Nutrient and climate change effects on coastal marshes and implications for management

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Anthropogenic impacts to salt marshes

• Nutrient over-enrichment
• Accelerated sea level rise
• Increase in the frequency and severity of storms
Marsh sustainability depends upon:

- Sediment supply
- Organic matter accumulation
Is nutrient enrichment a marsh stressor?
Southeast US, Minerogenic marsh system, North Inlet-Winyah Bay, SC, High sediment loads, 20 mg/L
control +P +N +N+P

North Inlet – Winyah Bay Fertilization Experiment, 1 g N m$^{-2}$ d$^{-1}$
Wigand et al. 2015
North Inlet- Winyah Bay fertilization experiment
Northeast US, Organogenic marsh system, Jamaica Bay, NY
JoCo, stable marsh

N Loading rate:
300 mg N m\(^{-2}\) d\(^{-1}\)

Black Bank, Deteriorating marsh
Effect of Nutrient Addition on a Salt Marsh System with Low Sediment Supply and High Inundation

Highly decomposed soils; increase in sulfides

Belowground plant productivity

Soil type

- Mineral
- Low organic
- Organic rich
Organogenic systems depend upon plant production and subsurface expansion to build up peat.

Very little sediment input in Jamaica Bay!
CT cross section images of Jamaica Bay

Most deteriorated:
Big Egg

Moderately deteriorated:
Black Bank

Stable:
JoCo marsh

Wigand et al. 2014
Jamaica Bay marsh soil CO$_2$ efflux

Bass Creek, reference marsh

Black Bank, deteriorating marsh
JoCo, stable marsh

mmol CO$_2$ m$^{-2}$ s$^{-1}$

2006  2007
Point of nutrient addition and area of exposure matter, Plum Island, MA

- Low sediment supply system;
- Low organic sediments;
- Long-term fertilization experiments

Fertilized Sweeney creekbank, Deegan et al. 2012

Fertilized marsh platform, Laws Pt., courtesy: K. Sundberg
Low marsh soil CO$_2$ efflux (µmol CO$_2$ m$^{-2}$ s$^{-1}$)

Student’s T-test, P < 0.001
Field Conclusions

• Nutrients increase belowground productivity in minerogenic systems and can decrease it in organogenic systems

• Marsh soil carbon dioxide efflux increases with nutrient additions
Annual average sea level at New London, CT. Sea level data comes from the NOAA New London, CT tide gage. Open circles indicate sea levels from 1939-1979 ($y=0.0019x - 2.33, R^2=0.46$) and filled circles indicate sea levels from 1980-2013 ($y=0.0047x - 7.91, R^2=0.71$). Dashed trend line represents entire dataset ($y=0.0026x - 3.53, R^2=0.76$).
Bristol, Colt State Park, RI tidal channel expansion

1939

2011
Narrow River Estuary, RI marsh ponding
Loss of high marsh habitat for salt marsh sparrow
Field mesocosm research

Watson et al., 2014.
Productivity responds to elevation

**Spartina alterniflora**

$r^2 = 0.74$

Total biomass (g m$^{-2}$) vs. Elevation (cm NAVD)

Watson et al., 2014, *Climatic Change*.
Narragansett Bay marshes

Watson, unpublished data.
Key Findings

• Tidal marsh vegetation changes are linked with marsh elevation

• Marshes lack elevation capital
Greenhouse multi-stressor research
Experimental Setup

**Ambient Precipitation**
- Rainfall = 65 mmol N l⁻¹
- Ambient = 3 mm (3.5 l) rainfall per day

**Drought**
- Storm = 10 cm (100 l) rainfall per storm

**Unfertilized Bay Water**, 5 - 7 mM DIN

**Fertilized Bay Water**, 70 mM DIN

+K¹⁵NO₃
The Greenhouse Isotope Study

In all three cases, the ambient treatment had significantly greater uptake of % N than the storm treatment at the mid and high elevations; no difference at the low elevations.

Oczkowski et al. 2015.
**Sustainable System**
- peat formation
- organic matter accumulation
- shoreline stabilization
- flood abatement

**Future Scenarios**
- less coarse roots and rhizomes
- less organic matter accumulation
- more watery peat
- increased residential flooding
Recommendations to Sustain Coastal Salt Marshes of Narragansett Bay

US EPA is working with State and Federal partners to develop climate adaptation strategies
Climate-change Adaptation Strategy For Salt Marshes

Increase system resilience

Stakeholders Meetings
Select restoration and reference marshes
Define restoration goals and climate adaptation actions
Develop conceptual models
Plan - Restoration activities
  - Triggers and targets
  - Interim criteria
  - Monitoring schedule

Conduct Climate Adaptation Actions

Adjust Schedule and Modify Actions as Needed

Adaptive Management

Monitor Restoration and Reference Marshes

Evaluate Monitoring Results (Compare with targets and triggers)

Goals are Met

Build shoreline resistance

Enable marsh transition