SOLANO Resource Conservation District
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Final Report January 11, 2022
P01-1605: Peterson Ranch Working Waterway Habitat Enhancement Project

Executive Summary

This document serves as a final report, and as a deliverable for the *Petersen Ranch Working Waterway Habitat Enhancement project* ("the project" herein). This project was proposed by the Solano Resource Conservation and was chosen for funding by the Delta Conservancy using Proposition 1 bond funds. The funding period began on September 1, 2017 and after an extension amendment, the funding period ended October 31, 2021.

This project aimed to improve conservation outcomes on a working ranch, resulting in benefits for both the environment and the ranch operation. This project used fencing to exclude cattle from 13.5 acres (nearly 6 miles) of ditch edges, planted those spaces with native vegetation, and provided alternative drinking water sources for cattle. As a result, cattle have improved drinking water quality, ditches need digging out less often, and the habitat along riparian areas has significantly more diversity and structure for wildlife.

The main challenges that arose during this project were largely due to variable hydrology resulting from flat topography, and location of habitat lines at the toe edge of flood irrigated pastures. In some cases, sites were simply too wet for too long to support the establishment of native grass and woody vegetation in the manner originally envisioned. The start of this project co-incided with the landowners' increased use of flood irrigated pasture. In the meantime, wetland vegetation has expanded considerably in some areas. As a result, Solano RCD pivoted our strategy in wet areas to using plants which are highly tolerant of wet conditions, including willows, rushes and sedges.

This project was a collaboration between many groups and people. Special thanks to the Hearn Family, Rio Vista High School, the Center for Land Based Learning SLEWS program, Delta Conservancy staff, and staff from USDA-NRCS Vacaville service center.

This report will attempt to summarize project work and outcomes from both administrative and on-the-ground perspectives. It will also recommend ongoing management of the site, touch on lessons learned, and include before and after photos.

Contents

Administrative Grant History

The grant agreement was amended twice over the course of the project. The first amendment (spring 2019) was necessary because the footprint of the project needed changes – some planned planting areas had developed into cattail marshes since contracting, so we chose another stretch of ditch where conditions were more appropriate for planting grass and woody plants. Specifically, this amendment removed the eastern portion of line 3, and the southern portion of line 4 from the planting plan, and added line 11 to make up the difference. This amendment also balanced some funds between line item budget categories.

The second amendment (spring 2020) was needed to shift funds between line items in the project budget, to ensure allocated funds could be put to the best use to finish project implementation. See Figure 1 showing spending by line item, for each quarter throughout the funding period.

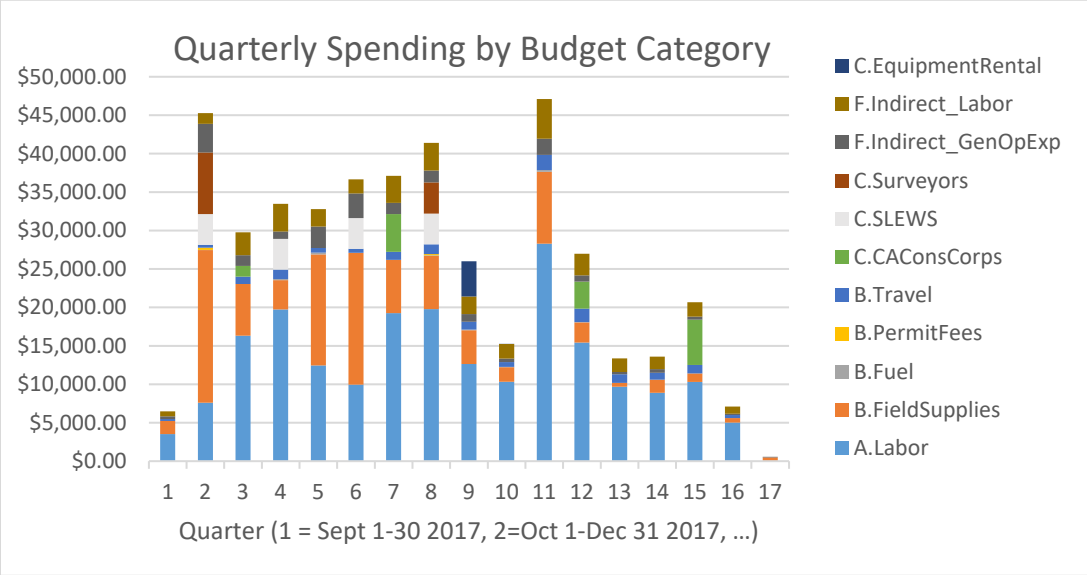

Figure 1. Showing the history of spending based on contractual budget categories, for each fiscal quarter over the funding period of this project. Note that quarter 1 and quarter 18 represent only 1 month periods, rather than full 3 month quarters.

In figure 1, there are notable events that demonstrate the progress of this grant, and coordination with project partners:

- In the second quarter of the grant (and again in quarter 8), surveyors were hired to develop legal descriptions of planting area.
- Quarter 2, 5, 6, 7, 8 and 11 showed large purchases of either fencing supplies, or plant materials.

- Participation with the SLEWS program – Rio Vista High School students came out to the site 3 times per winter for 3 years over the course of the project. A program of the Center for Land based Learning, SLEWS connects high school students and mentors from the natural resource professions by providing hands-on learning experiences at habitat restoration sites.
- Use of CA Conservation Corps crews, in quarter 3, 7, 12, and 15 of the project. We used crews from the Greater Valley Conservation Corps in Stockton, to assist with spreading native grass straw, planting plugs, planting trees and shrubs, planting cuttings, and other tasks.

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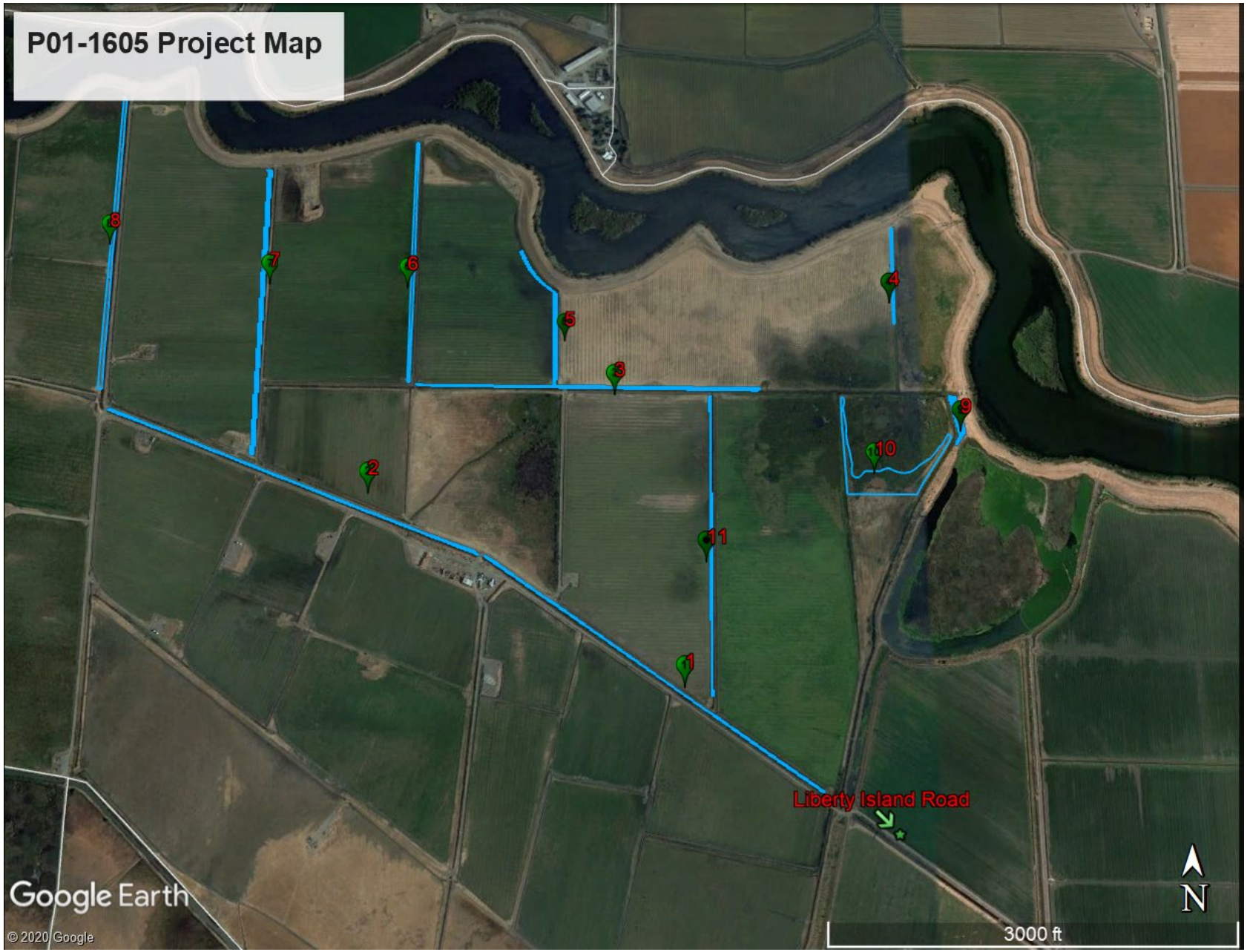
Project Map



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Installation History

There were a total of 11 habitat areas ("sites" herein) planted as part of this project. Each site was seeded with a mix of native grass and wildflower seed. Each site was also planted with trees, shrubs, perennial flowers, and at some locations native grass plugs to help establish grass cover. Sites are numbered 1 through 11 on the map above, and table below, which details installation date of each component of habitat. We planted 3 to 5 sites each year in 2017, 2018 and 2019, and replanted sites as needed one and two years after initial plantings to bolster the numbers of trees, shrubs, grasses, and flowering plants.

Site #	Linear Feet	Width	Acres	Grass Planted	T/S planted
1	3200	20	1.46	2017	2017
2	3200	20	1.46	2017	2017
3	2700	20	1.23	2017	2017
4	1000	20	0.45	2019	2019
5	1200	20	0.55	2018	2018
6	2100	20	1.00	2018	2018
7	2400	20	1.10	2018	2018
8	2450	25	1.50	2019	2019
9	450	60	0.62	2018	2018
10	1500	50	2.93	NA	2017 + 2020
11	2430	20	1.20	2019	2019
totals	**22630'**		**13.50**		

Figure 2. Table showing size of habitat areas, and dates planted with grass, and trees and shrubs. 2017 denotes the winter of 2017-2018, and so on.

Off-channel livestock pipeline and trough installation

This component of the project was inspected and signed off in spring 2019. This work was accomplished by the landowners with assistance from the USDA-NRCS EQIP program.

Fence installation

Fence building (welded steel braces, gates, and electric fence installation) occurred from 2017-2019, prior to planting given sites. Work was largely completed by the landowner. Solano RCD contributed considerably to electric fence construction, maintenance, and repair.

Grass seeding

Grass seeding areas (10 of 13.5 project acres) had soil prepared by the landowner, using a tractor and disc to loosen soils. Solano RCD then waited for weed seeds to germinate, and "sprayed out" the initial flush of weed seedlings. Then, we broadcast seeded and harrowed a native grass and wildflower mix. See list of species used below (figure 3). After seeding, sites were typically mowed 2x in the first and second year after seeding to reduce annual grass seed set, and also spot- or broadcast- sprayed 1-2x per year to control broadleaf weeds. Site 3-west and site 8 were re-seeded 2 years in a row. We used sprinkler irrigation on site 8 and 11 during the drought winter of 19-20 to try and improve coverage.

Lines 1, 2, 8, and 11 had a total of >5000 plugs of native grass planted after seeding, to try and increase coverage. Lines 1, 2 and 3 were mulched with native grass to increase germination rates of grass seed.

Figure 3. Seeded Native Grass and Forb Species List

Common Name	Scientific Name
Grasses	
Blue wildrye	*Elymus glaucus*
Creeping Wildrye	*Leymus triticoides*
Purple needlegrass	*Nassella pulchra*
Meadow Barley	*Hordeum brachyantherum*
Forbs	
Mugwort	*Artemisia douglasiana*
Sticky gumplant	*Grindelia camporum*
California Poppy	*Eschscholzia californica*
Evening Primrose	*Oenothera hookeri*
Narrowleaf Milkweed	*Asclepias fascicularis*
Broadleaf Milkweed	*Asclepias speciosa*
Goldenrod	*Euthamia occidentalis*
Purple Aster	*Aster chilensis*

Tree and shrub planting

Tree and shrub planting used a combination of container stock, and dormant hardwood cuttings of *Salix* and *Populus* species. We laid out poly drip tubing along each line, augured planting holes (for about ½ the lines), and installed 2 gallon per hour drip emitters. We planted trees or cuttings at drip emitters, and placed a tree protector tube (Tubex) and bamboo stake at each plant. After planting, we used backpack sprayers to spray "Roundup Rings" around each plant, to control competing vegetation in a 3 foot circle for 2 years after planting. Monitoring each summer revealed the number of plants which had died since planting – at each habitat site, we replanted for 1 or 2 years after the initial planting, to replace plants which had died. At some sites where too much water was impacting establishment, we shifted to using cuttings of willows and cottonwoods instead of the plant palette which was originally planned. Sites 4, 5, 6, 7 and 11 were all replanted with willow cuttings in the effort to establish woody cover despite high water levels. We also placed beaver caging around approximately 200 trees and shrubs, in order to protect against ongoing predation of choice plants for beaver. For 2-3 years after planting, trees and shrubs have been irrigated on a weekly to bi-weekly basis from April through October.

Figure 4. Tree, Shrub, and Vine Species List

Trees	Latin name
Valley oak	*Quercus lobata*
Box Elder	*Acer negundo*
Red Willow	*Salix laevigata*
Arroyo Willow	*Salix lasiolepis*
Cottonwood	*Populus fremontii*
Sycamore	*Platanus racemosa*
Black willow	*Salix goodingii*
Yellow willow	*Salix lasiandra*
Shrubs	
Coyote brush	*Baccharis pilularis*

California blackberry	*Rubis ursinus*
Buttonwillow	*Cephalanthus occidentalis*
California wild rose	*Rosa californica*
Dogwood	*Cornus sericea*
Mule fat	*Baccharis salicifolia*
Vines/Herbaceous Sub-Shrubs	
California wild grape	*Vitis californica*
Indian Hemp	*Apocynum cannabinum*
California Hemp	*Hoita macrostachya*
Marsh mulefat	*Baccharis glutinosa*

Plug planting

In addition to trees and shrubs, we planted thousands of plugs of wildflowers, sedges, rushes, and grasses. We planted these in the effort to bolster diversity, increase native cover where grass seeding was less successful, and in response to wet conditions on some habitat sites. As a result, there are dozens of patches of each of these plants on various habitat sites planted as part of this project. See figure 5.

Figure 5. Plug planting List

Wetland	**Latin name**
Bog rush	*Juncus effusus*
Common rush	*Juncus patens*
Iris leaved rush	*Juncus xiphioides*
White root sedge	Carex barbarae
Slender sedge	Carex praegracilis
Perennial Forbs	
Yarrow	*Achillea millefolium*
Goldenrod	*Euthamia occidentalis*
Milkweed	*Asclepias fasicularis*
Indian hemp	*Apocynum cannabineum*
Purple aster	*Symphotricium chilense*

Follow up steps

At this site, where cattle pastures are adjacent to habitat areas, maintaining electric fencelines will be critical to the continued growth and establishment of woody vegetation. Solano RCD plans to continue irrigating the last 2 planted sites through the end of 2022, and is working with the landowner to check and maintain fencelines.

Photos

Please see the full “Photo-monitoring” document attached to this document, for before-and-after photos of all habitat areas described here.

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Appendices

Monitoring final report

Written August 5, 2020

Overview

This document is constructed to fulfill **three** of the monitoring deliverables for this project (task 5):

c) Two sets of understory monitoring data
d) 2 CRAM surveys (have also been uploaded to EcoAtlas)
e) 8 water quality sampling events (have been uploaded to CEDEN)

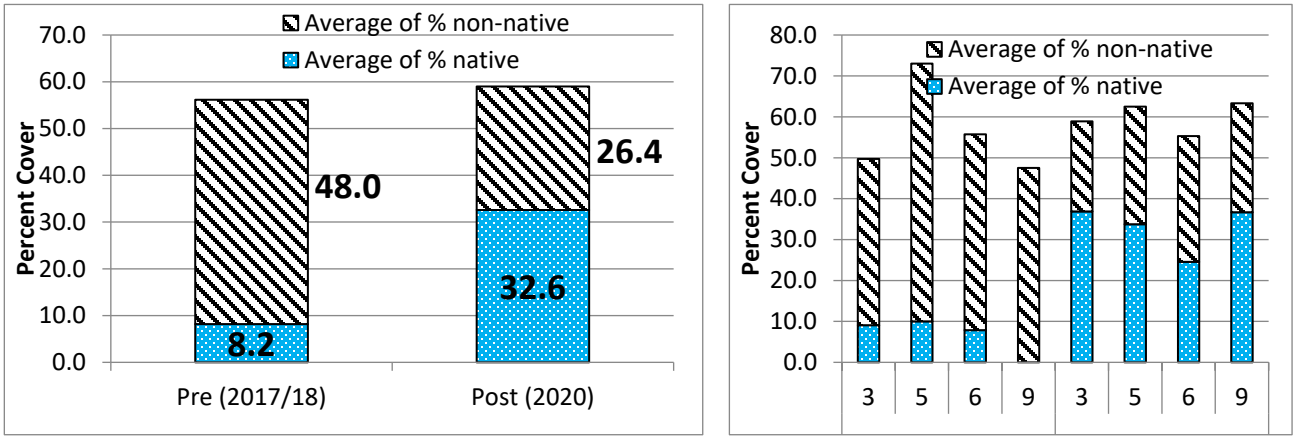
(a) tree and shrub counts have been completed 3 times, but will be completed a 4th time in fall 2020 and delivered along with the 2020 annual report (b) Photo monitoring will be compiled in a separate document.

This project is composed of 11 sub-sites. Sites *3, 5, 6* and *9* were chosen at the start of this project as primary monitoring targets for understory, California Rapid Assessment Method (CRAM), and water quality sampling.

Understory Monitoring

Understory Methods: On each of 4 lines (3, 5, 6, 9), we sampled one $1m^2$ quadrat every 100 meters, mostly in the middle of the line. At each quadrat, we recorded total vegetative cover, percent native cover, and percent non-native cover. On many plots, we listed species present in order of abundance, without giving specific cover estimates. Lines 3& 9 were first sampled in 2017, 5&6 in 2018, and all lines were re-surveyed in 2020.

Understory Findings: We found that the observed vegetative cover of native species was higher after grass and forb seeding, as compared to pre-restoration conditions.



Figures 1a and 1b: Showing average cover of native and non-native species, sampled before restoration (2017 or 2018) and after restoration (spring 2020).

Understory Discussion: The metric of "native versus non-native" is clearly a rough-cut measure of the success of restoration outcomes. A more interesting analysis would have recorded the abundance of individual species before and after restoration, and used community analysis techniques to describe the

change, in terms of alpha beta and gamma diversity. Such an analysis would demonstrate the shift in plant communities as a result of restoration activities, and might show that more than one transition is possible.

One of the challenges of understory restoration at this site is due to highly fluctuating water tables throughout the year, as a result of pasture irrigation and periodically blocked drainage due to beaver, muskrat, sedimentation, etc.

Two of the four lines that we sampled understory vegetation had good establishment of upland grasses and forbs that were seeded during restoration (lines 3 and 9). From survey notes, composition at these plots shifted from being dominated by annual and perennial weeds and pasture species in 2017 (yellow star thistle, bristly oxtongue, annual ryegrass, clover, alfalfa, birds foot trefoil), to being dominated by seeded native grasses (creeping wildrye, streambank wildrye, purple needlegrass). However, weedy and pasture species still have a significant presence at these sites, they are now just outnumbered by native species.

At lines 5 and 6, there was also a shift towards native cover, but along a different trajectory. These lines experience consistent flooding during both summer and winter due to their gradient and poor drainage. Over the course of this project, understory vegetation at lines 5 and 6 has transitioned towards being dominated by *Cyperus eragrostis* (tall flatsedge), a native weedy plant and other wetland species like curly dock, *Persicaria* (water smartweed). There are some seeded grasses present (especially meadow barley), and pasture species (clover and perennial ryegrass).

See photo monitoring for more context to this discussion.

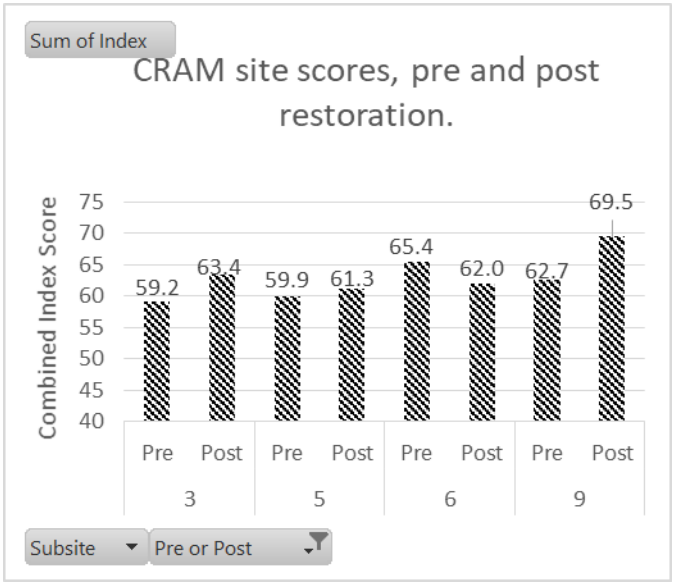
California Rapid Assessment Method

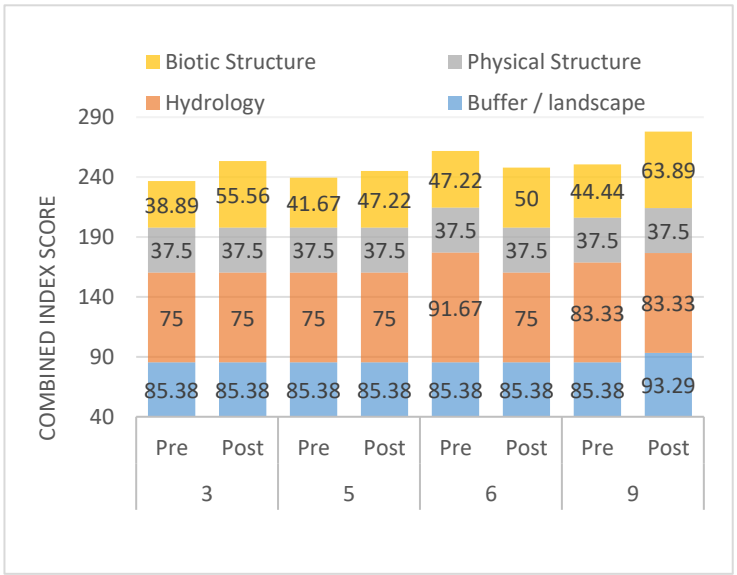
CRAM Methods: Methods are available at CRAMWetlands.org. We used the Riverine non-confined methods. Lines 3& 9 were first sampled in 2017, 5&6 in 2018, and all lines were re-surveyed in 2020. Surveyors collect information about 1)Buffer and landscape context, 2) Hydrology, 3)Physical structure and 4) Biotic structure. The CRAM method then takes these observations and converts them into a numerical index of stream health. CRAM.

CRAM Findings: The combined index score increased at 3 of 4 sites, due to increases in the score for biotic structure. The score for biotic structure increased at all 4 sites, reflecting increases in the number of co-dominant species, decreases in the number of invasive species and/or increases in the number of vegetation layers as a result of planting trees and shrubs. See photos and figures on the following page.

CRAM discussion: Although a useful methodology, the CRAM assessment is highly sensitive to a limited number of variables that had the potential to change over the course of the project. As this project did not involve major re-shaping of land, alterations to hydrology, or repair of an incised channel, changes in biotic structure were primary drivers of measured outcomes. As such, expanded vegetation monitoring would show similar results, with a more definitive metrics of what has changed.

Figures 2a and 2b: Site 3 (east side), CRAM photo taken in September 2017 (above left) and again in April 2020 (above right).





Figures 3a and 3b: CRAM site scores, pre and post restoration at sites 3, 5, 6 and 9. **3a (upper left)** shows combined index score. The score of ¾ of sites increased, reflecting improvements in overall riparian health. **3b (upper right)** shows the contributions of verious categories (biotic, hydrology etc) towards CRAM scores. You can see that improvements in CRAM scores resulted primarily from increses in the score of Biotic Structure. In the one case where the overall score decreased (site 6), this change resulted from an initial incorrect hydrologic assessment that water flow comes primarily from a natural source (rather than from irrigation which is the case).

Water quality sampling

Water Quality Sampling Methods: Solano RCD staff used SONDE type probes to sample water quality at lines 3, 5 6 and 9. Probes were calibrated according to specifications prior to each sampling event. Probes recorded: water temperature, pH, Dissolved oxygen (% and mg/L), specific conductivity ((µS/cm) and turbidity (NTU). We attempted to sample during irrigation events, but this was not strictly followed, so staff started observing the approximate rate of flow of the water at the time of sampling. We sampled in June 3 years in a row (2018-2020), and September 3 years in a row (2017-2019), with other sample events in May 2020 and October 2017.

Water Quality Sampling Findings: We report water quality findings in visual and tabular format on the following pages. Overall, it is difficult to determine a trend across the time period sampled for most measured indicators. This is largely due to the fact that there are large fluctuations in water flow (and thus water quality parameters) as flood irrigation is turned on and off. These fluctuations obscure any but the most obvious trends over time. Furthermore, we don't have any ability to distinguish which trends are due to restoration activities, or due to general trends across the ranch, given that there were no control sites sampled. As such, any analysis is descriptive, not conclusive.

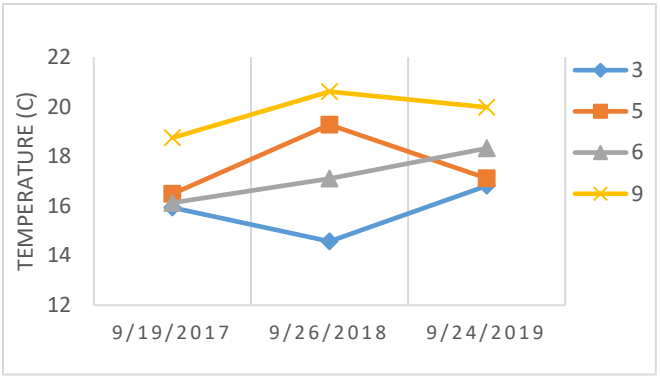
Dissolved oxygen (DO) has the best established water quality standards, among the measurements taken. In general, when DO drops below 2 mg/L, the environment is considered anoxic. Multiple sample points in June 2018, and May/June 2019 show DO values less than 2 across all sites.

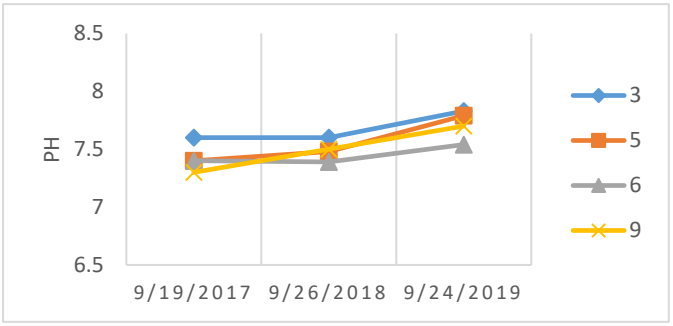
Figures on the following page show each measured parameter during June, and September sample dates across 3 years, in order to separate the impacts of season on water quality, and focus on inter-annual trends.

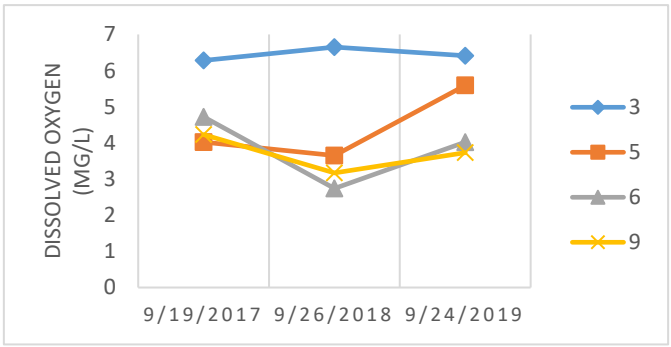
There appear to be some inter annual trends, if you consider only the September (especially) or the June sample date. For example, looking only at September samples, it appears as if pH, temperature, and specific conductivity have increased slightly over 3 years. However, values collected in June don't seem to support the same conclusions about trends.

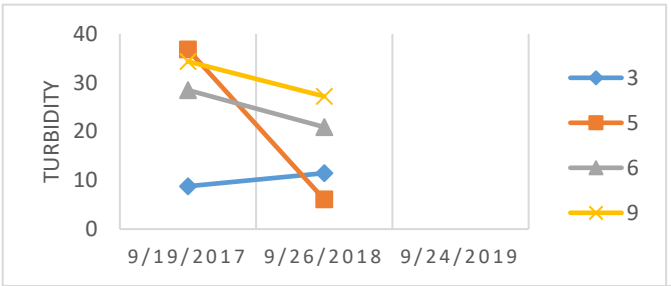
Water Quality Sampling Discussion: To better understand the impacts of restoration on water quality, future monitoring efforts should at a minimum use a sampling design that utilizes control sites, and time sampling events better with irrigation. Furthermore, any water quality improvements due to restoration are small (until trees and shrubs grow large), as compared to the impacts of water management, stocking rate, and/or use of fertilizers by land managers.

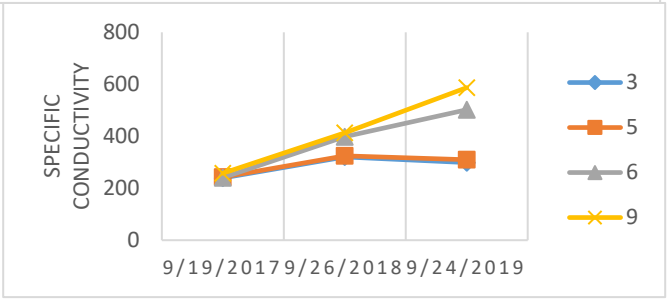
September Water quality – 2017 to 2019



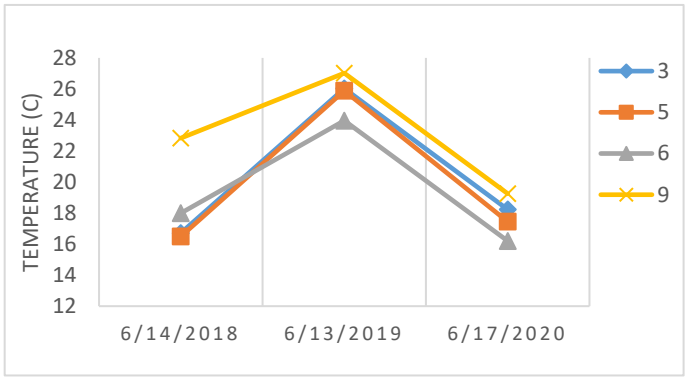


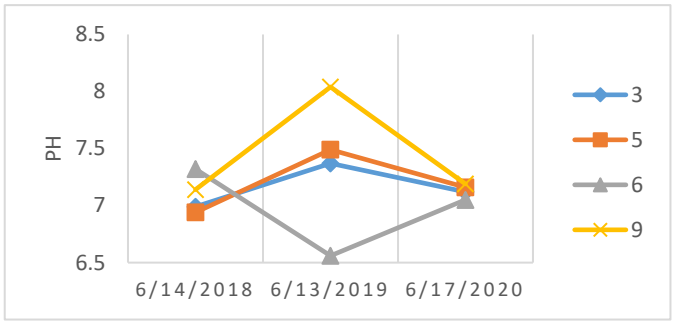


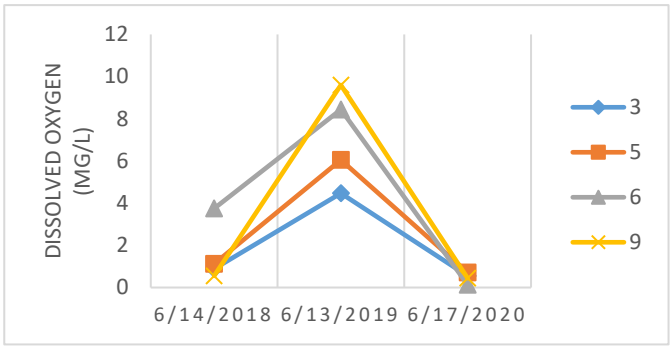


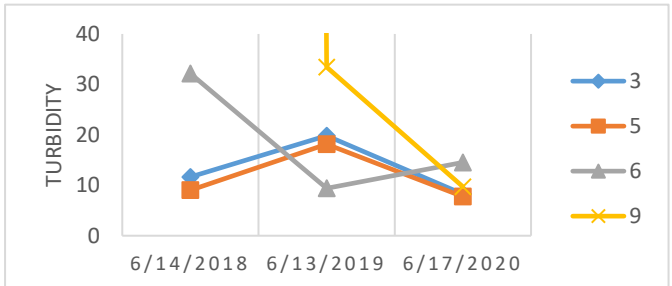


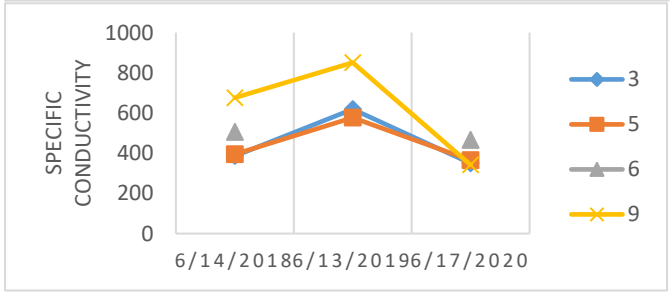
June Water Quality – 2018 to 2020











Date	Sub-Site #	Water Temp (˚C)	pH	Dissolved O (mg/L)	Dissolved O (%)	Specific Conductivity (µS/cm)	Turbidity (NTU)	Est. observed flow
9/19/2017	3	15.94	7.60	6.28	63.50	239.40	8.78	
9/19/2017	5	16.48	7.40	4.02	41.10	242.80	36.80	
9/19/2017	6	16.13	7.40	4.72	47.90	240.60	28.49	
9/19/2017	9	18.74	7.30	4.23	45.40	257.70	34.36	
10/10/2017	3	15.52	7.11	5.50	55.20	234.50	31.96	
10/10/2017	5	14.84	7.37	5.70	56.40	275.90	56.75	
10/10/2017	6	18.82	7.25	5.30	57.00	225.70	8.17	
10/10/2017	9	16.42	7.59	8.56	87.70	274.40	29.92	
6/14/2018	3	16.71	6.99	0.89	9.20	386.40	11.64	
6/14/2018	5	16.49	6.94	1.12	11.50	394.70	9.02	
6/14/2018	6	17.99	7.32	3.75	39.70	505.90	32.15	
6/14/2018	9	22.83	7.14	0.55	6.40	675.80	4160.02	
9/26/2018	3	14.57	7.60	6.65	65.40	320.30	11.46	
9/26/2018	5	19.27	7.48	3.65	39.80	324.60	6.07	
9/26/2018	6	17.10	7.39	2.74	28.50	398.30	20.91	
9/26/2018	9	20.61	7.50	3.17	35.30	413.20	27.21	
6/13/2019	3	26.03	7.37	4.47	55.20	619.00	19.83	0.1-1 cfs
6/13/2019	5	25.88	7.49	6.05	74.50	577.00	18.15	0.1-1 cfs
6/13/2019	6	23.96	6.56	8.44	100.20		9.40	0.1-1 cfs
6/13/2019	9	27.02	8.04	9.60	120.80	851.00	33.43	0.1-1 cfs
9/24/2019	3	16.81	7.83	6.41	66.10	298.60		0.1-1 cfs
9/24/2019	6	18.32	7.54	4.02	42.80	502.00		0.1-1 cfs
9/24/2019	5	17.11	7.79	5.59	58.00	309.70		0.1-1 cfs
9/24/2019	9	19.97	7.70	3.73	41.10	587.00		1-5 cfs
5/20/2020	3	17.86	7.13	0.53	5.60	357.10	15.81	0.1-1 cfs
5/20/2020	6	18.17	7.19	3.91	41.40	381.40	34.63	0.1-1 cfs
5/20/2020	5	14.63	7.30	0.62	6.10	309.40	61.09	1-5 cfs
5/20/2020	9	19.20	7.04	0.19	2.10	525.00	26.69	0.1-1 cfs
6/17/2020	3	18.23	7.12	0.55	5.80	349.60	8.26	0.1-1 cfs
6/17/2020	5	17.45	7.16	0.71	7.50	364.90	7.76	0.1-1 cfs
6/17/2020	6	16.20	7.05	0.13	1.40	466.50	14.53	0.1-1 cfs
6/17/2020	9	19.25	7.19	0.44	4.70	342.00	9.71	1-5 cfs

Date	Sub-Site #	Notes
9/19/2017	3	
9/19/2017	5	
9/19/2017	6	
9/19/2017	9	
10/10/2017	3	
10/10/2017	5	
10/10/2017	6	
10/10/2017	9	
6/14/2018	3	
6/14/2018	5	
6/14/2018	6	water shallow, barely? Flowing
6/14/2018	9	water surface covered in floating duckweedy stuff
9/26/2018	3	
9/26/2018	5	
9/26/2018	6	
9/26/2018	9	
6/13/2019	3	
6/13/2019	5	
6/13/2019	6	[DELETED 11.8 as specific conductivity value, out of range]
6/13/2019	9	water was moving; red pond scum cleared out
9/24/2019	3	10 am. No turbidity probe today. Windy, doesn't appear to be recently irrigated (note: this ditch is a drainage ditch for many fields, field north of 3 isn't flood irrigate)
9/24/2019	6	water level low, only ~ 6" deep. Windy. 2nd time sampling after new cattle fence.
9/24/2019	5	soil dry, gras green. 2nd sample since cattle exclusion fence.
9/24/2019	9	flow faster than at other sites. Drainage ditch, adjacent area not flood irrigated.
5/20/2020	3	water barely flowing
5/20/2020	6	field being irrigated
5/20/2020	5	barely flowing (mosquito fern cover water surface)
5/20/2020	9	barely flowing (mosquito fern cover water surface)
6/17/2020	3	water barely flowing
6/17/2020	5	barely flowing (mosquito fern cover water surface)
6/17/2020	6	field being irrigated
6/17/2020	9	flow faster than at other sites. (mosquito fern cover the edges of water surface)

END MONITORING REPORT

Survival Final Report

Below is a final tally of species established at planting sites, as of Summer 2021.

8/24/2021	survey date	Sub-site												8/24/2021 total
Species		**1**	**10**	**11**	**2**	**3e**	**3w**	**4**	**5**	**6**	**7**	**8**	**9**	
alder	Tree	6	0	4	4	2	2	5	0	3	4	28	0	58
ash	Tree	5	0	0	7	6	1	1	0	0	2	4	1	27
blackberry	Shrub	11	0	0	9	3	5	0	1	3	6	7	7	52
boxelder	Tree	8	0	8	7	1	2	1	1	4	9	3	5	49
buttonwillow	Shrub	1	3	10	4	2	4	5	27	16	26	30	0	128
cottonwood	Tree	2	9	3	2	1	1	0	1	0	5	2	2	28
coyotebush	Shrub	20	10	10	23	11	8	0	0	0	5	11	16	114
dogwood	Shrub	13	0	8	13	2	9	0	0	7	15	6	17	90
grape	Shrub	12	0	2	5	0	5	0	0	0	2	4	1	31
hibiscus	Shrub	0	0	20	2	1	0	16	22	4	8	42	22	137
hoita	Shrub	14	0	2	10	1	1	10	0	0	2	24	12	76
indian hemp	Shrub	0	0	3	6	0	2	3	2	0	6	3	0	25
mulefat	Shrub	29	8	43	38	0	11	29	9	15	13	47	0	242
quail bush	Shrub	0	0	3	0	0	0	0	1	1	2	1	3	11
rose	Shrub	21	8	26	11	13	3	8	0	12	29	42	25	198
sycamore	Tree	2	0	7	0	0	0	0	0	1	3	3	1	17
unknown	Shrub	0	0	0	0	0	0	0	0	0	0	3	0	3
Valley oak	Tree	5	0	9	7	4	5	0	0	0	1	10	9	50
Willow sp.	Shrub	10	65	46	8	4	9	55	51	34	36	19	3	340
walnut (black)	tree	0	0	0	0	0	0	0	0	0	0	13	0	13
marsh mulefat	Shrub	0	5	0	0	0	0	5	0	0	0	6	0	16
milkweed	forb	8	0	37	5	19	5	4	0	0	0	6	3	87
Grand Total		**167**	**108**	**241**	**161**	**70**	**73**	**142**	**115**	**100**	**174**	**314**	**127**	**1792**

Project Recognition signage

We used the Delta Protection Commission's template for signage to design and install a project recognition sign at the entrance to the ranch.