

OUR SHORE

A Reference Guide
for Shoreline Stabilization in Maine



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OUR SHORE: A Reference Guide for Shoreline Stabilization in Maine is produced by Maine's OUR SHORE Program. The guide is intended primarily for professionals and practitioners involved in shoreline stabilization. It is also a useful resource for property owners, local officials, educators, government agency staff, and others interested in learning about the concepts, materials, and options for cost-effective shoreline stabilization.

While many practices in this guide can be performed by homeowners, it is important to consult a professional shoreline stabilization practitioner or a Maine-licensed professional engineer where there is significant risk to life, habitat, or structures.

For more information about OUR SHORE:
www.maine.gov/dep/land/ourshore

On the Cover:

This conceptual drawing shows a lake waterfront property in Maine several years after completion of a shoreline stabilization project that used options discussed in the OUR SHORE Reference Guide. This is one of more than a dozen drawings included in the Shoreline Stabilization Scenarios developed by the OUR SHORE Program. See Appendix A for the complete OUR SHORE Lake Scenario and scenarios for rivers/streams, coastal bluffs, and coastal dunes. (Drawing by M. Richards/Roundwater Design + Waterview Consulting)

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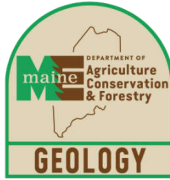
The Maine Department of Environmental Protection (DEP) extends sincere gratitude to the dedicated advocates who have championed living shoreline approaches for decades. Their ongoing commitment and collaboration have been essential to this work's success. The DEP acknowledges the critical contributions of numerous individuals from state and federal agencies, nongovernmental organizations, municipalities, and shoreline stabilization engineers, designers, landscape architects, and earthworks contractors whose research and experience improved understanding of shoreline stabilization practices across Maine's diverse freshwater and saltwater environments. Detailed content improvements were provided by partners through participation in field- and classroom-based workshops and trainings, during document reviews, and from field testing of the guidance materials with coastal and freshwater shoreline property owners. The OUR SHORE Program and Reference Guide reflect this collective commitment to shoreline resilience and environmental protection. Our hope is that continued collaboration will inform ongoing adaptation of this guide and increase its utility to users.

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7 Lakes Alliance
 Acorn Engineering
 Blue Hill Peninsula Forward
 Coastal Rivers Conservation Trust
 Cumberland County Soil & Water
 Conservation District
 Ecological Instincts
 FB Environmental
 Field Geology Services
 Flycatcher
 Gabriella's Gardens
 GEI Consultants
 Greater Portland Council of Governments
 Island Institute
 Knox-Lincoln Soil & Water
 Conservation District
 Lake Auburn Watershed
 Protection District

Lakes Environmental Association
 Linkel Environmental Construction
 McCullough Engineering Consultants
 Midcoast Conservancy
 Midcoast Council of Governments
 Parterre Ecological
 Portland Water District
 Sunrise County Economic Council
 The Home Place Team
 The Nature Conservancy
 United States Army Corps
 of Engineers
 University of Maine
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 University of Maine Cooperative Extension
 Knox & Lincoln Counties
 Wilkinson Ecological Design

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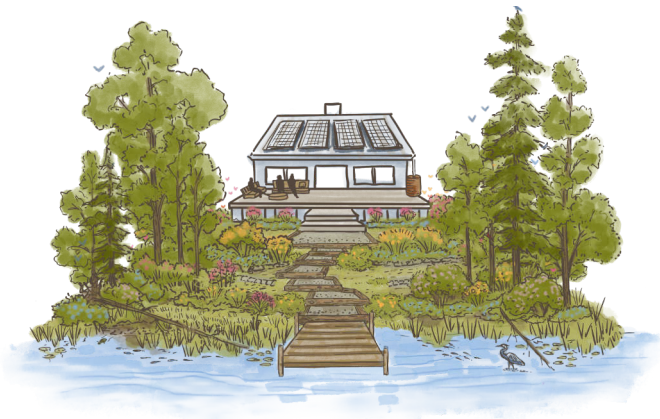
Orientation to OUR SHORE

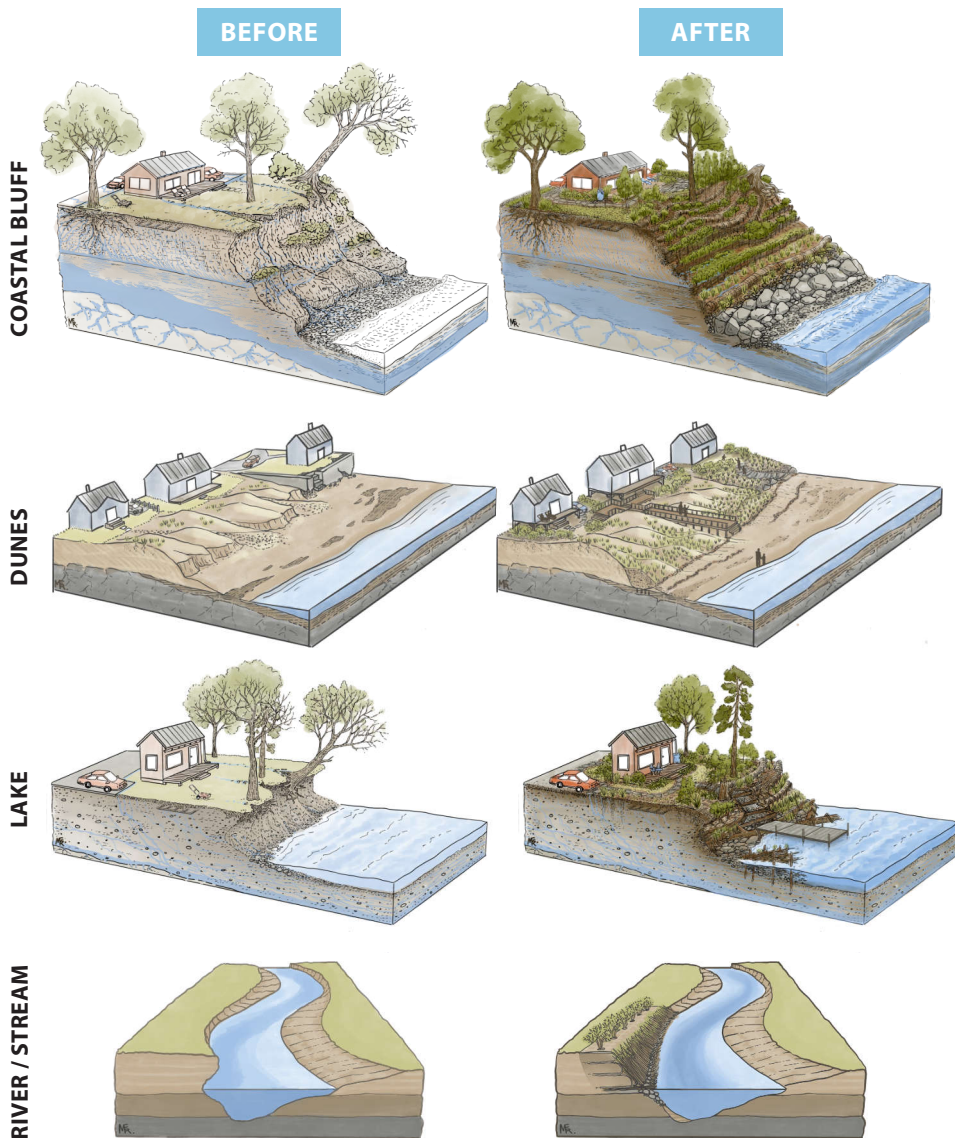
OUR SHORE focuses on helping people define goals for shoreline stabilization at a property, identify signs and sources of problems at the site, and choose suitable stabilization options. Through the OUR SHORE Program, state agencies and partners across Maine are working together to help people learn about state-of-the-art shoreline stabilization options and how to use them most effectively on freshwater and coastal properties. The OUR SHORE Reference Guide is one part of a broader set of resources available from the OUR SHORE Program.

The OUR SHORE Program offers extensive support for putting the concepts in this guide into practice because every shoreline deserves a site-specific solution. Resources available from the OUR SHORE Program include:

- Permit guidance to help people understand the process of applying for a permit
- A list of materials for shoreline stabilization
- Contractor and practitioner resources such as lists of material suppliers
- Plant lists of native species recommended for shoreline stabilization in Maine's freshwater and saltwater environments
- Trainings and workshops on shoreline stabilization
- Video and visual resources that illustrate the OUR SHORE approach
- Updates to these resources as new techniques, materials, or permitting options become available

Visit the OUR SHORE web page at
www.maine.gov/dep/land/ourshore





Unstable, eroding shorelines can be stabilized cost effectively into strong, long-lasting, wildlife-friendly, beautiful shorelines using the practices and principles in the OUR SHORE Reference Guide.

These illustrations show scenarios of shoreline properties in Maine before and after stabilization using the OUR SHORE approach. Appendix A features the complete set of OUR SHORE Shoreline Stabilization Scenarios.

CHAPTER 1

INTRODUCTION



Storm waves hitting the shore in Wells during March 2024 (A. Villator/Shutterstock).
Opposite page: Bubble Pond, Acadia National Park (Pexels); a river scene in Maine (N. Singh/Unsplash);
a view of Freeport's shoreline on Casco Bay (D. Hanscom/Shutterstock).

THERE ARE THOUSANDS OF PROPERTY OWNERS along the shores of Maine’s lakes and ponds, rivers and streams, wetlands, and coast. These shorelines are an iconic element of Maine and provide numerous benefits for people and wildlife. However, property owners often face challenges arising from erosion and shoreline instability. These natural processes can carve away land and threaten homes, other structures, shore access, and water quality.

The challenges have grown as stronger, more frequent storms slam Maine shorelines with intense rain, wind, waves, and ice, compounded by sea level rise. Severe storms in recent years have inflicted widespread damage on waterfront properties, including many that had been spared erosion and instability in the past.

During the past several decades, the most common way to deal with shoreline erosion was to put layers of large rocks called riprap along the water’s edge with a plastic geotextile fabric underneath. That approach can be understood as “unrooted riprap” because the plastic fabric does not allow plants to grow deep roots, which would help secure the site against erosion.

However, many years of experience have shown that unrooted riprap fails to provide effective, long-lasting stabilization of the shoreline. Moreover, unrooted riprap is expensive, can be counterproductive for protection, detracts from the scenic and functional nature of the shoreline, and harms fish, birds, mammals, and other wildlife. In Maine, we all have a stake in our shores, as one owner’s decision affects the neighbors and beyond.

Maine has...



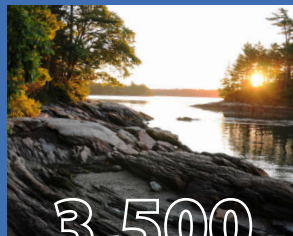
6,000

Lakes



45,000

Miles of Rivers



3,500

Miles of Coast

OUR SHORE: Maine's Partnership for Shoreline Stabilization

Engineers, scientists, earthworks contractors, landscape architects, and other experts recognize the need for better solutions for shoreline stabilization. Through Maine's OUR SHORE Program, they have compiled a toolbox of proven ways to address shoreline erosion and instability by harnessing the power of plant root systems and strong biodegradable materials. These options can be selected and combined in various ways to address site-specific conditions. This approach provides more robust, resilient, affordable, and habitat-enhancing shoreline stabilization.

The OUR SHORE Program helps people in Maine learn about state-of-the-art shoreline stabilization options and how to use them most effectively. By providing trainings, workshops, and information resources, state agencies are working together with partners across Maine through OUR SHORE to raise awareness of stabilization options.

Because Maine has many types of shorelines ranging from steep coastal bluffs lashed by ocean waves to gently sloping banks of meandering rivers, **OUR SHORE does not provide a one-size-fits-all solution. Rather, OUR SHORE focuses on helping people define goals for shoreline stabilization, identify signs and sources of problems at a site, and choose suitable stabilization options.**

OUR SHORE works with nature by using the stabilizing power of healthy root systems and soils combined with structural methods and natural materials to protect and strengthen shorelines. **Key underlying concepts in OUR SHORE include:**

- **minimize disturbance to the site during project implementation and**
- **enable shorelines to function as natural systems as quickly as possible.**

These concepts are essential for shoreline stability, water quality, and healthy habitat over the long term.



Unrooted riprap was installed twice in front of this house. It failed both times to prevent erosion.

Practical Solutions for Property Owners

It might seem that waves crashing against the land are the main cause of shoreline erosion. However, groundwater and surface water from nearby uplands are often major causes. OUR SHORE is unique in assessing these often-overlooked contributors to erosion problems and providing an integrated approach to address them.

In many cases, there are do-it-yourself steps that property owners can take to reduce the impacts of groundwater and surface water, such as planting more vegetation, slowing down water that is flowing over the land, and diverting water away from the bank. When houses or other structures are threatened, slopes are tall or steep, or other challenges exist, property owners may hire civil engineers and landscape architects to design shoreline stabilization projects.

The concepts in the OUR SHORE Reference Guide are intended to help property owners understand what issues need to be addressed, determine the minimum level of effort that is needed to deal with those issues, and implement a plan in the most environmentally friendly way possible. This process often results in simpler, faster permitting. In other words, although unvegetated options and synthetic materials might be possible to use, vegetation and biodegradable materials will work just as well in many cases, and it will be easier to get a permit.

OUR SHORE PROGRAM

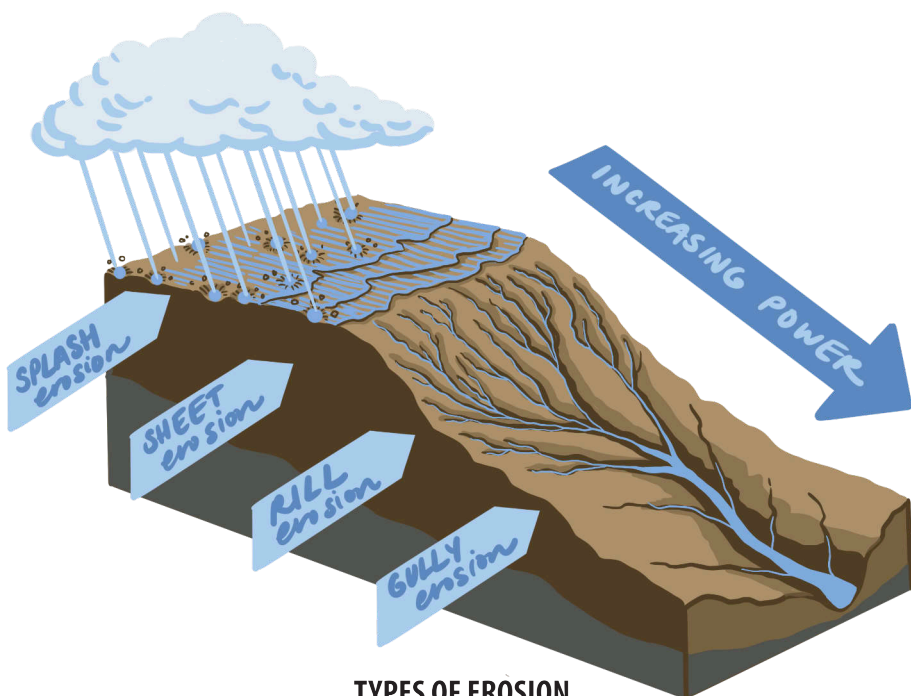
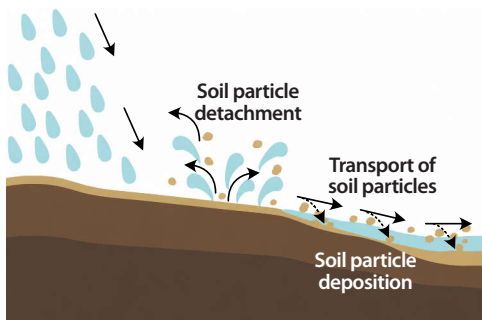
For more information about the OUR SHORE Program and shoreline stabilization, visit maine.gov/dep/land/ourshore.



OUR SHORE emphasizes planting native shrubs, groundcovers, and trees instead of lawn as a simple and cost-effective way to reduce erosion and stabilize the shoreline. Many other natural and biodegradable materials are also available for shoreline stabilization. (iStockPhoto)

Erosion 101: Key Concepts

Erosion is the process of water or wind detaching soil particles from the soil structure and moving them to new locations. It can happen at many scales—from the impact of a single raindrop to massive landslides. When soil particles suspended in water eventually settle, this is called sedimentation or deposition. Larger, heavier particles are eroded only by fast-moving water. Fine particles like silts and clays can be eroded at much lower water speeds and will settle only in very calm water.



TYPES OF EROSION

SPLASH EROSION is the detachment of soil particles by water droplets from precipitation or splashing waves. Vegetation and a duff layer on the soil surface can reduce splash erosion by deflecting and absorbing the droplets.

SHEET EROSION happens when water does not infiltrate into the soil and flows downhill. Even a thin sheet of moving water can erode small particles. Sheet erosion of one-eighth inch of soil from an acre of land equals fifteen cubic yards, enough to fill a dump truck.

RILL EROSION occurs as the sheet flow starts to build power and volume, and the water cuts small channels into the soil. The power of the moving water continues to build as it increases in volume and accelerates down the bank.

GULLY EROSION takes place when rills begin combining, causing water volume and velocity to increase significantly. Gully erosion leads to over-steepened channel walls and ultimately to slumping masses of soil.



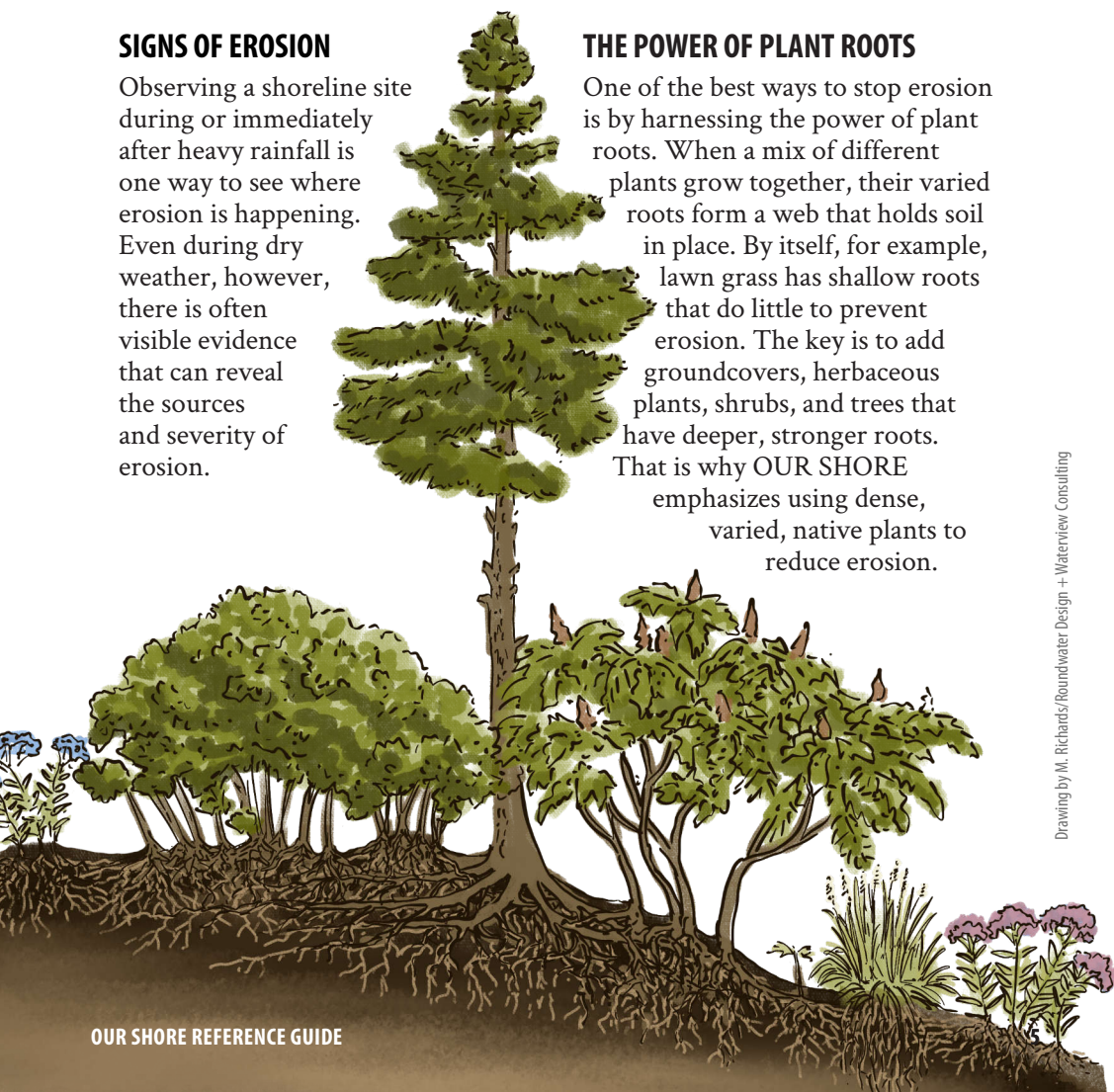
Examples of visible signs of erosion.

SIGNS OF EROSION

Observing a shoreline site during or immediately after heavy rainfall is one way to see where erosion is happening. Even during dry weather, however, there is often visible evidence that can reveal the sources and severity of erosion.

THE POWER OF PLANT ROOTS

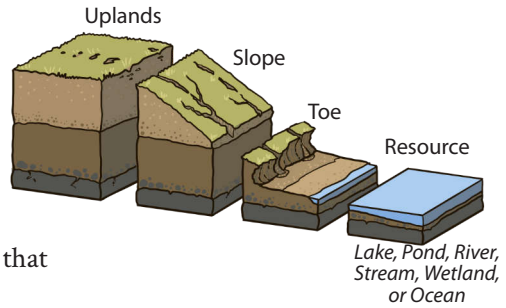
One of the best ways to stop erosion is by harnessing the power of plant roots. When a mix of different plants grow together, their varied roots form a web that holds soil in place. By itself, for example, lawn grass has shallow roots that do little to prevent erosion. The key is to add groundcovers, herbaceous plants, shrubs, and trees that have deeper, stronger roots. That is why OUR SHORE emphasizes using dense, varied, native plants to reduce erosion.



Drawing by M. Richards/Roundwater Design + Waterview Consulting

OUR SHORE: See the Whole Picture and Take Action

OUR SHORE provides a process for considering all sources of erosion and instability, including overland water from land use, groundwater, saturation, toe erosion, and slope height and steepness. The process focuses on assessing those sources and implementing a site-specific combination of stabilization options that function as a naturalized shoreline.



The OUR SHORE acronym outlines key elements of the process: defining goals, assessing sources, implementing stabilization options, and evaluating and enhancing the results over time.

DEFINE GOALS



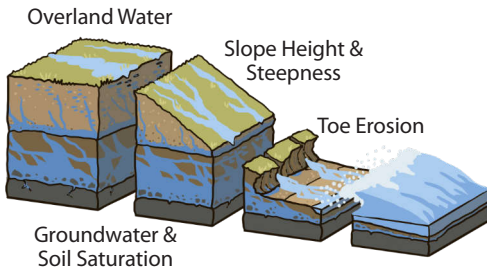
- O** Observe and Blend the Project with Undeveloped Shorelines Nearby
- U** Use Materials That Are Native, Natural, Living, and Biodegradable
- R** Reach Conditions That Function as a Naturalized Shoreline Over Time

ASSESS & IMPLEMENT

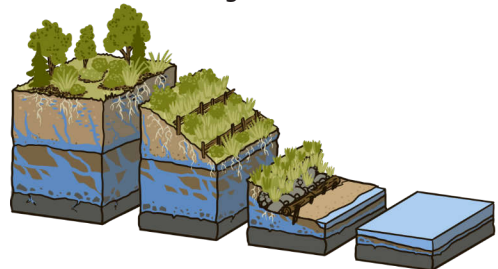


- S** Sources of Erosion and Instability
- H** Height and Slope Risks
- O** Overland Water from Land Use
- R** Restore and Revegetate
- E** Evaluate and Enhance

BEFORE: Sources of Erosion & Instability



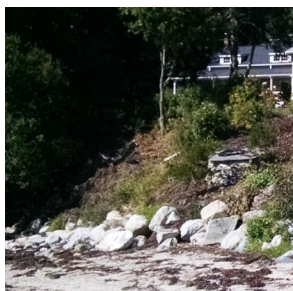
AFTER: Restored, Revegetated & Stabilized



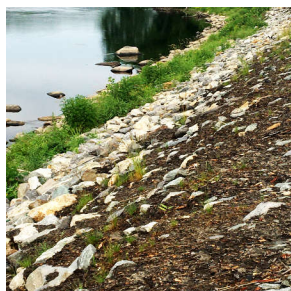
Drawings by M. Richards/Roundwater Design + Waterview Consulting

A Toolbox of Cost-Effective Options

OUR SHORE draws on a large toolbox of methods that use natural, living, and biodegradable materials in the uplands, on the slope, and at the toe. The overarching goal is to choose a cost-effective set of materials and methods that will enable plants to take root and nature to take over stabilization of the site. Projects often use a combination of materials. Chapter 2 introduces the toolbox of materials and methods. A few examples include:



Limited Riprap at the Toe



Rooted Riprap



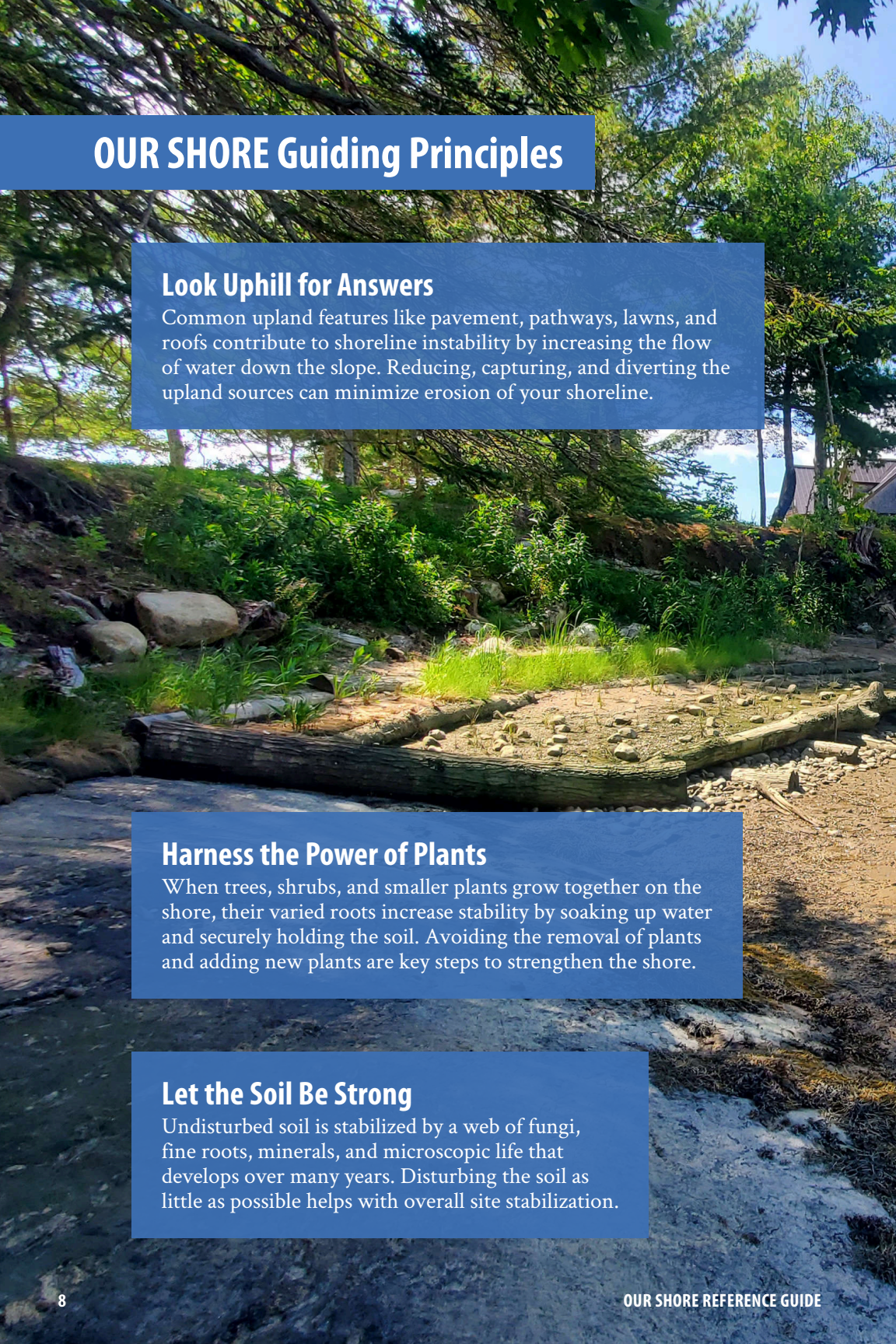
Live Stakes & Wattles

Shoreline stabilization options vary widely in cost. The table below gives a general comparison of costs for the spectrum of stabilization options. Chapter 3 provides more information about installation and maintenance costs.

RELATIVE COST OF STABILIZATION OPTIONS	
Examining how land use affects the shoreline Creating a “no mowing” zone near the water	NO COST
Planting and enhancing a vegetated buffer along the shoreline	\$
Targeted selection of additional nature-based options to minimize shoreline impacts	\$ \$
Engineered, hardened structure	\$ \$ \$

Using the OUR SHORE Reference Guide

The OUR SHORE Reference Guide provides detailed information to support this process. Chapter 2 focuses on O, U, and R. Chapter 3 covers S, H, O, R, and E. This information can be used for decision-making about which erosion control actions to take on a property. Some of those actions do not require specialized skills. However, when in doubt about assessment or installation, always contact a professional.



OUR SHORE Guiding Principles

Look Uphill for Answers

Common upland features like pavement, pathways, lawns, and roofs contribute to shoreline instability by increasing the flow of water down the slope. Reducing, capturing, and diverting the upland sources can minimize erosion of your shoreline.

Harness the Power of Plants

When trees, shrubs, and smaller plants grow together on the shore, their varied roots increase stability by soaking up water and securely holding the soil. Avoiding the removal of plants and adding new plants are key steps to strengthen the shore.

Let the Soil Be Strong

Undisturbed soil is stabilized by a web of fungi, fine roots, minerals, and microscopic life that develops over many years. Disturbing the soil as little as possible helps with overall site stabilization.

Achieve a Win-Win for People and Wildlife

A well-designed shoreline stabilization project provides security and scenic views for people; food, shelter, and movement pathways for wildlife; and flood control, climate regulation, and water purification for all.

Make It Last

Seawalls and unrooted riprap are strongest when first installed, and then they become weaker. Materials and methods in the OUR SHORE Reference Guide enable shorelines to strengthen over time. They provide long-lasting, cost-effective stabilization.

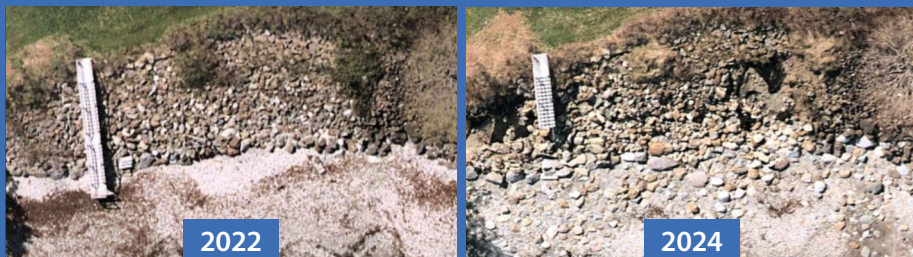
Pitch In

Every shoreline property owner, designer, and installer has a role in restoring Maine's shoreline habitats and making our shores resilient into the future.

This photograph shows a shoreline stabilization project in Blue Hill at low tide soon after it was completed. The project used coir (coconut fiber) logs, dead trees, cobble, and plantings along the high-water line and the upland edge. As the plants grow, their roots will further stabilize the soil. The marsh grass will slow down moving water.

Risks of Unrooted Riprap

Unrooted riprap refers to the method of placing plastic geotextile fabric on the ground and putting layers of large rocks on it. The plastic fabric layer can be effective at reducing erosion risk from lake, river, and ocean water. However, the fabric makes it impossible for plants to grow roots into the soil below. Without deep roots, the whole structure is not securely anchored.



Unrooted riprap at this site was torn apart by storms, leaving the property vulnerable to further erosion.

Unrooted riprap is strongest when first installed and then becomes weaker over time. Water moves through gaps behind the rocks, causing erosion that eventually leads to failure of the unrooted riprap structure. And if there is groundwater getting behind the geotextile, the combination of stormwater and waves can make it act like a trampoline, causing rocks to bounce off. In addition, geotextiles potentially release microplastic into the environment, the bare rocks are inhospitable to plant and animal life, and the barren shoreline takes away from the scenic value.

OUR SHORE offers ways to stabilize the shoreline that do not bring those risks. Among the many options is rooted riprap, which does not use plastic geotextile and involves filling the gaps among rocks with soil and plants. As the plants grow, their deep roots make the structure stronger and anchor it securely in place. Rooted riprap grows stronger over time, does not cause microplastic pollution, is wildlife-friendly, and is more visually attractive than unrooted riprap. Rooted riprap was used successfully for decades before plastic geotextiles were invented. Establishment of vegetation can be aided with gentler slope grades and appropriate use of a natural or biodegradable filter layer under the riprap, such as crushed stone, granular filters, or long-term biodegradable filter fabric.

The benefits of changing from unrooted riprap to rooted riprap, including alternative options, are covered in more detail in Chapter 3.



Rooted riprap has soil between the rocks and no plastic geotextile underneath, allowing plants to grow deep roots that help to stabilize the shore.

	Unrooted Riprap	OUR SHORE Options
MATERIALS	Rock, Plastic Geotextile Filter Layer	Rock, Natural or Biodegradable Filter Layer, Vegetation
COST TO INSTALL	Moderate–High	Low–High
STRENGTH OVER TIME	Decreases	Increases
SITE DAMAGE FROM CONSTRUCTION	High	Low–High
COST TO MAINTAIN/REPAIR	Low Initially, Then Increasing to High	Moderate Initially, Then Low
EROSION AND INSTABILITY FACTORS TARGETED	Waves/Ice, Height & Slope Risk, Groundwater	Waves/Ice, Height & Slope Risk, Groundwater, Overland Water
EFFECTS ON HABITAT AND WILDLIFE	Strongly Negative	Positive–Strongly Positive
SCENIC VALUE	Strongly Negative	Positive–Strongly Positive

Both unrooted and rooted riprap can contribute significantly to wave reflection and refraction, which can degrade adjacent coastal resources. At coastal sites exposed to strong waves, rooted riprap may be used most successfully above the reach of regularly occurring waves.

UNROOTED RIPRAP

Rocks are placed on a plastic geotextile fabric.



ROOTED RIPRAP

Rocks are placed directly on the native soil (as shown) or on a natural or biodegradable filter layer such as crushed stone, granular filters, or long-term biodegradable filter fabric.



DAY OF INSTALLATION

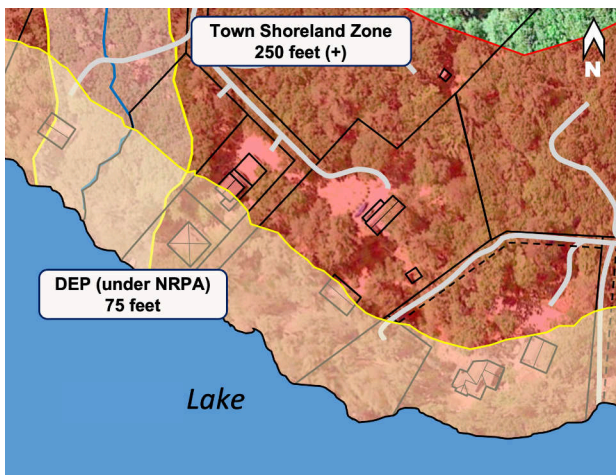
YEARS LATER

Over time, the plastic layer used for unrooted riprap prevents larger plants from growing among the riprap because it acts as a barrier and their roots cannot reach the soil below. Rooted riprap does not use a plastic barrier, so large plants can grow strong roots deep into the soil. Over the years, their roots increasingly anchor the riprap and soil against waves and fast-moving water.

Revised Rules Enable Faster Permitting

Individual property owners are responsible for compliance with local, state, and federal laws and regulations. Shoreline stabilization projects in Maine are covered by two separate state laws:

1. The **Natural Resources Protection Act (NRPA)** is administered at the state level by the Department of Environmental Protection (DEP). The DEP reviews proposed projects for compliance with NRPA, which applies to development activities in, on, over, and within 75 horizontal feet of protected natural resources (lakes, ponds, rivers, streams, brooks, freshwater wetlands, and tidal areas). Property owners intending to conduct a project within this jurisdiction will likely need to obtain a permit from DEP before construction activities can begin. There are two permitting programs under NRPA:
 - a. **Permit-by-rule (PBR)** applies to activities that are designed to meet specific standards within certain natural resources so that a quick review can be accomplished.
 - b. Projects that do not fit those standards must undergo **individual permitting**, which is a lengthier and more complex process.
2. The **Mandatory Shoreland Zoning Act (MSZA)** is a state law administered at the local level. Activities in the shoreland zone (all areas within 250 horizontal feet of lakes, ponds, rivers, tidal areas and freshwater wetlands, and at least 75 horizontal feet from certain streams) are regulated by the town through its code enforcement office and planning board. The DEP sets minimum standards for shoreland zoning, but towns can have local standards that exceed the minimums. A local code enforcement officer (CEO) reviews proposed projects for compliance with the town's shoreland zoning requirements and issues a MSZA permit to projects that meet the requirements. In unorganized territories, Shoreland Zoning is administered by the Land Use Planning Commission.



The DEP reviews under NRPA all proposed projects within 75 horizontal feet (yellow area) of protected resources, such as the lake and stream shown in this graphic. In municipalities, the local code enforcement officer (CEO) reviews under MSZA all proposed projects within 250 horizontal feet (red area) of protected resources. In some towns, the shoreland zone may be greater than 250 feet. Federal law and regulations frequently apply to coastal activity. Contact the US Army Corps of Engineers to ensure your project will comply with federal regulations.



Maine's Natural Resources Protection Act was revised in 2026 to allow some types of shoreline planting without a permit. At properties where a lawn extends to the shoreline, such as the one shown above, this revision may streamline the process of adding a buffer of native vegetation. A vegetated buffer is a simple, effective, and affordable step toward shoreline stabilization and water quality protection. (M. Andersen/Unsplash)

The number of shoreline stabilization permit applications has risen sharply in recent years, especially after major storms. In response, DEP revised its NRPA rules in 2025 to

- **speed up the permitting process,**
- **better address individual and cumulative impacts** from structural shoreline stabilization projects, and
- **encourage nature-based strategies.**

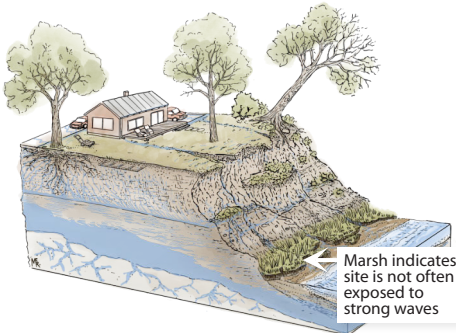
The revised rules enable more projects to qualify for the faster, simpler process of PBR. For example, most projects using only vegetation and biodegradable materials are now eligible for PBR. Because OUR SHORE aligns with the revised rules, using suitable options described in this guide may enable a proposed project to be eligible for the PBR process. To learn more about the state permitting process and understand the full range of options, visit www.maine.gov/dep/land/nrpa.

PERMITTING OPTIONS WITH MAINE DEP		
EXEMPT / DE MINIMIS	PERMIT-BY-RULE (PBR)	INDIVIDUAL PERMIT
No permit required	Performance-based standards in NRPA Chapter 305 with minimal impacts	Multi-agency comprehensive review to assess impacts
Planting vegetation by hand, revegetation of buffers/paths/lawns, reuse of fallen trees and other materials above high water or highest astronomical tide (HAT) line	Shortened review period (20 days) with professional design of riprap	Longer review (4+ months) with professional design
	Planting near wetlands, invasive species removal, nature-based, some riprap	Expanded armoring and stabilization, significant regrading, fill within resources

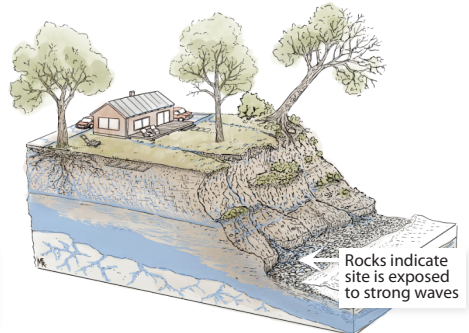
Permitting requirements depend on the project's size, materials, methods, and other factors. Exempt projects do not require a permit. PBR offers a simpler, faster process than an Individual permit.

Scenarios of Shoreline Stabilization

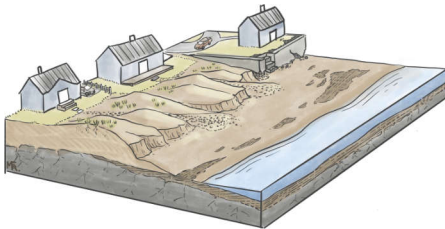
To illustrate how shoreline properties may be stabilized using the options in this guide, the OUR SHORE Program developed a set of scenarios that include “before” and “after” drawings for six types of shoreline environments with characteristics that are typical of Maine:



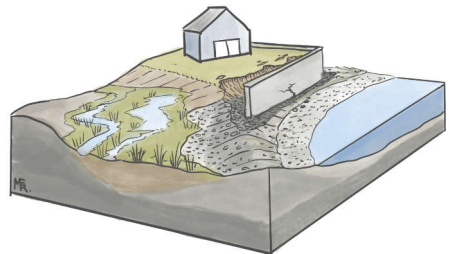
COASTAL BLUFF #1
Low-Energy Site



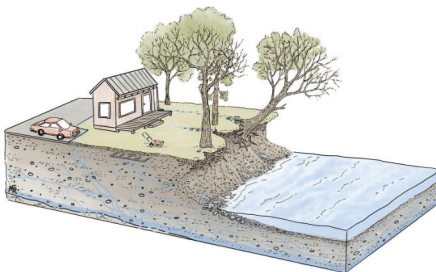
COASTAL BLUFF #2
High-Energy Site



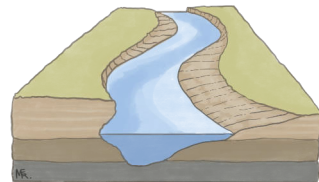
SAND DUNES



COBBLE DUNES



LAKE

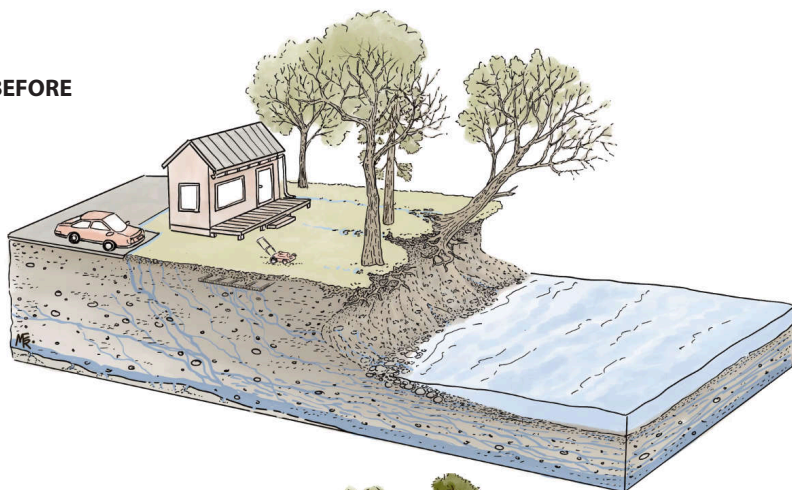


RIVER / STREAM

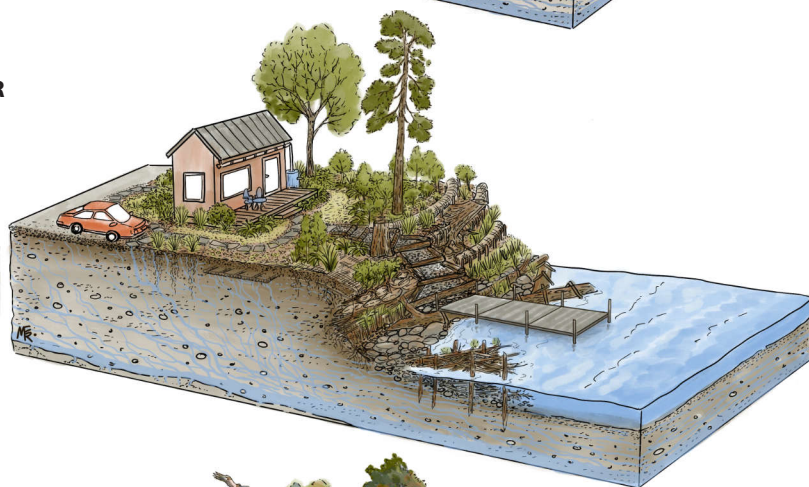
The “before” drawings for the scenarios highlight signs and sources of erosion and instability at the property. The “after” drawings show concepts of how the properties might look after completion of stabilization projects. The purpose of the scenarios is only to provide a general sense of how OUR SHORE could be applied at different types of sites. The specifics of the “after” could look quite different if other materials and methods were selected based on budget and other factors.

Appendix A presents the entire set of scenarios with “before” and “after” drawings accompanied by information about erosion and stability issues at the site and how they were addressed. As an example, the drawings for the Lake scenario are shown here; see Appendix A for the complete scenario.

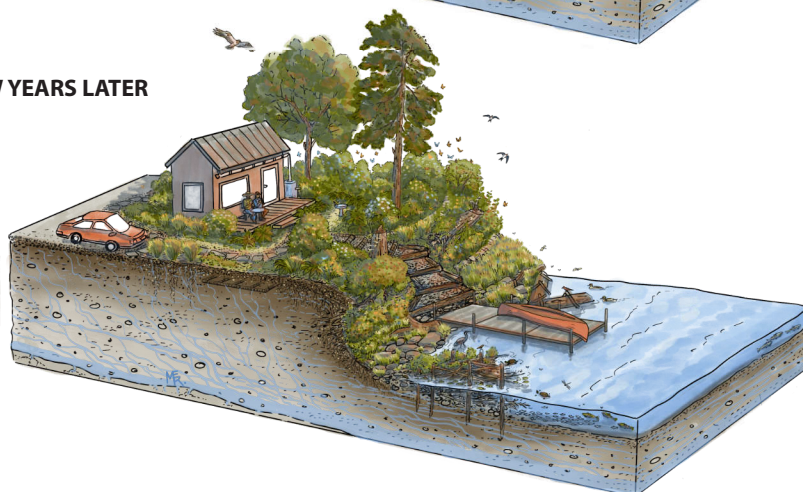
BEFORE

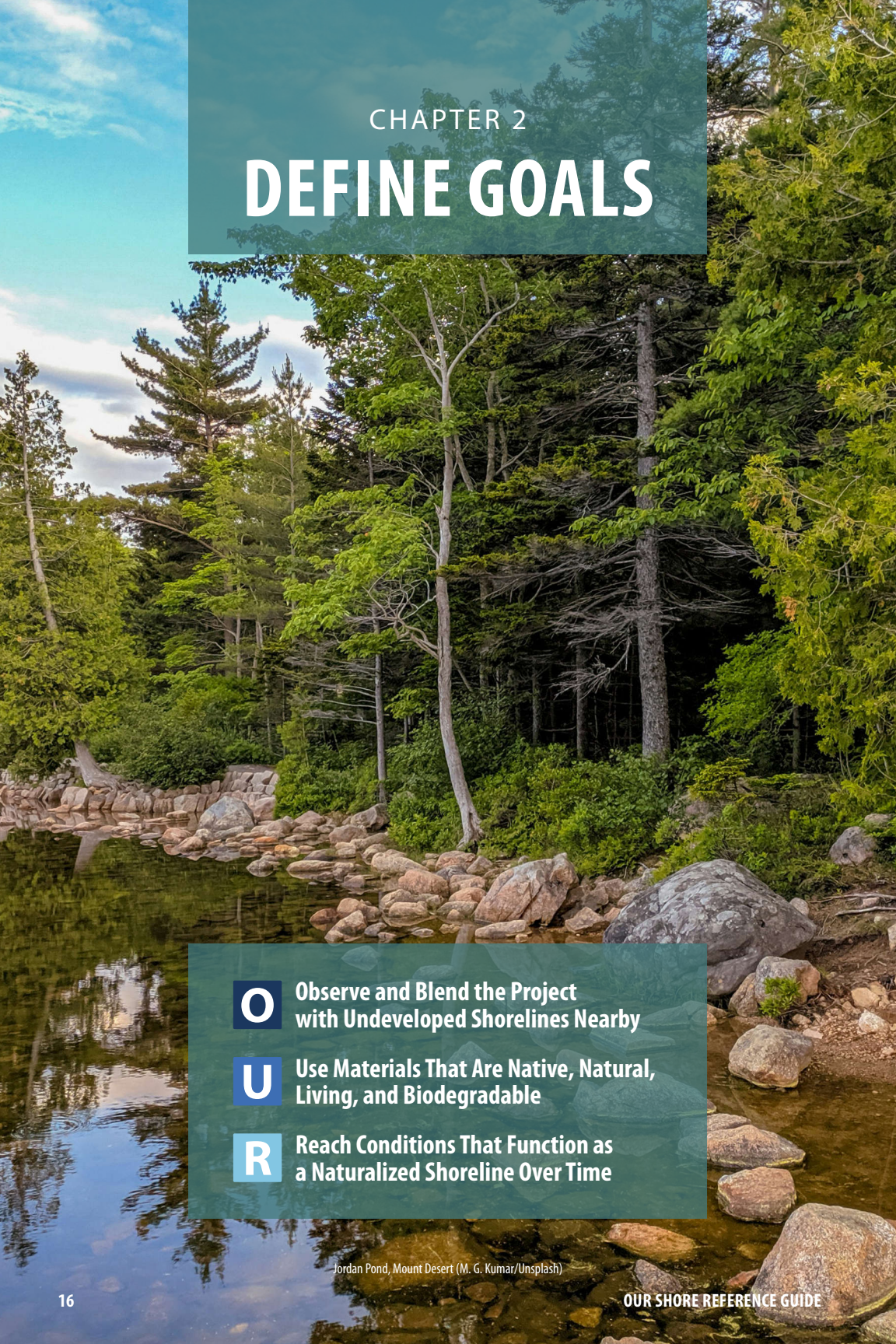


AFTER



A FEW YEARS LATER





CHAPTER 2

DEFINE GOALS

O

Observe and Blend the Project with Undeveloped Shorelines Nearby

U

Use Materials That Are Native, Natural, Living, and Biodegradable

R

Reach Conditions That Function as a Naturalized Shoreline Over Time

Jordan Pond, Mount Desert (M. G. Kumar/Unsplash)

O Observe and Blend the Project with Undeveloped Shorelines Nearby

Observing unaltered shorelines nearby is a useful way to identify a mix of plant species and terrain that can be matched at your property in the upland, on the bank, and along the water's edge. On their upland side, unaltered shorelines in Maine generally have a mix of trees, shrubs, and groundcovers. This vegetation along a shoreline is called a vegetated buffer. Vegetated buffers play an important role by

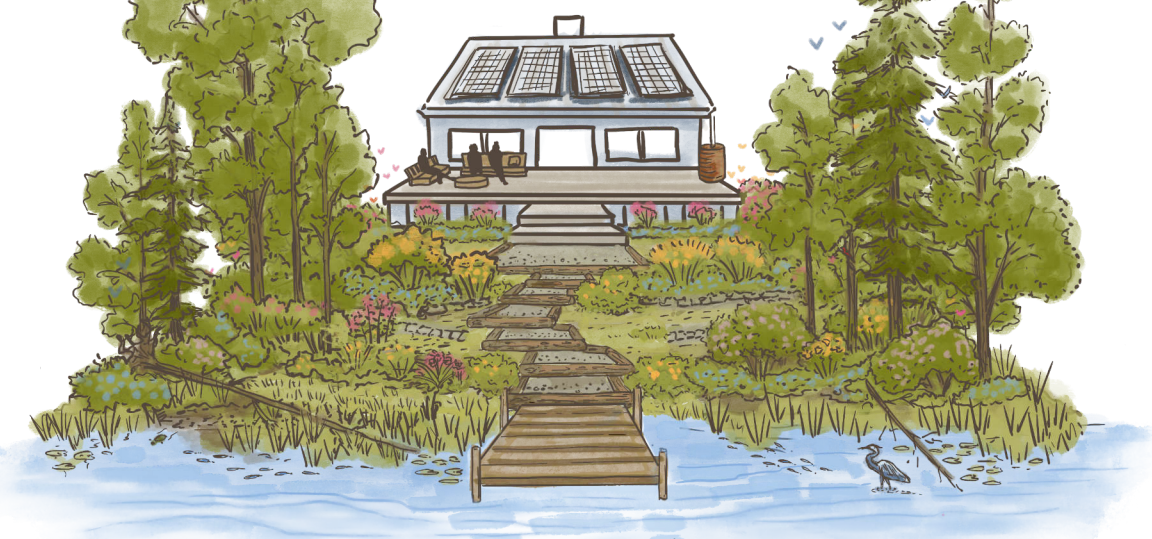
- slowing the overland flow of water,
- getting water into the ground,
- diffusing impacts of waves and scour,
- stabilizing the shore with their roots,
- providing wildlife habitat, and
- protecting water quality.

Shoreline stabilization projects can generate these same benefits by strategically incorporating dense vegetation into their design to establish a healthy vegetated buffer. Find a reference site nearby based on similar topography, soils, and hydrology. Reference sites can be helpful to inform native plants species to select for your site.

Shoreland habitat, sometimes called riparian habitat, is found adjacent to vernal pools, wetlands, streams, rivers, lakes, ponds, and coastal waters. More than 60 species of water-dependent birds, mammals, amphibians, and reptiles in Maine require shoreland areas for shelter or a critical part of their life cycle, such as for feeding or breeding. Shoreland habitat also provides other species access to drinking water and acts as a travel corridor as well as an important core habitat. Up to 85 percent of Maine's vertebrate species use the shoreland zone at some time during their lives. Shoreland habitat also filters runoff from developed areas, helping to maintain clean water that fish, insects, and other aquatic species need.

*Excerpt from Conserving Wildlife in Maine's
Shoreland Habitats (Maine Audubon)*





ELEMENTS OF A VEGETATED BUFFER

Trees

Trees play a crucial role in preventing erosion. They break up the forces of rain and wind, while their deep, strong roots anchor the soil. Their shade keeps soil from drying out. The canopy intercepts raindrops before they hit the ground, reducing soil erosion and promoting evaporation.

Shrubs

Evergreen and deciduous shrubs deflect wind and rain, help stabilize the shore against wave erosion, and are attractive to people and wildlife. Their medium-depth root systems help larger trees hold more soil in place.

Groundcovers

Vines, grasses and grass-like plants, annuals and perennials, and other non-woody plants slow down surface water and trap sediment and organic debris. Their shallow roots hold soil in place while protecting the ground surface from erosion. (Note: Some herbaceous plants native to Maine have deep roots.)

Dense, Diverse, Native Plants

Diverse plantings of native plants provide varied food sources, perches, and hiding spots for a wide range of wildlife species.

Wildlife Travel Corridors

Animals of all sizes need to be able to move along and adjacent to the shoreline. Dense cover and a traversable surface are essential to facilitating this movement.

Decomposing Wood

Decomposing wood feeds fungi and bacteria in the ground, promoting soil adhesion and health and enriching the surrounding environment.

Uneven Ground

Uneven ground surfaces with hummocks and depressions reduce erosion, as they slow water runoff by allowing it to collect in puddles and filter into the soil.

Duff Layer: The duff layer consists of accumulated leaf mulch, conifer needles, and other plant matter on the ground. Duff develops over decades, transforming organic matter into a natural filter for contaminants that cannot be replicated. This “super filter” layer acts like a sponge for stormwater, moderates soil moisture, traps sediment, and prevents sediment erosion. Duff is a host to microorganisms that break down plant material and recycle nutrients. Natural duff should be disturbed only if necessary.



Use Materials That Are Native, Natural, Living, and Biodegradable

OUR SHORE focuses on using natural materials that stabilize shorelines, reduce erosion, and manage water flow while supporting vegetation establishment. Living plants, particularly their roots, are essential materials for shoreline stabilization, while biodegradable materials provide protection and a growth medium until plants and soils can provide long-term stabilization. The type of site will determine which materials and stabilization options to use.

SHORELINE STABILIZATION MATERIALS	
Living Woody Materials	Live Stakes Live Poles Live Posts Living Brush Brush Mattresses Living Fascines Living Pole Drains Living Wattles
Dead Wood and Tree Materials	Dead Brush Bundles Logs and Posts (Anchored Tree Material) Tree Root Wads
Mulches and Organic Matter Mixes	Erosion Control Mix (ECM) Fine Shredded Wood Mulch (Super Humus) Hay or Straw Mulch Hydraulically Applied Mulches & Biotic Soil Media Composts Natural Mulches
Stone, Soil, Shells, and Aggregate	Bank-Run Stone and Cobbles Coarse Sand Crushed Stone Loam Shells Pea Stone Riprap Stone
Biodegradable Manufactured Products	Biodegradable Erosion Control Socks and Bags Coir (Coconut Fiber) Logs Encapsulated Soil Long-Term Erosion Control Blankets Temporary Erosion Control Blankets
Mixed Materials	Rooted Riprap Anchoring Materials*
Nonbiodegradable Materials	Cellular Confinement Systems French Drains and Curtain Drains Gabions and Green Gabions Plastic-Based Geotextile Fabrics Soil Nailing Turf Reinforcement Mats (TRMs)

* Combining materials with anchors often maximizes their effectiveness to provide stabilization.

Living Woody Materials

Living woody materials are cuttings of native plant species that are highly effective at re-rooting when placed in contact with soil.

Examples include willow, dogwood, elderberry, poplar, ninebark, and

buttonbush. A more complete list of species and timing for collection and installation is in Chapter 3, Section R. These materials are relatively simple and inexpensive to plant. They grow roots and shoots more quickly than starting from seed, and their function in shoreline stabilization increases over time as they become established. Survival is highest when they are installed during the colder seasons (early spring, late fall), when the plants are dormant. However, some species will re-root year-round when soils are sufficiently hydrated and at least half of the living woody material is in contact with soil.



Live stakes installed on a shoreland slope.



LIVE STAKES

Cuttings with variable sizes from 24 to 36 inches long and one-quarter inch to one inch in diameter. Installed vertically into the soil to grow new plants. Most effective when harvested from species with strong resprouting ability.

Dense live staking: A technique in which several rows of live stakes are planted in tight bunches, as close as one inch apart. The live stakes grow into mats of intertwined root systems that stabilize the soil.

Dense contour live staking: A type of dense live staking in which the live stakes are installed roughly level and on contour, meaning tracing a specific elevation line along the slope.



LIVE POLES

Long, slender, dormant poles, typically at least six feet long and one to three inches in diameter. Used to erect living structures such as fascines and wattles. Side branches are typically removed to create a single straight stem.



LIVE POSTS

Large-diameter live posts, typically greater than three inches, cut from mature live stake species such as willow or balsam poplar. Used as pilings driven into the ground or incorporated into living cribs and sills.



LIVING BRUSH

Untrimmed dormant branches and twigs used in brush layering or bundled to form fascines. Installed with basal ends buried into the bank and branches extending outward. Commonly used along the toe of slopes for stabilization and to trap sediments from moving water.



BRUSH MATTRESSES

Dense layers of untrimmed dormant cuttings arranged along eroded or graded slopes and staked firmly in place. Covered with soil and compacted to reduce air pockets and ensure soil contact. Can be used alone or as a living filter layer beneath stone in rooted riprap systems.



LIVING FASCINES

Long, cylindrical bundles of living brush or live poles bound with wire or twine. Installed in trenches or filled behind and secured with live stakes or untreated wood. Require good soil contact for rooting; mixed species are recommended.



LIVING POLE DRAINS

Bundles of dormant live poles, typically willow, installed lengthwise in trenches on slopes that have groundwater seeps or oversaturated soils. Have the ability to intercept surface and subsurface flows while absorbing excess moisture after rooting. Usually lightly covered with soil to maintain underground void spaces that allow subsurface water movement.



LIVING WATTLES

Woven structures consisting of upright live posts installed in a row with live poles woven between them. Typically less than six inches tall above the surface and installed with soil filled behind to encourage rooting. Used to stabilize slopes and slow surface water runoff. Can be installed on a graded slope or on unstable areas without pre-grading the area.



Wattles with live poles.

Dead Wood and Tree Materials

Dead wood and tree materials provide structural stability, energy dissipation, and habitat benefits in shoreline and slope stabilization projects. These materials are often used for toe protection and flow deflection. They require anchoring systems or can be driven into the soil. Additional site-specific considerations will be necessary based on local conditions.

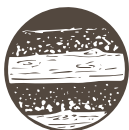


DEAD BRUSH BUNDLES

Bundles of untrimmed dormant or dead branches and twigs used in brush layering or to form fascines. Provide temporary stabilization and surface roughness.



Brush bundles with posts.



LOGS AND POSTS (ANCHORED TREE MATERIAL)

Untreated logs, posts, and large woody materials used for anchoring, log sills, log cribs, manufactured log jams, log skids, or targeted chop-and-drop applications. Provide structural support and energy dissipation.



TREE ROOT WADS

Large tree root masses, often with a section of trunk attached, used to dissipate water energy and stabilize banks. Commonly installed as toe protection, flow deflectors, or components of manufactured log jams. Can accumulate sediment and promote bank rebuilding. Note: Permitting requirements vary by placement location.

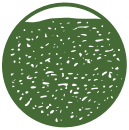
Mulches and Organic Matter Mixes

Temporary and biodegradable mulches and organic matter mixes are used to protect exposed soils from becoming too dry and to reduce erosion primarily as a means to protect water quality. They support plant establishment by reducing moisture loss and soil disturbance until plant roots can provide long-term stabilization. For information about mulches, refer to the *Maine Erosion and Sediment Control Practices Field Guide for Contractors* on the DEP website.



EROSION CONTROL MIX (ECM)

A well-graded mix of fibrous ground wood, fine organics, and soil that provides immediate stabilization without vegetation. Functions as a permanent mulch and berm material. Slow to vegetate and may inhibit seed germination. A list of ECM suppliers is available on the DEP website.



FINE SHREDDED WOOD MULCH (SUPER HUMUS)

A finer-textured variation of erosion control mix with shorter fibers and a more uniform appearance. Provides less holding strength than standard ECM but superior properties for germinating seeds. Not recommended for use in berms as it is easily carried away by water.



HAY OR STRAW MULCH

Temporary mulch used to reduce water velocity, retain soil moisture, and protect exposed soils during vegetation establishment. Provides short-term erosion control only; requires vegetation for long-term stabilization installed into the ground and anchored when used. Straw mulch may be preferable to hay mulch because of lower risk of introducing weeds.



HYDRAULICALLY APPLIED MULCHES AND BIOTIC SOIL MEDIA

Mulch products applied hydraulically to support erosion control and vegetation establishment. May include water, mulch fibers, tackifiers, seed, and additives. Some products intentionally introduce beneficial soil microbes and nutrients. Avoid over-spray near waterbodies and avoid fertilizer unless directed by a soil test. Soil tests are available through the University of Maine. Some municipalities restrict hydroseeding and fertilizer near water resources.



Hydraulically applied mulch.



COMPOSTS

Plant-derived or manure-based composts used sparingly as topsoil amendments or top dressing when necessary. Finished compost should be used, especially if using animal waste compost, which may leach nutrients and degrade water quality if not fully decomposed. Compost should not be applied in areas impacted by waves.



NATURAL MULCHES

Locally available organic materials such as leaves, pine needles, bark, and twigs can be used as cost-effective natural mulches when sourced responsibly. Overharvesting can cause erosion at the source. Note: Duff is partially decomposed organic matter, including leaves, needles, and other plant material, that accumulates on the forest floor beneath the litter layer. Duff should never be removed unless necessary.

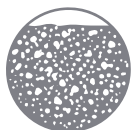
Stone, Soil, Shells, and Aggregate

Stone, soil, shells, and aggregate materials are used to provide weight, drainage, and structural stability in erosion control and shoreline applications. Material size, shape, color, and placement should be matched to site conditions, such as exposure to fast-moving water or waves. Regrading is a common method to shape the landscape to address water management, stability, and erosion control needs. Regrading can involve bringing new material to the site or using the existing material on site. Examples include forming swales or berms, or shaping slope to the angle of repose for the soil type and other site conditions.



BANK-RUN STONE AND COBBLES

Rounded or screened stone from excavation tailings. Not recommended for slopes steeper than 3:1 or areas with enough water movement to move the stones. Rounded stone can be a lower-cost alternative to riprap in low-energy sites with gentle grade. Can also be used to fill socks, mixed with Erosion Control Mix to add weight, and used in gabions and green gabions.



COARSE SAND

Sand with large particle sizes that provides drainage and compaction. Used as a bedding or filter material.



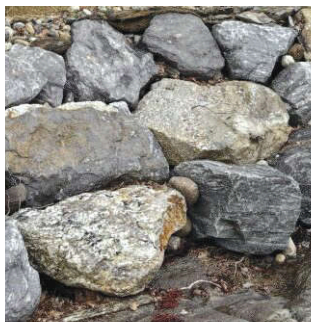
PEA STONE

Small gravel less than three-eighths of an inch in size. Manufactured or naturally occurring. Used where limited structural strength is required.



RIPRAP

Large angular or subangular stone resistant to weathering and composed of a range of sizes. Typically sourced from blasted or crushed ledge. Used for wave-exposed shorelines and slope stabilization when lighter-weight materials would be insufficient. Can be infilled with soil and planted with vegetation. “Unrooted riprap” when placed on plastic geotextile filter fabric. “Rooted riprap” when placed on a natural or biodegradable filter layer.

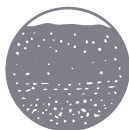


Riprap. (Linkel)



CRUSHED STONE

Angular stone with little to no fine content. Provides good drainage and interlocking structure. Commonly used in French drains to intercept and redirect groundwater.



LOAM

Mineral soil containing balanced proportions of sand, silt, and clay. Used primarily for its ability to support plant growth.



SHELLS

Recycled shells used as aggregate in shoreline stabilization applications. Shells will biodegrade over time. May provide some buffer to water pH. Note: Special permitting considerations apply when using shells because of risks of pathogens to living shellfish.

Biodegradable Manufactured Products

Biodegradable manufactured products are prefabricated materials designed to support erosion control, soil stabilization, and vegetation establishment.



BIODEGRADABLE EROSION CONTROL SOCKS AND BAGS

Biodegradable casings filled with untreated woody material, stone, shells, or coarse gravel without fines. Installed in place and secured with hardwood stakes or other anchoring methods. Available pre-manufactured or to be filled on-site. Plastic casing should be avoided unless it will be removed.



COIR (COCONUT FIBER) LOGS

Prefabricated erosion control logs made entirely of coconut fiber. Long-lasting and biodegradable, with a service life up to 5 years; however, in some applications may last 15-20 years or more. They can be planted with plugs of native herbaceous materials or seeded with native seeds to create living toe protection that will strengthen over time. Suitable for toe protection and low-disturbance installations. Can be designed for use as toe protection in high-energy coastal environments.



ENCAPSULATED SOIL

Soil contained within heavy fiber blankets, such as coir. Used to form lifts and mats (grow logs). **Lifts:** Created by layering blanket on bare ground, filling the landward side with a layer of soil, folding the blanket back over that soil, and anchoring with stakes.

Encapsulated soil lifts can be an effective way to re-establish vegetated coastal landforms such as the toe of coastal bluffs and salt marshes. **Mats (or grow logs):** Can be site assembled into "logs" of various diameters and lengths, filled with suitable soil matrix for site- and salinity-specific biome establishment. Can be used in stabilizing marsh and toe of shore where not exposed to strong waves.

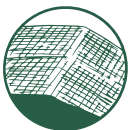


Encapsulated soil with live stakes soon after installation (upper) and after the live stakes began growing (lower).



LONG-TERM EROSION CONTROL BLANKETS

Natural fiber blankets used as filter layers beneath riprap and vegetation. Reduce erosion of fine sediments while vegetation establishes. Woven of strong materials such as burlap, natural fiber fabrics, or heavy coir.



TEMPORARY EROSION CONTROL BLANKETS

Lighter-weight, less durable fiber blankets for medium-term erosion control. Require vegetation to provide long-term stabilization. Installed with overlap and anchored at the top of slopes. Plastic netting should not be used.

Mixed Materials

Mixed materials combine stone, soil, organic matter, and/or vegetation to achieve multiple stabilization functions in one place. These combinations are often used to increase structural performance while supporting plant growth and ecological benefits. Common examples include rooted riprap, cobbles mixed with erosion control mix, and rounded stone combined with organic materials to support vegetation growth.



The riprap at this site is being infilled with soil. Then vegetation will be planted to increase stability.



ROOTED RIPRAP

Large angular or subangular stone with a natural filter layer such as crushed stone or brush mattress underneath. Gaps between rocks filled with soil. Plants grow in the soil and are able to extend deep roots through the natural filter layer.

IMPORTANCE OF ANCHORING MATERIALS

Shoreline stabilization projects often include anchors that secure the materials to the ground. Some anchors are permanent, while others are designed to be temporary and are made of materials that biodegrade as plants become established. Combining materials with anchors often maximizes their effectiveness to provide stabilization.

There are a variety of anchor types and compositions including wood stakes, timber deadmen, and earth anchors such as helical anchors, heavier-duty duckbill anchors, and other deep-seated anchoring devices.



Anchoring a coir log. (Linkel)

Anchors are often used in combination with biodegradable or metal tie-downs or cables.

The Maine Department of Environmental Protection (DEP) requires that stakes used to secure biodegradable stabilization materials must be made of wood. Anchors or cables used to secure biodegradable stabilization materials may be made of wood, bright steel, or galvanized steel. No stainless steel may be used.



Helical Anchor



Duckbill Anchor

Nonbiodegradable Materials

Nonbiodegradable materials are engineered products made with plastic or other nonbiodegradable components. They may have a limited role in stabilization where conditions preclude the use of only natural and biodegradable materials. Nonbiodegradable materials can be used in combination with vegetation. Project designs that include nonbiodegradable materials may involve more complex and time-consuming permitting considerations. Designs should be evaluated carefully to use nature-based materials to the fullest extent possible.



CELLULAR CONFINEMENT SYSTEMS

Grid or mesh systems that confine soil or gravel to prevent lateral movement. Used for unvegetated or vegetated surfaces in high-use or steep environments such as boat launches, driveways, and parking areas.



FRENCH DRAINS AND CURTAIN DRAINS

Similar to living pole drains, but they use perforated plastic pipe instead of living poles. Typically constructed by digging a trench and backfilling with a perforated pipe and clean stone. Intercepts surface water and/or ground-water and carries it elsewhere.



GABIONS AND GREEN GABIONS

Wire or plastic-coated metal cages filled with stone or soil. Installed similarly to riprap systems. Known as a green gabion when designed and constructed to support the growth of vegetation. Green gabions are generally best used in very steep eroded areas where the slope cannot be cut back and where native soils and energy levels make vegetating the area otherwise unlikely.



PLASTIC-BASED GEOTEXTILE FABRICS

Synthetic filter fabrics used for separation of different materials and for allowing water to pass through. Blocks growth of deep plant roots needed for shoreline stability. Natural alternatives, such as crushed stone and brush blankets, can be used instead to allow root growth. May not be needed above water saturation point. In some applications, holes can be poked into fabric that are small enough to let water out but hold back fine sediment. When geotextile is used, holes can be created for plantings.



SOIL NAILING

Highly engineered systems consisting of metal mesh anchored deep into slopes. Used to stabilize steep or unstable soils while allowing plant establishment. Typically applied where other stabilization methods are insufficient.



TURF REINFORCEMENT MATS (TRMS)

Plastic-based rolled materials used for surface erosion control and slope stabilization. Provide high strength in environments with very strong water movement while allowing plants to grow through the mat.



Soil nailing.

SELECTING A FILTER MATERIAL

A filter is a transitional layer of material placed between the underlying soil and the riprap or other erosion control treatments. The filter prevents the movement of the fine soil particles through voids in the stone, provides more uniform settlement, and allows hydrostatic pressures within the soils to be relieved.

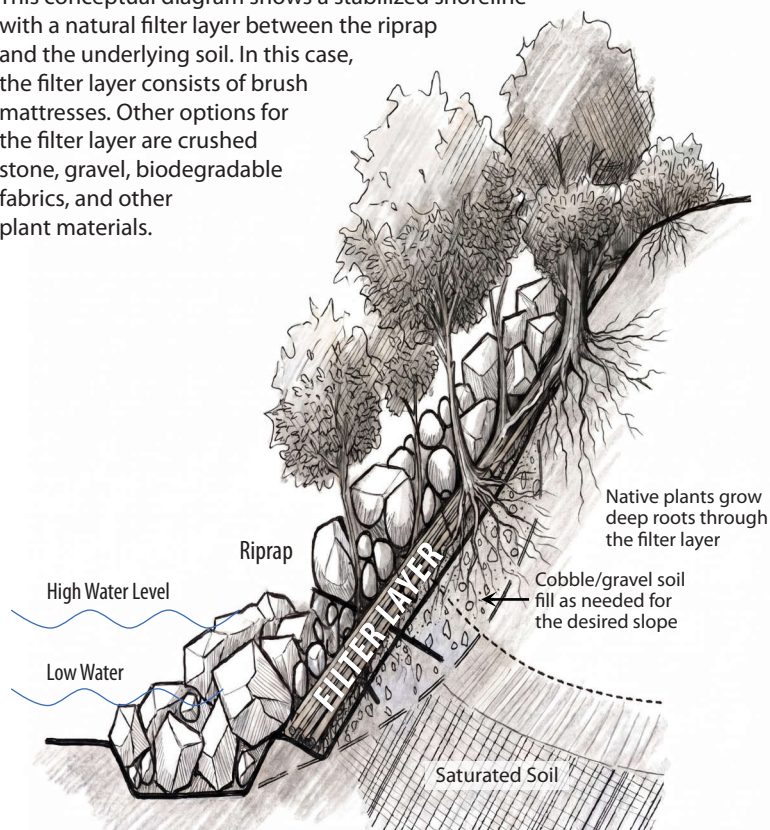
A filter should be used whenever riprap is placed where groundwater, saturation, or significant subsurface drainage are present, or where large void size in the stone may allow sediment to be dislodged from behind the surface treatment. In recent decades, the most commonly used type of filter has been plastic-based geotextile. However, the filter function can be provided by alternatives such as crushed stone, pea gravel, filter gravel, biodegradable fabrics, and brush mattresses and other plant materials.

What Does a Filter Layer Do?

- Protects soil fines behind unvegetated riprap from wave action
- Allows groundwater to escape and other water to move in and out of the soil behind the riprap without losing fine soil particles through the stone

Example of Rooted Riprap with a Natural Filter Layer

This conceptual diagram shows a stabilized shoreline with a natural filter layer between the riprap and the underlying soil. In this case, the filter layer consists of brush mattresses. Other options for the filter layer are crushed stone, gravel, biodegradable fabrics, and other plant materials.



(Continued on next page)

Why Plastic-Based Geotextile May Not Be the Best Option for Filter Layers

- 1) Has pores that clog over time from biological action in surrounding soils, reducing drainage
- 2) Inhibits growth of vegetation
- 3) Blocks vegetation from connecting with underlying soils, which can be a weak point of the design, causing sliding or shear
- 4) Potential contribution of microplastic to the environment
- 5) Can trap water behind the fabric when not properly keyed at the top and cause large riprap to roll or bounce off the shoreline during large storms

Choosing Filter Layers Compatible with Vegetation



Minimize Synthetic Geotextiles

Use nonbiodegradable, plastic-based geotextiles only in limited areas where plant growth will be constrained by tidal or water-level fluctuation.



Plant through Geotextile

Geotextile can be live staked through with small punctures or slits in the fabric to allow connection to the soils below.



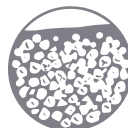
Long-Term Biodegradable Geotextiles

For stabilization projects with riprap and vegetation, long-term biodegradable filter blankets may be considered. Materials such as coconut coir have a long lifespan and can last years before breaking down. Filter fabric protects the underlying soil until the newly planted vegetation takes over that role once mature. It is recommended that sand be placed behind any filter fabric to extend the function and prevent clogging pores with fine sediments.



Crushed Stone or Pea Gravel

At sites with low or moderate wave energy, a layer of crushed stone or pea gravel to protect the underlying soil and properly graded riprap to minimize voids may function similarly to geotextiles.



Filter Gravel (Granular Filters)

Granular filters are mixes or layers of gravel or stone gradations used as a transitional layer between riprap and underlying soil. In some cases, further analysis of the granular filter layer may be warranted for higher-energy environments. Guidelines and advanced calculation of gradation for granular filter design are found in U.S. Department of Transportation Hydraulic Engineering Circular No. 11.



Brush Mattress (Living Filters)

While a brush mattress can be used as a standalone tool, it can also function as a filter layer behind stone. Living dormant poles and brush are arranged along the eroded or graded slope for maximum soil contact. Riprap can be placed on top of this living brush, resulting in a vegetated riprap stabilization with a living filter layer.

R

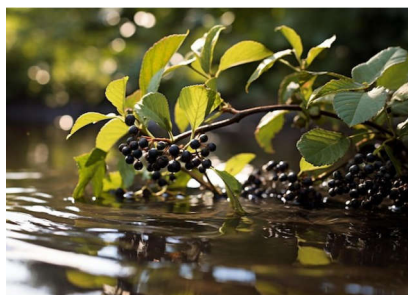
Reach Conditions That Function as a Naturalized Shoreline Over Time

Maintain Healthy Soil for Long-Term Stability

Soils in Maine were formed during the last glacial period, about 12,000 years ago. Over time, the soils were colonized by plants, microbes, fungi, and other life. This process created a cohesive soil structure, meaning that the particles stick together and do not easily wash away. Healthy soils are bound together with organic glues from microorganisms. When shoreline soils are disturbed, the soil structure is degraded. Particles become more easily eroded, and it takes many years for the soil life to recover and rebuild resistance to erosion. Minimizing disturbances to soil structure goes a long way towards preserving health of the shoreline soil system. To promote a healthy subsurface soil habitat, avoid common impacts of construction, such as compaction and smothering with too much inert soil (soil without living organisms or organic content).

Harness the Engineering Capabilities of Native Plants

Native plants are well-adapted to Maine's dynamic climate. They develop deep, extensive root systems that effectively prevent soil erosion along shorelines and slopes. When planted under the appropriate site conditions, these hardy plants can withstand our region's weather extremes—from summer droughts to winter freezes—making them resilient and self-sustaining. After establishment, their natural adaptations mean they require minimal maintenance, reducing the need for frequent replacement or intensive care. Beyond their benefits for erosion control, native plants provide essential habitat, food, and shelter for wildlife. Non-native plants are often of little value to native wildlife and pollinators and are sometimes invasive as well. Because seeds can travel long distances by water and readily establish where they land, the benefits of using only native plants for shoreline stabilization extend far beyond the planting site.



Native plants have deep roots that help prevent erosion, and they provide essential food and shelter for wildlife.

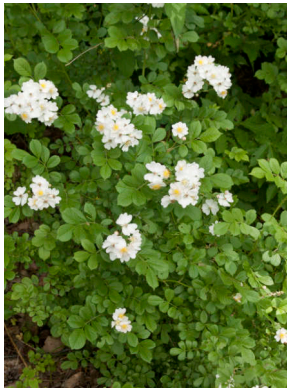
KEY FEATURES OF NATIVE PLANTS

- 1) **Minimal Maintenance:** Native plants require less attention once established and minimal fertilizer because they are adapted to the natural soil conditions.
- 2) **Important to Native Fish and Wildlife:** Native plants along the shoreline are important to both fish and wildlife. They provide shelter, food, and habitat functions. Certain native plants are especially important hosts and food sources for pollinators.
- 3) **Deeper Root Systems and Resiliency:** Native plants tend to have deeper root systems, which increase soil stability and tie together soil layers.

Remove Threat of Invasive Plants

An invasive plant is a non-native plant whose introduction to a particular ecosystem causes, or is likely to cause, economic harm, environmental harm, or harm to human health. Invasive plants can displace native vegetation and reduce species diversity, diminishing the cumulative benefits that diverse plant communities provide for wildlife habitat and erosion control.

Of the approximately 2,100 plant species found in Maine, approximately one-third are not native. Only a small number of the non-native species are considered invasive, but they have the potential to cause great harm to our landscape. Refer to the Maine Natural Areas Program list of fact sheets and the Department of Agriculture, Conservation and Forestry's (DACF) Maine Invasive Plants web page for general overviews and specific information about which species are invasive.



Invasive Japanese knotweed (left), which grows quickly and blocks the light for other plants, has been shown to accelerate soil erosion. Invasive species like multiflora rose (center) and Japanese barberry (right) form thorny, impenetrable thickets that do not provide the benefits of a native vegetated buffer. (Wikimedia, E. Efre/Pexels)

Invasive species have been imported for ornamental and landscaping purposes. Some have been intentionally planted due to the misconception that their vigorous growth makes them effective for erosion control, though diverse native plant communities are actually more effective for long-term erosion control and ecosystem stability. Accidental introduction is also common as seeds and plant fragments can be carried, often far away, by wind, water, wildlife, vehicle tires, boats, and other equipment—such as when soil is moved from one site to another for fill—to other locations where they can germinate.

Invasive plants are a direct threat to Maine's landscapes. The aggressive growth of invasive plants can affect forest regeneration, threaten recreational experiences, diminish native biodiversity, and potentially decrease property values. Species like Japanese barberry and multiflora rose form thorny, impenetrable thickets that do not provide the benefits of a native vegetated buffer. Japanese knotweed, which grows quickly and blocks the light for other plants, has been shown to accelerate soil erosion. Best practices to remove invasive plants are covered in Chapter 3.



Remember! Rocks Don't Have Roots

When a variety of different plant root systems grow at a site, it maximizes soil cohesion and holding strength in ways that rocks alone cannot provide. Herbaceous plants and the natural duff layer help to protect surface soil particles from erosion, while the root systems of shrubs and trees reach between soil layers, adding strength against sliding. The roots of trees and shrubs can also intertwine below ground, increasing the soil's resistance to erosion. Tree roots help stabilize slopes by supporting the weight of the soil above them and counteracting shear stress. Most tree roots are relatively shallow, generally extending only about eighteen inches deep. Some species develop taproots reaching greater depths, but most roots remain close to the surface. In frequently wet shoreline areas, roots are typically even shallower.

A mix of soil and rocks held in place by plant roots has a high shear strength, which is a material's capacity to resist the forces exerted by moving water or wind. Shear strength is affected by particle size, particle shape, the bonding properties of particles, any supporting structural network, and the level of water saturation. Consistent water saturation decreases soil cohesion and shear strength, which is one reason groundwater and toe saturation are important sources of shoreline instability. Other considerations are that loose soil has lower shear strength than undisturbed soil with intact soil structure, and rooted riprap has higher shear strength than unrooted riprap.

EXAMPLES OF MATERIALS AND SHEAR STRENGTH

MATERIAL	SHEAR STRENGTH (lb/ft ²)
Riprap (Boulder Toe) with Live Stakes	6.1
Brush Mattress	6.1
Coarse Gravel with Live Stakes	5.08
12-inch Rock Riprap	4
Willow Brush Layer	2.84
Live Fascine	2.45
Live Stakes	2.26
6-inch Rock Riprap	2
Grass and Legume Plot	1.4
1-inch Gravel	0.33

Comparison of shear strength for some materials used in shoreland projects. With their higher shear strength, riprap with live stakes, brush mattress, and coarse gravel with live stakes can withstand greater forces than materials such as unrooted 12-inch riprap and grass. Source: USDA

Don't Forget about Wildfire Resilience

Maintaining shoreline vegetation is important for the health of our waterways and coasts. Depending on where you live in Maine, it may also be a good idea to think about wildfire risk reduction, especially around homes and other important structures. With proper vegetation management, it is possible to reduce wildfire risk while also maintaining a healthy shoreline. Visit the Maine Forest Service website's Firewise page for more information.

Maintain Natural Sediment Transfer

Shoreline stabilization projects are concerned primarily with reducing the amount of soil that moves from land into the waterbody. It is important to remember, however, that some amount of sediment transfer is essential for healthy aquatic habitats. The transfer of sediment from land into the ocean creates habitats like eelgrass meadows, mudflats, beaches, and wetlands, which are critical for Maine wildlife. Species such as clams and mussels rely on sediment habitats—burrowing into mud, sand, or gravel—for feeding, shelter, reproduction, and growth. They filter food, oxygen, and nutrients through their siphons while anchored in the sediment. The painted turtle, wood turtle, snapping turtle, Blanding's turtle, and spotted turtle all rely on sediments or loose substrate for nesting and reproduction.



A clammer at work in Harpswell. Sediment from eroding shores creates habitats such as mudflats and tidal wetlands that support clams, striped bass, and other species. (P. Taylor/Waterview)

These vital environments also dissipate wave energy from storms. The movement of sediment in coastal waters helps protect coastlines from erosion by building natural barriers like dunes, sandbars, and marshes. A completely natural shoreline adjusts to its wave-energy environment, and sediment will flow accordingly.



Seawalls interfere with the land-sea connection and can cause losses of beach and other habitats. (C. Newton/Unsplash)

Seawalls and unrooted riprap interfere with that land-sea connection and can cause losses in beach, wetland, and shallow nearshore habitat. Depletion of these habitats can allow bigger waves to reach the shoreline, worsening erosion. Shorelines that blend with their surroundings are more likely to handle changing natural conditions.

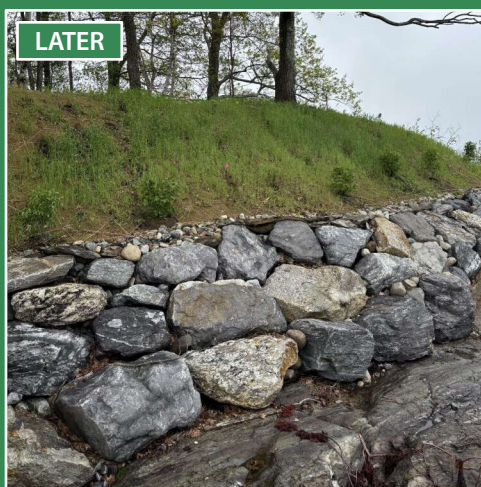
For these reasons, any shoreline stabilization plan must carefully consider sediment transport patterns. Allowing the natural transfer of soil from terrestrial to marine and freshwater environments is critical, and it is written into the Maine Natural Resource Protection Act (Title 38, §480-D: Standards) as a consideration during the permitting process.



The painted turtle is one of several turtle species in Maine that rely on sediments or loose substrate for nesting and reproduction. (A. Patrick/Pexels)

CHAPTER 3

ASSESS AND IMPLEMENT



THIS CHAPTER HAS FIVE SECTIONS with information for implementing OUR SHORE principles:

S Sources of Erosion and Instability

H Height and Slope Risks

O Overland Water from Land Use

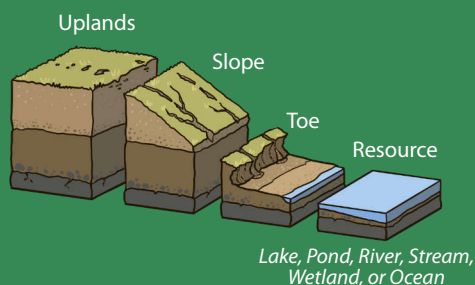
R Restore and Revegetate Habitat

E Evaluate and Enhance

Sections S, H, O, and R are organized according to a three-part process of identifying the most important causes of erosion at a site and the potential ways to address them:

- 1. SOURCES.** Consider the SOURCES of erosion and shoreline instability, as well as impacts on habitat and wildlife.
- 2. SIGNS AND SEVERITY.** Examine the shoreline site for visible SIGNS of each SOURCE. Determine SEVERITY of each SOURCE based on the observed SIGNS.
- 3. OPTIONS FOR STABILIZATION PROJECTS.** Based on the SIGNS and SEVERITY, consider a range of OPTIONS for reducing impacts from that source. Different materials and methods have differing abilities to address lower to higher severities of erosion.

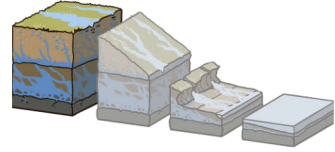
In most cases, a combination of factors needs to be assessed to determine severity of erosion. No single factor is likely to be the sole source of erosion. Section E focuses on maximizing the cost effectiveness of applying OUR SHORE concepts.



S Sources and Severity of Erosion

SOURCE: OVERLAND EROSION

Surface water plays a significant role in the stability of a shoreline embankment. As water from the uplands flows downhill and crests the bank, the increase in velocity moves soil particles in that flow down the hill and increases the area's overall saturation levels at the same time. Overland erosion can be exacerbated by land use features such as pavement and compaction of soils in heavily travelled areas. Wherever groundwater seeps out of the soil, it can become another source of overland erosion.



Signs and Severity

Low Severity

- ☐ Completely intact duff layer above and on the eroding bank, with no signs of soil movement from surface water flows
- ☐ No large lawn areas near the bank, with at least 25 feet of dense vegetated buffer between lawn and the water resource
- ☐ Surface flows sufficiently captured or diverted away from unstable areas

Moderate Severity

- ☐ Absence of duff layer, exposing soil
- ☐ Some evidence of sheet or rill erosion
- ☐ Evidence of soil movement during normal rain events
- ☐ Mowed lawn extending to the edge of the bank
- ☐ Structures or impervious areas near the edge of the bank



High Severity

- ☐ Extensive rill or gully erosion
- ☐ Bare soil visibly eroding during normal rain events
- ☐ Evidence of slumping or detaching soil masses
- ☐ Mowed lawn extending to the bank's edge
- ☐ Structures or impervious areas near the edge of the bank
- ☐ Lack of vegetation on the bank
- ☐ Evidence of channelized overland flows in the upper bank



Evidence of sheet erosion (upper) and an eroding upland bank with lawn (lower).

Options for Stabilization Projects

REDUCE LAND USE CONTRIBUTIONS

Overland erosion from runoff and wave spray can be combated by reducing the speed of moving water and dispersing it over a larger area. Water originating in the upland beyond the slope's crest can often be diverted to more stable areas, infiltrated, or spread away from unstable banks. See Section O: Overland Water Contributions from Land Use.

ESTABLISH DENSE VEGETATION

Whether a site is being enhanced as is or regraded, the goal should be a robustly vegetated embankment that shields the soil from flowing surface water and promotes long-term bank stability. The best way to accomplish this is by adding vegetation (nursery plants, live stakes, or seeds) and providing protection and support until the plants are established.

CONTROL SLOPE EROSION WITH COVERINGS

Wave spray and any remaining overland runoff can be managed either by protecting the soil from flowing water—using mulch, brush layering, or anchored fiber blankets—or by modifying water flow on the slope. Examples of materials and methods for controlling slope erosion:



Erosion Control Mix
(ECM)



Straw or Hay Mulch



Hydraulic Mulches
and Hydroseed



Erosion Control
Blankets

*“Slow the Flow.
Spread It Out.”*

CREATE SLOPE INTERRUPTIONS

Slope interruption reduces erosion by placing features across the slope that slow water flow. Rather than allowing water to flow straight down the bank, these installations transform concentrated water flow into a gentler sheet pattern and encourage water to soak into the ground. Swales (depressions built into the ground) and berms (material filled on top of the ground) can be effective options for slowing water. Examples of additional materials and methods for creating slope interruption:



Dense Contour
Live Staking



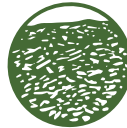
Living Fascines



Living Wattles



Log Sills



Erosion Control Mix
(ECM)

USE SURFACE ROUGHENING AND REVERSION

Surface roughening refers to creating a rougher surface on the bank to help slow down water, which can be accomplished in several different ways and using different materials. The concept can be expanded further to mimic the natural landscape elements along a shoreline. Reversion is light soil grading that does not disturb soil structure, allowing existing seeds and roots to remain in place and resprout more quickly. Examples of materials and methods for surface roughening and reversion:



Brush Mattresses



Rooted Riprap



Unrooted Riprap



Cellular Confinement
System



Gabions and Marine
Mattresses



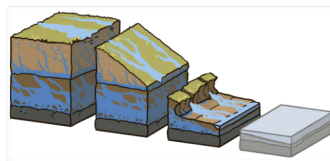
Soil Nailing



Turf Reinforcement
Mats (TRMs)

SOURCE: GROUNDWATER AND SOIL SATURATION

Groundwater is an often-overlooked contributor to shoreline instability. In Maine, groundwater often seeps out onto shoreline slopes, becoming erosive surface water. In addition, soils saturated with groundwater become less cohesive, meaning the soil particles do not “stick” to each other very well. Slope instability from landward groundwater may occur at the water resource's edge or higher up the slope. Sometimes groundwater is trapped above an impermeable soil layer, creating a flow (a “seep”) that emerges on the slope, which is especially hard to stabilize.



Signs and Severity

Low Severity

- ☐ No evidence of water (glistening soil, moving water) out of the bank following rain or tidal events
- ☐ Lack of fine soil movement observed on bare/steeper portions of the bank
- ☐ Fully vegetated slope above the high-water line
- ☐ Presence of well-draining soil textures

Moderate Severity

- ☐ Presence of wetland plants higher up on the bank
- ☐ Some evidence of tidal or groundwater seeps
- ☐ Presence of a hard pan under the topsoil or upper soil layers, or fine textured soil in the profile

High Severity

- ☐ Distinct separation of soil layers in the bank, resulting from fine soil erosion along the lower layer
- ☐ Visible “oozing” of soil out of the bank
- ☐ Large areas of glistening soil or water in the bank
- ☐ Presence of a hard pan under the topsoil or upper soil layers, or fine textured soil in the profile



Illustration of groundwater seeps on a shoreline bank.



Evidence of a groundwater seep.

Options for Stabilization Projects

Options for addressing excess groundwater and soil saturation range from covering exposed soil with organic materials to improving the site's drainage.

USE STONE FOR TARGETED STABILIZATION

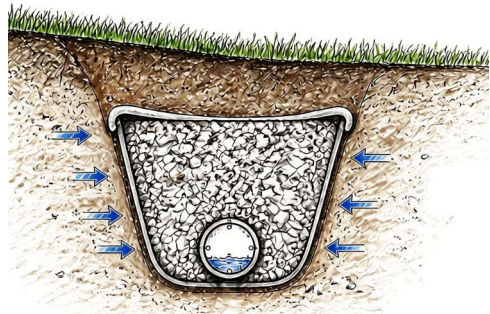
Areas with groundwater seeps can be stabilized using stones of varying sizes in a targeted way. Using riprap sparingly minimizes impacts on the surrounding natural resources and is preferable to extensive slope armoring. Riprap can be filled with soil and planted to promote revegetation, while controlling the transition of groundwater to surface water and its path.



Routed Riprap

INTERCEPT GROUNDWATER AND IMPROVE SUBSURFACE DRAINAGE

When groundwater is a major cause of instability, upslope interception can reduce or eliminate the need for direct bank stabilization. This technique redirects subsurface water to proper infiltration sites instead of allowing it to seep out of the bank. High-energy concentrated flows should be dissipated before they reach eroding banks. Note that when groundwater is intercepted, it needs to go somewhere to be discharged, and proper dissipation of the water will be necessary to prevent erosion elsewhere. Examples of materials and methods:



Cross-section diagram of a French drain. It intercepts water and carries it away to be discharged elsewhere.



Living Pole Drains



Brush Mattresses



Long-Term Erosion Control Blankets



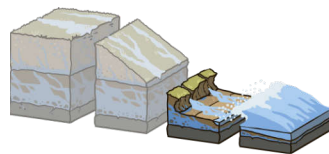
Filter Gravel



French Drains and Curtain Drains

SOURCE: TOE EROSION FROM WAVE ACTION OR ICE

Loss of sediment at the base of a bank along the water's edge is called toe erosion. At coastal sites and lakes, toe erosion most commonly occurs from waves hitting the shoreline. In rivers and streams, toe erosion is caused by scour along the edge of the bank. Other factors contributing to toe erosion include ice scour/pushing, groundwater seeps, and saturation/drainage of soils from water level fluctuations. Some toe erosion is common and by itself may not be cause for concern. This depends on the soil type, level of overall stability, rate of erosion, and presence of structures.



Signs and Severity

Low Severity

- ☐ Site is mostly sheltered from waves and scour
- ☐ Little to no exposed soil at or just above the normal high-water line
- ☐ Vegetation or fine sediment present along the water's edge
- ☐ Little sign of undercutting or slumping of unsupported soil at base of bank

Moderate Severity

- ☐ Site receives some regular wave action or flows, but only large storms cause visible erosion at the base of the bank
- ☐ Undercut base of the bank, but soil above holding due to healthy vegetation and soil structure
- ☐ Erosion at toe, but not elsewhere on slope
- ☐ Only stones along water's edge, no fine sediments

High Severity

- ☐ Site is regularly exposed to high-energy wave action or ice pushing
- ☐ Wave or ice action severely eroding the toe or undercutting the slope
- ☐ Slumping caused by toe loss from undercutting and wave erosion beyond toe
- ☐ Entire slope over-steepened due to toe erosion and slumping of the overburden soil



Evidence of toe erosion at a low-energy site, exposed during a period with a low water level.



Toe erosion happening during a storm at a high-energy site. (T. Dewey/Unsplash)

Options for Stabilization Projects

When toe erosion is low in severity, installation of toe protection is typically sufficient. In more severe cases, the toe must be reestablished to support the slope weight and prevent further toe erosion.

USE LIVING MATERIALS

Areas with groundwater seeps can be stabilized using stones of various sizes. For toe protection, plants and living materials can be used in lakes and rivers, especially in places where vegetation is present in the water or on the water's edge. Along the coast, because of tidal immersion in salt water at the toe, use salt-tolerant species in or near the water's edge.

Living materials can almost always be used for stabilization higher on the slope, above the high-water line in freshwater environments and above the highest astronomical tideline in saltwater environments. Examples of materials and methods:



Upper: Fascine toe protection with live stakes.
Lower: Encapsulated soil toe protection with brush layering.



Dense Live Staking



Living Fascines



Living Brush Layering

USE BIODEGRADABLE MANUFACTURED PRODUCTS

Biodegradable manufactured products can be used to reduce toe erosion and support vegetation establishment. Example materials and methods:



Coir (Coconut Fiber)
Logs



Biodegradable
Erosion Control Socks



Encapsulated Soil Toe
Protection

USE DEAD WOOD AND TREE MATERIALS

Dead wood and tree materials provide structural stability, energy dissipation, and habitat benefits in shoreline and slope stabilization projects. Examples of materials and methods:



Log Sill, Log Crib, Log Skids,
Manufactured Log Jam
(Freshwater Only)



Tree Root Wads



Log crib.

USE STONE

Stone can be used to provide weight, drainage, and structural stability for toe erosion. Examples of materials and methods:



Stone-packed Undercut,
Cobble Toe



Rooted Riprap



Toe riprap naturalizing as plants grow.

USE NON-BIODEGRADABLE MATERIALS

Nonbiodegradable materials can be used where conditions preclude the use of only natural and biodegradable materials. Example of materials and methods:



Green Gabions



Vegetated gabion wall.

USE IN-WATER AND FLOW ATTENUATION TOOLS

Some options for toe stabilization use an indirect approach by altering the flow of water near the shoreline. Since these options require work within a water resource as opposed to adjacent to it, they typically fall under a higher level of permitting. That said, they can provide long-term toe stabilization by preventing the bank from eroding. They sometimes even allow sediment to accumulate where it had previously eroded. Examples of materials and methods:



Root Wad Deflectors

Root wad deflectors are a variation on root wad toe protection. The tree roots face upstream in the river or stream, deflecting fast-moving water toward the channel's center. This technique effectively prevents bank erosion along a meandering river's outer bend, where concentrated water flow typically causes scouring. Can be entrenched at the base of a graded slope to provide support and protection in extreme environments.

Fringe wetlands and marshes have aquatic vegetation that can absorb wave energy before it reaches the shore. Restoring fringe wetlands and marshes creates a buffer between erosive forces and the shoreline. Sometimes logs or oyster shell sills may be necessary to help reestablish these habitats and help hold fine sediments in place. Variations using logs or other materials as a sill can increase the temporary protection while vegetation establishes and help hold fine sediments in place. This practice can be adapted to both saltwater and freshwater environments.

Chop and drop is a forestry technique that is primarily used for habitat enhancement but also effectively controls erosion by mimicking natural treefall, which stabilizes shorelines and creates natural buffers while enriching the surrounding ecosystem.

Veins, weirs, and groins are structures placed in flowing water to slow erosion by altering the direction and reducing the speed of the water. They are primarily used in rivers and streams but can also be used in other environments. It is essential to design them properly to prevent unintended damage elsewhere.



Groin in stream to slow flow in targeted areas.

Manufactured reefs and wave attenuation devices reduce the strength of waves before they break on shore. Materials used for wave attenuation structures, and their habitat value, range widely. Examples include oyster reef structures, concrete wave attenuation structures, reef balls, floating wetlands, and in-resource woody deposits and log jams.

Sand-catching woody materials such as brush and trees can be added to sand dunes to trap wind-blown sand and naturally build up sand deposits on land. In Maine, anchored, discarded Christmas trees have proven effective for this purpose but may require additional DEP permits since they are classified as waste material.



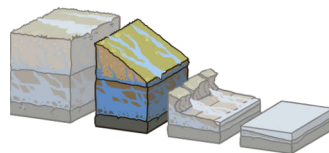
Height and Slope Risk

SOURCE: HEIGHT AND STEEPNESS OF SHORELINE BANK

When assessing erosion risk, both slope height and steepness are key factors. Vegetation and soil quality also influence overall stability.

Greater density of vegetation on the slope will increase stability. It is important to identify bare spots and restore a well-vegetated shoreline bank.

Slope grade alone does not determine erosion risk; for example, a slope steeper than 1:1 may remain stable if soils and vegetation provide adequate support. This is why it is important to consider all the forces acting on a site during the assessment process. As slopes become taller and steeper, the weight that must be supported at the base increases. In some cases, erosion and sedimentation risks can be reduced with toe stones or regrading, while in other cases additional measures may be needed. The following are important considerations for determining the appropriate amount of intervention when dealing with bank height and slope risk.



Slope Steepness and Angle of Repose: The angle of repose is the steepest angle at which loose soil can remain stable. The soil's particle size, shape, and moisture content influence this angle. Coarse particles like sand and angular stone have steeper angles of repose compared to finer soils like silt. Soils with a high moisture content often have a lower angle of repose. Fine marine sediment tends to maintain a lower slope than sites with coarse soil types, gravels, or glacial till deposits.

Treefall: When trees grow along shorelines, they often lean over the water to gain more sunlight. A tree leaning over the water is not an immediate cause for concern; however, when a tree gets extremely large, it can sometimes fall, tearing up portions of the shoreline. Tree limbs can be pruned to reduce weight and likelihood of treefall. Limbing can also provide sunlight for



Treefall contributed to instability and erosion of this high, steep slope. (Linkel)

shrubs and groundcover plants. If a tree has fallen, it may stabilize the immediate area and should be left alone when possible. When a tree needs to be

removed along any shoreline, it should be cut above ground to keep the root mass intact and holding the soil in place. Hardwood trees will often resprout if cut while dormant and therefore should be cut in the winter, when possible.

Shallow Ledge and Hard Pan Soils: Shallow ledge and hard pan soil layers are common in coastal Maine and can present challenges for stabilization. Water flows through the permeable top layers of soil, but when it reaches a ledge or hardpan, it pools and flows, resulting in groundwater seeps, sliding, or faster erosion rates. Typically, toe stones or other toe treatments are anchored into the ledge with rebar and epoxy, or through shaping/fracturing the ledge into a supportive toe trench for anchoring.

Height of Eroded or Failing Bank: To achieve a more stable angle using techniques such as regrading, one must consider the height of the bank, distance to structures, and other elements of instability present on the site. The bank's top must be relocated landward to reach a 1:1 slope on an over-steepened bank. When reaching a 1:1 slope is not feasible, an additional combination of structural and grading practices, such as terracing, may be practicable.

Highly Erodible Soils and Bluffs: Certain soils (like sands) have poor cohesion and are very susceptible to erosion from water or wind. Special considerations should always be made for the soil type at a specific site.

Rotational Failure and Landslide Risk: With higher and steeper slopes, there is a greater risk of rotational failure within the bank. Rotational failure occurs when the toe of the slope slides out and up, while the upper embankment slides down. When addressing areas where there is rotational failure or landslide risk, the involvement of a qualified engineer is highly recommended.

Signs and Severity

Low Severity

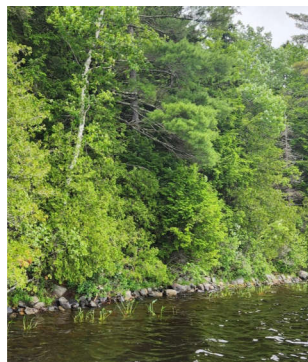
- ☐ Bank height less than 3 feet and/or embankment above toe is 3:1 or shallower
- ☐ Slope above the toe is densely and diversely vegetated (80-100% coverage), not lawn
- ☐ Well-structured soil with little or no sign of mass movement

Moderate Severity

- ☐ Bank height above the toe is moderate (3-6 feet) and/or embankment is between 3:1 and 1:1
- ☐ Slope above the toe is 50-75% vegetated
- ☐ Observable soil movement above areas of toe erosion

High Severity

- ☐ Bank height above the toe is greater than 6 feet, and slope is greater than 1:1
- ☐ More than 50% of the slope surface is bare soil without vegetation or duff



On this undeveloped shoreline, dense and diverse vegetation stabilizes the soil.

Options for Stabilization Projects

USE MINIMAL INTERVENTION (SITES WITH LOW OR MODERATE RISK)

Typically, when a shoreline has a low height and slope risk, no further action to address these factors will be necessary other than managing land use sources of water, adding mulch coverings, enhancing shoreline vegetation, or using slope interruption practices to help support stabilization naturally. The same is true for many sites with moderate height and slope risk. If healthy vegetation is already present on the bank, disturbing it can put the slope more at risk by compromising the existing stability provided by the vegetation. See Sections S and O for options to support stability.

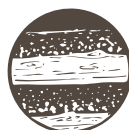
Many practices can be used without altering or grading the slope. In many locations, riprap's primary function is to provide protection against erosion because the natural erosion protection of the shoreline has been removed, leaving unvegetated, erodible soils. Slope grading creates the need for greater protection because direct wave contact, spray, and overland flows can more easily dislodge particles. Although vegetation can stabilize a site very effectively once mature, it provides limited strength immediately after planting, while roots are still developing. Even though many vegetation types have higher shear strength than riprap with twelve-inch stone or smaller, the riprap stone protects the soil until vegetation is established. At sites exposed to strong waves, regraded slopes may require stone for direct wave protection, but adding plants and soil provides a stronger long-term result.

ADD STRUCTURAL STABILIZATION

There are many reasons why grading an over-steepened slope may not be the best action or even possible. Considerations for buildings, access, landslide risks, and other factors may require structural stabilization. Sometimes, additional structural responses for the toe of the slope may also need to be considered to relieve or protect against the underlying instability problems identified at a site. While some structural solutions may be incompatible with vegetation, additional consideration to add habitat elements and restore lost functions can offset some of these impacts and unintended consequences. Examples of materials and methods:



Encapsulated Soil Lifts



Pilings / Vertical Slope Support



Living Crib Walls



Riprap Slope Coverings



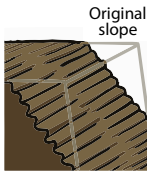
Green Gabion Walls and Mattresses



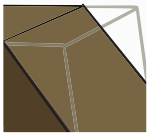
Soil Nailing

REGRADE OVER-STEEPENED SLOPES

Slopes steeper than 1:1, especially when affected by toe erosion or other factors like groundwater and overland flows, can be challenging to stabilize with vegetation alone. Establishing proper toe treatment for severe slopes is crucial as the toe supports the bank and protects it from further erosion. While treating just the toe may sometimes provide enough protection for vegetation to establish, additional slope modifications are necessary in other cases. Though regrading the slope should be avoided when possible, several options may provide effective stabilization if regrading is essential. Examples of materials and methods:



Surface roughening refers to creating a rougher surface on the bank to help slow down water. This is often done through tracking (for large slopes), reversion, loosening soil, adding a rough covering (Erosion Control Mix), or slope interruption practices. The concept can be expanded further to mimic natural landscape elements along a shoreline. Reversion is light soil grading that does not disturb soil structure, allowing existing seeds and roots to remain in place and resprout more quickly.



Cutting back slope with smooth grading is commonly done with oversteepened, unstable slopes. A consistent grade is created for areas where riprap will be used, where fiber blankets will be placed, or where surface roughening and vegetative support are used to slow down, but allow for, sheet flows. Riprap on smooth graded slopes should generally not exceed 1:1.



Benching and terracing are similar practices in which the slope is eased in small sections to allow plants to grow better and water to infiltrate. Since benching and terracing can create more vertical faces that might be problematic for wildlife movement, these benched areas should be of minimal height and have dense vegetation.



Contour swales are comparable to benching. Small swales are installed across the slope to capture and infiltrate flows coming down the embankment. Other previously mentioned slope interruption practices may be utilized for similar effect when properly anchored to the soil.



Pit-and-mound grading involves either matching the irregular topography of the surrounding untouched areas or digging small pits across the slope in an alternating pattern that doesn't allow water to find a pathway down the slope. Each pit can collect water and seeds to help create better growing conditions for diverse vegetation.

Important: Graded and Disturbed Slopes Need Protection

When slopes are graded or soil is disturbed, additional erosion control practices will be necessary to manage potential erosion of the bank. See Section O for practices that can serve this function.

ADAPTING UNROOTED RIPRAP TO ROOTED RIPRAP

Riprap embankments have commonly been constructed entirely of nonliving materials: large stones, smaller stones, gravel, sand, and plastic geotextile fabric. These unrooted riprap installations have been found to have several major shortcomings, including:

1. inhibiting the growth and naturalization of shoreline vegetation,
2. eliminating habitat for native fish and wildlife species,
3. potential release of microplastic into the environment, and
4. redirecting wave energy to neighboring non-armored shorelines and causing additional scour of bottom sediments.

Many options are available to construct rooted riprap that avoids those shortcomings:



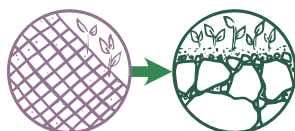
LIVE STAKES can be planted in riprap fairly easily, provided they can be inserted into a soil layer. This is easily done when granular filters are used instead of plastic-based geotextiles. However, stakes can be punctured through fabric to reach the soil behind.

SEEDING into riprap is successful if seed growth is not impeded with synthetic filter fabric and there is soil between the stones. Both seed and live-staked vegetation can be easily installed in riprap after it is infilled with soil and erosion control mulch.



LIVING BRUSH can be installed anywhere the stems will have good soil contact and moisture, such as under the toe stones or armor layer of riprap, and above riprap to allow overhanging and shading.

PLANTING POCKETS are pockets of soil or flattened benches on a slope to allow vegetation growth among the stone, reducing some of the negative impacts of riprap slopes. Planting pockets and shelves speed up the naturalization of riprap and create space for seeds to colonize. To be successful, roots must be able to reach the soil beneath the stone, so non-biodegradable fabrics may need to be removed or cut in those areas.



REMOVING SYNTHETIC FILTER FABRICS

from existing riprap may be possible in the upper portions of the slope, especially when smaller riprap was used. The stones can be removed temporarily to reveal and remove the

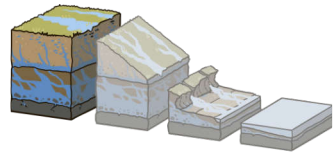
fabric before replacing the stone. This method will begin to allow natural or intentional vegetation growth in these areas.



Overland Water

SOURCE: FEATURES OF LAND USE

The most common causes of shoreline erosion in Maine originate not on the shoreline slope itself, but in the adjacent uplands. Features of the land area—such as lawns, buildings, and pavement—can strongly influence the amount of erosion on the shoreline by causing more water to flow overland to the shore. Any shoreline stabilization project should aim to address these contributions. Fortunately, fixing these issues is often the simplest, least-costly step in improving shoreline stability.



Signs and Severity

Low Severity

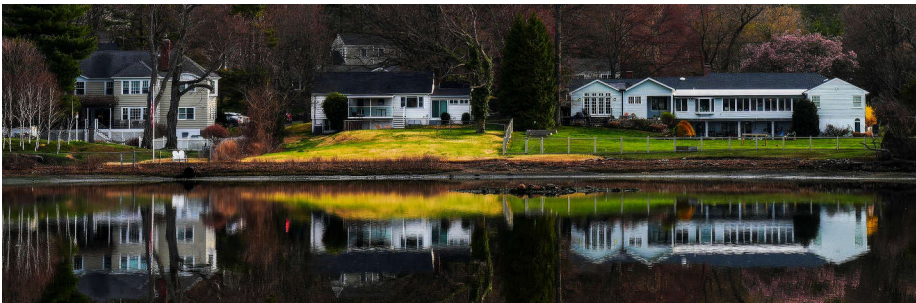
- ☐ No concentrated water flows toward the bank from developed areas
- ☐ No lawns or bare ground within 100 feet of the bank
- ☐ No roads, driveways, houses, or impervious surfaces within 100 feet of bank
- ☐ Surface flows from nearby developed areas are well managed with conservation practices such as rain gardens

Moderate Severity

- ☐ Some concentrated or channelized water is directed toward the bank
- ☐ No lawns or bare ground within 25 feet of the shoreline
- ☐ No roads, driveways, houses, or impervious surfaces within 25 feet of the bank
- ☐ A moderate amount of surface water moves toward the bank

High Severity

- ☐ Concentrated flows are directed at the embankment or shoreline access pathways
- ☐ Lawn area is present within 25 feet of the bank
- ☐ Roads, driveways, houses, or impervious surfaces within 25 feet of the bank



Land use features such as roads, houses, and lawns near the bank are signs that overland water could be severely affecting shoreline stability. (C. Denison/Pexels)

Options for Stabilization Projects

How people use and maintain adjacent land directly impacts slope stability. Simple changes in behavior can often reverse the development of erosion problems. Before making significant shoreline alterations, evaluate and deduce how land use practices contribute to the issue.

PROPERLY DESIGN AND MAINTAIN LAWNS AND GARDENS

Landscape maintenance can significantly influence erosion. Examples of materials and methods:

- Limit mowing frequency near the shore (every two weeks is ideal) and set the mower height to the highest setting (at least 3 inches)
- Maintain good lawn cover through effective grub control and prolific overseeding, especially when an opening is created by insect damage or weed control
- Refrain from raking or removing organic duff or vegetation, especially duff in areas near shoreline
- Be cautious with leaves and lawn clippings as mulch; if layered too thickly, these materials can smother growing plants
- Plant a variety of native trees, shrubs, perennials, and groundcovers (at least 70% is recommended)
- Don't treat the shoreline like a managed garden; gardens are best suited for upland areas, but the shoreline bank and area approaching the shoreline bank should be densely vegetated with deep-rooting species
- Cover bare soils with Erosion Control Mix (ECM)
- Minimize or reduce the lawn area and the manicured areas near the bank
- To reduce wildfire risk to structures, consider removing vegetation within five feet of structures, thinning vegetation within five to thirty feet so it does not create a continuous path to the structure, and thinning trees and shrubs between thirty and one hundred feet from structures. For more complete suggestions, visit the Maine Forest Service website's Firewise page.

Drawing by M. Richards/Roundwater Design + Waterview Consulting



PROPERLY DESIGN ACCESSWAYS AND PATHWAYS

Landscape maintenance can significantly influence erosion.

Examples of materials and methods:

- Make paths no more than 3-4 feet wide
- Design paths that meander, rather than making straight paths that would allow water to flow easily downhill
- Enable runoff to disperse from the path into vegetation
- Define and stabilize walking surfaces with 3-4 inches of material such as Erosion Control Mix, pine needles, bark mulch, crushed stone, or wood chips
- Focus access on more stable areas of the shoreline
- Use infiltration steps in steeper areas
- Don't store docks or recreation equipment on the shoreline or bank, as it disturbs plant growth



REDUCE WATER FLOW FROM DRIVEWAYS, PATIOS, AND OTHER IMPERVIOUS SURFACES

Water flowing from driveways, patios, and other impervious surfaces can quickly send large volumes of runoff toward a bank.

Examples of materials and methods:

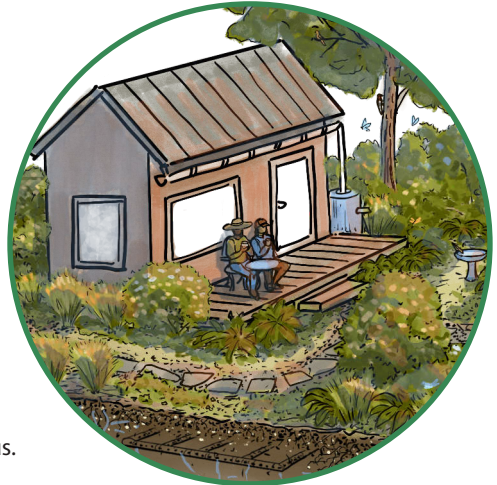
- Prevent/divert flows using water bars, infiltration swales, and/or rain gardens
- Minimize impervious surface area, especially near the top of the bank
- Break up flows with buffer vegetation and duff
- Use “permeable” pavers and grid materials that allow for vegetation to grow between the hard materials.

Note: Despite being more permeable to stormwater, many kinds of porous pavers or like materials may still be considered structures or impervious surfaces by regulation, especially if not maintained to continue to be impervious.

While they can be a better option than

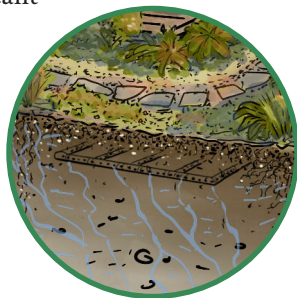
completely impervious surfaces, they often need

special base preparation. They require regular maintenance throughout the year to continue to function properly. When used, they should be located away from shoreline areas and embankments, especially steep slopes. Infiltration steps and walking areas with large inset stepping stones may be preferable to permeable pavers as most homeowners find these easier to install and maintain.



MAINTAIN SEPTIC SYSTEMS AND OTHER SOURCES OF SURFACE OR GROUNDWATER

Subsurface wastewater systems can contribute significant amounts of water to adjacent soil, particularly when used beyond their design capacity. The increase in groundwater can reduce soil stability, and it can seep out to become surface water on the slope. Regular inspections and pump-out maintenance of septic systems can reduce erosion, in addition to supporting human health and water quality. Other water-using equipment such as sprinkler systems should also be checked for leaks and runoff.



MANAGE ROOF RUNOFF

Water coming from roofs, gutters, and drains is concentrated and fast moving. If this channelized surface water flows overland toward the embankment without its energy being dissipated, it may contribute to erosion. For direct roof runoff, energy dissipation could be as simple as installing dripline trenches under the eaves. Houses with gutter downspouts may need additional energy dissipation such as rain barrels or cisterns. Appropriately located rain gardens (depressions for capturing overland water using wetland and water-loving plants) infiltrate water away from unstable shoreline areas.



BUILD UPLAND SURFACE WATER SYSTEMS

Flowing water that is allowed to concentrate can have the power to erode soil. When identifying shoreline erosion sources, look for places where water concentrates and flows down the bank from higher ground, such as ditches and stormwater drainage features. While the best approach is to spread out the water, there are options for drainage channel stabilization. Examples of materials and methods:

- **Temporary Erosion Control Blankets:** Stormwater channels and ditches should be vegetated whenever possible. Fiber blankets and similar biodegradable mats for these difficult flow areas can protect soil and seeds during germination. While these blankets come in various strengths and materials, fully biodegradable options without plastic components are recommended. The fine plastic netting in some blankets poses risks, as it can entangle wildlife, contaminate waterways, and persist in soil for decades.
- **Vegetated Stone/Riprap Channel:** In moderately sloped stormwater ditches where a geotextile filter fabric is not used, riprap or other stone can be placed to line newly graded channels that have been seeded. If the stone is not too thick, the seed will

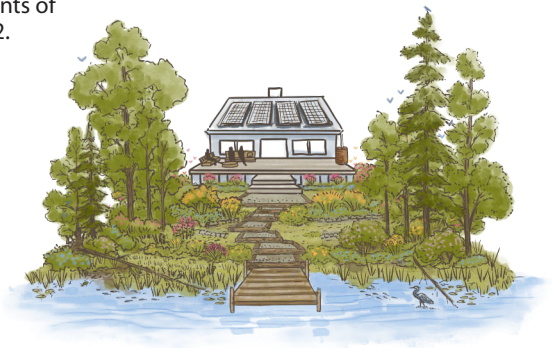
sprout between the stones and help lock this channel lining together while providing some shading and cooling to the stone. This method can be helpful where there is concern about thermal dams or heated water entering streams, which can harm fish and other aquatic life, especially during summer when conditions are already stressful.

- **Living Check Dams:** Living check dams are velocity-reducing structures comparable to the stone check dams commonly used in road ditches. This method is a variation of dense live staking where multiple rows of live stakes are installed close together, in succession, to slow channelized water.
- **Regenerative Stormwater Conveyances:** Regenerative stormwater conveyances, such as step pool swales, mimic elements of natural streams and rain gardens to manage channelized stormwater, often on steeper slopes. Step pool designs usually contain “weirs” of larger stone with smaller stone and sand to create pools and riffles similar to steep gradient stream systems. These treatments dissipate concentrated flow during storm events, and the pool beds filter and absorb water when flow is low.
- **Turf Reinforcement Mats (TRMs) and Grids:** TRMs and grid products are typically strong plastic-based materials installed like biodegradable blankets, used for slope stabilization within soil, or sometimes as encapsulated soil lifts. These materials bind with plant roots and stems throughout the site, effectively harnessing the combined strength of all roots across the slope. These materials enable vegetation to thrive on steep slopes and in erosive channels. While TRMs can be practical tools when needed, the use of persistent plastic materials near sensitive resources raises concerns for the natural ecology. Where feasible, biodegradable or natural alternatives should be considered first. TRMs are most effective when stormwater flow and volume are high; otherwise, biodegradable materials are often sufficient and effective.

SUPPORT NATURAL UPLAND HYDROLOGY

In an undisturbed forest, stormwater rarely forms channels. Most precipitation is intercepted by the canopy, absorbed by the duff, soil, and vegetation, or prevented from running off by the topography. The natural system allows water to slowly seep underground—cold and controlled—and to reach water bodies without causing erosion. Examples of materials and methods:

- **Hummocks:** Allow surface variation and uneven areas in yard to help slow water flow.
- **Vegetated Buffers:** See “Elements of a Vegetated Buffer” in Chapter 2.
- **Rock Sandwiches:** A rock sandwich consists of stones placed between two layers of filter fabric, allowing water to pass freely through the spaces between rocks from one side of a road, driveway, trail, or walkway to the other without becoming surface water. Rock sandwiches are primarily used to maintain groundwater flow and wetland connectivity without concentrating the water on the surface. Unlike culverts, these crossings help keep water in the ground and prevent concentrated flows, while preserving the natural soil hydrology. They may be used in conjunction with culverts to increase capacity.



CREATE STABLE OUTLETS FOR RUNOFF

Pay attention to where water is being directed to and have a way to manage it. Examples of materials and methods:

- **Rain Gardens:** Rain gardens are attractive and functional landscaped areas designed to capture and filter stormwater from roofs, driveways, and other hard surfaces. They collect water in bowl-shaped, vegetated areas and allow it to soak into the ground slowly. Rain gardens for single-family homes typically range from 150 to 300 square feet. Still, even a smaller one will help reduce stormwater and water pollution problems. For more concentrated flows, a stone energy dissipator can be installed just above the garden to slow the water and trap sediments. Rain gardens should be located at least 10 feet downslope from buildings.
- **Level Spreaders and Swales:** A level spreader is a discharge outlet that disperses runoff flows thinly (as sheet flow) across a slope and over a buffer to promote infiltration and prevent channelization. The lip of the level spreader must be installed level to ensure uniform flow distribution. It should blend smoothly into the downstream receiving area. This practice should not be used when the upgradient drainage area exceeds 10 acres, when discharge occurs within 25 feet of a stream, or when discharge crosses onto adjoining property. Stone can be used to create a level spreader, with the advantage that water flowing through the gaps between rocks will naturally sheet flow out of the spreader, eliminating the need for perfect leveling. Level spreaders should be constructed on undisturbed soil.
- **Ditch Turnouts:** Ditches can be diverted into forested areas. When done at regular intervals, this maintains surface hydrology while separating and absorbing the water volume, reducing the need for direct drainage into water resources.
- **Settling Basins and Plunge Pools:** When channelized stormwater enters a resource, it can carry pollutants and cause shoreline stability issues. Channel water should be diverted into surrounding buffer areas to infiltrate whenever possible. For turnouts or other outlets to wetlands or waterbodies, using an energy dissipator—such as a level spreader, stone apron, or settling basin—helps slow and filter water before it reaches the resource. Allow this dispersed water to have maximum vegetated space before it enters the wetland or waterbody.

WHAT'S WRONG WITH A LAWN?

Lawns alone cannot provide sufficient erosion protection for a shorefront lot. While lawn grasses offer some surface erosion protection, their shallow roots do not provide much deep stabilization. Lawns also allow stormwater to concentrate and pick up energy, increasing the erosive potential of the water. Lawns work best as part of an overall landscape design, providing open space for outdoor activities. However, they should be minimized in size near the water and kept as far back as possible to allow for thick natural vegetation to stabilize the buffer area. Most lawns are made up of non-native species that are poorly adapted to Maine's climate, often requiring extra water and maintenance. By reducing lawn areas and promoting native meadow conditions, property owners can save time and money, conserve water, and improve slope stability, water quality, and biodiversity.



R

Restore and Revegetate Habitat

SOURCE: LACK OF VEGETATION DENSITY AND DIVERSITY

Shoreline stability and a healthy shoreline ecosystem and habitat are closely linked. Increasing the amount and variety of vegetation, as well as installing multiple layers of vegetation such as groundcover, shrubs, and trees, can improve overall slope stability, create important wildlife habitat, and support ecological connectivity. Combining these practices yields the best results. As a general principle, it is important for habitat and shoreline stability to have denser vegetation closer to shore; however, having a variety and density of vegetation across the whole site provides greater habitat and stability. Habitat preservation and restoration can be incorporated into almost any shoreline stabilization design.

Signs and Severity

Low Severity

- ☐ Dense mix of shrubs and trees (coverage at least 70%) within 0-25 feet of water, 25-100 feet of water, and 100-250 feet of water
- ☐ Natural shoreline habitat; bank and vegetation not altered; no riprap or hardened structures installed

Moderate Severity

- ☐ Moderate density of shrubs and trees (coverage 20-70%) within 0-25 feet of water, 25-100 feet of water, and 100-250 feet of water
- ☐ Bank impaired by riprap or other hardened structures; vegetation present and pruned, mowed, or otherwise altered

High Severity

- ☐ Sparse shrubs and trees (coverage less than 20%) within 0-25 feet of water, 25-100 feet of water, and 100-250 feet of water



Example of a shore with riprap and sparse shrubs and trees. Planting a dense mix of shrubs and trees could reduce erosion and improve wildlife habitat. (P. Taylor/Waterview)

Options for Stabilization Projects

Habitat preservation and restoration can be incorporated into almost any shoreline stabilization design. This speeds naturalization of the shoreline, benefits fish and wildlife, and improves aesthetics. The following are key habitat elements to consider when modifying shorelines.

ENSURE A DENSE AND DIVERSE VEGETATED LANDSCAPE TO THE SHORELINE

Best achieved by preserving existing tree canopies and large shrubs, and by adding multiple species of native, locally sourced plants which, at maturity, will have varying heights, root depths, and growth forms (groundcovers, vines, woody shrubs, small trees, large trees) in non-linear and clumping arrangements. It is best to plant more densely than a typical garden because a thick tangle of roots and dense mosaic of plant species is best suited to manage erosion and mimic wildlife habitat. Consider soil types when choosing trees, shrubs, and herbaceous cover, and plant when appropriate. Sandy soils, wet soils, and shallow soils to hardpan or bedrock can create unstable environments for trees and lead to erosion risk as trees mature. Additionally, evergreens on shorelines can be shrubbed so they do not create erosive soils. Mature and seedling plantings can be supplemented and diversified with seeding. Leave or add sticks, standing dead trees, and logs where practical. Cover exposed soils with vegetation or non-erosive materials like erosion control mulch, which can serve as an adequate duff replacement.



This shoreline was stabilized using logs and dense vegetation. Existing vegetation was retained, and new plants were added. (The Home Place Team)

MAINTAIN PLANTED NATIVE VEGETATION

Years 1-3: Plants that have been added to a project are most vulnerable early on and become more resilient over time. Deep, weekly watering is likely necessary during the first year after planting. Plants that die in the first season typically received inadequate water or were planted too deeply. Ideally, water only the root system and not the foliage. Water deeply, so the water reaches the depth of the root ball. A mulch donut around the plant's dripline helps the water sink into the ground instead of running off and helps protect the stem from mower or string trimmer damage. In coastal areas, seaweed can function as an effective mulch. When stabilizing bare soil between plants, keep mulch 3 inches thick until about 6 inches away from plant stems or trunks. Between 6 inches and 2 inches away from the plant stem or trunk, gradually decrease mulch thickness from 3 inches to bare soil to prevent rotting, disease, and other stressors.

Years 4+: After the third year, you should only need to water if there is a lack of normal rainfall. Once the plants are well established, you can let the planted area naturalize. The duff layer of leaves and pine needles will serve as natural mulch.

Plants should be fertilized only if a soil test indicates a nutrient deficiency. To address identified nutrient deficiencies, use a nutrient-specific slow-release fertilizer at very low rates to protect developing roots and prevent algal growth in the water. Slow-release fertilizers mimic how plants naturally receive nutrients from the slow decay of the duff layer and surrounding soils. Using a nutrient-specific fertilizer is a cost-effective way to improve identified deficiencies and minimize water quality issues.

Maine freshwater lakes, ponds, rivers, streams, and wetlands are sensitive to even small increases in phosphorus levels, so use phosphorus-free soil nutrient amendments (fertilizers, composts, and other materials) unless applying seeds to stabilize an area or indicated by a soil test. Maine tidal wetlands, rivers, and bays are sensitive to small increases in nitrogen, requiring care when applying low rates of slow-release fertilizers with nitrogen to shoreline sites.

Time any fertilizer applications to plant development stages. For deciduous trees and shrubs, necessary fertilizer is beneficial in spring, early summer, or late fall, while fertilizer should only be applied to evergreen shrubs and trees in spring or early summer, as fall applications prevent them from preparing for winter. Soil pH impacts nutrient availability to plants. Some plants need acidic soils (pH under 7.0) to absorb nutrients while other plants prefer alkaline soils (pH over 7.0). To adjust soil pH, apply lime during the fall to raise soil pH or apply sulfur during the spring to lower pH.

Note: Maine law bans the use of phosphorus or nitrogen fertilizer within 25 feet of great ponds with some exceptions. The DEP website has information about phosphorous fertilizer sales law and guidance about use.



Excessive algae in the water can result from too much fertilizer use on land.

LIVE STAKE WITH DORMANT TREES AND SHRUBS

Live stakes are woody shrub cuttings that root once planted along the banks of streams, lakes, and other water resources. Live stakes make a sound, low-cost source of plant materials for stabilizing banks and restoring shoreland vegetation. Live stakes are also used away from water resources, using bioengineering techniques for slope stabilization, erosion control, carbon sequestration, and living fencing and structures. Some of the best native species to use for live stakes are pussy willows and other native willows, American elderberry, red osier dogwood, silky dogwood, and grey dogwood. These shrubs have strong root systems to stabilize banks, are naturally found along lakes and streams, and can grow from cuttings without much assistance. Like other plants, live stakes should be planted in sites that suit their sun, soil, and water needs. For more information on plant identification, visit www.plants.USA.gov. The following are important considerations when using live stakes.



Harvesting a live stake.

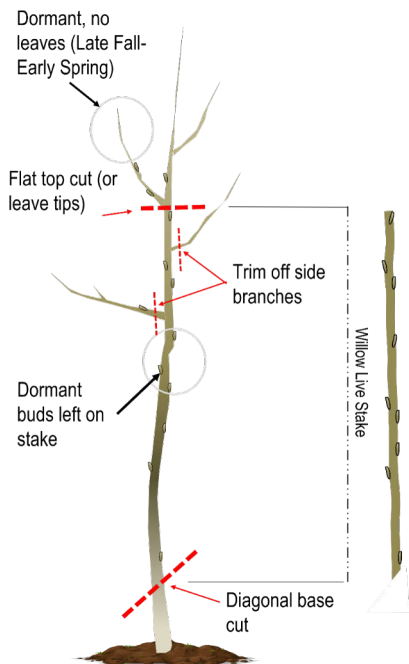
Timing Collection and Planting: For best results, live stakes should be harvested and planted while the plant is dormant during the period from late October until the ground is frozen, or in the spring before plants start to leaf out. Stakes can be planted in the fall while the ground is still workable or immediately after harvest in early spring, or they can be stored for later use in the growing season. The northern part of Maine should aim for spring plantings because frost heaves may dislodge plants that are not established. If stakes are properly planted while dormant, with good soil contact, expect an average of 50-80% success, depending on species. Some native willow species and others will also root after breaking dormancy. To increase chances of success, strip all leaves back to the woody twig and prune off side branches before planting to minimize moisture loss.

Harvesting Wild Live Stakes: Live stakes can be harvested from local plants near the project site. Obtain the landowner's permission before harvesting live stakes or other materials. Select established, healthy, mature plants. Make sure the thick end of the branch is at least one-half inch in diameter. At the base, cut on the diagonal to make a point. The angled cut will help you know which end goes into the ground when planting the stake. Remove all the side branches and make a straight cut at the top end of the branch about 12-18

TIMING FOR LIVING SHORELINES AND ASSOCIATED ACTIVITIES

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Growing season												
Winter erosion control practices												
Live stake collection												
Live stake installation	*	*	*	*	*							*
Dormant bare root planting			*									*
Dormant seeding												
Permanent seeding												
Non-dormant potted plants												
Inland in-water work window												

* When ground is not frozen



Left: How to harvest a live stake.
Upper: Storage of live stakes for later use.
Lower: Live stakes installed on a slope.

inches from the base. Generally, stakes should be 1-3 feet long, although longer cuttings can also be used. For example, longer cuttings may be used in living brush mattresses and living fences/structures. Remember that the more the plant is exposed to the air, the more quickly it may dry out. Local nurseries may carry live stakes for purchase, but advance notice is generally required. Live stakes are also available for sale online. Ensure that the plant species are native to Maine.

Storing Live Stakes for Later Use: To increase the survival rate of the stakes, it is best to plant within 24 hours of collection. Stakes can be stored in a cool, dark place for several weeks if kept damp by wrapping them in wet burlap sacks or soaking them in buckets of water. On the day of planting, stakes should be kept in the shade if the weather is warm. Stakes will die if allowed to dry out and may experience significant shock if planted once leaves begin to develop.

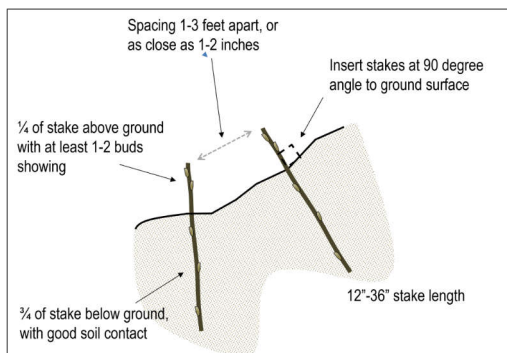
Refrigeration: Stakes can be stored for extended periods using refrigeration. Stakes kept moist and refrigerated will remain dormant and can be used for projects well into the growing season. For large installations involving many stakes, on-site refrigeration may be an option to prevent stake mortality.

Potting Live Stakes for Later Planting: Live stakes can be planted in nursery pots with potting soil to establish new plants that can be planted later in the growing season. These cuttings can be placed at high density, approximately one inch apart in the pots, or separated individually. The most critical time for survival of live stakes is when leaves begin forming (leaves emerge before roots start developing). Leaves will lose valuable water from the plant during this time, so tending the stakes early on can increase survival. Split plants from the pots before planting in small planting holes.

If live stakes are planted while dormant, shoots (leaves and small branches) should be seen in spring. If live stakes are planted during the growing season, it may take a full year or two to see results.

Basic Planting of Live Stakes and Dormant Cuttings:

- 1) The site should be prepared before planting the live stakes. Invasive and competing vegetation should be managed. The use of herbicide may cause the least disruption in some cases, such as when the invasive is deep rooted. Herbicide application requires a licensed commercial applicator. Information on invasive species can be found at www.maine.gov/dacf/mnap/features/invasive_plants/invasives.
- 2) Push carefully (or use a rubber mallet) to drive the pointed end of each live stake into the soil. If the stake doesn't go into the ground easily, first create a hole the length of the stake by using a metal rod, such as rebar. Live stake length should be one to three feet. Three-quarters of the stake length should be buried, and one-quarter of the stake length exposed, including a few buds sticking out of the ground. Ensure good soil contact with the stake.
- 3) If the stake will be shaded by surrounding vegetation, use longer stakes and leave one foot sticking above the ground. If a willow stake, in particular, gets too much shade, it will drop its new leaves and die. The side branches, or whips, that were snipped off during the collection process will grow well if they are planted in very moist areas at the edges of streams and wetlands. Push them into the ground as far as they will go without breaking.
- 4) Live stakes can be placed as far as one to three feet apart or in dense, close formations to increase root density. Note: In conjunction with live staking, cover bare soil with erosion control mulch (ECM) or annual grasses and hay mulch to hold the soil and help prevent weed establishment until the stakes are established.



The live stake rooting process can be accelerated by wounding or scratching away some of the bark that will be underground when planted. In addition, commercially available rooting hormones can be applied before planting to speed up the rooting process and increase success rates. Before planting, the cuttings can be placed in a bucket of water and left in a cool, dark area for several days, which will help conserve them.

At sites with high water flow or ice action, live poles can be installed extremely deeply into sand bars or slopes and placed at an angle away from the direction of ice or water flow. This method will allow the water or ice to slide over the cuttings. Since most plants with live-staking ability are adapted to these environments, they may get sheared off but roots will remain and vigorously send out new shoots the following growing season.

Live Staking in Coastal Environments: Some species used for live staking will not tolerate the salty or brackish conditions of a coastal shoreline. Many other species do have some salt tolerance, but using live stakes lower on the bank is not recommended. Species such as silky dogwood, meadowsweet, and elderberry can survive on coastal shorelines provided they can access fresh water adequately and will not be submerged in salt water for long periods.

MAINE NATIVE PLANTS FOR LIVE STAKING AND BIOENGINEERING

While many plant species can be propagated from cuttings, most require significant assistance and ideal conditions to form new roots and become self-sufficient. Many of Maine's native shrub species can be propagated by dormant cuttings, but survival is generally low, and rooting hormones may be required. While it is possible to root many deciduous shrubs and trees, certain ones like willows can form new roots.



Ninebark (*Physocarpus opulifolius*). (E. Hunt/Wikimedia)

Generally, you can expect 50-80% survival of live stakes, but this can be increased with simple maintenance and plant care in the first growing season. The primary reason for the failure of live stakes is that they dry out before being able to root. A higher percentage of the stake exposed to the air and sun will increase drying and leaf emergence before root establishment, resulting in a net loss of more moisture.

PLANT SPECIES	SIZE	SUN
Buttonbush <i>Cephalanthus occidentalis</i>	Shrub, 6-8 feet tall	Full sun to partial shade in moist to wet soils
Silky Dogwood <i>Cornus amomum</i>	Shrub, 6-9 feet tall	Prefers partial sun
Gray Dogwood <i>Cornus racemosa</i>	Shrub, up to 6 feet tall	Full sun, partial shade
Red Osier Dogwood <i>Cornus sericea</i>	Shrub, 6-9 feet tall	Full sun, partial sun, shade
Bebb Willow <i>Salix bebbiana</i>	Shrub, up to 10 feet tall	Part sun
Pussy Willow <i>Salix discolor</i>	Shrub or small tree, 10-15 feet tall	Full to partial sun
Missouri River Willow <i>Salix eriocephala</i>	Shrub, 7-13 feet tall	Full sun
Shining Willow <i>Salix lucida</i>	Shrub or tree, 12-20 feet tall, fast growing	Part sun
Black Willow <i>Salix nigra</i>	Tree, 70-80 feet tall, can be pruned to maintain shrub form	Full to partial sun
White Meadowsweet <i>Spiraea alba</i>	Shrub, 2-3 feet tall	Full sun, part shade
American Elderberry <i>Sambucus canadensis</i>	Shrub, 5-10 feet tall	Full sun, part shade
Ninebark <i>Physocarpus opulifolius</i>	Shrub, 3-9 feet tall	Full sun, light shade

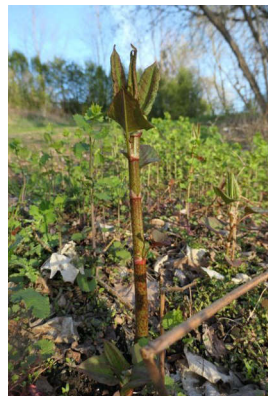
REMOVE INVASIVE PLANTS

The suppression and eradication of invasive plants requires careful research, persistence, and patience. The Maine Invasive Plants Field Guide (2019) advises identifying the species, determining the extent of its prevalence and priority level to remove, determining the appropriate control strategy, using proper disposal practices, evaluating and improving your techniques in following years, and preventing new introductions of invasives. **On Maine's shorelines, experts recommend manual removal and herbicide application as the primary control methods.** However, other methods exist, such as animal grazing. These methods can be used in combination.

- 1) **Manual Removal:** Shallow-rooted, small plants can be removed easily by hand. Manual removal of larger shrubs can be achieved using a weed wrench or a hand winch, which are used to uproot small shrubs by utilizing leverage and mechanical advantage. During and after manual removal, it is essential to prevent soil from entering the water because soil can carry nutrients and plant fragments with it, which can negatively impact water quality and spread invasives to other properties in the watershed.
- 2) **Herbicide Treatment:** Targeted herbicide treatments, such as cut surface treatments and stem injection ("cut-stem"), can be effective for difficult-to-manage species like glossy buckthorn, multiflora rose, Asiatic bittersweet, and Japanese knotweed. The herbicides must be applied with extreme caution to avoid contamination, especially around water. Maine has strict laws regarding the use of herbicides near lakes, rivers, streams, wetlands, and other water resources. The herbicides typically must be purchased and applied by licensed professional applicators. Consult the Maine Board of Pesticides Control website for information about legal requirements for herbicide use.

When removing invasive species, or other plants, from an area at risk of erosion, it is almost always best to keep the existing roots in the ground. Before removing invasive species, have resources and a plan in place to replant and revegetate. Root systems provide stabilization, regardless of whether they are roots from an invasive, native, or ornamental species. Removing the roots can cause further erosion and instability.

Depending on the species being removed and the severity of erosion, a combination of cutting the plant at the base, just above the ground, followed by targeted herbicide application, may serve to keep soils stabilized while giving the best possible chance of killing the invasive plant. A first round of manual or mechanical treatment may be helpful so that only resprouting plants would be

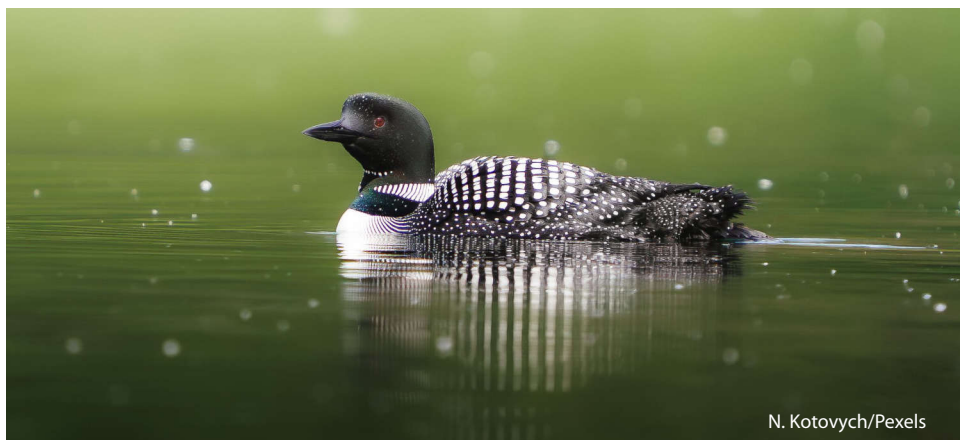


Invasive species, Japanese knotweed.

treated with herbicide. After the invasives have been cut and treated with herbicide, planting desired native species in the same area, between the invasives, can help establish vegetation for the long-term stabilization of the area.

When planting, select a species that survives under the soil and light conditions on the bank. If water is available at the site or there is a way to get water to them, live stakes might be a good option. Smothering invasive plants with temporary tarps or other coverings may be another appropriate method to consider, but it may only be effective in some cases and should be done only in upland areas and not on the slope. It can take several years to smother some invasives adequately. Smothering can be counterproductive as it can prevent native plant growth until beneficial bacterial and fungal communities can reestablish in the soil. Erosion control practices should be used on and downhill of the smothered area.

The Maine Natural Areas Program website has information about ways to deal with invasive plants, including species-specific control practices and replacement of invasive plants in gardens with non-invasive alternatives. The website also includes best practices to prevent the spread of invasives around the state, including preventing new introductions of invasives to your property as well as options for disposal.



N. Kotovych/Pexels

HELP IS AVAILABLE TO IMPROVE WATER QUALITY

Healthy shorelines go hand in hand with healthy watersheds and communities. Maine is lucky to have many groups and programs that help communities maintain healthy water quality and resources. The following are two examples.

LakeSmart is an education and outreach program that trains volunteers to visit shorefront properties to document areas of runoff and erosion and offer site-specific recommendations. The program is free, non-regulatory, confidential, and voluntary for homeowners.

Soil and Water Conservation Districts (SWCDs) are subdivisions of state government, governed by locally elected Boards of Supervisors. SWCDs hold workshops, set up demonstrations, offer educational programs, review development plans, and set priorities for technical assistance.

MINIMIZE SOIL DISTURBANCE WHEN PLANTING

Maintaining soil structure plays a vital role in soil stability. Wholesale bank disturbance can harm existing microbes, soil cohesion, root networks, and fungal mycelia. Practices like seeding and live staking are ideal since they preserve soil structure during installation. Installing living vegetation and larger potted plants may require more disturbance. The following are examples of planting methods that minimize soil disruption.

Allow Natural Growth and Regeneration: Increase growth indirectly by limiting mowing, pruning, and duff removal, and through thoughtful land use. Buffers will naturally revert over time and are a very cost-effective, low-maintenance option to increase buffer and bank stability. Some enrichment planting can take place to increase biological and structural diversity and other services. Strategic pruning of the buffer's woody plant species can also encourage plant health by allowing in more sunlight and producing woody debris for soil coverage and duff accumulation.

Spread Seed by Hand: Enhancing shoreline resilience and habitat can be achieved by seeding disturbed areas with a native seed mix of species adapted to the site's conditions. However, the seeds will require time and attention to establish. Temporary mulches or natural fiber blankets should be used to protect the soil and seeds from erosion. Hand seeding is preferred because it typically causes the least soil disturbance, but other seeding options are available. Seeds can be harvested from established plants or can often be purchased as native seed mixes.

Use Slit Planting: Slit planting is a method of planting live stakes, living brush, bare root shrubs, and trees that minimizes the disturbance of soil structure. The method involves creating a vertical slit in the soil with a shovel, then pushing the shovel forward to create space for planting. Make sure it is deep enough for the tree roots. Keep the slit open with your spade and place your plant material inside with the roots or live stake below ground level. Remove the shovel and push the soil back around the plant.

Use Bulb Auger Planting: Bulb auger planting is an easy method to install plant plugs (small potted seedlings) that also minimizes disturbance to surrounding roots and soil life. Select a drill-mounted bulb auger of the same or slightly larger diameter than the plugs. Start the drill and lightly push the plant auger into the ground, letting it cut through the soil until you reach the desired depth. Pull out the plant auger, place the plant in the hole, and backfill with soil. Press firmly for good contact.

Install Live Stakes: Live staking is a low-cost, relatively simple, and very effective way to add plants for shoreline stabilization.

AVOID DIGGING LARGE HOLES FOR PLANTS IF POSSIBLE

Installing larger potted plants, bare root plants, or transplanted wild plants requires a greater amount of soil disturbance compared to slit planting, bulb auger planting, and live staking. The soil disturbance is necessary to ensure that the plant will survive, but it can be counterproductive as part of a shoreline stabilization project. Because these methods require disturbance of the shoreline area, Maine DEP and local Shoreland Zoning permits may be necessary. Additional mulch stabilization may also be needed to stabilize the remaining disturbed or bare soil.

PRESERVE AND PROMOTE SHORELINE HABITAT

When planning a stabilization project, you can incorporate habitat preservation and restoration into almost any design to further minimize the long term impacts. This approach speeds naturalization, benefits fish and wildlife species, and improves visual impacts. These habitat elements can be integrated into the stabilizing features of a nature-based design, or they can be considered additional minimization elements when using more structural means. Below are key habitat elements to consider when modifying shorelines or retrofitting existing structural stabilizations.

Terrestrial and Aquatic Shade: The project should strive to provide shade cover for the affected shoreland over time. Shade cover is vital for keeping soils cool, maintaining soil moisture, providing overhead protection from predators for wildlife, and other benefits. This method can only be accomplished with sufficient numbers of plants and close enough spacing. It is best achieved by preserving existing canopy and understory vegetation, enhancing various heights of plants (and root systems), combining seeding with more mature plants, including multiple species and plant forms (e.g., groundcovers, vines, woody shrubs, small trees, large trees). Where appropriate, species and planting locations can be selected to provide nearshore aquatic shade and shading of stone with overhanging vegetation at maturity.

Cover Diversity: A shoreline should have diverse cover mimicking nearby natural systems in form and plant community. Look around at the surrounding untouched areas for inspiration. Plant in non-linear and clumping arrangements. Leave sticks or add snags or logs where practical; these are essential features that increase habitat value for many species. Where feasible, use grading practices that result in a less uniform surface such as roughening, reversion, or pit/mound topography. Exposed soils should be covered with



At this site, stabilization was implemented while also providing wildlife habitat and access for people.

vegetation or non-erosive materials like erosion control mulch. Where soil is bare and not exposed to wave energy, erosion control mix can be used as an adequate duff replacement.

Natural Vegetation Diversity: Dense native shoreline vegetation is key to the health of a wide range of fauna. Mixed vegetation provides food, shelter, perching, protection, shade, and other benefits to our fish and wildlife. It is imperative to have sufficient diversity between species and to source the plants locally, if possible. Aside from the above-ground habitat, these multiple layers of plant forms provide varied root interactions with undisturbed soil structure, adding strength and erosion resistance to the soil ecosystem.

Woody Material Inputs: According to many Maine biologists, most rivers and lakes are severely wood-starved. Downed woody debris is critical for in-water habitat diversity, sediment accumulation, and many aquatic macroinvertebrates. Woody material within or on the shoreline is encouraged to mimic or preserve natural stabilization processes. It can be used very effectively with minimal alteration. In nature, fallen trees can provide a place for sediment accumulation and protection by breaking up water's energy to erode. Practices such as root wad toe protection mimic this natural process.

Wildlife Travel Corridors: Shorelines provide a vital travel corridor for most wildlife species in Maine. From streams to lakes to coastal areas, these immediate shoreline areas are the highways of wildlife movement. Continuous vegetation cover along the shore provides this function for prey animals that tend to dislike being in the open, such as small mammals. A traversable surface is essential for all types of animals. This kind of surface can be accomplished by having the soil surface designed to match the surrounding terrain and surface covering, while encouraging or enhancing the local natural plant community.

Soil Health and Subsurface Habitat: Soil is more than a medium for plants to grow in or something to walk on. Soil is full of life, and supporting healthy soils requires maintaining soil structure and minimizing unnecessary disturbance. Soils need to breathe, too. Try to avoid compaction of the soil as well as practices that may smother or block water and air exchange. Certain species of fungus have symbiotic relationships with plants to allow for more efficient uptake of nutrients. Fungi in the soil consist of fine mycelia threads that help hold the duff layer to the soil surface in the soil and along with soil bacteria, increase soil cohesion and strength. Some plants may require fungal inoculants to be most healthy, but techniques to inoculate soil with beneficial soil microbes broadly can also be considered.

Natural Sediment Transfer: In some ecosystems, erosion of shoreline sediment into the water serves a key function. Adjacent to mudflats, for example, the hardened stabilization of bluffs can starve the mudflats of sediment, affecting clams and other living creatures. As sea levels rise, it is also crucial that natural sediment reaches the nearshore environment, which is vital for salt marshes, mudflats, and beaches to persist.

Species-Specific Habitat Considerations:

- **Insects and other pollinators** require many different habitat elements depending on their type and life stage. Many species of insects such as dragonflies transition from water to land as they grow, so adequate connection between the land and water is essential, as is diverse and overhanging vegetation. A wide variety of food sources is crucial for pollinator survival, and dead stem materials can provide shelter and overwintering locations. Many butterfly and moth species are also linked to specific "host plants" but need a mix of vegetation throughout their life cycle.
- **Aquatic invertebrates, clams, and mussels** have differing habitat needs. Clams and mudflat health in coastal areas rely on natural sediment inputs. Water quality is also crucial to many aquatic filter feeders, so a healthy, vegetated shoreline can help regulate temperature and filter overland flows.
- **Fish** benefit from increased cover from features like undercut banks and fallen logs or trees. Overhanging vegetation shades the water and plays a role in promoting cooler

water temperatures. Woody debris supports healthy stream habitats by providing food and shelter for aquatic insects that are eaten by Maine's native Eastern brook trout.

- **Amphibians** need access to land and water, so a good transition from land to water is beneficial. A healthy amount of woody debris and vegetation in water bodies gives amphibians places to attach their egg sacs. Vegetative shade cover, a healthy duff layer, and a traversable surface into the upland will help amphibian movements.
- **Reptiles** require both open spaces to bask in and pockets of protected cover. Snakes benefit from basking on sun-exposed surfaces, such as vegetated mats, root wads, and fascine bundles.
- **Turtles** living in streams and rivers, such as wood, Blanding's, and spotted turtles, rely on logjams and woody debris as important habitat features. Since some turtle species burrow into eroding banks for nesting, maintaining natural soil and portions of eroding banks for burrowing and nesting is crucial. A traversable surface supports turtle basking and movement along the shoreline and between land and water.
- **Birds** rely on thick, diverse vegetation for many reasons, such as perching on branches and feeding on berries, seeds, and insects. Diversity of vegetation, including dead vegetation, such as snags, can help provide nesting and food throughout the year. Many shorebirds and waterfowl require a thick vegetative buffer from human activities. Wading birds need well-vegetated shorelines to provide sufficient cover and space for nesting.
- **Mammals** such as the New England cottontail need dense shrubs and saplings (like those grown from live stakes and brush mattresses) as habitat. They travel under vegetation and cover to escape predators. Wide openings along the shore restrict the movements of some mammals. Species such as deer and raccoons regularly use the water and surrounding upland, and good connections along the shore and between land and water are required.
- If riprap must be used, fill between the rocks with soil and add plants to make rooted riprap, so that wildlife can move along the surface more easily. Design the soil surface to match the surrounding terrain.



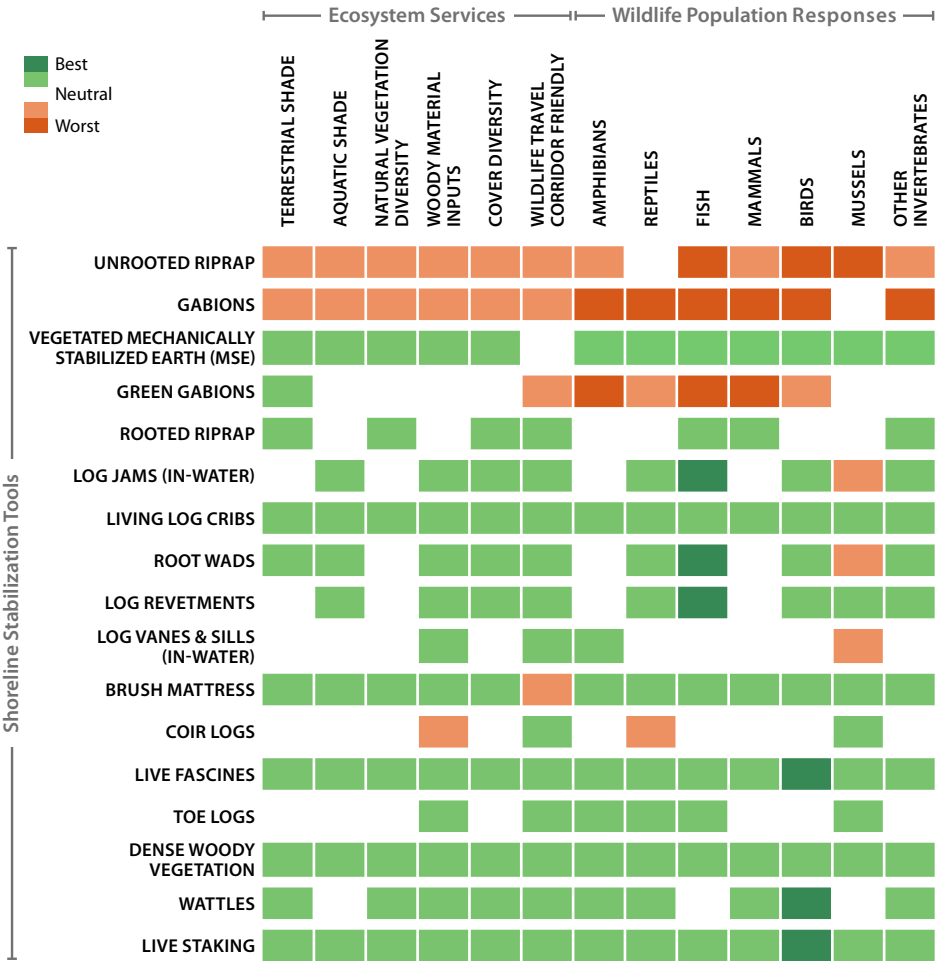
The belted kingfisher is one of many Maine species that rely on shoreline habitats with dense, diverse vegetation. (V. Andrews/Pexels)

GENERAL IMPACTS OF SHORELINE STABILIZATION TOOLS ON FISH AND WILDLIFE

Shoreline stabilization projects can provide benefits to fish and wildlife by using tools that have positive impacts on the ecosystem and avoiding tools that cause harm. This figure shows general impacts of shoreline stabilization tools on ecosystem services and wildlife populations, ranging from best (dark green) to worst (dark orange). Blank/white spaces are considered “neutral”.

For example, unrooted riprap has a wide range of negative impacts on the ecosystem and many animals. In comparison, infilled, vegetated, rooted riprap is better for wildlife. Live staking and wattles can also be highly beneficial to provide habitat.

This contingency table was constructed through structured expert elicitation interviews with Maine wildlife resource experts. Additional information was collected from US Department of Agriculture Natural Resource Conservation Service (USDA NRCS) National Engineering Handbook, as well as the New York Department of Environmental Conservation, the Vermont Agency of Natural Resources, and peer-reviewed literature. Results shown are considered to be general expected trends; in nearly all cases, there may be benefits or impacts depending on the context.



CHOOSING STABILIZATION OPTIONS BASED ON EROSION RISK OR INTENSITY

After an assessment of erosion and instability risks at a site, this table can be used to identify potential stabilization options. The first column is a list of options for addressing sources of erosion as discussed in Chapter 3. An X in the Low, Moderate, or High column indicates that the option may be appropriate to consider using to address that level of risk or intensity. This table is not prescriptive and is intended only as a starting point.

Options for Shoreline Stabilization	RISK OR INTENSITY OF EROSION SOURCE		
	Low	Moderate	High
S - SOURCES AND SEVERITY OF EROSION			
SOURCE: OVERLAND EROSION			
REDUCE LAND USE CONTRIBUTIONS	X	X	X
ESTABLISH DENSE VEGETATION	X	X	X
CONTROL SLOPE EROSION WITH COVERINGS			
• Straw or Hay Mulch	X		
• Hydraulic Mulches and Hydroseed	X	X*	
• Erosion Control Mix (ECM)	X	X	
• Erosion Control Blankets	X	X	
• Turf Reinforcement Mats (TRM)		X	X
• Brush Mattresses		X	X
• Rooted Riprap		X	X
• Unrooted Riprap			X
• Cellular Confinement System		X	X
• Gabions and Marine Mattresses			X
• Soil Nailing			X
CREATE SLOPE INTERRUPTIONS			
• Dense Contour Live Staking	X	X	
• Living Fascines	X	X	
• Living Wattles	X		
• Log Sills	X	X	
• Coir Logs		X	X
• Erosion Control Socks		X	
• Erosion Control Mix (ECM) Berms	X		
• Contour Swales	X	X	
• Roughening and Reversion	X	X	
USE SURFACE PROTECTION			
SOURCE: GROUNDWATER AND SOIL SATURATION			
USE STONE FOR TARGETED STABILIZATION			
• Riprap (stone toe covering)		X	X
FILTER LAYERS (when using stone surface)			
• Brush Mattresses		X	X
• Long-Term Erosion Control/Filter Blankets	X	X	
• Filter Gravel/Granular Filters		X	X
• Crushed Stone	X	X	
• Nonwoven Geotextile, TRMs			X
INTERCEPT GROUNDWATER AND IMPROVE SUBSURFACE DRAINAGE			
• Living Pole Drains		X	X
• French Drains and Curtain Drains		X	X
SOURCE: TOE EROSION FROM WAVE ACTION OR ICE			
USE LIVING MATERIALS			
• Dense Live Staking	X	X	
• Living Fascines	X	X	
• Living Brush Layering	X		

* Some municipalities restrict hydroseeding and fertilizer near water resources. See Chapter 2, Section U.

Options for Shoreline Stabilization (Continued)

	RISK OR INTENSITY OF EROSION SOURCE		
	Low	Moderate	High
USE DEAD WOOD AND TREE MATERIALS			
• Log Sill	X	X	
• Tree Root Wads		X	X
• Living Toe Crib		x	X
• Manufactured Log Jam (Freshwater Only)		X	
• Log Skids		X	
USE STONE			
• Stone-packed Undercut		X	
• Cobble Toe		X	
• Riprap Toe (or Brush layering under riprap toe)			X
USE BIODEGRADABLE MANUFACTURED PRODUCTS			
• Coir (Coconut Fiber) Logs		X	X
• Biodegradable Erosion Control Socks	X	X	
• Encapsulated Soil Toe Protection	X	X	
USE IN-WATER AND FLOW ATTENUATION TOOLS			
• Root Wad Deflectors		X	X
• Restored Fringe Wetland and Marshes	X	X	
• Chop and Drop	X	X	
• Veins, Weirs, and Groins		X	X
• Manufactured Reefs and Wave Attenuation Devices			X
• Sand-catching Woody Materials		X	X
USE NON-BIODEGRADABLE MATERIALS			
• Green Gabions			X
H - HEIGHT AND SLOPE RISK			
SOURCE: HEIGHT AND STEEPNESS OF SHORELINE BANK			
USE MINIMAL INTERVENTION (SITES WITH LOW OR MODERATE RISK)	X	X	
ADD STRUCTURAL STABILIZATION			
• Pilings / Vertical Slope Support		X	
• Encapsulated Soil Lifts	X	X	
• Living Crib Walls		X	X
• Soil Nailing			X
• Green Gabion Walls and Mattresses			X
• Riprap Slope Coverings		X	X
REGRADE OVER-STEEPENED SLOPES			
• Surface Roughening	X		
• Cutting Back Slope with Smooth Grading		X	X
• Benching and Terracing		X	X
• Contour Swales	X	X	
• Pit-and-Mound Grading	X	X	
• Overland Water Interventions	X	X	X
O - OVERLAND WATER			
SOURCE: FEATURES OF LAND USE			
PROPERLY DESIGN AND MAINTAIN LAWNS AND GARDENS			
• Limit mowing frequency near the shore (every two weeks is ideal) and set the mower height to the highest setting (at least 3 inches)	X	X	X
• Maintain healthy lawn cover through allowing deep root depth and overseeding bare or thin spots	X	X	X
• Refrain from raking or removing organic duff or vegetation, especially duff in areas near shoreline	X	X	X
• Be cautious with leaves and lawn clippings as mulch; if layered too thickly, these materials can smother growing plants	X	X	X
• Plant a variety of native trees, shrubs, perennials, and groundcovers (at least 70% is recommended)	X	X	X

Options for Shoreline Stabilization (Continued)	RISK OR INTENSITY OF EROSION SOURCE		
	Low	Moderate	High
• Don't treat the shoreline like a managed garden	X	X	X
• Cover bare soils with Erosion Control Mix (ECM)	X	X	
• Minimize or reduce the lawn area and the manicured areas near bank	X	X	X
PROPERLY DESIGN ACCESSWAYS AND PATHWAYS			
• Make paths no more than 3-4 feet wide	X	X	X
• Design paths that meander, rather than straight paths that allow water to flow easily downhill	X	X	X
• Enable runoff to disperse from path into plants	X	X	X
• Define and stabilize walking surfaces with 3-4" of material such as Erosion Control Mix, pine needles, bark mulch, crushed stone, or wood chips	X	X	
• Focus access on more stable areas of the shoreline	X	X	X
• Use infiltration steps in steeper areas		X	X
• Don't store docks or recreation equipment on the shoreline or bank, as it disturbs vegetation growth	X	X	X
REDUCE WATER FLOW FROM DRIVEWAYS, PATIOS, AND OTHER IMPERVIOUS SURFACES	X	X	X
MAINTAIN SEPTIC SYSTEMS & OTHER SOURCES OF SURFACE OR GROUNDWATER	X	X	X
MANAGE ROOF RUNOFF	X	X	X
BUILD UPLAND SURFACE WATER SYSTEMS			
• Temporary Erosion Control Blankets	X	X	
• Vegetated Stone/Riprap Channel	X	X	X
• Living Check Dams		X	X
• Regenerative Stormwater Conveyances			X
• Turf Reinforcement Mats (TRMs) and Grids			X
SUPPORT NATURAL UPLAND HYDROLOGY			
• Hummocks		X	X
• Vegetated Buffers	X	X	
• Rock Sandwiches	X	X	
CREATE STABLE OUTLETS FOR RUNOFF			
• Rain Gardens	X	X	
• Level Spreaders and Swales		X	X
• Ditch Turnouts		X	X
• Settling Basins and Plunge Pools	X	X	X
R – REVEGETATE AND RESTORE HABITAT			
SOURCE: LACK OF VEGETATION DENSITY AND DIVERSITY			
ENSURE A DENSE, DIVERSE VEGETATED LANDSCAPE TO THE SHORELINE	Use as many of these practices as possible to vegetate and restore shoreline habitat. Inclusion of additional practices can aid in minimizing impacts from stabilization projects and speed up naturalization.		
MAINTAIN PLANTED NATIVE VEGETATION			
LIVE STAKE WITH DORMANT TREES AND SHRUBS			
REMOVE INVASIVE PLANTS			
MINIMIZE SOIL DISTURBANCE WHEN PLANTING			
PRESERVE AND PROMOTE SHORELINE HABITAT			
• Terrestrial and Aquatic Shade			
• Cover Diversity			
• Natural Vegetation Diversity			
• Woody Material Inputs			
• Wildlife Travel Corridors			
• Soil Health and Subsurface Habitat			
• Natural Sediment Transfer			
• Species-Specific Needs and Habitat Considerations			

E Evaluate and Enhance

The options outlined in this guide can be used to inform both major stabilization project design and installation, and the incremental improvement of sites addressing identified problem areas and risks. After stabilization improvements to the shoreline have been implemented, this guide can also be used to support periodic evaluations and enhancement for continued habitat and stability needs.

PERFORMANCE AND COST OVER TIME

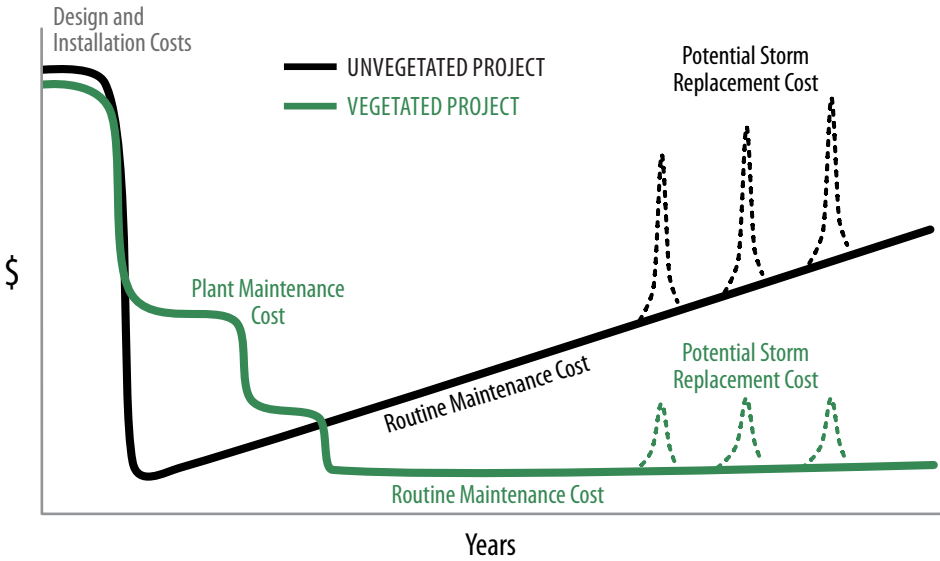
Performance and cost are the two most common considerations when selecting shoreline stabilization practices. Direct quantitative comparisons between options discussed in this guide are difficult, primarily due to variations in sites and materials and methods used at sites. However, experience shows that projects using the nature-based design options in this guide become more robust over time and offer greater sustainability than unvegetated options such as seawalls or unrooted riprap. They naturally adapt to environmental changes and often withstand storm events better than stone barriers alone. In addition, the properties may increase in value because of the enhanced aesthetic appeal and recreational opportunities.



A newly installed stabilization project that was designed to repair and protect a shoreline heavily damaged by storm waves in prior years. The riprap was installed during winter, the plantings were added in the spring, and this photograph was taken in the summer. (P. Taylor/Waterview)

RELATIVE COST OF VEGETATED VS. UNVEGETATED STABILIZATION PROJECTS

This conceptual graph illustrates how vegetated options for shoreline stabilization are cost-effective alternatives to unvegetated options. Generally, a vegetated project may have a higher maintenance cost in the early years until the plants become established, but long-term routine maintenance is consistently low. In contrast, the cost of routine maintenance for an unvegetated project increases over time until eventual replacement.



As an example, a comparison of rooted vs. unrooted riprap is described here:

1. Initial installation of unrooted riprap with plastic filter fabric (black line on graph) typically has a similar upfront cost to a rooted riprap design (green line on graph) that includes professional design and installation services, and materials (soil infill, seed, live stakes, and plants).
2. During the first two to three years, vegetated designs require periodic evaluation and, if needed, replanting to support successful establishment. These activities result in short-term annual maintenance costs, as shown by the green line. Unrooted riprap designs generally do not require monitoring or rebuilding in the initial years.
3. In later years, maintenance costs for rooted riprap drop to nearly zero once vegetation is established. The shoreline becomes stabilized by both the stone and the interlocking root systems, which hold the bank together as a single matrix. In contrast, unrooted riprap gradually loosens and degrades, becoming more vulnerable to storm damage. Over time, the risk of costly repairs or full replacement increases, as shown by the upward slope of the black line.

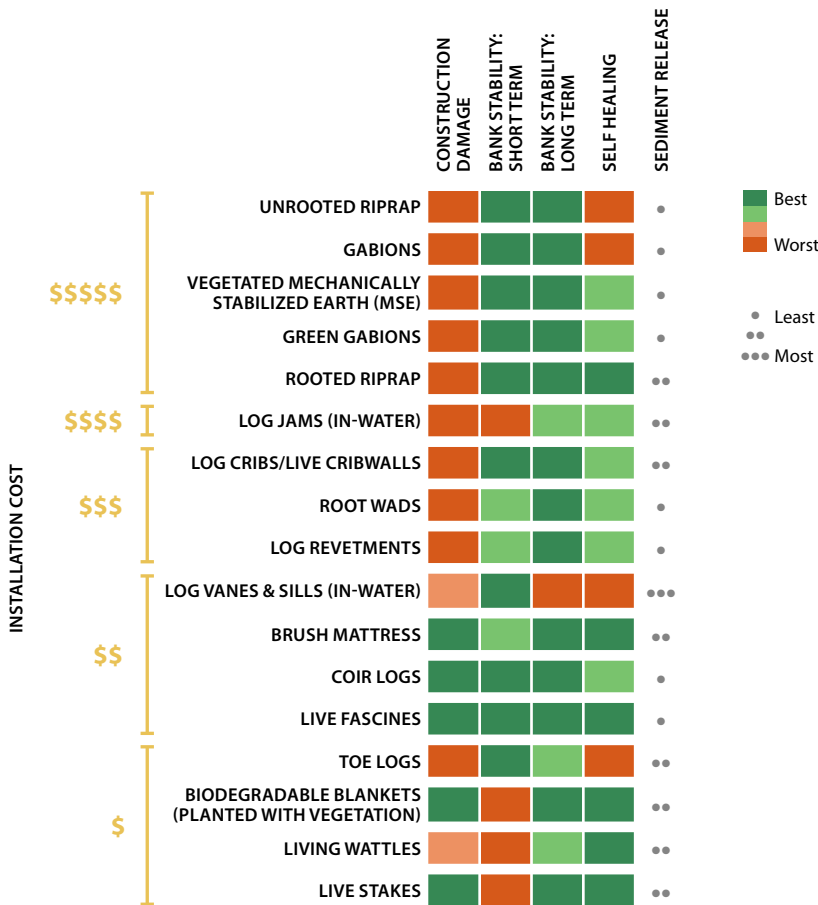
No shoreline protection strategy is entirely free from damage or repair costs. However, as shown in the description above, rooted riprap—where roots and sediment help hold the riprap together—can provide better long-term performance with lower maintenance costs.

RELATIVE COST AND PERFORMANCE OF SHORELINE STABILIZATION TOOLS

This figure compares the relative cost and performance of selected shoreline stabilization tools. Relative cost is indicated from highest (\$\$\$\$\$) to lowest (\$). Several aspects of performance are indicated from best (dark green) to worst (dark orange). Sediment release is indicated differently from least (•) to most (•••), as the favorability of different amounts of sediment release may vary among sites.

For example, unrooted riprap ranks worst for construction damage and self healing; best for short-term and long-term bank stability; and least for sediment release. Live stakes rank best for construction damage, long-term bank stability, and self healing; worst for short-term bank stability; and moderate for sediment release.

This contingency table was constructed through information collected from the USDA NRCS National Engineering Handbook, the New York Department of Environmental Conservation, and the Vermont Agency of Natural Resources.



INSTALLATION COST: Relative cost of installation at a shoreline site, highest (\$\$\$\$\$) to lowest (\$)
CONSTRUCTION DAMAGE: Comparative extent of residual, temporary construction disturbance
BANK STABILITY: Probability of bank remaining stable in comparative short term or long term
SELF HEALING: Ability of the installation to repair itself
SEDIMENT RELEASE: Amount of sediment movement from bank to water over time

APPENDICES

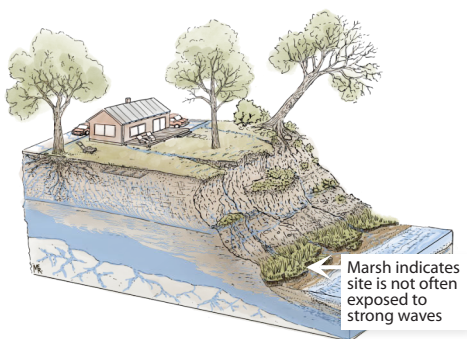
APPENDIX A: Shoreline Stabilization Scenarios

APPENDIX B: Site Assessment Checklist

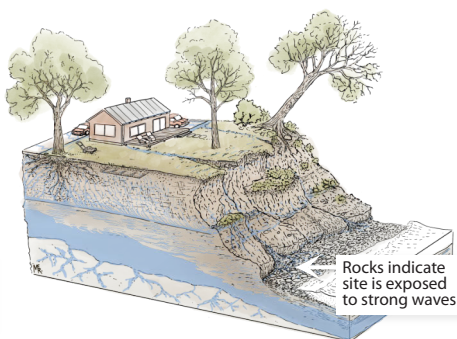
APPENDIX A:

SHORELINE STABILIZATION SCENARIOS

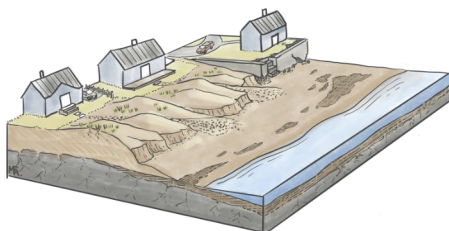
On the following pages are drawings of scenarios of shoreline stabilization in Maine. The OUR SHORE Program developed these scenarios to show some examples of how the options presented in this guide can be used to stabilize shorelines with characteristics that are typical of Maine. The scenarios include “before” and “after” images for six types of shoreline environments:



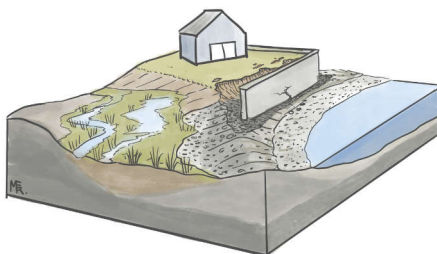
COASTAL BLUFF #1
Low-Energy Site



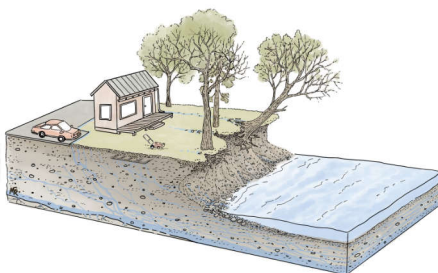
COASTAL BLUFF #2
High-Energy Site



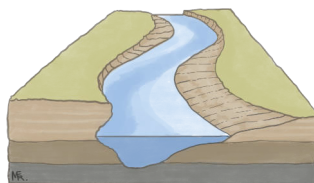
SAND DUNES



COBBLE DUNES



LAKE

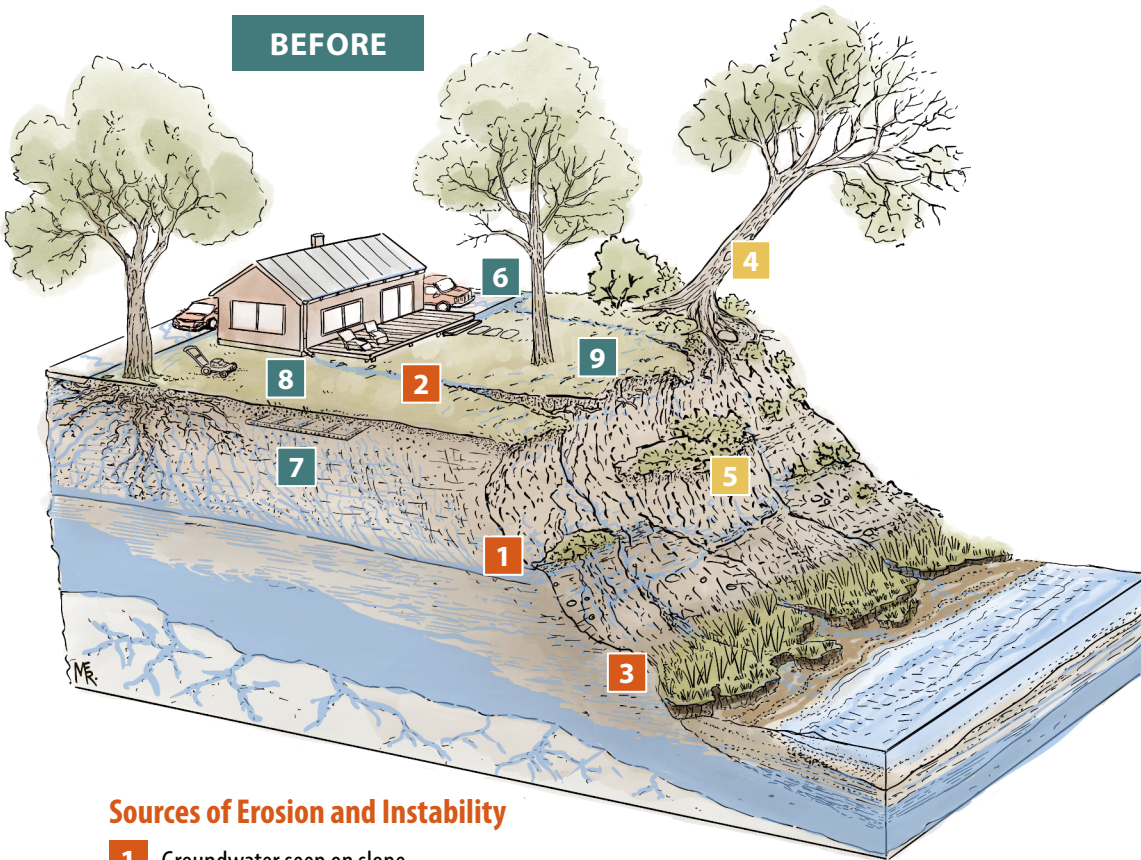


RIVER / STREAM

SHORELINE STABILIZATION SCENARIO

Coastal Bluff #1: Low-Energy Site

Nearly half of Maine's coastal shoreline is defined as unconsolidated coastal bluffs, which have at least three feet of erodible sediment above the high tide line. One-third of those bluffs are currently mapped as unstable and eroding. This scenario shows a property with tidal marsh along the base of the bluff. This is typical of a low-energy site, meaning it is not often exposed to strong waves. The numbered labels on the "before" image indicate features that contribute to erosion and instability at the site.



Sources of Erosion and Instability

- 1 Groundwater seep on slope
- 2 Overland erosion
- 3 Toe erosion: slumping and bare soils

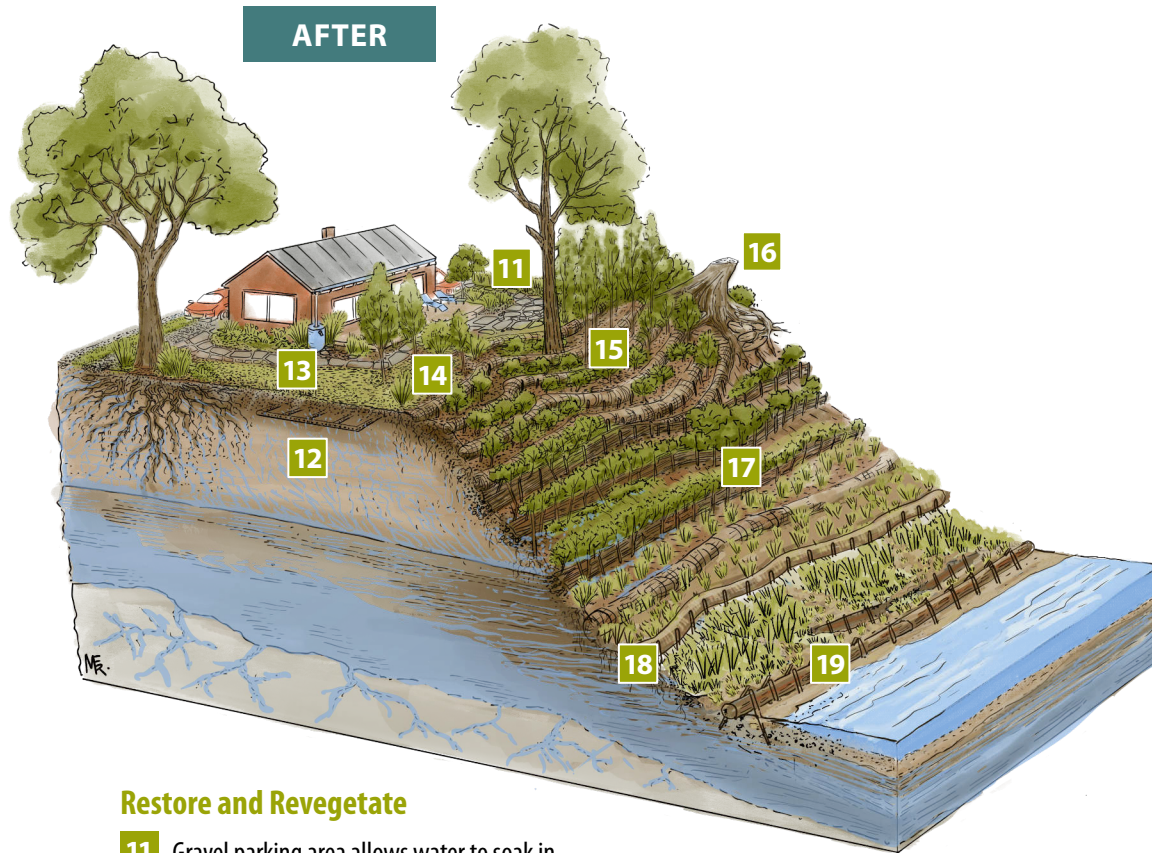
Height and Slope Risks

- 4 Hazard tree
- 5 Moderate height and slope

Overland Water from Land Use

- 6 Paved parking area causes runoff of water
- 7 Excess water from malfunctioning septic system
- 8 Gutter and downspout creating channelized flow
- 9 Lawn extends to edge of bank

The “after” image shows one concept of what the property could look like shortly after implementation of OUR SHORE stabilization options. The numbered labels indicate changes that were made to address the erosion and instability issues shown in the “before” image. Over time, the plants will grow in, and flowers will bloom. Various other combinations of OUR SHORE options could have been implemented at this site based on the property owner’s preferences, budget, and other factors.



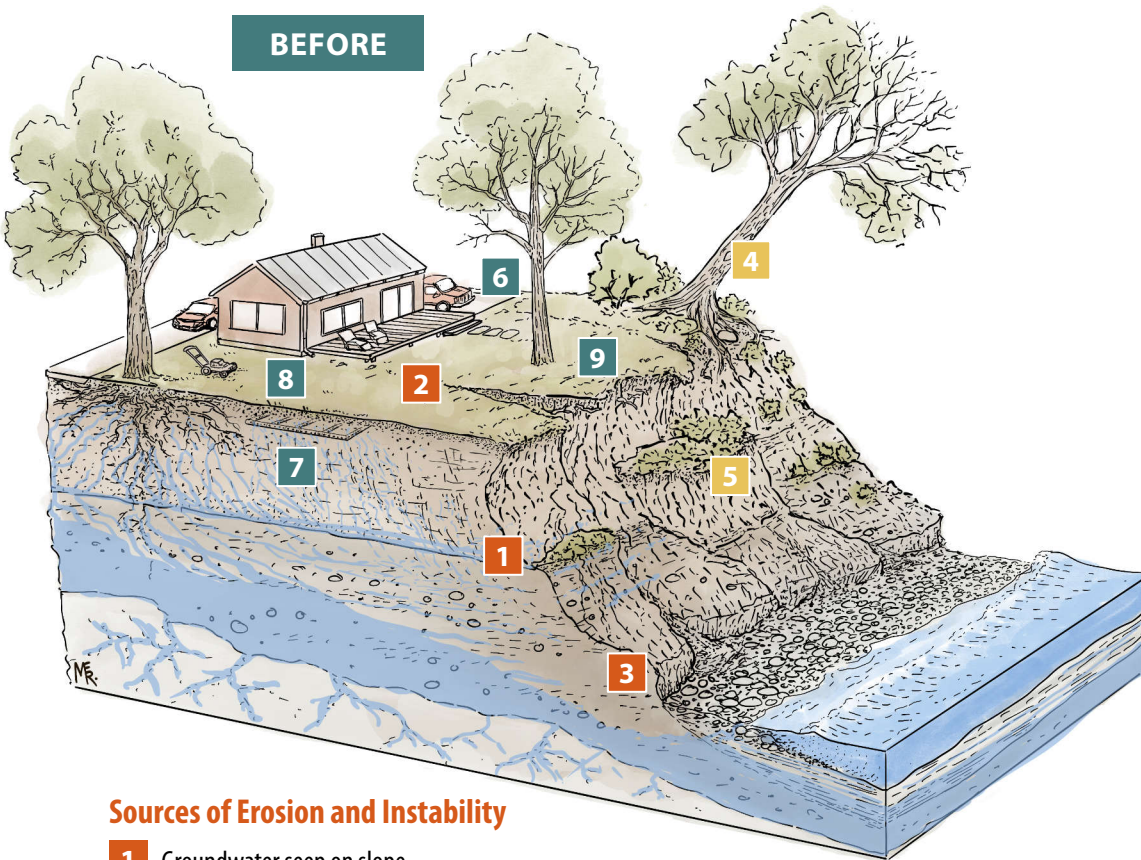
Restore and Revegetate

- 11** Gravel parking area allows water to soak in
- 12** Repaired septic system releases less water
- 13** Rain barrel collects water from gutters
- 14** Less lawn area with buffer of native plants
- 15** Greater density and variety of plants
- 16** Hazard tree roots left and graded around with varied slope
- 17** Regraded slope; living wattles and anchored logs added to interrupt slope
- 18** Toe stabilized with anchored coir log
- 19** Tidal marsh stabilized and restored to allow expansion

SHORELINE STABILIZATION SCENARIO

Coastal Bluff #2: High-Energy Site

Nearly half of Maine's coastal shoreline is defined as unconsolidated coastal bluffs, which have at least three feet of erodible sediment above the high tide line. One-third of those bluffs are currently mapped as unstable and eroding. This scenario shows a property with rocks along the base of the bluff. This is typical of a high-energy site, meaning it is often exposed to strong waves. The numbered labels on the "before" image indicate features that contribute to erosion and instability at the site.



Sources of Erosion and Instability

- 1** Groundwater seep on slope
- 2** Overland erosion
- 3** Toe erosion: slumping and bare soils

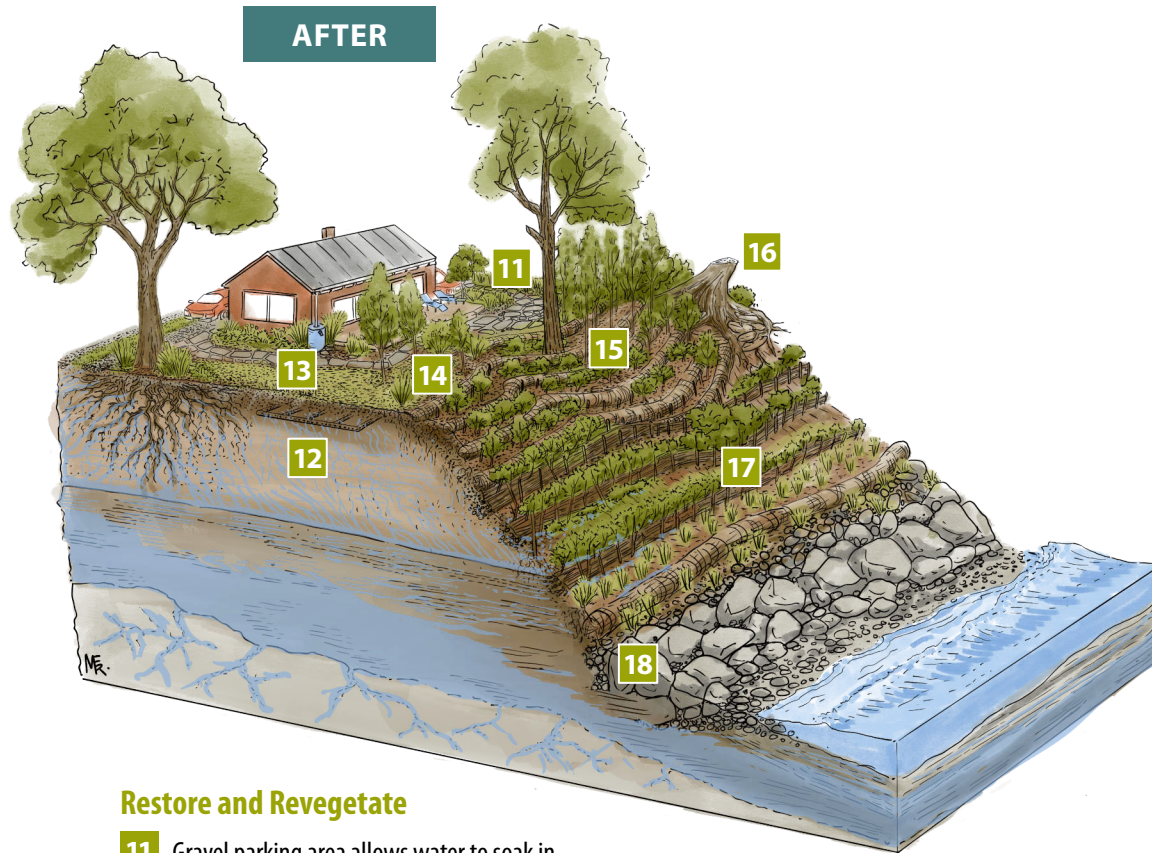
Height and Slope Risks

- 4** Hazard tree
- 5** Moderate height and slope

Overland Water from Land Use

- 6** Paved parking area causes runoff of water
- 7** Excess water from malfunctioning septic system
- 8** Gutter and downspout creating channelized flow
- 9** Lawn extends to edge of bank

The “after” image shows one concept of what the property could look like shortly after implementation of OUR SHORE stabilization options. The numbered labels indicate changes that were made to address the erosion and instability issues shown in the “before” image. Over time, the plants will grow in, and flowers will bloom. Various other combinations of OUR SHORE options could have been implemented at this site based on the property owner’s preferences, budget, and other factors.



Restore and Revegetate

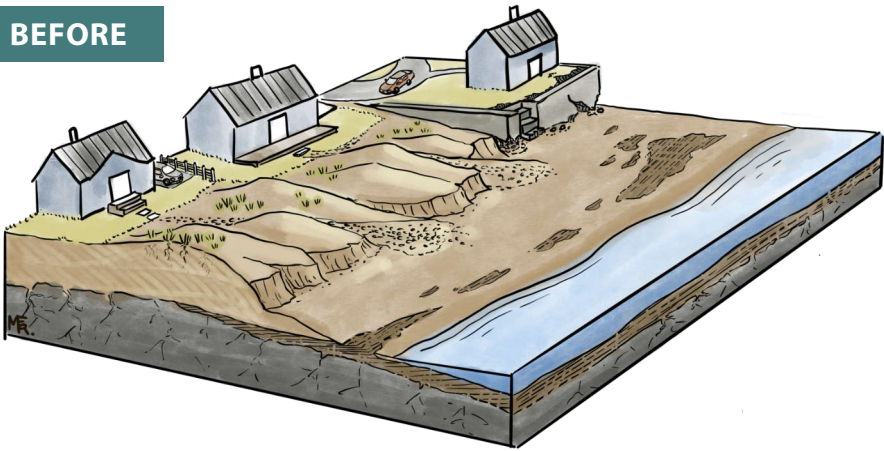
- 11** Gravel parking area allows water to soak in
- 12** Repaired septic system releases less water
- 13** Rain barrel collects water from gutters
- 14** Less lawn area with buffer of native plants
- 15** Greater density and variety of plants
- 16** Hazard tree roots left and graded around with varied slope
- 17** Regraded slope; living wattles and anchored logs added to interrupt slope
- 18** Toe stabilized with rooted riprap: large rocks of varied sizes placed on a layer of crushed stone or other natural filter material

SHORELINE STABILIZATION SCENARIO

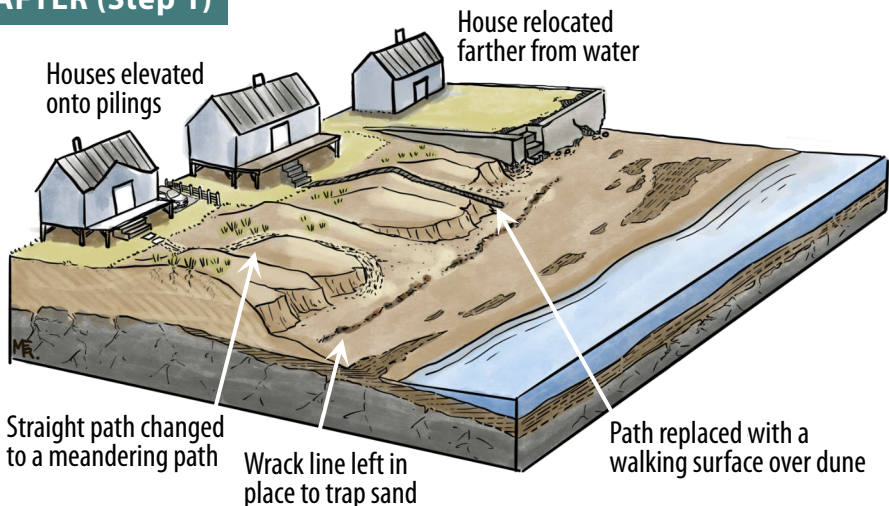
Sand Dunes

Some coastal properties in Maine are situated along sandy beaches with dunes. In these constantly shifting environments, ocean and wind ceaselessly move the sand, which creates challenges for property owners. In the “before” image of this scenario, the two houses on the left are frequently damaged by storm waves that breach the dunes—helped by paths that cut straight from the houses to the beach. The house on the right has an old, crumbling seawall that offers scant protection, needs frequent repairs, and makes erosion worse by reflecting the waves. The three “after” images show a sequence of changes that the owners of these three properties made to stabilize the shoreline.

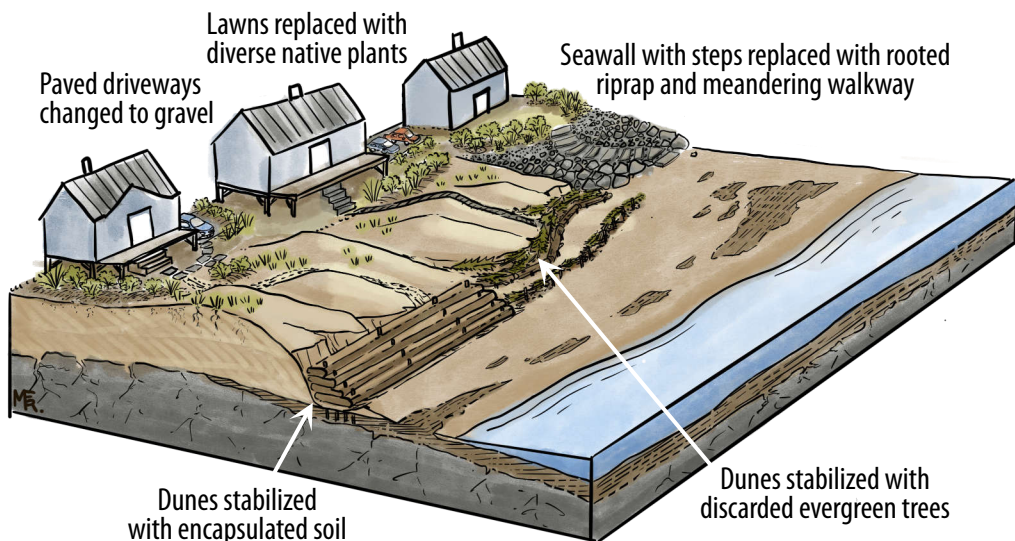
BEFORE



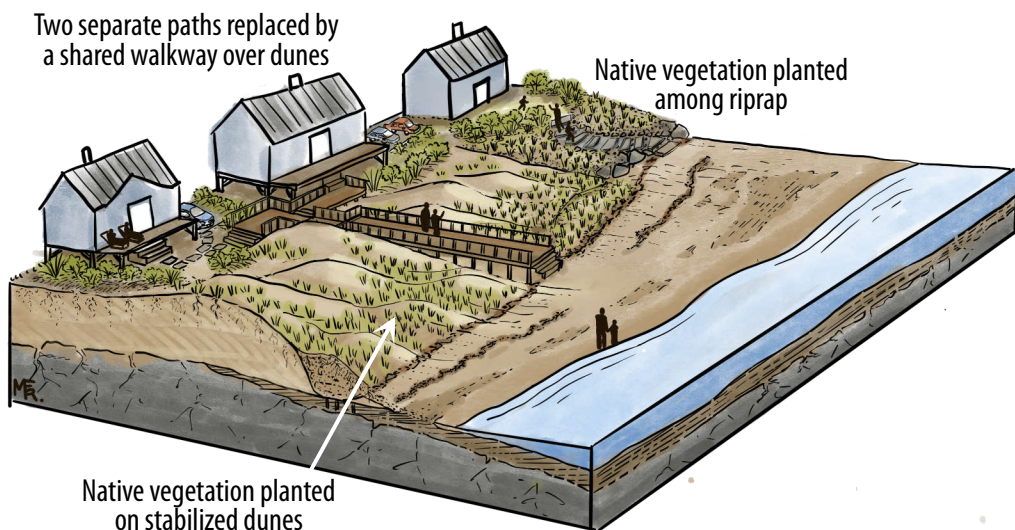
AFTER (Step 1)



AFTER (Step 2)



AFTER (Step 3)



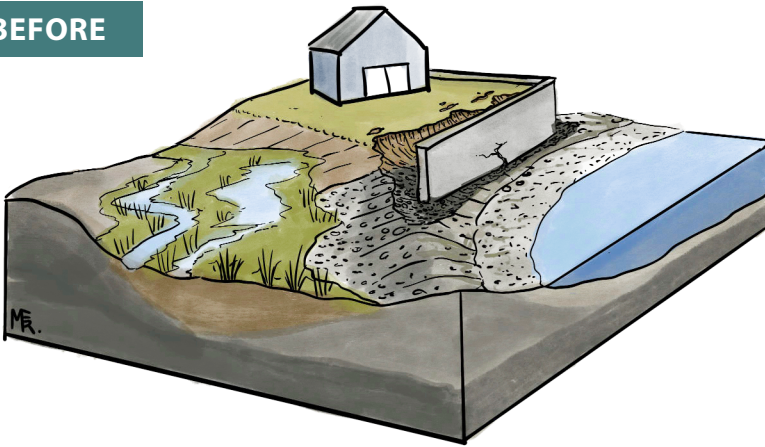
SHORELINE STABILIZATION SCENARIO

Cobble Dunes

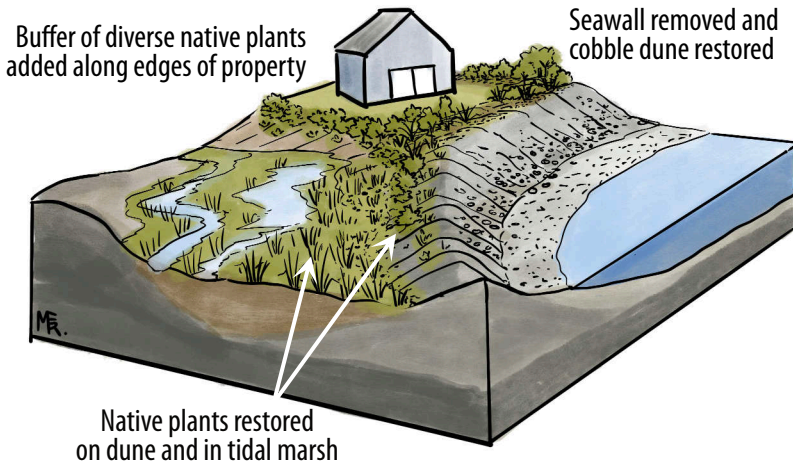
Cobble dunes are relatively common in Maine, especially in the midcoast and downeast regions. Like sand dunes, cobble dunes are frequently moved and reshaped by ocean waves, posing challenges for property owners.

In the “before” image of this scenario, an old seawall is cracked and crumbling after years of battering by storm waves and wave-flung cobbles. The seawall has worsened erosion by concentrating the energy of waves. Now the cobble beach in front of the wall and the lawn behind it are eroding. The “after” image shows changes implemented to stabilize the shoreline.

BEFORE



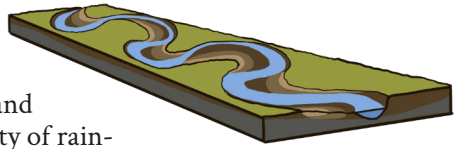
AFTER



SHORELINE STABILIZATION SCENARIO

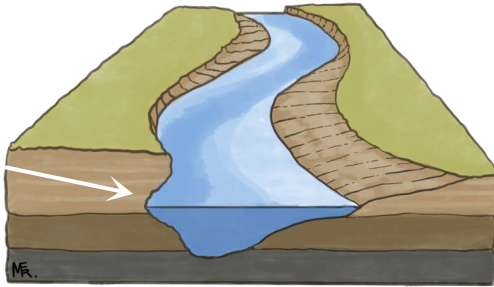
River / Stream

While it is normal for rivers and streams to erode their banks and shift their route over time (see illustration, right), this erosion sometimes imperils houses, roads, and other infrastructure. The increasing intensity of rainstorms in recent years has elevated those risks. Erosion processes in rivers and streams are similar even though they are different sizes. Property owners seeking to stabilize the bank of a river or stream have a range of options. The “before” image of this scenario shows a cross-section of a river. Visible on the left side is undercutting of the bank, which indicates erosion that could cause the bank to collapse. The “after” images show two different ways of using OUR SHORE options to stabilize the bank.



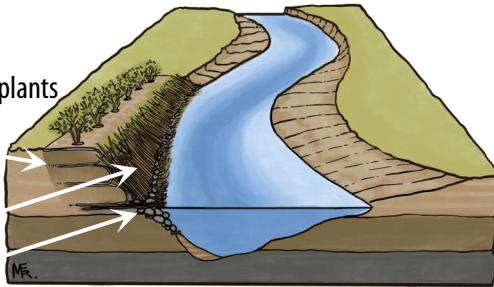
BEFORE

Undercutting of bank indicates erosion



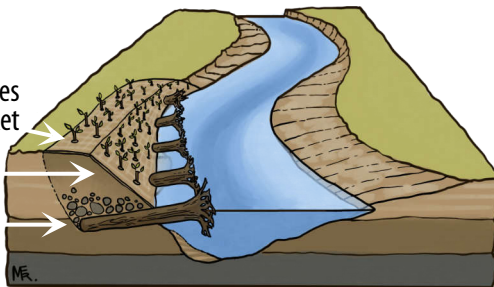
AFTER (Version 1)

Buffer of deep-rooted native plants
Regraded bank built with encapsulated soil
Brush mattresses installed on regraded bank
Rooted riprap



AFTER (Version 2)

Live stakes planted in holes through erosion control blanket
Regraded bank
Tree rootwad deflectors partially buried in bank

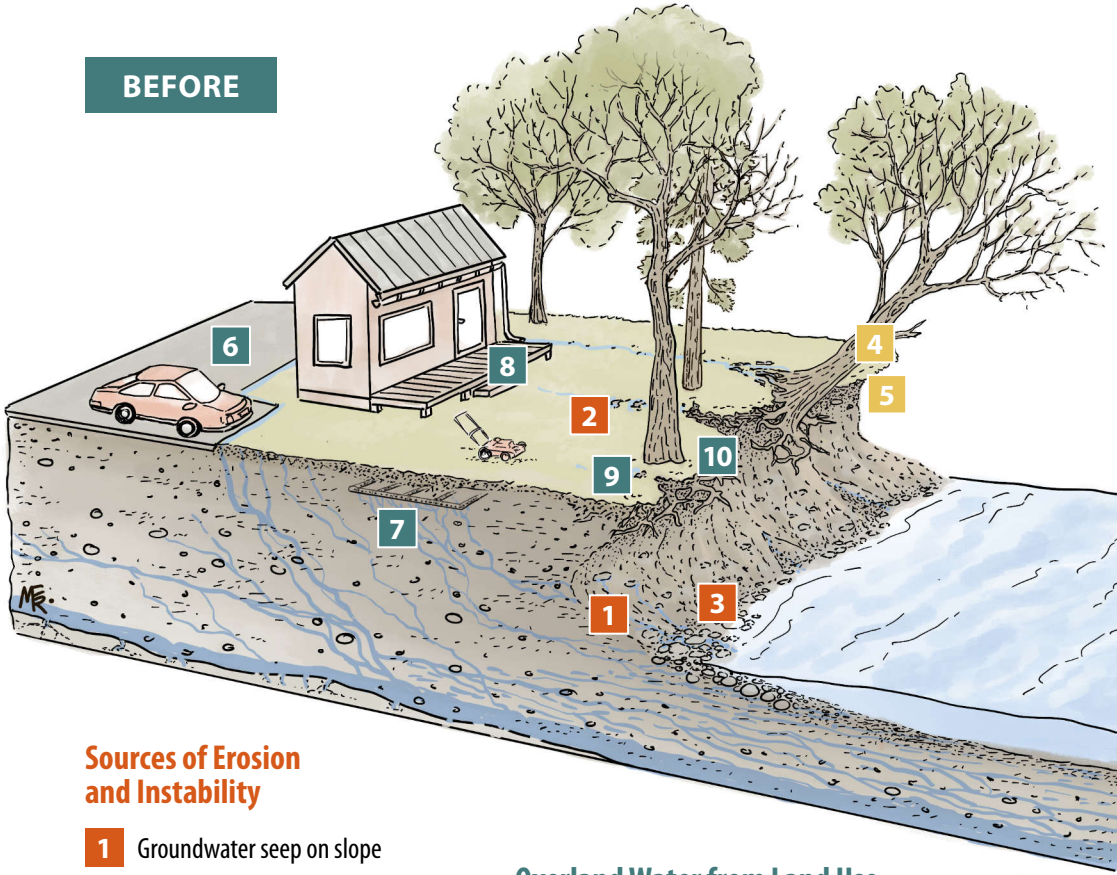


SHORELINE STABILIZATION SCENARIO

Lake

Maine has more than 6,000 lakes and ponds. The drawings in this scenario show a property with characteristics that are typical of lakefront land in the state. The numbered labels on the “before” image indicate features that contribute to shoreline erosion and instability.

BEFORE



Sources of Erosion and Instability

- 1 Groundwater seep on slope
- 2 Overland erosion
- 3 Toe erosion: slumping and bare soils

Height and Slope Risks

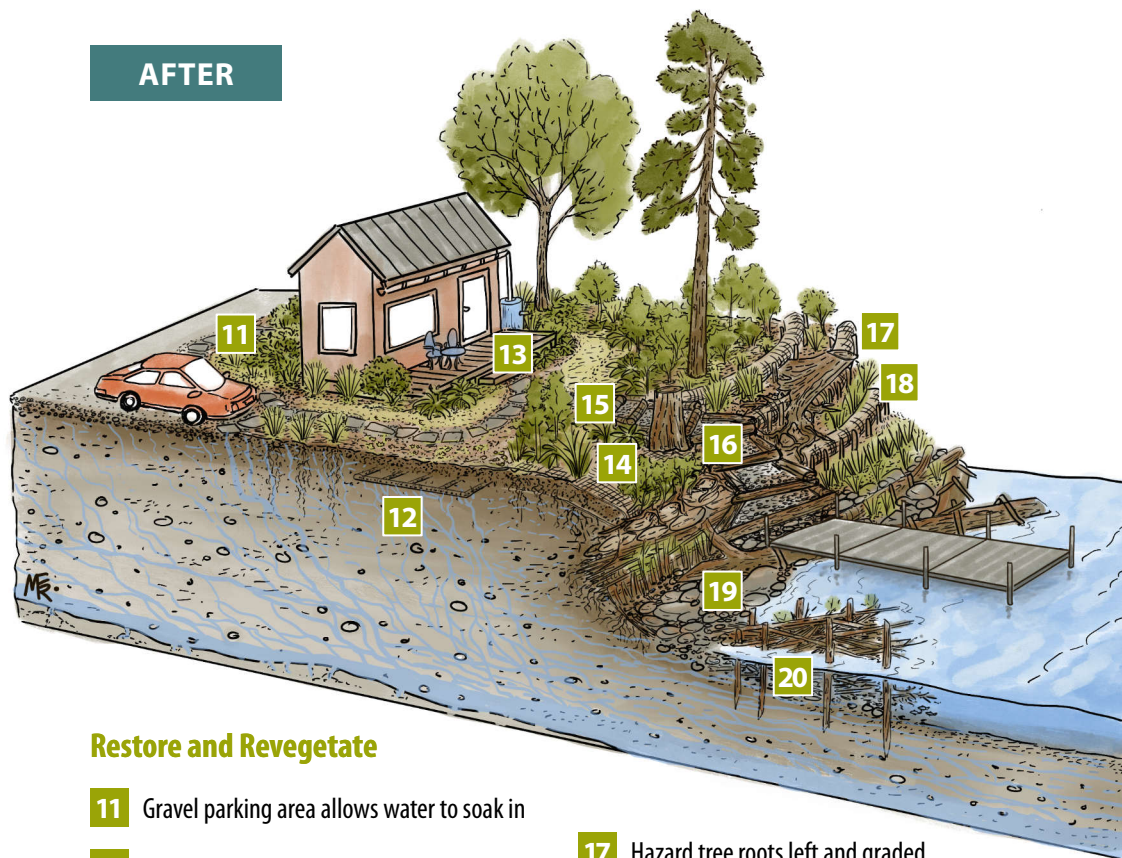
- 4 Hazard tree
- 5 Moderate height with slope over 1:1

Overland Water from Land Use

- 6 Paved parking area causes runoff of water
- 7 Excess water from malfunctioning septic system
- 8 Gutter and downspout creating channelized flow
- 9 Lawn extends to edge of bank
- 10 Unstable access path to shoreline

The “after” image shows one concept of what the property could look like shortly after implementation of OUR SHORE options. The numbered labels indicate changes that were made to address the erosion and instability issues shown in the “before” image. Over time, the plants will grow in, and flowers will bloom. The image on the front cover of the OUR SHORE Reference Guide shows what this property might look like a few years later. Various other combinations of OUR SHORE options could have been used based on the property owner’s preferences, budget, and other factors.

AFTER



Restore and Revegetate

- 11** Gravel parking area allows water to soak in
- 12** Repaired septic system releases less water
- 13** Rain barrel collects water from gutters
- 14** Less lawn area with buffer of native plants
- 15** Greater density and variety of plants
- 16** Redesigned path reduces downhill flow
- 17** Hazard tree roots left and graded around with varying slopes
- 18** Regraded slope; log sills and other materials added to interrupt slope
- 19** Toe stabilized with anchored logs and stones
- 20** Anchored woody materials absorb wave energy and create habitat

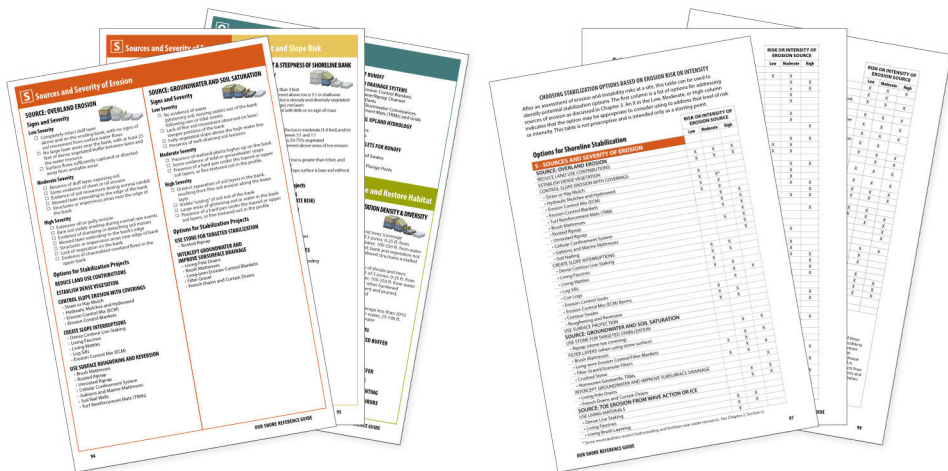
APPENDIX B: SITE ASSESSMENT CHECKLIST

The OUR SHORE Site Assessment Checklist is intended to be used in the initial steps of planning a shoreline stabilization project. It facilitates the application of the OUR SHORE approach to sites in Maine, including lakes and ponds, rivers and streams, coastal bluffs, and coastal dunes (sand and cobble).

The Site Assessment Checklist summarizes key information from Sections S, H, O, and R in Chapter 3 of the OUR SHORE Reference Guide. For each section, there is a checklist of visible signs that indicate the severity of erosion and instability. After each checklist is a list of stabilization options that may be appropriate to consider to address the observed signs and severity. The list is not prescriptive. It is intended only as a menu to help identify relevant options. For details about the options, refer to the corresponding sections of the Guide.

On the final pages of Appendix B is a table showing whether the options may be appropriate for low, moderate, or high levels of risk or intensity.

The completed Site Assessment Checklist and information from the OUR SHORE Guide can be used to explore potential ways to address erosion and instability at a property. While many options can be implemented by homeowners, it is important to consult a professional shoreline stabilization practitioner or a Maine-licensed professional engineer where there is significant risk to life or structures.



Disclaimer: The various materials and appropriateness of using them on a site are discussed in the OUR SHORE Reference Guide as suggested applications. The actual effectiveness of a material to achieve erosion reduction will vary site by site. The purpose of the Site Assessment Checklist is to provide a starting point only; it is expected that those designing and implementing a project will use their expertise in choosing which stabilization options to use in combination or independently for the desired outcomes.

SOURCE: OVERLAND EROSION

Signs and Severity

Low Severity

- ☐ Completely intact duff layer above and on the eroding bank, with no signs of soil movement from surface water flows
- ☐ No large lawn areas near the bank, with at least 25 feet of dense vegetated buffer between lawn and the water resource
- ☐ Surface flows sufficiently captured or diverted away from unstable areas

Moderate Severity

- ☐ Absence of duff layer, exposing soil
- ☐ Some evidence of sheet or rill erosion
- ☐ Evidence of soil movement during normal rainfall
- ☐ Mowed lawn extending to the edge of the bank
- ☐ Structures or impervious areas near the edge of the bank

High Severity

- ☐ Extensive rill or gully erosion
- ☐ Bare soil visibly eroding during normal rain events
- ☐ Evidence of slumping or detaching soil masses
- ☐ Mowed lawn extending to the bank's edge
- ☐ Structures or impervious areas near edge of bank
- ☐ Lack of vegetation on the bank
- ☐ Evidence of channelized overland flows in the upper bank

Options for Stabilization Projects

REDUCE LAND USE CONTRIBUTIONS

ESTABLISH DENSE VEGETATION

CONTROL SLOPE EROSION WITH COVERINGS

- Straw or Hay Mulch
- Hydraulic Mulches and Hydroseed
- Erosion Control Mix (ECM)
- Erosion Control Blankets

CREATE SLOPE INTERRUPTIONS

- Dense Contour Live Staking
- Living Fascines
- Living Wattles
- Log Sills
- Erosion Control Mix (ECM)

USE SURFACE ROUGHENING AND REVERSION

- Brush Mattresses
- Rooted Riprap
- Unrooted Riprap
- Cellular Confinement System
- Gabions and Marine Mattresses
- Soil Nailing
- Turf Reinforcement Mats (TRMs)



SOURCE: GROUNDWATER AND SOIL SATURATION

Signs and Severity

Low Severity

- ☐ No evidence of water (glistening soil, moving water) out of the bank following rain or tidal events
- ☐ Lack of fine soil movement observed on bare/ steeper portions of the bank
- ☐ Fully vegetated slope above the high-water line
- ☐ Presence of well-draining soil textures

Moderate Severity

- ☐ Presence of wetland plants higher up on the bank
- ☐ Some evidence of tidal or groundwater seeps
- ☐ Presence of a hard pan under the topsoil or upper soil layers, or fine textured soil in the profile

High Severity

- ☐ Distinct separation of soil layers in the bank, resulting from fine soil erosion along the lower layer
- ☐ Visible "oozing" of soil out of the bank
- ☐ Large areas of glistening soil or water in the bank
- ☐ Presence of a hard pan under the topsoil or upper soil layers, or fine textured soil in the profile

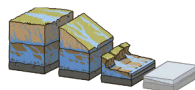
Options for Stabilization Projects

USE STONE FOR TARGETED STABILIZATION

- Rooted Riprap

INTERCEPT GROUNDWATER AND IMPROVE SUBSURFACE DRAINAGE

- Living Pole Drains
- Brush Mattresses
- Long-Term Erosion Control Blankets
- Filter Gravel
- French Drains and Curtain Drains



S Sources and Severity of Erosion

SOURCE: TOE EROSION FROM WAVE ACTION OR ICE

Signs and Severity



Low Severity

- ☐ Site is mostly sheltered from waves and scour
- ☐ Little to no exposed soil at or just above the normal high-water line
- ☐ Vegetation or fine sediment along water's edge
- ☐ Little sign of undercutting or slumping of unsupported soil at base of bank

Moderate Severity

- ☐ Site receives some regular wave action or flows, but only large storms cause visible erosion at the base of the bank
- ☐ Undercut base of the bank, but soil above holding due to healthy vegetation and soil structure
- ☐ Erosion at toe, but not elsewhere on slope
- ☐ Only stones along water's edge, no fine sediments

High Severity

- ☐ Site is regularly exposed to high-energy wave action or ice pushing
- ☐ Wave or ice action severely eroding the toe or undercutting the slope
- ☐ Slumping caused by toe loss from undercutting and wave erosion beyond toe
- ☐ Entire slope over-steepened due to toe erosion and slumping of the overburden soil

Options for Stabilization Projects

USE LIVING MATERIALS

- Dense Live Staking
- Living Fascines
- Living Brush Layering

USE DEAD WOOD AND TREE MATERIALS

- Log Sill
- Tree Root Wads
- Living Toe Crib
- Manufactured Log Jam (Freshwater Only)
- Log Skids

USE STONE

- Stone-packed Undercut
- Cobble Toe
- Rooted Riprap

USE BIODEGRADABLE MANUFACTURED PRODUCTS

- Coir (Coconut Fiber) Logs
- Biodegradable Erosion Control Socks
- Encapsulated Soil Toe Protection

USE IN-WATER AND FLOW ATTENUATION TOOLS

- Root Wad Deflectors
- Restored Fringe Wetland and Marshes
- Chop and Drop
- Veins, Weirs, and Groins
- Manufactured Reefs and Wave Attenuation Devices
- Sand-catching Woody Materials

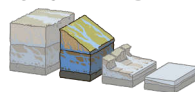
USE NON-BIODEGRADABLE MATERIALS

- Green Gabions

H Height and Slope Risk

SOURCE: HEIGHT & STEEPNESS OF SHORELINE BANK

Signs and Severity



Low Severity

- ☐ Bank height less than 3 feet and/or embankment above toe is 3:1 or shallower
- ☐ Slope above the toe is densely and diversely vegetated (80-100% coverage), not lawn
- ☐ Well-structured soil with little or no sign of mass movement

Moderate Severity

- ☐ Bank height above the toe is moderate (3-6 feet) and/or embankment is between 3:1 and 1:1
- ☐ Slope above the toe is 50-75% vegetated
- ☐ Observable soil movement above areas of toe erosion

High Severity

- ☐ Bank height above the toe is greater than 6 feet, and slope is greater than 1:1
- ☐ More than 50% of the slope surface is bare soil without vegetation or duff

Options for Stabilization Projects

USE MINIMAL INTERVENTION

(SITES WITH LOW OR MODERATE RISK)

ADD STRUCTURAL STABILIZATION

- Pilings / Vertical Slope Support
- Encapsulated Soil Lifts
- Living Crib Walls
- Soil Nailing
- Green Gabion Walls and Mattresses
- Riprap Slope Coverings

REGRADE OVER-STEEPENED SLOPES

- Surface Roughening
- Cutting Back Slope with Smooth Grading
- Benching and Terracing
- Contour Swales
- Pit-and-Mound Grading

SOURCE: FEATURES OF LAND USE

Signs and Severity

Low Severity

- ☐ No concentrated water flows toward the bank from developed areas
- ☐ No lawns or bare ground within 100 feet of bank
- ☐ No roads, driveways, houses, or impervious surfaces within 100 feet of bank
- ☐ Surface flows from nearby developed areas are well managed with conservation practices such as rain gardens

Moderate Severity

- ☐ Some concentrated or channelized water is directed toward the bank
- ☐ No lawns or bare ground within 25 feet of bank
- ☐ No roads, driveways, houses, or impervious surfaces within 25 feet of bank
- ☐ A moderate amount of surface water moves toward the bank

High Severity

- ☐ Concentrated flows are directed at the embankment or shoreline access pathways
- ☐ Lawn area is present within 25 feet of the bank
- ☐ Roads, driveways, houses, or impervious surfaces within 25 feet of the bank

Options for Stabilization Projects

PROPERLY DESIGN AND MAINTAIN LAWNS AND GARDENS

- ☐ Limit mowing frequency near the shore (every two weeks is ideal) and set the mower height to the highest setting (at least 3 inches)
- ☐ Maintain lawn cover through grub control and prolific overseeding, especially when an opening is created by insect damage or weed control
- ☐ Refrain from raking or removing organic duff or vegetation, especially duff in areas near shoreline
- ☐ Be cautious with leaves and lawn clippings as mulch; if layered too thickly, these materials can smother growing plants
- ☐ Plant a variety of native trees, shrubs, perennials, and groundcovers (at least 70% is recommended)
- ☐ Don't treat the shoreline like a managed garden
- ☐ Cover bare soils with Erosion Control Mix (ECM)
- ☐ Minimize or reduce the lawn area and the manicured areas near the bank

PROPERLY DESIGN ACCESSWAYS AND PATHWAYS

- ☐ Make paths no more than 3-4 feet wide
- ☐ Design paths that meander, rather than straight paths that allow water to flow easily downhill
- ☐ Enable runoff to disperse from path into plants
- ☐ Define and stabilize walking surfaces with 3-4" of material such as Erosion Control Mix, pine needles, bark mulch, crushed stone, or wood chips
- ☐ Focus access on more stable areas of the shoreline
- ☐ Use infiltration steps in steeper areas
- ☐ Don't store docks or recreation equipment on the shoreline or bank, as it disturbs vegetation growth

REDUCE WATER FLOW FROM DRIVEWAYS, PATIOS, AND OTHER IMPERVIOUS SURFACES



MANAGE ROOF RUNOFF

MAINTAIN SEPTIC SYSTEMS & OTHER SOURCES OF SURFACE OR GROUNDWATER

BUILD UPLAND DRAINAGE SYSTEMS

- Temporary Erosion Control Blankets
- Vegetated Stone/Riprap Channel
- Living Check Dams
- Regenerative Stormwater Conveyances
- Turf Reinforcement Mats (TRMs) and Grids

SUPPORT NATURAL UPLAND HYDROLOGY

- Hummocks
- Vegetated Buffers
- Rock Sandwiches

CREATE STABLE OUTLETS FOR RUNOFF

- Rain Gardens
- Level Spreaders and Swales
- Ditch Turnouts
- Settling Basins and Plunge Pools

R Revegetate and Restore Habitat

SOURCE: LACK OF VEGETATION DENSITY & DIVERSITY

Signs and Severity

Low Severity

- ☐ Dense mix of shrubs and trees (coverage at least 70%) in each of 3 zones: 0-25 ft. from water; 25-100 ft. from water; 100-250 ft. from water
- ☐ Natural shoreline habitat; bank and vegetation not altered; no riprap or hardened structures installed

Moderate Severity

- ☐ At least moderate density of shrubs and trees (coverage 20-70%) in each of 3 zones: 0-25 ft. from water; 25-100 ft. from water; 100-250 ft. from water
- ☐ Bank impaired by riprap or other hardened structures; vegetation present and pruned, mowed, or otherwise altered

High Severity

- ☐ Sparse shrubs and trees (coverage less than 20%) in any of 3 zones: 0-25 ft. from water; 25-100 ft. from water; 100-250 ft. from water

Options for Stabilization Projects

ENSURE A DENSE, DIVERSE VEGETATED LANDSCAPE TO THE SHORELINE

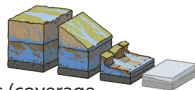
MAINTAIN PLANTED NATIVE VEGETATION

LIVE STAKE WITH DORMANT TREES AND SHRUBS

REMOVE INVASIVE PLANTS

MINIMIZE SOIL DISTURBANCE WHEN PLANTING

PRESERVE AND PROMOTE SHORELINE HABITAT



CHOOSING STABILIZATION OPTIONS BASED ON EROSION RISK OR INTENSITY

After an assessment of erosion and instability risks at a site, this table can be used to identify potential stabilization options. The first column is a list of options for addressing sources of erosion as discussed in Chapter 3. An X in the Low, Moderate, or High column indicates that the option may be appropriate to consider using to address that level of risk or intensity. This table is not prescriptive and is intended only as a starting point.

Options for Shoreline Stabilization	RISK OR INTENSITY OF EROSION SOURCE		
	Low	Moderate	High
S - SOURCES AND SEVERITY OF EROSION			
SOURCE: OVERLAND EROSION			
REDUCE LAND USE CONTRIBUTIONS	X	X	X
ESTABLISH DENSE VEGETATION	X	X	X
CONTROL SLOPE EROSION WITH COVERINGS			
• Straw or Hay Mulch	X		
• Hydraulic Mulches and Hydroseed	X	X*	
• Erosion Control Mix (ECM)	X	X	
• Erosion Control Blankets	X	X	
• Turf Reinforcement Mats (TRM)		X	X
• Brush Mattresses		X	X
• Rooted Riprap		X	X
• Unrooted Riprap			X
• Cellular Confinement System		X	X
• Gabions and Marine Mattresses			X
• Soil Nailing			X
CREATE SLOPE INTERRUPTIONS			
• Dense Contour Live Staking	X	X	
• Living Fascines	X	X	
• Living Wattles	X		
• Log Sills	X	X	
• Coir Logs		X	X
• Erosion Control Socks		X	
• Erosion Control Mix (ECM) Berms	X		
• Contour Swales	X	X	
• Roughening and Reversion	X	X	
USE SURFACE PROTECTION			
SOURCE: GROUNDWATER AND SOIL SATURATION			
USE STONE FOR TARGETED STABILIZATION			
• Riprap (stone toe covering)		X	X
FILTER LAYERS (when using stone surface)			
• Brush Mattresses		X	X
• Long-Term Erosion Control/Filter Blankets	X	X	
• Filter Gravel/Granular Filters		X	X
• Crushed Stone	X	X	
• Nonwoven Geotextile, TRMs			X
INTERCEPT GROUNDWATER AND IMPROVE SUBSURFACE DRAINAGE			
• Living Pole Drains		X	X
• French Drains and Curtain Drains		X	X
SOURCE: TOE EROSION FROM WAVE ACTION OR ICE			
USE LIVING MATERIALS			
• Dense Live Staking	X	X	
• Living Fascines	X	X	
• Living Brush Layering	X		

* Some municipalities restrict hydroseeding and fertilizer near water resources. See Chapter 2, Section U.

Options for Shoreline Stabilization (Continued)	RISK OR INTENSITY OF EROSION SOURCE		
	Low	Moderate	High
USE DEAD WOOD AND TREE MATERIALS			
• Log Sill	X	X	
• Tree Root Wads		X	X
• Living Toe Crib		x	X
• Manufactured Log Jam (Freshwater Only)		X	
• Log Skids		X	
USE STONE			
• Stone-packed Undercut		X	
• Cobble Toe		X	
• Riprap Toe (or Brush layering under riprap toe)			X
USE BIODEGRADABLE MANUFACTURED PRODUCTS			
• Coir (Coconut Fiber) Logs		X	X
• Biodegradable Erosion Control Socks	X	X	
• Encapsulated Soil Toe Protection	X	X	
USE IN-WATER AND FLOW ATTENUATION TOOLS			
• Root Wad Deflectors		X	X
• Restored Fringe Wetland and Marshes	X	X	
• Chop and Drop	X	X	
• Veins, Weirs, and Groins		X	X
• Manufactured Reefs and Wave Attenuation Devices			X
• Sand-catching Woody Materials		X	X
USE NON-BIODEGRADABLE MATERIALS			
• Green Gabions			X
H - HEIGHT AND SLOPE RISK			
SOURCE: HEIGHT AND STEEPNESS OF SHORELINE BANK			
USE MINIMAL INTERVENTION (SITES WITH LOW OR MODERATE RISK)	X	X	
ADD STRUCTURAL STABILIZATION			
• Pilings / Vertical Slope Support		X	
• Encapsulated Soil Lifts	X	X	
• Living Crib Walls		X	X
• Soil Nailing			X
• Green Gabion Walls and Mattresses			X
• Riprap Slope Coverings		X	X
REGRADE OVER-STEEPENED SLOPES			
• Surface Roughening	X		
• Cutting Back Slope with Smooth Grading		X	X
• Benching and Terracing		X	X
• Contour Swales	X	X	
• Pit-and-Mound Grading	X	X	
• Overland Water Interventions	X	X	X
O - OVERLAND WATER			
SOURCE: FEATURES OF LAND USE			
PROPERLY DESIGN AND MAINTAIN LAWNS AND GARDENS			
• Limit mowing frequency near the shore (every two weeks is ideal) and set the mower height to the highest setting (at least 3 inches)	X	X	X
• Maintain healthy lawn cover through allowing deep root depth and overseeding bare or thin spots	X	X	X
• Refrain from raking or removing organic duff or vegetation, especially duff in areas near shoreline	X	X	X
• Be cautious with leaves and lawn clippings as mulch; if layered too thickly, these materials can smother growing plants	X	X	X
• Plant a variety of native trees, shrubs, perennials, and groundcovers (at least 70% is recommended)	X	X	X

Options for Shoreline Stabilization (Continued)	RISK OR INTENSITY OF EROSION SOURCE		
	Low	Moderate	High
• Don't treat the shoreline like a managed garden	X	X	X
• Cover bare soils with Erosion Control Mix (ECM)	X	X	
• Minimize or reduce the lawn area and the manicured areas near bank	X	X	X
PROPERLY DESIGN ACCESSWAYS AND PATHWAYS			
• Make paths no more than 3-4 feet wide	X	X	X
• Design paths that meander, rather than straight paths that allow water to flow easily downhill	X	X	X
• Enable runoff to disperse from path into plants	X	X	X
• Define and stabilize walking surfaces with 3-4" of material such as Erosion Control Mix, pine needles, bark mulch, crushed stone, or wood chips	X	X	
• Focus access on more stable areas of the shoreline	X	X	X
• Use infiltration steps in steeper areas		X	X
• Don't store docks or recreation equipment on the shoreline or bank, as it disturbs vegetation growth	X	X	X
REDUCE WATER FLOW FROM DRIVEWAYS, PATIOS, AND OTHER IMPERVIOUS SURFACES	X	X	X
MAINTAIN SEPTIC SYSTEMS & OTHER SOURCES OF SURFACE OR GROUNDWATER	X	X	X
MANAGE ROOF RUNOFF	X	X	X
BUILD UPLAND SURFACE WATER SYSTEMS			
• Temporary Erosion Control Blankets	X	X	
• Vegetated Stone/Riprap Channel	X	X	X
• Living Check Dams		X	X
• Regenerative Stormwater Conveyances			X
• Turf Reinforcement Mats (TRMs) and Grids			X
SUPPORT NATURAL UPLAND HYDROLOGY			
• Hummocks		X	X
• Vegetated Buffers	X	X	
• Rock Sandwiches	X	X	
CREATE STABLE OUTLETS FOR RUNOFF			
• Rain Gardens	X	X	
• Level Spreaders and Swales		X	X
• Ditch Turnouts		X	X
• Settling Basins and Plunge Pools	X	X	X
R – REVEGETATE AND RESTORE HABITAT			
SOURCE: LACK OF VEGETATION DENSITY AND DIVERSITY			
ENSURE A DENSE, DIVERSE VEGETATED LANDSCAPE TO THE SHORELINE	Use as many of these practices as possible to vegetate and restore shoreline habitat. Inclusion of additional practices can aid in minimizing impacts from stabilization projects and speed up naturalization.		
MAINTAIN PLANTED NATIVE VEGETATION			
LIVE STAKE WITH DORMANT TREES AND SHRUBS			
REMOVE INVASIVE PLANTS			
MINIMIZE SOIL DISTURBANCE WHEN PLANTING			
PRESERVE AND PROMOTE SHORELINE HABITAT			
• Terrestrial and Aquatic Shade			
• Cover Diversity			
• Natural Vegetation Diversity			
• Woody Material Inputs			
• Wildlife Travel Corridors			
• Soil Health and Subsurface Habitat			
• Natural Sediment Transfer			
• Species-Specific Needs and Habitat Considerations			

GLOSSARY

This glossary provides general definitions to support understanding of the OUR SHORE Reference Guide. These are not regulatory definitions.

basal ends. The cut end of a live stake, pole, or branch that was closest to the roots of the original plant.

beach. A naturally formed area of sand, gravel, or cobble along the edge of a lake, river, or ocean shaped by waves and sediment movement.

bedrock. Solid rock underlying soil or loose materials.

benching. A slope modification technique that creates small, stepped areas or terraces across a slope to slow runoff, improve infiltration, and provide planting areas.

berm. A raised mound or ridge of soil, erosion control mix, or other material used to slow water, redirect flow, or provide added stability along a slope or shoreline.

bioengineering techniques. Stabilization methods that combine vegetation with natural or structural materials to control erosion and strengthen slopes.

biotic soil media. A hydraulically applied soil amendment that may include mulch, seed, tackifier, and soil microbes.

bluffs. Steep shoreline slopes, often found along the coast, that rise above a waterbody. May be composed of sand, clay, or glacial soils.

carbon sequestration. The process by which plants absorb and store carbon dioxide from the atmosphere in their tissues and in the soil.

channelized water. Water that has become concentrated into a defined path, ditch, or channel rather than flowing as dispersed sheet flow.

dune. A mound or ridge of sand or cobble typically found along coastal beaches.

ecological benefit. A positive effect on habitat, water quality, soil health, wildlife, or natural processes.

ecotype plant. A plant grown from seed or cuttings collected in the same geographic region where it will be planted.

eelgrass. A submerged marine plant that grows in shallow coastal waters. Eelgrass meadows provide habitat for fish and shellfish, stabilize sediments, and help dissipate wave energy.

geotextiles. Synthetic fabric materials used beneath stone or soil to provide separation or filtration in stabilization projects.

groin. A structure built outward from a shoreline into a waterbody to interrupt sediment movement and reduce erosion.

groundwater. Water that moves below the land surface through soil and gaps in rock.

groundwater seep. A location where groundwater slowly emerges at the surface of a slope or shoreline.

hard pan soil. A dense, compacted, or naturally cemented soil layer that restricts water infiltration and root growth.

headcutting. An erosive process where a small channel or gully erodes backward and upslope, extending its length over time.

herbaceous plants. Non-woody plants such as grasses, sedges, and wildflowers that die back to the ground each year.

hydroseeding. A planting method in which seed, mulch, water, and sometimes tackifier are sprayed onto soil using specialized equipment.

hummocks. Small raised mounds of soil that create uneven ground, which slows surface water and allows increased infiltration.

impervious surface. A surface that does not allow water to infiltrate into the ground, such as pavement, roofs, and compacted soil. *See also* pervious surface.

infiltration steps. Small step-like features built into a slope or pathway to slow water and encourage it to soak into the soil.

infiltration swales. Shallow, vegetated channels designed to capture and infiltrate stormwater runoff.

ledge. Exposed or shallow bedrock at or near the ground surface.

living fencing. A barrier made from live stakes, poles, or shrubs that root and grow over time.

macroinvertebrates. Aquatic animals without backbones that are large enough to see without magnification, such as insects, snails, and crustaceans.

microplastics. Very small plastic particles that result from the breakdown of larger plastic materials.

naturalization. The process of restoring a shoreline or landscape so it functions more like a natural system over time.

on contour. Aligned exactly horizontally on a slope, following the natural curve of the land at a single, consistent elevation.

overland flow. Water that moves across the surface of the land during rain or snowmelt rather than soaking into the soil. Also called stormwater runoff.

permeable pavers. Paving materials designed to allow water to pass through gaps or porous surfaces into the underlying soil.

pervious surface. A surface that allows water to infiltrate into the ground. *See also* impervious surface.

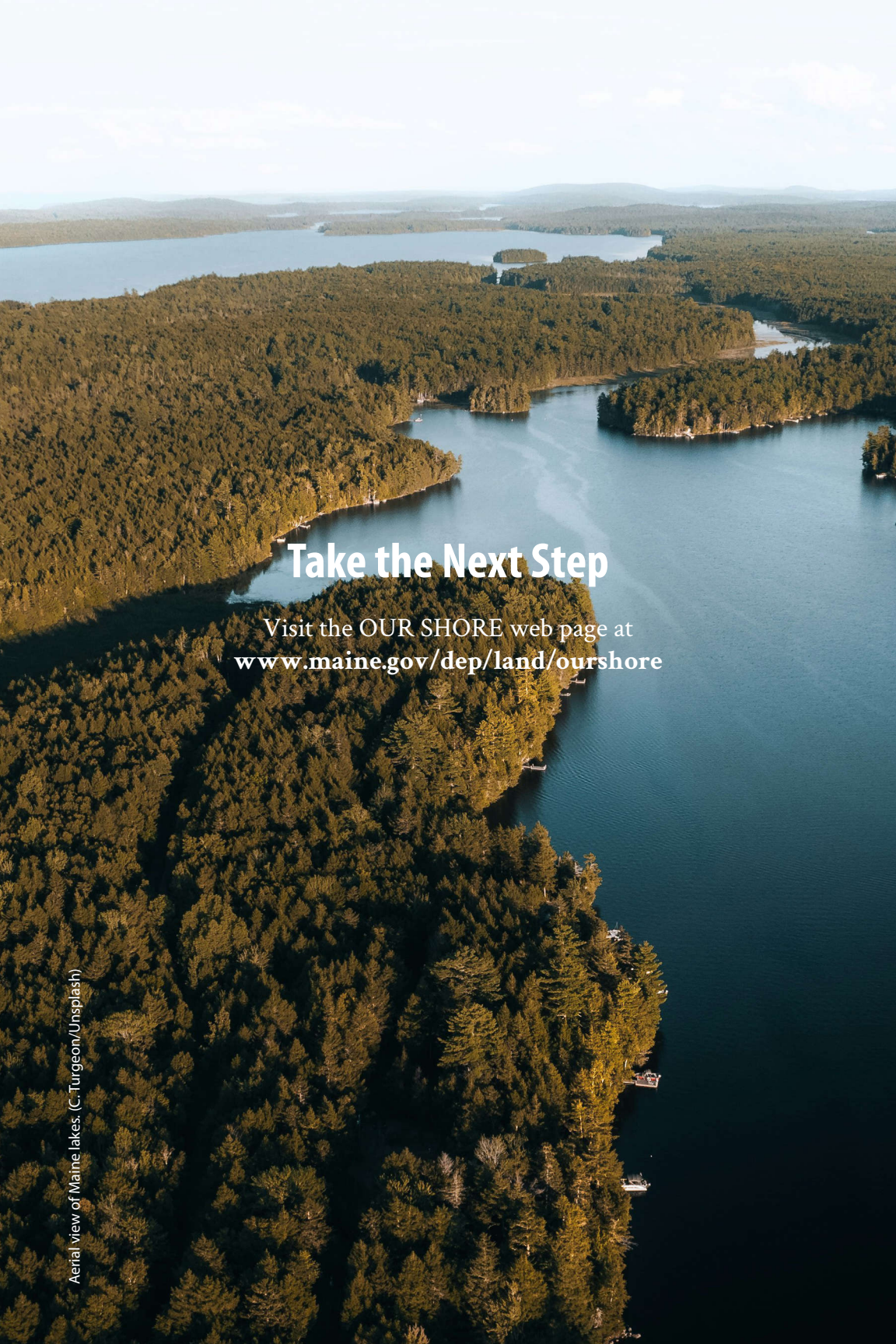
resilience. The ability of a shoreline or ecosystem to absorb disturbance, adjust to changing conditions, and recover while maintaining its basic functions.

riparian. Relating to the land area next to a river, stream, lake, or other waterbody. Riparian areas play important roles in stabilizing shorelines and protecting water quality.

sediment transport patterns. The natural movement of soil and sand along a shoreline or within a waterbody due to waves, currents, runoff, and wind.

settling basin. A constructed depression or basin designed to slow water and allow sediment to settle before runoff enters a waterbody.

shoreland zone. The land area adjacent to waterbodies that is regulated under Maine's Shoreland Zoning Act.

An aerial photograph of a large, winding lake in Maine. The lake is surrounded by dense, green forest. Several small islands and peninsulas are visible, some with small buildings or docks. The water is a deep blue, and the sky is a pale blue with some light clouds. The overall scene is peaceful and scenic.

Take the Next Step

Visit the OUR SHORE web page at
www.maine.gov/dep/land/ourshore

DEFINE GOALS

- O** Observe and Blend the Project with Undeveloped Shorelines Nearby
- U** Use Materials That Are Native, Natural, Living, and Biodegradable
- R** Reach Conditions That Function as a Naturalized Shoreline Over Time

ASSESS & IMPLEMENT

- S** Sources of Erosion and Instability
- H** Height and Slope Risks
- O** Overland Water from Land Use
- R** Restore and Revegetate Habitat
- E** Evaluate and Enhance

