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 M. Rybczyk, Stephen Crooks, Danielle Devier, Steve Emmett Mattox, Nathan Moore, Keeley A. (Keeley Anne) O’Connell, Katrina L. 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.
Crooks et al. 2014

EXPLANATION

- Drainage-basin boundary
- Subbasin boundary

190  Mean annual discharge, in cubic feet per second

Legend:
- Elwha River: 2,000
- Dungeness River: 460
- Dosewallips River: 670
- Duckabush River: 570
- Hamma Hamma River: 500
- Skokomish River: 1,300
- All other tributaries: 1,100
- Discharge River: 3,100
- Dungeness River: 2,100
- Skagit River: 3,600
- Vedder River: 400
- Deschutes River: 3,600
- Snohomish River: 10,000
- Stillaguamish River: 18,000
- North Fork Skagit River: 3,200
- Samish River: 190
- Mt. Vernon: 18,000
- Mt. Baker: 2,700
- Glacier Peak: 10,000

Geographic features:
- Olympic Mountains
- Puget Lowland
- Strait of Juan de Fuca
- Strait of Georgia
- Whidbey Island
- Mt. Rainier
- Mt. Baker
- Lake Washington Ship Canal
- British Columbia
- Washington
- United States
- Canada
- Pacific Ocean
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.

- Restore Estuarine Habitat
- Keep Pace with SLR
- Enhance Carbon Storage
- Fund Restoration Efforts
3 “Natural” Sites
5 Restored Sites
RESTORED AREAS

North Ebey (NE), Photo Courtesy of Earth Corps.

Union Slough (US), Photo Courtesy of Earth Corps.

Spencer Island (SP), Photo Courtesy of Earth Corps.

Smith Island South (SS), Photo Courtesy of Earth Corps.

Marysville (MA), Photo Courtesy of Earth Corps.
4 Potential Restoration Sites
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
- $^{210}\text{Pb}$
By Calculation

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

Natural Sites

Transitional Sites

Potential Restoration 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>1.61</td>
<td>352.1</td>
<td>7585</td>
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<td>WW</td>
<td>WDFW Wetland</td>
<td>0.12</td>
<td>92.7</td>
<td>319</td>
</tr>
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</table>
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 include:
- Quilceda
- Heron
- Otter
- Union Slough
- Marysville
- North Ebe
- Smith City
- Spencer
- Qwuloot
- Smith County
- WDFW W
- WDFW F

**g C cm$^{-3}$**
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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
Mean Carbon Density in the Upper 30 cm

Potential Restoration Sites

Natural Sites

Transitional Sites

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<th>Transitional Sites</th>
<th>Potential Restoration Sites</th>
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<tr>
<td>Quilceda</td>
<td>0.02</td>
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<tr>
<td>Heron</td>
<td>0.01</td>
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<td>0.08</td>
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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 $^{210}\text{Pb}$ 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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Relative Subsidence (0.5 – 1.0 m)

(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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