

Green is the New Black: Potential for natural and hybrid infrastructure to enhance ecosystem and community resilience

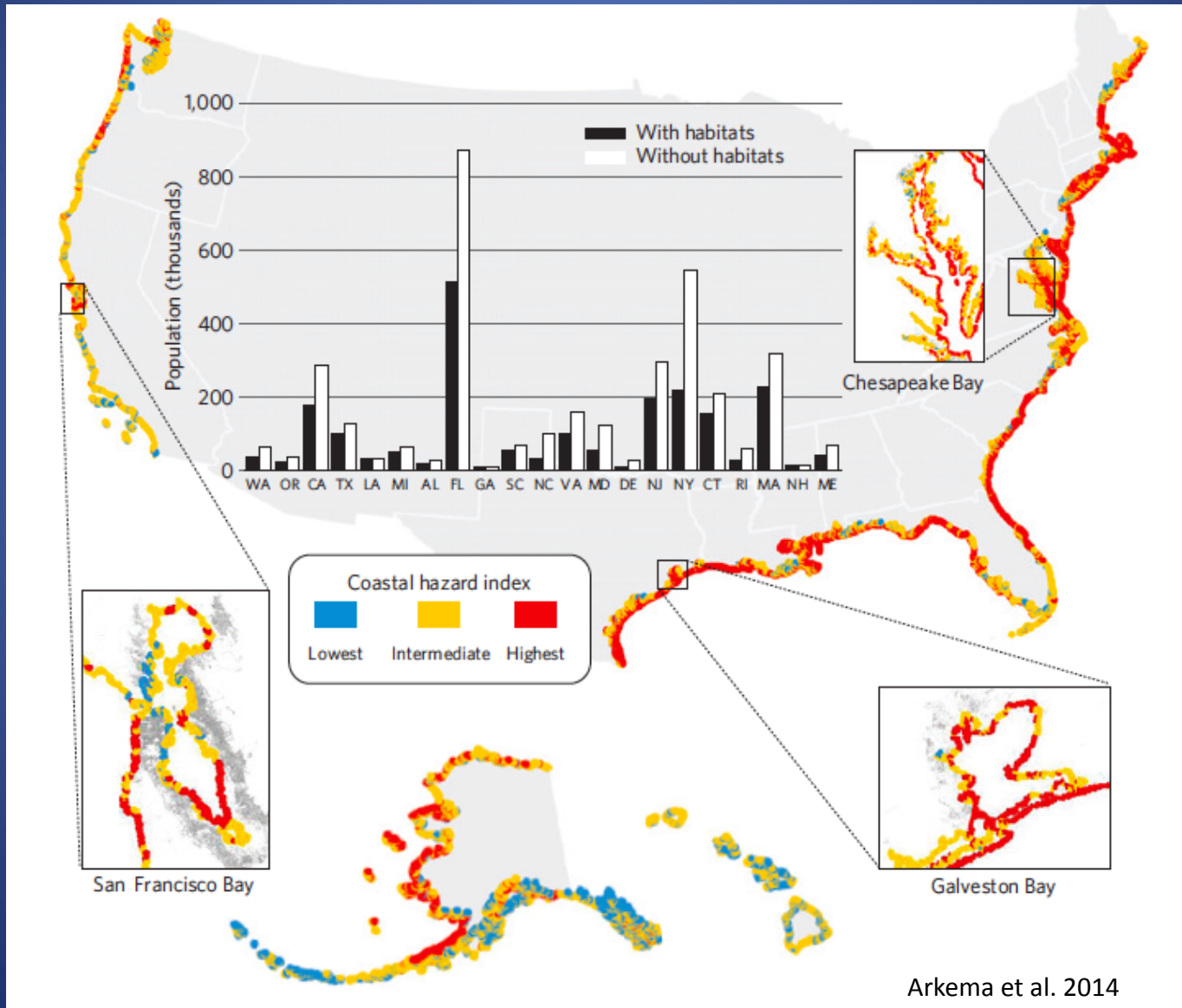


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Exposure of the U.S. coastline and coastal population to sea-level rise in 2100



Hurricane Sandy: A Turning Point?



Hurricane Sandy Task Force *Rebuilding Strategy*



On January 29, 2013 U.S. Congress passed the Disaster Relief Appropriations Act, 2013, which authorized \$50 billion for disaster relief agencies.

Funding required application of Infrastructure Resilience Guidelines to all federally-funded infrastructure projects (e.g., elevate one foot above the best available flood elevation data), and to:

- ✧ Provide technical assistance to help states and localities leverage disaster relief funding through public-private financing.
- ✧ Consider natural “green” infrastructure as a coastal hazard mitigation and stormwater management measure.

Gray (Built) Infrastructure

Sea Wall



Sea Wall and Riprap



Levee



Dike



Natural Infrastructure

Salt Marsh



Coral



Mangrove



Oyster

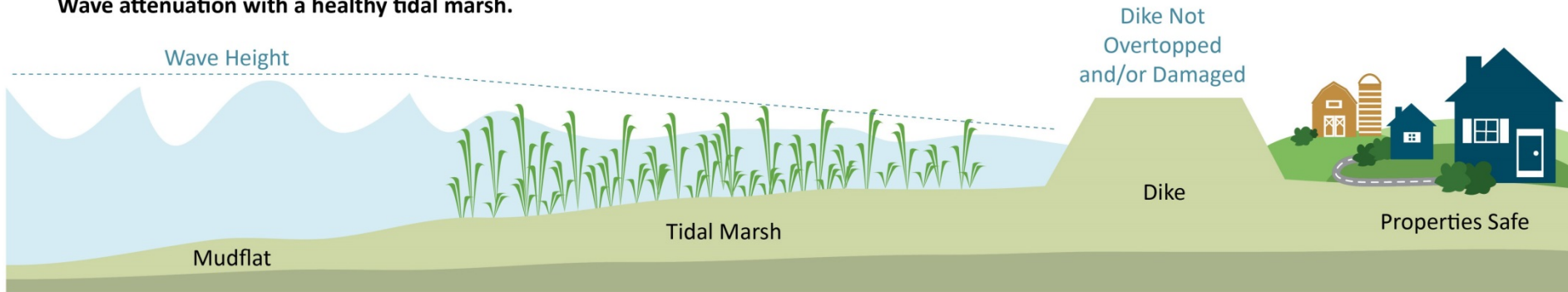


Dunes

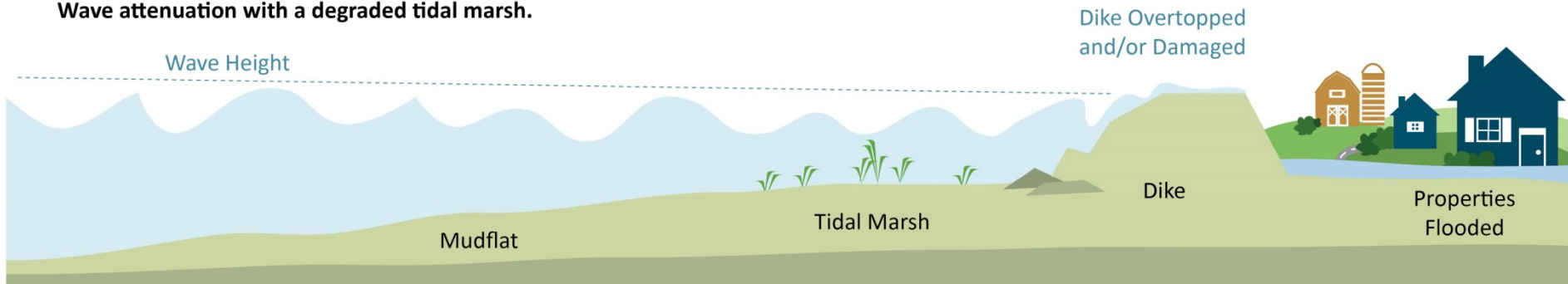


Natural infrastructure slows waves and reduces height

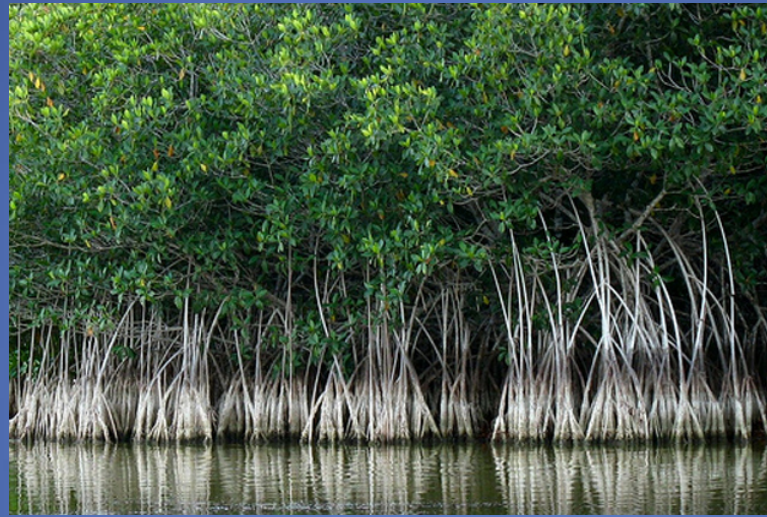
Wave attenuation with a healthy tidal marsh.



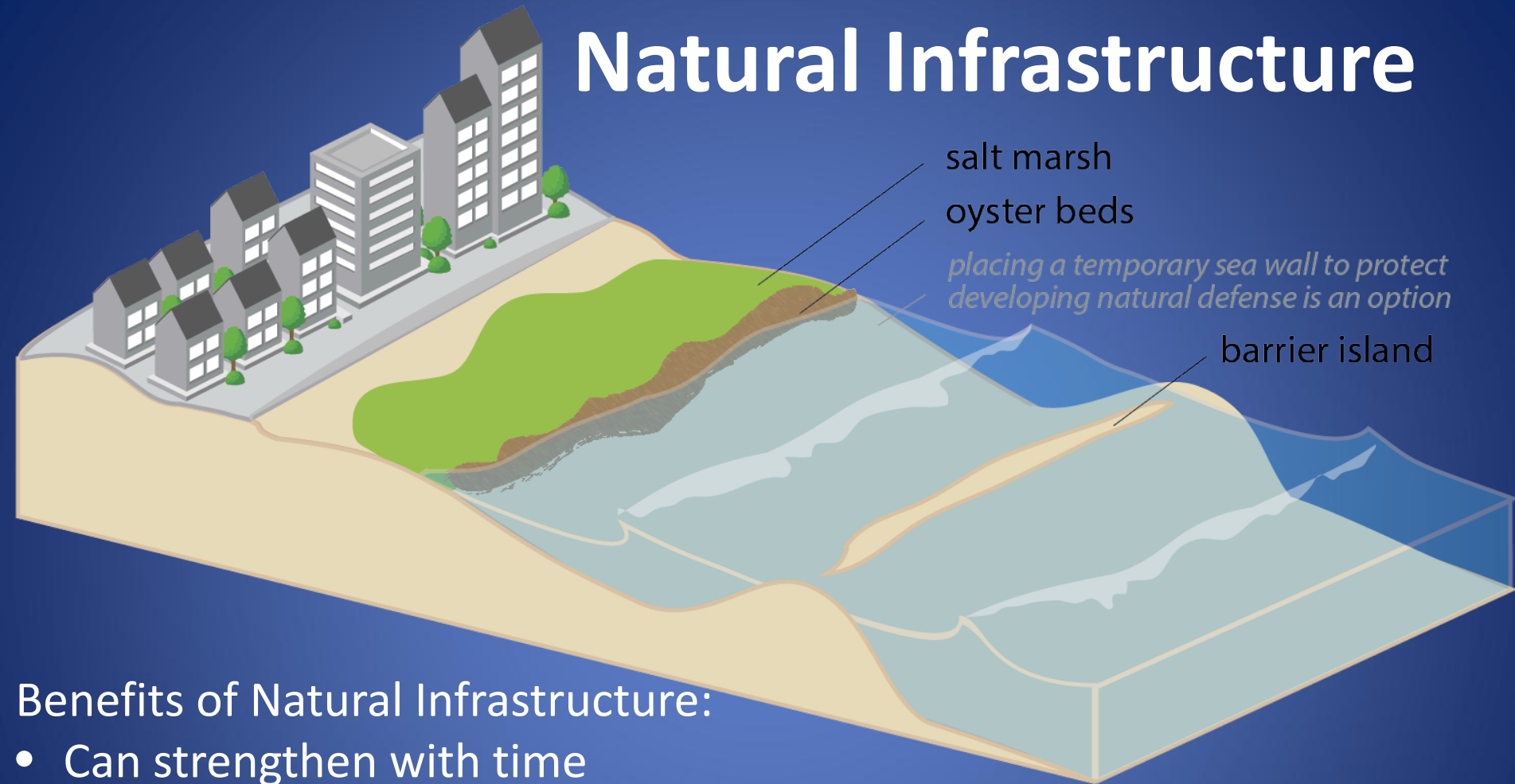
Wave attenuation with a degraded tidal marsh.



Many Factors Influence the Amount of Coastal Protection Provided by Natural infrastructure



Natural Infrastructure



Benefits of Natural Infrastructure:

- Can strengthen with time
- Can be self-maintaining and has the potential for self-repair after storms
- Can grow and keep pace with sea level rise
- Can be more cost-effective
- **Provides benefits all the time**



Additional Coastal Ecosystem Services

Examples of additional benefits:

1. Fisheries (recreational and commercial)
2. Recreation & tourism
3. Water filtration
4. Cultural services
5. Habitat for other species
6. Carbon sequestration & storage

Economic Benefits of Coastal Ecosystem Protection Services

U.S. coastal wetlands provide \$23.2 billion storm protection benefits annually
(Constanza et al.2008)



Analysis of 34 hurricanes
→ loss of 1 hectare of wetland in the model corresponded with increased average storm damages of \$33,000 per storm



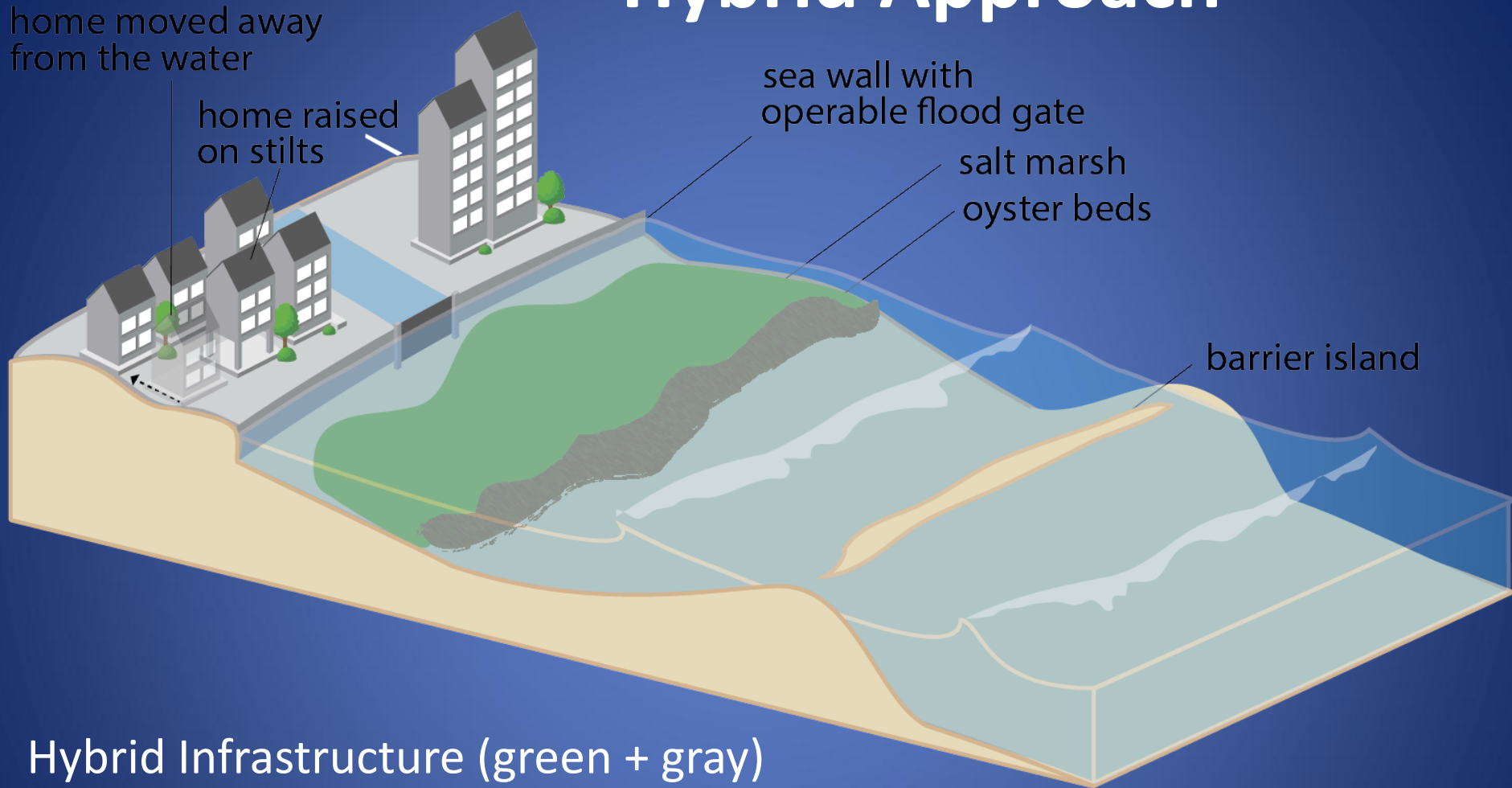
Restoring Natural Infrastructure can be cost effective

- \$1,290 per meter for a coral reef restoration project
- Compare to median cost of building tropical breakwaters = US\$19,791 per meter



Ferrario et al. 2014

Hybrid Approach



Hybrid Infrastructure (green + gray)

- Can combine strengths of green and gray
- Can use gray to protect green as it establishes
- Can use green to protect gray to extend the lifetime or reduce costs

Hybrid: Living Shorelines

- Living shorelines: Use a combination of habitat restoration and built features to provide protection from erosion and storms
- Provides many of the benefits of natural habitats
- Restored marsh with oyster sill



Before



After

Rebuild By Design: “Big U” Project Provides Climate Adaptation and Recreational Opportunities

- Hard and soft infrastructure with recreational benefits
- Actual Implementation: East Side Coastal Resilience Project
- Integrate flood protection into community, improve water access
- Berms and flood walls or barriers



Now is an exciting time!

ECOSYSTEM-SERVICE ASSESSMENT: RESEARCH NEEDS FOR COASTAL INFRASTRUCTURE

PRODUCT OF THE
Committee on Environment, Natural
Resources, and Sustainability
OF THE
NATIONAL SCIENCE AND TECHNOLOGY



August 2015



October 7, 2015

M-16-01

MEMORANDUM FOR EXECUTIVE DEPARTMENTS AND AGENCIES

FROM: Shaun Donovan, Director
Office of Management and Budget
Christina Goldfuss, Managing Director
Council on Environmental Quality
John Holdren, Director
Office of Science and Technology Policy

SUBJECT: Incorporating Ecosystem Services into Federal Decision Making

Overview. Nature provides vital contributions to economic and social well-being that are not traded in markets or fully considered in decisions. This memorandum provides agencies on incorporating ecosystem services into Federal planning and decision making. (Broadly defined, ecosystem services are the benefits that flow from nature to people, including nature's contributions to the production of food and timber; life-support processes such as air purification and coastal protection; and life-fulfilling benefits, such as places to recreate.)

Specifically, this memorandum:

- (1) Directs agencies to develop and institutionalize policies to promote consideration of ecosystem services, where appropriate and practicable, in planning, investment, and regulatory contexts. (Consideration of ecosystem services may be accomplished through a range of qualitative and quantitative methods to identify and characterize ecosystem services and, where appropriate, monetary or nonmonetary values for those services.)
- (2) Sets forth the process for development of implementation guidance and direct implementation of aforementioned policies and integrate assessments of ecosystem services into Federal decision making.

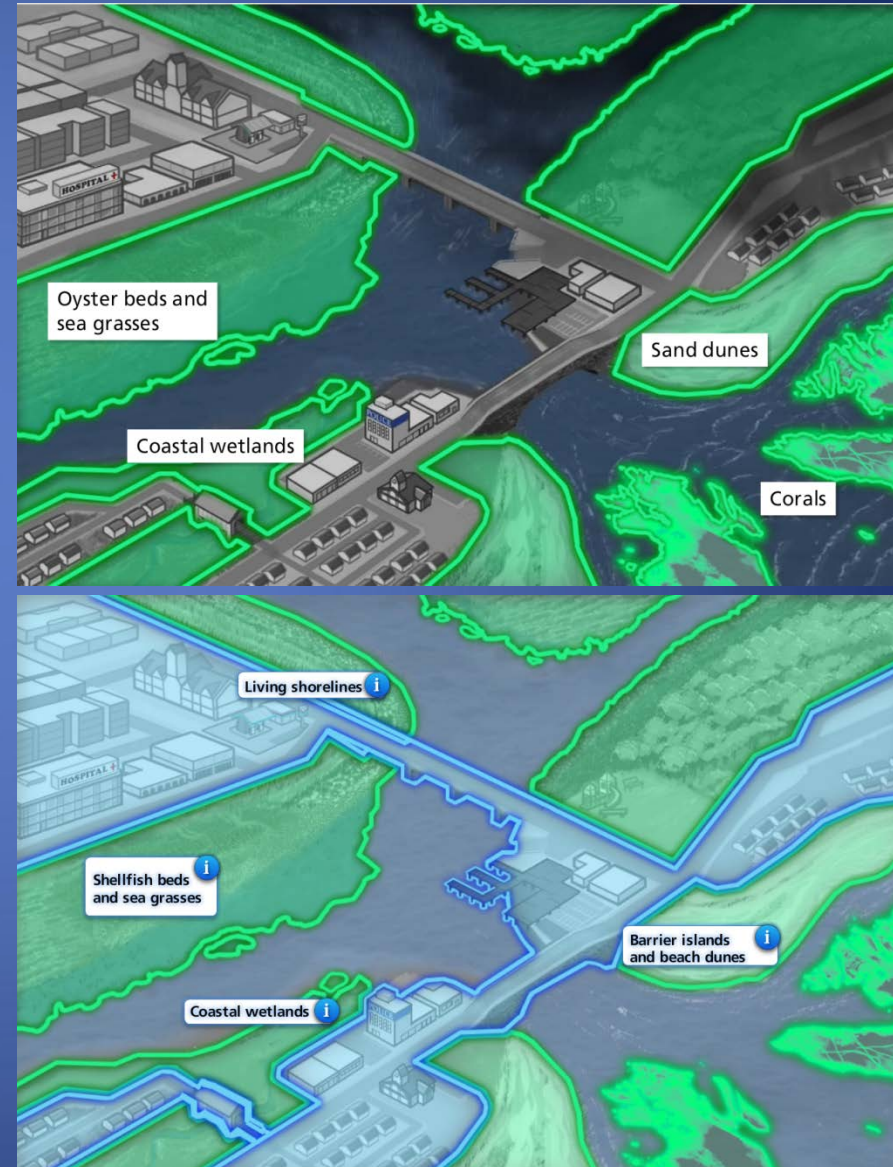
Guidance for Considering the Use of Living Shorelines

2015




Systems Approach to Geomorphic Engineering (SAGE) website



- **SAGE is a Community of Practice** of Federal, State, and Local Agencies, non-governmental organizations, academic institutions, engineers, and private businesses working to use and promote green-gray approaches to ensure coastal community and shoreline resilience
- <http://sagecoast.org/>




Restore America's Estuaries Living Shorelines

- Recent report: “Living Shorelines: From Barriers to Opportunities”
- Four Strategies:
 - 1) Education
 - 2) Improve permitting
 - 3) Increase capacity
 - 4) Public entities lead by example
- <https://www.estuaries.org/living-shorelines>

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Living Shorelines

What are living shorelines?

“Living shorelines” is a term used to define a number of shoreline protection options that allow for natural coastal processes to remain through the strategic placement of plants, stone, sand fill, and other structural and organic materials. Living shorelines often rely on native plants, sometimes supplemented with stone sills, on-shore or off-shore breakwaters, groins or biologs to reduce wave energy, trap sediment, and filter runoff, while maintaining (or increasing) beach or wetland habitat (National Research Council, 2007). Several of these techniques are hybrids of traditional shoreline armoring and the softer approaches to shore protection. The goal is to retain much of the wind, tide, and storm-related wave protection of a hard structure, while maintaining some of the features of natural

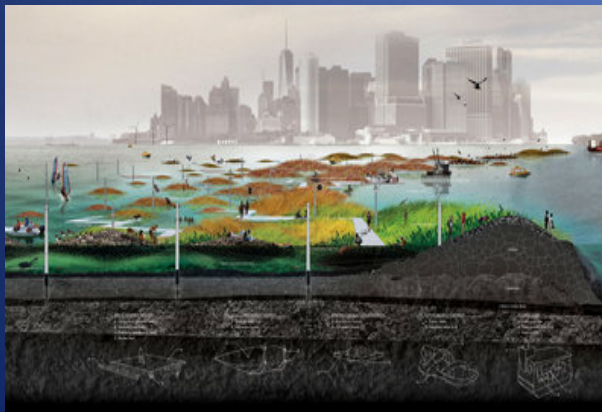


Natural and Hybrid Research Needs to Support Policy

- Natural and hybrid benefits?
- Value of storm protection benefits and co-benefits?
- Best practices for design?
 - Need Multidisciplinary efforts
- How to implement?



We know enough to implement these alternatives now. The choice is up to society on what we want our future coasts to look like.





Thank you!

**For more info: ariana.sutton-grier@noaa.gov
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Sutton-Grier et al. 2015. Future of our coasts: The potential for natural and hybrid infrastructure to enhance the resilience of our coastal communities, economies and ecosystems. Environmental Science & Policy.

Paper open access:

<http://www.sciencedirect.com/science/article/pii/S1462901115000799>

SAGE Brochure

GREEN - SOFTER TECHNIQUES

Small Waves | Small Fetch | Gentle Slope | Sheltered Coast

LIVING SHORELINE

VEGETATION ONLY

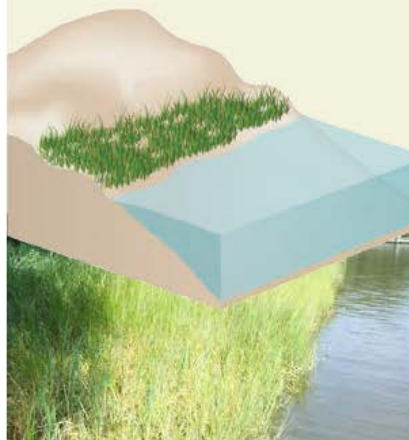


Photo Credit: Maryland Department of Natural Resources - Shoreline Conservation Service

Roots hold soil in place to reduce erosion. Provides a buffer to upland areas and breaks small waves.

Suitable For

Low wave energy environments.

Material Options

- Native plants*

Benefits

- Dissipates wave energy
- Slows inland water transfer
- Increases natural storm water infiltration
- Provides habitat and ecosystem services
- Minimal impact to natural community and ecosystem processes
- Maintains aquatic/terrestrial interface and connectivity

EDGING

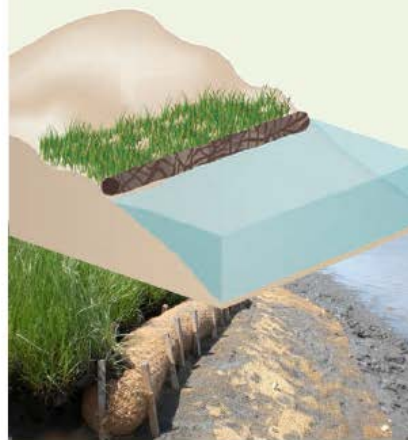


Photo Credit: Partnership for Delaware Estuary

Structure to hold the toe of existing or vegetated slope in place. Protects against shoreline erosion.

Suitable For

Most areas except high wave energy environments.

Vegetation* Base with Material Options

(low wave only, temporary)

- "Snow" fencing
- Erosion control blankets
- Geotextile tubes
- Living reef (oyster/mussel)
- Rock gabion baskets

Benefits

- Dissipates wave energy
- Slows inland water transfer
- Provides habitat and ecosystem services

SILLS

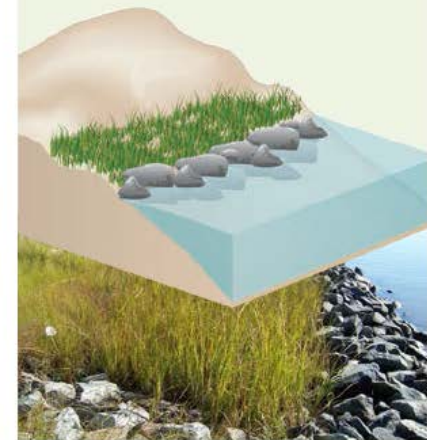


Photo Credit: Maryland Department of Natural Resources - Shoreline Conservation Service

Parallel to existing or vegetated shoreline, reduces wave energy and prevents erosion. A gapped approach would allow habitat connectivity, greater tidal exchange, and better waterfront access.

Suitable For

Most areas except high wave energy environments.

Vegetation* Base with Material Options

- Stone
- Sand breakwaters
- Living reef (oyster/mussel)
- Rock gabion baskets

Benefits

- Provides habitat and ecosystem services
- Dissipates wave energy

Living Shorelines

Innovative approaches are necessary as our coastal communities and shorelines are facing escalating risks from more powerful storms, accelerated sea-level rise, and changing precipitation patterns that can result in dramatic economic losses. While the threats of these events may be inevitable, understanding how to adapt to the impact is important as we explore how solutions will ensure the resilience of our coastal communities.