# Monitoring Water Quality Changes in a Forested Freshwater Wetland Threatened By Salinity

Jayakaran A.D.[1], T.M. Williams[2], W.H. Conner[3], D.R. Hitchcock[1], B. Song[1], A.T. Chow[4], E.M. Smith[5]

AUTHORS: [1] Assoc. Professor, Clemson University, Georgetown, SC 29440, USA. [2]Emeritus Professor, Clemson University, Georgetown, SC 29440, USA. [3]Professor, Clemson University, Georgetown, SC 29440, USA. [4]Assistant Professor, Clemson University, Georgetown, SC 29442, USA. [5]Research Coordinator, North Inlet-Winyah Bay National Estuarine Research Reserve System, Georgetown, SC 29440, USA.

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**ABSTRACT**. Coastal forested wetland swamps are sentinel sites for salinity intrusions associated with large tidally-influenced or storm-driven incursions of estuarine waters that may also indicate rising sea levels associated with climate change. A coastal freshwater forested wetland in coastal South Carolina has experienced dieback of freshwater forested wetland trees due to increased salinity within the wetland. Vegetation in the wetland is transitioning from a closed canopy of common freshwater wetland trees such as bald cypress, water tupelo and swamp tupelo, to a more open canopy due to the establishment of salt tolerant grasses. The swamp is prime habitat for several wildlife species as evidenced by game cameras and amphibian recorders installed within the swamp. A team of researchers at the Baruch Institute examined a series of historical aerial images to track changes in vegetation through the years. In June 2013, several water level and conductivity sensors were installed along the salinity gradient to measure temporal variations in water level and salinity within the swamp. Microclimatic conditions were also measured and water flux at the tidally influenced watershed outlet logged. The data reveal that there is a pronounced salinity gradient from the upper reaches of the swamp to its lowest tidally influenced section. Upper reaches of the swamp are influenced primarily by incident rainfall within the watershed, while at the outlet there appears to be a complex dynamic driven by tides, local rainfall, and estuarine backwater effects.

## INTRODUCTION

Tidal swamps are periodically influenced by salinity. Tidal freshwater wetlands in general are defined as occurring at salinities below 0.5 PSU (Odum et al., 1984; Simpson et al., 1983), but during periods of drought, storm surge, or even strong tides, they must periodically cope with salinity commensurate with landscape position (Baldwin, 2007; Doyle et al., 2007). Many environmental and biological factors influence the structure and dynamics of these forests but hydrology is one of the most important driving forces in determining forest structure (Streng et al., 1989; Jones et al., 1995; Hall and Harcombe, 1998) and productivity (Conner and Day, 1982; Anderson and Mitsch, 2008). It is well-documented that changes in hydrologic patterns (Conner and Day, 1976; Johnson and Bell, 1976; Schlesinger, 1978; Mitsch et al., 1979; Brinson et al., 1980; Brown, 1981; Conner et al., 1981; Brown and Peterson, 1983; Shure and Gottschalk, 1985; Megonigal et al., 1997; Yin, 1998) can impact existing forests. In addition, coastal ecosystems along the south Atlantic are currently undergoing forest dieback and decline from increasing tidal inundation, saltwater intrusion, and altered freshwater flow attributed to global climate change process and variability (Conner et al., 2007b).

Despite their key position in the coastal landscape, scientific inquiry into tidal swamps is lacking, and our understanding of ecological processes specific to these wetlands is not well developed (Conner et al., 2007a). Sensitivity to climate change is a key attribute of tidal swamps warranting their continued study and value as a model, sentinel system for how coastal habitats transition not only in the Southeast, but also throughout the world.

An important transition occurs as mean annual salinity levels increase to 2 PSU, at which point many tidal swamps are at advanced stages of degradation to tidal marsh (Hackney et al., 2007). During these transitory stages, salt tolerance of both woody and herbaceous plants may replace flood tolerance in controlling plant community composition and growth (see review by Krauss et al., 2007). Climate change, hence, has the effect of driving tidal swamp stands to monoculture of baldcypress (*Taxodium distichum*) as a stage of degradation associated with saltwater intrusion (Brinson et al., 1985; Williams et al., 1999; Conner et al., 2007b), a phenomenon that has become increasingly apparent (Williams et al., 2012) in a swamp located on Hobcaw Barony called Strawberry Swamp.

## PROJECT DESCRIPTION

The area of study is a forested coastal wetland that is located on Hobcaw Barony, in Georgetown County, SC (Figure 1) called Strawberry Swamp. The swamp is 236 hectares in area and only 1400 meters in length, dropping 6 m from its catchment ridge to its tidally influenced outflow into a tidal creek – the tidal creek in turn discharges into the Winyah Bay estuary. Forests on the Strawberry Swamp tract range from very dry upland sites to a permanently flooded swamp at its lowest reaches. The swamp has experienced considerable die-back of baldcypress trees, a phenomenon that was documented by Williams et al. (2012) by examining several decades worth of historical aerial imagery of the swamp.

## METHODS

In order to quantify salinity incursions and their juxtaposition between tidally influenced flows at the outlet, and precipitation driven flows that emanate from the upstream reaches of Strawberry Swamp, several conductivity temperature depth (CTD) sensors were deployed in the swamp (Figure 2) in June 2013. In addition to sensors deployed within the swamp, a weather station, a soil moisture sensor array, and a ground water well were installed at strategic locations to discern rainfall runoff processes that contribute freshwater input to the swamp. At the tidally influenced outlet, a bidirectional flow sensor was installed to quantify water and conductivity fluxes entering and leaving the swamp. Lastly, a CTD sensor was installed in the tidal creek that serves as the conduit between Winyah Bay and the swamp. Given the short term nature of the data record in Strawberry Swamp and the multi-decadal nature of the baldcypress die-back (Williams et al., 2012), we are also augmenting our database by including data from a National Estuarine Research Reserve System (NERRS) long-term monitoring water quality station that has recorded salinity in Winyah Bay from 1995 (Figure 1).

## RESULTS

Preliminary results suggest a considerable salinity gradient along the swamp from upland to outlet. The salinity readings are in concert with the baldcypress die-back that has been recorded within three distinct zones of stress imposed by the salinity. In the healthy zone (Figure 3), salinity values ranged from 0.5 to 1 PSU, while in the medium stressed zone, salinity ranged from 2 to 4 PSU (Figure 4). In the zone characterized by baldcypress trees that showed the most stress (also the zone that precedes total baldcypress mortality), the range of salinity readings were 5 to 7 PSU (Figure 5). Salinity at the swamp outlet just before it discharges into a tidal creek was much more variable ranging from 0.3 to 15.6 PSU and an average value of 8.5 ± 0.02 PSU (Figure 6).

## DISCUSSION

There is considerable temporal variability in one year's worth of salinity data that appears to be driven by a complex interaction between rainfall and the hydrodynamic forces that prevail in Winyah Bay. With documented sea-level rise at nearby locations (e.g. Charleston, SC), there is potential for even longer term climatic influences on salinity incursions to the swamp. Further analysis of data is necessary to determine specific drivers of salinity variability within Strawberry Swamp and its connection to the downstream tidal creek system. There is also a need to characterize how conditions in the tidal creek relate to conditions in Winyah Bay.

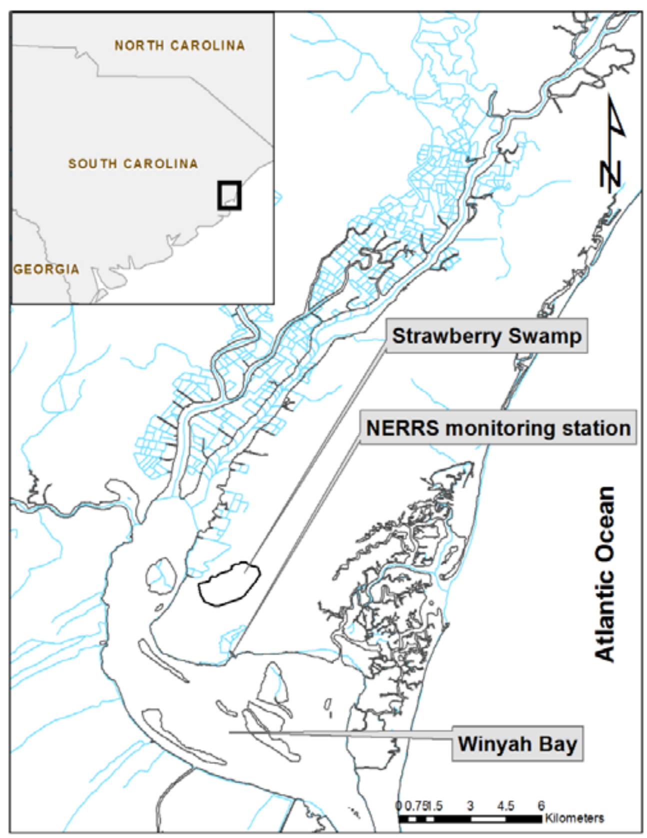


Figure 1: Location map of Strawberry Swamp.

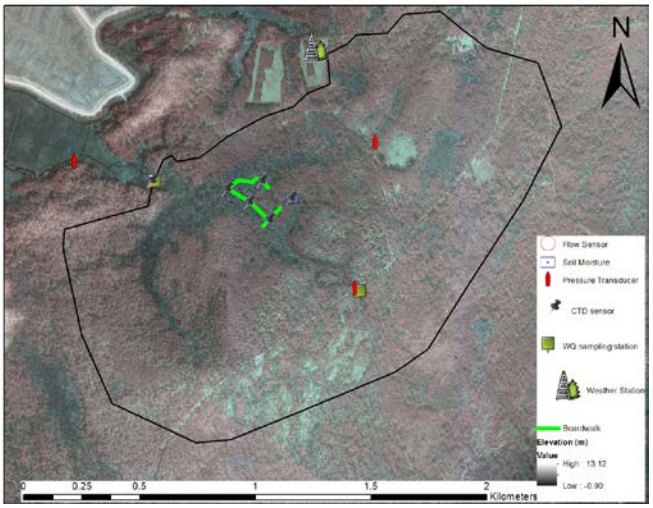


Figure 2: Environmental sensor network in Strawberry Swamp.

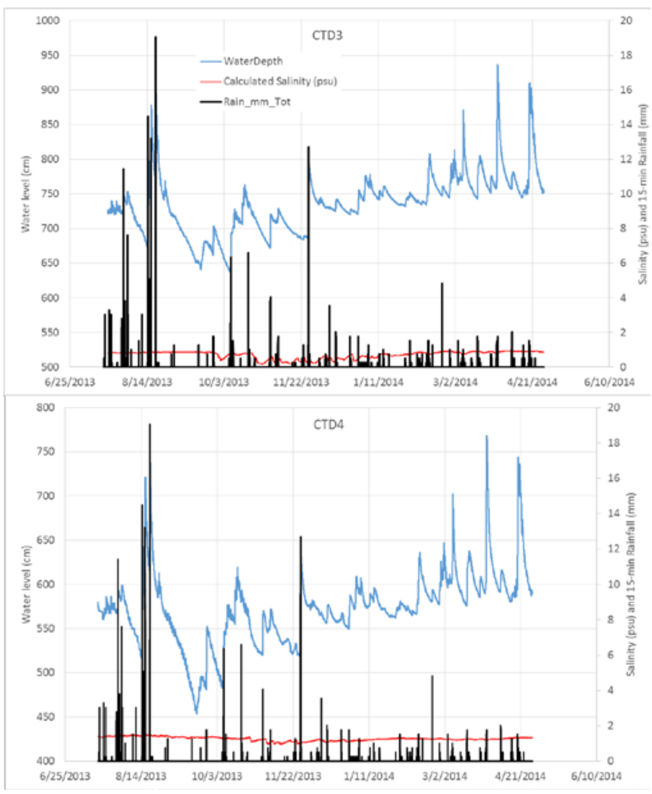


Figure 3: Rainfall, water level, and salinity at two sites in the "healthy" zone of Strawberry Swamp.

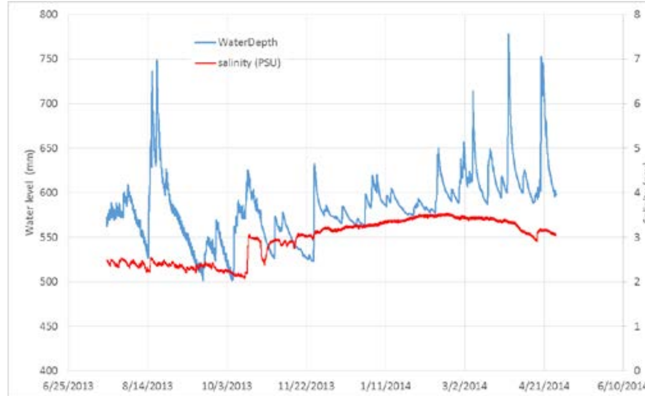


Figure 4: Water level, and salinity in the "medium-stressed" zone in Strawberry Swamp.

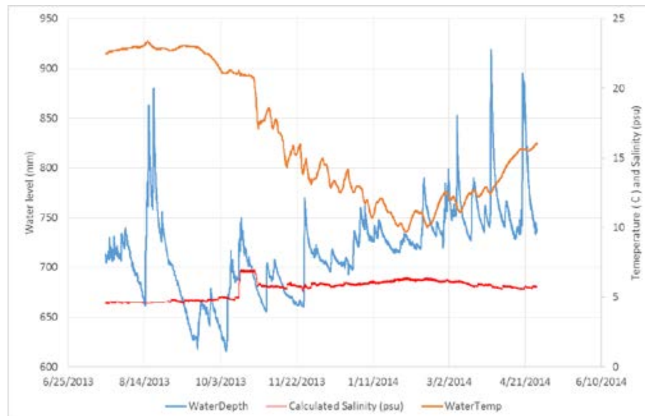


Figure 5: Water level, temperature, and salinity in the "stressed" zone in Strawberry Swamp.

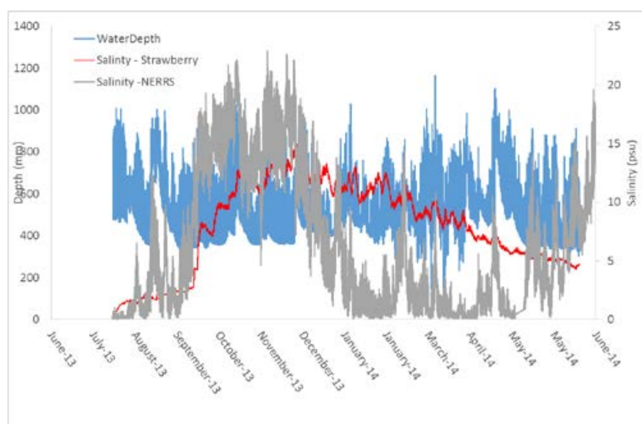


Figure 6: Water level and salinity at the outlet of Strawberry Swamp.

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