Thin-Layer Sediment Placement: Evaluating an Adaptation Strategy to Enhance Coastal Marsh Resilience

Project Location

East Coast
West Coast

Project Duration

November 2017 to October 2019

Project Lead

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Project Type

Collaborative research – Generating science that informs decisions

Project Partners

- Chesapeake Bay – Maryland National Estuarine Research Reserve
- Chesapeake Bay – Virginia National Estuarine Research Reserve
- Drexel University
- Elkhorn Slough National Estuarine Research Reserve
- Great Bay National Estuarine Research Reserve
- Narragansett Bay National Estuarine Research Reserve
- North Carolina National Estuarine Research Reserve
- Roca Communications, LLC
- San Francisco National Estuarine Research Reserve
- Waquoit Bay National Estuarine Research Reserve

Project Webpage

nerrssciencecollaborative.org/project/Raposa17

Overview

Tidal marshes provide key ecosystem services, but are threatened by sea level rise. For these ecosystems to survive, it will require active management to increase tidal marsh resilience. Researchers at the Narragansett Bay and Elkhorn Slough National Estuarine Research Reserves recently led the first national assessment of tidal marsh resilience to sea level rise to monitor coastal reserve sites across the continental United States. In this project, the group took the next step to test a strategy that can enhance tidal marsh resilience. Thin-layer placement is an emergent climate adaptation strategy that mimics natural deposition processes in tidal marshes by adding a small amount of sediment on top of marsh in order to maintain elevation relative to sea level rise. It is one of the only viable strategies to protect tidal marshes in their current footprint.

This project conducted coordinated restoration experiments at eight National Estuarine Research Reserves across the East and West Coasts to test the use of thin-layer placement across diverse marsh plant communities. The team assessed the impact of elevation, sediment type, and layer thickness on the success of this marsh adaptation technique. Greenhouse experiments exploring the effect of sediment texture and the addition of biochar as a soil amendment complemented these field studies. To support future use of thin-layer placement, an advisory committee of coastal managers at state and federal agencies and nonprofit groups worked with the project team to develop a suite of guidance documents. These included a consensus statement on thin-layer placement in tidal marsh ecosystems that synthesized the state of knowledge about thin-layer placement, guidance to navigate the permitting process, and universal metrics to track the success of thin-layer placement projects. Together, these project outcomes represent significant progress toward a national framework to enhance tidal marsh resilience through broadly applicable adaptation strategies.

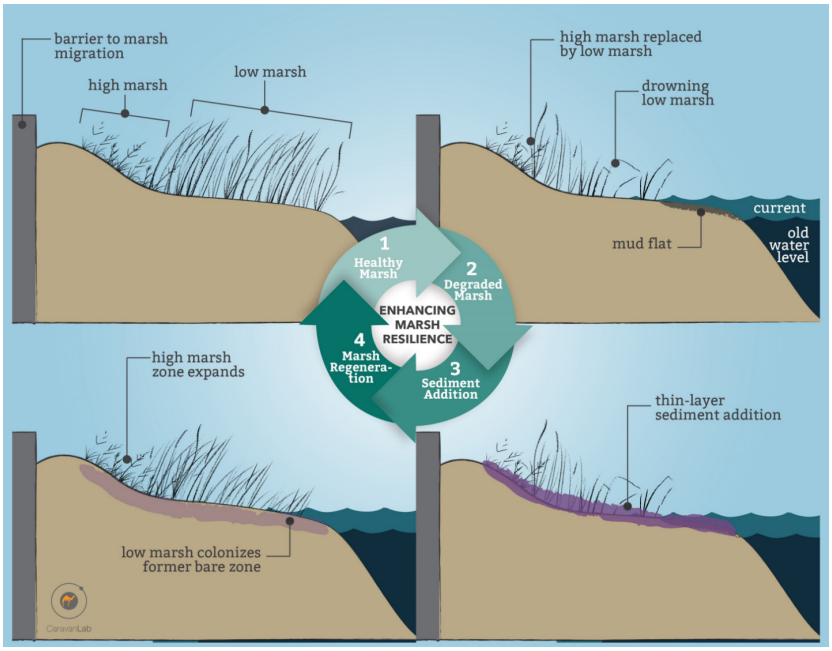
Project Approach

The project grew out of extensive existing relationships between reserve scientists and end-users and prior knowledge about the needs of coastal managers. An advisory committee provided formative feedback at every stage, from experimental design to the drafting of guidance documents. The National Estuarine Research Reserve System was an ideal platform for tidal marsh field experiments because of the consistent monitoring regime already in place across the system and reserve scientists' prior experience synthesizing data across broad spatial scales and multiple diverse sites.

Coordinated field experiments at eight National Estuarine Research Reserves tested marsh response to sediment addition based on two factors: marsh elevation and sediment thickness. These experiments were designed to help end-users determine if thin-layer placement can help reestablish low marsh recently degraded by sea level rise, or shore up high marsh communities being overtaken by migrating low marsh species. Monitoring of marsh vegetation, elevation, and sediment properties was conducted before and after sediment addition in experimental and control plots, as well as reference points representing desired healthy marsh conditions. Two levels of sediment thickness were tested—seven centimeters and 14 centimeters of added sediment—sourced from local quarries and amended with 10 percent local mud. Three reserves incorporated biochar amendments into their experiments, and two reserves used sediments dredged from local waterways.

Greenhouse experiments at Drexel University examined how different sediment textures (held fixed in field experiments) might affect plant growth for three common marsh species, and whether adding biochar could boost carbon sequestration or moderate pH. Marsh plants representing different regions were grown in four sediment mixes made up of different proportions of clay, silt, and sand.

Project findings were shared extensively within and beyond the National Estuarine Research Reserve System through a series of presentations, conference talks, workshops, webinars, and public meetings from 2017 to 2020.



How thin-layer placement of sediment supports tidal marsh resilience.

Results

Detailed research findings from the project's extensive field experiences are available in an upcoming journal article. A few key take-aways related to the project's core research questions are highlighted below.

Is sediment addition an effective adaptation strategy for marshes in the face of sea level rise?
The project found that sediment addition is largely effective at raising tidal marshes. Treated marshes generally maintained their elevation, keeping pace with sea level rise, or experienced some gradual elevation loss. However, field experiments did not show vegetation cover of desired marsh species recovering as quickly or extensively as hoped. None of the reserves reached their desired plant cover by 15 months after sediment addition. Monitoring continued for an additional year following the end of the grant to determine if marsh recovery improved over a longer period of time.

How does marsh resilience respond to different levels of sediment addition?
Vegetation cover recovered rapidly after sediment addition. Marsh plants began recovering more quickly, within just a couple of months, with the application of seven-centimeter sediment layers. However, after 15 months, vegetation cover was the same for seven- and 14-centimeter sediment treatments. Based on these results, restoration projects would be advised to use thicker sediment layers to gain as much height as possible.

The greenhouse experiments found that sediment texture can be an important factor. Plant biomass generally increased as sediments became coarser (with the exception of Spartina alterniflora, for which sediment texture did not appear to significantly impact plant growth). This suggests coarser sediments were better drained and oxygenated than fine sediments, leading to healthy marsh. This is good news for TLP projects, which generally rely on the addition of sediments that are more sandy than ambient marsh soil.

How do low versus high marsh habitats differ in their response to this restoration strategy?
Tidal marsh response varied greatly by geographic region and marsh elevation. Although revegetation happened soon after thin-layer placement in both low and high marsh, key species desired in each elevation zone generally did not return. This effect was more pronounced in high marsh habitats. High marsh plots that received sediment additions were largely repopulated by low marsh plants, and cover of desired high marsh species was lower than in control plots.

Taken collectively, these research findings suggest that the risks of thin-layer placement should be weighed against its long-term benefits. Thin-layer placement is best used to promote the long-term sustainability of tidal marsh, but this may involve a tradeoff with short-term vegetation cover. Thoughtful temporal and spatial planning (such as mosaics of bare and vegetated areas) can help mitigate these risks. Given the striking variation in results, coastal managers should also pay close attention to local conditions and avoid generalizing across regions.

Products

- *Guidance for TLP sediment placement*, including the following elements:
  - Consensus statement on thin-layer placement in tidal marsh ecosystems that summarizes the state of knowledge about thin-layer placement, calls for further restoration research to test its effectiveness, and makes recommendations for its use
  - Literature review of thin-layer placement for tidal marsh resilience in the continental United States
  - Permitting memo that outlines a sequence to navigate the permitting process, a table showing permits needed, and recommendations to streamline future permitting
  - Monitoring guidelines that provide universal metrics for restoration success
- Outreach materials, including a *summary brochure, webinars* and presentations, and a *project webpage*
- Upcoming journal article detailing research findings

Benefits

- Coastal managers, restorationists, funders, and policymakers gained a national framework to enhance coastal resilience through thin-layer sediment placement, summarized by an authoritative national consensus statement.
- Local and regional coastal managers and restoration groups have access to a suite of guidance tools and regionally-specific research findings to improve the effectiveness of future sediment addition projects.
- Future thin-layer placement projects can draw on standardized restoration targets and monitoring. This will allow researchers to expand the body of knowledge on sediment addition as a marsh adaptation strategy, and help regulators and funders better understand the criteria that lead to project success.

What's Next

- One additional year of planned field monitoring of project sites will take place in late summer/early fall 2020.
- The project team is continuing statistical work with field data that will be included in a peer-reviewed publication. An additional journal article is in development to share results from Beth Watson's greenhouse experiments.
- Presentations are planned for multiple conferences in 2020.

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**.