

Persistent saltwater intrusion alters ecosystem carbon cycling in tidal freshwater marshes:

Comparison of results from in situ manipulations
in Virginia and South Carolina

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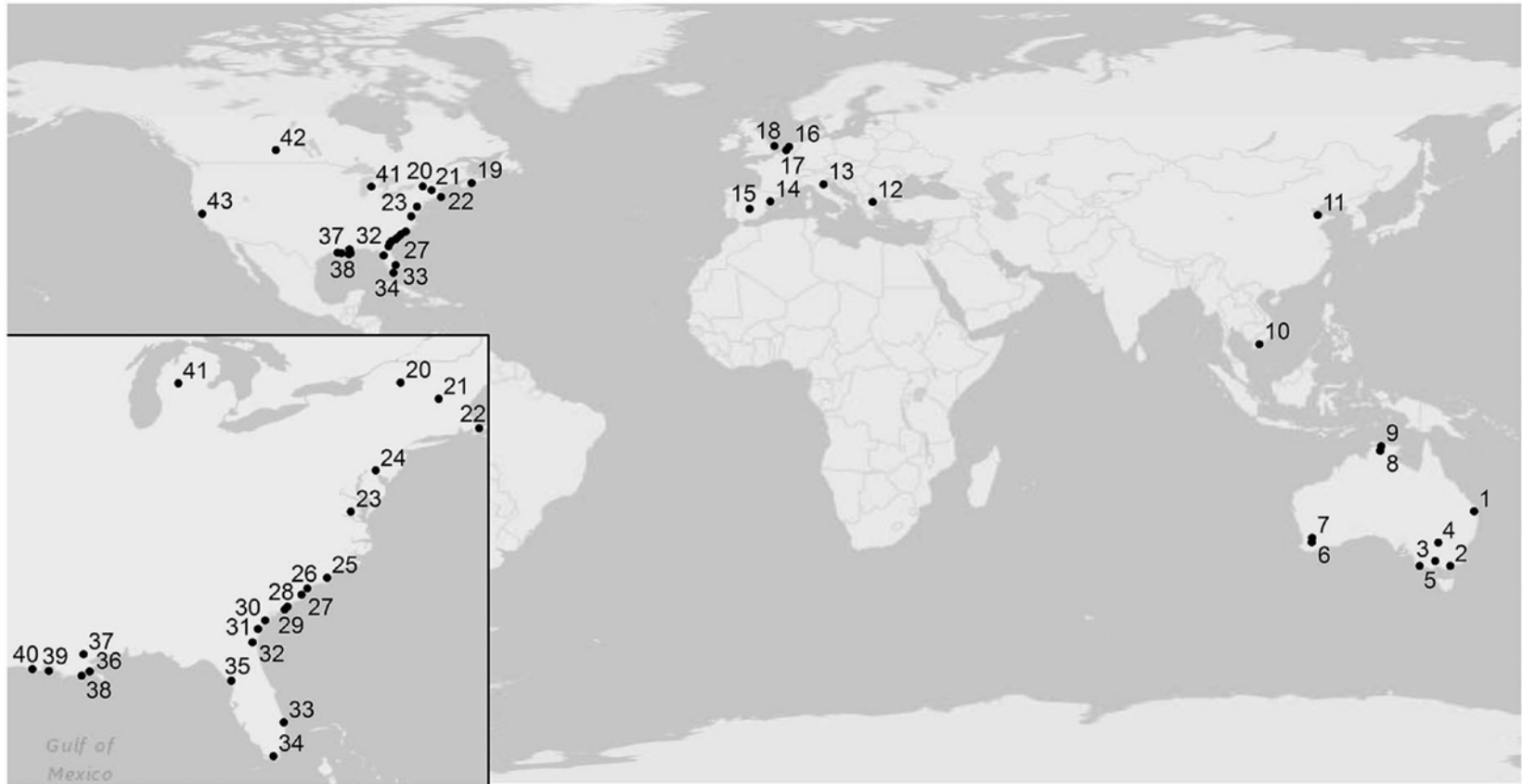
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Saltwater intrusion: A global issue



storm surge



river flow



drought

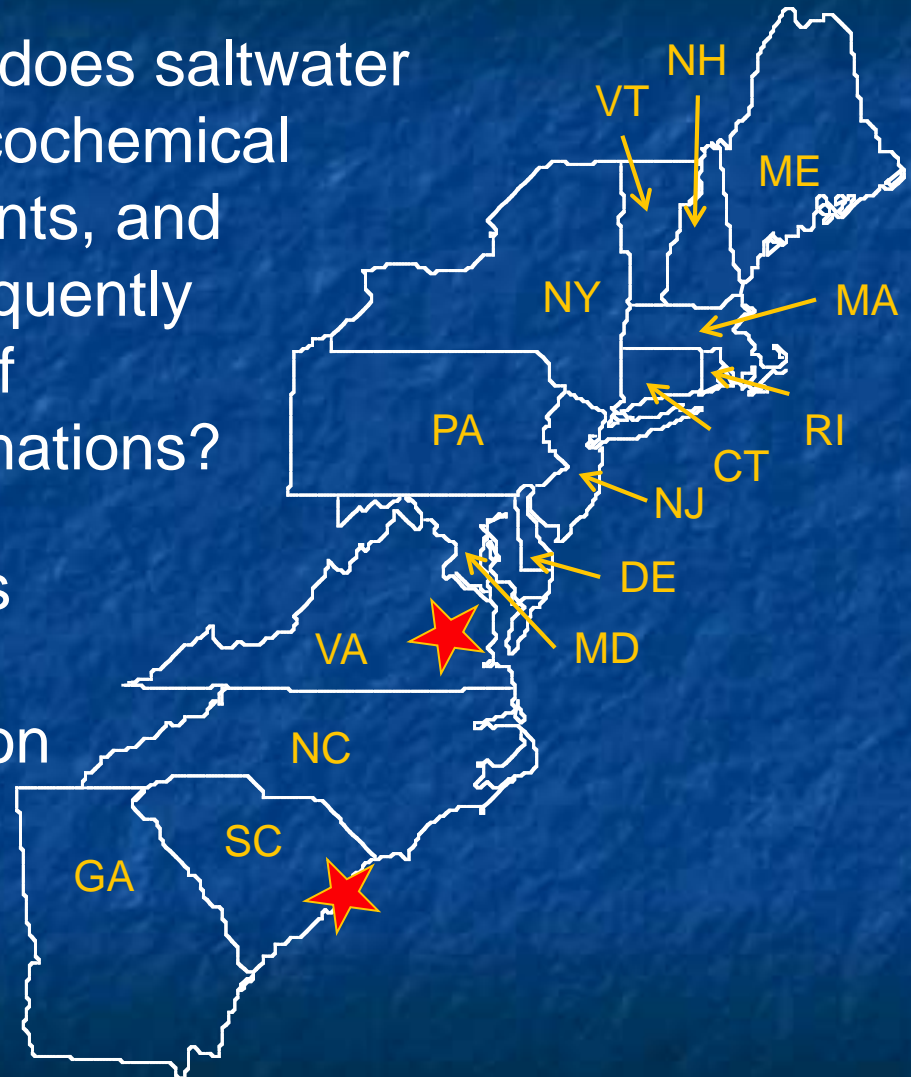


sea level rise

Research questions

Overarching question: How does saltwater intrusion affect the physicochemical environment, wetland plants, and soil microbes, and subsequently the rates and pathways of biogeochemical transformations?

Specific question: How does saltwater intrusion affect wetland primary production and decomposition?



Study sites

Cumberland

Pamunkey River, VA

2x daily

30 cm

35 %

0.14 g cm⁻³

17 species

Seasonal dominants

Where

Flooding freq.

Flood depth

Soil % organic

Bulk density

Plant richness

Dominant species

Brookgreen

Waccamaw River, SC

~20x monthly

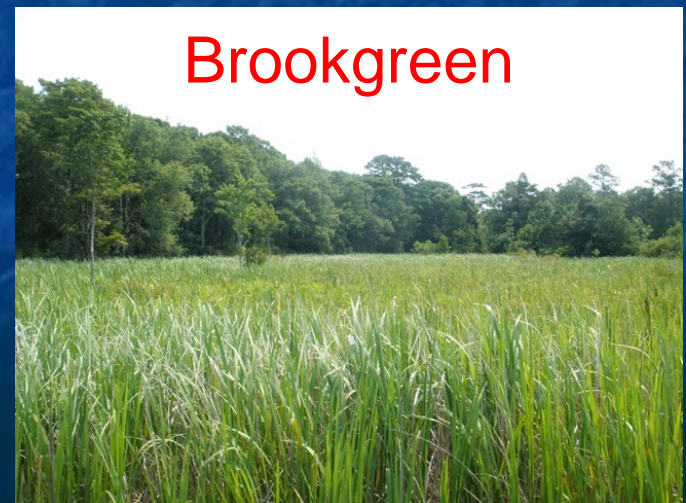
10-20 cm

70 %

0.07 g cm⁻³

32 species

Zizaniopsis miliacea



Experimental approach

» *In situ* increase of salinity from freshwater → oligohaline

» Three treatments per site

+salt

... add brackish water to marsh

+fresh

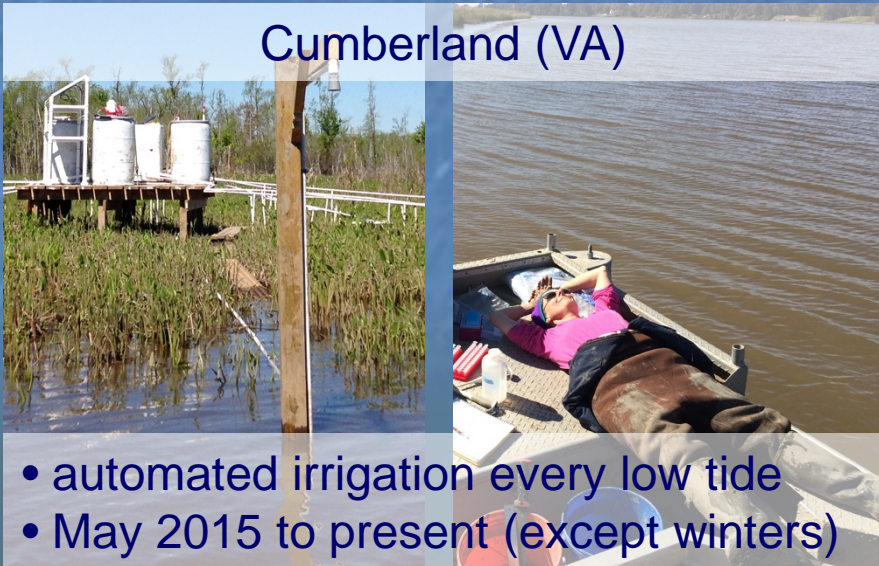
... add freshwater to marsh

control

... no manipulations

$n = 5$
per treatment
per site

Cumberland (VA)



Brookgreen (SC)



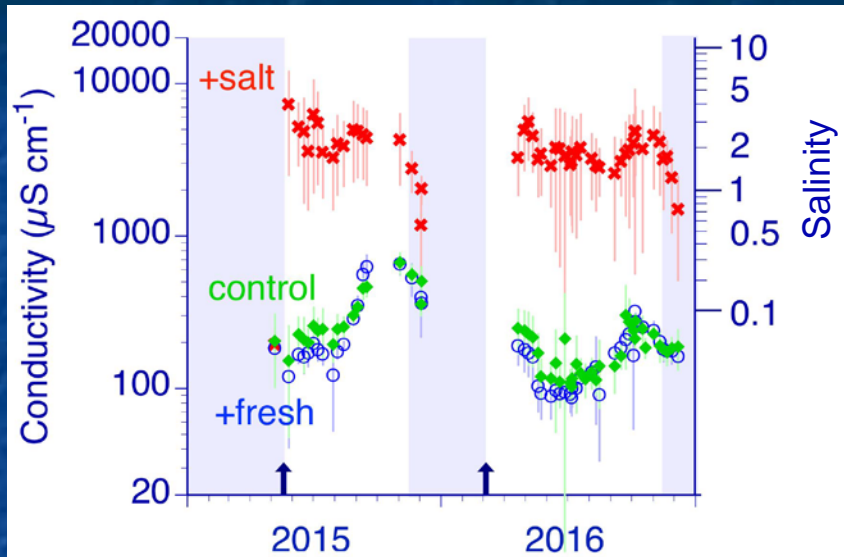
Measurements

- » Marsh-atmosphere CO_2 and CH_4 exchanges
 - ~monthly measurements
- » Soil CO_2 and CH_4 production potentials
 - **Cumberland**: seasonal measurements for first 2+ years
 - **Brookgreen**: one-time measurement after 3.5 years
- » Soil carbon and nitrogen content
 - same frequency as gas production assays



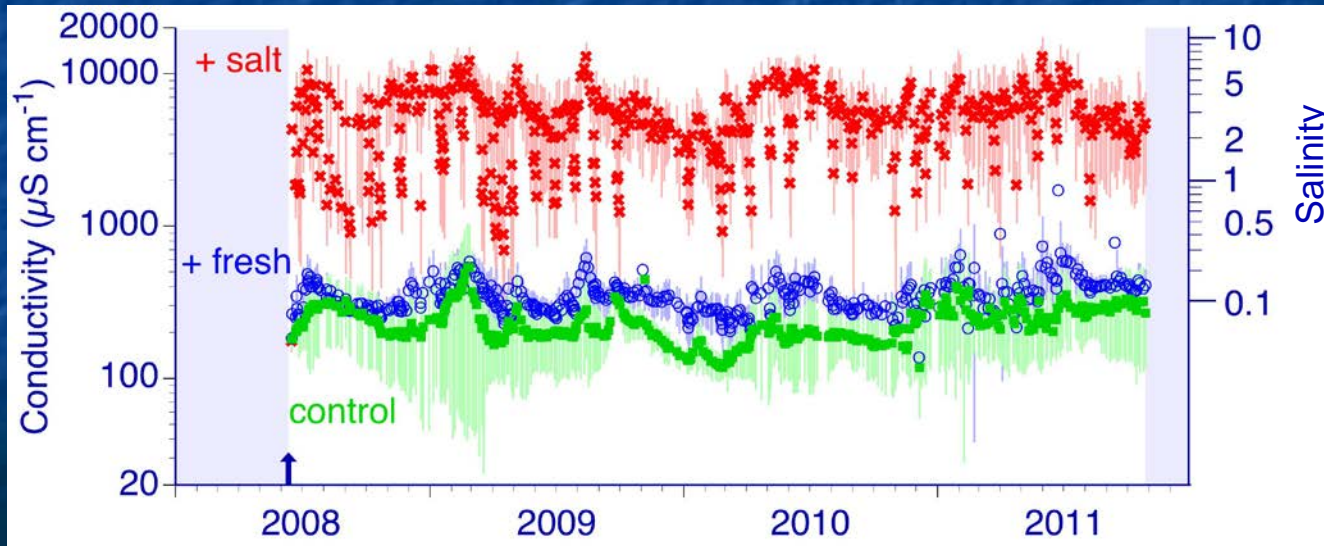
Porewater salinity

Cumberland (VA)



- » Brackish additions increased salinity from freshwater to oligohaline.
- » Freshwater additions did not affect salinity

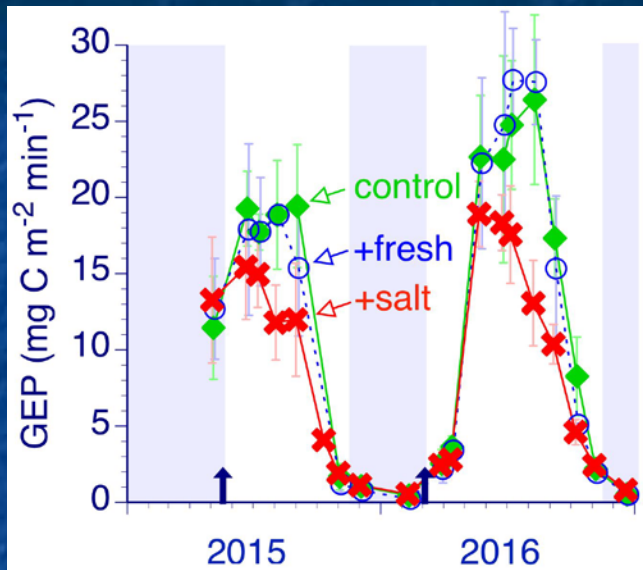
Brookgreen (SC)



Porewater salinity at 10 cm; values are means \pm std dev; $n = 5$ plots per date

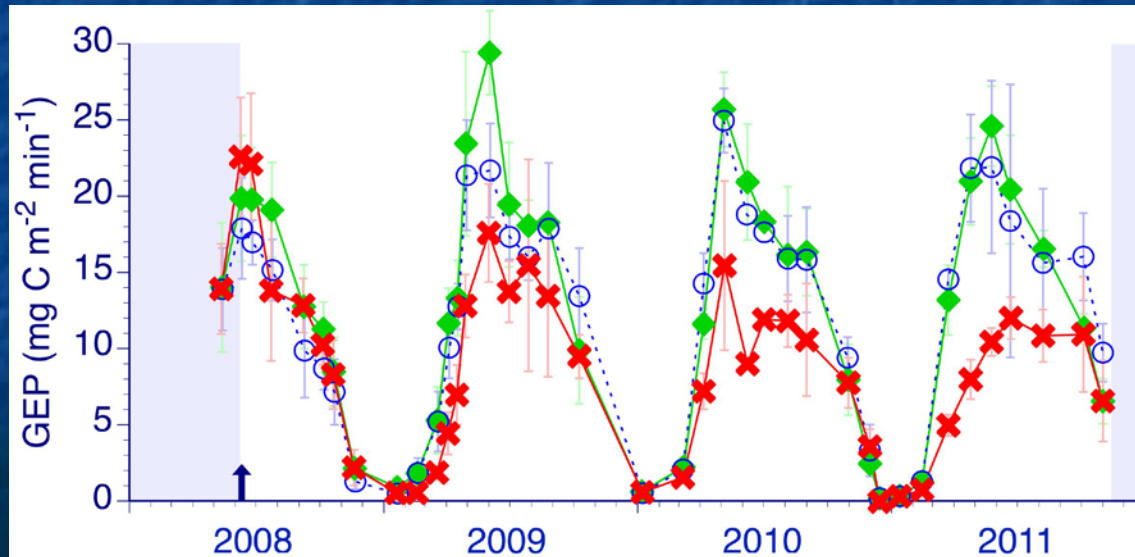
Gross ecosystem production

Cumberland (VA)



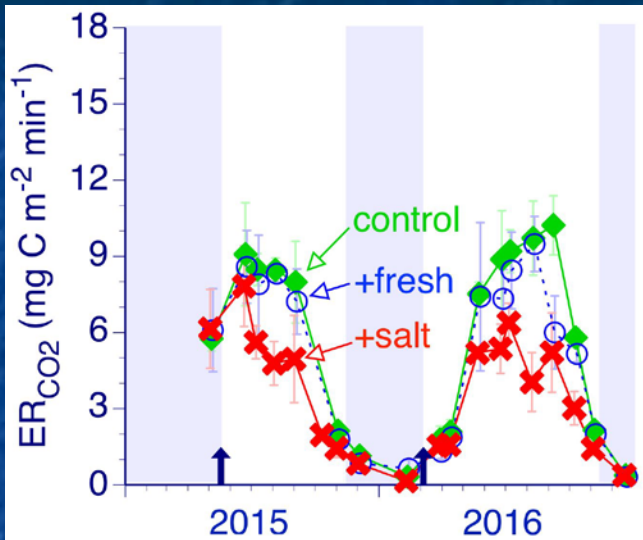
- » Saltwater intrusion ***decreases*** gross ecosystem production
- » Similar rates in both marshes

Brookgreen (SC)



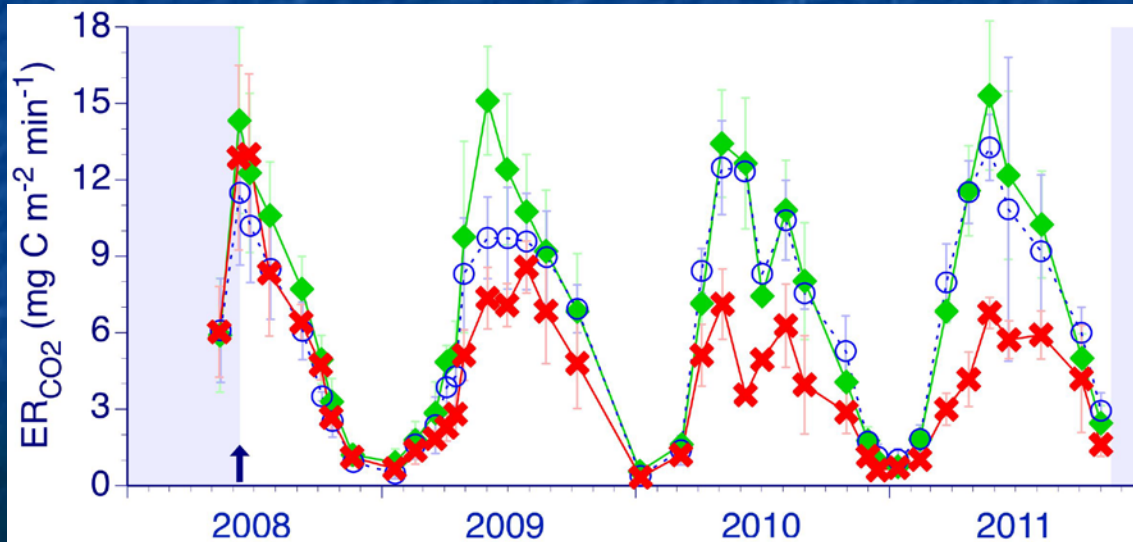
Ecosystem CO₂ emissions

Cumberland (VA)



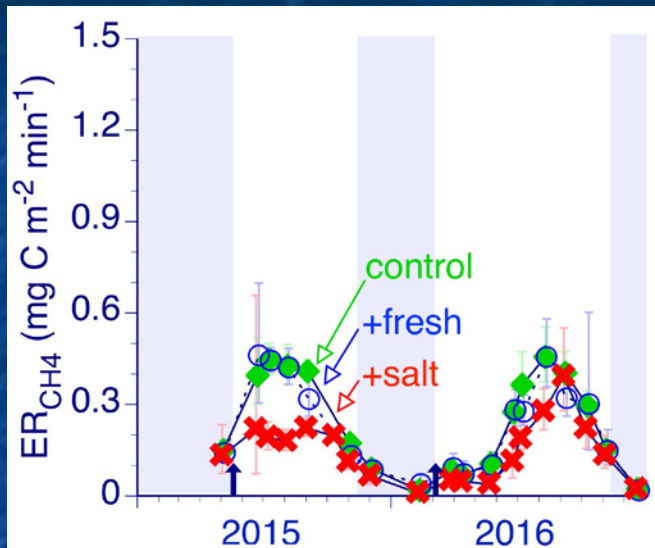
- » Saltwater intrusion **decreases** ecosystem CO₂ emissions
- » Higher ER_{CO₂} at Brookgreen

Brookgreen (SC)



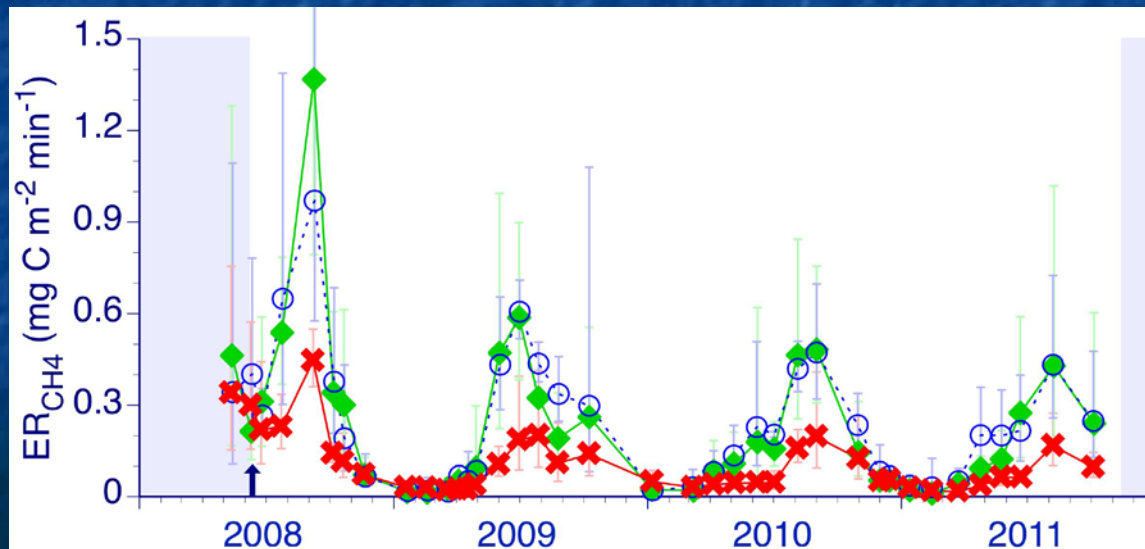
Ecosystem CH_4 emissions

Cumberland (VA)



- » Saltwater intrusion **decreases** ecosystem CH_4 emissions
- » Higher peak ER_{CH₄} at Brookgreen during first 2 years

Brookgreen (SC)



A tale of two marshes

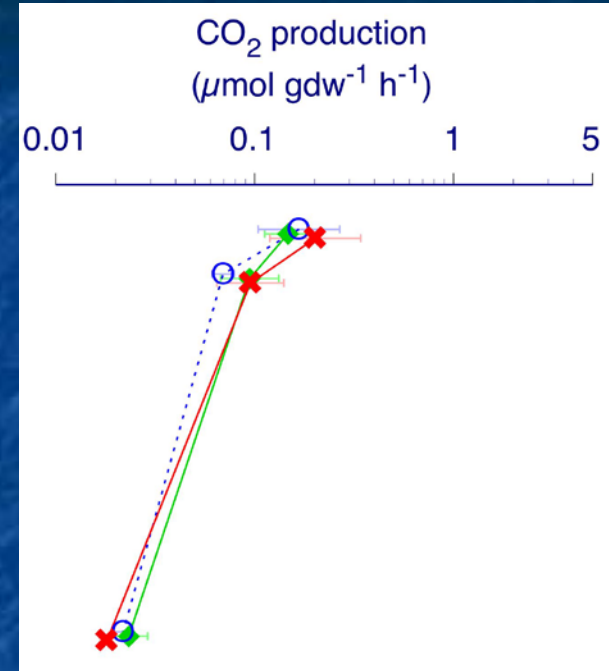
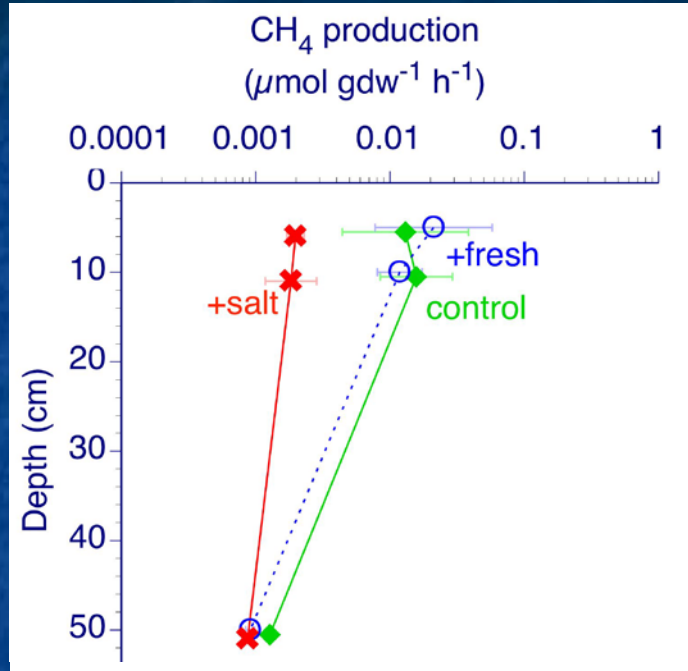
	Cumberland, VA	Brookgreen, SC
Hydrology:	regularly flooded	rarely flooded
Surface soil:	35% organic	70% organic
Plants:	seasonal dominants	<i>Zizaniopsis miliacea</i>

Process	Effect of...	(% change)	(% change)		
GEP	...salinization	22	26	33	44
ER _{CO2}	...salinization	26	12	40	37
ER _{CH4}	...salinization	24	30	48	55
NEP	...salinization	ns	55	ns	63
		2016	2009	2010	2011

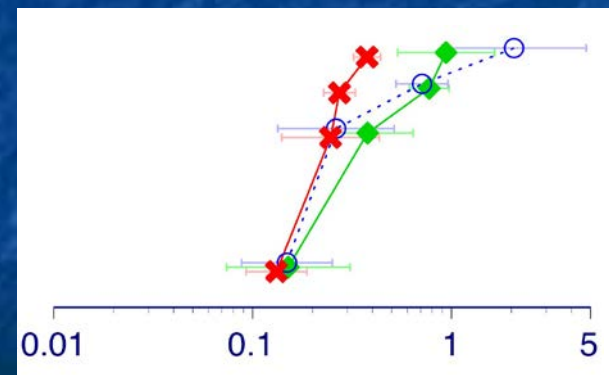
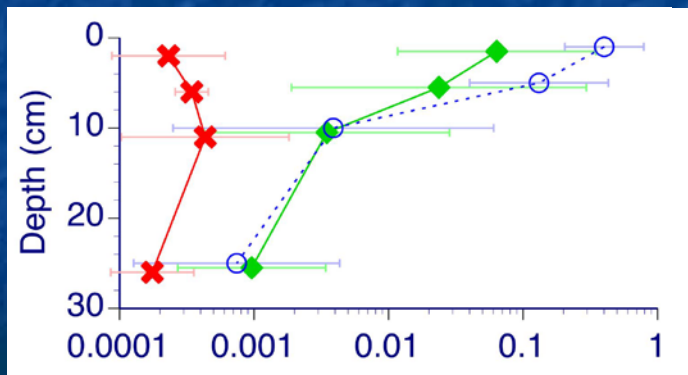
How do annual fluxes change with salinization?

Soil carbon mineralization

Cumberland (VA)



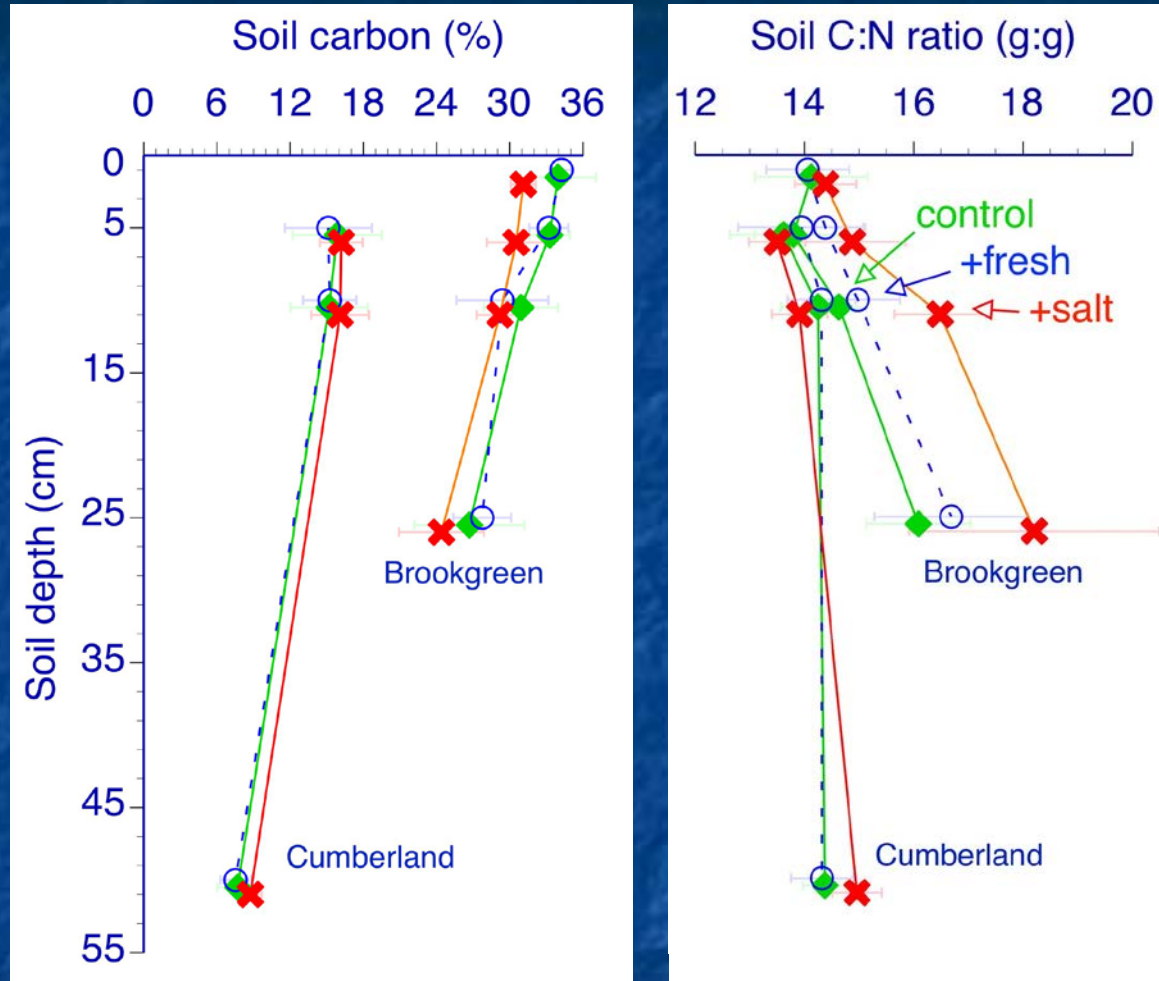
Brookgreen



Salinization... suppresses CH₄ogenesis
(Cumberland & Brookgreen)

...suppresses soil CO₂ prod.
(Brookgreen only)

Soil carbon



Cumberland (VA): No effect of salinization on %C

Brookgreen (SC): Salinization decreases %C; increases C:N

Conclusions

Saltwater intrusion...

- 1) ...reduces gross ecosystem production by 22-44%
 - lower plant biomass, diversity, richness (both sites)
- 2) ...reduces ecosystem CO₂ emissions by 12-40%
 - reduced autotrophic respiration (both sites?)
 - lower soil CO₂ production (Brookgreen only)
- 3) ...reduces ecosystem CH₄ emissions by 24-55%
 - reduced methanogenesis (both sites)
- 4) ...reduces net ecosystem production...sometimes
 - implications for marsh accretion

Thanks!

Collaborators

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- Seth Stewart
- Paul Kenny
- Stephen Forehand
- Tom Marshall

Site use

- Cumberland Marsh
Natural Area Preserve
- Brookgreen Gardens



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