Vegetation Use in Coastal Ecosystems

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INFORMATION BULLETIN 198

A Cornell Cooperative Extension Publication

A Cornell Cooperative Extension bulletin, published in cooperation with the College of Agriculture and Life Sciences at Cornell University. 1988.

This publication is issued to further Cooperative Extension work mandated by acts of Congress of May 8 and June 30, 1914. It was produced with the cooperation of the Department of Agriculture, Cornell Cooperative Extension, New York State College of Agriculture and Life Sciences, New York State College of Human Ecology, and New York State College of Veterinary Medicine, at Cornell University. Cornell Cooperative Extension offers equal program and employment opportunities. Lucinda A. Noble, Director.

Produced by Media Services at Cornell University

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280/385 5/88 2M MS 9546

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Preface

Many sections of the northeast United States coastline are naturally receding. Certain types of human development activities and severe weather events have the potential to increase the rates of erosion. In many cases in the past, erosion at one point on the coast has been merely moved or pushed beyond or within bays or inlets, but never eliminated. Even when local projects are fitted into regional coastal erosion control plans, erosion is not stopped completely. An objective for land managers is to minimize the rate of erosion and, thereby, to minimize its impact on societal uses of the coast.

Coastal communities and human-made erosion from so-called control structures have created enormous land use problems. Managers should become more aware of all the coastal processes affecting erosion of their coastal landforms over the years, then study various structures and vegetative alternatives with their effects, and plan a procedure to follow.

This bulletin is intended to be of use to public decision makers, community institutions, civic organizations, landscape planners, managers, and contractors, as well as owners of private properties, on the potentials and constraints of using vegetation for reduction of erosion and for other purposes on the coastlines of New York State. It has implications and value for similar areas elsewhere in the Northeast.

Approaches to vegetative and structural control of coastal erosion covered in this bulletin should be regarded as temporary in nature. Such heavy-duty structures as seawalls and breakwaters may have effective life spans of as short as 25 years or less in the event of major storm or high water episodes. Vegetative approaches, to serve for even short periods of time, will require monitoring to determine replanting needs and also management and regulation to reduce both natural and human impacts.

The authors are grateful to the following persons for their assistance and for material originally written by them and used in this publication:

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Allan Connell, USDA Soil Conservation Service, Suffolk County, N.Y.

Tom Doheny, Department of Waterways and Conservation, town of Hempstead, N.Y.

Stephen Lopez, New York Sea Grant Extension Program, New City, N.Y.

Robert Mower, Professor, Department of Floriculture and Ornamental Horticulture, Cornell University, Ithaca, N.Y.

David Newton, Suffolk County Cooperative Extension, Riverhead, N.Y.

Gerald Olson, Professor, Department of Agronomy, Cornell University, Ithaca, N.Y. (deceased)

Curtis Sharp, USDA Soil Conservation Service, Broomall, Pa.

Jay Tanski, New York Sea Grant Extension Program, Stony Brook, N.Y.

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Note: Affiliations of the persons noted above are those at the time of their contribution to this publication.

INTRODUCTION

Shoreline erosion is a concern to public and private owners and users of recreational, residential, and commercial properties, as well as to local and regional decision makers, conservationists, educators, and researchers. It is a natural phenomenon that occurs constantly and becomes a problem when it conflicts with human activities and societal expectations and desires. Coastal erosion is defined as "the loss or displacement of land along the coastline due to the action of waves, currents, tides, wind-driven water, waterborne ice, or other impacts of storms" (Coastal Erosion Hazard Areas Act of 1981). Other causes of erosion include the action of wind, runoff of surface waters, groundwater seepage, and human activities. Erosion should be regarded as a natural occurrence in shoreline areas where water meets land, such areas being in a constant dynamic state.

New York's coastal erosion management regulations define natural protective feature areas as "land or water area(s) . . . the alteration of which might reduce or destroy the protection afforded other lands against erosion or high water."

This bulletin relates to the functional considerations and uses of ecosystem management and vegetation as part of the array of total erosion control possibilities. It focuses on marine and Great Lakes areas. It does not address slopes of smaller inland lakes. The Hudson River, Finger Lakes, and Lake Champlain areas of New York State are excluded from specific coverage in this publication.

COASTAL ECOSYSTEMS—THINKING HOLISTICALLY

Formed by the interaction of living organisms and their nonliving environment and regulating themselves to a great degree, "coastal ecosystems, as defined for management purposes, must embrace a complete and integral unit of interactive natural forces" (Clark 1974).

In *Coastal Ecosystems: Ecological Considerations for Management of the Coastal Zone,* John Clark stresses the need for maintenance of coastal ecosystems at the highest achievable level of quality, which means as near the natural conditions as possible or at the level of the best achievable ecosystem function. To do so, it is necessary to

- apply fundamental ecological principles;
- arrive at general management rules;
- apply a variety of constraints on coastal development activities;
- have an environmental management program that embraces whole ecosystems;
- remember that any attempt to manage separately one of the many interdependent components of a complex ecosystem will likely fail and so will any attempt to control any one source of disturbance to the system (such as upland erosion), without controlling others (such as dredging or marsh filling); and
- be aware that professional analysis of the coastal ecosystem is usually needed to determine its values and vulnerabilities and to devise effective controls on potentially adverse activities.

Clark emphasizes that the framework for management analysis of an ecosystem must include not only the important plant and animal life of a region but also the major physical factors and the effect of each on the functioning of the ecosystem, how these factors interact, and how in combination they affect the life of the system. The basic unit of coastal management may be regarded as a single intact and complete ecosystem, including the coastal water basin and the related adjacent shorelands (fig. 1).

Some distinctions must be drawn in designating areas of environmental concern (those areas within

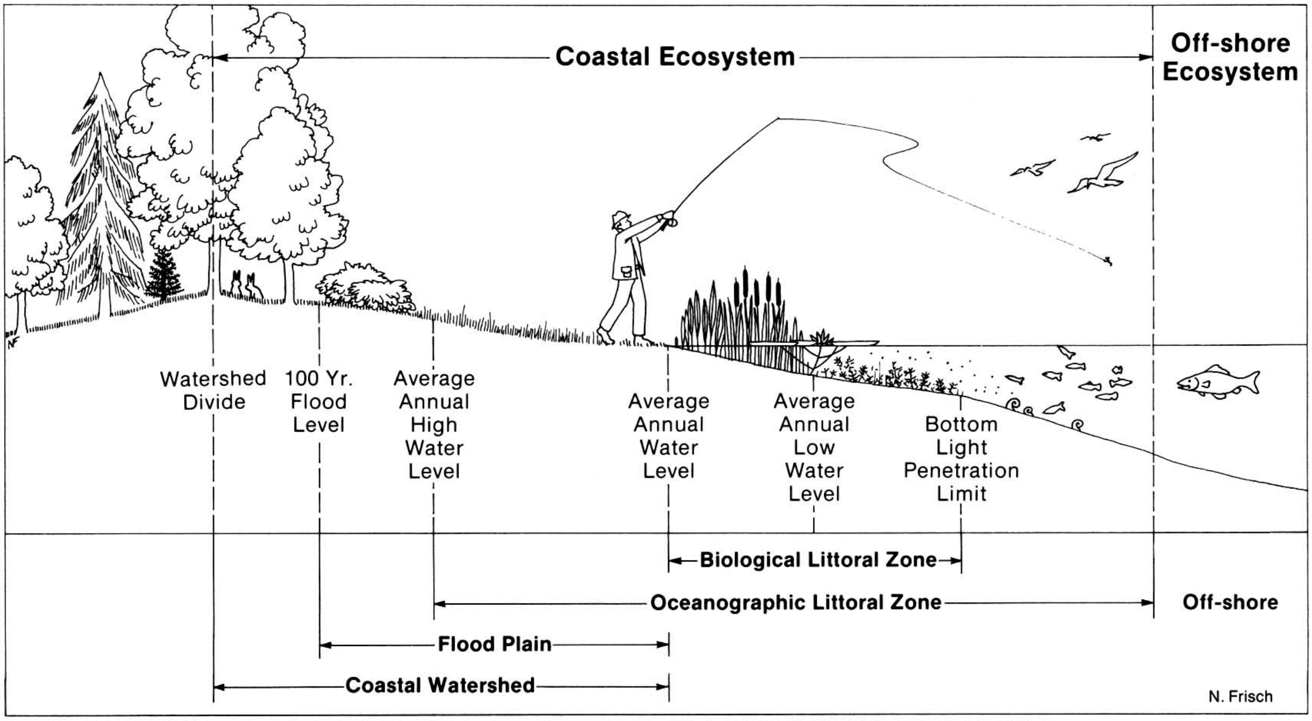


Figure 1. For coping with any coastal erosion problem, a management plan that embraces the complete range of interactions between living organisms and their nonliving environment—the ecosystem approach — must be developed. (*Source:* NY Sea Grant 1988)

which human activities must be controlled, although not necessarily prohibited), vital areas (smaller areas that are especially critical ecologically, to be designated for complete protection within areas of concern), and areas of normal concern (areas where only the normal levels of caution are required in utilization and in development activity).

Land designation may have the categories (1) preservation (or protection)—no development suitable; (2) conservation—carefully controlled development suitable; (3) utilization (or development)—intensive development suitable.

Management Principles

Management principles stressed by Clark include the following:

- Ecosystem integrity: Each coastal ecosystem must be managed with respect to the relatedness of its parts and the unity of its whole.
- Drainage: A fundamental goal of shoreland management is to retain the system of land drainage as near to the natural pattern as possible.
- Drainageway buffers: The need to provide vegetative buffer areas along drainageways increases with the degree of development.
- Wetlands and tidelands: The need to preserve wetlands and vegetated tidelands increases with the degree of development.
- Storage: Storage components of ecosystems are of extreme value and should always be fully protected. (Storage is the capacity of a system to store energy supplies in one or more of its components. A storage unit may be a stand of marsh grass, a fish school, a seed.)
- Energy: To maintain an ecosystem at optimum function, it is necessary to protect and optimize the sources and the flows of the energy that powers the system.

Organizing for Shore Protection

With the coastal ecosystem concerns in mind, let us now turn to the matter of organizing for shore protection activities.

Community organization has often been the key to successful emergency shore-protection measures. There are several good reasons for organizing groups of property owners in a coordinated approach to erosion control. Where individuals have attempted to go it alone, the results have often been ineffective. Individual protective structures have sometimes been damaged because of continuing erosion on unprotected adjacent properties. Improperly planned or implemented individual projects may shift erosion problems to adjacent properties (fig. 2). A well-planned, coordinated, and properly implemented system of shore-protection work extending for a considerable distance benefits from economy of scale, resulting in a lower cost per linear foot of protection.

In both public and private property instances where no development is present, consideration should be given to locating any proposed development a sufficient distance inland from the receding shoreline edge. This will help prevent its loss to naturally occurring coastal erosion, without the necessity of human intervention. Similarly, in those instances where there is space for existing development to be relocated farther inland from the receding edge, the economic and ecologic benefits of such relocation often far outweigh those of artificially stabilizing the shore.

The community or a group of property owners should organize its resources to prepare and implement a plan for shore protection. This plan may consist of some or all of the following:

- Administration—delegation of responsibilities, funding, and accounting
- Preconstruction and preplanting planning—assessment of the existing situation, inventory of existing shore protection works and their effectiveness, maps of the shoreline area, and establishment of surveillance points for photographs and surveying
- Development of plan of protection—construction and planting drawings and specifications, maintenance handbook, all with advice of coastal vegetation specialists, ecologists, engineers, and landscape architects

Public involvement should be encouraged at town, county, and bi- or multicounty levels for shoreline erosion control, consonant with an un-

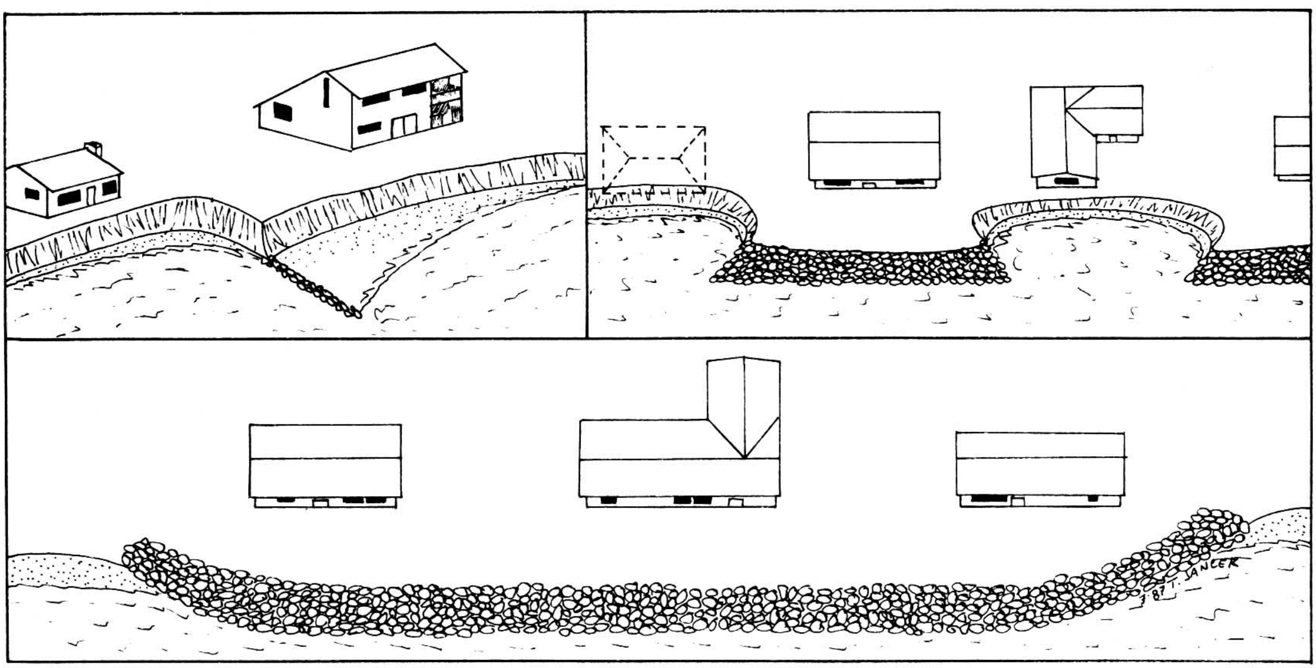


Figure 2. Attempts to control coastal erosion on a property-by-property piecemeal basis is often ineffective, with individual protective structures sometimes shifting erosion problems to adjacent properties or being damaged by continued erosion on adjacent properties. A proper erosion control approach is a unified, group project.

derstanding and utilization of ecological processes and systems. Conservation and protection of biological environments should be kept in mind. As coastal land use and management are planned for and policies implemented, several scales of involvement will come into play. (See key points developed in Clark 1974.)

PROCESS OF EROSION

Interactions between water, wind, and land occur at the coast, resulting in a constant alteration of the shoreline. Moving air and water carry material from place to place, and this results in erosion and deposition.

Most shoreline property owners are well aware of the effects of erosion as evidenced by the constant loss of their land to the sea. However, many are not familiar with the variety of processes responsible for this loss. Although shoreline erosion is complex and not completely understood, the primary processes have been identified. A general understanding of these processes can help the private and public owners of coastal property identify, and consequently deal more effectively with, the specific erosion problems they may encounter.

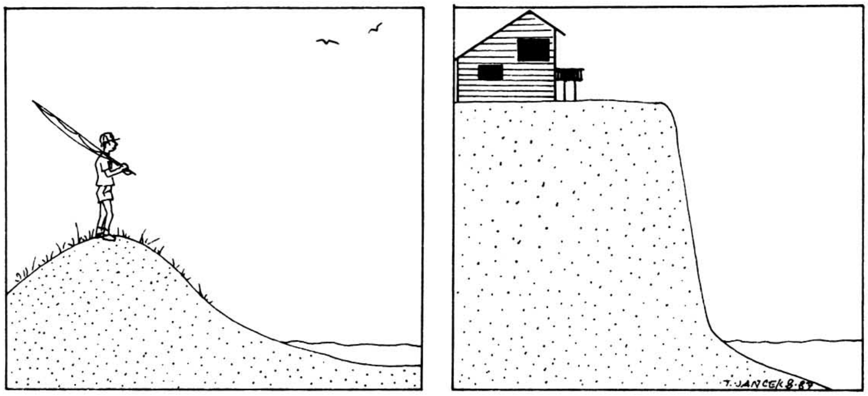


Figure 3. The south shore of Long Island includes flat beach and beach dunal areas (*left*), whereas much of the north shore, including parts of the north shore of the South Fork, evidences relatively narrow beaches backed by eroding sandy bluffs.

Considerable coverage of coastal processes, their magnitude, and impact may be found in a companion Cornell Cooperative Extension publication, Information Bulletin 199, *A Guide to Coastal Erosion Processes* (O'Neill 1985), and also in *Low Cost Shore Protection*, published by the U.S. Army Corps of Engineers (1981). Attention is given in illustrations and narrative to wind and water, different shore forms, shore building and erosion, and natural defenses. A third useful reference treating coastal ecology—including geophysical setting; ecological concepts; factors that limit carrying capacity; barrier island, beach, and shoreland systems; as well as estuarine, nearshore, and ocean systems—is *Coastal Ecosystems Management: A Technical Manual for the Conservation of Coastal Zone Resources* by J. Clark (1977). Chapters dealing with optimum carrying capacity, classification and survey of natural systems, management framework, management opportunities at the local level, and guidelines and standards for coastal projects will be of interest at various levels of concern. Another publication to be emphasized is the *Shore Protection Manual* of the U.S. Army Corps of Engineers (1977), important for detailed technical information. An interesting and useful exchange on the subject of structural and nonstructural solutions to coastal erosion problems is found in the May 1980 *Proceedings of Barrier Island Forum and Workshop* (Mayo and Smith), cosponsored by the National Park Service, North Atlantic Region, and the Provincetown Center for Coastal Studies.

The first stages in a practical approach to coastal erosion control are to (1) identify the problem, (2) identify processes causing the problem, (3) identify all practical control or minimization alternatives, (4) identify all environmental and socioeconomic effects of control, and (5) select an alternative and prepare a plan.

The coastlines along New York State's marine coast downstate consist of relatively flat beach and beach dunes, characteristic of the south shore of Long Island, and of relatively narrow beaches backed by eroding sandy bluffs (fig. 3), characteristic of much of the north shore of Long Island, including parts of the north shore of the South Fork. Reference to Great Lakes coastlines is made later, but some of the situa-

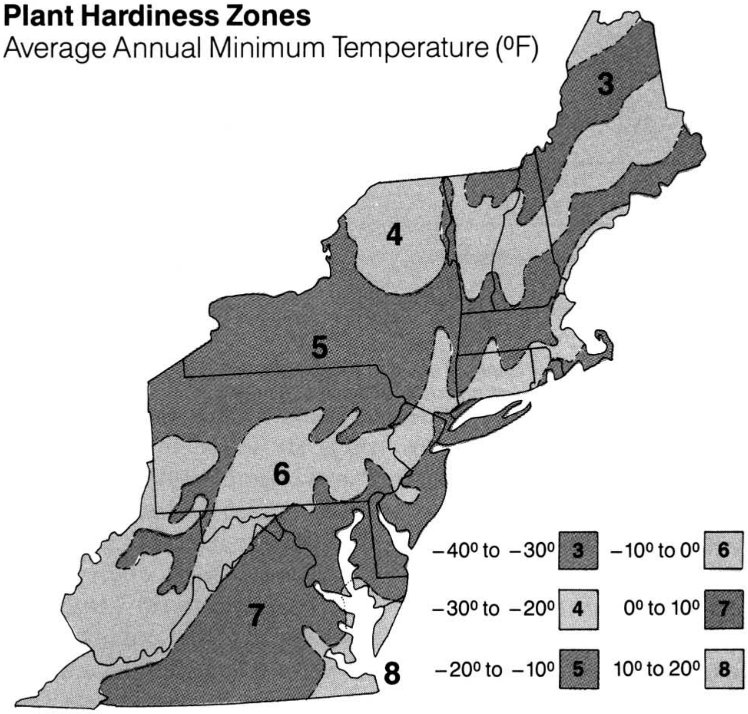


Figure 4. Native and cultivated plant hardiness can be determined using this Agricultural Research Service plant hardiness zone map.

tions downstate have parallels along the Great Lakes. Plants found in the Great Lakes locations may differ, primarily because of hardiness factors.

NOTE: Native and cultivated plants mentioned in this bulletin are hardy for zones 4 through 7 as defined in the Agricultural Research Services *Plant Hardiness Zone Map* (1972) (fig. 4). Seashore tolerances in terms of belts (see p. 17) are based on 40 years of observations within each belt under New York conditions and are not based on plant hardiness tolerances.

Using Vegetation to Reduce Shore Erosion

Barrier Beach Ecosystems

Coastal plantings serve an important function as natural erosion stabilizers for dunes and bluffs along the coastline. Ecological characteristics of dune and bluff plant communities are important in natural erosion control. The basic physical processes at work where water meets land cannot be changed by shore vegetation. They can, though, be modified under certain circumstances, and their destructive powers mitigated. Vegetation will almost never stand up to direct wave action.

Where beaches and dunes meld into the mainland, there is a gradual succession of plants from the primary foredune grasses and forbs (herbaceous plants other than grasses) to the secondary dune thickets, to forested uplands (the foredune is the ocean side of beach dunes) (fig. 5). These sands from the beaches and dunes and the flora are migrating inland. The speed of migration is directly proportional to the erosion rate of the beach. On barrier beaches, the secondary dunes lead to a protected bay. The bayshore ecology is often much different from the beach ecology and will not be discussed here.

For the plants growing on the dry dune areas (at higher elevations) behind the beach, conditions are very similar to a desert environment. It is very hot with sand surface temperatures of 120° F not being uncommon. It is also very dry. Plants found in very dry locations typically have waxy coatings on their stems and leaves or use other protective measures to avoid loss of moisture

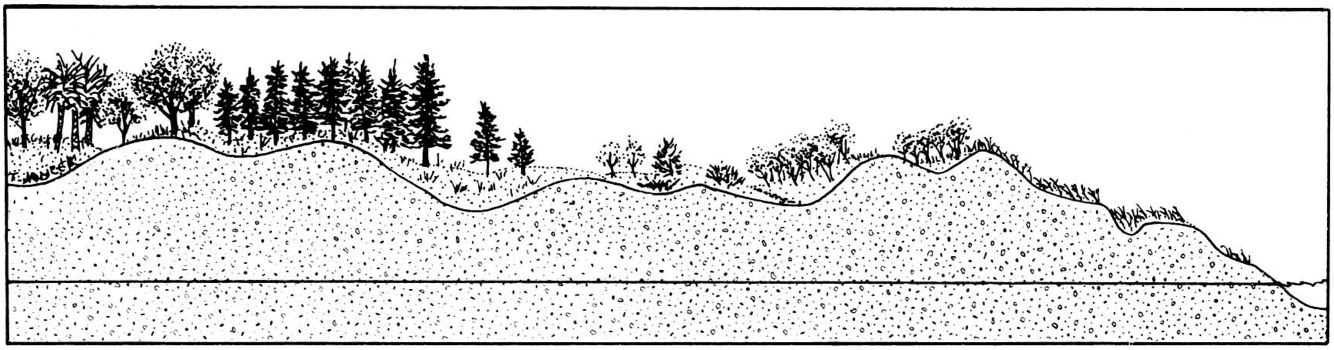


Figure 5. As one moves inland from the shore, primary foredune grasses and forbs give way to secondary dune thickets and forested uplands.

through transpiration. A limiting factor in foredune plantings is salt spray. High concentrations of salt are tolerated by few plants.

STABILIZING PLANTS ON COASTAL DUNES

The most common primary foredune plants are herbaceous perennial plants that die to the ground in the fall of each year and send up new shoots from their roots in the spring. By far the most common is American beachgrass (*Ammophila breviligulata*). American beachgrass is often interspersed with varying amounts of seaside goldenrod (*Solidago sempervirens*), sea rocket (*Cakile edentula*), seaside spurge (*Euphorbia polygonifolia*), beach pea (*Lathyrus japonicus*), and beach wormwood (*Artemisia stellerana*).

These primary foredune plants act as dune stabilizers. They slow the wind at the dune surface, causing deposition of windborne sand. During storms their root systems help hold sand in place, thereby slowing the rate of dune erosion. Where protective vegetation has been removed or killed by trampling, the dune is more susceptible to wind and water erosion. Worn pathways through primary dunes may be the site of an eventual blowout and subsequent breach; that is, the wind may blow a hole in the dune and then water may cut a channel through to the land or bay behind during a storm. Obviously, property would be destroyed in the process (fig. 6).

The back primary dune and the protected areas of secondary dunes are characteristically vegetated in a zoned mosaic pattern. Microenvironmental conditions favor the dominance of various plants in relatively close proximity, making generalizations about the area difficult. Two limiting factors seem to play a role here: height above sea level and exposure to salt-laden sea breezes.

Elevation controls distance from the dune surface to the water table. Plant communities below 5 feet above mean sea level in secondary dune areas have more water available and are often dominated by blueberry (*Vaccinium corymbosum*) interspersed with poison ivy (*Rhus radicans*) and common greenbrier (*Smilax rotundifolia*). Less-frequent species would include black tupelo (*Nyssa sylvatica*), sassafras (*Sassafras albidum*), and red maple (*Acer rubrum*). Very wet, marshy areas may support phragmites (*Phragmites australis* ssp. *australis, P. communis*) stands or freshwater marsh-plant communities.

Above the 5-foot elevation, conditions are much drier and harsher. Plants characteristic of this zone include common bayberry (*Myrica pensylvanica*), beach plum (*Prunus maritima*), black cherry (*Prunus serotina*), shadbush (*Amelanchier canadensis*), red cedar (*Juniperus virginiana*), American holly (*Ilex opaca*), pitch pine (*Pinus rigida*), poison ivy (*Rhus radicans*), beach heather (*Hudsonia tomentosa*), Virginia creeper (*Parthenocissus quinquefolia*), and pasture rose (*Rosa carolina*). A common introduced species is Japanese black pine (*Pinus thunbergiana*). Though the secondary dune area is host to a diverse woody plant community, the grasses and forbs common on the primary foredune are often in this area also.

All these plants serve to stabilize the dunes by holding the sand with their roots. When it is desired to build a dune relatively quickly, snow fence is commonly used to trap drifting sand. As a new dune is formed, beachgrass and other appropriate plants can be used to stabilize it (see appendix 2).

Beach and Bluff Ecosystems

The bluffs flanking the narrow beaches on Long Island's north shore are over 100 feet high in some

Figure 6. When the wind blows a hole in a dune, a blowout is formed. Storm waves may then cut a channel through to the land or bay behind, destroying property that had previously been naturally protected.

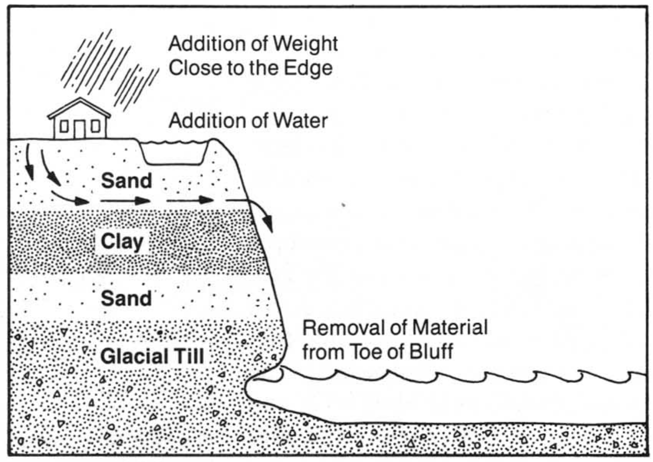


Figure 7. Wave attack at the toe of bluffs can cause major slumps or slides. This material is then washed offshore or moved along shore by wave action. Later, beaches may reach a new equilibrium approximating their original shape but with the foreshore moved landward. This can lead to recession of the bluff face, threatening homes and businesses located at the top of the bluff. (*Source:* After Clemens, 1977)

locations, as are bluffs along the Great Lakes. Where such bluffs occur with some regularity, bluff erosion is a primary source of material for beaches. Although the erosion of bluffs can be mitigated in a variety of ways, such a reduction of bluff erosion can deprive the associated beaches of their supply of sand and gravel. Complete stabilization of the bluffs may, in some cases, reduce the size of the beaches or eventually cause the beaches to disappear altogether.

The potential for damage to coastal bluffs depends, to a large degree, on the water level in front of the bluff and the size of storm waves attacking the shore. On the Great Lakes seasonal lake level fluctuations result in the highest waters of the year occurring in the summer or early fall; in marine waters spring or diurnal high tides coupled with storms can result in major episodes of erosion. During times of high-water levels, beaches typically are narrower than at times of lower water, allowing for greater amounts of wave attack at the toe of bluffs, undercutting the face, and causing major slumps or slides of bluff materials. Waves then wash out the fine bluff material and carry it offshore to deep water or move it along the shore by littoral currents. When a new equilibrium is reached, beaches may reform their original shape, but the foreshore will be moved landward. In areas where beaches at the bottom of bluffs are very low or narrow, such erosion at the toe of bluffs can cause the relatively flat area on top, where many homes and businesses are located, to recede (fig. 7). For a description of how to determine what water levels and wave heights to plan for when designing erosion control projects, refer to Information Bulletin 200, *Structural Methods for Controlling Coastal Erosion* (O'Neill 1986).

Water from above a bluff can run over the face, resulting in gullies that start at the top (lip) of the bluff (fig. 8). Such surface runoff can be lessened by building a berm (ridge) of soil along the top of the bluff, preventing runoff from flowing over the edge and directing it to a drain and pipe that can carry the water to the bottom of the slope without causing further erosion.

In addition to surface runoff from the top, bare, unvegetated portions of a bluff face are also susceptible to erosion by rain and wind, which pick up and remove unconsolidated material (fig. 9). The effects of these processes can be lessened by grading or terracing the slope and planting vegetation that provides a good ground cover and binds the soil with its root system.

Water added to the top of a bluff, either naturally by rainfall or artificially by septic-system leach fields or lawn sprinkler systems, can cause erosion in a variety of ways. Layers of clay or other impermeable barriers in the bluff will force groundwater to flow out the bluff face, removing material and causing surface erosion. Gullies that start part way down the bluff face may indicate groundwater problems. Groundwater trapped in the bluff can also freeze and expand, wedging large chunks of the bluff from the top, which slide down the bluff face. Groundwater problems can often be mitigated by installing a subsurface tile drainage system that intercepts the water before it reaches the face of the slope and transports it down to the shore in a drainage pipe (fig. 10). For a complete discussion of the causes of erosion in bluff areas and for details on both surface and subsurface drainage improvement, see Information Bulletin 199 (O'Neill 1985).

Narrow pathways on bluffs, where the natural vegetation has been trampled and killed, can become deep gullies, cut by runoff from above. Such gullies may enlarge very rapidly. Instead of surface pathways, wooden stairs should be constructed for access up and down the bluff. These stairs should be at least 12 inches above the soil surface. Slats should be spaced at least ¼ inch apart to allow light penetration to the soil underneath (fig. 11). Some plants such as Virginia creeper can get enough room and light to establish themselves and thus help prevent erosion under the stairs.

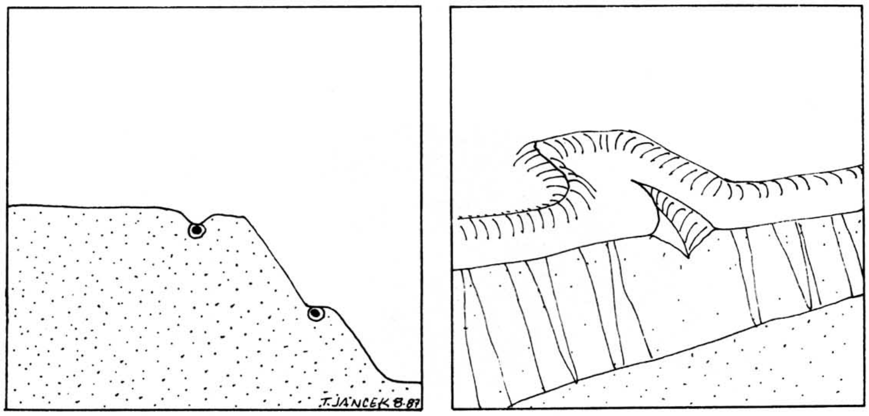


Figure 8. Surface runoff over the face of a bluff can result in gullies. This runoff can be lessened by constructing berms along the top of the bluff and redirecting the runoff to a drain that can carry the water to the bottom of the slope without causing further erosion.

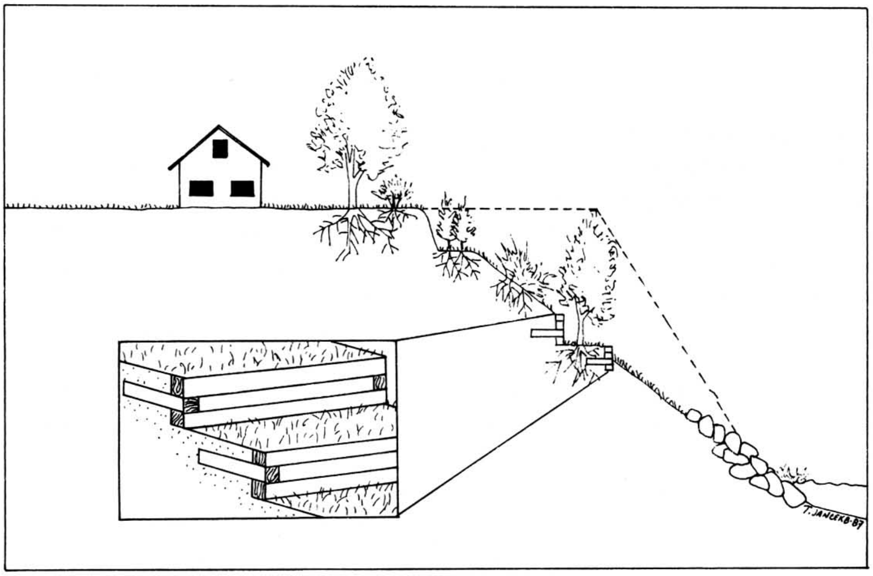
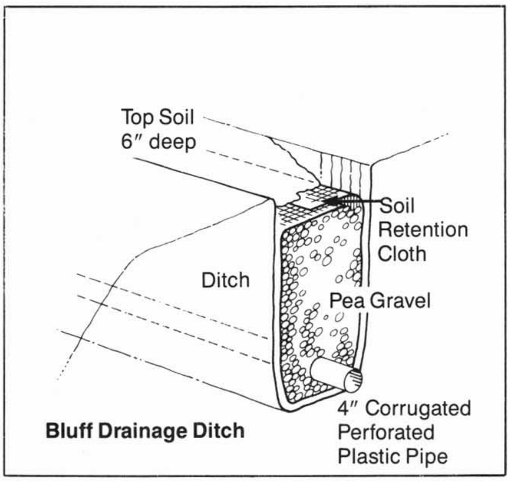


Figure 9. Regrading or terracing a slope and planting bare spots with vegetation that provides a good ground cover and binds the soil with its root system can lessen surface erosion caused by the action of rain and wind.



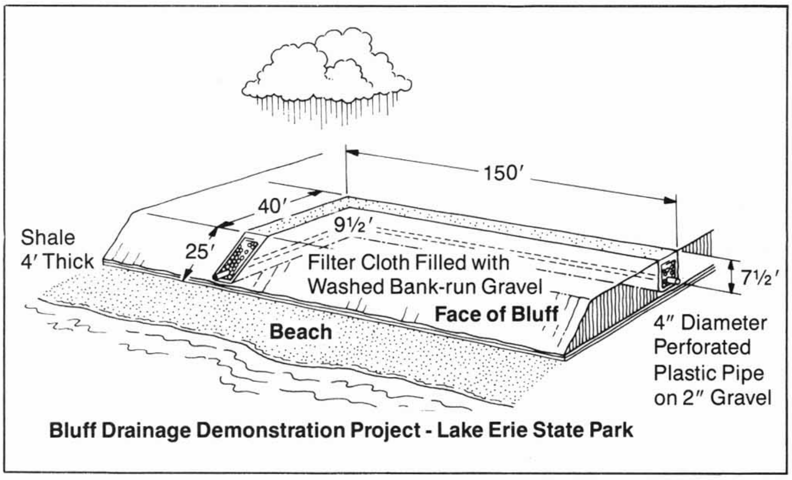


Figure 10. Groundwater problems caused by layers of clay or other impermeable barriers in a bluff can often be mitigated by installing a subsurface tile drainage system to intercept the water before it reaches the bluff face and transport that water to the shore in a drainage pipe.

Figure 11. Pedestrian traffic on bluffs can destroy the natural vegetation, allowing the formation of gullies. Instead of surface pathways, wooden stairs should be constructed for access up and down the bluff.

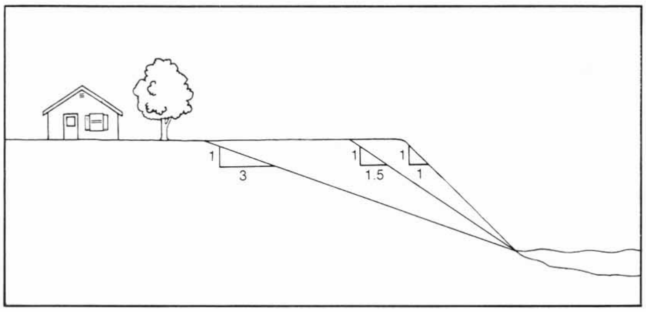


Figure 12. The maximum slope for vegetative stabilization projects is 1-foot vertical rise for each 1.5-foot horizontal run (a 1:1.5 slope).

VEGETATION USE ON
COASTAL BLUFFS

In the case of coastal bluffs, plants are useful to stabilize the bluffs in as steep an angle of incline as possible to maximize usable land area at the top of the bluff. Generally, the maximum slope to be considered for vegetative stabilization projects is a 1:1.5 slope (that is, 1-ft vertical rise for each 1.5-ft horizontal run, see fig. 12).

There are many good plants including grasses, vines, low shrubs, and minor trees that can be used for bluff-stabilization projects.

The commonly observed practice of disposing of grass clippings, leaves, branches, or other yard debris over the edge of the bluff is to be discouraged. Rather, such beneficial practices as enhancing existing vegetation or establishing new vegetation, as outlined in this publication, should be encouraged. In addition, dense stands of trees should be pruned to allow light penetration and promote the growth of a thick understory.

Many of the same plants that grow along primary and secondary dune areas will also grow on Long Island bluffs. In general, though, there will be fewer wet thicket areas. Those that do occur will likely be at the toe of the bluff where there is groundwater seepage through the face of the bluff. (See listing of plants on pages 16–17.) In addition, many of the same plants for the top of bluffs and the bluff face will work well along Long Island and the Great Lakes.

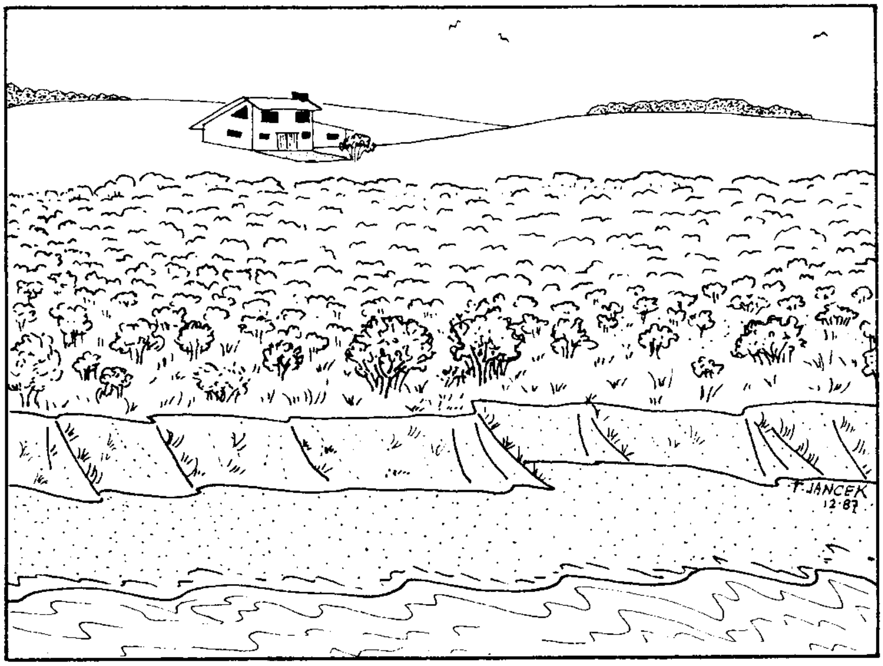


Figure 13. A "greenbelt" (strip of undeveloped land) should be maintained or reestablished along the edge of the top of a bluff to serve as a protective buffer for the bluff face, particularly in areas where bluffs are too steep and too high for economically feasible stabilization methods.

Top of the Bluff

The vegetation along the edge of the top of the bluff serves as a protective buffer for the bluff face. It should be maintained or reestablished as a "greenbelt," a strip of undeveloped land (fig. 13). This is particularly important in areas where bluffs are too steep and too high for economically feasible stabilization methods. For example, long shorelines of high bluffs in agricultural areas along Lake Erie would be too costly to attempt to stabilize. Therefore, a wide strip (100 m, or 300 ft, is desirable; 300 m, or 1,000 ft, is optional) of dense natural vegetation should be maintained along the bluff edge. This strip precludes human activity too close to the bluff edge and retards surface runoff from upland areas. Also, the roots of the vegetation strengthen the bluff's resistance to slumping. If the bluff edge is currently cleared, a strip should be left undisturbed to reestablish itself. To speed up the process, vegetative plantings could be implemented.

Bluff Face

Vegetation should be established on patchy and barren bluff faces to protect them from erosion and improve their appearance. Whether or not this is possible depends greatly on the character of the bluff, particularly on the steepness of the slope. A slope ratio of 1:1.5 can be considered the dividing line between a manageable slope and a slope so steep that vegetation would be difficult or impossible to establish.

Where possible and if room exists at the top of the bluff, steep slopes should be graded back to a more gentle configuration (1:3 or flatter is ideal because these slopes can be cultivated and planted with wheeled vehicles). However, in many coastal situations, bluff areas are much steeper or too high, and such major regrading may be neither economically feasible nor technically desirable for the individual property owner.

In cases where bluffs cannot be practically regraded to a 1:3 slope, modifications to the existing slope that will allow some vegetation to become established may still be made. This can be accomplished by terracing, providing horizontal steps in which to plant vegetation, or the slope can be broken up by the addition of contour wattles (fig. 14). Wattles are bundles of fresh willow cuttings that are anchored with willow stakes in trenches along the bluff face. They act as a base for vegetation growth and as a trap to slow surface runoff. Furthermore, the willow stakes and cuttings are capable of rooting in the bluff soil provided there is sufficient moisture.

Plants for the Bluff Face

For slopes and for the flatter areas created by terraces or contour wattles, various species and mixtures of species can be planted and expected to succeed in this rather severe environment. These include seed mixtures of grasses and legumes and a range of shrubs and minor trees. The lists on pages 16 to 17 provide a selection of both native and introduced species for Long Island and

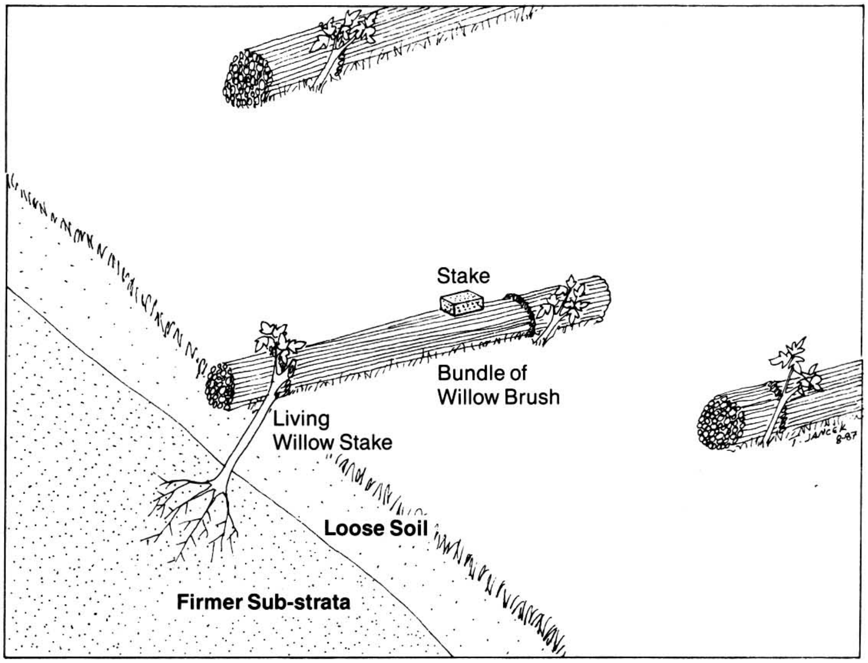


Figure 14. Where bluffs cannot be regraded to a 1:3 slope, some vegetation may still be established by using terracing (horizontal steps on which to plant vegetation) or contour wattles (bundles of fresh willow cuttings anchored with willow stakes in trenches along the bluff face).

Great Lakes coastal bluffs. The soil moisture conditions and fertilizer requirements should be determined before any selection of vegetation. Local county Cooperative Extension Associations, Soil Conservation Service, Soil and Water Conservation Districts, or other soil experts can provide this information.

Major trees, however, should be used on the face of bluffs sparingly and with caution. Such trees, if they collapse because of undermining of the root system by erosion, will pull tremendous amounts of earth with their roots as they topple down. The resulting large, bare areas are opened to further, accelerated erosion, endangering adjacent land and vegetation. New major trees generally should not be established on the face of coastal bluffs. Existing major trees should be closely monitored for signs of undercutting or other imminent toppling. In the event of threatened toppling, such trees should be cut before they fall, to leave the root system intact to hold the soil.

Plants for the Bluff Bottom (Toe)

In those situations where the bottom of the bluff is susceptible to frequent or periodic wave attack, vegetation alone will not suffice as an erosion control; in these cases some form of structural toe protection will also be required (O'Neill 1986).

Grasses and Legumes for Great Lakes Coastal Bluffs

'Lathco' flatpea

Crown vetch (*Coronilla varia*)

A quick-growing "nurse grass" such as perennial rye grass should be used in conjunction with legume plantings to provide immediate interim stabilization until the legumes are established and begin to spread.

Shrubs and Trees for Stabilizing Bluff Faces

	Soil moisture types			
Species	*Droughty*	*Well drained, good moisture*	*Imperfectly drained*	*Poorly drained*
Shrubs for Great Lakes and Long Island:				
Autumn olive * (*Elaeagnus umbellata*)	x	x		
Bearberry † (*Arctostaphylos uva-ursi*)	x	x		
Arnot bristly locust (*Robinia fertilis*)	x	x		
Rugosa rose (*Rosa rugosa*)	x	x		
For the Great Lakes, other shrubs recommended, but seldom available unless ordered by advance arrangements:				
Chokecherry (*Prunus virginiana*)		x		
Gray dogwood (*Cornus racemosa*)	x	x	x	
Red-osier dogwood (*Cornus sericea*)			x	x
Wild grape (*Vitis riparia*)	x	x	x	
Purpleosier willow (*Salix purpurea*)		x	x	x
Common juniper † (*Juniperus communis*)	x	x		
Staghorn sumac (*Rhus typhina*)	x	x		
Sandbar willow (*Salix interior*)		x	x	x
Heartleaved willow (*Salix cordata*)		x	x	x

Shrubs and Trees for Stabilizing Bluff Faces *(cont.)*

Other shrubs successful on Long Island:				
Bayberry (*Myrica pensylvanica*)	x	x		
Virginia creeper (*Parthenocissus quinquefolia*)	x	x		
Serviceberry (*Amelanchier* spp.)		x		
Sea buckthorn (*Hippophae rhamnoides)*		x		
Trees for stabilizing bluff faces:				
Russian olive (*Elaeagnus angustifolia*)	x	x		
Cottonwood (*Populus deltoides*)		x	x	
Black locust (*Robinia pseudoacacia*)		x		
Silver maple (*Acer saccharinum*)		x	x	x
Willow (*Salix* spp.)			x	x
Red maple (*Acer rubrum*)		x	x	
Box elder (*Acer negundo*)		x	x	

* Indicates introduced species.

† Not recommended for north-facing or shady bluffs.

Plants for Marine Seashores*

Growing conditions for many plants are especially difficult along New York marine seashores. Some plants that might survive have not been tested sufficiently to be recommended for general use. Others are difficult to obtain. The following lists include only plants that are accepted by competent and experienced Long Island planters as the most useful and generally successful on shore properties of Long Island and similar areas. Most of them are available from Long Island nurseries or shores. Some of these will prove useful in the Great Lakes locations as well.

No plants will thrive, and very few will even survive the rugged conditions of full and direct exposure to the ocean, even in average seasons. Occasional hurricanes and severe storms often eliminate survivors. In the following groupings, those listed for seashore conditions have the best chance of surviving extreme exposure, though many of them would have a better chance behind a shoreline windbreak. Japanese black pine, the most rugged of the trees, is the best possibility for a screen planting to protect lower-growing varieties. Plants for more-sheltered areas are less rugged, but do well in bay areas or on the landward sides of buildings, heavy screens, or tight fences.

Some of the plants suggested here can be found growing in barren, sandy soil, but would do better in good soil. For best results, provide soil improvement at planting time, watering in time of drought, insect and disease protection, and other accepted good maintenance practices.

Beach, coast, and seashore plants are interesting. Most of the growth in the dry, windswept sand dune area consists of knee-high grasses or heather thickets. In back of the dunes are salt marshes or wetlands, which are flooded daily, monthly, or only in the spring or during a storm. In some cases, the pressure of the salt water raises the ground's freshwater table so that there are moist areas among the sand dunes. Such low, wet areas may have broad-leaved plants in groves or even woodlands with wind- and salt-burned stunted trees.

Dune plants that are useful for landscaping also stabilize, anchor, and bind the sand. Therefore, when you are choosing plants that are tolerant of salt conditions, it is equally important to select the ones that are best suited to the site conditions.

The seaside plants listed here have been classified according to their suitability to coastal ecology.

Belt I, seashore conditions, is suitable for those plants that tolerate

*Adapted from Cornell Cooperative Extension Information Bulletin 59, *A List of Ornamental Plants for New York Seashores.*

Trees

Belt I	
Japanese black pine	*Pinus thunbergiana*
Belt II	
Bolleana poplar	*Populus alba* 'Pyramidalis'
Colorado spruce	*Picea pungens* and variants
Gray birch	*Betula populifolia*
Honey locust	*Gleditsia triacanthos* and variants
London plane	*Platanus* x *acerifolia*
Niobe weeping willow	*Salix alba* var. *tristis*
Red cedar	*Juniperus virginiana* and variants
Sycamore maple	*Acer pseudoplatanus*
Belt III	
American holly	*Ilex opaca*
Tupelo, sour gum, black gum	*Nyssa sylvatica*
London plane	*Platanus* x *acerifolia*

Shrubs

Belt I	
Bayberry	*Myrica pensylvanica*
Beach plum	*Prunus maritima*
California privet	*Ligustrum ovalifolium*
Rugosa rose	*Rosa rugosa*
Belt II	
Black chokeberry	*Aronia melanocarpa*
Black haw	*Viburnum prunifolium*
Chokeberry	*Aronia arbutifolia*
European cranberry bush	*Viburnum opulus* and variants
Japanese holly	*Ilex crenata* and variants
Japanese yew	*Taxus cuspidata* and variants
Morrow honeysuckle	*Lonicera morrowii*
Pfitzer juniper	*Juniperus chinensis* 'Pfitzerana'
Purpleosier willow	*Salix purpurea*
Regel's privet	*Ligustrum obtusifolium* var. *regelianum*
Summersweet	*Clethra alnifolia*
Spreading cotoneaster	*Cotoneaster divaricata*
Scotch broom	*Cytisus scoparius*
Swiss mountain pine	*Pinus mugo*
Tatarian honeysuckle	*Lonicera tatarica* and variants
Winterberry	*Ilex verticillata*
Wintergreen barberry	*Berberis julianae*
Belt III	
Arrowwood	*Viburnum dentatum*
Autumn elaeagnus	*Elaeagnus umbellata*
Firethorn	*Pyracantha coccinea* 'Lalandei'
Highbush blueberry	*Vaccinium corymbosum*
Japanese barberry	*Berberis thunbergii* and variants
Russian olive	*Elaeagnus angustifolia*
Serviceberry, shadbush	*Amelanchier* species
Winged euonymus	*Euonymus alatus*
Withe-rod	*Viburnum cassinoides*

the most-severe coastal conditions such as full blasts of sand, sun, and wind as well as occasional splashes of salt water. Site examples are the windward side of a dune, the top of bulkheads on the bay, or the face of bluffs. Dormant plants may even be flooded for one high tide in late winter storms. Growing plants, if coated with a film of salt crystals, may have burned leaves, but usually do not die back.

Belt II, more-sheltered areas, is suitable for those plants that require protection from direct wind and sand blasts. A site example is the leeward side of the dune. Distance from the salt water does not affect tolerance. The number of screens between the plant and the water is the important factor. Growing plants, if covered with a salt film, may show some terminal dieback.

Belt III, even more sheltered areas, is suitable for those plants that require even more protection, such as two screens, for example, a planting area behind a house that is behind a dune or a row or hedge of Japanese black pines. Growing plants, if salt covered, may suffer up to 12 inches of terminal dieback. Plants that tolerate belts I and II will also grow in belt III. (Some plants for belt III may truly be regarded less as erosion control plants and more as ornamentals.)

Ground covers

Belt I

American beachgrass	*Ammophila breviligulata*
Common bearberry	*Arctostaphylos uva-ursi*
Rock cotoneaster	*Cotoneaster horizontalis*
Shore juniper	*Juniperus conferta*
Virginia creeper	*Parthenocissus quinquefolia*

Belt II

Atlantic coastal panic grass	*Panicum amarum*
Baltic English ivy	*Hedera helix* 'Baltica'
Creeping juniper	*Juniperus horizontalis* and variants
Everblooming honeysuckle	*Lonicera heckrottii*
Hall's honeysuckle	*Lonicera japonica* 'Halliana'
Shore juniper	*Juniperus conferta*
Wintercreeper	*Euonymus fortunei* and variants

Belt III

Common periwinkle	*Vinca minor*

Useful Native Seashore Plants

Belt I

American beachgrass	*Ammophila breviligulata*
Beach wormwood	*Artemisia stellerana*
Common bearberry	*Arctostaphylos uva-ursi*
Golden heather	*Hudsonia ericoides*
Groundselbush	*Baccharis halimifolia*
Little bluestem	*Andropogon*
Poverty grass	*Hudsonia tomentosa*
Sea rocket	*Cakile edentula*
Seaside goldenrod	*Solidago sempervirens*

Belt II

Beach pea	*Lathyrus japonicus*
Marsh elder, highwater shrub	*Iva frutescens* var. *oraria*
Red cedar	*Juniperus virginiana* and variants

Belt III

American holly	*Ilex opaca*

Other Herbaceous Perennials

Golden aster	*Pityopsis falcata (Chrysopsis f.)*
Marsh pink	*Sabatia stellaris*
Opuntia cactus	*Opuntia humifusa*
Rose mallow	*Hibiscus moscheutos* ssp. *palustris*
Salt marsh aster	*Aster tenuifolius*
Sea lavender	*Limonium carolinianum*

Specific recommendations for procedures to follow at planting time and in later maintenance of coastal and upland plants will be found in the revised 1985 edition of Cornell Cooperative Extension Information Bulletin 24, *Suggested Practices for Planting and Maintaining Trees and Shrubs*. Readers are encouraged to use that publication as a companion to this bulletin. In most cases, follow low-maintenance practices. Use high-maintenance plants only in key areas where there is some access to irrigation water.

INFORMATION SOURCES

Sea Grant Extension, for coastal processes and structural and vegetative controls research and education. Cooperative Extension offices, for advice on low-maintenance plantings of trees, shrubs, vines, ground covers.

Soil Conservation Services, Soil and Water Conservation Districts, for technical assistance on soils, water runoff and drainage, and stabilization plantings.

New York State Department of Environmental Conservation, for management of and permits for water, vegetation, wildlife, wetlands, and shorelines.

U. S. Army Corps of Engineers, for permits, regulation, and technical information with regard to structural and vegetative controls and dredging.

For an expanded publication with good coverage on sources of help on coastal erosion, primarily specific to Long Island and downstate New York, readers are referred to the leaflet, *Finding Help on Coastal Erosion*, a directory of government agencies and educational institutions, available from New York State Sea Grant Extension Program, Dutchess Hall, SUNY Stony Brook, NY 11794.

APPENDIX 1

ECOLOGICAL DETERMINISM: THE USE AND MISUSE OF BARRIER ISLANDS

Ian McHarg, a leading proponent of ecological determinism in regional planning, in his book *Design with Nature*, presents a well-illustrated chapter, "Sea and Survival," dealing with a study of the New Jersey shore. He vividly characterizes the process at work and lays out basic prohibitions for human use, among them being "Thou shalt not walk on the dune grasses. Thou shalt not lower groundwater below the critical level. Thou shalt not interrupt littoral drift." He then mentions that "these proscriptions will merely insure the perpetuation of a natural sandbar and its native vegetation and expression. This will merely sustain a public resource." McHarg continues with a characterization of the tolerance or intolerance of the various environments to human use in general and to some particular uses (fig 15).

The beach zone is tolerant to intensive recreation, but no building should be done there. The next zone, that of the primary dune, is absolutely intolerant and must be prohibited to all uses. Bridges built over the dunes must be used to cross them to reach the beach. The primary dune offers defense against storms and floods. Thus, development should be forbidden on the primary dune, and no walking and no breaching should be allowed. Back of the primary dune is the trough, an area that is relatively tolerant, with limited recreation and limited structures possible. Still farther back is the inland (or secondary) dune, which is intolerant and should not be passed through, breached, or built upon. The backdune zone, next adjacent, is tolerant and the most suitable for development. The bayshore zone is a nutrient-rich location that is highly productive, serving as breeding ground and home of important waterfowl. It is here in salt marshes that the infantile stage of various fish takes place and also where shellfish are found. This zone should be inviolate, with no filling permitted.

McHarg concludes his chapter with planning prescriptions based upon understanding the ecological analysis of the various zones.

A spinal road could constitute a barrier dune and be located in the backdune area. It could contain all utilities, water, sewer, telephone, and

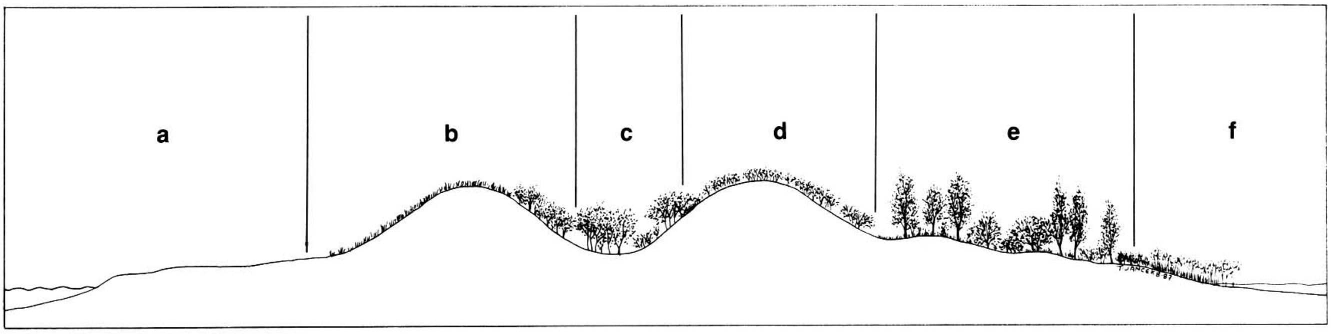


Figure 15. Tolerance of coastal environments to human use: (a) beach zone—tolerant to intensive recreation but not building; (b) primary dune—absolutely intolerant, all uses prohibited; (c) trough—relatively tolerant, limited recreation and structures possible; (d) inland (secondary) dune—intolerant, all uses prohibited; (e) backdune—tolerant, most suitable for development; (f) bayshore—inviolate, no filling permitted. (*Source:* adapted from McHarg 1969)

electricity and would be the guardian defense against backflooding. At the widest points of the backdune, settlement could be located in communities. Development would be excluded from the vulnerable, narrow sections of the sandbar. The bayshore would, in principle, be left inviolate. The beach would be available for the most intensive recreational use, but without building. Approaches to it would be by bridges across the dunes, which would be prohibited to use. Limited development would be permitted in the trough, determined by groundwater withdrawals and the effect upon vegetation. A positive policy would suggest accelerating the stabilizing processes, both of dune formation and of vegetative growth. To do this the appropriate vegetation for the associations would be planted. Particular attention would be given to planting marram grasses on dunes and to planting red cedars and pines on the backdune.

Appendix 2

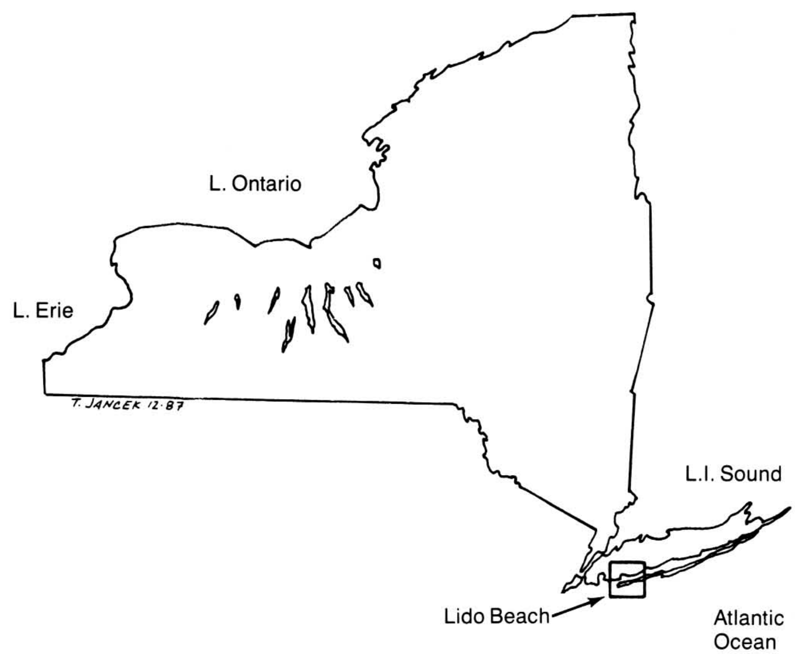
Dune Restoration and Conservation in the Town of Hempstead

A substantial dune line has been maintained over the years at Lido Beach, town of Hempstead, Nassau County, Long Island (see location map), as protection against the ravages of storm-driven ocean waves. East of the Lido Beach residential community is an open expanse of shorefront land on which the dunes were leveled to adjacent beach elevations in the early 1960s without concern for natural storm protection. This area later became the Lido Town Park.

Since 1971 the Town of Hempstead Department of Conservation and Waterways has been actively engaged in protection, expansion, and rehabilitation of dunes and beaches from Lido Beach to Point Lookout. In the fall of 1971 snow fences were erected in an L-shaped pattern in front of the town park picnic area and the Sands Beach Club. The winter buildup of sand was smoothed in an east-west direction, but left essentially in place rather than spread out to the south over the forebeach expanse. Another stretch of the Lido dune line has been maintained for decades by the residents of the old Lido Beach community through beachgrass planting and installation of winter sand fencing along this older, established dune.

In January 1975 a severe winter storm struck with a surge and waves that reached well into the play and parking areas of the park. Although less than in areas with no new sand accumulation, damage also occurred at the picnic area and the Sands Beach Club as the storm waves removed much of the accumulated sand from the 1971–75 seasons.

These facts were given serious consideration during later expansion of the town's park and recreation program. A cooperative beach-



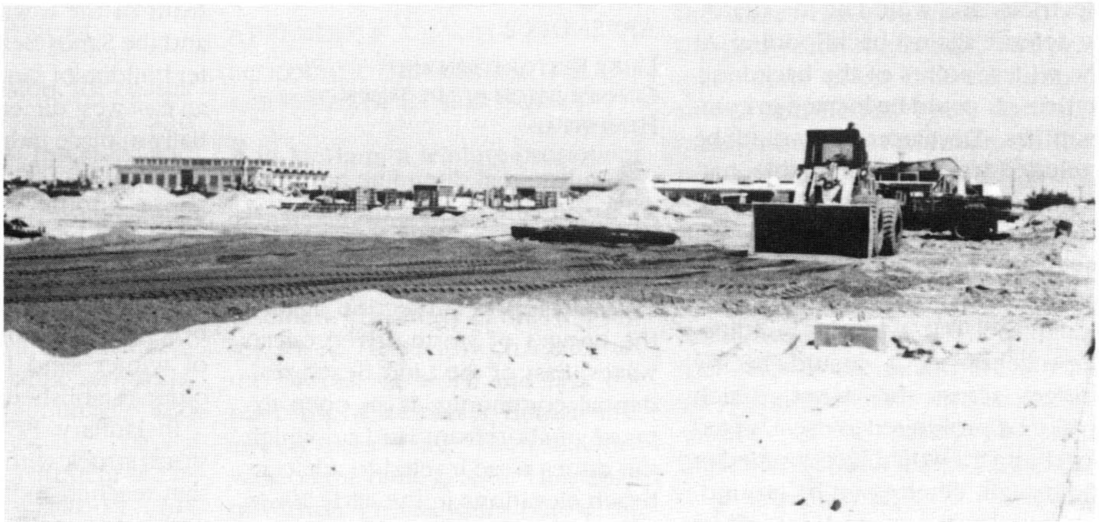


Figure 16. The use of a solid core of dirt fill covered with several feet of beach sand to build a 440-foot extension of the existing dune line, instead of natural sand accumulation on snow fencing, was a first in Hempstead's dune-building program.

enhancement/facilities-protection project was initiated by the Town Parks and Recreation Department and the Department of Conservation and Waterways in early May 1976.

A 440-foot extension of the easterly end of the existing Lido dune line was constructed, using a solid core of dirt fill covered with several feet of beach sand that had been stockpiled for this purpose over the winter. This approach, using fill instead of natural sand accumulation on snow fencing, was a first in Hempstead's dune-building program (see fig. 16).

The town parks engineering division supplied 10,000 cubic yards of loamy sand fill. With heavy equipment supplied by the town park at Point Lookout, a dune, 440 feet long, 10 to 12 feet high, and 24 feet wide at the base, was constructed in a matter of weeks. The dune was then fenced properly and planted with beachgrass (*Ammophila breviligulata*) on the top and front face (fig. 17).

When the dune was firmly established, the conservation department's beach management personnel began installing snow fence along the eastward side of the new dune, using the highly successful Y fence pattern (fig. 18) developed for the Lido dune system.

The department expanded its activities to include the building of an additional 500 feet of dune in front of the park picnic area and Sands Beach Club, using fencing and accumulated sand only. Parks department equipment was employed to reshape the winter sand accumulation into linear dune formations, which town personnel then planted and fenced. Fencing was installed along the seaward side in the Y pattern used in the other areas.

In 2 months this cooperative venture provided over 900 linear feet of dune protection for the Lido Town Park facility. This new dune system was tested in August 1976 when Hurricane Belle struck. The storm, coupled with high tide conditions, completely flooded the entire Lido beach face to the base of the dunes. The dunes, however, held, and the facilities behind them were protected.

More recently, in 1979, more than 50,000 cubic yards of trucked-in sand from an old dredge-disposal site were used to create some 1,800 feet of 15-foot by 30-foot dune west of the original "instant dune" site. After establishment of this new dune, Y-pattern fencing and vegetative plantings were used to promote natural accumulation of sand. Since

Figure 17. The "new" dunes were fenced to reduce the amount of foot traffic and planted with beachgrass.

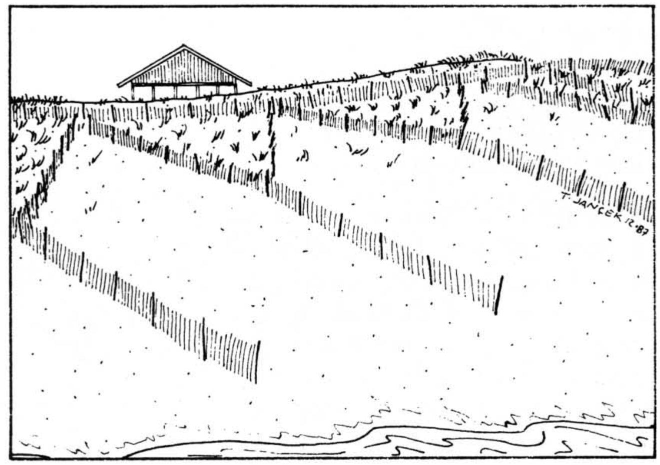


Figure 18. When the "new" dune was firmly established, snow fence was installed in a highly successful Y fence pattern.

that time, this dune has doubled in width. A good part of the success of this project is also attributable to the town's use of wooden crossovers to carry foot traffic over the dunes at specific locations and fencing to keep pedestrians off the sensitive dunes and beachgrass plantings (fig. 19).

The town originally established 11 acres of beachgrass nursery for transplant purposes, using commercially grown beachgrass stock. The amount of available transplant stock has since grown to between 50 and 60 acres as a result of the successful propagation of the grass on the established dunes.

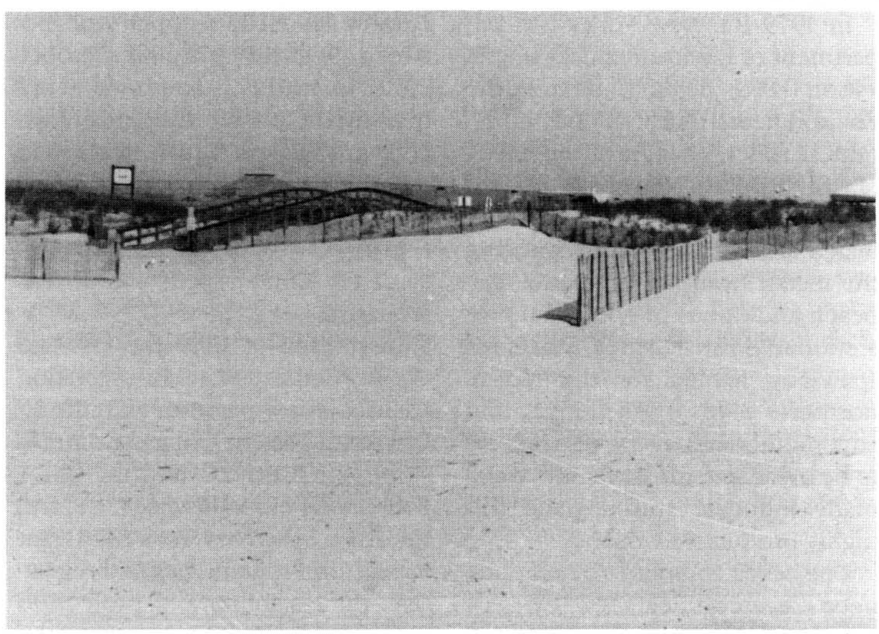
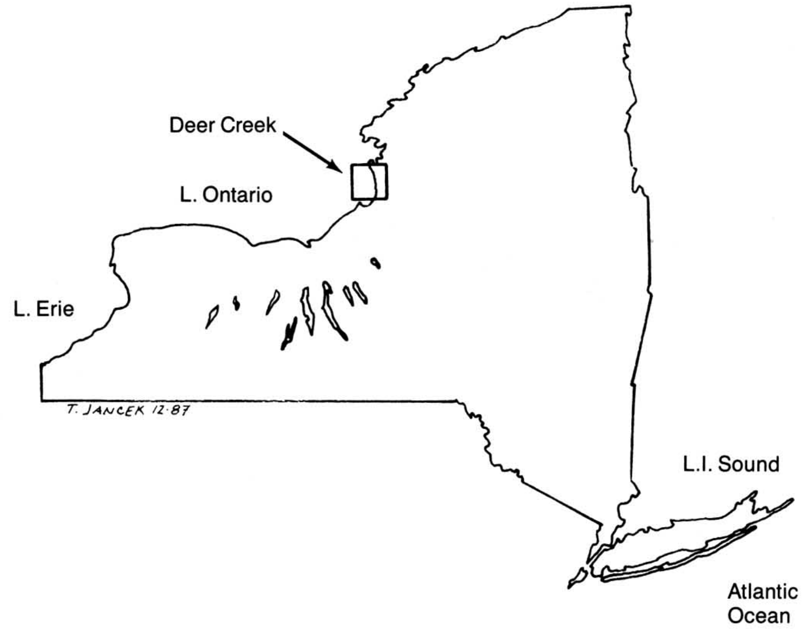


Figure 19. A successful dune-stabilization project uses wooden crossovers to carry foot traffic over the dunes at specific locations and fencing to keep pedestrians off the sensitive dunes and beachgrass plantings.

APPENDIX 3

THE USE OF AMERICAN BEACHGRASS TO STABILIZE SAND DUNES ALONG EASTERN LAKE ONTARIO — THE DEER CREEK DEMONSTRATION PROJECT



The Deer Creek barrier beach is part of an extensive area of sand dunes along the eastern shore of Lake Ontario (see location map). These dunes have been formed through the deposition of sand being transported from the west by longshore currents and blown inland from the beach by prevailing westerly winds. They are thought to be about 5,000 years old. Historically, the sand dunes along the shore of eastern Lake Ontario have been a fairly stable feature, although individual dunes are constantly changing.

In 1979 the New York State Department of Environmental Conservation (DEC), using funds from the Environmental Quality Bond Act, acquired the 1,325-acre Deer Creek Marsh Wildlife Management Area and the adjacent 60-acre barrier beach and dune system separating the marsh from Lake Ontario. The beach and dunes provide vital protection to the marsh area, which is a spawning habitat for the redfin, northern pike, muskellunge, and largemouth bass. If the dunes were to be breached, the lake could eventually inundate and degrade this highly productive wetland.

The beach and dunes had already been severely degraded by past sand-mining operations, the use of the area as a recreational vehicle park, and wind erosion (fig. 20). The Deer Creek dunes are open to westerly winds blowing over a fetch of up to 141 miles, at speeds sometimes exceeding 40 miles per hour. Periodic episodic erosion along the eastern Ontario dune system has reached rates of almost 15 feet per year (between October 1971 and October 1972). In April 1979 storm waves undermined a private residence adjacent to the Deer Creek beach and exposed buried sewer and water lines. Without proactive intervention by conservationists, the integrity of the dune system was in dire jeopardy.

In the fall of 1979 the Oswego County Soil and Water Conservation District, in cooperation with the St. Lawrence-Eastern Ontario Commission (SLEOC), DEC, and the USDA Soil Conservation Service (SCS) and funded by the New York Sea Grant Extension Program, began a vegetative dune-stabilization project to repair several major blowouts of the dunes and to test and demonstrate methods of stabilizing sandy areas along the eastern shore of the lake.

DEC agreed to provide access to the state-owned site and to protect the site against trespass. The district, SLEOC, SCS, and Sea Grant designed the stabilization and monitoring methods to be used. The district and SCS, with cooperation from the Youth Community Service volunteer program, provided the labor, materials, and equipment for the project. SLEOC agreed to provide long-term monitoring and assessment of the project, and all the participants planned to use the project as an educational demonstration site to inform eastern Lake Ontario landowners of how they could perform similar stabilization efforts.

As it was planned, the project involved testing four remedial techniques that appeared to be applicable to the eastern Ontario setting, including planting commercially available Cape-variety American beachgrass, transplanting native beachgrass, fertilization of native sand dune vegetation, and development of an on-site beachgrass nursery. Planting and other activities were undertaken during the period of April 24 through April 30, 1980, with a second application of fertilizer being applied in August 1980.

Figure 20. The beach and dunes at Deer Creek had already been severely degraded by past sand-mining operations, the use of the area as a recreational vehicle park, and wind erosion.

Figure 21. A 6,000-square-foot blowout on the lakeward side of the backdune was planted with Cape variety, with an 18-inch spacing.

Six test plots were worked as part of the demonstration. After each site was transplanted, it was fertilized at the rate of 50 pounds nitrogen per acre, by using a small cyclone spreader. A second fertilization, at the same rate as the first, was done in mid-August. Site 1, approximately 2,990 square feet, was a funnel-shaped foredune blowout. Although it was not planted with beachgrass at the time of the original project, this site was later stabilized using sand fencing.

Site 2, slightly over 3,000 square feet, was a rectangular blowout on the foredune. This site was planted with native beachgrass transplants, with plants 12 inches apart in rows 12 inches apart. The planting was done in three strips, parallel to the shore, covering some 1,285 square feet of the site. The native transplants were harvested from dense, healthy stands of native beachgrass, in narrow strips parallel to the shore on the back dune, to minimize the erosion risk to the harvest site. This spacing was dictated by the relative lack of native transplant stock available.

Site 3, a 5,200-square-foot rectangular blowout, was planted with commercially grown Cape-variety American beachgrass in 3-culm planting units, 12 inches apart in staggered rows.

Site 4, almost 6,000 square feet of blowout on the lakeward side of the backdune, was planted with Cape variety, with an 18-inch spacing (fig. 21).

Site 5, an hourglass-shaped foredune blowout, was also planted with Cape variety, with the 12-inch spacing in three strips parallel to the shore.

Site 6 was a 4,300-square-foot control site; although no transplants were established, this site was fertilized at the same rate as the transplant sites. Native plants present in this site, in order of their relative importance, included American beachgrass, beach wormwood, grape, evening primrose, mullen, wild rye, lily, dandelion, milkweed, and other grasses.

After the sites were planted and fertilized, they were roped off and marked with Keep Off signs to protect the beachgrass from trampling by foot (or vehicular) traffic.

Initial results, 6 months after planting, indicated an overall survival rate of 85-90 percent, with marked sand accumulation at each site. Because all plantings were in 3-culm units, propagation rates were easily observed. In September 1980 site 2 showed 4-5 culms; site 3, 6-7 culms; site 4, 5-6 culms; and site 5, 4-5 culms. After 2 years all test plots showed healthy, vigorous vegetative growth. Even site 6 where only fertilization took place showed more vegetative cover than did areas of the dunes that were not part of the project.

All four demonstration techniques are documented in an instructional 15-minute video tape entitled "Stabilizing Sand Dunes with Beachgrass." The video tape is available on loan from the New York Sea Grant Extension Program.

The Deer Creek project site is, perhaps, unique in that it is protected from disruptive human intervention by the wildlife management activities of DEC. Specifically prohibited are swimming, camp (or other) fires, camping, removing or disturbing any plants or minerals, walking or riding domestic hoofed animals, use of motorized transportation in the area, launching boats, and any form of dumping or littering. Enforcement is, however, not at a level to fully provide for the benefits of such prohibitions because of state and local budget constraints. Camping and campfires do take place during the summer months, invasion by all-terrain vehicles has become a problem, and portions of the sand fence (and even Test Plot and Keep Off signs) have been used for firewood.

Appendix 4

B. Forman Park Demonstration Project: The Use of Deep-rooted Conservation Plantings to Stabilize a Lake Ontario Coastal Bluff

In 1982 the New York Sea Grant Extension Program, the Wayne County Cooperative Extension Association, the U.S. Department of Agriculture Soil Conservation Service, and the Soil and Water Conservation District of Wayne County planned and implemented a vegetative stabilization project to demonstrate the erosion control effectiveness of smoothing a steep, moderately eroding coastal bluff (fig. 22) to a gentler slope and of planting that slope with a variety of deep-rooted conservation vegetation. To demonstrate how a landowner could perform similar slope-stabilization work as a low-cost, do-it-yourself project, all slope grading and planting were done by hand by four staff members of the sponsor agencies with assistance from four 4-H youth volunteers. Slope reshaping and planting work was done during the first week of May 1982.

This demonstration project is located in B. Forman Park, on Lake Road, town of Williamson, Wayne County, N.Y. (see location map), and provides a "living laboratory" in which landowners may view these types of vegetation actually being used to control erosion. Landowners can then decide whether such an erosion control method is practical for their coastal property.

Nine test plots illustrate different vegetation types, planting methods (seeding, transplanting), and mulching techniques. The success or failure of a vegetative stabilization project depends, in a large part, upon the angle of the face of the slope. Natural, noneroding slopes in the area of the demonstration project tend to be stable at an angle of about 34 degrees (1:1.5, 1-ft verti-

Figure 22. The B. Forman Park Demonstration Project involved smoothing a steep, moderately eroding coastal bluff to a gentler slope and planting that slope with a variety of deep-rooted conservation vegetation.

cal rise per 1.5-ft horizontal run). Steeper slopes in this area tend to be devoid of vegetation or else prove very difficult for establishing and maintaining a good long-term cover on them. The slope at the demonstration project was reshaped and graded by hand to about a 1:1.5 slope, and the top lip between the park lawn and the bluff slope was rounded off about 3 to 5 feet from the edge. The lip was then stabilized with deeper- rooted shrubbery than on the slope face. Shallow-rooted turf at the lip, as well as mowing out to the very edge of the bluff, has been discouraged.

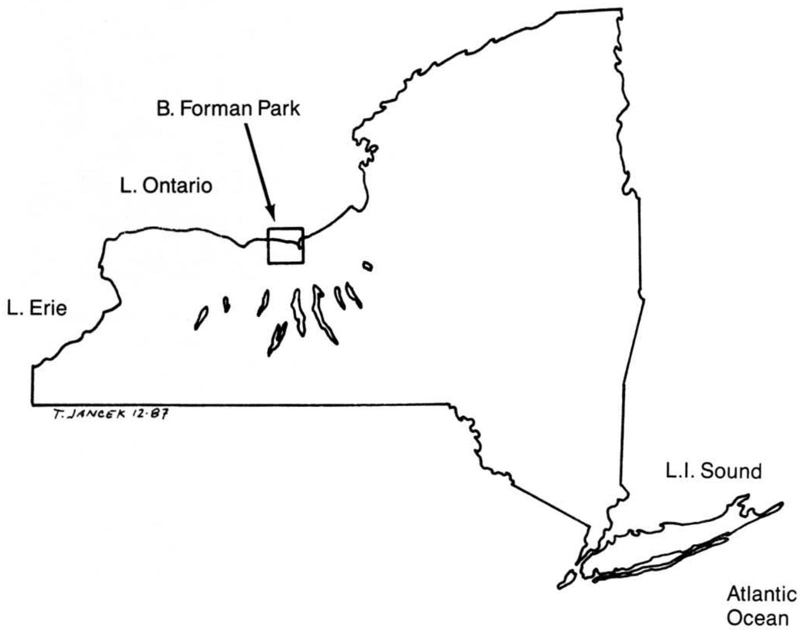


Figure 23. Straw, held in place by jute and plastic netting (*left*), and excelsior blanket mulch (*right*) were critical in protecting the seed, transplants, and soil against the elements.

The project team was concerned that a bare, regraded slope just seeded or planted with transplants could be particularly susceptible to surface erosion by wind and rain. Soil moisture could also be rapidly lost by exposure to the sun and wind, threatening the survival of both seeds and transplants. The team decided that it was critical to mulch the plots to protect the seed, transplants, and soil against the elements. The demonstration project used straw and excelsior blanket mulch, held in place by jute and plastic netting, on different test plots (fig. 23).

Test plots at the project demonstrate a variety of transplants and seed plantings. All test plots were overseeded with perennial rye as a nurse grass to provide a quick-growing first-season cover to augment the mulch in preventing erosion until the conservation plantings could take hold. One test plot, at the far east of the site, was seeded with crownvetch and mulched with straw tied down with jute net. Another plot was seeded and transplanted with crownvetch and mulched with straw tied down with jute net. A third plot was seeded with 'Lathco' flatpea and mulched with straw tied down with jute net. A fourth plot was seeded and transplanted with 'Lathco' flatpea and mulched with an excelsior blanket. Plot 5 was seeded with crownvetch, 'Lathco' flatpea, and birdsfoot trefoil and mulched with straw tied down with plastic netting. Plot 6 was seeded with birdsfoot trefoil and transplanted with crownvetch and mulched with straw tied down with plastic netting. Plot 7 was transplanted with crownvetch, 'Lathco' flatpea, and rugosa rose (to provide for a higher, denser-growing barrier to foot traffic) and mulched with straw tied down with jute netting. The final plot was planted with purpleosier willow and 'Lathco' flatpea transplants into the cobble-beach/till-bluff interface.

Although it is too early in the project's life to evaluate its long-term effectiveness, preliminary observations at the end of the project's first summer indicated that the mulching process improved short-term post-planting stability and that the primary conservation vegetation established fairly well with a minimum of maintenance. A number of spring and summer thunderstorms were weathered with little surface erosion evidenced.

During the first two summers of the project's life, lake wave erosion was not a factor in toe erosion because of generally normal lake levels and a lack of major on-shore storms. During the third summer, the lake's level was about 6 inches above its 20th century average, and several minor storms resulted in small (1-2-ft) waves reaching the willow plantings. No damage to the project resulted, but the site immediately to the east of test plot 1 lost approximately 1½ feet to erosion that year. During 1986, lake levels ranged from 12 to 22 inches above average, and several major on-shore blows during the autumn months removed part of the cobble beach in front of the willows. Up to mid-January 1988, no damage to the willow (or other) plantings was noted, but prospects of some damage during future high lake levels and storm periods cannot be discounted. Regarding surface erosion, the project has essentially prevented any recession of the bluff since the vegetation's establishment. The buffer strip at the top of the bluff is dense enough for foot traffic over the bluff to be discouraged; the crownvetch/flatpea cover on the face of the slope has choked out all but the most vigorously growing sumac and bamboo grass (fig. 24). The private property to the east, which has been viewed as a control plot, has lost about 3 feet during the 4 years since the project was planted.

Figure 24. The project's buffer strip is now dense enough to discourage foot traffic over the bluff; the crownvetch/flatpea cover on the face of the slope has choked out all but the most vigorously growing sumac and bamboo grass.

A bare, regraded slope that has just been seeded or transplanted is particularly susceptible to surface erosion by wind and rain. Soil moisture can also be rapidly lost by exposure to the sun and wind. While seeds are germinating and before seeded or transplanted vegetation is growing vigorously, it is critical to use mulch to protect the seed, transplants, and soil against the elements. Mulch materials include hay or straw, manure or compost, wood chips, and excelsior (wood shaving) blankets. The mulch should be held in place by jute or plastic netting or a spray of biodegradable binding material (except excelsior blankets, which are usually preattached to a binding net).

APPENDIX 5

HERBACEOUS ORNAMENTAL PLANTS FOR THE SEASHORE

The overriding objective of this bulletin is to consider the functional aspects of vegetation stabilization and erosion control. It is recognized that some readers may also want information on seashore-tolerant herbaceous plants that are primarily ornamental. These would include perennials and annuals useful in a coastline environment, either parkland or residential.

Many perennials perform well in sandy soils and sunny exposures provided they receive protection from excessive wind and salt spray and are adequately watered and fertilized. They do not have to be replaced each year and usually require little additional care except for proper winter mulching, adequate staking, and occasional pest control. The listed perennials have proved to be dependable performers in sunny, sandy coastal locations.

Perennials

Adam's-needle	*Yucca filamentosa*
Baby's-breath	*Gypsophila*
Bee balm, Oswego tea	*Monarda didyma*
Blanket flower	*Gaillardia x grandiflora*
Blue false indigo	*Baptisia australis*
Blue fescue	*Festuca ovina* 'Glauca'
Butterfly weed	*Asclepias tuberosa*
Candytuft	*Iberis sempervirens*
Chrysanthemum	*Chrysanthemum x morifolium*
Daylily	*Hemerocallis*
Lamb's-ears	*Stachys byzantina*
Lavender cotton	*Santolina chamaecyparissus*
Nippon chrysanthemum	*Chrysanthemum nipponicum*
Perennial coreopsis	*Coreopsis lanceolata*
Pinks	*Dianthus* species and variants
Sea campion	*Silene vulgaris* ssp. *maritima*
Sea holly	*Eryngium maritimum*
Sea lavender	*Limonium latifolium*
Silver mound	*Artemisia schmidtiana* 'Nana'
Snow-in-summer	*Cerastium tomentosum*
Speedwell	*Veronica* species
Stonecrop	*Sedum* species and variants
Thrift, sea pink	*Armeria maritima*
Thyme	*Thymus* species and variants
Volga wild rye, sea lyme grass	*Elymus racemosus*

Annuals are an integral part of most seaside gardens because they can be depended upon to provide excellent color displays during the summer months. Most annuals benefit from protection from drying winds and intense sun and should receive adequate moisture as needed. Windbreaks, such as a fence, wall, or hedge, are often beneficial. Some heat-tolerant and drought-resistant annuals are listed.

Annuals

California poppy	*Eschscholizia californica*
Cornflower, bachelor's-button	*Centaurea cyanus*
Flowering tobacco	*Nicotiana alata*
Garden nasturtium	*Tropaeolum majus*
Garden petunia	*Petunia x hybrida*
Geranium	*Pelargonium* species and variants
Heliotrope	*Heliotropium arborescens*
Ice plant	*Mesembryanthemum crystallinum*
Lantana	*Lantana camara*
Love-in-a-mist	*Nigella damascena*
Madagascar periwinkle	*Catharanthus roseus (Vinca r.)*
Marigold	*Tagetes* species and variants
Pincushions	*Scabiosa atropurpurea*
Portulaca, rose moss	*Portulaca grandiflora*
Red flowering tobacco	*Nicotiana x sanderae*
Sweet alyssum	*Lobularia maritima*
Treasure flower	*Gazania ringens*
Zinnia	*Zinnia* species and variants

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