EMP Habitat Monitoring 2022-2023

Lower Columbia Estuary Partnership

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Franz Lake Slough 2018

EMP Habitat Objectives

Hydrology
- Evaluate differences in growing season and daily marsh inundation among the sites across years

Vegetation
- Compare species abundances, diversity, and similarity across sites and years

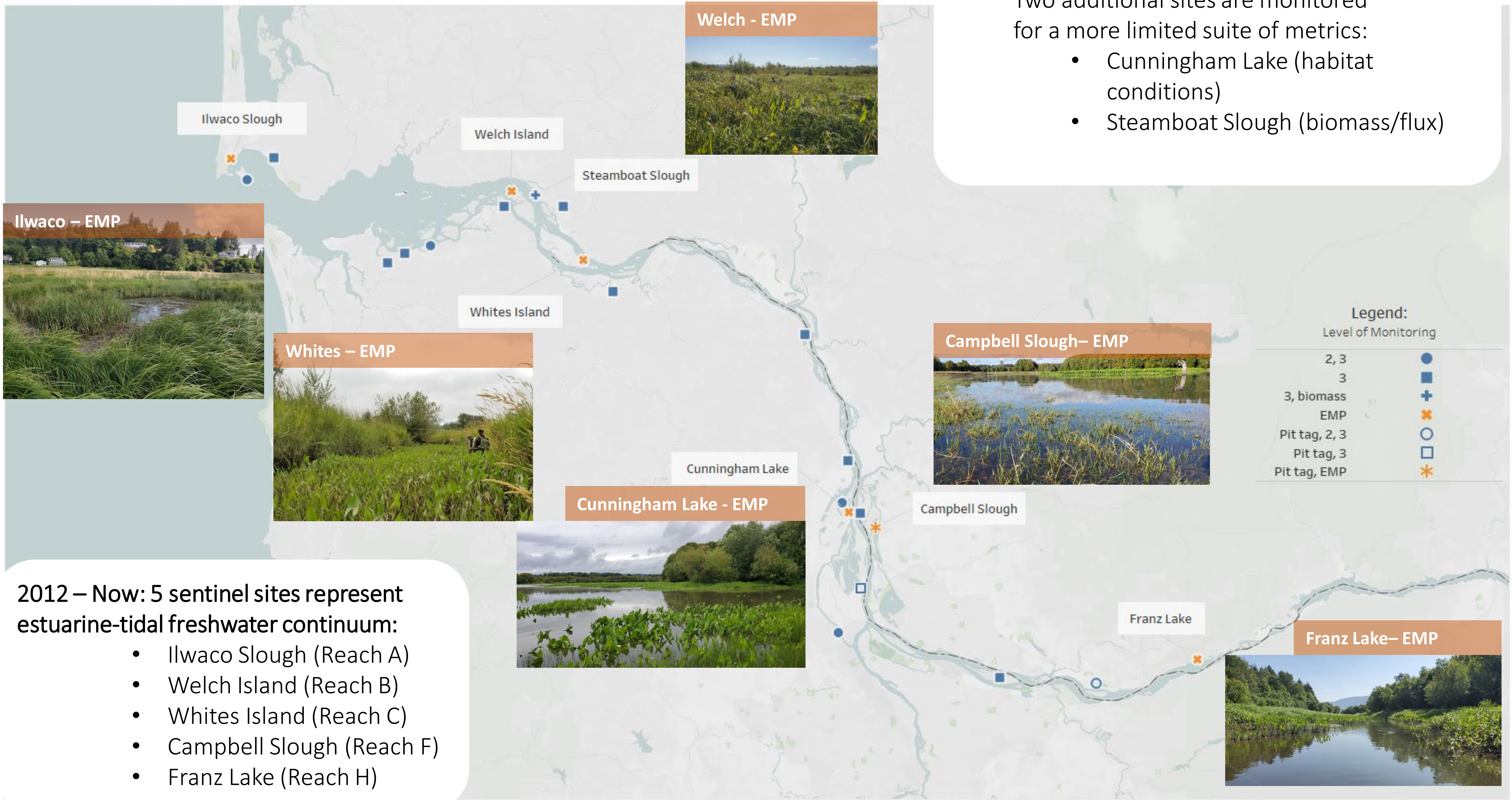
Sediment accretion and erosion
- Calculate the accretion and erosion rates across the sites by year
- Sediment dynamics and SLR Implications

Biomass
- Compare summer and winter biomass across sites and years, identify biomass export
- Evaluate detritus and biomass quality and quantity

2023 AEMR and EMP Monitoring

Two additional sites are monitored for a more limited suite of metrics:

- Cunningham Lake (habitat conditions)
- Steamboat Slough (biomass/flux)



2012 – Now: 5 sentinel sites represent estuarine-tidal freshwater continuum:

- Ilwaco Slough (Reach A)
- Welch Island (Reach B)
- Whites Island (Reach C)
- Campbell Slough (Reach F)
- Franz Lake (Reach H)

2023 Summer Habitat Sampling Stats

- 900 plots of detailed plant community data recorded
- 4,800 soil measurements recorded
- 1,100 sediment accretion and erosion measurements taken
- 400 bags of above-ground biomass collected
- ~45 data loggers (~450,000 water depth and temperature measurements) swapped
- 250 Ground Control Points laid
- 8 TB of drone data collected
- 1500 ground elevations surveyed
- 50+ miles hiked while collecting these data this summer

2023 EMP Hybrid Report

- Combination of written report and Tableau dashboard
- Written report includes
  - **Brief Executive Summary**
  - **Background and Methods, static results and discussion**
  - **Links to tableau dashboards**

- Tableau Dashboards
  - Standalone tableau dashes for research focus showing detailed results and discussions
  - All dashes are interlinked allowing for easy navigation

Lower Columbia River Ecosystem Monitoring Program
Annual Report for Year 17

BPA Project Number: 2003-007-00
Report covers work performed under BPA contract # 80237
Report was completed under BPA contract # 90999
Report covers work performed from: October 2022 – September 2023

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Habitat Structure Dashboard

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Habitat Structure by Ecosystem Monitoring Program

Welcome to the Habitat Metrics Ecosystem Monitoring Dashboard

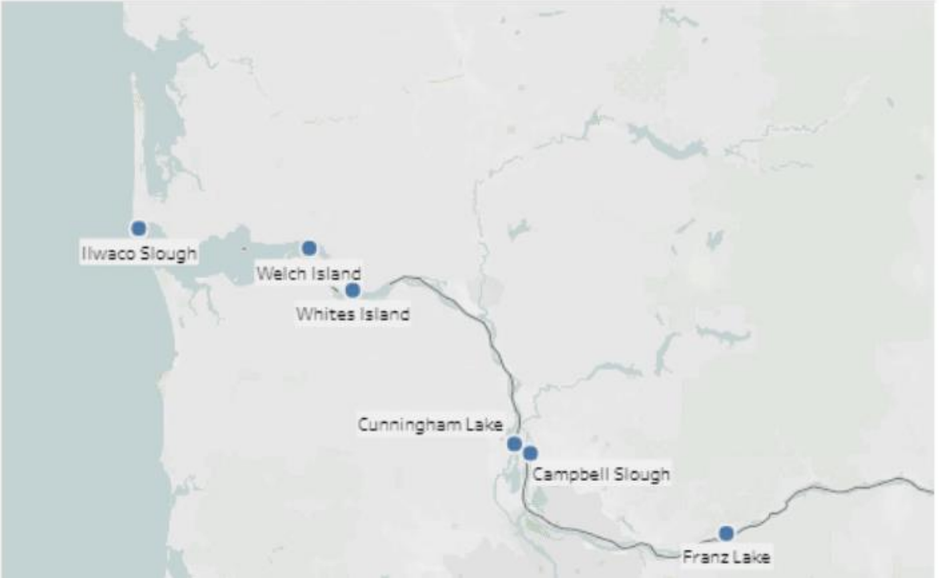
Developed for Bonneville Power Administration
Authors (Lower Columbia Estuary Partnership): Sarah Kidd, Ian Edgar, Sneha Rao

For more information, please contact skidd@estuarypartnership.org

Lower Columbia Estuary Partnership

BONNEVILLE POWER ADMINISTRATION

Overview Map



Navigate through the Habitat Dashboard by Clicking on the Sections Below

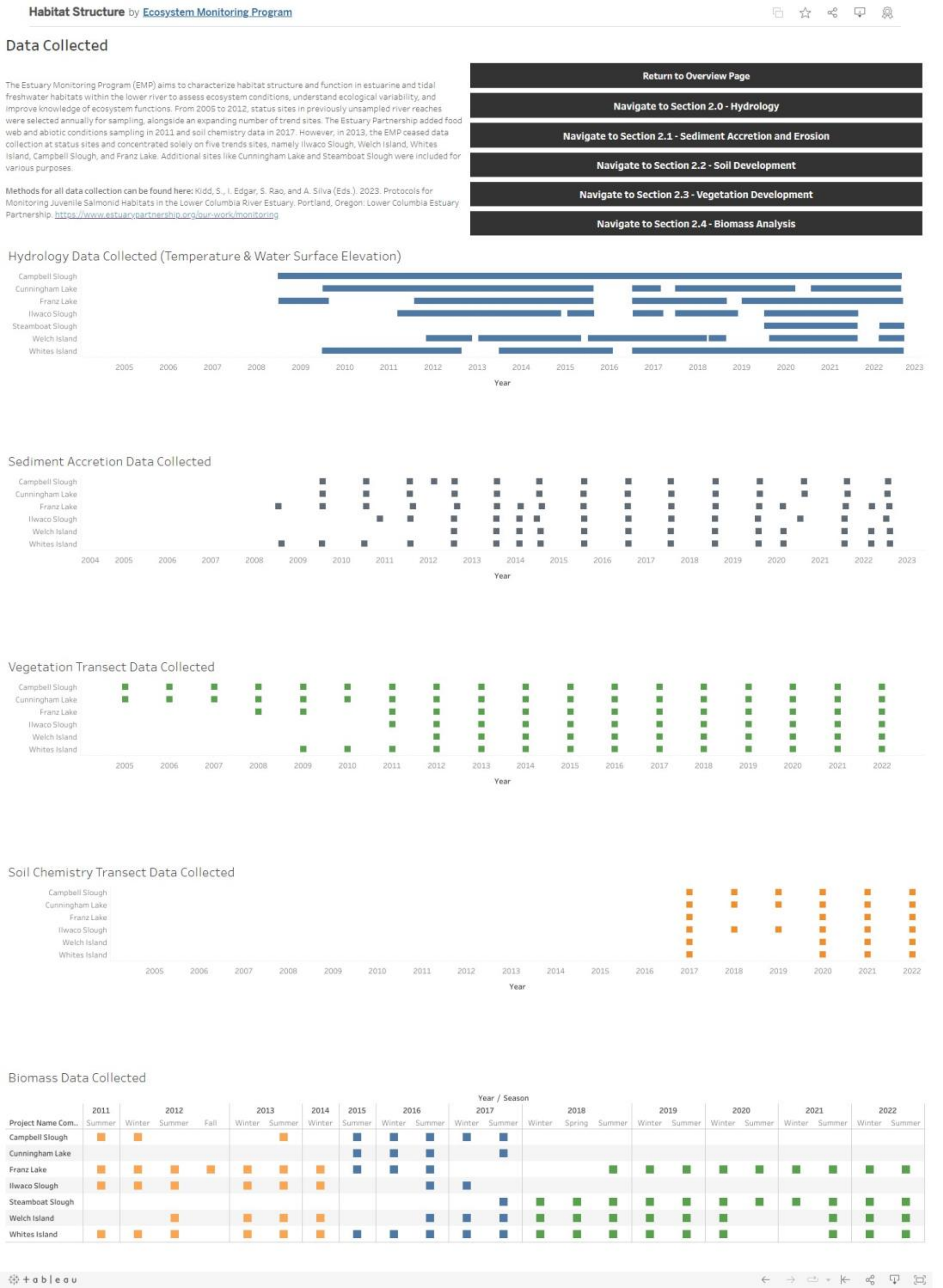
- Navigate to Section 1 - Sampling Effort and Data Inventory
- Navigate to Section 2.0 - Hydrology
- Navigate to Section 2.1 - Sediment Accretion and Erosion
- Navigate to Section 2.2 - Soil Development
- Navigate to Section 2.3 - Vegetation Development
- Navigate to Section 2.4 - Biomass Analysis

Executive Summary

In 2022, habitat conditions remained relatively stable compared to long-term average conditions, with plant cover maintaining consistent abundances across key areas, including Ilwaco Slough, Welch Island, Whites Island, and Franz Lake, adhering to historical, long-term averages. Yet, Cunningham Lake saw an ongoing increase in plant cover, indicating a likely recovery from heavy cattle grazing documented in 2017. Meanwhile, Campbell Slough presented a minor increase in total cover levels this year. Despite this, overall cover at Campbell remains low compared to non-grazed conditions due to persistent cattle grazing since 2017. Previous fencing efforts aimed at mitigating this issue have proven unsuccessful. To aid future analysis and generate data less affected by grazing, we introduced new transects at Campbell Slough in 2021.

In the last decade, the six most common plant species identified throughout the *arundinacea* (non-native), reed canarygrass, *Carex lyngbyei* (native), lyngby sed *Sagittaria latifolia* (native), wapato, *Leersia oryzoides* (native), rice cut grass, ar

https://public.tableau.com/app/profile/ecosystem.monitoring.program/viz/HabitatStructure/WelcometotheHabitatMetricsEcosystemMonitoringDashboard



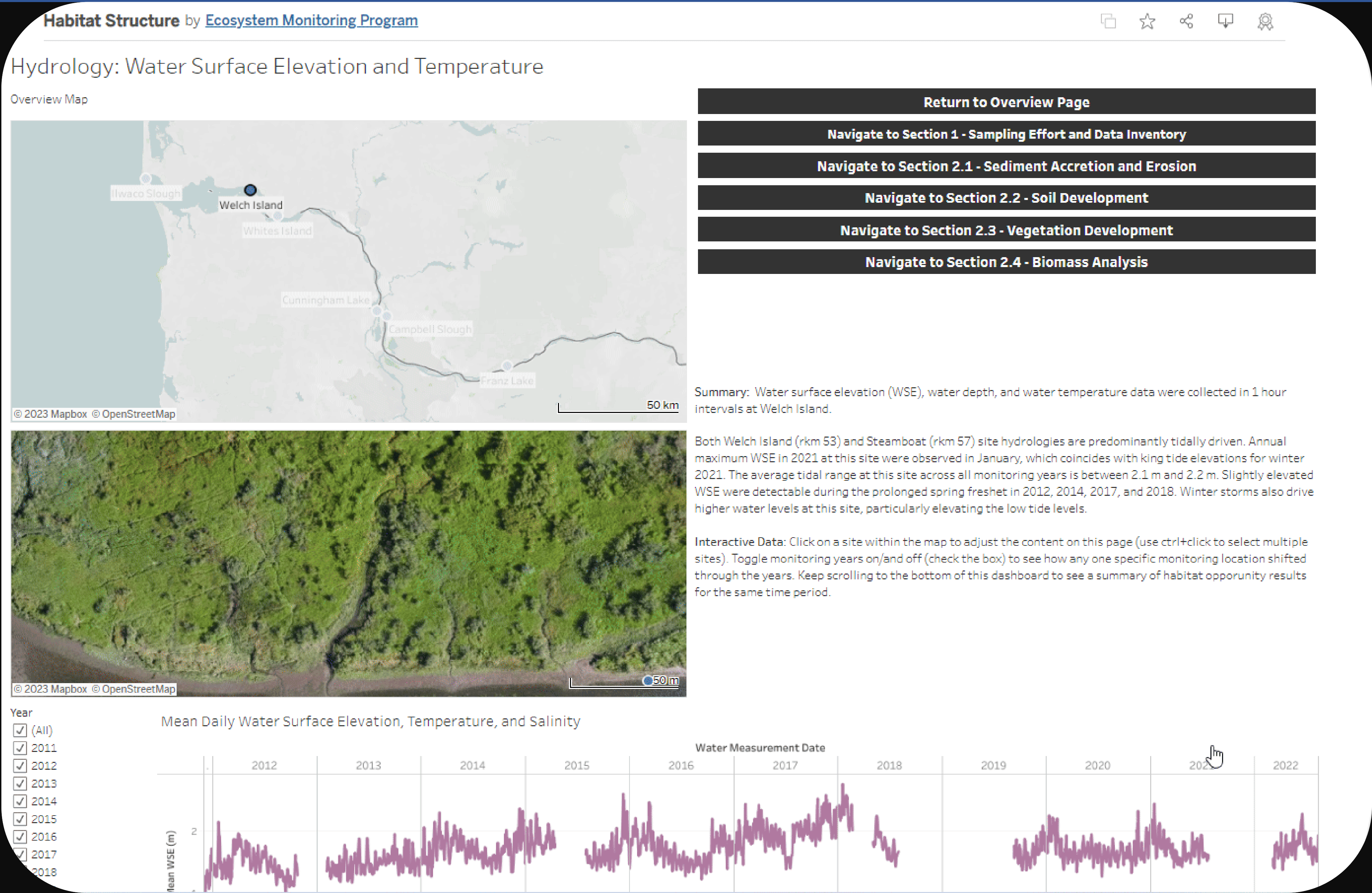
Habitat Structure Data Inventory

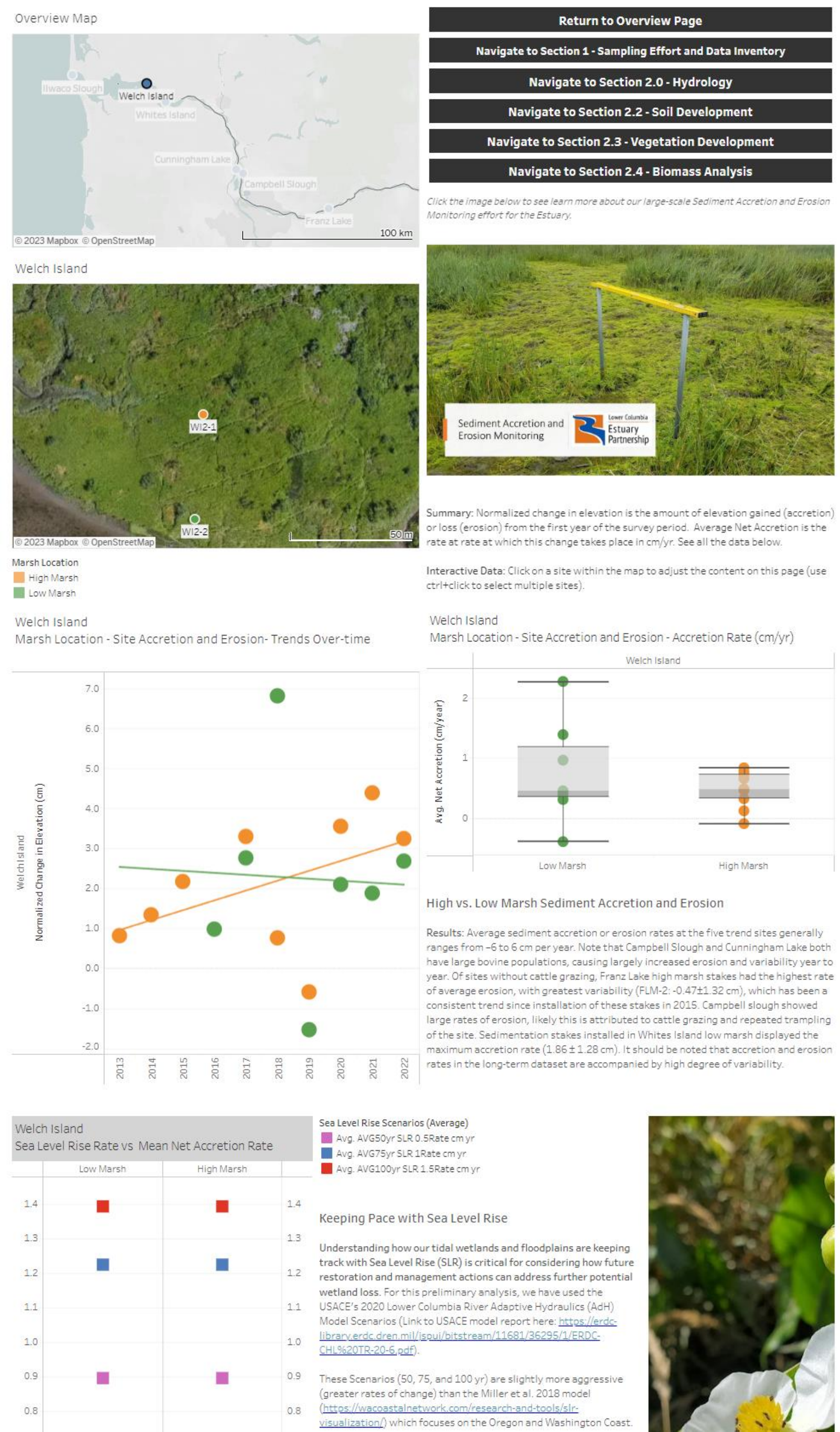
- Metrics include:
  - Hydrology – most data available from 2008. Steamboat slough from 2020
  - Sediment Accretion – consistent measurements from 2012
  - Vegetation Plot data – Campbell and Cunningham data from 2008. Welch Island from 2012.
  - Soil chemistry – included in 2017
  - Biomass (Primary productivity) – inventory shows the evolution of monitoring into the protocol we follow today,

Hydrology dashboard

Key features -

- Hydrographs
- Percent exceedance overlayed on elevation histogram
- Habitat Opportunity Analysis





Sediment Accretion Dashboard

Key features –

- Interactive map of sites – toggle between sites to see net accretion rates in high and low marsh areas.

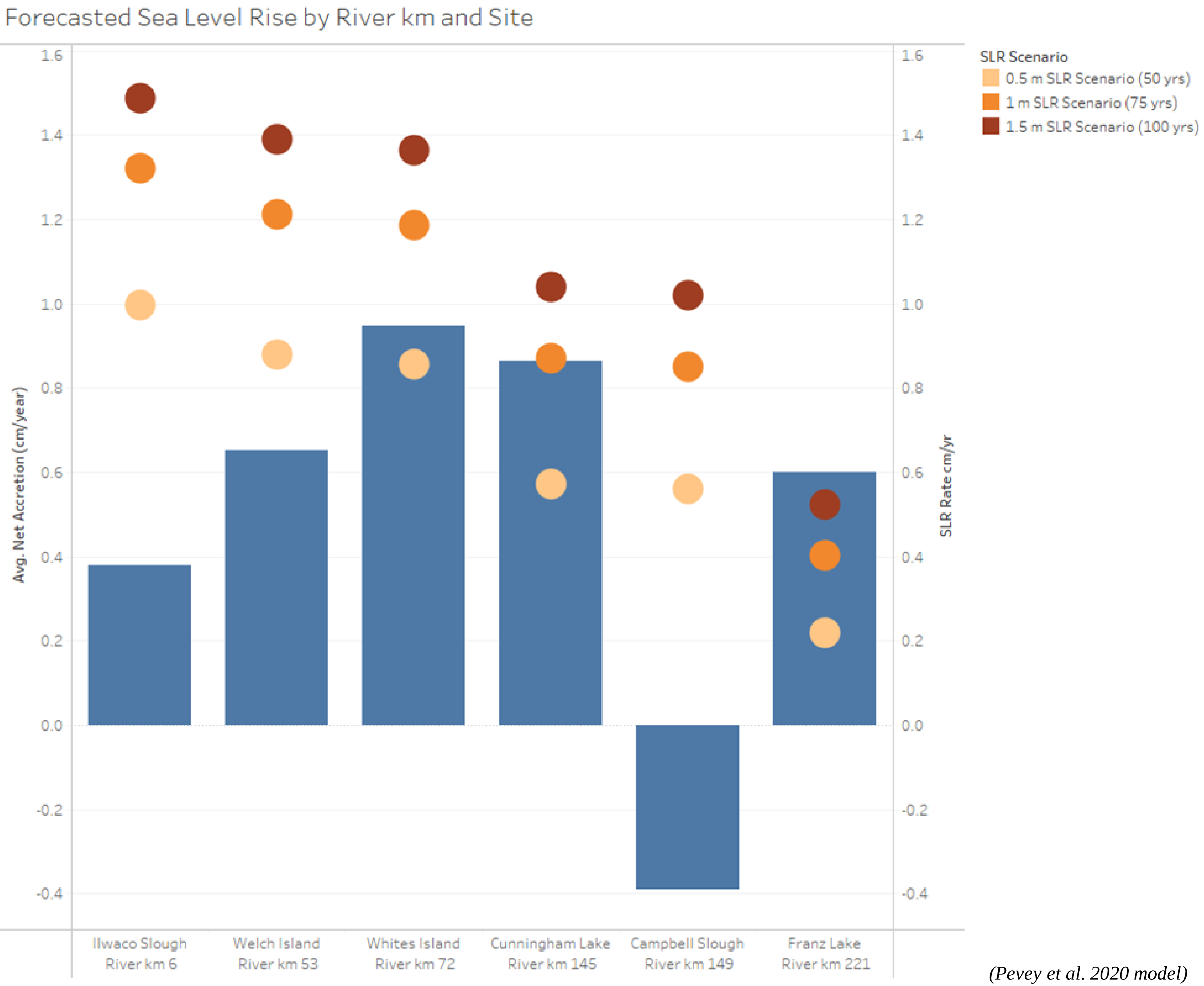
  Cntrl+click allows the selection of multiple sites.

- Location of sed benches at the site.

- Comparison of net accretion rates with USACE Army Corps SLR Scenarios

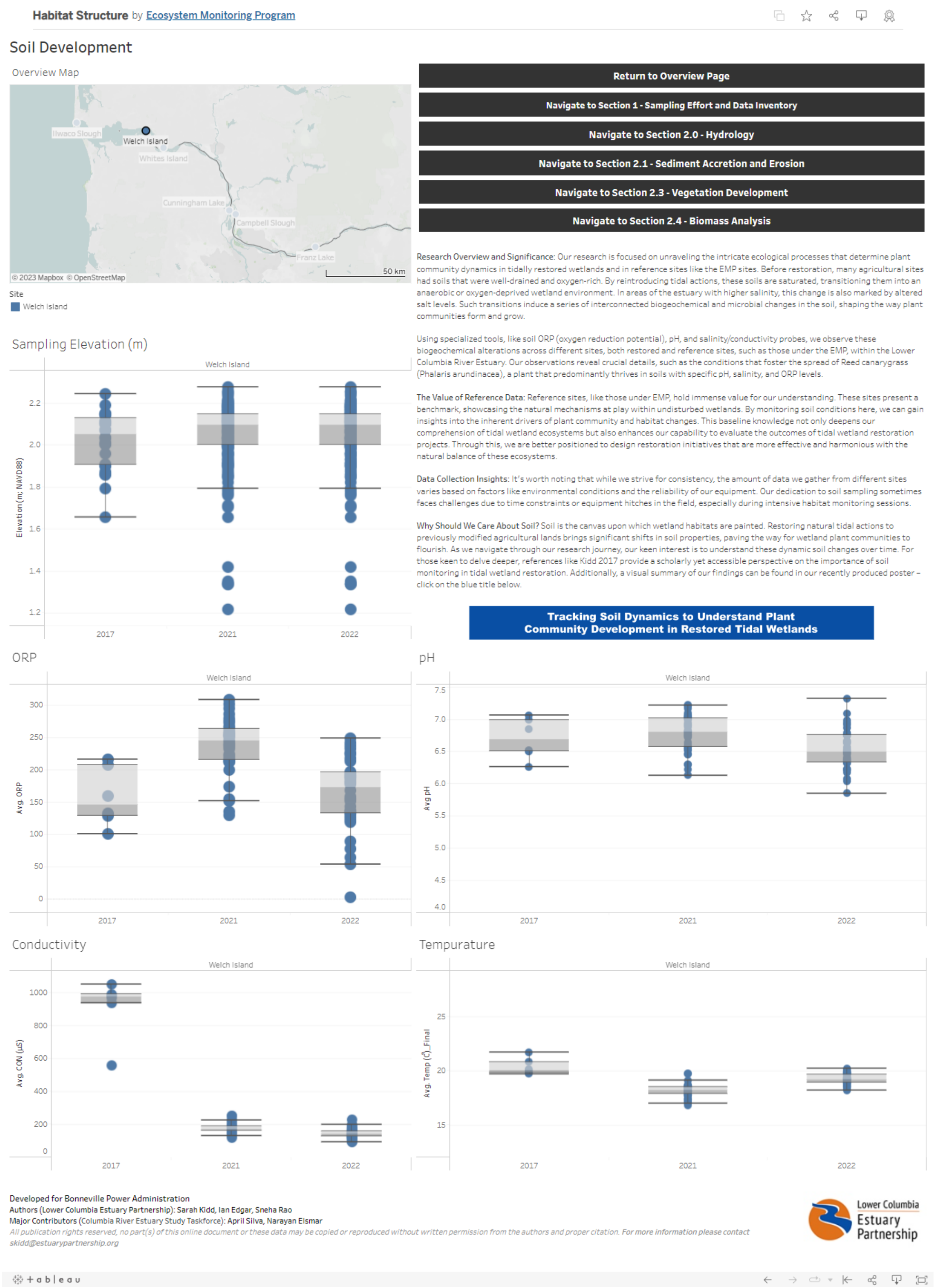
Trends in sediment accretion and erosion and Implications of SLR in tidal wetlands of the LCRE

- Net Accretion/Erosion rates of trend sites were compared to Sea Level Rise Scenarios.
- USACE's 2020 Lower Columbia River Adaptive Hydraulics (AdH) Model Scenarios
- Each site, except for Franz Lake, is accreting slower than the most extreme forecasted sea level rise scenarios.



(Pevey et al. 2020 model)

Soil Development Dashboard



- **Key features –**
  - Interactive map of sites – toggle between sites to see various soil parameters.
  - Data collection since 2017, available for 2017, 2018, 2021, 2022.
  - Opportunity to understand the biogeochemical template required for successful native plant community establishment.
  - Link to poster showing results of soil monitoring

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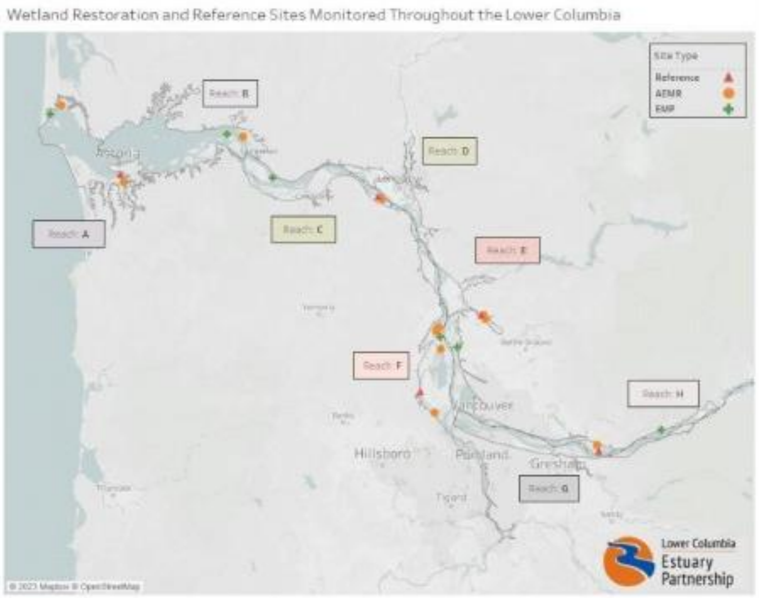
Abstract

Through monitoring soil conditions, this research aims to help us better understand the ecological mechanisms driving plant community development within tidally restored wetlands. Pre-restoration agricultural sites typically consist of well-drained soils with high oxygen concentrations. Reintroducing tidal flooding saturates the soil, creating an anaerobic wetland environment. In more saline sections of the estuary, this shift in soil oxygen levels is also accompanied by a shift in salinity. The restoration of these tidal wetland dynamics causes a cascade of biogeochemical and microbial reactions in the soil—ultimately affecting plant community establishment. In this study, we monitor these biogeochemical changes using in-situ soil ORP (oxygen reduction potential), pH, and salinity probes across multiple restoration and reference sites throughout the Lower Columbia River Estuary. These data provide insight into factors that drive the continued dominance and spread of Reed canarygrass (*Phalaris arundinacea*). In contrast to successful native plant communities, Reed canarygrass (*Phalaris arundinacea*) was found to thrive primarily in soil with lower pH and salinity values, and higher ORP levels. The results and methods developed from these soil monitoring efforts can be used to guide continued native plant community restoration and adaptive management efforts throughout the estuary.

Why Monitor Soil?

- Soil is a fundamental component of ecosystem structure and function. In wetlands, it drives essential functions such as nutrient retention, seed germination, and plant growth.
- Wetland restoration, including reintroducing or shifting flooding regimes, dramatically alters soil conditions.
- These soil changes form a new template for wetland plant community development.
- Monitoring these soil transitions allows us to better understand and manage this plant community development.
- This understanding guides more effective and resilient wetland restoration efforts.



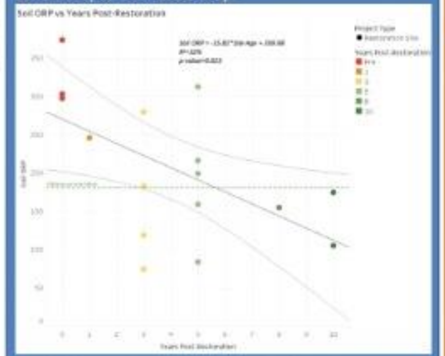
Soil Parameters Measured

Oxygen Reduction Potential (ORP): Indicates the shift from oxygen-rich, well-drained pre-restoration soil to anaerobic, waterlogged post-restoration soil.

pH: Influences nutrient availability and microbial activity, impacting plant growth and community composition. Reed canarygrass thrives in lower pH soils.

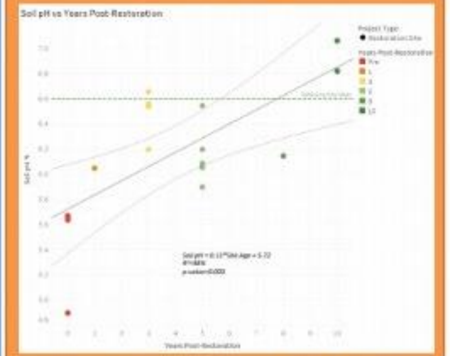
Salinity: Critical in estuary environments as it directly affects plant growth, species composition, and diversity. Shifts in salinity influence plant community responses and adaptations.

Hypothesis 1: The Oxygen Reduction Potential (ORP) in the soil is expected to decrease significantly after the reintroduction of tidal flooding. This shift from a high to low ORP will mark the transition from an oxygen-rich, well-drained soil environment to an anaerobic, waterlogged condition typical of wetland ecosystems. Consequently, we anticipate a corresponding decrease in the prevalence of Reed canarygrass (*Phalaris arundinacea*), a species known to thrive in higher ORP conditions, as ORP levels drop.



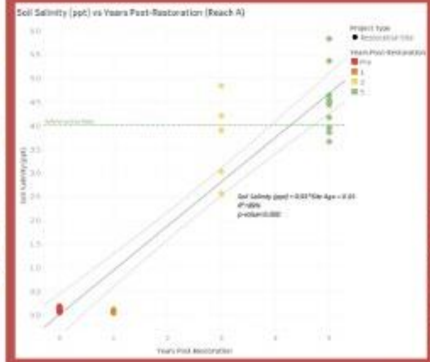
The findings of our study confirm the hypothesis that the Oxygen Reduction Potential (ORP) in the soil significantly decreases after the reintroduction of tidal flooding ($P = 0.023$), above, and below are significantly Correlated with a drop in Reed canarygrass abundance ($p<0.001$). This marked shift from high to low ORP underscores the successful transition from an oxygen rich, well-drained soil environment to an anaerobic, waterlogged condition typical of wetland ecosystems.

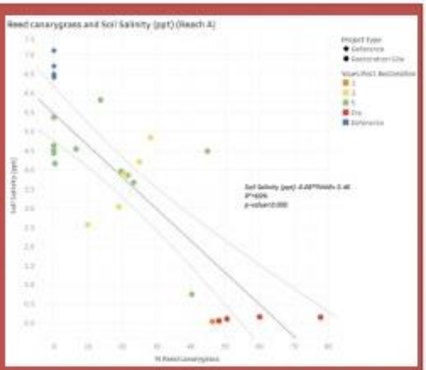
Hypothesis 2: The pH of the soil may increase, especially in areas exposed to prolonged flooding, after tidal flooding is reintroduced. This shift, potentially driven by changes in biogeochemical processes and microbial activity in a waterlogged, anaerobic environment, may be influenced by site-specific conditions such as initial soil properties and the type of vegetation present. An increase in soil pH is expected to negatively correlate with the cover of Reed canarygrass (*Phalaris arundinacea*), an invasive species found to thrive in lower pH soils and drier conditions.



Our research results substantiate the hypothesis that soil pH increases after the reintroduction of tidal flooding, particularly in areas exposed to prolonged flooding [$P < 0.003$]. Importantly, we observed a negative correlation between increased soil pH and Reed canarygrass (*Phalaris arundinacea*) cover, supporting the assertion that this invasive species thrives in lower pH soils and drier conditions.

Hypothesis 3: In Reach A, as salinity increases due to the reintroduction of tidal flooding, we anticipate a shift in plant communities. Reed canarygrass (*Phalaris arundinacea*), a species favoring lower salinity conditions, may decline. Conversely, native wetland species, which are adapted to higher salinity conditions, may become more dominant.



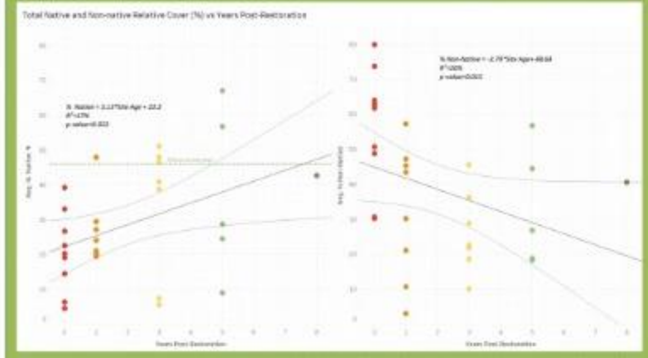


The data from our study robustly support the hypothesis that an increase in salinity triggers a shift in plant communities [$P < 0.01$]. We observed a noticeable decline in Reed canarygrass (*Phalaris arundinacea*), which prefers lower salinity conditions. Concurrently, native wetland species, adapted to higher salinity conditions, showed increased dominance, highlighting the critical role of salinity in influencing plant community composition in restored tidal wetlands.

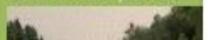
Hypothesis 4: Changes in soil parameters, including oxygen availability (as indicated by ORP), pH, and salinity, are expected to impact plant community composition in the restored wetland. As these soil conditions shift, it can lead to changes in microbial community composition and activity, influencing nutrient cycling processes, and consequently, the dynamics and development of plant communities.


Steigerwald, Restored 2022

Our research supports the hypothesis that wetland restoration significantly alters soil conditions, which in turn impact plant community dynamics. soil conditions in the restoration process.



Notably, non-native species such as Reed canarygrass (*Phalaris arundinacea*) decline, while native emergent wetland species like Wapato (*Sagittaria latifolia*) increase post-restoration. The provided figures collectively underscore these findings, highlighting the importance of understanding site-specific soil conditions in the restoration process.



Plant Community Development Dashboard

Habitat Structure by Ecosystem Monitoring Program

Plant Community Development

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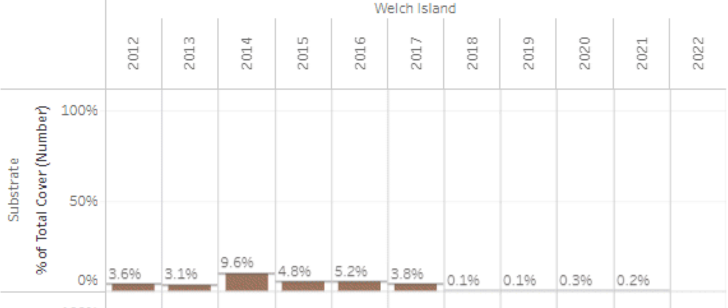
Summary: At each site, we surveyed vegetation cover and composition. This assesses changes to habitat structure related to restoration actions. Vegetation cover and composition is an indicator of the production of organic matter and the detritus produced by decaying vegetation forms the base of the food web for many species in the lower Columbia River and estuary (Borde et al. 2010, Maier and Simenstad 2009). Vegetation plot elevation was recorded to track the influence of marsh elevation on invasive vegetation abundance, local hydrology and native plant species growth.

Vegetation surveys across the estuary sites reveal stable plant cover in most locations, though Cunningham Lake shows recovery from past cattle grazing. Over a decade, six primary species, including the non-native *Phalaris arundinacea* and natives like *Carex lyngbyei*, dominate the estuary. Growth patterns for these plants correlate with the Columbia River's discharge levels, affecting their dominance. For instance, *C. lyngbyei* thrives in high discharge years at Ilwaco Slough due to lower salinity. In contrast, *S. latifolia* and *P. amphibium* display delayed growth responses. Further analysis comparing hydrology, biomass, soil conditions, and plant cover dynamics across sites is underway.

Welch Island Relative Cover by Habitat Type



Welch Island Relative Cover by Species and Status

Cover of species and substrate common across EMP sites

	Longterm Avg	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Carex lyngbyei	59.7%	58.0%	57.0%	58.5%	58.0%	62.1%	64.9%	63.4%	48.2%	53.2%	61.7%
open water	7.9%	0.2%	1.2%	9.4%	10.7%	6.2%	8.2%	3.3%	21.3%	8.1%	12.0%
Phalaris arundinacea	10.3%	10.7%	16.8%	13.4%	9.1%	11.0%	7.7%	10.1%	7.7%	10.0%	11.0%
bare ground	4.9%		0.5%	0.7%	0.2%	0.2%	6.5%	8.0%	7.6%	16.1%	5.6%
Eleocharis palustris	6.9%	15.3%	8.9%	4.4%	9.3%	7.0%	7.6%	6.0%	4.9%	4.9%	3.2%
Sagittaria latifolia	7.5%	10.7%	9.4%	11.4%	7.6%	6.6%	4.5%	7.9%	8.6%	6.5%	5.2%
Ludwigia palustris	0.1%										

Key features –

- Toggle between sites on the map to see the locations of survey grids and plant cover.
- Shannon diversity index across all sites and survey years

Biomass Analysis Dashboard

Key features

- Sampling locations by site
- Dry weights by species and living/dead
- Chemical compositions of dominant species

Publications and Data Synthesis

Transitioning into a hybrid report

Update on Manuscripts In-prep:

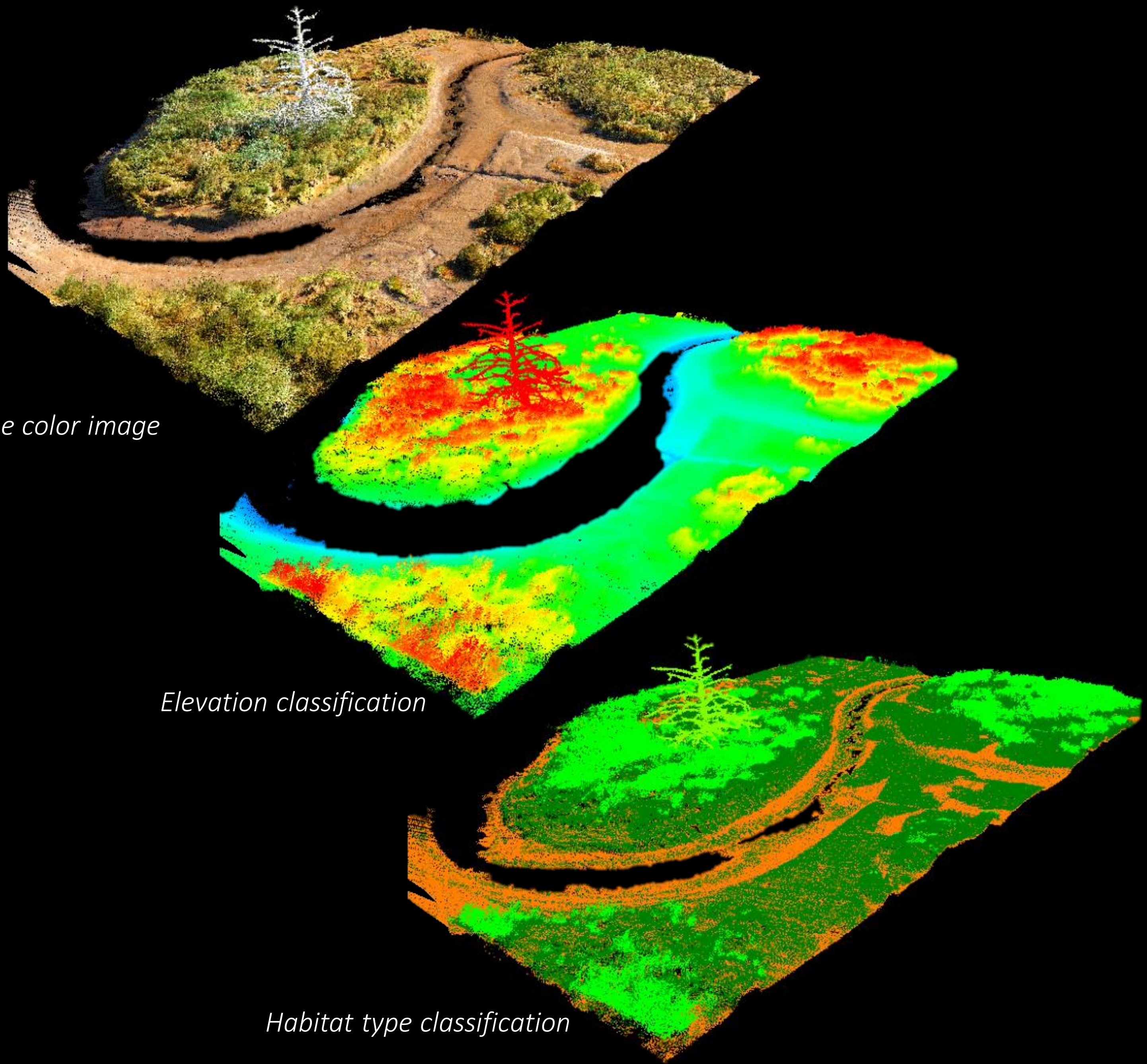
- *Multispectral UAV Data for Wetland Plant Community Mapping: Predicting and Evaluating Restoration Impacts: A case study of Wallooskee - **published online***
- *Ecological implications of restored tidal wetland topographic heterogeneity. - Wallooskee Mound Study*
- *Ecological drivers of Reed canarygrass dominance across the lower Columbia River Estuary*
- *Trends in sediment accretion and erosion in tidal wetlands of the LCRE*
- *Implications of SLR on sediment dynamics in wetlands of LCRE*
- *Trends in wetland plant biomass and detritus quality in the tidal wetlands of the CRE*

What's Next?

- Synthesis of long-term habitat status and trends data in Tableau
- Further investigations of wetland plant community and biomass dynamics and their relationship to annual and seasonal river discharge, WSE, salinity, soil conditions, etc.
- Multispectral and LiDAR Drone Image Analysis for site-wide vegetation and salmon habitat opportunity models

Stay tuned..

Salmon Opportunity in the CRE: applications with multispectral and high-density LiDAR UAV data



True color image

Elevation classification

Habitat type classification

- **755 million points within the LiDAR point cloud**
- **2.5 million points in True color image**
- **Point density of 850 points per square meter**
- **Accuracy of 3cm vertical, 2.5cm horizontal**

Wallooskee-Youngs 2023 LiDAR Flight

2023 Field Crew: Sarah Kidd, Ian Edgar, Derek Marquis, Andrea Hurzeler, Max Stecher, April Silva, Narayan Elasmar, Jodi Reed, Kim Biofra

Thank you! Questions?