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Sea Level Rise in Back Bay Wildlife Refuge: Barrier Island Impacts and Responses

1. Introduction

The United States Fish and Wildlife service currently has over 560 national wildlife refuges (NWR) and is responsible for managing upwards of 850 million acres of land throughout the country with at least one refuge in each state (USFWS, 2016). In Virginia, the Service manages 14 different refuges with three directly in the Hampton Roads region of Southeast Virginia: Back Bay NWR, Great Dismal Swamp NWR, and Nansemond NWR. Back Bay NWR with over 9,250 acres is the second largest behind the Great Dismal Swamp with 112,000 acres. Back Bay NWR was first established June 6, 1938 in effort to preserve and protect the land from urban expansion in Virginia Beach as it is a critical part of the Atlantic Flyway for migratory birds to feed and rest. The refuge contains several habitats including beach, dunes, woodlands, fields, and emerging wetlands which all provide important ecosystem services for local flora and fauna (USFWS, 2016). In terms of fauna, the refuge gives sanctuary to thousands of migrating geese, ducks, and swans every fall and winter season. Additionally, essential habitat is provided for many threatened, endangered and recovering species such as the Loggerhead Sea Turtle, the Piping Plover, Brown Pelican and Bald Eagle. The refuge, through vital partnerships, has been able to maintain and recover much of these habitats and protect them from chemical/fertilizer run off, pollution, and destruction by encroaching development. At this point in time, the refuge is charged with both meeting the goals attributed to the land and species within while also providing public educational and recreational opportunities.

Included in the refuge is a thin strip of barrier island along the Atlantic preventing Back Bay from being inundated with saltwater and creating a brackish zone which could harm the inhabitants. In the past, the barrier island has been breached as a result of major storms eroding the dunes through storm surges. These breaches allow for salt water intrusion into the bay and can lead to an alteration in salinity in the bay itself as well as the water table surrounding it. With Back Bay being a freshwater ecosystem, its inhabitants are naturally vulnerable to changes in salinity - however, the extent of vulnerability is specific to each species. Going into the future, an important part of conserving and protecting Back Bay NWR will be to understand the effects that current global changes will have on the morphology of the refuge. In particular, the impacts that sea level rise and storm intensification will have on the ecosystems must be studied in the area to understand where and under what circumstances ocean water might breach the barrier island, the severity of the potential breach, and what actions must be taken to help prevent or manage such an event should it happen. Given the uncertainty of the many changes occurring climatically and

hydrologically, proper foresight must be used to actively prepare and plan for the effects they might have on the refuge.

2. Sea Level Rise Related Hazards to Coastal Morphology

The Back Bay Refuge system is under direct threat of sea level rise on the bay side as the the majority of its emerging wetland ecosystems are on low lying islands. The barrier island dunes for the moment provide a vital barricade against the ocean with its dunes rising several meters above the water. Some areas of the barrier island are seen to be of lower elevation than others, leaving them more susceptible to overwash and ocean water inundation. Local sea level change in the Mid-Atlantic region of the East coast has been happening faster than other areas and is likely due to land subsidence (Paris et Al., 2015). When the morphology of the barrier island is considered, it can be seen that undeveloped barrier islands will naturally migrate as water levels rise. However, under current rates and future sea level rise projections of at least a 2 mm per year acceleration, Back Bay Wildlife Refuge has been identified as an area that should expect increases in overwash, erosion, and island breaching in the coming years. If sea level rise reaches the potential projection of 7 mm per year, rapid barrier island segmentation and migration will be highly probable in the area (Titus et Al., 2009). If such a scenario occurs, the bay area will transition to a brackish zone and have severe impacts on the local flora and fauna protected within the refuge. Rising sea level can pose dangers such as inundation of low lying areas with an increase in flooding, coastal erosion, wetland loss, and saltwater intrusion into estuaries and freshwater aquifers (Titus et Al., 2009). Salt water intrusion and inundation of the wetland and forested areas protected behind the barrier islands will result in critical loss of primary nesting, breeding, and foraging habitat for many of the protected species within the Back Bay refuge. Further research will be needed to more accurately determine the species facing the most imminent threats as a result of these changes and the areas they will occur.

3. Response of Barrier Islands to Sea Level Rise Impacts

Back Bay Wildlife Refuge has a largely low lying topography, with the exception of the barrier island dunes, which leaves the area prone to an increase in water level or rapid inundation should the dunes be breached. The dune and beach habitats on the barrier island are found to be vulnerable to storm surge and extreme weather occurrences such as tropical storms and hurricanes which can lead to erosion, overwash and inundation that could diminish the dune - a critical habitat for many species of flora and fauna (Smallegan et Al, 2017). If sea level rise accelerates too fast, the rate that the barrier islands respond and adapt may not be able to keep up. Should this happen, it is likely that rapid migration and segmentation of the barrier island will occur. Identifying the most vulnerable locations along the island through review of past

ocean breaches into the bay and storm surge related dune erosion will allow for more effective planning and mitigation efforts in the future.

4. Coastal Morphology Under Sea Level Rise at Back Bay NWR

Through proper foresight, decision makers and refuge managers will be able to plan for the hazards associated with sea level rise and the barrier islands. A good understanding of the locations, causes, and impacts of past incidences such as dune erosion, extensive overwash, or total breaching during severe storms will allow leaders to identify vulnerable points on the island that hold the highest potential to occur again in the future. With sea levels rising at an accelerating rate, climate change on an unprecedented scale, and human development encroaching on the barrier islands, the next big weather event could lead to a situation in which Back Bay is pushed far beyond its threshold for rebounding. Salt water intrusion on the bay and its surrounding water table as well as a rise in water level would happen much quicker than many species would have the capability to adapt to. Assessing which species are most vulnerable to these possible impacts and the threshold for not only barrier island breaching, but for salt water tolerance within Back Bay's ecosystems will be crucial in planning and mitigating future situations should they occur. In some cases, natural migration of the barrier island would occur if anthropogenic development is absent (Gutierrez et Al., 2007). It will be important to study how the barrier island might move under rapid sea level rise in order to prepare or buy up certain land areas behind it. Models and projections to assess the situation must be used while also looking beyond current models to achieve a level of awareness towards unpredictable changes in the Earth's climate and hydrologic systems. Further study, on top of previously mentioned requirements, is needed to fully understand what the future holds for the area.

5. Stakeholders/Decision Making

The US Fish and Wildlife Service will be the main leader in making decisions in the area for the refuge. However, the local and state governments, private development sector, non-profit organizations and the local public will be important stakeholders in the decision making process regarding the refuge. Understandably, the process by which these partnerships are developed can be long and arduous. Which is why, if foresight is applied, they should be sought after hastily. Through a system of systems perspective, it is possible to identify areas in which certain groups might find their investments threatened or be motivated to apply preemptive measures to prepare for the threats associated with sea level rise in the area. In some cases, regulation and legislation may needed to be introduced to protect and conserve the land from the public and private development.

6. Options

The nature of the problem facing the refuge, cerning sea level rise, is complex and dynamic requiring a multi-faceted approach to finding a working solution. Using a sustainable, adaptive approach will allow the refuge to create an initial plan that will be able, under changing climatic and hydrological conditions, to adjust and transition into a more appropriate option if necessary. Some direct options include beach replenishment, dune building, buried seawall, and raising the island (Smallegan et Al, 2017). Additionally, partnerships with local and state agencies to develop further policy changes that would allow for funding allocation as well as protection from anthropogenic hazards will be important in fulfilling comprehensive dune conservation plans for the refuge and surrounding lands.

7. Recommendations

Through my research at Back Bay NWR, I hope to provide adequate recommendations to that will address the hazards and vulnerabilities described above using sustainable methods. Through my preliminary research, it is clear that the first step in finding a viable and sustainable option to deal with sea level rise will be identifying the most vulnerable locations on the barrier island to breaching. In order to maintain the goals of the Fish and Wildlife Service of protecting important, endemic populations it will be necessary to identify which species will be most affected by the impacts of a large scale breach in the barrier island. Using this information the refuge and its partners will be able to create an appropriate, sustainable strategy to effectively tackle these issues going into the future.

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