Climate Change and the Fate of Coastal Wetlands

Christopher Craft[1], Indiana University, Ellen Herbert, Virginia Institute of Marine Sciences, Fan Li, University of Houston, Dontrece Smith, University of Georgia, Joe Schubauer-Berigan, U.S. Environmental Protection Agency, Sarah Widney, Indiana University, Christine Angelini, University of Florida, Steve Pennings, University of Houston, Patricia Medeiros, University of Georgia, Jeb Byers, University of Georgia, and Merryl Alber, University of Georgia

INTRODUCTION

Coastal wetlands, including tidal marshes and forests, provide a number of key ecosystem services, including habitat for recreationally and commercially important finfish and shellfish, protection from wind, waves, storms and floods, and removal of excess nutrients, namely nitrogen (N) and phosphorus (P), from agricultural and urban runoff (e.g., Tiner 2013). Along the coast, climate change will be manifested as rising sea level with attendant coastal flooding and saltwater intrusion. A more immediate impact which has already been experienced is drought, particularly in late summer and fall. These processes will lead to migration of tidal wetlands inland, where possible, and changes in habitat as freshwater wetlands convert to brackish marsh or open water (Figure 1).

As part of the National Science Foundation's Georgia Coastal Ecosystems Long Term Ecological Research (GCE LTER) project, scientists from seven institutions of higher learning, including the University of Georgia, Indiana University, Virginia Institute of Marine Sciences, University of Houston, University of Florida, Georgia Southern University, College of Coastal Georgia, and the U.S. Environmental Protection Agency, initiated a field experiment - *Seawater Addition Long Term Experiment* or SALTEx - to investigate how saltwater intrusion and increased flooding will alter the direction and pace of change of microbial, plant, and animal communities and key biogeochemical processes in a tidal freshwater marsh. SALTEx consists of an array of field plots that are used to answer three main questions regarding sea level rise and saltwater intrusion:

1. How does long-term, chronic ("press") addition of diluted seawater affect tidal freshwater marsh structure and function?
2. What are the effects of periodic pulsing of diluted seawater to simulate low river flow or drought conditions?
3. What are the effects of freshwater additions?

FIGURE 1. Aerial view of deteriorating tidal marsh in southeastern Georgia.

STUDY AREA

The SALTEx site is located on the Altamaha River near Sapelo Island, Georgia (Figure 2). The Altamaha River is the third largest river on the U.S. East Coast. It is not dammed along the 200-mile (330 km) stretch from the confluence of the Ocmulgee and Oconee Rivers to the Atlantic Ocean, making it one of the most ecologically intact river systems in the East. The river and estuary contain large areas of tidal marsh and forest and extensive alluvial bottomland hardwood forest upstream. The tidal freshwater marsh plant community consists of four dominant species that are common in freshwater marshes of the southeastern U.S.: creeping primrose-willow (*Ludwigia repens*), smartweed (*Polygonum hydropiper*), pickerelweed (*Pontederia cordata*), and giant cutgrass (*Zizaniopsis miliacea*).

[1] Corresponding author: ccraft@indiana.edu

METHODS

The SALTEx experiment was initiated in 2012 and consists of 30 field plots, each 2.5 m on a side. There are three treatments (Press, Pulse, and Fresh) and two types of controls (with and without sides), each consisting of six replicates. The Press treatment plots receive regular (4 times each week) additions of a mixture of seawater and fresh river water (Figure 3a). Pulse plots receive the same mixture of seawater and river water during September and October, which is typically a time of low flow in the river when saltwater intrusion naturally occurs. The Fresh treatment plots receive regular additions of fresh river water. Treatment water is added during low tide to facilitate its infiltration into the soil, and all plots are inundated by astronomical tides at high tide.

Response measurements include (1) soil porewater chemistry and nutrient cycling, (2) plant community, (3) terrestrial and aquatic invertebrates, (4) microbial activity, and (5) soil properties and soil elevation change (Table 1). Baseline (pre-treatment) data were collected in 2013 and early 2014 and treatments were initiated in April 2014.

RESEARCH FINDINGS TO DATE

Changes in porewater chemistry and microbial activity were evident almost immediately following treatment additions. Porewater chloride and sulfate (both present in seawater) and salinity increased within the first month following Press additions (Figure 4a). Hydrogen sulfide produced by sulfate-reducing bacteria also increased (Figure 4b), while the emission of methane (CH_4), a potent greenhouse gas, declined in the Press plots within six months of the start of treatments. The plant community also was affected during the first year of treatments. Creeping primrose-willow, a succulent groundcover species, disappeared from the Press plots during the first summer and never recovered. Smartweed and pickerelweed also declined later during the first year. By the second year of treatments, even the hardy giant cutgrass was in decline in the Press plots. The reduction of plant biomass led to reduced carbon uptake by emergent vegetation, which may lead to long-term declines in soil carbon sequestration. After 18 months of Press additions, vegetation in Press plots was nearly extirpated (Figure 3b) and some Press plots had lost nearly 2 cm of soil elevation, which we attribute to a loss of roots and rhizomes accompanying the loss of aboveground biomass.

FIGURE 2. Site map of the GCE LTER (inset). SALTEx's location is indicated with the black star.

FIGURE 2. (a) Delivery of seawater-river water mixture to a plot. (b) Press plot (replicate 3) in July 2015, 15 months after treatments were initiated. Note the loss of vegetation in the plot as only some giant cutgrass remains, and all other plant species have disappeared. The four porewater wells are visible in each quarter of the plot.

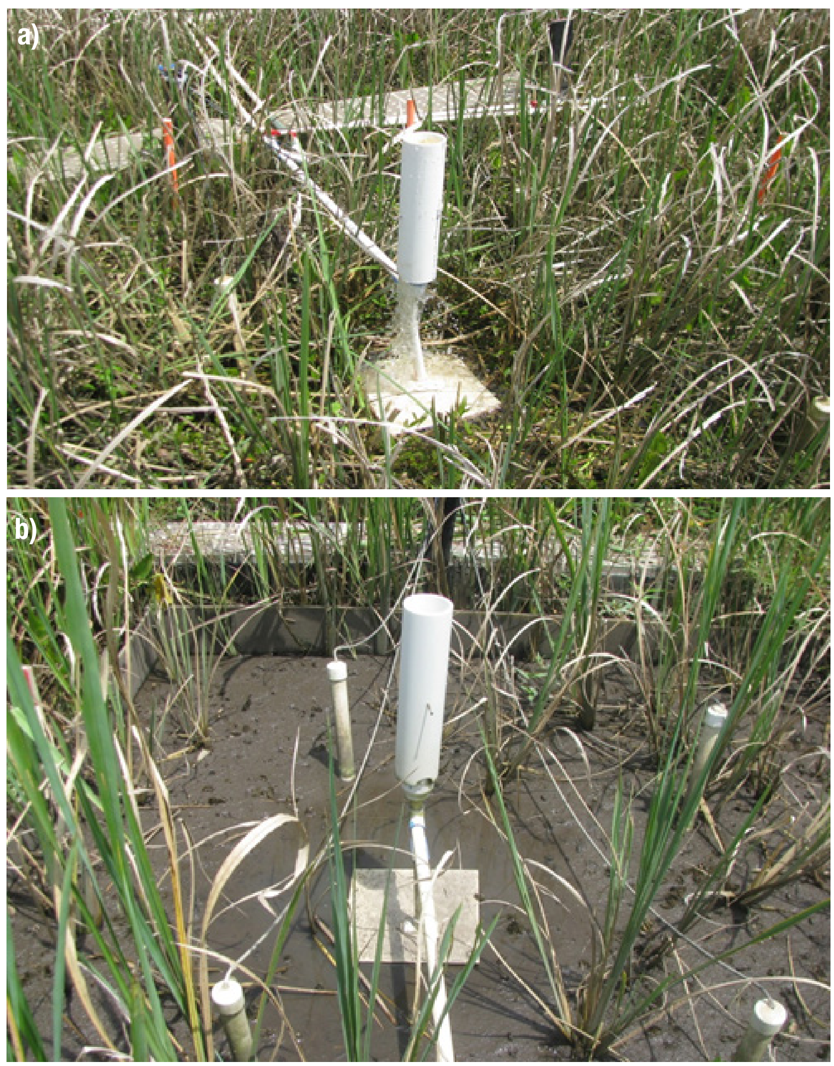
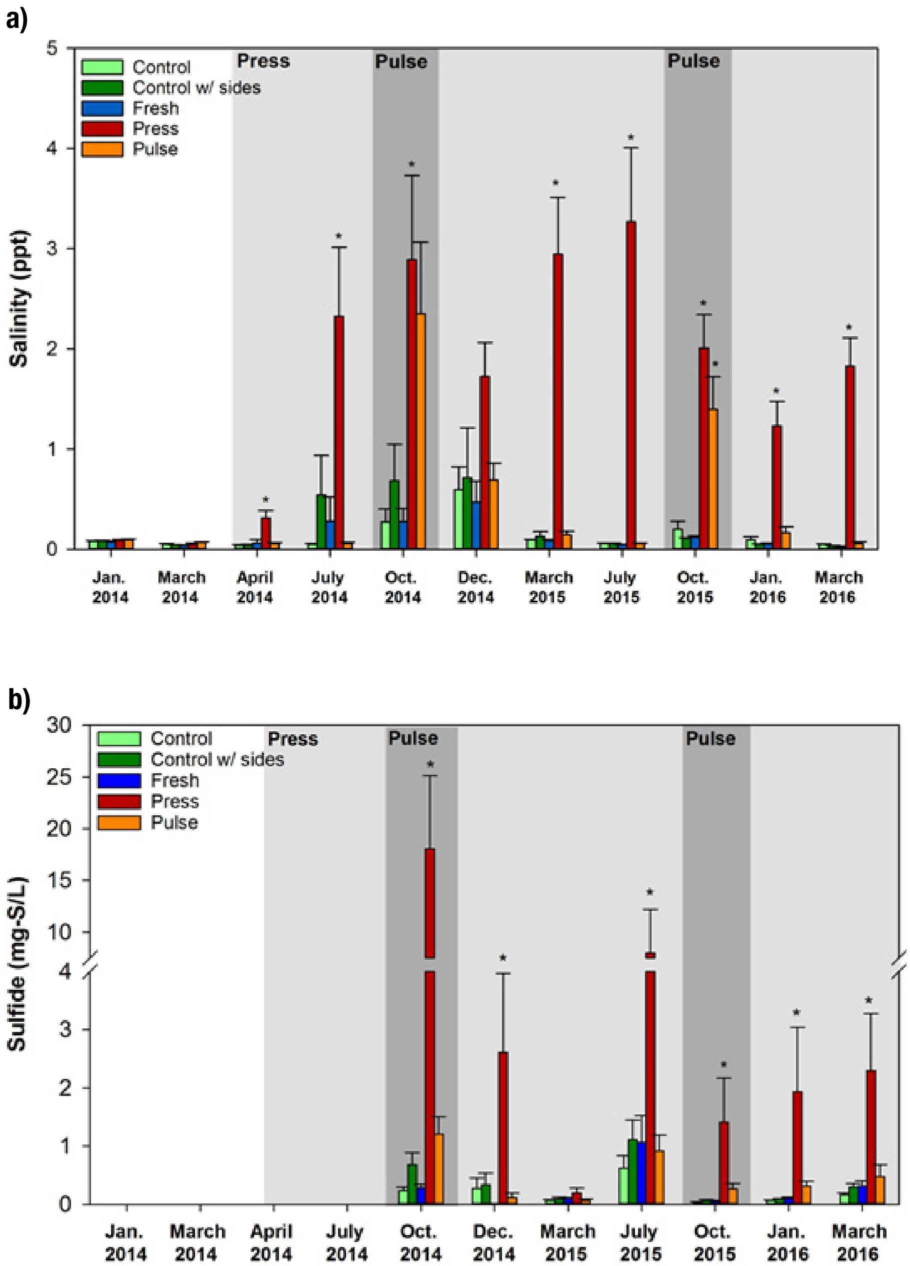


FIGURE 3. Concentrations of salinity (a) and sulfide (b) in SALTEx treatment plots pre- (January and March 2014) and post-treatment. Means with an asterisk (*) are significantly different from other treatments within the same month.



Pulse additions of diluted seawater led to transient increases in porewater salinity and sulfate that disappeared once treatments were halted (Figure 4a). Creeping primrose-willow nearly disappeared from Pulse plots after the first year, recovering only slightly in year 2. Other plant species were not affected by the Pulse addition, nor were greenhouse gas emissions affected.

WHAT IT MEANS

Our preliminary findings suggest that climate change-driven chronic saltwater intrusion will lead to rapid changes in microbial and plant communities with attendant changes in ecosystem services such as productivity, carbon sequestration, and greenhouse gas emissions. Of concern is the loss of vegetation and soil elevation within the first two years of Press addition of diluted seawater. We will continue treatments for several more years to better understand the effects of transient low flow or drought conditions and freshwater additions on tidal freshwater marshes. In addition, we plan to follow recovery of the plots when we discontinue the treatments to see if recovery follows the same trajectories in the different treatments and to see how quickly the system recovers, if at all. SALTEx is complemented by other work in the GCE LTER that examines ecosystems at the landscape scale, such as tracking vegetation productivity and community changes along the Altamaha River annually and relating these changes to salinity and other factors. We also have a long-term monitoring site at a healthy tidal freshwater forest to detect any possible saltwater intrusion in its early stages. We hope that understanding the response

TABLE 1. Measurements to assess the effects of SALTEx treatments on tidal freshwater marsh structure and function.

Porewater:	Salinity, chloride, sulfate, sulfide, dissolved organic C, inorganic and organic forms of N and P
Plant community:	Aboveground biomass, photosynthesis, leaf N and P, benthic microalgae
Animal community:	Grasshoppers, insects, crabs, snails
Microbial community:	Extracellular enzyme activity, diversity
Ecosystem:	Net ecosystem exchange, ecosystem respiration, greenhouse gases (CO_2, CH_4, N_2O)
Soils:	Bulk density, C, N, and P content, organic matter quality and composition, soil elevation, temperature

of marshes and forests to salinization will inform adaptive management strategies of coastal communities. Stay tuned.

ABOUT THE GCE LTER

The Georgia Coastal Ecosystems Long Term Ecological Research site was established in 2000 by the National Science Foundation. It encompasses three adjacent sounds, the Altamaha, Doboy, and Sapelo, that vary in freshwater input, and includes upland, intertidal, and subtidal habitat. The overarching goal of the GCE LTER is to understand how variation in source and amount of freshwater and seawater structure estuarine habitats and processes and to identify and predict changes that occur in response to natural and anthropogenic perturbations. More than 60 participants representing 14 academic institutions and agencies are involved in GCE LTER research and education programs. The field site is based at the University of Georgia Marine Institute on Sapelo Island and is administered by the University of Georgia Department of Marine Sciences. Christopher Craft is a founding member of the GCE LTER and serves on its executive committee (http://gce-lter.marsci.uga.edu/). ■

ABOUT THE INDIANA UNIVERSITY WETLANDS LABORATORY

The Wetlands Lab investigates the effects of human activities such as eutrophication, urbanization, and climate change on freshwater and estuarine wetlands and the ecosystem services they support, as well as how restoration can be employed to re-establish these services. The Lab actively supports graduate and undergraduate research, education, and service (http://www.indiana.edu/~craftlab/home.php).

REFERENCES

Tiner, R.W. 2013. Tidal Wetlands Primer: An Introduction to their Ecology, Natural History, Status, and Conservation. University of Massachusetts Press, Amherst, MA.

AIBS to Hold Communications Boot Camp

The need for effective and influential communication about science never been more important than it is today. Politicians and political interests are redefining and reinterpreting science—with great persistence and impact. While the majority of the public still respect scientists and value science, they often find it challenging to discern who and what is legitimate. The American Institute of Biological Sciences (AIBS) is responding to this need by offering scientists a new professional development opportunity. The AIBS Communications Training Boot Camp for Scientists expands on our highly successful media and science policy training workshops. The program meets the needs of everyone from graduate students to senior researchers and program administrators.

AIBS is the scientific organization that promotes the use of science to inform decision-making that advances biology for the benefit of science and society. The organization has a long and successful track record of engaging, informing, and influencing the public and science policy decision-makers. Our audiences include members of Congress, federal agency heads and program managers, state officials, and university administrators. In addition to working directly with these groups, we routinely engage the public through traditional and new media.

Our staff members have used their decades of science policy and communications experience to develop training materials and resources that provide scientists with the skills needed to successfully communicate about their research with decision-makers and reporters. To date, AIBS has trained more than 1,000 scientists.

AIBS is sponsoring a Communications Boot Camp, an intensive, two-day, hands-on training program in Washington, DC (December 7–8, 2016). Participants will learn:

- How to translate scientific findings for non-technical audiences
- How to tell a resonant story that informs decision-makers
- How to prepare for and participate in a news interview, including broadcast interviews
- How to prepare for and engage in a meeting with a decision-maker
- How to protect your scientific reputation
- How to identify and define the audience you need to reach
- What policymakers want and need to know from a scientist
- What reporters are looking for in an interview
- How the nation's science policy is developed and implemented

Participants will have the opportunity for formal and informal discussions with science policy and communications experts working in Washington, DC. Go online for more information about the Boot Camp including costs and a course outline: https://www.aibs.org/public-policy/communications_boot_camp.html?utm_source=AIBS+Master+List&utm_campaign=69e633d3fa-Bootcamp_Campaign8_4_2016&utm_medium=email&utm_term=0_def270e561-69e633d3fa-171091754. ■