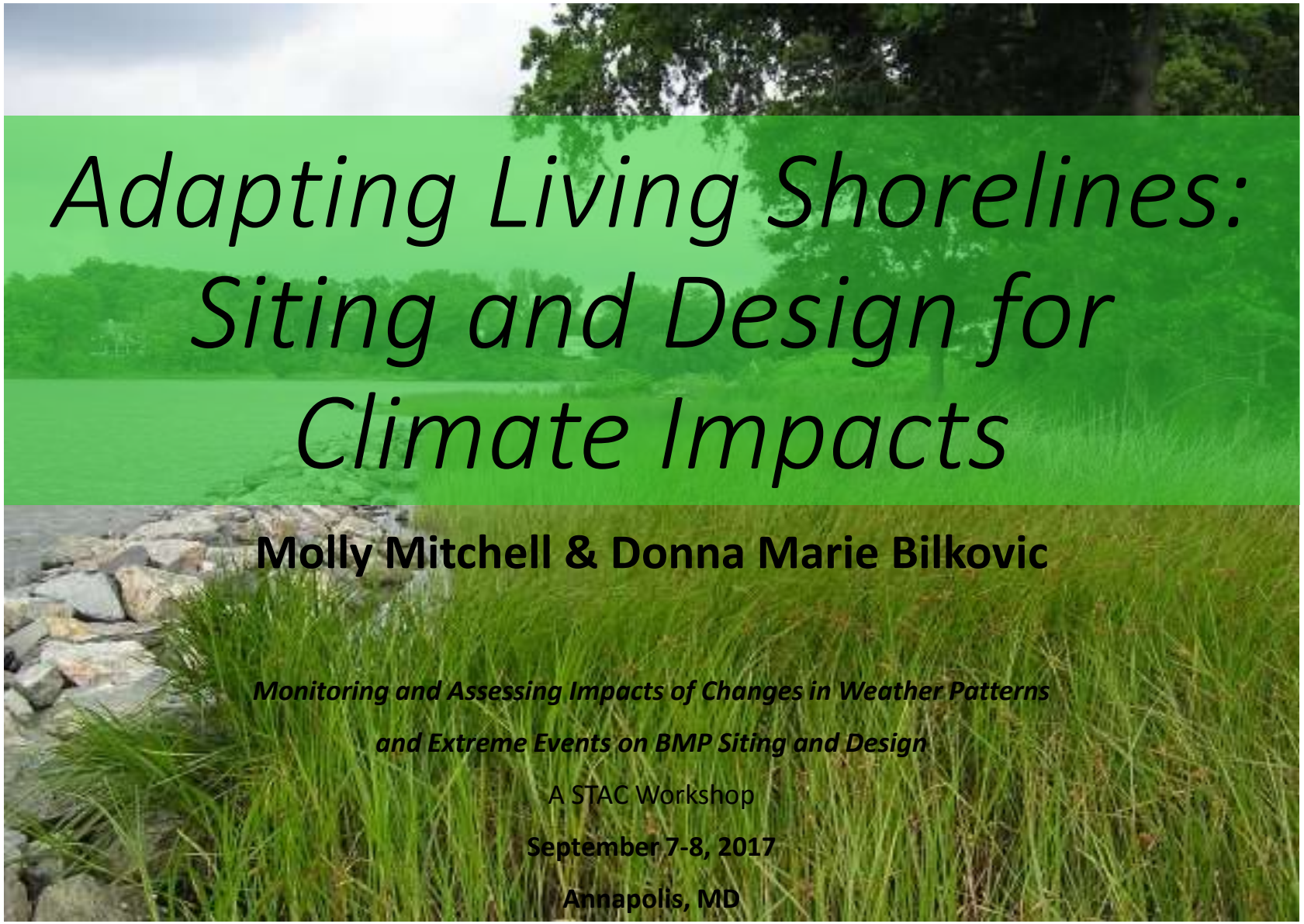


Adapting Living Shorelines: Siting and Design for Climate Impacts

Molly Mitchell & Donna Marie Bilkovic

Monitoring and Assessing Impacts of Changes in Weather Patterns

and Extreme Events on BMP Siting and Design

A STAC Workshop

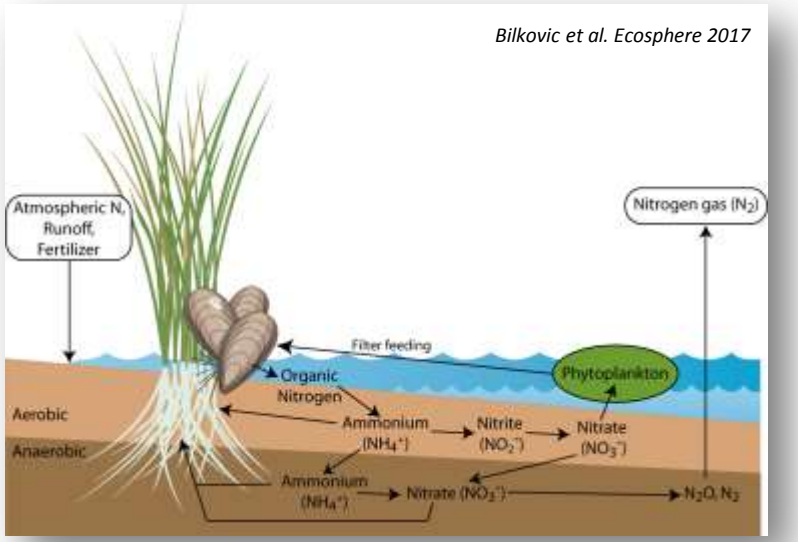
September 7-8, 2017

Annapolis, MD

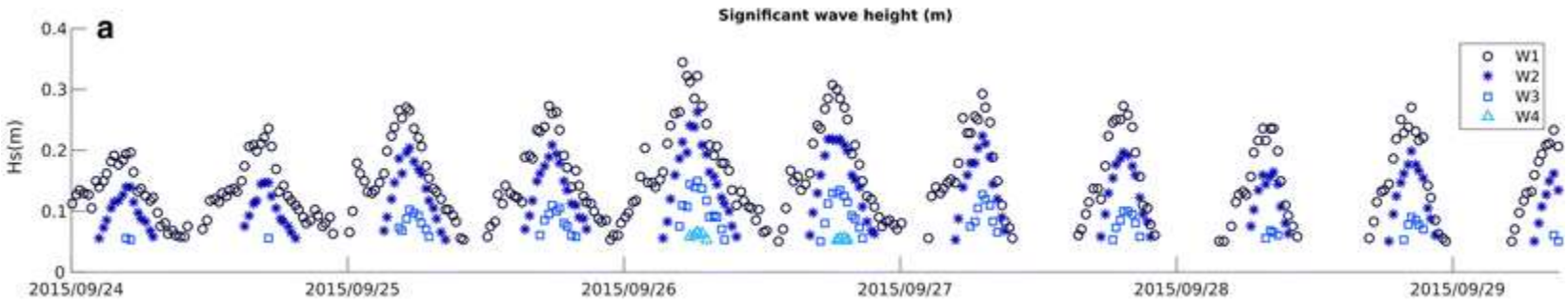
Center for Coastal Resources Management
VIMS | William & Mary
Virginia Institute of Marine Science

Living shorelines as coastal BMPs

- Remove sediment & nutrients from waters

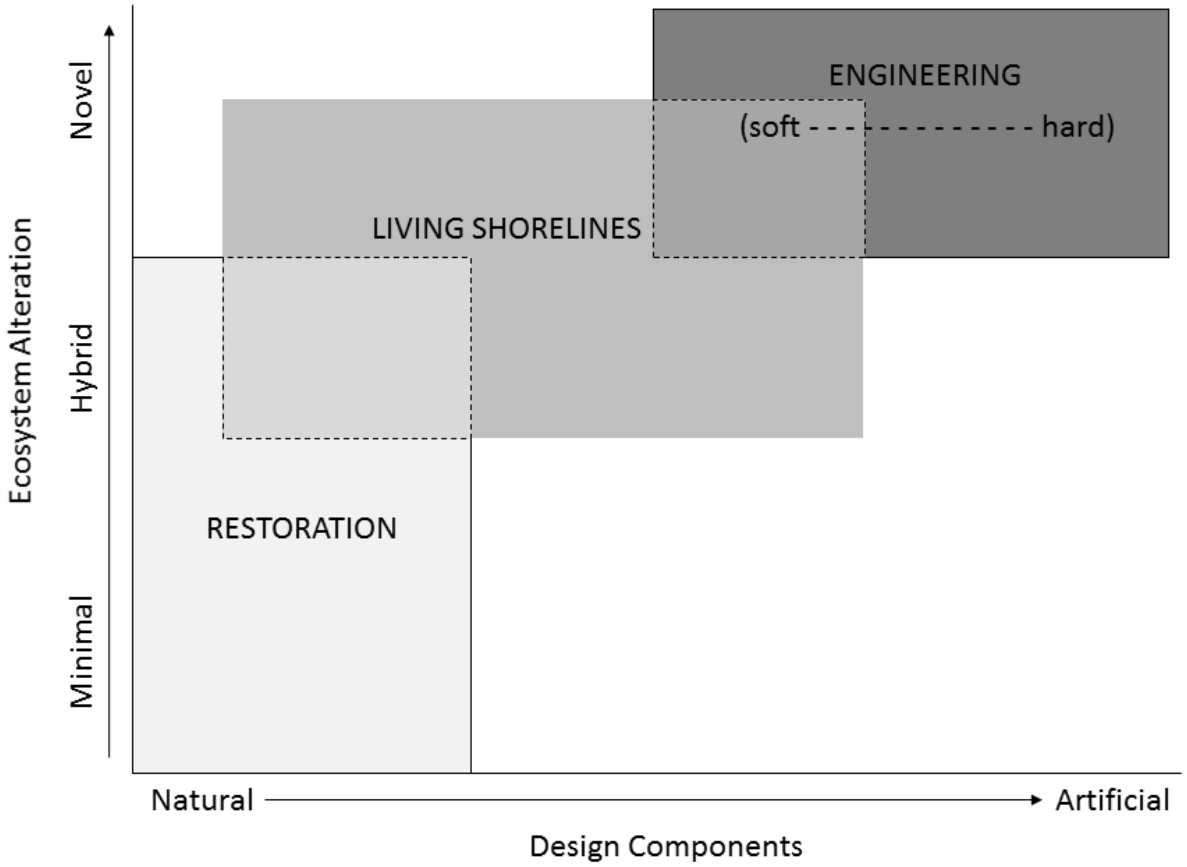


- Reduce storm energy and associated erosion

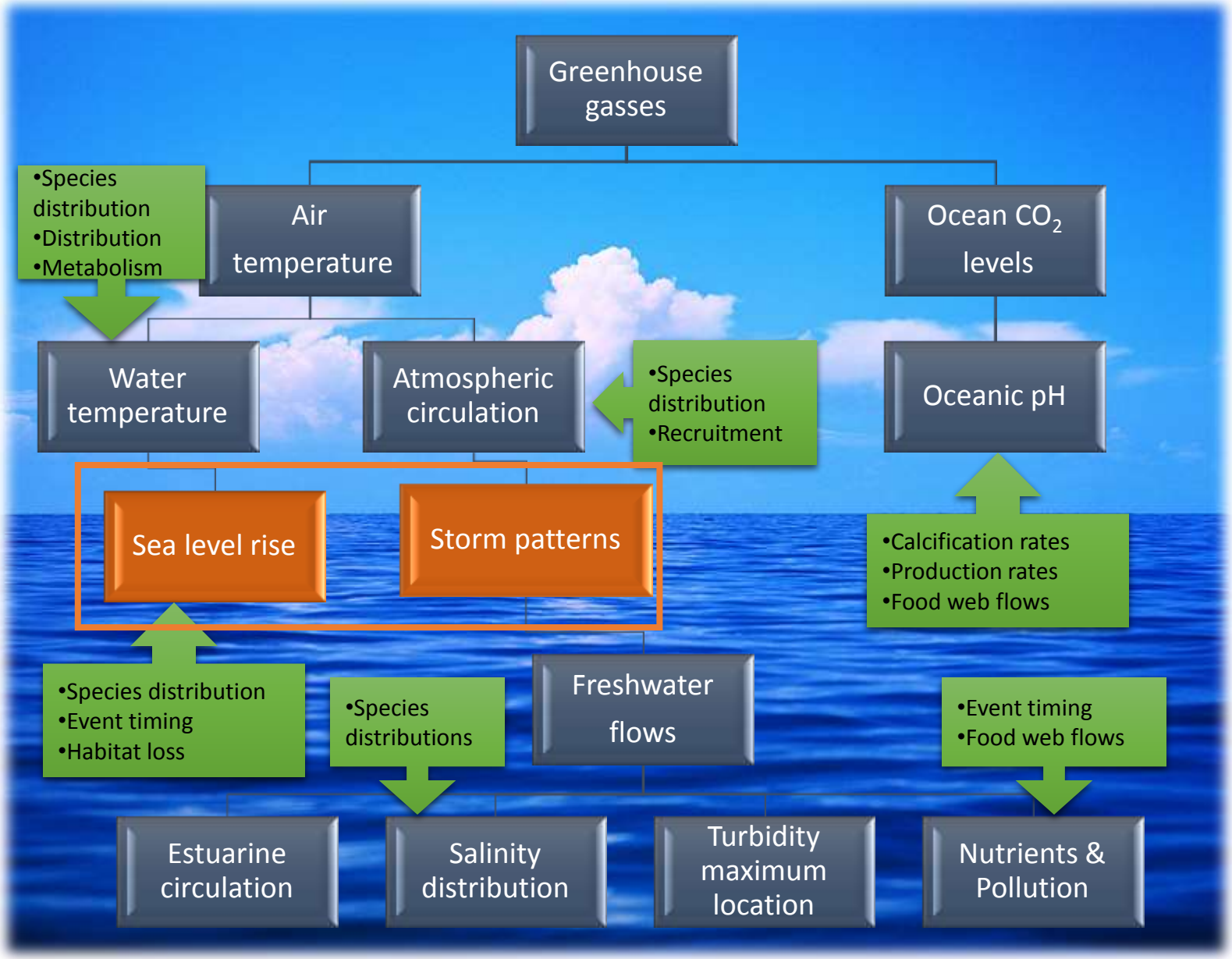


Paquier, Anne-Eleonore, et al. "Quantification of the Attenuation of Storm Surge Components by a Coastal Wetland of the US Mid Atlantic." Estuaries and Coasts (2016): 1-17.

Living shorelines' place in restoration



Toft et al. 2017. A synthesis of living shoreline perspectives. In *Living Shorelines: The Science and Management of Nature-based Coastal Protection, CRC Press*

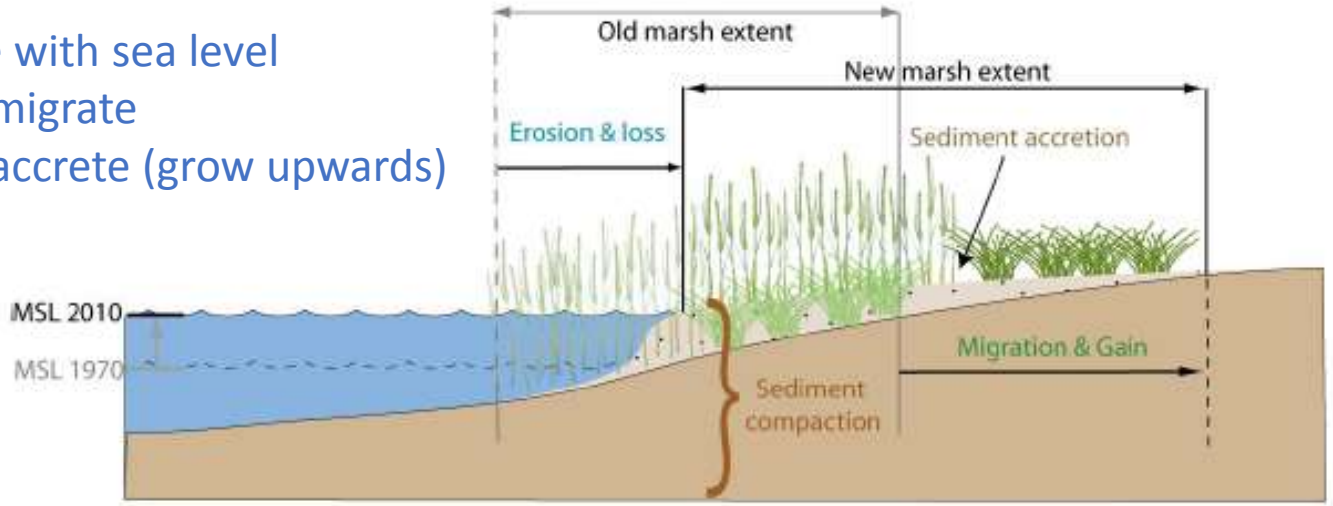

Greenhouse gasses
•Species distribution
•Distribution
•Metabolism
Air temperature
Ocean CO_2 levels
Water temperature
Atmospheric circulation
•Species distribution
•Recruitment
Oceanic pH
Sea level rise
Storm patterns
•Calcification rates
•Production rates
•Food web flows
•Species distribution
•Event timing
•Habitat loss
•Species distributions
Freshwater flows
•Event timing
•Food web flows
Estuarine circulation
Salinity distribution
Turbidity maximum location
Nutrients & Pollution

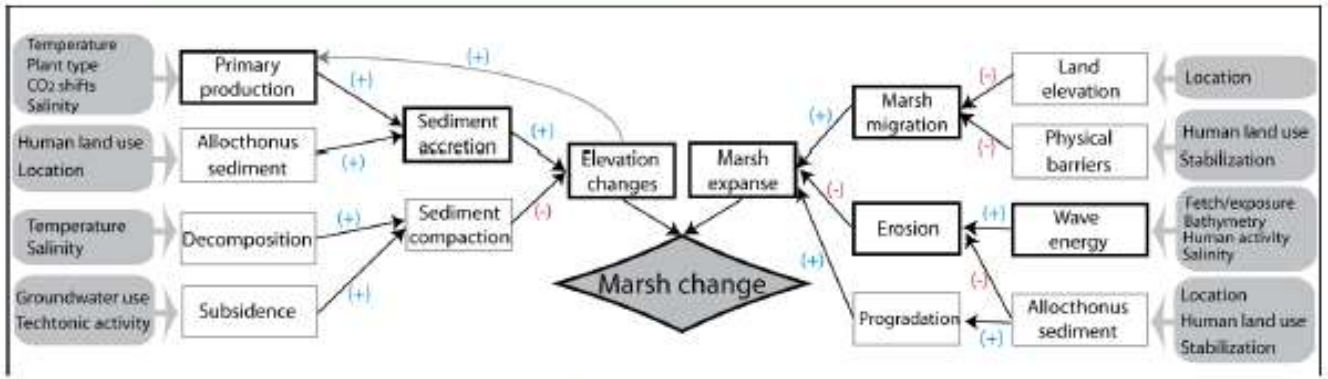
Living Shorelines can be flexible to allow for new understandings of risk

Marshes are naturally dynamic, so living shorelines should be designed as dynamic systems.

To keep pace with sea level

- Marshes migrate
- Marshes accrete (grow upwards)





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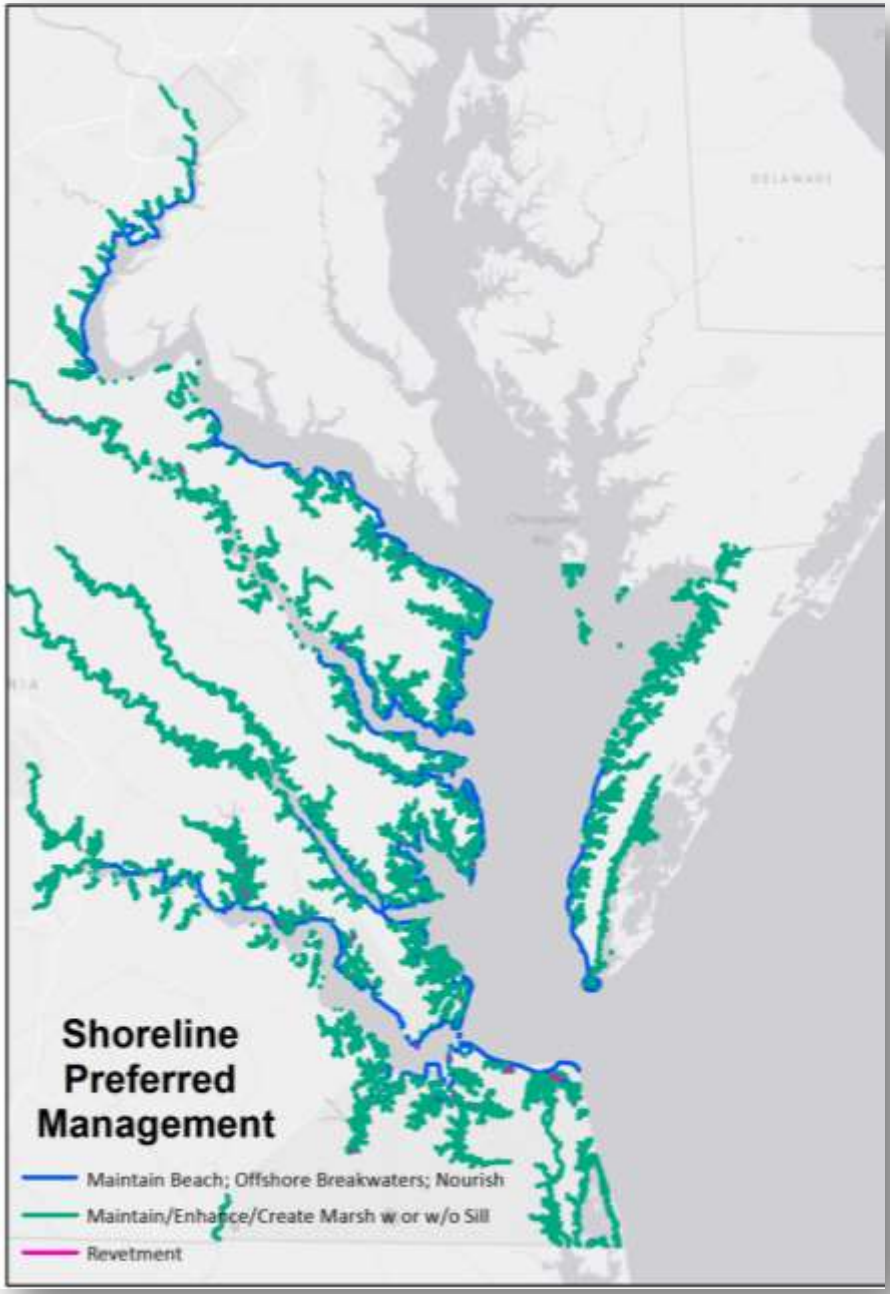
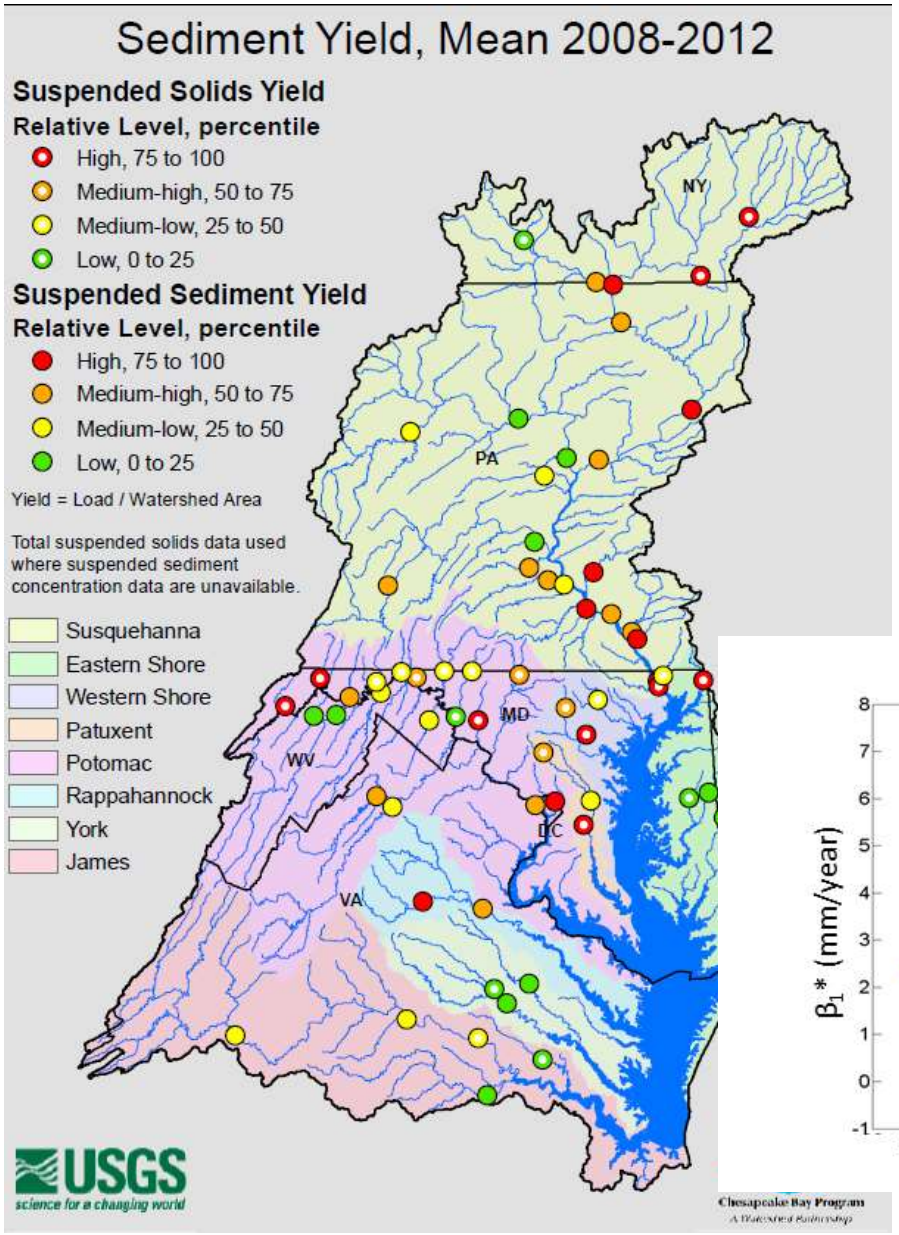
Living shoreline siting criteria

Living shorelines must be able to migrate or accrete with sea level rise!



Accretion potential in living shoreline siting



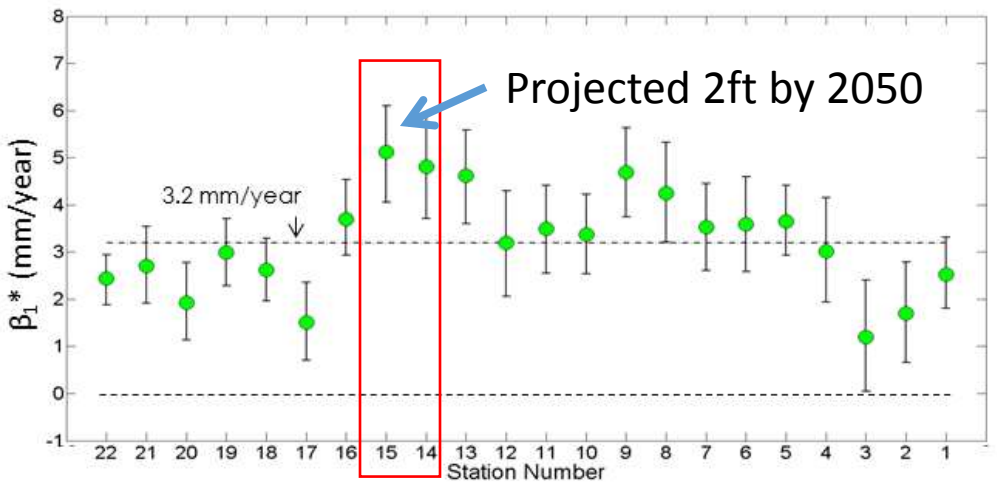
Map: Sediment Yields Measured in Watershed Streams and Rivers, Mean 2008-2012

Date created: Jan 02 2014 / **Download**

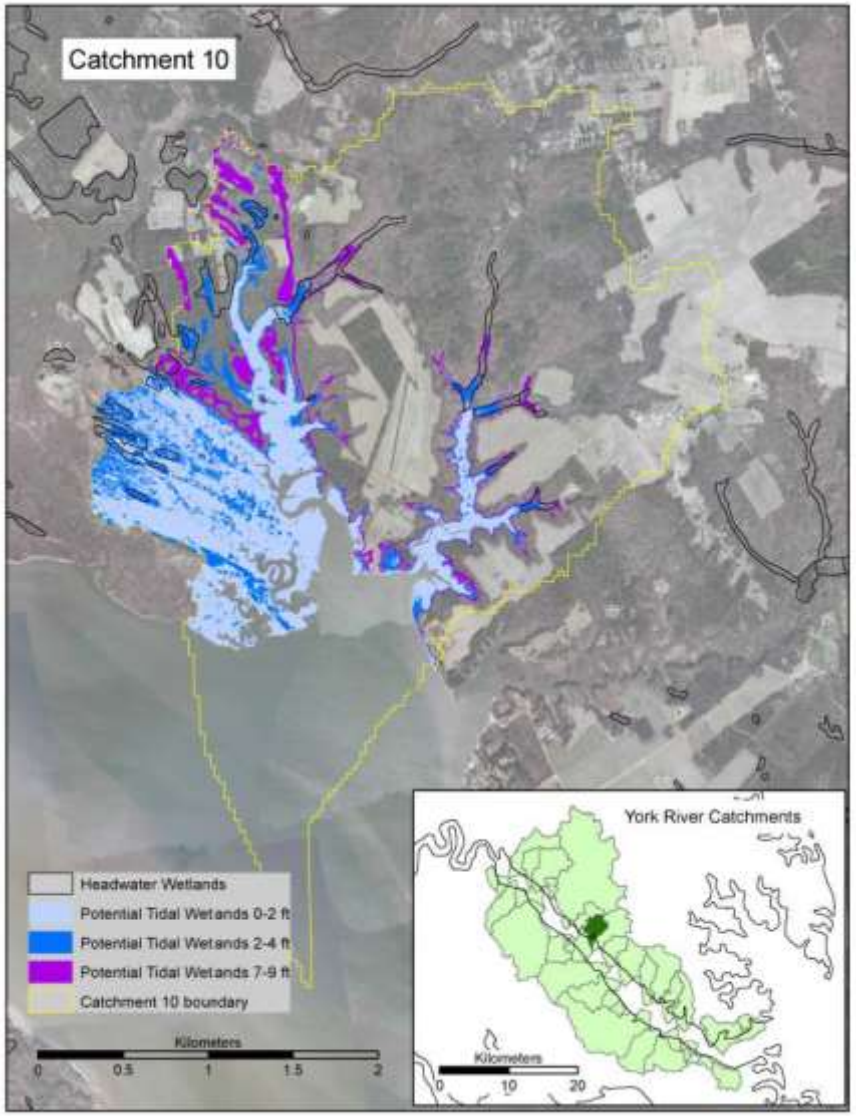
Watershed Yield: Sediment yields ranged from 9.3 to 648 tons per square mile. Each of the 17 sites in the high yield category carries more than 200 tons of sediment per square mile of watershed. High yielding sites are spatially dispersed across the Susquehanna, Potomac and Rappahannock watersheds. The lowest sediment yielding sites are located on the Eastern Shore and the York River Basin.

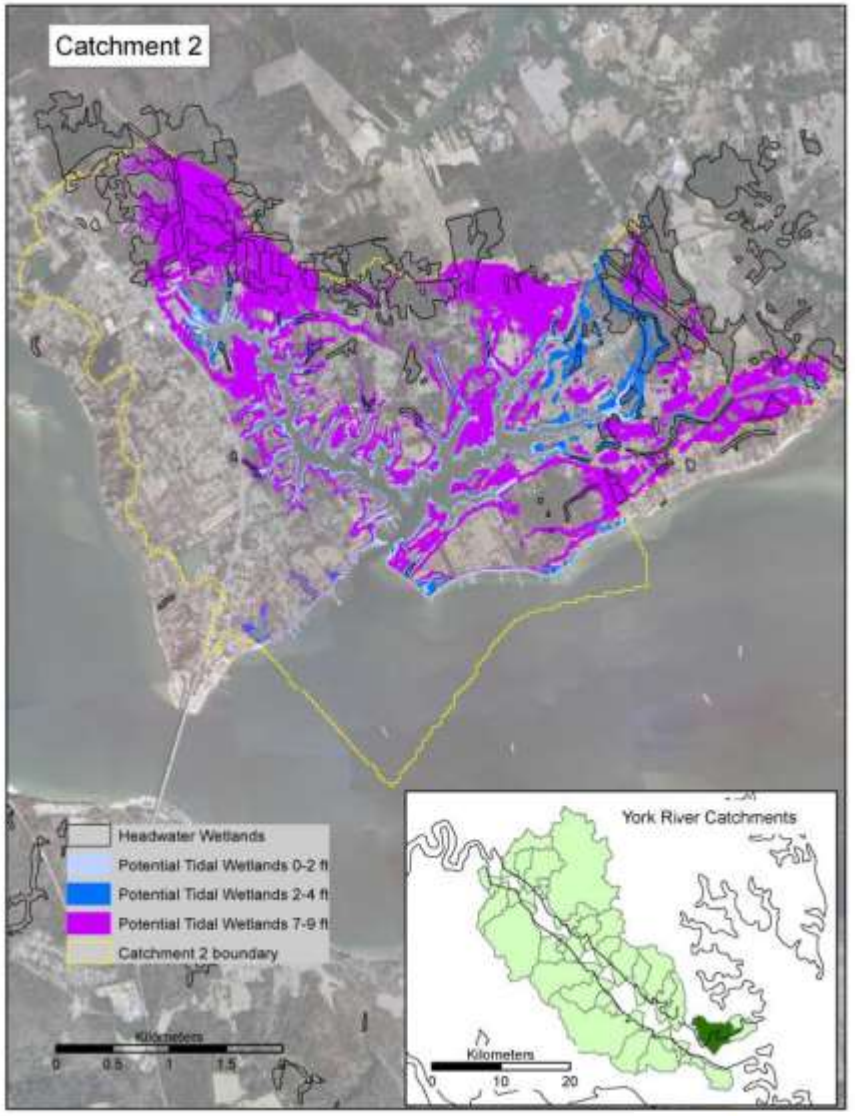
Sea level rise on the Atlantic Coast

Data from Boon & Mitchell 2015



Migration potential in living shoreline siting





Low Bank

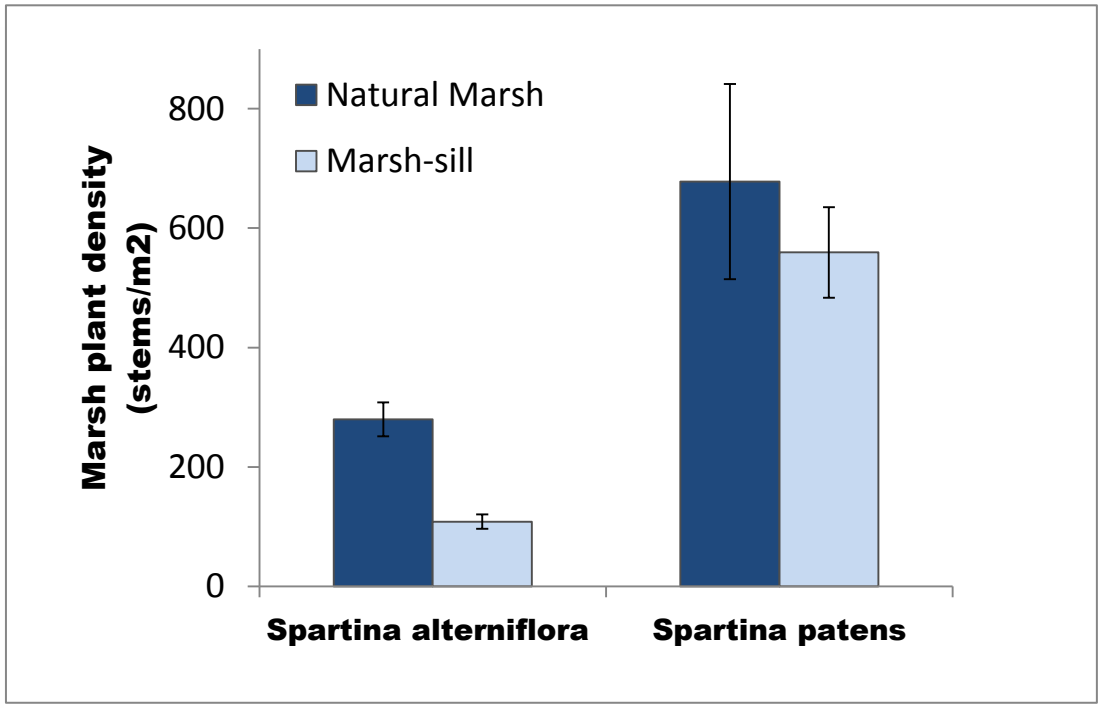
High Bank

Living shoreline design criteria

Living shorelines must be able to migrate or accrete with sea level rise!

Accretion potential in living shoreline design

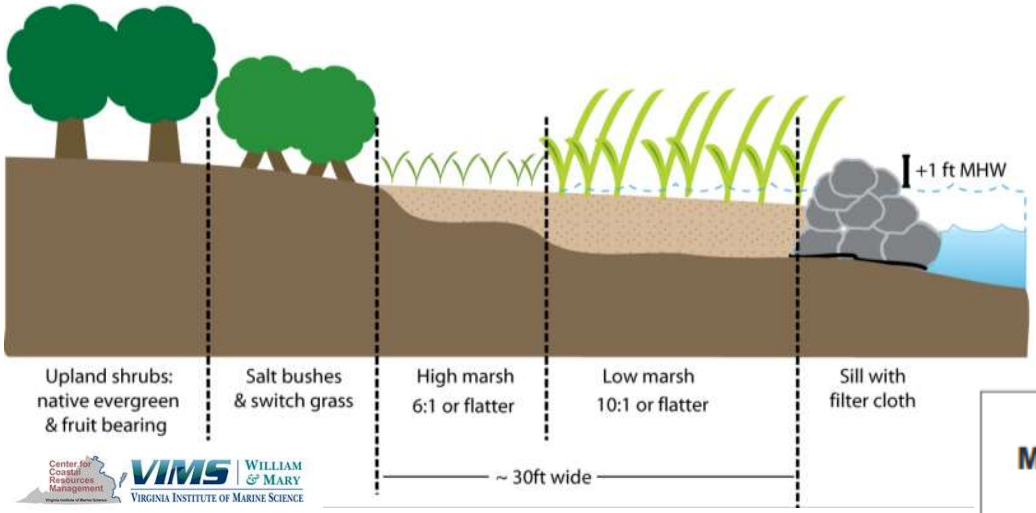
Marsh plant stem density, stem height, and aboveground biomass influence the marsh's ability to trap sediments and attenuate wave energy



- Marsh-sill low marsh stem counts lower than natural fringing marshes; high marsh similar
- No evident trajectory across age of marsh sampled (1-11 yrs)
- Organic matter very low in marsh-sills (<2%)

Accretion potential in living shoreline design

Sill design influences the marsh's ability to trap sediments and attenuate wave energy



Results from Surface Elevation Tables placed at the lower and upper edges of Spartina alterniflora in marshes behind stone sills (Sill) and nearby natural fringing marshes (Natural)

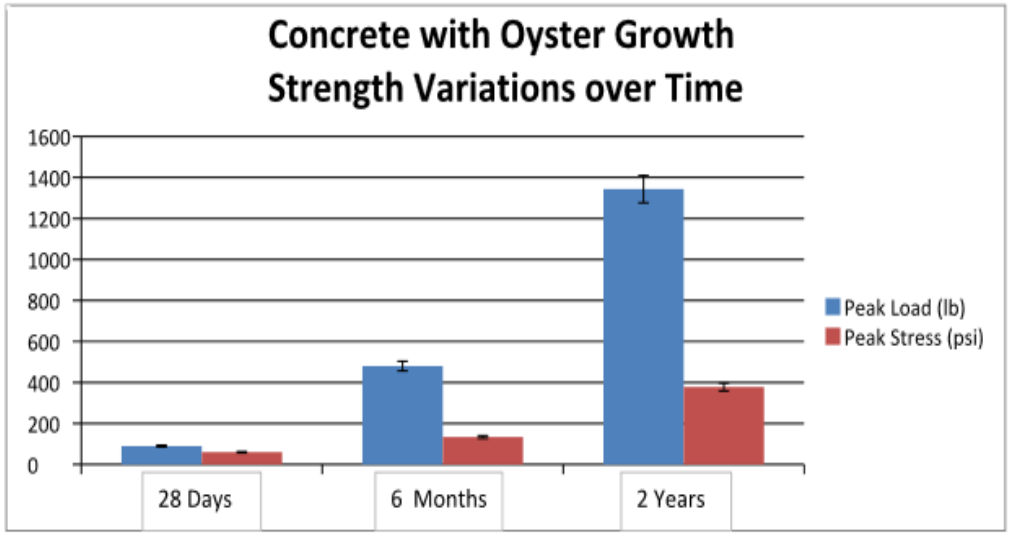
Marsh type	Marsh edge location	Net sediment accretion (mm y^{-1})	n
Natural	Lower	-6.92 A	4
Sill	Lower	5.36 B	4
Natural	Upper	1.18 A	4
Sill	Upper	4.73 B	4

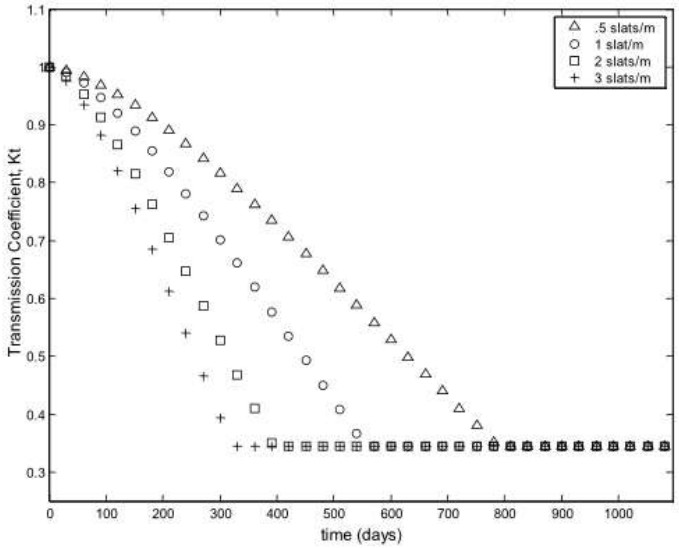
Currin, Carolyn A., W. Scott Chappell, and Anne Deaton. "Developing alternative shoreline armoring strategies: the living shoreline approach in North Carolina." (2010): 91-102.

- The height should be ~MHW in low energy settings to allow regular wave overtopping and access for marine organisms
- The height can be raised 1-2 ft above MHW in moderate energy settings

Accretion potential in living shoreline design

Living sills add a dynamic component to wave energy attenuation



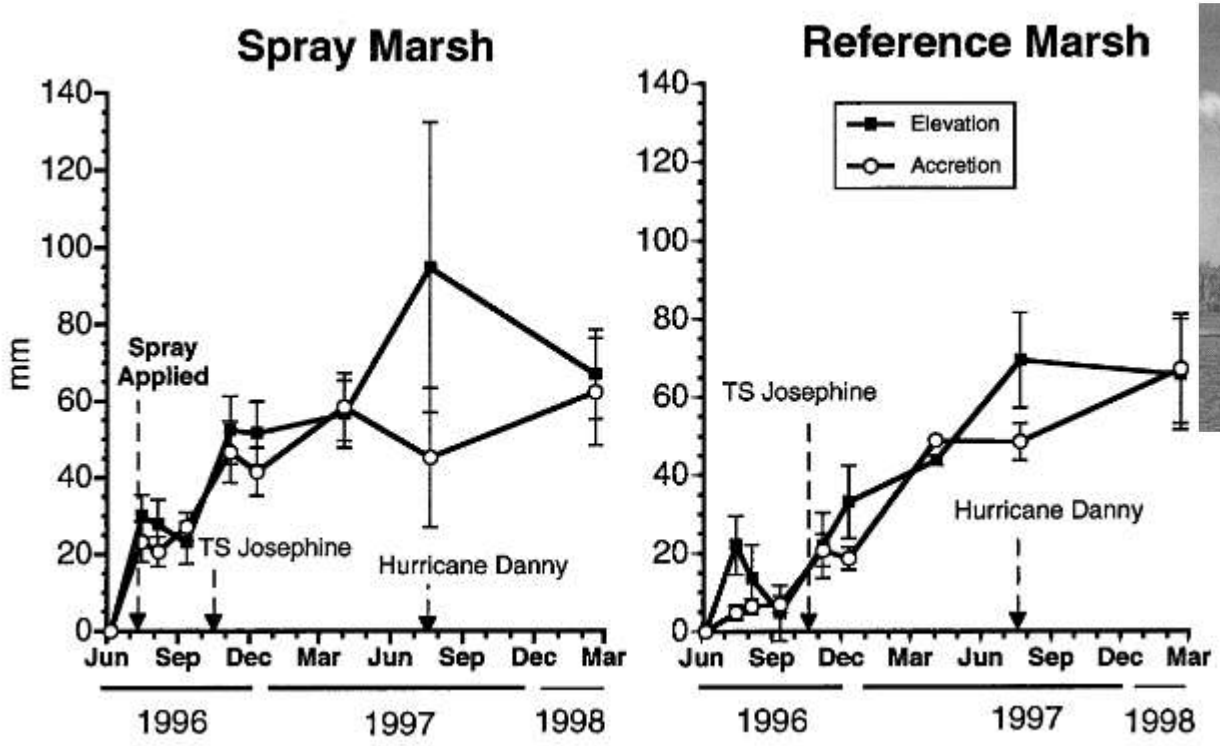


Hall et al. 2017 Growing Living Shorelines and Ecological Services via Coastal Bioengineering. In *Living Shorelines: The Science and Management of Nature-based Coastal Protection, CRC Press*

- Growth on structures reduces wave transmission as oysters grow
- Sills increase in height, width and density over time

Accretion potential in living shoreline design

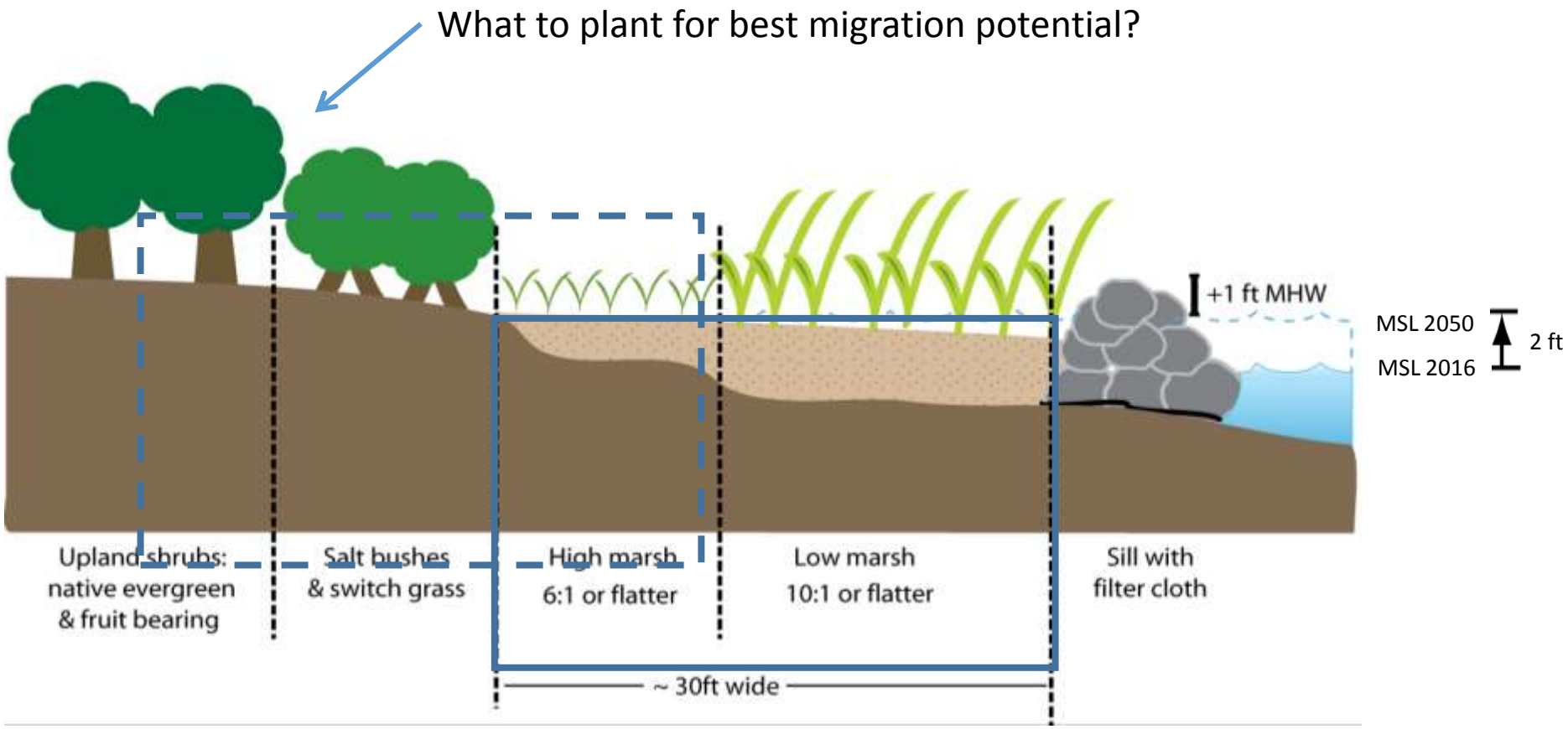
Thin layer deposition artificially maintains elevations in the tidal frame



Ford, Mark A., Donald R. Cahoon, and James C. Lynch. "Restoring marsh elevation in a rapidly subsiding salt marsh by thin-layer deposition of dredged material." Ecological Engineering 12.3 (1999): 189-205.

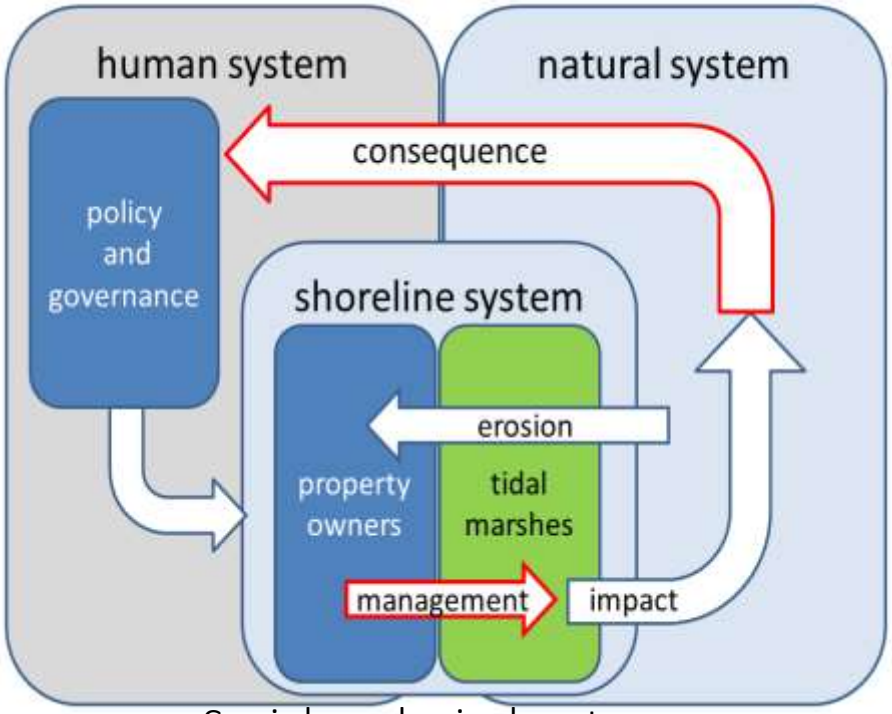
- Considered a beneficial use of dredge material and might help marshes stay within the tidal frame
- Might improve grass density leading to increased accretion
- Need more evidence of long-term usefulness

Migration potential in living shoreline design



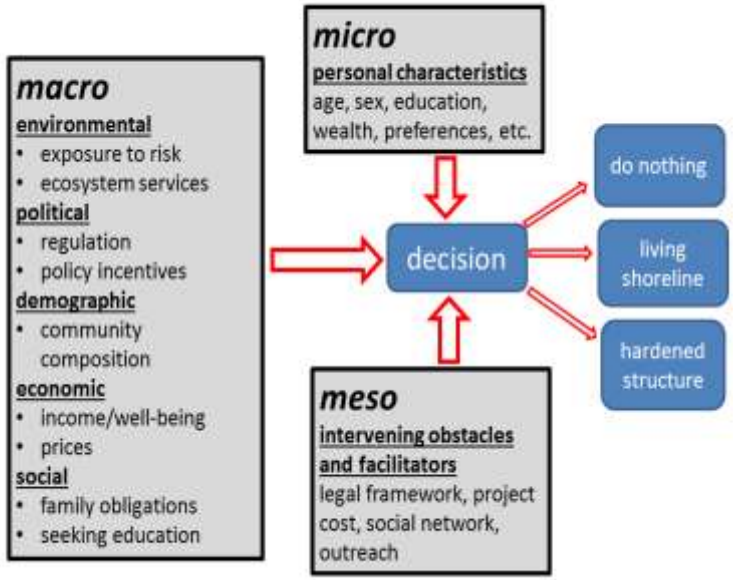
- Focus planting in the upper elevations of the tidal range
  - *Dubois, K. 2017. Overcoming barriers of Living Shoreline Use and Success*
- Preserve riparian land where elevations are suitable for marsh migration

Sustainability in Chesapeake Bay shorescapes: climate change, management decisions, and ecological functions



Social-ecological systems

Identify the decision factors influencing both shoreline property owners and the policy/management personnel governing property owners



Living shoreline during a Nor'easter storm. Although the sill and planted marsh were overtopped by storm waves, the wave energy and erosive force was reduced enough that no upland erosion or bank failure occurred like it did before the sill was in place. Photo by B. Burton