Science and management

Living shorelines

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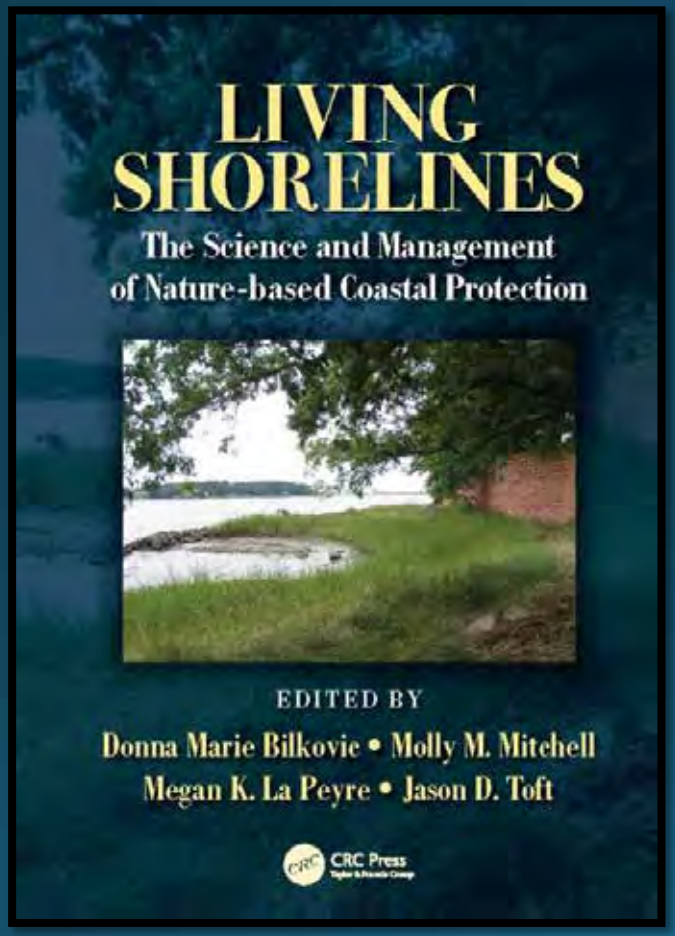
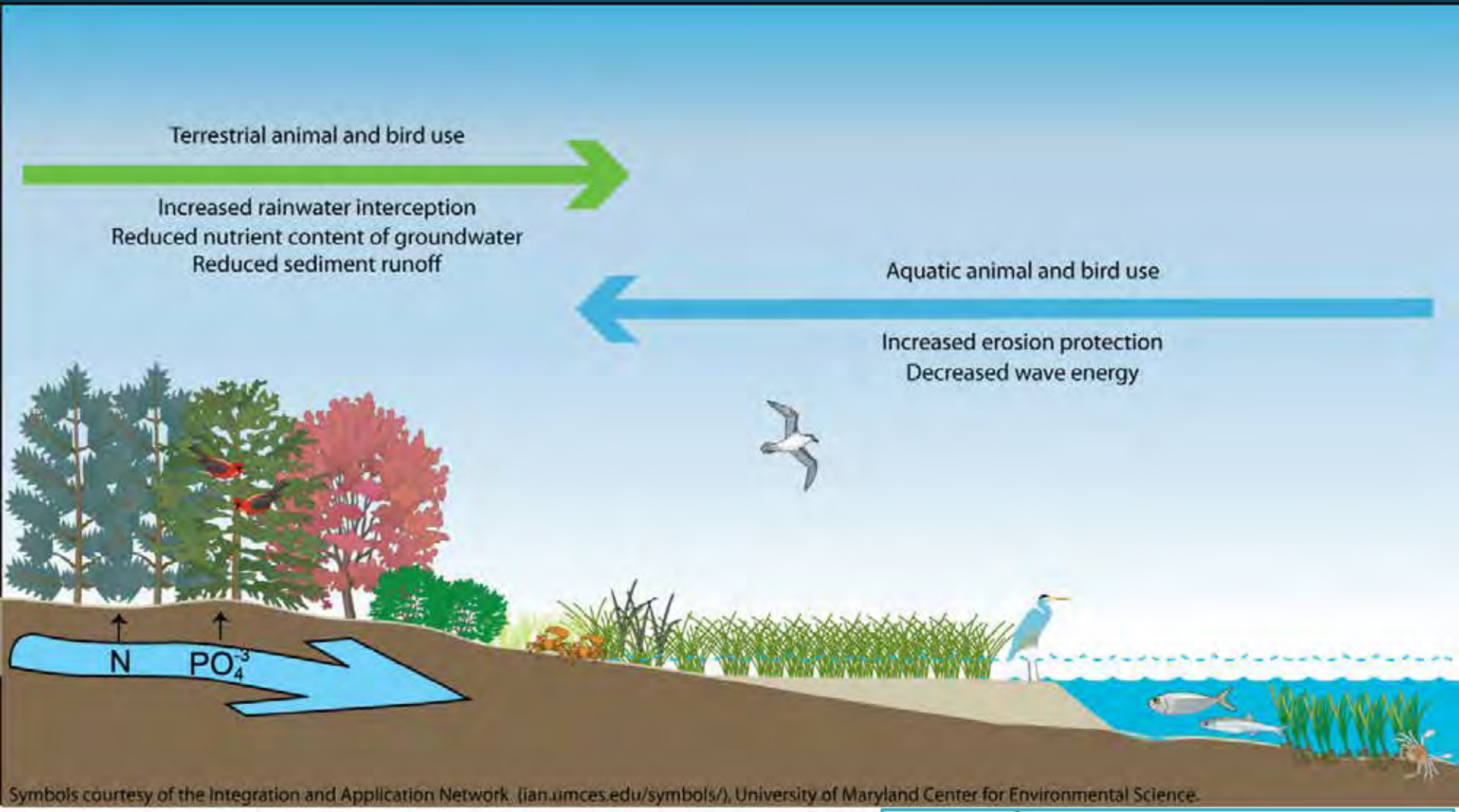
Wetland Workshop: Shoreline Best Practice Case Studies

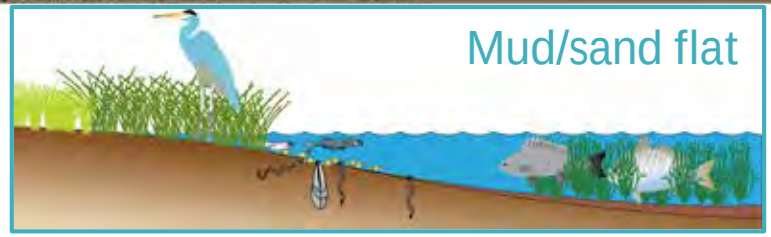
Center for Coastal Resources Management
VIMS | William & Mary
Virginia Institute of Marine Science

A synthesis of major points:



- What makes it "living"?
- How do living components enhance shoreline protection?
- What are co-benefits?
  - Habitat & water quality
- What makes it resilient?





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Benthic invertebrates – who cares?

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Ecosystem Service providers

Suspension/filter feeders: feed on algae & detrital particles suspended in the water
-Filter water, improve clarity

Tagelus plebeius
Stout Razor Clam


Oysters -sill


Ribbed Mussels – marsh

Interface feeders:
can switch

Tellina agilis
Tellin Clam

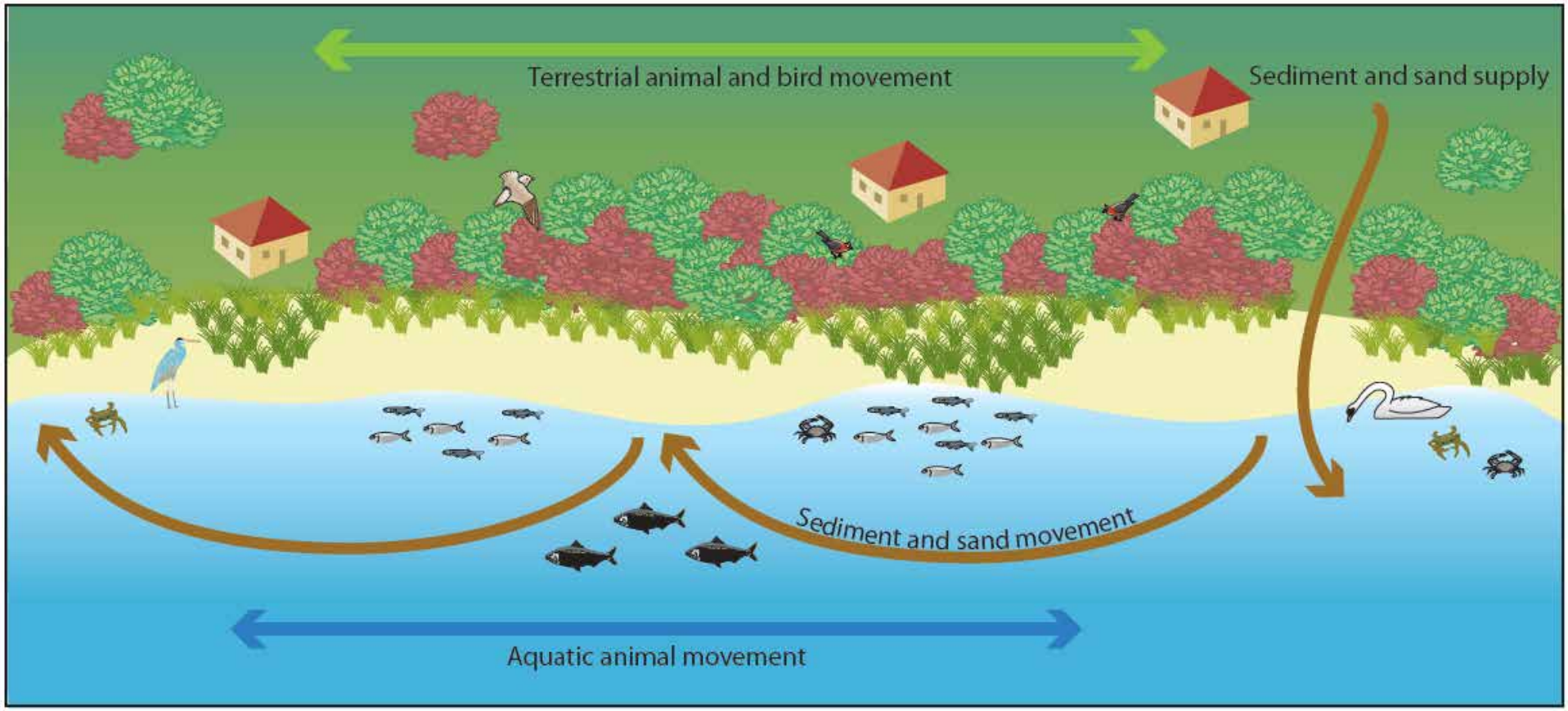
Macoma balthica
Baltic Macoma Clam

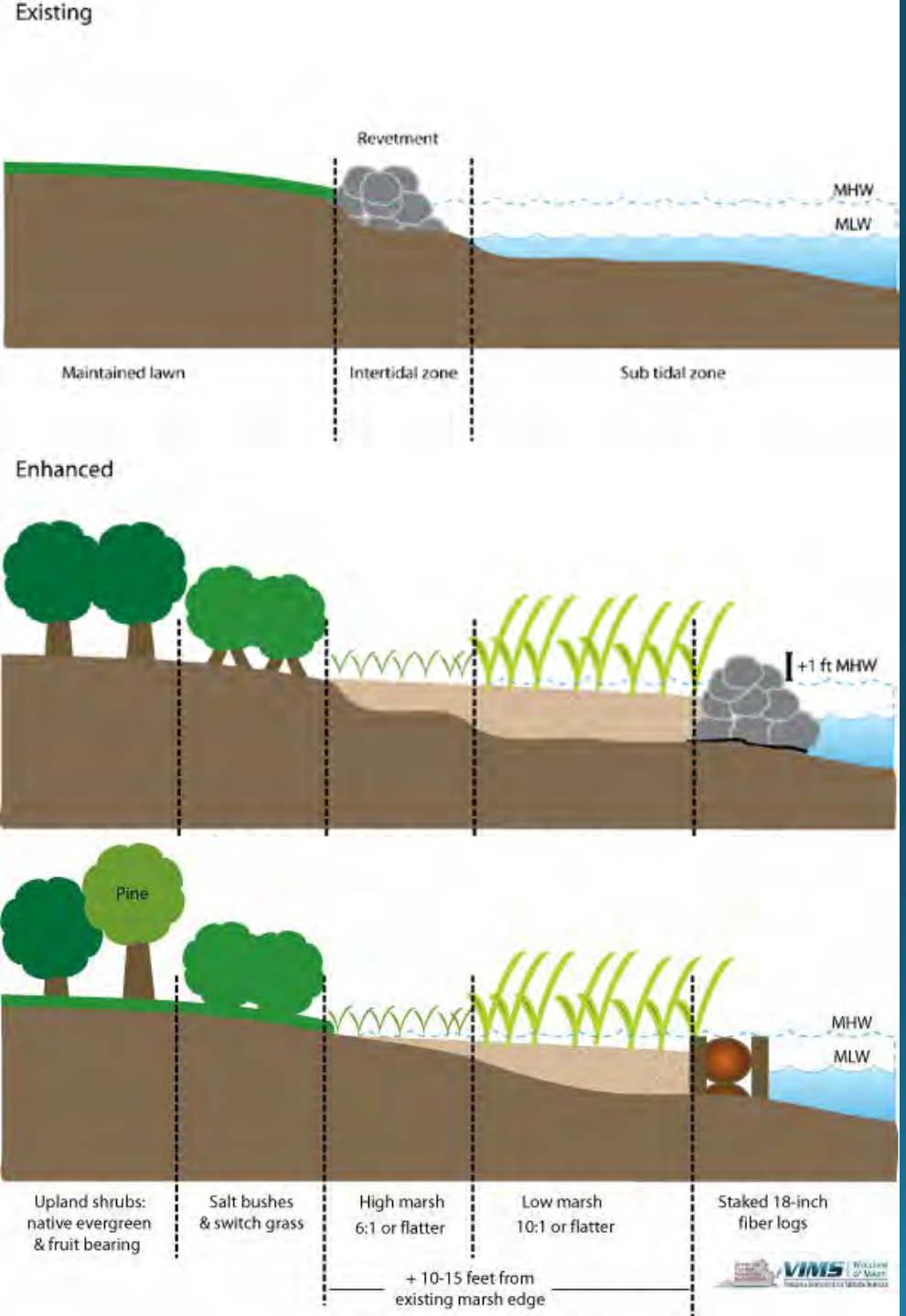
Corophium lacustre
tube-builder amphipod
Favored fish food

Infaunal Deposit feeders : ingest sediment & digest associated bacteria, microalgae & organic matter
-Mixing of sediment – increase oxygenation & nutrient cycling

Clymenella torquata
bamboo worm


Heteromastus filiformis
worm


Terrestrial animal and bird movement
Sediment and sand supply
Sediment and sand movement
Aquatic animal movement



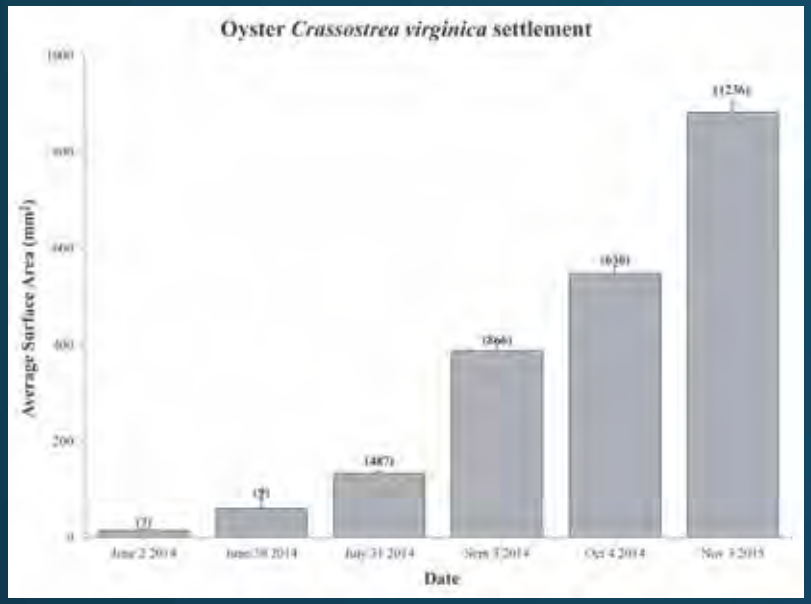
Connectivity improved

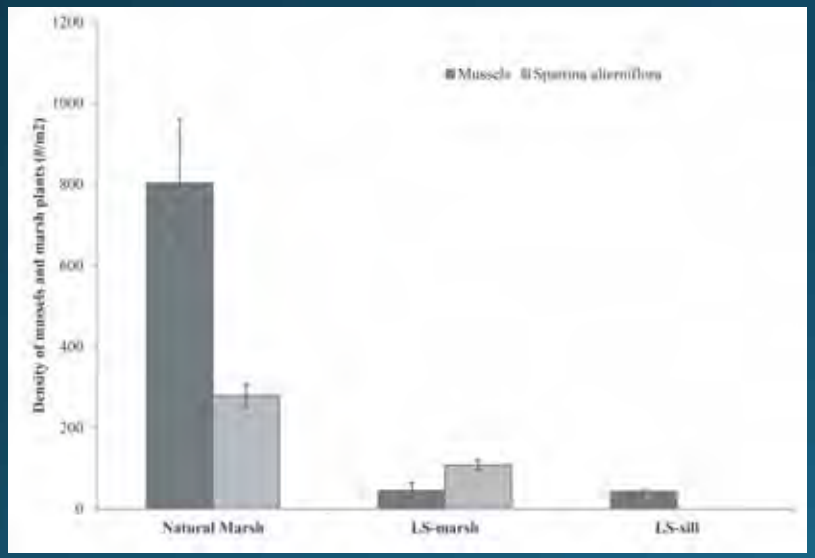
Natural habitat maximized

Artificial habitat minimized

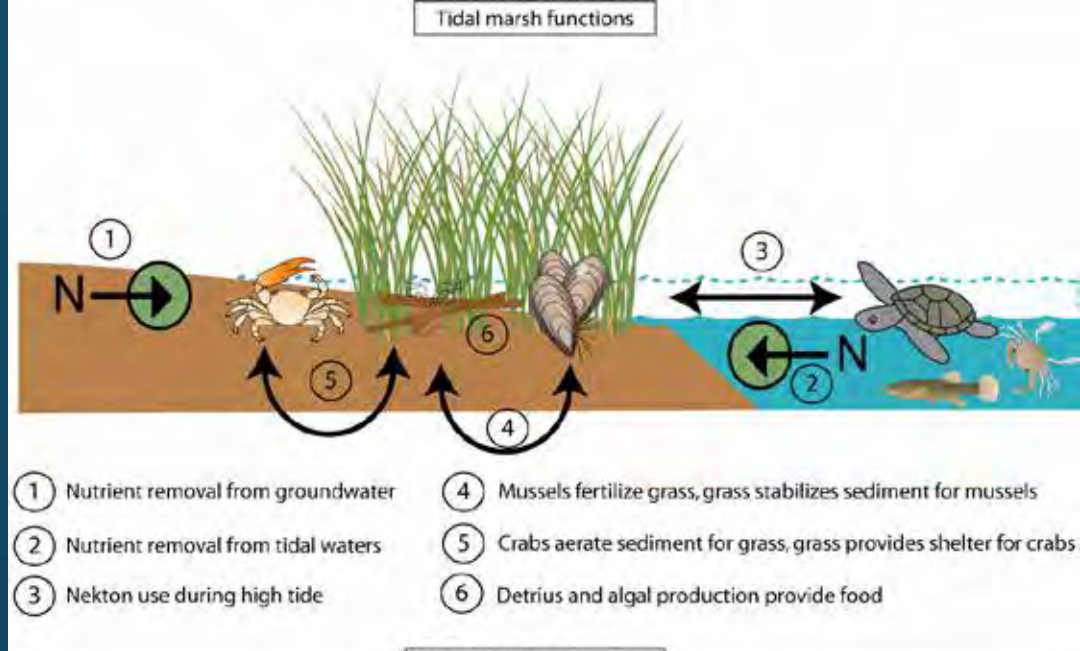
1. **Preserve the integrity and connectivity of shoreline processes**
2. **Maintain and enhance shoreline habitat diversity and function**
3. **Minimize and reduce pollutants to the shoreline environment**
4. **Reduce and reverse cumulative impacts to shoreline systems**

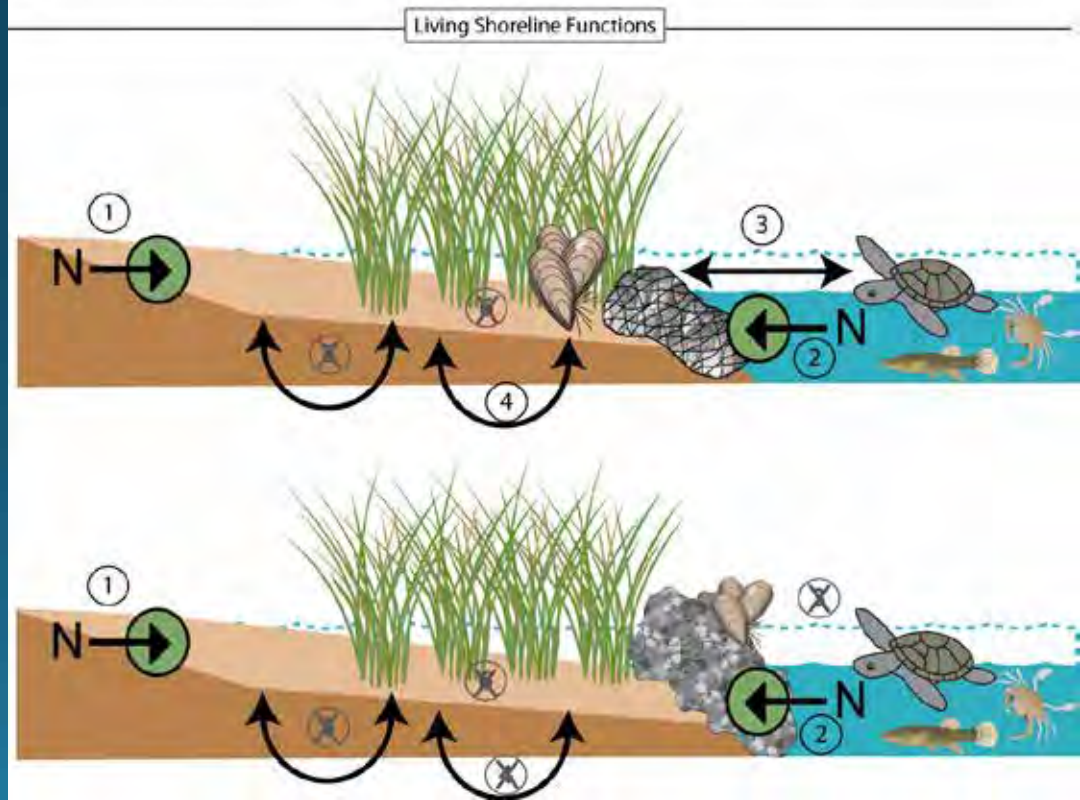
Emmett et al. 2017. Using voluntary ratings and certification programs to guide sustainable shoreline development



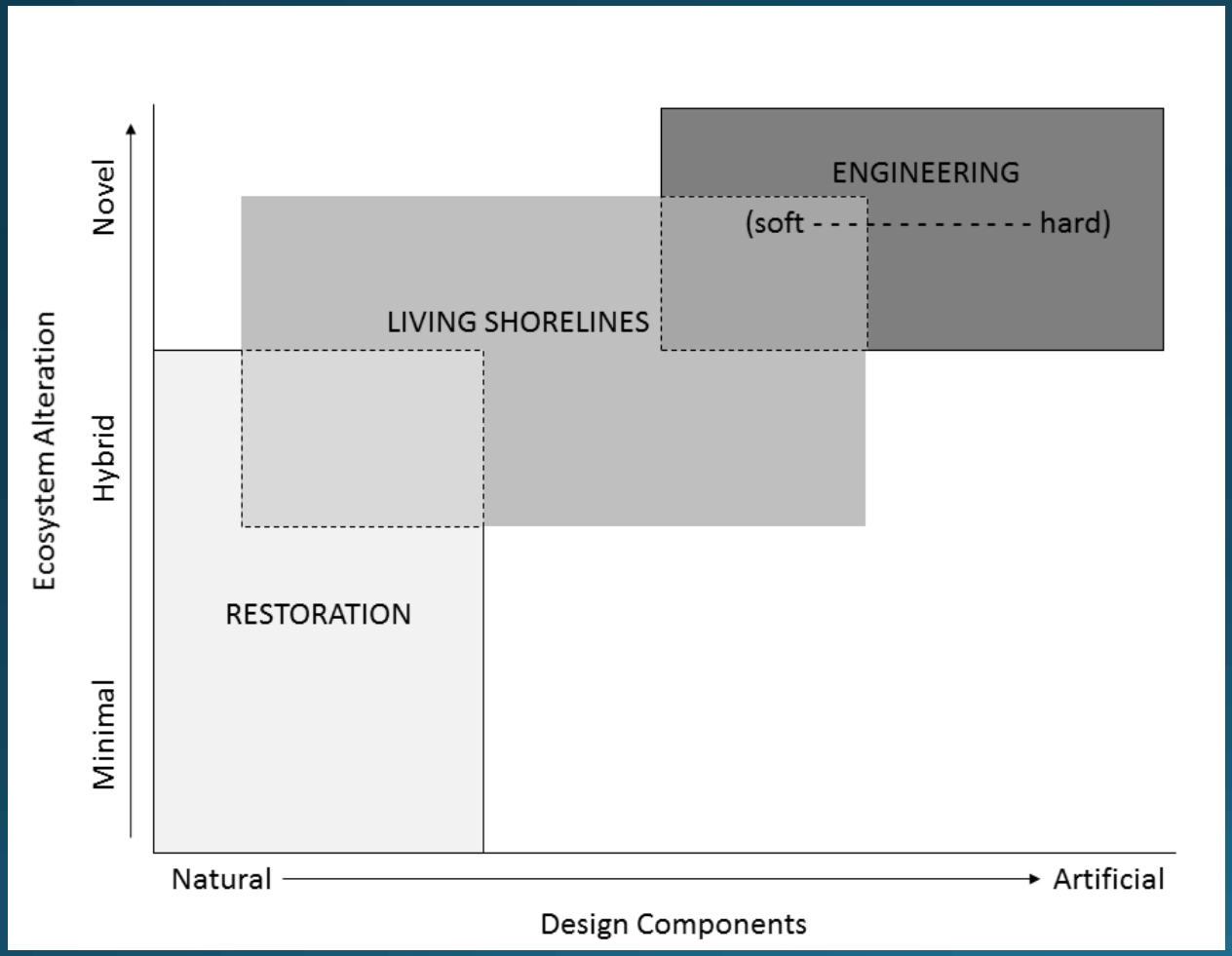


Bilkovic & Mitchell 2017. Designing living shoreline salt marsh ecosystems to promote coastal resilience.



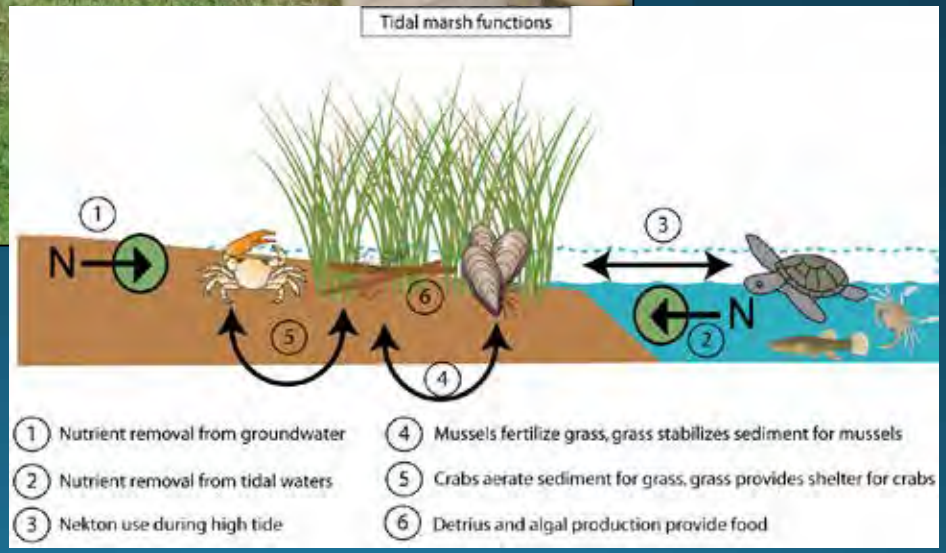


Living shoreline continuum



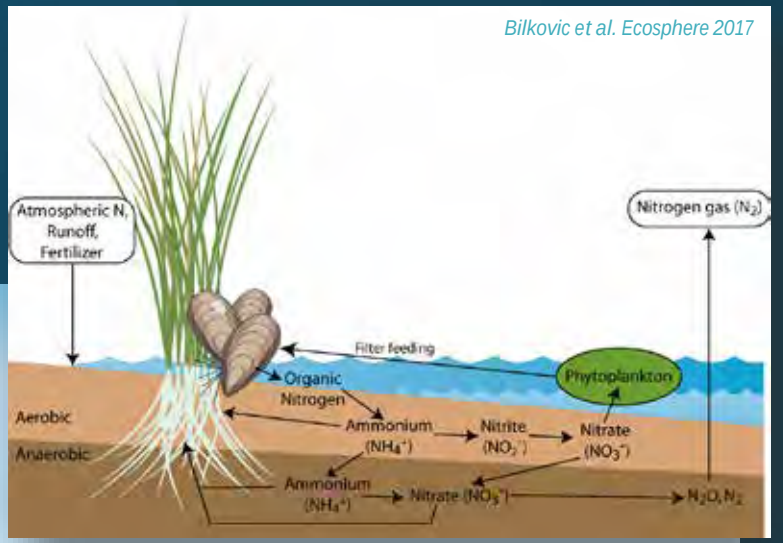
Toft et al. 2017. A synthesis of living shoreline perspectives.

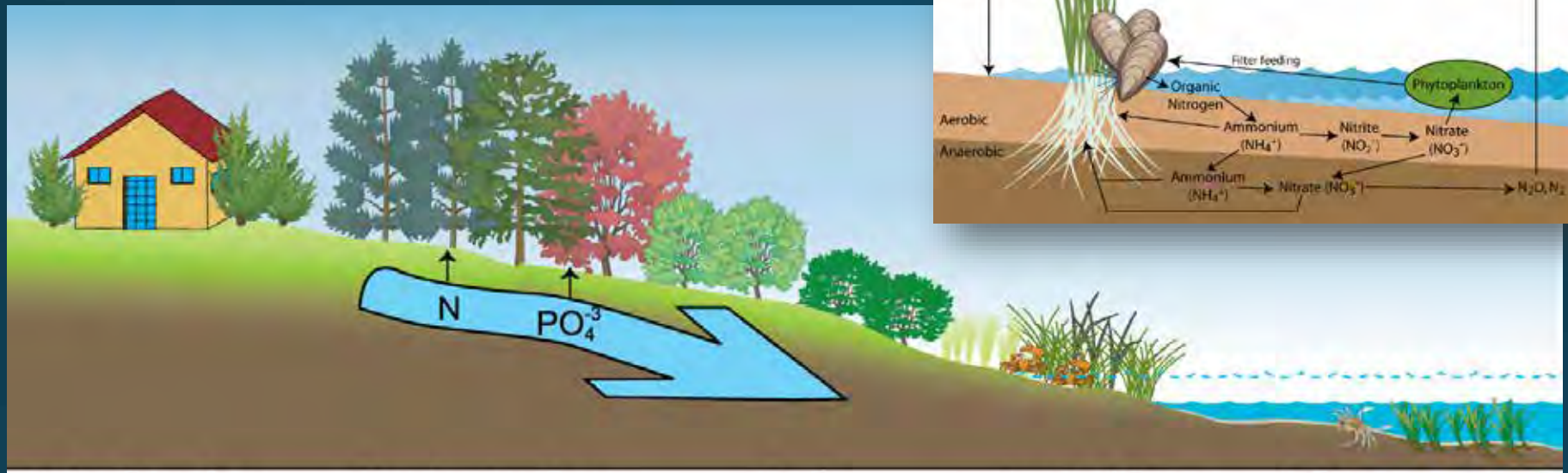
Preserve the integrity and connectivity of shoreline processes?



Co-benefits of living shorelines

Vegetation → water quality





Upland Landuse	Riparian Landuse	Banks	Intertidal Zone	Subaqueous Lands
Trees, shrubs, tall grass	Trees, shrubs, tall grass	Vegetated, Stable	Marshes, Phragmites	Seagrass (SAV)
		Partial vegetation	Coastal Sand Dunes	Oyster Reefs
Agriculture	Residential, Agriculture	Undercut	Riprap, Bulkheads	Aquaculture
Residential, Commerial	Industrial	Bare, Unstable	Boat ramps	Marinas

Symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols/), University of Maryland Center for Environmental Science.

Beck et al. 2017. Evaluation of living shoreline marshes as a tool for reducing nitrogen pollution in coastal systems

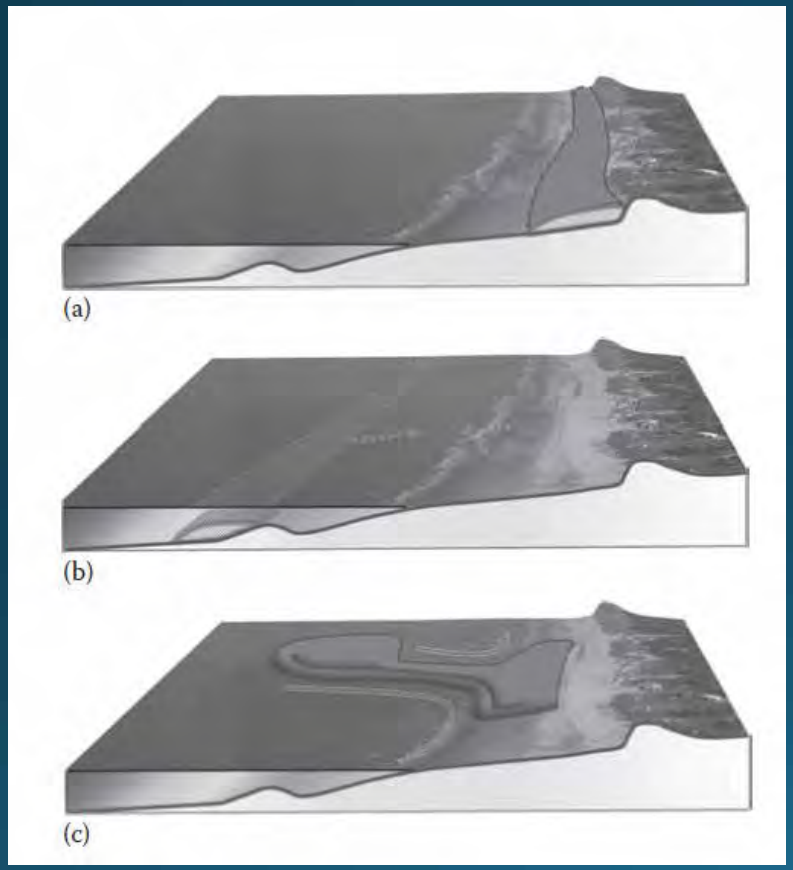
Cross shore Connectivity = min necessary structure

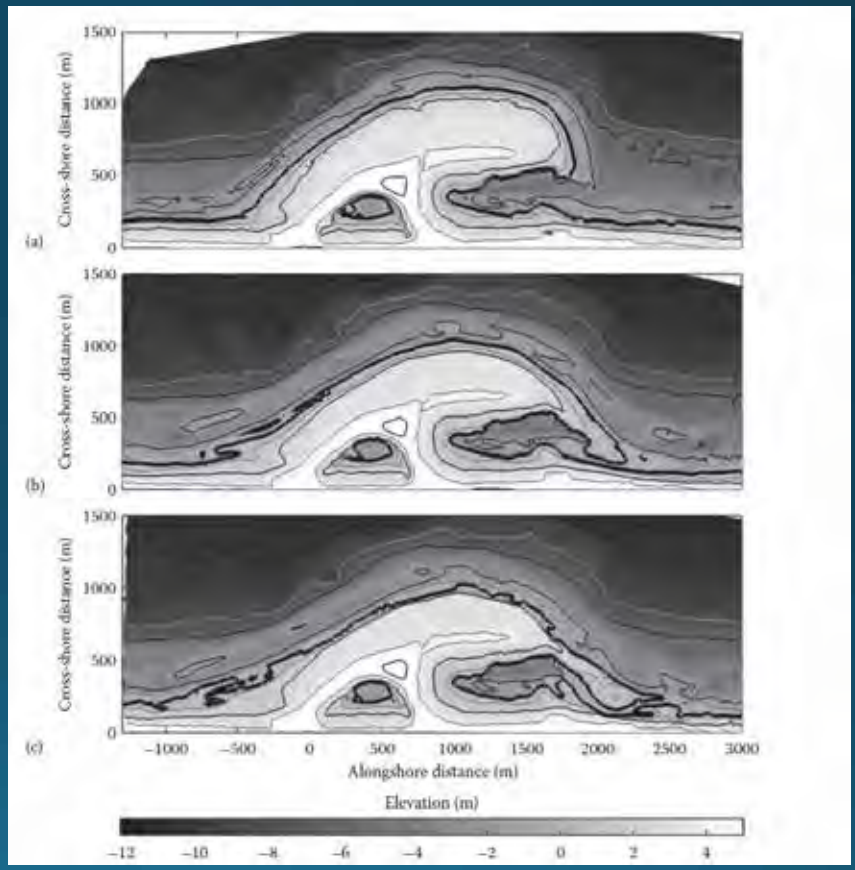
Parameter	Score	Criteria Values 1	2	3
Storm surge		2'	2' - 4'	>4'
Fetch		< 0.5 mi	0.5 - 1 mi	1 - 5 mi
Bank height		<3'	3' - 6'	>6'
Bank condition		Stable	Transitional	Eroding
Nearshore depths		<1'	1' - 2'	>3'
Sediment type		Mud	Mud/sand	Sand
Tide range		1' - 2'	2' - 4'	>4'
Erosion rate		1'	2'	>3'
Shoreline orientation		South	East or west	North
Shoreline configuration		Cove	Linear	Point
Infrastructure proximity		>100'	50' - 100'	<50'
Width of waterway		>300'	300' - 100'	<100'
Buffer condition		Lawn	natural grasses	Forest
Total Score	13 - 18		Low energy, trim trees and plant marsh	
	19 - 32		Medium energy, sill system	
	33 - 39		High energy, breakwater system	

These criteria are used in the shoreline management model

Priest. 2017. Practical Living Shorelines

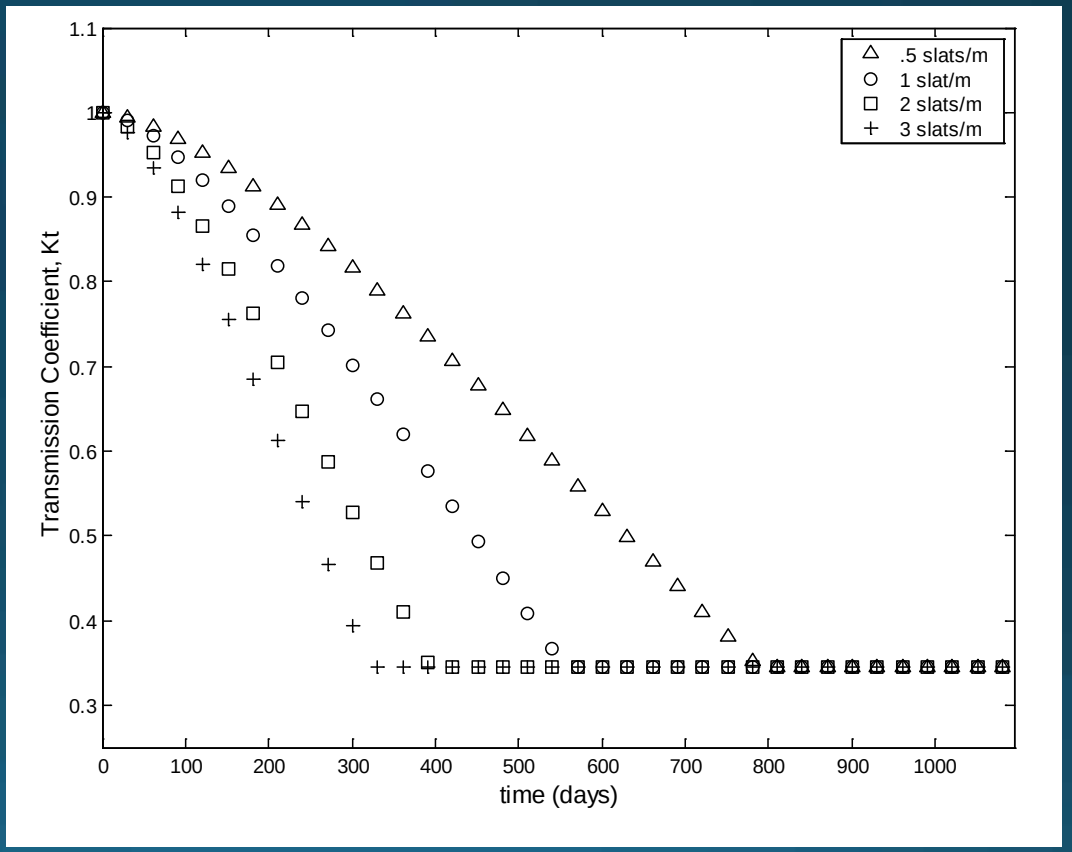
Shorescape connectivity: use dynamic components for sustainable protection





Borsje et al. 2017. Building with nature as a coastal protection strategy in the Netherlands

Leveraging dynamic biotic components for increased protection



Dense installation achieves excellent wave reduction in ~ 1 year; less dense structures achieve excellent wave reduction in ~ 3 year of good growth, with far less use of materials and construction costs

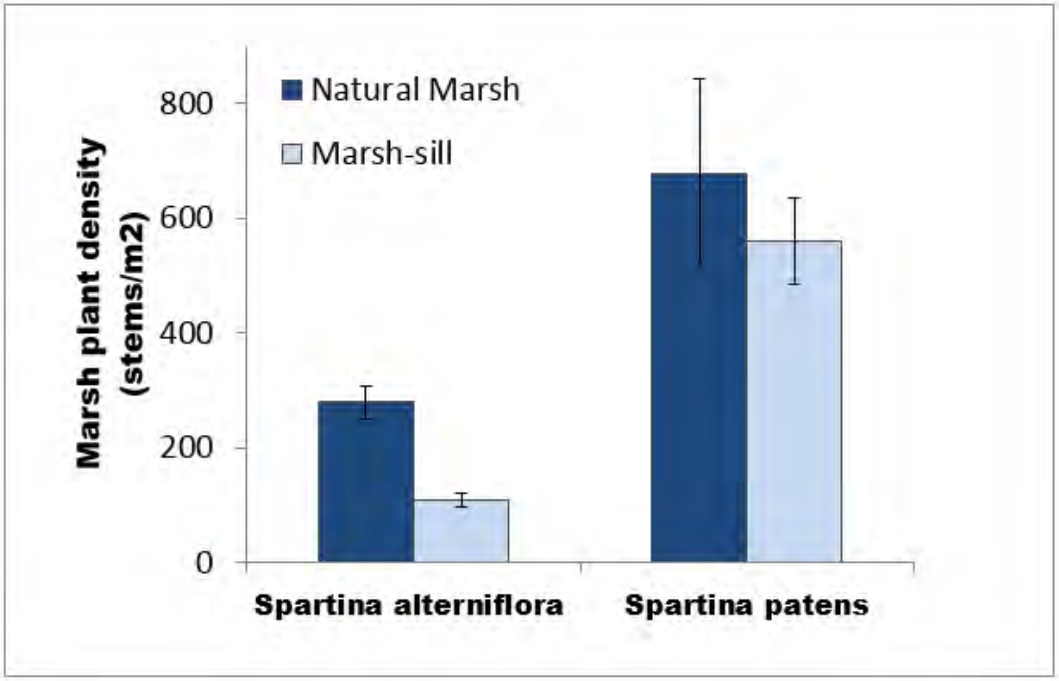
Hall et al. 2017. Growing Living Shorelines and Ecological Services via Coastal Bioengineering

Living shoreline resiliency

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

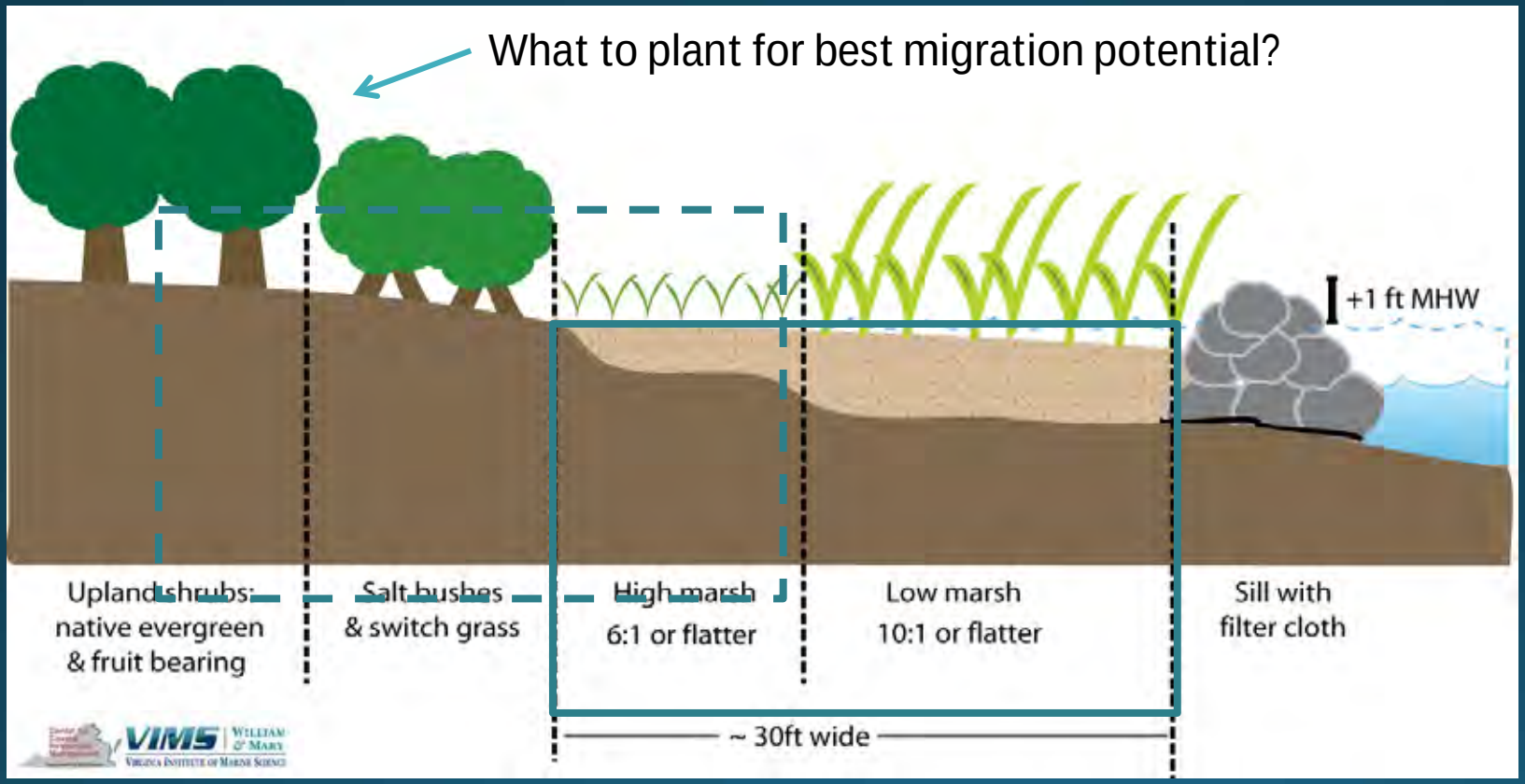
Accretion potential in living shoreline design

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%)

Migration potential in living shoreline design



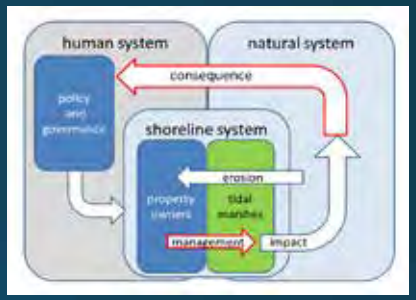
- Focus planting in the upper elevations of the tidal range
- Preserve riparian land where elevations are suitable for marsh migration

Dubois, K. 2017. Overcoming barriers of Living Shoreline Use and Success

Living shoreline related projects

NSF Coastal SEES

- Investigates the linkages between human and natural components of Chesapeake Bay shorescapes
- Research on ecology of living shorelines, human decision making, model changes under sea level rise
  - Talk to Donna Bilkovic (donnab@vims.edu) or Molly Mitchell (molly@vims.edu)

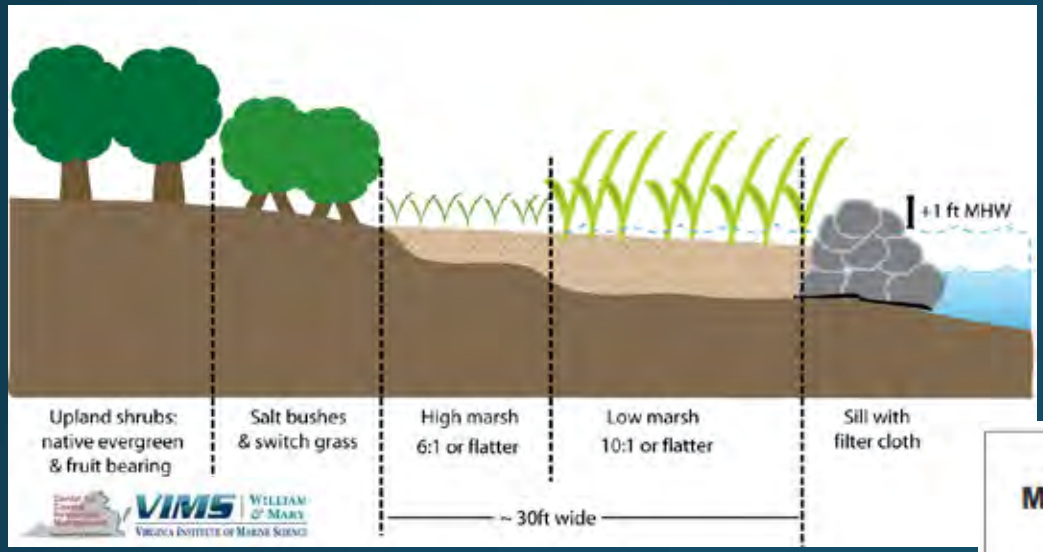


NOAA Coastal Resilience

- Focused on increasing the use of natural and nature-based features (NNBFs) to increase resilience of coastal communities to flooding caused by extreme weather events
- Develop siting and design guidance for NNBFs, explore crediting and co-benefits, help localities leverage NNBFs for resilience
  - Talk to Pam Mason (mason@vims.edu)

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

- 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 ft above MHW in moderate energy settings

Currin et al. "Developing alternative shoreline armoring strategies: the living shoreline approach in North Carolina." (2010): 91-102.