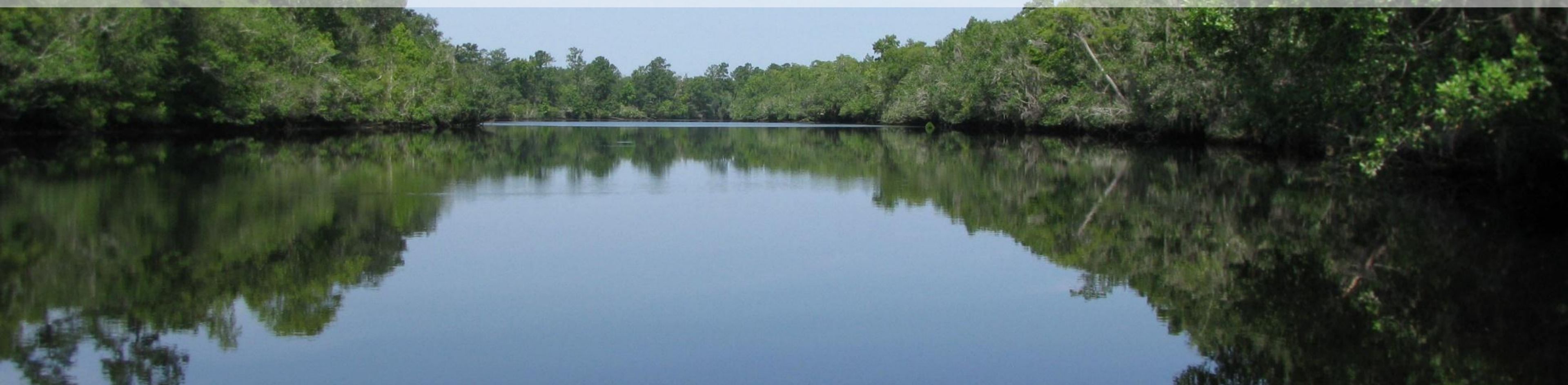
Predicting the Impacts of Saltwater Intrusion on Ecosystem Dynamics in Tidal Freshwater Floodplain Forests in Coastal Georgia



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Outline

- Overview of <u>*tidal*</u> freshwater floodplain <u>*forests*</u> and global change
- Changes in cycling of:
  - Carbon (C) & Sulfur (S)
  - Nitrogen (N)
  - Phosphorus (P)
- Scaling up using SLAMM
- Discussion & Conclusions
- Unknowns and future work

Tidal Forests

- Tidal pulsing with freshwater
- Storm surge abatement and water storage
- Habitat and biodiversity
- C sequestration in woody biomass and soils
- Water quality amelioration
- GHG production: CO_2, CH_4 & N_2O

Tidal Forests and Global Change

- SLR results in increased inundation rates
- Saltwater intrusion results from combination of:
  - Altered precipitation regimes
  - Anthropogenic alteration of freshwater flow
  - SLR

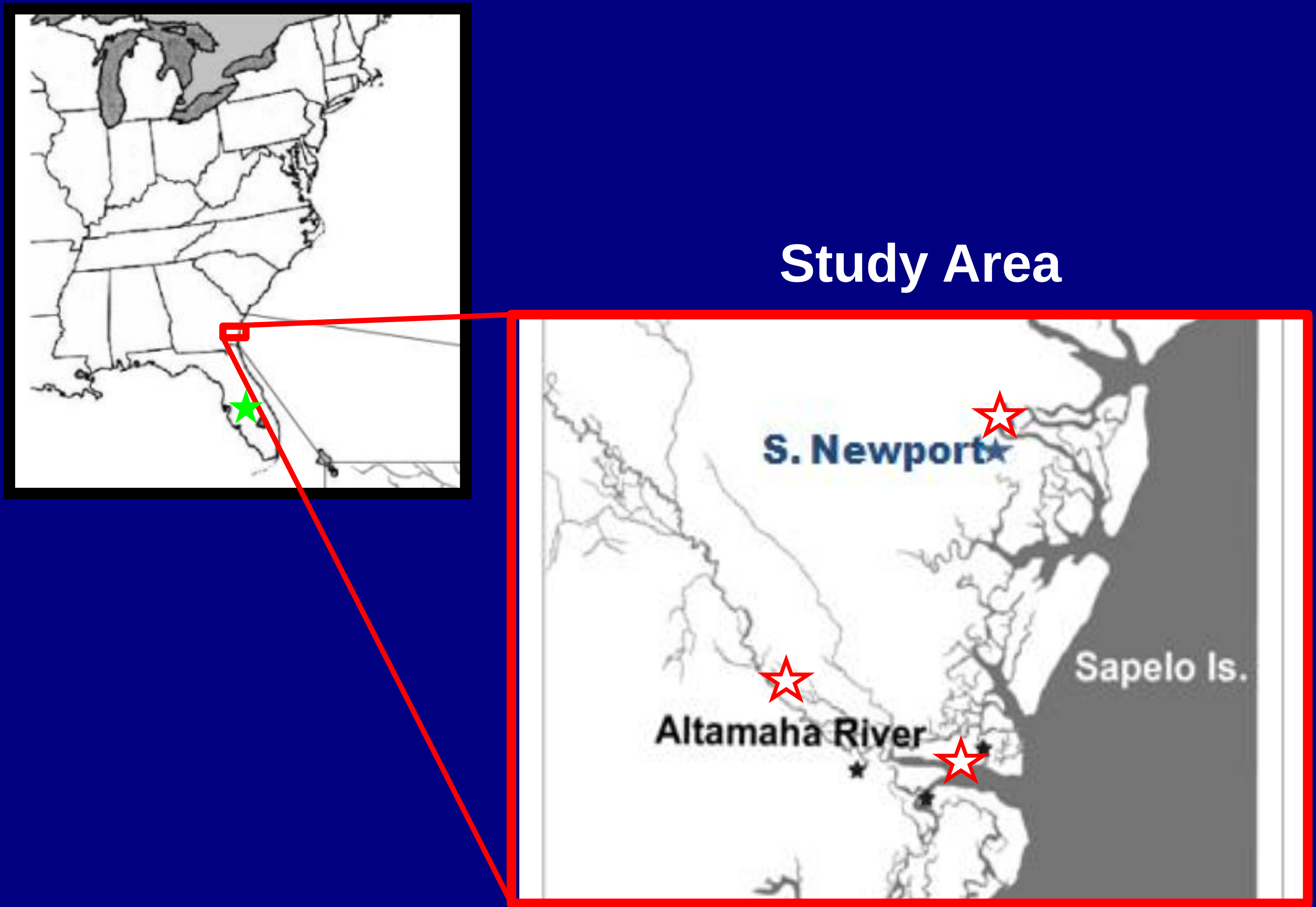
Global Change: Consequences

- Increased inundation rates = increased duration of anaerobic conditions
- Increased salinity
  - Introduce sulfate (SO_4^{2-}) ion
    - Methanogenesis ➔ sulfate reduction
    - Accelerate decomposition ➔ subsidence?
    - Release P
  - Change ionic strength


Blackwater NWR,
Maryland, USA

SE US Coast

Study Area



C Cycling I: Salinity & Decomposition

Objectives:

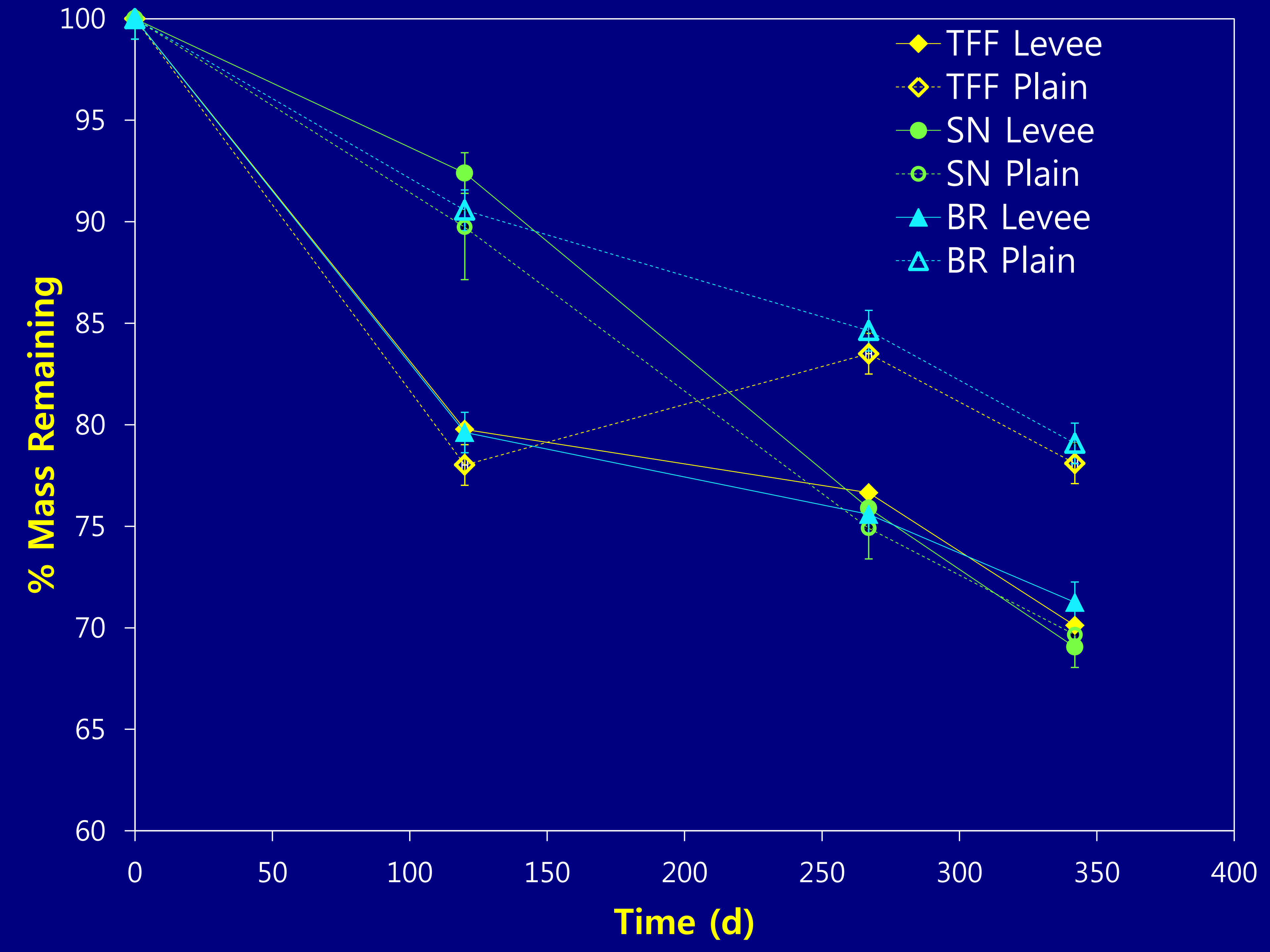
- How do salinity and hydrology impact the decomposit ion of the roots of bald cypress (*Taxodium distichum*)?

Methods:

Healthy tidal forest

Saltwater intrusion

Brackish marsh



TFF Levee
TFF Plain
SN Levee
SN Plain
BR Levee
BR Plain
% Mass Remaining
Time (d)
100
95
90
85
80
75
70
65
60
0
50
100
150
200
250
300
350
400

C & S Cycling: Saltwater and GHGs

Objectives

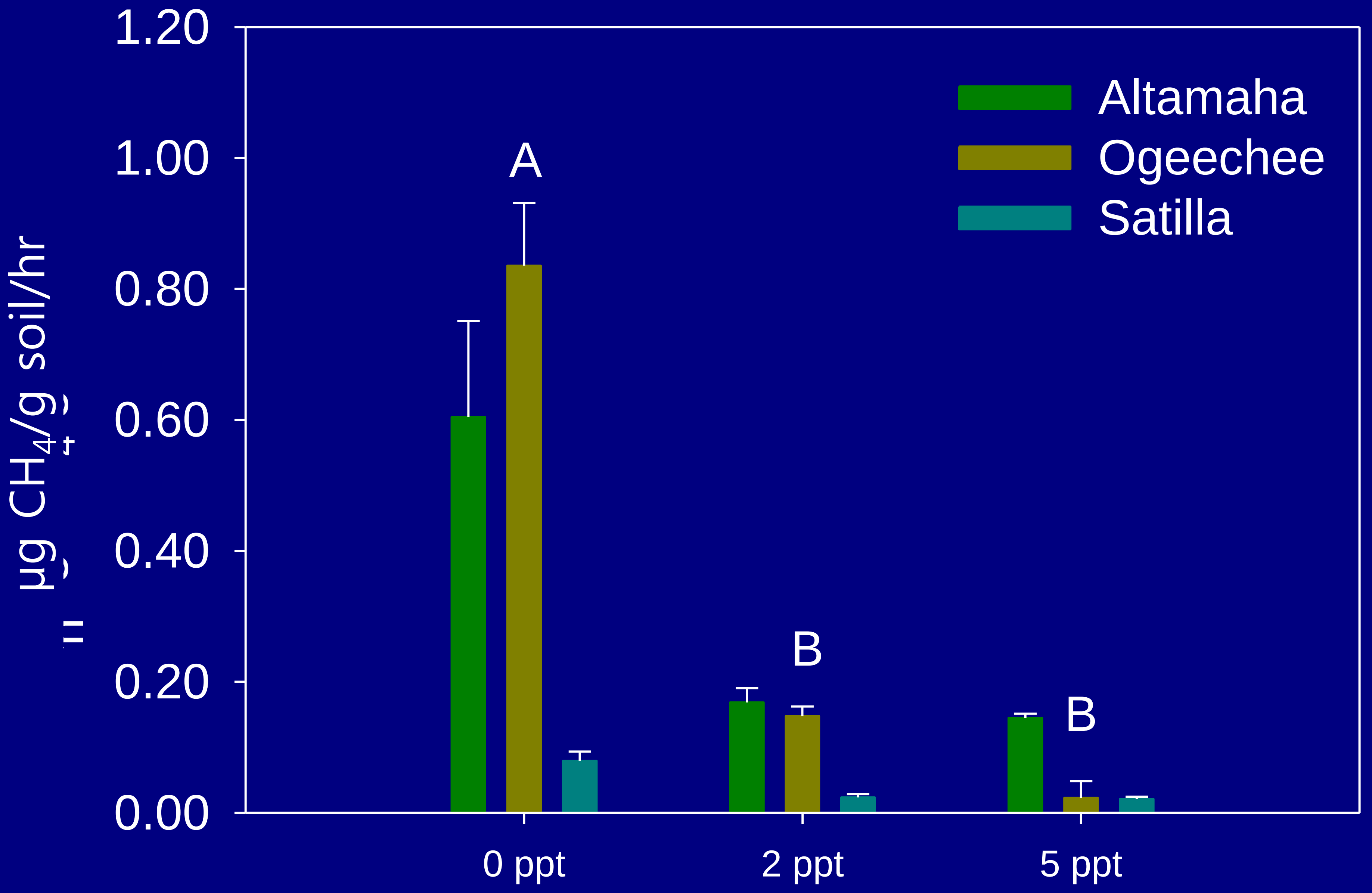
- How does simulated saltwater intrusion impact:
  - Greenhouse gas production?
  - Sulfur cycling?
  - Denitrification?

Methods:

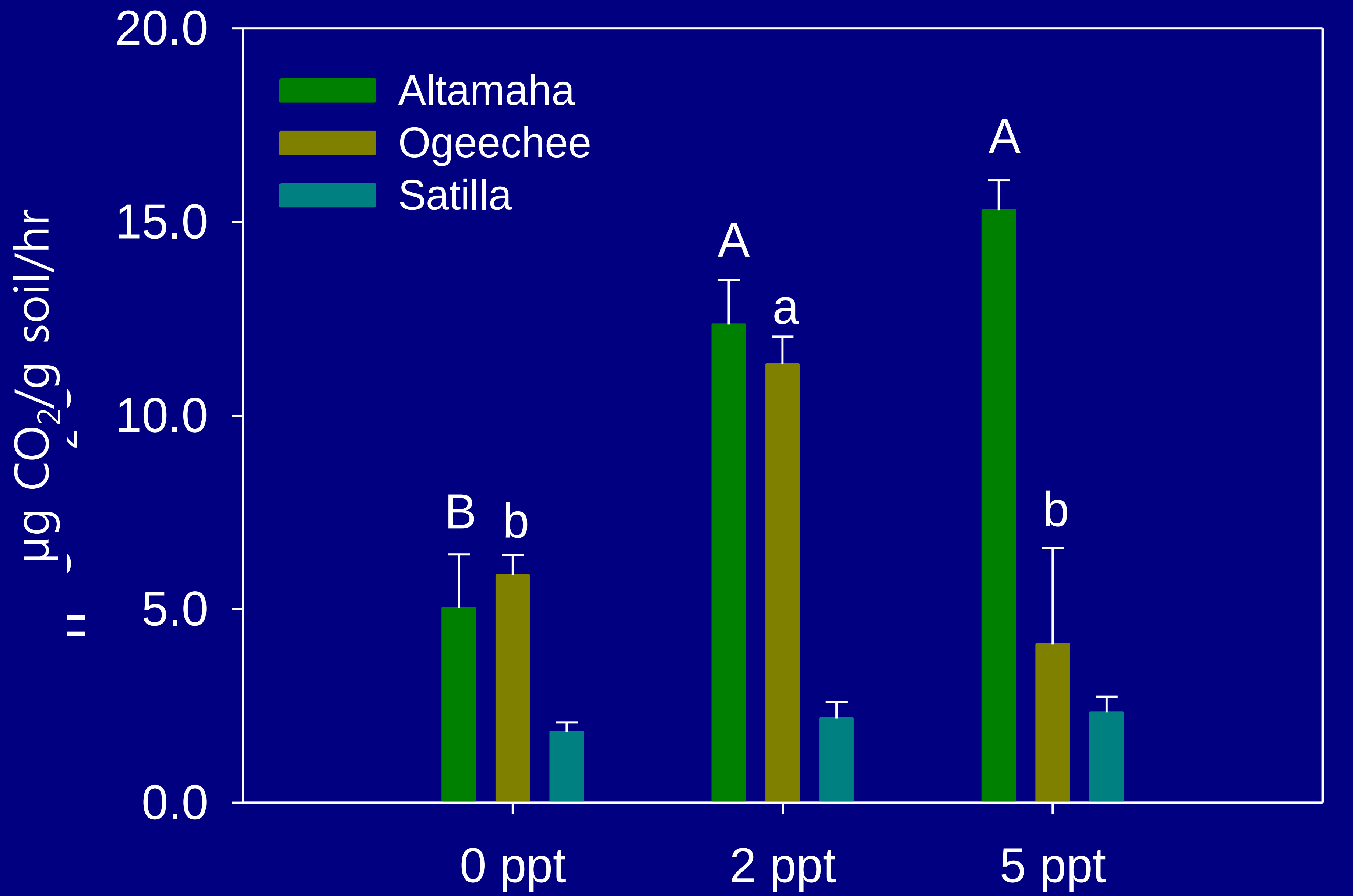
- Altamaha, Satilla, and Ogeechee Rivers
- Anaerobic bottle incubations at salinity of 0, 2, 5
  - Acetylene block for denitrification
- Extract acid volatile and chromium reducible sulfur

Marton et al. (2012) *Wetlands*

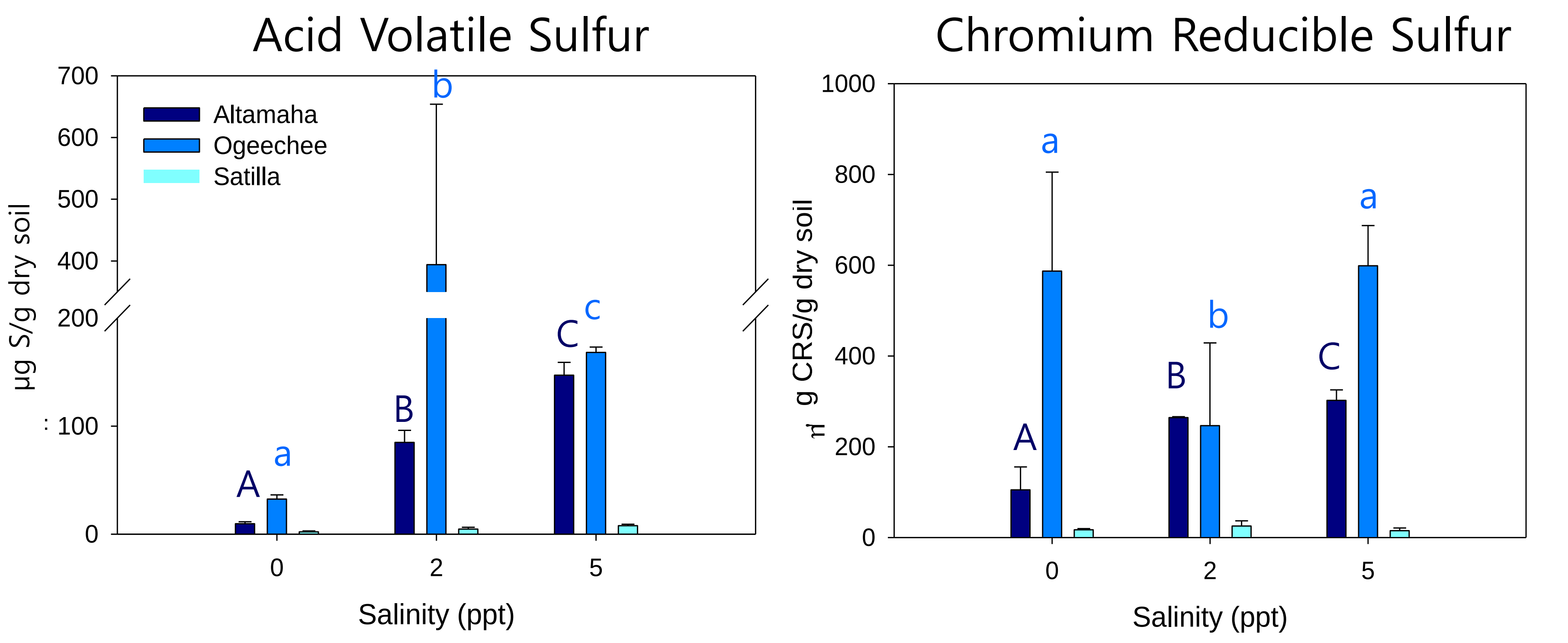
CH_4 Production



CO_2 Production

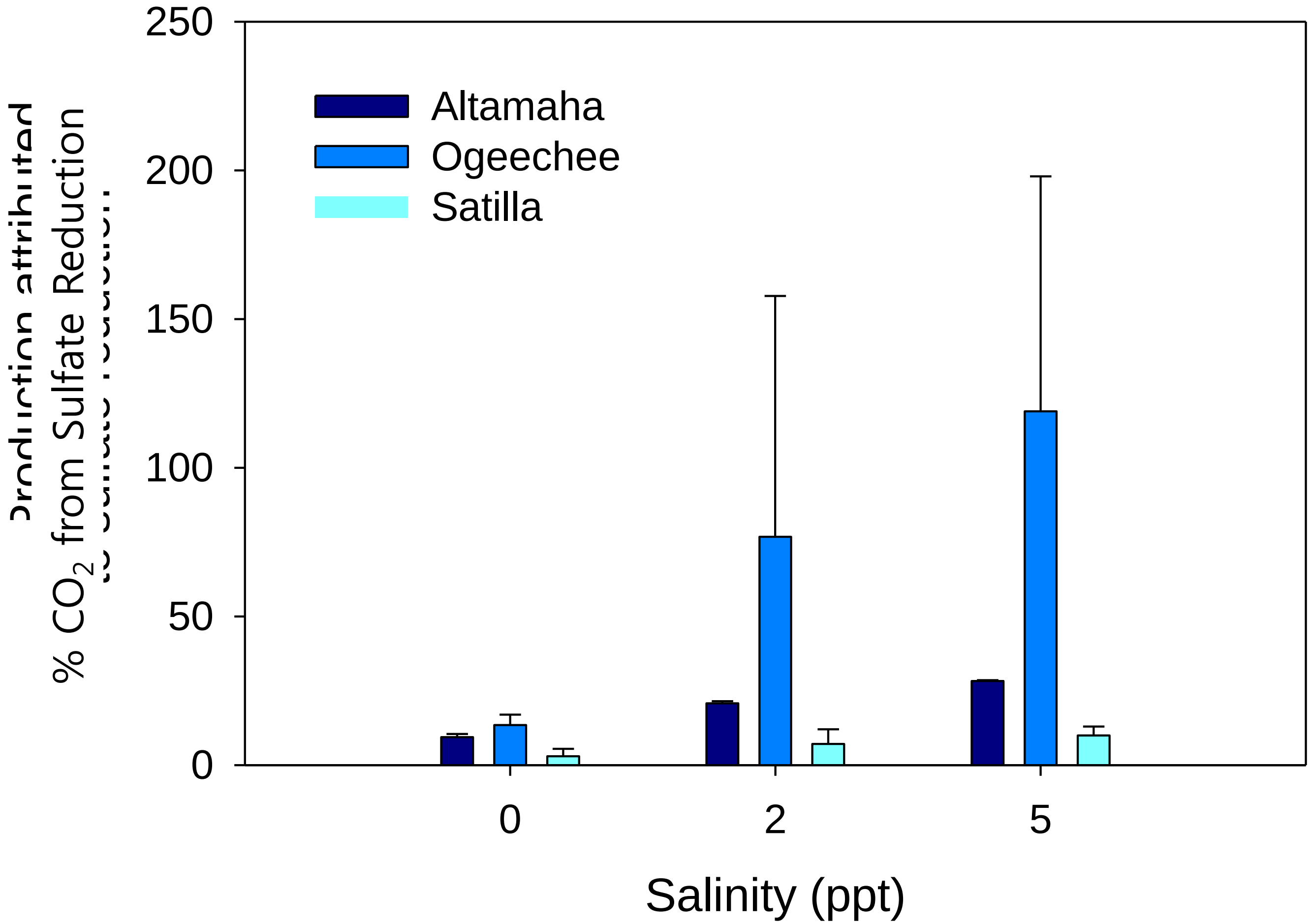


Evidence of Increased S Reduction



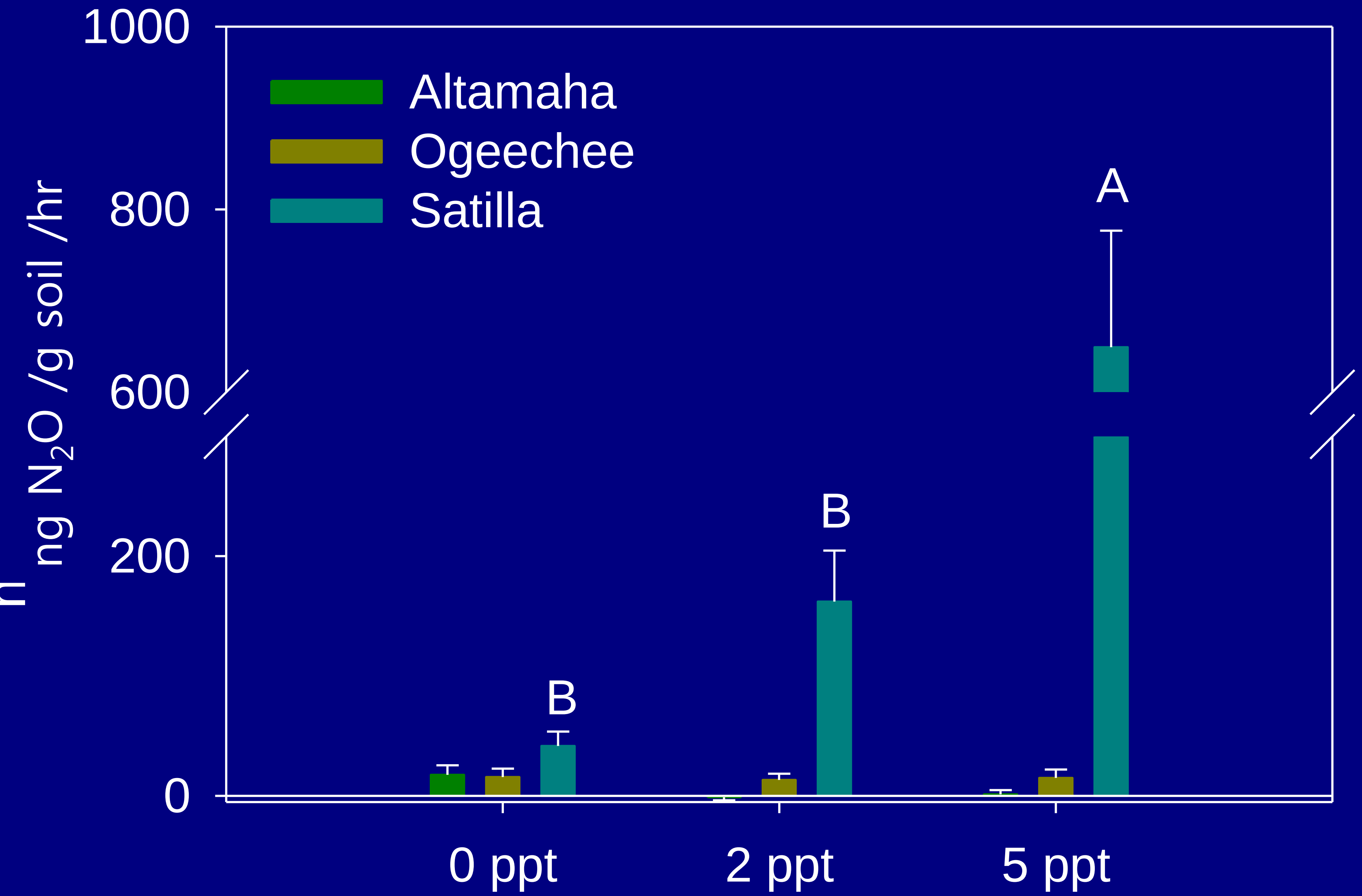
- Total reduced inorganic S increased in Altamaha and Ogeechee with salinity, indicating increased sulfate reduction
- Ogeechee had much higher initial S in soil and water

CO_2 Production from Sulfate Reduction

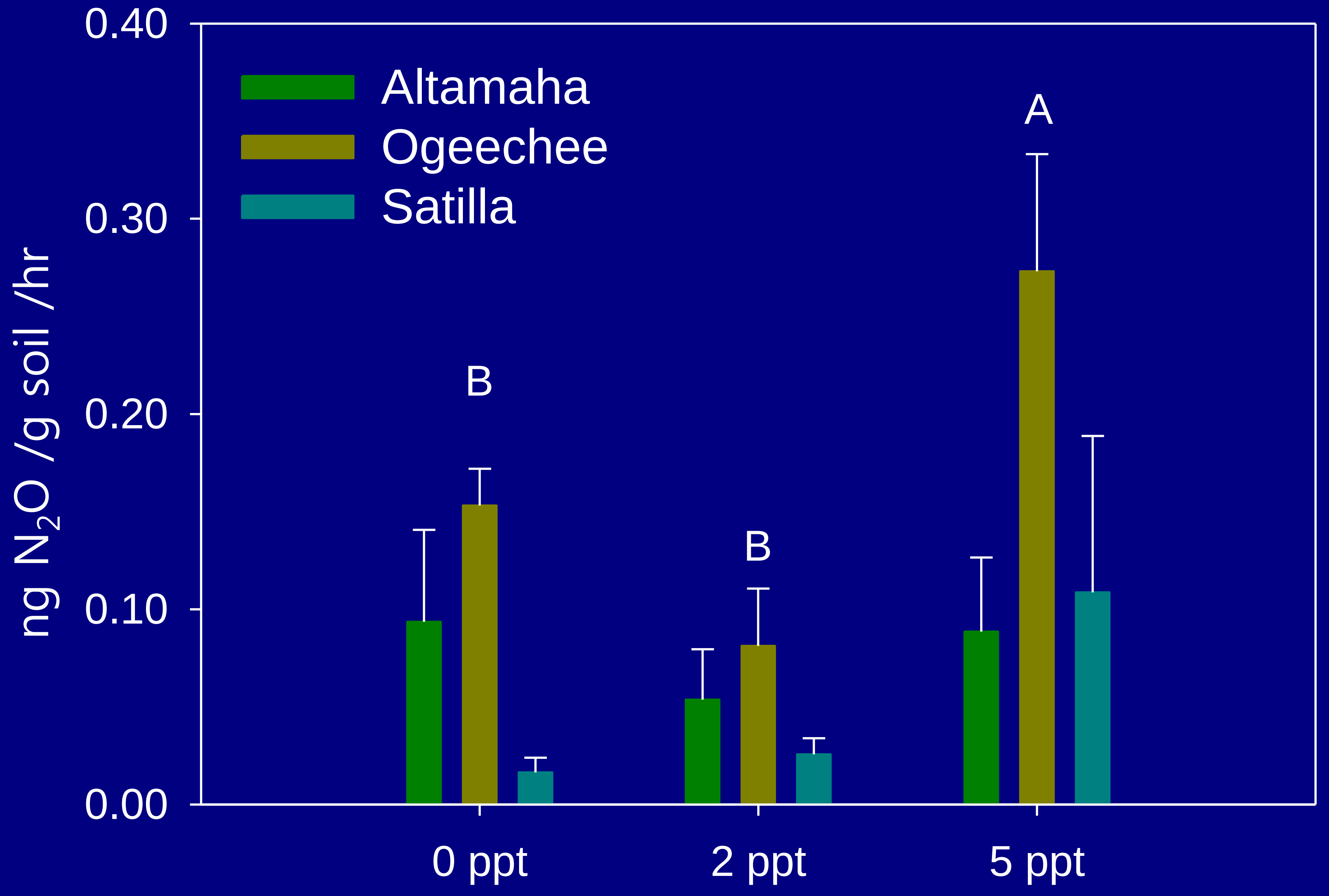


- Sulfate reduction greater than 100% of CO_2 production?

Ambient N_2O Production



Ambient Denitrification



N&P Sorption/Desorption

Objectives:

- Are tidal forest soils sources or sinks for inorganic N&P?

- How do increased salinity and inundation impact this?

Methods :

Sorption/Desorption:

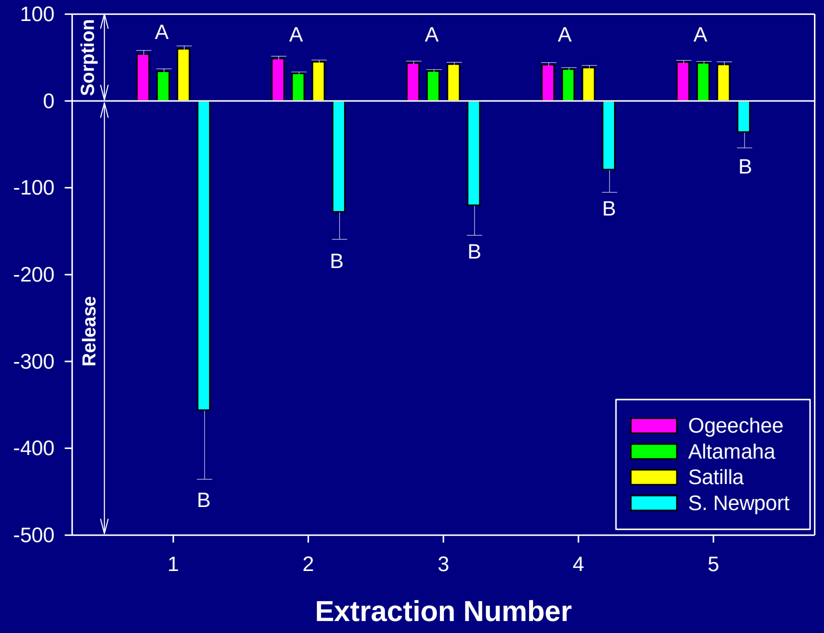
- Altamaha, Ogeechee, Satilla, S. Newport
- 5 tidal cycles
- Δ [NH_4-N] & [PO_4-P]

Salinity and Inundation:

- Salinity (0, 2, 5) * Inundation (5, 10 cm)

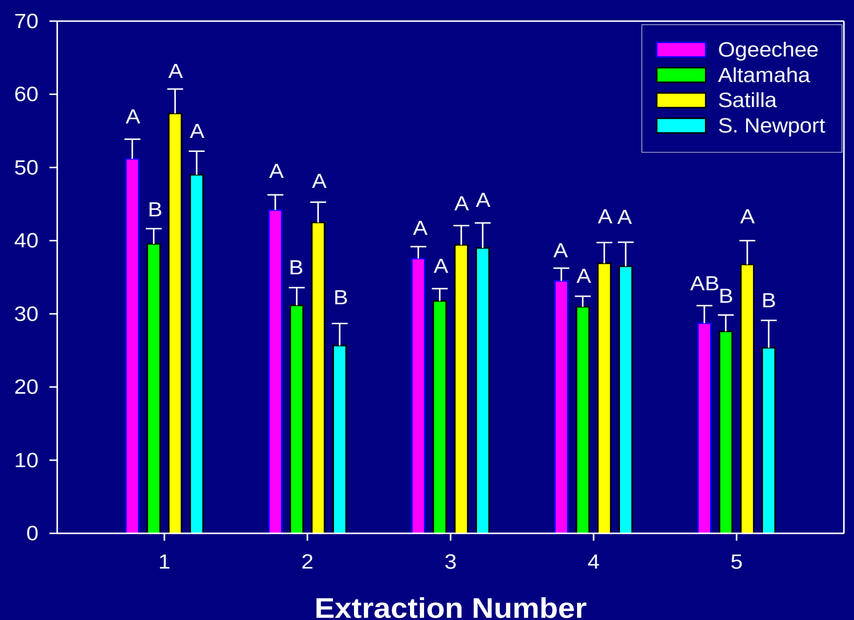
Jun et al. (2012) *Estuaries & Coasts*

NH_4-N Sorption/Desorption



- Sinks for PO_4^{3-} & NH_4^+

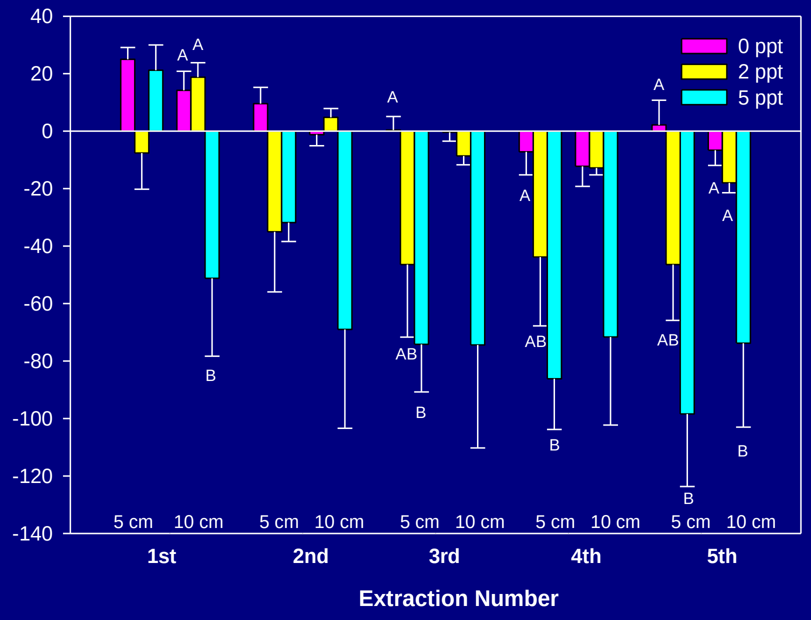
PO_4-P Sorption



- Saltwater intrusion release large amounts of NH_4^+.

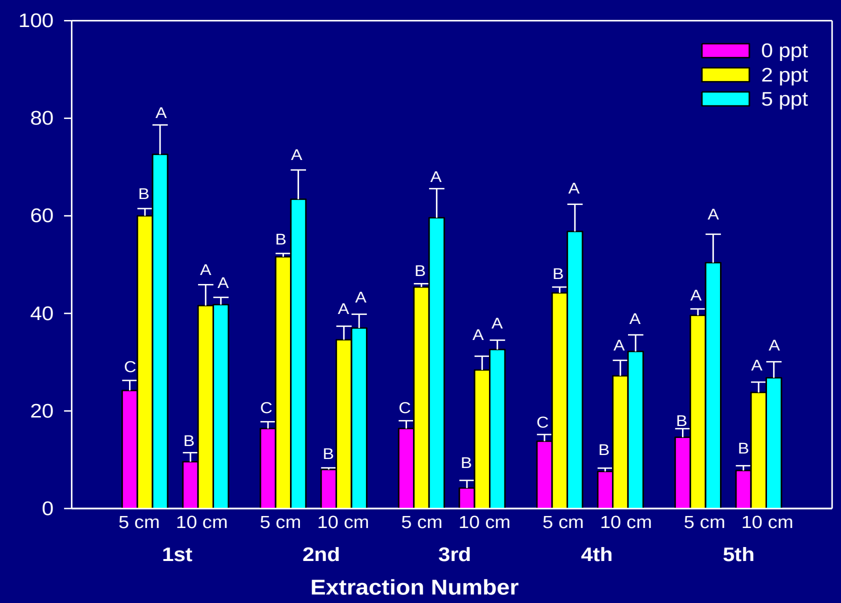
Altamaha River

NH_4-N Sorption/Desorption



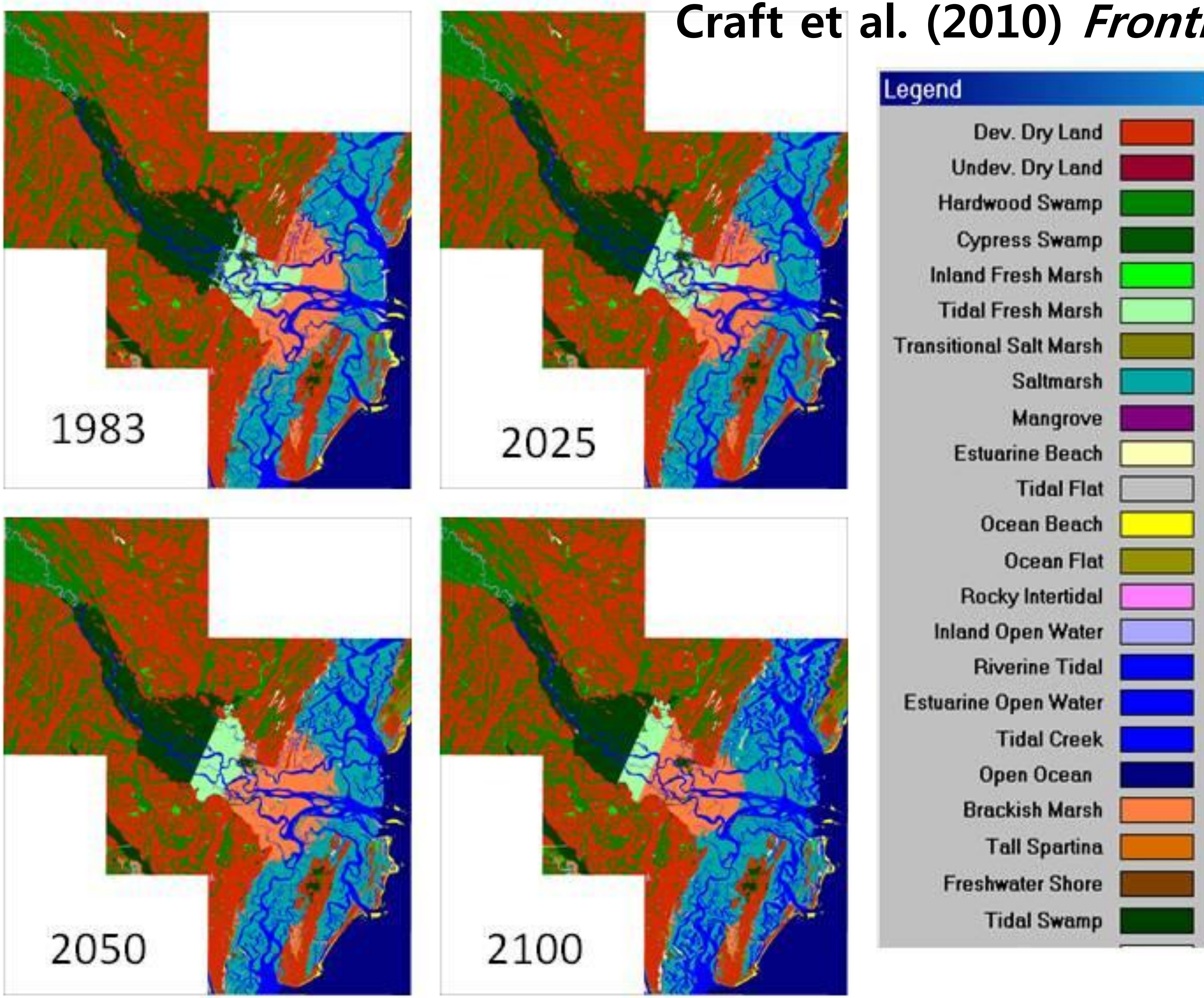
• NH_4^+ release increases with increasing salinity.

PO_4-P Sorption



• PO_4^{3-} sorption increases with salinity & decreases with inundation.

Craft et al. (2010) *Frontiers*



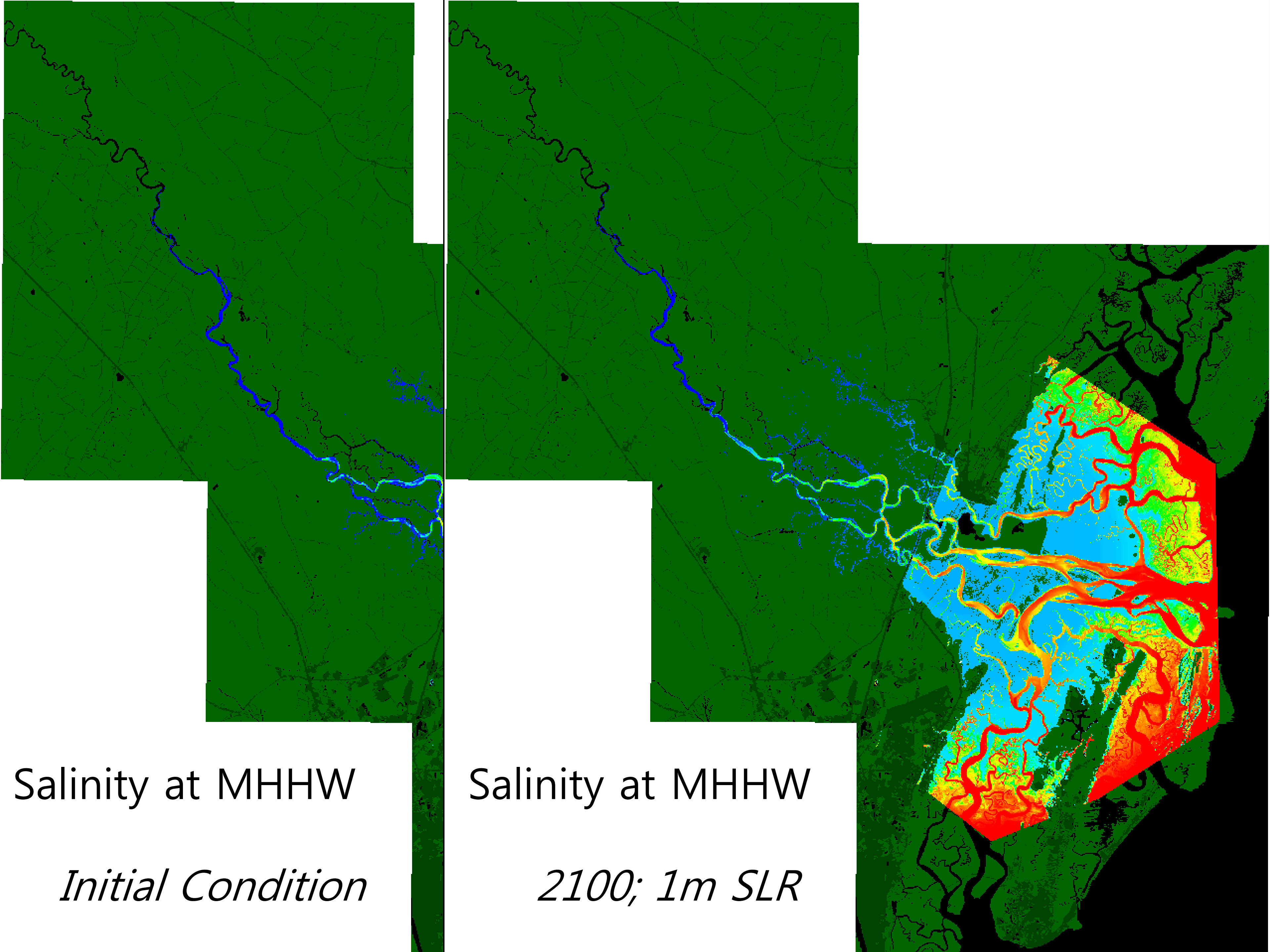
Scaling Up: SLAMM

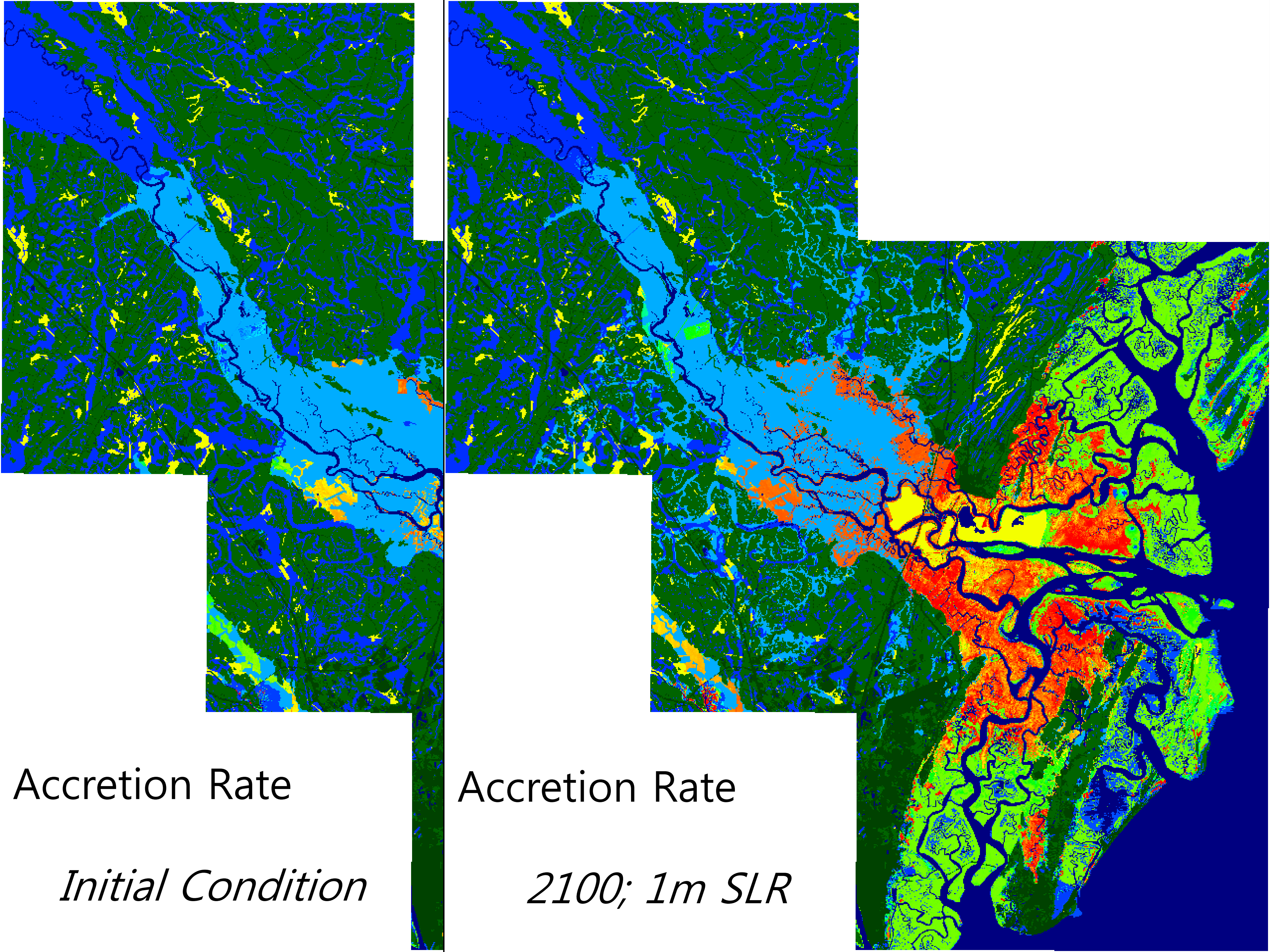
Objectives:

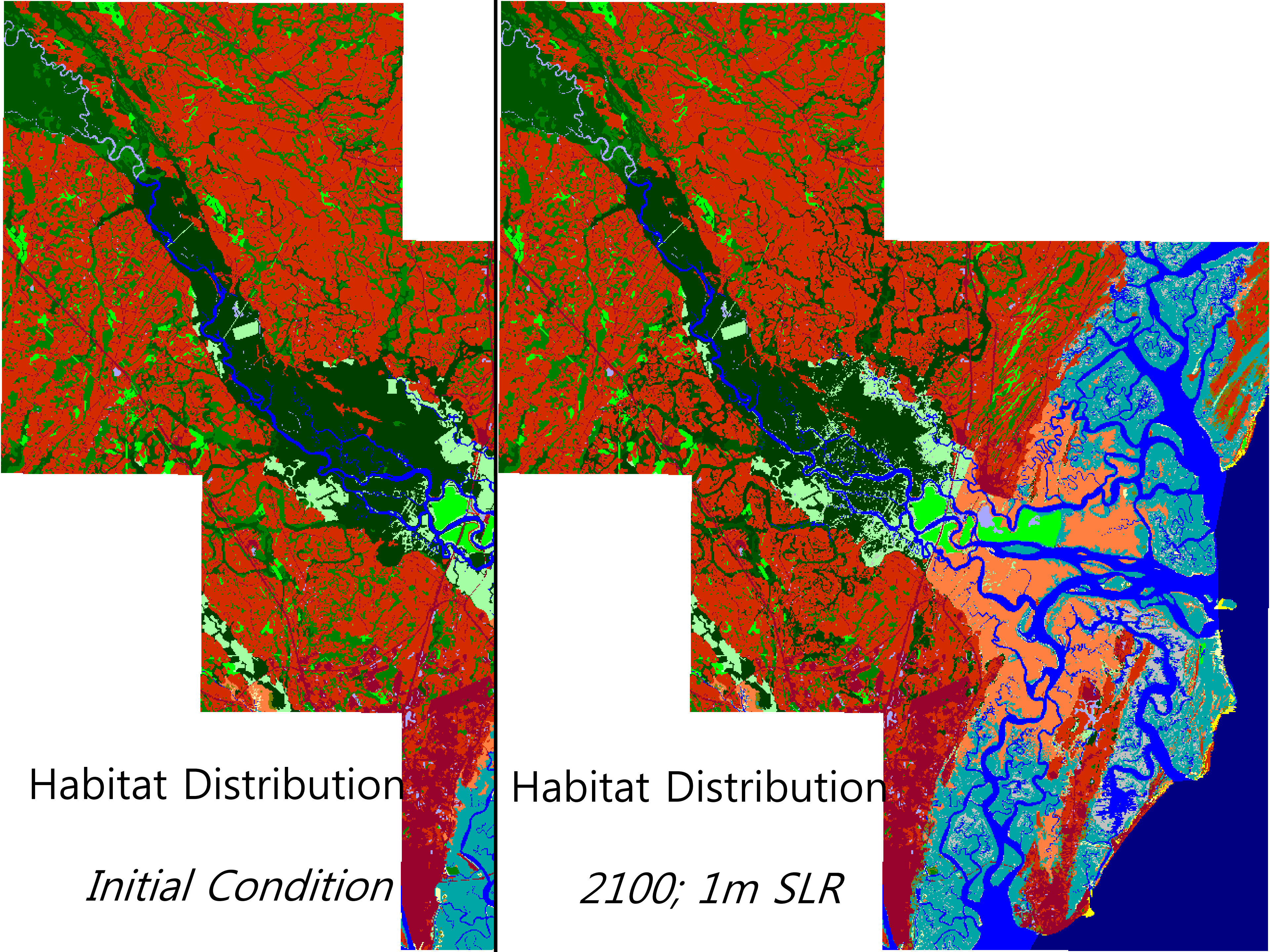
- Quantify wetland habitat changes on Altamaha River due to SLR

Methods:

- Sea Level Affects Marshes Model (SLAMM) 6.1
- Parameterization of the salinity sub-model
- LiDAR (2007)
- Bathymetry (from 2006)
- National Wetland Inventory (2007)
- Variable accretion rate using MEM 3.4 (Morris et al. 2002)


Salinity at MHHW
Initial Condition
Salinity at MHHW
2100; 1m SLR


Accretion Rate
Initial Condition
Accretion Rate
2100; 1m SLR


Habitat Distribution
Initial Condition
Habitat Distribution
2100; 1m SLR

Conclusions

- Saltwater intrusion promotes N and C release
  - CH_4 ↓
  - Sulfate reduction ↑
- Denitrification and N_2O production are unclear.
- P sorption: ↑ salinity; ↓ inundation
- Up-stream/inland migration of tidal forests

From the bottle to landscape…..

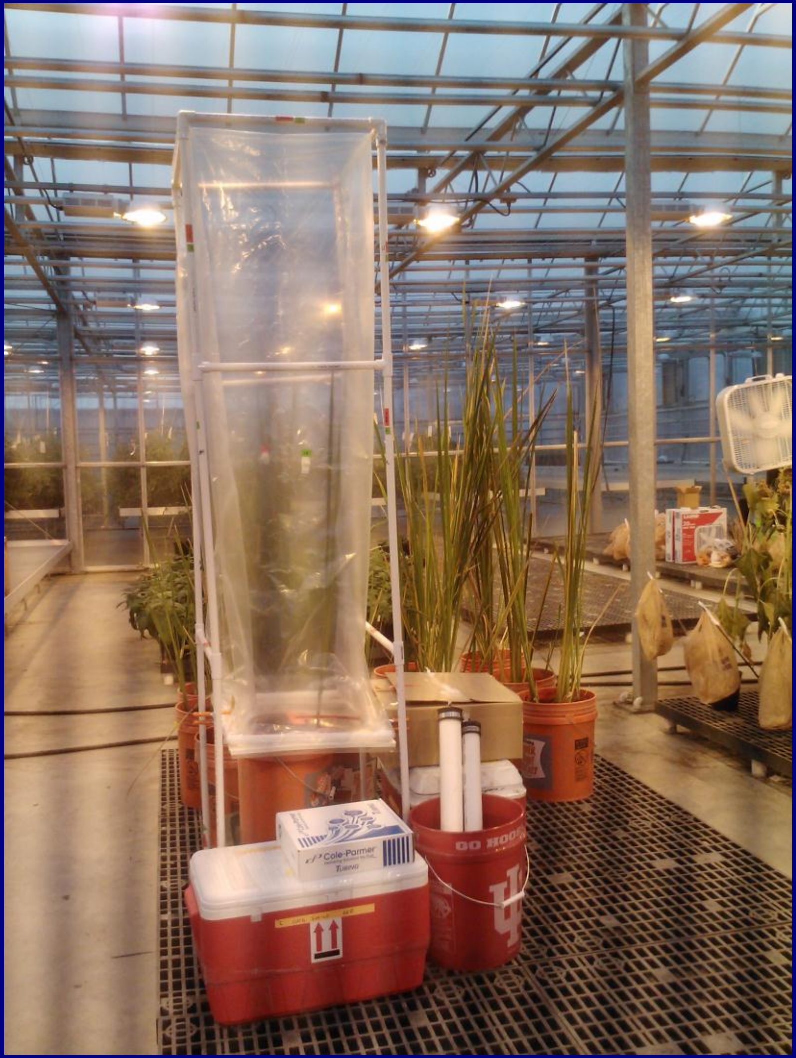
Unknowns and Future Work

- Spatial Variability
- Ecosystem migration (Ability? Timing?)
- Subsidence?
- Vegetation:
  - Productivity
  - Species composition

↓ Productivity + Δ Community → ↓ C Quantity + ↑ C min

- Interactions with other global change factors
- Out of the bottle…

How does saltwater intrusion alter C cycling in intact plant soil systems?



Pulse-Chase: $^{13}CO_2$

Insight into…

- Assimilation
- Short-term plant-soil flux
- C quality/quantity controls on mineralization pathway
- Microbial players?

…with minimal disturbance

Manipulative Field Experiment

Saltwater
Addition
Long
Term
Experiment

Georgia Coastal Ecosystems LTER Project

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