COLLABORATIVE SCIENCE FOR ESTUARIES

WEBINAR SERIES

Peter Sheng

University of Florida

Sarah Fernald

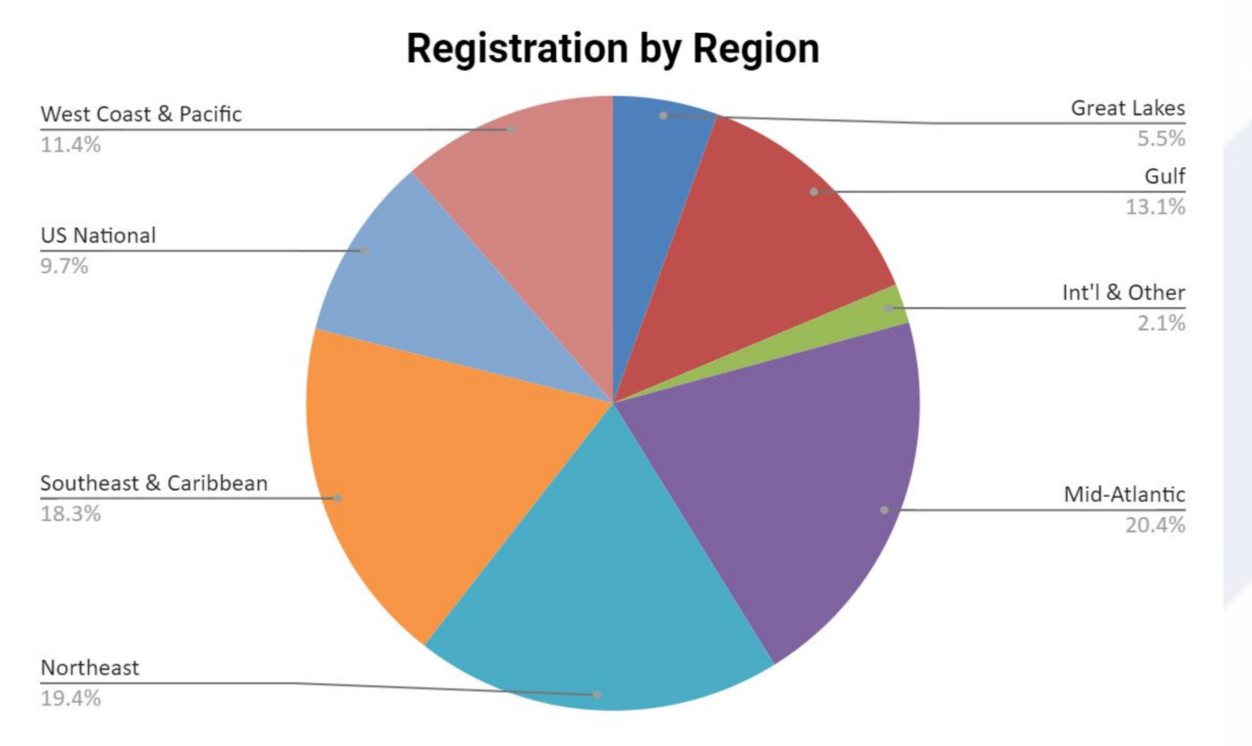
Hudson River NERR

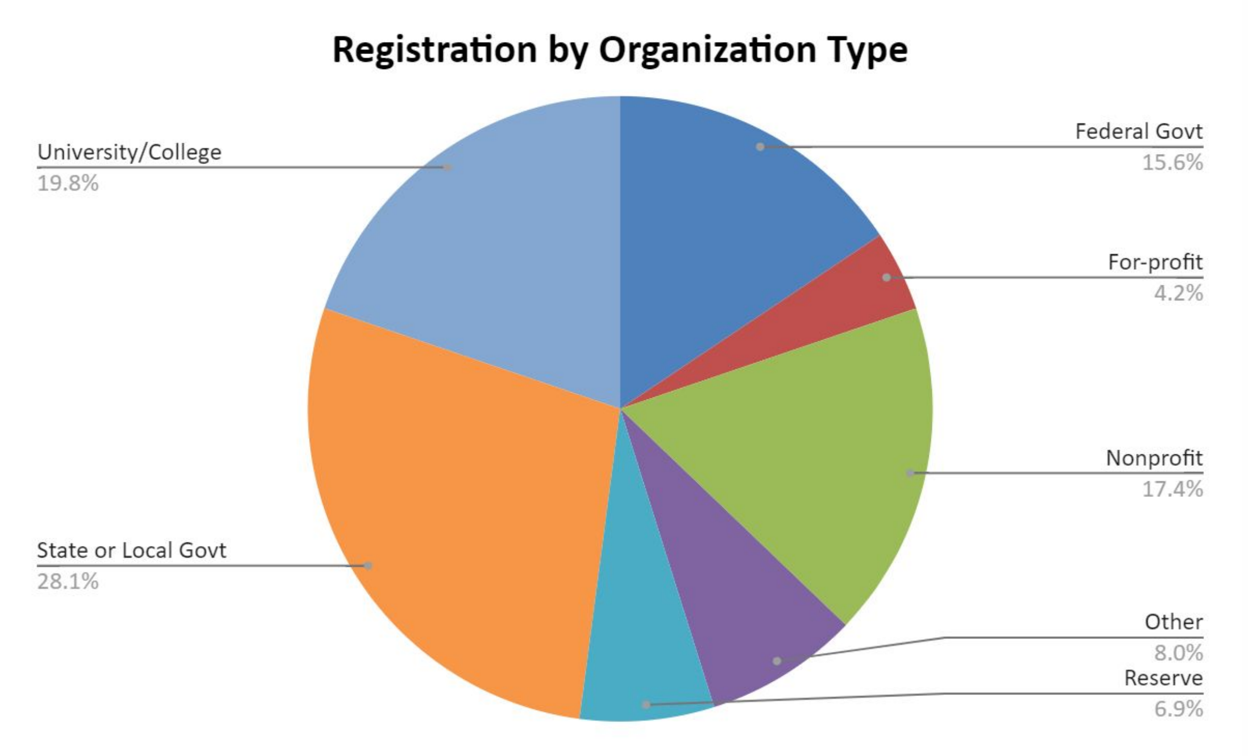
Understanding the Role Coastal Marshes Play in Protecting Communities from Storm Surge and Flooding

National Estuarine
Research Reserve System
Science Collaborative

Date: Wednesday, March 31, 2021
Time: 3:00-4:00 PM ET

Today's audience (by registration)





National Estuarine
Research Reserve System
Science Collaborative

New York State Department of Environmental Conservation

Hudson River National Estuarine Research Reserve

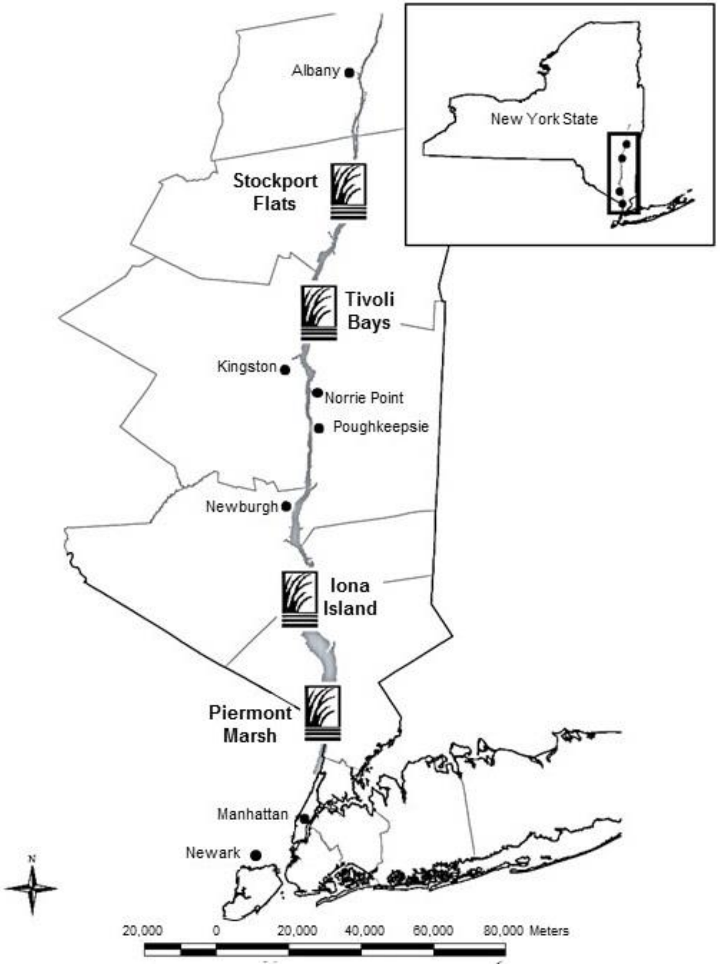
HRNERR Mission

- Federal Program with NOAA
- Partnership with NYS DEC
- Designated in 1982
- 5,000 protected acres at 4 sites

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

a NERRS Science Collaborative project

Hudson River NERR

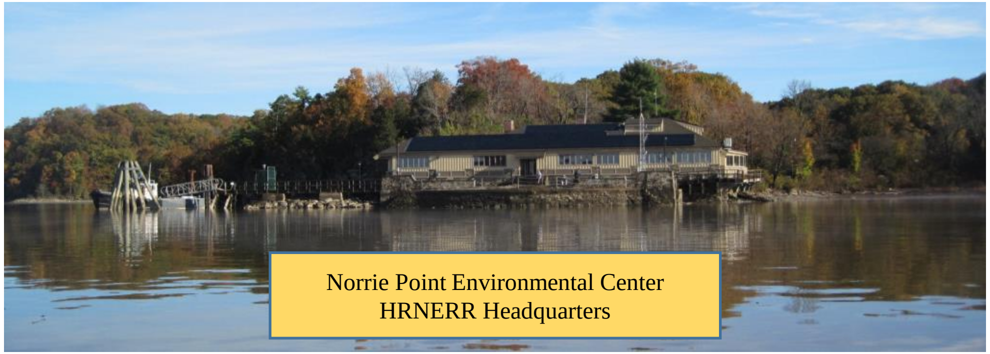


Stockport Flats

Tivoli Bays

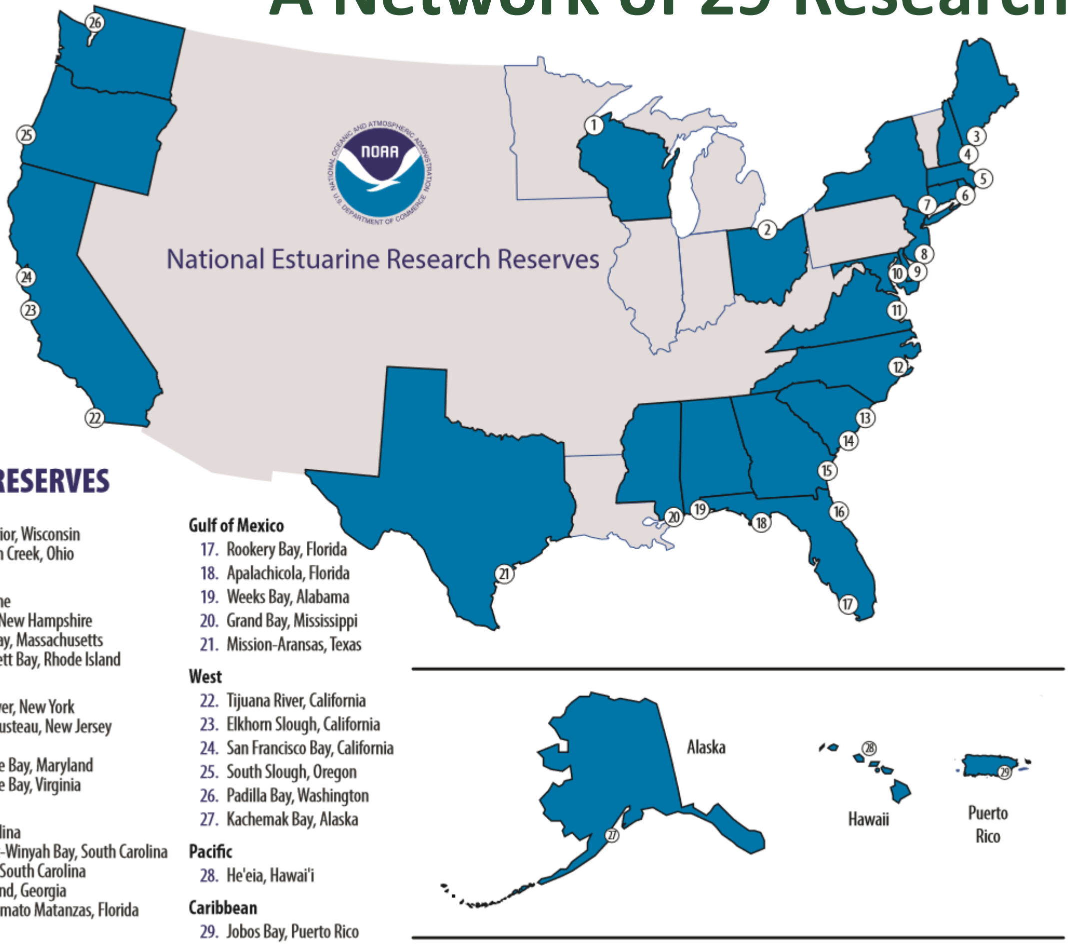
Iona Island

Piermont Marsh



Norrie Point Environmental Center
HRNERR Headquarters

A Network of 29 Research Reserves



LIST OF RESERVES

Great Lakes
1. Lake Superior, Wisconsin
2. Old Woman Creek, Ohio

Northeast
3. Wells, Maine
4. Great Bay, New Hampshire
5. Waquoit Bay, Massachusetts
6. Narragansett Bay, Rhode Island

Mid-Atlantic
7. Hudson River, New York
8. Jacques Cousteau, New Jersey
9. Delaware
10. Chesapeake Bay, Maryland
11. Chesapeake Bay, Virginia

Southeast
12. North Carolina
13. North Inlet-Winyah Bay, South Carolina
14. ACE Basin, South Carolina
15. Sapelo Island, Georgia
16. Guana Tolomato Matanzas, Florida

Gulf of Mexico
17. Rookery Bay, Florida
18. Apalachicola, Florida
19. Weeks Bay, Alabama
20. Grand Bay, Mississippi
21. Mission-Aransas, Texas

West
22. Tijuana River, California
23. Elkhorn Slough, California
24. San Francisco Bay, California
25. South Slough, Oregon
26. Padilla Bay, Washington
27. Kachemak Bay, Alaska

Pacific
28. He'eia, Hawai'i

Caribbean
29. Jobos Bay, Puerto Rico

MISSION:

To promote stewardship of the Nation's estuaries through science and education using a system of protected areas

NEW YORK STATE | Department of Environmental Conservation

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

UNIVERSITY OF MICHIGAN

National Estuarine Research Reserve System Science Collaborative

Coastal Issues in the NERRS

Facilitator

Research Reserve

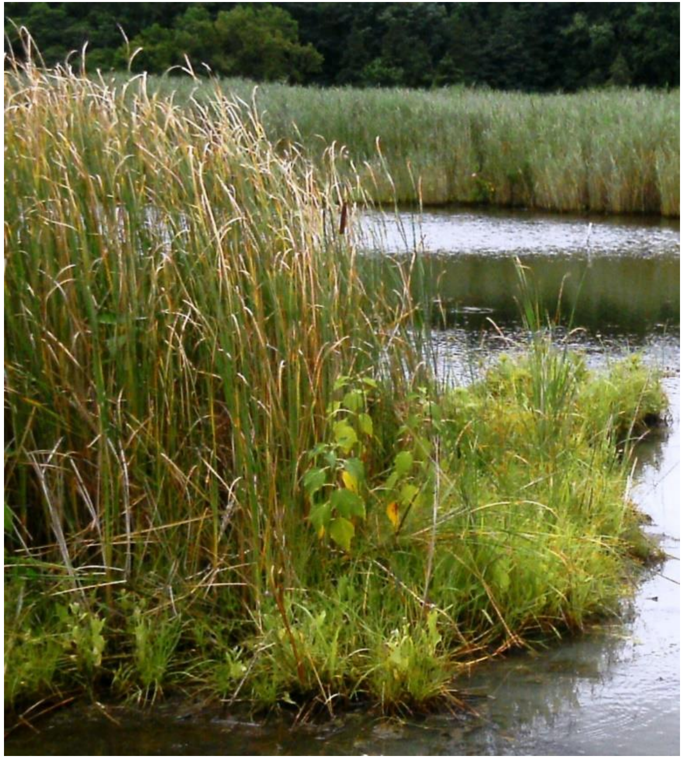
Researcher

End Users

End Product
Final Report

NEW YORK STATE
Department of Environmental Conservation

Coastal issue: protect tidal wetland function



Piermont Marsh diversity, Photo by S. Fernald 2011

Healthy tidal marshes support a wide variety of native plants, animals, insects, and microorganisms.

Native vegetation supports marsh health and maximizes the benefits that these tidal wetlands provide for fish, wildlife, and humans. Potential threats to native vegetation, such as invasive species need to be monitored.

New York State Department of Environmental Conservation

A diverse assemblage of species helps to protect the marsh, as each species fills a different niche and provides a range of environmental services:

- recreation
- carbon sequestration
- nutrient processing
- nesting habitat for marsh birds
- rest-stops for migratory birds
- nursery habitat for estuarine fishes
- foraging habitat for bees
- storm protection (Sheng study)

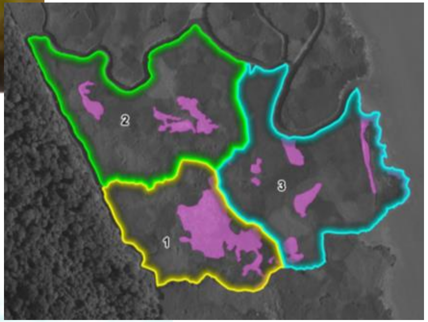
Hurricane Sandy 2012

Muskrat lodge, Photo by S. Fernald 2017

NEW YORK STATE | Department of Environmental Conservation

Draft Piermont Marsh Management Plan (2017)

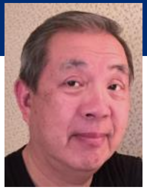
- Protect Native vegetation by controlling 40 acres of Phragmites in three phases over 10 years
- Piermont Village Residents voiced opposition to control of Phragmites



Updated Draft will be available for Public Comment in 2021

- Remove plan for large areas of Phragmites control
- Be responsive to public comments
- Include progress and results from 2019/2020 monitoring
- Use Dr. Sheng's final results to update the draft

Project Team

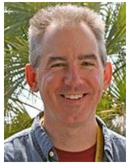


Principal Investigator — Peter Sheng
Research Professor
University of Florida

Team Member — Christine Angelini
Assistant Professor
University of Florida

Team Member — Justin Davis
Research Assistant Scientist
University of Florida

Team Member — Vladimir Paramygin
Research Assistant Scientist
University of Florida



Team Member — David Letson
Professor, University of Miami

Team Member — Timothy Hall
Sr Scientist, NASA Goddard Institute

NEW YORK STATE | Department of Environmental Conservation

Project Team

Team Member	Ronald Busciolano Supervisory Hydrologist United States Geological Survey
Team Member & End User	Edwin McGowan, Director of Science NYS Palisades Interstate Park Commission
Team Member & End User	Klaus Jacob, Appointed Representative Piermont Waterfront Resilience Commission
Collaborative Co-Lead	Bennett Brooks Senior Mediator Consensus Building Institute, Inc.
Collaborative Co-Lead & End User	Heather Gierloff Reserve Manager NYSDEC Hudson River NERR
Team Member Outreach/Education Lead	Emilie Hauser Coastal Training Coordinator NYSDEC Hudson River NERR






NEW YORK STATE | Department of Environmental Conservation

Thank You

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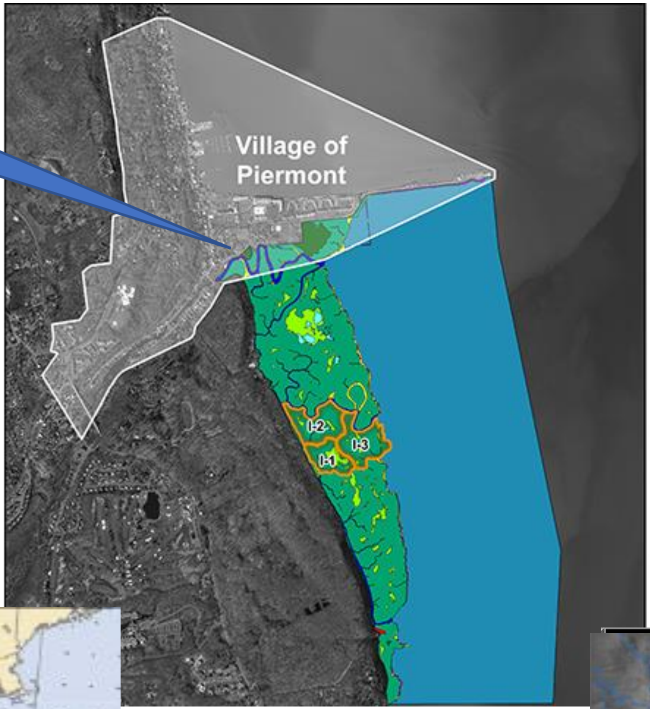
NEW YORK STATE | Department of Environmental Conservation

Understanding the Value of Coastal Marshes for Protecting Coastal Communities from Storm Surge and Flooding in a Changing Climate

University of Michigan
Piermont Waterfront Resiliency Commission
USGS
NASA
National Estuarine Research Reserve System Science Collaborative
NOAA
New York State of Opportunity
Hudson River National Estuarine Research Reserve
A program of New York State Department of Environmental Conservation in partnership with National Oceanic and Atmospheric Administration
cbi Consensus Building Institute
Scenic Hudson
University of Florida
University of Miami

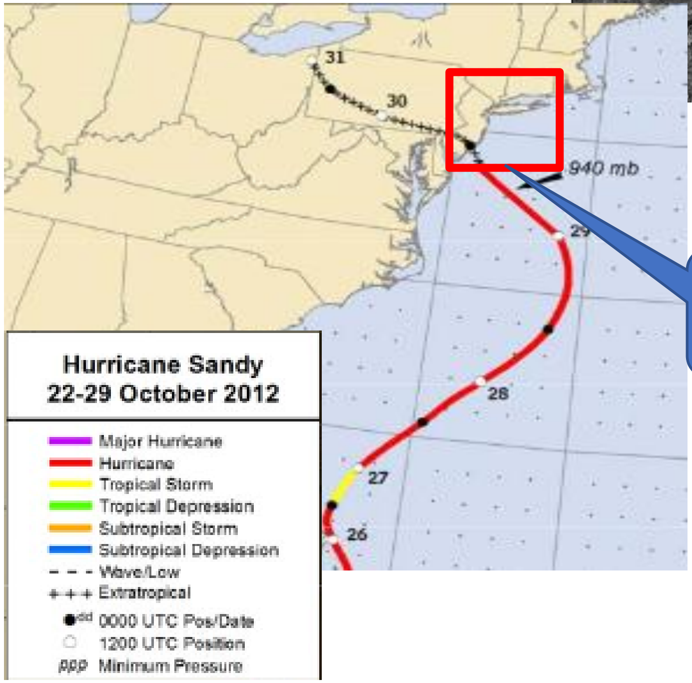
Piermont Marsh and Village (15 miles north of NYC)



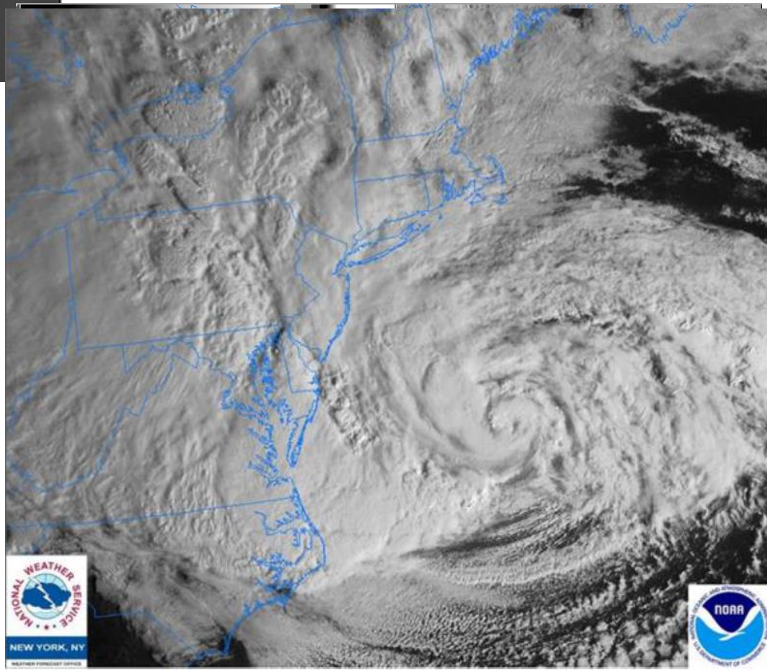
Local Scale

Superstorm Sandy (2012)

Huge Size (d=1100mi)
NJ Landfall
Cat 1
High Tide



Regional Scale



End User Engagement in Project Development

Project concept was identified, shaped and advanced by scientists, marsh managers, and community leaders in sincere collaboration, over many months, in public forums, and through much discussion.

January 2015 Forum on the Marsh's Role in Community Storm Resilience

Key Questions to be answered by this research

- What is the economic value of the buffering service the Piermont Marsh provide, now and in the future?
- How would Piermont Marsh’s buffering service change if marsh manager gradually restored vegetation in 20% of the marsh?
- How will Piermont marsh’s buffering capacity change as sea level rise?

Project Team

students

Principal Investigator

Peter Sheng
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University of Florida

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A. Rivera-Nieves

Ecologist

Christine Angelini
Assistant Professor
University of Florida

S. Sharp

Coastal Engineer

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Research Assistant Scientist
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Coastal Modeler

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Timothy Hall
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Ronald Busciolano
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Stakeholder

Edwin McGowan, Director of Science
NYS Palisades Interstate Park
Commission

Geophysicist
Stakeholder

Klaus Jacob
Appointed Representative
Piermont Waterfront Resilience
Commission

End User

Nathan Mitchell
Village of Piermont

Consensus Builder

Bennett Brooks
Senior Mediator
Consensus Building Institute, Inc.

Collaborative Lead

Heather Gierloff / Betsy Blair (former)
Reserve Manager
NYS DEC Hudson River NERR

Outreach/Education Lead

Emilie Hauser
Coastal Training Coordinator (retired)
NYS DEC Hudson River NERR

Project Manager
Lynn Vaccaro

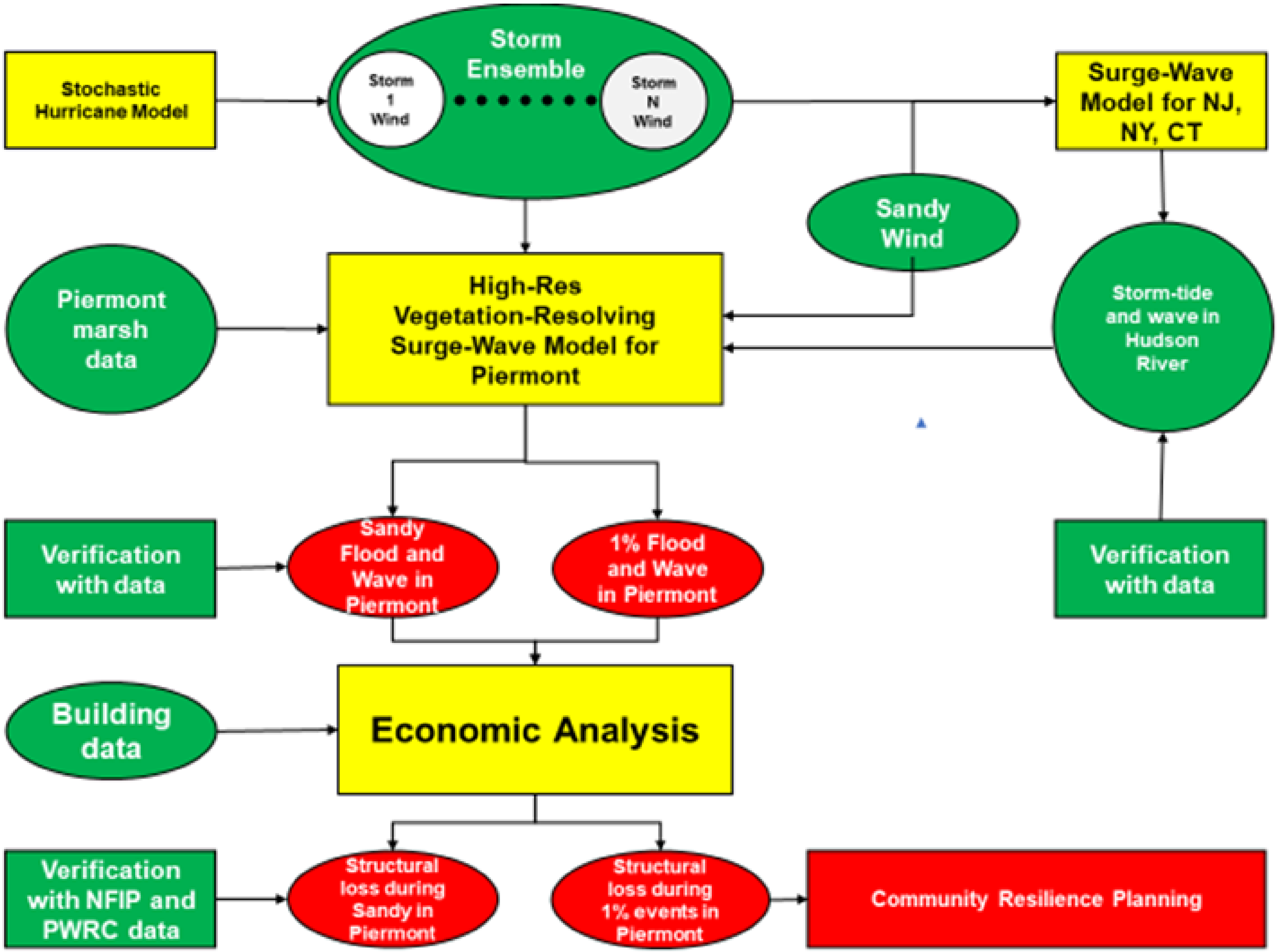
Research Coordinator

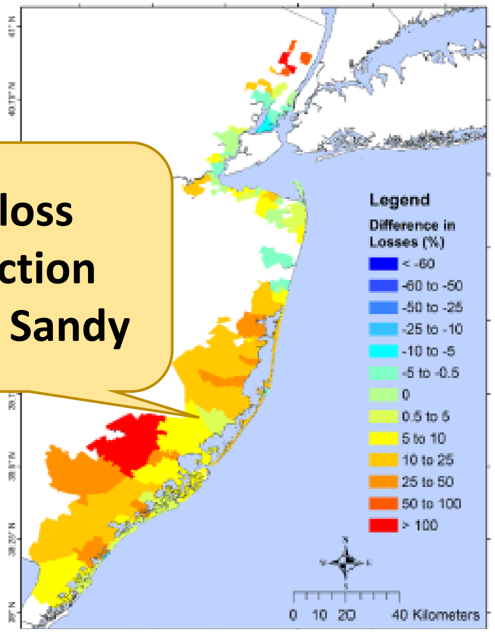
Sarah Fernald
Research Coordinator
NYS DEC Hudson River NERR

Integration of Dynamic Model Simulations with Extensive DATA

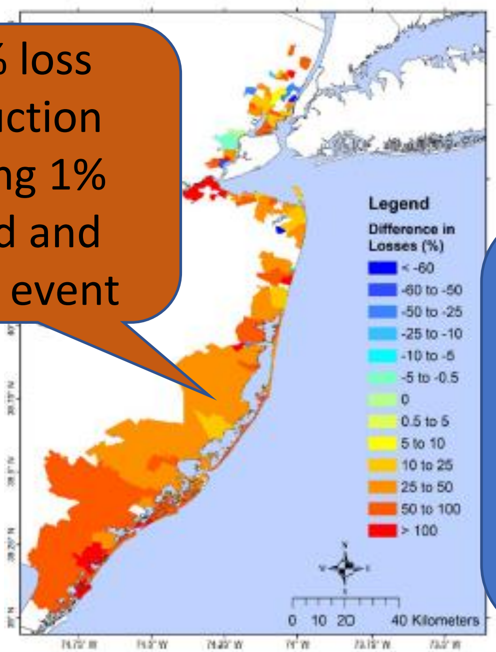
……….with a little bit of artificial intelligence

Data
Model
Product





8% loss reduction during Sandy



54% loss reduction during 1% flood and wave event

www.nature.com/scientificreports

scientific reports

http://rdcu.be/cgcuk/

Check for updates

Role of wetlands in reducing structural loss is highly dependent on characteristics of storms and local wetland and structure conditions

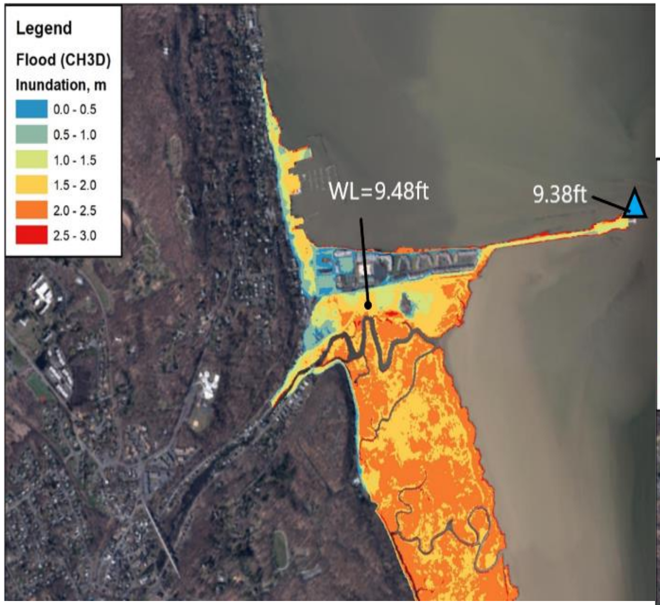
Y. Peter Sheng, Adail A. Rivera-Nieves, Ruizhi Zou & Vladimir A. Paramygin

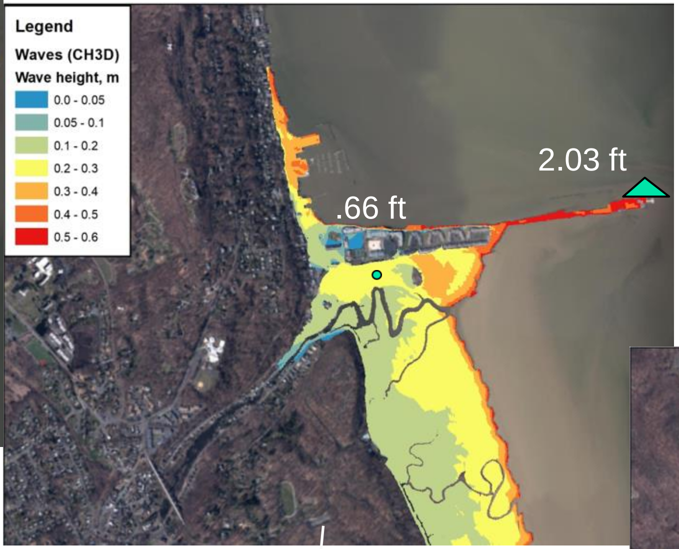
Relative loss = function of
(average wave crest, wetland coverage, at-risk property value)

on zip code level

What Happened to the Village during Sandy?

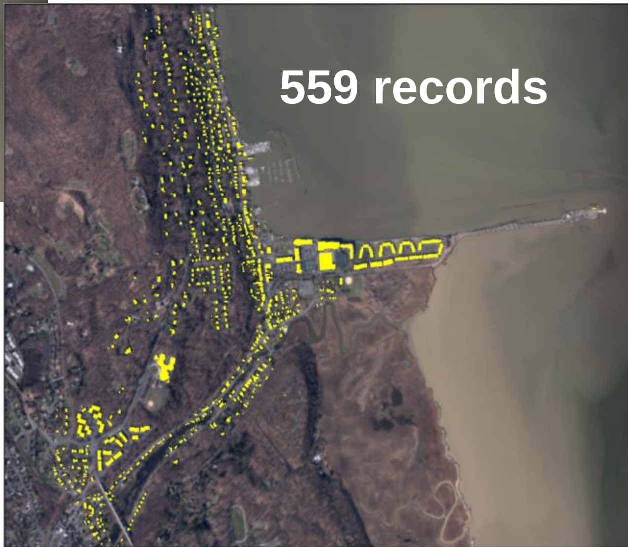
Maximum Flood Ht.



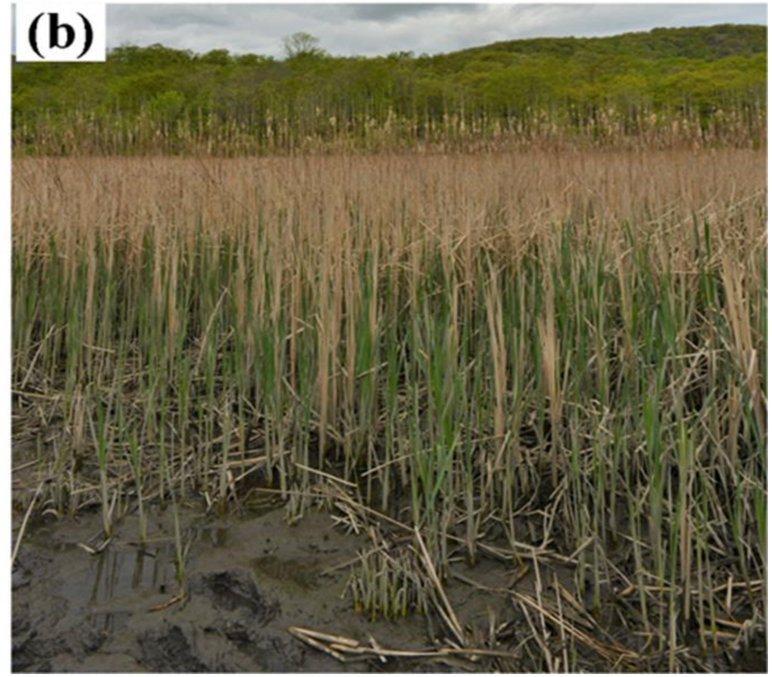


Maximum Wave Ht.

Residential Structures

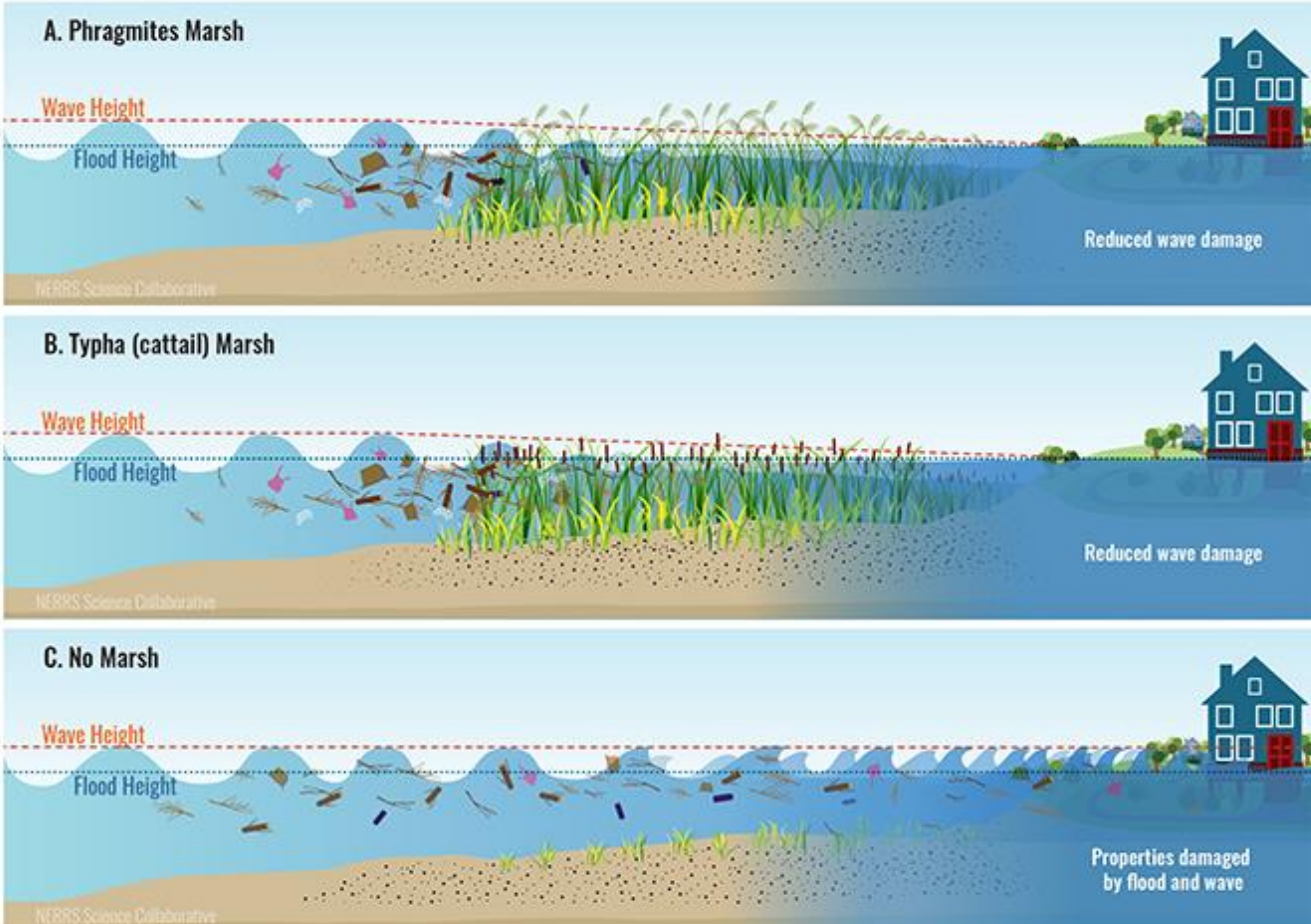


What if taller/rigid *Phragmites (a)* were replaced by shorter/flexible *Typha (b)*?



Marsh Buffering Capacity	Existing Phragmites (Common Reed) Marsh	Typha (Cattail) Marsh (Sept)	Typha Marsh (May)	No Marsh
Surge/Flood	<1%	<1%	<1%	nil
Wave	>2/3	>2/3	nil	nil
Current/Debris	100%	100%	nil	nil

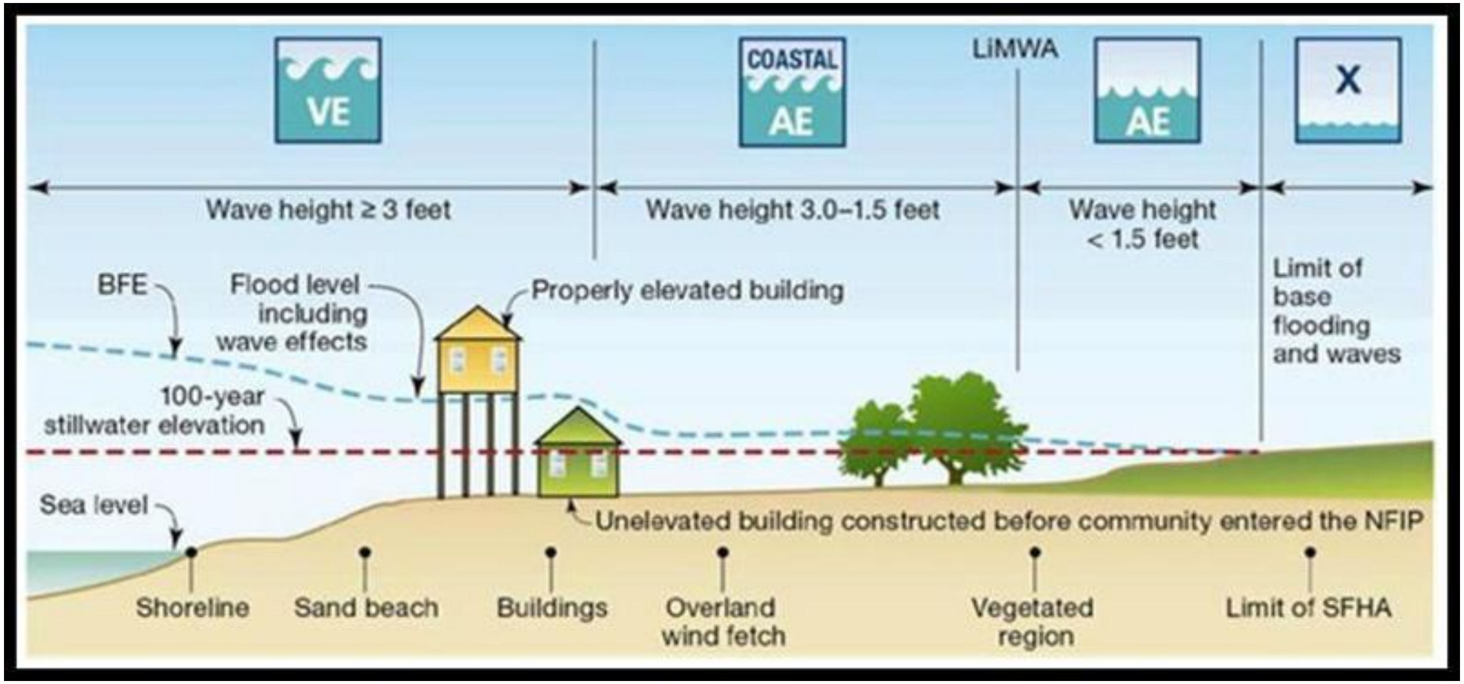
Piermont Marsh Buffered Wave and Debris but not Flood during Sandy



A. Phragmites Marsh
Wave Height
Flood Height
Reduced wave damage
NERRS Science Collaborative
B. Typha (cattail) Marsh
Wave Height
Flood Height
Reduced wave damage
NERRS Science Collaborative
C. No Marsh
Wave Height
Flood Height
Properties damaged by flood and wave
NERRS Science Collaborative

Key Questions…

- What was the structural loss of the Village due to flood and wave during Sandy? How did the estimate compare to FEMA NFIP loss payouts?
- How much additional damage would incur if Piermont Marsh were absent?
- Would the proposed potential marsh restoration and sea level rise impact the buffering capacity of the Village?



Flood and Wave can both damage buildings (FEMA)

Damage Assessment in a nutshell:

Calculate 1% flood elevation
Calculate 1% wave height
Calculate base flood elevation and wave crest
Find out which flood zone each house is in
Calculate damage to individual buildings due to flood and wave using damage functions developed by the USACE NACS

Invasive Phragmites Provides Superior Wave and Surge Damage Protection Relative to Native Plants During Storms

Sheng, Y.P., Rivera-Nieves, A., Zou, R., Paramygin, V., Angelini, C., and Sharp, S., ***Environmental Research Letters*, 2021** (online).

https://iopscience.iop.org/article/10.1088/1748-9326/abf288/pdf

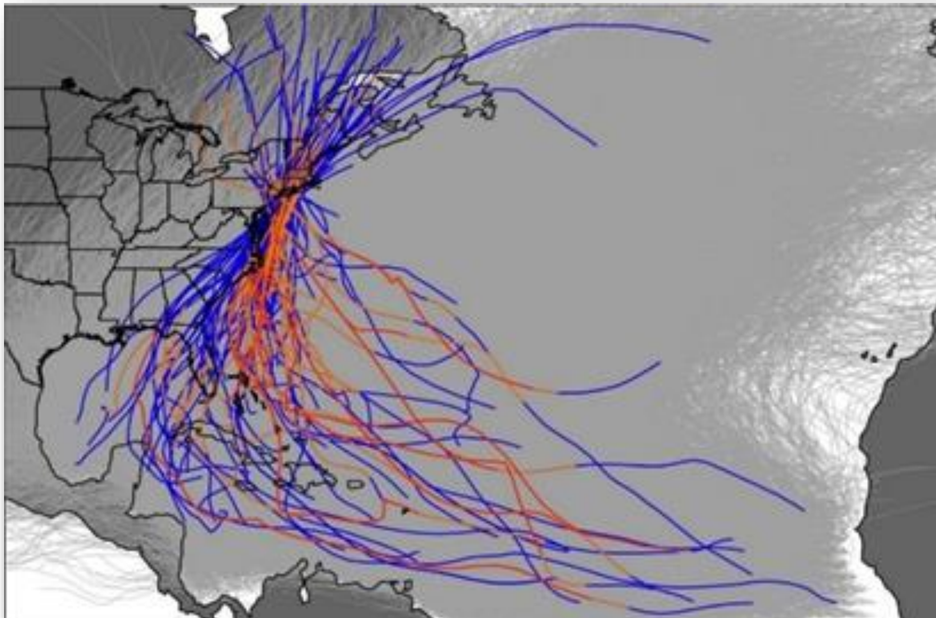
(Flood)	[illegible]	[illegible]	[illegible]6	0.001%
Structural Loss (Wave)	$1.11M	$1.67M	$563K	50.8%
Structural Loss (Flood+Wave)	$3.72M	$4.28M	$563K	15.1%

- **NFIP payouts $3.47M**
- **The Village avoided $563,130 in loss due to the presence of the Marsh**
- **Estimated loss compares well with NFIP loss payout**

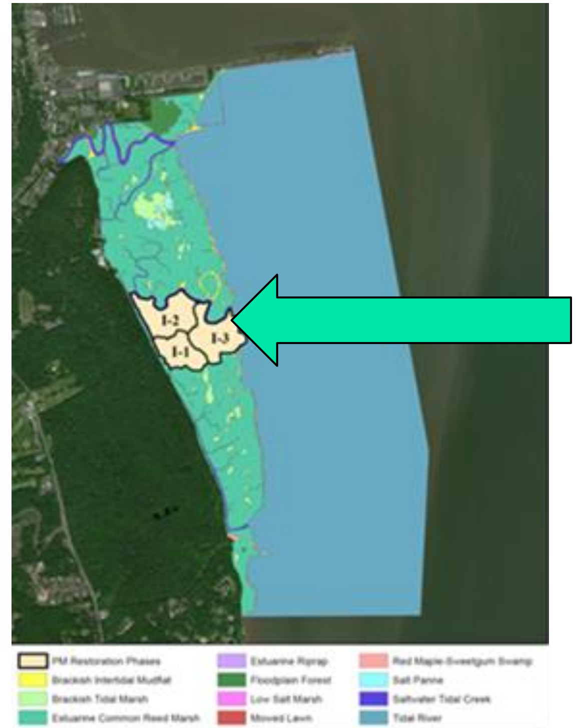
Parameters (All buildings)	Wetland Present	Wetland Absent	Avoided Loss	
Structural Loss (Flood)	$8.50M	$8.50M	$2,400	.0001%
Structural Loss (Wave)	$3.44M	$4.34M	$899K	26.2%
Structural Loss (Flood+Wave)	$11.9M	$12.8M	$902K	7.6%

- **PWRC(2014) estimated total loss ~ $20M (buildings, docks, marina, etc.)**

Coastal Resiliency Planning and Marsh Management cannot be based on Sandy

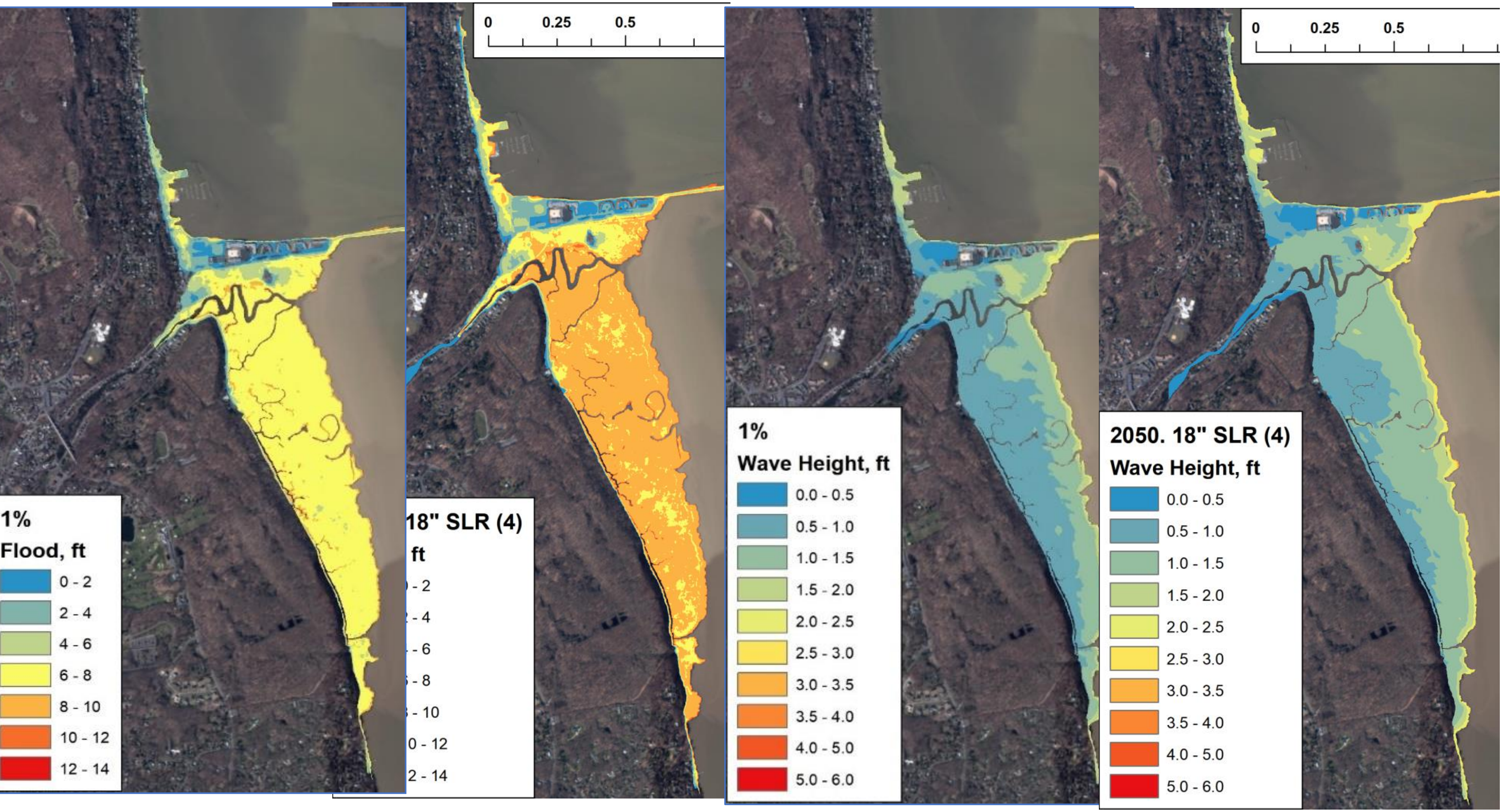


Storm ensemble predicted by Hall (2020)



40-acre hypothetical marsh management area *Phragmites* Replaced by *Typha* in phases

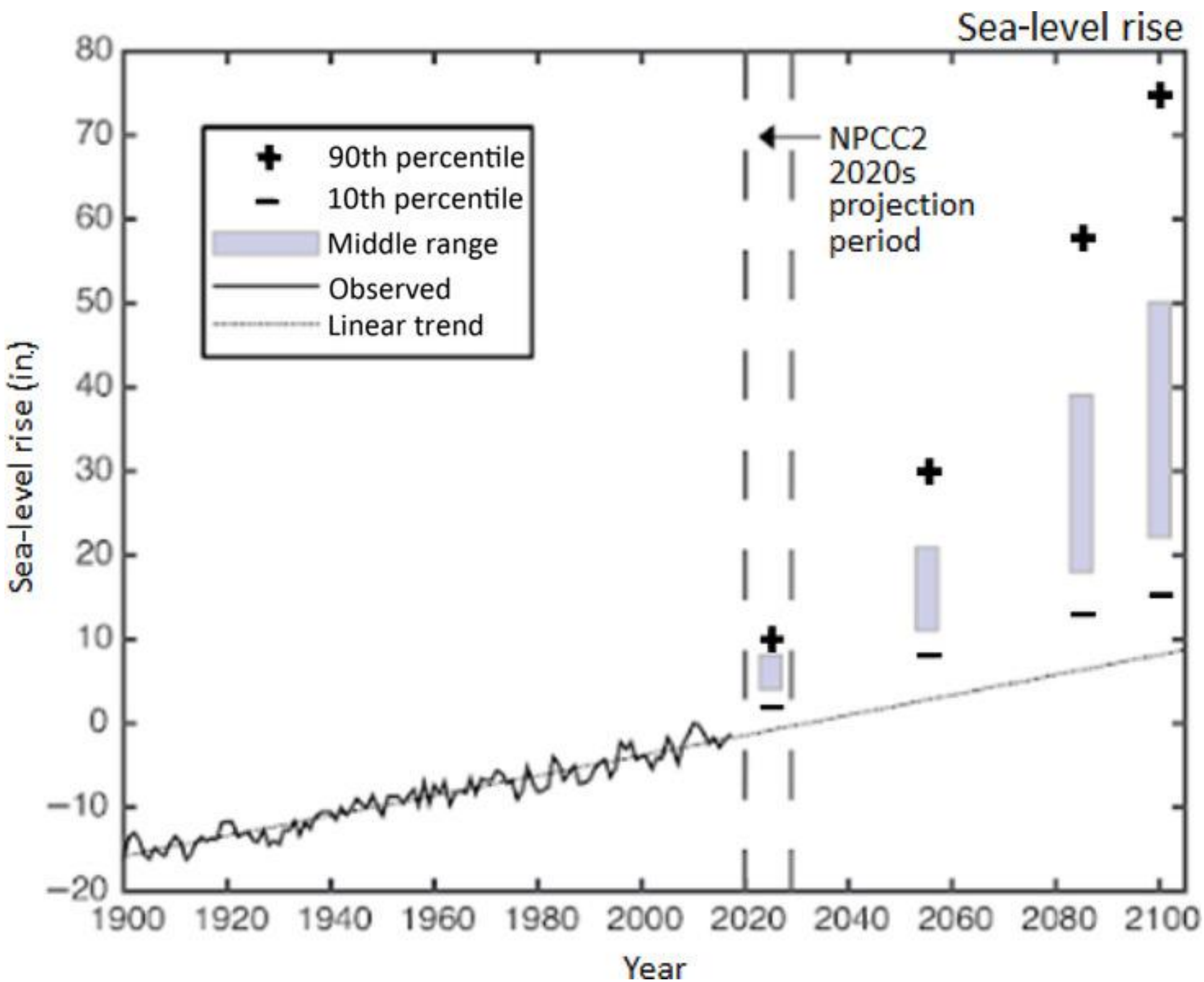
- Sandy is a 700-year storm which generated high surge tide and wave.
- The storm ensemble includes many less intense but more frequent storms which come in different sizes and from different directions.
- Each storm generate different flood and wave at the Marsh and the Village. In some storm with southeasterly wind, flood is buffered by the Marsh. In others like Sandy, wave is buffered by the Marsh.
- The cumulative effect of various storms generate the 1% annual chance flood and wave event in the Village.
- Coastal resiliency planning should be based on the role of Marsh in buffering flood, wave, and damage in 1% event.



1% Flood | 1% Flood w/ 18” SLR | 1% Wave | 1% Wave w/ 18” SLR

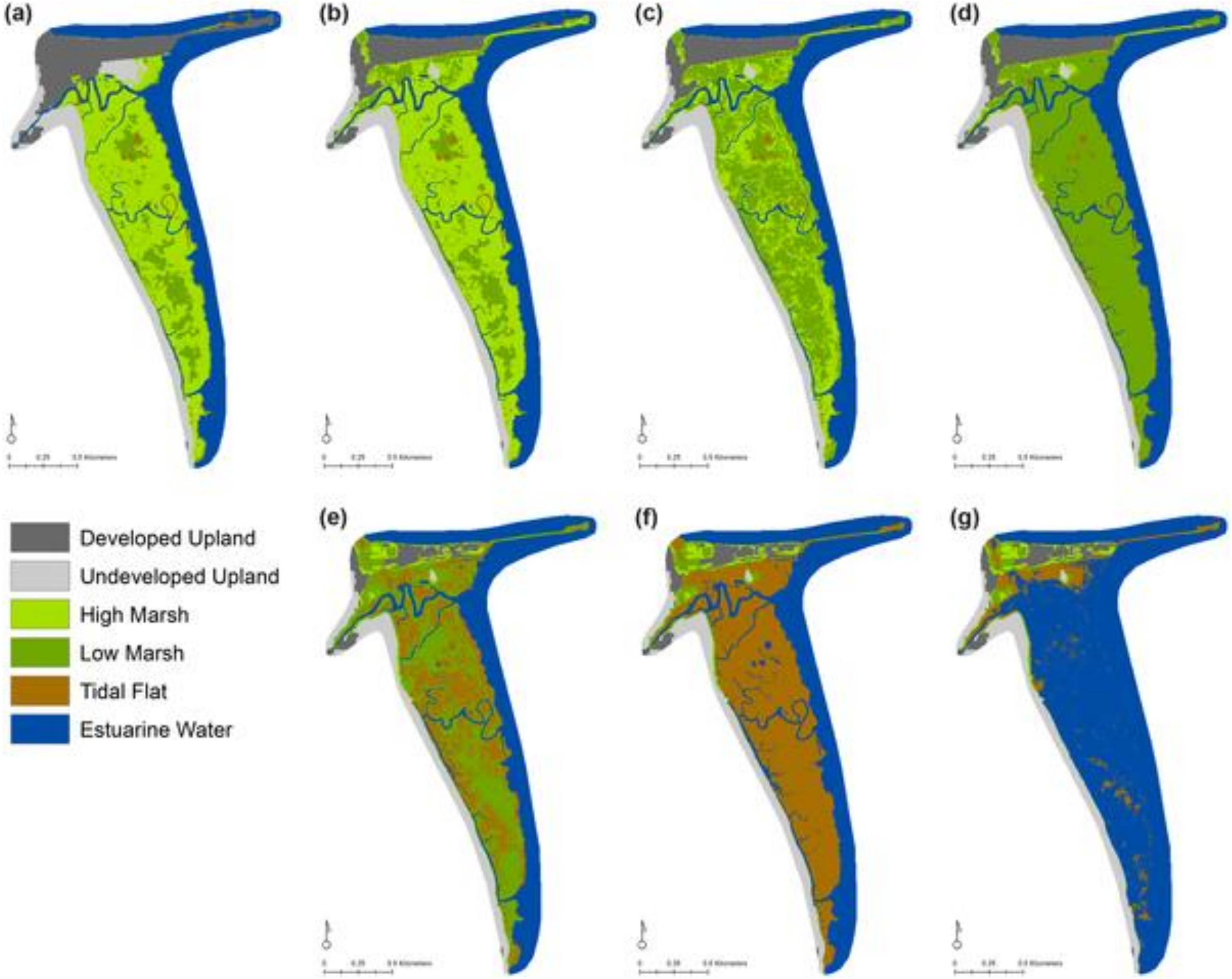
Future flood and wave will increase due to storms and SLR

Sea Level Rise at Battery (NPCC, 2019)



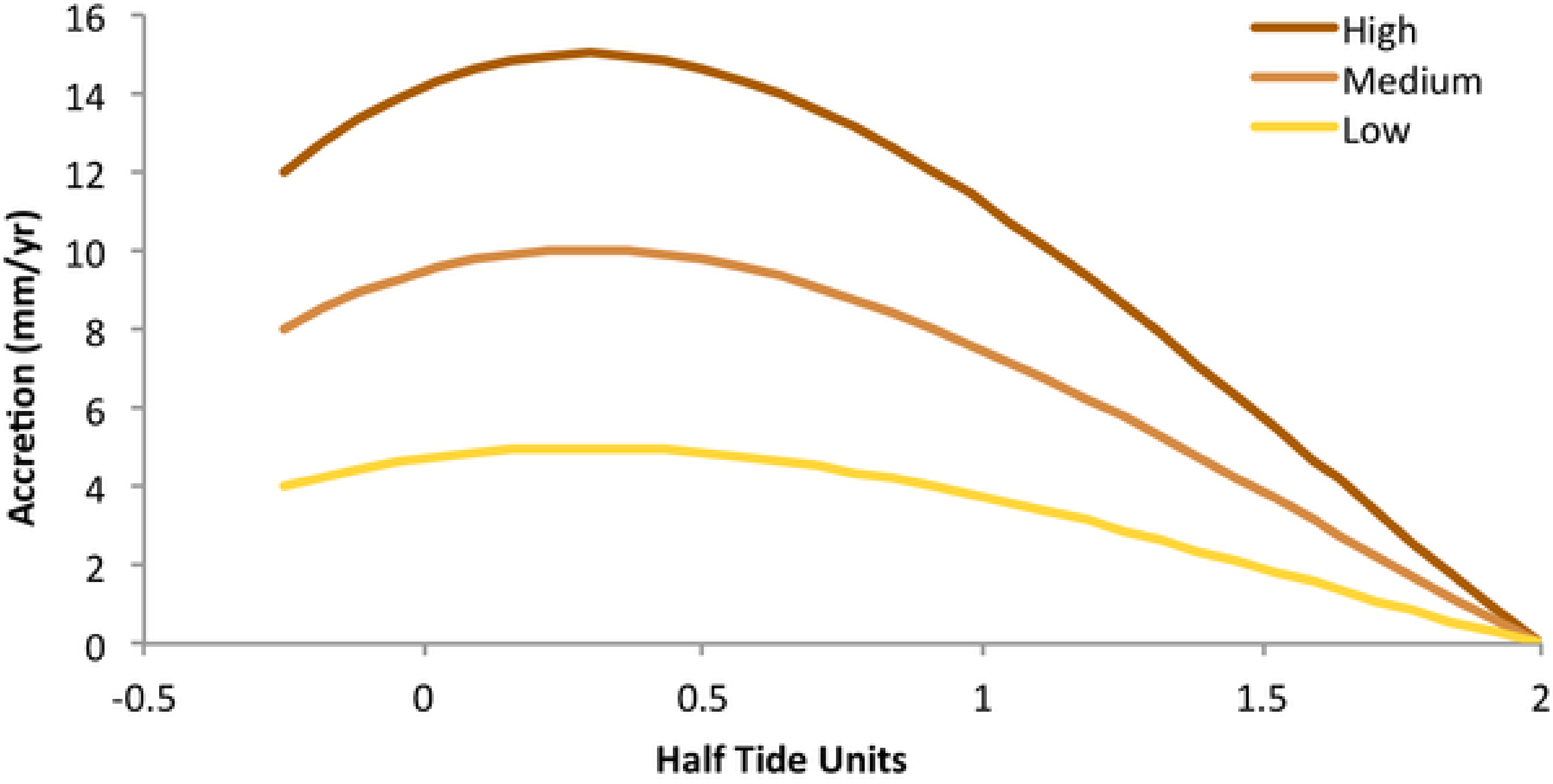
Projections for the Piermont Marsh tidal wetland area by 2100

(a) Time Zero (current conditions); MSLR with (b) HA, (c) MA, and (d) LA by year 2100; HSLR with (e) HA, (f) MA, and (g) LA by year 2100.



Tabak NM, Laba M, Spector S (2016) Simulating the Effects of Sea Level Rise on the Resilience and Migration of Tidal Wetlands along the Hudson River. PLOS ONE 11(4): e0152437. https://doi.org/10.1371/journal.pone.0152437
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0152437

The three generic accretion curves used to parameterize high, medium and low marsh accretion rates in SLAMM models.



Tabak NM, Laba M, Spector S (2016) Simulating the Effects of Sea Level Rise on the Resilience and Migration of Tidal Wetlands along the Hudson River. PLOS ONE 11(4): e0152437. https://doi.org/10.1371/journal.pone.0152437
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0152437

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.

Value of Piermont Marsh for Flood Protection

- Sandy:

$12.83M-$11.93M=$902,000→7.56%→$924,500/km^2 =$.90/m^2

- 100-yr Flood and Wave Event:

$20.95M-$18.82M=$2.13M→11.34%→$2.64M/km^2=$2.64/m^2

- 2050 100-yr Flood and Wave Event (18” SLR)

$31.70M-$28.13M=$3.57M→12.67%→$4.46M/km^2=$4.46/m^2

Summary

- Piermont Marsh buffered wave, current, and debris during Sandy, but surge (storm tide) and flood;
- Replacing Phragmites with Typha in the 40-acre area would not diminish the buffering capacity of the Marsh in Sandy;
- Structural loss during 1% surge & wave events will increase due to storms, SLR, and marsh loss in 21st century, but Marsh's value actually will continue to increase until overwhelmed by extreme SLR in 2100;
- Valuation of coastal marsh for flood protection requires integration of dynamic model results and extensive data over regional and local scales;
- To enhance the Piermont Marsh's buffering capacity, it is essential to ensure sediment supply and prevent marsh edge erosion;
- A Piermont Marsh Project (PMP) Geo Tool is developed to allow end user access for resilience planning.

Q&A

Q: Sarah, there have been a number of questions about why the Village was concerned about controlling *Phragmites* at the outset of the project. Could you explain their concerns and also share how Village residents and leaders are reacting to and using the new information?

- **A:** The Village keenly felt the impacts of Sandy. People could see how the debris was trapped in the marsh, and how the *Phragmites* protected them. When they heard we were looking to manage it, they were very concerned about their homes and they passionately responded and engaged with us.

Q: Why does the management plan include replacing *Phragmites* with *Typha*, instead of *Spartina*?

- **A:** The original plan was to remove the *Phragmites* and let the native seedbank return. There wasn't a plan to plant one species over another - the assumption was that removal of the *Phragmites* would allow the native *Typha angustifolia* to return because this was the result after similar *Phragmites* management at Iona Island..

Q: Is a 1% event the same thing as a 100-year flood or storm?

- **A**: The term "100-year flood" describes a flood that statistically has a 1-percent chance of occurring in any given year ([The 100-year Flood, USGS]). However, a 100-year flood is not the flood generated by a 100-year storm. Sandy, a 700-year storm, generated flood and waves which are more severe than the 100-year flood and waves. A 100-year flood is not produced by a 100-year storm, but an ensemble of storms which are more frequent but less intense than Sandy.

Q: Have there been comparisons of wave attenuation between robust plants (*Phragmites*) and smaller native plants other than cattail?

- **A:** Yes we have simulated the wave attenuation by different vegetation. The results may appear in a forthcoming paper.

Q: Are the cattails that were used for comparison native, or invasive cattails? And, Is there any evidence that *Typha* would be better than *Phragmites* in terms of buffering ability?

- **A:** The simulation used native *Typha* from nearby Iona island. By nature, *Typha* is shorter, sparser, and more flexible; as a result, it's not as capable of buffering waves and floods. In the case of Iona island, the *Typha* were pretty tall and could buffer quite a bit of wave energy. *Typha* is generally less desirable because it's more seasonal, becoming lower and sparser in non-growing seasons while *Phragmites* remains tall and dense throughout the year, providing continuous buffering capacity.

Q: What is edge stabilization?

- **A:** That's a small-scale pilot project we're working on at the moment, covering about 500 feet from the edge of marsh to the river's edge. The project is assessing different stabilization techniques to see what will be most effective for the dynamics of the edge of Piermont Marsh, quantifying how it's going to fill in, if there's carbon stored behind it, etc.

Q: How intensive is the modeling that you did for this project? Would it be feasible to run it for a larger area (e.g. the entire U.S. coast) at regular intervals, or would that be prohibitively expensive?

- **A:** For this study, we used regular desktop PCs to compute three-dimensional, vegetation-resolving, surge-wave models with 4-meter horizontal grid resolution in Piermont, but 30-meter resolution in the regional scale simulating the New Jersey and New York coasts. It is feasible to do a similar study for the entire U.S. East coast, if we have adequate wetland data, and sufficient computing resources (i.e. thousands of processors performing computations). We can use 30-meter resolution over regional scale and 4-meter resolution in selected areas with important wetland footprints. It is a question of time and money, but the cost should not be prohibitive.

Q&A

Q: There have been a few questions about the range of ecological services provided by different plants. Do the different plants under consideration have other ecosystem services such as carbon sequestration that might also add to the marsh value?

- **A:** Based on the literature, our understanding is that *Phragmites* has superior carbon sequestration capabilities. Carbon sequestration is something HRNERR is actively exploring, but we do know that the habitat quality of *Phragmites* is slightly lower than some of the other species such as cattail; e.g. breeding birds, foraging wildlife, fish species that can access the interior of the marsh. However, it should be noted that literature also showed many benefits of *Phragmites* marsh.

Q: Have you modeled the buffering capability of mangroves vs no wetlands in warmer climates (e.g., Florida)?

- **A:** Peter has a current NOAA-funded project exploring that issue in southwest Florida from the perspective of future flood risk and the role of mangroves in buffering damage from storm-induced waves and flooding. They found that during Hurricane Irma in 2017, mangroves helped to reduce approximately $13 million flood damage in Collier County. The damage reduction is more for a 1% flood and wave event.

Q: Does the marsh modeling account for stem bending? Also, do you have modeling that captures the seasonality effect on drag for Typha or Spartina that could affect buffering efficacy for winter storms?

- **A:** We did not include bending of the marsh or effects of wind in the model presently. I do have a PhD student doing a dissertation on the damage on mangroves by wind during storms. Our understanding is that during Sandy, the rigid *Phragmites* marsh did not sustain significant damage by wind.

Q: In addition to marsh vegetation height and stiffness, what other marsh attributes were important in the models to determine the marshes buffering ability?

- **A:** We use a three-dimensional vegetation-resolving surge-wave model to simulate the effect of vegetation on surge and wave. Before running the model, we transform several measured vegetation attributes - e.g. height, stem density, leaf area, debris, stem diameter - into two parameters which we need in the model: profile area and wetted area (averaged over the 4m x 4m grid) which generate profile drag and skin friction drag on the flow and wave.

Q: If you eventually find that the marshes aren't keeping up, will you consider using thin layer deposition to increase their elevation? This is showing promise in New Jersey.

- **A:** We have collaborated with people in NJ on their TLP projects. We had a small capacity building project to explore that in our area. The Hudson River is a Superfund site and our sediment is contaminated, so depositing locally dredged sediment on the marshes would be a permitting issue. It is something we might consider in the future if our sediment supply is severely lacking.

Q: Was it a SLAMM (Sea Level Affecting Marshes Model) model that was used to simulate vegetation changes with sea level rise? If not, what did they use?

- **A:** We didn’t really use the SLAMM model results except for the year 2100 prediction. According to the SLAMM estimate, the marsh is completely drowned due to the high sea level rise and low accretion rate.

Q: You spoke about edge stabilization, but what about sediment supply? How does one ensure sediment supply and prevent marsh edge erosion?

- **A**: Sediment supply to Piermont comes from the main stem of the Hudson. There is one tributary to this marsh, but the mouth of it is at the very northern edge near the village, and that sediment supply goes directly into the Hudson River. The source of sediment is then going to be inundation of the marsh. Over time as sea level is rising and storms are expected to increase in severity, sediment deposition is predicted to increase with rising waters.

Additional resources from the presenters

- Courtney, S., E.B. Watson, and F. Montalto. 2020. Is sea level rise altering wetland hydrology in Hudson River Valley tidal marshes? Section I: 1-34pp. *In* S.H. Fernald, D.J. Yozzo and H. Andreyko (eds.), Final Reports of the Tibor T. Polgar Fellowship Program, 2020. Hudson River Foundation.
- Montalto, F.A., T.S. Steenhuis, and J.Y. Parlange. 2006. The hydrology of Piermont Marsh, a reference for tidal marsh restoration in the Hudson river estuary, New York. Journal of Hydrology 316: 108-128.

See Webinar Resource summary page for PDFs

Comments

- Phragmites *can actually promote accretion and foster elevation gain for wetlands which can help marshes keep up with sea level rise.*
- *The avoided damage information would be great to include in emerging natural capital accounts if it were possible to expand and repeat this type of modeling.*
- Phragmites *also absorbs more CO_2 and N reducing the amount of eutrophication and climate change.*