



Tidal-Hydrological Dynamics of Water Temperature across Freshwater Forested Wetlands

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Context

Widespread loss of tidal
freshwater wetlands
impedes understanding of
their past and future role as
habitat and temperature
refugia



Research Questions

1. Are there temperature differences between the interior and exterior of tidal forests?
2. If so, what is the rate of change along the channel?
3. Are temperatures inside tidal forests different from
 - a. The mainstem?
 - b. A nearby emergent marsh?
 - c. A recently reconnected restoration site?
4. How does tidal hydrology affect temperatures?
5. How do site and landscape features affect temperatures?

Buenau, Diefenderfer and Borde, in review. Tidal-hydrological dynamics of water temperature across freshwater forested wetlands on the northeastern Pacific coast. JAWRA.

Study Area

Tidal forests:

Secret River (bay)

Crooked Creek (bay)

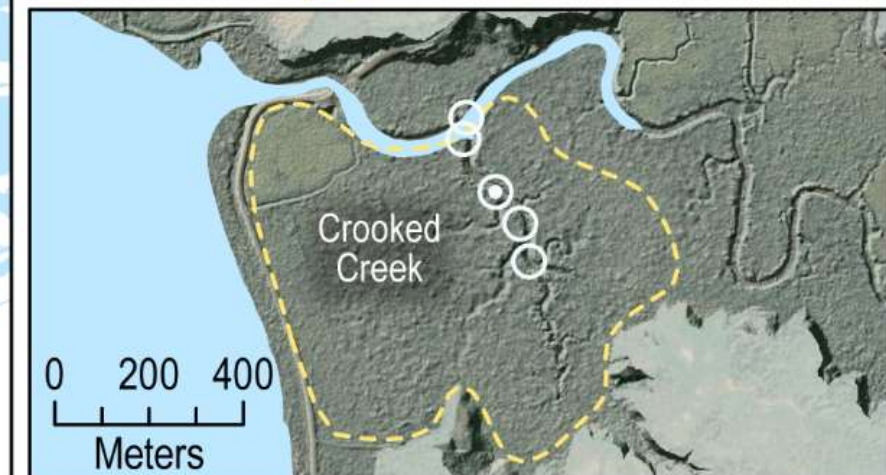
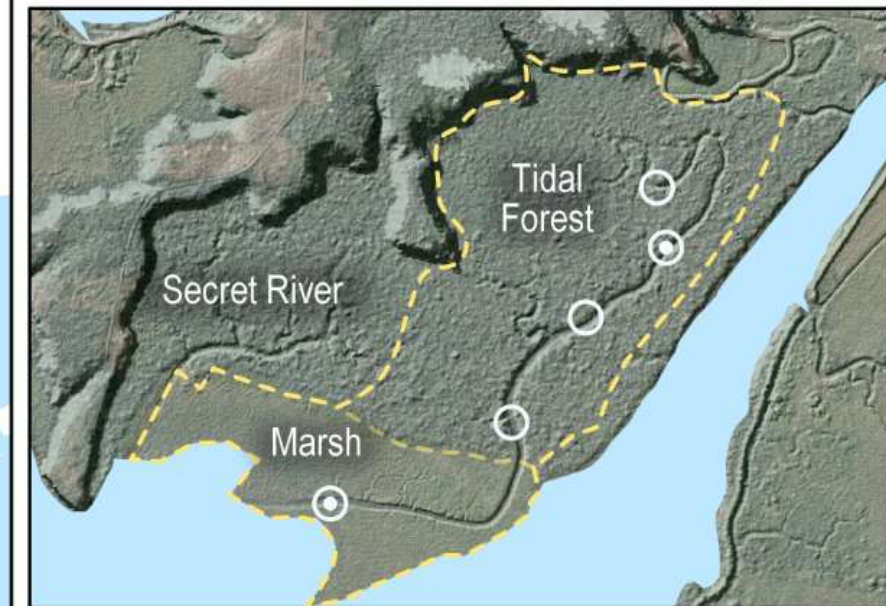
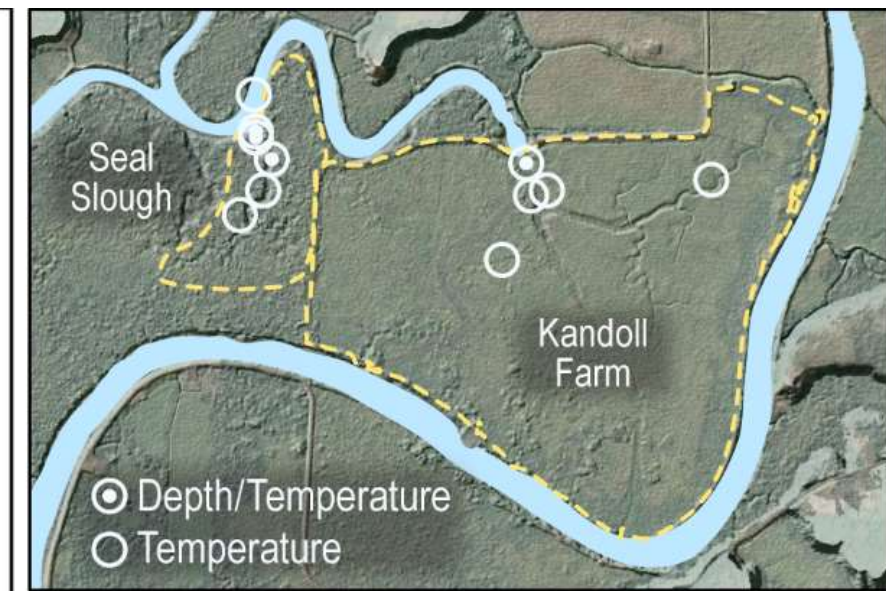
Seal Slough (trib.)

Emergent marsh:

Secret River (bay)

Restoration site:



Kandoll Farm (trib.)

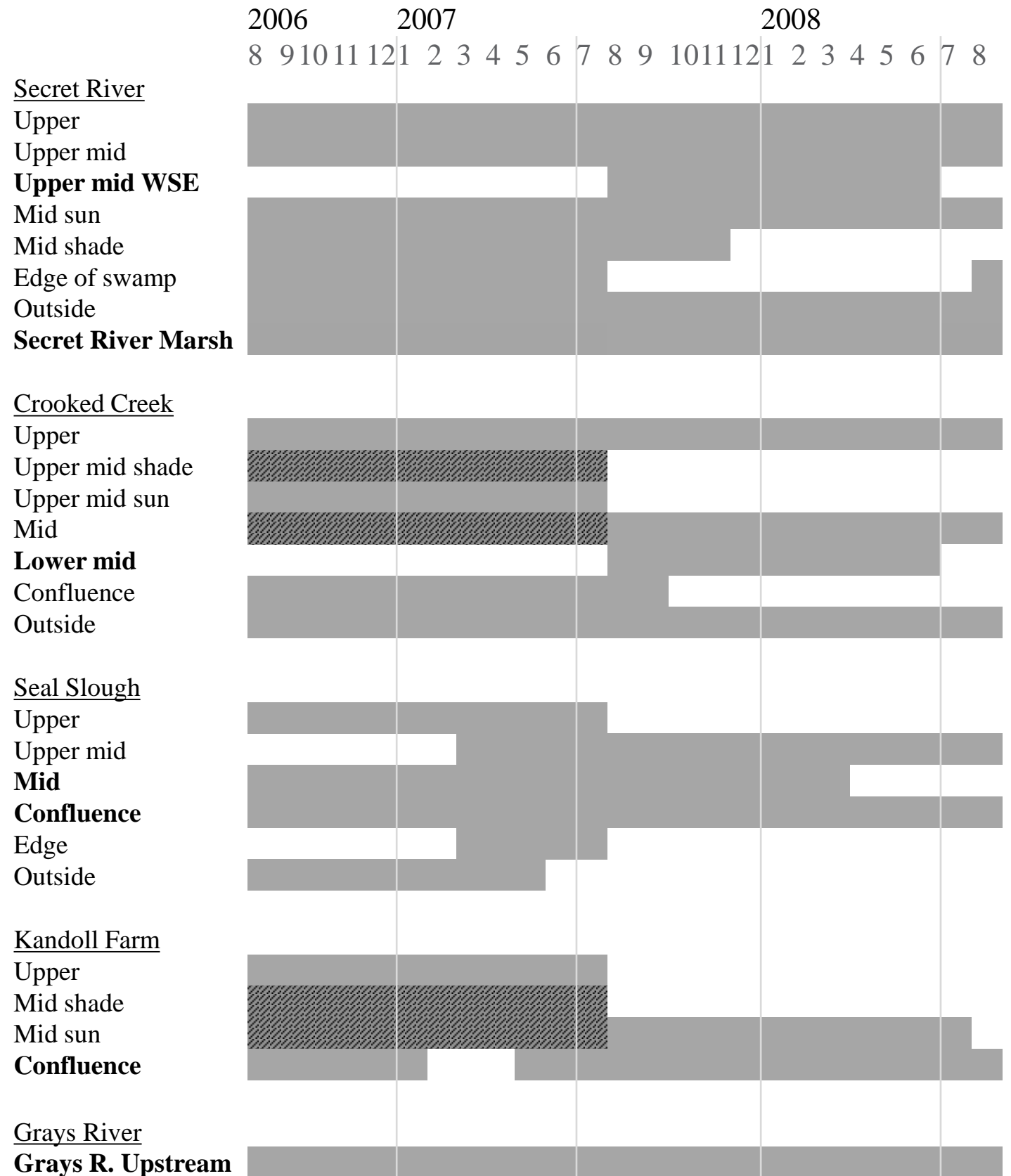




Data Collection

Temperature and water level
Temperature only

 Data available
 Some air-exposed data removed



Methods

Weekly metrics:

- Median temperature
- Average maximum temperature
- Temperature range
(90th–10th percentile)

Regression covariates:

- Month
- Mean water surface elevation (WSE;
Astoria)
- Tidal range (Astoria)

Analyses:

- Regression: inside – outside,
each site
- Gradient: change in temperature
per 100 m along channel
- Regression: site - mainstem

Median temperatures are cooler inside sites, with strong seasonal effect and small hydro effect

Grays Bay

Grays River

Tidal Forest

Restoration Site

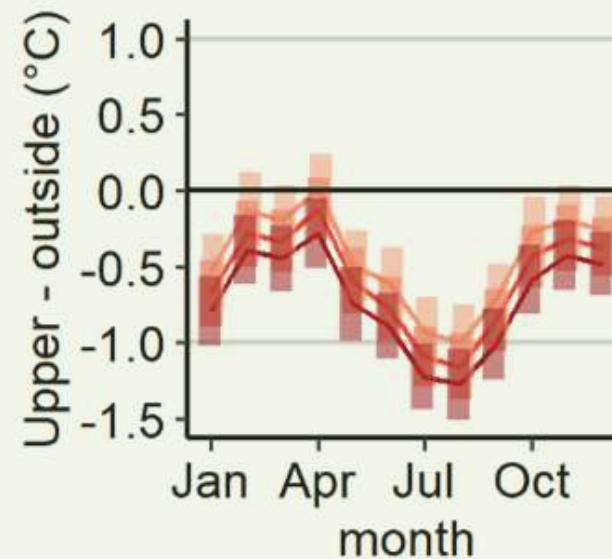
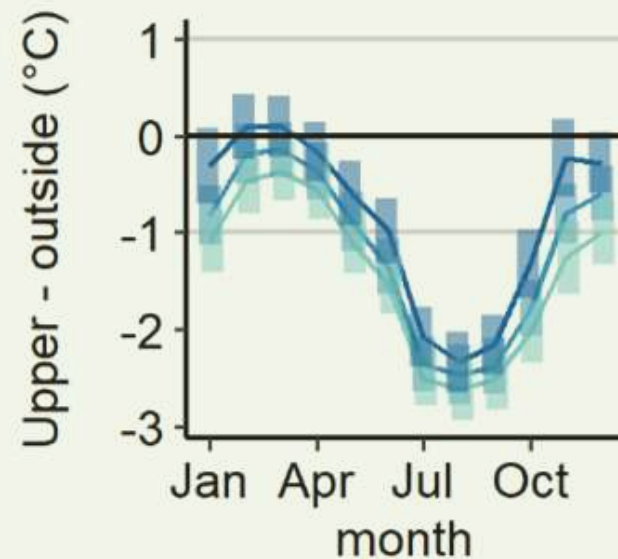
Secret River

Crooked Creek

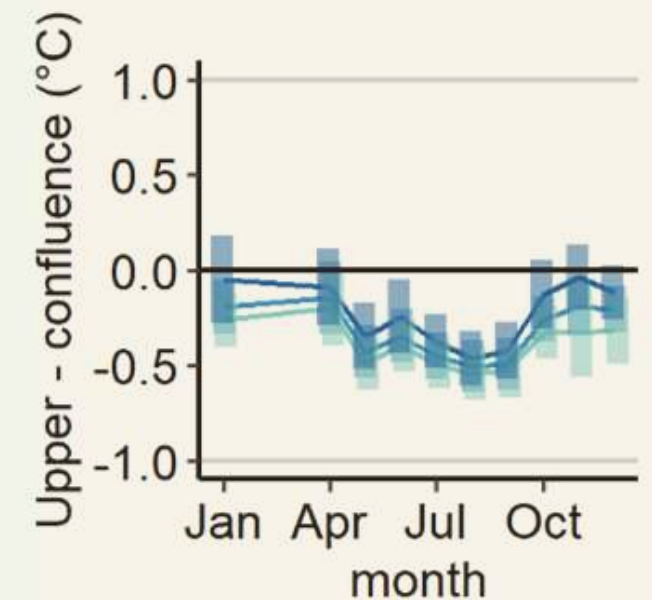
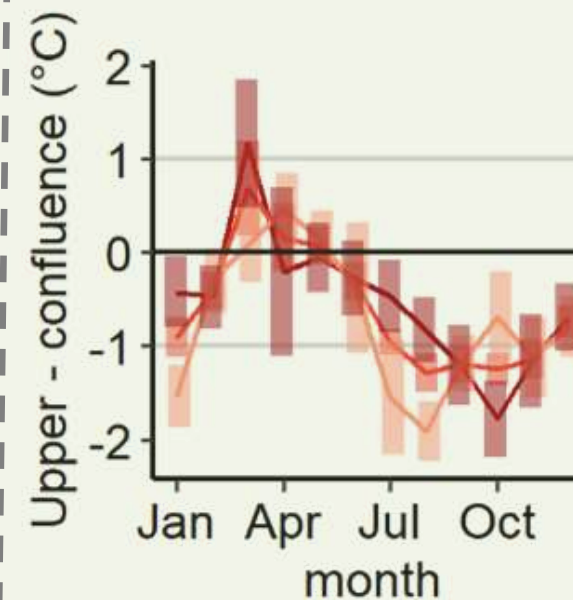
Seal Slough

Kandoll Farm

mean WSE (m)



tidal range (m)



Maximum temperatures are cooler in bay sites Seal Slough can be warmer inside

Grays Bay

Grays River

Tidal Forest

Restoration Site

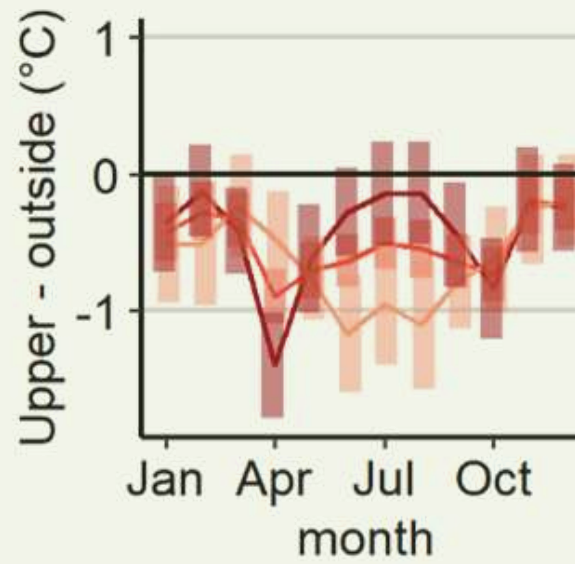
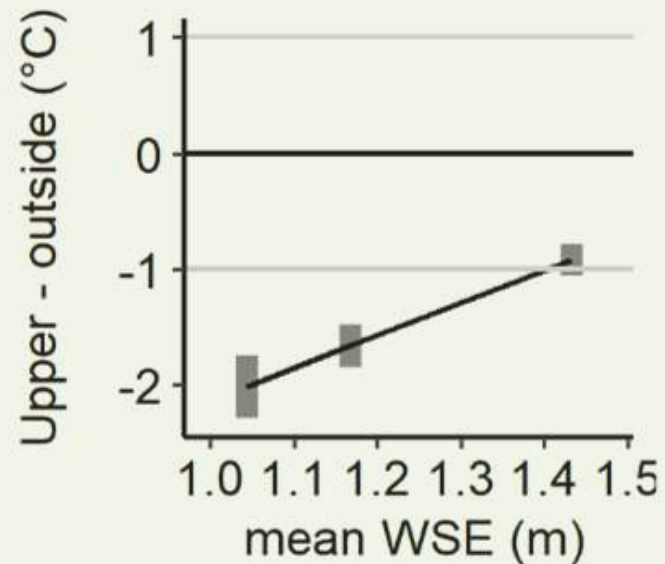
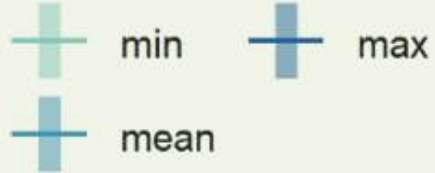
Secret River

Crooked Creek

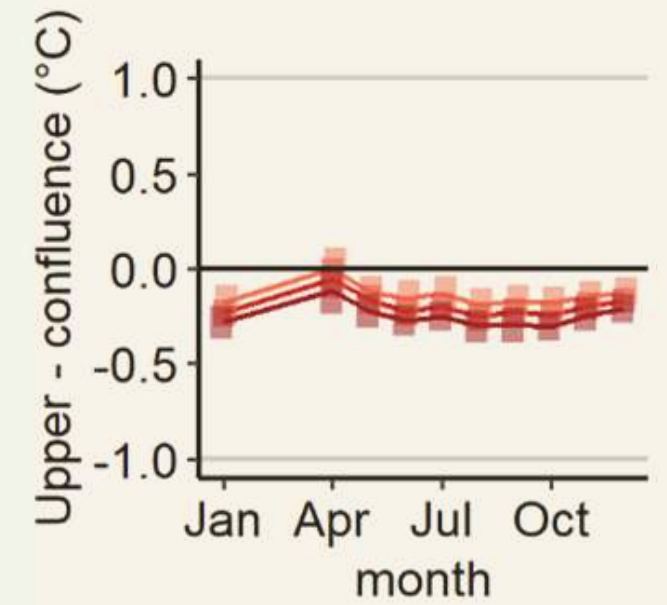
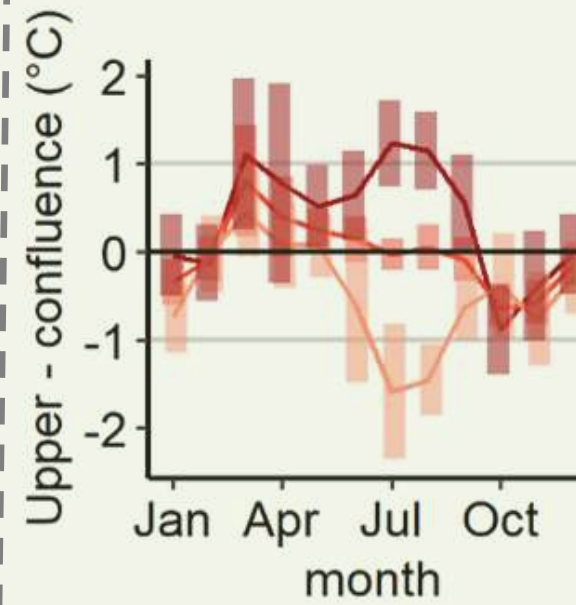
Seal Slough

Kandoll Farm

mean WSE (m)



tidal range (m)



Seal Slough is more variable inside than out, especially at high tidal range

Grays Bay

Grays River

Tidal Forest

Restoration Site

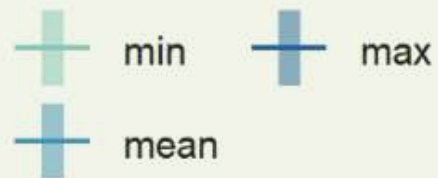
Secret River

Crooked Creek

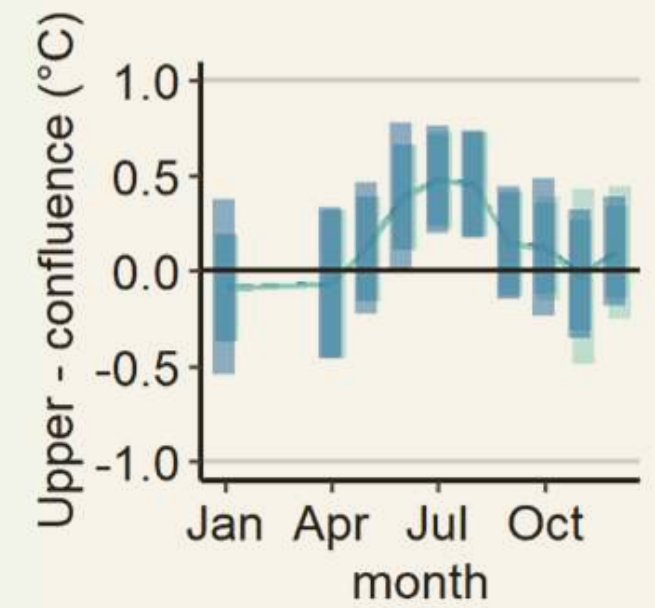
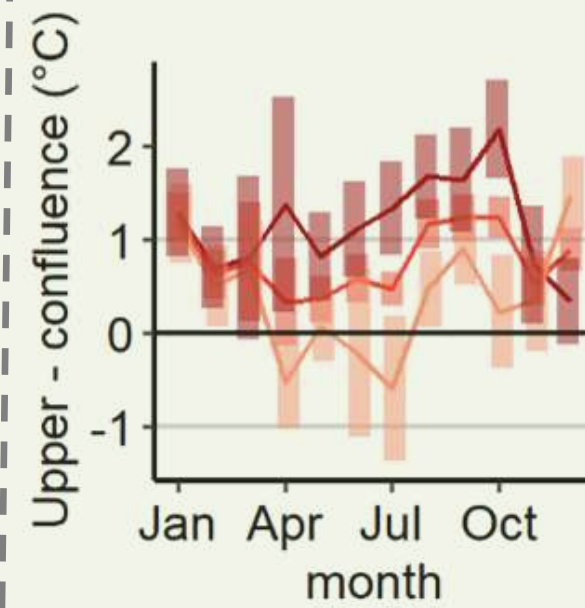
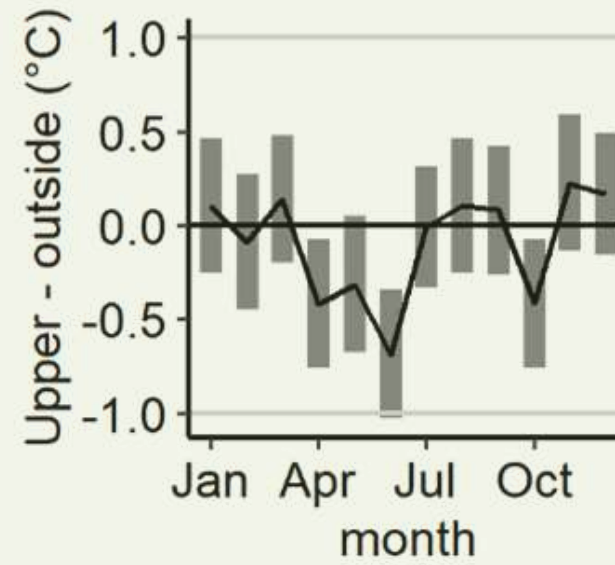
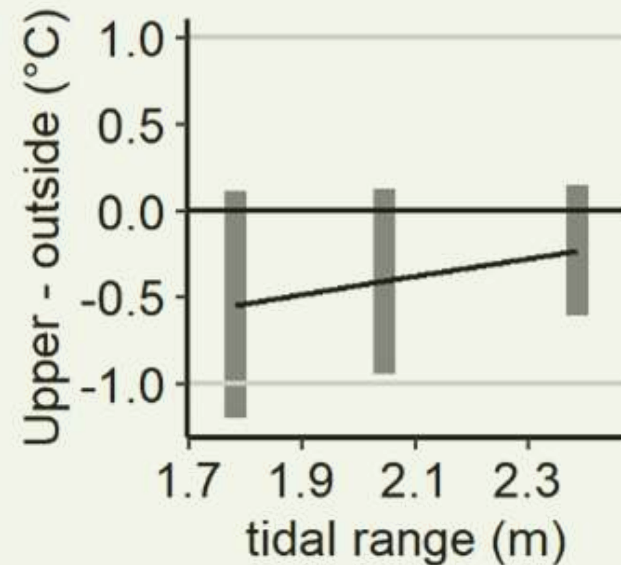
Seal Slough

Kandoll Farm

mean WSE (m)



tidal range (m)





Temperature gradients

Mean change per 100m up channel:

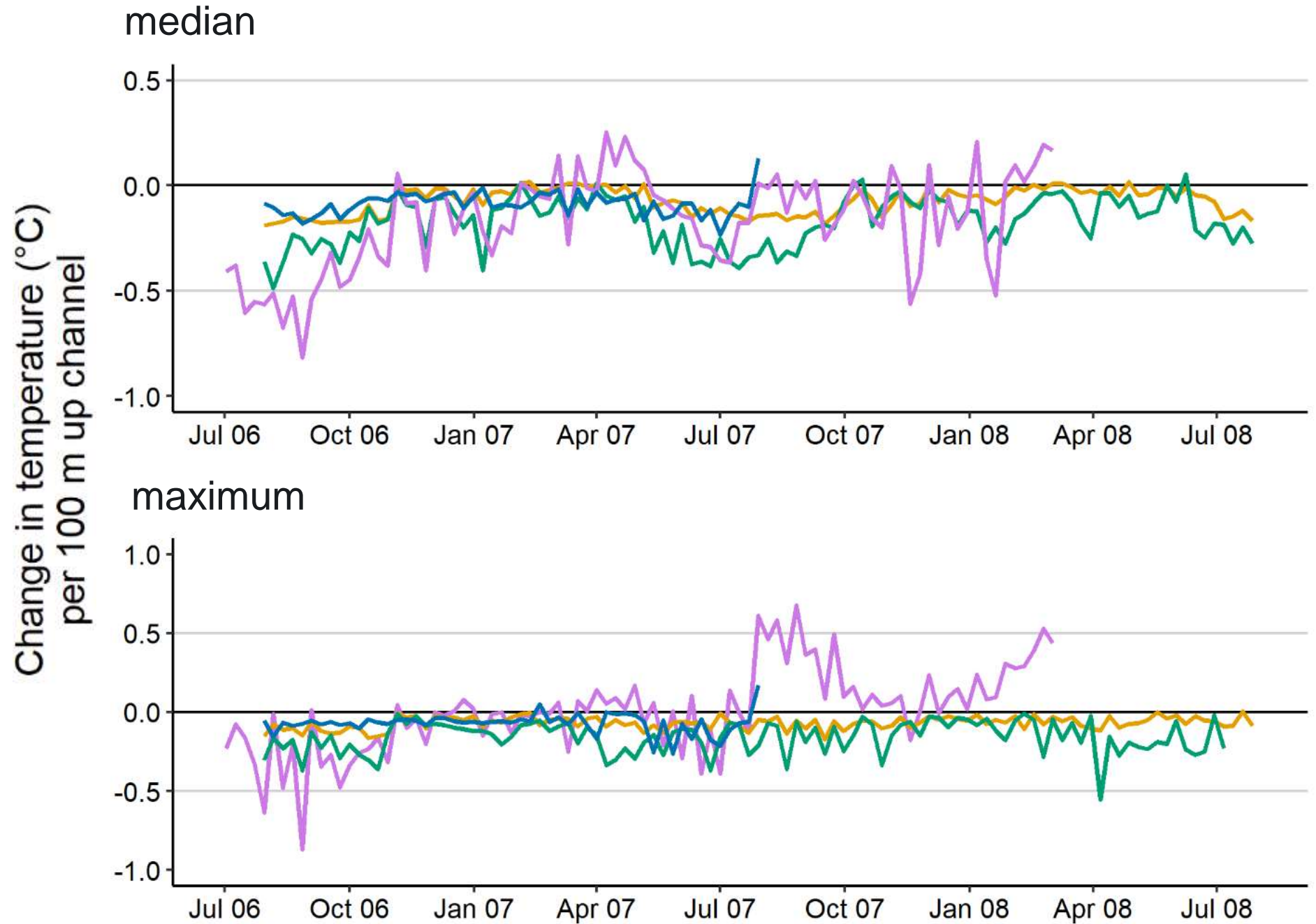
Secret River: -0.07°

Crooked Creek: -0.17°

Seal Slough: -0.16° to 0.25°

Kandoll Farm: -0.08°

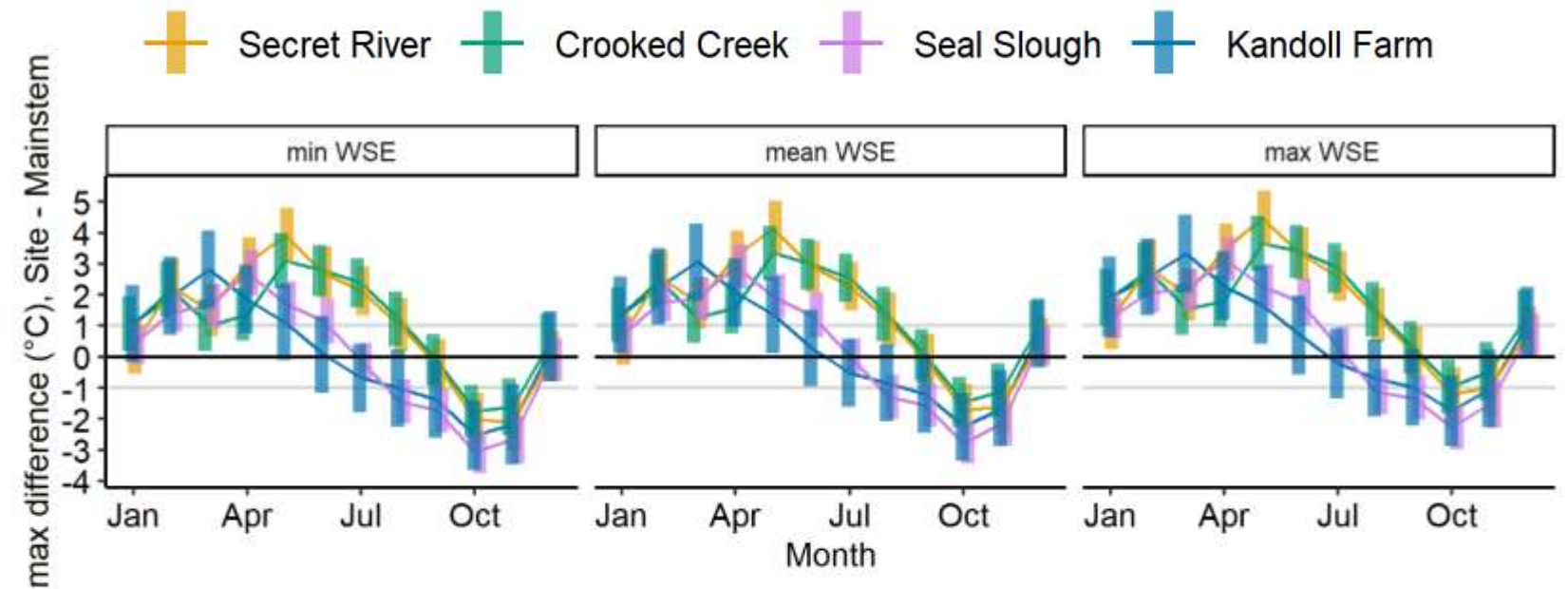
Secret River Crooked Creek Seal Slough Kandoll Farm



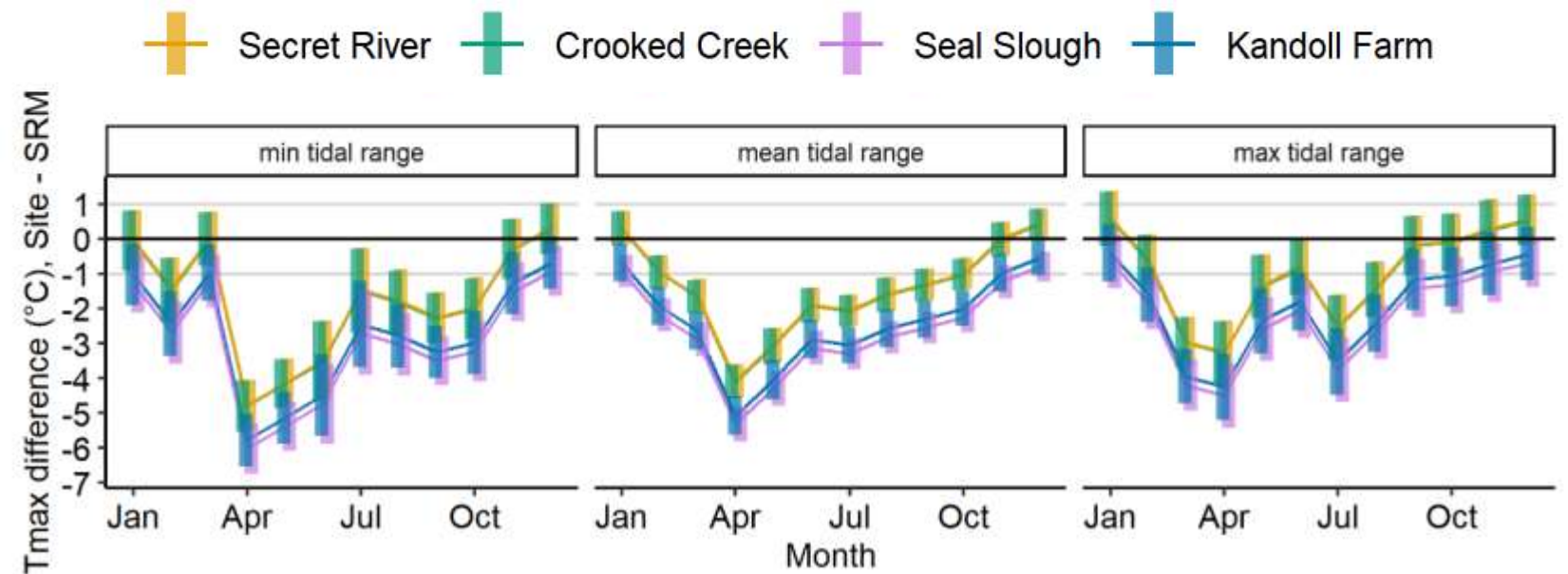
Differences between sites (maximum temp.)

- All sites cooler than tidal marsh
- cooler than mainstem in late summer and fall
- Grays River sites \leq Grays Bay sites
- Fewer hydrological effects when comparing sites than within sites

Difference between site and mainstem



Difference between site and emergent marsh



How do water temperatures in tidal forests compare to other wetland types?

- Hydrologic connectivity
- Vegetation cover
- Watershed input

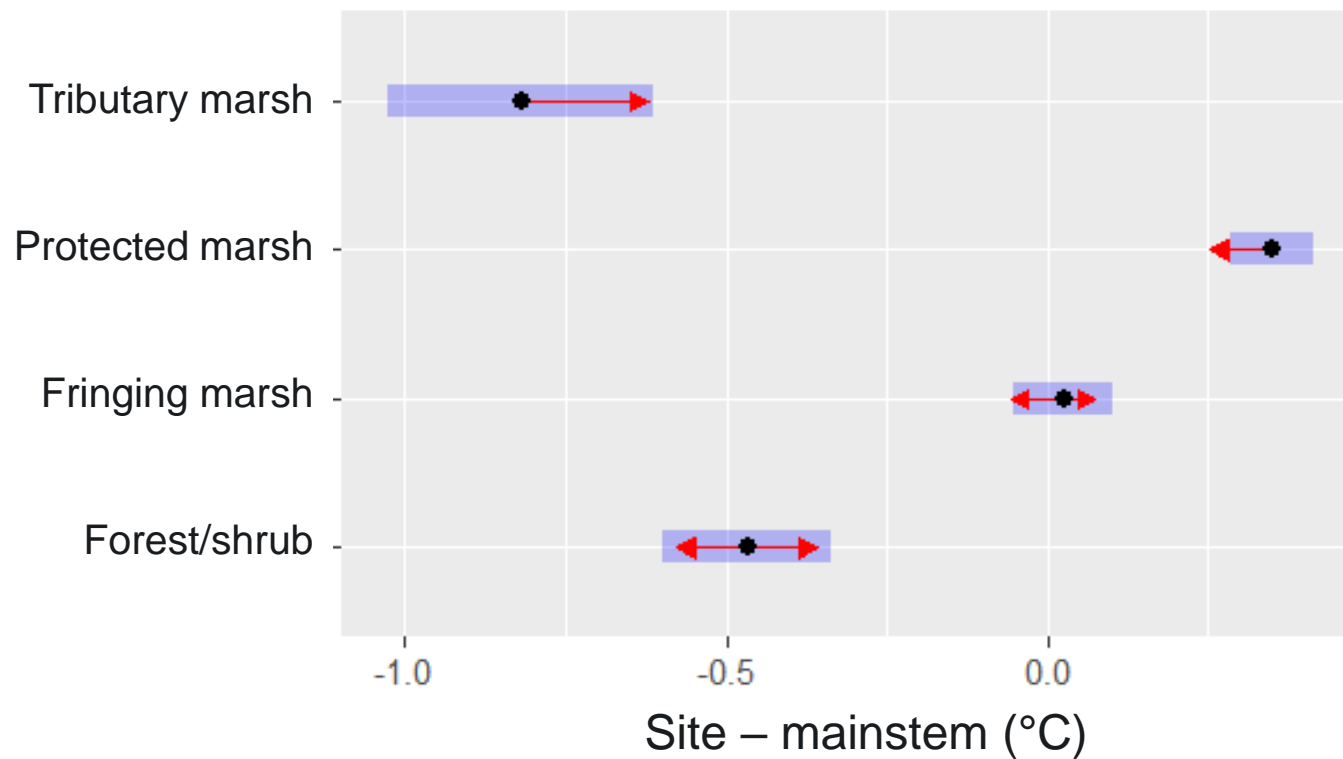
- ~40 sites throughout LCRE



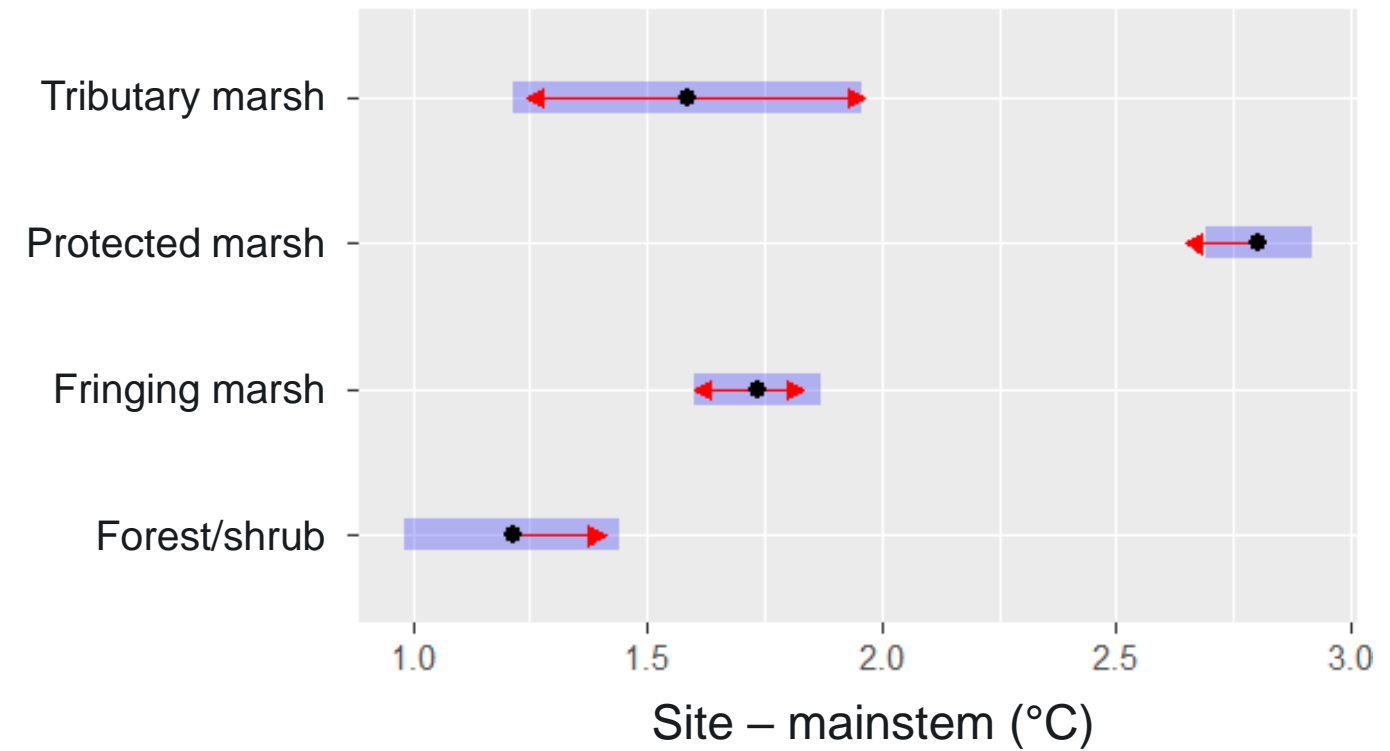
Effect of wetland type controlling for month, rkm, and hydrology

Tidal forests are cooler than fringing and protected marshes, moderately variable

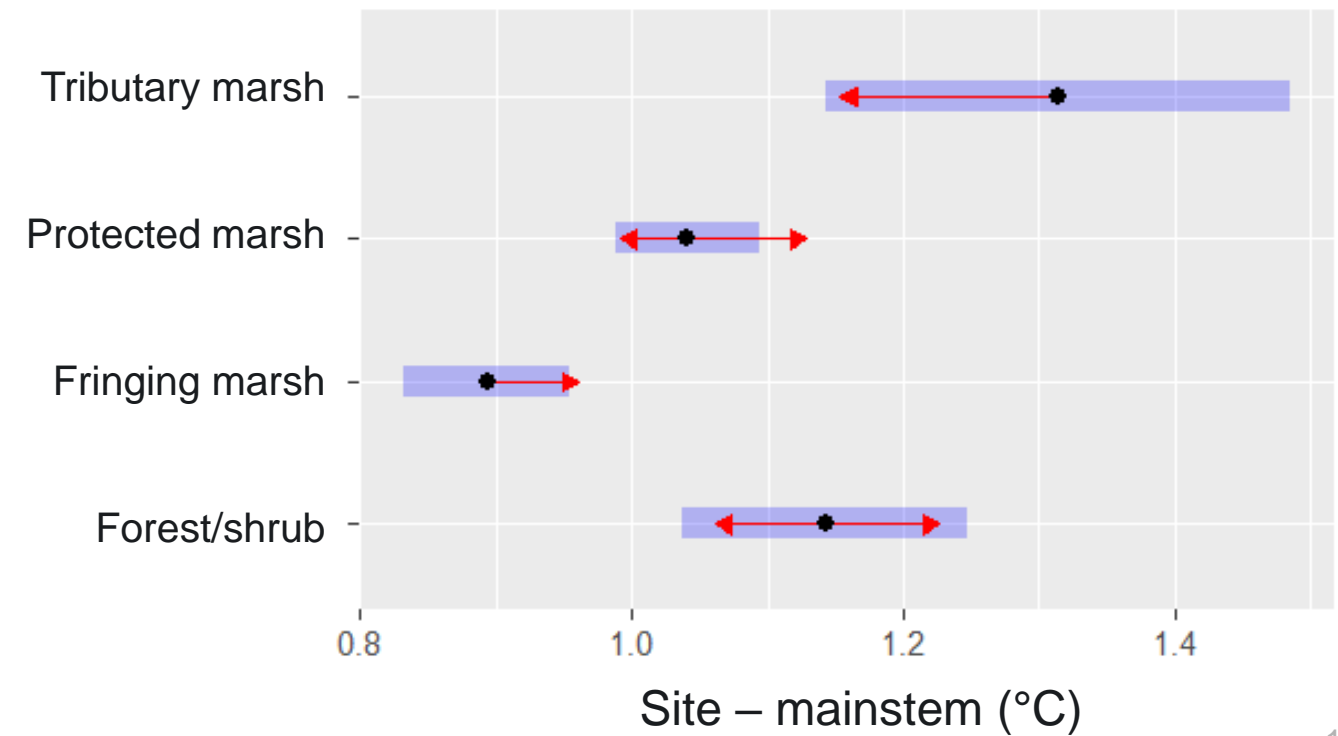
Weekly median



Weekly maximum



Weekly range



Summary—temperature patterns

- Tidal forests have cooler water temperatures than the emergent marsh and sometimes the mainstem
- Notable cooling effect of tributary on tidal forest temperature
- Grays Bay sites had -0.07° to -0.16° cooling per 100m upstream, on average
- Forested sites did not reduce temperature range as seen in non-tidal forested wetlands
- Sites had similar median temperatures, but different maximum and range

Summary—role of environment and hydrology

- The recently-reconnected site had very small effects on temperature ($< 0.5^\circ$)
- Site size and upland watersheds likely affected temperatures
- Hydrology affected differences within sites more than between sites
- Tidal range mattered in warm months for Seal Slough and Crooked Creek

Management implications

- Tidal forests had maximum temperatures cooler than emergent marshes by 4-6° C during warm, high-stress months for juvenile salmonids
- Strong seasonality of temperature differences suggest role of tidal forests will vary by life history strategy
- Sites on tributaries provide additional cooling benefits that may justify additional distance from mainstem
- Effects of tidal hydrology to enhance or reduce cooling likely depends on site morphology, e.g., extent of shallow water and overbank flow

Temperature mediation is a compelling justification for widespread restoration of tidal forests and tributary wetlands

Thank you!

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