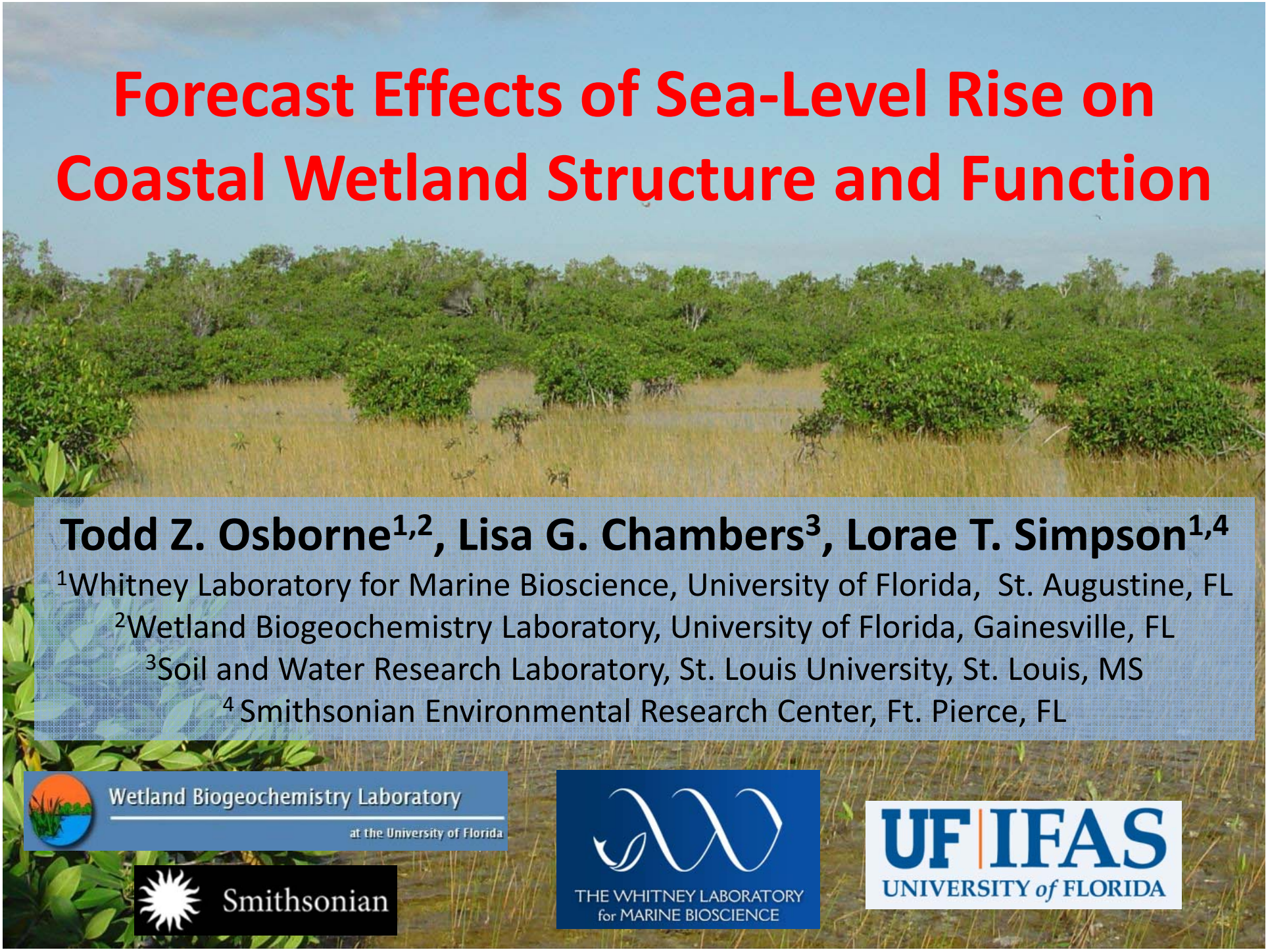
Forecast Effects of Sea-Level Rise on Coastal Wetland Structure and Function



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Wetland Biogeochemistry Laboratory at the University of Florida

Smithsonian

THE WHITNEY LABORATORY for MARINE BIOSCIENCE

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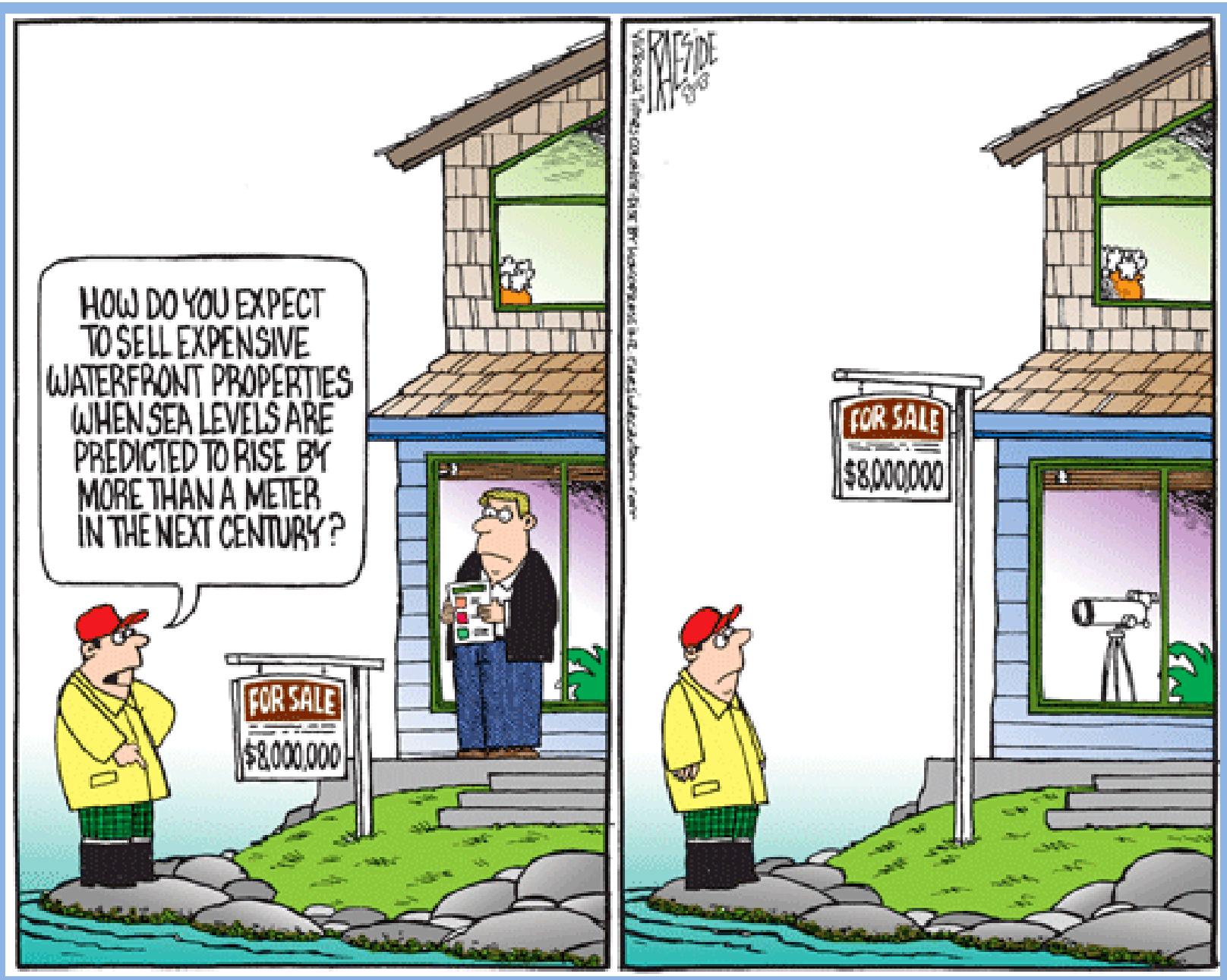


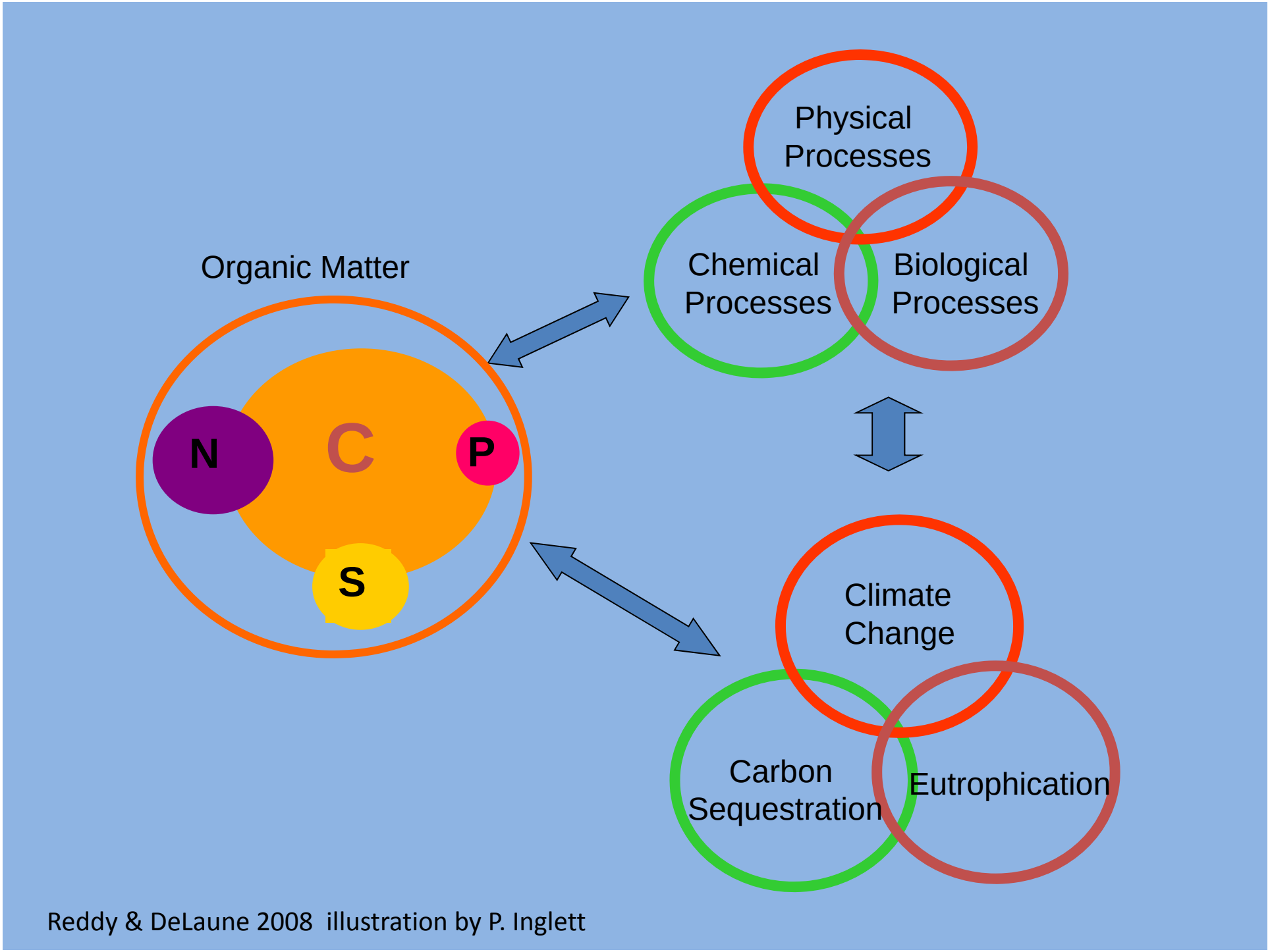
http://www.raesidecartoon.com/blog/wp-content/uploads/2012/02/sealevels.gif

Motivating Questions

- How will saline transgression events in fresh and brackish water systems alter C dynamics?
- How will increasing salinity affect soil stability and nutrient cycling along the freshwater ecotone?
- How will increasing salinity affect vegetation communities?

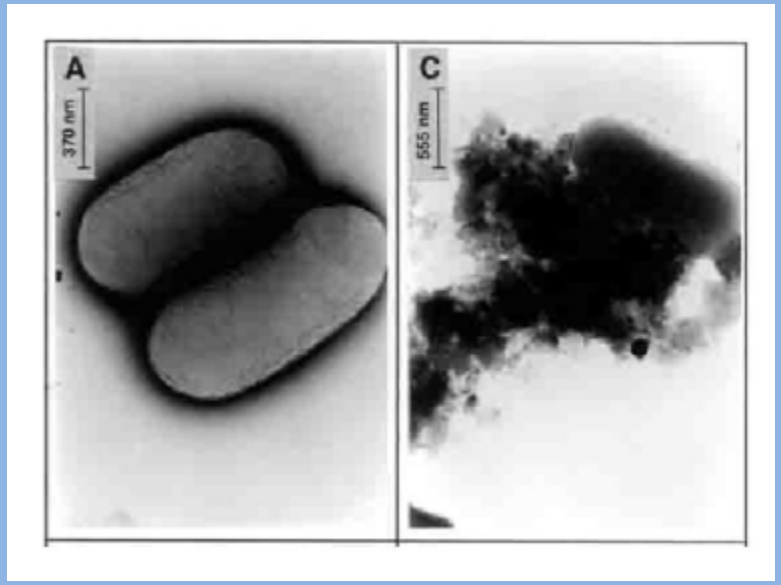
Ecological Effects of SLR

- Alteration of biogeochemical processes
  - C (N,P,S)
- Shifts in Vegetation Community Structure
  - displacement of salt intolerant species
- Destabilization of organic soils
  - biotic processes
  - abiotic processes


Physical Processes
Chemical Processes
Biological Processes
Organic Matter
N
C
P
S
Climate Change
Carbon Sequestration
Eutrophication
Reddy & DeLaune 2008 illustration by P. Inglett

Seawater Effects on Soil Microbes

"Salt Effect"



- **Osmotic stress, cell lysis, reduced metabolic & enzyme activities**

"Sulfate Effect"

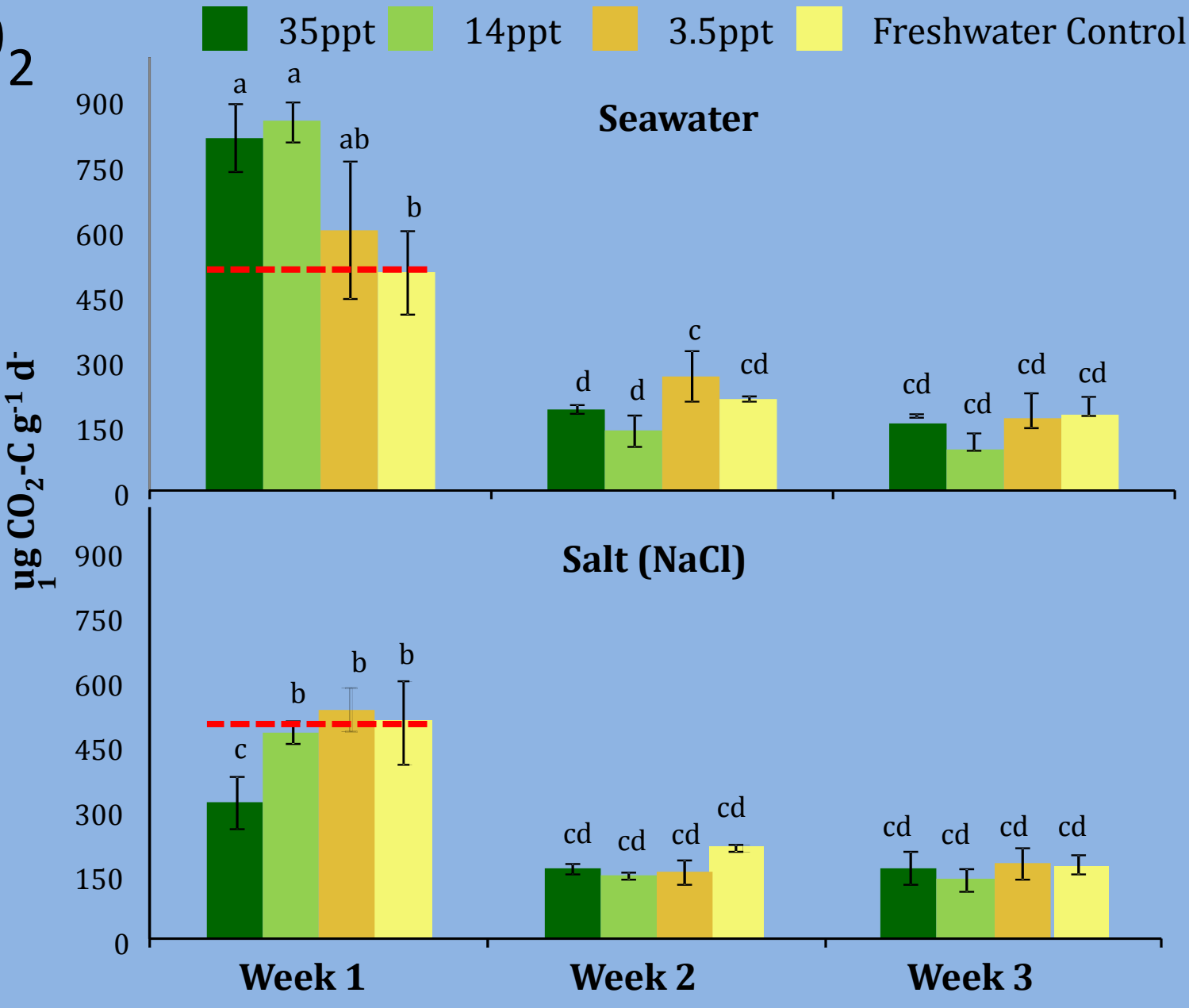
Decreasing energy yield

Electron Acceptor	C End-Product
O_2	CO_2
NO_3^-	CO_2
Mn^{4+}	CO_2
Fe^{3+}	CO_2
SO_4^{2-}	CO_2
CO_2	CH_4

- **Sulfate reducing bacteria replace methanogens in anaerobic respiration**

Chambers, L.G., T.Z. Osborne, and K.R. Reddy. 2011. **Soil Sci. Soc. Am. J. 75(5) 1-8**

CO_2



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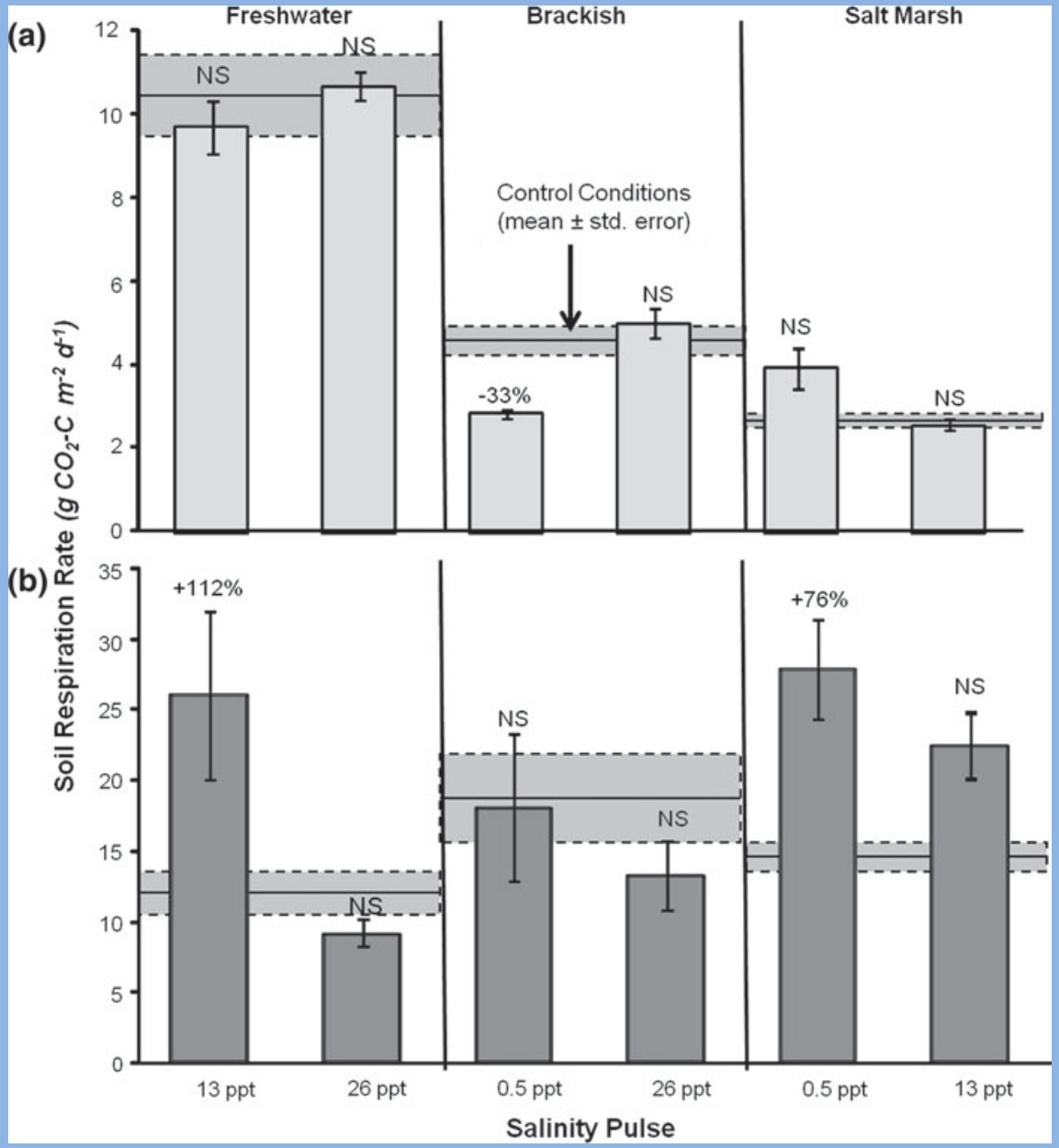


Chambers, L.G, T.Z. Osborne & K.R. Reddy. 2013. Biogeochemistry

Observations

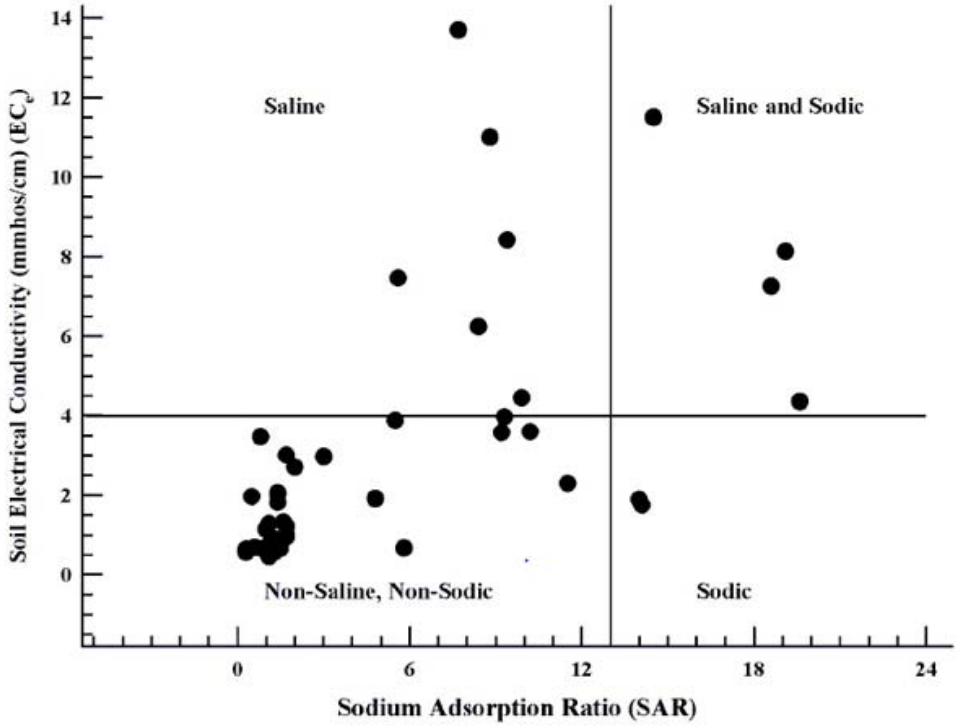
- Freshwater microbial populations respond quickly (~2 weeks) to salinity pulses
- Low-salinity (3.5 ppt) induced more C mineralization (+17%) than freshwater and higher salinity treatments (over time)
- Landward migration of seawater will have a significant effect on the C balance of coastal wetlands

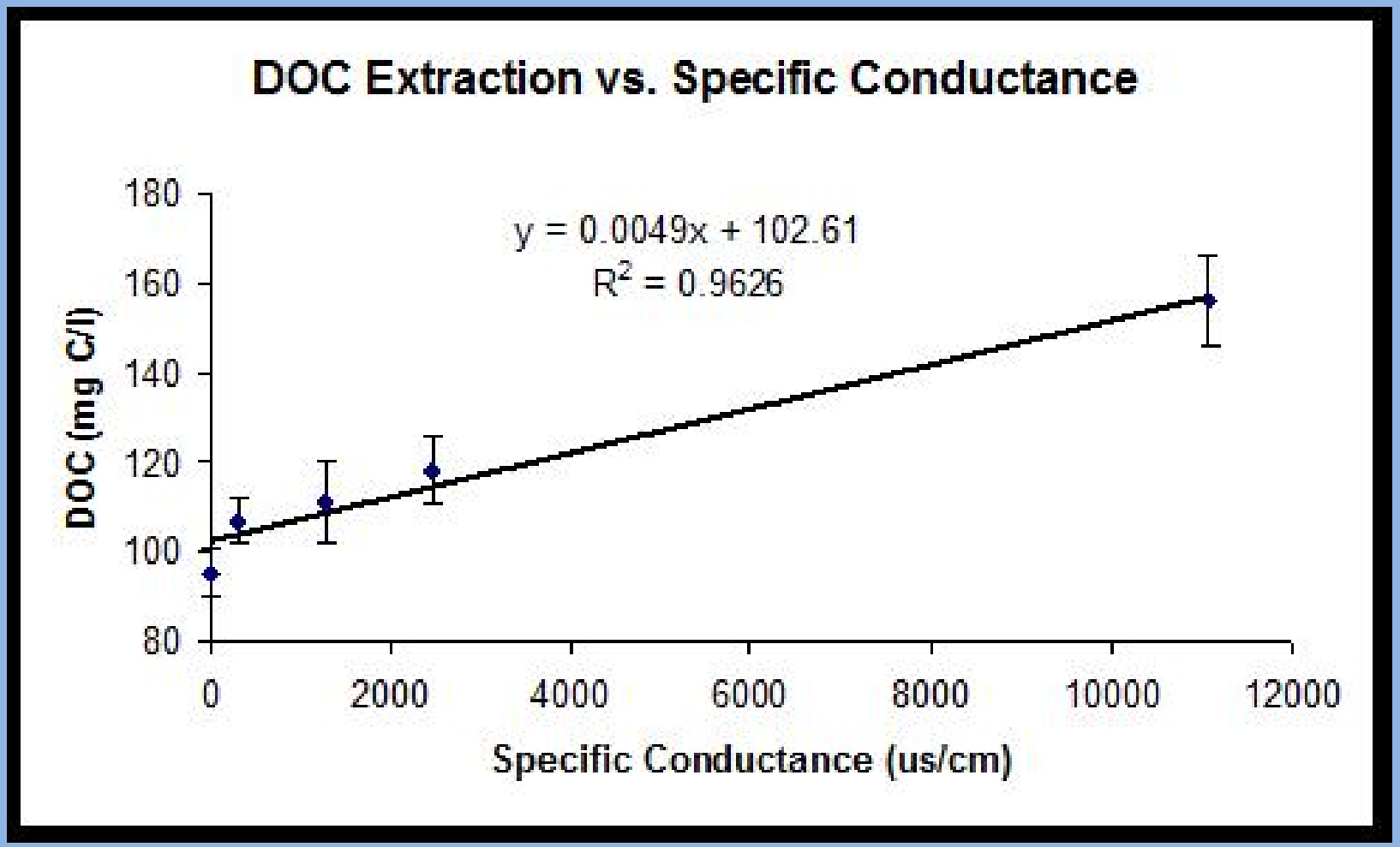
Soil Nutrients and Stability

SAR = sodium adsorption ratio= exchangeable [Na] / (0.5[Ca] + 0.5[Mg]) $^{0.5}$

EC = electrical conductivity = dS m^{-1}

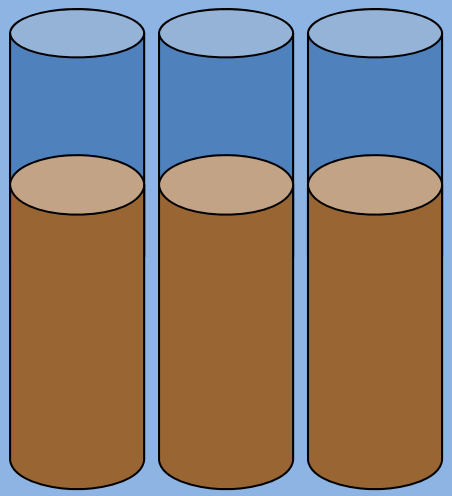
ESP = Exchangeable Sodium Percentage = $\frac{\text{exchangeable sodium } (cmol_c\ kg^{-1})}{\text{cation exchange capacity } (cmol_c\ kg^{-1})}$ X100





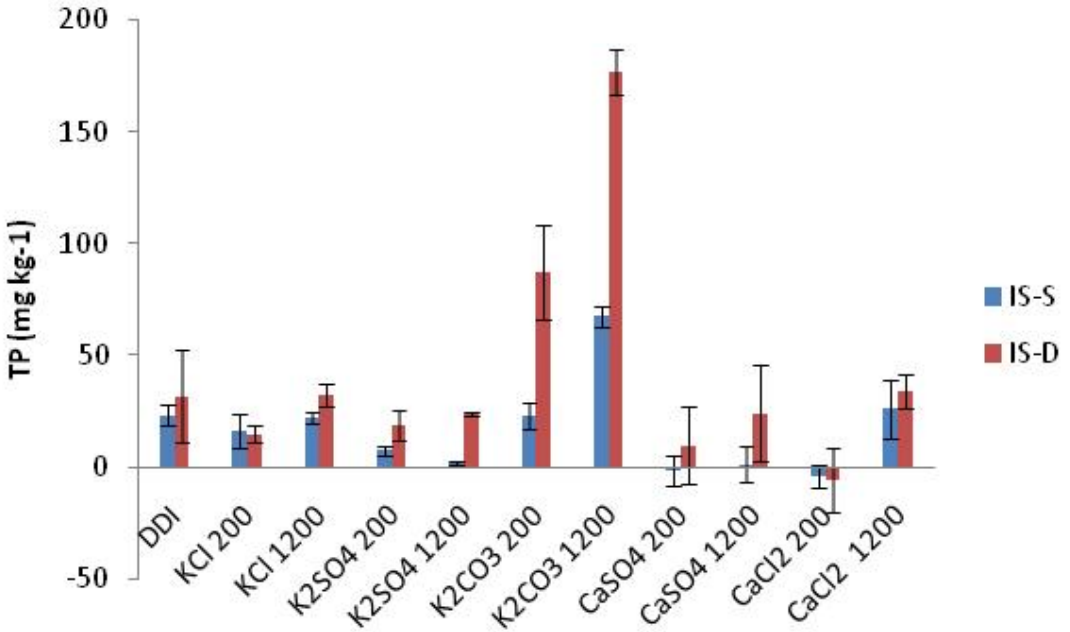
Osborne T.Z. and S. Newman. 2007

Intact Soil Core Flux Study LNWR

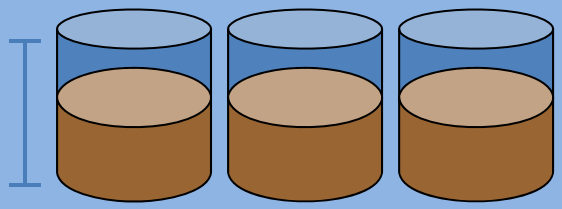


change in water column concentration

Osborne and Newman 2007

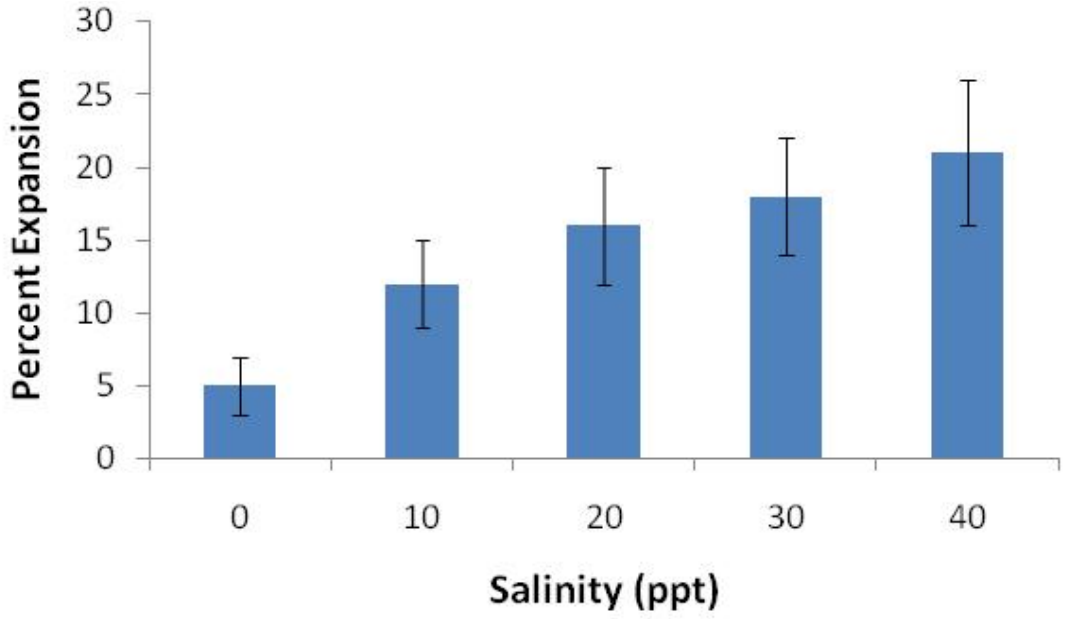


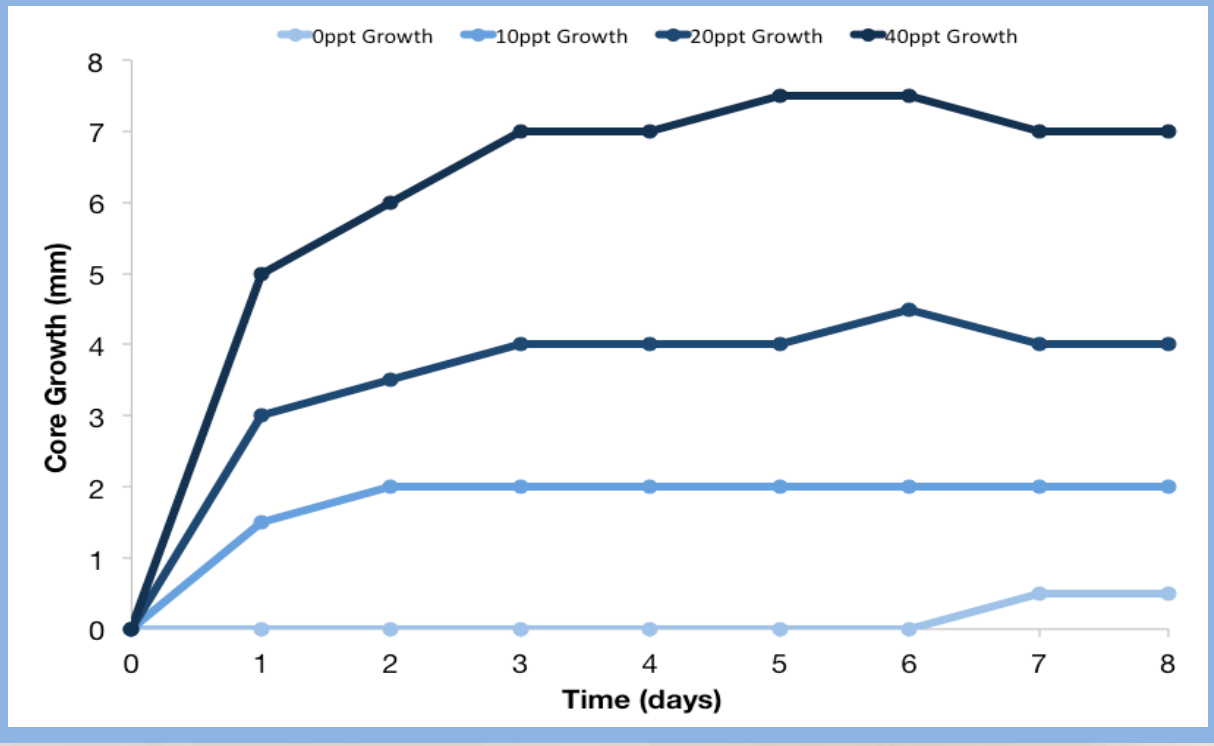
Soil Collar Study WCA-3A

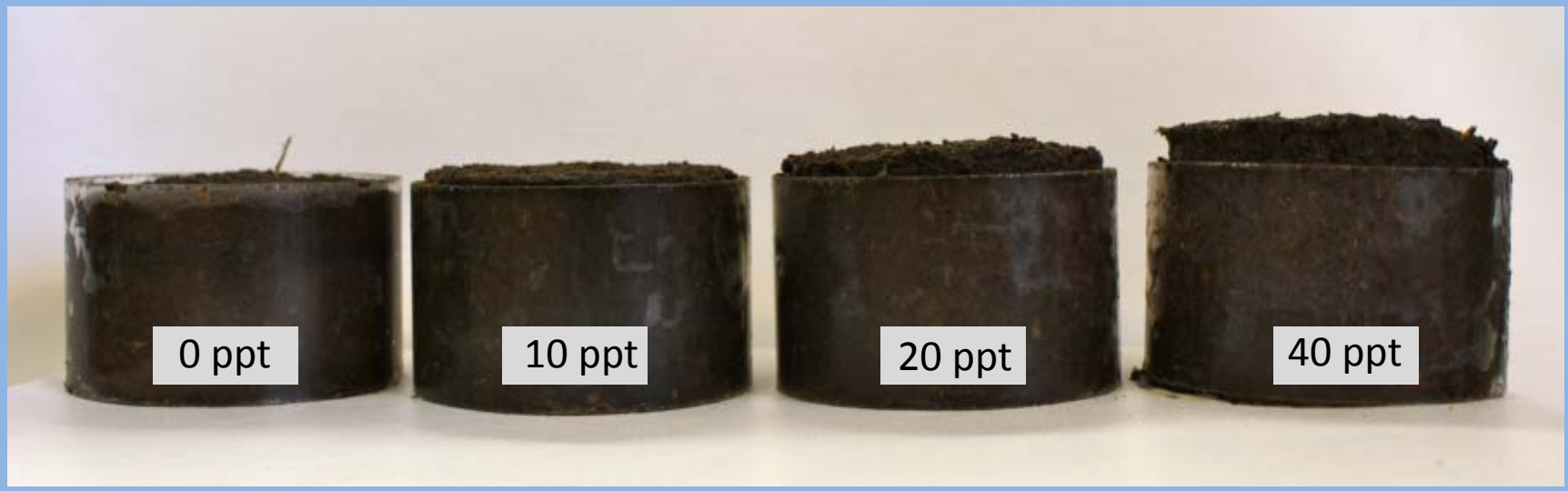


change in soil volume

Rozin and Osborne in review

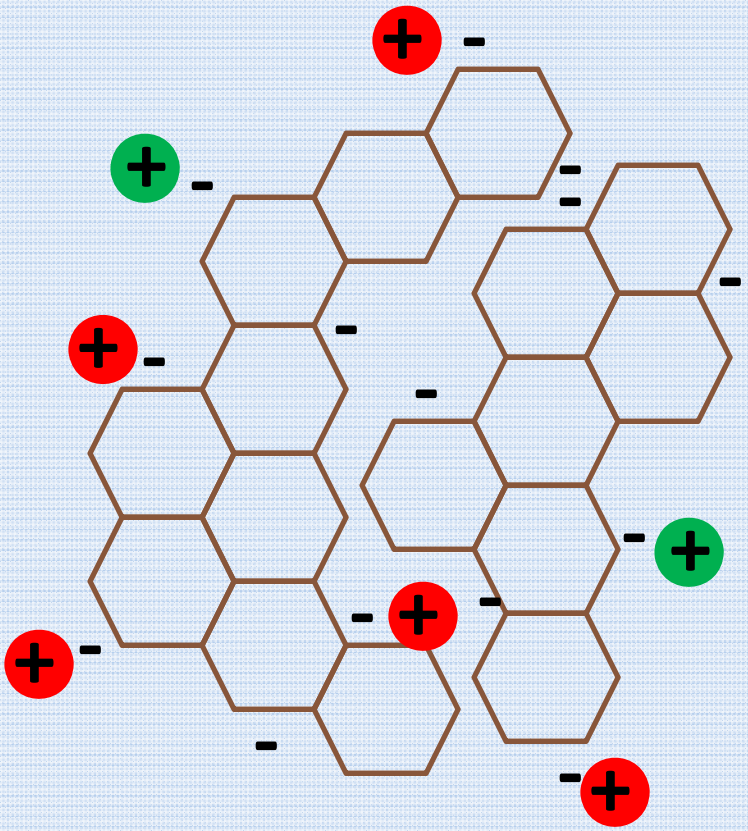






Rozin and Osborne *in review*

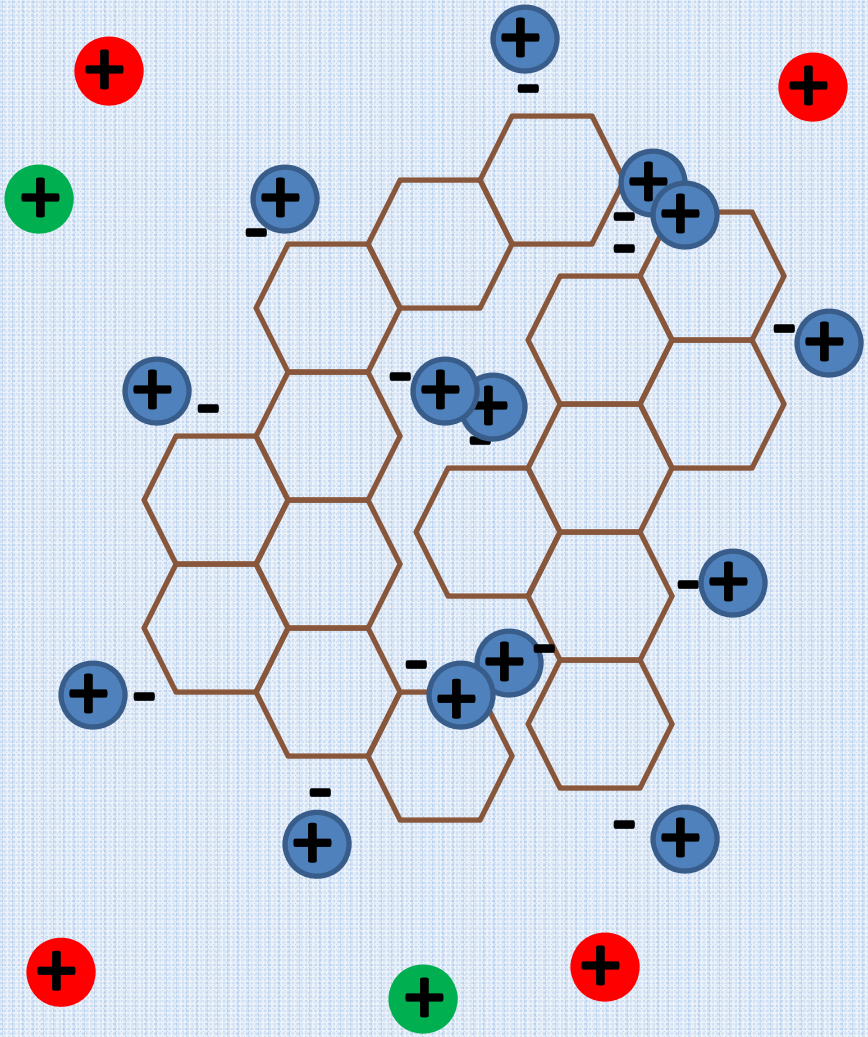
soil organic matter

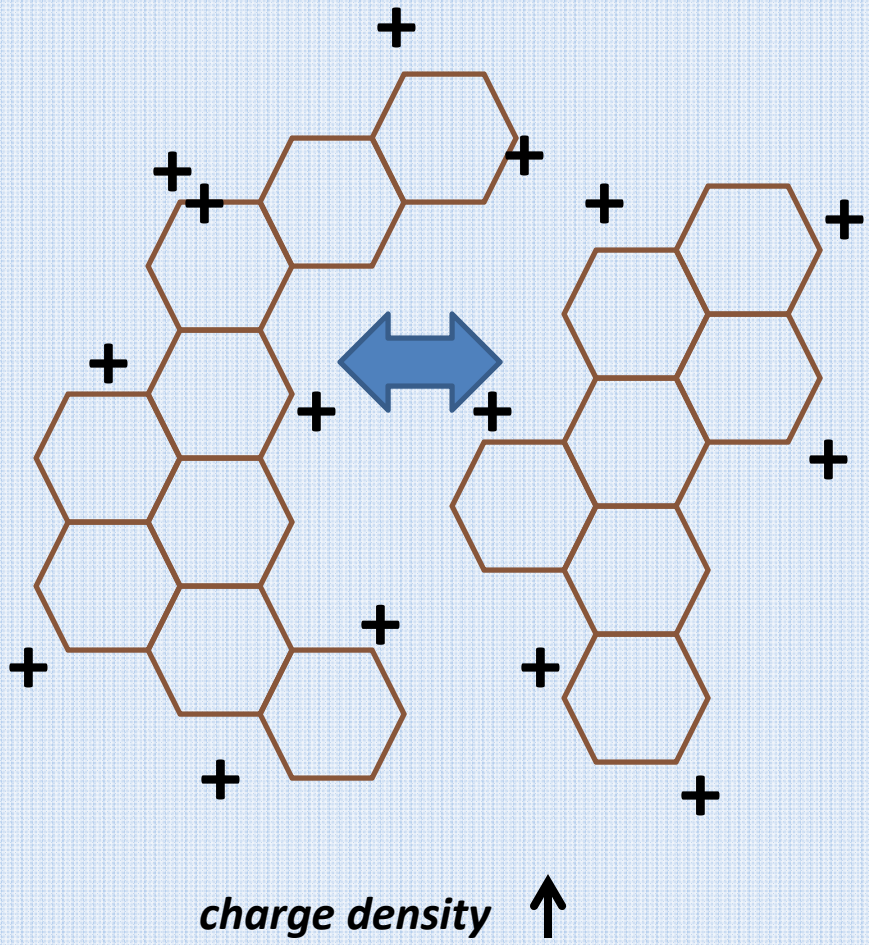


SOM (particle or molecule)

calcium cations

Less abundant cations
(Al, Fe, Mg, K)





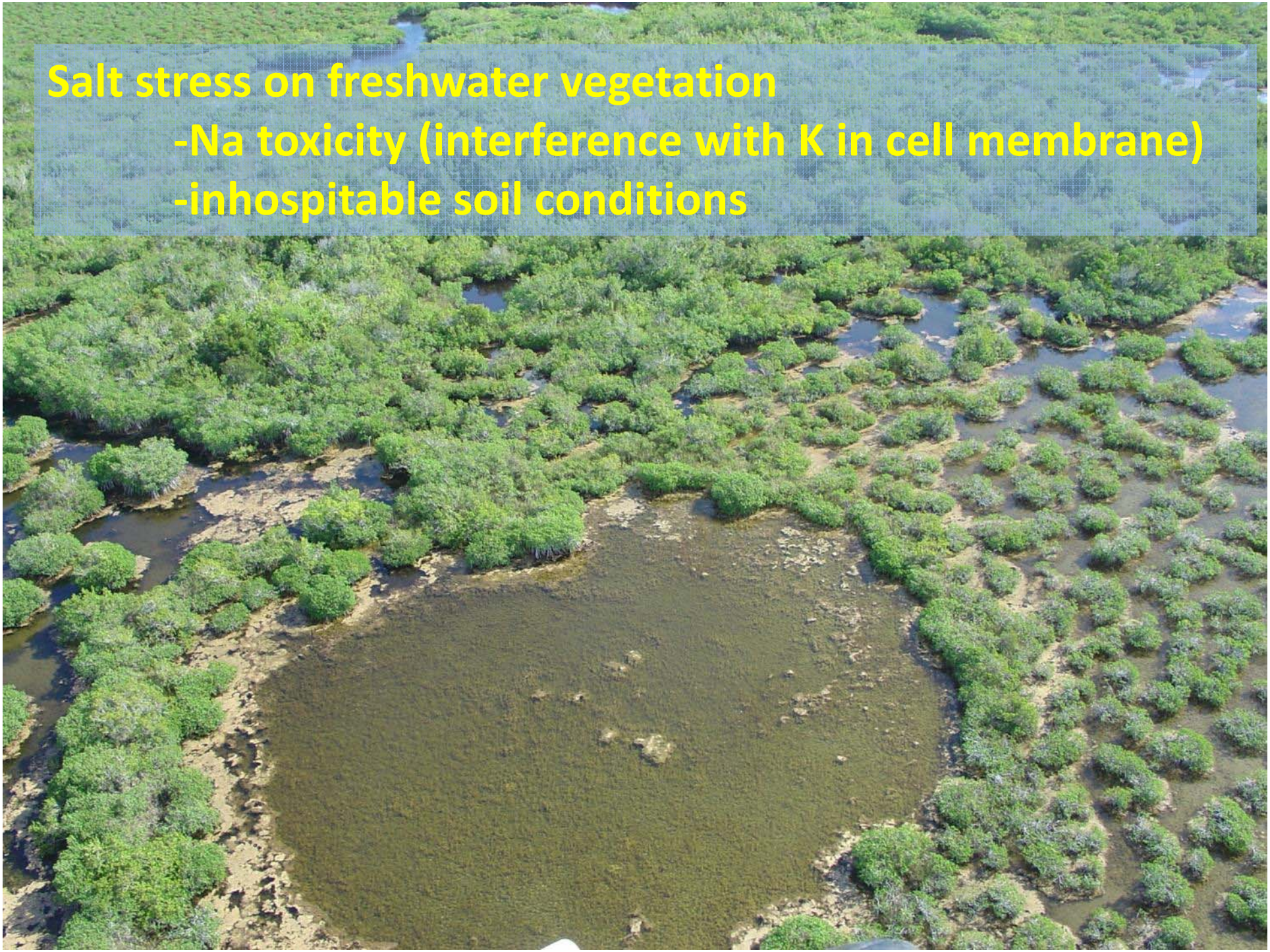
charge density ↑

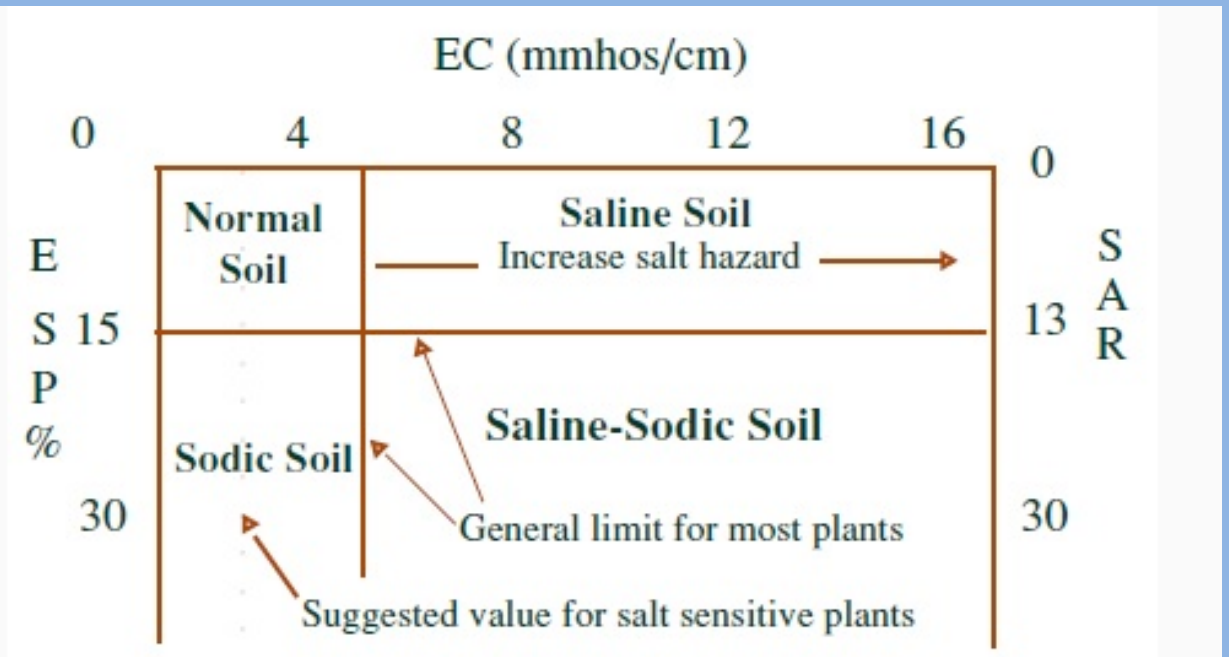
salt water transgression
Cation Exchange ⊕

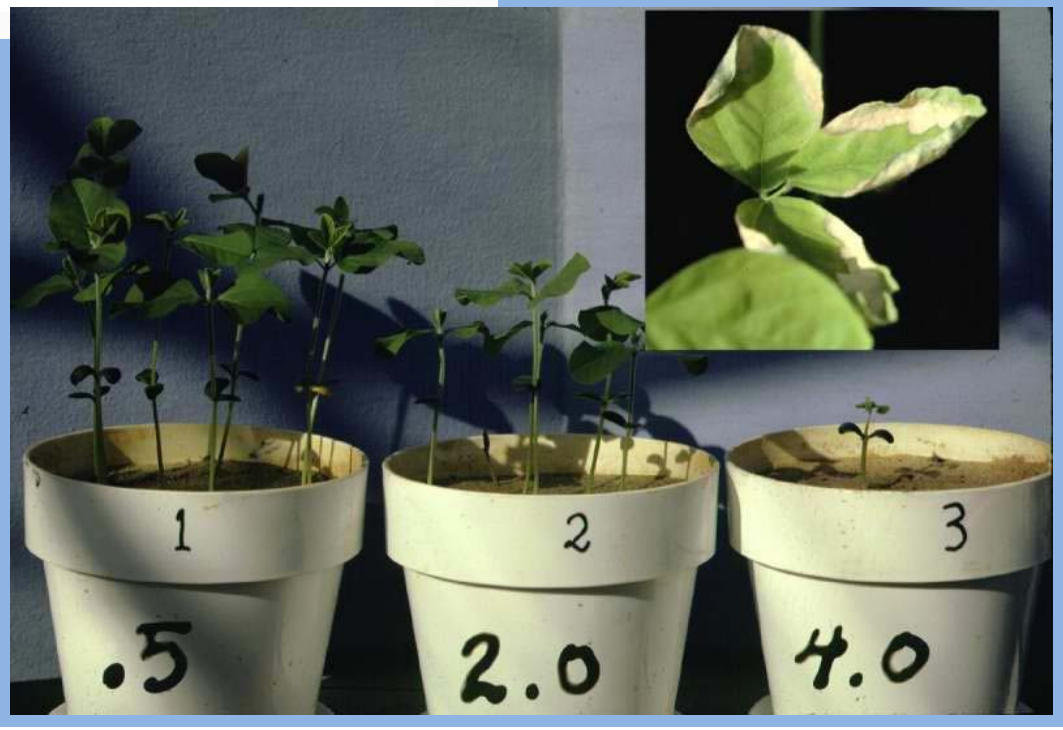
net surface charge +
dispersion

Observations

- Low level increases in salinity catalyze DOC flux from organic soils and detrital material
- K_2CO_3 increases extraction of P from organic soils and detritus (likely by precipitating $CaCO_3$ and removal of P from FeOx surfaces)
- Sodium induced dispersion may be a significant factor in peat collapse

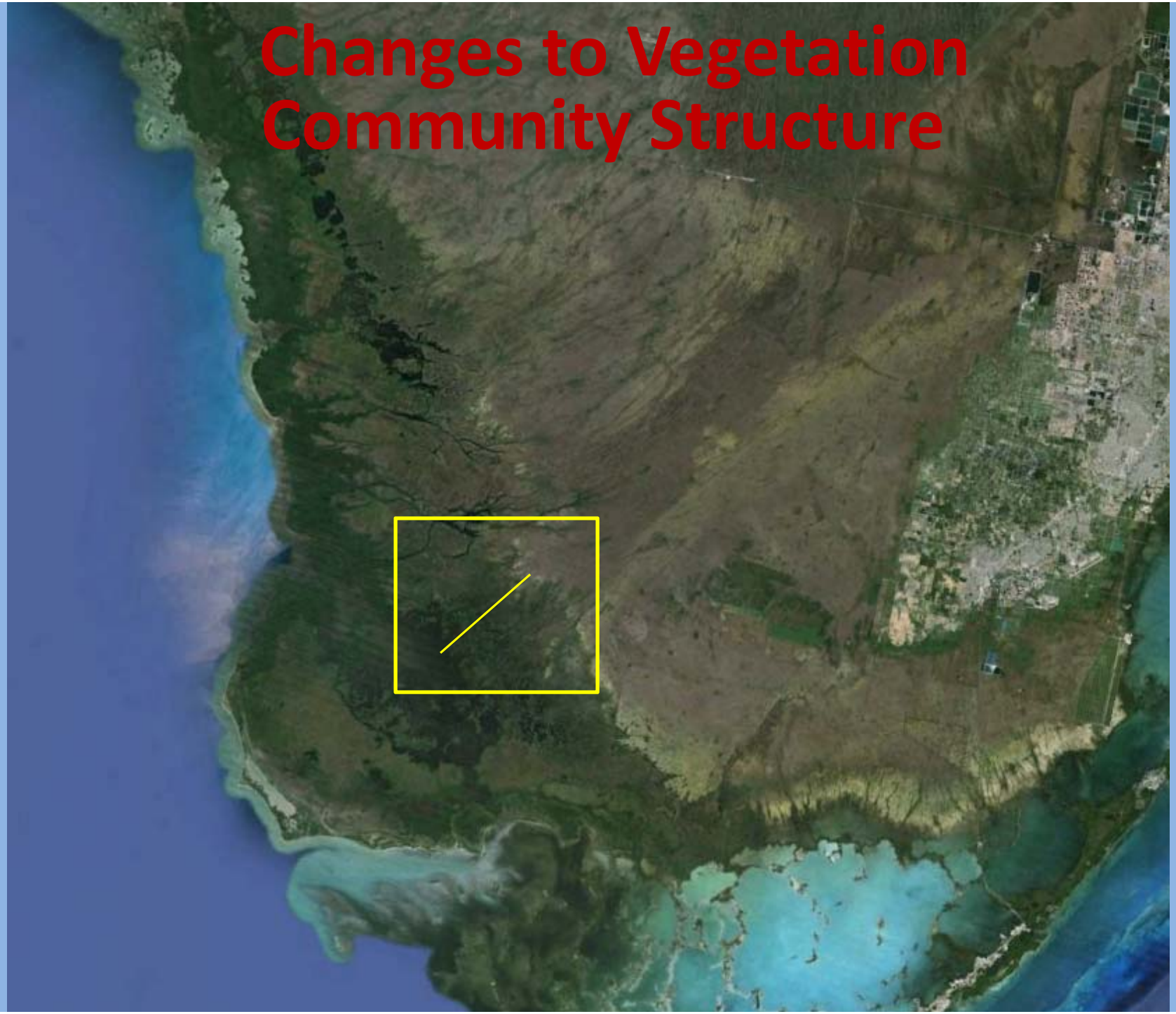

Salt stress on freshwater vegetation
-Na toxicity (interference with K in cell membrane)
-inhospitable soil conditions

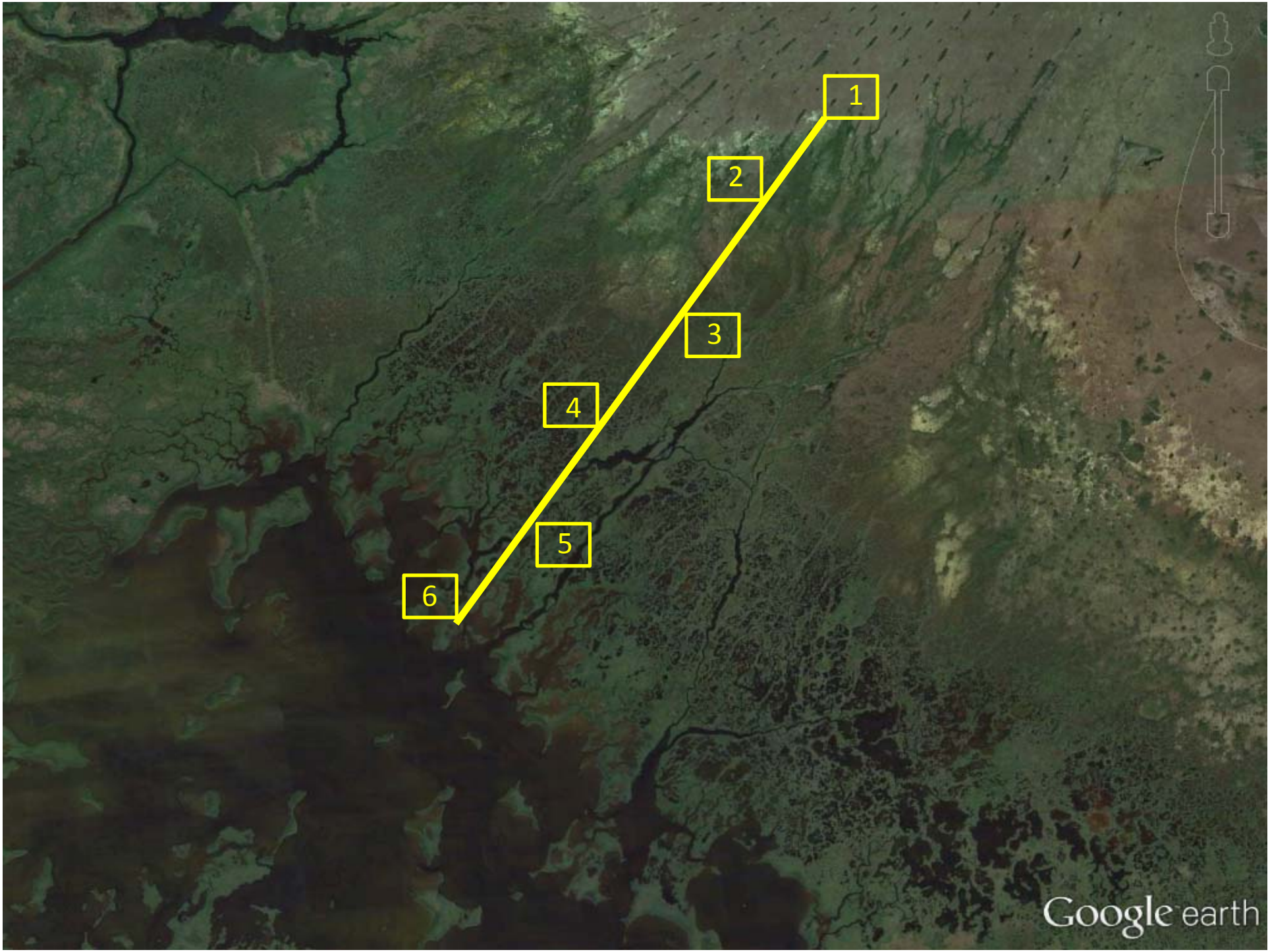




Brady & Weil 2008

Changes to Vegetation Community Structure

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Google earth

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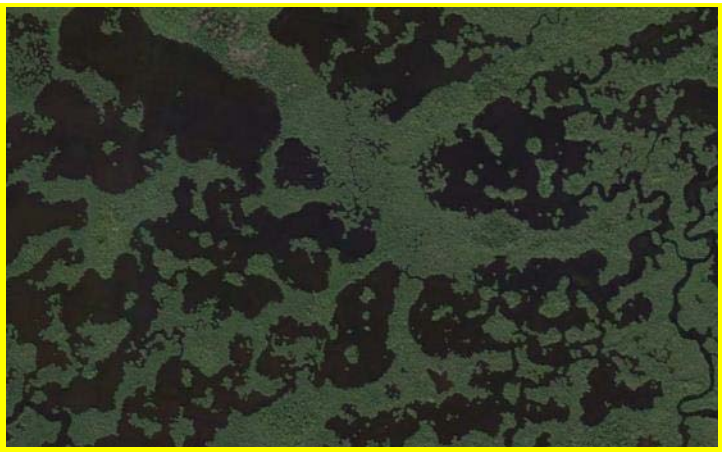

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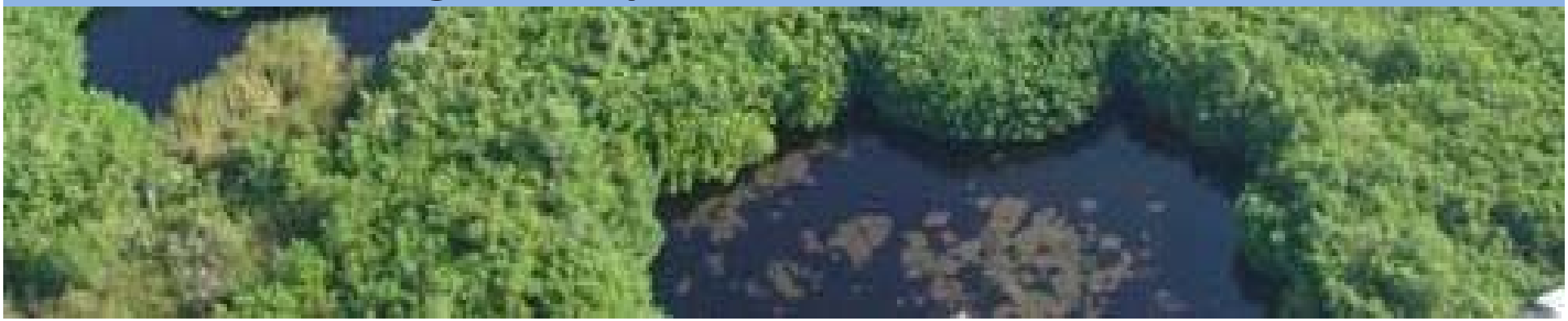
6

Parting thoughts

- Protection of organic soils is critical to nutrient immobilization and downstream water quality
- Saltwater intrusion can dramatically destabilize freshwater wetland soils by increasing both physical processes (dispersion) and biological processes (oxidation)
- Increased salinity induces vegetation shifts to favor salt tolerant species- but may also induce landscape change
- These effects will likely become more significant as climate change/ SLR proceeds



Thank You

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