Recent hydrologically-driven vegetation succession in Shark River Slough, the southern compartment of the Everglades Ridge and Slough landscape

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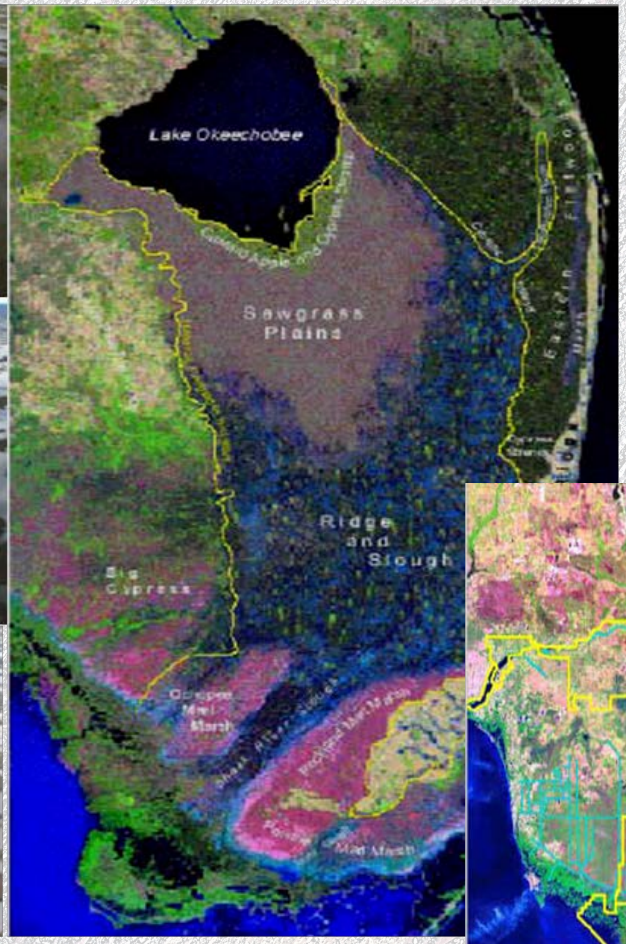
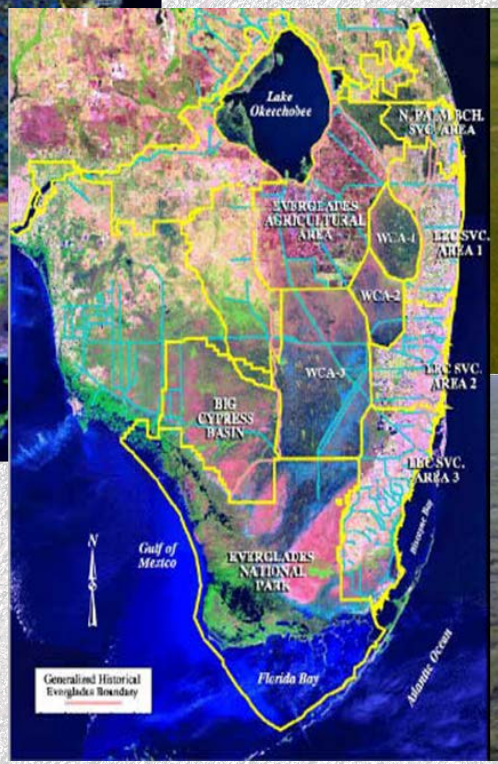
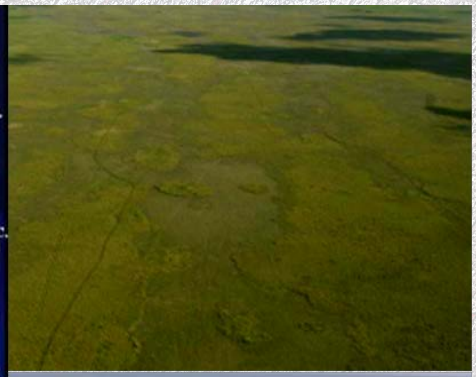
Ridge and Slough (R&S) landscape



Ridge-slough landscape in degraded conditions





Linear, flow-parallel orientation of ridges and sloughs under conserved conditions

R&S landscape: system-wide study design

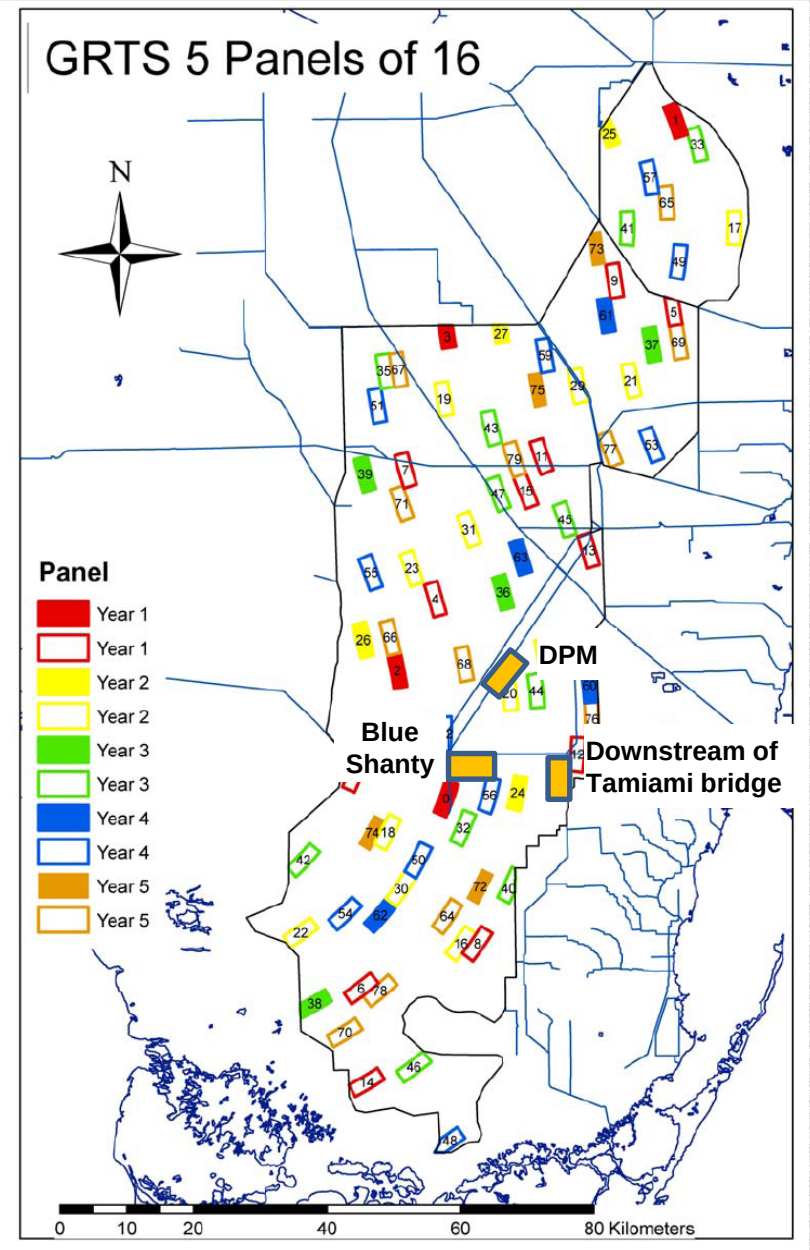
PSU
(Primary Sampling Unit)

The Generalized Random-Tesselation Stratified approach (GRTS) (Stevens and Olsen, 2004):
*a spatially-balanced probability-design drawn from a tiling of the ridge and slough and sawgrass prairie areas into 2km * 5km cells (Philippi, 2007)*

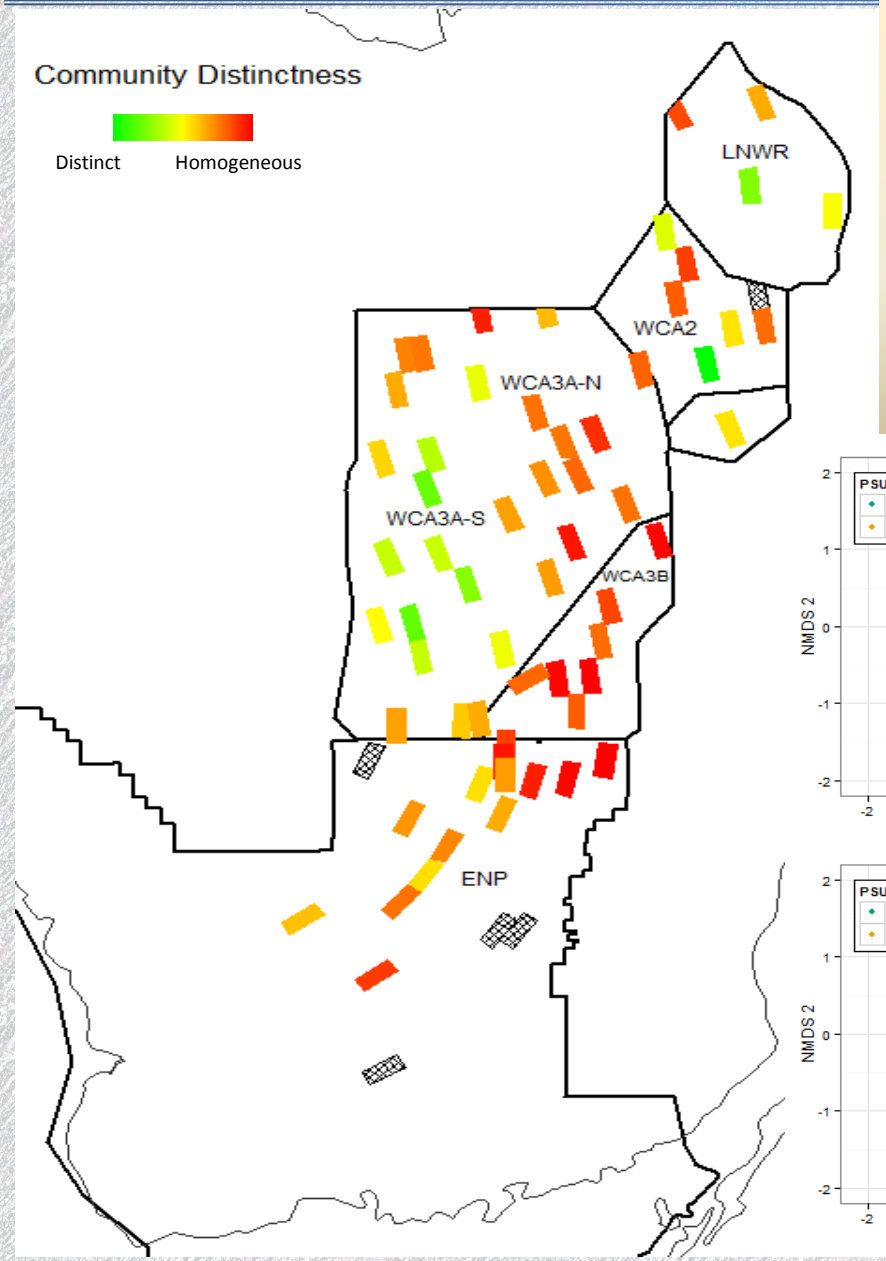
Total - 80 PSUs
16 PSUs per year for
5 years *(Planned)*

In 5 years (2009-2014) = 62 PSUs

- **10-14 PSUs per year**
  - ***Modified PSUs at targeted places***
  - ***Marl prairie PSUs not sampled***

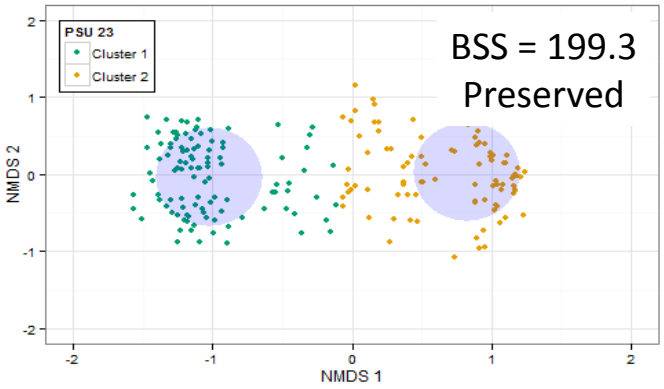


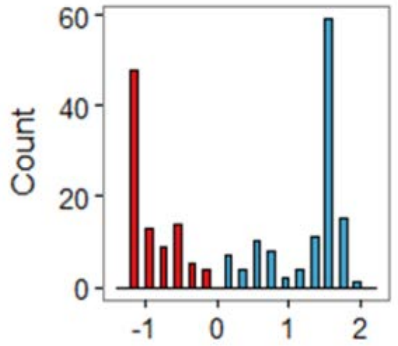
Spatial patterns of R&S landscape condition

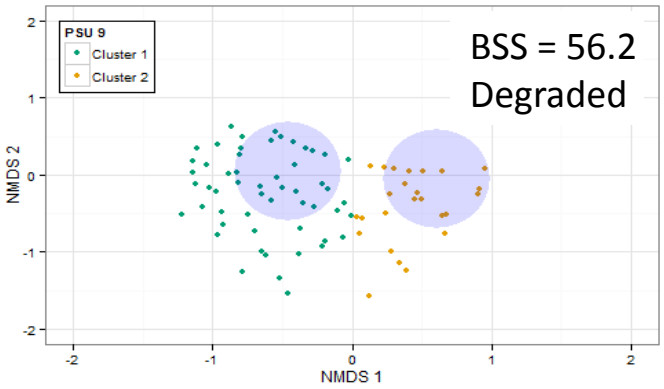


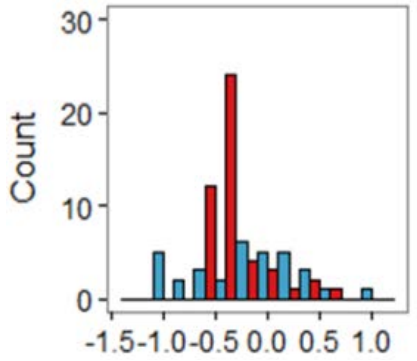
- **Non-metric Multidimensional Scaling (NMDS) Ordination**
- **Two Clusters by K-means clustering**

Vegetation community distinctiveness: ***the sum of square distance between two cluster centers (BSS)***

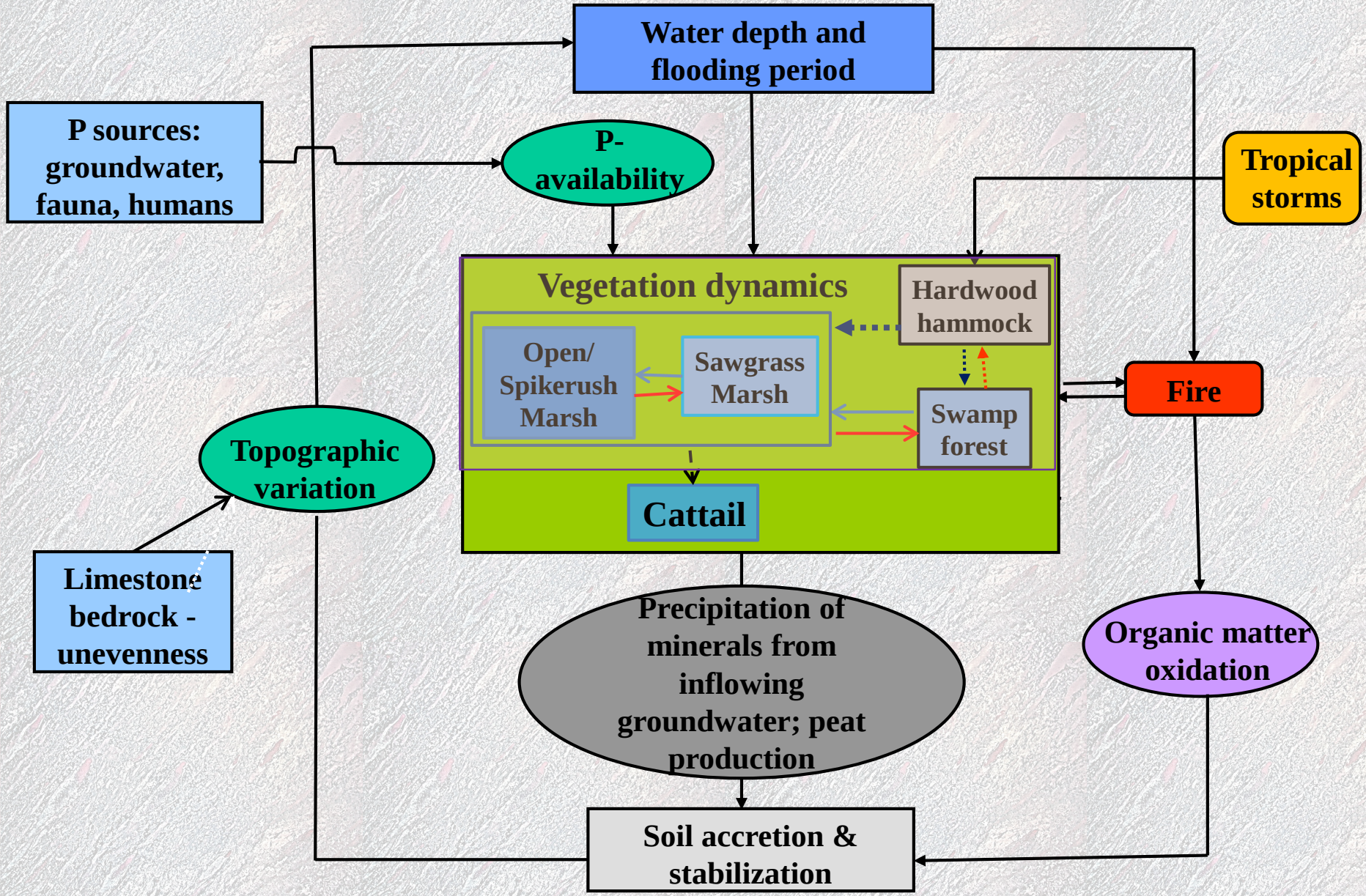




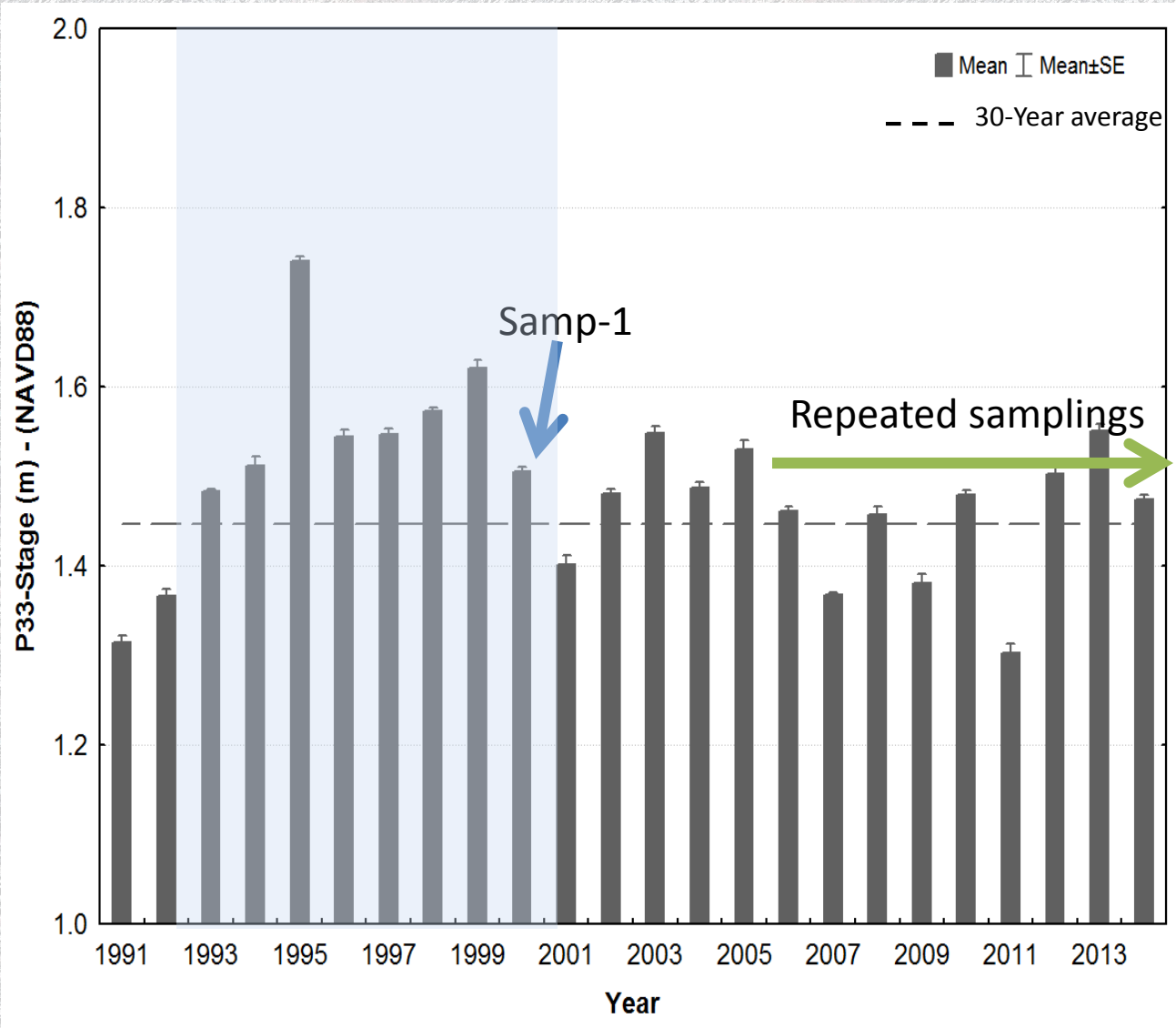


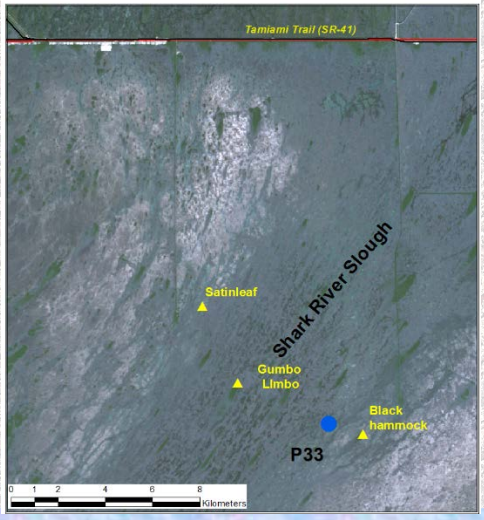


Vegetation dynamics in Shark River Slough Ridge & Slough landscape



Hydrologic condition in Shark River Slough





In Shark River Slough, short-term (decadal) fluctuations in hydrologic regimes resulted in above average water level in 1990s, but near or below average water level for many years in 2000s

Questions

In the past, long-term drying events or drought, natural or management-induced at multi decadal scale have led to advance succession, such as increase in sawgrass & woody vegetation, including formation & growth of tree islands in Everglades.

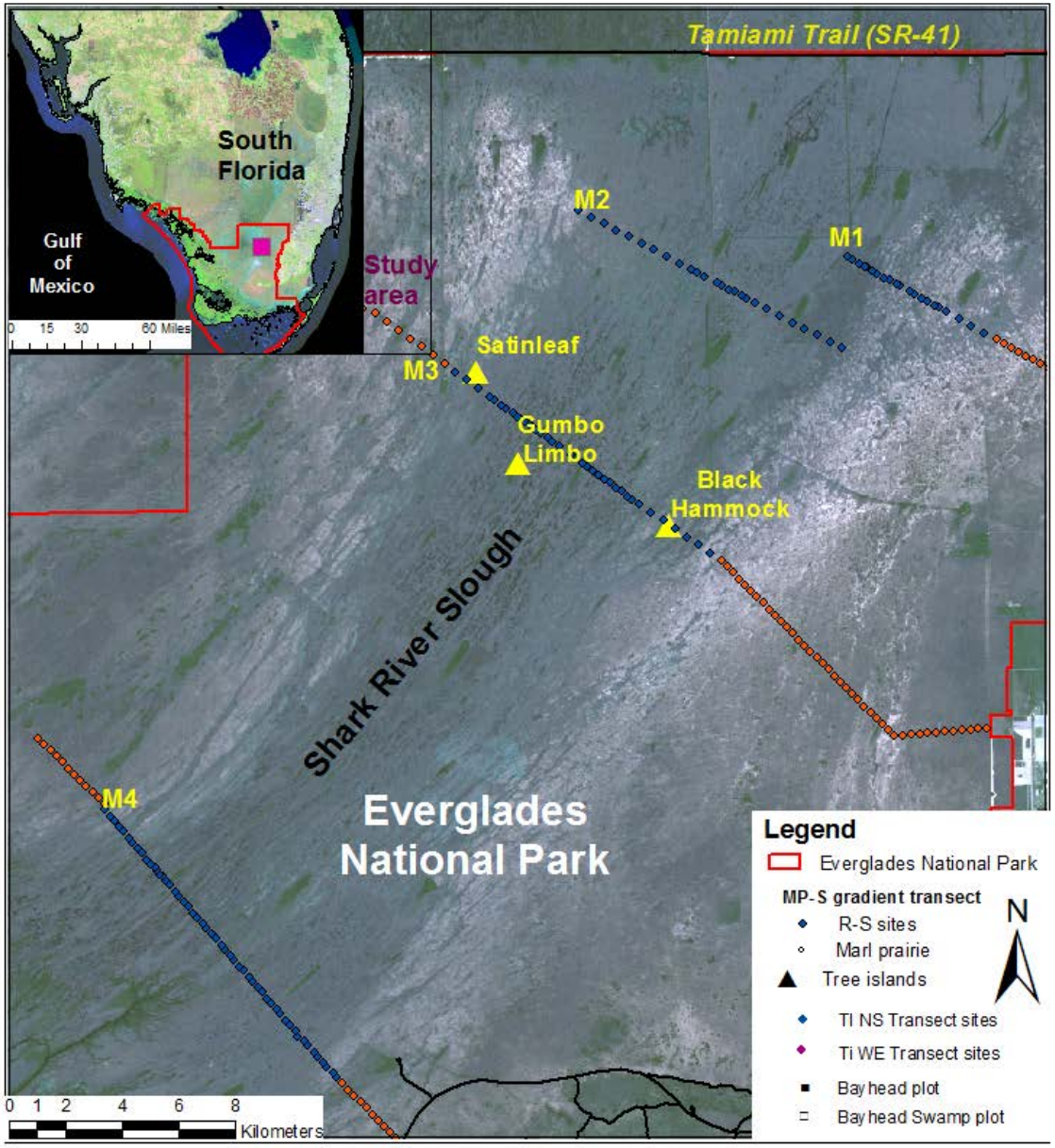
- Johnson 11958; - Kolipinsiki and Higer 1969; Willard et al. 2002, 2006

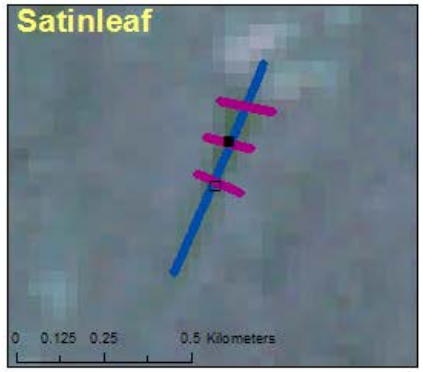
Questions:

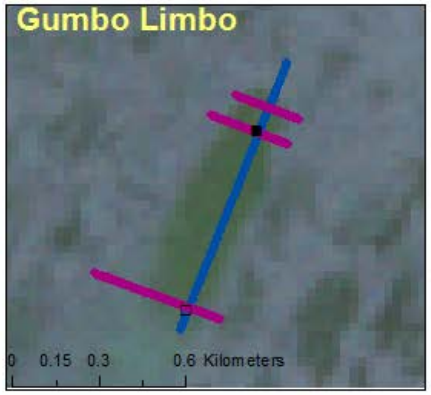
i. Does the short-term changes in hydrologic conditions also influence the vegetation successional process?

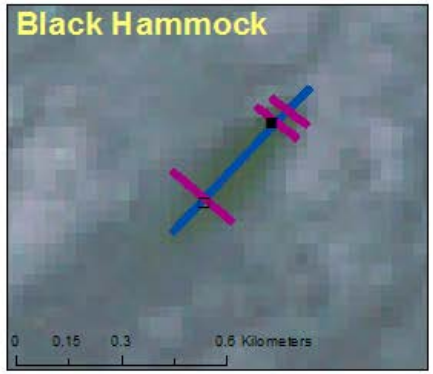
ii. Has the hydrology-induced decadal vegetation changes impacted the locations of boundaries between plant communities?

Study Area

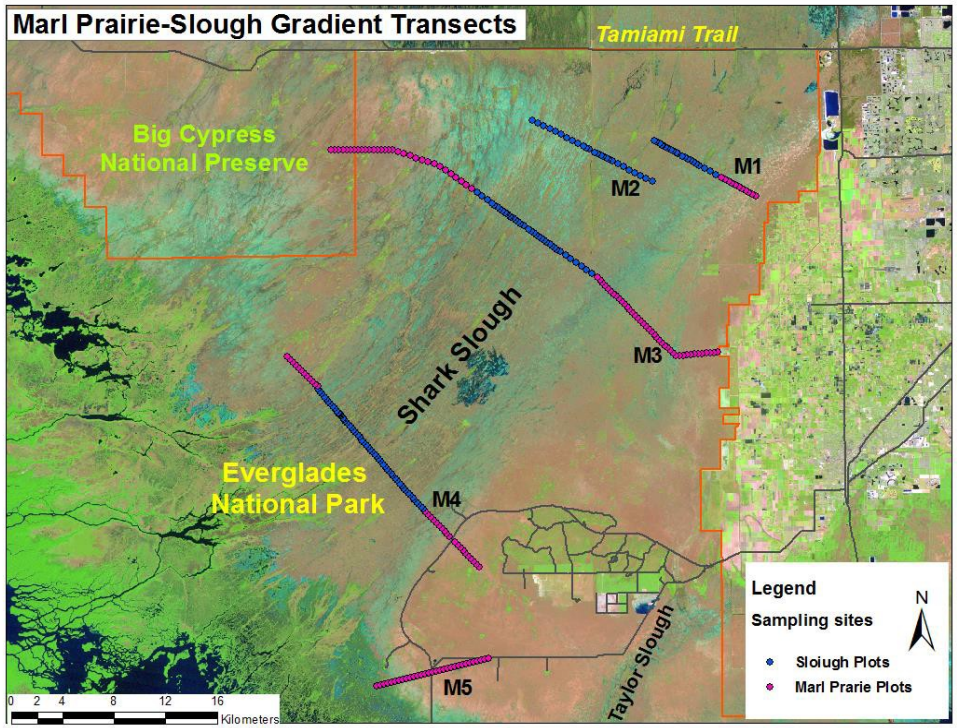

Tamiami Trail (SR-41)
South Florida
Gulf of Mexico
0 15 30 60 Miles
Study area
M1
M2
M3
M4
Satinleaf
Gumbo Limbo
Black Hammock
Shark River Slough
Everglades National Park
0 1 2 4 6 8 Kilometers
Legend
Everglades National Park
MP-S gradient transect
R-S sites
Marl prairie
Tree islands
TI NS Transect sites
Ti WE Transect sites
Bayhead plot
Bayhead Swamp plot
N


Satinleaf
0 0.125 0.25 0.5 Kilometers


Gumbo Limbo
0 0.15 0.3 0.6 Kilometers


Black Hammock
0 0.15 0.3 0.6 Kilometers

Marl Prairie-Slough Gradient Transects



Five transects (M1-M5):

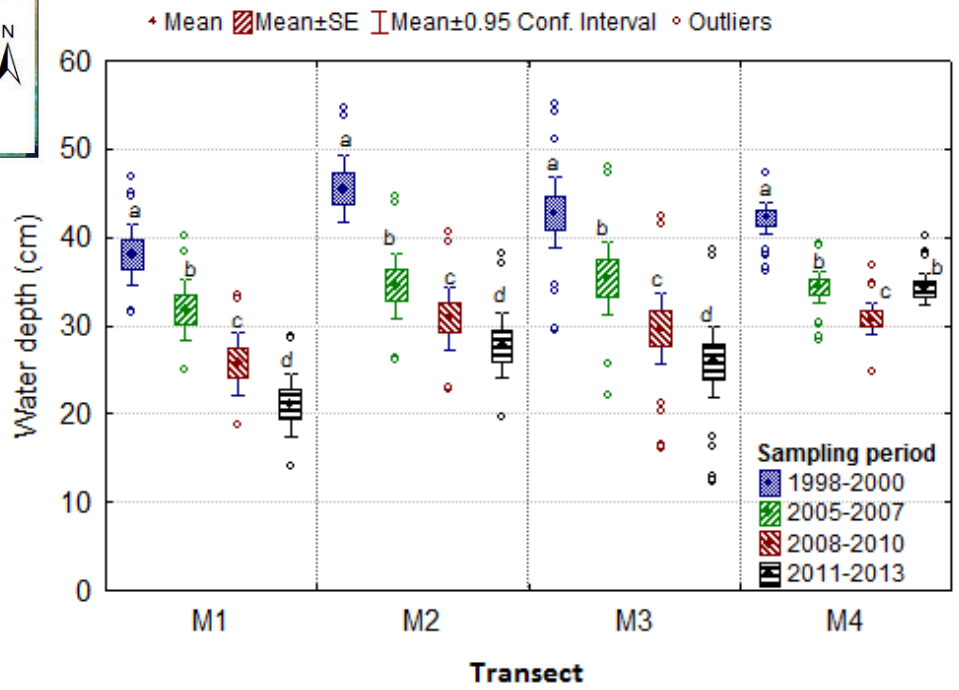
9.0 km – 35.5 km

285 plots (Since 2005)

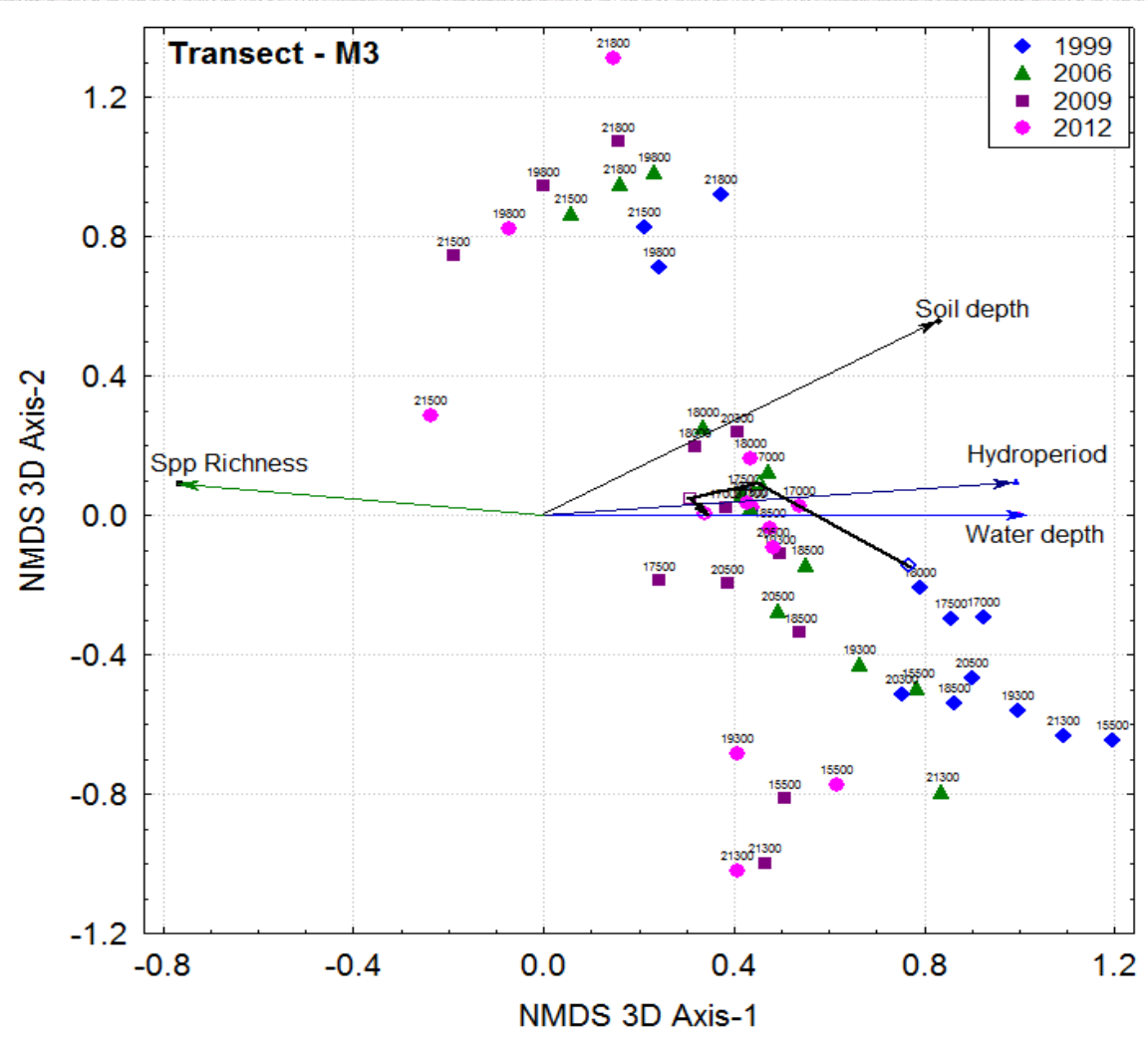
In Slough portion:

2005-2007; 2008-2010; 2011-2013

100 plots were also sampled in 1999/2000



Results: Vegetation trajectory trend



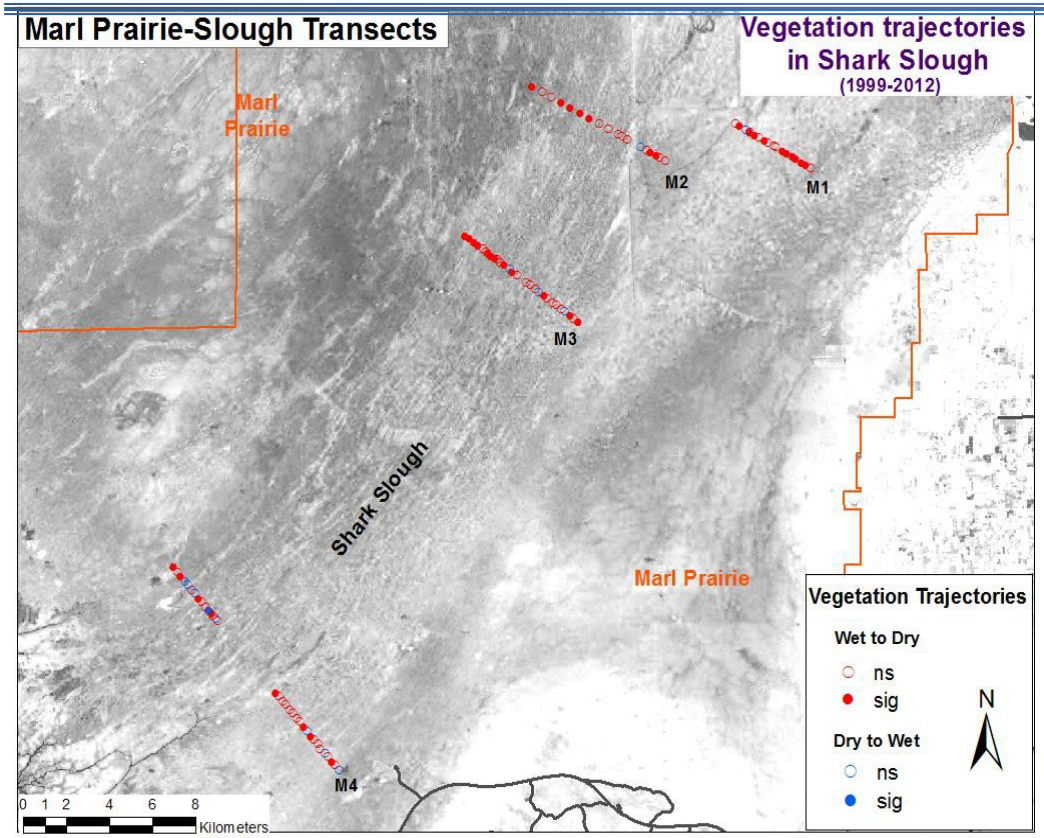
Trajectory Analysis

- Non-metric multidimensional Scaling (NMDS) Ordination to summarize the community dynamics
- Vector fitting to define a target direction
- Temporal trend in site scores along target vector (Delta (Δ) & Slope)

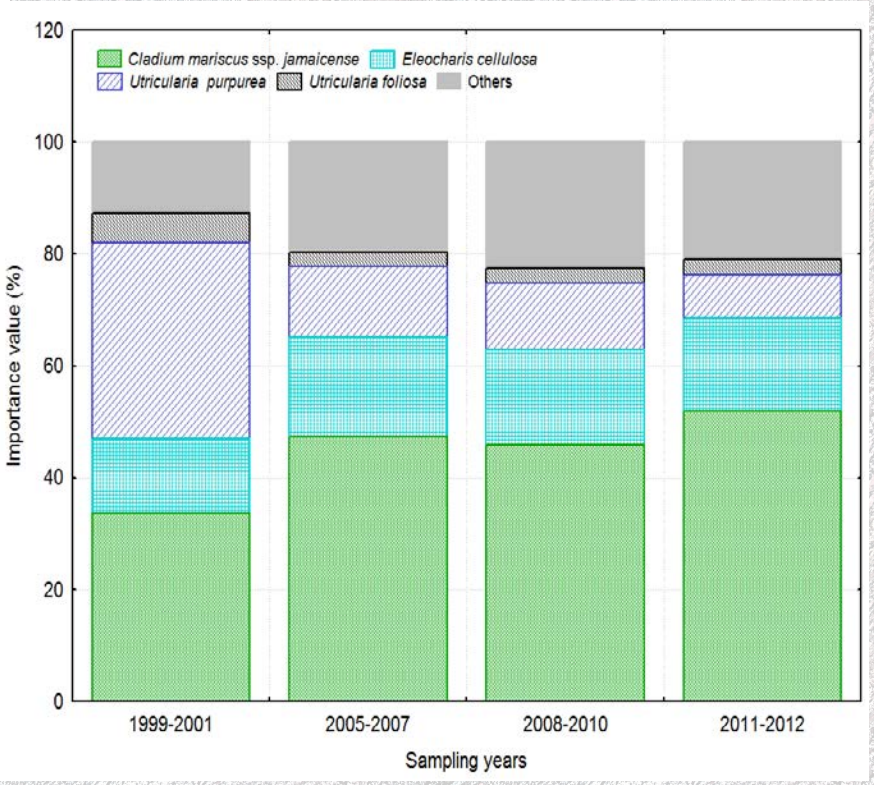
(Example: Sah et al. 2014)

As the sites became relatively dry, vegetation composition also shifted toward drier type in 13 years.

Spatial variation in vegetation change

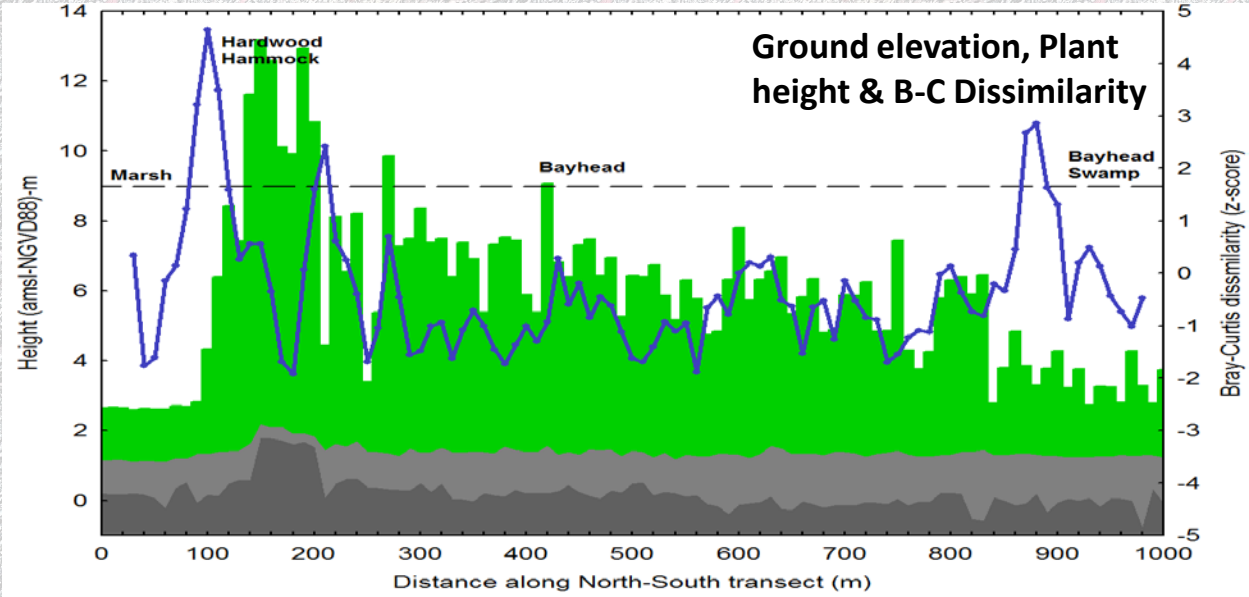


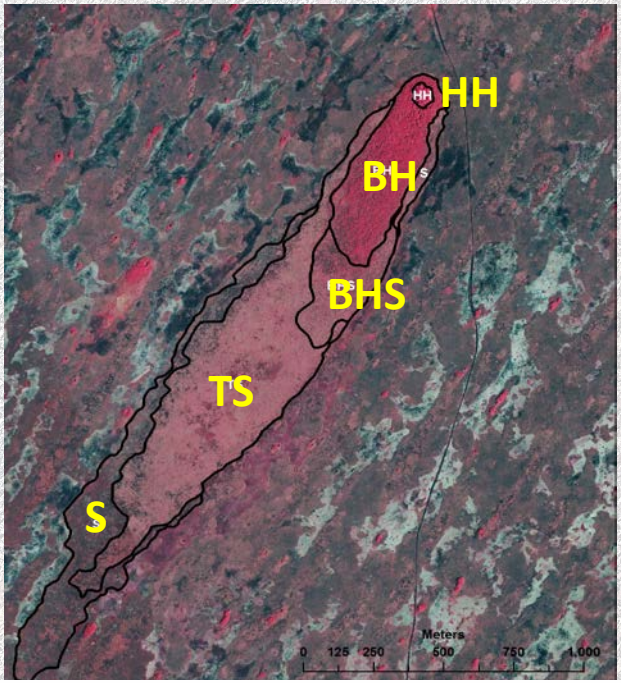
A shift in composition was spatially differentiated. Relatively more sites on northern transects showed drying trend.



Sawgrass cover increased by 50% at the expense of open slough, as evident by decrease in *Utricularia* sp.

Plant communities on a Shark Slough Tree Island

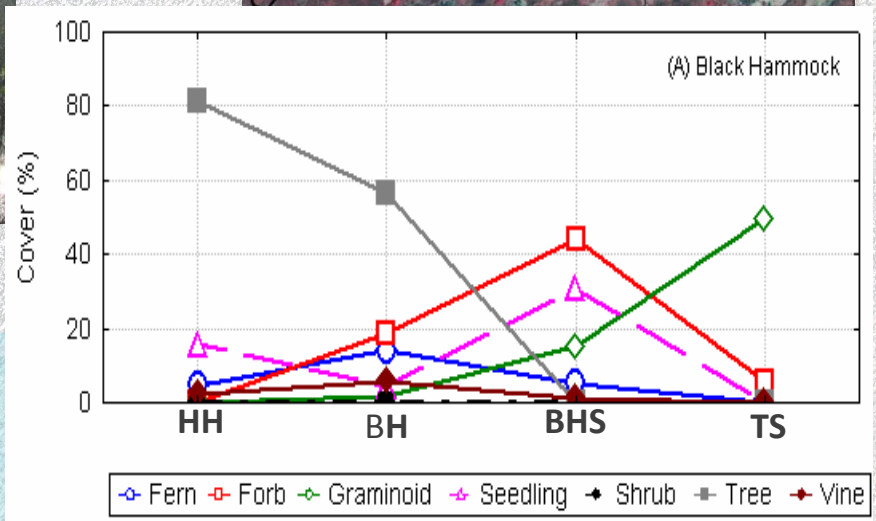




Hardwood Hammock (HH)

Bayhead (BH)

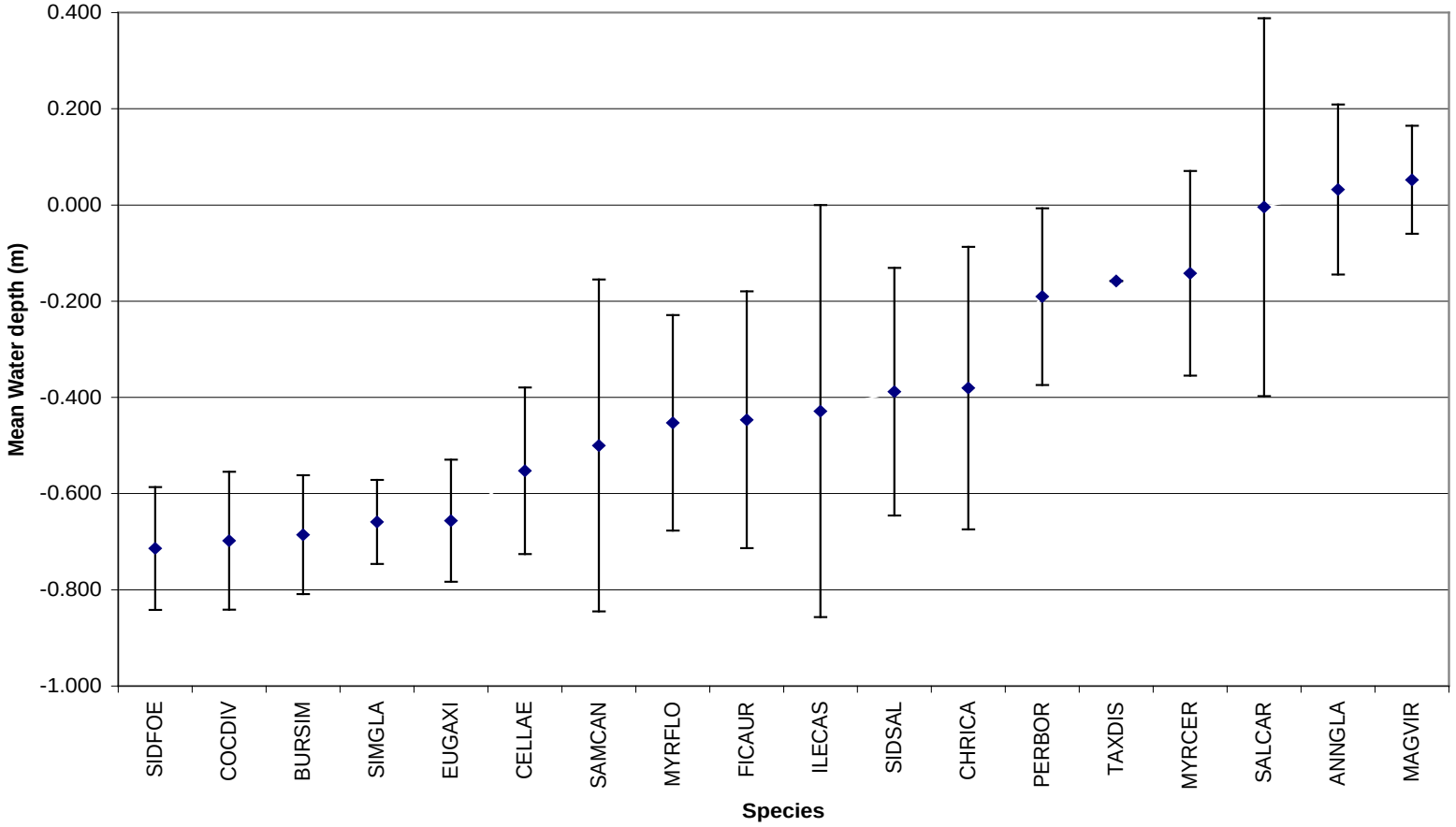
Bayhead Swamp (BHS)



Plant communities in and around tree islands - different stages of vegetation succession in ridge & slough landscape

Tree species along hydrologic gradient

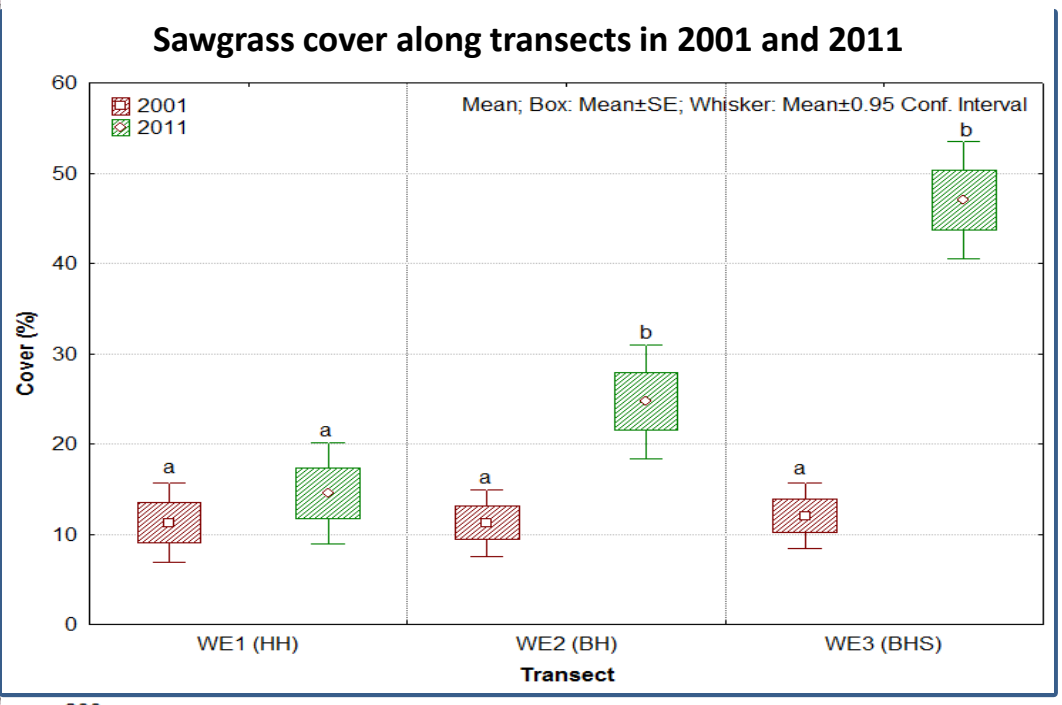
Mean water depth optima & tolerances of tree species

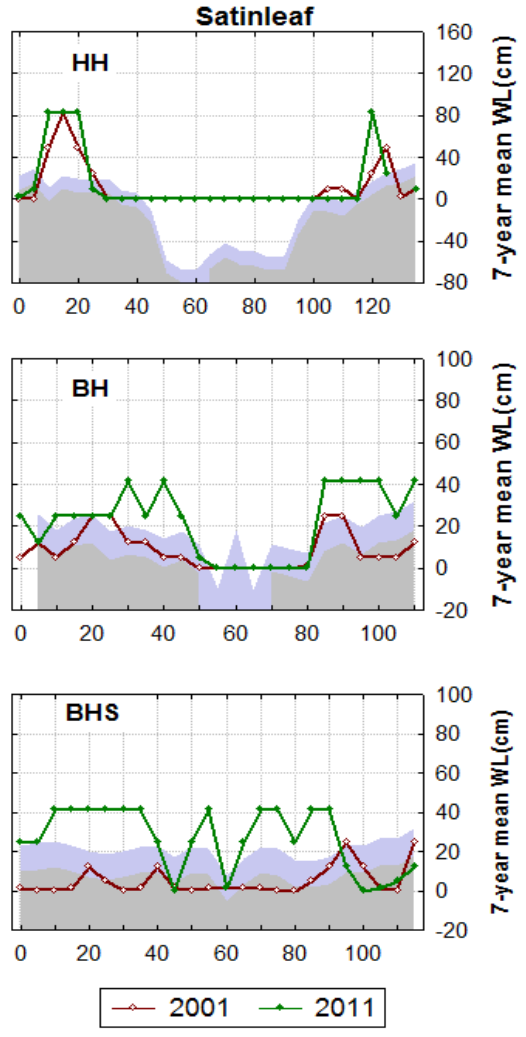


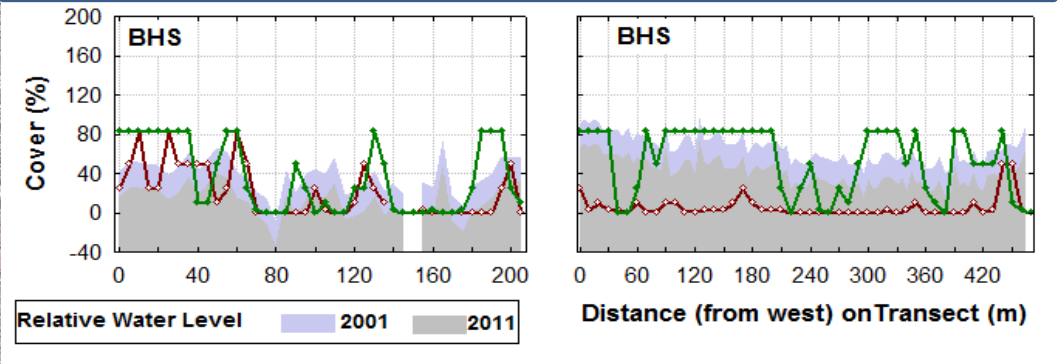
Tree species are arranged along hydrologic gradient on tree islands

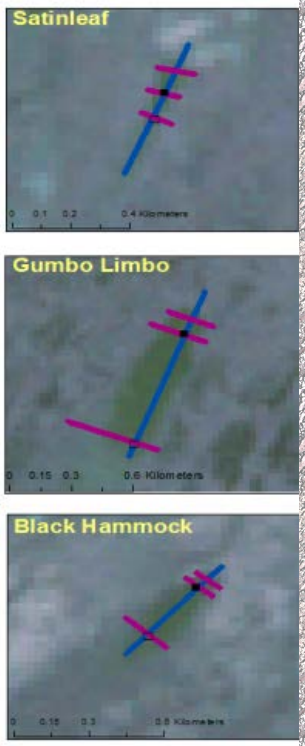
SSR 2009

Tree island vegetation response to hydrologic change





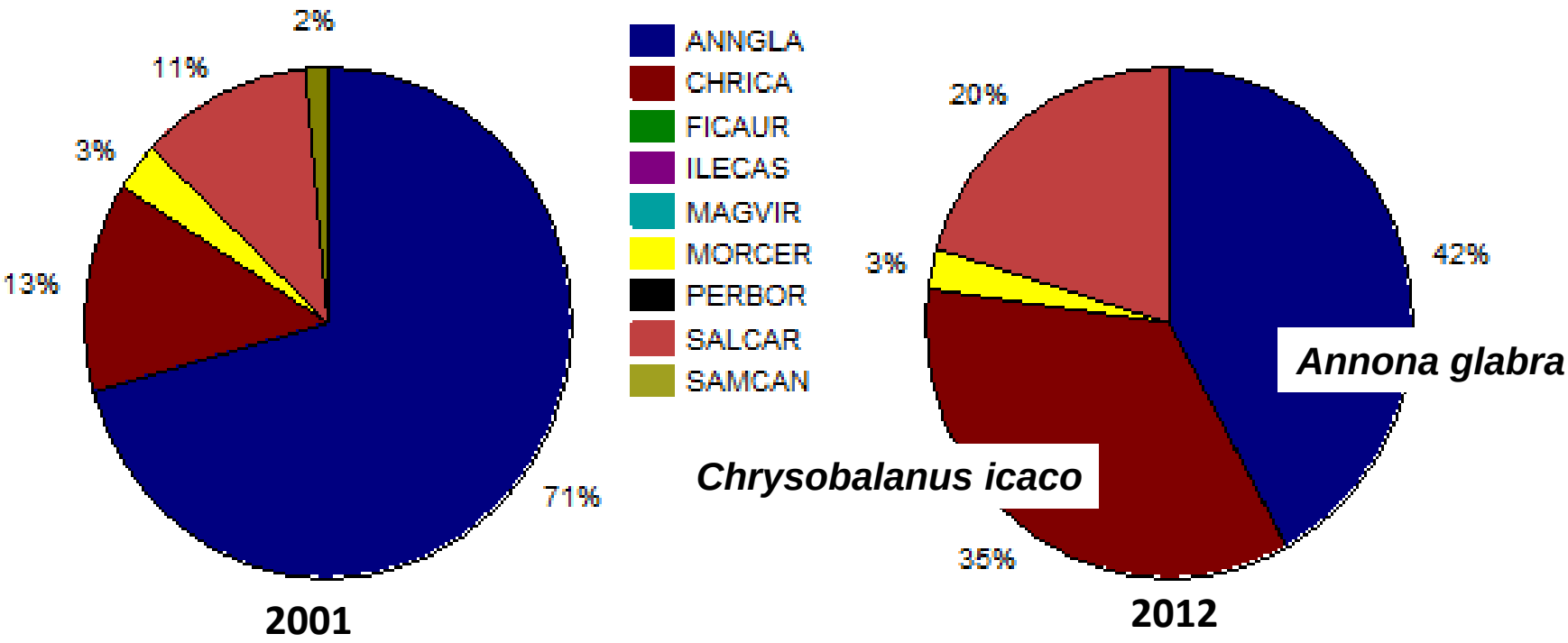




Sawgrass cover increased at the marsh sites of Hardwood hammock and Bayhead transects, and all along the Bayhead swamp transects

Tree island : Swamp forest (Bayhead & Bayhead swamp)

Vegetation response to hydrologic change



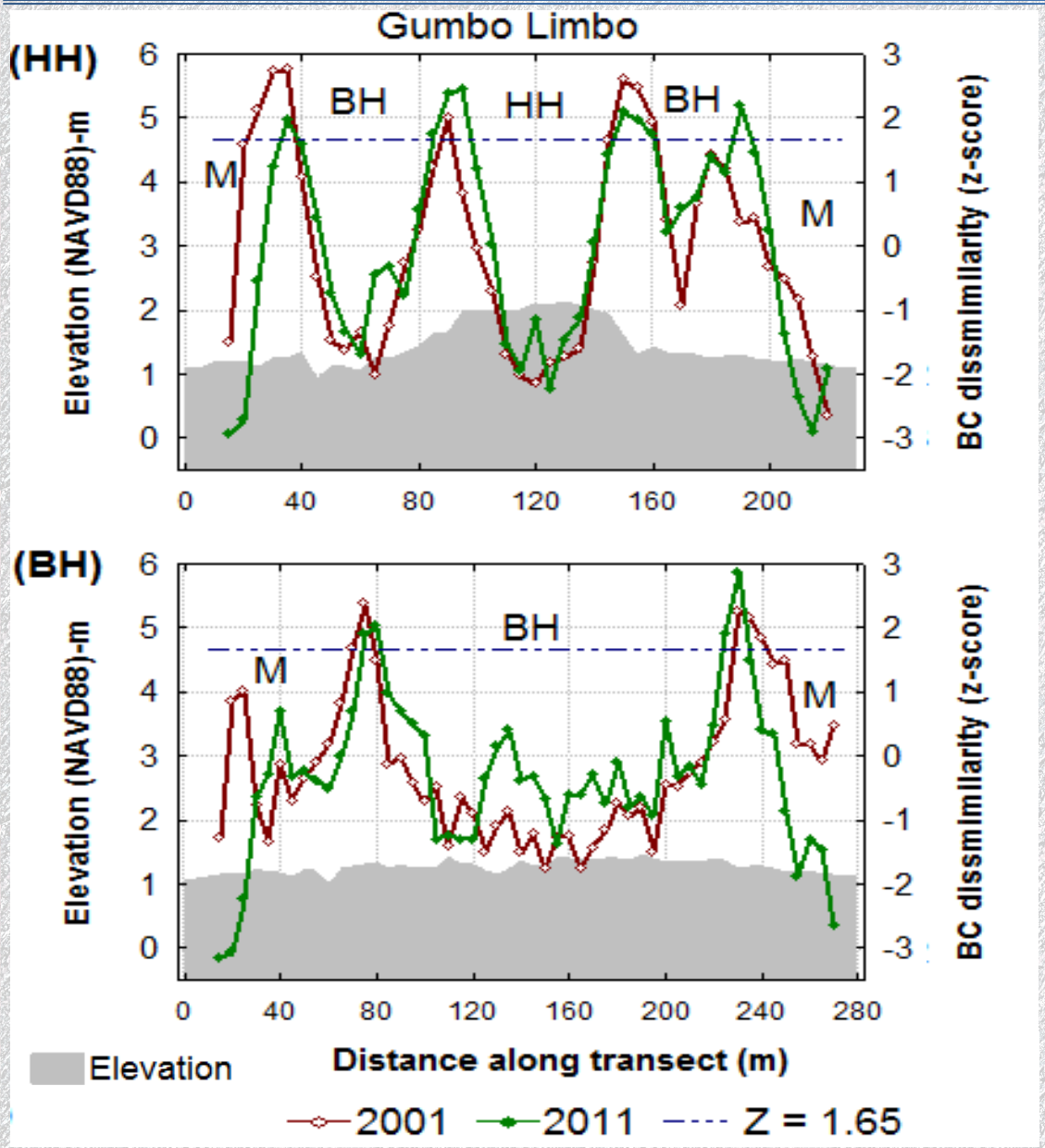
Tree species importance value (IV) in Black Hammock Bayhead Plot

In both the transect and plot studies:

- **Cover of flood tolerant species decreased, but**
- **Cover of moderately flood in-tolerant species showed opposite trend.**

Boundaries between communities

(along Hardwood hammock and Bayhead Transects)

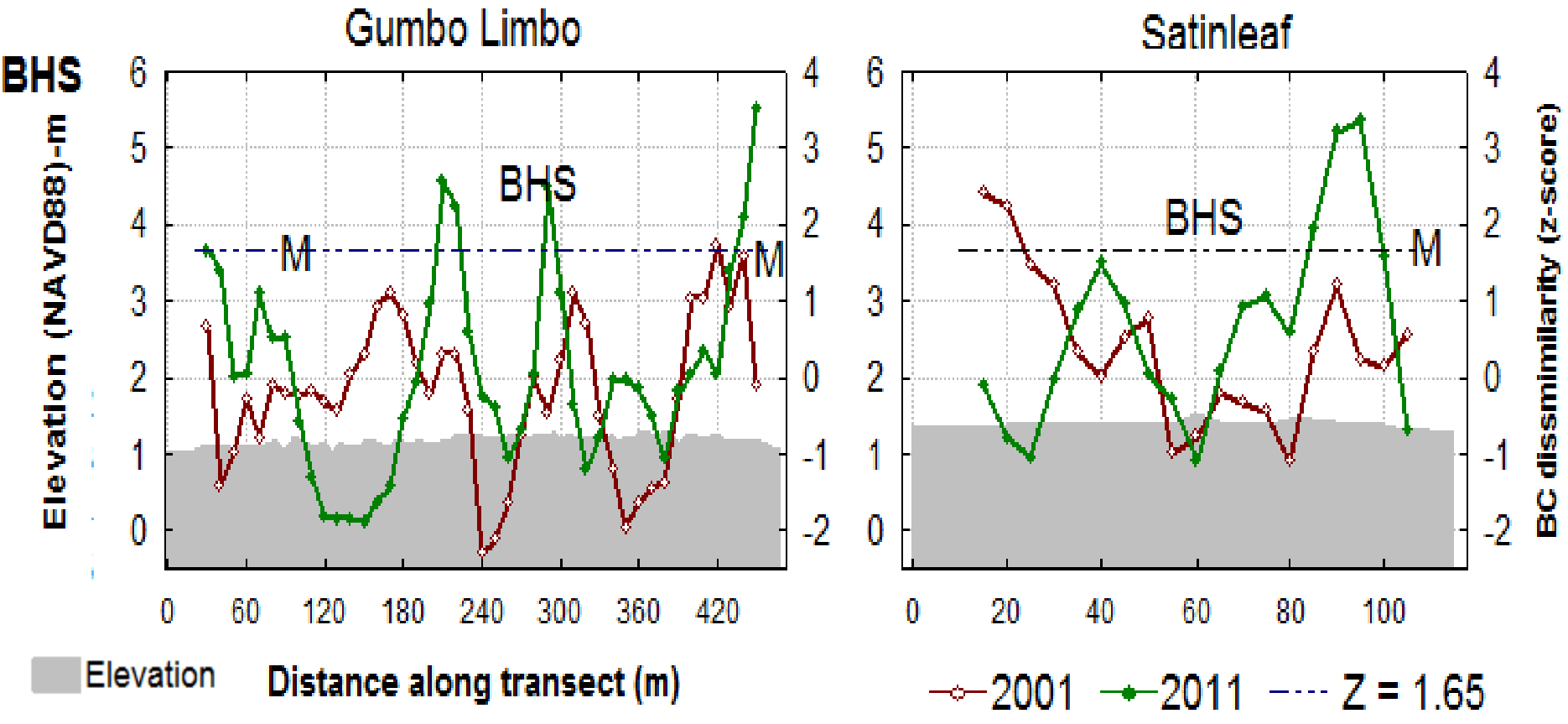


Changes in boundaries' position and attributes (sharpness) were minimal along hardwood and bayhead transects.

Effects of annual variation in hydrology probably did not surpass thresholds that would have resulted in regime shifts in individual communities.

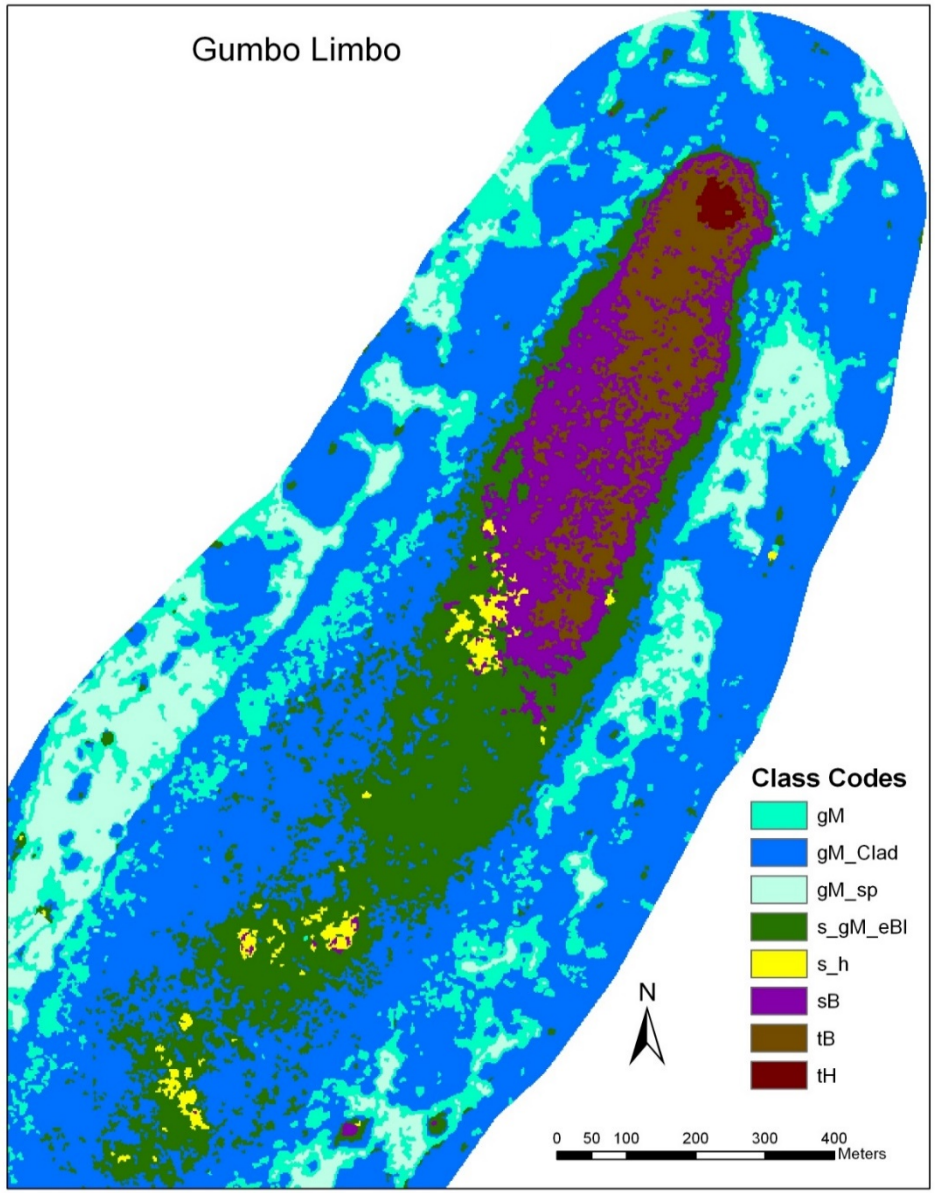
Boundaries between communities

(Bayhead Swamp & adjacent Marsh)



However, the changes in boundaries' attributes (sharpness) and positions were noticeable along bayhead swamp transect, especially in Gumbo Limbo and Satinleaf.

Fine-scale vegetation map
(Gumbo Limbo & surrounding marsh)



Imagery = WorldView 2 (WV2) multi-spectral satellite data (Pixel size = 2 x 2 m)

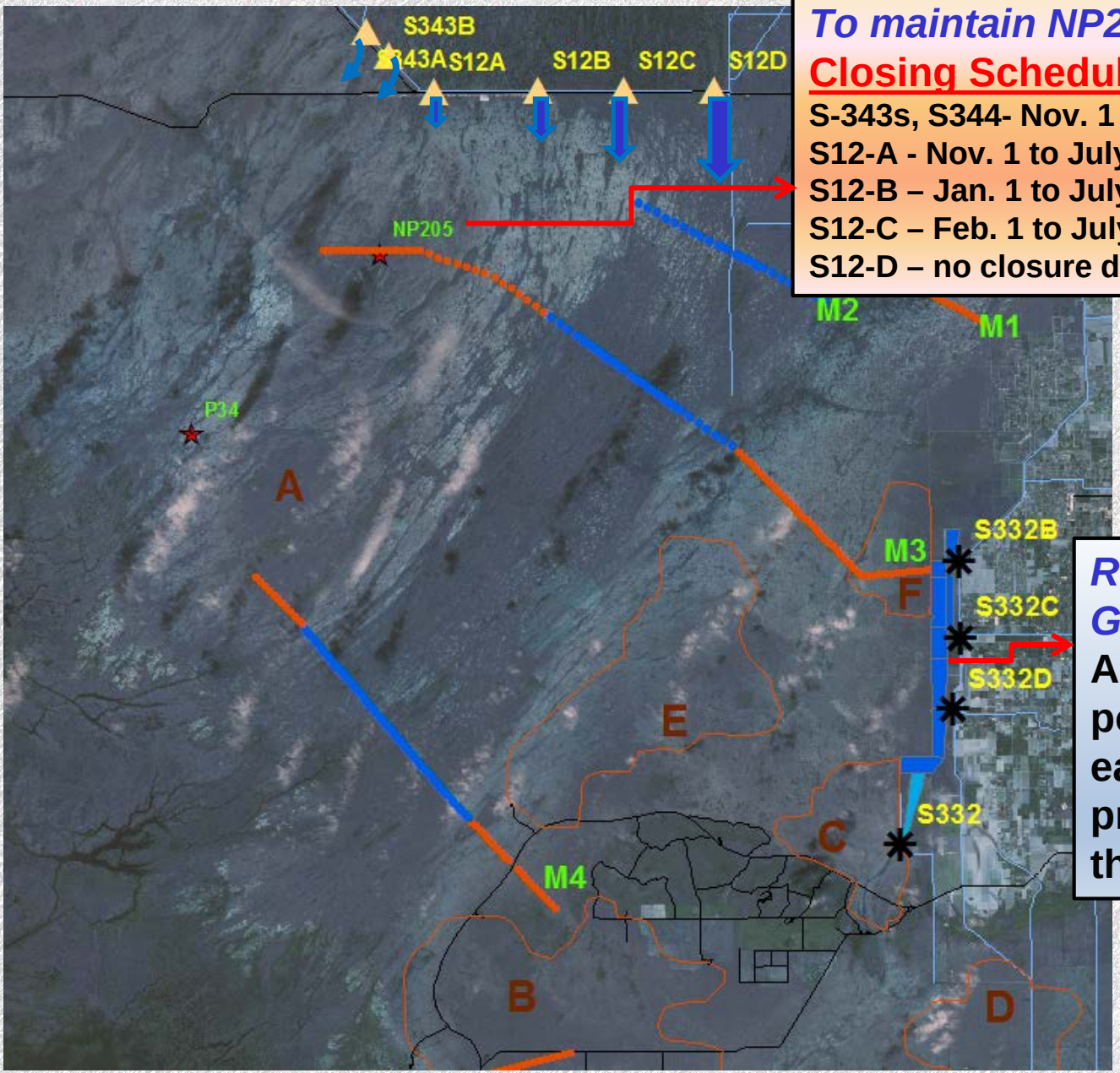
Training points on two islands
- Gumbo Limbo and NP202

Accuracy = 97.3% ± 1.0 (SE)

Minimum mapping area = 20 m^2

gM = Graminoid marsh, includes short graminoids and *Typha*
gM_Clad = *Cladium*-dominated marsh
gM_sp Sparse graminoid marsh
s_gM_eBl = Mixed shrub, graminoid, & emergent broadleaf
s_h = Scrub herbaceous
sB = Bayhead swamp,
tB = Bayhead forest
tH = Hardwood hammock

Water management & ecosystem restoration



To maintain NP205 <6 ft

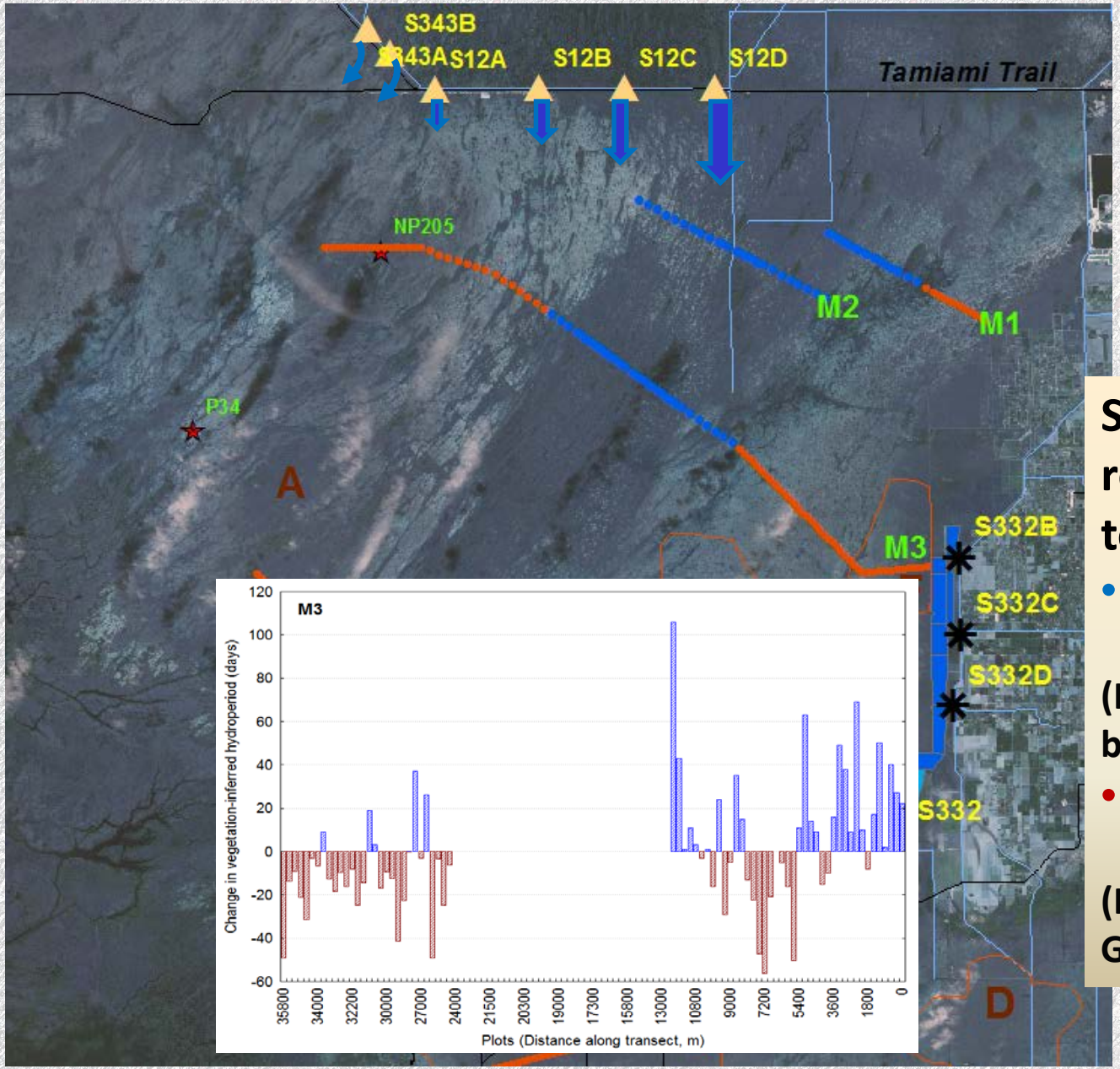
Closing Schedules

S-343s, S344- Nov. 1 to July 15
S12-A - Nov. 1 to July 15
S12-B – Jan. 1 to July 15
S12-C – Feb. 1 to July 15
S12-D – no closure dates

Re-hydrating the Rocky Glades

A series of retention ponds along ENP's eastern boundary to prevent seepage back to the canal

Response of Marl prairie vegetation to management



Spatially differentiated response of vegetation to hydrology:

- **Wetting trend in Eastern Marl Prairie**

(Increase in sawgrass & beakrush)

- **Drying trend in Western Marl Prairie**

(Increase in Bluestem & Gulfdune paspalum)

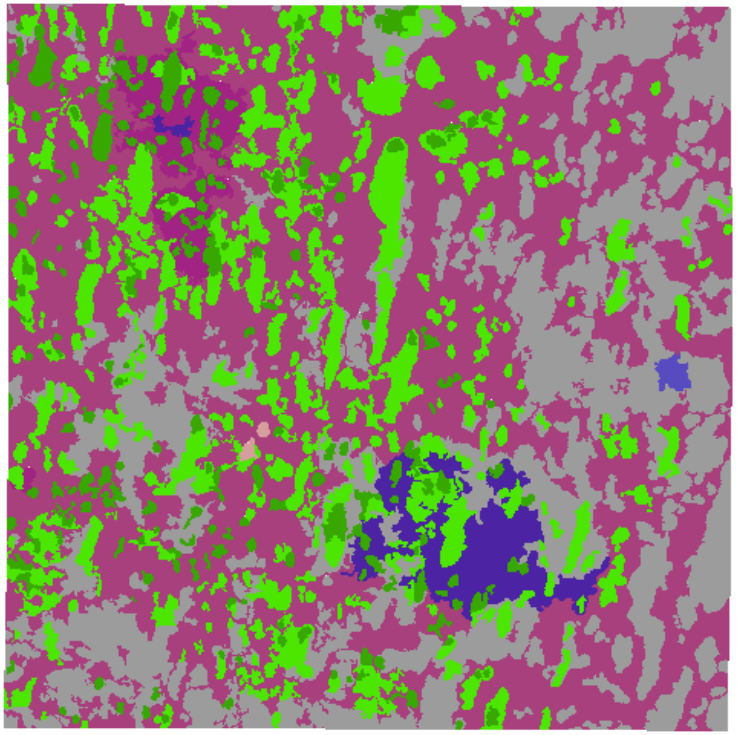
Conclusions

- Even short-term (decadal scale) fluctuations in hydrologic regime, resulting in below average water levels in Shark Slough can promote an increase in sawgrass cover.
- In the prolonged dry conditions, it is the progression towards sawgrass and establishment and growth of trees in the peat environment that drives successional processes towards the expansion, growth, and maturation of tree islands in the ridge and slough landscape.
- In general, shifts in boundaries among plant communities are presumed to initiate reductions in ecosystem resilience, resulting in regime shifts. However, the effects of annual variation in hydrology over a decade probably did not surpass the ecosystem's resilience, hence a minimal shift in boundary was observed on most transects on the tree islands.

Acknowledgments

- US Army Corps of Engineers (U.S. Army Engineer Research & Development Center).

- Susana Stoffella, Daniel Gann, Danielle Ogurcak, Ewan Isherwood, Lawrence Lopez, Adam Spitzig, Jesus Blanco, Junnio Freixa & many other SOFTEL members



Thank you