COASTAL DUNES

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A Primer for Dune Management with Models of Dune Response to Storm Frequencies

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Table of Contents

Coastal Dunes

Coastal dunes are natural features of the coastal landscape. They exist in conjunction with the beach and are part of the sand sharing system that actively exchanges sand between the dune, the beach, and the offshore bars. In areas of adequate sand supply, the coastal dunes achieve their full form; however, if sand supply is limited, the dunes may be small, narrow features that are frequently overwashed. In areas of very meager sand supply, the dunes will not exist.

Coastal dunes occupy a transitional zone between marine and continental processes, and mark the seaward location of the continental vegetation. Coastal dunes occupy an ecological niche that is the transition between the harsh, salty, open environment of the beach and the less harsh, protected environment to the lee of the dune crest. Natural dunes are replete with hollows and knolls, ridges and swales, blowouts and vegetated slopes. The location and dimensions of dunes on the profile are related to the developmental history of the shoreline. That is, under accretional conditions, older dunes are stranded inland and are succeeded by newer foredunes created in the upper beach. At erosional shorelines, the active dune form shifts inland as the beach retreats. As long as sufficient sand is present, the dunes will exist at the inland margin of the beach. However, if the erosion is too severe, or there is no space for the dune to shift inland as the shoreline erodes, the dunes will not persist.

In developed coastal zones, coastal dunes continue to perform their natural function of sand storage, but also perform an additional role of creating a natural barrier to storm surge and flooding. Thus, dunes are valued by the coastal communities because they offer a natural, esthetic, and protective component of the coastal landscape. Although dunes have been recognized as a form of coastal protection since the early 1930s in New Jersey, it was not until 1984 that coastal communities and the State took an active role in restoring, repairing, and maintaining the dunes. Through these efforts, the public value of the coastal foredune as a barrier against coastal storm surges and waves has been established and continues to increase. Concern for the creation of coastal dunes as part of a management program to provide protection for the people and communities inland from the beach was well-expressed in the New Jersey Department of Environmental Protection's (NJDEP) 1984 Assessment of Dune and Shore Protection Ordinances in New Jersey, which is a forerunner to the present booklet.

Because the preservation and restoration of coastal dunes can be almost entirely a community effort and responsibility, this booklet is directed towards assisting them understand dune processes and establish effective dune management programs. It provides guidance to communities as they develop strong dune maintenance programs to restore, to repair, and to enhance their dunes. The booklet also describes the processes which govern New Jersey's coastal dunes, and offers management strategies directed at the community level to maximize the function and effectiveness of their dunes. Lastly, the document includes a model ordinance which communities can adopt or incorporate into existing dune maintenance activities.

Attributes of Coastal Dunes

Understanding the processes that influence the creation of coastal dunes is an important aspect of their management. Coastal dunes are part of the natural beach system.

Whereas dunes in dry sandy areas are largely shaped by wind, dunes in the coastal zone are molded by waves as well as wind. In a beach profile, the coastal dune forms a ridge of sand that accumulates above the high tide line and inland of the extremely mobile, bare sand beach surface (Figure 1).

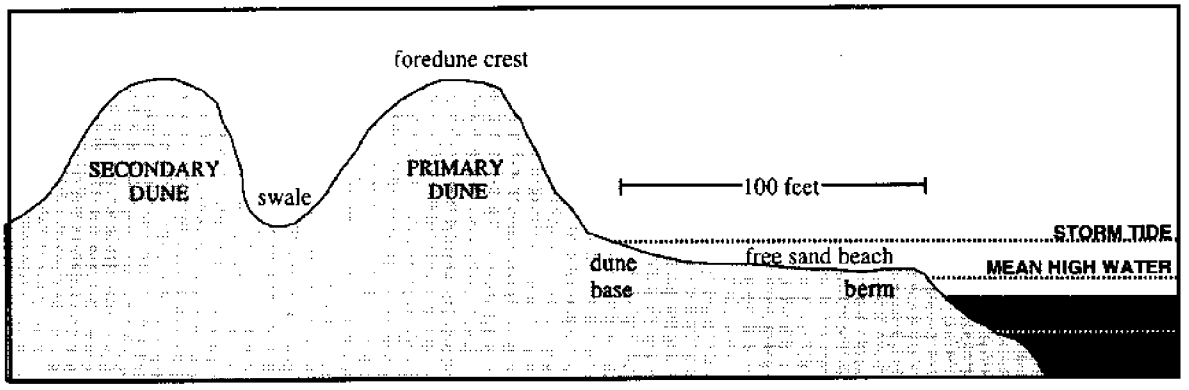

Figure 1. Dune/beach profile with selected terminology and relationship to water level.

This natural feature exists in the zone where pioneer vegetation traps sand transported inland from the beach primarily by wind action, and forms an accumulation in the shape of a coast parallel sand ridge. The active coastal dune, often referred to as the foredune to distinguish it from other and older dune forms, is located immediately inland of the bare sand beach. Other, older dunes may exist inland from the foredune. They may have been part of former foredunes, or they may be older sand ridges that have migrated inland from the beach. They are usually referred to as secondary dunes whereas the active foredune is the primary dune. It is the coastal foredune that is the subject of most of the remainder of this discussion. Unless otherwise noted, reference to the dune means the foredune, the primary dune in the beach/dune interactive system.

The principal attributes of natural coastal foredunes are that they are sites of sediment accumulation and storage. They exist because more sand is deposited in their locations than is removed. As a result, they become a physical form with height, width, and mass. The foredune is in dynamic interaction with the beach and the processes that move sand in the beach, including waves, currents, and winds.

Certain types of vegetation can tolerate the harsh conditions of heat, aridity, high salinity, and low nutrient availability found at the shore. These plants are referred to as pioneer plants and comprise the dune grasses and other plants that colonize the seaward face or crest of the foredunes. These primary plants are the natural foundation for the creation of dunes. When airborne sand moves across their foliage, the wind's velocity is decreased, and sand is deposited around the vegetation, beginning the natural cycle of dune formation. As the sand accumulates around the primary vegetation, roots and rhizomes spread from which new plants grow. This dense vegetation anchors the dune below the surface and stabilizes sediment on the surface providing a natural barrier to incoming waves. Without the presence of dune vegetation, dunes become extremely vulnerable to the forces that create them.

Natural coastal foredune development occurs inland of the frequent storm tide position where it is beyond the part of the beach that is constantly changing with the tides and wave variation. Foredune development also occurs in this zone because it is the area where vegetation can persist. Generally, the coastal foredune is not located seaward of the pioneer vegetation line, because there is a lack of a stabilizer to accumulate sand transported

inland from the beach. On accreting shorelines, the pioneer vegetation extends seaward from the dune face and eventually establishes a new line of sand accumulation. This process will continue until the foredune extends seaward to the storm tide line of the beach. This accretional situation gives rise to a series of low small dune ridges (Figure 2). However, most of New Jersey's beaches are eroding, and the seaward edge of the foredune is located extremely close to the storm water line and is frequently attacked by waves.

On many beaches that have a long history of erosion, the foredune continues to exist in the beach/dune profile. This is an indication that under some conditions, the foredunes can migrate inland as the beach erodes. In other words, dunes can exist as the eroding beach profile is losing sand to offshore and alongshore locations. These foredunes are capable of migrating because some of the lost sediments are transported back into the dunes during levels of high water, storm surges, and high wind. Additionally, the existence of dunes on an eroding shoreline indicates that sand is being blown into the dunes, and is carried inland to the lee side of the foredune, adding some mass to the backdune even as it is losing sand on the seaward side. After a storm, it is common to identify sand that has been transported into the dune and the swales inland of the foredunes, and to see fresh layers of sand blown atop of the foredune blanketing much of the vegetation (Figure 3).

Although the coastal foredune accumulates sand blown across the beach into the pioneer vegetation, it also loses sand when wave action erodes the beach and attacks or scarps the foredune. Scarping by waves is the process by which the sand held in storage in the foredune is returned to the beach for subsequent transfers offshore, alongshore, or to its original location in the dune profile (Figure 4). If the amount of sand lost by waves scarping the seaward margin of the foredune is replaced later by sand moved by wind from the beach to the dune, the net effect of the exchange is in balance. The dune will obviously lose dimension if the amount of sand removed is greater than the amount replaced. Conversely, the dune will gain in dimension if the amount of sand replaced is greater than was originally removed by the scarping process. Maintaining dense, healthy dune vegetation is one of the best means to stabilize a dune and to minimize mobilization and erosion.

The foredune is a ridge, higher than the beach surface, forming a natural barrier to the inland penetration of high water from storm surges. By functioning as a barrier, dunes limit the effects of storm waves and currents to the beach and the foredune face. While buffering the effects of these forces, sand stored in the dune is released by the mobilizing processes of waves and flowing water. Because the amount of protection is related to the mass of the dunes, higher and wider dunes will provide more buffering than lower and narrower dunes. However, the buffering effect of the coastal dune is obviously diminished when the dune crest is overtopped and eroded. Overwash may sometimes be so severe as to completely remove the dune form and transport much of the sand inland.

This discussion has focused on the processes by which natural dunes exist in the beach/dune profile and their interaction with the waves, winds, and currents. However, most of the dune forms in New Jersey have been modified by cultural activities that both diminish and enhance the remaining forms. In a few places, some natural, or near-natural, dunes still exist because of the absence of human interference. These dunes are located on the northern portion of Sandy Hook, much of Island Beach State Park, northern Barnegat Light, southern Sea Isle City, southern Stone Harbor, the shoreline portion of the Forsythe Wildlife Refuge,and the central portion of Avalon. The dunes located at Island Beach State Park and Avalon are important features of the New Jersey coastline because they show the overall

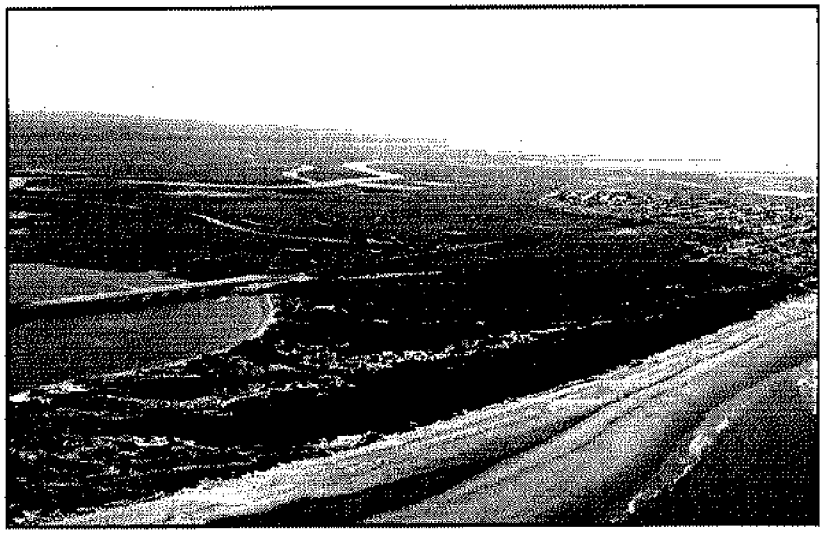

Figure 2. Accretionary foredune ridges are associated with positive sediment budget on the downdrift end of a barrier island. Corson's Inlet State Park

Figure 3. Storm has transported sand inland to cover existing vegetation. Island Beach State Park.

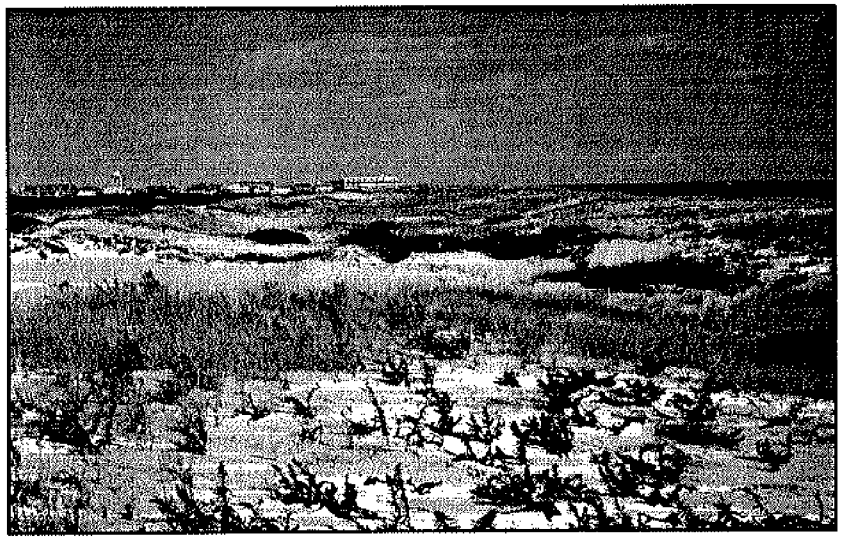

Figure 5. Primary and secondary coastal dune formation separated by a swale. Island Beach State Park.

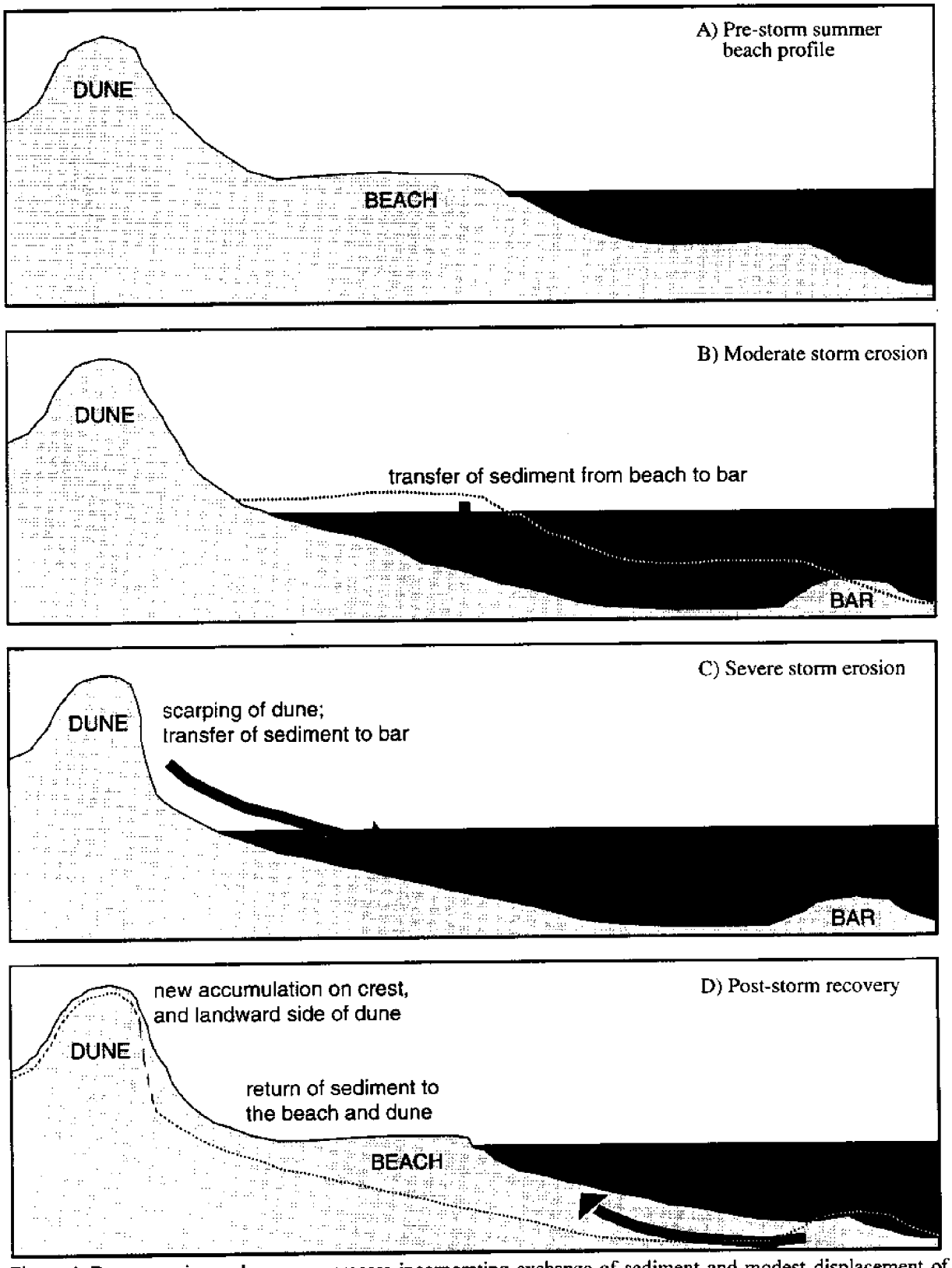

Figure 4. Dune scarping and recovery process incorporating exchange of sediment and modest displacement of the foredune position.

conditions of coastal dunes prior to the major development of the shore (Figures 5 and 6). Likewise, these locations demonstrate that even though erosion has occurred, primary and secondary dunes still survive. Further, they demonstrate the variety of dune forms and dimensions that can occur within short distances of the storm tide position and the interdependence of dunes with beach changes and sediment budget.

Rationale for Management

In 1930, the New Jersey Board of Commerce and Navigation produced a Report on the Erosion and Protection of the New Jersey Beaches. Whereas the report emphasized the continuation of structural solutions to reduce beach erosion, it noted that coastal dunes should be given more consideration for their protective qualities. It was not until 1972 that the attributes of coastal dunes were recognized nationally by the passage of the Coastal Zone Management Act. Among the basic tenets that formed the foundation of the Act was the desire to protect dunes as a natural protective feature (P.L. 91-583, 1972). Under the Act, states could receive federal funding to develop and to implement the Act's objectives. For the first time, there was a national impetus for coastal states to promote dune restoration and maintenance. However it was not until after the March 1984 storm, which destroyed much of New Jersey's dunes, that the State utilized these funds to implement the Federal Emergency Dune Restoration Program. With the availability of this federal funding, New Jersey coastal management strategy began to emphasize dunes as a preferred form of coastal protection through technical and financial support from the NJDEP and the New Jersey Office of Emergency Management (NJOEM) to communities for restoring these features.

In 1984, the NJDEP completed an Assessment of Dune and Shore Protection Ordinances in New Jersey, an evaluation of municipalities management of coastal dunes. The report concluded that State expenditures for shore protection would be the most cost effective if they coincided with programs that protect and create dunes, and that future shore protection expenditures by the State be conditioned upon municipal adoption and enforcement of an effective dune management program (NJDEP, 1984). As a by-product of the Section 306 dune restoration, NJDEP produced Guidelines and Recommendations for Coastal Dune Restoration and Creation Projects in 1985. The report was designed to "list recommended dune restoration and creation techniques, help municipalities plan effective and environmentally sound dune projects, and explain what information municipalities should submit to complete their applications for dune funds" (NJDEP, 1985).

The New Jersey Office of Emergency Management (NJOEM) has also continued to support a coordinated government program of dune creation, and expansion through the various State Hazard Mitigation Plan's recommendations (NJOEM, 1994). In addition through NJOEM, coastal communities can qualify for Hazard Mitigation Grant Program funding to restore, develop, and repair their dunes after a disaster.

As New Jersey's coastal management strategies shift from protection of property to the enhancement of public safety, coastal dune maintenance can easily be incorporated into these efforts. As previously stated, coastal dunes buffer the effects of storm surges and prevent subsequent damage. Therefore, the utilization of coastal dunes is consistent with both federal and state mitigation objectives. If the Federal government continues to decrease monetary support for beach nourishment projects as a type of coastal protection, the buffering abilities of coastal dunes may become the primary means of protection. Further, through dune maintenance programs such as annual beachgrass plantings, many municipalities

can bring various community resources together for a common cause, creating a feeling of community "togetherness" (Figure 7).

Determining Objectives

If coastal dunes are employed to protect communities from the effects of coastal storms, communities must determine the level of protection they wish to achieve from anticipated storm water levels prior to constructing the dunes. When determining their objectives, communities must balance the level of protection desired with the amount of space they will need to achieve their goals. The spatial dimensions of a foredune that would protect against a 1 in 5 year storm water level, for example, differ from the dimensions required to buffer a 1 in 50 year storm. Although a municipality may wish to provide protection from water levels of a 1 in 50 year storm, the dune/beach area may only provide adequate space for a foredune that can buffer a 1 in 20 year storm water level. If communities desire to develop dunes that will protect against higher magnitude storms, but do not have the desired space, they should consider rezoning the beach front areas. This zoning would allow communities to develop or expand existing dunes as space becomes available. Unless a community is willing to designate adjacent landward property as part of the dune area, limited space leads to smaller dunes that offer a lower level of protection.

Although many communities preserve their dunes because of their protective capabilities, there are other attributes of coastal dunes, such as their ecologic and esthetic values, that communities may wish to preserve as well. For example, the City of Brigantine incorporates into their dune protection ordinance regulations to preserve beachnesting bird habitats (City of Brigantine, 1986).

Something communities should consider when forming their objectives is the temporal component of dune preservation. Through time, the ability of coastal dunes to buffer storms is compromised by an eroding shoreline and rising sea levels. As the shoreline erodes, unless coastal dunes are able to shift inland in relation to these changes, they will be subject to scarping and to overwash, and may eventually be completely eroded. When determining a dune's level of protection, municipalities may want to incorporate a buffering area that will permit a coastal dunes' position to be translated landward in response to the dynamic nature of the coastline (Figure 8).

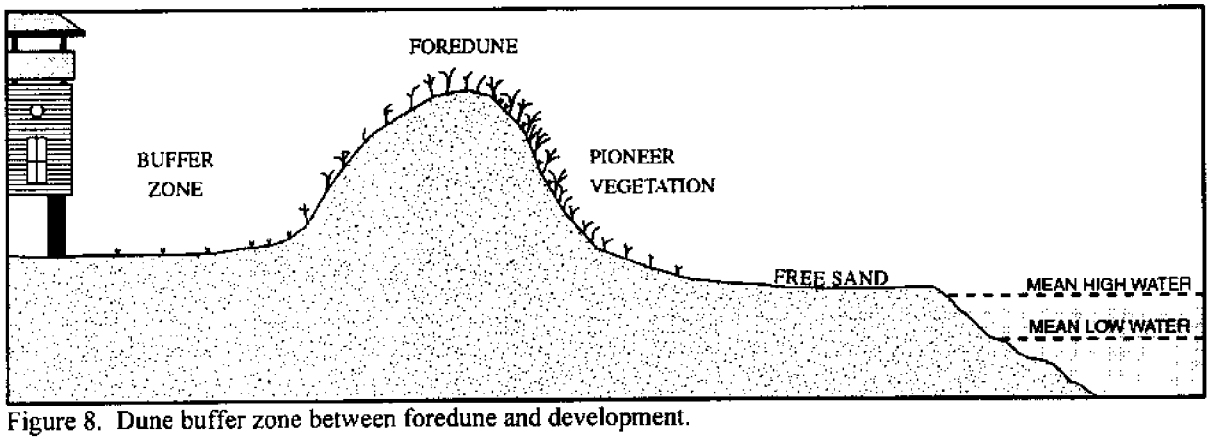

Figure 8. Dune buffer zone between foredune and development.

Figure 6.
Natural dune field in
Avalon NJ

Figure 7.
Dune adoption sign.

Figure 13.
Constructed dune with
parallel fencing to define
the dune's boundaries.
Lavallette NJ

Storm Erosion/Protection Models

The concept of coastal dunes providing a barrier to the penetration of storm surge is based on the height and width of the dune as well as the height and width of the beach seaward of the dune. In the following storm scenarios (Figs. 9, 10, and 11) the dune height is either 5 or 10 feet above the beach, which is either 5 or 10 feet above mean water level. Further, the beach width varies from 0 to 150 feet, with a foreshore slope of either 1-on-10 or 1-on-20.

Storm waves and storm surge levels will affect each of these profiles differently because of their differing configuration. A computer simulation has been run on each of these profiles with differing storm scenarios following the methodology originally developed by Kriebel (1995) and Kriebel and Dean (1985) in Delaware, and subsequently applied and verified for New Jersey by Psuty and Tsai (1997). Specific storm conditions were applied that relate to historic storms that have struck New Jersey that have been estimated as 10-year, 20-year, and 30-year storms as defined by measures of storm surge levels and storm duration[1]. For example, a 10-year storm has characteristics of a 7.9 feet storm surge above mean low low water and a duration of 50 hours. Wave height is characteristic associated with storms that has some variability. Thus, the model has been run with several different likely wave heights (they are open water wave heights before they interact with the beach). The offshore slope is another variable and the model uses the condition of a 1-on-30 slope, a common slope off of New Jersey beaches.

Each storm scenario has several different wave heights simulated acting upon the beach and dune profiles and the end products of the waves interacting with the storm surge and storm duration is shown as the inland extent of erosion on the several profiles (Figures 9-11). These portrayals depict the buffering effects of the differing dimensions of the beach and the dune. In general, the condition supporting the most protection to inland development is at the upper left of each storm frequency figure whereas the poorest protection is in the bottom right. These figures help to define levels of buffering by existing conditions or can be used in a prescriptive manner to show the dimensions needed to achieve a desired amount of buffering. In either application, the value of these simulations is to establish an objective procedure to rate the buffering capacity of particular dune/beach dimensions. As with any model, it is a simplification of a very complex process and it assumes that there is a very systematic application of the interaction of waves, surge, and sediment. These figures provide a type of guideline. Their utility is to assist in the establishment of a protection objective as well as to assist in the evaluation of existing dune/beach dimensions.

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[1] Using the Atlantic City tide gauge, the New Jersey Office of Emergency Management (1994) has established a storm frequency rating based on storm surge. Psuty and Tsai (1977) have augmented the NJOEM ratings with storm duration values associated with recurrence interval storms. As a basis for comparison, surge and duration values characteristic of a 10-year storm (probability of occurring once in 10 years) is similar to the March 1994 storm; the 20-year storm is slightly greater than the March 1984 storm, and the 30-year storm is slightly greater than the 1944 hurricane. Also for comparison, the December 1992 storm is evaluated as a 25-year storm.

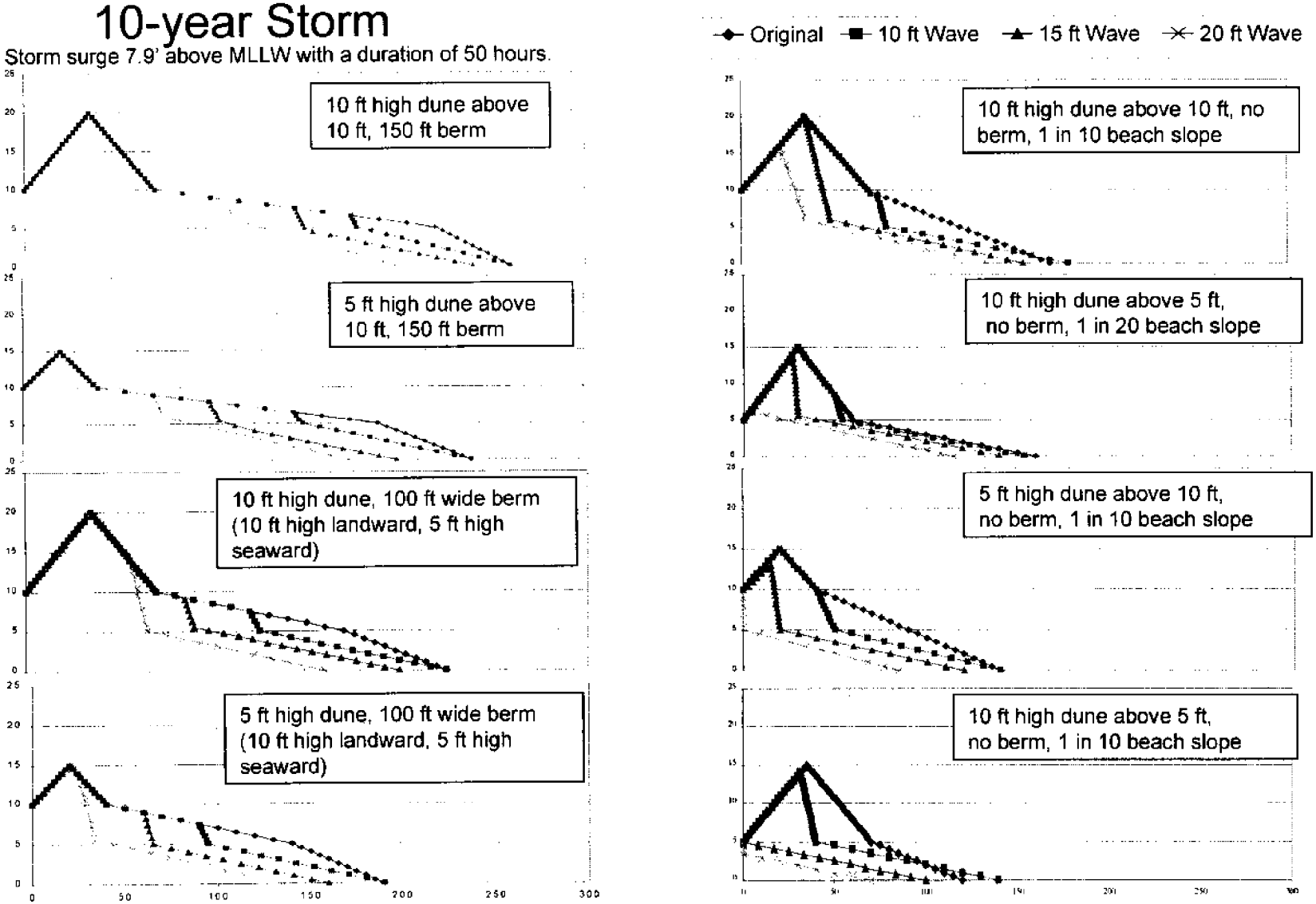

10-year Storm
Storm surge 7.9' above MLLW with a duration of 50 hours.
10 ft high dune above 10 ft, 150 ft berm
5 ft high dune above 10 ft, 150 ft berm
10 ft high dune, 100 ft wide berm (10 ft high landward, 5 ft high seaward)
5 ft high dune, 100 ft wide berm (10 ft high landward, 5 ft high seaward)
Original
10 ft Wave
15 ft Wave
20 ft Wave
10 ft high dune above 10 ft, no berm, 1 in 10 beach slope
10 ft high dune above 5 ft, no berm, 1 in 20 beach slope
5 ft high dune above 10 ft, no berm, 1 in 10 beach slope
10 ft high dune above 5 ft, no berm, 1 in 10 beach slope

Figure 9

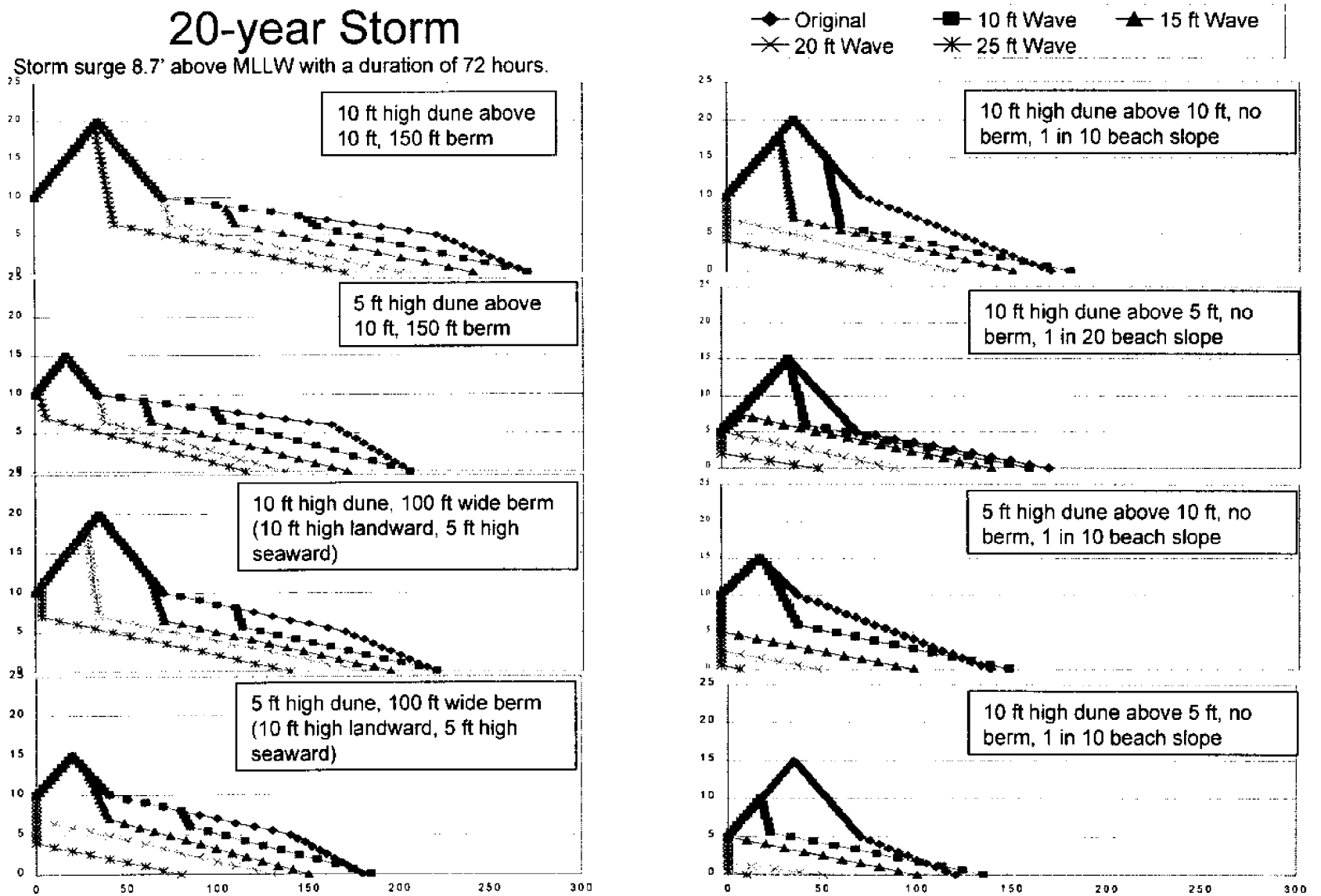

20-year Storm
Storm surge 8.7' above MLLW with a duration of 72 hours.
10 ft high dune above 10 ft, 150 ft berm
5 ft high dune above 10 ft, 150 ft berm
10 ft high dune, 100 ft wide berm (10 ft high landward, 5 ft high seaward)
5 ft high dune, 100 ft wide berm (10 ft high landward, 5 ft high seaward)
Original
10 ft Wave
15 ft Wave
20 ft Wave
25 ft Wave
10 ft high dune above 10 ft, no berm, 1 in 10 beach slope
10 ft high dune above 5 ft, no berm, 1 in 20 beach slope
5 ft high dune above 10 ft, no berm, 1 in 10 beach slope
10 ft high dune above 5 ft, no berm, 1 in 10 beach slope

Figure 10

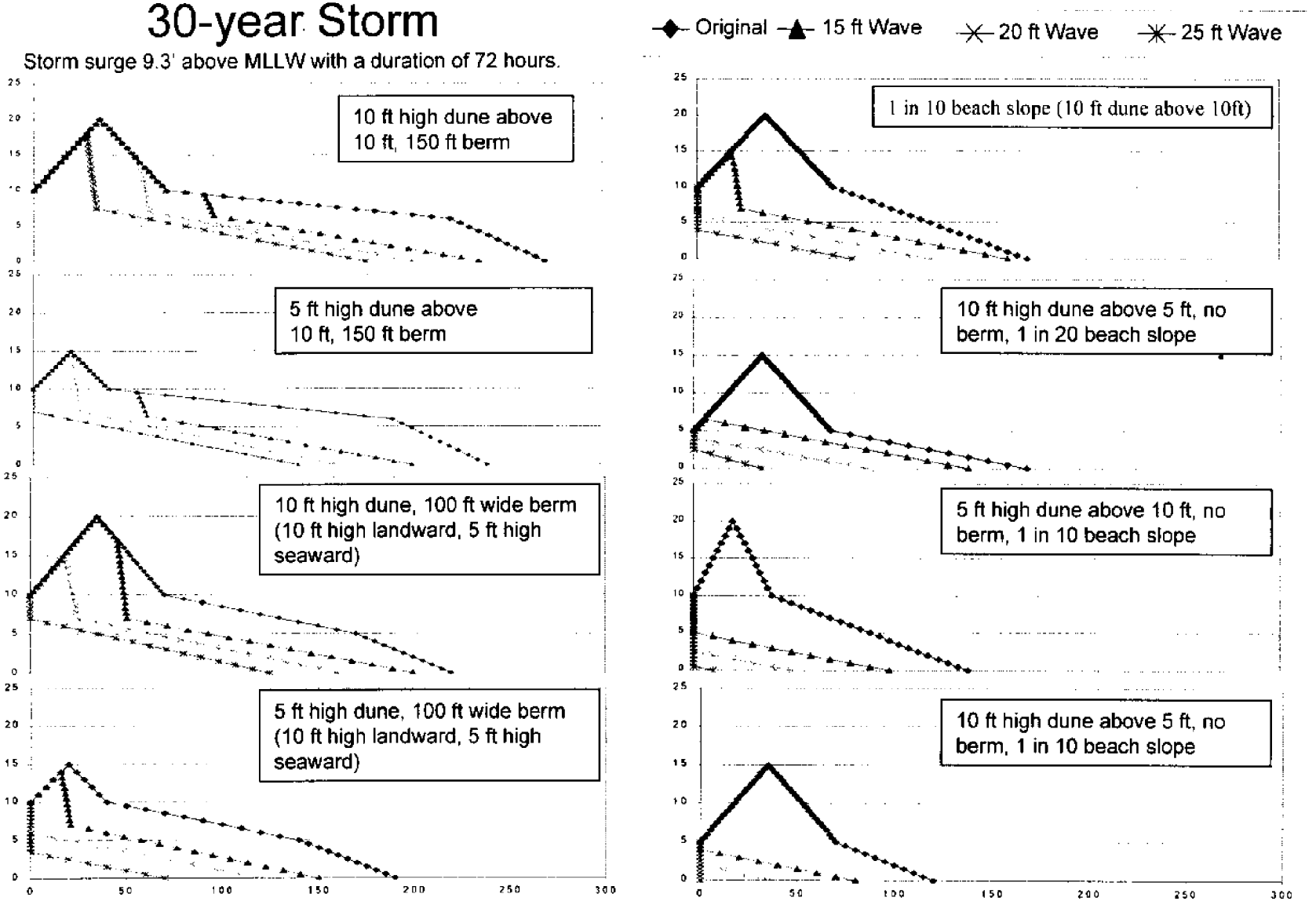

30-year Storm
Storm surge 9.3' above MLLW with a duration of 72 hours.
Original
15 ft Wave
20 ft Wave
25 ft Wave
10 ft high dune above 10 ft, 150 ft berm
5 ft high dune above 10 ft, 150 ft berm
10 ft high dune, 100 ft wide berm (10 ft high landward, 5 ft high seaward)
5 ft high dune, 100 ft wide berm (10 ft high landward, 5 ft high seaward)
1 in 10 beach slope (10 ft dune above 10ft)
10 ft high dune above 5 ft, no berm, 1 in 20 beach slope
5 ft high dune above 10 ft, no berm, 1 in 10 beach slope
10 ft high dune above 5 ft, no berm, 1 in 10 beach slope

Figure 11

Placement and Dimensions of a Dune

Coastal dunes exist in association with their adjoining beaches. The beach is both a source of sand and of protection from small storm events for the dune (Figure 1). Generally, a dune located 100' inland from the high tide water line on a beach with a 5' high berm will provide adequate protection against a 1-in-5-year storm. That is, the dune will not be eroded in less than these conditions. However, more severe storms will erode the protective berm and eventually erode the dune.

The amount of dune erosion from a storm is dependent on the storm conditions and on the pre-storm dune cross-sectional area (dune reservoir). FEMA (Federal Emergency Management Agency) applies the concept of the dune reservoir to the portion of the dune that is in front of the dune crest and above the hundred year flood level (Figure 12). Obviously, large dunes have greater cross-section and can survive larger storm events. FEMA (1995) suggests that in the event of a 100-year storm (reaching the 100-year storm water level), the dune would require a dune reservoir area of 540 ft^2 above the 100-year flood level to prevent overwash and to survive.

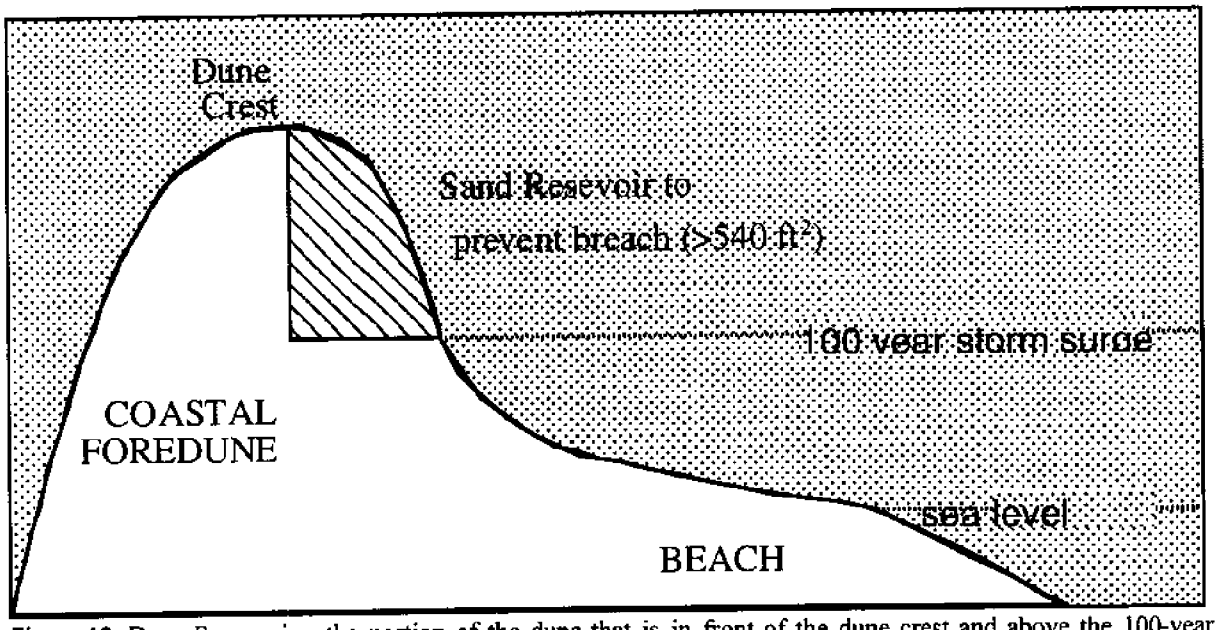


Figure 12. Dune Reservoir : the portion of the dune that is in front of the dune crest and above the 100-year flood level

Dune Placement: Because dunes derive their sand supply from the beach, which can undergo substantial changes in width through natural processes, natural dune development occurs inland of the storm tide position (Figure 1). Dunes should be placed sufficiently far enough inland from the storm tide position to provide a buffer and to protect the dunes against frequent storms. Otherwise, the dune can become substantially eroded during low magnitude storms and it will not be capable of providing any protection against larger events. In order for a dune to provide this additional buffering, specific dimensions of a dune need to be maintained. Dunes that are inland of the MHT line provide more buffering and there is a greater likelihood these dunes will survive less frequent storms.

Dune Height: The length of time required to reach a dune's optimum height varies with weather conditions, availability of sand, and the methods used to build a dune. Dune height,

which is influenced by the rate of sediment delivery as well as by the installation of fences and vegetation, should reach on the order of 8' to 15' above the beach. The initial accumulation and the growth may be rapid at first (Hammer *et al*, 1992). As dune height increases, the rate of increase of elevation slows because of vegetation and other perturbations on the dune face. Under ideal conditions, the combination of sand fencing, vegetation, and ample quantities of dry sand, dune elevation can reach up to 4' in one season (Hammer *et al*, 1992).

Dune Slope: Although there is a limiting slope for the natural accumulation of sand, a number of variables combine to adjust this slope on a dune face, such as vegetation, presence of organisms, salt content, and other disturbances. One measure of the relationship of dune slope was reported by Gares, *et al* (1983) from a survey of New Jersey dunes. Their study included eroding, accreting, natural dunes, altered dunes. On the basis of their surveys, they determined the New Jersey dunes were about 20 times as wide as they were high (Table 1). This number also includes instances of coalescing dunes and thus tends to be a bit high. Other measurements from coastal New Jersey and Long Island, NY (Psuty and Piccola, 1991) show that the human-constructed dunes are about 7 times as wide as they are high. In this case, the slope would be about 1 on 3.5 (Table 2).

Building and Enhancing Coastal Dunes

Once municipalities have established their objectives and have determined that there is adequate space to achieve these goals, the next step is to implement the construction of dunes. There are several different techniques available to create coastal dunes. Dunes can be built by mechanical manipulation, planting appropriate dune vegetation, erecting sand fences, or a combination of these methods.

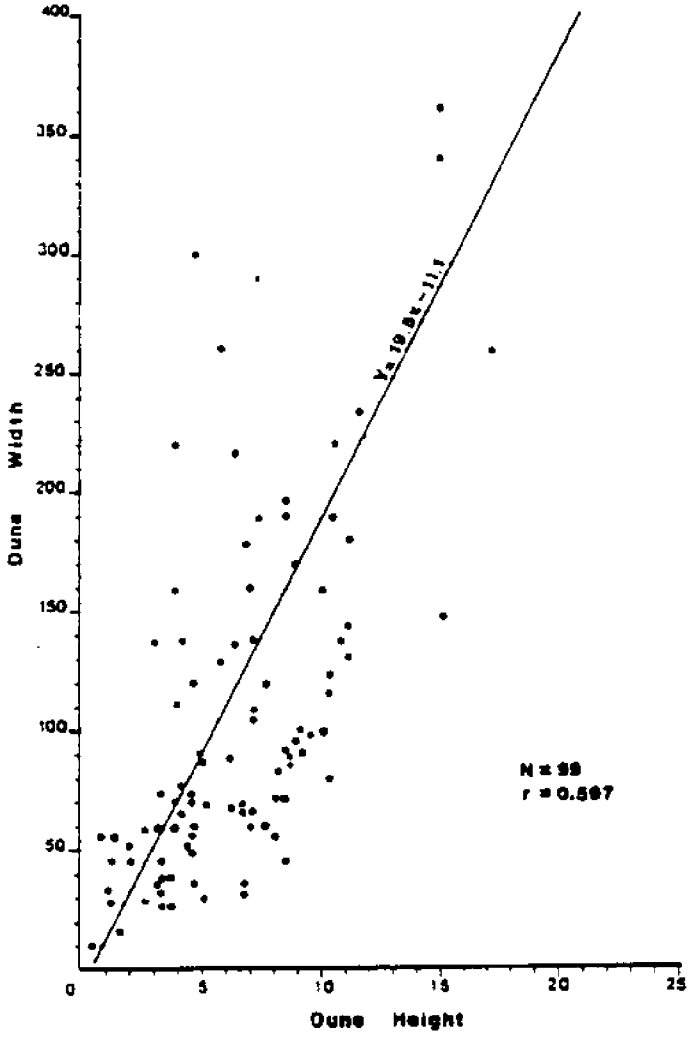
Mechanical Manipulation

A simple but relatively expensive method of creating a coastal dune is by bulldozing sand into the dimensions of a dune. An advantage to this method is that dunes and their protective qualities are instantly achieved. Sources of sand for creating a dune using this technique include transferring sand from the beach or obtaining sand from an outside source. Although it may be more expensive to transport sand into the system, an advantage to this method is that additional sand will be added to an already depleted system. When creating a dune through mechanical manipulation, at least one parallel sand fence should be placed on the landward side of the dune to create the boundaries of the dune area. In addition, a shore parallel sand fence could be erected on the seaward side of the dune to further define the dune's boundaries (Figure 13). When determining the placement of the dune, fencing should be placed slightly seaward of the dune zone because sand generally accumulates landward of the fence. It should be noted that the sediments comprising mechanically-made dunes are unstable because they are not bound together. Therefore, once the proper dimensions of a dune are established, vegetation and appropriate fencing should be emplaced and maintained to stabilize the dune.

Dune Vegetation

One of the simplest and least expensive methods used to create a dune is to plant 'Cape' American beachgrass, (*Ammophila breviligulata*) or other primary dune vegetation at adequate distances inland from the MHT (Figure 14). Unlike bulldozed dunes, this method

Table 1. Dune Height/Width Regression Line.



Adapted from Gares.,et al, (1983).

Table 2: Relationship Between Dune Height and Dune Width

Dune Height	Dune Width
5'	35'
8'	56'
10'	70'
12'	84'
14'	98'
16'	112'

Adapted from Psuty and Piccola, (1991).

takes some time before optimal dune dimensions are achieved. Once established, beachgrass accumulates sand to form a dune and its extensive root system helps to bind the sand in place.

'Cape' American beachgrass should be planted between October 15th and March 31st, as long as the sand is not frozen (Hammer *et al*, 1992). To maximize the dune-building process, beachgrass should be planted in continuous strips parallel to the shoreline 100'-150' landward of the MHT line. If space permits, it should be planted in a 40' to 50' wide strip, but no less than 20' wide and in at least 10 rows. Only fresh plants that have been cut back to 16-18 inches should be planted. Two plants should be planted in 7-to-9 inch deep holes, spaced about 18 inches apart. If there is severe erosion, the spacing should be reduced to 12 inches apart. The sand should be compacted firmly around the transplant to eliminate airpockets. Thirty days following the planting date, fertilizer should be applied at a rate equivalent to 600 pounds of 10-10-10 nitrogen/phosphorous/potassium per acre (Hammer *et al*, 1992).

Once established, American beachgrass will continue to grow relative to the supply of nutrients provided. With adequate sand transport into the vegetation zone, the nutrients will be delivered on the sand grains and in the propelling wind. However, if the sand supply is low, nutrient delivery will likely be reduced and the vegetative cover may become very thin. Dune growth and stabilization are dependent on the trapping effect of the vegetation. Obviously, well-fed vegetation will increase plant density and be a more effective sand trap, creating a more stabilized dune system.

In NJDEP's assessment of dune ordinances (1984), NJDEP noted many municipalities and environmental groups had misunderstood the dynamics of dunes and beachgrass. In an effort to secure the dune, some groups planted beachgrass on the leeward side of the dune with little success. Because the primary source of nutrients for beachgrasses is derived from ocean breezes and transported sand, beachgrass planted on the leeward side of the dune does not receive sufficient nutrients to survive. Also, some areas on the front of dunes may be deprived of sufficient nutrients because of the absence of sand receipt. Thus, in those areas of the dune in which the natural supplies of nutrients are deficient, fertilization is a necessity.

Sand Fences

Sand fencing is also an effective method for trapping sand. Whereas sand fencing (or snow fence material) builds dunes much faster than vegetation alone, it is still a fairly slow process and more expensive than vegetation alone. However, sand fencing is much cheaper than mechanical manipulation; costing as little as a $1 per linear foot. Sand fencing accumulates sand in the same manner as dune vegetation. As wind borne sand travels from the beach to the backbeach area, sand is deposited and accumulates to the lee of the fence line. As the sand accumulates, additional fencing can be placed over the filled areas until the dune reaches a desired level of protection or height. Hammer *et al* (1992) note that sand will generally only fill to a level about 3/4 of the depth of the sand fence. All fences should be at least 100' from the MHT line and approximately at a right angle to the prevailing winds. Hammer *et al* (1992) also recommend when building a dune just using fencing, planting should begin when the sand elevation approaches the top of the fence. These plants are necessary to hold the sand in place and bind the particles together.

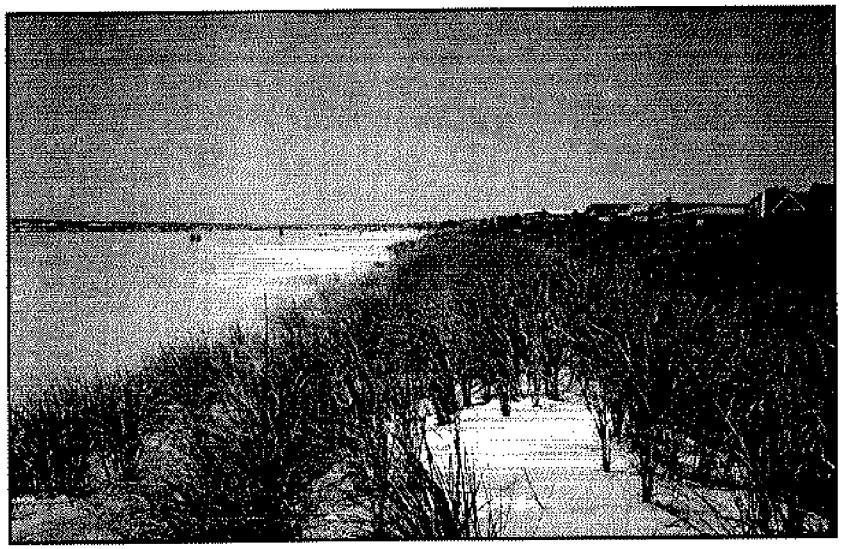


Figure 14. New foredune building and being stabilized by American beachgrass. Ocean City.

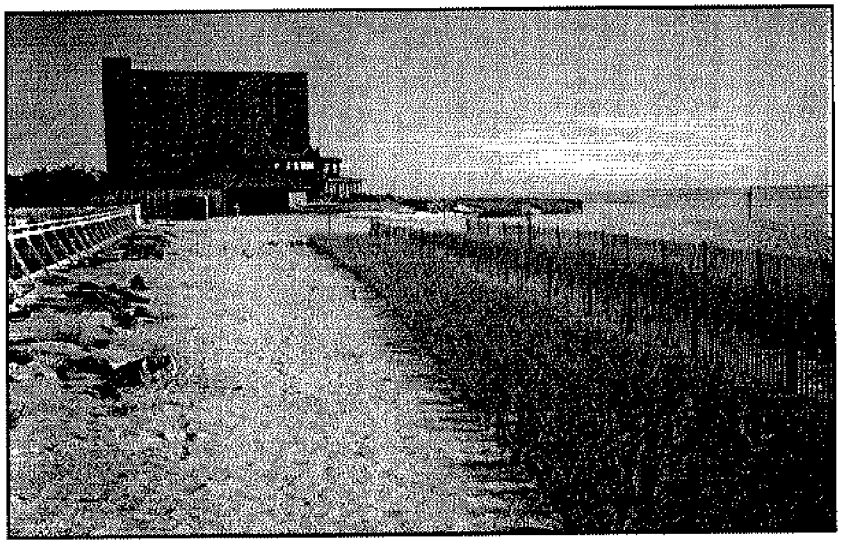


Figure 15. Parallel sand fences and beach grass planting. Monmouth Beach.

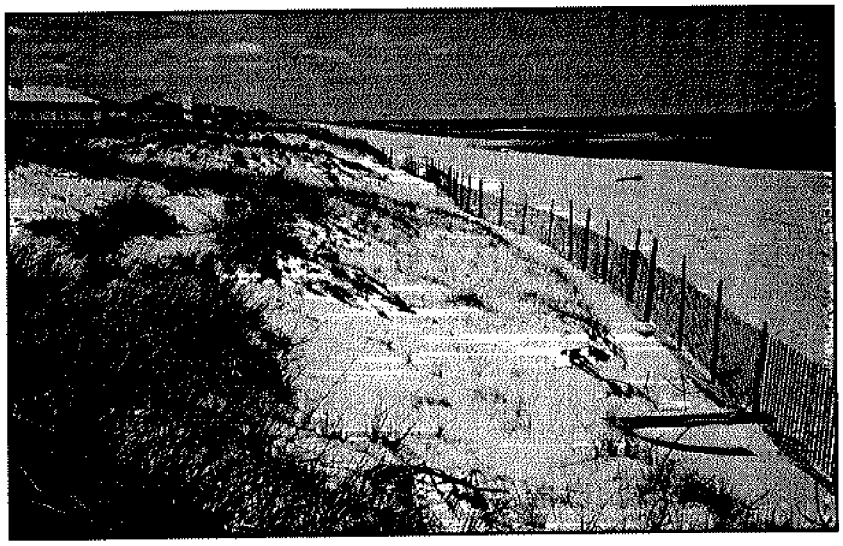


Figure 16. Sand fencing used to expand dune face farther seaward. Beach Haven.

There are several different configurations of sand fence placement, each creating a somewhat differently-shaped dune. The most cost-effective type of sand fence used to create a foredune is a single line of fence that is parallel to the ocean. Hammer *et al* (1992) recommend if it is possible, that two parallel fences should be erected 30' to 40' apart instead of a single fence (Figure 15). Parallel sand fences are also recommended to restore or to expand existing dunes and should be placed no more than 15' seaward from the base of the old dune *(Hammer et al,* 1992) (Figure 16). However, if the fence line is located too close to the water, its accumulated sand will be eroded.

When creating a dune, NJDEP recommends using zig-zag or parallel fences with side spur configurations (Figure 17 and 18). These designs will initially produce wider dunes than single parallel fences and they also offer the advantage of controlling pedestrian access (NJDEP 1985). Zig-zag fences tend to produce a wide, hummocky dune, whereas side spur fences produce a larger, more rounded dune only on the side with spurs. Because side spurs and zig-zag fencing requires more material, the cost of a project is greater than single parallel fencing. Hammer *et al* (1992) recommend parallel fences with 30' long perpendicular spurs at 40' intervals along the seaward side of the fence, at least 100' from the MHT.

Specifications for Sand Fence: Sand fences of various heights, material, and porosities have been studied for their effectiveness in building dunes. These studies have concluded that fences with at least a 50% porosity are the most effective in accumulating sand quickly (Hotta, Kraus, and Horiwaka, 1987; Janin, 1991). Studies have also proven that standard 4' wood slatted snow fence is also the most effective at trapping sand as long as the wood is sound, free of decay, and no wires or slats are broken (Hotta, Kraus, and Horiwaka, 1987). An alternative fence material is the polyvinyl type that has at least a 50% porosity (Hammer *et al,* 1992). Hammer *et al* (1992) recommend that the wooden posts for fence support should consist of black locust, red cedar, white cedar, or other wood of equal life and strength. Posts do not need to be chemically-treated. They should have a minimum length of 6.5' and a minimum diameter of 3 inches. Hammer *et al* (1992) note standard post fences are typically 7' to 8' in length and can be used if they meet the other requirements. The sand fence should be secured to the posts using four wire ties no smaller than 12-gauge galvanized wire. They should be installed so that alternate posts will have fence on their oceanside (Hammer *et al,* 1992). Lastly, Hammer *et al* (1992) recommend the posts should be set no more than 10' apart and at least 3' deep to make the fences more resistant to changes in the wind direction.

Combination of Sand Fence Plus Vegetation

A combination of sand fencing and beachgrass should be more effective at building a dune than either of the two alone (Figure 19 and 20). As the fence traps the sand, the beachgrass roots stabilize the accumulation, thus trapping more windblown sand then either could alone. To employ this method, sand fencing should be installed according to the above specifications. Strips of beachgrass should then be planted parallel to the fence. Vegetation should be planted up to 10' from the fence and approximately 20' wide to be the most effective. As the fences are covered by the sand, additional fencing can be erected to increase the elevation of the dune (Hammer *et al,* 1992).

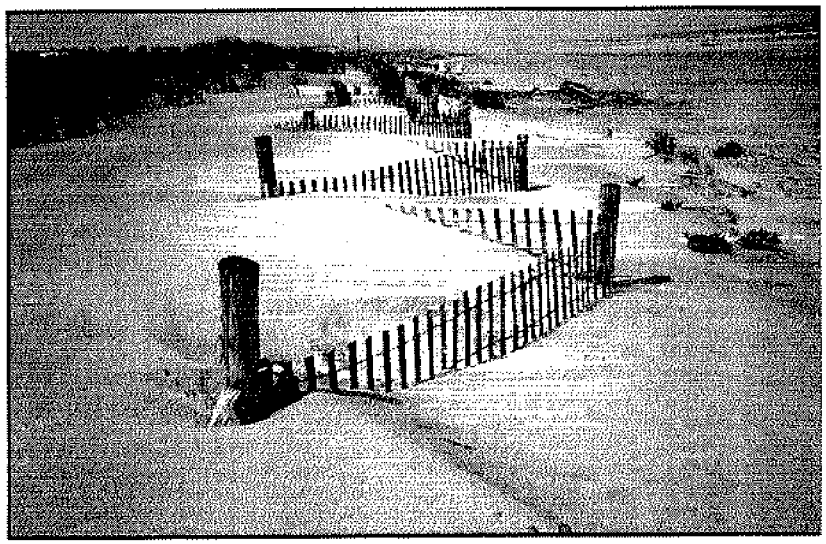


Figure 17. Zig-zag fencing used to facilitate sand accumulation at primary dune position. Ocean City.

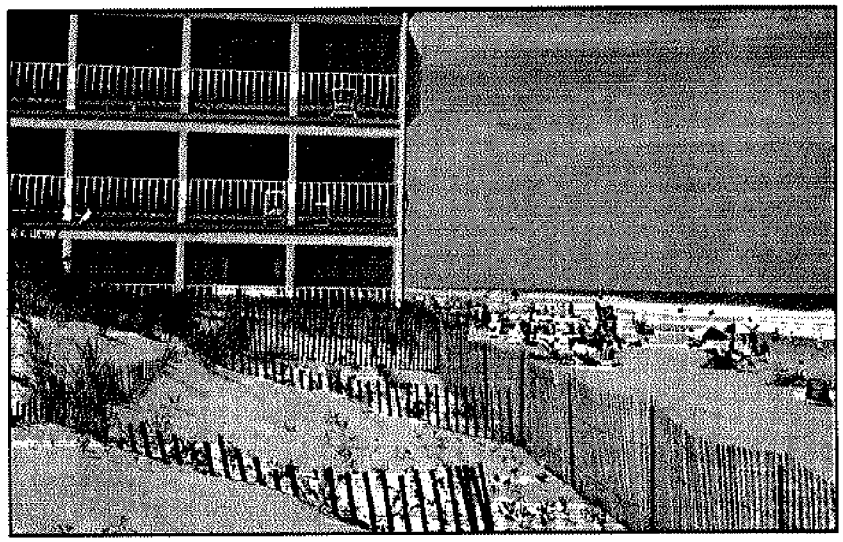


Figure 18. Creating a dune using side-spur fencing at margins to principal fence line. Building is in dune line. Brick.

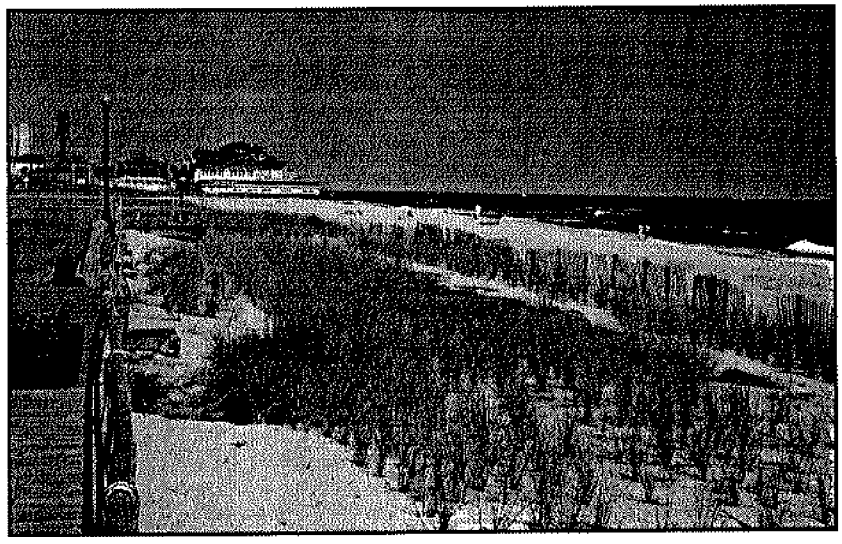


Figure 19. Combination of parallel fencing and dune vegetation. Ocean Grove.

Coastal Dune Restoration and Maintenance

The continuation of the coherent foredune requires a rigorous maintenance program. Even the best-vegetated dune will need attention to support a good vegetated cover and to retain the integrity of the sand ridge. Beach grass needs to be planted and fertilized, and broken fencing needs to be replaced on a continuing program. Additionally, any blowouts or scarping of the dunes will need to be stabilized.

Dune Vegetation:

Replacement of vegetation is an essential maintenance requirement for healthy dunes. Areas where vegetation has been destroyed should be replanted with beachgrass or other suitable primary dune vegetation at every opportunity. Maintenance fertilization for established beachgrass should not exceed 50 lb. of nitrogen per acre per year (Belcher, 1986).

Coastal dunes represent the zone in which coastal and inland vegetation converge, forming a unique area of biodiversity. To reduce the loss of dune vegetation through disease or environmental degradation, this biodiversity must be maintained. Other primary vegetation such as sea rocket, dune cordgrass, seaside goldenrod, and dusty miller are examples of suitable primary vegetation communities could plant.

After primary dune vegetation has been established, woody plants adopted to coastal climates can be planted in secondary coastal dunes for added stabilization and biodiversity. Hammer *et al* (1992) recommends bayberry, wax myrtle, beach plum, Japanese black pine, salt spray rose, and 'Emerald Sea' shore juniper as secondary dune vegetation. Secondary dune vegetation should be planted in accordance with guidelines in Hammer *et al* (1992). All secondary dune vegetation requires yearly fertilization and communities should follow Hammer, et al (1992) fertilization recommendations. Appendix B lists the nurseries in the New Jersey-New York-Delaware region that supply primary and secondary dune vegetation.

Preventing Indiscriminate Passage:

Dune vegetation can not tolerate any trampling. Even light foot traffic can cause breakage, churning up of the roots, and eventual destabilization of the dune if it is allowed to continue (NJDEP, 1984). Dune vegetation, therefore, must be protected from foot and vehicular traffic. By installing either elevated walkways or fenced paths, traffic can be controlled across the dune and access points can be limited (Figure 21). Fences can also be installed in the front and back faces of a dune as borders to further prevent indiscriminate passage. Signs should also be placed along dune areas and access points to educate and to remind the public not to walk across the vegetated dune areas.

Pathways:

Street-ends are often weak links in the coastal dune ridge, becoming sites of overwash and breaches. Therefore, the major concern when providing beach access through the dune area is to eliminate the straight-through excursion of storm waters through a street-end break in the dune ridge. NJDEP (1985) recommends that pathways be orientated on an angle to reduce the potential for overwash and reduce exposure to the storms. Offsets in the pathway or a curving pathway serve the same function in limiting overwash.

Another concern is the low elevation of the pathway. Elevated cross-overs can be installed to reduce vertical erosion of the dunes (Figure 22). If they are utilized, elevated walkways should be high enough to be above the design height of the intended dune.

Figure 20. Later stages of creating a primary dune using a combination of sand fencing and vegetation. Ocean City

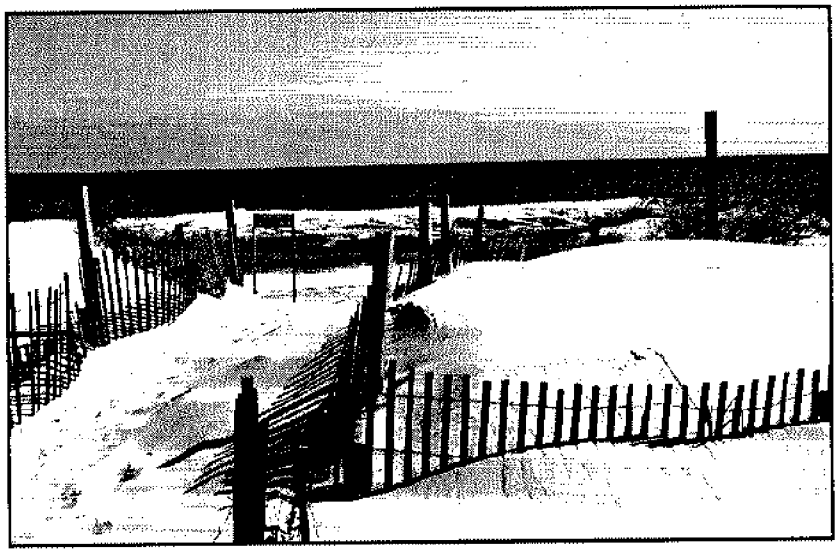


Figure 21. Sand fencing installed to direct pedestrian traffic across foredune. Lavallette.

Figure 22. Elevated cross-over constructed to reduce foot-traffic erosion of dunes. Fire Island, New York.

Otherwise, roll-up sidewalks or some other material that can be laid on top of the sand surface to prevent vertical destruction by foot traffic should be used.

Repairing Dunes

Each municipality needs to establish a yearly dune maintenance and monitoring program. Any changes in a dune system such as blowouts, wash-outs, or human-induced damage need immediate attention if dunes are going to provide their maximum amount of protection. Blow-outs can easily be repaired by installing a single shore-parallel sand fence between the existing dune parts. In order to prevent the wind from whipping around the ends and causing more erosion, it may be necessary to extend the ends of the fence into the existing dune (NJDEP, 1985).

Following major coastal storm events, dunes often become scarped from storm waves. (Figure 23) Scarping is the natural process of cutting back the face of the dune as the beach is eroded. Dunes which are located too far seaward will experience scarping from storms of low magnitude (Figure 24). Although the general post-storm reaction of communities is to restore the scarped dunes to their pre-storm dimensions, there may be a need to reevaluate the location of the dune area and the dune maintenance efforts. All repairs to scarped dunes should continue to observe the dune's placement of 100' from the MHT line. By keeping the dune location sufficiently inland, the beach will provide a buffer and protective area, and reduce future scarping. However, continued beach erosion, and sea-level rise will gradually narrow the protective beaches.

Following high magnitude storms, even well-maintained dunes may experience some degree of scarping. If these dunes are situated at the recommended minimum distance from the MHT line, the scarped dunes should be repaired by placing short perpendicular spurs into the scarped dune followed on the seaward side by zig-zag fencing (NJDEP, 1985). After a wedge of sand begins to accumulate, American beachgrass can be planted. Within a matter of months, the dune should have regained most of its natural profile.

Establishing Dune Buffer Areas

In an effort to maintain a static shoreline position, coastal dunes have often been used as a type of seawall, in an attempt to intercept waves and to prevent storm surge penetration. These management practices have often resulted in dunes being built within the reach of minor storm waves, subjecting them to frequent scarping and eventual destruction. An alternative approach to this problem is to place the dunes farther from the water and to manage the coastline in a manner that is more compatible with the natural forces that shape it. As New Jersey's coastline continues to erode due to a rising sea level coupled with sediment loss, coastal dunes will be subject to increased scarping and erosion if they are not permitted to shift inland naturally and maintain a distance from the MHT. Because the basic dune processes often cause transport of sediment inland of the dune crest, the creation of a buffer zone at the inland margin of the foredune supports the inland continuity of dune processes, form, and habitat as the dune shifts inland. (Figure 25)

Therefore, to ensure their longevity, dunes must be located a sufficient distance inland of the MHT line and they should have some buffer space at their inland margin (Figure 8). However, because development has occurred either directly next to or on top of dune fields, the creation of a buffer area is difficult. Where possible, it is highly desirable for communities to establish a formal dune buffer area inland of the built dune to permit the inland extension of

the dune processes.

Practical dimensions for a dune, therefore, could consist of the following:

- A 100' wide berm from the MHT line to the seaward toe of the dune.
- A 50-100' wide dune zone. Wider dune zones support higher dunes which provide more benefit.
- A buffer zone 10'-30' inland of the constructed dune which provides an area for the extension of the dune's natural processes.

Developing a Model Dune Protection and Maintenance Ordinance

Almost every coastal community in New Jersey has adopted a dune protection ordinance (Table 3). Many of these ordinances were passed as a result of the devastating 1962 nor'easter that damaged or destroyed much of the foredune development along the New Jersey coastline (NJDEP, 1984). Following the storm, local governments with Federal and State support rebuilt the dunes and municipalities subsequently passed ordinances to protect and preserve them. Table 3 lists each coastal municipality in geographical sequence and the date of the most recent revision of their dune ordinance. Because many of Monmouth County's beaches are not wide enough to support coastal dunes, many of the County's municipalities have not adopted dune protection ordinances.

Coastal dunes are managed and protected on a local level, and consequently, dune ordinances differ considerably from community to community. Although municipalities created ordinances with good intentions, many of these ordinances have failed to prevent dune damage or to provide clear guidance on the proper maintenance and construction of dunes (NJDEP, 1984). NJDEP notes (1984) this is not entirely the fault of the ordinances, but was also due to the lack of scientific knowledge on dune dynamics until the early 1980's. On a positive note, as further knowledge has become available, several communities have strengthened and amended their ordinances. As a result, their dunes provide enhanced protection from the effects of storms. The following section highlights the attributes of successful dune ordinances that have facilitated the preservation of dunes and have continued to provide safety from storm-related flooding.

Definitions

Defining the parameters of what is being regulated is a significant aspect of an effective dune ordinance. Without good definitions, what is being regulated comes into question. For example, most ordinances have legally defined dune areas (or building lines) as a static fixed line. However, dunes naturally migrate in response to wind, water, and other elements. As a consequence of this mobility, communities may become unable to prevent construction in natural dune areas that are landward of the fixed building line. The resulting narrower dunes are consequently unable to provide much protection from storm surge and overwash action. Because communities are unable to redelinate dune areas without the threat of a "takings" issue, many communities have not redefined the dune areas.

Since the 1981 Shore Master Plan, a few communities have revised their ordinances to provide a more scientifically-defined setback line that acknowledges dune migration. Specifically Mantoloking, Bay Head, and Point Pleasant use a case by case review for the construction or renovation of residences to keep development away from the backslope of the dune. The 1984 assessment of dune ordinances by NJDEP also acknowledged Long Beach Township's attempts to define a 150' wide beach-dune area district, but a clause in the

Figure 23 . Scarped foredune following January 1992 storm. Ocean City.

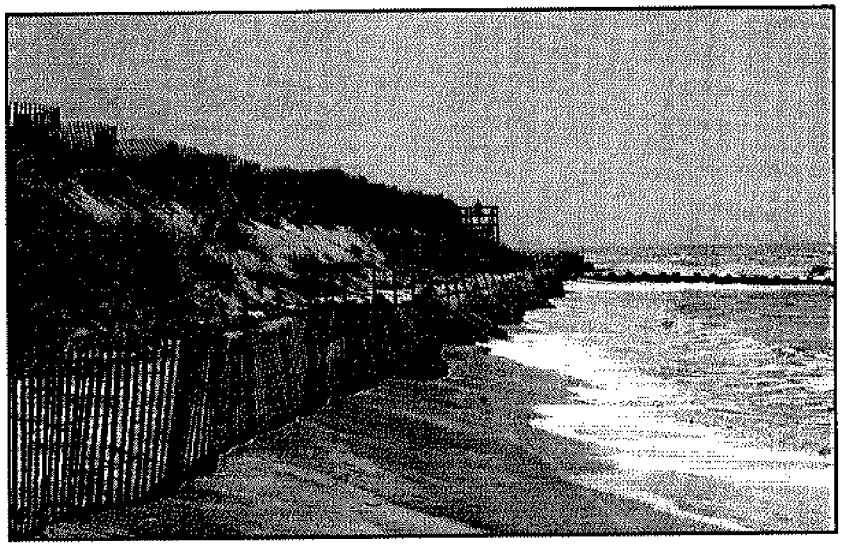


Figure 24. Dunes are scarped by wave action where there is insufficient beach width.

Figure 25. Dune buffer/setback area. South Seaside Park.

ordinance has allowed houses to be built upon the dunes as long as they are 20 feet behind the bulkhead line and the dune is 16 feet in height at the ocean front building line (NJDEP, 1984).

Table 3: Coastal Municipalities With Dune Ordinances

Municipalities	Date of Last Revision	Municipalities	Date of Last Revision
Monmouth County		**Atlantic County**	
Sea Bright	No Ordinance	Brigantine City	1986
Monmouth Beach	No Ordinance	Atlantic City	1989
Long Branch	No Ordinance	Ventnor City	1989
Deal	No Ordinance	Margate City	1991
Allenhurst	No Ordinance	Longport	1996
Loch Arbour	No Ordinance		
Asbury Park City	No Ordinance	**Cape May County**	
Neptune (Ocean Grove)	No Ordinance	Ocean City	1994
Bradley Beach	No Ordinance	Upper Township	1975
Avon-by-the-Sea	No Ordinance	Sea Isle City	1987
Belmar	1992	Avalon	1970
Spring Lake	1993	Stone Harbour	1985
Sea Girt	1994	North Wildwood City	No Ordinance
Manasquan	1989	Wildwood Crest	No Ordinance
		Wildwood City	No Ordinance
Ocean County		Lower Township	1988
Point Pleasant Beach	1994	Cape May City	1995
Bay Head	1993	Cape May Point	1974
Brick	1988		
Mantoloking	1995		
Lavallette	1985		
Seaside Heights	No Ordinance		
Seaside Park	1988		
Berkeley Township	1994		
Barnegat Light	1994		
Harvey Cedars	1989		
Surf City	1972		
Ship Bottom	1994		
Long Beach	1994		
Beach Haven	1994		
Dover Township	1981		

Whereas many ordinances do provide a definition of "dune areas", they fail to recognize dunes are subject to washovers and scarping, which may require immediate attention. Certain areas along the dune zone may require different upkeep practices whether they need to be maintained, repaired, or created. The City of Brigantine recognizes these different management requirements by dividing their dune area into three different dune districts: Dune Maintenance District, Dune Reconstruction District, and Dune Restoration District (City of Brigantine, 1986). Although Brigantine does not specify dune maintenance

requirements in the ordinance, it does supplement the ordinance with the Dune and Shoreline Management Plan, a topographical survey of the dune fields and beaches. Atlantic City is another municipality that recognizes in its ordinance that dunes migrate in response to natural forces. In the definition of the Dune Development District, Atlantic City requires the boundaries will be reviewed every twelve months, as well as following any storm which damages large portions of the District (Atlantic City, 1989).

In 1993, the New Jersey State Legislature redefined a dune when the Coastal Resources and Development Policy (CAFRA II) (N.J.A.C. 7:7E-3.16) was amended. Presently only a few communities have revised their definition to incorporate CAFRA II's new definition, for example, the Township of Berkeley has revised their definition as follows:

> Dunes: A dune is a wind or wave deposited or man-made formation of sand (mound or ridge), that lies generally parallel to, and landward of, the beach, and between the upland limit of the beach and the foot of the most inland dune slope. 'Dune' includes the foredune, secondary, and tertiary dune ridges, as well as man-made dunes, where they exist.
>
> 1. Formation of sand immediately adjacent to beaches that are stabilized by retaining structures, and/or snow fences, planted vegetation, and other measures are considered to be dunes regardless of the degree of modification of the dune by wind or wave action or disturbance by development.
> 2. A small mound of loose, windblown sand found in a street or on a part of a structure as a result of storm activity is not considered to be a "dune".
>
> (This definition is intended to reflect the definitions set forth in CAFRA regulations N.J.A.C. 7:7E-3.16 as it may be amended from time to time) (Berkeley, 1994).

Regulation of Activities

Because dune vegetation is easily disturbed by foot traffic or other activities, dune ordinances regulate all activities in the dune areas which may disturb the condition of the dunes. Typically ordinances regulate construction, public access to the beach area, and the maintenance of dunes. Whereas every dune ordinance regulates these activities to some degree, some municipalities' ordinances are more effective at preventing dune degradation.

Construction on the dune itself is prohibited by every community. The only exceptions are shore protection projects such as the construction of bulkheads, jetties, or groins approved by NJDEP, US Army Corps of Engineers, or the municipality. Mantoloking and Brick have added a clause that if any of these projects impede on the natural flow of sand supplementing the dunes, they will not be permitted (Mantoloking, 1995 & Brick, 1988).

In the 1984 assessment of dune ordinances, NJDEP concluded municipalities that permitted the use of brush type fencing (trees or shrubs) as a means of trapping sand had unintentionally transformed dune fields into dumping grounds. As a result of this finding, many communities eliminated this form of sand fence from their ordinances. However, several communities still allow dead trees and other shrubs to be used as drift fences.

Almost every community restricts public access over dunes to prevent the destruction of dune vegetation or the lowering of dune height. However only a few communities have addressed the problem of overwash into street-ends through walkways during periods of high water. Mantoloking and Bay Head recommend the use of elevated

walkways for both public and private access to the beach. Ocean City also tries to prevent overwash by recommending pathways should be constructed as zig-zag pathways angled to the southeast or whatever direction is at a right angle to the approaching waves in the area (Ocean City, 1994). In addition, many commutes are now putting an artificial surface on pathways, such as roll-up side walks, plastic mats, or cordgrass to prevent the vertical destruction of the dune.

Dune Maintenance

One of the purposes of dune ordinances is to achieve the maintenance of dunes at a height which will provide protection from the effects of storms. Most dune ordinances do not permit the lowering of dune height either through direct or indirect action of a person below an elevation deemed by the community. Only a few municipalities state directly in their ordinance the ideal height of dunes above Mean Sea Level. Bay Head recommends 16 feet as its ideal dune height (Bay Head, 1993). Whereas, Mantoloking (1995) states the minimum height of 18 feet at the prevailing dune crestline, and Long Beach (1994) recommends a minimum height of 16 feet. It should be noted the NRCS recommends the height of dunes should be between 12 to 16 feet (Hammer *et al*, 1992).

Further, the NJDEP (1984) assessment of municipalities dune ordinances found many communities failed to give clear guidance to either the municipality or private owners on the maintenance or growth of dunes. Mantoloking, Ocean City, Point Pleasant, Dover, Berkeley, and Brigantine are some of the communities that mandate specifications for the yearly maintenance of dune vegetation. The appendix to Mantoloking's 1995 ordinance is adopted from the NRCS 1992 Restoration of Sand Dunes Along the Mid-Atlantic Coast and is also a good reference for dune maintenance.

Conclusion

Communities benefit from the preservation and enhancement of coastal dunes, which are an important component of the natural coastal system. Although dunes are valued for their function as a natural barrier, there are many other roles and functions of dunes. By acting as a natural sand storage area for the sand sharing system, coastal dunes actively exchange sand within this system. Additionally, coastal dunes provide a habitat for diverse plant life and offer various esthetic qualities.

Standardized procedures that assist in the general maintenance and enhancement of coastal dunes can be developed on a community level. Dune protection ordinances provide a legal mechanism for communities to develop programs that maximize the function and effectiveness of dunes. It is important that these ordinances reflect the objectives of the community's dune preservation's efforts.

Whereas there is considerable interest in the creation of coastal dunes as part of a community effort, it must be stressed that dunes do not prevent erosion and they do not reverse an erosional trend. They do offer protection from storm surge and they do contribute sand to buffer the rates of shoreline displacement. Thus, dunes act as a barrier to communities and reduce storm-related damage. However, the dunes have a finite capacity to provide protection and buffering. They may be eroded and overwhelmed by waves and winds. They may be topped by very high storm surges. Although communities can extend the protective capabilities and other qualities of dunes through maintenance programs, it is likely that dunes should be considered as a short-term protective strategy that is within the

capabilities of the community to perform and that will have to be repeated at some time interval.

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Appendix A: Model Coastal Dune Protection Ordinance

Dune ordinances provide a legal mechanism for communities to establish and maintain certain levels of public safety from the effects of coastal storms. By adopting strong dune ordinances, communities can develop dune maintenance programs which preserve, restore, and enhance their coastal dunes. The following model dune ordinance information was extracted from existing dune ordinances to assist communities create, reassess, and improve their dune protection ordinances. Anything *italicized* is a change to an original ordinance; otherwise the municipality is noted.

I. Purpose:

1. Although there may be no *economical* long-term defense for fixed oceanfront structures against a constantly rising ocean level *and a decreasing sediment supply , there are methods of* effective protection of the oceanfront and adjacent coastal areas in the *short and middle term* against *oceanside storm surges* and flooding. *A well-developed dune system provides* elevation and breadth *to create a level of safety from the effects of the ocean and related hazards.* A well-*developed, coherent coastal foredune can* provide an *storm surge* barrier and a source of sand to mitigate the effect of storm waves for the benefit of the entire *town, inland* as well as oceanfront pr*operties*. Accordingly, the Borough has a vital interest in the continued maintenance and protection of the ocean beach and dune areas and has the right to cause their restoration in the event of damage or destruction. (Mantoloking)

2. Ocean and bayfront dunes are *dynamic valuable* physical features of the natural environment possessing outstanding geological, recreational, scenic, and protective value. Protection and preservation *of the coastal dunes* are vital to this and succeeding generations of the citizens of the City and the State. The dunes are dynamic migrating natural phenomena that help protect lives and property in adjacent landward areas, and *they* buffer barrier islands, *and* barrier beach spits from the effect of major natural coastal hazards such as hurricanes, storms, flooding, and erosion. Natural dune systems also provide important habitat for wildlife species. (Brigantine)

3. Sand dunes are vulnerable to erosion by *the natural process of the wind, and water, as well as the absence of good husbandry by those responsible for their maintenance and preservation.* The best available means of protecting said dunes against erosion is by preventing indiscriminate trespassing, construction, or other acts which might destroy or damage said dunes and *by encouraging* the use of native plantings, supplemented by sand fencing and other devices designed to *reduce* the free-blowing of sand and *to support* the maintenance of the surface tensions, root accumulations, normal contours and other features typical in natural dunes. (Brigantine)

4. The immediate dune and beach area is not capable of rigid definition or delineation or of completely firm stabilization, so that particular sites, at the time free of dunes, may, as a result of natural forces, become part of the dune area necessary for the continuation of the protection outlined above, and persons purchasing or owning such property shall do so subject to the public interest therein. (Brigantine)

5. This Ordinance does not attempt to define and regulate all parameters of dune delineation, function, or management and the Borough Council declares its intent to review and update this Ordinance periodically to reflect appropriately new and beneficial knowledge. (Mantoloking)

6. Because the Bar-Beach-Dune System provides the only viable protection to property, public and private, and persons within the Borough, from the clearly present hazards of erosion and flooding caused by the Atlantic Ocean during periods of storm, and otherwise, all of the provisions of this Ordinance are deemed necessary, material, and substantial; and therefore, they shall not be subject to waiver or variance. (Mantoloking)

II. Definitions:

Accretion: *Includes the accumulation of sediment by natural or human-induced means on the beach area.* "Natural accretion" is the buildup of land solely by action of the forces of nature on a beach by deposition of waterborne or airborne material. "Artificial accretion" is a similar buildup of land by reason of *a human act*, such as accretion formed by a breakwater or beachfill deposited by mechanical means. (Atlantic City, Brigantine)

Beach Area: Shall mean gently sloping unvegetated areas of sand or other unconsolidated material that extends landward from the mean high water line to either: the vegetation line; a man-made feature generally parallel to the ocean or bay such as a retaining structure, bulkhead or road; or the seaward (bayward) foot of dunes, whichever is closest to the ocean or bay waters (Barnegat Light)

Development Restriction Line: An artificial boundary delineating the extreme limit of allowable development along the shore *inland of* the existing dune fields and beaches. (Brigantine)

Dunes: A dune is a wind *and wave* deposited or man-made formation of sand (mound or ridge), that lies generally parallel to, and landward of, the beach, and between the upland limit of the beach and the foot of the most inland dune slope. "Dune" includes the foredune, secondary, and tertiary dune ridges, as well as man-made dunes, where they exist.

1. A formation of sand immediately *inland from the* beaches *which is* stabilized by retaining structures, and/or snow fences, planted vegetation, and other measures are considered to be dunes regardless of the degree of modification of the dune by wind or wave action or disturbance by development.
2. A small mound of loose, windblown sand found in a street or on a part of a structure as a result of storm activity is not considered to be a "dune". (This definition is intended to reflect the definitions set forth in CAFRA regulations N.J.A.C. 7:7E-3.16 as it may be amended from time to time). (Berkeley)

Dune Area: area between the seaward edge of the dune and the landward edge of the Dune. *This shall include all areas within the following districts: Dune Maintenance District, Dune Restoration District, and Dune Reconstruction District.* (Brigantine) This *Area* is considered to have dynamic boundaries which move in response to seasonal winds and storms. Consequently, the boundaries shall be reviewed every twelve months and following any storm which damages large portions of the *Dune Area.* The boundary review process will be conducted by the City Council, the Department of Public Works and representatives of the NJ Department of Environmental Protection, Division of Coastal Resources. (Atlantic City)

Dune Crest: the point or line where the dune's highest elevation is located. (Brigantine)

Dune Consultant: shall mean an expert on dunes and their care retained by the Borough. In any periods which no such expert is regularly retained, it shall mean such other person designated by the Borough Council. (Mantoloking)

Dune Inspector(s): shall mean that person or those persons appointed by the Mayor with the consent of the Borough Council. (Mantoloking)

Dune Maintenance District: An *artificially designated* area delineating dune fields containing *one* or more dune ridges and having a width greater than 300 feet. The dune surface is stabilized by natural vegetation. (Brigantine)

Dune Restoration District: An *artificially-designated* area delineating a dune field containing one or more dune ridges which may be discontinuous between the beach and upland structures and having a width of less than 300 feet. (Brigantine)

Dune Reconstruction District: An artificial area delineating a discontinuous dune field or beach area without dunes, poorly developed, unstable and less than 75 feet in width. (Brigantine)

Dune and Shoreline Map: *a topographic survey of dune fields and beaches delineating the following districts: Dune Maintenance District, Dune Restoration District, and Dune Reconstruction District. The survey will contain, but not be limited to the following information: the dune crestline, dune ridges, and the landward and seaward edge of the dunes. The Map shall be reviewed every twelve months and following any storm which damages large portions of the Dune Area.* (modified combination of Brigantine and Atlantic City)

Dune Vegetation: shall include all plant species found on beaches and dunes of northeastern U.S., either native or introduced, which can build and stabilize sand dunes. Specifically, it shall include, but not be limited to, such species as American beachgrass (Ammophila breviligulata), sea rocket (Cakile edentula), seaside spurge (Euphorbia polygonifolia), dune cordgrass (Spartina patens), seaside goldenrod (Solidago sempervirens), dusty miller (Artemisia stelleriana), bayberry (Myrica pennsylvanica), beach pea (Lathyrus japonicus), salt spray rose (Rosa rugosa), beach plum (Prunus maritima), etc., which normally grow or may be planted on the slopes of the dunes or behind them, with no distinction being made as to how such plants are introduced into their location. (Mantoloking)

Erosion: The wearing away of land by the action of natural forces. On a beach, the carrying away of beach materials by wave action, tidal currents, littoral currents or by deflation. (Brigantine)

Landward Edge of the Dune: is the line joining the average Landward Edge of the Dune of the adjoining oceanfront properties, or a line parallel to and 60 feet west of the Seaward Edge of the Dune, whichever is more westerly. (Mantoloking)

Mean High Water Line: is the line found by the intersection of a plane at the elevation of Mean High Water with the existing slope of the beach. (Mantoloking)

Mean Sea Level: *shall mean the average height of the sea surface, based on observations of all stages of the tide over a nineteen-year period in the United States.*

Pathway: is an improved, protective access way, at grade across the dune.(Mantoloking)

Person: natural persons, partnerships, firms, associations, joint-stock companies, syndicates and corporations and any receiver, trustee, conservator or other officer appointed pursuant to law or by any court, state or federal. "Person" also means the state of New Jersey, counties, municipalities, authorities, other political subdivisions and all departments and agencies within the aforementioned governmental entities. (Atlantic City)

Sand Fence: shall include the term "snow fence" of a barricade type established in a line or a pattern to accumulate sand and aid in the formation of a dune, such as picket type consisting of light wooden fence, 4 feet in height, held together by wire and affixed to wooden posts. Alternate types of "sand fence" may be utilized if approved by the Dune Consultant. (Mantoloking)

Seaward Edge of Dune: is the intersection line of the foreslope of the dune and the gradient of the Beach Area, or Vegetation Line, or the Upper Driftline, whichever is the more easterly. (Bay Head)

Setback Line: *is the line inland of the most westward margin of a Landward Edge of the Dune Area. The setback line is delineated on the Dune and Shoreline Map. This Area is considered to have dynamic boundaries which move in response to seasonal winds and storms. Consequently, the boundaries shall be reviewed every five (5) years.*

Upper Driftline: is that line produced by the Winter Spring Tides (highest tides of the year) which contains oceanic debris (flotsam such as seaweed, etc.) and the seeds, rhizomes, or detached plants which can germinate and/or grow to produce a zone of new dune vegetation. (Mantoloking)

Vegetation Line: is that line connecting the most seaward naturally occurring perennial plants with other such plants. (Mantoloking)

Walkway: a constructed means of crossing the dune area in accordance with approval by the Township. (Brick)

III. Permitted and Prohibited Activities:

Construction: Construction *seaward* of the Landward Edge of the Dune and the placement there, except temporarily, of any objects that would impede the flow of sand are prohibited, except as provided in this Ordinance and in accordance with any CAFRA regulations, the Land Use Ordinance of the Borough with the following exceptions (Mantoloking):

1. Dune management programs designed to either maintain, restore, or reconstruct dune fields such as supplemental planting of natural vegetation, placement of sand fences, construction of artificial dunes of berms or any other programs that may be authorized through written approval. (Brigantine)

Dune Platforms: Although Dune Platforms are not recommend because they affect dune stability and sand transport, some communities do permit them. Therefore the following is to serve as a guide to communities which already permit dune platforms to ensure there is a limited amount of disturbance to the dunes.

1. Each oceanfront lot shall be allowed a "dune platform" not to exceed 200 square feet, situated within the dune area and specifically located and delineated by the owner of the premises. The dune platform shall, in all events, be maintained in the same fashion and subject to the same regulations as may govern use of pathways and walkways.
2. The *specifications for a dune platform* call for neither length or width greater than 18 feet, an elevation of at least 18 inches above any point of sand surface, supporting 4x4 posts, beams no greater than 6 inches in vertical section, handrails no more than 2 inches in vertical section, planking shall be no more than 4" in width installed with at least a 16% gap area in order to permit dune grass to grow underneath;
3. The permit application for a Dune Platform is to be accompanied by a sketch, to scale, showing that it is at least 10 feet to landward of the mapped current Dune Crestline. The sketch may be prepared by the Dune Inspector;
4. Whenever the dune builds to the point that a part of the dune platform surface is less than 6 inches above the sand surface within 5 feet, that platform shall be raised or rebuilt. Raising an existing dune platform does not require a permit. Reconstruction of a dune platform shall be subject to issuance of a permit. (Combination of Mantoloking and Point Pleasant)

Sand Removal: Sand which is transported upon lands by action of wind, tides, storms, or any combination thereof shall not be removed from the lot upon which it is deposited by such action. Surplus sand deposited upon any improved street ends shall be restored into the Beach and Dune area. (Mantoloking)

Trespassing:

1. No person shall be in the Dune Area unless:
   (a) upon an improved Pathway, Walkway or Dune Platform; or
   (b) in the performance of such activities as may be reasonable and necessarily required to construct or maintain the dune or allowed structures; or
   (c) for the purposes of inspection, topographical survey, or enforcement of this Ordinance; entry for these purposes will not be deemed an actionable trespass. (Mantoloking)
2. No person shall operate a motor vehicle across or upon any Dune Area except as may be necessitated for allowed construction or for dune maintenance. (Bay Head)

Tampering with Dune Protection Devices:

1. The removal, cutting, burning or destruction of Dune Vegetation, Sand Fences, or such other types of approved dune protection devices by the Borough Council in the Dune area is prohibited, except as necessary for construction or maintenance authorized pursuant to *this ordinance.* (Mantoloking)
2. Placement of nonliving trees, brush, shrubs or other debris in the dune area or beach is prohibited. (Atlantic City)

Dune Systems Creation and Expansion:

Beach Access:

During storms and levels of high water, pathways are often weak links in the coastal dune ridge and become sites of overwash and breaches. Allowing a proliferation of man-made structures over the dunes is also esthetically displeasing and unnecessary. Therefore, the Borough shall restrict beach access to street ends where feasible. Dune pathways and steps to permit access across the dunes or berms to the open beach without damage to the dunes themselves shall be permitted under the following conditions:

1. Access to the beaches and dune fields in all districts delineated by the Dune and Shoreline Map shall be limited to those accessways shown on the Dune and Shoreline Map. No accessways across a dune field shall be constructed by a private owner without a permit issued by the Borough. (Brigantine) No walkways or steps, or combination thereof, shall be approved nor constructed to grant access to the beach on or across any lot, which lot has a boundary line or lot line adjacent to a public street, alley, or easement giving access to the open beach. (Long Beach)
2. One pathway or walkway across the dune area is permitted for each residence. It shall run, generally, the shortest practical course between the residence and the seaward edge of the dune, and shall not exceed four feet in width. (Bay Head) *At streetends, 10' walkways may be delineated which are angled to the southeast. A zig-zag or offset in the path is preferable as the dune area widens. These offsets are necessary to reduce direct overwash through the gap in the dunes.*
3. In the event that any pathway or walkway shall be or become, in the opinion of the Dune Consultant or Inspector, a substantial detriment to the development and maintenance of the continuous protective dune sought to be achieved by this ordinance, the owner of the premise shall be subject to the provisions of the *Permit section of this ordinance.* (Bay Head)

4. A walkway is exempt from any provisions requiring a construction permit provided that it: does not extend westward of the Landward Edge of the Dune or to the eastward of the Seaward Edge of the Dune; is at least four inches above the highest point of the Dune over which it passes; is not wider than four feet; provided at least 16% of the walkway surface as gap space between the walkway surface boards in order to permit dune grass to grow underneath; has a walkway surface including lateral supporting members with a vertical cross-section of not more than five inches. (Bay Head)
5. Where an elevated walkway is constructed and sand has accreted to a point where the walkway is on the surface of the sand at the dune crest and is below the adjacent crest, the natural accretion of the dune is impeded, unless the dune height exceeds the *acceptable dune height.* In such case, the Dune Inspector shall serve written notice, certified by mail return receipt requested, upon the record owner westward of the dune at his last known address, directing that the walkway be raised in compliance with the standards of this ordinance and , if the walkway is not raised within a period of six months from the date of such notice, the Borough may raise the walkway at the expense of the owner. In such case, the cost of construction shall become a lien on the real property situated immediately westward of the Dune. (Bay Head)
6. If an elevated walkway is not used to access the ocean, the pathway shall be protected by placing suitable material on the sand surface, to be removed when the premises are not occupied. The depth of a crestline gap is the vertical distance between the bottom of the pathway through the crest of the dune and a line connecting the highest points of the dune with 20 feet on either side of the pathway. (Mantoloking) *The construction of elevated walkways over the crest of the dune is encouraged to preserve the Dune Area. (Bay Head)* If the crestline gap depth is two feet or more at any time, the pathway shall be replaced by an elevated walkway. (Mantoloking)

Dune Dimensions: *One of the purposes of this ordinance is to achieve the maintenance of sand dunes at the highest level of protection from erosion and the effects of coastal storms. To this end, no dune shall be directly or indirectly reduced in height or width by the action or inaction of any owner or his/her agent. However, if any dune shall be or become lower or narrower than the dimensions deemed materially significant by the Dune Consultant, applying recognized criteria, with due regard to the intent of this ordinance and reasonable use of the premise, the owner thereof shall be obliged to install such Sand Fence and plantings in accordance with the specifications set forth in this ordinance at his/her expense. The owner shall have an obligation to maintain and replace, if necessary, such fences and plantings. In such case, the cost of construction shall become a lien on the real property situated immediately landward of the Dune. The dimensions of the dune area shall be as follows:*

1. *Dunes should be located on the order of 100 feet landward of the Mean High Tide (MHT) line.*
2. *The slope of a dune should be maintained at a 1:5 (vertical horizontal) slope.*
3. *The height /width ratio should be maintained at 1:10.*
4. *Dunes will be maintained at a minimum elevation of fourteen feet (14') above mean sea level at the bulkhead line and an elevation of sixteen feet (16') above mean sea level at the oceanfront building line.*

Dune Vegetation and Planting: In order to provide for effective protection and/or restoration of the Dune Areas, each owner shall plant or cause to be planted in the Dune Area adjoining his property suitable vegetation and erect, or cause to be erected, in the Dune Area, suitable sand fencing all *in accordance with the specifications set forth in this ordinance and in conformance with the current standards of the U.S. Natural Resources Conservation Service.* (Brick)

1. For initial planting, or replanting sparse areas, "Cape" American beachgrass (Ammophila breviligulata) should be used. The entire Dune Area shall be planted.
2. Planting may take place any time between October 15th and April 1st, if the ground is not frozen. Spring planting should be accompanied by frequent watering. Initial and subsequent fertilization is recommended at the rate of about 2 pounds of slow-release 10-10-10 per 1000 square feet.
3. Only fresh planting stock cut back to 16-18 inches long shall be utilized. Spacing shall be no greater than 18 inches, two stems to a hole, at least 7 inches deep. If not planted with a water flooding method, the sand shall be compacted by rains before planting is commenced *to eliminate any airpockets.*
4. After beachgrass has been established, other appropriate vegetation may be added. (Mantoloking)

Sand Fencing:
1. Fencing shall be standard 4-foot wood sand (snow) fence in good condition, secured to wooden posts of a minimum cross-section of 4 square inches and a minimum length of 6-1/2 feet, with maximum span between posts of 12 feet. Alternate fencing, as approved by the Dune Inspector with advice of the Dune Consultant, prior to installation, may be utilized.
2. There shall be at least two lines of fencing the length of the Dune Area of each property. At least one line of fencing should be in a zig-zag pattern with alternate posts offset by at least 5 feet. Half-height fencing may be used on the dune back.
3. A straight (or zig-zag) line of fencing may be erected adjacent to the seaward toe of the dune to prevent incursion into the dune area, but if it is more than 3 feet to seaward, a permit is required and such fencing must be removed during the winter months. (Mantoloking)
4. The construction of fencing along the western limits of the backshore and dunes areas and the provision of suitable markings to identify the *dune area is permitted to prevent damage to the dunes or berms from indiscriminate passage.* (Beach Haven)

Repairing and Maintaining Coastal Dunes:
Vegetation Maintenance: *Fertilization should be applied each spring after regrowth begins to established dune vegetation. Yearly fertilization for maintenance should not exceed 50 lb. of nitrogen per acre per year. Where vegetation has been destroyed, American beachgrass (Ammophila breviligulata) will be replanted following the specifications set forth by the U.S. Natural Resources Conservation Service.*

Signage: Due to the transient population of a summer resort, it is necessary to remind visitors that the dunes are fragile and it is illegal to walk on them. Signs must be placed to notify and educate beach users; consideration should be given to placing some signs on the sand fencing. (Ocean City)

Fixing Blowouts: *Blow-outs in the dune system will be repaired by placing a sand fence between the existing dune parts. One or more fences may be required. It is essential to tie the ends of the fence into the existing dune to keep the wind from whipping around the ends.*

Dune Replenishment: The municipality shall not undertake any mechanical manipulation, including but not limited to bulldozing, grading and scraping, of the beach and dune area unless written authorization is received from the New Jersey Department of Environmental Protection, Division of Coastal Resources (Brick)

Permits:

1) A permit shall not be required for the planting of dune grass or other appropriate vegetation, or for the erection of sand fencing or the placement of temporary walkway protection in the Dune area in compliance with approved standards set forth in this Ordinance. All other construction, modification, alterations, or like activity in the Dune area, unless specifically exempted in this Ordinance, shall require that the owner or his/*her* agent obtain a Dune Area Permit. Activities requiring a Permit include but are not limited to elevated walkways, dune platforms, and the placement of sand fencing more than 3 feet seaward of the Seaward Edge of the Dune. All permits are subject to revocation, suspension or modification in the event of changed site conditions, as determined by the Dune Inspector with advise of the Dune Consultant. The permittee or any agent shall promptly, upon request, allow any Borough official to examine the permit or a certified true copy thereof at any time.

2) The Dune Inspector shall make periodic inspections and shall provide written advice to owners. These writings shall not be deemed as notice of violations of this Ordinance, but shall be maintained as part of the record for the subject property and may be considered by the Court in the imposition of penalty upon conviction under any subsequent complaint for violation of this Ordinance. Further, the Dune Inspector shall coordinate his or her efforts with those of the Dune Consultant(s) to the end that the purposes of this ordinance may be achieved. (Mantoloking)

Conditions for Issuance of Permit:

No such permit shall be issued without a determination by the City Engineer, based upon an inspection of the area involved, that such removal *of sand* will not create or increase a danger or hazard to life or property. No permit will be granted if the proposed moving or displacement will:

1. Adversely affect the littoral drift in the districts delineated by the Dune and Shoreline Map *or other municipalities within this reach.*
2. Result in a reduction of dune protection as provided for in the Dune and Shoreline Map.
3. Interfere with the general configuration of the districts as delineated by the Dune and Shoreline Map.
4. Otherwise substantially impair or interfere with the intent and purpose *and objectives* of this ordinance. (Brigantine)

Enforcement:

The Borough Dune Inspector or, in his absence, the Chief of Police and in all events the Borough Council shall enforce the affirmative duty of each oceanfront owner, as set forth in this Ordinance. Owners have 30 days after receiving a written notice to begin to comply with the ordinance or they will be subject to pay the cost with interest at the highest legal rate via a lien on the property. (Mantoloking)

Violations and Penalties:

For each and every violation of this Ordinance, *the regulations or standards set forth in the Ordinance, or the terms and conditions of any permitted issued hereunder*, the owner of lands abutting the beach or Dune Area where such violation has been committed, or the trespasser *and any contractor or agent of the owner* shall for each and every violation be subject to a fine of not more than one thousand dollars ($1000) or imprisonment for a term not to exceed ninety (90) days, or both, at the discretion of the Court having jurisdiction in this matter. Each and every day that a violation continues shall be considered a separate offense. (Bay Head)

Appendix B: Suppliers of Dune Vegetation in the New Jersey, New York, and Delaware Region

'CAPE' Ammophila breviligulata (American beachgrass)

Greg Bunting
Cape Farms
RD #1, Box E 134A
Lewes, DE 19958
Phone: (302) 945-1840

Church's Greenhouse & Nursery
522 Seashore Road
Cape May, NJ 08204
Mauricetown, NJ 08327
Phone: (609) 884-3927

Gary Timberman
RD #1, Box 380
Bridgeton, NJ 08302
Phone (609) 451-2422

H. R. Talmage & Son
Attn: Ellen Talmage Friar's Farm
36 Sound Avenue, RFD #1
Riverhead, NY 11901
Phone: (516) 727-0124

Steve & Phil Dubreville
Old Cellar Creek Farms
801 N. Shore Road
Beeselys Pt., NJ 08223
Phone: (609) 390-0806 (Phil)

Peat & Sons
32 Old Country Road
West Hampton, NY 11977
Phone: (516) 288-3458

Phil Clarkson
P.O. Box 357
Tuckahoe, NJ 08250
Phone: (609) 628-2406

Judy Ord
1145 Fathom Road
Manahawkin, NJ 08050

Coastal Nurseries, Inc.
Arnold Clemenson
P.O. Box 42
Mauricetown, NJ 08327
Phone: (609) 476-3903
Fax: (609) 476-3903

'AVALON' Spartina patens (saltmeadow cordgrass)

Church's Greenhouse & Nursery
522 Seashore Road
Cape May, NJ 08204
Phone: (609) 884-3927

Coastal Nurseries, Inc.
Arnold Clemenson
P.O. Box 42
Mauricetown, NJ 08327
Phone: (609) 476-3903
Fax: (609) 476-3903

Don Knezick
Pinelands Nursery
RR1, Box 12 Island Road
Columbus, NJ 08022
Phone: (609) 291-9486

Peat & Sons
32 Old Country Road
West Hampton, NY 11977
Phone: (516) 288-3458

H. R. Talmage & Son
Attn: Ellen Talmage Friar's Farm
36 Sound Avenue, RFD #1
Riverhead, NY 11901
Phone: (516) 727-0124

'BAYSHORE' Spartina alterniflora (smooth cordgrass)

Peat & Sons
32 Old Country Road
West Hampton, NY 11977
Phone: (516) 288-3458

Coastal Nurseries, Inc.
Arnold Clemenson
P.O. Box 42
Mauricetown, NJ 08327
Phone: (609) 476-3903
Fax: (609) 476-3903

H. R. Talmage & Son
Attn: Ellen Talmage Friar's Farm
36 Sound Avenue, RFD #1
Riverhead, NY 11901
Phone: (516) 727-0124

'EMERALD SEA' Juniperus conferta (shore juniper)

Rhodo-Lake Nursery
Rolland DeWilde
RD #1
Bridgeton, NJ 08302
Phone: (609) 451-5877

Centerton Nurseries
RD # 5, Route 553
Bridgeton, NJ 08302
Phone: 455-0926

Mike Callis
Woodbourne Cultural Nursery
301 Colonial Spring Road
Melville, NY 11747
Phone: (718) 343-6400
(516) 249-2320

Ferruci Nurseries
Piney Hollow Road &
Victoria Avenue
Newfield, NJ 08344
Phone: (609) 697-1950

'OCEAN VIEW' Prunus maritima (beachplum)

Coastal Nurseries, Inc.
Arnold Clemenson
P.O. Box 42
Mauricetown, NJ 08327
Phone: (609) 476-3903
Fax: (609) 476-3903

Robert Ott
209 Old Cranberry Road
Cranberry, NJ 08512
Phone: (609) 395-1366

Hess Nurseries, Inc.
P.O. Box 326
Cedarville, NJ 08311
Phone: (216) 259-5571

Pinelands Nursery
RR1, Box 12, Island Road
Columbus, NJ 08022
Phone: (609) 291- 9486

Peat & Sons
32 Old Country Road
West Hampton, NY 11977
Phone: (516) 288-3458

Sepers Nursery
1003 Columbia Ave
Newfield, NJ 08344
Phone: (609) 691-0597

'SANDY' Rosa rugosa (rugosa rose)

Coastal Nurseries, Inc.
Arnold Clemenson
P.O. Box 42
Mauricetown, NJ 08327
Phone: (609) 476-3903
Fax: (609) 476-3903

Erie Perennial Farm
Atten: Terry O'Brien
3052 Kulp Road
Eden, NY 14057
Phone: 716) 992-9466

Peat & Sons
32 Old Country Road
West Hampton, NY 11977
Phone: (516) 288-3458

Sepers Nursery
1003 Columbia Ave
Newfield, NJ 08344
Phone: (609) 691-0597

Springfield Nursery, Inc.
490 Mountain Avenue
Springfield, NJ 07081
Phone: (201) 379-5811

'WILDWOOD' Myrica pensylvanica (bayberry)

Coastal Nurseries, Inc.
Arnold Clemenson
P.O. Box 42
Mauricetown, NJ 08327
Phone: (609) 476-3903
Fax: (609) 476-3903

Robert Ott
209 Old Cranberry Road
Cranberry, NJ 08512
Phone: (609) 395-1366

Arrowwood Nursey, Inc.
P.O. Box 418C
Malaga Road
Williamstown, NJ 08094
Phone: (609) 753-1160

Crowshaw Nursery
Mill Lane, P.O. Box 339
Columbus, NJ 08022
Phone: (609) 298-0477

Hess Nurseries, Inc.
P.O. Box 326
Cedarville, NJ 08311
Phone: (216) 259-5571

Pinelands Nursery
RR1, Box 12, Island Road
Columbus, NJ 08022
Phone: (609) 291- 9486

Peat & Sons
32 Old Country Road
West Hampton, NY 11977
Phone: (516) 288-3458

Sepers Nursery
1003 Columbia Ave
Newfield, NJ 08344
Phone: (609) 691-0597

Springfield Nursery, Inc.
490 Mountain Avenue
Springfield, NJ 07081
Phone: (201) 379-5811

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