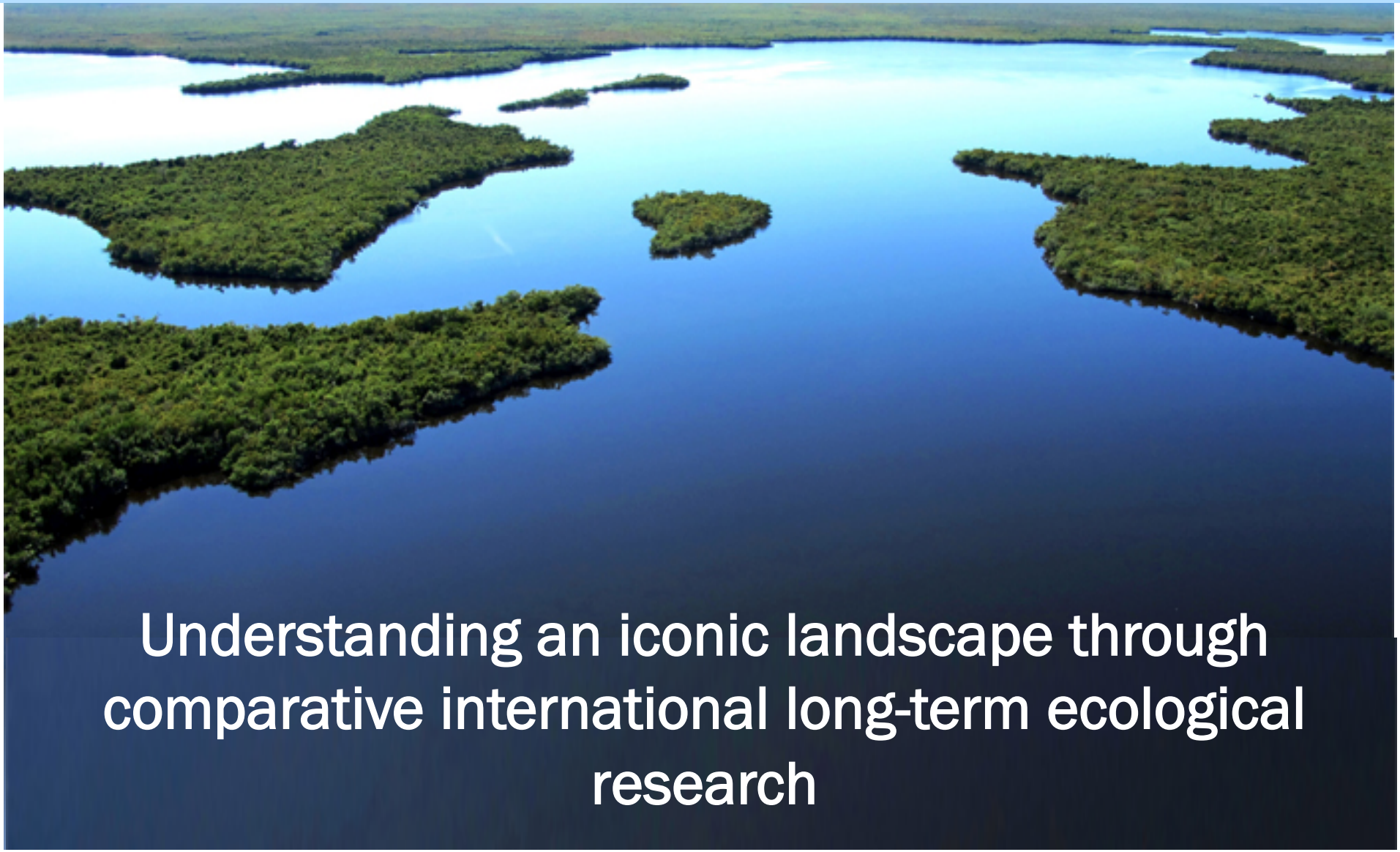
Florida Coastal Everglades
Long Term Ecological Research



Understanding an iconic landscape through comparative international long-term ecological research

Expanding the scope for US LTER research

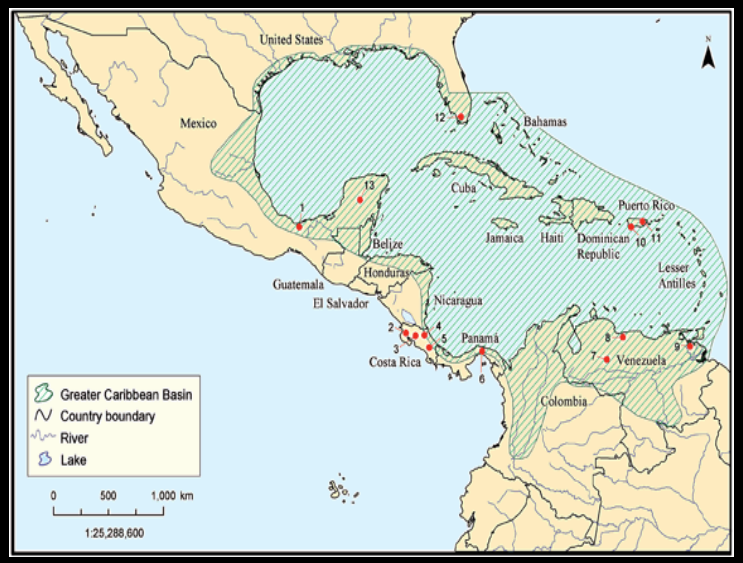
- Leveraging international contacts developed through ILTER to expand the geographic, ecological and social scales for investigation
- Broadening the platform to address new, high impact research questions and contributing to general ecological theory to explain ecosystem pattern and process
- Expanded policy relevance

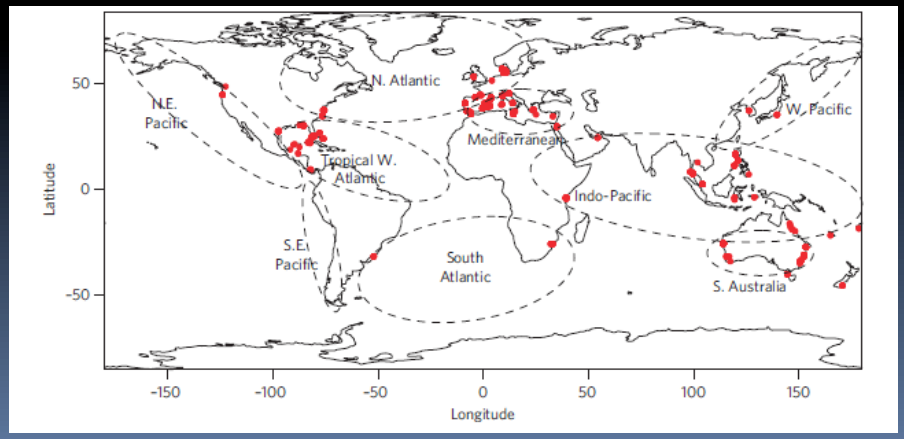
FCE collaborative research in the Caribbean and beyond

- Earlier initiatives motivated by understanding the ecology of FCE ecosystems because of commonalities (Rivera-Monroy et al. 2004) as well as a perceived uniqueness (Noe et al. 2001).

- Advancing hydrogeology and ecology of the Everglades and (karst) wetland systems in general.

- Leveraging these relationships, this work has expanded to new initiatives, research, and student opportunities while broadening the geographic scope to the Americas as well as several recent global assessments.

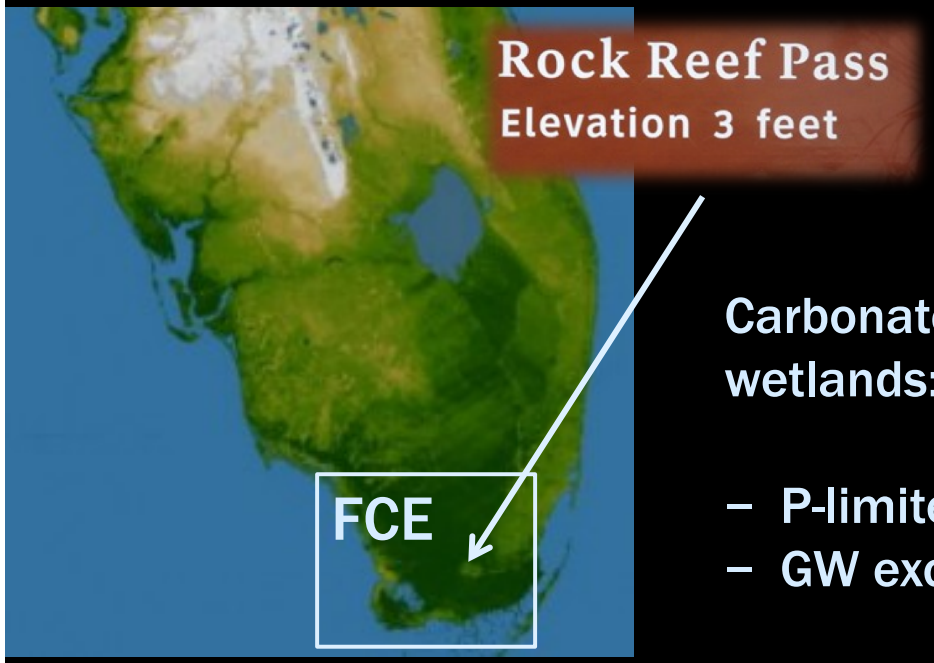




FCE collaborative research in the Caribbean and beyond

- Karst wetlands and the FCE
- The distribution of a few iconic features…
  - Upside-down estuary
  - Productivity paradox
  - Endemism
- Iconic ecosystem sustainability

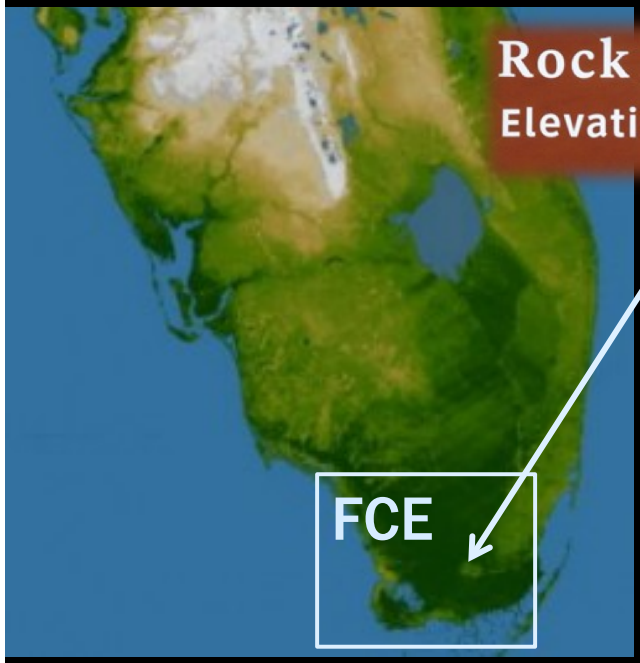
Karst Geology – a regulating feature



Carbonate wetlands:

- P-limited
- GW exchange

Karst Geology – a regulating feature



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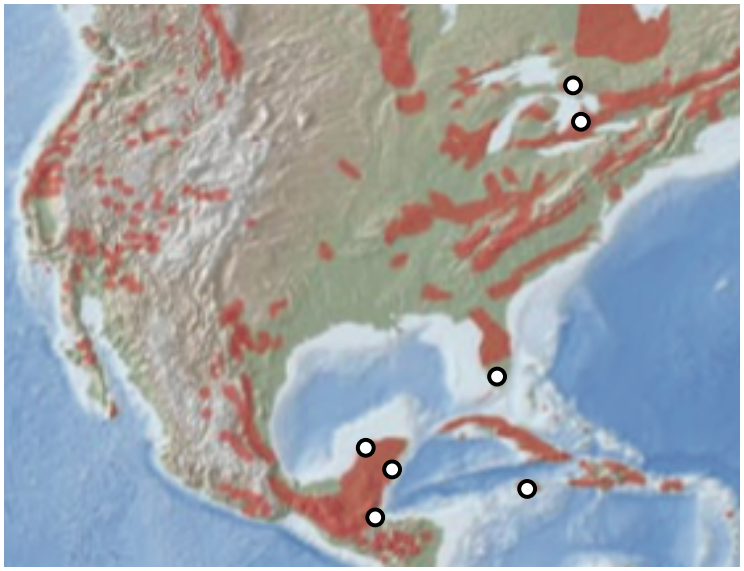
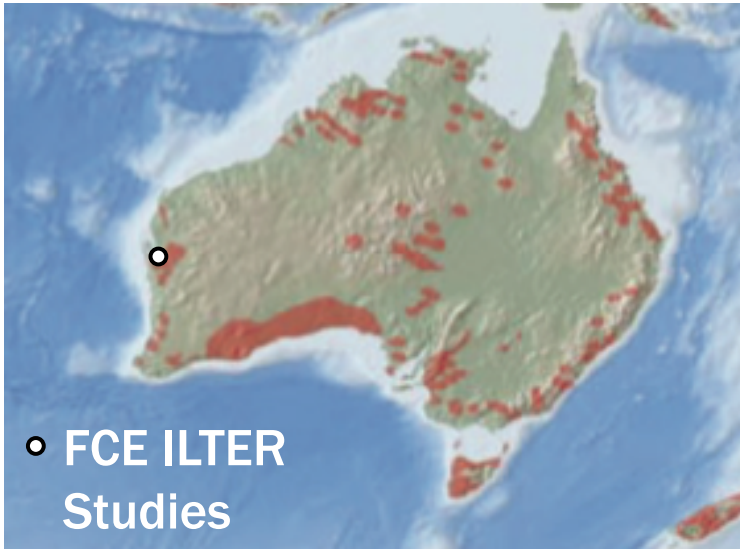
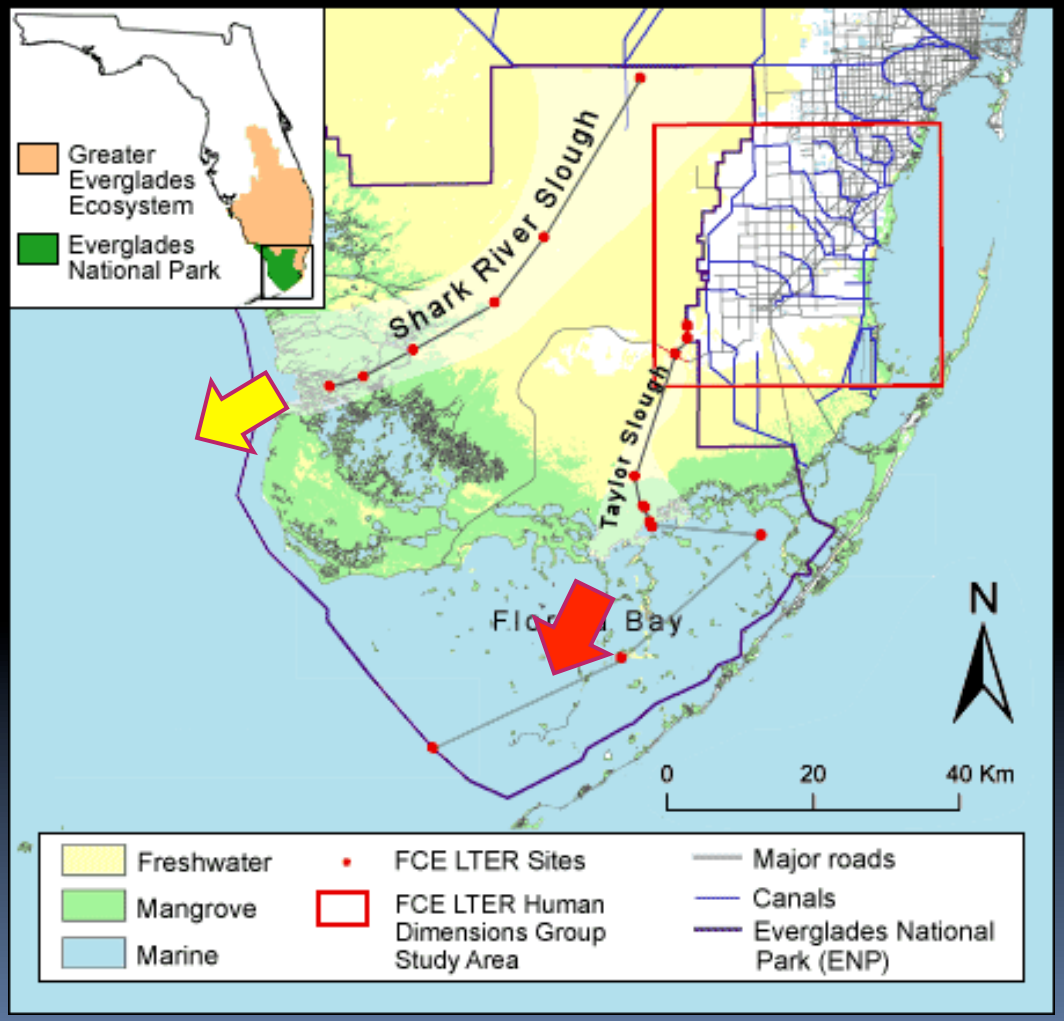
Karst Regions of the World





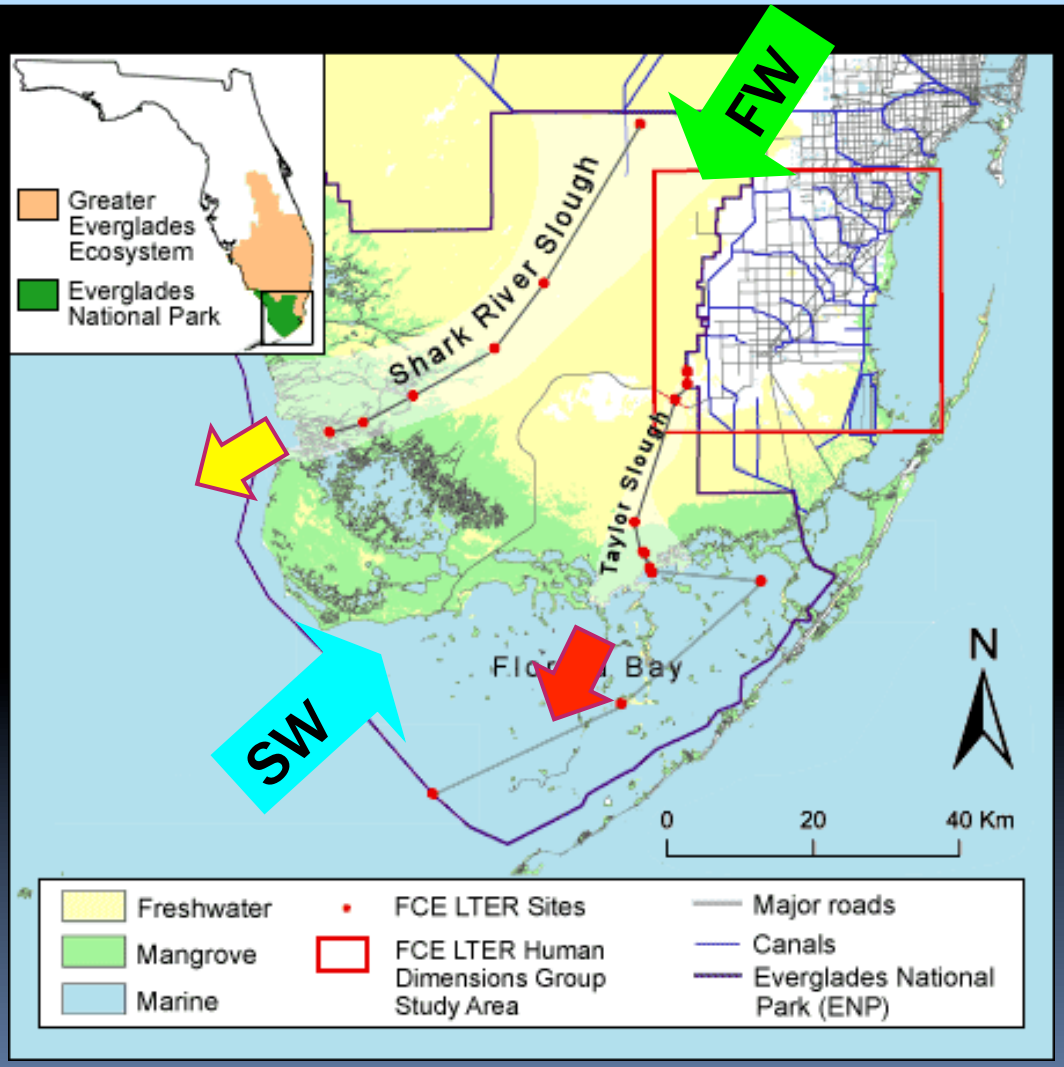
Florida Coastal Everglades
Long Term Ecological Research



<u>Central Question:</u>

How do climate change and resource management decisions interact to influence freshwater availability, ecosystem dynamics and the value and utilization of ecosystem services by people in the coastal Everglades?

Florida Coastal Everglades
Long Term Ecological Research



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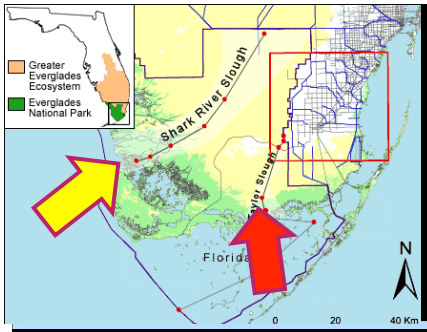


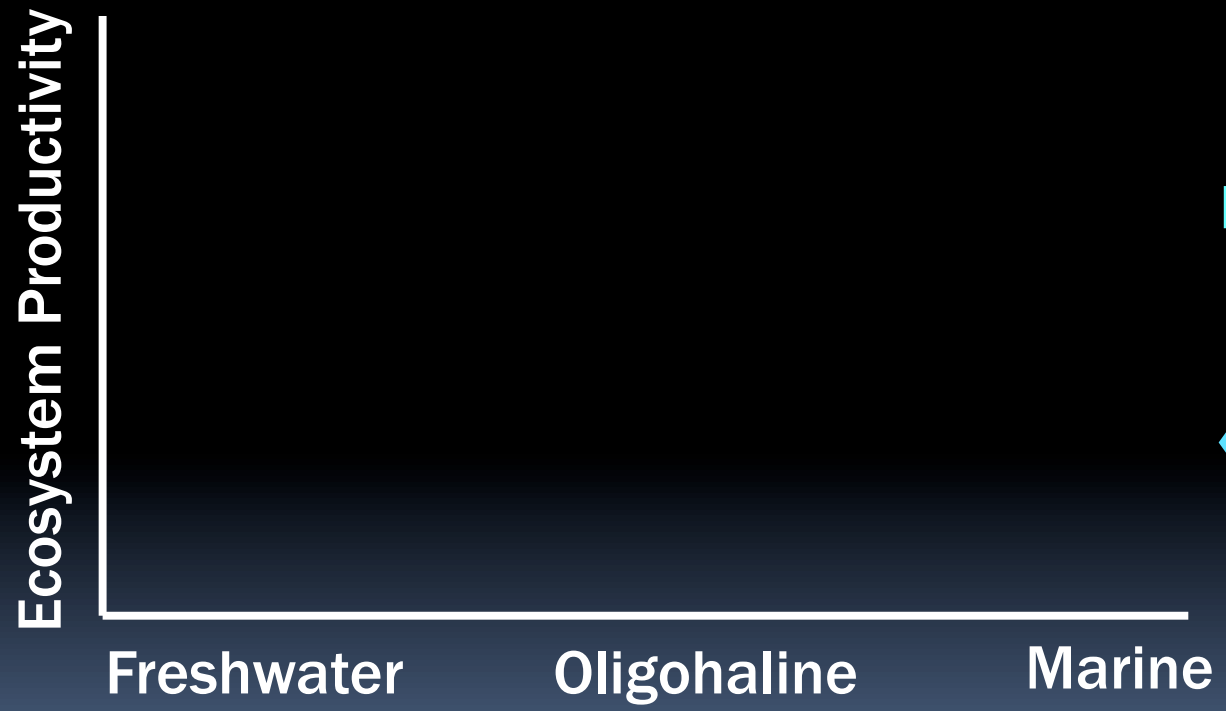
The Everglades is an "*Upside-Down*" estuary: marine supply of P determines productivity

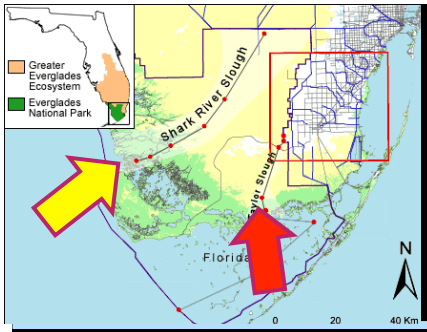
Restoration

Freshwater Inputs
Low [P]
High [N]

SLR

Marine Inputs
High [P]
Low [N]





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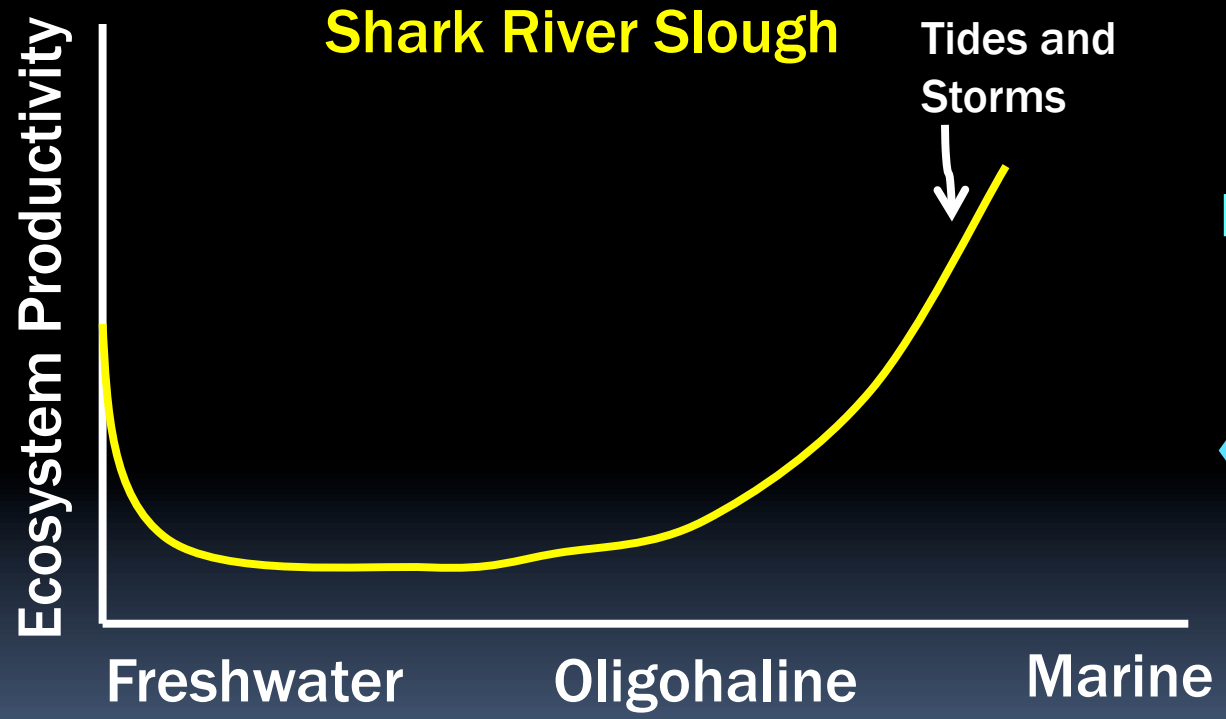

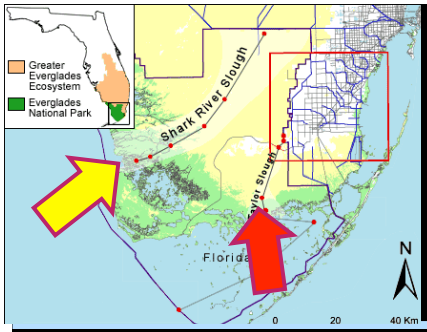

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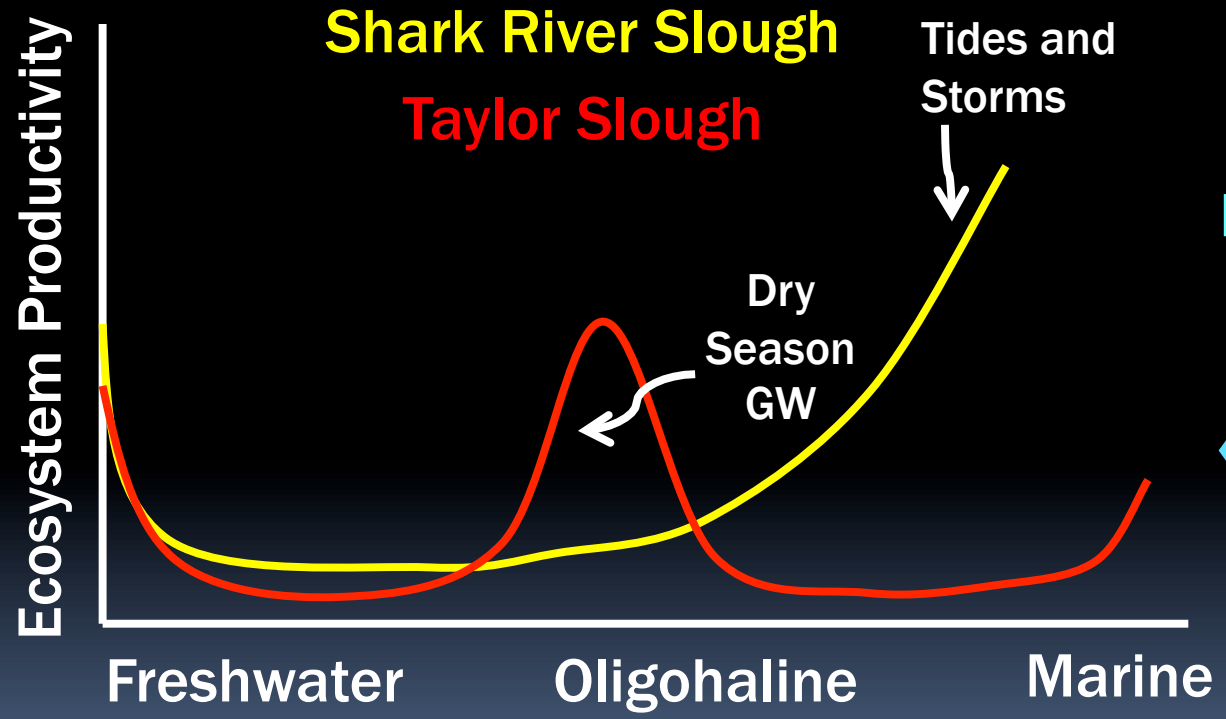
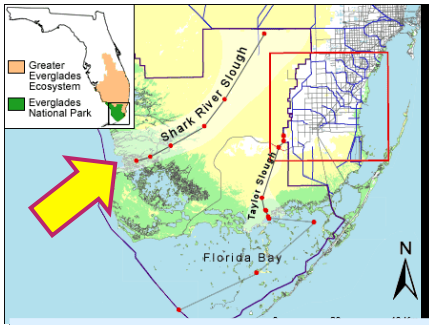
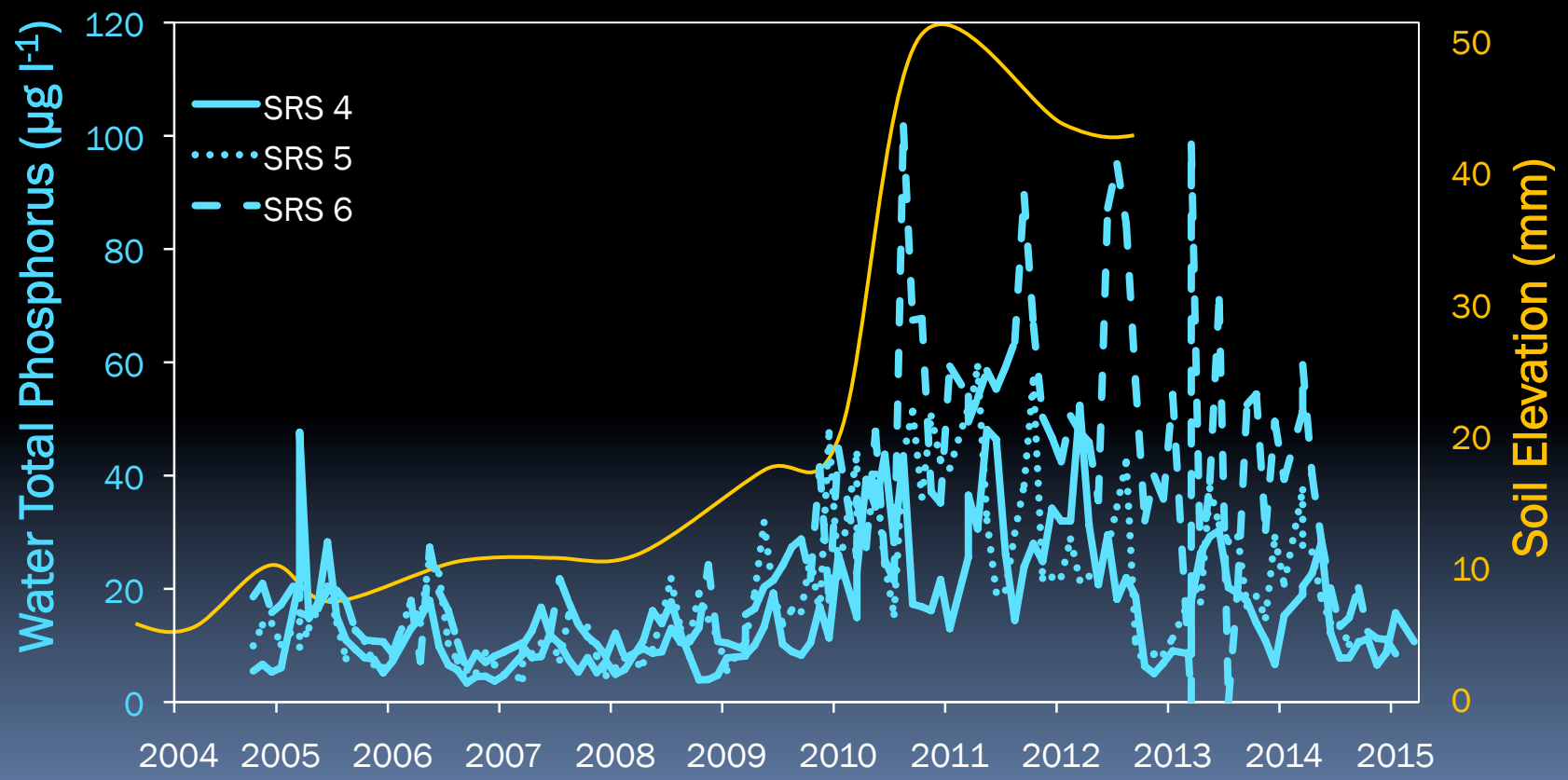
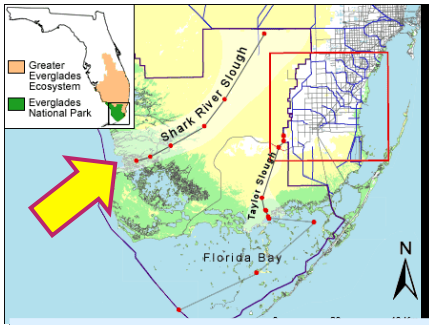




Storms and tides provide marine P to the estuary





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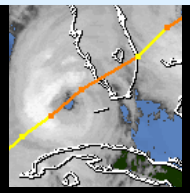
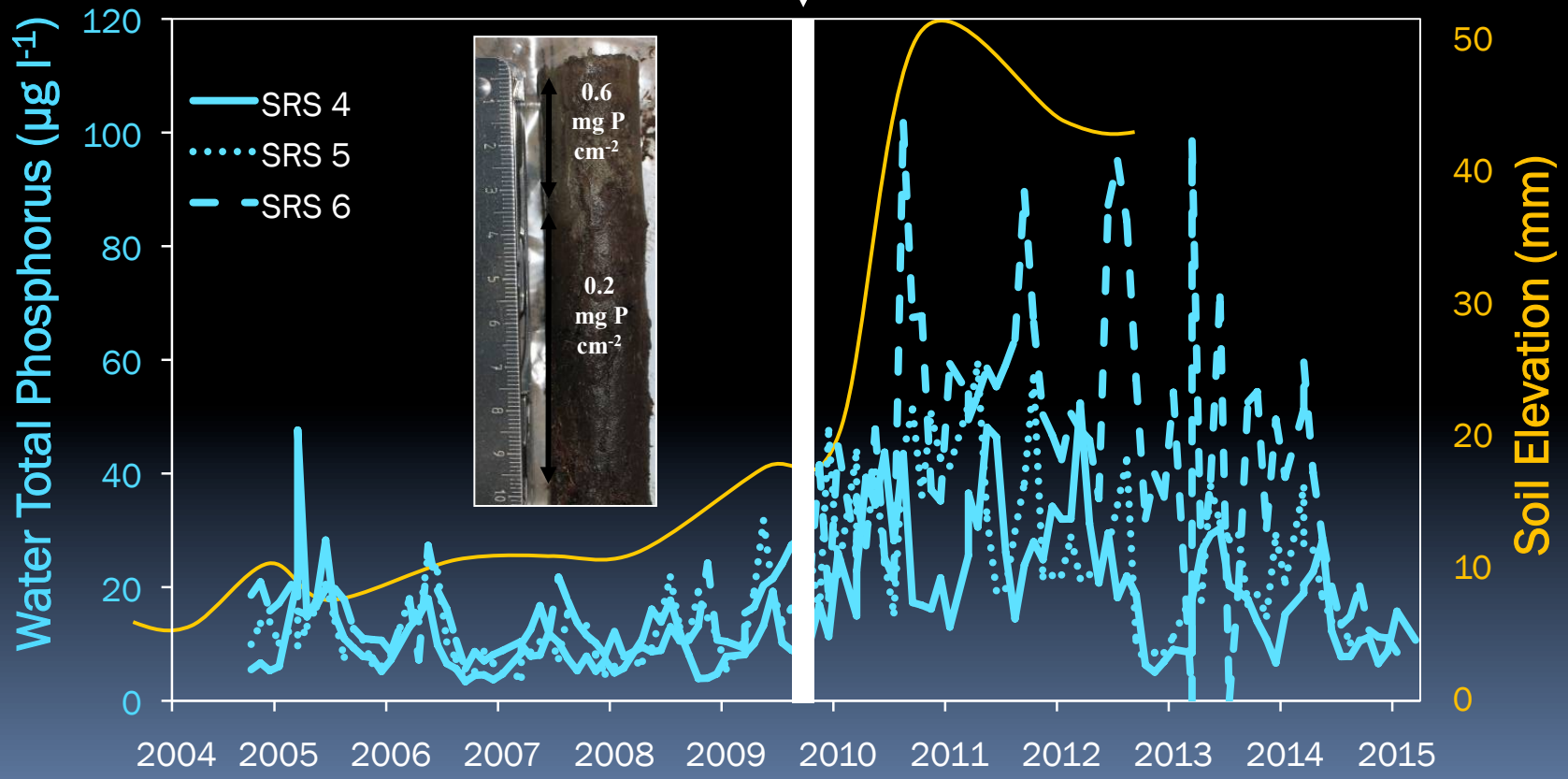
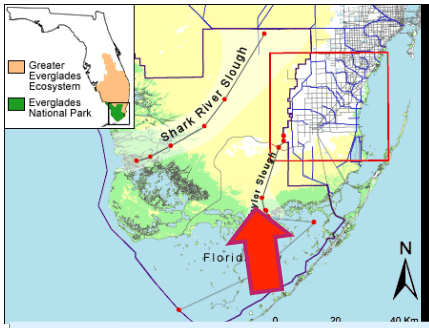
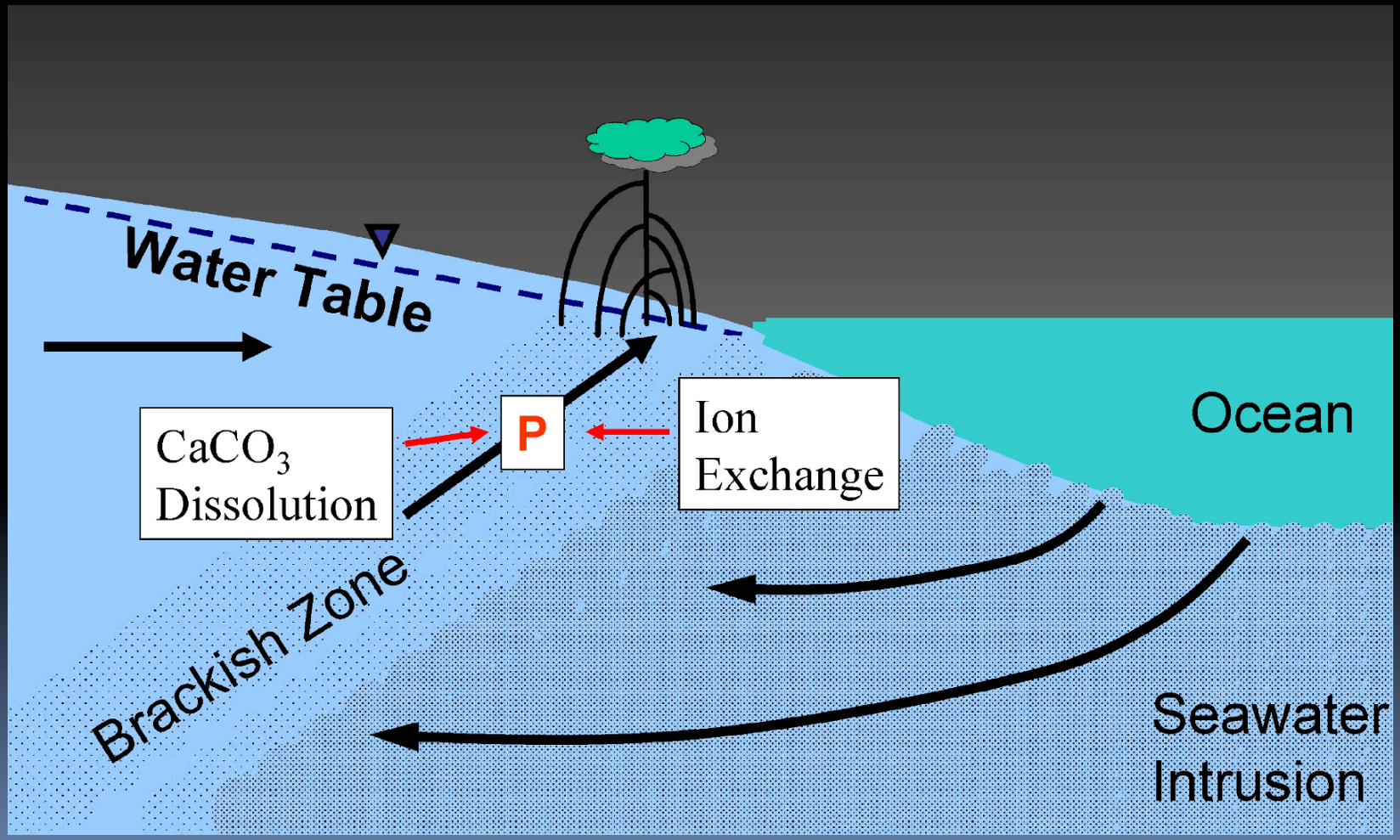


Hurricane Wilma

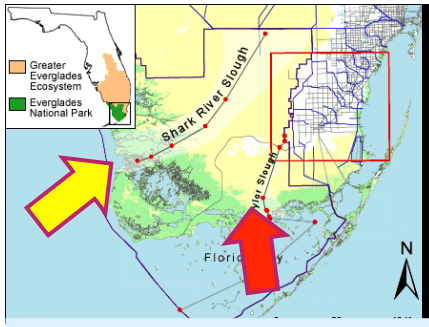




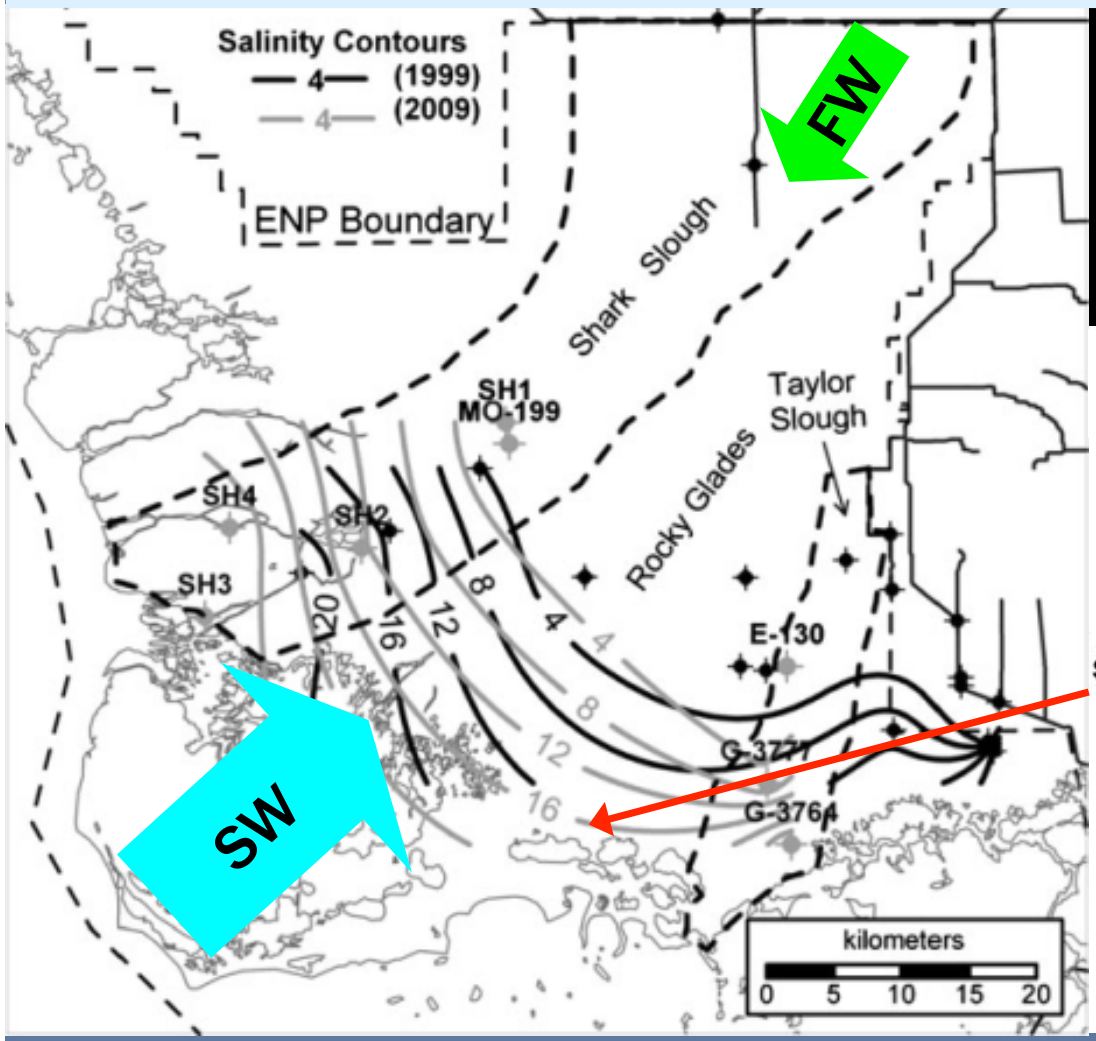
Marine P is also delivered underground through landward brackish water discharge



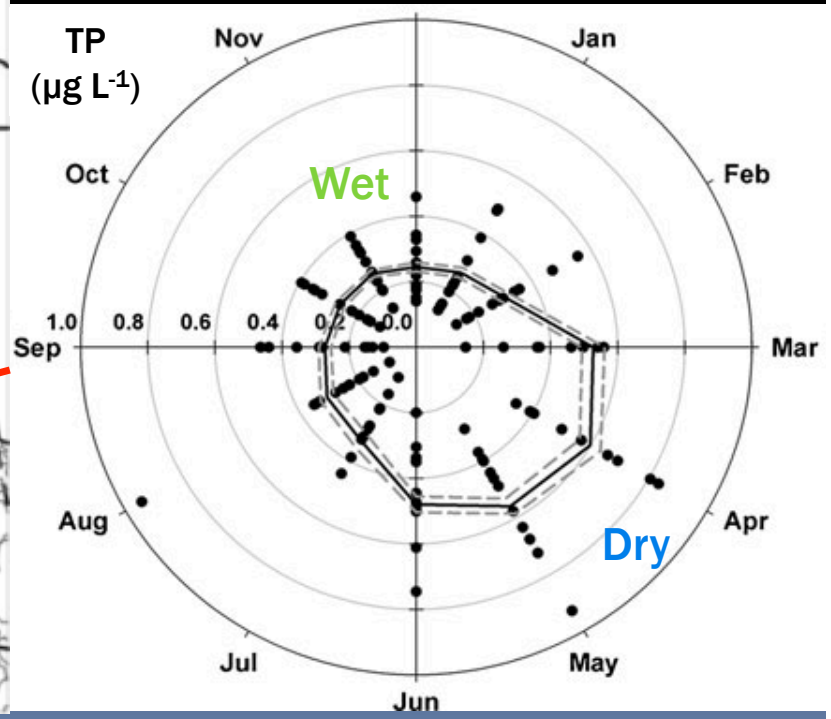
Price et al. 2006



Saltwater is intruding landward underground with SLR, bringing P to ecotone



- Notable GW influence on ecotone [P] in dry seasons and years



Saha et al. 2011

Koch et al. 2012

Are other karstic estuaries “upside-down?”

Yucatan Peninsula

Partners:

- **Ecosistemas Costeros de la Peninsula de Yucatan (ECOPEY) Mex-LTER**
- **Comisión Nacional de Áreas Naturales Protegidas (CONANP)**
- **Centro de Investigación y de Estudios Avanzados (CINVESTAV-Unidad Mérida)**

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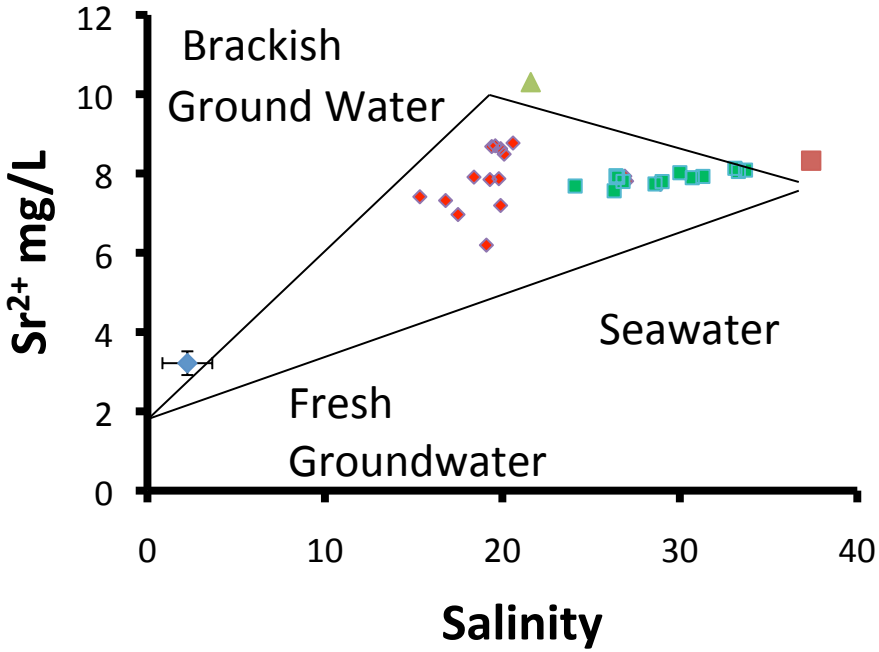

In the Celestún estuary:

- Seawater is the dominant source of water (40-43%)
- Brackish and fresh groundwater account for 31-35% and 25-26% of water input.

Stalker et al. 2013

Are other karstic estuaries "upside-down?"

Yucatan Peninsula

NASA WaterSCAPES

Science of Coupled Aquatic Processes in Ecosystems from Space

Are other karstic estuaries "upside-down?"

Yucatan Peninsula

AGU MEETING OF THE AMERICAS
Cancun, Mexico | 14–17 May 2013

Special Session H08. Recent Advances in Ecohydrology of Coastal Wetlands (René Price, Fernando Miralles-Wilhelm, Shimon Wdowinski, Jorge Herrera Silveira)

NASA WaterSCAPES

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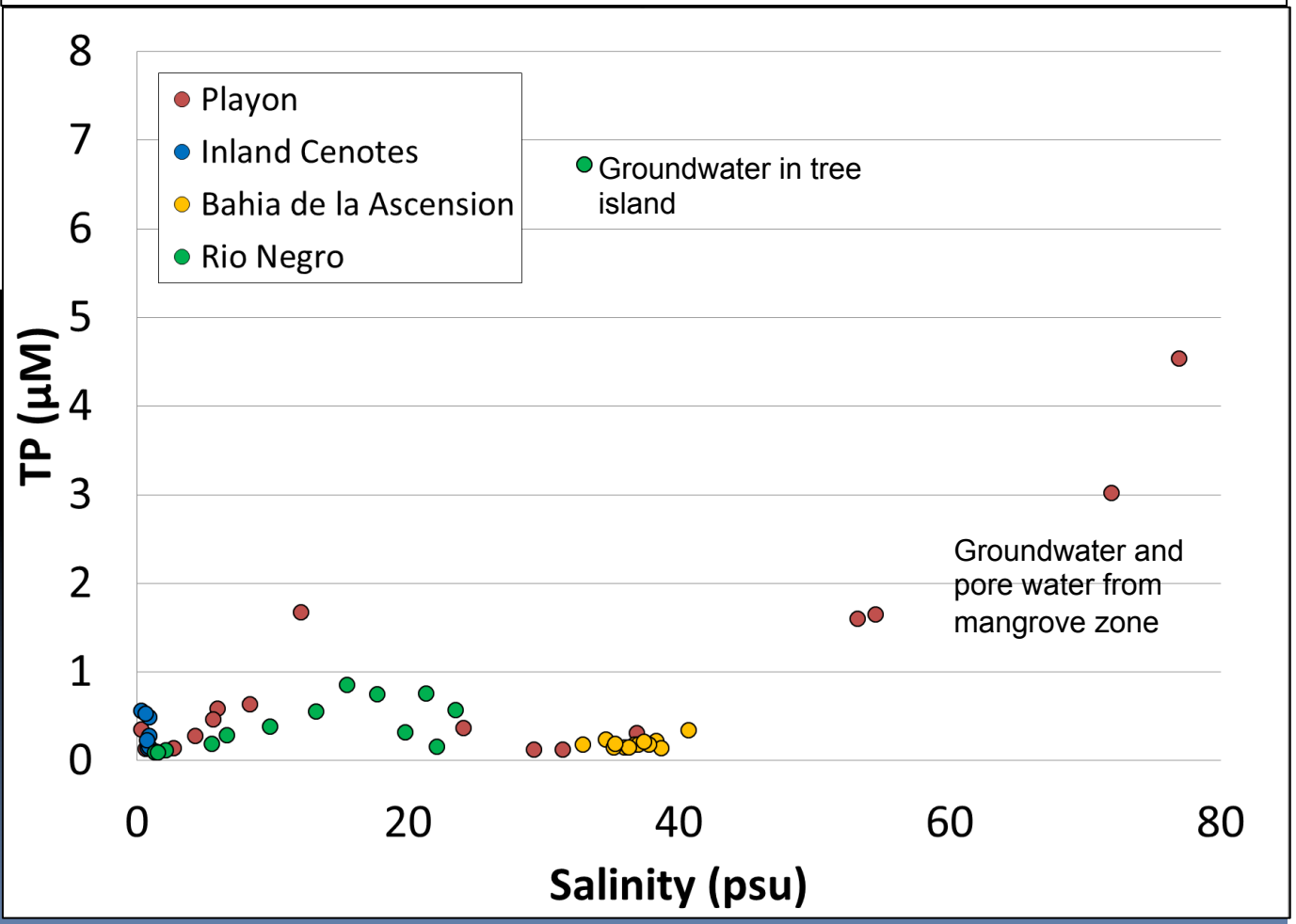
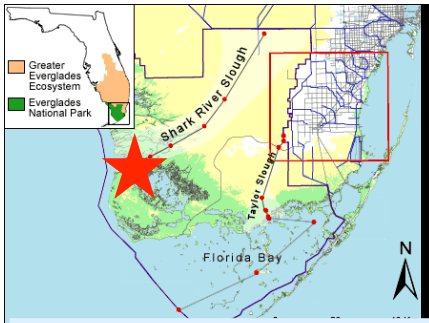
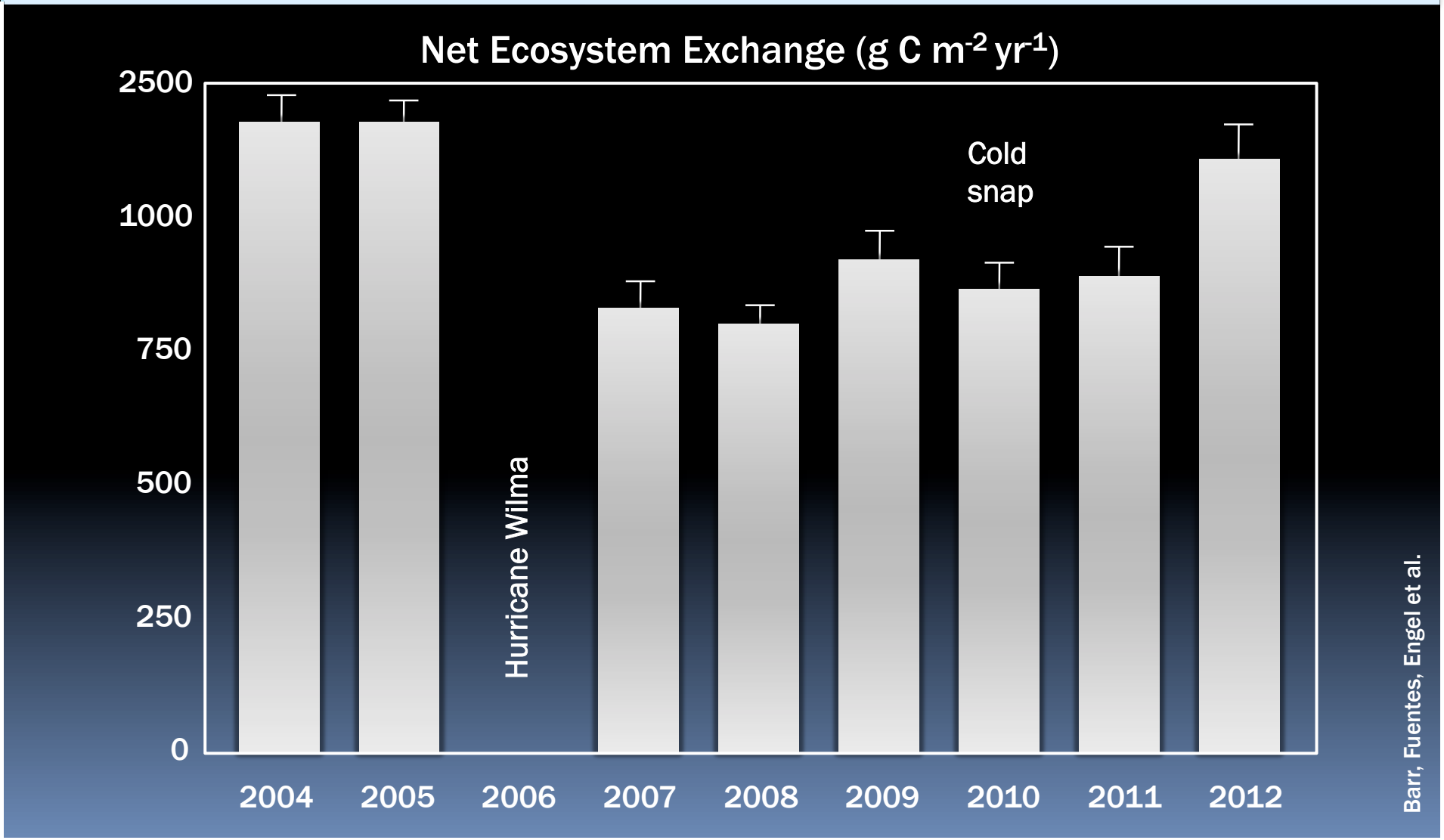


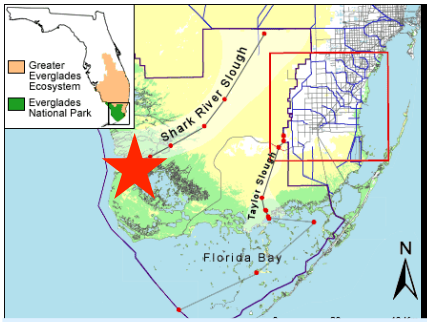
Lagomasino, Price et al. 2013

You and 4 others like this.

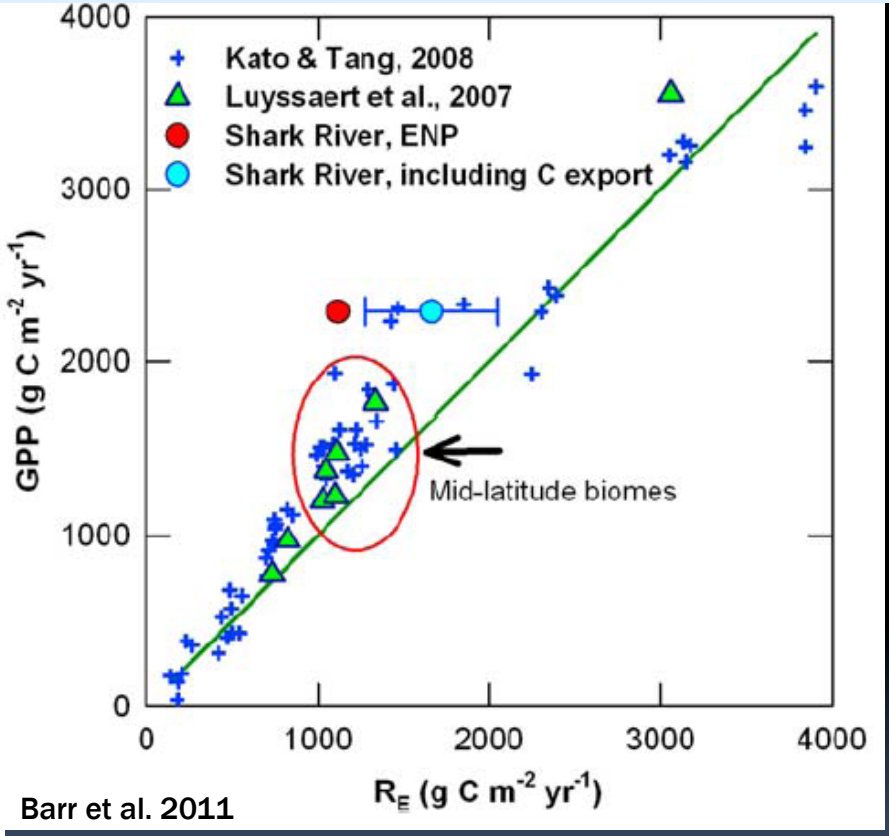


Marine P subsidizes mangrove forest production

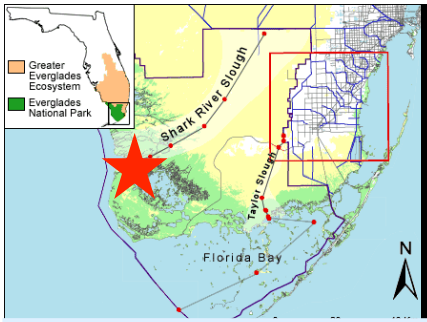




Carbon sequestration in subtropical mangrove forests



Barr et al. 2011



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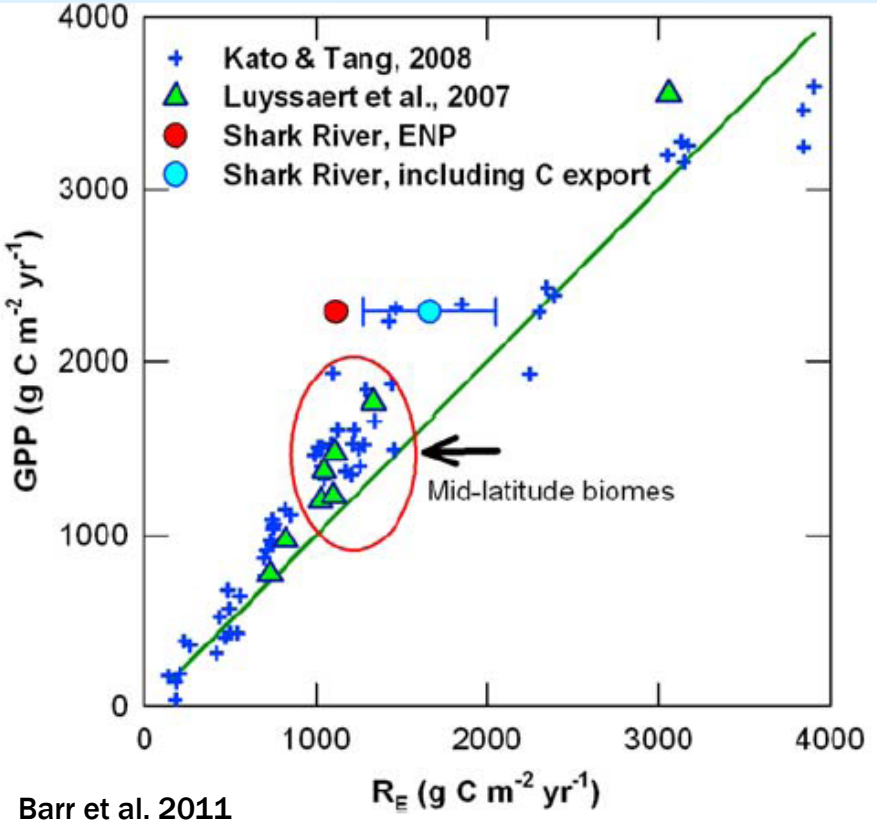

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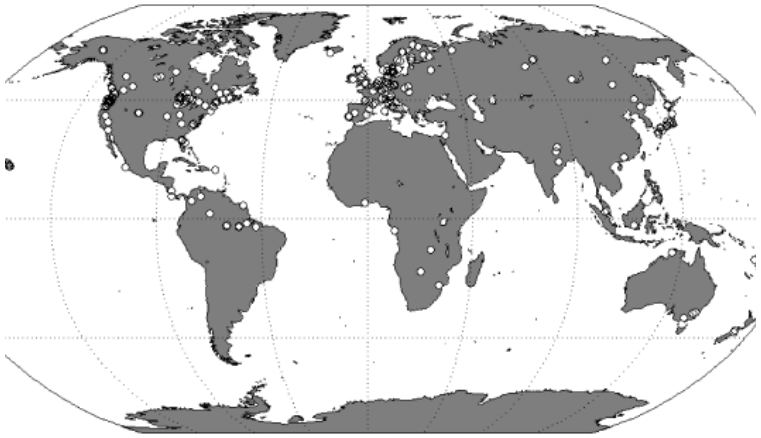
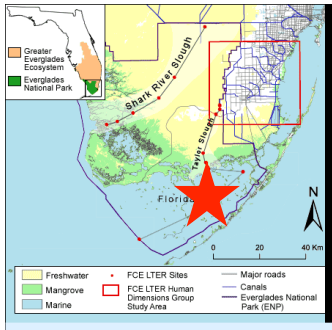


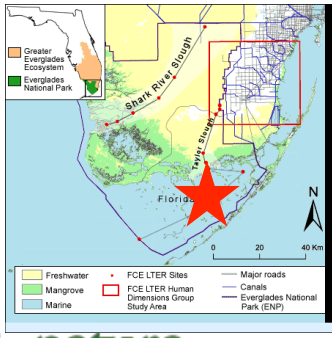
Region	1980 Area (10^3 ha)	2000 Area (10^3 ha)
Africa	3659	3351
Asia	7857	5833
Oceania	1850	1527
North and Central America	2641	1968
South America	3802	1974
World total	19809	14653

- Subtropical mangrove forests among most productive on planet
- Need to constrain lateral OC transport
- Need to consider global biogoechemical consequence to high areal loss rates

Rivera-Monroy et al. 2011; Wilkie and Fortuna (2003)



Seagrass ecosystems as a globally significant carbon stock



Seagrass ecosystems as a globally significant carbon stock

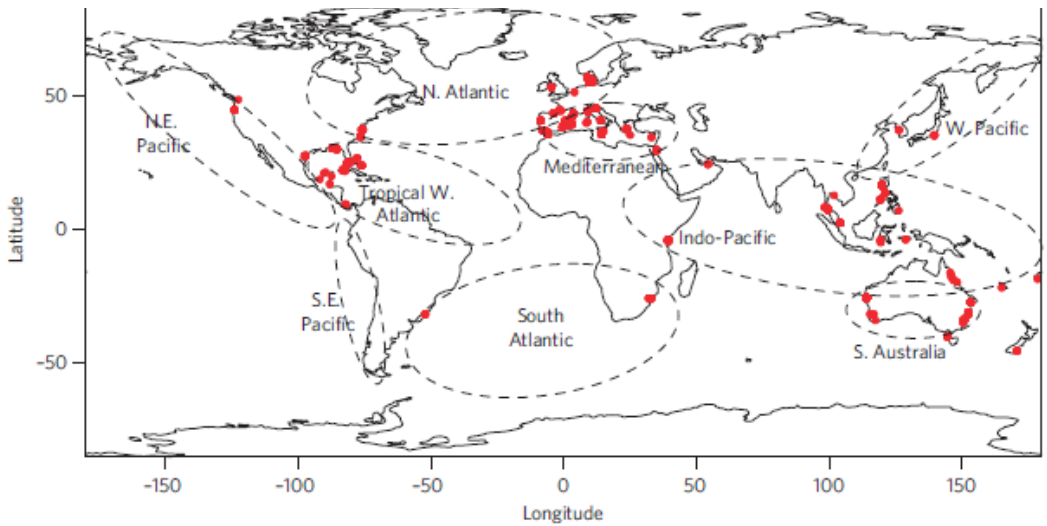
nature geoscience

ARTICLES

PUBLISHED ONLINE: 20 MAY 2012 | DOI: 10.1038/NGEO1477

James W. Fourqurean[1]*, Carlos M. Duarte[2,3], Hilary Kennedy[4], Núria Marbà[2], Marianne Holmer[5], Miguel Angel Mateo[6], Eugenia T. Apostolaki[7], Gary A. Kendrick[3,8], Dorte Krause-Jensen[9], Karen J. McGlathery[10] and Oscar Serrano[6]

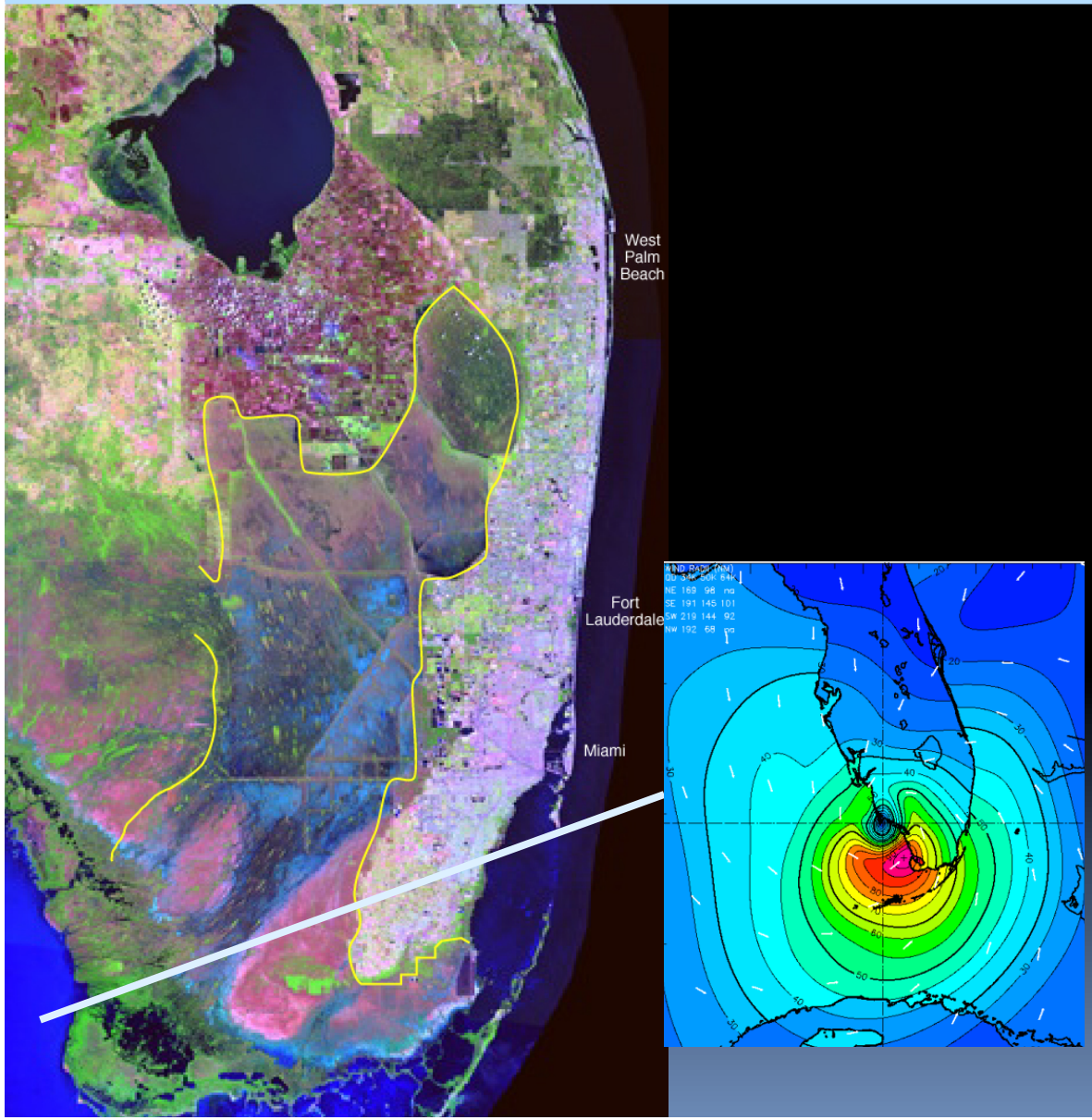
Carbon stocks examined in over 900 seagrass meadows



A multi-billion dollar carbon sink ... Professor Jim Fourqurean studies the seagrasses of Shark Bay. (Photo: Gary Kendrick)

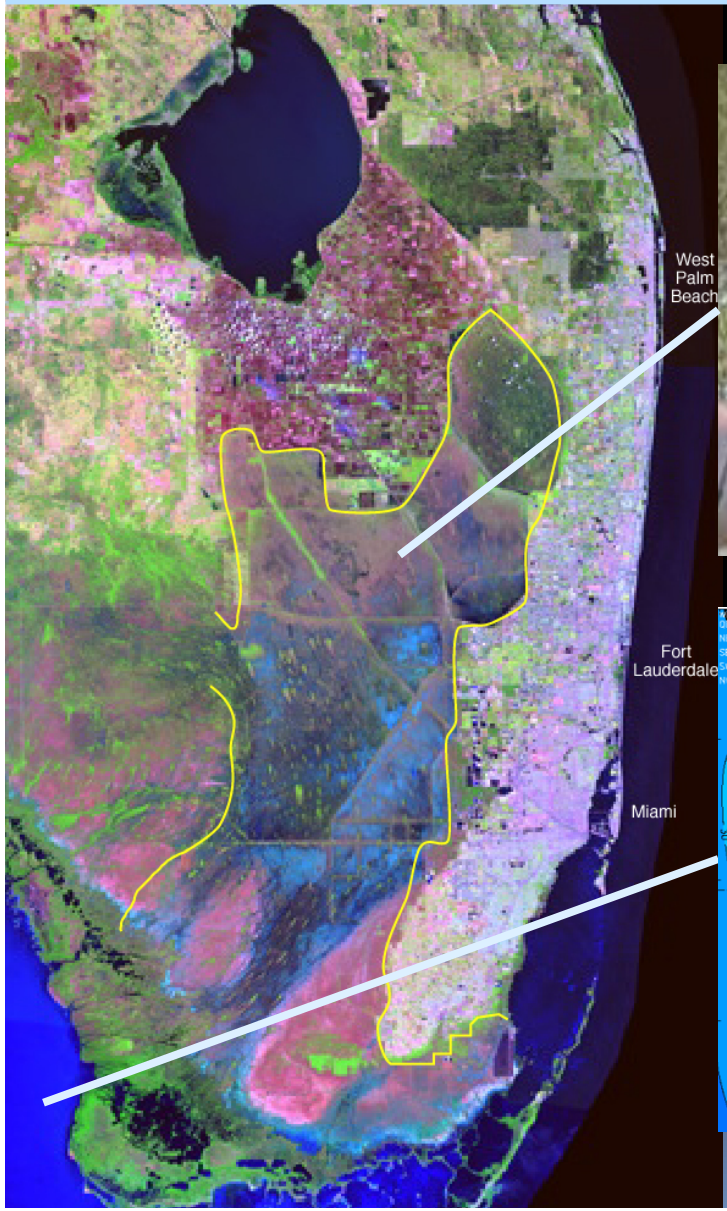
The amount of carbon stored per unit area of seagrass meadow is equivalent to forests

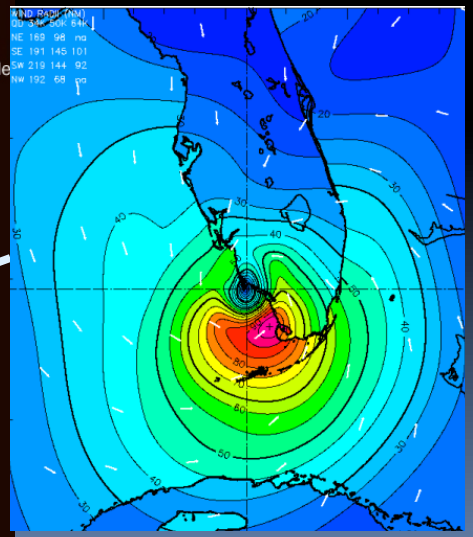
Carbonate chemistry creates a productivity paradox



- Storms, tides and groundwater deliver marine P subsidy that stimulate high coastal productivity

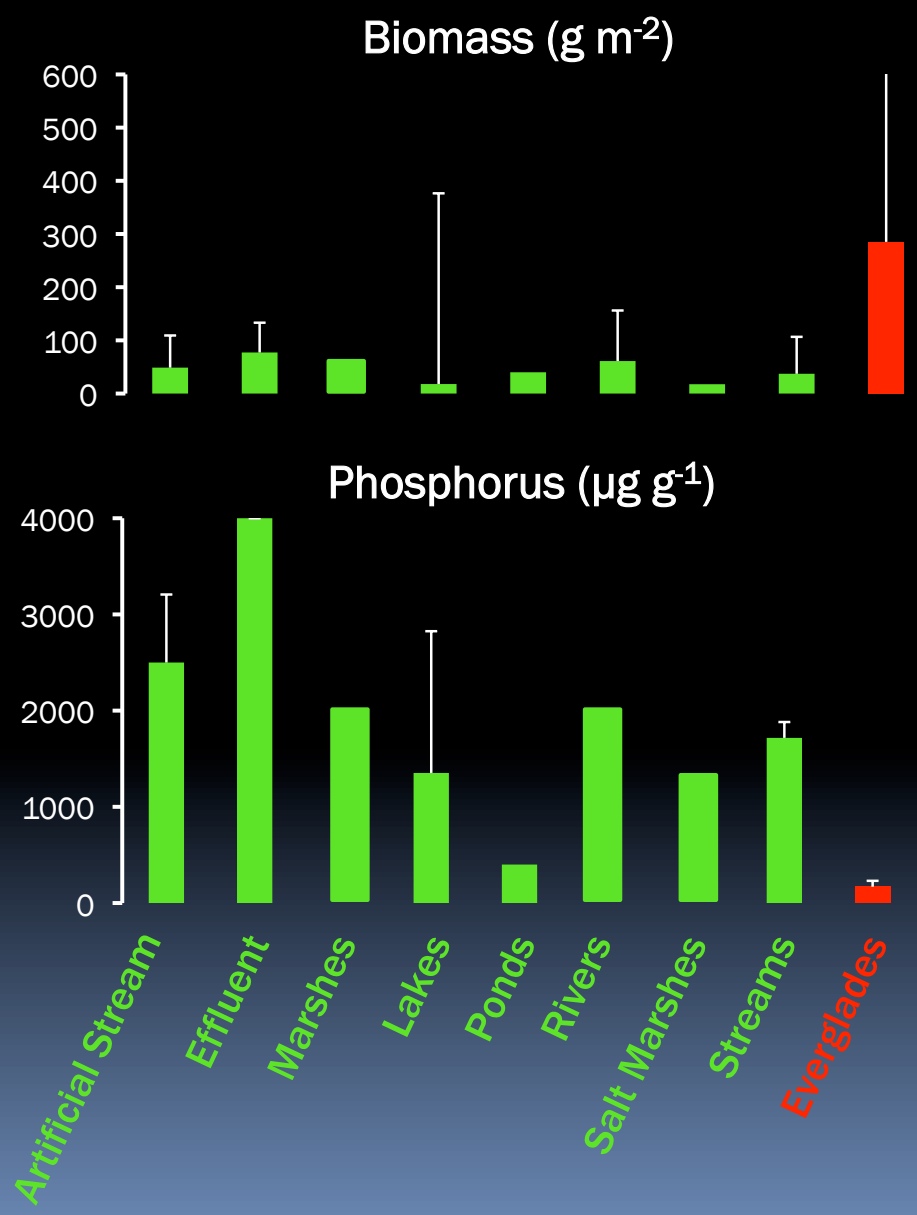
Carbonate chemistry creates a productivity paradox





- Limestone and periphyton regulate water column P concentrations to oligotrophic levels (10 ppb)
- Storms, tides and groundwater deliver marine P subsidy that stimulate high coastal productivity

Productivity Paradox – an iconic Everglades feature



- Freshwater Everglades marshes are highly P-limited
- Benthic microbial biomass is several orders of magnitude higher than other aquatic ecosystems

Productivity Paradox – Iconic feature of karstic wetlands?

Karst periphyton studies

Karstic wetland field team from FIU and UNAM at the Sian Ka'an Biosphere Reserve in Quintana Roo, Mexico

1. Everglades, Florida

2. New River, Belize

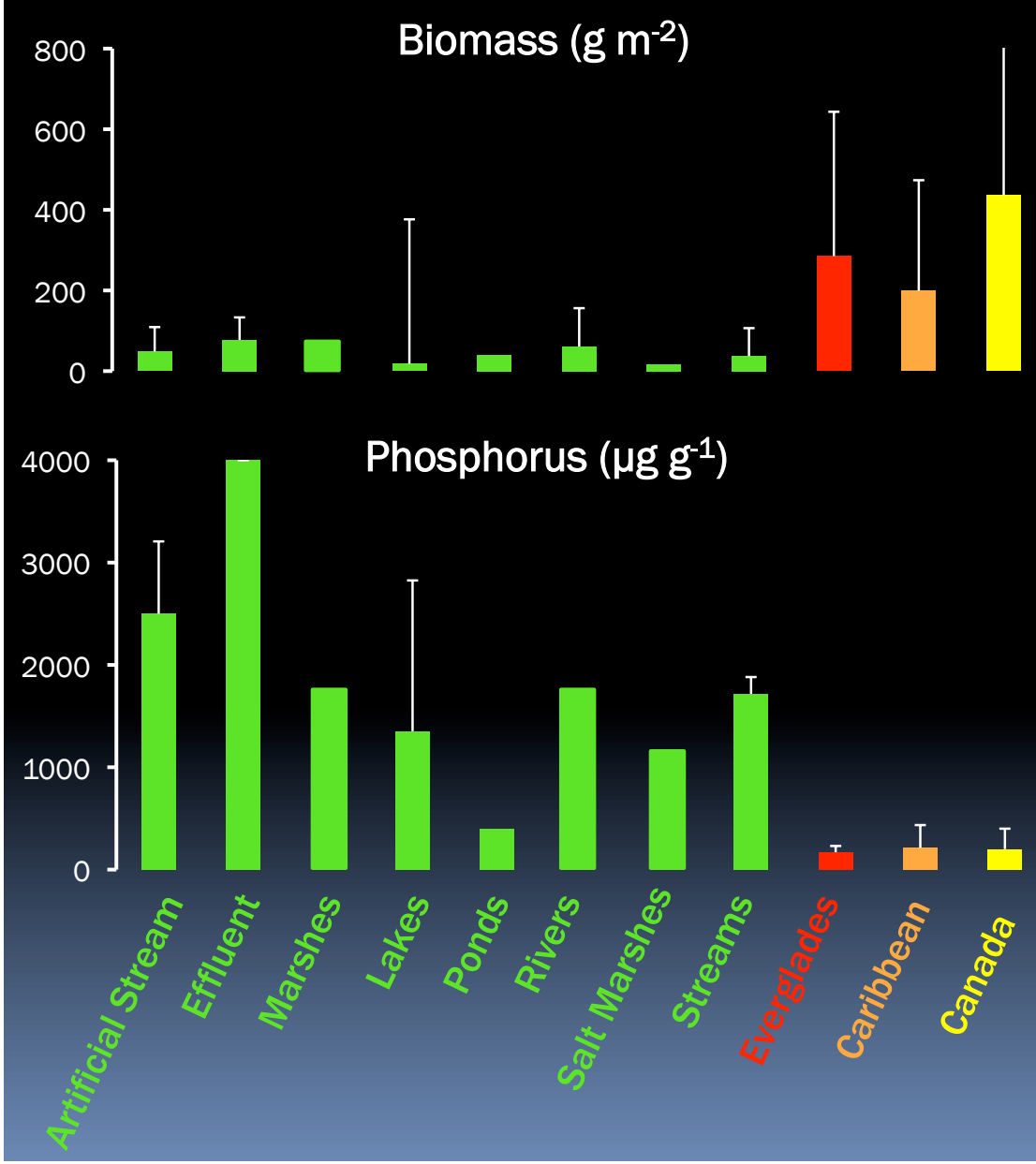
3. Sian Ka'an, Yucatan

4. Black River, Jamaica

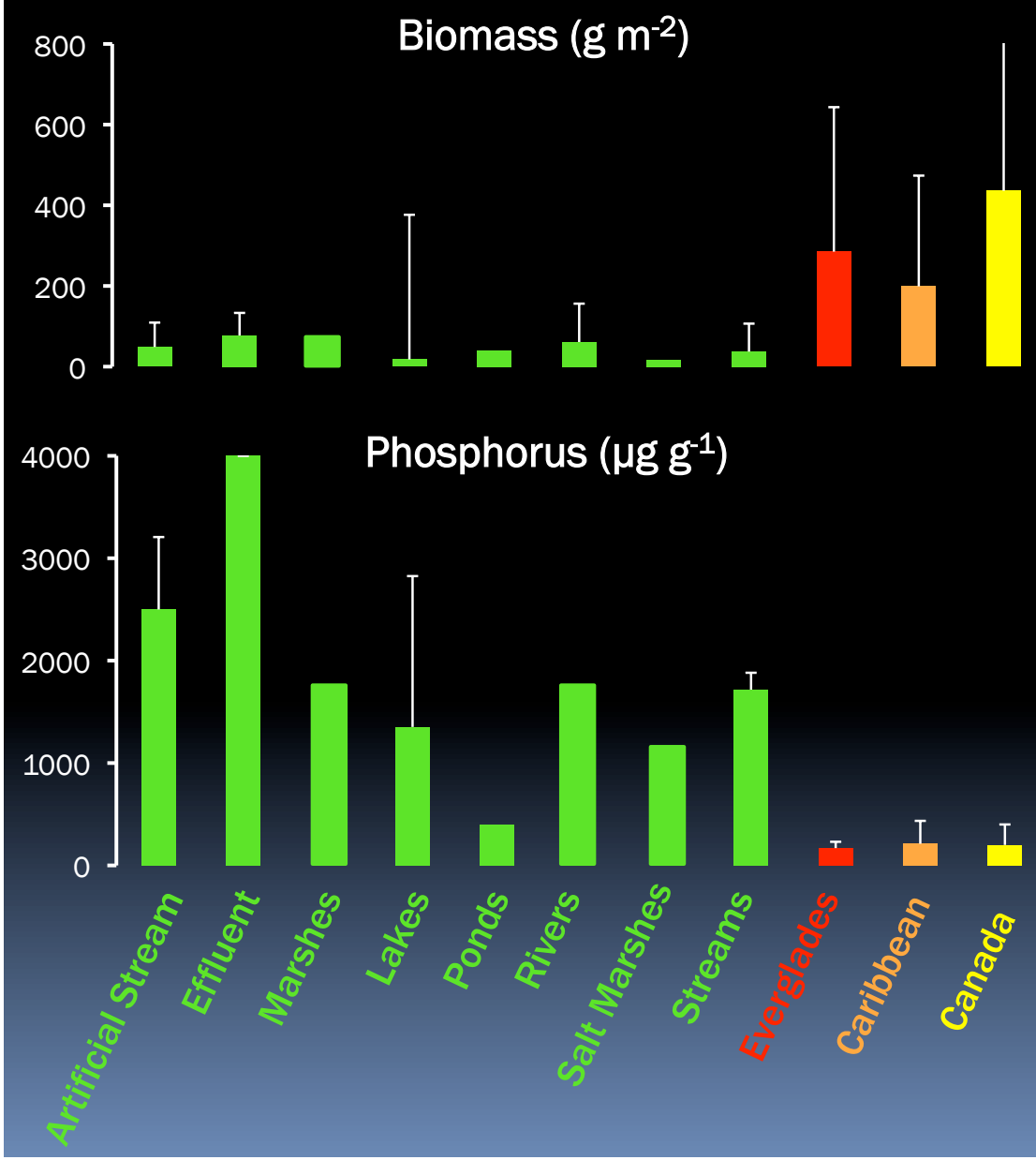
5. Dorcas Bay, Ontario

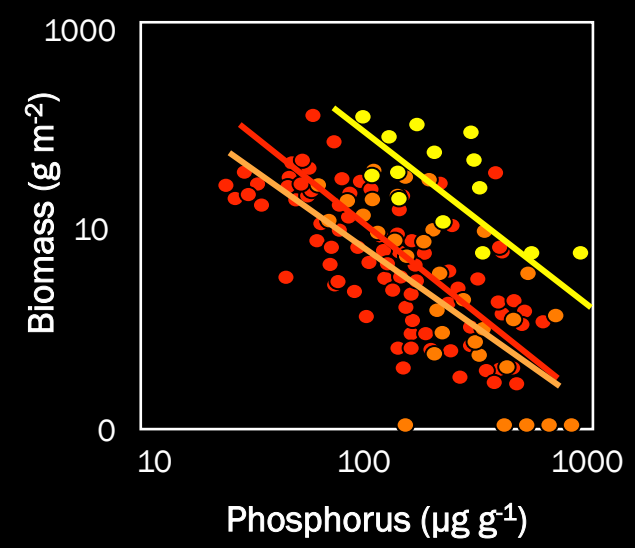
6. Beatie Bay, Ontario

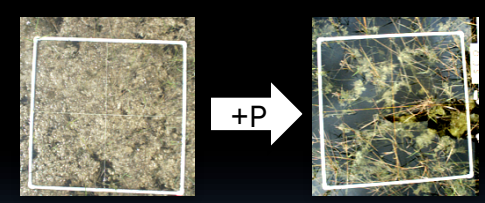
Productivity Paradox – Iconic feature of karstic wetlands?



Productivity Paradox – Iconic feature of karstic wetlands?







- Benthic microbial biomass consistently high across karstic wetlands
- Inverse relationship to P availability is consistent

Microbial Species Endemism…or is everything everywhere?

Microbial mat, Everglades

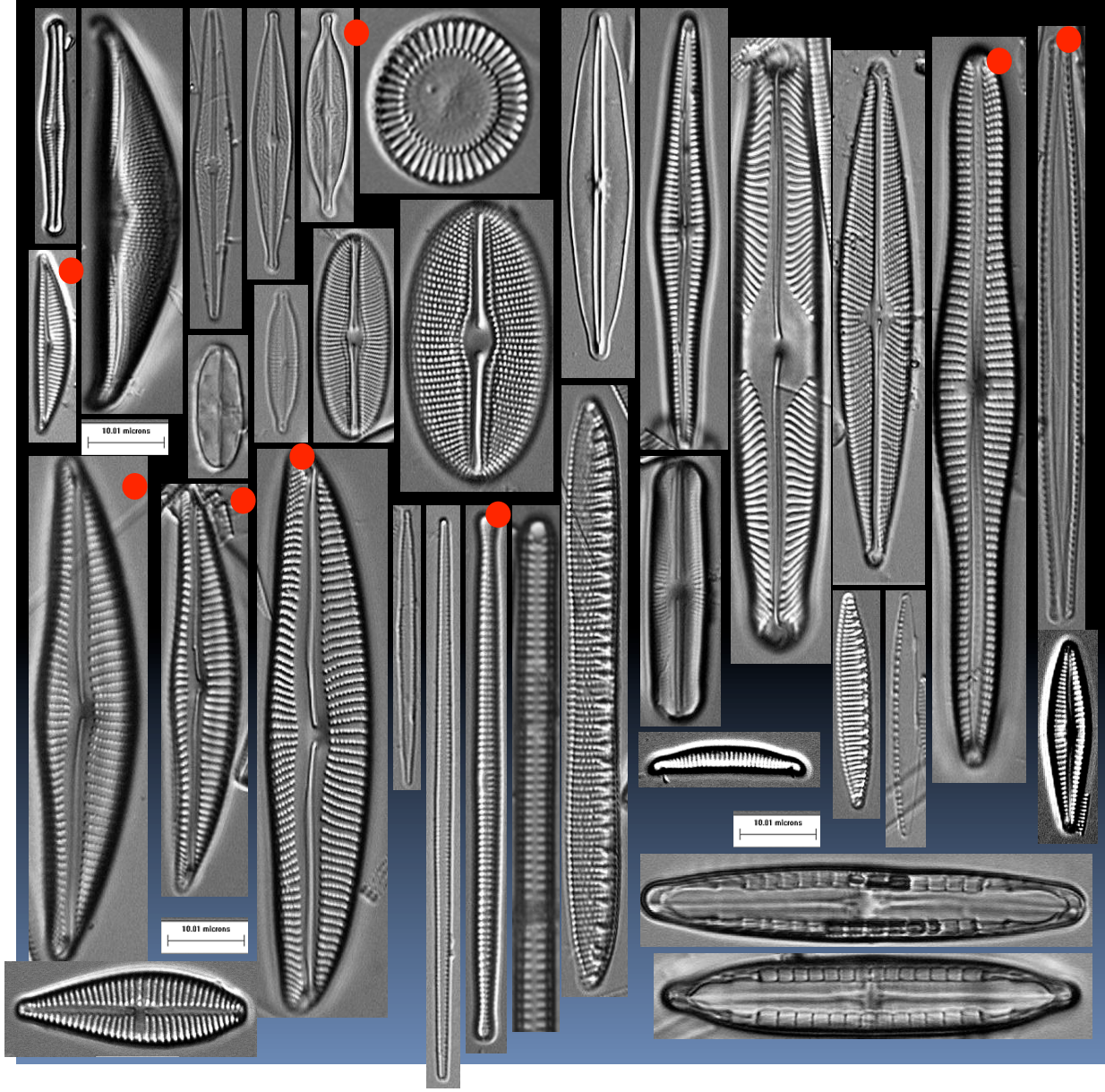
- Cyanobacterial assemblage contains globally distributed stromatolitic taxa

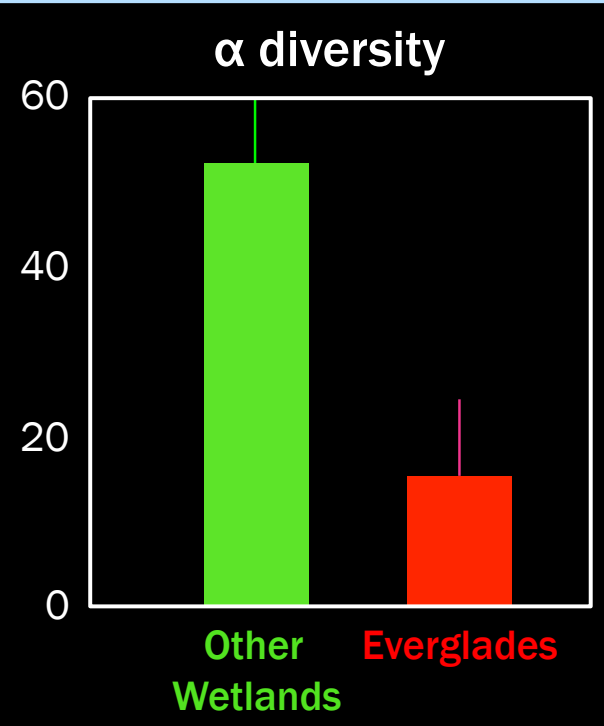
- Initial investigations of Everglades diatom flora indicated 20% endemics and many new species

Stromatolites, Shark Bay, Western Australia

Microbial Species Endemism…or is everything everywhere?

Most abundant Everglades diatoms

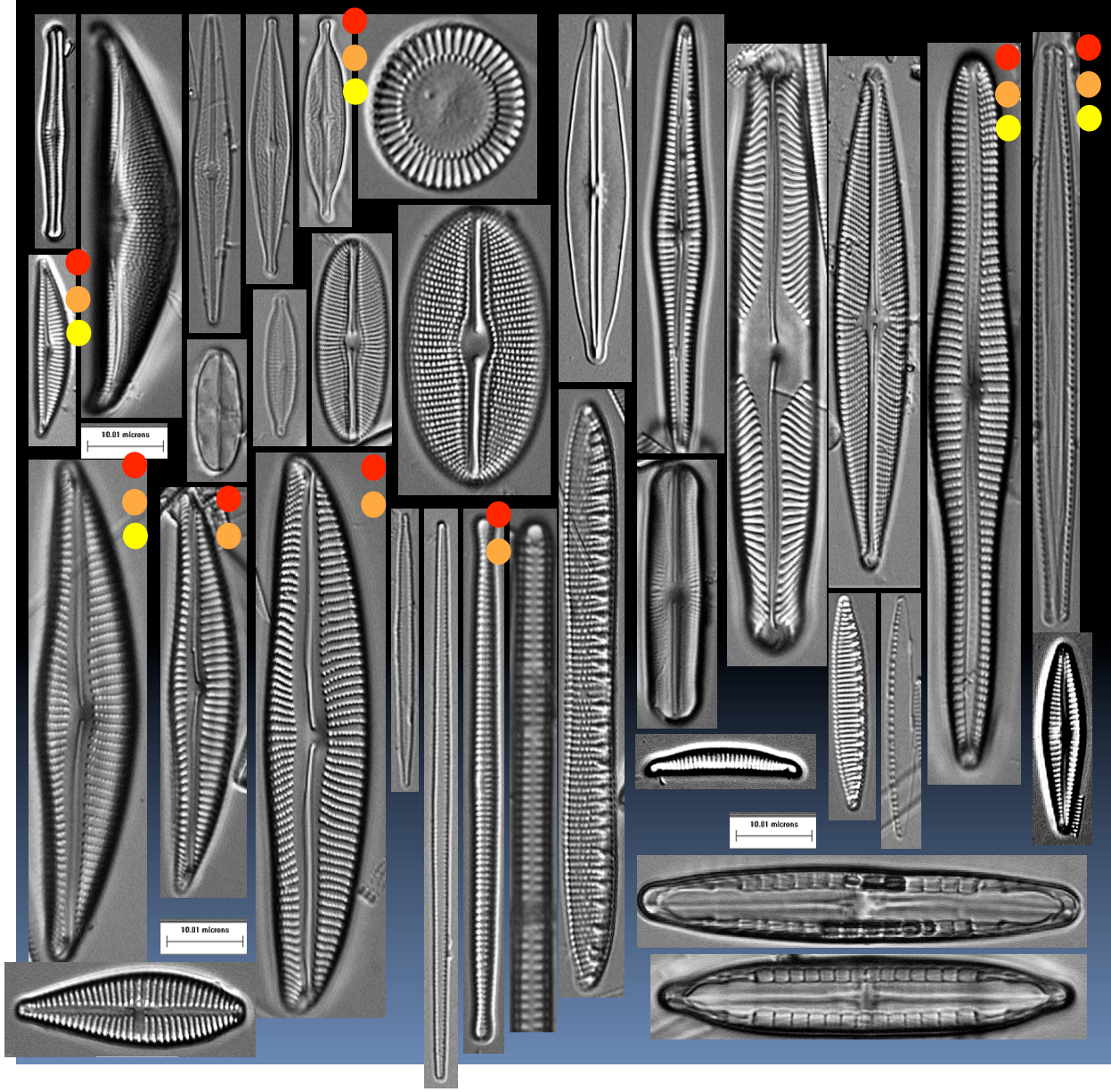


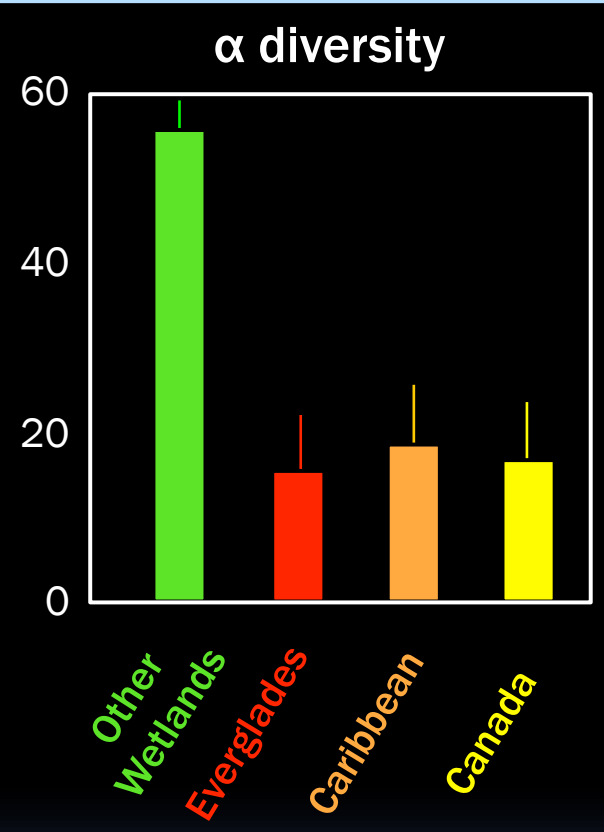


● Known only to Everglades

Microbial Species Endemism…or is everything everywhere?

Most abundant Everglades diatoms

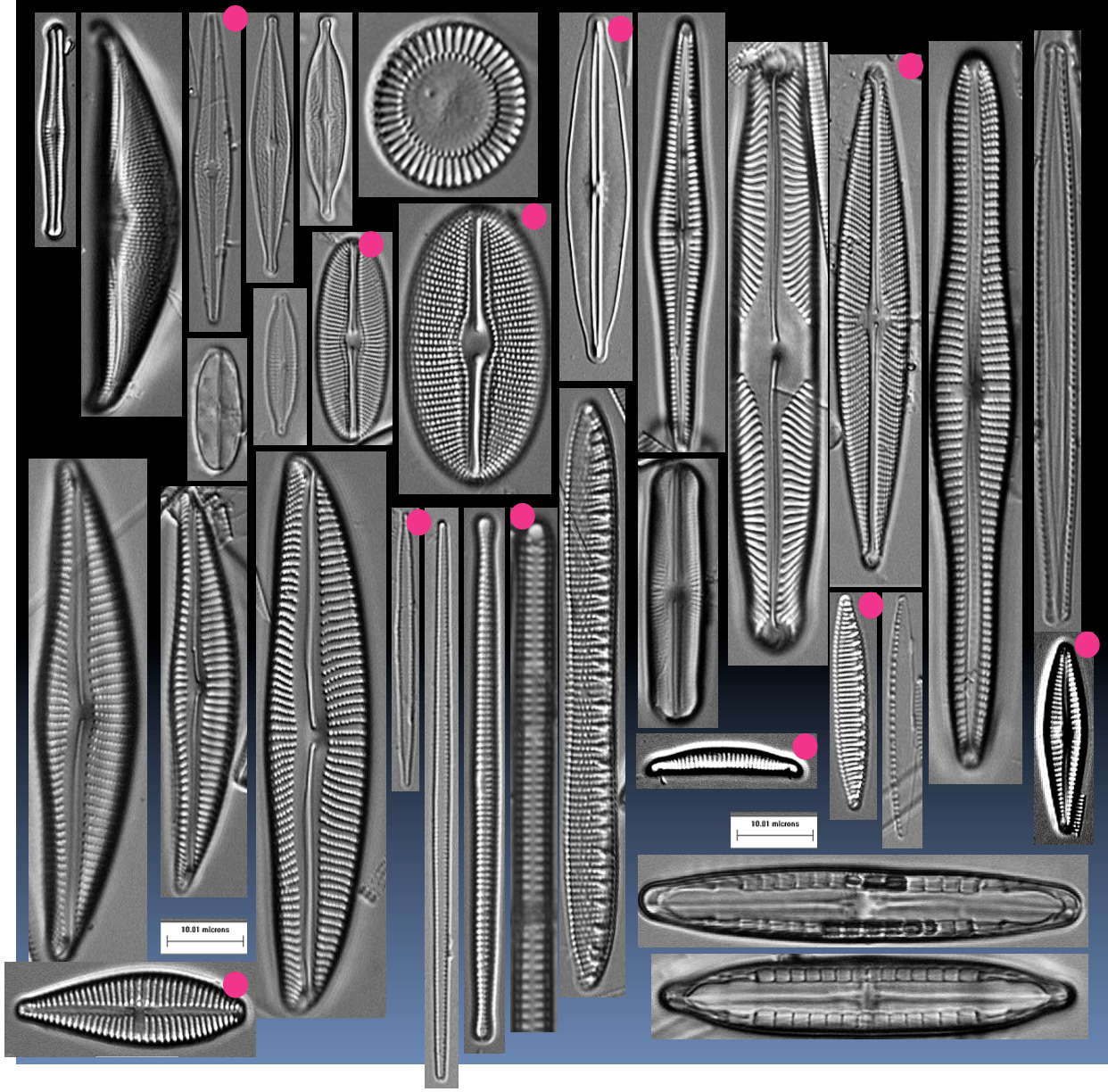


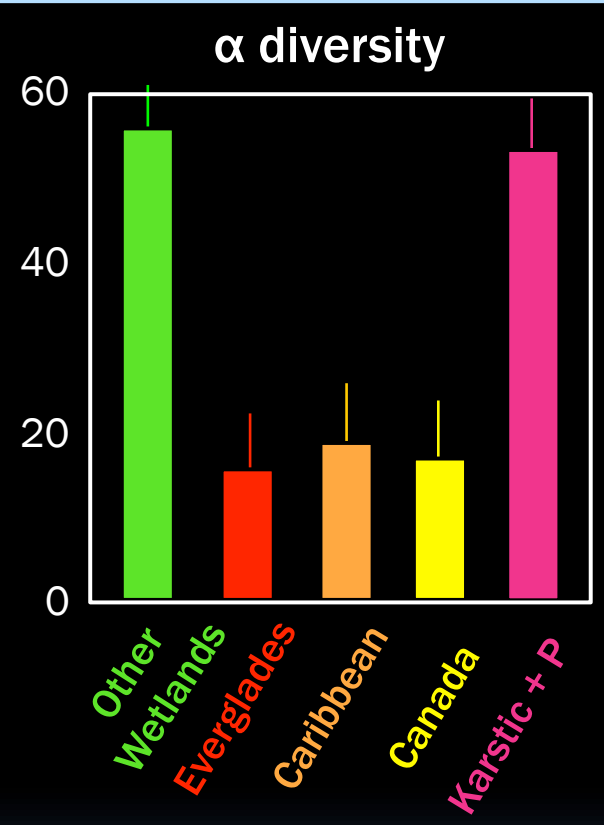


- Known only to Everglades
- Found in Caribbean
- Found in Alvars

Microbial Species Endemism…or is everything everywhere?

Most abundant Everglades diatoms





Diatom-based P inference models calibrated in Caribbean wetlands using Everglades assessment approach

● Cosmopolitan Weedy Taxa

La Hée & Gaiser 2011

Iconic ecosystem sustainability

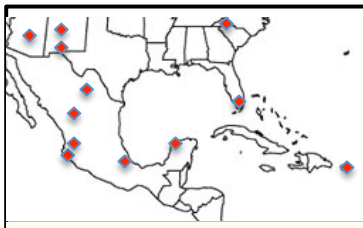
- International studies reveal iconic features broadly characteristic of karst wetlands
  - Upside-down biogeochemistry
  - Paradoxical productivity patterns
  - Constrained biological assemblages

- ILTER studies have allowed robust understanding of drivers of long-term hydrological, ecological, and social change in these distinctive ecosystems, reducing uncertainties about long-term sustainability under different agents of change.

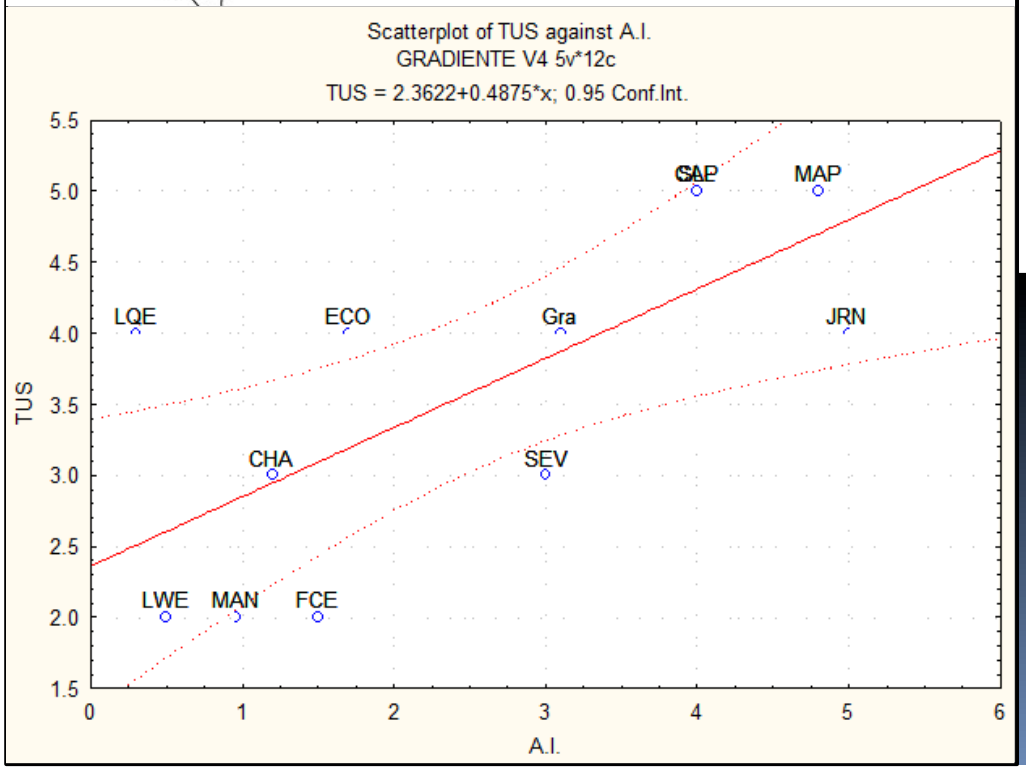
Catalyzing international collaborations to develop a platform for ecohydrological research

Workshop in Chamela, Jalisco, Mexico, September 2012 (Bill McDowell, PI)

How do biophysical and social attributes facilitate or limit the ability to build the resilience of social ecological systems such that sustainability of water is ensured in the face of internally and externally driven changes?



Relationships between aridity and water use at US and Mexican LTER sites



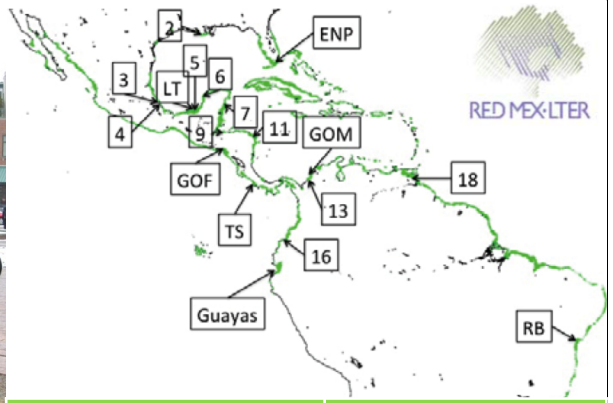
- Preliminary analyses that stratified each of the sites by social and ecological indices revealed strong patterns in, for example, aridity and water use.
- Gradient approach was proposed for development as manuscript and proposal.

Vulnerability Assessment of Mangroves in the Americas

Marc Simard (Jet Propulsion Laboratory), Rinku Roy-Chowdhury (Indiana University & FCE), Temilola Fatoyinbo (Goddard Space Flight Center), Victor- H. Rivera-Monroy (Louisiana State University & FCE)

NASA Land Cover Land Use Change Program (Spring 2012-Winter 2015)

Goal: To develop spatially explicit models of mangrove forest vulnerability across North, Central and South America by integrating socioeconomic coarse datasets and *local surveys* with multi-sensor remote sensing of mangrove use and cover change.



Intensive Sites	Planned dates for field campaigns
Celestun/Campeche	August 2012
Brazil (Caraguatuba region)	November 2012
Golfo de Morosquillo, Colombia	2013
Terraba Sierpe, Costa Rica	2013
Everglades National Park, USA	ongoing
Guayas, Ecuador	2013
Gulf of Fonseca, Honduras	2014

- *Leveraging existing collective databases, collaborations and expertise,* two nested sets of sites were selected for extensive (17) and intensive (7) sampling, representing a wide range of socio-demographic, economic, policy and ecogeomorphic contexts found throughout the Americas.
- Intensive assessments will be conducted for calibration and validation of the regional-scale models, relating socioeconomic activity with local changes in mangrove forest use and cover.

FCE collaborative research in the Caribbean and beyond

Leveraging expertise, data products and insight within US LTER and among international LTER Networks is contributing vital ecosystem research for addressing critical global policy issues, advance research and education beyond what could otherwise be accomplished and continue to engender globally-engaged US scientists