# Ecology of Newly Restoring Floodplain and Tidal Wetlands in the Lower Columbia River and Estuary

Ronald Thom[1], Curtis Roegner[2], Heida Diefenderfer[1], Amy Borde[1], Gary Johnson[1], Dana Woodruff[1]

[1]Pacific Northwest National Laboratory and
[2]NOAA Fisheries

*Columbia River Estuary Conference*
*16 May 2012*
*Astoria, Oregon*

US Army Corps of Engineers ®
Portland District

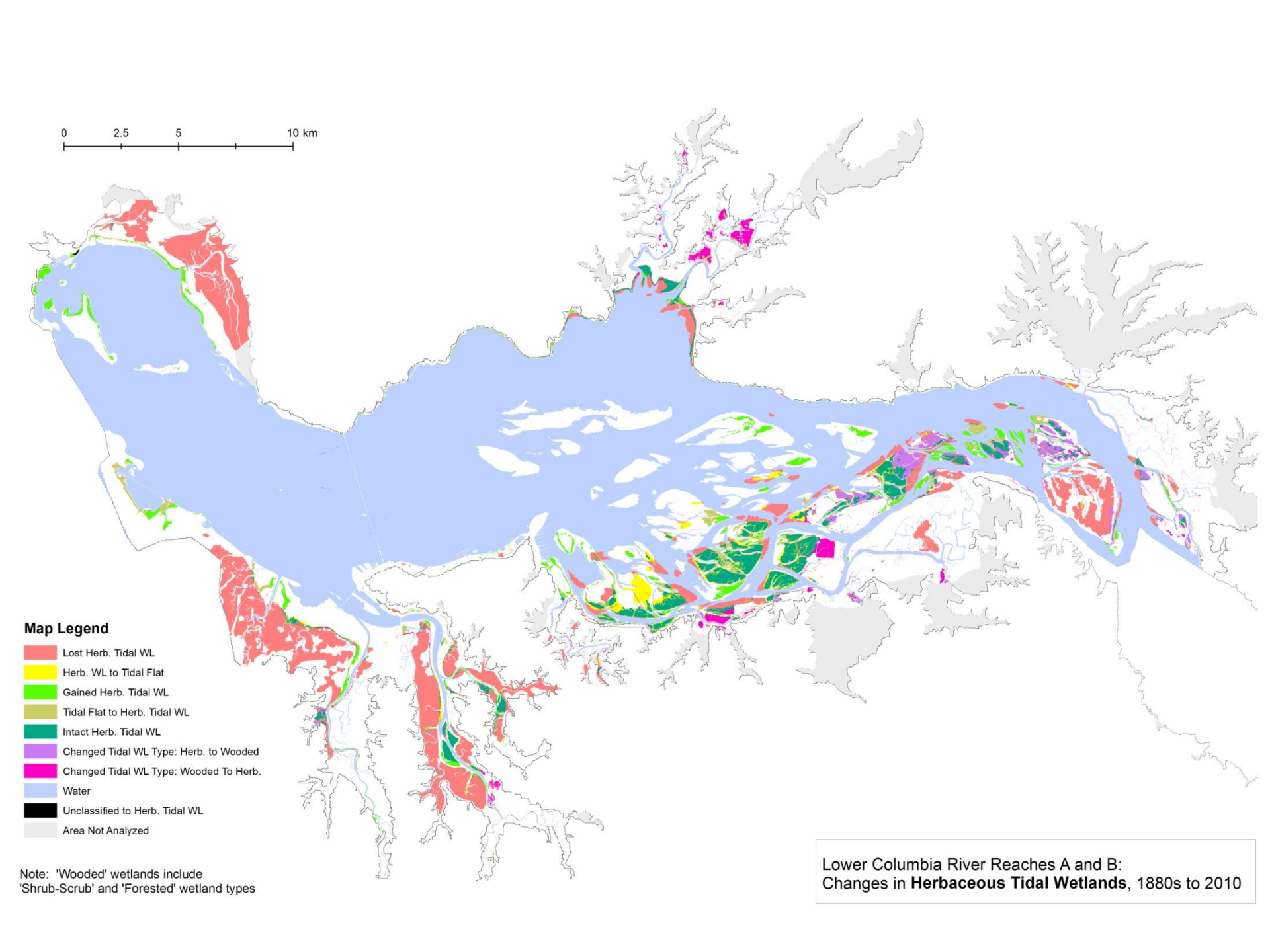
Pacific Northwest
NATIONAL LABORATORY

# Cumulative Effects Study Goal

- Develop and employ science-based methods to quantify cumulative effects on ecosystem function from salmonid habitat restoration in the Columbia River estuary.[1]
  - My talk will summarize some of the ecological findings

[1] Johnson et al. 2012. Evaluating the cumulative ecosystem response to restoration projects in the Lower Columbia River and Estuary.


Washington
Oregon
Victoria
Seattle
WASHINGTON
Tacoma
Yakima
Richland
Portland
Salem
N
Diked Areas
Historic Floodplain
40
Kilometers
Pacific Northwest
NATIONAL LABORATORY


0
2.5
5
10 km
Map Legend
Lost Herb. Tidal WL
Herb. WL to Tidal Flat
Gained Herb. Tidal WL
Tidal Flat to Herb. Tidal WL
Intact Herb. Tidal WL
Changed Tidal WL Type: Herb. to Wooded
Changed Tidal WL Type: Wooded To Herb.
Water
Unclassified to Herb. Tidal WL
Area Not Analyzed
Note: 'Wooded' wetlands include 'Shrub-Scrub' and 'Forested' wetland types
Lower Columbia River Reaches A and B:
Changes in **Herbaceous Tidal Wetlands**, 1880s to 2010

# Primary Changes to the Lower Columbia River and Estuary

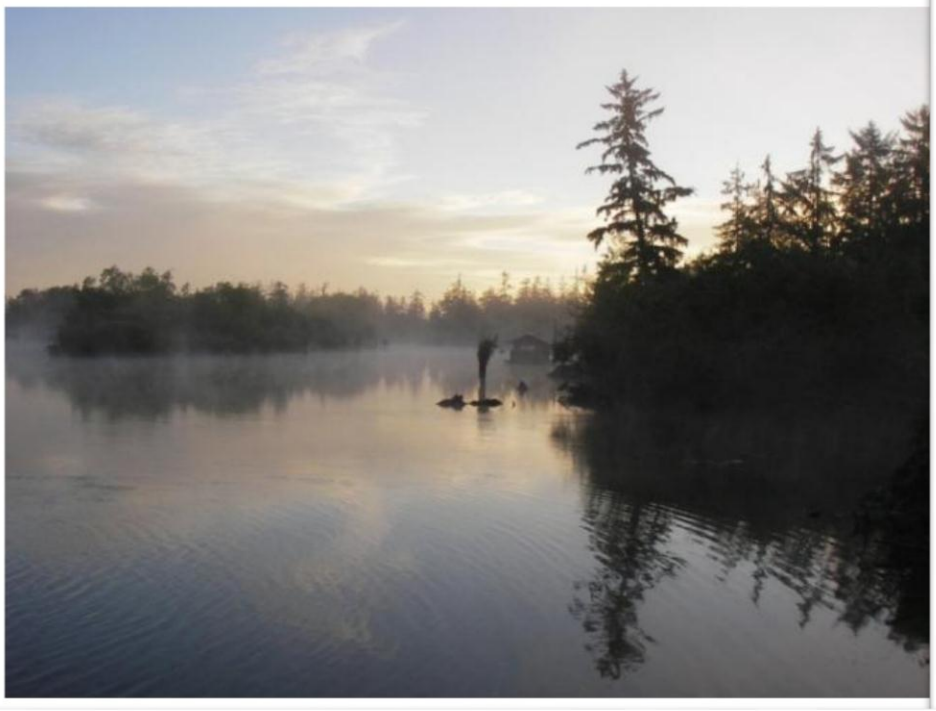
- 30 major dams and numerous minor dams throughout the basin
- Diking & >40% flow reduction during spring freshet → 62% reduction in shallow water juvenile salmon habitat in the estuary (loss of access to critical habitats)
- Altered food web in estuary (loss of marsh macrodetritus)

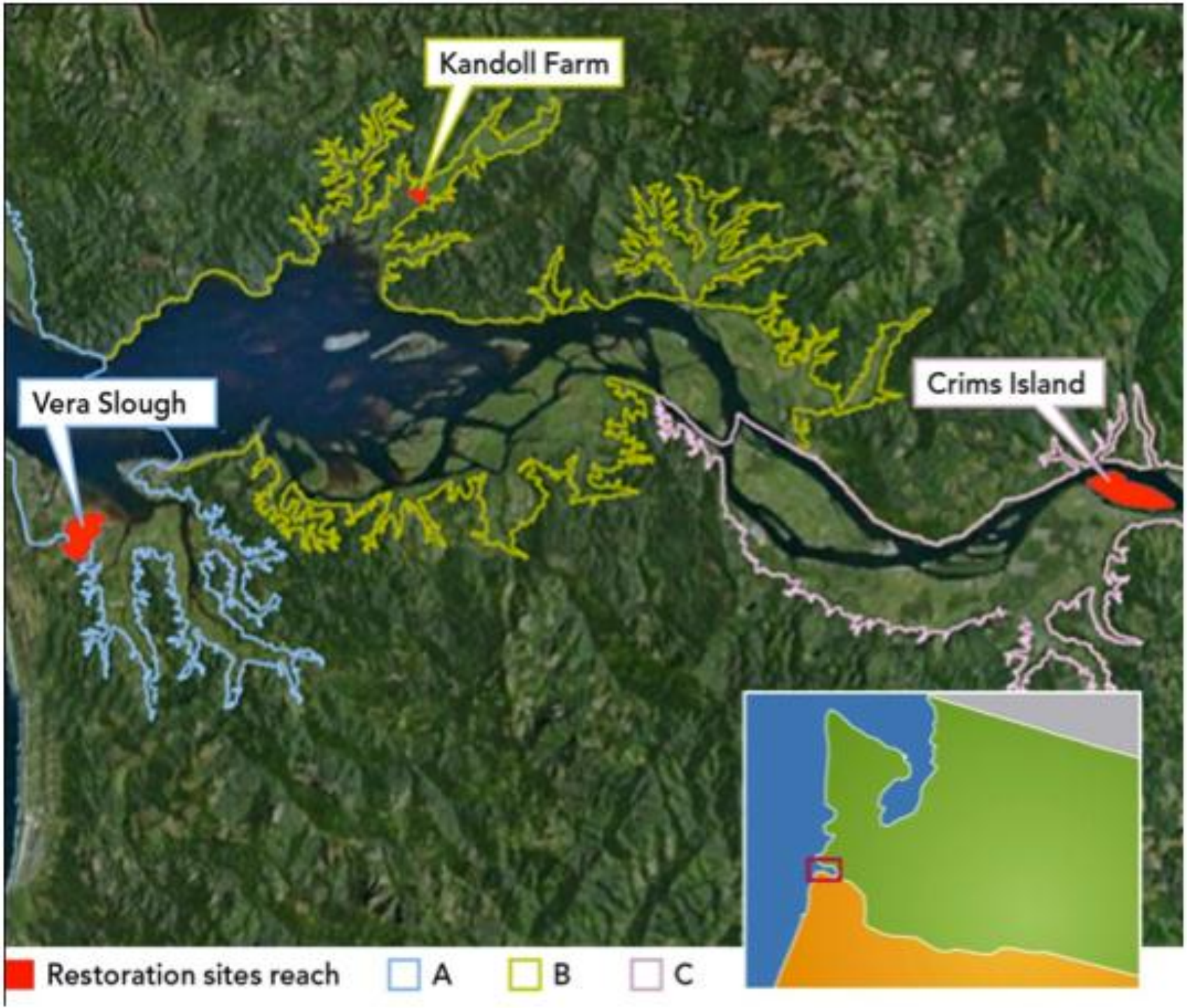
(Sherwood et al. 1990; Kukulka and Jay 2003)

Pacific Northwest
NATIONAL LABORATORY

# Primary Actions to Restore Salmonid Habitat

- Reconnect the floodplain to natural hydrodynamics
- Enhance fish opportunity to access sites
- Enhance the carrying capacity of habitats
- Enhance the processes that support broader ecosystem functions and values (e.g., export of OM)



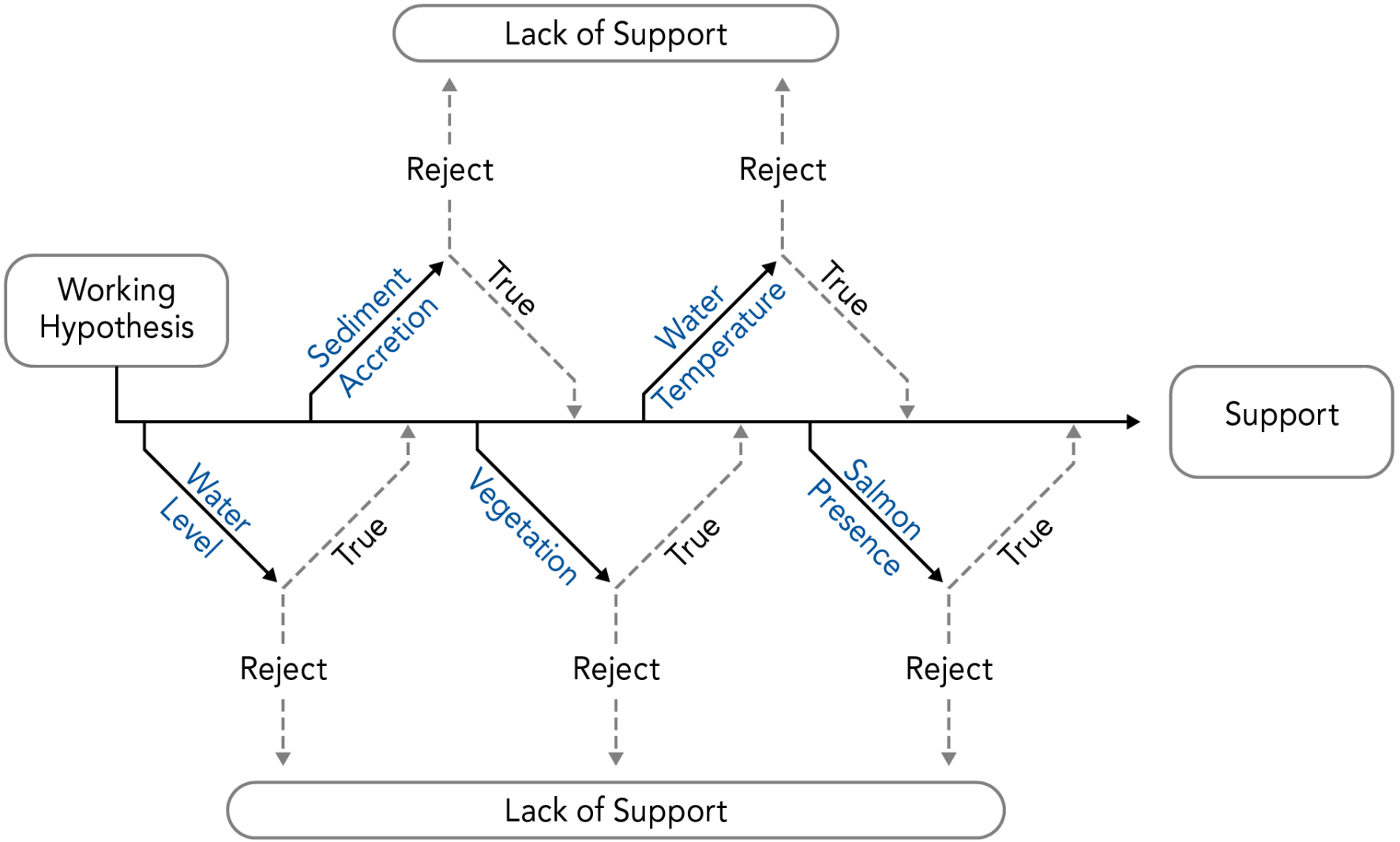

Kandoll Farm
Vera Slough
Crims Island
Restoration sites reach
A
B
C

# Hypotheses – Site Scale

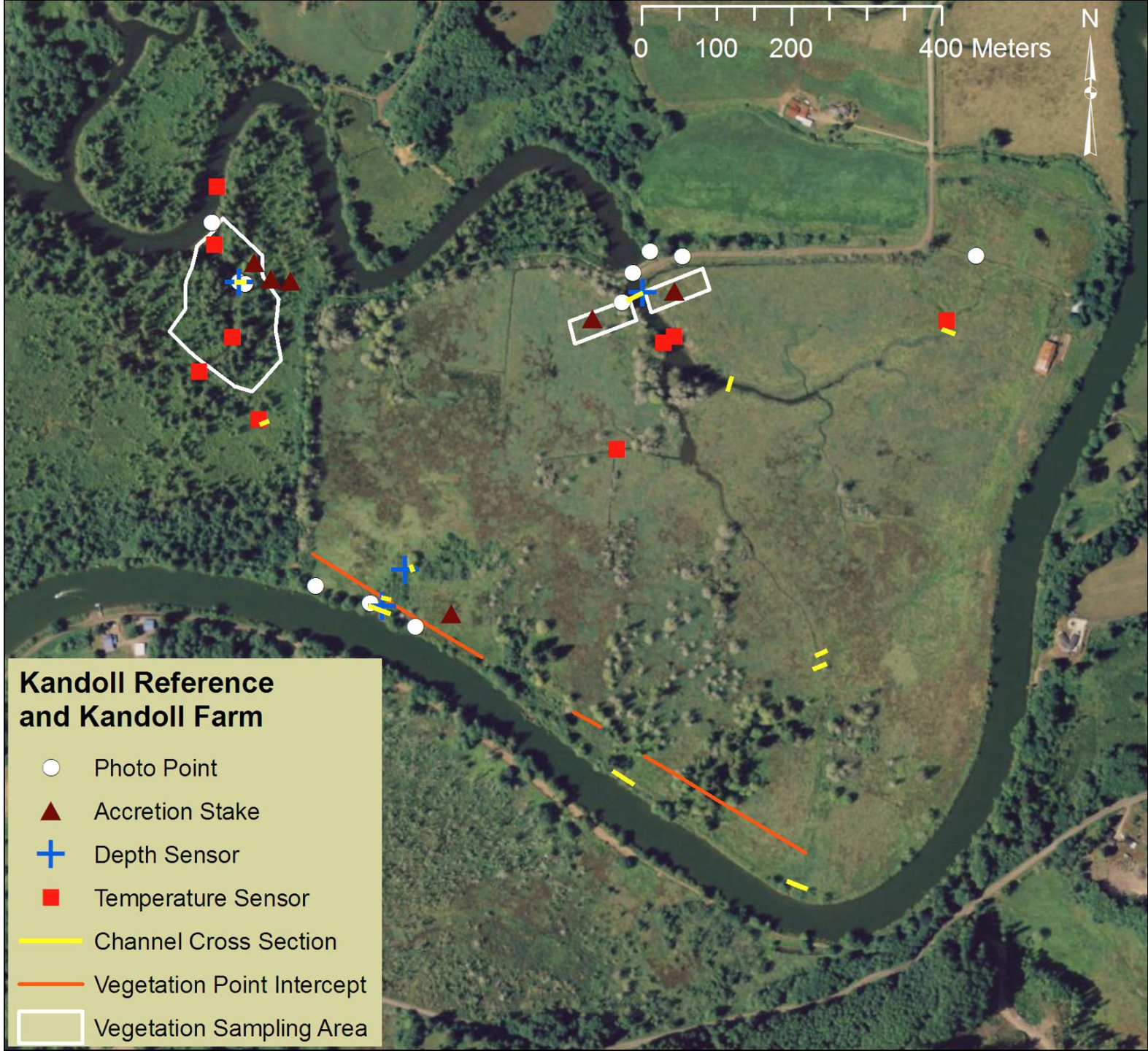
- **Working $H_1$** = Habitat restoration activities in the estuary will have a beneficial effect on salmon
- **Ancillary $H_1$** = Monitored indicators will trend toward reference conditions
  - Hydrology – area time inundation index
  - Water quality – temperature
  - Topography/bathymetry – land elevation, sedimentation rate
  - Vegetation – percent cover by species
  - Fish – presence, abundance, res. time, diet, growth rate, fitness
  - Exchange – plant biomass, TOC, nutrients, chlorophyll, macro-invertebrates

Diefenderfer et al. 2011. A levels-of-evidence approach…*Ecological Restoration*

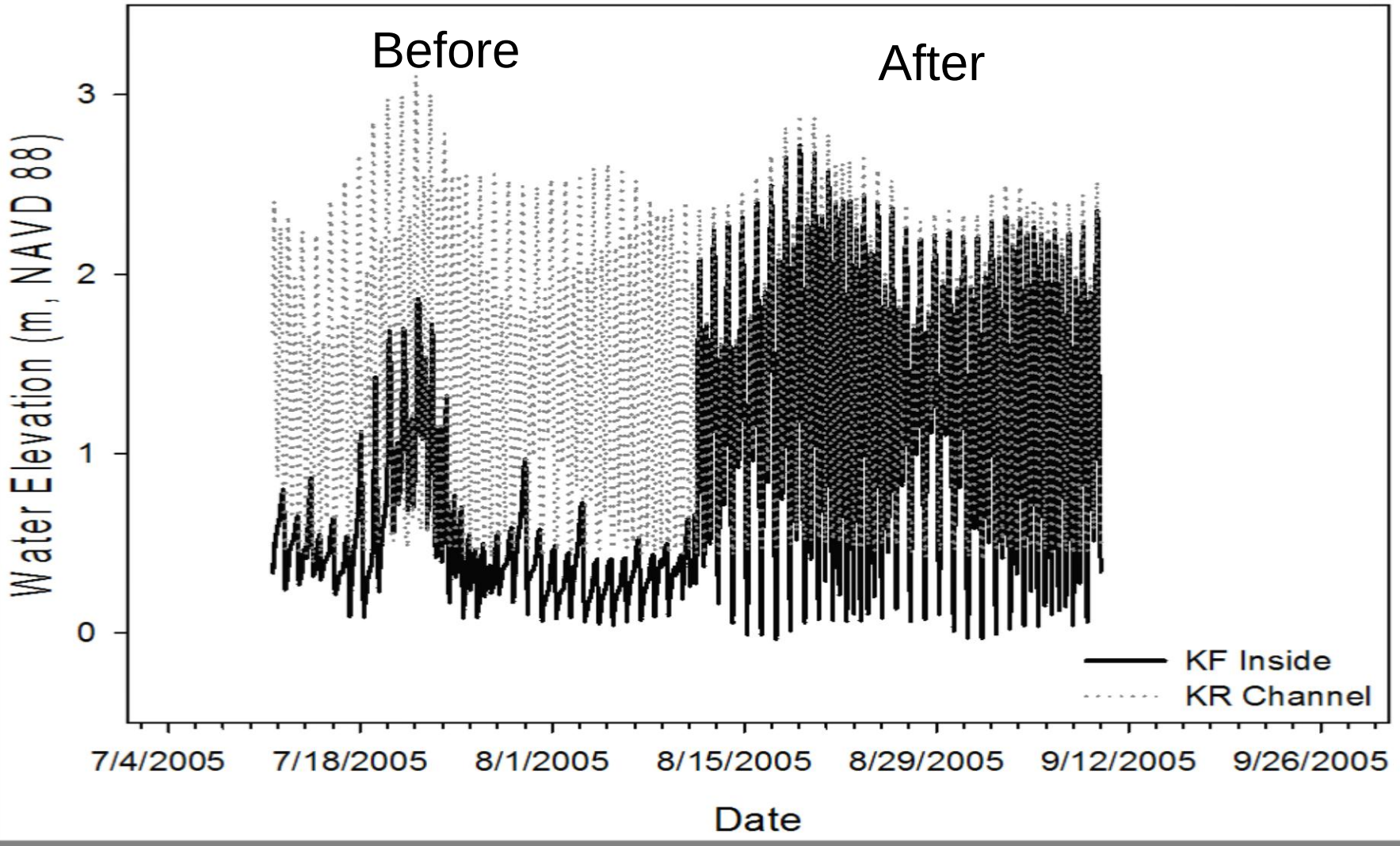
# Core Indicators from Protocols as a *Cascade* of Testable Ancillary Hypotheses



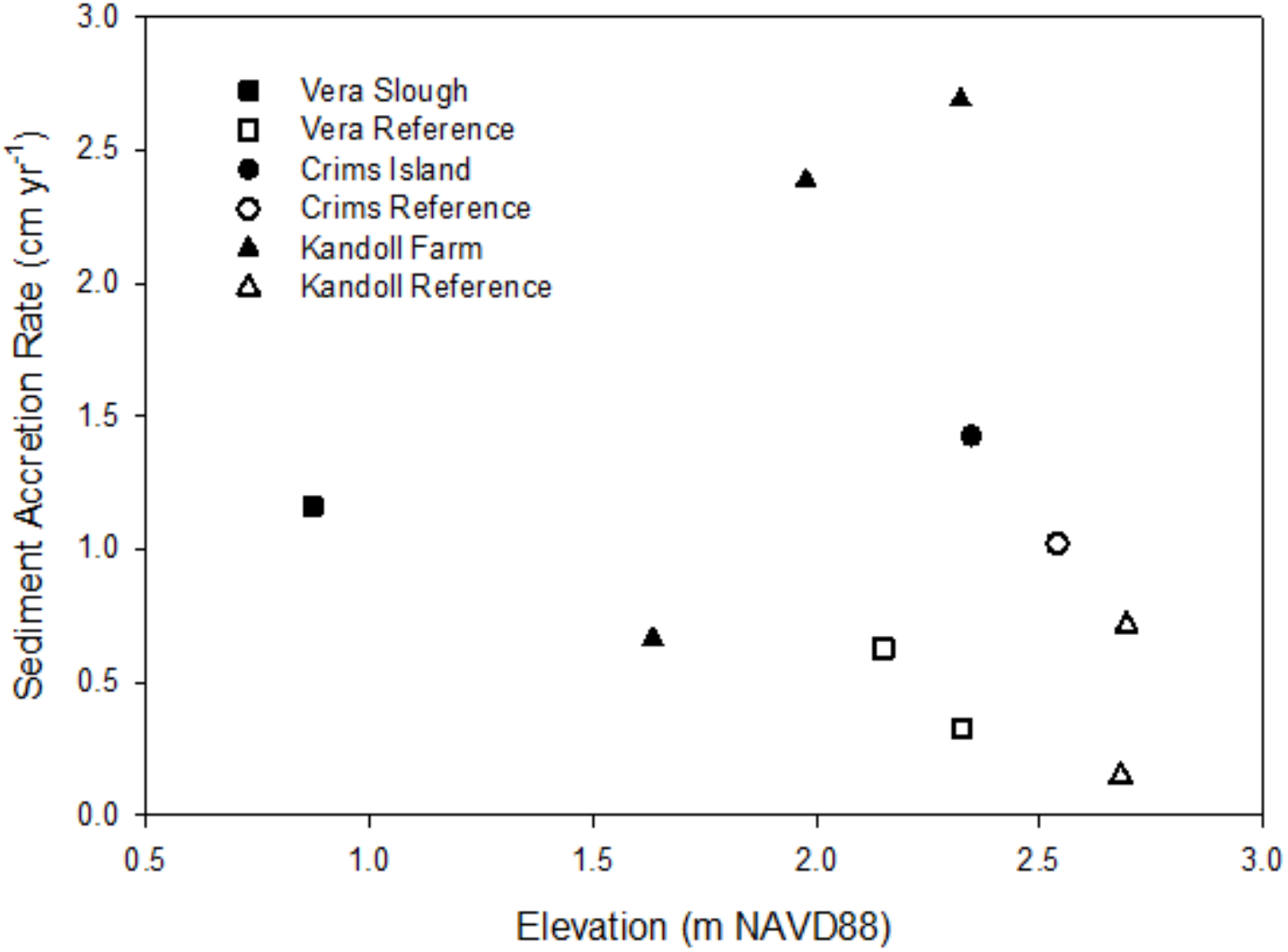
# Sampling Points at Kandoll Farm and Reference



# Hydrologic Regime Change: Tidal-Fluvial Signals at Restoration and Reference Sites



# Topographic Change: Sediment Accretion

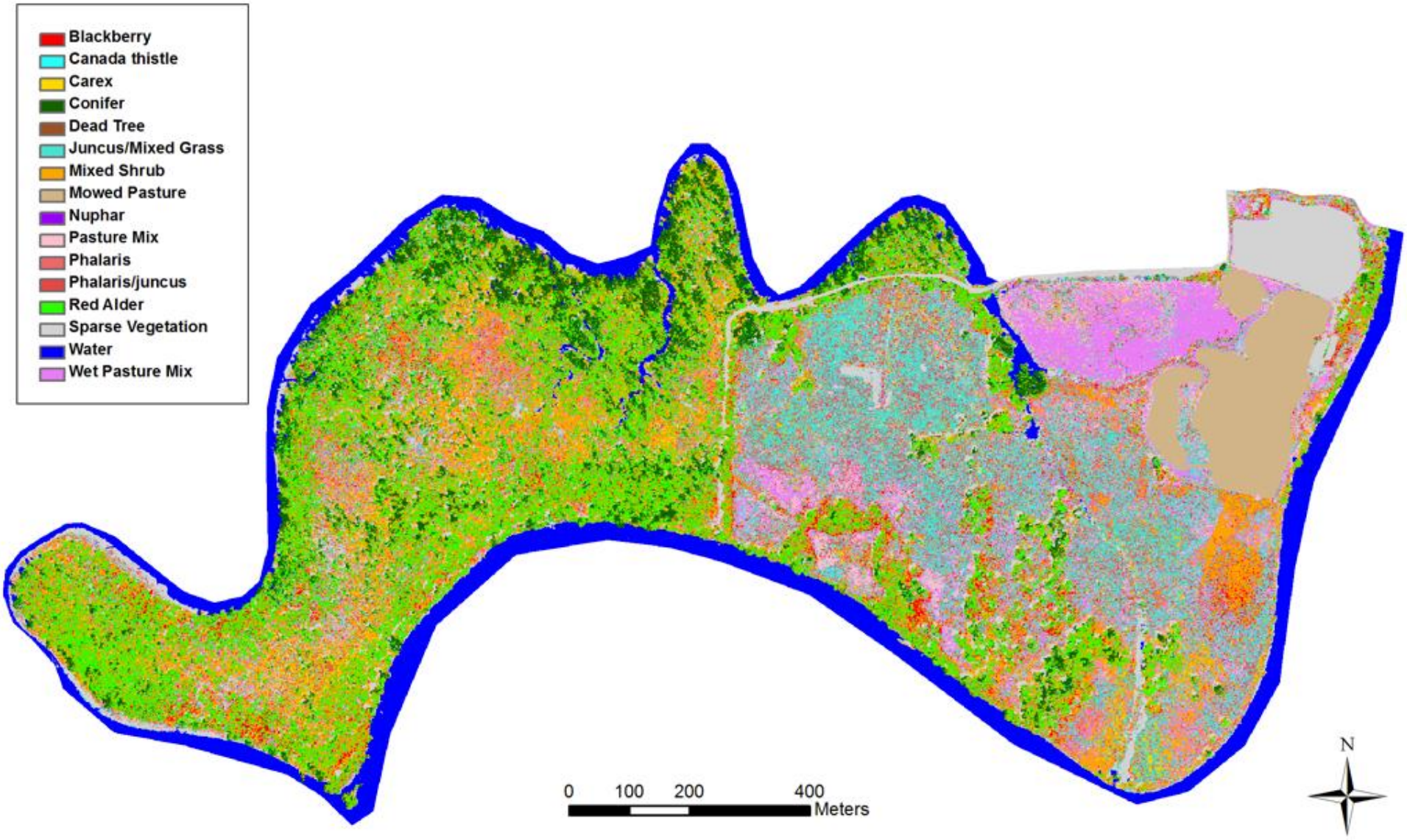


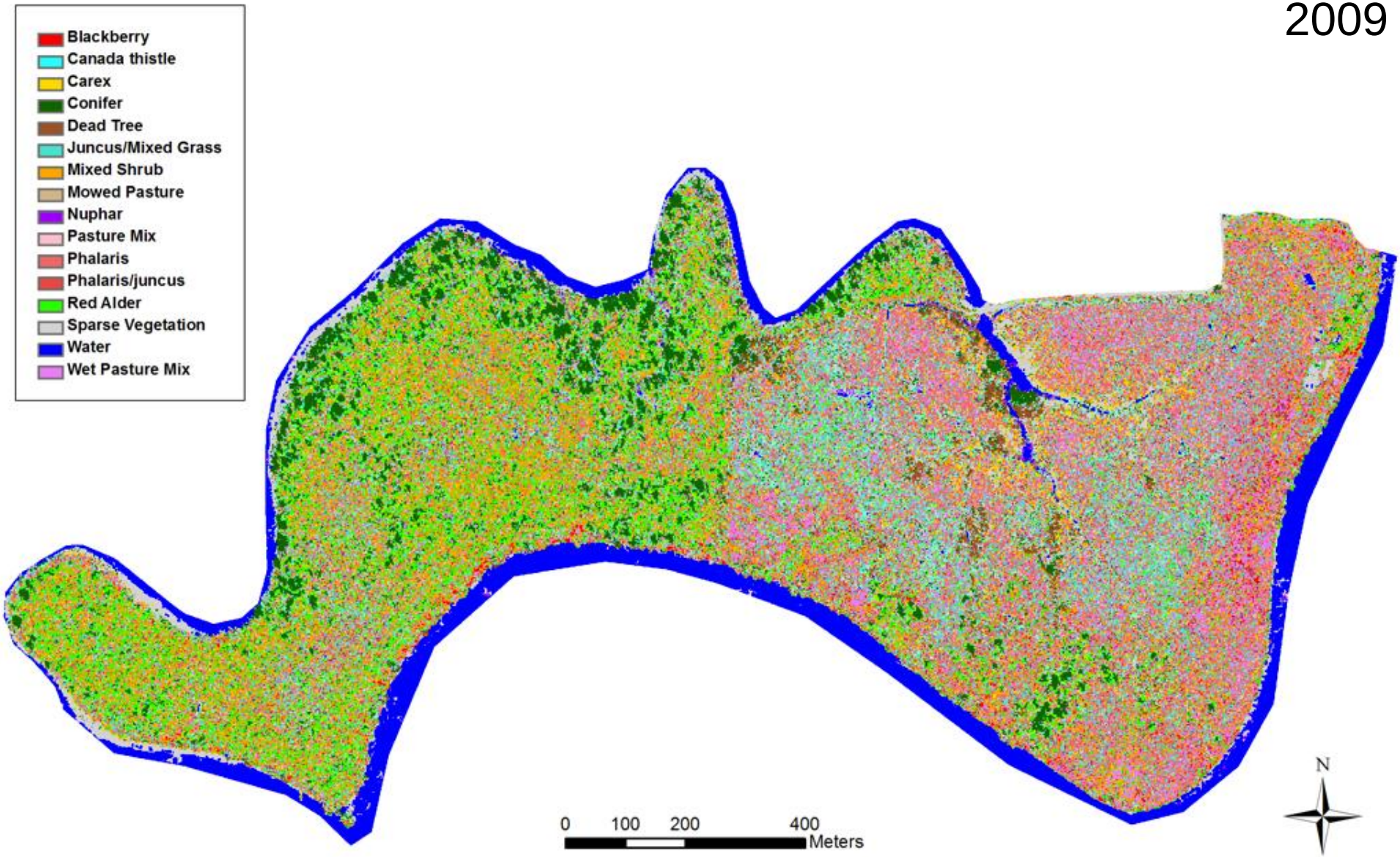

Findings:
(4-year rates, 2005-2009, with annual records)

1. In all cases, accretion rate at restoration site is greater than at paired reference site.
2. Highest rate at dike breach, followed by channel excavation, and lowest at tide-gate replacement.

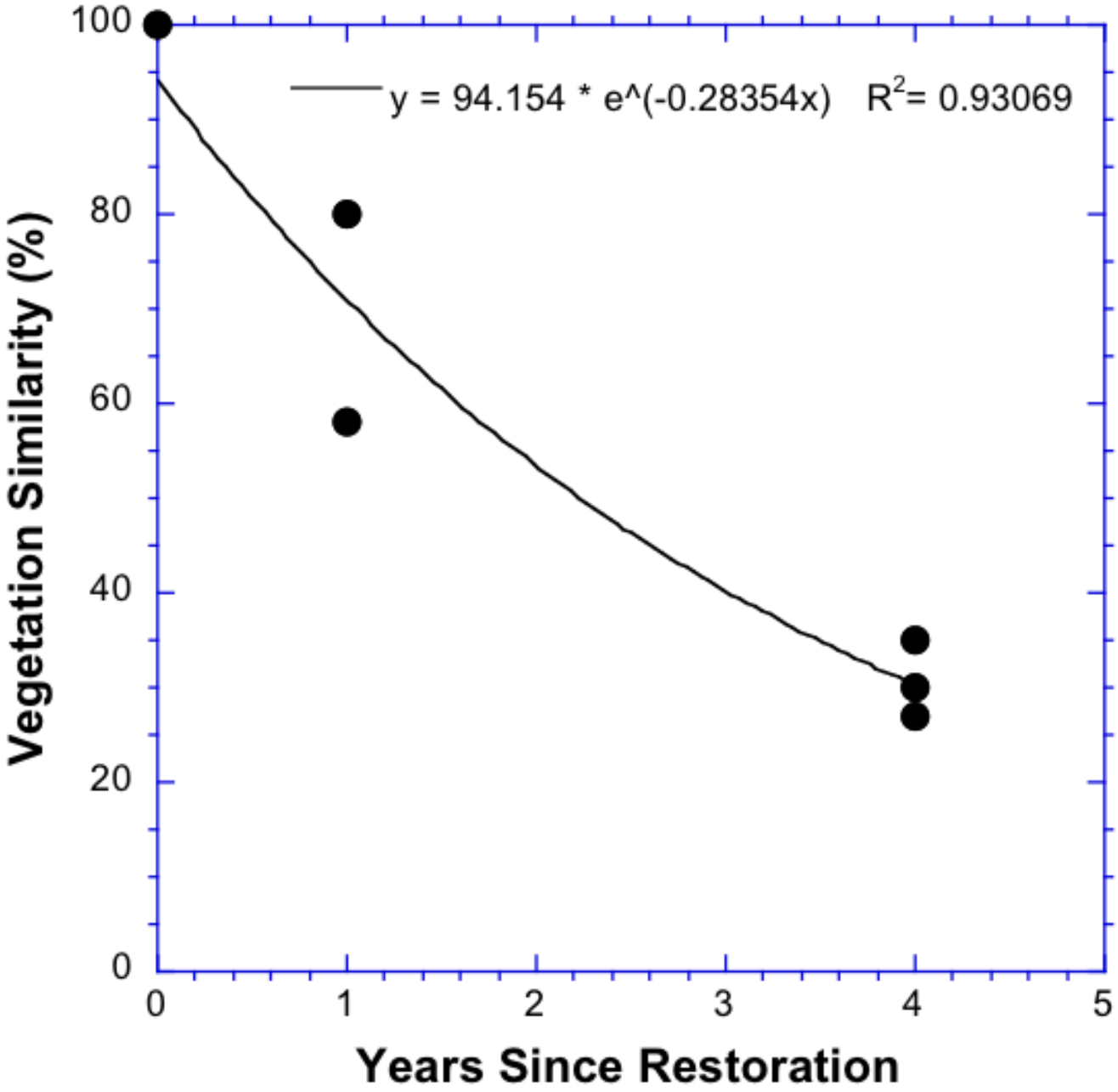
Pacific Northwest
NATIONAL LABORATORY

2005

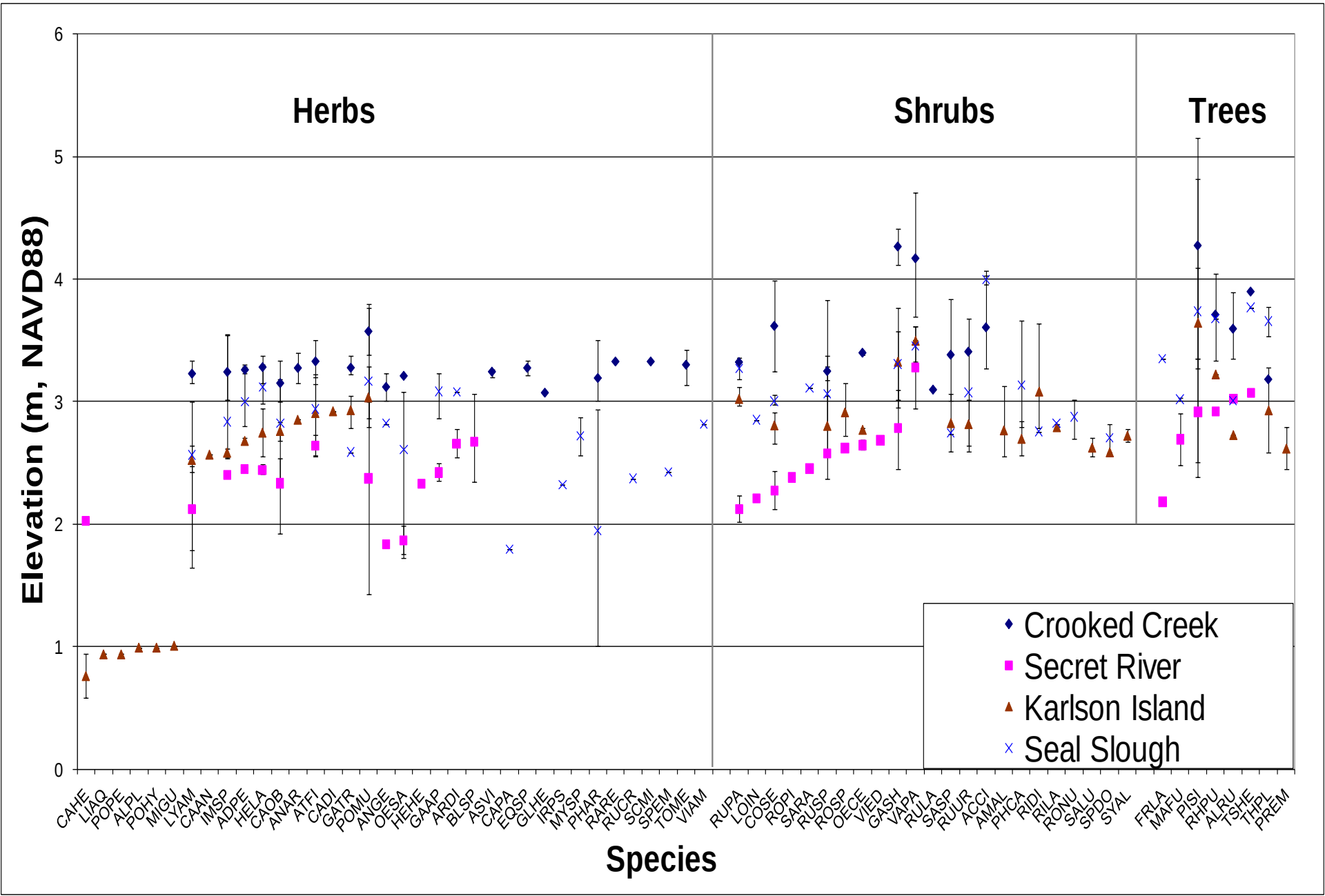

Blackberry
Canada thistle
Carex
Conifer
Dead Tree
Juncus/Mixed Grass
Mixed Shrub
Mowed Pasture
Nuphar
Pasture Mix
Phalaris
Phalaris/juncus
Red Alder
Sparse Vegetation
Water
Wet Pasture Mix
0
100
200
400
Meters
N


2009
Blackberry
Canada thistle
Carex
Conifer
Dead Tree
Juncus/Mixed Grass
Mixed Shrub
Mowed Pasture
Nuphar
Pasture Mix
Phalaris
Phalaris/juncus
Red Alder
Sparse Vegetation
Water
Wet Pasture Mix
0
100
200
400
Meters
N

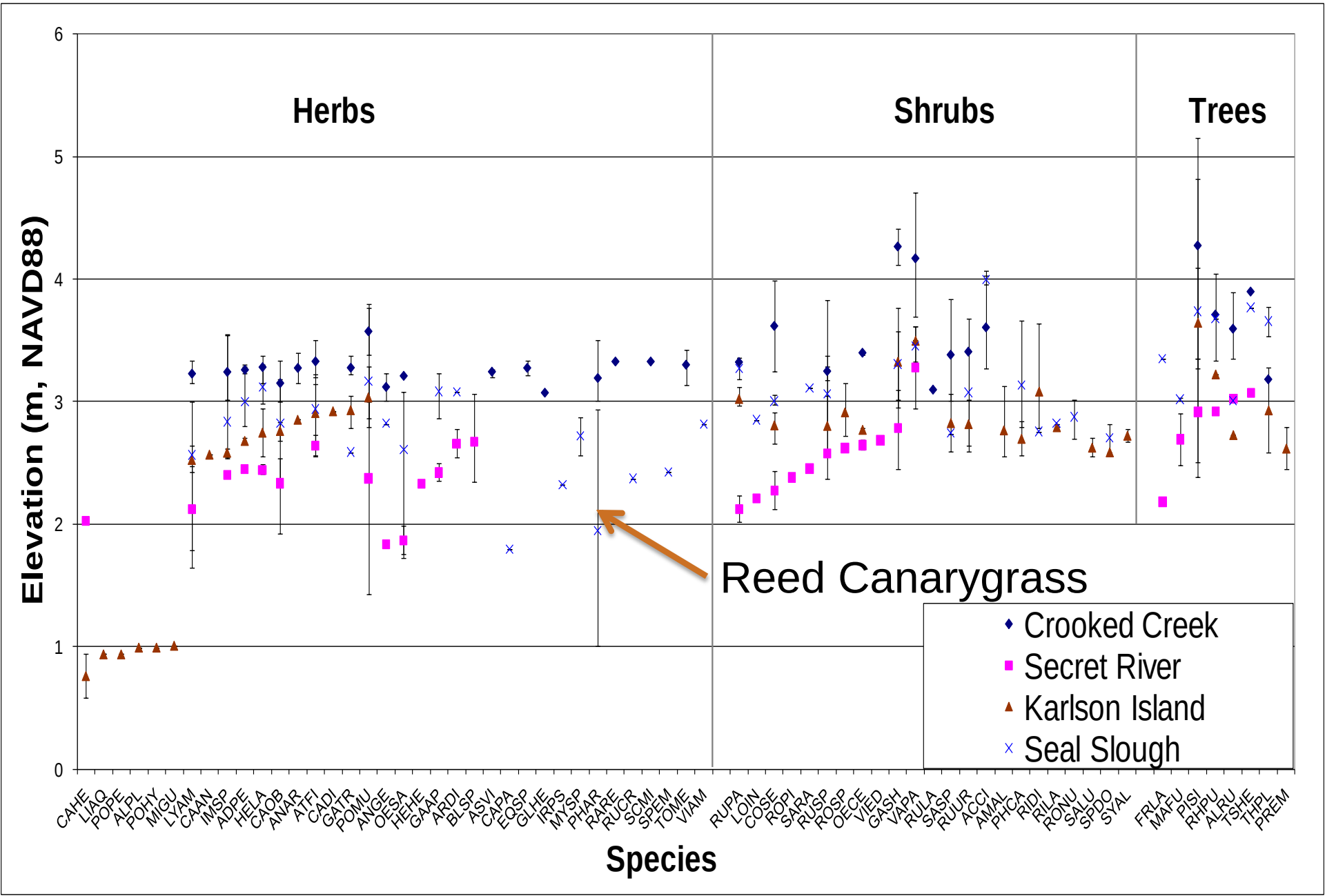
# Biotic Change: Plot-Scale Similarity Indices



# Plant Species-Elevation Relationships

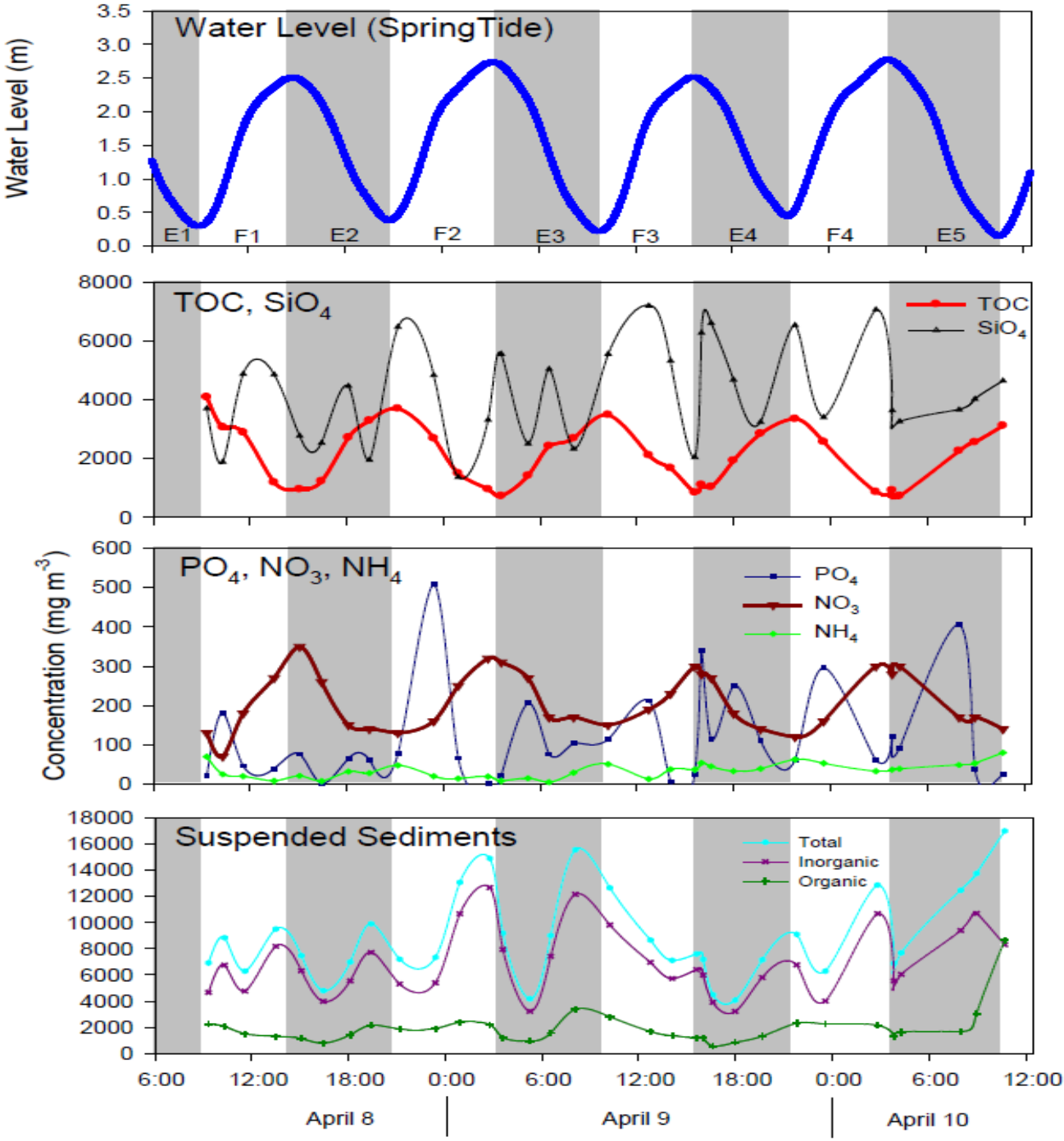


# Plant Species-Elevation Relationships

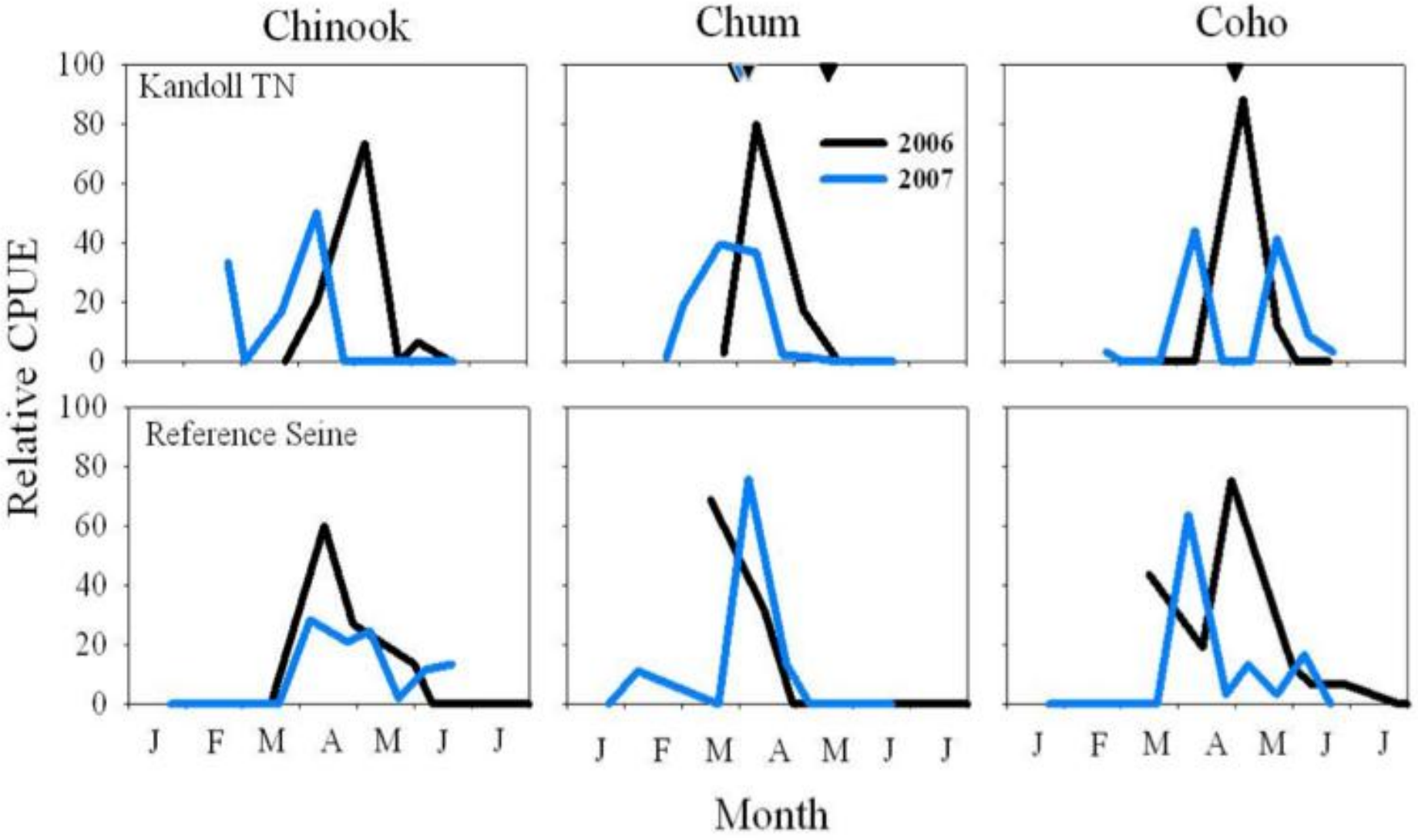


# Water Properties and Exchange

- Water Level
- TOC, $SiO_4$
- $PO_4$, $NO_3$, $NH_4$
- Suspended sediments



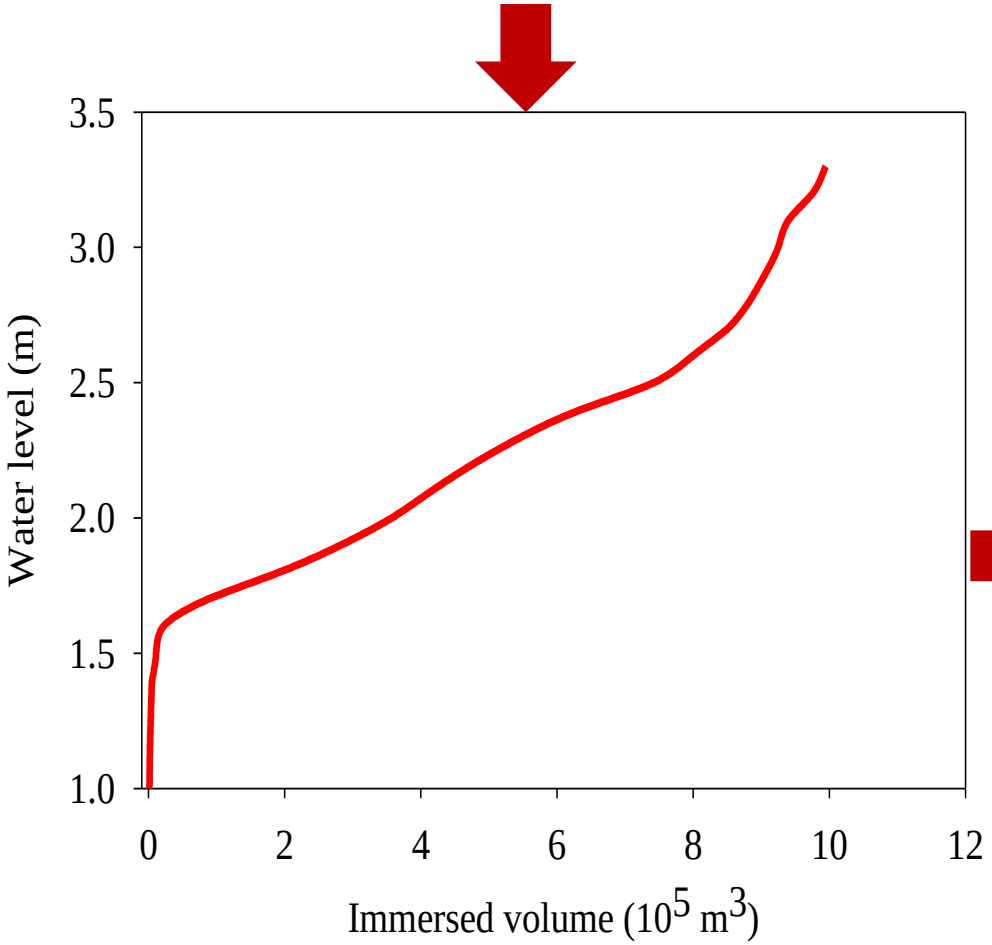
# Juvenile Salmonid Presence Following Reconnection



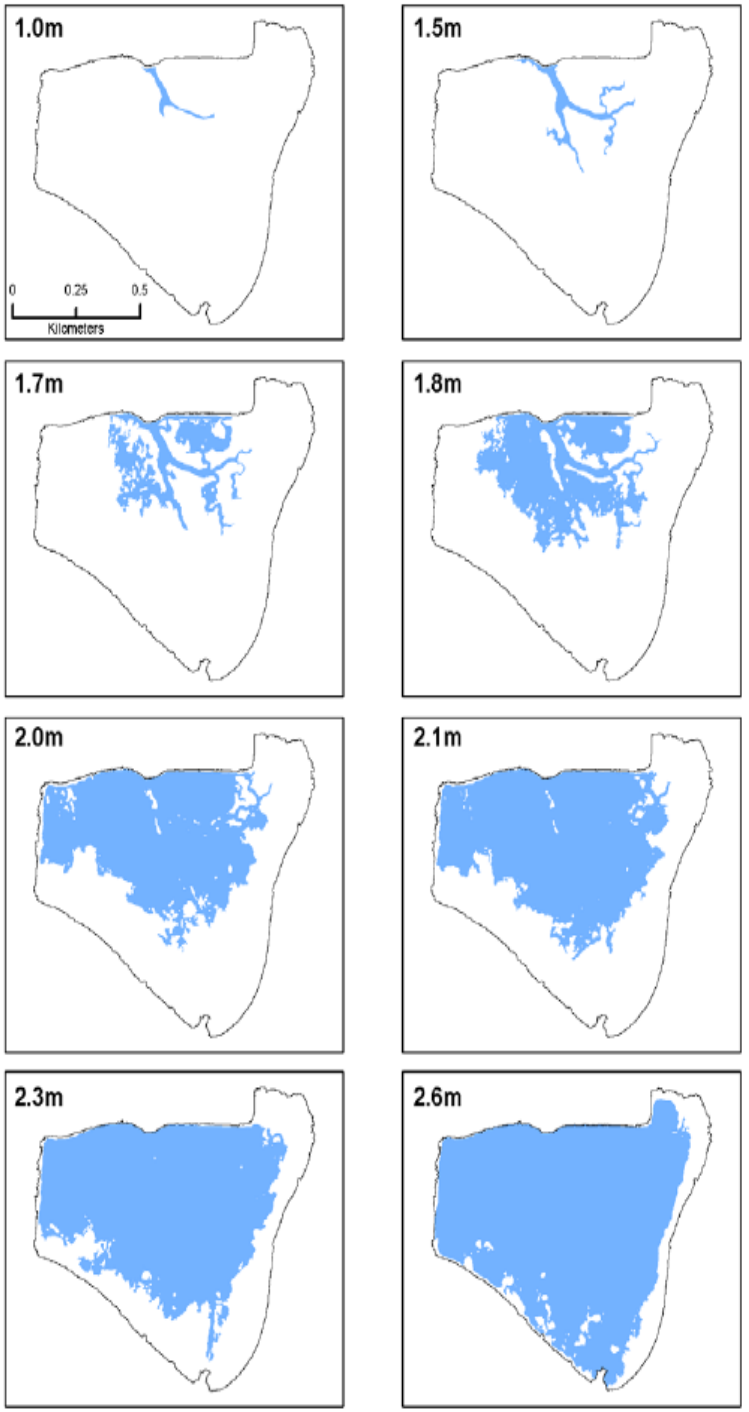
# Potential Habitat Opportunity

Inundation by water level

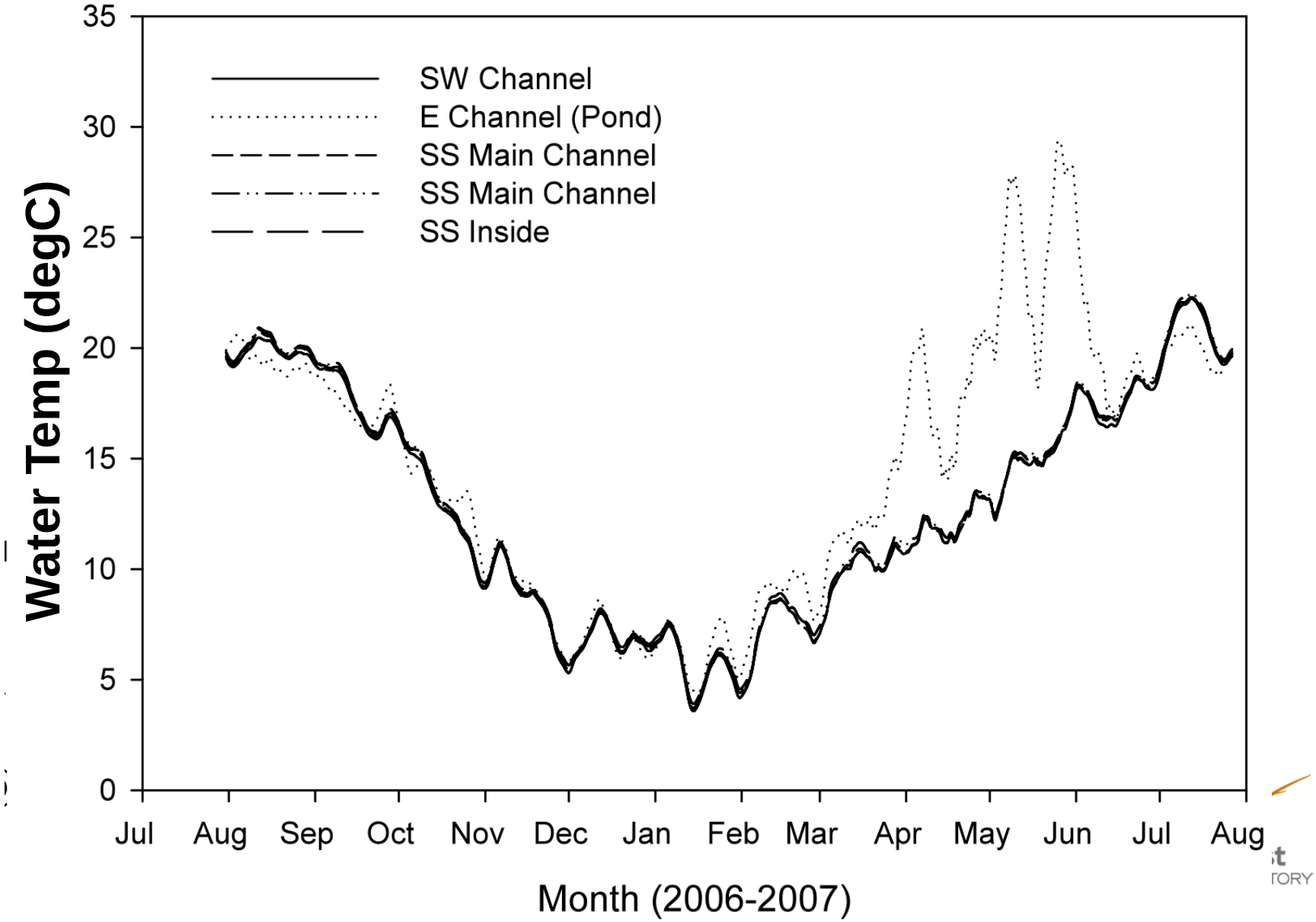
Tidal fluctuation (field data)




Tide-volume relation (modeled)



# Implications for Aquatic Organisms: Water Temperature Change

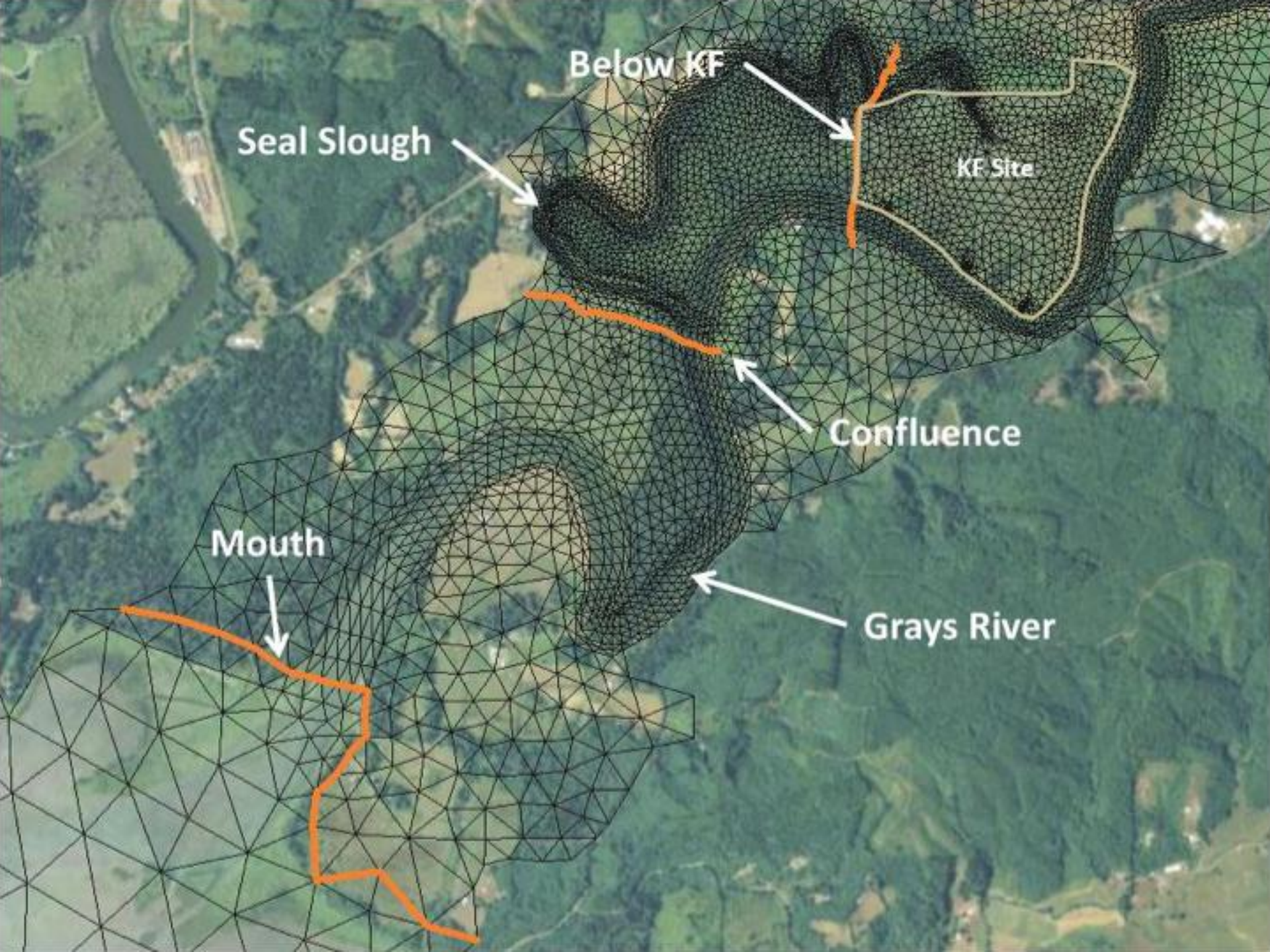


# Juvenile Salmon Prey Resources

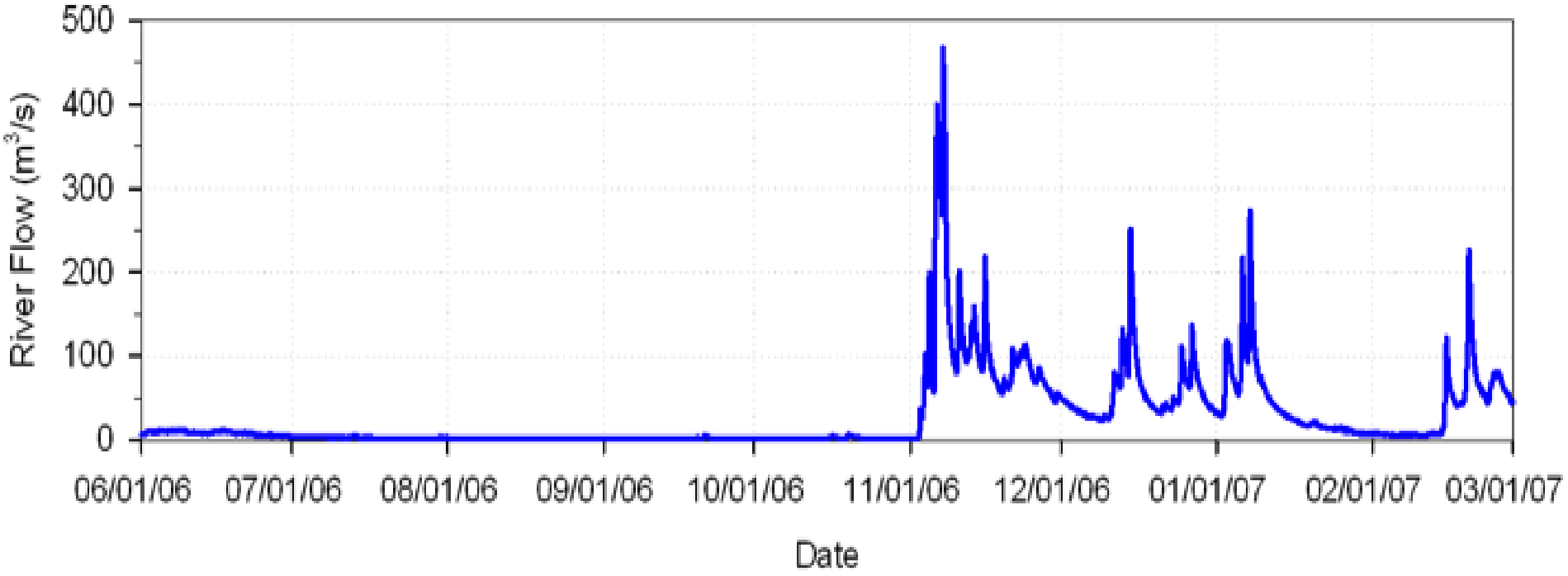
58 insect taxa in insect fallout traps & ½ of these present in juvenile salmon diets-suggests consumption of prey produced in the swamp system.

46 taxa including several insect families, crustaceans, molluscs and nematode and oligochaete worms (most numerous taxa were cladocerans and copepods, both planktonic organisms).

Restoring site and swamp had dense nematodes and oligocheates, and some chironomid and ceratopogonidae fly larvae.

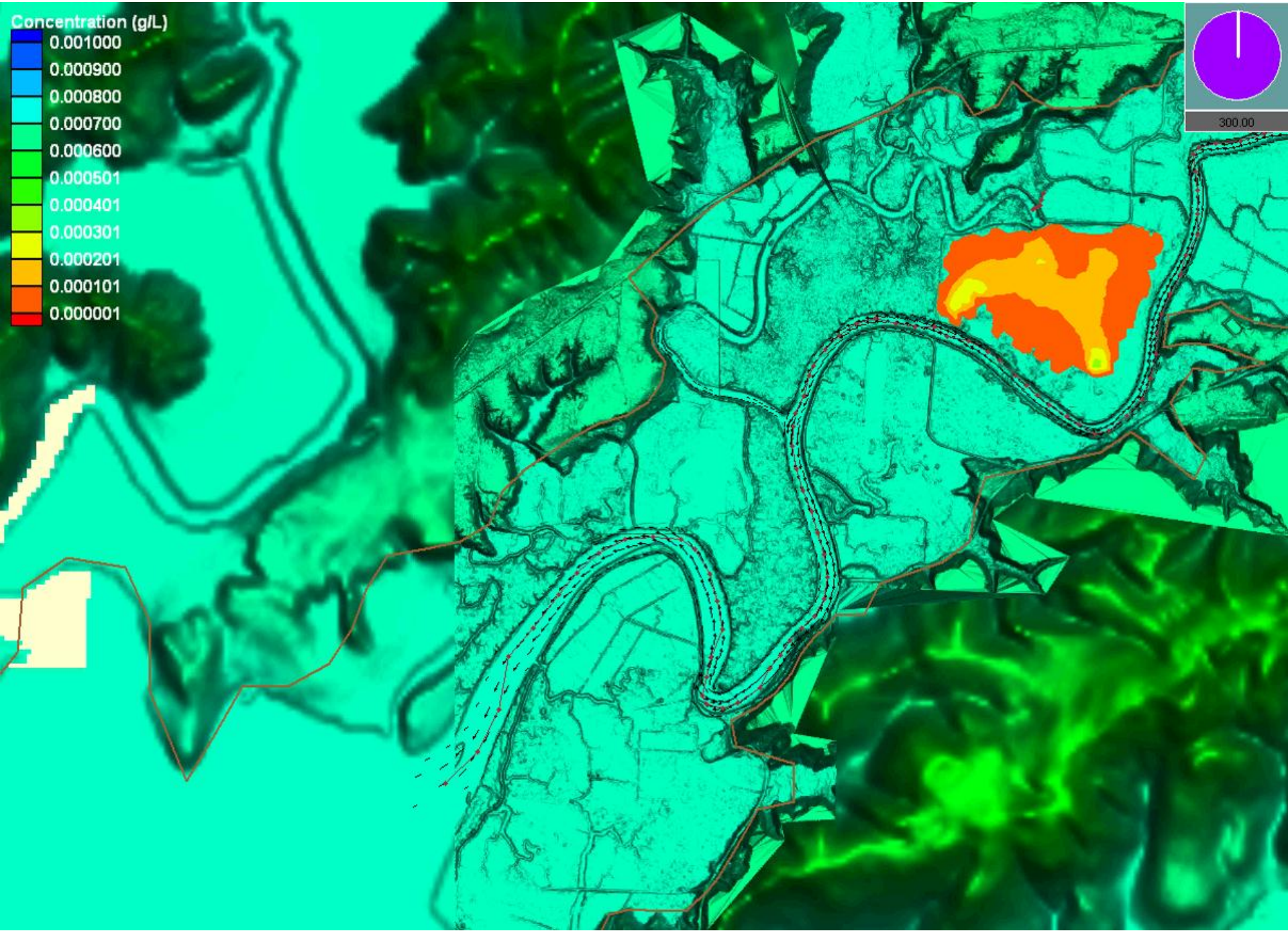

Below KF
Seal Slough
KF Site
Confluence
Mouth
Grays River

# Grays River Flow used for Export Model Runs






Pacific Northwest
NATIONAL LABORATORY


Concentration (g/L)
0.001000
0.000900
0.000800
0.000700
0.000600
0.000501
0.000401
0.000301
0.000201
0.000101
0.000001
300.00

# Marsh Macro-detritus Organic Matter Export

- 96 ha (237 acres) of restoring sites in Grays River could be exporting 391 metric tons (dry wt) (~431 tons) of marsh macro-detritus annually
- Major ‘pulsed’ hydrological events force major export of OM into estuary
- 50% of the POM exported reaches the estuary over a distance of ~7km
- Insect production high in marshes
- The macro-detritus drift contains insects
- Inference is that the restored wetland in contributing OM and salmon prey

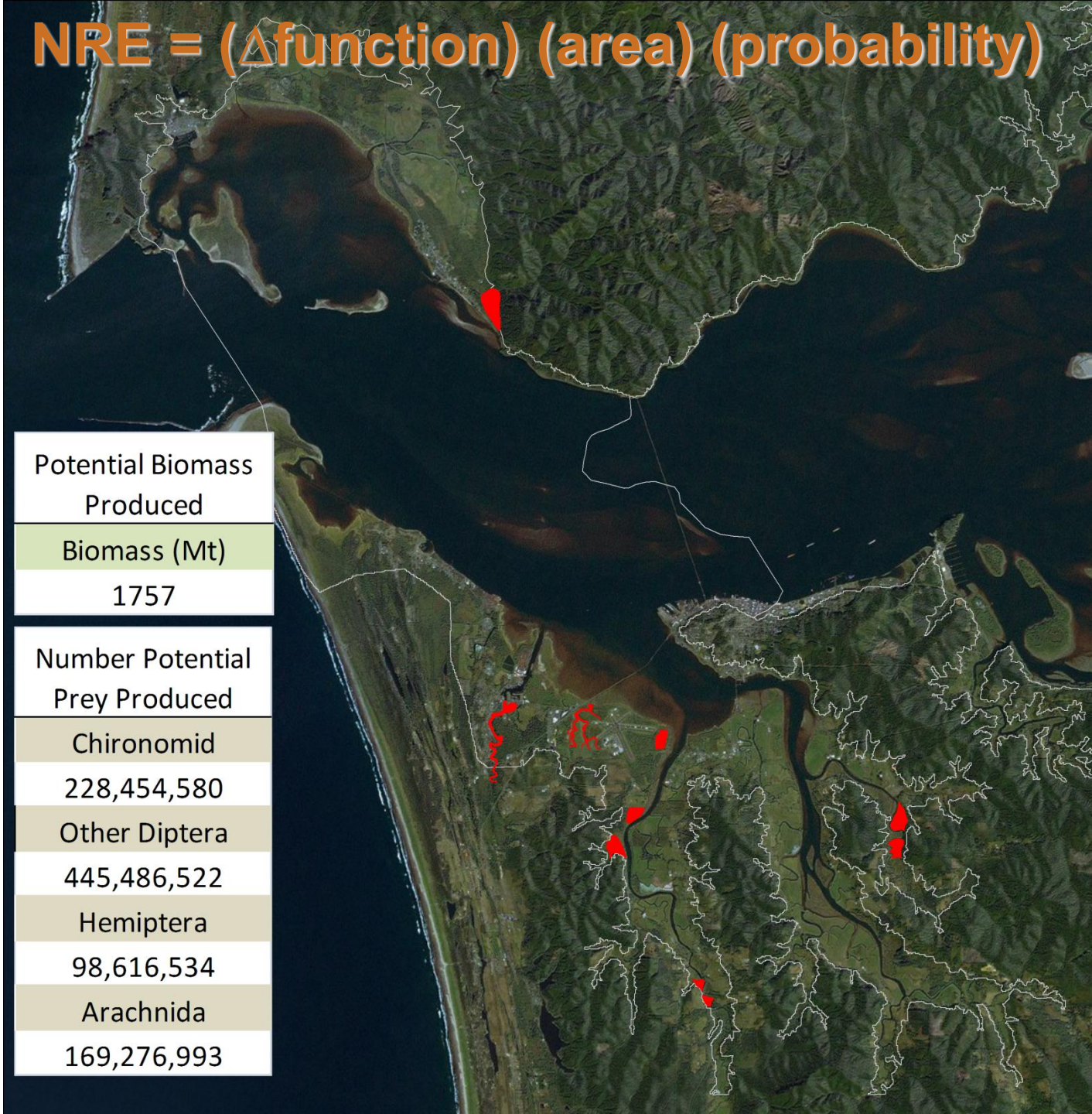
# Ratio-based Estimators

**F= *plant production and prey production***

**A= *new wetted area***

**P= *sd based on replicate sites***

(A. Borde, Keith Marcoe, Ron Kaufmann)



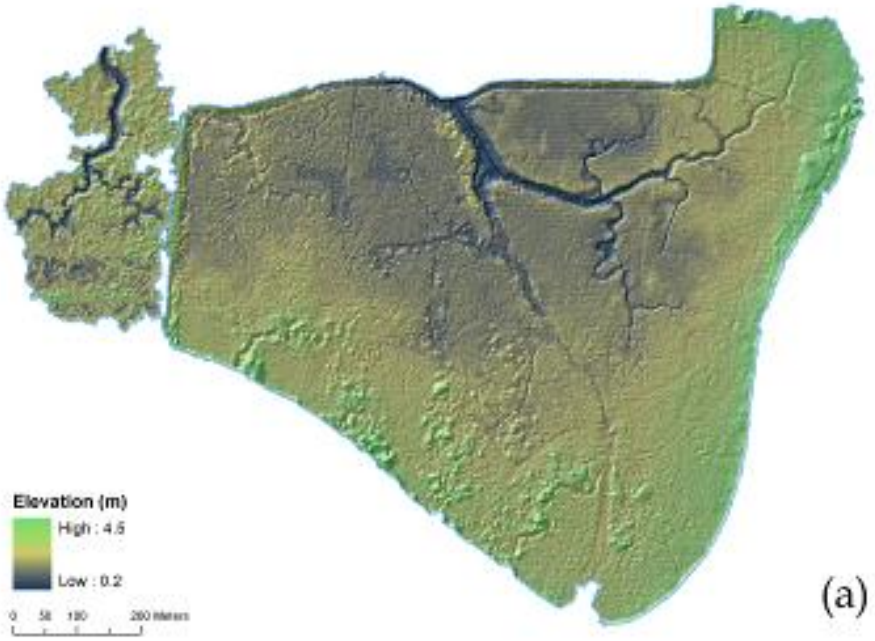

| Potential Biomass Produced |
|---|
| Biomass (Mt) |
| 1757 |

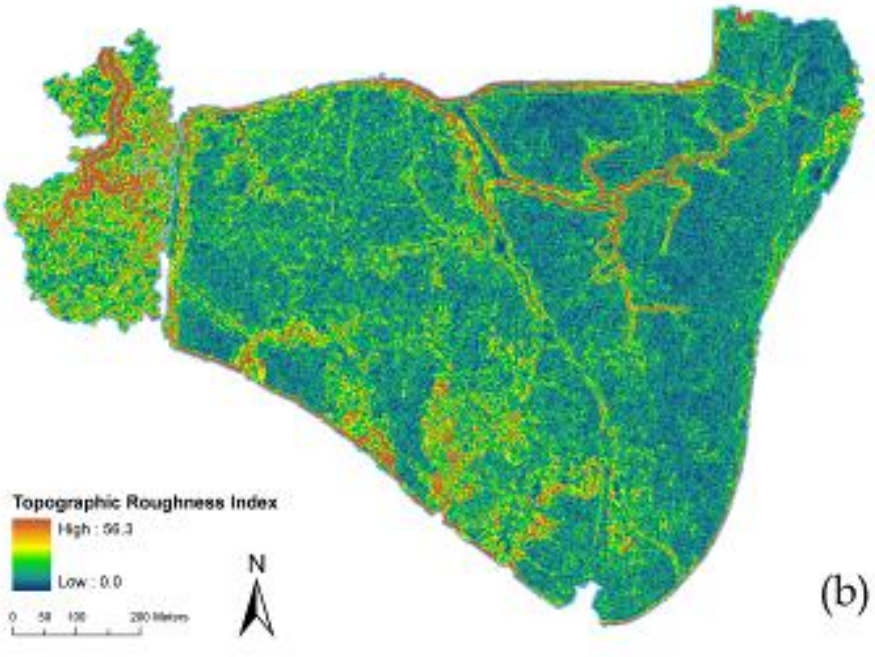
| Number Potential Prey Produced |
|---|
| Chironomid |
| 228,454,580 |
| Other Diptera |
| 445,486,522 |
| Hemiptera |
| 98,616,534 |
| Arachnida |
| 169,276,993 |


# Hydraulic Geometry

Diefenderfer and Montgomery (2008)

# Microtopography: Subsidence, Compaction, & Grading of Forested Wetlands




- Mean elevation of Seal Slough restoration site (prior to hydrologic reconnection) = 2.2 m
- Mean elevation of adjacent Seal Slough swamp reference site = 2.9 m
- Mean roughness index of the restoration site = 1.40; of the swamp reference = 2.63

Role of large wood in producing a hummocky swamp microtopgraphy and substrate for tree reproduction.

Diefenderfer, HL, AM Coleman, AB Borde, and IA Sinks. 2008. *Ecohydrology and Hydrobiology* 8:339-361

Pacific Northwest NATIONAL LABORATORY

# Floodplain reconnection…

- Initiates sediment accretion, channel formation, wetland vegetation shift
- Forces rapid changes within 5 years, but full restoration can take decades to centuries
- Allows non-native invasive species to possibly dominate newly restored sites
- Restricts wetland vegetation to a small (~1m) elevation range
- Allows immediate, frequent, prolonged salmon use
- Improves temperature conditions for salmon
- Drives prey production for fish
- Enhances substantial export of macro-detritus and fish prey

# Management Implications

- Working hypothesis is supported
- Habitat structural shift and ecological processes are rapid with substantial reconnection
- Focus on restoring self-sustaining habitat forming and maintaining processes
- Tide gate replacements remain in question in terms of processes, recovery rate, and salmonid benefit
- Consider elevation and species pool carefully, to minimize invasives, and maximize functions
- Pulsed hydrological events are ecologically important and should be incorporated in planning
- Sites up to 15km up tributaries from the mainstem can contribute to the broader estuary food web
- Restoration to historical conditions may be an unrealistic goal, but net ecosystem improvement may be achievable

# Acknowledgements

*Research Sponsor:* Blaine Ebberts, U.S. Army Corps of Engineers, Portland District, Columbia River Fish Mitigation Program

*Contributors:* Earl Dawley, Dave Montgomery, John Skalski, Ian Sinks, Kristina Vogt, Stephen Breithaupt, Amanda Bryson, April Cameron, Catherine Corbett, Val Cullinan, Erin Donley, Kern Ewing, Kate Hall, Nathan Johnson, Ron Kauffman, Yinghai Ke, Scott McEwen, Lee Miller, Doug Putman, Micah Russell, Kathryn Sobocinski, Cindy Studebaker, Allan Whiting, Dana Woodruff, Shon Zimmerman