Sustainability of Salt Marshes: Still a Realistic Goal?

Merryl Alber, Dept. of Marine Sciences
University of Georgia

Functions of marshes

Habitat: Food and refuge for fish, shellfish, shorebirds

Shoreline protection: Wave energy attenuation; buffer; erosion control

Water quality: Sediment trapping; pathogen removal; stormwater runoff

Nutrient cycling: Denitrification; microbial processing of organic matter

Carbon sequestration: Greenhouse gas reduction

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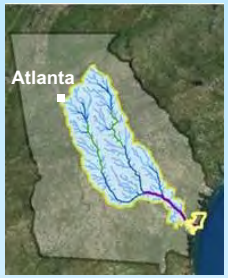
Georgia Coastal Ecosystems (GCE)



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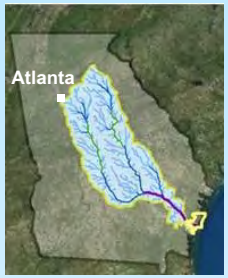

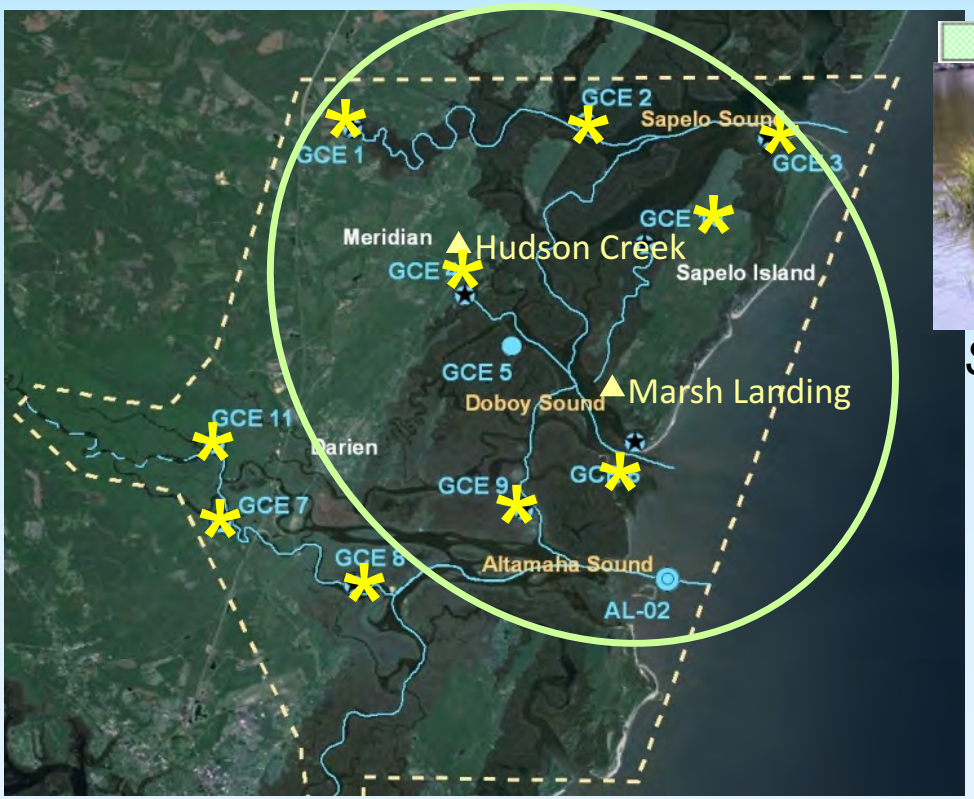

S. alterniflora

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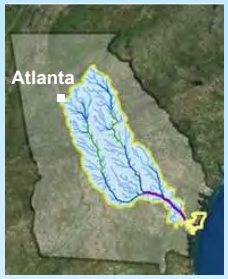
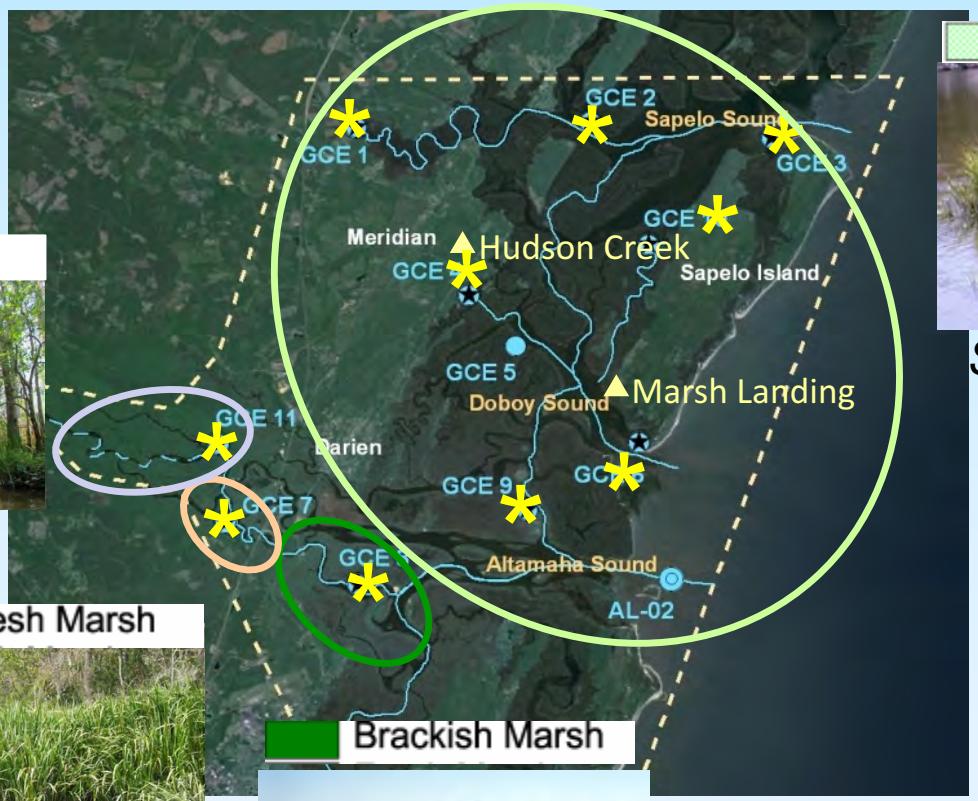




S. alterniflora

Taxodium

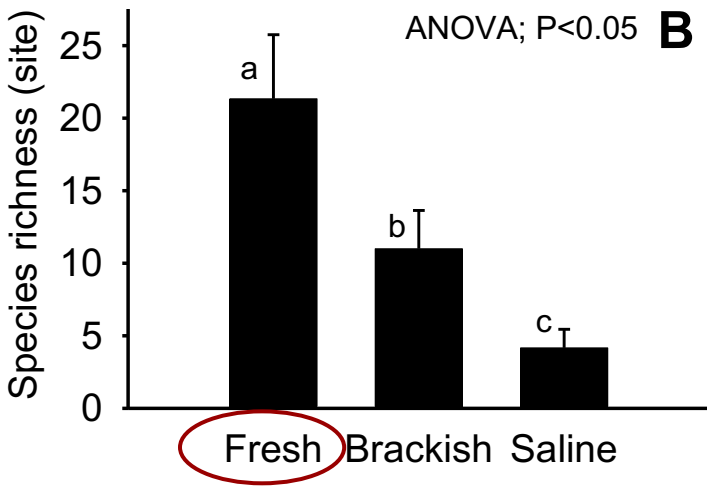
Zizaniopsis

S. cynosuroides

J.romerianus

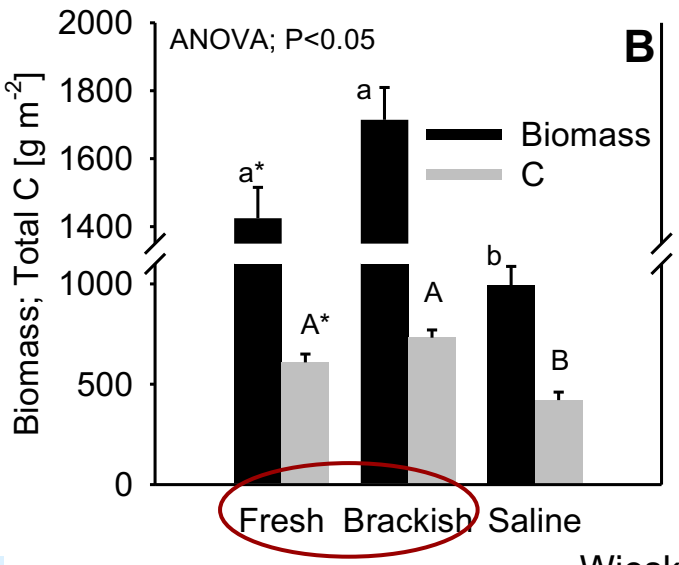
As you move upstream…

Increased species richness



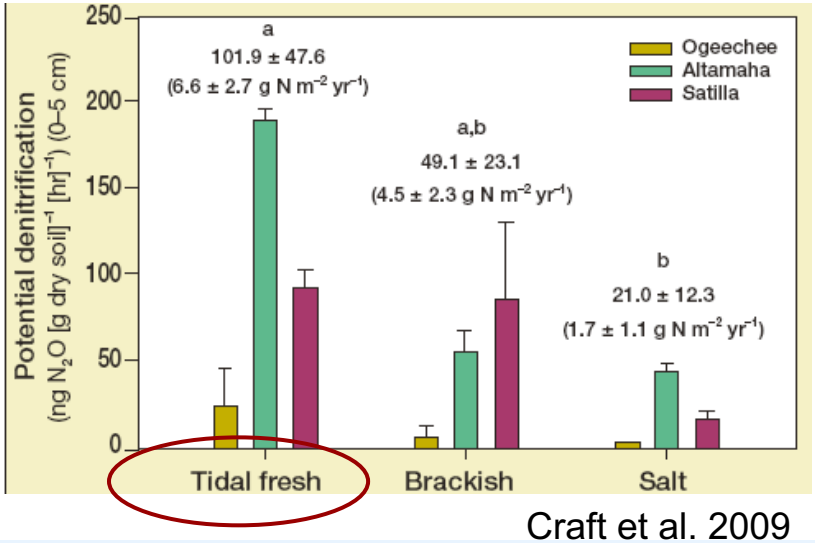
Wieski et al. 2010

Increased plant biomass



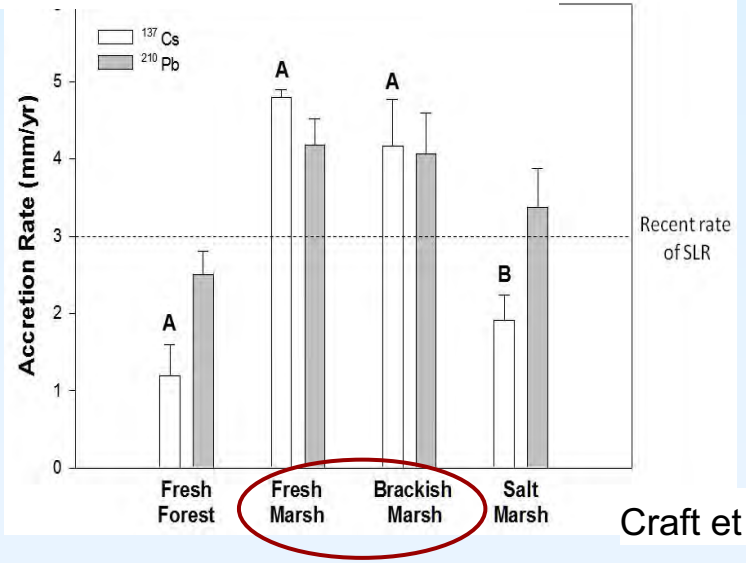
Wieski et al. 2010

Increased denitrification



Craft et al. 2009

Increased accretion rate



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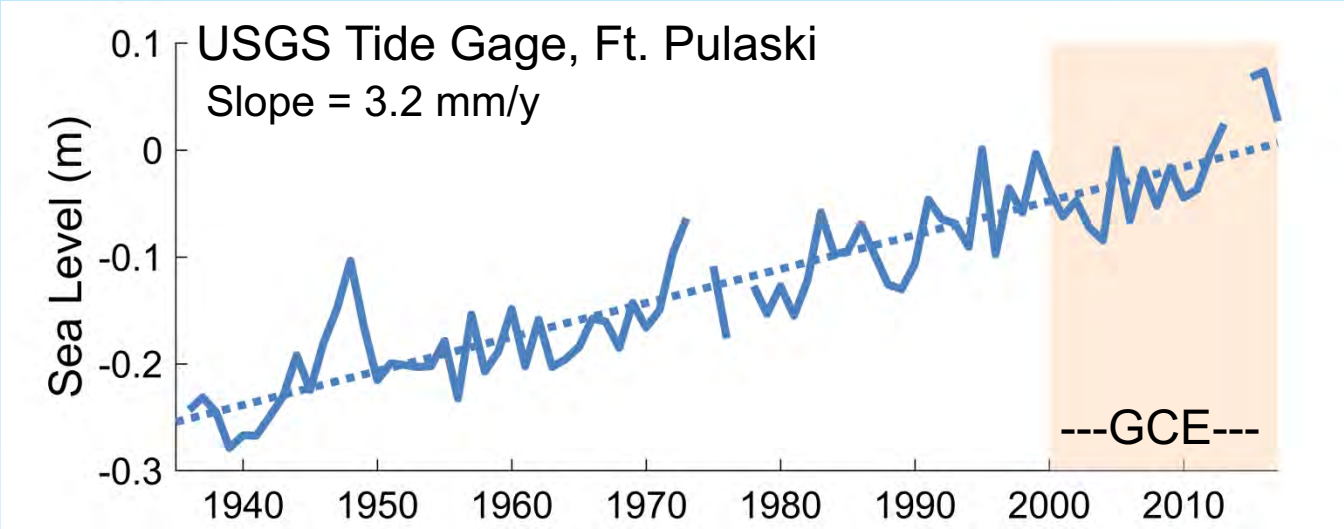
How will sea level rise affect marshes?



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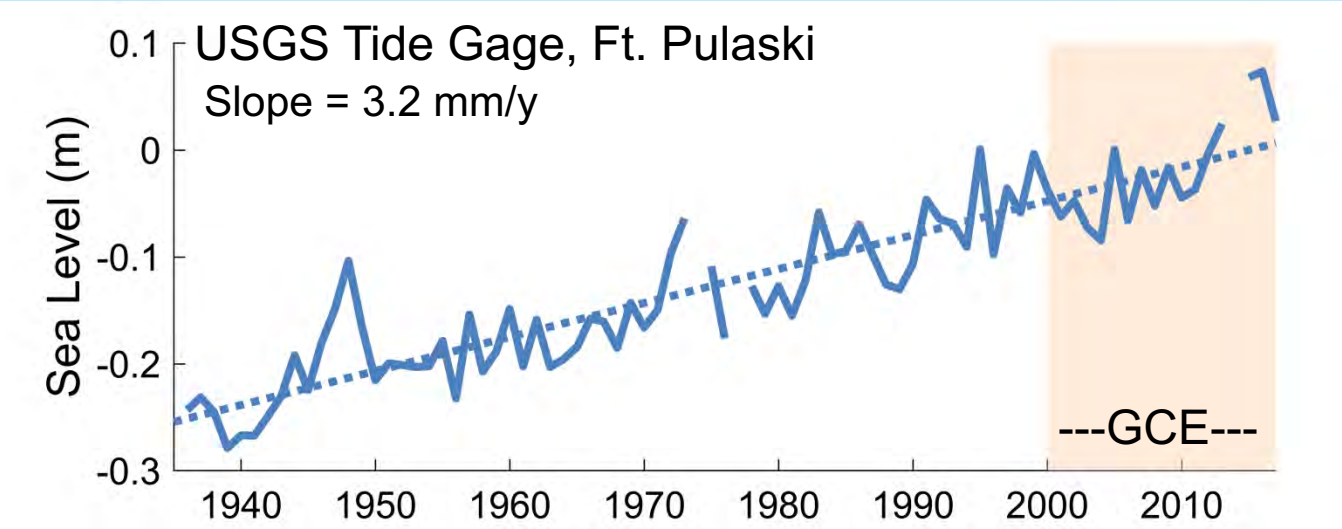
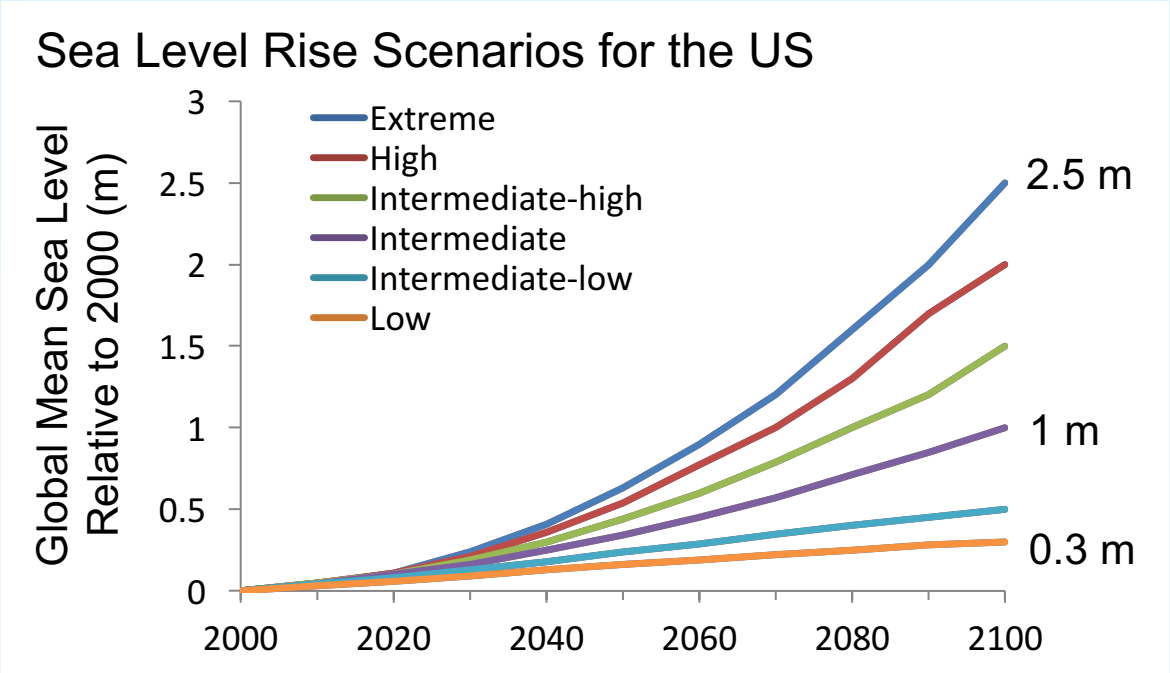




Source: NOAA Technical Report; Sweet et al. 2017

As sea levels rise, vital salt marshes are disappearing

Ganju et al. 2017 Nature Communications

AP News February 11, 2017

Salt marshes will vanish in less than a century if seas keep rising and California keeps building, study finds

Thorne et al. 2018 Science Advances

LA Times February 21, 2018

Energy and Environment

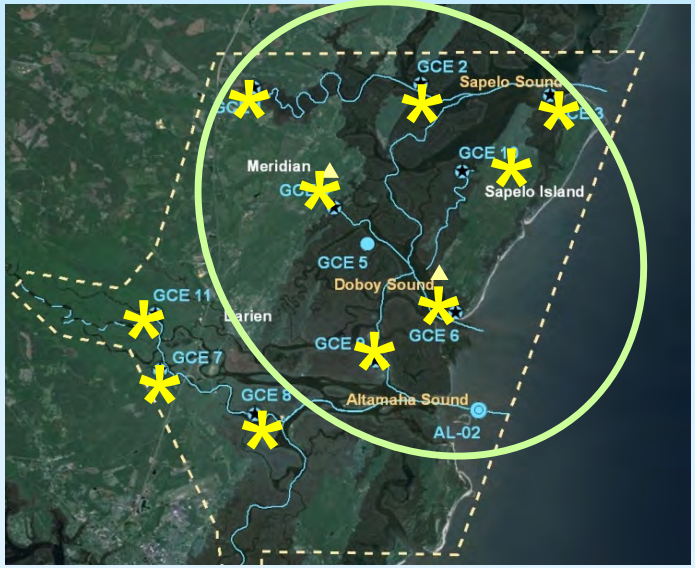
The Washington Post April 11, 2018

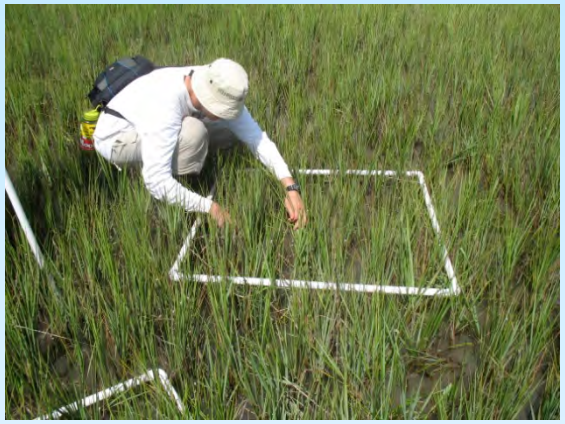
Seas are rising too fast to save much of the Mississippi River Delta, scientists say

Chamberlain et al. 2018 Science Advances

Spartina biomass over time

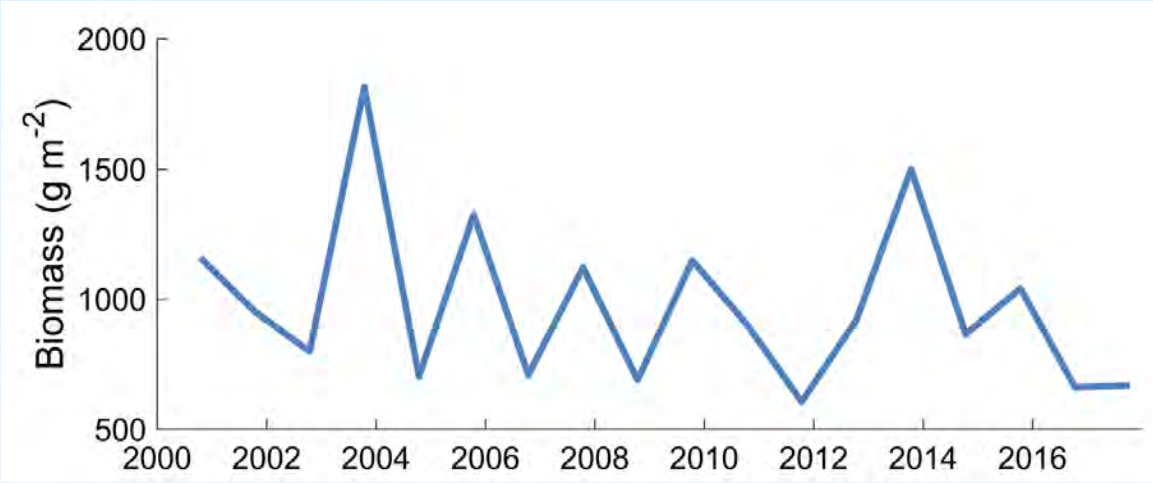
Marsh monitoring: Permanent plots



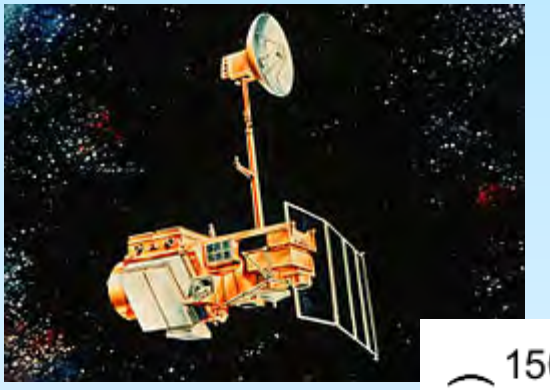


	Creekbank		
Site	River flow	**Sea level**	Max temp
1	0.73	**0.48**	0.64
2	0.68	**0.66**	
3	0.57		
4	0.84	**0.43**	0.41
5	0.74	**0.57**	
6	0.58	**0.51**	
8		**0.40**	
9	0.57		
10	0.54	**0.39**	0.40

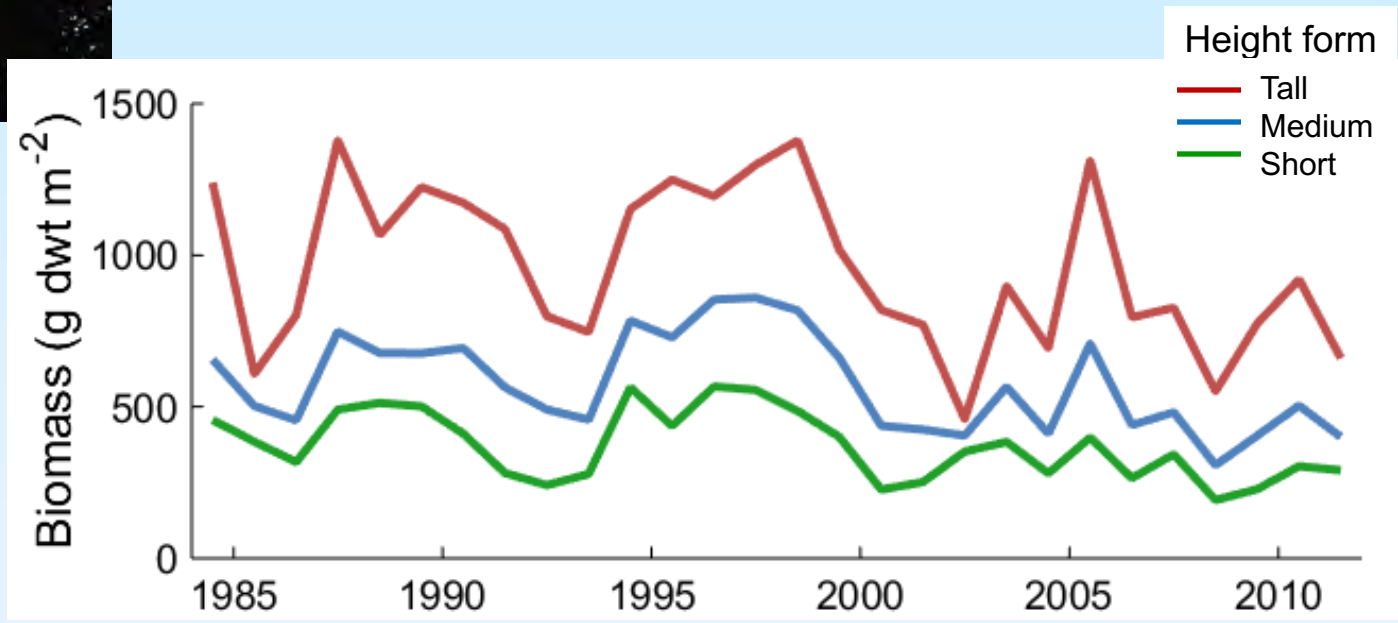
Wieski and Pennings 2013



Spartina biomass over time



Landsat 5
1984-2012

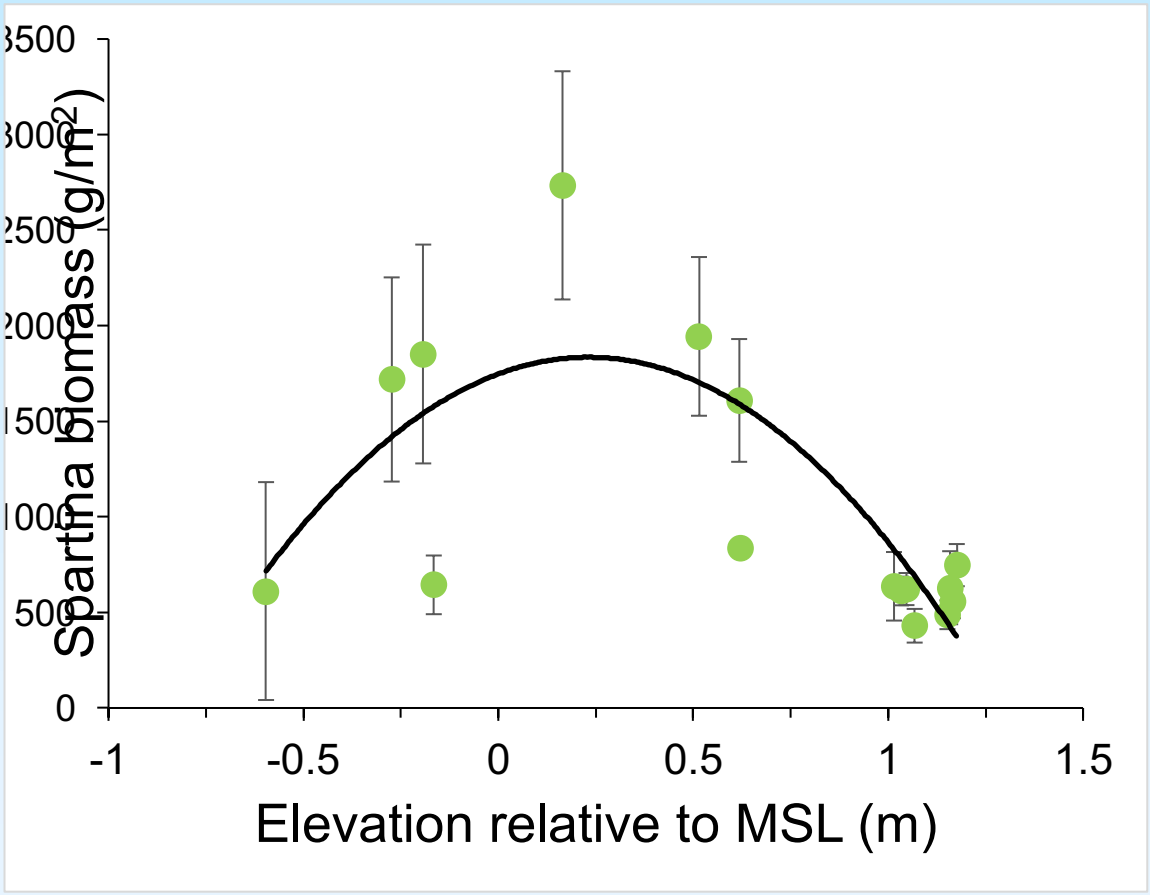


O'Donnell and Schalles 2016

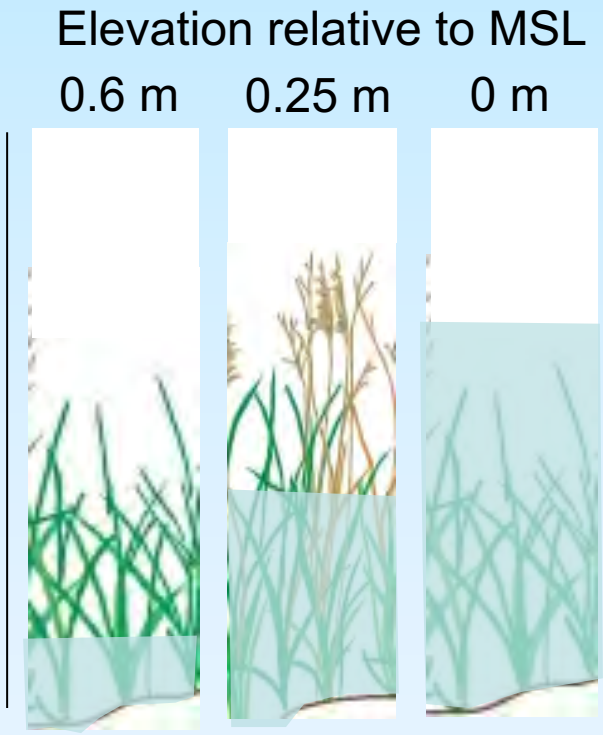
Varies with

- Altamaha River discharge
- Palmer Drought Severity Index
- **Sea level**
- Temperature

Effect of inundation on Spartina growth



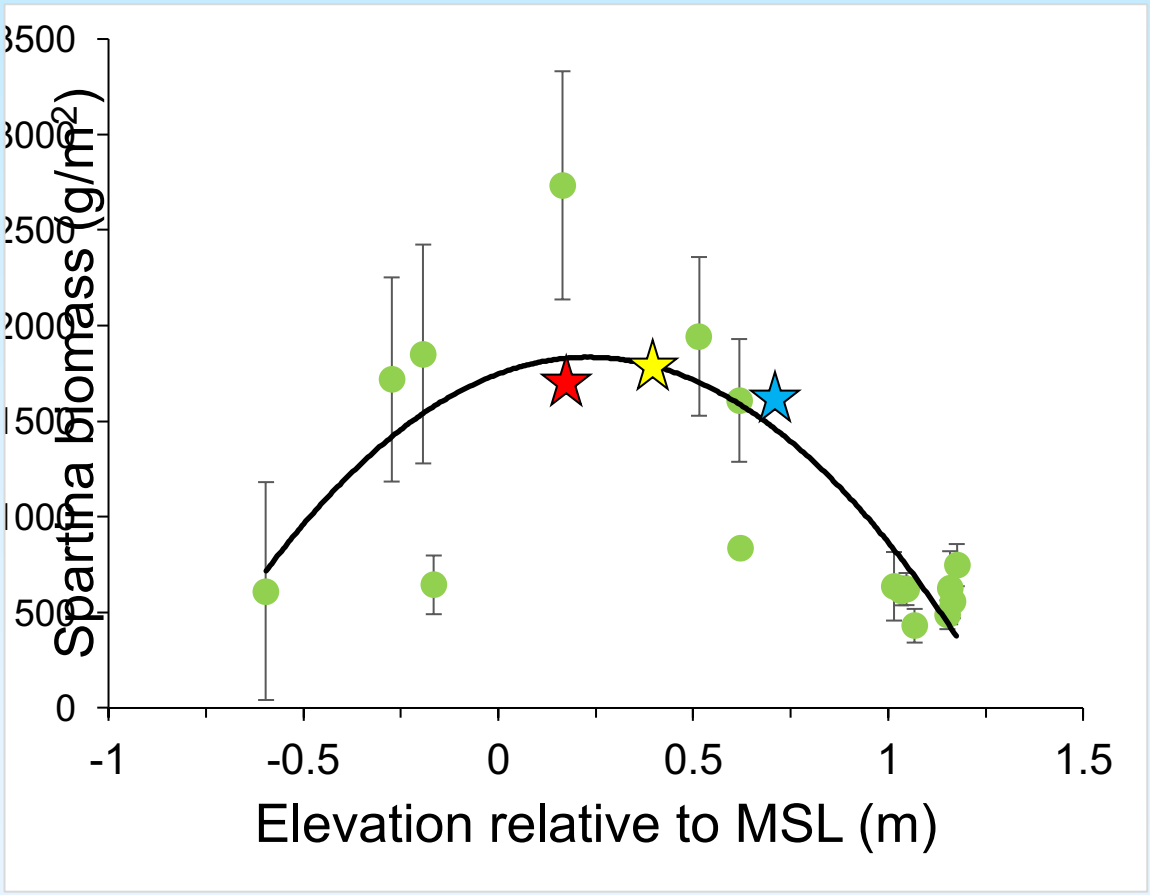
Inundation

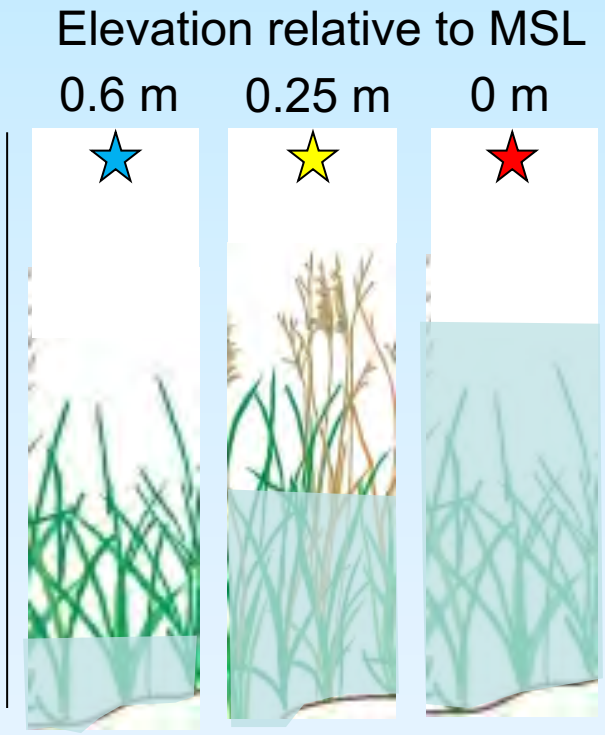


Inundation

Courtesy E. Herbert & C. Hladik

Effect of inundation on Spartina growth



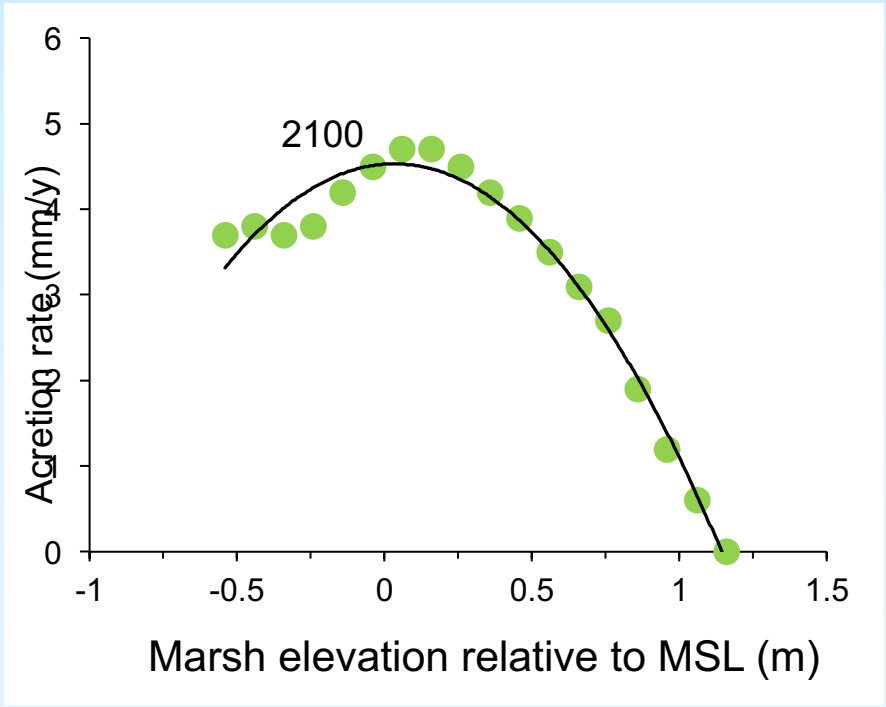


Inundation

Inundation

Courtesy E. Herbert & C. Hladik

Effect of inundation on accretion: Sea Level Affects Marshes Model (SLAMM)



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Courtesy E. Herbert & C. Hladik


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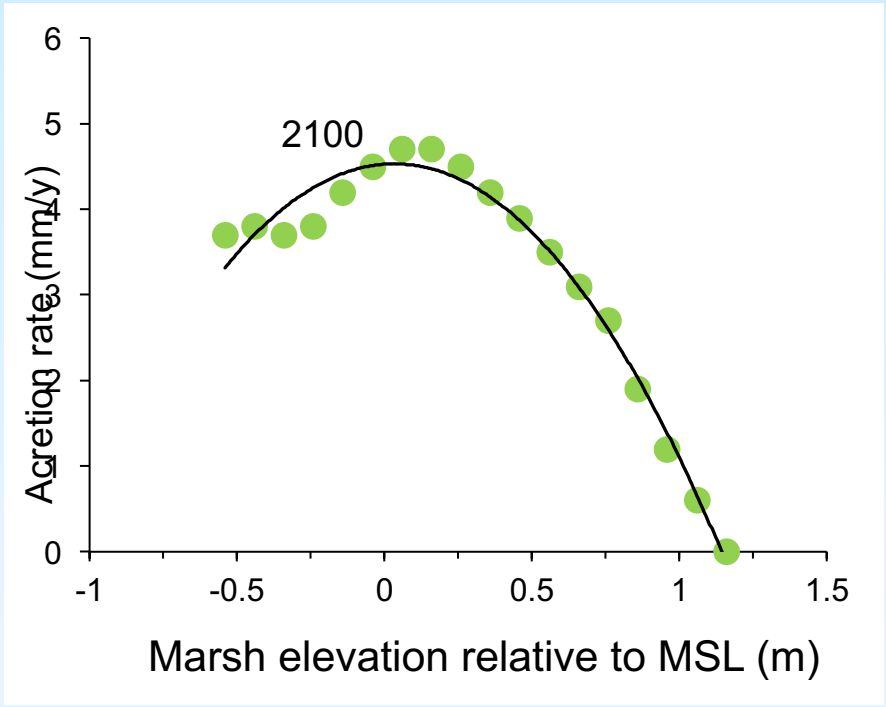

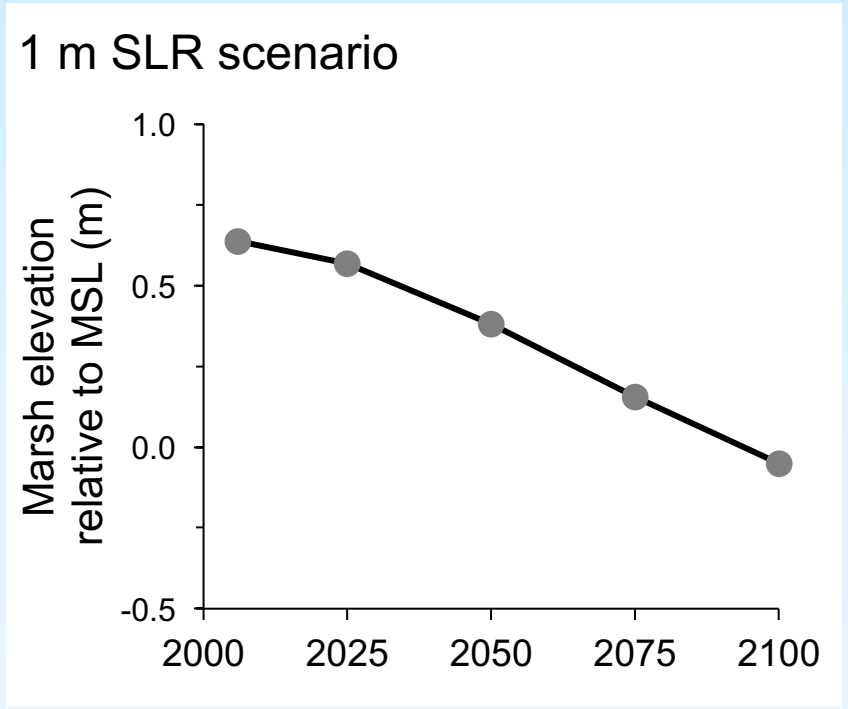

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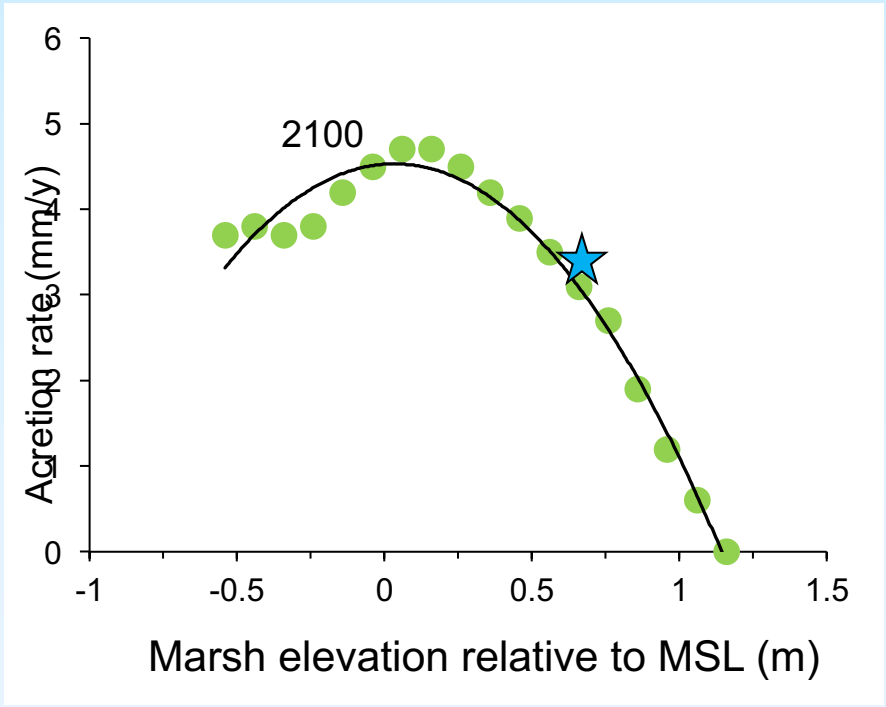

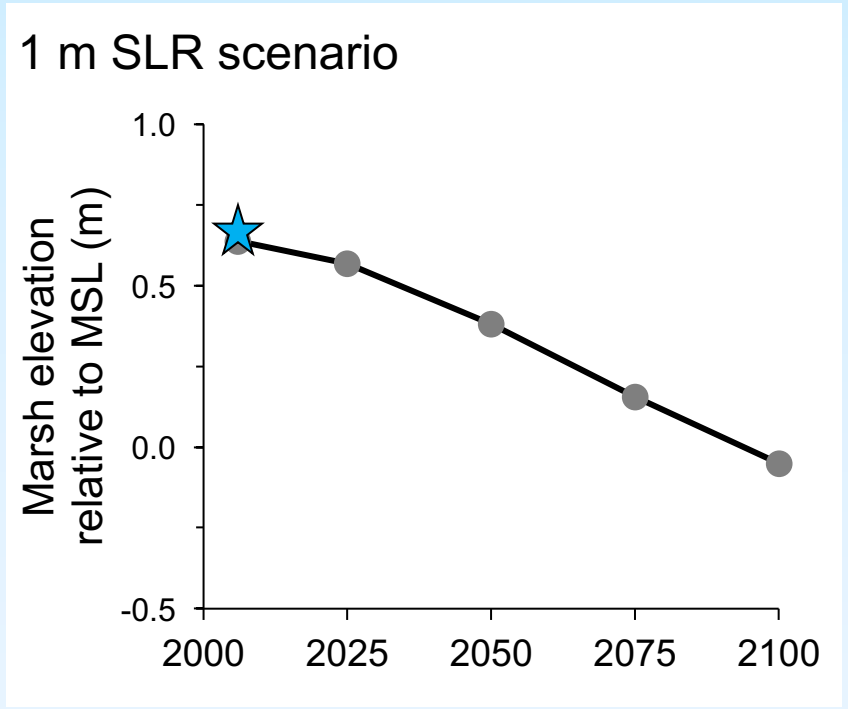

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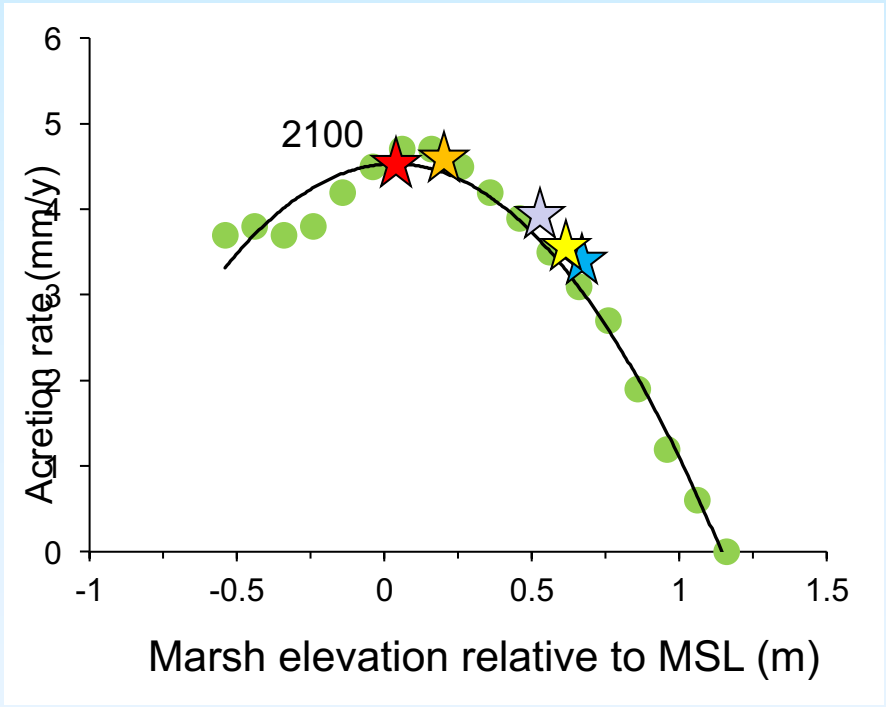

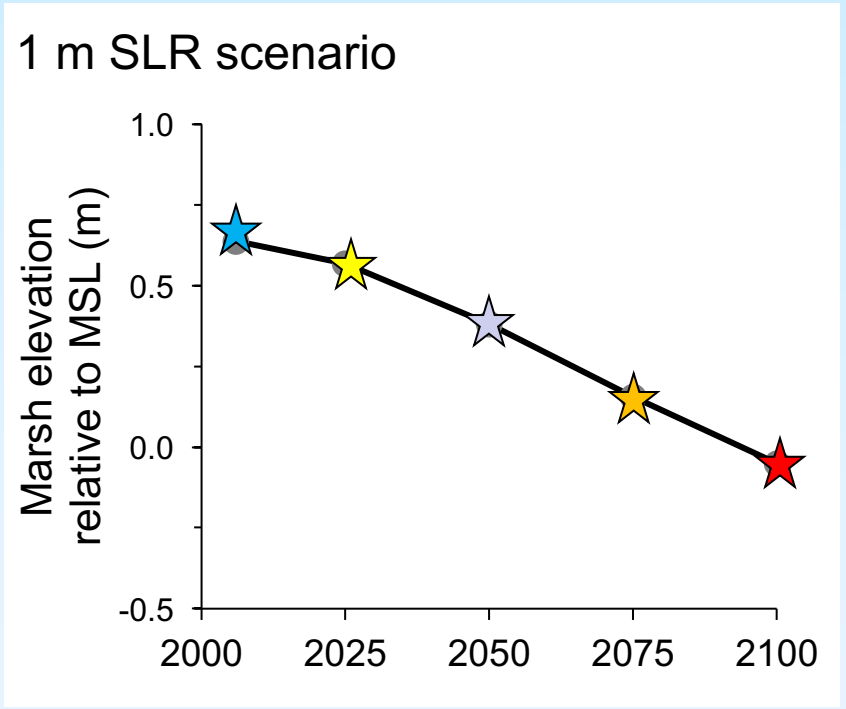

Inundation

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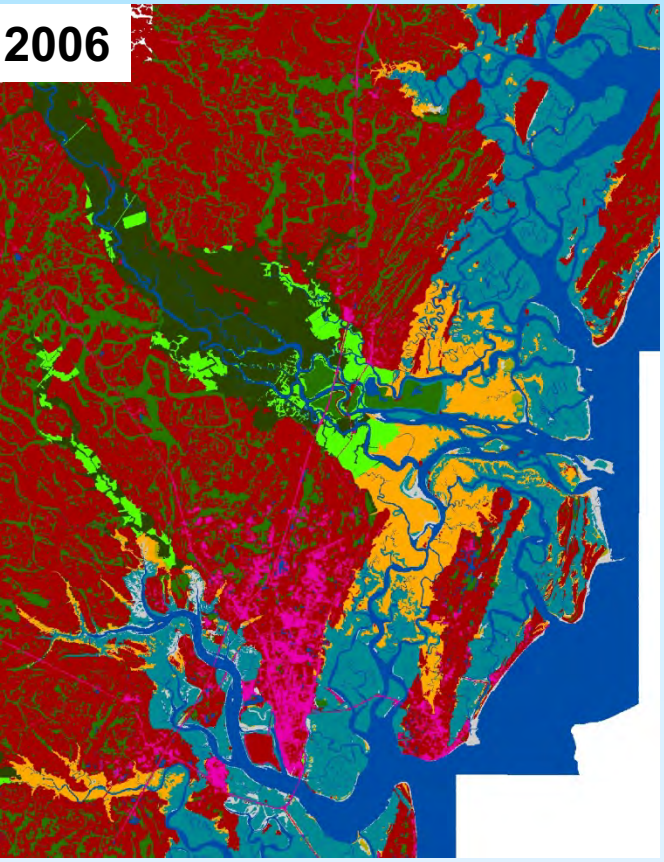
SLAMM Model Results
Altamaha River Estuary



- Salt marsh
- Brackish marsh
- Fresh marsh
- Tidal forest

Courtesy C. Hladik & E. Herbert

SLAMM Model Results
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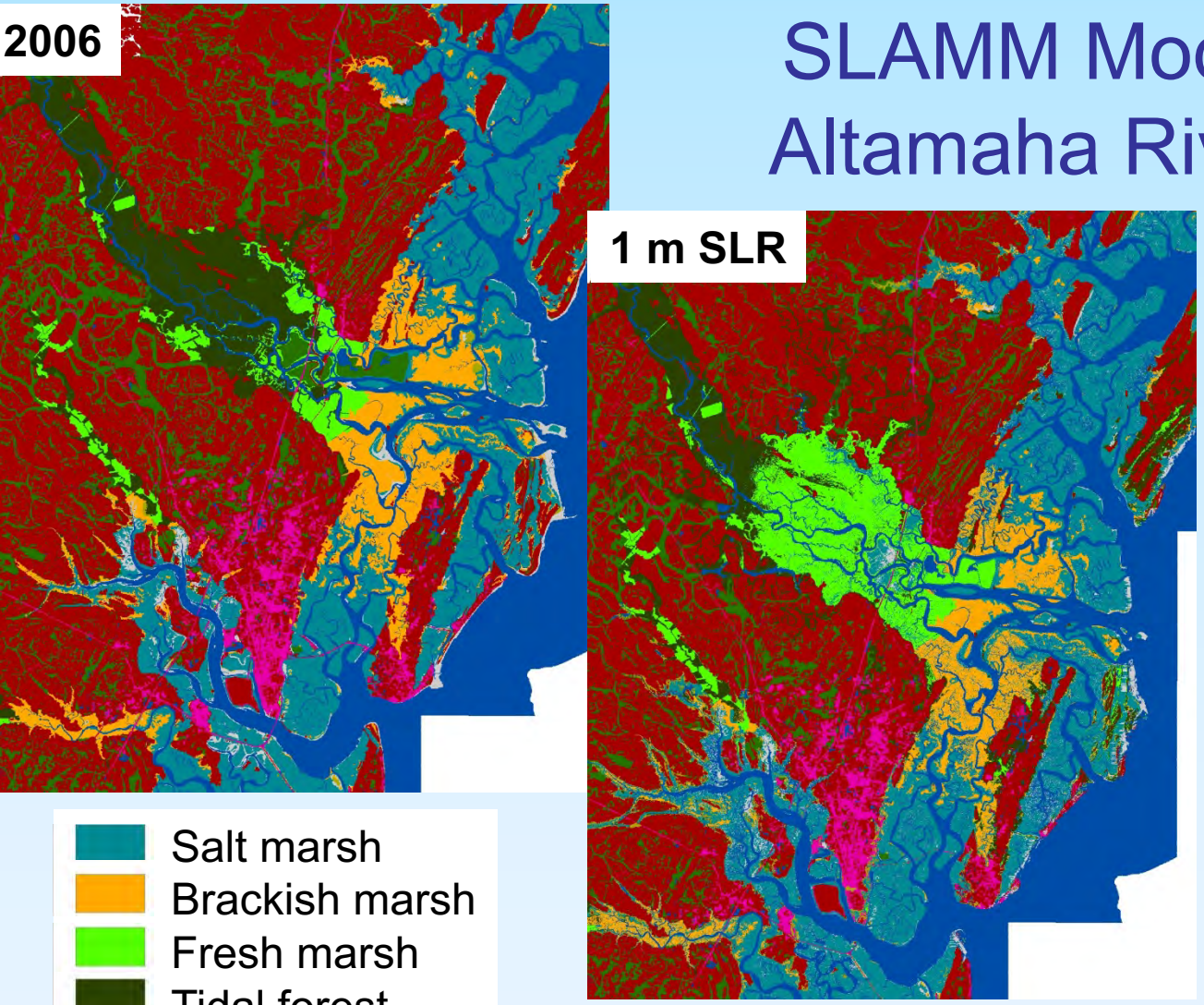

Upstream habitat shifts
Increase in marsh area

Courtesy C. Hladik & E. Herbert

SLAMM Model Results
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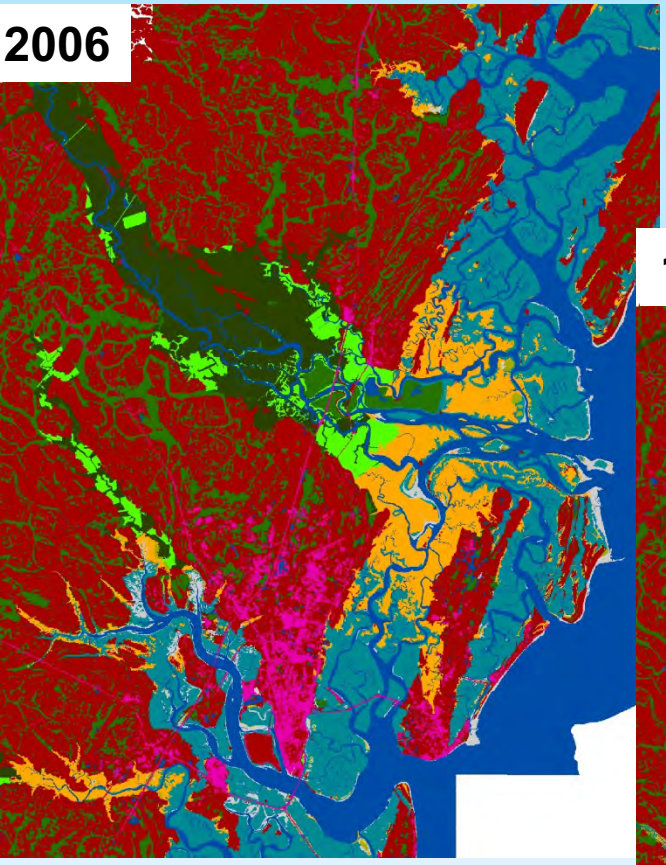
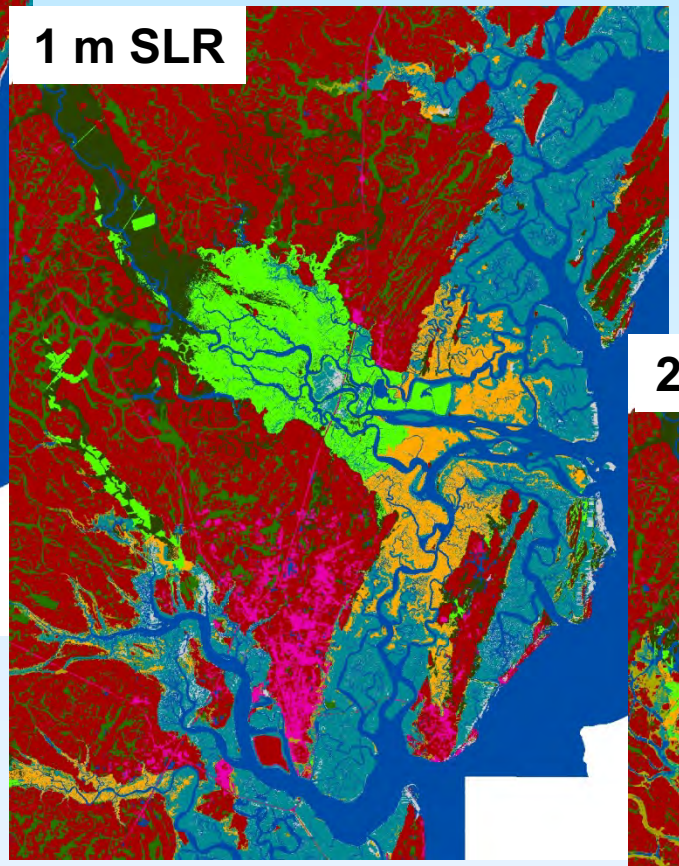
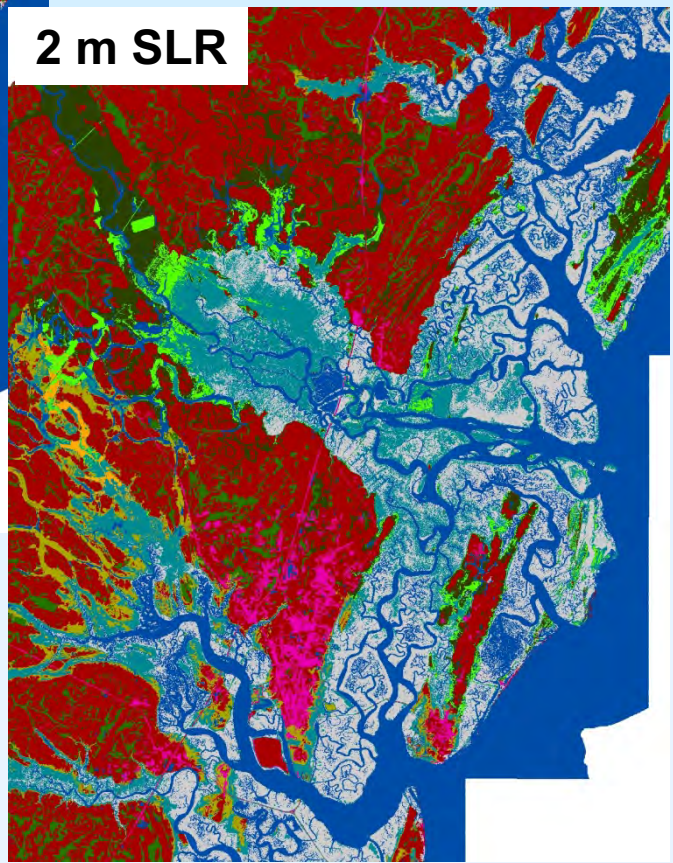






Salt marsh
Brackish marsh
Fresh marsh
Tidal forest

Upstream habitat shifts
Increase in marsh area

Further upstream migration
Decrease in marsh area
Drowning at seaward edge

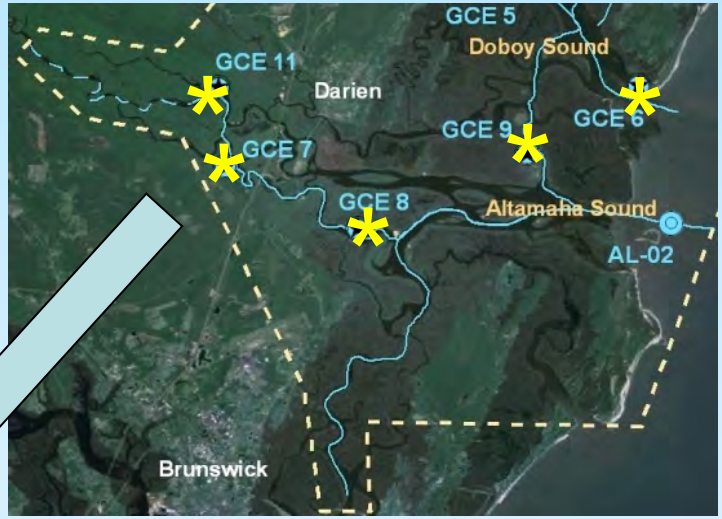
Courtesy C. Hladik & E. Herbert

Mechanisms for Marsh Gain & Loss

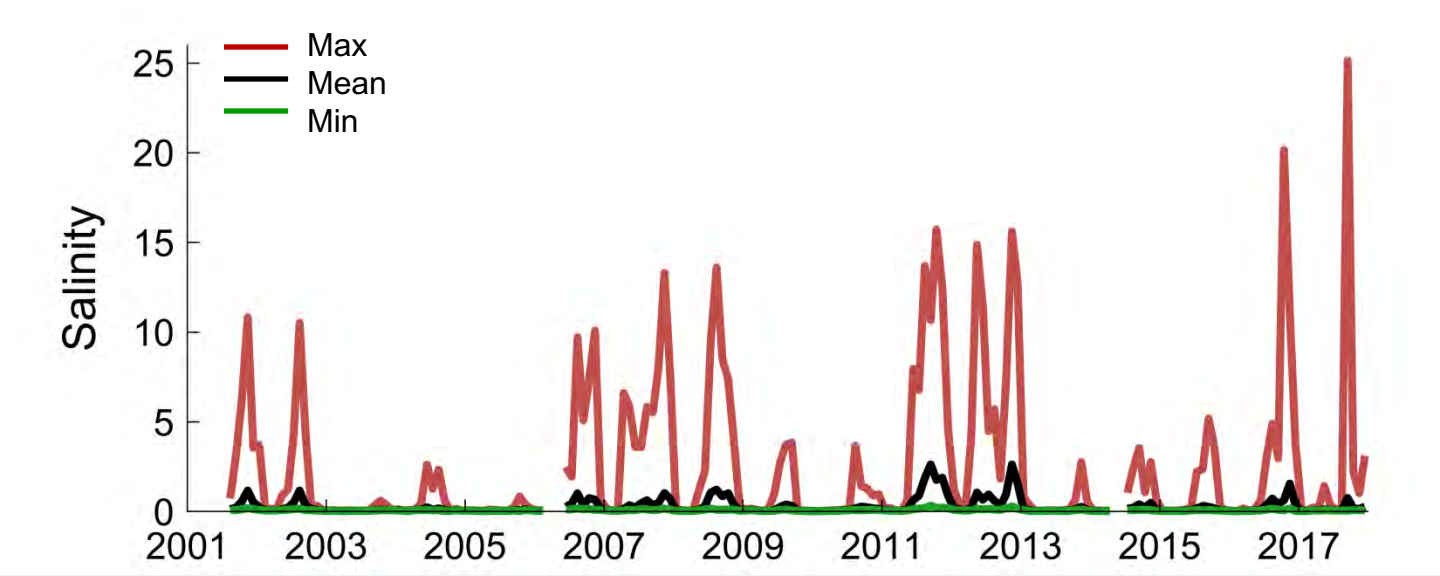
Vertical Accretion
f (sediment,
elevation, biomass)

Mechanisms for Marsh Gain & Loss

Salinity intrusion on fresh marsh



GCE 7 salinity



Seawater **A**ddition **L**ong **T**erm **Ex**periment

SALTEx is a large-scale field experiment being conducted to evaluate how both chronic and acute pulses of saltwater affect freshwater wetlands.

Press duration: April 2014- Oct 2017
Pulse delivered: Sep-Oct, 2014-2017

30 plots (2.5 m^2)

Response in Press Treatments

Plant loss

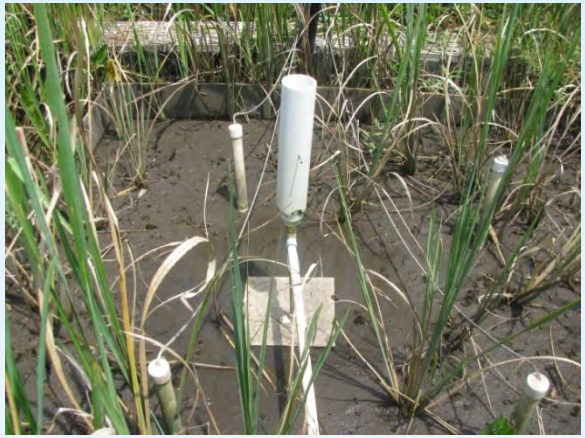
Ludwigia

Polygonum

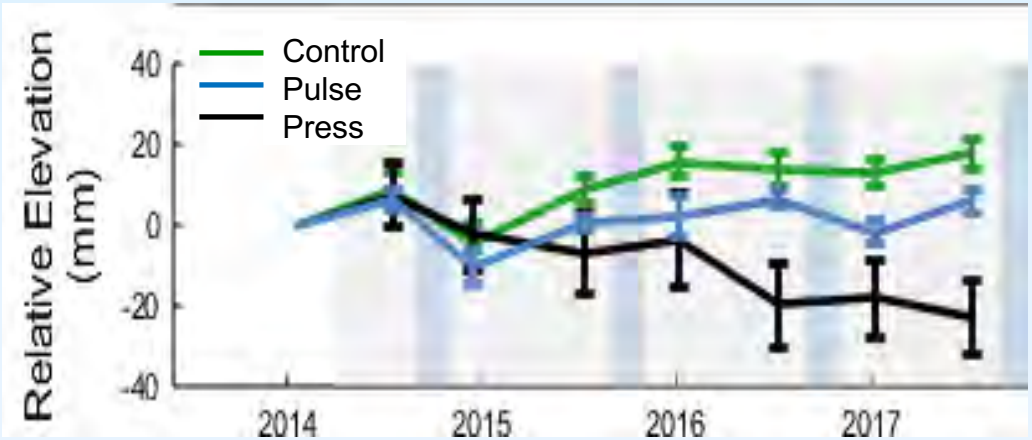
Pontedaria

Zizaniopsis

Li et al., subm.

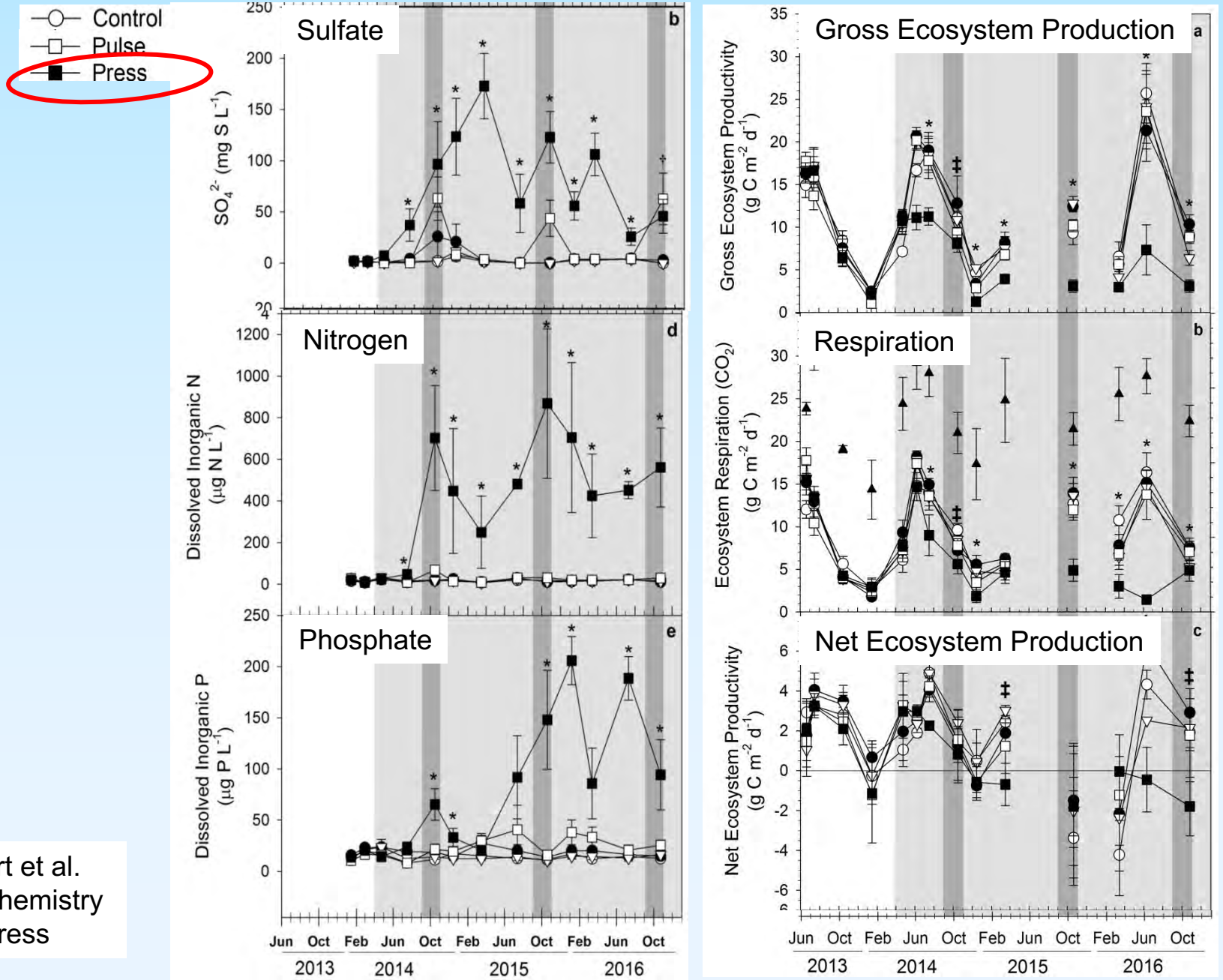


Elevation loss



Courtesy C. Craft and S. Pennings

Press plots had increases in: and decreases in:



Herbert et al.
Biogeochemistry
In press

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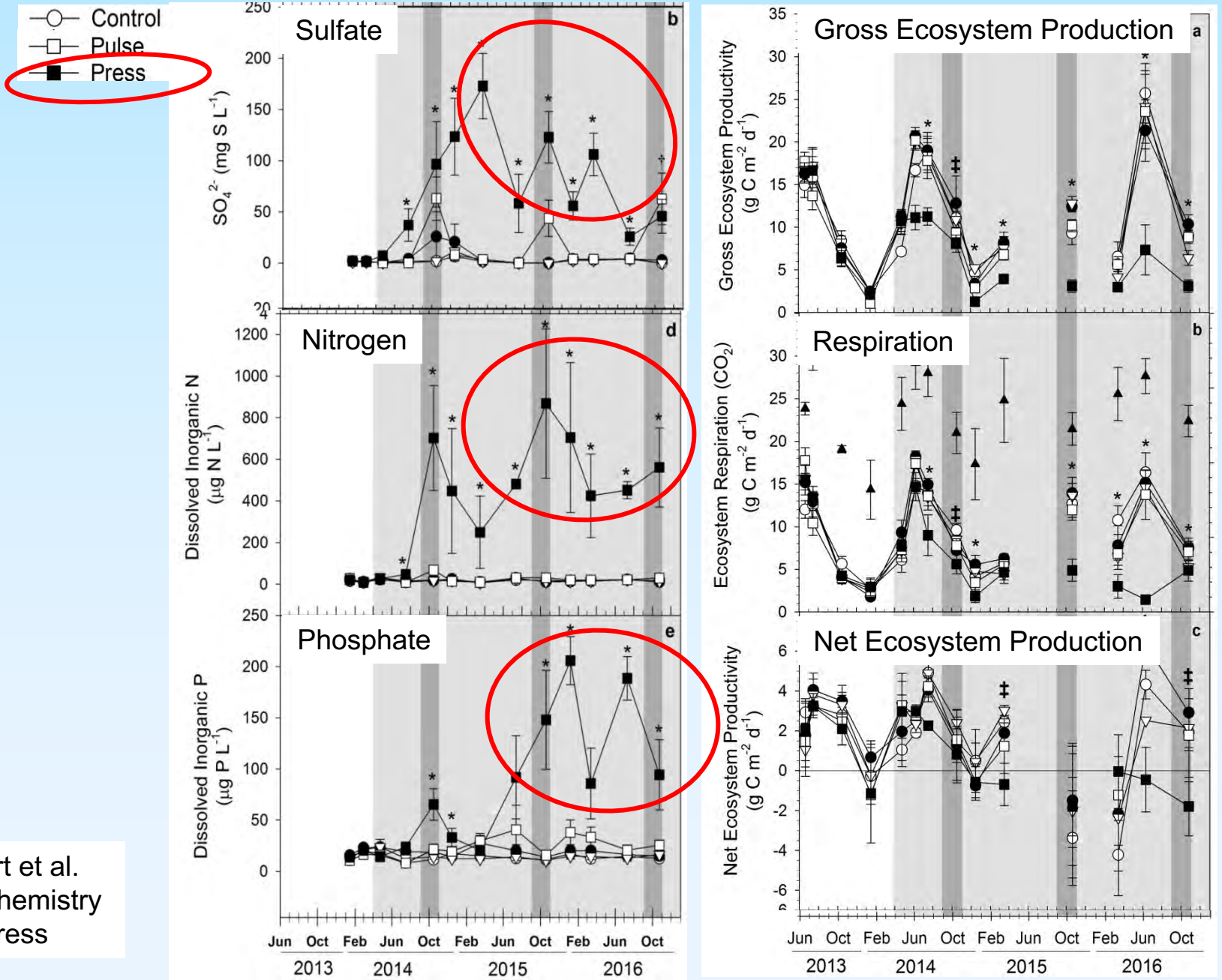

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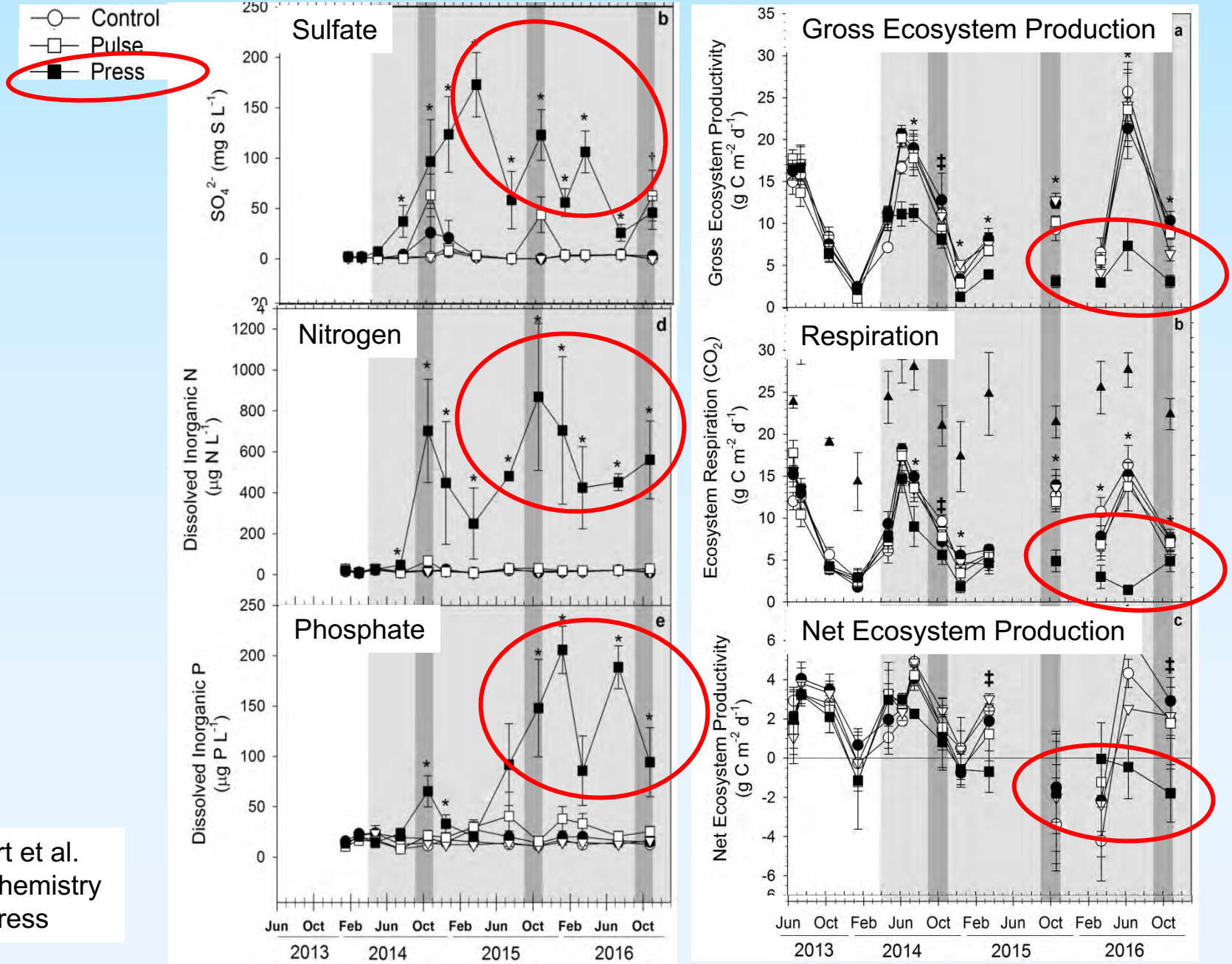

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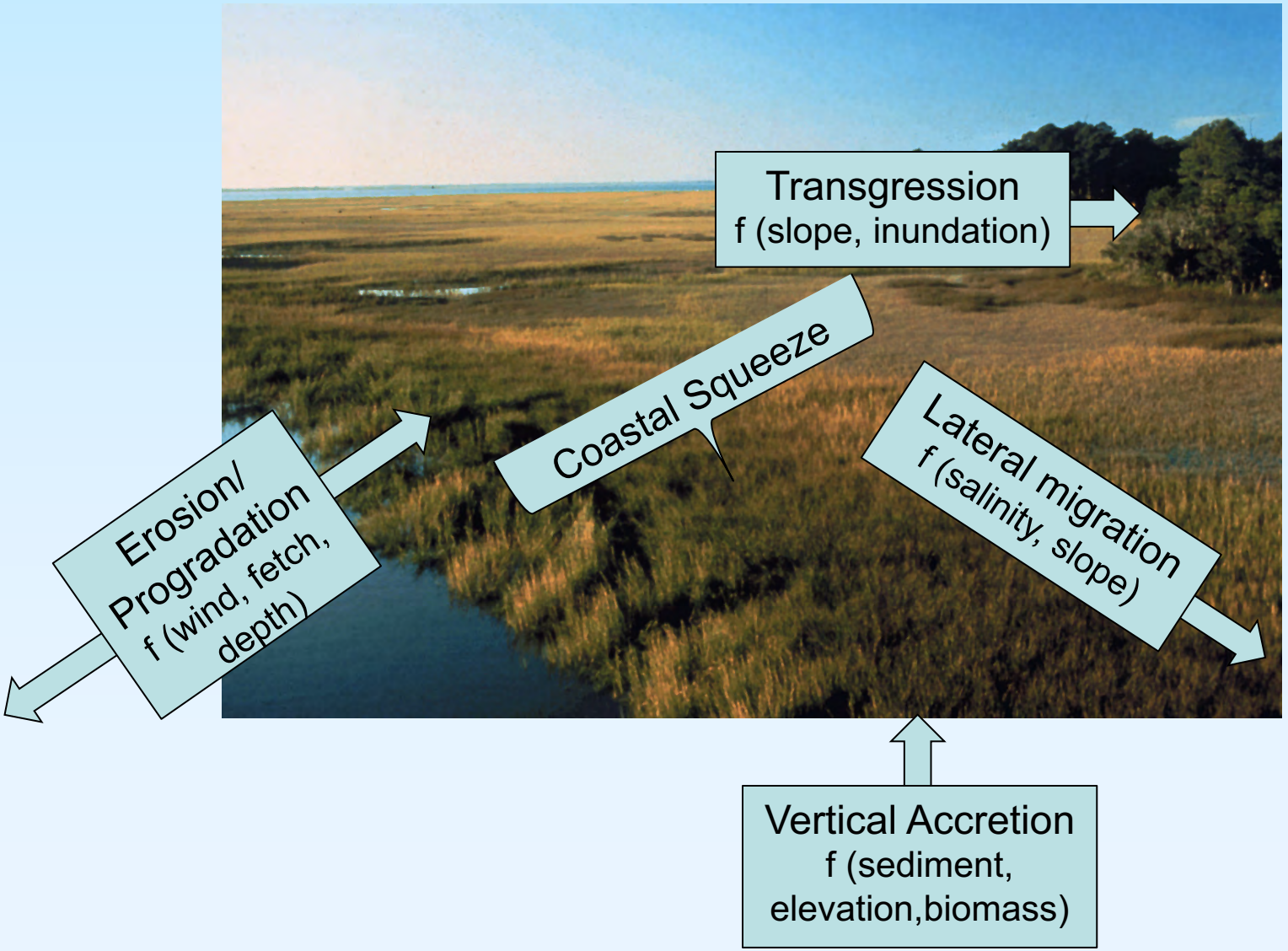
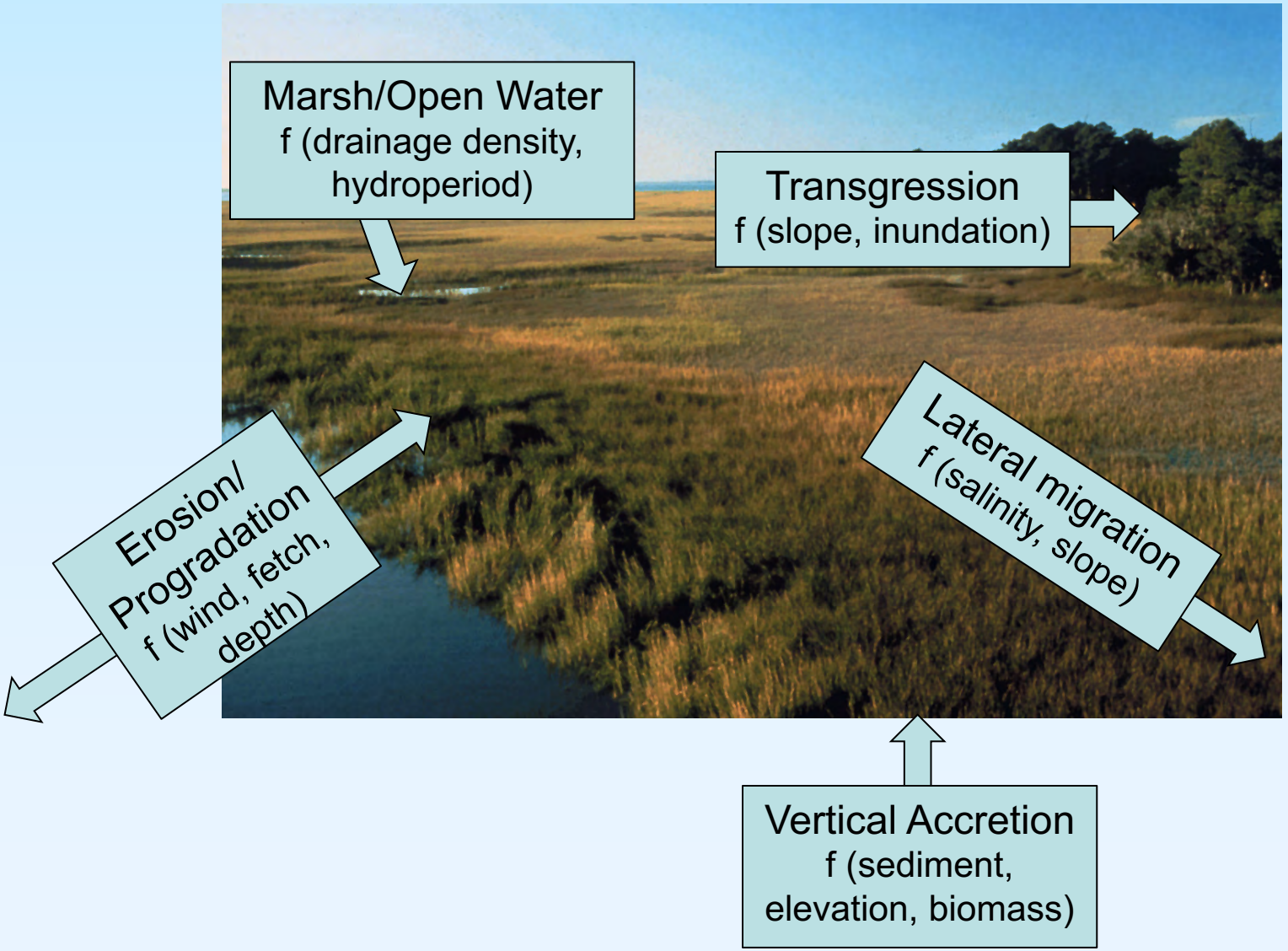
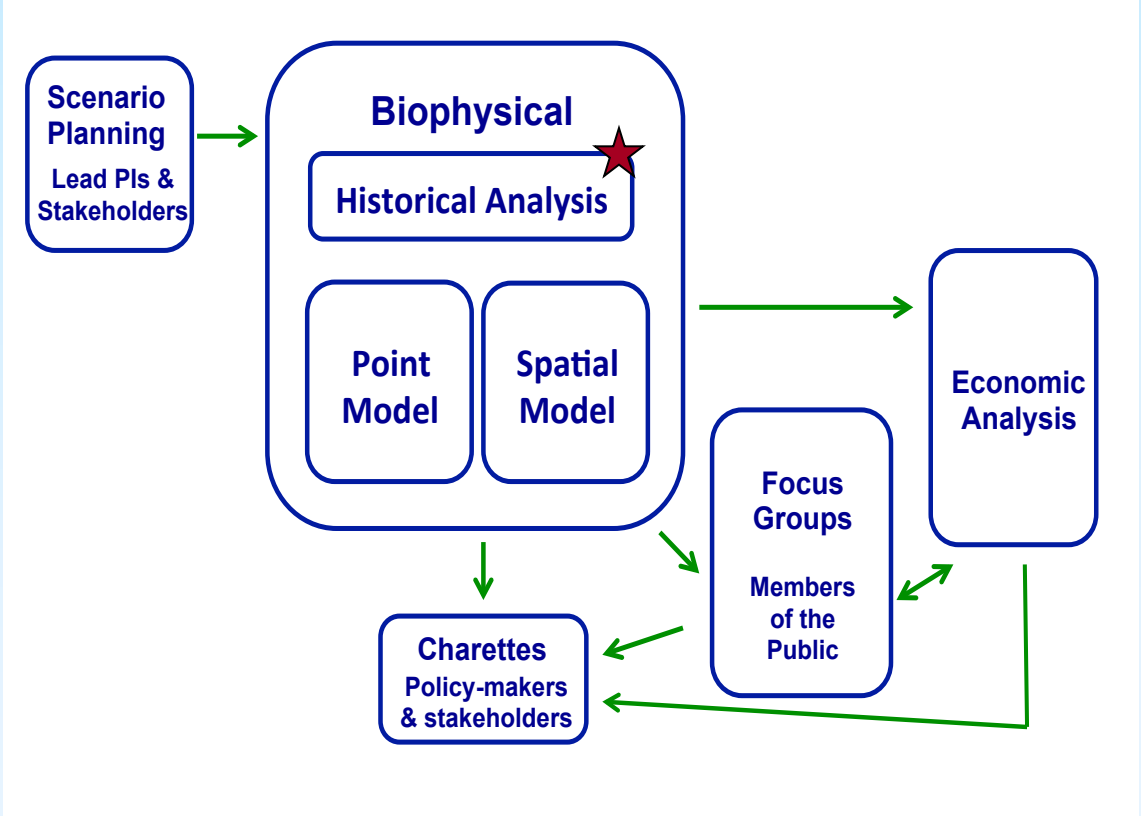
Mechanisms for Marsh Gain & Loss



Mechanisms for Marsh Gain & Loss



Coastal SEES: A cross-site comparison of salt marsh persistence in response to sea-level rise and feedbacks from social adaptations

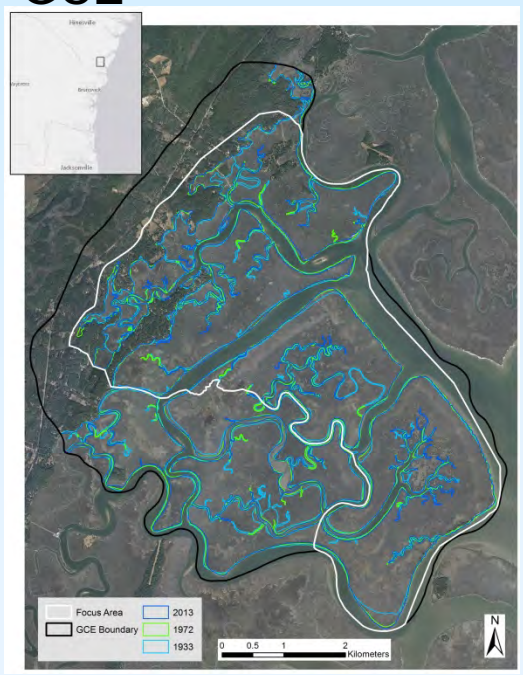


Collaborators:
PIE: Anne Giblin, Jim Morris, Rob Johnston, Colin Polsky
VCR: Karen McGlathery, Matt Kirwan, Pat Wiberg
GCE: Merryl Alber, Clark Alexander

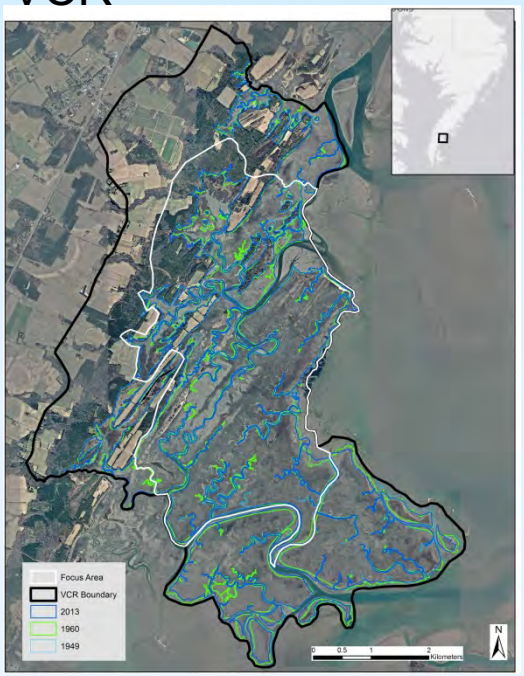
Historical Analysis

Site	Time 1	Time 2	Time 3	Focus Area	Overall Area
GCE	1942	1972	2013	25 km^2	40 km^2
VCR	1949	1957	2013	18 km^2	40 km^2
PIE	1938	1972	2013	21 km^2	21 km^2

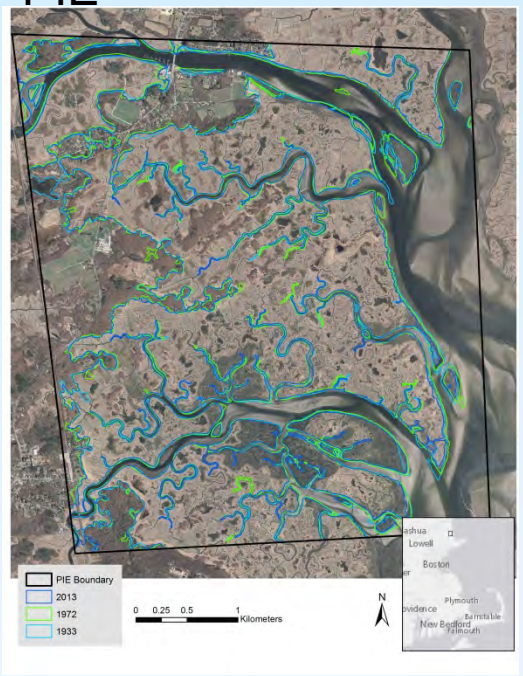
GCE



VCR



PIE



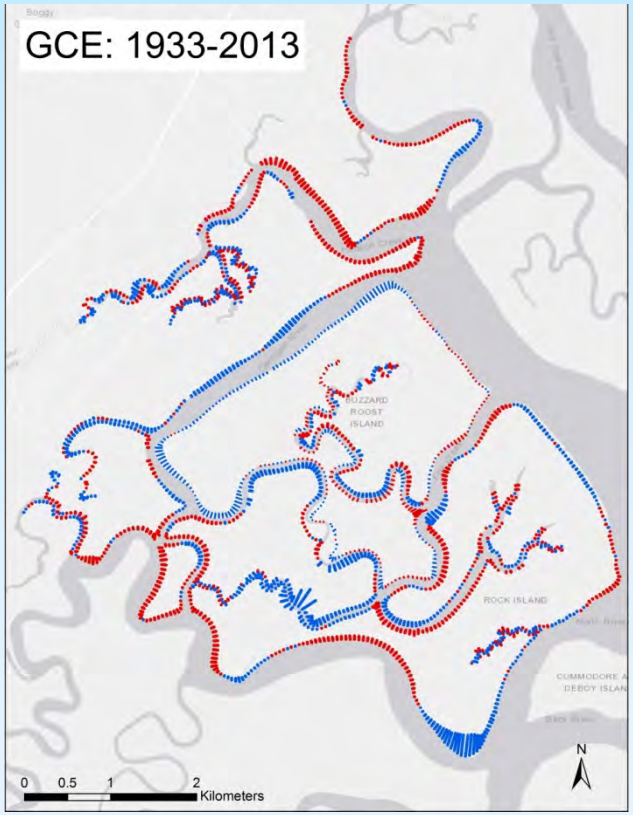
Courtesy C. Burns & C. Alexander

Shoreline Change Rate Calculation

AMBUR: Analyzing Moving Boundaries Using R

Jackson et al., J. of Computer & Geosciences 2012

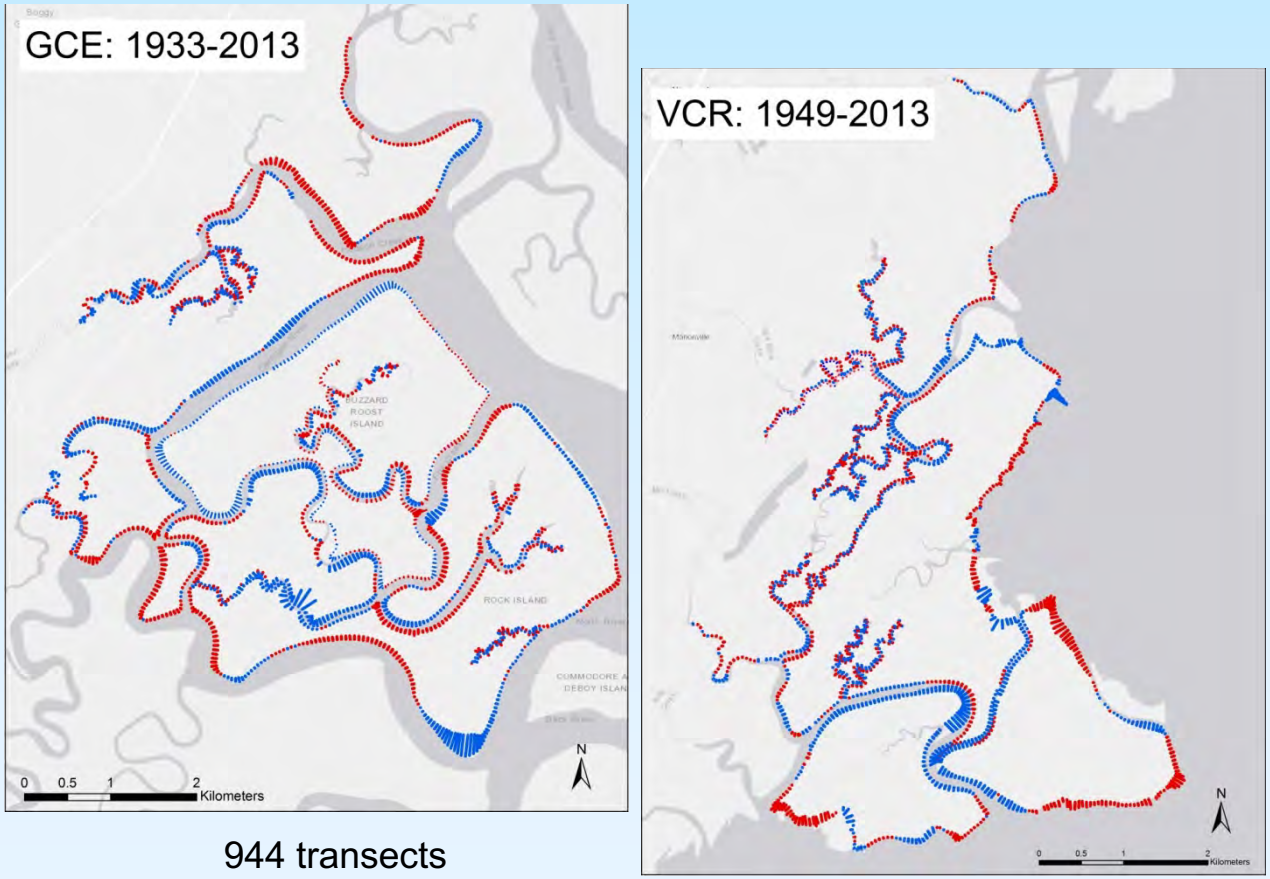
Shoreline change



944 transects
50% eroding; 50% prograding

Courtesy C. Burns & C. Alexander

Shoreline change

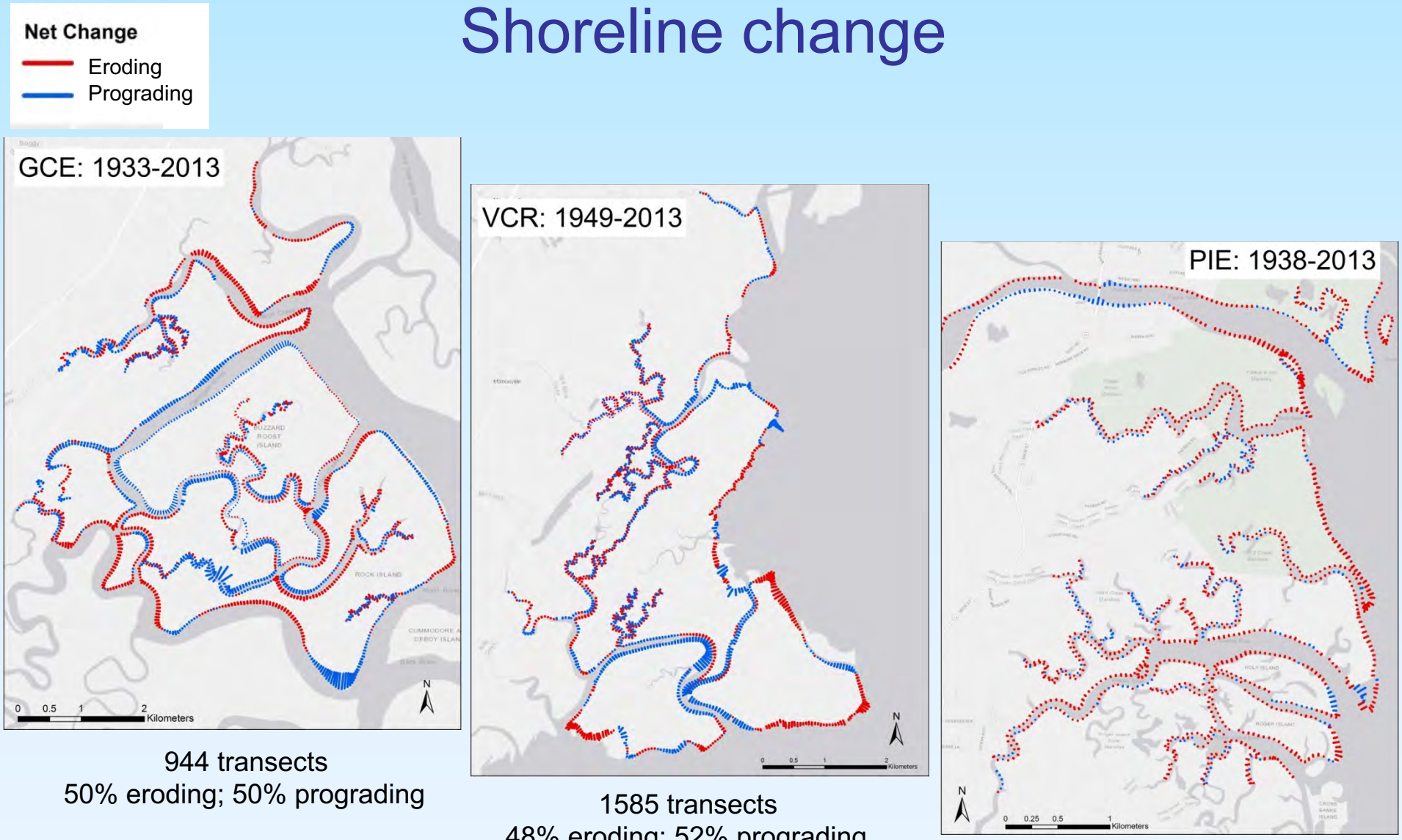


944 transects
50% eroding; 50% prograding

1585 transects
48% eroding; 52% prograding

Courtesy C. Burns & C. Alexander

Shoreline change



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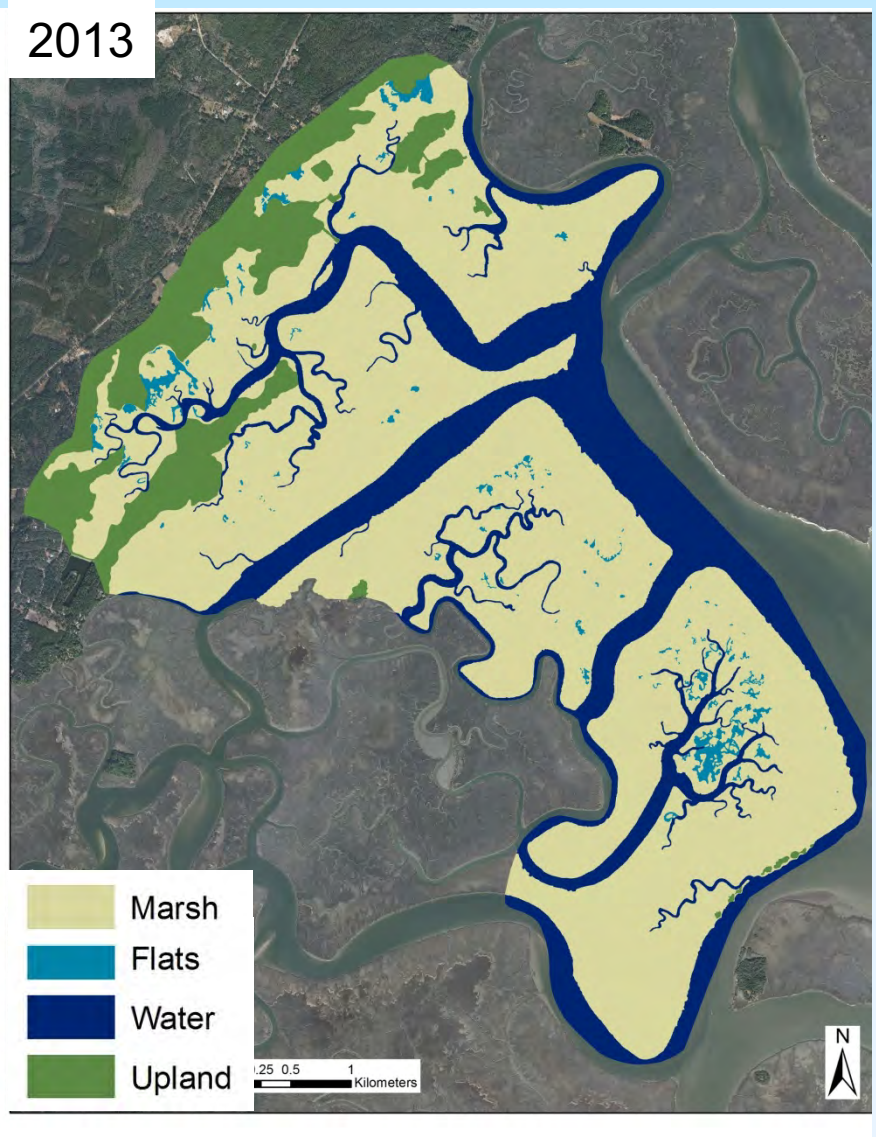
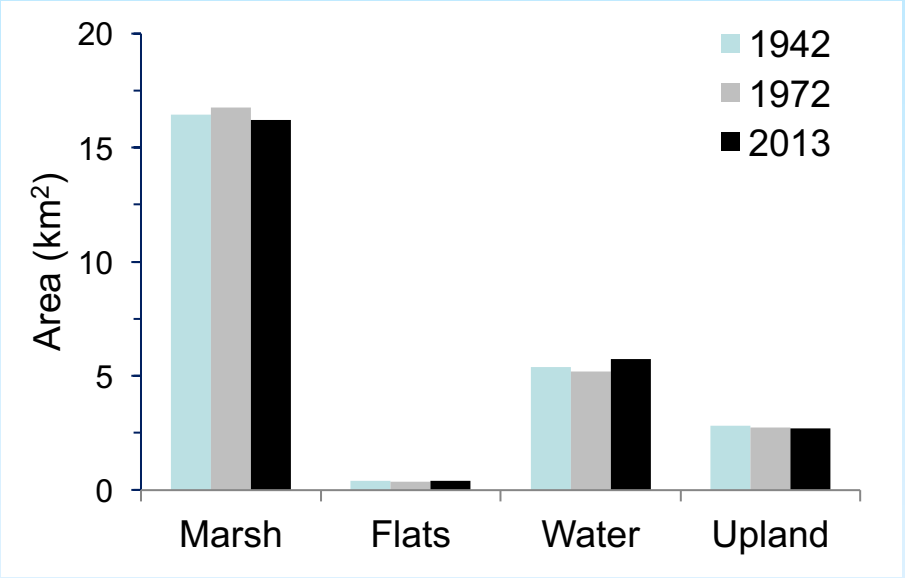
48% eroding; 52% prograding

1397 transects
74% eroding; 26% prograding

Courtesy C. Burns & C. Alexander

Marsh Features - GCE

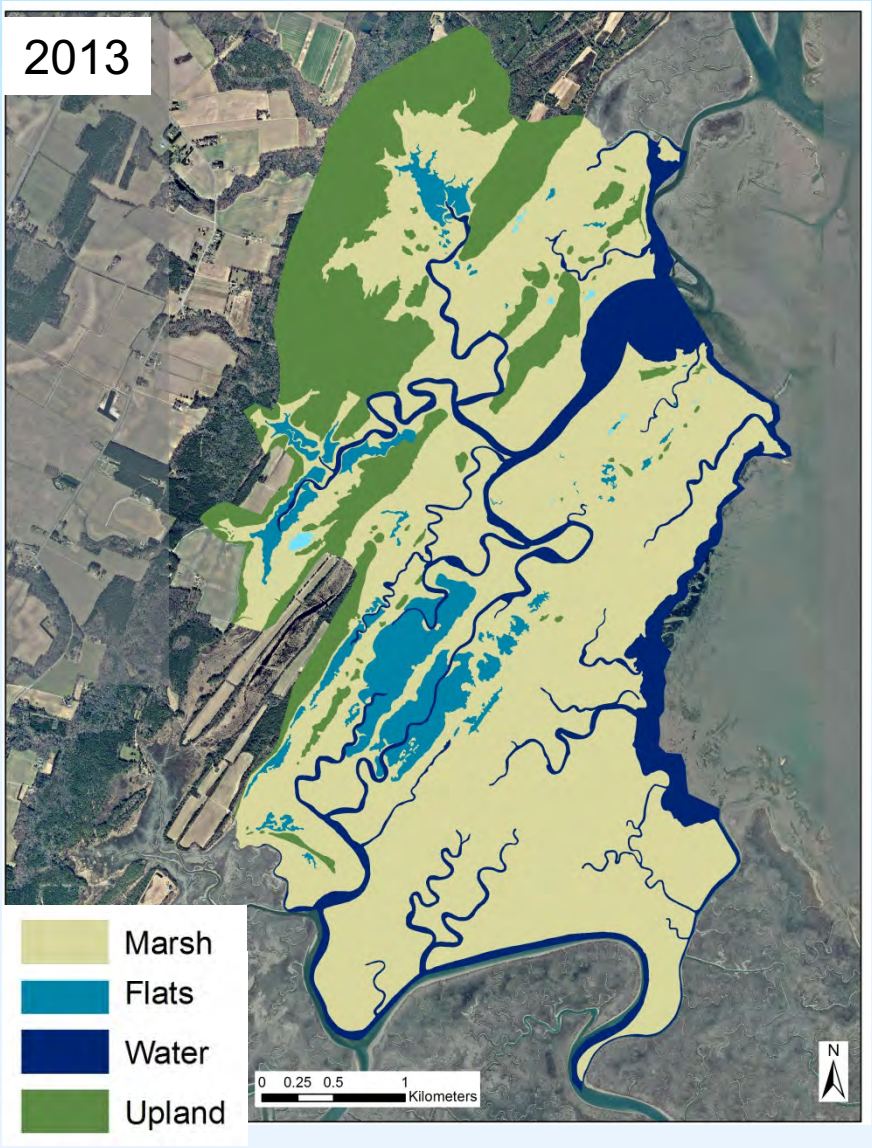


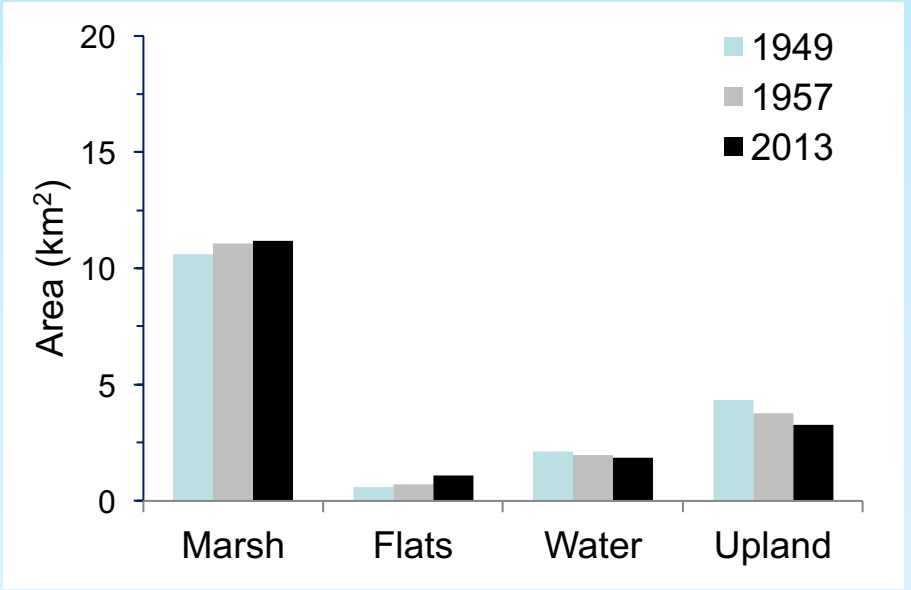


Little change over time

Courtesy C. Burns & C. Alexander

Marsh Features - VCR

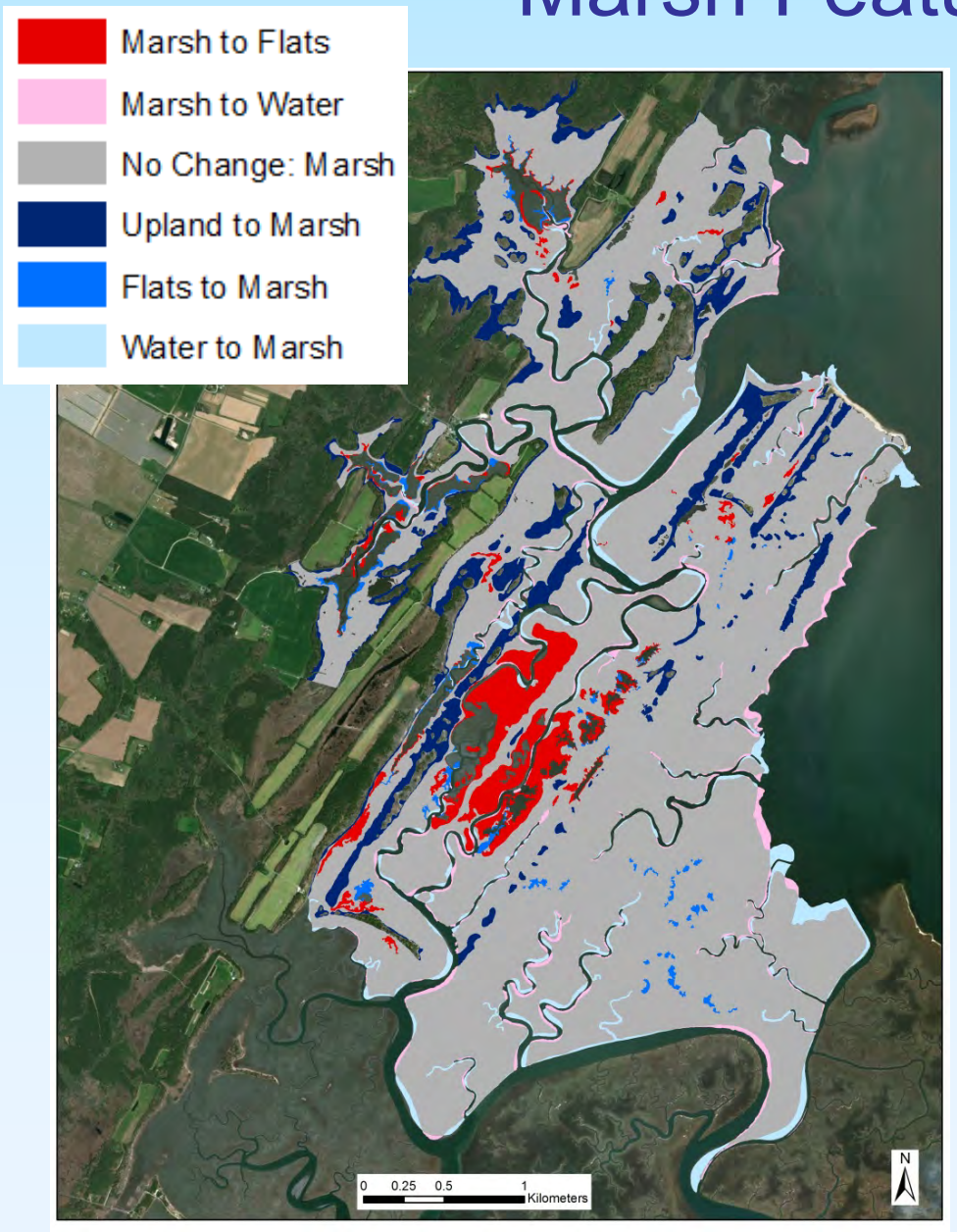


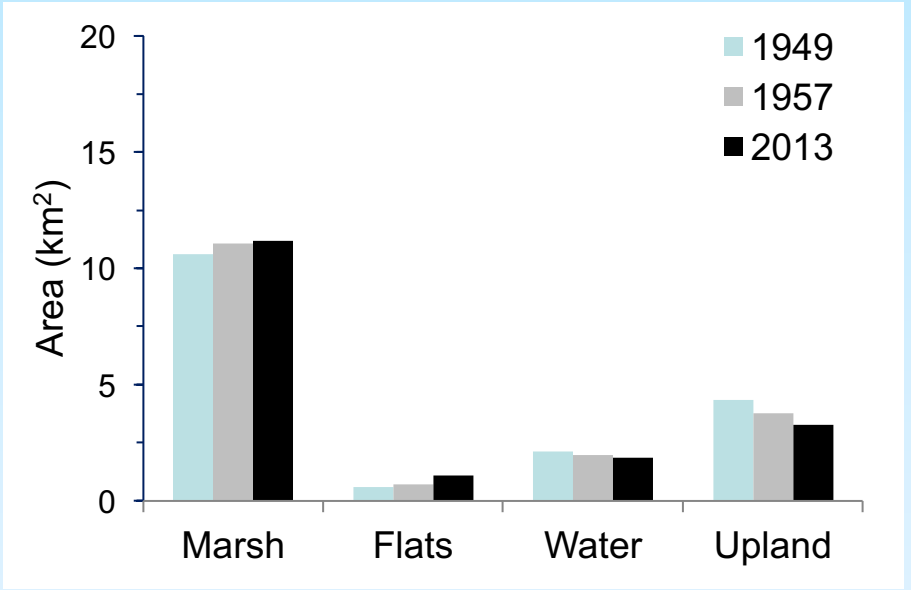


Increase in marsh area
Some upland transgression
Marsh & creeks converting to flats

Courtesy C. Burns & C. Alexander

Marsh Features - VCR





Increase in marsh area
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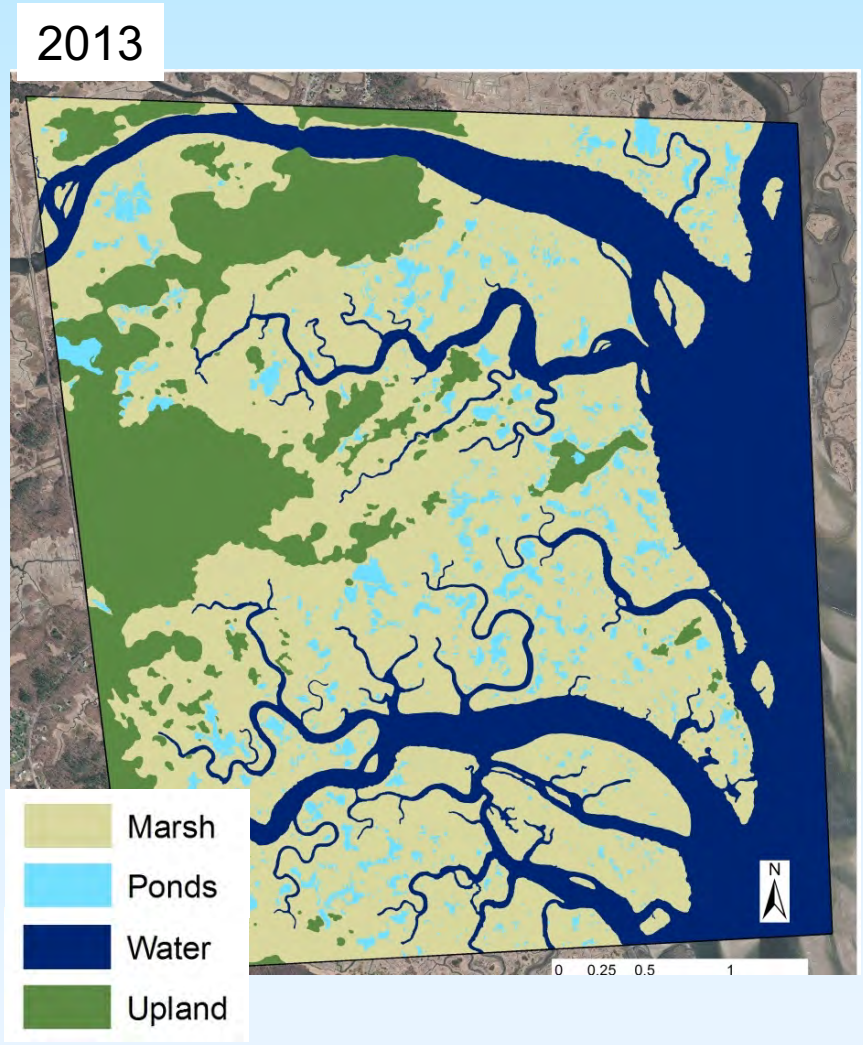
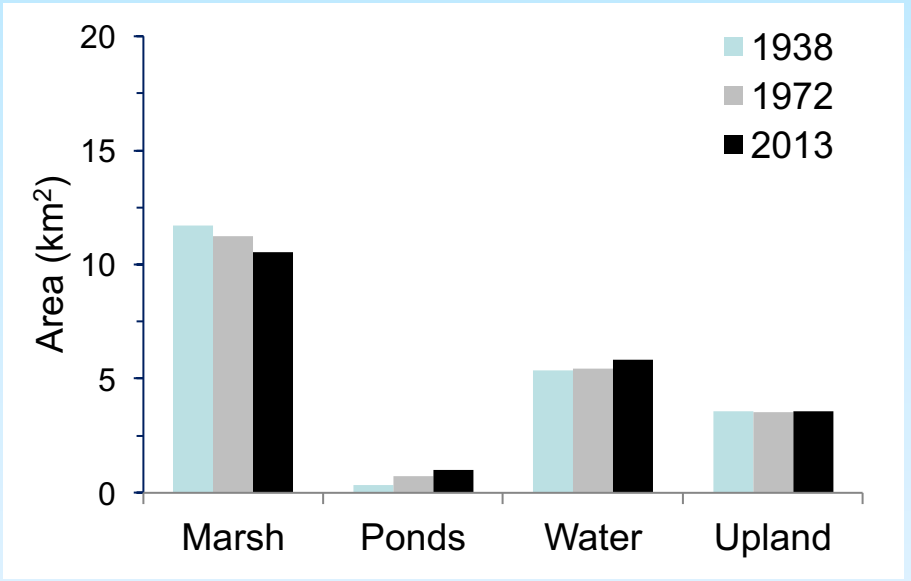
Courtesy C. Burns & C. Alexander

Marsh Features - PIE

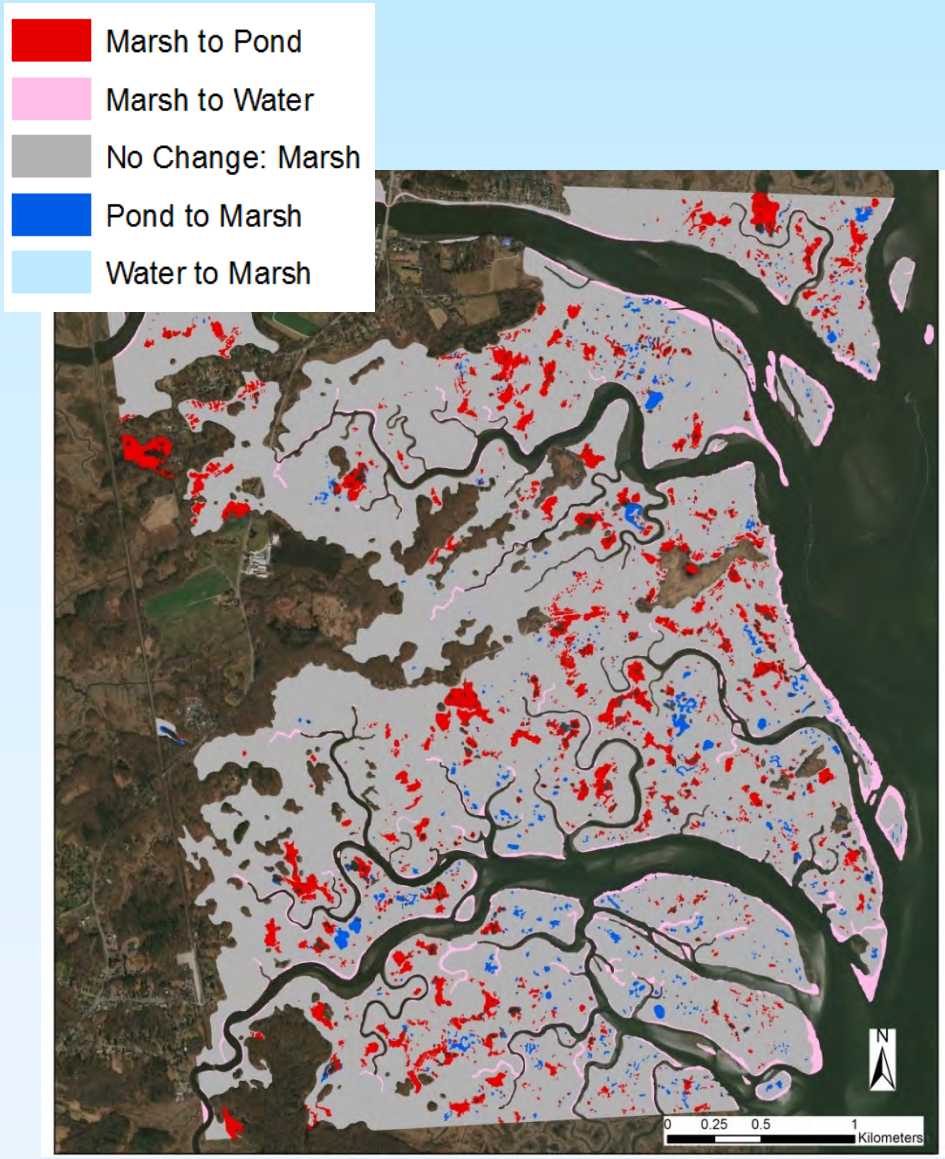


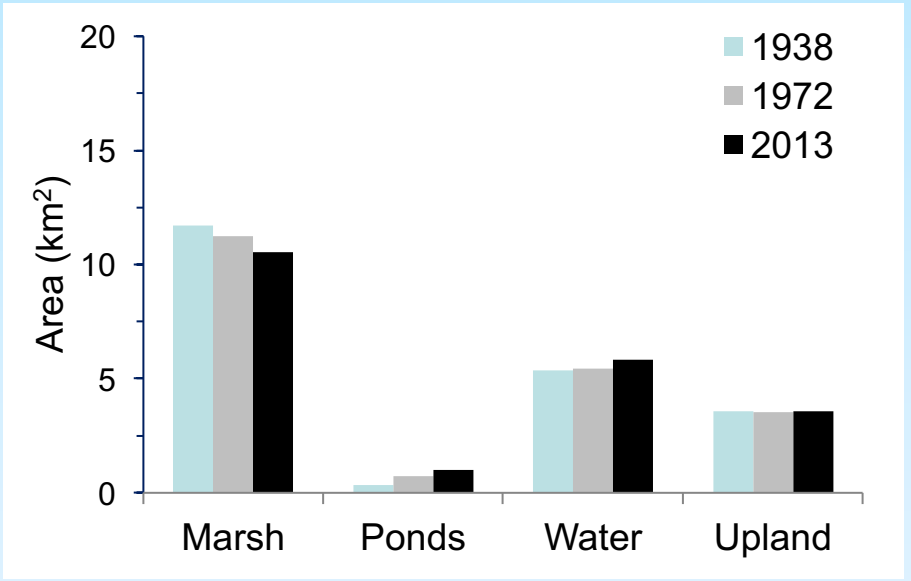


Decrease in marsh area
Increase in ponds

Courtesy C. Burns & C. Alexander

Marsh Features - PIE

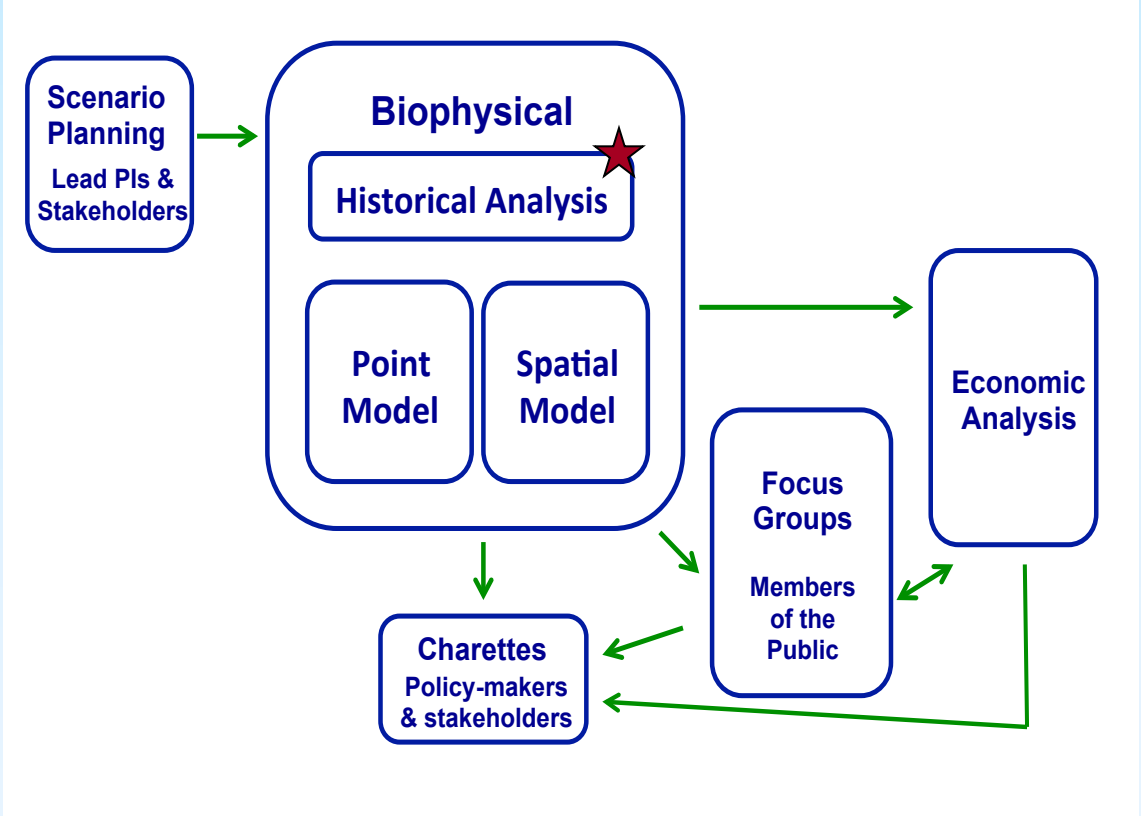




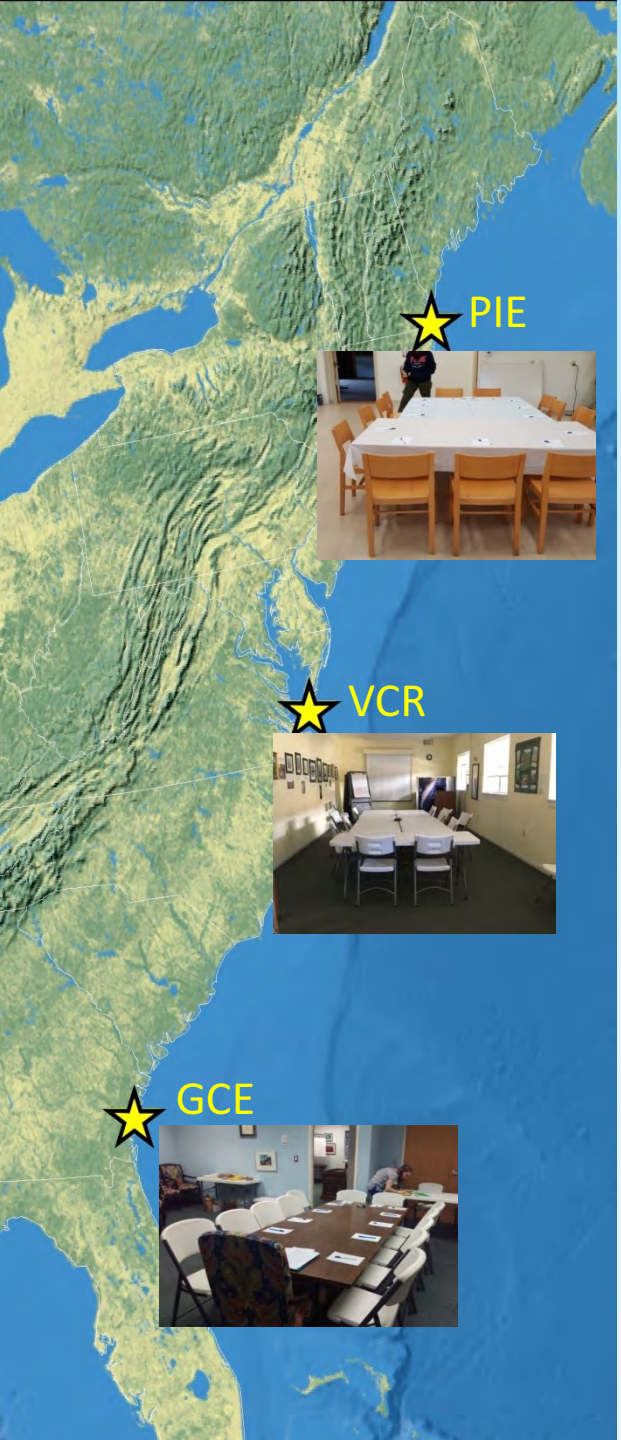
Decrease in marsh area
Increase in ponds

Courtesy C. Burns & C. Alexander

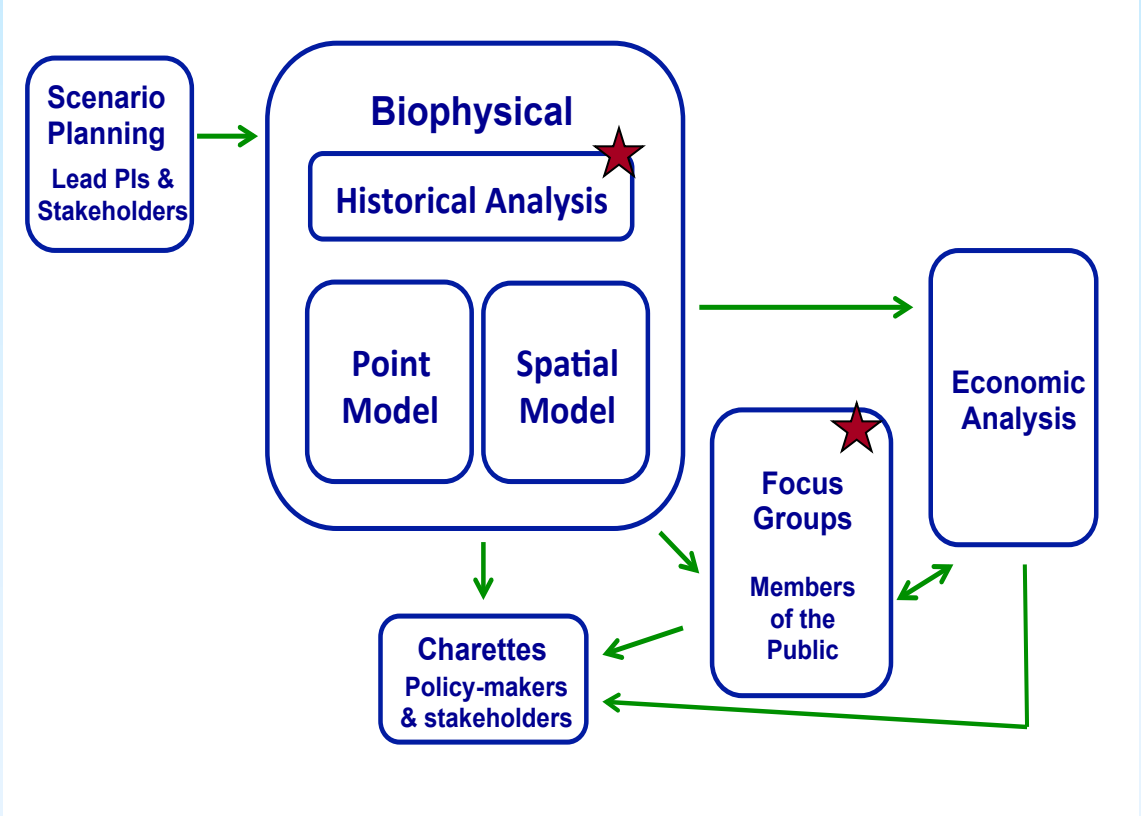
Coastal SEES: A cross-site comparison of salt marsh persistence in response to sea-level rise and feedbacks from social adaptations



Collaborators:
PIE: Anne Giblin, Jim Morris, Rob Johnston, Colin Polsky
VCR: Karen McGlathery, Matt Kirwan, Pat Wiberg
GCE: Merryl Alber, Clark Alexander



Coastal SEES: A cross-site comparison of salt marsh persistence in response to sea-level rise and feedbacks from social adaptations



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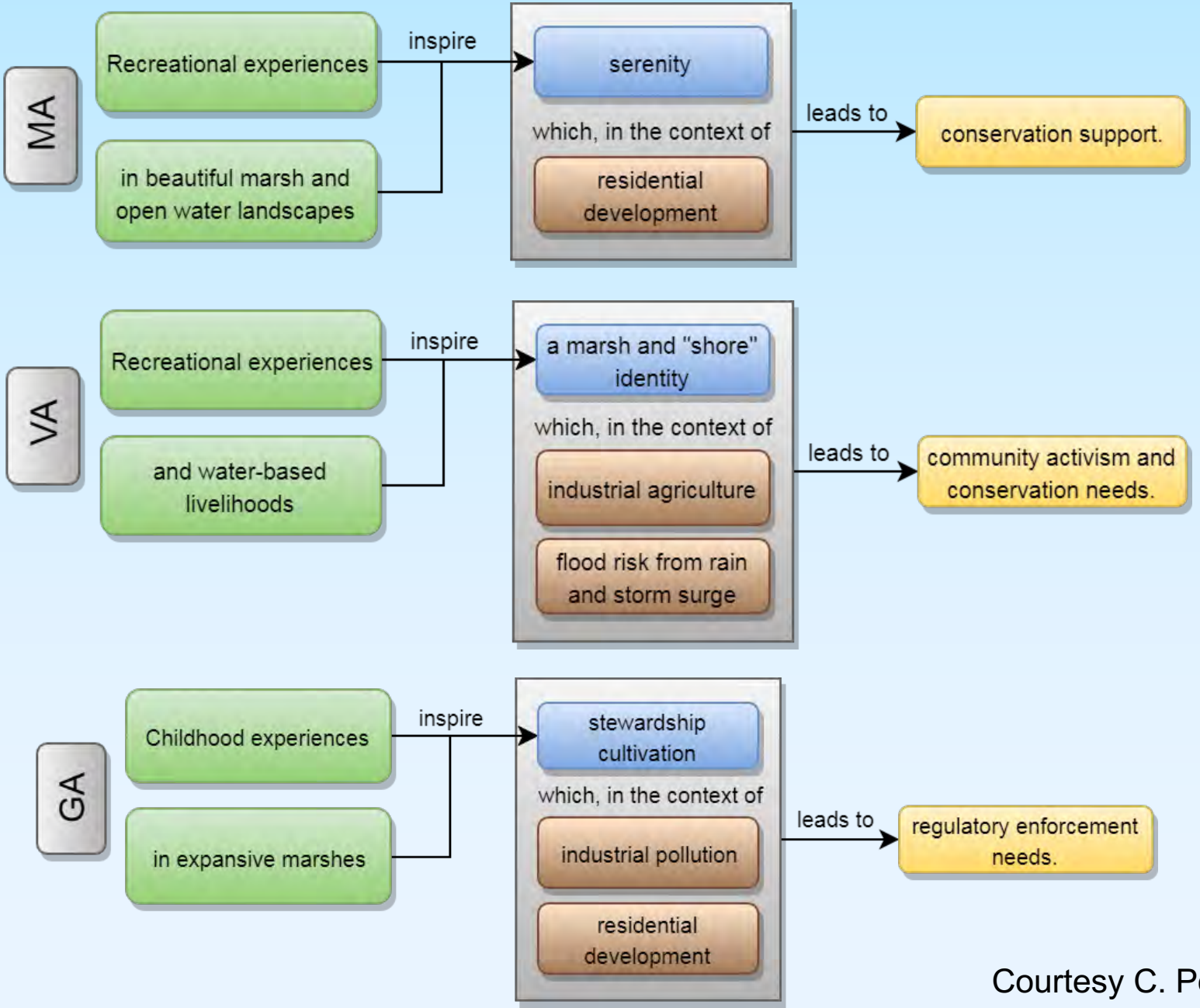
Coded Responses

All Themes – Clusters 1, 2, and 3					
Selective Code	Description	MA	VA	GA	Illustrative Quotation
COASTAL PROTECTION AND FLOODING	Concerns regarding flooding and storms, and appreciation of the coastal protection provided by the marsh.	9%	15%	9%	MA 3.7: …if we didn't have the marshes we would've been flooded just like a lot of other areas that build in the marshes just like a lot of areas.
COMMUNITY AGENCY AND ENGAGEMENT IN PROTECTION	The ways in which local communities or individuals are interested and/or active in protecting their local environment.	20%	20%	15%	GA 1.2: On a local level, we can continue to show up at the zoning board meetings and the commission meetings and let our voice be known.
CULTURAL BENEFITS	Experiences and cognitive processes that contribute to personal well-being or communal fulfillment.	39%	20%	30%	MA 3.11: …the lack of light pollution here, the gorgeous sunsets being able to see so many shooting stars, watching storm clouds rolling in, all of that is just, it's just priceless to me…
ECONOMIC DEPENDENCE	Industries and livelihoods that are dependent on the marsh, coast, and inland natural resources.	1%	6%	4%	GA 1.7: …if it's not for the marsh, these communities along the coast would be ghost towns. Literally.
FEELING DISAVOWED BY GOVERNMENT	Concern for indifference, corruption, or a lack of appropriate funding or support from federal, state, and local governments.	–	3%	8%	VA 1.1: …with all the cutbacks that's goin' on in Washington DC now, we just spittin' in the wind.
KNOWLEDGE OF ECOSYSTEM FUNCTIONS	The ways in which the community understands provisioning, regulating, and supporting ecosystem services.	2%	3%	2%	GA 1.1: They pollinate the marsh grass. Without those sand gnats, we wouldn't have any shrimp. So we gotta put up with them.
THREATENING THE MARSH OR PROVISION OF SERVICES AND BENEFITS	Anthropogenic factors contributing to a decline in marsh ecosystem health or provision of services.	12%	15%	16%	VA 1.9: …runoff where you get chemicals in the ground, it goes right to our water source so it kills our fish, shellfish, everything.
WILDLIFE AND HABITAT	Presence, characteristics, and changes in wildlife and habitat.	18%	18%	16%	MA 1.5: I've seen changes with, you know with the fish populations over the years…we had baby blue fish up this way a couple years ago and I've never seen them up here before.
	Total	100%	100%	100%	

Courtesy C. Polsky

Ecosystem services, Threats, & Community Responses



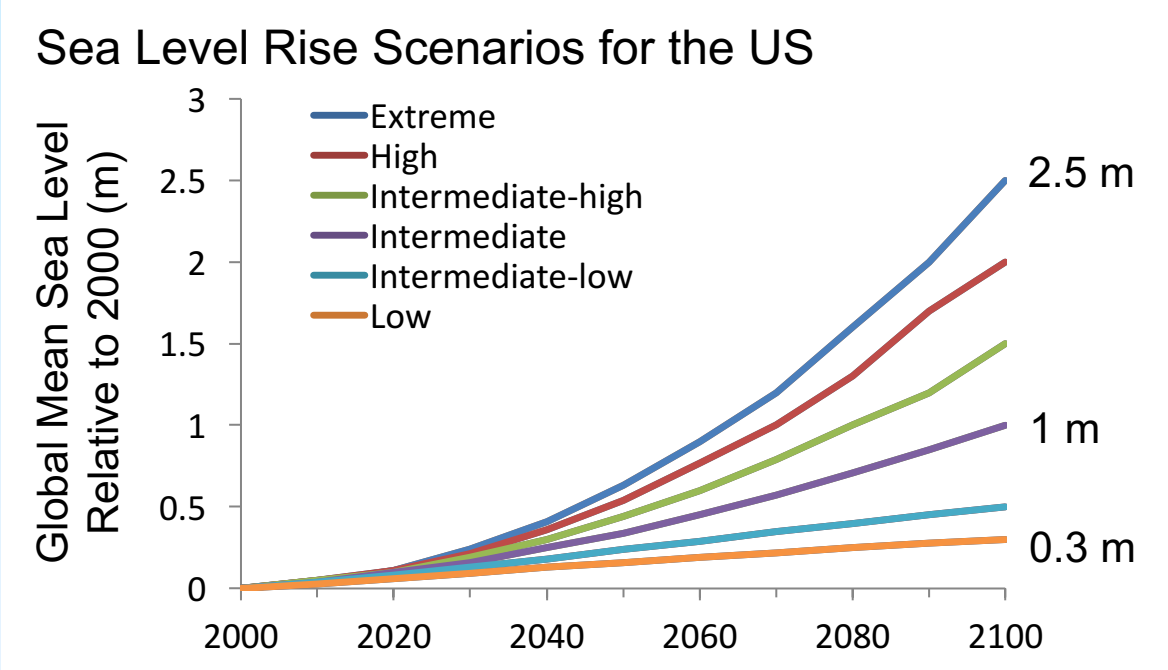
Courtesy C. Polsky

Take Home Messages

1. Sea level rise will affect both plant biomass and vertical accretion
2. In addition to vertical accretion, there are other mechanisms for marsh gain and loss:
   - GCE likely to experience upstream migration
   - VCR showing evidence of upland transgression
   - PIE showing marsh loss due to shoreline erosion and ponding
3. Although there are regional differences, the public identifies primarily with cultural ecosystem services

Sustainability of Salt Marshes: Still a Realistic Goal?

Depends on rate of sea level rise in relation to accretion and the potential for both upland transgression and lateral migration,



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all of which depend primarily on human actions.

Thanks to: Ellen Herbert, Christine Hladik, Christine Burns, Clark Alexander, Steve Pennings, Chris Craft, Colin Polsky & Joan Sheldon