Particulate Organic Matter Export from a Restored Tidal Freshwater Wetland in the Columbia River Estuary

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NOAA
US Army Corps of Engineers
Portland District
Pacific Northwest National Laboratory

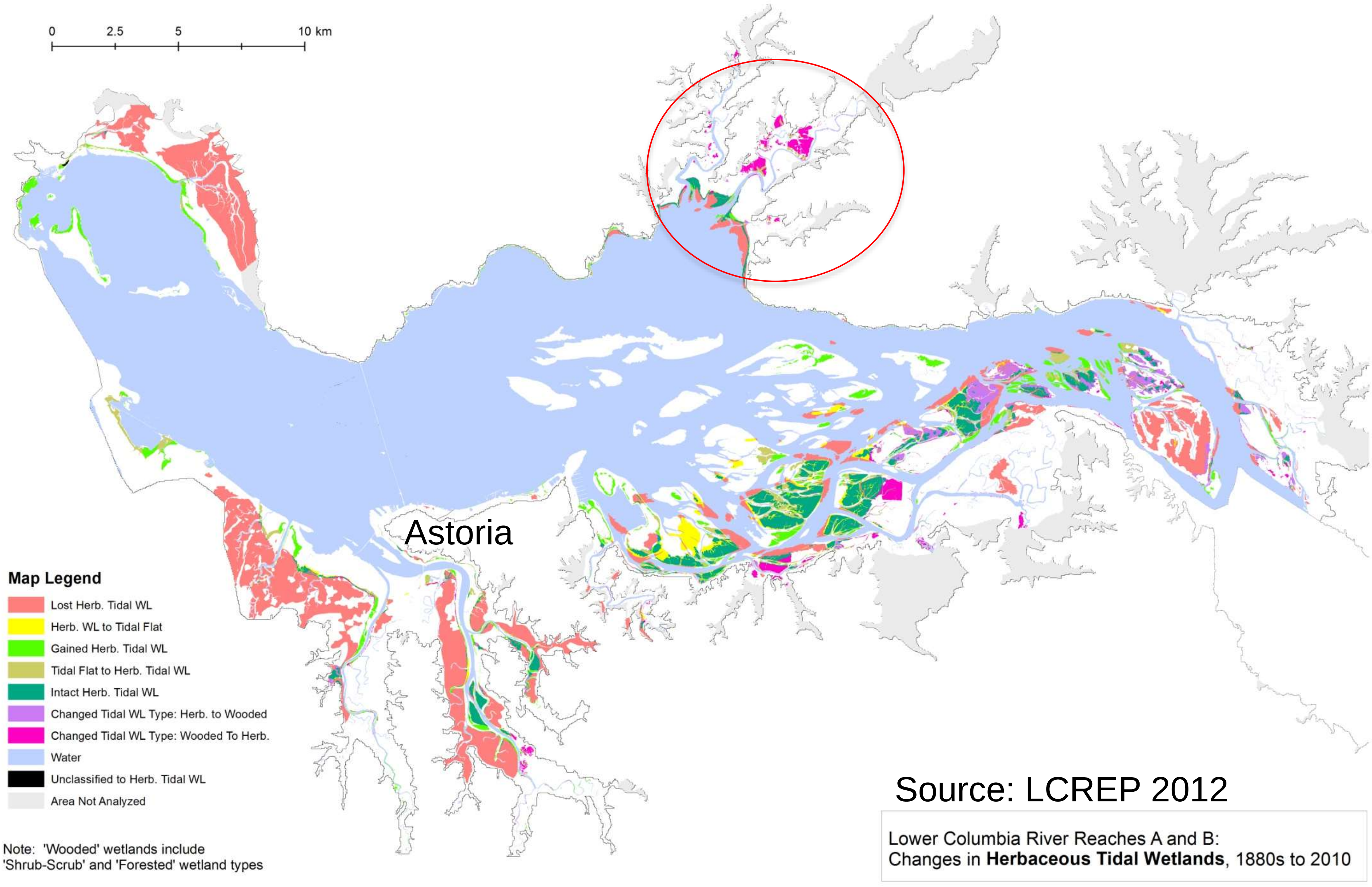
Study Issue, Question, Method

- **Issue**: Loss of 11,622ha of emergent wetlands since the late 1800's interrupted the flow of organic matter from the wetlands to the broader estuary by 82%, and shifted food web from macrodetritus-based to plankton-based[1,2]
- **Question**: Can reconnecting floodplain wetlands to the mainstem enhance delivery of marsh macrodetritus to other parts of the ecosystem and ultimately provide a source of organic matter for the mainstem estuarine food web?
- **Method**: Utilized a numerical hydrodynamic model to estimate the mass of particulate organic matter (POM) exported from a restoring tidal emergent marsh in the Grays River, a tributary to the Columbia River estuary[3]

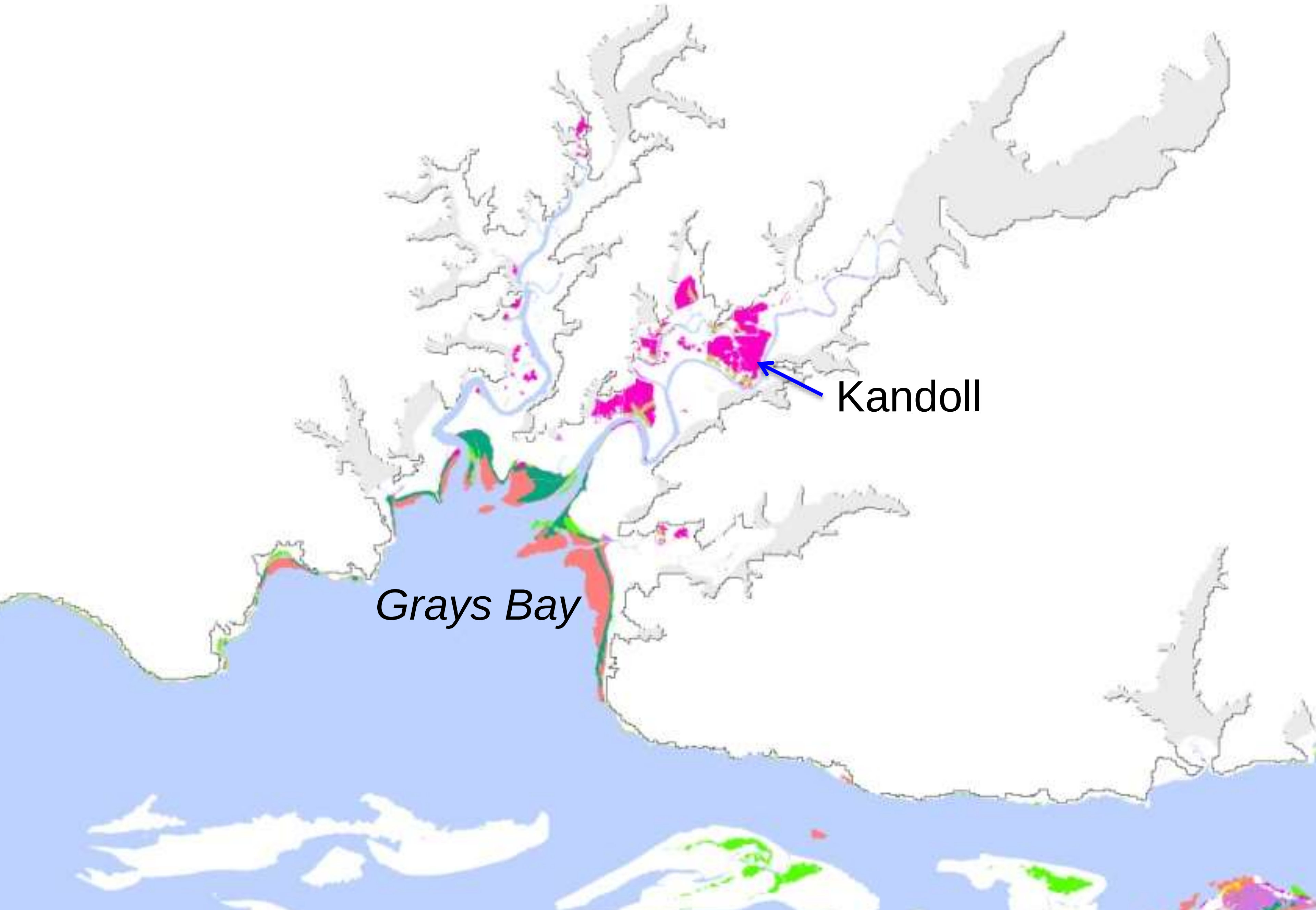
[1]Sherwood et al. 1990.

[2]LCREP 2012

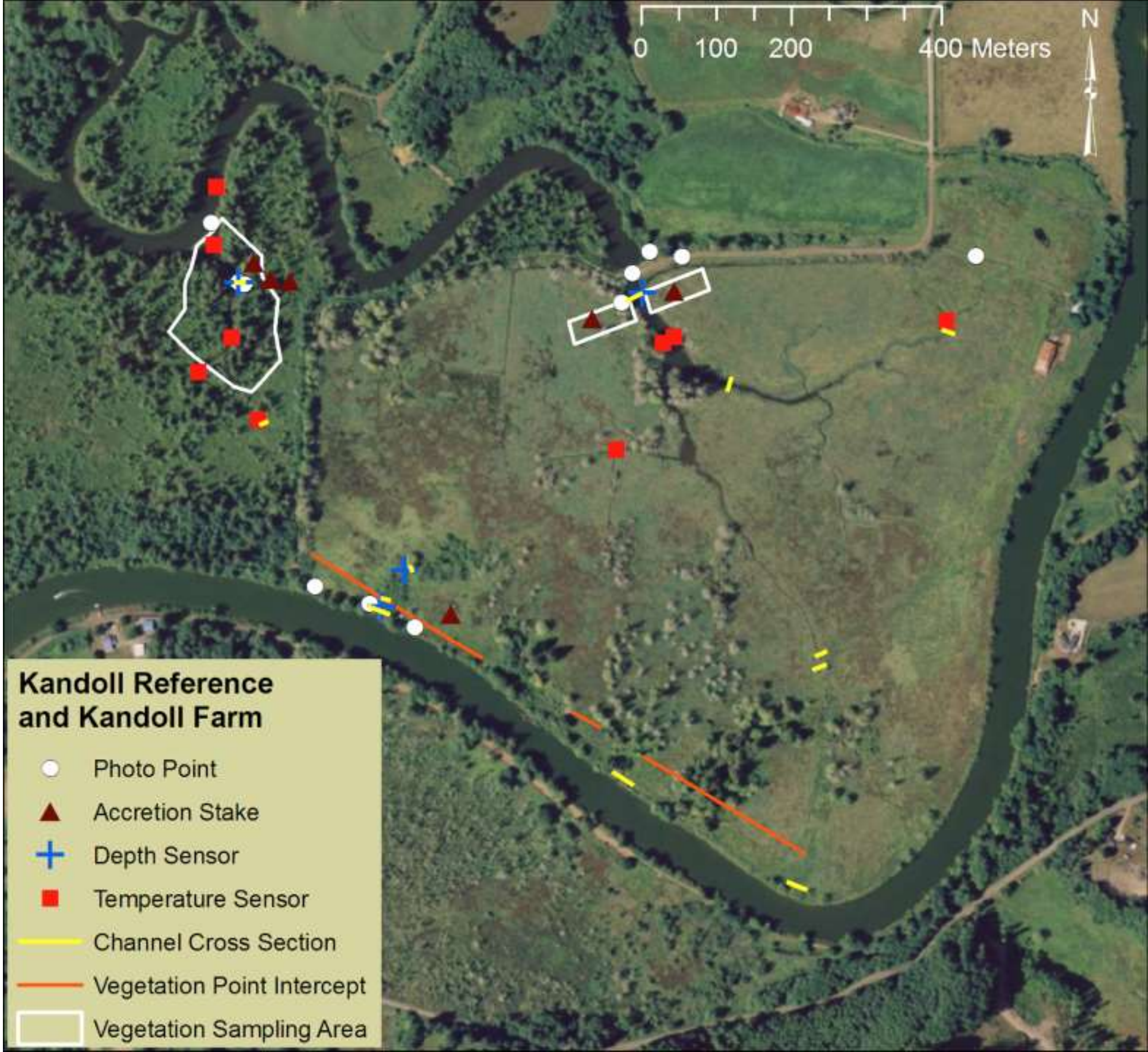
[3]Thom et al. in preparation



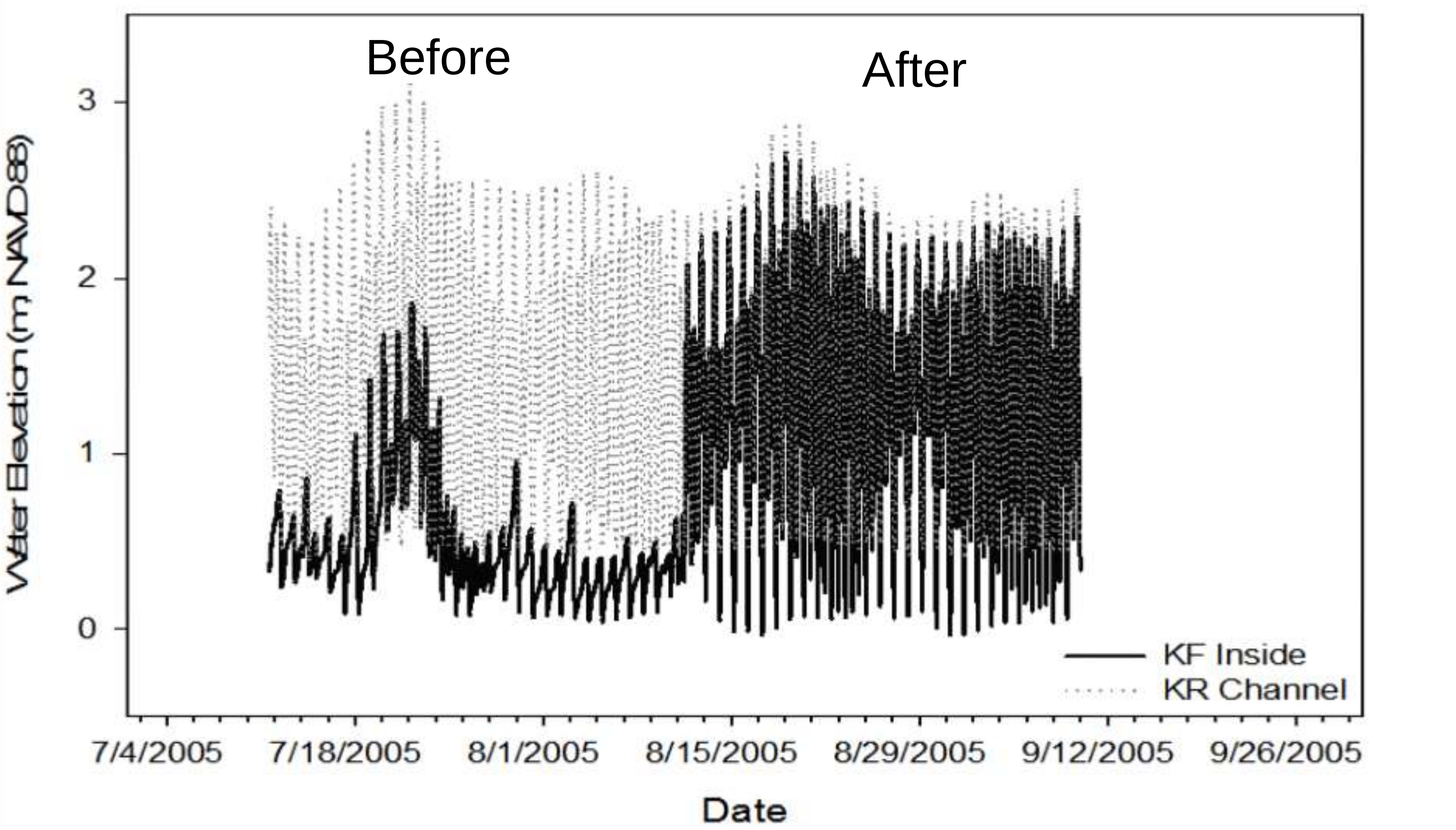
0
2.5
5
10 km
Astoria
Map Legend
Lost Herb. Tidal WL
Herb. WL to Tidal Flat
Gained Herb. Tidal WL
Tidal Flat to Herb. Tidal WL
Intact Herb. Tidal WL
Changed Tidal WL Type: Herb. to Wooded
Changed Tidal WL Type: Wooded To Herb.
Water
Unclassified to Herb. Tidal WL
Area Not Analyzed
Note: 'Wooded' wetlands include
'Shrub-Scrub' and 'Forested' wetland types
Source: LCREP 2012
Lower Columbia River Reaches A and B:
Changes in **Herbaceous Tidal Wetlands**, 1880s to 2010


Kandoll
Grays Bay

Sampling Points at Kandoll and Reference



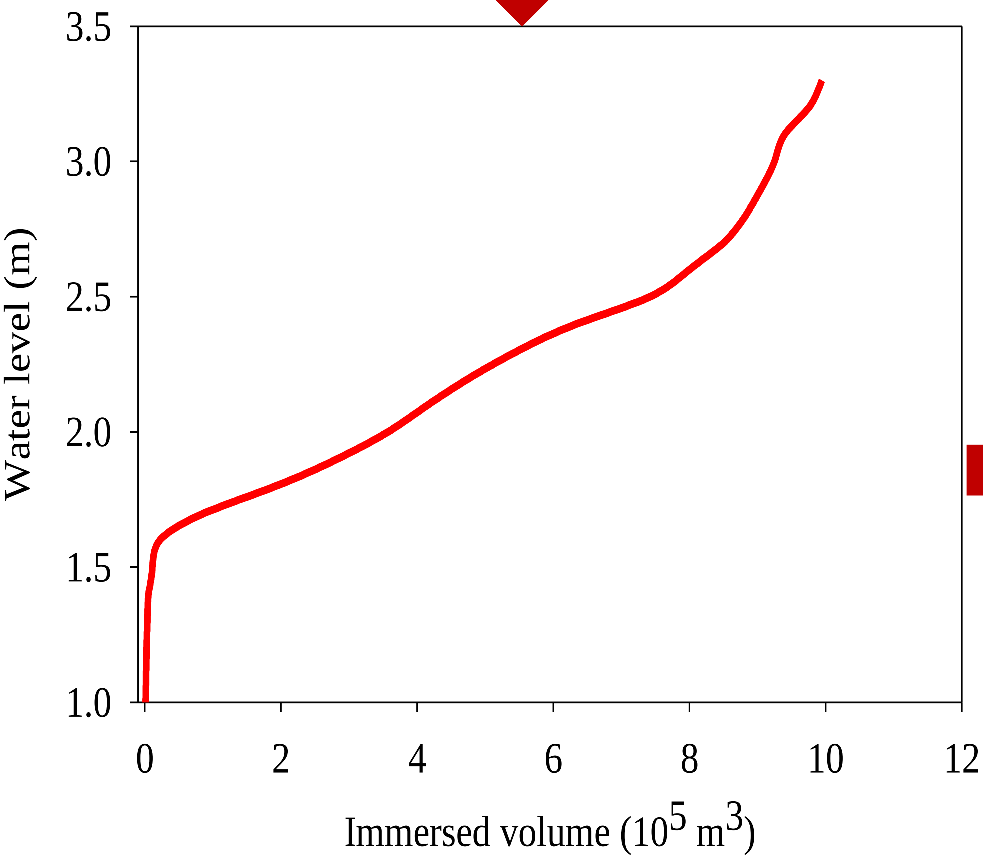
Hydrologic Regime Change: Tidal-Fluvial Signals at Restoration and Reference Sites



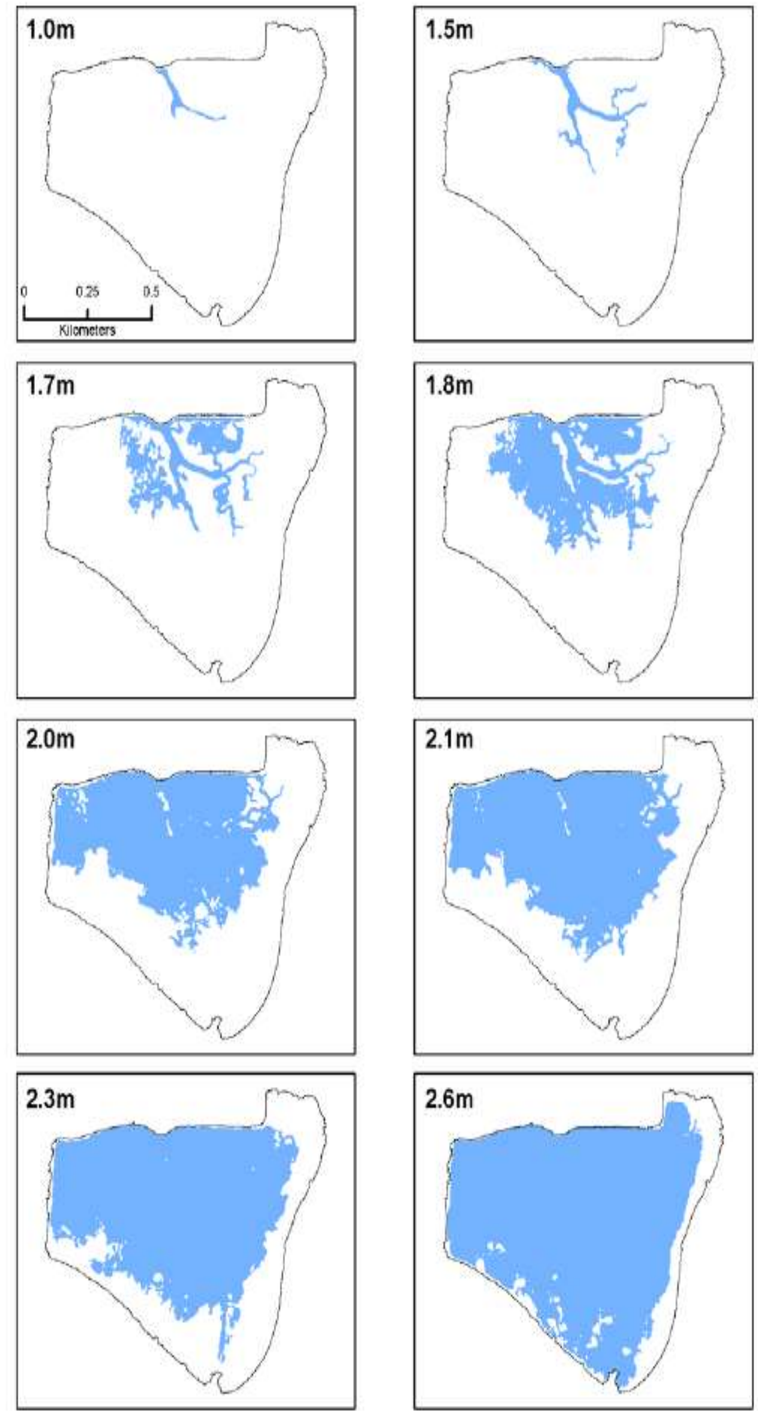
Potential Habitat Opportunity

Inundation by water level

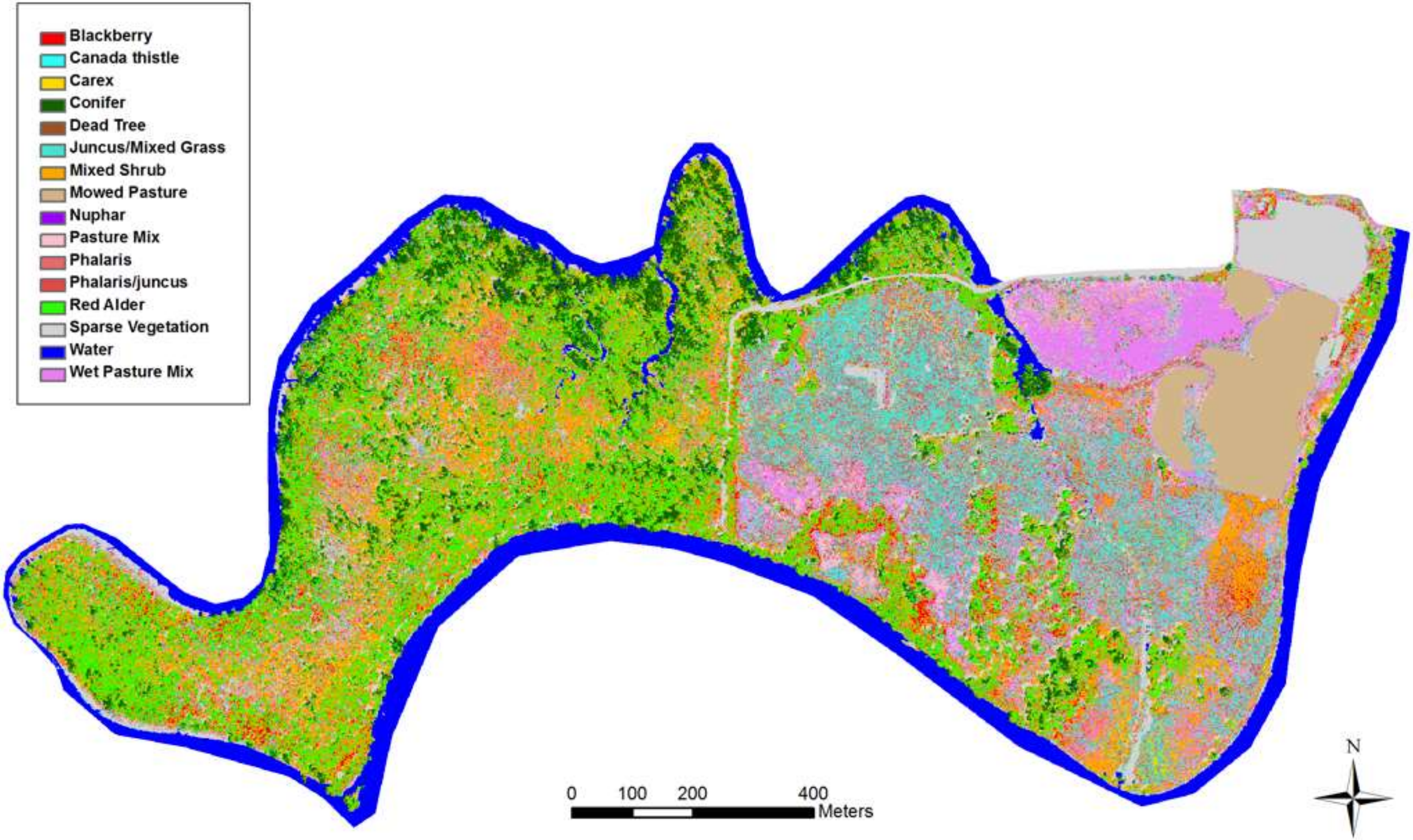
Tidal fluctuation (field data)



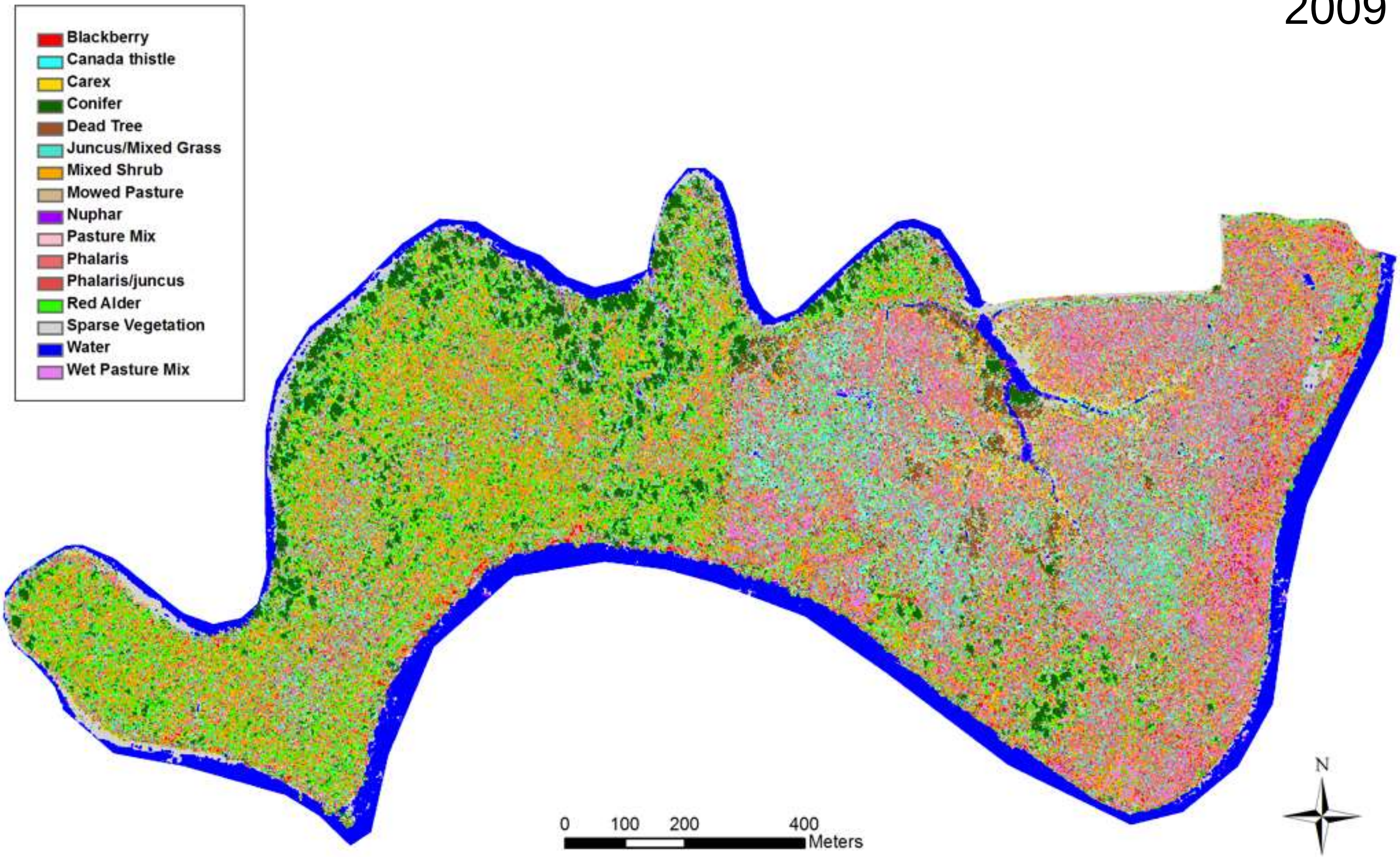
Tide-volume relation (modeled)



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

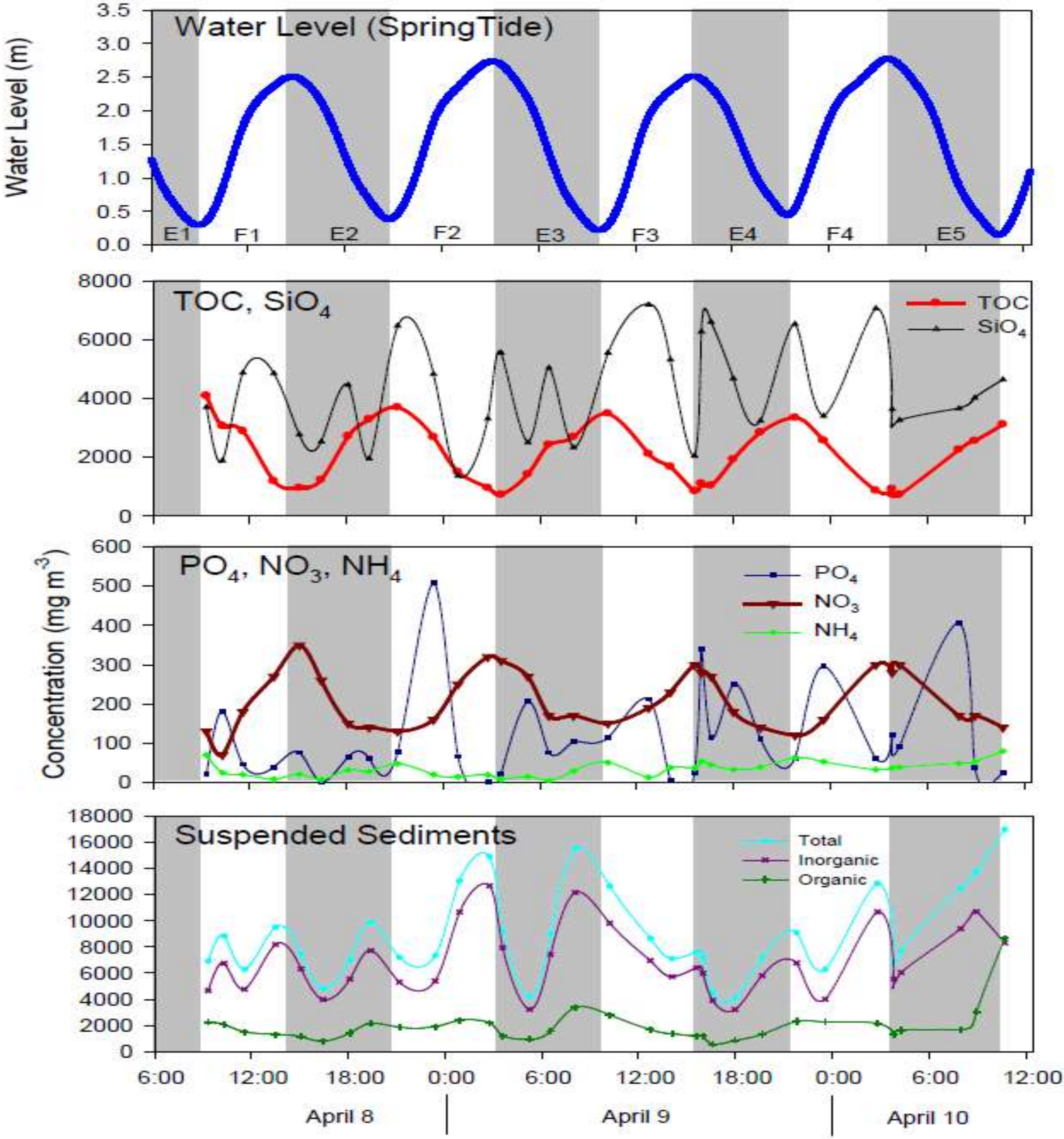
2009

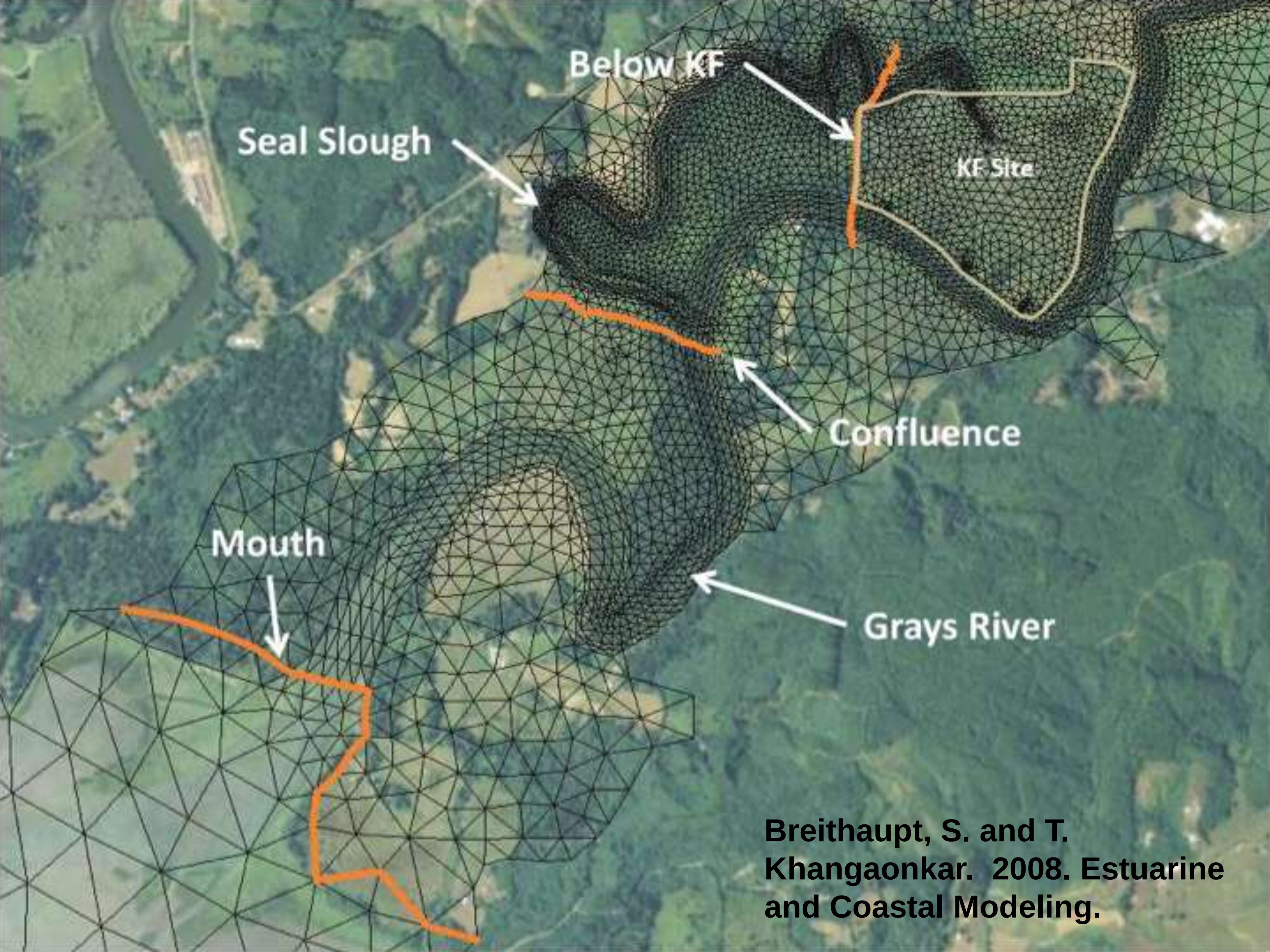


Blackberry
Canada thistle
Carex
Conifer
Dead Tree
Juncus/Mixed Grass
Mixed Shrub
Mowed Pasture
Nuphar
Pasture Mix
Phalaris
Phalaris/juncus
Red Alder
Sparse Vegetation
Water
Wet Pasture Mix
0 100 200 400
Meters
N

Water Properties and Exchange

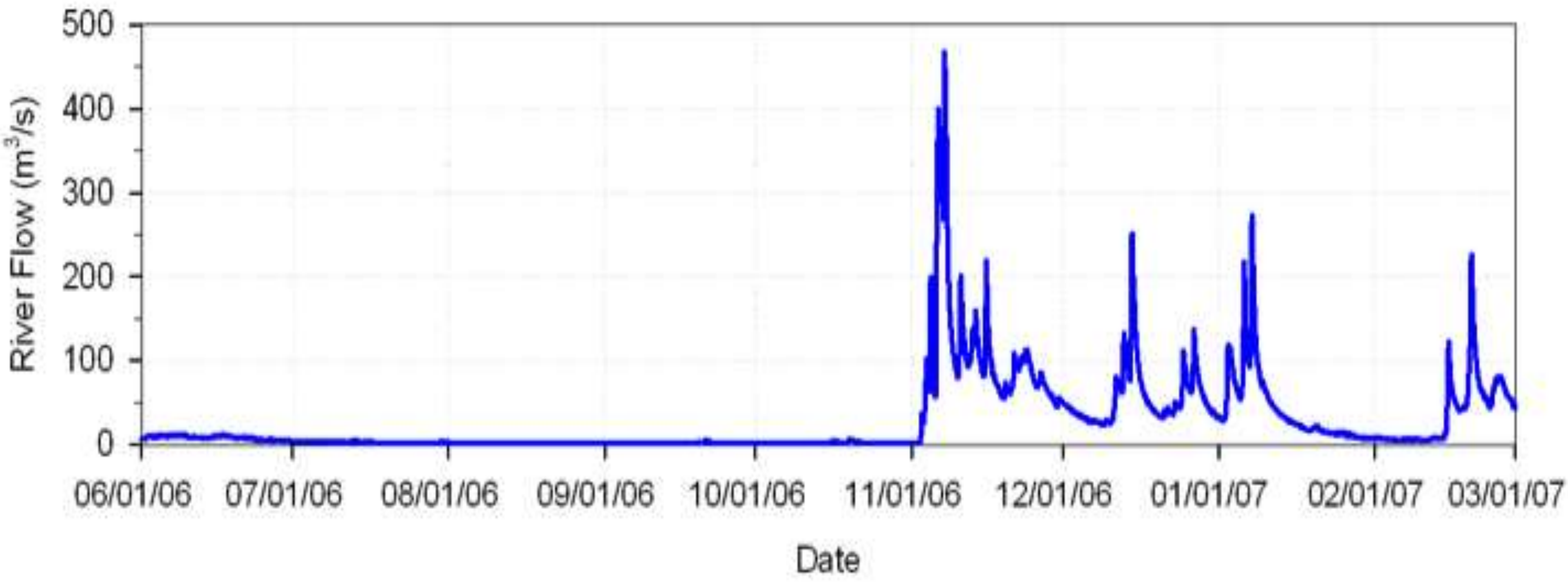
- ►Water Level
- ►TOC, SiO_4
- ►PO_4, NO_3, NH_4
- ►Suspended sediments

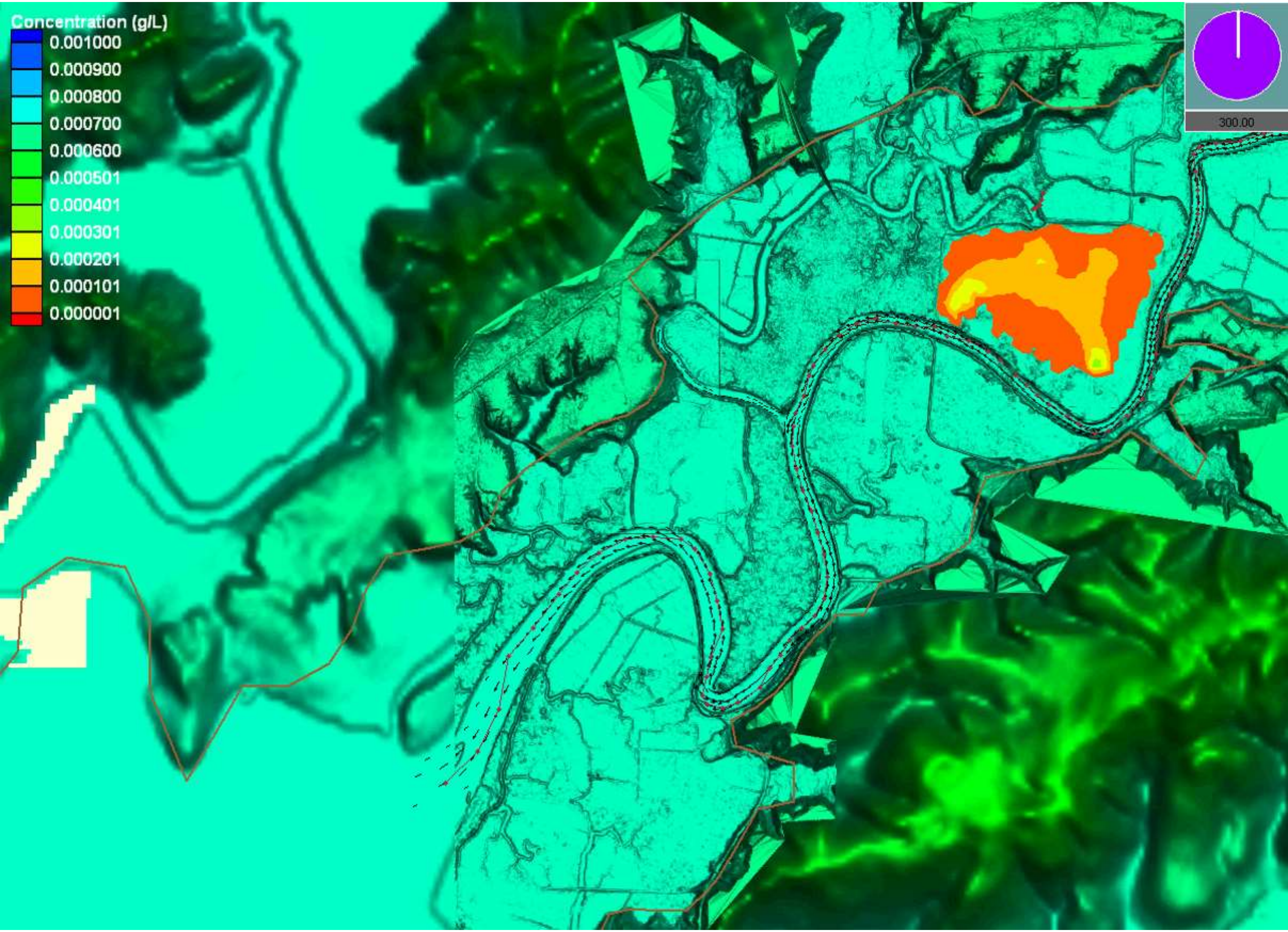




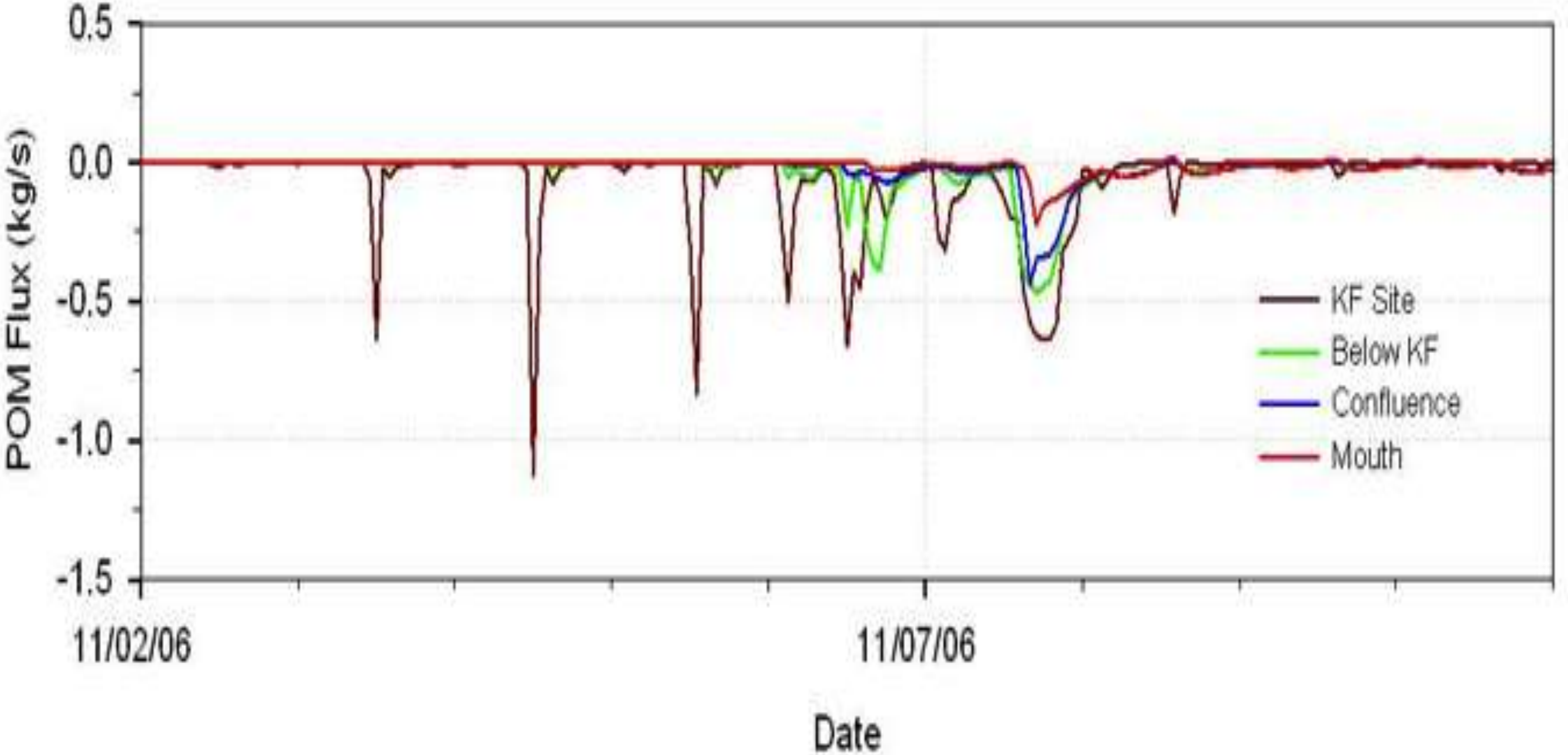
Breithaupt, S. and T. Khangaonkar. 2008. Estuarine and Coastal Modeling.

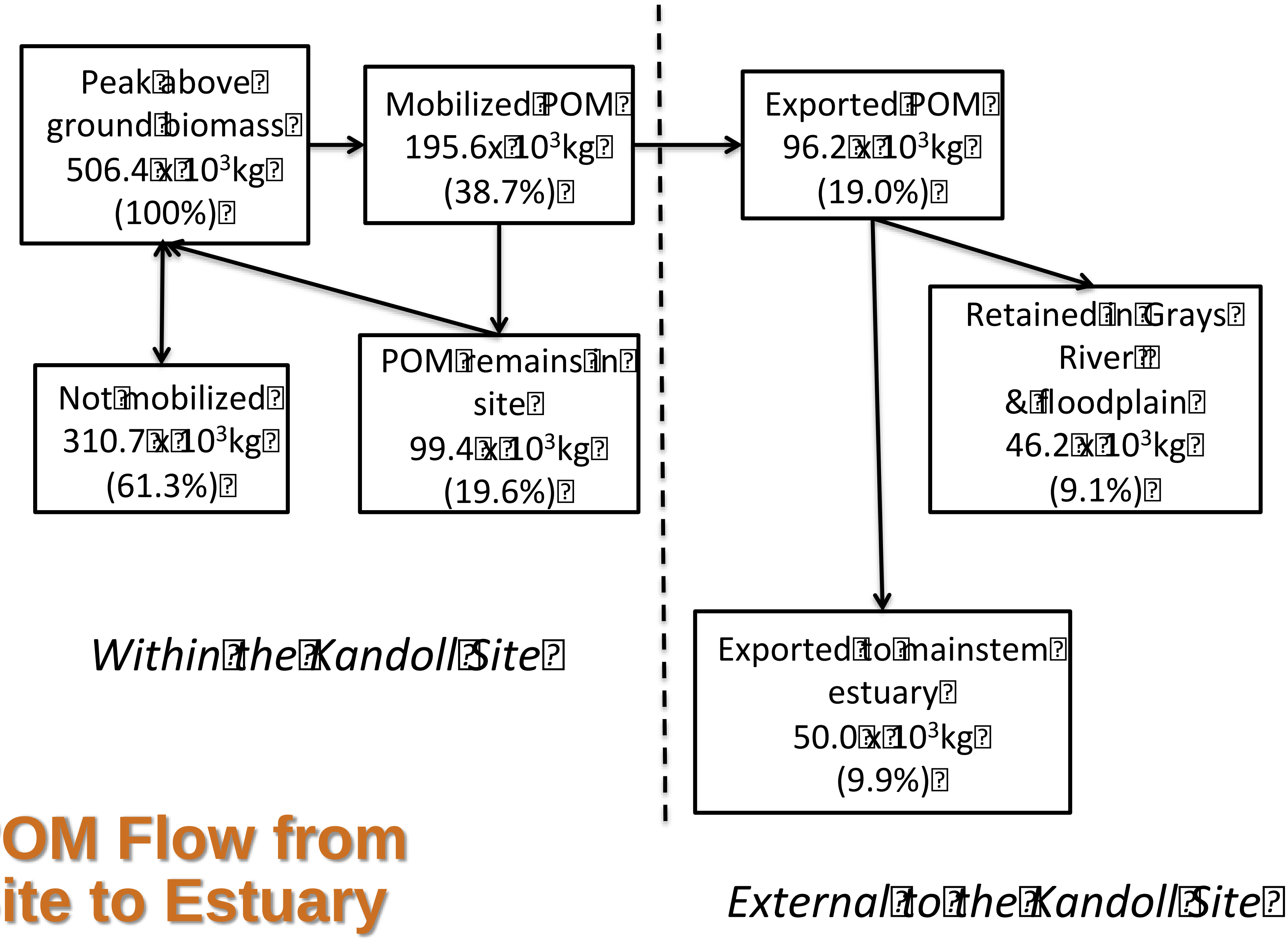
Grays River Flow used for Export Model Runs




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

POM Flux During Flooding Event (3-9 November 2006)





POM Flow from Site to Estuary

Implications of Results

- The 65 ha Kandoll site represents 0.56% of the *11622* ha emergent marshes lost from the system since the 1800's (LCREP 2012).
- The reintroduction from Kandoll of 3.85×10^5 kg C represents a 0.46% reversal of this loss.
- Our estimate that 19% of the production is exported is low compared to other estimates of 37% and 47% (Kistritz et al. 1983; Simenstad et al. 1990)
- Following hydrological connection, Kandoll became dominated by reed canary grass which is shown to be more recalcitrant to mobilization (Griffiths et al. 2012)
- We estimate that to fully restore marsh macrophyte detritus delivery to the system would require about *14773* ha of wetland restoration

Application to resource management, such as species recovery and ecosystem restoration

- Floodplain reconnection can result in contributions of marsh macrodetritus to mainstem *and to other floodplain wetlands*
- Sites *up to 15km* up tributaries from the mainstem can contribute to the broader estuary food web
- Although exchange occurs with tidal dynamics, major export of OM is forced by flooding events, so project locations, size and connection design should consider facilitating *effective* pulsed events under an altered hydraulic regime (i.e., flow regulation and climate change)

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Implications of Results –data to back up

- The 65 ha KF site represents 0.56% of the 11622 ha wetlands lost from the system since the 1800's (LCREP 2012). Using the factors of 3.28×10^3 kg C ha^{-1} (= 2.13×10^5 kg C/65 ha) production from the KF site, 11622 ha of herbaceous wetlands lost and 23% export of marsh macrophyte production, means that 3.60×10^7 kg C x 0.23 = 8.28×10^6 kg C export to the ecosystem was lost since the 1800's. The reintroduction from KF of 3.85×10^5 kg C (= 9.62×10^4 kg exported x 0.4 kg C/kg dry wt) represents a 0.46% reversal of this loss. This means that to fully restore marsh macrophyte detritus delivery to the system would require about 14773 ha of wetland restoration.
- Our estimate of vascular plants standing crop (0.78 kg m-^{2}) at KF is within thee range reported by Small et al. (1990) of 0.27 to 1.65 kg m^{-2}. Simenstad et al. (1990) estimated for the Columbia estuary that herbivores remove 15% of annual emergent plant carbon production, and that translocation to the roots removes 38%, leaving approximately 47% to enter the POM pool. For the Fraser River tidal delta in southern British Columbia, Kistritz et al. (1983) showed that approximately 37% of the sedge marsh biomass was exported off the marsh plain annually, and that virtually all of that took place during winter. Although we did not measure loss via herbivory, translocation, or burial, our estimate that 19% of the production is exported is somewhat low compared to these other regional estimates. We wonder if this may be due to differences in wetland species. Following hydrological connection, KF became dominated by reed canary grass. This species developed thick, tough mats formed by reed canarygrass (*Phalaris arundinacea*) that may be more recalcitrant to mobilization (i.e., Griffiths et al. 2012) than those (e.g., the sedge *Carex lyngbyei*) dominating sites studied by Simenstad et al. (1990) and Kistritz (1983).

Evidence Based Evaluation (EBE) 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*

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