How Will Tidal Freshwater Forested Wetlands Respond to Sea Level Rise?

Brooke V. James[1], Carl C. Trettin[2], Timothy J. Callahan[1], Thomas Williams[3], Bo Song[3]

1- Environmental Studies Graduate Program, College of Charleston, South Carolina
2- Center for Forested Wetlands Research, US Forest Service, Cordesville, SC
3- Belle Baruch Institute of Coastal Ecology and Forest Science, Clemson University, Georgetown, SC

COLLEGE of CHARLESTON
MASTER OF ENVIRONMENTAL STUDIES PROGRAM

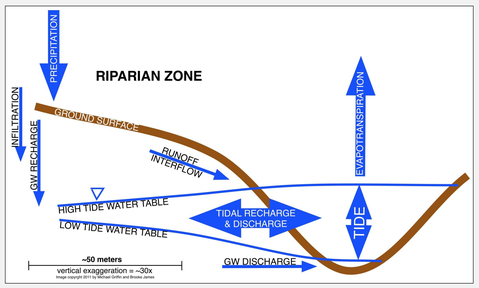
Introduction

- Tidal Freshwater Forested Wetlands (TFFW) are functionally unique, riparian zones, that act as a transition zone between estuaries and upland terrestrial ecosystems; they offer valuable ecosystem services to surrounding and downstream communities.
- Sea level rise will expand the reach and area of freshwater tidal streams hence the area of TFFW, and likely changing the functionality of existing TFFWs.
- Most research concerning TFFW and sea level rise is focused on potential changes in salinity and concomitant ecosystem response. However, the lower coastal plain of South Carolina contains large areas of freshwater tidal influence beyond the projected extent of changes in salinity.
- There is considerable uncertainty how bottomlands will respond to a persistent freshwater tide.

Background

Tidal Freshwater Forested Wetlands

- TFFW are found in the lower coastal plain along the Atlantic and Gulf Coasts.
- The National Wetland Inventory (1991) estimated that tidal freshwater forests occupy over 200,000 hectares (ha) of land area in the southeastern United States.
- The extent of TFFWs in the South Carolina coastal plain has not been determined, but estimated to exceed 40,000 ha.



Hydrologic Cycle of a Tidal Freshwater Forested Wetland
Change in stream stage height and corresponding water elevation from incoming and outgoing tide has the greatest hydrologic effect on the riparian zone. Incoming tide causes water table mounding and tidal recharge through the stream bank.

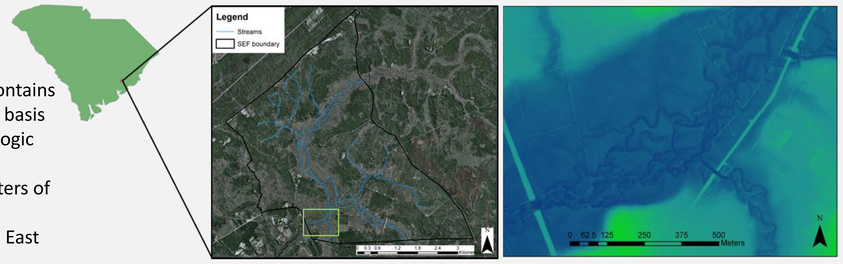
Objectives

- Determining how a freshwater tidal stream is connected to the riparian zone as a basis for assessing potential effects of sea level rise.
- Quantify differences in water table dynamics, vegetation communities, and biogeochemical functions of tidally-influenced and non-tidal wetland riparian zones.

Methods

Location:

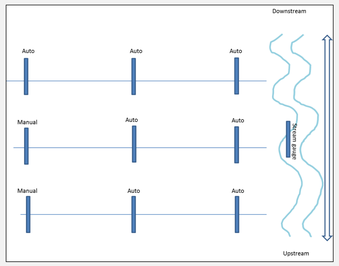
- The Santee Experimental Forest contains gauged watersheds that provide a basis for assessing the long-term hydrologic functions of bottomlands. These watersheds comprise the headwaters of Huger Creek.
- Huger Creek is a headwater to the East Branch of the Cooper River which discharges into the Charleston Harbor estuary.
- The wetland forest is typical of Atlantic coastal plain types, with mixed pine and hardwood flat woods, bottomland hardwoods, and deep swamp species in the stream bottoms.



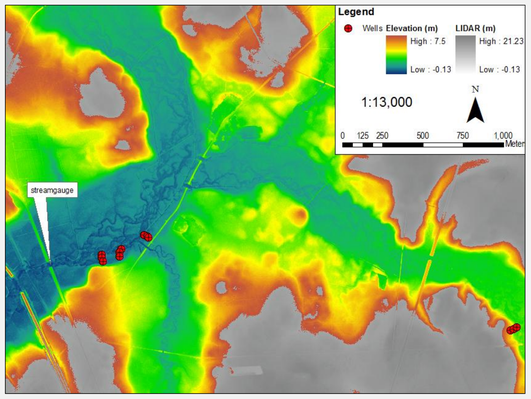
Location map of Santee Experimental Forest in the Francis Marion National Forest showing 7.5 minute topographic streams. Green box represents focused study area of Huger Creek floodplain; shown by LIDAR imagery on right.

Approach:

- Comparison of tidally-influenced and non-tidal riparian zones within a single drainage system (Huger Creek).
- A network of surface water, groundwater, and soil moisture monitoring stations, installed in transects that reflect a decreasing tidal gradient within the riparian zone.



Conceptual drawing of groundwater monitoring transects.



Overview map of bare earth LIDAR imagery showing Hwy 402 bridge streamgauge and groundwater monitoring transect locations.

Riparian zone study plot

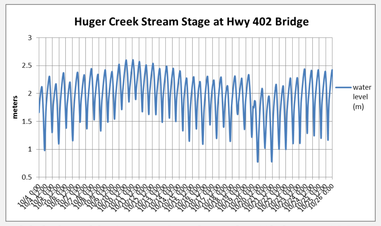
Huger Creek stream channel

Huger Creek streamgauge

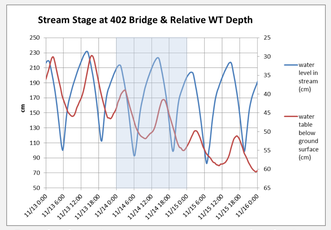
Low tide in the forest

High tide in the forest

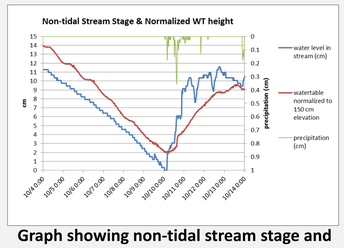
Preliminary Results



Tidal signal in Huger Creek at the Highway 402 Bridge. Tide stage is plotted over time at fifteen minute intervals for an 11 day period. Time period covers 1st quarter moon phase to new moon in October. This streamgauge site location at Huger Creek is approximately 30 km inland from the coast.



Graph showing stream stage and relative water table height in response to incoming and outgoing tide. Groundwater monitoring well is located 300 meters upstream from bridge, and is measured as cm below ground surface. In this graph, water table elevation has an amplitude between 4.5 and 16.5 cm as it responds to the daily tide signal.



Graph showing non-tidal stream stage and water table height normalized to a 150 cm elevation. Secondary x-axis represents hourly precipitation in cm. Graph depicts corresponding drop in water table elevation as stream channel dries out. Note that precipitation restores flow and causes a steep rise in water table.

Summary To-Date

Tidal extent of Huger Creek and Water Table Amplitude:

Bridge:
Tidal Range: 5.16 feet
Average Stage: 6.16 feet
Max: 8.67 feet
Min: 2.51 feet

Forest site:
Tidal Range: 2.60 feet
Average Stage: 3.18 feet
Max: 5.39 feet
Min: 0.19 feet

Water Table:
0.9-1.64 feet

- Our preliminary results and observations of tidal signal in groundwater wells indicate there should be functional linkages between the freshwater tidal stream and the riparian zone.
- This data is particularly valuable for Charleston, South Carolina, as the long term eustatic sea level rate due to sedimentary basin subsidence of the coastal plain is 3.2 mm/year, a is rate among the highest on the east coast.
- The Intergovernmental Panel on Climate Change reported that due to climate change factors, sea level will increase 30 to 100 cm over the next 100 years.
- Results from this study will provide new data and insight into how ecological functions and ecosystem services will be altered from a persistent freshwater tide as sea level rises.

Literature Cited

Day RH, William TM, Swarzenski. Chapter 2 – Hydrology of tidal freshwater forested wetlands of the southeastern United States. In: Conner WH, Doyle TW, Krauss KW, editors. Ecology of tidal freshwater forested wetlands of the southeastern United States. Dordrecht, The Netherlands: Springer; 2007. p 321-348.

Doyle TW, Krauss KW, Conner WH, From AS. 2010. Predicting the retreat and migration of tidal forests along the northern Gulf of Mexico under sea-level rise. Forest Ecology and Management; SI. 259(4):770-777.

Ozalp M, Conner WH, Lockaby BG. 2007. Above ground productivity and litter decomposition in a tidal freshwater forested wetland on Bull Island, SC, USA. Forest Ecology and Management 2007; 245:31-34.

Seybold CA, Mersie W, Huang J, McNamee C. 2002. Soil, redox, pH, temperature, and water-table patterns of a freshwater tidal wetland. Wetlands. 22(1):149-158.

Acknowledgements

Support for this work is being provided by the US Forest Service, Southern Research Station, and the College of Charleston Master of Environmental Studies Program. Michael Griffin provided helpful comments in developing the poster.