Vegetative Best Management Practices

{ A MANUAL FOR PENNSYLVANIA/LAKE ERIE BLUFF LANDOWNERS }

Pennsylvania Coastal Resources Management Program

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VEGETATIVE BEST MANAGEMENT PRACTICES}

Preface


Photo - Andrew Lapiska

A typical reach of Pennsylvania's Lake Erie shoreline, where bluffs can range from zero to 180 feet in height.

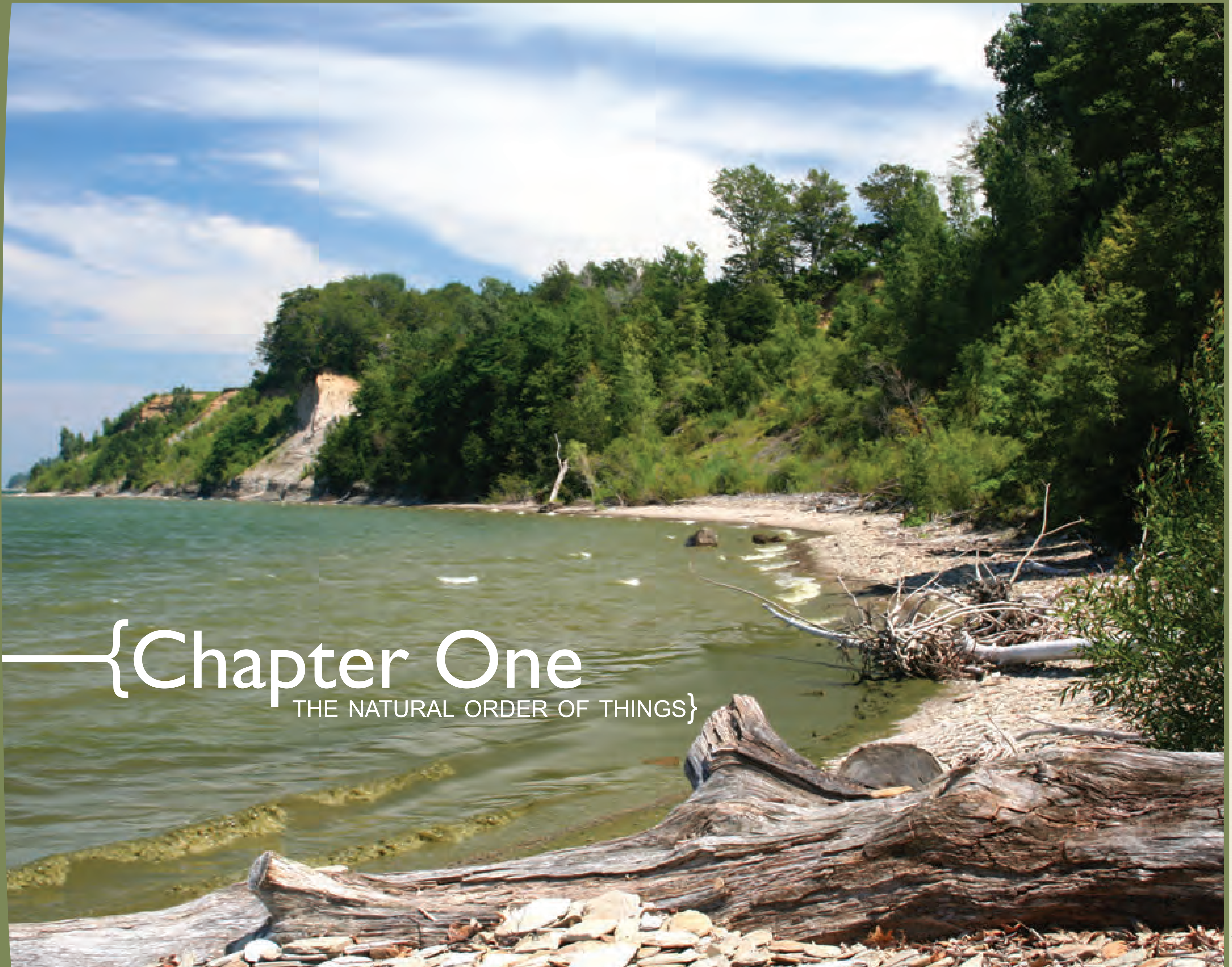
One of the goals of the Pennsylvania Coastal Resources Management (CRM) Program is to provide "…technical assistance to Lake Erie property owners affected by shoreline erosion and bluff recession" (DEP, 1996). This manual is meant to give property owners information regarding how to use and manage vegetation on their bluff properties in order to minimize erosion.

It is important to understand that even the very best management of bluff vegetation will not prevent all bluff recession. Bluff recession is a naturally occurring phenomenon and is a part of a larger cycle of physical processes happening every day along the Lake Erie shoreline. Bluff recession and shoreline erosion will occur with or without human influences. However, human activities, including development, may significantly increase the rate of bluff recession. Because of human activities, more structures have been built along the bluff. Construction and excavation have meant the removal of deeply rooted trees and other vegetation along the bluff. This has led to an increase in groundwater and surface water runoff and the bluff has become less stable.

Average bluff recession rates for the nine coastal municipalities of Erie County range from 0.30 to 0.96 feet of lost land per year. These numbers, however, do not really reflect the true situation. A more accurate picture of bluff recession includes the idea that in some areas, the bluffs appear stable and recession rates are essentially zero; while, in other areas—perhaps right next door—large pieces of land may be lost in a single collapse. It is estimated that 417,519 cubic yards of sediment are eroded from the bluffs and shoreline along Pennsylvania's Lake Erie coast each year (Knuth, 2001). That is equivalent to about 19,000 semi-trailer loads of sediment.

Ultimately, it is the Lake Erie shoreline property owners who decide how to manage the vegetation on their individual parcels of shoreline property. Each and every site is unique and is in a constant state of change. This manual contains information that will help the homeowner develop a plan of action to manage vegetation in order to help foster bluff stability. For more information on specific topics, please see the accompanying Web site or contact one of the experts listed in the appendix. We recommend that property owners consult with the Coastal Resources Management specialist working for the Department of Environmental Protection.

Figure 1 The focus area of this manual is the Pennsylvania – Lake Erie shoreline from the Ohio border in the west to the New York border in the east. Average recession rates for each part of the shoreline are shown.



{Chapter One
THE NATURAL ORDER OF THINGS}

Photo - Andrew Lapiska

The shoreline of Lake Erie is a place of great natural beauty. The views and sunsets can be breath-taking and the climate is moderated by the lake. It is precisely for these reasons that a great deal of residential construction has taken place along the lake. This has altered the natural order of things, and may be responsible for increased rates of erosion and bluff recession.

It is important, especially for owners and caretakers of lakefront property, to understand the natural processes that are at work on the shoreline. Land owners also need to understand the impact that human activities have on these processes.

Bluff landowners almost always face problems due to erosion of their property. Sections of their yards at the crest of the bluff may suddenly slough off and slide down the bluff during a spring thaw or a rainy week. It can be dangerous to walk above sections of the bluff that are undercut by erosion. To some extent, this is a natural process that has continued since Lake Erie formed. Wind, waves, rain, melting snow, freezing, and gravity are all forces that wear away the bluff and shoreline. The flow of groundwater and surface water runoff can also contribute to bluff recession.

The native plant community along the bluff and land adjacent to the bluff has always played a major role in stabilizing the bluff and counteracting erosive forces. A selected list of native plants that naturally grow along the bluff can be found in Chapter 7. It is important to remember, however, that maintaining a robust, healthy plant community cannot stop all erosion. In fact, a bare bluff is often an indicator that erosion is occurring so fast that the plant community cannot keep up with it. A bluff owner can plant vegetation to speed up the revegetation process, and choose fast-growing, hardy plants, but this may not solve the problem. The underlying causes of the erosion should be determined and addressed. Recommended Best Management Practices (BMPs), described in Chapter 8, can help landowners to address these underlying causes of erosion. This, in addition to managing the vegetation on bluff property, will help to minimize recession. Since vegetation, geology, hydrology, and soil all play a part in the natural balance along the bluff, each of these topics will be addressed in the following chapters.

Photo - Andrew Lapiska

North East Township.

{Chapter Two
VEGETATION AS A STABILIZING FACTOR}

Photo - Andrew Lapiska

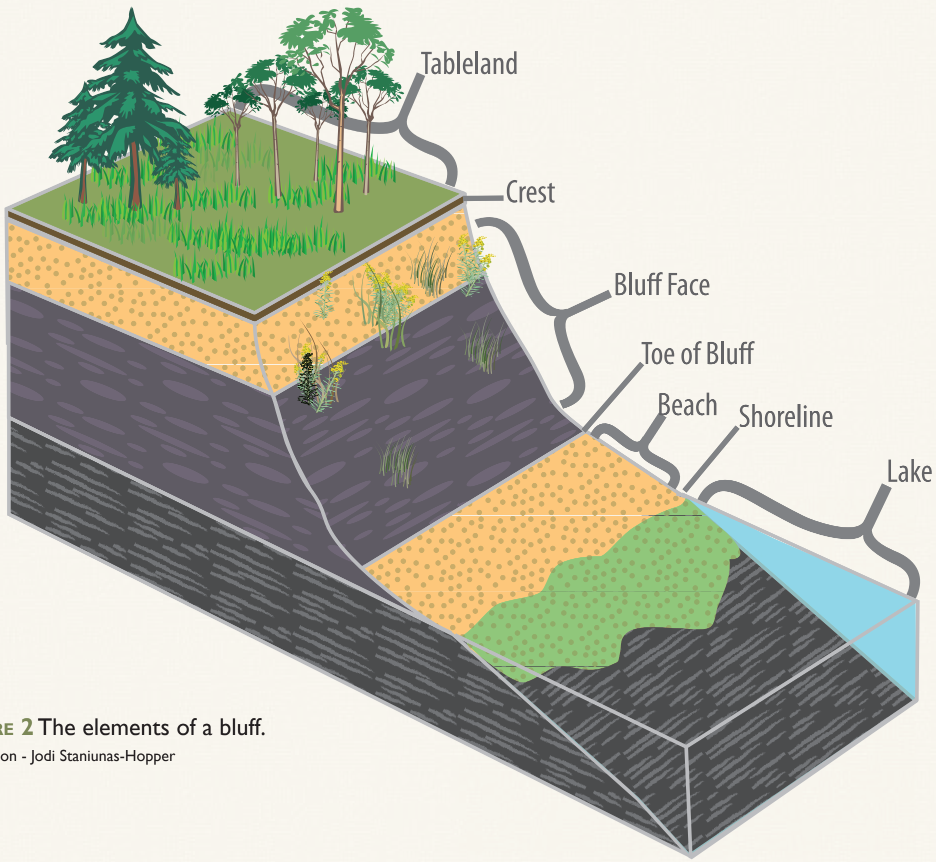


Figure 2 The elements of a bluff.
Illustration - Jodi Staniunas-Hopper

Vegetation plays an important role in stabilizing the bluff. It does so in two locations: on the face of the bluff and on the flat land at the top of the bluff (the bluff tableland).

Vegetation on the tableland and bluff face has these positive stabilizing effects:

1. **Plant roots** (especially tree roots) can remove water from the tableland and bluff, intercepting the water on its way out to the bluff face. The driving force for this wicking up of water is transpiration, the evaporation of water from the leaves of plants. As water is transpired from the plant leaves, more water is pulled in by the roots. One large tree may wick more than 200 gallons of water in this way on a sunny day, and perhaps even more if it is windy. Thus, there will be less seepage on the bluff and erosion may decrease. Note, however, that during the winter, only plants that keep their leaves continue to pull groundwater out of the soil.

2. **Plant roots**, depending on the kind of plant, may form a shallow mat or may penetrate deep into the ground and spread out laterally. Roots physically hold the soil in place. Plants that form shallow, fibrous roots, such as grasses, tend to prevent lateral shear of soil. Plants with deeper roots, including many shrub and tree species, tend to provide good vertical anchorage. With a mixture of trees, shrubs, and herbaceous plants, the root systems interlock to stabilize the soil.

   The depth that plant roots extend into the soil varies greatly depending on the type of plant. Grasses typically form most of their roots in the top three to five inches of soil, but some grasses and non-woody herbaceous plants are deep-rooted, sending roots down several feet or more. Even these, though, have most of their roots in the upper eight to twelve inches. Many trees have the potential to send roots deep into the soil. The sandy upper layer along the bluff is able to hold enough water and oxygen to allow tree roots to grow throughout the layer. Tree roots here may penetrate from three to twelve feet, or more, into the soil. (It is a commonly held idea that tree roots penetrate as deeply as a tree is tall, but this is not realistic. Most tree roots are in the upper few feet of the soil.)

3. **The canopy effect**: Above-ground plant parts lightly shade the ground, thus helping maintain moisture and making it easier for other vegetation to thrive.

4. **Organic matter** will collect in the standing vegetation. Dead leaves and other plant matter will enrich and loosen the soil.

5. **Vegetation**, by its physical presence, reduces the impact of storms—wind, rain, and ice—that would erode the bluff face.

The grass growing in lawns takes up very little groundwater, and only take it from the top layer of the soil where the grass roots are located. Larger vegetation, such as trees and shrubs, take up (and therefore remove) much more groundwater. Depending on the underlying geology, the area of land contributing to the groundwater flow can extend a long distance inland; therefore, it is important to maintain vegetation, especially larger vegetation, on as much land as possible leading up to the bluff.

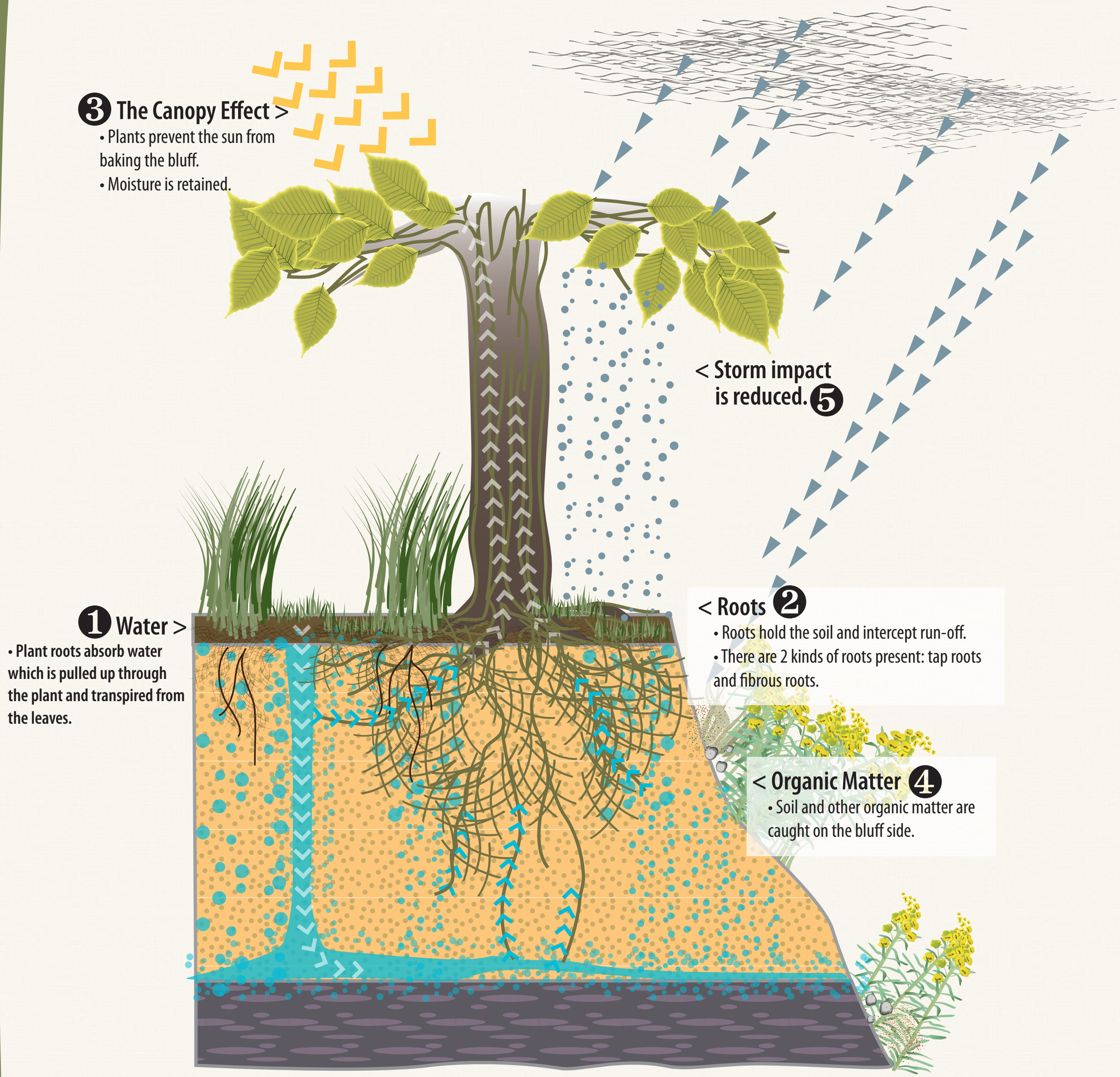


FIGURE 3 Vegetation can have these positive stabilizing effects.
Illustration - Jodi Staniunas-Hopper

Native vs. Non-native Plants

Most of the plants recommended in this manual are native species. This means they are plants that have grown in the local area for a long period of time, and are not species introduced recently from some other country or location. Not all introduced plants are inherently bad as bluff plants. They may, however, require more care because they may not be well-adapted to the harsh habitat on the bluff. Examples include many common garden plants such as flowering crab apples or phlox. Native plants are usually well-adapted to their local environment and have a complex set of interactions with a large number of other local species. Because of these interactions, the native plants thrive and the habitat remains diverse. The distinction between native and non-native is not always clear. For example, yarrow has been naturalized here for a long time and grows well on the bluffs of Lake Erie, but it is considered an introduced species from Europe and, therefore, non-native (Rhoads, 2000).

Invasive Plants

Some introduced species can become invasive. An invasive plant is a species whose introduction does or is likely to cause economic or environmental harm. Some of the characteristics of invasive plants – their toughness, vigor, and rapid growth – would seem to qualify them as perfect bluff plants. However, they should be avoided even on the bluff because they may spread aggressively to locations where they are not wanted. Invasive species often crowd out all other plant species, and thereby decrease the diversity. Often, the native plants that are displaced by the invasive plants were serving as wildlife food and erosion control.

Local Plants vs. Plants from Other Parts of the Country

Even plants of the same species can vary tremendously in different parts of their range. Each local group, called an ecotype, is adapted to its particular habitat. For bluff restoration projects, it is recommended that local native species be used instead of the same species grown from seeds collected in a distant location. The local stock is more likely to be better adapted to the unique habitat along the bluff, since it has grown there for so many generations. The bluff habitat differs significantly from conditions even a short distance inland with respect to temperature, soils, and wind speeds. The ecotype of the species of plants growing on the bluff may differ genetically from the same species growing inland. For this reason, local seeds or cutting sources are likely to produce plants that have a better chance of survival on the bluff. This is not a new idea. For those who do restoration work professionally, local plant sources are the preferred choice. When purchasing from a company, ask them about the source. Some companies make a special effort to have local plant material available.

It should be noted, however, that while the research shows that some species—like sugar maple—grow and survive better if grown from local seeds, for many species, this research has not been done, and the advantage of using local seed is not known.

Natural Succession

When a part of the bluff has very recently collapsed, a bare piece of ground is exposed. Often there is no soil here, only the subsoil of sand and clay, which is very nutrient-poor. New vegetation will eventually reestablish on this bare ground through the process of natural succession. Normally this process starts on the lower portions of the bluff face.

Photo - Andrew Lapiska

This section of the bluff has recently experienced a failure.

Photo - Andrew Lapiska

A section of the bluff in the early-successional stage.

Photo - Andrew Lapiska

A section of the bluff in the late-successional stage.

Succession is a soil-building process. Each successive type of vegetation increases the fertility of the sediment, changing it so that the next group of plants can grow there. Early-successional plants must be able to grow in sediments that are very low in organic matter and nutrients. The first plants to establish will be grasses and other tough herbaceous plants. These begin the process of adding organic matter and minerals to the sediments. Often, these first plants are weedy.

At this stage of succession, the area is especially susceptible to invasive species.

Next, seedlings of shrubs, trees, and other herbaceous plants begin to establish themselves. Plants like black locust and speckled alder have an extra advantage because they have beneficial nitrogen-fixing bacteria in their roots. These bacteria are able to convert the nitrogen from the air into a type of nitrogen that plants can use as a nutrient. On the nitrogen-poor sediments of the bluffs, this is a great advantage for the plants.

The soil fertility will slowly improve over time as each successive generation of plants adds more organic matter to the soil. Eventually, if no further collapses occur, trees and shrubs become well-established and the area may become a mature and stable part of the forest.

In nature, the successional process takes many years, so consider that it will be years before newly planted vegetation on the bluff gives the desired positive effects.

{Chapter Three
GEOLOGY AND HYDROLOGY}

Photo - Andrew Lapiska

Bluff Stratigraphy and Groundwater Flow

Bluff recession is tied very closely to the geology and hydrology along the Pennsylvania Lake Erie coast. Most of the bluff along the shoreline shows the following pattern of layers from top to bottom:

1. A layer (often very thin) of **topsoil**.

2. A **sandy layer** with minor clay/silt deposits. This layer is yellow-brown in color, and varies in thickness —depending on the location—up to 10 to 15 meters. It was originally deposited when lakes from melting glaciers covered the area. Water infiltrates this sandy layer and moves freely downward through it as groundwater until it hits the layer below. When the sandy layer is saturated with water, it is very unstable and easily flows down the exposed bluff.

3. An impermeable **silt and clay layer** (diamict) with minor sand deposits and some rock fragments. This layer is a gray or blue-gray color. It was deposited as glacial till and is inherently tilted toward the lake. Groundwater, filtering down through the sandy layer, pools on the upper surface of this

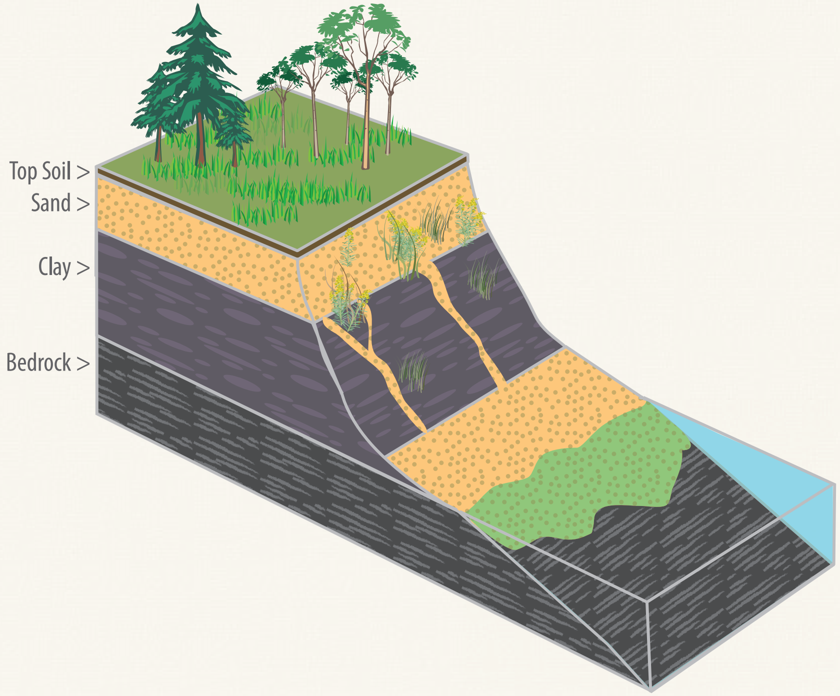


FIGURE 4 The typical geologic layers of the sediments along the Pennsylvania Lake Erie coast. The bedrock layer is shown here at lake level, but it may be exposed, or be entirely below the lake surface, depending on the location.

Illustration - Jodi Staniunas-Hopper

Photo - Marlene Cross

The sand and clay layers.

Photo - Marlene Cross

Springfield Township. The bluff here shows, from top down, the topsoil layer, the brown sandy layer, and the gray clay layer. The clay layer is partially covered with sand that has washed down from above. The bedrock layer is below the lake surface here.

Photo - Andrew Lapiska

Along this part of the bluff in Harborcreek, the bedrock layer at the base of the bluff extends to five to eight feet above the water layer.

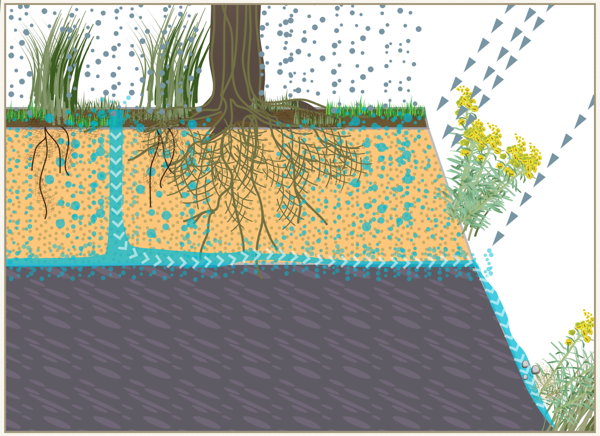


FIGURE 5 Groundwater moves through the sandy layer, but cannot flow into the impermeable clay layer.

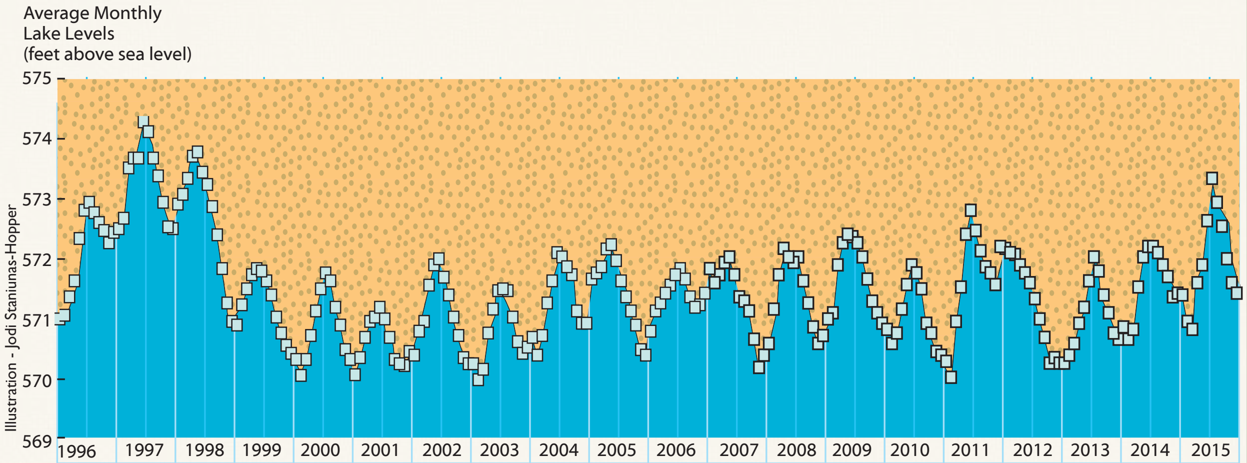


FIGURE 6 The average lake levels since 1996. Note that lake levels typically fluctuate in a yearly pattern with the highest levels occuring in June or July. Lake levels also fluctuate year to year; for example, 1997 was a high lake level year. This data is from the United States Army Corps of Engineers, Detroit District, web site at http://www.lre.usace.army.mil/greatlakes/hh/greatlakeswaterlevels/historicdata/greatlakeshydrographs/. The monthly record highs and lows are listed in the table below.

impermeable layer. It then runs along the layer in a downhill direction (usually toward the bluff where it emerges as a spring or seep).

4. **Bedrock**. This layer is very old (formed during the Devonian Period) and consists of layers of shale and sandstone. In the eastern part of Pennsylvania's Lake Erie shoreline, the bedrock layer is commonly above the water level at the toe of the bluff. Here, because this layer is so resistant to wave action, it acts as a stabilizing force. Along some parts of the bluff, the bedrock layer is unexposed and below the lake surface; and, therefore, does not contribute to bluff stability. This is the case along much of the Pennsylvania bluff to the west of Presque Isle (Buyce, 2005). The bedrock layer is visible on eroded stream bottoms where they contact the shore on the west side of the county.

Groundwater movement, interacting with the layers listed above, is one of the factors affecting bluff recession. Chapter 5 describes the effects of groundwater on bluff recession.

Lake Levels

Lake Erie water levels fluctuate in cycles of approximately 10 to 15 years. The average yearly water level may vary up to one meter over this time period. For example, 1997 was a year of high lake levels—nearly one meter higher on average than in 2001, a low lake-level year. Also, within a given year, lake levels may fluctuate up to one meter. Typically, the lake levels are at their yearly high in June and their yearly low in mid winter. At different lake levels, waves may be hitting different layers of the sediment, and this can affect the rate of recession along the bluff. Chapter 5 discusses the effects of lake level fluctuations on bluff recession.

Some scientists predict that lake levels in the Great Lakes could decline by several feet in the next 100 years because of global warming (Sousounis and Glick, 2000). This may reduce erosion hazards due to wave action at the base of Lake Erie bluffs, but will not affect erosion that is caused by other factors such as groundwater movement.

Month	Record High	Record Low
January	573.69	568.27
February	573.42	568.17
March	573.75	568.24
April	574.08	568.83
May	574.05	569.03
June	574.28	569.06
July	574.24	569.06
August	573.95	568.99
September	573.59	568.83
October	573.95	568.57
November	573.65	568.24
December	573.82	568.21

TABLE 1 Estimated record high and low lake levels for Lake Erie since 1918 (in feet above sea level).

Ice Cover

During most winters, large parts of Lake Erie freeze over. Large sheets of ice are pushed against the Pennsylvania shoreline where they build up as ice dunes. The dunes are treacherous and should never be walked on, but they are often very protective of the beach and shoreline. When windy winter storms rage along the lakeshore, the ice dunes prevent both wind and waves from causing erosion. In years when the ice dunes form later in the winter, or not at all, more erosion may occur. Sometimes, however, when ice dunes form along the shoreline during times of high lake levels, the dunes can begin to shift and can actually cause a cutting action at the base of the bluff, leading to destabilization there.

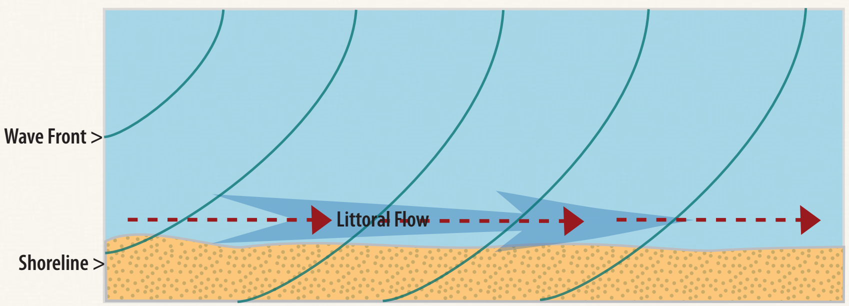
Littoral Flow

The waves of Lake Erie do not flow directly toward the shoreline. Instead, they usually strike the shoreline at an angle from west to east, being affected by the prevailing winds which blow from southwest to northeast. Because of this, the sand and sediment particles are slowly moved eastward along the shore. This is called littoral flow or littoral transport and is a natural process in which sand is constantly being deposited and removed. (Figure 7A) The sediment material that is moved is called littoral drift. Any man-made structure in the water along the lake shore—such as groins, walls, and breakwaters, can greatly alter littoral flow and cause some areas to be deprived of sand while other areas are enriched. For example, if a concrete wall is built out into the lake to serve as a dock or pier, waves coming from the west will deposit their load of sand and silt on the western side of the wall (the updrift side). As a result, sand will build up there. On the east side of the wall (the downdrift side) and for some distance down the shore to the east, the beach at the toe of the bluff will not receive much sand and will become narrower. (Figure 7B) The narrower the beach, the less the toe of the bluff behind it is protected from erosion by waves. Therefore, the erosion of the beach can lead to the acceleration of bluff recession. Typically, the downdrift area affected by a wall or groin extending into Lake Erie is four to five times the distance that the wall extends into the lake. (To calculate the impacted area, the groin should be measured from the water's edge to the end of the groin, and this distance should be multiplied by four or five.) A wall built by one land owner, therefore, has the potential to impact their neighbor's beach.

An ongoing example of this problem can be seen with respect to the long breakwaters that project into the lake from the federal harbor at Conneaut, Ohio. Sand builds up on the west side of the harbor and within the harbor itself at a rate of approximately 9,950 cubic yards annually. The Pennsylvania shoreline to the east of these breakwaters is deprived of sand by an equal volume and as a result has severe shoreline erosion and accelerated bluff recession. If this material is dredged from the harbor and deposited in open waters, the replenishing sands needed for Pennsylvania's beaches will be lost to the bottom of the lake. The Conneaut Harbor problem is described in more detail in the "Historical Perspectives" section of Chapter 5.

Photo - CMS File Photo

Sand and stones can be seen building up on the west (left) side of this groin.



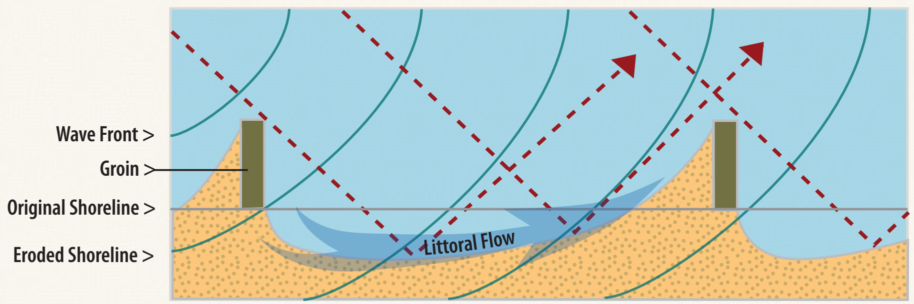


Figure 7A Littoral Flow. Along the Pennsylvania Lake Erie shoreline, littoral flow moves sediments to the north east.
Figure 7B The effect of a groin or wall on littoral flow. The flow of sand along the shoreline is interrupted, and sand is deposited on the updrift side of the groin.

Illustrations - Jodi Staniunas-Hopper

Chapter Four

THE SOIL

Photo - Andrew Lapiska

Planting vegetation on the bluff is very different from planting in a garden. A good garden soil is typically a mix of sand, silt and clay with decaying organic matter mixed in. It has a ready supply of the minerals that plants need for healthy growth. It is teaming with both bacteria and fungi, many of which are important to the health of the plants because they help to release minerals from the organic matter, and they contribute to the porous structure of the soil.

The layers of the bluff, as described in Chapter 3, are called sediments and not soil. They contain little to no organic matter. Due to the lack of fertility in the bluff sediments, most plants will not grow well there. An analysis of the bluff sediments, taken in areas with little to no vegetation, gave the following results in a recent study conducted by Mercyhurst College in Erie, PA:

Nitrogen is very low in the bluff sediments—probably limiting to plant growth. If garden soil had nitrogen readings this low, the recommendation would be to add organic matter.

Potassium and phosphate are also low. Phosphate (P), and potassium (K), along with nitrogen (N) are considered the major plant nutrients. Plant growth is usually limited by a deficiency of one of these three major nutrients. (These are the three nutrients that commercial fertilizers most often provide. Commercial fertilizers often list three numbers - for example, 20-20-20. These three numbers stand for percent N, P, and K, respectively.)

The pH varies depending on the layer and the location. The pH of the sandy layer is more acidic than the optimal pH for many plants; while, the pH of the clay layer is more basic than the optimal pH for many plants. When choosing plants for the bluff, consider their optimal pH requirements.

The Cation Exchange Capacity (CEC) is high in the clay and low in the sand, as expected. CEC is an indicator of how many sites are present

Soil Type	pH	Nitrogen (%)	Phosphate (lb/A)	Potash (meq/100g)	Magnesium (meq/100g)	Calcium (meq/100g)	CEC
Bluff- Yellow, sandy	5.6	0.04	very low (36)	very low (0.1)	optimum (1.2)	very low (3.5)	3.5
Bluff-Gray, clay	7.8	0.05	extremely low (2)	low (0.2)	above optimum (3.4)	extremely high (29.2)	18.6
Desired Level	6.5-7	0.1-0.15	100-146	0.4- 0.6	0.5-1.5	5-10	15

Table 2 Bluff sediment test results. The table gives typical data for the two main layers of the bluff: the upper, yellow sandy layer and the lower, gray clay layer. This test was run on samples from the bluff in Springfield Township. Results may vary depending on location.

on the soil particles to hold nutrients. This means that in the sand, mineral nutrients can easily wash away and plants may have difficulty getting the nutrients they need to grow. Nutrients would not wash out of the clay layer easily.

Bluff owners should have their soil tested before investing in plants, since pH, nutrients, and mineral levels at specific sites may differ from the values reported here. Soil samples can be tested for a modest price by laboratories at Penn State University through the Erie County Extension Office. See Appendix A for contact information.

The soil test does not tell the whole story. The sunbaked sediments on the bluff face often become so hard that it is very difficult for plants to grow. For the small roots of new seedlings, this characteristic alone can stop all growth.

Another important characteristic of the bluff sediments (not shown by the soil test) is the low amount of microscopic life that flourishes there. Healthy soil contains a great diversity of bacteria and fungi, and many of these are beneficial to the plants that grow with them. A study done by Mercyhurst College (Cross, 2007) showed that bacterial counts are much lower in the sediments of the bluff than in the soil of the table land at the top of the bluff. Also, the types of bacteria present in the bluff sediments

Photo - Marlene Cross

Layers of sediment that have washed down to the base of the bluff.

are significantly different than the types found in the typical bluff tableland soils. Two particular groups of microbes are especially important to the growth of healthy vegetation:

Nitrogen-fixing bacteria. Some types of bacteria can fix nitrogen from the atmosphere into a form that plants can use. These are especially important in the nitrogen-poor bluff sediments. Preliminary tests have shown that nitrogen-fixing bacteria occur in low numbers in the bluff sediments.

Mycorrhizal fungi. A group of fungi called mycorrhizal fungi interact with the roots of plants to help them pull up water and minerals (especially phosphorous) from the ground. A study is currently being done to determine the relative numbers of these types of fungi on the bluff.

Most plants will not thrive in soils where these two beneficial groups of microbes are scarce.

The above conditions make the establishment of vegetation on a bare bluff face challenging. The soil/sediment characteristics must be taken into account, however, if a successful revegetation program is to be implemented.

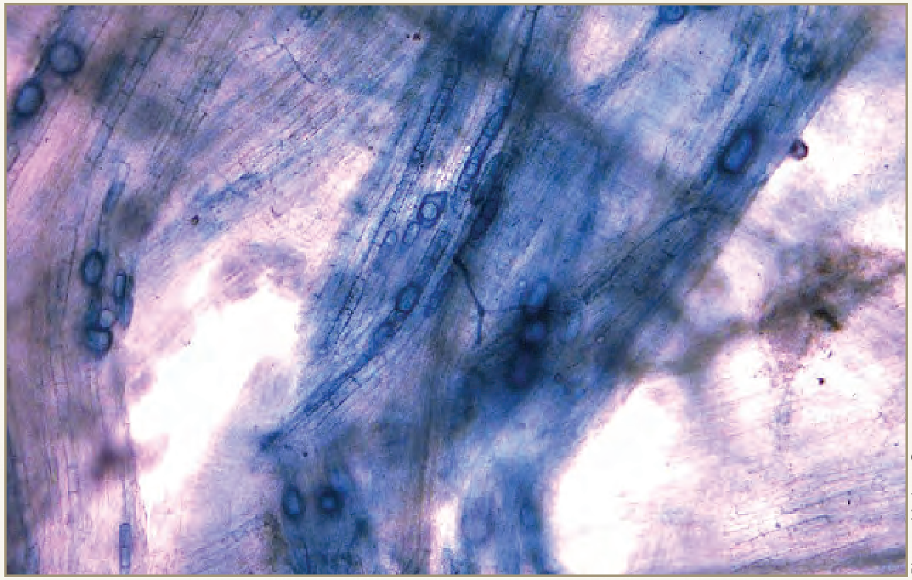


Photo - Marlene Cross

Mycorrhizal fungi (dyed blue in this picture) grow on the roots of plants and out into the soil. They help the plants get minerals and water.

Photo - Marlene Cross

The nodules on this speckled alder root, growing on the bluff, contain bacteria that fix nitrogen for the alders.

{Chapter Five

NATURAL AND MAN-MADE FORCES THAT CONTRIBUTE TO COASTAL EROSION AND BLUFF RECESSION}

Photo - Andrew Lapiska

Why is the bluff receding?

The natural and man-made forces that contribute to bluff recession include:

Physical erosion by storms, wind, rain, hail, sleet and snow. Anyone who has spent time along the Lake Erie bluffs knows that the environment is often harsher and windier than locations inland. During storm events, the force of nature pelting the bluff can be awesome to observe. Erosion can occur rapidly during these times, especially in areas with little or no vegetation to help moderate the impact. Even areas with mature, healthy vegetation may be affected by violent storms.

Surface water runoff. Surface water runoff occurs any time the ground does not absorb all of the precipitation, and, instead, it runs over the surface. Even during gentle summer rains, poorly vegetated bluff sediments may be washed downward into the lake by surface runoff. Runoff from roof tops, paved areas and saturated lawns can also flow down over the crest of the bluff from the tableland. The greater the percentage of paved or impervious areas on the tableland near the bluff, the greater the potential runoff and problems. Proper management of runoff (directing it into properly installed drainage systems that empty at the bottom of the bluff) can help to minimize erosion. See the Best Management Practices (BMPs) listed in Chapter 8 for more detail.

Groundwater seepage. Groundwater is water that has been absorbed into the soil over a very large area in the watershed. It includes all of the water that seeps into the ground from rain, snowmelt, septic systems, and human uses such as watering the garden and washing the car or driveway. Water tends to be drawn downward through the soil by gravity until it meets a layer of the sediment that is impervious. It then flows along that interface. (*See Figure 5 on page 11*.) In the Lake Erie watershed, the upper layer is usually a sandy permeable layer, through which water flows freely. Beneath that is a clay layer that water does not easily penetrate; therefore, water flows along the top of this layer, usually out to the bluff face. This is a simplified picture because the clay layer has many irregular areas of a more sandy type of sediment within it, and since these sandy areas may carry water, the course of the water flow is not easily predictable. Whatever path it takes, groundwater emerges on the face of the bluff—sometimes as a seep and sometimes as a gushing rivulet or rill. At that point, the running water washes the sediments down the bluff face, eventually undercutting the weak, sandy layer above. In time, that sandy layer will also collapse down the bluff.


Photo - CRM File Photo

In this area in North East Township the sandy layer is especially deep, making it more susceptible to collapse.

The degree to which groundwater contributes to bluff recession is a very complicated and site-specific determination. Groundwater flow is, of course, a natural occurrence and can be a beneficial source of moisture and minerals for the vegetation on the bluff face. Too much groundwater, however, can be an important cause of bluff recession, and one that people may have some control over. Human activity along the bluff has contributed to increased groundwater flow, not only because many trees on the table land are cut down, but also in some areas because city water has been installed without a sewer system. Before city water was available, household water supplies came from area wells which drew from the groundwater. After use, this same water reentered the ground through the septic systems, during lawn and plant watering, and through pipe leakage. City water introduces additional water to each property, which is not drawn from the local groundwater but adds to it after use. (If a sewer system is present, a large part of this "additional" water is never added to the groundwater, but is carried away.) Vegetation on the tableland - in the entire area that flows toward the bluff—helps to intercept and decrease the amount of groundwater seepage.

Man-made drainage systems, in some cases, are a feasible option for intercepting excess water. For example, water from downspouts and runoff from driveways can be collected and piped directly to lake level. This process is called channeling and it intercepts water before it infiltrates the ground, minimizing both surface runoff and groundwater flow.

Dewatering, the interception and removal of groundwater, has also been tried. In this process, a trench is usually excavated parallel to the bluff face and down into the impermeable clay layer. Permeable piping is laid in to intercept the groundwater and to channel or pump it down to the lake. These groundwater interceptor trenches can be very expensive and the results are difficult to predict. Their success depends on the depth, regularity, and slope of the clay layer in the area, which is difficult to determine. Success also depends on whether or not groundwater is playing a part in erosion of the bluff in that particular area.

In addition to erosion caused by groundwater seepage, as described above, excessive groundwater also increases the rate of bluff recession in a second way: If groundwater levels are high, the saturated ground near the bluff is much less stable and is more likely to slump. A slump occurs when a large piece of the sediment breaks away and slides down the bluff. Many of the BMPs listed in Chapter 8 are designed to avoid damage caused by excessive groundwater. It should also be noted that too little groundwater can have a similar effect, leaving the ground so dry that it may be more likely to slump.

Freeze-thaw cycles. During the early spring, groundwater near the surface undergoes a series of freeze-thaw cycles as the temperatures drop and then increase again as the sun hits the surface. Water changes volume during these temperature fluctuations and frozen pockets in the soil surface can expand and cause sections of the soil to flake off. Sometimes when conditions are right, and the warm sunlight hits a frozen bluff, this phenomenon can be observed. A series of small cracking sounds are followed by small showers of dirt sliding down the bluff. A great deal of erosion occurs during the spring due to freeze-thaw cycles.

Wave action. Most of the bluffs along Lake Erie shore are too steep to survive over time without landslides. There is, for any given sediment type, an "angle of repose" that is stable. When the bluff becomes steeper than this angle (called over-steepening), it is no longer stable. It may remain intact for some amount of time, but eventually, it will collapse. If not for wave action, sediments falling down the bluff could build up at the toe, thereby creating a more gradually sloping bluff face that is more stable and less subject to recession. However, wave action at the toe of the bluff can remove sand and sediments, leading to over-steepening of the bluff face. This is especially true when a storm causes the waves to surge and pound the coast. A familiar part of the beach may be a changed and unrecognizable area after a major storm.

Waves can also deposit new material at the toe of the bluff. If more sand is being deposited than removed, a wide beach may develop. A wider beach decreases the frequency of wave contact at the toe of the bluff. The power of the waves will be exerted on the sloping beach sand instead of the bluff toe, and erosion rates may decrease. The natural process of deposition and removal of sand by the waves is called littoral flow and is described in Chapter 3. Both natural and man-made factors affect the balance between deposition and removal of beach sediments; and, when the balance tips in favor of removal of sediments, erosion rates increase. While vegetation can soften the blow of gentle waves, it is—for the most part—ineffective in preventing erosion due to the most severe wave action.

Lake level fluctuations. During times of low lake levels, the wave action is directed at certain layers of sediments. When lake levels rise, sediments higher on the bluff are impacted. Erosion amounts can vary widely depending on what type of material is exposed to wave action and wind. If wave action is directed at clay or sand layers, erosion will occur rapidly. If wave action is directed at the lower bedrock layer, it is likely that very little erosion will occur. During high lake level periods, waves are much more likely to contact the softer sediments above the bedrock layer. There, the waves are capable of removing the established vegetation. With the vegetation gone, soils and sediments become more susceptible to erosion.

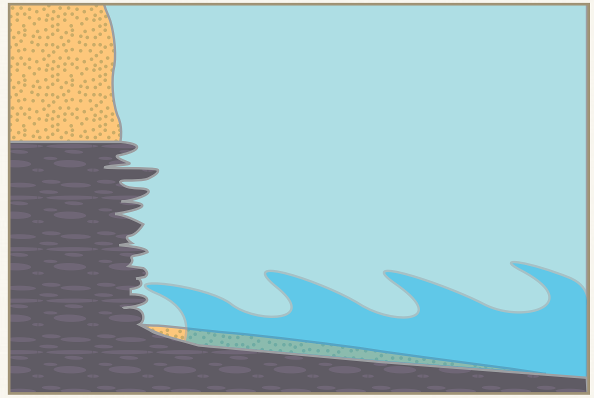


Figure 8a When lake levels are low, waves may expend their force against the resistant bedrock layer, and erosion occurs slowly.

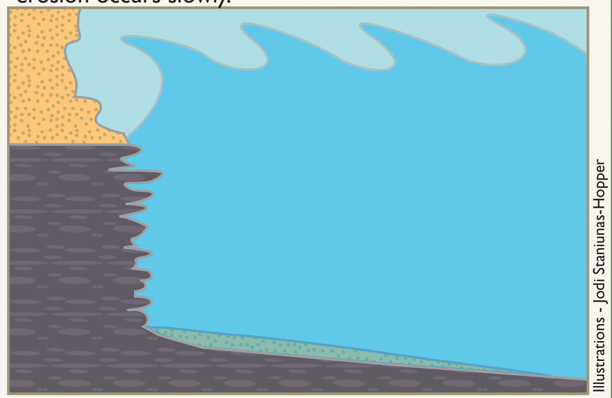


Figure 8b When lake levels are high, waves are more likely to impact the softer sediment layers above the bedrock, and erosion rates increase.

Illustrations - Jodi Staniunas-Hopper

Another effect of lake level fluctuations on the rate of bluff recession involves the beach. At low lake levels, the beach is likely to be broader. A broad beach results in less erosion from wave action. As indicated in Chapter 3, the role of lake level fluctuation in affecting bluff recession may change in the future due to global warming.

Internal shear stress failure. This type of failure involves medium to large pieces of the bluff and table land breaking off and sliding down into the lake. Shear stress can occur due to overloading, for example, putting heavy structures at the top of the bluff such as swimming pools or buildings. Shear stress can also occur because the ground is highly saturated with water or because the ground is extremely dry. When the stress reaches a critical point, the ground will give way and slip down the bluff. A sand castle can be used as an analogy. The sand castle may be strong and solid at first; but, if you put a rock on top of it, or if you pour too much water on it, or if it dries out too much, parts of it will begin to collapse. Shear stress failure is more likely to occur on steeper bluffs than on bluffs with a gradual slope. Vegetation, no matter how healthy, is not likely to have any effect on preventing sheer stress failure. Groundwater management and limiting the weight at the top of the bluff may decrease the risk of shear stress failure.

Human effects. People affect the rate of bluff recession in the following ways:

- By their direct contact with the bluff face - walking, climbing, riding, etc.
- By increasing the load on the bluff by constructing swimming pools, buildings, decks or stairs.
- By bulldozing for roads or other access to the lake.
- By adding to the groundwater and surface water runoff in many ways.
- By adding fill or other debris to the bluff face.

Chapter 8 provides a list of practices that can minimize these human effects, without minimizing the enjoyment of this beautiful habitat.

Monitoring Program

In 1974, the Commonwealth of Pennsylvania supported a team led by Paul Knuth of Edinboro University of Pennsylvania, Edinboro, Pa., to begin an erosion monitoring program on the Pennsylvania shoreline of Lake Erie (Knuth, 2001). Currently, one-hundred-thirty pins (control points) are placed at a distance landward of the bluff crest, every one-half kilometer along the shoreline. Since 1982 - at four to five year intervals - measurements have been made of the distance from the control points to the bluff crest. (In 1982, only 64 of these control points were established; the rest were added four years later.) From these studies, recession rates have been determined for each pin location along the bluff (*See Figure 9*). This collection of data gives resource managers,

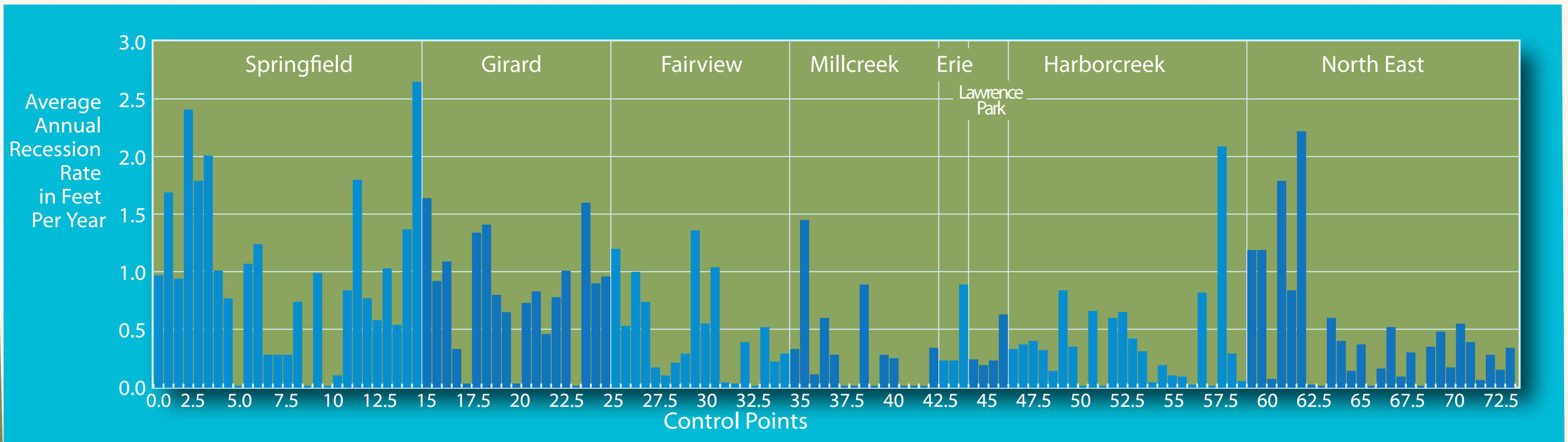


Figure 9 Control points are located approximately every 0.5 km along the Pennsylvania Lake Erie shoreline. The above graph shows the average yearly recession that has occurred at each control point. The recession rate varies a great deal from point to point, and some places along the bluff show little to no recession while neighboring sections may have had substantial losses. The area around control point 61.5 has a very deep sandy layer just beneath the topsoil, and has shown higher than average recession rates, but generally, it can be seen that the western part of the Erie county shoreline has a higher recession rate than the eastern side. Note that no data was available for control points 1.0, 26.0, 37.0-44.0 (no control points are placed in this area), 71.5, and 72.0. This data was obtained from the Coastal Resources Management Program.

planners, township officials, and property owners an idea of where the most active areas of bluff recession are, and gives them a basis for deciding on setback laws.

Historical Perspectives

The occurrence of erosion on Lake Erie bluff slopes is certainly not a phenomenon unique to the modern era. The fundamental forces that contribute to bluff recession have exerted similar effects continually ever since prehistoric Lake Erie receded to its current stage. Early historical accounts of the geology and topography of Erie County and its coast contain no in-depth descriptions of the condition of Pennsylvania's Lake Erie beaches or bluffs, besides brief notations regarding long-term variations in lake levels.

Current focus on the bluff recession problem originated in the early 1970s when high lake levels increased concerns of landowners regarding losses of property and structures in erosion and flood-prone areas of the Lake Erie coast (PA-DEP 2006). Scrutiny of shoreline problems intensified following the establishment of the Pennsylvania Coastal Zone Management (CZM) program in 1980, which included the passage of the Bluff Recession and Setback Act (BRSA). The implementing rules and regulations for the BRSA are found in Title 25, Chapter 85. Since its establishment, CZM has been renamed the Coastal Resources Management (CRM) program.

The CRM Program analyses of the coastal environment led to the realization that shoreline development activity—including installation of permanent stabilizing structures—contributes to erosion of beaches and bluffs by interrupting or interfering with the natural wave-induced movement of sand along the shore. For example, Shamus Malone of Pennsylvania's CRM Program noted in a federal agency newsletter that bluff recession problems in the western portion of Pennsylvania's Lake Erie coast worsened in the late 1960s, following construction of a wall on the east side of Conneaut's harbor. The wall apparently trapped sediment in the harbor at the mouth of Conneaut Creek and prevented its normal passage into the west-to-east flow of material along the Lake Erie shoreline (NOAA 2000).


Photo - Maggie Campbell

The Conneaut Harbor extends into the lake and interrupts the flow of sediments along the lake shore.

Malone, quoted in the 2000 NOAA newsletter article, indicated that: "Twenty-five to 30 cottages have gone into the lake or been abandoned since the mid to late 60s." and that "…the erosion has been so bad that a railroad spur originally several hundred feet from the bluff crest is now a hundred feet in the lake." The studies carried out by the Pennsylvania CRM program indicated that the area affected by Conneaut Harbor "…had the most severe erosion rates of anywhere along Pennsylvania's coastline." (NOAA 2000).

{Chapter Six
RAVINE SYSTEMS}

Photo - Andrew Lapiska

The bluff face along Pennsylvania's Lake Erie shoreline is interrupted by dozens of stream valleys and ravines of varying sizes. The steep slopes of valley and ravine walls present lakefront property owners with the same erosion and recession problems as the bluffs, except that these features dissect lakefront property along lines that are generally perpendicular to the shore.

Ravines that discharge groundwater to the lake via springs and small streams are common in bluff areas where highly permeable sandy soils are prominent in the upper layer of the bluff (AMA 2001). These ravines typically form as a result of groundwater seeps eroding headward (away from the beach) into the upland. Rates of headward and sideward erosion of groundwater seep ravines depend upon the volume of water flowing in the springs that initiate their formation. Ravines dissecting the bluffs contribute to the total load of sediment entering Lake Erie from bluff recession, which accounts for nearly 100 percent of the sediment arriving at Pennsylvania's Lake Erie beaches (Knuth 2001). Although the relative contribution of ravines to sediment-loading in Lake Erie is unknown, it has been estimated that erosion of a typical small (less than 1-acre) ravine may contribute between 10 and 50 cubic yards of sediment to the littoral (nearshore) environment of Lake Erie each year (AMA 2001). This is relatively minor compared to the estimated total amount entering Lake Erie from the bluff face (*see Preface*).

Some shoreline sections have very few ravine systems. If surface layers along the bluff are composed of less permeable clay and silt (glacial till) soils, drainage is mainly via surface runoff, and surface water is more likely to reach the lake through the channels of larger streams. In shoreline sections where ravines occur frequently, the impermeable clay and silt layer lies beneath sandy surface sediments. When erosion by spring seeps in ravines reaches the clay layer, water accumulating on the ravine floor supports the development of wetlands – with distinctive growth of hydrophytic (water-adapted) plants. Wetland plants that may abound in ravine systems include silky dogwood, rough bedstraw, skunk cabbage, and spotted jewelweed. AMA (2001) found that the entire floor of a typical, small ravine may present wetland characteristics.

Lake Erie bluff ravine systems present a unique microclimate (i.e. cooler in summer, sheltered from wind, and warmer in winter) and support plant and animal communities that differ from adjoining beach, bluff, and upland habitats (AMA 2001). The distinctive fauna of Pennsylvania Lake Erie ravine systems include mountain dusky salamanders, web-building spiders, and diverse insect communities. Ravine seeps are also closely linked with bluff habitats containing rare wetland plant species (AMA 2001), such as Pennsylvania-threatened Richardson's rush, small-headed rush and Pennsylvania-endangered variegated horsetail (collection records of Dr. James Bissell, Cleveland Museum of Natural History: 1988-1997).

Management recommendations for erosion problems on ravine slopes are approximately the same as for the bluff face (*see management do's and don'ts in Chapter 8*). There is a tendency for people to deposit debris on the sides and heads of ravines, or attempt to fill in these low-lying areas. Adding extra weight to the top face of a ravine slope will likely decrease its stability and increase the possibility of slope failure (shear stress). Filling a ravine that contains a wetland is illegal without a permit from the state and federal government. Property owners should seek advice from an environmental professional before attempting to fill in any portion of a ravine, to avoid costly fines or mitigation requirements.


Photo - CRM File Photo

A narrow ravine in Springfield Township.


Photo - Marlene Cross

Sunset in North East Township.

{Chapter Seven
THE PLANTS}

Photo - Andrew Lapiska

What should be planted on the bluff?

The conditions on a bare bluff face are too harsh for many plants to succeed. To be successful, a potential bluff plant should:

- Be able to withstand this harsh environment (wind and harsh storms, steep slope with low nutrient content).
- Have a good root system to hold the soil and help prevent erosion. The best mix will include a combination of plants with a fibrous root system and plants with a tap root system.
- Be easy or quick to grow.
- Be able to withstand being reburied periodically. This quality is one that can be observed in most of the successful bluff vegetation. Plants on the bluff would die if they could not sprout back up through the sediments that wash down over them each year. Many trees cannot tolerate this, but a good bluff tree must.
- Recommended but optional: Be a native plant from a local source.

Table 3 contains a list of native bluff plants that have been chosen because they fit most or all of the criteria above. All have been successfully grown on the bluff. Following the table, there is a brief description of each plant, highlighting its strengths as a bluff plant. This is far from being an all-inclusive list.

For information about methods for taking cuttings and germinating seeds, please see Appendix C. For a list of plants that are considered invasive and are not recommended, please see Appendix B.

Establishing Plants on the Bluff

While the plants in this chapter can be propagated by the landowner, many can also be purchased from local nurseries and native plant growers. When purchasing plants from local growers, be aware that some growers import their plant materials from other states, and some of these plants may not be well-adapted to the local environment. The Web site for the "Pennsylvania Native Plant Society" at http://www.pawildflower.org/04_links/links2.htm gives a list of Pennsylvania nurseries. Alternatively, an on-line search for 'native plant nurseries of Pennsylvania' may be helpful.

Planting seeds directly on the bare bluff sediments is rarely successful, and is not recommended. This is because the sediments are so low in nutrients and organic matter and the surface is so hard and crusted that seedlings rarely survive. Also, the weather conditions can be very harsh. More success can be expected when planting well-rooted plants or using live stakes. Live stakes are simply hardwood cuttings that are inserted directly into the soil. See Appendix C. Methods of planting live stakes or branches on the bluff include wattling, brush layering, brush matting, and simple live staking. An excellent review of these methods, with illustrations, can be found in "The Shoreline Stabilization Handbook for Lake Champlain and Other Inland Lakes." See Appendix A, Websites and Manuals, for information on how to access this manual online or to request a hard copy.

Establishing vegetation on the tableland is much easier than planting on the bluff face because topsoil is present and the land is not steeply sloping. Trees and shrubs are often removed from the tableland to provide a better view of the lake. However, tableland vegetation plays a very important role in decreasing groundwater runoff and in holding the soil. Instead of removing trees, consider keeping them and allowing them to "frame the view."

Photo - Marlene Cross

Springfield Township.

Common Name	Scientific Name	Ideal pH	Soil Type	Moisture/Drought Factors	Sun/Shade Tolerance
Shrubs					
Silky Dogwood	*Cornus amomum*	6.1-8.5	Various, very tolerant	Wet to moist	Full sun
Red-osier Dogwood*	*Cornus sericea*	6.1-8.5	Various, very tolerant	Wet to moist	Full sun to partial shade
Staghorn Sumac*	*Rhus typhina*	5.5-7.5	Various, very tolerant	Well-drained soil, tolerates salt	Full sun to partial shade
Purple-flowering Raspberry	*Rubus odoratus*	6.0-8.0	Various	Moist to dry, well-drained	Partial to full shade
Sandbar Willow	*Salix exigua*	5.5-8.0	Deep, moist loams	Prefers moist areas	Full sun to partial shade
Heartleaf Willow (Diamond Willow) and Pussywillow	*Salix eriocephala and S. discolor*	4.0-7.0	All except very rocky, coarse soils	Moist to very moist	Full sun to partial shade
Common Elderberry	*Sambucus canadensis*	5.0-8.0	Various	Prefers moist, tolerates dry	Full sun to partial shade
Northern Arrowwood*	*Viburnum recognitum*	4.0-7.0	Various	Prefers moist, well-drained areas, tolerates salt	Full sun to full shade
Trees					
Red Maple	*Acer rubrum L*	4.0-7.4	Various, very tolerant	Prefers moist areas, flood tolerant	Full sun, some shade tolerance
Sugar Maple*	*Acer saccharum*	5.5-7.3	Well-drained, various	Moist to dry (locally adapted)	Full shade to full sun
Speckled Alder	*Alnus incana, ssp. rugosa*	4.8-7.7	Various	Wet to moist	Full sun to light shade
Gray Birch	*Betula populifolia*	3.5-6.0	Tolerates poor, sandy, rocky, or heavy soils	Moist to dry	Full sun
Red Ash, White Ash	*Fraxinus pensilvanica and F. Americana*	5.0-7.5	Various	Moist to periodic drying (use red ash in wetter sites	Full sun to partial shade
Witch Hazel*	*Hamamelis virginiana*	4.5-6.2	Various	Moist (avoid very dry areas)	Full sun to full shade (shade tolerant)
Black Walnut	*Juglans nigra*	6.0-8.0	Prefers deep loam	Moist, well-drained (tolerates some dryness)	Full sun to partial shade
Hophornbeam	*Ostrya virginiana*	5.0-7.5	Various rocky or sandy soil	Moist to somewhat dry, well-drained	Full sun to partial shade-understory
White Pine	*Pinus strobus*	4.0-6.5	Various (locally adapted)	Moist (tolerates dry and bogs)	Full sun to partial shade

Seed Dormancy	Propagation by Cuttings				Form	Origin	Root type	Usage Area
	Soft Wood	Hard Wood	Semi Hard Wood	Root Cuttings				
Shrubs								
Dormant	•	•			Woody deciduous	Native	Deep, extensive root system, excellent stabilizer	Table, ravine, face, toe
Dormant/Double Dormant	•	•	•		Woody deciduous	Native	Deep, extensive root system, very good stabilizer	Table, ravine, face, toe
Double Dormant				•	Woody deciduous	Native	Fibrous, shallow, spreading, suckering roots, good stabilizer	Table, ravine, face, toe
Dormant		•	•		Woody deciduous	Native	Fibrous	Table, ravine (face or toe if partially shaded)
No Dormancy	•	•	•		Woody deciduous	Native	Fibrous, spreading, suckering roots, excellent stabilizer	Table, ravine, face, toe
No Dormancy	•	•	•		Woody deciduous	Native	Fibrous, spreading, suckering roots, excellent stabilizer	Table, ravine, face, toe
Double Dormant	•	•			Woody deciduous	Native	Suckering roots, very good stabilizer	Table, ravine, face, toe
Double Dormant	•	•			Woody deciduous	Native	Suckering root, good stabilizer	Table, ravine, face, toe
Trees								
No Dormancy	•				Woody deciduous	Native	Shallow roots, very good stabilizer	Table, face, toe, mid successional
Dormant	very difficult				Woody deciduous	Native	Tap root, extensive lateral root branches	Table, ravine, face
Dormant		difficult			Woody deciduous	Native	Roots form nodules w/ N-fixing bacteria good stabilizer, good colonizer from suckers	Table, ravine, face
Dormant			•		Woody deciduous	Native	Suckering root system, often shallow	Table, toe (not best on steep slope), early-successional
Dormant					Woody deciduous	Native	Extensive root system	Table, ravine, face
Double Dormant	difficult	difficult			Woody deciduous	Native	Usually shallow-rooted	Table, ravine
Dormant		very difficult			Woody deciduous	Native	Tap root (hard to transplant), release a compound which inhibits the growth of some other plants	Table, ravine
Dormant					Woody deciduous	Native	Variable, deep or shallow, depending on the soil	Table, ravine
Dormant					Woody evergreen	Native	Wide-spreading, deep root system, tap root not dominant	Table, ravine

Common Name	Scientific Name	Ideal pH	Soil Type	Moisture/Drought Factors	Sun/Shade Tolerance
Eastern Cottonwood	*Populus deltoides*	4.5-8.0	Various	Moist (tolerates drought and salt)	Full sun to partial shade
Quaking Aspen	*Populus tremuloides*	6.0-8.0	Various	Moist to dry	Full sun
Black Cherry	*Prunus serotina*	5.5-7.5	Prefers deep loam, tolerates heavy soil and sandy soil	Moist (tolerates dry)	Full sun to partial shade
Black Locust*	*Robinia pseudoacacia*	4.8-7.5	Various, rich or poor, except swampy	Drought and salt tolerant	Full sun
Basswood	*Tilia americana L*	6.0-7.5	Prefers deep loam, tolerates heavy or sandy soil	Moist (tolerates dryness)	Full sun to partial shade
Herbaceous Plants					
Goldenrod	*Solidago sp.*	4.0-8.0	Various	Variable	Full sun to partial shade
Aster	*Aster sp.*	5.5-7.2	Various	Moist to dry	Full sun
Boneset*	*Eupatorium perfoliatum*	5.6-7.8	Various	Prefers very moist but tolerates some drying	Full sun to partial shade
Virginia Creeper*	*Parthenocissus quinquefolia*	5.0-7.5	Various	Moist (tolerates drought)	Full sun to full shade
Bentgrass	*Agrostis perennans*	5.5-7.5	Various	Dry (some moisture but not wet)	Full sun to partial shade
Indian Grass	*Sorghastrum nutans*	5.0-7.8	Various	Moist (tolerates drought)	Full sun
Switchgrass*	*Panicum virgatum*	4.5-8.0	Various	Moist to dry	Full sun
Wild Rye (Bottle-brush Grass)	*Elymus riparius*	4.5-7.2	Various	Wet to moist	Sun to partial shade
Virginia Wild Rye	*Elymus virginicus*	5.0-7.4	Various	Wet to moist	Full sun to full shade
Bottle-brush Grass	*Elymus hystrix*	5.0-7.5	Various	Intermediate moisture	Partial shade to full shade
Coltsfoot	*Tussilago farfara*	6.6-8.5	Various	Moist to dry	Full sun to partial shade
Yarrow	Achillea millefolium	5.6-7.5	Various	Moist (tolerates dry)	Full sun to partial shade

Seed Dormancy	Propagation by Cuttings				Form	Origin	Root type	Usage Area
	Soft Wood	Hard Wood	Semi Hard Wood	Root Cuttings				
No Dormancy- plant immediately	•	•		•	Woody deciduous	Native	Will root from stems when buried, suckers	Face, toe, early to mid successional
No Dormancy				•	Woody deciduous	Native	Extensive root system to 2-3 feet, sinker roots to 5 feet or more, will sucker	Face, toe, early successional
Dormant	difficult				Woody deciduous	Native	Tap root, with shallow spreading roots, some sinker roots to 4 feet (roots will stay above poorly drained layer)	Table, ravine, face, toe
Double Dormant				•	Woody deciduous	Native	Extensive root system, roots form nodules w/ N-fixing bacteria, suckers	Face, toe, early successional (see note below[1])
Double Dormant - difficult			•		Woody deciduous	Native	Mostly lateral roots, can form adventitious roots from stem if buried	Table, late successional
Herbaceous Plants								
No Dormancy	Basal stem cuttings or stem tip cuttings in spring				Perennial	Native	Fibrous roots, most with vigorously spreading rhizomes	Table, ravine, bluff face
Dormant- slight	Basal stem cuttings in spring				Perennial	Native	Fibrous roots, often from a course root stock, and many species form rhizomes	Table, ravine, bluff face
Dormant	Basal stem cuttings or crown division in spring				Perennial	Native	Fibrous root system, spread by rhizomes, forming large colonies	Table, ravine, bluff face
Dormant	•			•	Woody vine	Native	Root system can be extensive, with adventitious roots forming along the stem, vigorous growth	Table, ravine, face, toe
No Dormancy					Perennial	Native	Fibrous root system	Face, toe, as a part of a mix
May require cold stratification					Perennial	Native	Forms short rhizomes, may penetrate deeply into the soil	Face, toe, grows well on steep slopes, helps prevent wind erosion, readily colonizes disturbed areas
Dormant					Perennial	Native	Spreads by rhizomes, and will form a sod	Face, toe, often used for erosion control
No Dormancy					Perennial	Native	Fibrous root system, without rhizomes	Face, toe, often used for erosion control
No Dormancy					Perennial	Native	Fibrous root system, will form vegetative offsets, and slowly form a sod	Face, toe, often used for erosion control
No Dormancy (2 weeks of cold is helpful)					Perennial	Native	Fibrous root system (spreads mainly by seed)	Face, toe, often used for erosion control
No Dormancy				•	Perennial	Eurasia	Spreads by rhizomes, root system is deep and extensive, fleshy	Face, toe
No Dormancy				divide root ball	Perennial	Europe	Fibrous root system forming root ball	Face, toe

*According to some sources, deer are not fond of these plants. They can be thought of as deer-resistant, but not deer-proof.

[1]Note- Some researchers recommend that black locust not be planted near sandy lake bluffs that support sand barrens or oak savannas, because black locust quickly spreads into these areas.


Red-osier Dogwood


Staghorn Sumac


Purple-flowering Raspberry

Silky Dogwood, *Cornus amomum* and **Red-osier Dogwood**, *Cornus sericea*

These dogwood shrubs are recommended as bluff plants because they can grow on a wide variety of soils and form excellent root systems for stabilization. They can withstand being partially buried by bluff sediments and will simply grow more roots from their buried stems.

They are both easy to propagate. A very simple way to establish these shrubs on the bluff is to take cuttings after they become dormant (November through March) and simply stick those cuttings directly into the bluff. They also can be stuck into the garden. By June, the rooted cuttings can be moved either into a pot. As soon as a vigorous root system develops (July or August), they can be planted on the bluff. Both these shrubs can also be purchased from local commercial nurseries.

The seeds from these shrubs exhibit dormancy. (*See Appendix C for methods for taking a cutting and for starting dormant seeds.*)

Staghorn Sumac, *Rhus typhina*

Staghorn sumac is often one of the first woody plants to grow on a bare bluff in this area. It is a good reclamation plant because of its dense, shallow root system which spreads by root suckers. It is very tolerant of poor soils. It is rarely used as a specimen plant in the landscape, but for naturalizing, it will form large attractive clumps that turn a vivid red in the autumn.

Sumac can easily be propagated by digging up some of the small root suckers in spring before they get their leaves. The seeds have a double dormancy, and after a three month cold-moist period, they must be rubbed well between sandpaper to scarify them before they will germinate.

Purple-flowering Raspberry, *Rubus odoratus*

This showy flowering plant grows naturally along the bluff and in the ravines of the area in any location that provides some shade. Its growth pattern is similar to a raspberry; and, like them, it can spread by tip layering. Tip layering is the characteristic that allows the shoots to form roots wherever they touch the ground. A new plant then forms at this point. The new plants can be dug up and moved to a new location. Pin down the tips to increase the number of new plants. The hundreds of seeds are also easy to collect and to grow if given a cold-moist period.

Common Elderberry

Sandbar Willow

Northern Arrowwood

Common Elderberry, *Sambucus canadensis*

Elderberry bushes have a suckering root system that can help to stabilize the soil. They also provide edible fruit that many birds also enjoy.

Elderberry can be propagated by the home gardener without special equipment. Softwood cuttings taken in July will root if a rooting hormone is used (preferably 0.3 – 0.8 % IBA) and the cuttings are misted daily or kept in a very humid enclosure. The seeds are difficult to germinate, and have a double dormancy. An easy way to overcome this is to plant the seeds in a protected garden plot as soon as the fruit ripens and allow them to break dormancy the natural way. This may take two or more years.

Sandbar Willow, *Salix exigua*, Heartleaf Willow, *Salix eriocephala*, and Pussywillow, *Salix discolor*

All three of these small bushy willows have extensive root systems which help to hold soil in place. They grow quickly and can tolerate being buried. They are valuable bluff plants. Pussywillow has the added characteristic of being very showy in the early spring when it blooms.

It is extremely simple to propagate these willows. Cuttings can be taken at virtually any time of year. Stems with pencil- to thumb-thick wood can be rooted with no hormone in peat moss, vermiculite, perlite, potting soil, water, or just by sticking the cutting into the soil where it is to grow. Willows are very vigorous and they produce an abundance of their own rooting hormones.

Northern Arrowwood, *Viburnum recognitum*

The viburnums are a very diverse and versatile group of plants that are used extensively in wildlife plantings as well as in landscaping. Northern arrowwood grows naturally on the bluff, and the related maple-leaved viburnum (Viburnum acerifolium) grows in the ravines and on the forested table land.

The seeds of these two species are easy to gather, but very difficult to germinate. If the seeds are planted without being allowed to dry out, they may come up in two or three years.

Hardwood or semi-hardwood cuttings may root moderately well for viburnums. See Appendix C for methods of taking hardwood and semi-hardwood cuttings.

An invasive beetle that defoliates many shrubs in the Viburnum genus has become well established in the last decade. Most of the severely defoliated shrubs are now weak or dying. Certain species of Viburnum impacted by this beetle may no longer be good candidates for revegetation on the bluffs.

Sugar Maple

Speckled Alder

Gray Birch

Red Maple, *Acer rubrum*, and **Sugar Maple**, *Acer saccharum*

Red and sugar maples form a tap root with an extensive lateral root system, which makes them good for stabilizing the soil. Their fall color is variable, but can be spectacular.

Sugar maples are simple to grow from seed. Many of the seeds will be empty and should be discarded. A fertile seed will be hard when squeezed. Seeds can be placed in moist peat moss or sand in a baggie and stored in a refrigerator for two to three months. When seeds begin to sprout, they can be planted in pots.

The disadvantage of growing sugar maples from seed is that they are slow-growing, so do not expect too much size in one year. The advantage to growing sugar maples from seed is that local seeds will grow into locally adapted plants, which is thought to be important with maples. When purchasing maples, it may therefore be valuable to ask about the seed source. Like many hardwood trees, maples are very difficult to start from cuttings.

Speckled Alder, *Alnus incana, ssp. rugosa*

The speckled alder is a well-adapted bluff plant because it is one of a small number of local trees that can fix nitrogen in its roots. Nitrogen is fixed by bacteria that live in nodules on the roots of the alder. The alders are thus supplied with an abundant amount of nitrogen and therefore grow even in infertile soils. Alders also have extensive root systems that sucker and form colonies. While listed as a facultative wetland plant, it grows in healthy colonies on the bluff.

Cuttings of alder are difficult to root unless a mist bed is used, but alder is easy to grow from seeds. They can be treated as described above for sugar maple and planted after three months of cold treatment. Several local nurseries also supply speckled alder.

Black Alder, *Alnus glutinosa*, is not a native to our area. It should be avoided.

Gray Birch, *Betula populifolia*

Gray Birch is a small early-successional tree. The trunk is a chalky white color with dark triangular markings. It grows easily from seeds, following the cold moist treatment described above for sugar maple. Cuttings are difficult to root; semi-hardwood cuttings are the recommended method. Used as a bluff plant, gray birch will usually spread by self-seeding as well as root suckering.

White Ash

Witch Hazel

Black Walnut

Red Ash, *Fraxinus pennsylvanica* and White Ash, *Fraxinus americana*

Ashes grow well on the bluff because they can send up sprouts from their stems even if they have been knocked over and partially buried by falling sediments.

Ashes can be grown from seeds after a cold, moist treatment. The seeds may not sprout until six to seven months of cold. Cuttings are not suggested as a method for propagating the ashes. Red ash is a facultative wetland plant, meaning it grows especially well in moist soils. Its cousin, the white ash, grows best in dryer, well-drained soils.

Witch Hazel, *Hamamelis virginiana*

This small tree, usually under 20 feet tall, has fragrant yellow, spider-like flowers late in the fall. It is available from nurseries, and this is the easiest way to obtain specimens. It is most often started from seeds, though they have a double dormancy and require a warm-moist period, then a cold-moist period. Seeds planted outside in the fall should germinate during their second spring.

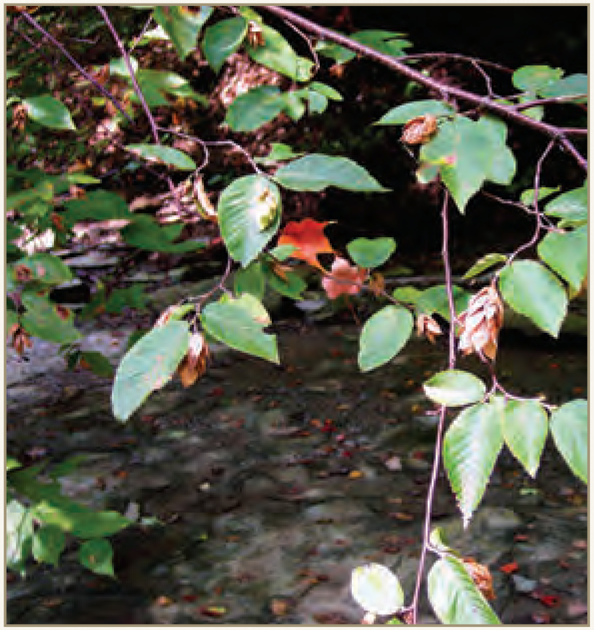
Witch hazel is familiar to many because an extract from the twigs is an old remedy and is often found in medicine cabinets. It is used externally as an ingredient in lotions, soaps, and creams. Compounds in the bark have been shown to have antioxidant, anti-inflammatory, and radiation-protective properties.

Black Walnut, *Juglans nigra*

Black Walnut is a valuable lumber tree in our area. It also supplies nuts for wildlife and humans. It can be found growing naturally along some parts of the bluff and along the streams and ravines that flow into the lake.

A very easy way to grow walnut trees from seed is to remove the husks and plant the nuts in a garden plot in the fall. They should not be dried before planting. A screen on a wooden frame will keep the squirrels away from the seeds. In the spring, the walnut sprouts can be easily (gently) dug and potted up. Propagation of walnut by cuttings is said to be difficult and to be possible only in very young walnut trees.

Note: It is known that black walnut releases chemicals from the roots that inhibit the growth of other nearby plants. Some plants are affected, and others are not. Therefore, walnut might not be the best choice of a tree in areas where a diversity of plants is desired.



Hophornbeam

White Pine

Eastern Cottonwood

Hophornbeam, *Ostrya virginiana*

Hophornbeam is a tree that often can be found growing along the edge of the woods along the bluff. It can grow in sun or shade and can tolerate sandy soil. It is easy to gather the seeds for this tree, but difficult to germinate them. A long cold-moist period (eight to nine months) was required for germination in a study done by Mercyhurst College.

Cuttings are not suggested as a method for propagating hophornbeam. Since it is slow to germinate and to grow, it may be best to purchase this tree from a nursery.

White Pine, *Pinus strobus*

White pine was once common on the tableland along Lake Erie. Most of those early stands have since been harvested for lumber. This tree is recommended for the land at the top of the bluff. Because it is an evergreen, it removes groundwater year round, although at a slower rate in the winter.

Seeds from white pine can be collected from August to September, when the cones just begin to open. The cones are usually formed at the tops of the trees, but the cones hold many of their seeds until after they fall and can be gathered easily then. The seeds need a two to three month cold-moist period.

Eastern Cottonwood, *Populus deltoids*, and **Bigtooth Aspen**, *Populus grandidentata*, and **Quaking Aspen**, *Populus tremuloides*

These three local poplars are fast-growing, early-successional trees. Cottonwoods are especially adapted to growing along the lake. One of their qualities as a bluff plant is that the small trees can be partially buried by sand or sediments from above, survive, and root along their buried stems.

Cottonwood seeds are easy to collect when the "cotton" is released. They should be planted immediately and will germinate very well. Like many early season seeds, they exhibit no dormancy. Softwood or hardwood cuttings are another good way to propagate cottonwood.


Black Cherry


Black Locust


Basswood

Black Cherry, *Prunus serotina*

Black cherry is a large common timber tree in Pennsylvania. Birds love the clusters of small cherries it produces, which are edible. Black cherry is often used as a reclamation plant because it is early-successional, and in areas with a sandy soil, its root system will become extensive. It is not difficult to propagate from seed if given a four month cold stratification. The seedlings should be grown for at least one year in pots before planting in the desired location, and may need protection from deer for their first few years.

Black Locust, *Robinia pseudoacacia*

Black locust can be found growing in many recently disturbed bluff areas. It has many attributes that are desirable in a bluff plant. It is early-successional and has a spreading root system that sends up new shoots as it spreads. It is a legume and, therefore, harbors bacteria in its roots to fix nitrogen. It also can survive being buried. However, some scientists consider the black locust a "native invasive species" in sandy areas.

Seeds require a cold period, but do not need cold-moist treatment. The key to germinating the seeds is to scarify them. Black locust can also be propagated by root cuttings. See Appendix C for seed scarification and root cutting techniques.

Basswood, American Linden, *Tilia americana*

Basswoods are tall, stately trees that grow naturally on the tableland of the Lake Erie bluff. They have extensive root systems that are thought to pull nutrients from deep in the soil, but have no distinct taproot. Cuttings can be taken in late June, but they are difficult to root. Their seeds are very difficult to germinate due to a double dormancy, with the biggest obstacle being the very hard seed coat. Seeds may take three years to germinate in nature. This is another tree that may be best to purchase from a nursery.


Goldenrod


Aster


Bonset

Goldenrod, *Solidago sp.*

Goldenrod is a perennial plant that forms a very extensive root system. It is a tough native plant and several different species are native to the bluff. They are one of the first colonizers of newly disturbed bluff and grow well even in the poor sediments there.

Local species include Solidago canadensis and S. Altissima, but any species found along the bluff could be propagated and used.

Goldenrod can be propagated from seeds or from basal stem cuttings. Seeds require more care and time than cuttings. Start the seeds in the spring in a cold frame. No cold stratification is required. Lightly cover them and do not allow the soil to dry out. Place individual seedlings in pots and let them grow through their first winter. Plant them out into their permanent positions the next spring or early summer. Each plant may spread to form a large clump. Basal stem cuttings root very well for goldenrod. Take them when growth from the crowns begins in the spring. See Appendix C for details on this method.

Aster, *Aster sp.*

Another perennial plant that is hardy enough to grow well on the bluff is the aster. Several species grow locally.

Seeds can be collected from late July to October, depending on the species. Seeds can be stored moist or dry, but if stored dry, they should be pre-chilled for at least two weeks. Locally collected seeds will need this chilling, while some purchased seeds may not. When the seedlings are large enough to handle, place them into individual pots and allow them to grow roots to fill their pots before planting them out in the summer.

Basal cuttings are a quicker method of propagation and should be taken in late spring, as described for goldenrod.

Boneset, *Eupatorium perfoliatum*

Boneset is a perennial and is a very flexible plant with respect to the type of soil it will grow in, but it grows best in areas that do not dry out too severely.

To start this plant from seed, gather the seeds in the late autumn when they are mature. Dry them, and then give them a one to three month cold-moist stratification before planting. The plants will flower in the autumn of their first year.

Boneset can also be propagated by division. The crowns can be divided in spring, or basal stem cuttings can be taken in spring as described for goldenrod.


Virginia Creeper


Indian Grass


Coltsfoot

Virginia Creeper, *Parthenocissus quinquefolia*

Virginia creeper is a perennial vine that becomes woody and so does not really fit in the category of herbaceous plants. It is a beautiful native, prized for its bright red fall color. It can be propagated via cuttings, taken in the early summer and treated with rooting hormone. It can also be propagated from seeds. Seeds should be given a cold-moist period for six weeks at 5°C before planting. Germination is variable.

Bent Grass, *Agrostis perennans*; **Indian Grass**, *Sorghastrum nutans*; **Switch Grass**, *Panicum virgatum*; **Bottle-brush Grass**, *Elymus riparius, E. virginicus, E. hystrix*

Perennial grasses have fibrous root systems that can help hold the soil in place, especially when used in combination with deeper-rooted plants. Many grasses also have spreading rhizomes that help them to form large colonies. All of the grasses listed here can be grown from seed. When trying to establish grasses on the bluff, the recommended procedure is to plant the seeds in small pots and allow them to become well-established (though not root-bound) before transplanting them to the bluff. In good soil, grass can simply be directly seeded, but direct seeding on the bluff sediments is rarely successful.

Non-native Plants: **Coltsfoot**, *Tussilago farfara* and **Yarrow**, *Achillea millefolium*

While these plants are not native to Erie County, they have grown in this area for a long time. They are included here because they can commonly be found growing along the bluff, and, in fact, flourish there. If the goal is to get plants established on the bluff to begin the successional process, then these plants should be considered, and, in fact, will probably begin growing there without needing to be planted.

Of these two plants, only coltsfoot might be considered invasive, but only in disturbed areas. Coltsfoot has a remarkable root system. The large, fleshy rhizomes (underground stems) can be found deep in the bluff. These rhizomes help coltsfoot to survive on the bluff by storing nutrients, and also help to stabilize the bluff sediments.

{Chapter Eight

BLUFF MANAGEMENT DO'S AND DON'TS}

Photo - Andrew Lapiska

Best Management Practices (BMPs) have been developed to guide property owners and the professionals that work in the ever-changing areas along the Lake Erie bluff. BMPs are actions that property owners can take to reduce their impact on the bluff in an effort to reduce erosion. This is done in several ways: by using vegetation (especially maintaining existing vegetation) to retain topsoil and remove water from the soil on the tableland and bluff face; by redirecting storm water and surface water runoff away from the bluff face; by avoiding actions which would lead to additional groundwater flow; by maintaining the drains, swimming pools, and septic systems that change the flow of water across and through the ground; by limiting the number and size of the structures that are built on bluff property and by keeping those structures back from the crest of the bluff.

The following pages list some of the recommended actions that can be taken.

Keep the plants

Think twice before clearing trees from your property. Trees remove a great deal of moisture from the bluff area through evapotranspiration. Clear-cutting, topping or drastic thinning of trees on the bluff tableland and/or the bluff face to enjoy the view will severely impact or limit the effectiveness of evapotranspiration in minimizing damage due to excessive water flows (*See Chapter 2*). It should be noted that, during the winter, most trees loose their leaves and, therefore, transpiration is minimal. In plants that keep their leaves through the winter, including pines and spruces, transpiration continues, although it does slow down. Also, removing trees along the bluff destabilizes the bluff because the soil-stabilizing effect of their root systems is lost.

Retain a buffer of 10-20 feet of undisturbed land from the bluff's edge.

Cutting lawns to the edge of the bluff removes the plants, shrubs and trees that naturally dewater this area and hold the soil in place. Leaving a 10-20 foot deep buffer may help to protect this critical edge from erosion and failure.

Photo - Andrew Lapiska

Mowing right to the edge of the bluff can be dangerous and can contribute to erosion.

Frame your view.
Clear-cutting the bluff to enjoy the view removes the plant buffer. Try framing the view by leaving as much vegetation as possible, yet still allowing a view of the lake. Leave the trees in position and cut the lower branches to allow for a better lake view if necessary. An exception to this is a tree that has already started to fall over the bluff. In this situation, the tree can be cut off at three to five feet from the ground allowing the root ball to stay intact while removing the bulk of the weight of the wood.

Establish and maintain healthy vegetation on the face of the bluff. See Chapter 7 for suggestions and information.

Lose the water

Limit paved areas.

Avoid surface flows down the bluff face. Divert drainage directly to the base of the bluff (through tubes or pipes) or away from the lake towards the road if the road has a storm drainage system. Be sure to monitor and control surface water runoff. Surface water runoff can be very erosive, especially if water runs across impervious surfaces. Impervious surfaces are those areas that do not allow water to percolate into the soil, but quickly route runoff down slope, aggravating erosion. Install a drainage ditch along the edge of these areas and route the water into an appropriate drainage system to lessen the impact of runoff on the bluff. Direct the water from roof downspouts into a drainpipe that empties at the bottom of the bluff. This will decrease both the amount of surface runoff and the amount of groundwater.

Install septic and drain fields well away from the bluff (between the house and the road rather than the house and the lake). See the section on groundwater seepage in Chapter 5 for a discussion about the effect of well water vs. city water.

Maintain all water-using systems such as swimming pools so they do not add additional surface or groundwater to the area via leaks.

The above suggestions will help to minimize the human impact on the amount of surface water and groundwater. While excess groundwater can contribute to erosion on the bluff, there is, of course, an amount of groundwater that is natural and, in fact, necessary for the plants that are growing on the tableland and the bluff face. Eliminating groundwater is not the goal, and would not be a solution. But minimizing the amount of excess water added by human activities can contribute to bluff stability.

Limit the construction

Limit weight near the bluff. Physical structures such as homes, sheds, stairs, etc. that are situated too close to the bluff add extra weight. This leads to more potential erosion, and more storm water runoff. Follow setback regulations for your township. Appendix B provides contact information for the zoning officer for each township.

Choose your path carefully. If you choose to access the beach by foot from the tableland, install a switchback path rather than a path which is a straight line from the top of the bluff to the bottom. A switchback path acts less as a conduit for runoff than a straight down path. A switchback path is also easier to navigate. For additional information, contact the Coastal Resource Management office (see *Appendix A*), or do a web search under 'trail maintenance'.

If stairs are necessary, use open-backed stairs which allow more light to penetrate, this will help maintain plant cover. A list of suggestions about steps can be found at the end of this chapter.

Practice Good Housekeeping

Don't mow along the edge of the bluff (think buffer).

Don't throw grass clippings and other yard waste over the bluff. Throwing mulch and yard waste over the bluff may seem to be a form of composting. It is an organic fill but it consolidates and gets heavy when soaked and can slide down the bluff face, taking sediments with it. It also kills the vegetation underneath that would normally help to stabilize the bluff.

Maintain pools, septic systems, gutters and drains, steps and other structures.

Avoid adding groundwater. Excessive groundwater seepage may cause bluff instability issues. Dewatering might be considered in areas where seepage is substantial. Dewatering is the capture of groundwater before it reaches the bluff. By digging a well or trench and re-channeling the water to the bottom of the bluff in a pipe, erosion of the bluff

Photo - Marti Martz

Yard waste thrown onto the bluff face can do more harm than good.

Photo - Andrew Lapiska

Bank swallows nesting in the sandy layer.

face decreases. It should be noted, however, that groundwater interceptor trenches can be expensive, and due to the fact that the exact geology at a given site is very difficult to know, the results of installing such a trench are difficult to predict.

Plan on regular maintenance (every five to seven years) for all drainage trenches, pipes, structures such as steps and buildings, swimming pools, and septic systems. Monitor vegetation on a regular basis.

Miscellaneous

Though bank swallows nesting in the bluff may seem to be a destabilizing influence, these birds are nesting in the steep, vertical face of the bluff that is nearly ready to go anyway and they provide a valuable service—they eat insects. It is not recommended that they be removed.

Hard stabilization is the installation of some physical structure on or along the bluff to prevent erosion. This includes such things as walls, revetments and groins. An excellent review of several useful types of hard stabilization has been published in "The Shoreline Stabilization Handbook for Lake Champlain and Other Inland Lakes." (*See Appendix A – Web sites and Manuals*.)

While hard stabilization has been successful in many cases, it is often expensive, and must be maintained regularly. Also, hard stabilization can have unwanted environmental impacts. For example, if the movement of sand along the lake shore is interrupted, erosion

Photo - by permission from Dan Dahlkemper

This is part of a drainage system designed to intercept surface runoff and groundwater. A drain (not shown) was installed in the low part of the yard.

Photo - Marlene Cross

An example of hard stabilization.

may increase downdrift of the property. (Along the Pennsylvania Lake Erie shore, this would be to the east of the structure.) Before installing hard stabilization, please contact the Pennsylvania DEP and the municipality to determine if state or local permits are required.

Many bluff landowners would like to have access to the lake from their property. In many cases, this requires a large expense and extensive construction that, if done improperly, can lead to major erosion problems. Trails or roads that go straight down to the lake should be avoided, because erosion will occur rapidly along them. This is due both to the disturbance caused during the construction and the tendency of surface water to run down along the path. It is easier to prevent erosion along a pathway that switches back diagonally along the bluff than one that goes straight down.

Steps

Steps are often constructed down to the lake for easy access. The installation of steps can cause erosion problems if not done correctly. Some suggestions are:

1. Consider the topographic features of that specific part of the bluff. A consultation with a representative from the DEP Coastal Resource Management Program office may be helpful.
2. Try to avoid any excavation of bluff materials during construction.
3. Choose a style that is as open as possible, letting light through for plant growth. If the bluff face is bare of vegetation under the steps, water dripping from and around the steps may flow faster down the slope. This may lead to erosion and instability of the structure. Management of water under and near the step structure is extremely important.
4. The posts that support the steps can encourage surface water or groundwater to flow to the post location, especially if the posts are large in diameter. Erosion may occur at the base of the posts. Heaving of the posts may also occur due to freeze-thaw cycles. Monitor these locations closely.
5. Steps can be designed as a part of a natural trail. Landings or small decks incorporated into the steps can serve as the locations for switchbacks.
6. Check the condition of the steps regularly. Be vigilant. Maintenance will likely be required every five to seven years to ensure bluff stability and **safety**.
7. **Safety is Paramount!** Steps are extremely slippery when wet or icy. Also, a single bluff slump episode may cause steps to become unusable or unsafe.

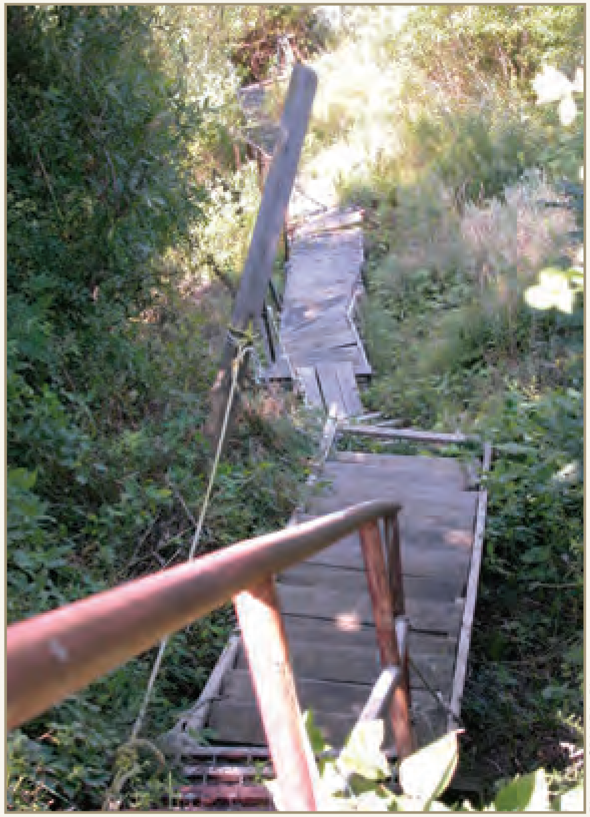


Photo - CRM File Photo

Steps on the bluff face can be difficult to maintain.

Photo - Marti Matrz

This switchback path was installed to give the homeowners access to the lake with minimal disturbance of the bluff face.

Photo - Andrew Lapiska

{Chapter Nine
WHAT THE LAWS SAY}

All municipalities are different with respect to the laws about construction along the bluff. Some require permits for buildings, sheds, stairs, etc. And some don't. Contact the township zoning administrator for information that applies to your property. See Appendix A for contact information.

As a general rule, two permits are required for construction along the Lake Erie shoreline in Pennsylvania; a township zoning permit, and a Uniform Construction Code (UCC) building permit. The township zoning permit and UCC building permit work together to ensure sustainable development along the Lake Erie bluff and Erie County waterways.

Township zoning permit: This specifies that the structure in its proposed location is in compliance with the township's setback requirements, etc. This takes into consideration things such as setbacks for side yards, roads, rights of way, utilities, height of building, distance from bluff crest, etc. In this process, the township zoning officer meets the property owner on site and can issue a permit. A township variance may be necessary to build or expand a structure. The township zoning officer (see Appendix A) can explain the current regulations and processes.

Building permit thru the UCC: The UCC was passed in 1999 and took effect in 2004. All residents must conform to UCC requirements. Some townships provide UCC inspections as a service to property owners; others do not. Property owners that reside in townships that do not provide this service must find an independent building inspector. Check with your township to see if they have a list of contractors to share with property owners. The UCC inspection is ongoing until the project is complete. Inspectors may return several times to check things such as type of block used in the basement, placement of stairs and fences along the bluff, etc.

The chart below lists bluff front setbacks (in feet) for residential, commercial and industrial development along the Pennsylvania stretch of the Lake Erie shoreline by township. These setbacks are correct as of January, 2017, but please note that they may be revised as bluff recession rates are updates or new recession hazzard areas are identified.

These setbacks are enforced by township officials and are the distances required for building permits along the lakeshore.

In some cases, there may be municipal setback regulations from stream banks and wetlands. Some townships have their own local zoning regulations, but be aware that state guidelines supersede township regulations. The best source of information for regulations along streams and wetlands is the Erie County Conservation District Resource Conservationist or the Department of Environmental Protection (*see contact information in Appendix A*).

Municipality	Residential	Commercial	Industrial
Springfield Township	100	150	200
Girard Township	200	200	200
Lake City Borough	150	150	150
Fairview Township	100	100	100
Millcreek Township	50	75	100
City of Erie	25	25	25
Lawrence Park Township	50	75	100
Harborcreek Township	50	75	100
North East Township	50	75	100

TABLE 4 Setback distances (in feet) as established by municipal ordinance. These setbacks apply to any construction requiring permits along the Pennsylvania Lake Erie Bluff.

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Glossary

angle of repose
The maximum angle or slope at which a material, such as soil or loose rock, remains stable and does not collapse. (EPA)

annual
A plant that completes its life cycle (grows, flowers, and makes seeds) in one season; then dies.

bluff
Any high bank or bold headland with a broad, precipitous cliff face, overlooking a lake. (Bluff Recession Act)

bluff recession
The ongoing movement of a shoreline in a landward direction, due to the eroding away of bluff materials.

bluff recession hazard area
Any area or zone where the rate of progressive bluff recession creates a substantial threat to the safety or stability of nearby or future structures or utility facilities. (Bluff Recession Act)

BMPs
Best Management Practices. These are the currently recommended practices for managing an area or resource.

breakwater
A structure that is designed to protect the shore, harbor or beach from waves.

buffer zone (riparian buffer)
An area of permanent vegetation that borders a body of water, field, etc. And is intended to protect that area from the erosive effects of wind, rain and runoff.

canopy
The layer formed by the uppermost leafy portion of trees or shrubs.

channeling
A method of intercepting water, as from downspouts and driveways, before it infiltrates the ground, and piping it to a desired location. (Along the bluff, water is usually piped directly to lake level.)

coastal erosion
The wearing away of land along the coast.

crest (of the bluff)
The part of the bluff where the tableland begins to slope downward to the lake.

deciduous
In the northeast, plants that loose their leaves in the winter. Not evergreen.

dewatering
The interception and removal of groundwater.

diamict
A layer of sediment that is often of glacial origin, in which there are grains of various sizes mixed together (said to be "poorly sorted").

dormancy
A state of reduced physiological activity. A dormant seed will not grow, even if given the proper amounts of water, warmth and light.

double dormancy
A type of dormancy that is being maintained by two factors, for example a chemical in the seed and a hard seed coat.

downdrift
Along the shore in the direction of the predominant movement of the sand and sediments.

ecotype
A distinct genetic subgroup within a certain species that is adapted to a specific environment yet is still considered part of that same species.

evapotranspiration
Water lost in vapor form, both from the leaves of plants via transpiration and by evaporation from the surfaces of the vegetation and the ground.

glacial till
The mix of rocks and ground materials deposited when a glacier melts. (See also 'diamict'.)

groin
A structure that is designed to protect the shore by trapping littoral drift. It usually is built perpendicular to the shoreline.

groundwater
Water that has been absorbed into the soil over a large area and moves through the ground below the surface.

hard stabilization
The installation of any physical structure on or along the bluff (or elsewhere) to prevent erosion.

hardwood cutting
A cutting taken from a woody plant during its dormant period (i.e. during the winter months).

herbaceous
Flowering plants that do not produce a woody stem during their life cycle.

hydrology
The study of the distribution, circulation, and properties of water.

impermeable
A characteristic of soil or any other material that prevents water from moving through it. Clays are often impermeable.

impervious
A surface characteristic that prevents water from entering the soil. Concrete driveways are usually impervious.

invasive species
An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health (EPA).

littoral
Having to do with the shore, especially of a large body of water.

littoral flow
A natural process in which sand and sediment particles are slowly moved along the shore by water currents and waves. Along the Pennsylvania Lake Erie shoreline, littoral flow moves sediments to the north east.

littoral drift
The sediments that are moved along the shore by littoral flow.

microbial diversity
All of the different types of microscopic organisms in a certain environment.

mycorrhizae
The beneficial symbiotic relationship between the roots of most plants and certain species of fungi. The plant gives sugars to the fungi and the fungi gives minerals and water to the plant.

native species
Species that have grown in the local area for a long period of time; not species introduced recently from some other country or location.

nitrogen fixation
The process of converting unusable nitrogen from the atmosphere (N_2 gas) into forms of nitrogen that plants (and then animals) can use (NH_4^+, ammonia). The only living organisms that can do this are certain bacteria.

non-native species
Species that have been recently introduced into an area from some other country or location.

organic matter
The part of the soil that is composed of materials that were once living organisms or produced by living organisms. Organic matter consists of carbon compounds in some state of decomposition.

perennial
A plant that lives for many years. It may die to the ground during the winter, but the root and crown persist and grow back the next year.

pH
A measure of how acidic a solution is on a scale of 0-14 where 7 is neutral. A pH below 7 is acidic and a pH above 7 is basic. pH is actually the hydrogen ion concentration of the solution, equal to the
$-\log [H^+]$.

permeable
A characteristic of soil or any other material that allows water to move through it easily. Sandy soils are usually very permeable.

propagation
With respect to plants, propagation is increasing the number of plants through seeds (sexual) or through cuttings, division, or layering (asexual).

ravine
A deep narrow cleft in the earth's surface, usually formed by a stream or runoff.

reclamation plants
Plants used to help restore disturbed land to a previous, environmentally healthier condition.

rooting hormone
A plant hormone that can be used to stimulate the formation of roots on plant cuttings. Rooting hormones can be purchased in powder or liquid forms, and usually contain an auxin such as indole-3-butyric acid and/or 1-napthaleneacetic acid.

seep
A location where groundwater emerges on the face of the bluff or other bank, or any place where groundwater seeps to the surface.

semi-hardwood
A cutting taken from a woody plant after its growth period, when the new season's wood has hardened (i.e. during mid-to-late summer).

setback
The legally required minimum distance that a building must be from a property line or, on bluff-front property, from the crest of the bluff.

softwood
A cutting taken from a woody plant during its growth period, or shortly after growth stops, while the new wood is still very soft (i.e. during the spring and
early summer).

stratigraphy
The study of the layers (strata) of the sediments that have been sequentially deposited over time.

subsoil
The layers of sediment that lie beneath the topsoil and above the bedrock. It contains little or no organic matter.

surface runoff
Water from rain or other sources that flows over the surface of the ground and does not soak into the ground.

successional process
The gradual process by which one plant community replaces another over time. Usually, the early plant community changes the soil or environment in a way that favors the next plant community.

suckering root system
A root system that produces buds that form new shoots. In a plant with a suckering root system, new plants will often arise all around the parent plant.

tableland
The flat or rolling land at the top of a bluff.

taproot
A single, vertical, main root, often with many lateral branches, formed by some plants.

tip layering
A method of propagating plants by bending the shoot tip down and burying it in the ground with just the tip emerging. The buried stem will form roots, producing a new plant that can be separated from the parent plant.

toe of the bluff
The part of the bluff at the base where the steep slope meets the beach.

topsoil
The upper layer of the soil, which contains organic matter and is richer in nutrients than layers below. Most of the roots of plants, and their mycorrhizal fungi, are found in this layer.

transpiration
The evaporation of water from plant tissues, usually through the leaves.

watershed
All of the land area that is drained by one waterway and all of its tributaries.

Appendix A
CONTACTS AND RESOURCES

Local Resources

Erie County Conservation District
ENS Technician
1927 Wager Road
Erie, Pa 16509
(814) 825-6403

Erie County Department of Planning Coastal Resources Management Planner
140 West 6th Street
Erie, PA 16501
(814) 451-7328

Erie County Department of Health and Safety Environmental Programs
606 West 2nd Street
Sewage/Septic Permits
(814) 451-6775

Pennsylvania Department of Environmental Protection Coastal Resources Management Program
Tom Ridge Environmental Center
301 Peninsula Drive, Suite 4
Erie, PA 16505
(814) 217-9634

City of Erie Zoning Officer
Erie City Hall
626 State Street
Erie, Pa 16501
(814) 870-1265

Fairview Township Zoning Officer
7471 McCray Road
Fairview, PA 16415
(814) 474-5942

Girard Township Zoning Officer
10140 Ridge Road
Girard, PA 16417
(814) 774-4738

Harborcreek Township Zoning Officer
5601 Buffalo Road
Harborcreek, PA 16421
(814) 899-3171

Lake City Borough Zoning Officer
2350 Main Street
Lake City, PA 16423
(814) 774-2116

Lawrence Park Township Zoning Officer
4230 Iroquois Avenue
Erie, PA 16511
(814) 899-2305

Millcreek Township Zoning Officer
3608 West 26th Street
Erie, Pa 16505-2037
(814) 833-2935

North East Township Zoning Officer
10300 West Main Road
North East, PA 16428
(814) 725-8606

Springfield Township Zoning Officer
13300 Ridge Road, Box 274
West Springfield, PA 16443
(814) 922-3274

Erie County Extension Office
606 West 2nd Street
Erie, PA 16507
(814) 825-0900
(For soil tests)

Regional Resources

Department of Environmental Protection
Northwest Regional Office
230 Chestnut Street
Meadville, PA 16335
(814) 332-6945

Contractors

A list of "Contractors for Shoreline Protection and Bluff Stabilization Services" can be obtained from the Coastal Resource Management Office and on the PA Sea Grant Web site. The contractors on this list have attended a Best Management Practices workshop for professionals, presented by Pennsylvania Sea Grant and the Coastal Resource Management office. Professional contractors can also be found in the Yellow Pages of your local phone book.

Web Sites and Manuals

The on-line Pennsylvania version of this manual is available through the Sea Grant Web site.

Appendix B
NOXIOUS WEEDS

The Coastal Resources Management Program recommends against using the following plants, because they have been shown to invade and degrade coastal habitats:

- Reed canary grass - *Phalaris arundinacea*
- Crownvetch – *Coronilla varia*
- 'Arnot' bristly locust – *Roninia fertilis*
- Hall's Japanese honeysuckle – *Lonicera Japonica Halliana*
- Purpleosier willow – *Salix purpurea*
- Amur honeysuckle – *Lonicera maackii*
- Black alder – *Alnus glutinosa*
- Hybrid poplar – *Populus ssp.*


Photo - Francia Aguilara

Common Reed, *Phragmites australis*.

In addition, the following plants should always be avoided because they are recognized as invasive species in Pennsylvania:

Grasses
- Cheat grass – *Bromus tectorum*
- Common reed – *Phragmites australis*
- Shattercane – *Sorghum bicolor ssp. Drummondii*
- Johnson grass – *Sorghum halepense*

Herbaceous Plants
- Musk thistle – *Carduus nutans*
- Canada thistle – *Cirsium arvense*
- Bull thistle – *Cirsium vulgare*
- Goatsrue – *Galega officinalis*
- Giant hogweed – *Heracleum mantegazzianum*
- Purple loosestrife – *Lythrum salicaria, L. virgatum*
- Japanese knotweed – *Polygonum cuspidatum*

Vines
- Japanese honeysuckle – *Lonicera japonica*
- Mile-a-minute vine – *Polygonum perfoliatum*

Shrubs
- Japanese barberry – *Berberis thunbergii*
- European barberry – *Berberis vulgaris*
- Russian olive – *Elaeagnus angustifolia*
- Autumn olive – *Elaeagnus umbellate*
- Common privet – *Ligustrum vulgare*
- Honeysuckles: Amur, Morrow's, Bell's, Standish, and Tartarian – *Lonicera maakii, L. morrowii, L.morrowii x tattarica, L. standishii,* and *L. tartarica*
- Multiflora rose – *Rosa multiflora*

The above list is an abbreviated list from the DCNR's "Invasive Plants in Pennsylvania" website. For a more extensive list of invasive species and for descriptions, please contact DCNR, Bureau of Forestry, P.O. Box 8552, Harrisburg, PA 17105-8552
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Appendix C
PLANTING TECHNIQUES

How to take a cutting.

Choose healthy woody stems that are between pencil-sized and thumb-sized in diameter. Make a cut diagonally just below a bud (or node). Make a second cut straight across the stem just above a node so that the cutting is eight to ten inches long. Hardwood cuttings are those taken from late fall until early spring while the plant is dormant. Softwood cuttings are those taken from the soft, new growth in the late spring or early summer, before this growth becomes hardened. Semi-hardwood cuttings are taken from semi-hardened wood in the late summer.

To get these cuttings to root, you may need to dust them with rooting hormones or treat them in certain ways. One easy way to root cuttings is to take the cutting during winter and simply stick it in the garden until spring. Willow and dogwood are two examples of plants that root and grow very easily this way. Once growth has become vigorous in summer, dig up these cuttings and either put them into pots or plant them directly in the intended location.

How to start dormant seeds.

Many of our local shrubs, trees, and perennials have seeds that exhibit dormancy and will not grow, even under perfect conditions, until a certain amount of time (and usually a cold period) goes by. This is their natural mechanism to prevent germination from occurring so late in the summer that the seedlings may be too tender to survive the winter.

In some seeds, dormancy can be broken by a few months in the refrigerator. Often, the cold period is only effective if the seeds are also kept moist. It is easy to give seeds this "cold-moist" treatment by putting them in a baggie with some moist (but not soggy) peat moss or sand. Keep the baggie in the refrigerator for the required dormancy period. Check the baggie periodically to insure that the medium does not become dry. This process is called stratification.

Some seeds have such a hard seed coat that they also must be scarified before they will germinate. (See below.)

The easy way to get around these requirements might be to allocate a small section of garden to seed germination, plant the seeds there and let Mother Nature do the stratifying. Note that for "tasty" seeds that the squirrels may eat, the garden area should be covered with something protective like metal screen.

How to scarify seeds.

Scarify seeds by rubbing them between two sheets of sandpaper. This nicks the seed coat to allow the seedling to push through. Some sources recommend scarifying with acid or hot water. Experiments with black locust seeds at Mercyhurst College found that, in addition to the sandpaper technique, hot water worked well. To use this method, pour boiling water into a cup, allow it to cool for approximately 5 minutes, then add the seeds and allow them to soak for 12 hours before planting.

How to take basal stem cuttings.

Goldenrods and asters, as well as many other perennials, grow by forming a large clump. If the clump is dug up in spring as growth begins and the soil is shaken off, many small shoots can be seen coming out from below what used to be the soil surface. These shoots can be pulled or cut apart and planted individually, either in pots or directly into the garden in a protected location. Once the basal cuttings are well established (later in the summer), they can be moved to the desired location.

How to take root cuttings.

Roots (1/2 to 1" diameter) can be dug early in the spring, cut into 2-3" pieces, and stored in barely moist sand in a cool place. After 3 weeks, the root pieces will be "calloused" and can be planted horizontally in soil, pots, or flats. (Method from Dirr, 1987)

Notes

2017

Vegetative Best Management Practices

{A Manual for Pennsylvania/Lake Erie Bluff Landowners}