Consequences of climate change, eutrophication, and anthropogenic impacts to coastal salt marshes: multiple stressors reduce resiliency and sustainability

Elizabeth Burke Watson[1], Cathleen Wigand[1], Joanna Nelson[2,3], Kerstin Wasson[2,4]

(1) ORD-NHEERL, U.S. Environmental Protection Agency, Narragansett, RI
(2) Elkhorn Slough National Estuarine Research Reserve
(3) Dept. of Environmental Studies, University of California, Santa Cruz
(4) Dept. of Ecology & Evolutionary Biology, University of California, Santa Cruz

I. INTRODUCTION

While the **negative impacts of fertilization to aquatic ecosystems** are well documented, the jury is still out regarding the negative consequences of fertilization to terrestrial ecosystems and global biogeochemical cycles. Fertilization of terrestrial ecosystems has been found to stimulate productivity (e.g. Bubier et al. 2001), increase Rubisco enzyme concentrations (Cheng et al. 2009), increase radiation-use efficiency (Gough et al. 2004), to increase greenhouse gas emissions (Halvorson et al. 2011), and to cause declines in soil organic matter (Fauci and Dick 1994). Here, we consider the consequences of fertilization to coastal marshes in Central California and Southern New England, where fertilization and coastal eutrophication may have important consequences for wetland sustainability.

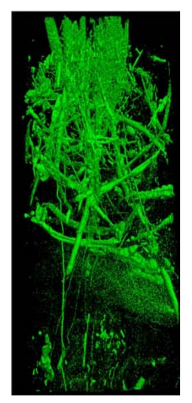
negative impacts of fertilization to aquatic ecosystems

II. EXPERIMENTS & FIELD STUDIES

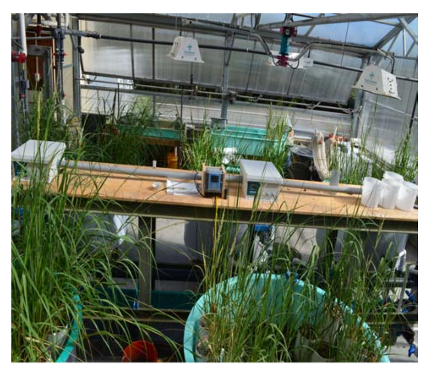
To better understand the consequences of fertilization to coastal marshes, in concert with other anthropogenic stressors, we are implementing field and laboratory mesocosms, manipulative experiments, and correlative studies. Measures of soil respiration, soil organic matter composition, and decomposition are being conducted in fertilized and control plots, along eutrophication gradients, and in pristine vs. degrading salt marshes.

PRODUCTIVITY

- **Root structure** is being characterized by subjecting sediment cores and soil mesocosm pots to CT scanning and image analysis.



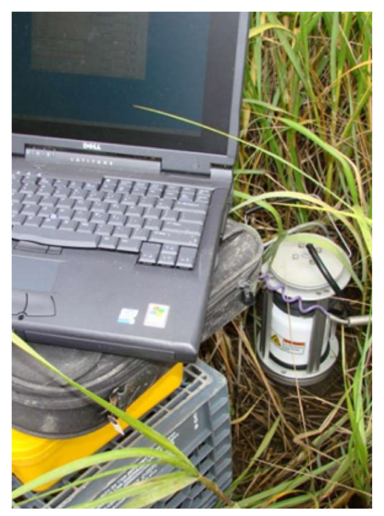
- **Collections of standing plant matter and root material** have been conducted during late winter and late summer to characterize above and belowground productivity and standing biomass.



- **Laboratory mesocosms** are being used to compare productivity under different levels of tidal flooding and nutrient enrichment.

DECOMPOSITION

- **Soil respiration measurements**, defined as carbon dioxide efflux from bare sediments between culms, were measured in the field with an infra-red gas analyzer and dome system (LiCor 8100).



- **Decomposition rates** are measured through the placement and collection or litterbags with dried plant leaf and root matter sequestered at specific depths (leaf matter at surface, root/rhizome matter at 0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm, and 20-25 cm depth).

- **Soil organic matter composition** is measured by analyzing shallow sediment cores for organic content, and total carbon content using loss on ignition methods in concert with a Carlo Erba NA 1500 NCS elemental analyzer.

- **Sediment elevation tables** (SETS) are being used to compare marsh elevation trajectory in stable and degrading wetlands.

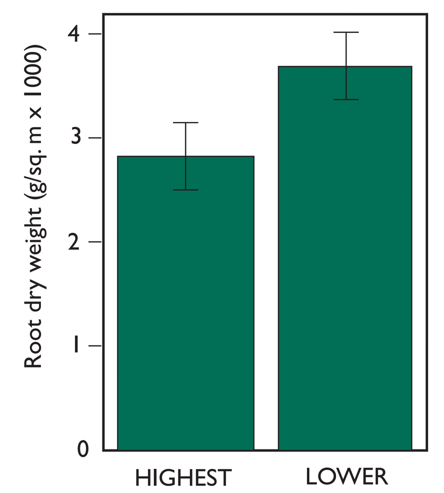
- **Field mesocosms** are being used to compare productivity and decomposition under different inundation regimes.

III. IS FERTILIZATION A BAD THING?

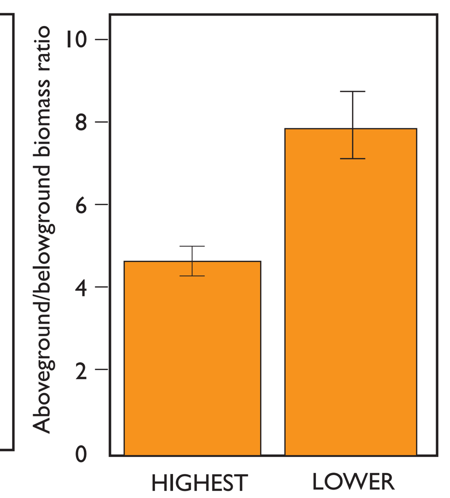
Well, at our study sites in Central California & Southern New England, it has been associated with...

Poor water quality

Decline in belowground biomass

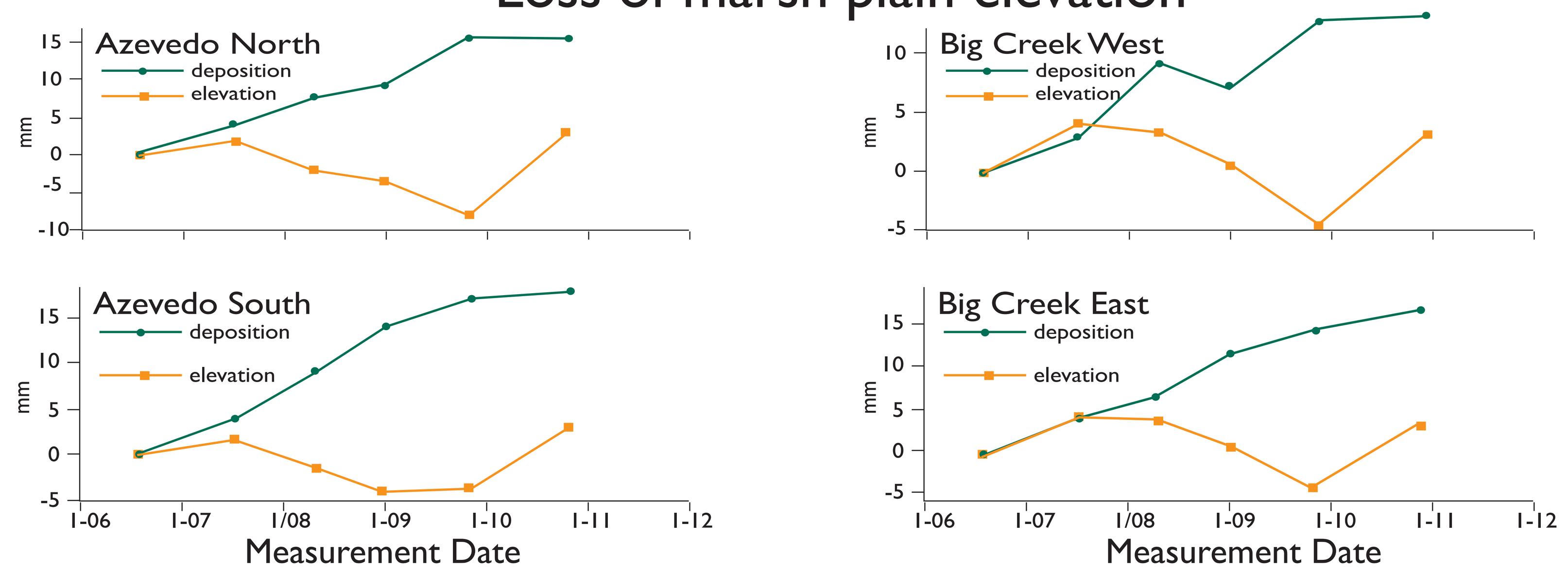


Decline in root: shoot ratio

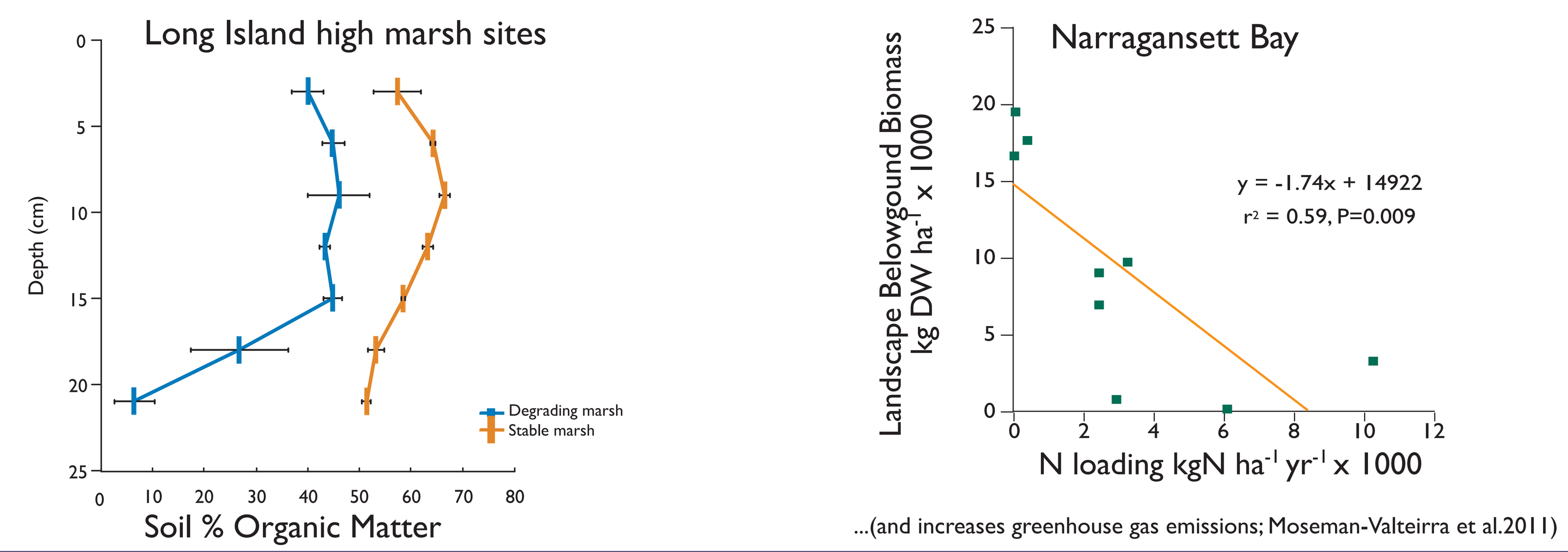


Ambient nutrients at Elkhorn Slough

Loss of marsh plain elevation

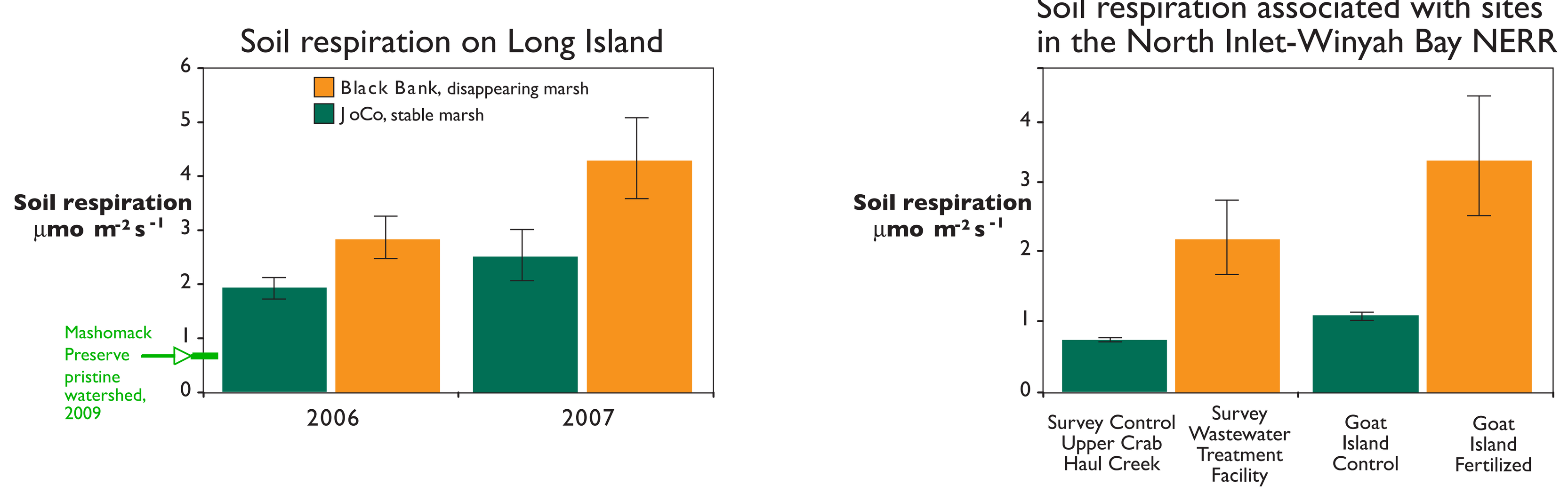


Declines in carbon sequestration



...(and increases greenhouse gas emissions; Moseman-Valteirra et al.2011)

Increased soil respiration rates



IV. CONCLUSIONS

- In both Central California and Southern New England, high nutrient inputs have been associated with wetland deterioration, loss of elevation, and changes in belowground root structure. Impacts vary due to differences between dominant species.
- Measures of soil respiration and decomposition demonstrate enhanced decomposition of organic matter and resulting CO_2 efflux from fertilized marshes. Over time, this loss of organic matter may result in wetland soil elevation loss, and plant mortality.
- While fertilization is not always definitively negative, interactions with other anthropogenic stressors suggest that nutrient inputs to coastal marshes are decreasing resilience of this important habitat.
- Coastal wetlands provide important ecosystem services, including providing habitat for diverse resident and migratory fauna, protection of coastal areas from storm surges and coastal flooding, removal of sediments from coastal waters, carbon sequestration, and recreational activities such as kayaking, bird watching, and fishing. Where nutrient additions compromise marsh integrity, ecosytem services such as sediment removal, flood protection, and carbon sequestration will be lost.

IMPACTS OF FERTILIZATION ON MARSH SUSTAINABILITY

IMPACT	CONSEQUENCES
Increased aboveground biomass	Increased Resilience
Increased shoot:root ratio	Decreased Resilience
Increased aggressiveness of weedy species	Uncertain outcome
Increased decomposition	Decreased Resilience
Loss of fine roots	Decreased Resilience

Future study will focus on (1) quantifying the effects of nutrient inputs in order to parameterize predictive marsh sustainability models (SLAMM), and (2) quantifying ecosystem services of degrading salt marsh. Furthermore, we are testing the hypothesis that enhanced bacterial and fungal diagensis of soil organic matter drives enhanced soil respiration rates.

V. ACKNOWLEDGEMENTS

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