TREE ISLANDS AS PHYSICAL MODELS OF NUTRIENT SEQUESTRATION

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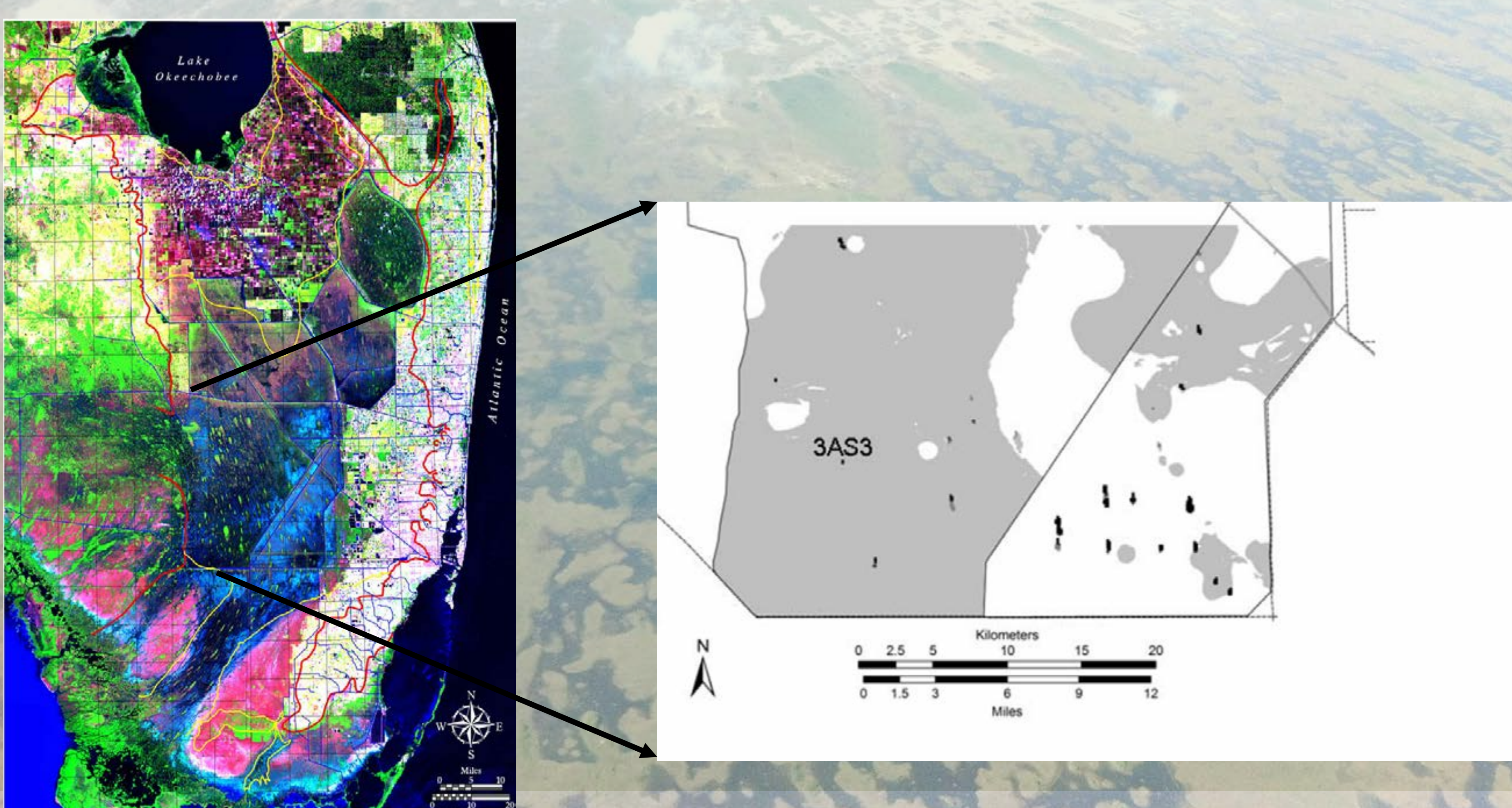
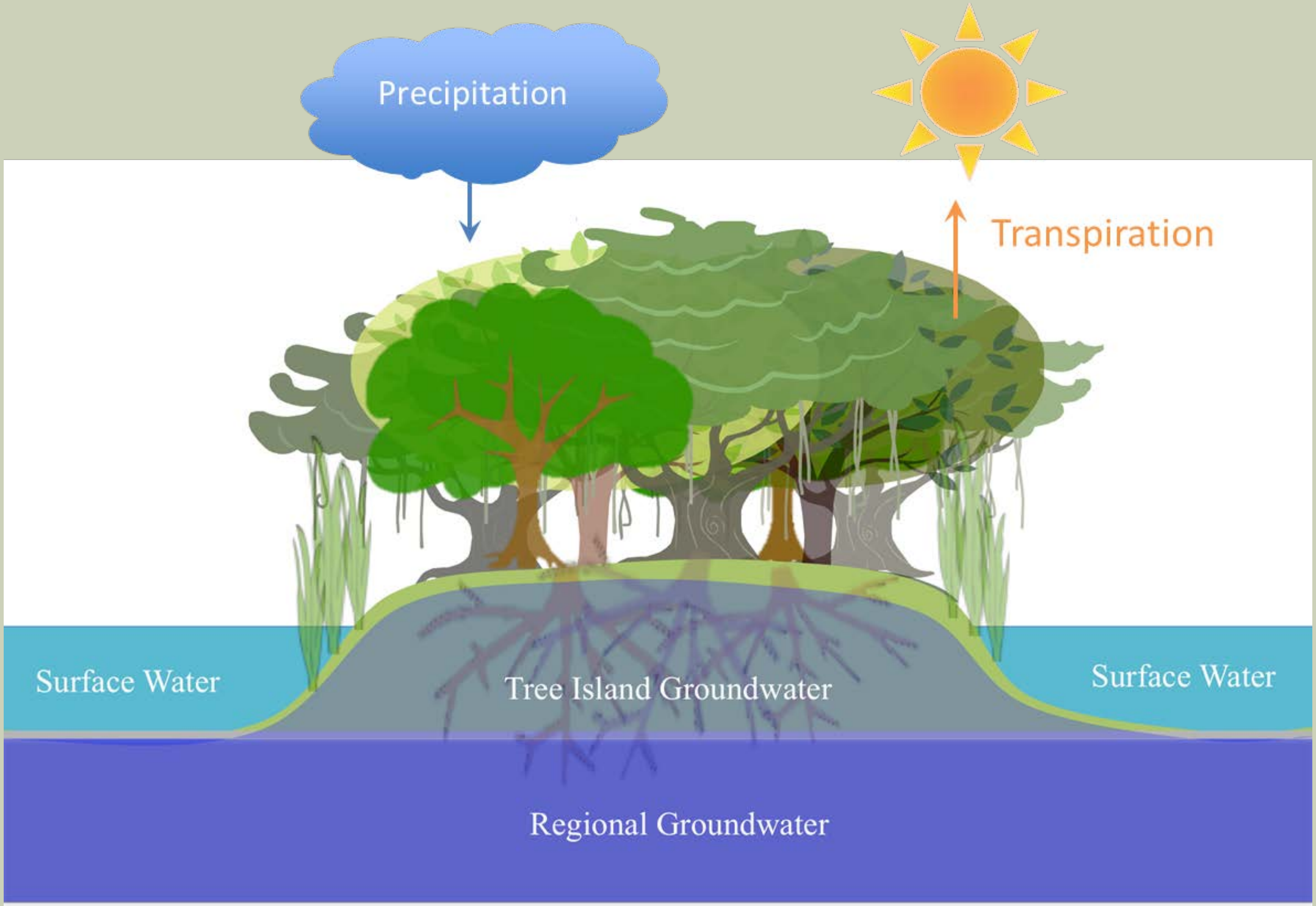
- Significant for **wildlife habitat, cultural and recreational and regional-scale indicators of the ecological "health"** of the Everglades landscape.
- **Hydrologic alterations** have affected tree islands - too drained in some areas (parts of WCA 3B) and too flooded in other areas (parts of WCA 3A).
- Effects include changes in tree island forest structure and loss of tree island area (**more than 50% since 1940**).
- Soil P concentrations on tree islands are up to **100 greater** than the surrounding marshes and sloughs.



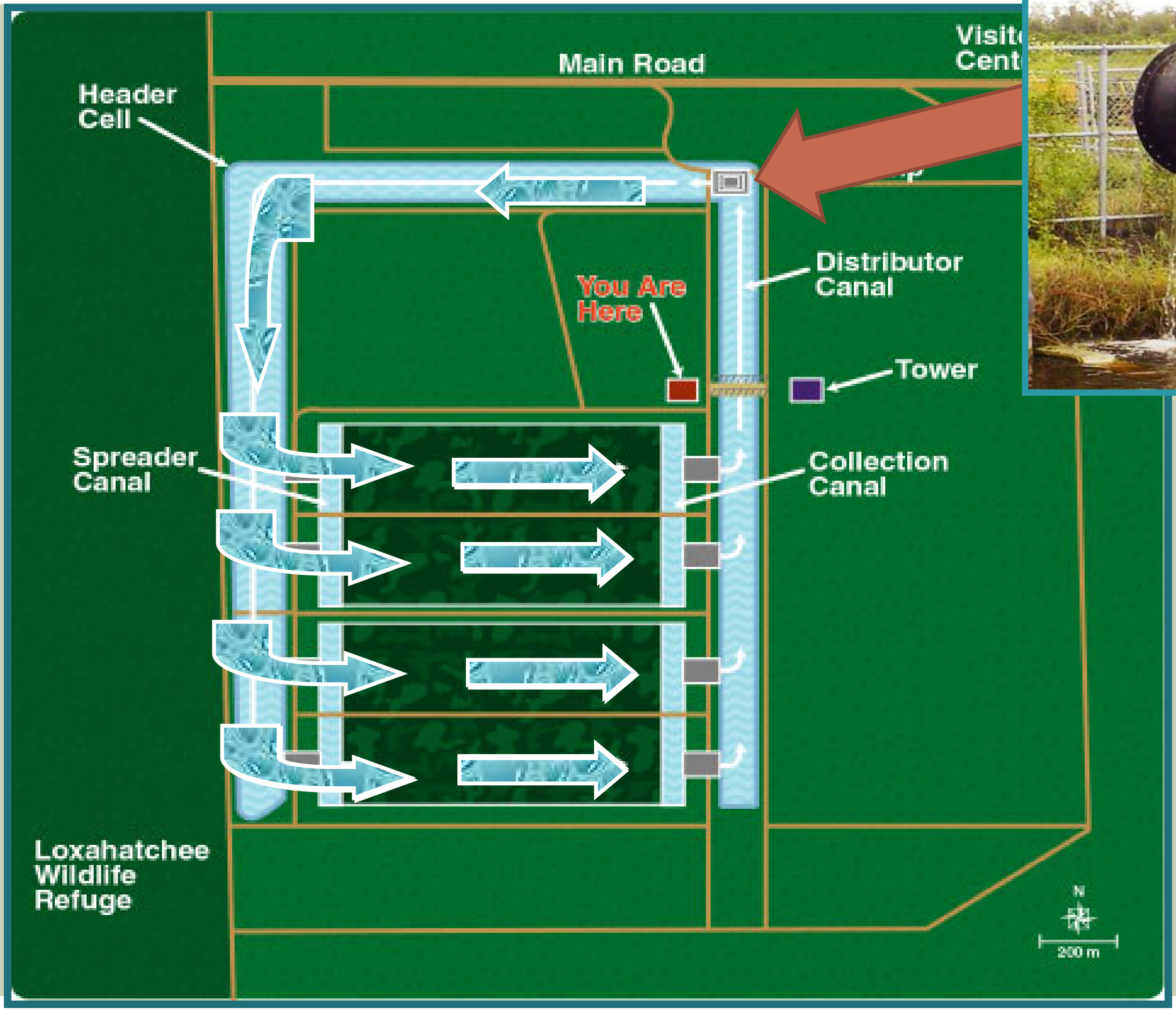
Conceptual Model:

Plant Community-Hydrogeochemical interaction associated with Transpiration and Precipitation

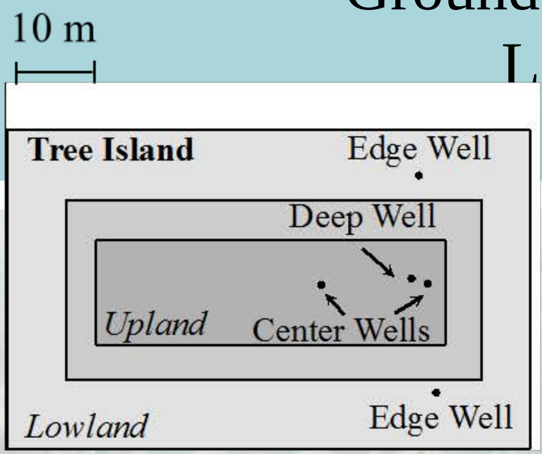


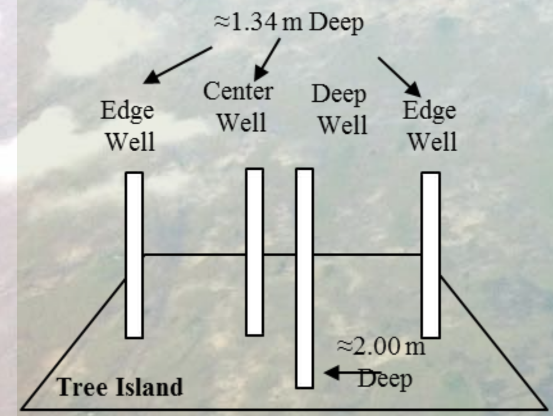
LILA Tree Islands: A Physical Ecosystem Model

LILA DESIGN

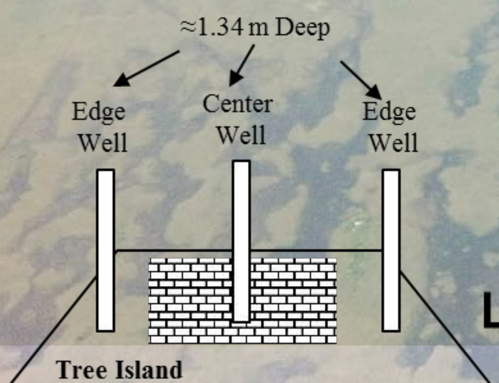

Main Road
Visit
Cent
Header
Cell
Distributor
Canal
You Are
Here
Tower
Spreader
Canal
Collection
Canal
Loxahatchee
Wildlife
Refuge
N
200 m

Groundwater and Surface Water Monitoring Locations on LILA Tree Islands



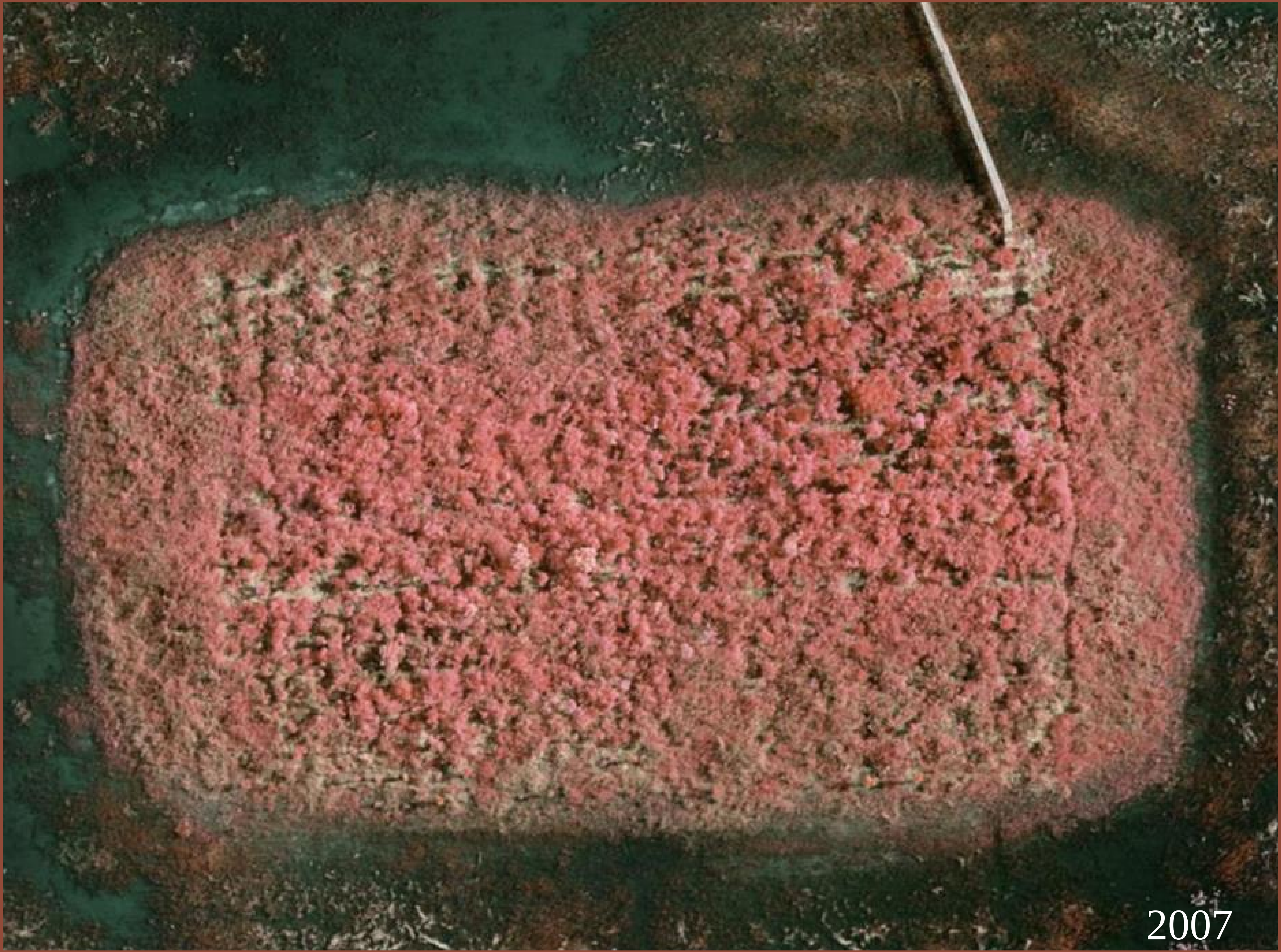


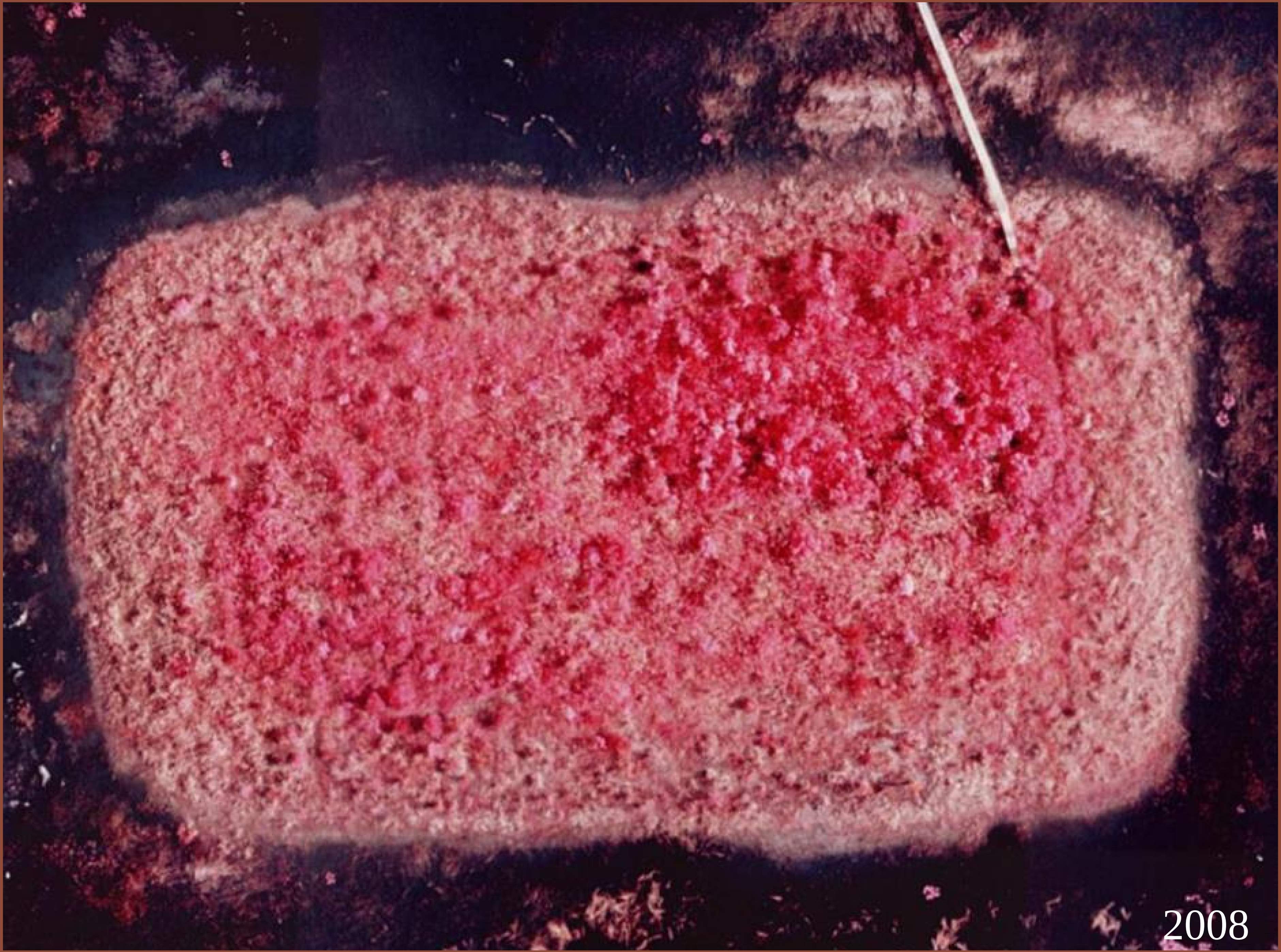
Peat Tree Island



Limestone Tree Island

Time

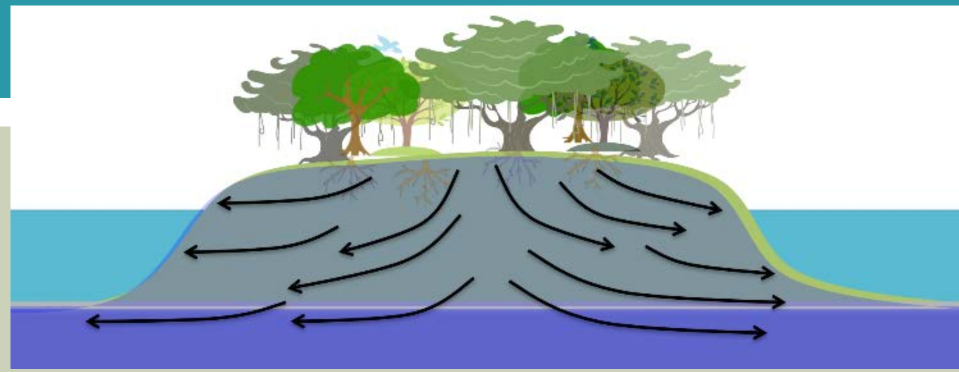

2007


2008


2009

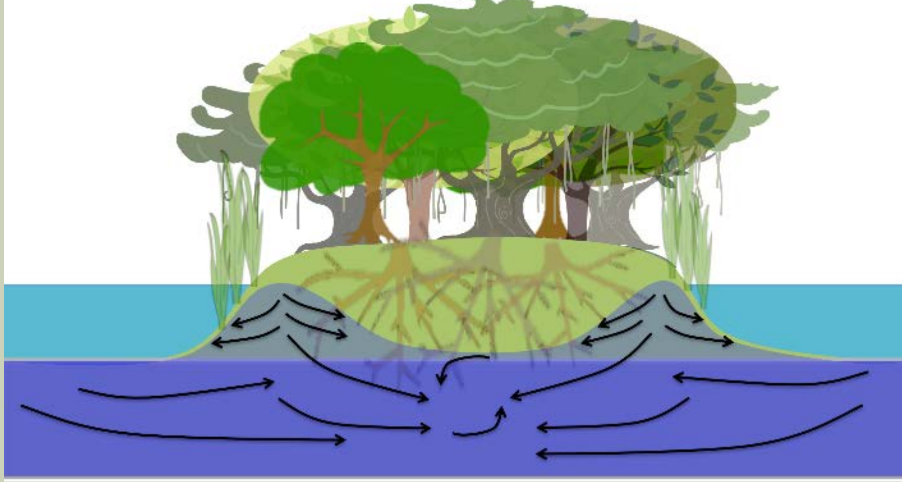

2010

Predominant direction of GW flow
after trees were planted

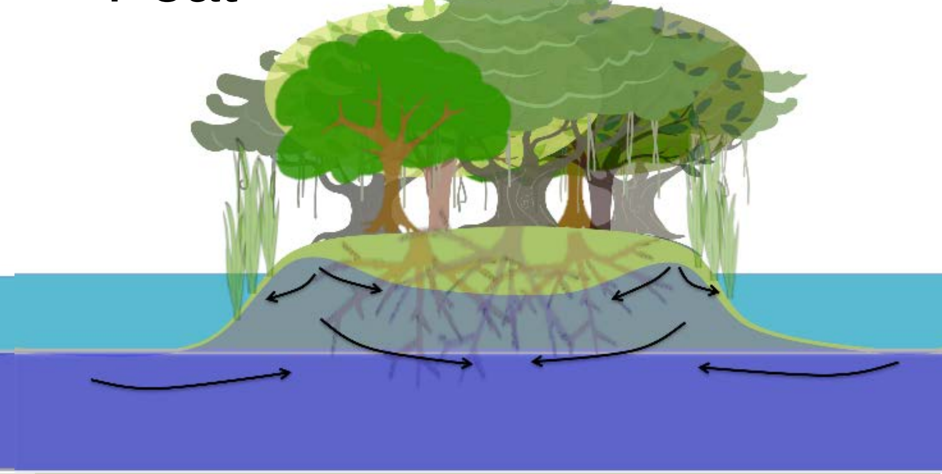


Predominant direction of GW flow 3 years later

Limestone

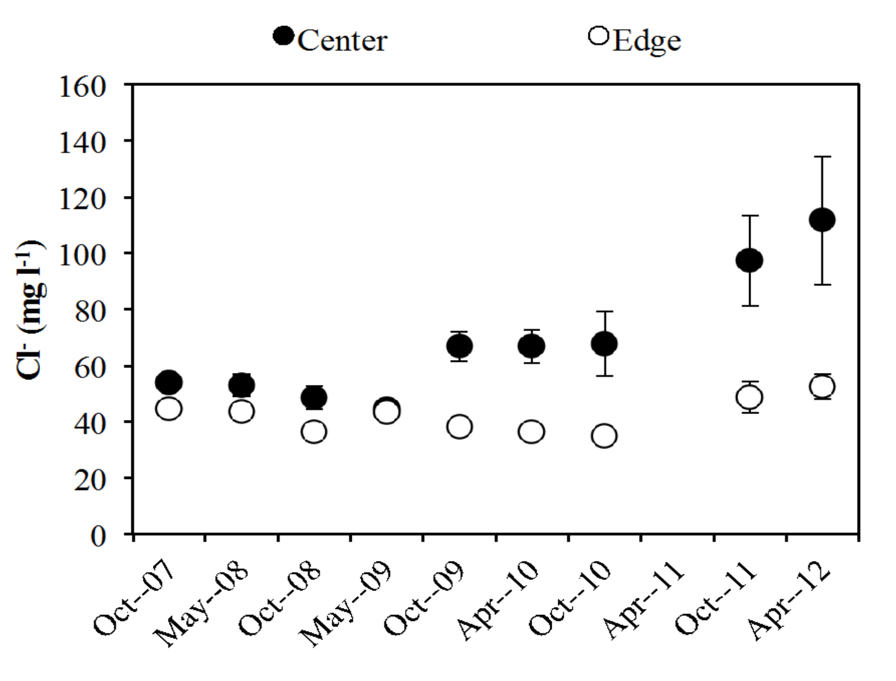


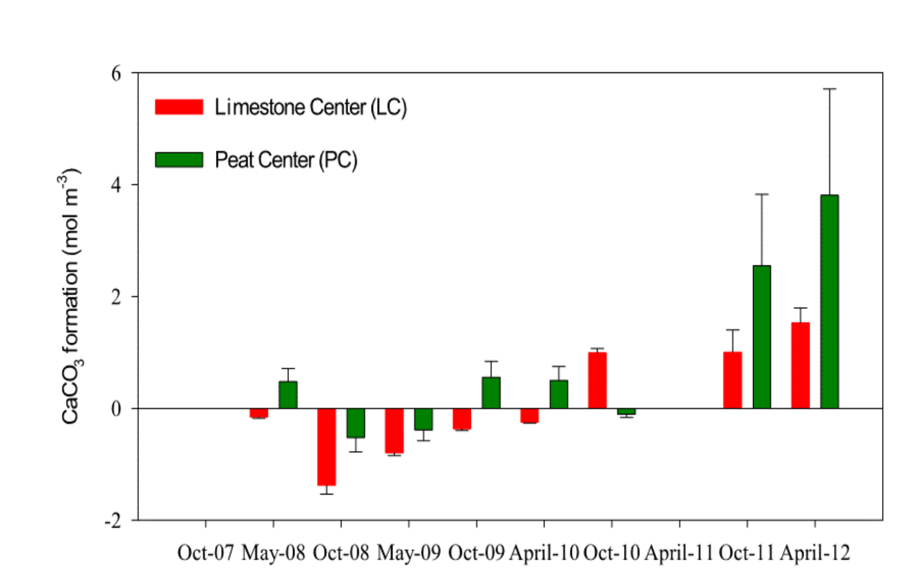
Peat

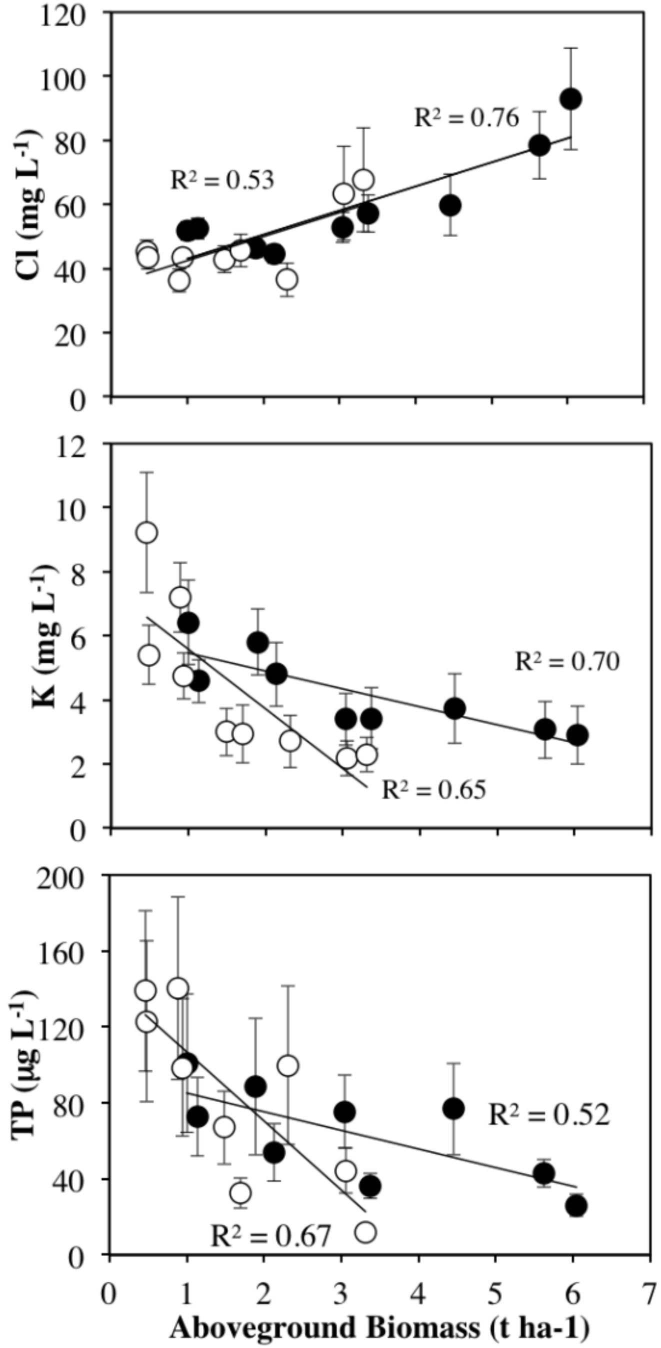


Sullivan PL, Price RM, Ross MS, Scinto LJ, Stoffella SL, Cline E, Drechel TW, Sklar FH. 2011. **Hydrologic processes of tree islands in the Everglades: Tracking the effects of tree establishment and growth**. Hydrogeology Journal 19, 367-378.DOI: 10.1007/s10040-010-0691-0

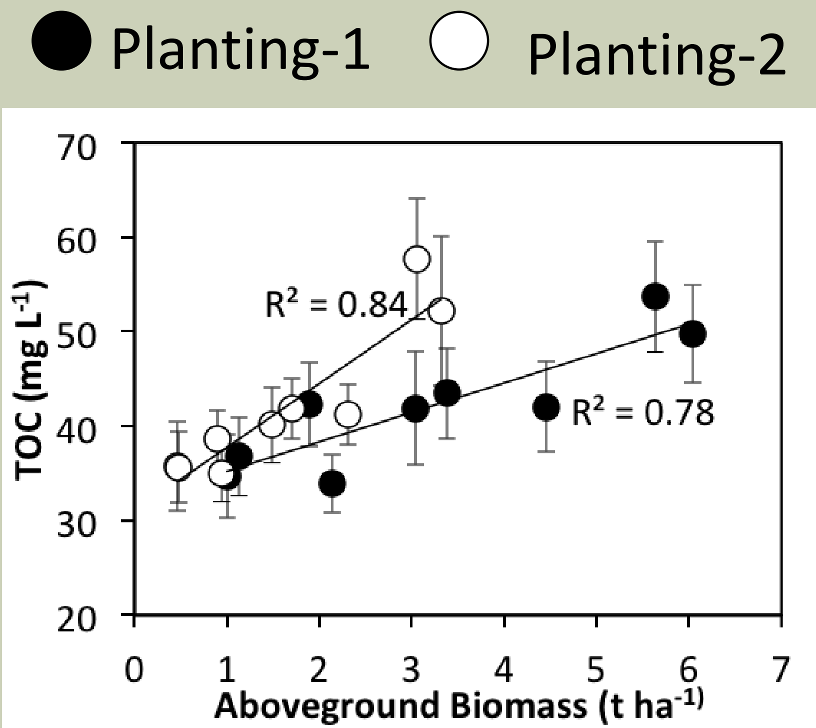
Increased concentrations of the non-reactive tracer Cl^- and $CaCO_3$ formation in Tree Islands (TI) over time. Data compares **Center** to the Edge groundwater and Limestone TI to Peat TI





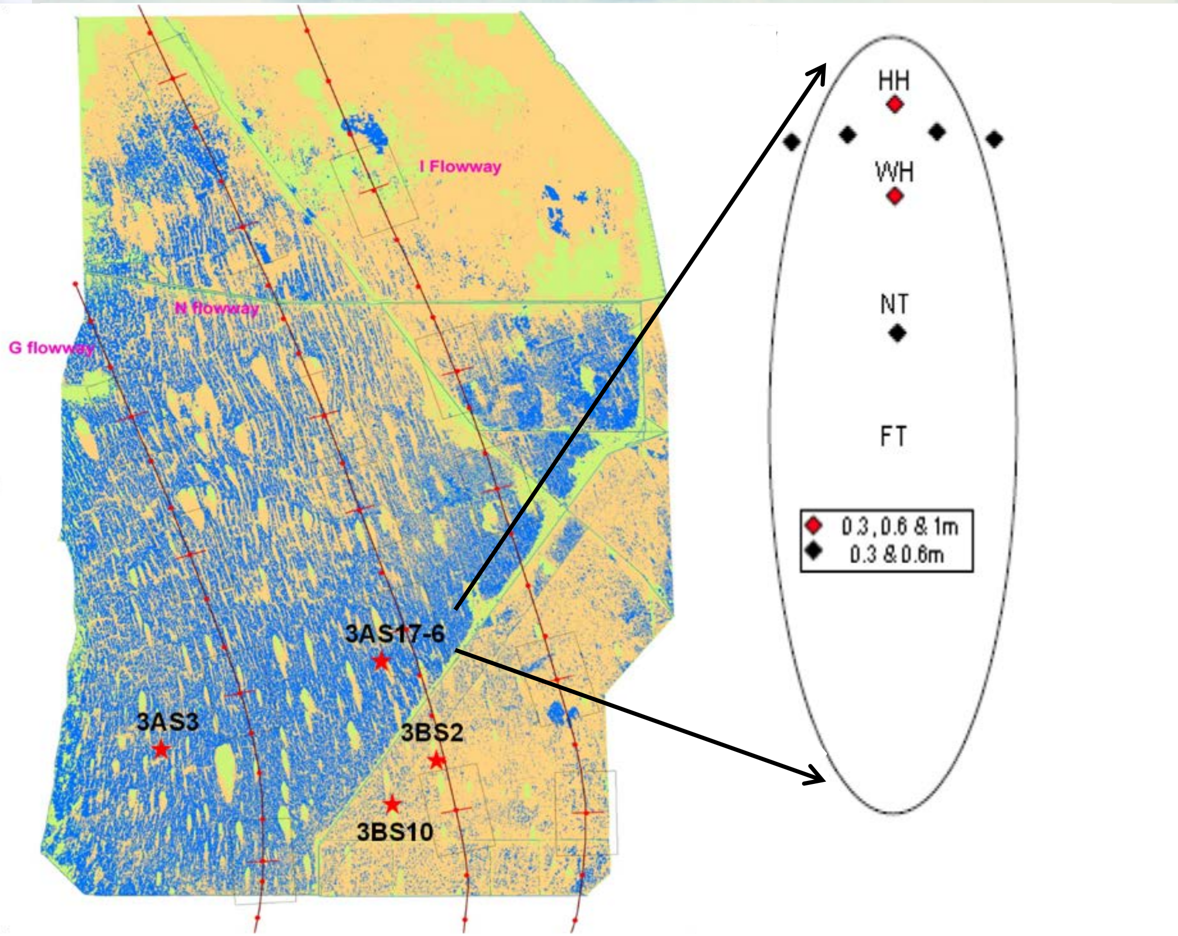


Increase in aboveground biomass (t ha^{-1}) was positively correlated with an increase in major ions (Cl, Na, Mg and Ca) and TOC concentrations but negatively correlated with K and TP concentrations



Current Landscape Monitoring Design

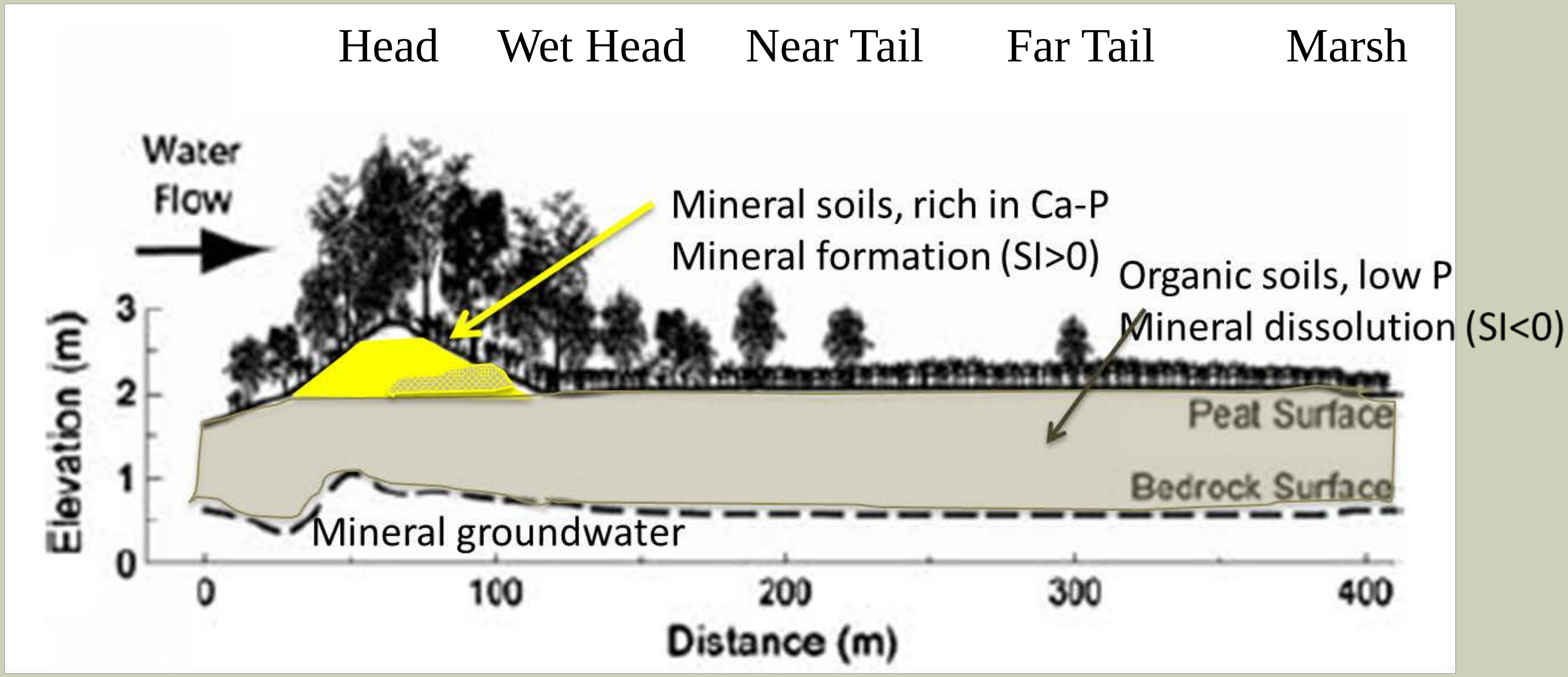
Hydraulic and geochemical properties are key to address questions and are critical parameters to monitor degraded and pristine Tree Islands



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 pore water phosphorus:** indicate P availability, mobility and potential for loss

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



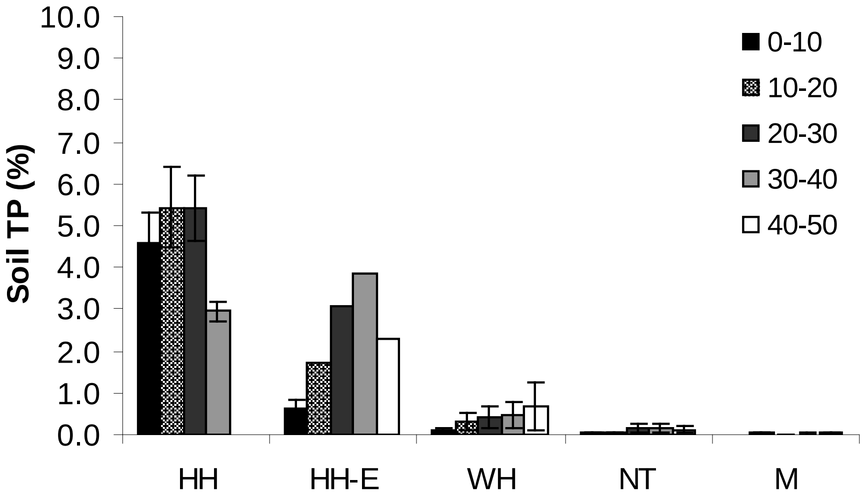
Potential sources of minerals in peat forming soils (saturation indices):

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

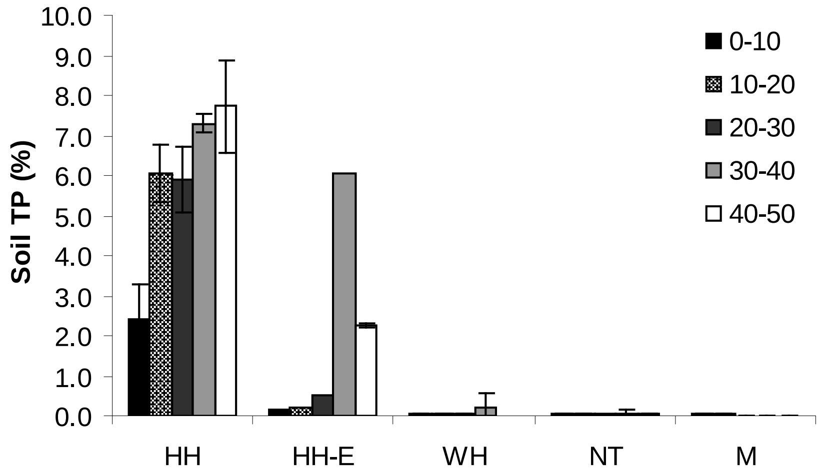
Irick et al. 2013. SSSAJ;
Troxler et al., 2014. Biogeosciences

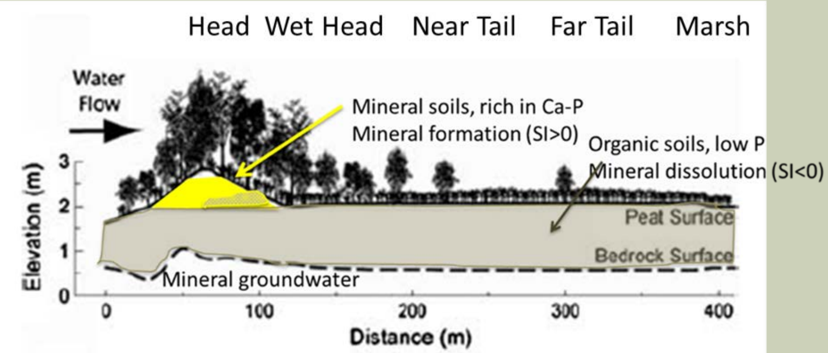
Soil Total Phosphorus across plant communities over depth

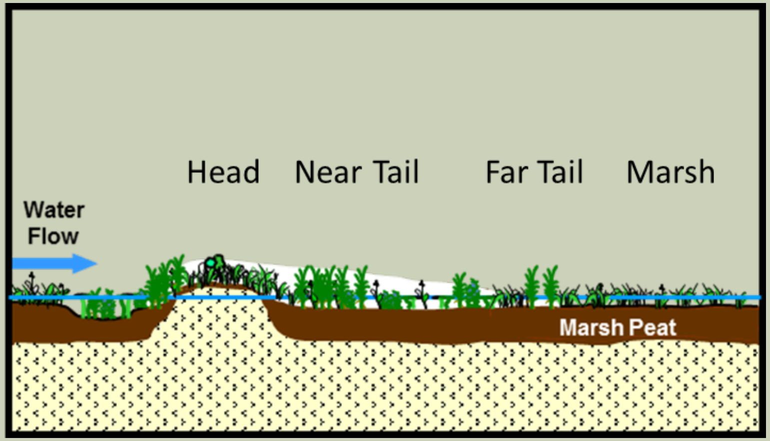
3AS3 (3A) – Dry/Wet, intact



Ghost Island (3A) - Wet, degraded

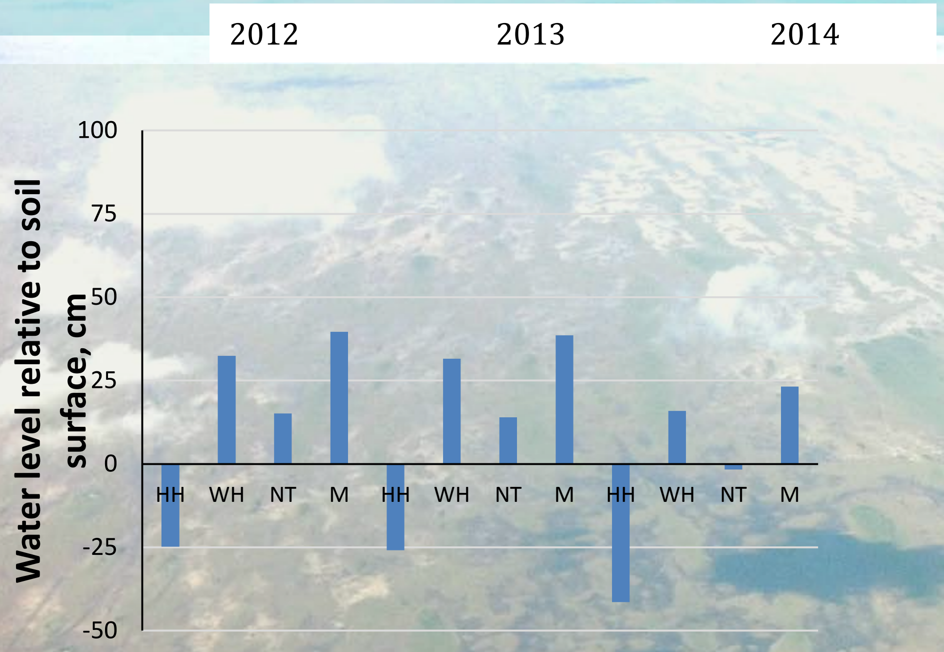


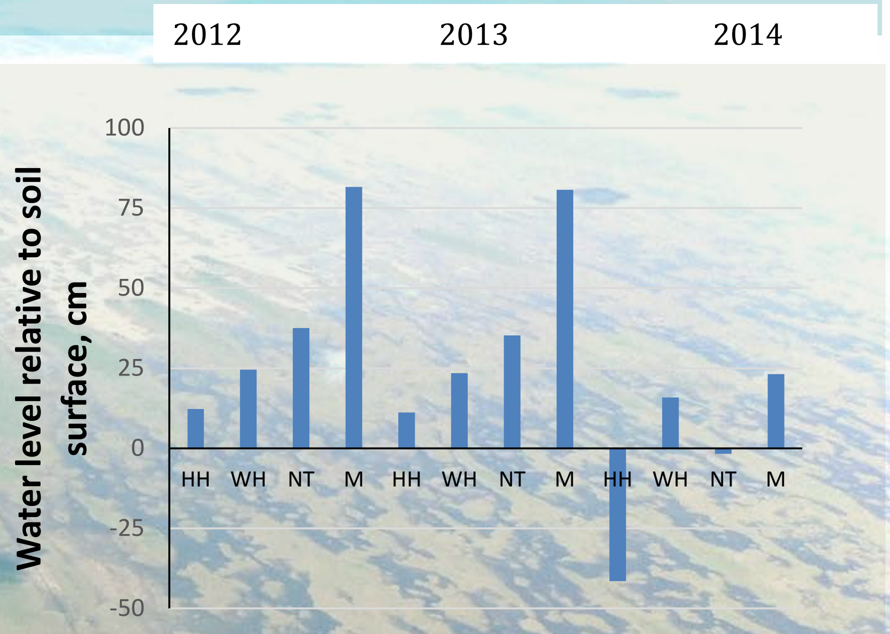


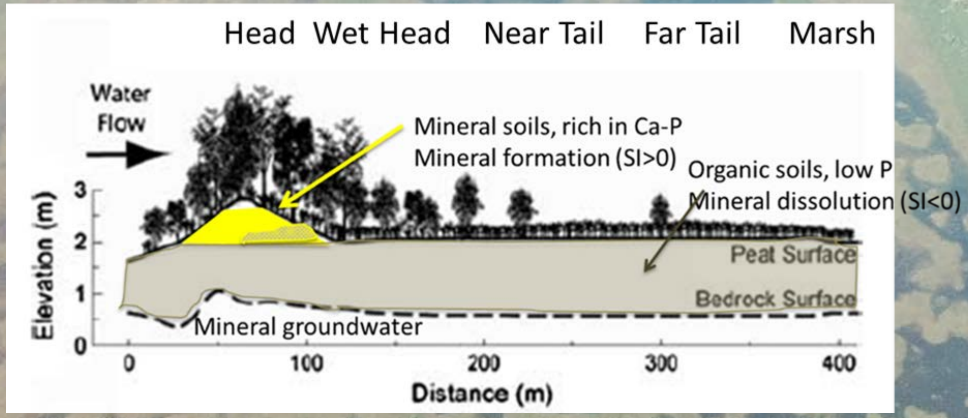


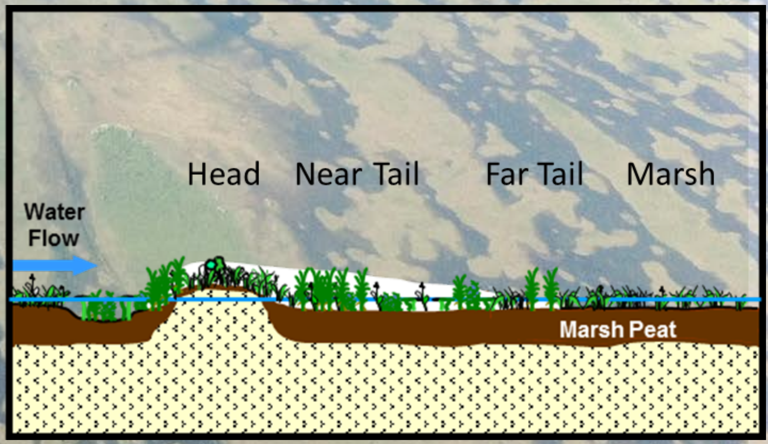
3AS3 (Pristine Tree Island)

Ghost (Degraded Tree Island)



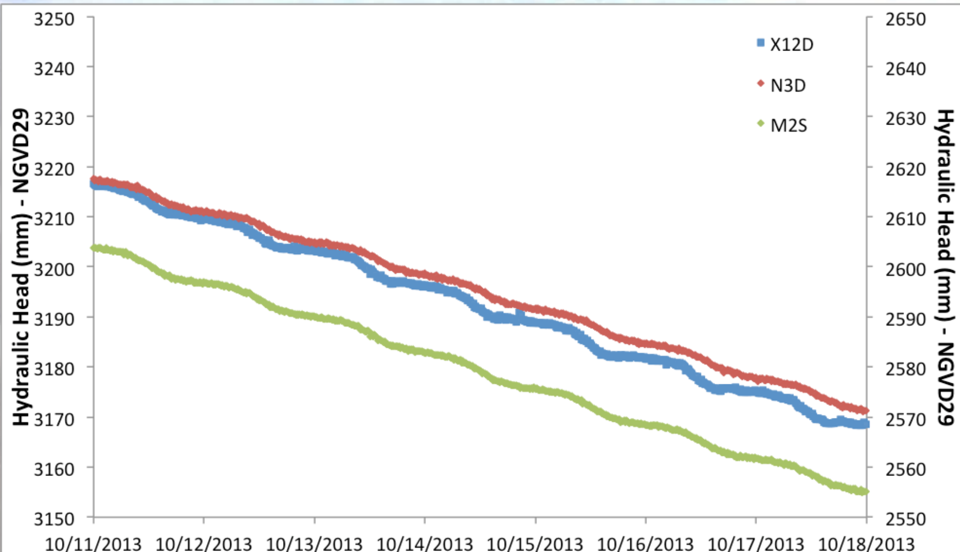




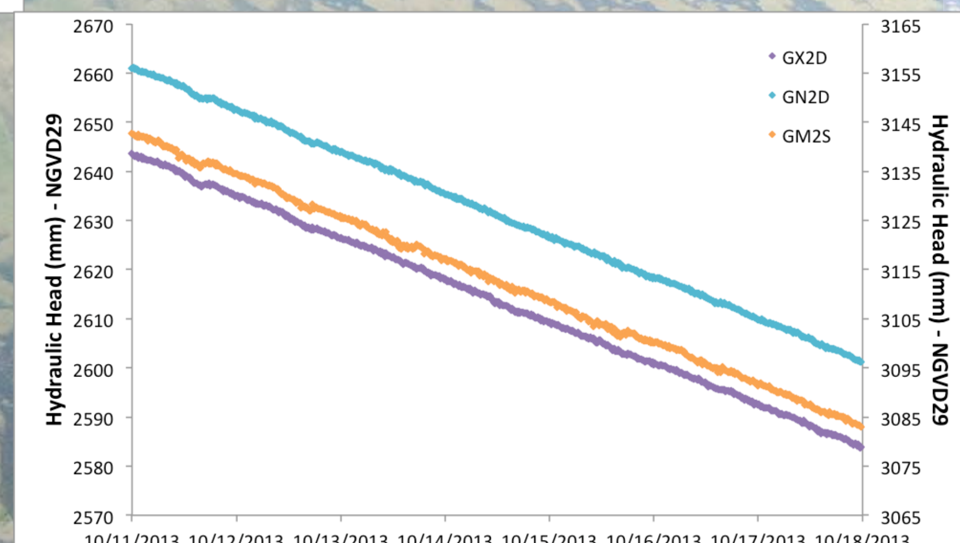


Plant community evapotranspiration pattern – diurnal drawdown (Wet Season)

3AS3 – Dry/Wet, intact



Ghost Island - Wet, degraded



Plant community evapotranspiration pattern – diurnal drawdown (Dry Season)

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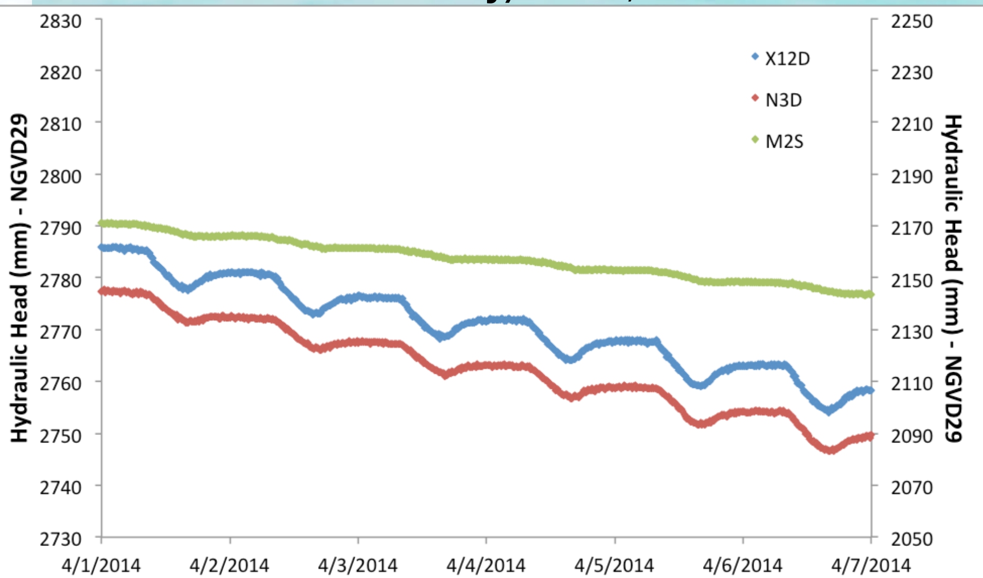
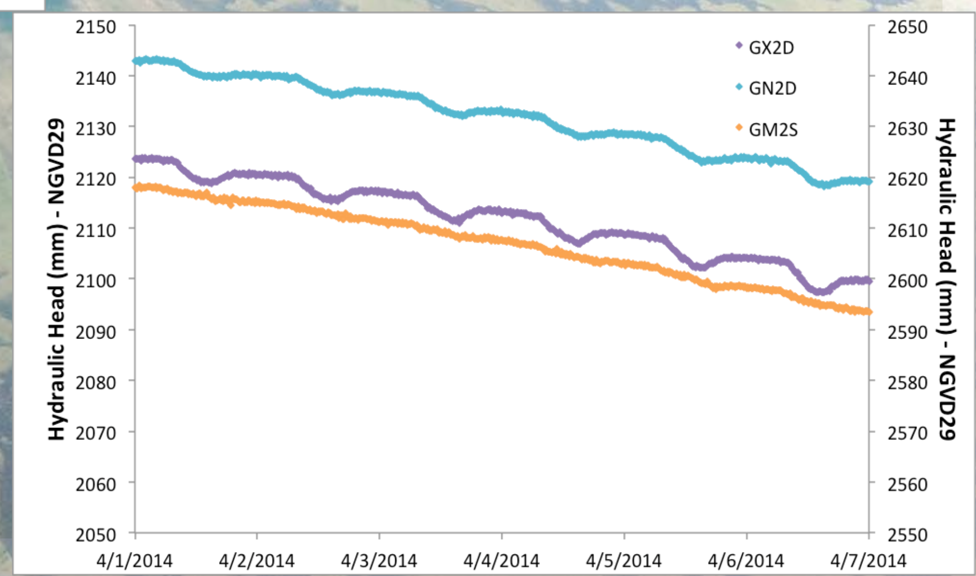


Ghost Island - Wet, degraded



GEOCHEMISTRY – OCTOBER 2013 – WCA 3A ISLANDS

3AS3	omm	Station	Depth	TDPO4 mg L-1	calciteSI
3AS3	High Head	X12S	30	0.447	1.194
3AS3	High Head	X15D	60	0.218	1.094
3AS3	High Head	X14D	60	0.234	1.065
3AS3	High Head	X12D	60	0.291	1.052
3AS3	High Head	X15DD	90	0.233	1.034
3AS3	High Head	X14DD	90	0.136	1.025
3AS3	High Head	X12DD	90	0.075	1.163
3AS3	Wet Head	N4SW	0	0.002	0.100
3AS3	Wet Head	N3SW	0	0.002	0.110
3AS3	Wet Head	N2SW	0	0.002	0.055
3AS3	Wet Head	N4S	30	0.027	1.071
3AS3	Wet Head	N3S	30	0.092	0.411
3AS3	Wet Head	N2S	30	0.011	-0.174
3AS3	Wet Head	N4D	60	0.027	0.719
3AS3	Wet Head	N3D	60	0.281	0.955
3AS3	Wet Head	N2D	60	0.007	0.211

Ghost	m	Station	Depth	TDPO4 mg L-1	calciteSI
GI	High Head	GX2	0	0.002	0.115
GI	High Head	GX3S	30	2.064	0.631
GI	High Head	GX2S	30	0.561	0.251
GI	High Head	GX1S	30	1.772	0.702
GI	High Head	GX3D	60	0.521	1.297
GI	High Head	GX2D	60	0.406	1.089
GI	High Head	GX1D	60	2.504	0.601
GI	High Head	GX2DD	90	0.395	1.174
GI	Wet Head	GN3SW	0	0.002	0.077
GI	Wet Head	GN2SW	0	0.003	0.084
GI	Wet Head	GN1SW	0	0.002	0.202
GI	Wet Head	GN3S	30	0.038	-0.192
GI	Wet Head	GN2S	30	0.085	-0.220
GI	Wet Head	GN1S	30	0.008	-0.240
GI	Wet Head	GN3D	60	0.018	0.210
GI	Wet Head	GN2D	60	0.093	0.177
GI	Wet Head	GN1D	60	0.014	-0.095

- Wet, intact 3AS3, relatively lower $TDPO_4$ throughout profile, and SI calcite >1
  → lower soil water phosphorus, higher potential for mineral precipitation
- Negative correlation between $TDPO_4$ and SI calcite in high head of wet, degraded Ghost island
- Increase in SI calcite with depth in high head of wet, degraded Ghost island, with most SI values < 1
  → Higher soil water phosphorus, lower potential for mineral precipitation

Conclusions from LILA/WCA-3A

- Transpiration by trees concentrates ions in the groundwater and support calcite precipitation within 2 years of establishing the forest, especially on limestone islands (LILA)
- Tree Island degradation appear to be largely the result of a hydrologic decoupling of the trees from the mechanism of evapotranspiration, especially during the dry season, when hydrological conditions promote mineral P sequestration, (Everglades)
- In pristine tree island Wet-Dry seasonality promotes mineral precipitation and P retention in the High Head and organic matter accumulation in Wet Head and Near Tail communities (Everglades)
- These results highlight the importance of tree islands as physical models for nutrient sequestration and help to establish targets and metrics to measure success on tree island restoration projects.