

Considering Nitrogen and Black Mangrove in Context: Lessons Learned

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Plant-nutrient Interactions in Tropical Wetlands



Photo: Tracy Enright, USGS



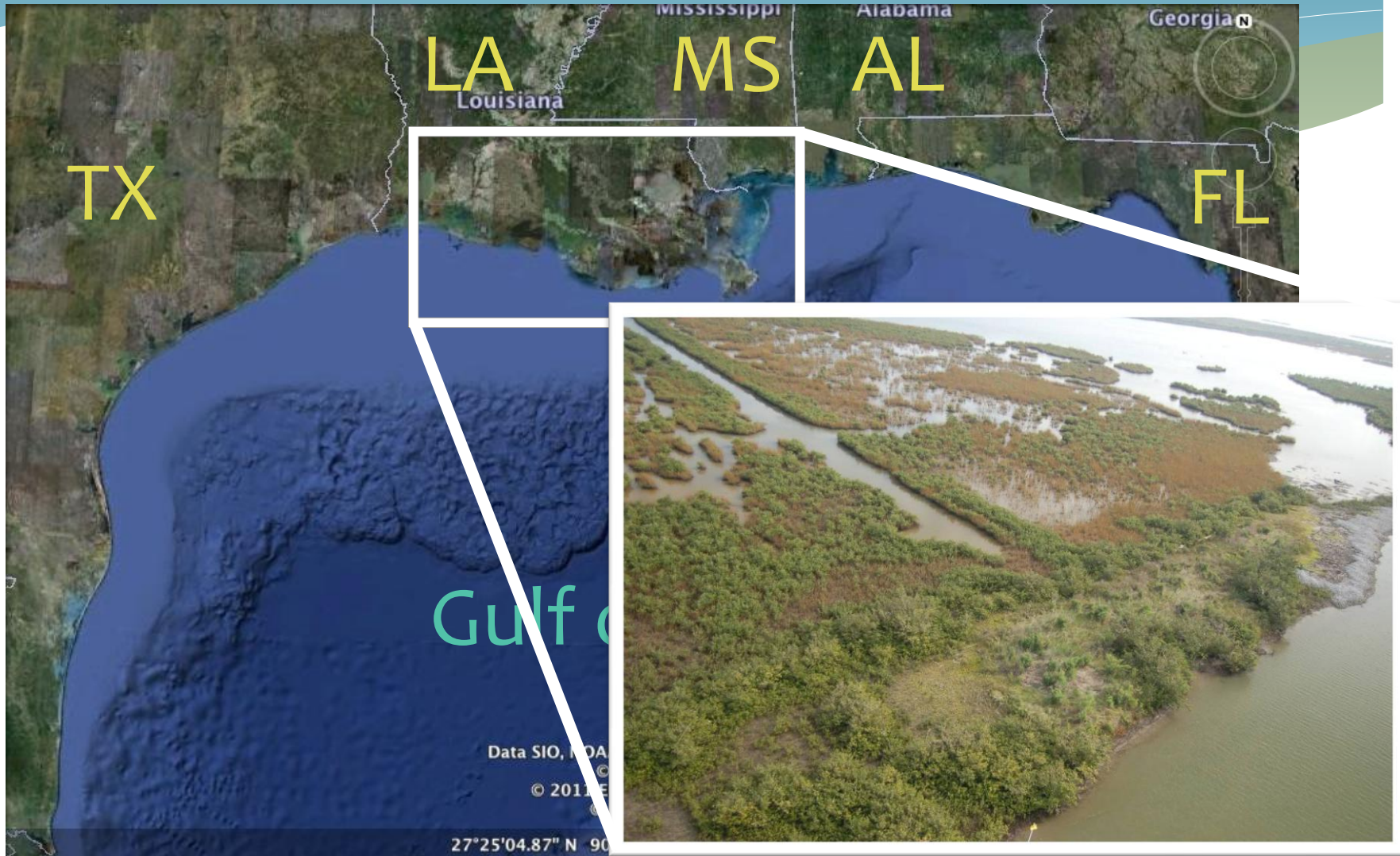
Photo: Mark Hester

Plant-nutrient Interactions in **Subtropical** Wetlands

Salt Marsh-Mangrove Ecotones



Black Mangroves in Northern Gulf of Mexico



Nitrogen in the Gulf of Mexico

- * Salt marshes and mangroves are often nitrogen limited
- * Increase growth
- * Improve uptake of other nutrients
- * Improve osmoregulation in high salinity
- * Nitrogen loading
 - * Mississippi River
- * Dead zone
 - * Anoxic conditions
- * Salt marsh eutrophication
 - * Increased decomposition, soil respiration

3 Black Mangrove Studies

Black Mangrove Studies

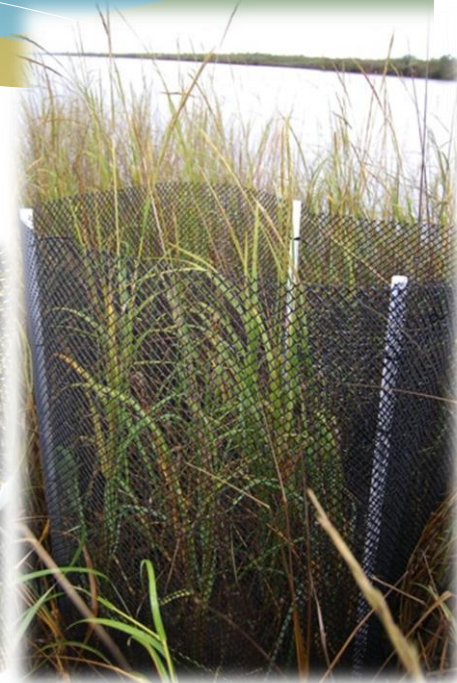
1. Latitudinal Transplant Study

Objective

- * Determine positive and negative interactions between mangrove and salt marsh along a cold temperature stress gradient

Latitudinal Transplant Study

- * 4 marsh sites along cold temperature gradient
 - * 2 canopy treatments- clipped and unaltered
 - * 2 life history stage treatments- propagule and seedling



3 Black Mangrove Studies

Black Mangrove Studies

1. Latitudinal Transplant Study
2. Effects of nitrogen and CO₂ on aboveground and belowground response of a mangrove- salt marsh association (Rhizotron Study)

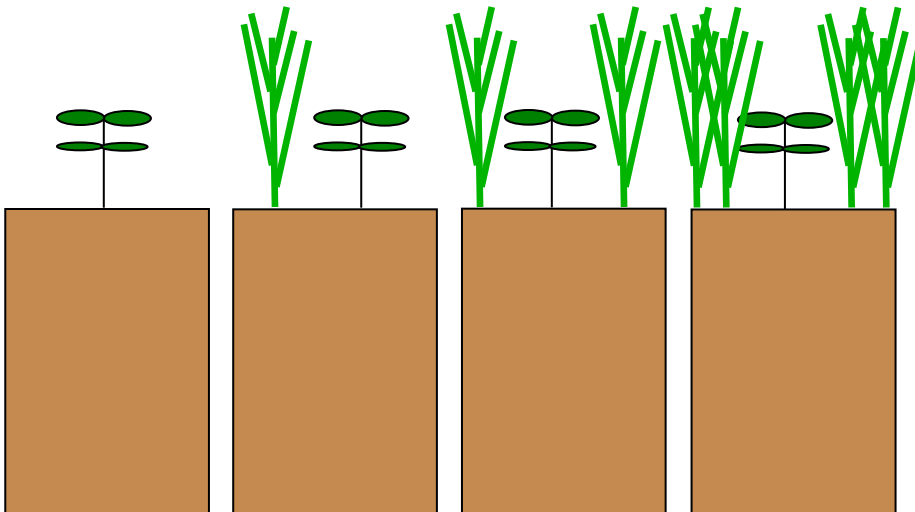
Objective

- * Identify mechanisms that support observed competitive suppression of mangrove by herbaceous marsh species



Rhizotron Study:

- * Ambient and elevated CO₂
 - * 370 and 720 ppm
- * Nitrogen supply
 - * High (10 mol m⁻³)
 - * Low (0.5 mol m⁻³)
- * *S. alterniflora* stem density:
0, 1, 2, 4 stems/rhizotron



3 Black Mangrove Studies

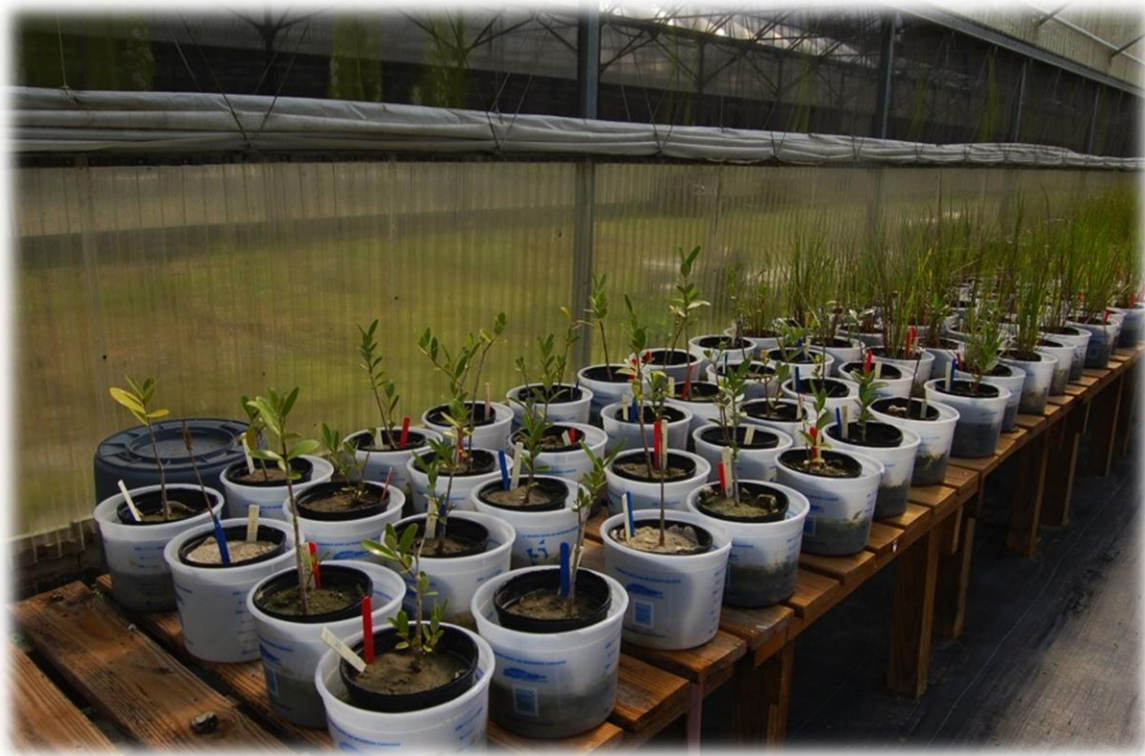
Black Mangrove Studies

1. Latitudinal Transplant Study
2. Effects of nitrogen and CO₂ on aboveground and belowground response of a mangrove- salt marsh association (Rhizotron Study)
3. Enhancement of black mangrove restoration at a back-barrier island salt marsh

Objective

- * Determine effectiveness of a soil amendment and restoration design

Humic Acid & Fertilizer Greenhouse Study



- * 0 and 500 ml m⁻² Humic Acid
- * Low (10% Hoagland's solution) and High (100% Hoagland's solution) fertilization



Photo: T Baker Smith

Nitrogen Aspect of Studies

Study	Component	Nitrogen Manipulation and Levels	Nitrogen Application	Measurements
Latitudinal Transplant in Marsh	Field	No		Porewater-nitrogen, sediment characteristics
Nitrogen, CO ₂ , and <i>Spartina</i> in Rhizotrons	Greenhouse	Yes: 0.5 mol m ⁻³ 10 mol m ⁻³	Water replaced every 2 weeks	Physiology, morphology, biomass
Mangrove Restoration	Greenhouse	Yes: 10% Hoagland's 100% Hoagland's	Added once in beginning	Physiology, morphology, biomass
Mangrove Restoration	Field	No		Porewater-nitrogen, sediment characteristics

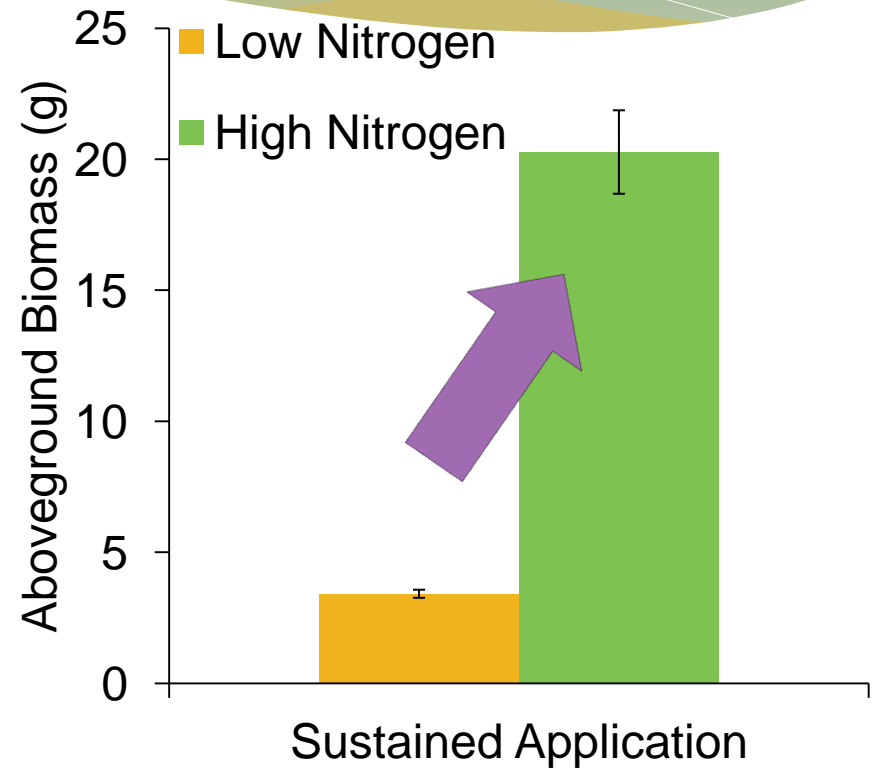
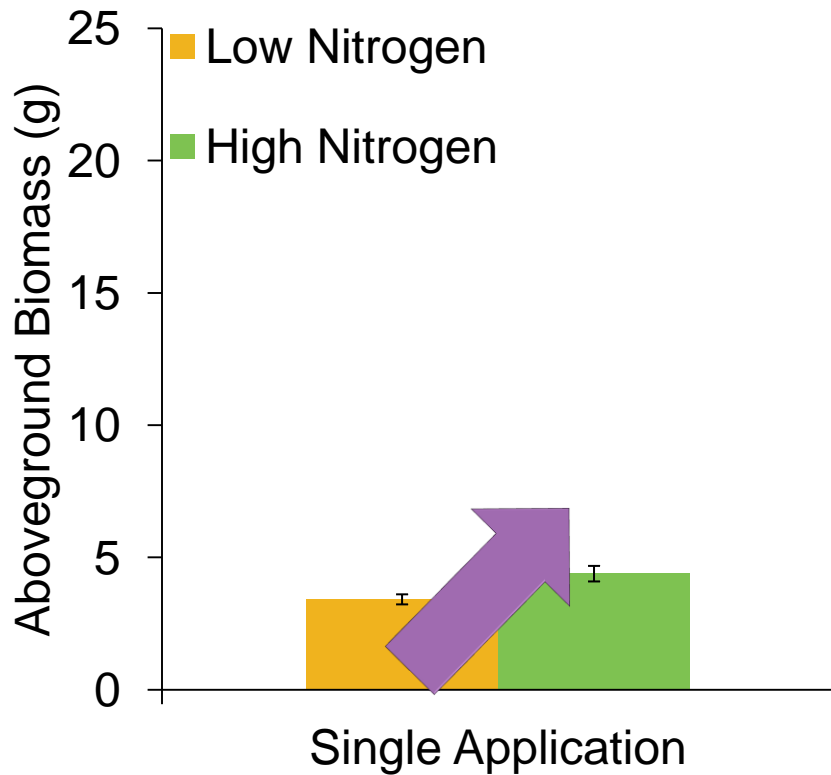
Black Mangroves and Nitrogen

- * How does the application level and frequency of nitrogen addition affect the black mangrove response?
- * Which factors enhance or diminish the observed black mangrove response to nitrogen addition?
- * What environmental variation in nitrogen exists in the northern Gulf of Mexico that could affect black mangrove growth?

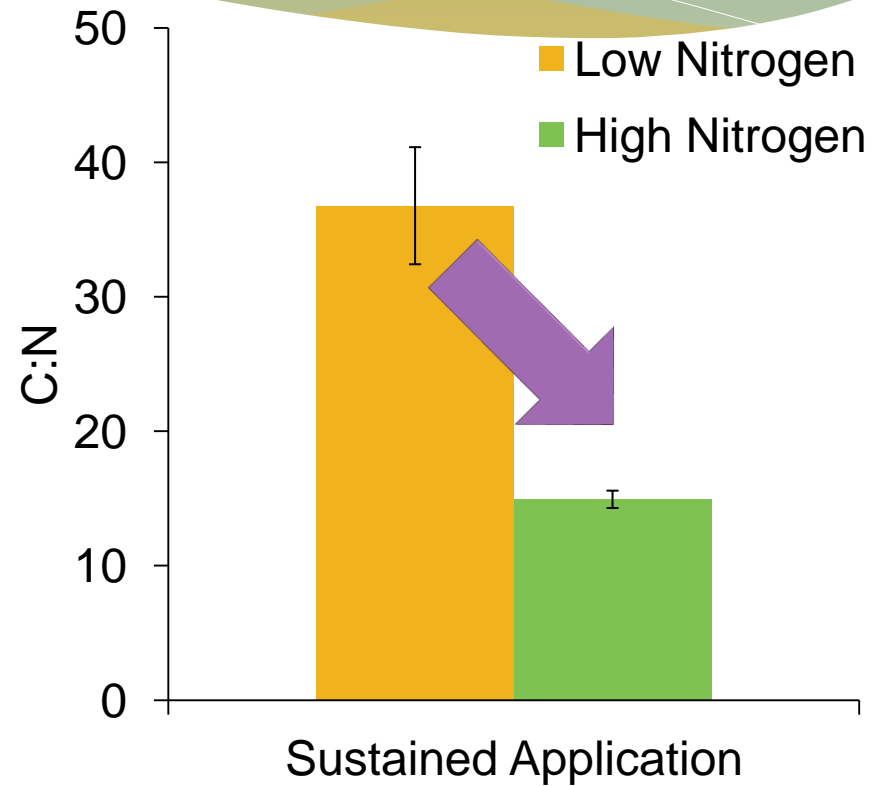
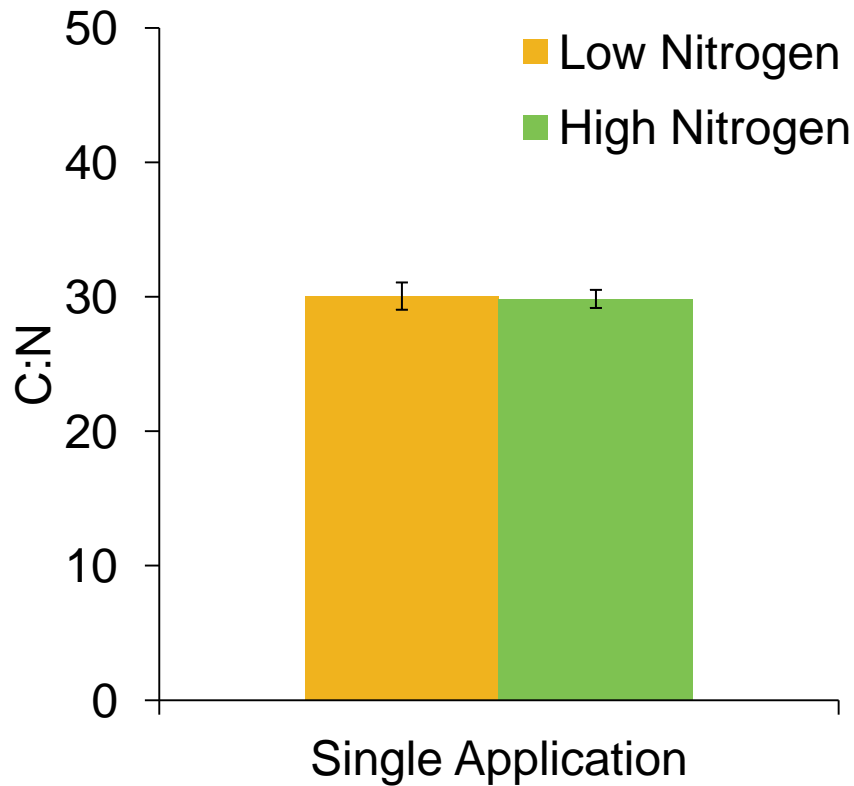
Amount and Frequency of Nitrogen Addition

- * Compared data from studies where nitrogen was applied differently:
 - * Single Application- Mangrove restoration greenhouse study
 - * Sustained Application- Rhizotron study

Aboveground Biomass



C:N Ratio



Lesson 1: More Nitrogen, More Effects at More Scales

Single Application

- * Nitrogen Effect on:
 - * Biomass
 - * Branch Length
 - * Total Leaf Area
- * No Nitrogen Effect on:
 - * Specific Leaf Area
 - * Cumulative Height
 - * C:N Ratio

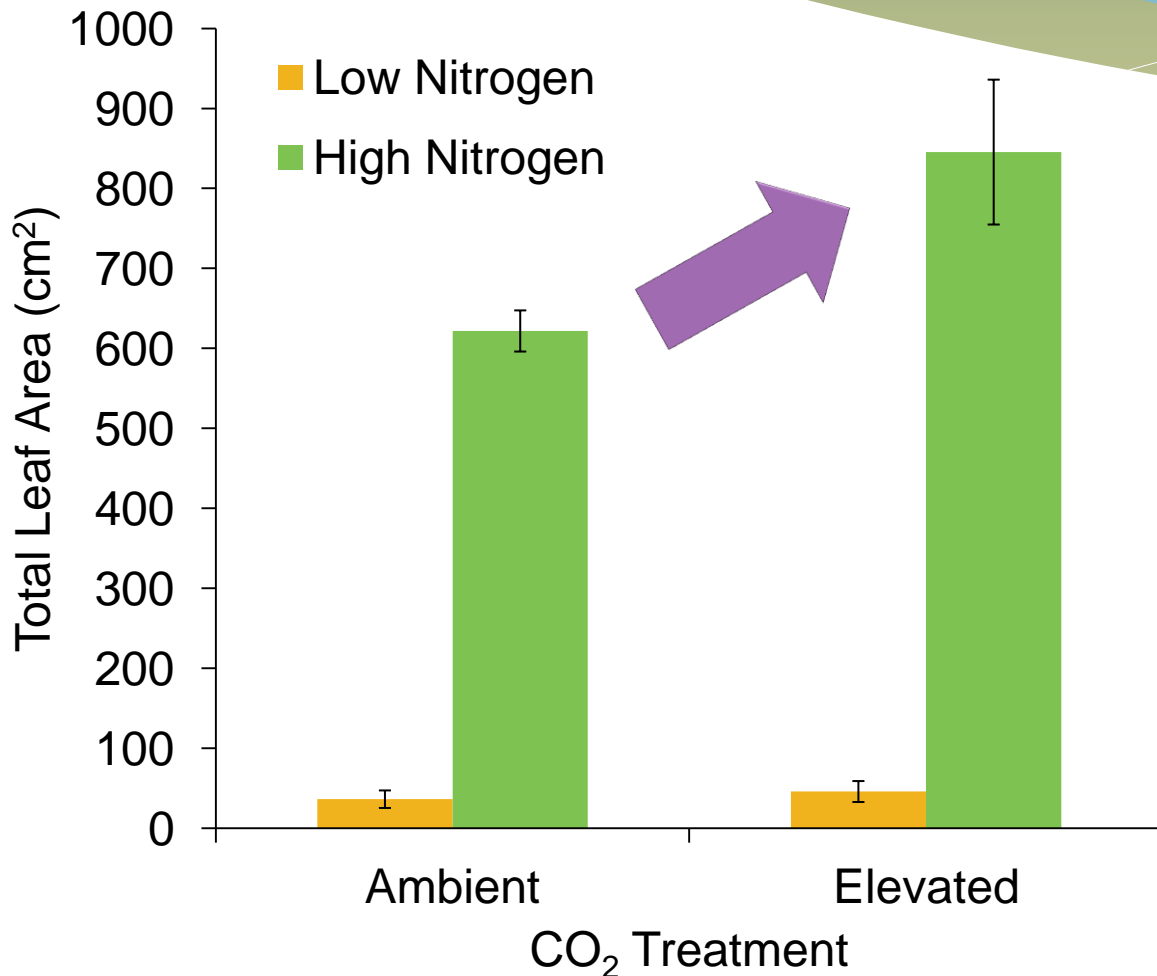
Sustained Application

- * Nitrogen Effect on:
 - * Biomass
 - * Specific Leaf Area
 - * Cumulative Height
 - * C:N Ratio
 - * Photosynthesis
 - * Root Morphology

Enhancing and Diminishing Nitrogen Effects

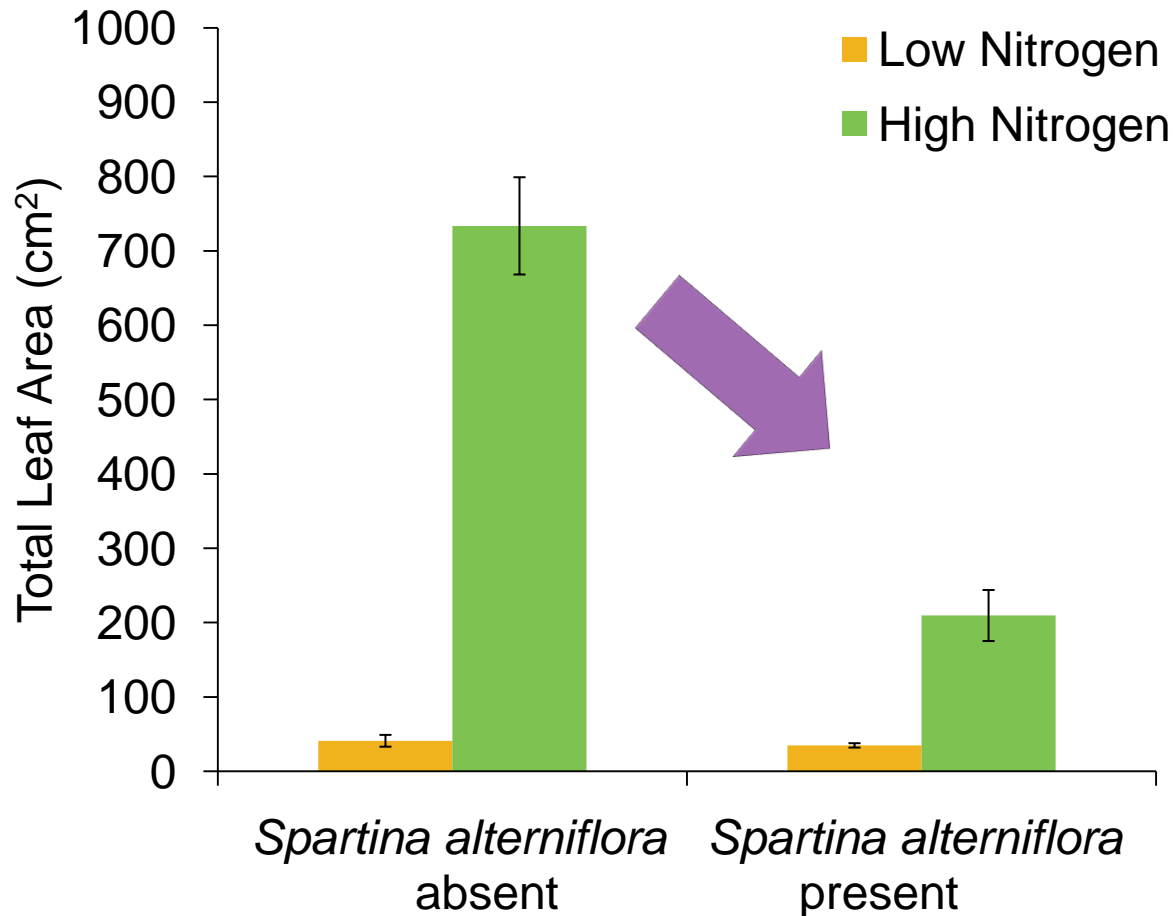
- * Compare total leaf area data from CO₂, Nitrogen, and *Spartina alterniflora* Rhizotron Greenhouse Study
 - * Enhanced Effect- with elevated CO₂
 - * Diminished Effect- with *Spartina alterniflora* presence

Enhanced Nitrogen Response



* Lesson 2:
Elevated CO₂ can
enhance the positive
effect of nitrogen

Diminished Nitrogen Response



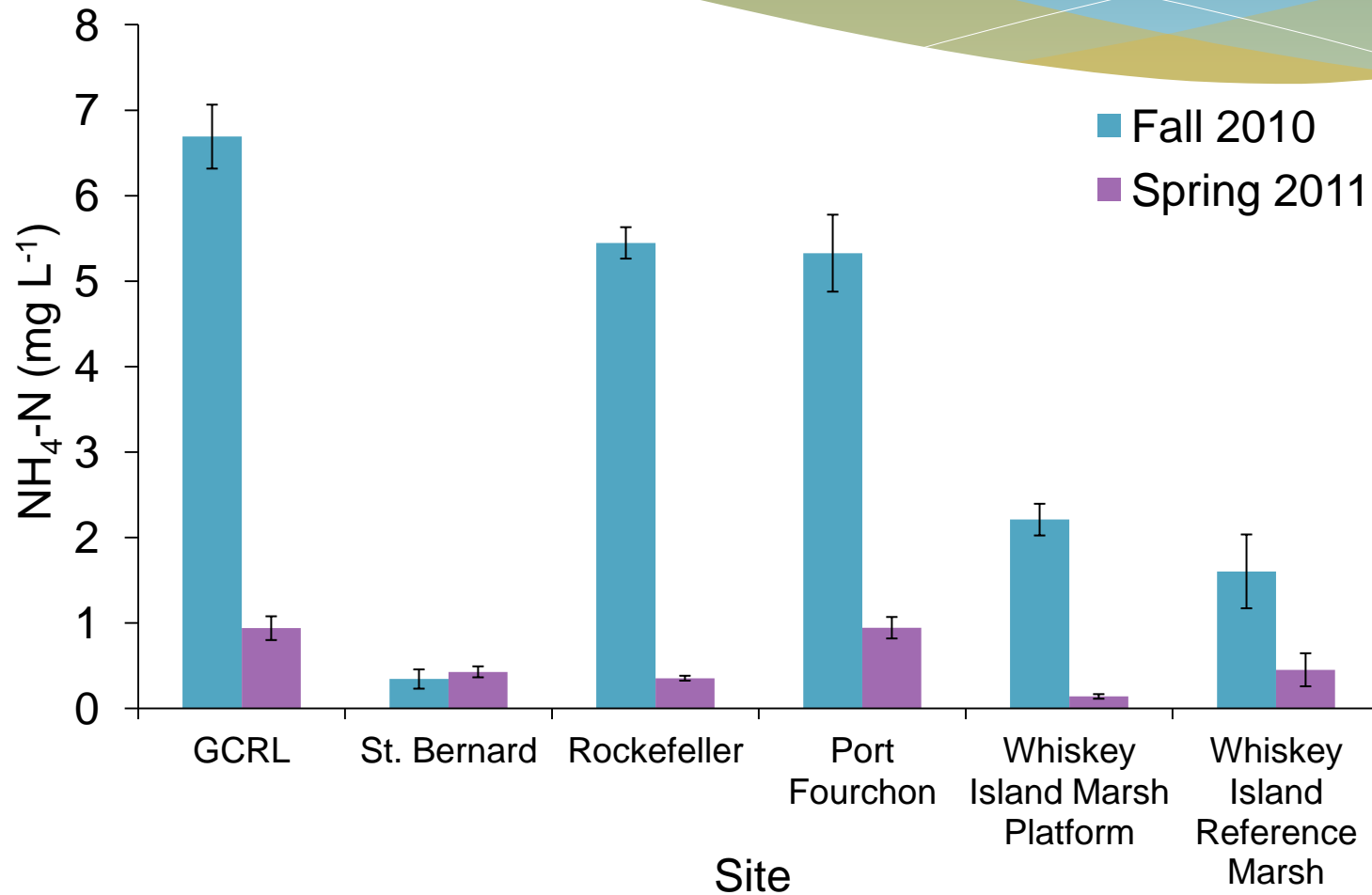
* Lesson 3:

Species interactions (competition) can alter the outcome of nitrogen addition

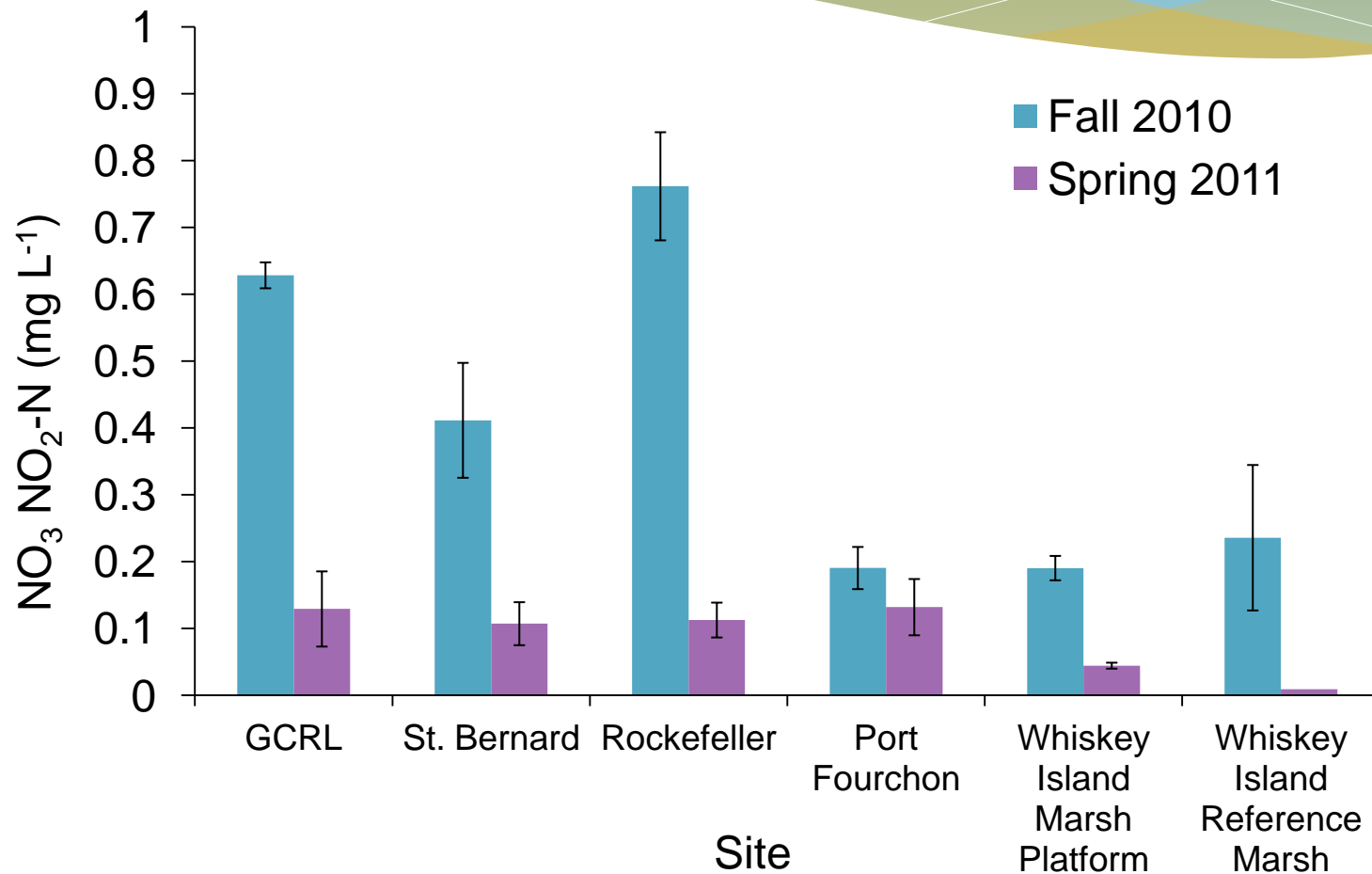
Environmental Variation

- * Examine porewater-nitrogen in Fall 2010 and Spring 2011 from field studies:
 - * Latitudinal Transplant Study- four salt marsh sites
 - * Mangrove Restoration Study- Whiskey Island back-barrier salt marsh platform and reference plots
- * Examine sediment characteristics in Fall 2010 and Spring 2011
 - * % Organic Matter
 - * Bulk Density

Environmental Variation in Ammonium



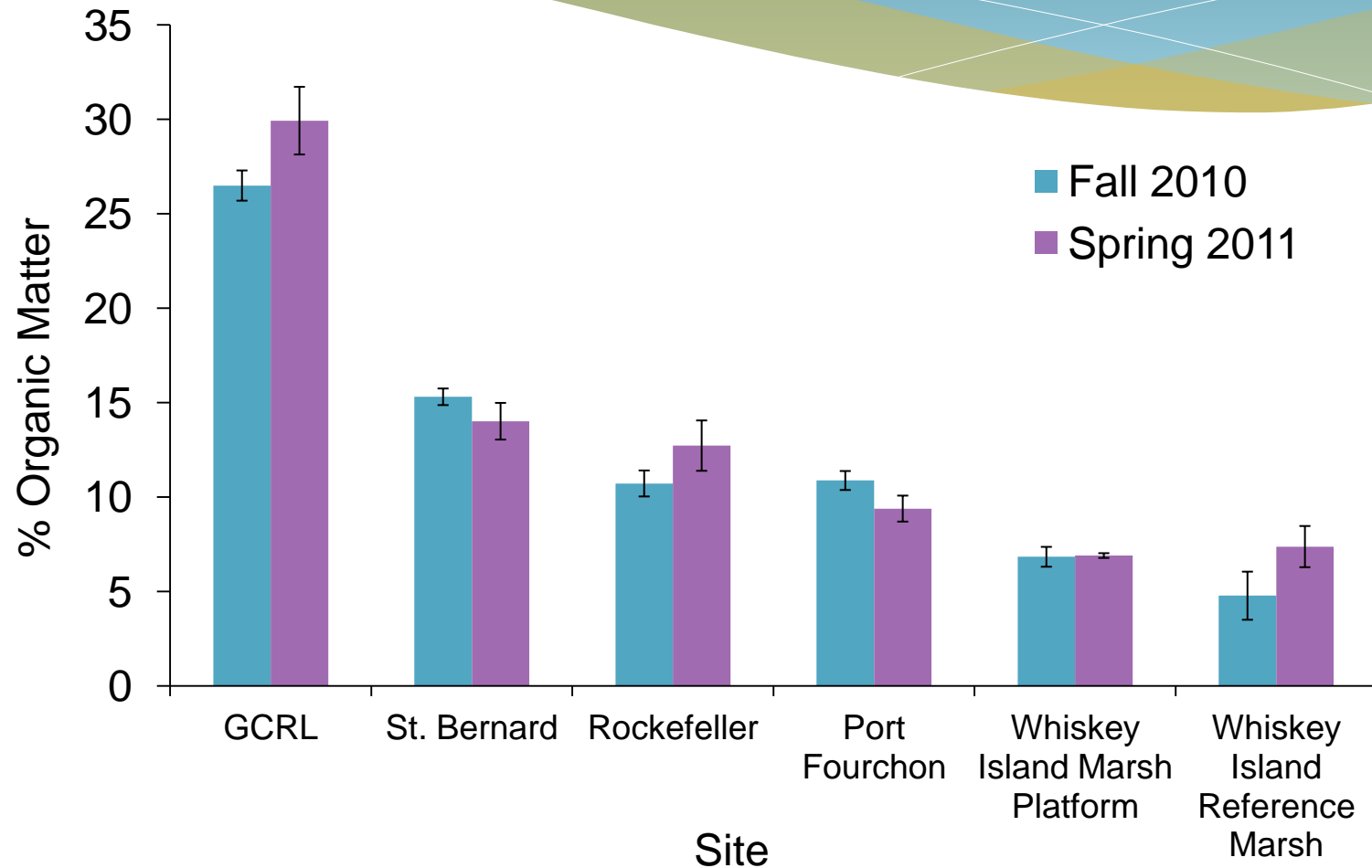
Environmental Variation in Nitrate-Nitrite



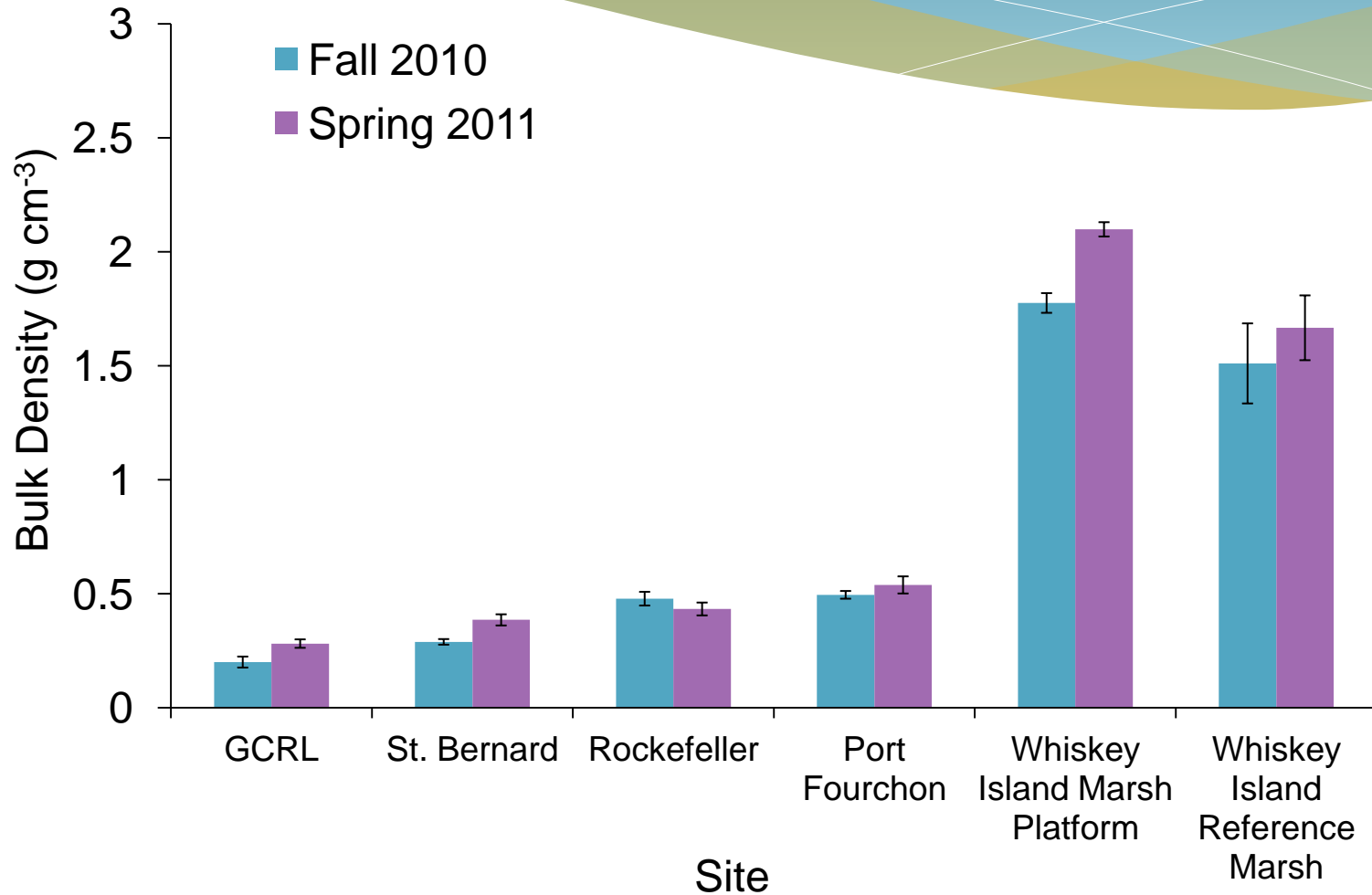
Lesson 4: Natural Variation

- * Seasonal variation in nitrogen
 - * Low in spring when growth rates are high
 - * Nitrogen transferred from soil and roots to leaves
 - * High in fall as growth slows
 - * Nitrogen mineralization and release with leaf turnover
- * Spatial variation in nitrogen
 - * May be related to sediment characteristics

Variation in Sediment Percent Organic Matter



Variation in Sediment Bulk Density



Mangrove and Nitrogen Patterns in the Tropics

- * Black mangroves can be nitrogen or phosphorus limited
 - * Nutrient limitation can change along a gradient
 - * Nitrogen fertilization results in increased productivity, but not water relation improvement
 - * Type of response to fertilization may depend on degree of limitation
- * Salinity and flooded soil conditions may alter nitrogen acquisition and use
- * Nitrogen enrichment may lead to increased mortality in high salinity/low rainfall conditions
- * Nitrogen fertilization can alter herbivory

Lessons Learned Summary

- * Lesson 1: More nitrogen added, more effects at multiple scales- photosynthetic, leaf, and whole plant
 - * If trying to achieve desired effect, make sure to add enough nitrogen
- * Lesson 2: CO₂ can enhance nitrogen effect
 - * Possible benefit with climate change, however:
- * Lesson 3: Species interactions can diminish nitrogen effect
 - * Competing species can suppress growth
- * Lesson 4: Natural variation in nitrogen and sediments
 - * Consider environmental patterns with expansion of black mangrove populations

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Questions?