RESEARCH PARTNERS

THANK YOU

April Silva, CREST
OVERVIEW

- Action Effectiveness Monitoring and Research Status
  - Programmatic AEMR
  - Sites 2019, 2020, 2021
- 2019 Results Highlight

- Group Discussion
COLUMBIA ESTUARY ECOSYSTEM RESTORATION PROGRAM (CEERP) OBJECTIVES:

1. Increase the capacity (quality) of estuarine and tidal-fluvial ecosystems
2. Increase the opportunity for access by aquatic organisms to and for export of materials from shallow water habitats
3. Improve ecosystem realized functions for juvenile salmonids
**Action Effectiveness Monitoring Levels**

**Level 1 – Intensive**
E.g. fish density, growth, genetics, diet
Duration: variable lengths of monitoring

**Level 2 – Extensive**
E.g. channel cross-sections, salmonid prey, plant species composition
Duration: Pre, Years 1, 3, 5*, 10, Fish check-in at year 5

**Level 3 – Basic (or Standard) Measurements**
E.g. water surface elevation, water temperature, sediment accretion, photo points
Duration: Pre through 5 yrs., 10 yrs

# Restoration Projects

# Monitored Metrics

---

$\text{\$\$\$\$}$

$\text{\$\$\$}$

$\text{\$\$}$

$\text{\$\$\$}$
COMMON GOALS

• Plant community development
  • Native plant community recovery

• Tidal hydrology
  • No longer restricted by dikes or tide gates

• Sediment and channel dynamics
  • Tidal wetland sediment erosion/accretion and channel and floodplain development and maintenance (SLR, Carbon dynamics, etc.)

• Macroinvertebrate and Salmonid food web dynamics
  • Conditions which foster salmonid utilization and sustainable food web interactions (such as flux of detritus and macros into the mainstem)

LEVEL 2 & 3 OVERARCHING QUESTION: HOW ARE RESTORATION SITES DEVELOPING OVER TIME COMPARED TO REFERENCE WETLANDS (IDEAL) AND GOAL (PLANNED) CONDITIONS?

Wallooskee, Year 3, Cowlitz Tribe
RESULTS 2019: ACTION EFFECTIVENESS MONITORING AND RESEARCH

Wallacut, Year 3, CLT

NU2: Millionaire, Year 5, CREST

NU2: Deep Widgeon, Year 5, CREST

Steamboat Slough, Year 5, USACE

Steigerwald, Pre, LCEP

RESULTS 2019: ACTION EFFECTIVENESS MONITORING AND RESEARCH

Wallacut, Year 3, CLT
NU2: Millionaire, Year 5, CREST
NU2: Deep Widgeon, Year 5, CREST
Steamboat Slough, Year 5, USACE
Steigerwald, Pre, LCEP

OVERVIEW 2020: ACTION EFFECTIVENESS MONITORING AND RESEARCH

- Looking great! Abundant native recovery at Wallooskee, Year 3, Cowlitz Tribe.
- Progress slow and hard to access due to heavy mowing at Flights End, Year 3, CREST & ODFW.

- Shrub-scrub plantings doing well at Steigerwald, Pre, LCEP.
- Low marsh zones dense with Wapato at La Center Wetlands, Year 5, LCEP.
- Reed canarygrass abundant in high marsh at La Center Wetlands, Year 5, LCEP.
PLANNING 2021: ACTION EFFECTIVENESS MONITORING AND RESEARCH

Wallacut, Year 5, CLT

West Sand Island, Year 1, CREST

NU1: Ruby Lake, Year 8, CREST

John Palensky, Pre, CREST

Steigerwald, Construction, LCEP
RESEARCH QUESTION: WHAT IS THE PROGRESS OF NATIVE PLANT COMMUNITY RESTORATION?

Major Drivers of Plant Community Distributions and Recovery:

• Flooding Frequency and Duration (site elevations and hydrology)
• Salinity (flood waters and soil)
• Soil Conditions (flooding, scrape down, existing conditions)
• Existing Plant Community (resistance to change, Reed canarygrass, Common Rush, etc.)
• Available Seed Bank
• Ongoing Management (such as grazing, mowing, plantings, and spraying herbicides)
Wallacut Slough is in Bakers Bay. The reference Site is Ilwaco Slough, which is also an Ecosystem Monitoring Program (EMP) site.

In 2016, Wallacut Slough network was restored through the removal of barriers and channel enhancements. Data collection started in 2014.

Current management includes active treatment of invasive species (gorse, thistle, and yellow flag iris)
Data Collected, 2014-2019, 2021:
✓ Plant Community
✓ RTK Elevations
✓ Water Depth & Temperature
✓ Sediment Accretion and Erosion & Channel Cross-Sections
✓ Soil pH, Salinity, ORP (2019, 2021)
✓ RGB and NIR Orthomosaics, Digital Surface Model (2019, 2021)
✓ 5 Year Fish and Macro check-in (2021)
Wallacut Restoration Site
3 yrs. Post Restoration (Current Conditions)
Drone Imagery (2019)

THANKS NARAYAN ELASMAR!
WALLACUT RESTORATION SITE
3 yrs. Post Restoration (Current Conditions)
Drone Imagery (2019)

INTENSIVE VEG MONITORING AREAS
- Wallacut Mouth
- Wallacut Upper
- WSE Loggers
**Elevation Histogram (Based on Veg Transects)**

**Habitat - Key Points**

- Elevation range of **Wallacut Mouth and Upper** are similar and primarily Mid- to High Marsh.

- Elevation of the **Reference site (Ilwaco Slough)** is much **lower**, Mid- to Low Marsh in elevation.

- Restored slough hydrograph mirrors reference site

- **Important to keep these differences in mind while reviewing results**
WALLACUT RESTORATION SITE
3 yrs. Post Restoration (Current Conditions)
Drone Imagery (2019)

INTENSIVE VEG MONITORING AREAS
- Wallacut Mouth
- Wallacut Upper

2019 VEG MONITORING RESULTS
Dominant Plant Community Characterizations
- Mixed non-natives, standing dead, and bareground
- Mixed native plant community
**INTENSIVE VEG MONITORING AREA RESULTS**

**Native Relative Cover (%)**

**Dominate Natives**
Reference: Lyngby sedge, *Carex lyngbyei*

**Dominate Non-natives**
Wallacut: Reed canarygrass, *Phalaris arundinacea*, & Creeping bentgrass, *Agrostis stolonifera*
Reference: Creeping bentgrass, *Agrostis stolonifera*
**INTENSIVE VEG MONITORING AREA RESULTS**

**Native Relative Cover (%)**

*Dominate Natives*
- **Reference**: Lyngby sedge, *Carex lyngbyei*

**Non-native Relative Cover (%)**

*Dominate Non-natives*
- **Wallacut**: Reed canarygrass, *Phalaris arundinacea*, & Creeping bentgrass, *Agrostis stolonifera*
- **Reference**: Creeping bentgrass, *Agrostis stolonifera*

*Years Post-Restoration: 0, 1, 3*
Reed canarygrass, *Phalaris arundinacea*, Non-native

**INTENSIVE VEG MONITORING AREA RESULTS**

Years Post-Restoration

<table>
<thead>
<tr>
<th>Years Post-Restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

Standing Dead and Bareground

Reed canarygrass

Relative Cover (%)

- **Wallacut Mouth**
- **Wallacut Upper**

Reference Long-term Mean
### Baltic Rush, *Juncus arcticus*, Native

#### Intensive Veg Monitoring Area Results

<table>
<thead>
<tr>
<th>Years Post-Restoration</th>
<th>0</th>
<th>1</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relative Cover (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Wallacut Mouth**: 
  - 2014: 0%
  - 2015: 0%
  - 2016: 0%
  - 2017: 20%
  - 2018: 30%
  - 2019: 33%

- **Wallacut Upper**: 
  - 2014: 0%
  - 2015: 0%
  - 2016: 0%
  - 2017: 5%
  - 2018: 10%
  - 2019: 15%

- **Reference Long-term Mean**: 

<table>
<thead>
<tr>
<th>Year</th>
<th>Baltic Rush</th>
<th>Pacific silverweed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pacific silverweed, *Argentina egedii*, Native

![Graph showing the relative cover of Pacific silverweed over years post-restoration](image)

**Graph Key**
- **Wallacut Mouth**
- **Wallacut Upper**
- **Reference Long-term Mean**

**Legend**
- **Years Post-Restoration**
  - 0
  - C
  - 1
  - 3

**Graph Details**
- The graph illustrates the relative cover (%) of Pacific silverweed over the years post-restoration.
- The data is collected from two sites: Wallacut Mouth and Wallacut Upper.
- The reference long-term mean is shown as a horizontal line.

**Notes**
- The graph shows an increase in relative cover from 2014 to 2019, particularly noticeable at Wallacut Mouth.
- The years C, 1, and 3 represent specific data points indicating recovery trends over time.
**Soil Conditions: Wallacut Slough, 3 Years (2019) Post-Restoration**

- **Soil Salinity**
  - Reference: 5.9
  - Wallacut Mouth: 2.2
  - Wallacut Upper: 1.1

- **Soil pH**
  - Reference: 6.6
  - Wallacut Mouth: 6.2
  - Wallacut Upper: 5.9

Soil conditions such as Salinity and pH can be slow to respond to the reintroduction of flooding. Slightly more soil response observed at the Mouth than in the Upper monitoring area.
SOIL CONDITIONS: WALLACUT SLOUGH, 3 YEARS (2019) POST-RESTORATION

• Post-restoration soil conditions such as Salinity and pH can be slow to respond to the reintroduction of flooding
• Slightly more soil response observed at the Mouth than in the Upper monitoring area

2019 VEG MONITORING RESULTS
Dominant Plant Community Characterizations
- Mixed non-natives, standing dead, and bareground
- Mixed native plant community
**Soil Conditions: Wallacut Slough, 3 Years (2019) Post-Restoration**

### Soil ORP

- **Soil Oxygen Reduction Potential (ORP):**
  - Essential a measure of how waterlogged/saturated the soil is and how long that has been (lower ORP = saturated longer).
  - Elevated Soil ORP conditions reflect how Wallacut is primarily Mid-Upper Marsh while the Reference (Ilwaco) is Low Marsh.
  - Upper monitoring area may receive less frequent flooding (higher ORP) which would also explain slower soil Salinity and pH responses.

---

**2019 Veg Monitoring Results**

**Dominant Plant Community Characterizations**

- Mixed non-natives, standing dead, and bareground
- Mixed native plant community

---

**Wallacut Slough Monitoring Sites:**

- Wallacut Mouth
- Wallacut Upper
- Reference (Ilwaco)
Elevated Soil ORP conditions reflect how Wallacut is primarily Mid-Upper Marsh while the Reference (Ilwaco) is Low Marsh.
Soil ORP vs. Elevation

- Elevated Soil ORP conditions reflect how Wallacut is primarily Mid-Upper Marsh while the Reference (Ilwaco) is Low Marsh
- We see similar Reed canarygrass thresholds in ORP and Elevation (proxy for flooding) across our other EMP and AEMR sites
- Year 5 data will be illuminating, and further multivariate analysis will be conducted
Wallacut Restoration Site
3 yrs. Post Restoration (Current Conditions)
Classification of Drone Imagery (2019)
Wallacut Restoration Site
3 yrs. Post Restoration (Current Conditions)
Classification of Drone Imagery (2019)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Acers</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>0.4</td>
<td>5</td>
</tr>
<tr>
<td>Native wetland matrix</td>
<td>2.5</td>
<td>29</td>
</tr>
<tr>
<td>Dead veg &amp; bareground</td>
<td>1.6</td>
<td>19</td>
</tr>
<tr>
<td>Reed canarygrass mix</td>
<td>1.2</td>
<td>15</td>
</tr>
<tr>
<td>Trees and shrub-scrub</td>
<td>2.7</td>
<td>32</td>
</tr>
</tbody>
</table>

- 0.25 m² resolution
- Highly accurate (>90%) when cross checked with ground control points for elevation and plant community composition
### Wallacut Restoration Site

**Future Plant Community Development Projections (5-10 yrs.)**

Classification of Drone Imagery (2019)

<table>
<thead>
<tr>
<th>Classification</th>
<th>3 yrs. Post 2019</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>0.4</td>
<td>5</td>
</tr>
<tr>
<td>Native wetland matrix</td>
<td>2.5</td>
<td>29</td>
</tr>
<tr>
<td>Mixed</td>
<td>2.8</td>
<td>34</td>
</tr>
<tr>
<td>Reed canarygrass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trees and shrub- scrub</td>
<td>2.7</td>
<td>32</td>
</tr>
</tbody>
</table>

**Existing Conditions 2019**

Projected Conditions 2021-2026

Projected 2021-2026

3 yrs. Post 2019
WALLACUT RESTORATION SITE
Future Plant Community Development Projections (5-10 yrs.)
Classification of Drone Imagery (2019)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Acers</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>0.4</td>
<td>5</td>
</tr>
<tr>
<td>Native wetland matrix</td>
<td>2.5</td>
<td>29</td>
</tr>
<tr>
<td>Mixed</td>
<td>2.8</td>
<td>34</td>
</tr>
<tr>
<td>Reed canarygrass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trees and shrub-scrub</td>
<td>2.7</td>
<td>32</td>
</tr>
</tbody>
</table>

Projected Conditions 2021-2026

Existing Conditions 2019

3 yrs. Post 2019
WALLACUT RESTORATION SITE
Future Plant Community Development Projections (5-10 yrs.)
Classification of Drone Imagery (2019)

<table>
<thead>
<tr>
<th>Classification</th>
<th>3 yrs. Post 2019</th>
<th>Projected 2021-2026</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acers</td>
<td>%</td>
</tr>
<tr>
<td>Water</td>
<td>0.4</td>
<td>5</td>
</tr>
<tr>
<td>Native wetland matrix</td>
<td>2.5</td>
<td>29</td>
</tr>
<tr>
<td>Mixed</td>
<td>2.8</td>
<td>34</td>
</tr>
<tr>
<td>Reed canarygrass</td>
<td>2.7</td>
<td>32</td>
</tr>
<tr>
<td>Trees and shrub-scrub</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Existing Conditions 2019

Projected Conditions 2021-2026
WALLACUT SLOUGH CONCLUSIONS

- General trajectory is positive towards recovery of native plant community composition across most of the wetland areas

- Recommendation is to potentially reduce herbicide treatments to allow natural plant recovery for several years

- Future adaptive management could entail targeted planting of shrub-scrub species in higher marsh areas

- 2021 – Year 5 monitoring
North Unit Phase 2 - Millionaire and Deep Widgeon Lakes - Sauvie Island. Reference site is Cunningham Lake, which is also an Ecosystem Monitoring Program (EMP) site.

In 2014, water-control structures were removed from both lakes, and wetland scrape downs and berms were strategically located. Data collection started in 2014.

Current management includes heavy cattle grazing.
Data Collected, 2014-2019, 2022, 2024:
✓ Plant Community
✓ RTK Elevations
✓ Water Depth & Temperature
✓ Sediment Accretion and Erosion & Channel Cross-Sections
✓ Soil pH, ORP (2019)
✓ RGB and NIR Orthomosaics, Digital Surface Model (2019)
✓ Fish Community Check-in (2019)
✓ Possible 8 yr. Check-in 2022, 10 yr. in 2024 (sans grazing?)
Two days of sampling within two locations at each site in April 2019.
Chinook salmon were caught at all sampling sites on Millionaire and Widgeon Lakes.

Both marked (adipose fin clip) and unmarked (no adipose fin clip) salmon were caught.

Length frequency of Chinook varied.
Non-salmonid catch details:

- 7 different species were caught in Millionaire Lake
- 9 different species were observed in Deep Widgeon Lake
- 13 different species sampled across both lakes
- 7 species being non-native to the Columbia River.
- Natives: Threespine sticklebacks, redsided shiner, and peamouth were the most observed species at both lakes sampled.
FISH COMMUNITY CHECK-IN (NOAA, 2019): NORTH UNIT PHASE 2, 5 YEARS (2019) POST-RESTORATION

FISH CHECK-IN SUMMARY:

• Results are similar to what we’ve observed at other Sauvie Island restoration sites like North Unit Phase 1: Ruby Lake in 2018

• Results indicate salmonids and other fish species are successfully accessing these restoration sites

• Recommendation, more fish and macro check-ins with similar intensity and scope to those of the EMP reference sites would be helpful to understand the breath of benefits received and salmonid habitat use patterns of these restored wetlands
PLANT COMMUNITY: NORTH UNIT PHASE 2, 5 YEARS (2019) POST-RESTORATION
PLANT COMMUNITY: NORTH UNIT PHASE 2, 5 YEARS (2019) POST-RESTORATION

Pre-Restoration Conditions (Veg Survey 2014)
Google Earth Imagery (2014)
PLANT COMMUNITY: NORTH UNIT PHASE 2, 5 YEARS (2019) POST-RESTORATION

Pre-Restoration Conditions (Veg Survey 2014)
Google Earth Imagery (2014)

5 Years Post-Restoration Conditions (Veg Survey 2019)
Google Earth Imagery (2018)

Scrape down & Berm
Millionaire North

2014 Veg Monitoring Results
Dominant Plant Community Characterizations

Mixed non-natives, standing dead, and bareground

Mixed native plant community

2019 Veg Monitoring Results
Dominant Plant Community Characterizations

Mixed non-natives, standing dead, and bareground

Mixed native plant community
**Plant Community: North Unit Phase 2, 5 Years (2019) Post-Restoration**

**Heavy Grazing Can**

- Slowed recovery of native plant communities and tree/shrub plantings
- Increased non-native species richness (cattle associated weeds)
- Reduces plant biomass and detritus contributions to the salmonid food web

See Kidd & Yeakley 2015 for a review of grazing impacts to Columbia river wetlands: https://goo.gl/urJW8
PLANT COMMUNITY: NORTH UNIT PHASE 2, 5 YEARS (2019) POST-RESTORATION


Deep Widgeon South


Scrape down & Berm

Deep Widgeon North

2014 Veg Monitoring Results
Dominant Plant Community Characterizations

- Mixed non-natives, standing dead, and bareground
- Mixed native plant community

2019 Veg Monitoring Results
Dominant Plant Community Characterizations

- Mixed non-natives, standing dead, and bareground
- Mixed native plant community
DEEP WIDGEON

**Native Relative Cover (%)**

*Dominate Natives*

**Non-native Relative Cover (%)**

*Dominate Non-natives*
North Unit Phase 2 & Reference: Reed canarygrass, *Phalaris arundinacea*, Spotted ladysthumb, *Polygonum persicaria*
• Hydrology of reference site is a good match to both Deep Widgeon and Millionaire
• Bareground, Native, and non-native dominant plant communities are clearly delineated along the wetland's hydrologic gradient/elevation range
**Plant Community: North Unit Phase 2, 5 Years (2019) Post-Restoration**

Elevation Range of Dominant Native and Non-native Plant Communities
2019 – 5 Years Post-Restoration

- Bareground, Native, and non-native dominant plant communities are clearly delineated along the wetland's hydrologic gradient/elevation range.

- **Thresholds may shift depending on annual freshet conditions**

  > 2.7-2.8 m, Common Reed Canarygrass Boundary

  2.8-2.4 m, Native Emergent Zone

  <2.4-2.3 m, Mudflat, Channel Zone
Wetland Elevation vs. Soil ORP

Reference

Elevation, m, NAVD88 vs. ORP (mV)

- **Common spikerush, Eleocharis palustris, Native**
- **Wapato, Sagittaria latifolia, Native**
- **Reed canarygrass, Wapato Mix**
- **Reed canarygrass, Phalaris arundinacea, Non-native**
Common spikerush, *Eleocharis palustris*, Native

Wapato, *Sagittaria latifolia*, Native

Reed canarygrass, Wapato Mix

Reed canarygrass, *Phalaris arundinacea*, Non-native
Elevated Soil ORP conditions reflect how North Unit Phase 2 is primarily Mid-Upper Marsh while the Reference (Cunningham) is Low Marsh.

We see similar Reed canarygrass thresholds in ORP and Elevation (proxy for flooding) across our other EMP and AEMR sites.
CONCLUSIONS

- 5-Year fish check-in indicates salmonid utilize the restored habitat
- Trajectory of native wetland plant community recovery is variable - depending on restored site elevations and grazing intensity
- Future adaptive management could entail:
  - Fencing to prevent cattle grazing in wetland habitats (esp. Millionaire)
  - Targeted planting of shrub-scrub species in high marsh zones
- 2022 – Year 8 monitoring check-in and full site UAV analysis
Steamboat SLough is a restoration site located in the Julia Butler Hansen Refuge, WA. Reference site is Welch Island, which is also an Ecosystem Monitoring Program (EMP) site.

In 2014, tidal influence was restored through the removal of levee barriers throughout the system and the development of a channel network. Data collection started in 2014.

Current management – passive, no herbicide treatments or grazing observed
STEAMBOAT SLough, 5 YEARS (2019) POST-RESTORATION

Data Collected, 2014-2019, 2024:
✓ Plant Community
✓ RTK Elevations
✓ Water Depth & Temperature (2019)
✓ Biomass and Detritus (ongoing EMP study, 2017, 2019)
✓ NO UAV data collection due to current federal restrictions
✓ Level 1 data can be found PNNL and NMFS 2020 AEM report

https://www.webapps.nwfsc.noaa.gov/apex/parrdata/inventory/projets/project/290865

- PIT tag arrays were installed at Welch Island and Steamboat Slough in 2017. Results from Steamboat Slough are available till 2019.
- Salmonids were detected at Welch Island in 2017 and Steamboat in 2017-2019.
- Fall Chinook salmon were the most prevalent stock detected at Steamboat, with the longest residence times.
- Adults were also detected at Steamboat; however, residence times were short.

McNatt et al., 2020, Chapter 4, PNNL and NMFS 2020 AEM report
PLANT COMMUNITY: STEAMBOAT SLOUGH, 5 YEARS (2019) POST-RESTORATION
Pre-Restoration Conditions (Veg Survey 2013)
Google Earth Imagery (2012)

2013 Veg Monitoring Results
Community Characterizations
Mixed non-natives, standing dead, and bareground
Mixed native plant community

Dominant Plant

Mixed non-natives, standing dead, and bareground
Mixed native plant community
**HABITAT- KEY POINTS**

- Hydrology of restoration site mirrors that of the reference site.

- Elevation range of **Steamboat slough West** is higher than **East**, both East and West are generally lower in elevation than the reference site (Welch Island).
**Native Relative Cover (%)**

**Dominate Natives**
Steamboat: Wapato, Sagittaria latifolia, Nodding beggar-ticks, Bidens cernua,
Reference: Lyngby sedge, Carex lyngbyei, Water parsley, Oenanthe sarmentosa

**Non-native Relative Cover (%)**

**Dominate Non-natives**
Steamboat: Reed canarygrass, Phalaris arundinacea, Soft rush, Juncus effuses
Reference: Reed canarygrass, Phalaris arundinacea, Common forget-me-not, Myosotis scorpioides

---

**Years Post-Restoration**


0, C, 1, 3, 5
INTENSIVE VEG MONITORING AREA RESULTS

Bareground and Standing Dead (%)

<table>
<thead>
<tr>
<th>Years Post-Restoration</th>
<th>0</th>
<th>C</th>
<th>1</th>
<th>3</th>
<th>5</th>
</tr>
</thead>
</table>

- Steamboat East
- Steamboat West

Reference Long-term Mean

Steamboat East (2019)

Steamboat West (2019)
Reed canarygrass, *Phalaris arundinacea*, Non-native

**INTENSIVE VEG MONITORING AREA RESULTS**

**Steamboat East (2019)**

**Steamboat West (2019)**

Relative Cover (%)

- Steamboat East
- Steamboat West

Reference Long-term Mean

Years Post-Restoration

<table>
<thead>
<tr>
<th>0</th>
<th>C</th>
<th>1</th>
<th>3</th>
</tr>
</thead>
</table>
INTENSIVE VEG MONITORING AREA RESULTS

Wapato, Sagittaria latifolia, Native

Steamboat East (2019)

Steamboat East (2019)

Wapato, Sagittaria latifolia, Native

Steamboat East (2019)

Wapato, Sagittaria latifolia, Native

Steamboat East (2019)

Wapato, Sagittaria latifolia, Native

Steamboat East (2019)
Nodding beggars-ticks, *Bidens cernua*, Native

INTENSIVE VEG MONITORING AREA RESULTS

<table>
<thead>
<tr>
<th>Years Post-Restoration</th>
<th>Steamboat East</th>
<th>Steamboat West</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2014</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2015</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2016</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2017</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>2018</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Zonation clear at the reference site, still developing at the restoration site
Steamboat Slough Conclusions

- Robust wetland soil and native plant community development
- Ecosystem Monitoring Program Study: Biomass and soil characteristics at reference levels by 3 years post-restoration (Kidd et al. 2019)
- Level 1 PNNL and NMFS (2020) Fish and Flux Studies: show high productivity at the site with both fish use and macro/detritus flux 3-5 years post-restoration
- 2024 – Year 10 monitoring check-in and (hopefully) full site UAV analysis
**NEXT STEPS**
**MONITORING/RESEARCH**

- Consistently incorporate UAV veg and soil conditions monitoring into all Level 2 data collection
- UAV general photo monitoring recommended for all sites (Level 1-3)
- Increase number and distribution of sed benches/pins across sites
- Monitor water salinity at Wallacut
- Monitoring Protocols Update (Fall 2021) (link)

**RESTORATION TRAJECTORIES - ADAPTIVE MANAGEMENT SUGGESTIONS**

- Reduce herbicide treatments at Wallacut
- Reduce grazing intensity at North Unit Phase 2
THANK YOU!

QUESTIONS?

SWG Group Discussion

• What thresholds and endpoints are we looking for to determine if more restoration or monitoring is needed?
  ➢ Project Design
  ➢ Frequency of Monitoring

• How should we better incorporate monitoring data into an adaptive management framework?
  ➢ Site topography and hydrology
  ➢ Wetland plant community
  ➢ UAV Technology
  ➢ Fish and Macroinvertebrate Sampling
Additional Efforts – Monitoring Protocols Update

- 2018 & 2019 - Provided Update to WSE/Temp Monitoring

- 2020 – Provided Update to Sediment Accretion Monitoring, Soil Monitoring, Channel Cross-Sections
  - April Silva (CREST) started drafting an *updated Protocol Document* incorporating some of these updates

- 2021
  - Winter-Summer: Continue to Update the New DRAFT Protocols
  - Fall: Distribute Draft Protocols for Comment