

Habitat Structure, Connectivity and Organic Matter Flux

Heida L. Diefenderfer and Amy B. Borde

Pacific Northwest National Laboratory,
Marine Sciences Laboratory,
Sequim, Washington

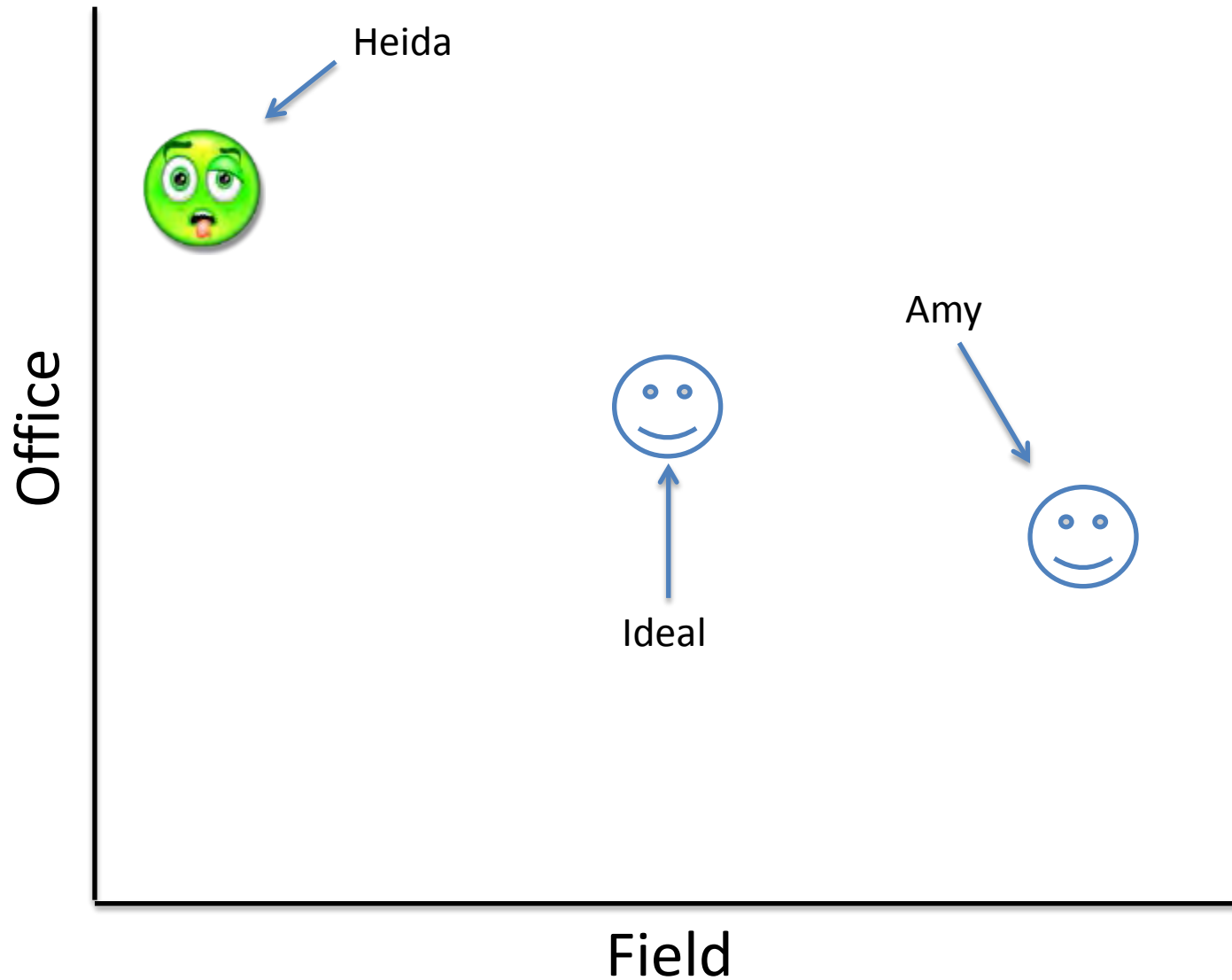
Workshop:

Role of Floodplain Lakes for Juvenile Salmonids in the LCRE

June 18, 2013

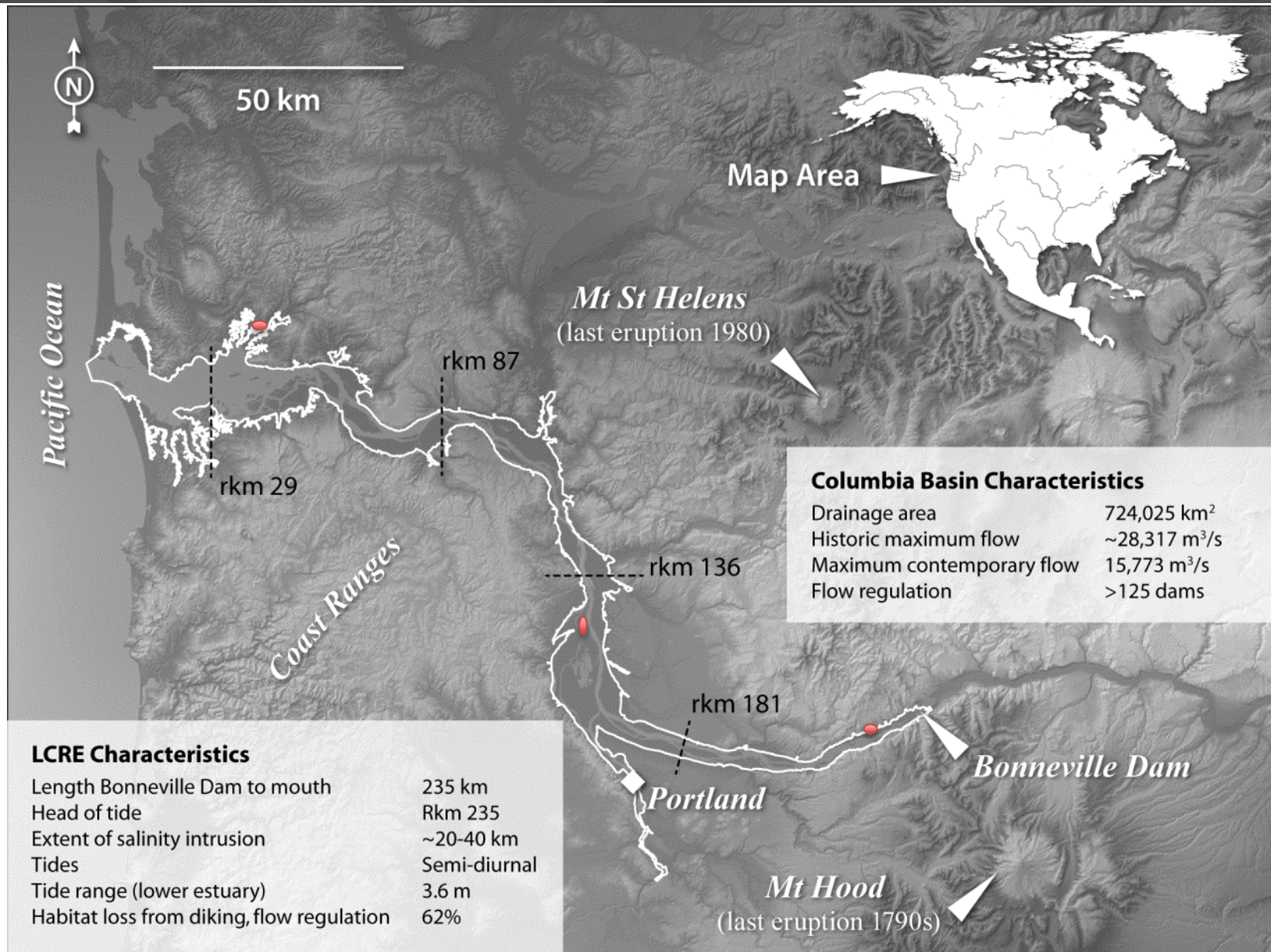
Portland, OR

The Ecologist's Domain

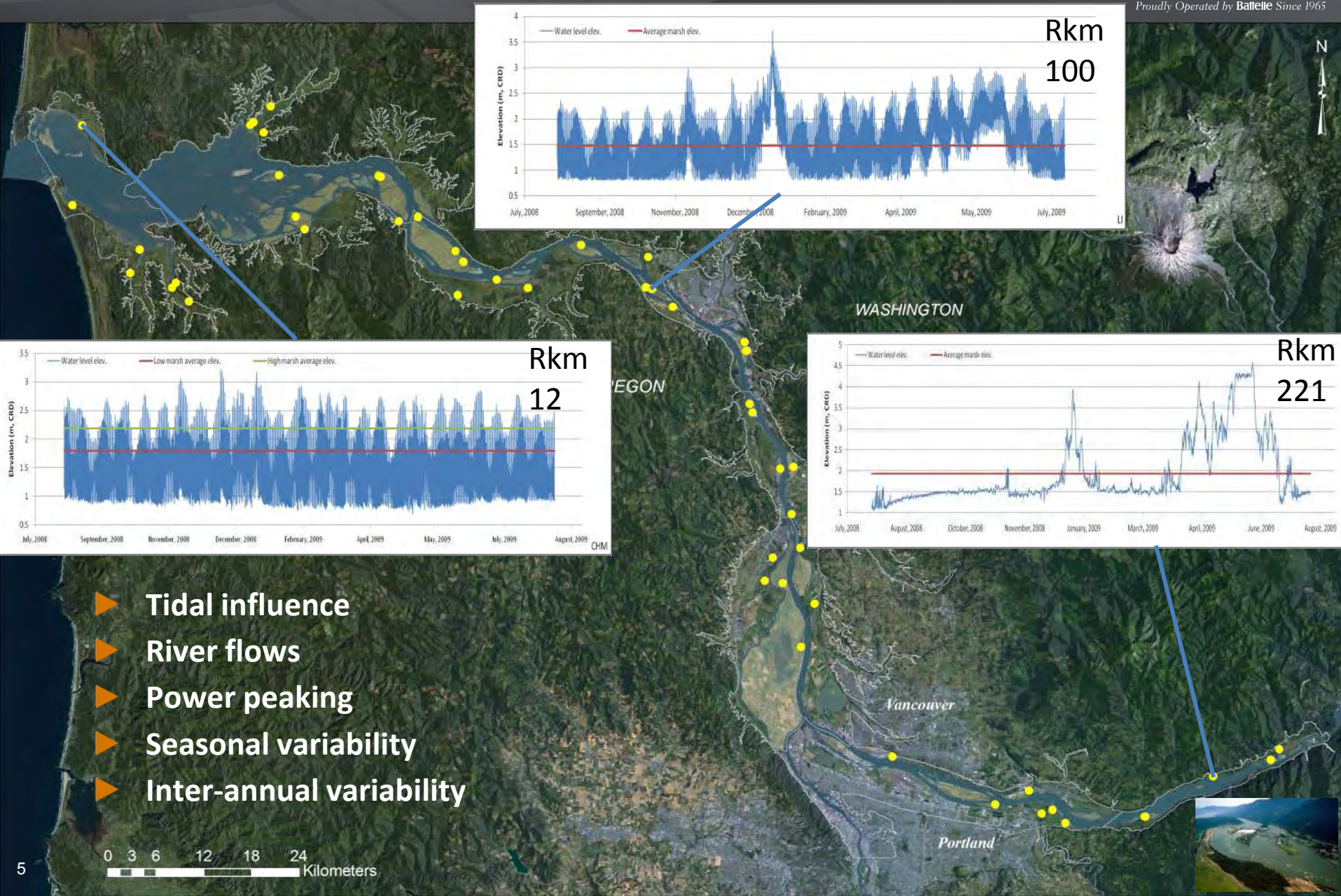


- ▶ Background variability in Lower Columbia River and Estuary affects floodplain lake hydrology and plant communities
- ▶ Connectivity at BPA/LCEP Ecosystem Monitoring sites: Franz Lake Channel and Cunningham Lake.
- ▶ Plant Community Change at Franz Lake Channel and Cunningham Lake
- ▶ Non-Floodplain Lake Plant Biomass Productivity in the LCRE
 - Illustration from Grays River
 - Additive model of data in the literature for levels-of-evidence assessment
- ▶ Summary and Recommendations

Zonation: Floodplain Lakes in Portland Vicinity



Water Levels: Tidal-Fluvial Continuum



- ▶ Tidal influence
- ▶ River flows
- ▶ Power peaking
- ▶ Seasonal variability
- ▶ Inter-annual variability

Tidal Freshwater Marshes



All Floodplain Lakes are Not Created Equal: Are All of Them “Lakes”?

► Vegetation Versus Open Water

- Some are vegetated at low water; e.g., Franz Lake (wapato), Cunningham Lake (wapato in 2005 (first sampling year); since then, flats with sparse veg).
- Important to segregate lakes (open water) from large emergent wetlands; see *Floodplain Fisheries* report, FAO; open water is the defining difference; need to consider interannual/seasonal variation

► Connectivity

- Variable connectivity between high/low water years; high/low water seasons; positions in river. How to define a “floodplain lake”?

► Important variables:

- the source of water (upland in addition to CR?)
- lake/wetland elevations
- channel gradient
- classification

Connectivity: Franz Lake Channel (rkm 221)



Low CR flow

The **lowest** elevation along the transect is inundated only during high winter and spring flows: **27%** of the 2008-09 year and **44%** of 2011-12

June 17, 2013

Yellow plot = Ecosystem Monitoring multi-year vegetation sampling
Yellow line = transect monitored in early years



High CR flow

Beaver Dams and Impoundment in Sloughs Between Main Stem and Floodplain Lakes

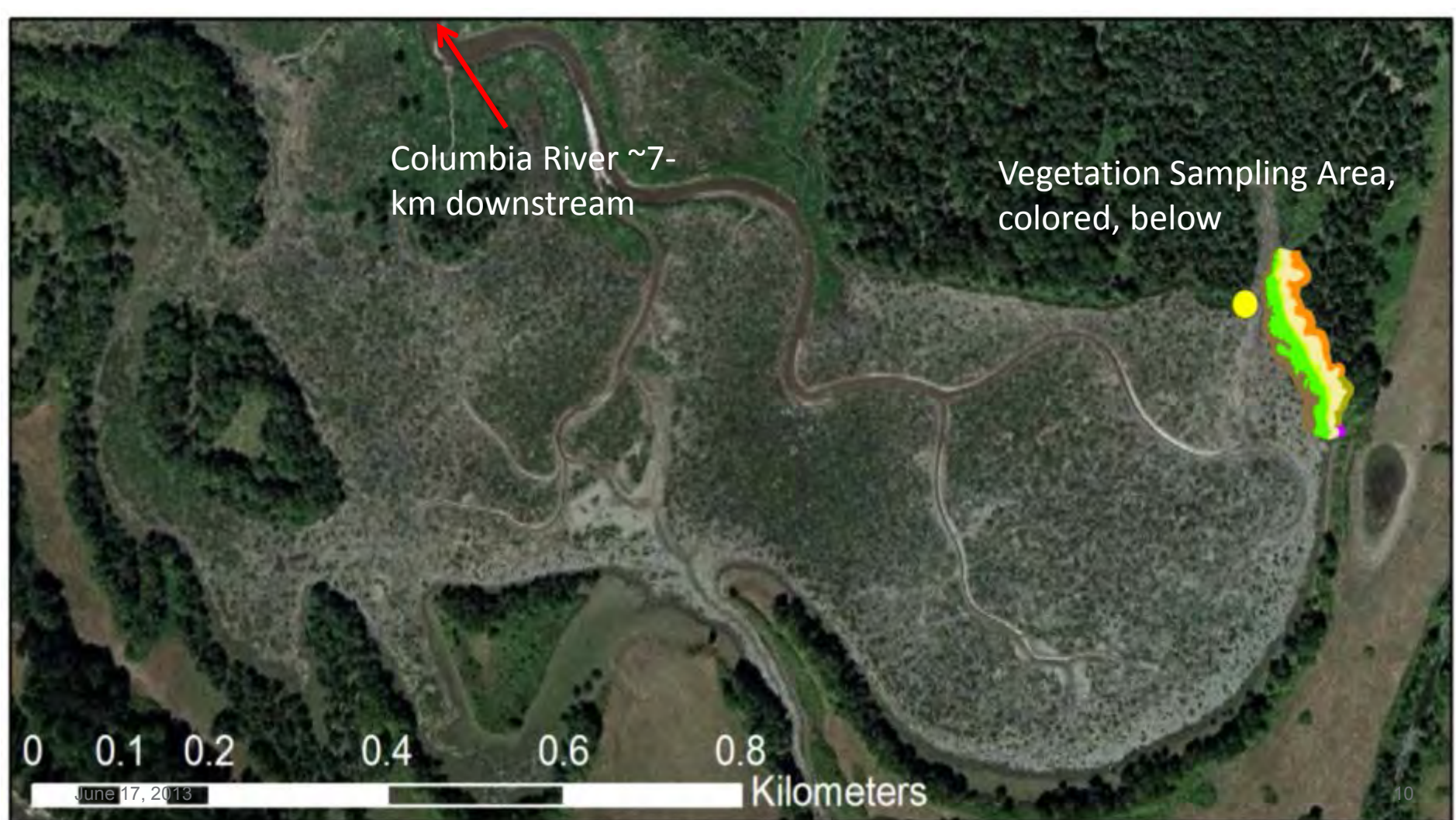
Beaver dams in the slough below Franz Lake. The largest one (left) is located the furthest upstream, near the north end of the transect. The most downstream one (middle, right) is located in the EM sampling area.



- ▶ We observed 4 beaver dams in the slough.
- ▶ The uppermost one is ~109-m long; may not be active. In 2008, water was flowing under it in some places.
- ▶ The other three are 12-m to 17-m in width.
- ▶ Impoundment can be seen in aerial photos at low CR flow.

Connectivity: Cunningham Lake (rkm 145)

The cover at Cunningham Lake is generally bare ground and wapato in this 2010 aerial.



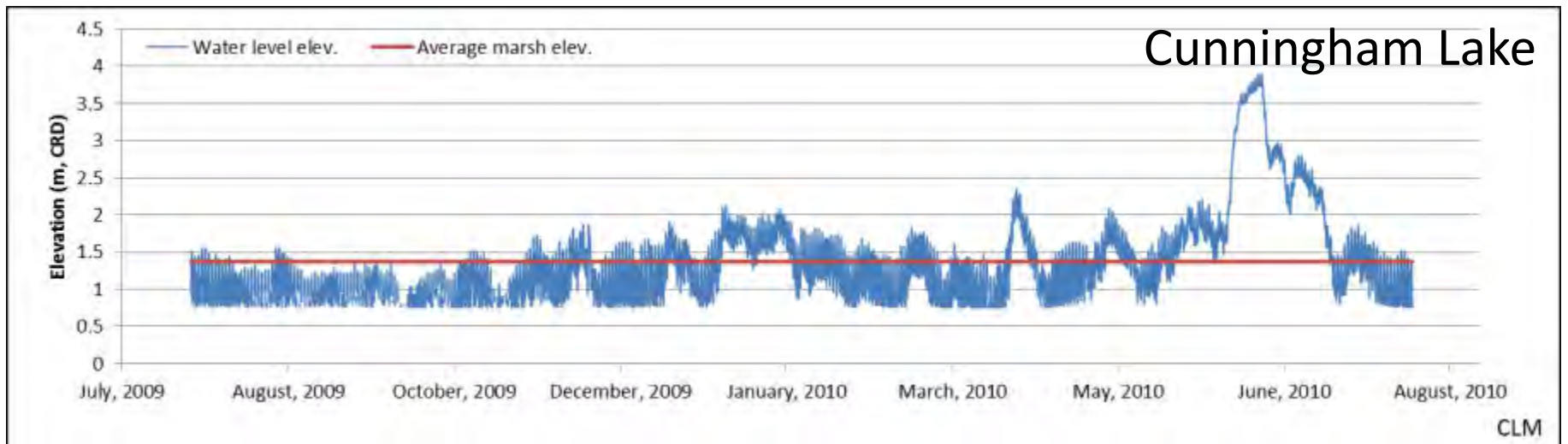
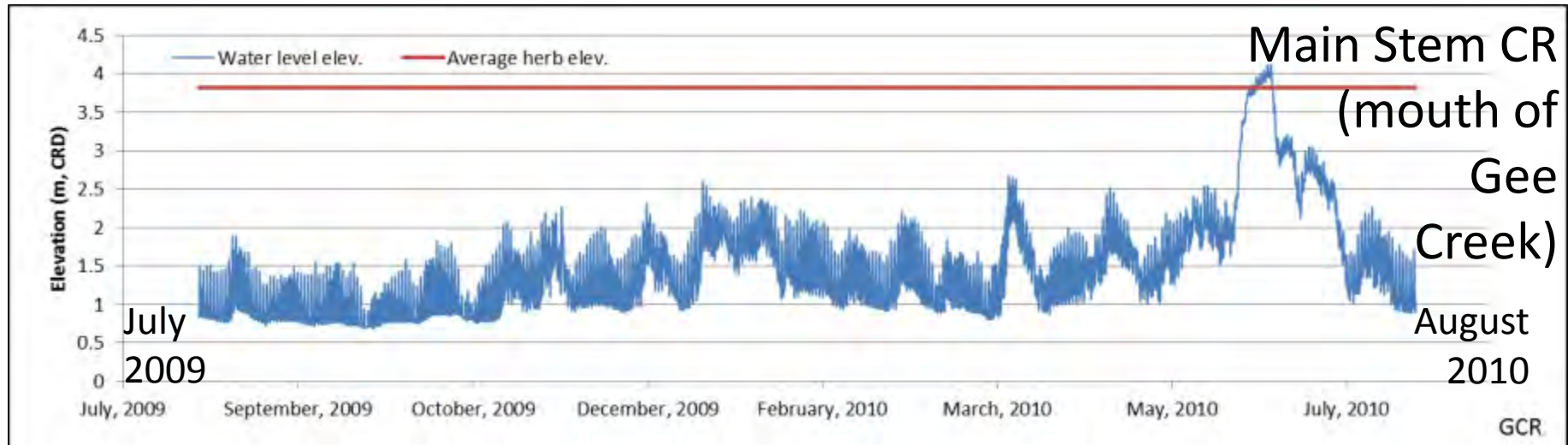
Hydrographs: Main Stem and Cunningham Lake



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

Floodplain is frequently inundated except in summer; smaller tidal range at CL.



- ▶ Vegetation data collected annually 2008 through 2012, however, EM site is near mouth of channel, not in the lake
- ▶ Therefore, limited inference to the floodplain lake
- ▶ Franz “Lake” observed to have wapato (*Sagittaria latifolia*)
- ▶ Also a 190-m transect sampled in 2008 and 2009, but only connected at high water events during the spring freshet
- ▶ The channel is steep
- ▶ Observed flows from an upland creek at north edge of lake after a rain in the fall, when CR flows too low to connect the lake; appears to influence vegetation and outflow.

2012 Franz Lake Channel Plant Community Shift to *Polygonum amphibium*

- Occurred after high water at site for 5 months in 2012.



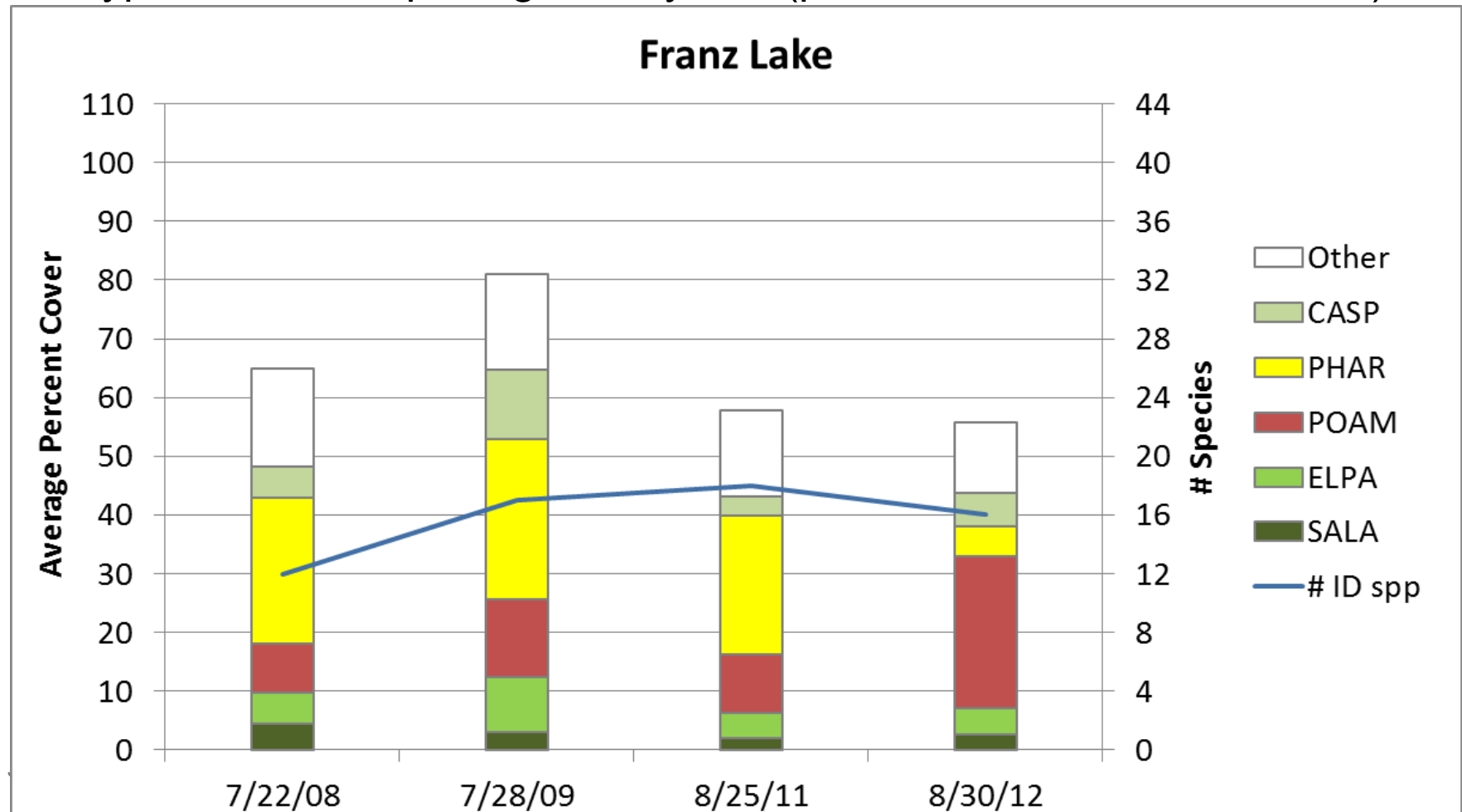
21 July 2012



30 August 2012

Franz Lake Channel Plant Community: 2008-2012

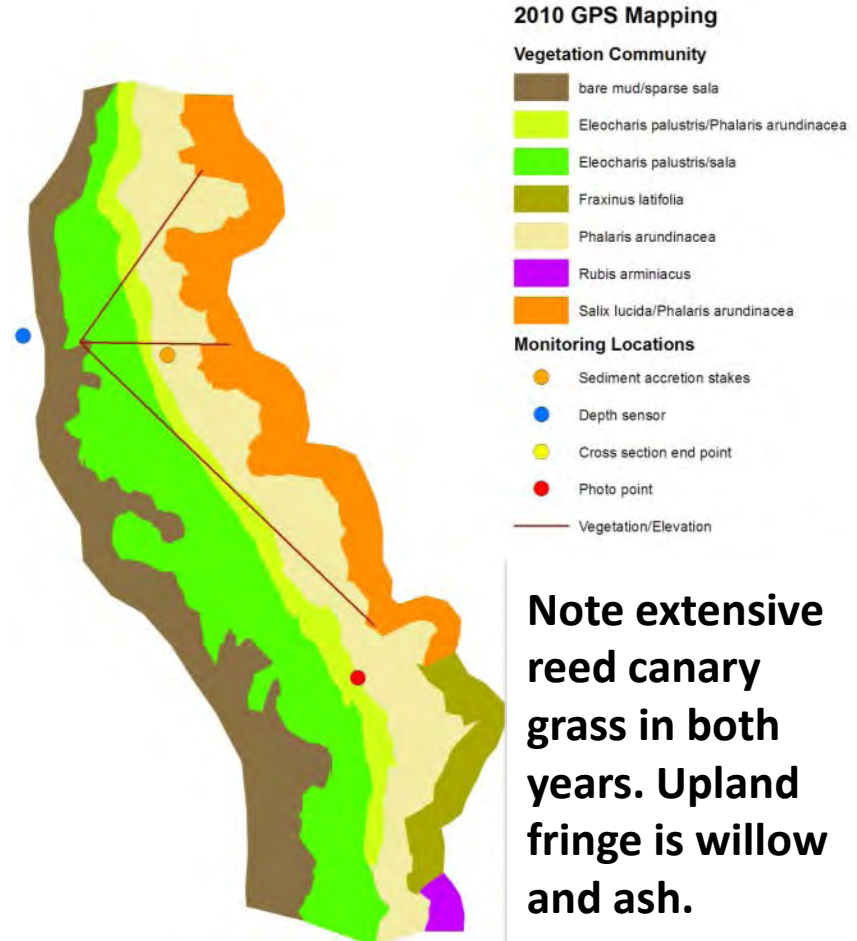
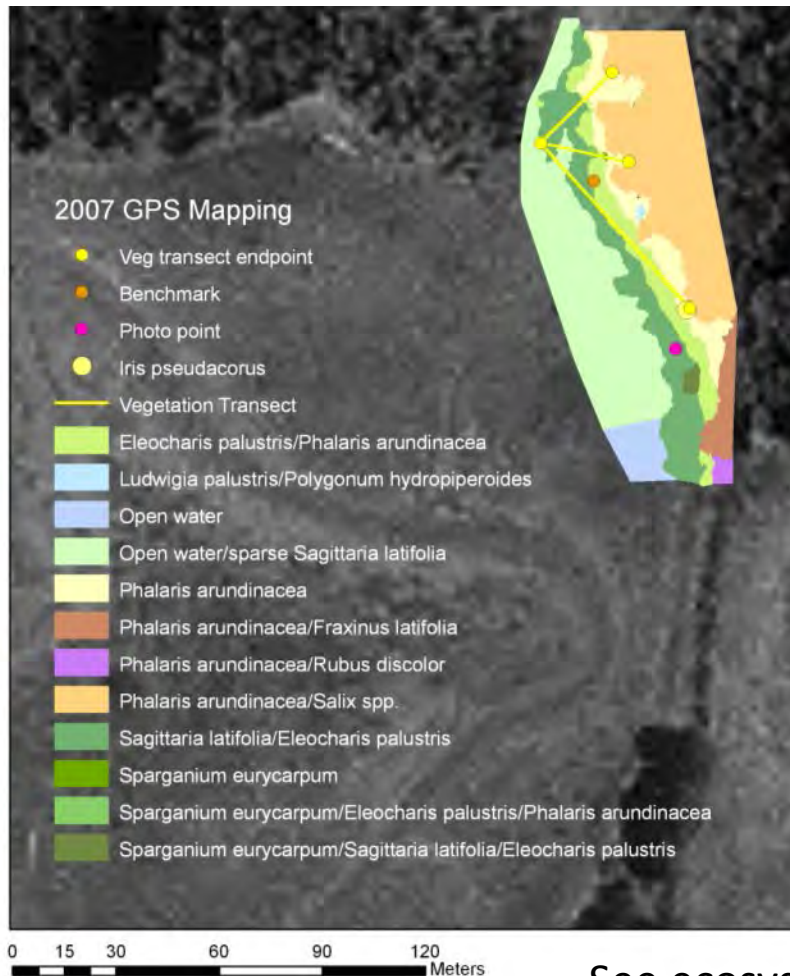
- ▶ Shift from reed canary grass to *Polygonum amphibium*, a plant common on lake shores.
- ▶ Hypothesis: multiple high flow years (plant can reach 2-m and float)



- ▶ 7-km channel leads to the lake
- ▶ EM site is on the upper part of the channel, close to the edge of the lake
- ▶ During low water the tide range is about 0.40-0.75 m
- ▶ the lowest elevation of the marsh (presumably an elevation close to what the rest of the “lake” is) is **inundated 77-79% of each year between 2009 and 2012**

Cunningham Lake Plant Community Change

Hypothesis: High flows overwhelmed tolerance of wapato (*Sagittaria latifolia*, light green at left in 2007) and by 2012 it had not recovered (brown at right is bare mud and sparse wapato in 2010, green is *Eleocharis palustris*).



See ecosystem monitoring reports for complete plant data.

Cunningham Lake Variability: Late July 2005 and 2008

July 26, 2005



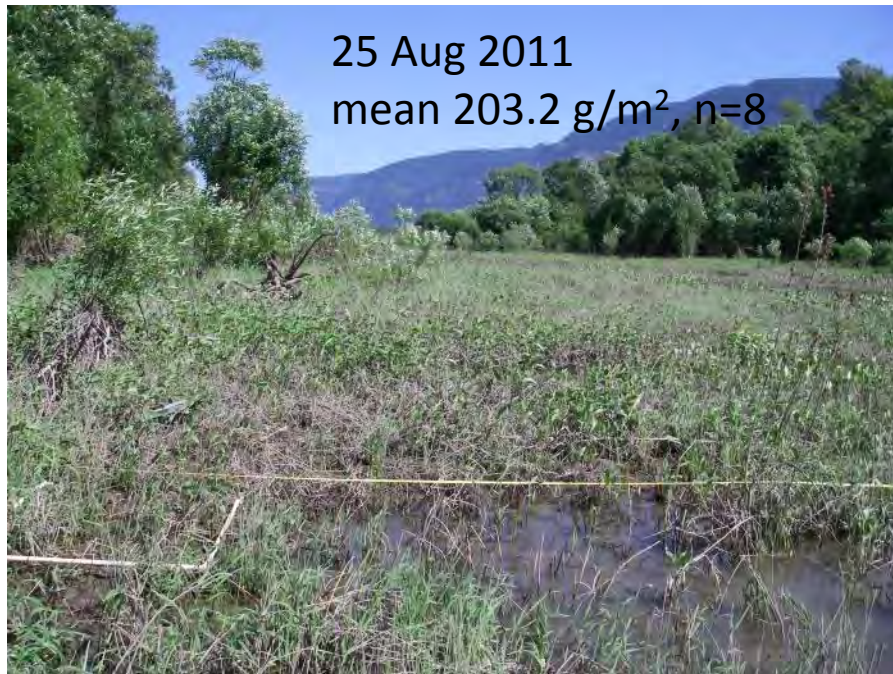
July 21, 2008



Note extensive vegetation coverage (wapato), and wapato visible in foreground, in 2005.

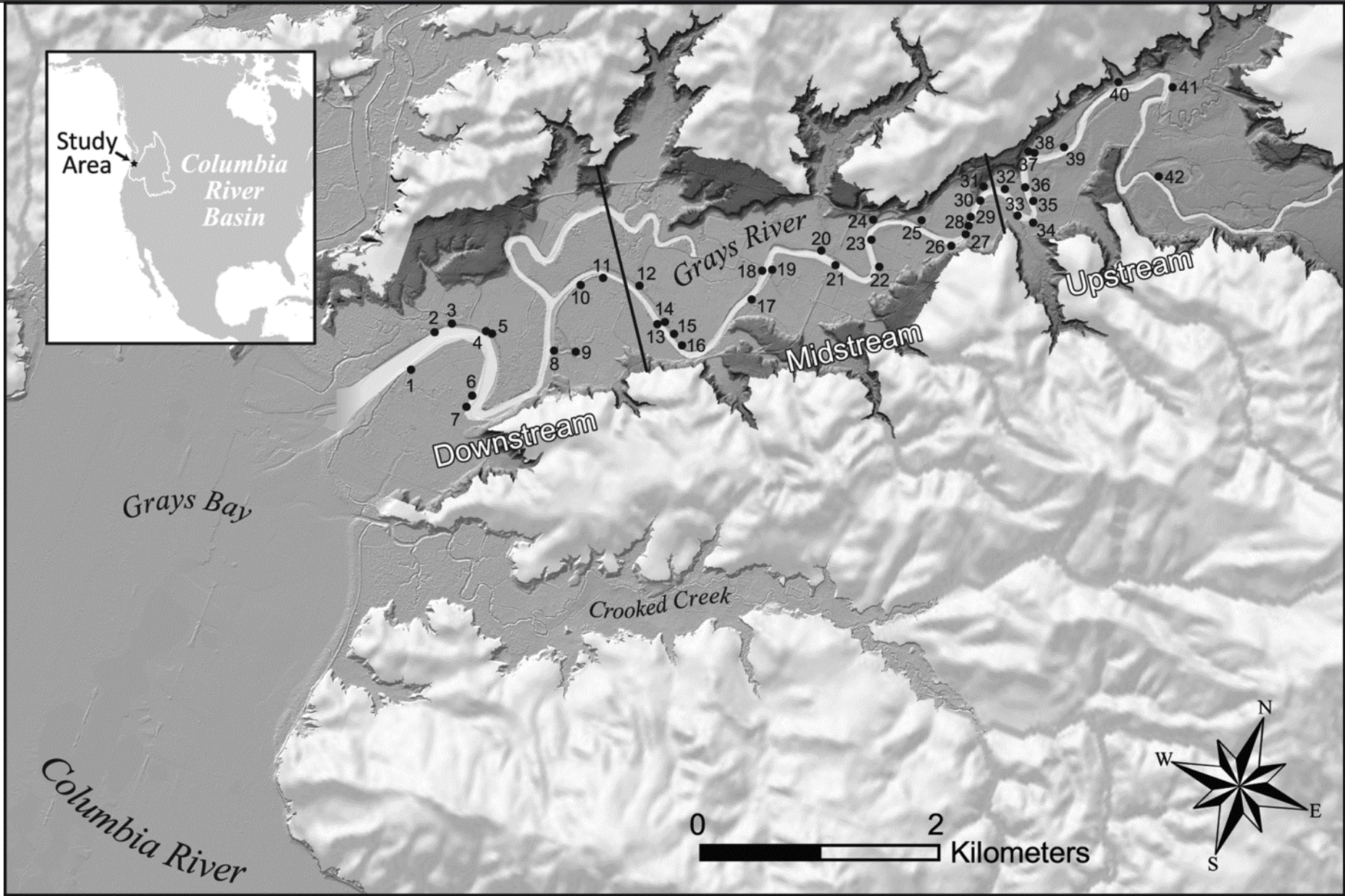
Aboveground Herbaceous Plant Biomass Dynamics at Franz Lake Channel

➤ No known data on CR floodplain lakes

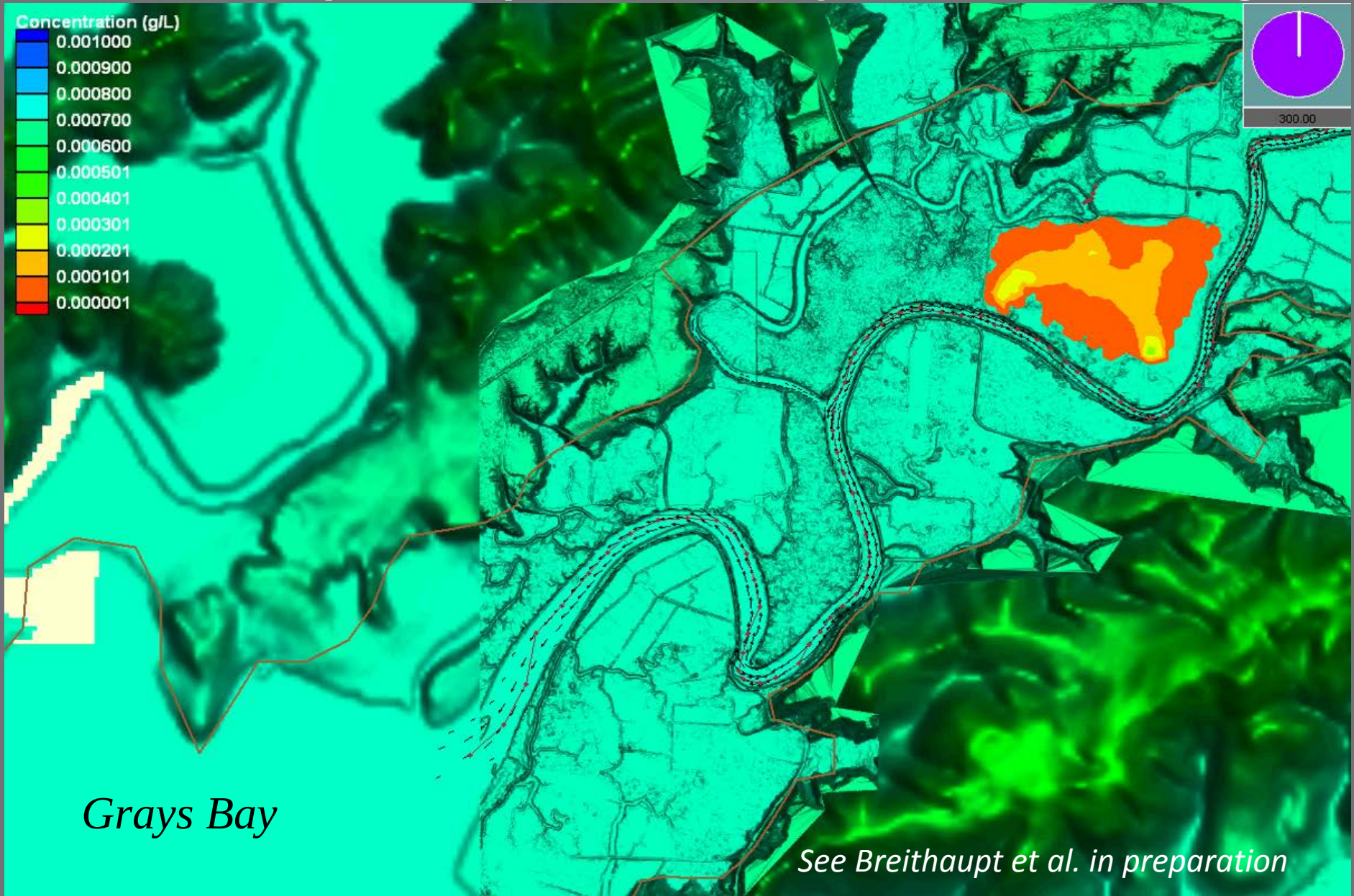


Much of the biomass present in summer is still present in winter, unlike tidally dominated areas where flux occurs in the fall/winter. Here, the freshet is associated with peak floods. We estimate that peak biomass occurred in Oct-Nov timeframe in 2011 because of extended flooding into August and a very mild fall, not midsummer. Flux cannot always be calculated as “summer biomass-winter biomass” in this system as it is in the estuary.

Flux: Model of Kandoll Farm Restoration in Tidal Freshwater Grays River Area, ~rkm 32



Particulate Organic Matter (POM) Finite Volume Coastal Ocean Model (FVCOM): 7 km of Grays River/Seal Slough



Aboveground Herbaceous Plant Biomass: Non-Floodplain Lake, Lower River/Estuary Marshes

- Data sources: MacDonald (1984) for 1980-81 and our own from 2005-2010 - Months: July and August - Range of mean values for emergent marshes: 600-1125 g dry/m² - Standard deviation of means in parentheses - Note decreasing trend upriver (200-234 g/m² at Franz Channel) - Ongoing EM metric	River Kilometer	Plant Community	No. site/yr samples	Dry Weight (g/m ²)
	0 - 30	Emergent marsh	16 - 147	1125 (465)
	0 - 30	Restored	2 - 14	849 (613)
	31-87	Emergent marsh	16 - 131	866 (415)
	31-87	Restored	2 - 16	909 (387)
	88-136	Emergent Marsh	2 - 16	600 (36)
	88-136	Restored	3 - 24	445 (196)

See Diefenderfer et al., Levels-of-Evidence Assessment, Draft 2012 Final In Prep.

Aboveground Herbaceous Plant Biomass Flux Estimates: Non-Floodplain Lakes

Site Name	Year Range	Average Summer Biomass (g/m ²)	Average Winter Biomass (g/m ²)	Biomass Flux (g/m ²)
Gull Island	2006- 2007	574.6	108.7	465.9
Gull Island	2009- 2010	500.7	371.4	129.3
Youngs Bay (Vera Reference)	2005- 2006	755.1	265.0	490.1
Youngs Bay (Vera Reference)	2006- 2007	798.7	101.4	697.3
Youngs Bay (Vera Reference)	2009- 2010	989.3	402.4	586.9
Julia Butler Hanson - Duck Lake Slough	2007- 2008	1530.0	1064.7	465.3
Julia Butler Hanson - Ellison Slough	2007- 2008	1147.0	519.9	627.2

- ▶ Connectivity (access and inundation) differs by season and year. Defining floodplain lakes using extent of open water will be a challenge.
- ▶ We have calculated inundation at one floodplain lake (Cunningham) and below another (Franz) using surveyed land and water surface elevations: At Cunningham, floodplain is inundated 3-seasons (not in summer); at Franz, the channel below it is only inundated during the spring freshet.
- ▶ Currently, floodplain lake aboveground herbaceous plant biomass production (peak time and magnitude) and dynamics (season of flux) are unknown. No data from a floodplain lake in the C.R.
- ▶ The C.R. position and connectivity of each lake will influence flux.
- ▶ Biomass production does appear to decrease with distance from CR mouth so floodplain lakes could have lower biomass than marshes further downriver. However, all data are from sloughs/channels, not lakes per se.
- ▶ Only one vegetation site from the ecosystem monitoring and reference sites programs is on a floodplain lake; very limited ability to extrapolate.
- ▶ Significant changes in plant communities (& biomass?) can occur in 1-5 yrs.

Remaining Questions

- ▶ Are there any floodplain lakes in the lower Columbia River floodplain?
- ▶ Do some 'lakes' shift to emergent wetlands during dryer years and/or seasons? Is the shift predictable?
- ▶ How do beaver dams affect a lower CR floodplain lake classification system? Can they maintain a lake vs. wetland hydrological condition?
- ▶ Do higher Columbia River flows increase the connectivity; productivity; and/or flux from floodplain lakes?
- ▶ What are the dynamics of flux from floodplain lakes and how do they complement flux from other CR wetlands? How does spatial position (generally upriver) affect the impacts of floodplain lake flux on the main stem river?

- ▶ To evaluate C.R.F.L. biomass production and dynamics (currently unknown):
 - Collect data seasonally and compare inter-annual effects of CR flow.
 - Examine frequency/magnitude of outflow based on individual site connectivity.
- ▶ To evaluate habitat structure of a floodplain lake:
 - Existing methods from ecosystem monitoring program sufficient for veg.
 - However, only 1 vegetation site from the ecosystem monitoring and reference sites programs is directly on a floodplain lake; consider adding sites.
 - Incorporate lake-specific data from methods presented by others today, e.g., classification, morphology.
- ▶ To evaluate connectivity (access to, and flux from) a floodplain lake, model or calculate inundation. For a simple calculation:
 - Cross-section surveys of the slough connecting the lake to the CR
 - Elevation of the lake and fringing vegetation
 - Time series water surface elevation data from the lake, slough or near CR
 - (Make predictions, *and* do before- and after- surveys to verify accuracy)
- ▶ Global literature review of floodplain lakes.

Acknowledgements

This research was supported by Bonneville Power Administration, the Lower Columbia Estuary Partnership, and the U.S. Army Corps of Engineers Portland District.

Portions of this research appear in:

– Borde et al., Ecosystem Monitoring report, 2013
(PNNL report to the LCEP)

Amy.Borde@pnnl.gov

– Johnson et al., Cumulative Effects report, 2012 (a collaboration between PNNL, NOAA, the UW and PSU)

Gary.Johnson@pnnl.gov

– Diefenderfer et al., Levels-of-Evidence assessment, 2012 (a collaboration between PNNL and NOAA)

Heida.Diefenderfer@pnnl.gov

Many thanks to all of the field assistants and others who contributed, particularly Jina Sagar, Blaine Ebberts, and Cindy Studebaker.

