INTEGRATING TREE ISLAND METRICS TO UNDERSTAND POTENTIAL MECHANISMS FOR PAST DEGRADATION AND FUTURE RESTORATION

Tiffany G. Troxler[1], Carlos A. Coronado-Molina[2], Fred H. Sklar[2]
[1]Florida International University, [2]South Florida Water Management District

Contributors: S. Krupa, S. Newman, M. Manna, D. Rondeau, O. Sanchez, R. Price

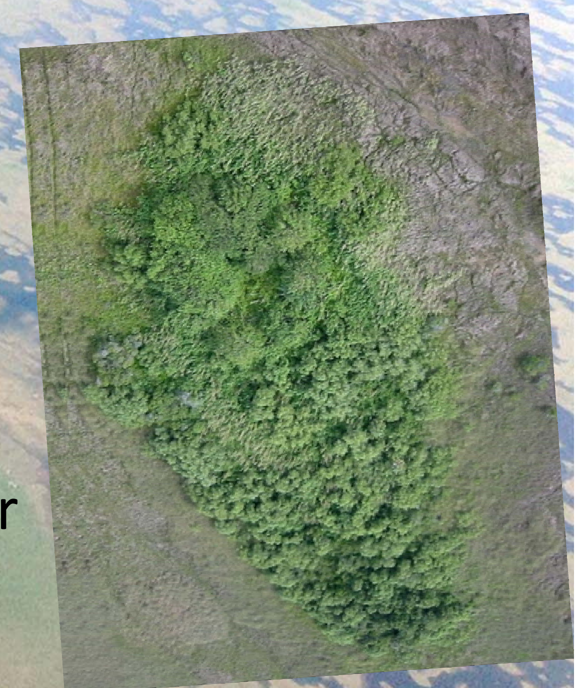
GEER April 23, 2015

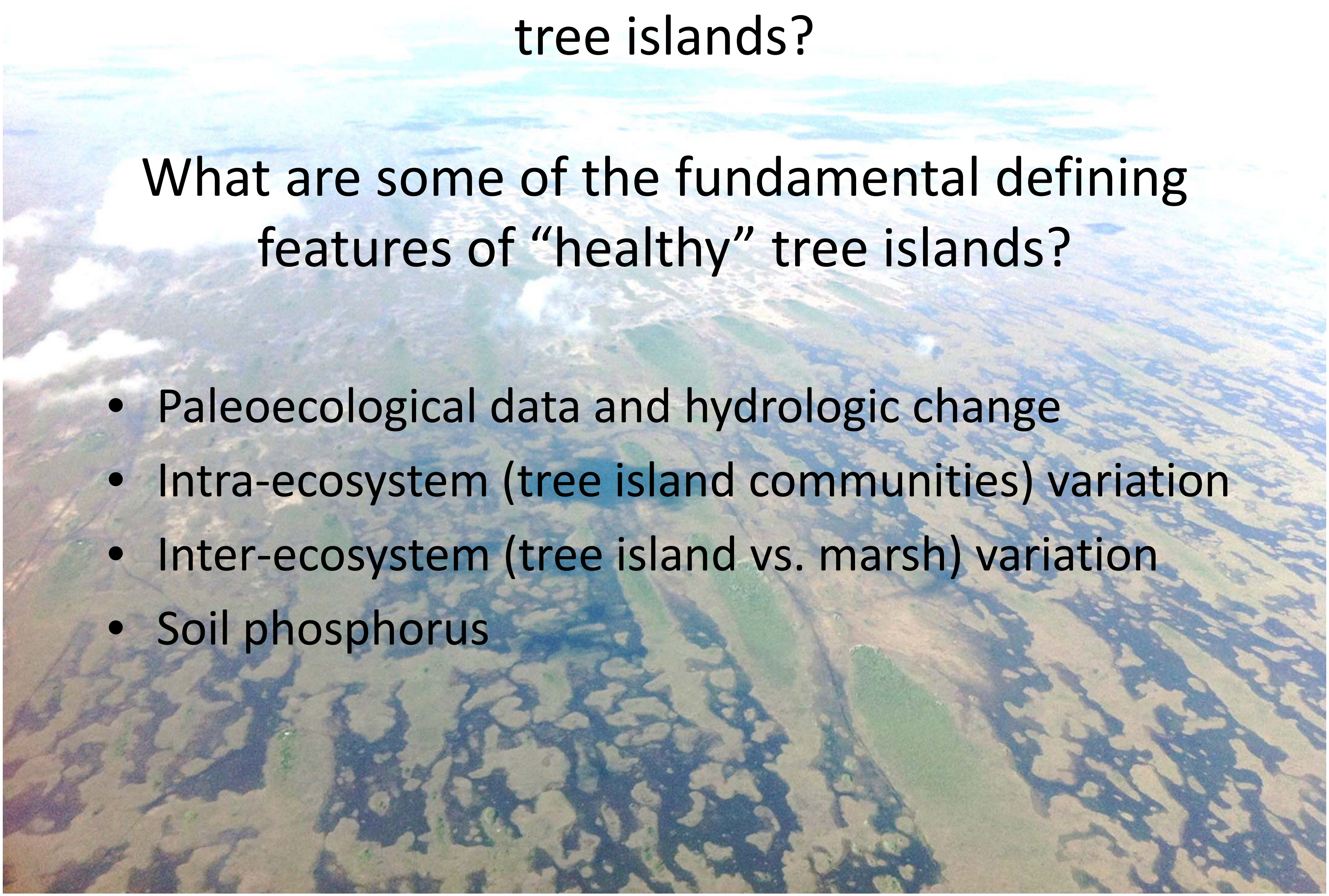
Tree Island Background and Management Relevance

- Significant for **wildlife habitat, cultural and recreational and regional-scale indicators of the ecological “health”** of the Everglades landscape.
- Potential phosphorus source in oligotrophic marsh landscape -- soils of upland communities can **contain P >100 higher** than marsh soils
- **Hydrologic alterations** have affected tree islands - too drained in some areas (parts of WCA 3B) and too flooded in other areas (parts of WCA 3A).
- Effects include changes in tree island forest structure and **loss of tree island area**.

Key Management Questions:

- How to maintain the soil P reserve to prevent P enrichment of local, oligotrophic marsh communities?
- How to restore tree islands structure and function where they have been degraded or lost?



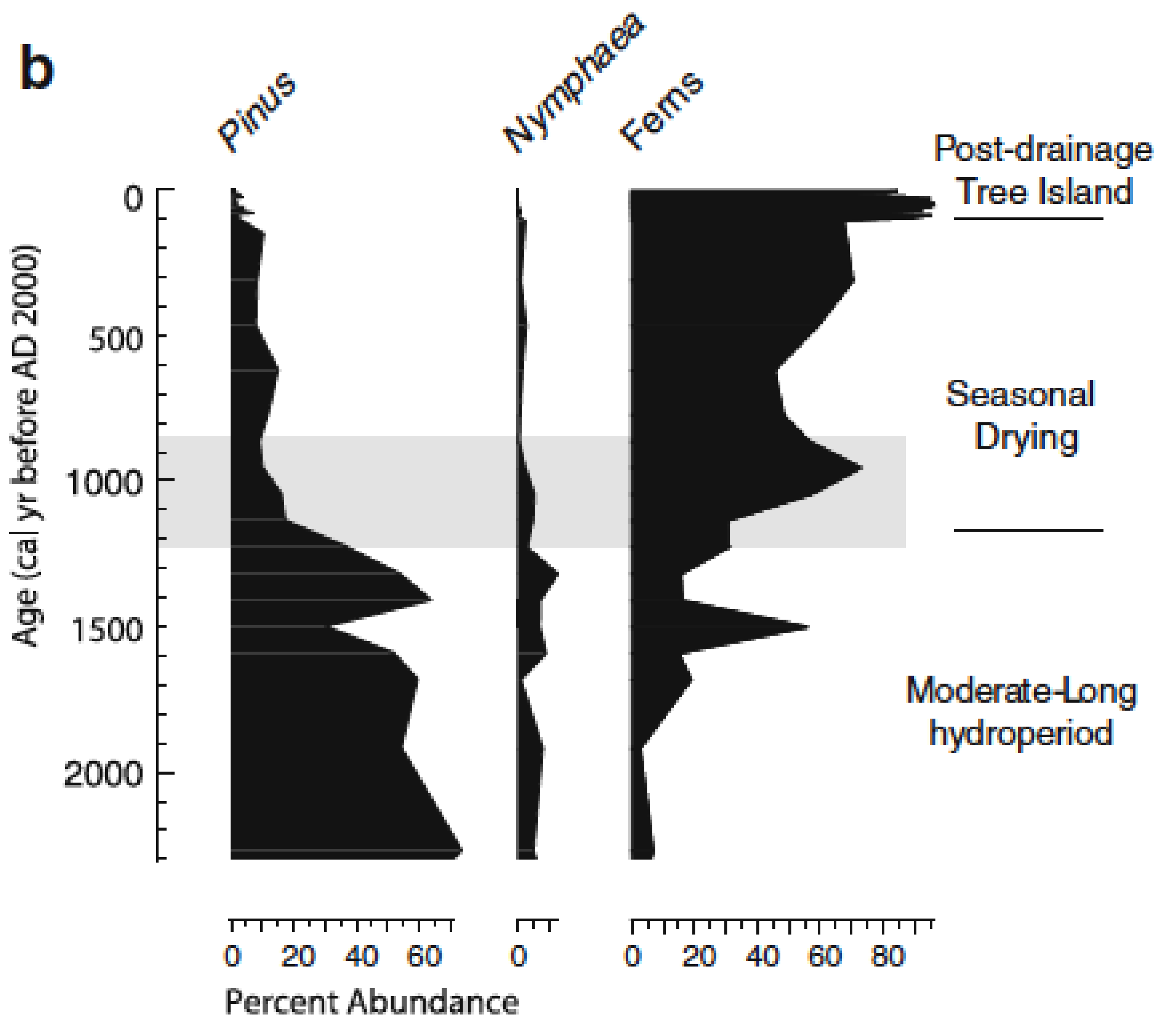


How can we determine a target for "healthy" tree islands?

What are some of the fundamental defining features of "healthy" tree islands?

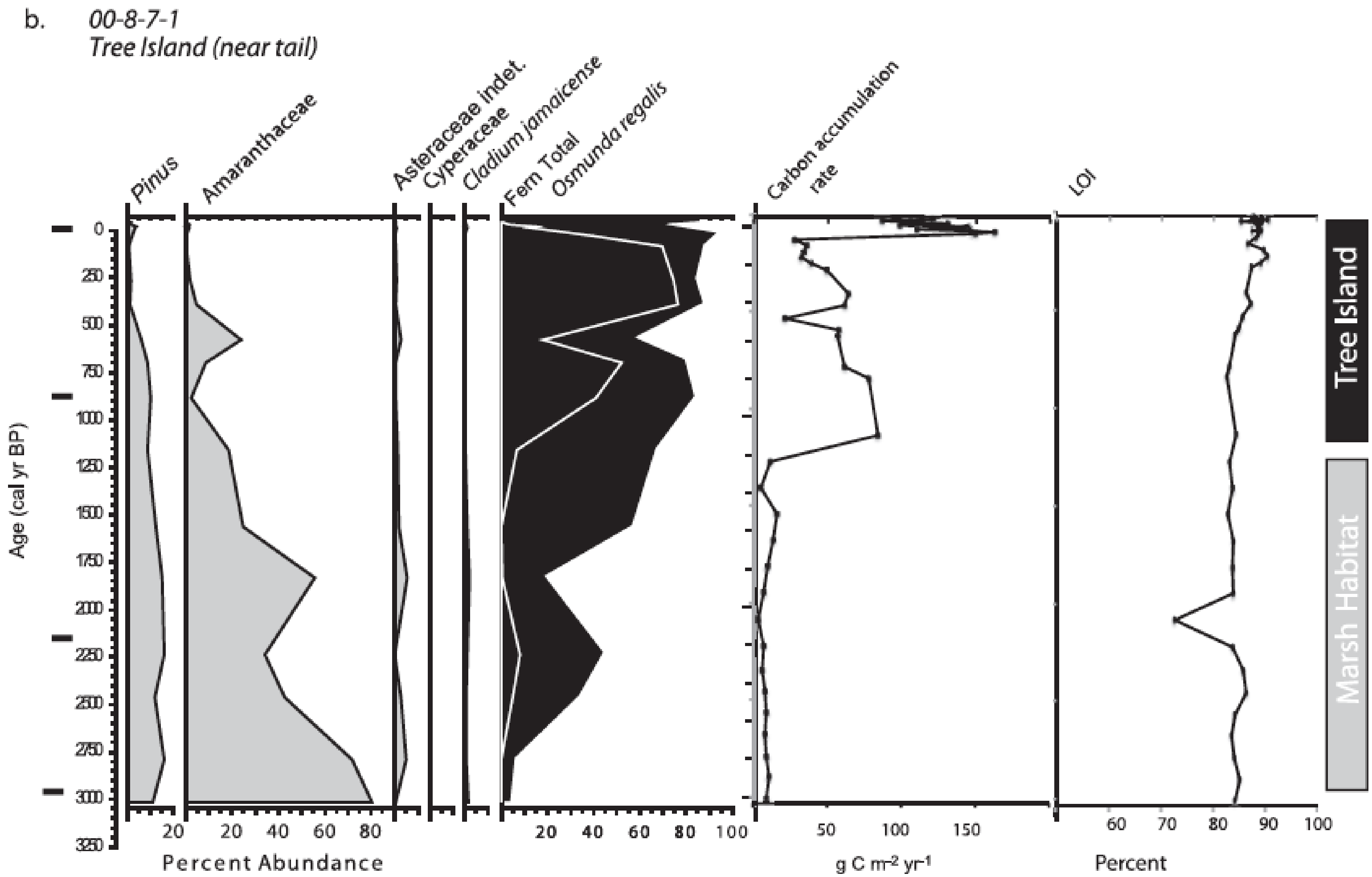
- Paleoecological data and hydrologic change
- Intra-ecosystem (tree island communities) variation
- Inter-ecosystem (tree island vs. marsh) variation
- Soil phosphorus

Paleoecological data and hydrologic change



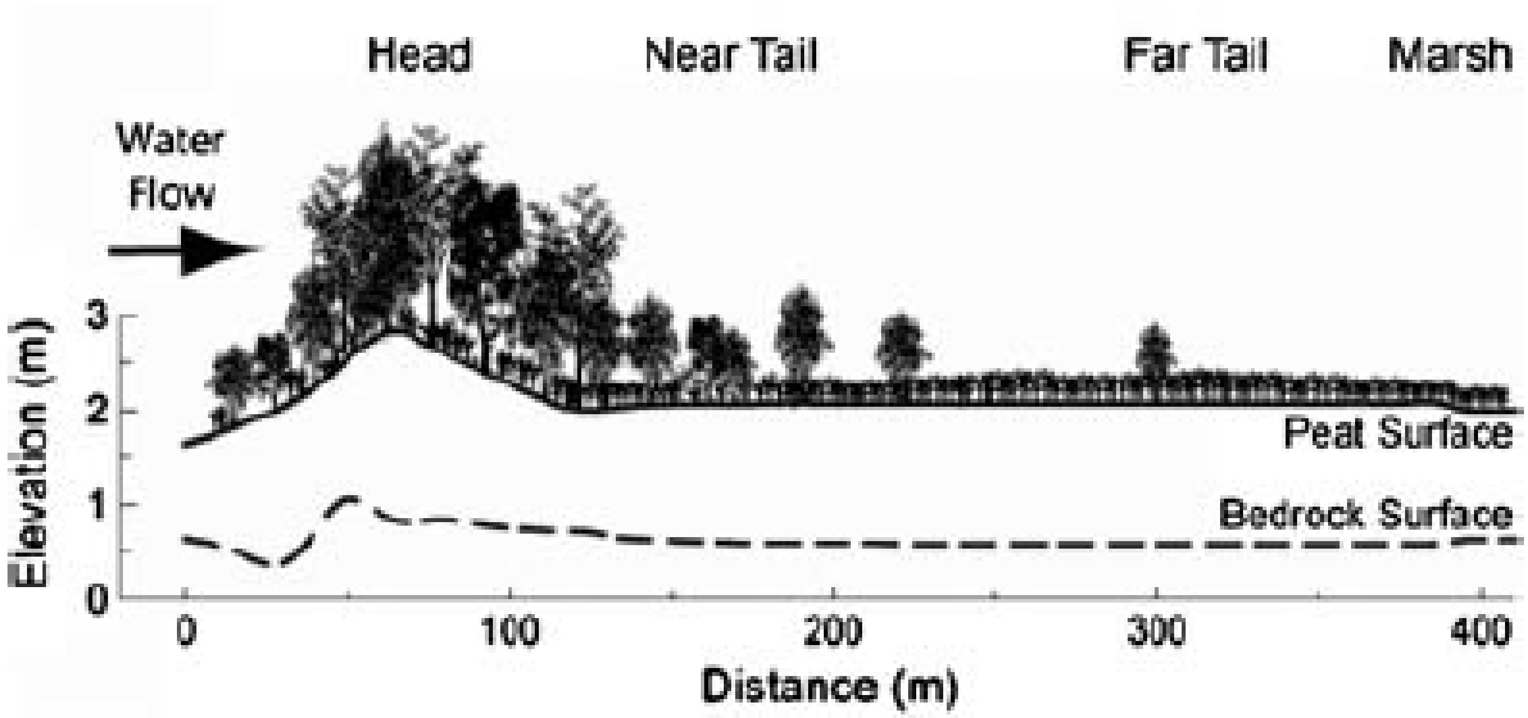
Advent of tree island development associated with "seasonal drying"; Willard & Bernhardt 2011

Paleoecological data and hydrologic change



Greatest peat accumulation in the "near-tail"; Jones, Bernhardt & Willard 2014

Plant community types – variation within tree islands and between islands and marsh



Wetzel et al., 2009. Plant Ecology.

Soil phosphorus

A.

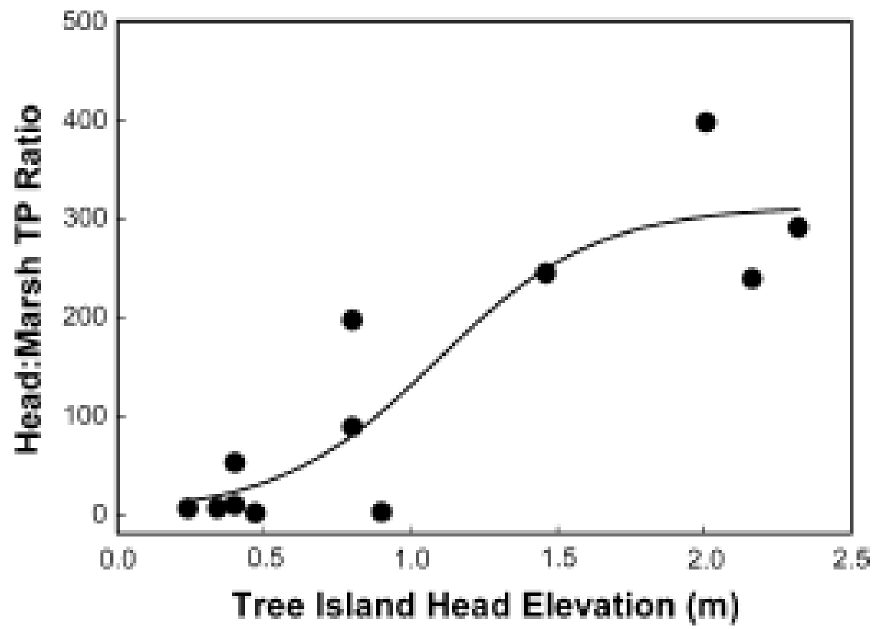
Table 1 Total soil phosphorus concentrations at three depths on the heads, near tails, and far tails of 12 tree islands and adjacent marshes in the Everglades

Soil depth (cm)	Total phosphorus (g m^{-2a})			
	Marsh	Head	Near Tail	Far Tail
0–10				
Mean (SE)	6 (1)	421 (93)	18 (4)	21 (15)
Median	5	35	8	8
Range	2–12	6–3,576	4–233	4–80
10–20				
Mean (SE)	3 (0)	699 (131)	34 (7)	7 (1)
Median	3	67	11	7
Range	2–3	5–5,539	4–347	4–11
20–30				
Mean (SE)	2 (0)	775 (257)	36 (4)	5 (1)
Median	2	95	15	4
Range	1–3	8–6,078	3–307	3–6

[a] Square meter over a depth of 10 cm

Wetzel et al. 2009. Plant Ecology

B.



A. Total soil phosphorus is higher on “high head” of tree island soils than in “tail” or marsh soils

B. The greater the difference between marsh and head elevation, the higher the total phosphorus on the head

Overall Goals

1. Draw upon previous observations and studies to identify, characterize and monitor:
   a. processes that have preserved tree island soil P for millennia
   b. the potential for restoring them where they have been lost

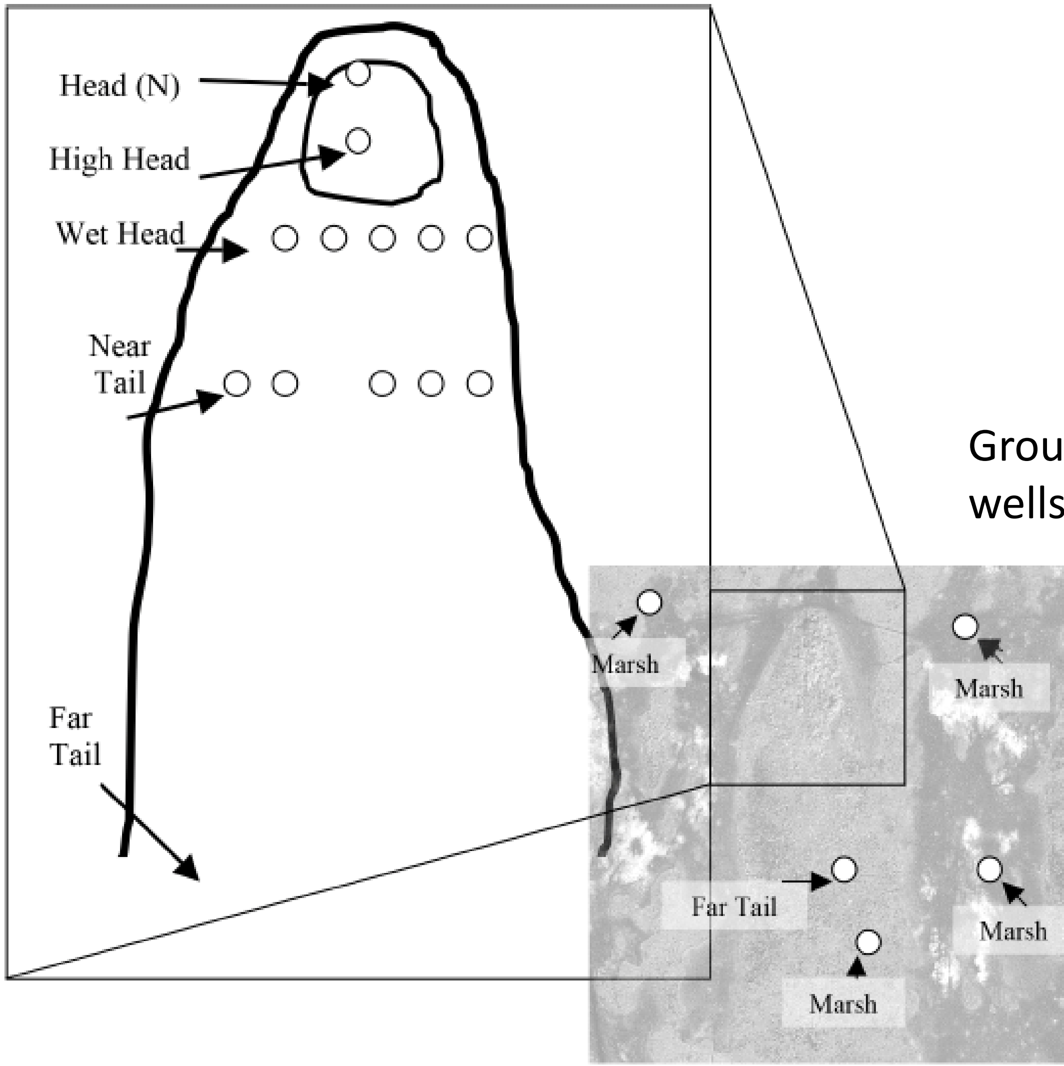
2. Link local tree island hydrodynamics, vegetation and soil structure with regional hydrology to develop tree island performance measures and assessment tools

What have we learned about the interaction of plant community, hydrology, geochemistry and tree island stability?

- Plant transpiration, evaporation and water flux
- Subsurface geochemistry
- Biogenic calcium phosphate deposition
- Precipitation (rain events)

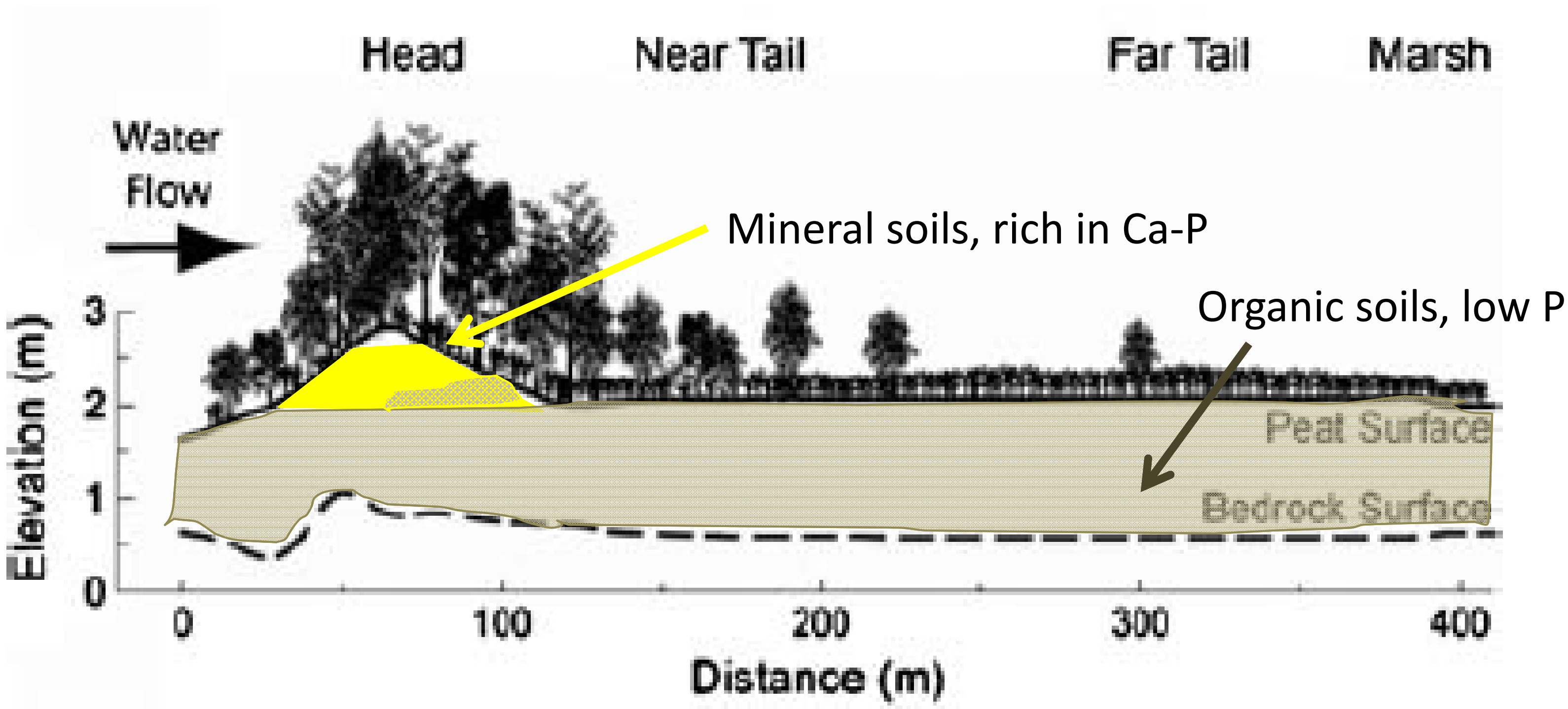
Intensive monitoring on a "pristine" tree island in WCA 3A

Shallow piezometers



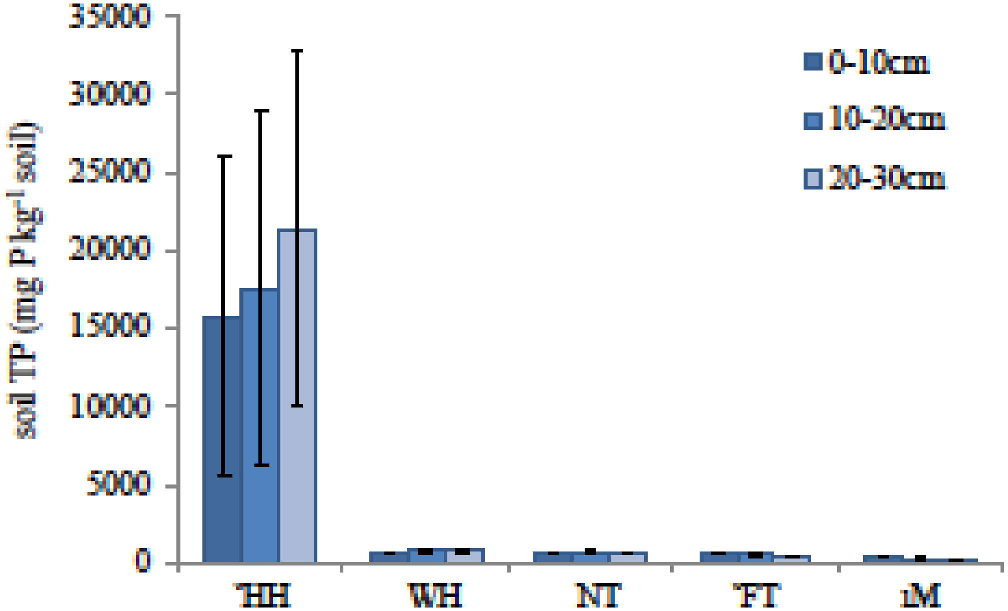
Groundwater wells

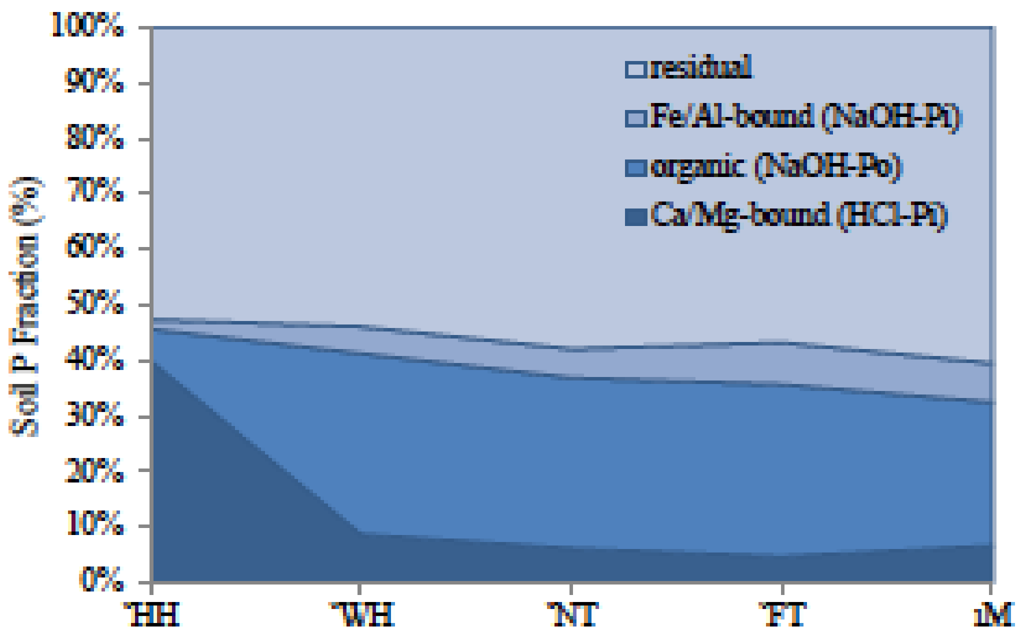
Soil phosphorus of a "pristine" tree island (3AS3)



Irick et al. 2013. SSSAJ;
Troxler et al., 2014. Biogeosciences

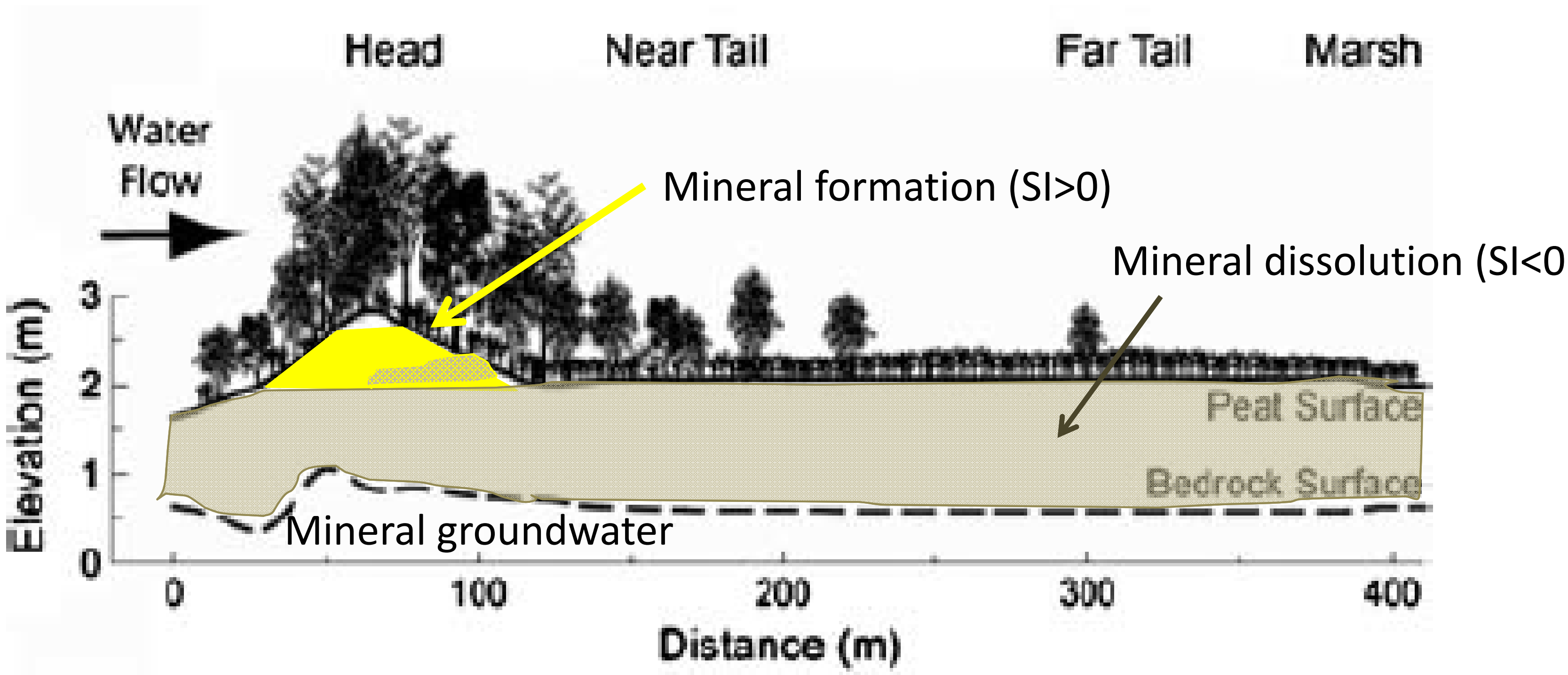
Soil phosphorus of a "pristine" tree island (3AS3)





Troxler et al., 2014.
Biogeosciences

Subsurface geochemistry of a "pristine" tree island (3AS3)

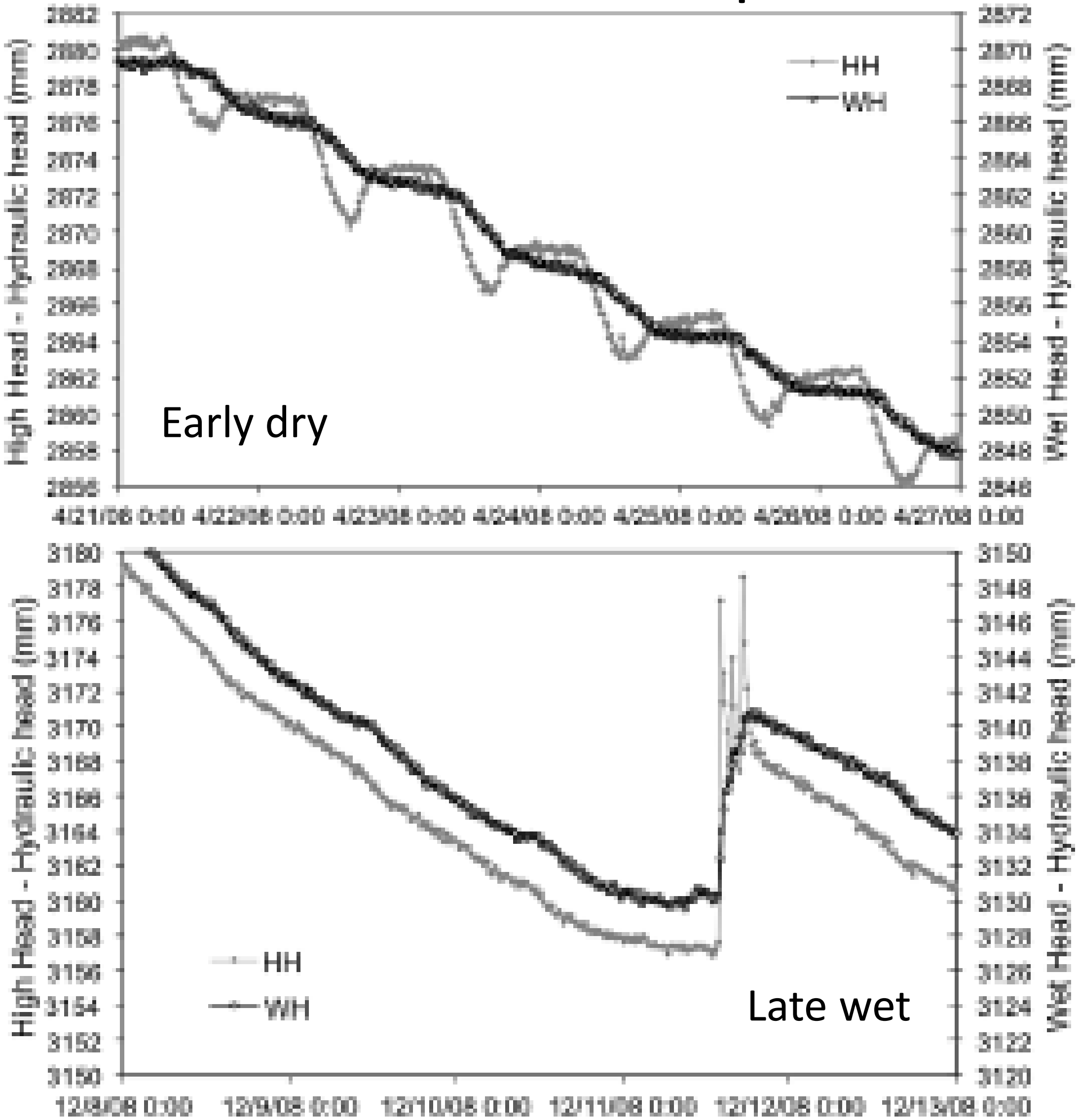


Potential sources of minerals in peat forming soils (saturation indices):

- Groundwater contribution
- Ion exclusion and accumulation
- Deposition of aerosols
- Mineral soil components

Troxler et al., 2014. Biogeosciences

What are processes modulating mineral precipitation within soils of a "pristine" tree island?



Subsurface drawdown at 60cm below the soil surface in early dry (late April) and late wet (mid Dec.)

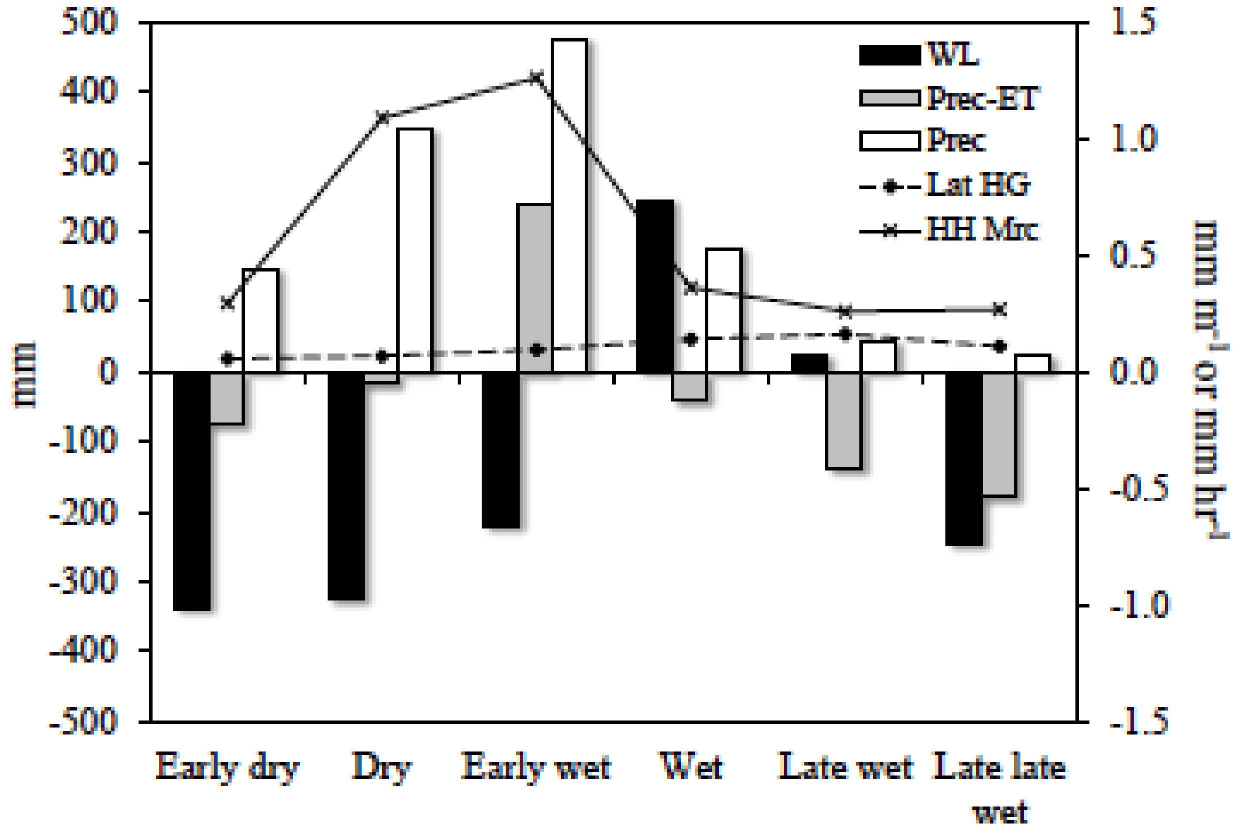
Evapoconcentration

- Diurnal drawdown promotes ion accumulation, favoring mineral precipitation
- Rain water infiltration provides a mechanism promoting P release
- P release under conditions favoring mineral precipitation permits reformation of mineral-bound P

Ion exclusion

Troxler et al., 2014. Biogeosciences.

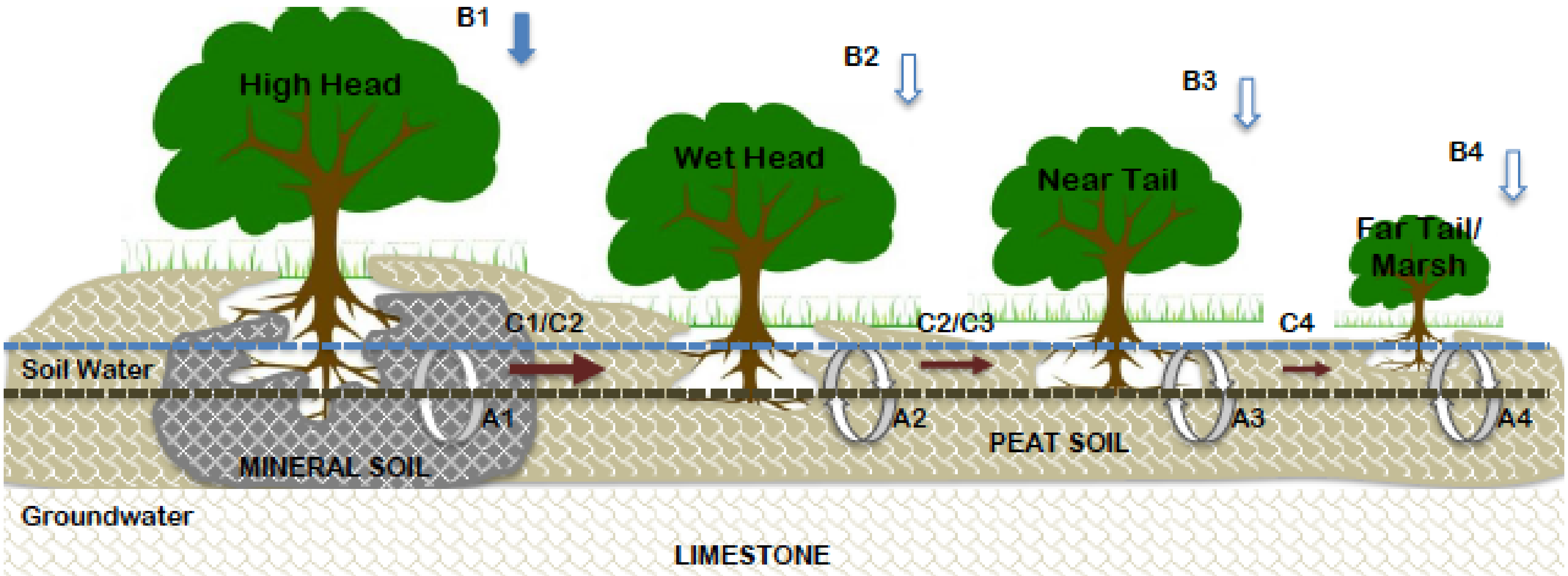
What are the processes modulating P flux within soils of a "pristine" tree island?



Dynamics of tree island water level (WL), ratio of precipitation to evapotranspiration (Prec-ET), precipitation (Prec), lateral hydraulic gradient (Lat HG) and porewater recharge rate (HH Mrc) in the high head

Troxler et al., 2014. Biogeosciences.

Local climatic, biotic and hydrogeochemical processes that contribute to soil P stability or soil P loss

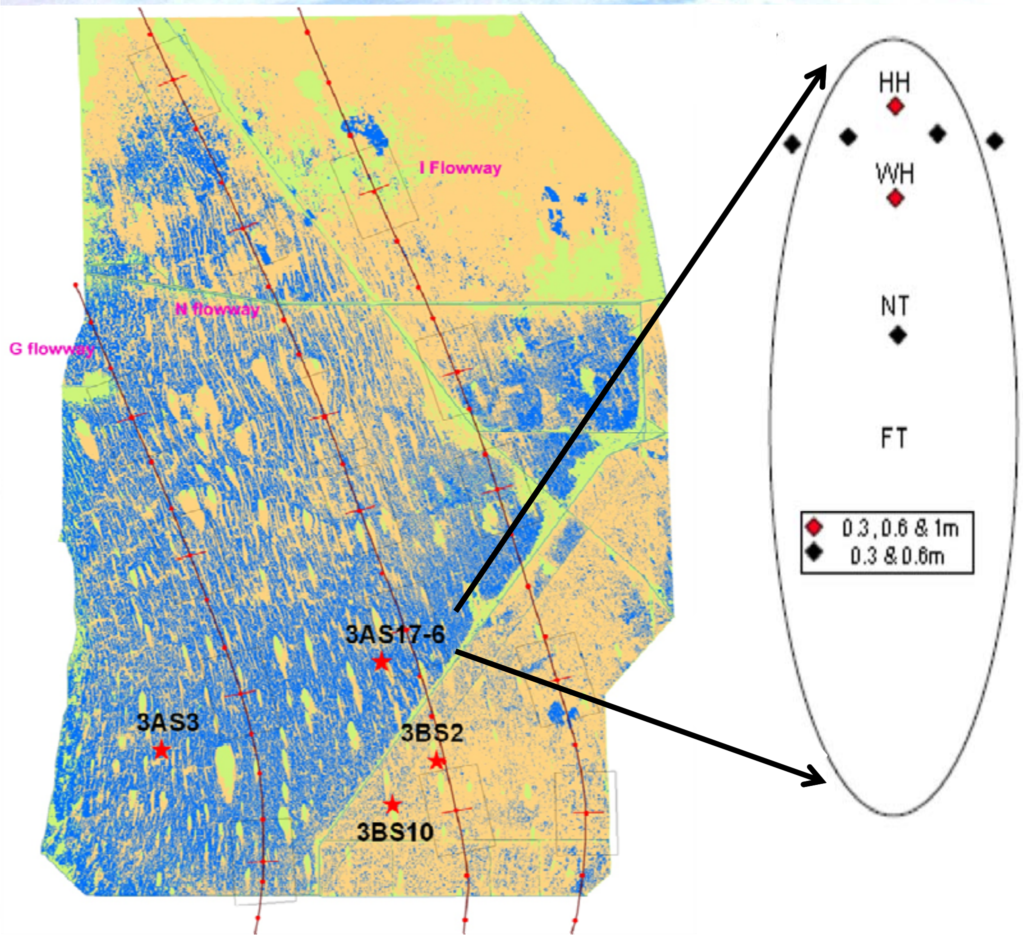


SOIL P MAINTENANCE: Landscape position and elevation of high head conserve phosphorus in tree islands by geochemical processes promoting mineral precipitation and dissolution and reprecipitation of Ca-P.
SOIL P LOSS: Landscape position and elevation prohibit mineral precipitation or promote leaching of mineral soil P.

Troxler et al., 2014. Biogeosciences.

Current Landscape Monitoring Design with Schematic of Well Locations

Hydraulic and geochemical properties are key to address questions and are critical parameters to monitor “health” of tree islands.



HH: High Head   WH: Wet Head   NT: Near Tail   M: Marsh

- **Evapotranspirational pumping:** daytime drawdown of tree island soil water table
- **Ion composition and strength:** indicate plant-water interactions to build ionic strength and mineral soil stability
- **Soil and soil water phosphorus:** indicate P availability, mobility and potential for loss

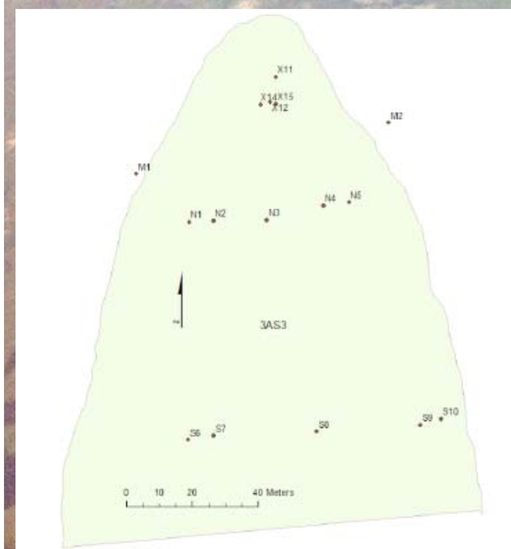
Monitoring Approach

Combine intensive measurements of –

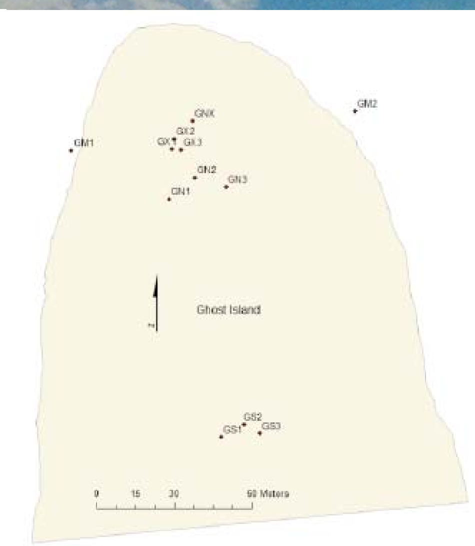
1. hydraulic head gradients and ionic strength in surface and shallow soil water wells,
2. spatial patterns of soil and soil water phosphorus, and
3. stem and/or source water ^{18}O and ^{2}H isotopic composition

In four tree islands along different hydrologic and disturbance gradients in Water Conservation Areas (WCA) 3A and 3B–

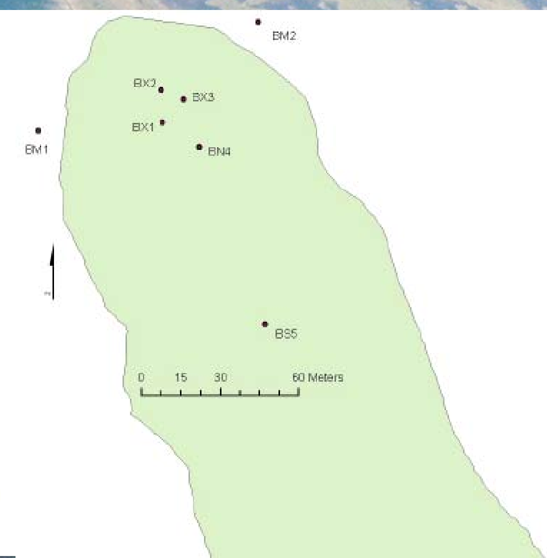
Wet, Intact (3AS3-WCA3A)



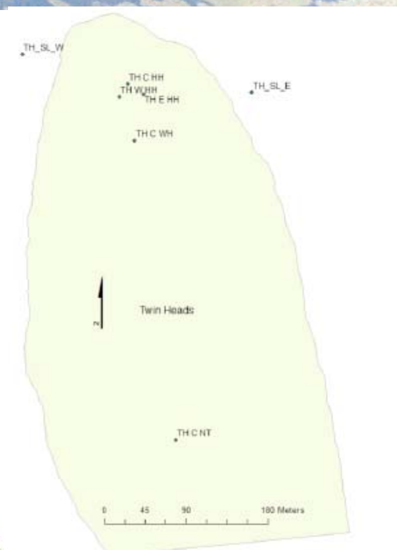
Wet, Degraded (Ghost Island-WCA3A)



Wet, Degraded (3BS2-WCA3B)

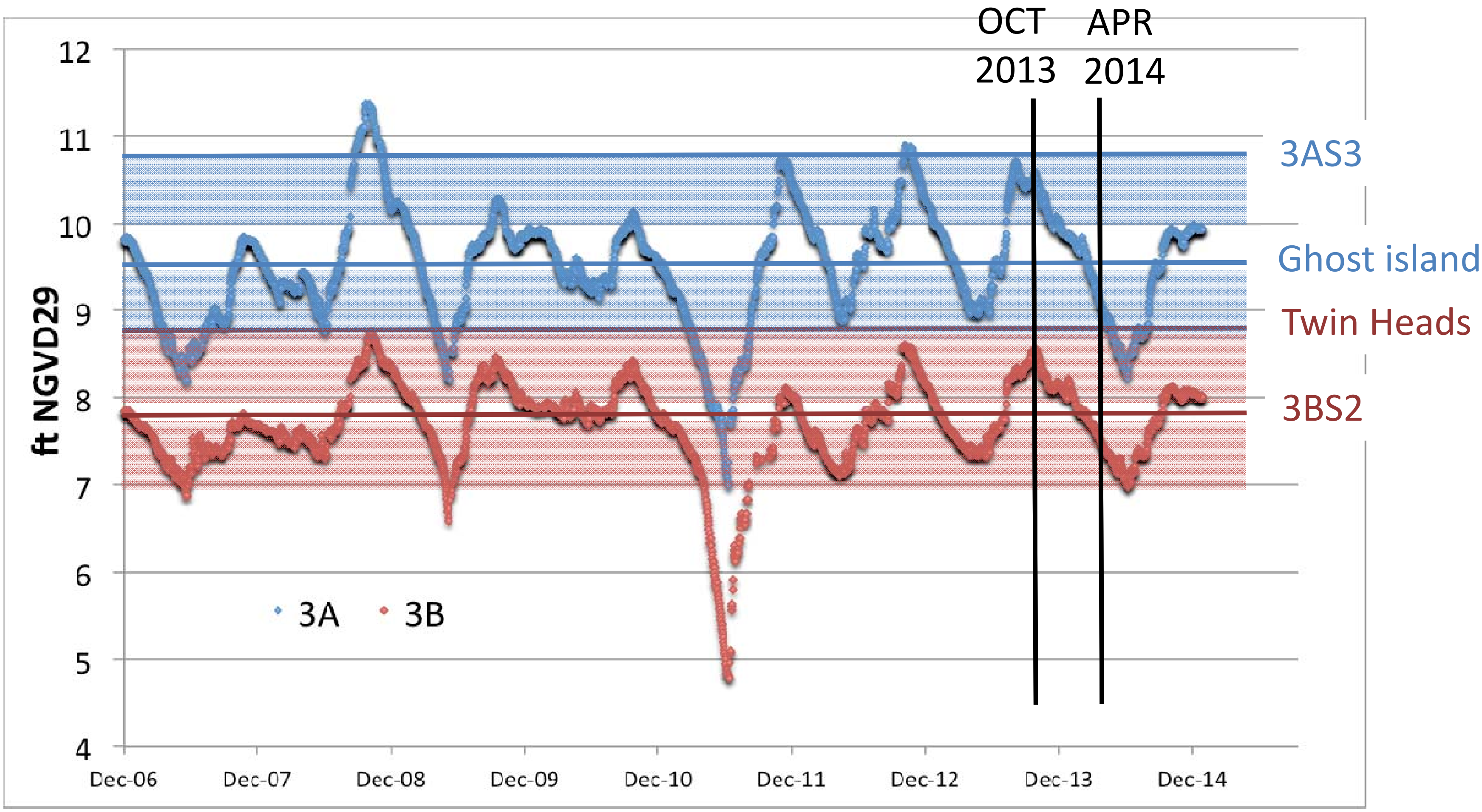


Dry, Degraded (Twin Heads-WCA3B)

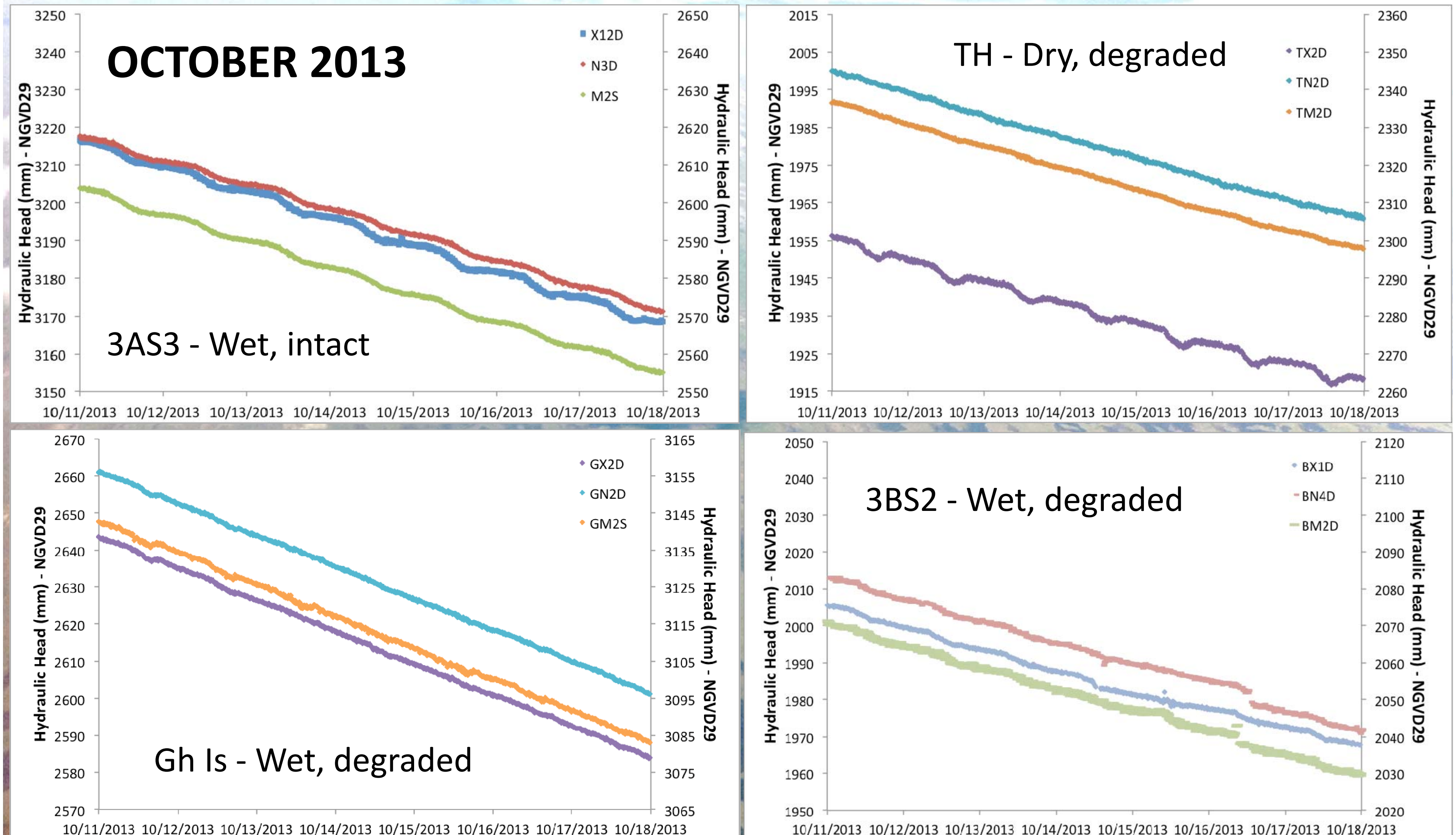


Hydrology of WCA 3A and 3B (2006-2014)

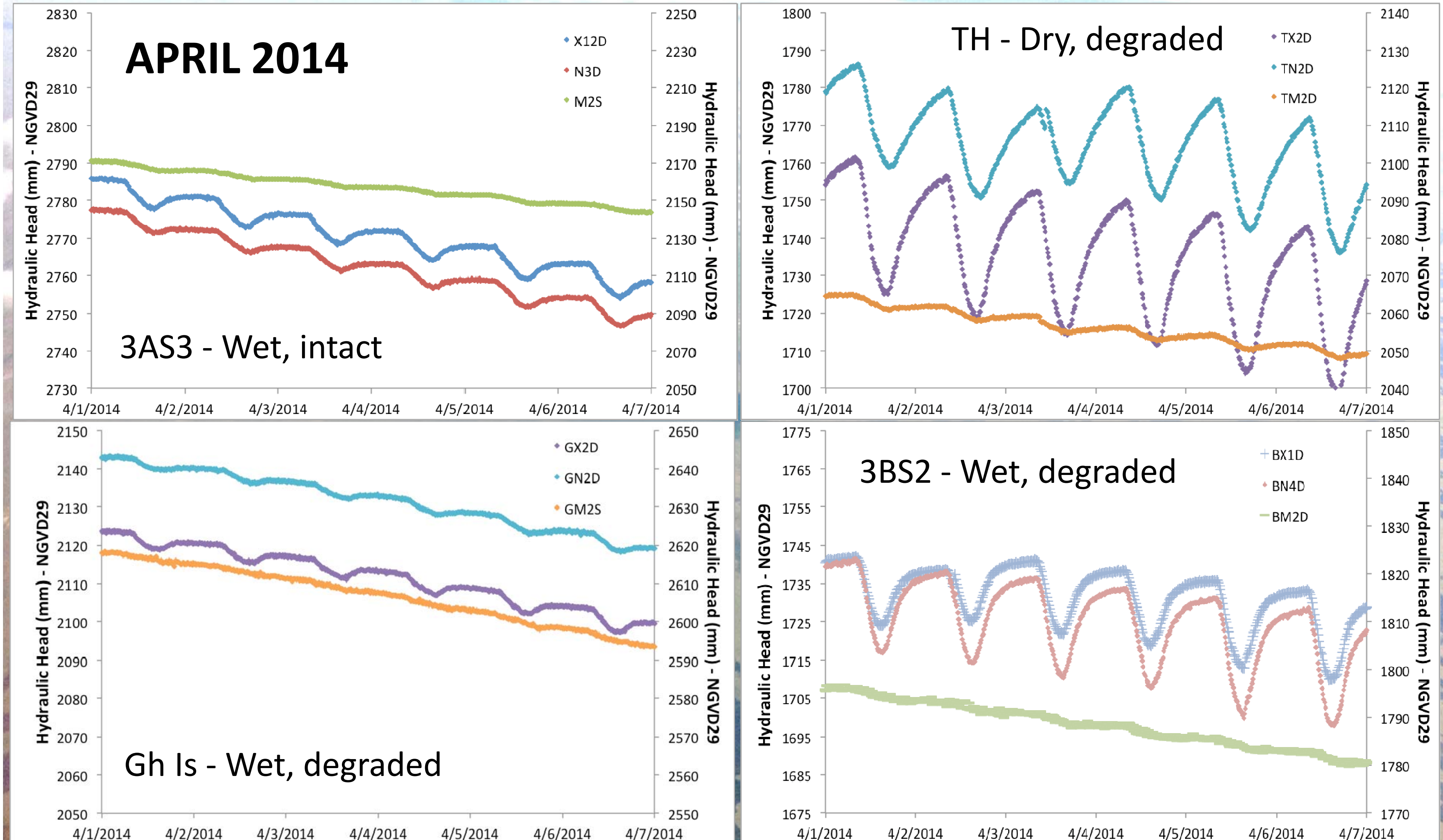
HIGH HEAD ELEVATION and EXTENT of ROOT INUNDATION (~0-30cm)



Plant community evapotranspiration pattern – diurnal drawdown

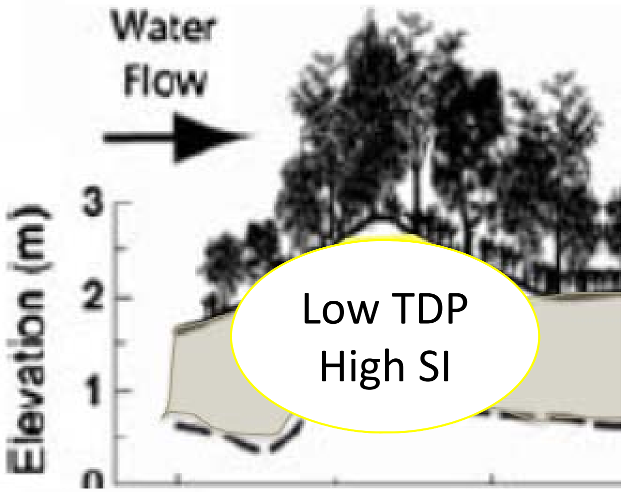


Plant community evapotranspiration pattern – diurnal drawdown

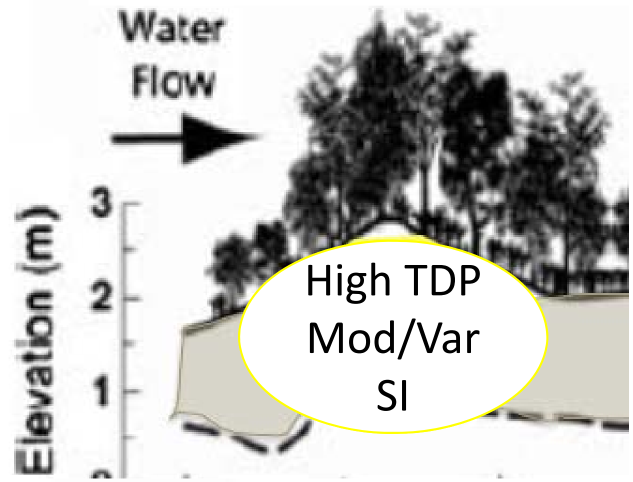


Subsurface geochemistry

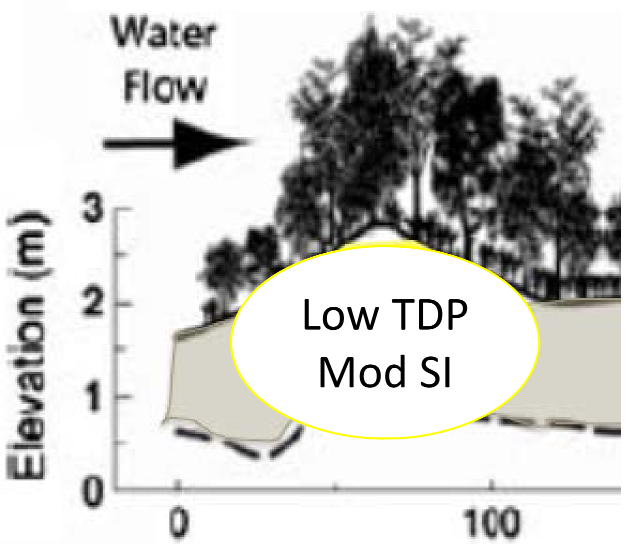
3AS3 (3A) – wet, intact



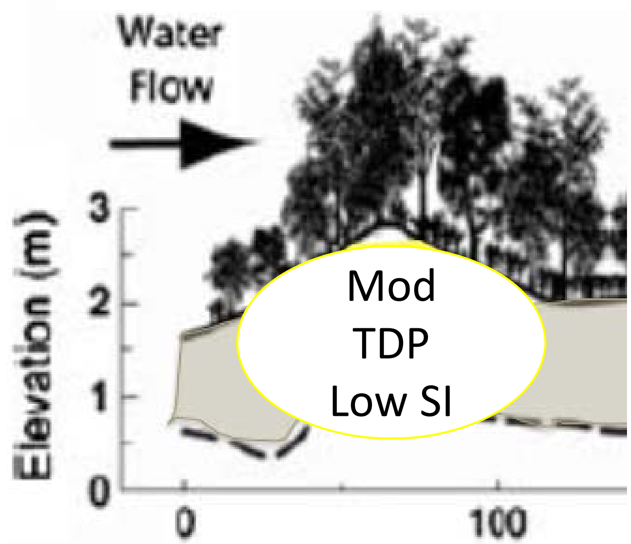
GI (3B) – wet, degraded



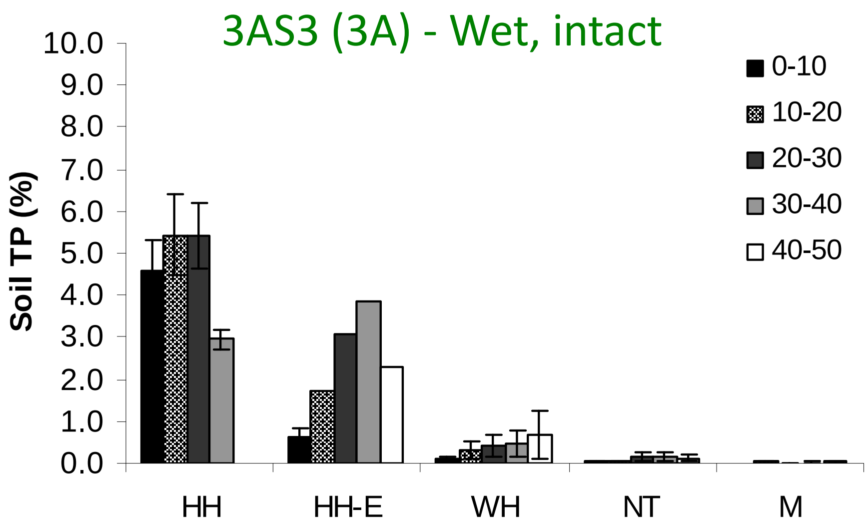
TH (3B) – dry, degraded

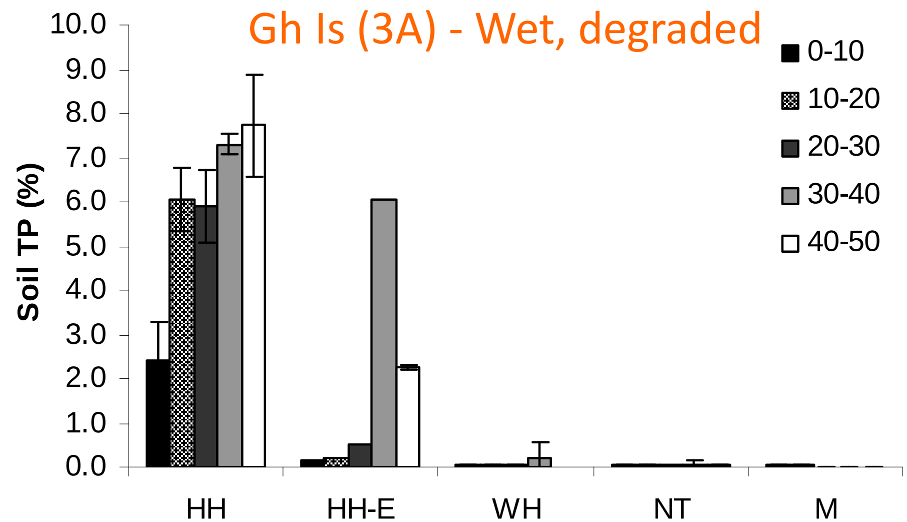


3BS2 (3B) – wet, degraded

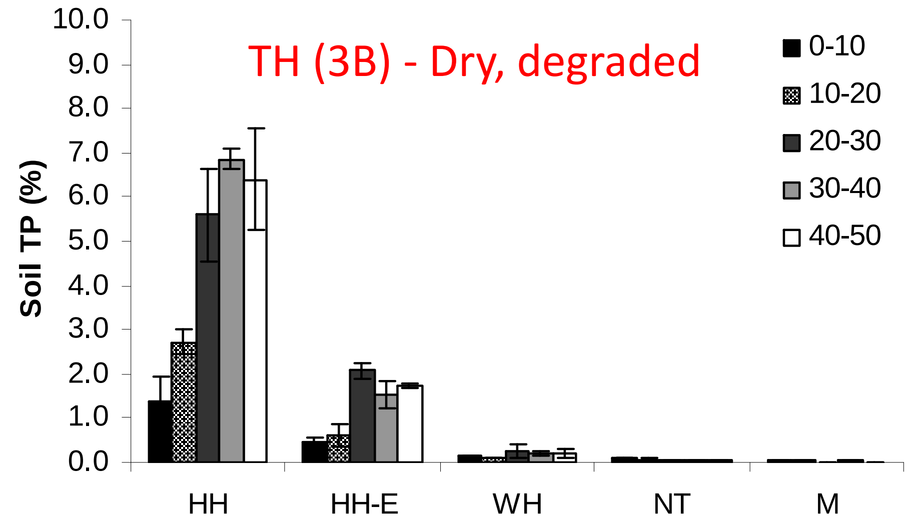


Soil Phosphorus across communities and with depth

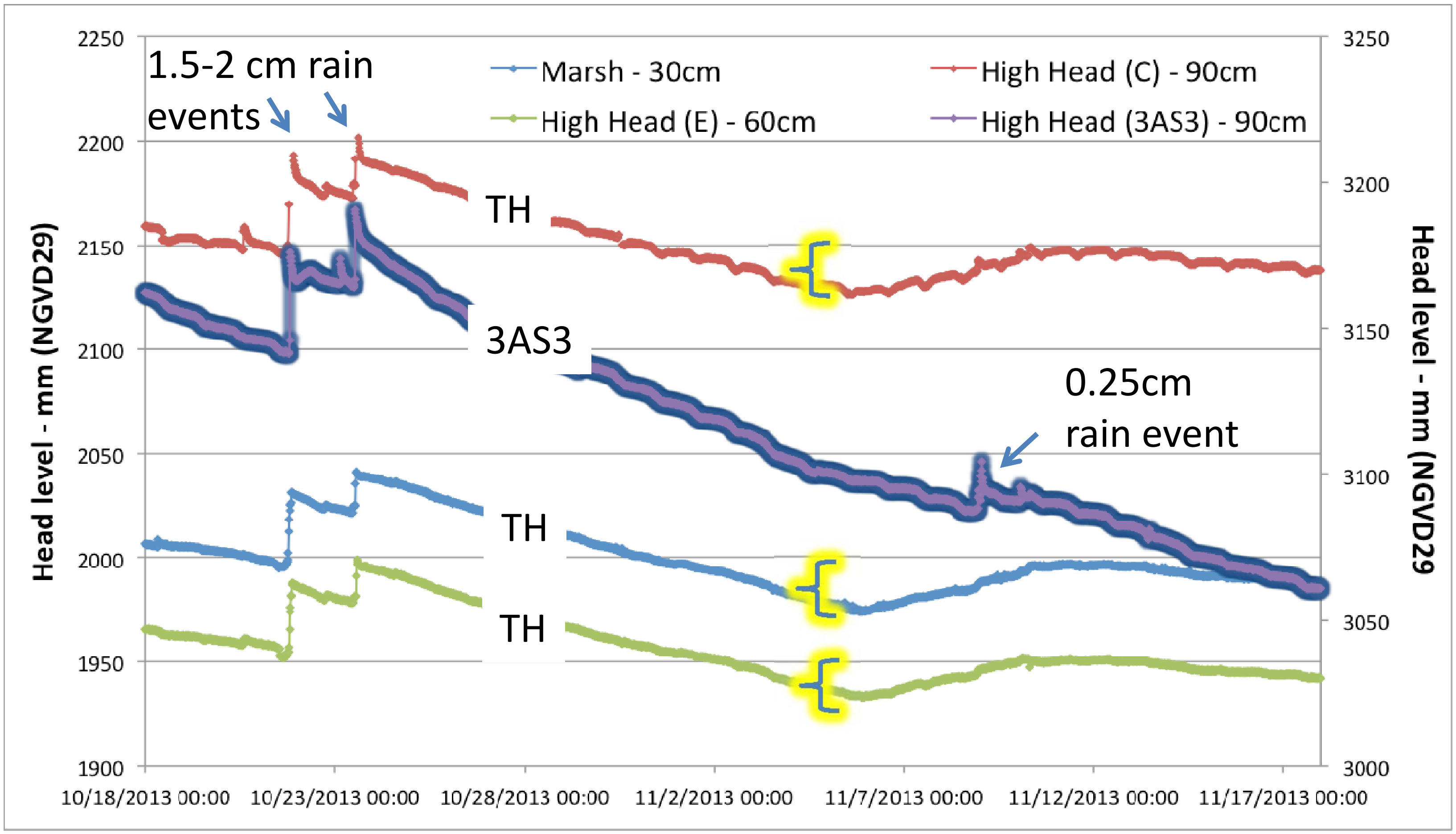




3BS2 (3B) - Wet, degraded
(not available)



Decomp Operations – November 5, 2013 – *Influence on tree island hydraulic head*



- 2 cm increase in hydraulic head at 30cm depth in marsh
- 1.5-1.8 cm increase in hydraulic head at 60 and 90 cm depth in tree island “head”

Key Findings

- Results suggest degraded tree islands exposed to overdrying or overflooding ware associated with decoupling, both in time and space, of environmental conditions that promote water and P uptake and mineral P retention in the High Head.
- Restoring degraded tree islands lies in restoring the hydrological conditions that achieve plant performance across a plant community gradient within tree island
  - promote mineral precipitation and P retention in the High Head and organic matter accumulation in Wet Head and Near Tail communities.
- However, extensive overdrying that has led to lower elevation “high head” (3BS2) or overflooded conditions (GI) may require active management
- Tests associated with Decomp operations suggest increased flow will contribute to steeper tree island head gradients and greater lateral P flux