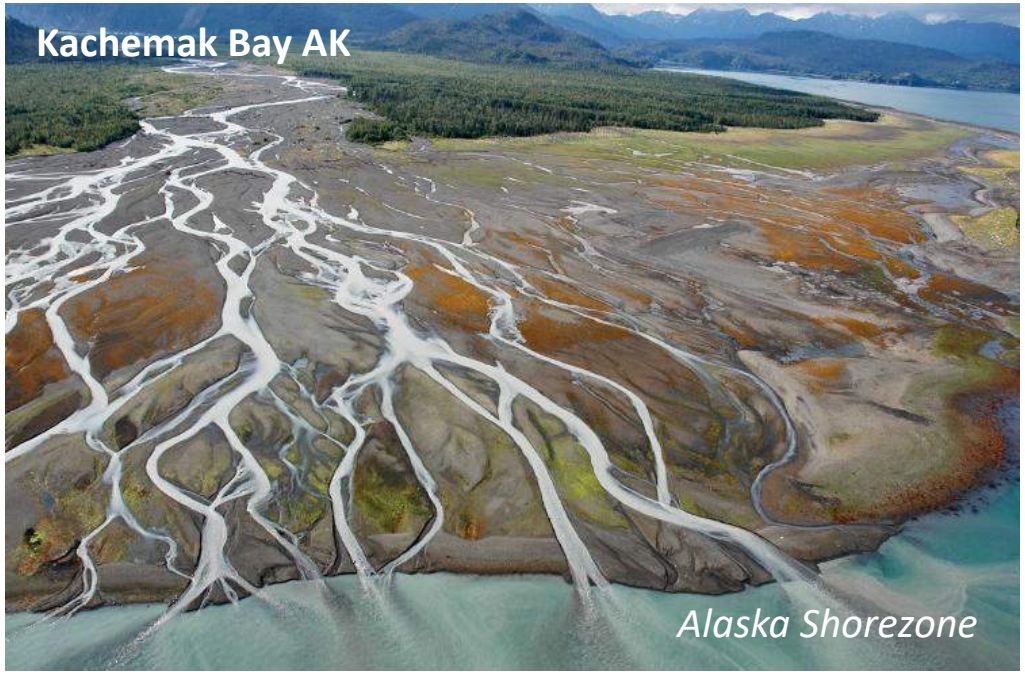
Jumpstarting fluvial and tidal processes in estuaries

Correigh Greene
Skagit River System Cooperative



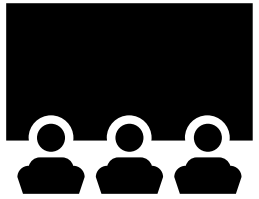
Today's symposium: Jumpstarting process-based restoration

Process-based restoration considerations

Jumpstarting fluvial and tidal processes in estuaries	**Correigh Greene**, Skagit River System Cooperative
Restoring tidal swamps -- practical restoration ecology	**Laura Brophy**, Estuary Technical Group, Institute of Applied Ecology
Beaver in tidal wetlands: implications for restoration	**Greg Hood**, Skagit River System Cooperative

Case Studies

Implementing process-based restoration: lessons learned from the Wasson Creek restoration project	**Alice Yeates**, South Slough National Estuarine Research Reserve
Restoring self-sustaining off-channel habitat in the Smith River Estuary	**Monica Scholey**, Smith River Alliance and Dylan Caldwell, Stillwater Sciences
Love letters to salmon: stories of process-based restoration in the Stillaguamish Delta	**Emily Howe**, The Nature Conservancy
Healing the ecotone: community-driven restoration of Batiquitos Lagoon's upland edge	**David Boehmer**, WildCoast
Designing considerations and case studies for shoreline restoration in Washington State	**Jessica Cote**, Blue Coast



How do we recover lost estuary habitat processes?

- Extensive loss of estuary habitats and their habitat forming processes (Brophy et al. 2019)
- What does process-based restoration mean in our highly modified estuaries?
- What rules of thumb can help speed recovery of habitat processes?
- Focus of this talk: Riverine estuaries and deltas
- For what species are we restoring habitat?

Jessica Cote

David Boehmer

Juvenile fishes
Chinook salmon
Coho salmon
Chum salmon
Delta smelt

Process-based habitat restoration in rivers

Process-based principles for restoring river ecosystems
(*Beechie et al. 2010, Bioscience*)

- Target root causes of habitat and ecosystem change
- Tailor restoration actions to local potential
- Match scale of restoration to scale of the problem
- Be explicit about expected outcomes

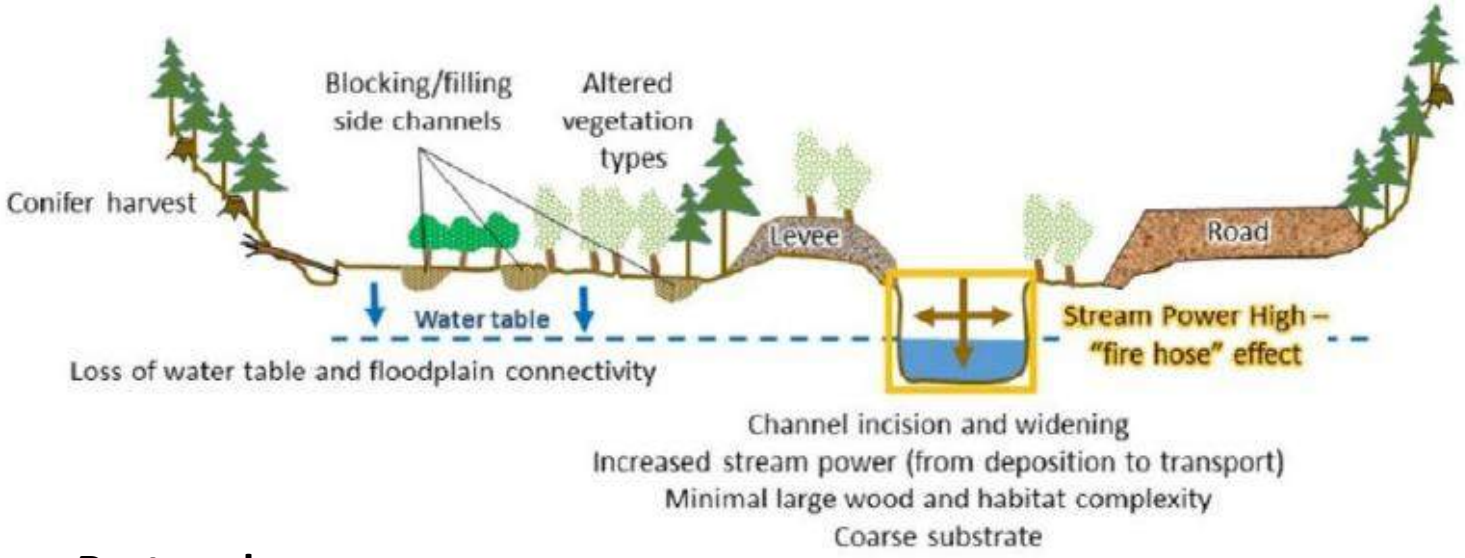
Challenge for estuaries

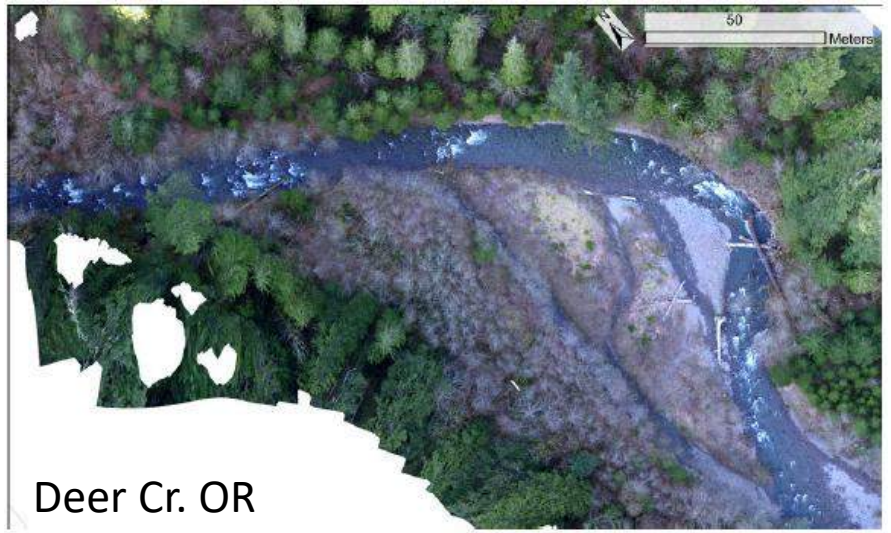
- Cumulative habitat impacts in estuaries
- Local potential determined by both freshwater and tidal processes
- Restoration project extent is smaller than extent of impacts
- Recovery time is slow
- Outcomes for target species can be hard to quantify

Stage 0* restoration in floodplains

**Cluer and Thorne 2013*
River Research and Applications

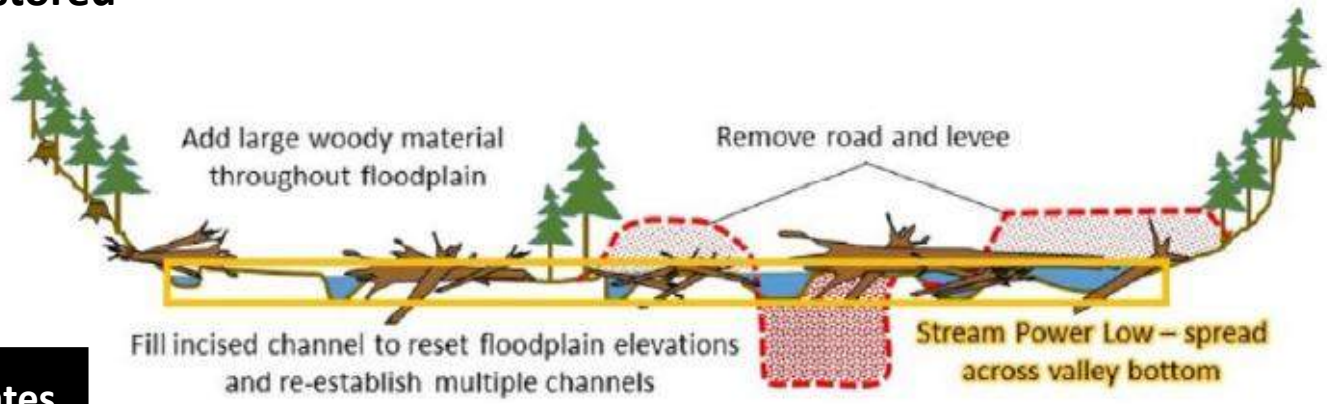
Current





Deer Cr. OR

Restored



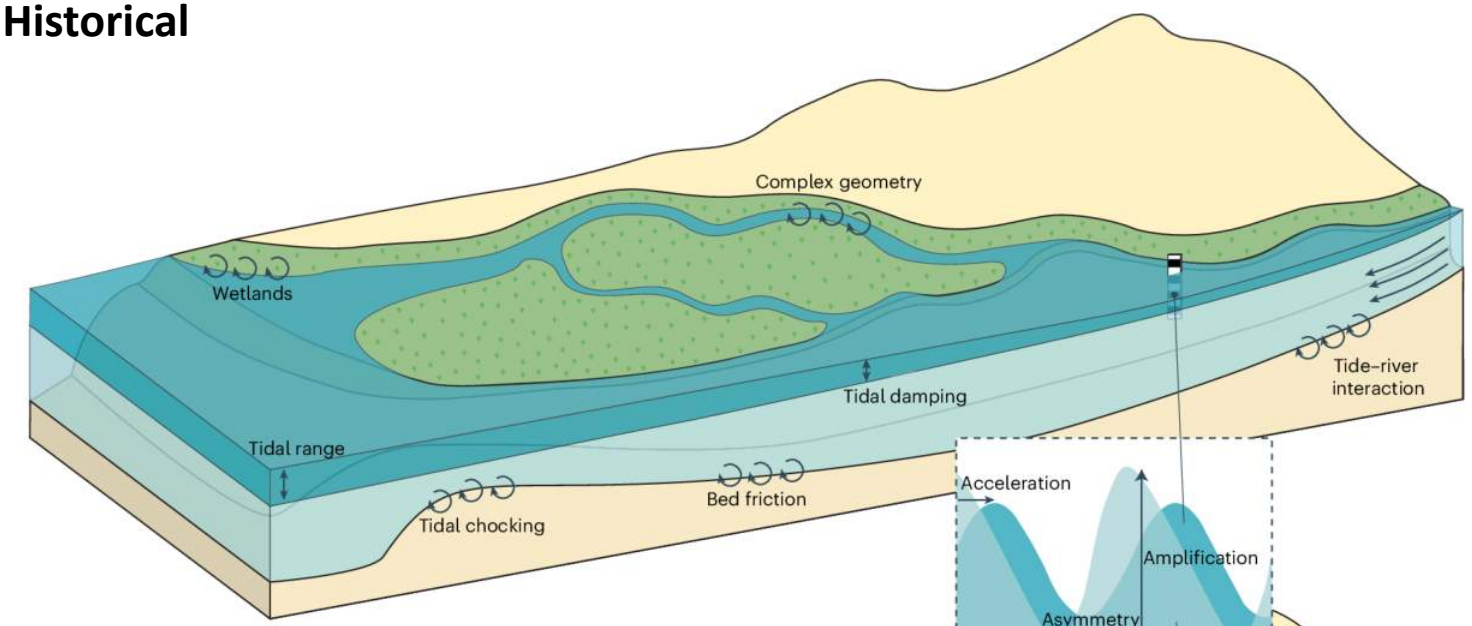
Schneider et al. 2022

Alice Yeates

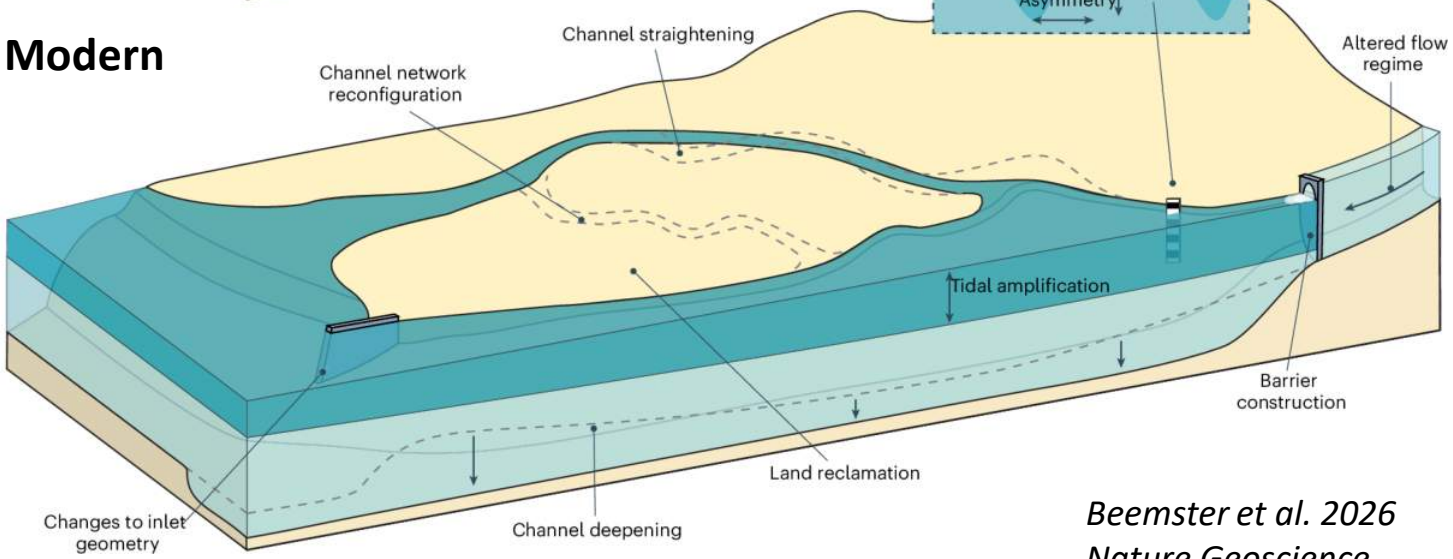
Process-based/Stage 0 restoration in estuaries

How do we impact the channel network in estuaries?

Historical



Modern



Beemster et al. 2026
Nature Geoscience

Cumulative landscape impacts

- Dikes and levees
- Wetland subsidence
- Sediment compaction
- Channel straightening
- Network reconfiguration
- Channel deepening
- Tidal muting structures
- Altered riverine flow regimes

Towards jumpstarting river and tidal processes in estuaries: Rules of thumb

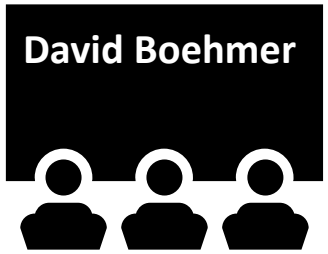
1. Rebuild tidal channels
    a. Follow geomorphic scaling rules
    b. Restore channel sinuousity
    c. Restore local connectivity: setbacks over breaches and tide gates
    d. Break up compacted clay layers

2. Reconnect distributaries

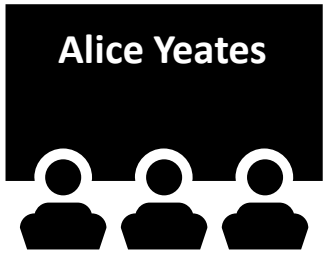
Large scale restoration
in Port Susan Bay

3. Build up subsided wetlands
to support a diversity of vegetation

Tidal swamp
site selection



Restoring upland
vegetation



Log cribs
for woody plants

Beaver dams
& beaver dam analogs

Rebuild tidal channels


Skagit River delta


Stillaguamish River delta

Rebuild tidal channels

- Follow geomorphic scaling rules
- Restore channel sinuousity
- Restore local connectivity
- Break up compacted clay layers

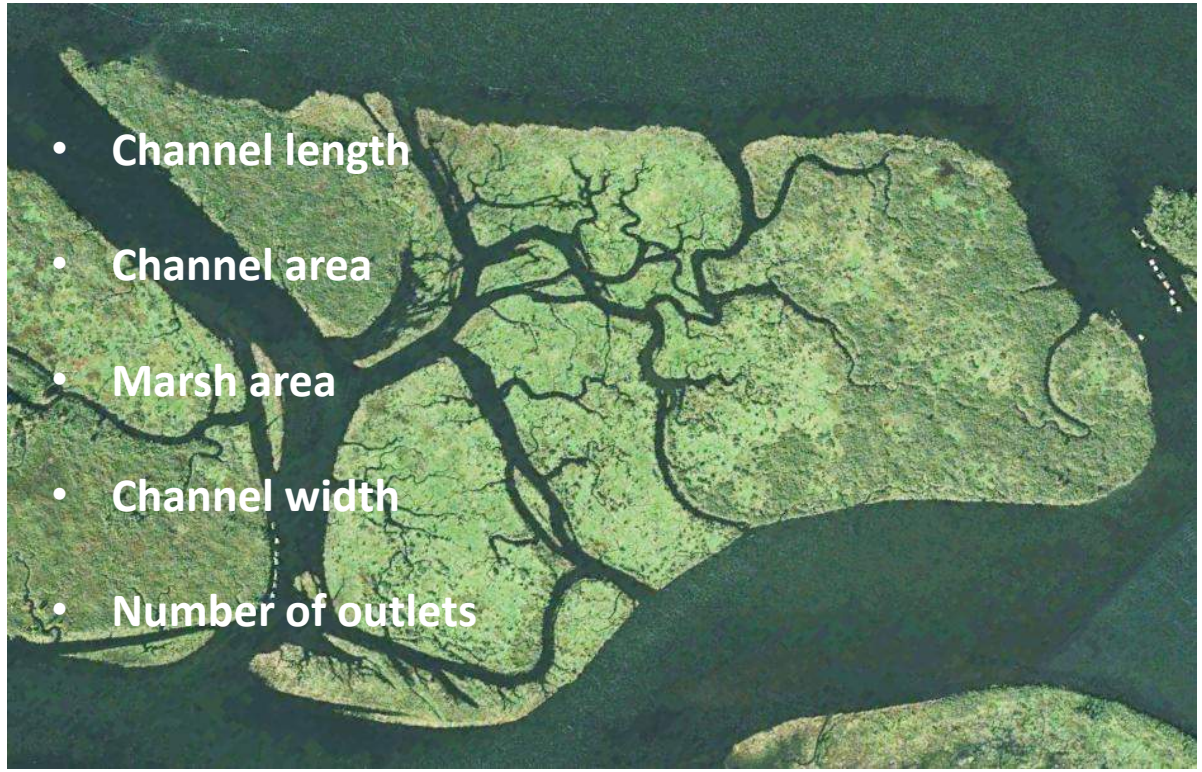
Emily Howe

Monica Scholey

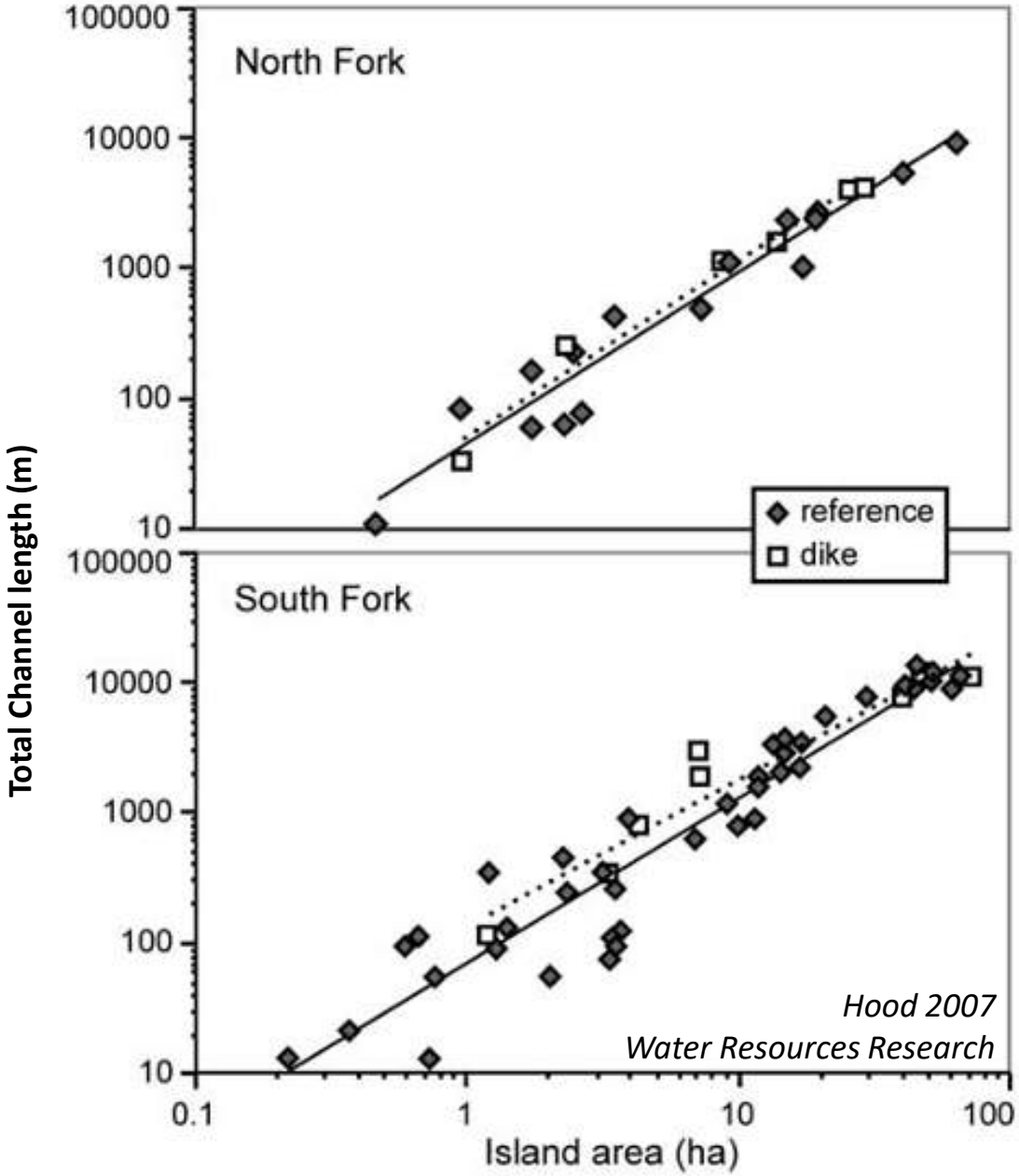

Qwuloolt, Snohomish River delta


Zis a ba I, Stillaguamish River delta

Follow geomorphic scaling rules



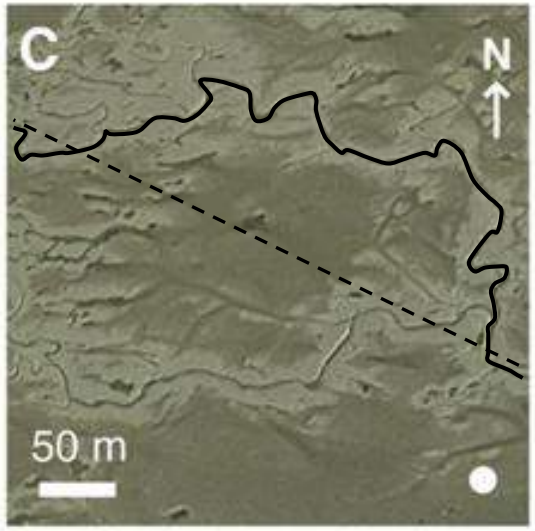
Skagit River

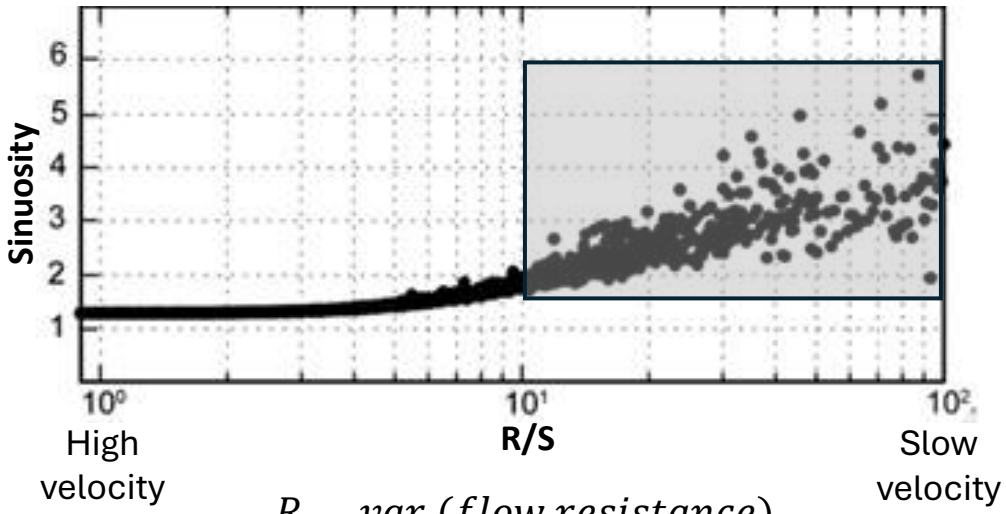


Restore channel sinuosity

$$Sinuosity = \frac{flow\ distance}{absolute\ distance}$$

Design channels that are 2-6 times the absolute distance to outlet





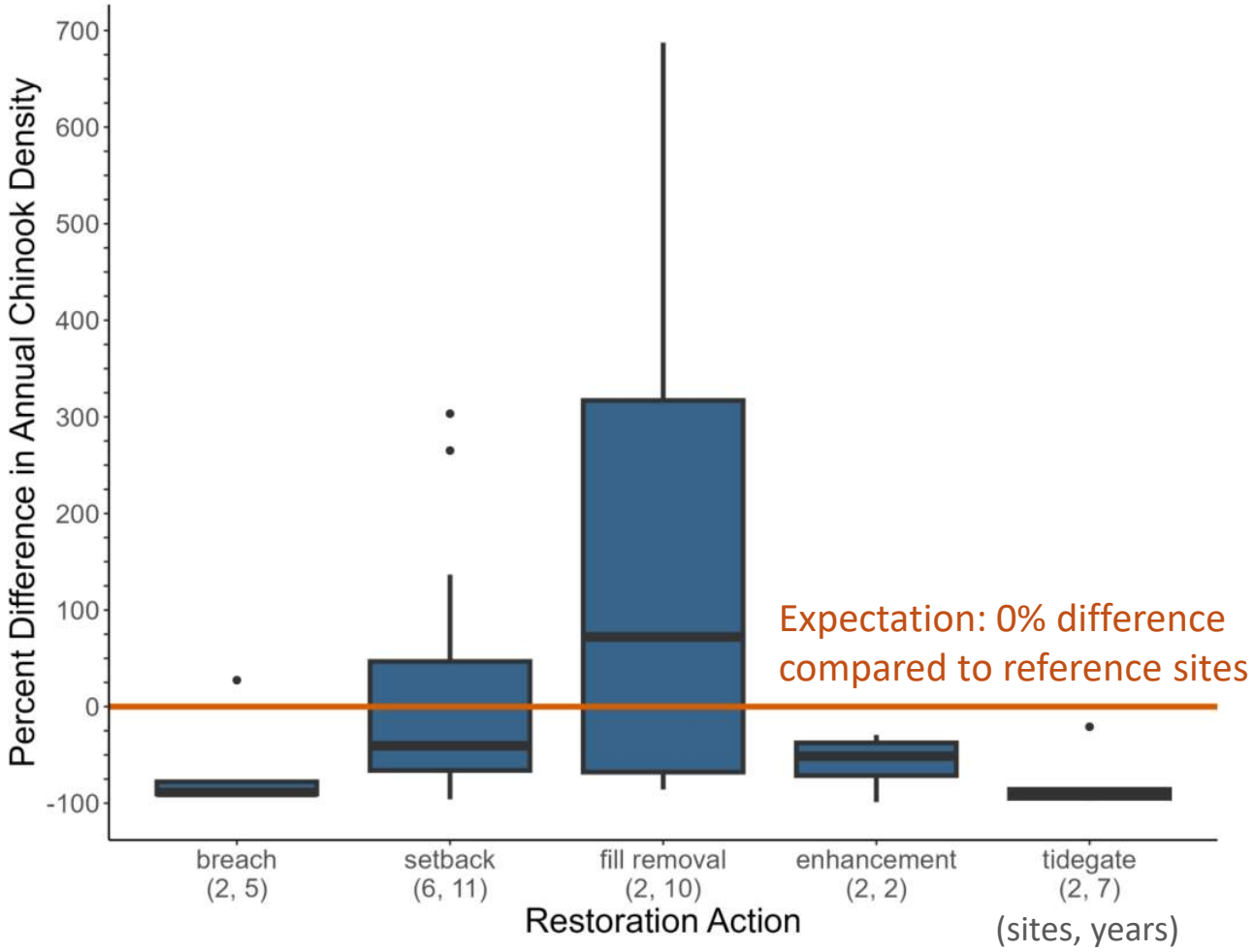
$$\frac{R}{S} = \frac{var\ (flow\ resistance)}{Slope}$$

> 1 for mudflats & vegetated wetlands

Lazarus & Constantine (2013)
PNAS 110:8447-8452

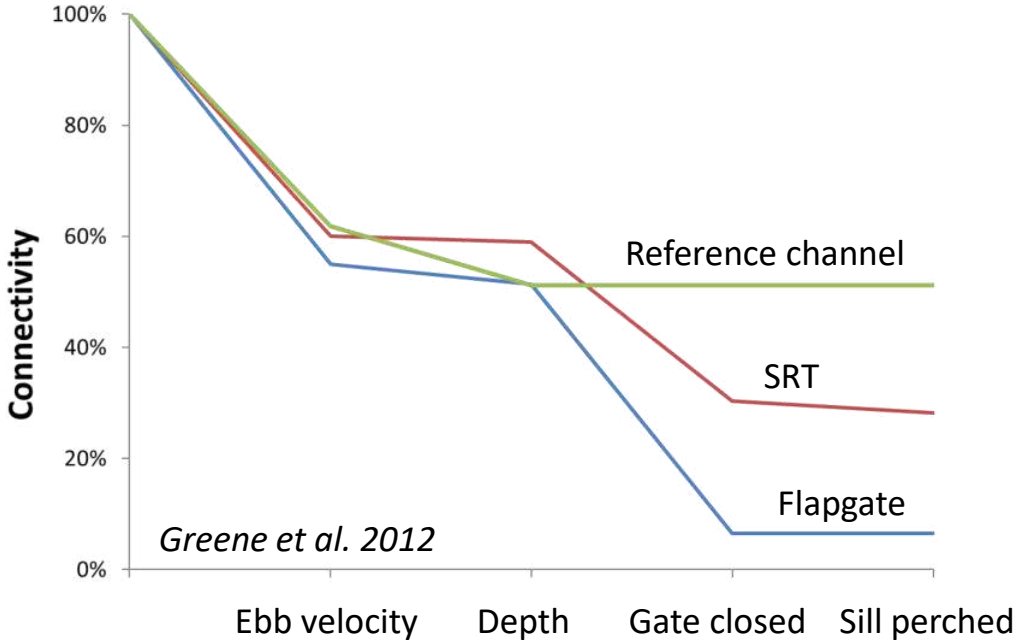
Restore local connectivity

Skagit tidal delta effectiveness monitoring



McKeegan et al. 2025

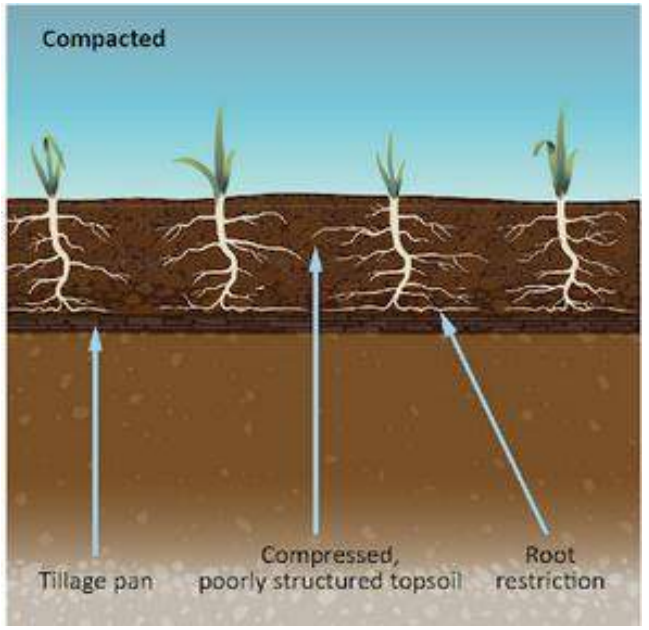
Tidegates in Oregon and Washington

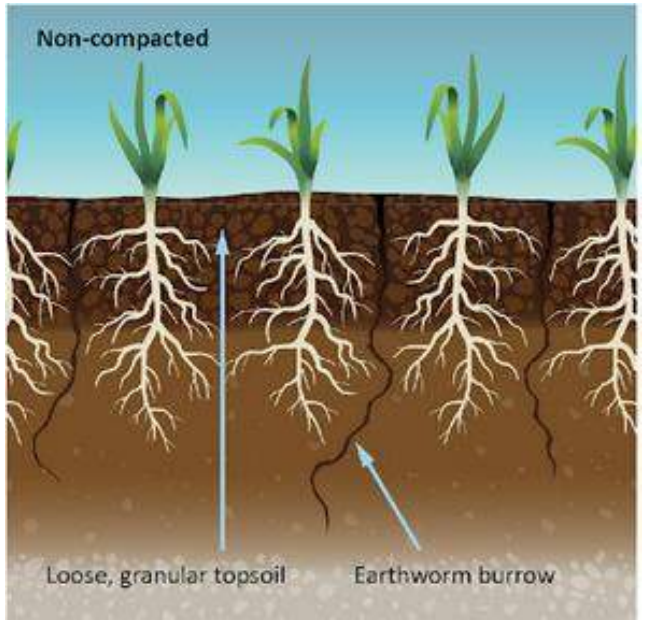


Break up compacted clay layers

Emily Howe

Plow pan





Towards jumpstarting river and tidal processes in estuaries: rules of thumb for rebuilding tidal channels

- Follow geomorphic scaling rules
  - Provide guides for the right amount of channel construction

- Restore channel sinuousity
  - 2-6x absolute distance to outlet

- Restore connectivity: setbacks over breaches and tide gates
  - More pathways for material recruitment and fish habitat use

- Break up compacted clay layers
  - Allows for action by tides and vegetation

Final thought: We can't fix everything: focus on what you can do, and consider **overbuilding** to the extent supportable by science and society

Thanks!

Questions?

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