Summary of Social Science Investigations:

Shoreline Decision Modeling

NSF COASTAL SEES Initiative - 2021

Project Activity: Living Shoreline Installation and Marsh Survival Simulation

Development of an iterative simulation to examine potential combined scenarios of living shoreline installation and marsh survival along coastal shorelines in Gloucester Count, Virginia, integrating physical and social influences on shoreline management decisions.

Objective: To simulate the potential consequences of rising sea level on tidal marshes over the next 30 years (2050) and to support evaluation of the influences of agents in the social network informing shoreline property owner decisions regarding management of eroding shorelines.

Methods: A spatially explicit inventory of the tidal shoreline conditions in Gloucester County was used to identify the location of all existing tidal marshes, adjacent land use, shoreline structures, bank height, and wave exposure. From this, we developed an iterative model that simulated how likely a given segment of shoreline was to be converted to a living shoreline in each year of the 30-year window. Management decisions were based on the relative influence of each of the actors included in the model: homeowners, neighbors, contractors, and scientists/managers. Homeowners were assumed to base their decisions primarily on the physical risk to their property from wave-induced erosion. Neighbors were included as a purely background rate of installation (i.e., what proportion of shoreline segments receive a living shoreline in a given year, on average), and not as a true spatial neighbor effect. Contractors were assumed to recommend living shorelines about 50% of the time, based on survey results. Scientists and managers were assumed to always recommend a living shoreline anytime the best available science (in this case, the Shoreline Management Model recommendations). With the exception of the scientists/managers, each of the underlying probabilities were included as distributions rather than fixed values to allow us to incorporate uncertainty in each of the estimates. The cumulative influence of all actors was then multiplied by the physical risk of the segment in a given year to obtain a probability of living shoreline installation. Annual physical risk was simulated based on the wave exposure at a site, storm impacts, forecasted rate of SLR, and whether there was an existing shoreline modification upland of the existing marsh that would diminish migration potential.

To estimate marsh survival through the end of the simulation, we focused on migration potential. Given that a shoreline segment currently has marsh along it, we estimated the probability that, assuming the marsh could migrate, there would still be marsh there in some form, even if greatly diminished. We included a variety of possible scenarios to account for factors that may negatively impact a segment's ability to maintain marsh in the future, including shading from riparian vegetation, erosion, mowing or other vegetation management by property owners, future development and/or shoreline modification (including armoring), and unsuitable soil conditions/legacy effects. We set the upper and lower bounds for reasonable survival scenarios, and then allowed the simulation to select any scenario in between the extremes for each run. The upper bound assumes that ~88% of all marshes that can migrate will have a 50% chance or better of still being present in 2050. The lower bound assumes that only ~56% of all marshes that can migrate will have a 50% chance or better of still being present in 2050.

The completed model was run for 10,000 iterations, varying the actor influence and marsh survival for each iteration, under two different scenarios: one where marshes are allowed to migrate onto residential property, and one where it is assumed that unless a living shoreline is installed, homeowners will prevent marsh encroachment onto their property. At the end the runs, the total number of living shorelines and the length of shoreline that remained marsh were totaled.

Findings: Overall, the simulation suggests that there may be between ~35 – 75% of shoreline that is able to maintain marsh until at least 2050 (Figure 1A). If marsh is restricted from migrating onto residential property, best case scenarios result in only ~55% of marsh remaining. In contrast, if marsh is allowed to migrate onto residential property, then worst case scenarios result in ~50% survival.

The number of installed living shorelines during the 30-year timeframe of the simulation ranged from 36 to 1,171, with a median of 552. The median value represents an average of 18.4 living shorelines per year, which is slightly above the current 5-year average of 14.2 in Gloucester County. The model does, however, assume, that rates will increase in the future as a result of changes in legislation and as sea level rise accelerates and directly impacts more properties. With these values, living shorelines are only expected to be able to account for, at maximum, ~10% of future marsh, and then only under extremely accelerated rates of installation and worst-case scenarios for marsh migration. As such, it is highly unlikely that living shorelines are likely to be able to appreciably offset marsh loss from rising water levels in Gloucester County without dramatic increases in the rate of installation.

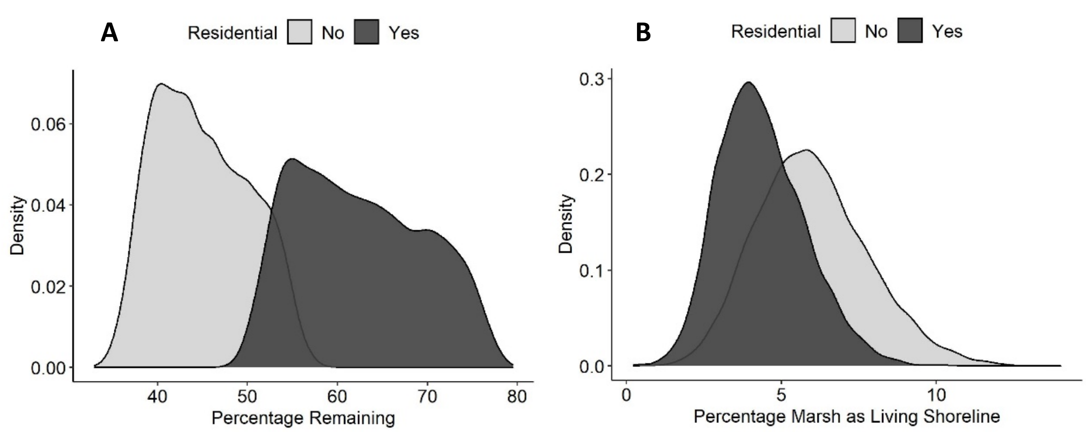

Figure 1 – Simulation results for amounts of expected remaining marsh (A) and how much of that is likely to be living shoreline (B). Scenarios that restricted migration onto residential property are shown in light grey, and those that allowed migration onto residential property are shown in dark grey.