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Three birds with one stone: Tidal wetland restoration, carbon sequestration, and enhancing resilience to rising sea levels in the Snohomish River Estuary, Washington

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Speaker
John Rybczyk, Steve Crooks, Danielle Devier, Steve Emmett Mattox, Nathan Moore, Keeley O'Connell, Katrina Poppe, and Nelson Salisbury

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Three birds with one stone:
Tidal wetland restoration, carbon sequestration, and enhancing resilience to rising sea levels in the Snohomish River Estuary, Washington

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2. Restore America's Estuaries, Arlington, VA, United States.
3. Earth Corps, Seattle, WA, United States.
Pre-Settlement (1861)

- 4000 ha of tidal wetlands
- Mix of mudflats, emergent marsh, emergent scrub/shrub and forested wetlands.
Current Conditions

- Only 16% of estuarine wetland remain.
- Industrial infrastructure, 2 landfills, 2 sewage treatment plants, I-5.
- 71 kilometers of dikes and associated drainage for agriculture.
- Restricted sediment delivery and shallow subsidence.
Estuaries at Risk

Rising Sea Levels

Sediment Deficits

Subsidence
A Multi-Agency Restoration Effort:
Levee Removal/Breaching

- Restore Estuarine Habitat
- Keep Pace with SLR
- Enhance Carbon Storage
- Fund Restoration Efforts
A Multi-Agency Restoration Effort: Levee Removal/Breaching

Quantify sedimentation rates, carbon storage, and carbon accumulation rates in the estuary.
Site Selection
3 “Natural” Sites
5 Restored Sites
4 Potential Restoration Sites
POTENTIAL RESTORATION AREAS

Qwuloolt (QW), Photo Courtesy of Earth Corps.

WDFW Forest (WF), Photo Courtesy of Earth Corps.

Smith Island North (SN), Photo Courtesy of Earth Corps.

WDFW Wetland (WW), Photo Courtesy of Earth Corps.
Field Methods

- 2 cores
- RTK Elevation
- Pore water salinity
- Rapid Veg. Assessment
Laboratory Methods

- Cores sliced into 2cm sections
- Bulk Density
- LOI % O.M. and Mineral Matter by Weight
- Carbon by CHN analyzer
- $^{210}$Pb
By Calculation

- Sediment core profiles
- Mean carbon densities in top 30 cm
- Sediment accretion rates
- Carbon accumulation rates
Results

The graph illustrates the elevation data for different sites, categorized into Natural Areas, Transition Areas, and Possible Restoration Areas. The x-axis represents the sites, while the y-axis shows the elevation in meters (m, NAVD88) ranging from MLLW to MHHW.

For Natural Areas:
- Quilceda Marsh
- Heron Point
- Otter Island

For Transition Areas:
- Union Slough
- Marysville
- North Ebey
- Smith Island (City)
- Spencer Island

For Possible Restoration Areas:
- Qwuloolt
- Smith Island (County)
- WDFW Wetland
- WDFW Forested

The data indicates varying elevations, with some sites reaching higher elevations closer to MHHW, suggesting potential impacts or considerations for these areas.
Quilceda Marsh (Natural Condition Site)

- Estuarine Emergent
- *Carex lyngbyei*
- Salinity = 8 ppt
Quilceda Marsh (Natural Condition Site)
Mean Carbon Density in the Upper 30 cm

Potential Restoration Sites
Natural Sites
Transitional Sites

Quilceda
Heron
Otter
Union Slough
Marysville
North Ebey
Smith City
Spencer
Qwuloot
Smith County
WDFW W
WDFW F
<table>
<thead>
<tr>
<th>Site</th>
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<td>173.1</td>
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<tr>
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<td>North Ebey</td>
<td>1.61</td>
<td>352.1</td>
<td>7585</td>
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<tr>
<td>WW</td>
<td>WDFW Wetland</td>
<td>0.12</td>
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WDFW (Potential Restoration Site)

- Diked and drained in the early 1900’s, later abandoned
- *Phalaris arundinacea.*
- *Agrostis* sp.
- Salinity = 6 ppt
WDFD: Unrestored Former Ag. Land.
Mean Carbon Density in the Upper 30 cm

- Natural Sites
- Transitional Sites
- Potential Restoration Sites

Sites: Quilceda, Heron, Otter, Union Slough, Marysville, North Ebe, Smith City, Spencer, Qwuloot, Smith County, WDFW W, WDFW F

Mean Carbon Density in grams C per cm³.
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North Ebey (Restored Site)

- Breached between 1965 and 1970
- Soft Stemmed Bulrush, *Typha sp.*
- Salinity = 1 ppt
North Ebey: Restored Marsh

**NE: Carbon content**

**NE: Bulk density**

- X-axis: Carbon by weight (%)
- Y-axis: Depth (cm)

- X-axis: Bulk density (g/cm³)
- Y-axis: Depth (cm)
Mean Carbon Density in the Upper 30 cm

- Potential Restoration Sites
- Natural Sites
- Transitional Sites

Sites:
- Quilceda
- Heron
- Otter
- Union Slough
- Marysville
- North Ebey
- Smith City
- Spencer
- Qwuloot
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- WDFW W
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Conclusions

• All of the formerly diked, or still diked sites revealed evidence of subsidence.

• Natural sites were accreting at a rate equal to or exceeding the rate ESLR.

• Carbon storage in the natural sites were within the range reported for other sites on the west coast.

• High carbon density does not necessarily mean high carbon accumulation rates.

• Breached sites show great potential for successful restoration, high rates of carbon storage, and resilience to rising sea levels.
Objectives
\[ y = 0.5472x - 1.6219 \]

\[ R^2 = 0.9892 \]
Rates of sediment accretion, carbon accumulation, and mineral accumulation for the three natural sites. Accretion rates were determined from the distribution of excess $^{210}$Pb activity with depth using one core from each site. Carbon and mineral accumulation rates were calculated from the accretion rates and the average carbon or mineral density within the top 30 cm.

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(Grossman and Fuller In Prep.)
Union Slough (Restored Mudflat)
Rates of sediment accretion, carbon accumulation, and mineral accumulation for five sites + the North Ebey Restoration Site.

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