Submergence or Survival? The Role of *Phragmites australis* and *Spartina alterniflora* in the Survival of Tidal Marshes

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Introduction

Tidal marshes provide vital habitat areas, protection areas from storms, flood water mitigation zones, and increased water quality [1]. These dynamics systems are at the forefront of change with pressures deriving from coastal development and natural processes [2]. A report, by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research, informs that tidal wetlands in the Mid-Atlantic region become stressed under 5mm-6.35mm/year Relative Sea Level Rise (RSLR) [3]. The 20-year average rate of local RSLR is predicted to be between 7.6 to 12.7 mm/year under a high emission scenario and 5.08 to 10.2mm /year under in a low emission scenario [4]. A loss of these tidal ecosystems may increase the risk from storm surge, and thus reduce wildlife habitat areas, reduce storm water mitigation areas, increase flooding, create new flood zones, and increase damage to homes.

Understanding tidal marsh gain and loss along the Raritan River, NJ ,while investigating the role of two marsh species (*Spartina alterniflora*, *Phragmites australis)* to the marsh accretion process, will provide local insight for keeping up with SLR as well as contribute to the highly-debated topic of vegetation contribution to marsh accretion [5]. While there are vegetation and accretion data and research to suggest predictions for gains and losses of tidal marshes in the uppermost Delaware Bay and the Barnegat Bay, there are no published datasets along the Raritan River to understand local wetlands' capacity to keep up with SLR and to predict what the Raritan River will look like in the future. The historic and rapid urbanization of the Raritan River Watershed and presence of historic and urban wetlands provide an opportunity to explore the interactions and effects that urbanization, invasion, and sea level rise (SLR) have on tidal marsh vegetation, accretion, and survival, and, in turn, the effects it will have on marsh ecosystem function and local planning.

SLR alters physical and biological components of tidal wetlands, calling for a two-way coupling comparison of biotic and abiotic processes to more accurately predict changes to these systems [6, 7]. The vulnerability of tidal wetlands to RSLR is studied though a comparison between the rate of RSLR and vertical accretion rates, with a majority of studies being modeling exercises, greenhouse exercises, and mesocosm studies, which are limited in scale [8]. These exercises provide a foundational understanding of ecogeomorphic feedbacks that can be replicated under controlled settings. Many modeling studies assume that these coastal systems are static, and do not include feedback mechanisms between hydrodynamic and ecological systems, and do not include the role of nonlinear feedbacks for changes in micro topography [9, 10]. Models that include nonlinear feedbacks have suggested that under certain conditions tidal wetlands can avoid submergence from SLR [8, 11]. Modeled studies identify contributions by vegetation in salt marshes in the sediment accretion process in maintaining elevation and keeping up with SLR [7] but do not take vegetation type, density, or biomass into account. Including these variables will provide more detailed information about a marsh's ability to keep up with SLR.

Understanding the role of vegetation in the process of sedimentation, namely vertical accretion, is vital to understanding the effects of SLR on the survival of tidal wetlands [12, 13]. Marsh vegetation density, abundance, aboveground and belowground biomass, and morphology aid in the accretion process by slowing down the flow of water, which allows for suspended sediment to settle on the marsh and by creating roots [14, 15]. The combination of vegetation growth, hydrodynamics, and soil accretion creates strong positive feedback that drives wetland formation [16]. This feedback becomes more important in marsh stability as you move from the elevated landward part to the lower seaward edge of the marsh, which represents a gradient in inundation stress imposed by tidal seawater, temporal periods of inundation, and elevation change [17]. Understanding the interactions - of the sedimentation process within the interior and the edge of tidal marshes to account for accretion, sediment loss, and patterns of sediment deposit – would provide a more complete account of marsh gain and loss (Figure 1). If tidal wetlands are to survive faster rates of SLR, then they will have to depend on sediment availability, biotic responses to environmental change, and available space for wetlands to migrate inland [18]. The data collected through the proposed experimental and monitoring processes will increase the effectiveness of mechanistic models of SLR affecting marshes by accounting for the difference in vegetation composition and biogeological feedback loops associated with tidal wetlands.

Research Questions

My research aims to answer the following questions: ***Q1***-What is the current accretion rate of tidal wetlands in the Raritan River? **Baseline Collection/ No Hypothesis.** ***Q2***-Do accretion rates differ by vegetation species type and density? ***H2-*** Null: There will be no difference between the accretion rates of sites, regardless of vegetation type, density, and biomass. Alternative: Accretion rates will differ both by vegetation species, density, and SLR depth scenario. ***Q3***-What is the probable accretion rate of tidal marshes under current and predicted Sea Level Rise? ***H3***- Null: Accretion rates will be similar under current conditions and SLR scenarios. Alternative: Accretion rates will be higher in tidal marshes that are flooded more often and for longer periods of time.

Methods

Five (5) tidal marshes along the Raritan River have been identified and selected as research sites to set up experimental passive weirs [19], conduct vegetation assessment, establish sediment markers, and install water level and conductivity loggers. Sites were selected according to accessibility (Publicly owned or permitted by landowners) and with vegetation of interest: *S alterniflora* and *P. australis. These species* have been selected for this experiment since they are the most abundant species in tidal marshes on the Raritan River. Vegetation assessment will include surveying the species of plants within the drainage area of the passive weir and around the weir (Figure). Passive weirs will be used to influence tide time by increasing water level and increasing inundation duration within weir drainage areas. At each tidal marsh site there will be two weirs installed, treatment 1 (Tide height 1), treatment 2 (Tide height 2), and an adjacent control. Tide height 1 (1.4ft) and 2 (2 ft) are derived from Kopp et al.'s report for the projected SLR in NJ in 2050 [4]. 1.4ft is selected as height 1 since it is the central estimate for SLR in 2050, meaning there is the 50% probablity that SLR will meet or exceed this projection and 2ft is selected as height 2 since it is the less likely estimate for SLR in 2050 (5% probablity) but a likely range by 2100. Within each weir there will be a level logger recording water height over time. There will be an additional level logger above ground to correct for barometric pressure and increase the accuracy of water level readings. At each marsh, there will be one conductivity logger to record the salinity of the tides inundating the marsh. Feldspar will be placed 4 randomly selected points within the weir drainage area to measure short-term marsh accretion rates. These measurements will be recorded quarterly over the span of two years.

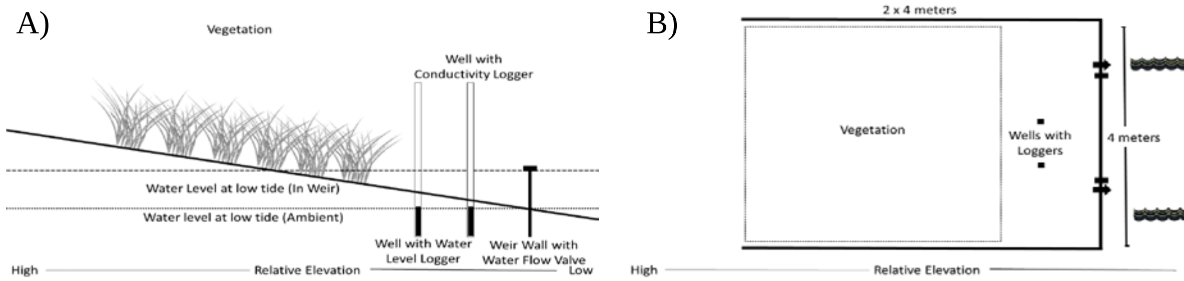

Figure 1. Proposed weir installation and design. A) Section view that shows flooding of vegetation at ambient and weir conditions. Water level and conductivity recorded are proposed within the weirs to capture maximum flooding effects on vegetation. B) Plan perspective shows proposed weir size, design, and valve locations for drainage.

Experimental passive weirs are designed to mimic aspects of SLR by increasing inundation depth at low tide as well as increasing inundation times and slowing drainage rates during ebb tides. The weirs will slow water drainage and hold more water for longer during ebb tides, resulting in greater Mean Low Water (MLW) levels with no effect on Mean High Water (MHW) and achieving water levels under projected SLR. Passive weirs are constructed with three walls (open on the upslope end), including one front wall parallel to shore and two sidewalls perpendicular to shore. Valves in the front wall permit filling during flood tides at a rate similar to ambient conditions, but slow the rate of drainage during ebb tides, thereby enhancing both inundation depth and time. The effects of this manipulation should be observed throughout the weir drainage areas, but the extent of inundation will vary based on differences in surface elevation within the weir footprint (i.e. higher elevations flooded to a lesser extent and for less time) and can be manipulated by adjusting wall heights and drainage valve position relative to the soil surface [19].

Vegetation cover and species density will be calculated at the time of weir instillation. Vegetation cover will be calculated through two methods, foliar cover and canopy cover. Foliar cover measures the vertical projection of exposed leaf areas and canopy cover measures the areas covered by the plant. These surveys will measure vegetation within the weir drainage basin and surrounding the weir at a radius of 10 meters. Within the 10 meters there will be two types of measures taken: vegetation data and environmental factors. The use of surrounding vegetation and environmental factors provide an additional classification and may provide information about the influence of the surrounding vegetation on results. After two years the vegetation within the weirs will be harvested to calculate biomass under control and treatment conditions.

Salinity data will be collected by conductivity loggers and will be used to observe and account for changes in salinity throughout the duration of the experimental process. This information will be used to determine the potential effects of increased inundation time of water at different salinity concentrations. It is expected that sites and weirs further from the Raritan Bay will have lower concentrations of salinity and the loggers will quantify these differences. Marsh accretion will be measured by placing feldspar and a sediment plate following the installation of each weir. Feldspar will serve as a reference layer within the soil, which will measure the accumulation of mineral and organic sediment [20, 21]. Measurements will be taken by revisiting sites and using a corer to sample the four randomly selected locations and measuring the distance from the marker to the current marsh surface. This process will also be done for the sediment plate on the same dates. Sediment plates serve as a fixed point within the weir to measure accretion, to last longer than horizon markers, and to serve as another measure for short term accretion [22, 23]. Both processes are selected because of the time resolution provided by the method, which range from months to years, and because of the high precision of data that is collected [24].

Timeline
Selection of marshes occurred in the summer/fall of 2017 and the installation of weirs is set to begin in late March 2018. Following a settling period of two weeks, data will be collected across all project marshes. Data will be analyzed and prepared for publication upon the completion of the second field season (September 2019) and marsh modeling will commence thereafter (November 2019).

How the study benefits coastal wetlands

Research will provide a deeper understanding of short-term accretion in tidal marshes along the Mid-Atlantic and will provide end user materials and information for coastal managers, flood plain managers, planners, and public officials. The outcome of this research will present an example of coupling biotic and abiotic factors into projecting marsh gain and loss, identify areas for conservation and restoration efforts, and provide recommendations for future coastal planning.

Budget

Funds provided by the GCA Scholarship for Coastal Wetlands will be used for the following: ONSET HOBO Water Level Data Logger (8 units at $299) and ONSET HOBO Conductivity Logger (4 units at $750). Sum of materials is $5,392. The amount of support requested is $5,000. Other attained funds will be used to complete total cost of materials and additional costs.

Plans or opportunities for sharing research results with a larger audience

As part of my research I work with various local townships, nonprofits, and community groups to communicate my research to the public, present at local schools, and public meetings. I plan on sharing my research findings and experiences through in-class projects at local schools, partnering with Rutgers Film Lab to work on a mini-documentary about SLR and its impact on tidal marshes that can be shared with all partners, and by presenting at meetings for non-profit and public partners. All outreach and education events will include topics such as climate change, sea-level rise, and coastal ecology. All material, media, talks, and published material will mention Garden Club of America Coastal Wetlands Scholarship for their support.

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