Differential responses of tidal marsh area and delivery of ecosystem services to rising sea level

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Climate change is one of the most pressing issues of the 21st century, and one of the biggest potential impacts of climate change will be sea level rise. More than 50% of the world's population lives in the coastal zone, and coastal wetlands, tidal marshes and mangroves provide ecosystem services that benefit these coastal residents. These services include disturbance regulation (e.g. shoreline protection potential), biological productivity (e.g. primary production) and waste treatment (e.g. nitrogen (N) retention and removal).

A recent paper in *Frontiers in Ecology and the Environment* (Craft et al. 2009) suggests that, although rising sea level will lead to a decline in tidal marsh area along the southeastern U.S. (Georgia) coast, their delivery of ecosystem services will be less affected. Researchers from the Georgia Coastal Ecosystems (GCE) LTER, with funding from the U.S. EPA Science to Achieve Results program, employed field and laboratory measurements and simulation modeling to predict how tidal marsh area and delivery of ecosystem services will be affected by accelerated sea level rise (ASLR) in the coming century. Model simulations based on the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios A1B mean and maximum (max) estimates of sea level rise suggest that tidal marsh area along the Georgia USA coast will decline by 12% and 33%, respectively, by 2100. However, the reduction in ecosystem services, primary production (macrophyte aboveground biomass), N retention in soil, and potential denitrification, will be less, 4-8% and 23-28%, under the A1B mean and max scenarios respectively. Simulations of ASLR using the Sea Level Affects Marshes Model predict that marshes at the extremes of the salinity gradient, tidal fresh marsh and salt marsh, will be most susceptible to ASLR. The predictions show that salt marsh area will decline by 20% and 45% by 2100, under the A1B mean and max scenarios, respectively, as they convert to open water. Tidal fresh marsh area is unchanged (+1%) under the A1B mean scenario but is predicted to decline by 39% under the A1B max scenario. Brackish marsh, which delivers high levels of ecosystem services relative to salt marshes, is predicted to increase by 10% (mean scenario) and decrease by only 1% (max scenario) by 2100 as brackish marshes migrate inland and replace former freshwater habitats.

These differences also explain the discrepancy between the decline in marsh area and the reduction in delivery of ecosystem services as sea level rises. For example, tidal fresh marshes and brackish marshes contain more aboveground biomass, possess high rates of vertical accretion and accumulate more N in soil than salt marshes. Potential denitrification also is greater in tidal fresh marshes than in brackish marshes, and greater in brackish than salt marshes.

Thus, whereas sea level rise is predicted to lead to marsh loss in the coming century, the decline in ecosystem services is predicted to be less than forecast solely based on the change in tidal marsh area because of the high levels of ecosystem services provided by brackish marshes and tidal freshwater marshes and their ability to migrate as sea level rises. This work suggests

that an important management goal should be to protect habitat that will be occupied by these marsh types as sea level rises.

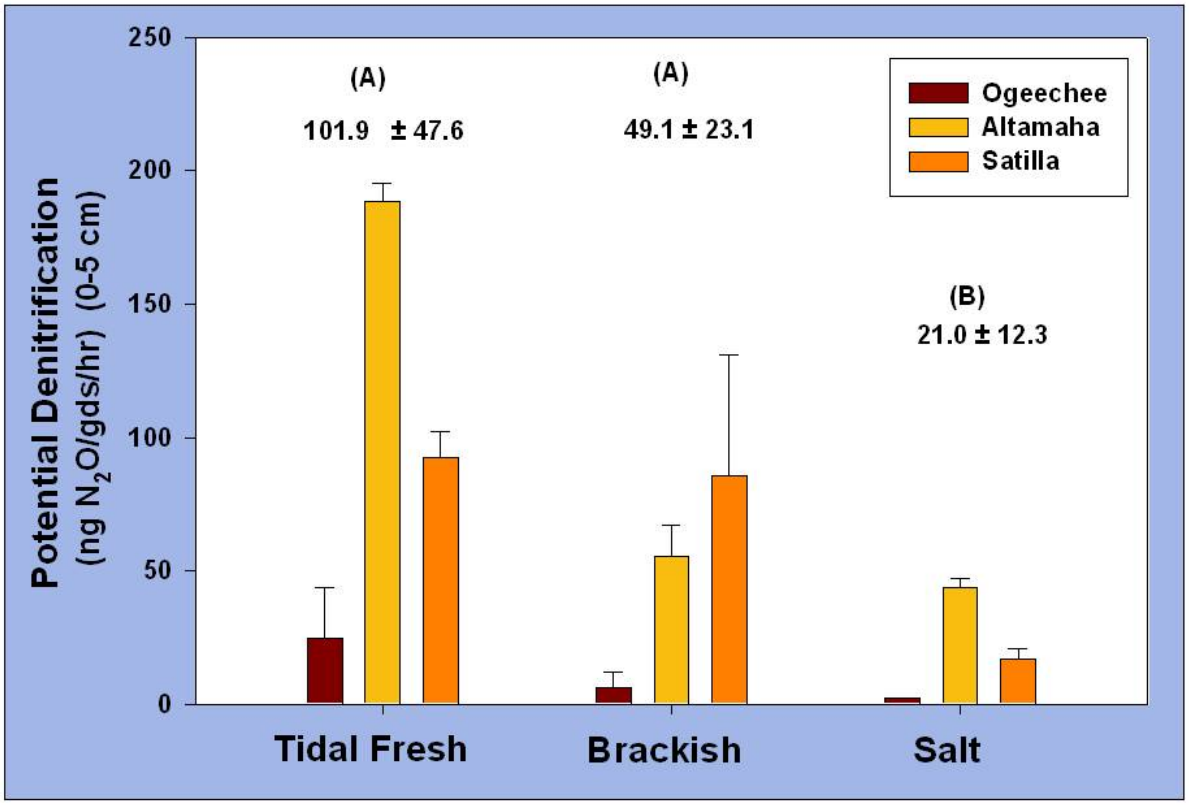

Figure 1. Potential denitrification in tidal fresh, brackish and salt marshes of the three Georgia river systems. Means were separated using ANOVA followed by the Ryan-Einot-Gabriel-Welsch Multiple Range test

a

b

Figure 2. Two species and habitats of concern in a changing climate; (a) Wood Storks (*Mycteria america*) hunkered down in the salt marsh waiting out Tropical Storm Barrie in June 2007, (b) The American alligator (*Alligator mississippiensis*) sunning on the banks of a tidal freshwater marsh in March 2005.