Erosion and Recession of New York's Coastal Bluffs

Sea Grant
New York

Figure 1. Many types of bluffs, in various shapes, sizes, and compositions, exist in New York State. They include but are not limited to rapidly-eroding glacial lake sands in Wayne County (1A), unconsolidated sediments ranging in grain sizes in the bluffs of Long Island (1B), and bedrock bluffs in Angola on Lake Erie (1C) which are topped with glacial lake sand and gravel.

Introduction

Bluffs are steep, soft cliffs or banks common throughout the coastal areas of New York State. Bluffs can range in height from ten feet to upwards of fifty feet and are composed of loosely compacted sediments varying in size from clays, silts, sand, gravel, up to large boulders. Due to their steep nature and the influence of waves and water level, seepage and runoff, bluffs are susceptible to erosion and episodic failure that may result in large quantities of sudden land movement. Along some shorelines of the Great Lakes, such as along Lake Erie and northeastern Lake Ontario, exposed bedrock can also form steep, rocky cliffs that erode slowly, but are topped with similarly steep, more easily erodible bluffs (reference Figure 1C).

Bluff Formation in New York

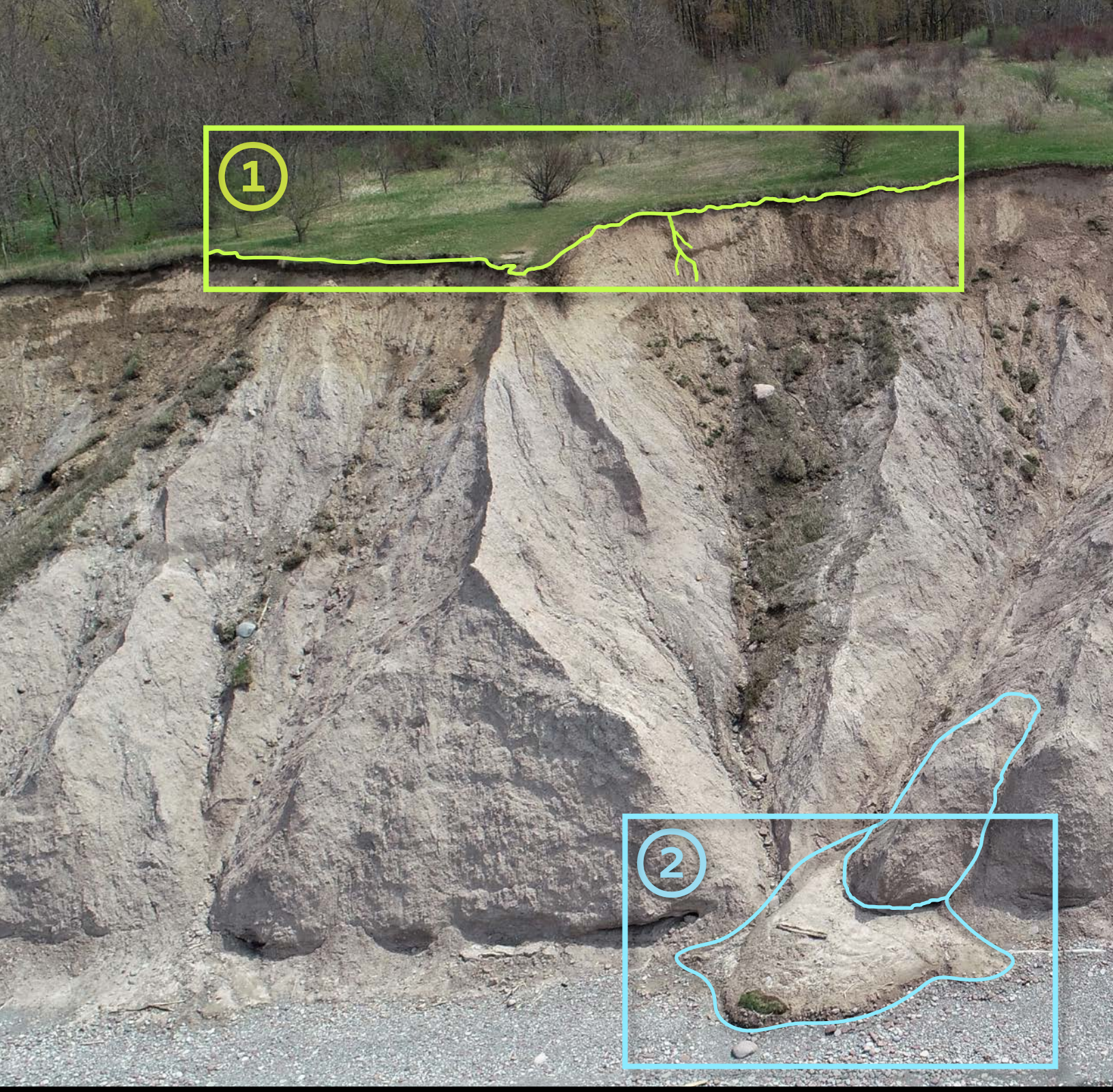
As the Laurentide Ice Sheet moved south from the Arctic during the last ice age (9,000-21,000 years ago), it collected sediment. Once the ice sheet reached its maximum southerly extent at modern day Long Island, long ridges of unconsolidated sediments, called moraines, were deposited. The bluffs on Long Island are the eroding face of these remnant ridges.

In the Great Lakes, glaciers also contributed to the formation of bluffs. Drumlins, which are elongated, often teardrop-shaped hills, were deposited beneath the glaciers as they spread out across the landscape. Today, the northern edges of many of these drumlins form steep and often scenic drop offs to the shore of Lake Ontario. On Lake Erie, remnant glacial lake shorelines, beach ridges and deeper glacial lake sediments (including lake clays, silt, sand and gravels) also create bluffed shores.

Erosion Processes on Coastal Bluffs

Coastal bluffs are susceptible to erosion by wave action from below, as well as from above due to water flowing over land or through the soil. Erosion may also occur naturally on an unvegetated slope due to wind, and people or animal movement on the bluff face. Beaches form at the bottom of most bluffs as the sediment erodes and is redistributed along the shoreline by waves and currents. When this sediment supply is cut off due to the construction of hard, vertical structures such as bulkheads, seawalls, or jetties at protected harbor and river mouths, erosion of the beach will occur. While beaches at the bluff toe may continue a cycle of erosion and growth, the erosion of the bluff itself is permanent and sediment can only be replaced by human intervention, such as beach renourishment and artificial fill.

Photo credits by Roy Widrig (Great Lakes) and Kathleen Fallon (Long Island)



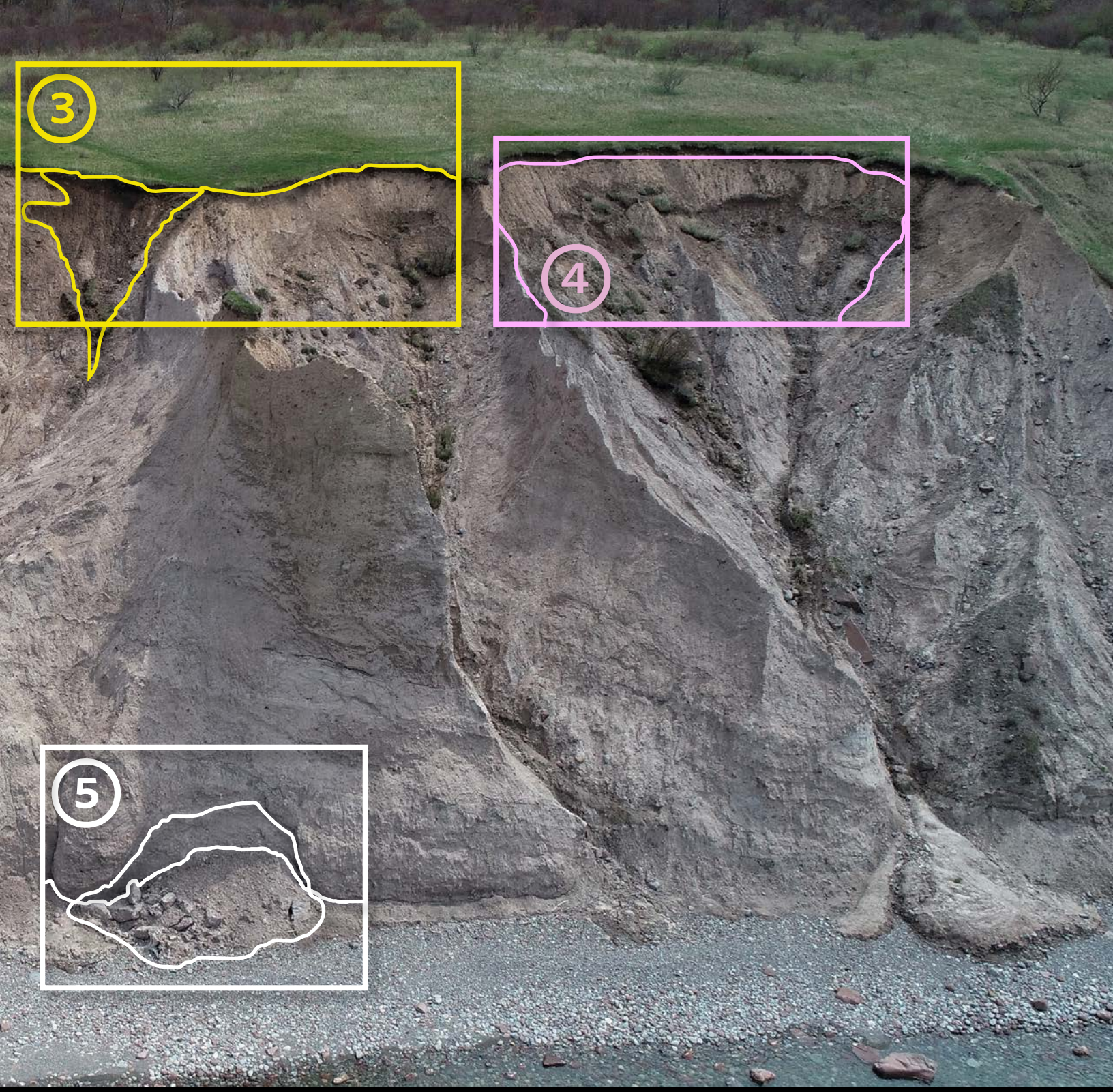
Erosion Processes on Coastal Bluffs

① Bluff Crest Erosion

Water flowing over the top of the bluff, or bluff crest, comes in contact with the exposed sediment on the bluff face, adding weight to the soil and causing accelerated erosion. Bluff crests, along with the toe of the bluff, often experience the highest rates of erosion and have the steepest slopes.

② Overland Flow

During rain events, from excessive lawn watering, and during freeze/thaw cycles, soil on the slope of bluffs is carried downslope by water flowing over the land. While this rate of erosion is slower than toe erosion or slumping, it can happen more often and more consistently throughout the year, resulting in significant loss of bluff material and bluff steepening all year long.



③ Disturbance

Dense, deep roots from native plant species can help stabilize bluffs and reduce long-term erosion risk. Here, a mowed area and footpath along the top of the slope does little to reduce erosion, instead contributing to soil and grass creep downslope.

④ Slumping

Slumping, where large masses fall off at once, is one of the fastest mechanisms of bluff erosion. Here, a large block of bluff fell off at the toe and was quickly washed away by wave action during a high water event.

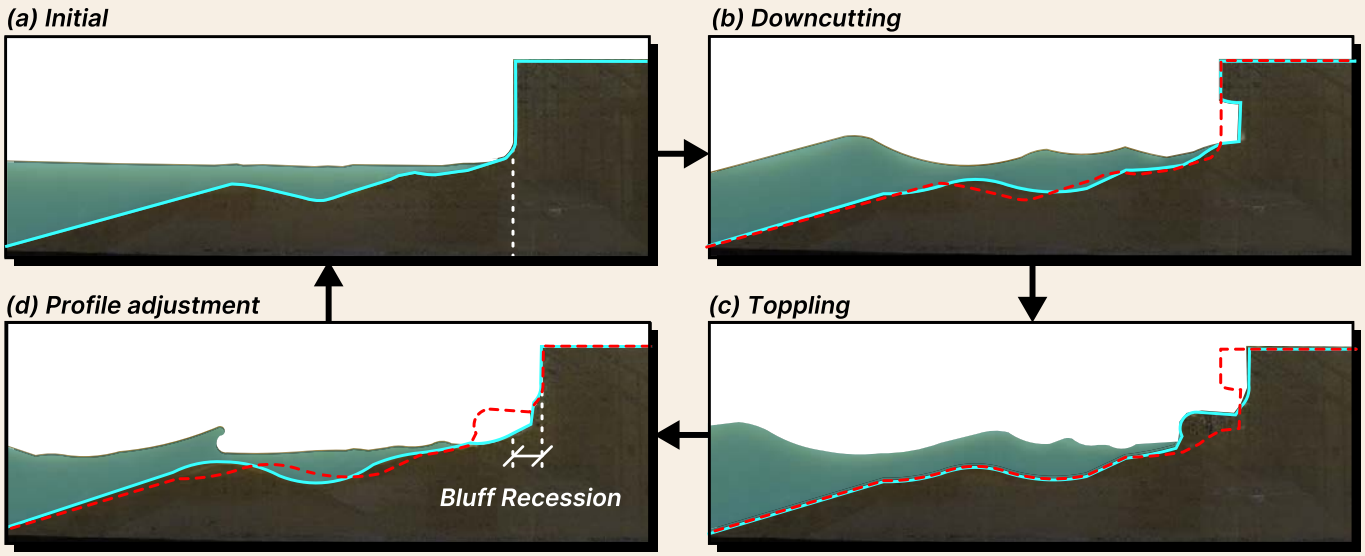
⑤ Toe Erosion

Toe erosion is one of the dominant drivers of bluff erosion. The toe, where the slope meets the water or beach, is in direct contact with incoming waves during storm events and times of high water.

Figure 2. Oversaturated soils from intense rainfall or overwatering of lawns can cause soil to move away from and off of steep bluff faces in mass movements, sometimes as soil creep or earthflow (as seen above) but other times in small to large landslides (see insert.)

Mass Movements of Bluffs

Bluff erosion is often episodic, with erosion and slope failure being driven by high water events in the Great Lakes, and by coastal storms and sea level rise on Long Island. These episodic events can take the form of small landslides or slumping, and can range from small to large movements of bluff material down the bluff face to the beach. Additionally, large blocks can also slough off at once. These erosion events often correspond with high lake levels and freeze-thaw cycles on the Great Lakes. Increased runoff or groundwater can also lead to bluff instability causing slumping events. Additionally, wave action at the toe of the bluff results in undercutting which can cause abrupt collapse. Since New York's bluffs were formed during the last ice age, there is currently no natural way for them to rebuild themselves. Therefore, the erosion and recession of New York's coastal bluffs is permanent.



Ghazian Arabi, M., Khosravi, M., and Farhadzadeh, A. (2020). "Effects of fines content and relative density on erosion and recession of predominantly sandy beach-bluff system", Journal of Waterway, Port, Coastal, and Ocean Engineering. https://doi.org/10.1061/(ASCE)WW.1943-5460.0000625.

Figure 3. Wave tank experiment showing the cycle of bluff downcutting, toppling and beach adjustment: (a) initial profile, (b) foreshore downcutting, (c) bluff topping failure, (d) profile adjustment. Initial profile for each stage: Red dashed line; Final profile for each stage: light blue line.

Conserving Bluffs and Slowing Erosion

There are several ways to protect bluffs and prevent or slow the erosion of sediments. The solution needs to typically address both land and water processes, such as water level and waves, and runoff and groundwater movement such as seepage. This can be achieved through simple measures, such as planting native vegetation, which helps reduce the amount of runoff over and seepage through the land. Atop bluffs, vegetation such as deeply-rooted grasses, shrubs and trees creates an erosion-resistant network of roots, holding soil in place, and reducing the speed of runoff. When vegetation is removed or water is added (such as through excessive watering of turf grass), the rate of erosion at the top of the bluff as well as the face is often accelerated.

Other protective techniques may include the use of nature-based features, bioengineering or hard structures. However, these options are typically more costly and may require more maintenance over time. For shoreline erosion management projects, be sure to obtain expert advice and the appropriate permits before beginning work.

Figure 4. A vegetated bluff on Long Island.

Figure 5. Toe erosion and slumping on the shore of Lake Ontario.

Monitoring and Reporting Bluff Erosion

When living close to the bluff's edge, it is important to monitor your shoreline to establish a baseline for the rate of retreat of the bluffs on your property. This can be done by measuring from stationary objects such as buildings, trees, or other features to the edge of the bluff every season, and before and after storm events. Maintaining a photographic database is also helpful. Always exercise caution when nearing the edge of the coastal bluff.

To report bluff erosion and begin monitoring your shoreline, or receive assistance contact New York Sea Grant:

Long Island: Survey123 Link - https://arcg.is/5eHjf

Great Lakes: Survey123 Link - https://arcg.is/149P9m

New York Sea Grant is part of a nationwide network of 34 university based programs working with coastal communities through the National Oceanic Atmospheric Administration (NOAA). Sea Grant research and outreach programs promote better understanding, conservation, and use of America's coastal resources. Sea Grant is funded in New York through SUNY and Cornell University and federally through NOAA. New York's Sea Grant Extension Program provides Equal Program and Equal Employment Opportunities in association with Cornell Cooperative Extension, U.S. Department of Agriculture and U.S. Department of Commerce and cooperating County Cooperative Extension Associations.

Great Lakes Resources:
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Shoreline Erosion Management for New York's Great Lakes Shorelines
https://seagrant.sunysb.edu/glcoastal/pdfs/ErosionManagement.pdf

Working with Nature: A Guide to Native Plants for New York's Great Lakes Shorelines
https://nyseagrant.org/Images/Uploads/PDFs/GreatLakes-ShorelinePlantsGuide.pdf

Long Island Resources:
Kathleen Fallon, Ph. D., Coastal Processes and Hazards Specialist
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Dynamic Shorelines: Long Island Story Map Collection
https://storymaps.arcgis.com/collections/ef289e23b3cf4e85a8ae188f77ea635f

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