Importance of spatiotemporal variation in *Spartina alterniflora* belowground biomass

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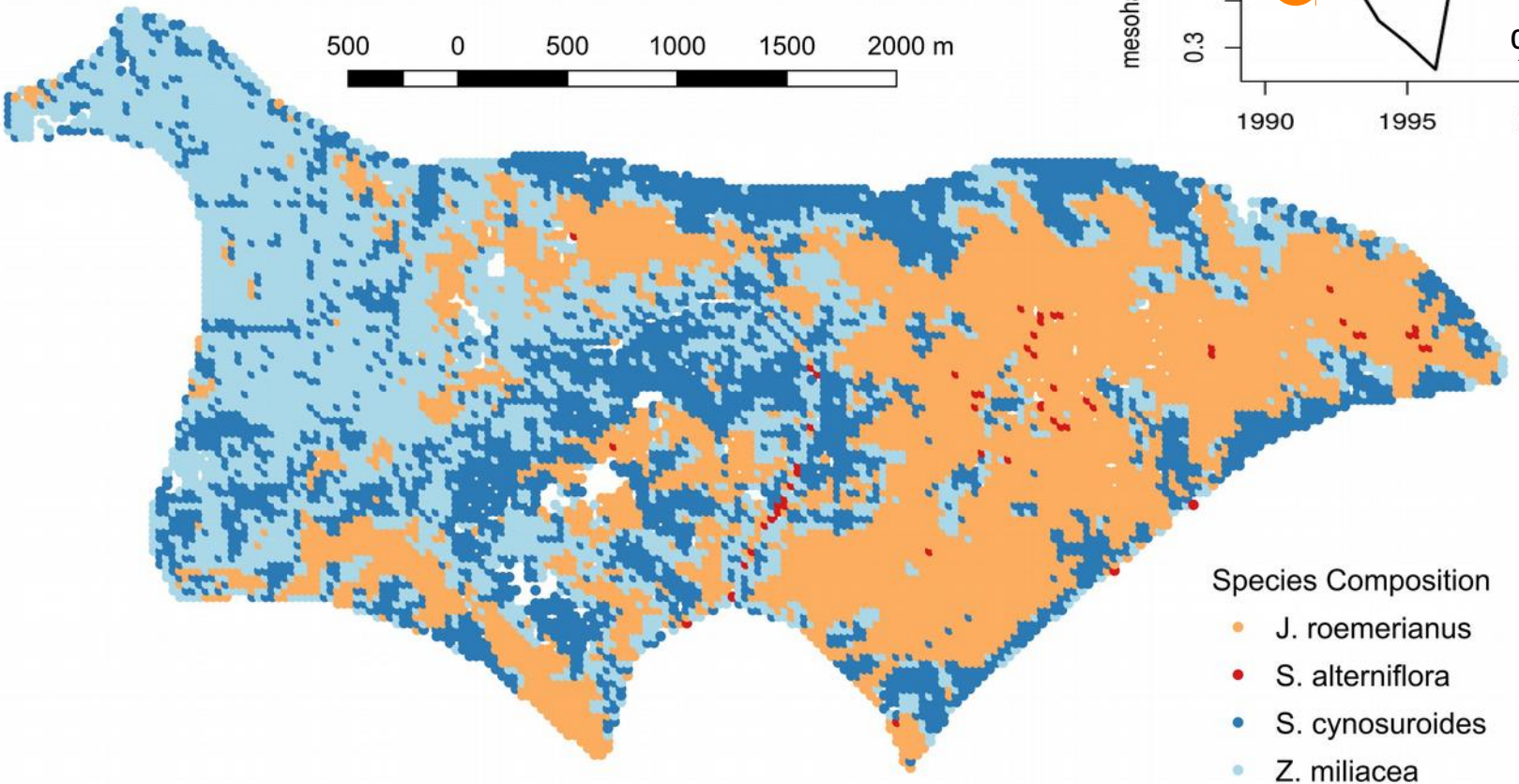
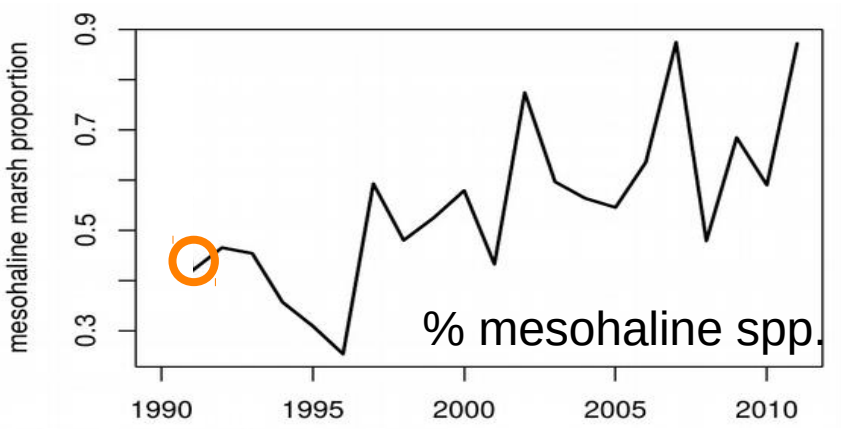
Topics I work on now

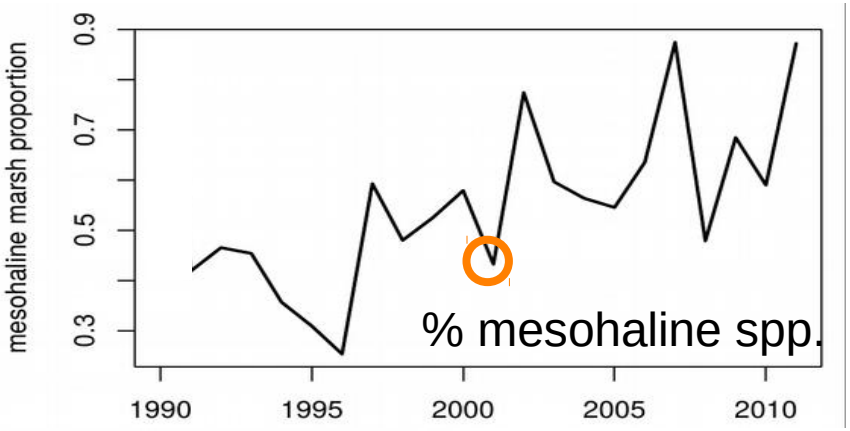
- Transitions in species composition
- Phenology of tidal marshes
- Gross Primary Production
- Mapping belowground biomass

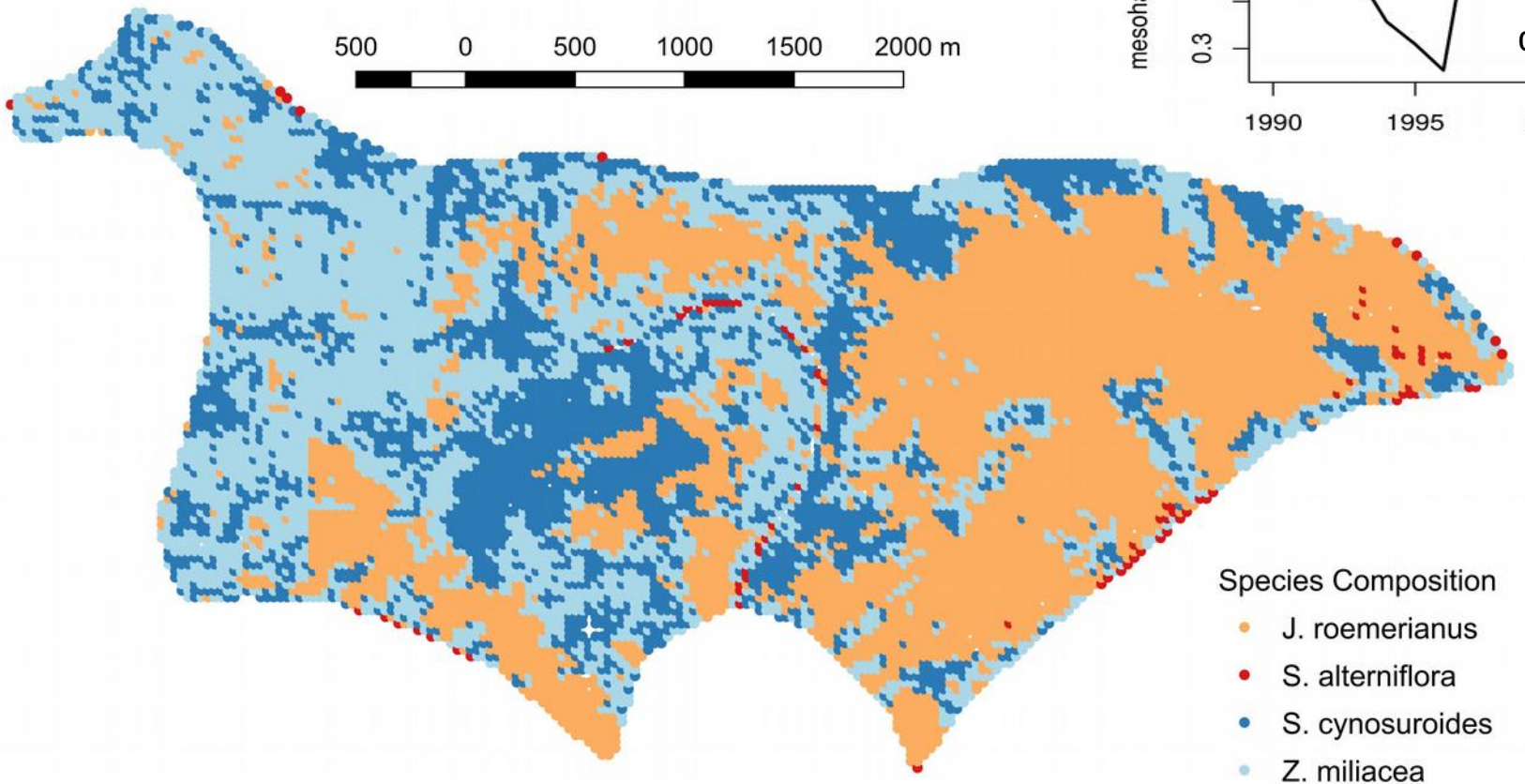
Species composition through time



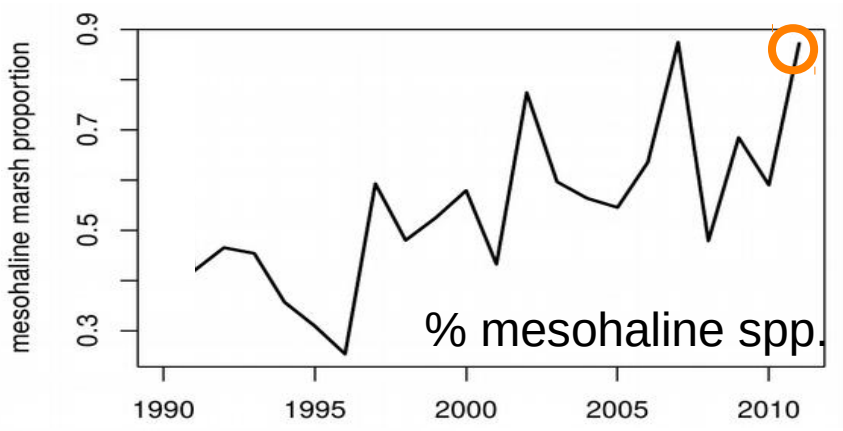


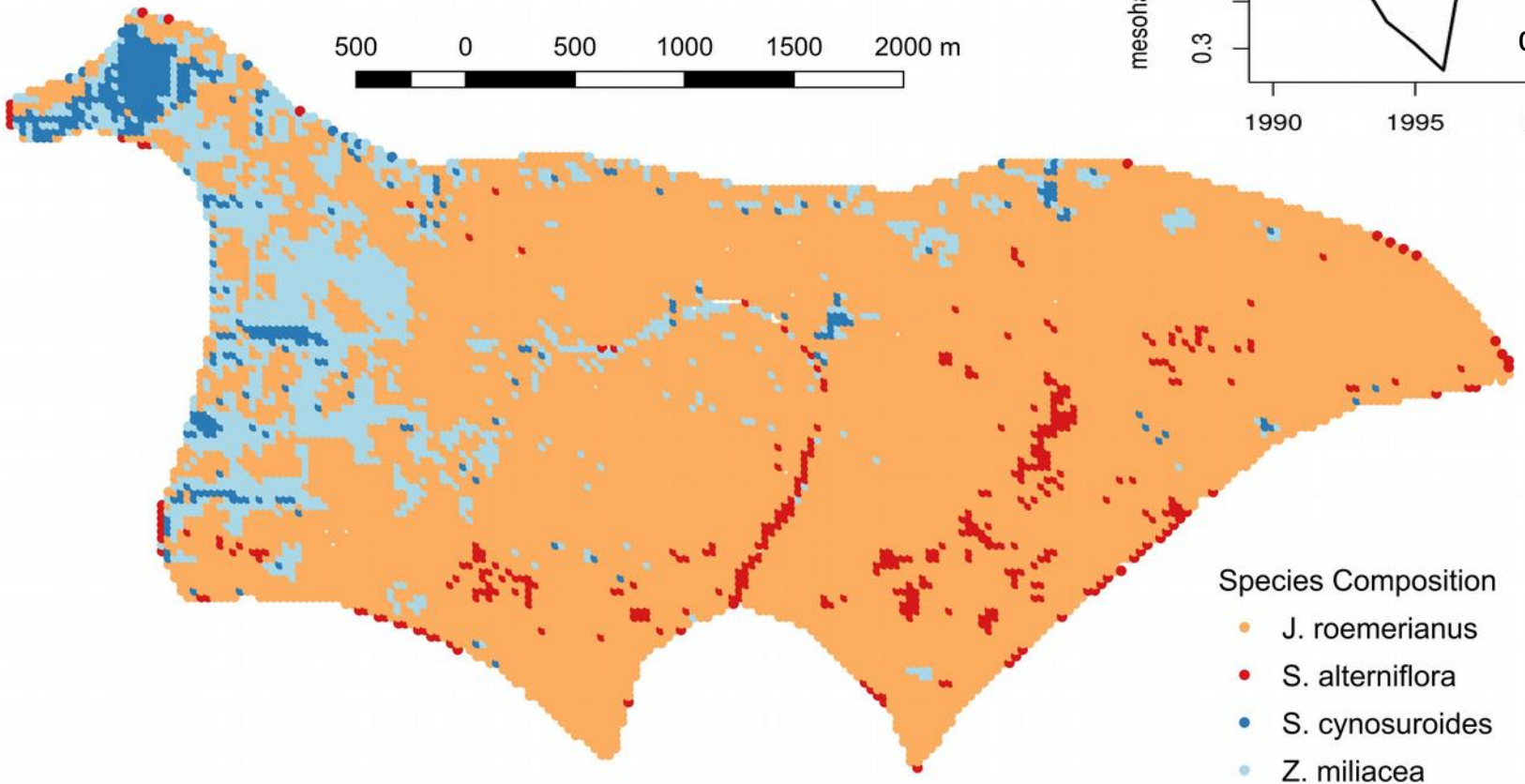
Species composition through time



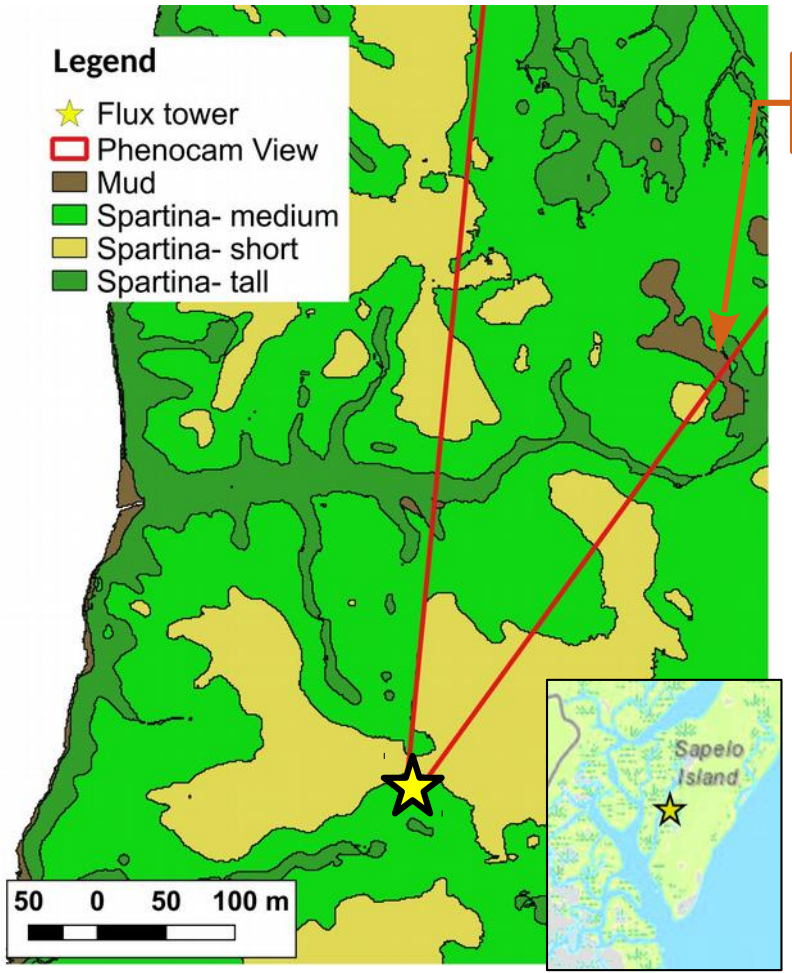


Species composition through time





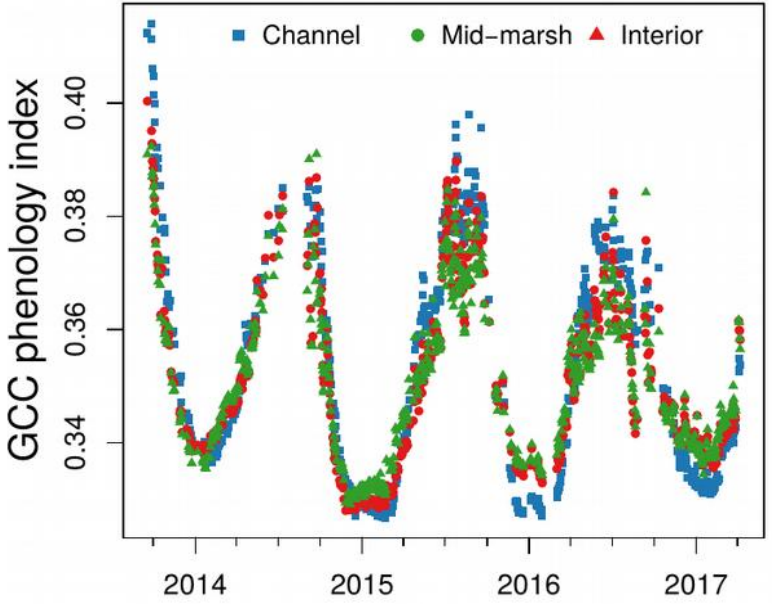
Sapelo Island PhenoCam



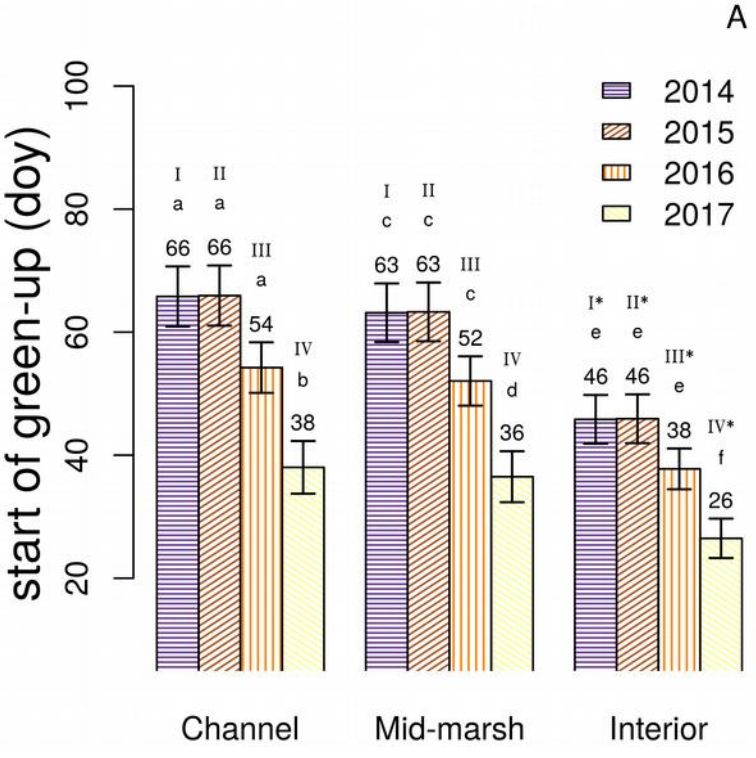
PhenoCam field of view

Collecting data since 2013-09-17

Spatial and temporal phenology

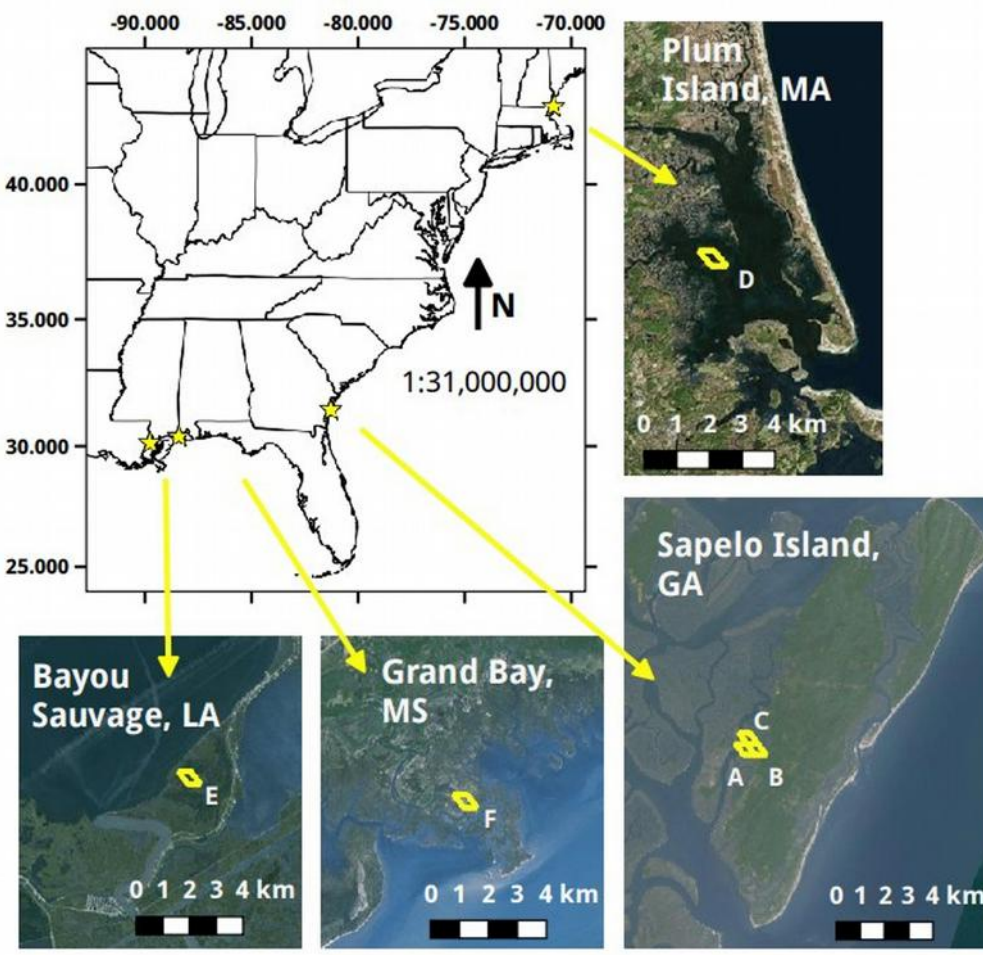


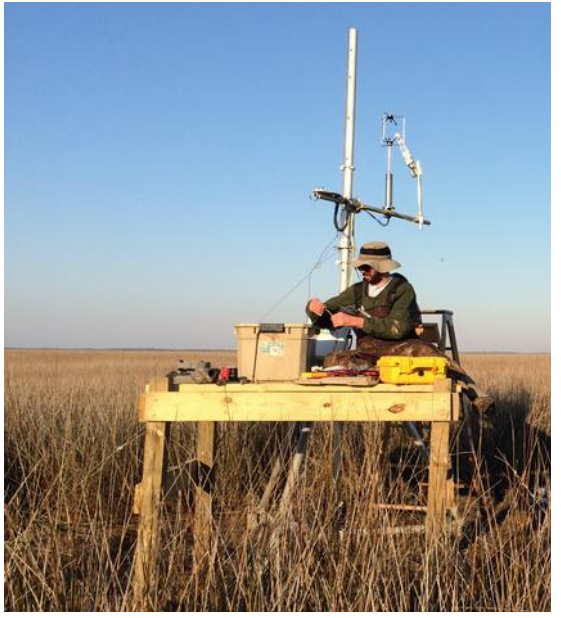
channel
mid-marsh
interior



- Green-up onset advancing and early in the marsh interior

Flux towers at 4 locations

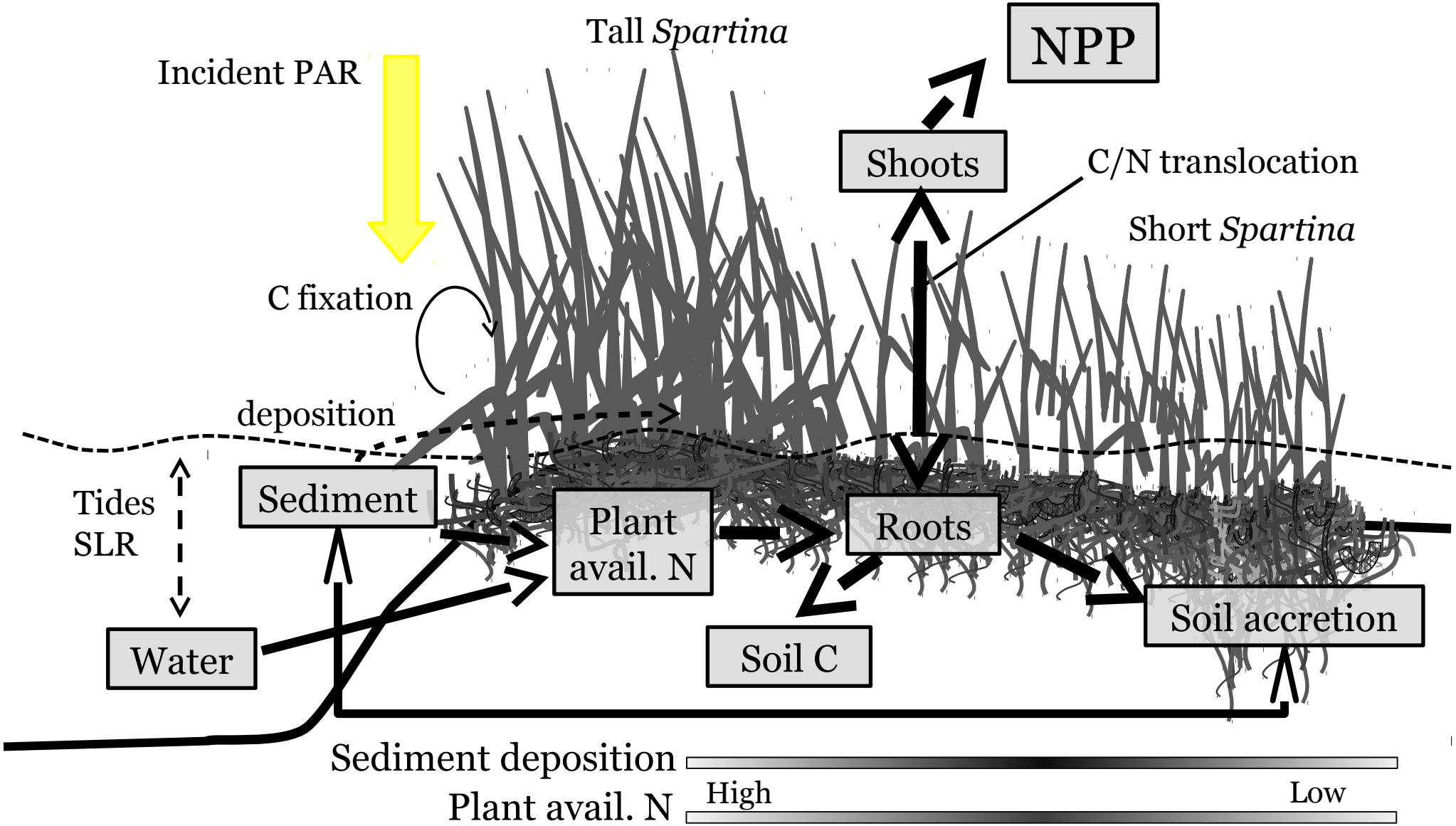




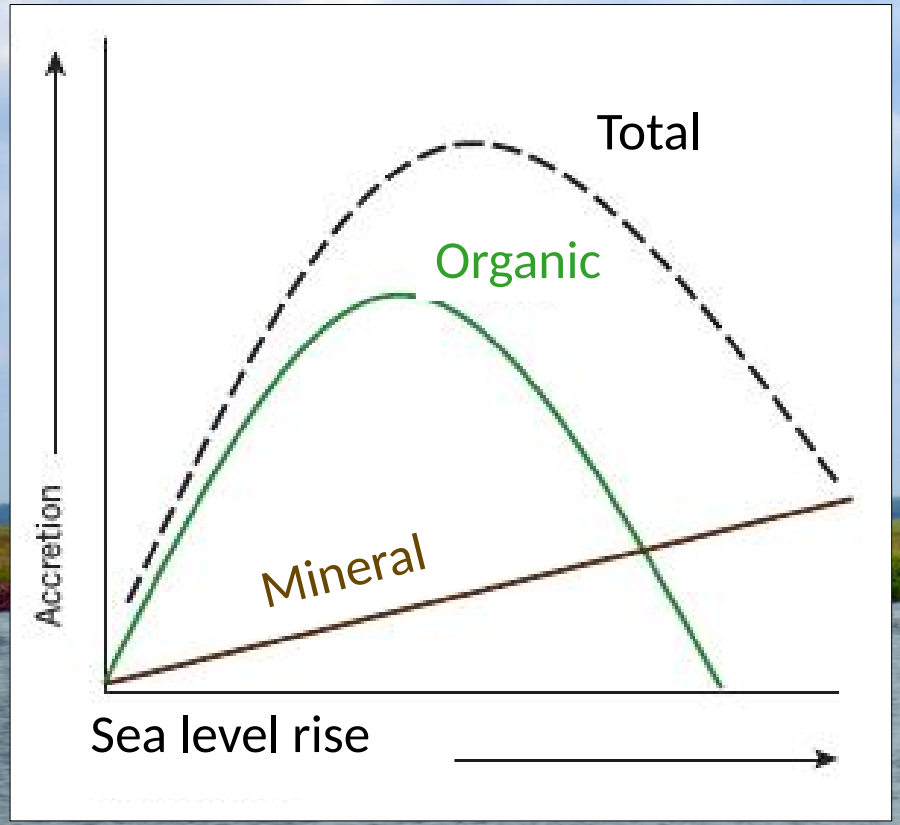
Belowground productivity: importance within coastal marsh

- Contributes to soil organic matter to build “blue carbon”

- Contributes to marsh stability as sea level rises


Tall *Spartina*
NPP
Incident PAR
Shoots
C/N translocation
Short *Spartina*
C fixation
deposition
Tides
SLR
Sediment
Plant
avail. N
Roots
Soil accretion
Water
Soil C
Sediment deposition
Plant avail. N
High
Low

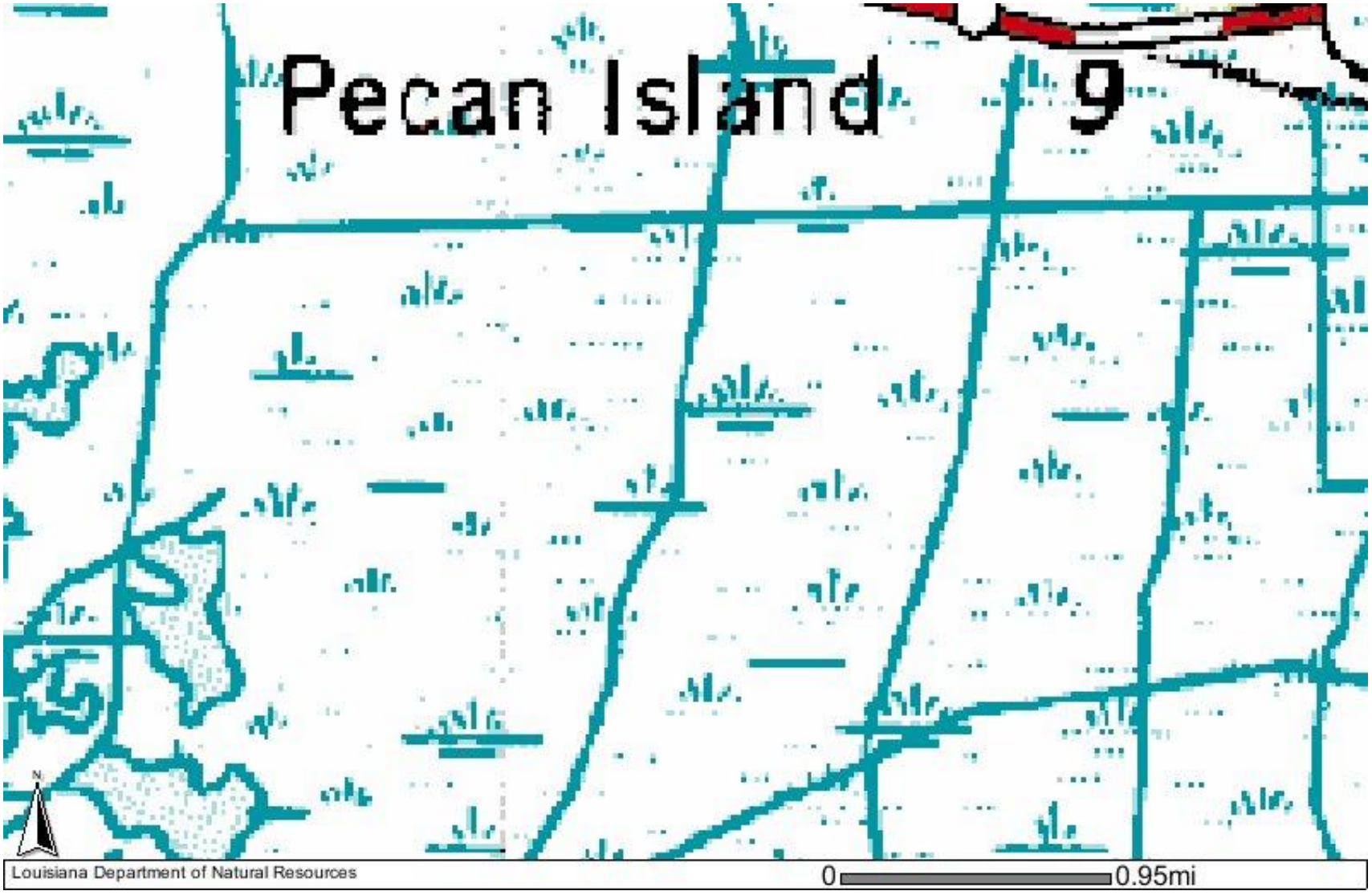
Marsh productivity can keep pace with SLR



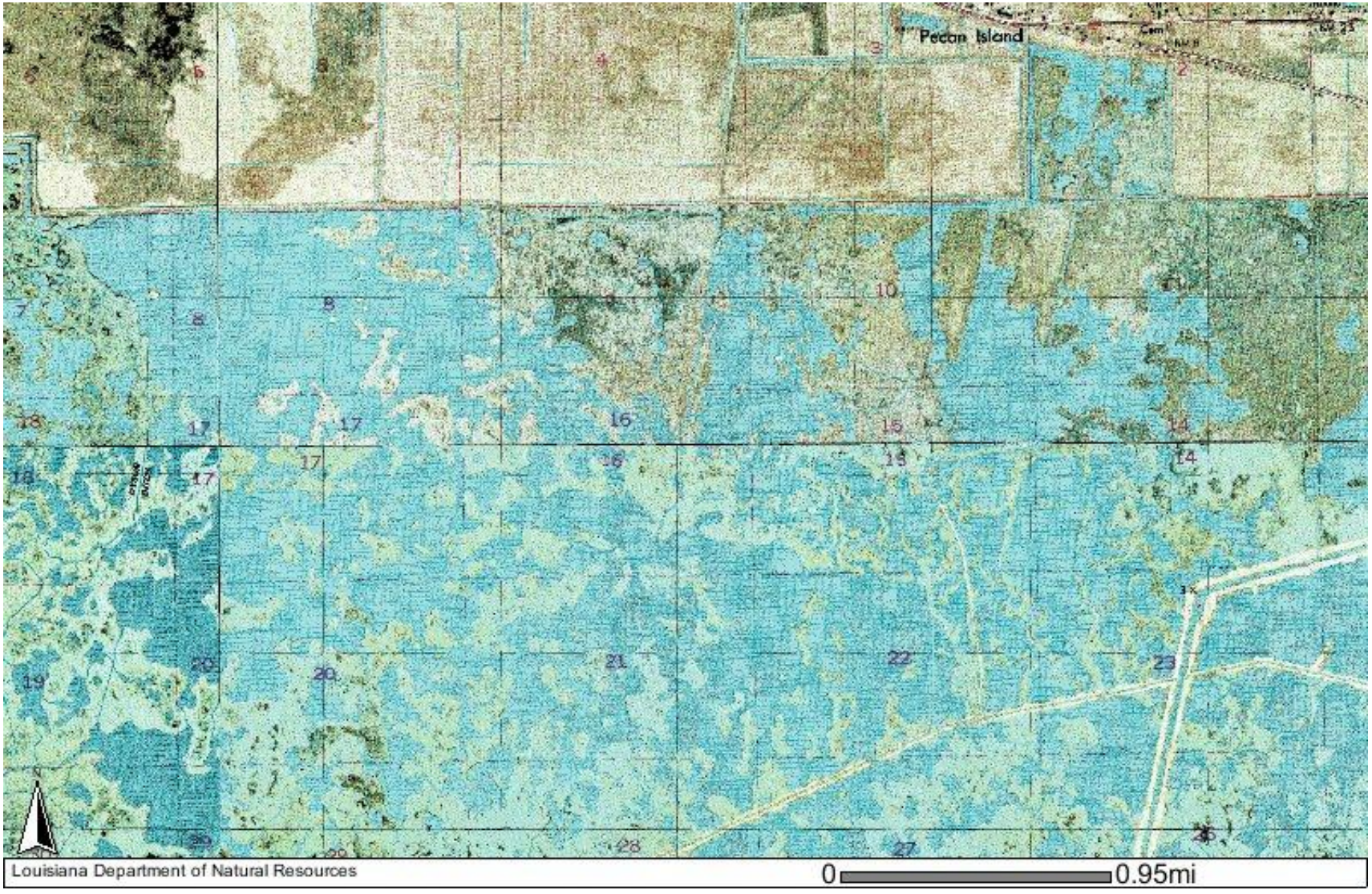
Elevation keeps pace with sea level rise when:

↑belowground biomass

Kirwan & Megonigal. 2013. Nature


Pecan Island 9
N
Louisiana Department of Natural Resources
0
0.95mi

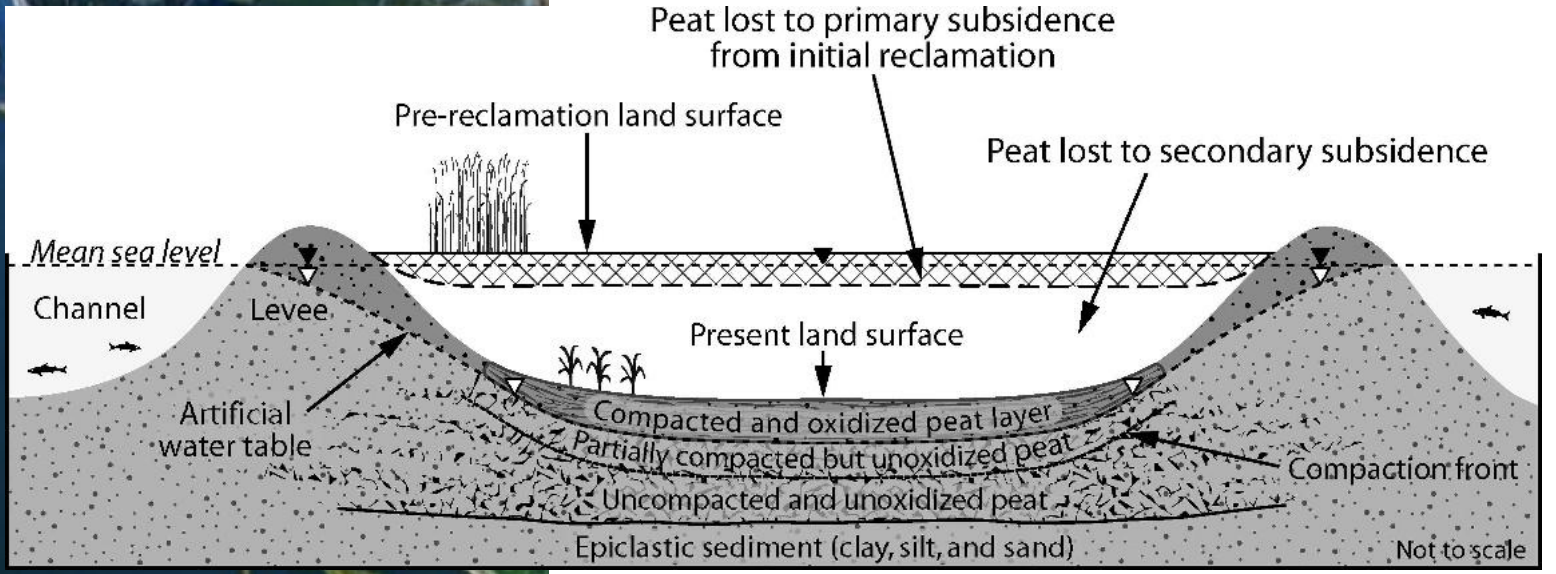

6
Louisiana Department of Natural Resources
0
0.95mi


Pecan Island
Louisiana Department of Natural Resources
0
0.95mi

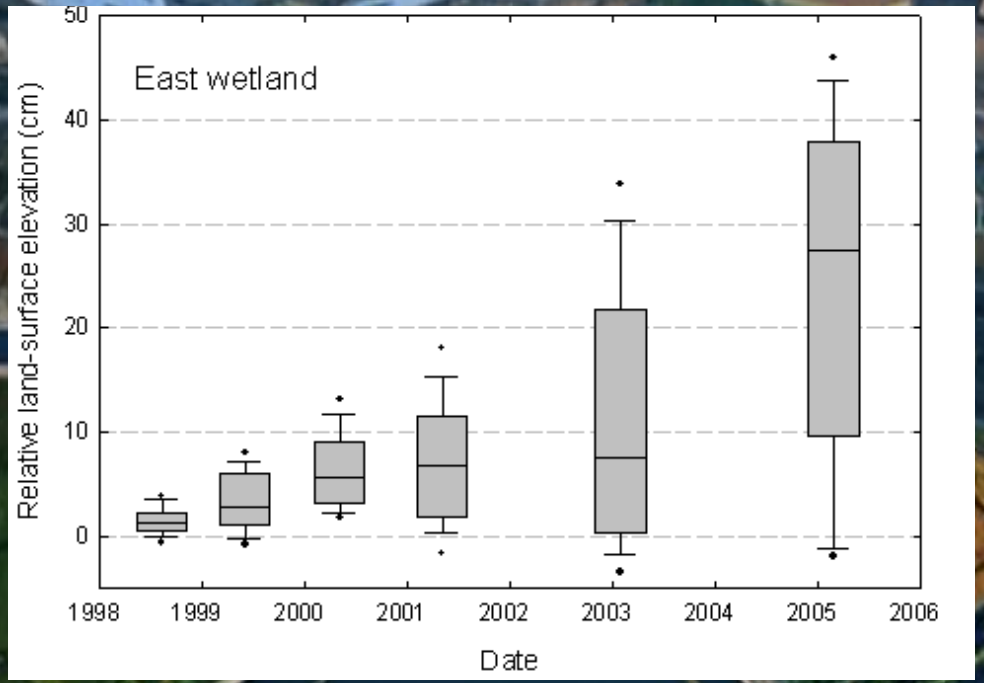

Louisiana Department of Natural Resources
0
0.95mi

California's Sacramento-San Joaquin Delta

Historical peatlands w/subsidence up to 8 m from agriculture



California's Sacramento-San Joaquin Delta



Miller et al. 2008. San Francisco Estuary and Watershed Scien

- Subsidence reversed in restored wetlands through biomass gains:

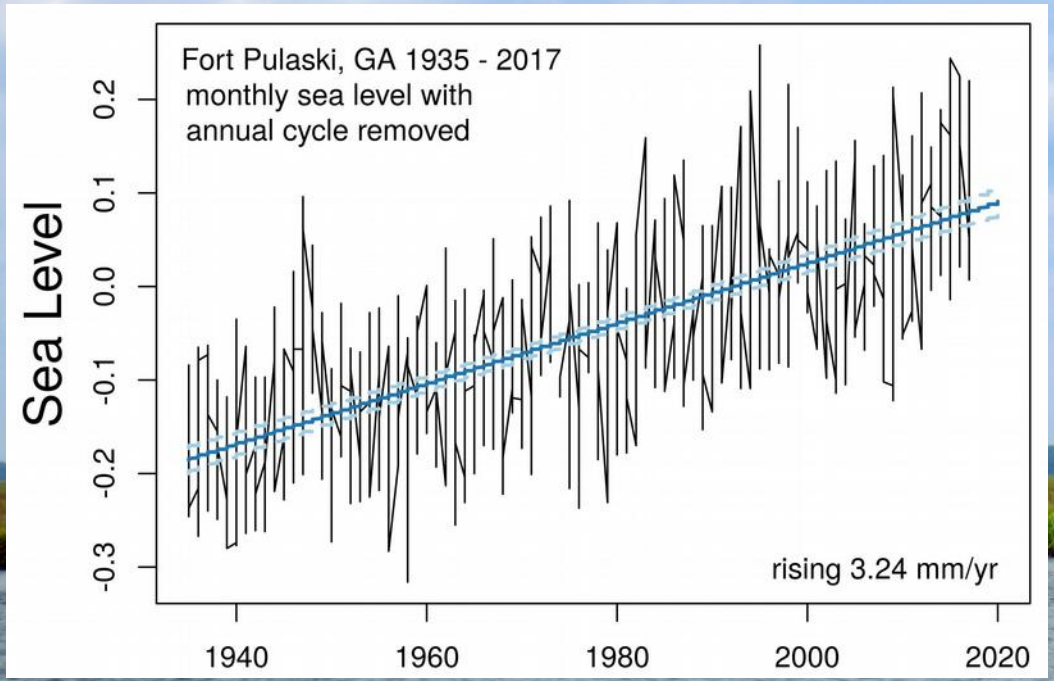
  Plant production 1-3 kg C m^2 yr^{-1}

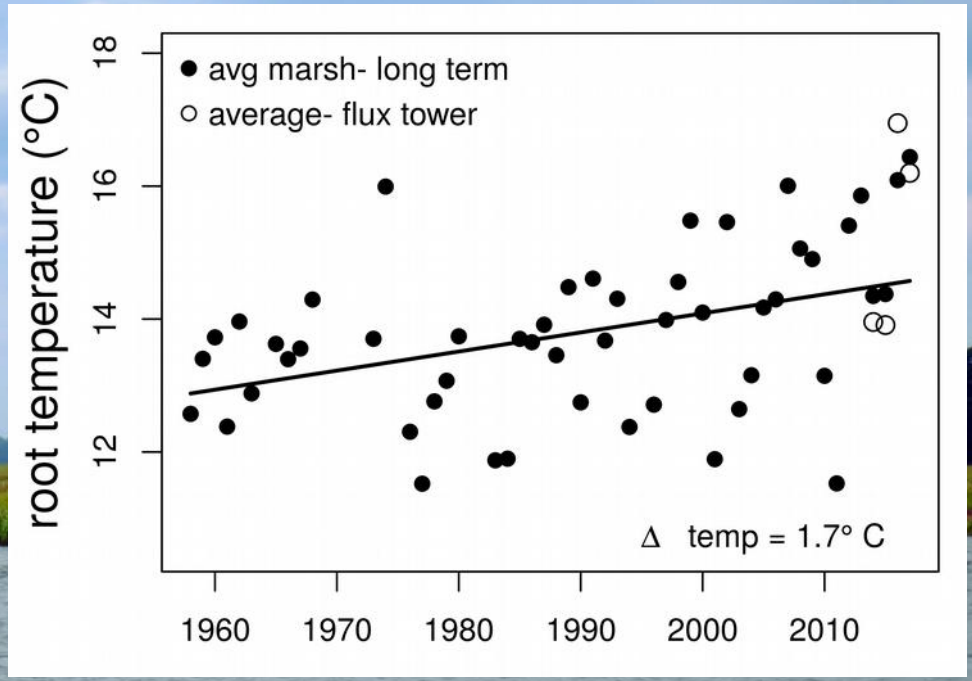
  Accretion of 3-9 cm yr^{-1}

Marsh resiliency is a plant process

- Forecasting resiliency depends on knowing patterns and drivers of phenology and productivity
- Forecasting resiliency also depends on scaling up from local processes to landscape trends

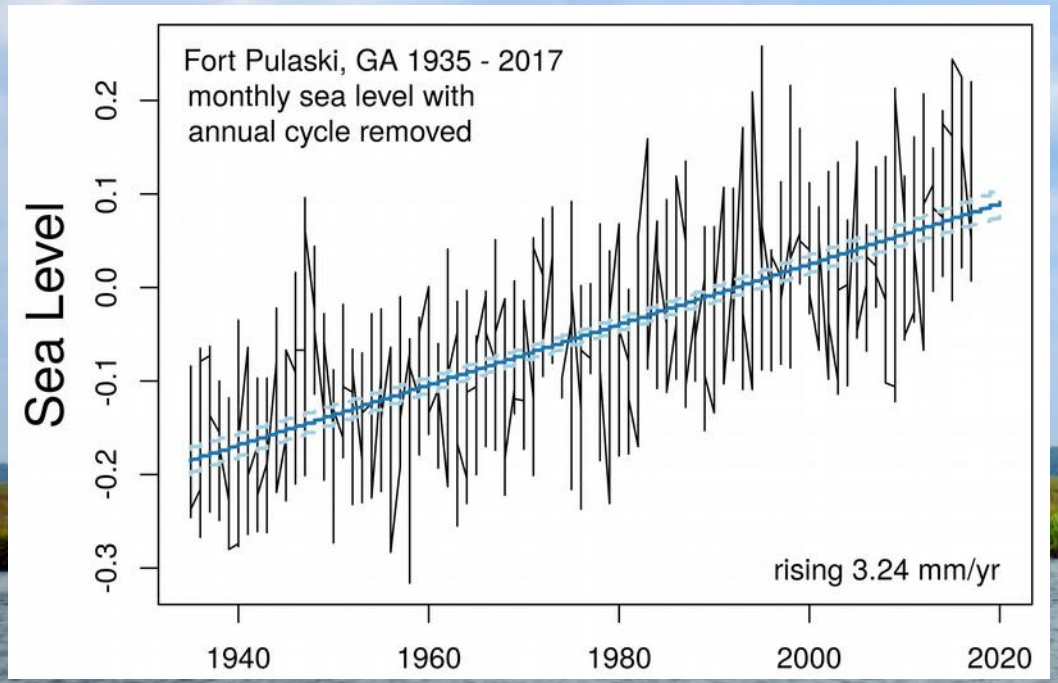
Pressures on marsh productivity in Georgia

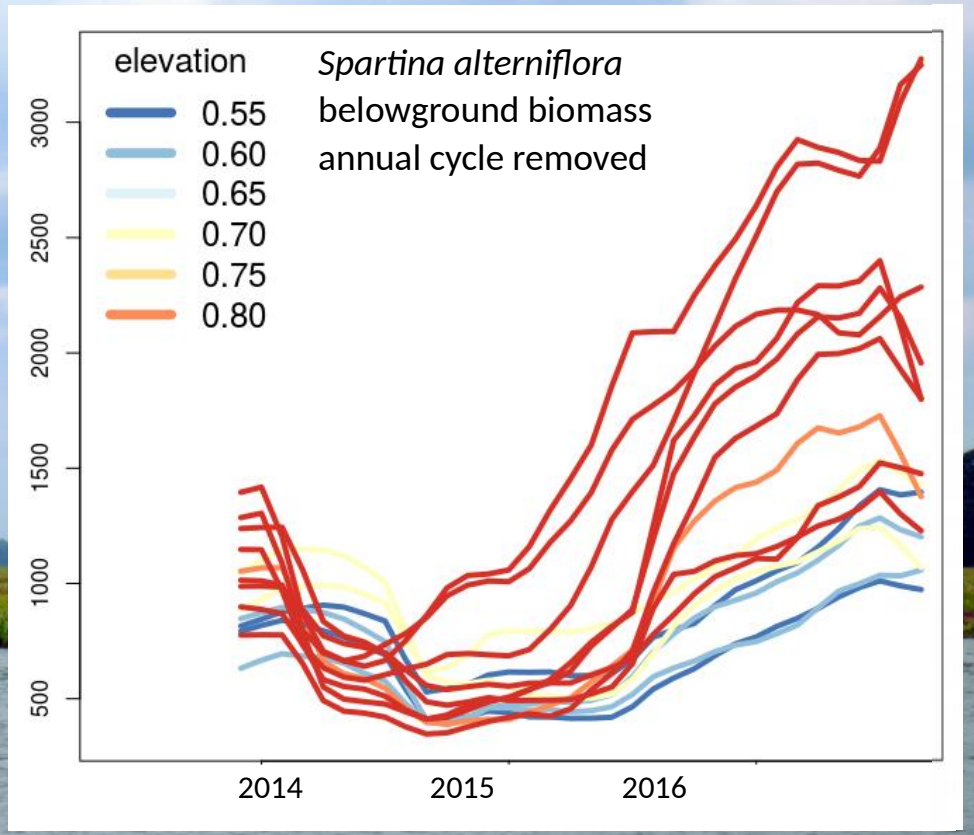




From tidesandcurrents.noaa.gov

Pressures on marsh productivity in Georgia





Biomass data from GCE-LTER

Belowground measures difficult

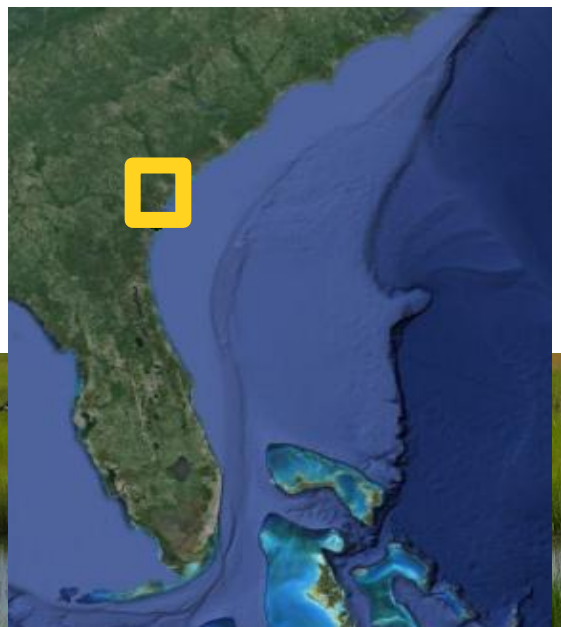
- Direct measures time consuming
- Indirect measures must account for light, phylogeny, competition, leaf area, temp, nutrients
- Root:shoot ratios are variable
- Assuming belowground from aboveground is misleading

Remote sensing may help scale belowground measurements

- Remote sensing detects surface temperature, foliar N, chlorophyll (mostly N), leaf area index (LAI) and aboveground biomass
- Species specific field data needed for calibration

Objective:

- Map *Spartina alterniflora* belowground biomass through aboveground proxies within salt marsh using remote sensing methods



Field approaches

- Permanent vegetation plots measured monthly for stem height and stem density 2013-2016

- Collected remote sensing data: spectral reflectance, LAI, leaf N and Chlorophyll

- Collected root cores adjacent to plots

Hybrid Belowground biomass model

time

Site-wide spectral **leaf area index**

Site-wide **elevation**

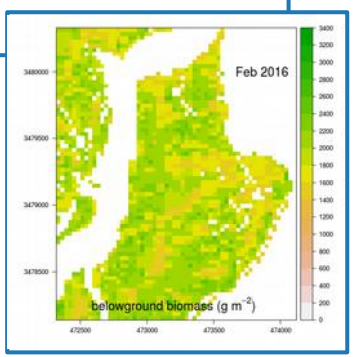
Site-wide spectral **% chlorophyll**

Machine Learning

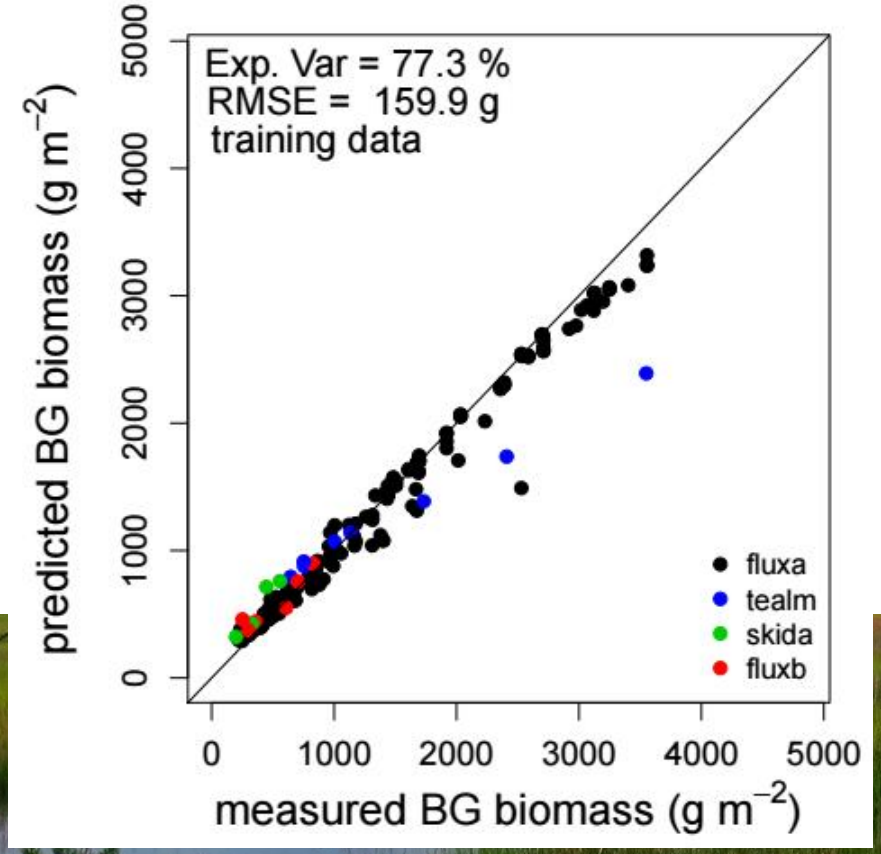
Site-wide spectral **surface temp**

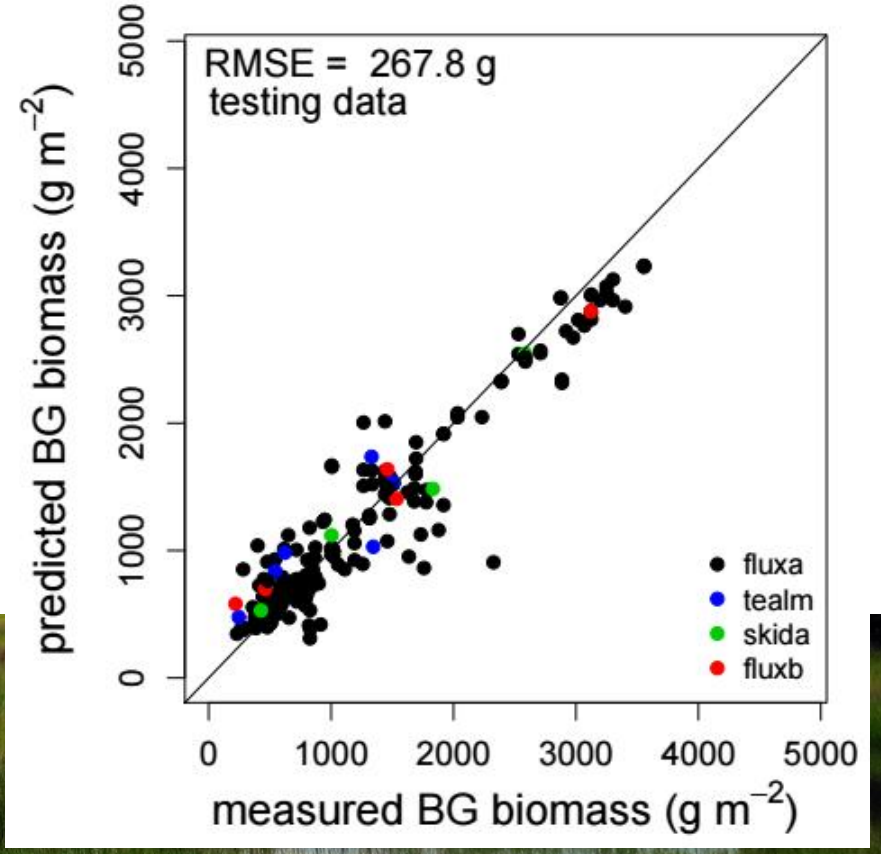
=

Site-wide spectral **belowground** biomass

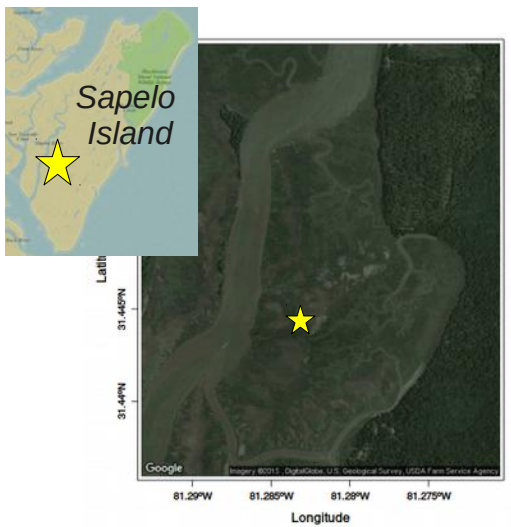


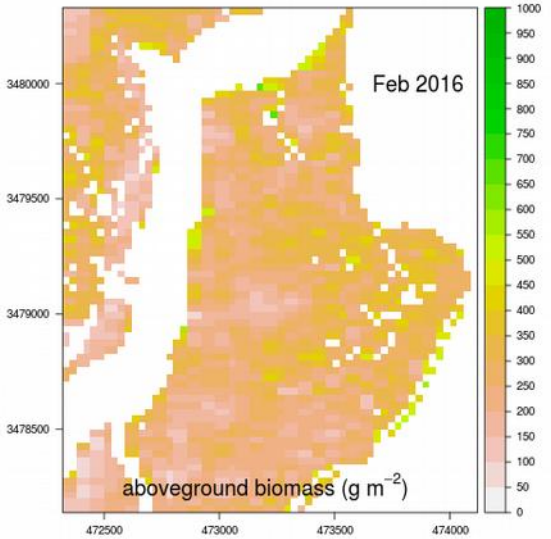
Prediction accuracy: belowground biomass

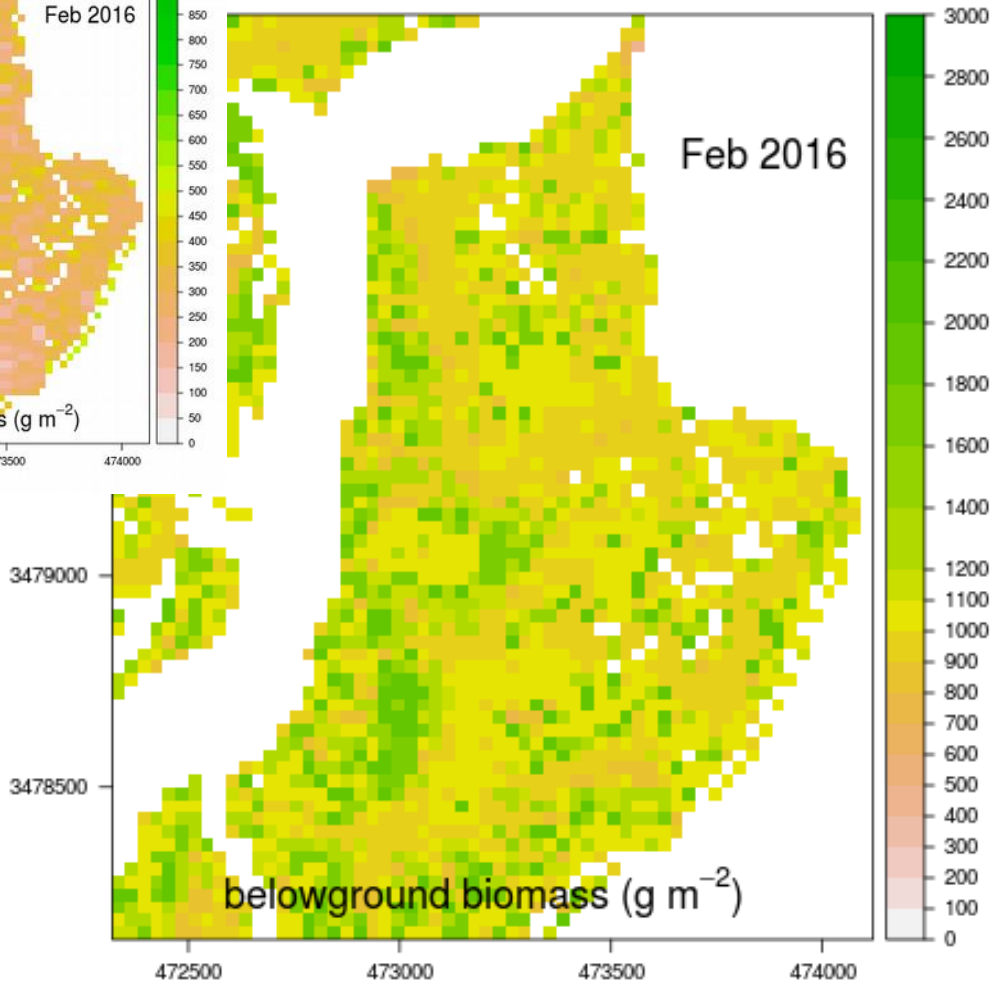




Spectral predictions







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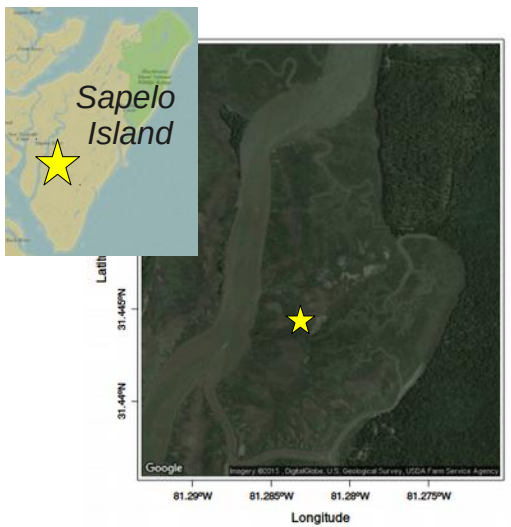

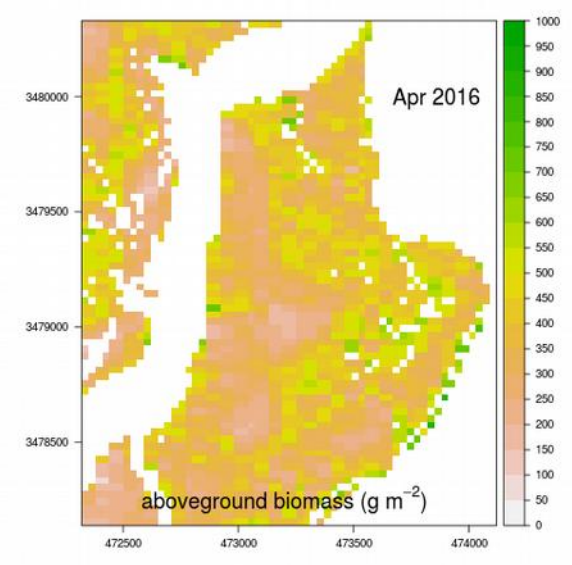

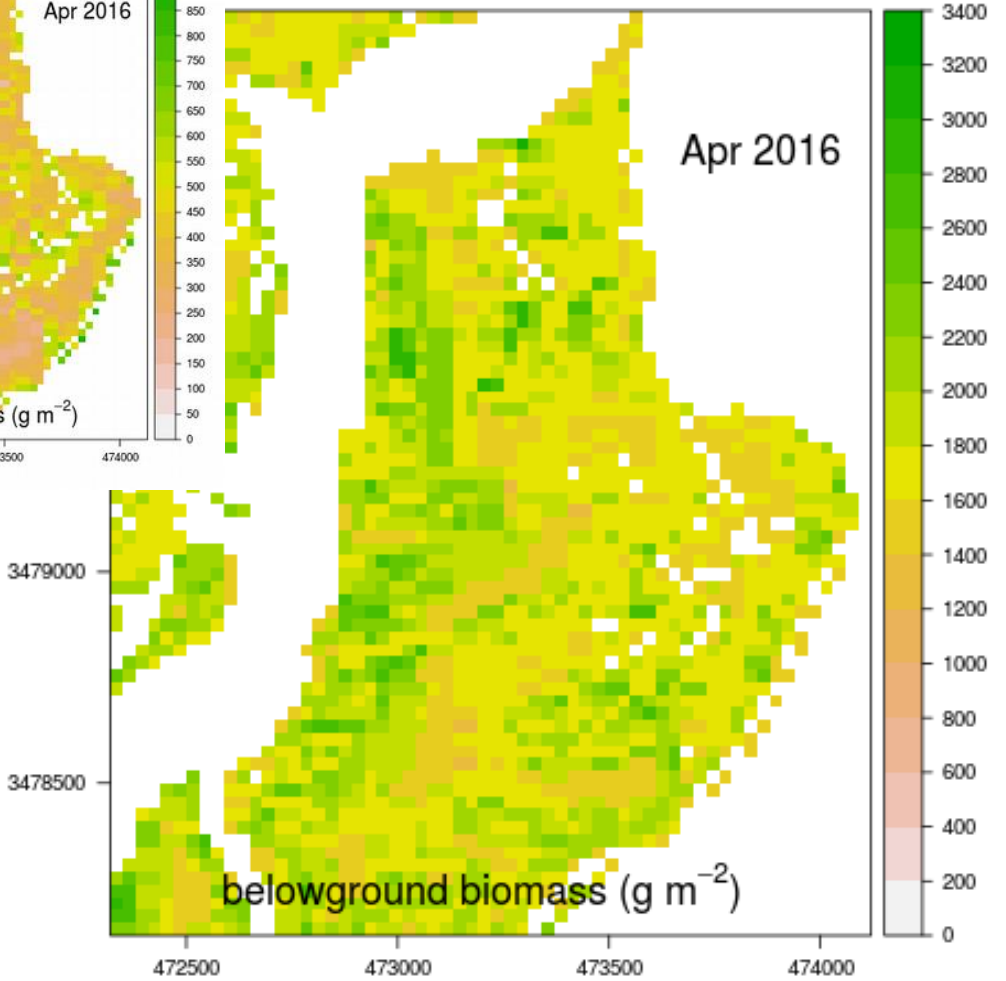

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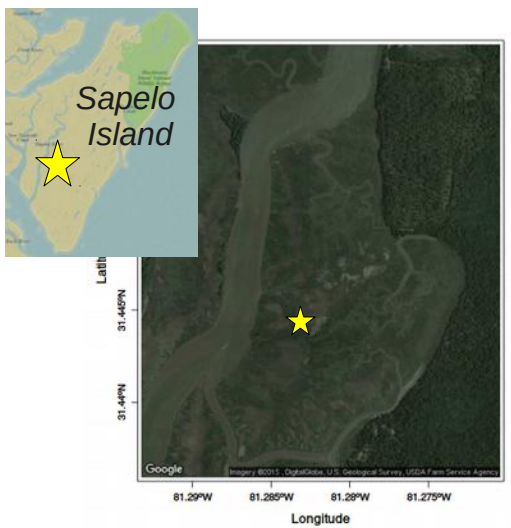

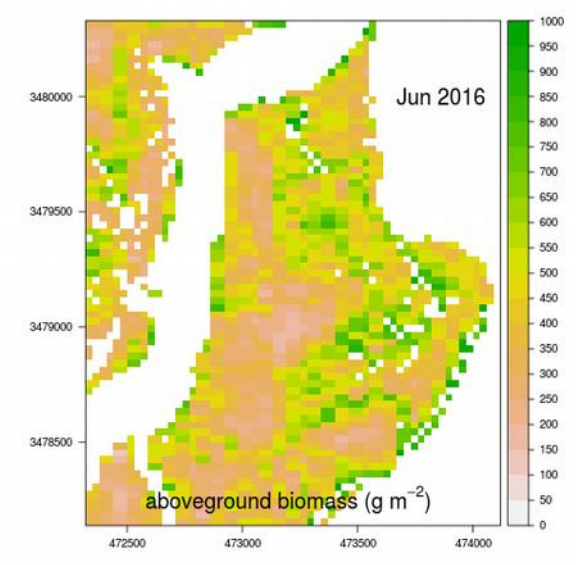

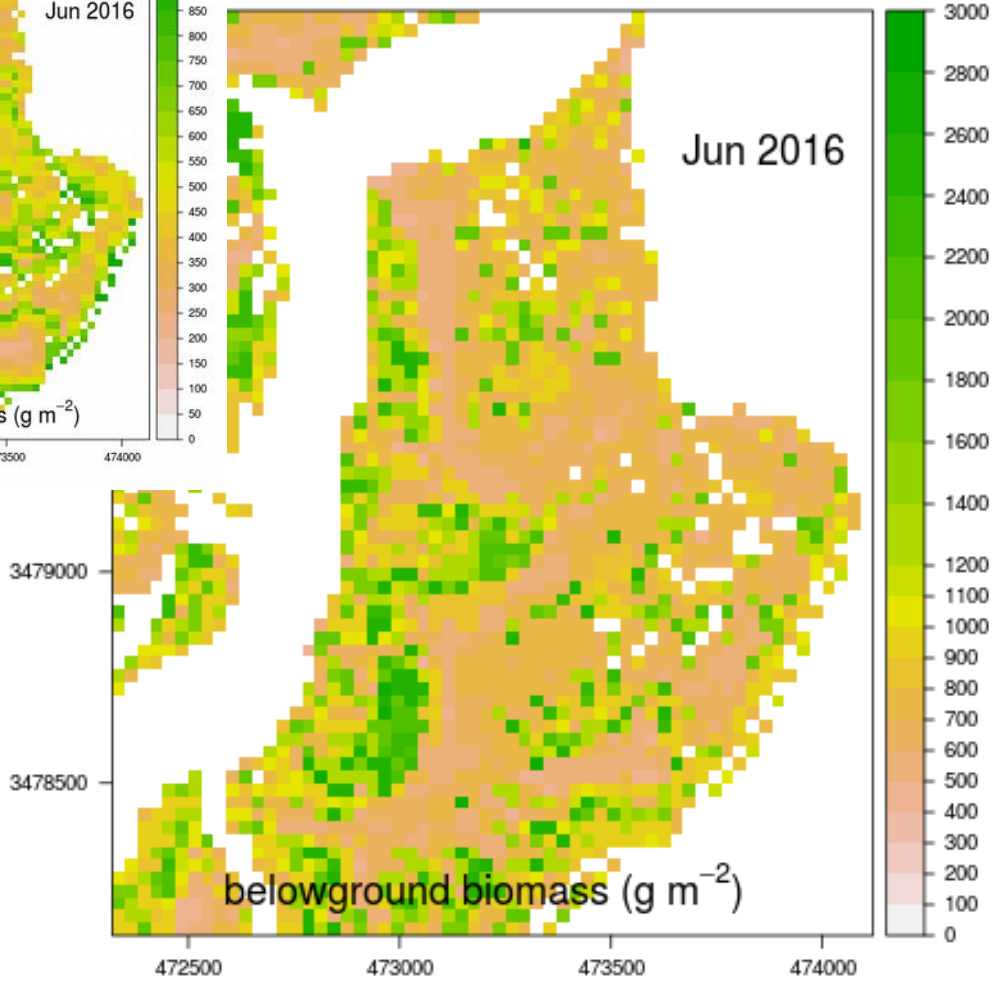

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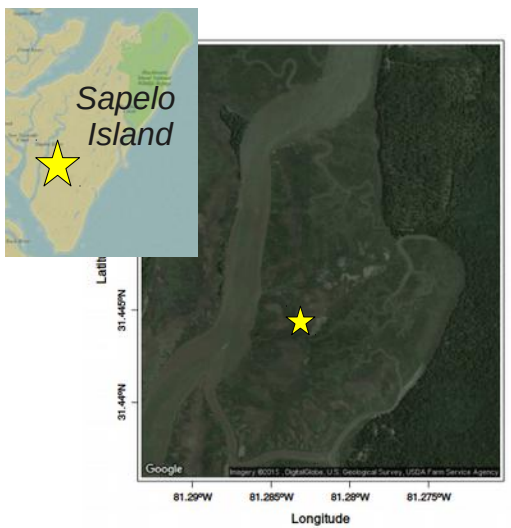

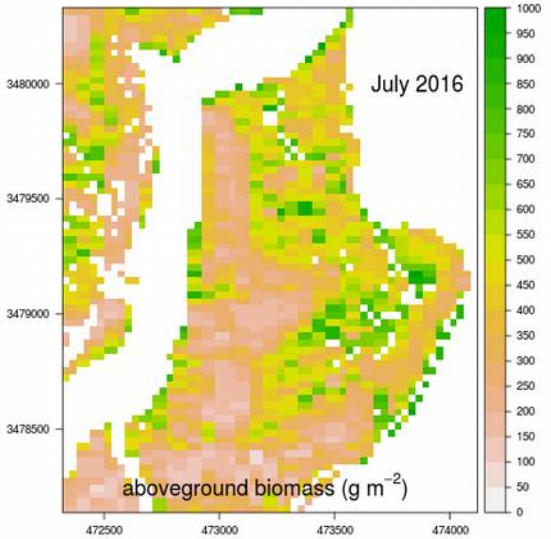

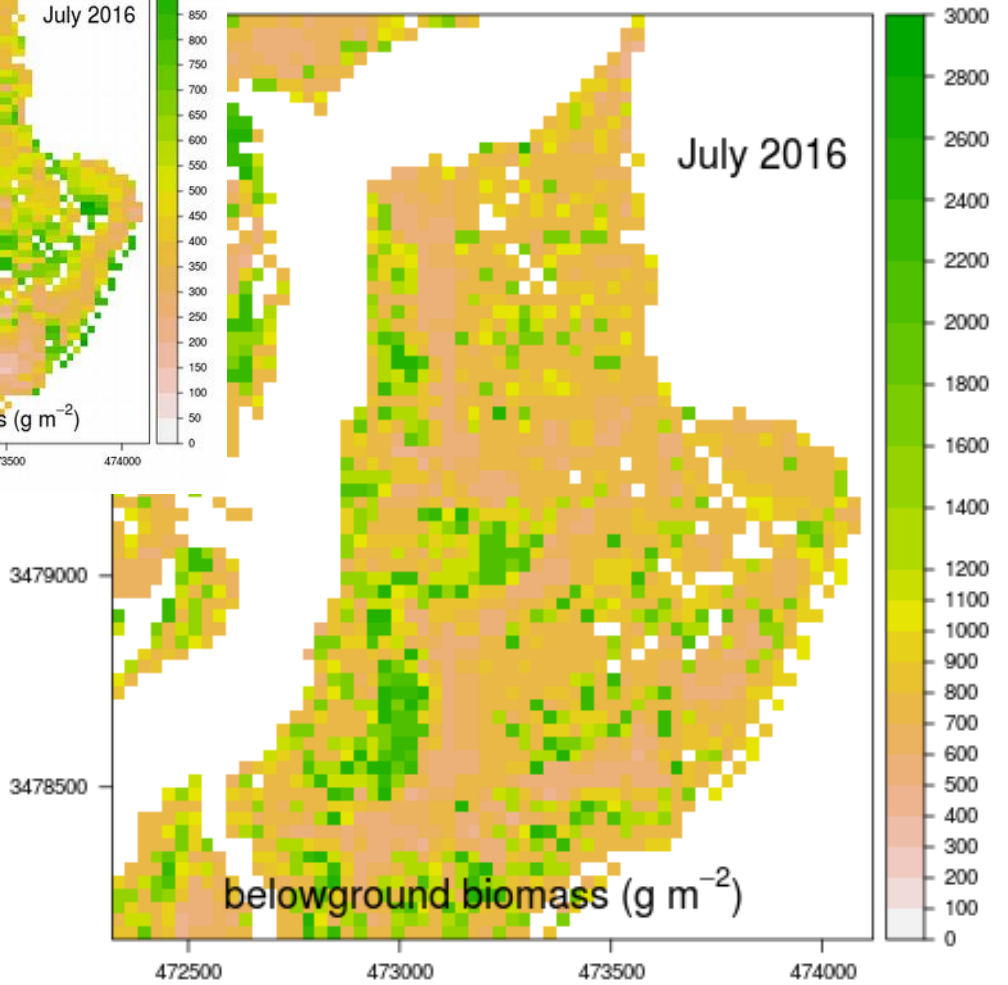

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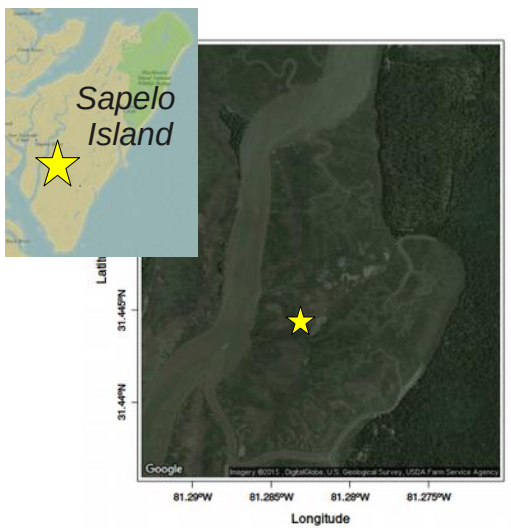

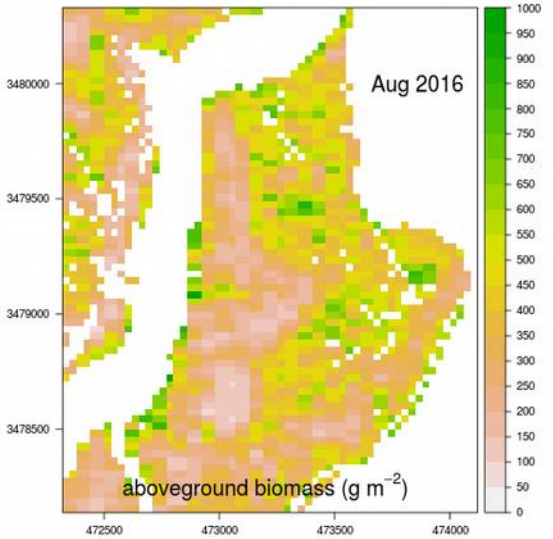

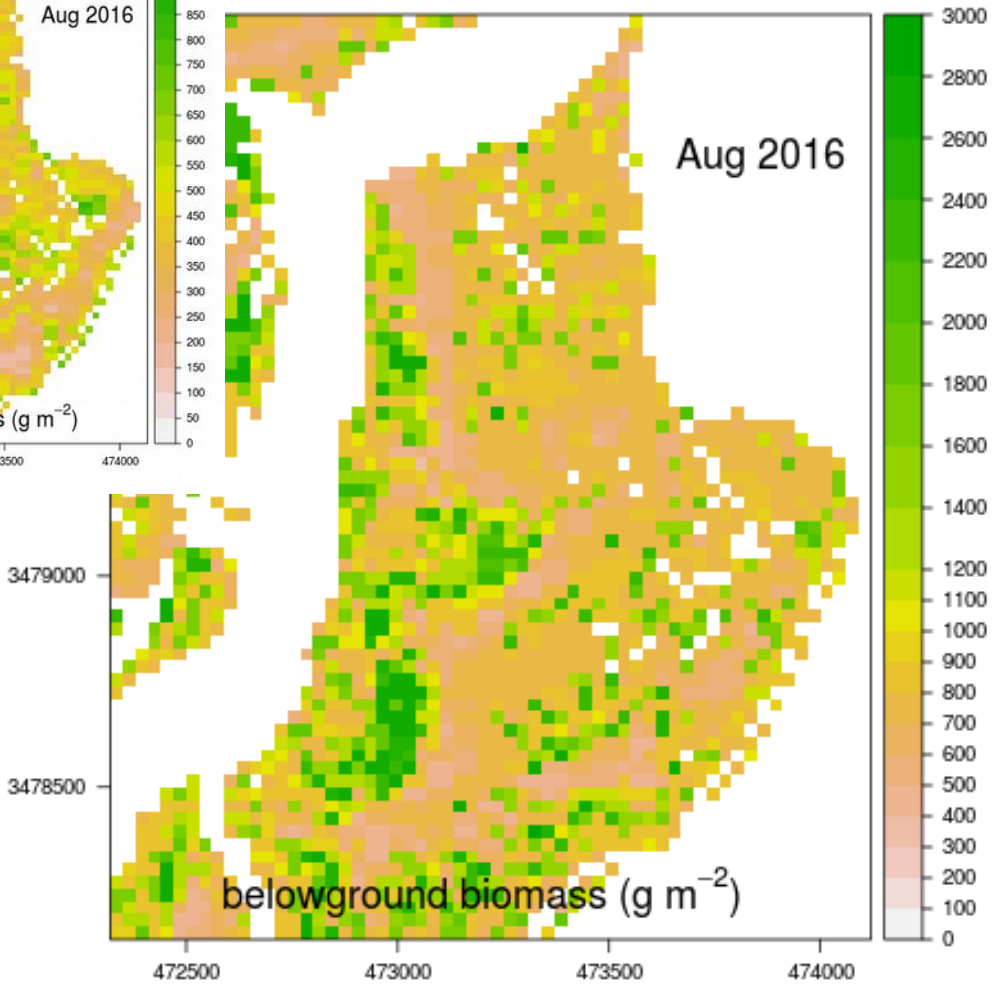

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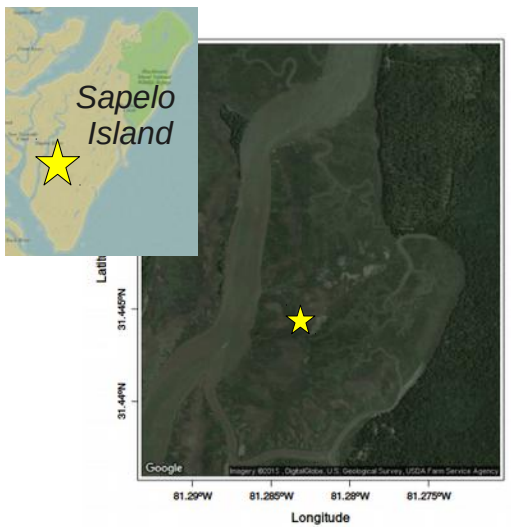

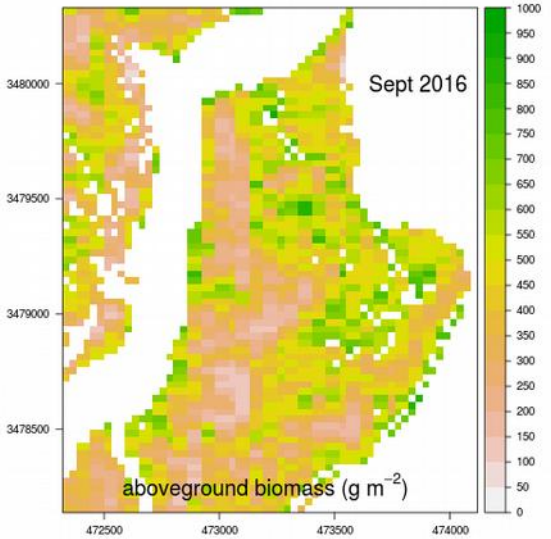

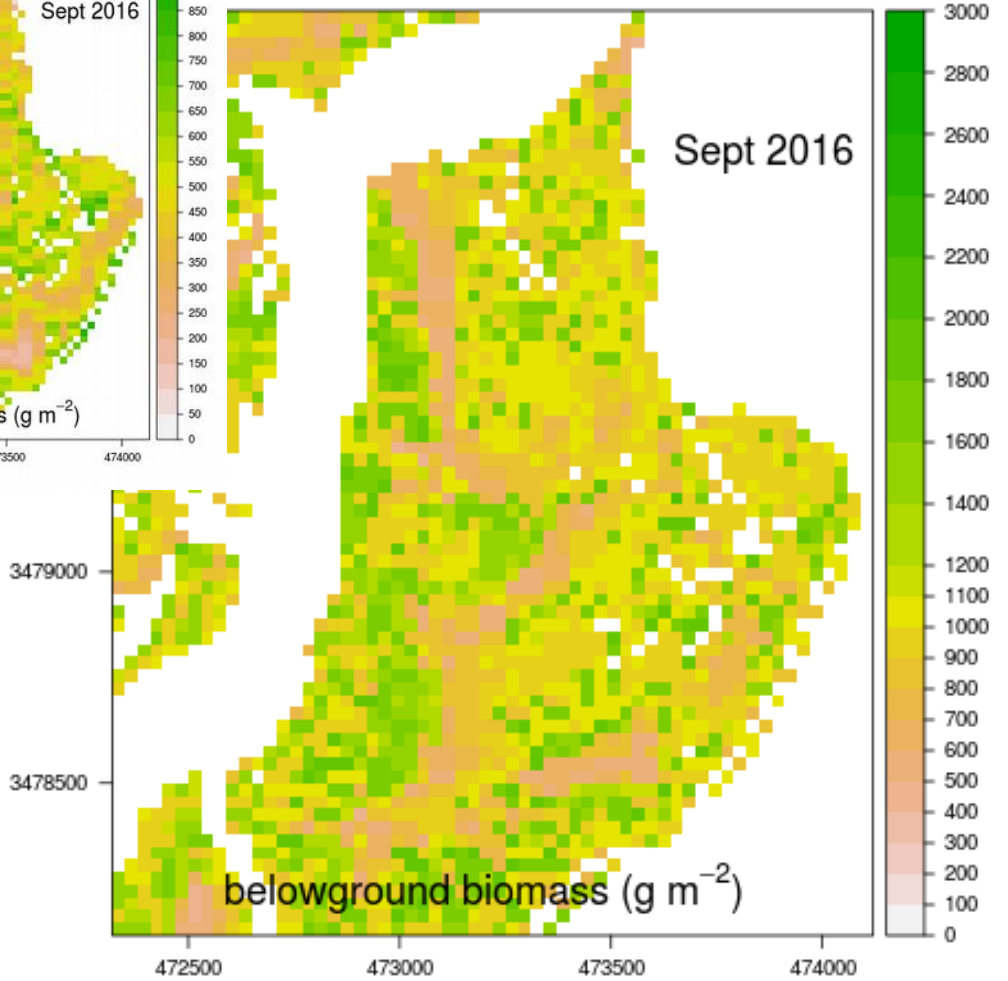

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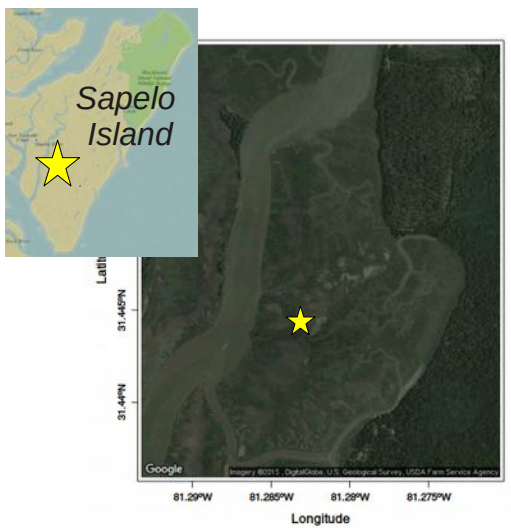
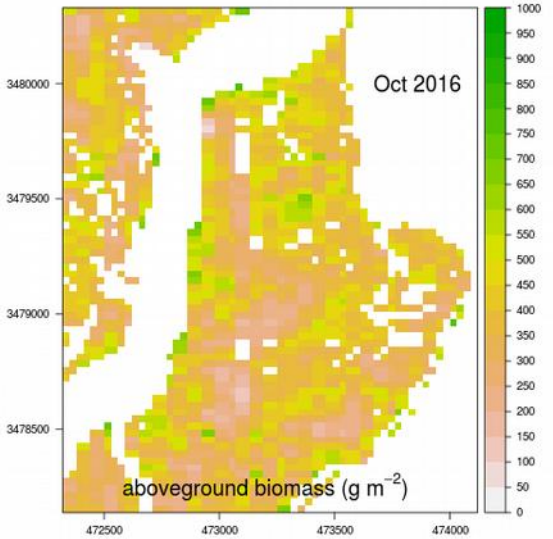
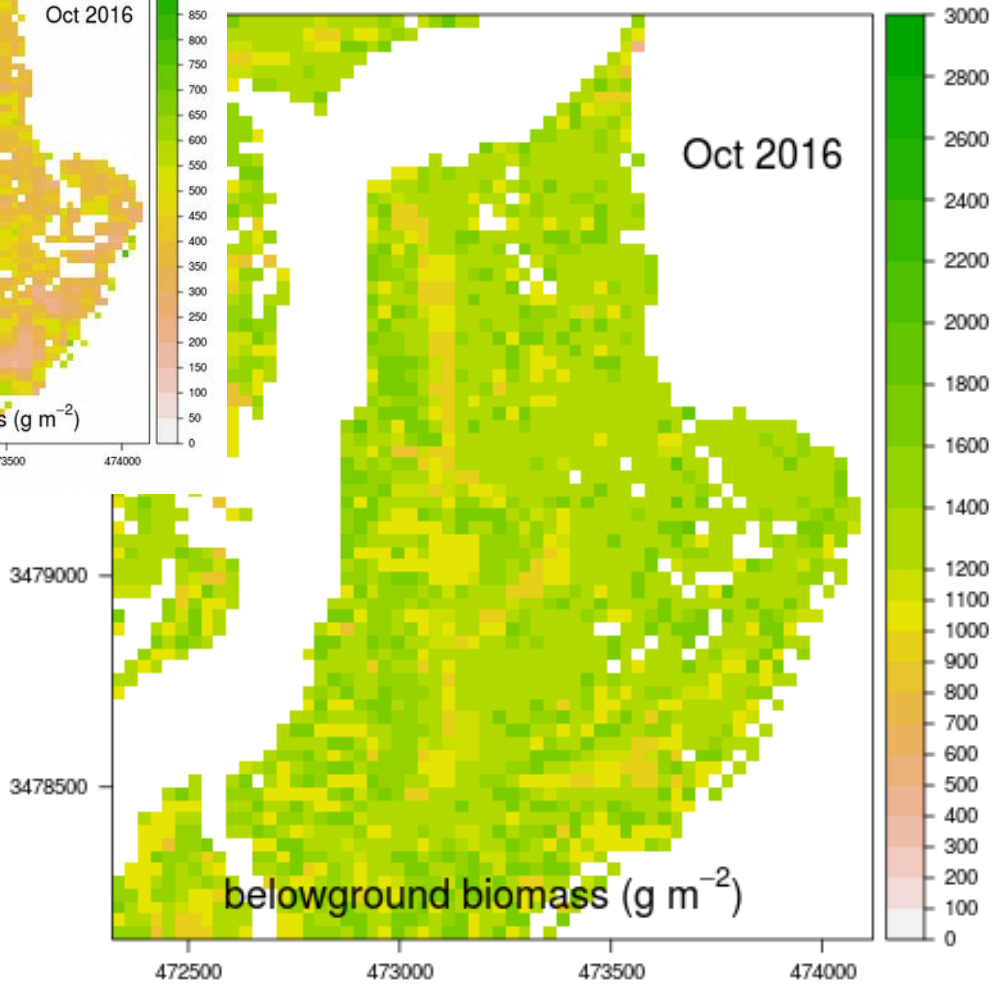






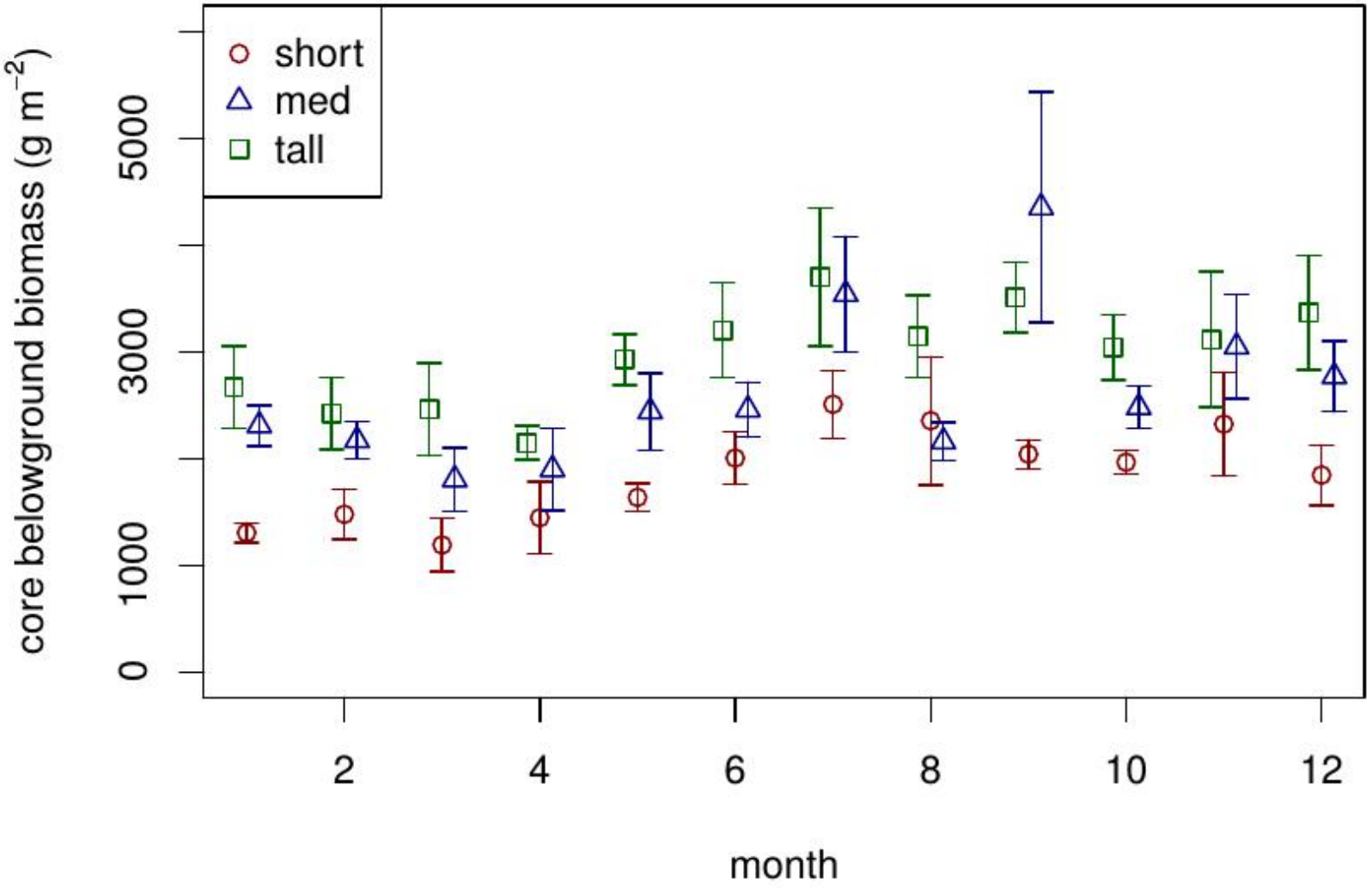
Conclusions

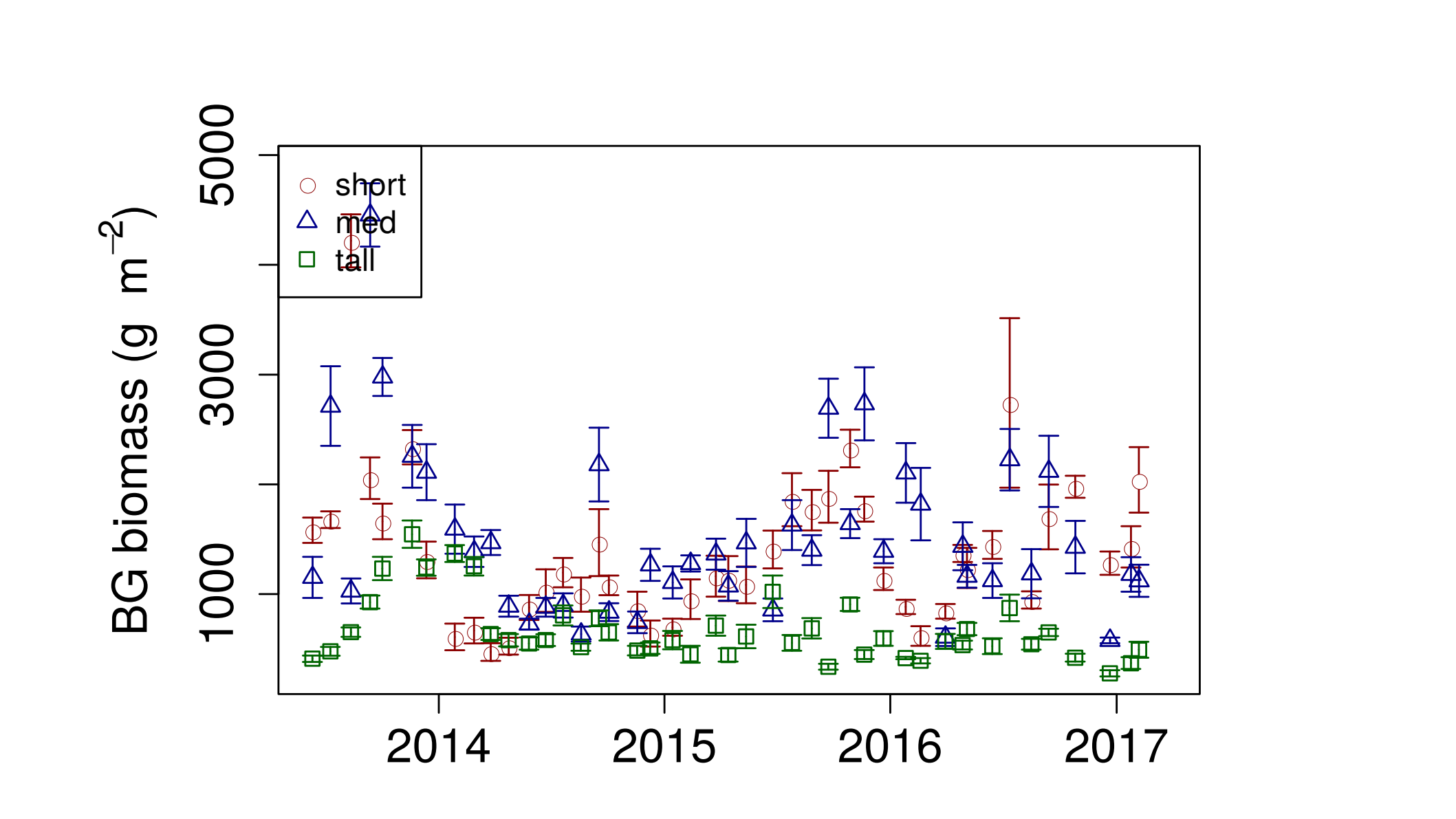
- Spectral reflectance estimates of belowground biomass possible for many marsh plants
- Future work will extend and automate these models
- Future work also will examine drivers, broad spatial patterns and long-term trends

Acknowledgements

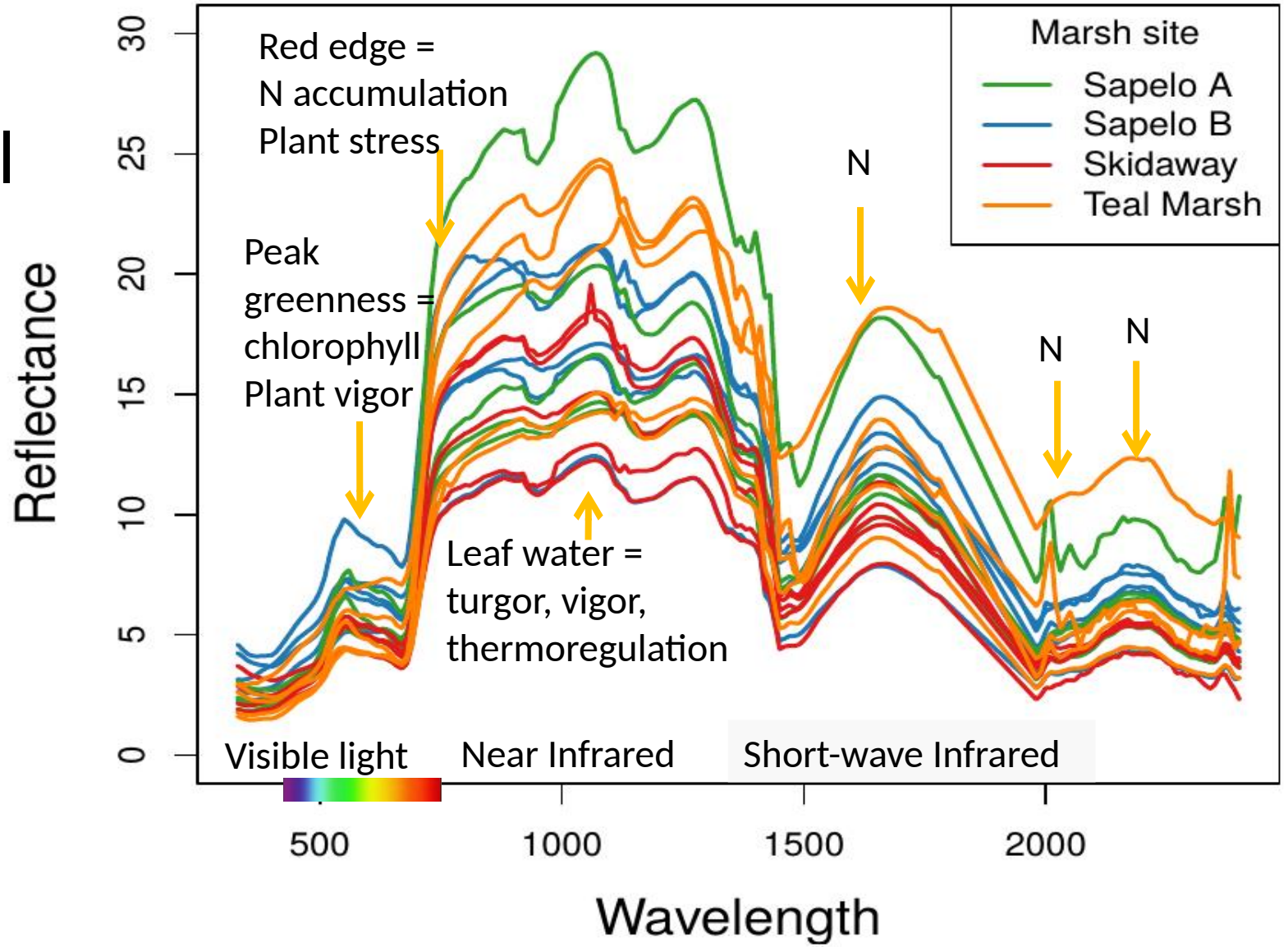
- Supported by the Georgia Sea Grant and the Georgia Coastal Ecosystems Long-Term Ecological Research project

- We thank Adam Sapp, Steve Pennings, Caroline Reddy, Tim Montgomery, Shuvo Ghosh, Jieun Rim, and Elizabeth Benyshek for their assistance or support

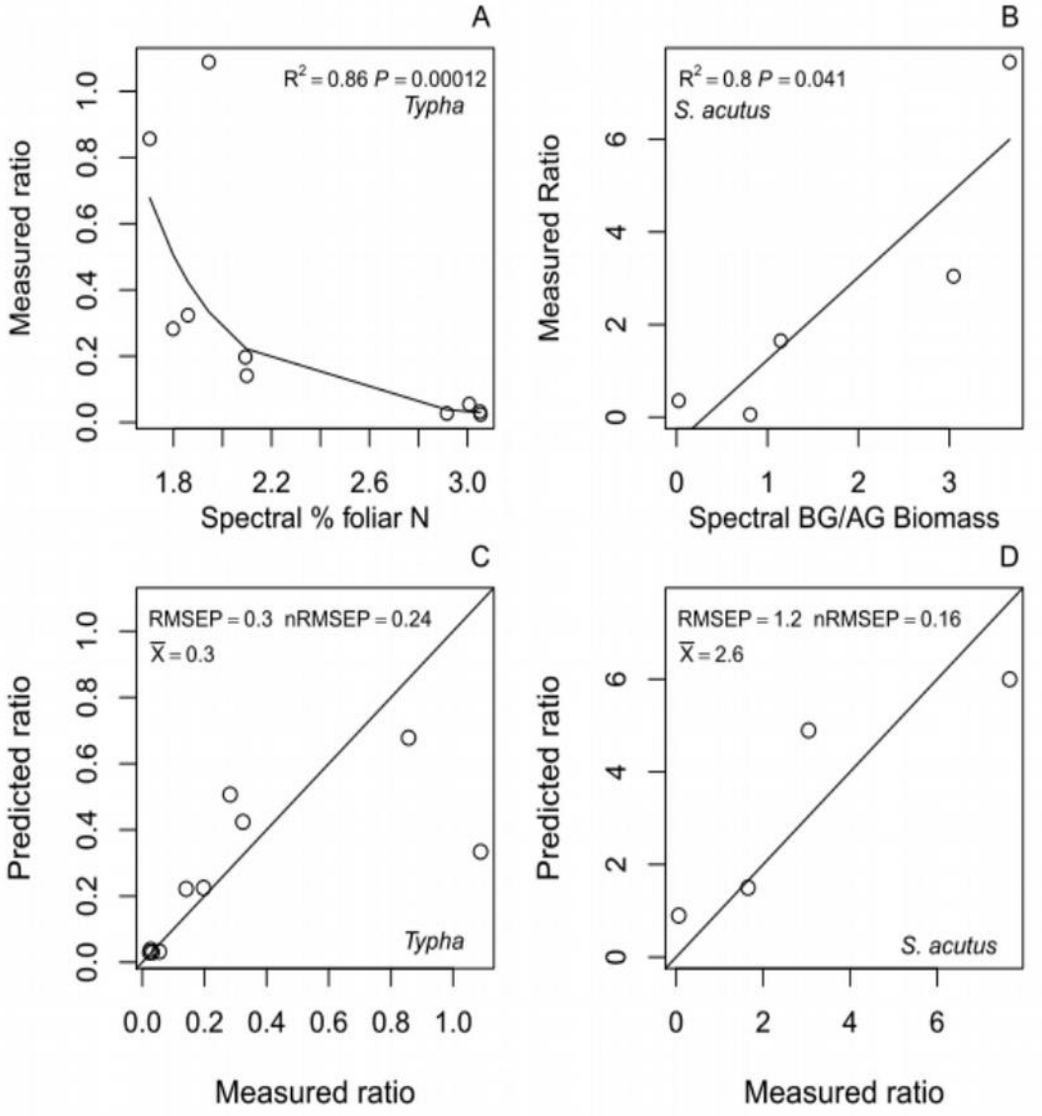

short
med
tall
core belowground biomass (g m^{-2})
0
1000
3000
5000
2
4
6
8
10
12
month


BG biomass (g m^{-2})
1000
3000
5000
short
med
tall
2014
2015
2016
2017

In situ hyperspectral

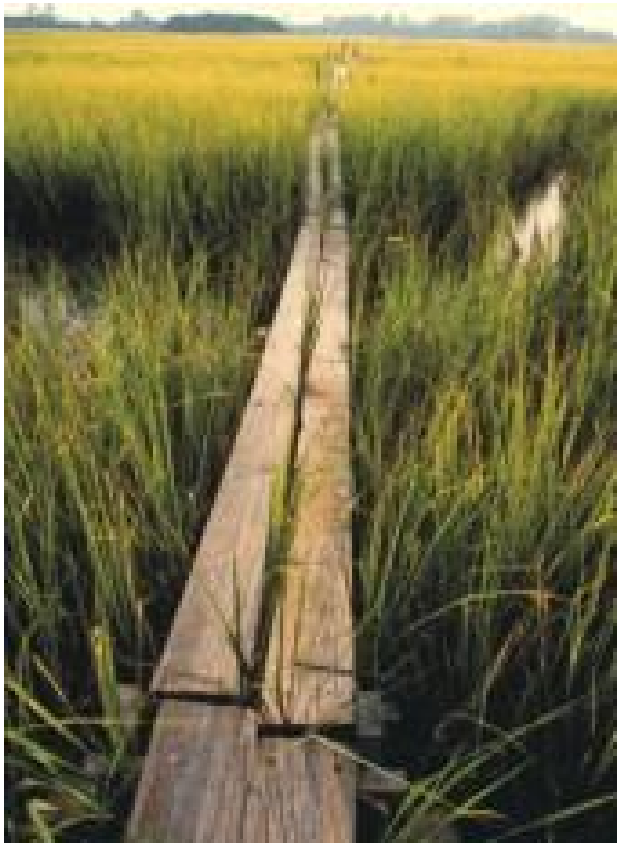


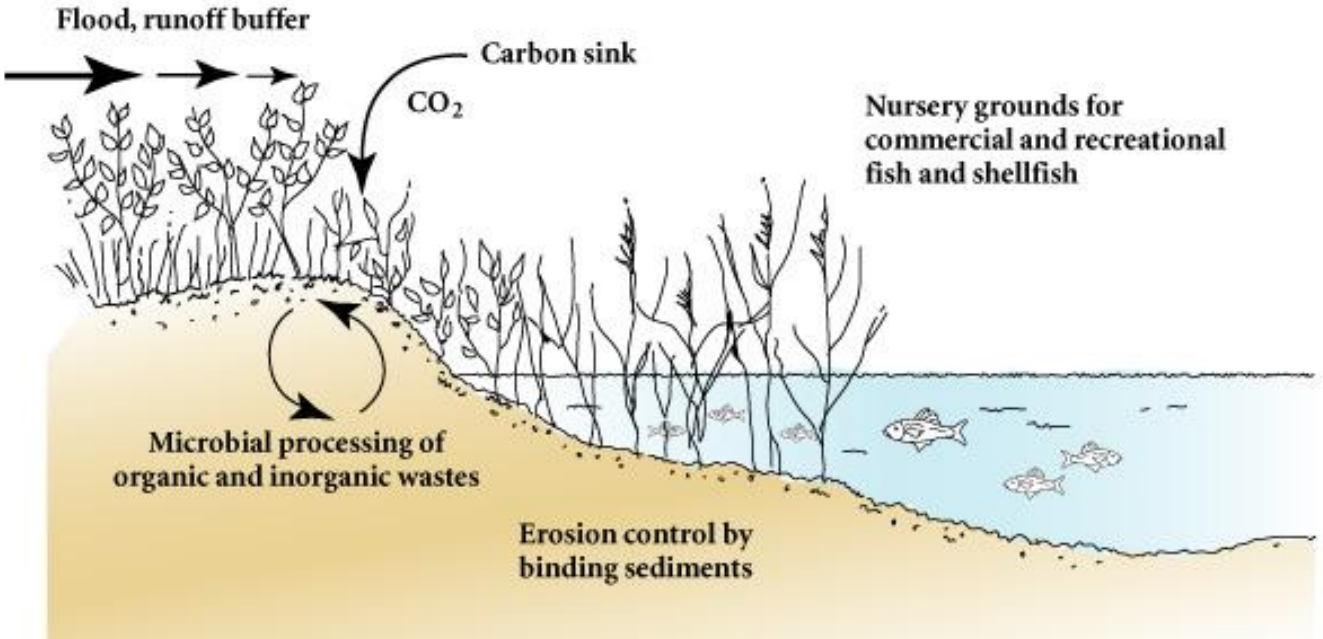
Previous work



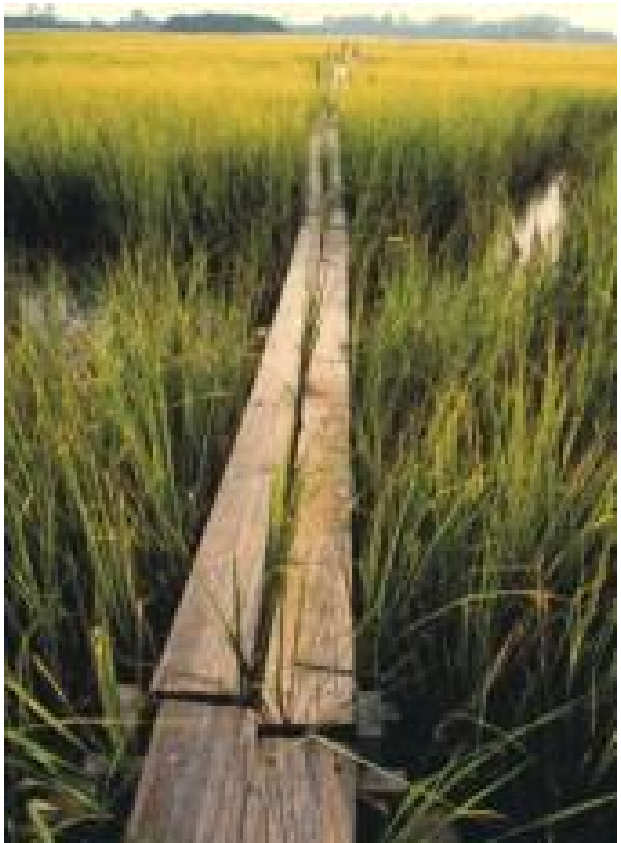
From: O'Connell, Byrd, Kelly. 2015. Remote Sensing

Tidal wetland ecosystem services

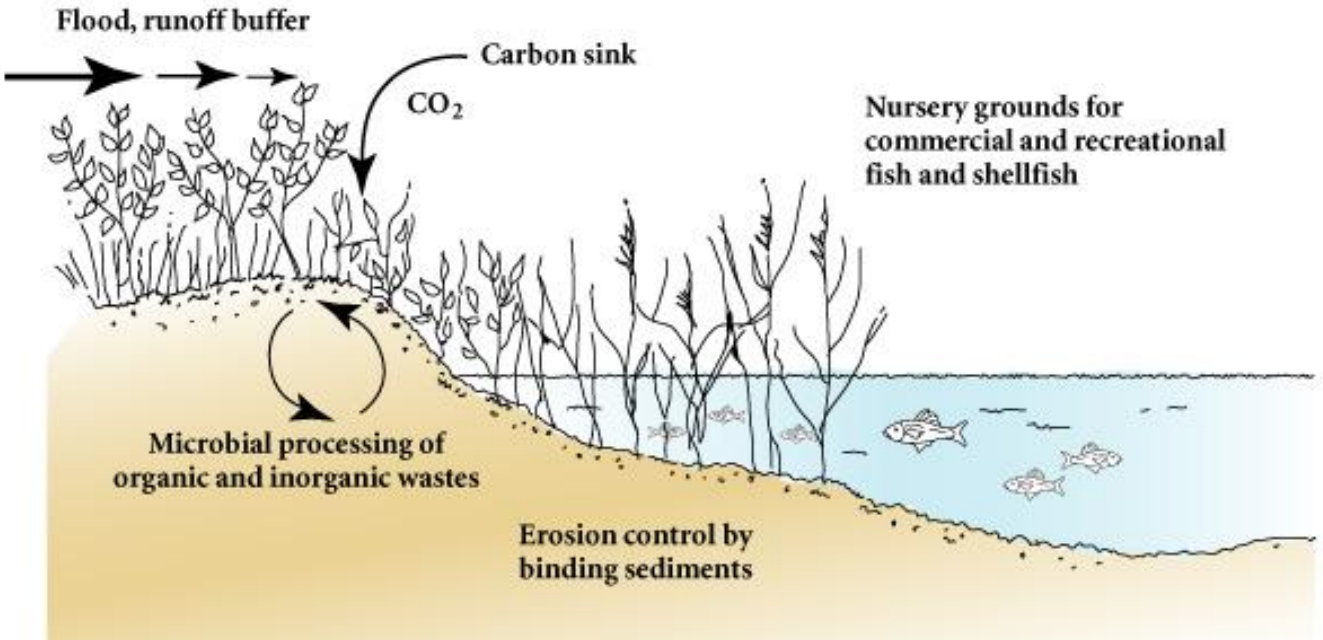


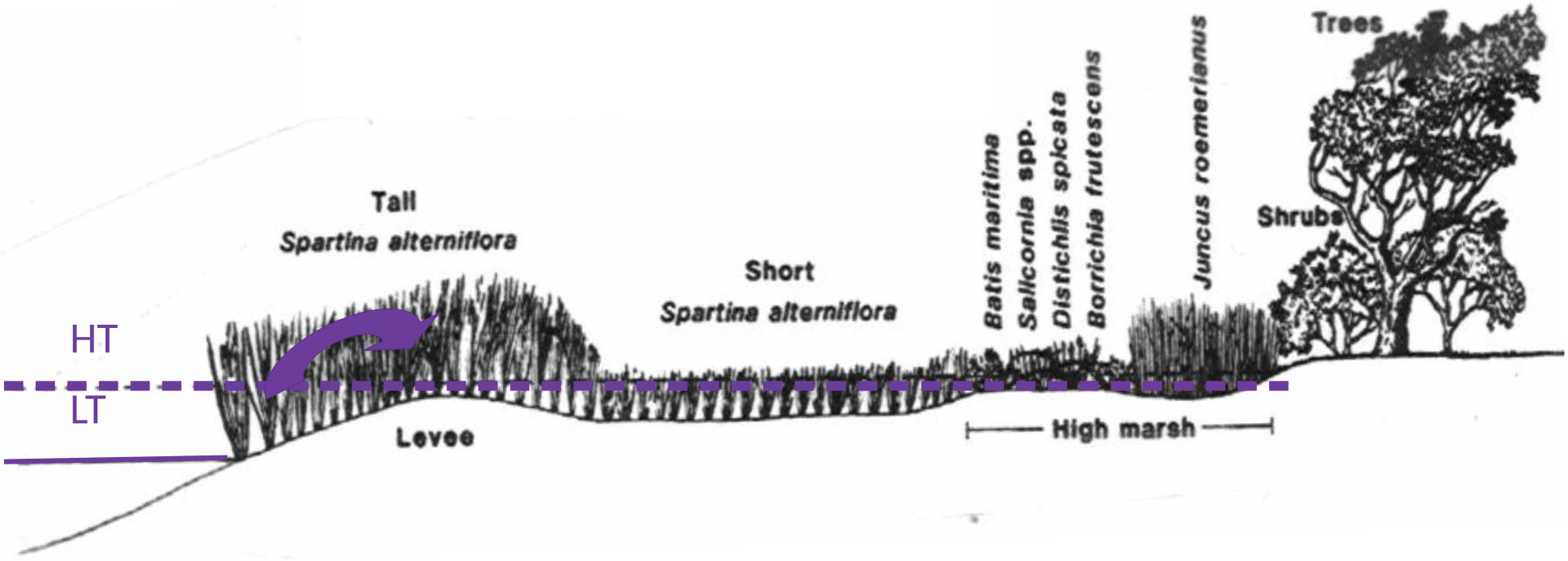


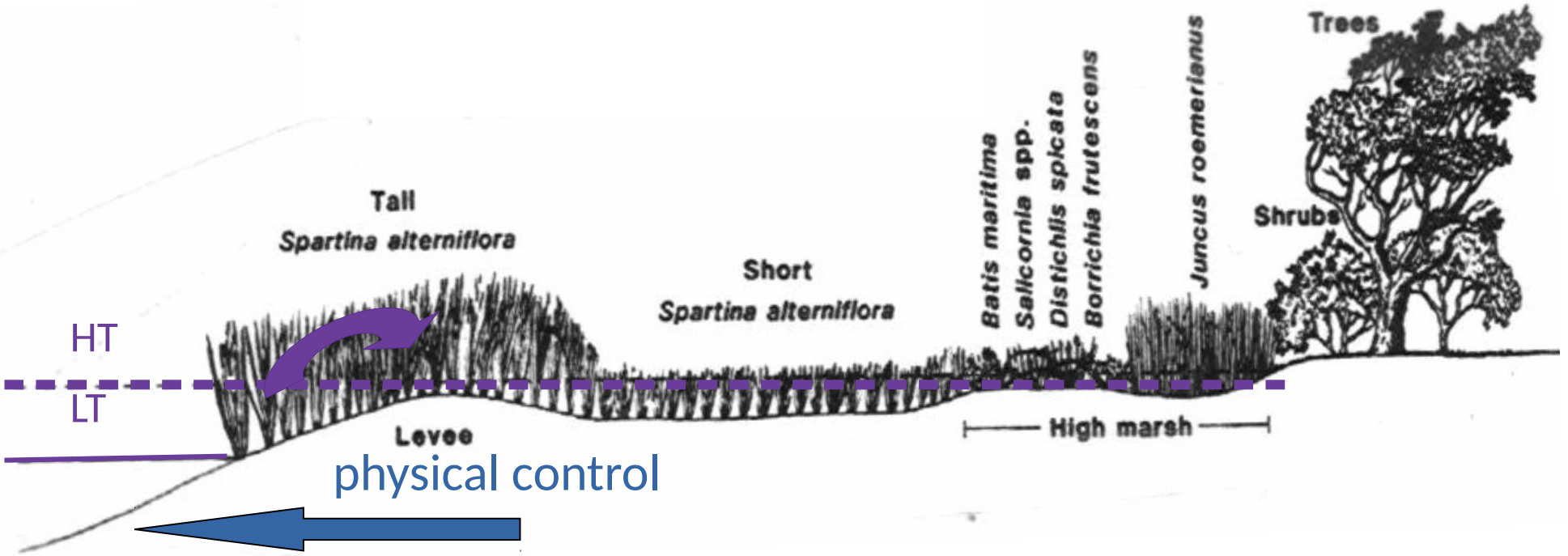
Tidal wetland ecosystem services



"Blue Carbon" (Mcleod et al. 2011)




Trees
Shrubs
Juncus roemerianus
Borrichia frutescens
Distichlis spicata
Salicornia spp.
Batis maritima
Short
Spartina alterniflora
Tall
Spartina alterniflora
HT
LT
Levee
High marsh

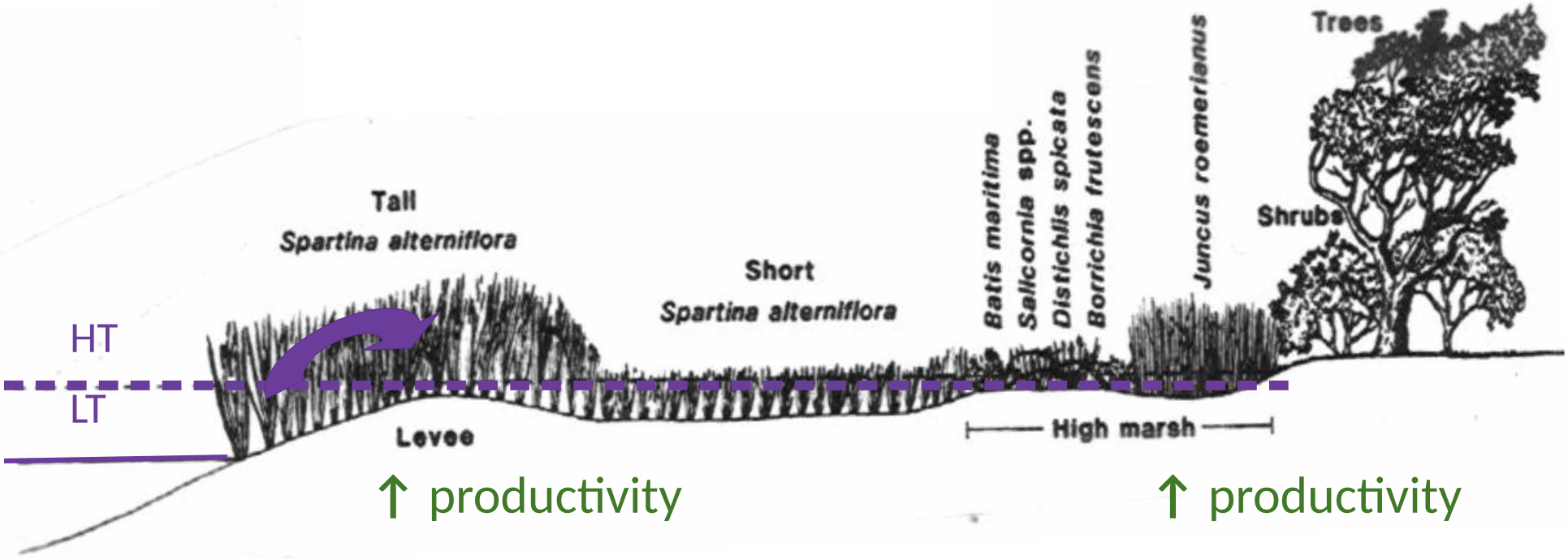


physical control

↑ tidal inundation
↑ tidal flushing
↑ O_2
↑ Sedimentation, N
↓ salinity
↓ H_2S

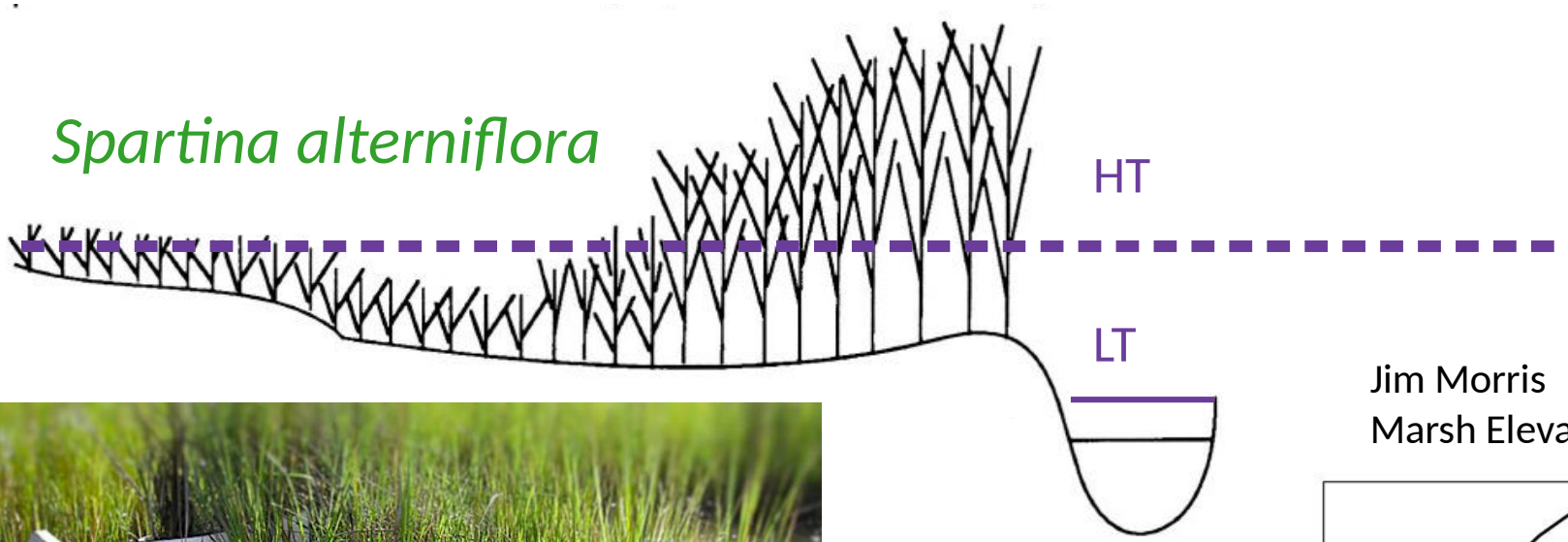
Elevation drives gradients in inundation and salinity

Environment filters species recruitment

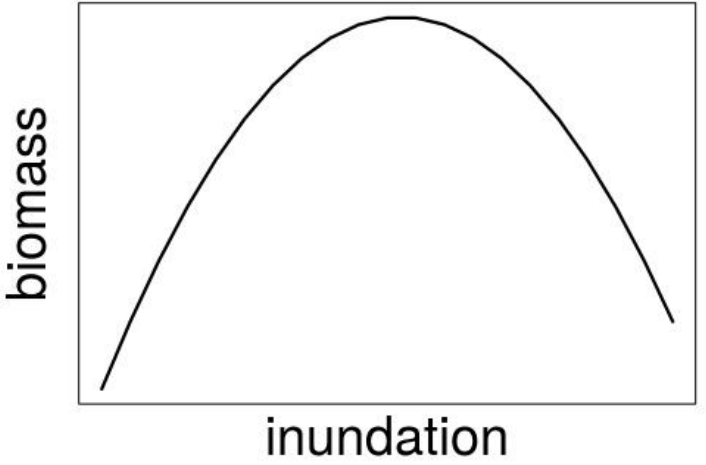


Elevation drives gradients in productivity

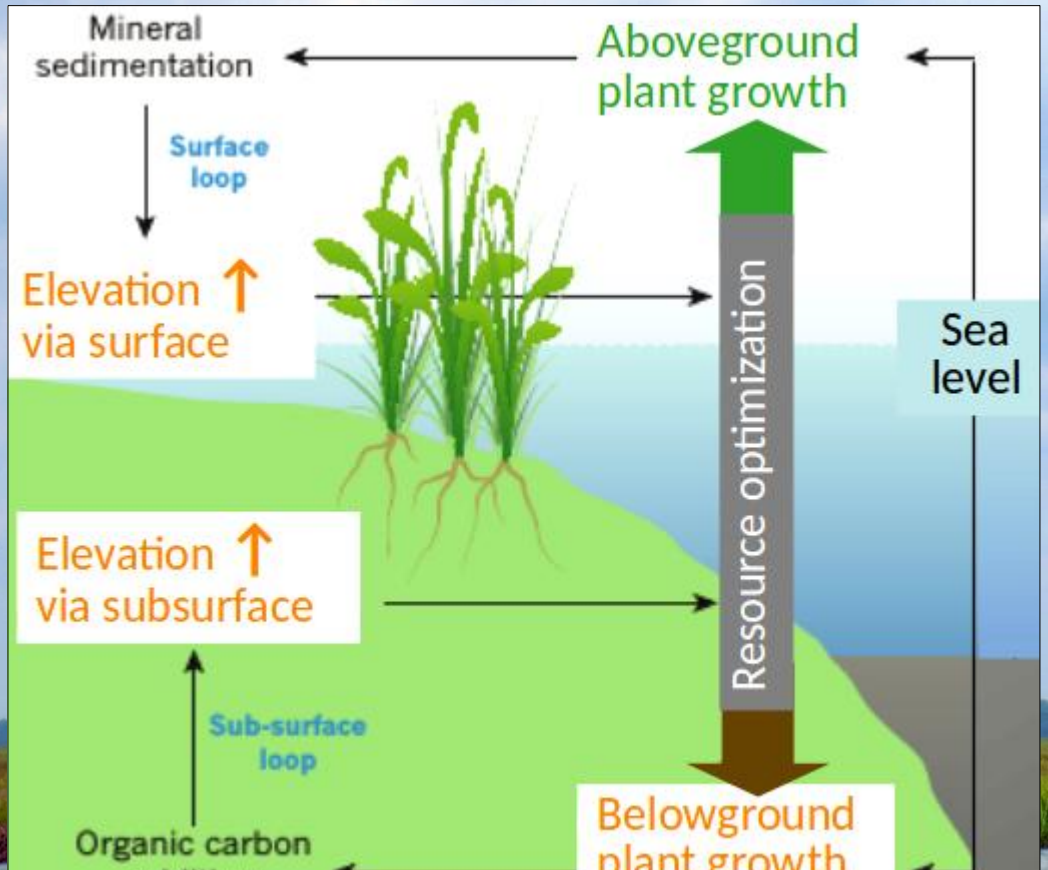
Elevation drives gradients in productivity

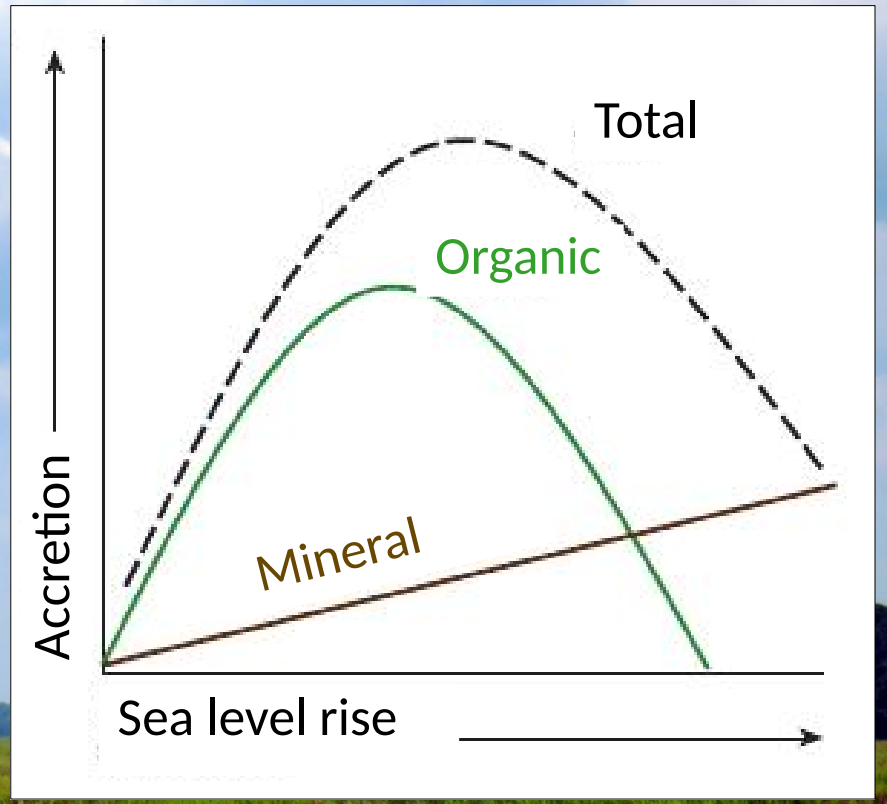


Jim Morris
Marsh Elevation Model (MEM)



Productivity also drives elevation

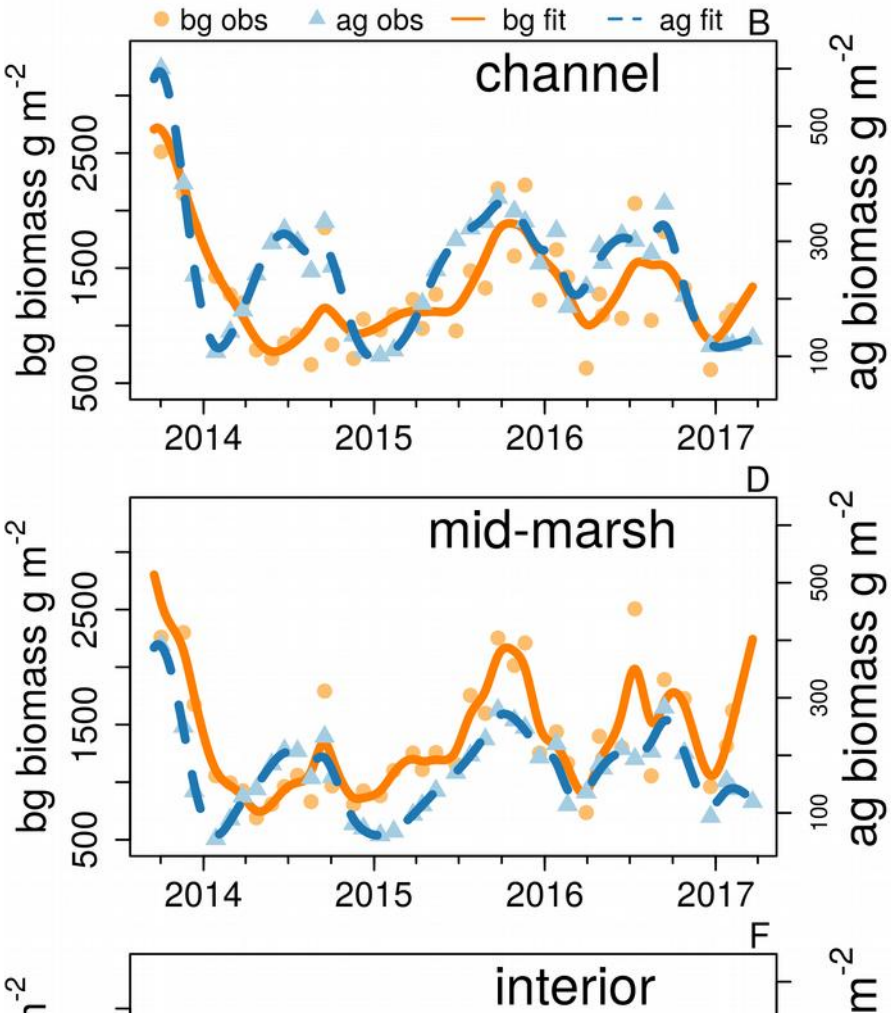


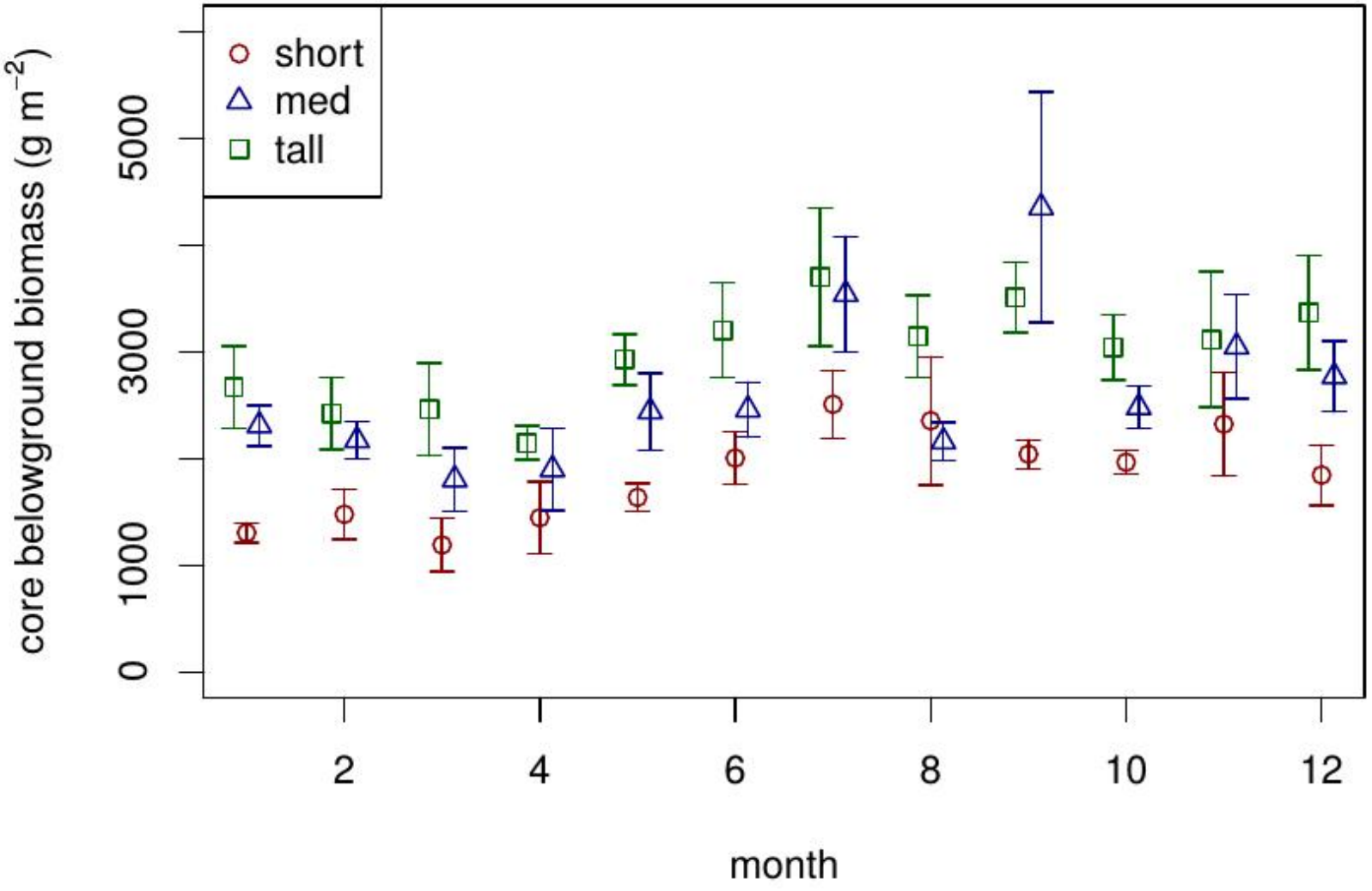


Previous work: California's Sacramento-San Joaquin Delta

- Estimated belowground biomass and root:shoot ratio in tidal freshwater marsh (*Schenoplectus acutus*, *Typha*)
- Used hybrid modeling to join spectral estimates of foliar N & aboveground biomass to estimate belowground

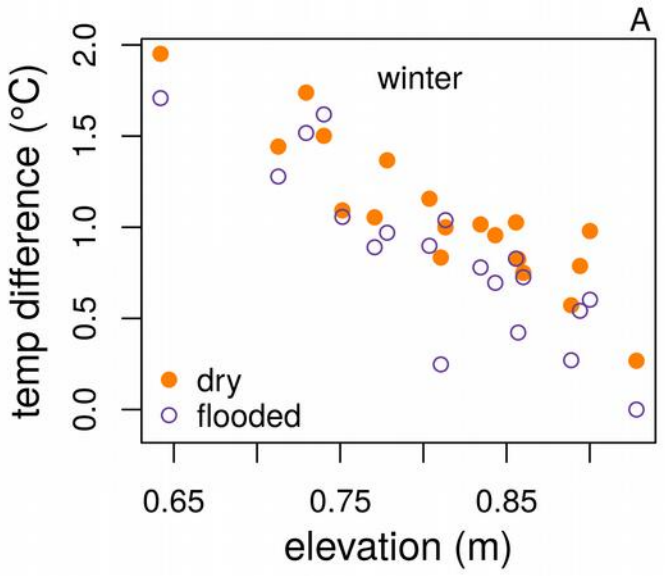
Plot scale phenology

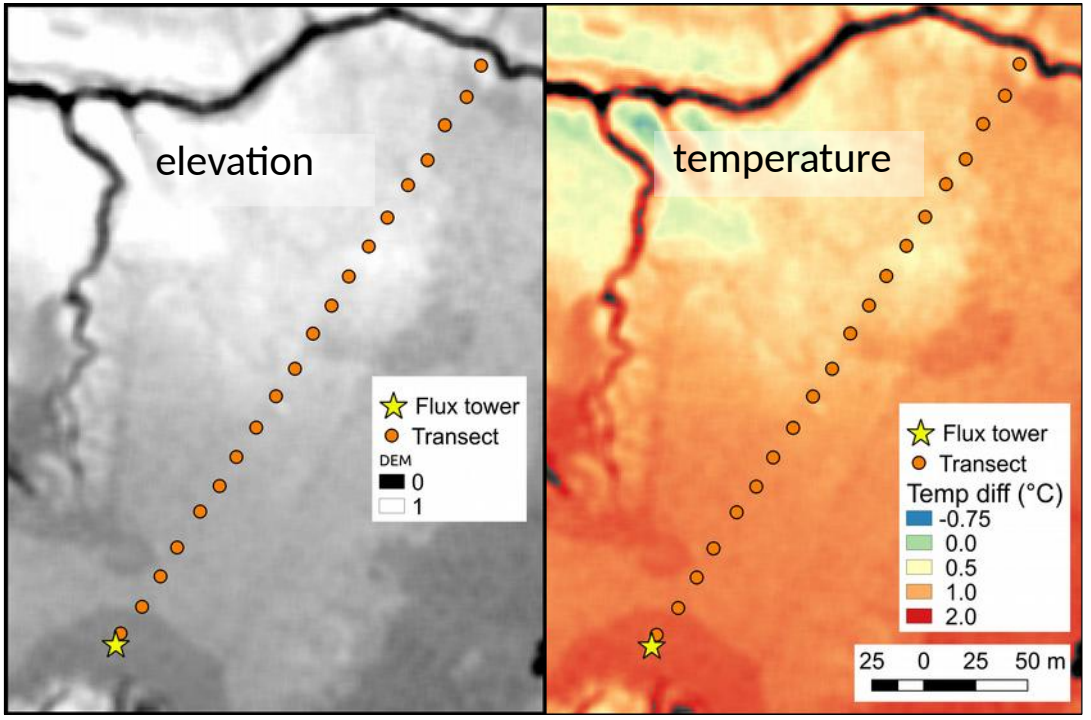



short
med
tall
core belowground biomass (g m^{-2})
0
1000
3000
5000
2
4
6
8
10
12
month

Predictors: elevation and start of growing season

- Winter soil temperature is a proxy for spring green-up and varies with elevation





Predictors: elevation and start of growing season

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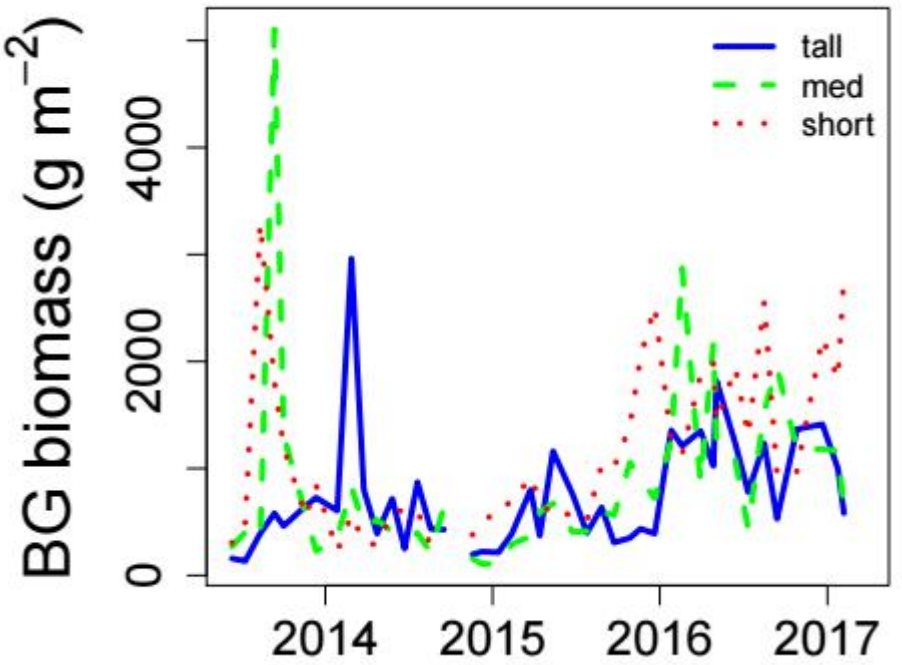
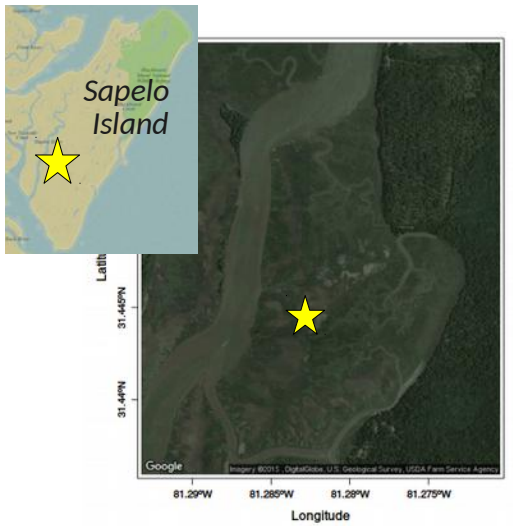
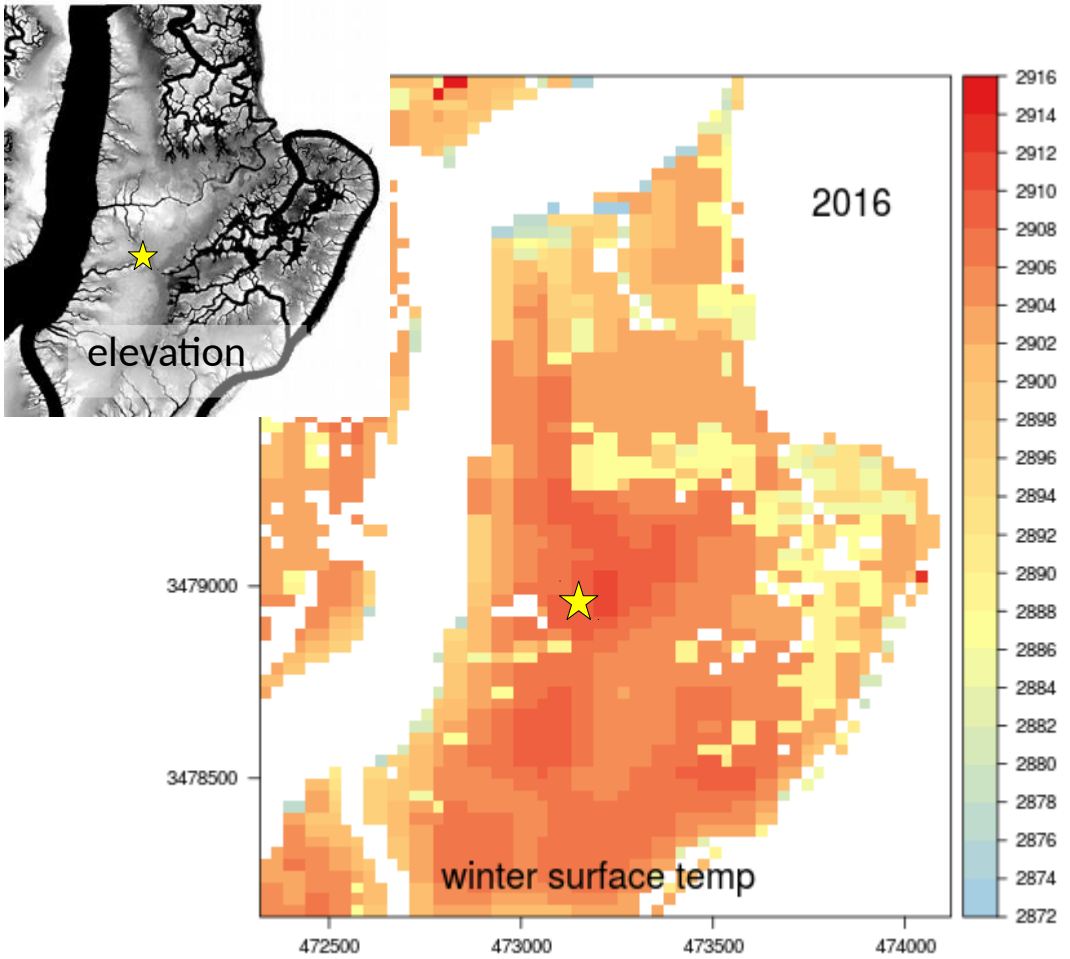


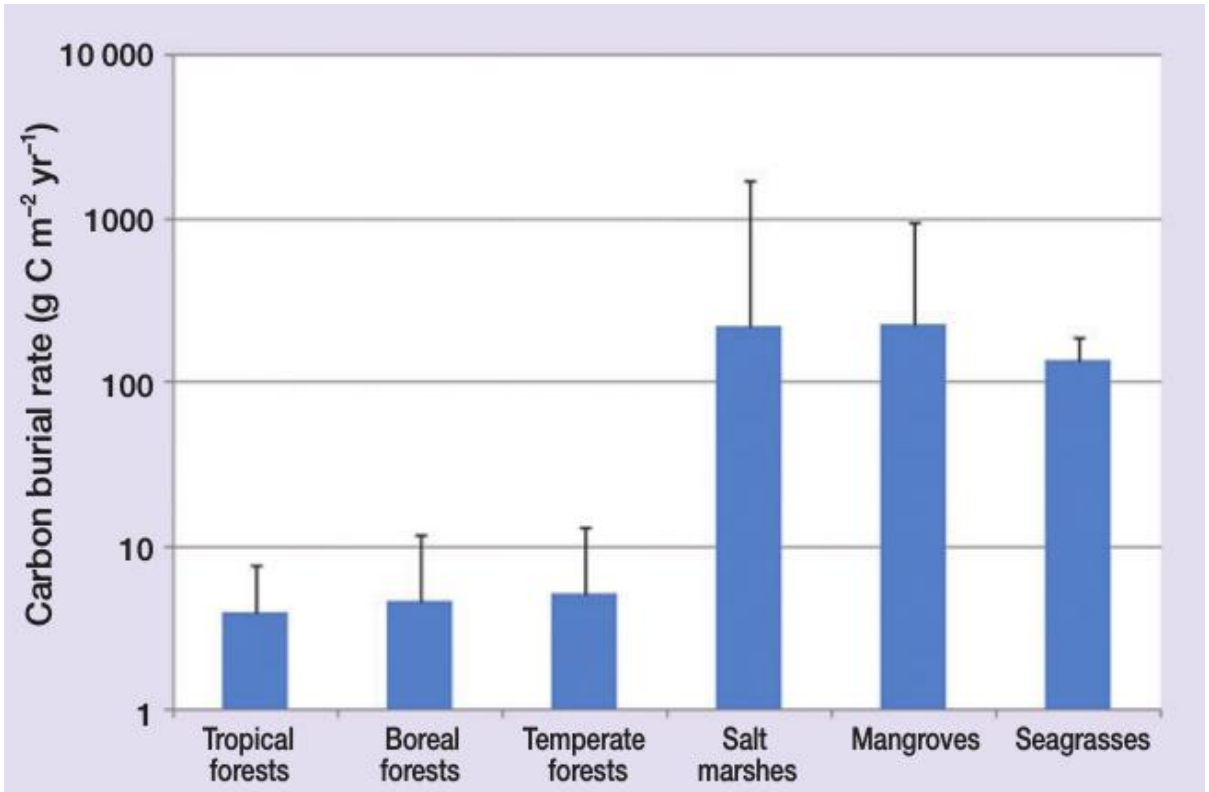
Predictors: elevation and start of growing season

- Elevation from corrected DEM
- Landsat 8 can estimate winter surface temperature variation (band 10)





Marshes highly productive



McLeod et al. 2011. Frontiers in Ecol. & the Envir.

Predictors: vegetation parameters

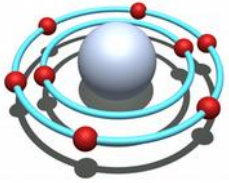
Landsat 8 spectral data

+

Aboveground biomass

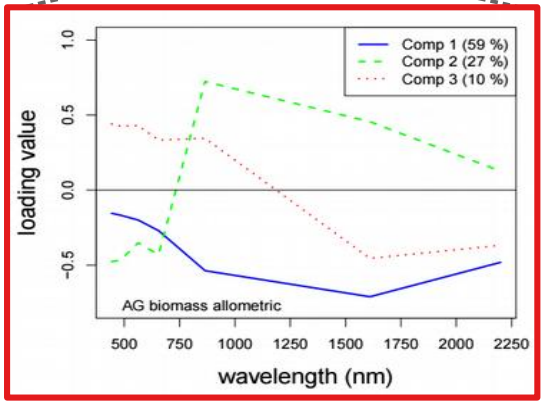
Landsat 8 spectral data

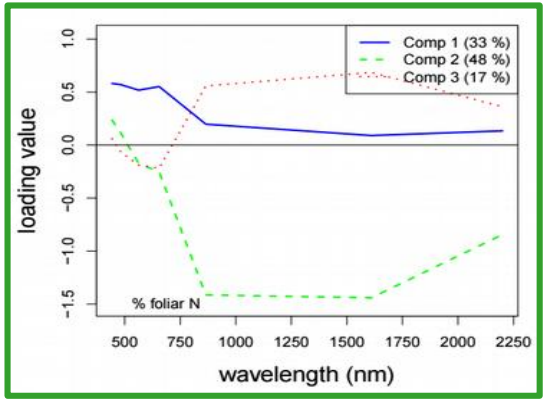
+



% chlorophyll

PLSR





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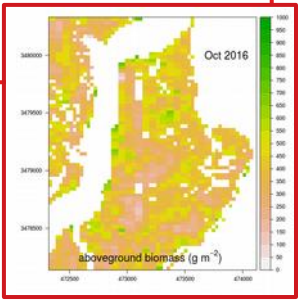
Site-wide spectral **aboveground** biomass



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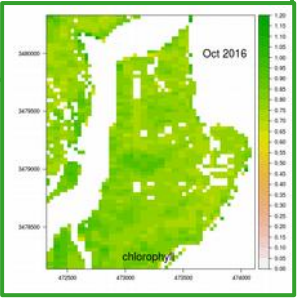
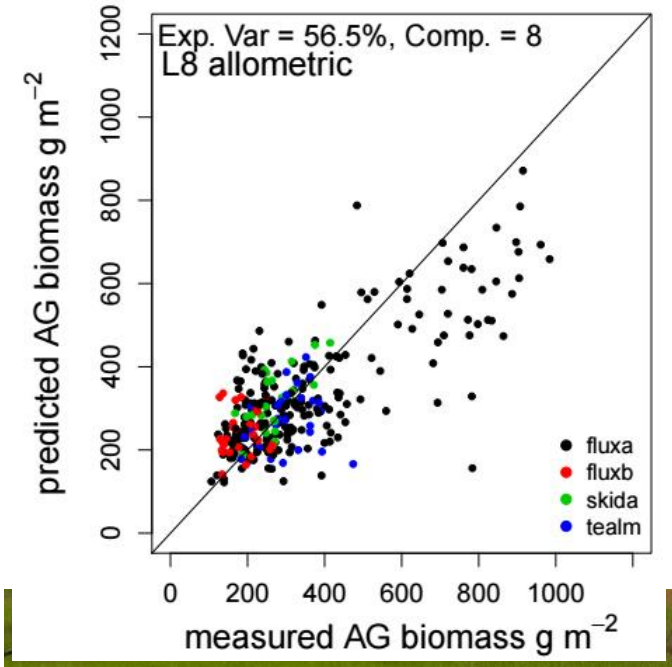
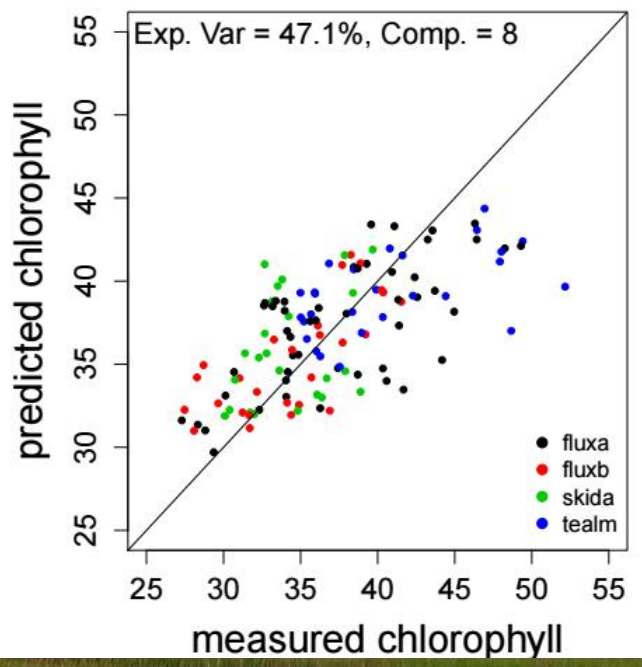
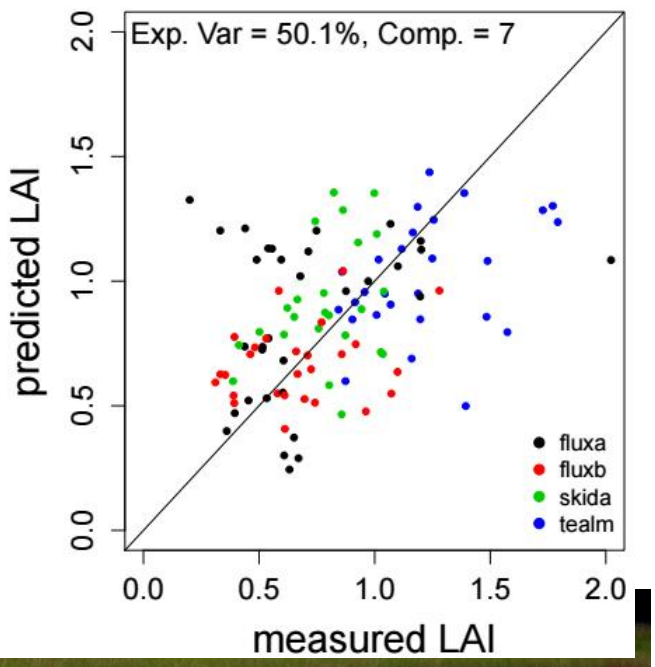
Site-wide spectral % **CHL**

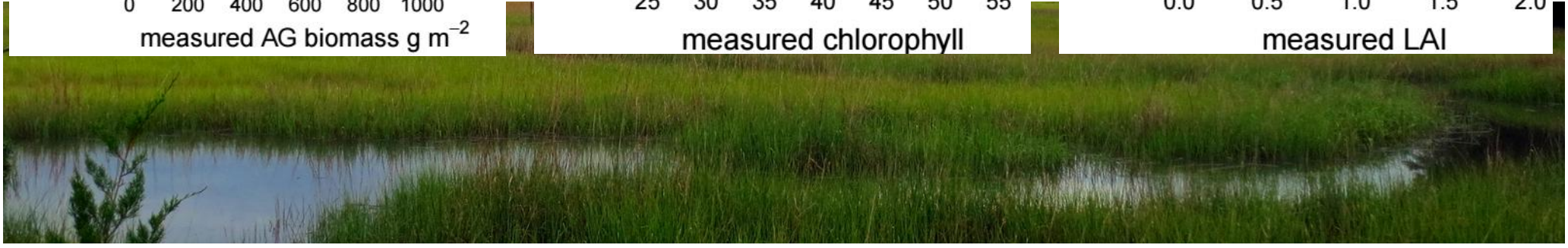


Prediction accuracy: aboveground inputs





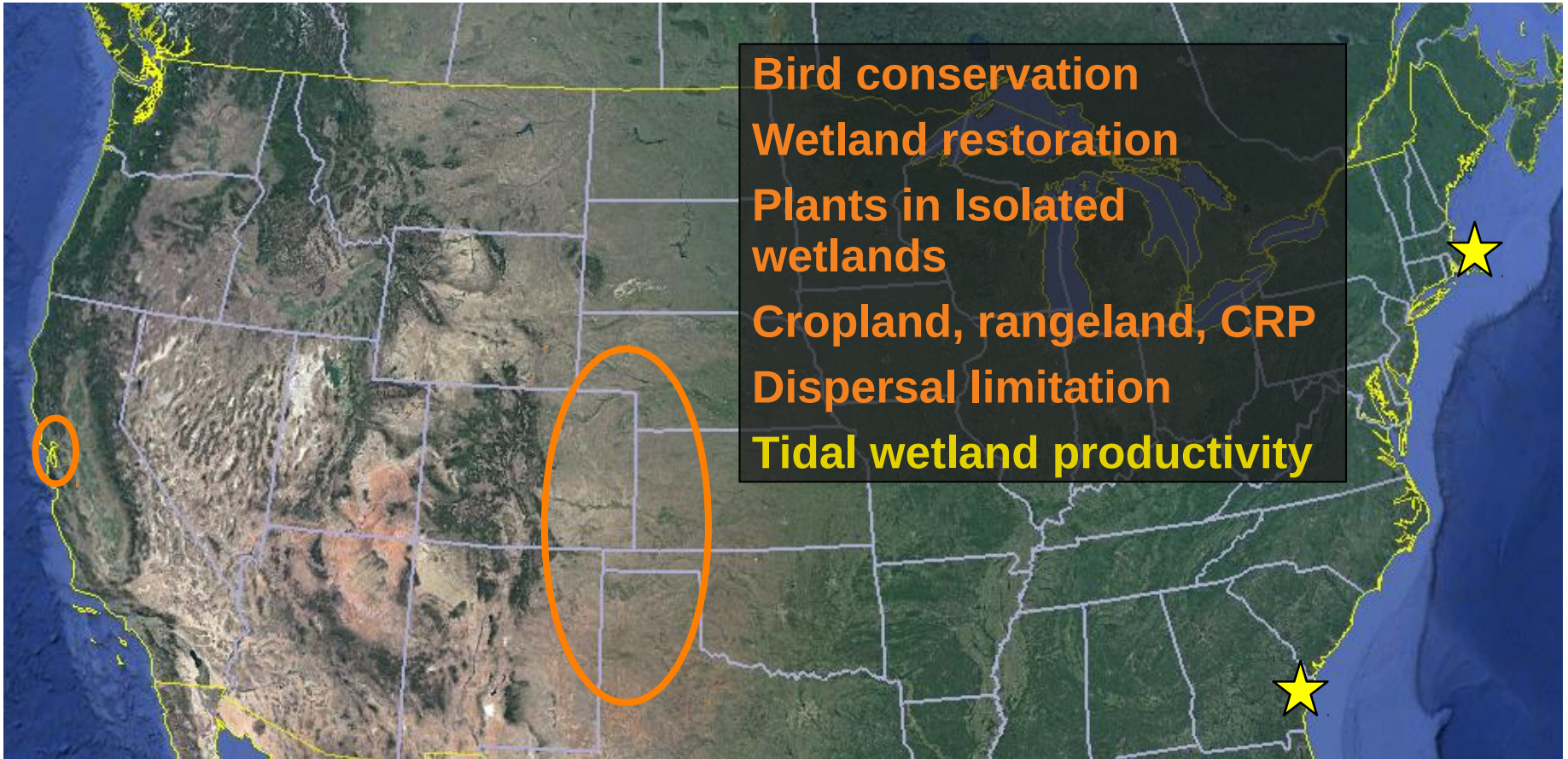




Past and current study sites

Past research

Current work



Scaling up belowground biomass

- First estimate aboveground predictors from satellite data
- Create hybrid model that combines aboveground predictors into a belowground biomass estimate