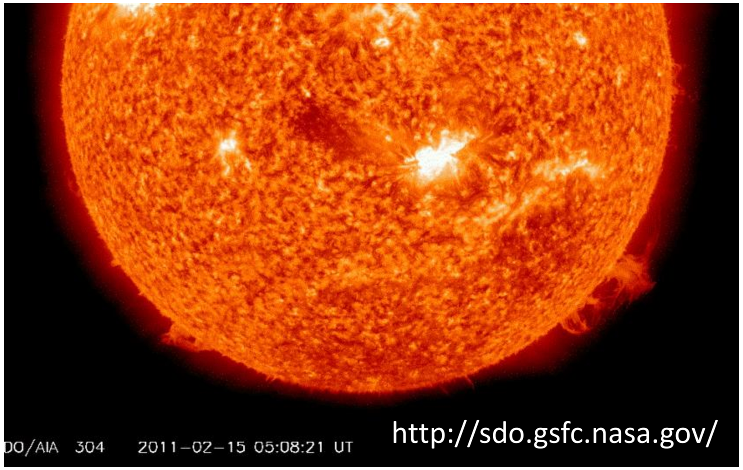
Dynamic hotspots of nitrous oxide and methane in coastal marshes:

Responses to two long-term fertilization experiments



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THINK BIG WE DO

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Despite small size, coastal salt marshes affect global carbon sequestration

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

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

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

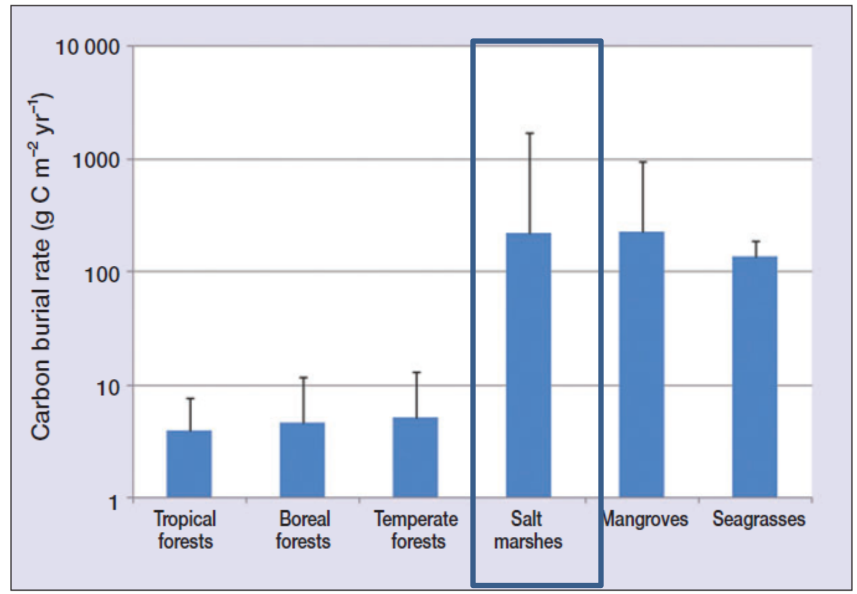
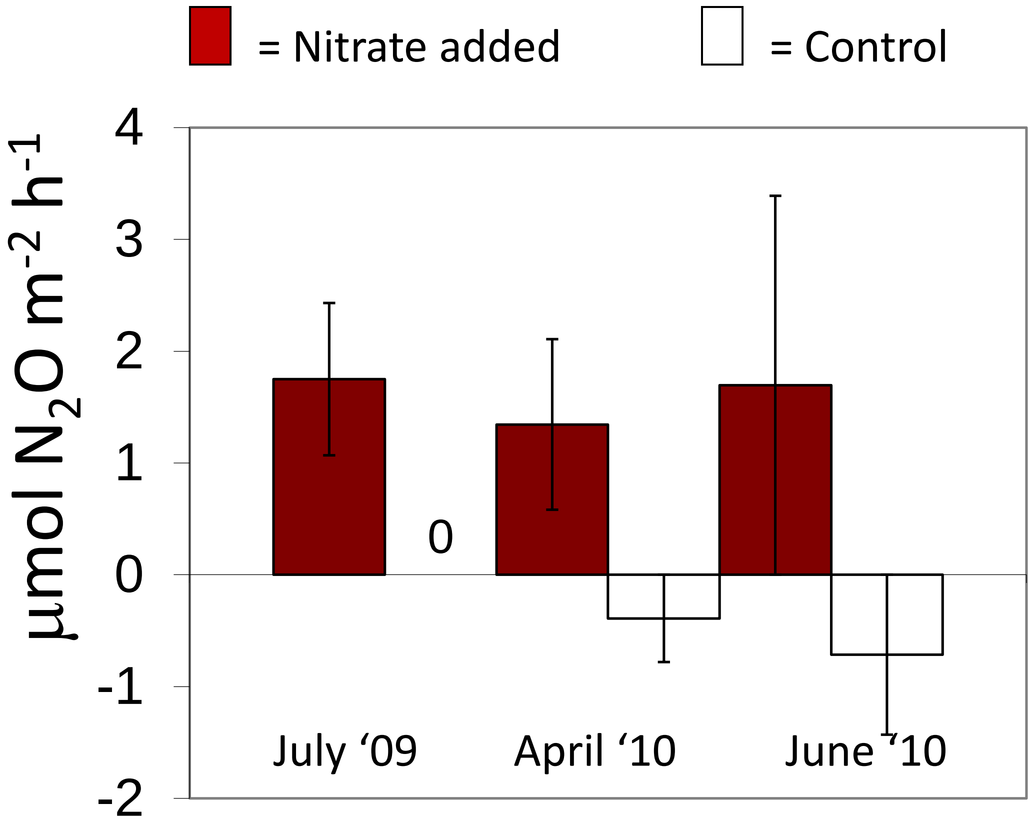


Figure 5. *Mean long-term rates of C sequestration (g C m^{-2} yr^{-1}) in soils in terrestrial forests and sediments in vegetated coastal ecosystems. Error bars indicate maximum rates of accumulation. Note the logarithmic scale of the y axis. Data sources are included in Tables 1 and 2.*

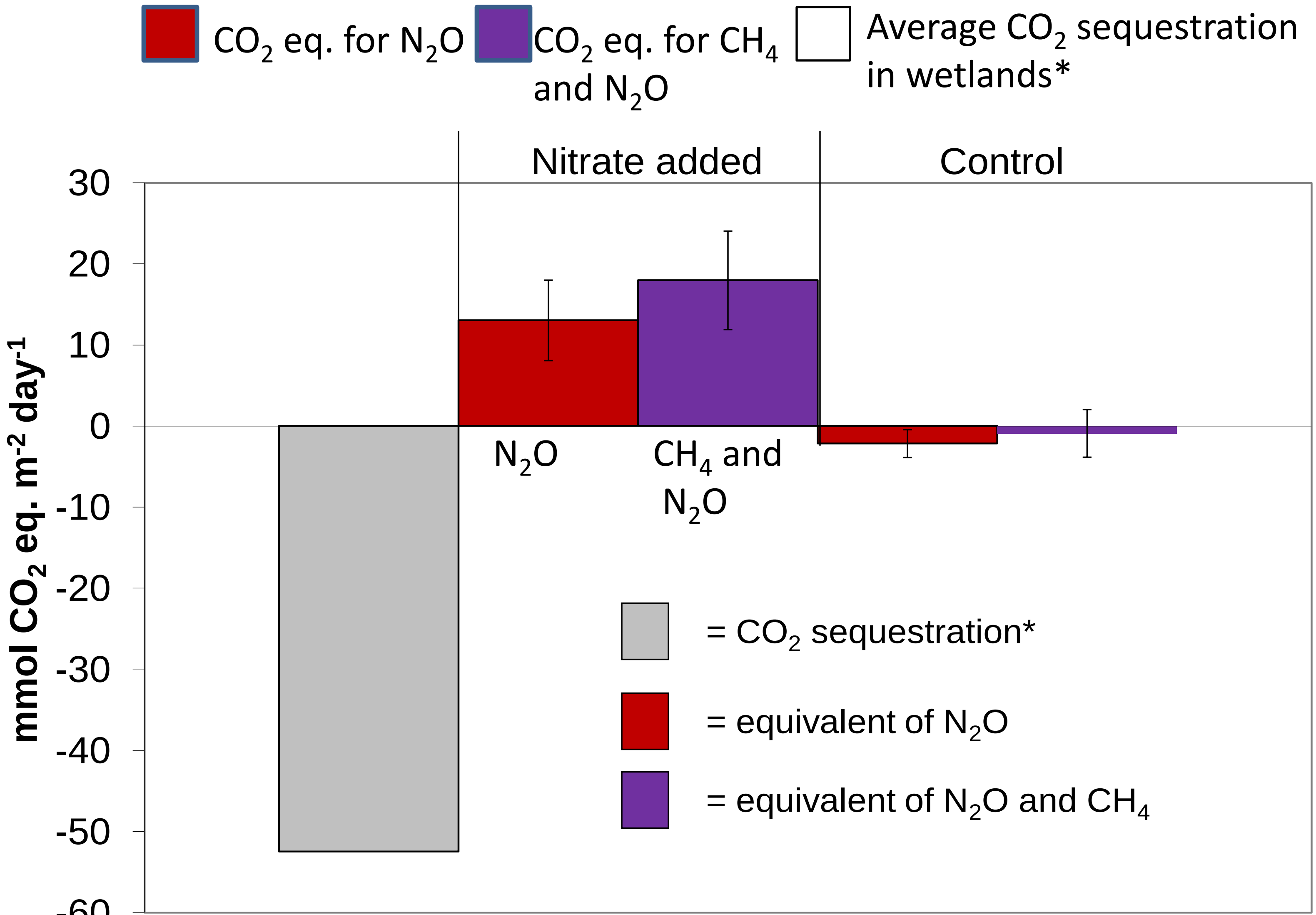
Reviewed in Mcleod et al. 2011 Front. Ecol. Environ.

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)



Moseman-Valtierra et al. 2011. Atmospheric Environment

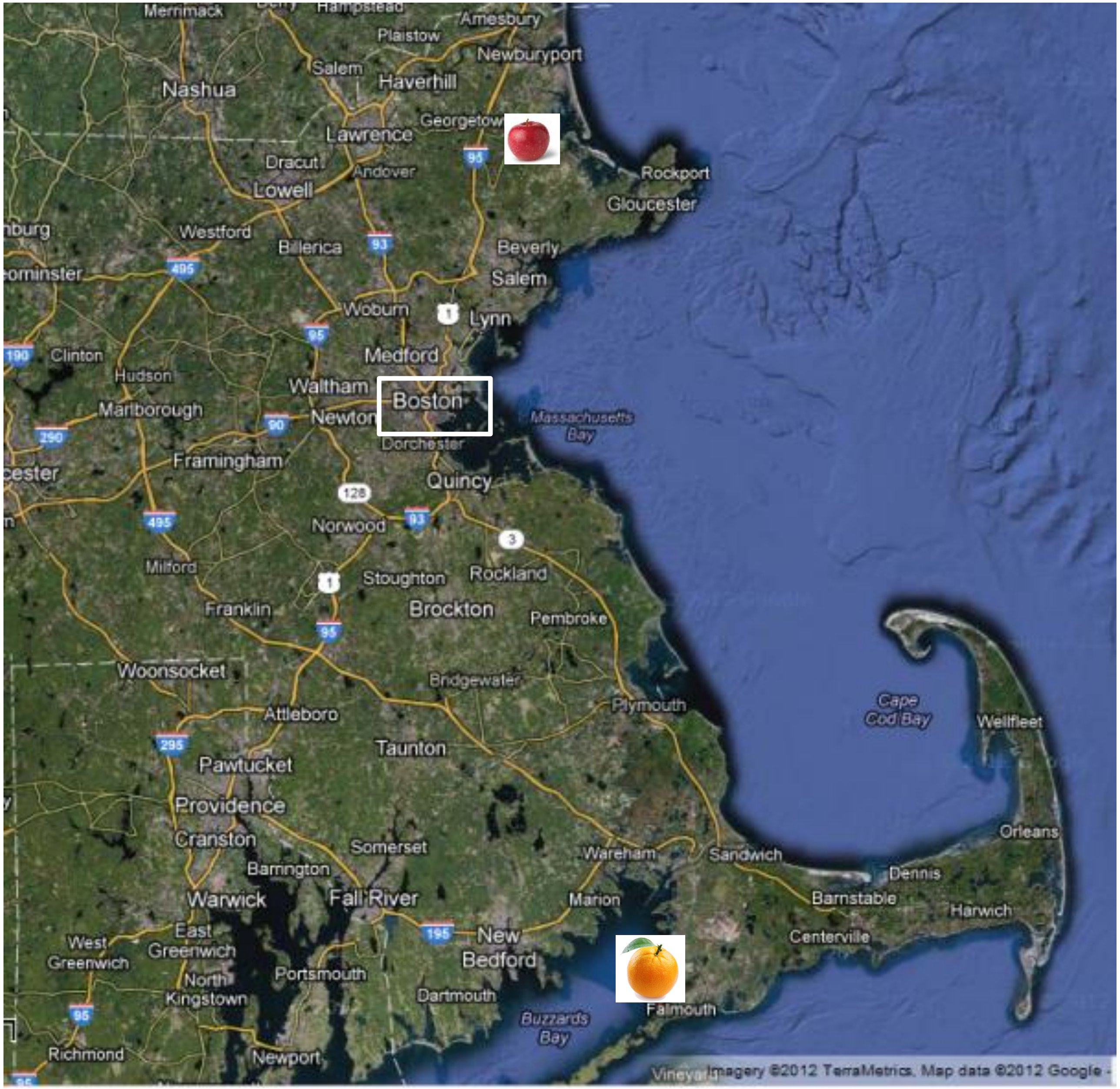
*Source: *http://cdiac.ornl.gov/SOCCR*

The First State of the Carbon Cycle Report (SOCCR)

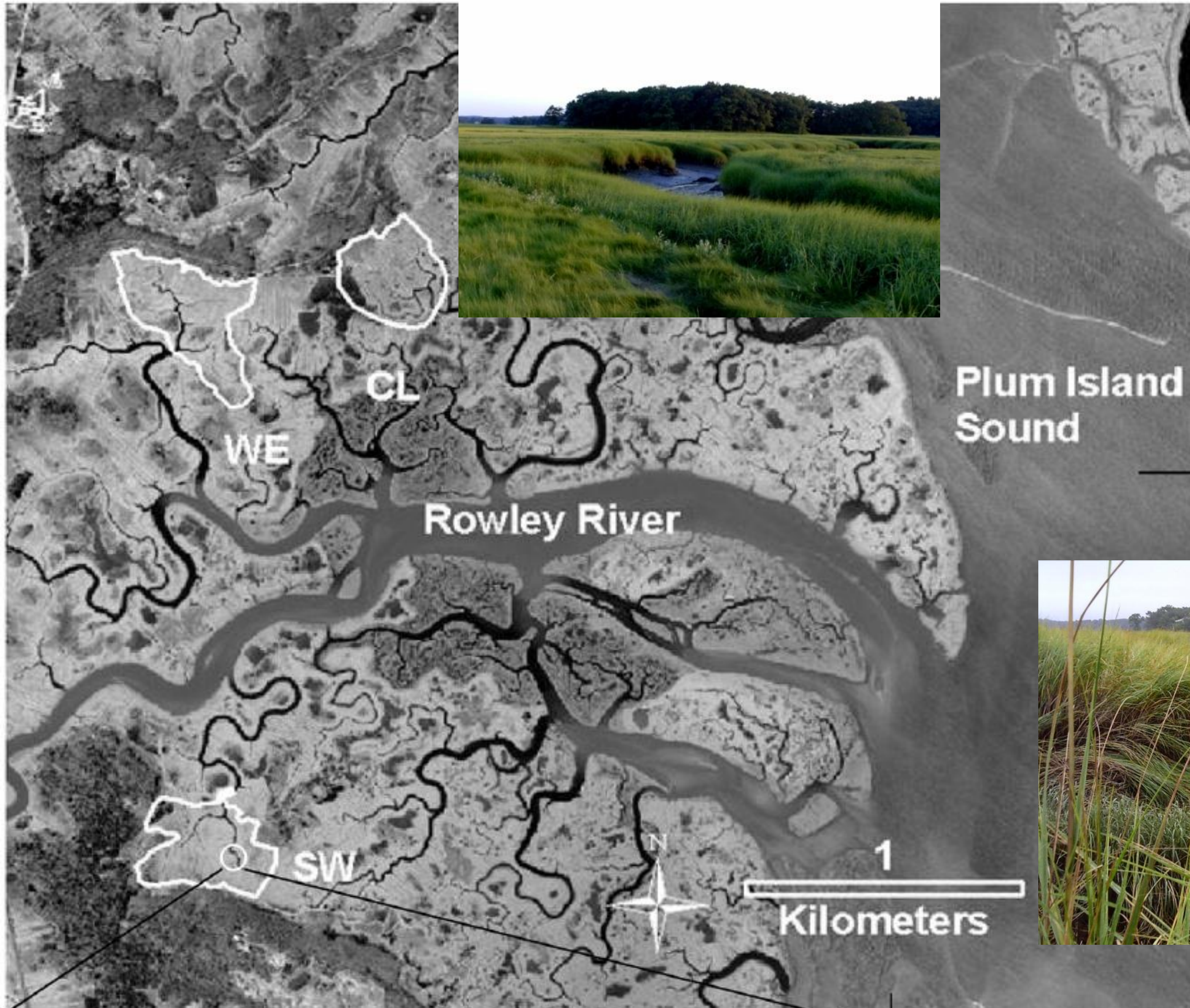
The North American Carbon Budget and Implications for the Global Carbon Cycle

…but what happens over longer time scales?

Two Long-term Experiments


Merrimack
Hampstead
Amesbury
Plaistow
Newburyport
Salem
Haverhill
Nashua
Lawrence
Dracut
Andover
Lowell
Rockport
Gloucester
Westford
Billerica
Beverly
Salem
Woburn
Lynn
Clinton
Hudson
Medford
Waltham
Boston
Newton
Marlborough
Massachusetts Bay
Dorchester
Framingham
Quincy
Norwood
Milford
Stoughton
Rockland
Franklin
Brockton
Pembroke
Woonsocket
Bridgewater
Plymouth
Attleboro
Cape Cod Bay
Wellfleet
Taunton
Pawtucket
Providence
Cranston
Somerset
Orleans
Barrington
Wareham
Sandwich
Dennis
Warwick
Fall River
Marion
Barnstable
Harwich
East Greenwich
New Bedford
Centerville
West Greenwich
North Kingstown
Portsmouth
Dartmouth
Falmouth
Buzzards Bay
Richmond
Newport
Imagery ©2012 TerraMetrics, Map data ©2012 Google

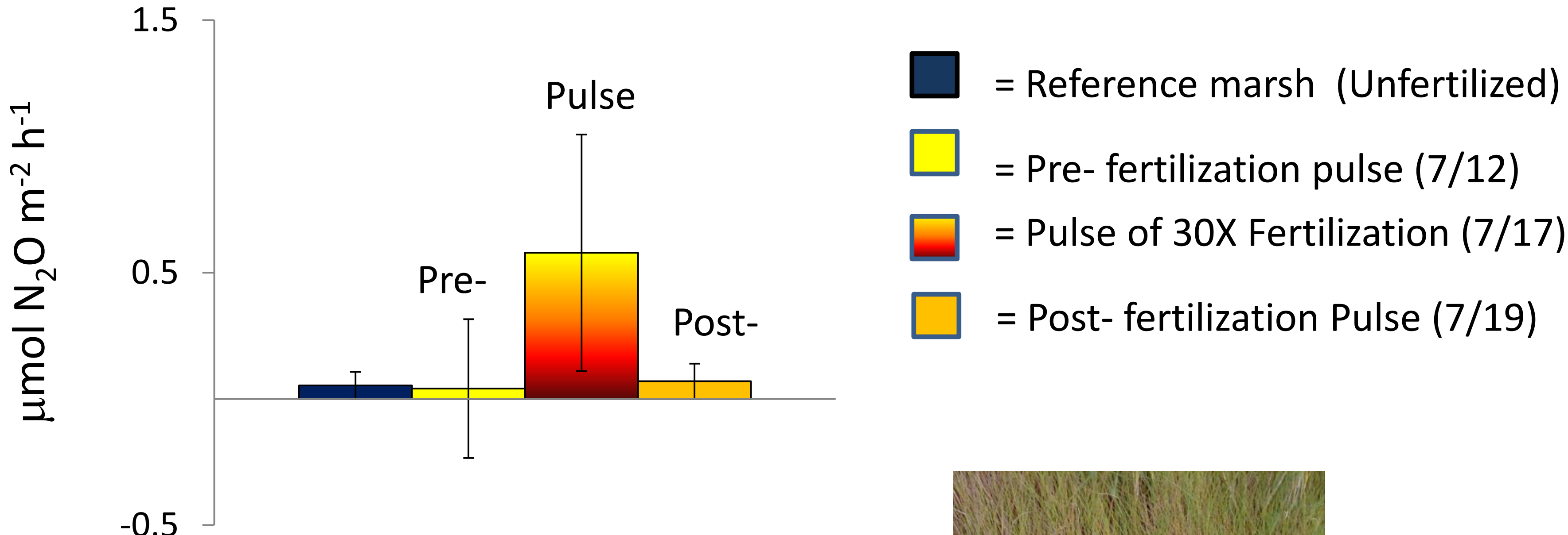
7-8 year fertilization at Plum Island (T.I.D.E.S.)



70 µM NO_3^-
15X background

Map from Johnson and Fleeger et al. 2009

During a transient doubling of fertilization…

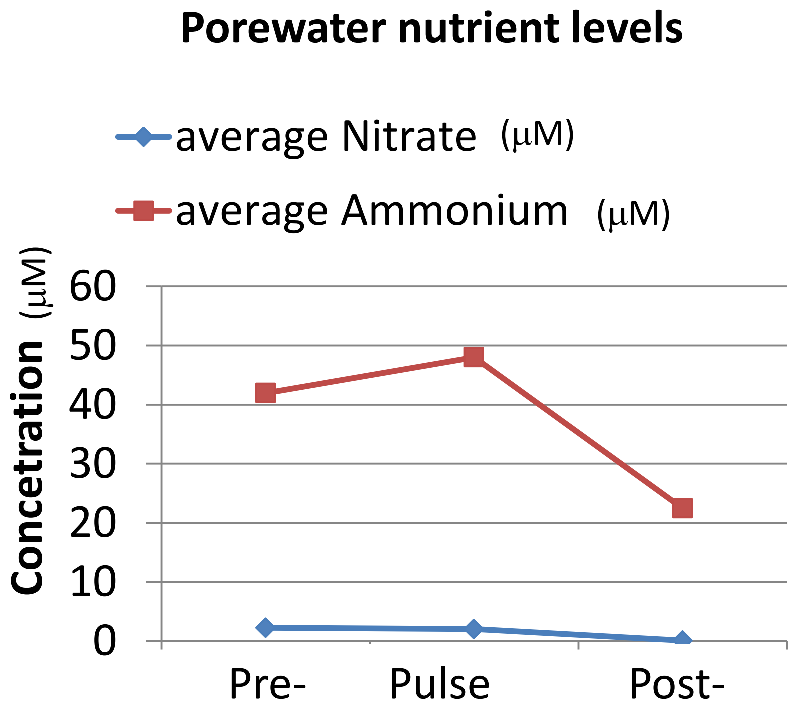


Why were N_2O fluxes so low?

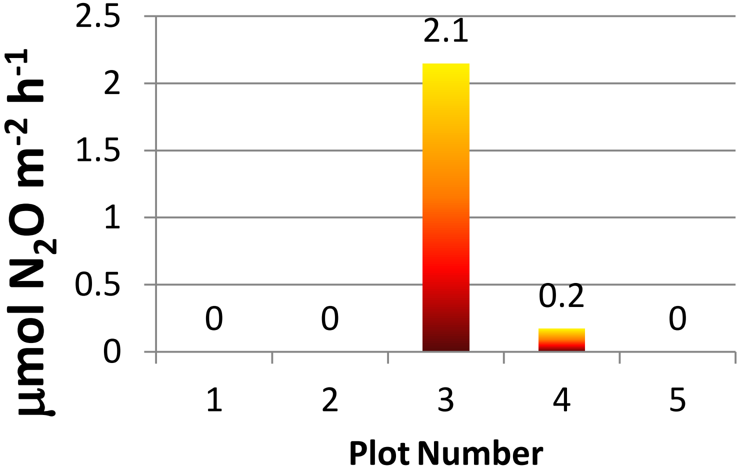
Creek water nutrient levels

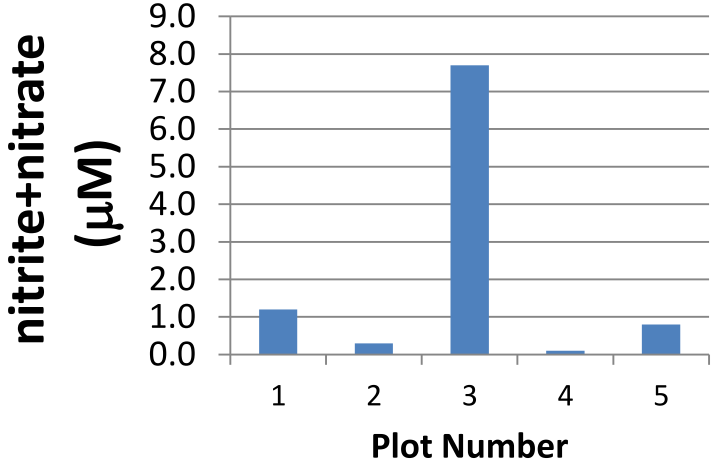
During pulse:
Nitrate on Flood tide averaged 112 μM
(13 μM NO_3^- during flux measurements)

Ammonium was less than 18 **μM**

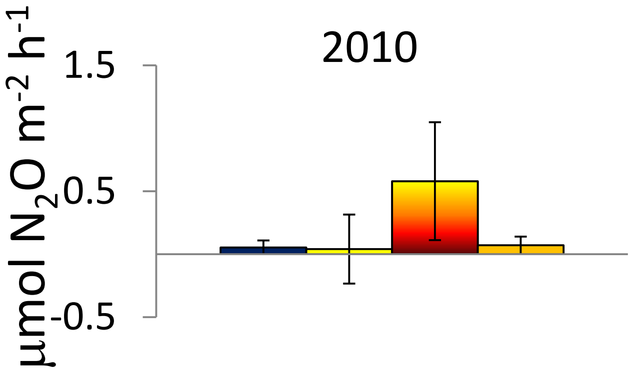


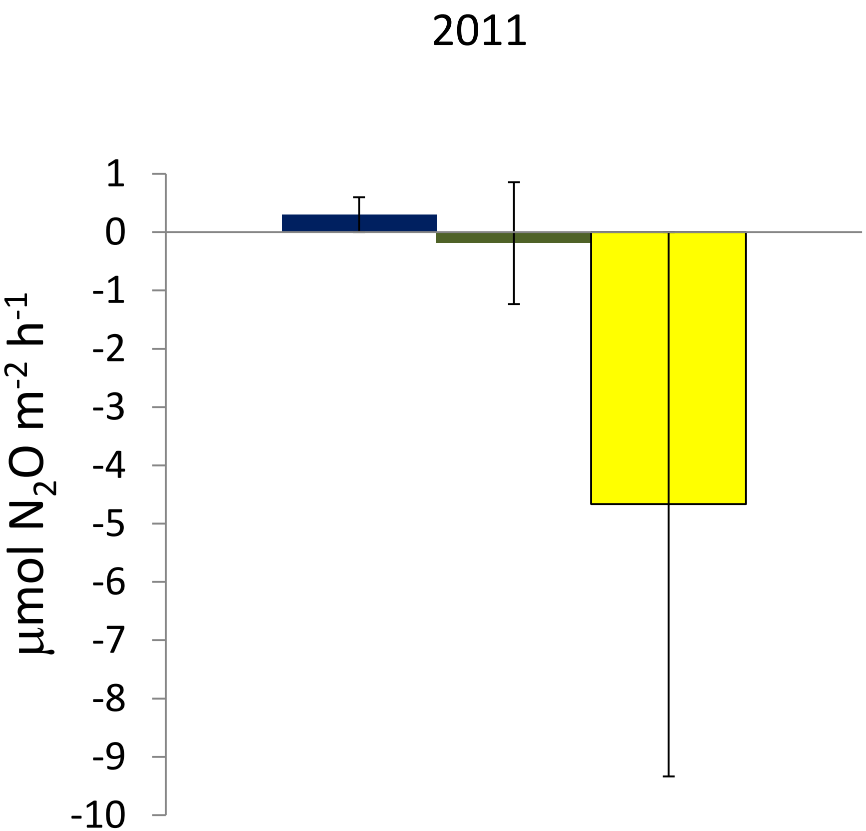
N_2O fluxes reflect porewater nitrate concentrations



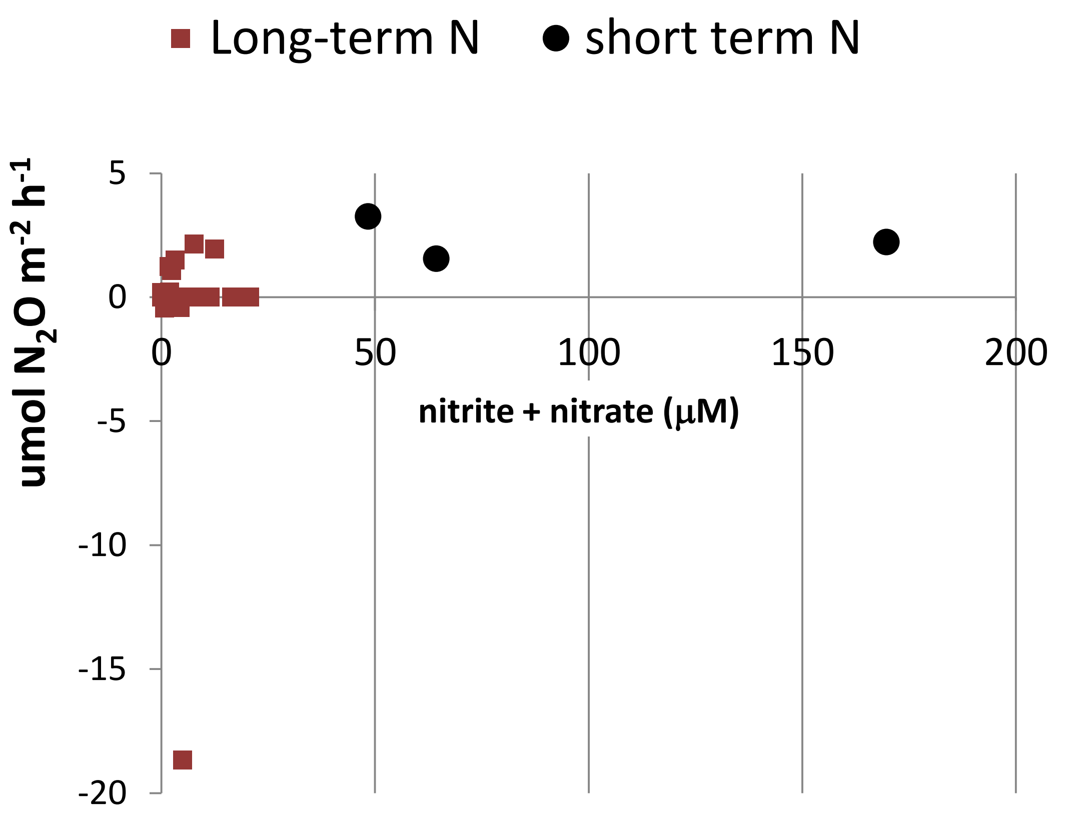


Direction of N_2O flux reverses when the fertilization ceases





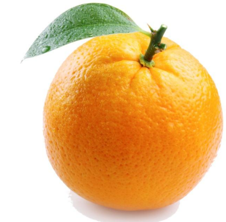
Why did results of long- and short-term experiments differ?



Conclusions

- Long term (7-8 year) fertilization did not affect N_2O or CH_4 fluxes…but nutrient concentrations were not very high and not constant.
- Marshes may be resilient! N reductions may prevent or limit GHG emissions.

41-42 year fertilization at Sippewissett Marsh

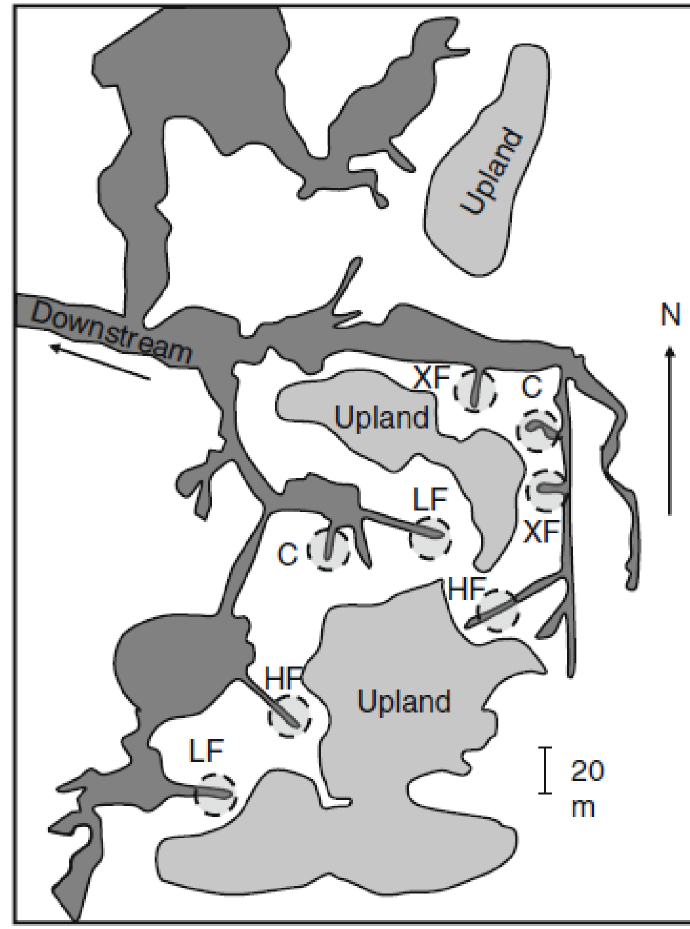


XF=Extra-high fertilization ($7.56\ g\ N\ m^{-2}\ wk^{-1}$)

HF=high fertilization ($2.52\ g\ N\ m^{-2}\ wk^{-1}$)

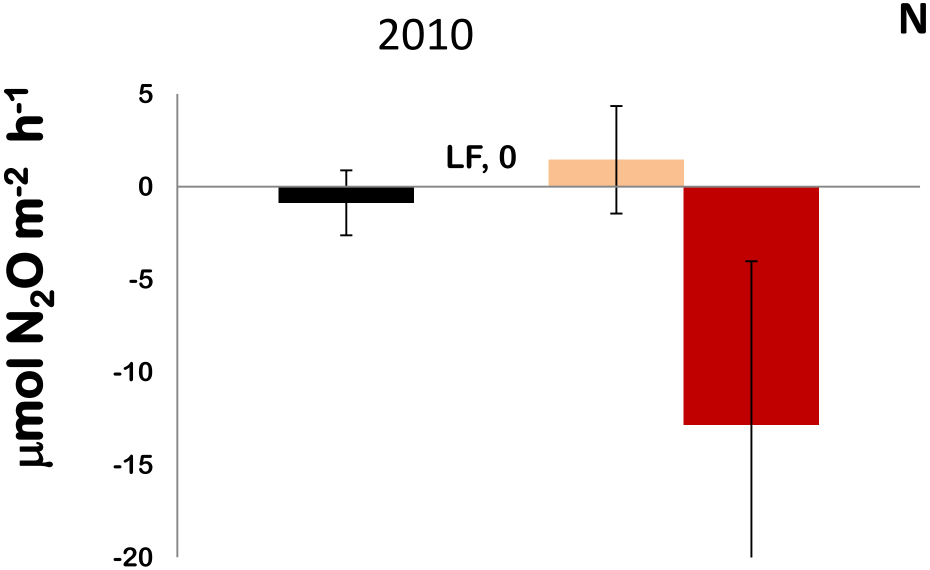
LF= low fertilization ($0.86\ g\ N\ m^{-2}\ wk^{-1}$)

Control= no fertilization



Map: Fox et al. 2012 Estuaries and Coasts

N_2O fluxes display spatial variability



No significant differences between treatments

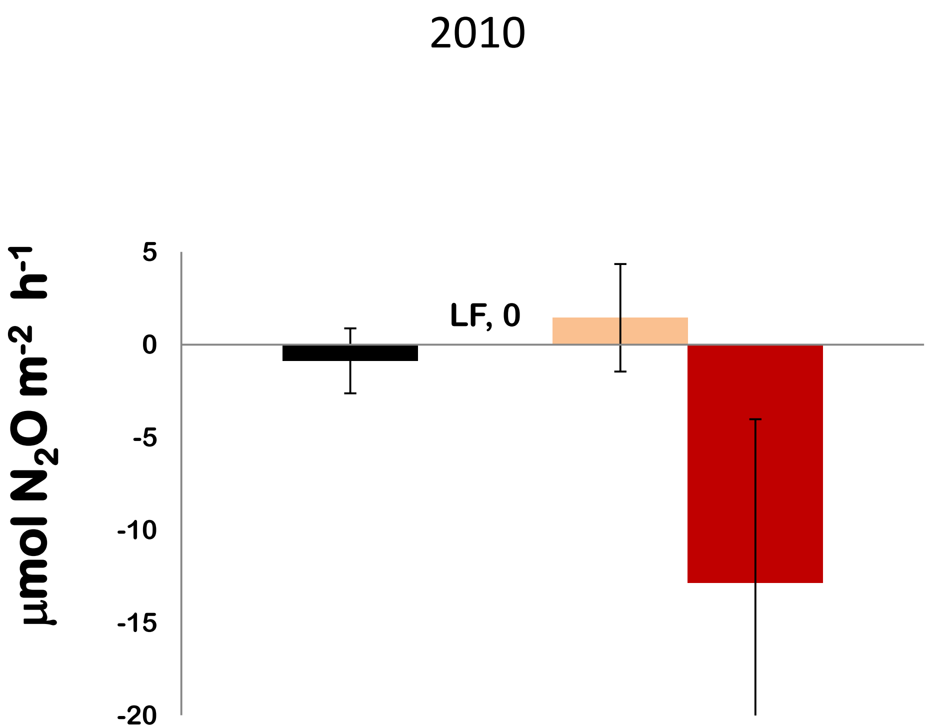
= XF (7.56 g N m^{-2} week^{-1})

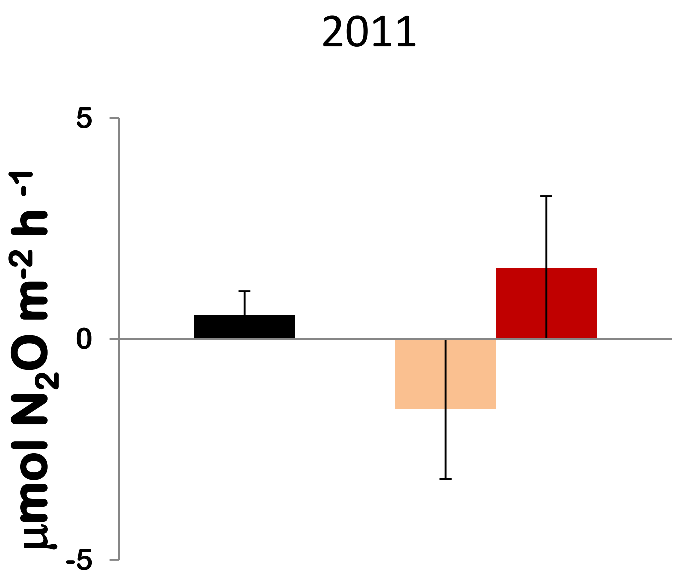
= HF (2.52 g N m^{-2} week^{-1})

= LF (0.86 g N m^{-2} week^{-1})

= Control (0 g N m^{-2} week^{-1})

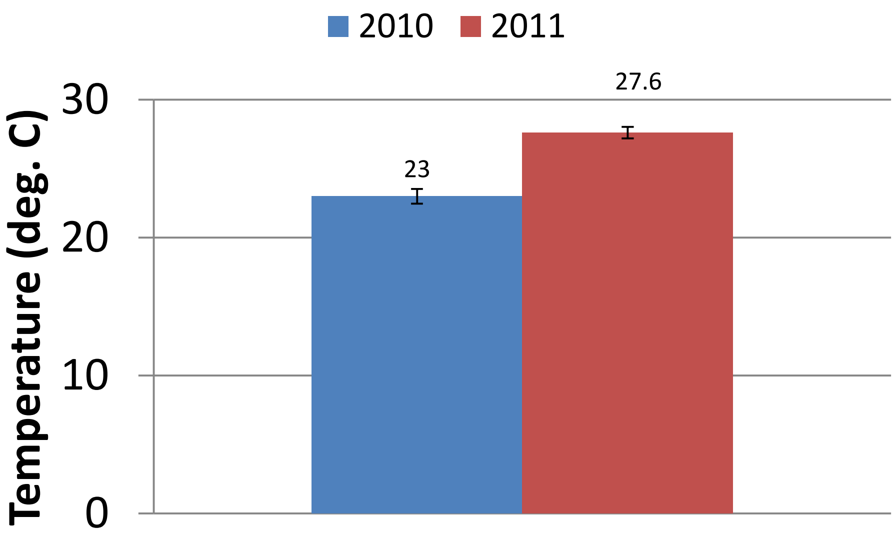
Nearly all N_2O fluxes completely reverse directions between 2 years





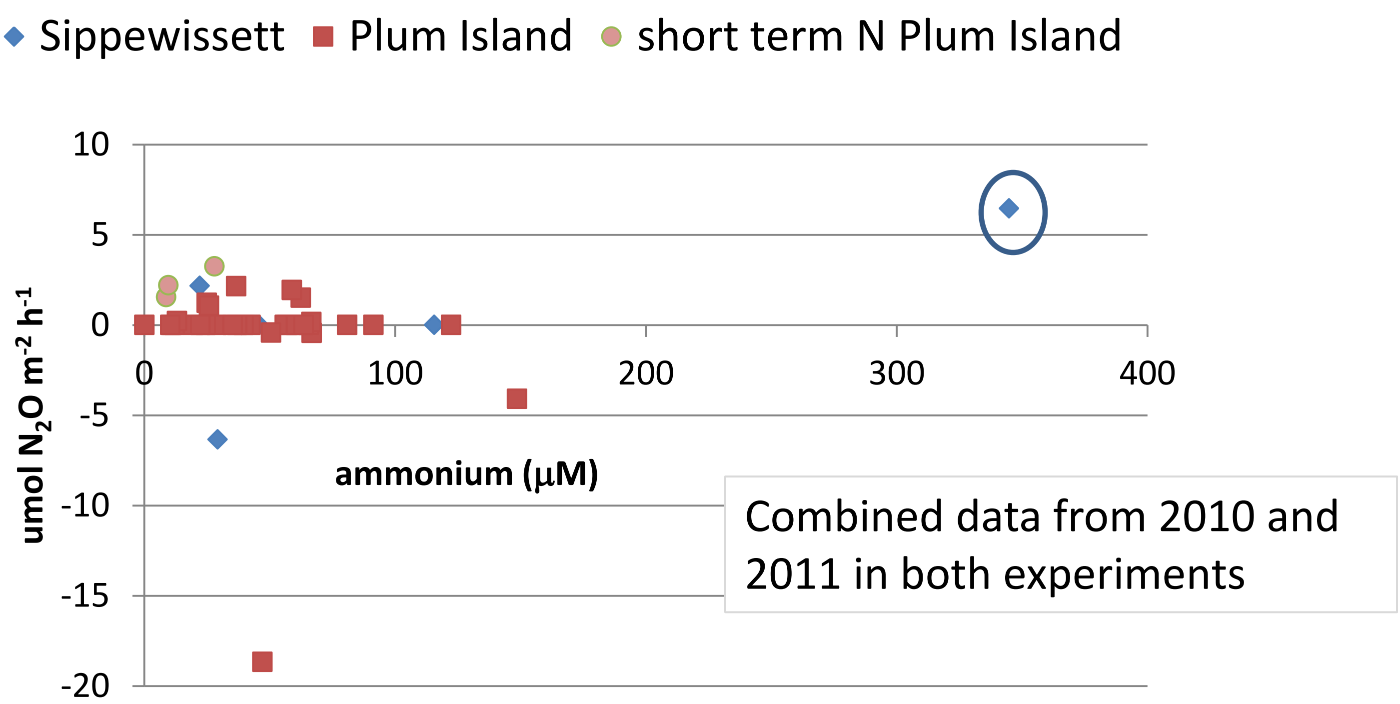
Why such a difference between years?

- One possibility is temperature:

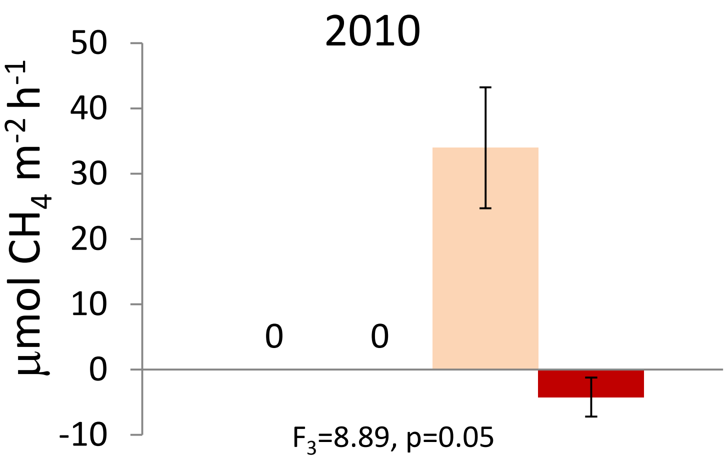


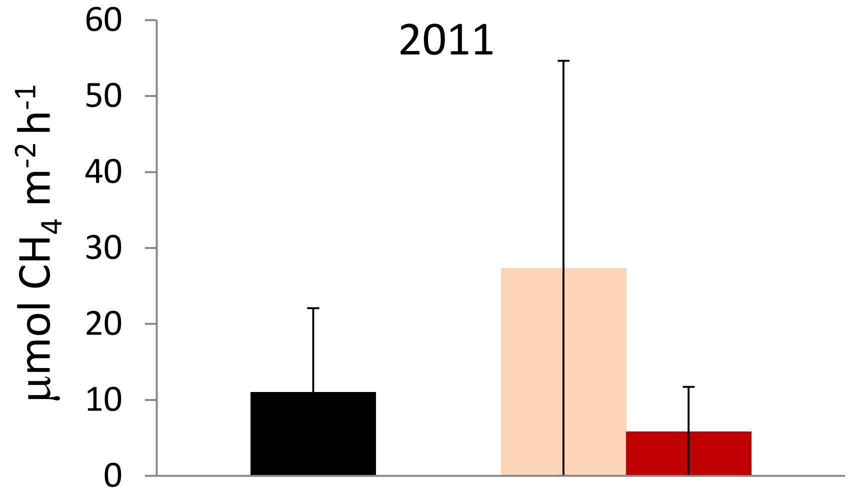
<u>No difference over time in:</u>
Salinity,
pH,
Oxidation reduction

Highest N_2O flux in plot with highest pore water ammonium



Highest methane fluxes in plots with high fertilization (HF)





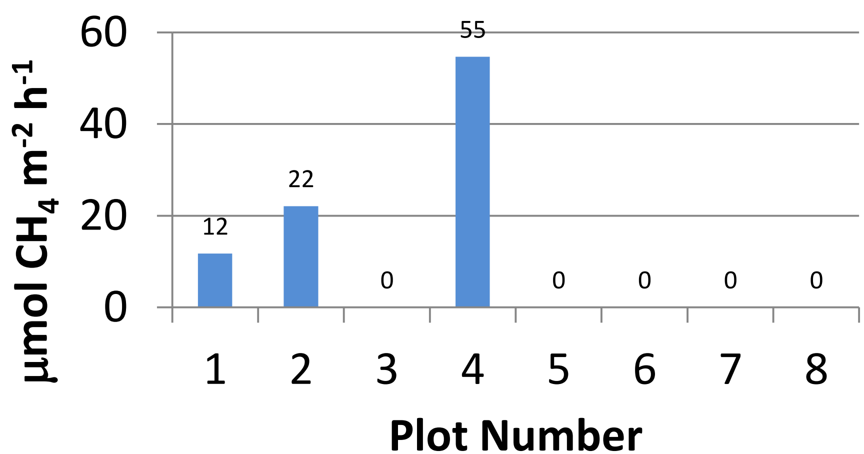
= XF (7.56 g N m^{-2} $week^{-1}$)

= HF (2.52 g N m^{-2} $week^{-1}$)

= LF (0.86 g N m^{-2} $week^{-1}$)

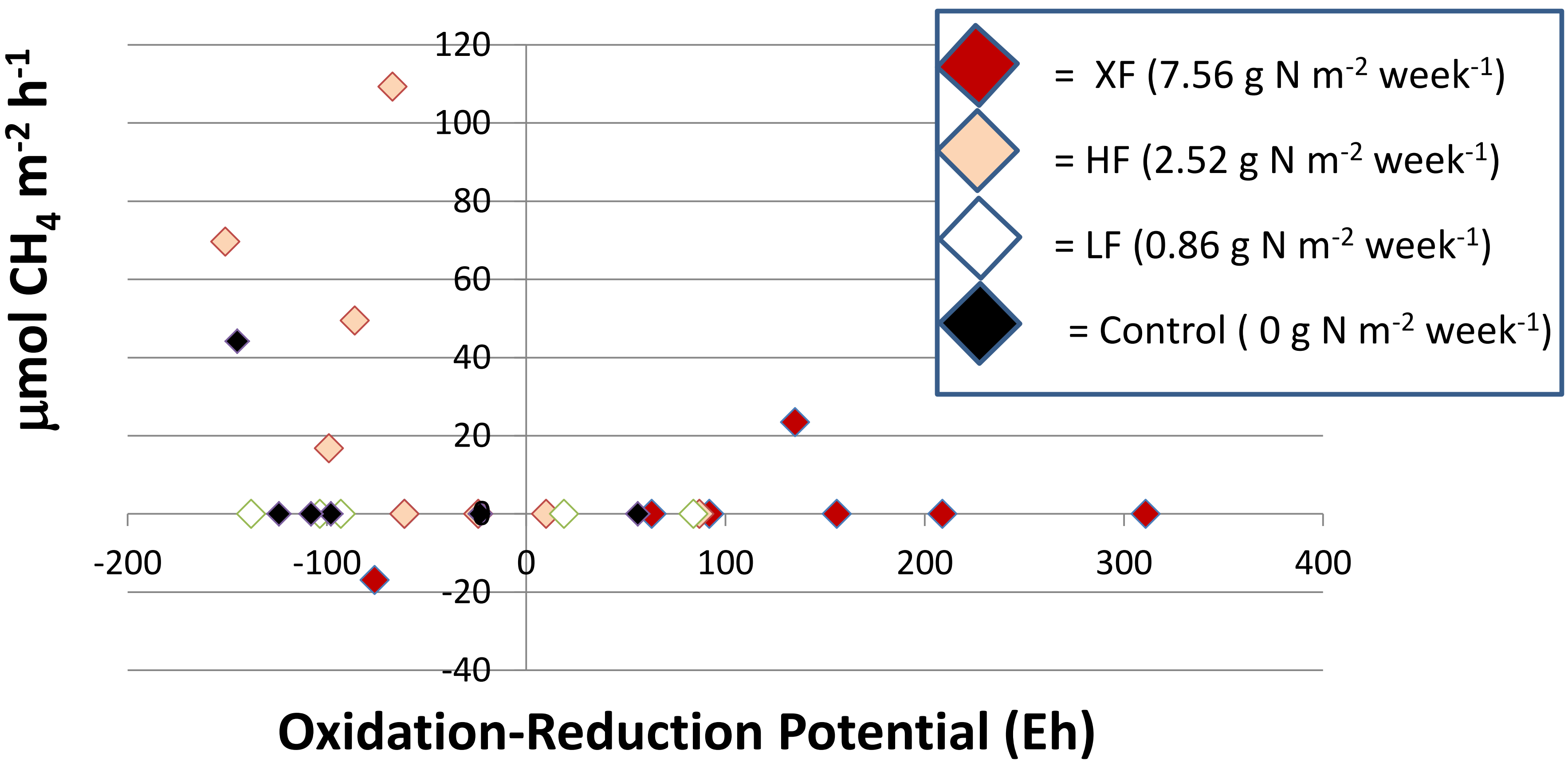
= Control (0 g N m^{-2} $week^{-1}$)

…but high variability in 2011



Why were methane fluxes not as large in plots with the highest fertilization (XF)?

Soil oxidation-reduction potential



Several questions remain

Estuaries and Coasts (2012) 35:445–458
DOI 10.1007/s12237-012-9479-x

Vegetation Cover and Elevation in Long-Term Experimental Nutrient-Enrichment Plots in Great Sippewissett Salt Marsh, Cape Cod, Massachusetts: Implications for Eutrophication and Sea Level rise

Liza Fox · Ivan Valiela · Erin L. Kinney

Fig. 4 View of experimental marsh plot treated with the XF dosage, showing the marked responses of vegetation that have occurred after decades of chronic nutrient enrichment

Conclusions

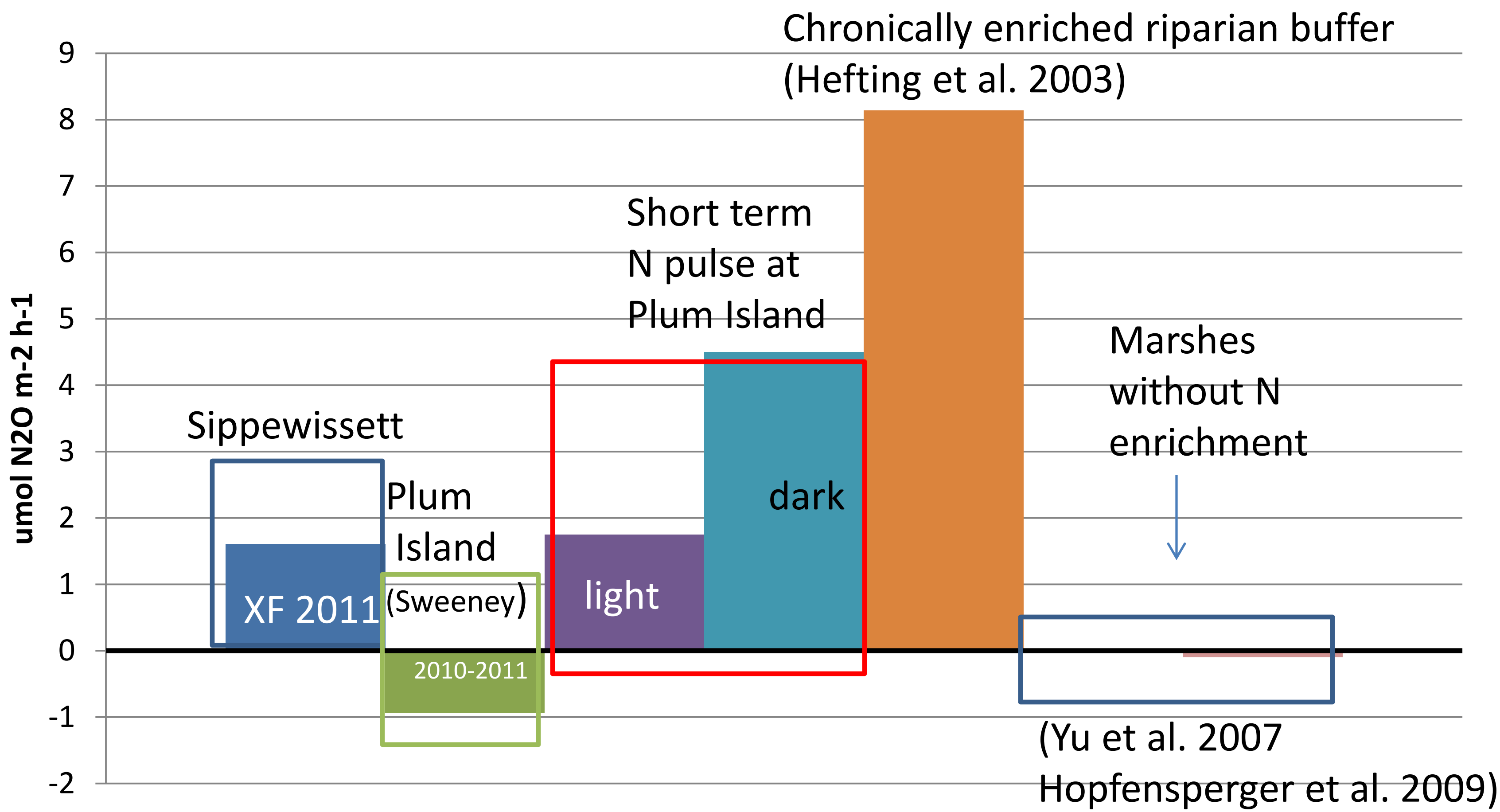
- Long term fertilization (40 years) did not significantly change N_2O fluxes (in one of the plant zones)

  -Reversal of the direction of N_2O fluxes may have been related to temperature

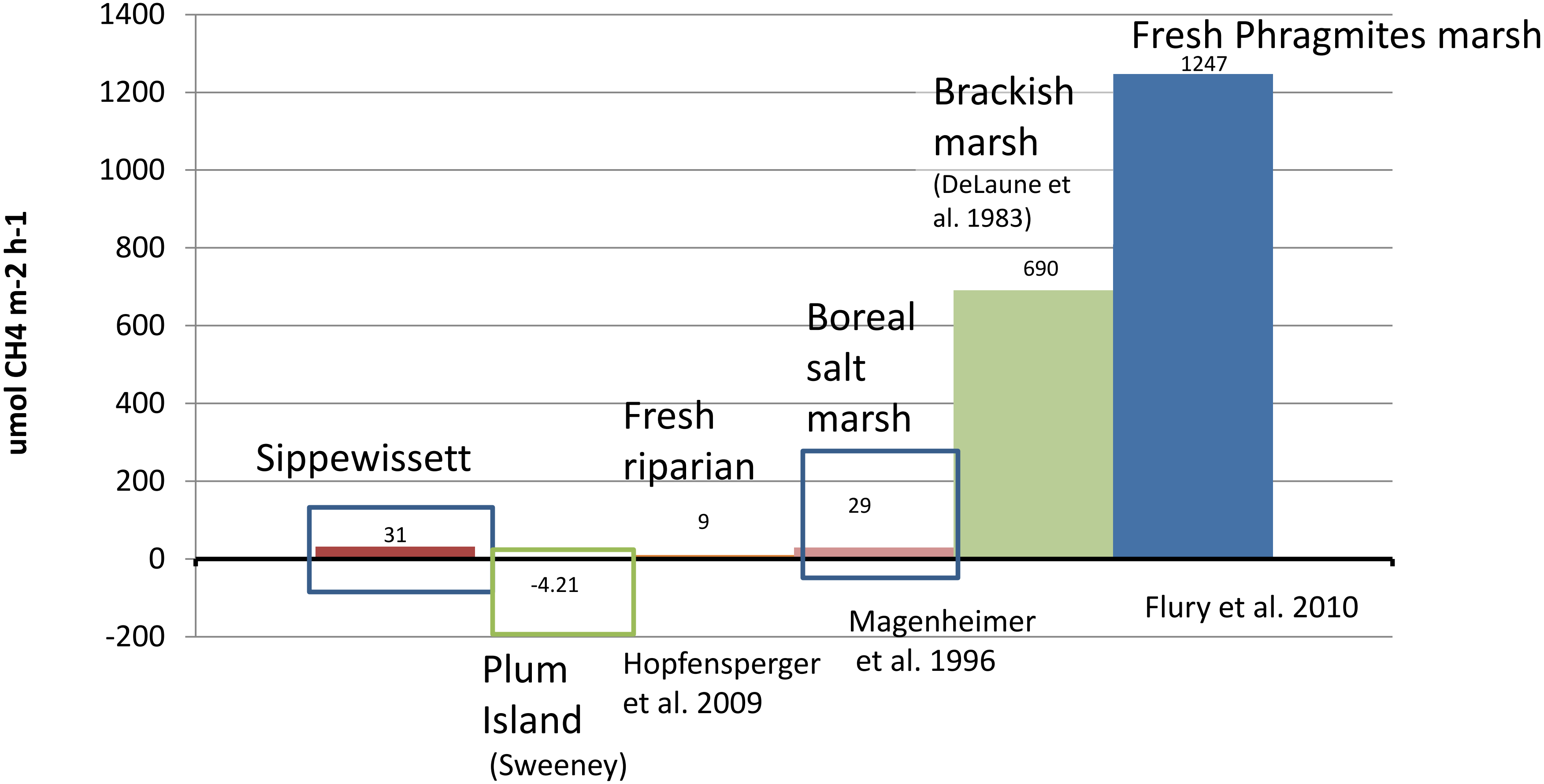
  (Does warming lead to higher emissions?)

- CH_4 fluxes were significantly higher in the High Fertilization plot (in one of 2 years)

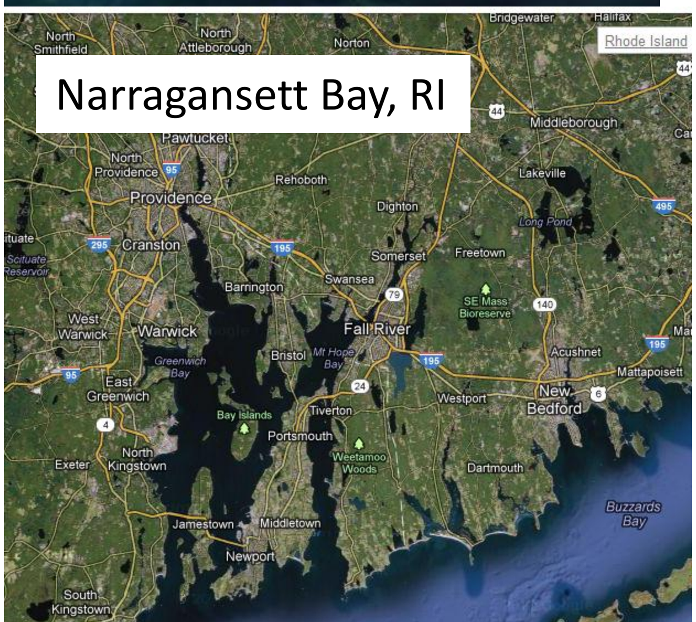
Large N_2O fluxes of N-enriched marshes



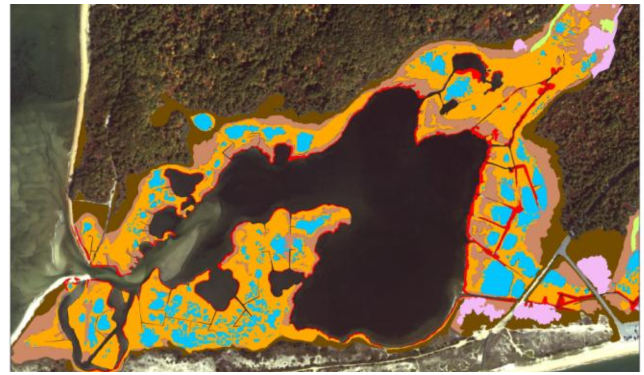
CH_4 fluxes are *not* large relative to other wetlands



Future directions: The "Real" N experiments



Studying relationships of GHG fluxes to plant zones with *in situ* analyzers



Colors indicate distinct zones in Sage Lot Pond (Waquoit Bay)

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T. Surgeon-Rogers,
S. Emmett-Mattox,
I.Emmer, S. Crooks,
P. Megonigal,
T. Walker,
C. Weidman

Testing potential interactions of N loading and warming

Collaborator:
B. Govenar

Acknowledgements

- **Students**: Rosalinda Gonzalez (Woods Hole Partnership Education Program), Kelsey Fisher, David McChesney (Boston College)
- **Collaborators** : Dr. Linda Deegan, Dr. Ivan Valiela,
  Dr. Jianwu Tang (Marine Biological Laboratory),
  Dr. Breea Govenar (Rhode Island College)
  Field support: (USGS)Wally Brooks, Adrian Green, Sandy Baldwin; Kate Morkeski, David Johnson (MBL)
  Nutrient Analyses: Linda Green (URI), Paul Henderson (WHOI)
- **Funding**: USGS Mendenhall Post-Doctoral Research Fellowship
  USDA Agricultural Experiment Station and University of Rhode Island (start-up funding)
  National Estuarine Research Reserve System Science Collaborative 2012-2014
  Rhode Island Research Alliance Collaborative Grant 2012

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