PIERMONT MARSH BUFFER RESEARCH

A project to assess the value of Piermont Marsh in protecting coastal communities from storm surge and flooding amid a changing climate

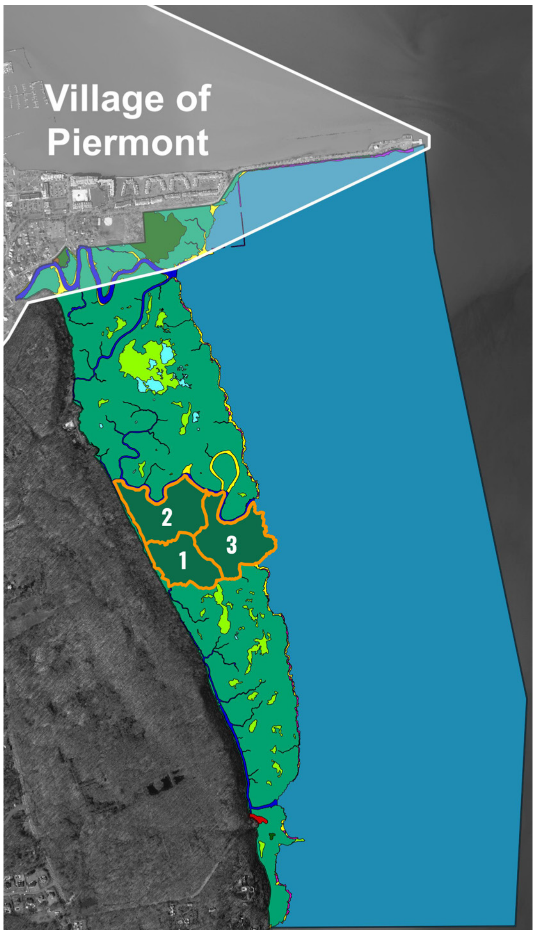

Figure 1: *The Village of Piermont and Piermont Marsh, including three marsh areas formerly slated for a proposed vegetation management plan. A new plan is anticipated in 2021. The village and marsh lie 15 miles upriver from New York City.*

The benefits of wetlands include carbon sequestration, cultural and recreational value, water filtration, and habitat. This study shows that another benefit can be buffering of wave, debris, and flood inundation, depending on the storm characteristics.

The study focuses on Piermont Marsh, a 200-acre brackish tidal wetland located 15 miles upriver from New York City, adjacent to the Village of Piermont. The marsh is the southernmost component of the Hudson River National Estuarine Research Reserve and part of Tallman Mountain State Park. It is dominated by *Phragmites australis* (common reed) and has smaller areas of vegetation characteristic of brackish tidal marshes, and also includes saltwater tidal creeks and a few shallow saltwater ponds.

The Village of Piermont is at risk now and in the future of flooding resulting from both winter nor'easters and summer and fall tropical cyclones. In addition, according to the National Oceanic and Atmospheric Administration, sea-level rise will likely cause more sunny day flooding and higher coastal inundation levels from tropical storms (www.gfdl.noaa.gov/global-warming-and-hurricanes).

When tropical storm Sandy hit New York on October 29, 2012, the Village of Piermont experienced wind, waves, and a powerful storm surge, resulting in significant damage to Piermont's waterfront. There was severe flooding everywhere, but residents noticed that homes adjacent to Piermont Marsh had less damage than neighboring homes, attributing the difference to the marsh's capacity to buffer waves and filter water-borne debris.

Marsh managers and village residents and leaders decided to learn more about the village's flood risk, the marsh's capacity to buffer against storm damage, how marsh management might affect buffering capacity, and the economic values associated with the marsh's buffer role. A collaborative partnership was formed of village leaders and advisors, marsh managers, and a multi-disciplinary team of climate, coastal, ecological, and economic scientists led by Peter Sheng to carry out research to answer these questions using local marsh data and state-of-the-art coastal and hurricane models.

FORMER PROPOSED MANAGEMENT PLAN

Concerned about lack of biodiversity in Piermont Marsh, in 2019 marsh managers released a proposed vegetation management plan. Had it been adopted, the plan would have taken place in three phases over three areas covering a total of 20% of the marsh (40 acres) over a time period of ten years. This research project used computer models to examine the potential impact of that marsh management plan.

Figure 1 shows the locations (Areas 1, 2 and 3) where managers were considering restoring marsh vegetation in phases. To model the plan, researchers used native cattail (*Typha angustifolia*) as the proxy for native vegetation and carefully simulated each phase of the restoration process. Phase 1 comprised controlling *Phragmites* in Area 1 with herbicides, resulting in a period with no vegetation in that area. In Phase 2, *Phragmites* in Area 2 would be controlled while cattail with low density and low biomass would grow in Area 1. In Phase 3, *Phragmites* would be controlled in Area 3; cattail would grow to full height and density in Area 1 and remain at lower density in Area 2. At the end of ten years, mature cattail plants would fill the 40 acres of Areas 1-3.

A new marsh management plan is anticipated in 2021.

UF | UNIVERSITY of FLORIDA · UNIVERSITY OF MIAMI · NOAA · National Estuarine Research Reserve System Science Collaborative · NASA · NEW YORK STATE OF OPPORTUNITY · Hudson River National Estuarine Research Reserve · CBI CATALYZING COLLABORATION · USGS

METHODOLOGY AND OUTPUTS

PROJECTING FLOOD RISK FOR THE VILLAGE OF PIERMONT UNDER CURRENT AND FUTURE CONDITIONS

To understand Piermont's flooding risk from tropical storms, the research team developed a three-dimensional surge-wave model that includes Piermont Marsh vegetation distribution and structure. The model was used to estimate the amount of damage that would be expected in the Village under different hypothetical future storm scenarios.

An advisory committee of end-users (Piermont Village leaders, Piermont Waterfront Resiliency Commission members, marsh managers, and coastal modelers) agreed on a set of modeling scenarios that would help them better understand the role of the marsh in protecting the Village.

Based on robust predictions of future storm patterns, the team evaluated the impact of an ensemble of many storms that could occur in a given year. The ensemble includes many less intense but more frequent storms than Sandy with varying characteristics (direction, strength, size, speed, and landfall location). Each would generate different floods and waves risks for Piermont but taken all together they generate a picture of what the future might look like. The research team used data from Sandy to confirm that their model produced valid results.

The team calculated the 1% flood elevation and wave height – the flood elevation and wave height that has a 1% annual chance of being exceeded at each location under different modeled scenarios. To project future flood risk, they used the sea-level rise projections recommended by local advisors and the former management plan for Piermont Marsh.

Table 1: Projected damage to Piermont Village structures as predicted based on different assumptions for future scenarios, as well as Superstorm Sandy. Each scenario predicts the impact of an extreme storm that has a 1 percent chance of occurring that year, and the results are influenced by sea-level and marsh vegetation.

Assumptions used for each storm scenario that was modeled				Projected Damage to Village
Storm Scenario	Year	Sea-Level Rise	Marsh Vegetation	
Superstorm Sandy	2012	0 in	*Phragmites* (current condition)	$11.9M
Superstorm Sandy	2012	0 in	No vegetation	$12.8M
Scenario 0	2020	0 in	*Phragmites* (current condition)	$18.8M
Scenario 0	2020	0 in	No vegetation	$21.0M
Scenario 1	2020	0 in	Management Plan Phase 1	$18.8M
Scenario 2	2022	0 in	Management Plan Phase 2	$18.8M
Scenario 3	2025	6 in	Management Plan Phase 3	$21.4M
Scenario 4	2050	18 in	Management Plan Complete	$28.1M
Scenario 5	2050	18 in	*Phragmites* (current condition)	$28.1M
Scenario 6	2100	114 in	Marsh loss predicted by sea-level affecting marsh model	$63.3M

A full explanation of modeling methods and results is being published by Peter Sheng.

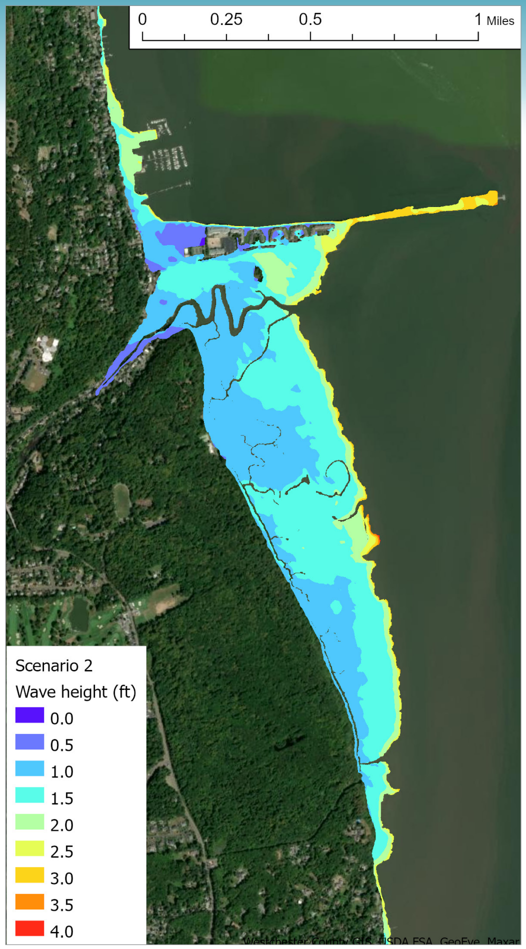

***Figure 2:** The research team produced numerous maps like the one above to show how various hypothetical storm scenarios would affect Piermont Marsh and the adjacent village. All flood, wave, and structural loss maps for the tested scenarios are included in a web-based GeoTool and are accessible to end users for resiliency and marsh management planning.*

PREDICTING DAMAGE FROM FUTURE STORMS

Once future flood risk was understood, researchers used a robust parcel-specific method to estimate how much the future storm would damage structures in the village.

- Calculate flood elevation
- Calculate wave height
- Calculate damage to individual buildings due to flood and wave
- Add up the individual building damages to get total structural loss damage

Damage predictions are based on 559 village structures with a combined market value of ~$580 million in 2018. This economic analysis was completed for Superstorm Sandy and the modeled 1% annual chance flood and wave event using the various sea-level rise and marsh management scenarios. The costs associated with projected damages are summarized in the last column in Table 1.

WHAT DOES THIS MEAN FOR FUTURE RESILIENCY PLANNING?

When trying to anticipate future risks from storms, property owners and decision-makers need to consider how the storm could affect both flood height and wave height. Modeling projects like this one can help people anticipate a range of possible storm impacts.

Each storm generates different patterns of flooding and waves, which the marsh may or may not be able to mitigate. In a storm like Sandy, the marsh buffered only waves and debris. But in other storms, flood may be buffered as well.

Coastal resiliency planning should be based on the role of marsh vegetation in buffering flood and wave damage for a range of possible extreme storms, as opposed to the experience of Sandy alone. The role of the marsh in buffering wave and surge can vary significantly with storm characteristics.

Planners should also consider how much protection the marsh could provide in future storms with sea-level projections. As time goes on and sea-level rise increases, the marsh's ability to protect assets will diminish.

To enhance Piermont Marsh's buffering capacity, it is important to protect and manage marsh vegetation, allow sediment carried by the river to reach the marsh, and prevent erosion along the edge of the marsh.

MORE INFORMATION

- **HRNERR** https://www.hrnerr.org/conservation-and-stewardship/piermont-marsh-storm-protection. For access to technical papers, email hrnerr@dec.ny.gov or call (845) 889-4745
- **Piermont Marsh GeoTool.** Contact nmitchell@piermont-ny.gov
- **Piermont Waterfront Resiliency Commission** https://www.piermont-ny.gov/government/waterfront_resiliency_commission.php
- **Draft Piermont Marsh Management Plan (2017)** https://www.hrnerr.org/wp-content/uploads/sites/9/2018/01/Draft-PMR-Plan-Final_Web-Formatted.pdf
- **NERRS Science Collaborative** http:// www.nerrssciencecollaborative.org/ project/Sheng16
- **Y. Peter Sheng, Ph.D.**, University of Florida, pete@coastal.ufl.edu

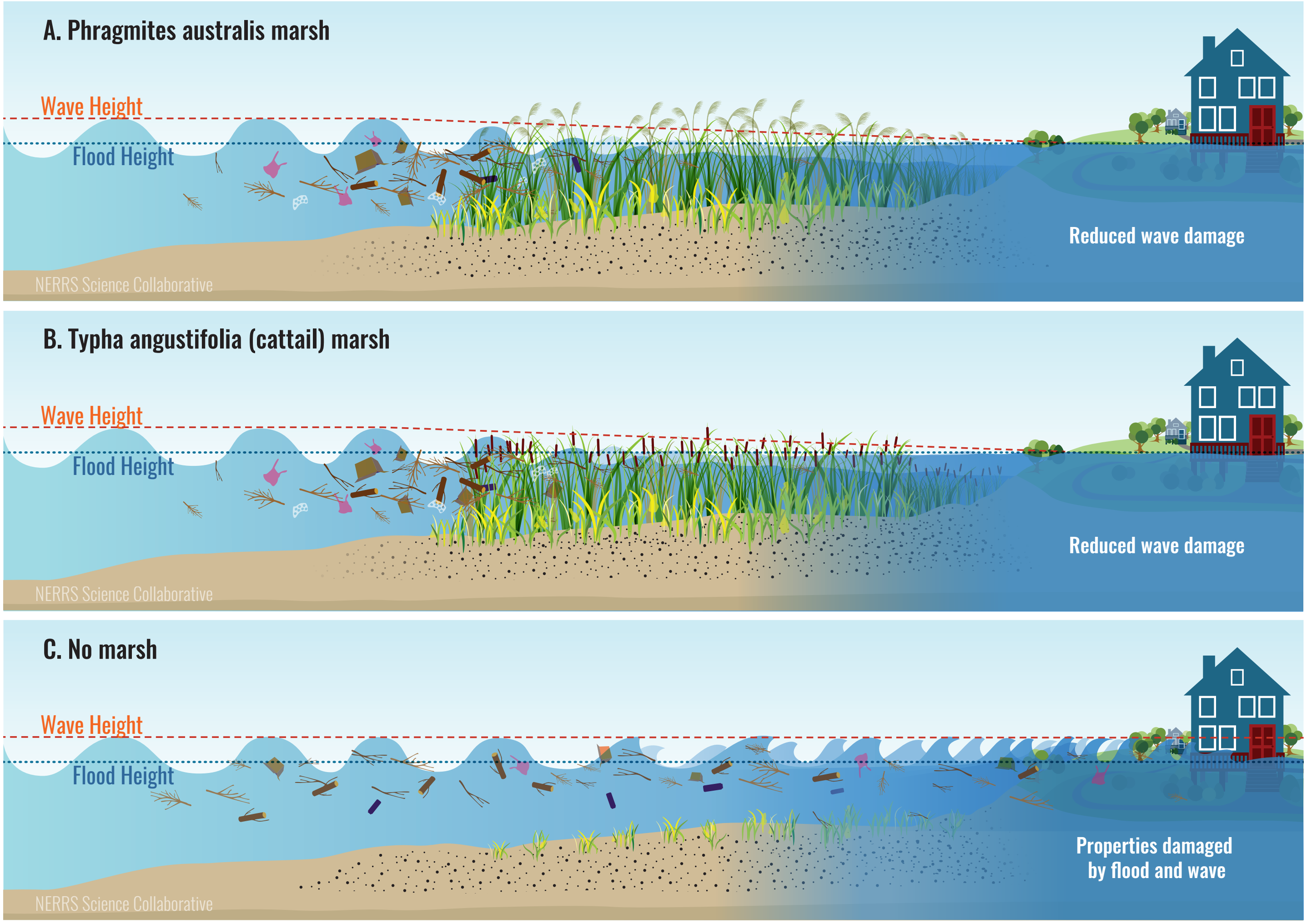

Figure 3: This study found that marsh vegetation acts as a buffer against wave energy and the damage from debris during a storm. However, simulations of Superstorm Sandy in 2012 indicated that Piermont Marsh did not reduce the height of flood waters. ***Phragmites*** *(common reed) and* ***Typha*** *(cattail) would dampen the height and impact of waves to a similar extent based on this project's model (See: A and B). If there were no marsh vegetation, shoreline structures would be more vulnerable to damage from waves and debris (See: C).*

KEY FINDINGS FROM THE COASTAL MODELING

How would Piermont Marsh's buffering services change if marsh managers gradually restored native vegetation in 20% of the marsh?

Prior to this project, marsh managers had proposed a plan to restore native vegetation like cattail to Piermont Marsh by controlling *Phragmites australis* with herbicides in 40 acres (20%) of marsh area (Figure 1). This project's modeling found that if that proposed plan had been implemented, the marsh's buffering capacity would not have changed.

This conclusion was developed by comparing the damage estimates generated by Scenarios 0, 1, and 2, which tested the impact of restoring parts of Piermont Marsh to cattails (Table 1). During the late summer and fall hurricane season, marsh plants are fully grown and offer the most buffering capacity. Modeling indicates that the village would be comparably protected from wave and debris damage whether the marsh was composed of *Phragmites* entirely or a center core of fully grown cattail.

Subsequent scenarios (3, 4, 5, 6) simulated the impact of increasingly higher sea-levels. In these scenarios, sea-level rise is the driver of damage to the village, and any changes to marsh vegetation have no detectable impact.

What is the economic value of the buffering services the marsh provides, now and in the future?

This study confirmed that Piermont Marsh significantly lessened the damage to Piermont Village caused by waves and debris during Superstorm Sandy. Although the marsh did not reduce flood inundation, just under $1 million of property damage was avoided because Piermont Marsh protected the village from waves and debris.

The avoided loss is the economic value of the marsh's buffering service and can be estimated by looking at the last column in Table 1. For example, the total damage from Sandy with current vegetation would be $11.9 million and, if the marsh vegetation were absent, building damage would increase to $12.8 million. For a more generic extreme storm (a 1% event) in 2020, approximately $2.2 million in damages would be avoided because of the marsh vegetation (see Scenario 0 in Table 1). These modeling results provide additional evidence that protecting Piermont Marsh will benefit the adjacent village, although the value of the benefits will vary depending on the unique characteristics of the storm.

How will Piermont Marsh's buffering capacity change as sea-level rises?

Sea-level rise will become an increasingly important contributor to shoreline structural damages, by amplifying the flooding caused by individual storms. As time goes on and sea-level rise increases, the marsh's ability to protect assets is expected to diminish.

Modeling results in Table 1 illustrate the impacts of rising seas. For example, in 2025, a six-inch rise in seas would increase property damage during an extreme storm (Scenario 2 and 3). In 2050, sea level is expected to rise by 18 inches, and storms and sea-level rise will contribute about equally to property damage. This study did not make any predictions for storms between 2050 and 2100 because the uncertainties of future storm patterns and sea-level rise increase after 2050.

Experts project that Piermont Marsh will not be able to keep up with sea-level rise and is likely to disappear in the mid- to late-21st Century, losing all of its buffering capacity. Permanent inundation would overwhelm the storms as the dominant factor driving property damage in those future scenarios.

ABOUT THE PROJECT

As a result of this project, marsh managers better understood coastal wetlands' role in enhancing community resilience to storm events and have more tools and knowledge to make sound decisions. The project was grounded in a frequent and ongoing dialogue with end users, including Piermont Village leaders, Piermont Waterfront Resiliency Commission, and marsh managers from PIPC and HRNERR, to ensure the project was generating useful information. End users were essential in providing guidance on key assumptions (Sea-level rise assumptions, marsh management scenarios, etc.), and advising on the project's outreach approach.

PARTNER INSTITUTIONS AND CONTRIBUTIONS

University of Florida: Y. Peter Sheng *(Principal Investigator)*, Christine Angelini, Justin R. Davis, Vladimir Paramygin, Ruizhi Zou, Sean Sharp, Adail Rivera-Nieves

NY Department of Environmental Conservation Hudson River National Estuarine Research Reserve: Heather Gierloff, Sarah Fernald, Emilie Hauser *(retired)*, Betsy Blair *(retired)*

NASA's Goddard Institute of Space Sciences: Timothy Hall

University of Miami / RSMAS: David Letson

Scenic Hudson, Inc.: Nava Tabak

Consensus Building Institute: Bennett Brooks

Others: Klaus H. Jacob of LDEO of Columbia, Edwin McGowan of PIPC/OPRHP, Nathan Mitchell of Village of Piermont and Ronald Busciolano and William Capurso of US Geological Survey.

Advisory Committee End Users: Mayor Bruce Tucker, Sylvia Welch, Usha Wright, Kenneth DeGennaro, Steve Silverberg, Lisa DeFeciani, Laura Straus, Stan Jacobs.