

Effects of Erosion and Accretion on Coastal Landforms

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Photo by Heather Weitzner, New York Sea Grant

Bluffs found along New York's Great Lakes shorelines are affected by erosion resulting from a variety of factors including waves, high water levels, groundwater seepage, and runoff.

New York has a diverse shoreline along the Great Lakes that includes coastal landforms such as sand beaches, dunes, offshore bars, bluffs, cobble beaches, wetlands and various combinations of these features. Some of these landforms provide erosion protection, reducing the vulnerability of landward areas and the naturally formed and human built environment found there. These areas are also susceptible to erosion and accretion (build up of sediment) caused by such forces as wind and waves, which help shape the shoreline. While humans can also impact the shoreline by intensifying erosion and accretion, this fact sheet aims to introduce coastal landforms found along New York's Great Lakes shorelines and discuss how they are affected by the more natural forces and factors that influence shoreline evolution.

Beaches

Beaches extend from the toe of a dune (or bluff) to the outermost point where waves begin to break. They are composed of erodible, unconsolidated sand, gravel, and/or cobble, which may be moved by waves and wind. Beaches act as natural barriers between waves and upland features, such as dunes. The wider and higher the beach, the more wave energy is dissipated before reaching the shoreline.



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As waves break onshore, they disturb bottom sediment, which can then be moved (refer to the New York Sea Grant fact sheet, “Coastal Processes and Causes of Shoreline Erosion and Accretion” for a description of waves). Gentle, long period waves found in calmer weather, known as swells, tend to move sediment onshore, building up the beach. Steep, choppy waves associated with storms and strong winds tend to transport sediment offshore, eroding the beach. If the shore is gently sloping, wave energy can be dissipated over a longer distance, causing less erosion. If the shore is steep, waves will break closer to shore, concentrating their energy in a smaller area and causing more erosion. The rise in water levels associated with storms, called storm surge, allows waves to reach farther up the beach to areas that would not normally be exposed to wave action (refer to the fact sheet, “Coastal Processes and Causes of Shoreline Erosion and Accretion” for a description of storm surge).

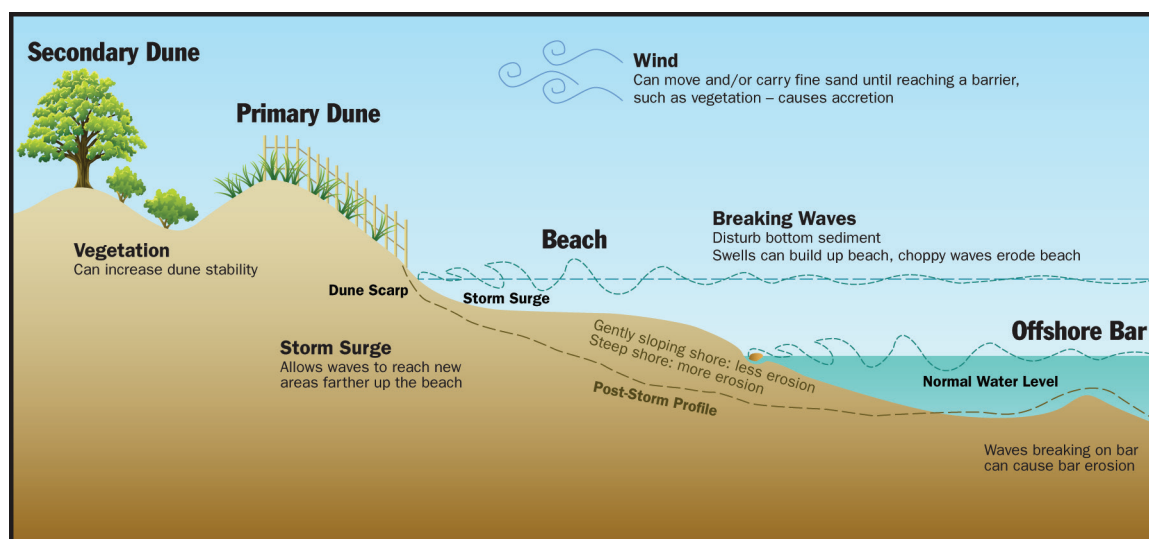
Wind blowing across the beach can move finer grained particles, shaping, and, in some cases, eroding the beach. Wind-blown sediment will continue to move until it reaches a barrier, such as vegetation, which reduces the wind speed and causes sediment to be deposited. It is this accretion that forms dunes.

On the Great Lakes, ice can also influence what happens on the beach. While anchored or stabilized ice can form a protective barrier from erosion, thawed and/or broken ice can be moved onshore or along the shore by wind and waves. This causes beach scour, which is a localized loss/erosion of sediment.

Offshore Bars

Offshore bars are underwater deposits of sediment that form parallel to the shoreline. They can act as wave barriers, if large enough, by forcing waves to break farther offshore than they normally would. This reduces the amount of wave energy that reaches the shore. Bars are formed from deeper water sediment, or from material carried away from a beach during times of high wave activity or higher-than-normal water levels.

Although the bar may reduce beach erosion by causing waves to break farther offshore, the action of waves breaking on the bar can cause erosion of the bar itself. Large storm waves can also erode the bar and/or carry sediment far enough offshore that it is no longer available for beach building. Long swells can cause a bar to migrate shoreward by carrying sediment towards the beach. If long swells are not present, the bar and beach may not be rebuilt after erosive events, even if there is adequate sediment in the system.



Factors affecting dunes, beaches and offshore bars.

Dunes

Dunes are mounds or ridges of sand deposited by the wind immediately landward of the beach. Primary dunes are closest to the beach and are usually lightly vegetated with grasses, while secondary dunes are farther landward and may have a more dense vegetation cover that can include shrubs and trees. Vegetation can trap and hold windblown sand on dunes. If large enough, primary dunes can provide protection from flooding and wave action for the upland area, and may replenish some sand to eroded beaches. If a primary dune is breached, secondary dunes (if present) provide erosion and flooding protection to landward areas.

Should the water level rise (e.g., storm surge), waves may reach areas farther up the beach, even all the way to or over the dune, and begin to erode the upper beach and dune area. As with beaches and offshore bars, the breaking of a wave on or at the base of a dune can pick up and transport sand leaving a scarp, which is a steep, almost vertical slope. The eroded sand can be transported to the beach or offshore. During extreme storms, portions of the primary dune can be completely eroded, causing an overwash where water carries sand through the dune and deposits it on the landward side in a feature known as a washover fan. The material is lost to the beach system, but dunes may reform in a more landward position on the fan if there is sufficient sand.

Wind can be the cause of both dune formation and dune erosion. Barriers, such as vegetation, cause an accretion of sand, building up the dune. The absence of these barriers allows winds to transport sand from the dune. Although vegetated dunes tend to be better protected against wind, a major storm may still remove or severely damage a dune by creating a dune blowout.

Barriers and Spits

Barrier islands are long, relatively narrow deposits of sediment that form parallel to the shoreline. Unlike submerged offshore bars, they are higher in elevation and rise above normal lake water levels. These features may be populated by human development and support natural ecosystems. Bay barriers and spits are similar to barrier islands in that they are created by the transport of sand or other sediment. However, bay barriers extend partially or fully across the mouth of a bay and spits are narrow accumulations of sediment that have one end attached to the mainland and the other extending into the water.

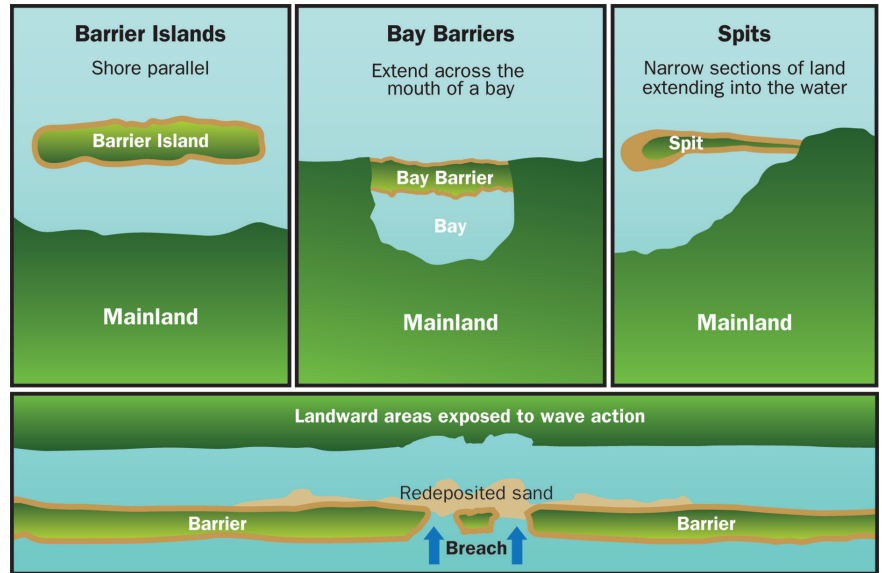
These landforms are vulnerable to the same wind and wave action that can erode beaches,

dunes, and offshore bars. Wind and waves associated with large storms can cause severe damage to and potential breaches of barriers and spits, exposing landward areas, such as bays and wetlands, to increased flooding and erosion.

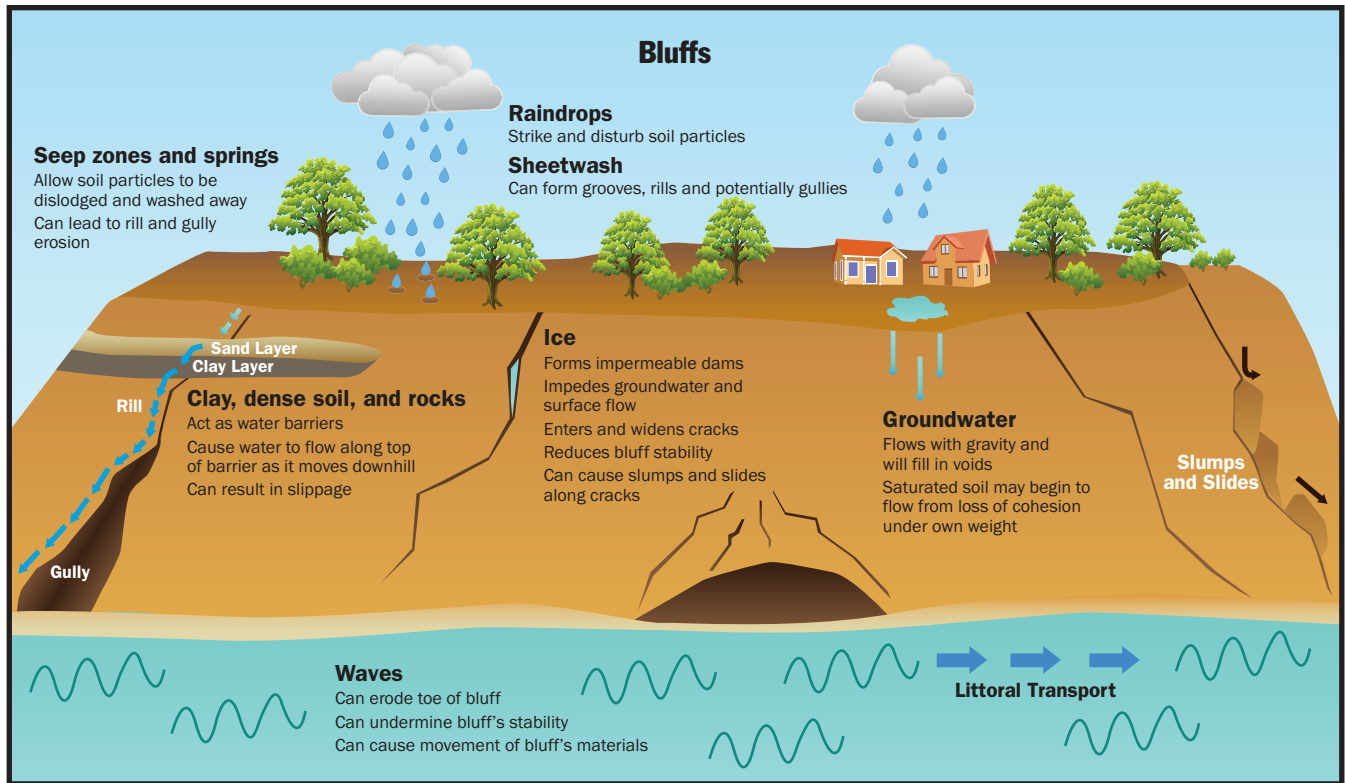
Obstruction of, or changes in, littoral (nearshore area) transport that provides sediment to these landforms can cause erosion. Because coastal barriers can intercept incoming waves and storm surge, erosion of these landforms can expose landward features (natural and human-made) to erosion. Similar to the effects on beaches, scouring of barriers and spits can occur from broken ice pushed landward by wind and waves.

Bluffs

Bluffs are steep sloping landforms composed of erodible material such as sand, silt, gravel, and clay that can protect inland areas from direct wave attack. They provide a substantial amount of sediment to littoral transport, which can then be moved to beaches and offshore bars. Bluffs found along New York's Great Lakes shorelines were formed thousands of years ago by glacial processes that no longer impact the shore. As a result, bluffs, unlike dunes, cannot accrete or grow; they can only erode or remain stable.



Barriers and spits.



Factors affecting bluffs.

Waves can erode the toe of a bluff, undermining the bluff's stability and causing movement of the bluff's material (i.e., slides or slumps), which can then be deposited at the toe and removed by waves. Maintaining sediment supply to the beaches fronting a bluff can reduce incoming wave forces on the bluff. The stability of a bluff is also improved by protecting the vegetative cover. Factors that affect slope stability include:

1. Slope steepness
2. Size, shape, and cohesiveness of soil particles
3. Presence and health of stabilizing vegetation
4. Amount of moisture in the soils
5. Human activity on the slope
6. Upland runoff

Ice can form impermeable dams along, or within, bluffs, that impede groundwater and surface flow. Ice and moisture can also enter cracks of a bluff and widen these crevices, allowing additional water to enter. This reduces the bluff's stability and has the potential to cause slumps and slides along cracks. Additionally, broken ice can be pushed into the bluff, causing scour.

Raindrops strike and disturb upland soil particles, which are then removed by the flow of water over the slope. Sheetwash (unconfined flow over the ground surface after rainfall) progresses and becomes concentrated, potentially forming grooves and rills (shallow channels), which then widen into gullies. Runoff from these flow channels can reach higher velocities than sheetwash, dislodging and carrying away larger particles.

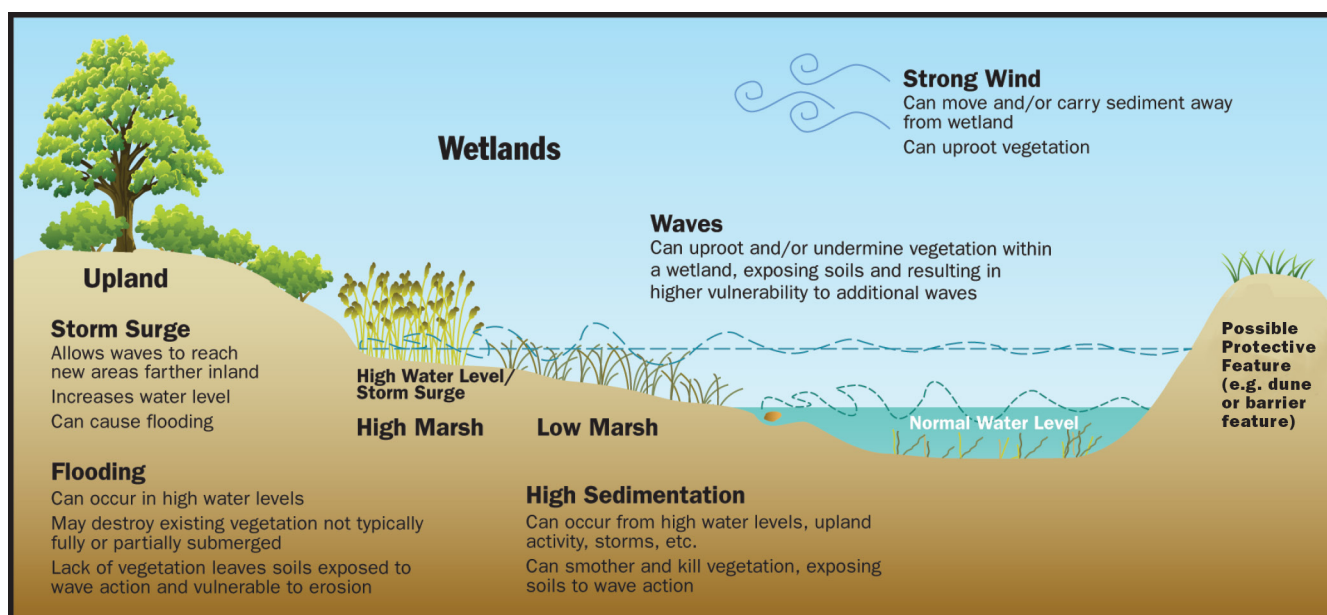
Water flows with gravity and will fill in voids within bluffs. Fine grained sediment allows water to percolate slower, while coarse sediment allows water to percolate faster. Moisture content can exceed the maximum water capacity of the soil, causing additional water to run off the bluff surface or force expansion of soil pores. Saturated soil may begin to flow from loss of cohesion under its own weight (i.e., slide or slump). Groundwater that percolates through the bluff and eventually seeps out of the face can ultimately lead to the movement of bluff material. Seep zones (dark bands of moist soil) and springs allow soil particles to be dislodged and washed away from the bluff face. The water flowing from seeps or springs can cause rill and gully erosion.

Layers of clay (or hardpan - dense layer of soil) or some types of rock like sandstone or shale act as water barriers within the soil, which cause water moving downward through the soil to flow along the top of the barrier. The wet top of the embedded barrier layer acts as a lubricated slide beneath the overlying layers, and moisture filling voids in the surrounding soil can result in slippage.

Wetlands

Wetlands are areas that are inundated or saturated with water either permanently or seasonally, and may provide several benefits depending on their size, location and vegetation type or density. These benefits may include temporarily storing flood waters if large enough, providing a buffer for wave energy, filtering pollutants from runoff, collecting and stabilizing soil, and supporting a wide range of wildlife and vegetation. In some cases wetlands are protected by, or offer protection to, other coastal landforms. Once the protective landforms are breached or removed, the wetland may become susceptible to erosion. Likewise, if protective wetlands are removed, the exposed landforms may be exposed to increased erosion.

Wave action can uproot and/or undermine vegetation within a wetland, exposing soils and resulting in higher vulnerability to additional waves. Flooding of a wetland can occur during high water levels and can bring higher levels of sediment. Prolonged inundation and high sedimentation can destroy existing vegetation with a possibility of replacing it with other vegetative communities.



Factors affecting wetlands.

All illustrations by Loriann Cody

Summary

The diverse landforms found along New York's Great Lakes shorelines can vary significantly depending on location. Although some of these coastal landforms serve as natural erosion protection features, they are also susceptible to erosion and accretion caused by such forces as wind and waves. These forces help shape the shoreline, which is a dynamic environment that evolves under the effects of both natural and human influences. To learn more about natural processes and possible management alternatives when faced with their effects, please visit New York Sea Grant's website (www.nyseagrant.org/glcoastal) for additional publications.

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