



Denier Restoration Biophysical Monitoring

Center for Watershed Sciences, UC Davis

2014 Annual Report

Executive Summary

Several exciting developments occurred during the 2014 calendar year that marked the transition from pre-restoration monitoring to restoration process monitoring. Primarily, earthwork was completed to breach several levees on the Oneto-Denier project area, and the first post-breach flood event was observed. This report summarized the activities completed throughout 2014 in preparation for these changes, and focuses on activities completed during the fourth quarter (October 1 – December 31, 2014). Details about all tasks have been provided in previous quarterly reports.

We are pleased to report that due to strategic monitoring decisions in the years leading up to the levee breaches, the UC Davis Cosumnes Research Group 3 (CRG3) completed 2014 with resources available extend its scientific evaluation of the Oneto-Denier Restoration project to evaluate one full winter of conditions on the connected floodplain, and potentially extend some task through a second winter. Integration of data across each task is continuing, and preliminary data has already been collected of the first post-levee breach flood events. Additional data will provide a unique perspective to how floodplains respond to large-scale restoration activities by tracking the dynamics of fish, plants, hydrology, and geomorphology.

Task 1 Project Management

Continued communication between TNC and UCD is ongoing and was critical to completing our research objectives and field activities throughout the year. Foremost among the project management tasks that were addressed during the fourth quarter were the hiring of a project manager, continuation of the contract amendment process, and response to the recent theft of research materials from the project site.

A Project Manager position was filled to coordinate extensive field and internal activities between the UC Davis CRG3 and The Nature Conservancy (TNC). As Project Manager, Ms. Ann Willis' tasks focus on streamlining communication between Principal Investigator(s) of CRG3 and The Nature Conservancy, as well as overseeing project tasks, deliverables, and budgets. Her background in project management of other TNC projects, including the Shasta, Garcia, and Navarro projects, as well as her specialized knowledge of water resource management for conservation objectives, give her unique insight to potential issues and objectives of the TNC-CRG3 partnership. During the fourth quarter, one of her primary assignments was to facilitate the contract amendment process between UCD and TNC. To that end, her activities included drafting a preliminary budget and scope amendment as well as coordinating the process with TNC staff over phone calls and in meetings.

The response to the recent theft of field equipment from the on-site storage container at the project site has been primarily assigned to the recently hired Field Coordinator, Mr. Kyle Phillips. Key equipment losses included an ATV and jon boat, which will limit ability of researchers to access monitoring sites. Equipment that remained in the storage container has been moved off-site. Replacement of the stolen

items is pending the completion of the insurance process, and will facilitate improved access to monitoring sites during periods of flooding.

Task 2 Groundwater Response

Research during the first three quarters of 2014 generally focused on monitoring; data collected during those activities were used to develop and calibrate a regional scale, heterogeneous, integrated hydrologic model using the computer code ParFlow (Figure 1). The model was constructed using groundwater budget terms for the time period 1969-1985 from previous work (SACIWRM; RMC, 2011) in addition to the detailed stratigraphy depicted in Figure 1. We then applied flooding scenarios (3.5 year, 10 year and 100 year) to the lower Cosumnes River floodplain from Flo2D model (RBI 2013) to obtain preliminary estimates of groundwater recharge potential as affected by both inundation time and the subsurface distribution of aquifer and aquitard (non-aquifer) materials.

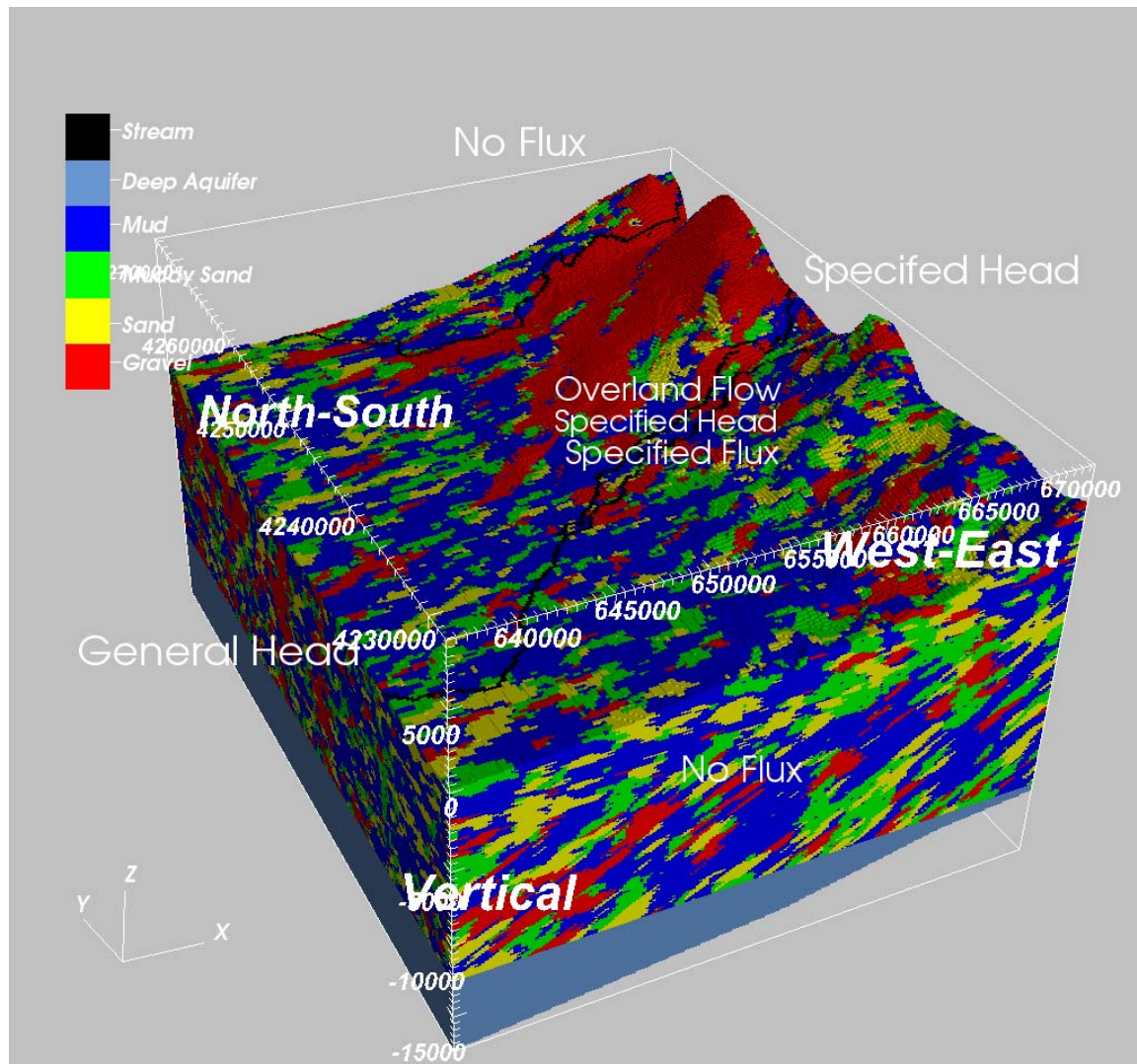


Figure 1. Integrated groundwater-surface water flow model in ParFlow, and corresponding boundary conditions. The model domain covers east-west 36200 m, north-south 45400 m, and vertical 600 m with discretization 200 m by 200 m by 1 m on horizontal and vertical direction, respectively. In total, there are over 10 million nodes. Vertical 100x exaggeration. Note: the heterogeneous subsurface model only goes to 125 m below mean sea level, the deep aquifer system is represented by homogeneous layers)

The simulations are helping to elucidate the dynamics of groundwater recharge and subsurface storage redistribution in a realistically complex characterization of the Cosumnes alluvial aquifer system. The model indicates that storage increases in the aquifer materials (sands and gravels), which make up a minority of the system, are fast, but minimal in terms of volume. The much greater capacity for storage lies in the non-aquifer materials, which have a much slower response time. Calibration with the latest floodplain inundation data will allow model improvements that will provide more reliable estimates of these dynamics and of total storage changes in both aquifer and non-aquifer materials as a function of time.

Task 3 Geomorphic and Hydrologic Response

Hydrologic monitoring activities in 2014 consisted principally of characterizing the frequency and duration of flooding throughout the Center Basin of the Oneto-Denier restoration site. Flooding in February, March and December 2014 allowed a quantitative comparison of flood characteristics prior to and following levee breach and floodplain excavation activities conducted the Summer and Fall of 2014.

February/March 2014 flooding

Due to statewide drought conditions, the Cosumnes River adjacent to the Oneto-Denier restoration site was dry until February 9, 2014. On this date, a large, regional precipitation event allowed for a rapid increase in streamflow magnitudes in the Cosumnes River to 3860 ft³/s (as measured by the United States Geological Survey at Michigan Bar; see Figure 2). The annual recurrence interval for this observed flow is approximately 1.4 years. In early March 2014, two ~1.2 year recurrence interval floods (~1,500 ft³/s) were observed in the Cosumnes River.

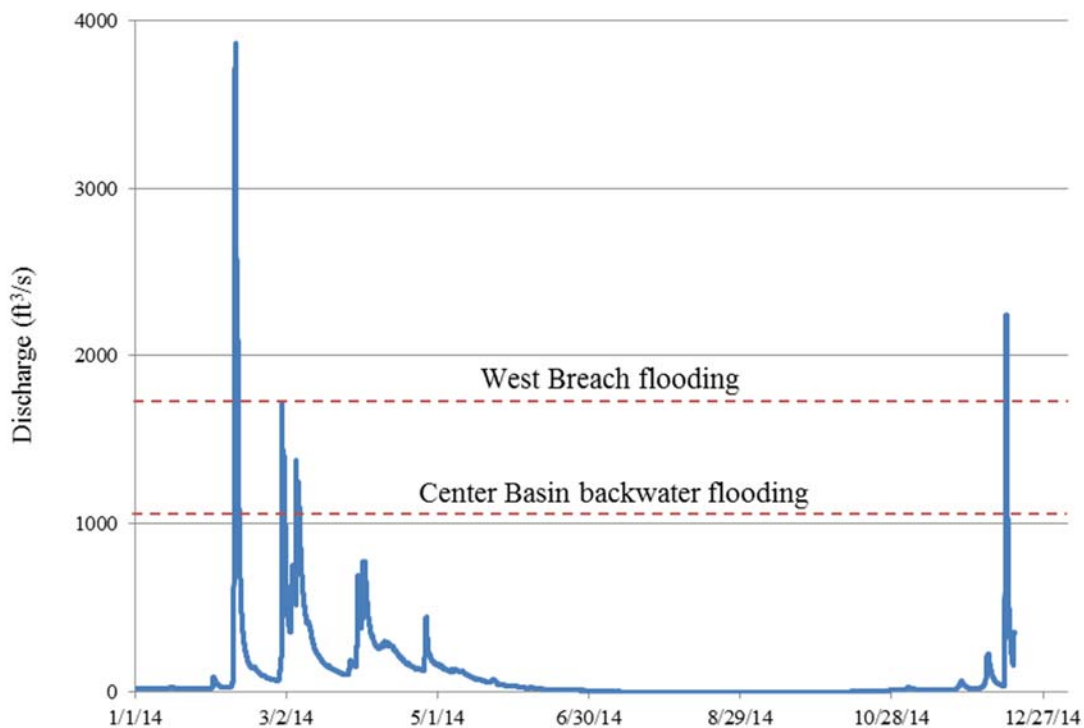


Figure 2. River hydrograph for the Cosumnes River at Michigan Bar from January 1, 2014 through December 14, 2014.

Observations during winter 2014 indicated that flooding of the Center Basin of the Oneto-Denier Restoration site (Figure 3) occurred during the February and March 2014 flood events. Floodwaters entered the Center Basin in two ways. During the February 2014 hydrologic event (peak flow of 3860 ft³/s), floodwaters entered the Center Basin through both the “West Breach” and as backwater flows from the small channel located along the western edge of the Center Basin. However, during the smaller magnitude March hydrologic events (<1700 ft³/s), flood flows did not enter the West Breach. As such, observed flooding only occurred in response to backwater flows in the western Center Basin channel. Backwater flooding appeared to initiate when flows in the Cosumnes River exceeded approximately 1000 ft³/s. Floodwaters were not observed in the Center Basin south of the Ring Field during the winter of 2014.

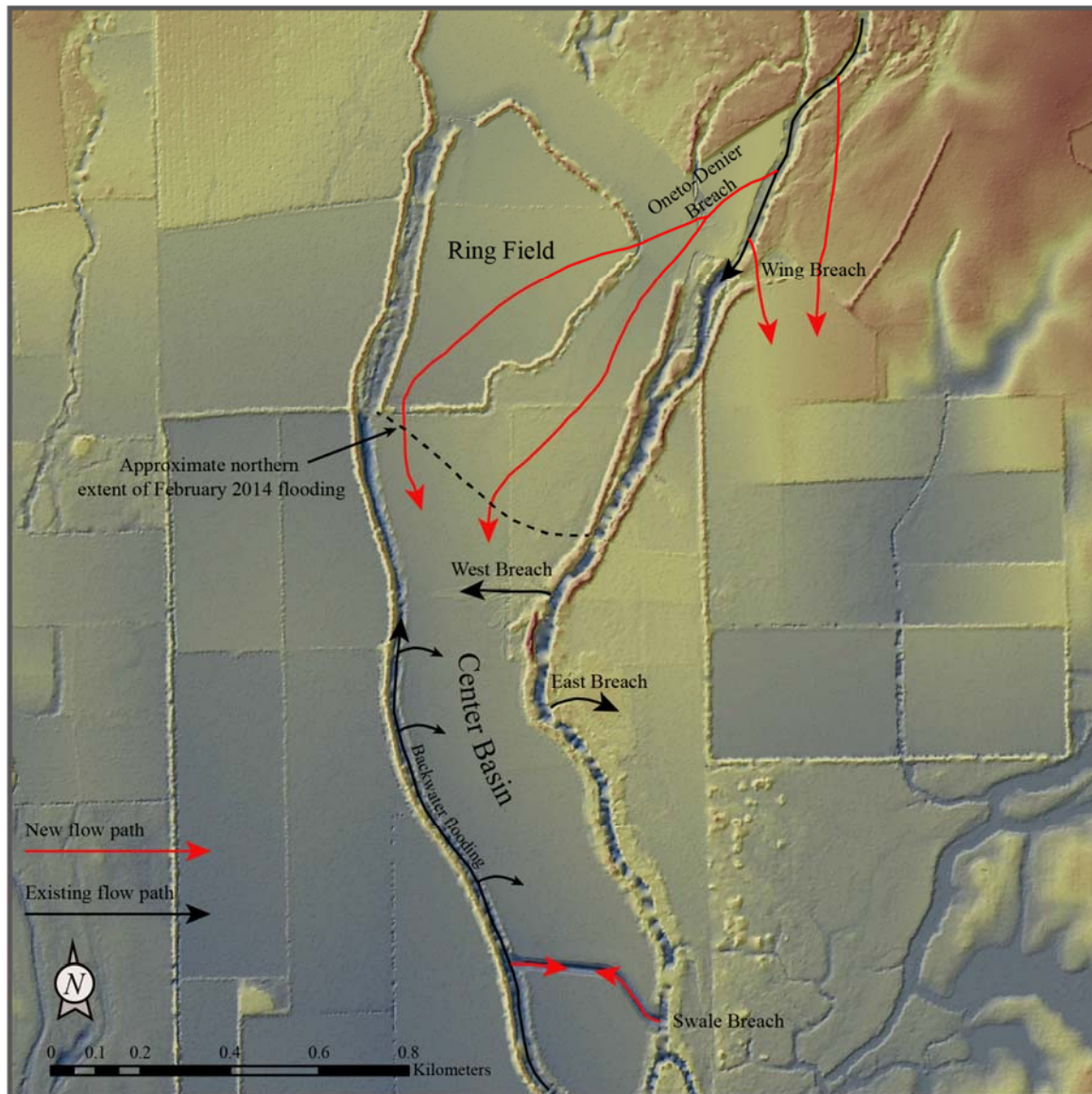


Figure 3. Oneto-Denier floodplain topographic conditions in Fall 2014 (following earthwork activities). Prominent levee breaches and flood flow paths are identified.

Floodwater characteristics were monitored throughout the Center Basin (Figure 4) in the Winter and Spring of 2014 to assess the spatial variability in floodwater timing, duration and depth. Due to existing

floodplain topography, flooding in the southern and western portions of the Center Basin was deeper, more frequent, and of longer duration. For example, during the February 2014 flood event, flooding was observed in the southwest corner of the Center Basin (Site 108) for approximately 78 hours, and flood depths exceeded 1m (Figure 5). However, at Site 104 along the eastern edge of the Center Basin, flooding during the same hydrologic event only lasted 30 hours, and maximum observed water depths were 0.22m (Figure 5). During the smaller magnitude floods in March 2014, only the southwestern portion of the Center Basin (Sites 108 and 208) were inundated with floodwaters (Figure 5). These observations identified considerable spatial variability in floodwater characteristics throughout the Center Basin, particularly during small floods (<2 year recurrence intervals).



Figure 4. Floodplain depth loggers places in the Center Basin of the Oneto-Denier Restoration site in Winter/Spring 2014.

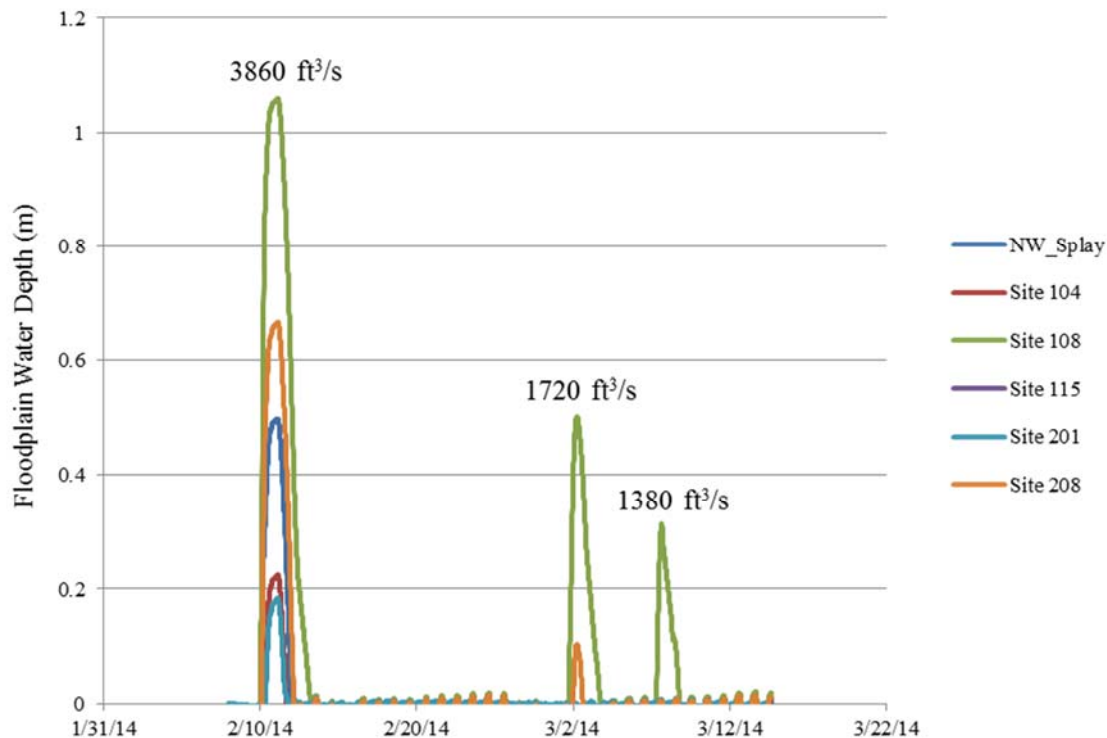


Figure 5. Timing, duration and depth of floodwaters in the Center Basin during February and March 2014. Maximum flow magnitudes during each flood event are presented.

December 2014 flooding

An early winter storm in December 2014 provided an opportunity to observe flood characteristics in the Center Basin following floodplain excavation and grading activities completed in Fall 2014. On December 12, 2014 streamflows of approximately 2,240 ft³/s were observed in the Cosumnes River at Michigan Bar. On December 13, 2014 these flows reached the Oneto-Denier Restoration Site. Qualitative observations indicate floodwaters entered the Center Basin through multiple pathways, including the newly constructed Oneto-Denier Levee Breach and the Swale Breach (Figure 3). Estimated thresholds for flooding are approximately 2000 ft³/s for the Oneto-Denier Levee Breach and 400 ft³/s for the Swale Breach. Water depths/elevations will be monitored at selected channel, levee breach and floodplain sites (n=15) throughout 2015 to quantitatively assess flooding characteristics.

Geomorphic Response

Geomorphic monitoring activities focused on: 1) documenting geomorphic changes associated with levee breach and floodplain excavation activities; and 2) surveying channel cross-section topography for use in hydrodynamic modeling activities.

Breach and Excavation Topographic Surveys

Detailed topographic surveys were conducted in levee breach and floodplain excavation areas throughout the Oneto Denier restoration site (e.g. Figure 6). Following earthwork activities, more than 20,000 topographic points were collected with a Realtime Kinematic (RTK) Global Positioning System (GPS) survey unit to document post-construction topographic conditions. Topographic data points collected with the RTK survey unit were integrated with an existing topographic data set [Central Valley Floodplain Evaluation and Delineation Program (CVFED) LiDAR] to create a Digital Elevation Model

(DEM) of the project site (see Figure 3). This 1 m-resolution DEM will serve as the topographic baseline data set for the restoration project.



Figure 6. Oneto-Denier floodplain excavation and the Oneto-Denier Levee, Wing Levee and Ring Levee breach locations.

Cross-Section Surveys

During Summer 2014, river channel cross-sections were surveyed at regular intervals along the channel reach extending from approximately 1km upstream of Badger Creek to the “Triangle Floodplain” restoration site (Figure 7). Surveyed cross sections extended onto the floodplain banks, and documented major topographic breakpoints, including the bank edges, toes and channel thalweg. These data will be used to characterize baseline geomorphic conditions prior to levee breaching activities, and to support hydrodynamic modelling efforts of the CRG3 research group.

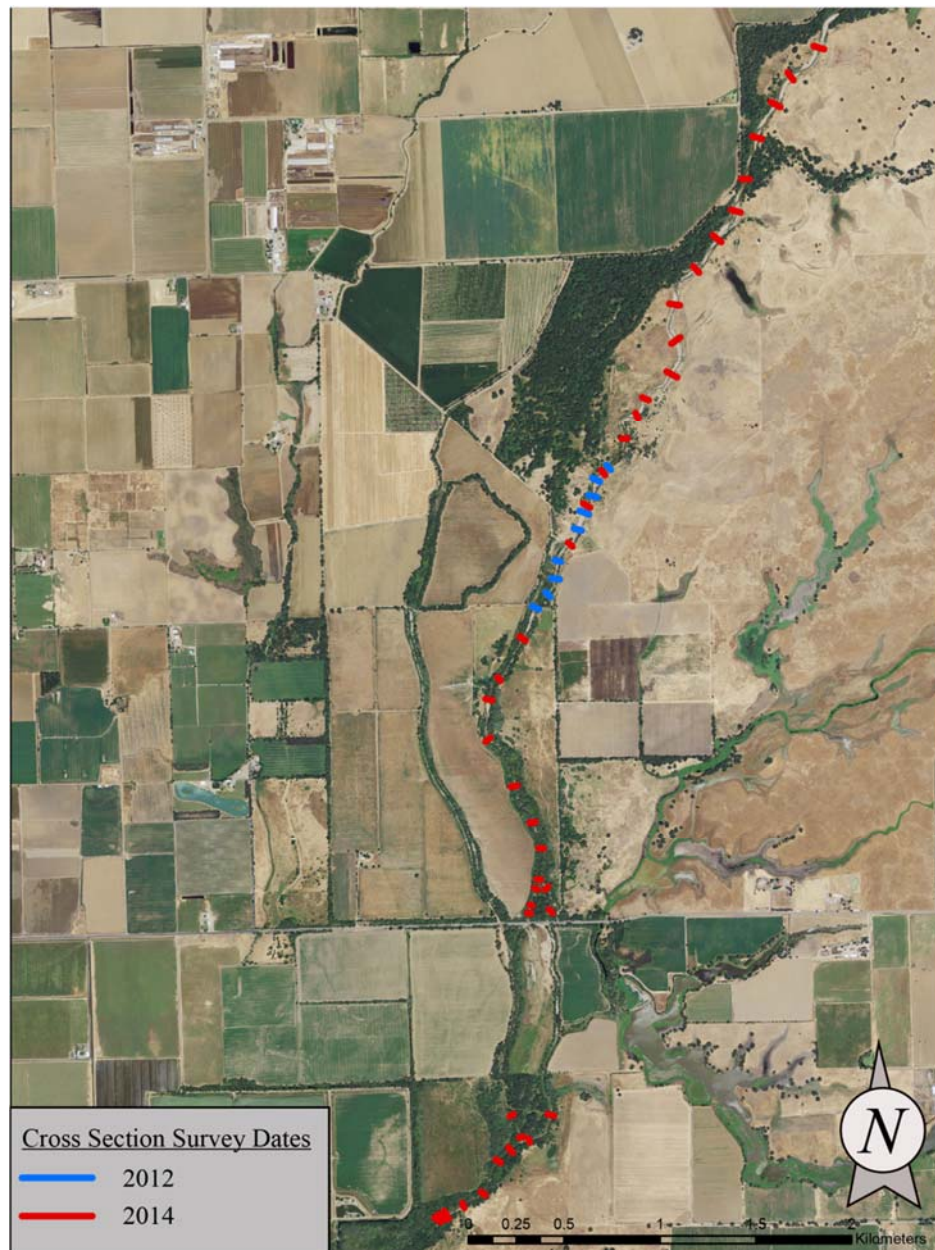


Figure 7. Channel cross sections surveyed in 2012 and 2014.

Task 4 Soil and Soil Carbon Response

During the period in question we divided previously sampled soil carbon (C) data to statistically analyze and determine if ecosystem processes were influencing soil C content. A generalized linear model was used to test if there were significant differences in soil C contents seen between ecosystems at varying soil depths. Despite testing different depths and different ecosystem classifications the data was found to be not statistically significant (Figure 8 and Table 1). This finding has led to the conclusion that soil C is too heterogeneous at this scale for an ecosystem approach and perhaps geospatial analysis may better suit an interpretation of this data.

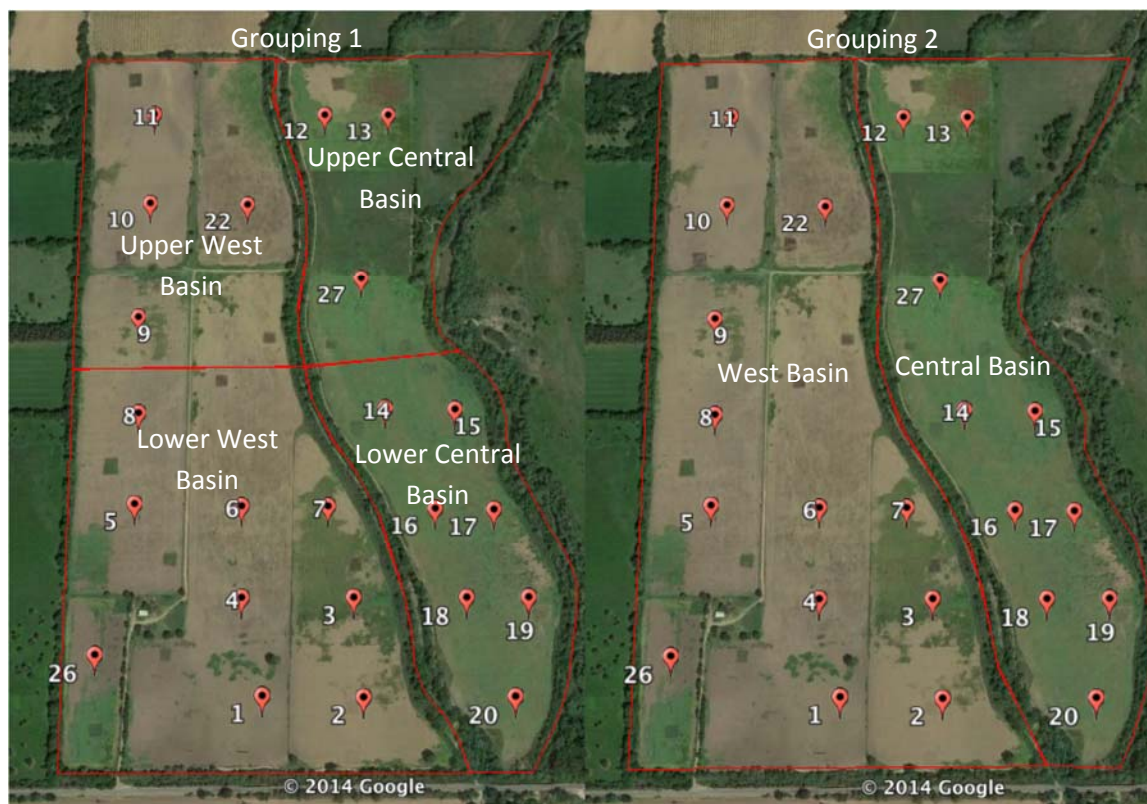


Figure 8. A map of the two ecosystem groupings analyzed for % C.

Table 1. *p* values comparing %C in each ecosystem grouping. No significant differences were seen in the grouping for these depths.

Grouping 1		Grouping 2	
Depths	Pr > F	Depths	Pr > F
0 – 1 ft	0.0695	0 – 1 ft	0.0903
1 – 2 ft	0.2958	1 – 2 ft	0.0664
2 – 6 ft	0.0666	2 – 6 ft	0.0942
2 – 10 ft	0.1757	2 – 10 ft	0.8069
6 – 10 ft	0.1419	6 – 10 ft	0.1778
Layer with highest C below 1ft	0.5084	Layer with highest C below 1ft	0.9601

In the next approach, soils were categorized as either having or not having a buried horizon depending on the quantity of soil carbon found at the surface compared to that found at depths of 3-6 feet. A generalized linear model was used to compare the C contents of the surface and buried/nonburied

horizons. A significant difference was found between the C content of the surface horizons (0-1 ft) and deep horizons with low C contents (Figure 9 and Table 2) but not between the surface and buried deep horizons with high C contents. This result indicated that the soils categorized as having a 'buried' horizon do in fact have a buried horizon. A buried horizon is defined as a surface horizon that becomes buried due to a depositional even, such as a flood. This event halts further soil forming processes to occur. Buried horizons have higher C contents than expected for horizons at their depth. Because there is no significant difference between the C content of the deep and surface horizons for the soils categorized as buried, it can be inferred that these deep horizons are buried horizons. The statistical analysis verified this approach where non-buried horizons had statistically significantly lower C contents than the surface horizon (0-1 ft).

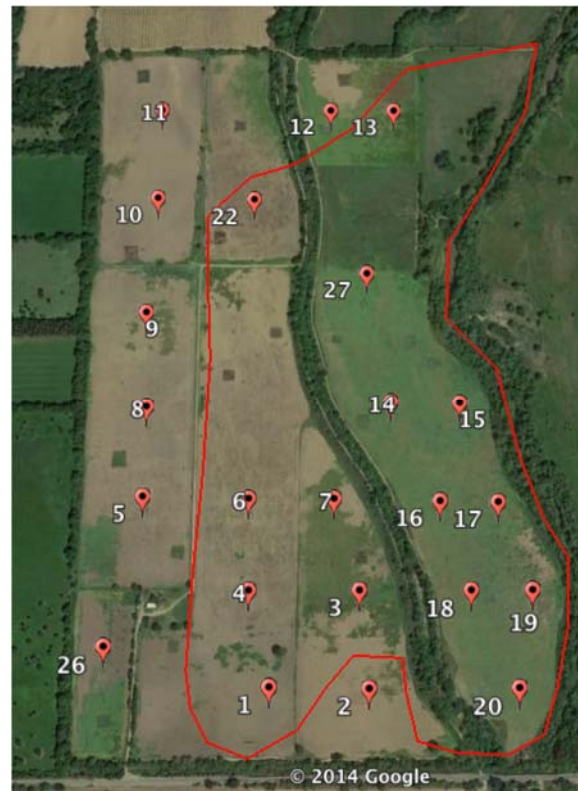


Figure 9. Map showing the soil sites that contain a buried horizon.

Table 2. *p* values comparing buried and non-buried horizon sites to the surface.

Buried Soil Horizon Statistics	
	Pr > F
Buried v Surface	0.8567
Non-buried v Surface	<0.001

In looking at historical maps of the floodplain, there may be a geomorphic connection to the distribution of soil carbon and more specifically the presence or absence of a buried high organic-C horizon that

would support our original hypothesis that soil C is sequestered on floodplains. It is very possible that soils from boreholes 11, 10, 9, 8, 5 and 26 above represent the historical channel of the Cosumnes River seen in maps from the 1850s. Soil textural data is a key component to further analyzing these geomorphic connections. In the coming month, this connection will be explored further by measuring particle size distribution using the hydrometer method.

The pH analysis for the deep and surface soil samples were also completed during the final quarter of 2014. The analyses showed that only 4% of deep C soils analyzed had pH greater than or equal to 8 (Table 3). These samples came from 7 out of 21 total deep C sites. No surface soils had pH greater than 8. In the coming quarter a sub-set of alkaline soils will be acidified and reanalyzed for soil C percentages and $\delta^{13}\text{C}$ to ensure that there is no inorganic carbonates interfering with these organic-C analyses.

Table 3. pH results for the surface and deep soil samples.

Soil pH						
	% Above pH 8.0	Avg pH	Min pH	Max pH	Std Dev	Total number of samples
Deep Soil C	4%	6.95	4.67	9.09	0.67	642
Surface Soil C	0%	6.48	4.79	7.90	0.58	208

Task 5 Hydrochory Response

The third year of the Cosumnes hydrochory project included a full season of instream hydrochory sampling and on floodplain vegetation monitoring. This year was marked a very late and short lived stream reconnection which impaired our ability to look at seasonality and flood events in 2014.

Instream Hydrochory Monitoring

In the 2014 water year we sampled the instream debris twice a month, starting in February and through April at both the Low Water Crossing at the Oneto Property and at the breach at the top of the Triangle. Each sampling event consisted of two samplers standing in the river for twenty minutes with fine mesh nets. On February 9, 2014 no sample was collected at the Triangle floodplain as we were collecting the “reconnection” event of the LWC. The debris collected was transferred back to the UC Davis greenhouses and potted up. When debris samples germinated, species were identified and removed from pots to decrease competition. A sample was collected on 12/12/14, but no data has yet been recorded in the greenhouse.

We recorded 33 distinct species, 19 of which were native and 14 of which were non-native that germinated in the greenhouse (Figure 10) from samples collected at the Low Water Crossing and Triangle floodplain. Instream samples that contained the greatest number of species and the greatest number of germinating material coincided with the 3/1/14 small flood event.

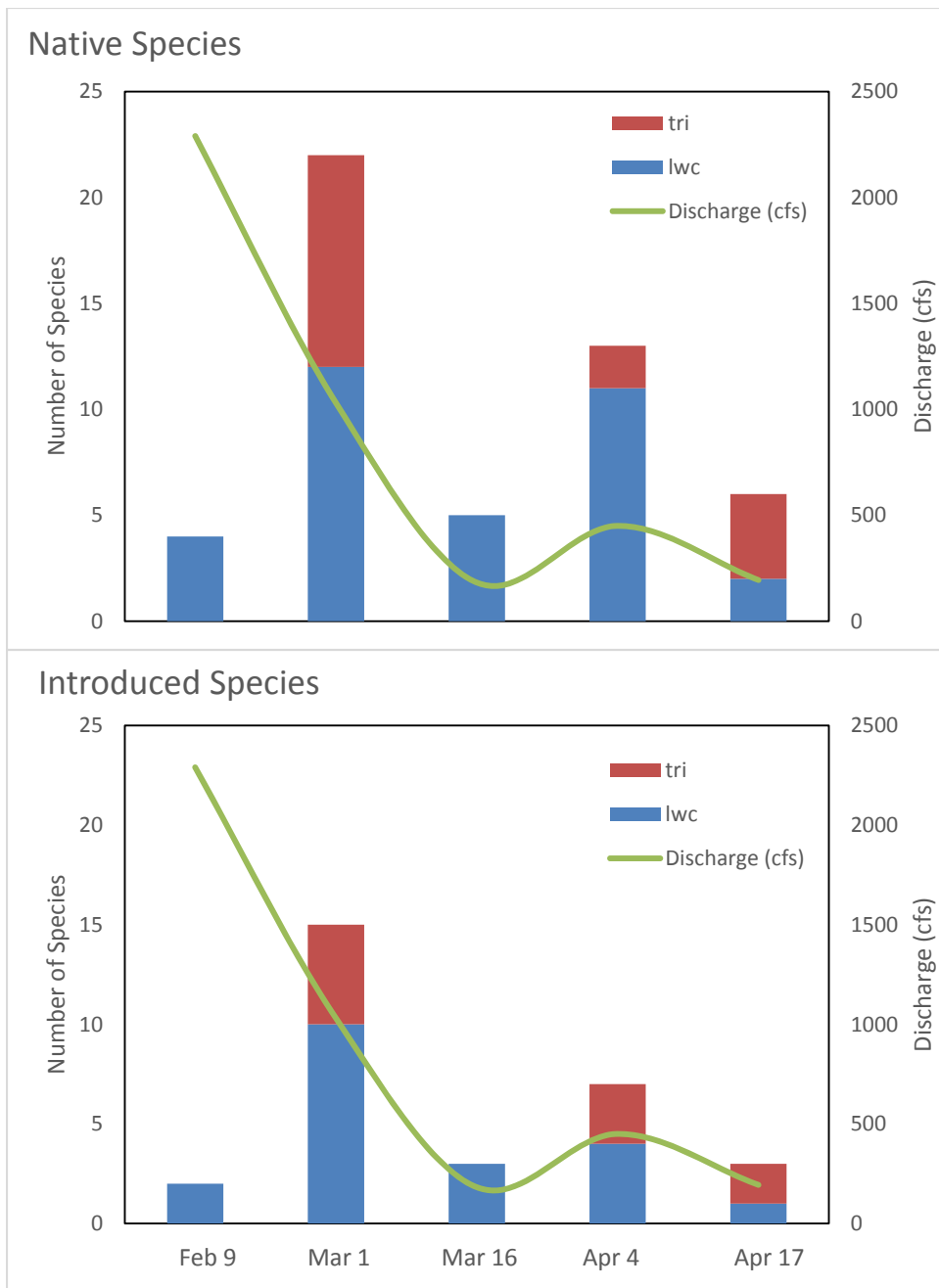


Figure 10. Instream hydrochory species counts (diversity) by sampling date for native and non-native species at the Low Water Crossing and the Triangle. Discharge (cfs) at the Michigan Bar gage is displayed on the secondary Y-axis.

Floodplain Vegetation

Floodplain vegetation from plots sampled in 2014 is not yet analyzed. In 2014, we sampled a subset of plots that will be used to directly compare changes to floodplain vegetation from levee removal in the fall of 2013.

Sediment Mats and Tiles

There was little to no deposition onto sediment mats and tiles in 2014.

iButton

iButton data was not analyzed in 2014 due to the fact that the floodplain did not experience extensive flooding.

Floodplain Microtopography

There was very little change in the micro-topography of most floodplain surfaces in 2014. However, we did detect that surfaces that were planed in summer 2013 are now much flatter while surfaces that were not planed maintained their microtopography. We hypothesize that increased surface microtopography will increase species diversity and encourage beta-diversity across the site.

Seedbank Sampling

No seed bank sampling occurred in 2014.

Biomass

No biomass data was collected in 2014.

Task 6 Aquatic and Hydrological Response

Due to the lack of flow during 2014, minimal aquatic and hydrologic monitoring occurred. Generally low flows restricted discharge to the river channel. Observations from modest flood events early this year suggested that the Cosumnes functions as non-natal rearing habitat from Mokelumne River Hatchery steelhead. Other fish observed utilizing the floodplain included splittail and Pacific lamprey. However, these flood events did not coincide with the presence of adult salmon, preventing later utilization by juveniles.

Extensive planning of sampling activities around the Oneto-Denier floodplain was completed in anticipation of the end of construction activities and potential flood events. Floodplain and river channel utilization and floodplain escapement by fishes will be determined by placing fyke nets at the entrance to the floodplain and the toe drain of the restored floodplain. Fish collected at the entrance fyke and during beach seining will, if large enough, be implanted with passive integrated transponder (PIT) tags to determine duration and growth while utilizing the restored floodplain. Fish collected in fyke traps above the floodplain will also be implanted with PIT tags to determine growth and migration duration through the main channel adjacent to the restored floodplain. Data collected under this task will be invaluable to relating various floodplain functions to their role supporting fish.

Activities Proposed January 1 – March 30th, 2015

Task 1 Project Management

- Continue to work with TNC to amend existing scope of work to extend monitoring activities into 2016
- Work with TNC to develop and secure field site, including infrastructure, as needed
- Continue to conduct periodic project meetings about past and current activities at the site
- Update and streamline project website to focus on research objectives and products

Task 2 Groundwater Response

- Continued monitoring of groundwater levels

- Analysis of trends in water levels to ascertain interplay between changes in groundwater storage, irrigation, precipitation, and river stage
- Improved calibration of regional model to regional and local hydrologic conditions

Task 3 Geomorphic and Hydrological Response

- Download data from iButtons and stage loggers
- Continue to photo monitor the river
- Run sediment transport model under revised surveys

Task 4 Soil and Soil Carbon Response

- Continued to analyze soils for physical and chemical properties

Task 5 Hydrochory Response

- Sample instream debris twice a month and on the ascending limb of any flood events
- Monitor germinants in the greenhouse
- Present research findings at the CNPS conference in San Jose – “Interactions among plant phenology, hydrochory and flow regime before floodplain re-connection on the Cosumnes River Oneto floodplain in California’s Central Valley”

Task 6 Aquatic Response

- Depending on flow events, fyke nets will be set up to catch fish entering a leaving the floodplain
- Fish will be measured and PIT-tagged, then placed on the downstream side of the capture net.
- A PIT-tag antenna array will be placed in both the river channel as well as in the swale to detect tagged fish without having to recapture them.