.5	19.5	19.5	0.0	0.0	0.0	0.0
Water	0.5	1.5	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	100.8

Cover type	Average Total Percent Cover – Downstream Reaches								
	Reach 4A		East Side Bypass		Mariposa Bypass		Reach 4B2		Reach 5
	2011	2012	2011	2012	2011	2012	2011	2012	2012
Native Plant Cover	11.3	6.6	29.8	25.2	63.5	17.0	41.5	28.8	19.5
Introduced Plant Cover	7.0	14.0	17.5	18.5	30.5	26.5	39.9	37.9	26.0
Total Plant Cover	18.3	20.6	47.3	43.7	94.0	43.5	81.4	66.7	45.5
Litter	7.5	26.7	22.7	39.5	4.5	55.0	11.8	32.8	42.0
Bare	74.2	52.7	30.0	16.8	1.5	1.5	6.8	0.5	12.5
Rock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water	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

Table 2.—Species richness (number of species detected) for herbaceous and woody plants by reach along the San Joaquin River in 2011 and 2012.

Species Richness												
	# Herbeceous species detected						# Woody species detected					
	Total		Native		Introduced		Total		Native		Introduced	
Reach	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
1A	13	12	8	6	5	6	6	6	6	6	0	0
1B	3	6	1	3	2	3	6	6	4	4	2	2
2A	15	10	7	4	8	6	2	3	1	2	1	1
2B	8	10	5	4	3	6	3	4	3	4	0	0
3	14	4	10	1	4	3	2	2	2	2	0	0
4A	9	7	4	3	5	4	1	1	1	1	0	0
ESB	16	16*	9	7	7	6	1	0	1	0	0	0
MB	14	10*	8	4	6	5	No woody spp					
4B2	16	16	8	6	8	10	1	1	1	1	0	0
5		19*		8		7	na	1	na	1	na	0

*Includes unidentified plants, which could be either native or introduced

decreased in all reaches – with the exception of Reach 1B – from 2011 to 2012, which is consistent with the drop in native plant cover over the same time period.

Relative percent herbaceous cover of lifeforms by reach is shown in Figure 6. In 2011, native forbs and grasses were typically the most common lifeforms detected. In 2012, dominant lifeforms shifted to primarily introduced grasses in the upper reaches and introduced forbs in the lower reaches. Native species were dominant relative to introduced species among herbaceous 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, where relative cover of native species was 57.7 percent (Table 3).

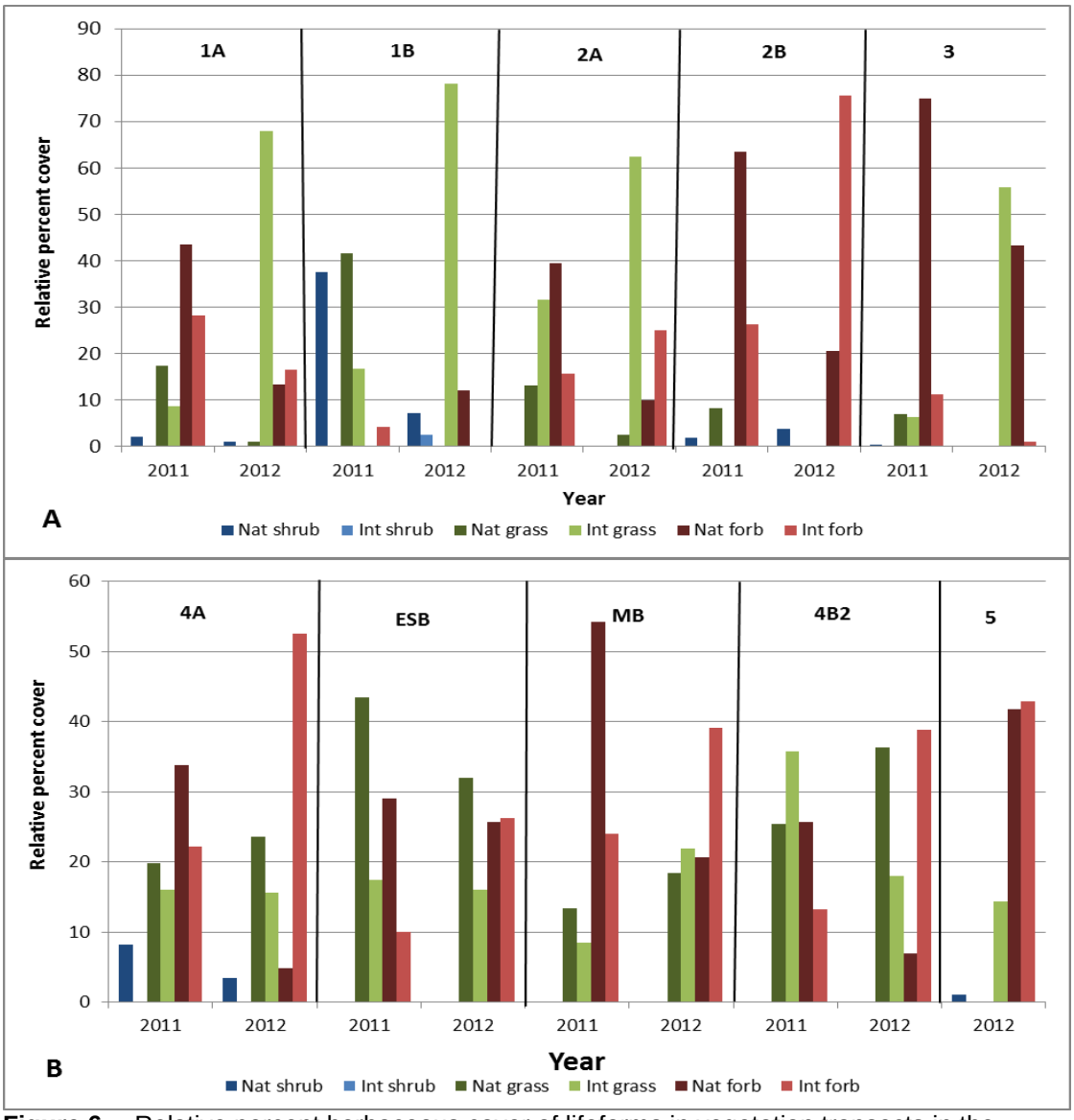


Figure 6.—Relative percent herbaceous cover of lifeforms in vegetation transects in the upper (A) and lower (B) reaches of the San Joaquin River in 2011 and 2012.

Table 3.— Proportion of native and introduced species in the herbaceous and overstory layers by reach along the San Joaquin River in 2011 and 2012.

Relative Percent Cover								
	Herbaceous layer				Overstory layer			
	Native spp		Introduced spp		Native spp		Introduced spp	
Reach	2011	2012	2011	2012	2011	2012	2011	2012
1A	63.0	15.5	37.0	84.5	100.0	100.0	0.0	0.0
1B	79.2	22.0	20.8	78.0	81.8	82.3	18.2	17.7
2A	52.6	12.5	47.4	87.5	100.0	100.0	0.0	0.0
2B	73.8	24.5	26.2	75.5	100.0	100.0	0.0	0.0
3	82.3	43.3	17.7	56.7	100.0	100.0	0.0	0.0
4A	61.9	31.8	38.1	68.2	no overstory			
ESB	51.0	57.7	49.0	42.3	100.0	no overstory	0.0	no overstory
MB	72.5	39.0	27.5	61.0	no overstory			
4B2	67.6	43.3	32.4	56.7	100.0	100.0	0.0	0.0
5	NA	42.9	NA	57.1	NA	100	NA	0

Overstory vegetation

There was a total of 11 woody species detected in the overstory layer (woody species > 1m in height) of all transects combined (Table 4). No overstory was recorded along transects within Reach 4A and the Mariposa Bypass in either year. There was little change in total overstory cover from 2011 to 2012 in any reach except 2B, where cover increased from 7.2 to 19.4 percent (Table 4). In 2012, total percent overstory cover was highest in the most downstream reach 5 (62.8 percent) followed by the uppermost reaches 1A and 1B, with estimates of 46.7 and 58.9 percent, respectively. The average height of the tallest overstory shrubs 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. Gooding's willow was the most frequently documented woody species, detected in 6 of the 9 river reaches in 2011 and 7 of 10 in 2012.

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. Both species are classified as a noxious weed in California.

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 and Mariposa Bypasses. In 2011, highest densities were found in upstream Reaches 1A, 1B, and 2B. In 2012, these same reaches sustained relatively high densities, although densities in Reach 1B decreased from 4.44 to 2.37 stems/m^2 in all size classes (with stems dominantly sandbar willow) while

Table 4.— Total percent cover and average height of woody overstory species (>1 m) detected in vegetation transects for upstream reaches (A) and downstream reaches (B) of the San Joaquin River in 2011 and 2012. No overstory species were documented in transects within Reaches 4A and Mariposa Bypass in either year.

Average Total Percent Overstory Cover - Upstream Reaches																				
	1A				1B				2A				2B				3			
	2011		2012		2011		2012		2011		2012		2011		2012		2011		2012	
Species	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)
White alder	0.6	4.3	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
Button bush	7.1	2.2	9.0	3.4	7.6	2.4	7.8	2.7	0.0		0.0		0.0		0.0		0.0		0.0	
Oregon ash	8.9	10.3	17.6	15.0	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
Fremont cottonwood	0.0		0.0		4.1	2.0	2.7	3.7	0.0		0.0		0.0		0.0		16.7	15.0	14.4	15.0
Valley oak	21.1	12.1	20.0	21.3	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
Sandbar willow	5.7	2.2	9.4	2.4	22.1	2.8	28.3	2.8	0.0		0.0		0.0		0.0		0.0		0.0	
Gooding's willow	0.0	0.0	1.8	2.7	11.8	3.5	12.7	3.5	1.1	3.9	0.9	4.1	4.4	5.9	12.5	6	0.8	3.0	2.8	3.0
Arroyo willow	4.7	4.9	3.8	6.0	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	
Black elderberry	0.0		0.0		0.0		0.0		0.0		0.0		2.8	4.2	6.9	4.8	0.0		0.0	
Total native	48.0		61.6		45.5		51.5		1.1		0.9		7.2		19.4		17.4		17.2	
Giant reed	0.0		0.0		9.8	4.4	9.5	5.2	0.0		0.0		0.0		0.0		0.0		0.0	
Scarlet wisteria	0.0		0.0		0.3	1.3	1.6	1.7	0.0		0.0		0.0		0.0		0.0		0.0	
Total introduced	0.0		0.0		10.1		11.1		0.0		0.0		0.0		0.0		0.0		0.0	
Total canopy*	45.2		46.7		54.9		58.9		1.1		0.9		7.2		19.4		17.4		16.1	

Average Total Percent Overstory Cover – Downstream Reaches										
	ESB				4B2				5	
	2011		2012		2011		2012		2012	
Species	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)
Gooding's willow	0.2	na	0.0		9.3	8.6	8.5	10.5	62.8	4.4
Total native	0.2		0.0		9.3		8.5		62.8	
Total canopy*	0.2		0.0		9.3		8.5		62.8	

*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 in 2011 and 2012.

Average # stems/m^2														
Species	**Size class***	**Reach**												
		1A		**1B**		**2A**		**2B**		**3**		**4A**		**5**
		2011	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2012**
Giant reed	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0.22	0.12	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Button bush	**1**	0.01	0	0.01	0	0	0	0	0	0	0	0	0	0
	2	0.07	0.14	0.22	0.16	0	0	0	0	0	0	0	0	0
	3	0.18	0.15	0.28	0.12	0	0	0	0	0	0	0	0	0
	4	0.02	0	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	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0.01	0	0	0	0	0	0	0	0	0	0	0	0
	4	0.01	0.02	0	0	0	0	0	0	0	0	0	0	0
Fremont cottonwood	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0.07	0.07	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Valley oak	**1**	0.01	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0
	4	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0
Sandbar willow	**1**	0.01	0.08	0	0	0.19	0	0.01	0.02	0	0	0	0	0
	2	0.14	0.04	2.49	0.84	0.04	0.04	0	0.11	0	0	0	0	0
	3	0.31	1.21	1.14	0.95	0	0	0	0.05	0	0	0	0	0
	4	0.02	0	0.01	0	0	0	0	0	0	0	0	0	0
Goodding willow	**1**	0	0	0	0	0	0.13	1.56	0.80	0	0	0.02	0	0
	2	0	0	0	0	0	0.12	0	1.78	0	0	0.41	0.86	0.76
	3	0	0	0.05	0.16	0	0	0.06	0.68	0.04	0.04	0	0	0.58
	4	0	0.01	0	0	0	0	0	0	0	0	0	0	0
Shining willow	**1**	0.04	0	0	0	0	0	0	0	0	0	0	0	0
	2	0.22	0.05	0	0	0	0	0	0	0	0	0	0	0
	3	0	0.10	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Black elderberry	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0.32	0.10	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Scarlet wisteria	**1**	0	0	0	0	0.02	0.02	0	0	0	0	0	0	0
	2	0	0	0.02	0.01	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Total by size class	**1**	0.10	0.08	0.01	0	0.21	0.15	1.57	0.82	0	0	0.02	0	0
	2	0.43	0.22	2.73	1.02	0.04	0.16	0	1.96	0.07	0	0.41	0.86	0.76
	3	0.50	1.47	1.69	1.35	0	0	0.38	0.83	0.04	0.04	0	0	0.58
	4	0.06	0.03	0.01	0	0	0	0	0	0	0	0	0	0
TOTAL stems/m^2		1.08	1.80	4.44	2.37	0.25	0.31	1.95	3.62	0.11	0.04	0.43	0.86	1.34

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

densities in Reach 2B increased from 1.95 to 3.62 stems/m^2 in all size classes (with stems dominantly Goodding's willow). Reach 5, newly established in 2012, had a relatively high density as well, at 1.34 stems/m^2. Most stems were recorded in size classes 2 and 3 in 2012, with less current year's establishment (i.e. class 1) than in 2011.

Habitat Variables

The highest ranking habitat variables (>7) were found in the uppermost reaches 1A and 1B and the lowermost reach 5 in 2012 (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 6.0) were 2A, 2B, and 3. All other reaches ranked between 3.55 and 4.95. These sites similarly ranked relatively low in variables "Coverage and Spatial Diversity", "Stuctural Diversity", "Micro- and Macrotopographic Complexity", and "Biogeochemical Processes". Changes in habitat variables from 2011 to 2012 differed among reaches, though none were drastic.

Statistical Analysis

The graph in Figure 7 shows a Bray-Curtis similarity matrix of the 10 sub-reaches over 2 years based on total percent species cover and using a square root transformation of the data. A similarity value of 0 indicates that 2 sites had no species in common and a value of 100 indicates that 2 sites had exactly the same percent species composition (Clark and Warwick 2001).

The highest similarities were between years in Reaches 1A and 1B (in bold and highlighted in blue in Figure 7), indicating that the least amount of change happened between 2011 and 2012 at these sites. Between year comparisons in Reaches 2B and 4B also had relatively high similarity. Reach 4A had very low similarity between years (value of 7), indicating that species composition changed quite a bit between 2011 and 2012.

When looking at similarities between the different reaches, the only reaches that maintained a relatively similar species composition in both years were 4B (San Luis NWR) and Mariposa Bypass (RMB in Figure 7). Not surprisingly, reaches appear to be more similar when close in geographic proximity. In general, upstream reaches show higher similarity to each other than they do to downstream reaches, and vice versa, with a break around Reach 3. Interestingly, Reach 3 was more similar to downstream reaches in 2011 and to upstream reaches in 2012.

Table 6.—Ranking of habitat variables as an indicator of riparian condition by reach along the San Joaquin River in 2011 and 2012.

	1A		1B		2A		2B		3		4A		ESB		MB		4B2		5
Variable	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2012**
Coverage & Spatial Diversity	1.00	0.90	1.00	1.00	0.25	0.40	0.25	0.40	0.45	0.55	0.20	0.20	0.18	0.23	0.20	0.25	0.40	0.40	0.5
Structural Diversity	0.70	0.65	0.75	0.85	0.25	0.40	0.40	0.40	0.60	0.50	0.20	0.20	0.18	0.25	0.25	0.30	0.40	0.40	0.7
Contiguity of Habitats	1.00	1.00	0.80	1.00	0.80	0.90	0.90	0.90	0.65	0.80	0.80	0.80	0.90	0.90	1.00	0.80	0.80	0.90	1.0
% Invasive Woody Vegetation	1.00	1.00	0.90	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0
Hydrology	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.80	0.90	1.00	0.60	0.50	0.30	0.30	0.60	0.70	0.60	1.0
Micro- & Macrotopographic Complexity	1.00	0.80	0.85	0.90	0.80	0.50	0.35	0.70	0.70	0.25	0.35	0.20	0.28	0.28	0.20	0.20	0.50	0.45	0.9
Characteristics of Flood-prone Area	1.00	1.00	1.00	1.00	0.90	1.00	0.90	0.90	0.80	0.70	1.00	0.30	0.83	0.33	0.30	0.30	0.80	0.80	1.0
Biogeochemical Processes	0.90	0.90	0.80	0.95	0.35	0.30	0.30	0.50	0.60	0.50	0.20	0.30	0.40	0.28	0.40	0.35	0.60	0.40	1.0
Total Score*	7.60	7.25	7.10	7.60	5.35	5.50	5.10	5.80	5.60	5.20	4.75	3.60	4.25	3.55	3.65	3.80	5.20	4.95	7.1

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

Year	Reach	2011 R1A	2011 R1B	2011 R2A	2011 R2B	2011 R3	2011 R4A	2011 R4B	2011 RESB	2011 RMB	2012 R1A	2012 R1B	2012 R2A	2012 R2B	2012 R3	2012 R4A	2012 R4B	2012 RESB	2012 RMB
2011	R1B	24																	
2011	R2A	16	5																
2011	R2B	13	12	**38**															
2011	R3	20	24	21	21														
2011	R4A	17	21	26	20	37													
2011	R4B	18	16	25	22	30	29												
2011	RESB	15	14	17	13	26	39	27											
2011	RMB	14	8	16	9	26	22	57	26										
2012	R1A	63	28	14	9	12	9	7	6	4									
2012	R1B	22	75	8	10	16	12	15	9	6	36								
2012	R2A	14	9	44	25	10	19	16	10	13	28	29							
2012	R2B	11	17	13	53	14	8	20	11	12	11	18	27						
2012	R3	20	27	17	19	39	22	14	13	8	31	22	29	20					
2012	R4A	8	5	16	21	7	7	23	3	10	10	14	38	33	6				
2012	R4B	17	16	10	23	19	14	52	14	38	16	17	17	32	21	28			
2012	RESB	13	8	19	7	15	21	36	33	26	8	14	20	13	11	26	32		
2012	RMB	12	0	8	12	0	0	27	5	32	5	0	14	19	0	23	47	24	
2012	R5	15	7	19	18	28	15	26	17	18	7	9	17	23	12	32	23	31	5

between all plots in 2011

between all plots in 2012

between years, same plot

Figure 7.— Bray-Curtis similarities of plant species based on square root transformation of total percent cover data between reaches along the San Joaquin River in years 2011 and 2012. Highest similarities are in bold. Note R5 was only sampled in 2012.

Photo Stations

Photographs taken from the end of vegetation transects the first two years of monitoring are shown in Appendix F. Differences in vegetation along transects within many of the reaches are evident when comparing the 2011 and 2012 photos.

Groundwater Monitoring

Groundwater wells were not yet installed; therefore no correlations between groundwater levels and vegetation were analyzed in 2012. A wide range of hydrologic regimes have been observed from year to year on the San Joaquin River, which is expected to be captured in groundwater well data. In turn, the effects of varying hydrology should be apparent in vegetation development.

Discussion

Following is a descriptive analysis comparing vegetation parameters from 2011 to 2012 by reach. The 2011 and 2012 Water Years were very different hydrologically (Figure 4), which was likely the cause for many of the changes observed.

Reach 1A – This reach was the only to show a perceptible increase in herbaceous plant cover from 2011 to 2012, increasing from 23.0 to 48.5 percent in total cover (Table 1). This rise was due to a substantial increase in introduced species, from 8.5 to 41.0 percent; these species were exclusively introduced grasses (Table E-1, Appendix E). This change is evident in photos from 2011 and 2012 (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. In 2012, 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 to 6.0 percent in 2012, which was likely due to high flows and major flooding that caused scouring in 2011 and was not a factor in 2012. The increase in herbaceous introduced species resulted in a shift in dominance of native species at the site, with relative cover of herbaceous native species decreasing from 63.0 percent in 2011 to 15.5 percent in 2012 (Table 3). Herbaceous species richness decreased from 13 species detected to 12, with native species detected decreasing from 8 to 6 (Table 2). Total cover of overstory species within this reach remained essentially the same although the

cover of native species increased from 48.0 percent in 2011 to 61.6 percent in 2012 (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 the highest diversity of woody species, with species richness remaining at 6 (Table 2). The species themselves changed from 2011 to 2012, with white alder dropping out and Goodding's willow newly detected. Stem density in Reach 1A slightly increased from 1.08 to 1.80 stems/m^2 (Table 5). The dominant size class in both years was Class 3 (>1 m in ht and <10 cm DBH), though more so in 2012. Finally, habitat variable rating decreased from 7.6 to 7.25 (Table 6), although this reach still remained among the top in riparian health.

Reach 1B – Total herbaceous cover within this reach increased slightly from 12.0 percent in 2011 to 20.5 percent in 2012 (Table 1). There was a notable increase in total percent litter (from 20.0 to 40.5 percent), while bare cover decreased from 55.0 to 32.5 percent. These results were presumably related to flows and flooding – high river discharge in 2011 caused scouring (higher bare cover) and lower flows in 2012 led to the accumulation of litter in 2012. Total cover of introduced species increased from 2.5 to 16.5 percent, which was predominantly due 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 in 2012, with relative cover of native herbaceous species decreasing from 79.2 to 20.8 percent (Table 3). Species richness in Reach 1B increased from 3 herbaceous species detected in 2011 to 6 detected in 2012, and despite dominance of introduced species in 2012, native species richness increased from 1 to 3 (Table 2). Total overstory cover showed a negligible increase, with total cover of the introduced species scarlet wisteria increasing slightly from 0.3 to 1.6 percent from 2011 to 2012 (Table 4). Stem density remained fairly high relative to other reaches despite a notable decrease from 4.44 to 2.32 stems/m^2 (Table 5). The site was dominated by sandbar willow stems in size classes 2 and 3 in both years, and this is where the drop in overall stem density was observed. Habitat variable rating increased in Reach 1B, from 7.1 to 7.6 (Table 6), which ranks it highest among reaches in 2012. This rating was very near the highest possible score of 8, which indicates excellent riparian health.

Reach 2A – Total herbaceous cover within this reach remained essentially the same from 2011 to 2012, although native herbaceous cover decreased from 9.0 to 2.5 (due to a drop in native forbs) and introduced herbaceous species cover increased from 10.0 to 17.5 percent (due to a rise in introduced grasses; Table 1). As a result, relative percent cover of native species decreased from 52.6 to 12.5 percent (Table 3). Herbaceous species richness dropped from 15 in 2011 to 10 in 2012, with native species richness decreasing from 7 to 4 (Table 2). Total overstory cover was only around 1.0 percent in both years, with only Goodding willow detected in the overstory measurements (Table 4). Woody species richness, on the other hand, increased from 2 to 3, with stem density measurements increasing from 2 to 3 species counted. Density increased very

slightly, from 0.25 to 0.31 stems/m^2 (Table 5). Riparian condition was ranked moderately, slightly increasing from 5.35 in 2011 to 5.5 in 2012 (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 2B – Similar to Reach 2A, total herbaceous cover remained the same, while total native cover decreased (19.1 to 6.3 percent) and total introduced cover increased (6.7 to 19.3 percent). Litter cover increased and bare cover decreased, both by around 10 percent (Table 1). Relative cover of native species decreased from 73.8 percent in 2011 to 24.5 percent in 2012 due to a decrease in native forbs and an increase in introduced forbs (Table 3, Figure 6), making introduced herbaceous species dominant at the site. Species richness increased from 8 herbaceous species detected to 10, although native species richness decreased from 5 to 4 (Table 2). This reach showed the largest increase in both total overstory cover (7.2 to 19.4 percent; Table 4) and stem density (1.95 to 3.62 stems/m^2 ; Table 5). The majority of stems shifted from size class 1 in 2011 to size class 2 in 2012. Woody species richness increased from 3 to 4 (all native species). At this point in the study, Reach 2B shows the most potential for identifying change over time and effects from Interim Flows as a healthy riparian community appears to be developing. Young willow and cottonwood seedlings became established over the year, increasing in cover, size and density (see photos from 2011 and 2012 in Appendix F; Reach 2B, Transect 1; 1A-Toward transect). Riparian condition remained moderate, increasing from 5.1 in 2011 to 5.8 in 2012 (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).

R**each 3** – This reach showed substantial changes from 2011 to 2012, decreasing in total herbaceous cover from 73.4 to 31.5, which was the second highest drop among all reaches (Table 1). Total native cover decreased from 60.4 to 13. 6 percent and litter cover increased from 16.0 to 56.9 percent. Dominance in native herbaceous species relative to introduced species shifted in 2012, when native species composed 43.3 percent , down from 82.3 in 2011 (Table 3). This shift was related to an increase in introduced grasses at the site. Herbaceous species richness experienced a huge drop, from 14 to 4, going from one of the most diverse sites in 2011 to the least diverse in 2012 (Table 2). Native species richness fell from 10 to 1. Total overstory cover remained the same (around 16.5 percent; Table 4), as did woody species richness (2 species detected; Table 2) from 2011 to 2012. Stem density decreased from 0.11 to 0.4, with stems detected only in size class 3 in 2012 (Table 5). The difference in hydrologic conditions between the first 2 years of the study appeared to have large effects on herbaceous species within this reach, with drier conditions in 2012 presumably causing cover, species richness and the native species component to decrease considerably. This

site has high cutbanks, which likely prevented overbank flows in 2012. Reach 3 received a moderate ranking in riparian condition (from 5.6 to 5.2) with a relatively large drop in the micro- and macrotopographic complexity (mixture of topographic features) variable rating from 2011 to 2012.

Reach 4A – Total herbaceous cover remained essentially the same at around 20 percent from 2011 to 2012 in Reach 4A, but consistent with most reaches, native species cover decreased while introduced species cover increased (Table 1). Litter cover increased from 7.5 to 26.7 percent and bare cover decreased from 74.2 to 52.7, which was another common trend that was likely related to flooding and scouring in 2011 and low flows in 2012. Regardless, this site still had the highest percentage of bare ground in both years. Native herbaceous species were no longer dominant relative to introduced species in 2012, decreasing from 61.9 to 31.8 relative percent cover (Table 3). No overstory cover was documented. Goodding's willow was, however, detected in both herbaceous cover and density measurements in both years (woody species richness = 1; Table 2), indicating potential for willow riparian habitat if river conditions can sustain woody species along this reach. Stem density did increase slightly, from 0.44 to 0.86 stems/m^2 ; all stems were detected in size class 2 in 2012, however, which suggested no recruitment of seedlings as in 2011, when stems were also detected in size class 1 (Table 5). Riparian condition was ranked relatively low, decreasing from 4.75 in 2011 to 3.6 in 2012, with low scores in most variables (Table 6).

East Side Bypass – Total herbaceous cover within this reach remained around 45 percent in both 2011 and 2012, with litter cover increasing from 22.7 to 39.5 percent and bare cover decreasing from 30.0 to 16.8 percent. Unlike other reaches, native herbaceous species remained dominant relative to introduced species (Table 3), with native grasses the most common life form in both years (although there was a relatively high increase in relative percent cover of introduced forbs in 2012; Figure 6). Herbaceous species richness was the same in both years at 16, which is high relative to other transects, although fewer of the species detected were native in 2012 (from 9 to 7; Table 2). In 2012, 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 herbaceous or stem density measurements. The East Side bypass received the lowest score in riparian condition of all reaches in 2012, decreasing from 4.25 to 3.55. Rankings were 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 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. Delta button celery, which is a State-listed endangered plant, was detected in the Merced NWR within this reach (Figure 8). 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.

Figure 8.—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.

Mariposa Bypass – Vegetation was strictly herbaceous with no woody species of any size detected in transects within the Mariposa Bypass in either year. The largest decrease in total herbaceous cover from 2011 to 2012 occurred in this reach, dropping from 94.0 (highest total cover in 2011) to 43.5 percent (Table 1). Total cover of native species showed a substantial decrease from 63.5 percent in 2011 to 17.0 percent in 2012 while introduced species cover remained the same. The decrease in total plant cover was replaced with litter cover, which increased considerably, from 4.5 to 55.0 percent. Native species were no longer dominant in the herbaceous layer, with relative percent cover decreasing from 72.5 to 39.0 percent from one year to the next (Table 3). Herbaceous species richness dropped from 14 in 2011 to 10 in 2012, with native species richness decreasing from 8 species detected to 4. Mariposa Bypass received the lowest ranking in riparian condition of all reaches studied in 2011. The habitat variable score increased slightly in 2012, but was still relatively low. Improvement is needed 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), micro- and macrotopographic complexity (mixture of topographic features), and biogeochemical processes (i.e. vegetation with woody debris, leaf litter, detritus in channel).

Reach 4B2 – Reach 4B2 had the highest total herbaceous cover of all reaches in 2012 at 66.7, decreasing from 81.4 percent in 2011. Similar to most reaches, total native herbaceous cover decreased (41.5 to 28.8 percent) with a consequent increase in litter cover (11.8 to 32.8 percent). Also consistent with the majority of

reaches, relative cover of native species decreased from 67.6 to 43.3 with herbaceous plant cover composed predominantly of introduced forbs (Table 3). The native grass component did increase in 2012, however (Figure 6). Herbaceous species richness remained high at 16 both years (Table 2), although less than half of species detected were native (from 8 in 2011 to 6 in 2012). While mature Goodding's willow was measured in total overstory cover both years (around 9 percent), no woody species were detected in herbaceous cover or stem density measurements, indicating that recruitment is potentially low. Reach 4B2 received a moderately low ranking in riparian condition, slightly decreasing from 5.2 to 4.95. 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; therefore only baseline data exists and no comparisons between years are discussed. Habitat quality appears to be relatively good in Reach 5, which had the highest herbaceous species richness for all plants (19) and for native plants (8) compared to other reaches. This site also had the highest total overstory cover at 62.8 percent, although Goodding's willow was the only woody species detected. Riparian condition was also rated relatively high at 7.1, following only the upper reaches 1A and 1B in ranking.

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). In 2012, river discharge was lower (approximately 1,000 cfs) throughout the year, prohibiting typical overbank flows. Due to such differences in precipitation patterns and hydrology, it is doubtful that any changes in vegetation were related to Interim Flow implementation over the study period.

Total herbaceous native cover decreased in all reaches, as did herbaceous native species richness. Herbaceous cover was composed of principally native species in 2011. This condition shifted to dominance of introduced species in the herbaceous layer in 2012 in all but one of the reaches. Prolonged flooding in 2011 appeared to affect composition and cover of native herbaceous species along

the river and likely deterred the establishment of introduced species, which are generally not as adaptable to inundation as native riparian species. Native species were dominant in 2011, presumably because they are tolerant of anaerobic conditions and because of less competition from exotic species. The predominance of introduced species in 2012 could be attributed to drier conditions. Herbaceous cover was closely linked to discharge, with abundance of these shallow-rooted plant species dependent upon the amount of available water near the surface.

Total litter cover increased in all reaches in 2012. This result can be attributed to a decrease in herbaceous cover. 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.

Deeper rooted woody species in the overstory layer did not appear to be affected by lower flows, with total cover showing little change from 2011 to 2012. The exception was in Reach 2B, where overstory cover increased in 2012 and where numerous willow seedlings were documented in 2011. Apparently these plants were established enough to withstand drier conditions in 2012 and expand in cover. Riparian recruitment sustained over 2011-12 at the Reach 2B site is likely a result of Interim Flows. Willow recruitment was documented after the 2011 flood year and these new plants were maintained by Interim Flows. This situation is in contrast to Reach 4A, where SJRRP is not releasing flows and bare ground still dominates.

Stem density was variable, increasing or decreasing among reaches. A consistent trend within all reaches, however, was a decrease in stem density in Size Class 1 (i.e. current year's growth), indicating little recruitment of new seedlings in 2012. This was most likely due to a lack of flooding in 2012, a condition that is conducive to regeneration of willow and cottonwood species.

Generally, upstream reaches (*i.e.* 1A through 3, but particularly 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, downstream reaches – 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. Transects in Reach 5 (the furthermost downstream reach in the study) were added in 2012. This reach was comparable to upstream reaches in that relatively high values were recorded for cover and density of woody species and habitat variable rankings. Reach 5 also had high herbaceous species richness. Because current riparian conditions at Reach 5 are relatively good, effects may be more difficult to detect here as well. 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, with 2 new transects added to the study further downstream. SJRRP will continue to monitor these transects during 2013.

Literature Cited

CDWR (California Department of Water Resources). 2002. Riparian vegetation of the San Joaquin River. Prepared by CDWR, San Joaquin District, Fresno for San Joaquin River Habitat Restoration Program, Fresno, California.

Clark, K.R. and R.M. Warwick. 2001. Change in Marine Communities: An Approach to Statistical Analysis and Interpretation, 2nd edition. Plymouth, United Kingdom.

Stein, E.D., Tabatabai, F., Ambrose, R.F., 2000. Wetland mitigation banking: a framework for crediting and debiting. Environmental Management 26:233-250.

Stillwater Sciences. 2003a. Restoration Objectives for the San Joaquin River. Prepared by Stillwater Sciences, Berkeley, CA for Natural Resources Defense Council, San Francisco, CA and Friant Water Users Authority, Lindsay, CA.

Stillwater Sciences. 2003b. Draft Restoration Strategies for the San Joaquin River. Prepared by Stillwater Sciences, Berkeley, CA for Natural Resources Defense Council, San Francisco, CA and Friant Water Users Authority, Lindsay, CA.

USDA, NRCS. 2012. The PLANTS Database (http://plants.usda.gov, 19 January 2012). National Plant Data Team, Greensboro, NC 27401-4901 USA.

Appendix A

Aerial Photos of Vegetation Transects by River Reach
Upstream to Downstream

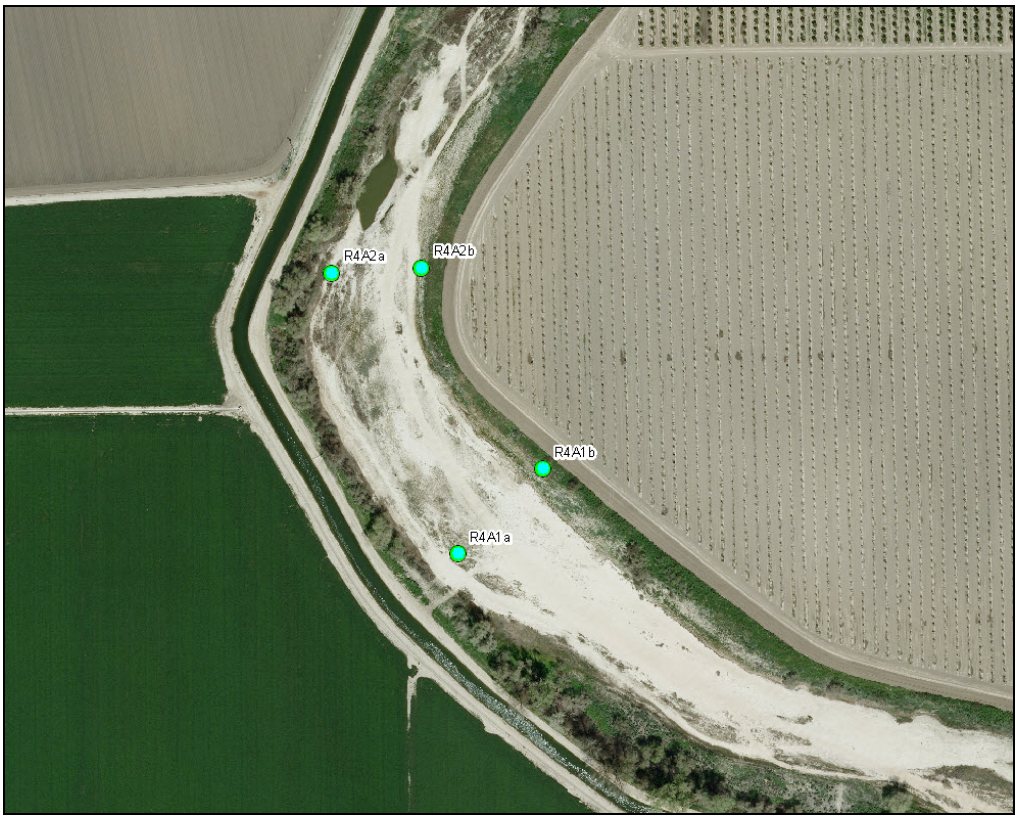
Reach 1A

Reach 1B

Reach 2A

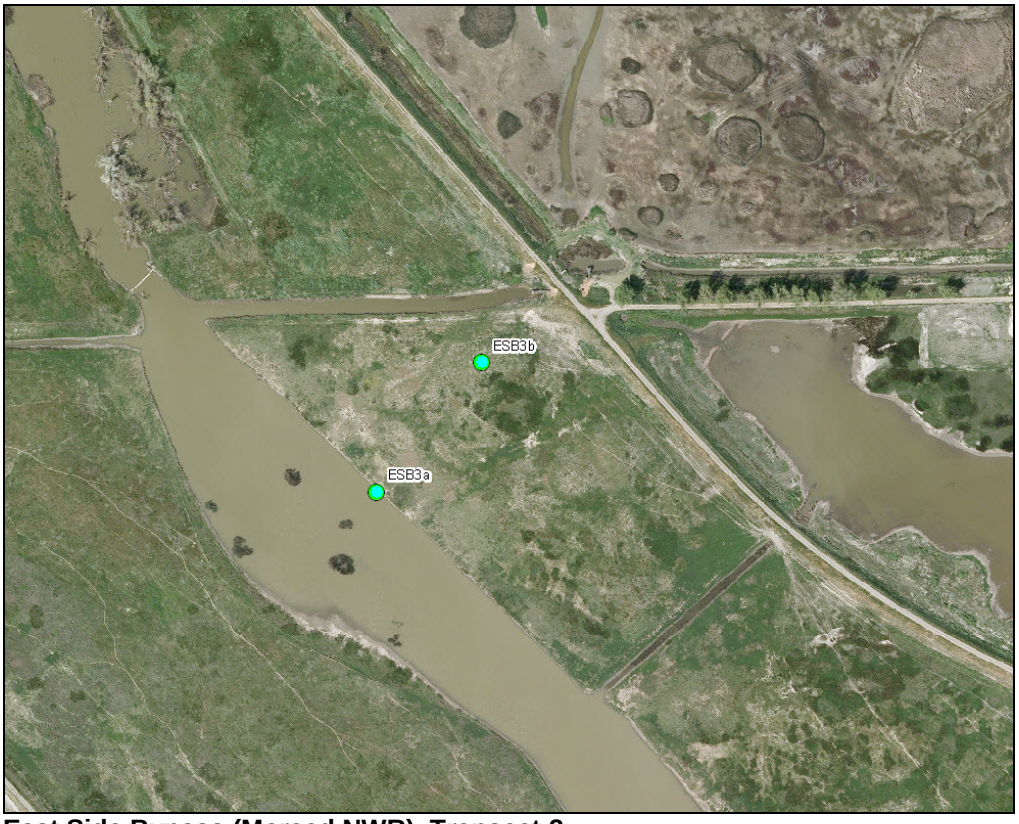
Reach 2B

Reach 3



Reach 4A

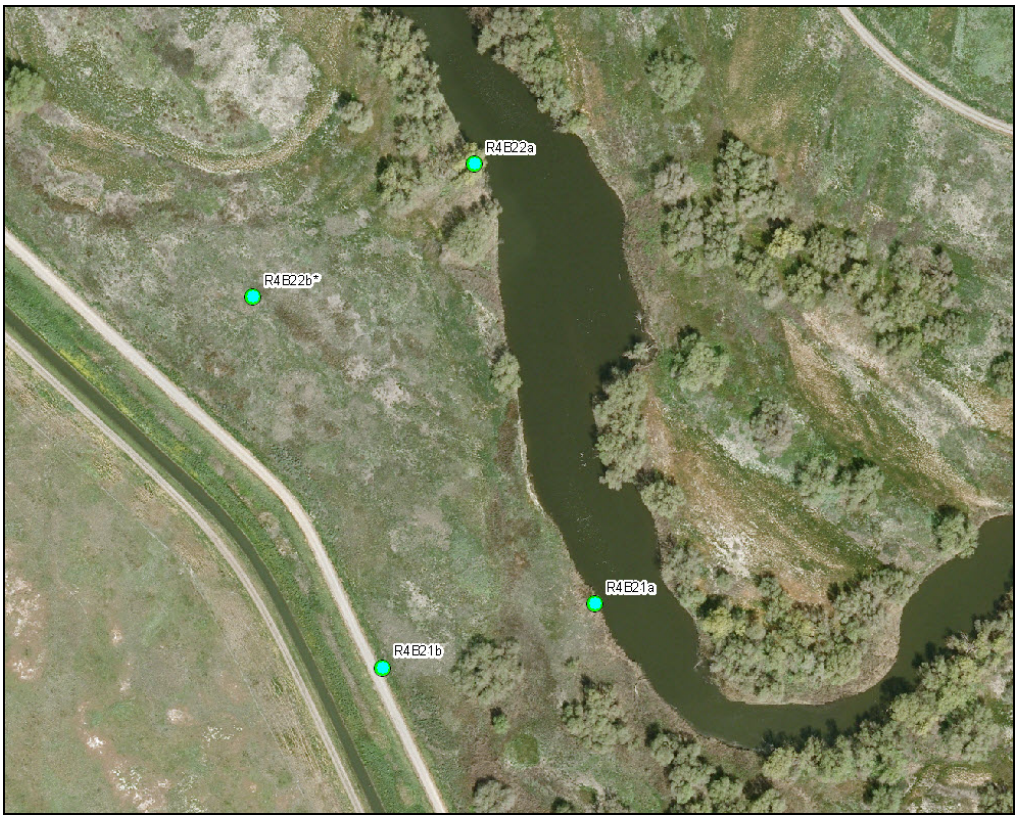
East Side Bypass



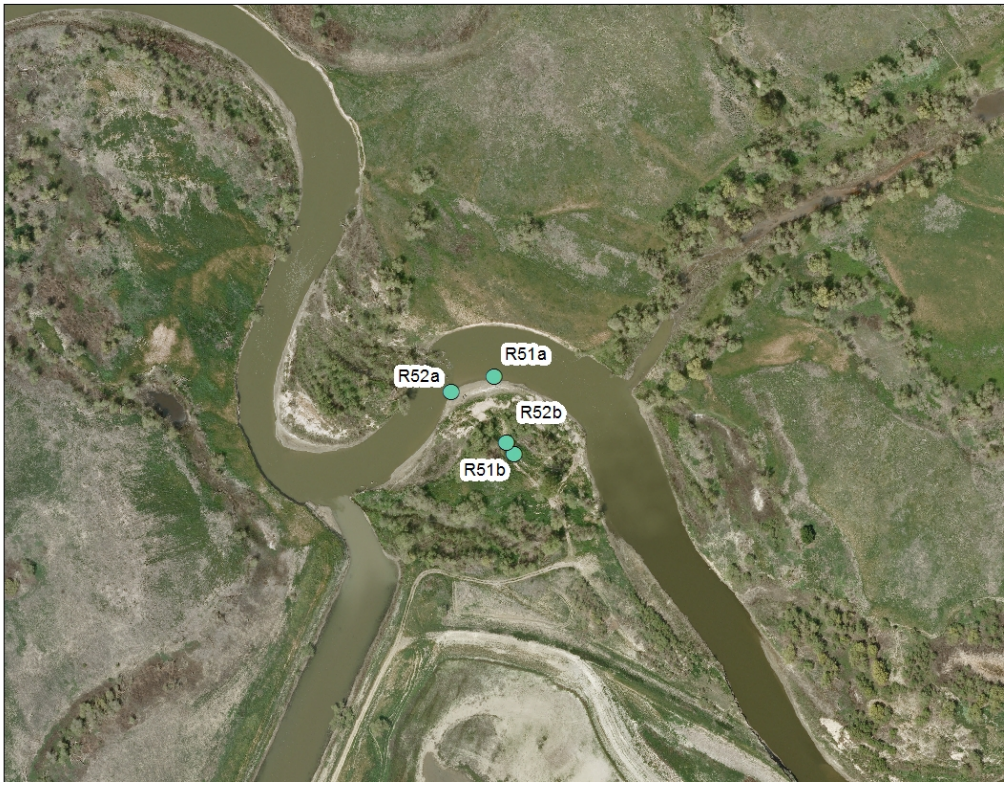
East Side Bypass (Merced NWR), Transect 3

East Side Bypass (Merced NWR), Transect 4

Mariposa Bypass



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
R4A	1	718414	4100615	718463	4100664	10S
	2	718341	4100777	718393	4100780	10S
MB	1	703911	4119706	703910	4119656	10S
	2	703797	4119712	703795	4119662	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.—Herbaceous 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 macro-topographic features.	0.2	Flood-prone area contains micro- and/or macro-topographic features such as pits, ponds, hummocks, bars, but is predominantly homogenous or flat surface	0.5	Flood plain mostly hetero-geneous, characterized by micro-topo-graphic features ie pits, ponds, hummocks,bars. However, there are no macro-topographic features, such as braiding, 2° channels, backwaters.	0.8	Flood-prone area is characterized by micro- and macro-topographic complexity, such as meanders, bars, braiding, 2°channels, backwaters, terraces, pits, ponds, hummocks, etc.	1.0		

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 and 2012

CODE	SCIENTIFIC NAME	COMMON NAME	LIFEFORM	REACH									
				1A	1B	2A	2B	3	4A	ESB	MB	4B2	5
Tree/shrub													
ALRH	*Alnus rhombifolia*	White alder	NT	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	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	X							
Graminoid													
ALSA	*Alopecurus saccatus*	Pacific foxtail	NG								X	X	
ARDO2	*Arundo donax*	Giant reed	IG		X								
BRDI	*Bromus diandrus*	Ripgut brome	IG	X		X		X					
BRHO	*Bromus hordeaceus*	Soft chess brome	IG	X							X	X	
BRMA	*Bromus madritensis*	Foxtail chess	IG	X	X	X			X	X			
CYDA	*Cynodon dactylon*	Bermuda grass	IG	X	X	X		X	X	X	X	X	X
CYER	*Cyperus erythrorhizos*	Redroot flatsedge	NG							X			
CYES	*Cyperus esculentus*	Yellow nutgrass	NG		X			X	X	X	X		
CYSP	*Cyperus sp.*	Flatsedge		X									
DISP	*Distichlis spicata*	Salt grass	NG	X					X	X	X	X	
ECCR	*Echinochloa crus-galli*	Barnyard grass	IG	X		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*	Foxtail barley	IG							X	X		
JUBA	*Juncus balticus*	Baltic rush	NG	X						X	X	X	
LEUN	*Leptochloa uninervia*	Mexican sprangletop	NG	X		X	X	X	X	X			
LETR	*Leymus triticoides*	Creeping wildrye	NG							X			
ORSA	*Oryza sativa*	Rice	IG			X							
PADI	*Paspalum dilatum*	Dallis grass	IG			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			
Forb													
AMRO	*Ammania robusta*	Grand redstem	NF							X	X		
ANCO	*Anthemis cotula*	Dog fennel	IF							X			
ARDO	*Artemisia douglasiana*	California mugwort	NF	X			X	X				X	X
ARVU	*Artemisia vulgare*	Common mugwort	IF						X				
BRNI	*Brassica nigra*	Black mustard	IF	X		X	X		X	X	X	X	X
CEPA	*Centromadia parryii ssp rudis*	Pappose tarweed	NF								X	X	
CHCA	*Chenopodium californicum*	California goosefoot	NF					X			X	X	X
CHLI	*Chrysothamnus linifolius*	Spearleaf rabbitbrush	NF	X	X								
CIVU	*Cirsium vulgare*	Bull thistle	IF								X	X	
COMA	*Conium maculatum*	Poison hemlock	IF									X	
COCA	*Conyza canadensis*	Horseweed	NF				X		X				X
DAWR	*Datura wrightii*	Jimson weed	NF										X

CODE	SCIENTIFIC NAME	COMMON NAME	LIFEFORM	REACH									
				1A	1B	2A	2B	3	4A	ESB	MB	4B2	5
Forb, cont.													
ERSE	*Eremocarpus setigerus*	Doveweed	NF			X							
ERWR	*Eriogonum wrightii*	Wright's buckwheat	NF			X							
ERCI	*Erodium cicutarium*	Redstem storks bill	IF				X		X				
ERRA	*Eryngium racemosum*	Delta button celery	NF							X			
ESCA	*Eschscholzia californica*	California poppy	NF		X	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	
KOSC	*Kochia scoparia*	Kochia	IF			X	X						
LASE	*Lactuca serriola*	Prickly lettuce	IF			X		X		X	X	X	X
LELA	*Lepidium latifolium*	Perennial peppergrass	IF									X	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			X
MEAR	*Mentha arvensis*	Field mint	NF	X									
MEPU	*Mentha pulegium*	Pennyroyal	NF	X									
PHNO	*Phyla nodiflora*	Lippia	NF							X	X		
POAR	*Polygonum arenastrum*	Common knotweed	IF							X	X	X	
POLA	*Polygonum lapathifolium*	Pale smartweed	NF					X					
PSST	*Pseudognaphalium stramineum*	Cottonbatting cudweed	NF		X	X	X			X			X
ROPA	*Rorippa palustris*	Yellow cress	NF				X	X	X			X	X
RUCR	*Rumex crispus*	Curly dock	IF					X	X	X	X	X	
RUDI	*Rubus discolor*	Himalayan blackberry	IF	X									
SATR	*Salsola tragus*	Russian thistle	IF			X							
SASP	*Salsola sp.*	Saltwort	IF					X	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			
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	X

Appendix E

Total percent herbaceous cover of individual species, life-form, and cover type
in vegetation transects along the San Joaquin River
in 2011 and 2012.

Table E-1.—Average Total Percent Herbaceous Cover										
Species	**Reach 1A**		**Reach 1B**		**Reach 2A**		**Reach 2B**		**Reach 3**	
	2011	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
Button bush	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sandbar willow	0.5	0.0	4.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Goodding's willow	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	0.3	0.0
Shining willow	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Native trees/shrubs	0.5	0.5	4.5	1.5	0.0	0.0	0.5	1.0	0.3	0.0
Scarlet wisteria	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Introduced trees/shrubs	0.0	0.0	0.0	0.5	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	3.5	0.0
Flatsedge	1.0	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
Baltic rush	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mexican sprangletop	0.5	0.0	0.0	0.0	1.5	0.5	2.2	0.0	1.6	0.0
Canary reedgrass	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified grasses*	0.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Native graminoids	4.0	3.0	5.0	0.0	1.5	0.5	2.2	0.0	5.1	0.0
Ripgut brome	0.5	13.0	0.0	0.0	3.0	6.0	0.0	0.0	0.0	16.0
Bermuda grass	1.0	1.5	2.0	10.5	0.0	0.5	0.0	0.0	4.1	1.6
Barnyard grass	0.5	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.6	0.0
Rice	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Soft chess brome	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Foxtail chess	0.0	3.0	0.0	5.0	0.0	4.0	0.0	0.0	0.0	0.0
Dallis grass	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Rat-tail fescue	0.0	10.0	0.0	0.5	1.5	2.0	0.0	0.0	0.0	0.0
Introduced graminoids	2.0	30.5	2.0	16.0	7.0	12.5	0.0	0.0	4.7	17.6
California mugwort	8.0	4.5	0.0	0.0	0.0	0.0	1.4	2.9	10.5	13.6
California goosefoot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0
Doveweed	0.0	0.0	0.0	0.0	0.5	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
Threepetal bedstraw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0
Sunflower	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
American bird's-foot trefoil	0.0	0.0	0.0	0.0	3.5	0.0	9.3	0.0	0.0	0.0
Field mint	0.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pale smartweed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4	0.0
Yellow cress	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	2.2	0.0
American black nightshade	0.0	0.0	0.0	0.0	0.5	0.0	4.3	0.0	2.8	0.0
Cocklebur	1.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	20.6	0.0
Spearleaf rabbitbrush	0.0	0.5	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Pennyroyal	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
California poppy	0.0	0.0	0.0	0.5	0.0	1.0	0.0	0.0	0.0	0.0
Cottonbatting cudweed	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.0
Horseweed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
Unidentified forbs*	0.5	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.7	0.0
Native forbs	10.0	6.5	0.0	2.5	7.5	2.0	16.4	5.3	55.0	13.6
Black mustard	1.0	0.0	0.0	0.0	2.0	4.5	4.1	12.4	0.0	0.0
Prickly lettuce	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.8	0.0
Curly dock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Himalayan blackberry	5.5	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Russian thistle	0.0	0.0	0.0	0.0	0.5	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
Clover	0.0	0.0	0.0	0.0	0.0	0.0	2.1	4.3	0.0	0.0
Stinging nettle	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0
Redstem storks bill	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
Koschia	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.7	0.0	0.0
Prickly sowthistle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	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
Introduced forbs	6.5	8.0	0.5	0.0	3.0	5.0	6.7	19.3	8.3	0.3

Table E-1.—Average Total Percent Herbaceous Cover										
Species	**Reach 1A**		**Reach 1B**		**Reach 2A**		**Reach 2B**		**Reach 3**	
	2011	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
Total Plant Cover	23.0	48.5	12.0	20.5	19.0	20.0	25.8	25.6	73.4	31.5
Litter	33.5	39.0	20.0	40.5	16.5	17.5	22.9	32.8	16.0	56.9
Bare	37.0	6.0	55.0	32.5	45.0	43.0	51.3	41.6	10.6	11.6
Rock	6.0	5.0	13.0	6.5	19.5	19.5	0.0	0.0	0.0	0.0
Water	0.5	1.5	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

*Unidentified spp may be either native or introduced

Average Total Percent Herbaceous Cover									
	River Reach								
	4A		**ESB**		**MB**		**4B2**		**5**
Species	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2012**
Goodding's willow	1.5	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Native trees/shrubs	1.5	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Pacific foxtail	0.0	0.0	0.0	0.0	5.5	0.0	1.0	0.0	0.0
Redroot flatsedge	0.0	0.0	1.0	2.3	0.0	0.0	0.0	0.0	0.0
Yellow nutgrass	1.4	0.0	1.0	0.0	0.5	0.0	0.0	0.0	0.0
Salt grass	0.0	4.9	0.0	10.7	0.0	1.5	14.4	19.1	0.0
Common spikerush	0.0	0.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0
Baltic rush	0.0	0.0	0.7	0.0	6.5	6.5	5.2	5.1	0.0
Mexican sprangletop	2.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Creeping wildrye	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Unidentified grasses*	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Native graminoids	3.6	4.9	15.9	14.0	12.5	8.0	20.6	24.2	0.0
Bermuda grass	1.2	0.0	2.7	3.0	3.0	0.0	2.0	4.0	1.0
Barnyard grass	1.7	0.0	0.3	0.0	0.0	0.0	26.1	0.0	0.0
Mediterranean barley	0.0	0.0	0.0	0.0	5.0	5.5	1.0	2.5	0.0
Bahia grass	0.0	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0
Soft chess brome	0.0	0.0	0.0	0.0	0.0	2.0	0.0	5.5	0.0
Foxtail chess	0.0	3.2	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Rabbitsfoot grass	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	5.5
Foxtail barley	0.0	0.0	0.0	0.3	0.0	2.0	0.0	0.0	0.0
Dallis grass	0.0	0.0	4.5	1.7	0.0	0.0	0.0	0.0	0.0
Rat-tail fescue	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Introduced graminoids	2.9	3.2	12.8	7.0	8.0	9.5	29.1	12.0	6.5
California mugwort	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.5
Pappose tarweed	0.0	0.0	0.0	0.0	33.0	0.0	1.3	0.0	0.0
California goosefoot	0.0	0.0	0.0	0.0	1.5	0.0	3.5	1.3	0.5
Delta button celery	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Sunflower	0.0	0.0	0.0	0.0	3.0	0.0	7.1	0.0	0.0
Yellow cress	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.6	2.5
American black nightshade	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	1.5
Cocklebur	4.2	0.0	7.3	2.7	12.0	0.0	7.1	0.0	1.0
Cottonbatting cudweed	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	2.0
Horseweed	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Gumweed	0.0	0.0	0.0	0.3	0.0	4.5	0.0	1.1	0.0
Lippia	0.0	0.0	0.0	5.2	0.0	4.0	0.0	0.0	0.0
Jimson weed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Grand redstem	0.0	0.0	3.0	0.0	0.0	0.5	0.0	0.0	0.0
Unidentified forbs*	2.0	0.0	3.0	2.5	1.5	0.0	0.0	0.0	9.0
Native forbs	6.2	1.0	13.8	11.2	51.0	9.0	20.9	4.6	19.0
Common mugwort	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Black mustard	0.0	4.6	0.0	1.3	9.0	16.5	5.8	10.3	1.0
Prickly lettuce	0.0	0.0	0.0	0.3	1.0	0.0	1.0	0.0	1.0
Alkali mallow	0.0	0.0	1.0	1.3	0.0	0.0	0.6	0.0	1.0
Common knotweed	0.0	0.0	0.0	0.5	9.5	0.0	2.1	1.9	0.0
Curly dock	0.7	0.0	0.5	3.0	3.0	0.0	1.3	0.6	0.0
Saltwort	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Average Total Percent Herbaceous Cover									
	River Reach								
	4A		ESB		MB		4B2		5
Species	2011	2012	2011	2012	2011	2012	2011	2012	2012
Clover	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0
Redstem storks bill	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Prickly sowthistle	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
White sweetclover	0.0	5.7	0.0	0.5	0.0	0.0	0.0	0.0	9.0
Bull thistle	0.0	0.0	0.0	0.0	0.0	0.5	0.0	1.3	0.0
Poison hemlock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3	0.0
Perennial pepperweed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	7.5
Birdsfoot trefoil	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.6	0.0
Dog fennel	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0
Milk thistle	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
Introduced forbs	4.1	10.8	4.8	11.5	22.5	17.0	10.8	25.9	19.5
Total Plant Cover	18.3	20.6	47.3	43.7	94.0	43.5	81.4	66.7	45.5
Litter	7.5	26.7	22.7	39.5	4.5	55.0	11.8	32.8	42.0
Bare	74.2	52.7	30.0	16.8	1.5	1.5	6.8	0.5	12.5
Rock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water	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

Appendix F

Photo Stations
August 2011 and June 2012

Reach 1A, Transect 1

1A – Toward transect

August 2011

June 2012

1A – Away from transect

August 2011

June 2012

1B – Toward transect

August 2011

June 2012

1B – Away from transect

August 2011

June 2012

Reach 1A, Transect 2

2A – Toward transect

August 2011

June 2012

2A – Away from transect

August 2011

June 2012

2B – Toward transect

August 2011

June 2012

2B – Away from transect

August 2011

June 2012

Reach 1B, Transect 1

1A – Toward transect

August 2011

June 2012

1A – Away from transect

August 2011

June 2012

1B – Toward transect

August 2011

June 2012

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

August 2011

June 2012

Reach 1B, Transect 2

2A – Toward transect

August 2011

June 2012

2A – Away from transect

August 2011

June 2012

2B – Toward transect

August 2011

June 2012

2B – Away from transect

August 2011

June 2012

Reach 2A, Transect 1

1A – Toward transect

August 2011

June 2012

1A – Away from transect

August 2011

June 2012

1B – Toward transect

August 2011

June 2012

1B – Away from transect

August 2011

June 2012

Reach 2A, Transect 2

2A – Toward transect

August 2011

June 2012

2A – Away from transect

August 2011

June 2012

2B – Toward transect

August 2011

June 2012

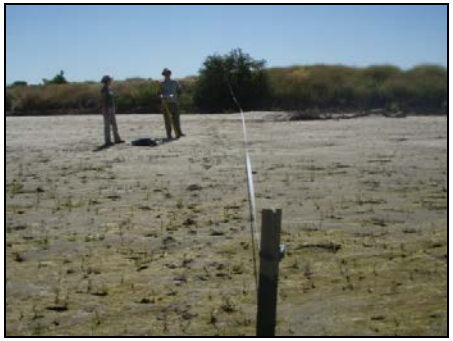
2B – Away from transect

August 2011

June 2012

Reach 2B, Transect 1

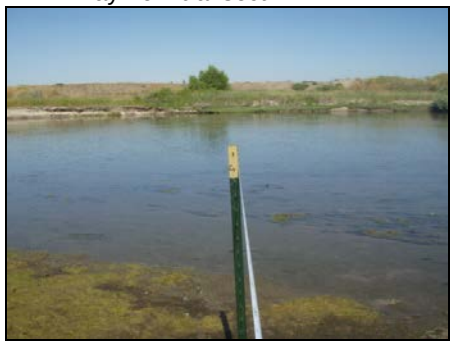
1A – Toward transect



August 2011

June 2012

1A – Away from transect

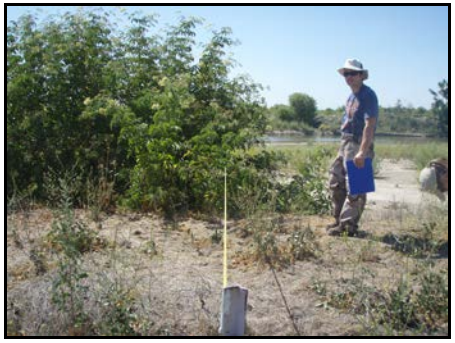


August 2011

June 2012

1B – Toward transect

August 2011



June 2012

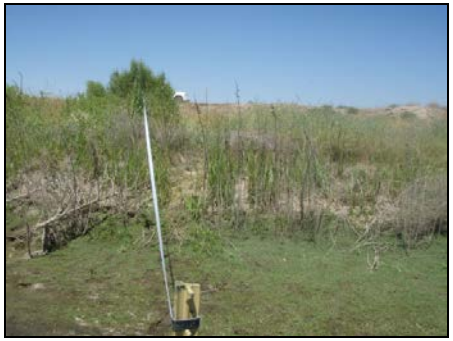
1B – Away from transect

August 2011

June 2012

Reach 2B, Transect 2

2A – Toward transect



August 2011

June 2012

2A – Away from transect

August 2011

June 2012

2B – Toward transect (taken from different angles in each year)

August 2011

June 2012

2B – Away from transect

August 2011

June 2012

Reach 3, Transect 1

1A – Toward transect

August 2011

June 2012

1A – Away from transect

August 2011

June 2012

1B – Toward transect

August 2011

June 2012

1B – Away from transect

August 2011

June 2012

Reach 3, Transect 2

2A – Toward transect

August 2011

June 2012

2A – Away from transect

August 2011

June 2012

2B – Toward transect

August 2011

June 2012

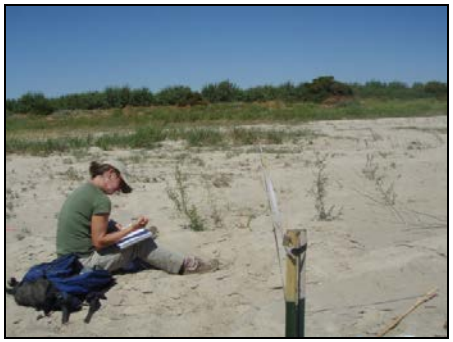
2B – Away from transect

August 2011

June 2012

Reach 4A, Transect 1

1A – Toward transect



August 2011

June 2012

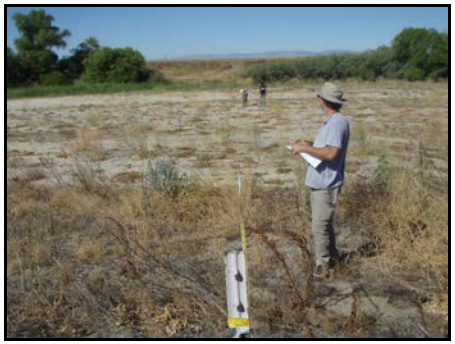
1A – Away from transect

August 2011

June 2012

1B – Toward transect

August 2011
2011



June 2012
2012

1B – Away from transect

August 2011
2011

June 2012
2012

Reach 4A, Transect 2

2A – Toward transect

August 2011

June 2012

2A – Away from transect

August 2011

June 2012

2B – Toward transect

August 2011

June 2012

2B – Away from transect

August 2011

June 2012

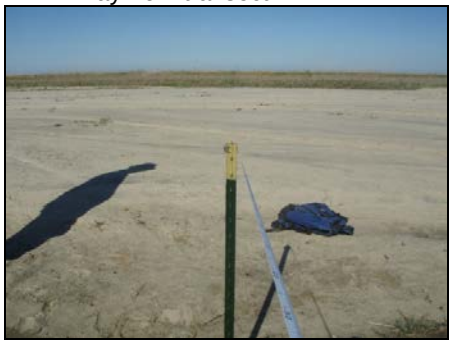
East Side Bypass, Transect 1

1A – Toward transect

August 2011

June 2012

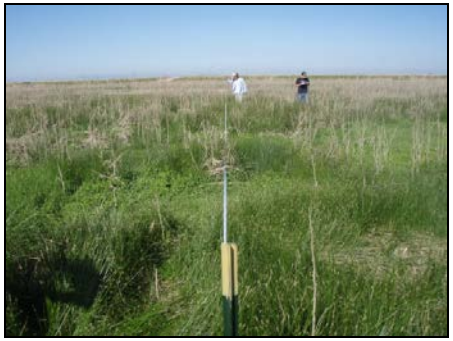
1A – Away from transect



August 2011

June 2012

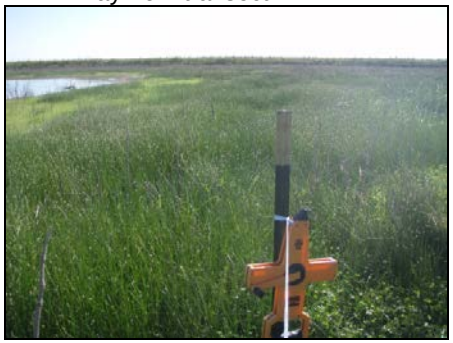
1B – Toward transect



August 2011

June 2012

1B – Away from transect



August 2011

June 2012

East Side Bypass, Transect 2

2A – Toward transect

August 2011

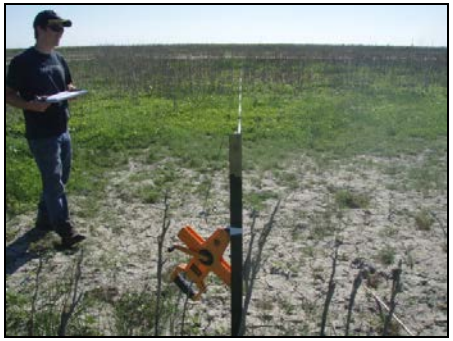
June 2012

2A – Away from transect

August 2011

June 2012

2B – Toward transect



August 2011

June 2012

2B – Away from transect

August 2011

June 2012

East Side Bypass (Merced NWR), Transect 3

3A – Toward transect

August 2011

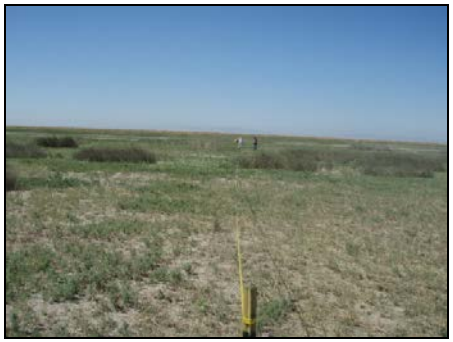
June 2012

3A – Away from transect

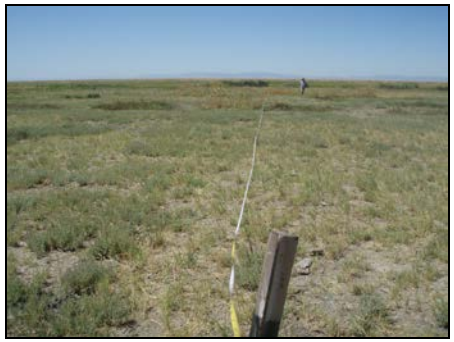
August 2011

June 2012

3B – Toward transect



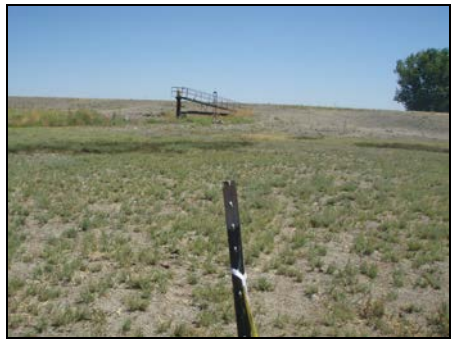
August 2011



June 2012

3B – Away from transect

August 2011

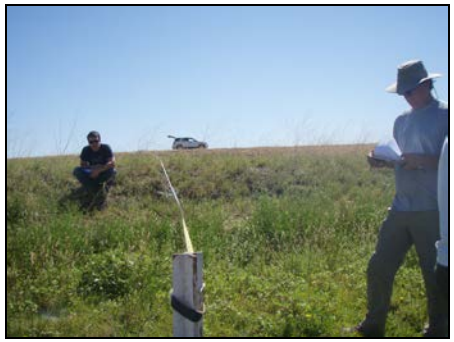


June 2012

East Side Bypass (Merced NWR), Transect 4

4A – Toward transect

August 2011



June 2012

4A – Away from transect

August 2011

June 2012

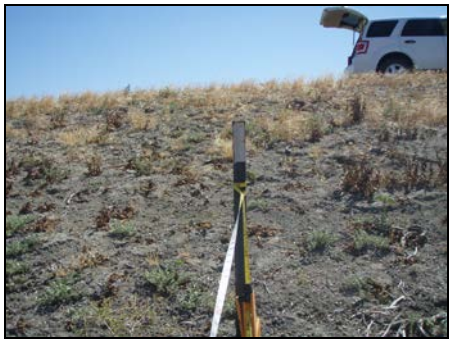
4B – Toward transect

August 2011

June 2012

4B – Away from transect

August 2011

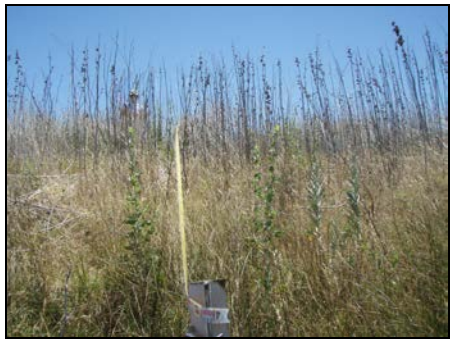


June 2012

Mariposa Bypass, Transect 1

1A – Toward transect

August 2011



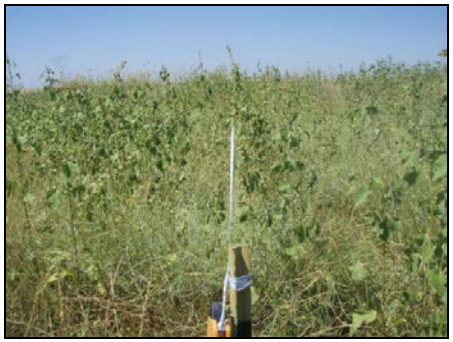
June 2012

1A – Away from transect

August 2011

June 2012

1B – Toward transect



August 2011

June 2012

1B – Away from transect

August 2011

June 2012

Mariposa Bypass, Transect 2

2A – Toward transect

August 2011

June 2012

2A – Away from transect

August 2011

June 2012

2B – Toward transect

August 2011

June 2012

2B – Away from transect

August 2011

June 2012

Reach 4B2 (San Luis NWR), Transect 1

1A – Toward transect

August 2011

June 2012

1A – Away from transect

August 2011

June 2012

1B – Toward transect

August 2011

June 2012

1B – Away from transect

August 2011

June 2012

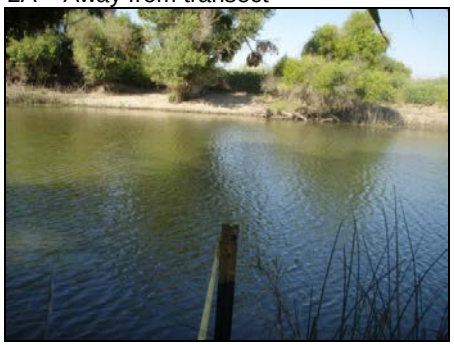
Reach 4B2 (San Luis NWR), Transect 2

2A – Toward transect

August 2011

June 2012

2A – Away from transect



August 2011

June 2012

2B – Toward transect

August 2011

June 2012

2B – Away from transect

August 2011

June 2012

Reach 5, Transect 1

1A – Toward transect

June 2012

1A – Away from transect

June 2012

1B – Toward transect

June 2012

1B – Away from transect

June 2012

Reach 5, Transect 2

2A – Toward transect

June 2012

2A – Away from transect

June 2012

2B – Toward transect

June 2012

2B – Away from transect

June 2012