GEER 2025
Greater Everglades Ecosystem Restoration

# Assessing Biomechanical Properties of Mangrove Roots Across a Salinity Gradient in the Florida Coastal Everglades.


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FCE LTER

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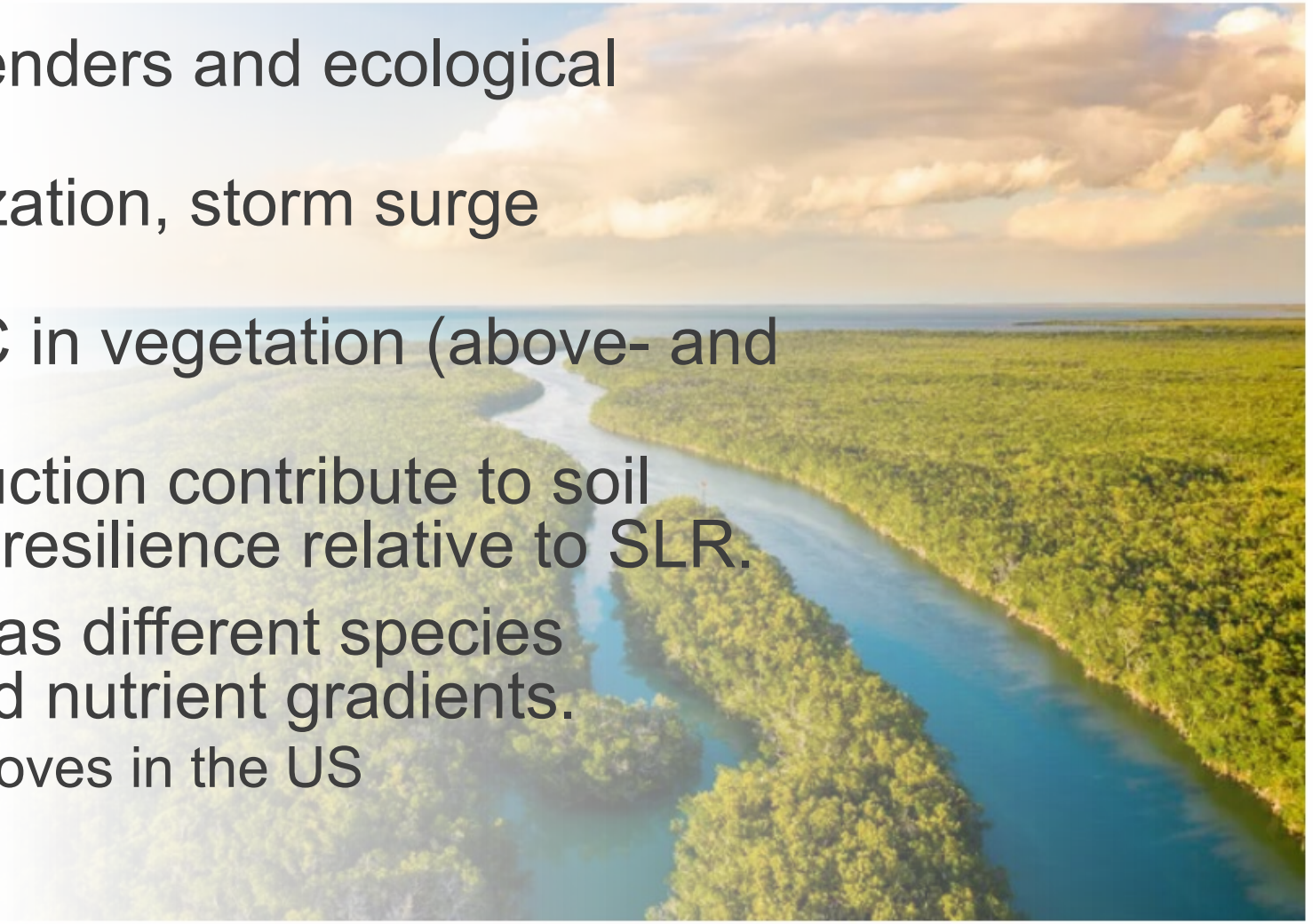
April 24, 2025

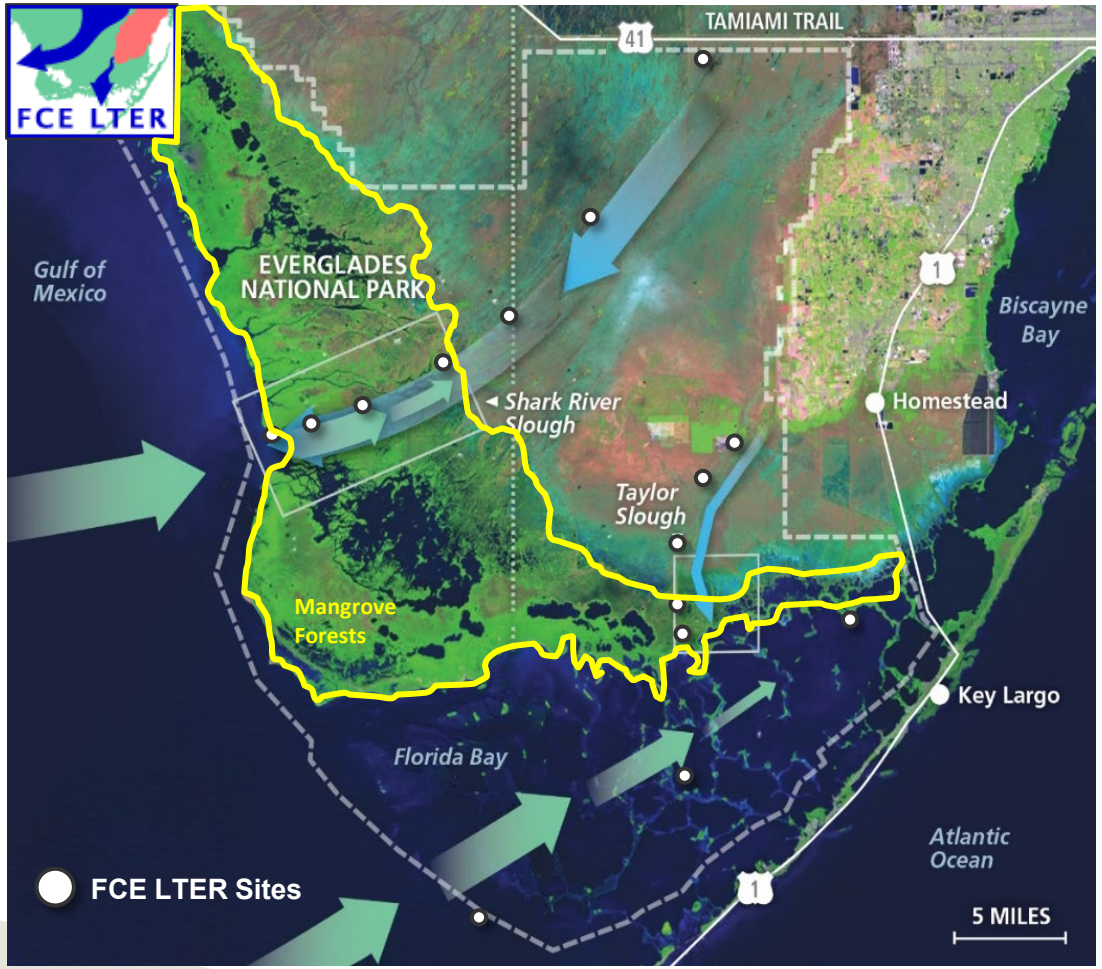
# *Introduction and Background*

- Mangroves are coastal defenders and ecological engineers
  - Provide shoreline stabilization, storm surge buffering, and habitat.
  - Store large amounts of C in vegetation (above- and belowground) and soils.
  - Plant biomass and production contribute to soil elevation and mangrove resilience relative to SLR.
- Everglades National Park has different species distributed along salinity and nutrient gradients.
  - Largest distribution of mangroves in the US



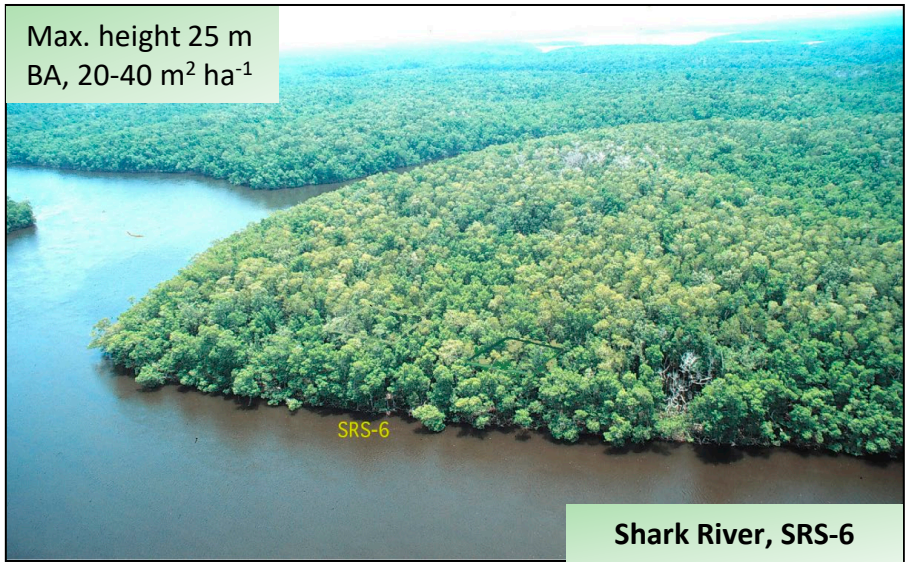
# The Florida Coastal Everglades (FCE)

- Karstic Oligotrophic P-limited system
- Inverse estuary
- P is supplied by the Gulf of Mexico during hurricanes

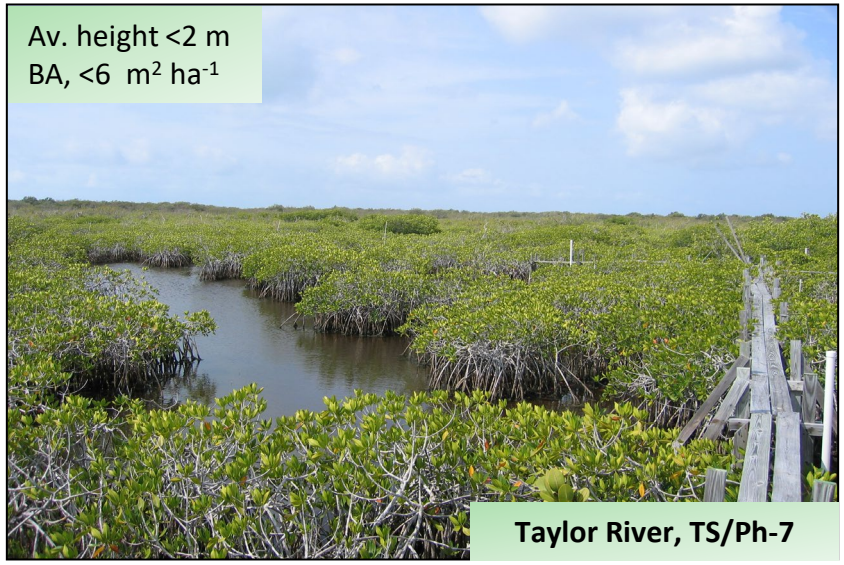





# *Landscape Gradients in Resources (nutrients), Regulators (sulfide), and Hydroperiod*




- Hydroperiod: Tide-dominated
- P gradient: downstream to upstream limitation upstream (N:P = 105)
- PW Sulfide: Negligible (<0.06 mM)
- PW Salinity: 5-27 ppt



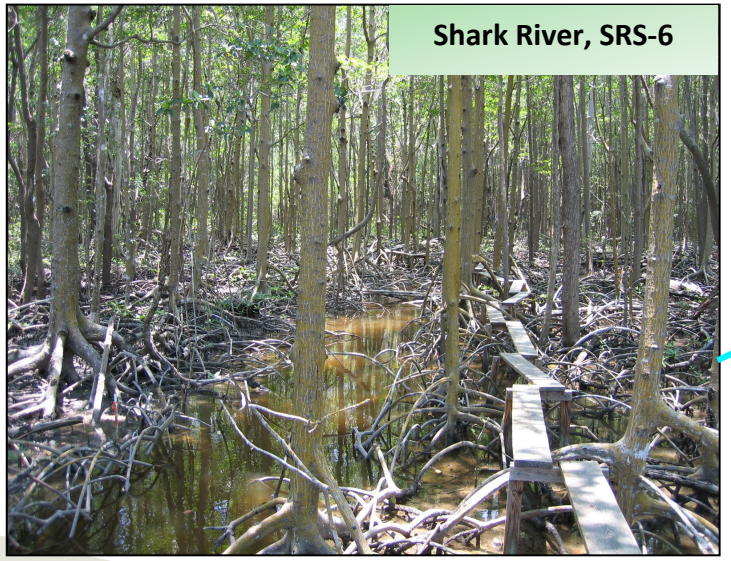

- Permanently or seasonally flooded
- No P gradient: P limitation in all sites (N:P ranges from 70-109)
- High (1.0-2.3 mM)
- 17-20 ppt

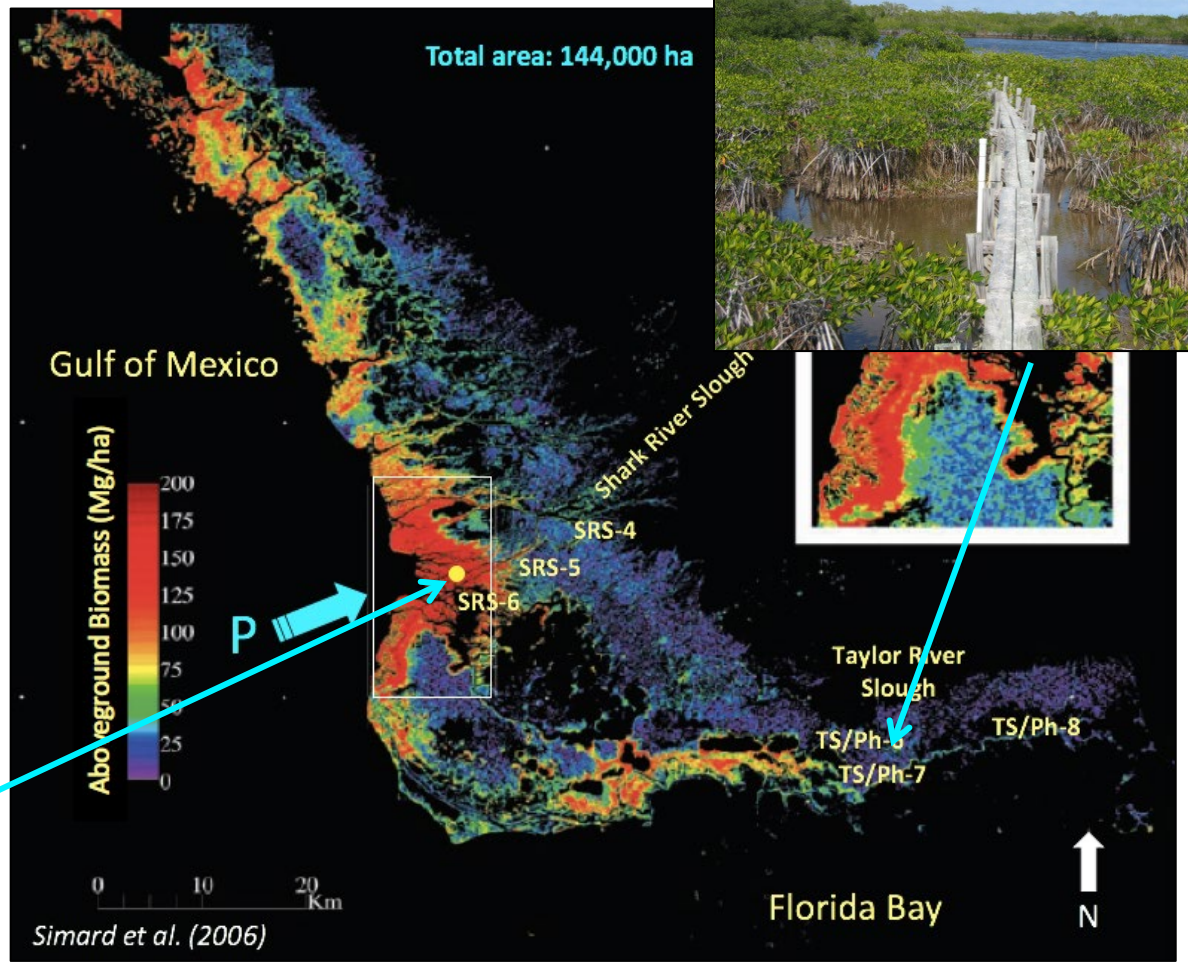


*Castañeda-Moya et al. (2013)*

# Landscape Mangrove Vegetation Patterns

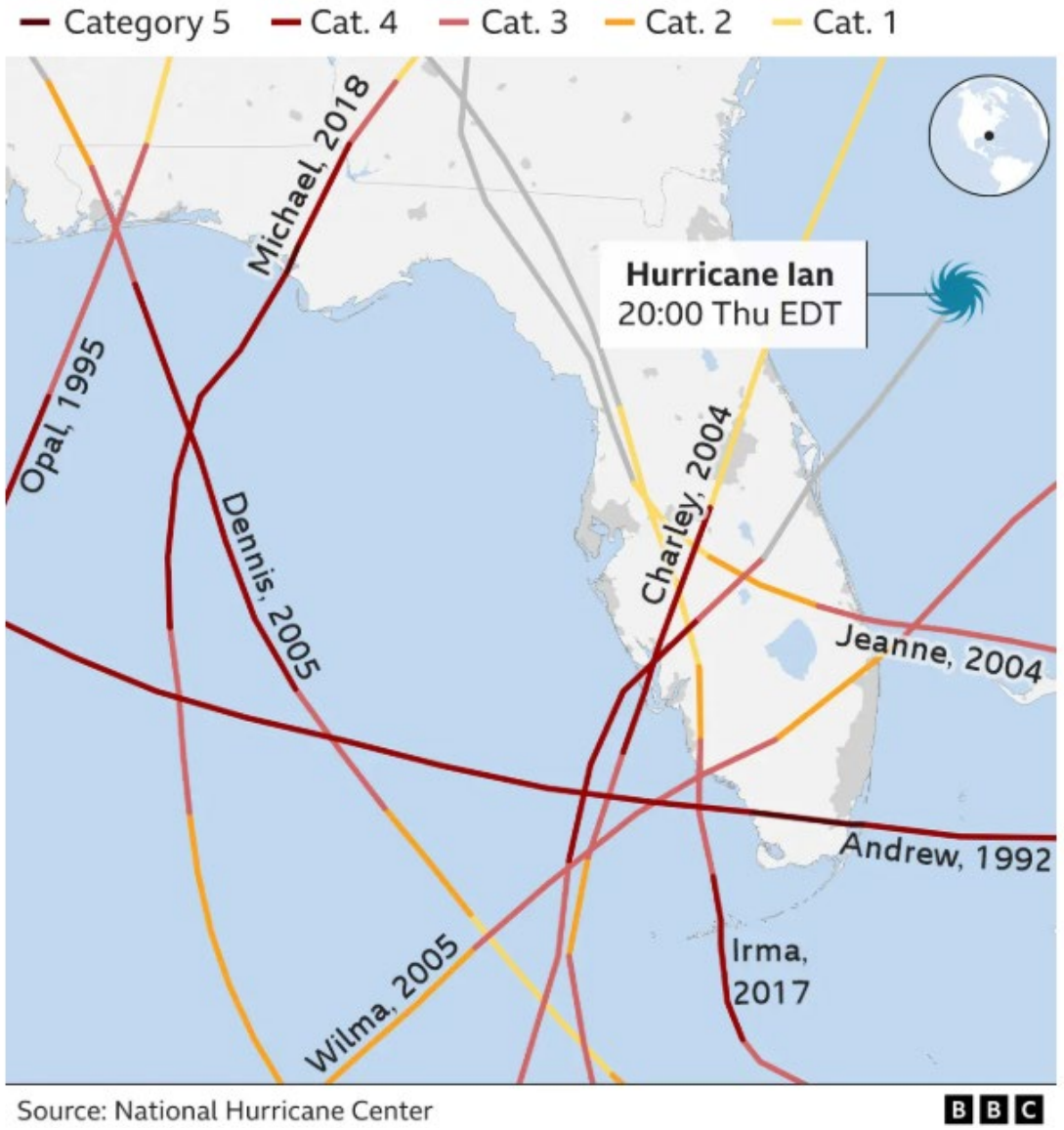
- Largest mangrove area in the continental US.
- Different mangrove ecotypes at the same latitudinal gradient.
- ENP TOC (vegetation & soil) storage valuation = $2-3.4  billion (Jerath et al. 2016).




# *High Recurrence of Hurricanes in South Florida*

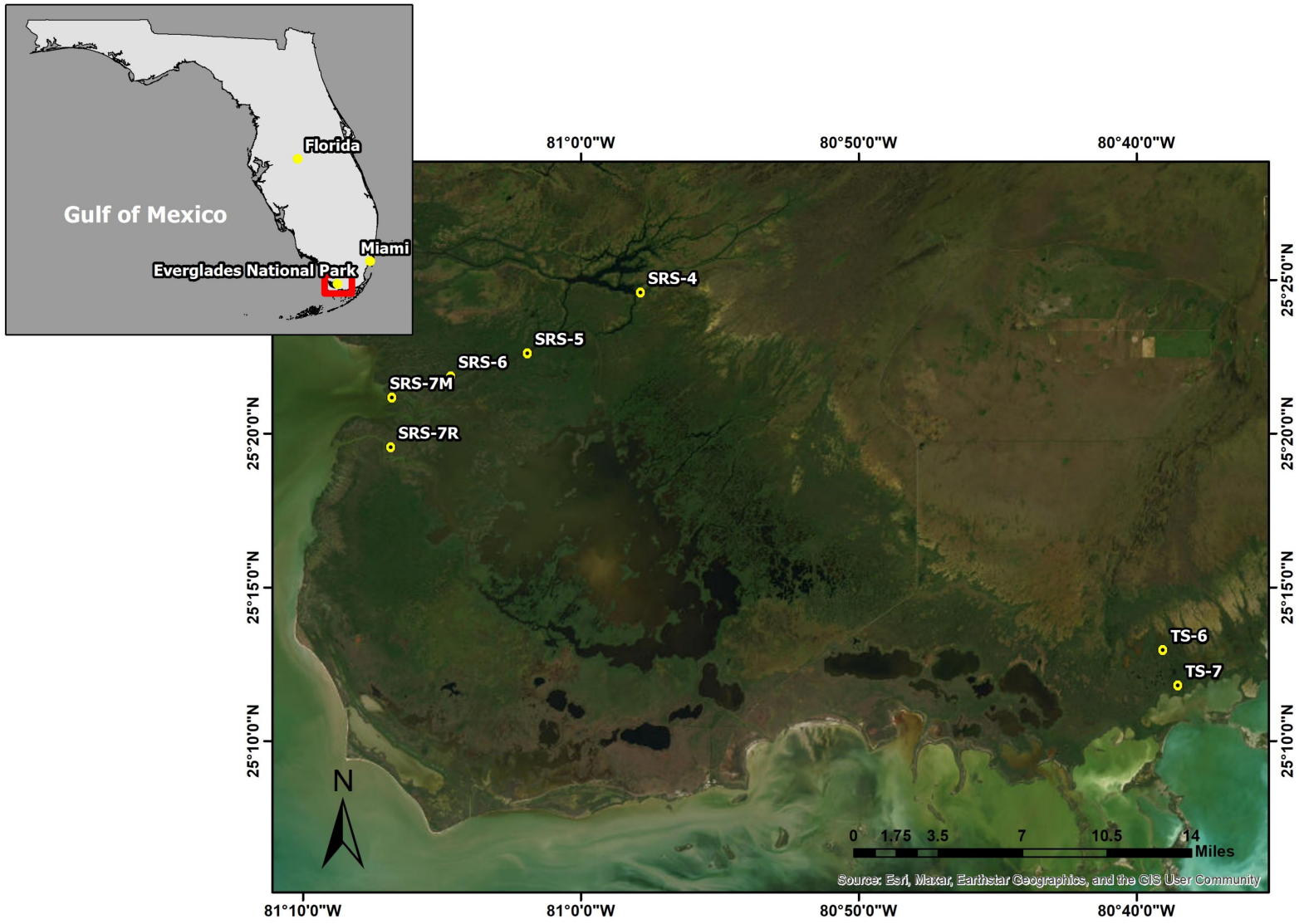
- 19 hurricanes impacting the Florida Coastal Everglades (FCE) since 1926
- Three Cat 4 storms
- Two major hurricanes in the last 20 years:
  - **Wilma** – Oct 2005
  - **Irma** – Sep 2017



# Objectives

- Measure in-situ soil shear strength using a Cone Penetration Test (CPT).
- Evaluate how mangrove root biomass varies across salinity and nutrient gradients.
- Explore relationships among root traits, salinity, soil nutrients, and soil strength.

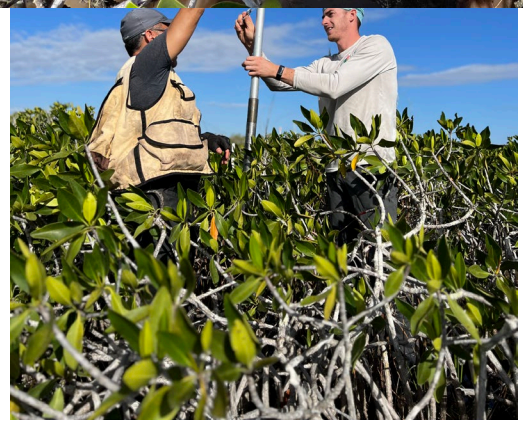
# Study Site: *The Florida Coastal Everglades (FCE)*



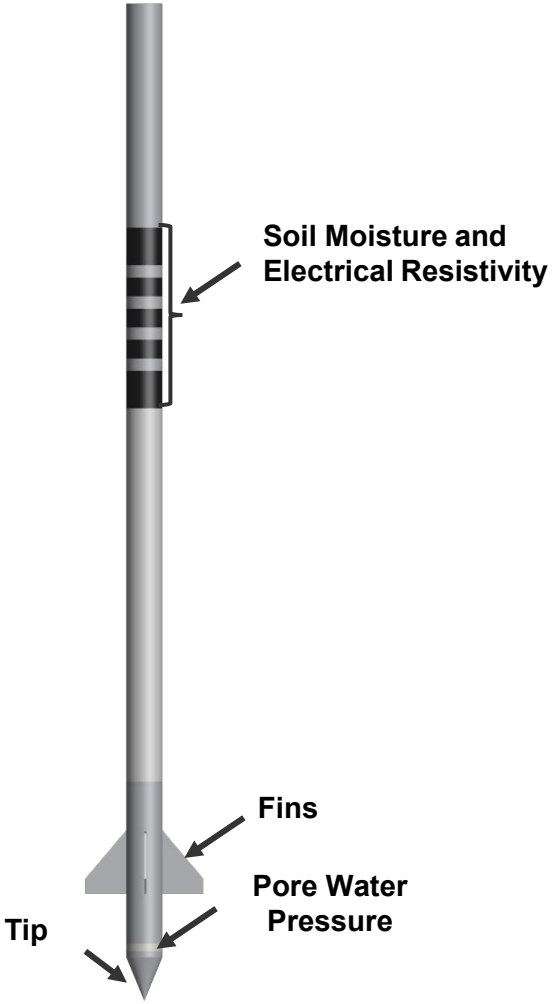

Everglades Foundation

# Cone Penetration Test

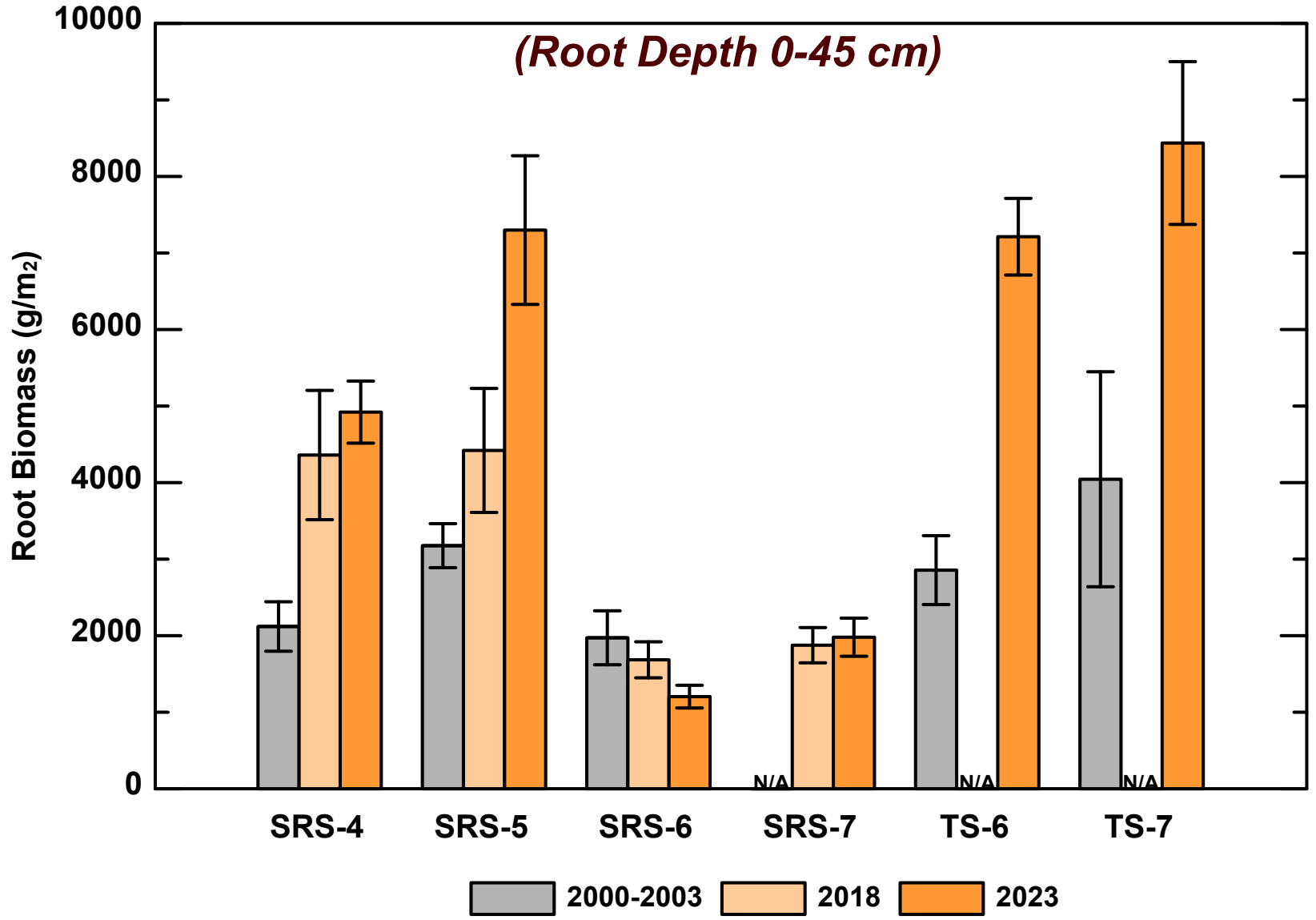
- (PCPT) is a lightweight CPT that can be pushed manually in soft soil.
- The PCPT has been adapted to work in coastal/marine conditions. The most notable modifications are:
  - It is a handheld device pushed by manpower rather than a truck or a rig.
  - It has a 2.5-ton load cell to increase the sensitivity of tip resistance.
  - Fins can be incorporated to better detect the strength contribution of roots.
- The PCPT can obtain tip resistance, sleeve friction, porewater pressures.



# Cone Penetration Test



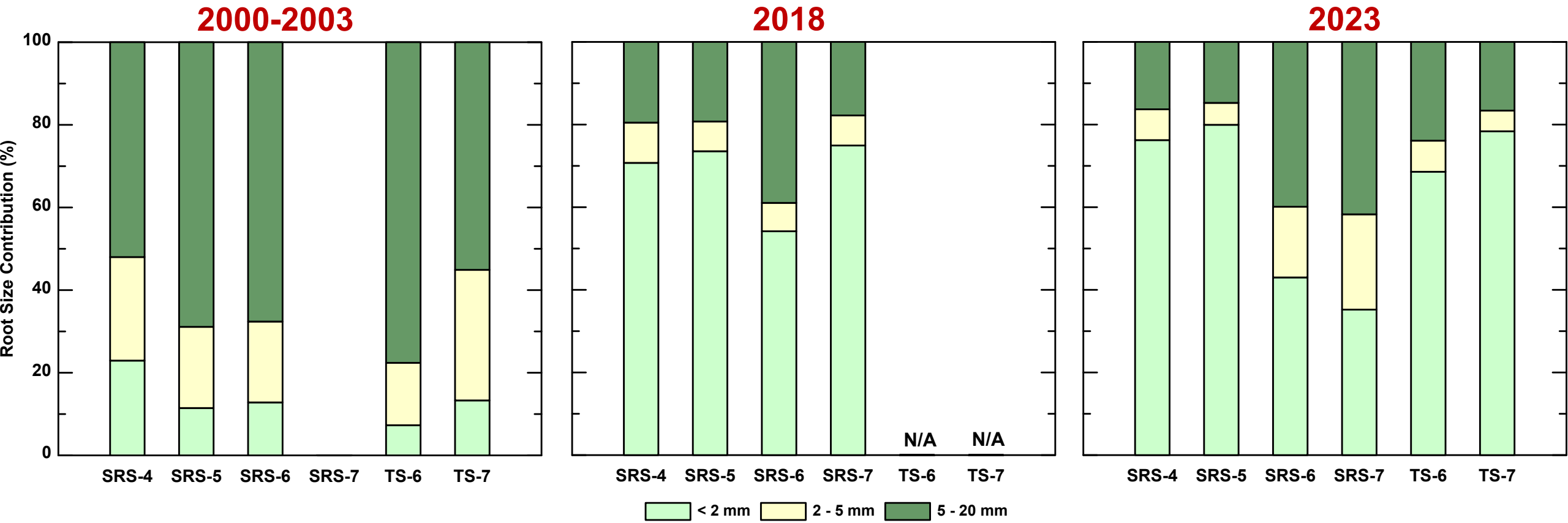
# Temporal Variation of Root Biomass




Castañeda-Moya et al. (2011) and Castañeda-Moya et al. (in review)

# Temporal Variation of Root Size Distribution

*(Root Depth 0-45 cm)*

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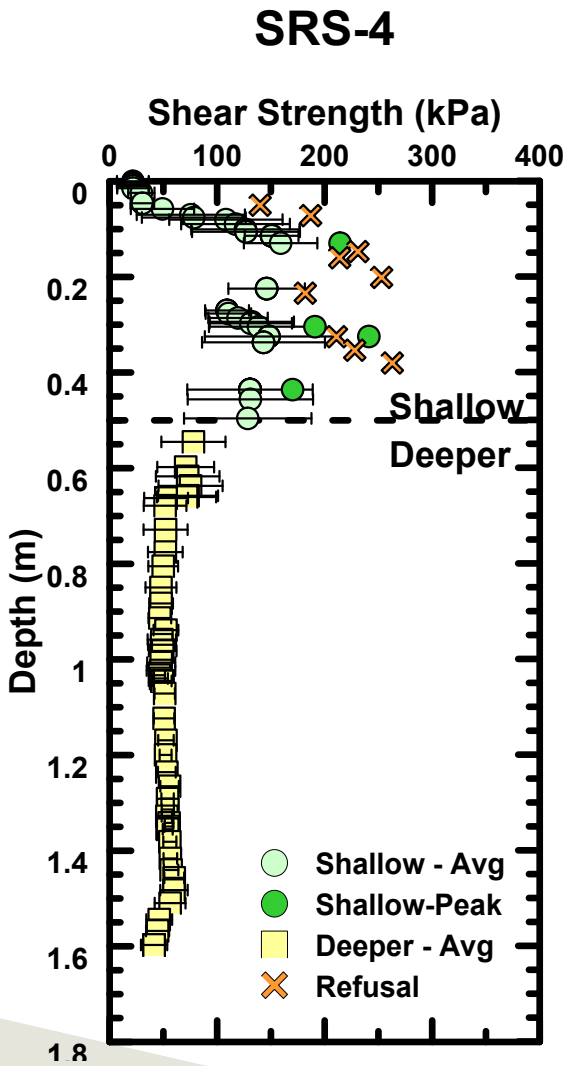
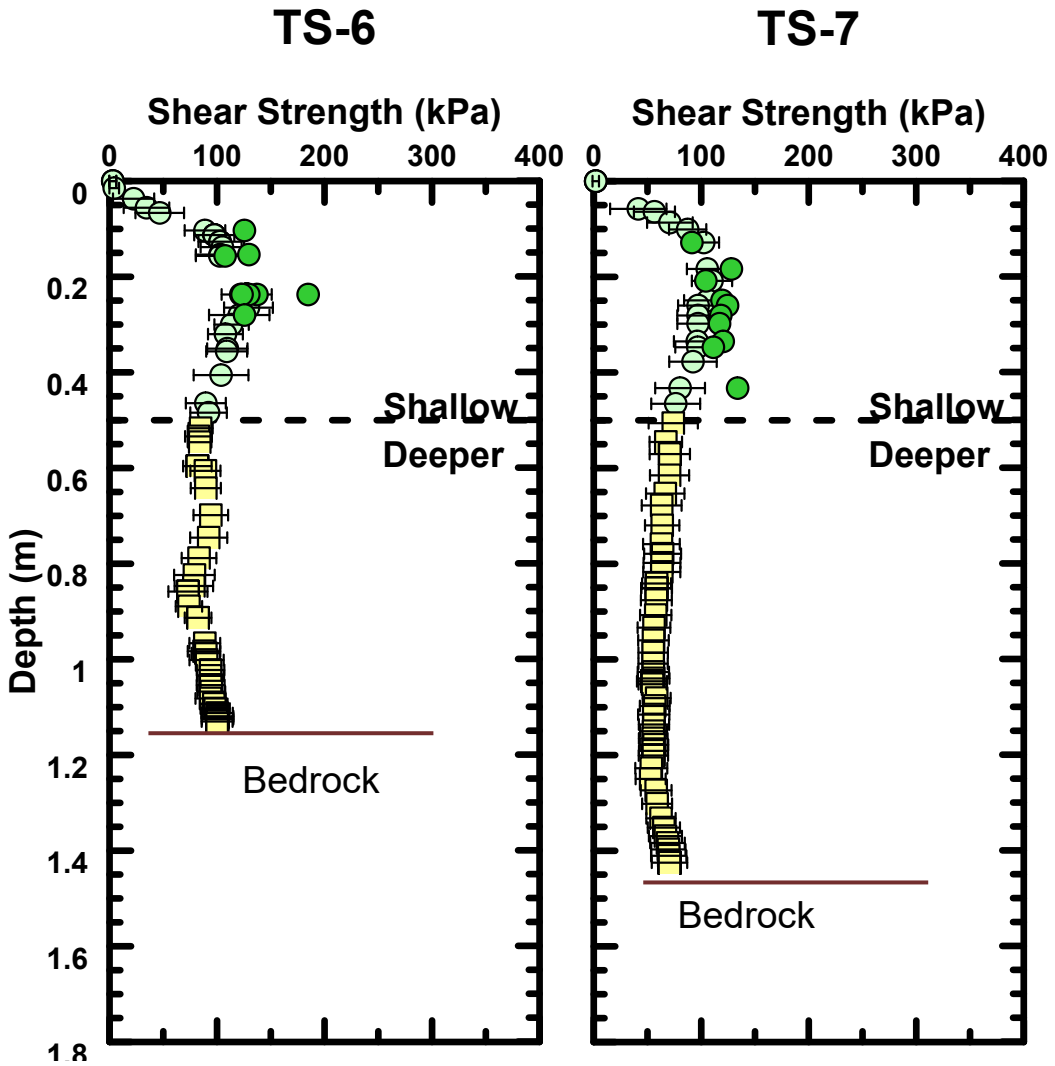
# CPT in Shark River Slough



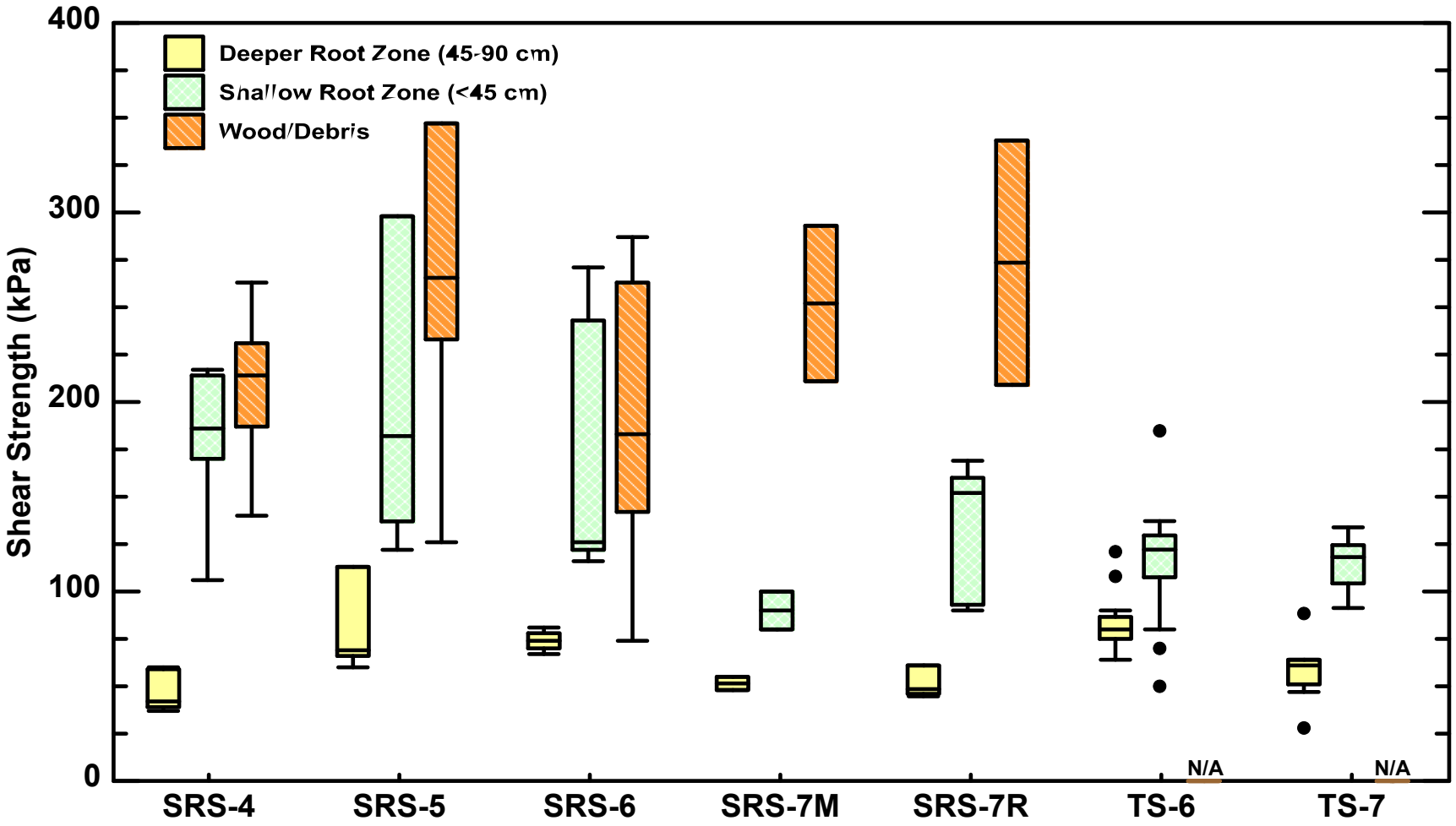

Riverine

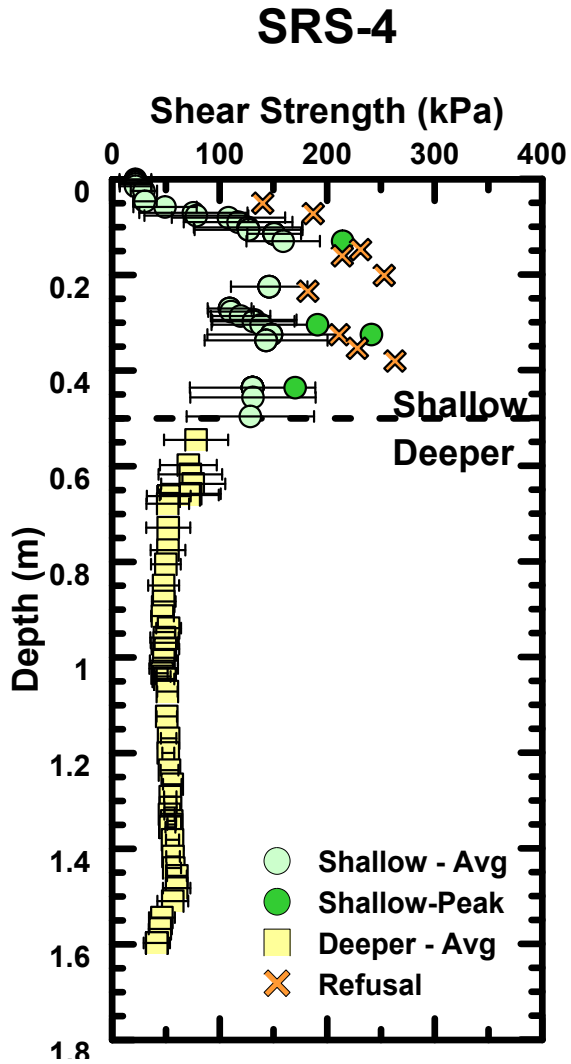
# CPT in Taylor Slough



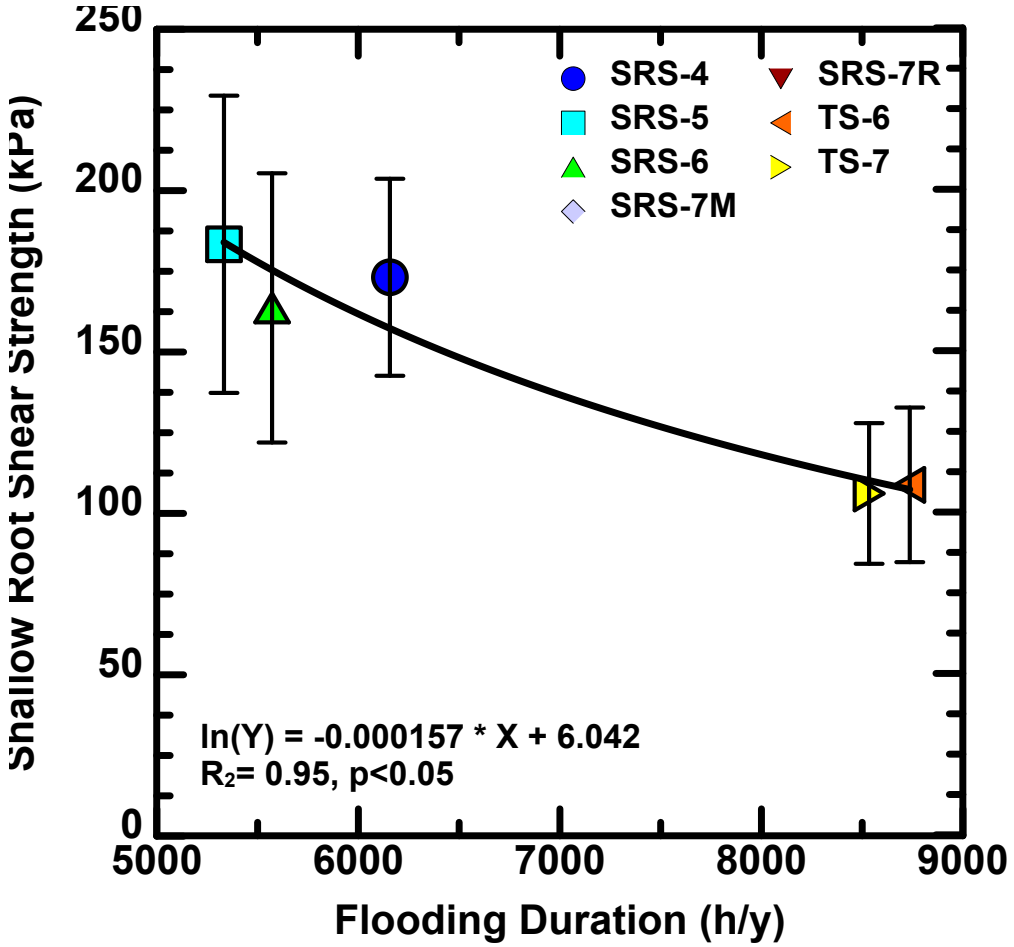

Scrub Mangrove Forests

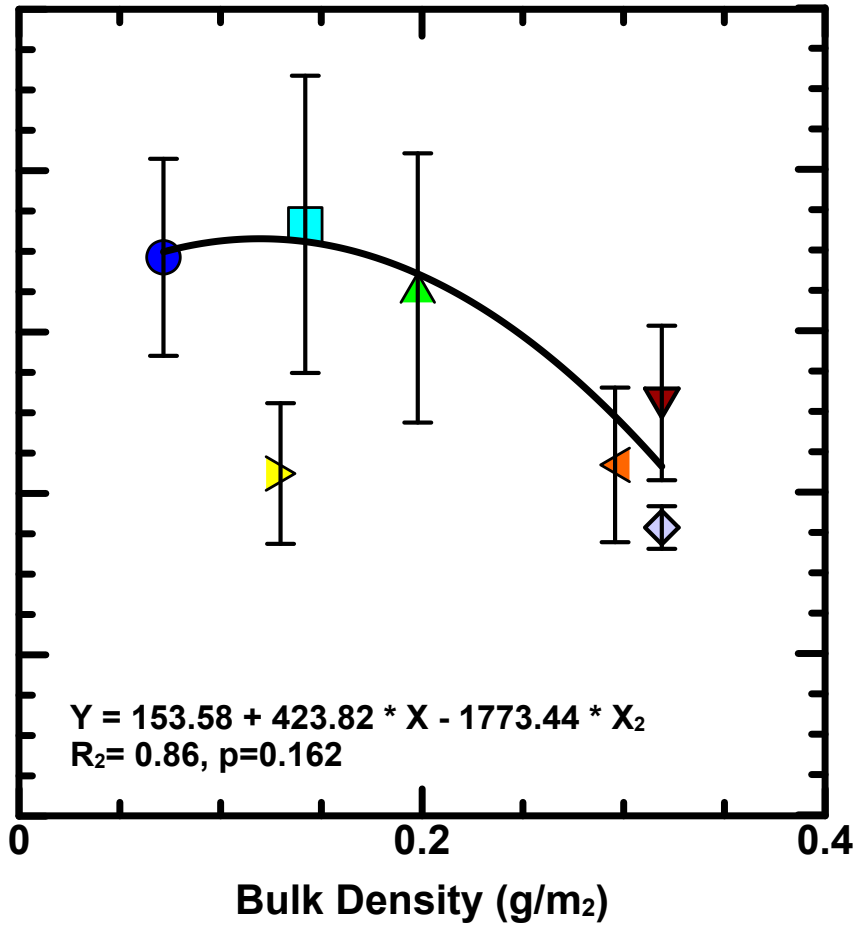
# Spatial Variation of Root Shear Strength



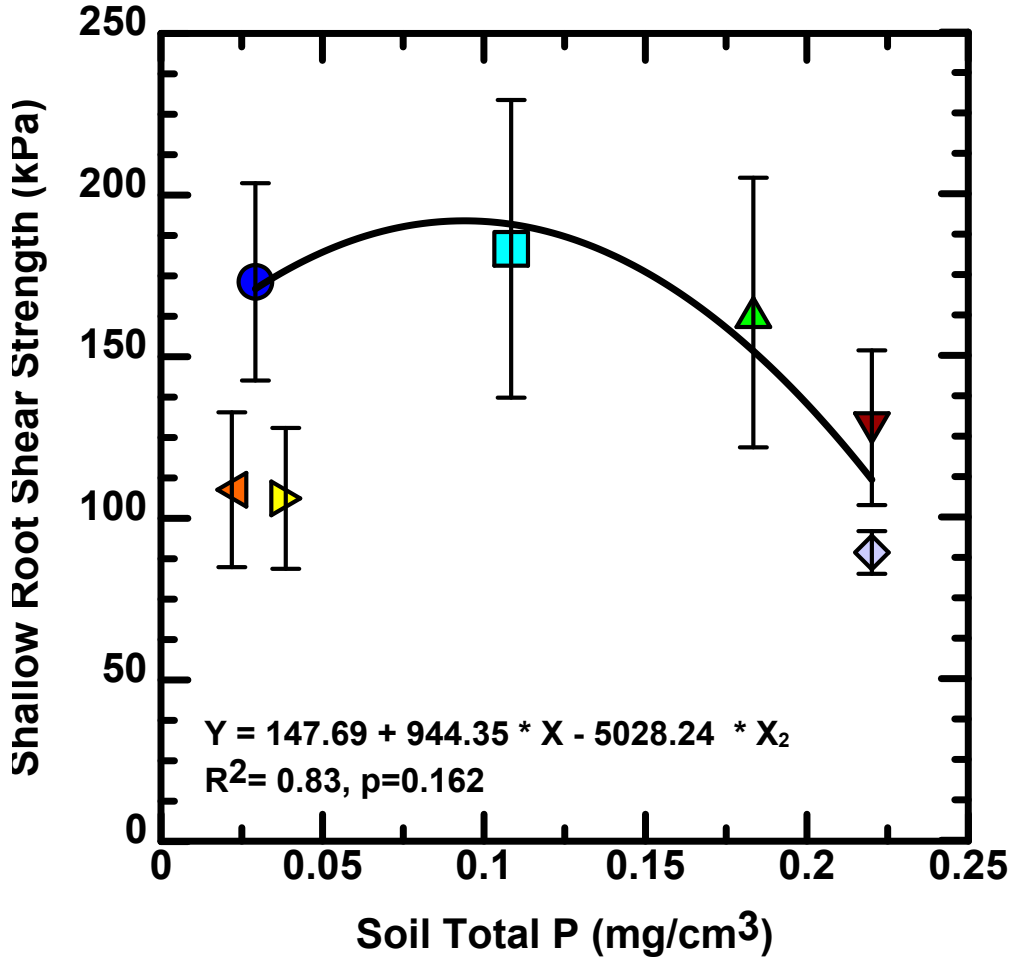
# Biomechanical Properties of Shallow Root Zone



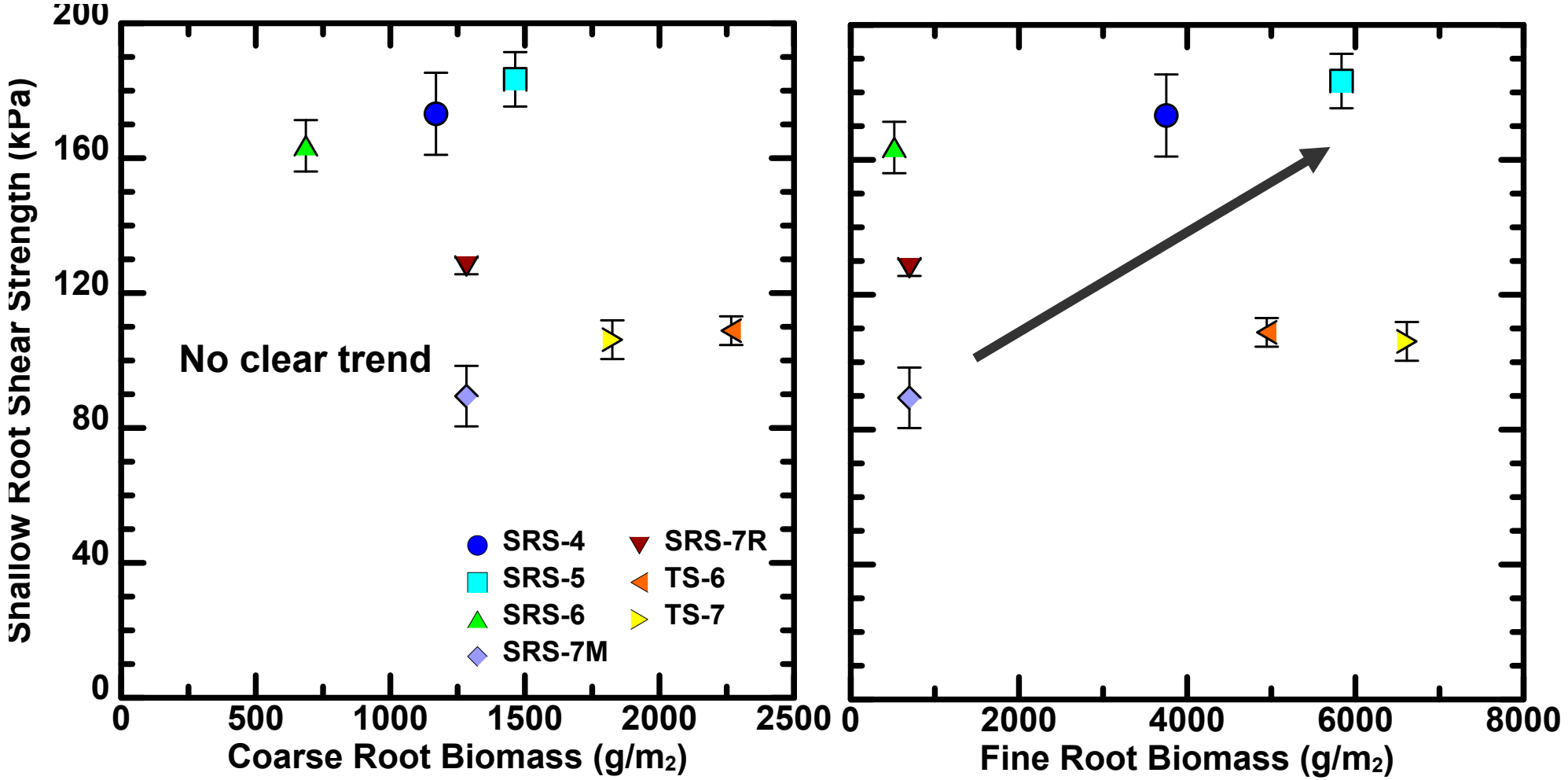




Avg 45 cm depth

# Biomechanical Properties of Shallow Root Zone



# Root Biomass with Root Shear Strength



# Conclusion

- Mangrove root biomass and shear strength vary significantly across salinity and nutrient gradients in the Florida Coastal Everglades.
- Higher root biomass correlates with increased shear strength, especially in lower salinity zones.
- Cone Penetration Test (PCPT) proved effective in capturing spatial variability of in-situ shear strength in soft mangrove soils.
- Root biomechanical properties are influenced by both environmental conditions (salinity, nutrients).

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