Blue Carbon Research to Establish Baseline Conditions and Inform Restoration Planning in the Pacific Northwest

Amy B. Borde, Christopher Janousek, Craig Cornu, Heida Diefenderfer, Scott Bridgham, Trevor Williams, Maggie McKeon, Matthew Brand, Katrina Poppe, John Rybczyk, Jude Apple, Boone Kauffman, and Laura Brophy

PNW Blue Carbon Working Group

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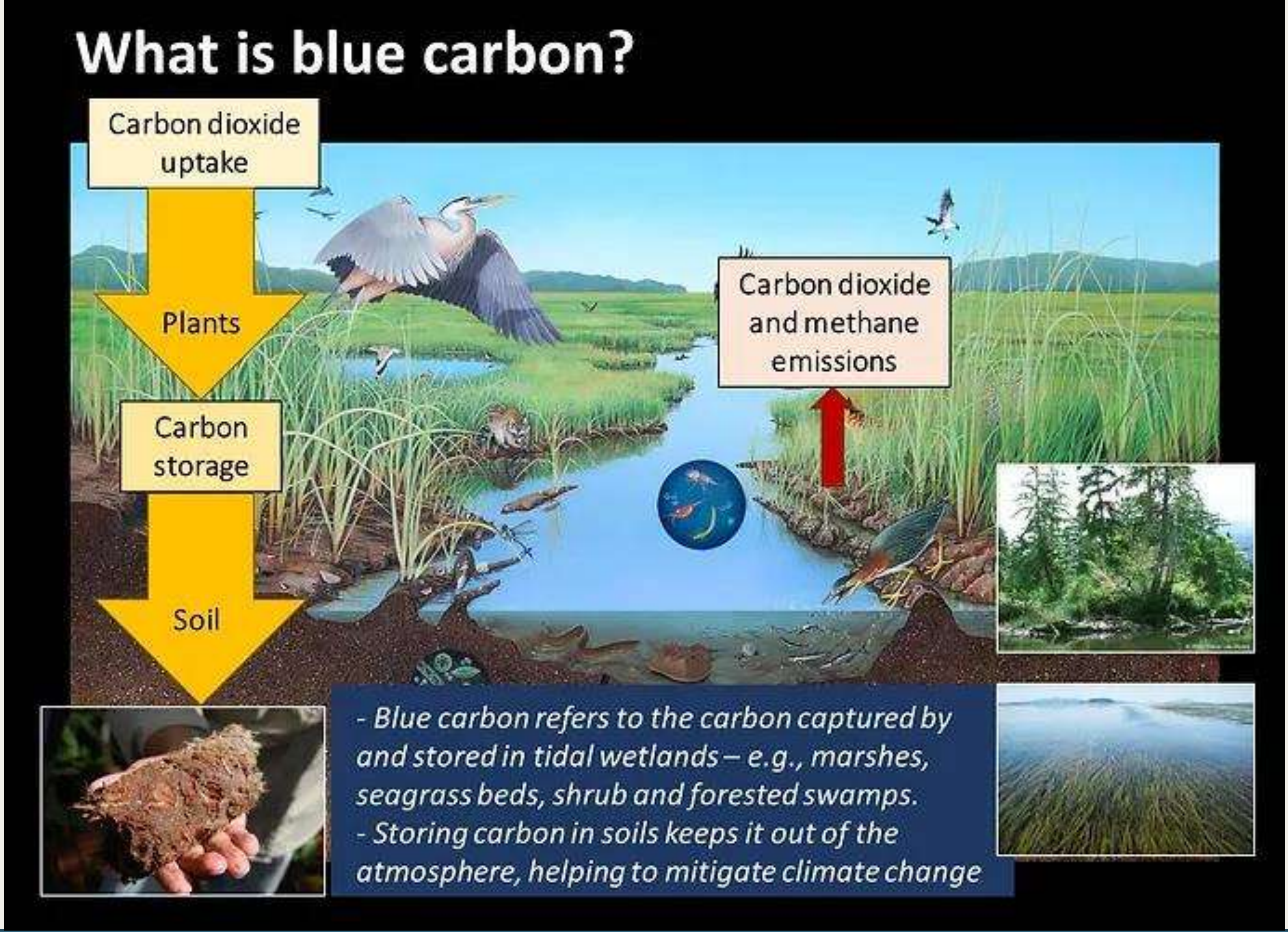
- Aster Global Environmental Solutions
- Bonneville Environmental Foundation
- Bonneville Power Admin
- CA Air Resources Board
- CA Department of Insurance
- CA Ocean Protection Council
- California Coastal Conservancy
- California Ocean Protection Council
- California Ocean Science Trust
- Clallam County MRC
- Castalia Environmental
- Columbia River Estuary Study Taskforce
- Columbia Land Trust
- Coos Watershed Association
- Cowlitz Indian Tribe
- Ducks Unlimited
- Environmental Science Associates
- Institute of Applied Ecology
- Gordian Knot Strategies
- Hakai Institute
- High Tide Foundation
- ICF Jones and Stokes
- Lower Columbia Estuary Partnership
- NOAA
- OR State Parks
- Oregon Sea Grant
- Oregon State University
- OR Watershed Enhancement Board
- PNW National Laboratory
- Pac. States Marine Fisheries Commission
- Padilla Bay NERR
- Parks Canada
- Pew Charitable Trusts
- Portland State University
- Puget Sound Partnership
- Restore America's Estuaries
- Silvestrum Climate Associates
- Simon Fraser University
- Smithsonian Environmental Research Center
- Snohomish County
- South Slough NERR
- Terracarbon LLC
- The Climate Trust
- The Nature Conservancy
- The Nature Conservancy Canada
- The Wetlands Conservancy
- Tillamook Estuaries Partnership
- OR Global Warming Commission
- Tulalip Tribes
- U.S. EPA
- UC Davis
- University of British Columbia
- University of Oregon
- University of Victoria
- US Fish and Wildlife Service
- US Geological Survey
- VERRA/Verified Carbon Standard
- WA Dept of Natural Resources
- Washington Department of Fish and Wildlife
- Western Washington University



Tidal wetland graphic: Barbara Harmon

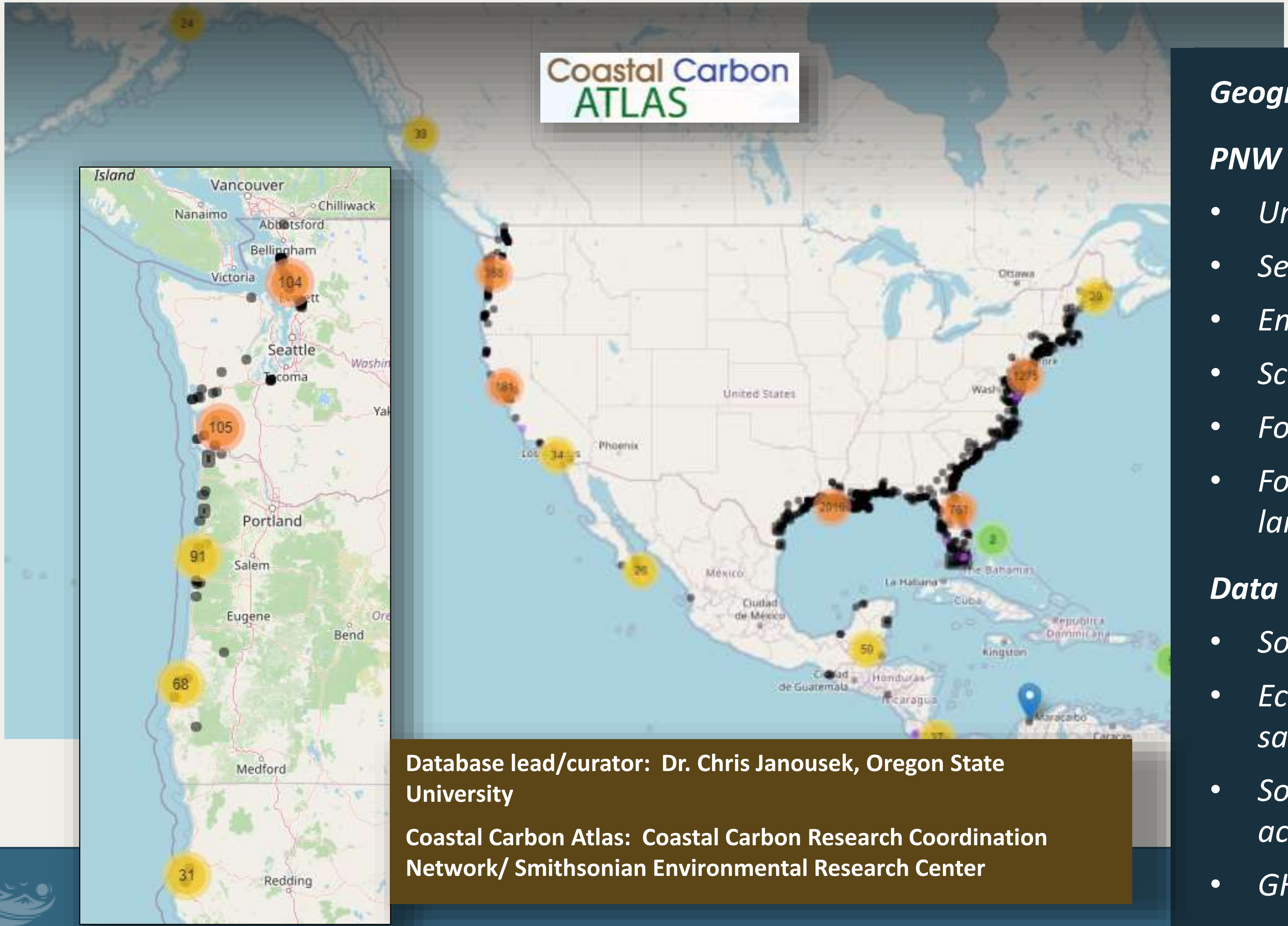
PNW Blue Carbon Working Group: *Framework*

Core objective: fill PNW blue carbon data gaps

- *Geographic scope—PNW coastal area from British Columbia's Strait of Georgia to California's Cape Mendocino*
- *Habitat scope—PNW tidal wetland classes*
- *Land uses—natural and managed lands*
- *Link key environmental drivers to variations in blue carbon metrics—tidal inundation, channel and groundwater level and salinity, wetland elevation plant community…etc*

Northeast Pacific Regional Blue Carbon Database

National Estuarine
Research Reserve System
Science Collaborative



Database lead/curator: Dr. Chris Janousek, Oregon State University

Coastal Carbon Atlas: Coastal Carbon Research Coordination Network/ Smithsonian Environmental Research Center

Geographic Scope: *Canada, US, Mexico*

PNW Wetland Types:

- *Unvegetated tide flats*
- *Seagrass/SAV*
- *Emergent tidal marsh*
- *Scrub-shrub wetlands*
- *Forested tidal wetlands*
- *Former tidal wetlands converted to ag lands and restored tidal wetlands*

Data Types:

- *Soil carbon density and stocks*
- *Ecosystem drivers (e.g., elevation, salinity, plant communities)*
- *Soil accretion and carbon accumulation rates*
- *GHG emissions …coming soon*

Carbon Stock Assessment (2016-2019)

9 estuaries

34 sites

5 sites in Columbia River Estuary

National Estuarine Research Reserve System Science Collaborative

NCCOS NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

GHG Emissions (2020-2023)

6 estuaries

39 sites

7 sites in Columbia River Estuary

1. How do carbon stocks, sequestration rates, and emissions vary by wetland type and land-use class?
2. How do major environmental drivers such as salinity impact sequestration and emissions?
3. What are the potential effects of sea-level rise on GHG emissions?

Salinity and wetland class	Emergent marsh	Forested tidal wetland	Disturbed wetlands/ pastures
Freshwater	SEC, MIO, KAN, MIR	SEC, SES, MIS	WAS, WAS2, ALD, PBD, JRW, JRD, SFC
Oligohaline	MLC, JRO, SCS, SFC	WIN, JRS	SAU, PBW
Mesohaline	FSM, DAN, FIR, JRM, DSI, KZL, KZH, FRE, FRR, SFC		
Polyhaline	MIL, MET, GP, MIL, JRR, SFC		
Euhaline	BIS		

Least-disturbed sites; restored sites; disturbed/non-tidal sites

Carbon Stock Methods

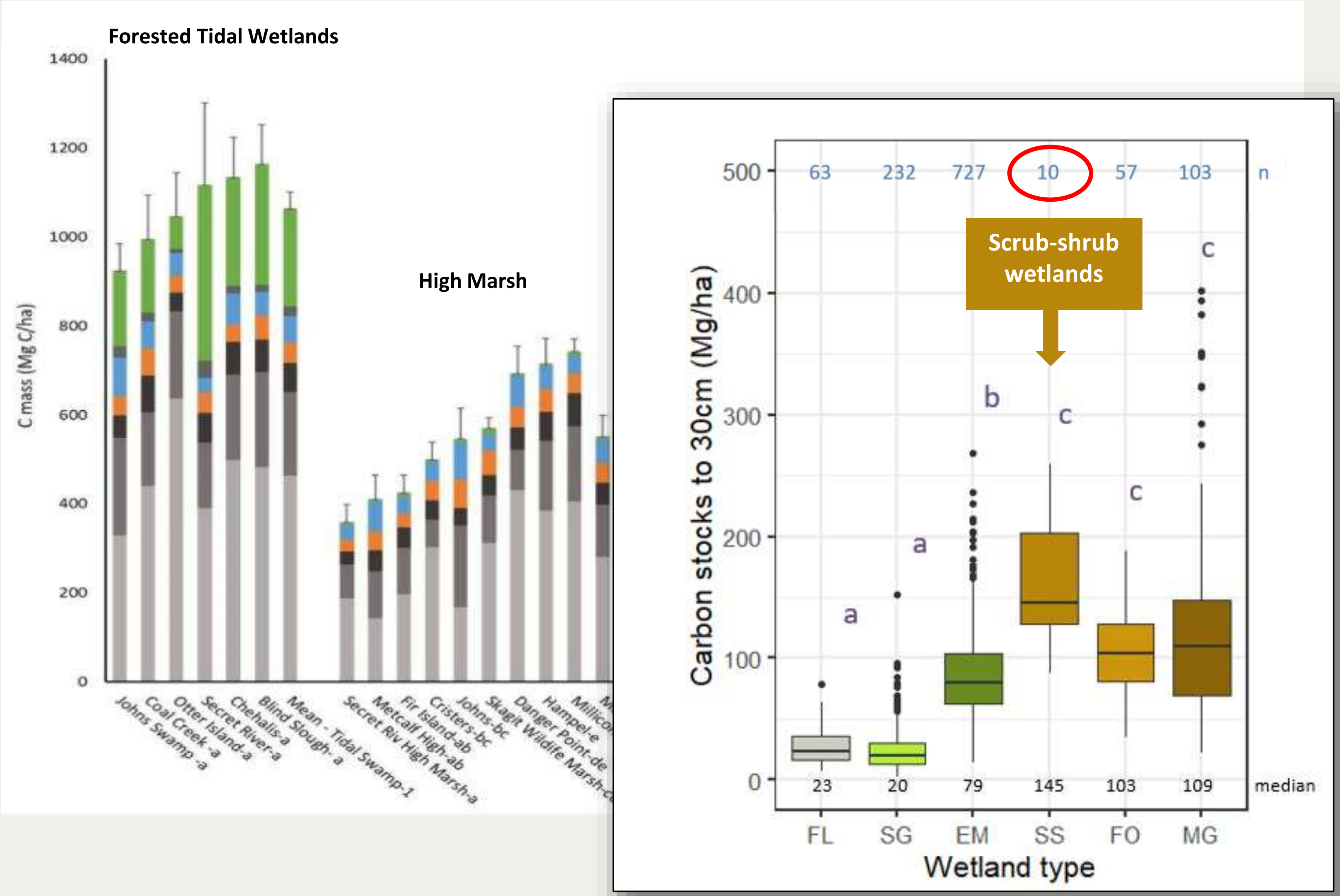
- At each site measured total ecosystem carbon stocks
  - Soil carbon (cores up to 3m depth)
  - Above and below-ground plant biomass
- 6 replicates per site

Kauffman et al. (2020) *Global Change Biology*

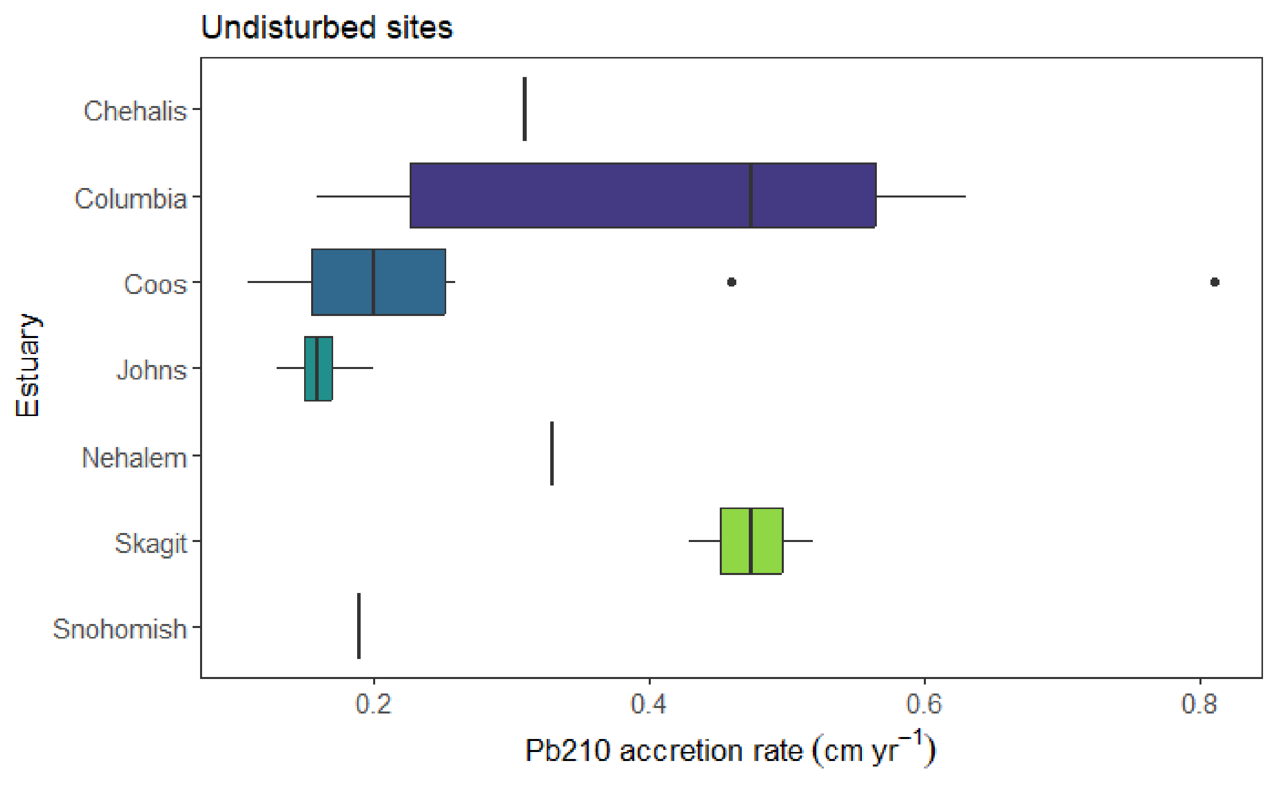
Carbon Stocks Results

Carbon storage capacity is greatest in forested tidal wetlands and lowest in eelgrass beds.

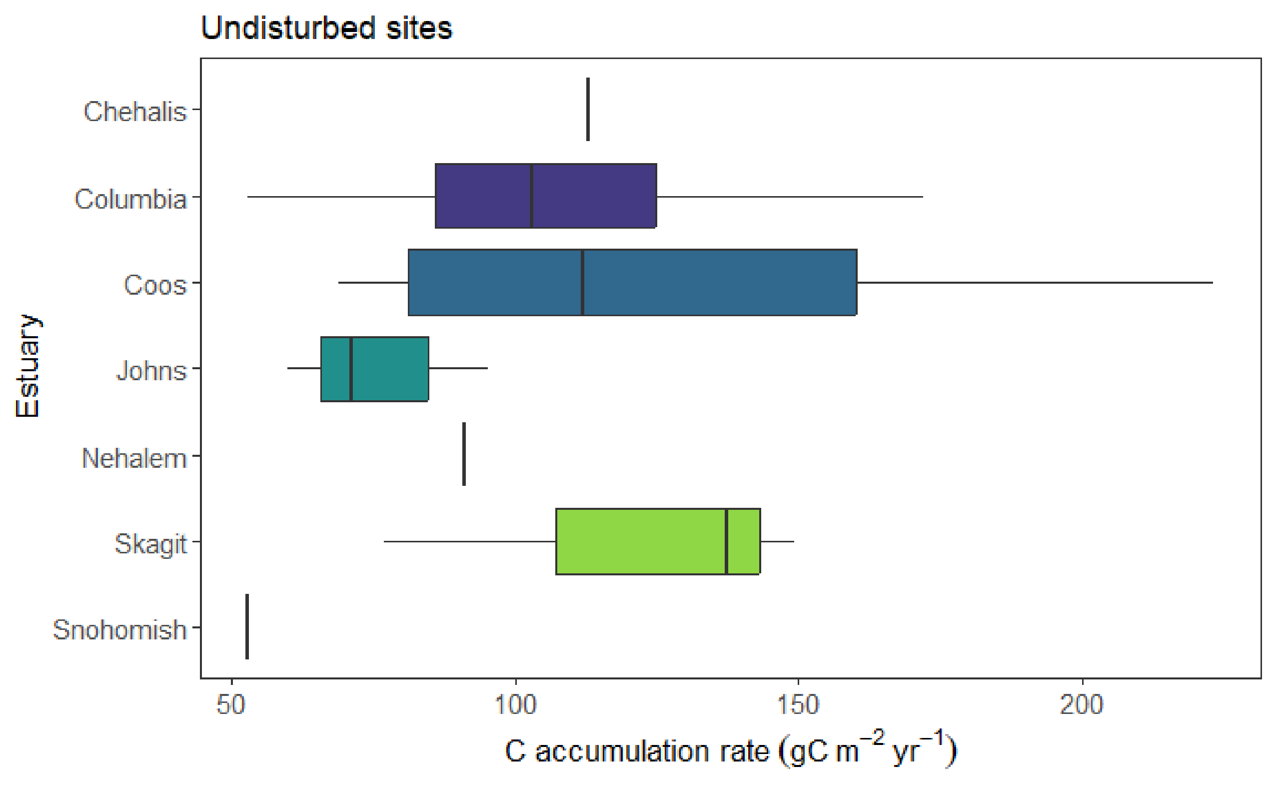
Virtually all carbon is stored in soils except in forested wetlands.



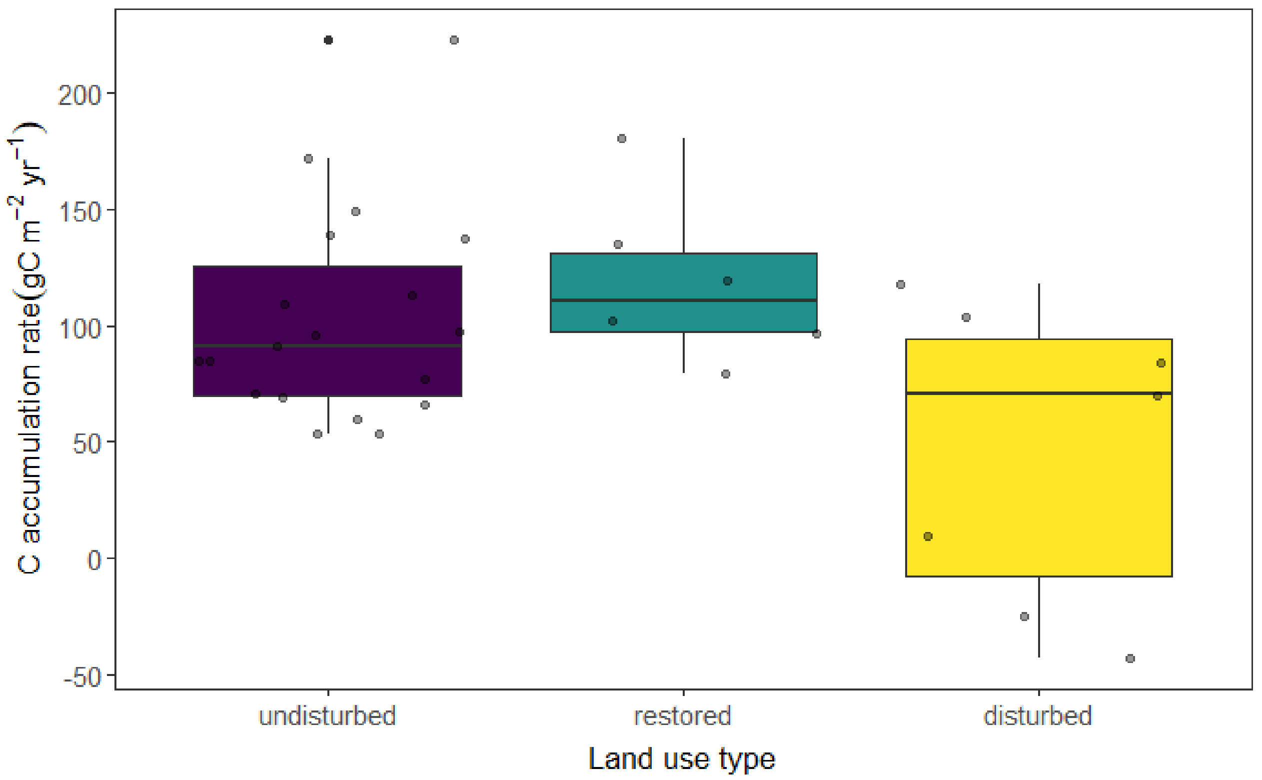
Accretion and Carbon Accumulation

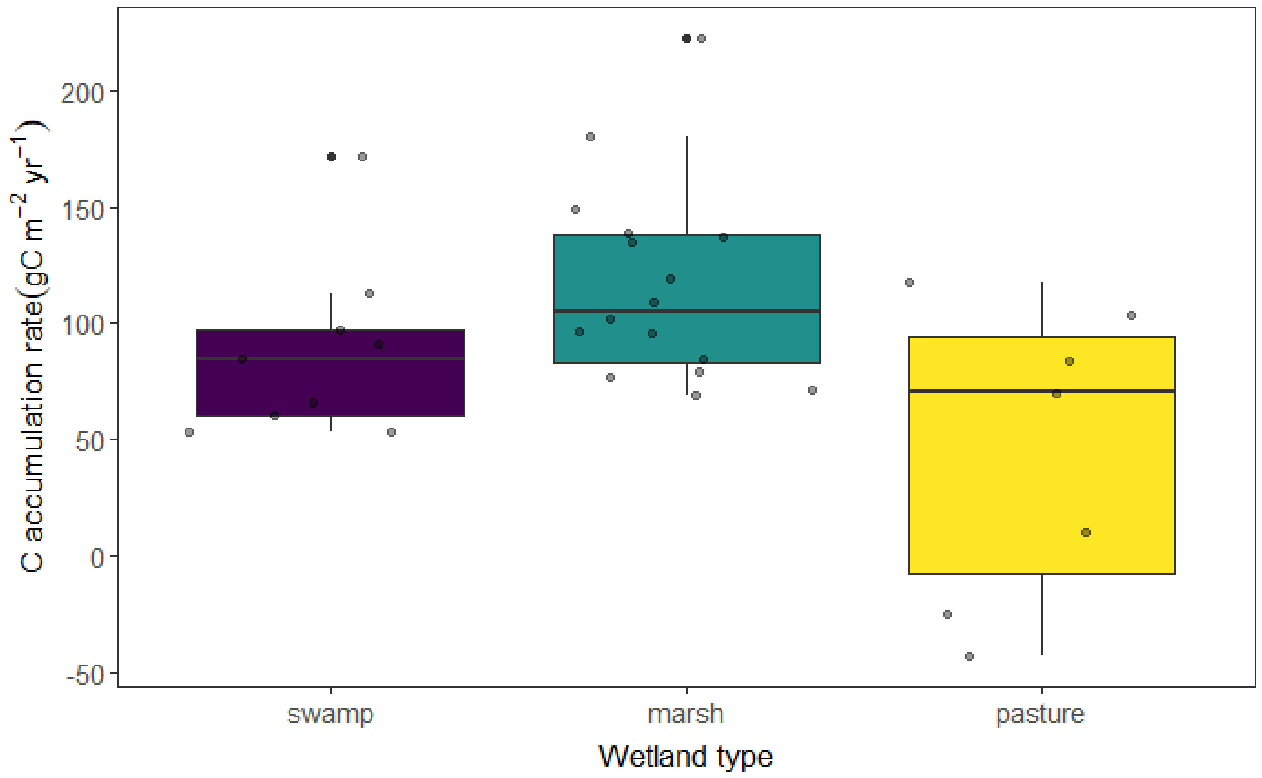


- 50 cm cores
- Analyzed using Pb210 to calculate accretion rates



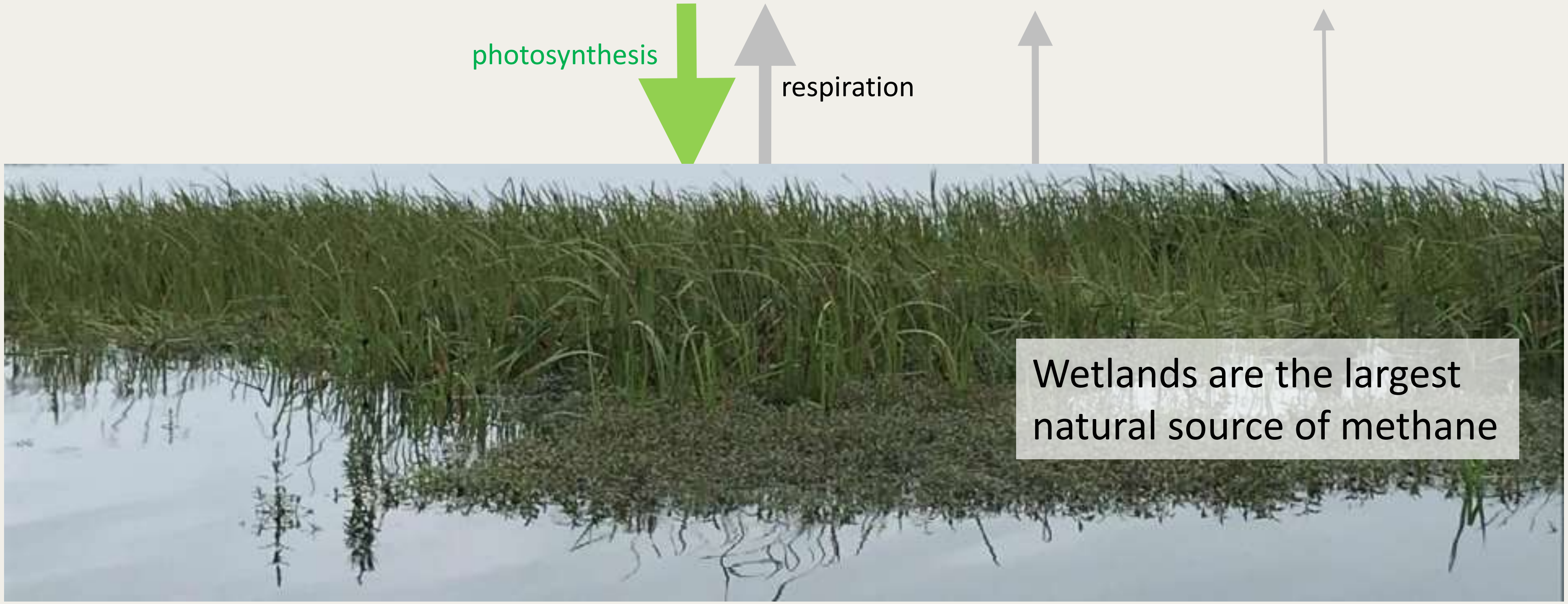
Accretion and Carbon Accumulation





Wetland GHG Emissions

	CO_2	CH_4	N_2O
20 yr global warming potential	1	84	264
100 yr GWP	1	28	265



Bridgham et al. 2013 *Global Change Biology*

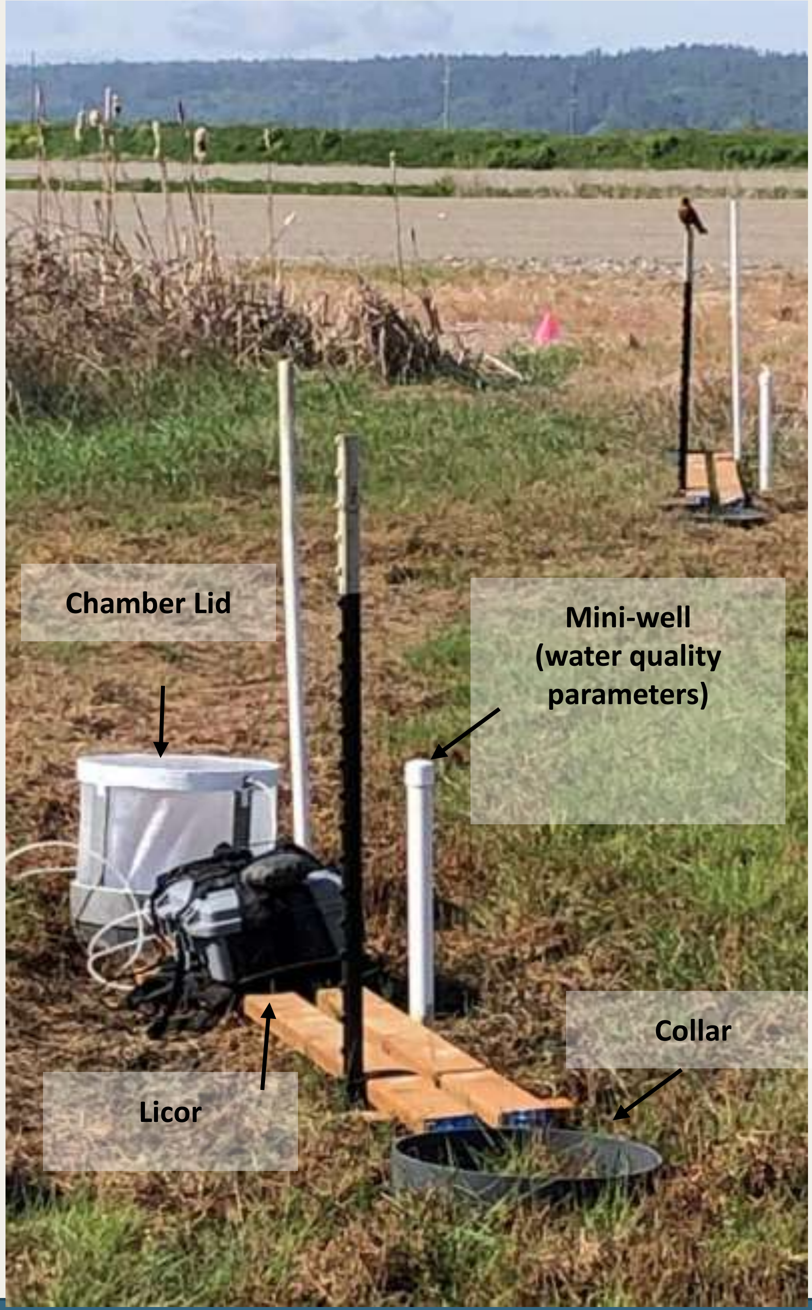
GHG Flux Methods

GHG fluxes (CO_2, CH_4, N_2O)

- 10 min measurements (Licor/Gasmet)
- Dark treatment (no photosynthesis)
- 60s flushing to ambient concentrations
- Light treatment

Environmental drivers

- Water quality: salinity, pH, temperature
- Water table
- Biomass: species, cover, height
- Photosynthetically active radiation (PAR)
- Soil temperature
- Soil accretion
- Soil characteristics
- Elevation



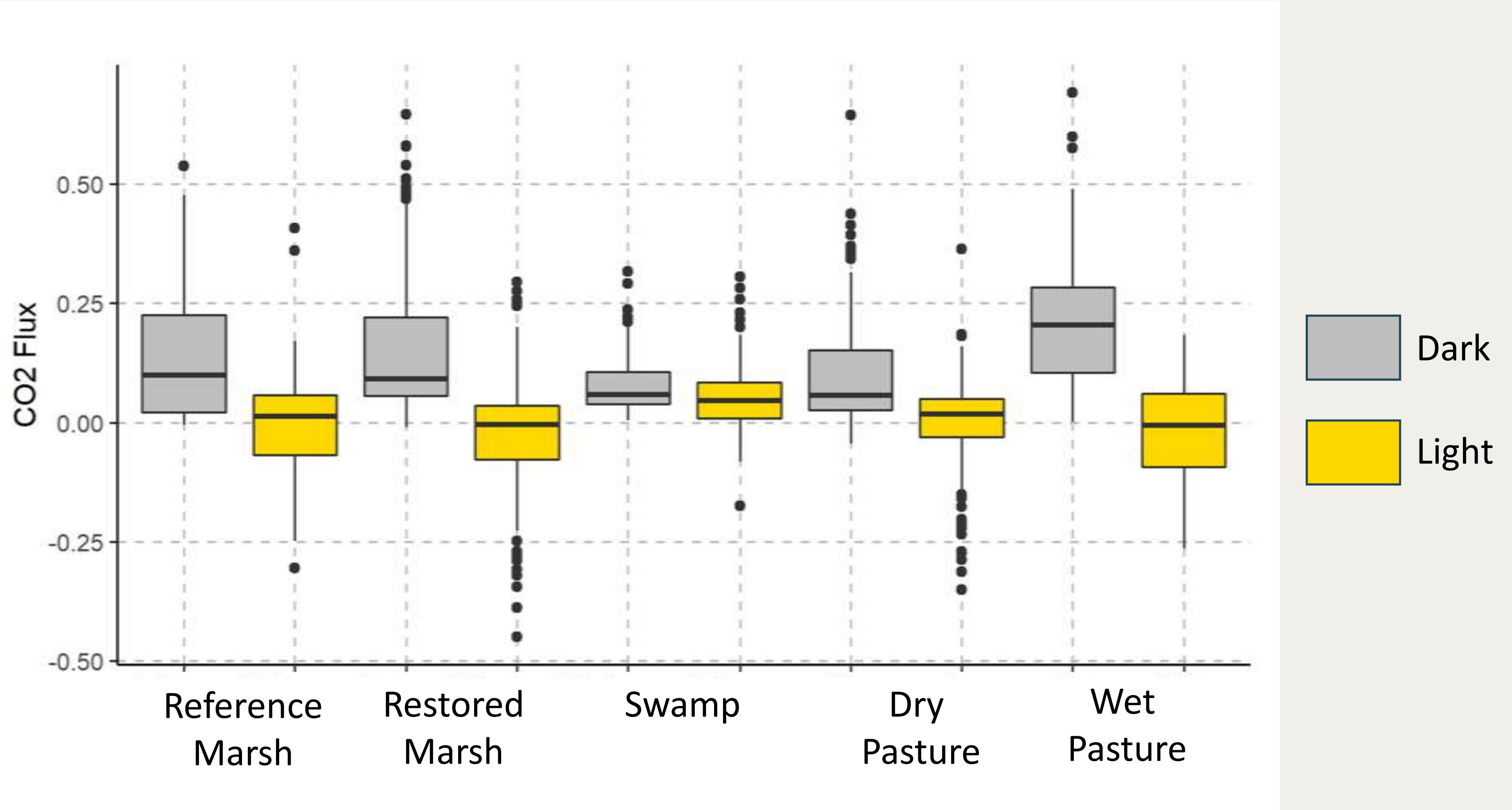
Dark Treatment

Collar Extensions
(to accommodate plants)

GHG Results - CO_2

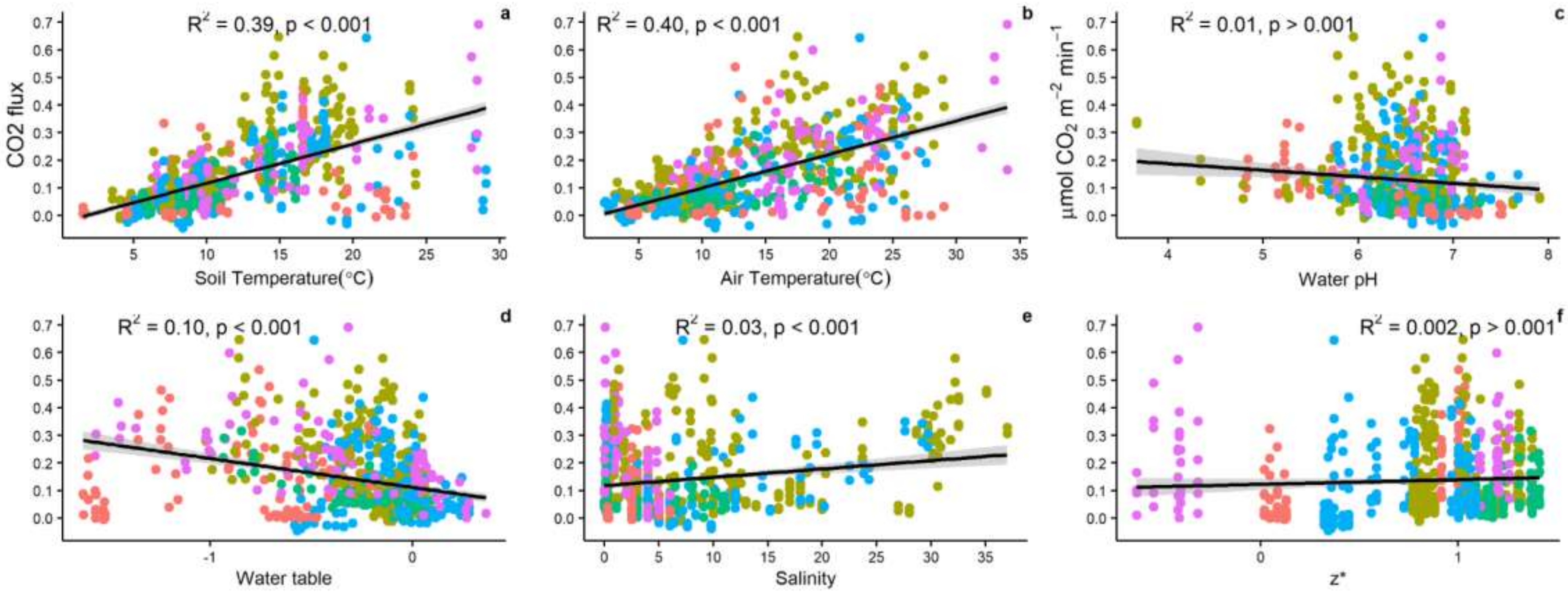
PRELIMINARY RESULTS

- Dark measurements higher due to respiration
- Swamp shows very little difference due to lack of light at collars
- Wet pastures have highest median respiration



GHG Results - CO_2

PRELIMINARY RESULTS

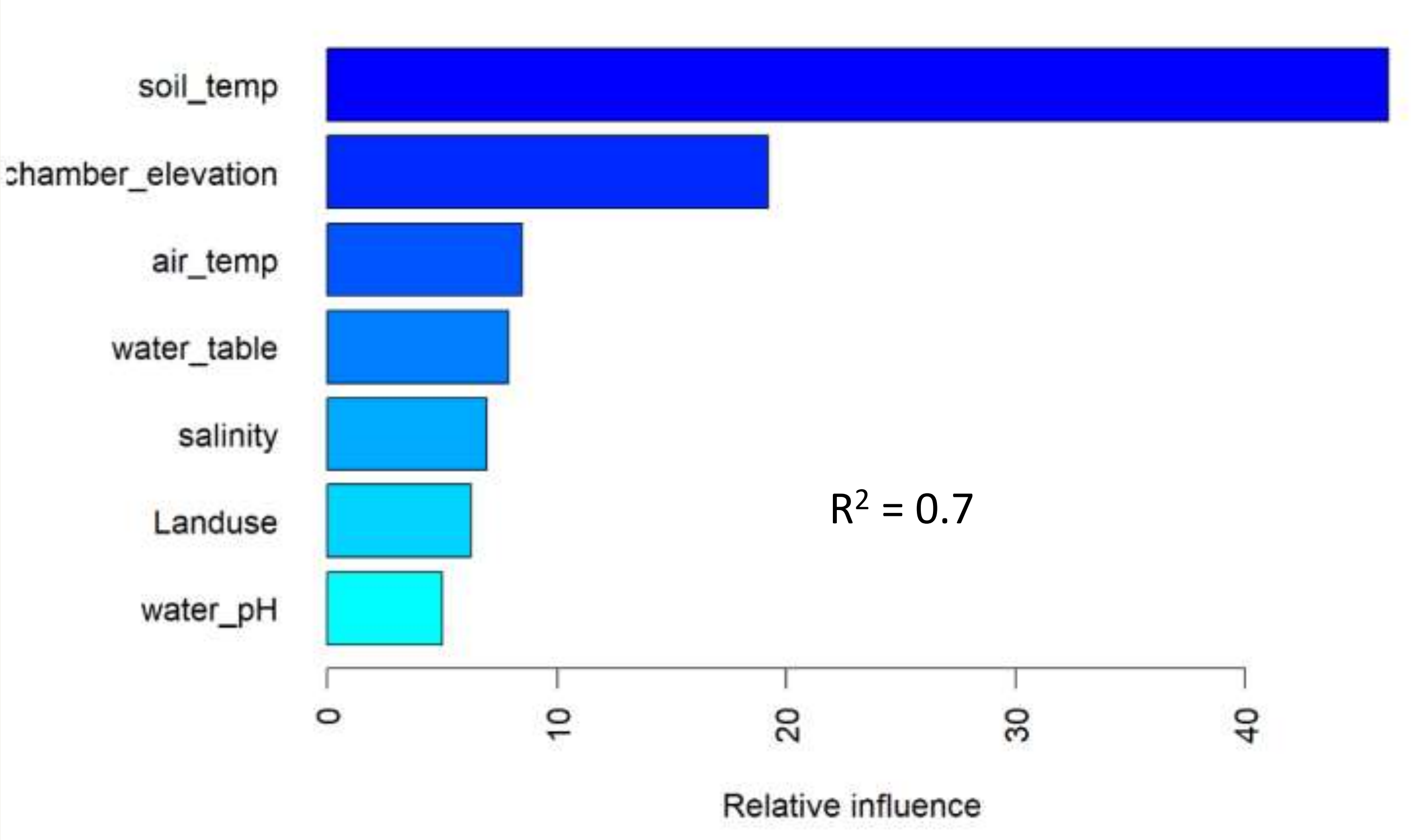


- Linear regression of DARK CO2 data by environmental drivers.
- Soil temp and air temp are the two most important

GHG Results - CO_2

PRELIMINARY RESULTS

- Boosted Regression Tree (BRT) model of DARK CO2 data by environmental drivers
- Soil temp and chamber elevation (z*) are the two most important

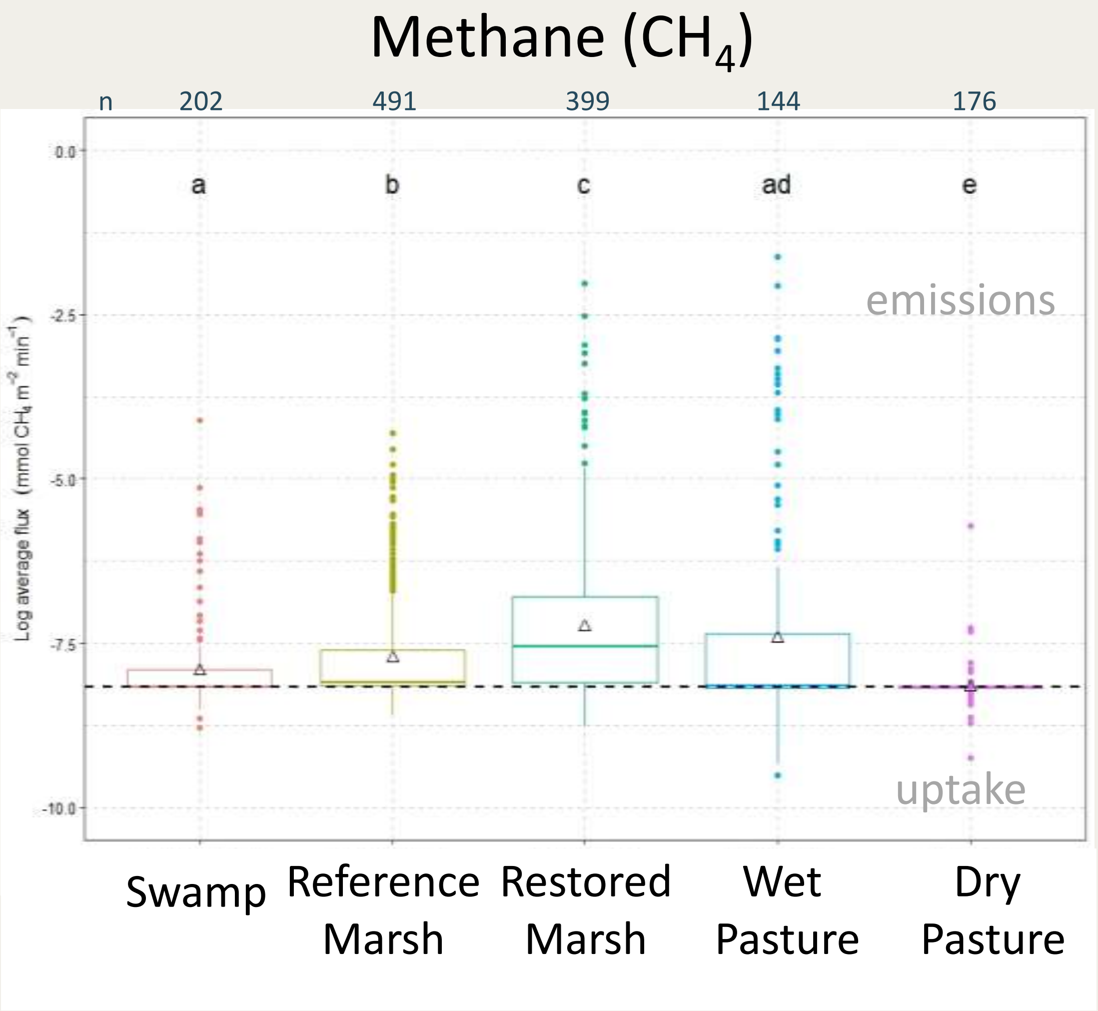


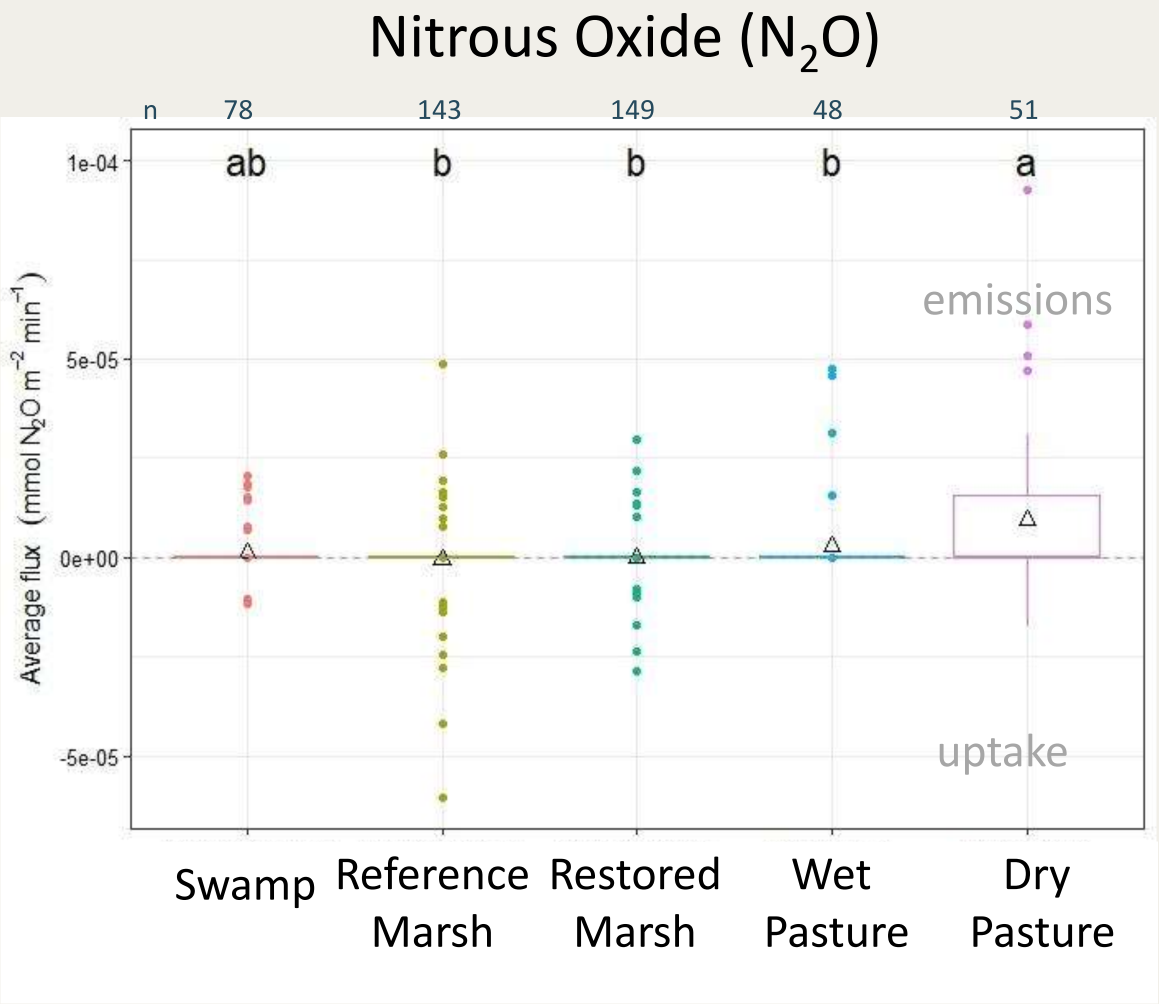
$R^2 = 0.7$

- Next steps
  - Including soil carbon content
  - Modeling light CO2
  - Using light + dark models to annualize CO2 fluxes from year-long timeseries of environmental factors

GHG Results – Methane and N_2O

PRELIMINARY RESULTS

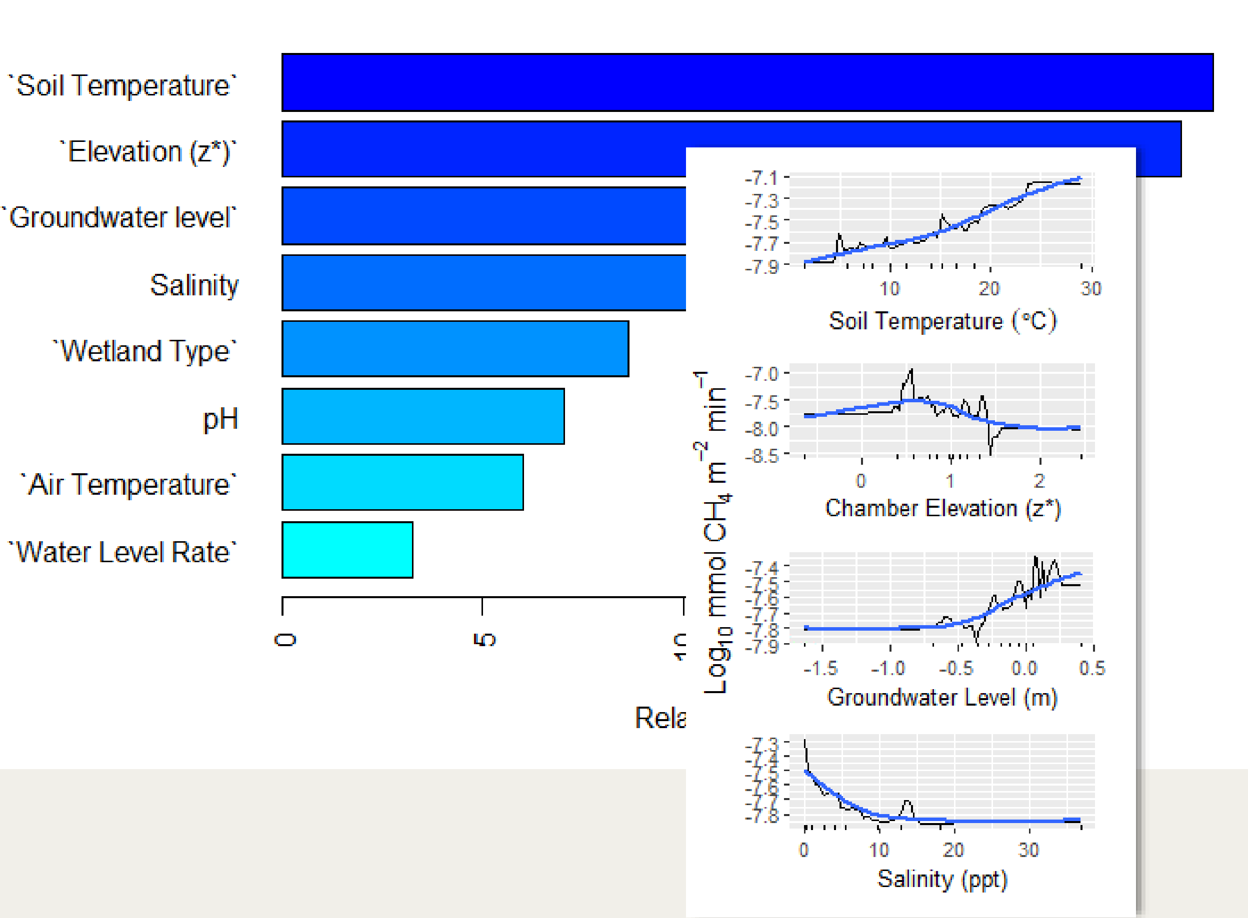




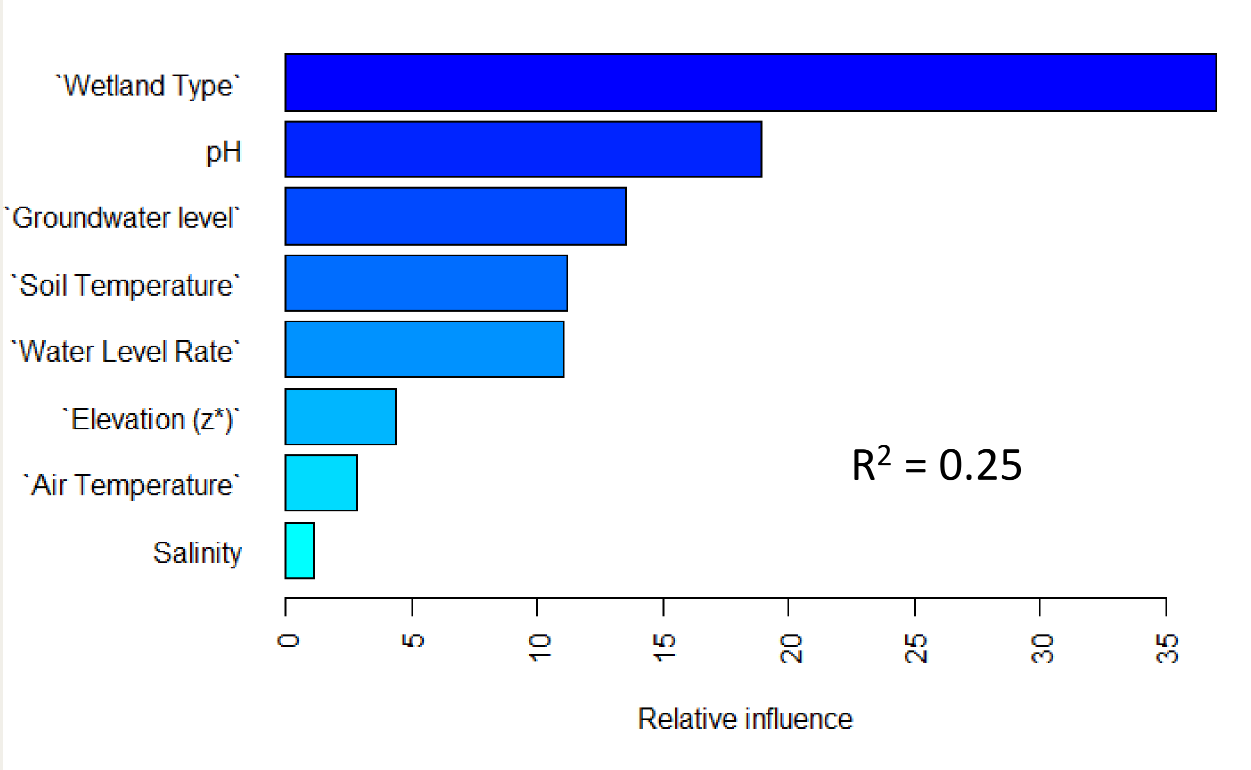
GHG Results – Methane and N_2O

PRELIMINARY RESULTS

Methane (CH_4)



Nitrous Oxide (N_2O)



Conclusions

Carbon stocks

- Stocks differ by wetland type and with elevation in the NE Pacific
  - Woody wetlands > marshes > seagrass & tide flats
- Stocks can vary considerably within individual estuaries and sites
- PNW tidal swamps have high stocks, comparable to tropical mangroves

GHG emissions

- BRT model shows promise for explaining drivers and predicting flux
- Wet pastures which are low in salinity, and sometimes have high water tables, can have high CO_2 and methane fluxes
- Dry pastures can have high N_2O flux.
- Restoration of pastures to tidal influence can reduce emissions and will likely continue to decrease over time as reference conditions are restored.

Next Steps

- Complete GHG flux analysis
- Develop net ecosystem carbon balance
- Develop a regional blue carbon calculator
- Apply results to restoration and climate-change forecast modeling

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- Oregon Watershed Enhancement Board

ASSISTANCE

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