The State of Our Understanding of the Biogeochemical Processes on Tree Islands in the Greater Everglades

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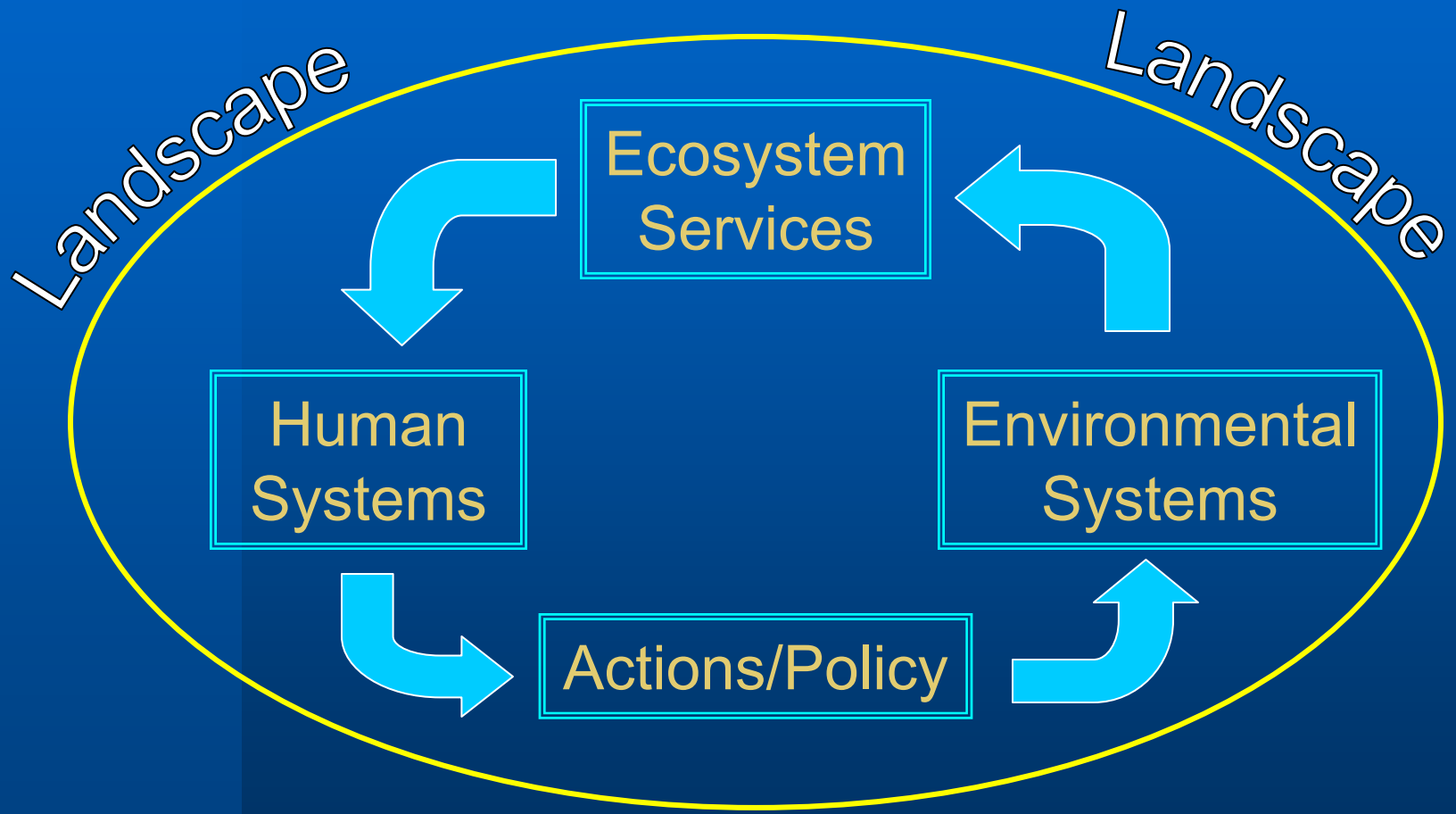
Why do we care about Tree Islands?



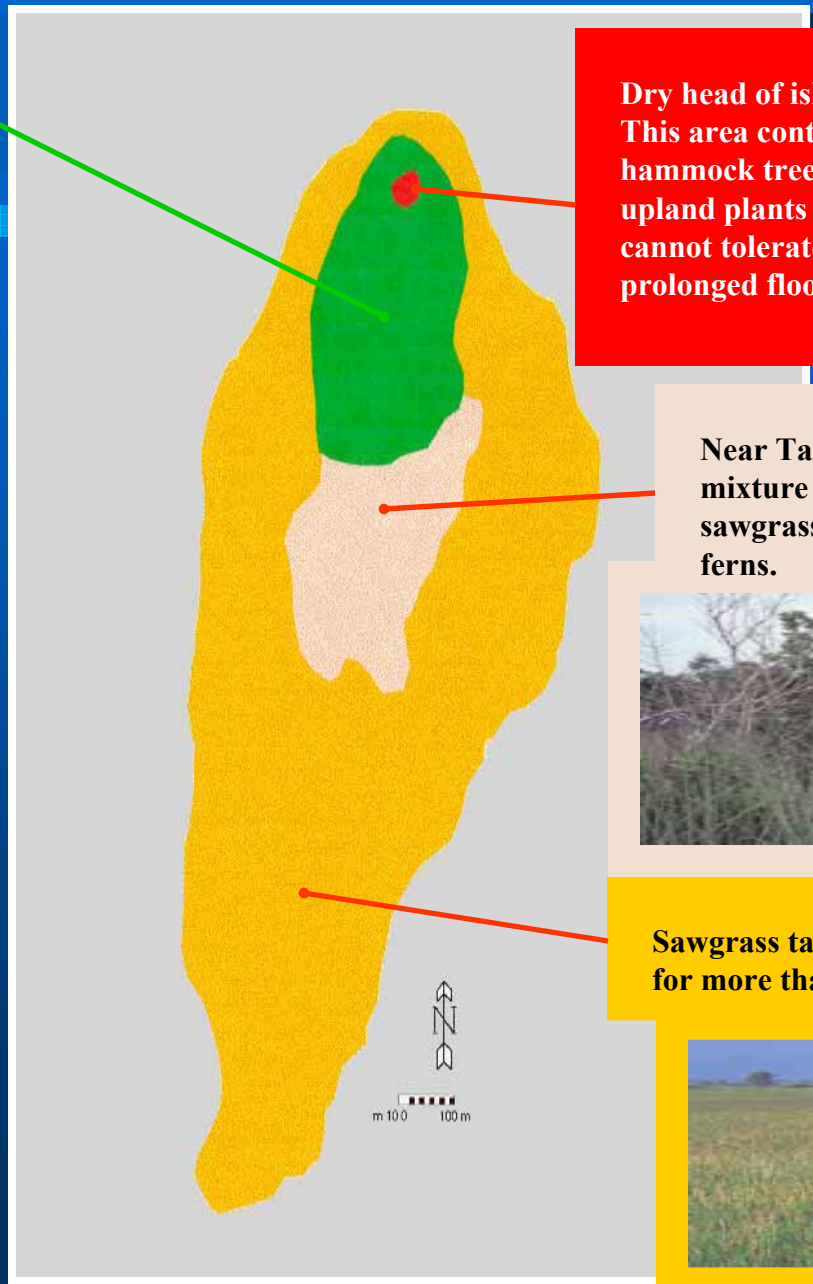
Coupled Human-Ecosystem Interactions

Real and Hypothesized Tree Island Services

- Biodiversity hotspots
- Rookery habitat
- Wildlife refuge during high water
- Breeding and nesting ground for reptiles, amphibians, mammals and birds
- Archeological resource
- Public aesthetic and recreational value
- Integral physiographic component:
  - Nutrient sink?
  - Driver of oligotrophy?

Regions of a "Classic" Tree Island

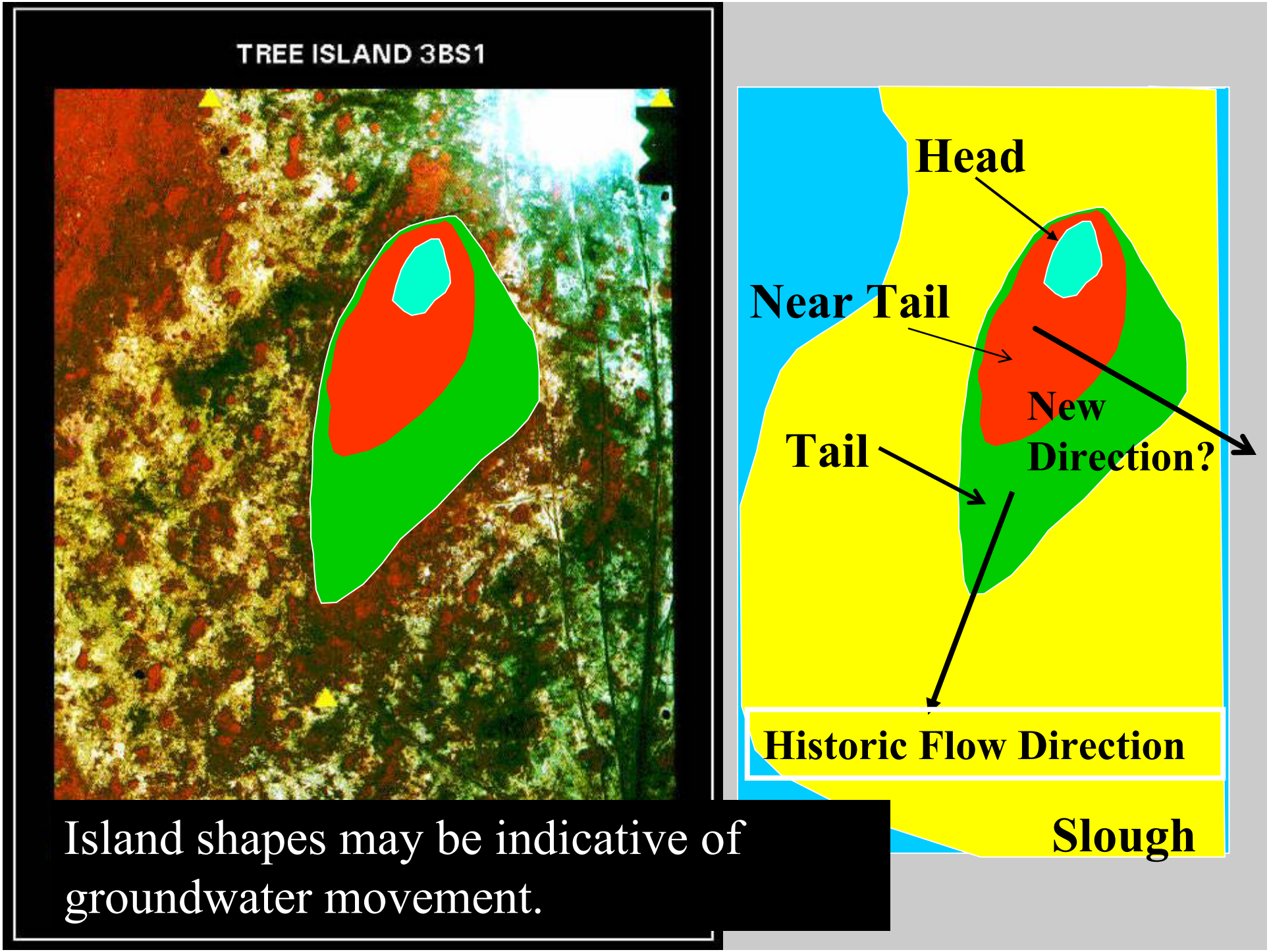
Wet Head: This area contains many ferns, shrubs, and trees that tolerate varying degrees of flooding.



Dry head of island: This area contains hammock trees and upland plants that cannot tolerate prolonged flooding.

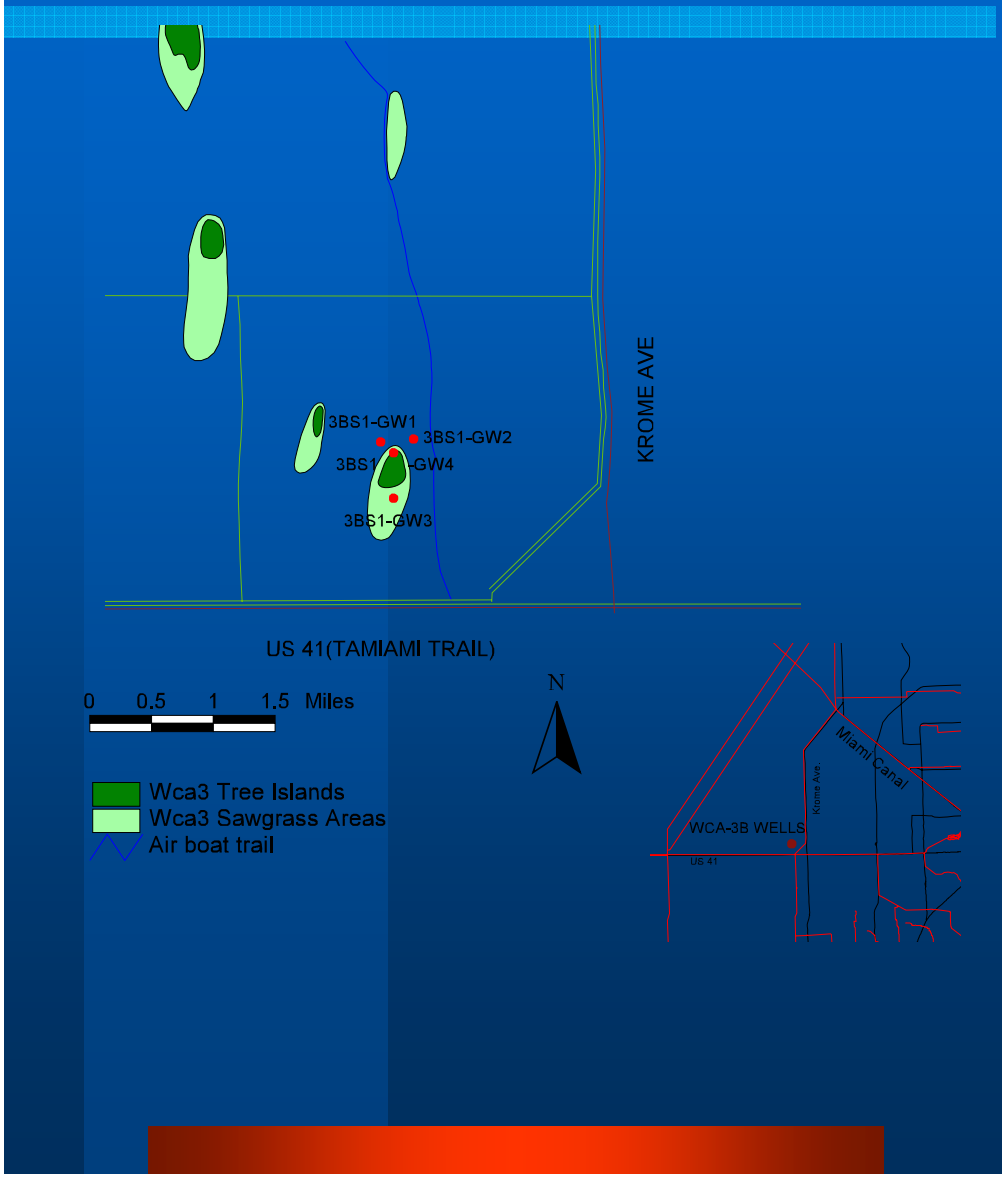
Near Tail: This area contains a mixture of flood-tolerant shrubs, sawgrass, broadleaved plants and ferns.

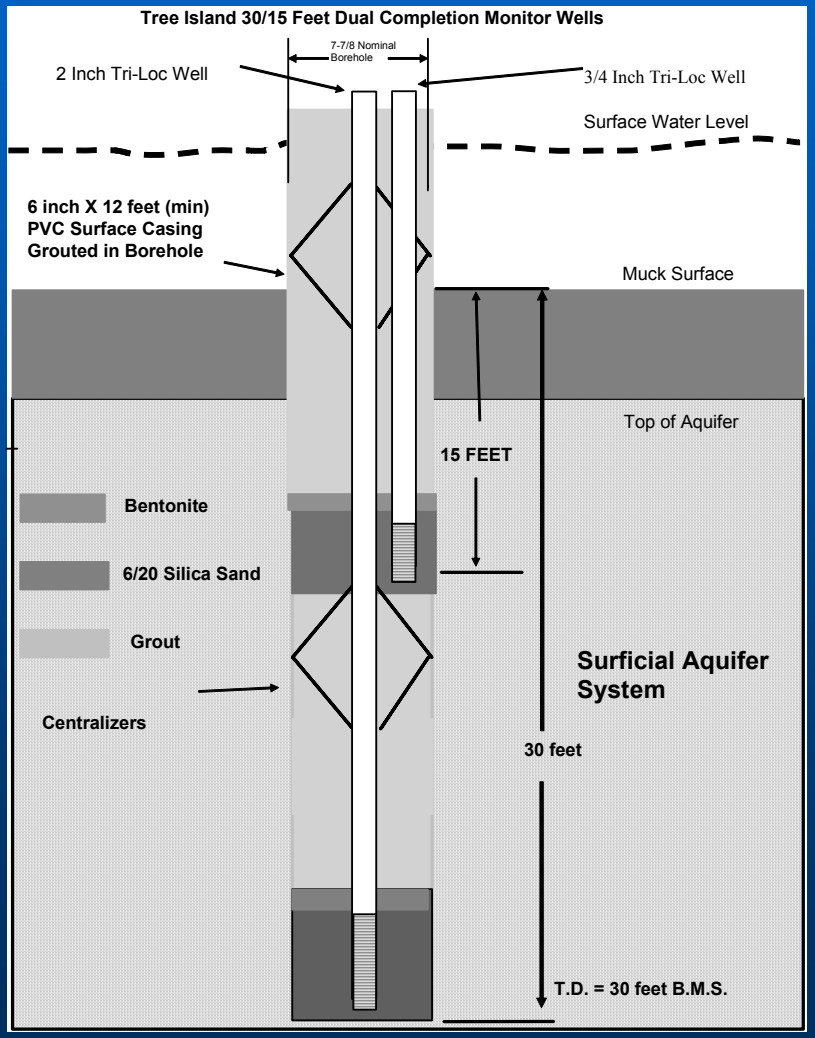
Sawgrass tail: This region can extend for more than a mile.

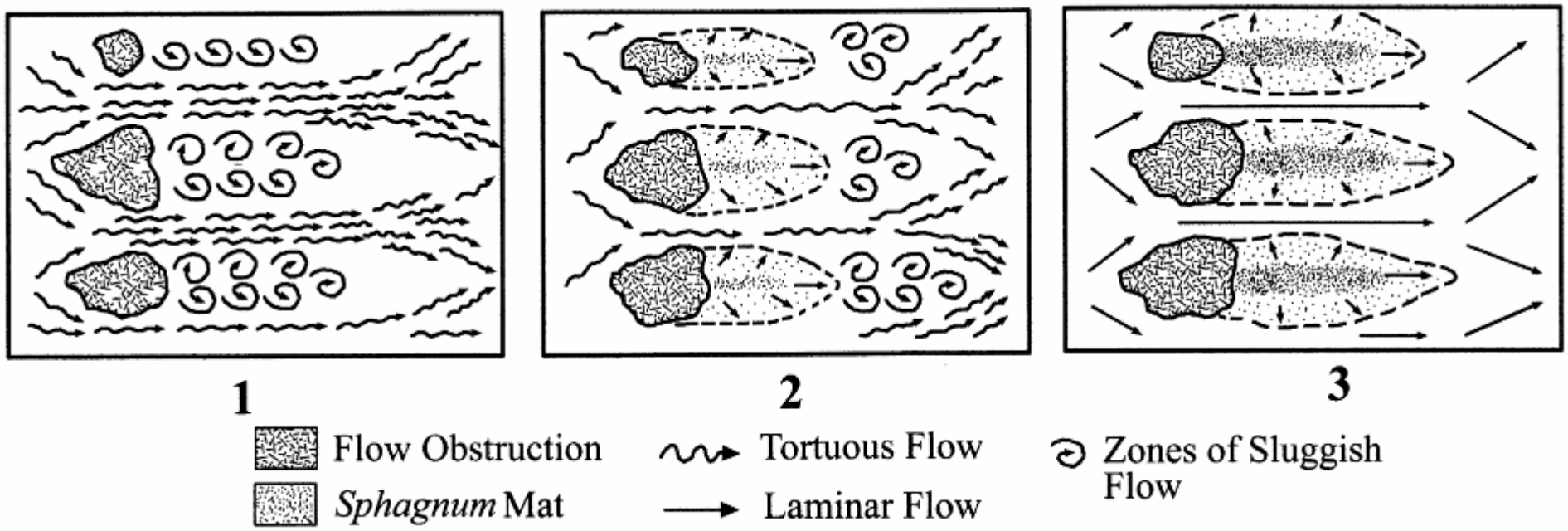


Island shapes may be indicative of groundwater movement.

To evaluate groundwater movement four sets of wells were drilled on and around three islands. Each set has a shallow (15 ft) and deep (30 ft) well, and a port for sampling water quality.







Arctic tadpole shaped islands (bog islands):

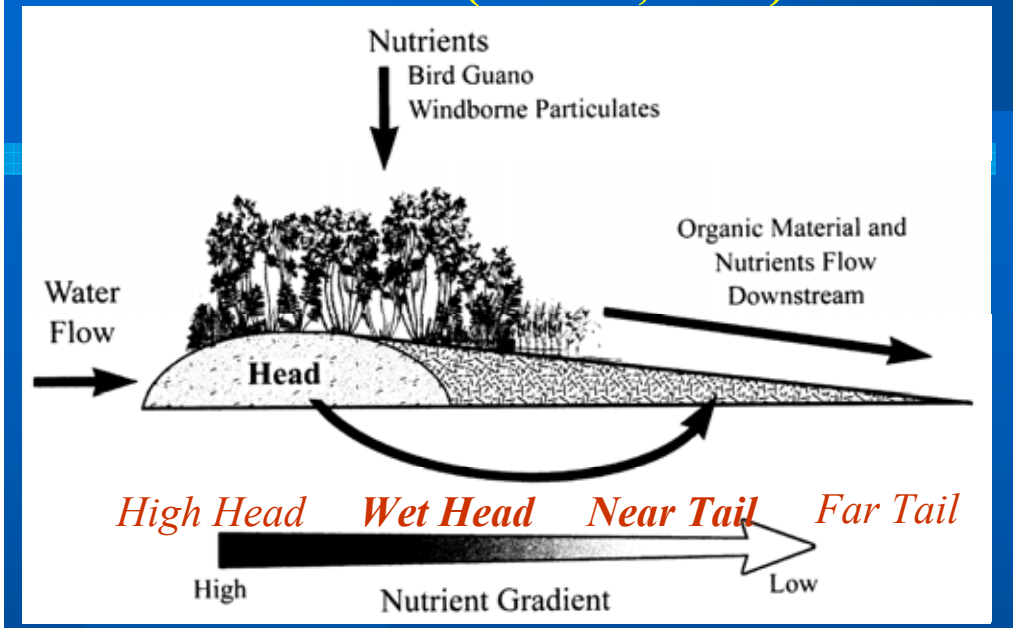
1) *Sphagnum* becomes established downstream of obstructions in zones of sluggish water flow.

2) Presence of a *Sphagnum* mat acidifies the sluggish water zone and the mat advances outward.

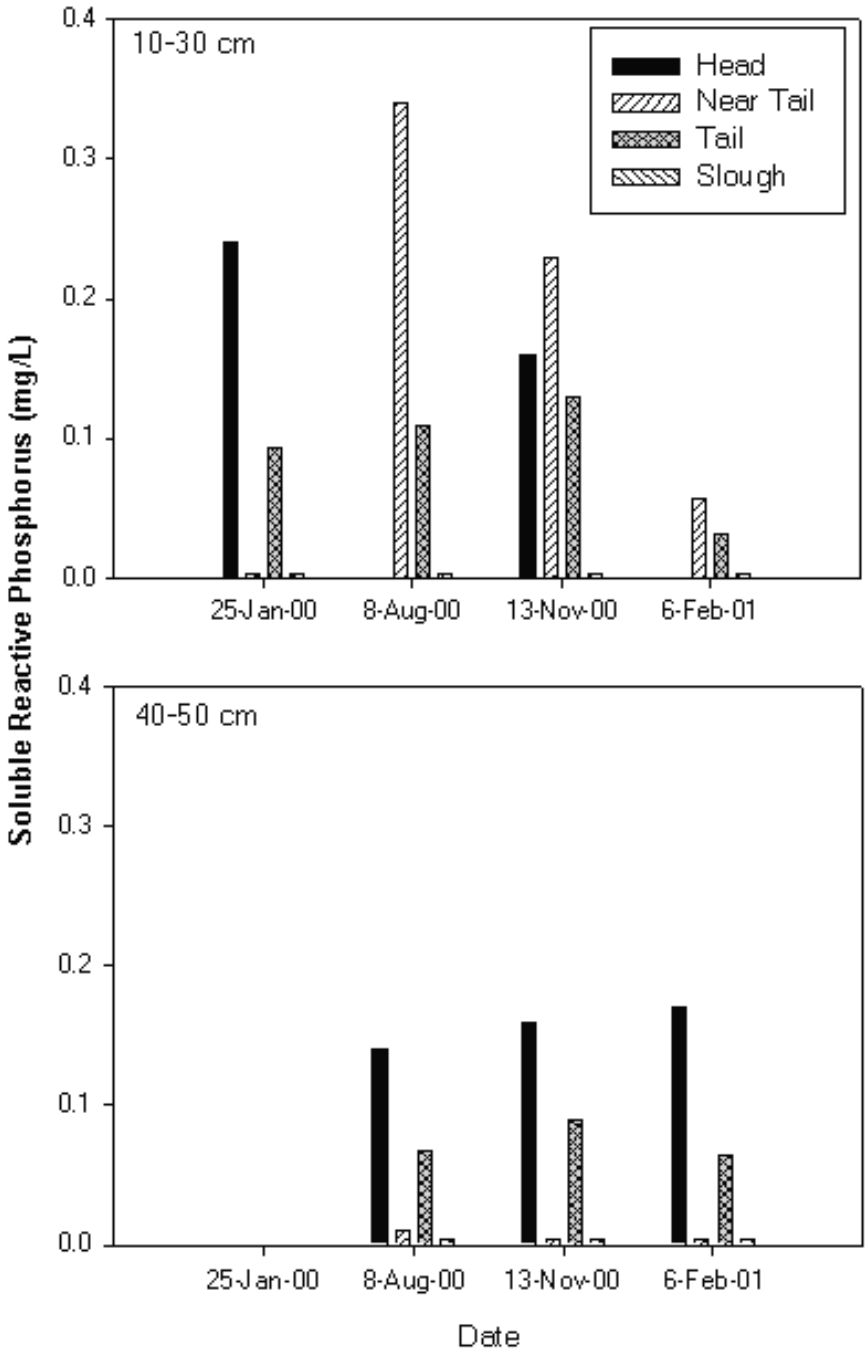
3) Further advance is blocked by higher alkalinity and flux of cations along the main drainage paths.

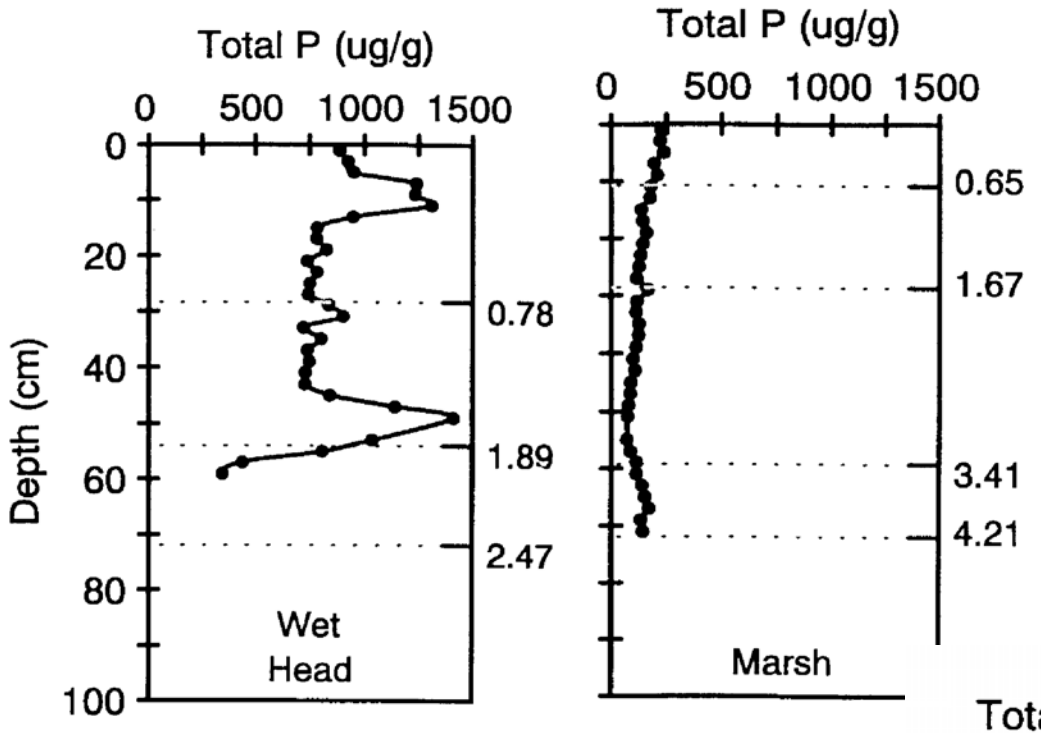
From Wetzel, 2002

Chemo-hydrodynamic process of tree island formation (Wetzel, 2002)



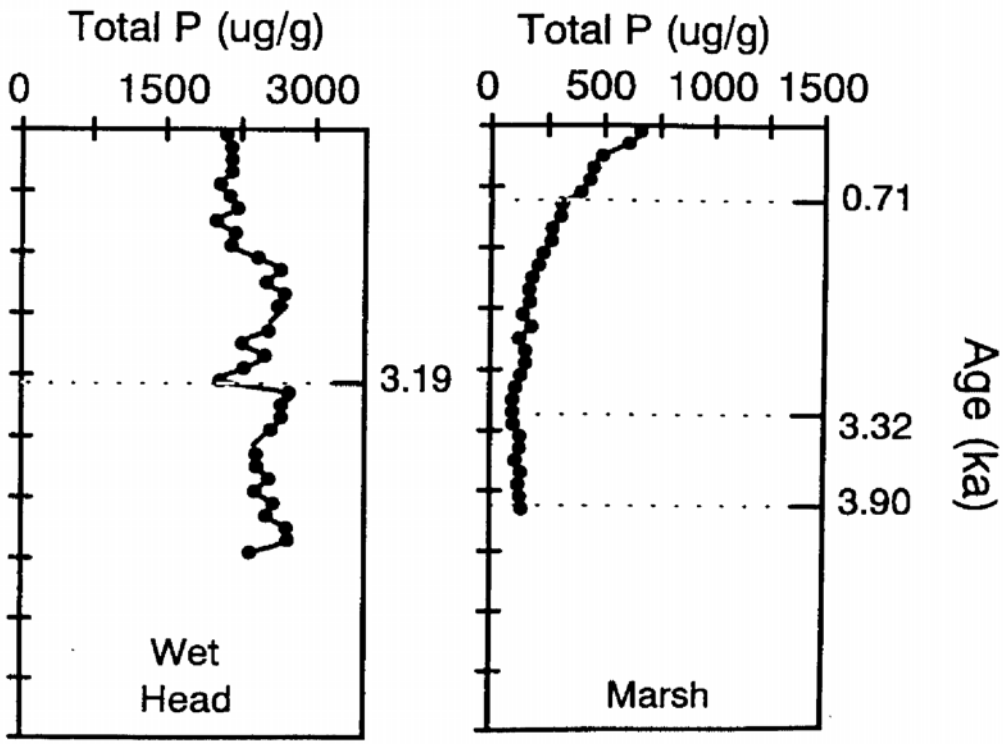
Bioavailable P across 3AS4 at two depths indicate a general trend of decreasing nutrients downstream of the tree island head (Newman, unpub).





Nuthouse

Gumbo Limbo

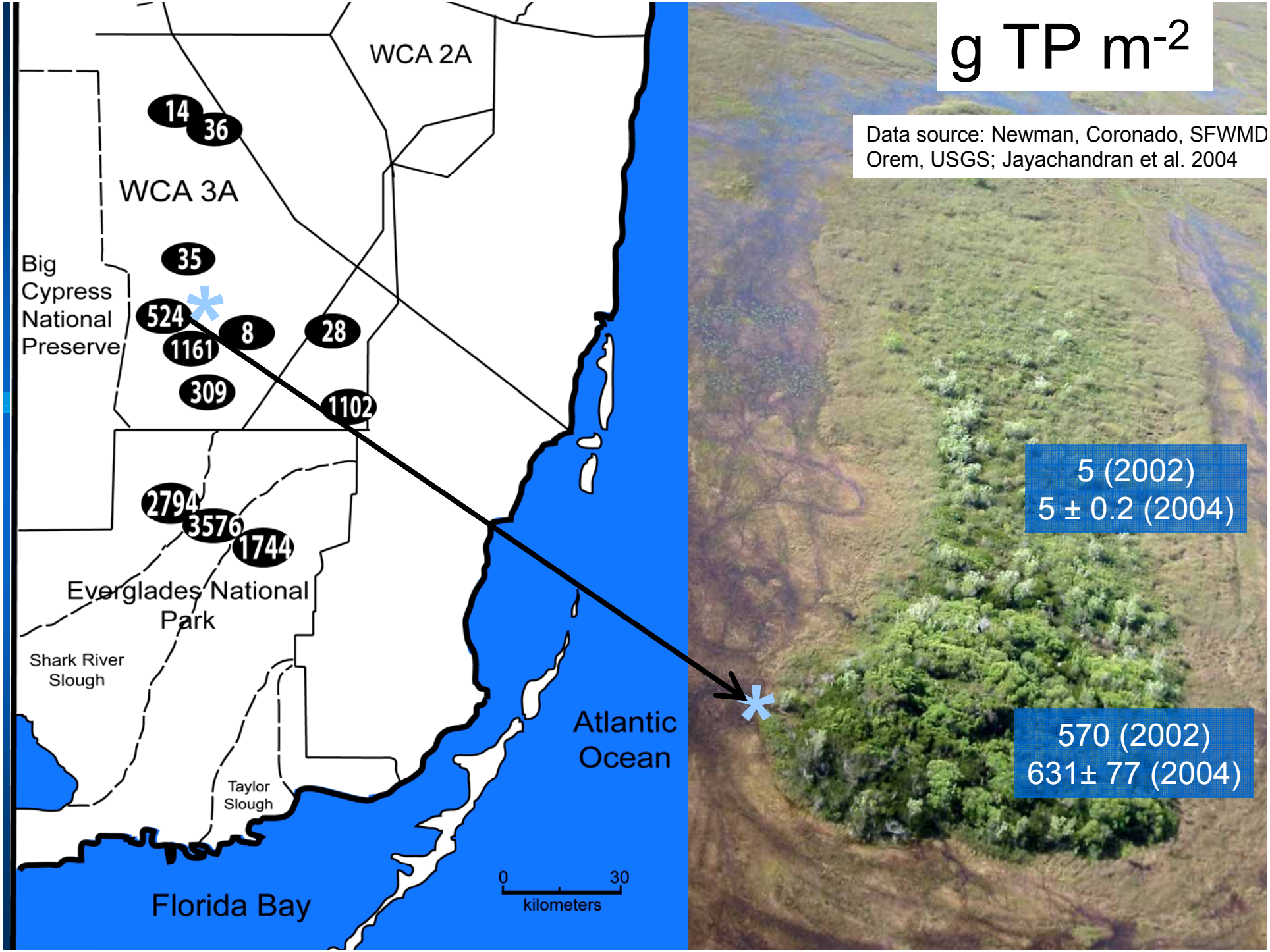


Plots of total phosphorus concentration (ug/g dry wt.) vs depth for sediments (Orem et al. 2002

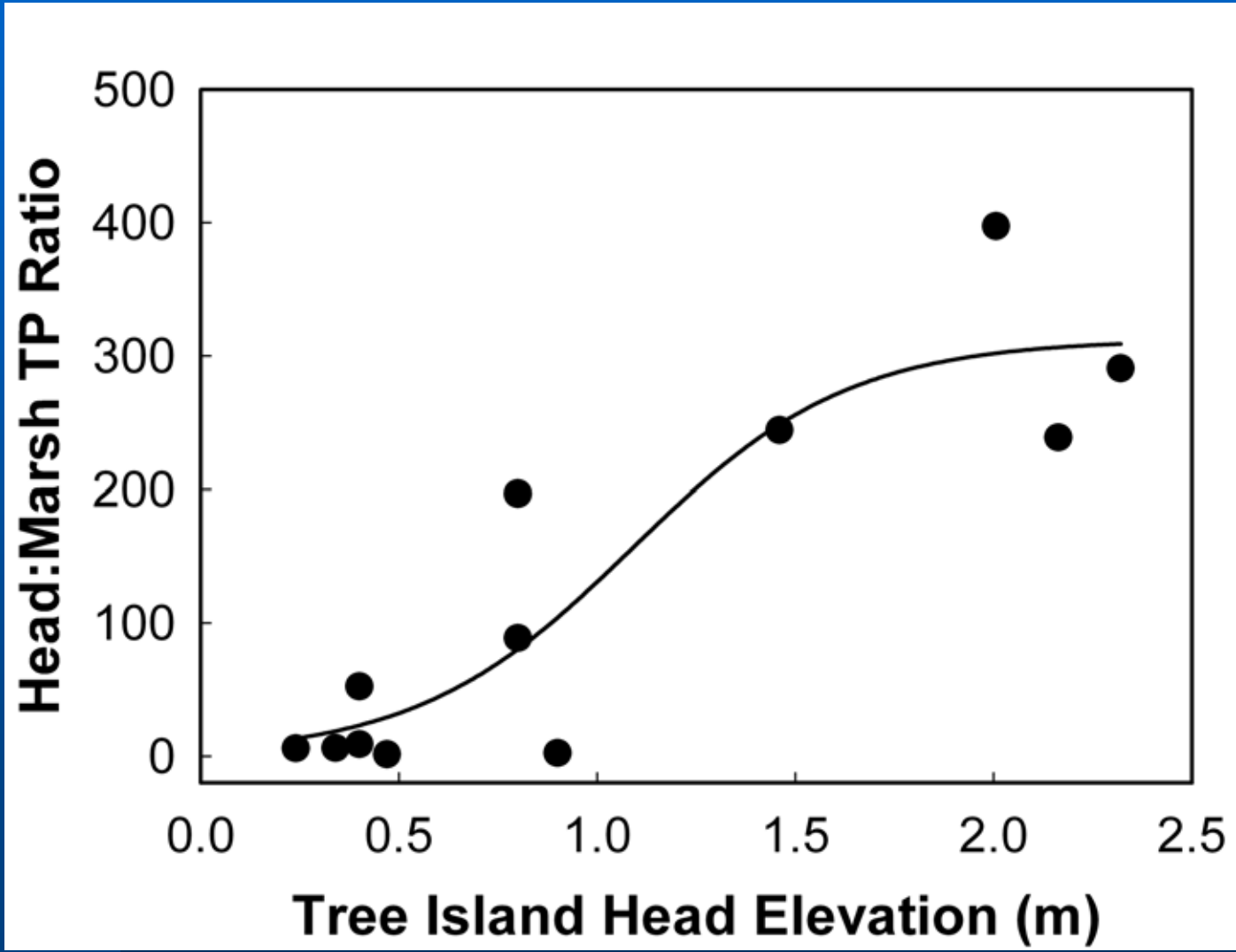
Soil Depth (cm)	Total Phosphorus (g m^{-2})			
	Marsh	Head	Near Tail	Far Tail
0–10				
Mean (S.E.)	**6 (1)**	**421 (93)**	**18 (4)**	**21 (15)**
Median	**5**	**35**	**8**	**8**
Range	**2–12**	**6–3576**	**4–233**	**4–80**
10–20				
Mean (S.E.)	**3 (0)**	**699 (131)**	**34 (7)**	**7 (1)**
Median	**3**	**67**	**11**	**7**
Range	**2–3**	**5–5539**	**4–347**	**4–11**
20–30				
Mean (S.E.)	**2 (0)**	**775 (257)**	**36 (4)**	**5 (1)**
Median	**2**	**95**	**15**	**4**
Range	**1–3**	**8–6078**	**3–307**	**3–6**

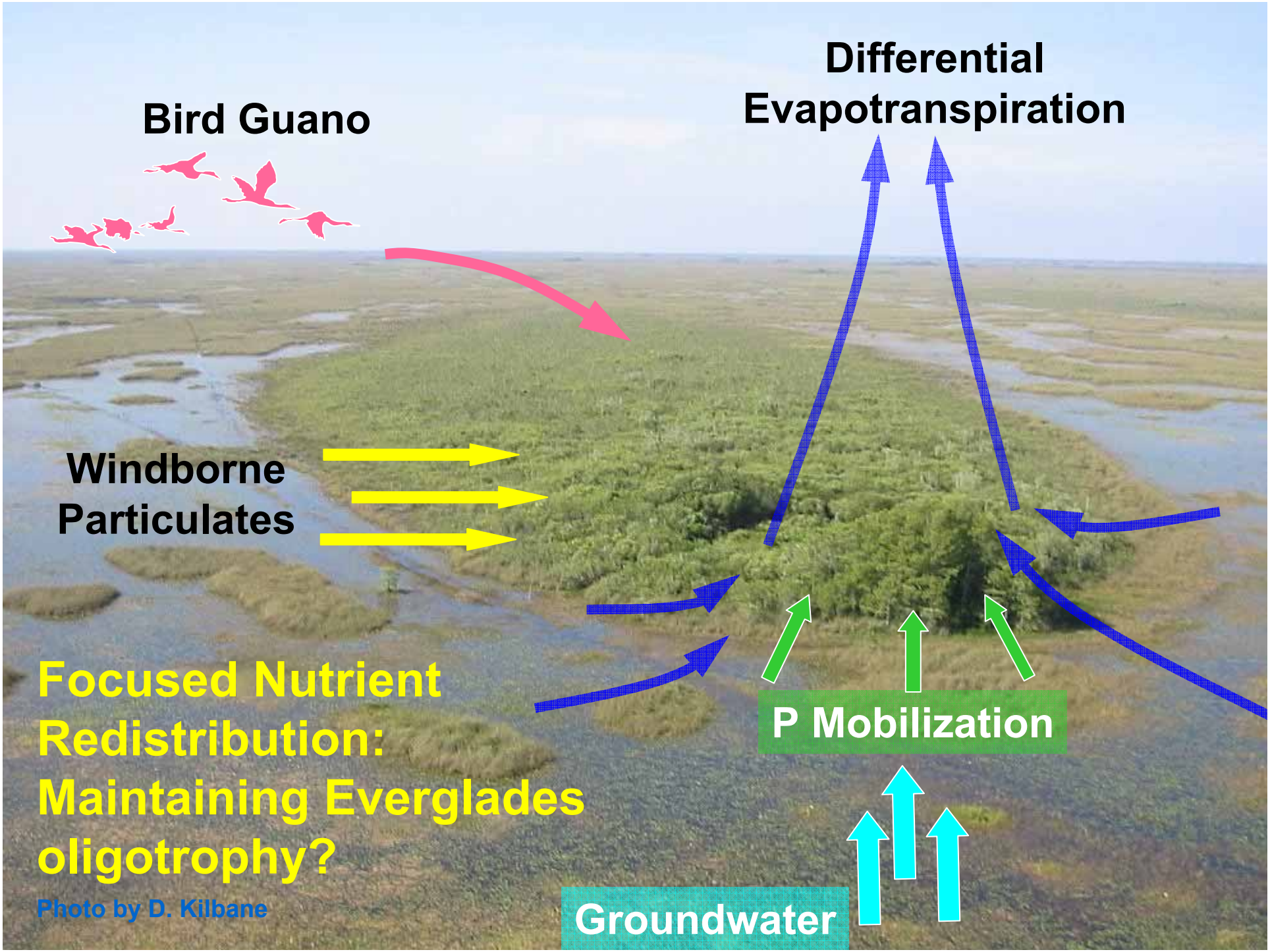
† Square meter over a depth of 10 cm.

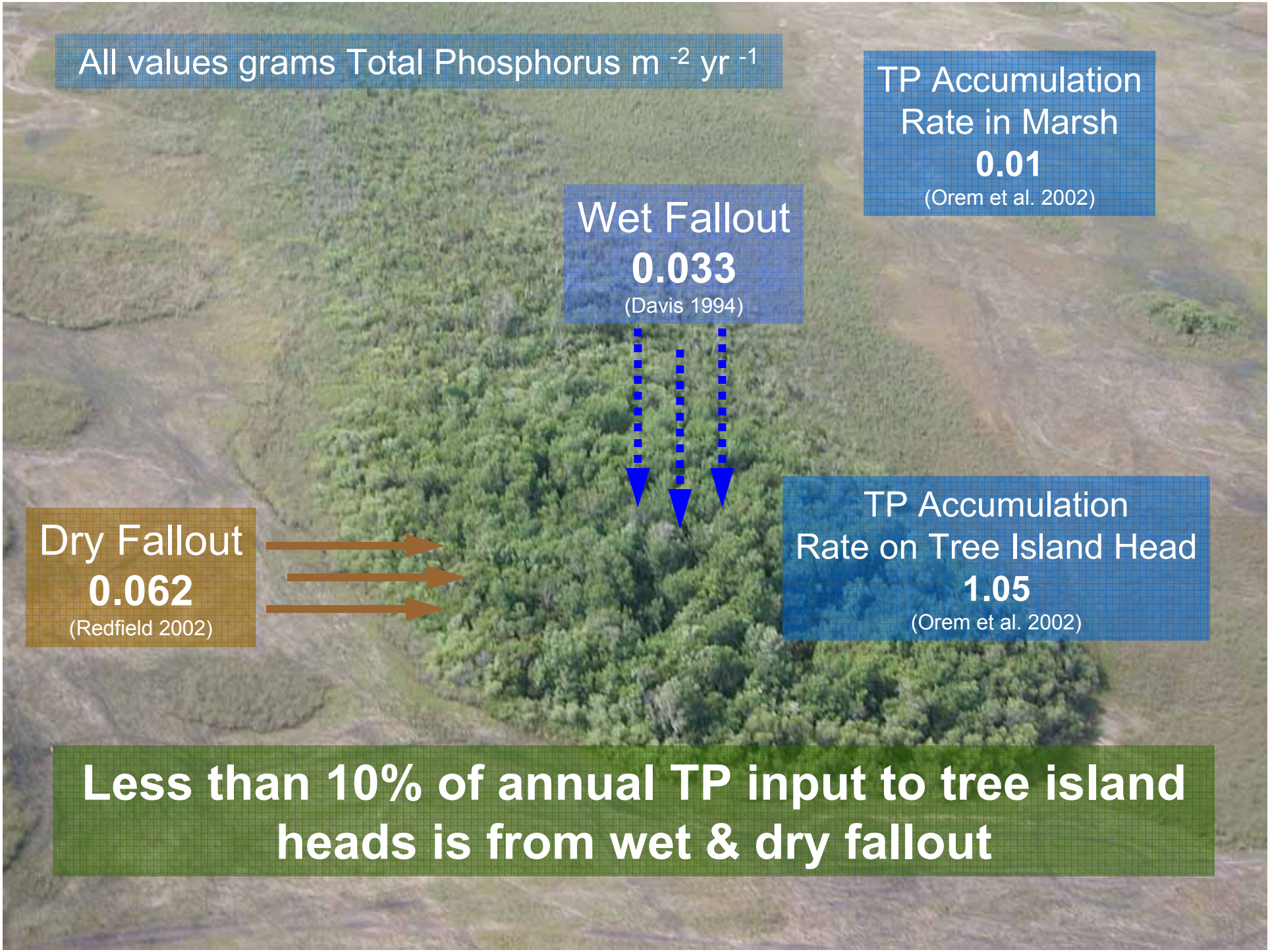
Data sources: S. Newman and C. Coronados, South Florida Water Management District; W. Orem, U.S. Geological Survey; Jayachandran et al. 2004.

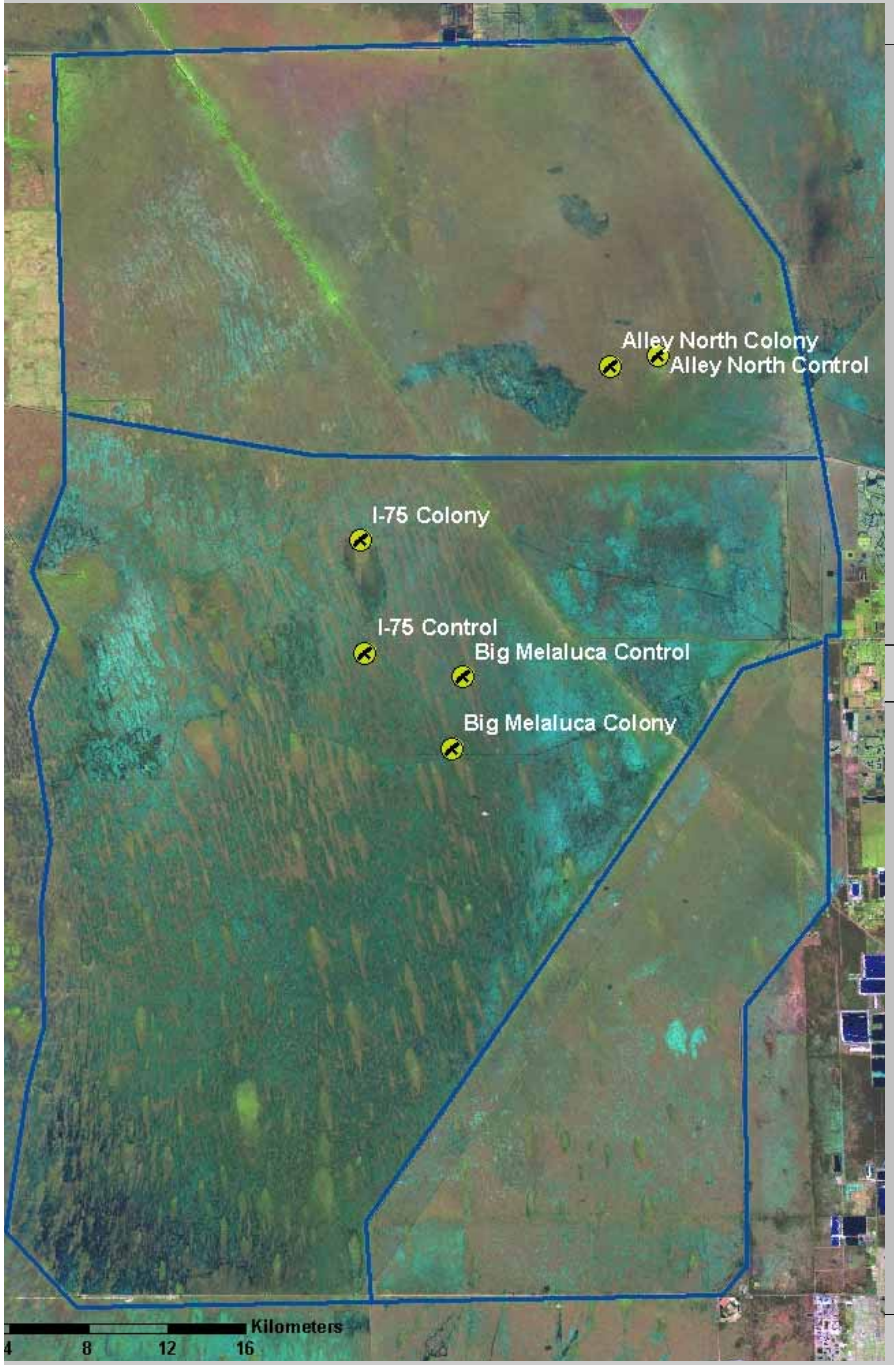

g TP m-2
Data source: Newman, Coronado, SFWMD
Orem, USGS; Jayachandran et al. 2004
WCA 2A
WCA 3A
14
36
35
524
8
28
1161
309
1102
Big
Cypress
National
Preserve
2794
3576
1744
Everglades National
Park
Shark River
Slough
Taylor
Slough
Atlantic
Ocean
Florida Bay
0
30
kilometers
5 (2002)
5 ± 0.2 (2004)
570 (2002)
631± 77 (2004)

Relationship between the ratios of total soil phosphorus (g m–2 in the upper 10 cm) on the head to the surrounding marsh and the maximum elevation of the tree island heads (r2=0.81; p=0.0005) for 12 tree islands in the Everglades.

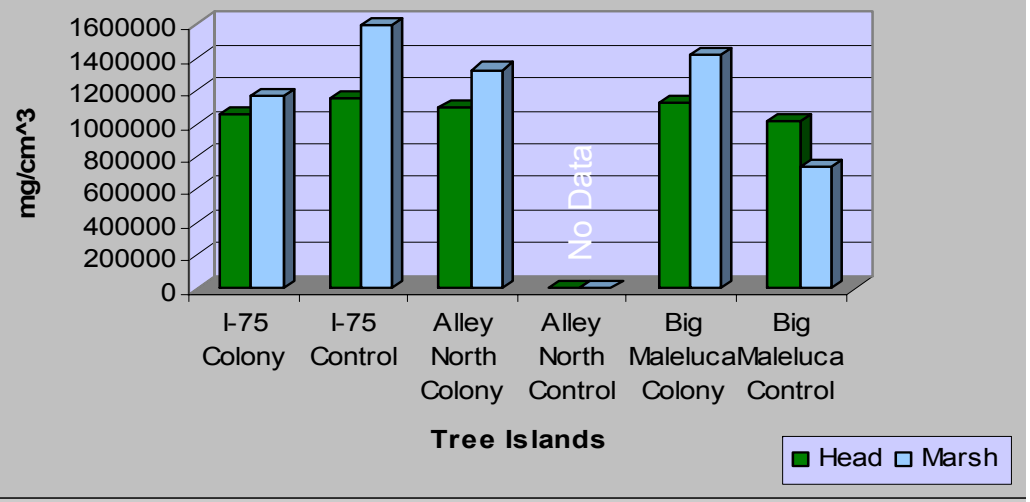



Bird Guano
Differential
Evapotranspiration
Windborne
Particulates
Focused Nutrient
Redistribution:
Maintaining Everglades
oligotrophy?
Photo by D. Kilbane
P Mobilization
Groundwater

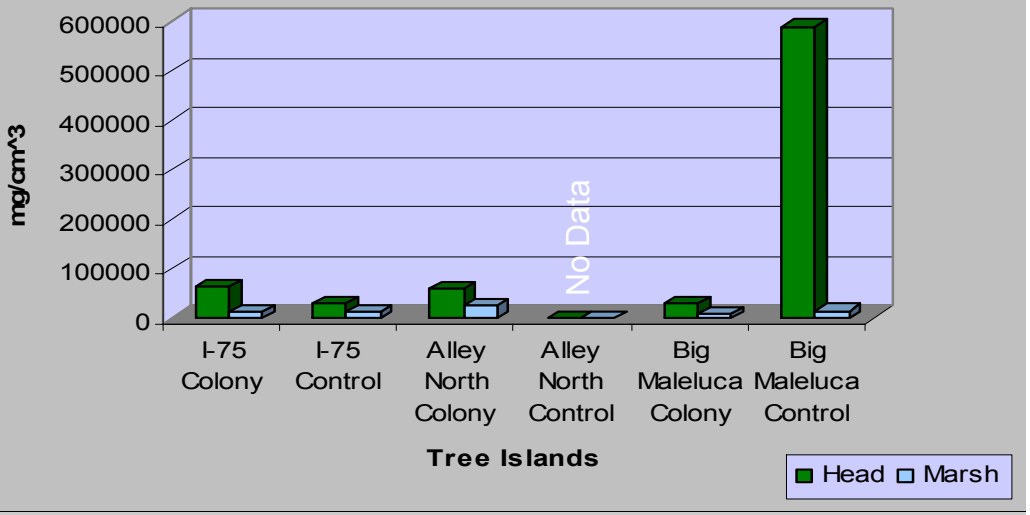

All values grams Total Phosphorus m -2 yr -1
TP Accumulation Rate in Marsh
0.01
(Orem et al. 2002)
Wet Fallout
0.033
(Davis 1994)
Dry Fallout
0.062
(Redfield 2002)
TP Accumulation Rate on Tree Island Head
1.05
(Orem et al. 2002)
Less than 10% of annual TP input to tree island heads is from wet & dry fallout

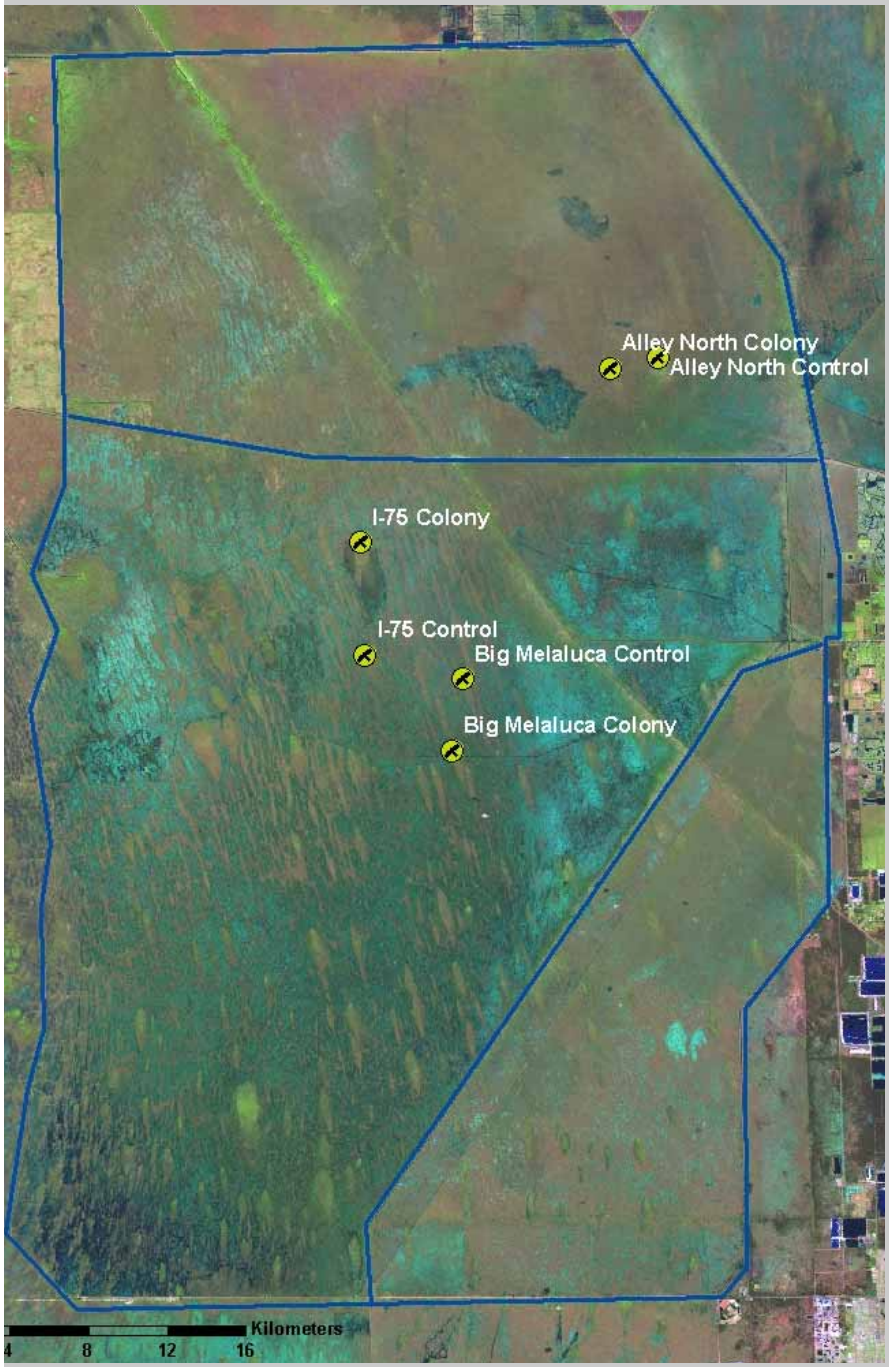


Mean Nitrogen Content



Mean Phosphorus Content





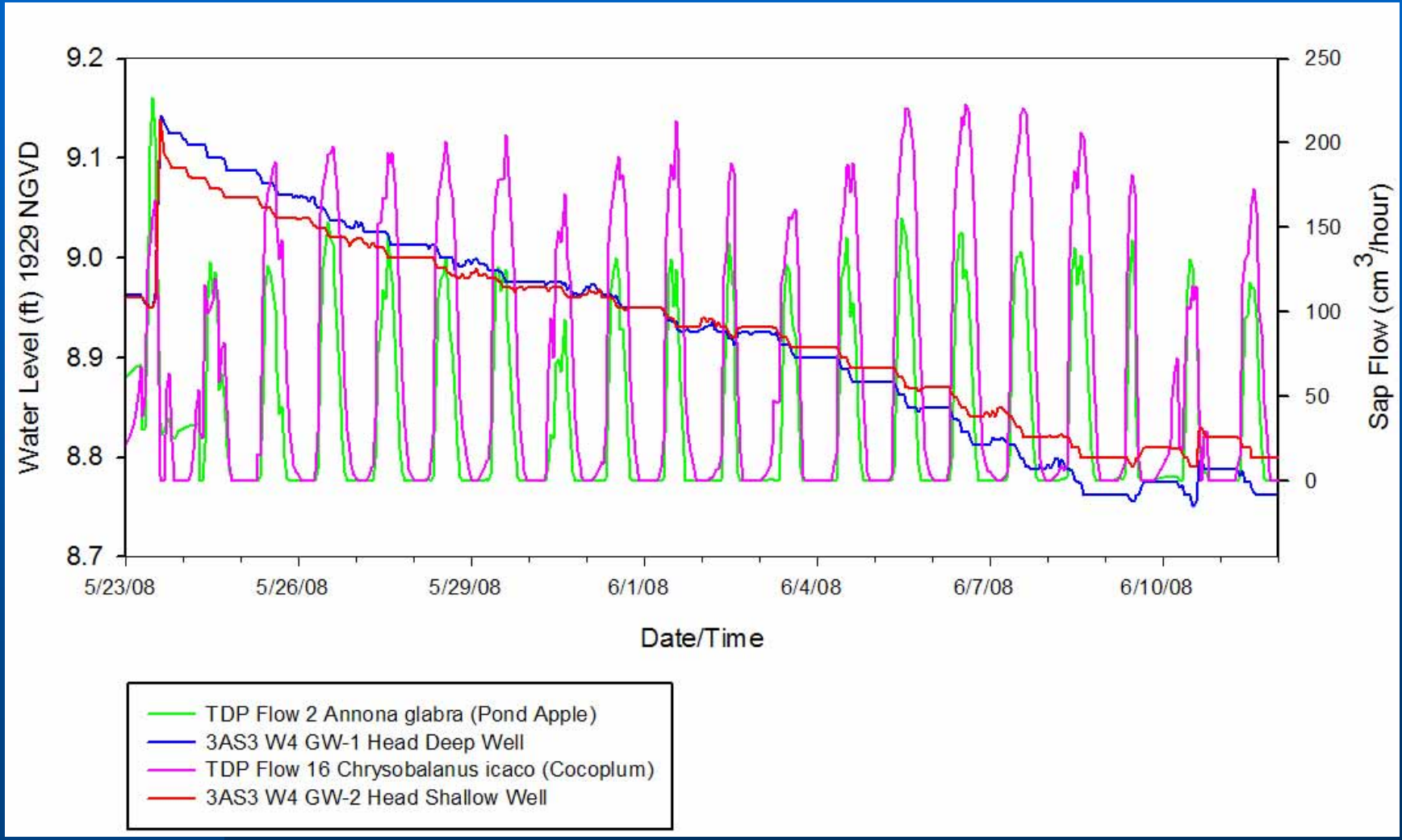
Tree Island Head vs Marsh (Wilcoxon p-values)

Tree Island	TP	TN	N:P
I-75 Colony	0.0277	0.0177	0.0192
I-75 Control	0.0003	0.0138	0.0007
Alley North Colony	0.0394	0.482	0.0246
Alley North Control	0.0004	0.009	0.0089
Big Melaleuca Colony	0.0044	0.0019	0.0032
Big Melaleuca Control	0.01	0.0013	0.0519

Colony vs Control (Kruskal-Wallis p-values)

Environment	TP	TN	N:P
Head	0.0722	0.0773	0.0281
Marsh	0.7803	0.6385	0.8789

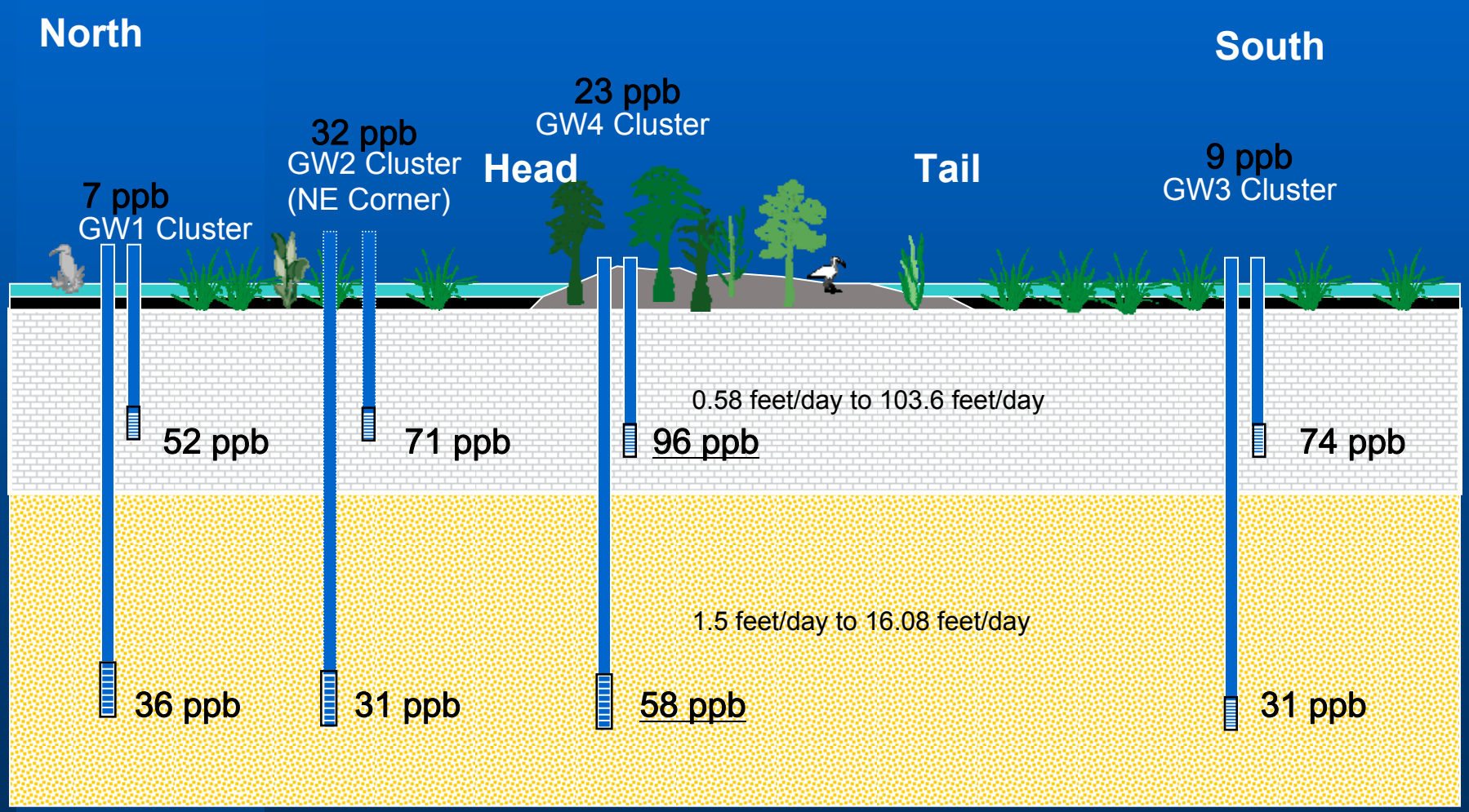
Daily sap flow velocities for two tree species during the 2008 dry season indicate a day-time influence on shallow and deep groundwater elevations on the 3AS3 Tree Island.



Significantly higher concentrations of Total Phosphorus in the green leaves and litter from Pond Apple and Cocoplum were found on the head of the 3AS3 Tree Island.

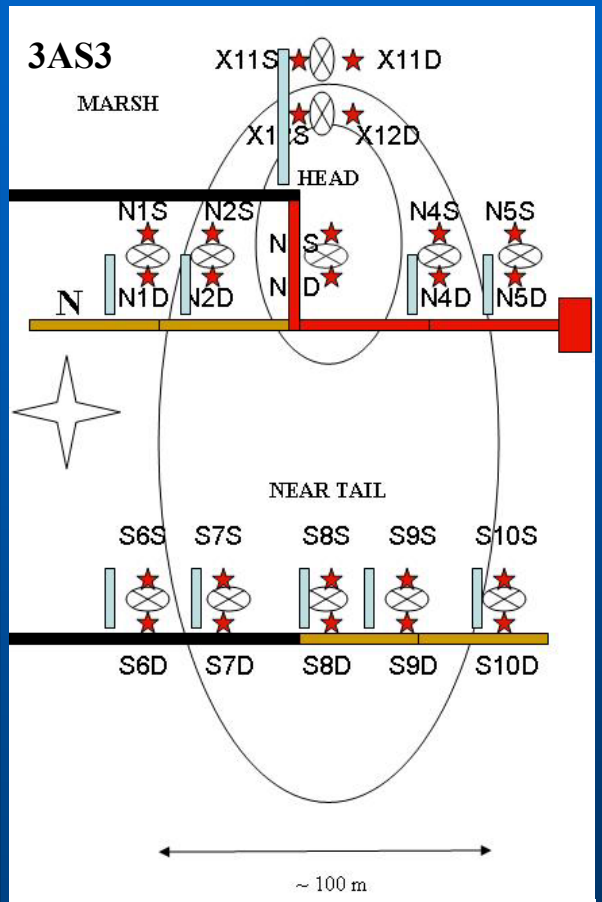
	TP mg/g Head	TP mg/g Near Tail	TN mg/g Head	TN mg/g Near Tail
Green Leaves				
Pond Apple	**1.21**	**1.11**	**21.7**	**22.2**
Cocoplum	**1.27**	**0.43**	**15.0**	**11.8**
Litter	*			
Pond Apple	**1.05**	**0.65**	**14.0**	**14.2**
Cocoplum	**1.29**	**0.15**	**6.2**	**5.9**

Generalized Geological Cross Section Through 3AS3 with TP Groundwater Quality (n=4)

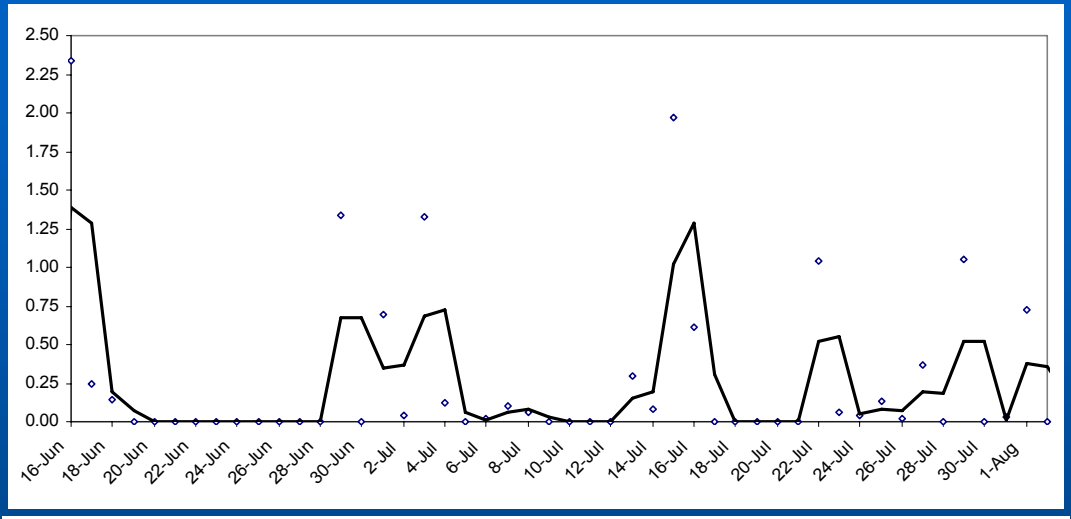


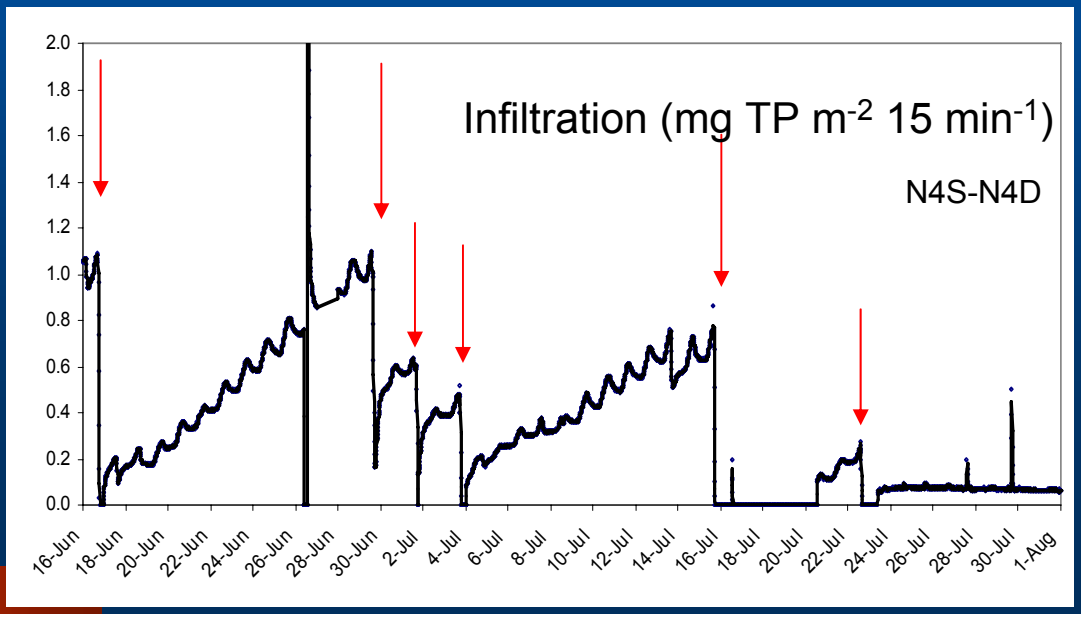
For more on diurnal drawdown impacts see Pam Sullivan in the LNWR Session, Wed. at 11:40.

WET HEAD: Early Wet Season -- Precipitation events slow infiltration rates as water table rises above soil surface. Infiltration increases as water drains below soil surface (Troxler et al. unpub).



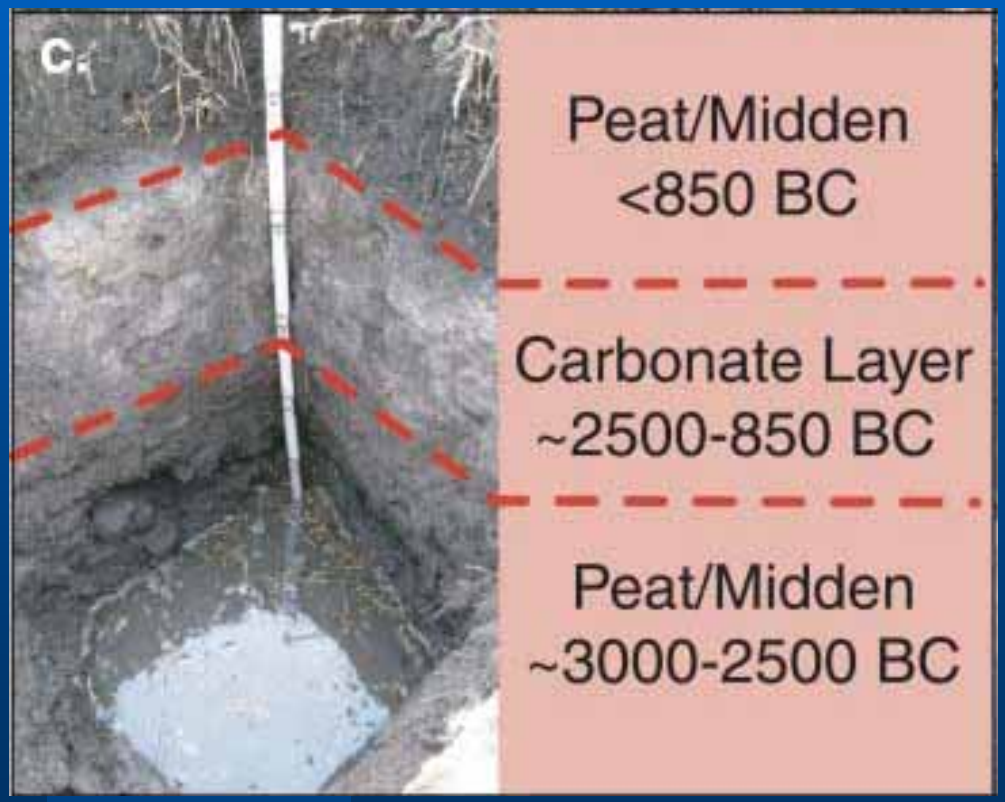
Each of the 12 sets of pizometers has 2 wells (30 cm and 100 cm)





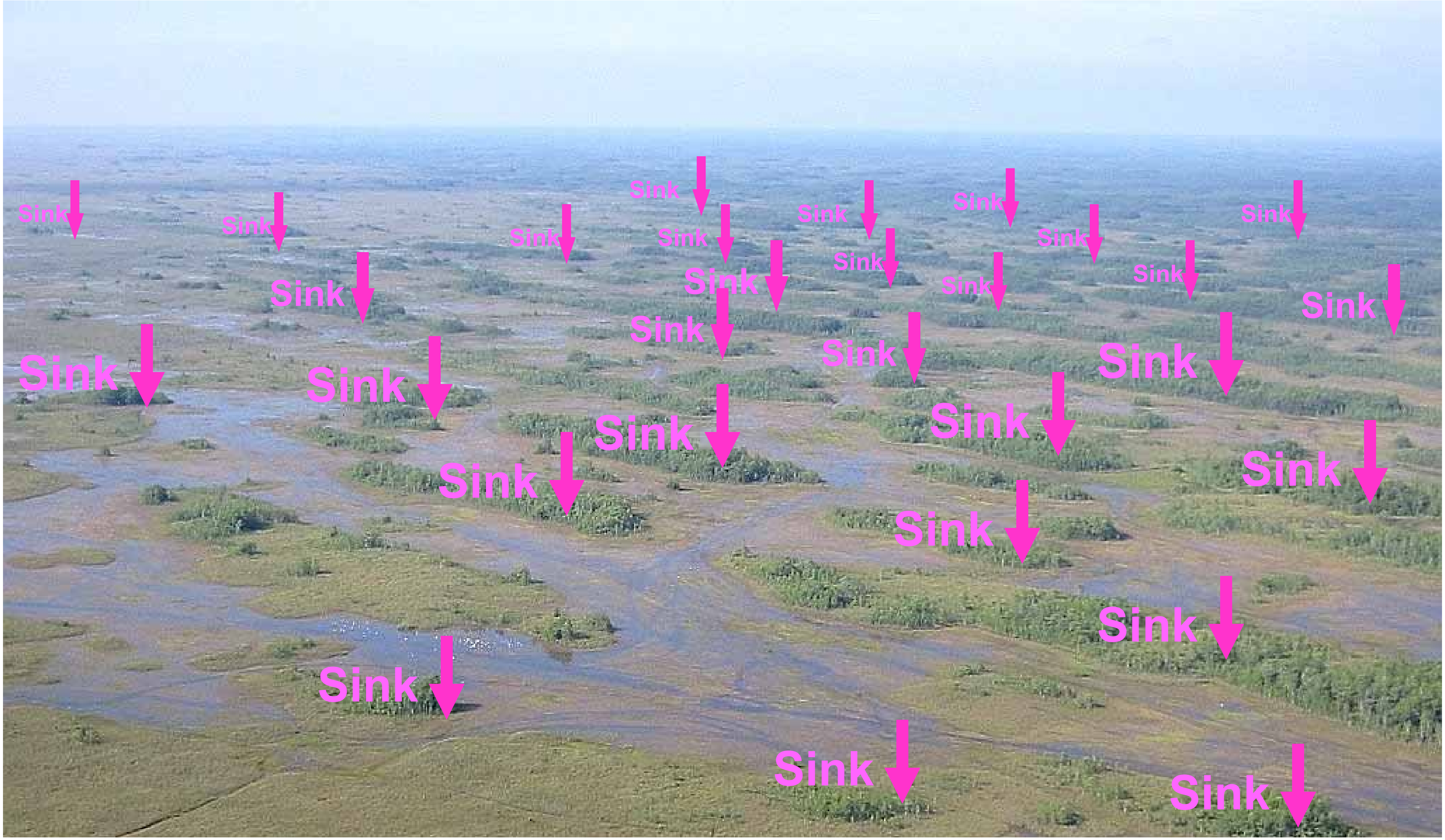
M.T. Graf, M. Schwadron, P. A. Stone, M. Ross, and G. L. Chmura Eos, Vol. 89, No. 12, 18 March 2008 (see the Marie Graf poster #25):

1. ***Humans were present earlier and more intensively than previously thought.***
2. ***This could be re-precipitated calcium carbonate that is biologically meditated through ET.***
3. ***It may be phosphorus source or sink.***



C. Archaeological test pit exposing mineralized layer and unconsolidated sediments below.

D. Carbonate layer with surface sediments removed.



A Landscape Hypothesis with implications for Restoration: ***Flow and focused nutrient redistribution facilitate the ridge & slough landscape pattern and the sustainability of tree islands.***

The State of Our Understanding of the Biogeochemical Processes on Tree Islands in the Greater Everglades?

Much better than it was 10 years ago, and still fascinating!