

Action Effectiveness Monitoring for the Lower Columbia River Estuary Habitat Restoration Program

Project Number: 2003-007-00

Report covers work performed under BPA contract #: 62931

Report was completed under BPA contract #:66764

Performance/Budget Period: October 1, 2013 – September 30, 2014

**Technical Contact: Matthew Schwartz
Research Scientist**

Lower Columbia Estuary Partnership
811 SW Naito Parkway, Suite 410
Portland, Oregon 97204
Phone: (503) 226-1565 x 239
mschwartz@estuarypartnership.org
Report Created 3/2015

**BPA Project Manager: Jason Karnezis
Policy Analyst**

Bonneville Power Administration
905 NE 11th Avenue
Portland, Oregon 97208
Phone:

**Action Effectiveness Monitoring for the Lower Columbia River Estuary Habitat
Restoration Program Annual Report for Year 10 (October 2013 to September 2014)**

Matthew D. Schwartz*
Amy B. Borde¹
Jason Smith²
Narayan Elasmar²

*Prepared by the Lower Columbia Estuary Partnership
with funding from the Bonneville Power Administration

Lower Columbia Estuary Partnership
811 SW Naito Parkway, Suite 410
Portland, OR 97204

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

This report should be cited as follows:

Schwartz M.S., A.B. Borde, J. Smith, and N. Elasmar. Action Effectiveness Monitoring for the Lower Columbia River Estuary Habitat Restoration Program. October 2013 – September 2014, Project Number: 2003-007-00.

¹ Pacific Northwest National Laboratory

² Columbia River Estuary Study Taskforce

Contents

<i>Abbreviations and Acronyms</i>	8
<i>Abstract</i>	9
<i>Introduction</i>	10
<i>Methods</i>	12
Site Selection	12
Habitat Monitoring.....	16
Fish Monitoring	17
Analysis.....	17
Non metric Multidimensional Scaling	18
Indicator species analysis.....	19
Similarity Index	19
Species Richness and Shannon Diversity Index	19
<i>Results</i>	19
Vegetation	19
Non-metric multidimensional scaling.....	19
Indicator species analysis.....	21
Similarity Index and Species Diversity.....	23
Terrestrial Macroinvertebrates.....	32
Water Temperature	35
Fish Detection and Passage.....	39
<i>Discussion/Conclusion</i>	40
<i>Adaptive Management & Lessons Learned</i>	43
<i>References</i>	44
<i>Appendices</i>	45
Appendix A: Site Sampling Reports.....	45
Wallacut Restoration.....	46
Kandoll Farm Restoration.....	48
Ilwaco Reference	51
Secret River Reference	53
Sauvie Island North Unit Phase 1 (Ruby Lake).....	55
Sauvie Island North Unit Phase 2 (Deep Widgeon)	57
Sauvie Island North Unit Phase 2 (Millionaire Lake)	60
Sauvie Island North Unit Reference (Cunningham Lake).....	62
Sandy River (Mouth)	63
Sandy River (Dam Removal).....	65

Sandy River Reference (Gary Island).....	67
Appendix B: 2014 Site Prioritization Results.....	70

Table of Figures

Figure 1. 2014 Level 2 and Level 3 AEM sites	15
Figure 2. 2014 Level 2 AEM pre-restoration, post restoration, and reference site monitoring locations.	16
Figure 3. NMS ordination of sample units in species space. Axis 1 is correlated with river Km, vegetation zone, and vegetation zone with site condition. Different vegetation zones are demarcated.	20
Figure 4. NMS ordination of sample units in species space. Axis 3 is correlated with species richness, evenness, and species diversity. Range of site conditions are demarcated with bars....	21
Figure 5. NMS ordination illustrates similarity within and between sites. Open triangles represent pre-restoration condition, circles represent post restoration condition, and squares represent reference condition.....	25
Figure 6. Vegetation cover and composition pre and post restoration at Kandoll Farm	26
Figure 7. NMS ordination illustrates similarity within and between sites. Open triangles represent pre-restoration condition, circles represent post restoration condition, and squares represent reference condition.....	28
Figure 8. Vegetation cover and composition pre and post restoration at Sauvie Island North Unit Phase 1	30
Figure 9. NMS ordination illustrates similarity within and between sites. Open triangles represent pre-restoration condition, circles represent post restoration condition, and squares represent reference condition.....	32
Figure 10. Percent composition of terrestrial macroinvertebrates at Kandaoll Farm	33
Figure 11. Percent composition of terrestrial macroinvertebrates at Sauvie Island North Unit Phase 1 and 2	34
Figure 12. Terrestrial macroinvertebrate Frequency of occurrence at Wallacut Slough and Reference	35
Figure 13. Pre and post restoration 7 day moving average maximum water temperature data for Sauvie Island North Unit Phase 1 and Control Site.....	37
Figure 14. 7-day moving average maximum temperatures for study period pre-restoration year 2010 and post restoration year 2014	38
Figure 15. 2014 vegetation and macroinvertebrate sampling locations at Wallacutt restoration site.	48
Figure 16. 2014 vegetation and macroinvertebrate sampling locations at Kandoll Farm restoration site.....	51
Figure 17. 2014 vegetation and macroinvertebrate sampling locations at Ilwaco marsh.....	53
Figure 18. 2014 vegetation and macroinvertebrate sampling locations at the Secret River marsh reference site.	55
Figure 19. 2014 vegetation and macroinvertebrate sampling locations at the North Unit Phase 1 (Ruby Lake) restoration site.....	57

Figure 20. 2014 vegetation and macroinvertebrate sampling locations at the North Unit Phase 2 (Deep Widgeon) restoration site. 59

Figure 21. 2014 vegetation and macroinvertebrate sampling locations at the North Unit Phase 2 (Millionaire Lake) restoration site. 61

Figure 22. 2014 vegetation and macroinvertebrate sampling locations at the Cunningham Lake reference site. 63

Figure 23. 2014 vegetation and macroinvertebrate sampling locations at the Sandy River mouth restoration site. 65

Figure 24. 2014 vegetation and macroinvertebrate sampling locations at the Sandy River dike breach restoration site. 67

Figure 25. 2014 vegetation and macroinvertebrate sampling locations at the Gary Island control site. 69

Table of Tables

Table 1. Restoration sites and associated reference sites selected for Level 2 monitoring in 2014	13
Table 2. Restoration sites receiving Level 3 monitoring in 2014	14
Table 3. Sites and years included in analysis	18
Table 4. Average species diversity for all pre-restoration, post restoration, and reference sites..	21
Table 5. Significant indicator species for vegetation zone one from indicator species analysis ..	22
Table 6. Significant indicator species for vegetation zone five from indicator species analysis..	23
Table 7. Similarity index for restoration and reference sites in vegetation zone one. Yellow highlights represent 60-69% similarity and green highlights represent >70% similarity.....	24
Table 8. Species richness and species diversity pre and post condition at Kandoll Farm.....	26
Table 9. Similarity index for restoration and reference sites in vegetation zone four. Yellow highlights represent 60-69% similarity and green highlights represent >70% similarity.....	29
Table 10. Species richness and species diversity at Sauvie Island North Unit Phase 1 pre and post restoration	30
Table 11. Similarity index for restoration and reference sites in vegetation zone four. Yellow highlights represent 60-69% similarity and green highlights represent >70% similarity.....	31
Table 12. Terrestrial macroinvertebrate species richness and species diversity at Kandoll Farm pre and post restoration	33
Table 13. Terrestrial macroinvertebrate species richness and species diversity at Sauvie Island North Unit Phase 1 pre and post restoration	34
Table 14. Terrestrial macroinvertebrate species richness and species diversity at Wallacut Slough pre restoration and reference site.	35
Table 15. Dates during the 2013 and 2014 March through July study period when the 7 day moving average maximum water temperature exceeded the Washington Department of Ecology threshold of 17.5° C	36
Table 16. Fish detected in 2014 at Horsetail Falls PIT-tag array	40

Abbreviations and Acronyms

AEM	Action Effectiveness Monitoring
BPA	Bonneville Power Administration
CREST	Columbia River Estuary Taskforce
EMP	Ecosystem Monitoring Program
ESA	Endangered Species Act
NMS	nonmetric multidimensional scaling
PIT tag	passive integrated transponder tag
RPA	Reasonable and prudent alternative
USACE	U.S. Army Corps of Engineers

Abstract

The goals of the Lower Columbia Estuary Partnership's Action Effectiveness Monitoring (AEM) program are to determine the effectiveness of habitat restoration actions on salmon recovery at the site and landscape scale, identify how restoration techniques address limiting factors for juvenile salmonids, and improve restoration techniques to maximize the effect of restoration actions. To accomplish AEM program goals, the Estuary Partnership implements the Columbia Estuary Ecosystem Restoration Program (CEERP) AEM Programmatic plan (Johnson et al. 2014), employs standardized monitoring protocols, and coordinates between stakeholders to collect and share AEM data. AEM is conducted at one of three levels of intensity to ensure all restoration sites receive some monitoring. The AEM levels consist of Standard (Level 3), Extensive (Level 2), and Intensive (Level 1). In 2014 the objectives of the AEM program were to examine changes in vegetation composition, prey availability, and water temperature at the site and landscape scales.

In 2014 sixteen restoration sites received AEM in the lower Columbia River and Estuary. Using the prioritization process outlined in the AEM Programmatic Plan, five restoration sites were selected for additional Extensive Level 2 monitoring in addition to receiving Standard Level 3 monitoring. Four associated reference sites were selected to establish a Before After Reference Impact monitoring design. Eleven restoration sites received Standard Level 3 monitoring. All monitoring was conducted following standardized protocols outlined in Roegner et al. (2009). A PIT tag array was established at Horsetail Creek to determine residency time of salmonids and address uncertainties related to fish passage through long culverts.

Emergent wetland vegetation was evaluated at the site scale and at a landscape scale using previously defined emergent wetland vegetation zones (1-5 following the estuarine tidal freshwater gradient; 1 being located closest to the river mouth and 5 being closest to Bonneville Dam). In this analysis, the term "site condition" is used to distinguish between pre-restoration, post-restoration, and reference sites. Vegetation data at all sites were strongly correlated with river kilometer and emergent vegetation zone. When all sites were grouped together, species richness, species diversity, and evenness were moderately correlated with site condition. Reference sites had higher species diversity compared to pre- and post-restoration sites. An indicator species analysis was conducted to examine if certain vegetation species were associated with specific emergent vegetation zones and site condition. Reference sites were associated with native species, while both pre- and post-restoration sites were associated with native and invasive plant species. A vegetation similarity index was created to evaluate differences between pre-restoration, post-restoration, and reference sites. Similarity between site conditions varied depending on emergent wetland zone with similarities highest between sites in the lower estuary and the lowest site similarities near Bonneville Dam. At the restoration site scale, vegetation similarity differed pre- and post-restoration depending on specific restoration actions. Restoration sites with intensive marsh elevation lowering were dissimilar pre- and post-restoration due to removal of dominant reed canarygrass (*Phalaris arundinacea*). Restoration actions focused on tidal reconnection without intensively lowering of marsh elevations were similar pre- and one year post-restoration. Dipterans were prevalent at all sites regardless of habitat condition and comprised a large portion of the terrestrial macroinvertebrate samples collected. There were more dipterans available during the 2014 sampling period than during the 2013 sample period at all sites. Water temperature at analyzed restoration sites showed no

change or a slight decrease and was dependent on site location and associated physical processes like frequency of inundation by the mainstem Columbia River or ambient climate factors. Tagged fish detected at Horsetail Creek restoration site represented hatchery and wild stocks from spring, fall, and winter runs. Juvenile steelhead (*Oncorhynchus mykiss*) were found to transit the Horsetail Creek culvert in spring. Adult coho (*Oncorhynchus kisutch*) transited the culvert in summer and fall and used the barrel containing the redesigned fish passage structure during low flow periods. Species detection at the Horsetail site was consistent with seasonal occurrence data for Chinook (*Oncorhynchus tshawytscha*) and other salmonid species observed at other nearby reference study sites.

The small numbers of sites with monitoring data limits our ability to make clear inferences related to restoration efforts and improvements in ecological condition. However, this preliminary analysis indicates that restoration sites are responding to restoration actions. At the site scale, restored sites will need to mature to a more ecologically stable state before the impact of restoration actions on juvenile salmonid habitat and prey can be accurately assessed. Furthermore, preliminary analysis indicates that the duration for Standard Level 3 monitoring needs to be increased for water temperature and water surface elevation due to inter-annual variability. Long-term monitoring data from the Ecosystem Monitoring Program (EMP) helped to put the results from restoration site monitoring in temporal context, allowing for analysis of long-term trends as well as inter-annual variability. As more sites are monitored under the new programmatic plan for AEM, a larger and longer term dataset will improve our ability to elucidate ecological changes at the site and landscape scale.

Introduction

The Lower Columbia Estuary Partnership's (Estuary Partnership's) mission is "to preserve and enhance the water quality of the estuary to support its biological and human communities." The Action Effectiveness Monitoring (AEM) Program is part of the Columbia Estuary Ecosystem Restoration Program (CEERP) providing primary funding agencies the Bonneville Power Administration (BPA) and the Environmental Protection Agency, restoration partners (e.g., USACE and CREST), and others with information useful for evaluating the success of restoration projects. AEM facilitates improvements in project design and management, increases the success of restoration projects for ESA listed salmonids, and addresses RPA 60 of the 2008 Draft Biological Opinion (NMFS 2008). In 2008, the Estuary/Ocean subgroup (EOS) recommended four projects for AEM during the pilot phase of the program. The selected AEM sites were monitored annually until 2012 and represented different restoration activities, habitats, and geographic reaches of the river. The initial phase of AEM resulted in site scale monitoring and the standardization of data collection methods, but also highlighted the need for expanded monitoring coverage of paired restoration and reference sites to evaluate reach and landscape scale ecological uplift.

On-the-ground AEM efforts collect the data needed to assess the performance and functional benefits of restoration actions in the lower Columbia River and estuary.

The goals of the AEM Program are to:

- Determine the impact of restoration actions on salmon recovery at the site, landscape, and ecosystem scale

- Improve restoration techniques to maximize impact of habitat restoration actions and better track long term project success
- Identify how restoration techniques address limiting factors for salmonids
- Use intensive AEM to focus extensive AEM efforts to improve data collection to inform management decisions

The Estuary Partnership aims for the AEM Program to complement our existing Ecosystem Monitoring Program (EMP). The EMP implements monitoring activities to characterize status and trends of relatively undisturbed emergent wetlands and assess juvenile salmonid usage of those habitats. The EMP provides valuable information for improving restoration effectiveness, provides a baseline ecosystem condition from which to compare action effectiveness monitoring data, and provides pertinent information regarding which extensive monitoring metrics relate to improved opportunity and capacity related to juvenile salmonids. The Estuary Partnership's EMP continues to monitor many parameters likely to be included in AEM (e.g., vegetation, water quality, food web, and salmon) and the collection of comparable datasets by the two programs (where possible) will continue to fill data gaps and add to our understanding of habitat conditions and juvenile salmonids in the lower river.

To meet AEM program goals, the Estuary Partnership is engaged in the following tasks:

- Implementing AEM as outlined in the Estuary RME plan (Johnson et al. 2008), Programmatic AEM plan (Johnson et al. 2014), and following standardized monitoring protocols (e.g., Roegner et al. 2009) where applicable
- Developing long-term datasets for restoration projects and associated reference sites
- Coordinating between stakeholders to improve AEM data collection efficiency
- Supporting a regional cooperative effort by all agencies and organizations participating in restoration monitoring activities to create a central database to house monitoring data
- Capturing and disseminating data and results to facilitate improvements in regional restoration strategies

The AEM program consists of three monitoring levels that are implemented at selected restoration sites as follows:

- Level 3 – includes “standard” monitoring metrics: water surface elevation, water temperature, sediment accretion, and photo points that are considered essential for evaluating effectiveness of hydrologic reconnection restoration. This monitoring is done at all restoration sites within the CEERP.
- Level 2 – includes the Level 3 metrics and also metrics that can be used to evaluate the capacity of the site to support juvenile salmon. These metrics include vegetation species and cover; macroinvertebrate (prey species) composition and abundance; and channel and wetland elevation. This monitoring is done at a selected number of sites chosen to cover a range of restoration actions and locations in the River and is intended to provide a means of monitoring an “extensive” area.
- Level 1 – includes Level 2 and 3 metrics and also more “intensive” monitoring of realized function at restoration sites, such as fish use, genetics, and diet. Since this monitoring is more expensive it is conducted at fewer sites with the goal of relating the Level 1 results to the findings of the Level 2 and Level 3 monitoring.

In 2014 the objectives of the AEM program were to examine site scale changes related to vegetation composition, terrestrial macroinvertebrates, and water temperature related to restoration efforts at the site and the larger emergent wetland vegetation zone scale. Extensive and standard action effectiveness monitoring is intended to characterize habitat conditions pre- and post-restoration. Using larger spatial scales to examine ecological changes at restoration and reference sites, then comparing data from the ecosystem monitoring program, provides a way to examine how changes at restoration sites fit into a larger landscape context. Furthermore, the collection of fish and habitat condition metrics at ecosystem monitoring sites provides a pathway to draw some parallels about the favorability of restoration site conditions to juvenile salmonids.

Methods

Site Selection

Sixteen restoration sites received action effectiveness monitoring in 2014 (Table 1 and Table 2). Five restoration sites were selected for Level 2 and Level 3 monitoring (Table 1) using the prioritization criteria outlined in Johnson et al. (2014). Four associated reference sites were chosen to establish a before-after reference -impact monitoring design which puts pre- and post-restoration site data into ecological context (Table 1). Eleven restoration sites were scheduled for Level 3 monitoring. Two Ecosystem Monitoring Program sites (Campbell Slough and Franz Lake) were included in the vegetation analysis for comparison due to their location in emergent vegetation zones. The full results of the 2014 site selection process can be found in Appendix B .

Horsetail Creek was selected for fish monitoring to determine residency time of salmonids in streams in upper reaches of the lower Columbia River and address uncertainty related to fish passage through long culverts. The site was selected for fish monitoring prior to the establishment of AEM prioritization process (Figure 2).

Table 1. Restoration sites and associated reference sites selected for Level 2 monitoring in 2014

Restoration Site	Location	Pre-Restoration Monitoring Date	Post-Restoration Monitoring Date	Reference Site and Monitoring Date(s)
Wallacut Slough	Rkm 57	23-24 June 2014		<u>Ilwaco</u> 4 Aug 2012 26 July 2013 27 June 2014
Kandoll Farm	Rkm 37 and approximately 5 km up the Grays River	25-28 June 2013	25-26 June 2014	<u>Secret River</u> 24-25 July 2013 14-15 July 2014
Sauvie Island North Unit Phase 1 (Ruby Lake)	Rkm 145	29-30 July 2013	21 July 2014	<u>Cunningham Lake</u> 29 July 2013 18 July 2014 <u>Campbell Slough</u> 10 August 2012 27 July 2013 18 July 2014
Sauvie Island North Unit Phase 2 (Millionaire and Deep Widgeon Lakes)	Rkm 143	22 August 2013 16-17 July 2014		<u>Cunningham Lake</u> 29 July 2013 18 July 2014 <u>Campbell Slough</u> 10 August 2012 27 July 2013 18 July 2014
Sandy River Dam Removal	Rkm 200	17 July 2006 6 August 2007	22-23 July 2014	Gary Island 2014 Franz Lake 30 August 2012 31 July 2013 7 August 2014

Table 2. Restoration sites receiving Level 3 monitoring in 2014

Restoration Site	Location	Pre-Restoration Monitoring Year	Post-Restoration Monitoring Year
Gnat Creek	Rkm 48	2013	2014
Louisiana Swamp	Rkm 77	2013	2014
Chinook River	Rkm 11	2014	
Skamokawa	Rkm 54		2014
Skipanon Slough	Rkm 16	2014	
Sharnelle Fee	Rkm 27	2014	
Karlson Island	Rkm 42	2014	
Thousand Acres	Rkm 200	2014	
Wallooskee-Youngs	Rkm 24	2014	
Multnomah-Wahkeena Phase 1	Rkm 218	2014	
Horsetail Creek	Rkm 223	2010	2014

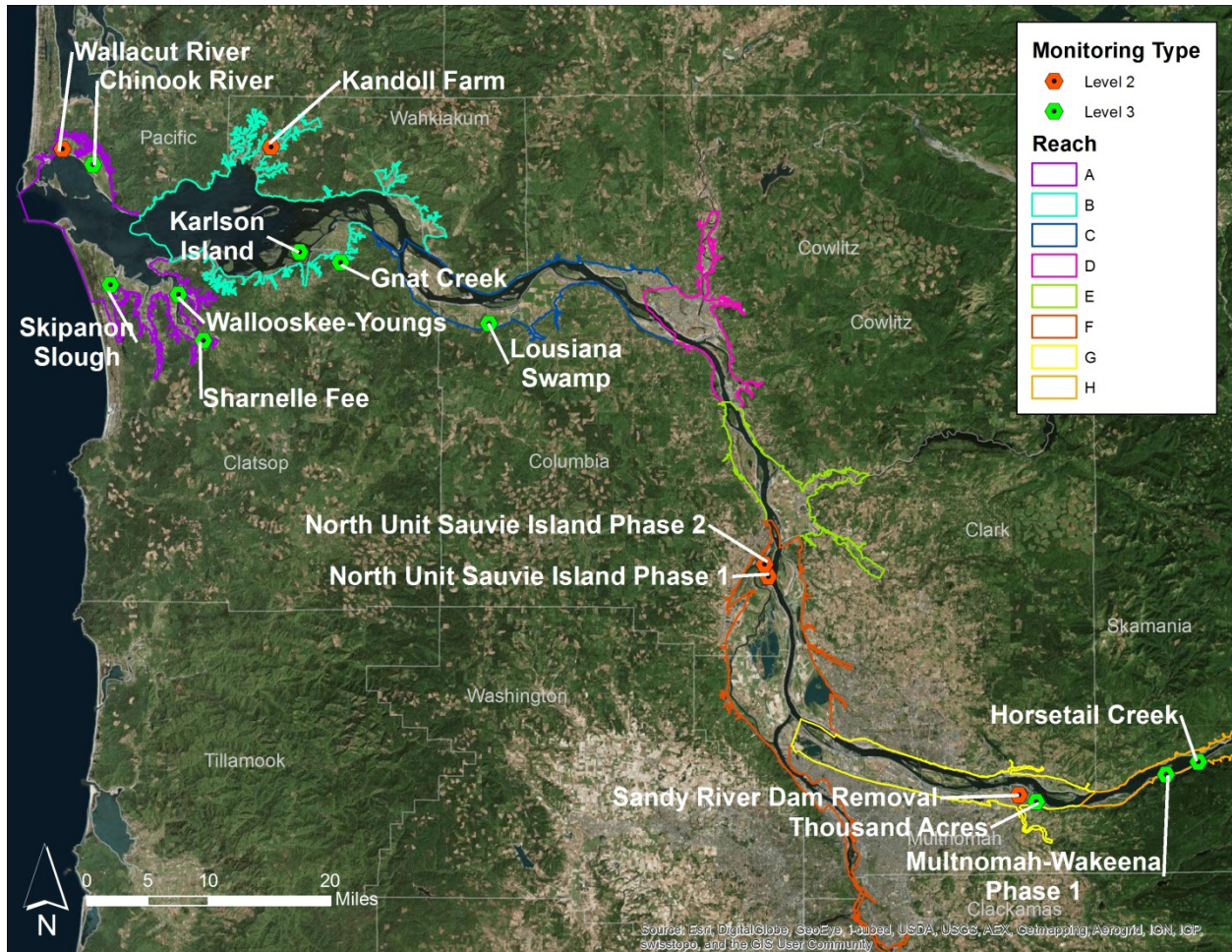


Figure 1. 2014 Level 2 and Level 3 AEM sites

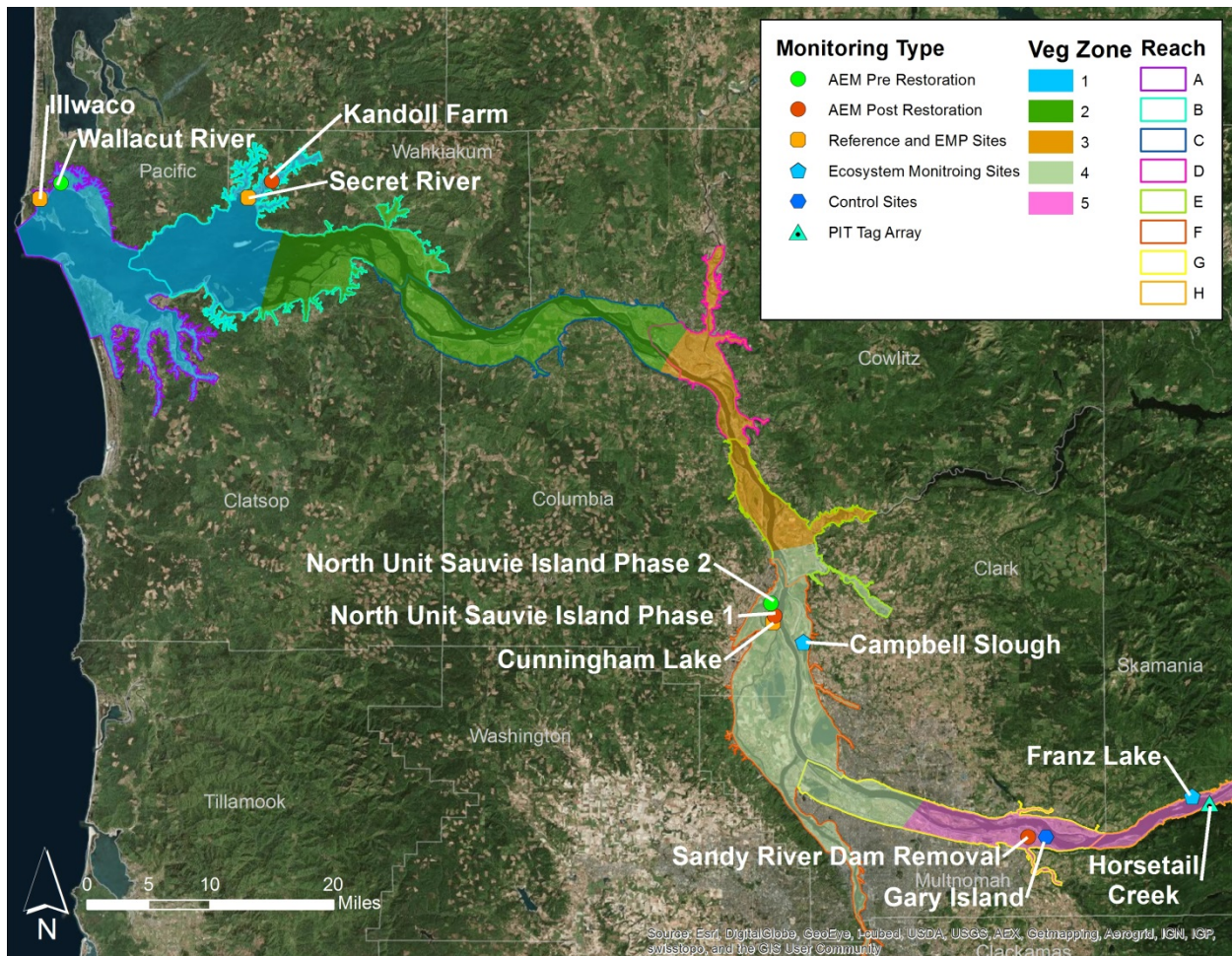


Figure 2. 2014 Level 2 AEM pre-restoration, post restoration, and reference site monitoring locations.

Habitat Monitoring

Methods from the protocol “Lower Columbia River Estuary Habitat Action Effectiveness v1.0” were used to evaluate changes related to restoration actions and quantify ecological uplift (Roegner et al. 2009, [Protocol ID: 460](#)). Detailed site sampling reports are in Appendix A.

Vegetation cover and composition ([Method ID: 822](#)) was used to assess changes to habitat structure related to restoration actions. Vegetation cover and composition is an indicator of the production of organic matter and the detritus is the base of the food web for many species in the lower Columbia River and estuary (Borde et al. 2010, Maier and Simenstad 2009). Elevation ([Method ID: 818](#)) of vegetation plots were recorded to track the effectiveness of lowering marsh elevations (soil scrape) to control invasive vegetation and promote native plant species. At each restoration site two vegetation monitoring areas were established – one in an area directly impacted by restoration actions and one in an area indirectly impacted by restoration actions. Two vegetation sampling areas provide an overview of overall site condition pre- and post-restoration. Photo points were established ([Method ID: 820](#)) near the vegetation sampling area. Sediment Accretion ([Method ID 818](#)) was measured to determine if constructed wetlands are self-sustaining. Water Temperature ([Method ID 816](#)) was measured to determine habitat

suitability for juvenile salmonids. Water Surface Elevation ([Method ID 814](#)) was measured to determine opportunity for juvenile salmonid species to access the site and determine timing and level of wetland inundation.

To assess the capacity of a restoration site to provide prey resources for juvenile salmonids, terrestrial macroinvertebrate fallout traps were deployed once for a 48 hour period to sample insects that fall into the water from the aerial environment. Terrestrial macroinvertebrates were collected following methods outlined in “Terrestrial Invertebrates Standard Operating Procedures” (USGS and Nisqually Indian Tribe 2012). At each restoration and reference site terrestrial macroinvertebrates were collected, four macroinvertebrate fall out traps were installed in proximity to each vegetation sampling area to capture species assemblage of invertebrates and track changes in the terrestrial invertebrate community related to restoration actions.

Fish Monitoring

A PIT tag detection system was installed at the confluence of Horsetail and Oneonta Creeks to monitor fish passage through a culvert located under the I-84 highway. The system was idled in early December 2013, but was powered back up on February 12, 2014. The system consists of a Biomark FishTRACKER IS1001-MTS distributed Multiplexing Transceiver System (MTS). The MTS unit receives, records, and stores tag signals from 10 antennas, which measure approximately 6' by 6' and are mounted on the north and south sides of the 5-barrel culvert system running under the freeway. The system is powered by an 840 watt solar panel array and supported by 24-volt, 800 amp-hour battery bank backup. The unit is connected to a fiber optic wireless modem that allows for daily downloads of tag data and system voltage monitoring updates.

Analysis

An analysis of pre-restoration, post-restoration, and reference sites were conducted to determine if differences in site condition existed related to emergent marsh vegetation zones. The term site condition is used to distinguish pre-restoration, post-restoration, and reference sites. Emergent marsh vegetation zones (vegetation zones) are defined by distinct vegetation species composition and cover groups as determined by salinity and inundation patterns (Borde et al 2011). Segregating the river using vegetation zones is a more intuitive method to analyze vegetation at larger spatial scales rather than hydrogeomorphic reach. Vegetation data collected through the Ecosystem Monitoring Program was included for applicable years and vegetation zones. The inclusion of long term status data establishes a baseline which describes natural variation and puts into context changes related to restoration activities.

PC-ORD version 6.20 was used to conduct the analysis (McCune and Mefford 2011). Prior to analysis, vegetation data was summarized by calculating the average cover of identified species present in the survey area. Species with less than three occurrences in the dataset were removed. Deleting species that occur in less than 5% of the sample units reduces noise in the dataset without losing much information; furthermore, it often enhances the detection of relationships between community composition and environmental factors (McCune and Mefford 2002). One outlier site was detected in the initial percent cover data summary. The vegetation data was arcsine square root transformed to eliminate unequal variance and improve normality (Sokal and Rohlf 1995). No outliers were detected after the data transformation. The vegetation matrix was

constructed of 37 sample units (rows) and 94 vegetation species (columns) reported as percent cover (Table 3). The environmental matrix consisted of 37 sample units (rows) and 7 environmental characteristics - species richness, evenness, Shannon Diversity, river Km, vegetation zone, vegetation zone with site condition, year (columns).

Table 3. Sites and years included in analysis

	Pre-Restoration	Post-Restoration	Reference
Vegetation Zone 1			
Wallacut Slough - Mouth	2014		
Wallacut Slough - Upper	2014		
Ilwaco			2012, 2013, 2014
Kandoll Farm - A site	2013	2014	
Kandoll Farm - E site	2013	2014	
Secret River High			2013, 2014
Secret River Low			2013, 2014
Vegetation Zone 4			
North Unit Sauvie Island Phase 1 - North	2013	2014	
North Unit Sauvie Island Phase 1 - South	2013	2014	
North Unit Sauvie Island Phase 2 - Deep Widgeon North	2014		
North Unit Sauvie Island Phase 2 - Deep Widgeon South	2014		
North Unit Sauvie Island Phase 2 - Millionaire North	2014		
North Unit Sauvie Island Phase 2 - Millionaire South	2014		
Cunningham Lake			2013, 2014
Campbell Slough			2012, 2013, 2014
Vegetation Zone 5			
Sandy River - Dam Site	2006, 2007	2014	
Sandy River - Old Mouth Site	2007	2014	
Gary Island			2014
Franz Lake			2012, 2013, 2014

Non metric Multidimensional Scaling

Nonmetric multidimensional scaling (NMS) was used to examine the relationship between emergent vegetation communities and environmental characteristics. For NMS analyses, a random starting configuration was used with 250 runs performed with the real data. The number of dimensions assessed for the analysis was determined by a Monte Carlo randomization test (250 runs) to determine the number of significant axes with a low stress solution.

Indicator species analysis

Indicator species analysis was used to identify emergent wetland plant species that are unique to a site condition and vegetation zone (Dufrêne and Legendre 1997). The steps to determine indicator values (IV) are 1) calculate the proportional abundance of a particular species in a particular group relative to the abundance of that species in all groups 2) calculate the proportional frequency of species in each group 3) combine the two proportions calculated in the previous steps 4) the highest IV for a given species across groups is saved as a summary of the overall indicator value of that species 5) statistical significance of IV is evaluated by the Monte Carlo method. For this analysis, 4999 randomizations were used for the Monte Carlo test.

Similarity Index

A similarity index was constructed to examine the similarity between sites based on wetland emergent vegetation cover. The similarity index compared each vegetation sampling area in each emergent vegetation zone. The NMS represents a dissimilarity index between sites and years and was calculated using a Sorenson (Bray-Curtis) distance measure. The similarity index was calculated by subtracting 1.0 from the dissimilarity matrix.

Species Richness and Shannon Diversity Index

For site scale analysis species richness and Shannon diversity index (species diversity) were calculated for both vegetation and terrestrial macroinvertebrates. Species richness and species diversity were used to track inter-annual variability and changes related to restoration actions. Species Richness is the number of species represented in the sampled ecological community. Shannon diversity index (Equation 1, Shannon and Wiener 1949) represents abundance and evenness of species present in a sampled ecological community.

Equation 1. Shannon Diversity Index

$$H' = - \sum_{j=1}^s p_i \ln p_i$$

where H' = Shannon Diversity Index

p_i = importance probability in column

i= matrix elements relativized by row totals (see Greig-Smith 1983, p.163; based on Shannon and Wiener 1949).

Results

Vegetation

Non-metric multidimensional scaling

A NMS ordination with a three dimensional solution of plots in species space was used (Final stress= 11.62, final stability \leq .000001, number of iterations= 45). The three axis solution explained 84% of the variation in the data. The solution was rotated so river km (RKM),

vegetation zone (VZ), and vegetation zone with site condition (TVZ) were parallel with axis one and species richness (SR), species diversity (H), and evenness (E) were parallel with axis three (Figure 3 and Figure 4). Axis one shows vegetation at reference and restoration sites are strongly correlated with river Km ($r = .90$), vegetation zone ($r = .88$), and vegetation zone with site condition ($r = .74$) (Figure 3). Axis three shows a moderate correlation with species richness ($r = .57$), evenness ($r = .47$), and species diversity ($r = .62$) (Figure 4). When species richness, evenness, and species diversity is averaged across all sites by condition, reference sites exhibit higher values in the aforementioned measures than both pre- and post-restoration sites (Table 4).

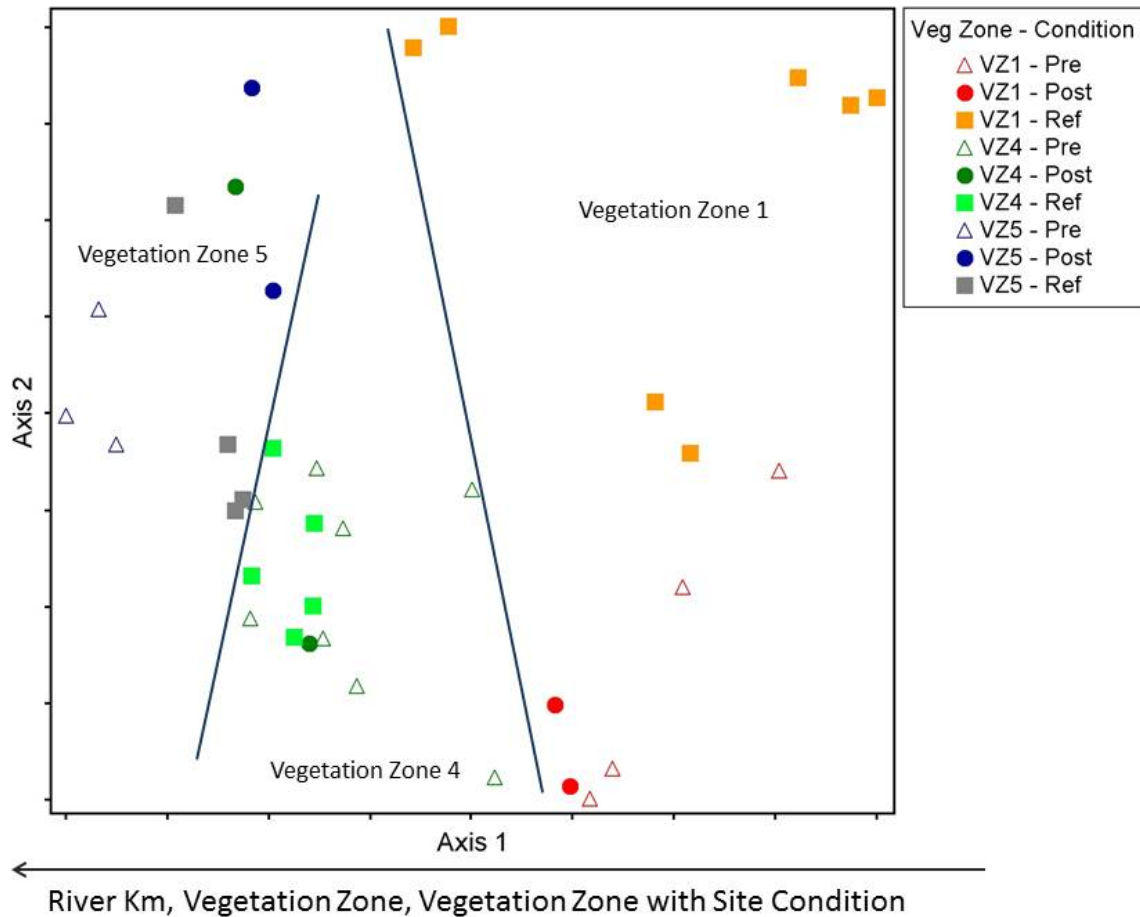


Figure 3. NMS ordination of sample units in species space. Axis 1 is correlated with river Km, vegetation zone, and vegetation zone with site condition. Different vegetation zones are demarcated.

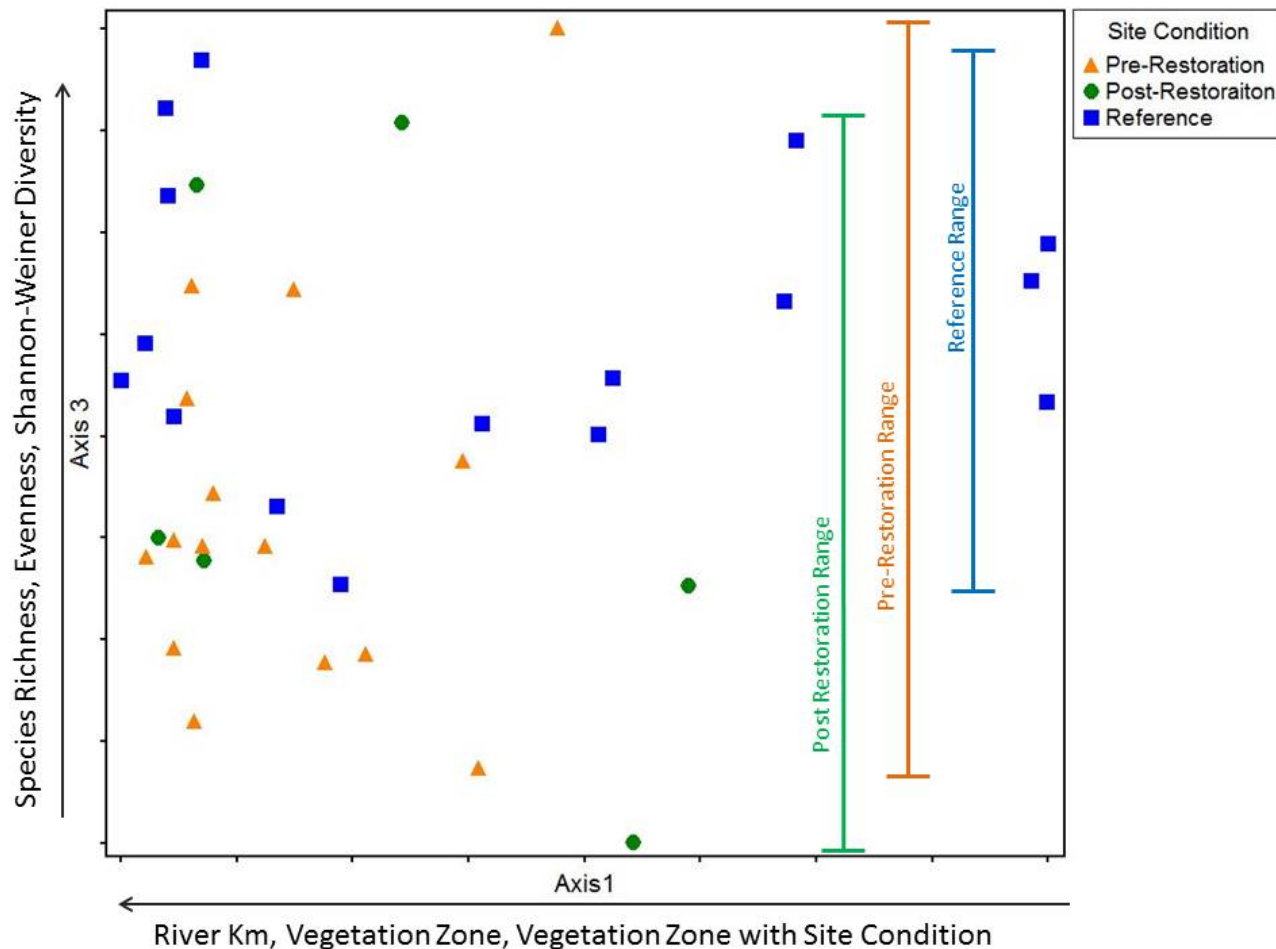


Figure 4. NMS ordination of sample units in species space. Axis 3 is correlated with species richness, evenness, and species diversity. Range of site conditions are demarcated with bars.

Table 4. Average species richness, evenness, and species diversity for all pre-restoration, post-restoration, and reference sites

Site Condition	Species Richness	Evenness	Species Diversity
Pre-Restoration	17.7	0.54	1.6
Post Restoration	22.3	0.58	1.7
Reference	23.1	0.62	1.9

Indicator species analysis

The indicator species analysis identified unique vegetation species associated with each of the three site conditions in vegetation zones one and five. No indicator species were identified in vegetation zone four.

At pre-restoration sites in vegetation zone one, two invasive species common and two native species were found to be indicator species (Table 5). The wetland status of the native indicator species were facultative wet and invasive species were facultative. Three invasive species and

four native species were identified as indicators at post-restoration sites in vegetation zone one (Table 5). The wetland status was predominately facultative wet. Ten native vegetation indicator species were identified at reference sites in vegetation zone one. The wetland status of the reference indicator species had more obligate species than either pre or post-restoration condition (Table 5).

Table 5. Significant indicator species for vegetation zone one from indicator species analysis

Species	Condition	Observed Indicator Value	Indicator value from randomized groups		p-value	Wetland Status**
			Mean	Std. Dev.		
Vegetation Zone 1						
Common velvetgrass*	Pre-Restoration	65.5	23.4	12.9	0.023	FAC
Soft Rush	Pre-Restoration	71.2	23.2	12.79	0.017	FACW
Birdsfoot trefoil*	Pre-Restoration	47.1	23.3	12.78	0.047	FAC
northern starwort	Pre-Restoration	44.4	12.2	12.23	0.033	FACW
Meadow foxtail*	Post - Restoration	66.3	24.2	13.15	0.017	FACW
Willow herb	Post - Restoration	48	21.1	10.66	0.036	FACW
Pacific bedstraw	Post - Restoration	47.6	20.7	10.78	0.042	FACW
jewelweed	Post - Restoration	78.1	22.8	12.03	0.012	FACW
Common forget-me-not*	Post-Restoration	52.9	24.1	13.85	0.032	FACW
Creeping buttercup*	Post - Restoration	60.6	24.7	12.56	0.027	FACW
Small-fruited bulrush	Post - Restoration	62.5	24.2	13.06	0.022	OBL
Nodding beggars-ticks	Reference	42.9	23	12	0.036	FACW
paint-brush owl-clover	Reference	42.9	22.5	11.65	0.034	FACW
Lyngby sedge	Reference	90.6	21.3	10.61	0.000	OBL
Tufted hairgrass	Reference	47.7	22.4	12.01	0.051	FACW
Western lilaeopsis	Reference	64	21.8	11.71	0.016	OBL
Yellow monkeyflower	Reference	42.9	23.1	12.11	0.038	OBL
American bulrush	Reference	42.9	22.6	11.9	0.039	OBL
Seacoast bulrush	Reference	42.9	22.8	12.14	0.043	OBL
Douglas aster	Reference	97.2	21.3	11.12	0.000	FACW
horned pondweed	Reference	57.1	23	12.31	0.021	OBL

*Invasive Vegetation Species

** OBL-Obligate, FACW-Facultative Wetland, FAC-Facultative, FACU-Facultative Upland

At pre-restoration sites in vegetation zone five, ten vegetation species were identified as indicators of pre-restoration condition. Of those ten identified species, five indicator species were invasive and five species were native. The wetland status of the identified species ranged from obligate to facultative upland (Table 6). Only one vegetation species was identified as indicator species at post-restoration sites in vegetation zone five. At reference sites in vegetation zone five two native wetland obligate vegetation species were identified as indicator species (Table 6).

Table 6. Significant indicator species for vegetation zone five from indicator species analysis

Species	Condition	Observed Indicator Value	Indicator value from randomized groups		p-value	Wetland Status
			Mean	Std. Dev.		
Vegetation Zone 5						
American sloughgrass	Pre-Restoration	92.5	22.6	12.53	<0.001	OBL
Coontail	Pre-Restoration	44.9	21.4	10.8	0.060	OBL
Hedge false bindweed*	Pre-Restoration	43.7	22.8	12.17	0.044	FAC
crabgrass*	Pre-Restoration	42.9	23.5	12.88	0.042	FACU
Small forget-me-not	Pre-Restoration	60	24.2	12.97	0.024	OBL
Curly leaf pondweed*	Pre-Restoration	48.3	21.7	10.5	0.029	OBL
swamp smartweed	Pre-Restoration	52.3	24.4	10.76	0.022	OBL
Spotted ladythumb*	Pre-Restoration	53.8	23.4	12.76	0.027	FACW
Himalayan blackberry*	Pre-Restoration	42	22	11.84	0.056	FACU
Willow	Pre-Restoration	82.4	24	12.64	0.002	OBL-FACU
Black cottonwood	Post -Restoration	45	21.3	11.11	0.049	FAC
Standing Dead	Post- Restoration	40.2	20.2	9.72	0.036	
Small mixed greens	Post- Restoration	72.2	22.4	12.51	0.014	
Rice cutgrass	Reference	49.8	21.5	9.99	0.012	OBL
water smartweed	Reference	74.3	23.8	12.4	0.015	OBL

*Invasive Vegetation Species

**OBL-Obligate, FACW-Facultative Wetland, FAC-Facultative, FACU-Facultative Upland

Similarity Index and Species Diversity

Vegetation Zone One

Only eight sites (n=78) had a vegetation composition similarity greater than 50% in vegetation zone one when all years were included. At the Ilwaco (ILWA) reference site, there was a 70% similarity or greater between the 2012, 2013, and 2014 sampling years. The similarity of sites at Secret River in 2013 and 2014 (SRL and SRH) was also above 70%. Pre-restoration, the Wallacut slough site (WAUP and WAMO) had a 50% similarity between the two vegetation sampling areas and had less than a 22% similarity with the Ilwaco reference site (Table 7, Figure 5).

The Kandoll Farm restoration site consisted of two sampling areas. At Kandoll Farm Site A (KFA), there was a 69% similarity between pre- and post-condition, while the Site E (KFE) there was an 87% similarity in plant community composition between pre- and post-condition (Table 7, Figure 5). In 2014, the Kandoll Farm post-restoration sites were found to have less than a 30% similarity to the Secret River reference site (Table 7, Figure 5).

Table 7. Similarity index for restoration and reference sites in vegetation zone one. Yellow highlights represent 60-69% similarity and green highlights represent >70% similarity

Site	WAMO 14	ILWA 14	KFA 14	KFE 14	SRL 14	SRH 14	KFE 13	KFA 13	SRL 13	SRH 13	IIWA 12	IIWA 13
WAUP14	0.50	0.15	0.29	0.17	0.10	0.24	0.18	0.28	0.09	0.20	0.16	0.18
WAMO14		0.22	0.27	0.42	0.10	0.43	0.42	0.28	0.06	0.38	0.21	0.22
ILWA14			0.02	0.02	0.30	0.36	0.00	0.00	0.19	0.32	0.77	0.74
KFA14				0.41	0.11	0.22	0.44	0.69	0.11	0.20	0.05	0.05
KFE14					0.03	0.30	0.87	0.41	0.03	0.32	0.01	0.01
SRL14						0.22	0.00	0.05	0.70	0.16	0.21	0.21
SRH14							0.27	0.24	0.20	0.79	0.35	0.38
KFE13								0.46	0.01	0.31	0.00	0.00
KFA13									0.05	0.25	0.00	0.01
SRL13										0.19	0.16	0.18
SRH13											0.30	0.32
IIWA12												0.77

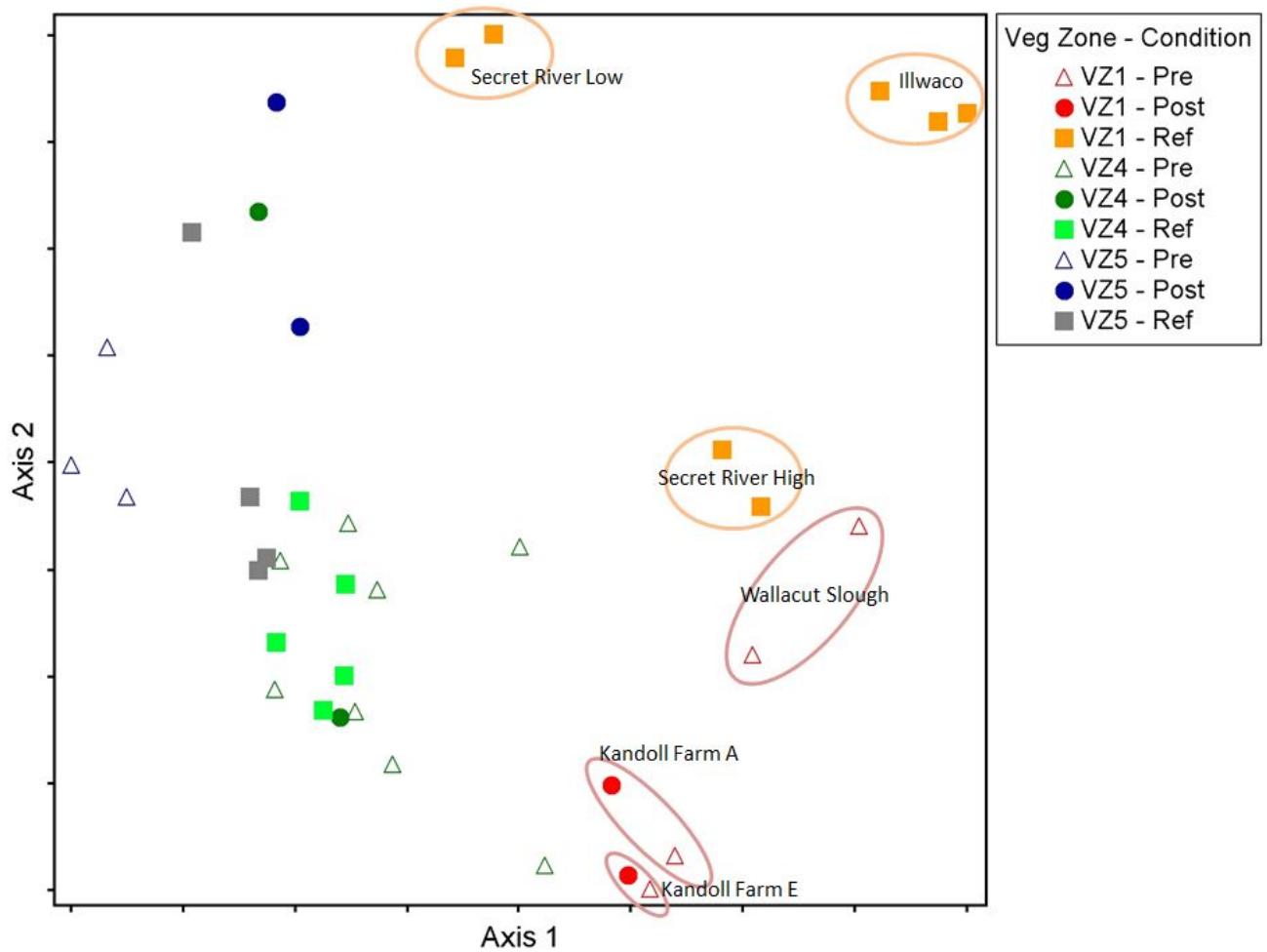


Figure 5. NMS ordination illustrates similarity within and between sites. Open triangles represent pre-restoration condition, circles represent post-restoration condition, and squares represent reference condition.

Species richness was higher post-restoration at Kandoll Farm Site A and Site E than pre-restoration condition (Table 8). Species diversity increased at Site A, but remained unchanged at Site E post-restoration. Site A had a decrease in percent cover of invasive reed canarygrass and creeping buttercup and an increase in bare ground and detritus post-restoration (Figure 6). There was a slight increase in species diversity at Site A post-restoration. There was an increase in detritus post-restoration, but no change in reed canarygrass cover at Site E post-restoration (Table 8, Figure 6).

Table 8. Species richness and species diversity pre- and post-condition at Kandoll Farm

	Species Richness	Species Diversity
Kandoll Farm Site A 2013	29	2.49
Kandoll Farm Site A 2014	35	2.725
Kandoll Farm Site E 2013	16	1.101
Kandoll Farm Site E 2014	21	0.808
Secret River High 2013 (Reference)	29	1.868
Secret River High 2014 (Reference)	33	2.04

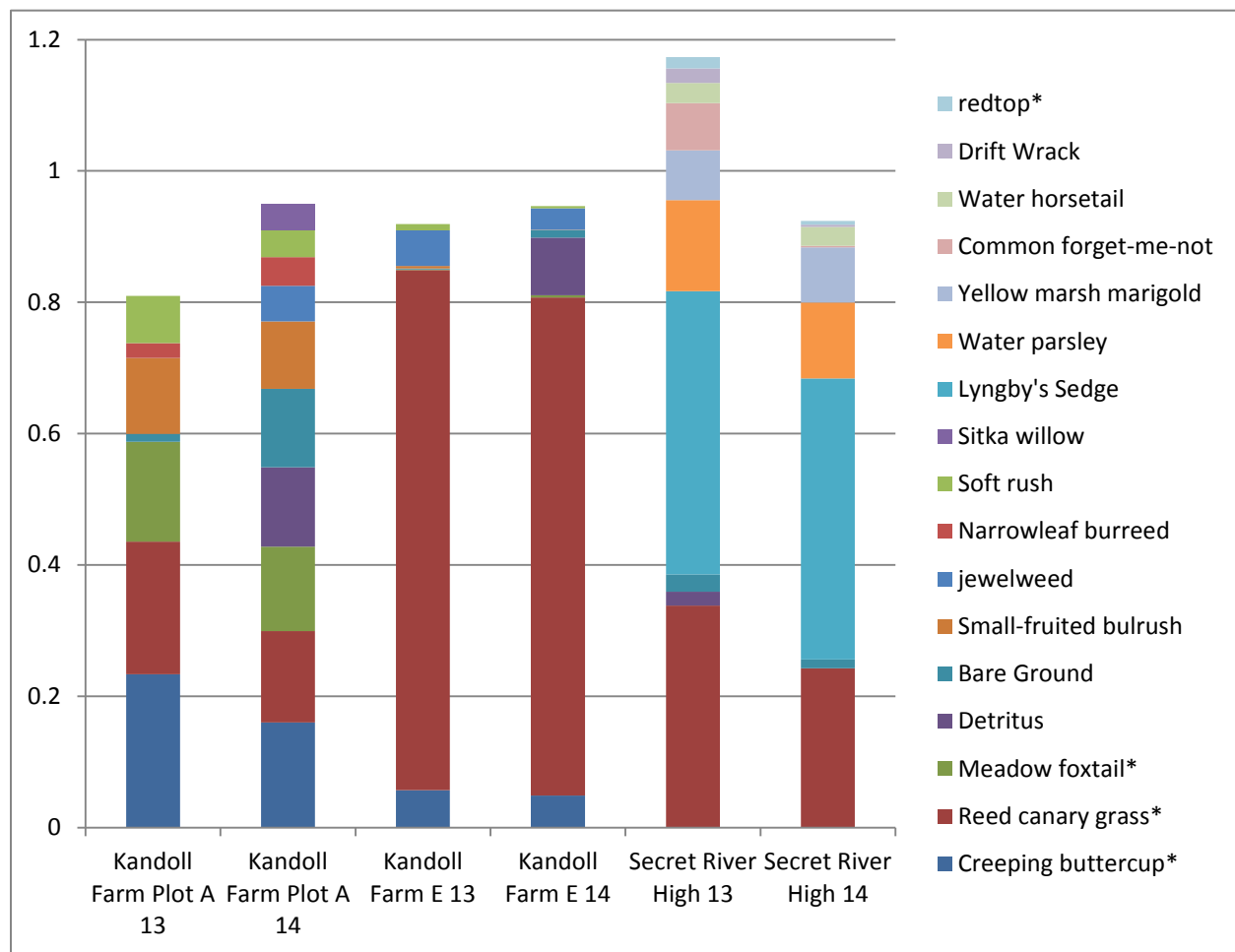


Figure 6. Vegetation cover and composition for Kandoll Farm pre-restoration, post-restoration, and reference

Vegetation Zone Four

When all years were examined in vegetation zone four, 38 sites (n=105) were found to have a similarity of greater than 50%. Cunningham Lake (CL) reference site had a 61% similarity between 2013 and 2014. At the Campbell Slough (CS) reference site a similarity between 67%

and 69% for years 2012 to 2014. The similarity between Cunningham Lake and Campbell Slough reference sites for 2013 and 2014 ranged from 41% to 53% (Table 9).

The North Unit Phase 1 (NUP1) site consisted of two vegetation sampling areas. The vegetation similarity at the north sampling site (NUP1N) between pre- and post-condition was 4% (Table 9, Figure 7) at the soil scrape down area. The vegetation similarity in south sampling area at North Unit Phase 1 (NUP1S) where no direct action restoration actions occurred was 86% (Table 9, Figure 7, Figure 8). Post-restoration, the similarity of North Unit Phase 1 site to the Cunningham Lake reference site ranged from 33% at the north sampling area to 46% at the south sampling area for vegetation composition (Table 9).

The North Unit Phase 2 site consisted of four vegetation sampling areas because Cunningham Slough bisects the restoration area. The four vegetation areas were divided into two sites, Millionaire Lake (NUP2M) and Deep Widgeon (NUP2D). Millionaire Lake, in pre-restoration condition, had a vegetation similarity of 54% between the north and south sampling areas and had a similarity range of 61% (NUP2MN) to 67% (NUP2MS) compared to the Cunningham Lake reference site (Table 9). Pre-restoration Deep Widgeon had a within site similarity of 46% and a similarity range of 36% (NUP2DN) to 56% (NUP2DS) compared to the Cunningham Lake reference site (Table 9).

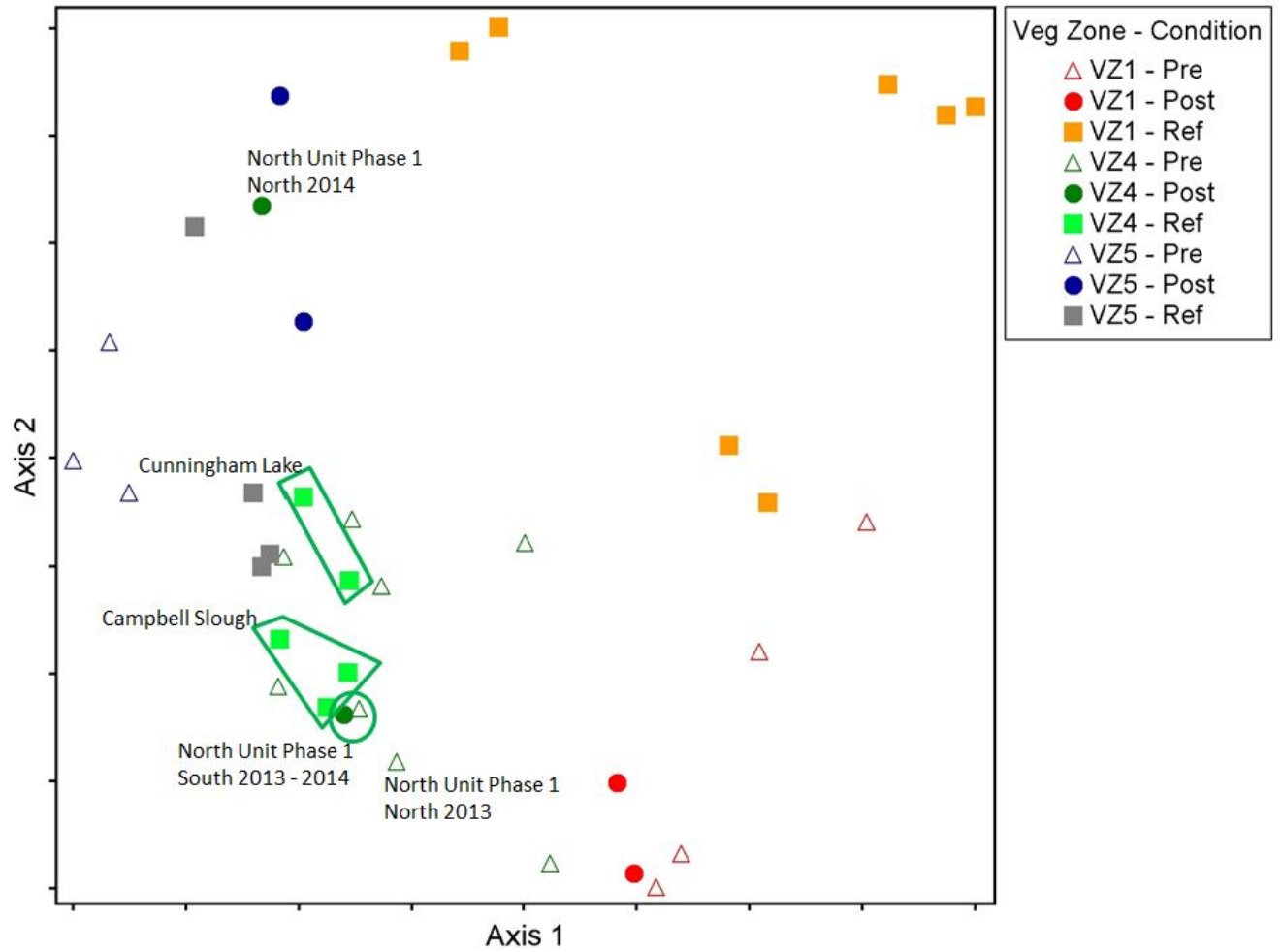


Figure 7. NMS ordination illustrates similarity within and between sites. Open triangles represent pre-restoration condition, circles represent post-restoration condition, and squares represent reference condition.

Table 9. Similarity index for restoration and reference sites in vegetation zone four. Yellow highlights represent 60-69% similarity and green highlights represent >70% similarity

Site	CL14	CS12	CS13	CS14	NUP1 N13	NUP1N 14	NUP1S 13	NUP1S 14	NUP2DN 14	NUP2D S13	NUP2D S14	NUP2MN 14	NUP2MS 13	NUP2MS14
CL13	0.61	0.53	0.52	0.48	0.33	0.20	0.66	0.65	0.45	0.50	0.59	0.56	0.59	0.60
CL14		0.37	0.43	0.41	0.25	0.33	0.47	0.46	0.36	0.41	0.56	0.61	0.40	0.67
CS-12			0.68	0.67	0.21	0.07	0.49	0.49	0.24	0.34	0.37	0.32	0.46	0.49
CS-13				0.69	0.28	0.09	0.55	0.55	0.23	0.46	0.46	0.43	0.51	0.50
CS-14					0.25	0.09	0.48	0.49	0.22	0.35	0.38	0.35	0.40	0.51
NUP1N13						0.04	0.45	0.38	0.35	0.59	0.38	0.32	0.29	0.24
NUP1N14							0.09	0.09	0.25	0.12	0.36	0.29	0.09	0.25
NUP1S13								0.86	0.30	0.65	0.52	0.43	0.60	0.58
NUP1S14									0.29	0.59	0.50	0.42	0.55	0.62
NUP2DN14										0.31	0.46	0.38	0.25	0.31
NUP2DS13											0.64	0.45	0.55	0.49
NUP2DS14												0.63	0.53	0.50
NUP2MN14													0.43	0.54
NUP2MS13														0.53

CL = Cunningham Lake

NUP2DN = Sauvie Island North Unit Phase 2 Deep Widgeon North

NUP2DS = Sauvie Island North Unit Phase 2 Deep Widgeon South

NUP2MN = Sauvie Island North Unit Phase 2 Millionaire North

NUP2MS = Sauvie Island North Unit Phase 2 Millionaire South

NUP1N = Sauvie Island North Unit Phase 1 North

NUP1S = Sauvie Island North Unit Phase 1 South

CS = Campbell Slough

At North Unit Phase 1 North species richness increased from two species pre-restoration to 25 species post-restoration as a result of soil scrape down actions (Table 10, Figure 8). Species diversity at North Unit Phase 1 North also increased as a result of the increase in species at the site which shifted from a reed canarygrass dominated site to a site characterized by bare ground. At North Unit Phase 1 South there was a slight increase in species richness and species diversity. This site was not directly impacted by restoration actions; the change in hydrology related to the removal of the water control structure may impact this site in the future (Table 10, Figure 8).

Table 10. Species richness and species diversity at Sauvie Island North Unit Phase 1 pre-, post-restoration, and reference sites

	Species Richness	Species Diversity
North Unit Phase 1 North 2013	1	0
North Unit Phase 1 North 2014	17	1.597
North Unit Phase 1 South 2013	9	1.19
North Unit Phase 1 South 2014	19	1.931
Cunningham Lake 2013 (Reference)	11	1.42
Cunningham Lake 2014 (Reference)	16	2.003

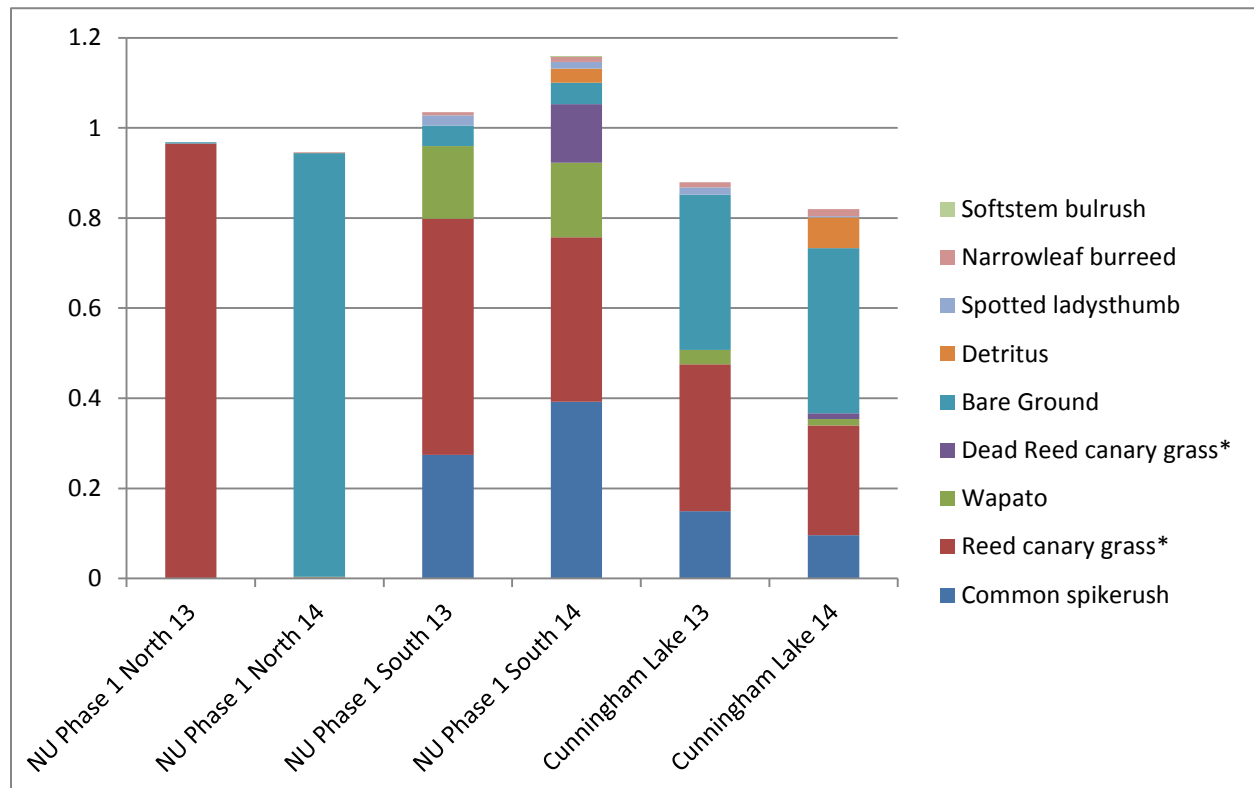


Figure 8. Vegetation cover and composition pre- and post-restoration at Sauvie Island North Unit Phase 1

Vegetation Zone Five

When all years in vegetation zone five were examined, 5 sites (n=36) had a vegetation similarity greater than 50%. The Franz Lake reference site had a vegetation similarity range from 62% to 69% for sampling years 2012, 2013, and 2014 (Table 11, Figure 9). The vegetation similarity between the Gary Island (GI) control site and Franz Lake (FL) reference sites ranged between 23% and 32%.

The Sandy River Delta site consisted of two vegetation sampling areas, the dam removal site (SRDD) and the old Sandy River dam mouth (SRDM). In 2014, post-restoration, the vegetation similarity between the vegetation sampling areas in the Sandy River Dam site was 36% (Table 11). The old Sandy River dam mouth had a 42% vegetation similarity to the Gary Island control site, while the dam removal site had a 26% similarity to Gary Island (Table 11). In 2006 and 2007, pre-restoration, the Sandy River dam removal site between years had a 47% vegetation similarity; post-restoration the vegetation similarity to 2007 was 26% (Table 11). At the old Sandy River dam mouth the similarity between pre-restoration vegetation in 2007 and post-restoration in 2014 was 24%. The Franz Lake reference had a high similarity range of 62% to 69% between years, but had a low vegetation similarity to Sandy River dam mouth and dam site (Table 11, Figure 9).

Table 11. Similarity index for restoration and reference sites in vegetation zone four. Yellow highlights represent 60-69% similarity and green highlights represent >70% similarity

	FL13	FL14	GI14	SRDD06	SRDD07	SRDD14	SRDM07	SRDM14
FL12	0.69	0.62	0.32	0.25	0.24	0.31	0.34	0.15
FL13		0.66	0.23	0.30	0.27	0.36	0.34	0.13
FL14			0.23	0.20	0.27	0.24	0.30	0.15
GI14				0.31	0.26	0.26	0.34	0.42
SRDD06					0.51	0.23	0.47	0.19
SRDD07						0.26	0.51	0.16
SRDD14							0.36	0.36
SRDM07								0.24

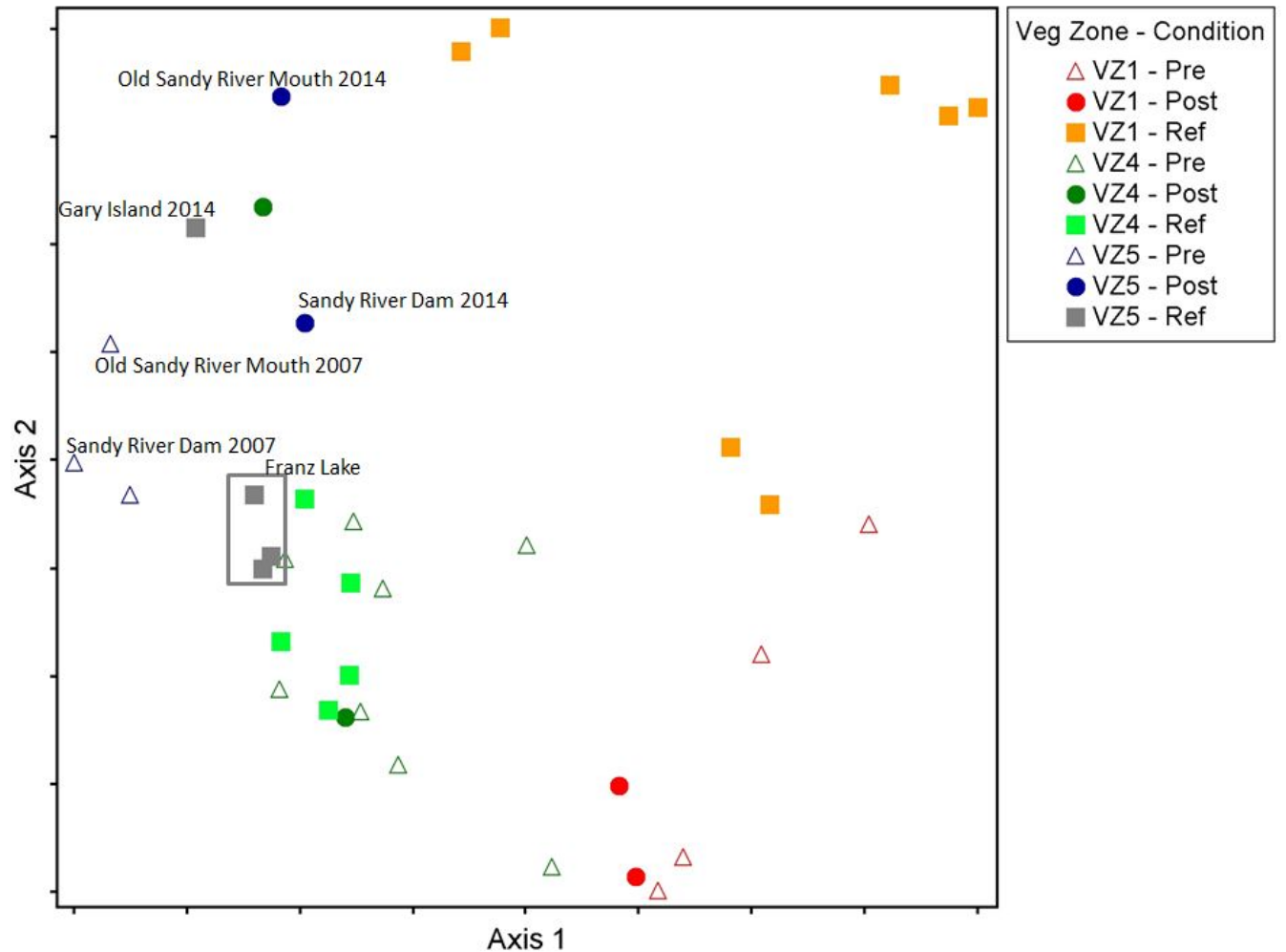


Figure 9. NMS ordination illustrates similarity within and between sites. Open triangles represent pre-restoration condition, circles represent post-restoration condition, and squares represent reference condition.

Terrestrial Macroinvertebrates

Kandoll Farm Phase 2 and Sauvie Island North Unit Phase 1 were monitored for terrestrial macroinvertebrates pre-restoration in 2013 and post-restoration in 2014. Sauvie Island North Unit Phase 2 and Wallacut Slough pre-restoration sites were monitored for terrestrial macroinvertebrates in 2014 (Figure 2). Also in 2014, terrestrial macroinvertebrates were collected at Wallacut Slough reference site; however, due to logistical issues, terrestrial macroinvertebrates were not collected at Kandoll Farm Phase 2 reference or Sauvie Island North Unit Phase 1 & 2 reference sites.

Species diversity at Kandoll Farm was lower post-restoration than pre-restoration and reference conditions (Table 12). The lower species diversity was a result of an increase in frequency of Dipterans macroinvertebrates species observed at the site. In 2014 Dipterans accounted for 89% of species sampled while in 2013 Dipterans, accounted for 66% of species sampled. At the Kandoll Farm reference site in 2013, Dipterans accounted for 23% of species sampled (Figure 10).

Table 12. Terrestrial macroinvertebrate species richness and species diversity at Kandoll Farm pre- and post-restoration

Site	Species Richness	Species Diversity
Kandoll Farm Phase 2 Pre-restoration 2013	20	2.153
Kandoll Farm Phase 2 Reference 2013	16	2.307
Kandoll Farm Phase 2 Post-restoration 2014	27	1.398

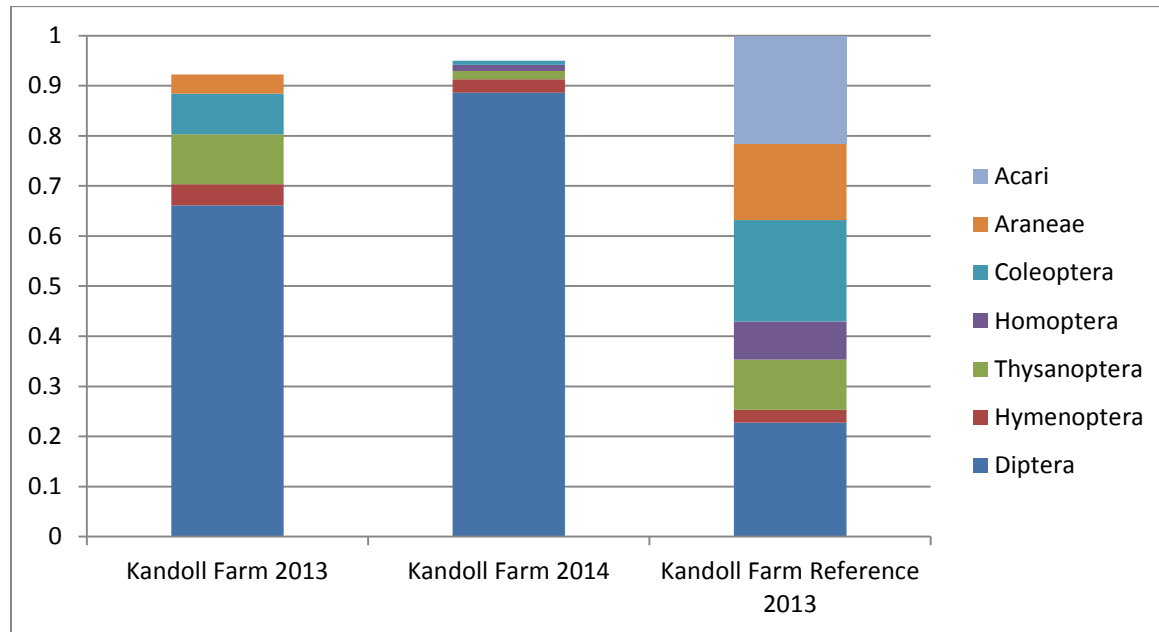


Figure 10. Percent composition of terrestrial macroinvertebrates at Kandoll Farm

Sauvie Island North Unit Phase 1 showed a decrease in species diversity following restoration activities compared to pre-restoration and reference conditions (Table 13). In 2014 Dipterans accounted for a large portion of species sampled at 61%. In 2013, Dipterans were less prevalent at Sauvie Island North Unit Phase 1 pre-restoration and reference sites and accounted for 15% and 25% of total species sampled respectively. At Sauvie Island North Unit Phase 2 Deep Widgeon and Millionaire, Dipterans were the prevalent order at 55% and 56% of total species sampled (Table 13, Figure 11).

Table 13. Terrestrial macroinvertebrate species richness and species diversity at Sauvie Island North Unit Phase 1 pre- and post-restoration

Site	Species Richness	Species Diversity
Sauvie Island North Unit Phase 1 Pre-restoration 2013	32	2.701
Sauvie Island North Unit Reference 2013	24	2.682
Sauvie Island North Unit Phase 1 Post-restoration 2014	31	2.046
Sauvie Island North Unit Phase 2 Pre-restoration Millionaire 2014	24	2.542
Sauvie Island North Unit Phase 2 Pre-restoration Deep Widgeon 2014	28	2.333

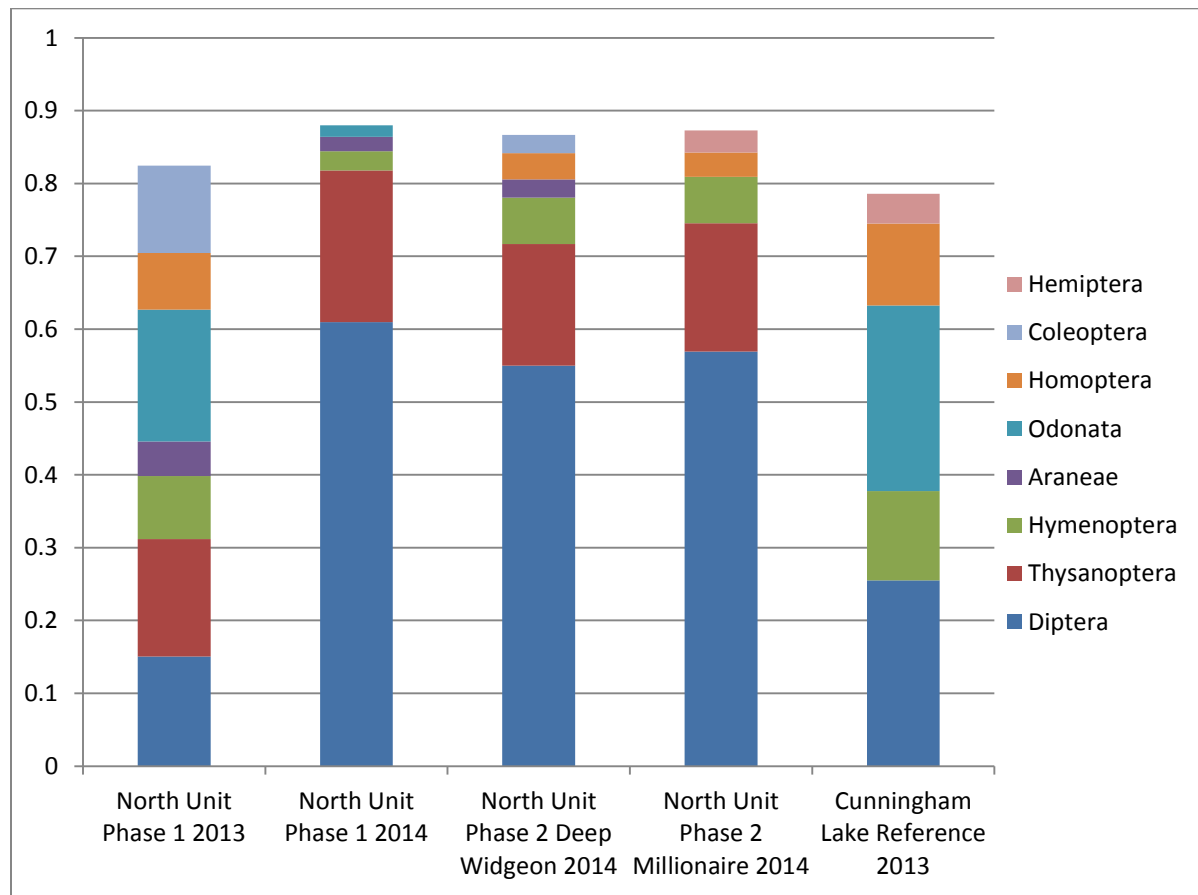


Figure 11. Percent composition of terrestrial macroinvertebrates at Sauvie Island North Unit Phase 1 and 2

At the pre-restoration Wallacut Slough and the reference site (Ilwaco), Dipterans comprised similar amounts of the total sample at 42% and 45% respectively (Figure 12). In addition to Diptera, Homoptera accounted for 45% of species collected in the Ilwaco sample. Homoptera was present in only 5% of the Wallacut Slough sample. The high representation of Homoptera

and Diptera in the Ilwaco sample resulted in Ilwaco having lower species diversity than Wallacut pre-restoration site (Table 14).

Table 14. Terrestrial macroinvertebrate species richness and species diversity at Wallacut Slough pre-restoration and reference site.

Site	Species Richness	Species Diversity
Wallacut Slough Pre-restoration 2014	37	2.832
Wallacut Slough Reference 2014	24	1.856

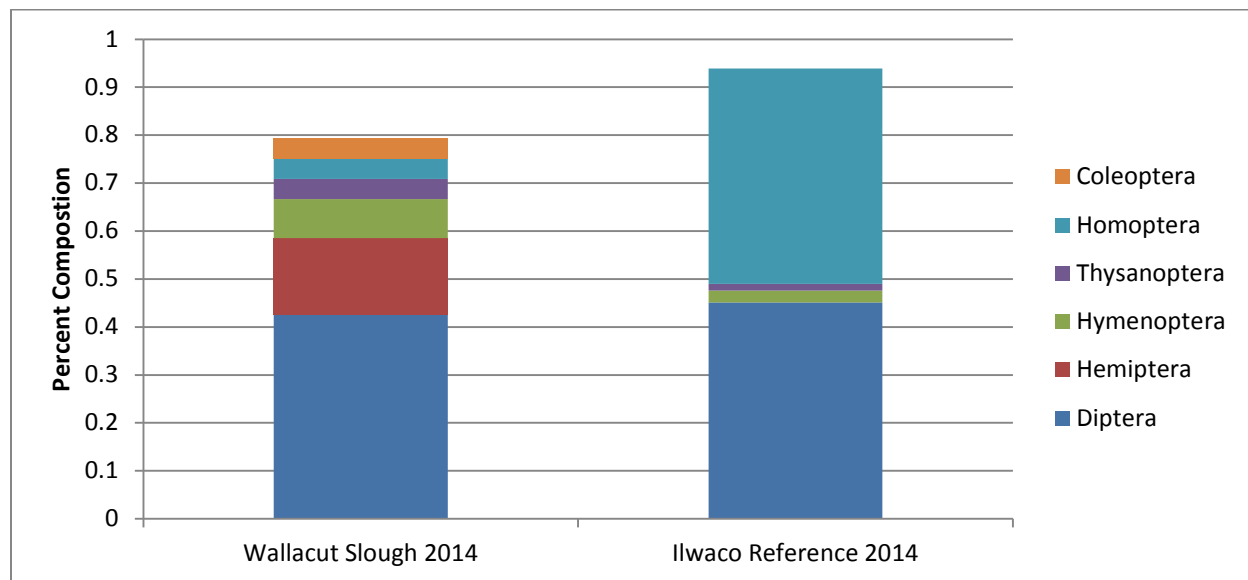


Figure 12. Terrestrial macroinvertebrate Frequency of occurrence at Wallacut Slough and Reference

Water Temperature

The seven-day moving average of the daily maximum water temperature (7DMAM) was calculated for the Sauvie Island North Unit Phase 1 from March 15th to July 30th. The Washington Department of Ecology (WADOE) 7DMAM temperature threshold of 17.5 °C for salmonid rearing and migration was used to evaluate habitat suitability pre- and post-restoration.

In 2013, the 7DMAM at Sauvie Island North Unit Phase 1 pre-restoration exceeded the WADOE threshold for short period from late March to early April. The same trend was observed outside the site at the control measurement location in the Columbia River (Table 15). In late April both the restoration site and control site exceeded 17.5 °C threshold and remained above the threshold through the end of the analysis period at the end of July (Table 15).

In 2014, post-restoration, Sauvie Island North Unit Phase 1 7DMAM exceeded the WADOE threshold in early May for a brief period (Table 15). Outside the restoration site, a similar pattern was observed, but for a slightly longer duration from late April and early May. Mid-May the 7DMAM post-restoration exceeded and remained above WADOE threshold for the remainder of

the study period. A similar trend was overserved at the control site in the Columbia River. The nearby Campbell Slough reference site observed a sustained 7DMAM greater than the WADOE threshold from Mid-May to the end of study Period (Hanson et al. 2015).

Table 15. Dates during the 2013 and 2014 March through July study period when the 7 day moving average maximum water temperature exceeded the Washington Department of Ecology threshold of 17.5° C

Site	Condition	Year	Dates Exceeding Threshold
Sauvie Island North Unit Phase 1	Pre-restoration	2013	March 28 - April 2 April 26 - July 30
Sauvie Island North Unit Phase 1	Control	2013	March 27 - April 2 April 26 - July 30
Sauvie Island North Unit Phase 1	Post-Restoration	2014	May 2 - 4 May 13 - July 30
Sauvie Island North Unit Phase 1	Control	2014	April 30 - May 5 May 13 - July 30
Campbell Sough	Reference	2014	May 5-6, 16-29 June 1- July 30

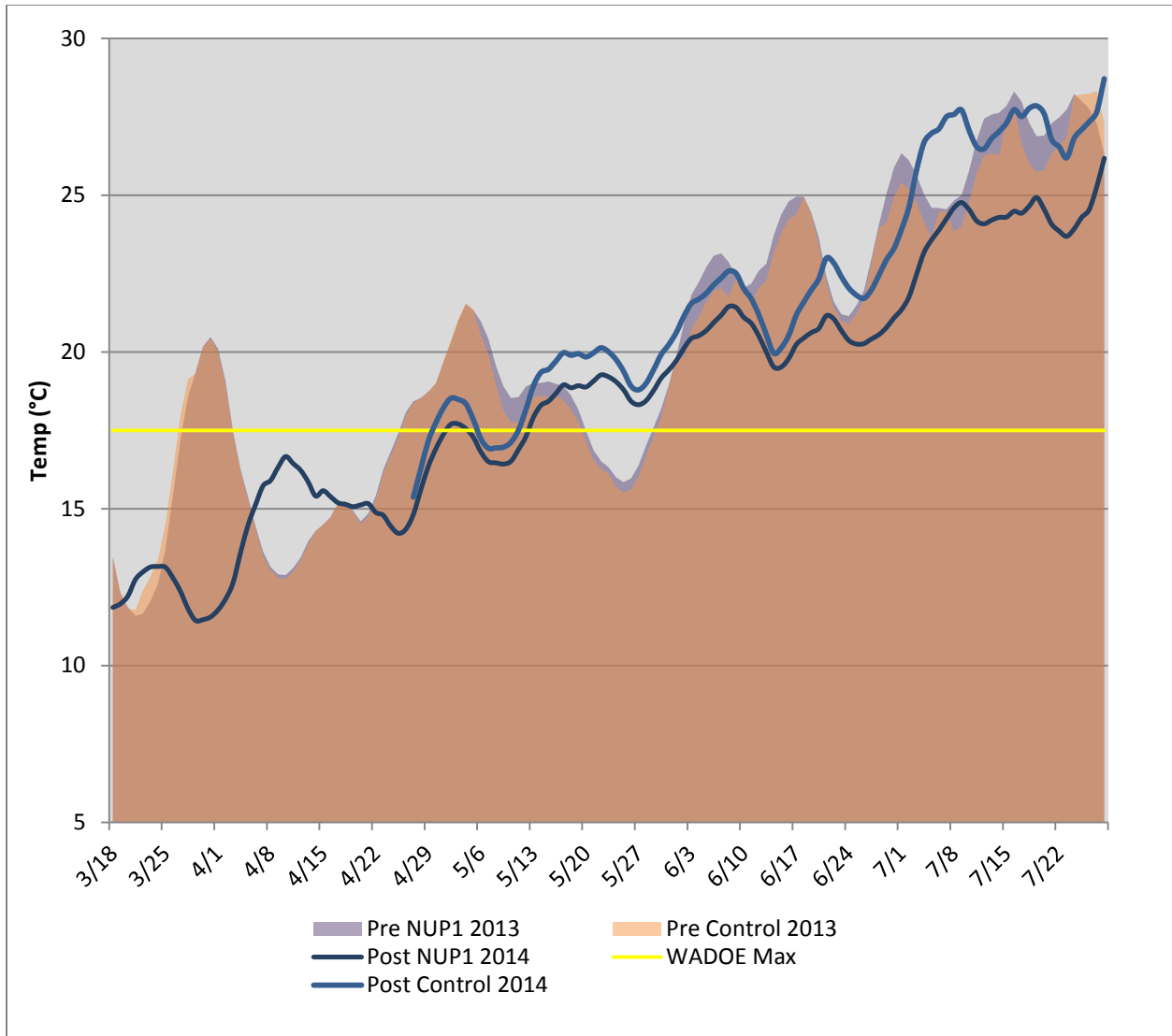


Figure 13. Pre- and post-restoration 7 day moving average maximum water temperature data for Sauvie Island North Unit Phase 1 and Control Site. Yellow line represents Washington Department of Ecology temperature threshold for rearing salmonids.

At Horsetail Creek, surface water temperatures were monitored from mid-July through mid-September at a network of fixed stations located throughout the site during 2010 and 2014. The study period coincides with specific restoration project goals related to lowering site temperature during summer months. During both study periods, the lowest mean 7DMAM temperatures (13.6°C in 2010; 15.5°C in 2014) occurred at the reference station at the upstream end of Horsetail Creek (Figure 14). The lowest mean 7DMAM temperatures at our other reference monitoring station (the upstream end of Oneonta Creek) were 15.7°C and 17.4°C. Temperatures at these reference stations were not affected by project activities and upstream watershed conditions are relatively undisturbed, so the increase observed between years at each station is hypothesized to be the result of differing climatic conditions immediately before and during the monitoring period.

Stream flow and ambient air temperature are the two climatic variables that affect stream temperature. To track regional climate conditions affecting stream temperature at the restoration site, historic, 2010, and 2014 air temperature and precipitation data for July through August at the two weather stations located closest to Horsetail Creek were compared. When ambient air temperature from both weather stations were averaged together, 2014 was 1.8°C or 7% warmer than the historic record and 3.2°C warmer than 2010. When precipitation for both weather stations were averaged together, 2014 was 2.2 inches below or 51% less than historic precipitation levels and 2.5 inches below less than observed precipitation in 2010. In summary, the 2010 monitoring period was wetter and cooler than average, while the 2014 monitoring period was drier and warmer than average.

The highest mean 7DMAM temperatures were observed at the downstream end of Horsetail Creek (the Horsetail/Oneonta Confluence) during both 2010 and 2014 (16.3°C and 18.3°C respectively, Figure 14). As noted above, the difference in temperatures at the downstream monitoring location likely is due in part to climatic variations; however, it's informative to assess loading through the site to see how restoration may have affected Horsetail Creek's thermal regime. In 2010 the mean 7DMAM temperature in Horsetail Creek increased by 2.7°C, compared to a 2.8°C degree increase between the same stations in 2014. Additionally, thermal loading through the gravel pond area decreased from 5.5°C in 2010 to approximately 2°C in 2014, while discharge from the gravel pond to Horsetail Creek appeared to remain constant during these two years.

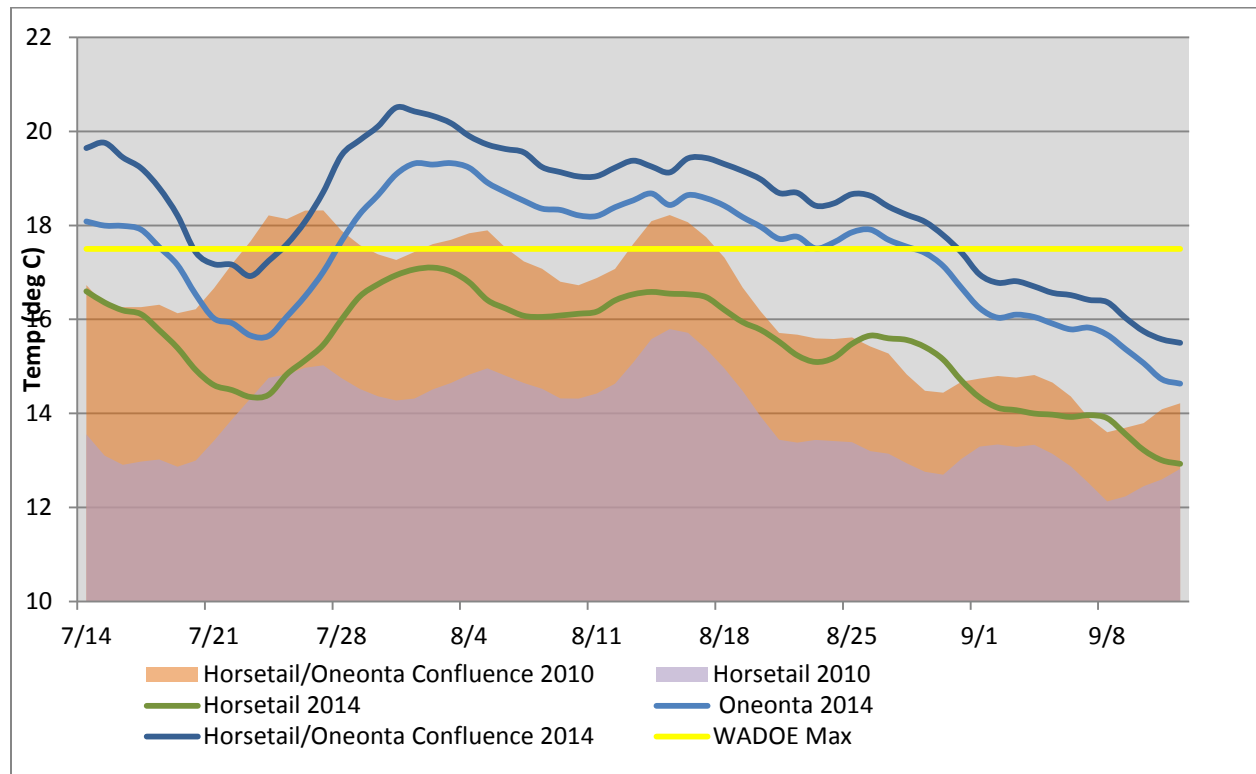


Figure 14. 7-day moving average maximum temperatures for study period pre-restoration year 2010 and post-restoration year 2014

Fish Detection and Passage

Operational problems resulted in lengthy periods with no data collection in 2014. A faulty antenna control node and detached antenna on the Columbia River side resulted in no detections for most of the juvenile salmonid spring downstream migration. The only detections registered during this time were from fish that successfully navigated through the culvert. Vandalism to the solar array resulted in the entire system being shut off from mid-June to mid-July.

There were 36 unique tags detected in 2014. Using the PTAGIS database we were able to determine species and site origination for all but seven tags (Table 16). A white sturgeon was the fish detected in 2014 and was only recorded on the Columbia River side of the culvert. Four fish, all juvenile steelhead (*Oncorhynchus mykiss*), were detected at the site in May and June. The steelhead passed through the culvert and were detected by the functioning antennas on the Horsetail Creek side of the culvert. Most of the juvenile steelhead were at the site for one to two days, while one individual steelhead was detected multiple times over an 11-day period. These fish represented both hatchery and wild stocks of summer and winter steelhead runs. The four juvenile steelhead detected at the site in the spring and early summer represent a marked drop-off in detections compared to 2013. This is most likely a result of the Columbia River side antennas not operating for most of the spring period.

Between late July and mid-August there were 11 unique detections. Compared to 2013, this represents an increase in the number of mid-summer detections at the site. Five fish detections represented hatchery spring and summer Chinook (*Oncorhynchus tshawytscha*), hatchery and wild summer steelhead, and hatchery coho (*Oncorhynchus kisutch*) (Table 16). The remaining six fish did not show up in the PTAGIS data base. The hatchery Chinook salmon originated the South Fork of the Salmon River in Idaho and the Little White Salmon Hatchery in Stevenson, WA (above Bonneville Dam). Identified steelhead came from the Hood River watershed, Lyons Ferry Hatchery on the Snake River, and the Grande Ronde River in eastern Oregon. The hatchery steelhead from Lyons Ferry was again detected in November and possibly spent the summer/fall within the Horsetail/Oneonta watershed. The Coho salmon originated from a hatchery in the Wenatchee River basin.

There were no detections for the entire month of September. Fish were detected again from October through early December. The detected fish were predominantly adult Coho salmon, however there was one adult steelhead that had been captured and tagged in the lower river as part of an upstream migration study. Three juvenile salmon, a hatchery summer Chinook from the Wenatchee basin and two juvenile hatchery Coho salmon, were also detected in the fall. The Coho originated from the Kooskia National Fish Hatchery in Idaho and the Yakima basin and both had been tagged/released in early 2013.

Table 16. Fish detected in 2014 at Horsetail Falls PIT-tag array

<i>Species</i>	<i># fish detected</i>	<i>Months Present</i>	<i>Length (mm)</i>	<i>residency (days)</i>	
				<i>range</i>	<i>mean</i>
Juvenile hatchery spring chinook	1	July	138	1	
Juvenile hatchery summer chinook	2	Aug, Nov	76, 121	1 - 16	8.5
Juvenile hatchery coho	3	Aug, Oct, Nov	97 - 112	1 - 5	2.3
Juvenile hatchery steelhead	3	May, July	n/a	1 - 116	42.7
Juvenile wild steelhead	3	May, June, Aug	94 - 188	1 - 2	1.7
Adult coho	15	Oct, Nov	570 - 890	1 - 18	7
Adult steelhead	1	Oct	n/a	1	
White sturgeon	1	Mar	780	1	

Discussion/Conclusion

Emergent vegetation zones for the analysis of pre-restoration, post-restoration, and reference vegetation composition offer a viable method to assess site condition related to habitat in the lower Columbia River and estuary. A strong correlation between vegetation composition, river kilometer and vegetation zone was found based on collected vegetation data. Therefore, grouping sites by emergent vegetation zone for analysis allows for the assessment of vegetation similarities between pre-restoration, post-restoration, and reference sites within each zone. Reference sites were associated with higher species diversity, species richness, and species evenness on average than either pre- or post-restoration sites. This indicates that undisturbed reference sites have a greater variety of vegetation species. Pre-restoration sites were found to have moderate species diversity and richness, but not at the same level as reference sites. Conceptually pre-restoration sites are in an established disturbed state that has reached vegetation equilibrium, while restoration activities are expected to cause a shift towards a natural state post-restoration.

Specific vegetation species were identified as indicator species for specific site conditions within vegetation zones one and five. In zone four there were no unique species that were indicative of any of the site conditions. In zones one and five, native plants were found to be indicator species for reference sites whereas both native and non-native vegetation species were indicators of pre- and post-restoration conditions. It was expected that pre-restoration sites would have a mix of invasive and native plants. The presence of native and non-native plants at post-restoration sites is likely due to an immature vegetation community, recent hydrologic reconnection, and the disturbance associated with the restoration actions. We hypothesize as vegetation at the site matures and the reconnected hydrology affects plant communities, the restoration site will shift towards a native plant dominated community.

Annual within site vegetation similarity at reference sites was consistent between years. This within site similarity can establish a range of expected values to compare similarities between pre-restoration and post-restoration condition at sites within the same vegetation zone. A high vegetation similarity at reference sites in vegetation zone one between years is likely a result of a regular tidal inundation cycle. Reference site similarity was less in zones four and five, which has been previously documented as part of the EMP long-term monitoring in this zone and is likely due the vegetative response to hydrologic variability between years (Hanson et al., 2015). Vegetation zone four had the most amount sites with an annual similarity between restoration sites and between restoration-reference sites greater than 60%. Possible factors contributing to the similarity between these sites are the proximity of sites to each other and similar geomorphology (i.e. Wetland cantena), both of which result in for similar timing, frequency, and magnitude of physical processes affecting the sites. These same factors are probably what is driving the low similarity between sites in vegetation zone five. Here, the distance between sites is greater and the geomorphology of the sites are very different (i.e., wetland, intermittently exposed, lake/pond cantena). The variability of vegetation similarity between zones was greater than expected; however, using reference sites to set a baseline similarity can help evaluate how restoration sites compare to relatively undisturbed reference sites.

Vegetation similarity pre- and post-restoration at the site level vary based on the intensity of restoration actions. At Sauvie Island North Unit Phase 1, the low similarity between pre- and post-conditions is related to soil scrape down at the site which removed areas of reed canarygrass and dramatically changed the vegetation composition. At Kandoll Farm Phase 2, vegetation similarity was higher between pre- and post-restoration because the site did not undergo an intensive marsh elevation lowering. Instead an extensive channel network was established which allows for greater and more frequent inundation that is expected to affect the plant community over time. At the Sandy River a low vegetation similarity was found between pre- and post-restoration. Again, the restoration actions at the Sandy Dam site (i.e., a dam removal) involved major excavation resulting in changes to the site elevation and plant community. One year of post-restoration monitoring is not a sufficient amount of time to determine the effectiveness of lowering marsh elevations to control reed canarygrass. Subsequent years of vegetation monitoring will elucidate how marsh lowering affects vegetation communities as the site achieves a stable ecological state.

The impact of restoration activities related to terrestrial prey availability is inconclusive. The total number of terrestrial prey species observed in 2014 was slightly lower than 2013. However, Dipteran frequency was higher throughout the lower river regardless of site condition. More pre- and post-data collection of terrestrial macroinvertebrates should show if the increase in Dipterans at restoration sites is a sustained trend related to restoration actions or a result of natural inter-annual variability.

Preliminary results for sites with water temperature data available indicate that following restoration water temperatures improve. Following the removal of the water control structure at Sauvie Island North Unit Phase 1, water temperature is following similar trends observed at reference and control sites. At Horsetail Creek one year post-restoration the results are not as clear. The site's thermal regime appears to be similar to pre-restoration conditions, however, in

the context of the air temperature and precipitation, the Horsetail restoration site is exhibiting resiliency to increased ambient temperature. From July through September, 2014 air temperature was warmer and drier than both 2010 and the historic average. These warmer and drier ambient conditions were reflected in increased water temperatures at control/reference stations on Oneonta Creek and Horsetail Creeks. 2010 was cooler and wetter than 2014, but the observed difference of the mean seven day moving average maximum temperature from upstream to downstream locations on Horsetail Creek were similar. Based on climate data alone, one would expect the warmer and drier conditions observed during the 2014 monitoring period would have resulted in higher temperatures throughout the system than in 2010. However, a similar temperature increase across the Horsetail Creek site indicates that reduced thermal loading through the gravel pond area had a positive effect on temperature. It is expected, as the shrub and tree plantings mature, stream temperatures across the Horsetail Creek restoration site will decrease and the capacity of the site to remain cool in warmer and drier conditions (i.e., its resiliency) will increase.

Tagged fish detected at the Horsetail Creek restoration site in 2014 represented hatchery and wild stocks from spring, summer and winter runs. Fewer adult salmonids were detected at the site in fall 2014 compared to fall 2013. The reduced number of juvenile fish detections was likely a function of periods of time when the PIT tag array was not functioning. The lack of adult Chinook detections suggests none were tagged for 2014 upstream migration studies and any adult Chinook that may have visited the Horsetail Creek site would not have been detected by the array. Although beach seine sampling is not conducted at the Horsetail Creek site, species detection timing at the Horsetail Creek site was consistent with seasonal occurrence data for juvenile Chinook salmon and other juvenile salmonid species observed at Franz Lake, an ecosystem monitoring site in Reach F.

Although there were operational issues with the PIT tag array, limited data indicate juvenile and adult salmonids will pass through the Horsetail Creek culvert. In the spring, juvenile steelhead passed through the culvert and most adult salmonids successfully transited through the culvert during periods of lower flows. In late summer and fall, the reconstructed western barrel (containing the fish ladder structure) was the only barrel with reasonable water depths (greater than six inches) and pools (created by the ladder structure). The Horsetail PIT tag array also shows evidence that upstream salmonids are using lower Columbia River restoration sites.

Changes to wetland emergent habitat metrics as a result of restoration actions were varied. Only two sites with one year pre- and one year post-restoration have received extensive Level 2 monitoring at this point, which has made it difficult to determine trends in vegetation composition and terrestrial macroinvertebrates. The limited restoration sites used in this analysis showed no change or a slight decrease in water temperature. Changes to water temperature due to restoration actions varied based on site location and associated physical processes like frequency of inundation by the mainstem Columbia River or ambient climate factors. As more restoration sites are monitored post-restoration and the sites begin to mature, a better assessment of ecological change related to restoration actions can be completed.

Adaptive Management & Lessons Learned

The limited number of sites with pre- and post-restoration monitoring coupled with those sites having only one year of post-restoration data prevents clear inferences from being made about changes in ecological condition due to restoration efforts. Although a limited number of sites have pre- and post-restoration monitoring, initial analysis shows the need for not only reference sites but additional ecosystem monitoring sites to accurately characterize changes at the site scale and at larger spatial scales. Establishing a range of ecosystem values can be used to assess ecological changes related to restoration actions at larger spatial scales. The variation in metrics like vegetation and water temperature show the difficulty in assessing change related to restoration actions when only viewed at the site level. Including additional reference site data sets the range of values a “restored” site should achieve given the location of the site in the river. Also, the ability to compare restoration sites to ecosystem monitoring reference sites provides a method to determine the suitability of restoration sites to juvenile salmonids. With a lack of fish monitoring at AEM sites, comparing habitat metrics between restoration and reference sites is currently the only method to linking restoration actions to realized fish use.

Post restoration sites will need to achieve a new stable ecological state before restoration impacts related to vegetation composition and available salmonid prey can be determined. Restoration efforts act as a quick but significant disturbance to a site. For tidal reconnection projects, the immediate response of unrestricted inundation can be easily seen one year post restoration. Other metrics take more time to assess the true impact. Sauvie Island North Unit Phase 1 significantly lowered marsh elevation to control reed canarygrass. Since the site is one year post restoration, in areas with soil scrape down, bare ground is the predominant cover type. It will take time for a new plant community to become established and the site to reach a stable ecological state. We will monitor the site again three years post restoration and this monitoring event should provide the first insight into the effectiveness of soil scrape down in the control of reed canarygrass. A subset of standard metrics (water temperature and sediment accretion) should receive more monitoring time to assess actual changes in habitat condition. To adaptively manage restoration projects it is necessary to monitor at regular intervals post restoration; however, a realistic assessment of the post restoration ecological uplift is not possible until the new ecological stable state of the site is reached.

Based on early analysis covered in this report, the monitoring interval for standard (Level 3) metrics should be increased. Currently Standard Level 3 metrics are scheduled for monitoring one year and five years post-restoration. However, the annual variability in water temperature and water surface elevation can make the assessment of changes to ecological condition related to restoration efforts difficult to detect. Water temperature and water surface elevation are controlled by a number of environmental factors including rainfall and ambient air temperature. These two factors can vary annually and mask improvements to water quality at the site that are a result of the restoration action. Additionally, at many sites vegetation is planted to shade and moderate water temperatures, but it takes time for the vegetation to mature to a point of providing shade. Scheduling additional monitoring years could reduce uncertainty in the actual impact restoration conditions versus confounding ambient environmental factors.

References

- Borde A.B., V.I. Cullinan, H.L. Diefenderfer, R.M. Thom, R.M. Kaufmann, J. Sagar, and C. Corbett. 2012a. *Lower Columbia River and Estuary Ecosystem Restoration Program Reference Site Study: 2011 Restoration Analysis*. Prepared for the Lower Columbia River Estuary Partnership by Pacific Northwest National Laboratory, Richland, Washington.
- Borde A.B., S.A. Zimmerman, R.M. Kaufmann, H.L. Diefenderfer, N.K. Sather, R.M. Thom. 2011. *Lower Columbia River and Estuary Ecosystem Restoration Program Reference Site Study: 2010 Final Report and Site Summaries*. Prepared for the Lower Columbia River Estuary Partnership by Pacific Northwest National Laboratory, Richland, Washington.
- Dufrêne, M, and P. Legendre. 1997. Species Assemblages and Indicator Species: The need for a Flexible Asymmetrical Approach. *Ecological Monographs* 67, no. 3 (8): 345-366.
- Hanson et al. EMP report
- Johnson, G.E., H.L. Diefenderfer, B.D. Ebberts, C. Tortorici, T. Yerxa, J. Leary, and J.R. Skalski. 2008. *Federal Columbia River Estuary Research, Monitoring, and Evaluation Program (ERME)*. Available from PNNL, Portland, OR.
- Johnson, G.E., C.A. Corbett, J.A. Doumbia, M.S. Schwartz, R.W. Scranton, and C.A. Studebaker. 2014. *A Programmatic Plan for Restoration Action Effectiveness Monitoring and Research in the Lower Columbia River and Estuary*. Lower Columbia Estuary Partnership.
- Maier, G.O. and C.A. Simenstad. 2009. *The role of marsh-derived macrodetritus to the food webs of juvenile Chinook salmon in a large altered estuary*. *Estuaries and Coasts* 32:984-998
- McCune, B. and J.B. Grace. 2002. *Analysis of Ecological Communities*. Gleneden Beach, Or: MjM Software Design.
- McCune, B. and M. J. Mefford. 2011. PC-ORD, Multivariate analysis of ecological data, version 6.20, MjM Software, Gleneden Beach, Oregon, U.S.A.
- National Marine Fisheries Service (NMFS). 2008. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation; Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program (Revised and reissued pursuant to court order, NWF v. NMFS, Civ. No. CV 01-640-RE (D. Oregon).
- Roegner, G.C., H.L. Diefenderfer, A.B. Borde, R.M. Thom, E.M. Dawley, A.H. Whiting, S.A. Zimmerman, and G.E. Johnson. 2009. *Protocols for monitoring habitat restoration projects in the lower Columbia River and estuary*. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-97, 63 pp.

Shannon, C.E. and W. Wiener. 1949. The Mathematical Theory of Communication. The Bell System Technical Journal. 27 (3) 379-423.

Sokal R.R. and F.J. Rohlf. 1995. Biometry. W. H. Freeman & Co., New York

US Geological Survey and Nisqually Indian Tribe. 2012. Terrestrial invertebrates, fall-out trap standard operating procedures. Unpublished protocols. USGS, Western Ecological Research Center, San Francisco Bay Estuary Field Station, Vallejo, CA. Nisqually Indian Tribe Natural Resources Office, Olympia, WA. <http://www.tidalmarshmonitoring.org/pdf/USGS-WERC-Terrestrial-Invertebrates-SOP.pdf>

Washington Department of Ecology. 2012. Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC. <https://fortress.wa.gov/ecy/publications/summarypages/0610091.html>

Appendices

Appendix A: Site Sampling Reports

The summaries are presented in order starting from the mouth of the estuary to up-river. Additional background information about the sites sampled in the AEMR Program is often available in restoration project planning documents and reports, or in previous monitoring reports. To the extent possible, these are cited in the descriptions of each site.

Equipment

Equipment for each of the metrics sampled is outlined below.

- *Vegetation*: 100-m tapes for the baseline and transects, a compass for determining the baseline and transect azimuth, 1-m quadrat, data sheets, and plant books for species identification. GPS to identify location of base stakes and quadrats.
- *Insect Fallout Traps*: 4 tubs (26.7x15.8 inches) for trapping macroinvertebrates. 125µm sieve, garden sprayer, 96% denatured ethanol, and plastic jars with lids were used to field process macroinvertebrates for transport back to the lab for identification.
- *Sediment Accretion Rate*: 2 gray 1-inch PVC conduit pipes, at least 1.5m long, construction level, meter stick. GPS to identify location of stakes.
- *Photo Points*: camera, stake for including in photo, previous photos at location for reference, GPS to identify location of point.
- *Elevation*: AshTech ProMark 200 GPS with real-time kinematic (RTK) correction. Other survey equipment in case GPS equipment is non-functional, including an auto-level, tripod, and stadia rod.

Teaming: Roles and Responsibilities

At each of the restoration and reference sites five individuals comprised the AEMR Level 2 monitoring team. The team included Estuary Partnership Ecologist Matthew Schwartz (Program Manager), PNNL Wetlands Ecologist Amy Borde (Vegetation Sampling Lead), PNNL Research Associate Allie Simpson, CREST Habitat Restoration Biologist Jason Smith, and CREST Field Biologist Narayan Elasmr. In general, the roles and responsibilities of team members were as follows:

- Types of sampling for this site were determined according to the Estuary Partnership's Scope of Work.
- PNNL staff prepared the site sampling design prior or during to the field work, based on prior knowledge of the site and the protocols for randomization, and brought navigation information previously collected in GPS or created in GIS for sites formerly monitored by PNNL as part of the following research projects:
 - Ecosystem Monitoring Program (EM)
 - Cumulative Effects of Restoration Program (CE)
 - Tidal Freshwater Research (TFR)
- Estuary Partnership staff collected GPS points on sampling locations.
- PNNL staff trained CREST and Estuary Partnership staff on setting up transects and collecting vegetation cover data according to the Roegner et al. (2009) protocols.
- PNNL staff recollected all relevant photo point, sediment accretion, water surface elevation, and temperature data, in an effort to maximize inter-annual consistency at the sampling locations which had been previously established by PNNL staff under the three research projects described above.

Sites

Wallacut Restoration

General Site Location

The site is located near the mouth of the Wallacut River, which empties into Baker Bay, at approximately rkm 7.

Ecosystem Type

Diked, planned restoration site

Sampling History in the CEERP

None known

Current Role of Site in the CEERP

The Wallacut site is owned by the Columbia Land Trust. The site is slated for hydrologic reconnection through the removal of three culverts, removal of a low levee, ditch filling, and tidal channel creation. In addition, invasive species removal of gorse (*Ulex europaeus* L.) has been implemented to increase native species colonization.

Dates of Sampling in 2014

23 – 24 June

Types of Sampling in 2014

- *Vegetation*: Herbaceous cover (2 sample areas of 36 quadrats each, 72 quadrats total)
- *Insect Fallout Traps*: 4 fallout traps, 2 per vegetation sample area
- *Photo Points*: 2
 - Top of dike near the location of the lower vegetation monitoring plot
- *Elevation*: collected elevation at all vegetation quadrats

Vegetation Sampling Design

2 sampling areas were set up. New vegetation sample areas were established to capture the current condition and potential change that would occur as follows:

Mouth Veg Sample area (Wallacut North, Figure 15)

- Located in area near the mouth of the channel
- 60 m x 30 m, with 36 quadrat locations
- Baseline azimuth: 60° magnetic
- Transect azimuth: 105° magnetic
- Transect spacing: 10 m, random start: 5
- Quadrat spacing: 5 m, random starts: 2, 1, 2, 2, 3, 2
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

Upper Veg Sample area (Wallacut South, Figure 15)

- Located in area that will be affected by the dike removal, but away from the channel excavation.
- 60 m x 30 m, with 36 quadrat locations
- Baseline azimuth: 185° magnetic
- Transect azimuth: 95° magnetic
- Transect spacing: 10 m, random start: 9
- Quadrat spacing: 10 m, random starts: 2, 2, 4, 2, 3, 2
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

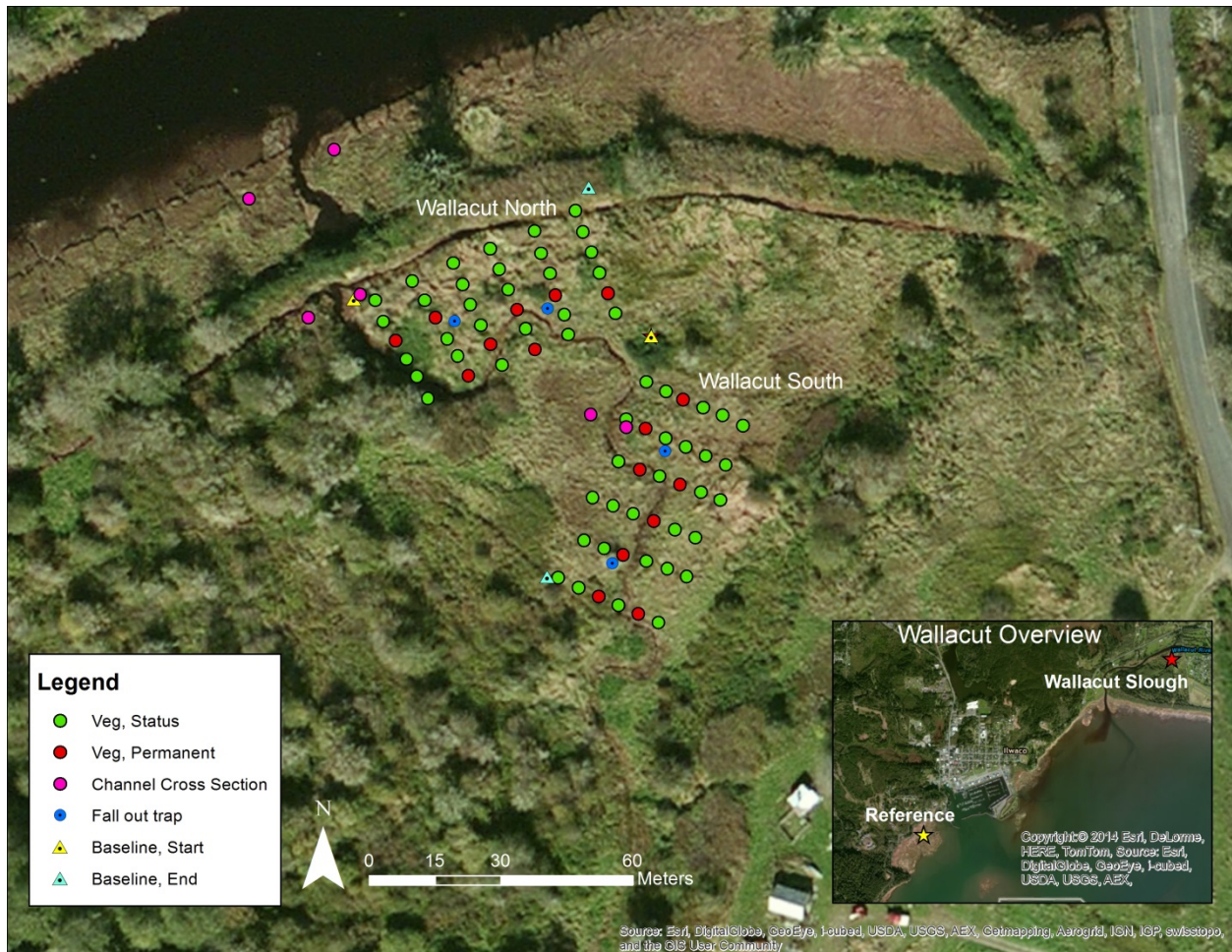


Figure 15. 2014 vegetation and macroinvertebrate sampling locations at Wallacut restoration site.

Markers Left on Site

All marking stakes are white ¾ inch PVC. We marked the following locations:

- End stakes of the baseline for the vegetation sample areas.
- Permanent quadrat stakes; 2 stakes per location in the diagonal corners (SW and NE).

Macroinvertebrate Sampling

Macroinvertebrate fall out traps were placed in two separate locations. Two fall out traps were placed in the Wallacut Mouth vegetation sampling area. Two fall out traps were placed in the Wallacut Upper sampling area.

Kandoll Farm Restoration

General Site Location

The site is located approximately 5.5 km up the Grays River, which empties into Grays Bay at rkm 37.

Ecosystem Type

Restoration site, formerly diked.

Sampling History in the CEERP

The Corps of Engineers' Cumulative Effects Team intensively sampled the Kandoll Farm Site (Thom et al. 2012) as part of phase one restoration in 2005 (pre-restoration), 2006 (year 1), and 2009 (year 4). Additional metrics (and more intensive sampling of standard metrics) were also sampled in dissertation research by Heida Diefenderfer at this site starting in 2005 (Diefenderfer 2007; Diefenderfer et al. 2008; Diefenderfer and Montgomery 2009). The site was monitored in 2013 prior to phase two restoration as part of the AEMR level 2 monitoring.

Current Role of Site in the CEERP

Kandoll Farm is a restoration site now in the second phase of restoration actions. The first phase occurred in 2005 and included 1) the replacement of a small tide gate with 2 large 13-foot culverts at the end of Seal Slough; 2) the breaching of the Grays River dike in three locations; and 3) tree and shrub plantings in locations throughout the site. The second phase restoration occurred in late summer 2013 and includes channel excavation, along-channel mounding, filling, and dike removal.

Dates of Sampling in 2014

25-26 June

Types of Sampling in 2014

- *Vegetation*: Herbaceous cover (2 sample areas, 66 quadrats total) and point intercept of all species (2 lines, 97 meters (m) and 150 m long)
- *Insect Fallout Traps*: 2
- *Sediment Accretion Rate*: measured one previously installed pair of stakes
- *Photo Points*:
 - photographed three previously established photo points near Seal Slough culverts and two previously established photo points on Grays River dike.
 - Established new photo points at the following locations:
 - Area A Veg Sampling area at 0 m on baseline
 - Area E Veg Sampling area at 0m on point intercept and
 - Area E Veg Sampling area at 70 m on transect baseline
- *Elevation*: collected elevation at all vegetation quadrats and the end points of the point intercept lines

Vegetation Sampling Design

Status Sampling. This site had been previously monitored as part of the Phase 1 restoration. However, the previous vegetation sample areas were in a location that was completely modified by the Phase 2 restoration. Therefore, new vegetation sample areas were established in 2013 to capture the current condition and potential change that would occur with Phase 2. The same sample design and quadrat placement was used in 2014 since the changes at the site were so great.

Area A Veg Sample area (Figure 16)

- Located in area near the dike removal and the channel excavation; in the area where “mounds” will be created.

- 60 m x 60 m, with 36 quadrat locations
- Baseline azimuth: 101° magnetic
- Transect azimuth: 11° magnetic
- Transect spacing: 10m, random start: 9
- Quadrat spacing: 10 m, random starts: 5, 7, 6, 6, 4, 9
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

Area E Veg Sample area (Figure 16)

- Located in area that will be affected by the dike removal, but away from the channel excavation.
- 70 m x 60 m, with 36 quadrat locations
- Baseline azimuth: 101° magnetic
- Transect azimuth: 11° magnetic
- Transect spacing: 12m, random start: 5
- Quadrat spacing: 10 m, random starts: 0, 7, 6, 6, 7, 4
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

Trends Sampling. Within the new vegetation sample areas, permanent quadrats that were established in 2013 were re-monitored. In addition, two line intercept transects that were previously sampled in 2005, 2006, 2009, and 2013 were resampled as part of this effort. The transect specifications are as follows:

Area A Line Intercept -

- 97 m long, with 0 at the western end
- Azimuth 101° magnetic
- Sampled every meter

Area E Line Intercept -

- 150 m long, with 0 at the western end
- Azimuth 101° magnetic
- Sampled every meter

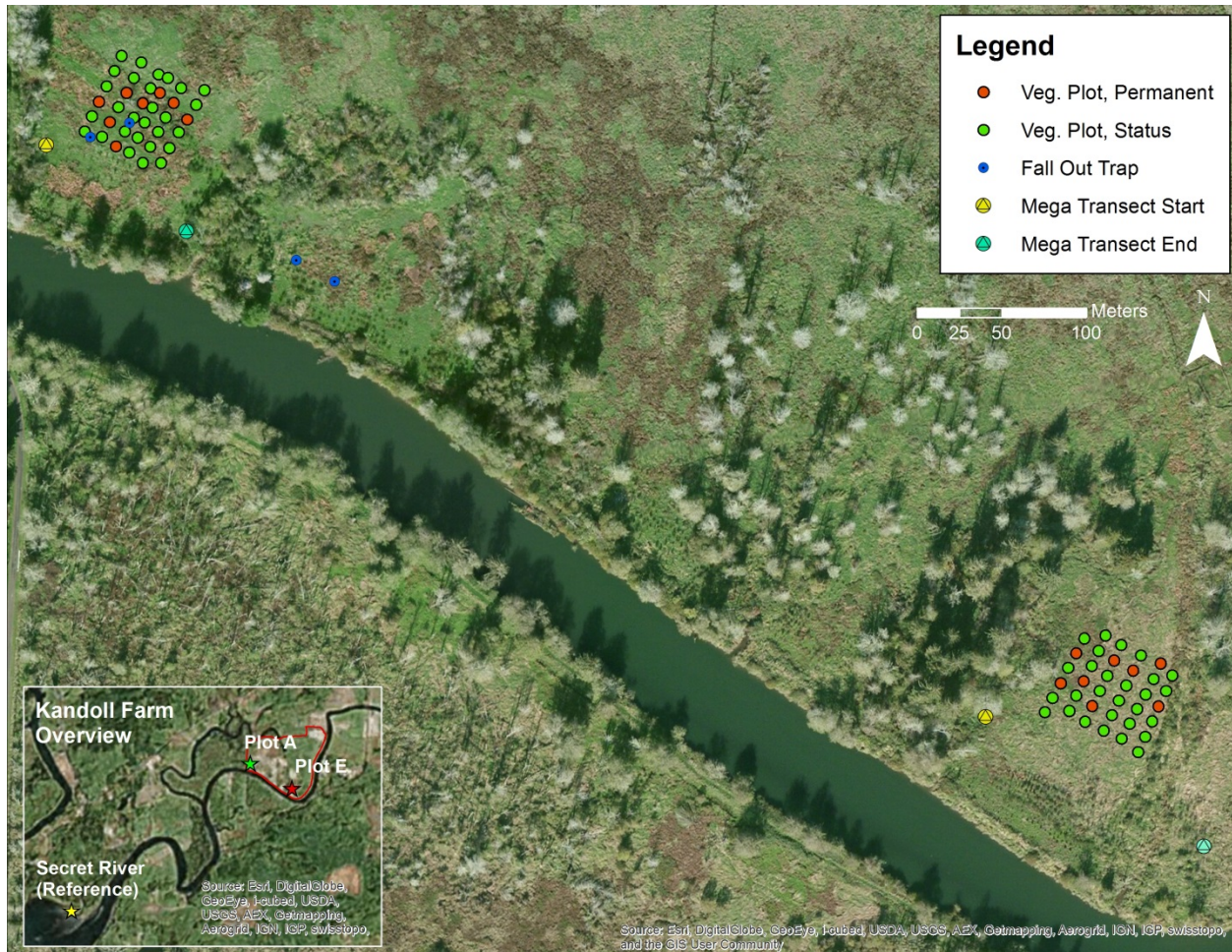


Figure 16. 2014 vegetation and macroinvertebrate sampling locations at Kandoll Farm restoration site.

Markers Left on Site

All marking stakes are white $\frac{3}{4}$ inch PVC with orange duct tape or flagging at the top. We marked the following locations:

- End stakes of the baseline for the vegetation sample areas.
- Permanent quadrat stakes; 2 stakes per location in the diagonal corners (SW and NE).
- End stakes of the point intercept transects.

In addition the gray 1 inch PVC sediment stakes that were placed at the site in Area B in 2005 were measured and left at the site.

Macroinvertebrate Sampling

Macroinvertebrate fall out traps were placed in two separate locations. Two fall out traps were placed in site A vegetation sampling area. The large constructed channel eliminated two additional traps locations. The lost trap locations were not redeployed.

Ilwaco Reference

General Site Location

Northwest side of Baker Bay west of Ilwaco marina.

Ecosystem Type

Tidal brackish emergent wetland

Sampling History in CEERP

This long-term monitoring site has been surveyed annually since 2011 site as part of the Estuary Partnership's Ecosystem Monitoring Program.

Current Role of Site in the CEERP

Ilwaco is being sampled as a reference site for baseline monitoring for the restoration actions being conducted in 2014 at Wallacut Restoration site.

Dates of Sampling in 2014

27 June

Types of Sampling in 2014

See map below for sampling locations (Figure 17).

- *Vegetation*: Herbaceous cover (1 sample area of 40 quadrats)
- *Insect Fallout Traps*: 2
- *Photo Points*:
 - 360° from 2 m east of the 0 m baseline stake
- *Sediment Accretion Rate*: measured one previously installed pair of stakes
- *Elevation*: collected elevation at all vegetation quadrats

Vegetation Sampling Design

Status Sampling. The sampling design implemented for the EMP was used for monitoring. This sampling design is similar to that used for the AEMR sampling except that the same quadrats are sampled from year to year to evaluate trends.

Vegetation Sample Area (Figure 17)

- Veg sample area covered the mid-marsh elevation gradient which contained primarily *Agrostis stolonifera* and *Carex lyngbyei*.
- 200 m x 100 m, with 40 quadrat locations
- Baseline azimuth: 240° magnetic
- Transect azimuth: 330° magnetic
- Transect spacing: 50m, random start: 16
- Quadrat spacing: 10 m, random starts: 4, 7, 2, 6

Trends Sampling. No permanent plots were placed at this site. Future trends monitoring will be conducted according to the EMP sample design.

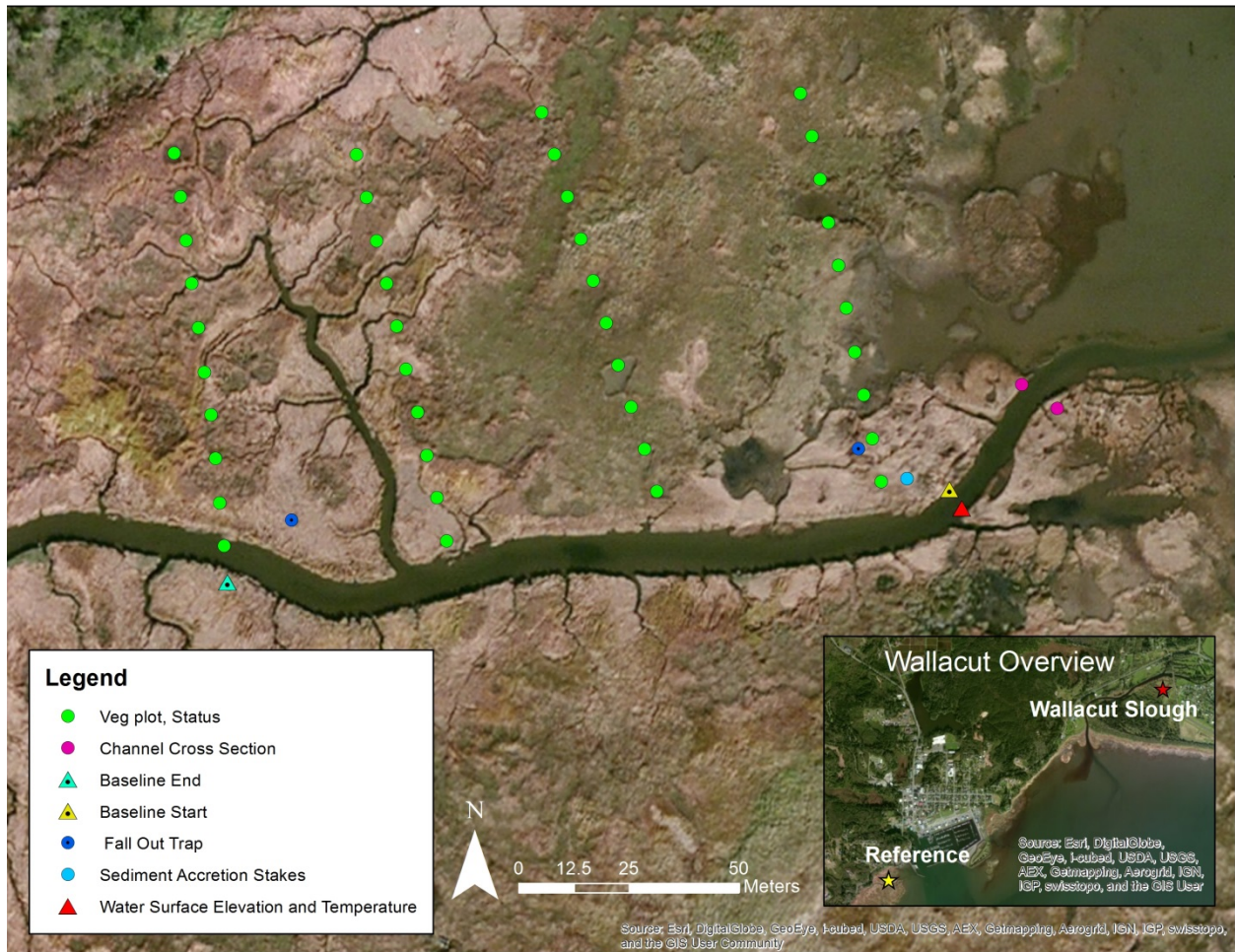


Figure 17. 2014 vegetation and macroinvertebrate sampling locations at Ilwaco marsh

1.1.1.1 Markers Left on Site

All marking stakes are white ¾ inch PVC. Marks left:

- End stakes at each of the transects in the vegetation sample area.

In addition, 2 1” gray pvc sediment accretion stakes are located on the site and a depth sensor is located inside 1 ½” PVC on a t-post in the channel.

Macroinvertebrate Sampling

Two macroinvertebrate fall out traps were placed in two separate locations within the vegetation sampling area.

Secret River Reference

General Site Location

The Secret River site is located at rkm 37 on the north side of Grays Bay.

Ecosystem Type

Reference site, tidal emergent wetland

Sampling History in the CEERP

This long-term monitoring site was surveyed in 2008 and has been surveyed annually since 2012 as part of the Estuary Partnership's Ecosystem Monitoring Program.

Current Role of Site in the CEERP

Secret River marsh is being sampled as a reference site for baseline post-restoration monitoring for the restoration actions conducted in 2013 at Kandoll Farm restoration site.

Dates of Sampling in 2014

14 – 15 July

Types of Sampling in 2014

- *Vegetation*: Herbaceous cover (2 sample areas of 20 quadrats, 40 quadrats total)
- *Photo Points*:
 - 2 photo points at the high marsh sampling area
 - 360° panorama taken at channel bank out from sediment stakes and cross-section end stake at the southwest corner of sampling area
 - 360° panorama taken at 0 m on baseline
 - 2 photo points at the low marsh sampling area
 - 360° panorama taken on log/mound near baseline
- *Elevation*: collected elevation at all vegetation quadrats

Vegetation Sampling Design

Status Sampling. The sampling design implemented for the EMP was used for monitoring. This sampling design is similar to that used for the AEMR sampling except that the same quadrats are sampled from year to year to evaluate trends.

High Marsh Sample area (Figure 18)

- Located in the higher elevation area of the marsh closer to the swamp area of the channel. Vegetation sample area covered a mixed *Carex lyngbyei* zone.
- 60 m x 50 m, with 20 quadrat locations
- Baseline azimuth: 263° magnetic
- Transect azimuth: 173° magnetic
- Transect spacing: 15m, random start: 7
- Quadrat spacing: 10 m, random starts: 3, 1, 7, 8

Low Marsh Sample area (Figure 18)

- Located in the lower elevation area of the marsh close to the mouth of the channel.
- 60 m x 50 m, with 20 quadrat locations
- Baseline azimuth: 263° magnetic
- Transect azimuth: 353° magnetic
- Transect spacing: 15m, random start: 7
- Quadrat spacing: 10 m, random starts: 3, 1, 7, 8

Trends Sampling. No permanent plots were placed at this site. Future trends monitoring will be conducted according to the EMP sample design.



Figure 18. 2014 vegetation and macroinvertebrate sampling locations at the Secret River marsh reference site.

Markers Left on Site

All marking stakes are white ¾ inch PVC. We marked the following locations:

- End stakes of the baseline for the vegetation sample areas.

In addition, 6 1” gray pvc sediment accretion stakes are located on the site and a depth sensor is located inside 1 ½” PVC on a t-post in the channel.

Sauvie Island North Unit Phase 1 (Ruby Lake)

General Site Location

North End of Sauvie Island on the Oregon Side of the River at rkm 144.

Ecosystem Type

Post-restoration, emergent tidal wetland

Sampling History in CEERP

Vegetation sampling was conducted during the pre-restoration phase in 2012 and 2013 to characterize the vegetation found at the site.

Current Role of Site in the CEERP

The restoration at Sauvie Island North Unit Phase 1 occurred in 2014 and involved the removal of a water control structure and soil scrape down at the site. The site was chosen for Level 2 restoration monitoring as a result of the AEMR prioritization process and will be monitored years 1, 3, and 5 post restoration. Monitoring in 2014 was Year 1 post-restoration.

Dates of Sampling in 2014

21 July

Types of Sampling in 2014

- *Vegetation:* Herbaceous cover (2 sample areas of 36 quadrats, 72 quadrats total)
- *Insect Fallout Traps:* 4 traps
- *Photo Points:*
 - 1 photo point at the North Veg Sample area - 360° from 2 m north of the 0 m baseline stake
 - 2 photo points at the South Veg Sample area
 - 180° from permanent plot 47-59, looking south
 - 360° from 2 m northwest of the 0 m baseline stake
- *Elevation:* collected elevation at all vegetation quadrats

Vegetation Sampling Design

North Veg Sample area (Figure 19)

- Located at north end of the southern part of the site. Veg sample area spanned elevation gradient which contained only reed canarygrass and would be scraped down to an elevation to prevent recolonization of reed canarygrass.
- 70 m x 60 m, with 36 quadrat locations
- Baseline azimuth: 180° magnetic Transect azimuth: 270° magnetic
- Transect spacing: 11m, random start: 2
- Quadrat spacing: 10 m, random starts: 9, 1, 5, 2, 3, 5
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

South Veg Sample area (Figure 19)

- Located at the southern end of the southern part of the site. Veg sample area spanned elevation gradient from lowest elevation SAV and bare mud through low marsh up to an elevation dominated by reed canarygrass.
- 70 m x 80 m, with 36 quadrat locations
- Baseline azimuth: 191° magnetic
- Transect azimuth: 281° magnetic
- Transect spacing: 11m, random start: 3
- Quadrat spacing: 13 m, random starts: 0, 10, 1, 2, 7, 8
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

Trends Sampling. we established and marked permanent quadrats locations for future trends sampling.

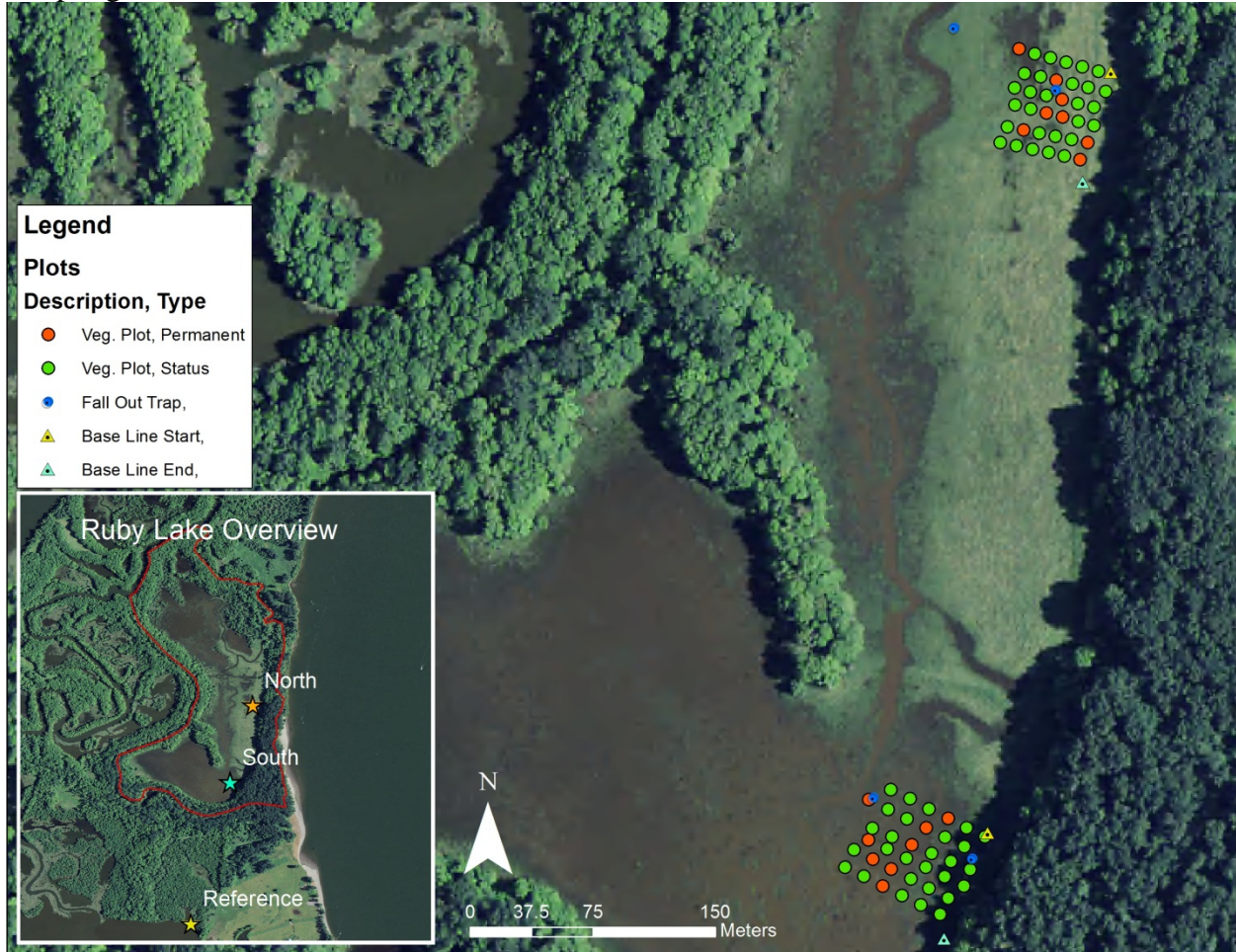


Figure 19. 2014 vegetation and macroinvertebrate sampling locations at the North Unit Phase 1 (Ruby Lake) restoration site.

Markers Left on Site

All marking stakes are white 3/4 inch PVC with orange duct tape or flagging at the top were left on site from previous year's marking. Marks left:

- End stakes of the baseline for the vegetation sample areas.
- Permanent quadrat stakes; 2 stakes per location in the diagonal corners (SW and NE).

Macroinvertebrate Sampling

Insect fall out traps were placed in the same locations as 2013. Two traps each were placed at the North and South vegetation sampling areas to characterize the macroinvertebrate species richness and diversity.

Sauvie Island North Unit Phase 2 (Deep Widgeon)

General Site Location

North End of Sauvie Island on the east side of Cunningham Slough at rkm 144.

Ecosystem Type

Pre-restoration condition, tidally impaired wetland

Sampling History in CEERP

AEMR Level 3 monitoring occurred starting in 2014. No other monitoring is known.

Current Role of Site in the CEERP

The restoration at Sauvie Island North Unit Phase 2 is scheduled to occur in 2014 and involves the removal of a water control structure and soil scrape down at the site. The site was chosen for Level 2 restoration monitoring as a result of the AEMR prioritization process and will be monitored years 1, 3, and 5 post-restoration. The monitoring in 2014 represents pre-restoration baseline monitoring.

Dates of Sampling in 2014

16 July

Types of Sampling in 2014

See map below for sampling locations (Figure 20)

- *Vegetation*: Herbaceous cover (2 sample areas, 72 quadrats total)
- *Insect Fallout Traps*: 4 traps
- *Photo Points*:
 - 1 photo point at the North Veg Sample area - 360° from 2 m northeast of the 0 m baseline stake
 - 1 photo points at the South Veg Sample area - 360° from 2 m south of 0 m baseline stake
- *Elevation*: collected elevation at all vegetation quadrats

Vegetation Sampling Design

North Veg Sample area (Figure 20)

Veg sample area spanned the proposed elevation gradient which currently is covered by reed canarygrass and will be scraped down to an elevation to prevent recolonization.

- 40 m x 50 m, with 36 quadrat locations
- Baseline azimuth: 229° magnetic
- Transect azimuth: 319° magnetic
- Transect spacing: 10m, random start: 4
- Quadrat spacing: 5 m, random starts: 4, 0, 4, 1
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

South Veg Sample area (Figure 20)

Veg sample area spanned the proposed elevation gradient which currently is covered by reed canarygrass and will be scraped down to an elevation to prevent recolonization.

- 50 m x 50 m, with 28 quadrat locations
- Baseline azimuth: 57° magnetic
- Transect azimuth: 327° magnetic
- Transect spacing: 8m, random start: 6

- Quadrat spacing:
 - 4 transects with 5 quadrats at 10 m spacing
 - 2 transects with 4 quadrats at 12 m spacing
 - Random starts: 6, 5, 10, 3, 2, 2
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

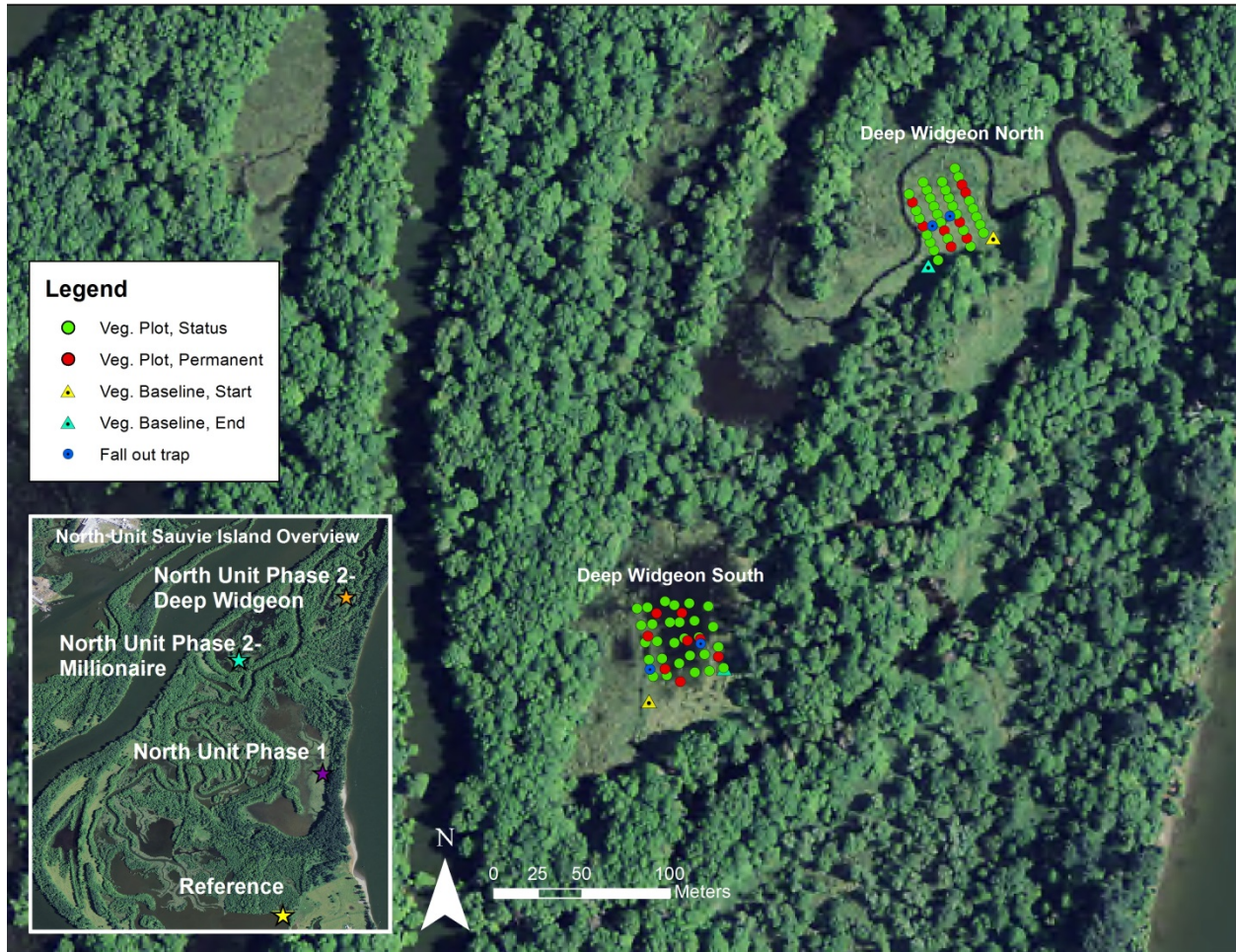


Figure 20. 2014 vegetation and macroinvertebrate sampling locations at the North Unit Phase 2 (Deep Widgeon) restoration site.

Markers Left on Site

All marking stakes are white $\frac{3}{4}$ inch PVC. Marks left:

- End stakes of the baseline for the vegetation sample areas.
- Permanent quadrat stakes; 2 stakes per location in the diagonal corners (SW and NE).

Macroinvertebrate Sampling

Macroinvertebrate fall out traps were placed in two separate locations. Two fall out traps were placed in the Deep Widgeon North vegetation sampling area. Two fall out traps were placed in the Deep Widgeon South vegetation sampling area.

Sauvie Island North Unit Phase 2 (Millionaire Lake)

General Site Location

North End of Sauvie Island on the west side of Cunningham Slough at rkm 144.

Ecosystem Type

Pre-restoration condition, tidally impaired wetland

Sampling History in CEERP

AEMR Level 3 monitoring occurred starting in 2014. No other monitoring is known.

Current Role of Site in the CEERP

The restoration at Sauvie Island North Unit Phase 2 is scheduled to occur in 2014 and involves the removal of a water control structure and soil scrape down at the site. The site was chosen for Level 2 restoration monitoring as a result of the AEMR prioritization process and will be monitored years 1, 3, and 5 post-restoration. The monitoring in 2014 represents pre-restoration baseline monitoring.

Dates of Sampling in 2014

17 July

Types of Sampling in 2014

- *Vegetation*: Herbaceous cover (2 sample areas, 72 quadrats total)
- *Insect Fallout Traps*: 4 traps
- *Photo Points*:
 - 1 photo point at the North Veg Sample area - 360° from 2 m east of the 0 m baseline stake
 - 1 photo points at the South Veg Sample area - 360° from 2 m southwest of 0 m baseline stake
- *Elevation*: collected elevation at all vegetation quadrats

Vegetation Sampling Design

North Veg Sample area (Figure 21)

- Located at north end of the southern part of the site. Veg sample area spanned elevation gradient which contained primarily reed canarygrass and will be scraped down to an elevation to prevent recolonization of reed canarygrass.
- 60 m x 50 m, with 36 quadrat locations
- Baseline azimuth: 343° magnetic
- Transect azimuth: 253° magnetic
- Transect spacing: 10m, random start: 8
- Quadrat spacing: 8 m, random starts: 0, 5, 4, 5, 2, 0
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

South Veg Sample area (Figure 21)

- Located at the southern end of the southern part of the site. Veg sample area spanned elevation gradient from lowest elevation SAV and bare mud through low marsh up to an elevation dominated by reed canarygrass.
- 80 m x 70 m, with 28 quadrat locations
- Baseline azimuth: 323° magnetic
- Transect azimuth: 233° magnetic
- Transect spacing: 13m, random start: 2
- Quadrat spacing:
 - 4 transects with 5 quadrats at 14 m spacing
 - 2 transects with 4 quadrats at 18 m spacing
 - Random starts: 5, 8, 2, 4, 5, 10
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

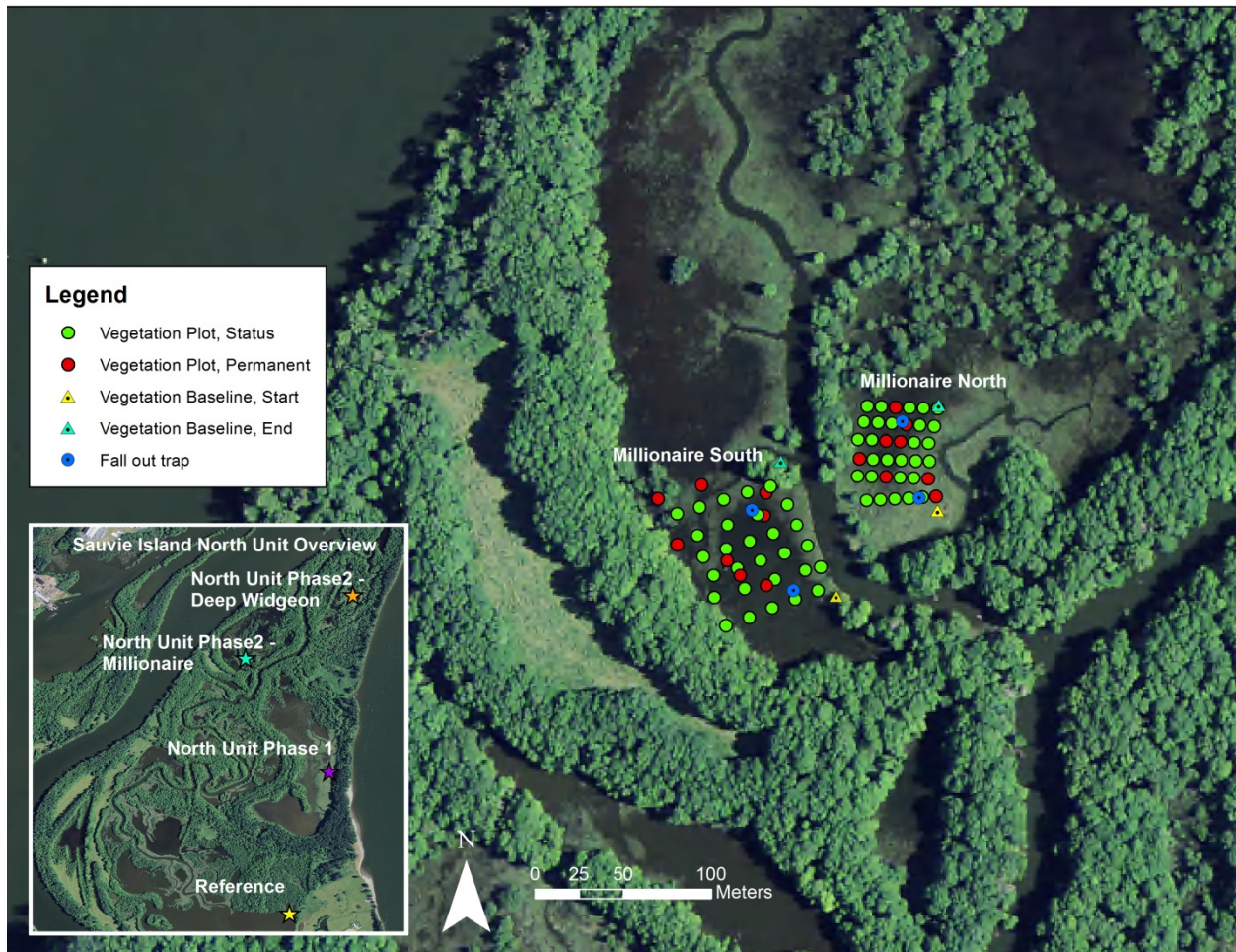


Figure 21. 2014 vegetation and macroinvertebrate sampling locations at the North Unit Phase 2 (Millionaire Lake) restoration site.

Markers Left on Site

All marking stakes are white 3/4 inch PVC with orange duct tape or flagging at the top were left on site from previous year's marking. Marks left:

- End stakes of the baseline for the vegetation sample areas.
- Permanent quadrat stakes; 2 stakes per location in the diagonal corners (SW and NE).

Macroinvertebrate Sampling

Macroinvertebrate fall out traps were placed in two separate locations. Two fall out traps were placed in the Millionaire North vegetation sampling area. Two fall out traps were placed in the Millionaire South vegetation sampling area.

Sauvie Island North Unit Reference (Cunningham Lake)

General Site Location

Cunningham Lake is a floodplain lake located at rkm 145 on Sauvie Island in the Oregon DFW Wildlife Area. The mouth of the Slough is located between rkm 142 and 143 close to where Multnomah Channel meets the Columbia River. The end of Cunningham Slough is approximately 8.7 km from Multnomah Channel.

Ecosystem Type

Reference Site, Fringing Emergent Marsh at the upper extent of the extremely shallow “lake”

Sampling History in the CEERP

This long-term monitoring site has been surveyed annually since 2005 site as part of the Estuary Partnership’s Ecosystem Monitoring Program.

Current Role of Site in the CEERP

Cunningham Lake is being sampled as a reference site for baseline post-restoration monitoring for the restoration actions being conducted in 2014 at Sauvie Island North Unit Phase 1.

Dates of Sampling in 2014

18 July

Types of Sampling in 2014

See map below for sampling locations (Figure 22).

- *Vegetation*: Herbaceous cover (36 quadrats total)
- *Insect Fallout Traps*: 0
- *Photo Points*: 1 photo point
 - 360° panorama taken at location near south end of vegetation sample area.
- *Elevation*: collected elevation at all vegetation quadrats

Vegetation Sampling Design

Veg Sample area (Figure 22)

- Located along the fringe of the very shallow Cunningham Lake. Vegetation sample area spanned elevation gradient from unvegetated flats to the shrub/tree zone.
- 70 m x 25 m, with 36 quadrat locations
- Baseline azimuth: 147° magnetic
- Transect azimuth: 57° magnetic
- Transect spacing: 11m, random start: 10

- Quadrat spacing: 4 m, random starts: 2, 4, 0, 2, 1, 5
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

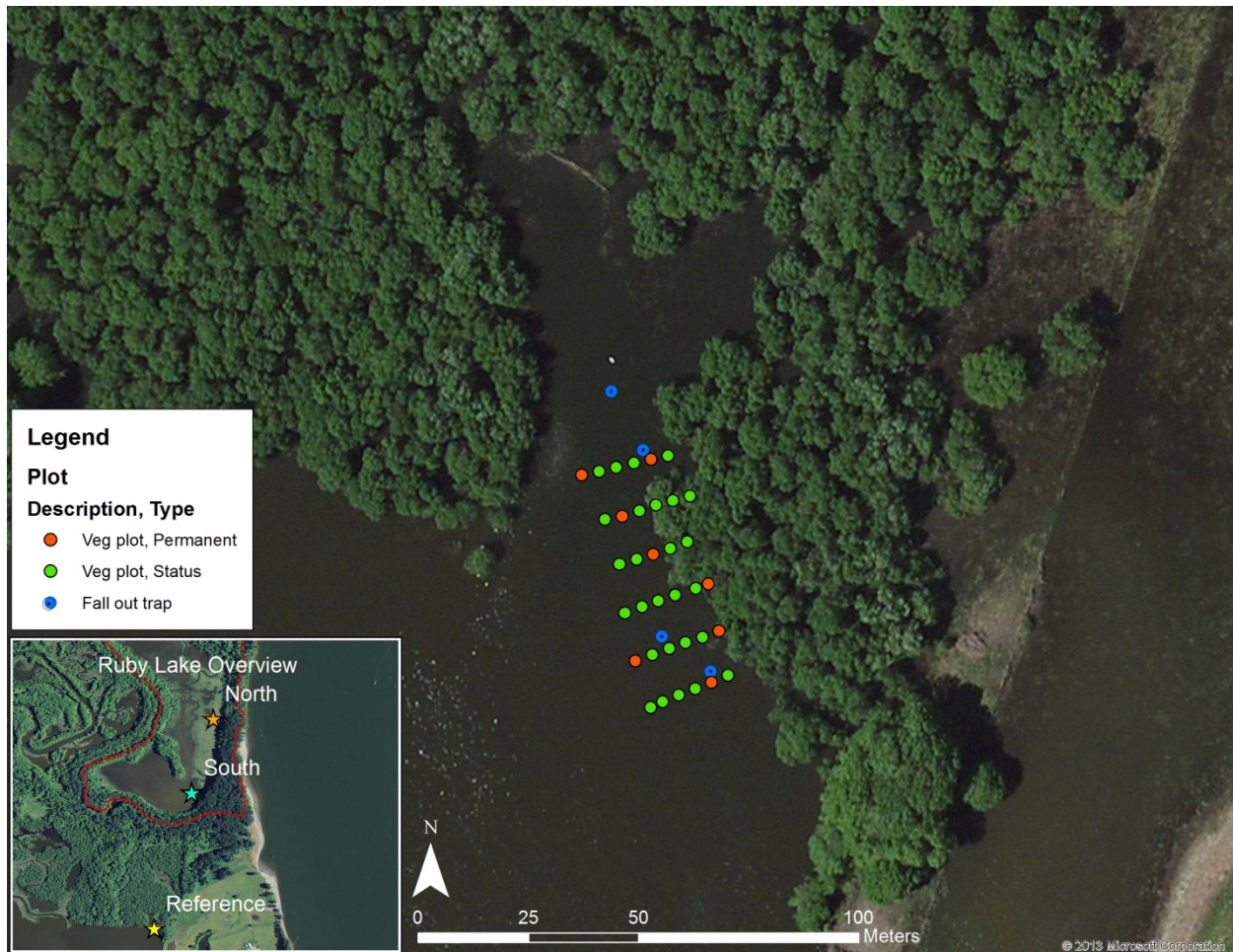


Figure 22. 2014 vegetation and macroinvertebrate sampling locations at the Cunningham Lake reference site.

Markers Left on Site

All marking stakes are white $\frac{3}{4}$ inch PVC with orange duct tape or flagging at the top. We marked the following locations:

- End stakes of the baseline for the vegetation sample areas.
- Permanent quadrat stakes; 2 stakes per location in the diagonal corners (SW and NE).

In addition, 2 1" gray pvc sediment accretion stakes are located on the site and a depth sensor is located inside 1 $\frac{1}{2}$ " PVC on a t-post in the channel.

Macroinvertebrate Sampling

Due to logistical oversight no fall out traps were deployed in 2014.

Sandy River (Mouth)

General Site Location

Near the mouth of the restored Sandy River channel between Gary and Sundial Islands at rkm 198

Ecosystem Type

Post-restoration condition, channel construction

Sampling History in CEERP

Pre-restoration monitoring (primarily fish and macroinvertebrate) by PNNL was conducted for the USACE between 2006-2012. Vegetation sampling was conducted as part of this program by PNNL in 2007.

Current Role of Site in the CEERP

The restoration on the Sandy River occurred in the summer of 2013 and involved the removal of an earthen dam and channel modification at the site. The site was chosen for Level 2 restoration monitoring as a result of the AEMR prioritization process and will be monitored years 1, 3, and 5 post-restoration. The monitoring in 2014 was Year 1.

Dates of Sampling in 2014

22 July

Types of Sampling in 2014

- *Vegetation:* Herbaceous cover (1 sample area of 36 quadrats)
- *Insect Fallout Traps:* 0
- *Photo Points:*
 - 360° from the veg hub
 - From T-3 100 m end stake
- *Elevation:* collected elevation at all vegetation quadrats

Vegetation Sampling Design

Vegetation Sample Area (Figure 23)

Located on the west side of the mouth of the restored channel.

- 3 Transects with 36 quadrat locations
 - T-1: 149° magnetic, 20 m
 - T-2: 200° magnetic, 70 m
 - T-3: 250° magnetic, 95 m (end stake at 100 m)
- Quadrat spacing: 5 m, random starts: 3
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects (T1-18, T2-3, T2-33, T2-63, T3-38, T3-48, T3-78, T3-83)

Trends Sampling. We sampled the previously established transects from 2007 to the extent possible to look at change historically. The permanent plots on these same transects will be monitored in the future to evaluate trends post-restoration.



Figure 23. 2014 vegetation and macroinvertebrate sampling locations at the Sandy River mouth restoration site.

Markers Left on Site

All marking stakes are white ¾ inch PVC. Marks left:

- Only the end stake at 100m on transect 3 was left due to the dynamic nature of the site.

Macroinvertebrate Sampling

The site was not scheduled for macroinvertebrate sampling.

Sandy River (Dam Removal)

General Site Location

Near the earthen dam removal on the old channel of the Sandy River at rkm 198

Ecosystem Type

Post-restoration condition, channel construction

Sampling History in CEERP

Pre-restoration monitoring (primarily fish and macroinvertebrate) by PNNL was conducted for the USACE between 2006-2012. Vegetation sampling was conducted as part of this program by PNNL in 2006 and 2007.

Current Role of Site in the CEERP

The restoration on the Sandy River occurred in fall of 2013 and involved the removal of an earthen dam and channel modification at the site. The site was chosen for Level 2 restoration monitoring as a result of the AEMR prioritization process and will be monitored years 1, 3, and 5 post-restoration. The monitoring in 2014 was Year 1.

Dates of Sampling in 2014

23 July

Types of Sampling in 2014

- *Vegetation*: Herbaceous cover (2 sample areas, 46 quadrats total)
- *Insect Fallout Traps*: 0
- *Photo Points*:
 - 360° from 2m west of 0 m on the new baseline
- *Elevation*: collected elevation at all vegetation quadrats

Vegetation Sampling Design

Previous Veg Sample area

- Located just downstream of the removed dam, spanning the new channel. Most of T-3 unsampleable because it is located in the fast flowing new channel.
- 3 Transects forming a “T” with 13 quadrat locations
- Transect azimuth:
 - T-1: 326° magnetic, 30 m
 - T-2: 146° magnetic, 40 m
 - T-3: 260° magnetic, 85 m
- Quadrat spacing: 5 m, random starts: T-1 = 2, T-2 = 3, T-3 = NA

New Veg Sample area (Figure 24)

- Located on the north side of the channel just downstream of the removed dike. Transect 77 overlaps with T-1 from the previous veg sample area.
- 80 m x 30 m, with 36 quadrat locations
- Baseline azimuth: 56° magnetic
- Transect azimuth: 146° magnetic
- Transect spacing: 13 m, random start: 12
- Quadrat spacing: 5 m, random starts: 2, 2, 0, 0, 2, 2
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects (T12-12, T25-2, T25-22, T38-15, T51-0, T51-10, T64-17, T77-12)

Trends Sampling. We sampled the previously established transects from 2006 and 2007 to the extent possible and overlapped one of the original transects with one of the new transects to be able to look at change historically. The new transects will be monitored in the future to evaluate trends post-restoration.

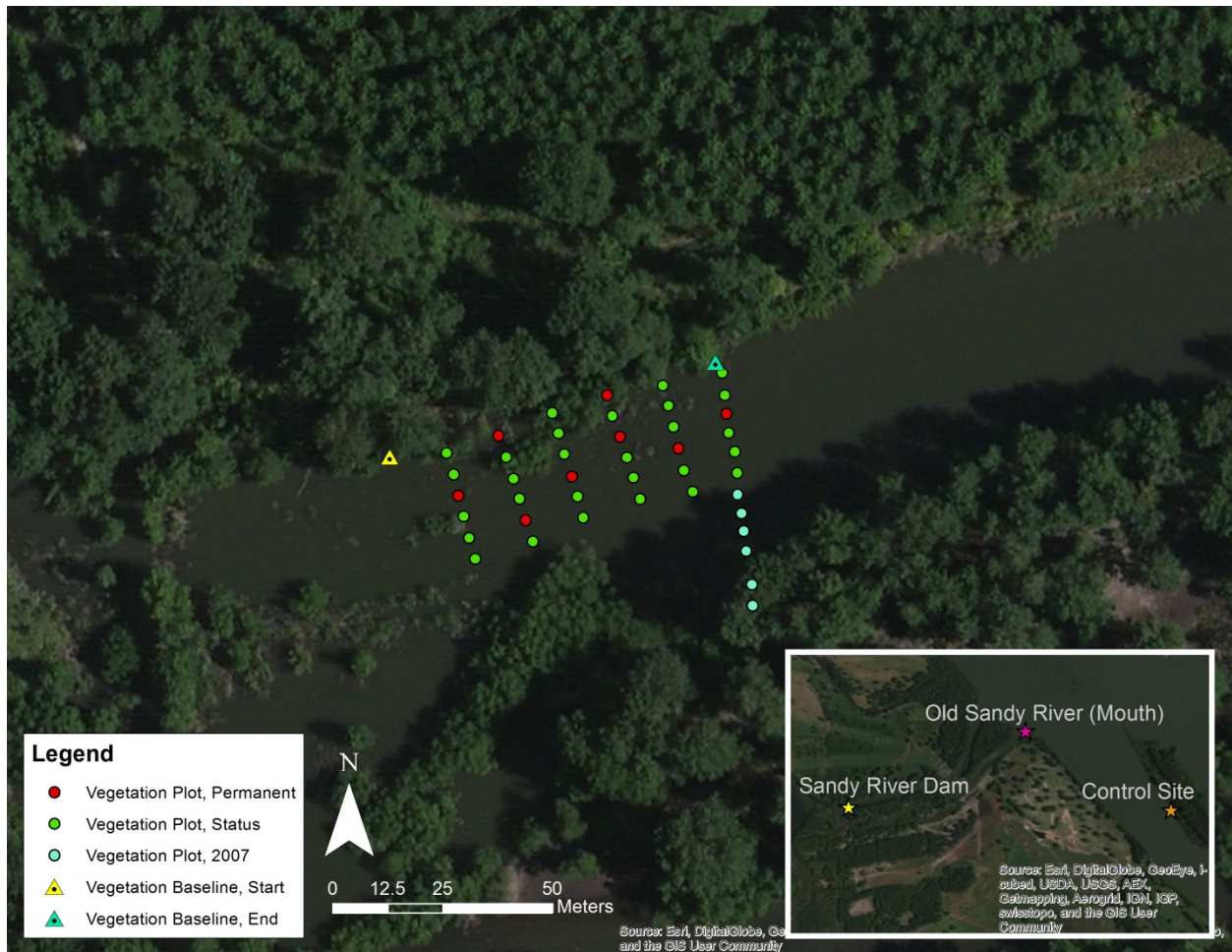


Figure 24. 2014 vegetation and macroinvertebrate sampling locations at the Sandy River dike breach restoration site.

1.1.1.2 Markers Left on Site

All marking stakes are white $\frac{3}{4}$ inch PVC. Marks left:

- End stakes of the baseline for the vegetation sample areas.
- Permanent plot stakes were not left due to heavy human use of site.

Macroinvertebrate Sampling

The site was not scheduled for macroinvertebrate sampling.

Sandy River Reference (Gary Island)

General Site Location

Gary Island is located in the Columbia River, upstream from the restored Sandy River channel at rkm 200.

Ecosystem Type

Island fringing wetland

Sampling History in CEERP

The site has been used as a control site for the PNNL fish and invertebrate sampling that has been done by PNNL between 2006-2012. Vegetation sampling was conducted during the pre-restoration phase of the project by PNNL for the USACE in 2008.

Current Role of Site in the CEERP

Gary Island is being sampled as a reference site for baseline post-restoration monitoring for the restoration actions conducted in 2013 on the Sandy River.

Dates of Sampling in 2014

24 July

Types of Sampling in 2014

- *Vegetation:* Herbaceous cover (1 sample area of 36 quadrats)
- *Insect Fallout Traps:* 0
- *Photo Points:*
 - 360° from 0m on the baseline
- *Elevation:* collected elevation at all vegetation quadrats

Vegetation Sampling Design

Veg Sample area (Figure 25)

- Located on the southwest side of the island. Veg sample area spanned elevation gradient from the water to the trees.
- 100 m x 24 m, with 36 quadrat locations
- Baseline azimuth: 132° magnetic
- Transect azimuth: 38° magnetic
- Transect spacing: 20 m, random start: 0
- Quadrat spacing: 5 m, random starts: 2, 2, 1, 1, 1, 1
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

Trends Sampling

We sampled the previously established 4 transects from 2008 to the extent possible to evaluate change historically. In addition we added 3 new transects to the east. In future years the former T-4 will be eliminated because it is very narrow, and only the remaining 6 transects will be surveyed. The permanent plots on these same transects will be monitored in the future to evaluate trends post-restoration.

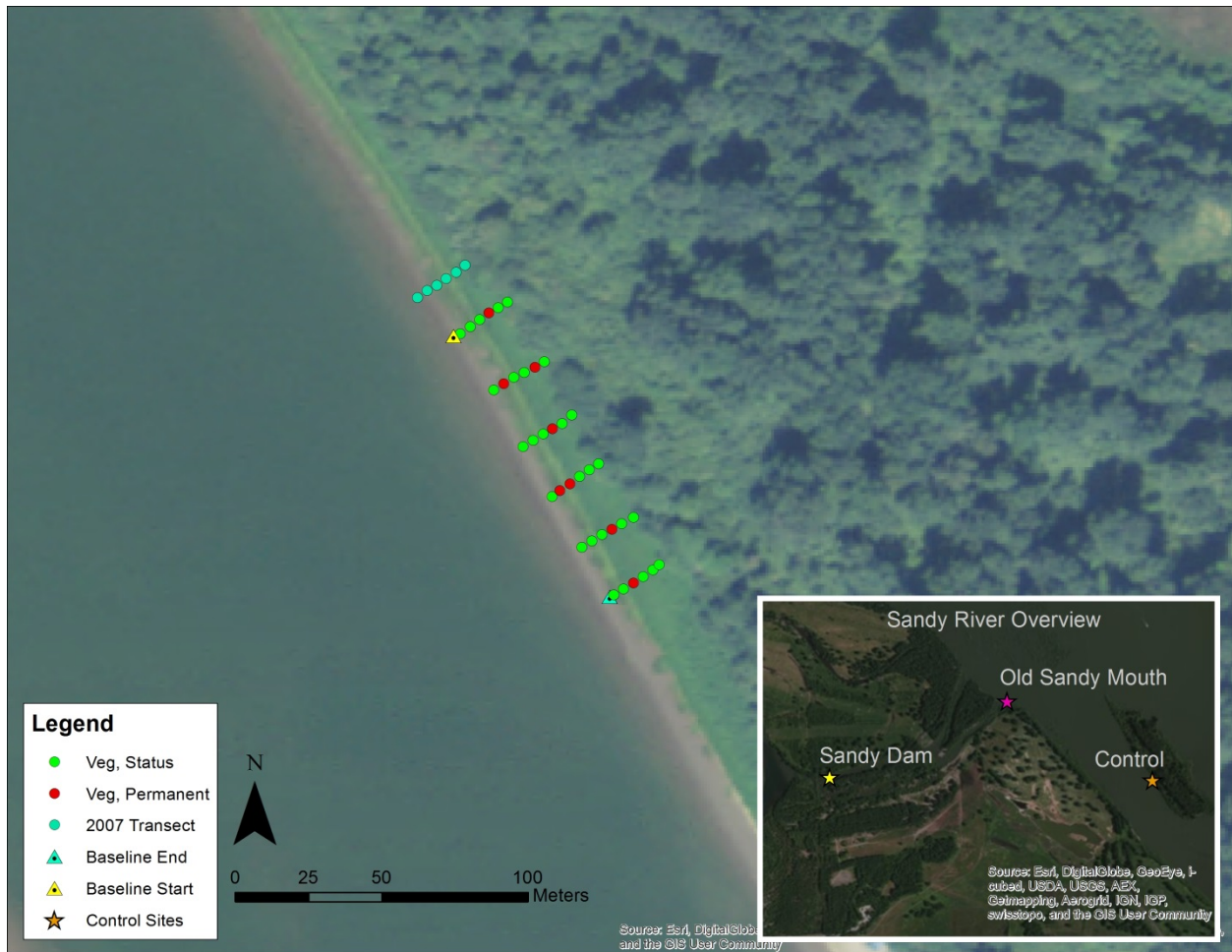


Figure 25. 2014 vegetation and macroinvertebrate sampling locations at the Gary Island control site.

Markers Left on Site

All marking stakes are white $\frac{3}{4}$ inch PVC. Marks left:

- Stakes at the 24 m end of 0 m and 100 m transects (in the trees). Baseline was in the water, but decided to leave stakes at other end of transects to reduce visibility of stakes and potential for water hazards to boaters.
- Permanent quadrat stakes; 1 stakes per location in the SW corner.

Macroinvertebrate Sampling

The site was not scheduled for macroinvertebrate sampling.

Appendix B: 2014 Site Prioritization Results

Grey shaded cells were monitored in 2014.

Name	Reach	Type(s) of Actions	Amount New Actions	Amt Previous AEMR	Uncertainty Score		SBU Result	Score
					LWD 2=applies; 1=partially applies; 0=doesn't apply	RCG 2=applies; 1=partially applies; 0=doesn't apply		
Columbia Stock Ranch (CSR) - Restoration (CLT)	E	4	2	3	2	2	3	25
La Center Wetlands, Lewis River East Fork - Site 43 (LCEP)	E	4	2	3	1	2	3	23.5
Wallooskee Youngs - Restoration (Cowlitz)	A	4	2	2	2	2	2	22
Grays Bay - Kandoll Farm Restoration - Phase 2 (CLT)	B	4	2	2	2	2	2	22
Julia Butler Hansen NWR - Steamboat Slough	B	4	2	2	2	2	2	22
Sauvie Island, North Unit Phase 1 (CREST)	F	4	2	3	0	2	2	20
Buckmire Slough - Phase 1 (CREST)	F	4	2	3	1	1	2	20
Wallacut River - Restoration Phase (CLT)	A	4	2	2	2	2	1	20
Sauvie Island, North Unit Phase 2	F	4	2	3	1	2	1	19.5

Crooked Creek Upstream (CLT)	B	4	2	2	0	2	2	19
LA (Louisiana) Swamp (LCEP)	C	4	2	3	2	2	0	19
Gnat Creek - Phase 2 (CREST)	B	4	2	2	2	0	2	19
Sharnelle Fee (CREST)	A	4	2	2	2	1	1	18.5
Buckmire Slough - Phase 2 (WDFW)	F	4	2	3	0	1	2	18.5
Karlson Island Restoration (CREST)	B	4	2	2	1	2	1	18.5
Marys Creek (CREST)	B	4	2	2	2	1	0	16.5
Thousand Acres, Sandy River Delta Restoration (LCEP)	G	4	1	3	1	2	0	16.5
Skipanon Slough, 8th St Dam - Phase 2 Tidegate Removal (CREST)	A	4	2	2	0	0	2	16
Sandy River Dam Removal	G	4	1	3	0	1	1	15.5
Horsetail Creek (LCEP)	H	4	1	3	1	1	0	15
Chinook River WDFW - Restoration Phase (WDFW)	A	2	2	2	1	1	1	13
Skamakowa Creek - Dead Slough Restoration - Phase 2 (CREST)	B	4	2	2	0	0	0	12

Scoring Criteria

Topic	Criterion	CEERP Priorities	Weighting	Scoring Measures
Types of restoration actions	Actions important to the restoration program, but whose ecological effects are poorly understood	Hydrological reconnections; habitat creations; pile structure modifications	**	Breach Dikes=4 Remove Tide Gates/Culverts=4 Restore degraded off-channel habitat=4
Landscape locations of AEMR study sites	Locations in landscapes where restoration actions may be concentrated or LCRE areas where little AEMR has occurred reference site(s) are available	Results from GAIL and AEMR inventory	*	1=much; 2=some; 3=little
Addresses a key uncertainty in action effectiveness	See list in the section above on State-of-Science and ERTG Uncertainties	TBD	***	2 = applies; 1 = doesn't apply
Preliminary SBU	Project size; location relative to main stem; ecological uplift anticipated (see ERTG Doc# 2010-02)	Large project size (>100 acres); near main stem; large ecological uplift anticipated	**	3 = >3 SBUs; 2=1-3 SBUs; 1=.3-.99 SBU; 0=<.3