Integrated Landscape Trends of Hydrology, Nutrients, Soils, and Vegetation Under Future Management Scenarios
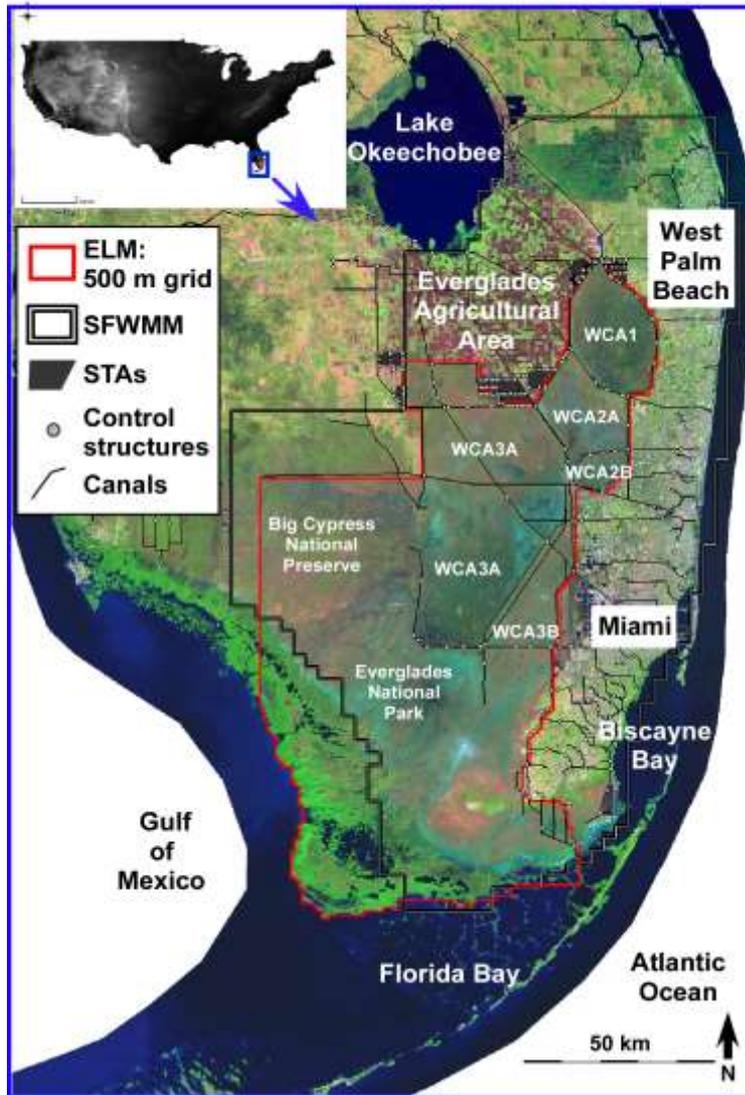
GEER 2017
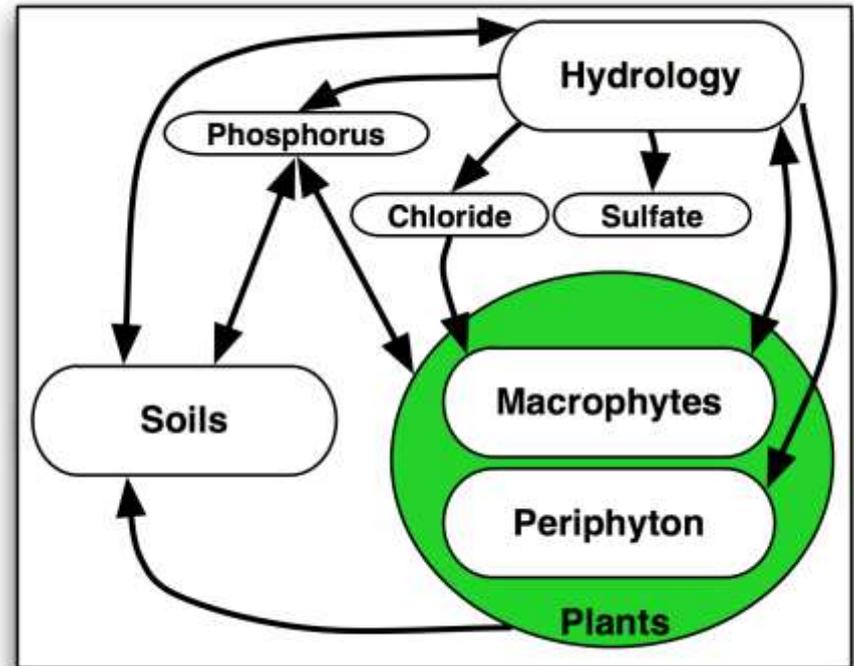
H. Carl Fitz[1,2]
Hilary D. Flower[2]
Mark C. Rains[2]

[1]EcoLandMod, Inc.
[2]Univ. South Florida

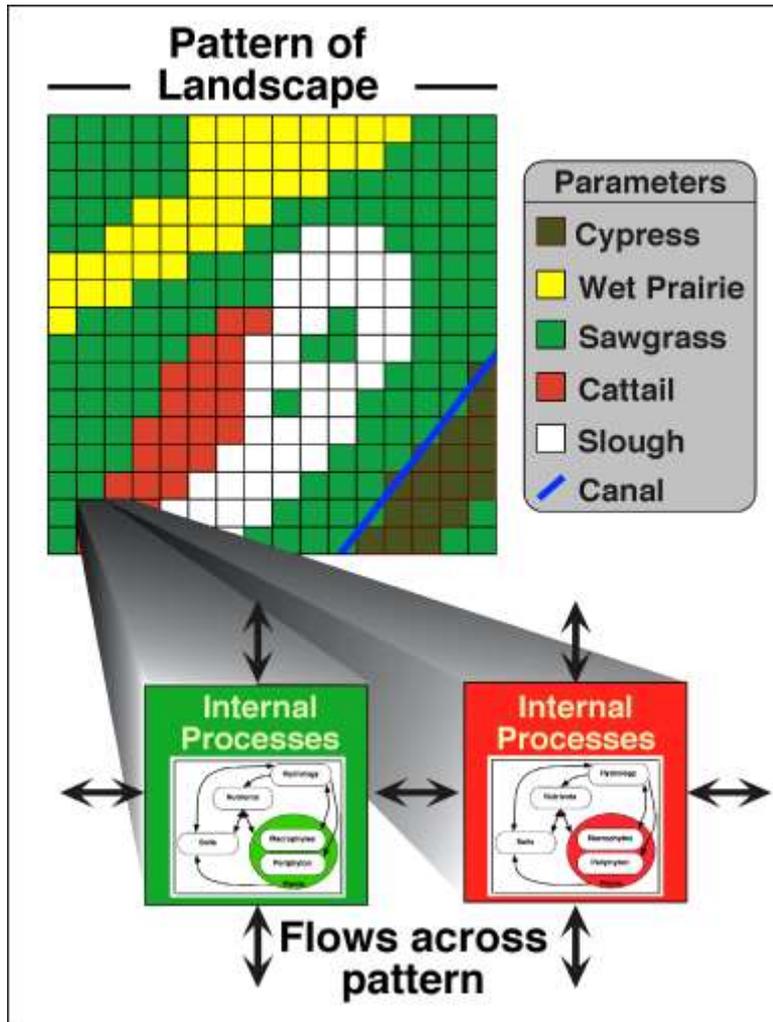**Ecological Landscape Modeling**   http://www.ecolandmod.com

ELM Design:
Integrating ecological interactions

• **Ecosystem model, integrating dynamic processes of hydrology, biogeochemistry, & plant biology**

• **Arrows denote flows of carbon, water, & phosphorus, and information feedbacks among modules**

ELM Design:
Pattern-process spatial interactions

Pattern of Landscape

Parameters
- Cypress
- Wet Prairie
- Sawgrass
- Cattail
- Slough
- Canal

Internal Processes

Internal Processes

Flows across pattern

- **Landscape *pattern* (of habitats) affects local ecosystem *processes***

- ***Processes* affect landscape *pattern* (via habitat succession)**

- **Canals represented by exact vectors, dynamic canal-marsh interactions; managed flows at point water control structures**

- **Integrated surface-ground water exchanges**

ELM skill assessments

- **Calibration/validation** (decadal history-matching) statistics

  - **Marsh stage (median, 82 stations): bias= 0 cm; NS Efficiency= 0.61**

  - **Water quality bias (median, 78 stations):**

    - **Phosphorus: marsh= 0 mg•L^{-1}; canals= 0 mg•L^{-1}**

    - **Chloride: marsh= 8 mg•L^{-1}; canals= 13 mg•L^{-1}**

    - **Sulfate: marsh= 0 mg•L^{-1}; canals= -2 mg•L^{-1}**

  - **Other ecological metrics**

    - **Range of analyses at multiple scales/regions (soil processes, succession of cattail, sawgrass, mangroves …)**

- **Peer reviews** over past 20+ years

  - **Research journals (Ecol Model; Restor Ecol; Crit Rev Env Sci Tec; Sust Water Qual Ecol; …)**

  - **Applications for CERP (Independent Panel; Interagency Modeling Center)**

ELM applications:

Scenarios - water quality & periphyton

GEER 2017 session,

Evelyn Gaiser, Melodie Naja, Daniel Childers, and Carl Fitz

Scenarios - soils

GEER 2015 session,

Todd Osborne, Carl Fitz, and Steve Davis

Restoration Ecology (2017)
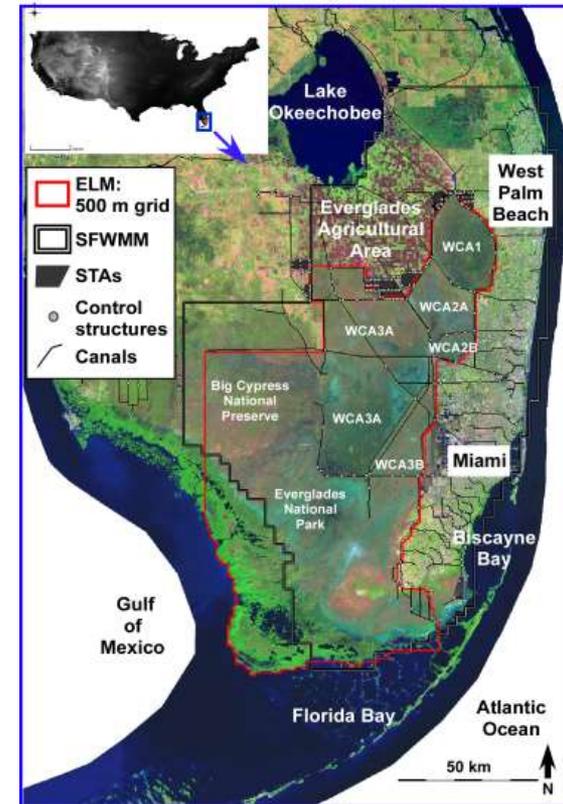
doi: 10.1111/rec.12496

Scenarios - sulfate & methylmercury distributions

GEER 2017 session,

William Orem, David Krabbenhoft, George Aiken, and Carl Fitz

Related CERP ASR project w/ others:
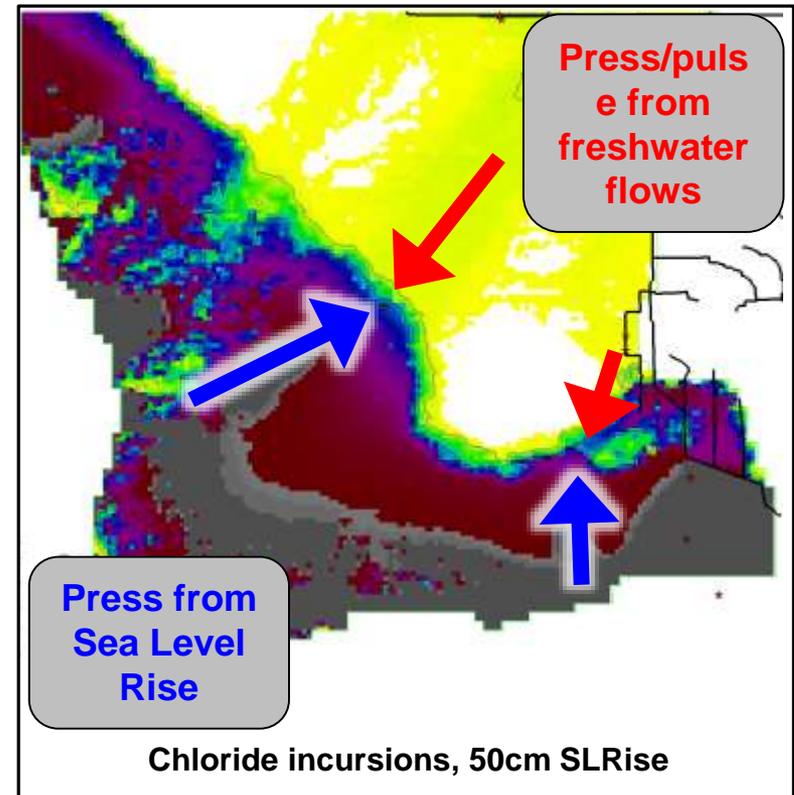*Sust Water Qual Ecol (2014)*

doi:10.1016/j.swaqe.2014.11.004

ELM application:

Visioning the future: scenarios modeling of the Florida Coastal Everglades (FCE)

Just submitted to Environmental Management;
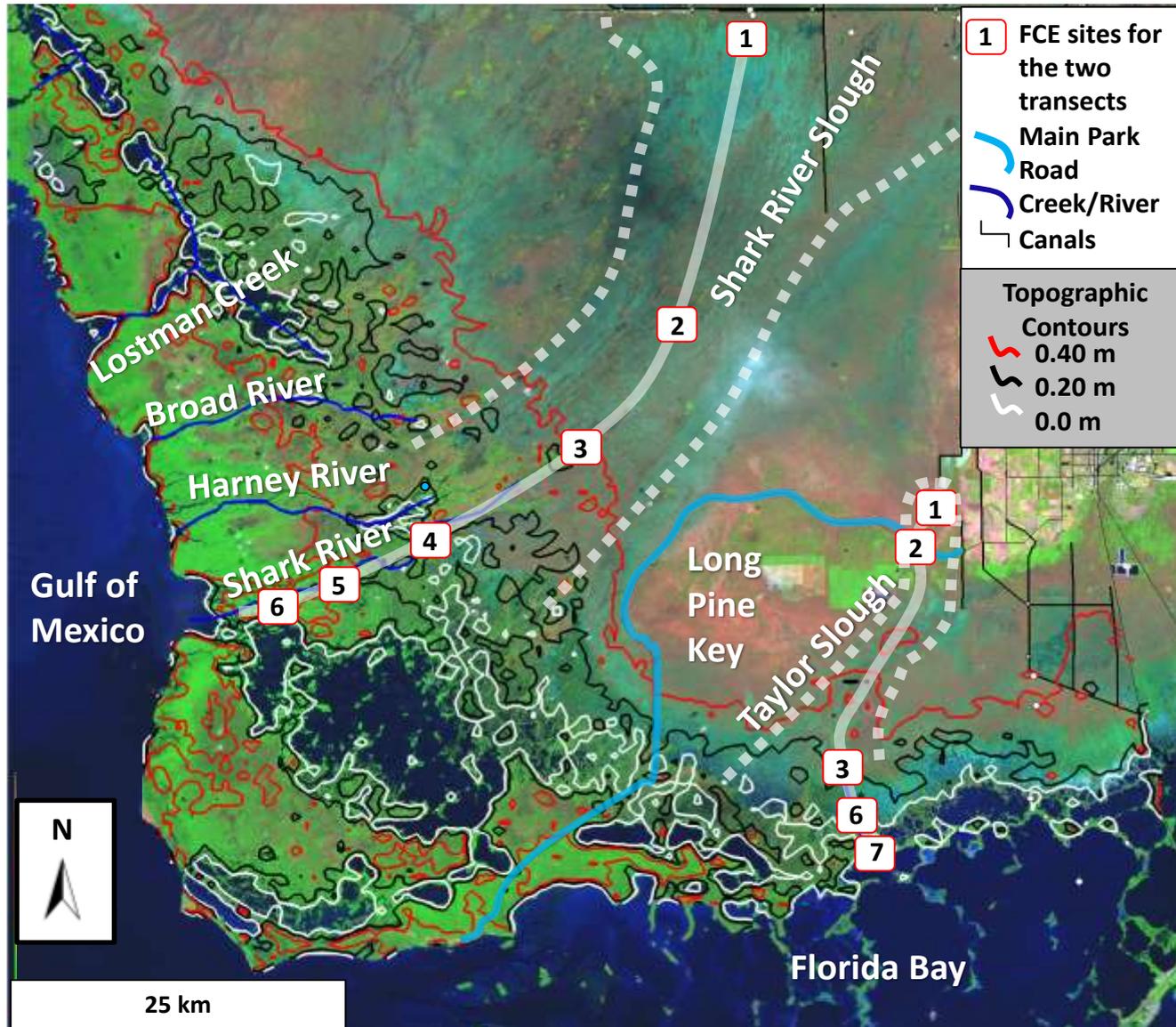**Hilary Flower, Mark Rains, and Carl Fitz;**

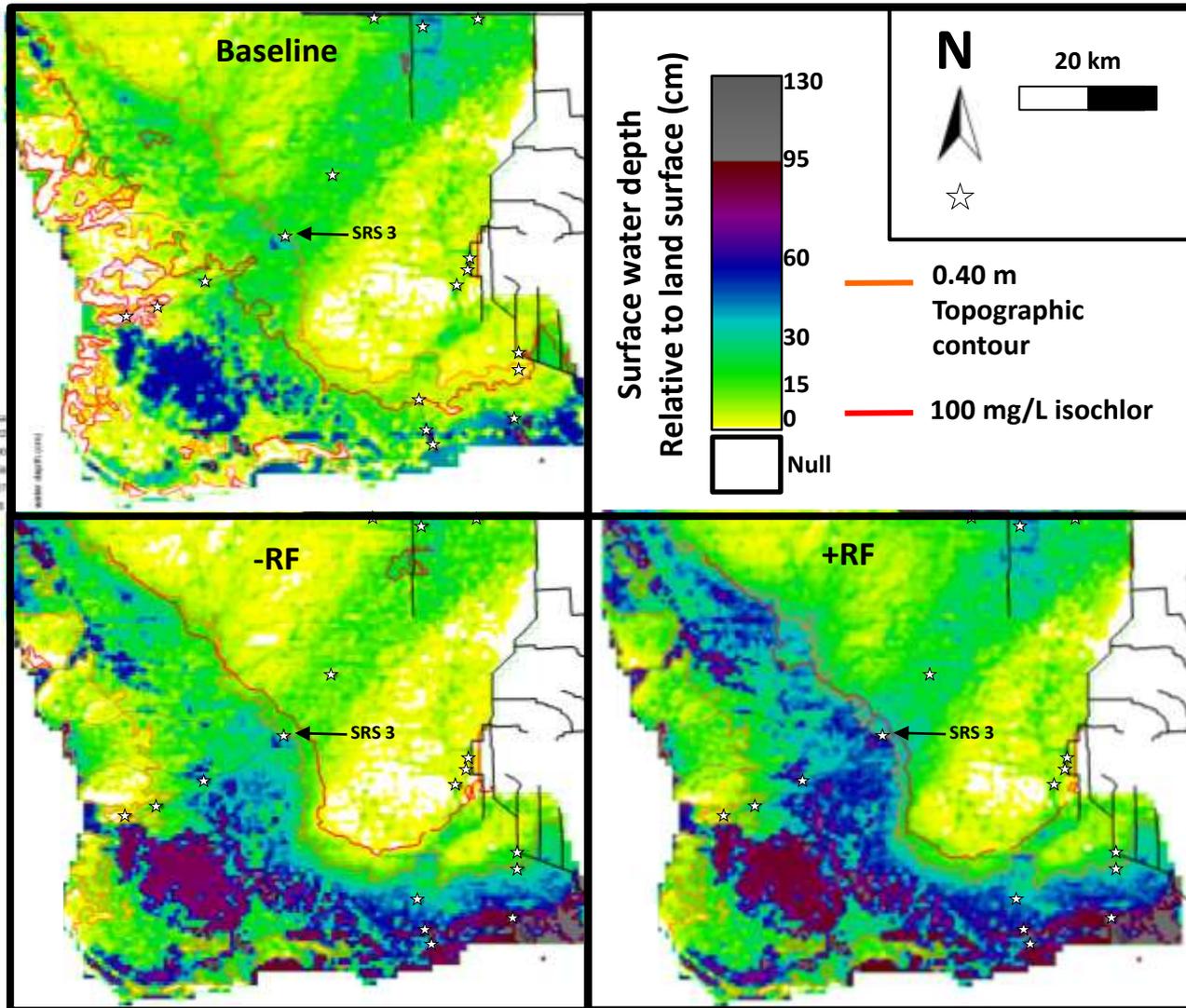*SFWMM runs provided by Jayantha Obeysekera and Jenifer Barnes (SFWMD)*

Press/pulse from freshwater flows

Press from Sea Level Rise

Chloride incursions, 50cm SLRise

ELM application overview

- **Compare landscape responses among 36-yr scenarios of climate change and Sea Level Rise (SLR)**
- **Climate-SLR bookends**
    - § **Existing condition Base**
    - § **Increase rain 10%; Increase temp 1.5° C & pET 7%; Increase Initial sea level by 50cm**
    - § **Decrease rain 10%; Increase temp 1.5° C & pET 7%; Increase Initial sea level by 50cm**
- **Water management & ecology**
    - § **SFWMM water management (Obeysekera & Barnes, SFWMD)**
    - § **ELM driven by SFWMM (point) water control structures, then simulated finer scale hydrology and ecological dynamics**
- **Hydro-ecological Performance Measures**
    - § **Water depths & flow velocities**
    - § **Phosphorus & chloride concentrations (sulfate ignored here)**
    - § **Soil processes**
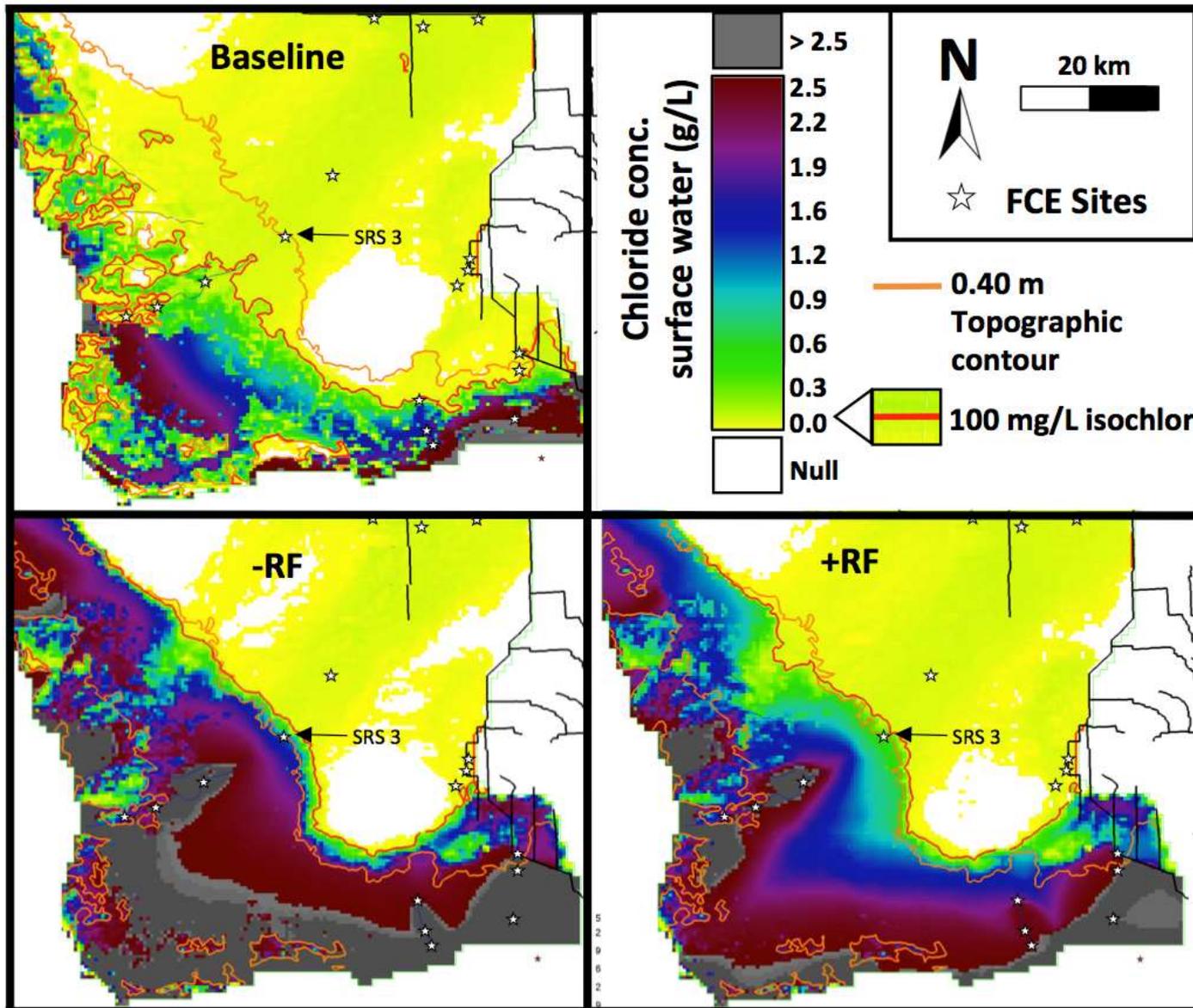   - § **Succession among habitats**

Everglades National Park (model subdomain)

Legend:
- **1** FCE sites for the two transects
- Main Park Road
- Creek/River
- Canals

Topographic Contours
- 0.40 m
- 0.20 m
- 0.0 m

Lostman Creek
Broad River
Harney River
Shark River
Shark River Slough
Long Pine Key
Taylor Slough
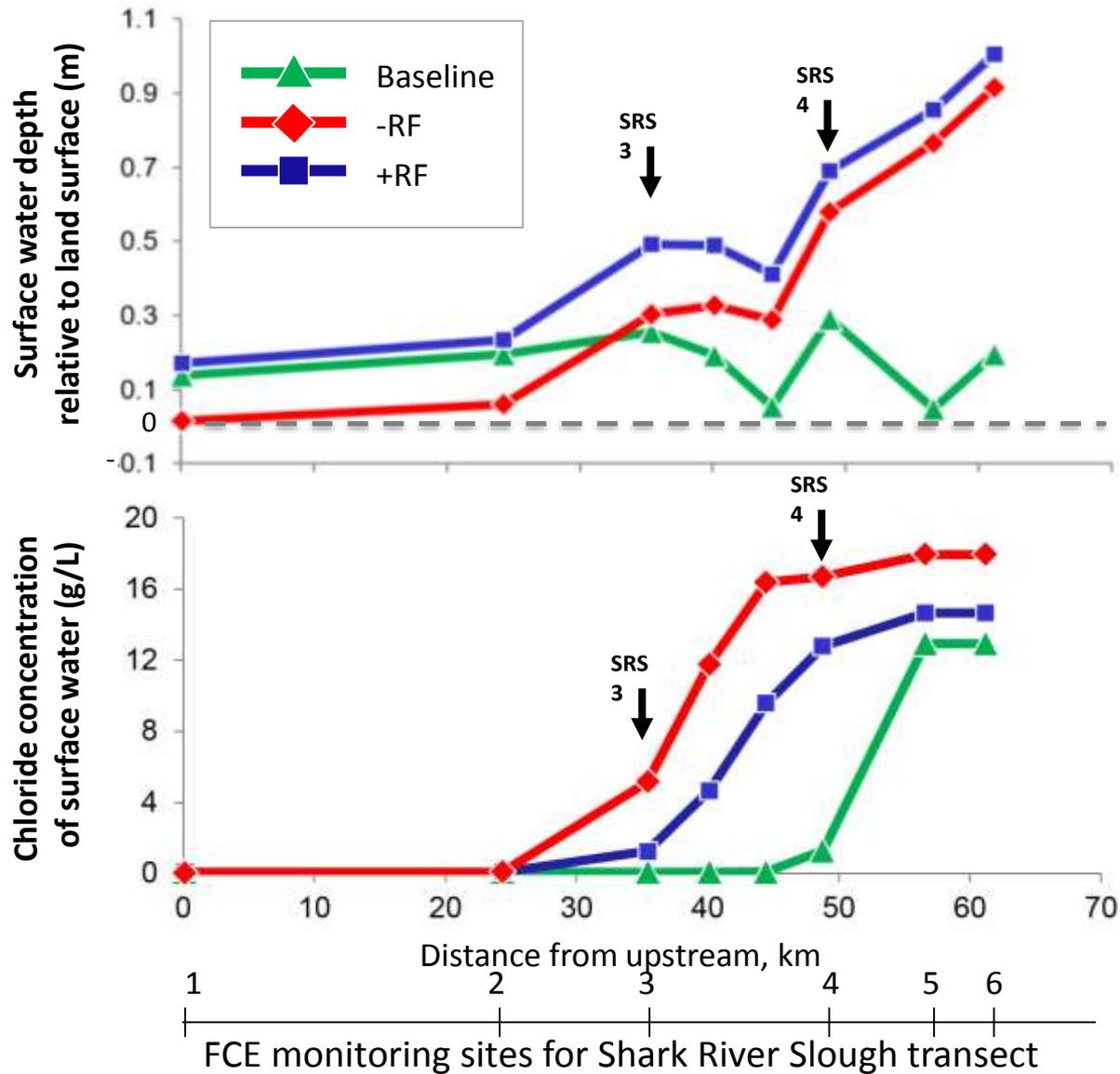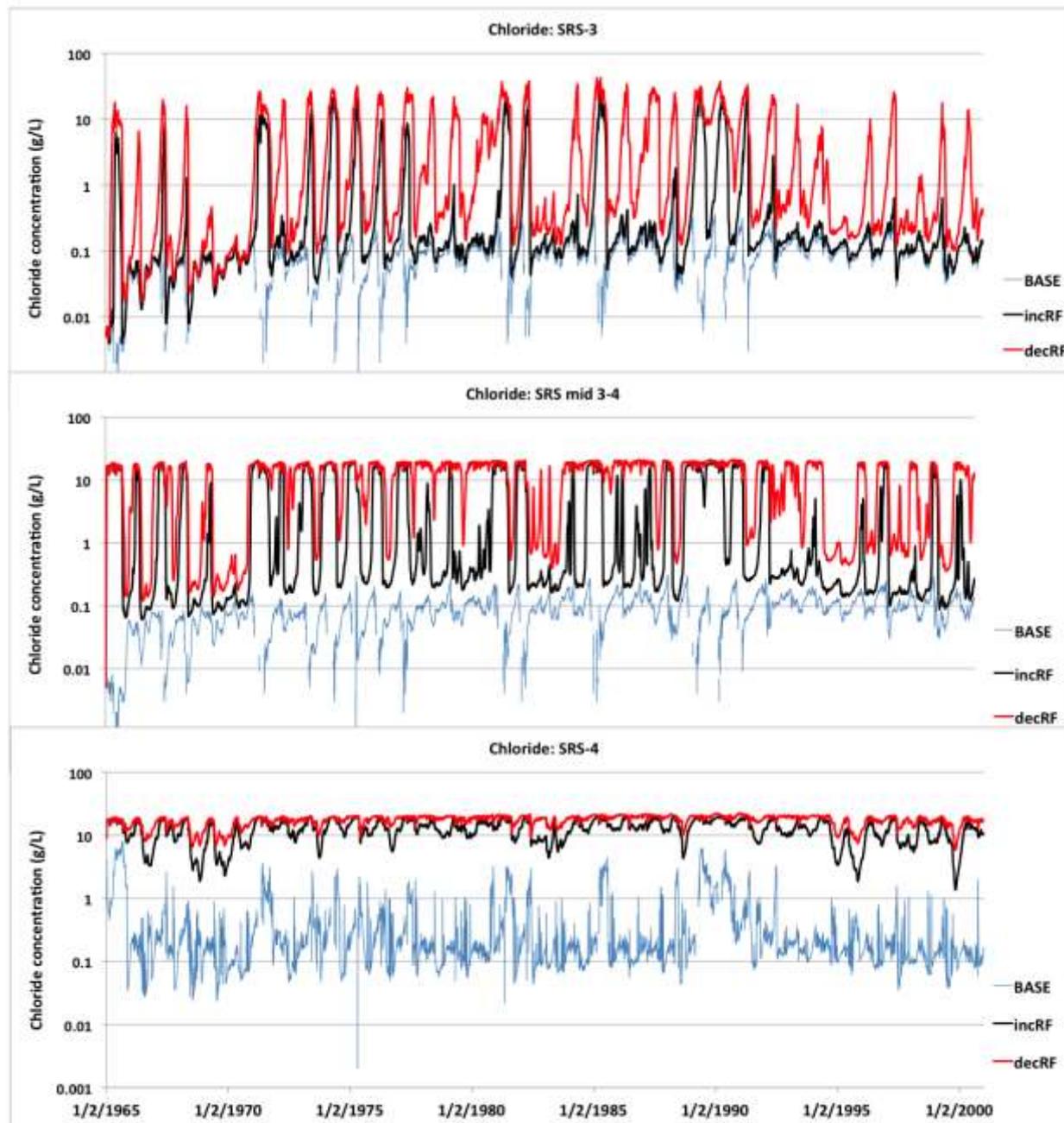Gulf of Mexico
Florida Bay

N

25 km
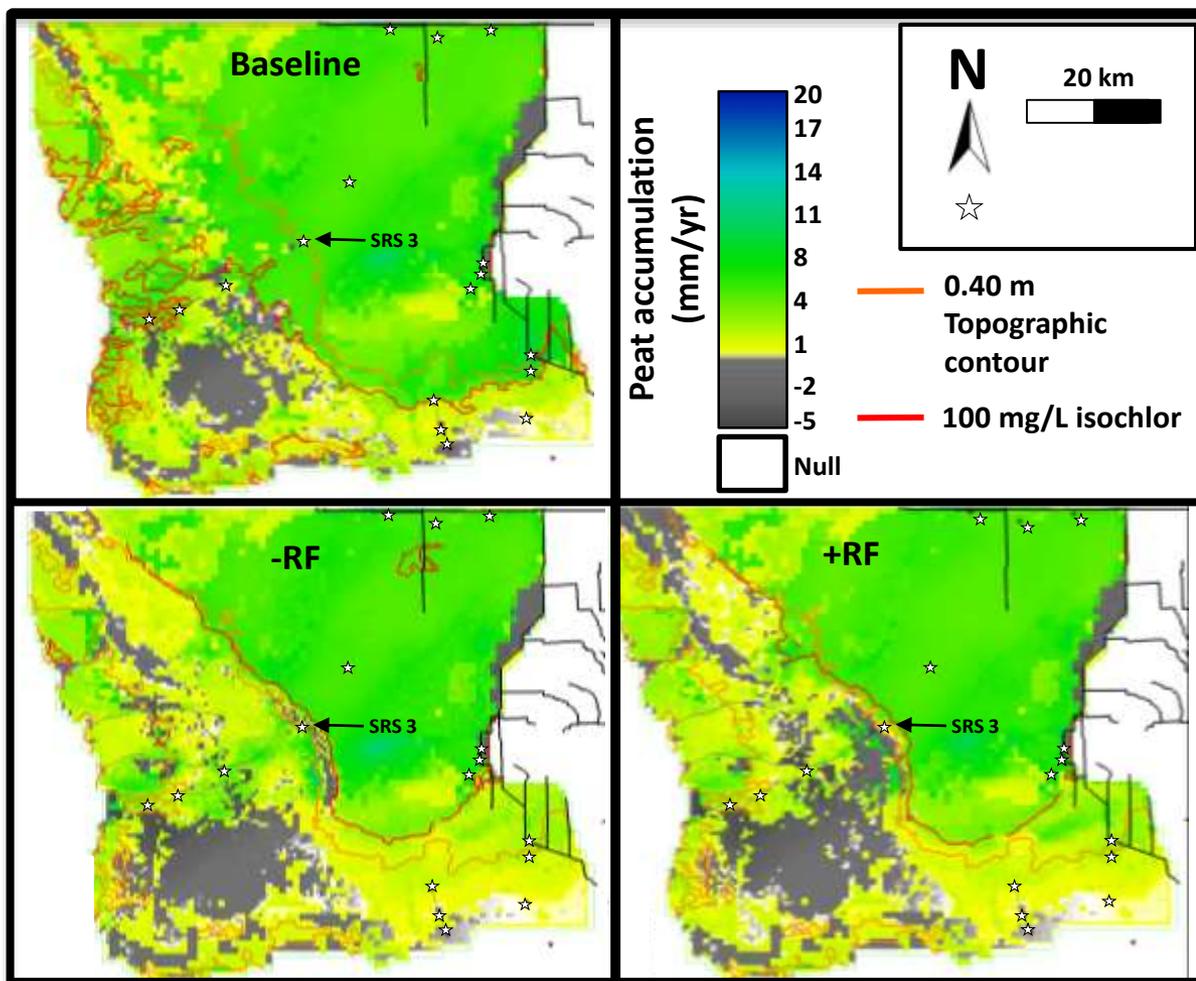
Surface water depth

Surface water chloride
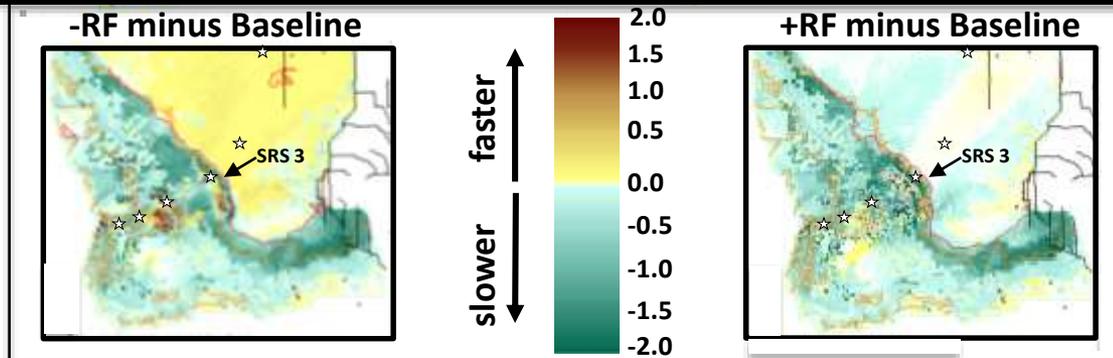
FCE SRS transect gradients: Water depth & chloride

Spatio-temporal gradients: chloride

Peat accretion

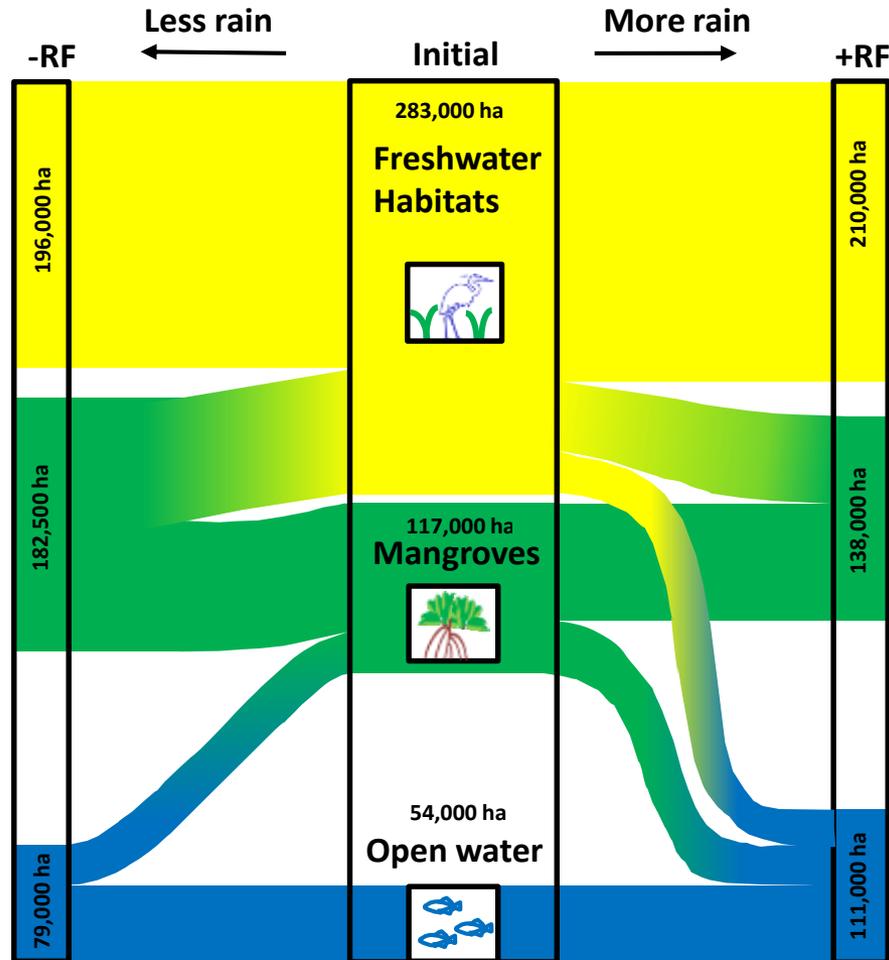**Peat accretion differences**

Baseline

−RF

+RF

−RF minus Baseline

+RF minus Baseline

SRS 3

Peat accumulation (mm/yr)

20
17
14
11
8
4
1
−2
−5

N

20 km

0.40 m Topographic contour

100 mg/L isochlor

Null

faster

slower

2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0

Phosphorus accumulation

Phosphorus accumulation
Difference from Baseline (mg/m²/yr)
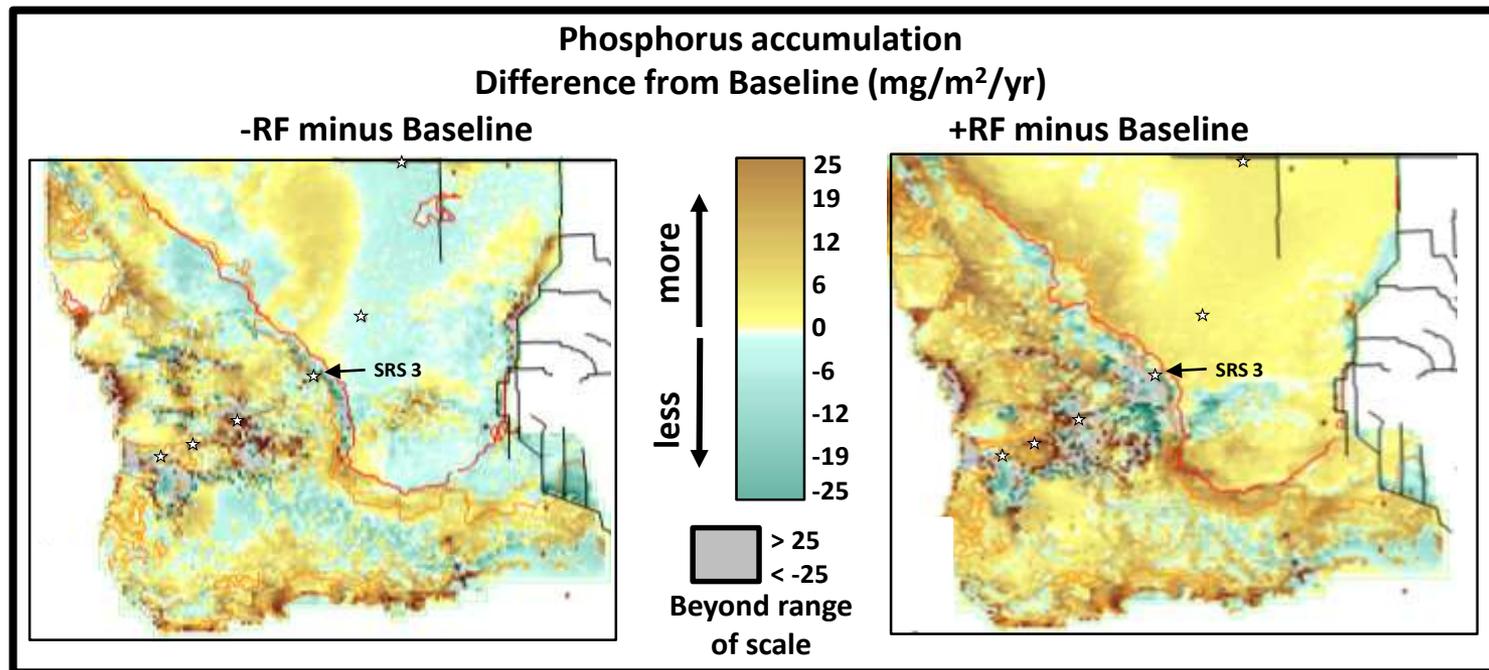
Habitat succession
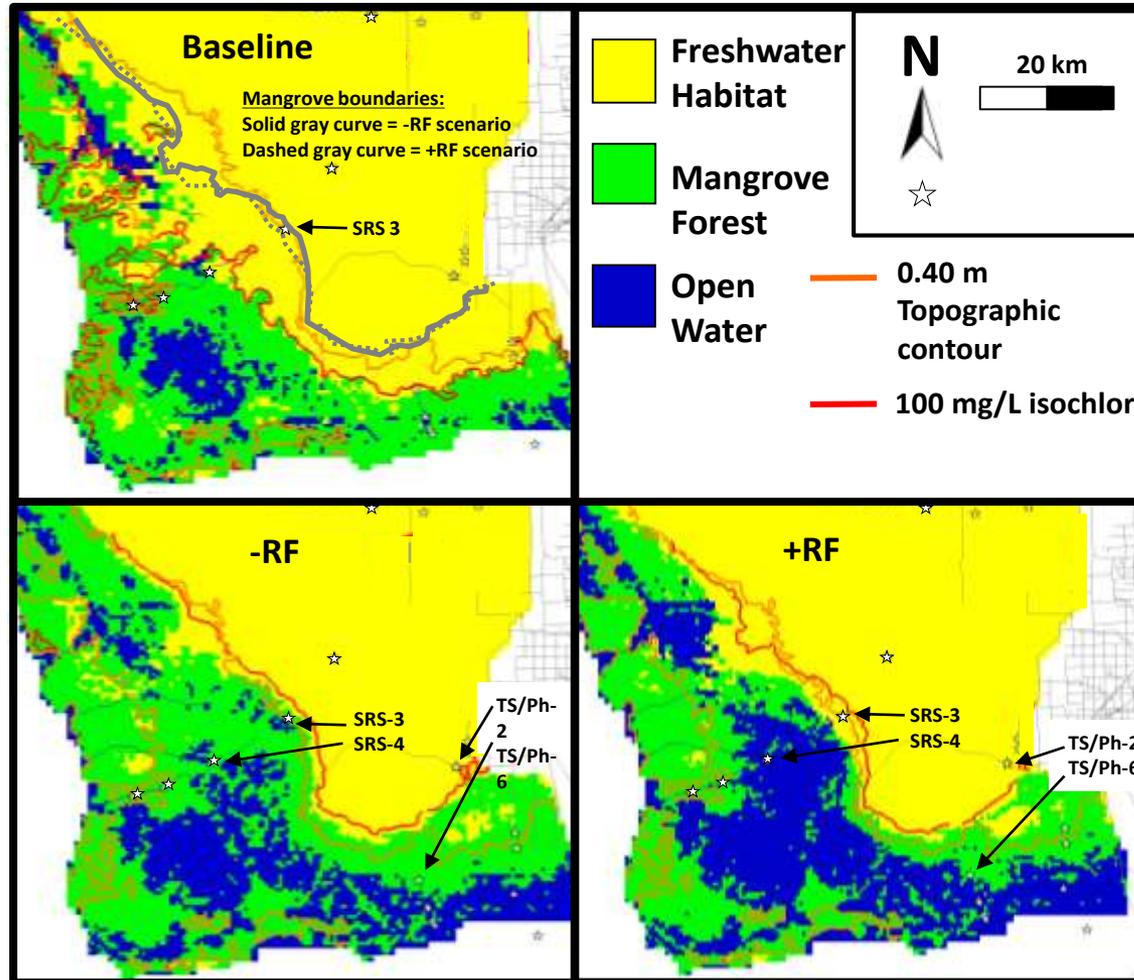
Habitat succession synthesis

Less rain ← | More rain →

-RF | Initial | +RF

283,000 ha
Freshwater Habitats

196,000 ha | 210,000 ha

182,500 ha

117,000 ha
Mangroves

138,000 ha

54,000 ha
Open water

79,000 ha | 111,000 ha

Ecological Landscape Modeling   **ELM** EcoLandMod, Inc.   **http://www.ecolandmod.com**

Integration…

- **Modeling & data-research integration advancing within FCE LTER program**

- **ELM: Ecosystem process integration works (but difficult: e.g., "funky" model vegetation can cascade to dynamics of soils, nutrients, …)**

- **ELM: Extrapolate local-scale research understanding across heterogeneous landscapes & multiple decades (aka spatio-temporal integration)**

- **FCE: Multi-model integration, with linking/learning among models of various scales and processes**

- **Iterative process, leading to improved models*, and to refined hypotheses**
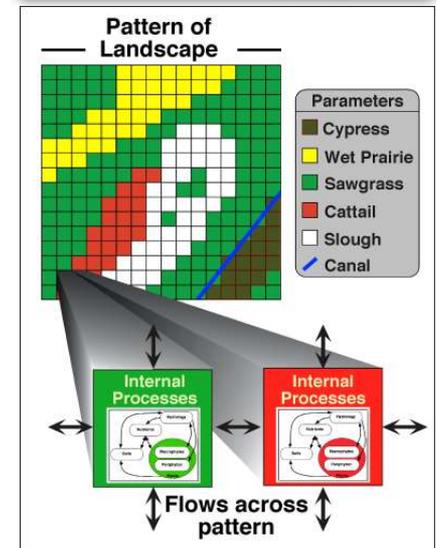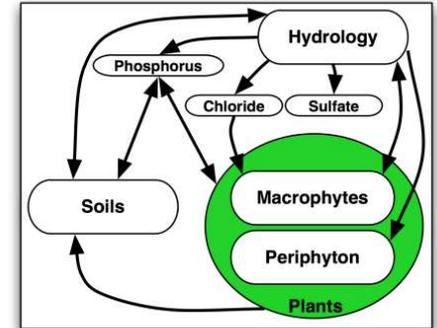
* All models are wrong, but some are useful.

…. End of meeting – sail away!