“Marshing” Up the Land:

A Suitability Analysis of Salt Marsh Accretion Adjacent to Plum Island, Massachusetts

Christian Casolaro

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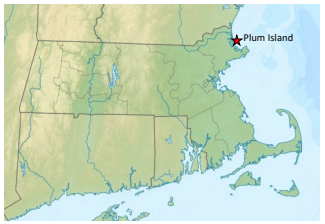
GERALD J. AND DOROTHY R.
Tufts UNIVERSITY | Friedman School of Nutrition Science and Policy

Background

One of the many outcomes of climate change predicted to harm coastal communities and ecosystems is increased rate of sea level rise. Cities like Boston have already witnessed inundation from extreme tides and are now including sea level rise into their city planning documents (Boston Planning and Development Agency, 2017). Some ecosystems are more resilient than others to the effect of sea level rise. Specifically, salt marsh ecosystems have a built-in ability to move upland in response to sea level rise if given the correct conditions to do so. In 2012 a joint project by USGS and the Dept. of the Interior attempted to model salt marsh accretion up to 60 cm in sites adjacent to Acadia National Park in Maine using GIS and Remote sensing techniques. That report found highly variable results across the 114 salt marshes dependent on a few factors such as elevation and landward barriers (Nielson & Dudley, 2013).

Figure 5: Salt Marsh Accretion at Great Meadow



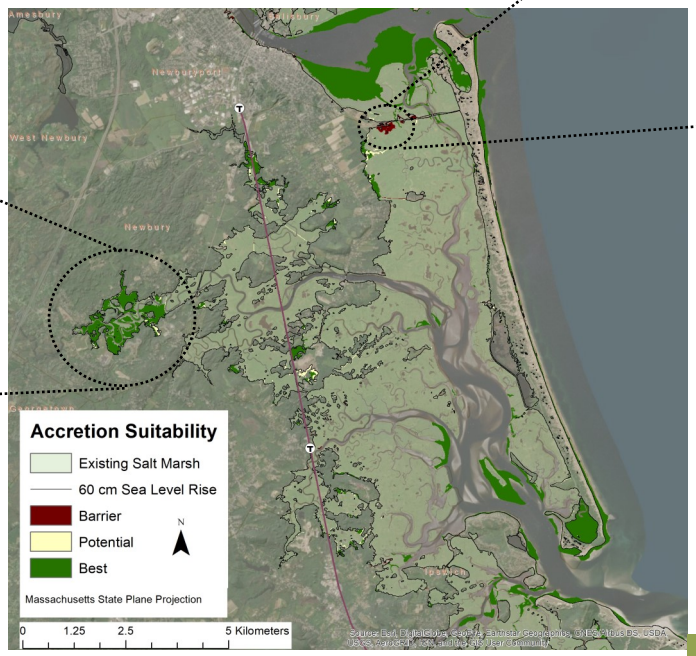
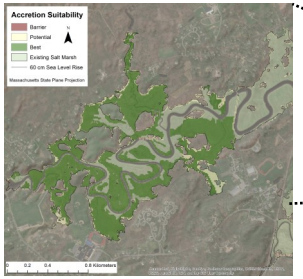


Figure 1: Salt Marsh Accretion Suitability for Plum Island with 60 cm Sea Level Rise



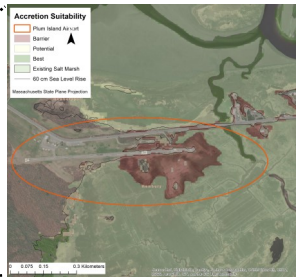


Figure 6: Barriers to Salt Marsh Accretion at Plum Island Airport

Objectives

This project attempts, using data made available by USGS and MassGIS, to build upon the previous model and map the extent to which salt marsh adjacent to Plum Island in the towns of Newbury, Newburyport, and Rowley may be able to expand given a predicted 60 cm of sea level rise.

The 60 cm (2 ft) sea level rise was measured in relation to the mean elevation of the salt marsh in the area of interest. Land use that was below the 60 cm sea level rise contour line was categorized based on suitability for salt marsh accretion. This categorization was then used to create a suitability ranking scheme that could potentially be useful for land planning decisions in the future. Highly developed areas, areas with roads and infrastructure, etc, were considered less suitable for migration than natural areas such as freshwater wetlands, forests and open lands. For the sake of the assessment, this is a simplified grading scheme that could be made more precise in future projects.

Relevance

Plum Island, on the northeast coast of Massachusetts is home to the Parker River National Wildlife Refuge, a valuable home and stopping ground for migratory and nesting birds. The survival of at least one species of bird is entirely dependent on the ability of salt marsh habitat to move and survive the effects of sea level rise. The Salt Marsh Sparrow makes its nest in salt marshes and survival of the nest is sensitive to SLR (Bayard & Elphick 2011).

Figure 2: Salt Marsh and Elevation Layers

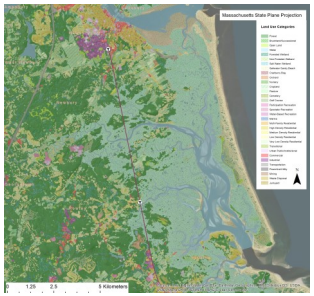


Figure 3: MassGIS Land Use (2005)

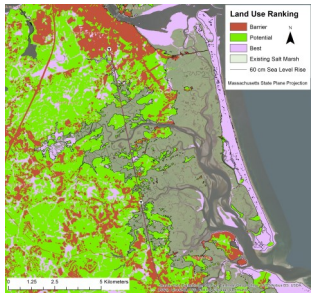


Figure 4: Land Use Suitability Raster

Methods

In order to draw a contour line at 60 cm of sea level rise in relation to salt marsh, data from the Mass DEP 2005 Wetland Layer was used to create a raster for just the Salt Marsh category at 10 m resolution. Using Zonal Statistics of the USGS DEM, the mean elevation of the salt marsh in the area of interest was determined to be 1.22 m above sea level. A contour line of 1.82 m (1.22 m + 0.60 cm) was created using the Contour List function. The results of these preliminary steps can be seen in Figure 2.

Next, the MassGIS 2005 Land Use layer (Fig.3) was rasterized and reclassified into categories reflecting suitability score for salt marsh accretion AT 10 m resolution (Fig 4). Current Salt Marsh and Ocean were given a value of “NoData,” land uses that served as barrier to accretion such as Residential or Commercial land were given a value of “0,” natural spaces such as woodlands and open land or pasture were given a value of “1,” and lastly, freshwater wetland and beaches were given a value of “2.” Values “0,” “1,” and “2” were labeled as “Barrier,” “Potential,” and “Best” respectively. To model potential areas of spread, the USGS DEM raster was reclassified to give all elevation values below 60 cm of SLR a “1” and everything else as “NoData” at 1 m resolution. Using this new raster as a mask, a cost path function was created using the USGS DEM that limited areas of spread to only areas touching the original Salt Marsh raster, assigning these areas a value of “1” and everything else a value of “NoData.” Finally, this raster was multiplied with the land use category raster using a raster calculator to generate categorized areas under 60 cm SLR that were adjacent to exiting salt marsh (Fig. 1).

Results and Conclusions

The model created an area of 9.65 km^2 that was adjacent to salt marsh but below the 60 cm of sea level rise threshold. This is about one fifth of the size of the existing marsh in the area of interest (52 km^2). Great Meadow, in Newbury contributed a large fraction to this total (Fig. 5). This model did not attempt to determine the amount of existing marsh that would be lost by this SLR scenario. Combining that information with the data presented in this model would make for a compelling story about the dynamics of SLR on this important habitat. This would be a valuable future direction to take this project. Also, land use and salt marsh information were collected as recently as 2005, so the analysis could benefit from more current data.

Overall the model found most of the land adjacent to salt marsh that was under the 60 cm SLR scenario to be suited for salt marsh accretion (82.55% : “Best,” 14.87% : “Potential”). Barriers to accretion only existed in 2.58% of the area, most of which was located on or adjacent to Plum Island Airport (Fig. 6). The “Best” category took up such a large percentage likely because the summary function used by this model generated a mean elevation that may have been an underestimate of the actual height of the marsh. The 2012 USGS survey used the elevation at the landward side of the marsh using surveying equipment for each marsh studied. This information was not available for this study, so mean height was substituted given that marshes are generally flat. At such a low target elevation, there not a lot of barriers present in the study area. For example, most roads and MBTA tracks were well above the 1.82 m elevation. To better improve this study for the future, more accurate elevation measures would be needed to give a more nuanced and detailed depiction of SLR in this area.

Sources:

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