Bringing Wetlands to Market: Examining the Role of Nitrogen in Blue Carbon

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I. Blue Carbon

II. Bringing Wetlands to Market

III. Role of Nitrogen

What is "blue carbon"?
Blue carbon is carbon (C) sequestered and stored in coastal ecosystems such as seagrasses, salt marshes, and mangroves. Carbon is sequestered through uptake of CO_2 during photosynthesis, then stored in leaves, roots, and sediments. Can be stored for millennia.

<u>Total Global C Burial</u>

Temperate Forests:
53 Tg C $year^{-1}$

Tropical Forests:
78.5 Tg C $year^{-1}$

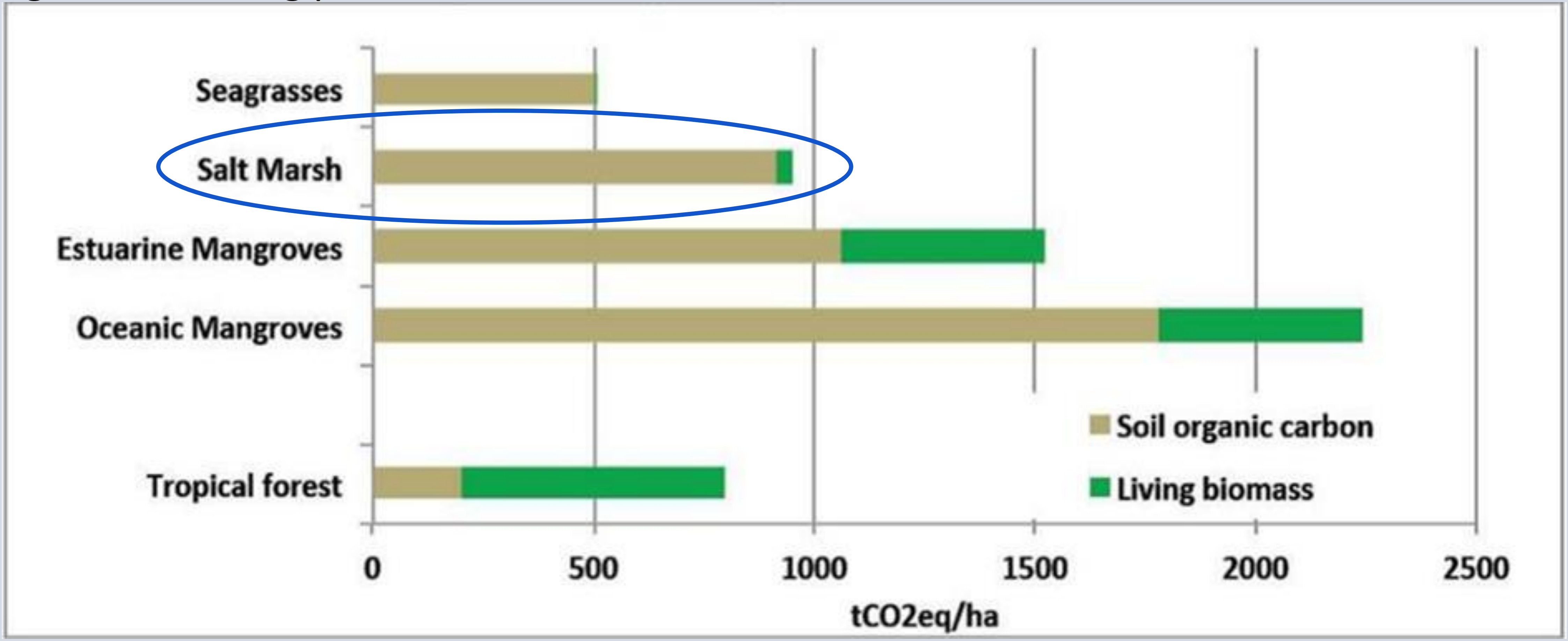
Salt Marshes:
5-87 Tg C $year^{-1}$

(McLeod et al. 2011)



Blue Carbon and Climate Change

- Low oxygen in wet soils slows down decomposition
- Provides benefit of retention and removal of carbon from the atmosphere that has global warming potential

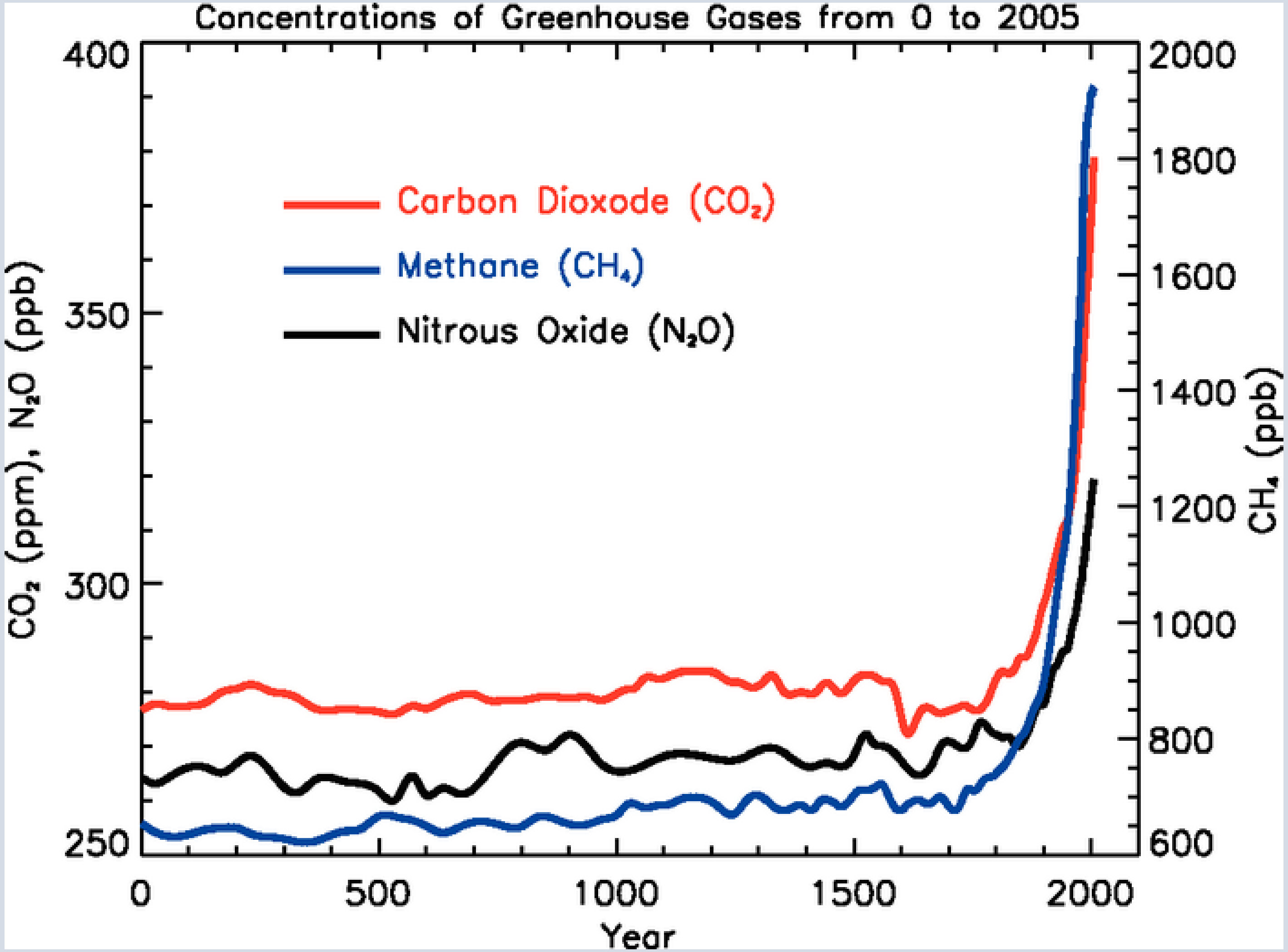


*tCO2eq/ha is tons of carbon dioxide per hectare

Source: Murray et al., 2011

Why is blue carbon important?

-Greenhouse Gas Concentrations are Increasing in the Atmosphere-

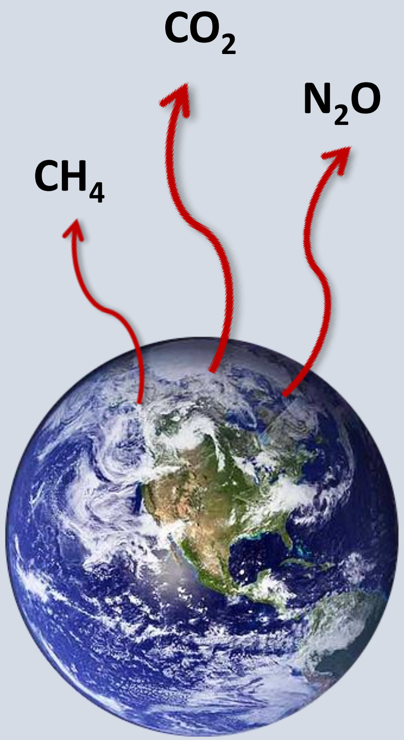


Source: Karl, 2009

Why do CH_4 and N_2O matter?

Global Warming Potential (GWP)

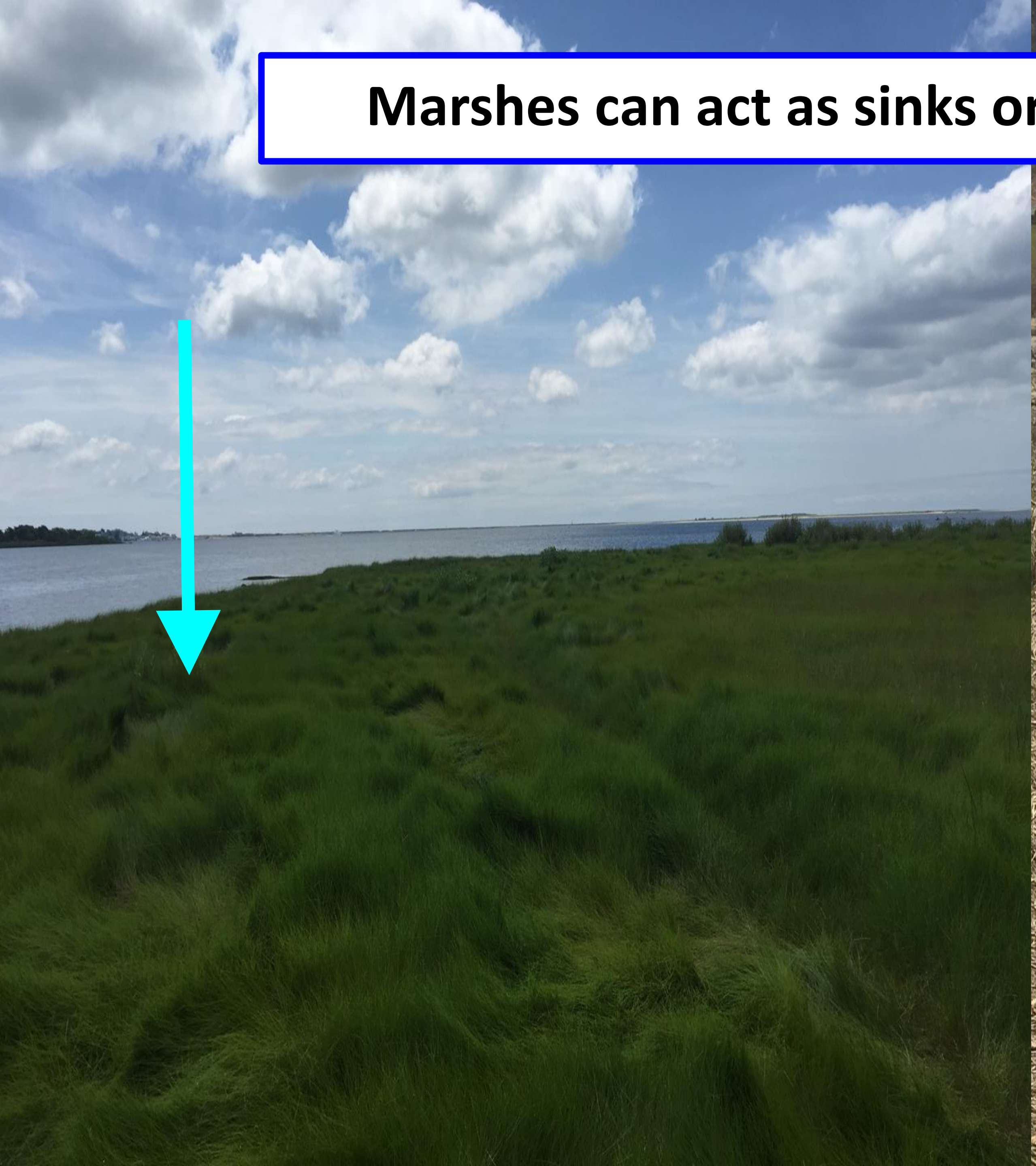
	Lifetime (years)	GWP (Cumulative forcing over 100 years)
Carbon Dioxide (CO_2)	0	1
Methane (CH_4)	12.4	28
Nitrous oxide (N_2O)	121.0	265

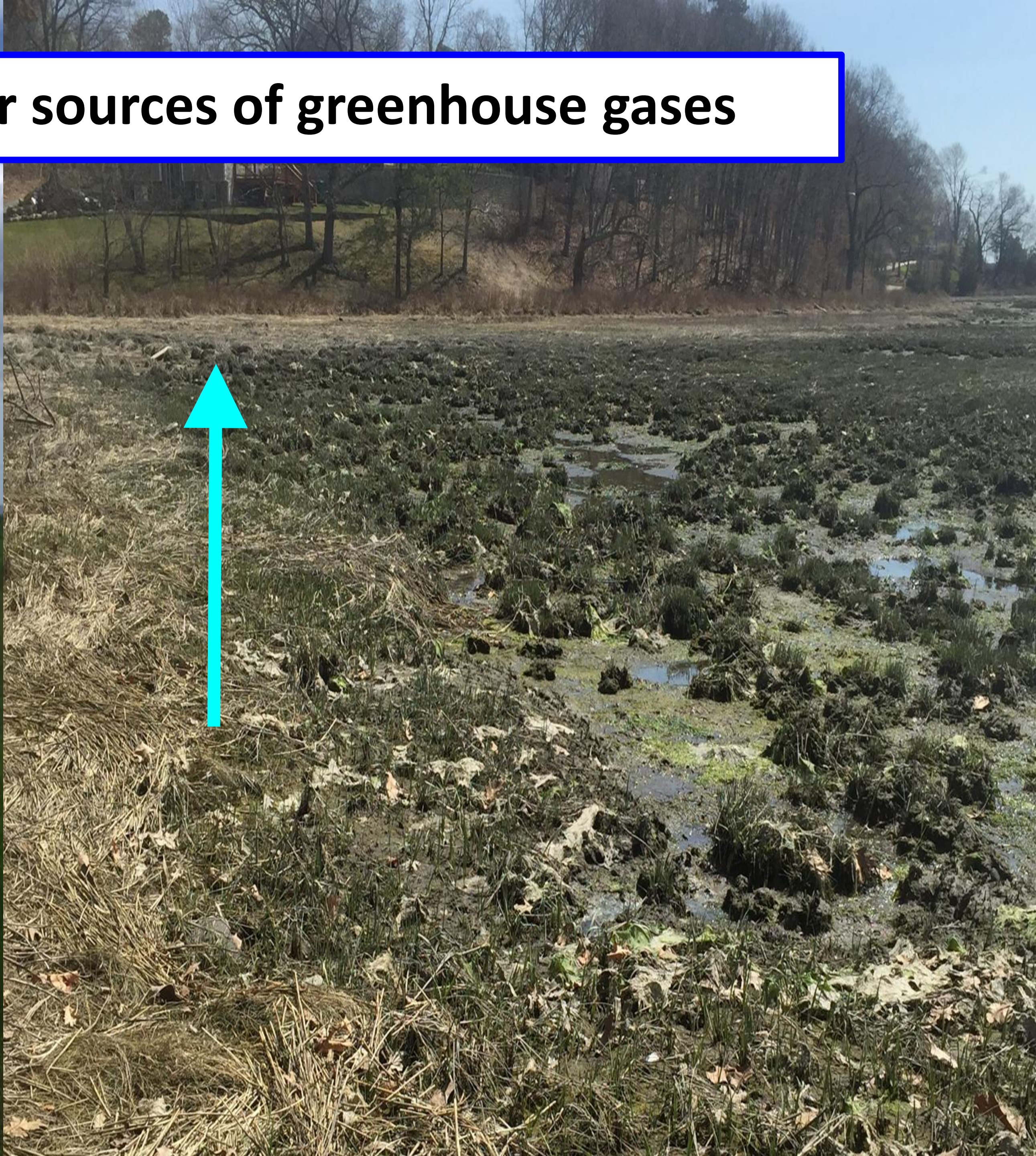


*CO_2 is unable to be given a lifetime because its removal rate from the atmosphere is so variable

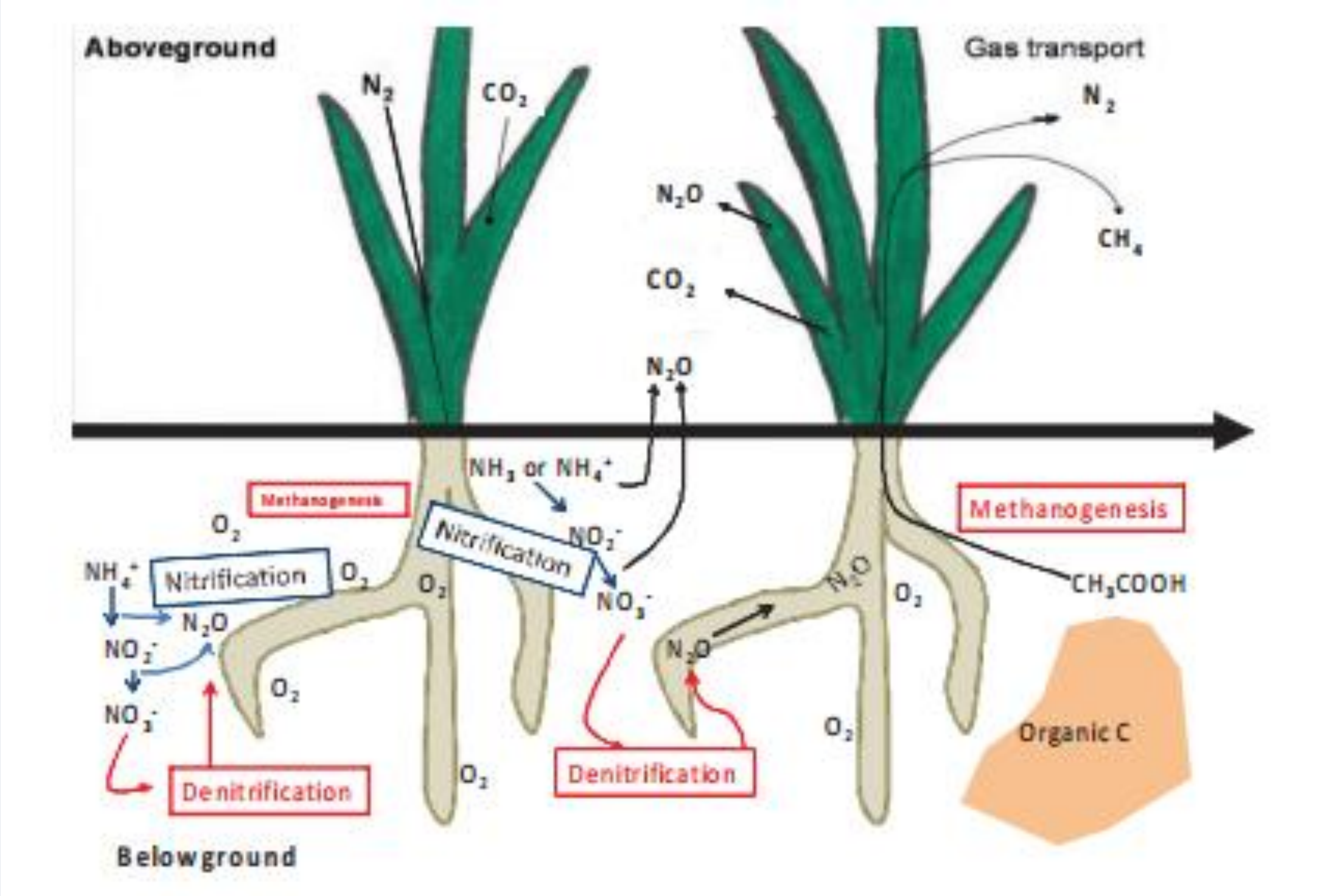
Source: IPCC,2014

Marshes can act as sinks or sources of greenhouse gases



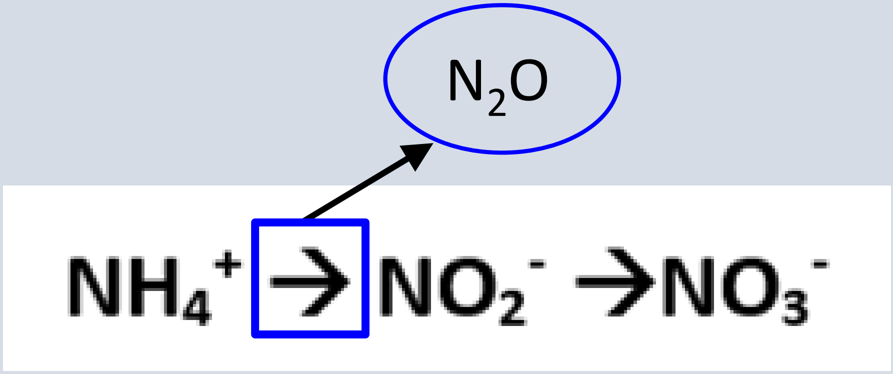


What is the role of greenhouse gases in salt marshes?

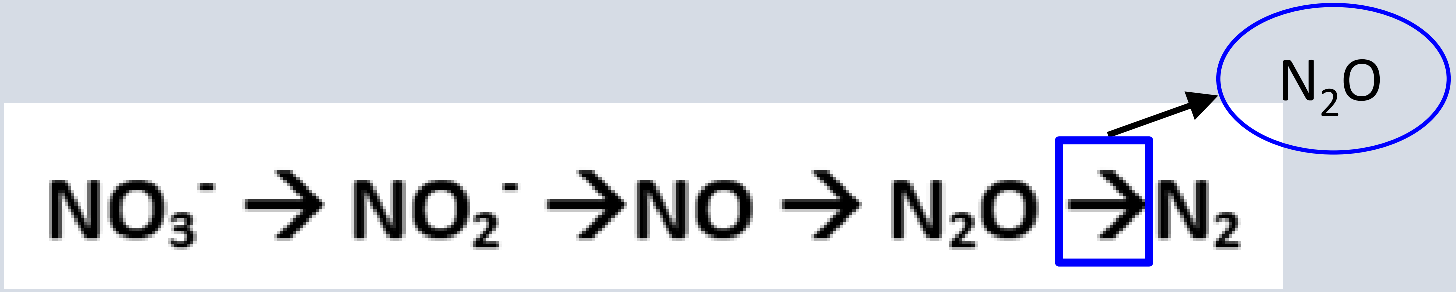


Production of Nitrous Oxide in Salt Marshes via Soil Microbial Processes

1. Nitrification of ammonium (NH_4^+)



2. Denitrification of nitrate (NO_{3-})



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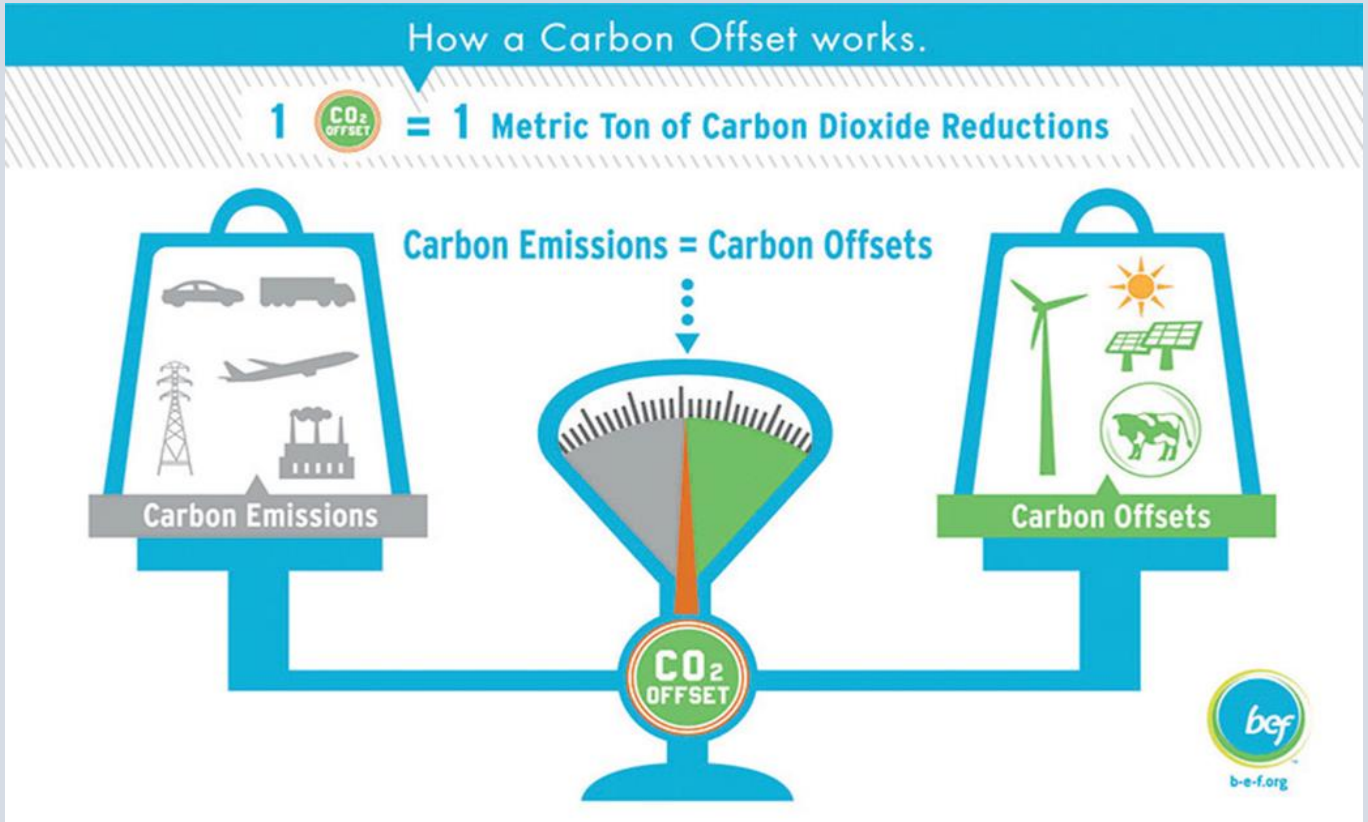
How does a carbon market work and what are the benefits?

<u>Carbon market</u>: Individuals or companies purchase carbon credits to offset their emissions

The ability to purchase credits could provide an incentive to *manage, protect, and restore*, valuable coastal wetlands



Source: b-e-f.org

Carbon Markets: Financial Incentives

$2.0 Billion

Market based payments for forest carbon since early 2000s

Source: Goldstein ,2016. View from the Understory: State of Forest Carbon Finance 2016. **Courtesy of Scott Settelmyer, Terracarbon**

Bringing Wetlands to Market

WAQUOIT BAY NATIONAL ESTUARINE RESEARCH RESERVE

About the Reserve | Research & Monitoring | Education & Training | Visit the Reserve | Land & Facilities | Waquoit Bay Reserve Foundation

Who: Led by Waquoit Bay National Estuarine Research Reserve and funded by NOAA National Estuarine Research Reserve Science Collaborative

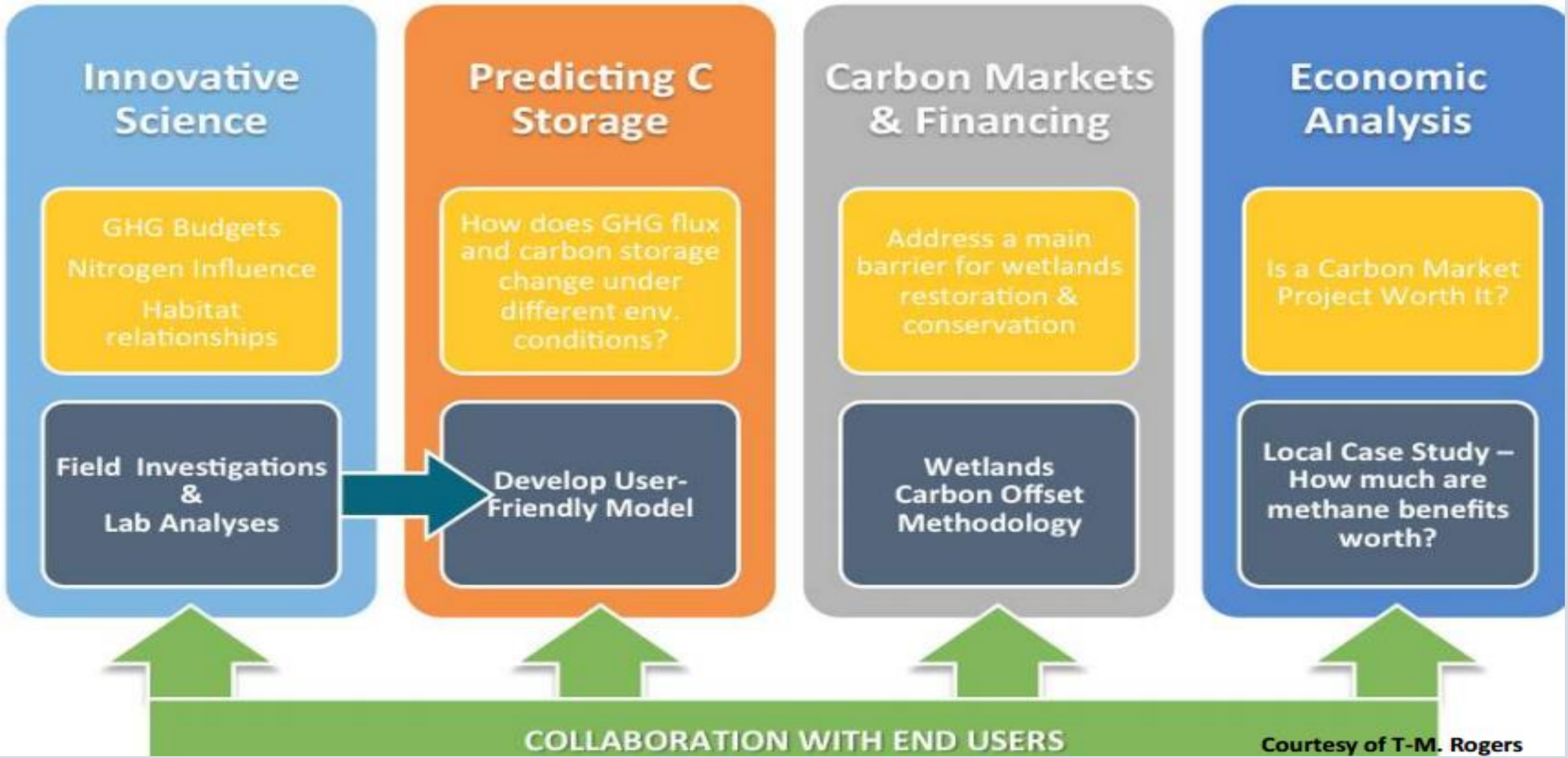
What: Collaborative project between team of scientists, policymakers, economists, and end users with aim to study relationship between salt marshes, climate change, and nitrogen pollution

Where: Cape Cod, MA and Narragansett Bay, RI

When: Part I (2012-2015), Part II (2015-2018)

Why: To provide science and tools to help incentivize wetland restoration and protection through blue carbon

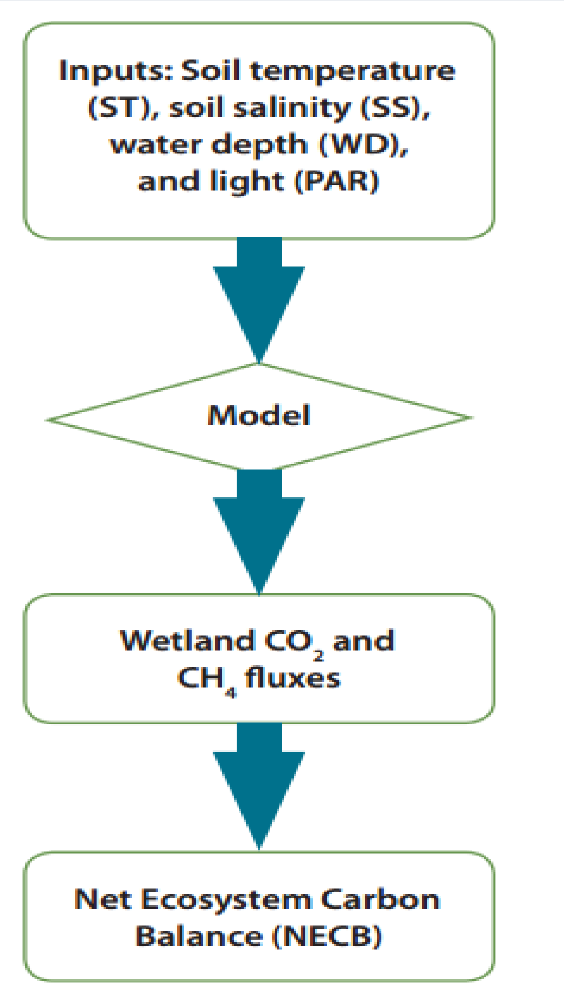
Bringing Wetlands to Market Overview



Bringing Wetlands to Market: Part I

Project Goals:

- Develop methodology for tidal wetland and seagrass restoration
- Develop user friendly model for predicting greenhouse gas fluxes and carbon sequestration
  - Quantify greenhouse gas fluxes across a marsh landscape and test for potential proxies of C fluxes



	Input Variables							
Number of observations	Photosynthetically active radiation, PAR (micromole/m2/s)	Soil temperature, ST (OC)	Soil salinity, SS (ppt)	Water depth related to marsh surface, WD (m)	Net lateral flux over the growing period (g/m2)	Enter threshold value of light, PAR (micromole/m2/s)	Enter the number of days for which you want to estimate wetland carbon storage (NECB)	Enter CO2 equivalent global warming potential (GWP) for CH4
1					0	100		1
2								
3								

Bringing Wetlands to Market: Part II

Project Goals:

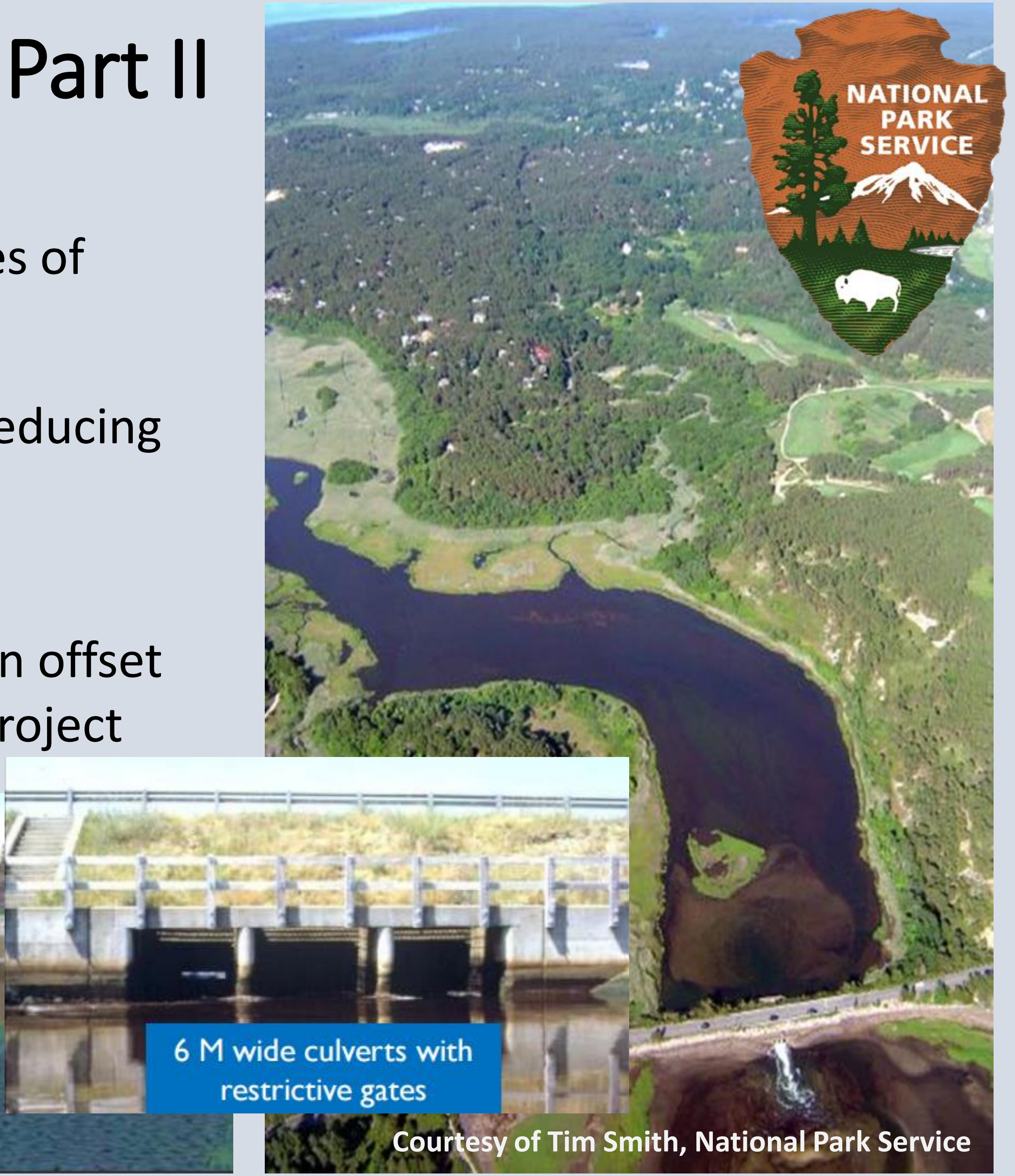
- Examine feasibility of creating carbon market using largest salt marsh restoration project in New England

- Broaden model: analyze how marsh stressors, such as nitrogen pollution, impact C sequestration

Bringing Wetlands to Market: Part II

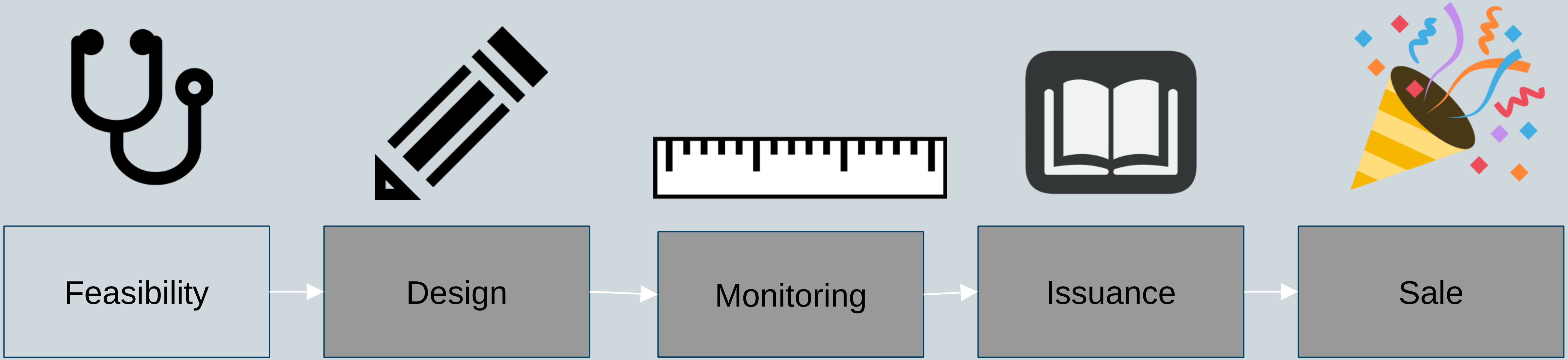
Herring River Restoration (HRR) Project

- Restore tidal flow, restoring flow to 1,000 acres of former salt marsh
- Generate greenhouse gas (GHG) benefits by reducing methane emissions and increasing carbon sequestration in restored marsh soil
- Feasibility study evaluates developing a carbon offset project to monetize GHG benefits from HRR project



Courtesy of Tim Smith, National Park Service

Carbon Project Cycle



Courtesy of Scott Settelmyer, Terracarbon

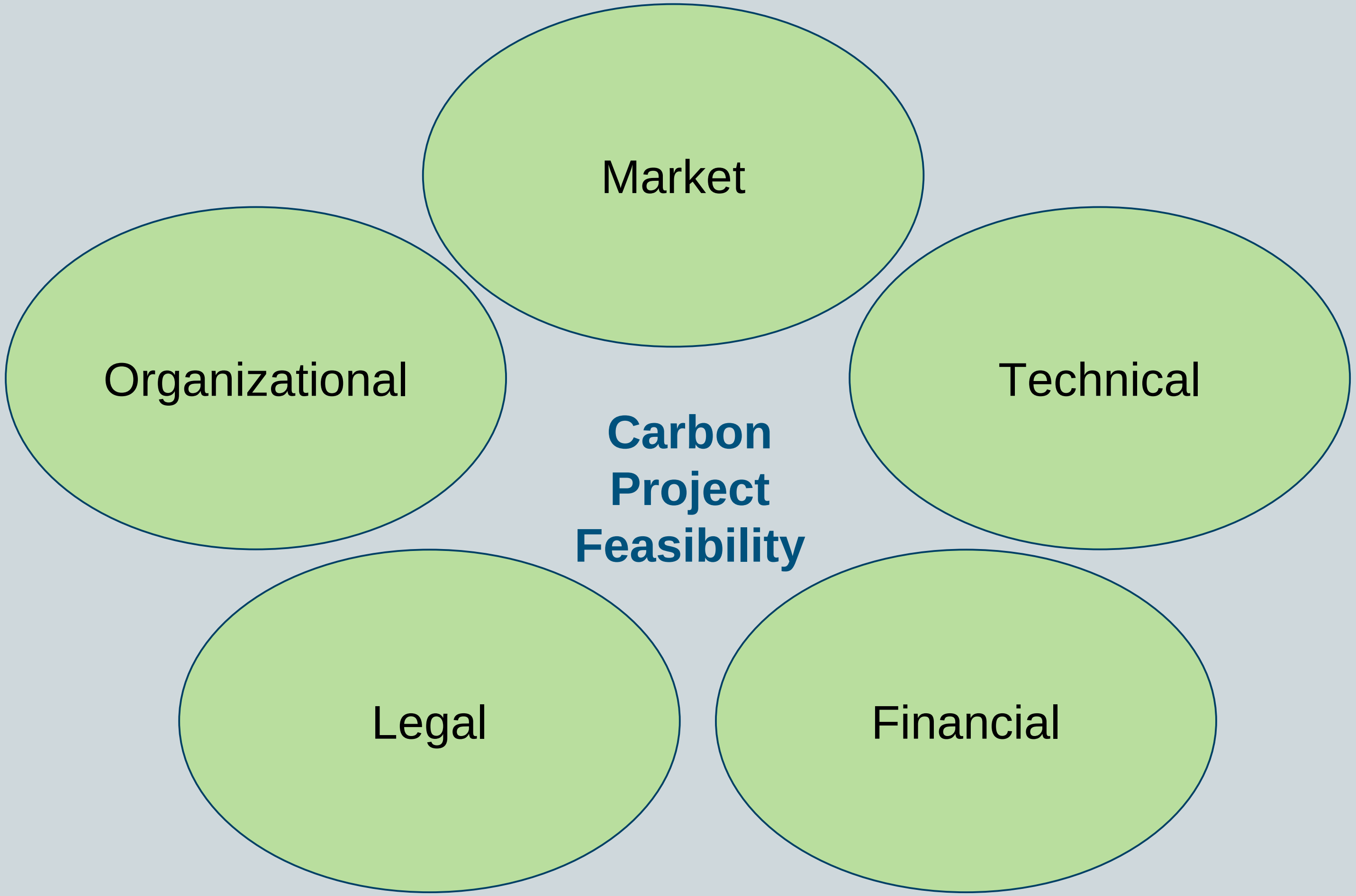
Objectives of Feasibility Study

Questions to answer:

1. What are the costs, benefits, risks, of developing a carbon project to help finance restoration of a blue carbon ecosystem?
2. What is the opportunity to help finance broader restoration of similar ecosystems across the region?

Courtesy of Scott Settelmyer, Terracarbon

Carbon Project Feasibility



Courtesy of Scott Settelmyer, Terracarbon

What is the end goal of the feasibility study?

To provide better information to inform decisions about future carbon project development

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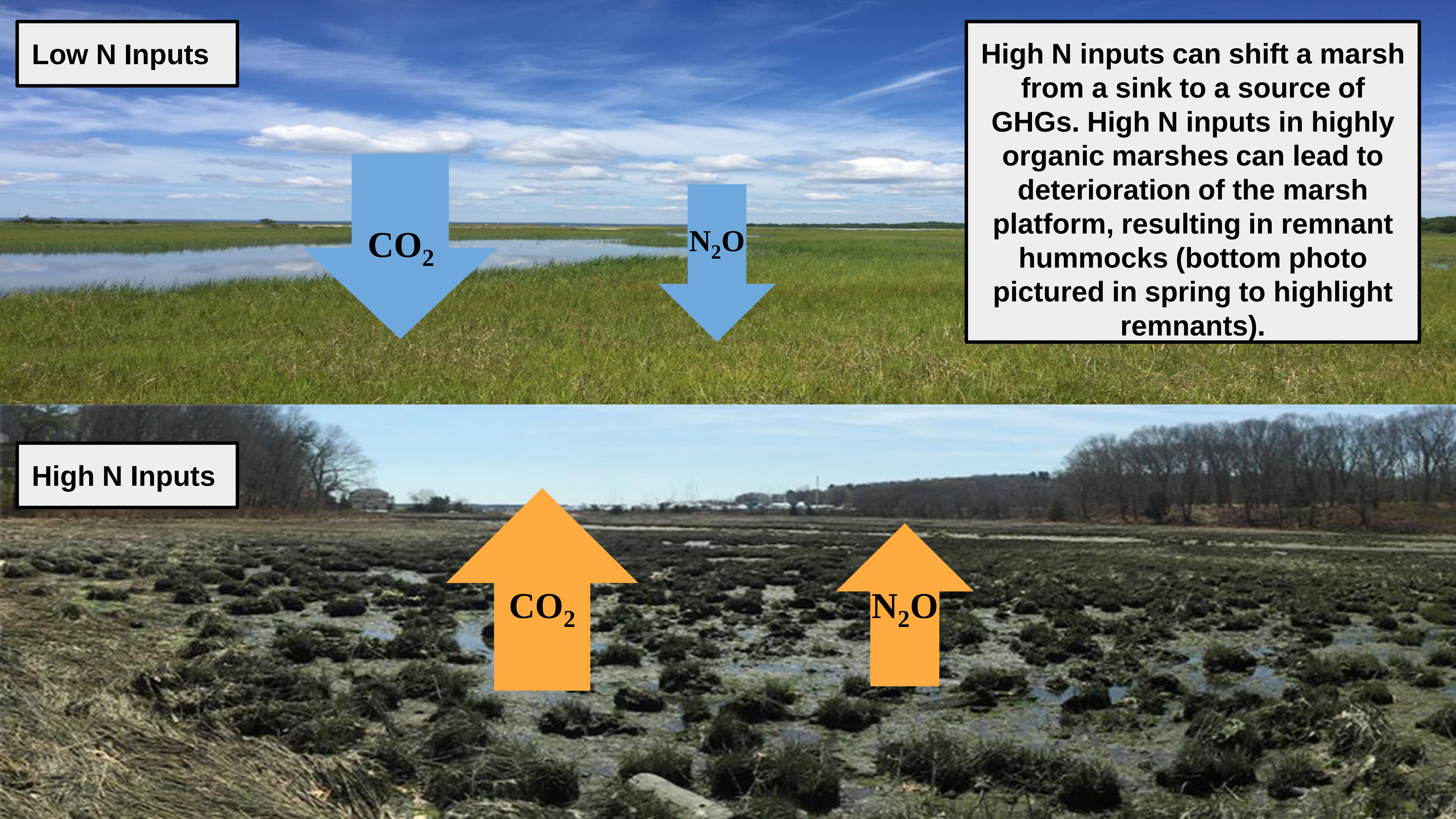
How Does Nitrogen Loading Impact Salt Marshes?

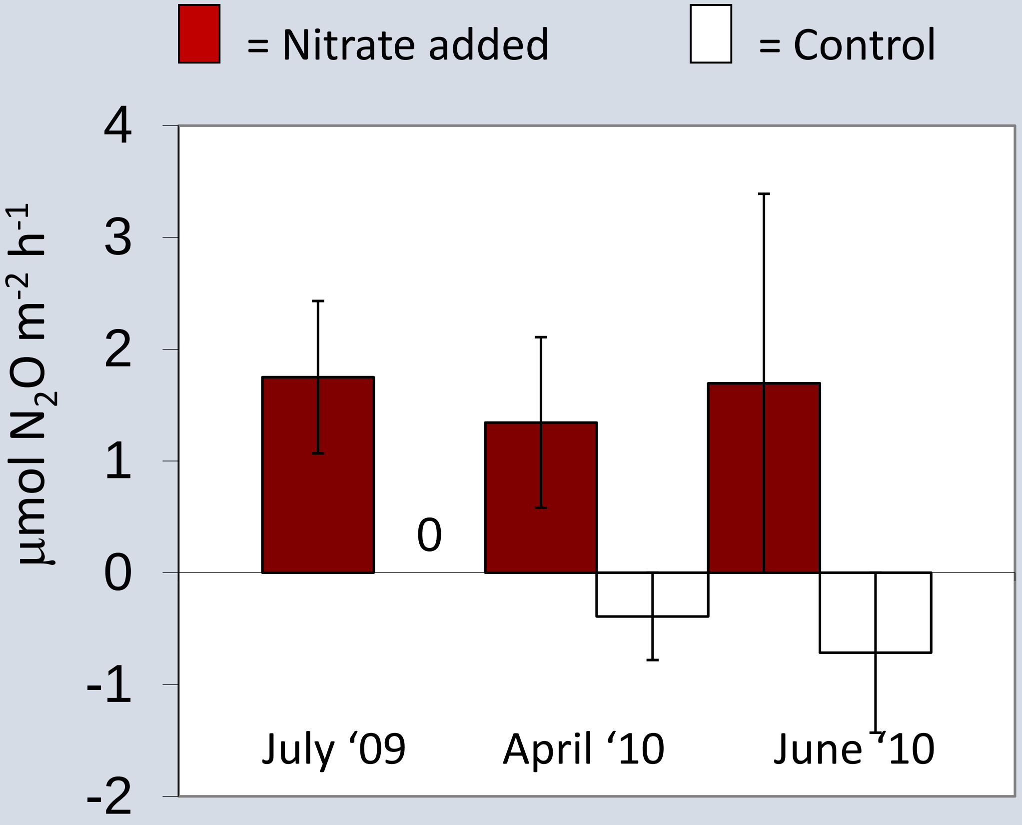
Mary's Creek, RI: 200 g N m^{-2} y^{-1}

Source for N loads: Wigand et al. 2003


Low N Inputs
CO_2
N_2O
High N inputs can shift a marsh from a sink to a source of GHGs. High N inputs in highly organic marshes can lead to deterioration of the marsh platform, resulting in remnant hummocks (bottom photo pictured in spring to highlight remnants).
High N Inputs
CO_2
N_2O

Short-term nitrate addition shifted salt marsh from N_2O sink to source

Plots received single pulses of nitrate (0.5L of 300 μM)



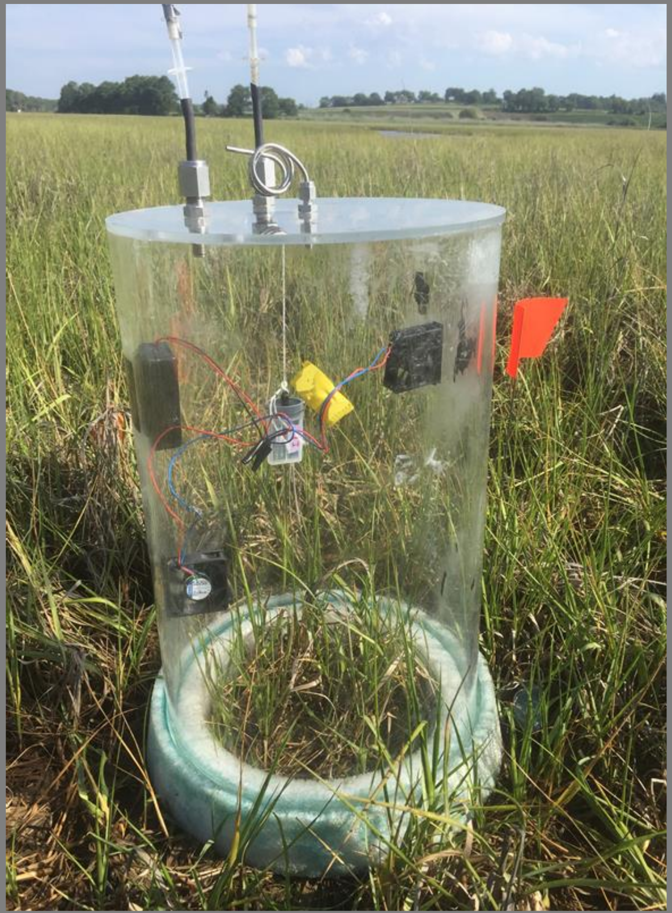
(Moseman-Valtierra et al. 2011. Atmospheric Environment)

RI Sites within the Context of Connecticut

Source for N loads: Wigand et al. 2003

Greenhouse Gas Flux Measurements

- Fluxes taken in *Spartina alterniflora*, dominant marsh grass at RI sites
- Six replicates per site
- Measurements taken bi-weekly, alternating two analyzers



LIMNOLOGY and OCEANOGRAPHY: METHODS

ASLO

Limnol. Oceanogr.: Methods 00, 2016, 00–00

doi: 10.1002/lom3.10105

Evaluation of laser-based spectrometers for greenhouse gas flux measurements in coastal marshes

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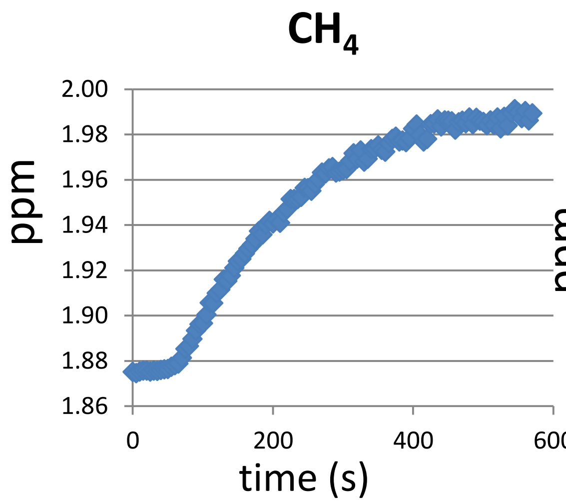
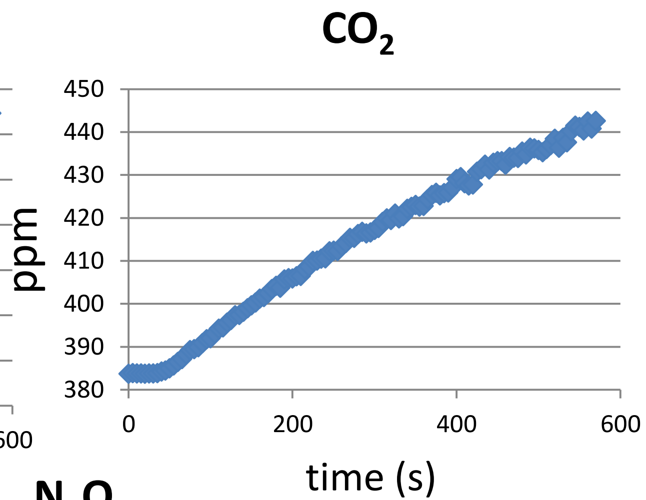
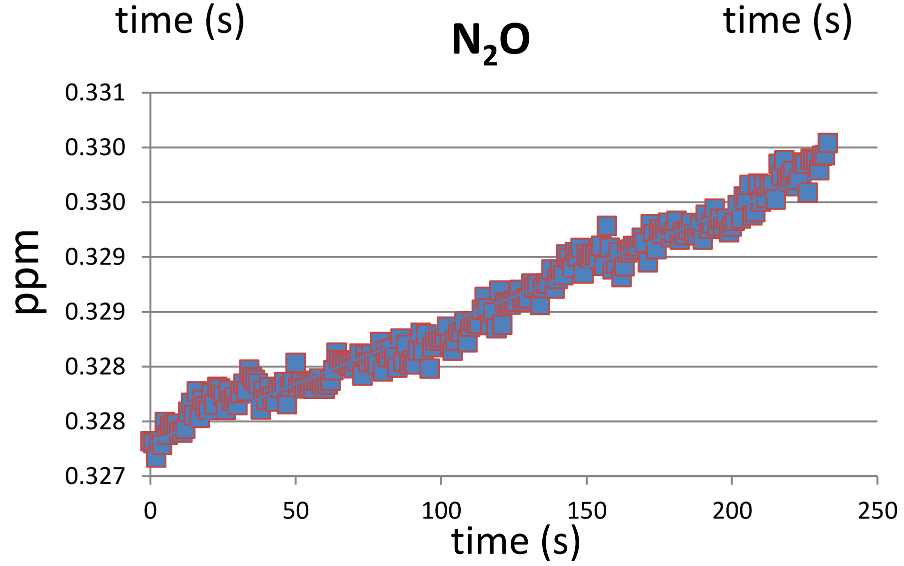
Picarro G2508 CO_2, CH_4

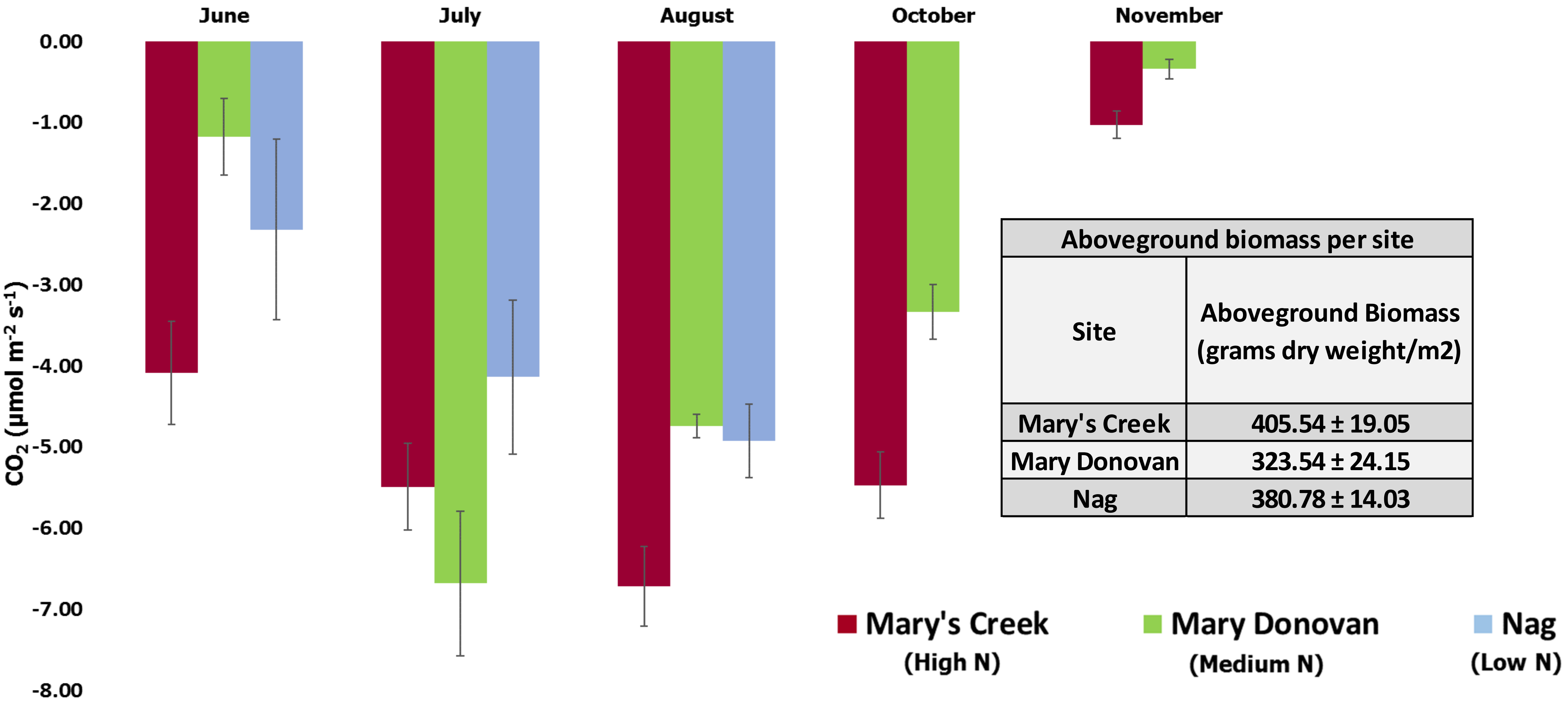






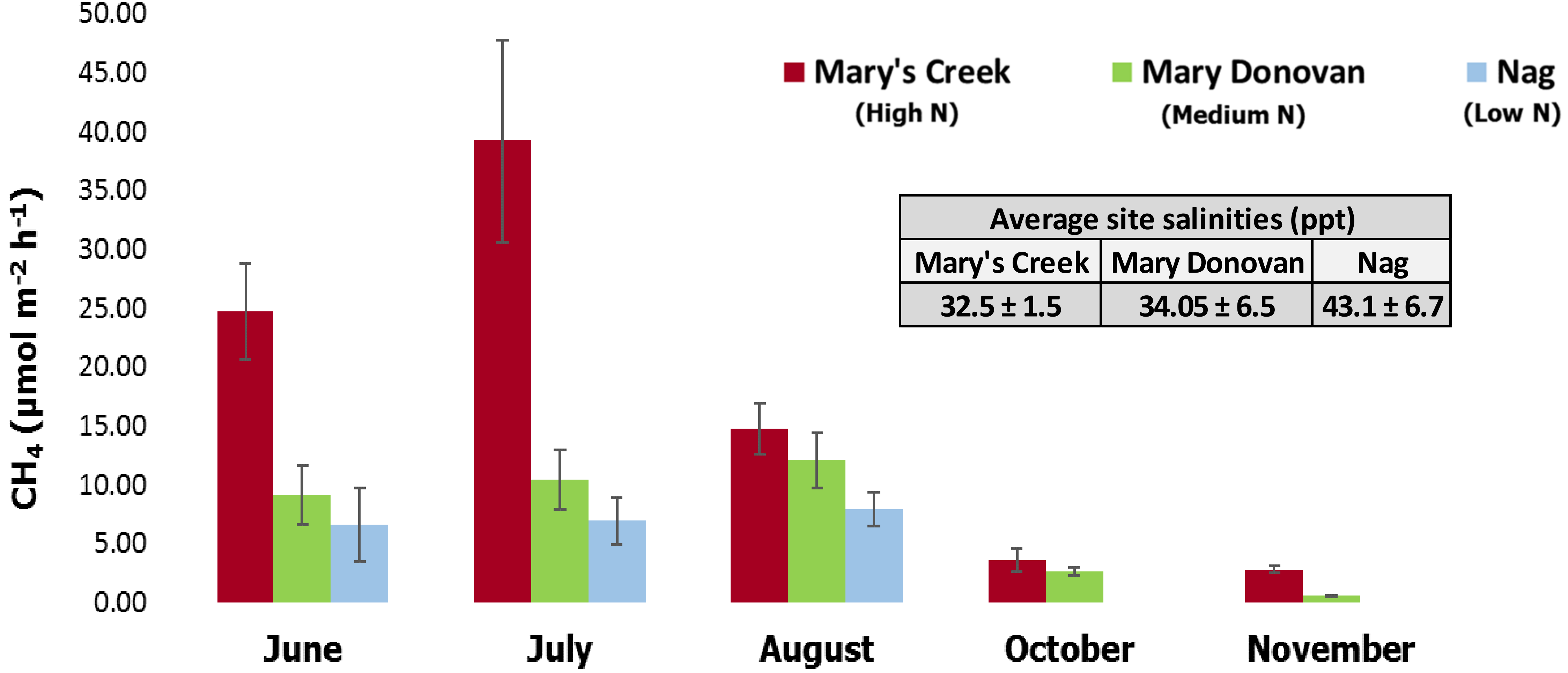
Los Gatos Research Analyzer, N_2O

Carbon Dioxide (CO_2) Fluxes by Month



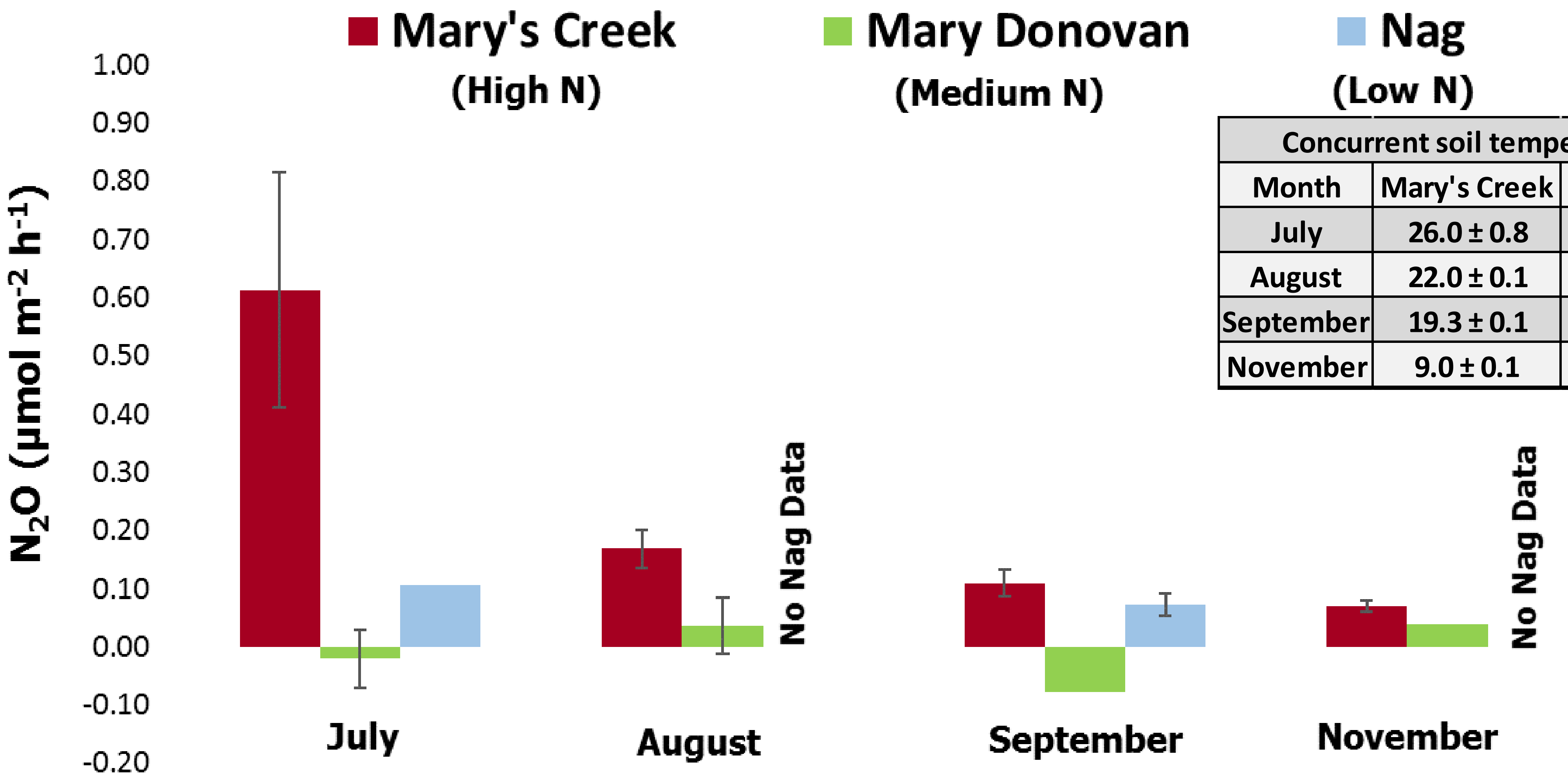
Aboveground biomass per site	
Site	Aboveground Biomass (grams dry weight/m2)
Mary's Creek	405.54 ± 19.05
Mary Donovan	323.54 ± 24.15
Nag	380.78 ± 14.03

Methane (CH_4) Fluxes by Month



Average site salinities (ppt)		
Mary's Creek	Mary Donovan	Nag
32.5 ± 1.5	34.05 ± 6.5	43.1 ± 6.7

Nitrous Oxide (N_2O) Fluxes by Month



Concurrent soil temperatures (°C) per month			
Month	Mary's Creek	Mary Donovan	Nag
July	26.0 ± 0.8	24.7 ± 0.5	26.1 ± 0.5
August	22.0 ± 0.1	22.3 ± 0.0	24.9 ± 0.2
September	19.3 ± 0.1	16.7 ± 0.1	17.0 ± 0.5
November	9.0 ± 0.1	9.6 ± 0.1	NA

RI Net GHG Fluxes

Gas	CO_2 Equivalents m^{-2} d^{-1}
CO_2	-16,990
CH_4	138
N_2O	57

How much CO_2 uptake is offset from N_2O and CH_4 emissions?

1%

*Based on Average Flux Calculated for Each Gas Over Entire Course of Study

Conclusions

- Coastal wetlands are efficient C sinks with great potential for mitigating climate change
- Carbon markets are an innovative way to provide an economic incentive to *manage, protect, and restore* coastal wetlands
- Marshes have high capacity for receiving nitrogen, but not releasing large N_2O from *S. alterniflora* marshes
- Stressors, such as nitrogen, that have the potential to alter C sequestration need to be accounted for in carbon markets

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