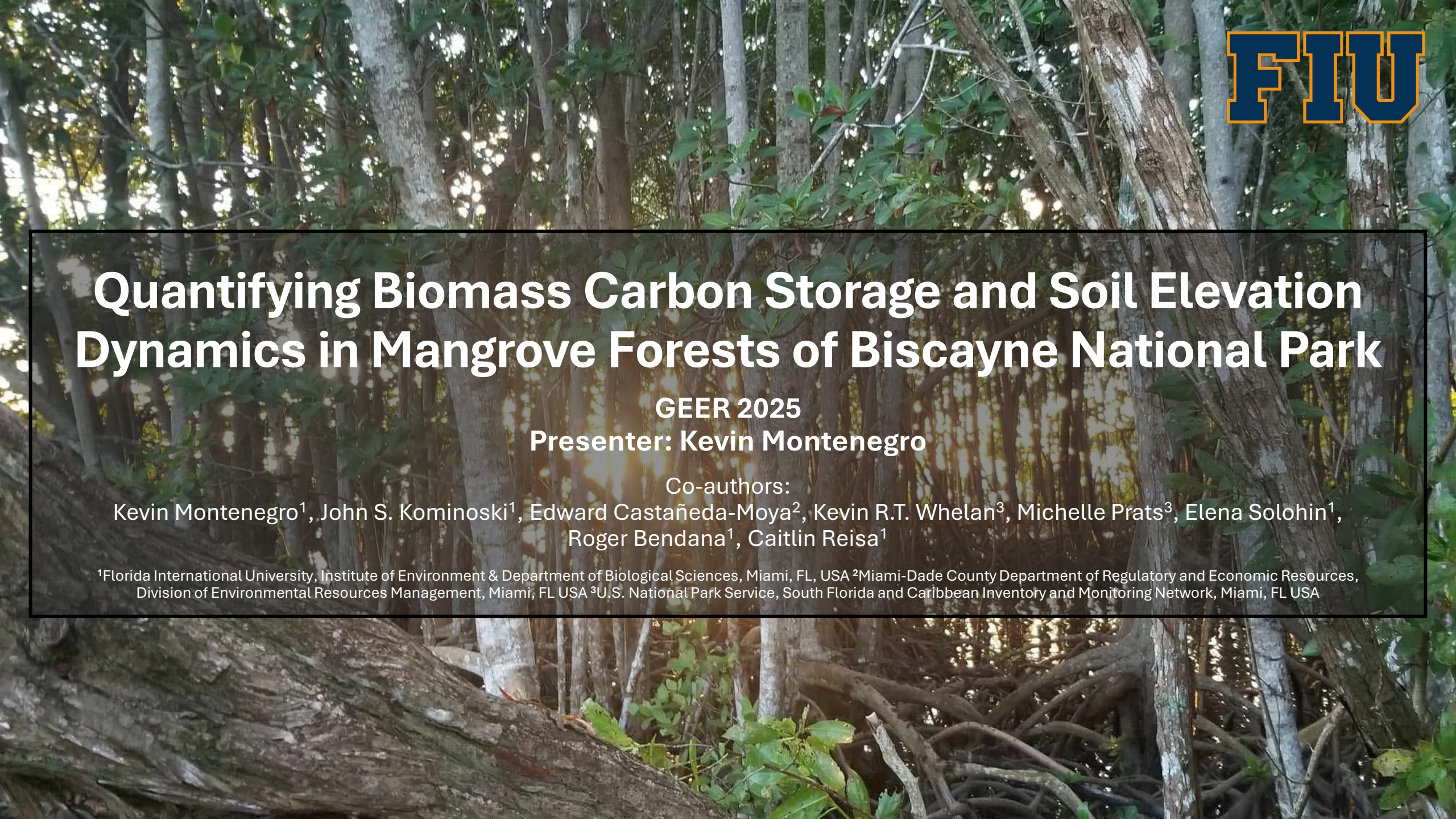

Quantifying Biomass Carbon Storage and Soil Elevation Dynamics in Mangrove Forests of Biscayne National Park

GEER 2025

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Co-authors:

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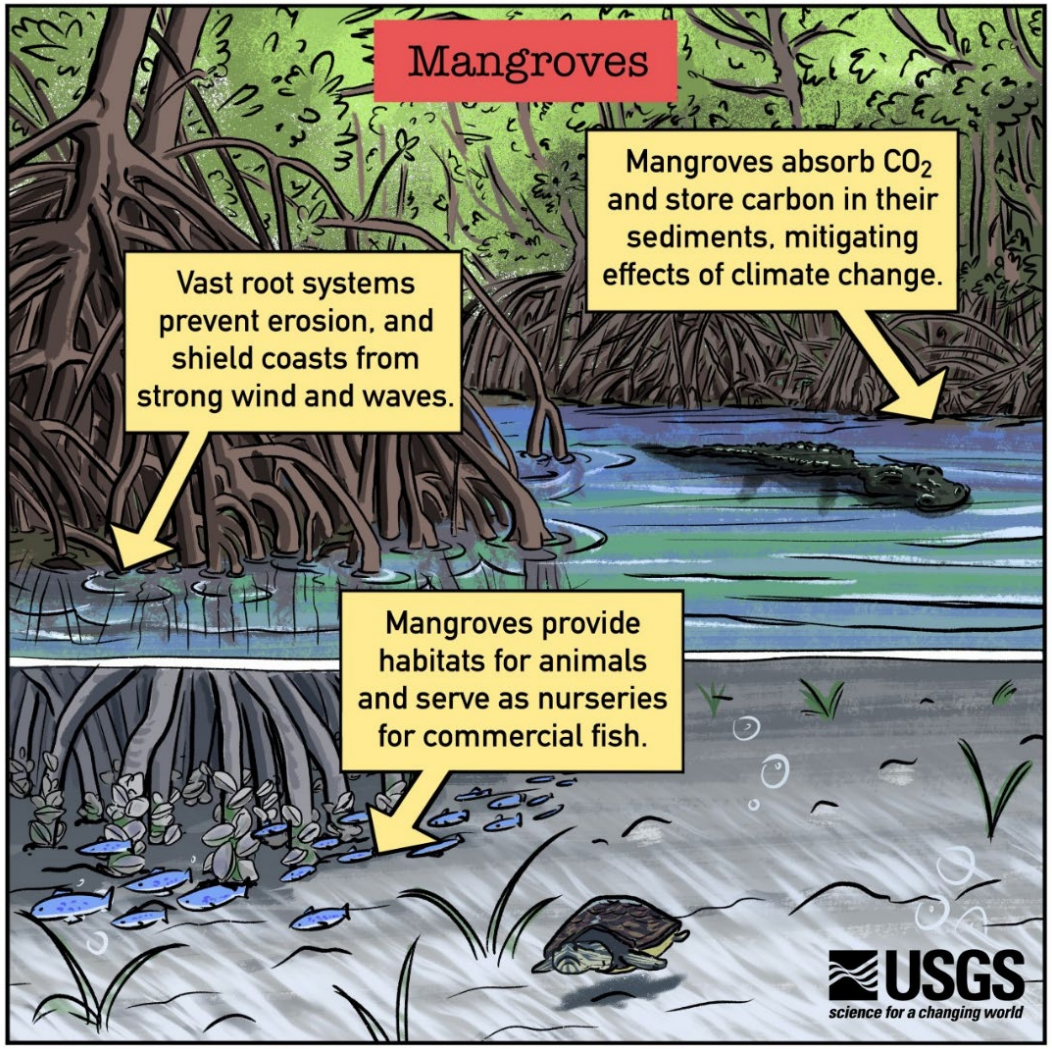
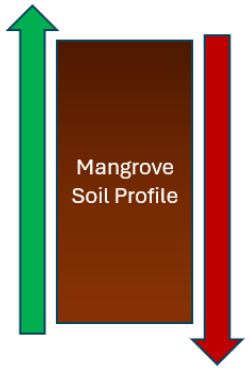
Mangrove Forests

- Community composed of salt-tolerant tree species
- Phenotypic plasticity
- Ecosystem engineers that build and stabilize our shorelines



Mangrove forest resilience is dependent on growing their soil elevation to keep pace with relative sea level rise (SLR)



Will mangrove **soil surface elevation rates** keep pace with relative SLR?

Yes

No

Are conditions suitable for the mangrove community to expand landward?

Yes

Landward expansion

No

Mangrove wetland loss

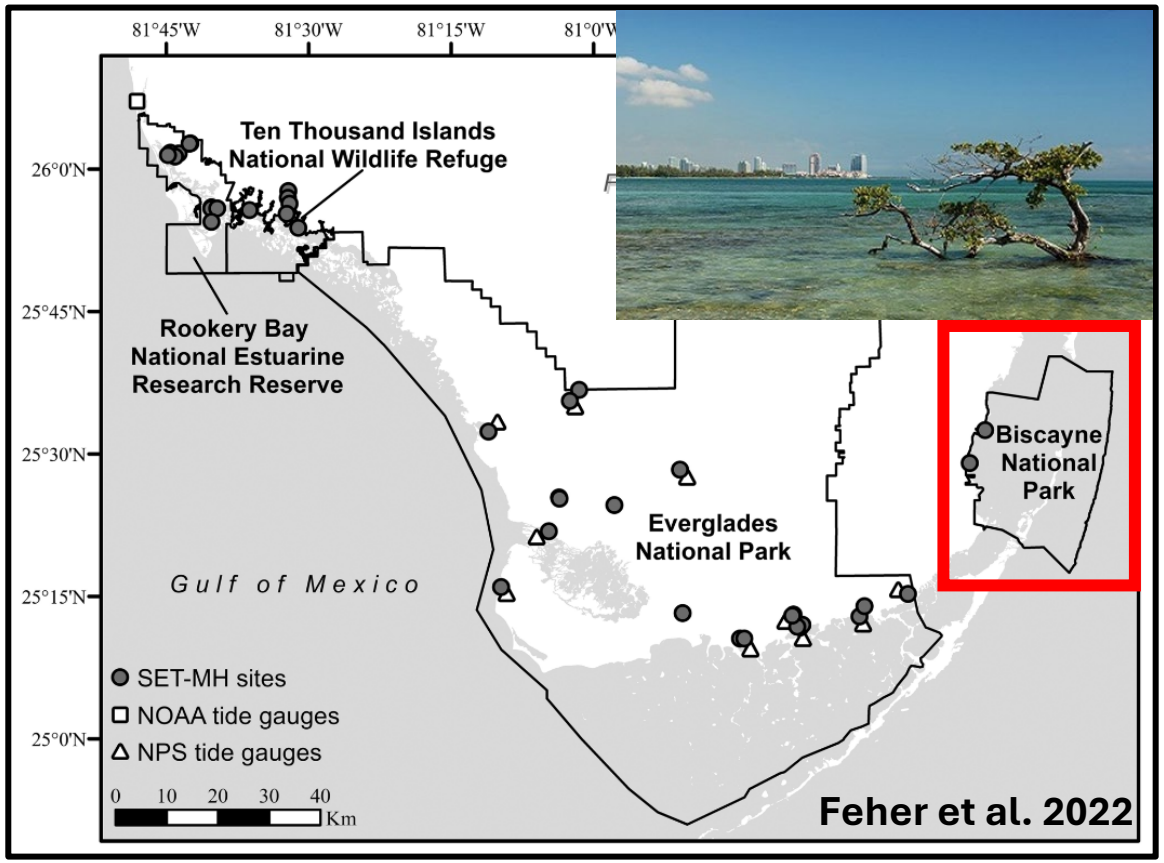
Photos courtesy of NPS and USGS

Soil elevation change are highly variable throughout the Greater Everglades in response to SLR

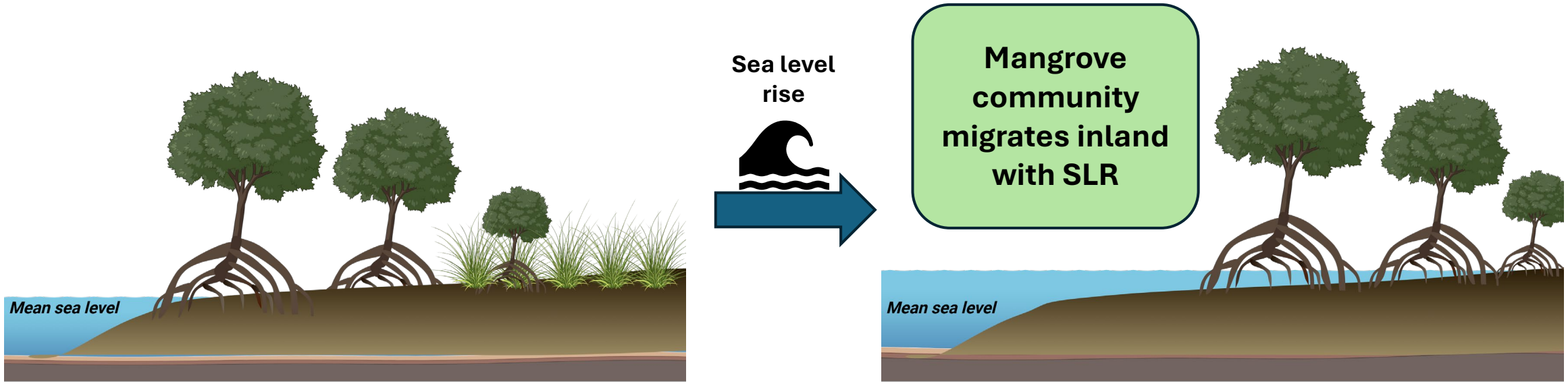
Nearly half of the sites are being outpaced by relative SLR (Feher et al. 2022)

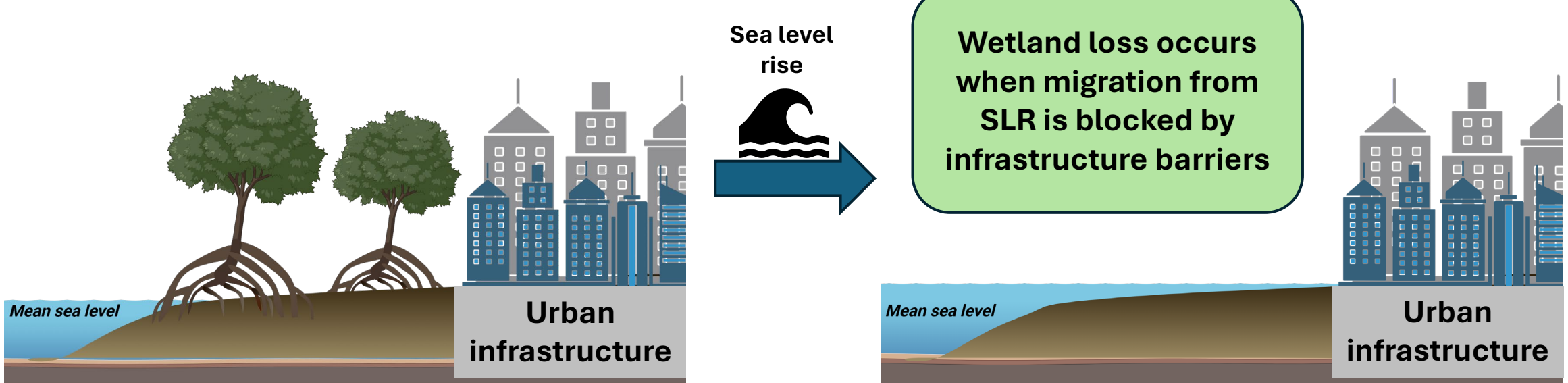
Biscayne National Park's mangrove forests are understudied compared to other sites in the region

Sea level rise and impending hydrologic restoration will have uncertain consequences on soil accretion (Meeder et al. 2021; Parkinson & Wdowinski 2022; Thurman et al. 2024)

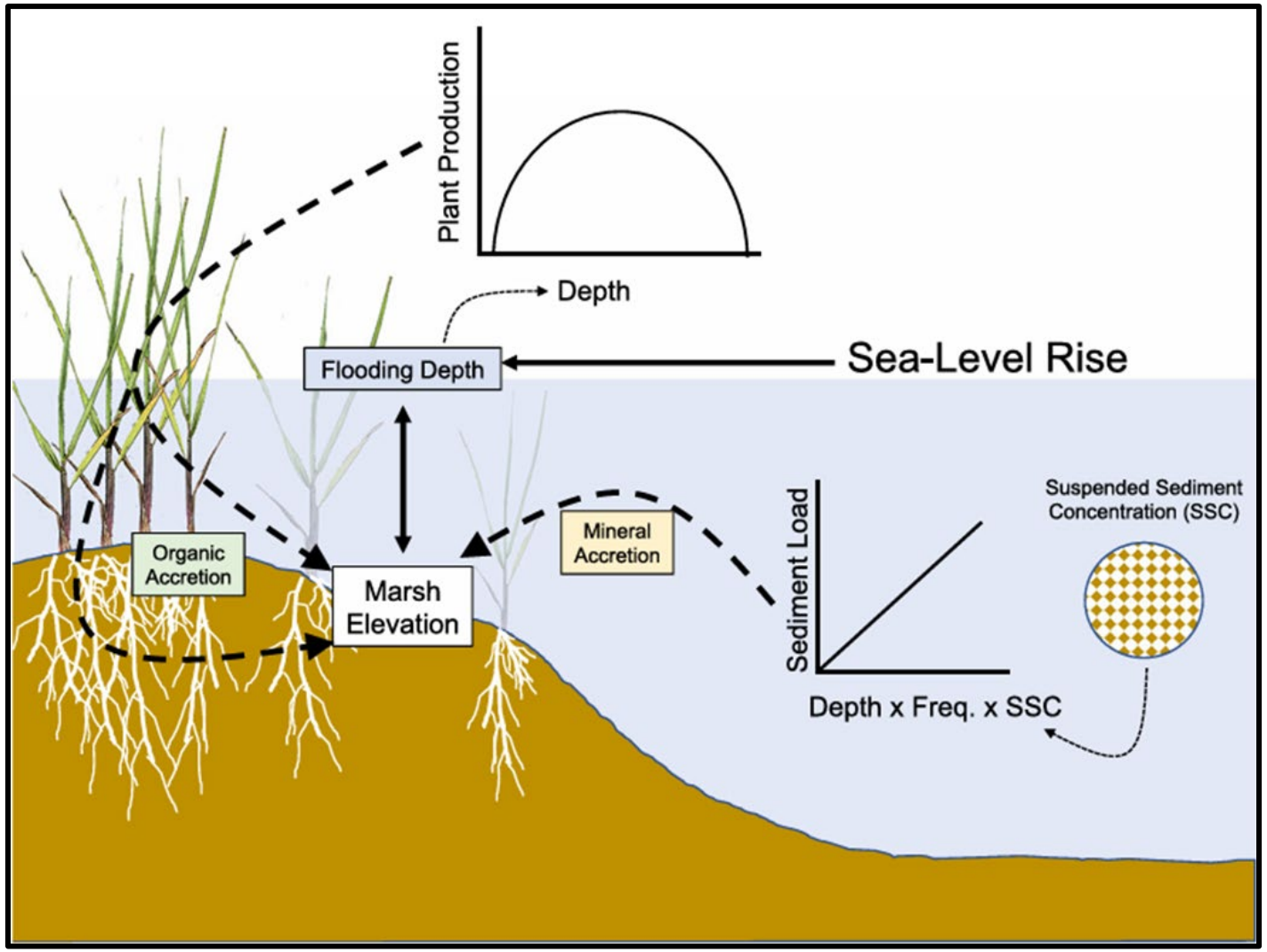


Urbanization is causing coastal squeeze





Plant biomass and production can enhance mangrove wetland elevation and blue carbon storage



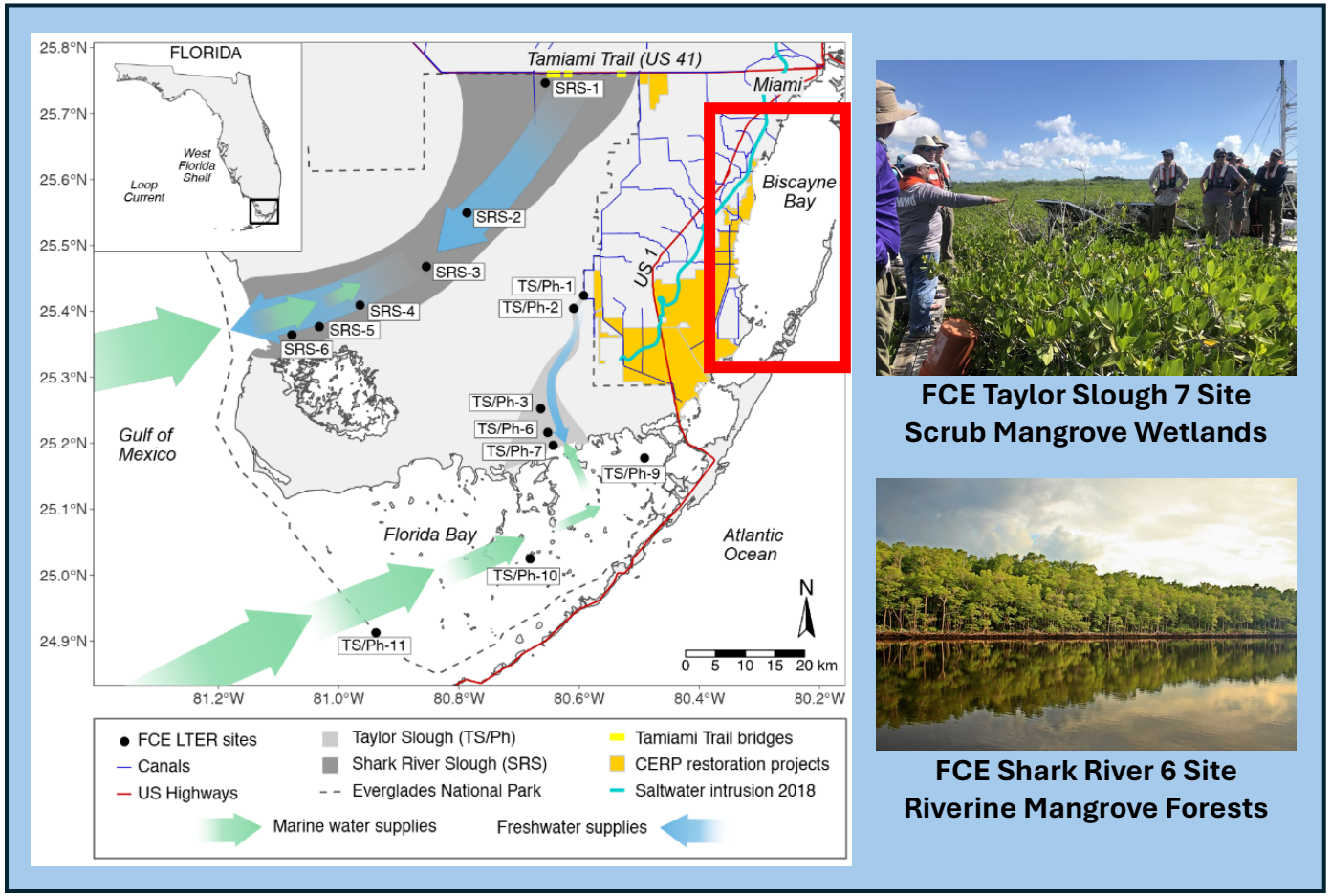
Cahoon et al. 2021

Lessons from Florida Coastal Everglades Long-Term Ecological Research

Variation in forest structure is an index for wetland **blue carbon** storage

Carbon storage and soil elevation are regulated by **subsidies, stressors, and hydrologic connectivity**

We applied knowledge to assess carbon storage and soil elevation trends in **Biscayne National Park**



FCE Taylor Slough 7 Site
Scrub Mangrove Wetlands

FCE Shark River 6 Site
Riverine Mangrove Forests

Questions

1) Are fringe mangrove forests keeping pace with sea level rise?

2) How do forest structure, above-ground C storage and productivity contribute to peat formation and geomorphic trends?

Hypothesis

We estimated that C storage, productivity, and forest structure would be a reliable indicator of soil elevation trends

Biscayne National Park
Fringe Mangrove Forests

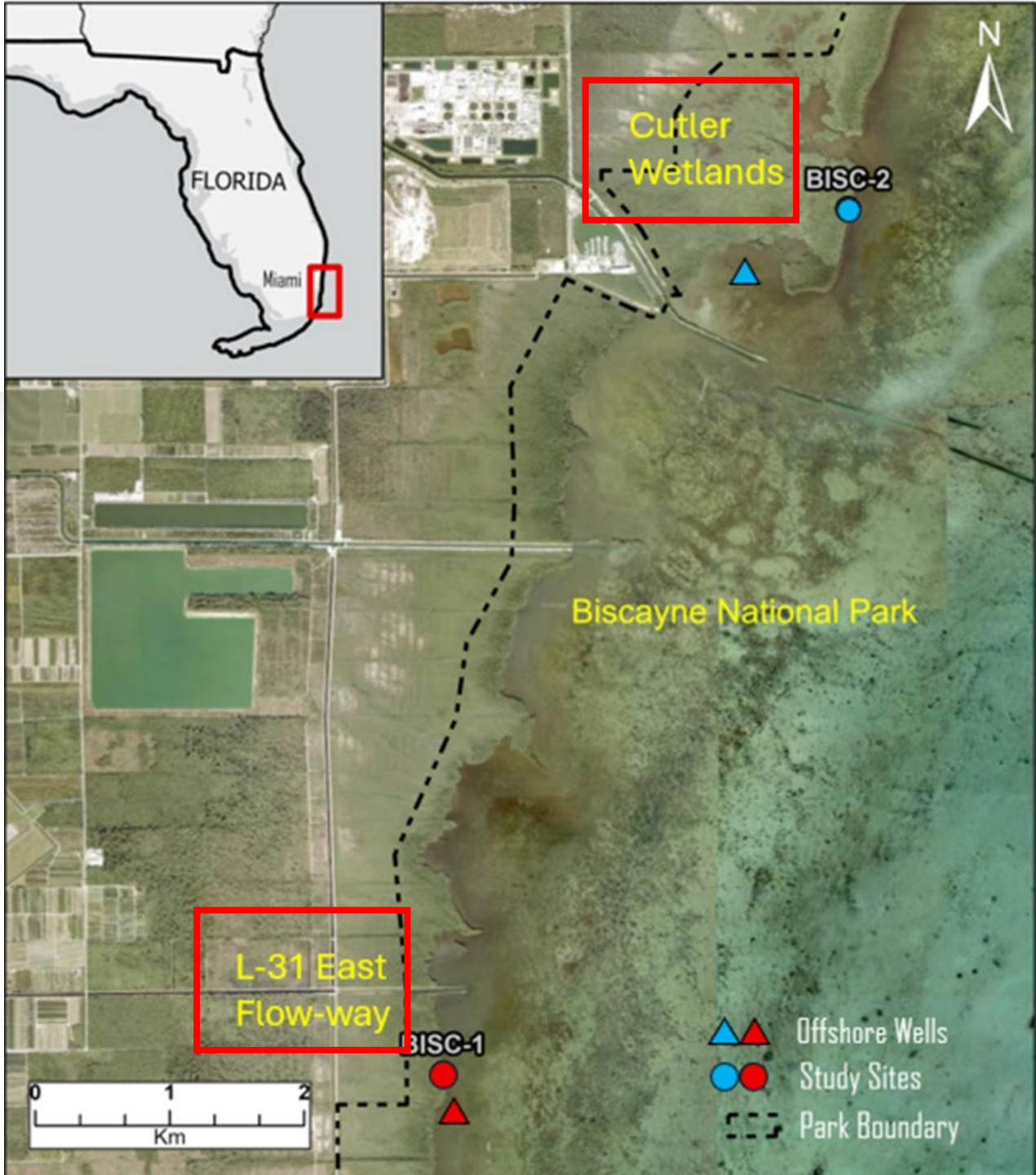
Study sites in Biscayne National Park

BISC-1 and **BISC-2** monitored since 2011 and 2012 to index **soil elevation trends in park**

Historically restricted from overland freshwater flow due to infrastructure

Within the Biscayne Bay Coastal Wetlands (BBCW) hydrologic restoration area

Mixed community composition of *A. germinans*, *L. racemosa*, and *R. mangle*



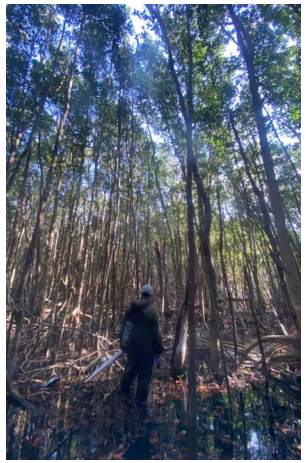
Methods

Surface elevation table (SET) and marker horizon plots used to measure soil elevation and accretion changes

Forest structure (basal area, tree density, and above-ground biomass) and soil cores are used to estimate organic carbon storage in forests

Litterfall baskets are collected monthly to measure above-ground litterfall net primary productivity

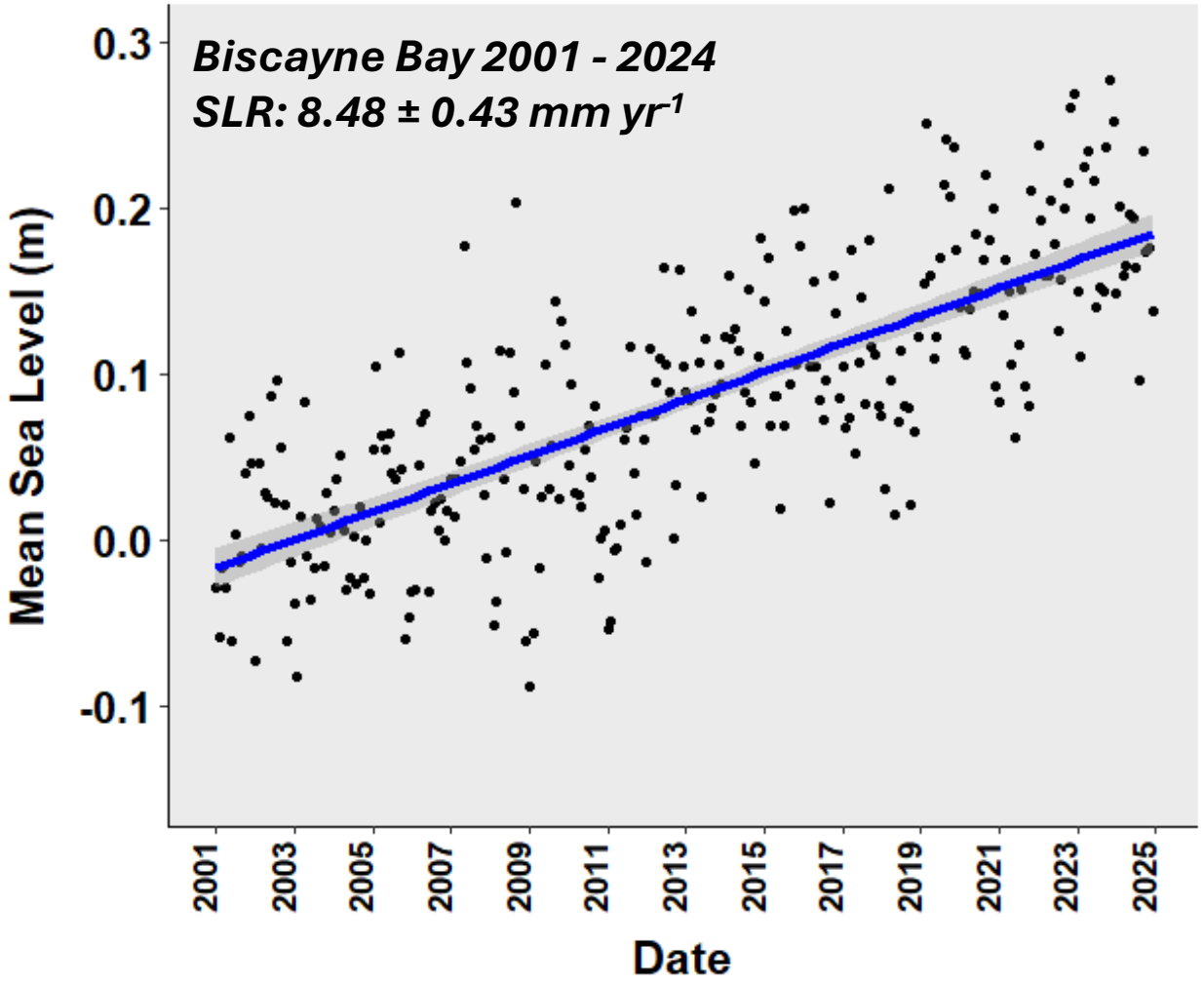


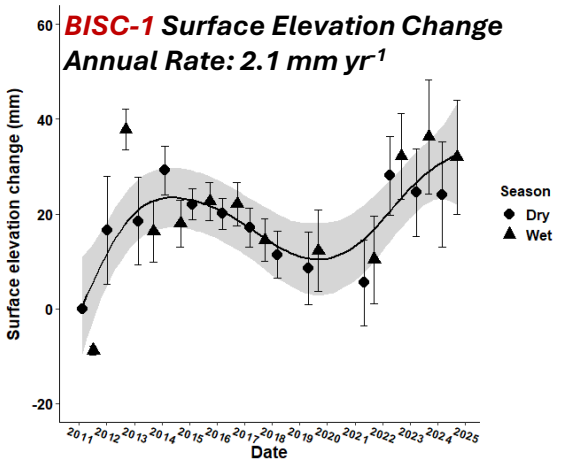


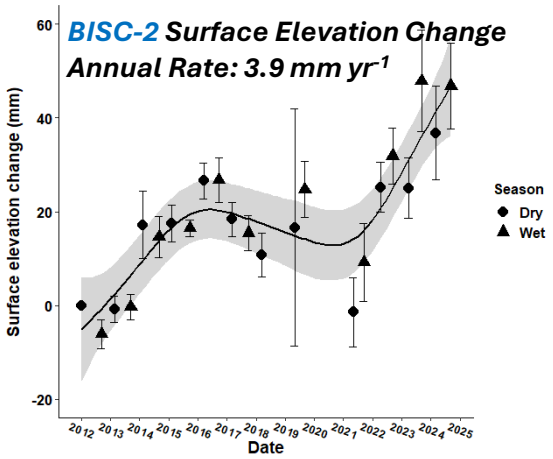
SET Site

Biscayne Bay

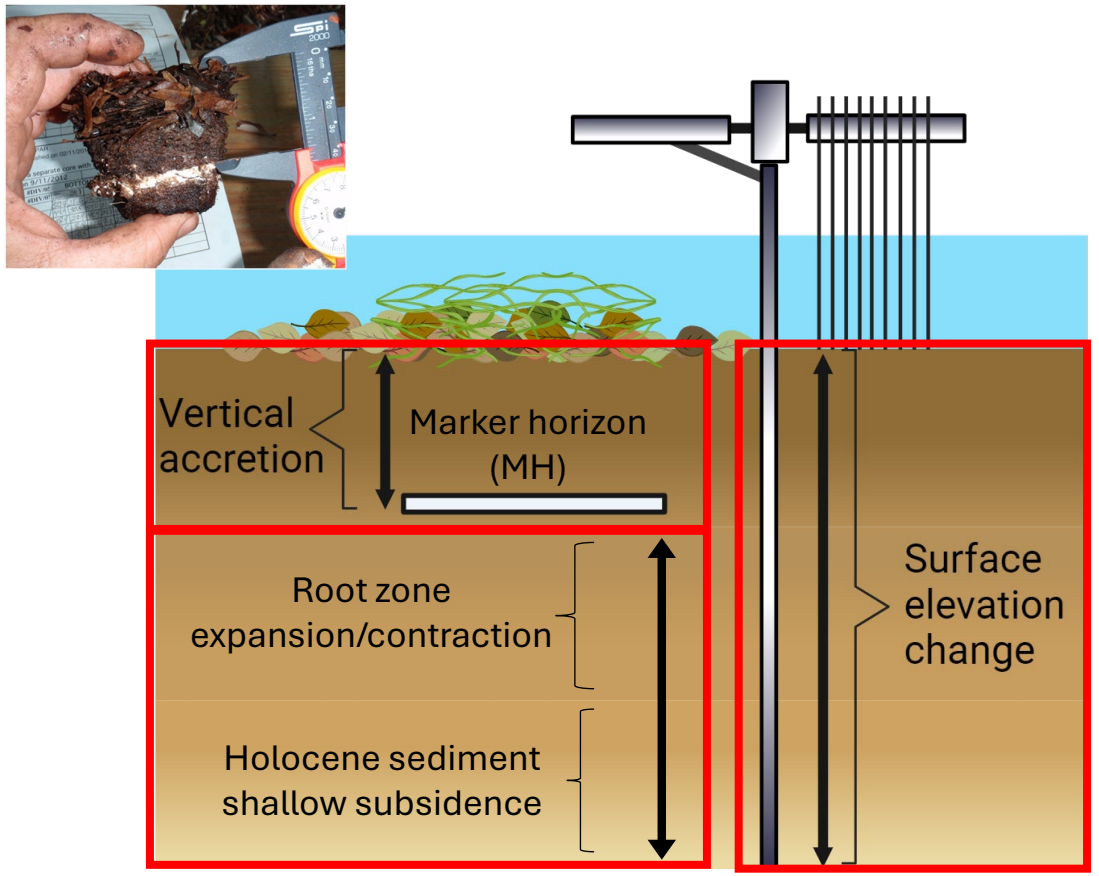
Biscayne Bay has one of the highest relative SLR rates in the Greater Everglades region





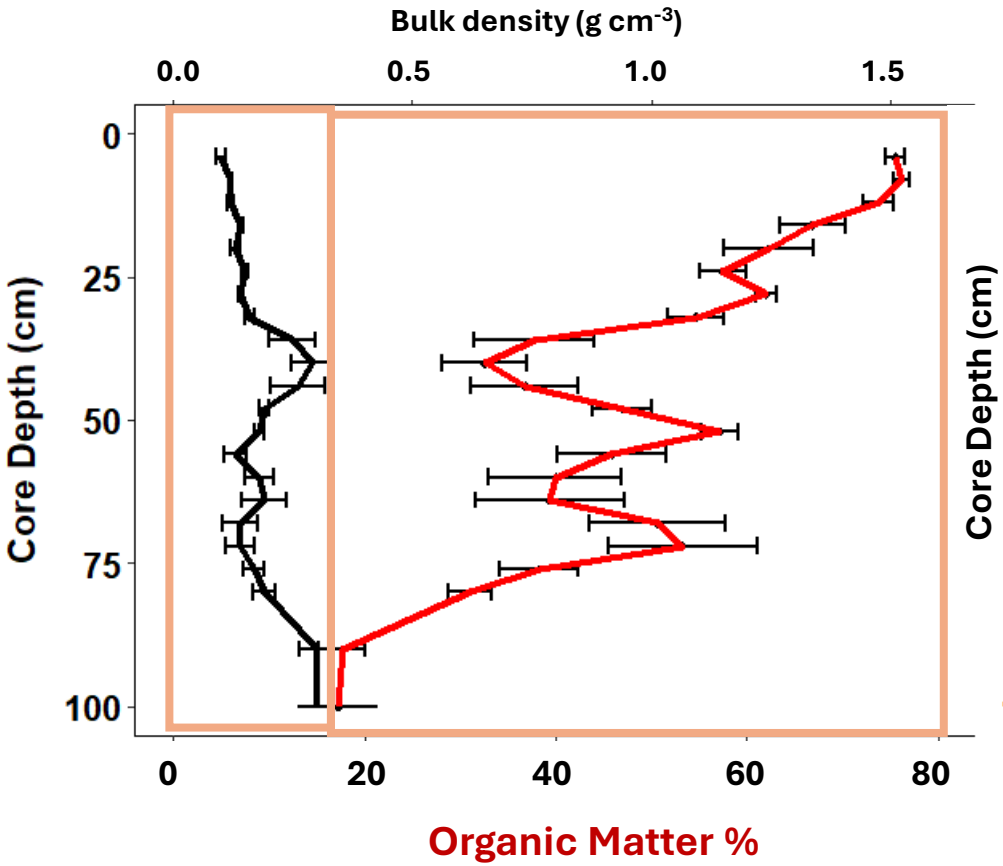


Surface elevation change is greater at BISC-2 but not keeping pace with SLR (8.5 mm yr^{-1})

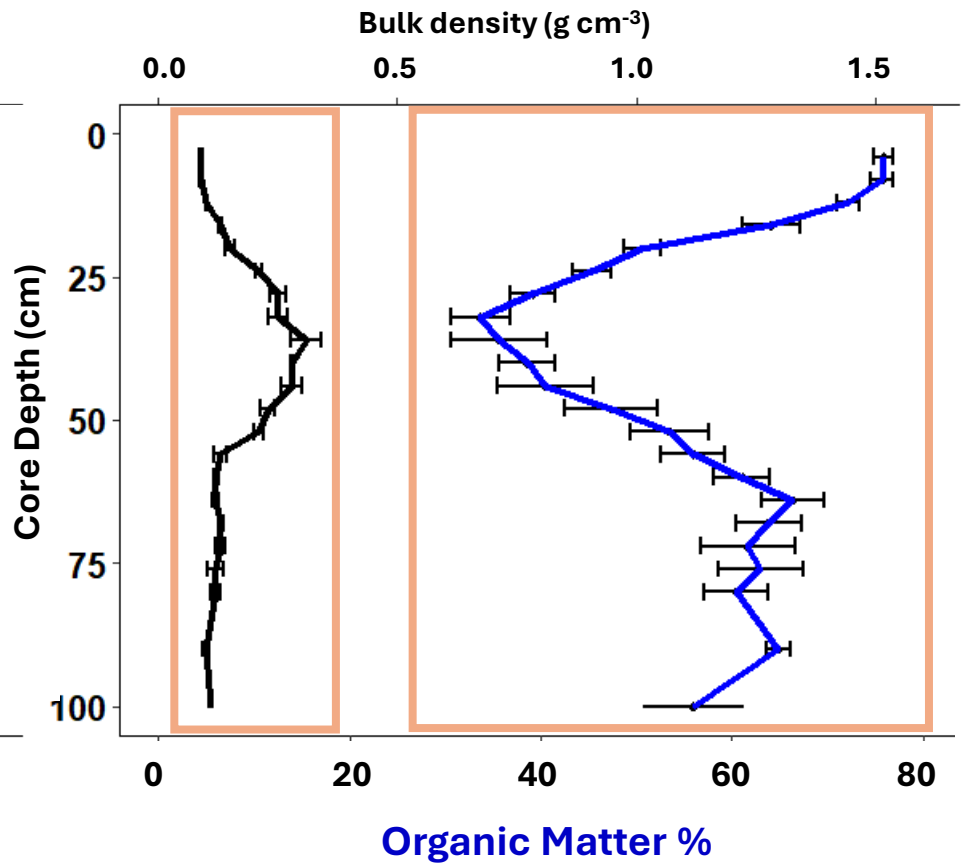


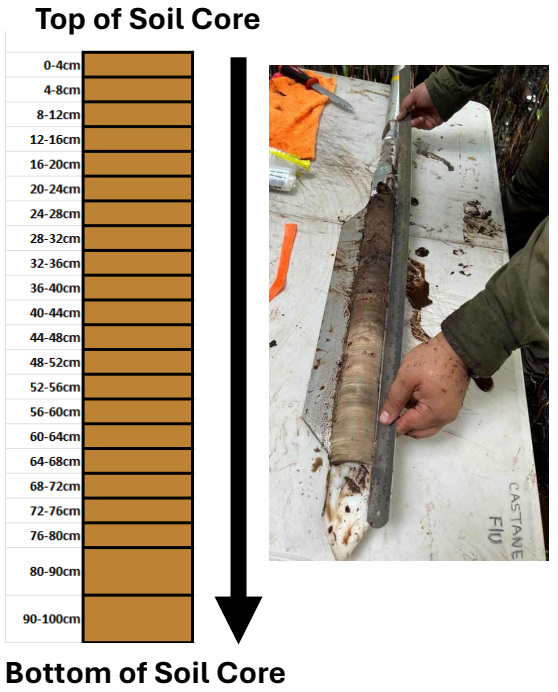
BISC-2 overall has higher buried organic matter beneath the forest

BISC-1 (*L31E Flow-way*)

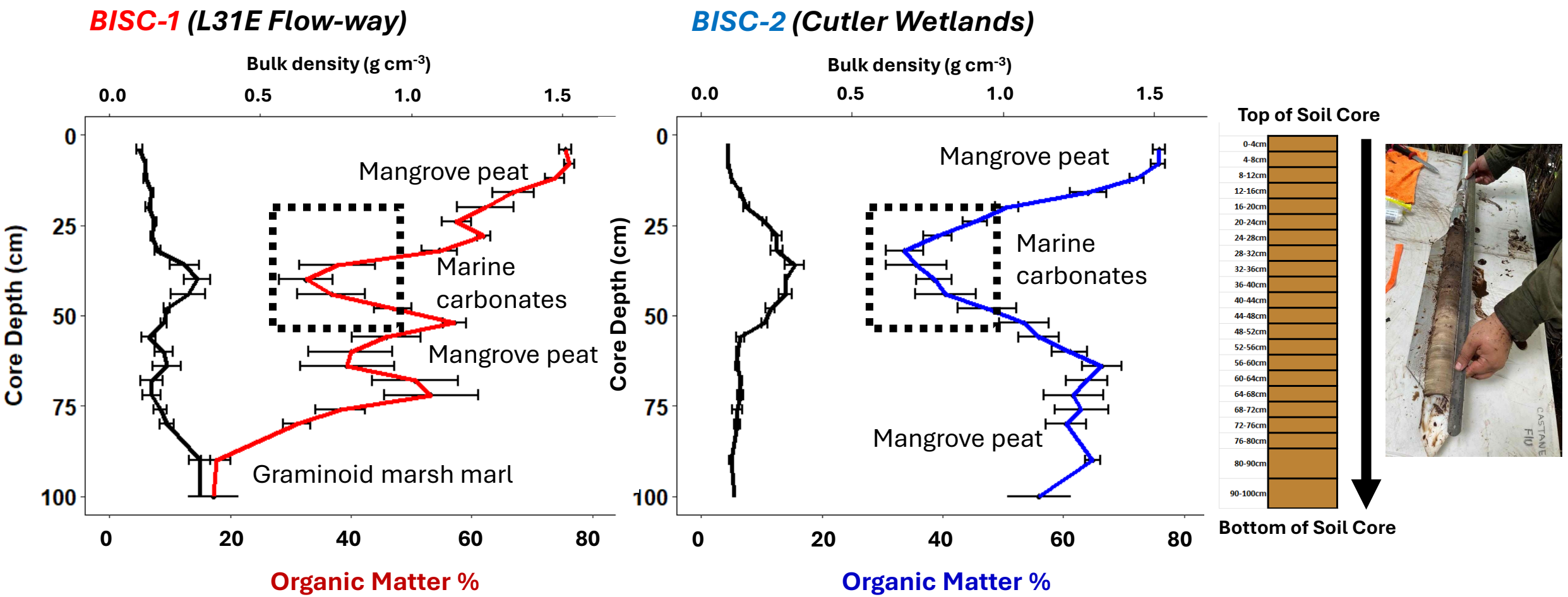


BISC-2 (*Cutler Wetlands*)

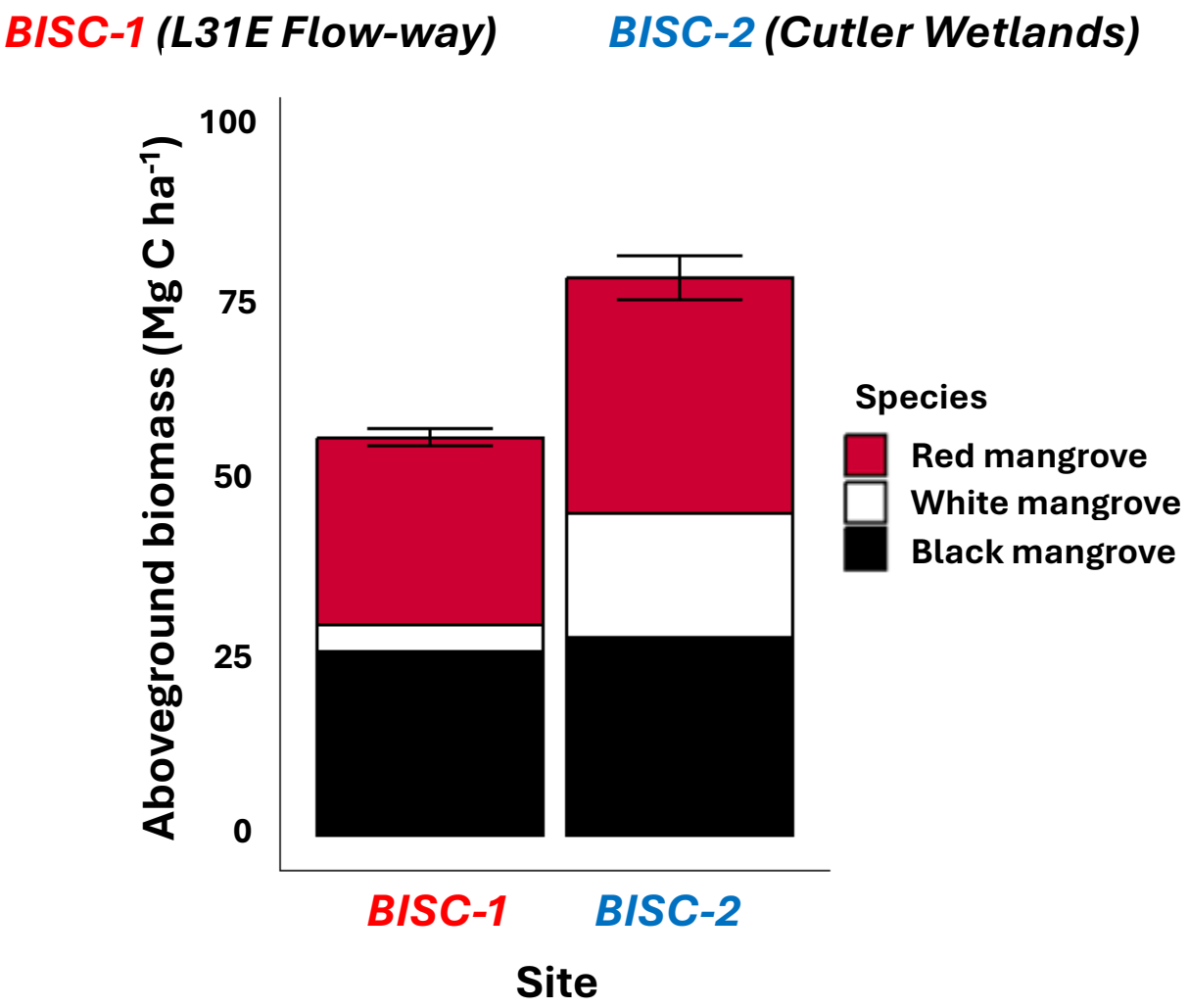


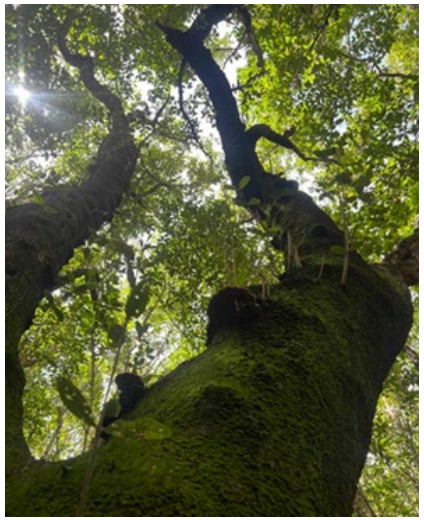


BISC-2 overall has higher buried organic matter beneath the forest



Aboveground biomass C storage varied between sites and species



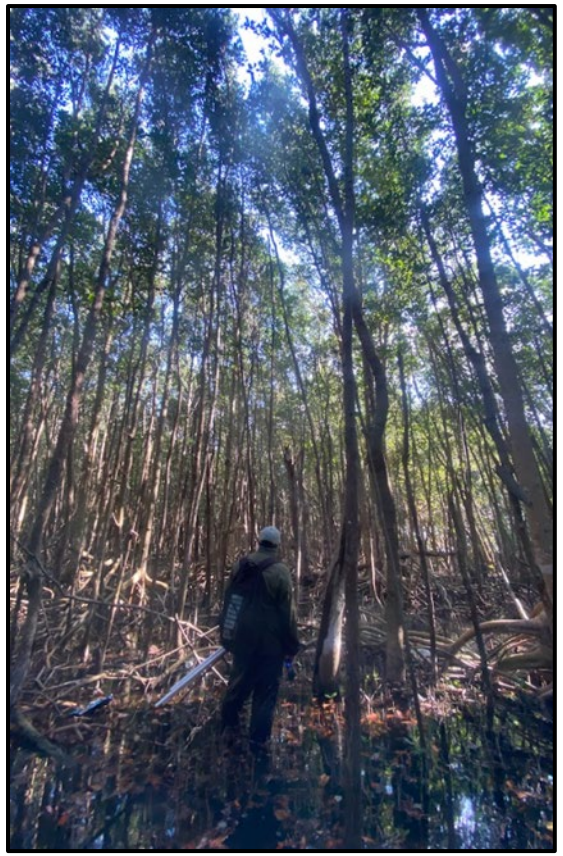


Black mangrove

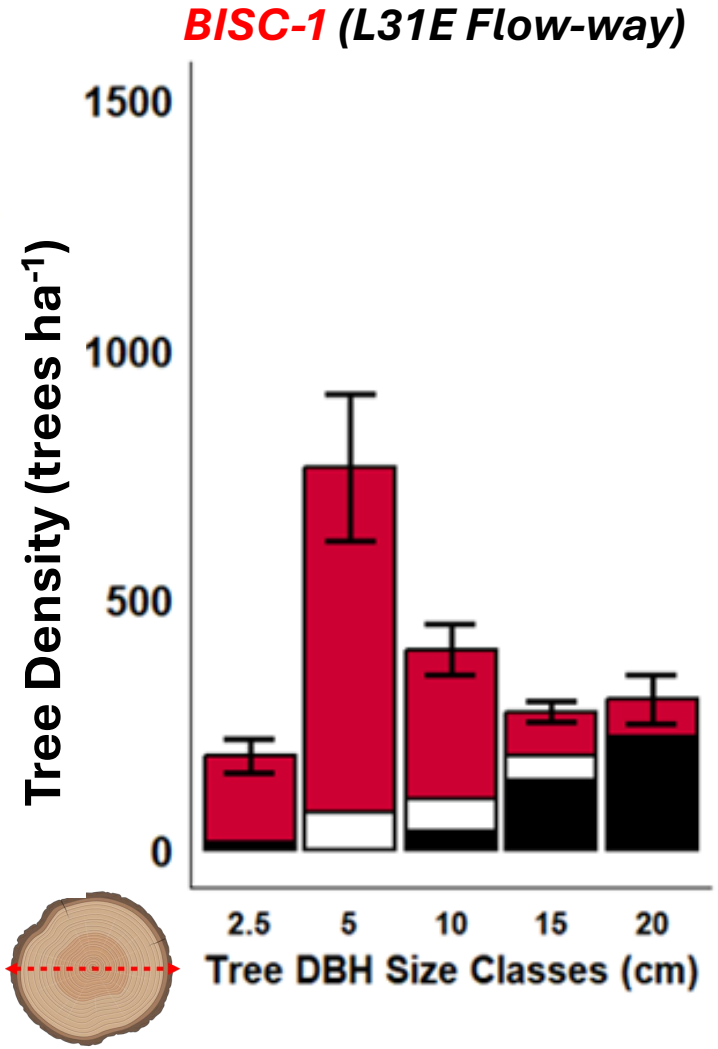
Red mangrove

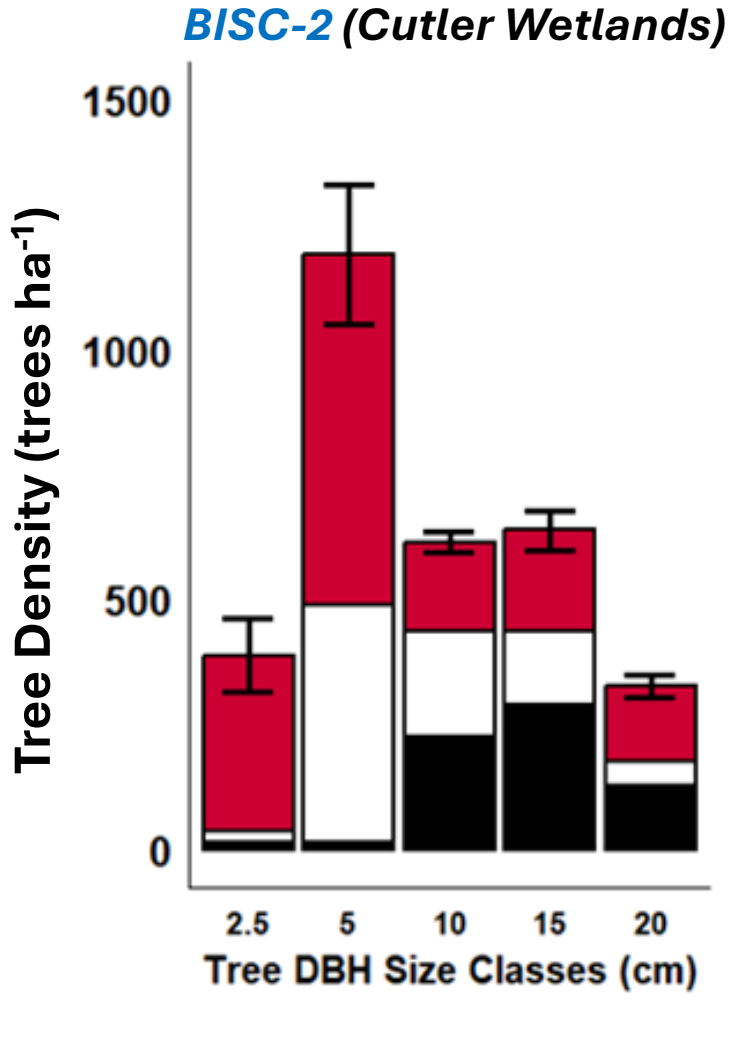
White mangrove

Fringe forest tree density is highest at Cutler Wetlands



Site Mean + SE
Tree Density (trees ha^{-1})
BISC-1: 1925 ± 150
BISC-2: 3150 ± 100



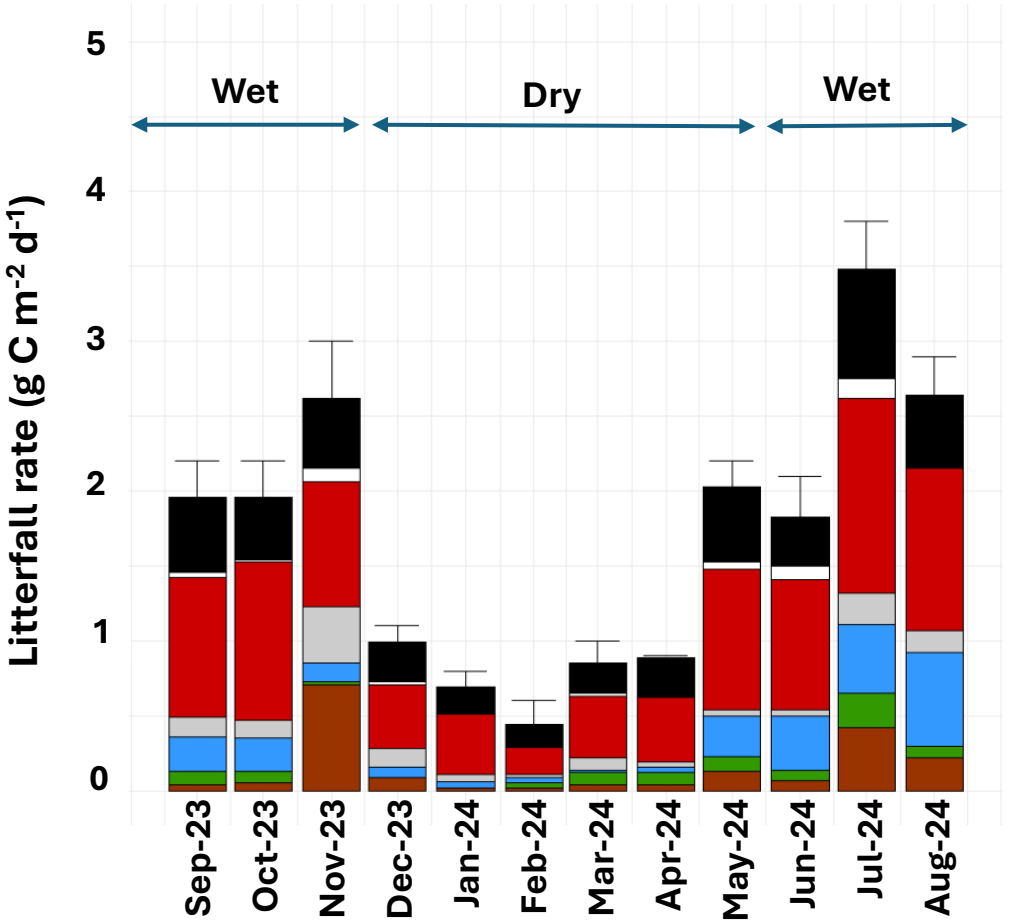


Species
Red mangrove
White mangrove
Black mangrove

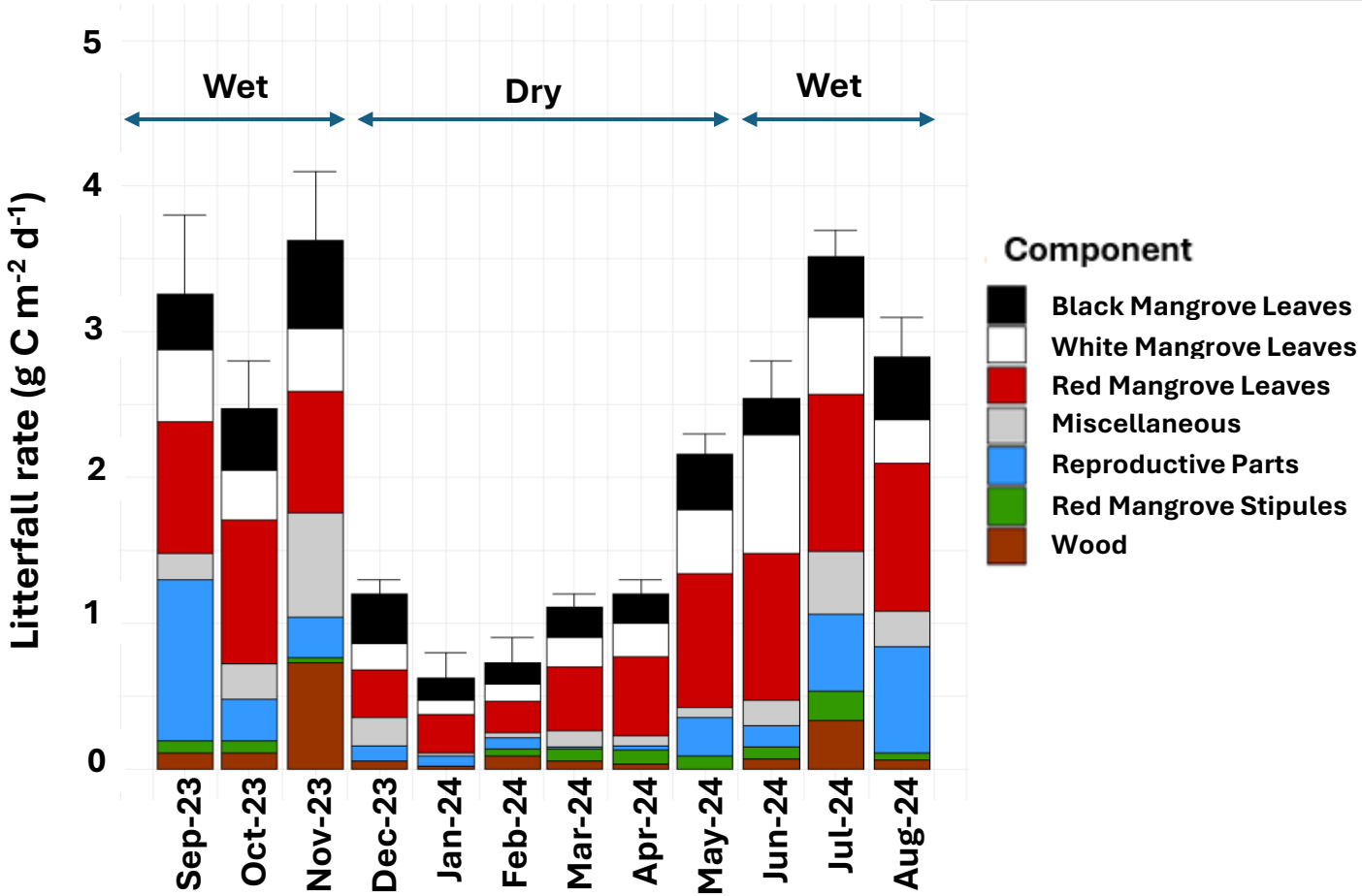
Daily Litterfall Productivity Greater at BISC-2 (Cutler Wetlands)

Site Mean + SE
Annual Litterfall Rate (Mg C ha^{-1} yr^{-1})
BISC-1: 6.5 ± 0.60
BISC-2: 8.0 ± 0.04

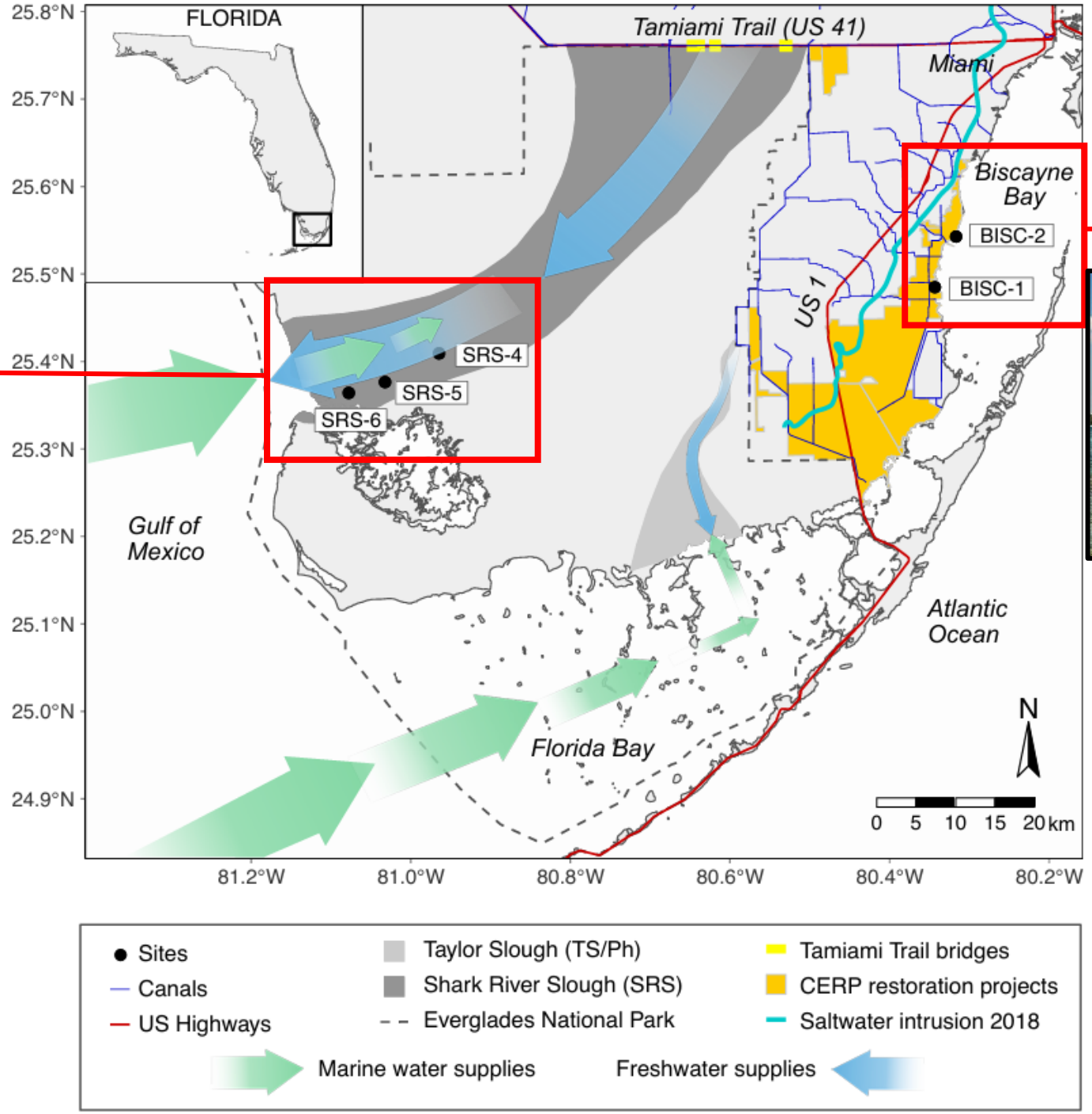
BISC-1 (L31E Flow-way)



BISC-2 (Cutler Wetlands)

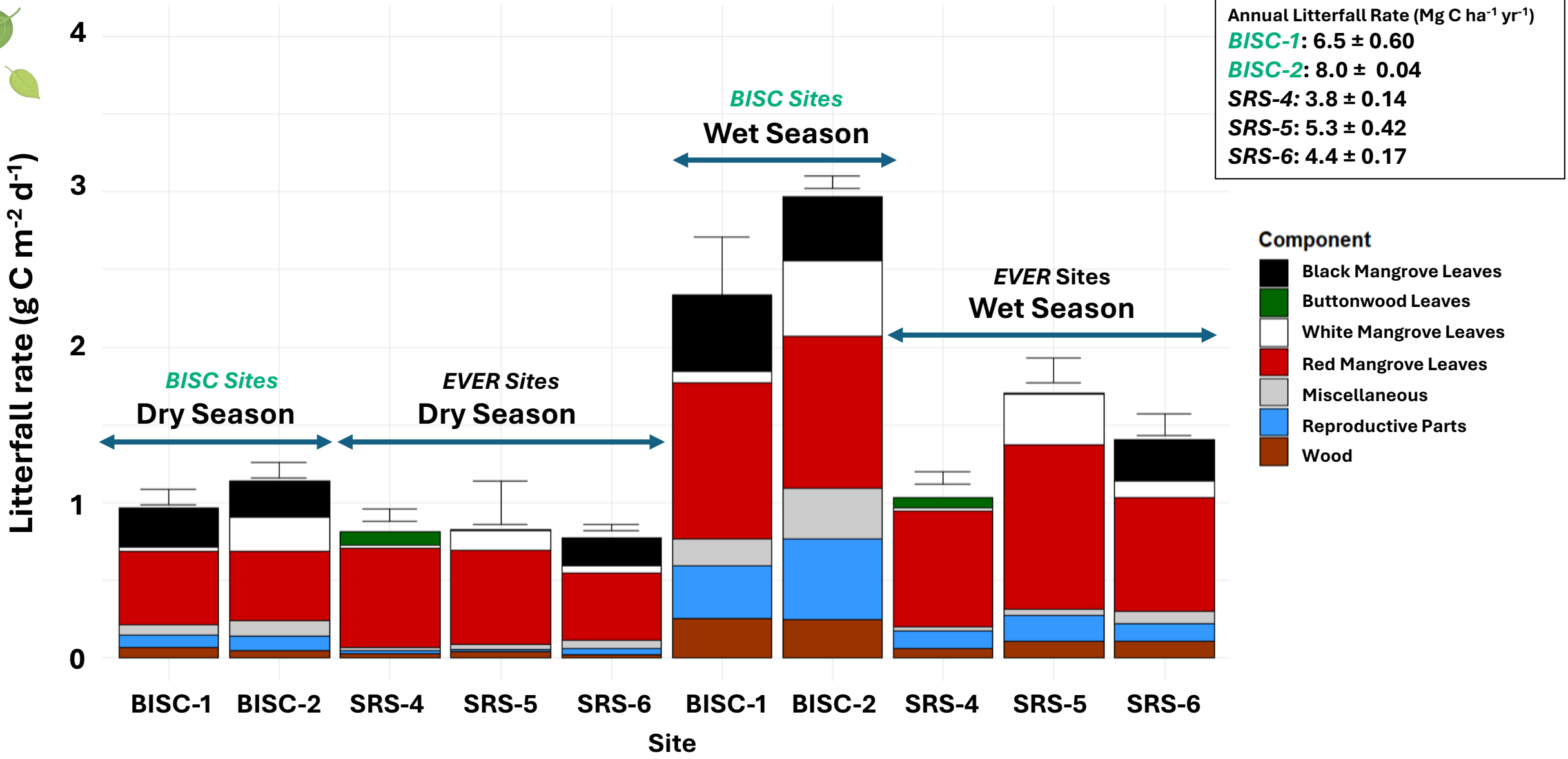


FCE-LTER
Everglades Shark River
Mangrove Sites



Biscayne Bay
Mangrove Sites

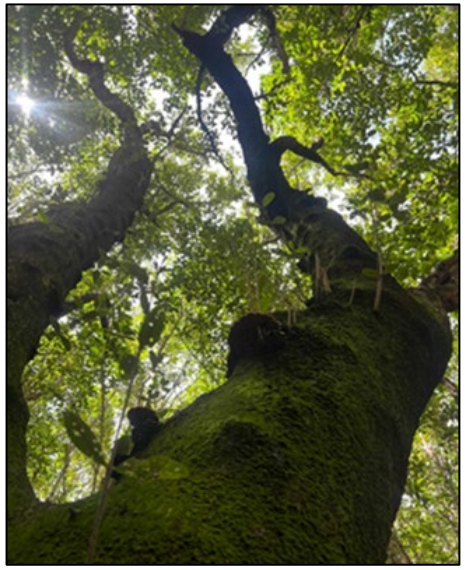
Daily Litterfall Productivity Greater at Fringe Mangrove Forests in Biscayne NP



Main Takeaways

- ✓ **Sea level rise is outpacing soil elevation change**
- ✓ Detected **greater soil elevation change and peat formation** where **aboveground biomass, tree density, and litterfall productivity were the highest**
- ✓ Size class contributions to tree density suggest there is **major carbon storage potential** for these forests to grow
- ✓ **Restoration** needs to aim to **enhance sedimentation** in our mangrove wetlands and increase the biomass and productivity of our mangrove forests

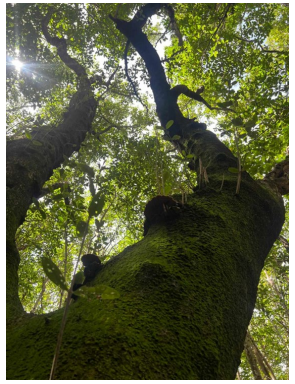





Future Directions: Total Ecosystem C Stocks

Measuring each mangrove carbon (C) pool contribution
1) C stocks, necromass, and sequestration rates
2) Stable isotope signatures

Tree Biomass Aboveground C



Black mangrove
White mangrove
Red mangrove

+

Root biomass Belowground C

Black mangrove
White mangrove
Red mangrove

+

Soil core Belowground C

=

Total Ecosystem C Stocks

Future Directions: Carbon Sequestration Rates in Coastal Mangrove Forests

Aboveground wood production

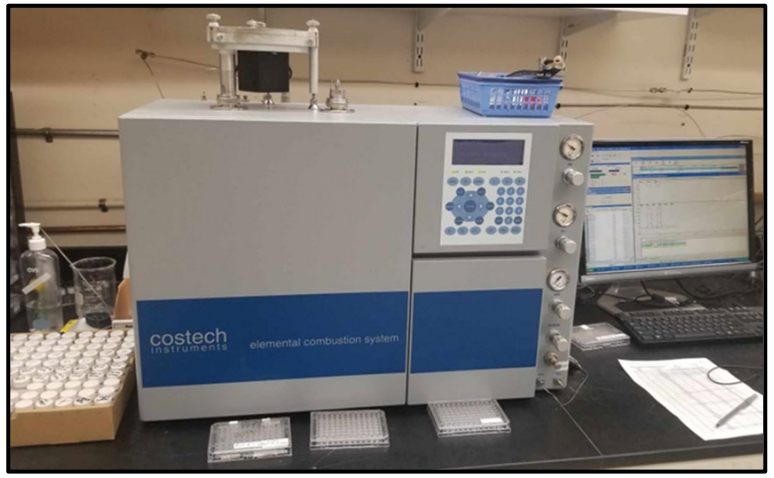
18 months

Belowground root production

12 months

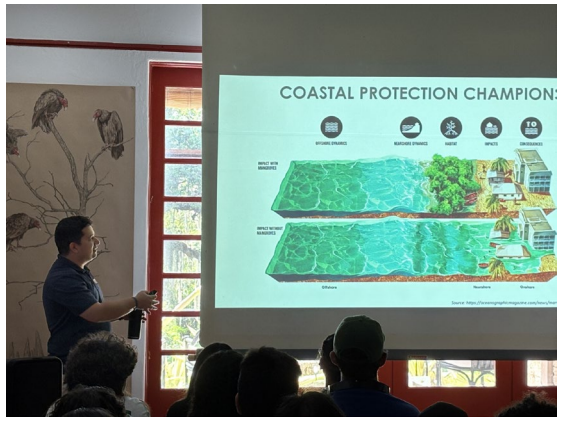
Measuring the following to explain differences in productivity, turnover, and decomposition:

- **Stable isotopes** ($\delta^{13}C$ and $\delta^{15}N$)
- **Stressors** (Salinity, sulfide concentration, anoxia)
- Soil, porewater, plant tissue **nutrients**
- **Tidal hydroperiod**

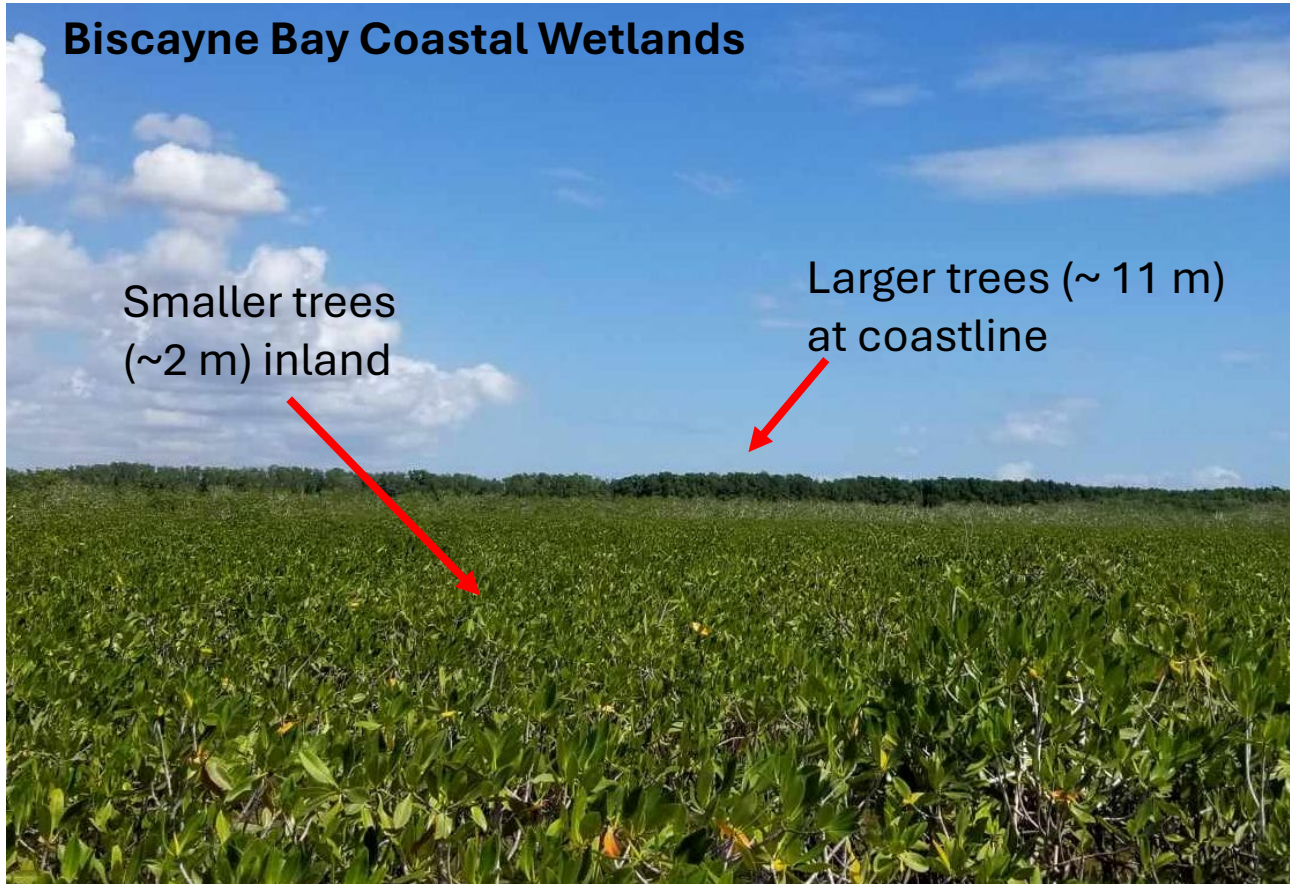


Broader Impacts

- Engage the public and management with reports and outreach events
- Collaborate with local teachers to present data in Miami-Dade classrooms
- Establish groundwork and baseline for future research in Biscayne National Park



Mangrove wetlands in Biscayne Bay have major potential for carbon sequestration and storage



Restoration, research, public interest, and education are underway to protect these wetlands!

Acknowledgments

- This project was funded by NPS Cooperative Work Agreement P21AC11346-00, FIU ForEverglades Scholarship 2022, and the Cristina Menendez Memorial Fellowship 2024 - 2025
- This project acknowledges it was located on lands originally cared for by the Miccosukee, Seminole, and Tequesta communities in Florida
- <u>This project was made possible by support from:</u>

❖ *My wife and family*
❖ *Ecosystem Ecology Lab*
❖ *National Park Service SFCN*
❖ *Biscayne National Park*
❖ *FCE LTER Community*
❖ *Miami-Dade County DERM*
❖ *FIU Institute of Environment*
❖ *FIU CREST-CAChE*
❖ *Everglades Foundation*
❖ *National Science Foundation*
❖ *Miami-Dade County Schools*
❖ *My committee and mentors*







Questions?

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