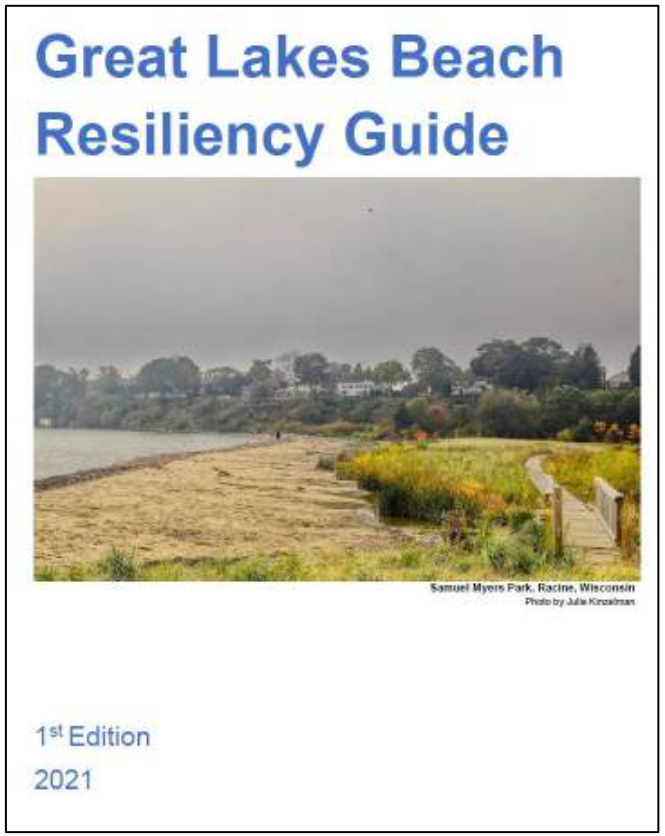
Resources on Coastal Resilience Practices



Wisconsin Coastal Management Program

SEWRPC
Serving the counties of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha

College of Engineering
University of Wisconsin-Madison

Sea Grant
University of Wisconsin

https://publications.aqua.wisc.edu/product/nature-based-shoreline-options-for-the-great-lakes-coasts/

Nature-Based Shorelines use or mimic natural feature to stabilize the coast

Green-to-Gray Spectrum of Shore Protection

U.S. Army Corps of Engineers

Systems Approach to Geomorphic Engineering

Nature-Based Shorelines
Living Shorelines
Coastal Green Infrastructure
Natural and Nature-Based Features (NNBF)
Engineering With Nature (USACE)

Coastal Structures
Hard Armoring
Gray Infrastructure

http://sagecoast.org/info/information.html

Benefits of Nature-Based Shorelines

Barry Kreiner, City of Marysville, Mich.

Michigan Department of Environment, Great Lakes and Energy

- Habitat creation or improvement
- Water quality improvements
- Can use hybrid approaches

- Aesthetic enhancements
- Public access may be easier
- Costs may be lower

Challenges in the Great Lakes

Adam Bechle

Adam Bechle

- High wave energy
- Ice impacts
- Water level fluctuations

- Short growing season
- Maintenance needs
- Emerging practices

NBS Techniques Summary

Vegetation

Native vegetation planted on the shore to reinforce sediments with its roots, dissipate wave energy and slow erosive runoff and wind.

Nourishment

The placement of clean sediment, often sand, on beaches, dunes or in nearshore waters to replace lost sand or build dunes.

Slope Stabilization

Regrading or reinforcing an eroding or failing bluff, bank or dune to a stable slope to allow vegetation to establish.

Edging

The placement of coir logs, wood or stones at the toe, or base, of the shoreline to prevent erosion and allow vegetation to establish.

Sill

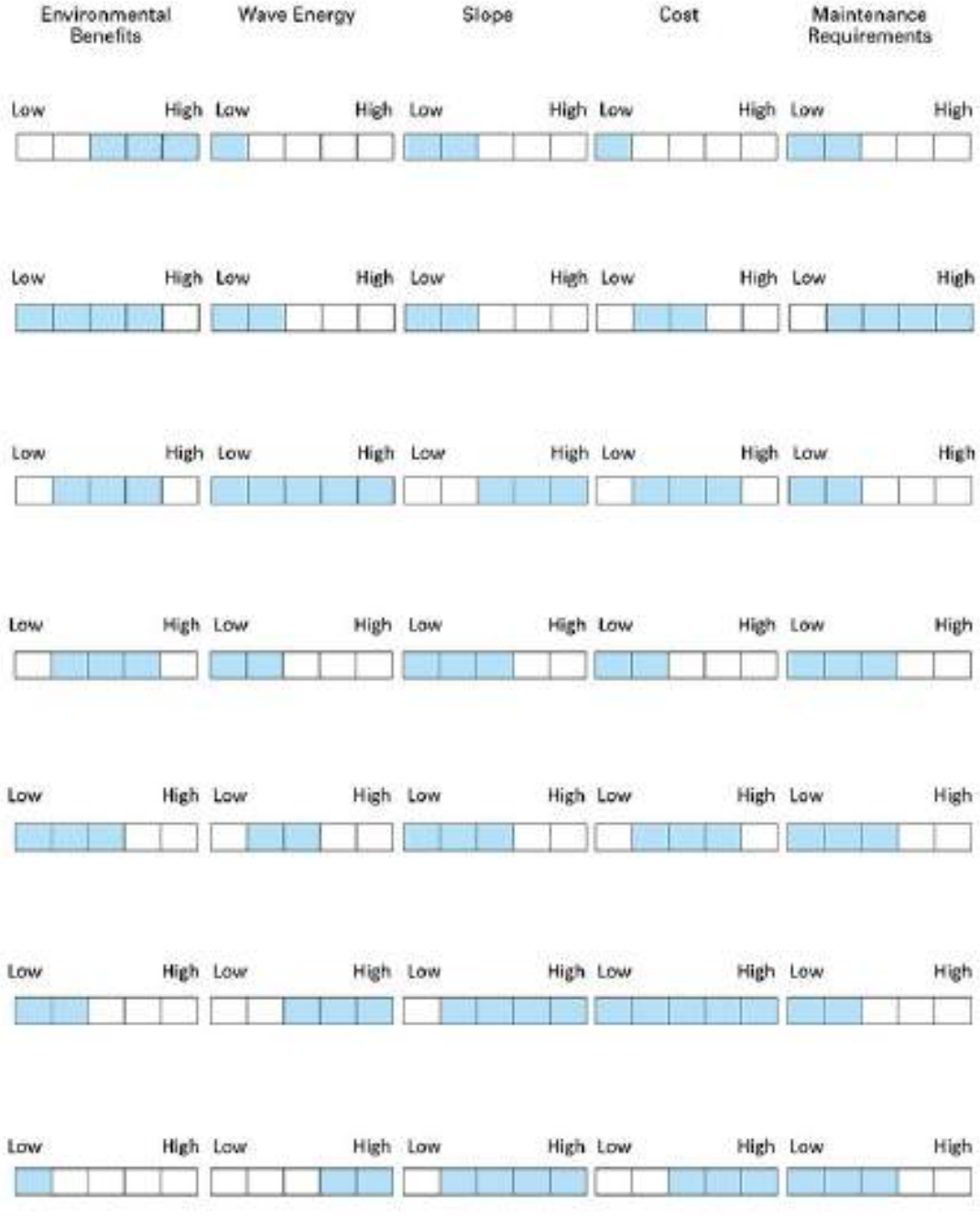
A low-profile structure located in the water just off the shoreline to dissipate wave energy and create an area of protected natural marsh.

Ecologically Enhanced Hard Armoring

Vegetation, textured surfaces or other features added to conventional hard armoring structures to provide habitat and other benefits.

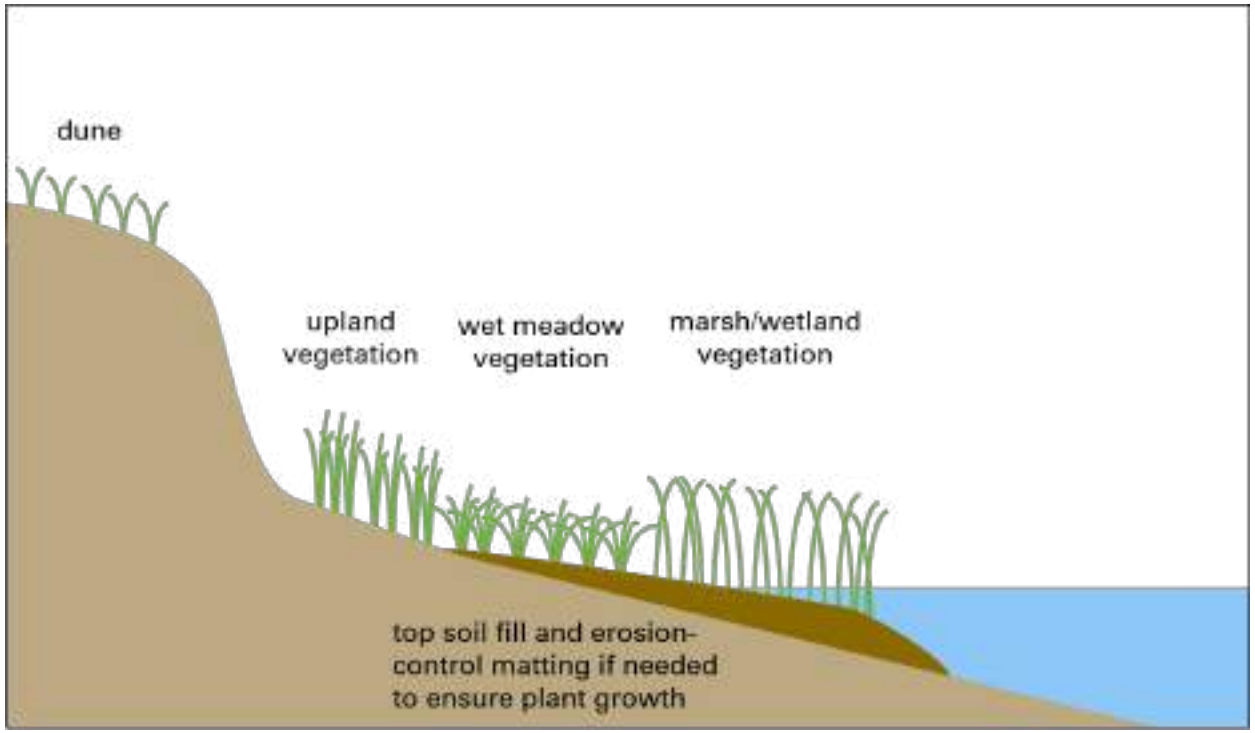
Hard Armoring

Rock, concrete or steel structures placed along the shoreline to slow erosion such as revetments, seawalls, groins and breakwaters.



Vegetation

Native vegetation planted on the shore to reinforce sediments with its roots, dissipate wave energy and slow erosive runoff and wind.



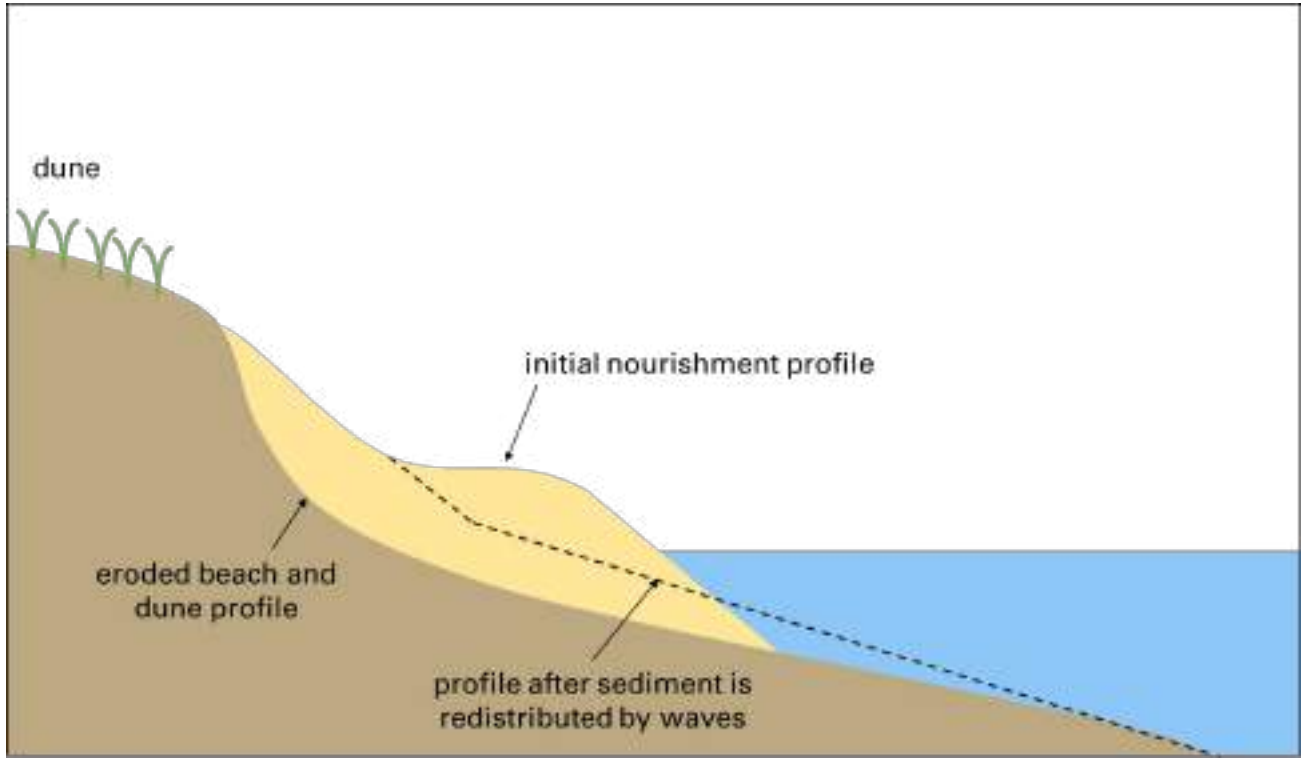
<u>Case Study</u>

Bradford Beach
Milwaukee, WI

Stevan Keith, Milwaukee County

Nourishment

The placement of clean sediment, often sand, on beaches, dunes or in nearshore waters to replace lost sand or build dunes.



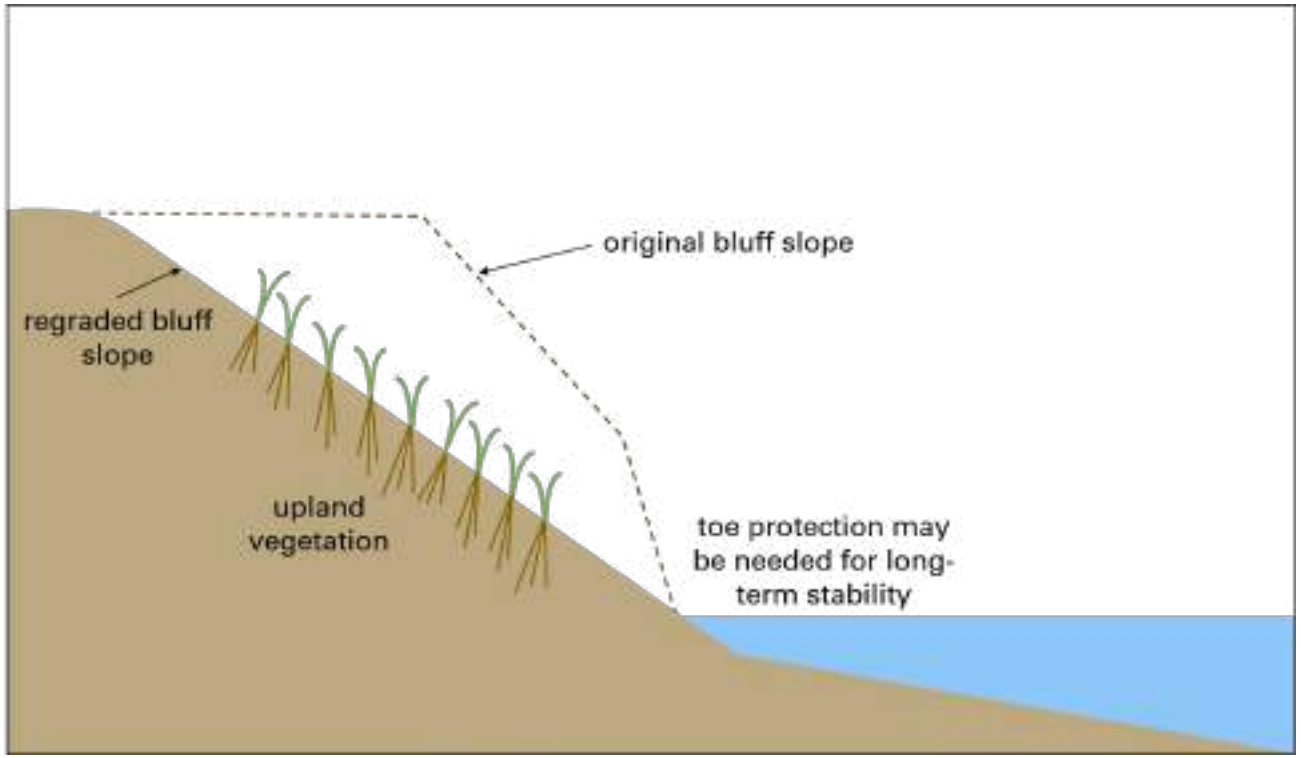
<u>Case Study</u>

Blue Harbor Beach
Sheboygan, WI

Capt. Dennis Carr, Wisconsing Wing – Civil Air Patrol

Slope Stabilization

Regrading or reinforcing an eroding or failing bluff, bank or dune to a stable slope to allow vegetation to establish.



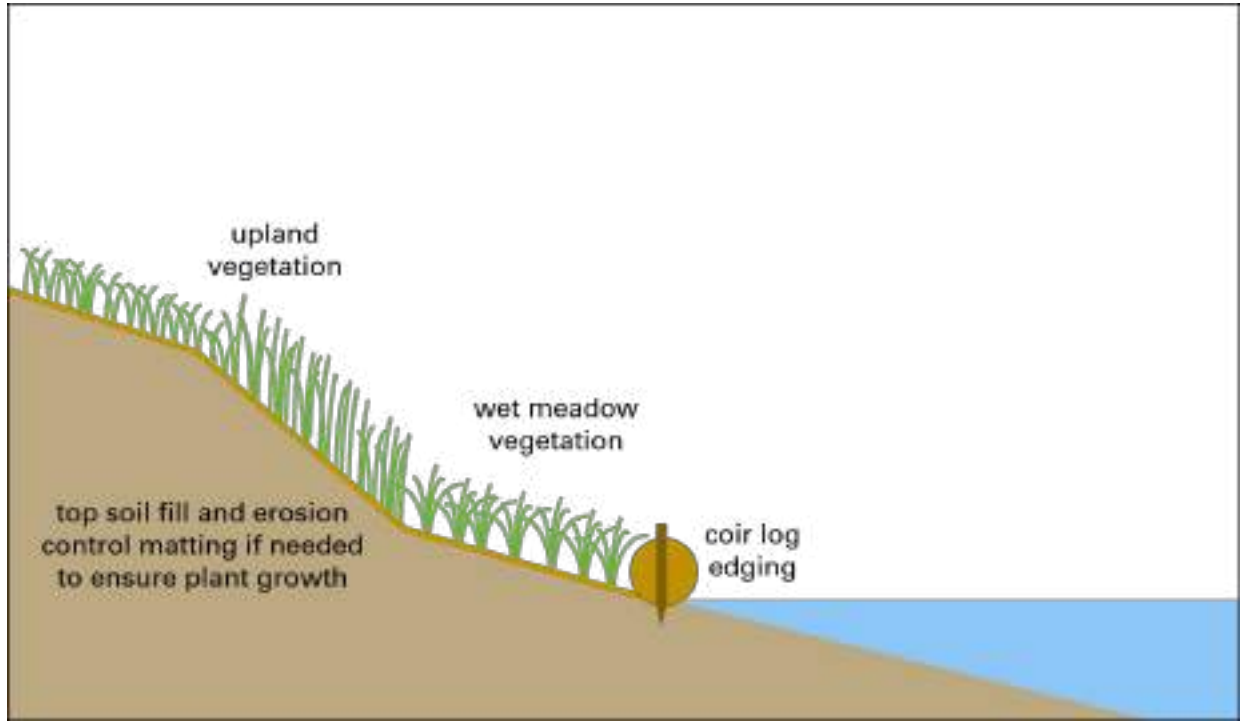
<u>Case Study</u>

Former University of Wisconsin-Milwaukee Chancellor Residence Shorewood, WI

Marek Landscaping

Edging

The placement of coir logs, wood or stones at the toe, or base, of the shoreline to prevent erosion and allow vegetation to establish.

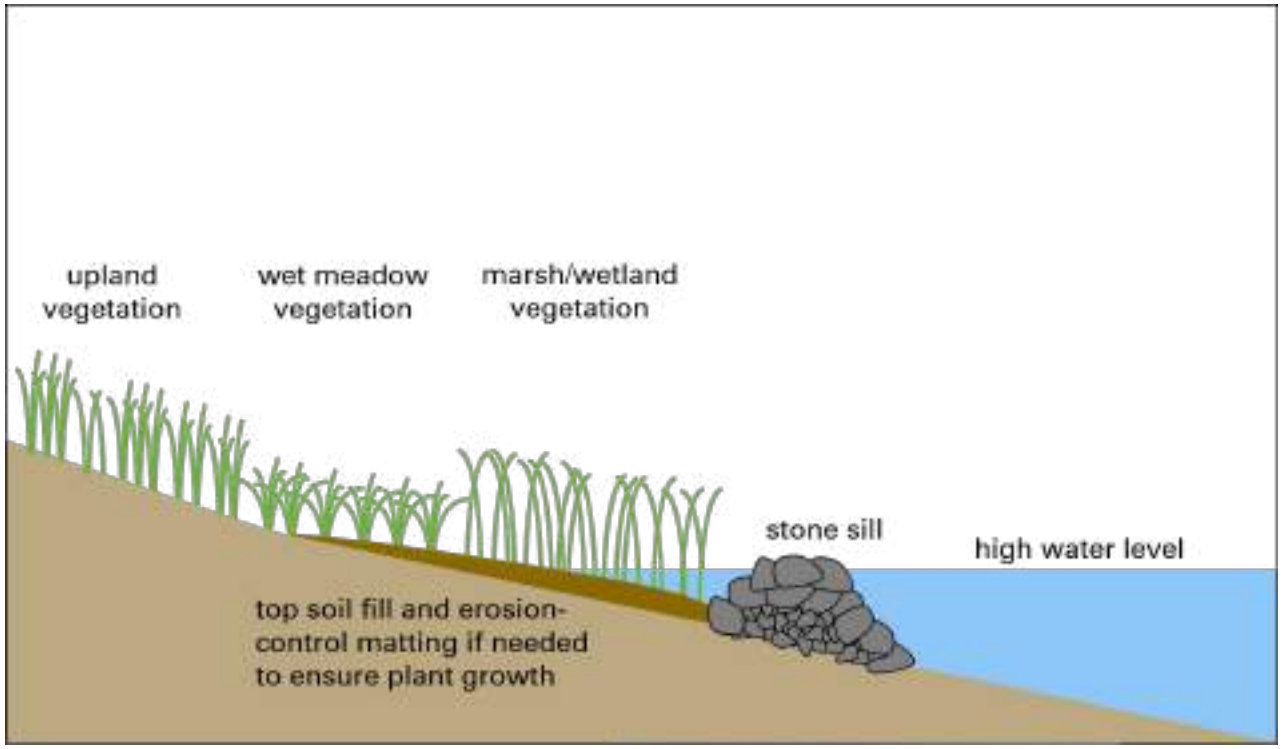


<u>Case Study</u>
Shoreline Park
Sandusky, Ohio

Erie Soil and Water Conservation District

Sill

A low-profile structure located in the water just off the shoreline to dissipate wave energy and create an area of protected natural marsh.



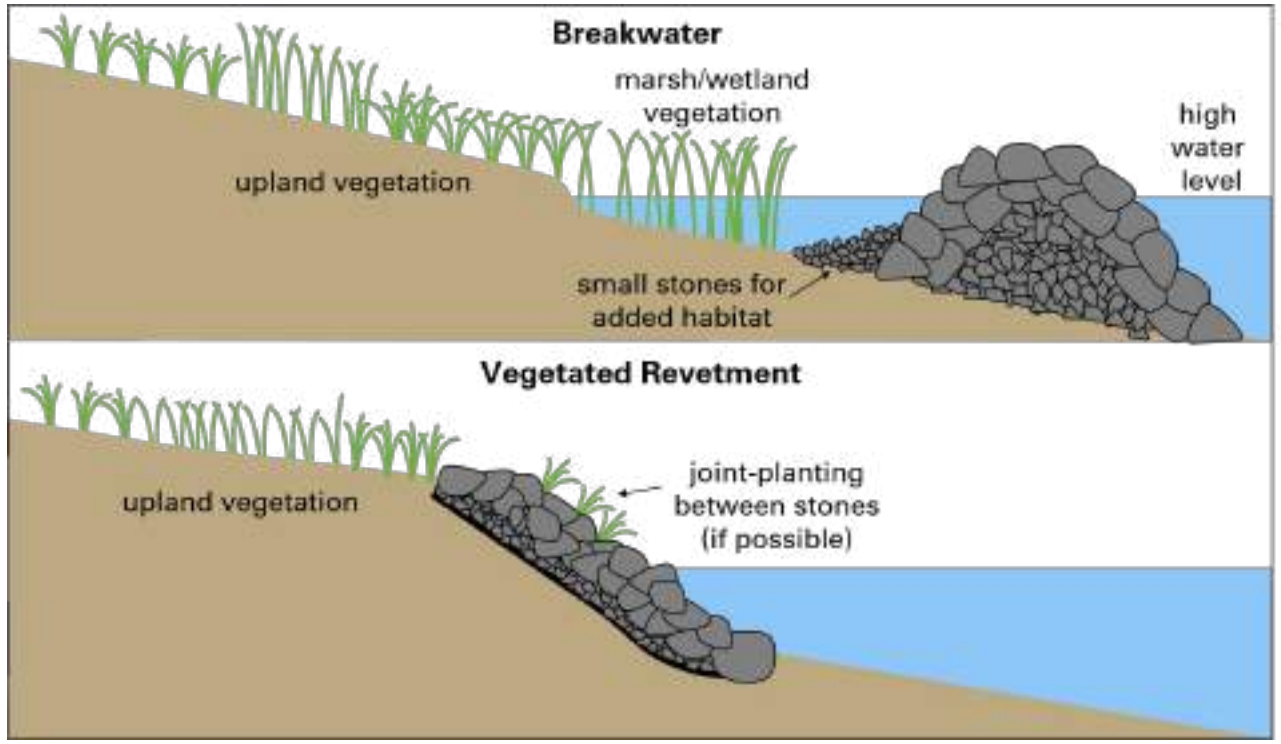
Case Study

Marysville Living Shoreline
Marysville, Michigan

Michigan Department of Environment, Great Lakes, and Energy

Ecologically Enhanced Hard Armoring

Vegetation, textured surfaces or other features added to conventional hard armoring structures to provide habitat and other benefits.



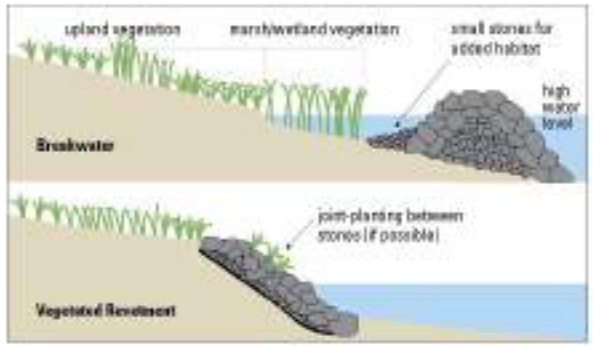
<u>Case Study</u>

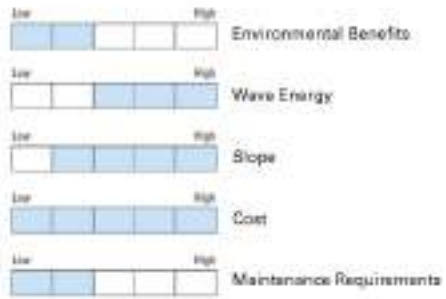
Samuel Myers Park
Racine, Wisconsin

Capt. Dennis Carr

	Environmental Benefits	Wave Energy	Slope	Cost	Maintenance Requirements
	Low High	Low High	Low High	Low High	Low High
Vegetation Native vegetation planted on the shore to reinforce sediments with its roots, dissipate wave energy and slow erosive runoff and wind.					
	Low High	Low High	Low High	Low High	Low High
Nourishment The placement of clean sediment, often sand, on beaches, dunes or in nearshore waters to replace lost sand or build dunes.					
	Low High	Low High	Low High	Low High	Low High
Slope Stabilization Regrading or reinforcing an eroding or failing bluff, bank or dune to a stable slope to allow vegetation to establish.					
	Low High	Low High	Low High	Low High	Low High
Edging The placement of coir logs, wood or stones at the toe, or base, of the shoreline to prevent erosion and allow vegetation to establish.					
	Low High	Low High	Low High	Low High	Low High
Sill A low-profile structure located in the water just off the shoreline to dissipate wave energy and create an area of protected natural marsh.					
	Low High	Low High	Low High	Low High	Low High
Ecologically Enhanced Hard Armoring Vegetation, textured surfaces or other features added to conventional hard armoring structures to provide habitat and other benefits.					
	Low High	Low High	Low High	Low High	Low High
Hard Armoring Rock, concrete or steel structures placed along the shoreline to slow erosion such as revetments, seawalls, groins and breakwaters.					

ECOLOGICALLY ENHANCED HARD ARMORING





Overview

In high wave energy environments, hard armoring like seawalls, breakwaters or revetments may be necessary to reduce erosion and flooding. However, there are several ways to enhance hardened coastal infrastructures to add some ecological benefits and/or lessen their impact on the environment.

Breakwaters, which are large structures of stone placed offshore, reduce wave energy at the shore, which can allow for naturalized beaches, vegetated shorelines or wetlands to establish where they might not otherwise exist along high wave energy coasts. Submerged reef breakwaters can also provide aquatic habitat for fish.

Revetments, which are shore parallel structures of erosion-resistant stone, can have vegetation incorporated between the stones, called a joint-planted revetment, or in the upland area to improve terrestrial and aquatic habitat compared to an unvegetated upland.

Modifying coastal structures with textured surfaces or additional smaller cobble stones can provide surfaces for aquatic species habitat that are unavailable on large armor stones, sheet pile or smooth concrete blocks.

Benefits

- A low-cost way to enhance an existing hard shoreline project with vegetation or textured surfaces
- Improves ecosystems of armored shorelines
- Improves visual appeal of armored shorelines

Challenges

- May disrupt natural coastal processes and accelerate erosion of adjacent properties
- May be a barrier for access to the shoreline for wildlife
- Can require more complicated design and construction than for a standard hard structure

Terrestrial vegetation growing adjacent to revetments. At armored coasts in Lake Erie, fish species richness was observed to be higher at sites with terrestrial vegetation than at non-vegetated sites (Sorensen, 2017). *Adam Bechle*

Maintenance

Hard armor structures should be inspected for signs of damage routinely, at least once per year, and repaired as needed. Vegetation may need to be maintained with occasional replanting, weeding and invasive species control.

Resources

Engineering with Nature (EWN)

The goal of this USACE initiative is to align nature and engineering to provide economic, environmental and social benefits. Their website features ongoing projects, atlases of case studies, tools and a number of USACE publications.

ewn.el.erdc.dren.mil

Sustainable Coastal Design and Planning – The Hard Habitats of Coastal Armoring

This book chapter, written by Richard Hindle, provides background on the novel ecology of hard armor materials and summarizes several examples of ecologically enhanced hard armoring.

escholarship.org/uc/item/1ha0d1hv

Related Options

Sills may be used in lower wave energy environments.

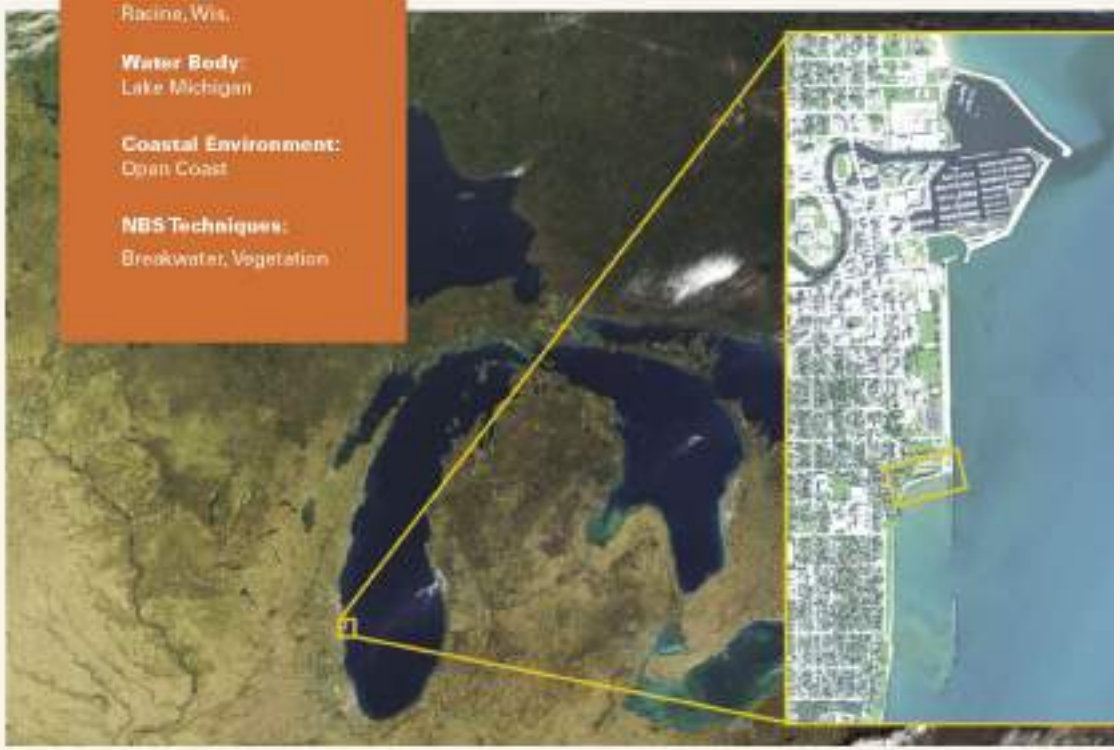
The USACE modified a section of the Milwaukee Harbor breakwater with a shallow slope of cobblestones to increase availability of fish habitat. *USACE - Engineering Research and Development Center*

Location:
Racine, Wis.

Water Body:
Lake Michigan

Coastal Environment:
Open Coast

NBS Techniques:
Breakwater, Vegetation



Case Study: Samuel Myers Park

Before Prior to the project, the area adjacent to the breakwater was eroded due to overtopping and the rest of the park was dominated by invasive Phragmites. *USACE*

After The raised breakwater facilitated construction of connected wetland areas. Invasive species were replaced with diverse native vegetation. An overflow channel was built adjacent to the breakwater to handle extreme storm surge and precipitation events. *Capt. Bianca Carr*

Overview

The Racine Health Department improved surface water quality at Samuel Myers Park by raising an existing breakwater, which allowed an existing native wetland to be restored and multiple green infrastructure components to be installed. Before the project, waves routinely overtopped the breakwater, causing erosion that formed a channel of stagnant water. Untreated runoff from the upland area of the park also contributed to the poor water quality. Vegetation at the beach was also confined to invasive species, primarily Phragmites. Raising the breakwater provided a protected area for the wetland restoration along this stretch of high wave energy open coast. The city received funding from 23 sources for this project, including the U.S. EPA Great Lakes Restoration Initiative, Wisconsin Coastal Management Program, Fund for Lake Michigan, U.S. Forest Service, U.S. Fish & Wildlife Service and the Root-Pike Watershed Initiative Network. The cost of raising the breakwater was $41,000 (~$205 per lineal foot), though salvaging limestone riprap from a legacy revetment on site reduced material costs significantly.

Design

The breakwater was raised by 3 to 4 feet to prevent overtopping from waves. This reduced erosion of the adjacent shore, allowing the existing wetland area to be protected and incorporated into a larger constructed wetland. Invasive species were removed and the constructed wetland and wetland fringe area were revegetated with native species. Dunes were also built to help capture runoff. In the upland area of the park, a rain garden and bioswale were built to help capture runoff and increase infiltration. Native vegetation was planted throughout the park, creating a diversity of habitat types including sand prairie, dune and wetland. The design has been adapted over time to help control large storm surges and excess runoff from significant precipitation events. This has included connecting the constructed wetlands with a drainage system, installing flow dissipaters to reduce runoff intensity and building an overflow drainage channel along the breakwater.

NATURE-BASED SHORELINES RESOURCE COLLECTIONS

Cold Regions Living Shorelines Community of Practice (CRLS CoP)
This community of practice focuses on communication, information sharing and knowledge-exchange to develop, support and steward the effective uses of living shoreline ideas and principles in a temperate North American climate. Their website features a library of resources, events calendar, recent news and a forum for discussion (registration required).
go.wisc.edu/q275qz

Engineering with Nature (EWN)
The goal of this United States Army Corps of Engineers Initiative is to align nature and engineering to provide economic, environmental and social benefits. Their website features a list of projects and a variety of literature.
go.wisc.edu/gt5m3q

Hudson River Sustainable Shorelines
A project focused on providing science-based information on shoreline management options that preserve natural function in New York's Hudson River Estuary, led by the Hudson River National Estuarine Research Reserve. The webpage has resources on design considerations, the performance of living shorelines in storms, case studies, outreach materials and other resources.
go.wisc.edu/1ny41p

NOAA Digital Coast Topic: Natural Infrastructure
Directory of National Oceanic and Atmospheric Administration (NOAA) guidance, data, tools, trainings and webinars on natural and nature-based solutions for minimizing coastal flooding, erosion and runoff. A specific resource of interest is the "Quick Reference on Nature Based Solutions."
go.wisc.edu/1f767g

NOAA Living Shorelines Website
National Oceanic and Atmospheric Administration (NOAA) webpage on living shorelines, including a map of NOAA-supported living shorelines projects.
go.wisc.edu/nvs66c

Living Shorelines Academy
Put together by the North Carolina Coastal Federation and Restore America's Estuaries, this site provides online courses in living shorelines for property owners and professionals. It also features a comprehensive list of living shorelines resources, projects and professionals.
livingshorelinesacademy.org

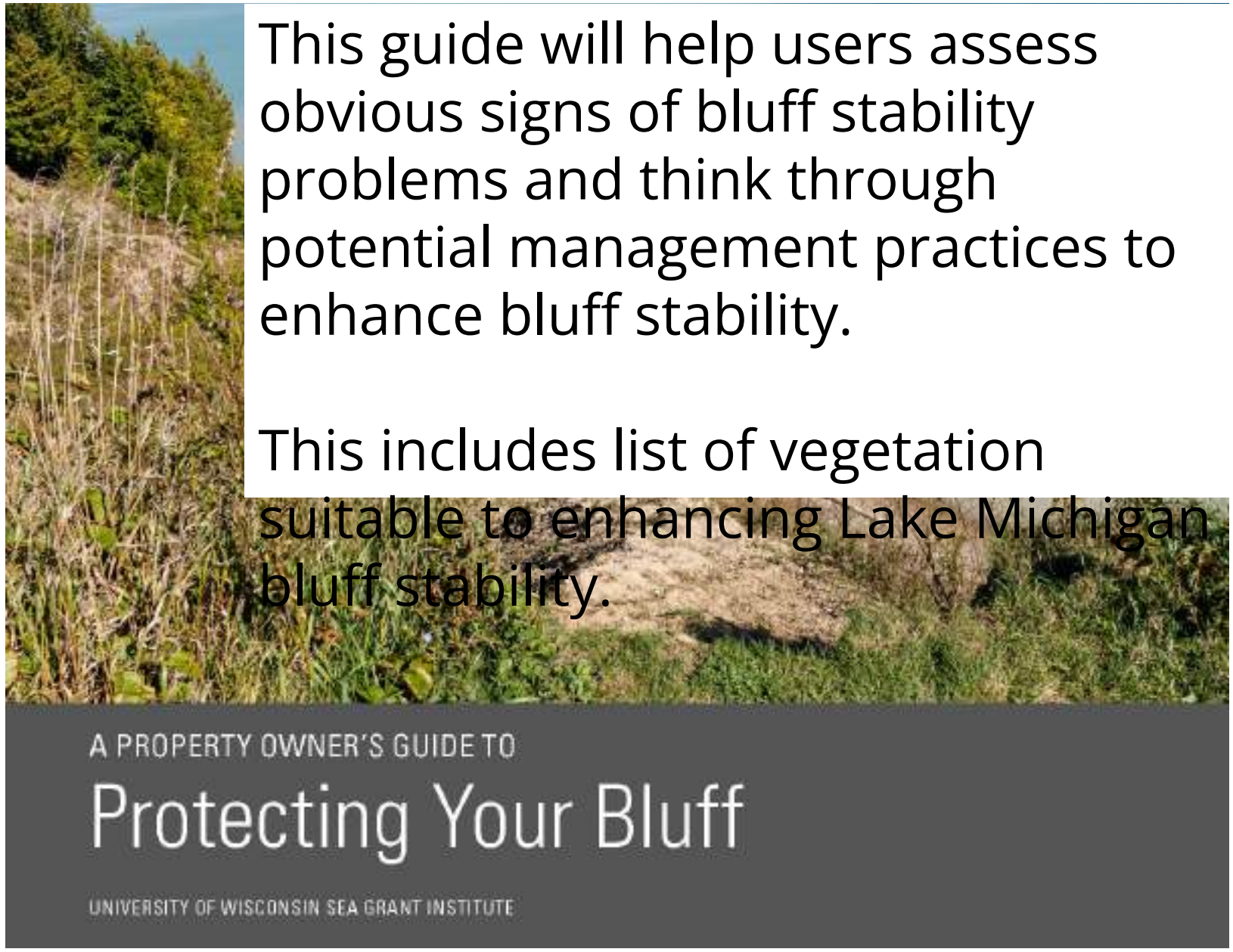
Naturally Resilient Communities
The website of this partnership provides information on using nature-based solutions to protect against flooding and erosion. They feature solutions and case studies for different hazards, regions and scales.
nrcsolutions.org

The Nature Conservancy's Coastal Resilience Program
This is a program led by The Nature Conservancy to examine nature's role in reducing coastal flood risk. The program consists of an approach, a web mapping tool and a network of practitioners around the world supporting hazard mitigation and climate adaptation planning.
coastalresilience.org

Systems Approach to Geomorphic Engineering (SAGE)
This community of practice focuses on promoting the use of green and gray integrated solutions for coastal resilience across many coastal regions. Their website features a project database, a list of resources for technical guidance and more.
sagecoast.org

Virginia Institute of Marine Science (VIMS) Living Shorelines Webpage
Website with descriptions of living shoreline practices, examples of living shorelines in Virginia, design guidance and a site suitability tool for selecting living shorelines on Virginia coasts.
go.wisc.edu/nuh65m

https://publications.aqua.wisc.edu/product/a-property-owners-guide-to-protecting-your-bluff/



This guide will help users assess obvious signs of bluff stability problems and think through potential management practices to enhance bluff stability.

This includes list of vegetation suitable to enhancing Lake Michigan bluff stability.

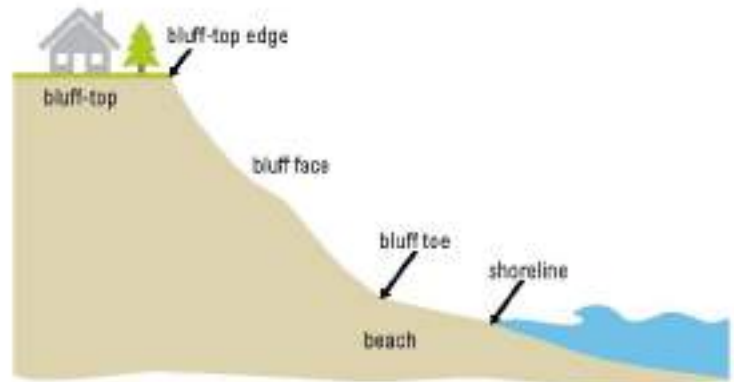
Lydia Salus, Adam Bechle, Gene Clark, Julia Noordyk, Tierny Bocsi, Dan Carter

CHAPTER 1 INTRODUCTION

LIVING ON A GREAT LAKES COASTAL BLUFF

This guide is intended to help Great Lakes coastal bluff property owners maintain and enhance the stability of their bluffs, as well as recognize obvious signs of bluff stability issues that may need further attention. Great Lakes coastal bluffs are a unique place to live because of the dynamic coastal processes that continually shape and change them. The recession, or landward erosion, of coastal bluffs is a natural phenomenon that occurs in response to processes acting from both the land and the water, across all zones of the bluff from the top to the bottom. The blufftop is where coastal investments like homes, businesses and infrastructure are often located. The sloping zone below the top is known as the bluff face or bluff slope. The bluff toe is at the base of the bluff and is where the bluff interacts with the lake. The beach lies between the bluff toe and the shoreline, which is the point at which the lake meets the land.

Bluff stability is the balancing act between the force of gravity pulling down on the bluff and the bluff's shear strength, which is the ability of the bluff soils to resist those forces. If the force of gravity becomes greater than the shear strength, the bluff slope becomes unstable and may collapse. An unstable bluff can fail rapidly in a large slump or progressively in a series of slides that work their way up the bluff over a period of years. Bluff stability is influenced by the bluff soil material, bluff slope angle, wave erosion, Great Lakes water levels, nearshore sediment transport, surface water runoff, groundwater saturation and seepage, and human activities on or near the bluff.



Major zones and features of coastal bluffs.

Guiding Principles

- Manage land use to keep structures and other assets as far away from the bluff-top edge as is feasible
- Avoid adding excess weight and other disturbances near the bluff-top edge
- Direct surface water runoff away from the bluff-top edge
- Minimize inputs to the groundwater and remove excess groundwater that causes slope stability issues
- Maintain and enhance bluff vegetation, especially deep-rooted native species
- If absolutely necessary, use well-designed shore protection structures and slope stabilizing earthwork to address bluff instability that threatens buildings

CHAPTER 2 BLUFF-TOP MANAGEMENT

The top of the bluff is where coastal investments like homes, businesses and infrastructure are often located. Because of this, the bluff-top is where many human activities can either improve bluff stability or work to destabilize the bluff. This section describes the obvious signs of bluff stability problems that may be present at the bluff-top and a number of bluff-top practices to promote bluff stability through managing land use, surface water runoff, groundwater infiltration and vegetation.

BLUFF-TOP INDICATORS OF SLOPE STABILITY ISSUES

There are a handful of visual signs that may appear at the bluff top that indicate stability issues with the bluff. It should be noted that there may be visual signs of bluff stability issues present on the bluff face or toe prior to indicators appearing at the bluff top. These signs are covered in Chapter 3: Bluff Face and Toe Management. While visual cues can be indicators of ongoing coastal bluff stability issues, they may not always be present before a bluff failure occurs. A professional evaluation is the only true way to determine whether a bluff is stable. Nevertheless, routine monitoring for visual indicators of bluff issues may give notice of ongoing issues and signal a need for further investigation by a professional.

Ground cracks

Ground cracks at the bluff top may indicate the slope has started to slide or slump lakeward. This movement in the slope is likely to continue.

Tilted trees

Trees or shrubs that are leaning toward the lake may indicate that the slope is unstable and a bluff failure is beginning.

Runoff drainage over the bluff-top edge

Pathways for runoff to collect and drain over the edge of the bluff can increase bluff erosion locally as water flows down the bluff face and removes soil particles. These concentrated drainage pathways usually result in rills and gullies on the bluff edge and bluff face.

Noticeable ponding of water or wetland vegetation on the bluff top

Areas of the bluff top that routinely have standing water after rains or sustain wetland vegetation like cattails may indicate high groundwater conditions in the bluff. These areas of ponding could also be locations

CLOCKWISE FROM RIGHT Horizontal ground cracks at the top of the bluff that preceded a slope failure. *Gene Clark*

Trees leaning lakeward on an unstable bluff slope. *Adam Bishop*

Runoff drained to a low spot on the bluff top and flowed over the edge, resulting in a bare, eroding face that was the only unstable portion on this stretch of bluff. *Adam Bishop*

BLUFF-TOP MANAGEMENT PRACTICES

Bluff stability can be promoted through bluff-top management of land use, surface water, groundwater and vegetation. Property owners should also be sure to avoid common mistakes that work against bluff stability.

Land use

Locate structures an adequate distance away from the bluff-top edge. This reduces the risk that the structure will be affected by bluff failure during its useful life. This also reduces the chance that costly shoreline erosion control or bluff earthwork will be needed to protect the structure in the future. An adequate building setback minimizes the structure's impact on bluff stability from the additional weight placed on the bluff and changes to surface water drainage patterns. A professional evaluation by a qualified engineer or geologist can help determine an adequate setback distance for a given site. Before adding any new structure or other additions to a site, consult with your local planning and zoning office to see if ordinances specify a minimum required setback distance for these additions.

To enjoy scenic views, locate lightweight and easily moved minor structures like small gazebos and decks nearer to the bluff edge than the primary structure. Compared to a house, these types of structures will add much less weight to the bluff-top edge, are much smaller monetary investments and can be more easily relocated if threatened by bluff instability. Before adding any new secondary structure or other additions, consult with your local planning and zoning office to see if ordinances specify a minimum required setback distance for these additions.

Avoid adding excess weight or other disturbances near the bluff-top edge. Adding weight near the bluff-top edge from earthwork, machinery, buildings, pools or other heavy additions increases the loads on the bluff and reduces stability. Limit substantial digging or other ground disturbances near the bluff-top edge. Also avoid unnecessary compaction of soil on the bluff top during landscaping or construction. Compaction of soil can limit the soil's ability to absorb water, leading to increased runoff.

Lake view from a home with a more-than-adequate setback from the bluff-top edge. Sara Stelter

Permeable pavers used for bluff-top parking spots. Adam Bruhn

TOP A well-vegetated bluff top with a mixture of native ground cover and shrubs. Sara Stelter BOTTOM A framed Lake Michigan view over the top of low-growing vegetation. Sara Stelter

act between the aesthetic and property use preferences on the bluff top with landscaping practices that protect the integrity the bluff.

Maintain and enhance bluff vegetation, especially deep-rooted native species. Deep-rooted vegetation helps to stabilize the bluff by removing moisture from the soil and increasing the bluff's shear strength. By comparison, turfgrass offers little stabilization benefits due to its shallow roots. Avoid removing established native plants and manage the site for invasive species. If some vegetation must be removed, utilize practices like trimming, pruning or thinning to retain as much vegetation as possible rather than clearcutting.

The benefits of bluff-top vegetation can be enhanced by planting multiple native species that have well-mixed root networks and offer bluff stabilization benefits as well as aesthetic appeal. Ornamental or invasive plants are not recommended because they can outcompete native species, require more maintenance and have negative impacts on the local habitat. A mixture of trees, shrubs and herbaceous plants will provide a network of diverse, interwoven root structures to increase the strength of the bluff's soil. Further considerations for selecting plant species to enhance your bluff's vegetation are given in Appendix A: Selecting Suitable Vegetation for Enhancing Lake Michigan Coastal Bluff Stability in Southeastern Wisconsin.

Frame lake views through areas of low-growing and selectively pruned vegetation rather than removing vegetation. Views of the lake may become obscured by high-growing vegetation. Frame desired sightlines of the lake by pruning low tree limbs and planting low-growing vegetation in these areas. There are also several shrubs and trees that tolerate, or even thrive, when aggressively cut back, such as willows, cottonwoods and aspen. Find out more about how you can choose low-growing species by reading Appendix A: Selecting Suitable Vegetation for Enhancing Lake Michigan Coastal Bluff Stability in Southeastern Wisconsin.

Remove large trees near the bluff-top edge. Large trees can add excess weight to the bluff-top edge. Trees near the bluff-top edge may tip over, tearing out a large portion of the bluff top with them. As erosion encroaches upon large bluff-top trees, consider cutting or top-killing the tree to

CHAPTER 3 BLUFF FACE AND TOE MANAGEMENT

Stability issues may appear on the face and toe of the bluff before they work their way to the bluff top and impact homes. The bluff face and toe are treated together in this chapter because many of the physical processes that can affect these zones are connected and often need to be managed together to stabilize a bluff. This section describes the obvious signs of bluff stability problems that may be present at the bluff face and toe and a number of practices to promote bluff stability through managing land use, surface water runoff, groundwater infiltration and vegetation. If there are major bluff stability problems that threaten a home, some combination of bluff regrading and toe protection may need to be considered to stabilize the bluff.

BLUFF FACE AND TOE INDICATORS OF SLOPE STABILITY ISSUES

There are a handful of visual signs that may appear on the bluff face and toe that indicate stability issues with the bluff. These signs may be present before recession of the bluff top occurs. While visual cues can be indicators of ongoing coastal bluff stability issues, they may not always be present before a bluff failure occurs. A professional evaluation is the only true way to determine whether a bluff is stable. Nevertheless, routine monitoring for visual indicators of bluff stability issues may give notice of ongoing issues and signal a need for further investigation by a professional.

Surface water drainage rills or gullies

Rills, which are small channels eroded into the bluff face, can indicate that water is flowing from the bluff top over the slope and causing surface erosion of the bluff face. Gullies indicate that water drainage down the slope is concentrated enough to erode small valleys. Bluff crest recession is often more severe where gullies have formed.

Groundwater seepage

Wet areas in the middle of an otherwise dry bluff face may indicate that groundwater is seeping through the bluff face. Because saturated soils have a less stable slope angle than dry soils, the presence of groundwater in the bluff can reduce slope stability. Groundwater seepage may also cause "sapping," in which the seeping water erodes soil from the bluff face.

TOP Rills on the face of the bluff caused by surface water drainage down the slope. *Sara Stathas* BOTTOM A small gully channel where surface water drains over the bluff face. Note the increased crest recession at the top of the gully compared with the surrounding bluff crest. *Adam Beahr*

TOP Water seeping out of the middle of the bluff face. *Adam Beahr* BOTTOM Cattail growth on the lower bluff face. Groundwater was visibly seeping from the face and likely contributing to the erosional scarp. *Sara Stathas*

plant species that can tolerate the dynamic bluff face environment are given in Appendix A: Selecting Suitable Vegetation for Enhancing Lake Michigan Coastal Bluff Stability in Southeastern Wisconsin.

Use temporary stabilization measures to help new plants establish on the bluff face. Soil movements and high-velocity surface water runoff on the bluff face can hinder the ability of vegetation to establish and thrive. In some cases, erosion-control matting, coir logs or synthetic geotextiles may be necessary to help stabilize soil on the bluff face while the vegetation establishes. Use of live stakes can help some plants like willows or dogwoods establish on the bluff face.

It can be nearly impossible to establish vegetation on a bluff face that is too steep, has ongoing slides or has significant runoff flowing down the face. These bluff faces are typically rather bare of existing vegetation already and likely need to be regraded before vegetation can establish. In this situation, consult with a professional engineer or geologist to evaluate the stability of the bluff (see Bluff Regrading on page 20).

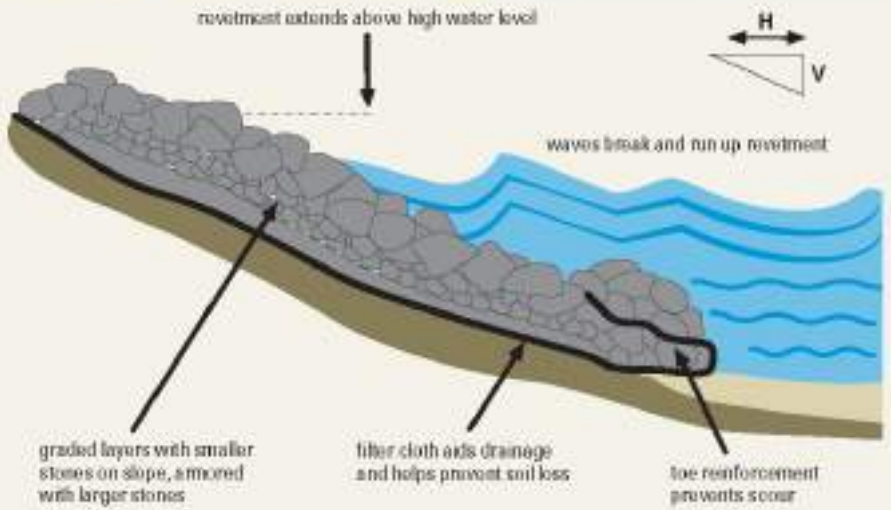
Well-vegetated natural shoreline and bluff toe showing no signs of wave erosion, even at high water levels. Adam Bowie

Healthy bluff vegetation on the bluff face. Sara Stefkas

Coir logs staked into the bluff to slow surface water flow down the bluff face and help vegetation establish. Cydo Zaha

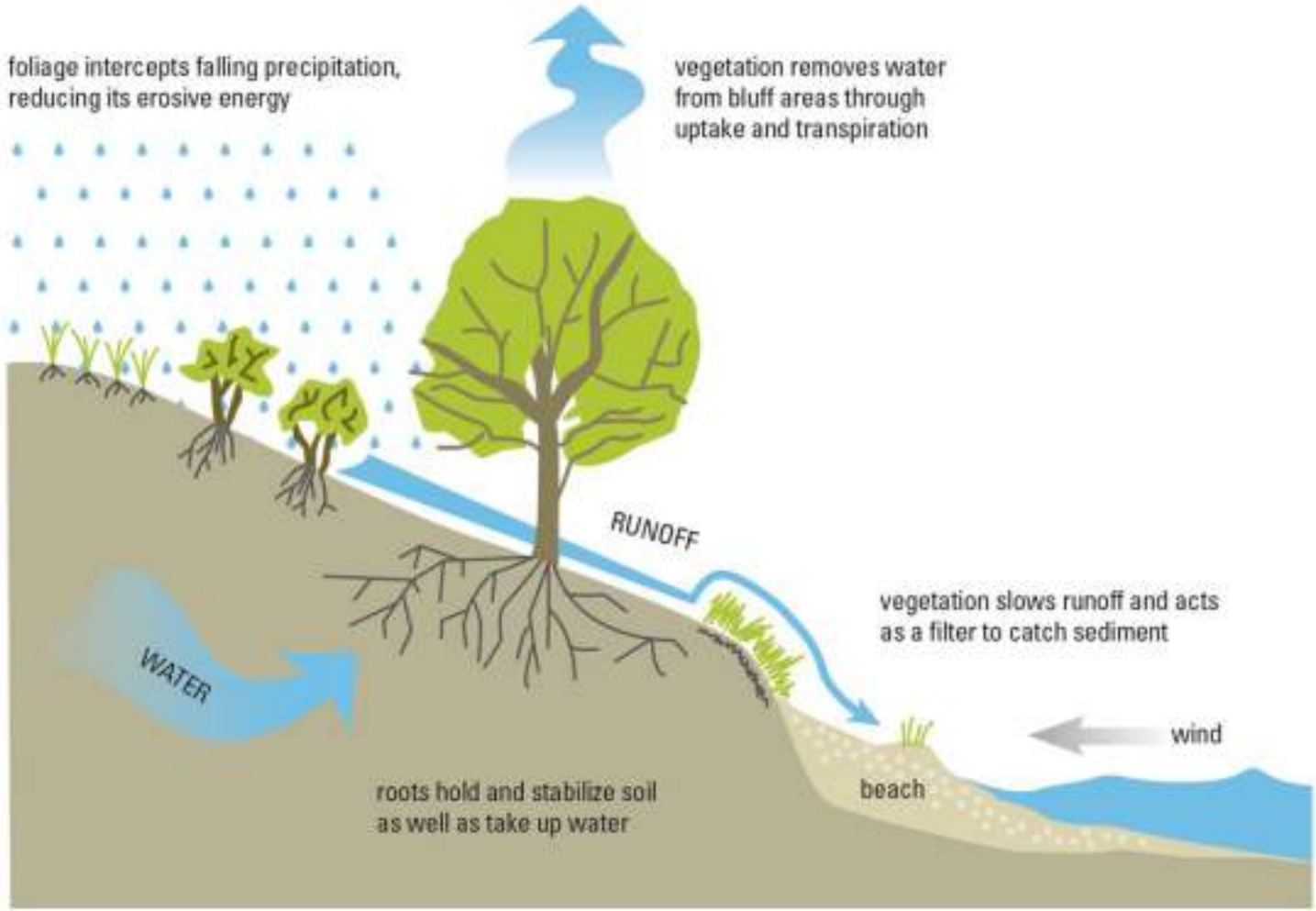
ABOVE A stone revetment at the bluff toe. Sara Stefkas

RIGHT Typical elements of a properly designed revetment. V H describes the slope.



APPENDIX A

SELECTING SUITABLE VEGETATION FOR ENHANCING LAKE MICHIGAN COASTAL BLUFF STABILITY IN SOUTHEASTERN WISCONSIN



SHRUBS

Common Name(s)	Scientific Name(s)	Usage Area	Root Type	Mature Height	Soil Type	Moisture	Sun/Shade Tolerance	Wildlife/Pollinators
Round-Leaved Dogwood	*Cornus rugosa*	Top, ravine, toe	Deep, extensive, suckering	10-15'	Any	Medium to somewhat dry	Partial sun	Somewhat deer tolerant, flowers support native bees, host plant for many moths and butterflies, fruits consumed by birds and mammals
Red Osier Dogwood, Gray Dogwood and Silky Dogwood	*Cornus sericea*, *Cornus racemosa* and *Cornus amomum*	Top, ravine, face, toe	Deep, extensive, suckering	6-15'	Any	Wet to medium, depending on the species	Full sun to partial sun	Somewhat deer tolerant, flowers support native bees, host plant for many moths and butterflies, fruits consumed by birds and mammals
Common Ninebark	*Physocarpus opulifolius*	Top, ravine, face, toe	Spreading, fibrous, extensive, suckering	5-10'	Any	Moist to somewhat dry	Full sun to partial sun	Deer tolerant, flowers support native bees, host plant for moths and butterflies
Chokecherry	*Prunus virginiana*	Top, ravine, toe	Spreading, suckering	5-30' (shortest in sunny, exposed locations)	Any	Moist to somewhat dry	Full sun to full shade	Deer tolerant, flowers support native bees,* host plant for many moths and butterflies; fruits consumed by birds and mammals
Hop Tree	*Ptelea trifoliata*	Top, face, toe	Extensive, but does not sucker from roots or rhizomes	10-20'	Any	Medium to dry	Full sun to partial sun	Seldom browsed significantly by deer, flowers support native bees, host plant for the giant swallowtail butterfly
Staghorn Sumac and Smooth Sumac	*Rhus typhina* and *Rhus glabra*	Top, ravine, face, toe	Spreading, suckering to form large colonies	15-25'	Any	Medium to dry	Full sun	Deer tolerant, flowers support native bees (mason bees also hollow out stems for nests), host plant for moths and butterflies, fruits consumed by birds and mammals
Pussy Willow, Missouri River Willow and Bebb's Willow	*Salix discolor*, *Salix eriocephala*, *Salix bebbiana*	Top, ravine, face, toe	Extensive, Fibrous, suckering	6-20'	Any	Wet to moist	Full sun to partial sun	Deer tolerant, early spring floral resource for bumblebees,* host plant for many moths and butterflies
Sandbar Willow	*Salix interior*	Top, ravine, face, toe	Extensive, Fibrous, suckering to form large colonies	8-20'	Sands and loams	Wet to moist	Full sun to partial sun	Deer tolerant, early spring floral resource for bumblebees,* host plant for many moths and butterflies

SHRUBS

Silky Dogwood. *Doug McGrady*

1. Red Osier, Gray and Silky Dogwood
(Cornus sericea, C. racemosa and
C. amomum)

These shrubby dogwoods are recommended as bluff plants because they tolerate a wide range soil types, grow quickly, form extensive root systems, sucker when aboveground portions are removed and can withstand being partially buried by bluff sediments. All prefer moist conditions, though gray dogwood disfavors the very wettest sites and tolerates medium or even slightly dry sites. All can be purchased from local or regional nurseries.

Round-Leaved Dogwood. *Dan Carter*

2. Round-Leaved Dogwood *(Cornus rugosa)*

This large, shrubby dogwood is often found growing in the understory on wooded slopes and ridges near Lake Michigan as well as the transition from the beach to steep, wooded slopes. Like other shrubby dogwoods, it suckers and has an extensive root system, but it tolerates drier and somewhat shadier conditions. This species is exceptionally ornamental with textured leaves, white flowers, white berries and good pink to crimson red fall color. This species is occasionally offered by local and regional nurseries and is worthy of greater use.

Common Ninebark. *F.D. Richards*

3. Common Ninebark *(Physocarpus opulifolius)*

Ninebark occurs naturally on the bluff face, where it occasionally forms large colonies, and it tolerates a wide range of soil types and moisture levels. Ninebark grows quickly, even from small or bare-root nursery stock. It is adorned by profuse clusters of small, white flowers, which are followed by attractive pendant seed capsules that persist into winter. Exfoliating bark provides additional aesthetic interest in the winter. Ninebark is widely available from local and regional nurseries.

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Great Lakes Beach Resiliency Guide

Samuel Myers Park, Racine, Wisconsin
Photo by Julie Kinzelman

1st Edition
2021

The objective of this document is to provide a blueprint to communities and stakeholders on how to plan, build and maintain beaches that are resilient to coastal hazards

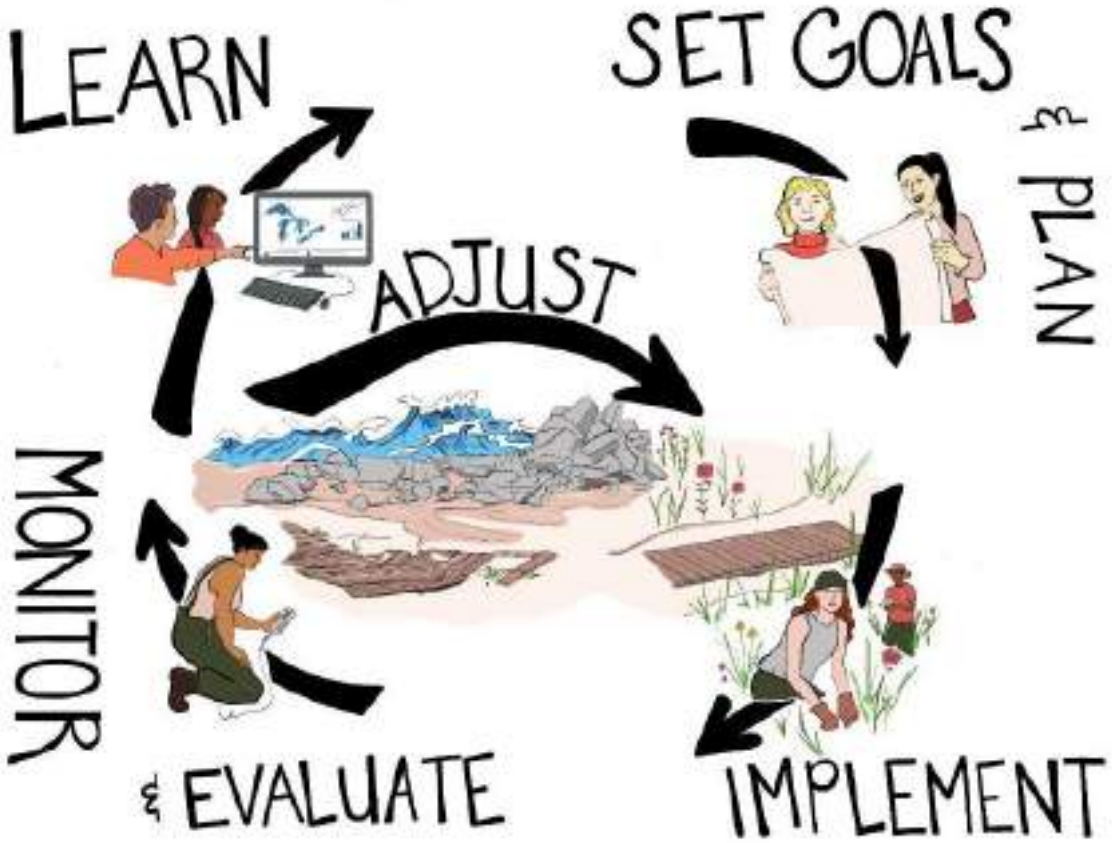

Figure 3.1. Monitoring and adaptive management framework (Brooke Bowser).

Thank You

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