Understanding the Role Coastal Marshes Play in Protecting Communities from Storm Surge and Flooding

Project Location

Piermont Marsh, Hudson River, New York

Project Duration

November 2016 to September 2020

Project Leads

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Project Type

Collaborative Research – generating science that informs decisions

Products

- Piermont Marsh Coastal GeoTool to visualize modeling results
- Research summaries for outreach
- Modeled flood and wave height maps under different scenarios
- Journal articles

Project Partners

- Hudson River National Estuarine Research Reserve
- Consensus Building Institute
- NASA Goddard Institute for Space Sciences
- Palisades Interstate Park Commission
- Piermont Waterfront Resilience Commission
- University of Miami
- U.S. Geological Survey, New York Water Science Center

Project Webpage

nerrssciencecollaborative.org/project/Sheng16

Overview

Coastal communities are striving to safeguard themselves from increasing storm risks with ways to maximize the protective powers of natural features, such as coastal wetlands. This project closely examined a marsh complex that lies adjacent to Piermont Village along the Hudson River Estuary in New York. Village residents wanted to better understand how Piermont marsh buffers their village from storm-induced flooding and waves, and whether a proposed plan to restore native cattails within a small area of the *Phragmites*-dominated marsh would lessen its buffering capacity. Residents had observed that their marsh offered some protection from Superstorm Sandy, an extremely damaging hurricane that made landfall in New Jersey in 2012.

In partnership with the local community, a research team designed and applied state-of-the-art coastal and hurricane models to address these questions. The team simulated the effect of marsh vegetation on waves and flooding during an ensemble of storms with computer models. The modeling covered a series of past and future scenarios, including sea level rise and a potential marsh management plan. Modeling results are helping marsh managers better understand how to sustain the suite of ecosystem services provided by the marsh, and village residents now have new tools to anticipate and manage the impacts associated with intense storms.

Project Approach

With the help of a professional facilitator, the research team worked closely with an advisory committee of end users, including the Hudson River Reserve, Piermont Village officials, and the Piermont Waterfront Resiliency Commission. This advisory committee refined the project's research questions and agreed on a set of modeling scenarios that would help them better understand the role of the marsh in protecting the community.

To understand Piermont's flooding risk from tropical cyclones, the research team developed a three-dimensional surge-wave model to simulate the waves and flooding in the village and the marsh under different storm conditions. The team measured the physical attributes of two dominant vegetation types in Piermont marsh—native cattails (*Typha angustifolia*) and invasive common reed (*Phragmites australis*). The vegetation data, along with local water level data, were used as input to the model to ensure the model would accurately simulate the effect of marsh on waves and flooding. Data from Superstorm Sandy in 2012 were used to confirm that their model produced valid results.

The validated model was used to examine the potential impact of a marsh management plan, which, had it been adopted, would have restored native cattails to 20 percent of the marsh area over 10 years. Based on robust predictions of future storm patterns, the team evaluated the effects of an ensemble of storms that could occur in a given year, including storms that varied in their direction, strength, size, speed, and landfall location. Each simulated storm generated different levels of flood and wave impacts on the village, and taken together they generated a picture of possible future conditions. To anticipate future flood risk, they used sea level rise projections and simulated the different phases of the proposed marsh management plan in the years 2022, 2025, 2050, and 2100.

Once future flood risk was understood, researchers used a robust parcel-specific method to estimate the damage to structures in Piermont Village. Damage predictions are based on 559 village structures with a combined market value of approximately $580 million in 2018. This economic analysis was completed for Superstorm Sandy and each of the future storm scenarios to calculate the costs of projected damage to the village.

Results

Project results have been summarized in journal articles, slide decks, and an illustrated four-page outreach document. In addition, the team developed a Piermont Marsh Coastal GeoTool to allow village officials and resource managers to explore how homes and buildings would be affected under different marsh management and sea level rise scenarios. Highlights of project results are explained here.

To what extent does Piermont marsh protect the village from storm impacts?

The project's modeling revealed that Piermont Marsh significantly reduces the impact of storm-induced waves on the adjacent village. For example, the marsh reduced wave energy by 66 percent during Superstorm Sandy. Marsh vegetation also significantly limits the transport of debris, such as tree branches or pieces of a dock, which can worsen storm-related damage to shoreline buildings. However, during Superstorm Sandy, the marsh did not reduce the height of storm surge or the severity of flooding in the village.

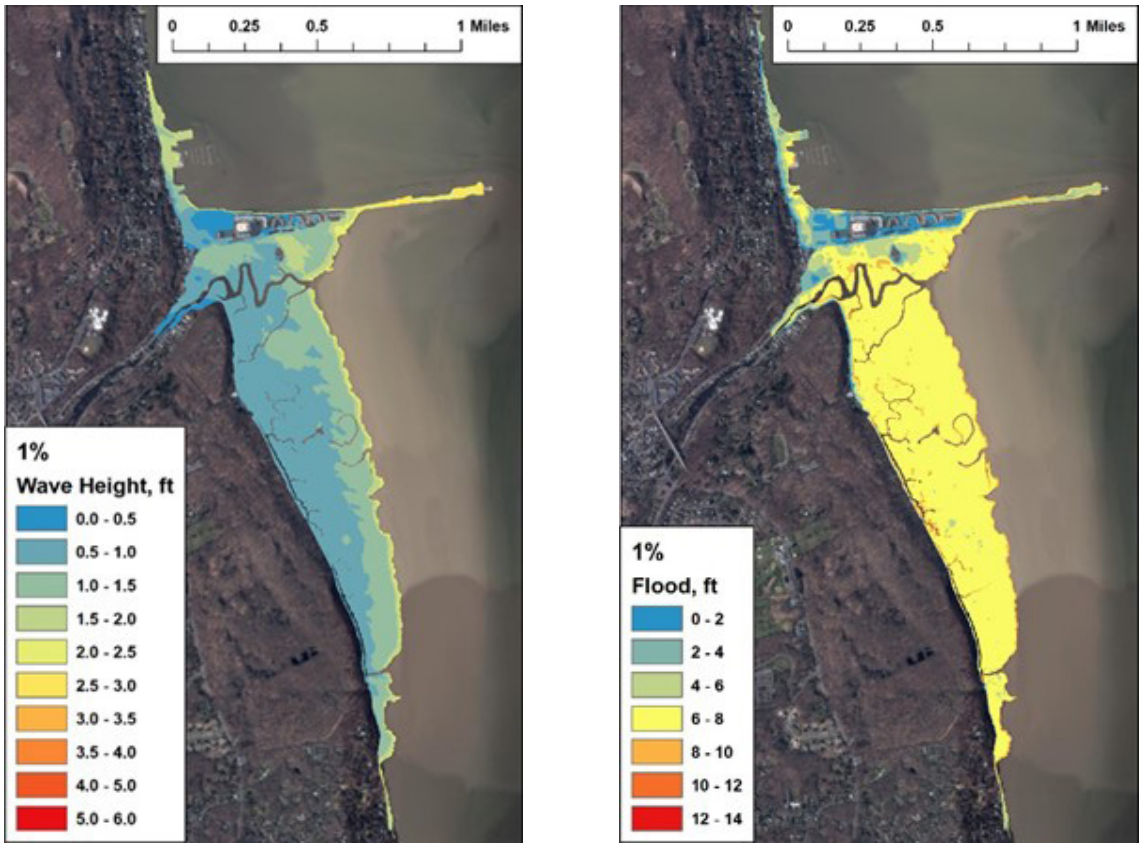
By modeling a range of future storms, the project illustrated how each storm generates different patterns of flooding and waves, and therefore the marsh's ability to buffer the impacts will vary as well. For example, it's possible that the marsh could reduce both wave impacts and flooding from storms with different characteristics than Sandy.

How would restoring native marsh plants affect the marsh's buffering services?

Stands of the invasive common reed are tall, dense, and rigid, which creates friction and reduces the momentum of currents and waves passing through the marsh, leading to a reduction of water currents and wave height. The team's field measurements confirmed that cattail stands are somewhat shorter, denser, and more rigid when compared to common reed, and the differences are most noticeable in the spring. Careful simulations of the proposed Piermont Marsh Management Plan found that the marsh's ability to buffer a severe storm such as Sandy would not be reduced by restoring cattails in 20 percent of the marsh. However, had Sandy occurred in May or June, when cattail plants are much shorter and sparser, the marsh would have been unable to buffer the wave and debris as effectively.

What is the economic value of the buffering services the marsh provides?

By modeling Hurricane Sandy in 2012 and estimating how much worse the damage could have been without the marsh, the research team was able to put a dollar value on Piermont Marsh's buffering services. They found that approximately $901,000 in damages were avoided because of the marsh in 2012. From the wide range of future storm scenarios modeling, they calculated an even higher value for the marsh's protection against a flood and wave event with a one percent chance of occurring each year. Specifically, they predicted that $2.13 million in damages would be avoided by Piermont Village because of the marsh, which is 11.3 percent of the $18.8 million estimated loss for a one-percent flood and wave event.



These two maps were generated by the project's wave-surge model and illustrate wave and flood height in Piermont Marsh during an intense storm. The left image shows how wave height declines significantly as waves move from the water's edge to the edge of the upland. The right image illustrates how the height of flooding is consistent across the marsh.

Benefits

Marsh managers and village stakeholders now have a better understanding of the role of the marsh in enhancing community resilience under current and future conditions. The project opened up a productive dialogue between parties that had opposing views at the project's start. Marsh managers are working on a revised management plan for the marsh, and village residents are working to safeguard village buildings from storm-induced flooding, waves, and damage from debris.

What's Next

- The chair of the Piermont Waterfront Resiliency Commission plans to train other end users in the village in the use of the Piermont Marsh Coastal GeoTool, which will help the village predict and manage storm risks.
- By looking ahead to 2050 and 2100, this project illustrated how the buffering services of the marsh, as with many coastal marshes, are likely to decline over time as sea level rises and the marsh area shrinks. This realization is helping focus attention on protecting marsh vegetation, allowing sediment carried by the river to reach the marsh, and preventing erosion along the edge of the marsh.

About the Science Collaborative

The National Estuarine Research Reserve System's Science Collaborative supports collaborative research that addresses coastal management problems important to the reserves. The Science Collaborative is managed by the University of Michigan's Water Center through a cooperative agreement with the National Oceanic and Atmospheric Administration (NOAA). Funding for the research reserves and this program comes from NOAA. Learn more at nerrssciencecollaborative.org or coast.noaa.gov/nerrs.