

Opportunities to Integrate Carbon Dioxide Removal with Coastal Resilience Projects

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Motivation

United States' coastlines support dense populations, vital ecosystems, and major economic activity, yet are increasingly threatened by sea-level rise, erosion, flooding, and compounding climate-driven disasters. At the same time, growing investment in coastal resilience infrastructure creates a timely opportunity to pair adaptation with carbon dioxide removal (CDR), delivering dual climate benefits. **This work is motivated by the potential to integrate abiotic marine CDR directly into widely deployed resilience strategies, such as living shorelines, ecosystem restoration, and stormwater management, using materials and systems already central to coastal protection.**

Pathways

Living shorelines

HOW GREEN OR GRAY SHOULD YOUR SHORELINE SOLUTION BE?

GREEN - SOFTER TECHNIQUES GRAY - HARDER TECHNIQUES

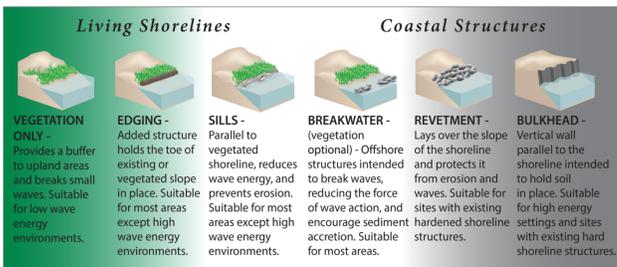


Figure 1: Living shorelines. Strategically placing materials (e.g., shellbags, rocks, and dunes) can improve coastline resilience to erosion and extreme weather. Many living shoreline designs integrate sand and gravel to enhance shoreline stabilization. Including alkaline-rich sediments can remove carbon from the atmosphere and lock it away in the ocean.

Figure credit: NOAA

Ecosystem restoration

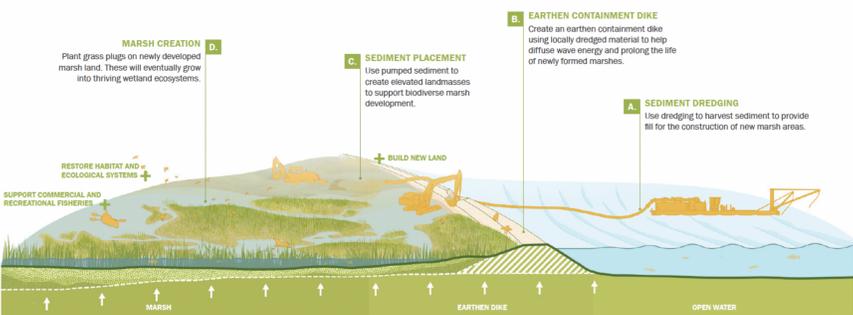


Figure 2: Ecosystem restoration. Organic-rich marshes help to decrease wave energy thereby mitigating coastal flooding. They are great environments to facilitate the breakdown of carbon-absorbing material in addition to naturally generating alkalinity. In many states, the use of sediment on the marsh, or thin-layer placement, is used in restoration projects to combat rising sea level. Alkaline material can be used in this process to enhance the amount of carbon taken up by these organic systems.

Stormwater management

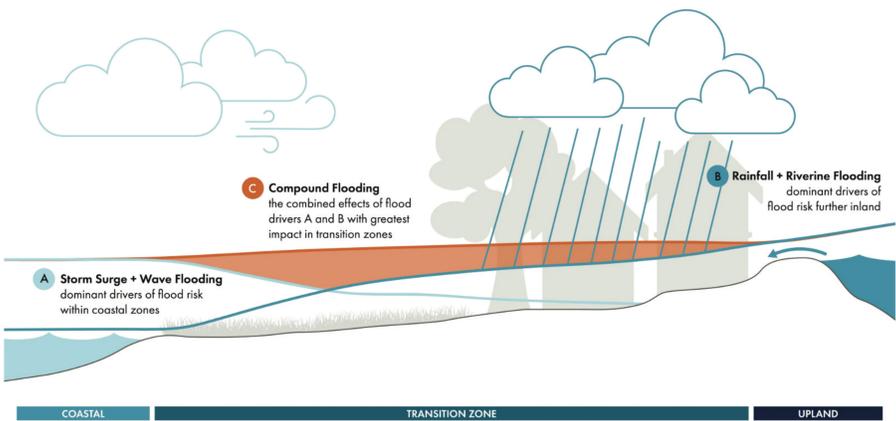
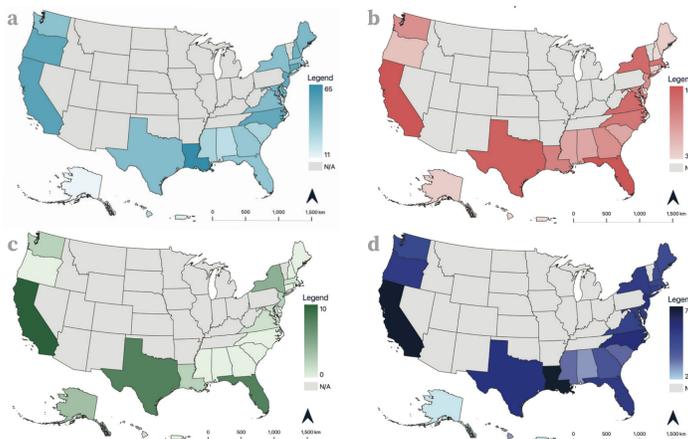


Figure credit: The Water Institute

Figure 3: Stormwater management. Coastal flooding from sea level rise is compounded with increasingly large rainfall events in many coastal states. Pump stations, retention tanks, wet-weather treatment trains, existing combined sewer overflow infrastructure, and new green infrastructure all help to combat compound flooding. This infrastructure can be used to add alkaline materials to stormwater in a contained, measurable system.

Scope

Figure 4: Geographic scope. Distribution of the weighted scores, where a) is the policy-focused criteria only, b) is the need and capacity criteria only, c) is the economic and geographic criteria only, and d) are the compiled weighted scores. The weighted scores were used as a means to focus the scope of the roadmap on illustrative examples.

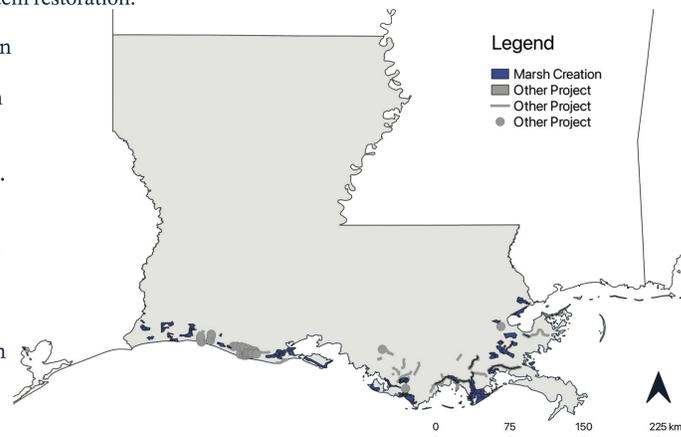


Case Studies

Louisiana

Pathway highlight: ecosystem restoration.

Figure 5: Geospatial distribution of 23 proposed coastal marsh creation projects, selected from a portfolio of 77 restoration projects associated with the state's 2023 Coastal Master Plan. The USGS equates land loss in Louisiana in recent years to a football field-worth of wetlands disappearing into water every 100 minutes, therefore marsh creation projects are a key element of the state's ecosystem restoration portfolio.



California

Pathway highlights: living shorelines and stormwater management*.



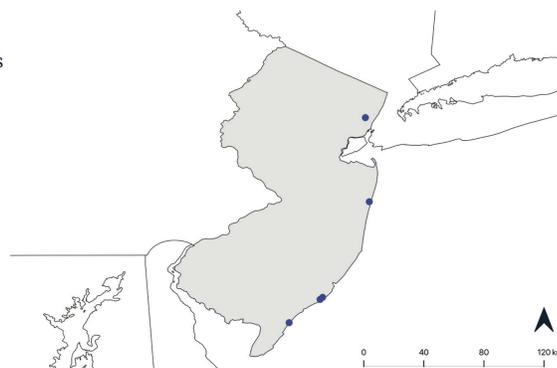
Figure 6: Twenty-five dune restoration projects across California recorded by the California Coastal Dune Science Network. While living shorelines are often implemented in protected environments, California's coastal dune systems function as living shorelines along much of the coastline. Further inland, increasing plant cover forms dune mats and foredunes often dominated by grasses and perennial species that enhance sediment retention and stability.

*Stormwater management integrations are not demonstrated visually on this poster, but discussed in depth in the roadmap content.

New Jersey

Pathway highlights: living shorelines and stormwater management.

Figure 8: Current mapping tools highlight 11 living shorelines in the New Jersey area. Adapted from New Jersey Department of Environmental Protection. The agency notes they have permitted over 200 nature-based solution projects with 50-60 of them meeting the definition of a living shoreline. These projects utilize sand and other sediment to secure their structures, grade the area, or create new habitat, which is an opportunity to incorporate alkaline material.



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North Carolina

Pathway highlights: living shorelines* and ecosystem restoration.

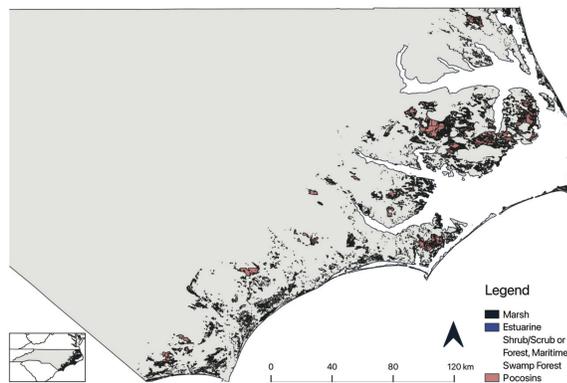


Figure 7: Subset of areas in North Carolina's coastal counties that are suitable for restoration. This figure includes marsh (salt or brackish), estuarine shrub/scrub or forest, maritime swamp forest (vegetated areas generally near high tide), and pocosins (habitats between stream divides). Data from the North Carolina Department of Environmental Quality, who have created an online mapping tool to identify wetland restoration sites.

*NC living shoreline integrations are not demonstrated visually on this poster, but discussed in depth in the roadmap content.

Acknowledgements

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The completed roadmap is now published! Read it by scanning the QR code to the right.

