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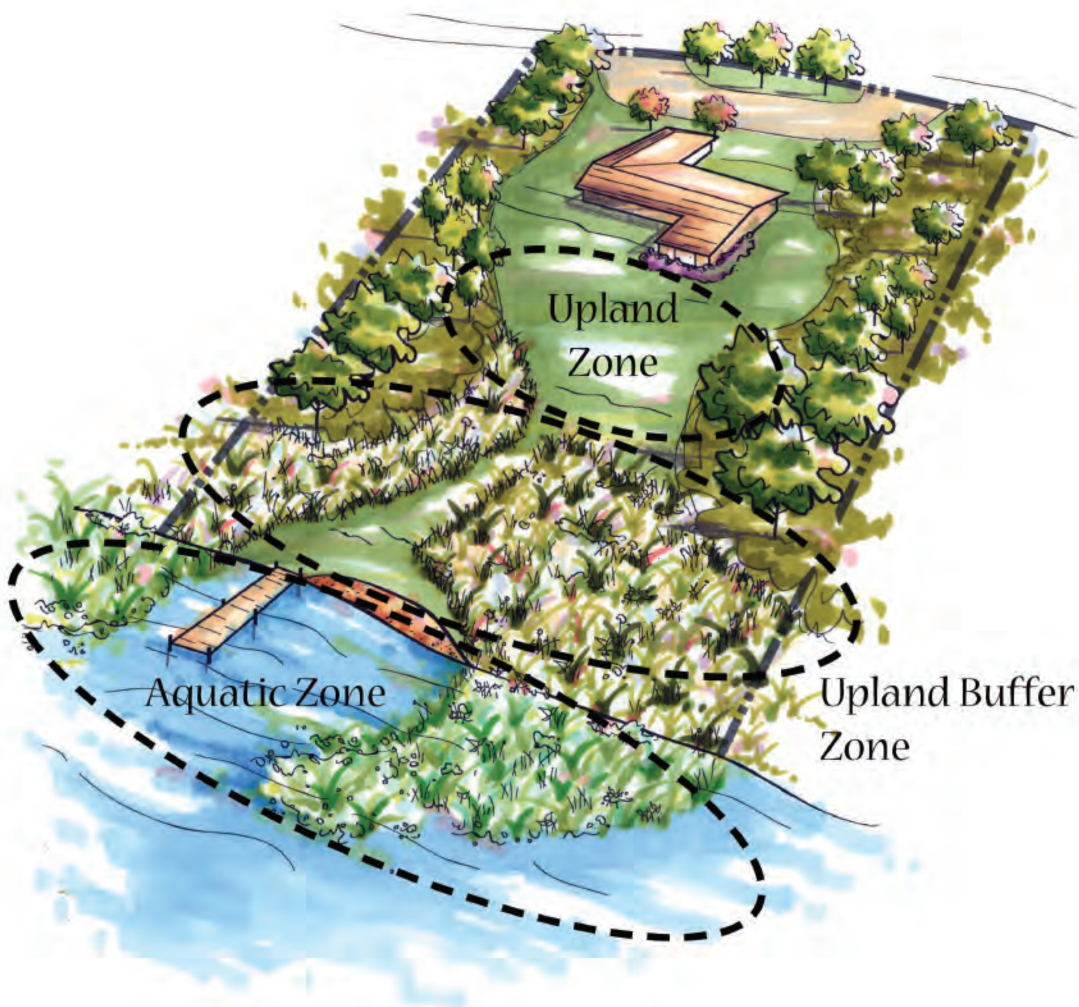
MICHIGAN NATURAL SHORELINE PARTNERSHIP

Promoting Natural Shoreline Landscaping to Protect Michigan's Inland Lakes

Natural Shoreline Landscapes on Michigan's Inland Lakes

Guidebook for Property Owners



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Natural Shoreline Landscapes on Michigan's Inland Lakes

Guidebook for Property Owners

First edition (2011)

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Introduction

A Message from the Michigan Natural Shoreline Partnership

With the state's abundance of inland lakes, waterfront property is important to both residents, the health of the lakes and the wildlife they support. The shoreline and shallow water areas of a lake provide essential habitat for many fish and wildlife species.

Overdeveloped shorelines cannot support the fish, wildlife and clean water that attract Michigan property owners to the waterfront. High-impact lakefront landscaping, with lawn to the water's edge, creates problems for the lake ecosystem and waterfront owners. Rainwater carries lawn fertilizer, pet waste, leaves and grass clippings into the lake, which can promote algal growth and the seasonal blooms that cause "green water". Plants with shallow roots, including grass, allow the shoreline to erode easily. Perfectly manicured lawns attract nuisance wildlife species such as geese.

Alternative landscaping solutions can create attractive waterfronts that allow the use of the shoreline while mimicking the wild shoreline of an undeveloped lake. Research indicates that high-impact shoreline development can negatively affect lake ecosystems and destroy fish and wildlife habitat (Radomski and Goeman, 2001).

The Michigan Natural Shoreline Partnership (MNSP) was formed in 2008. The partnership's mission is to promote the use of natural landscaping and erosion control to protect Michigan's inland lakes. The partnership brings together technical expertise and organizational support to address informational, educational and policy needs related to natural shoreline development. It is a public/private partnership consisting of governmental agencies, industry associations, industry representatives, academic institutions, and environmental and nonprofit organizations actively engaged in promoting natural shoreline management.

Partnership Objectives:

- Train contractors and landscape professionals in shoreline technologies and bioengineered erosion control.
- Educate property owners about natural shorelines and technologies that benefit lake ecosystems.
- Research, demonstrate and develop natural shoreline technologies that benefit lake ecosystems.
- Encourage local and state policies that promote natural shoreline management.

MNSP Partnership Members

- JFNew, Inc.
- Mich. Assn. of Conservation Districts
- Mich. Chapter of the North American Lake Management Society
- Mich. Dept. of Natural Resources and Environment Fisheries Division
- Mich. Dept. of Natural Resources and Environment Water Resources Division
- Mich. Lake and Stream Assn.
- Native Plant Producers Assn.
- Mich. Nursery and Landscape Assn.
- Mich. Sea Grant College Program
- Mich. State University (MSU) Dept.of Horticulture
- MSU Institute of Ag Tech
- MSU Extension
- Tip of the Mitt Watershed Council
- Trident Dock and Dredge
- Fishbeck, Thompson, Carr and Huber

The Michigan Natural Shoreline Partnership (MNSP) is also pleased to be working with the Michigan Inland Lakes Partnership, an organization with which we share several goals as well as many public and private members.

Purpose of this Document

The Michigan Natural Shoreline Partnership recognizes the important role that lakefront property (riparian) owners serve in preserving the quality of Michigan's vast treasure of inland lakes. One of the goals of the partnership is to assist riparian property owners in making lake-friendly decisions about the management of their respective shorelines.

This publication was written to provide lakefront property owners with:

- A broad understanding of healthy inland lake ecosystems.
- An understanding of why natural shorelines are important for lakes.
- Ideas for creating an attractive, more natural shoreline.
- Ideas for soft-shoreline alternatives to hard-shoreline structures in low-energy conditions.
- A basic understanding of regulatory requirements affecting work done at the shoreline.

Chapter

1 Healthy Lake Ecosystems

This chapter will help you:

- Learn about the general health of Michigan's inland lakes.
- Learn about the biggest problem with the nation's lakes.
- Understand the various lake habitats.
- Understand the important functions that plants perform in keeping a lake healthy.

Michigan Inland Lakes Status

Michigan, Wisconsin and Minnesota are considered the lake-rich states within the lower 48 states. They are often referred to as the glacial lake states because their soils, water and land forms have been heavily influenced by glacial activity. From the air, the influence of the glaciers can be seen in the presence of the Great Lakes and thousands of smaller inland lakes. Michigan has approximately 11,000 inland lakes with a surface area of 5 acres or more, with nearly 3,500 lakes over 25 acres in size. Of these lakes, 730 are deemed public access lakes.

> Michigan has more than 11,000 inland lakes greater than 5 acres.

Starting in 1973, the Department of Natural Resources (DNR) began sampling lakes to document water quality, focusing on the 730 public access lakes. The DNR also used the data collected to classify the lakes by their trophic condition. A lake's trophic condition is simply a measure of the lake's biological productivity — a measure of how many plants and animals the lake can produce based on the nutrients in the water.

These monitoring efforts found that the lakes of the Upper Peninsula and the northern half of the Lower Peninsula support diverse aquatic communities and generally have good to excellent water quality. Many of these lakes support cold-water (trout and whitefish) fish populations. Lakes in the southern half of the Lower Peninsula generally have good water quality. These lakes generally have warm-water (bass and bluegill) fish communities with a few supporting cold-water fish.

The southern half of the Lower Peninsula is an area of major urban and suburban development as well as extensive agricultural lands. Urbanization and land development throughout the state have influenced sedimentation, nutrient enrichment, toxic pollutant and hydrologic loading to lakes. This has resulted in decreased water quality and biological habitat. Lake ecology is generally showing improvement where programs are in place to address these problems.

Some lakes in Michigan are unique for their quality and habitat. They are known as "cisco lakes" because they support cisco, a member of the trout and salmon family. These fish require very high water quality and are identi-

> Poor lakeshore habitat is the biggest problem in the nation's lakes
>
> *(Source: National Lake Assessment.)*

fied as a state threatened species. Michigan has about 150 lakes that may be cisco lakes. This species is very sensitive to habitat degradation and has disappeared from lakes that do not meet minimum temperature and oxygen conditions. The Michigan Department of Natural Resources (DNR) is studying the status of cisco populations in Michigan so that protective best management practices (BMPs) can be promoted.

Although Michigan's inland lakes generally have good to excellent water quality, some issues remain. The majority of Michigan's public access lakes have moderate or low nutrient levels, but nutrient levels are high enough in several lakes to warrant corrective action. Many lakes with moderate to high nutrient levels are located in the southern Lower Peninsula, where large population centers and fertile soils exist. Lakes with low nutrient levels are located in the northern Lower Peninsula and Upper Peninsula, where the population density is lower, soils are less fertile, and lakes tend to be larger and deeper. A statewide mercury-based fish consumption advisory applies to all Michigan lakes. Contaminated sediment is also an issue in a few lakes, and remediation efforts are planned or under way.

Trophic Status: Inland Lakes and Reservoirs

Carlson's Trophic Status Index (TSI) is used by the Michigan Department of Natural Resources and Environment (MDNRE) to assess and classify Michigan's 730 public access lakes. This classification system is based on field measurements of summer Secchi depth (water clarity/transparency), summer total phosphorus concentration in the lake's surface water and chlorophyll concentrations in the upper lighted zone of the lake (photic zone). The values for these field measurements are used in a mathematical formula to produce a number from 1 to 100. The lower a lake's TSI number, the lower the lake's biological productivity and the better the water quality conditions. Low-productivity lakes are referred to as oligotrophic; moderately productive lakes are known as mesotrophic; highly productive lakes are called eutrophic; and excessively productive lakes are referred to as hypereutrophic.

Data collected by the MDNRE reveal that the state's inland lakes are primarily oligotrophic and mesotrophic (Table 1.1) (MDNRE, 2010).

Table 1.1. Trophic status summary of Michigan's public access lakes sampled in 2007 and 2008 (N=161).

Trophic status	Number of lakes
Oligotrophic (low nutrients)	40 (25%)
Mesotrophic (moderate nutrients)	88 (55%)
Eutrophic (high nutrients)	29 (18%)
Hypereutrophic (excessive nutrients)	4 (2%)

Figure 1.1. A Michigan inland lake natural shoreline. *(Photo: Nancy Cuncannan.)*

National Lake Assessment

In 2007, Michigan participated in the U.S. Environmental Protection Agency's (EPA) National Lakes Assessment (NLA). This survey provided detailed information on the condition of the nation's lakes. The NLA provides unbiased estimates of the condition of natural and man-made freshwater lakes, ponds and reservoirs greater than 10 acres and at least 1 meter deep. During summer 2007, some 1,028 lakes were sampled for the NLA, including 50 Michigan lakes. Highlights of the survey may be seen in the following boxes.

The results of the National Lakes Assessment suggest that inland lakes need better care. The condition of each lake depends on interrelationships of many physical, chemical and biological factors. A healthy lake is a functioning

Biological quality

Fifty-six percent of the nation's lakes are in good biological condition. Natural lakes are more than 1 1/2 times more likely to be healthy than are man-made lakes.

Nutrients

About 20 percent of lakes in the United States have high levels of phosphorus and nitrogen. High nutrient levels are the second biggest problem in lakes. Lakes with excess nutrients are 2 ½ times more likely to have poor biological health than lakes without excessive nutrients.

Lake physical habitat

Poor biological health is three times more likely in lakes with poor lakeshore habitat. Of the stressors included in the NLA, poor lakeshore habitat is the biggest problem in the nation's lakes — more than one-third exhibit poor shoreline condition.

Physical habitat stressors

Lakeshore habitat is considered good in 54 percent of the lakes in the Upper Midwest ecoregion. Forty-six percent of the lakes show moderate to high levels of lakeshore human disturbance.

To learn more:

National Lake Assessment: **www.epa.gov/lakesurvey/**

MDNRE Integrated Report: found on the DNR website under "Water Quality Monitoring: Assessment of Michigan Waters": **www.michigan.gov/deq/0,1607,7-135-3313_3686---,00.html**

Understanding Lake Data: **www.dnr.state.wi.us/lakes/publications/under/**.

This guide was written to help people understand information about lake water quality and to interpret lake data. Each lake possesses a unique "personality," or set of physical and chemical characteristics that may change over time. Lakes exhibit chemical changes on a daily basis: other changes, such as plant and algae growth, occur seasonally.

ecosystem and safe for recreation. The aquatic habitats supply food, cover and spawning areas for fish, and the natural shoreline vegetation supports a variety of other wildlife species.

There are many factors in the lake ecosystem that people do not have control over – for example, the amount of rain and snow each lake receives. However, people do have control over how land is managed. A lake's ecosystem includes its watershed (an area of land that drains to a common point). The important thing about watersheds is that what we do on the land affects water quality. Figure 1.2 illustrates how the rain falling on the land gets into a lake. Whatever is carried with the rainwater can end up in the lake or in groundwater. Fertilizer, pet waste,

A healthy lake:

- Is a functioning ecosystem.
- Is not overloaded with nutrients.
- Is safe for recreation.
- Has aquatic habitats that supply food, cover and spawning areas for fish.
- Has natural shoreline plants to support a variety of wildlife.

sediment, oil, gasoline and many other types of pollutants flow with the water over the land and through storm drains to the lake.

A lake's health is a reflection of how the land and the stormwater are managed. The effects can either benefit or harm a lake. It is impossible to change one characteristic without altering another part of the ecosystem. For example, removing all rooted aquatic plants will have a negative impact on the fish population. Changes made by humans can have and have had negative impacts on the overall health of lakes.

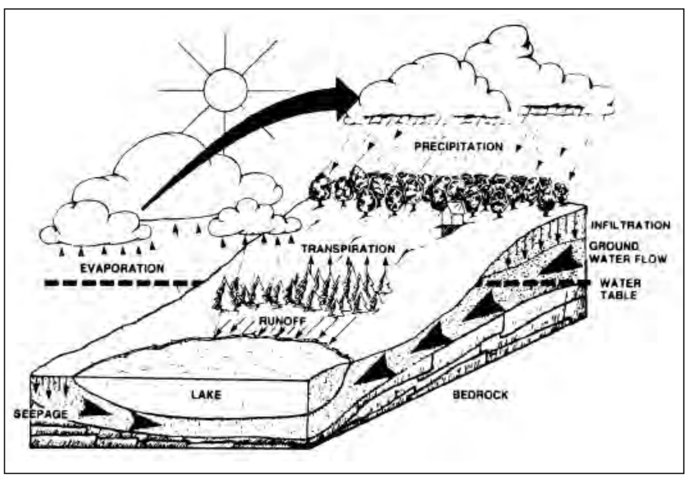


Figure 1.2. Precipitation pathways to inland lakes. *(Source: Lake and Reservoir Restoration Guidance Manual,[1st ed.].)*

Habitats of Inland Lakes

The habitats near inland lakes are extremely diverse. Combined, they provide the needs for a wide variety of plants and animals. Restoring or maintaining the health of a lake requires understanding of these various habitats.

Lake Zones

Lakes are divided into zones on the basis of the amount of sunlight that reaches the bottom of the lake. The amount of sunlight determines the type of plants in each zone. The depth of a lake helps determine the size and influence of each zone within the lake. A typical lake consists of five distinct zones (Figure 1.3):

Habitat: A place where species get what they need to survive: food, water, cover and a place to raise young.

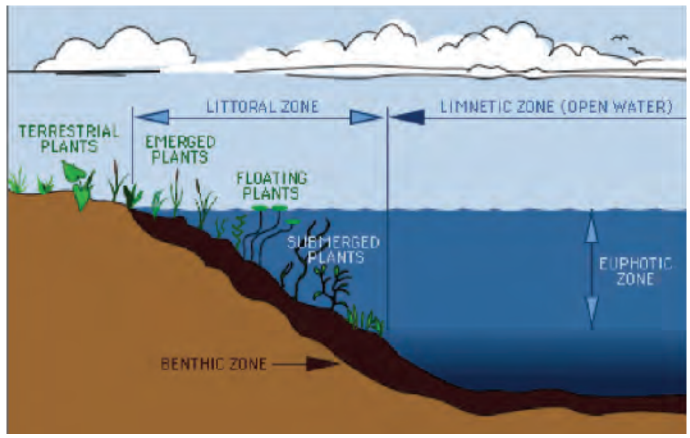


Figure 1.3. Lake ecological zones. *(Source: WOW [www.Wateron-theWeb.org], University of Minnesota-Duluth, Duluth, Minn., 2009.)*

- *Euphotic zone*: This area is the layer of water from the surface of the lake down to the depth where the light becomes too low for photosynthesis. The depth depends on water clarity. In most Michigan lakes, this zone is 8 to 20 feet deep. The euphotic zone has two subzones: the *littoral* and the *limnetic* zones.
- *Littoral zone*: This is the shallow and warmest part of the lake. Enough light gets through the water column to allow rooted aquatic plants to grow. A very clear, shallow lake will have a very large littoral zone supporting an abundance of plants, fish and wildlife populations. It is the zone most affected by shoreline development and alteration.
- *Limnetic zone*: This is the open-water area of the lake. It's too deep to support rooted plant

The **littoral zone** is most affected by shoreline changes.

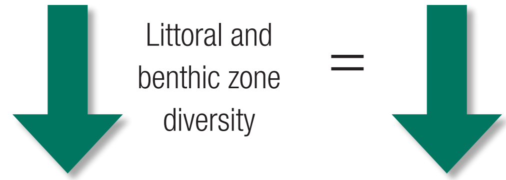
growth but has a variety of free-swimming (fish) and free-floating organisms (algae and plankton). Many fish move back and forth from this zone to the littoral zone.

- *Profundal zone*: If a lake is deep enough, below the euphotic zone is the profundal zone. Light does not reach this zone, and as a result, photosynthesis does not occur. Instead, bacteria use oxygen to break down organic matter. In many lakes, oxygen can be completely depleted. This restricts most animals from using this zone.
- *Benthic zone*: This area is the lake bottom. It may be made up of sand, mud or marl or a mixture of the above. This zone provides a nursery, refuge and foraging areas for fish, amphibians, birds, aquatic insects and crustaceans. Benthic habitats within the littoral zone are vulnerable to shoreline development and alteration. Negative impacts to this zone will decrease a lake's fishery by reducing food sources and spawning and safety areas. As the littoral and benthic zones decrease, so do fish populations.

Did you know?

Some dragonfly larvae spend up to three years in the bottom of the lake before becoming adults (Figure 1.4).

Figure 1.4. Adult dragonfly. *(Photo: Amy Peterson.)*



Shoreline plant communities

A lake's ecosystem includes various plant communities. These native plant communities are divided into three plant zones: upland, wetland and aquatic (Figure 1.5). Native plants in lakes are an important link in a lake's life system. The depth, soil type and amount of light in the lake determine the types and locations of these in and around lakes.

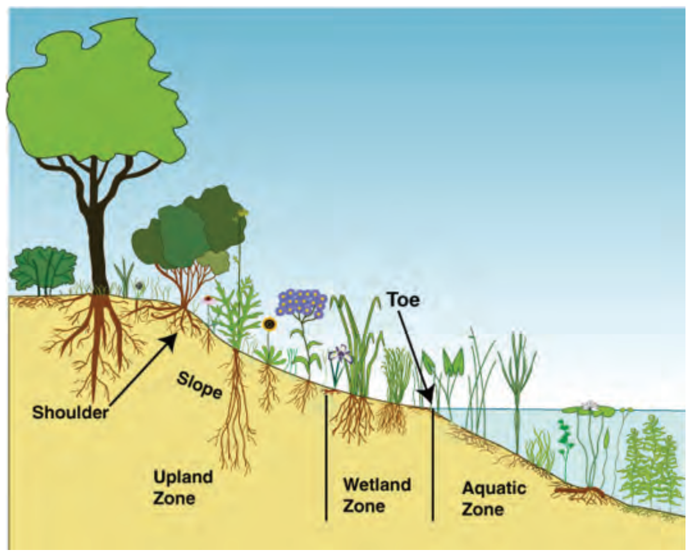


Figure 1.5. Cross-section of a natural shoreline depicting ecological zones. *(Source: Michigan State University Extension Land and Water Unit.)*

- *Upland zone*: These areas are typically associated with dry soils. These plants are away from wet areas because they cannot withstand prolonged wet soils. Their roots keep the soil on the slopes in place.
- *Wetland zone*: These areas are between the upland and aquatic systems. They typically have high water tables with consistently wet soils and/or standing water. Plants within these systems can handle long periods of flooding as well as periods of dryness.
- *Aquatic zone*: This area is in the lake. The aquatic plants are divided into four groups on the basis of

structure and adaptation to life in the water – *emergent, floating-leaf, submergent and free-floating plants* – and are found within the littoral zone (Figure 1.6).

Emergent aquatic plants are rooted in the lake bottom, but their leaves and stems extend into the air. They are limited by water depth, usually less than 4 to 5 feet deep. Sedges, rushes, cattails and arrowhead are common plants of this plant group.

Floating-leaf aquatic plants grow mostly below the water but have leaves that float on the water surface. One of the most common floating-leaf plants is water lilies. Floating-leaf plants are adapted to deeper water than most emergent plants but rarely grow in water over 6 feet deep.

Submergent aquatic plants are rooted to the lake bottom and are adapted to life below the surface, though most send flowers above the surface for pollination. They also have special adaptations that help their flexible stems and leaves to remain upright within the water. Submergents may be found throughout the littoral zone, with certain species adapted to specific ranges of water depth.

Free-floating plants drift freely with the wind and currents. They are not rooted in the lake sediments and are often found in quiet, protected areas. Most free-floating plants, such as duckweed (Figure 1.7), are small and may be mistaken for algae. Other free-floating aquatic plants, such as coontail and bladderwort, resemble submergent plants but are so loosely rooted in lake-bottom sediments that they easily dislodge and can survive as free-floating plants.

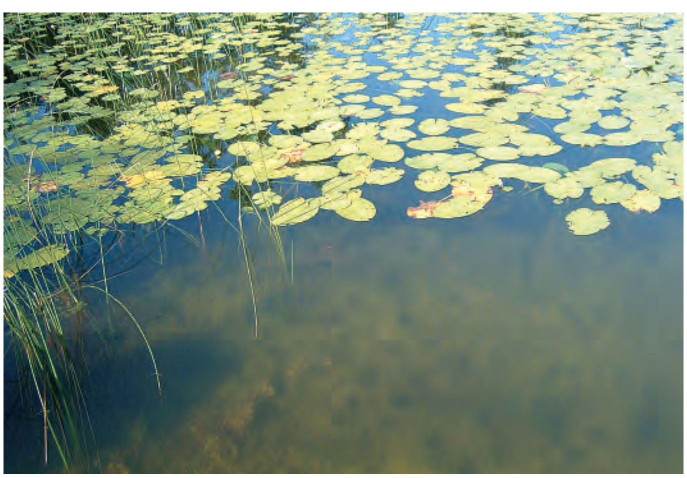


Figure 1.6. Lake littoral zone supporting overlapping aquatic plant communities. *(Photo: Jane Herbert.)*

Figure 1.7. Duckweed showing root system. *(Photo: Mark Oemke.)*

Functions of shoreline plants

Shoreline plants are an essential part of a healthy lake ecosystem, but they are often seen as a problem because they interfere with water uses. When lakefront property owners are confronted with too many plants in the wrong places, a common reaction is to remove them all. Decisions to remove plants do not always take into account the important role that plants play in the water environment. Understanding the functions that plants pperform is vital to avoiding negative impacts to wildlife, fish and other forms of life. Table 1.2 shows many ways that plants meet animals' needs and help maintain a healthy lake. Additionally, a vegetated shoreline (Figure 1.8) will provide the root structure that stabilizes soils against erosion, wave action and ice push.

Fish and wildlife habitat

Natural shoreline plant communities create complex habitats. They provide necessary space, shelter and food for a large number of animals, including mammals, birds, reptiles, amphibians, fish, insects and crustaceans. These aquatic and wetland plants, woody shrubs and trees support a rich diversity of life forms (Figure 1.9). Additionally, connected plant communities provide safe travel corridors that allow animals to move along the lakeshore. Many of these animals depend on easy movement between aquatic and terrestrial habitats to complete

Table 1.2. Important functions of plants in and around lakes.

Submergent and emergent plants	Shoreline and upland plants
• Plants produce leaves and stems (carbohydrates) that fuel an immense food web. • Aquatic plants produce oxygen through photosynthesis. The oxygen is released into lake water. • Submergent and emergent plants provide underwater cover for fish, amphibians, birds, insects and many other organisms. • Underwater plants provide a surface for algae and bacteria to adhere to. These important microorganisms break down polluting nutrients and chemicals in lake water and are an important source of food for organisms higher in the food chain. • Emergent plants break the energy of waves with their multitude of flexible stems, lessening the water's impact on banks and thus preventing erosion. • Plants stabilize bottom sediments, which otherwise can be resuspended by currents and wave action. Stabilizing them reduces turbidity and nutrient cycling in the lake.	• Shoreline and upland plants provide food and cover for a variety of birds, amphibians, insects and mammals above the water. • The extensive root systems of shoreline plants stabilize lake-bank soils against pounding waves. • Plants growing on upland slopes that reach down to lakes hold soil in place against the eroding forces of water running over the ground and help to keep lake water clean. • Upland plants absorb nutrients such as phosphorus and nitrogen, found in fertilizers and animal waste, which in excessive concentrations are lake pollutants. *(Source: Lakescaping for Wildlife and Water Quality; Minnesota Department of Natural Resources)*

Figure 1.8. Native plants helping to keep a shoreline stable on a Michigan inland lake property. *(Photo: Jane Herbert.)*

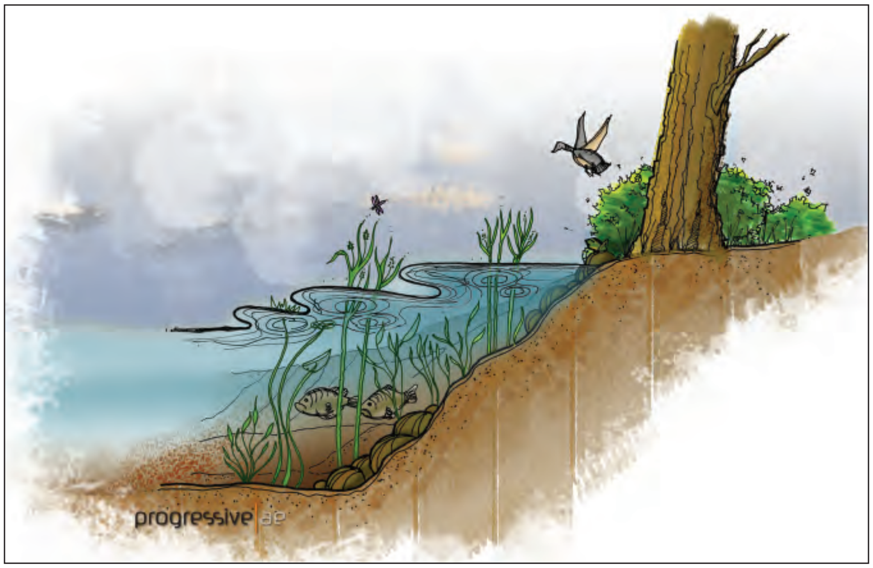


Figure 1.9. Natural shorelines support a rich diversity of life forms. *(Source: Progressive AE.)*

their life cycles. Fragmentation of these habitats reduces fish and wildlife populations.

An often overlooked component of a natural shoreline is woody debris, such as downed trees and branches, in the water. The woody debris provides safe areas for fish and substrate for the aquatic life stages of insects, such as mayflies. Healthy Michigan inland lakes provide habitat for a very large number of fish and other wildlife species, so it is important to protect and/or recreate these areas.

Twenty-four species of amphibians, 25 species of reptiles, 87 species of birds and 19 species of mammals are supported by Michigan inland lakes *(O'Neal et al., 2006)*.

Sixty-five species of Michigan native fish, 18 of which are identified as species of greatest conservation need in the Michigan Wildlife Action Plan, are supported by critical habitat found in the littoral and nearshore areas *(Eagle et al., 2005).*

Chapter

2

Understanding the Shoreline

In this chapter, you will learn about:

- The anatomy of a shoreline.
- The negative effects of high-impact development activities on lakes.
- The negative effects of hard shoreline structures on lakes.
- Potential causes of erosion.
- The importance of wave energy in the erosion and restoration processes.

Anatomy of a Shoreline

Maintaining the various ecological zones – aquatic, wetland and upland zones – of a natural shoreline is important in keeping the shoreline stable. A stable shoreline should have a natural slope and be well-vegetated. The benefits of this are: the plants absorb and decrease wave energy, accessible habitat-rich travel corridors are provided for wildlife, and the plants hold the soil particles together to keep them from eroding.

Shorelines are composed of a bank *shoulder* and a bank *toe* (Figure 2.1). The shoulder is the point at which the bank completes the transition to upland. The toe of the bank is the place where the water meets the land. The toe is the area most affected by wave action. If the toe becomes unstable and begins eroding, even well-vegetated upslope areas may slump and erode into the lake.

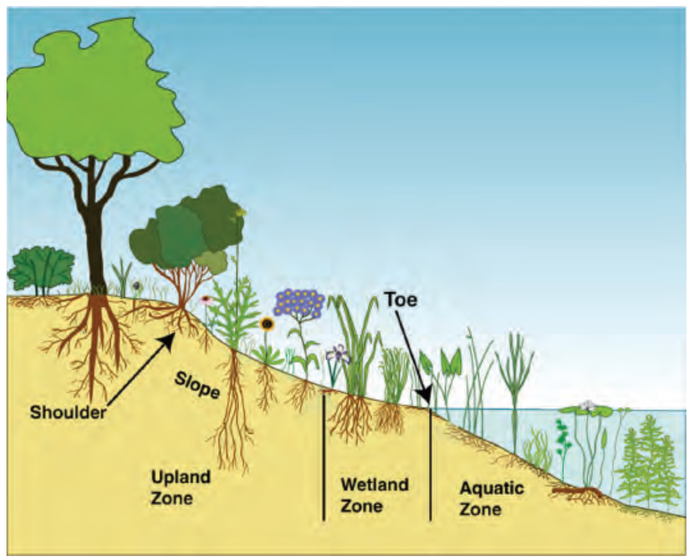


Figure 2.1. Cross-section of a natural shoreline depicting the location of the bank toe and shoulder. *(Source: Michigan State University Extension Land and Water Unit.)*

The Effects of High-impact Development Activities

High-impact development drastically changes the lakeshore ecosystem. Activities involve excessive removal of vegetation to allow for the construction of buildings, roads, storage areas and parking areas, and to open up views of the lake. The creation of hard surfaces and the filling of wetland areas and areas of the lakebed are also high-impact development activities. These types of development activities have historically been used and are still currently being used along many lakeshores in Michigan. They allow more pollutants to enter the lake by increasing the amount and velocity of water that carries pet waste, fertilizer, sediment, oil, gasoline, salt, etc., into the lake. Of all of these, the two most destructive actions causing impacts on the lake ecosystem are native vegetation removal and hardening of the shoreline.

Native Vegetation Removal: Consequences on Inland Lakes

Typically, high-impact development replaces the native shoreline vegetation with lawns or leaves shorelines bare. Removing the native vegetation along lakeshores, both on land and in the water, has many consequences to the lake ecosystem.

Lawn

- **Shallow roots:** Roots of lawn grasses at the shoreline are too shallow to hold the soil in place against ice push, changing water levels and wave energy. Note in Figure 2.2 that the slope has mainly been replaced with lawn. The expanding area of eroding slope is adding sediment to the lake. The bank toe is also beginning to erode.

Figure 2.2. Receding bank *(Photo by Scott Brown.)*

- **Loss of habitat:** Lawns up to the edge of the lake offer minimal habitat benefits. The wildlife that depended on the native vegetation have lost their source for food, shelter, safe travel pathways and nursery sites. The consequence is that the fish and wildlife – including birds, butterflies and frogs, animals that people typically like to see around their homes – will either be greatly reduced in numbers or disappear completely.
- **Nuisance animal habitat creation:** Lawns up to the edge of the lake are common along developed lakeshores. These lawns create attractive, safe feeding grounds for Canada geese. Lawns provide a continual supply of new green growth for food. The wide-open area makes geese feel safe because it is very easy for them to spot any potential predators. Their droppings become problematic to the property owner and the lake. When the droppings are washed into the lake, they add *E. coli* bacteria and excessive amounts of phosphorus to the lake. The *E. coli* poses a health risk for people and animals, and the phosphorus promotes excessive plant growth.

Shoreline Erosion

- Shoreline erosion is one of the most common problems that lakeshore property owners experience. An eroding lakeshore can be the result of natural or human elements, can be site-specific or widespread, and may have more than one cause. Causes of shoreline erosion may differ because of a property's location on the lake, water level changes and season. Shorelines affected by wind-driven ice and waves are more prone to erosion. Examples of natural factors affecting erosion potential are a large tree uprooted during a windstorm and a flood resulting from a torrential rainstorm. Human disturbances include the removal of natural vegetation along the shoreline, dredging or construction activities. Solving shoreline erosion is a challenge that requires proper diagnosis of lake conditions. This includes understanding lake processes as well as looking critically at what is happening on the land.

Loss of Shade

- **Increased temperatures:** Removing trees along a shoreline results in the loss of shade. Less shading of the water means warmer water temperatures. In short, converting tree-dominated shorelines to lawn substantially diminishes habitat quality. This has been found to cause a significant change in or disappearance of both aquatic and terrestrial organisms that have evolved to grow, reproduce and survive along lakeshores (Merrell et al., 2009).

Loss of trees
= loss of habitat
= loss of fish and wildlife

Polluted Stormwater

- **Increase in amount of polluted water entering the lake:** As native vegetation is removed when lake communities develop, there is an increase in impervious surfaces such as roofs, roads, parking areas, patios and walkways that deliver precipitation over land or through storm sewers to the lake. This stormwater runoff brings pollutants such as soil particles, fertilizers, pesticides, vehicle fluids and pet waste into the lake. The more impervious surfaces there are, the more polluted water enters the lake.
- **Decrease in natural filtering benefit:** Natural shoreline vegetation slows and filters pollutants in rainwater coming from the land and impervious surfaces. When the natural vegetation is removed, this filtering benefit is lost, and there is a dramatic increase in pollutants that contribute to excessive aquatic plant growth and degrade lake water quality.

Excessive Plant Growth and Algae Blooms

- **Nutrient increases:** Native vegetation removal leads to an increase in phosphorus entering lakes. The increase in phosphorus comes from many sources, including eroding soils rich in phosphorus, nutrients in stormwater, nutrients from septic systems and the use of phosphorus-based fertilizers. As phosphorus inputs into a lake increase, algal blooms increase, plant growth becomes excessive and water clarity decreases. It takes only a small amount of phosphorus to cause significant overgrowths of aquatic plants and algae. It has been shown that one unit of phosphorus entering a water body can produce 500 times its weight in algae (Wetzel, 1983).
- **Oxygen loss:** As the phosphorus concentration in the lake increases, the algae blooms get worse. This can upset the natural balance of the lake ecosystem because the decomposition of the algae removes oxygen from the water.
- **Recreation impacts:** Excessive plant growth and algae also make it difficult for boats to navigate the lake and decrease fishing and swimming opportunities. Algae blooms can also give off an odor that makes it unpleasant even to be around the lake.
- **Chemical treatment:** Chemical-based aquatic plant management programs are routine for many developed inland lakes experiencing excessive plant growth from nutrients or invasive species. Chemical treatments during periods of high water can result in the loss of important nearshore aquatic plants in the littoral zone. If not done appropriately, chemical treatments lead to excessive plant die- off. This can reduce oxygen levels in a lake and may cause fish kills. Aquatic plant management can help manage lakes for recreation and even help stop invasions of exotic plants, but it can be expensive, and it commonly requires repeated treatments to achieve the desired result.

To learn more

Visit the Department of Natural Resources and Environment Aquatic Nuisance Control Web site – **www.mi.gov/dnreinlandlakes** – to find out more about Michigan's aquatic plant management program.

A Citizen's Guide for the Identification, Mapping and Management of the Common Rooted Aquatic Plants of Michigan Lakes (Water Quality Series WQ-55): **www.msue.msu.edu/portal/**. Search under "Publications."

Sandy Beach Maintenance:

- **Beach erosion:** Many lakes in Michigan have naturally sandy shores, but many do not. Many homeowners create sandy beaches when they remove natural vegetation. Sandy beaches along lakeshores are a highly desired amenity, but these unnatural beaches harm the lake ecosystem. The sand in an unnatural setting rarely stays in place because wave action and surface runoff will cause it to erode into the lake, covering up aquatic plant beds and degrading fish and wildlife habitat.

Caution: A permit is required by the Michigan Department of Natural Resources and Environment (DNRE) for the creation of a beach in a lake. See Chapter 7 for more information.

Deadwood Removal:

- When the amount of deadwood (Figure 2.3) entering a lake is reduced important fish cover and substrate for the aquatic insects on which the fish feed are lost. At any one time, up to 15 species of fish may inhabit a single submerged tree. Over the past 420 million years, fish and lakeside forests have evolved together, yet in the past 100 years we have interrupted or in some cases eliminated that cycle. Proper woody debris management requires that we protect sources in the lake and along the shoreline.

Loss of vegetation and woody debris

= loss of habitat

= loss of fish and wildlife

= loss of fishing opportunities

Fish species found in one submerged white pine in Katherine Lake, Wisconsin

- Black crappie
- Mottled sculpin
- Smallmouth bass
- Largemouth bass
- Walleye
- Muskellunge
- Rockbass
- Bluegill
- Pumpkinseed
- Logperch
- Jonny darter
- Yellow perch
- White sucker
- Cyprinids (minnows)*

*Cyprinids could represent multiple species but are difficult to visually identify during diving (Bozek, 2001).

Hardening of the Shoreline: Consequences on Inland Lakes

Property owners look for ways to control shoreline erosion when it becomes a problem. This typically results in use of hard structures (Figure 2.4).

Seawalls and rock riprap are the most common types of hard structures that are installed when shoreline erosion becomes a problem.

Figure 2.4. Developed shoreline with natural vegetation removed, fill added and neighboring seawalls. *(Photo: Jane Herbert.)*

Figure 2.3. Waterlogged deadwood left in the littoral zone provides habitat for burrowing insect larvae. *(Photos: Jane Herbert.)*

Wave Energy Problems:

- **Scour:** Waves have a lot of energy that needs to go somewhere when they hit hard structures such as seawalls. Waves directed downward (Figure 2.5) scour the lake bottom sediments (benthic zone), disturbing and suspending sediments.
- **Sedimentation:** The suspension of sediment caused by scour is a problem because it reduces water clarity, buries fish food and spawning areas, and makes it very difficult for any natural habitat at the lake edge to develop.
- **Wave flanking:** When one property has a seawall, the wave energy directed sideways can cause the erosion of neighboring properties (Figure 2.6). This has led to a proliferation of seawalls around Michigan on lakes on which shoreline development has occurred.

Figure 2.6. Waves flanking off neighboring seawall. *(Photo: Jane Herbert.)*

Habitat Destruction

- **Loss of plant communities:** The practice of hardening lake shorelines with rock riprap and seawalls has resulted in the cumulative loss of shoreline and littoral zone habitat on Michigan inland lakes (O'Neal, 2006). When these plant communities are lost, so are the beneficial functions they once served.
- **Loss of fish and wildlife:** Hardened shorelines (including riprap, see Figure 2.7) reduce fish and wildlife populations. Burrowing, spawning, feeding and protection areas, and nesting and perching opportunities are removed for birds, insects and other wildlife dependent on the lake for food. A Minnesota Department of Natural Resources study compared littoral zone vegetative cover on a total of 44 developed and undeveloped Minnesota lakes. Emergent and floating-leaf vegetation was reduced by an average of 66 percent on developed lakes. In addition, the abundance and size of certain fishes – northern pike, bluegill and pumpkinseed – were greater when these plants were present (Radomski and Goeman, 2001).

Figure 2.7. Rock riprap erosion control on developed lakefront property. *(Photo: Jane Herbert.)*

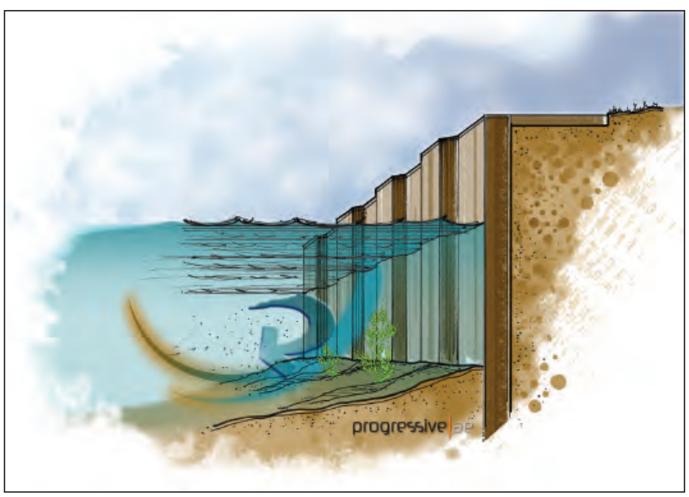


Figure 2.5. Wave energy directed downward off a seawall scours the lake bottom sediments (benthic zone), disturbing littoral communities. *(Source: Progressive AE.)*

- **Barriers for animals:** Many animals require both land and aquatic habitats to complete their life cycles. Vertical and semi-vertical seawalls and even rock riprap can obstruct animals' access to necessary habitats for feeding and reproduction by making it difficult if not impossible for them to move between the water and the land. An example of such an animal is the Blanding's turtle, listed as a species of special concern by the Michigan Department of Natural Resources and Environment (Figure 2.8).

Looking for Erosion Causes

Understanding an erosion issue begins with a walk on your property to look for the possible causes of the erosion. This will help in determining what the solution or solutions will be. It is wise to do this under a variety of weather conditions throughout the year to get an understanding of the different seasonal impacts because most erosion is likely to occur during periods of high water and/or high winds. Watching what happens on a shoreline during these times and comparing it with normal conditions or water levels can be insightful. When reviewing your property, think about whether the evidence that you find indicates the erosion is:

- Naturally caused.
- Human-caused.
- Site-specific (only on your property).
- Widespread

Figure 2.8. The Blanding's turtle (above) inhabits clean, shallow waters with abundant aquatic vegetation and soft, muddy bottoms over firm substrates. This species is found in ponds, marshes, swamps, bogs, wet prairies, river backwaters, embayments, sloughs, slow-moving rivers, lake shallows and inlets. The Blanding's turtle also occupies terrestrial habitats in the spring and summer during mating and nesting seasons and in the fall to a lesser extent. *(Photo: Jim Harding.)*

Potential causes of erosion

Overland Runoff

Overland runoff is water that flows over the surface of the ground rather than soaking into it. Runoff can increase in volume and velocity as a result of both natural conditions (slope, soil type, drainage pattern) and human activities (impervious surfaces, vegetation removal, construction in progress). Runoff picks up and carries soil particles and other pollutants into the lake and can also create gullies and bank failure. Runoff may originate quite a distance away from a shoreline erosion site.

Groundwater Seepage or Springs

Groundwater seepage is generally a natural condition that occurs where the water table meets the land surface. These areas may appear as a wet spot, a wet layer in a steep bank or a definite flow of water. This seepage and saturated conditions can loosen and move soil particles. Freeze and thaw cycles can cause the ground surface to heave and buckle, dislodging chunks of soil. When the soils in these banks are loosened, the result can be bank failure. Preserving or restoring the native vegetation in these areas can stabilize soils and slow erosion.

Removal of Vegetation

On land: The root systems of woody shoreline vegetation help strengthen all types of soils. Many shoreline erosion problems occur simply because the vegetation that was holding the soil in place has been removed. Bank failures can also be a result of losing vegetation along the shoreline when a large amount of soil sloughs off the side of the bank. Bank trampling and soil compaction by humans and vehicles are also significant causes of vegetation loss and shoreline erosion.

In the water: In natural shorelines, tree trunks, limbs and other woody material, as well as aquatic plants, are often abundant in the water. These materials help to protect the shore by taking the brunt of wave and ice energy, and they help keep the bottom sediments in place. Once these are removed, the shoreline is exposed to erosive energy that causes shoreline erosion.

Waves

Waves, either natural or man-made, are the most common cause of shoreline erosion. Lake size, shape, bottom contours and orientation to prevailing winds and the amount of boating activity all influence the effects that waves have on the shoreline. Properties located on the windward side of large lakes may experience significant wave activity; properties in small, protected bays will have less wave activity. Boating activity has increased on most water bodies in recent years, and boats have increased in size and power. The result is increased frequency and energy of waves from boats. Accelerated erosion is often associated with recreational boating, especially on small lakes, protected bays and channels, and many rivers.

Ice Action

Ice push happens when ice is pushed up onto the shoreline as temperatures rise (Figure 2.9). The ice causes the bank to move; what remains is typically an ice ridge. Ice ridges indicate regular ice action. Many times the ice ridge is not seen because it has been removed. This practice is not recommended because ice ridges protect the shoreline from repeated ice damage. They should be stabilized with vegetation.

Figure 2.9. Ice ridge resulting from ice push on Lake Cadillac, Wexford County, Mich. *(Photo: Jane Herbert.)*

As you look at your property, here are some questions to ask:

- Are there any downed trees? What was the cause – a windstorm or something else?
- Has most of the natural vegetation been removed from the shoreline property?
- Is there only turfgrass up to the edge of the lake, creating an unstable lakeshore?
- Were the aquatic plants removed? (Note: some lakes do not naturally have a lot of aquatic nearshore plants because of the type of lake they are.)
- Are waves coming from neighbor properties (wave flanking)?
- Is there a lot of natural wave action from the lake?
- Is there a lot of wave action from boats?
- Is there a lot of overland water flow? Watch what happens to the water coming off the land during a rain event. Where does the runoff come from and from how far away?
- Is there a lot of ice push during the winter months?
- Is there a high-traffic area at the shoreline?
- Are there any unnatural objects in the water that might be changing energy patterns?
- Have any low areas been filled anywhere on the lake property?
- Are there any constant wet spots where groundwater is seeping?

Is the Erosion Fast or Slow?

Determining what is normal erosion and what is accelerated erosion can be difficult.

Erosion rates depend on many factors, including soil type, the slope of the land, wave and wind action, type of vegetation, rain and runoff from the land. Many times accelerated erosion can be detected by comparing developed shorelines with neighboring undeveloped areas or looking at old photos. An assessment of erosion rates (feet per year) can provide valuable insight about the need for

Signs of trouble

Warning signs of accelerated erosion problems:

- Large areas of bare soil along the shore, especially on a steep, high shoreline bank.
- Large or small gullies caused by overland runoff along the shoreline.
- Frequent landslides or excessive bank slumping
- Noticeable recession of the shoreline over a period of time.
- Leaning or downed trees with exposed roots on the shoreline.
- Large patches of unusually cloudy (turbid) water near a lakeshore, especially during periods of high water.

erosion control. The highest priority for erosion control is at sites with rapid recession rates (more than 1 foot per year) (Tip of the Mitt Watershed Council, 2007.)

Understanding Wave and Ice Erosion Potential

Lake level changes, wave energy and ice action influence the potential severity of erosion and the prospects for success with an erosion control project. It is important to understand what the potential wave energy and ice action are at a particular site because this will determine what type of control technique will need to be constructed.

> As fetch length increases and wind speed increases, so do the wave length and height, resulting in increased wave energy.

Ice action is difficult to predict and can vary from year to year at any point on your lake. The prevailing spring wind patterns play an important role in how much ice action occurs on a lake. Property owners can be good resources when you're trying to predict how often and how heavily a shoreline might be subjected to significant ice action.

The size of waves created by wind depends primarily on two factors: wind speed and lake fetch. "Fetch" is the distance the wind can travel over water before meeting with land. Fetch distances can be used to predict the depth to which wave energy extends below the water's surface. This is important because the greater the fetch distance, the greater the potential for large waves (O'Neal et al., 2006). As fetch length increases and wind speed increases, the wave length and height and resulting wave energy increase.

Wind duration and water depth are also factors, particularly on the very large inland lakes. In general, the larger the lake, the larger the waves will be in windy conditions. Waves of different speeds and waves created in different locations can come together to make larger waves. All of this affects the total wave size, wave frequency and wave energy. As a wave approaches shallow water, friction from the lake bottom slows the wave. As a result, a shallow run-up (drop-off) to the shore will cause waves to break and lose energy farther from the shoreline than a steep run-up will. Wave energy can be categorized as low, moderate or high. The higher the wave energy, the higher the potential for shoreline erosion. Also, the higher the wave energy, the more challenging the solution to shoreline erosion becomes. Wave energy should be calculated before any shoreline erosion control project begins.

What is the wave energy at my property?

The Wisconsin online Erosion Calculator can be used to find what the wave energy is at a particular site:

http://dnr.wi.gov/waterways/shoreline_habitat/erosioncalculator.html.

It requires the use of a lake map showing the contours of the bottom of your lake. Many Michigan inland lake maps are available on the Michigan Department of Natural Resources and the Environment Web site:

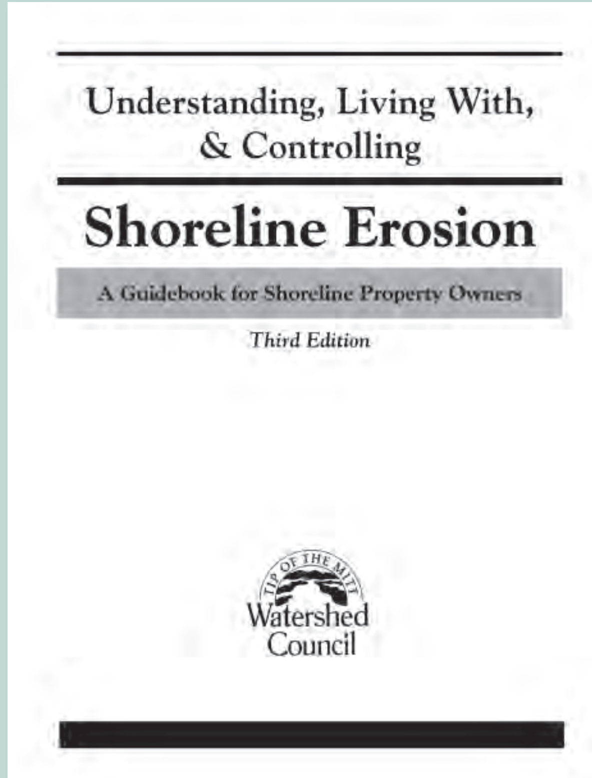
www.michigan.gov/dnr/0,1607,7-153-30301_31431_32340---,00.html.

To learn more on:
Erosion control along the shoreline,

Please refer to the Tip of the Mitt Watershed Council publication Understanding, Living With, and Controlling Shoreline Erosion: A Guidebook for Shoreline Property Owners (3rd edition).

It is available for purchase from Tip of the Mitt or for free download on its Web site: **www.watershedcouncil.org/**.

(See Chapter 4 for discussion on some options for addressing shoreline erosion.)



Chapter 3

Planning a Natural Shoreline Landscape

In this chapter, you will learn about:

- Planning a shoreline landscape.
- Steps for designing a successful natural shoreline project.
- How to draw a base map of your property.
- How to do a basic site inventory.
- Ideas for designing a lake-friendly landscape.

Planning a Natural Shoreline Landscape

A well-designed shoreline landscape should protect and enhance shoreline and near-shore aquatic habitats. It can balance lake access, views and aesthetics with shoreline stabilization and habitat restoration (Figure 3.1). Rethinking what a shoreline is supposed to look like can be the biggest challenge for many lakeshore property owners. A recreated natural shoreline does not have to look messy -- a finished and well-manicured look can be achieved through careful planning.

Figure 3.1. Natural shoreline landscape. *(Photo: NativeScapes LLC.)*

It can be challenging to change a lakeshore landscape that provides little benefit to the lake ecosystem (Figure 3.2) to a more ecological, lake-friendly landscape. Other challenges may include financial limitations and lack of familiarity with plants or sources for them, ways to deal with erosion issues and physical limitations, and sources of help. The planning process should begin with identifying your specific challenges. Completing this task will enable you to recognize what you can do yourself and what help you may need. These choices can be important in helping to minimize the costs.

> Rethinking what a shoreline is supposed to look like can be the biggest challenge in creating a natural shoreline!

Steps for a Successful Natural Shoreline Landscape

- Determine what your needs are.
- Integrate your goals with healthy lake goals.
- Draw a base map.
- Do a site inventory.
- Select appropriate materials and methods (Chapter 4.)
- Determine the desired maintenance level (Chapter 6).

Figure 3.2. Starting the planning process. *(Source: MSU Extension.)*

Step 1: Determine property owner needs

The first step is to explore your wants, needs and priorities. You may wish various areas of the property to have different appearances and uses. Appearances may be manicured or wild, open or secluded. The property may be divided into areas for passive (sitting and relaxation) and active (swimming, boating and fishing) uses. Write down your expectations for the shoreline landscape. The following questions can help you identify specific wants, needs and priorities.

Personal Wants and Needs

- How much area do you need for play or relaxing?
- What type and how much storage do you need and where does it need to be?
- What views do you want to preserve or enhance?
- How much lawn do you need? Where is lawn necessary?
- Is privacy a concern?
- What types of plants do you desire – tall, short, flowering?
- What is the desired landscape style – natural or formal?
- Do you want to attract more wildlife, such as birds, butterflies, frogs and turtles?
- Do you want to provide better habitat for fish and other aquatic wildlife?
- What type of lake access do you need -- boating, swimming, fishing, etc.?
- Do you want to incorporate any pathways?
- Other?

Legal and Financial Needs

- Do you have the authority to implement your project? Do you own to the water's edge?
- Is there an easement, deed restriction, lease or other encumbrances on the property?
- Are there any state permit requirements for the potential work to be done? (See Chapter 7.)
- Are there local ordinances or requirements such as setback requirements?
- What is the potential budget?
- Who will do the work? Will this be a do-it-yourself project or will you need to hire a professional contractor?

Design Tip: If there is a need for erosion control techniques other than plants, a professional should be consulted. There are many variables in these types of projects that can decrease the successfulness of a project.

Priorities and Timeline

Have you established priorities and a timeline for installation? This will help in keeping the entire site manageable. For example, an eroding shoreline may need immediate attention. Erosion solutions can be the place where time and money are focused first.

Step 2: Draw a base map of your property

The second step is to draw a base map of your project site or, if appropriate, the entire property. The base map does not have to be a work of art -- it merely has to represent the site. A base map will be useful in performing the site inventory and will be the foundation for developing a design for the shoreline landscape.

Materials needed

- Any existing property maps or surveys.
- Pencils.
- Paper. Graph paper works really well for this. If your property is fairly big, you may want to consider using larger paper because this will allow you to add detail without making the map too crowded.
- Ruler and measuring tape (at least 100 feet).
- Inventory notes.

Process

- Scale of map: Decide on the scale for the drawing. Common scales for landscape designs are based on inches. For example: 1/16 inch = 1 foot; 1/8 inch = 1 foot; or 1/4 inch = 1 foot.
- Add an arrow to your base map indicating where north is.
- Take measurements of the buildings, driveway, road, property lines, lake and other permanent features. Draw these on your base map. Then measure and map the locations of existing landscaping features that will be staying. An example of a base map is shown in Figure 3.3.
- Create a cross-sectional view of the property that includes the shoreline. This will show the height of the bank and the slope of the property.

Step 3: Do a site inventory

Completing a site inventory will allow you to understand the current site characteristics. This is accomplished by walking around your property and looking carefully at the entire property -- upland, wetland and building areas. Knowing what you have to start with will help in developing an appropriate design. Use the checklist below as a guide and take lots of notes. Record information from the site inventory directly in the appropriate area on the base map.

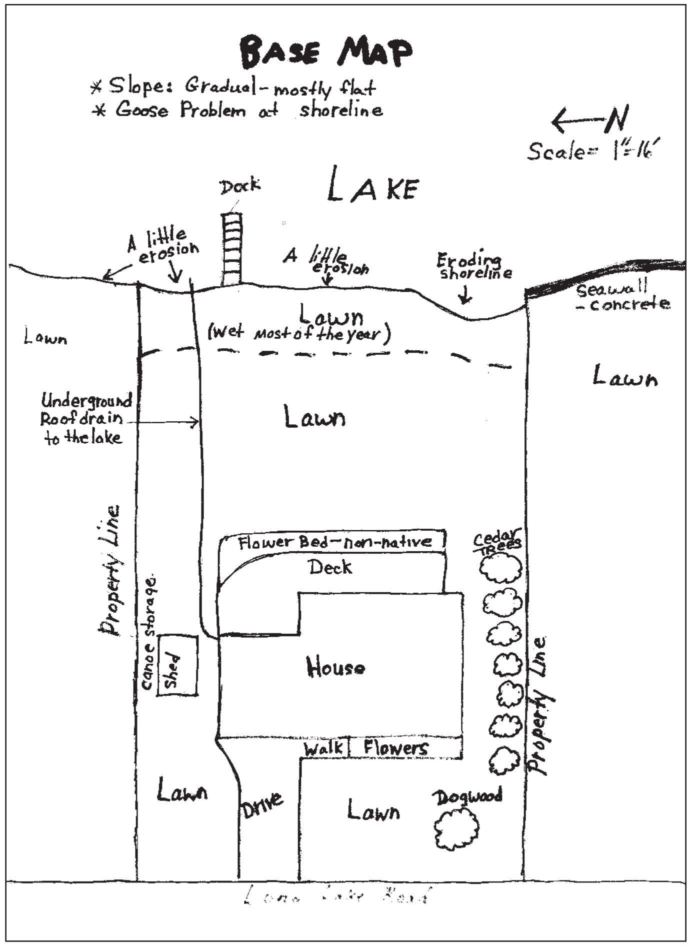


Figure 3.3. Example base map.

Things to look at:

Upland

Existing plants: trees, shrubs, flowers, invasive species, etc.

- What are their names?
- What are their sizes?
- Are they intended to stay or be taken out?

Existing lawn:

- Where are the lawn areas?

Are there any erosion problems?

- Are there any bare areas?

Inventory Tip 1: Photos!
Take photos of each area during the various seasons. This can show varying water levels, the plants at different growth stages, how the rain water flows, and the extent of ice push and wave action. Remember to date them!

If there is a septic system:

- Where are the septic tank and drainfield?
- Where is the pump-out location?

Stormwater runoff:

- Where does it come from and where does it go?
- Are there any prominent pathways that stormwater travels through the property? Are these areas eroded?

> Hint: the best time to see where the water goes is during a rain event.

Soil:

- What type of soil is on the property – sand, muck, clay?
- How wet or dry is the soil throughout the year?

Sun/shade:

- Where are shady and sunny areas?
- How much sun/shade does each area get?

Slope

- What is the general slope of the upland property -- steep, gradual, flat?

At the Shoreline

Seawalls:

- Is there a seawall on the property?
- Are there neighboring seawalls?
- What type(s) of seawalls?
- What condition are they in?

> **Inventory Tip 2:**
> **Don't know that plant?**
>
> Don't worry if you don't know the exact name of a plant. Taking photos of it can help later in identifying it.

Lawn:

- Is there lawn up to the edge of the lake?

Plants:

- Are there any shrubs and trees?
- What are their sizes?
- Are any invasive species present?

Soil:

- What is the soil type on the shoreline bank?

Animals:

- Are there any nuisance animal problems?

Shoreline erosion:

- Is the shoreline erosion a site-specific problem?
- Is it widespread along other properties?
- Is the shoreline receding quickly or slowly?
- What is the slope of the shoreline area – steep, gradual, flat?

Ice push:

- Is there an ice ridge on the shoreline?
- Is there a lot of ice movement at the shoreline?

In the Lake

Water level:

- What is the water depth at the shoreline?
- Does the depth change gradually, or is there an immediate dropoff?
- What are the lake level changes (seasonal or rain event)? Do changes occur fast or slow? How often?

Soil:

- What is the soil type in the lake bottom near shore?

Waves:

- Are the waves frequent and big?
- Is there a lot of wave action from boats?
- Are waves coming from neighboring properties (wave flanking) causing any problems?

> **Inventory Tip 3:**
> **Take a boat ride.**
>
> Many lakefront properties have few to no native plants along the shoreline. Take a boat ride around the lake. Find a property that has similar characteristics and has a natural shoreline. Take photos and write down some general descriptions of the plants and the depth of water they are in. This type of information can help in plant selection later.

Property location on the lake:

- Is the property in a backwater "protected" area of the lake?
- Is the property exposed to prevailing wind and wave action?

Plants and woody debris:

- Are any aquatic plants currently growing in the near-shore areas?
- Are there any invasive species?
- Are there any dead branches in the lake near the shore?

Step 4: Integrating landowner goals with healthy lake goals

A sustainable shoreline landscape combines the site characteristics, the design goals and the various plant communities in a way that benefits the lake quality and wildlife habitat. A developed site does not necessarily have to be restored to predevelopment condition, but it should provide many of the same benefits to a lake, such as fish and wildlife habitat and shoreline stabilization. For lakeshore property owners, the process of developing a natural shoreline can seem overwhelming, but it is important to keep in mind that there is more than one right way to do it. These next steps will help you through the process of developing a basic layout of your property. Ideally, this layout will incorporate your goals as well as changes that will benefit the lake.

Review:

- Begin by reviewing the site inventory and base map of the property. The site inventory should have identified any problems such as erosion, stormwater runoff and nuisance wildlife.
- Next, review the wants, needs and priorities. Have they changed? Are those areas on the map correct?

Divide the property

- Break down your property into zones: upland and zones at the water's edge (refer to Chapter 2). The zones at the water's edge may include wetland, the bank itself and the aquatic zone. Figure 3.4 shows the zones overlaid on the base map. Each area will require different plants and site-specific solutions. Identifying zones will also break the property down into manageable areas. In addition, zones may blend into each other.

What does the lake need?

- Remember, a healthy lake ecosystem needs a stable shoreline and plants that provide habitat for fish and wildlife. Determine the areas on your property where changes can reduce erosion and increase habitat.

Once your wants, needs and priorities have been identified, it is important to transfer these ideas into areas on a base map.

A well-designed shoreline landscape starts with careful planning. It integrates the wants, needs and priorities of the property owner with goals for a healthy lake. It balances lake access, views and aesthetics with shoreline stabilization and habitat restoration. A recreated natural shoreline can provide aesthetic, environmental, ecological and economic benefits.

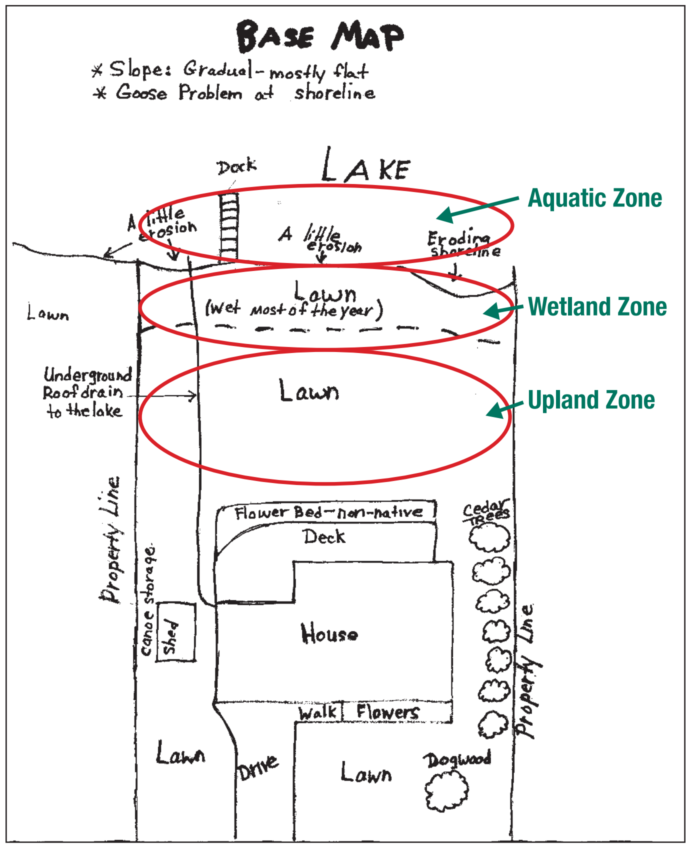


Figure 3.4. Base map illustrating the various zones. *Source: Julia Kirkwood.*

Chapter

4 Design Ideas for a Natural Shoreline Landscape

In this chapter, you will learn about:

- Tips for creating fish and wildlife habitat.
- Options for shoreline stabilization.
- Products used to stabilize shorelines.
- Options for properties with seawalls.
- Michigan case studies.

Design Ideas

The two main design goals for contributing toward a healthier lake are increasing wildlife habitat and stabilizing the shoreline. Techniques can be used to accomplish more than one goal and can range from simple to complex. For example, a simple technique is to use only plants to attract wildlife and protect the shoreline. This technique is typically called a "buffer" (Figure 4.1). It is best used when shoreline erosion is not present or is fairly minimal. Buffers can be developed either by actively planning and choosing specific plants or by creating what is called a "no-mow zone." Creating a no-mow zone is simple: merely stop mowing at the shoreline to allow existing plants to grow. If active shoreline erosion is occurring, more complex techniques will be needed to stabilize the shoreline.

Natural shoreline projects must be conducted in accordance with applicable laws and regulations. In addition, a property owners association may govern development on the site and its potential impact on surrounding properties. In 2010, the Michigan Department of Natural Resources and Environment issued a new minor permit category to encourage the use of certain bioengineering practices to stabilize shorelines at low-energy sites on Michigan inland lakes. (This permit is discussed in more detail in Chapter 7.)

Figure 4.1. A buffer strip of native plants at the Kellogg Biological Station Shoreline Management Demonstration Area on Gull Lake, near Hickory Corners, Mich. *(Photo: Leah Worthington.)*

Many options are available to a lakeshore property owner. Figures 4.2., 4.3 and 4.4 depict a property that has gone from providing minimal lake benefits to one that has high lake benefits. The design also incorporates shoreline stabilization and property owner needs, including space for relaxing, swimming and boat access, while maintaining an open view of the lake. Not all lakeshore properties are as large as this one, and not everyone will be able to afford a full transformation of his/her property, but it is possible to make even small improvements to any property that will benefit the lake ecosystem.

Figure 4.2. Residential lakefront landscape that provides minimal benefits to the lake ecosystem. *(Source: MSU Extension.)*

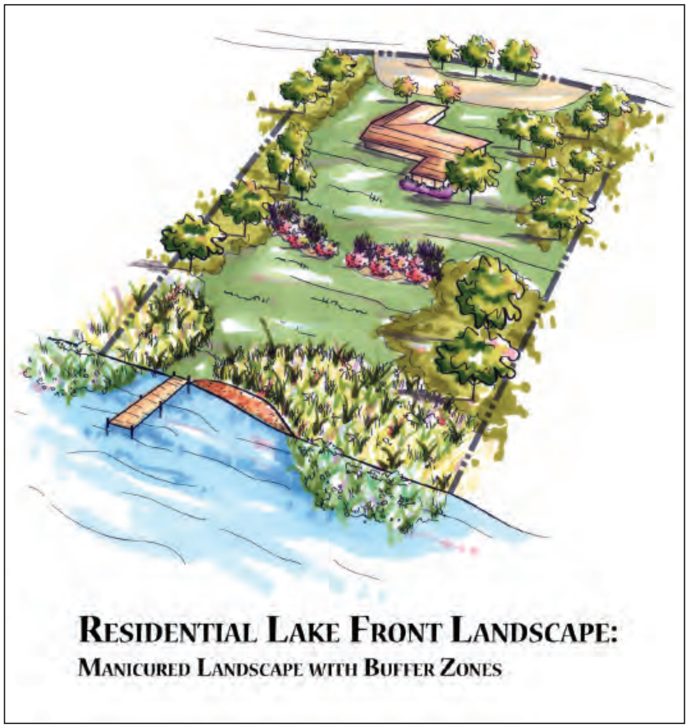


Figure 4.3. Residential lakefront landscape integrating a more manicured approach with buffers. *(Source: MSU Extension.)*

Figure 4.4. Residential lakefront landscape with outlined upland and aquatic zones. *(Source: MSU Extension.)*

Design Examples

Creating a Buffer

Below are some examples of various combinations of plants directly along the lakeshore. Wave energy on each of these sites is assumed to be low with minimal erosion problems. The ordinary high water mark (OHWM) is identified on both – note the differing locations. The plants chosen are ones specific for each zone, provide a variety of colors throughout the growing season, and also provide variable heights and textures. They are placed to create a managed look.

Figure 4.5 depicts a gradual slope. It remains wet for much of the year, is typically flooded during high water but also may have an occasional dry period.

Figure 4.6 depicts a steeper slope than the previous design. The area above the OHWM is still moist much of the year, but prolonged flooding is infrequent. The width of this shoreline planting is actually narrower than that in Figure 4.5 because the soil moisture conditions have transitioned to upland.

Figure 4.5. Gradual slope, between water level and ordinary high water mark: 1. Tussock sedge. 2. Lake sedge. 3. Marsh milkweed. 4. Swamp aster. 5. Boneset. 6. Allegheny monkeyflower. 7. Great blue lobelia. *(Source: MSU Extension.)*

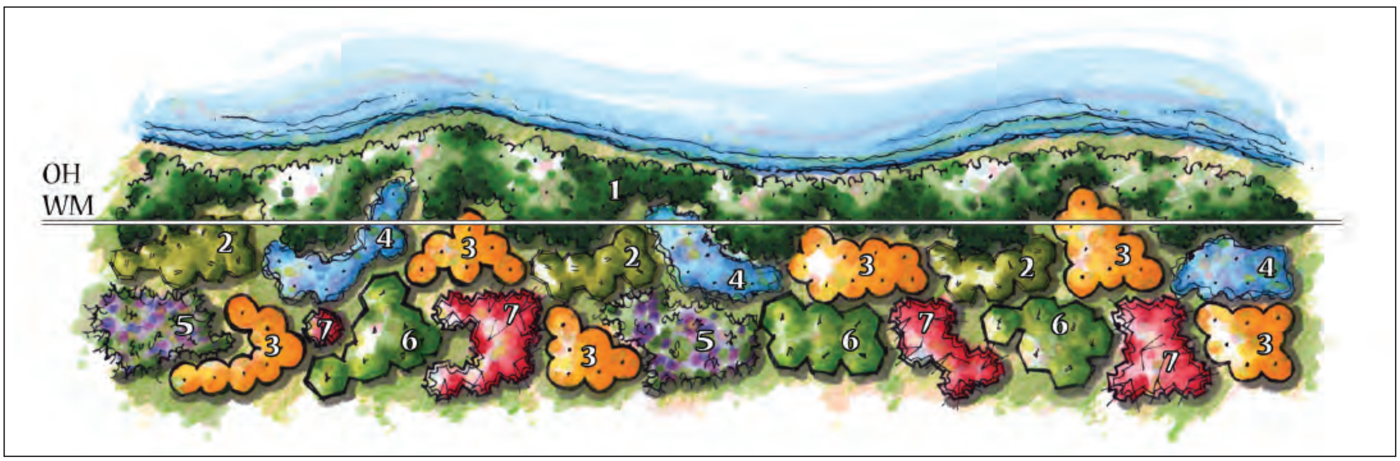


Figure 4.6. Steep slope. Between water level and ordinary high water mark: 1. Soft rush. Above the ordinary high water mark: 2. Canada blue-joint grass. 3. Golden Alexanders. 4. Sensitive fern. 5. Dense blazing star. 6. Canada anemone. 7. Turtlehead. *(Source: MSU Extension.)*

Designing for Fish and Wildlife

Attracting wildlife

It is the combination of the three communities – upland, wetland and aquatic – in a natural shoreline that provides the highest diversity of benefits to the lake and wildlife. A landscape that supports diverse wildlife must contain a variety of native plants, such as grasses for grains and greens, shrubs and ground covers for fruit, flowering plants for nectar and seed, and trees for fruit and nuts. Although the overall goal of providing wildlife habitat may be the same across zones, the plants and techniques differ between these zones because of the differing site characteristics.

The water's edge can be the easiest area to design for wildlife. If this area is currently lawn, it will be important to replace the lawn with plants that are appropriate for the wetted edge of the lake. A large diversity of plants can be used to provide habitat for many birds (Figure 4.7), dragonflies, frogs, turtles, butterflies and many other animals. Also, remember that a natural shoreline does extend into the lake, so consider plant-

Figure 4.7. Great egret eating a fish. *(Photo: Amy Peterson.)*

ing some aquatic plants and providing or leaving woody debris in the lake. This will provide additional beneficial aquatic habitat. If your goals include having recreational or storage areas as well as lake access needs, pay attention to what types of plants would work best to complement these areas. For example, tall plants and shrubs can be used to hide storage buildings or provide privacy; shorter plants can be used along the edges of a path. The upland area should also be included in the overall design for a more comprehensive approach, which will provide the most benefit to the lake and wildlife.

> **Design Tip #1**
> Properties that provide habitat for wildlife can be certified with the National Wildlife Federation: **http://www.nwf.org.**

Discouraging nuisance animals

One of the challenges in designing for acceptable habitat is discouraging wildlife that can be destructive or unwanted. The important factor is first to understand what type of habitat an animal likes best and why. For example, Canada geese tend to be the nuisance wildlife most frequently found on lakeshore properties (Figure 4.8). Geese are grazers, so wide-open, expansive lawns up to the edge of the lake are perfect habitat for them. The more lawn, the better because this gives them a constant supply of food, is barrier-free and offers no hiding places for potential predators. Reducing the mowed areas and narrowing the access to the remaining mowed areas will discourage geese. A well-designed buffer strip should be at least 3 feet high and 6 feet deep to help deter the geese during their flightless phase (Figure 4.9). This discourages geese because it reduces their ability to spot predators. Additionally, narrowing the water access reduces escape routes and makes turf areas less desirable for feeding. Goose families tend to return to the same areas to raise their next generations, so modifying the shoreline landscape to make it less desirable can produce long-term benefits.

Figure 4.8. A family of geese grazes on mowed turfgrass near a lake. *(Photo: Amy Peterson.)*

> **Design Tip #2** If geese are a problem there should be plans to create a goose exclosure using string and stakes. Otherwise the geese will graze down the new plants. See case study 3.

Designing for Stormwater Management on Shoreline Properties

Creating a stable shoreline will likely require a comprehensive approach across the entire property because the erosive forces of water are not limited to the water's edge. This will include addressing any upland problems

Figure 4.9. A dense shoreline buffer can decrease the summertime use of shoreline property by geese. *(Photo: Jane Herbert.)*

Is it a rain garden or a bioretention cell? There are many opportunities on shoreline properties to collect and rapidly infiltrate stormwater. Relatively clean roof water may be collected and infiltrated into the groundwater table using a *rain garden*. Roads and parking areas collect oil, gas and other vehicle fluids that create polluted stormwater during rain events. A specially designed *bioretention cell* can collect and treat this polluted water and reduce the amount of contaminants that infiltrate into groundwater and the lake.

at the source as well as the shoreline. Rainfall events result in flash flows that can move large volumes of stormwater runoff into waterways during a short period of time. The site inventory should have identified sources of runoff, pathways for the runoff, areas that are bare and eroding areas. In the upland zone, low-impact development practices (see SEMCOG LID manual reference below) should be installed to capture excess water and thus prevent erosion problems. Bare areas should be landscaped properly to reduce the amount of water and sediment running off the land. Remember, turfgrass can be incorporated into the overall design, but it may not be appropriate for severe erosion issues.

Low-impact development focuses on stormwater collection and infiltration techniques used in landscape development. On shoreline properties. these might include rain barrels, rain gardens, bioretention cells or buffer strips. These techniques collect stormwater and reduce runoff. Rain gardens and bioretention cells are designed to collect and then infiltrate stormwater so it can soak into the ground instead of running off into the lake.

Designing for Shoreline Stability

Soft shoreline erosion control

Many techniques are available to address shoreline erosion in a way that supports the lake ecosystem and protects lakefront property. "Soft-armoring" or "bioengineering" is a natural solution to address shoreline erosion. This method uses plants, plant products and special techniques to protect the shoreline rather than hard structures such as concrete and rocks. Keep in mind, however, that these methods are very successful in controlling shoreline erosion but may not be the best solution for all situations.

Soft-armoring (bioengineering) reintroduces deep-rooted plants to create a system that mimics naturally stable shorelines. Sometimes lake properties may require additional protection provided by combining some hard materials such as rock riprap with bioengineering for erosion control. This approach is sometimes referred to as biotechnical shoreline erosion control. This approach might be necessary on sites that experience wave flanking off of neighboring seawalls (see case study 2).

For more information on the stormwater collection techniques mentioned above, please refer to the Southeast Michigan Council of Governments (SEMCOG) publication "Low Impact Development Manual." The manual is available as a free download. It can be downloaded in its entirety or by individual chapters at: **www.semcog.org/LowImpactDevelopment.aspx**.

The following Web site will provides a wealth of information on rain gardens: **www.raingardens.org**.

Soft-armoring (bioengineering) techniques have many benefits for both the lake and the property owner. The keys to success are a good design, proper installation and follow-up maintenance. It is important that a control method is chosen that is well-suited for the site and will also meet state regulations.

A combination of hard and soft (biodegradable) materials is sometimes referred to as "biotechnical shoreline erosion control." This may involve the use of rock as well as vegetation to protect the shoreline.

Benefits of using soft-armoring (bioengineering) techniques

- Relies on living materials.
- Creates wildlife habitat for birds, insects and amphibians.
- Creates habitat for fish near the water's edge.
- Is useful for areas that are difficult to access with heavy equipment.
- Bioengineered structures are typically self-repairing (if installed and maintained properly).
- Structures become stronger as plants grow (hard-armor materials weaken over time).

Soft-armoring shoreline erosion control usually consists of a system of applications that stabilizes both the upland and the bank toe of the shoreline. Many inland lake shorelines can be stabilized by simply planting or allowing native vegetation to restore a root structure that can withstand erosive forces. Some natural shoreline projects will require temporary protection from waves and ice until the plants are well-established. Other shorelines may need a combination of riprap and vegetation, particularly those on large lakes that are experiencing active and ongoing erosion. Figure 4.10 shows some combinations of options for natural shoreline erosion control. As the problems with erosion and the wave energy increase, so does the complexity of the methods needed. Though soft-armoring typically costs less than hard-armoring, increasing complexity increases costs. With any shoreline protection or construction project, a design that does not take your lakeshore conditions into consideration may fail and leave you with a bigger and more expensive erosion problem than existed to begin with.

Caution: A design which does not take your lakeshore conditions into consideration may fail and leave you with a bigger and more expensive erosion problem than originally existed.

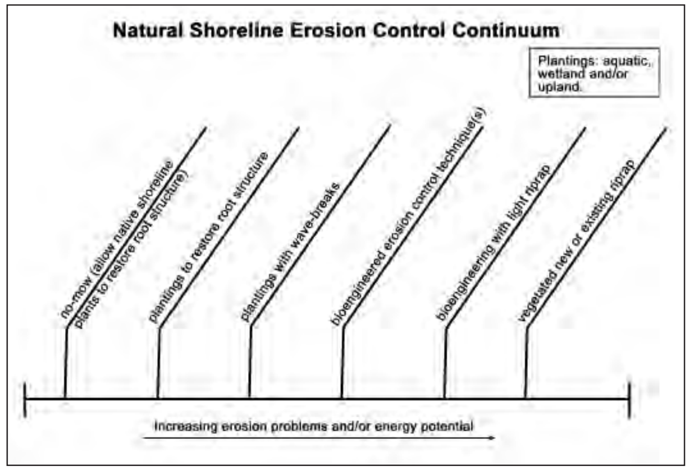


Figure 4.10. Continuum of options for natural shoreline erosion control for shorelines with increasing energy potential and/or existing erosion problems. *(Source: MSU Extension Land and Water Unit.)*

Products used in natural shoreline erosion control

Many methods and products are used in bioengineered shorelines. The products used will depend on the site and financial limitations. Remember, any work that is done on a lakeshore below the OHWM requires a permit from the MDNRE.

Coir logs

Coir fiber logs also called biologs are commonly used in soft-armoring erosion control. Figures 4.11 and 4.12 depict erosion control using coir logs and a buffer strip of aquatic and wetland plantings. The coir log eventually biodegrades, but it provides good conditions for plant growth and enhances establishment of the shoreline vegetation.

Coir logs provide good conditions for plant growth and are natural, rot-resistant, biodegradable and wildlife safe.

Figure 4.11. Bioengineered erosion control and buffer strip of native wetland and aquatic plants at seven weeks after installation. Gull Lake, Kalamazoo County, Mich. *(Photos: Jane Herbert.)*

Figure 4.12. Undercut bank stabilized with a biodegradable log (brush bundle) and plantings. *(Photo: Jane Herbert.)*

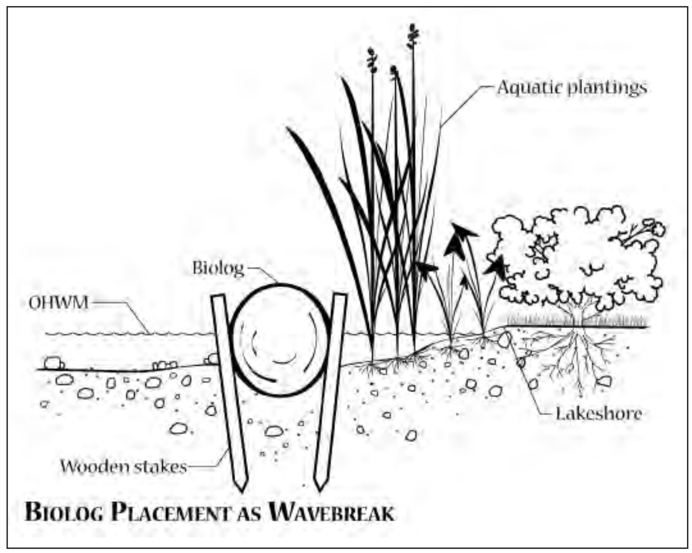


Figure 4.13. Biodegradable linear shoreline protection placed lakeward as a wave break to protect aquatic plants. *(Source: MSU Extension.)*

The coir logs can be placed directly on the bank and at the bank toe to protect and stabilize the shoreline. They can also be placed offshore to break waves, thus protecting any plantings and encouraging sedimentation to improve growing conditions. Figure 4.13 illustrates a cross-sectional view of the use of coir logs to provide a wave-break. Once installed properly, they will slowly biodegrade to leave a self-maintaining erosion prevention system. If these are not sized properly or installed correctly, they will not provide the intended protection (Figure 4.14).

Erosion control blankets

Erosion control blankets (ECBs) (Figure 4.15) are also used to prevent bank erosion due to wave action or rain events.

Woody vegetation

Woody vegetation is used in many techniques such as wattles (Figure 4.15). Wattles are bundles of branches used to protect banks from eroding. The branches used come from cuttings of shrubs such as red-osier dogwoods

Figure 4.14. Coir logs of insufficient diameter are overtopped by waves, which then disturb nearshore aquatic plantings. *(Photo: Jane Herbert.)*

Figure 4.15. Wattles staked in to secure ECBs at their overlap. Notice how the upper blanket overlaps the lower blanket. *(Photo: Jane Herbert.)*

and willows. These are bundled together and placed along the shoreline in selected areas to reduce water velocity, trap sediment and hold the soil in place. They will sprout and grow where they are placed. Live stakes (Figure 4.16) are similar cuttings of shrubs, but they are installed vertically in the ground along the shoreline.

Figure 4.16. Autumn installation of dormant live stakes (foreground) and whips to repair shoreline damaged by an uprooted tree. *(Photo: Jane Herbert.)*

Table 4.1 provides comparative information about the most common construction materials used for controlling erosion: vegetation, stone or riprap, and concrete or sheet piling, including the cost per linear foot, effectiveness, maintenance requirements, appearance, and impacts on fish and wildlife habitat for each set of materials. The information can be a tool to help in the decision process however will vary depending on the project goals and site conditions.

Table 4.1 Comparison of Erosion Control Methods

	Estimated Cost per linear foot	Effectiveness	Maintenance	Appearance	Habitat Value
Vegetation	$5 to $20, depending on type and maturity of plants selected	Excellent at reducing erosion and stabilizing flat or moderate slopes	Little maintenance required. Varies depending on desired effect	Preserves natural, scenic beauty of shoreline. Can provide a privacy screen for lake residents	Reduces soil erosion and nutrient contamination of lake. Excellent habitat for fish and wildlife
"Soft-armoring" Bioengineering	$30 - $100 depending on method selected and severity of erosion	Excellent at dissipating moderate waves, controlling erosion and stabilizing most slopes	If installed properly, requires little maintenance beyond aesthetic management.	Supports natural vegetation and scenic value	Dampens wave action. Strength and habitat value for fish and wildlife improve over time.
"Hard-armoring" Glacial stone or riprap	$20 - $40 for a shoreline with 8 feet between high and low lake levels	Excellent at dissipating moderate waves and stabilizing slopes up to 2-1.	Occasional maintenance necessary to move and replace rocks	Provides natural appearing rocky shoreline. Allows native vegetation to grow between stones.	Dampens wave action. Good habitat for fish and wildlife, especially if plant growth is allowed.
"Hard-armoring" Concrete, steel or vinyl piling	$50 - $200 depending on type of seawall	Structural barrier against strong waves and ice. Increases erosion in lake and along nearby shoreline.	Requires regular maintenance to repair cracks and check for toe erosion. Must be completely replaced or refaced upon breaking	Permanently alters shoreline contour and prevents establishment of native vegetation along lake shoreline.	Poor habitat value. Increases wave action. Reduces diverse feeding and spawning areas for fish and other aquatic animals
* These are 2000 figures. Actual costs may vary considerably, depending on local prices, the conditions at your lakeshore, and the level of erosion protection needed.					

Source: Lakeshore Protection in Indiana; Indiana Department of Natural Resources, 2007

Soft-armoring erosion control on Michigan inland lakes

Soft-armoring erosion control is an excellent solution for many inland lake properties, but this natural approach may not be sufficient to withstand the eroding forces under high wave energy situations (see Chapter 2 for the influence of wave energy on erosion).

What if I already have a seawall?

Many lakeshores already have significant sections of shoreline with hard-armored seawalls. Though these seawalls cause harm to the lake ecosystem, it is understandable that certain restrictions, such as wave energy and allowable space, do not allow for their removal. If you already have a seawall that is in excellent condition, you can reduce its negative effects. A plant buffer adjacent to

For additional information on shoreline erosion control, please see the publication "Understanding, Living With, and Controlling Shoreline Erosion – A Guidebook for Shoreline Property Owners" produced by Tip of the Mitt Watershed Council (TMWC). It can be purchased from TMWC and is also available as a free download at: **www.watershedcouncil.org**.

the seawall can offer many habitat benefits. Riprap placed in front of the seawall can help to dissipate wave energy and reduce the scour effects of waves. In Figure 4.17, the site already had a seawall. Rocks were placed in front of it and a buffer was planted in the spring of 2009. The photo was taken during the summer of 2010.

Figure 4.17. Lakeshore buffer along Gun Lake, summer 2010. *(Photo: Shawn McKenney.)*

Some sites have seawalls in poor condition. A seawall in poor condition could be replaced with a more natural solution. Figure 4.18 shows a site with a failing wooden seawall.

Figures 4.18. "Before" picture of a failing wooden seawall, *(Photo: Jane Herbert.)*

Figures 4.19. "After" picture. Erosion control included a mix of soft- and hard-armoring techniques to stabilize the shoreline and offer protection from erosive forces. *(Photo: Jane Herbert.)*

How to find help

Many shoreline properties can be stabilized with plantings. It is recommended that you seek professional assistance in designing and installing soft-armoring erosion control for sites that require techniques beyond plants. Each site is unique, and each technique has specific standards that need to be met to ensure project success. Additionally, professionals are familiar with the permit procedures.

The Michigan Natural Shoreline Partnership maintains a statewide list of Certified Natural Shoreline Professionals on its Web site: **www.mishorelinepartnership.org** (see Chapter 5 for more details on the Certified Natural Shoreline Professionals). These individuals have successfully completed the partnership's four-day certification training and a certification exam. Contacting a professional who specializes in shoreline protection and who is familiar with state regulations can ensure the most time- and cost-effective results. (The scale and intensity of shoreline processes on the Great Lakes may require different techniques than those used on smaller, inland lakes. Please seek assistance from the Michigan Department of Natural Resources and Environment, 1-800-662-9278, or other qualified professionals.)

Case study 1:

Project location: **Gull Lake, Barry and Kalamazoo counties, Mich.**
Owner: **private residence**

Problem: Waves coming from a neighboring seawall (wave flanking) were causing shoreline erosion. A no-mow zone had been installed to deter geese, filter runoff and allow shoreline plants to develop root structure that could withstand wave and ice action (Figure 4.20), but the wave flanking did not allow the plants to develop completely.

Figure 4.20. No-mow zone unable to withstand waves projected from the neighboring seawall (July 2007). *(Photo: Jane Herbert.)*

Site assessment: Gull Lake is a natural, heavily spring-fed 2,000- acre lake with five small feeder streams. A level-control structure keeps summer water levels typically 12 to18 inches above winter levels. The lake levels can rise rapidly and stay high for weeks because of heavy summer rain events and/or extended high groundwater tables. The property is shady in the afternoon. The potential wave energy was estimated to be moderate for the following reasons: no major boating lanes are within 300 feet; the property faces southwest with a perpendicular distance across the lake of 1.1 miles.

Solution: Ten feet of linear shoreline protection (coir log) was tied into the neighboring seawall. The coir log was predrilled to allow for wetland flowering plants. Light riprap was used in front of the coir log to help withstand the wave flanking (Figure 4.21).

Plant list: Sweet flag, swamp milkweed, New England aster, blue-joint grass, fringed sedge, porcupine sedge, brown fox sedge, boneset, queen of the prairie, fowl manna grass, sneezeweed, halberd-leaved rose mallow and purple osier willow live stakes.

Figure 4.21. Coir log installation, March 2008. *(Photo:Jane Herbert)*

Details: The project was installed in March 2008 to accommodate dormant live staking. Plugs were added in late spring that same year. The bank lip was hand trimmed to allow for better log placement against the bank. The coir log was placed against the bank and was staked to hold it tightly against the bank. Dormant live stakes were placed into the bank immediately behind the log.

Cost estimate: Materials are estimated to have cost $55 per foot, which included a live stake harvest from a nearby property.

Follow-up:

- A high-water event during the first growing season (2008) caused some plant loss, but the log remained in place (Figure 4.22).
- Joe-pye weed (Eupatorium sp.)already growing in the no-mow zone had begun colonizing the coir log by the end of the first growing season.
- Shade is a challenge for live stakes and the plant selection on this site.

Figure 4.22. High-water event in September 2008 caused plant loss. *(Photo: Jane Herbert.)*

- Invasive reed canary grass needs to be controlled.
- Ice push has not yet been a problem.
- Live stake survival to date is 100 percent.
- Lost plant plugs were not replaced, reducing chances for the complete colonization of the coir log.

Lessons learned:

- A 20-inch-diameter biolog would have prevented plant loss during the first-season high-water event.
- Willow trees should be trimmed back to allow for more light.
- Missing plugs or failing live stakes should be replaced to make sure the log is colonized properly.
- A maintenance plan that includes dealing with opportunistic or invasive plants is critical for successful plant establishment (Figure 4.23).
- The property owners expressed regret over not making the stakes more attractive by trimming off the blue ends and staining them to match the log.

Figure 4.23. Reed canary grass (foreground) invading the no-mow zone, August 2009. *(Photo: Jane Herbert.)*

Case study 2:

Project location: **Paw Paw Lake, Berrien County, Mich.**

Owner: **private residence**

Problem: About 100 feet of eroding shoreline (Figure 4.24) due to the turfgrass root system being too shallow to hold the bank together against wave action. The site was also difficult to mow because it was continuously wet.

Site assessment: Paw Paw Lake is a natural 891-acre lake that is 91 feet deep at its deepest point. The project site has an open, sunny, east-facing shoreline. The wave energy at this property was estimated to be moderate.

Solution: A wide native plant buffer along the shoreline with soft shoreline protection to protect the plantings. The shoreline restoration was completed in conjunction with a planned open pile deck, a boardwalk through the wetland and a permanent dock in the lake.

Plant list: 2,000 native plants, including swamp rose mallow, great blue lobelia, marsh blazing star, pickerel-weed, blue flag iris, swamp milkweed and joe-pye weed.

Figure 4.24. Eroding shoreline before the installation of a native plant buffer strip (spring 2005). *(Photo: JFNew.)*

Other materials: Ten coir logs 10-foot-long, 12-inch-diameter and 7-pound/cubic-foot-density and approximately 8 cubic yards of stone 12- to 18-inch-diameter.

Figure 4.25. Lashing down staked coir logs with nylon rope (foreground). Previously placed stones are being rearranged by hand. *(Photo: JFNew.)*

Details: Native plants were installed in groups of 20 to 40 plants per species after the turfgrass was killed with two treatments of an aquatic-approved glyphosate-based herbicide. The coir logs were placed approximately 2 to 3 feet lakeward of the shoreline and were lashed together with rope (Figure 4.25). Stones were used to avoid damage to the coir logs during the construction process. Once the logs were set, the stones were rearranged by hand to provide additional shore protection. Native wetland plants were installed in and behind the coir logs (Figure 4.26).

Cost estimate: The project cost approximately $160 per linear foot, including all materials and labor.

Figure 4.26. Planting native wetland plants in and behind the coir logs (May 2005). *(Photo: JFNew.)*

Follow-up:

- As of 2009, follow-up inspections have shown a stable shoreline and no structural failures in the bioengineered shoreline.
- The native plants have been successful (Figure 4.27). Follow-up maintenance was necessary and included the selective weeding of undesired species, including willows and smartweeds.

Figure 4.27. A native plant buffer strip with a boardwalk (July 2006). The coir logs are completely colonized by wetland plants. *(Photo: JFNew.)*

Lessons learned:

- A maintenance plan that includes dealing with opportunistic or invasive plants is critical for successful plant establishment. In any shoreline project, follow-up weed management is essential for long-term success in both aesthetics and functionality. Shorelines have naturally rich, moist soil conditions, which can make them vulnerable to invasion by a wide array of less desirable but opportunistic native wetland plants and/or invasive plants. This is especially true once the shoreline is protected from wave action.

Case study 3:

Project location: **Klinger Lake, St. Joseph County, Mich.**

Owner: **private residence**

Problem: The shoreline was receding because the turfgrass root system was too shallow to hold the bank together against wave action (Figure 4.28). The property was receiving wave flanking from neighboring seawalls on both sides. An attempt to stop the recession with small boulders failed.

Site assessment:

Klinger Lake is a natural 830-acre lake. A level-control structure keeps summer water levels typically 12 to 18 inches above winter levels. The property has full sun at the shoreline. The wave energy was estimated to be low.

Figure 4.28. Shoreline recession (foreground) at low (winter) water levels (April 2006). *(Photo: landowner.)*

Solution: The receded area was filled with soil to reclaim this area. The shoreline protection consisted of 40 feet of coir logs and a small amount of rock riprap at each end to protect the project from waves flanking off adjacent seawalls.

Plant list: 56 wetland plants: blue flag iris, blue lobelia, cardinal flower, marsh blazing star, soft-stem bulrush, porcupine sedge and swamp oval sedge.

Other materials: Silt fence (required to prevent fill from entering the lake); glacial stone riprap (4 to 8 inches in diameter); gravel and topsoil fill; vinyl geoweb with metal stakes; sod to cover fill; four 10-foot coir logs, 16-inch diameter and 9-pound/cubic foot density, predrilled to accept wetland plugs every 6 inches; 3/8-inch manila rope; wooden stakes; stakes and string to construct waterfowl exclusion.

Details: The fill and erosion control was completed on April 14, 2006. The fill consisted of gravel and topsoil reinforced with vinyl geoweb and then stabilized with sod. The shoreline protection consisted of 20 foot-long predrilled coir logs (Figure 4.29) the entire length of the property. The logs were connected end-to-end and secured with a row of stakes and rope. Light rock riprap (4 to 8 inches in diameter) was used at both ends of the project at the neighboring seawalls to protect the log ends from wave flanking. The logs were planted with wetland plant plugs on May 23, 2006.

Cost estimate: The cost of the project is estimated to be $55 per linear foot, which includes materials as well as 34 hours of homeowner labor valued at $12 per hour.

Figure 4.29. Gravel and topsoil fill reinforced with vinyl geoweb. *(Photo: landowner.)*

Follow-up:

First season

- Some wetland plants were lost on one end of the project because of overtopping waves and grazing down by waterfowl. A stake and string exclosure constructed in late May solved the grazing problem (Figure 4.30).
- Ice action pushed the center of the project landward, creating a gap on one end that allowed waves to erode the new fill. A 2- by 2-foot hole was created. Fill was replaced and blanketed, and existing riprap was rearranged to protect the fill.

Second season

- Good plant growth (Figure 4.31), but jewelweed (Impatiens capensis), an opportunistic native wetland plant, began to colonize the logs and compete with planted plugs. The shallow roots of jewelweed provide no erosion control benefit. The landowner started weeding regularly.
- Ice push was not a problem.

Figure 4.30. A stake and string exclosure created to deter the grazing of plants by waterfowl. *(Photo: landowner.)*

Figure 4.31. The Klinger Lake project, second growing season (2007). *(Photo: landowner.)*

Third season

- Plants are colonizing the logs. The homeowner notes that flowering wetland plants are more vigorous on the shallower end of the project, and emergent aquatic plants (rushes and sedges) are more vigorous on the deeper end of the project.
- Ice push was not a problem.

Lessons learned:

1. The displacement of logs by ice push may have been avoided by staking the logs on the lakeward side.
2. One end of the project is farther lakeward than the other because the coir logs were lined up with the adjacent seawalls, which were historically built without regard for the ordinary high water mark. Overtopping of waves during high water can be a problem in the deeper water end of the project. This resulted in the loss of some plants during the first growing season, and sand continues to be deposited on land behind the log at the deeper end (Figure 4.32). This problem may have been avoided by using a 20-inch-diameter log on the deeper end of the project, or following the OHWM for the entire length of the project, regardless of the location of neighboring seawalls.
3. On lakes where waterfowl are a problem, an exclosure should be constructed immediately after planting.
4. A maintenance plan that includes dealing with opportunistic or invasive plants is critical for successful plant establishment.

Figure 4.32. Sand deposited behind a log that was placed below the OHWM. *(Photo: Courtesy of landowner.)*

Chapter

5

Plant Selection, Planting Stock and Site Preparation

In this chapter, you will learn about:

- The concept of "right plant, right place."
- Ideas on how to choose plants.
- Suggested native plants.
- Types of plant stock.
- Finding native plant nurseries.
- Finding professional help.

Choosing the Right Plants

Overview

Property owners face some challenges when trying to correct erosion problems, develop a natural shoreline or just add some Michigan native plants into their lakeshore landscapes. These challenges include choosing the right plant, identifying the best installation options, finding locations to purchase native plants, and finding a knowledgeable professional who can appropriately and effectively fix the erosion problem with natural techniques. The following information is intended to help property owners overcome these challenges.

Right plant, right place

Once the general plan has been created, an important next step involves choosing the right plants. These plants will need to meet the site characteristics, reinforce the design concepts and serve the property owner's expectations. The degree to which a plant performs a function is determined by the physical characteristics of the plant, including overall form, leaf shape and size, branching structure, root structure and rooting depth; its soils and environmental requirements; and the physical conditions at the proposed site. In natural shoreline projects, native plants specific to lakeshore habitats are highly recommended because they are adapted to the lakeshore conditions and provide fish and wildlife habitat.

The "right plant, right place" approach selects plants through a process that integrates the function, appearance and adaptability of the plant and the management required to ensure long-term success. It also considers the relationships between plants, insects and wildlife that are critical in a healthy natural shoreline landscape.

Plant selection begins with looking closely at the site conditions, what is already growing in or near a lake, and property owner expectations. The information collected as part of a site inventory (see Chapter 3) will assist you, natural resource professionals, nurseries, landscape contractors and consultants in identifying the right plants for your shoreline.

Plant selection considerations

The ordinary high water mark (OHWM)

Many lakeshore property owners may have heard the term "ordinary high water mark" (OHWM). The OHWM is the level where the presence and action of waters are so common and maintained for a sufficient period of time that they leave evidence on the landscape. (See Chapter 7 for more OHWM discussion.) Evidence of the OHWM may be debris deposits, marks on trees or marks on seawalls. It is usually the point at which natural vegetation shifts from mostly water-dependent plants to terrestrial plants. Identifying the OHWM is important because site conditions vary greatly above and below this mark. Certain plants will be adapted to grow in conditions below the OHWM, and others will be adapted to grow above the OHWM.

Native plants

Plants native to Michigan are highly recommended for any natural shoreline project. For projects that require a permit from the Michigan Department of Natural Resources and Environment (MDNRE), native plants must be used below the OHWM (see Chapter 7 for more discussion on the MDNRE permit).

> The MDNRE Bioengineering Minor Permit requires that native plants are used below the OHWM.

Here's the definition of a native plant from the Plant Conservation Alliance: "A native or indigenous species is one that occurs in a place (e.g., habitat and ecosystem) as a result of natural forces exclusive of human actions. Species native to the U.S. and other parts of North America are generally recognized as those occurring on the continent prior to European settlement." Plants that have local origins are of the greatest importance. A native plant grown from seed or cuttings that were taken from the immediate area is more ecologically desirable than a plant grown from another U.S. region, even though they may share the same scientific name.

Native plants are adapted to the site and climatic conditions in their natural habitats. They provide fish and wildlife habitat along lakeshores. Selecting plants according to site conditions and natural habitat will ensure that shoot and root characteristics will provide maximum benefits. Figure 5.1 depicts the root depth of some native plants associated with lake shorelines.

Non-native plants

Non-native plants contribute to aesthetics, environmental quality and ecological function in similar ways as native plants and can be used effectively above the OHWM. Plant selection above the OHWM can include both native and non-native species using the right plant, right place approach to emphasize aesthetics, structural characteristics, environmental attributes and ecological functionality. These plants can also provide food and shelter for wildlife, stabilize soil, filter stormwater and enhance the overall appearance of many landscapes. The selection criteria for non-native plants should include biological character – how a plant reproduces and how it interacts within the environment. For example, a non-native plant may be very aggressive in its growth characteristics and

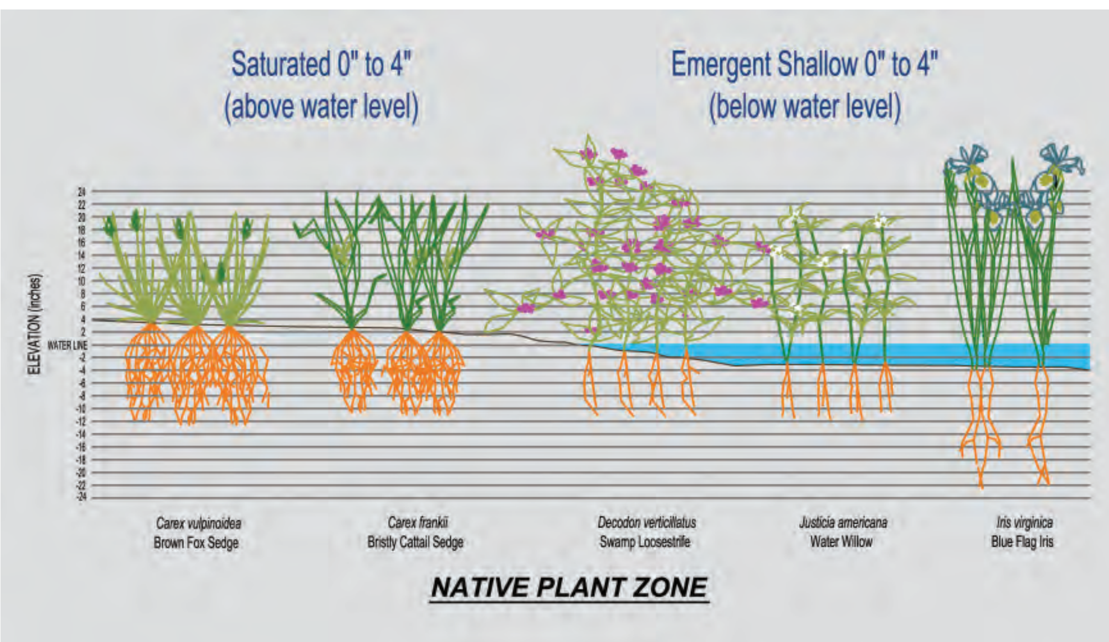


Figure 5.1. Depth of root systems on select native wetland plants. *(Source: JFNew.)*

have the potential to become invasive and outcompete other plants. Examining biological character is important in preventing the introduction of potentially invasive plants. Native or non-native invasive plants should never be used. (See Chapter 6 for more information on invasive plants.)

Shoreline Zones

Chapter 2 identifies three zones along a lakeshore: upland, wetland and aquatic. During the initial planning phase, the property should be divided into each of these areas. This is important because long-term establishment and performance of the plants depend on understanding the site conditions and choosing the correct plants. Diverse plantings can lead to an area having various types of flowers throughout the seasons and attracting several species of birds and butterflies. If a particular open view is important, then short plants should be chosen. The native plant lists found in this chapter can assist in finding the right plant for the right zone.

Aquatic zone

The plants found in this zone are the emergent, submergent and floating-leaf plants (Figure 5.2). Some lakes may not have a naturally occurring aquatic zone because of the lake size, wave action and depth. Trying to create an aquatic zone where one did not naturally exist will be a waste of time and money. Types of plants in this zone are fairly limited. For the low-energy sites, only two to three species of plants should be chosen from the suggested list to limit competition between plants. As the plants grow, they will naturally move around to find the best conditions. Remember, even in low-energy situations, wave-break protection will probably be necessary to ensure plant establishment.

Figure 5.2. An emergent plant example: pickerelweed – Pontederia cordata. *(Photo: Amy Peterson)*

Wetland zone

Plant selection for this zone must consider wetness duration, water level fluctuations and the OHWM. The plants found between the water level and the OHWM like consistently wet soil throughout the year, but they can tolerate some drier periods. Most importantly, the plants closest to the lake should be best suited to maintaining a stable shoreline against the powers of waves and ice. A diverse group of plants – grasses, sedges, rushes, forbs, shrubs and trees– is highly recommended but not always necessary depending on the site.

Upland zone

These plants will be in the drier locations upslope of the wet areas. They also play an important role in maintaining a stable shoreline. Consider low-growing herbaceous plants as well as shrubs and trees to gain the most benefit. Keep in mind that most lakeshores were once heavily wooded. You may be reluctant to plant trees, but it can be done without obscuring the view if trees are planted and maintained properly (Figure 5.3).

Figure 5.3. A forested lakeshore with trees pruned for a view. *(Photo: Jane Herbert.)*

Plant List

The following plant list (Table 5.1) has been developed to make plant selection easier. Each of the plants on the list is native to Michigan, and none are listed as threatened or endangered. From the many plants native to Michigan, the plants on this list were chosen because they are generally broadly adapted to a variety of site conditions (meaning that they are not extremely fussy about where they grow), they have a broad natural distribution around the state, and they are currently on the market.

The list has four categories. The first three categories are plants that are associated with aquatic and wetland habitats. The fourth category has plants associated with an upland habitat. The plants have been placed in each category on the basis of their suitability for the water levels and other variables such as wave action. Once these plants have been planted, however, they may move into different areas. This occurs because natural conditions at each particular site are highly variable, and each plant will find areas most suitable for its growth.

- **Below the water level:** These are the plants that are found in the aquatic zone. Use these plants for planting areas within the lake.

Table 5.1. Michigan Natural Shoreline Partnership suggested native plants.

Planting zone = below the water level							
Botanical name	**Common name**	**Sun***	**Height****	**Bloom time**	**Color**	**Siltation**	**Adaptive features**
Acorus calamus	Sweet flag	f/p	1’-4’	May-June	Green	Low	Aromatic leaves; clump-forming; wildlife food and cover
Alisma plantago-aquatica	Water plantain	f	2’-4’	July-Sept	White	High	Tolerates water fluctuation; wildlife food and cover
Cephalanthus occidentalis	Buttonbush	f/p/s	15’	June-Aug	White	High	Deep, spreading roots; commonly used as live stakes
Iris versicolor	Blue flag (wild iris)	f/p	2’-3’	May-July	Blue	Medium	Tuberous roots send out fibrous masses
Iris virginica	Blue flag (wild iris)	f/p/s	2’’-3’	May-July	Purple	Medium	Tuberous roots send out fibrous masses
Nuphar advena	Yellow pond lily	f/p	1’	May-Sept	Yellow	High	Breaks up wave action; deep-water plant
Nymphaea tuberosa	White water lily	f/p	1’	May-Sept	White	High	Breaks up wave action; deep-water plant
Peltandra virginica	Arrow arum	f/p/s	2’-5’	June-July	Green	High	Massive root system forms clumps
Pontederia cordata	Pickerelweed	f/p	1’-3’	June-Sept	Violet	Med./high	Thick, spreading rhizomes; forms colonies
Sagittaria latifolia	Arrowhead	f/p	1’-4’	June-Sept	White	Medium	Wildlife food and cover
Sagittaria rigida	Stiff arrowhead	f/p	1’-3’	July-Sept	White	Med./high	Wildlife food and cover
Schoenoplectus acutus	Hard-stem bulrush	f	3’-9’	May-Sept	Brown	Medium	Spreads opportunistically by rhizomes
Schoenoplectus pungens	Three-square bulrush	f/p	3’-5’	July-Sept	Brown	Medium	Spreads opportunistically by rhizomes
Schoenoplectus tabernaemontani	Soft-stem bulrush	f/p	3’-9’	June-Sept	Brown	Medium	Spreads opportunistically by rhizomes
Sparganium eurycarpum	Common bur-reed	f	2’-6’	May-Aug	Green	High	Spreads readily from rhizomes; can be opportunistic

Table 5.1. Michigan Natural Shoreline Partnership suggested native plants, continued.

Planting zone = between the water level and the ordinary high water mark							
Botanical name	**Common name**	**Sun***	**Height****	**Bloom time**	**Color**	**Siltation**	**Adaptive features**
Alnus incana	Speckled alder	f/p/s	25'	Mar-May	Brown	Medium	Shallow-rooted; can be opportunistic
Asclepias incarnata	Marsh milkweed	f/p	3'-5'	June-Sept	Pink	Medium	Monarch host; rhizomes form single plants
Aster puniceus	Swamp aster	f/p	3'-6'	Aug-Oct	Lav/white	Med./high	Spreads opportunistically from rhizomes
Betula pumila	Bog birch	f/p	3'-7'	Apr-May	Yellow		
Carex aquatilis	Water sedge	f/p	2'-3'	Apr-June	Green	High	Spreads opportunistically by rhizomes
Carex comosa	Bristly sedge	f/p	2'-3'	May-June	Green	High	Rhizomes form dense clumps
Carex hystericina	Porcupine sedge	f/p/s	2'-3'	May-June	Green	Med./high	Rhizomes form dense clumps
Carex lacustris	Lake sedge	f/p/s	2'-4'	May-June	Green	Medium	Spreads opportunistically by rhizomes
Carex stricta	Tussock sedge	f/p	2'-3'	Apr-June	Brown	Med./high	Forms hummocks; slow- spreading with dense roots
Cornus amomum	Silky dogwood	f/p	10'	May-July	White	Low	Wildlife; fibrous roots; can be opportunistic; commonly used as live stakes
Cornus sericea	Red-osier dogwood	f/p	10'	May-Sept	White	Med./high	Wildlife; fibrous roots; can be opportunistic; commonly used as live stakes
Decodon verticillatus	Swamp loosestrife	f/p	2'-4'	July-Sept	Magenta		Often colonizes in monotypic stands – has great potential in bioengineering techniques
Elymus virginicus	Virginia wild rye	f/p	2'-4'	June	Green	Medium	Bunching, cool-season, short-lived
Eupatorium maculatum	Joe-pye weed	f/p	4'-7'	June-Oct	Pink	Low	Shallow, fibrous roots
Eupatorium perfoliatum	Boneset	f/p	3'-5'	July-Oct	White	Low	Shallow, fibrous roots
Eupatorium purpureum	Purple joe-pye weed	p/s	3'-6'	July-Sept	Pink	Low	Shallow, fibrous roots; more shade-tolerant than the other Eupatoriums
Juncus balticus	Baltic rush	f/p	1'-2'	May-Aug	Brown	High	Spreads opportunistically by rhizomes, forming clumps; prefers sandy shores
Juncus effusus	Soft rush	f/p	1'-4'	July	Brown	High	Spreads opportunistically by rhizomes
Lobelia cardinalis	Cardinal flower	f/p	2'-4'	July-Sept	Red		Shallow roots, short-lived
Lobelia siphilitica	Great blue lobelia	f/p	1'-3'	July-Sept	Blue		Shallow, fibrous roots
Mimulus ringens	Allegheny monkeyflower	f/p	1'-3'	July-Sept	Blue		
Myrica gale	Sweet gale	f/p	2'-6'	May-June	Yellow-green		
Penthorum sedoides	Ditch stonecrop	f/p	1'-3'	June-Oct	Green	Medium	Fibrous, shallow root system; can be opportunistic
Polygonum amphibium	Water smartweed	f/p	1'-2'	June-Oct	Rose	Med./high	Spreads by rhizomes
Populus deltoides	Eastern cottonwood	f	75'-100'	Apr-May	Brown	High	Commonly used as live stakes

Table 5.1. Michigan Natural Shoreline Partnership suggested native plants, continued.

Planting zone = between the water level and the ordinary high water mark, continued							
Botanical name	**Common name**	**Sun***	**Height****	**Bloom time**	**Color**	**Siltation**	**Adaptive features**
Rosa palustris	Swamp rose	f/p/s	2'-7'	June-Aug	Pink		
Salix discolor	Pussy willow	f/p	15'-25'	May	Silver	Medium	Wildlife; fibrous roots; can be opportunistic; commonly used as live stakes
Salix interior	Sandbar willow	f	6'-20'	Apr-May	Yellow	High	Commonly used as live stakes
Salix nigra	Black willow	f/p	35'-50'	Apr-May	Yellow-green	Med	Commonly used as live stakes; shallow roots
Saururus cernuus	Lizard's tail	p/s	2'-4'	June-Aug	White	Med./high	Spreads by rhizomes
Scirpus fluviatilis	River bulrush	f	3'-7'	May-July	Green	High	Spreads opportunistically by rhizomes
Scripus cyperinus	Wool grass	f	3'-5'	June-Sept	Tan	High	Strong, fibrous roots form clumps in high water

Planting zone = above the ordinary high water mark							
Botanical name	**Common name**	**Sun***	**Height****	**Bloom time**	**Color**	**Siltation**	**Adaptive features**
Acer rubrum	Red maple	f/p/s	75'-100'	Mar-May	Green/red		
Acer saccharinum	Silver maple	f/p	75'-100'	Mar-Apr	Red		Shallow, widespread, fibrous roots
Anemone canadensis	Canada anemone	f/p	1'-2'	May-Sept	White	Medium	Rhizomes spread readily with some stabilization of soils
Aster novae-angliae	New England aster	f/p	3'-6'	July-Oct	Violet	High	Short rhizomes; readily reseeds on disturbed soils
Aster umbellatus	Tall flat-top white aster	f/p	1'-4'	July-Oct	White	Medium	Fibrous roots
Betula alleghaniensis	Yellow birch	p/s	60'-80'	Apr-May	Purple/ yellow		
Calamagrostis canadensis	Canada blue-joint grass	f/p	2'-4'	June	Brown	Medium	Spreads opportunistically by rhizomes
Carex crinita	Fringed sedge	f/p/s	2'-5'	May	Green	Med./high	Likes semi-shade; forms dense clumps
Carex stipata	Awl-fruited sedge	f/p/s	1'-3'	Apr-May	Brown	High	Prefers calcareous soils; fibrous roots form clumps
Carex vulpinoidea	Fox sedge	f/p	2'-3'	May-June	Brown	Med./high	Rhizomes form dense clumps
Celtis occidentalis	Hackberry	f/p	50'-75'	Apr-May	Yellow-green	Low/med.	Deep, spreading roots, medium to fast growing, long-lived
Chelone glabra	Turtlehead	f/p/s	2'-4'	Aug-Sept	Cream	Low	Deep, fibrous roots
Cinna arundinacea	Sweet woodreed	f/p/s	3'-4'	Aug-Sept	Green		
Coreopsis tripteris	Tall tickseed	f/p	4'-8'	Aug-Sept	Yellow	Low	
Elymus riparius	Riverbank wild rye	p/s	2'-4'	July-Aug	Green		
Euthamia graminifolia	Grass-leaved goldenrod	f/p	1'-4'	July-Sept	Yellow	Low	Spreads opportunistically from rhizomes
Gleditsia triacanthos	Honey locust	f/p	30'-75'	May-June	Yellow		

Planting zone = above the ordinary high water mark, continued

Botanical name	Common name	Sun*	Height**	Bloom time	Color	Siltation	Adaptive features
Glyceria striata	Fowl manna grass	f/p/s	1'-5'	May-June	Green	High	Bunching, cool-season grass with dense roots
Helenium autumnale	Sneezeweed	f/p	3'-5'	July-Nov	Yellow	Low	Fibrous, shallow root system; can be opportunistic
Helianthus giganteus	Tall sunflower	f/p	5'-12'	July-Sept	Yellow	Medium	Spreads from rhizomes
Ilex verticillata	Michigan holly	f/p/s	6'-12'	May-June	White		Male and female plants; prefers acidic soil; shallow, fibrous roots
Juncus torreyi	Torrey rush	f	1'-2'	June-Sept	Brown	High	Spreads opportunistically by rhizomes
Liatris spicata	Dense blazing star	f	3'-5'	July-Sept	Pink		
Onoclea sensibilus	Sensitive fern	p/s	1'-2'		Green	Low	Branching rhizomes
Osmunda regalis	Royal fern	f/p/s	3'-6'		Green	Low/med.	Stout rhizomes, fibrous roots, spreads slowly
Panicum virgatum	Switchgrass	f/p	4'-6'	Aug-Oct	Green	Low/med.	Bunching, cool-season grass with dense roots
Physocarpus opulifolius	Ninebark	f/p	10'	May-June	White		Commonly used as live stakes
Physotegia virginiana	Obedient plant	f/p	2'-5'	Aug-Oct	Pink	Low	Nectar source; spreads by small rhizomes to carpet area
Platanus occidentalis	Sycamore	f/p/s	100'	Apr-June	Green		
Populus balsamifera	Balsam poplar	f	60'-80'	Apr-May	Yellow-brown		Clonal – propagate by stem cuttings
Pycnanthemum virginianum	Virginia mountainmint	f/p	1'-3'	July-Sept	White	Low/med.	Stoloniferous rhizomes, aromatic
Quercus bicolor	Swamp white oak	f/p/s	70'	May	Green/ yellow	Medium	Shallow, fibrous roots; prefers acidic soil
Quercus rubra	Red oak	f/p/s	90'	May	Green/ yellow		Fast growing
Rudbeckia laciniata	Cut-leaved coneflower	f/p/s	3'-10'	July-Sept	Yellow		
Sambucus canadensis	American elderberry	f/p/s	5'-12'	June-Aug	White		Spreads by rhizomes
Scripus atrovirens	Green bulrush	f	3'-5'	June-Aug	Brown	High	Strong, fibrous roots form clumps in high water
Solidago ohiensis	Ohio goldenrod	f/p	2'-4'	July-Oct	Yellow		
Solidago patula	Roundleaf goldenrod	f/p/s	3'-6'	Aug-Oct	Yellow		
Solidago riddellii	Riddell's goldenrod	f	2'-3'	Sept-Nov	Yellow	Medium	
Spartina pectinata	Prairie cord grass	f	3'-7'	July-Aug	Green	High	Spreads opportunistically by rhizomes
Spiraea alba	Meadowsweet	f/p	3'-6'	June-Aug	White	Low/med.	Dense, fibrous roots; can be opportunistic; suckering, shallow roots

Planting zone = above the ordinary high water mark, continued

Botanical name	Common name	Sun*	Height**	Bloom time	Color	Siltation	Adaptive features
Thalictrum dasycarpum	Purple meadow rue	f/p	3'-6'	May-July	Cream	Med./high	Fibrous, shallow root system; can be opportunistic
Thuja occidentalis	Northern white cedar	f/p/s	50'	Apr-May	Brown		Favorite deer browse
Tilia americana	Basswood	f/p	60'-100'	June-July	Yellow		
Verbena hastata	Blue vervain	f/p	3'-6'	June-Sept	Violet	Med./high	Short, spreading, tough roots; any soils; opportunistic; short-lived
Vernonia missurica	Missouri ironweed	f	3'-5'	July-Sept	Purple	Med./high	Nectar source; thick root system
Veronicastrum virginicum	Culver's root	f/p	2'-6'	June-Sept	White	Low	Nectar source; thick root system; likes alkaline soils
Viburnum dentatum	Arrowwood	f/p/s	15'	May-June	White	Low	Suckering
Viburnum lentago	Nannyberry	p/s	20'	Apr-June	White	Low	Suckering; shallow, fibrous roots
Zizia aurea	Golden Alexanders	f/p/s	1'-3'	Apr-June	Yellow	Med./high	Nectar source; thick root system

Planting zone = upland

Botanical name	Common name	Sun*	Height**	Bloom time	Color	Adaptive features
Forbs						
Actaea pachypoda	White baneberry	p/s	1'-2'	May	White	Woodland
Actaea rubra	Red baneberry	p/s	1'-2'	May	White	Woodland
Agastache scrophulariifolia	Purple giant hyssop	p/s	3'-7'	July-Oct	Purple	Attracts bees and butterflies
Allium cernuum	Nodding wild onion	f/p	1'-2'	July-Aug	Pink	Low-growing and versatile
Aquilegia canadensis	Wild columbine	f/p/s	1.5'	Apr-July	Red/yellow	Attracts hummingbirds; woodland wildflower, short-lived perennial
Aralia racemosa	Spikenard	f/p/s	3'-6'	June-Aug	White	Versatile and very attractive in seed
Asarum canadense	Wild ginger	s	.5'	Apr-May	Dark red	Ground cover, woodland
Asclepias tuberosa	Butterfly weed	fp	1'-3'	June-Aug	Orange	Attracts butterflies, especially monarchs; sandy soils
Aster laevis	Smooth aster	f/p	3'-5'	Aug-Oct	Blue	Nectar source for butterflies and seed source for birds
Aster macrophyllus	Big-leaf aster	p/s	1'-3'	July-Aug	Violet	Larval host and nectar source for butterflies; good for dry shade; found over a large portion of the state
Aster oolentangiensis	Prairie heart-leaved aster	f/p	2'-3'	Aug-Sept	Blue	Larval host and nectar source for butterflies

Planting zone = upland, continued						
Botanical name	**Common name**	**Sun***	**Height****	**Bloom time**	**Color**	**Adaptive features**
Forbs *(continued)*						
Campanula americana	Tall bellflower	p/s	6'	June-Sept	Blue	Adapted to moist ground, open moist woods and streambanks
Campanula rotundifolia	Harebell	f	1'-2'	June-Aug	Blue	Low-growing and well adapted to dry slopes; not competitive when combined with other plants – they are easily outcompeted without regular thinning of other plants
Caulophyllum thalictroides	Blue cohosh	p/s	1'-3'	Apr-May	Yellow	Woodland; berries turn dark blue; deer-resistant
Coreopsis lanceolata	Sand coreopsis	f	2'	June-July	Yellow	Grows great on sandy soils but also on well-drained loamy soils; readily reseeds; provides seed for birds and nectar for butterflies
Coreopsis tripteris	Tall coreopsis	f	3'-6'	July-Sept	Yellow	Tolerant to heat, humidity and drought
Echinacea pallida	Pale purple coneflower	f	2'-5'	May-Aug	Lavender	Attracts butterflies, hummingbirds and small songbirds (not considered to be native to Michigan, although a very worthy species)
Fragaria virginiana	Wild strawberry	f/p	0.5'	April-June	White	Ground cover; beneficial to wildlife; edible fruit
Geranium maculatum	Wild geranium	p/s	1.5'-2.5'	April-June	Lavender	Woodland
Heliopsis helianthoides	False sunflower	f/p	2'-5'	June-Sept	Yellow	Easily grown; grows well in clay
Helianthus occidentalis	Western sunflower	f/p	2'-3'	July-Sept	Yellow	Nectar and seed source
Heuchera americana	Alum root	p/s	1'-3'	May-June	Green	Deer-resistant
Liatris aspera	Rough blazing star	f	2'-5'	Aug-Sept	Purple	Drought-tolerant; attracts butterflies; blooms late
Monarda fistulosa	Wild bergamot	f/p	2'-4'	June-Sept	Purple	Aromatic; attractive to butterflies and hummin-birds
Penstemon digitalis	Foxglove beard tongue	fps	3'-4'	May-June	White	Beautiful flower, attractive to butterflies and hummingbirds; deer-resistant
Penstemon hirsutus	Penstemon	f	1'-2'	May-July	Pink	Low-growing and well-adapted to dry slopes; attractive to birds
Polygonatum biflorum	True Solomon's seal	f/p/s	1'-4'	Apr-June	Green/ white	Deer-resistant
Ratibida pinnata	Yellow coneflower	fp	3'-5'	July-Sept	Yellow	Wildlife benefits; attracts butterflies; sandy and clay soils
Rudbeckia fulgida	Black-eyed Susan	f/p	2'-3'	Aug-Oct	Yellow	Nectar source for butterflies
Rudbeckia hirta	Black-eyed Susan	f/p	1'-3'	June-Sept	Yellow	Wildlife benefits; does well in sandy soils
Rudbeckia triloba	Three-lobed coneflower	f/p	2'-4'	Aug-Oct	Yellow	Low, wet woods, thickets, rocky slopes
Silphium terebinthinaceum	Prairie dock	f	2'-10'	July-Sept	Yellow	Tall and wild – a true prairie species; nectar and seed source
Smilacina racemosa	False Solomon's seal	p/s	1'-2'	May-June	White	Woodland

Planting zone = upland, continued						
Botanical name	**Common name**	**Sun***	**Height****	**Bloom time**	**Color**	**Adaptive features**
Forbs *(continued)*						
Smilacina stellata	Starry Solomon's seal	f/p	1'-2'	May-July	White	Moist meadows in woodlands, woodland borders, sandy riverbanks, semi-wooded slopes
Solidago juncea	Early goldenrod	f/p	2'-4'	June-Sept	Yellow	Attracts butterflies, moths, game birds and songbirds
Solidago rigida	Stiff goldenrod	f	1'-5'	July-Oct	Yellow	Tall and wild – a true prairie species; nectar source
Solidago speciosa	Showy goldenrod	f/p	1'-4'	July-Oct	Yellow	Tall and wild – a true prairie species; nectar source
Tradescantia ohiensis	Spiderwort	f/p	2'-4'	June-July	Blue	Wildlife cover; has a long bloom time
Verbena stricta	Hoary vervain	f	2'-3'	July-Sept	Dark blue	Tall and wild – a true prairie species; nectar source
Ferns and grasses						
Andropogon gerardii	Big blue stem	f/p	3'-8'	July-Aug	Green	Grass; erosion control use, beneficial to birds; can be opportunistic
Cystopteris bulbifera	Bulblet fern	p/s	2'-3'			Needs consistent moisture but well-drained soil
Elymus canadensis	Canada wild rye	f	2'-5'	June-Aug	Green	Grass; cool-season, clump-forming; dry, sunny slopes
Hystrix patula	Bottlebrush grass	s	3'	May-June	Green	For dry shade, savanna, rocky upland woodlands
Koeleria macrantha	June grass	f	1'-2'	May-June	Green	Clay soils, woodlands; tolerates seasonal flooding
Polystrichum acrostichoides	Christmas fern	p/s	1'-2'			Fern; grows in fountain-like clumps; erosion control
Schizachyrium scoparium	Little blue stem	f	2'-4'	Aug	Green	Grass; attractive reddish brown fall color
Sisyrinchium angustifolium	Blue-eyed grass	f/p	1'	May-Aug	Blue	Short and very attractive
Sorghastrum nutans	Indian grass	f/p	4'-6'	Aug	Green	Grass; showy; clump-forming; larval host and nectar source for butterflies
Sporobolus heterolepis	Prairie dropseed	f/p	1'-3'	Aug-Sept	Green	Very ornamental
Trees and shrubs						
Acer saccharum	Sugar maple	f/p	100'	April-May	Yellow	Tree; shade provider; used for maple syrup production
Amelanchier arborea	Serviceberry	f/p/s	15'	April-May	White	Shrub; attracts game birds and songbirds; edible berry
Betula papyrifera	Paper birch	f/p	30'-60'	May-June	Brown	Larval host for butterflies
Ceanothus americanus	New Jersey tea	f/p	3'-4'	June-July	White	Shrub; taprooted; drought-tolerant; larval host and nectar source for butterflies
Cercis canadensis	Redbud	f/p/s	16'	May	Pink/purple	Shrub; flowers bloom early spring; larval host and nectar source for butterflies

Planting zone = upland, continued						
Botanical name	**Common name**	**Sun***	**Height****	**Bloom time**	**Color**	**Adaptive features**
Trees and shrubs *(continued)*						
Corylus americana	Hazelnut	f/p	3'-13'	Mar-April	Yellow	Shrub; beneficial to a variety of wildlife; fruit is edible; plants are either male or female
Hamamelis virginiana	Common witchhazel	p/s			Yellow	
Pinus strobus	White pine	f/p	150'			Evergreen tree; tolerates many soil types; Michigan's state tree
Prunus americana	Wild plum	f/p	10'-25'	April-May	White	Larval host for butterflies; fruit is edible
Prunus serotina	Black cherry	f/p	50'-85'	May-June	White	Fruit is edible; larval and nectar source for butterflies
Ptelea trifoliata	Hop tree	f/p	6'-15'	June	Green	Larval host for butterflies
Quercus alba	White oak	f/p	25'			Tree; excellent residential tree; large crown; red fall color
Quercus macrocarpa	Bur oak	f	60'-85'	May-June	Green	Larval host for butterflies; food source for wildlife
Quercus rubra	Red oak	f	65'-90'	May-June	Green	Larval host for butterflies; food source for wildlife
Quercus velutina	Black oak	f	60'-80'	May-June	Green	Larval host for butterflies; food source for wildlife
Sambucus canadensis	American elder	f/p	5'-12'	June-July	White	Fruit is edible; great for birds
Sambucus racemosa (pubens)	Red-berried elder	f/p	5'-12'	May-June	White	Found all over the state; great for birds
Staphylea trifolia	American bladdernut	p/s	10'-15'	May	White	Shrub; easily grown
Viburnum acerifolium	Maple-leaf viburnum	f/p/s	2'-6'	June	White	Shrub; reddish purple fall color; black fruit; beneficial to wildlife

* Light requirements: f = full sun, f/p = full sun to partial shade, f/p/s = full sun to shade, p/s = partial shade to sun, s = shade

** Height at 20 years

This list of native plants suggested for use in natural shoreline design was developed by the plant subcommittee of the Michigan Natural Shoreline Partnership's Research and Demonstration Committee.

- **Between the water level and the ordinary high water mark:** These plants like it wet but do not like to actually be in the lake. They can handle frequent water level changes ranging from being flooded for days at a time to being dry for short periods of time. These plants are also the best ones to withstand the energy from wave action and ice push.
- **Above the ordinary high water mark:** These plants are still considered wetland plants, but they are typically farther from the lake edge. They like the soil to be consistently moist, and they can handle a small amount of flooding. They do not like the constant stress that comes from waves and ice.
- **Upland plants:** These plants like dry conditions. This section was included to provide property owners with native plant suggestions to use in the remaining part of the landscape.

Additionally, information is provided on the preferred light levels, plant height, bloom time and color, special adaptive features and the degree of tolerance to siltation – soil particles building up around the crown and root system of the plant. A "high" on the plant matrix indicates that a particular plant has a high level of tolerance to siltation.

Planting Stock

Plants used for natural shoreline landscaping come in many forms: seeds, live stakes, plugs, bare-root plants, container plants, and balled and burlapped plants. Understanding the differences associated with each type of planting stock is important when planning, purchasing and planting in a shoreline project. With the exception of seeds and live stakes, each type is grown and marketed according to a set of industry standards.

The price, the amount of time it takes for a site to become established and how much maintenance is required should be considered before deciding on what type of planting stock to use. Generally, seed is the most economical source for native and non-native plants, but a site that is seeded will take much longer to become fully established than a site that uses live plants. Any project using seed can take three to five years to become fully established; using live plants will take less time. A challenge with using seed is that weeds tend to grow faster and taller and thus shade out desired seedlings. This creates the need for higher weed maintenance for sites that have used seed. On smaller projects, it may be wise to choose live plants to ensure successful establishment. On larger projects, it may be wise to intersperse live plants with seed.

Seeds

Seed packets for native plants may be more expensive than commercial grass seed or non-native flowers because seed of native plants is often collected by hand. Sowing rates and directions can vary between plant species -- please follow the directions provided with the seed packet or contact the seed provider if no instructions are included. It is important that weeds are removed as the desired plants get established. It is best to remove weeds while they are small to minimize the disturbance of native plant seedlings.

It is important when purchasing native plant seed to consider the following information:

- Can the proper maintenance be provided for seeded sites?
- Are all the plants in the seed/seed mix appropriate for the site? Many suppliers can custom design a seed mix for particular conditions.
- Is a cover crop included? These are annual plants, such as annual rye, that will grow quickly to help compete against the weeds and help stabilize the soil but will die off.
- What is the germination percentage? Germination rates can be quite variable. Do the seeds require a pretreatment for germination?
- What is the seed source? Sources from Michigan are preferred.
- What size area will the seed cover? Seeding rates can vary – check seeding rates with the suppliers.
- What time of year should seeds be planted? Some plants require warm temperatures for germination; others will germinate in the cool temperatures of spring or fall. Consult your supplier for optimum timing and site preparation when choosing seed for your shoreline project.
- What type of site preparation is needed for proper seeding? Is this feasible?

Live stakes

Live stakes are long hardwood cuttings that are planted directly into the ground. They are expected to root, grow, stabilize shoreline soils and contribute to ecological function. Live stakes are relatively straight pieces of stems that do not have lateral branches or leaves on them. Stakes can be made from wood of a variety of ages, and results may vary with species. Lengths and diameters may also vary and depend on the species and the site conditions (Water and Land Resources Division, 2001). Live stakes must be harvested and installed during their dormant stage (after leaf fall and before spring bud break) and handled carefully to ensure viability. Some native plant nurseries grow and harvest dormant cuttings to order. Most woody shrubs (shrub dogwoods and willows) suitable for bioengineering can be harvested for live stakes (Figure 5.4).

Container plants

Container plants (Figure 5.5) are any plants produced and sold in a container with intact soil or growing media. Plugs (Figure 5.6) generally describe seedlings or rooted cuttings produced in individual cells. Plug sizes may vary from the diameter of a thumbnail to 2 ¼ inches and are sold in cell packs or flats (Figure 5.7). Many herbaceous plants used in natural shoreline landscapes are typically

Figure 5.4. Live stakes from shrub willow and red-twig dogwood. *(Photo: Robert Schutzki.)*

purchased from nurseries in plug form. Spacing and planting recommendations depend on the plant species and container size.

Figure 5.5. Container shrub *(Photo: Robert Schutzki.)*

One problem with container plants is that the roots become potbound. Disruption of the root system is required to encourage root development and promote plant establishment. If plugs are not severely root-bound, it is easy to loosen the root system by gently prying apart the roots in the bottom half of the root system. Simply massage or tease the root mass, letting media particles fall from the roots. The loosening promotes contact between roots and backfill soil. For severely root-bound plants, cut a thin slice of root mass off the bottom and cut halfway up to the crown. On larger containers that have dense, tight root masses, the butterfly method is most often used. This involves slicing through the root mass approximately one-third up from the bottom of the mass, turning the mass 90 degrees and slicing through it again. This will produce four lobes and open the core of the container root mass to backfill soil. The extent of the disruption depends on the nature of the root mass. Butterflying may cause slight water stress to container plants depending on the stage of growth, so make sure the container media and backfill soil have adequate moisture following planting.

Figure 5.6. Plant plug. *(Photo: Robert Schutzki.)*

Figure 5.7. Plant plug flats. *(Photo: Robert Schutzki.)*

Bare-root plants

Bare-root plants do not have soil or other media attached to the roots (Figure 5.8). Plants are harvested while dormant in either fall or early spring. The first consideration when using bare-root planting stock is to check for root damage and keep roots moist before planting. Broken or frayed roots missed during processing should be pruned to facilitate new root regeneration. New root regeneration occurs immediately behind severed root ends; clean cuts can enhance their production. Planting depth and stability in

Figure 5.8. Bare-root seedling of a deciduous shrub. *(Photo: Robert Schutzki.)*

the hole are also considerations when planting bare-root stock. Plants should be planted at a level that corresponds to the trunk/root collar. Backfill soil needs to be worked around and throughout the root system. Failure to do this will result in plant/soil settling and/or a shifting of the plant within the planting hole. Staking is recommended for all bare-root trees.

Balled and burlapped (B&B)

Balled and burlapped (Figure 5.9) plants are typically trees and large shrubs grown in field soils and harvested with an intact soil ball wrapped in burlap or other mesh material. When using B&B planting stock, it is important to pay attention to moisture levels. Soil ball moisture is lost during the period between harvest and planting. Care must be taken to ensure that water infiltrates into the ball rather than run off into the planting backfill. Also remember that an automatic irrigation system does not ensure that water is penetrating into soil balls at the planting site during establishment.

Figure 5.9. Balled and burlapped trees. *(Photo: Robert Schutzki.)*

Planting Techniques

Planting procedures consist of digging the planting hole, positioning the plant, watering, fertilizing if necessary, backfilling the hole, staking and mulching.

Planting hole

Planting holes should be large enough for the root system, allow plants to be positioned properly and provide an optimum rooting environment. The characteristics of the hole addressed in planting are width, depth, bottom and sides.

- **Width:** Recommendations are varied and usually based on plant type. A recommended width from the outside of the root system to the hole wall is 3 inches for plugs (Figure 5.10), 6 inches for small container plants and 12 inches for container or B&B trees.

> Planting tip: Remember to label some of the plants. It is also helpful to take photos of the plants as they grow. This will help in determining what is a "weed" and what was planted.

- **Depth:** Recommendations depend on soil ball or container size and the top of the root system. The hole should be deep enough so that the top of the root system is on the same level with the soil surface around the hole. This is especially true for plugs and container stock. The bottom of the hole should be firm to prevent future settling or shifting of the plant. For soil root balls, it is important to determine the true level of the root system. Remove any wrapping material from the trunk. Pull away the soil from

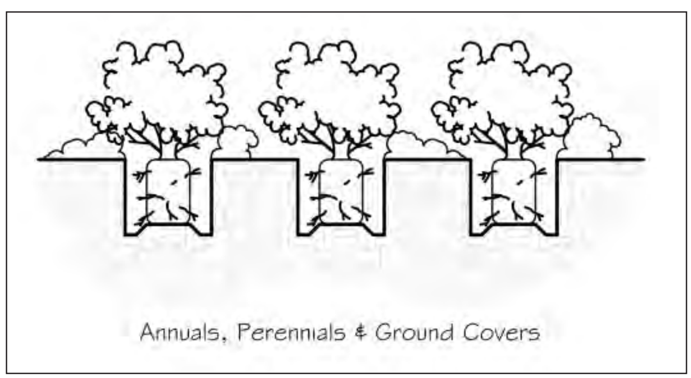


Figure 5.10. Planting holes for plugs and other small container plants. *(Source: Robert Schutzki; graphics by Kristin Faasse.)*

the trunk and locate the uppermost structural roots of the plant. Locating the true level of the root system will guide you in determining planting depth. The false top may be common on B&B trees, although large field-grown shrubs may also exhibit an altered soil level.

Positioning the plant in the hole

Orient the plant in the hole for optimal viewing and/or alignment with structures or other architectural features on the site. Align individual plants so that they complement surrounding plants and contribute to the overall shape of the mass. The plant should be plumb (vertically straight) and set firmly on the bottom of the hole.

Backfilling the hole

Backfilling is critical in stabilizing the plant and providing for optimal root establishment. Backfilling should be done in layers; compact each soil layer around the root mass. Backfilling and compacting in layers will minimize or eliminate future soil settling and shifting of the plant. Always check the plumb line of the plant as the layers are added and make adjustments accordingly. The last layer should be done with soil sliced from the sides of the hole (Figure 5.11). Slicing soil at an angle from the sides of the hole provides an expanded zone of loose soil for root penetration without having to excavate a wider hole. The final step consists of grading a smooth transition to the surrounding soil grade and shaping a water saucer. A water saucer is a circular depression positioned directly over the root mass to allow collected water to penetrate to the roots. Too wide a saucer will allow water easily to run off the root mass and filter into the backfill.

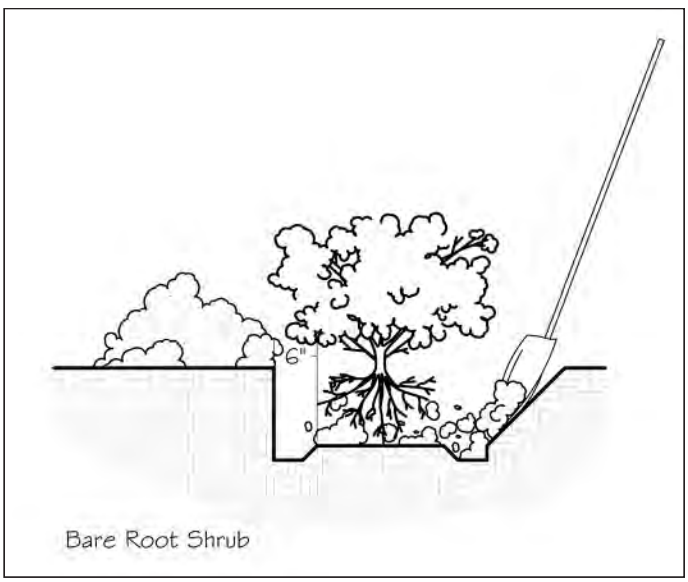


Fig. 5.11. Backfilling the hole. *(Source: Robert Schutzki; graphics by Kristin Faasse.)*

Staking

Generally, stakes are used to protect trees from mechanical trunk damage, to prevent shifting caused by prevailing winds, and to stabilize bare-root trees and B&B trees with shallow roots or in loose soils. Staking specifications may call for one, two or three stakes (2-inch by 2-inch wooden stakes, metal posts, anchors) evenly distributed around the tree, with one stake on the windward side (Figures 5.16 and 5.17). Stakes should be removed after one year except in the case of larger trees – stakes may stay in place for two years.

Mulching

Mulching a site prevents soil erosion, holds moisture in the soil, prevents weeds, keeps the soil cool and helps create a neatly landscaped look. Recommendations call for applying 3 inches of mulch evenly across the planting area without allowing it to be in contact with the trunks or stems of plants. Many types of mulch can be used, though types that float and are easily washed away are undesirable. Be careful not to mulch directly along the shoreline – mulch can easily be washed into the lake.

Watering

The plants should be watered before going into the holes to ensure adequate moisture at planting. Newly installed plants rely on soil ball or container media moisture to supply their needs (Figure 5.12). Additionally, after planting, the area should be thoroughly watered to encourage deep rooting. Future watering and timing should be based on stock type, available irrigation systems and weather conditions.

Pruning

Pruning at planting is recommended to minimize the demand for water by the emerging shoots and expanding leaves. Pruning on newly planted plants should be limited to shoots that do not contribute to overall crown shape or appearance. Thinning the internal branches will reduce water demand.

Fertilization

Nutrient uptake is important for plant growth and development. Fertilization at planting can promote root growth, enhance establishment and minimize the transplant shock period, and so achieves both aesthetic and environmental benefits sooner. If fertilization is done, the rates at planting should be based on soil tests of the backfill or site soils. Soil testing information can be obtained from local MSU Extension offices or by visiting **www.css.msu.edu/SPNL**. Once established, plants do not need regular fertilization. It is critical to utilize fertilizer with extreme caution along lakeshores because improper quantities or poor placement of fertilizers can cause them to enter the adjacent lake and promote nuisance plant growth that will impair lake quality.

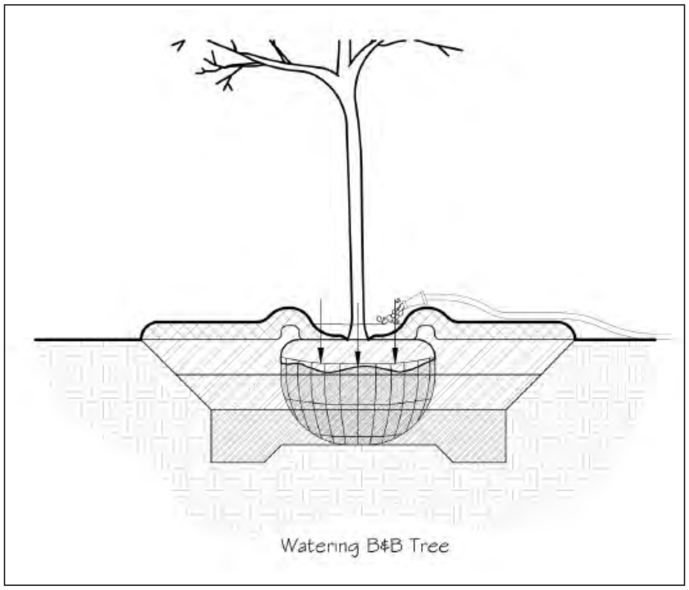


Figure 5.12. Watering a B&B tree in the saucer. *(Source: Robert Schutzki; graphics by Kristin Faasse.)*

The following figures show planting procedures for annuals, perennials and ground covers (Figure 5.13); bare-root shrubs (Figure 5.14); container shrubs (Figure 5.15); bare-root trees (Figure 5.16); and balled and burlapped trees (Figure 5.17).

Planting in water

Natural shoreline landscapes may entail planting within the water body. Plants may need to be anchored to the bottom of the water body to minimize disturbance from wave action or rises in water levels during establishment. Methods to accomplish this successfully should be discussed with a knowledgeable professional.

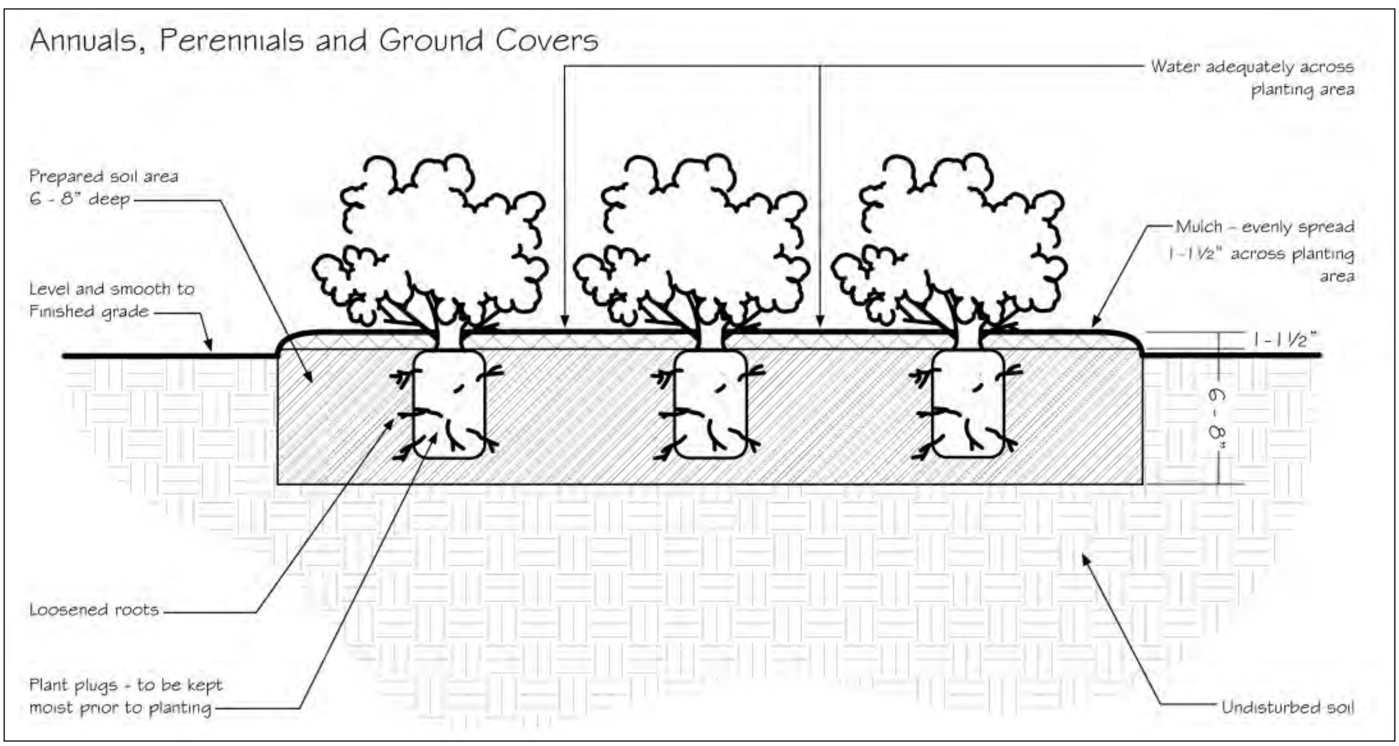


Figure 5.13. Planting detail – annuals, perennials and ground covers. *(Source: Robert Schutzki; graphics by Kristin Faasse.)*

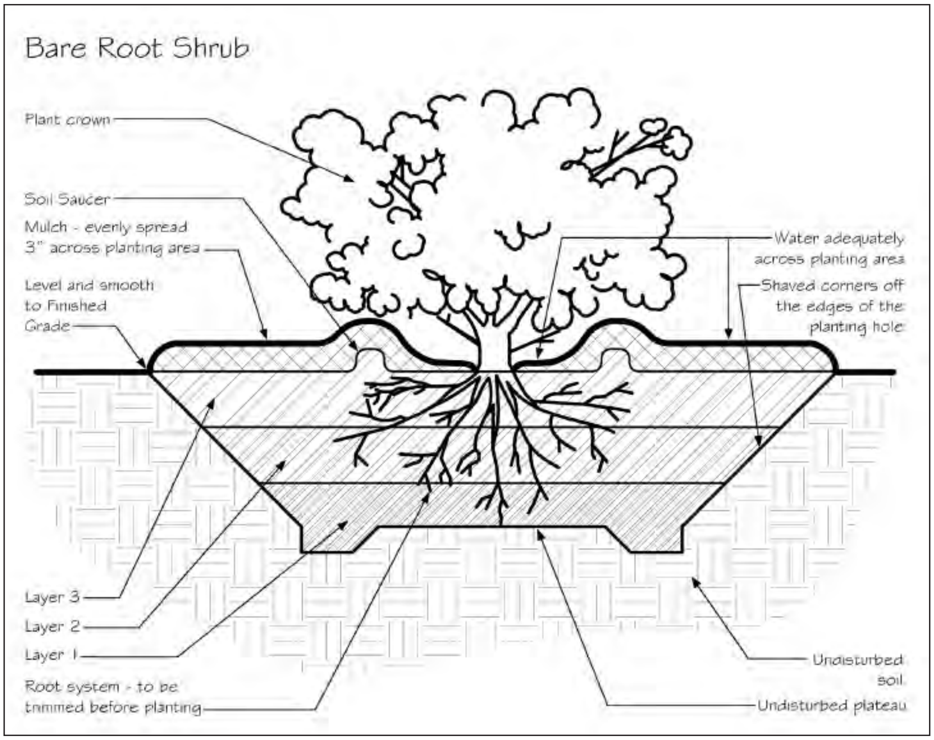


Figure 5.14. Planting detail – bare-root shrub. *(Source: Robert Schutzki; graphics by Kristin Faasse.)*

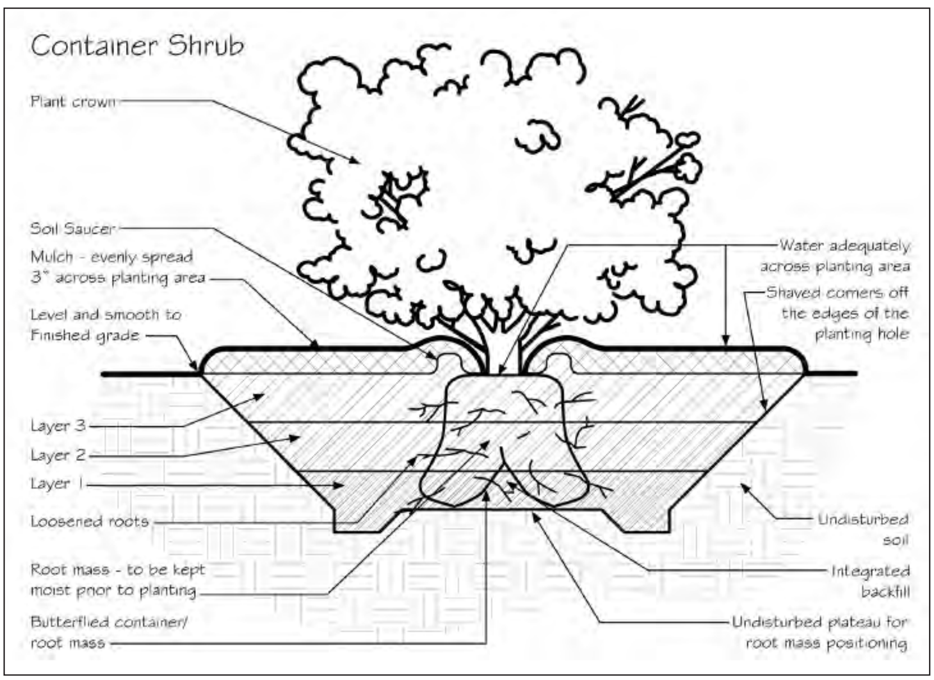


Figure 5.15. Planting detail – container shrub. *(Source: Robert Schutzki; graphics by Kristin Faasse.)*

Timing

Optimal timing for planting depends on several factors, such as type of planting stock being used, how wet the soils are, whether the area is prone to flooding or inundation, and accessibility of supplemental water during the first year of establishment. As a general rule, plants should be planted after the threat of frost in the spring. Planting time may be extended when an irrigation source is available, when water levels are steady and predictable, or when plants are installed directly in standing water. It is important to note that the risk of a failure increases when the installation date approaches the dry summer months of July and August. On sites where soils are saturated or prone to flooding, the risk of frost heaving greatly increases when the material is planted after the middle to the end of October. Planting before October 15 in these situations generally allows enough time for roots to anchor the plant and protect it against frost heaving.

Transplanting plants on-site or from off-site should be done while the plants are dormant. Planting at their new location should occur as soon as possible. Bare-root woody plants should be planted while they are dormant.

Seed is best sown in late fall (called frost seeding) or in early to late spring. Frost seeding works well on flat ground where there is little risk of flooding or inundation during the winter and spring. On slopes or in flood-prone areas, spring is the preferred time to sow seeds.

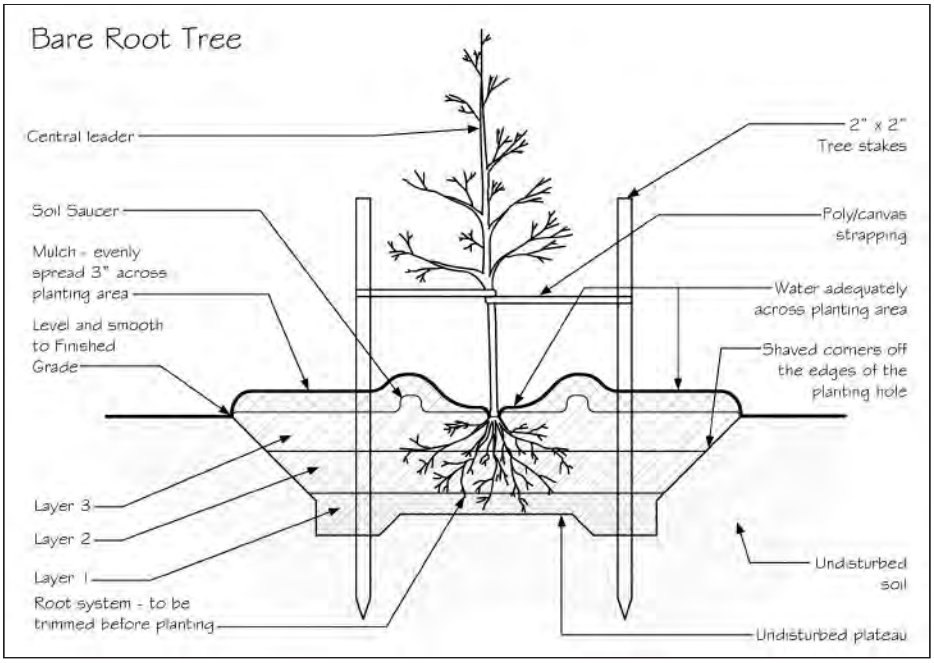


Figure 5.16. Planting detail – bare-root tree. *(Source: Robert Schutzki; graphics by Kristin Faasse.)*

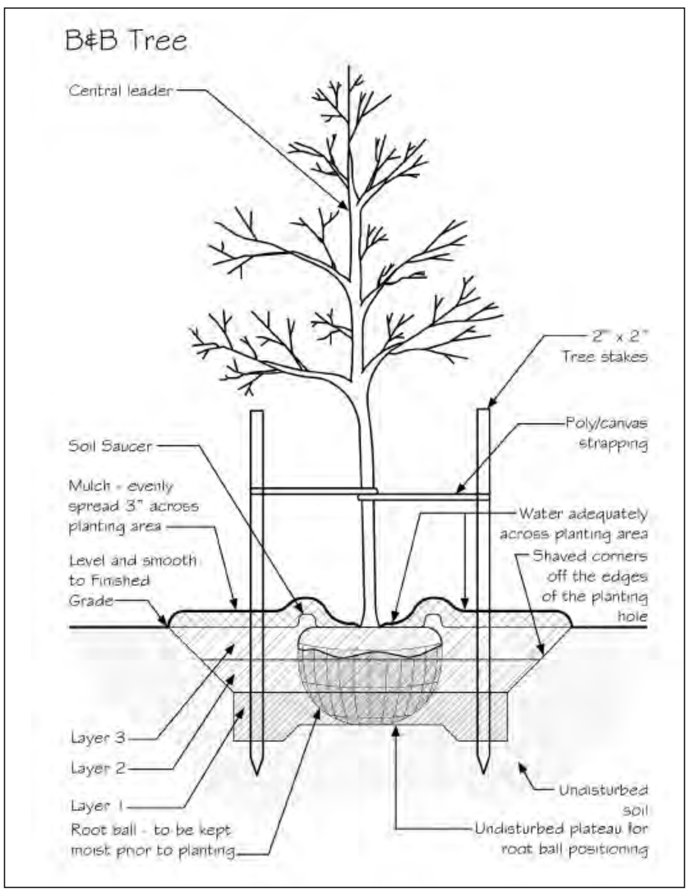


Figure 5.17. Planting detail – balled and burlapped tree. *(Source: Robert Schutzki; graphics by Kristin Faasse.)*

Site Preparation

Site preparation is an important factor in the successful establishment of a natural shoreline landscape. The extent of preparation depends on the character of the site, its soils, and any previous disturbance or construction.

The first step in site preparation is to eliminate any undesirable vegetation. This minimizes competition with newly planted vegetation. Undesirable vegetation, including turf, can be removed mechanically or through the use of an approved herbicide. It may take 10 to 14 days for herbicides to work and ensure that turf, herbaceous weeds and invasive plants are adequately killed. Mowing or removing the dead top growth may be necessary to facilitate planting. Soil tilling in planting areas may be recommended in compacted soils or in the preparation of a seed bed. Tilling exposes dormant weed seeds in the soil, so allow enough time for these seeds to germinate and then remove the weed seedlings before planting. If tilling is required, soils should be stabilized as soon as possible to minimize the potential for erosion into the water or other adjacent areas. Tilling should not be done at the water's edge. Soil disturbance at the shoreline must comply with any regulations.

Finding Sources of Plants

The **Michigan Native Plant Producers Association** consists of 11 independently owned nurseries located throughout Michigan. Together they grow and sell more than 400 species of Michigan native plants and seeds – trees, shrubs, wildflowers, grasses, and ferns. As responsible propagators of Michigan native plants, they are committed to enhancing the diversity and health of Michigan's unique natural heritage.

For information on the availability of native plant seed and whole plants, visit **www.mnppa.org**.

Figure 5.18. Elimination of undesirable vegetation during initial site reparation *(Photo: Robert Schutzki.)*

The Wildflower Association of Michigan encourages the preservation and restoration of Michigan's native plants and native plant communities. This organization maintains a list of the members of the Michigan Native Plant Producers Association as well as other businesses that may supply plants and provide other consulting services. Visit **www.wildflowersmich.org/**.

PlantMichiganGreen.com is a Web site sponsored by the members of the Michigan Nursery and Landscape Association (MNLA). This site features useful and practical information on a variety of subjects compiled from reliable sources in the green industry.

The site features a handy locator to find a landscape or garden retail specialist in your area offering plants suitable for natural shoreline landscapes. Using the locator, you can search by specialty, name, city, county or zip code.

Visit **http://plantmichigangreen.com/** for suppliers of plants and other plant-related products for use in natural shoreline landscapes.

Finding Professional Help

Certified Natural Shoreline Professional

The intent of the Michigan Certified Natural Shoreline Professional (MCNSP) Training and Certification Program is to promote the use of green landscaping technologies and bioengineered erosion control to protect Michigan inland lakes. This program is designed to equip professional landscape, marine, and natural resource contractors with the tools to design, implement and maintain natural shoreline landscapes and erosion control on inland lakes. To receive a certificate of completion, individuals must participate in classroom instruction, attend the field training session and receive a passing grade on the certification examination. Certification is provided by the Michigan Natural Shoreline Partnership and must be updated every three years through continuing education.

The title "certified natural shoreline professional" indicates that the listed individual has successfully completed the Michigan Natural Shoreline Partnership's (MNSP) Certified Natural Shoreline Professional Course (CNSP). All potential clients of the individuals listed are advised to exercise good judgment in selecting a qualified contractor or consultant and investigate all businesses as they would any other providers of professional services.

Please visit **www.mishorelinepartnership.org** for a list of Certified Natural Shoreline Professionals.

Chapter

6 Natural Shoreline Success

In this chapter, you will learn about:

- Maintenance needs for a successful natural shoreline project.
- Signs of trouble.
- Specific maintenance needs for the various planting zones.
- Invasive species control.
- Good stewardship practices.

Overall Maintenance of the Natural Shoreline

Landscape management is unavoidable, regardless of the degree to which natural principles guide site design and construction. Designing and constructing a landscape is a short-lived activity. Site management addresses the long-term life of the site. Plant selection that is completed with sensitivity to a site's characteristics and limitations can minimize the management time, energy and money needed to maintain the landscape. Many of the problems associated with the success of a landscape could be avoided by incorporating long-term site management plans into preliminary design discussions. This would underline the need for commitment on the property owner's part to carry out maintenance to ensure the future success of the overall project. Remember, the shoreline is a dynamic system, and attempting to naturalize the shoreline requires such commitment to ensure long-term stability. All of the energy forces that created an erosion problem are still there, working against any bioengineered erosion control techniques.

The keys to having a successful project are:

1. Having a comprehensive plan.
2. Installing the project correctly.
3. Understanding the maintenance requirements up front.
4. Maintaining the shoreline landscape.

Figure 6.1. Recently installed natural shoreline landscape *(Photo: Robert Schutzki.)*

Plant management within the shoreline landscape contributes to its overall appeal and level of success. There is no such thing as a maintenance-free landscape, but low-maintenance sustainable landscapes are possible. Before making decisions on the shoreline project, the property owner needs to determine the acceptable level of maintenance. Many projects take three to five years to become fully established. Projects will have varying levels of maintenance time commitments because of the size and type of project and the kinds of planting stock used. The first three years of growth are a critical time for maintenance to ensure that the plants are successful. Consider the following aspects of maintenance in making decisions.

- **Maintenance tasks:** These tasks include cutting plant material (mowing turf, pruning shrubs and trees), removing plant waste (leaves, grass and trimmings), introducing materials that aid in plant growth (water, fertilizer, lime and pesticides), and physically modifying soils (through aeration and mulching). Appropriate planning can reduce the time and energy spent on many of these tasks.
- **Supplemental irrigation:** During the plant establishment phase, soil moisture will need to be monitored and water applied as needed. Once established, most plants will need supplemental water only during periods of extended drought.
- **Fertilization:** Fertilization at the time of planting aids in plant establishment. Remember all fertilization should be based on soil tests.
- **Pest and disease management:** The susceptibility and/or tolerance of a plant to major insects and diseases should be considered during plant selection. Pest management strategies also may focus on problematic wildlife. For example, deer browse may be an issue. An appropriate strategy includes selecting deer-resistant plants or providing seasonal barriers that restrict access to the desirable plants.
- **Costs:** Maintenance costs are often overlooked during the design phase. If you are working with a designer, he/she should inform you of the expected maintenance requirements and associated costs. The designer may also develop a maintenance plan to guide the property owner or landscape service in properly maintaining the site.

Professional contractors should be consulted on how to develop a site management plan that takes into account all the aspects in the shoreline project. Ask your contractor if he/she supplies a site management manual. A site management manual provides the overall rationale for the site design and the approach that should be taken to maintain the site in an aesthetically acceptable condition and environmentally sound manner.

Property owner tips:

1. Discuss with the contractors follow-up responsibilities and any associated costs.
2. Is there any warranty? If so, what are the details?
3. Become familiar with the overall project so that you know what was done and how it was completed. Ask questions if you are uncertain.
4. Become familiar with all of the plants that were installed.
5. Label the plant species where they are planted to help you remember their names.
6. Take time to look at your site weekly and learn to recognize signs of trouble (discussed later in this chapter).
7. Take notes and photos of the site before, during and after construction.
8. Remember to water the plants as needed until they become established.
9. Remove weeds from the project area. If you are not able to determine if a plant is a weed or one that was purposefully planted, ask your contractor.
10. Keep an eye out for invasive species and remove them immediately.

The maintenance 3 W's:
W: WATCH
W: WATER
W: WEED

Signs of Trouble

Inspect the entire site weekly. Problems with planting stock or flaws in construction may show up after a relatively short period of time. Some key events that may cause some problems are heavy rains that have concentrated stormwater or caused lake levels to rise, freezing and thawing, and times of drought or continual rain. Take good notes on what is happening, and document the progress with photos.

Ask yourself:

- Are there animal burrows that were not there previously?

- Are erosion control blankets still in place? They sometimes get moved by wind, waves and/or concentrated stormwater flows from upland areas.
- Are there any signs of erosion on the shore or on the bank? Does the soil appear to be moving?
- Are there any areas where a concentrated flow of water is pushing mulch or plants out of the way? This may cause future erosion problems.
- Have any plants been uprooted?
- Are there signs of animal browsing on the plants?
- Are the ropes and stakes from any linear shoreline protection still in their proper places? (Note: it is good to have photos for this to review [Figure 6.2]).
- Are coir logs still in their correct places?

It is important for the homeowner to be watching for these signs of trouble. In many cases, the homeowner will be able to make repairs, but others may require consulting with the contractor to assess the situation and make any needed changes. You should know up front about any follow-up responsibilities of the contractor and when he/she should be called. (For more information on monitoring, refer to "Adopt-A-Buffer Toolkit: Monitoring and Maintaining Restoration Projects," published in 2003 by the Delaware Riverkeeper Network.)

Figure 6.2. Poorly maintained coir logs can become a navigational hazard when displaced by wave action. *(Photo: Jane Herbert.)*

Plant maintenance

- Native and non-native plants provide many advantages in the natural shoreline landscape. Diligent maintenance during the establishment phase is critical to success. Many failures can be attributed to plant loss or lack of weed control. The word "maintenance" may bring to mind a lot of work. The type and amount of work that need to be done depend on the extent of the project. The establishment phase is a critical time for weed management and watering. Expect this phase to last about three years. Once plants are established, some maintenance will still be needed depending on the type of shoreline project. A comprehensive look at maintenance gives the greatest chance for success and considers the needs of the plantings in each area: lawn, upland and wetland plants, and aquatic plants.

- **Lawn care:** Property owners may have reduced the amount of lawn by incorporating buffer areas. Lawn care needs to be considered because of the potential impact on the lake. The lawn should be mowed (cutting off no more than one-third of the blade at one time) to a height of at least 3 inches because taller turf can slow runoff. A mulching mower should be used to reduce clipping waste. Clippings left on the lawn reduce the need for fertilizers in sensitive shoreline areas.

Nutrient applications should be based on soil tests and include little to no phosphorus. (Note: some areas in Michigan have residential phosphorus bans in place that ban the use of fertilizers containing phosphorus unless soil tests show that there is a need for it.) Aeration should be done annually to promote deep rooting and improve water infiltration. An integrated pest management approach can be used to deal with insects, diseases and weed problems in an environmentally sensitive manner.

- **Upland and wetland plants:** Upland plant management and wetland plant management are very similar. Management depends on plant species and their location in the landscape, as well as whether they are established.
  - ***Watering:*** Providing supplemental watering during the first year of growth is probably the most important action that a property owner can take to assure the success of the shoreline landscape. Following establishment, plants should not need supplemental water unless prolonged drought conditions occur.
  - ***Weeding:*** Eliminating weeds, especially during the first year after planting, is probably the second most important task. This needs to be done to give the plants a competitive edge while they are developing their root structure. Weeds should be pulled weekly or every other week and not allowed to go to seed. This is very important because you want to reduce the weed seed source. The following seasons of growth will still need diligent weed management. Typically after the third year, weed removal is down to just a couple of times a year, with the main focus on invasive species such as purple loosestrife and reed canary grass. Spot treating unwanted plants with herbicides must be done carefully to keep chemicals off of the desirable plants and out of the lake water.
  - ***Fertilizing:*** Fertilization at the time of planting aids in plant establishment. Any subsequent fertilization should be based on soil tests.
  - ***Pruning/mowing:*** Plan pruning or mowing in the spring, just before plant growth resumes, to avoid extended periods without plant cover. The extent of pruning depends on whether the plants are woody or herbaceous and on the plant species in question.
  - ***Burning:*** Burning can be a management tool for upland plants. Check for specific protocols and restrictions in your area. Wetland plants are not fire-dependent and will die if burned. Burning along a lakeshore can release excessive nutrients into the lake when rain washes the ash into the lake.
  - ***Plant replacement:*** At times, it may be advantageous to remove existing plant materials and replace them with more appropriate species or cultivars. This can lead to long-term sustainability and reduce inputs and overall costs. Plants that do not survive may need to be replaced or an alternative species substituted.
  - ***Pest management:*** If pests become a problem, seek help from your local Extension office. Employ an integrated pest management (IPM) program for insects, diseases and weed problems.
  - ***Mulching:*** Placing mulch between and around plants will help discourage weed growth. Avoid placing mulch so close to the lake that it may wash into it.
- **Aquatic plants:** Aquatic plants are the emergent and submergent plants found in the littoral zone of the lake. They need to be protected from the waves to allow them to get their root systems established, and they should be inspected weekly to make sure they are still anchored in place. Other plants establishing themselves at the shoreline are a sign of success as your shoreline finds its balance. Once this area has established itself, it will need very little maintenance. The only plants that should be removed from this area are the non-native invasive species such as purple loosestrife and reed canary grass.

Invasive species control

An invasive species can be any plant, native or non-native, that is aggressively outcompeting desired plant species for light, nutrients and space, and causing environmental or economic harm. When invasive species have become established, they change the balance of the system. Michigan has many invasive species that can affect a natural shoreline project by displacing desired species.

Figure 6.3. Purple loosestrife establishing along a shoreline. *(Photo: JFNew.)*

Some of these are purple loosestrife, reed canary grass, phragmites and Eurasian water milfoil. Contact the Michigan Invasive Plant Council (**www.invasiveplantsmi.org**) for information about invasive species in Michigan.

The key to success is early identification and elimination. Soil disturbance can lead to invasion or the spread of existing plant populations. When the soil is disturbed, the numerous seeds lying dormant are exposed. The smaller the site, the easier it is to control invasive plants. Knowing what the plants that were installed look like will help property owners recognize problem plants when they appear.

Controlling invasive species typically uses one or a combination of these methods: mechanical, chemical and biological. In small areas, pulling (mechanical) any invasive species is typically the safest method, especially so near to a lake. Spot control with herbicide can also be done. Consult first with the local Extension office, the Michigan Department of Natural Resources and Environment (MDNRE), the Michigan Department of Agriculture (MDA) or another professional resource for appropriate herbicide recommendations. Information on pesticide application businesses and pesticide applicator certification can be obtained from the MDA (see "Licensing, Certification & Registration of Pesticides" at **www.michigan.gov/mda/0,1607,7-125-1569_16988---,00.html**). In addition, all herbicide applications over standing water or on Great Lakes shorelines in Michigan require a permit from the MDNRE Aquatic Nuisance Control program. Information on this program can be found online on the MDNRE "Aquatic Nuisance Control" Web page (**www.michigan.gov/deq/0,1607,7-135-3313_3681_3710---,00.html**).

Nuisance animals and wildlife

The monitoring of natural shorelines should include occasional assessments of any damage created by wildlife, such as muskrats burrowing into erosion control structures. Waterfowl (geese and ducks) grazing on new plants can cause the loss of plant material designed to colonize bioengineered structures such as coir logs. Temporary "cages" constructed of string or wire can prevent grazing by waterfowl until plants are established (see case study 3 in Chapter 4). Nuisance animals such as deer and rabbits can be deterred from natural shoreline landscapes in the same way they might be deterred from upland landscapes. Rabbit-wire fencing in certain configurations can also deterred muskrats from erosion control structures. Muskrats can cause considerable damage to bioengineered erosion control on sites experiencing low to moderate wave energy. Damaged bioengineering structures and plant material must be repaired or replaced to maintain the integrity of the project. Be sure to follow all state regulations when harvesting or controlling wildlife.

Figure 6.4. Nuisance waterfowl grazing. *(Photo: Robert Schutzki.)*

Adaptive management

Regardless of the level of planning that goes into the design and management of a natural shoreline landscape, real-world conditions often result in unanticipated situations. It is important that any landscape management plan be flexible to allow for adjustments to altered conditions. This concept, known as adaptive management, means that the project plan is continually reevaluated on the basis of new information presented by site conditions.

The most successful shoreline landscapes are often the result of a continuous cycle of monitoring, managing, reevaluating and updating the management plan. An investment in a management plan is a commitment to the long-term development of a site and is a prerequisite to achieving a sustainable natural shoreline landscape. A comprehensive management plan will efficiently manage resources, protect the natural environment, and create and maintain a healthy built environment.

Good Stewardship Practices

Living on a lake comes with a certain responsibility to practice good stewardship to prevent pollutants from entering the lake. Many activities on or around your property can harm water quality. The challenge is to look critically at your actions, the reasons why you take them and any problems your actions can cause. If problems do arise, then options for different actions should be sought.

Understanding why change is important becomes clear when you acknowledge how pollutants get to your lake and realize that your individual actions do matter. The most significant pathway by which pollutants get into lakes is stormwater runoff. Stormwater runoff can come directly from your property and from surrounding areas. Storm sewers also drain directly to lakes and streams and deliver pollutants such as fertilizers, pesticides, detergents, pet waste, ashes from burn areas, petroleum products, sewage and nutrients from septic systems, salt and sediment. Keeping these pollutants out of the water is another critical factor in maintaining a healthy lake.

The harmful effects of many activities can be minimized by simply improving on activities. Look for ways to:

- Improve lawn care practices.
- Improve pest control.
- Use less fertilizer and no-phosphorus fertilizer.
- Capture or divert runoff from driveways, sidewalks and roofs (rain gardens, rain barrels, changing locations of the downspouts).
- Improve septic systems or encourage installation of sewers around your lake.
- Improve pet waste management.
- Improve wildlife management.
- Encourage water-friendly land use planning.

Many resources are available that can provide information for each of these areas. Two particular resources that can help evaluate the risk of causing problems are the “Home Assessment System” (Home*A*Syst, bulletin WQ-51) and a supplement to it called “Managing Your Shoreline for Water Quality” (WQ-52).

The Home*A*Syst is a confidential self-assessment program used to evaluate a home and property for pollution and health risks. Home*A*Syst’s risk assessment exercises can be done one at a time or all together—it’s up to you. The main idea is to take the time to find out if your property poses health risks or pollution threats to the environment. Then, where feasible, you can take action to reduce those risks and prevent problems. “Managing Shoreline Property to Protect Water Quality” examines the special role that shoreline residents have in preventing contamination of their lake or stream.

Both of these documents are available as free downloads from the Michigan State University Extension Bulletin Office at: **www.msue.msu.edu/portal/**. Search under “Publications.” County conservation district staff members may be available to assist with the assessment.

Chapter

7 Michigan Rules and Regulations

Michigan's Inland Lakes: Shoreline Regulations

Michigan has more than 11,000 inland lakes and more than 36,000 miles of streams that are regulated under the authority of Part 301, Inland Lakes and Streams, of the Natural Resources and Environmental Protection Act, Act 451 of 1994, as amended (Part 301). The Michigan Department of Natural Resources and Environment (MDNRE) Water Resources Division is responsible for administering Part 301.

IMPORTANT DEFINITION: An inland lake or stream is defined under Part 301 as a natural or artificial lake, pond or impoundment; a river, stream or creek that may or may not be serving as a drain as defined by the drain code; or any other body of water that has definite banks, a bed, and visible evidence of a continued flow or occurrence of water, including the St. Marys, St. Clair and Detroit rivers. "Inland lake or stream" does not include the Great Lakes, Lake St. Clair, or a lake or pond that has a surface area of less than 5 acres.

Under Part 301, Inland Lakes and Streams, a permit is required for these activities:

- Dredge or fill bottomland.
- Construct, enlarge, extend, remove or place a structure on bottomland.
- Construct, reconfigure or expand a marina.
- Create, enlarge or diminish an inland lake.
- Structurally interfere with the natural flow of an inland lake or stream.
- Construct, dredge, commence, extend or enlarge an artificial canal, channel, ditch, lagoon, pond, lake or similar waterway where the purpose is ultimate connection with an existing inland lake or stream, or where any part of the artificial waterway is within 500 feet of the ordinary high water mark of an existing inland lake or stream.
- Connect any natural or artificially constructed waterway, canal, channel, ditch, lagoon, pond, lake or similar water with an existing inland lake or stream for navigation or any other purpose.

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Ordinary high water mark (OHWM): The OHWM is the line between upland and bottomland that persists through successive changes in water levels, below which the presence and action of the water is so common or recurrent that the character of the land is marked distinctly. Structures placed below the OHWM are placed on the bottomlands and therefore regulated under Part 301.

The MDNRE shall not issue a permit under Part 301 unless it determines both of the following:

- That the adverse impact to the public trust, riparian rights and the environment will be minimal.
- That a feasible and prudent alternative is not available.

Shoreline projects that are exempt from Part 301 (they do not require a permit), include:

- Seasonal private, non-commercial recreational structures that don't unreasonably interfere with use of the lake by others (for example, seasonal docks).
- Reasonable sanding of beaches to the existing water's edge.

Figure 7.1. Arrows indicate common features used to estimate the ordinary high water mark on residential lakefront property. Common features may include changes in soils and vegetation and watermarks on seawalls.

Typical shoreline projects that require a permit under Part 301 include but are not limited to:

- Shoreline protection. (e.g. bioengineering, seawalls, rock riprap).
- Permanent docks.
- Sanding of swim areas.
- Dredging.
- Boat wells.
- Boat ramps.
- Removal of existing structures.

MDNRE BIOENGINEERING MINOR PROJECT (MP) CATEGORY

The Michigan Department of Natural Resources and Environment has a minor project category to support the use of bioengineering practices to stabilize inland lake shorelines as needed to prevent erosion and restore native shorelines while protecting and enhancing fish and wildlife habitat and other natural features associated with inland lakes

Limitations and conditions:

- Projects are of no more than 300 linear feet.
- Top of the bank is no more than 3 feet above the ordinary high water mark.
- Vegetation used, including plantings, live stakes and others, must be native vegetation, below the OHWM.
- Engineered materials shall be made up of inert plant fiber, which may be non-native.
- Excavation and backfill are limited to the extent necessary to stabilize slopes.
- All engineered and natural materials shall be staked and secured.
- All raw areas from construction shall be promptly stabilized with native plant material.
- Projects shall not destroy native wetland or aquatic vegetation.
- Projects shall not harm threatened or endangered species.
- The MP is not applicable to streams, rivers or Great Lake shorelines.

An application and instructions for Part 301 projects can be found at www.mi.gov/jointpermit.

Application EZ Guides

EZ guides are intended to provide a simplified list of the necessary information needed to submit a complete application for certain minor project categories and streamline that application preparation process. They are available at **www.mi.gov/jointpermit**.

(NOTE: Michigan is one of only two states that are approved to administer the Federal Section 404 program therefore only one permit from the DNRE is required for most inland lake and stream projects.)

Additional Part 301 information can be found at www.mi.gov/dnreinlandlakes or obtained by contacting the appropriate district office as shown on the Land/Water Interface Permitting Staff Map or the Inland Lakes and Streams Program coordinator at 517-241-4512.

ADDITIONAL REGULATIONS: In addition to Part 301, the following regulations may apply to shoreline projects:

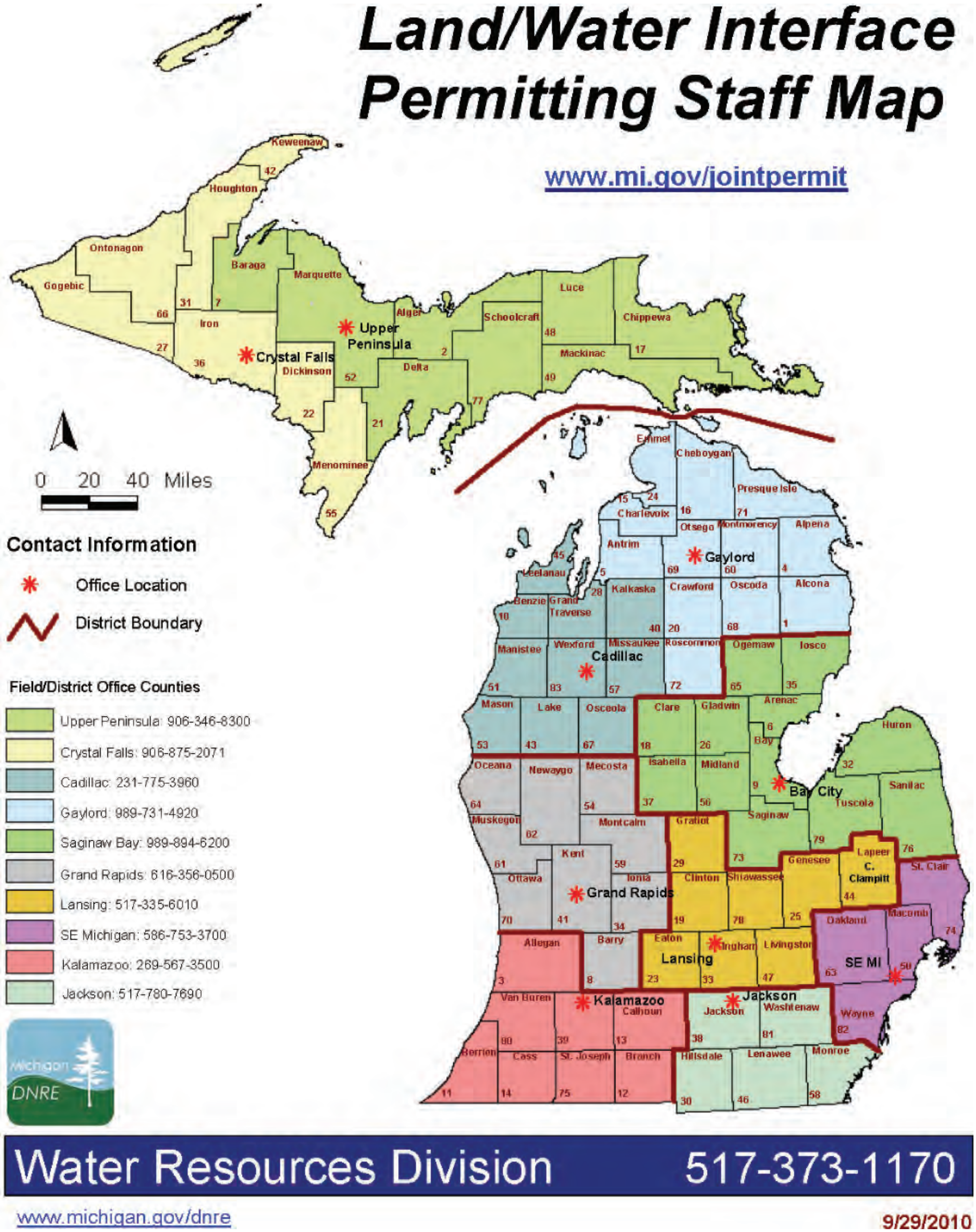
The state's floodplain regulatory authority, found in Part 31, Water Resources: The DNRE is responsible for administering Part 31, and a permit may be required for work in a stream or within the 100-year floodplain of a stream with a watershed area of greater than 2 square miles. Additional information can be found at www.mi.gov/dnrefloodplainmanagement.

Part 33, Aquatic nuisance control: A few species of aquatic plants, such as Eurasian water milfoil, are not native to the Great Lakes region and can significantly alter the aquatic ecosystem if left unchecked. Permits are required to chemically control nuisance aquatic plants, algae and swimmer's itch. Additional information can be found at **www.mi.gov/dnreinlandlakes**.

Part 91, Soil Erosion and Sedimentation Control Permit: Permit is administered by local or county officials and is required when there is earthen work within 500 feet of an inland lake or stream, or an earthen disturbance greater than 1 acre. Additional information can be found at **www.dnre.state.mi.us/sesca**.

Part 303, Wetlands Protection: The MDNRE is responsible for administering Part 303, though some local municipalities have additional wetland regulations. Wetlands provide many important ecological functions and are often found around inland lakes and streams. Additional information can be found at **www.mi.gov/dnrewetlands**.

Federal Jurisdiction - Section 10 Waters: The U.S. Army Corp of Engineers retains jurisdiction over Section 10 waters along the Great Lakes coastlines and nearby lakes and rivers. Additional information can be found at **www.lre.usace.army.mil**.



Land/Water Interface
Permitting Staff Map
www.mi.gov/jointpermit
Keweenaw
Houghton
Ontonagon
Gogebic
Baraga
Marquette
Iron
Crystal Falls
Dickinson
Upper Peninsula
Alger
Delta
Schoolcraft
Luce
Chippewa
Mackinac
Menominee
Emmet
Cheboygan
Presque Isle
Charlevoix
Otsego
Montmorency
Alpena
Antrim
Gaylord
Leelanau
Kalkaska
Crawford
Oscoda
Alcona
Benzie
Grand Traverse
Manistee
Wexford
Missaukee
Roscommon
Ogemaw
Iosco
Cadillac
Mason
Lake
Osceola
Clare
Gladwin
Arenac
Huron
Bay
Oceana
Newaygo
Mecosta
Isabella
Midland
Bay City
Tuscola
Sanilac
Muskegon
Montcalm
Gratiot
Saginaw
Kent
Ottawa
Ionia
Clinton
Shiawassee
Genesee
Lapeer
C. Clampitt
St. Clair
Grand Rapids
Allegan
Barry
Eaton
Ingham
Livingston
Oakland
Macomb
Lansing
SE MI
Van Buren
Kalamazoo
Calhoun
Jackson
Washtenaw
Wayne
Berrien
Cass
St. Joseph
Branch
Hillsdale
Lenawee
Monroe
0 20 40 Miles
Contact Information
Office Location
District Boundary
Field/District Office Counties
Upper Peninsula: 906-346-8300
Crystal Falls: 906-875-2071
Cadillac: 231-775-3960
Gaylord: 989-731-4920
Saginaw Bay: 989-894-6200
Grand Rapids: 616-356-0500
Lansing: 517-335-6010
SE Michigan: 586-753-3700
Kalamazoo: 269-567-3500
Jackson: 517-780-7690
Michigan DNRE
Water Resources Division 517-373-1170
www.michigan.gov/dnre
9/29/2010

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Plant Conservation Alliance — **www.nps.gov/plants**.

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Water and Land Resources Division. 2001. "Live Stake Cutting and Planting Tips." Natural Resources and Parks, King County, Washington. (**http://dnr.metrokc.gov/wlr/pi/Cutting.htm**).

Wetzel, R.G. 1983. Limnology (second edition). Elsevier, Science Academic Press,

Additional Information

Erosion Control

Wisconsin online Erosion Calculator: **http://dnr.wi.gov/waterways/shoreline_habitat/erosioncalculator.html**.

Understanding, Living With, and Controlling Shoreline Erosion: A Guidebook for Shoreline Property Owners (3rd edition). Tip of the Mitt Watershed Council publication. It is available for purchase from Tip of the Mitt or for free download at: **www.watershedcouncil.org/**.

General Lake Information

Inland lake maps:
www.michigan.gov/dnr/0,1607,7-153-30301_31431_32340---,00.html.

Native Plants

Michigan Native Plant Producers Association
www.mnppa.org/

Wildflower Association of Michigan
www.wildflowersmich.org/

Michigan Natural Features Inventory
http://web4.msue.msu.edu/mnfi/

Plant for Stormwater Design. Minnesota Pollution Control Agency. Available for purchase or free download at: **www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/stormwater-management/plants-for-stormwater-design.html?menuid=&missing=0&redirect=1**.

PLANTS database: U.S. Department of Agriculture Natural Resources Conservation Service. The PLANTS database provides standardized information about the vascular plants, mosses, liverworts, hornworts and lichens of the United States and its territories. View at: **http://plants.usda.gov/index.html**.

Invasive Species

Michigan Invasive Plant Council
www.invasiveplantsmi.org.

A Field Guide to Invasive Plants of Aquatic and Wetland Habitats for Michigan. 2010.
Available for purchase or free download at:
http://web4.msue.msu.edu/mnfi.

A Field Identification Guide to Invasive Plants in Michigan's Natural Communities. 2009. Available for purchase or free download at: **http://web4.msue.msu.edu/mnfi**

MDNRE "Aquatic Nuisance Control" Web page :
www.michigan.gov/deq/0,1607,7-135-3313_3681_3710---,00.html.

Good Stewardship

Home *A*Syst – Home Assessment Guide 2008. Michigan State University Extension Bulletin WQ-51. Available at: **www.msue.msu.edu/portal/**.

Managing Shoreline Property to Protect Water Quality 2008. Michigan State University Extension Bulletin WQ-52. Available as a free download at: **www.msue.msu.edu/portal/**.

Adopt-A-Buffer Toolkit: Monitoring and Maintaining Restoration Projects. 2003. Published by the Delaware Riverkeeper Network. Available for download at: **http://www.delawareriverkeeper.org/programs/monitoring.asp**

"Licensing, Certification & Registration of Pesticides," MDA (**www.michigan.gov/mda/0,1607,7-125-1569_16988---,00.html**)

Natural Shoreline Landscapes on Michigan's Inland Lakes

Guidebook for Property Owners

About the Michigan Natural Shoreline Partnership

The mission of the Michigan Natural Shoreline Partnership (MNSP) is to promote natural shorelines through use of green landscaping technologies and bioengineered erosion control for the protection of Michigan inland lakes. The MNSP is a collaboration of government agencies, academic institutions, private industries, and conservation groups dedicated to the development of shoreline management practices that are beneficial to lake ecosystems and attractive to consumers.

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