Probabilistic Modeling of Coastal Vegetation Succession with Sea Level Rise

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Purpose

Regional modeling of coastal landscape change with restoration and climate change

- Identifying potential areas at risk and spatial distributions of change
- Inform management and policy decisions
- Identifying information gaps & limitations of existing landscape data and models

Mangrove – Environmental response

High level of trait plasticity in response to salinity, flooding, and nutrients

The seedlings of all species require a very low salinity for their early growth

Phosphorous & hydroperiod differentiate species:

- White mangrove *(Laguncularia racemose):* more fertile sites
- Red mangrove *(Rhizophora mangle):* P-limited sites
- Black mangrove *(Avicennia germinans):* relatively high salinity and low N
- Red mangrove *:* permanently low salinity and relatively high N concentrations
- White mangrove and Black mangrove: Flooding duration < 50% of the year

If the rate of accretion and subsurface root accumulation is less than relative SLR, mangroves will become progressively drowned (e.g., Ellison & Stoddart 1991)

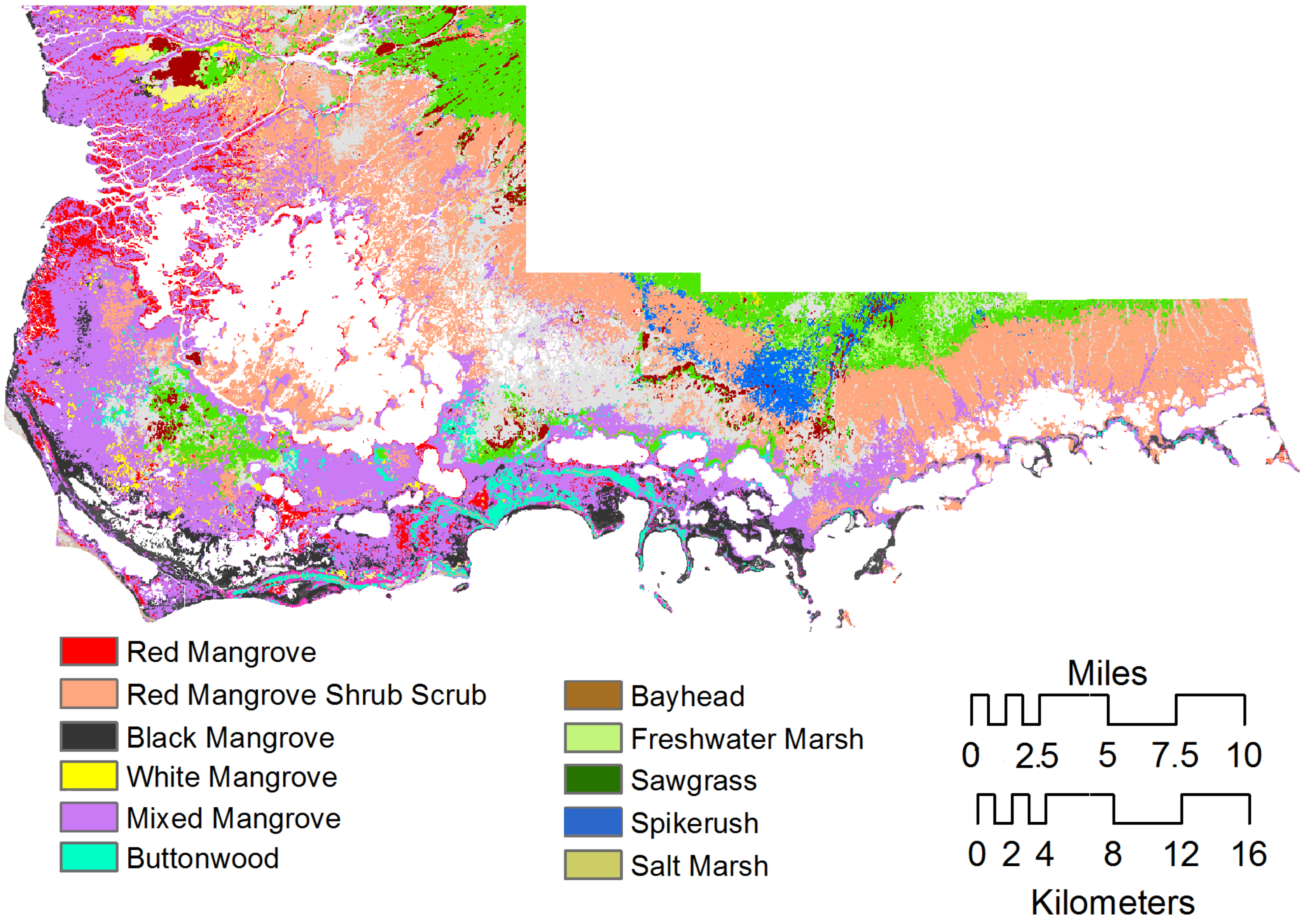
Increased CO_2 benefit may be offset by reduced growth from increased flooding and increased hydroperiod (e.g., Krauss et al 2008)

Fire

Frost

Vegetation Classification

NPS, South Florida & Caribbean Network



What drives mangrove distribution?

- Competition
- Nutrients
- Light
- Disturbance
- Salinity
- Temperature
- Hydrology

Biscayne and Southern Everglades Coastal Transport model

BISECT

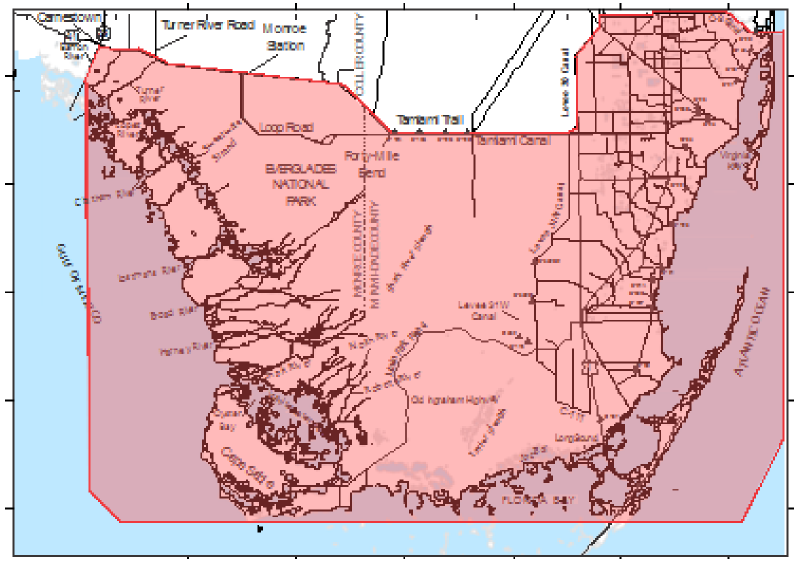
Hydrodynamic 2D representation of surface water

3D representation of groundwater

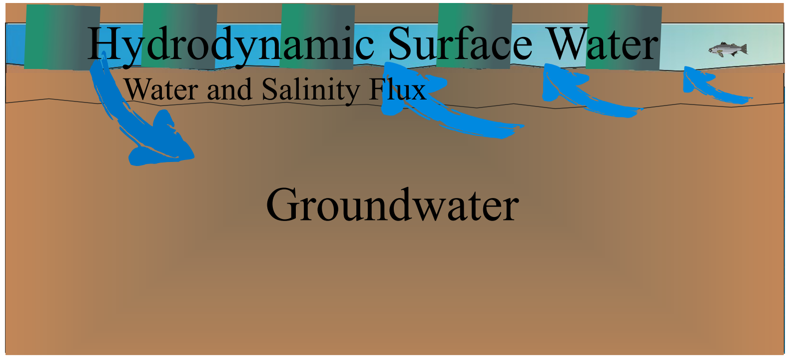
Salinity transport is represented and passed with leakage

Covers Everglades National Park and eastern coastal area

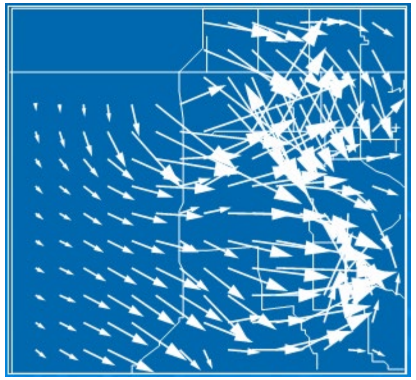
Enhanced resolution with 2017 ENP Lidar

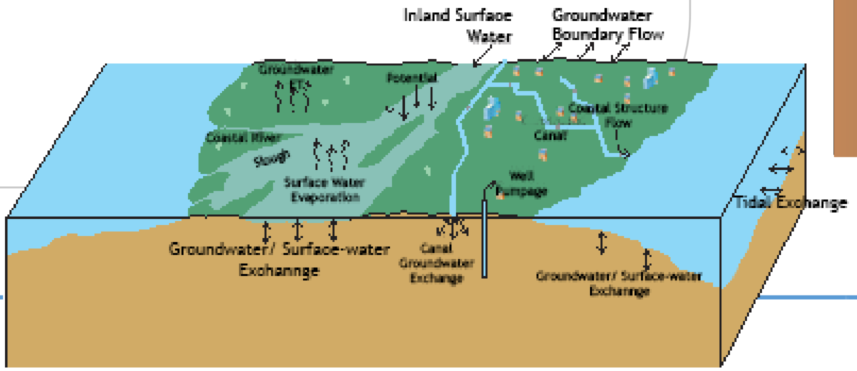


Model Domain

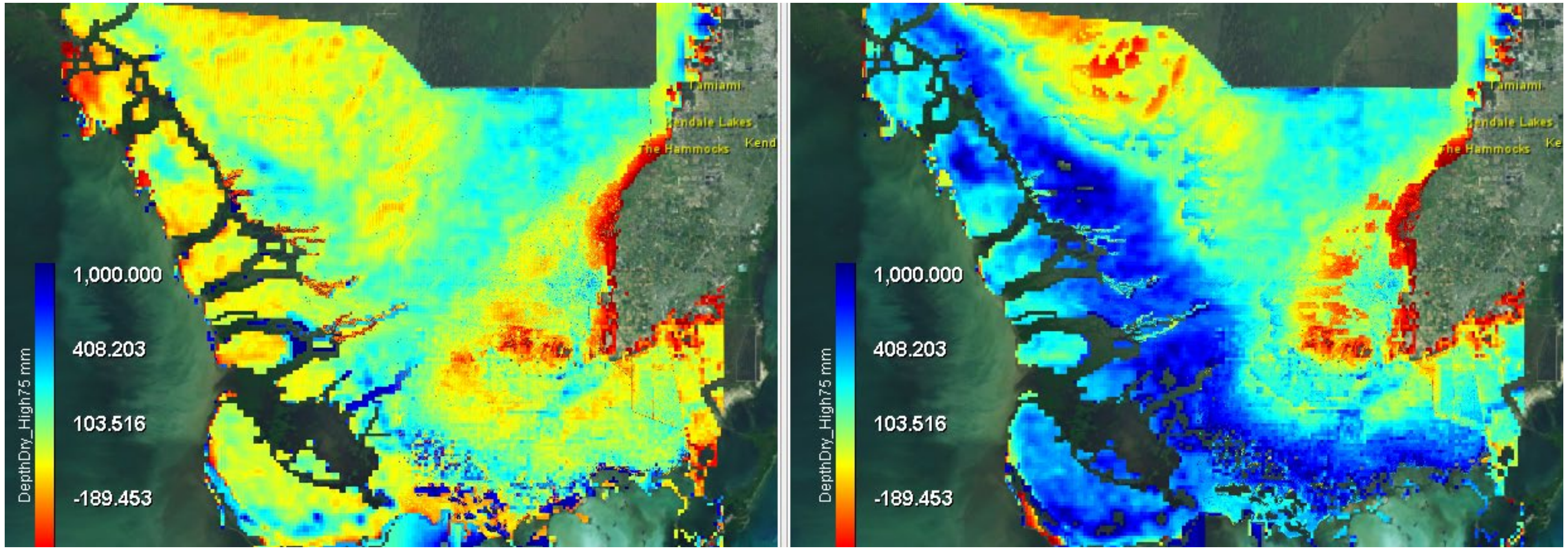


Groundwater Flux



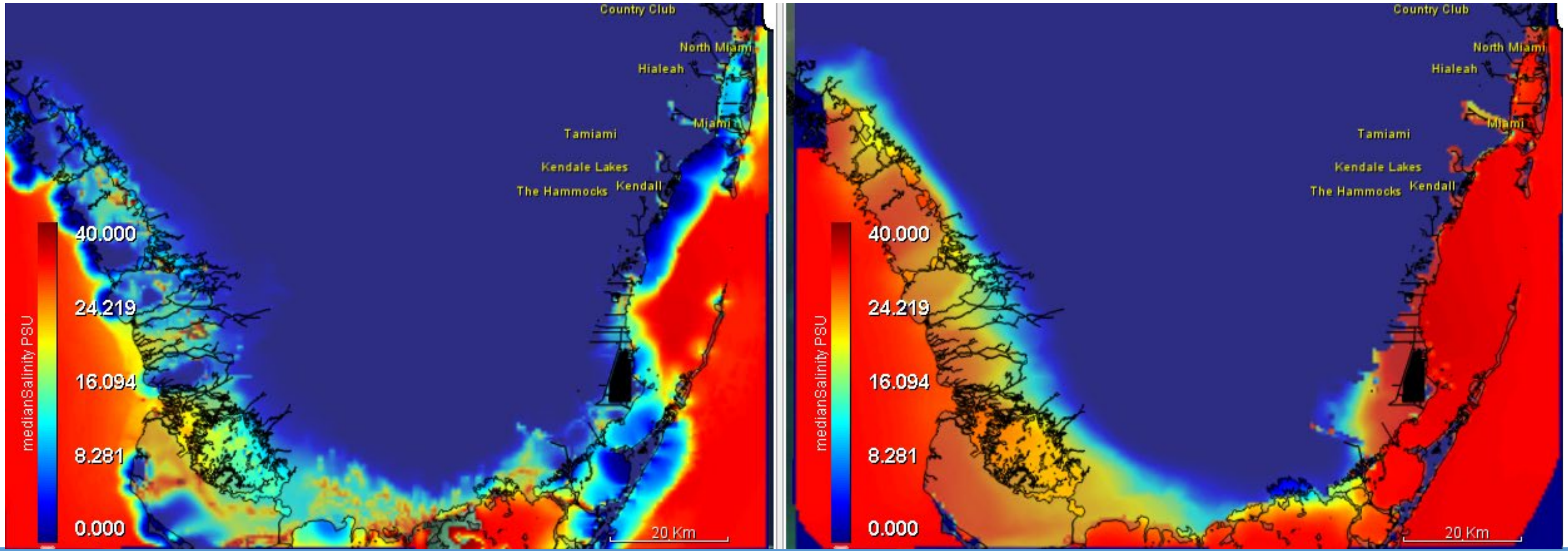


BISECT



4-year mean
Dry Season,
Upper Quartile Depth

Current (2003) & 2’ SLR



4-year mean
Median Salinity

Current (2003) & 2’ SLR

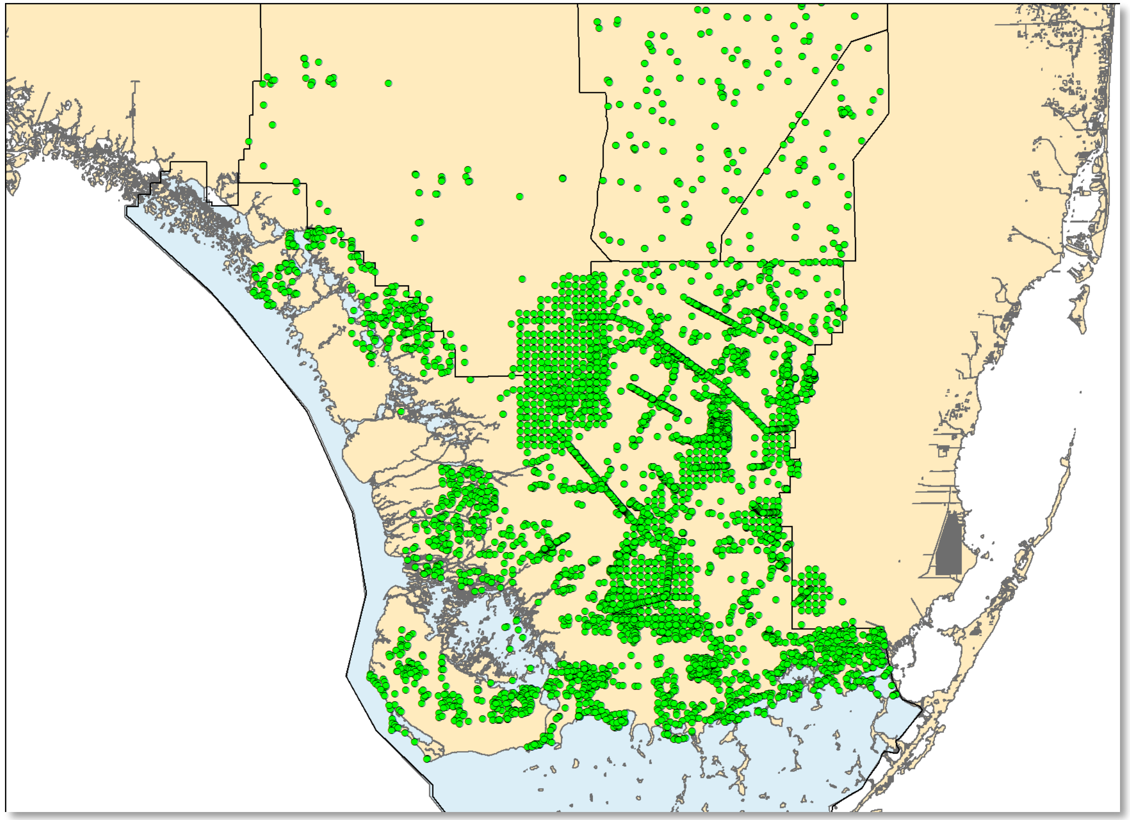
Everglades Landscape Vegetation Succession

ELVeS

Empirically-based probabilistic functions of vegetation community responses to changing environmental conditions.

Linking ELVeS with wildlife planning tools provides a dynamic land cover layer for habitat.

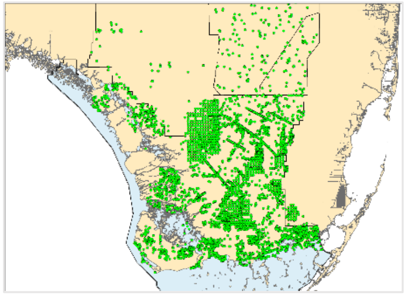
Designed to encourage updating as new information becomes available.



1966 obs points below Tamiami Trail. 80% used for calibration.

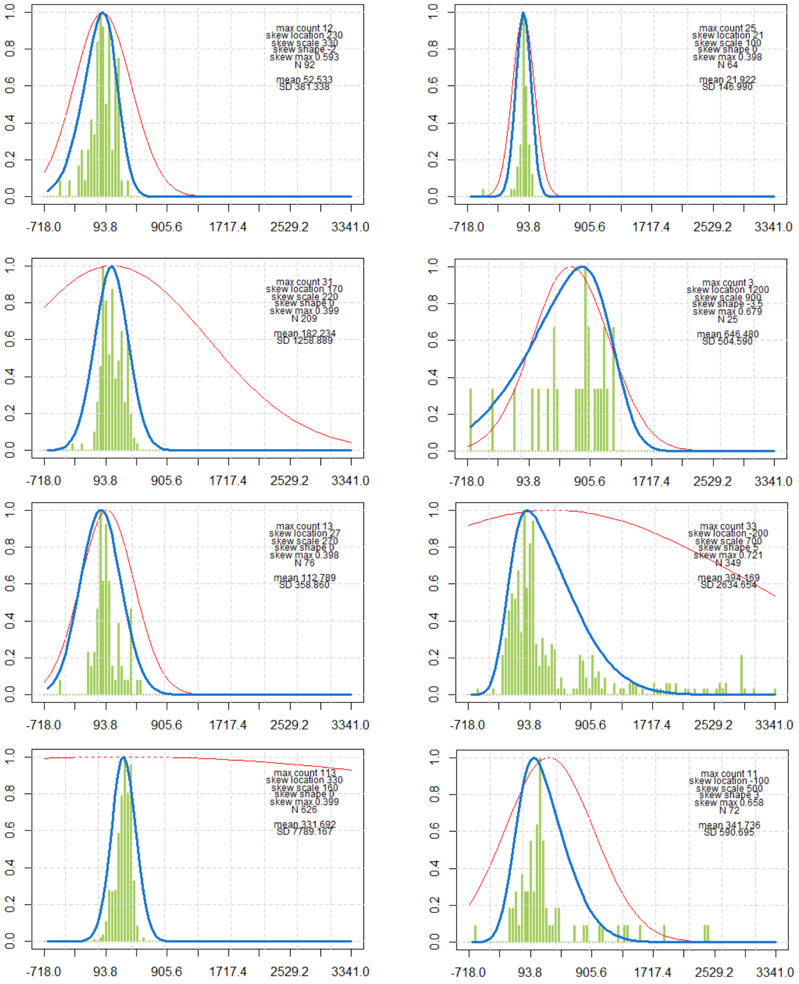
Source: Jay Sah, Mike Ross, Jennifer Richards, Joel Trexler, NPS SFCN

Everglades Landscape Vegetation Succession



Example Conditional Probabilities:

Dry Season Upper Quartile Water Depths



Muhly

Blackrush-Bluetop

Sawgrass-WP

Coastal Hammock

Sawgrass

Mangrove

Spikerush-Sawgrass

Red Mangrove Shrub

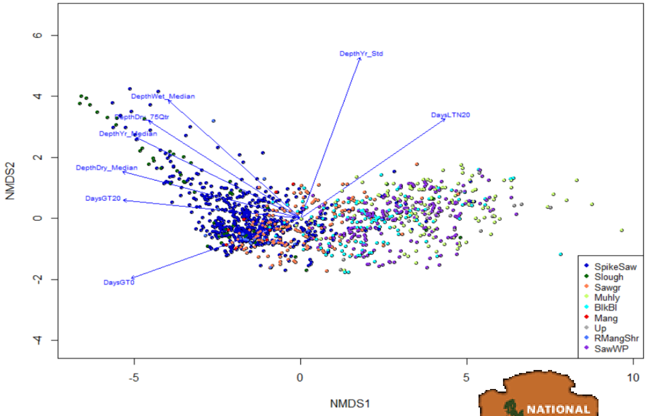
Modeling Variables

- **6 Hydrologic metrics**

  (4—year mean
  May – April climate years)

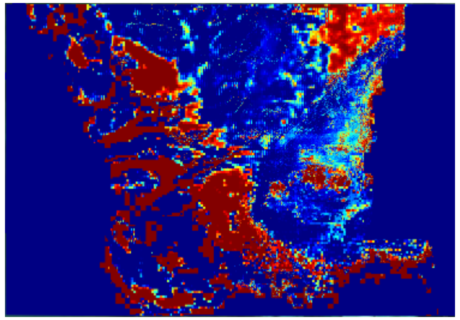
  - Days at depth 0 to 15 cm
  - Days Days at depth 10 to 25 cm
  - Annual depth std dev
  - Wet season depth std dev
  - Median depth in Dry season
  - Upper Qtr depth in Dry season

- **Median Salinity**

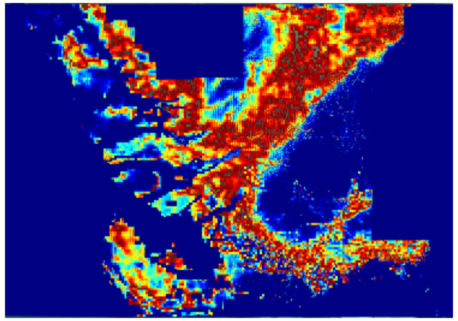


ELVeS Indexed Joint Conditional Probabilities

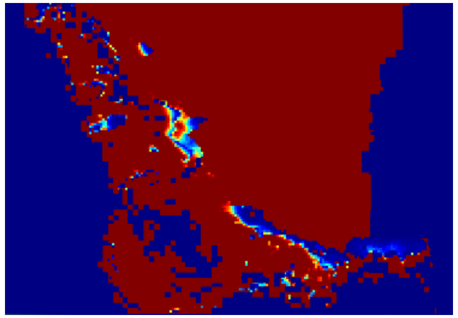
Example: Probability of Spikerush-Sawgrass community GIVEN:



$\times$



$\times$ … $\times$



4-year mean
Days 0-5 cm

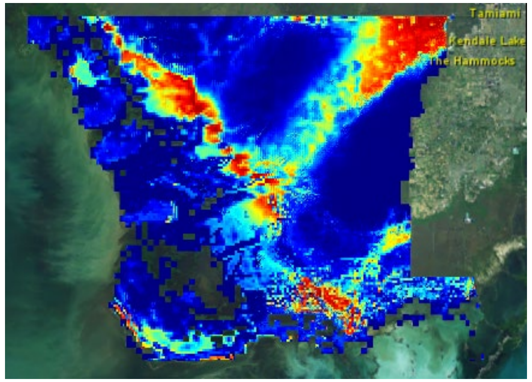
4-year mean
Dry Season Median

Median Salinity

$$= \sqrt[n]{P1 * P2 * \cdots * Pn}$$

= joint probability of one community in one grid

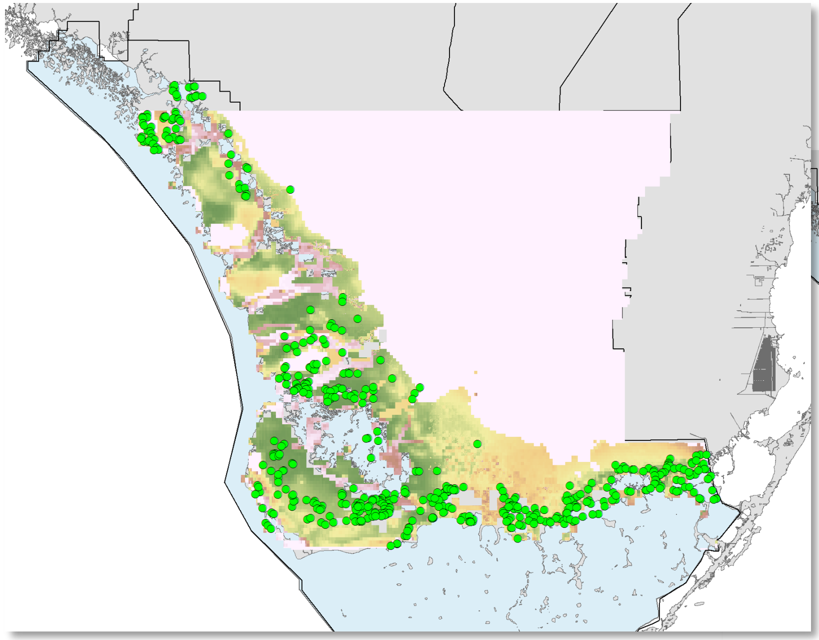
=



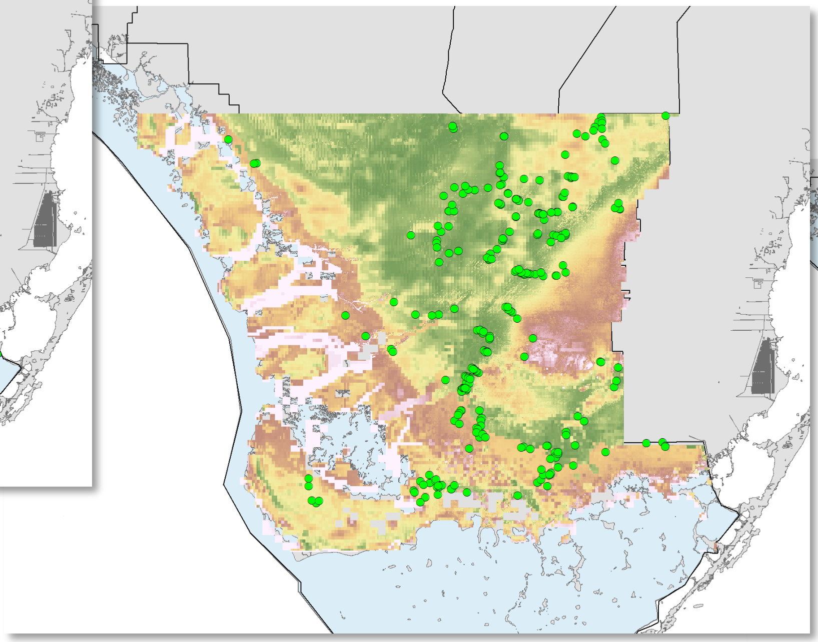
Indexed Joint Conditional Probability

“Equal effect” assumption

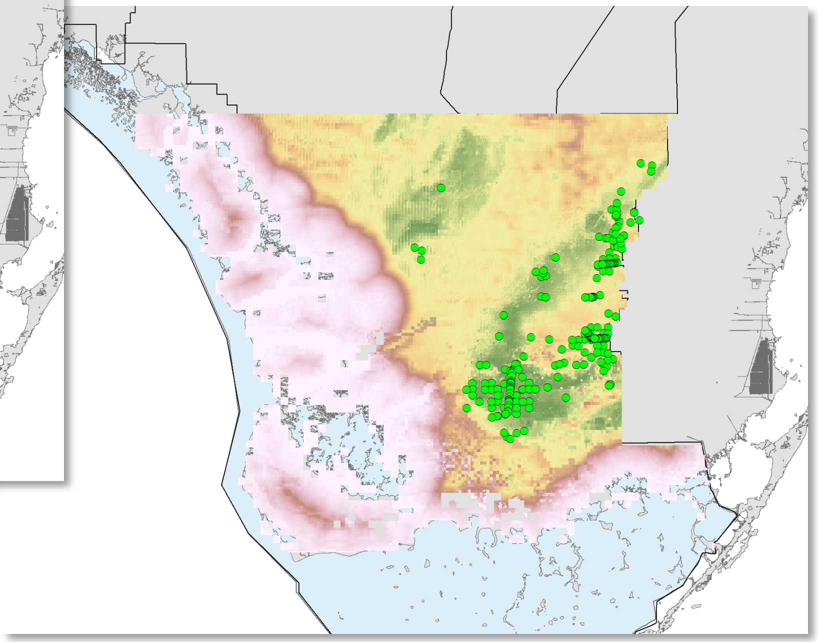
Everglades Landscape Vegetation Succession



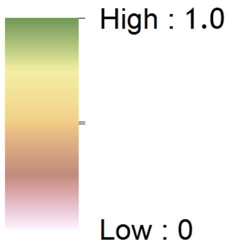
P(Mangrove) vs Observations



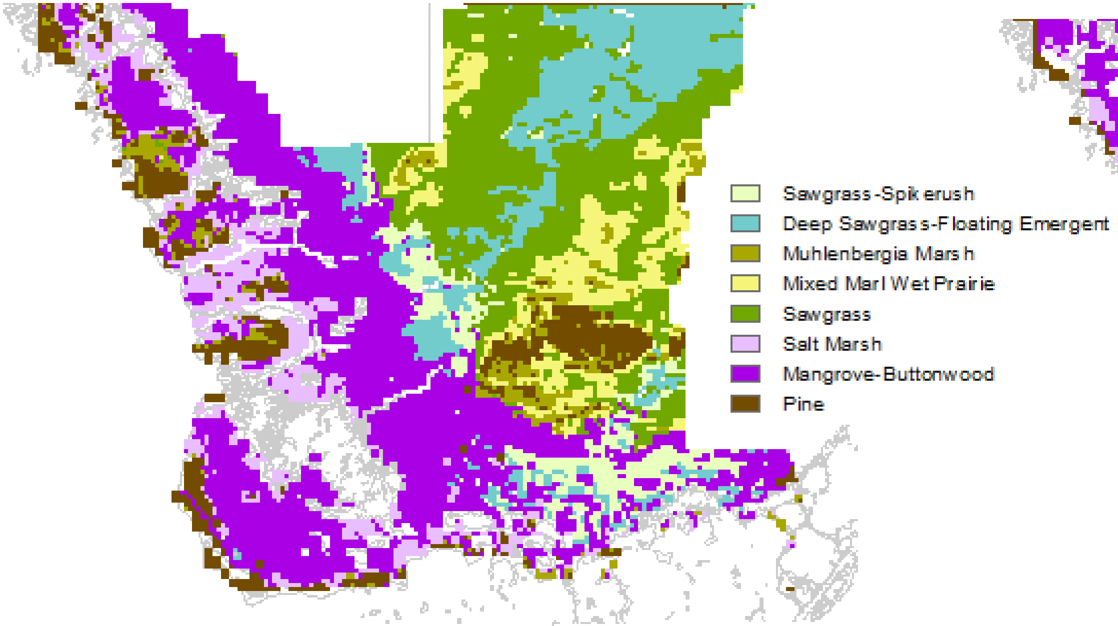
P(Sawgrass) vs Observations



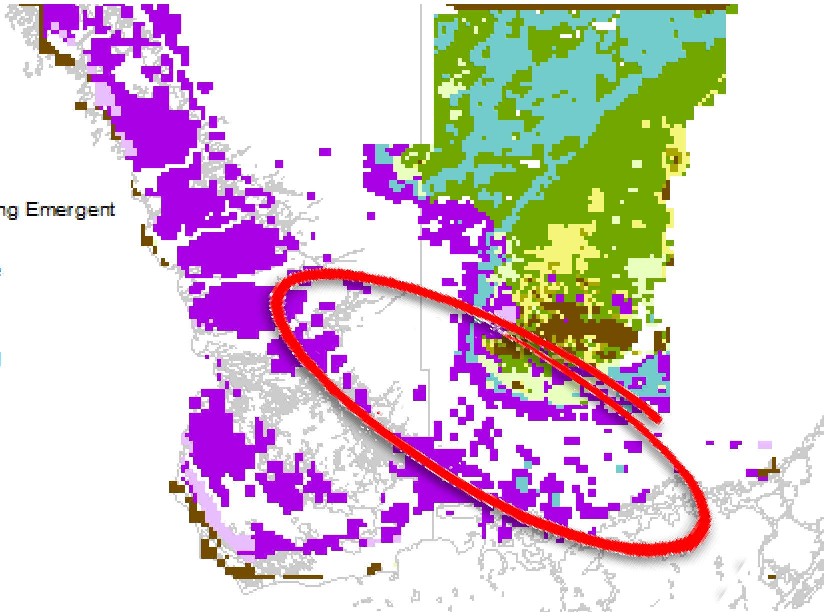
P(Muhly) vs Observations



Everglades Landscape Vegetation Succession



Modeled Existing Conditions

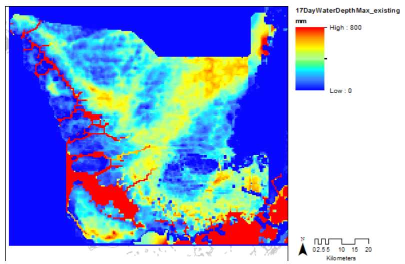


Modeled 2 ft SLR

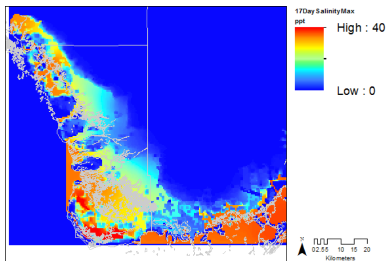
Regime Shift

Fresh Marsh

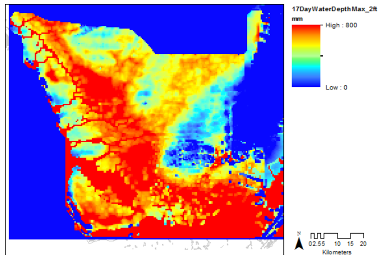
Health Estuary?



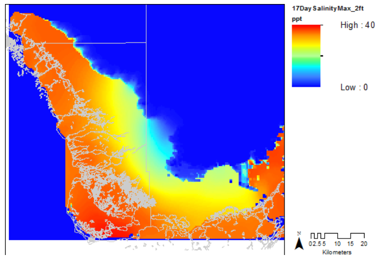
running average
Maximum Water Depth



running average
Maximum Salinity

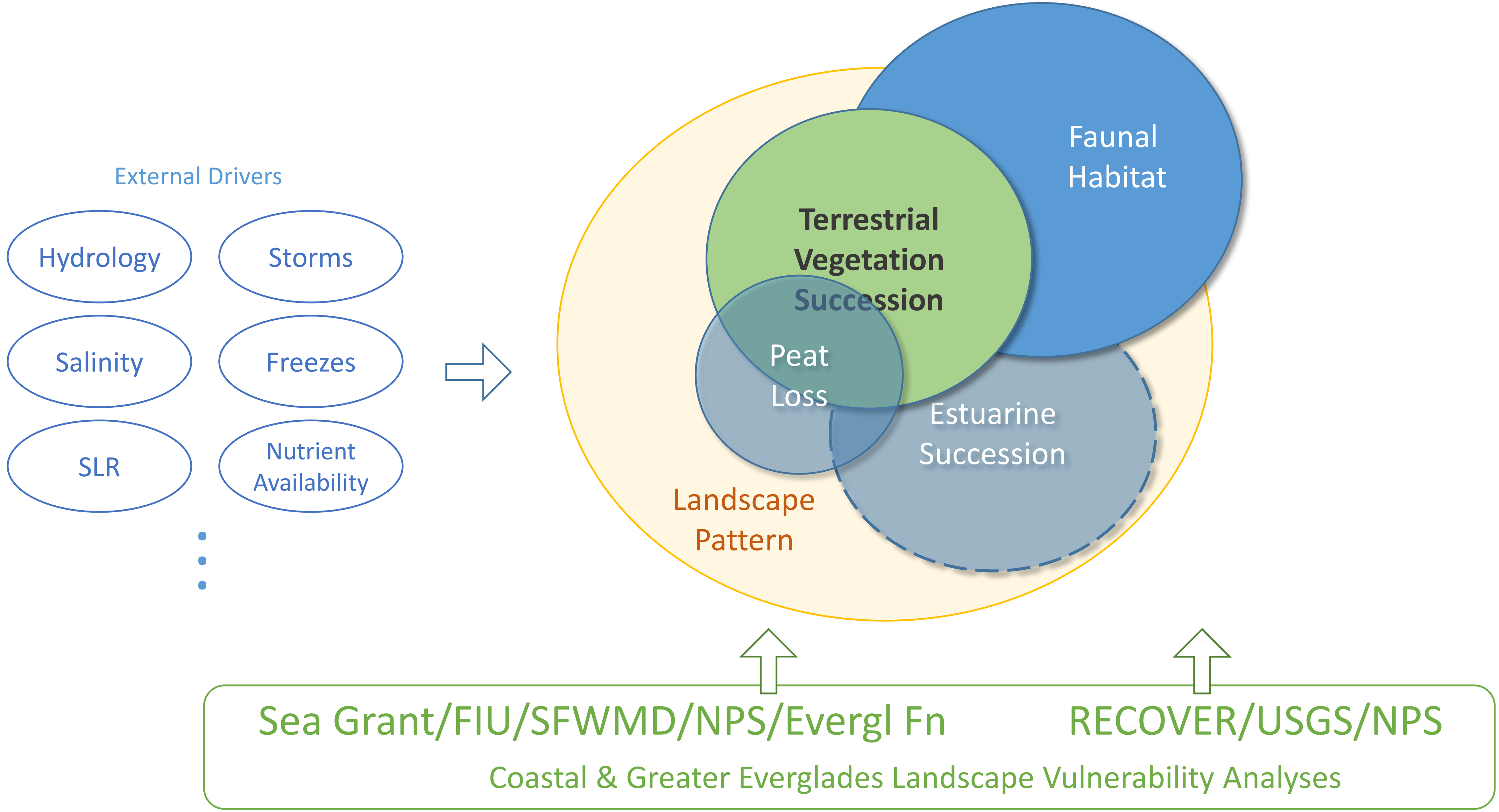


running average
Maximum Water Depth



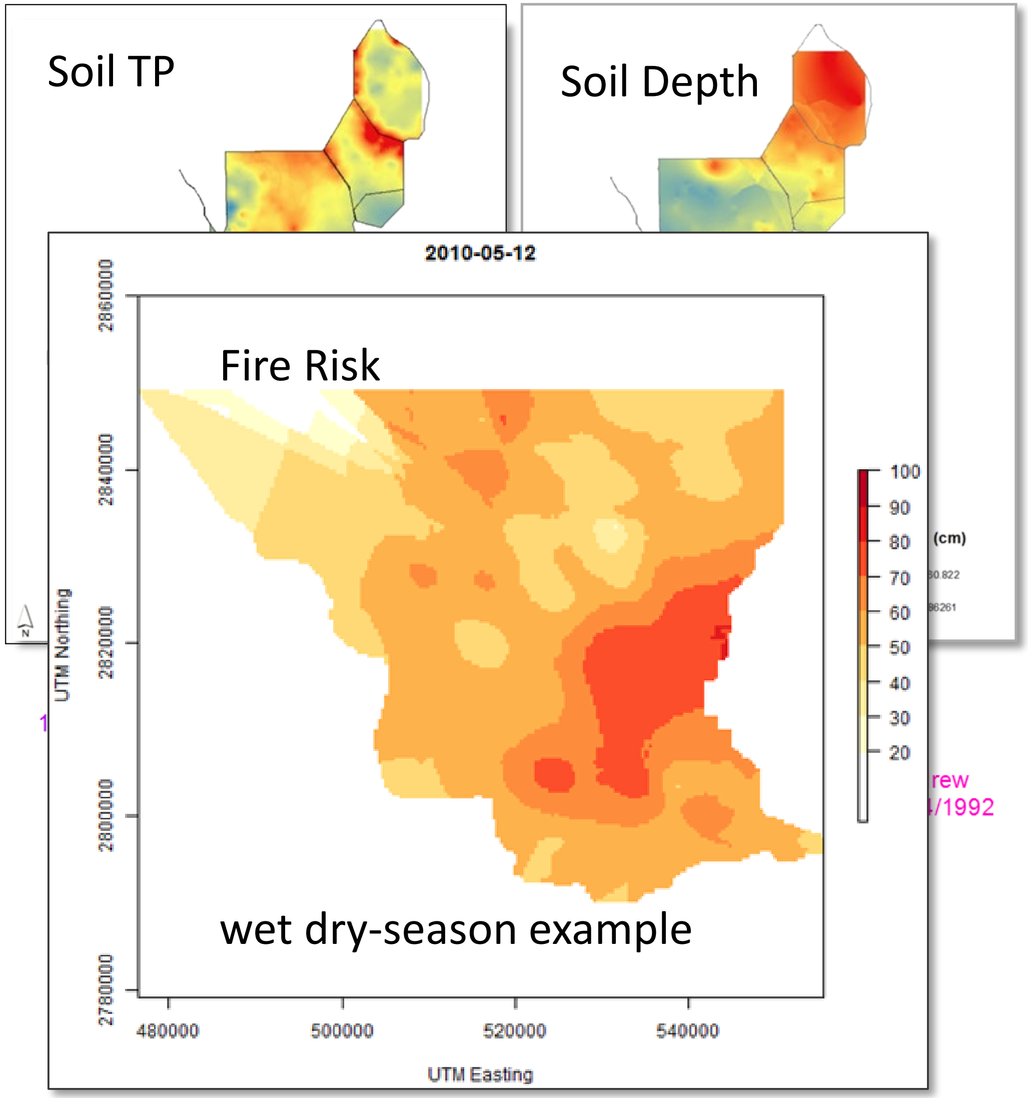
running average
Maximum Salinity

Integrated Landscape



Continuing Exploration: Spatial Data Needs

- Phosphorous dynamic modeling: upstream and offshore sources
- Soils: type and depth
- Fire, Storms, Temperature extremes
- New SLR & Climate scenarios



Continuing Exploration: Spatio-temporal Modeling

- Random forests
- Multinomial logistic regression
- Bayesian
  mulltinomial logistic regression
- Integrated modeling and
  vulnerability decision support