Transpiration as a Hydrologic Driver of Ion and Mineral Accumulation on Tree Islands

Tree Islands GW– TP= 388 µg L^{-1}, Cl^-= 140 mg L^{-1}, Ca^{2+}= 176 mg L^{-1}

Marsh GW– TP= 11 µg L^{-1}, Cl^-= 55 mg L^{-1}, Ca^{2+}= 47 mg L^{-1}

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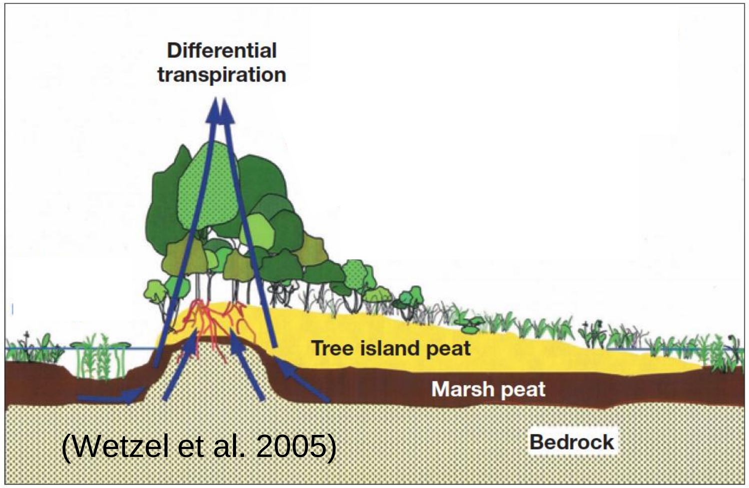
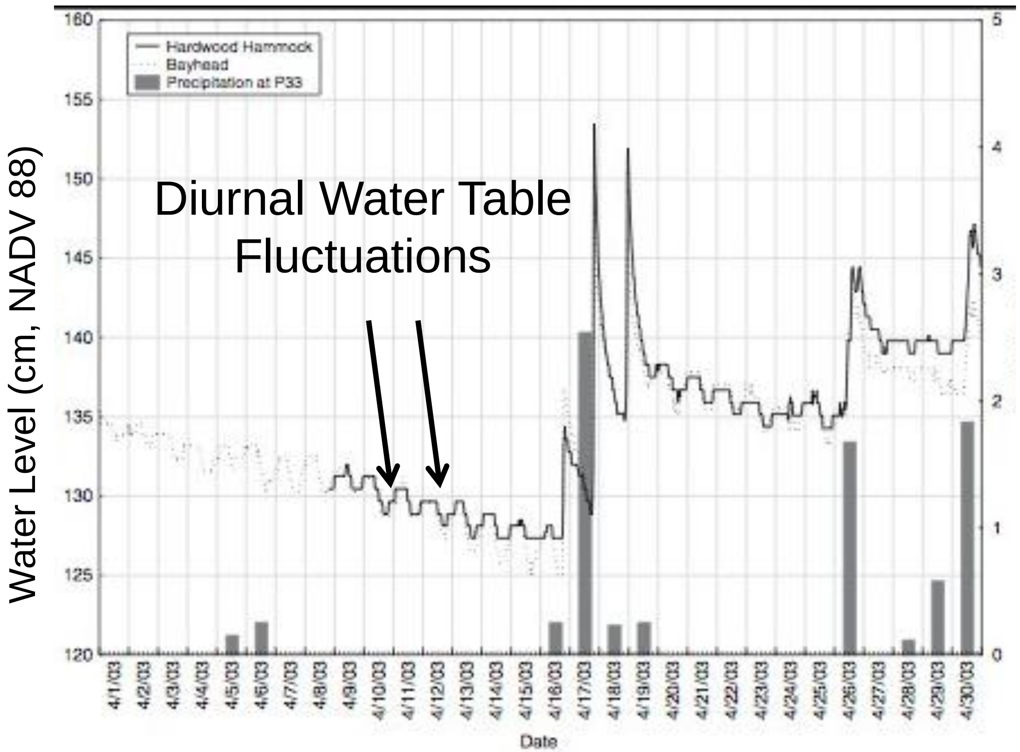
Transpiration driven inputs of groundwater has been hypothesized to support the elevated ion and nutrient concentrations



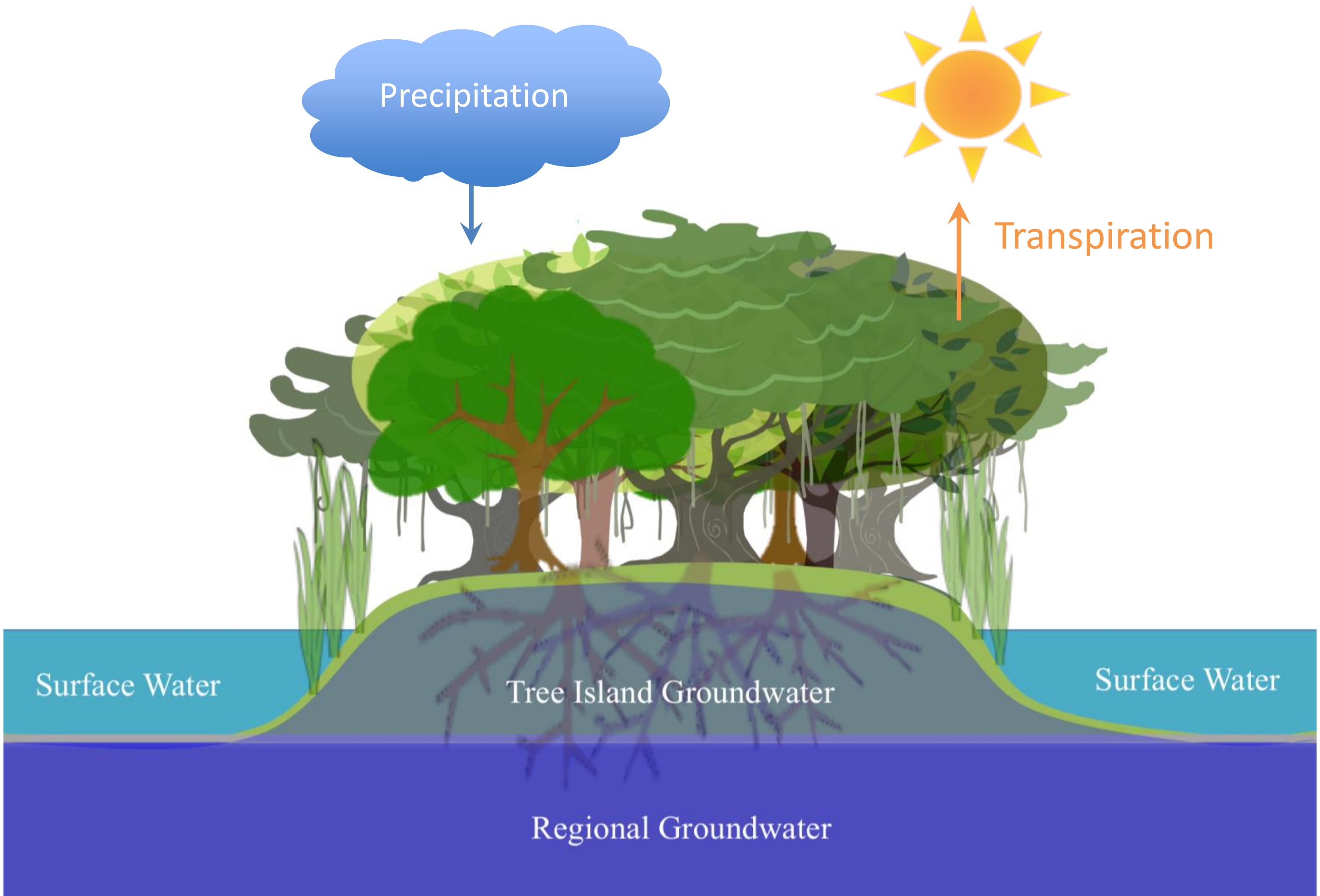
Groundwater Level on a Tree Island During Dry Season (Ross et al. 2006)



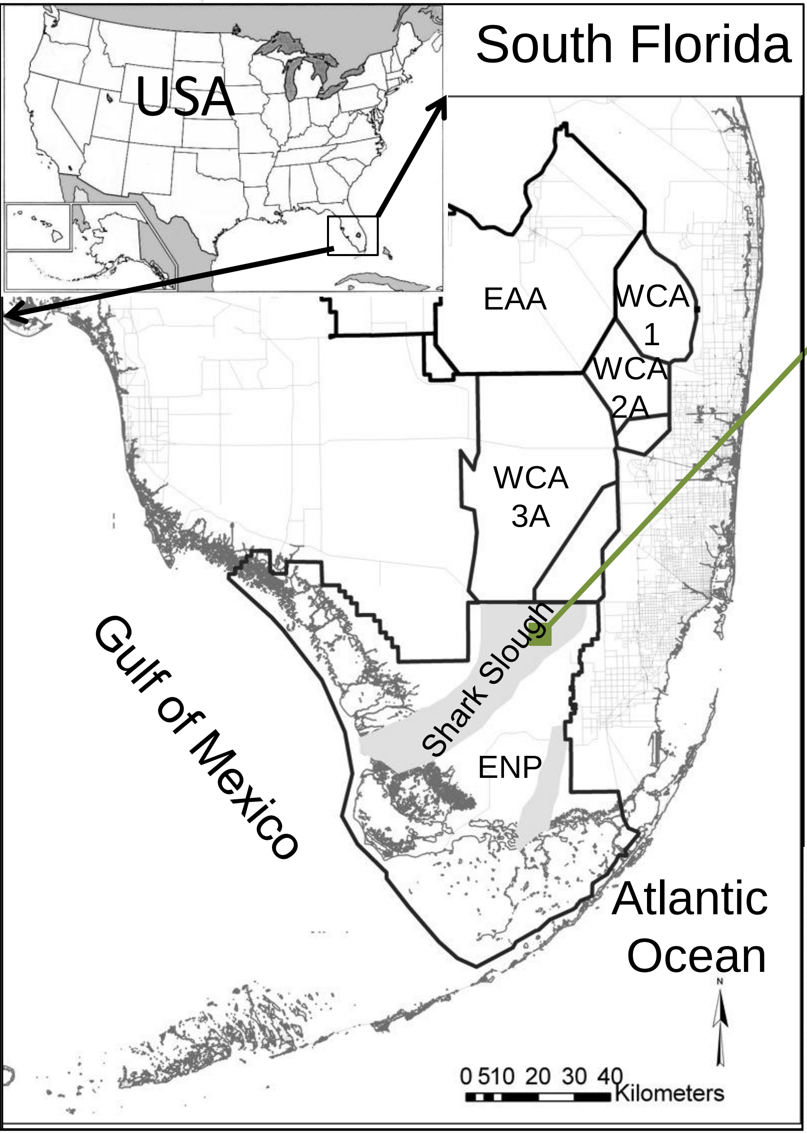
Enigmatic Carbonate Layer on the Head of an Island (Schwadron et al. 2006, Churma et al. 2011)

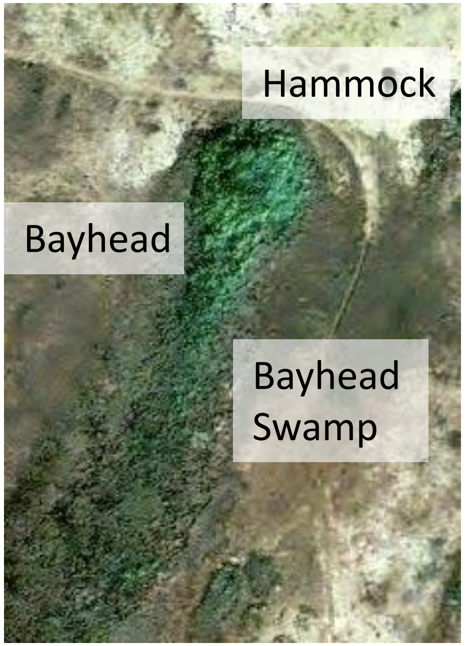
Objective:

Determine if root water uptake by the overlying vegetation and tree island hydrodynamics controls potential mineral formation by affecting the distribution and concentration of ions in tree island groundwater

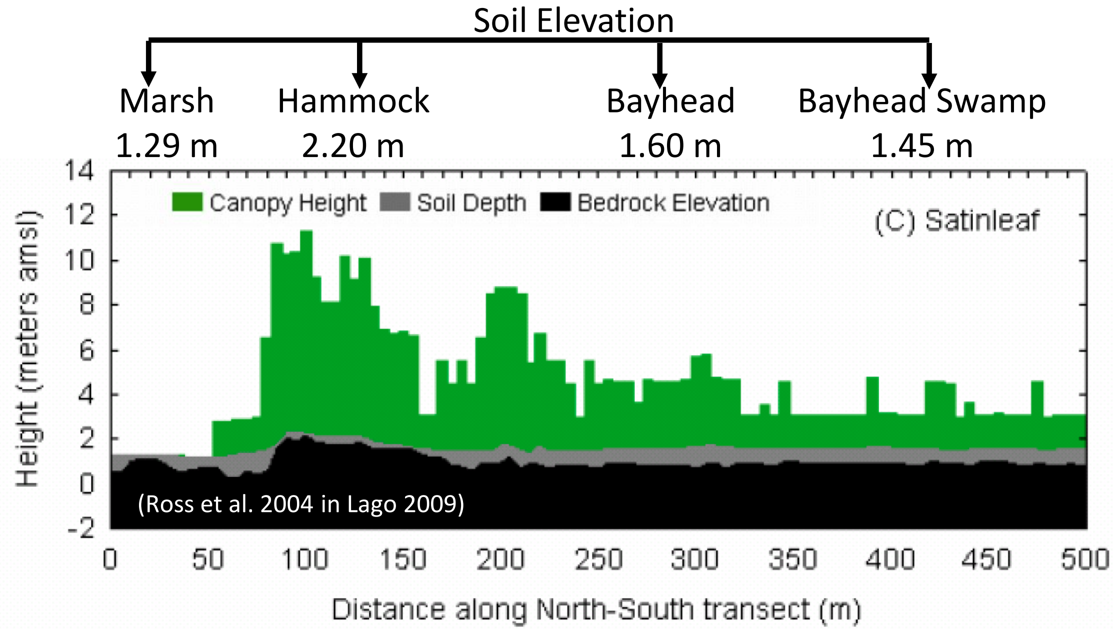


Study Area: Satinleaf Tree Island



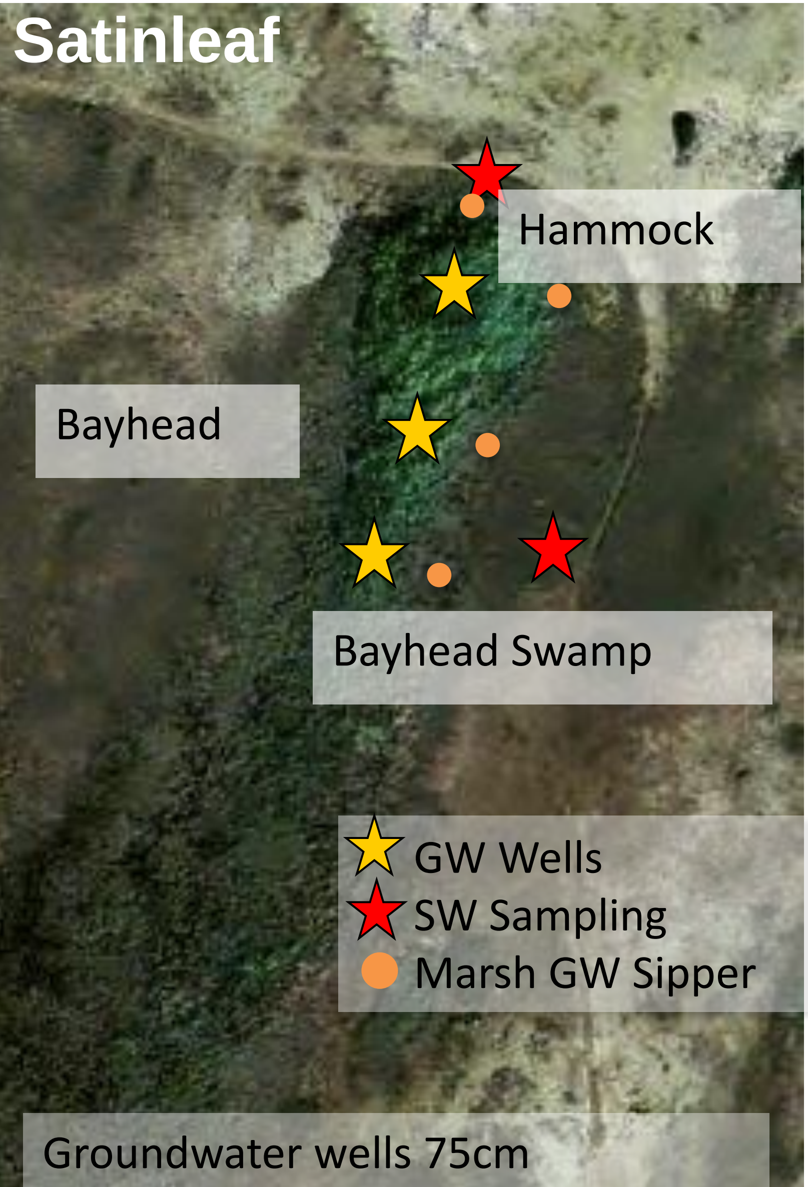


- Located in Everglades National Park
- Teardrop in Shape
- Contains 3 differing plant communities



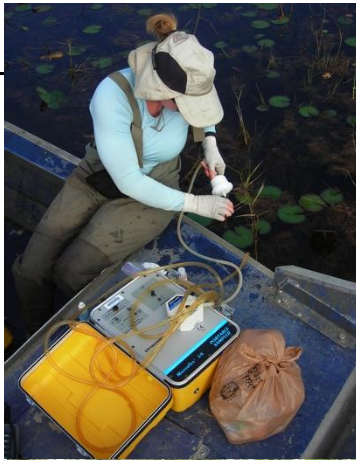
Methods:

Monitoring Locations



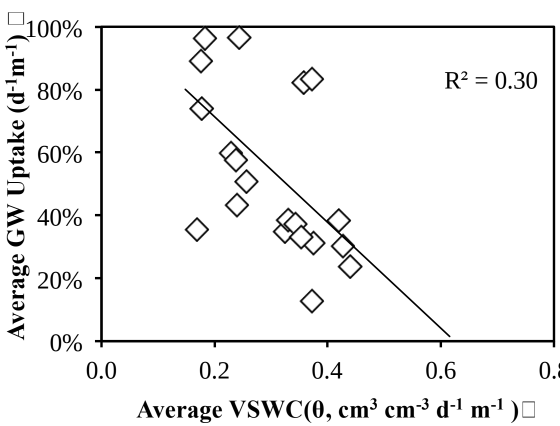
Sampling Scheme

Monitored	Satinleaf
Groundwater and Surface Water Level Monitoring	**2007-2010** 3 GW Wells 1 SW Site 30 min rate of collection
Groundwater Surface Water Chemistry	**Quarterly 2008-2010** 3 GW Wells 4 GW Sipper 2 Surface Sites Analyzed for: Major ions, Oxygen and Hydrogen Isotopes, Nutrients
Soil	**2007-2010** Relative Volumetric Soil Water Content (Hammock only)
Trees	**2007-2010** Sap Flow on 4 species(Hammock only)

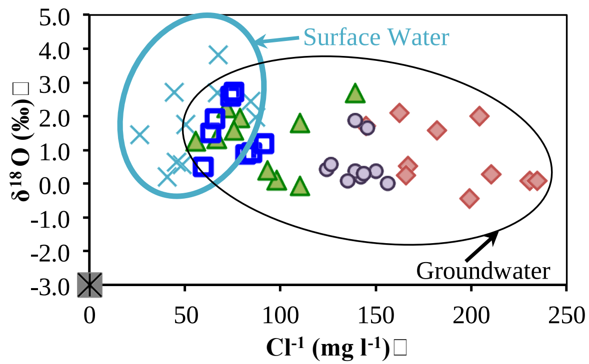


Transpiration as a driver of ion accumulation and potential mineral formation

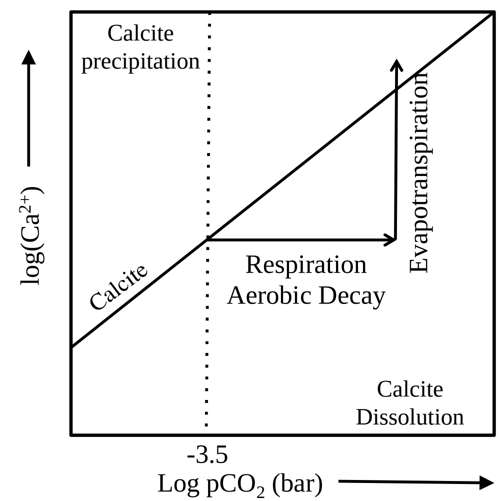
I. Groundwater Uptake



II. Inputs of Water (Water Levels and Chemistry)

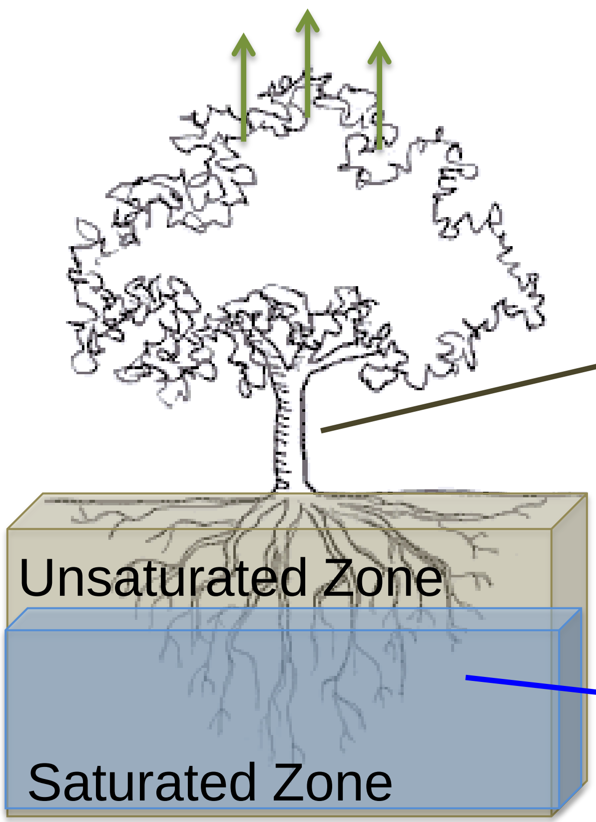


III. Saturation State of Groundwater with Respect to Calcite and Aragonite

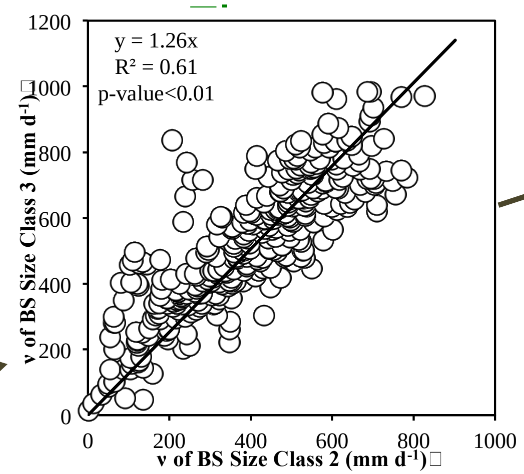


1.Uptake of Groundwater by Overlying Trees

Transpiration= Water from the Unsaturated + Saturated Zones



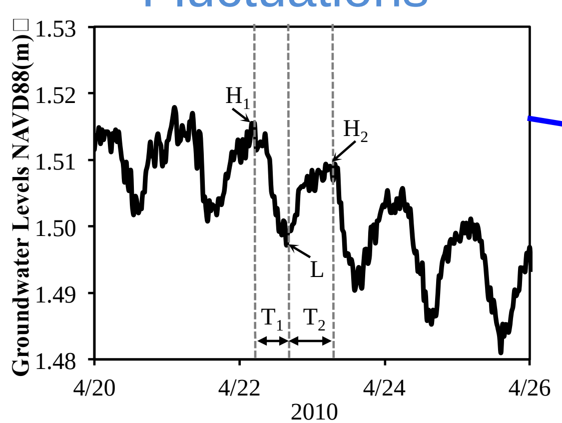
Sap



Stand Level Transpiration (E)

$$E = \left(\sum_{j=1}^{3} \sum_{i=1}^{4} V_{avg,i,j}\, \rho_{i,j}\right) \frac{\rho_{Stand}}{\rho_{mon}}.$$

Diurnal Water Table Fluctuations

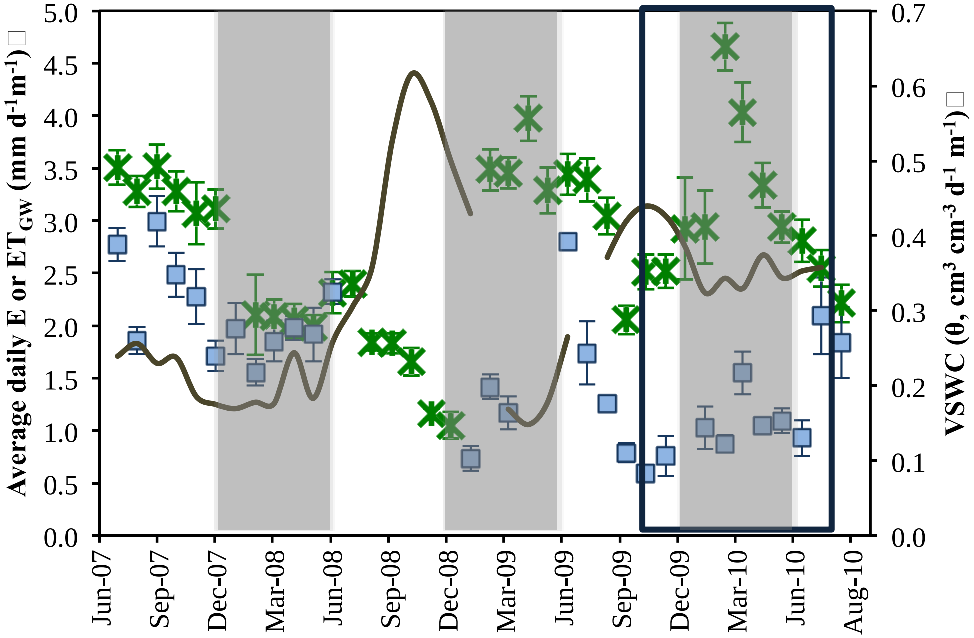


Groundwater Evapotranspiration (ET_{GW})

$$ET_{GW} = \left[(H_1 - L) + \frac{(H_2 - L)}{T_1} T_2\right] 1000 S_y$$

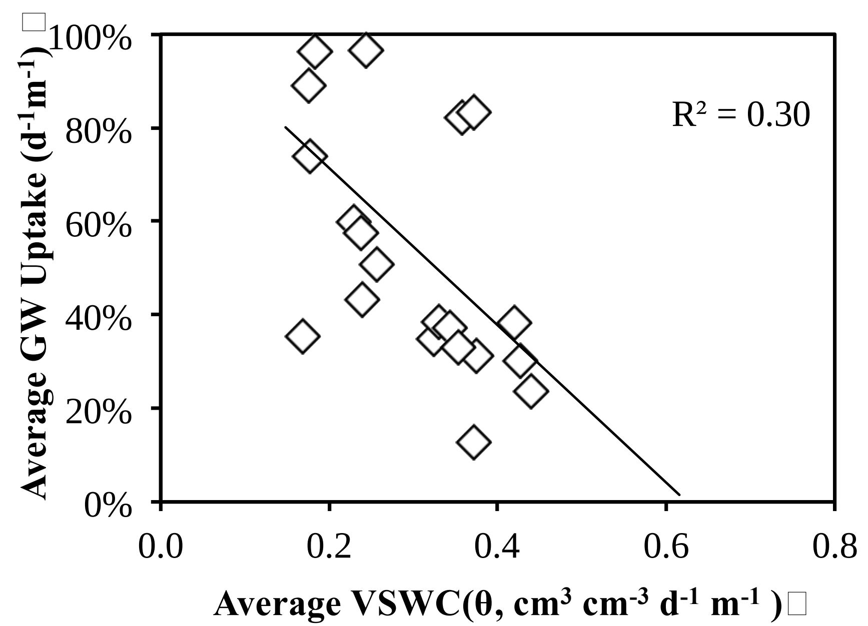
I. Uptake of Groundwater by Overlying Trees

Transpiration (E), Groundwater Evapotranspiration, Volumetric Soil Water Content (VSWC) at on the Hammock

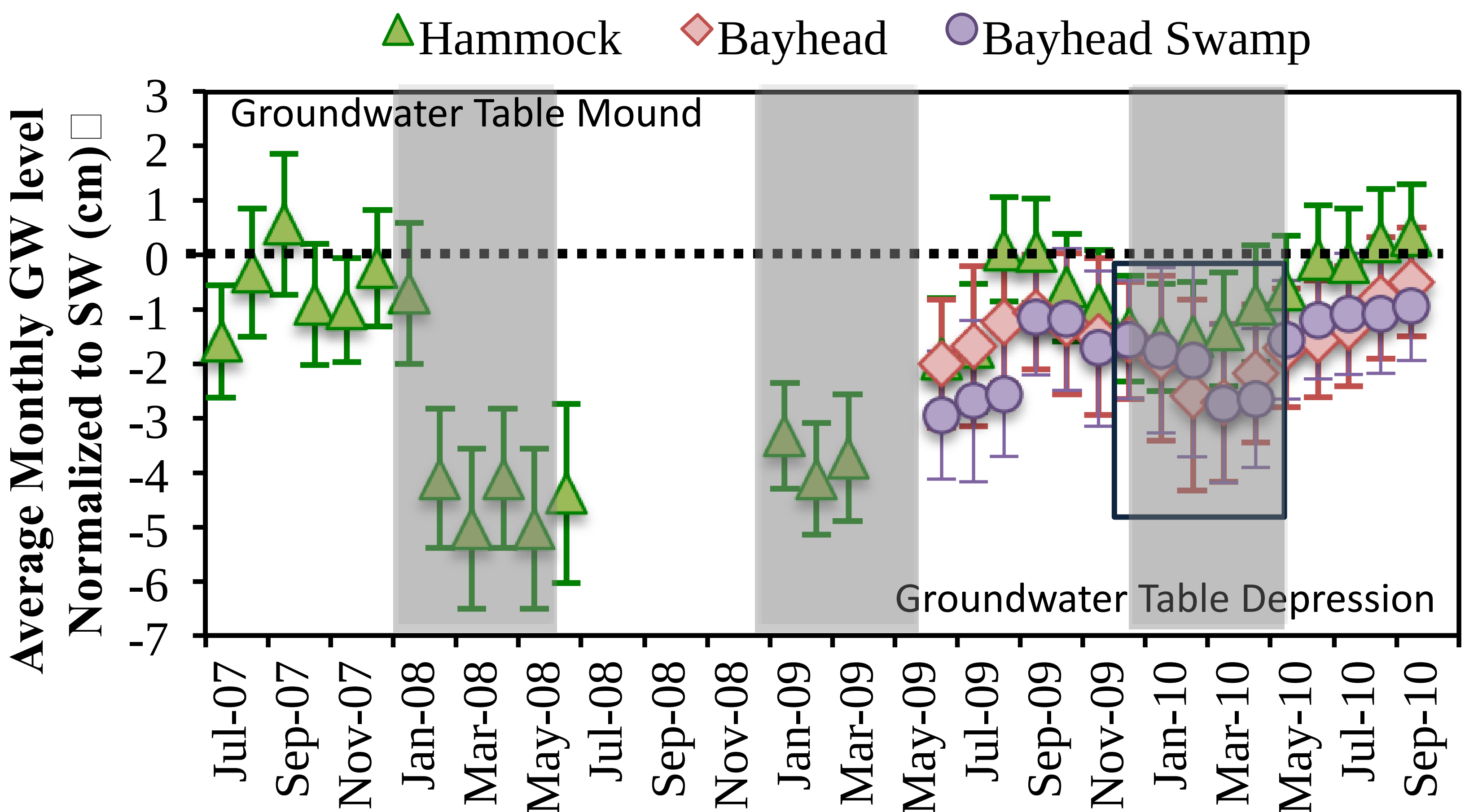


$$\text{Groundwater Uptake} = \frac{ET_{GW}}{E}$$

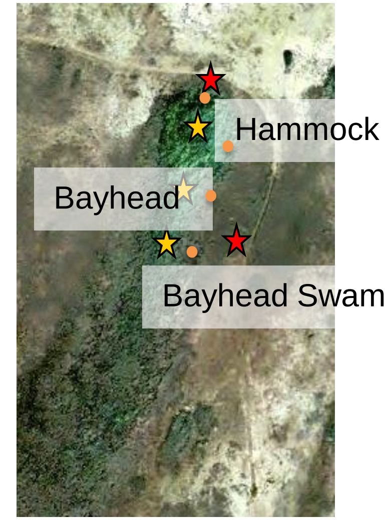
Average Groundwater Uptake Compared to Volumetric Soil Water Content (VSWC) at on the Hammock



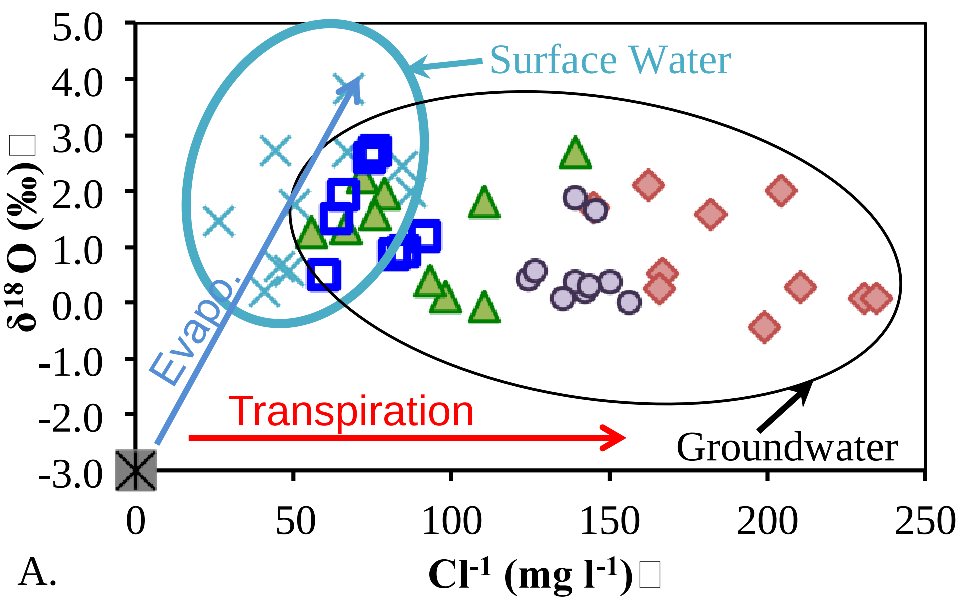
II. Inputs of Water : Water Levels



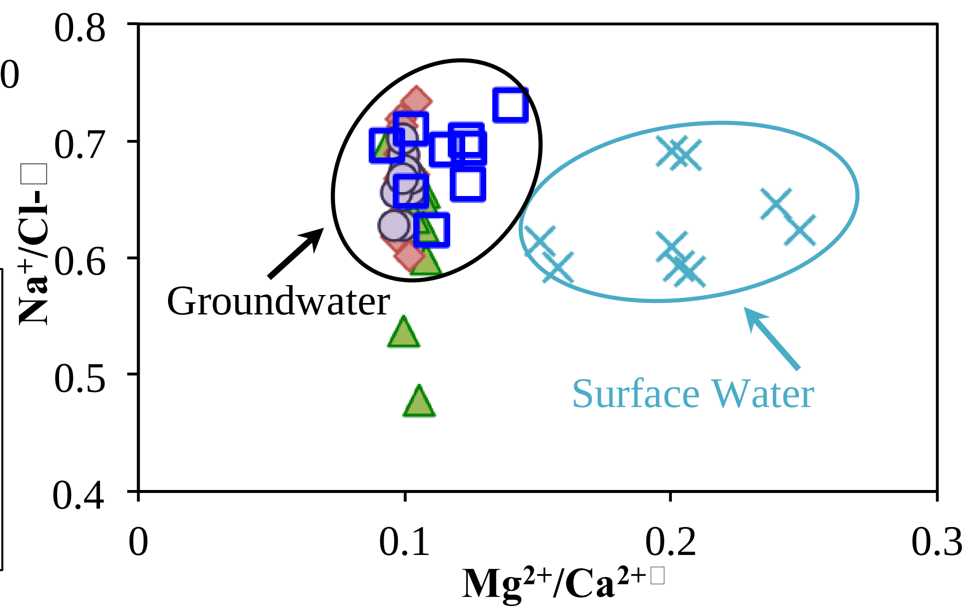
II. Inputs of Water: Water Chemistry

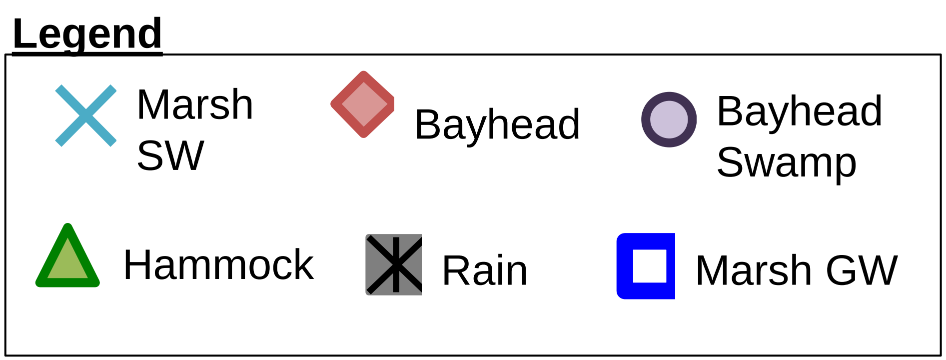


δ¹⁸O and Cl⁻ concentrations of groundwater indicated transpiration had a dominant influence on the tree island groundwater chemistry



Ionic ratios of groundwater and surface water indicated all communities were recharge by marsh groundwater





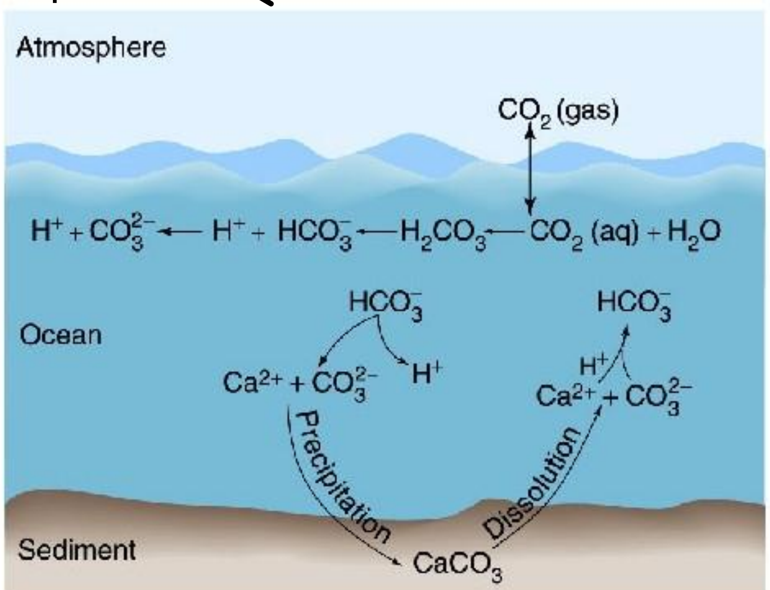
III. Calcium Carbonate $CaCO_3$ (e.g. calcite) and Saturation State

Precipitation and Dissolution

Calcite: $CaCO_3$ ⟷ Calcium Ions: Ca^{2+} + Carbonate: CO_3^{2-}

→ Dissolution

Precipitation ←



Saturation State of Water

$$SI = log\left(\frac{IAP}{K_{sp}}\right)$$

Ion Activity Product (**IAP**)

(Water Sample)

$$\frac{(aCa^{2+})(aCO_3^{2-})}{(aCaCO_3)}$$

Calcite Equilibrium Constant (**K_{sp}**)

(Known Value)

$$\frac{(aCa^{2+})(aCO_3^{2-})}{(aCaCO_3)} = 10^{-8.48}$$

IAP:K_{sp}	SI State	SI Value
IAP=K_{sp}	Equilibrium	0.00 ± .05
IAP<K_{sp}	Undersaturated	<-0.05
IAP>K_{sp}	Supersaturated	>0.05

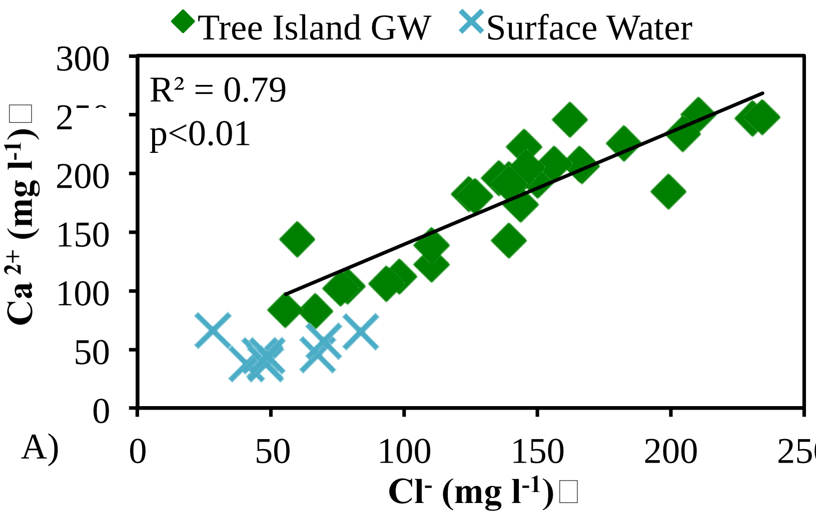
Saturation State of Calcium Carbonates Influenced by :

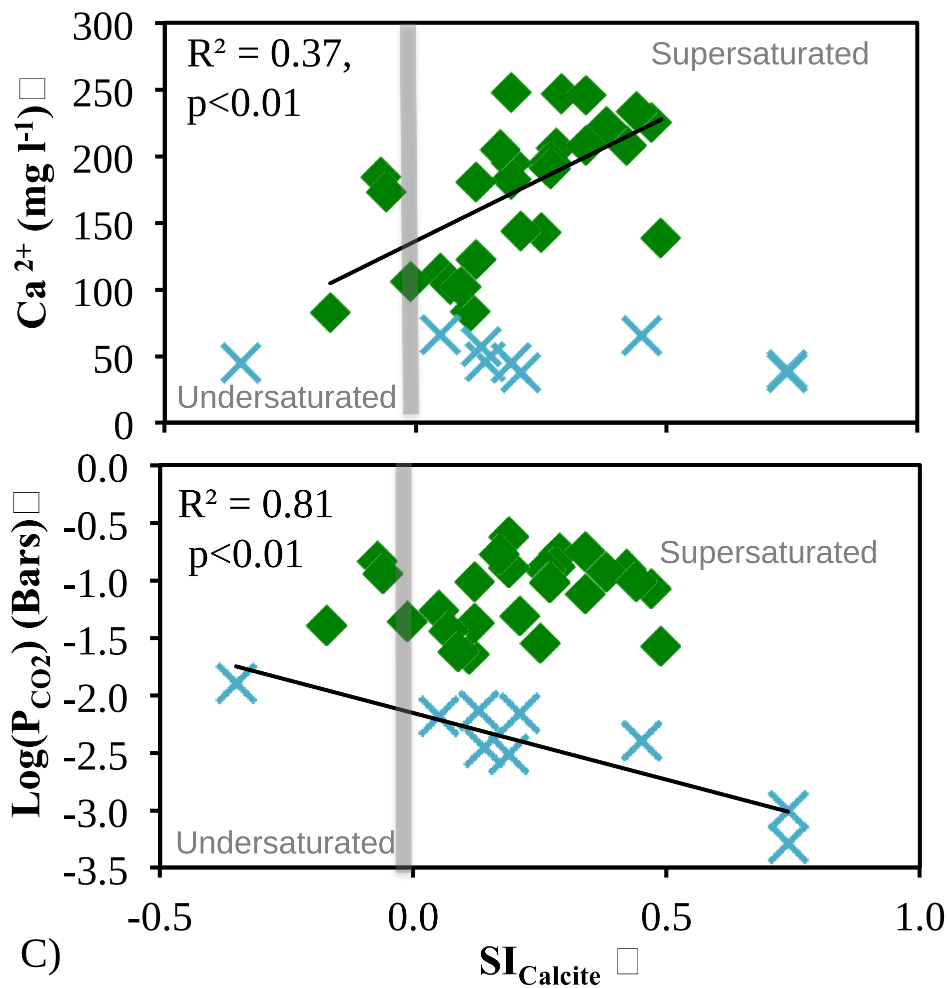
- temperature
- concentration of CO_2
- common ion effect
- ionic strength of the water
- respiration, decay
- photosynthesis

III. Saturation State of Groundwater and Surface Water at Satinleaf

1. Calcium Compared to Chloride concentrations in Groundwater and Surface Water

2. Calcium Concentrations to Calcite Saturation in Groundwater and Surface Water





3. Partial Pressure of Carbon Dioxide (Pco_2) and the Calcite Saturation in Groundwater and Surface Water

Conclusion:

Water level, transpiration, and hydrogeochemical data presented above generally support the hypothesis that root water uptake from phreatophytic vegetation drives groundwater fluxes toward the tree island from surrounding areas

The supersaturated state of calcium carbonate minerals found in the tree island groundwater was a result of ion exclusion during root water uptake and indicated for the first time that transpiration-driven processes may potentially lead to mineral soil formation.

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