Theoretically and Empirically based modeling of the evolution of multi-species marshes

National Science Foundation
WHERE DISCOVERIES BEGIN

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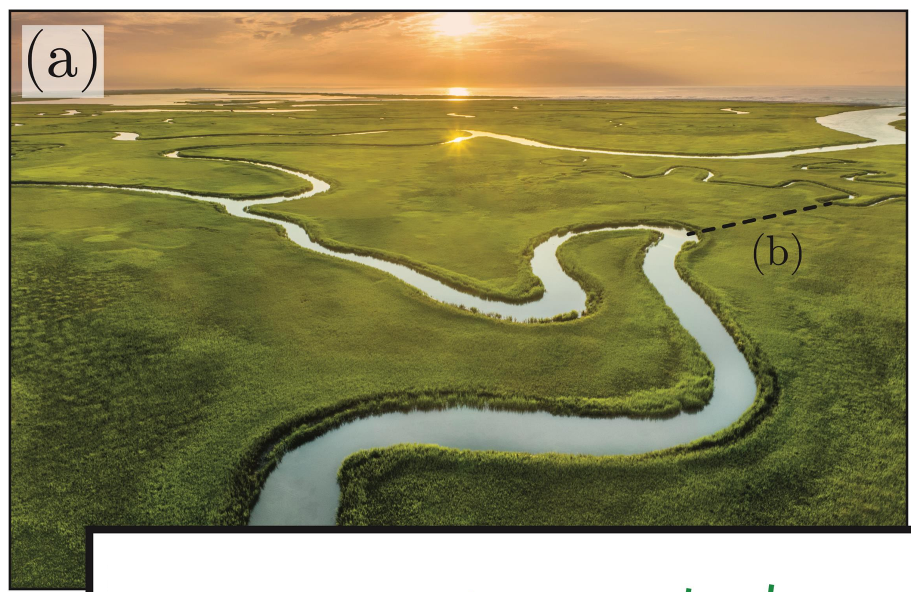


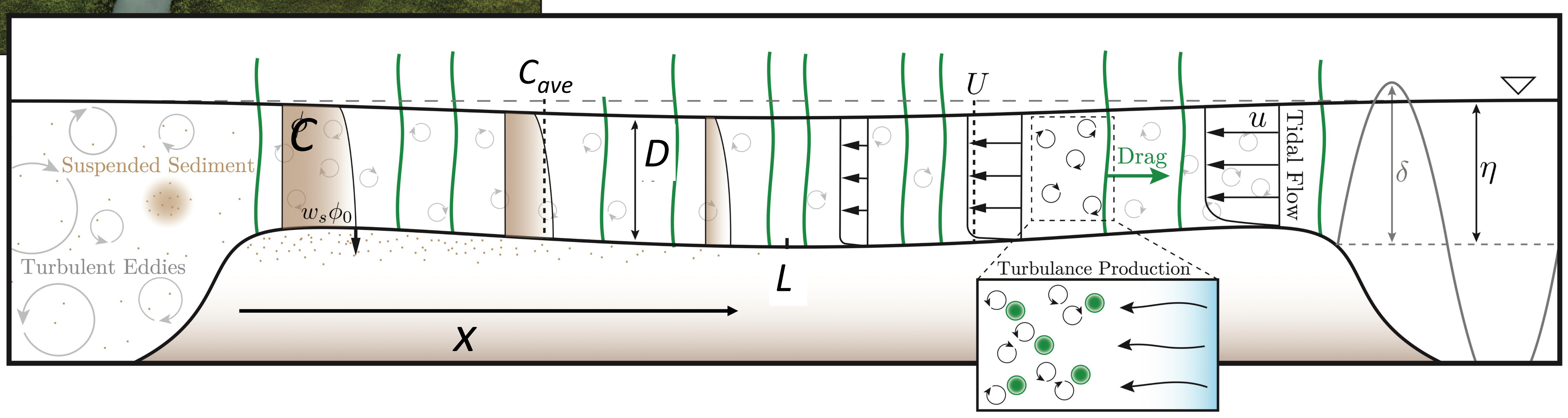
***Questions*:**

Marshes and increasing Sea-Level-Rise Rates (R_{SLR}):

How will extent, species mixes, elevations evolve?

Or, which ones will drown? How thoroughly? How soon?

How to model with mixed vegetation?



***Answers(?)*:**

Remote Observations + Theory

→ Simple Model w/solid foundation

***For a marsh, and a R_{SLR}*:**

morphology, species distribution

Background: Marsh Vertical Feedbacks

1) Depth, Sediment Feedback:

Shallow surface rarely flooded
→ depth (below high tide) ↑ $\frac{dD}{dt} \approx R_{SLR}$

→ flooding, deposition (A_{inorg}) ↑ $\frac{dD}{dt} = R_{SLR} - A_{inorg}$

→ unvegetated equilibrium depth $R_{SLR} - A_{inorg} = 0$

2) Vegetation Feedback:

Organic deposition (roots; α Biomass, B; A_{org}):

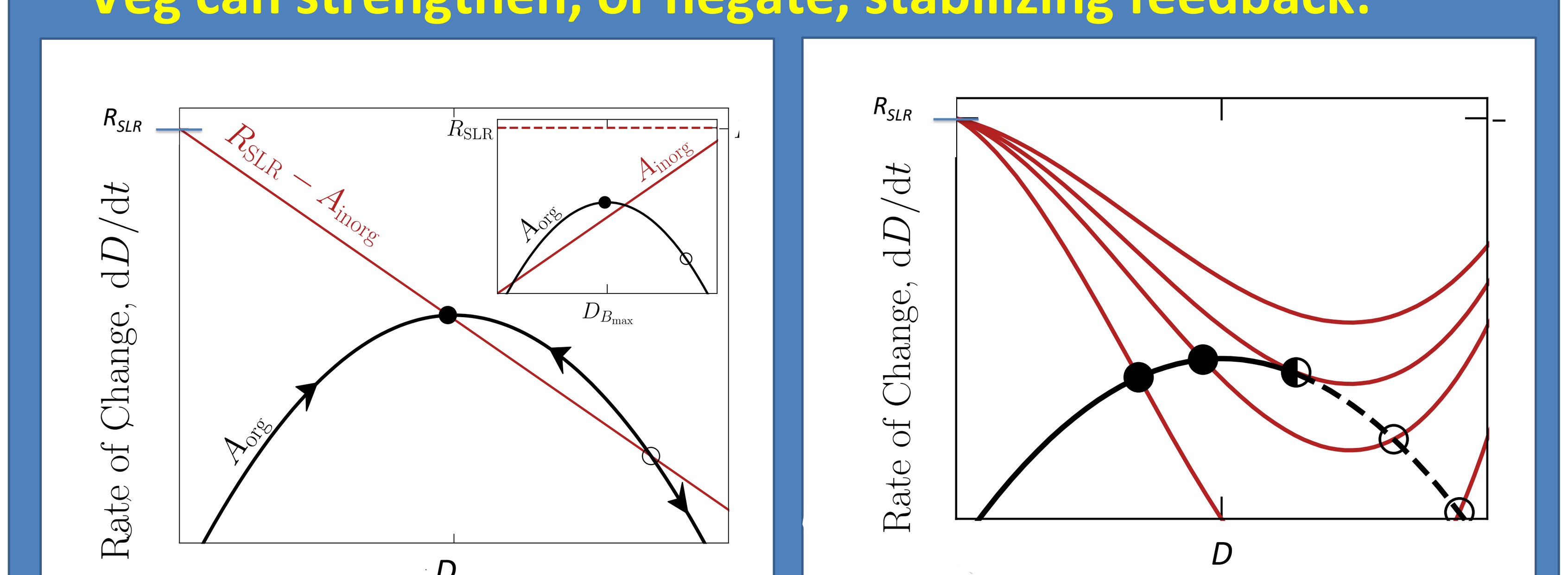
$$\frac{dD}{dt} = R_{SLR} - A_{inorg} - A_{org}$$

Vegetated equilibrium:

$$R_{SLR} - A_{inorg} = A_{org}$$

$$A_{inorg} = f(C, D, B); \quad A_{org} = kB(D)$$

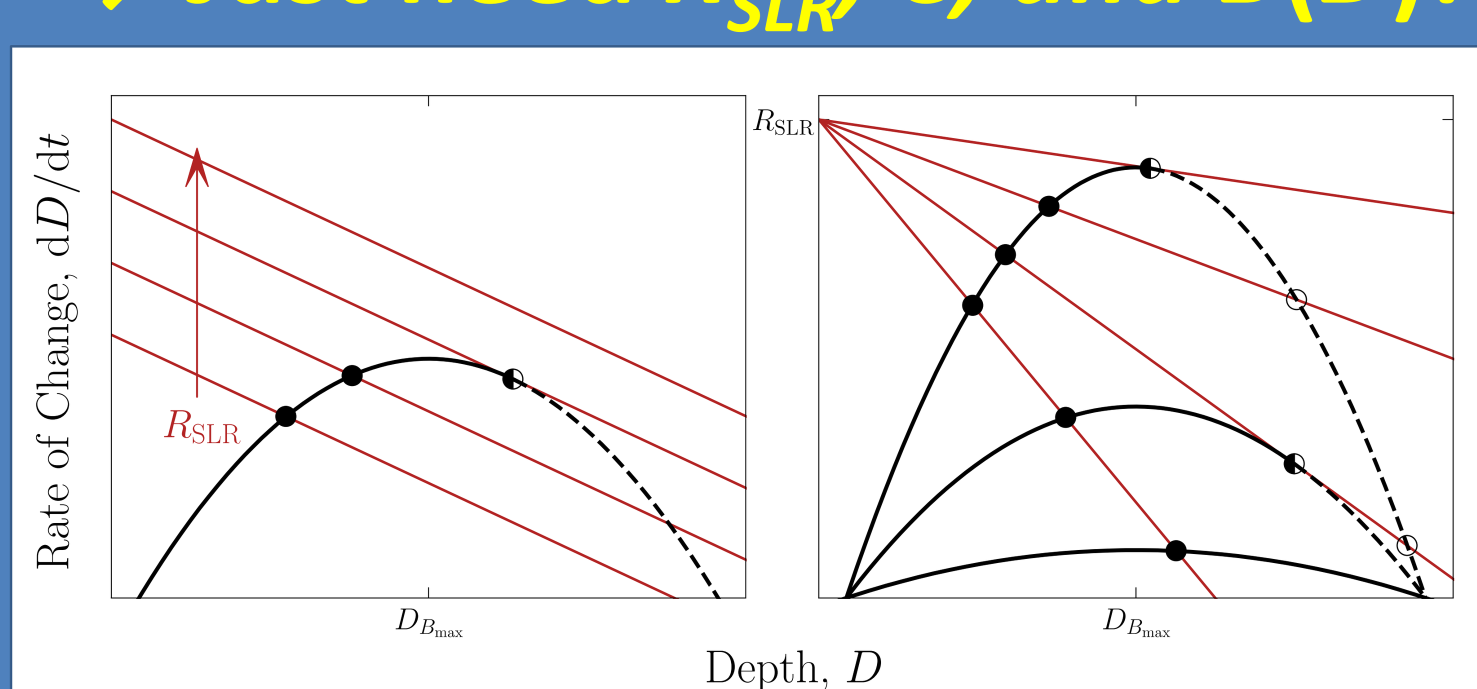
Veg can strengthen, or negate, stabilizing feedback:



If A_{inorg} depends on C and D

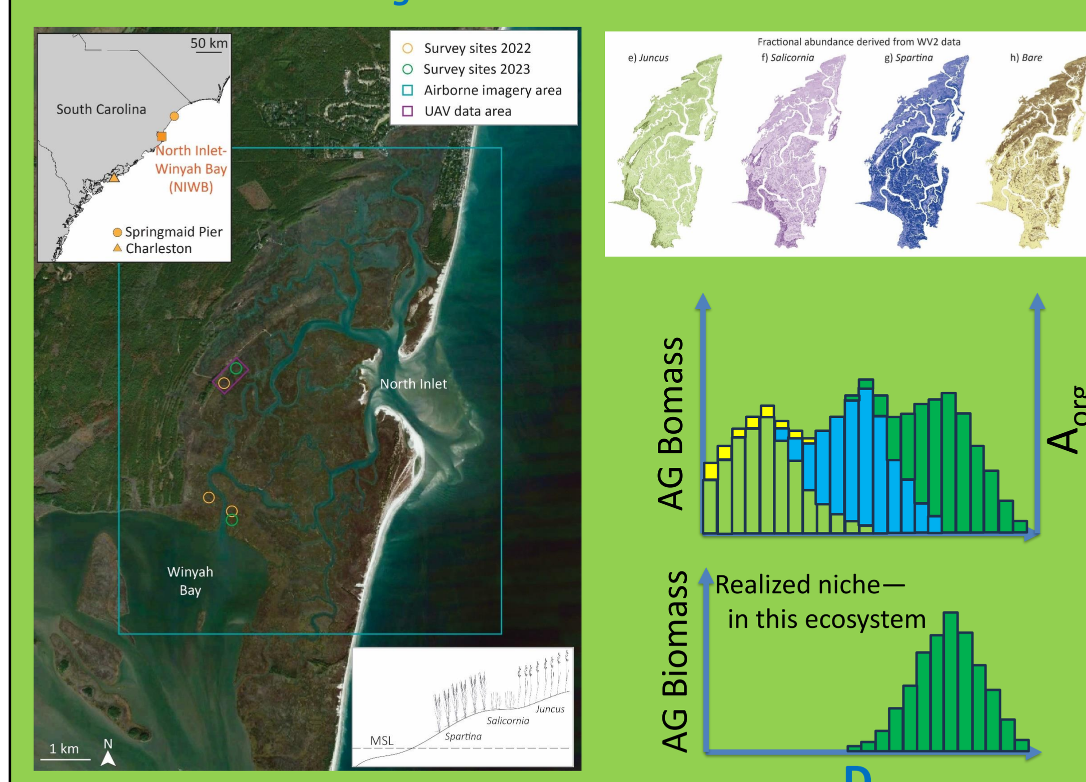
If A_{inorg} depends also on B

→ Just need R_{SLR}, C, and $B(D)$!



Observations

How to get $A_{org}(D)$ for multi species?



Field + Drone + Airborne

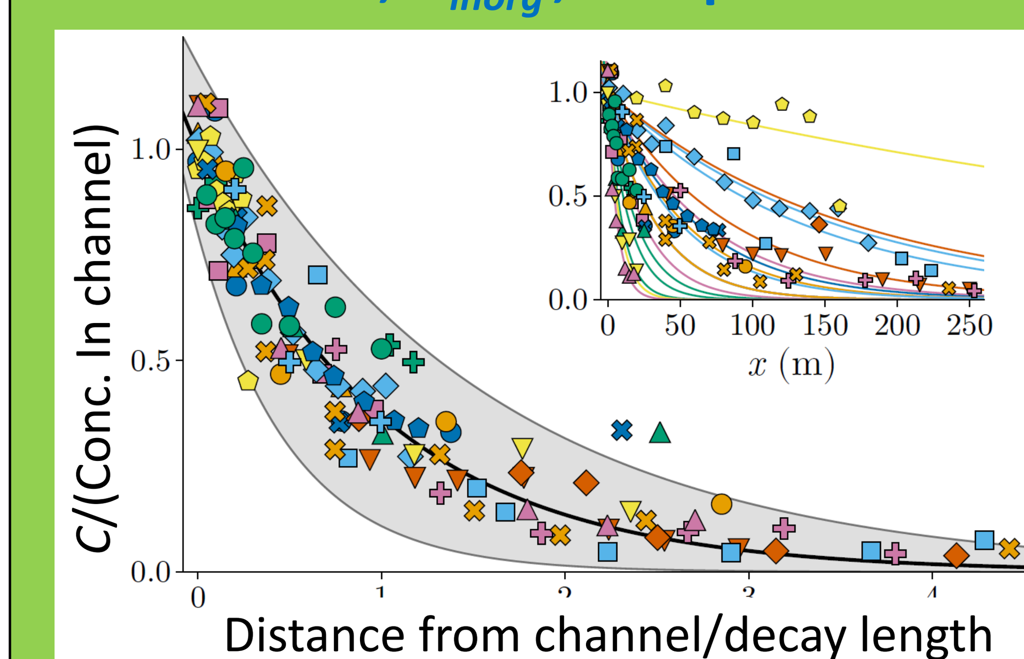
→ $A_{org}(D)$ from Satellites

(Yang et al., GIScience & Remote Sensing, 2025)

Theory

C. of Mass, Detailed modeling →

Tidal flow, A_{inorg}, independent of B



→ A_{inorg} = f(distance from channel, x), rescaled by sub-basin length, L

(Lester et al., in prep)

→ Simplified Modeling

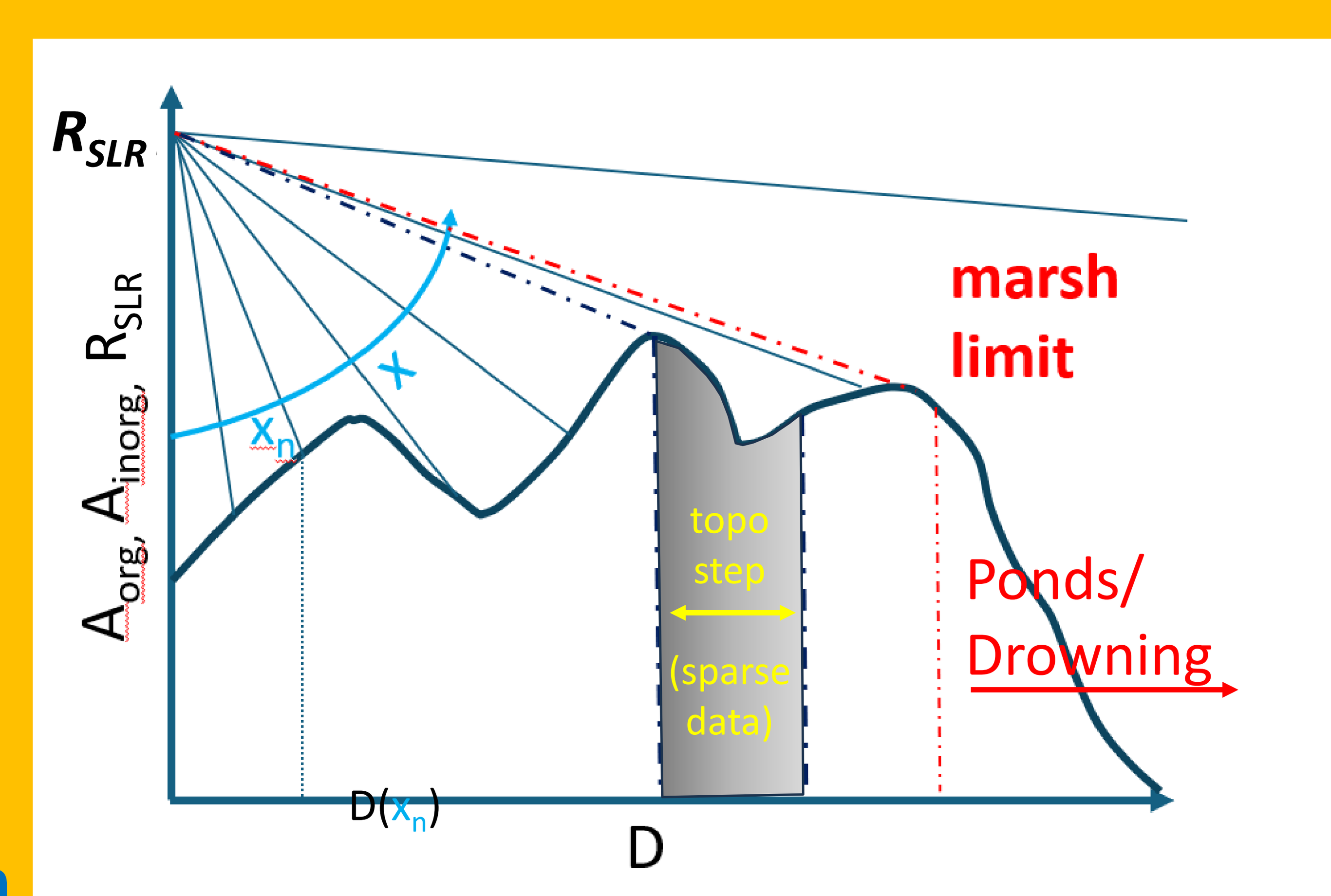
Start w/C_0 in channels

A_{inorg} slope ↔ C;
$C = C_0f(x/L)$

A_{org} = f(B(D))
(for each environment)

For a R_{SLR} → map of:

- **elevations; steps**
- **species mixes; zonation**
- **marsh extent; ponds, drowning**



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