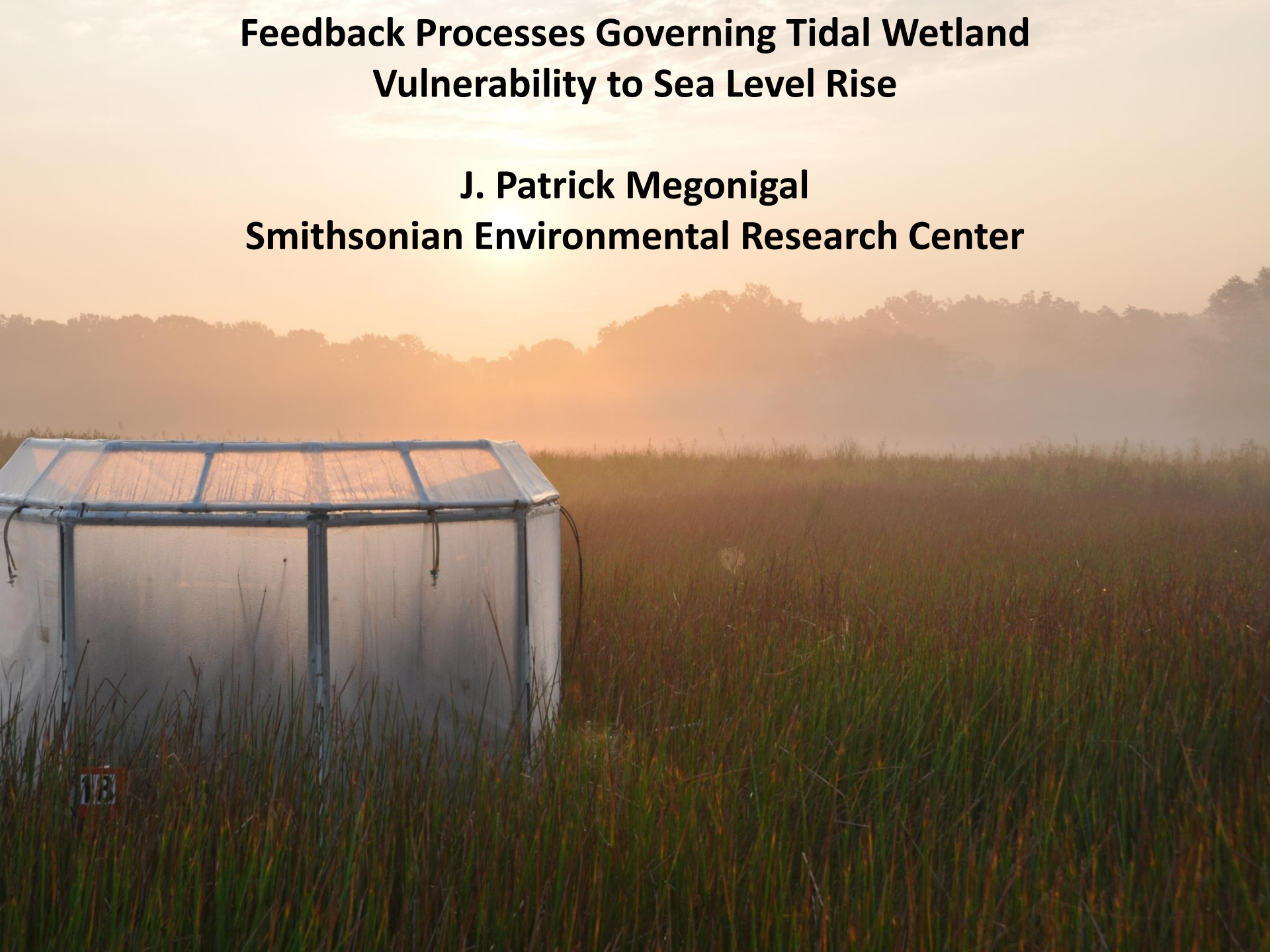
# Feedback Processes Governing Tidal Wetland Vulnerability to Sea Level Rise

J. Patrick Megonigal
Smithsonian Environmental Research Center



## Colleagues

Adam Langley, Villanova University
Tom Mozdzer, Bryn Mawr College
Matt Kirwan, Virginia Institute of Marine Science
Glenn Gunternspergen, US Geological Survey
Don Cahoon, US Geological Survey
Bert Drake, Smithsonian Institution

## Funders

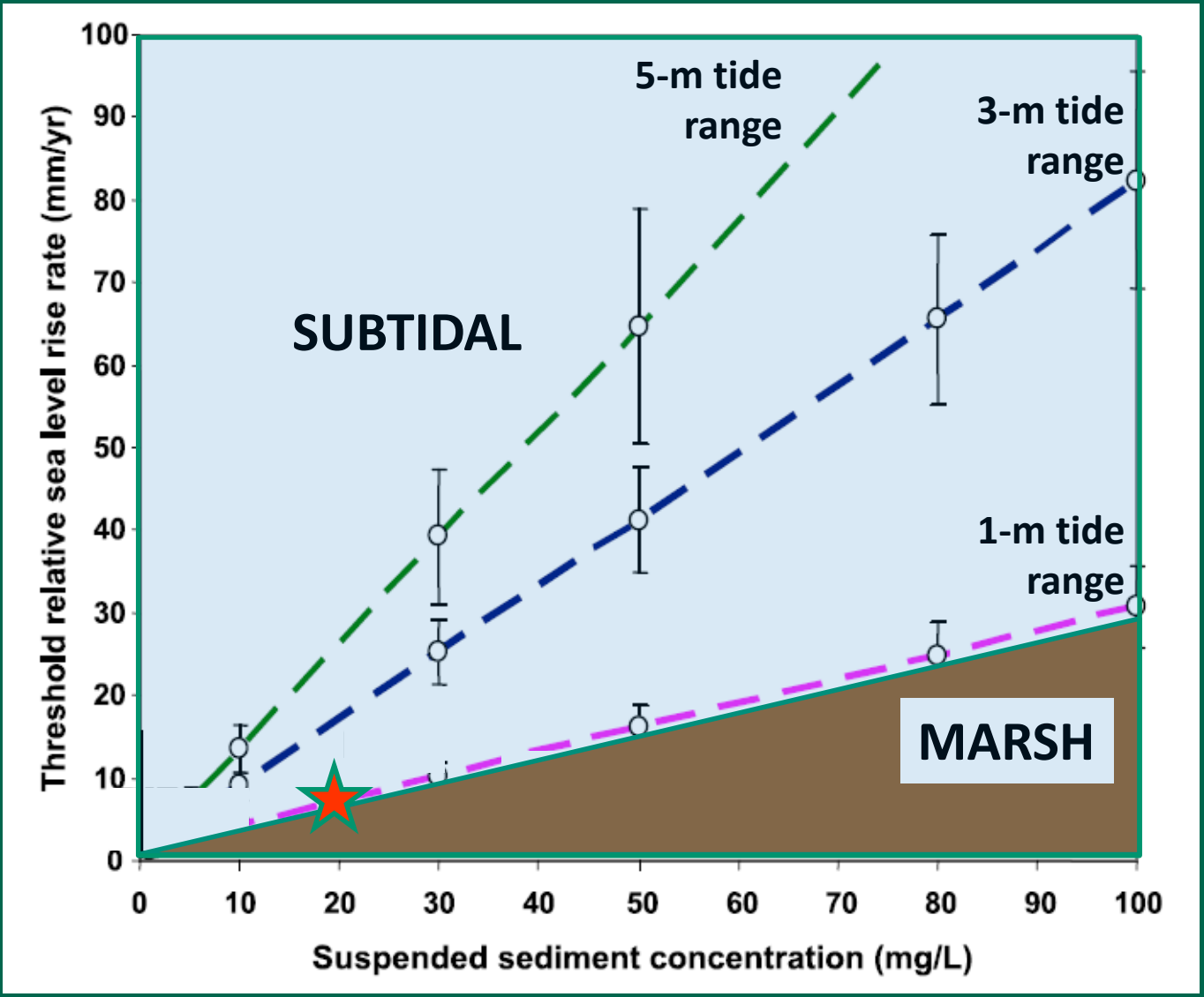





# Smithsonian Global Change Research Wetland




# High Sediment & High Tidal Range Favors Marsh Stability

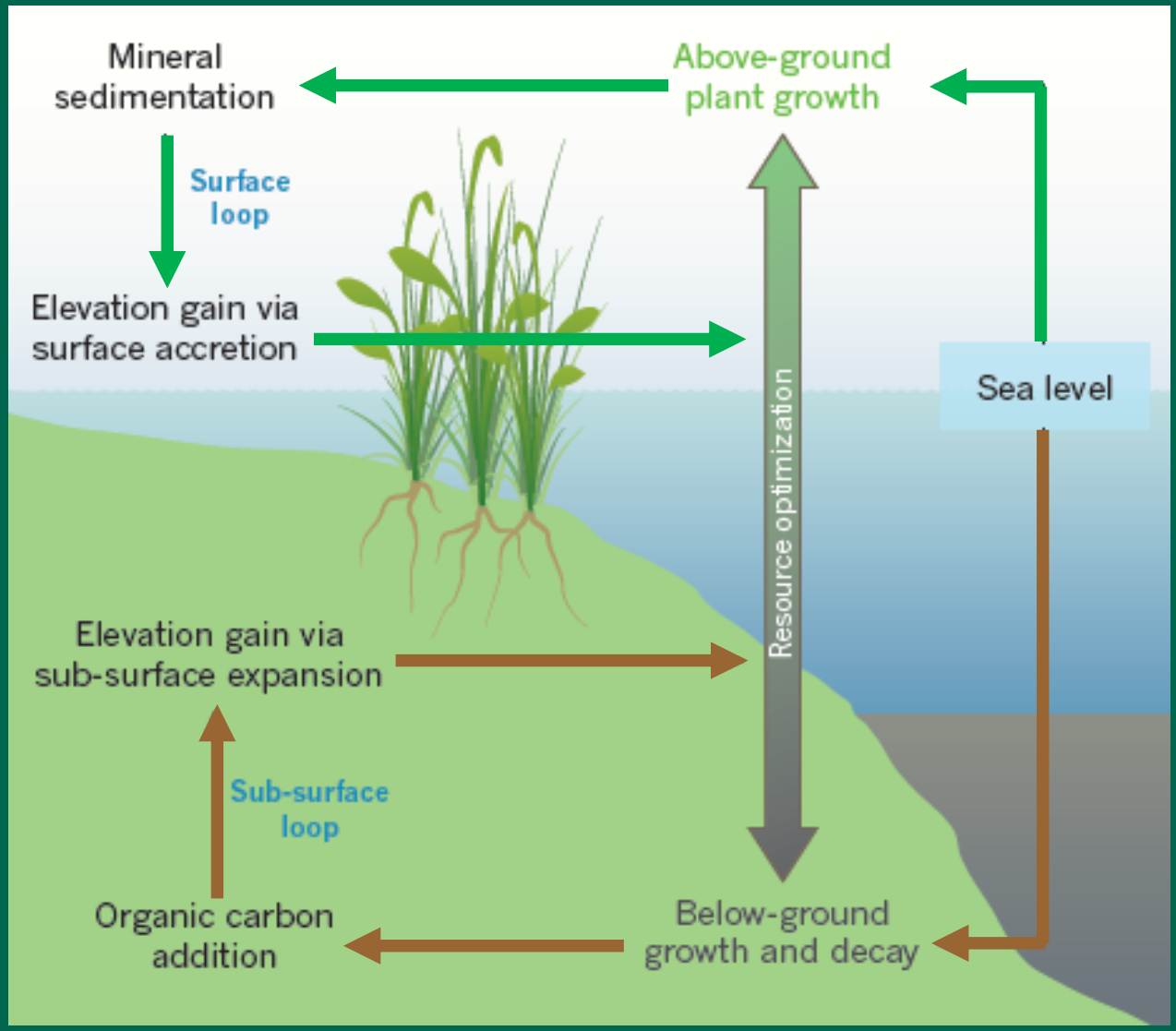



Kirwan et al. (2010) *Geophysical Research Letters*

# Plants Engineer Tidal Wetland Elevation

**Global Change Perturbations**

- Elevated $CO_2$
- Nitrogen Pollution
- Sea Level Rise
- Temperature




Kirwan & Megonigal (2013) *Nature*

## Elevated $CO_2$ by Community Type

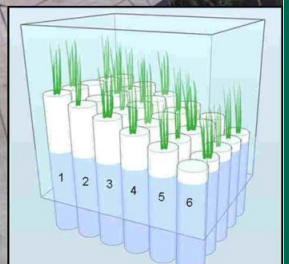
*Spartina patens* ($C_4$)

*Schenoplectis americanus* ($C_3$)

## Elevated $CO_2$ and N Eutrophication

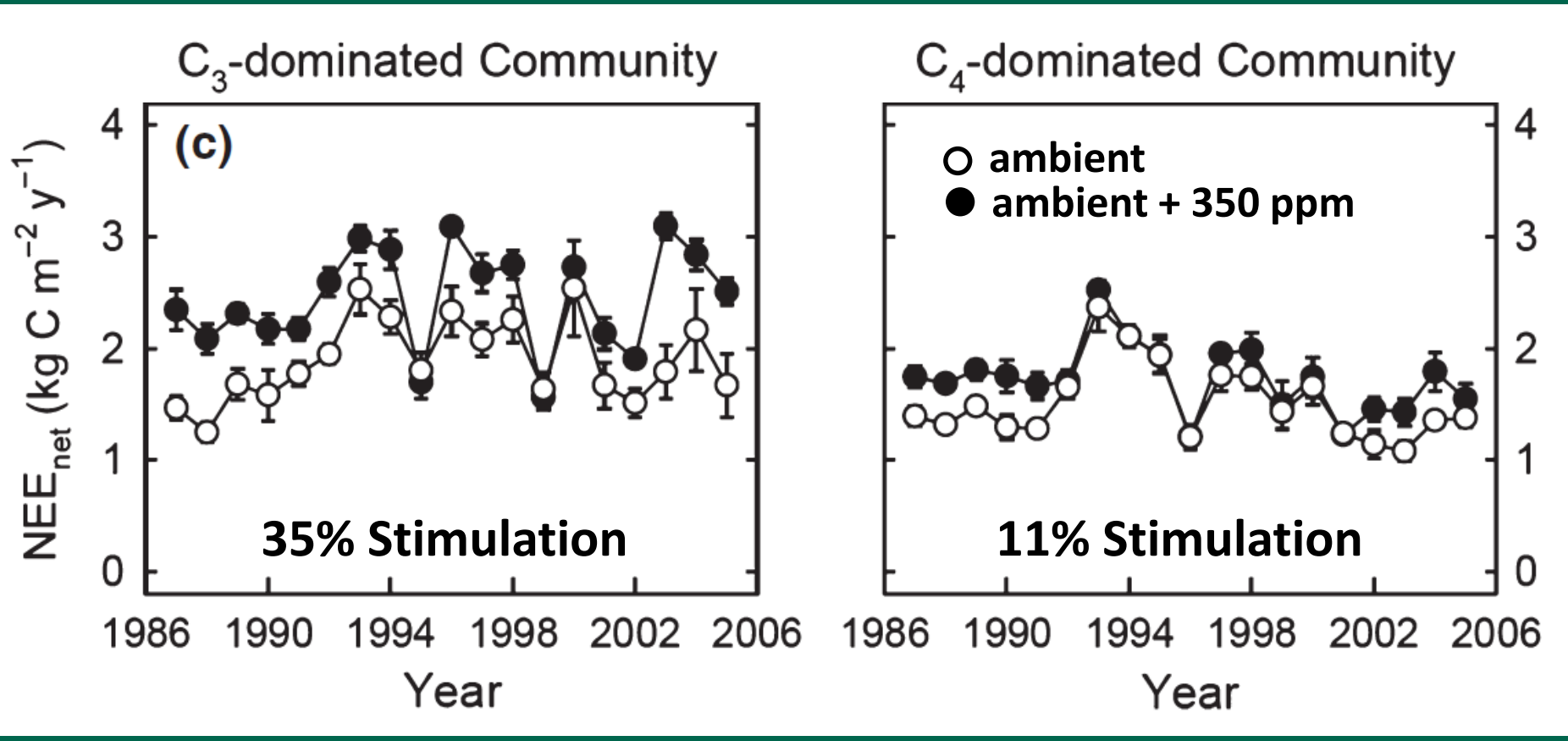
2 levels $CO_2$ (ambient, +350 ppm)
2 levels N (ambient, +25 g $NH_4$-N $m^{-2}$ $y^{-1}$)

## Sea-Level x $CO_2$ x N




## Invasive Phragmites x Elevated $CO_2$ X N

# Bottom Line: Elevated $CO_2$ Subsidizes $C_3$ Plant Growth



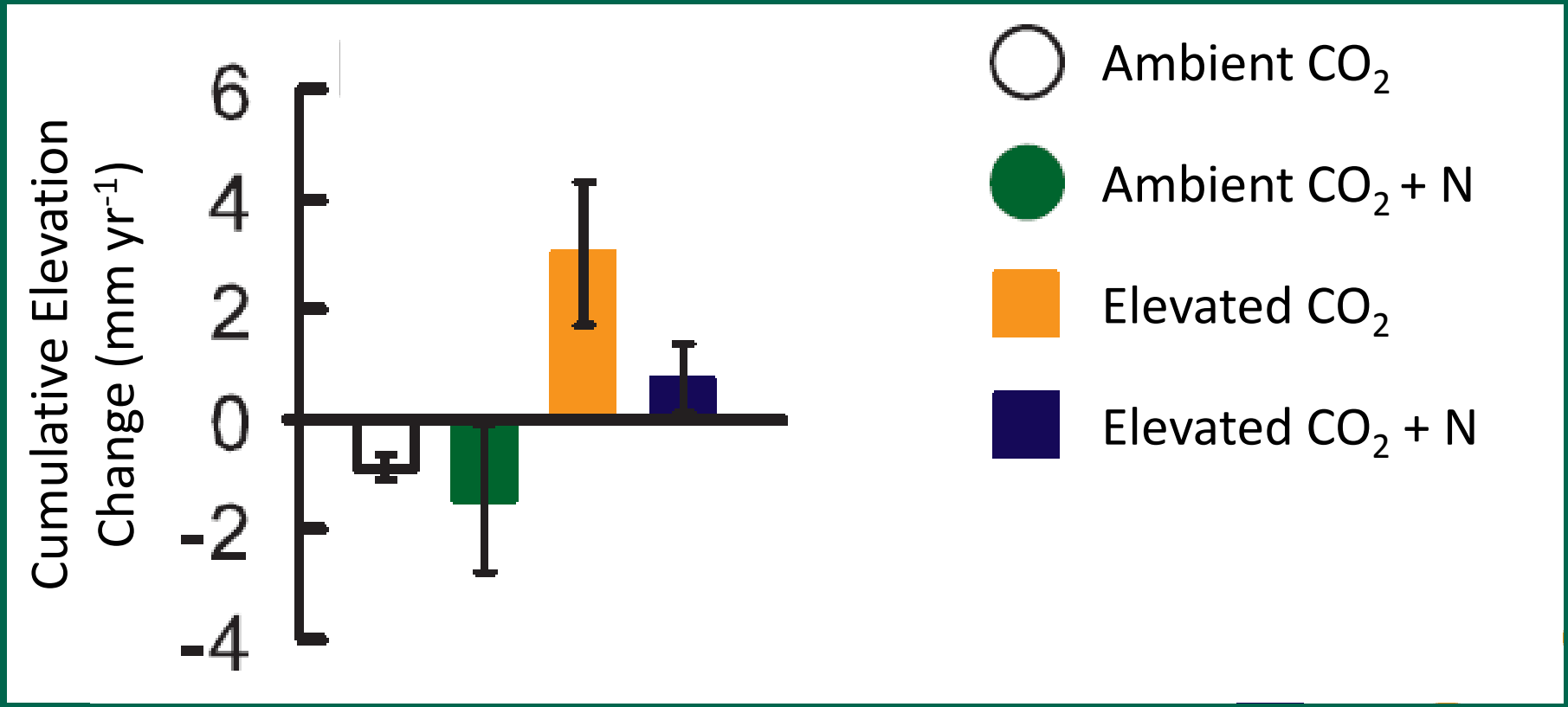

**$C_3$-dominated Wetlands**
**Brackish & Freshwater Marshes**

**$C_4$-dominated Wetlands**
**Salt marshes (NA)**

Erickson et al. (2013) *Global Change Biology*

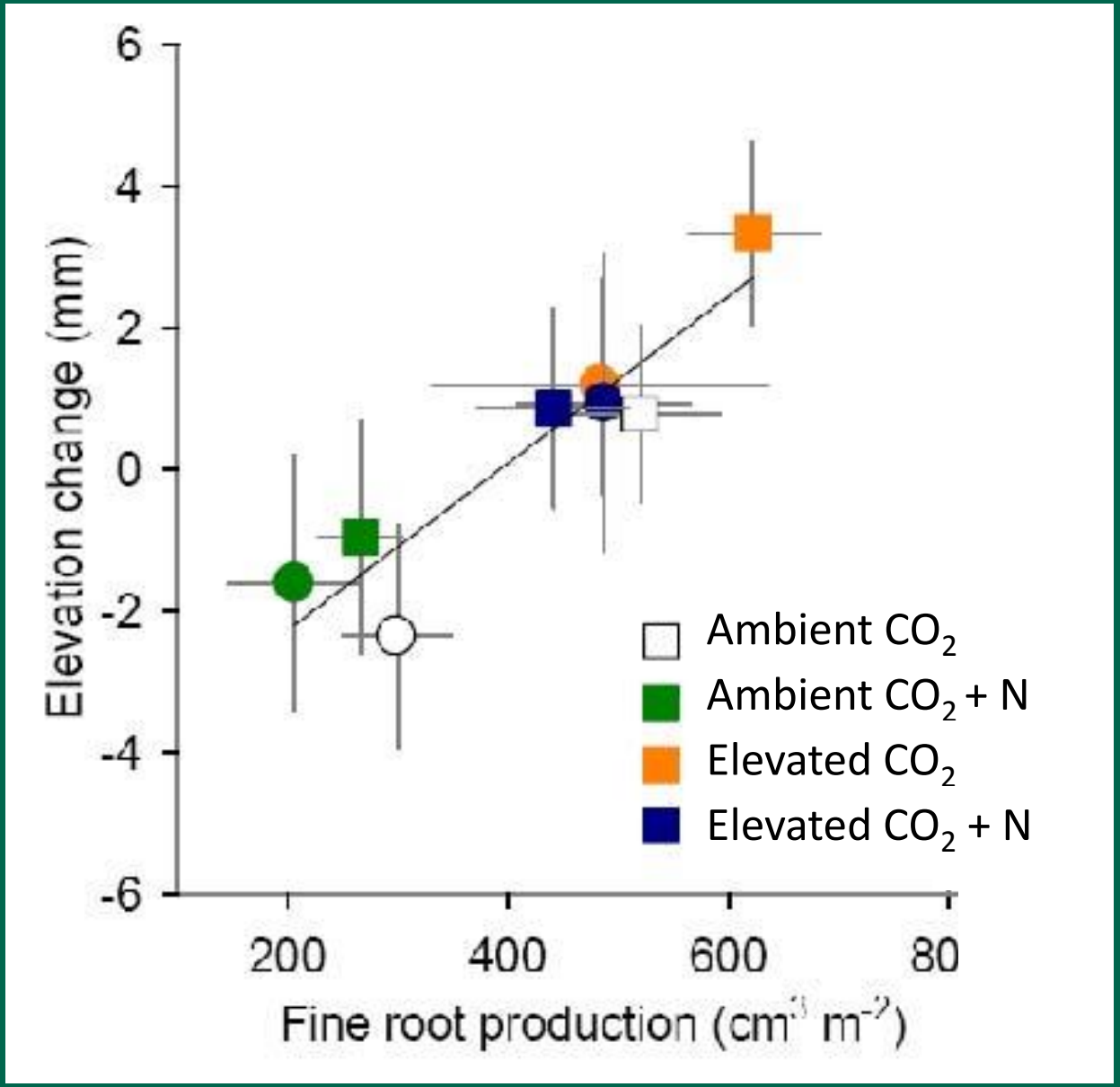
# Sentinel Site Infrastructure: Surface Elevation Tables

# Effects of Elevated $CO_2$ and N on Surface Elevation 2006-2007



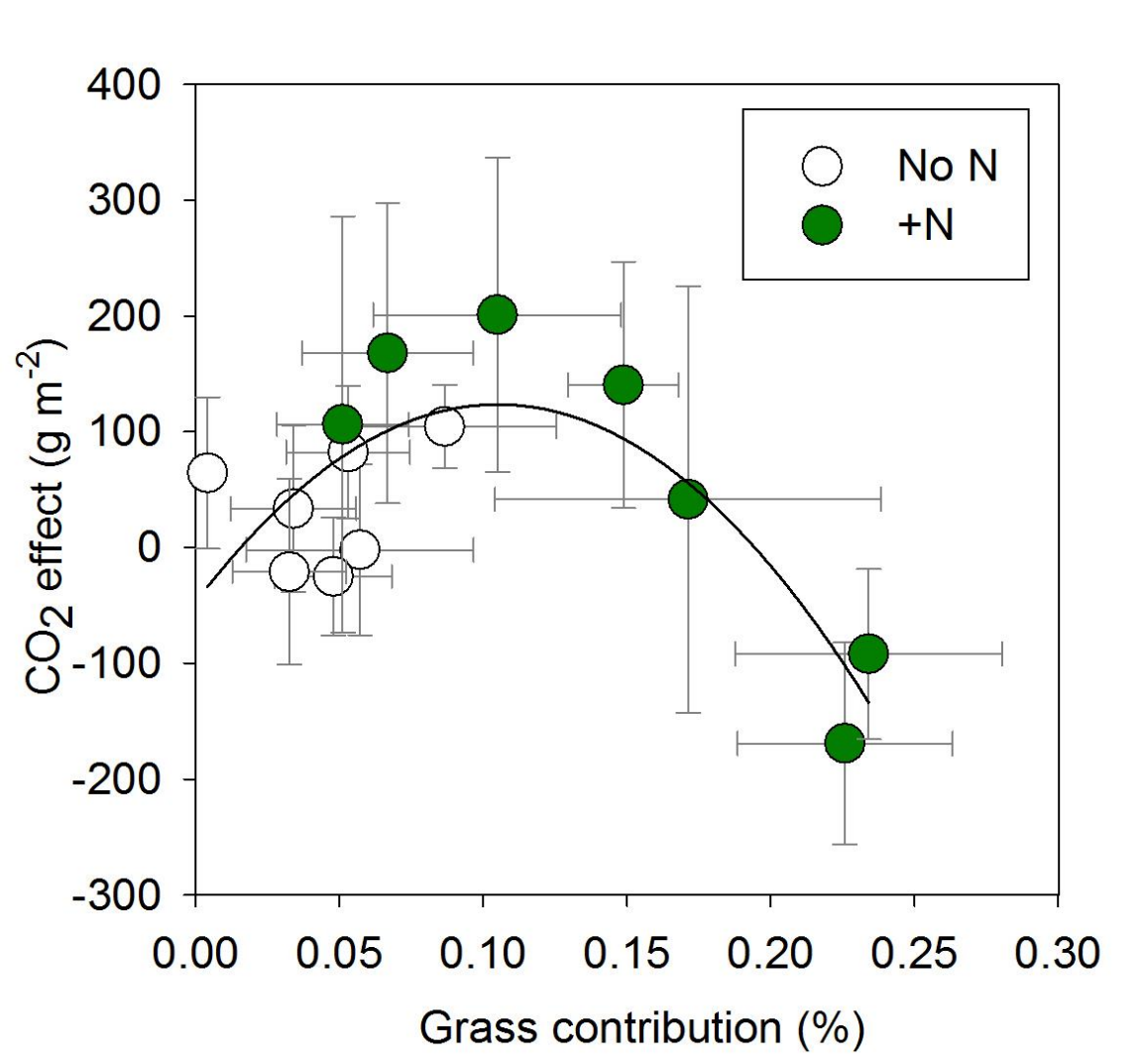

Langley et al. 2009, *PNAS*

# Belowground Productivity Drives Surface Elevation



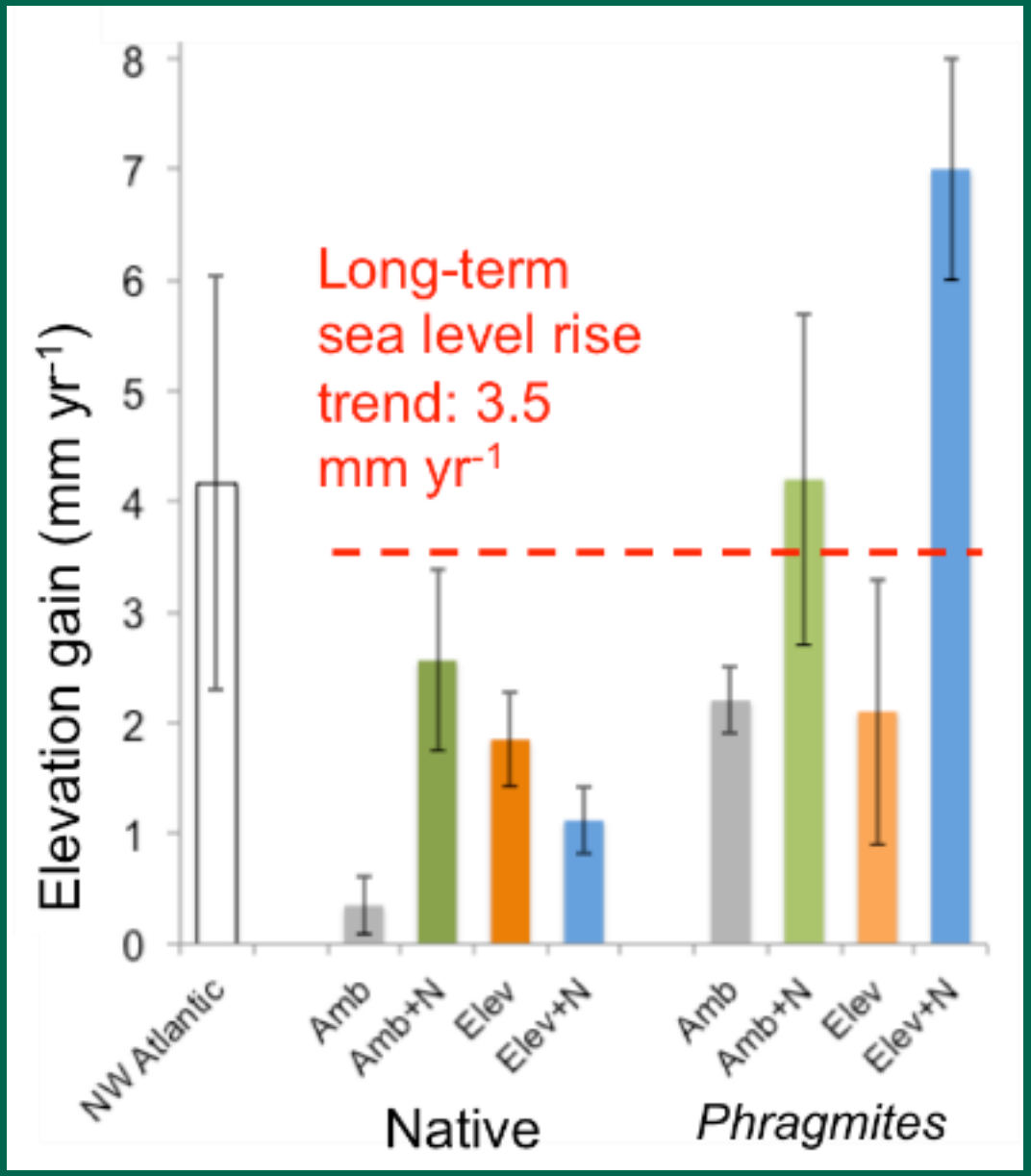

Langley et al. (2009) *PNAS*

# N Supersedes $CO_2$ via Species Shift




Adam Langley, unpublished data

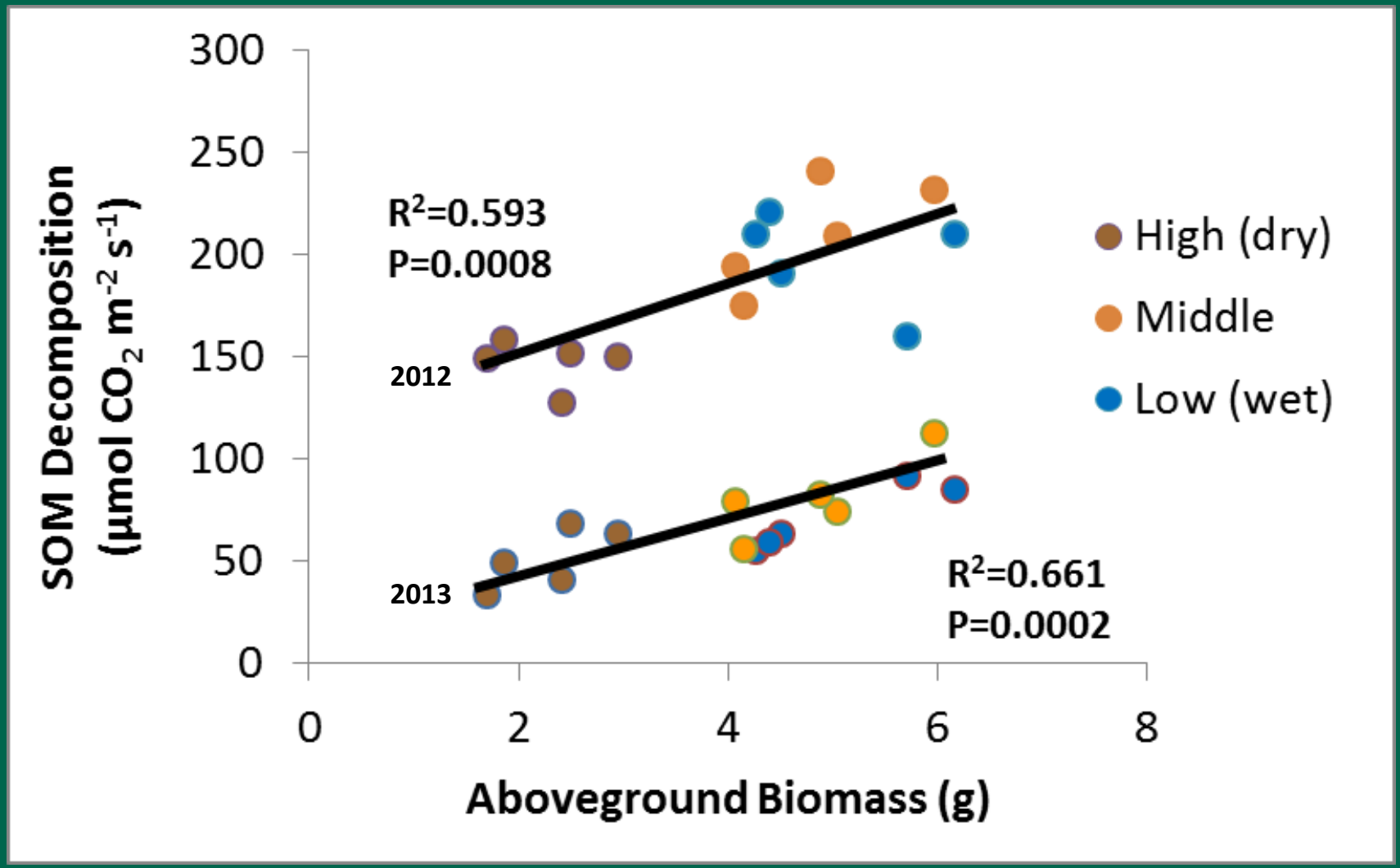
# Invasive *Phragmites* Increases Elevation Gain




Tom Mozdzer, unpublished data

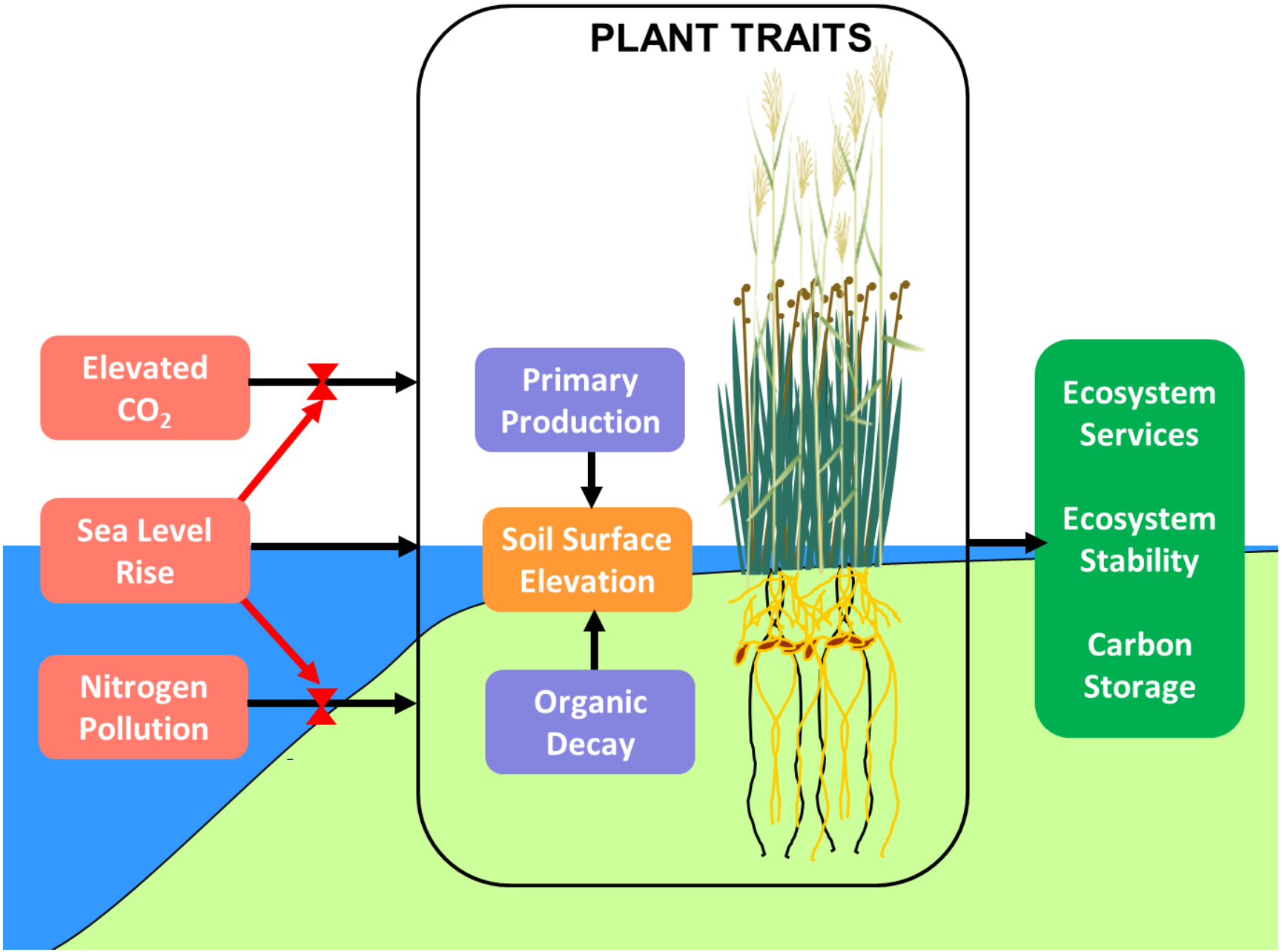
# Decomposition

# Plants (Not Flooding) Control Soil Organic Matter Decay

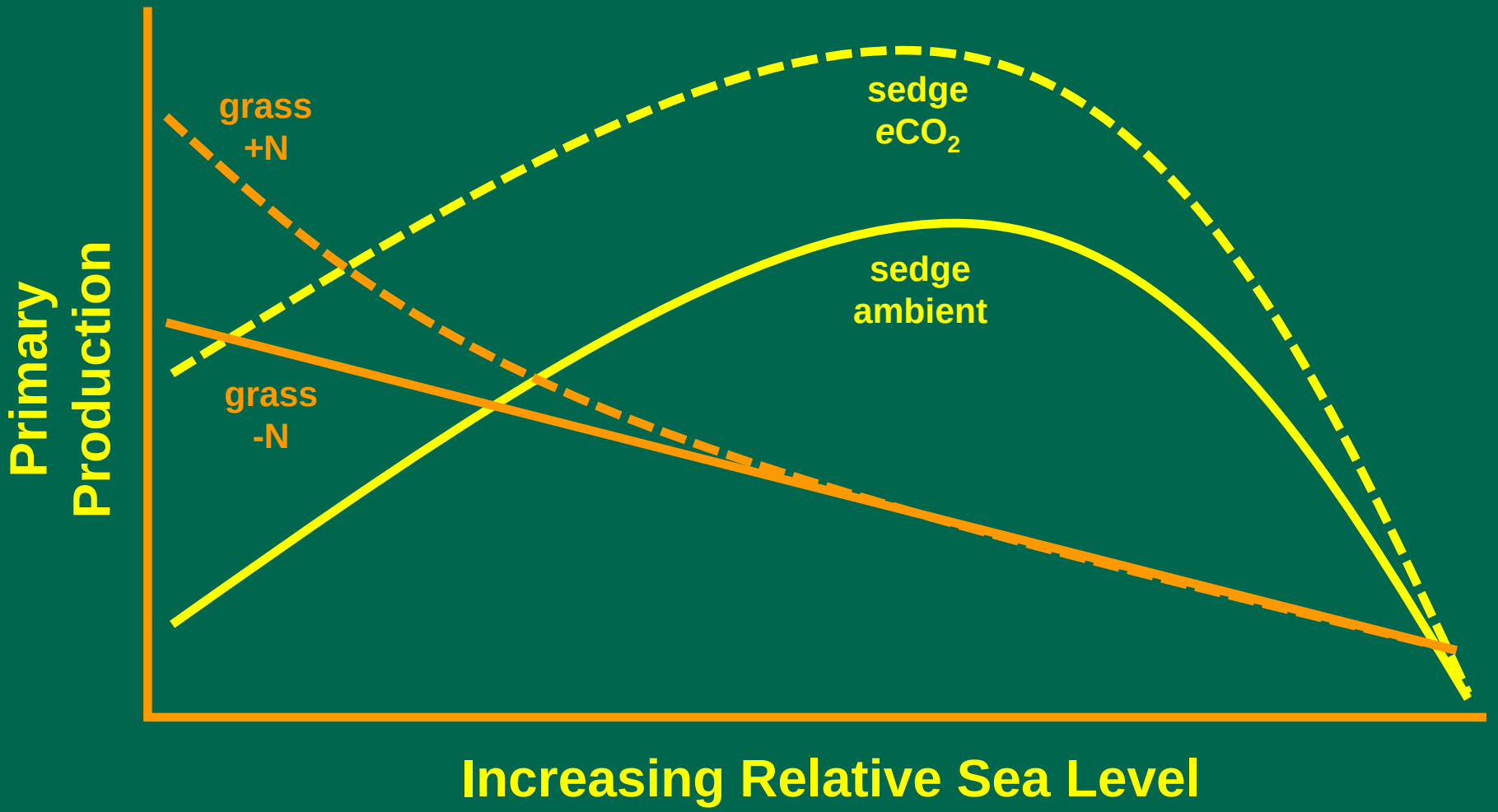



Mueller, Jensen & Megonigal (2016) *Global Change Biology*

# Global Change Factor Interactions



# Forecast of Tidal Marsh Responses to SLR

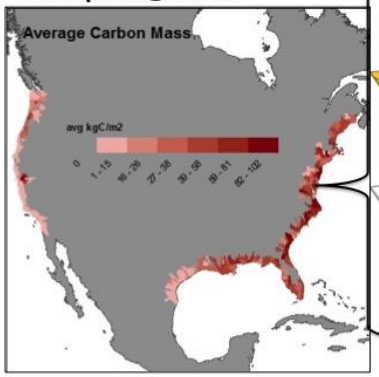


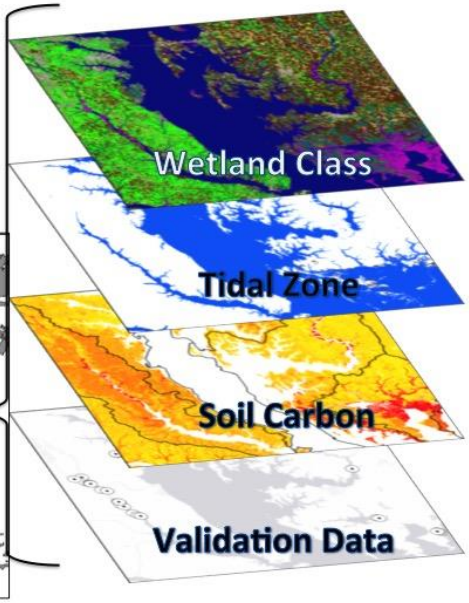
# Scaling Through Extrapolation & Modeling

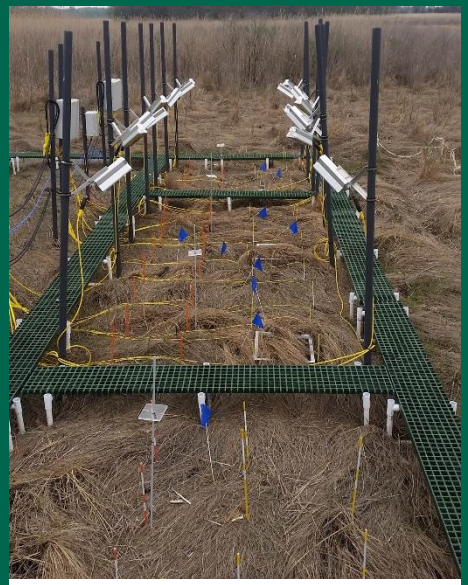

(PI: Lisamarie Windham-Meyer, USGS)

**NASA Blue Carbon Monitoring System**

James Holmquist
HolmquistJ@si.edu

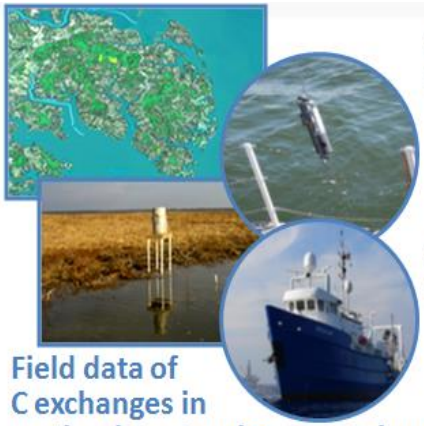


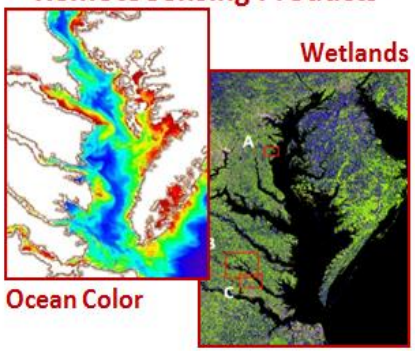



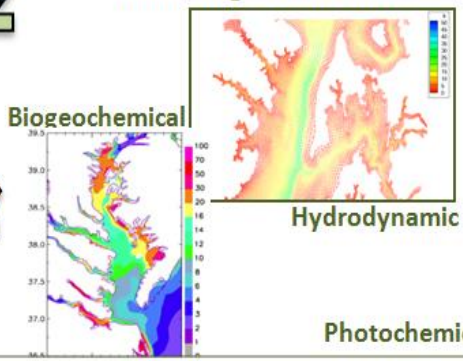
DOE: Ecosystem & Earth System Modeling

MarshCycle (PI: Maria Tzortziou, CUNY)



Field data of C exchanges in wetlands, estuaries, coastal waters




$$\frac{\Delta a}{a}(jj,\lambda_o) = \int_{200\,\mathrm{nm}}^{700\,\mathrm{nm}} H_a(jj,\lambda)\cdot W(\lambda)\cdot WSF(\lambda,\lambda_o)\cdot d\lambda + c_2$$

***Improved Understanding of tidal wetlands as C sources & sinks***

***Decision Making***

- *Stake Holders*
- *Scenario Analysis*
- *Integration into enhanced decision support systems*