Restoring and Maintaining Naturally-Functioning Landforms and Biota on Intensively Developed Barrier Islands Under a No-Retreat Alternative

By

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ABSTRACT

Changes to beaches and dunes in New Jersey reveal that hard-protection structures are not the final phase in evolution of landforms on an eroding, developed coast. Beach nourishment provides the basis for restoration of landforms and biota, and for recovery of lost environmental heritage. Landform evolution is linked to changes in federal and state policies and programs that are triggered by damaging storms. The economic value of beaches and dunes as shore protection is crucial to willingness to construct them, but natural values are an important byproduct that increases acceptability of future restoration programs. Stable funding for shore protection is key to creating and preserving restored habitat, as are prevention of beach raking (required, in places, by the need to protect nesting birds) and resistance to demands for new construction. Achievable dune-restoration outcomes are identified in selected municipalities. Dunes can evolve as natural dynamic landforms on the seaward side and be stable on the landward side, providing vegetative diversity and protective value. Restoration of habitat makes the case for nourishment more compelling, but conservation of this habitat may not occur unless there is a long-term commitment to nourishment and control of subsequent human activities on the coast.

Keywords: Beach nourishment, dune building, endangered species, habitat, raking, restoration, vegetation, New Jersey.

INTRODUCTION

It now appears that development and protection of shores is inevitable, despite warnings of many scientists about the incompatibility of maintaining fixed structures on mobile coastal landforms and attempts of planners and managers to regulate development (Nordstrom 2000). There is no reason to expect that the pace and scale of coastal development will decrease. Development is determined by growth demand, based on rising income and employment in inland areas, and coastal resources and tourism are often used to support economic programs (Sorensen and Brandani 1987; Huber and Meganck 1990; Hillyer et al. 1997; Cordes and Yezer 1998). International tourism is a rapid growth industry in developed and developing countries (Huber and Meganck 1990; Awosika and Ibe 1993; Pearsall 1993; Houston 1996). Governments often become catalysts in resort developments by passing tourism-encouragement laws, building or providing subsidies for access routes and infrastructure, and entering into partnerships with entrepreneurs (Atherley et al. 1991; Chou and Sudara 1991; Awosika and Ibe 1993; Bringas Rábago 1993; Domroes 1993; McDowell et al. 1993; Schmahl and Conklin 1991; Wong 1993).

Developed coastal landscapes reveal great variety of physical and cultural characteristics, but most share a common evolution from natural environments to cultural artifacts through stages driven by changes in economics, transportation and construction technologies (Butler 1980; Wong 1993; Meyer-Arendt 1990, 1993). Shore protection methods may also change in types and frequency of implementation, revealing an early preference for groins, followed by a period of construction of shore-parallel structures, to a period of beach nourishment that is currently favored (Caputo et al. 1991; Kana 1991; Paskoff and Kelletat 1991; Nordstrom 2000). Nourishment has been advocated as an environmentally compatible alternative, but many municipalities that have nourished their beaches have also graded and raked them, and the beaches lack topographic and species diversity. Thus restoration of ecosystems or landforms (other than a wide flat beach) is not an automatic byproduct of beach nourishment (Nordstrom 2000).

Coastal evolution may take different routes, and the development process need not proceed unidirectionally toward total elimination of natural environments in favor of structures or a flat, featureless recreation platform. We would like to identify ways that the trend toward cultural artifact can be reversed, highlighting environmentally compatible strategies adopted on the intensively developed shore in the state of New Jersey. This state has been mentioned often as an example of a natural system gone awry, and the unflattering term "New Jerseyization" has been applied to a developed, eroding coast where the outcome of the conflict between natural and human processes is replacement of beaches by seawalls (Pilkey 1981). Events in New Jersey reveal that hard structures are only one phase in the cycle of changes on an eroding, developed coast that may include a phase of regeneration of landforms and biota, aided by human efforts.

Our purpose is to show: 1) how the undesirable stage of shoreline armoring can be overcome by adopting a strategy of large-scale beach nourishment, and 2) how management actions can be taken to restore naturally-functioning beaches and dunes and re-discover the coastal-environmental heritage. The strategy involves preserving the coastal position by nourishment while allowing for controlled natural dynamism in a way that resembles in some respects the Dutch national policy of no retreat. The Dutch policy was approved by that government and includes an agenda for action and formal guidelines. The only statement in a New Jersey document that could be loosely interpreted as official is the phrase "retreat is not the answer." It is

contained in a report prepared under the direction of the governor to stimulate discussion and renewed cooperation among parties with a stake in protection and management of the coast (NJDEP 1997). Despite the lack of a binding statement, "no retreat" appears to be a de facto policy in New Jersey because most local governments and property owners would probably advocate management options that approach the status quo, even given increased sea level rise (Titus 1990). Also, there is no legal mechanism to prevent rebuilding of storm-damaged structures. The great value of land and real estate is the driving force; too much is invested in the highly developed shore to consider anything short of holding the line. Beach nourishment is now the preferred method of addressing erosion (Mauriello 1991), offering new options for managing the shore under a no retreat plan.

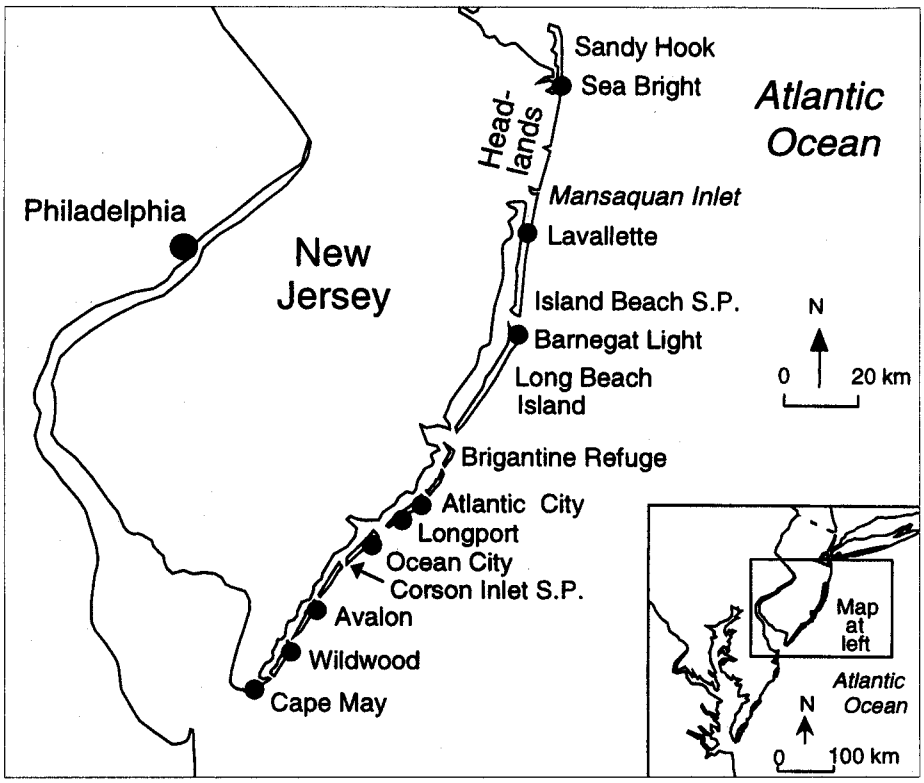

Figure 1. Shoreline of New Jersey.

Previous studies of state management policies and their implications for beach nourishment and dune building are presented in Mauriello and Halsey (1987) and Mauriello (1989, 1991). Descriptions of dune characteristics are provided by Gares (1990), Nordstrom and Arens (1998) and Nordstrom et al. (2000 in press). The present study updates the changes in policy and practice identified in those studies and evaluates alternative ways that beaches and dunes can evolve under management frameworks that attempt to make greater use of natural values.

The characteristics of natural foredunes reflect differences in winds, waves, sediment and biota. Characteristics of human-altered dunes reflect additional differences in: 1) the perception of their value for human use (sea defense, nature, recreation); 2) the degree that activities in the dune are controlled (laws and administrative levels for management decisions); and 3) the latitude allowed for natural processes to shape the human-altered landforms (Nordstrom and Arens 1998). Assessments of changes to dune systems and identification of target states for restored landscapes must consider natural and human processes and landforms as integrated, co-evolving systems.

Our comments and suggestions apply to a shore that is already developed to the point where return to fully natural conditions is not likely and where the level of development and investment is sufficient to justify a long-term economic commitment to nourishment. We do not encourage new development or intensification of existing human uses, and our suggestions are not meant to diffuse the need to preserve and protect existing undeveloped areas – a goal that is of utmost importance in preserving biological diversity and integrity (Callicott et al. 1999).

THE NEW JERSEY STUDY AREA

The ocean shore of New Jersey (Figure 1) is about 205 km long and consists of sandy barrier spits and barrier islands and two low (< 7.5 m high) headlands composed of unconsolidated sediments. Average annual significant wave height is 0.82 m, with a wave period of 8.3 s (Thompson 1977). Tides are semi-diurnal, with a mean range of 1.18 m (NOAA 1999). Dominant winds blow from the northwest, although northeasterly winds are strong during storms. The shore is sheltered from the most severe effects of hurricanes, and the storms that have caused the greatest alteration are mid-latitude cyclones. The most damaging storms in recent times occurred in March 1962, March 1984 and December 1992. Many human alterations to beaches and dunes have taken place since intensive human modification began in the mid 19th Century. These alterations are considered here in historical context, with most of the discussion devoted to changes after the storm of 6-8 March 1962, which is the most damaging storm in recent memory.

CHANGES IN DUNE CHARACTERISTICS THROUGH TIME

Prior to the mid 19th Century, the foredunes formed broad-based ridges in relatively stable portions of the barrier islands, with hummocks in more dynamic areas near inlets (Nordstrom 1994). The backdune portions of the barriers had lush growth of cedar, holly and other trees and a variety of grasses (Sea Isle City 1982). A general indication of the kinds of landscapes that existed is provided in only a few remaining park reserves in Sandy Hook National Recreation Area, Island Beach State Park, Brigantine National Wildlife Refuge, Corson Inlet State Park and the town of Avalon (Figure 1). Modifications of the rest of the coast included grading dunes and destroying natural vegetation to facilitate construction of buildings and roads. Growth of coastal resorts was rapid following construction of railroads in the second half of the 19th Century and increased use of private automobiles in the early 20th Century (Koedel 1983).

Protective coastal structures became widespread after 1900, and about half of the present structures were in place by 1950 (Nordstrom 1994).

Legacy of the March 1962 Storm

Much of the ocean shore was developed in residential properties by the time of the March 1962 storm. Damage assessments for this storm were $105,055,000 (1962 dollars) in the shore counties of New Jersey south of Manasquan Inlet (USACOE 1963).[1] Many bulkheads and public utility systems failed; thousands of residences were damaged by flooding or suffered structural damage; and nearly all of the dunes along entire barrier islands were destroyed (USACOE 1962; 1963). Post-storm reconstruction activities included restoration of beaches and dunes, reconstruction or replacement of damaged buildings, construction of new groins, bulkheads and seawalls, including the seawall at Cape May, that has been used as a symbol of New Jerseyization (Pilkey 1981). Less than a decade after the storm, many houses had been built farther seaward, and the number and sizes of the buildings were increased, documenting the common finding that human processes, not storm processes, are the dominant agent of landscape change where economic and population pressures are great (Nordstrom 2000).

The value of dunes as shore protection was revealed during the storm, in that enclaves where property owners built protective dunes prior to the storm were not overwashed, even where complete destruction occurred on both sides of them (USACOE 1962). The vulnerability of the shore to future storms required an immediate response, and the great cost of providing protection for the whole state required a cost-effective, compromise solution. Beaches and dunes were restored to provide protection against a storm having a frequency of one in 10 years (USACOE 1963). Although these dunes were acknowledged to be undersized given the potential hazard, the image they conveyed set a standard for the size of dunes subsequently built.

Increasing Regulations on Beaches and Dunes

Some municipalities instituted their own dune-building programs after the 1962 storm, and some passed ordinances to preserve the newly-created dunes. The program of beach and dune management at Avalon (Figure 1), considered one of the best in the state (Mauriello 1991), began just after this storm. Significant early actions included building dunes along the entire ocean front using sand fences and vegetation plantings and raising $165,000 to purchase undeveloped shorefront lots to retain natural environments and reduce future property losses. The value, use, and control of dunes in Avalon were subsequently codified in regulations in 1967, 1968 and 1978 (Nordstrom et al. in press).

The Coastal Area Facility Review Act (CAFRA) of 1973 was the first State control on construction in the beach/dune environment. CAFRA required a permit for construction of residential structures of more than 24 dwelling units. Restrictions limited high-rise buildings but did not do much to protect beaches and dunes from development because small units could not be regulated, and subsequent construction resulted in a high density of multiple-unit low rise structures. Dune protection remained largely a municipal responsibility (NJDEP 1984).

The state had some leverage via state aid agreements for shore protection, making money available if municipalities made their ordinances consistent with the Coastal Zone Management rules on beaches, dunes, erosion hazard areas and coastal high hazard areas. The required ordinances did not always reflect sound management or protection of resources, and state enforcement of the ordinances was lax. An example of the problem is the Long Beach Township ordinance that established a static development limit line running across the crest of the primary dune, with no consideration of where the dune actually existed. As a result, the ordinance allowed many homes to be built on the dune crest and backdune, providing no protection to the dune itself.

A renewed State focus on dunes as shore protection followed damaging storms during 1977-78, passage of the Beaches and Harbor Bond act of 1977 (that made $20 million available for shore protection), formulation of a set of Coastal Zone Management Rules (NJAC 7:7E) in 1978 and development of the New Jersey Shore Protection Master Plan in 1981 that encouraged use of non-structural approaches to shore protection (NJDEP 1984). The Coastal Zone Management rules are the substantive standards that guide coastal permit decisions. Pursuant to the Administrative Procedures Act, these rules need to be readopted every five years, but they have been amended or readopted more frequently (20 times since 1978) and have evolved to provide better standards for regulating coastal development.

The National Flood Insurance Program (NFIP), administered by the Federal Emergency Management Agency (FEMA) had an influence on coastal construction beginning in the late 1960s and early 1970s. The initial impact of the program was to change the way homes were built by requiring buildings in hazard areas to be elevated rather than slab-on-grade. In the late 1980s, FEMA introduced dune dimensions to define limits of coastal high hazard areas (codified in a 1988 revision to the NFIP regulations) and established a prohibition on alteration of primary dunes if that alteration increased flood potential. This regulation was not foolproof because FEMA left the determination to licensed consultants who often signed off on client wishes.

Legacy of the March 1984 Storm

The storm of 28-29 March 1984, which caused severe erosion of beaches and dunes, was a benchmark in New Jersey in terms of documenting the value of dunes as natural shore protection. The storm caused the state to adopt a formal Hazard Mitigation Plan, completed in 1985 and subsequently updated. This plan recommended dune creation and enhancement as one of the primary hazard mitigation efforts, due to documented success, relatively low cost and ease of implementation. Another result of the storm was the $2 million Emergency Beach and Dune Restoration Grant (NA-85-AA-D-CZ070) sponsored by Senator Bradley and issued as part of the US Department of Commerce Appropriation Bill of August 1985. Funds were passed through NJDEP and used to provide vegetation for planting dunes and materials for constructing sand fences in 18 municipalities and some state parks (affecting

1 Editor's Note: Several articles in the April 1962 issue of Shore & Beach, Volume 30, No. 1, give storm reports for the devastating "Ash Wednesday" northeaster. In an article entitled "The March Storm New Jersey and Delaware," total damages "...have been estimated to reach $100 million dollars." The titles of such articles are readily found by searching on the ASBPA web site, www.asbpa.org.

about 80 km of ocean-front dunes). The cost share was 95% Federal and 5% municipal. As a condition of this funding, municipalities signed a state aid agreement requiring them to adopt or amend municipal ordinances to conform with state coastal zone management rules on beaches, dunes, erosion hazard areas and public access. Some municipalities declined the funds because they did not want to enter into the agreements.

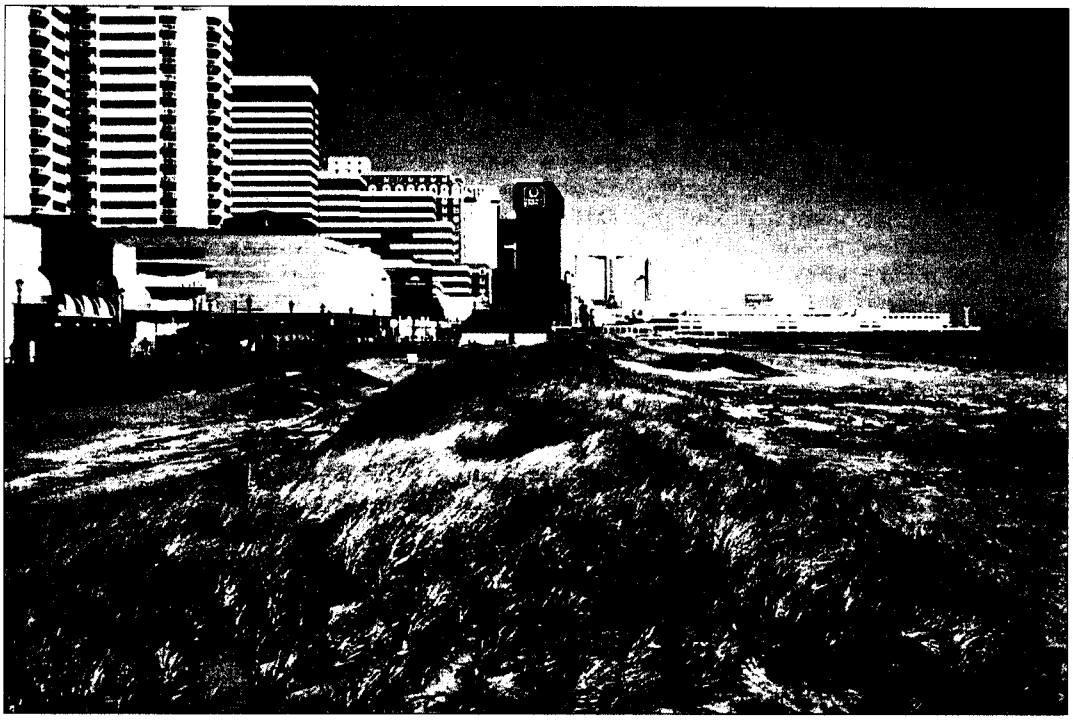

Figure 3. Atlantic City, New Jersey, showing the potential for use of dunes as a form of shore protection on an intensively developed coast where beach width is at a minimum.

FEMA began to require hazard mitigation initiatives as a condition of federal disaster aid, and municipalities found that dune building was a cost-effective way to accomplish this goal. Municipalities began to take advantage of the FEMA Hazard Mitigation Grant Program created in November 1988 through Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The amount of funds available to municipalities is 15% of the federal funds spent on public and individual assistance for each declared disaster. The funds are activated after a damaging storm but are used to reduce damages in a subsequent storm. Preference is given to acquiring damaged properties or retrofitting structures to make them more hazard resistant, but the state made a case for using funds to build dunes, given the reluctance of residents to leave the coast and the desirability of protecting a larger segment of the coast than locations previously damaged. Reconstruction of roads, boardwalks and other infrastructure was too costly without federal funds, so municipalities had to agree to dune building as a condition of the aid. The state accessed this program to fund other hazard mitigation activities including: acquiring, relocating, elevating or retrofitting structures; mapping hazard areas; conducting flood studies; planning for evacuation of threatened areas; installing tide gauge and telemetry systems; and conducting education programs.

Figure 2. Dune at Lavallette, New Jersey, showing a dune built as a sand dike primarily for protection on a shore where beach space prevent restoration of a large fully-functioning dune.

One of the most challenging aspects of the state dune enhancement program was convincing residents and municipal officials of the need to build dunes where they did not exist and to increase the height and width of existing dunes (Mauriello 1989). Local interests still argued for making dunes as small as possible to retain views of the sea from boardwalks and residences. Mauriello and Halsey (1987) and Mauriello (1989), in their case study of dune building in Lavallette (Figure 2), provide perspective on the compromises required in constructing a dune where none existed and where the boardwalk and houses are at the approximate elevation of the backbeach. The dunes were built to existing FEMA guidelines that specified a dune with a minimum height 2.56 m above mean sea level and a cross-sectional area of more than 50.2 m^2 above the 100-year recurrence interval storm flood level. Concern about sand inundation caused managers to place sand fences on the landward side of protective foredunes and to retain a flat trough between the dune and boardwalk where earth moving equipment could be used to mechanically remove sediment blown inland. These practices cause the dunes to remain narrow, linear, and fixed in location (Figure 2).

Actions at Atlantic City following the 1984 storm are interesting because they reveal that dunes were considered an acceptable alternative in the most urbanized coastal environment where dunes had not been considered an option since they were eliminated in the 19th Century. The dunes were constructed just after a state-funded nourishment project restored beach

widths in 1986. The dunes (Figure 3) are up to 1.9 m above the backbeach but they do not block views because the boardwalk is about 1.0 m above the maximum elevation of the backbeach, and buildings are constructed so bottom floors are at boardwalk elevation. The dune has a geotube core, buried using earth-moving equipment, but subsequent aeolian accretion gave this structure an aeolian veneer that mimics a natural dune in appearance if not in origin.

Beach Raking

Beach raking became common practice in New Jersey in the late 1980s, when beaches were subject to pollution by human litter, including medical waste. Large amounts of floating debris in the summers of 1987 and 1988 led to beach closings and a major loss of revenue for the New Jersey shore (Ofiara and Brown 1999). Stakeholders in shorefront municipalities found that raking the beach to create a clean (but sterile) environment was good for public relations. By the early 1990s, many municipalities raked their beaches, and many were able to obtain loans to purchase equipment from the Clean Beach Program of the NJDEP. The added funding increased the budget and staff in the public works departments in the municipalities and increased their ability to modify the beaches and dunes using their own equipment and labor.

Raking eliminates plant growth and the litter that serves as a sand trap or source of nutrients. It thus eliminates topographic and vegetation diversity and the incipient dunes that could grow into naturally evolving foredunes. Raking may increase aeolian transport of sediment to any foredunes that exist landward of the beach, but it eliminates the likelihood of natural cycles of growth and destruction of dunes on the beach. Raked beaches have a neat, clean look that appeals to many users but conveys the impression that beaches are recreation platforms, not natural resources.

Increasing Frequency and Scale of Beach Nourishment Operations

A relatively large number of beach nourishment projects (including beach disposal and sand bypass) were implemented in New Jersey beginning in the 1930s at Atlantic City (Valverde et al. 1999), and some are in progress or scheduled to be implemented in the near future (Bocamazo 1991; USACE 1996, 1997). Recent projects with potential for restoring natural environments include Sea Bright to Manasquan, Ocean City, Avalon, and Cape May. These projects have not all had the same success in reestablishing natural beach and dune habitat. The advantages are most clearly revealed in events in Avalon and Ocean City (discussed below).

Creating a Stable Source of Funding

A program for stable funding is key to ensuring non-federal support for large-scale shore protection projects, but is often difficult to accomplish (Smith 1991; Aceti and Avendaño 1999; Woodruff and Schmidt 1999). Stable funding in New Jersey began in 1992 as a result of legislative action. The impacts of storms in October 1991, January 1992, and December 1992 pushed the legislature to approve a $15 million annual appropriation for shore protection (primarily for beach nourishment) from the Real Estate Transfer Tax. The appropriation was subsequently raised to $20 million and is used to pay the non-federal share of federal beach nourishment costs.

Figure 4. Dune at Ocean City, New Jersey, showing the great width of dune possible if raking is prevented on a nourished beach.

Protecting Endangered Species

The recent initiative in New Jersey for protecting shore birds under the Endangered Species Program administered by the New Jersey Division of Fish, Game and Wildlife has revealed great potential for restoring naturally-functioning foredunes. Protection of endangered and threatened species is built into the state coastal zone management regulations and also is the responsibility of the US Fish and Wildlife Service. This program requires municipalities to ensure that nesting birds are not adversely affected by human activities. Identification of nests on beaches leads to establishment of protected enclaves where the state restricts activities such as raking, bulldozing, scraping, and backpassing sand during the nesting season from mid-April to mid-August. Elimination of these disturbances leads to accumulation of litter in wrack lines, colonization by plants, and growth of incipient dunes. Incipient dunes that formed on protected sites on the nourished beach at Ocean City survived several winter storm seasons and grew into new foredunes seaward of the dunes maintained by sand fences. These foredunes (Figure 4) are characterized by greater dynamism and topographic diversity than municipally-maintained dunes occurring where the beach is raked and sediment transport is inhibited by fences and vegetation plantings.

Protection of shore birds has been restricted to species listed as endangered and threatened by the US Fish and Wildlife Service, but amendments are proposed by NJDEP to address feeding habitat for other shorebirds. This would be done by changing the standards for beach and dune maintenance in the Coastal Zone Management Rules to confine raking to within 100 yd (91 m) of areas formally designated for swimming and watched by lifeguards. This expansion of no rake zones could convert a substantial portion of the upper beach into a naturally functioning environment.

Increasing the Impact of CAFRA

Legislative amendments to CAFRA in 1993/94 gave the State greater control over activities on the beach and in dunes in municipalities by requiring permits for construction or expansion of single-family houses or duplex houses located in dunes, erosion hazard areas, beaches, coastal bluffs and endangered habitats. Permitted uses must be in the public interest, and mitigation must occur for resources that would be adversely impacted. The state was able to take some highly restrictive

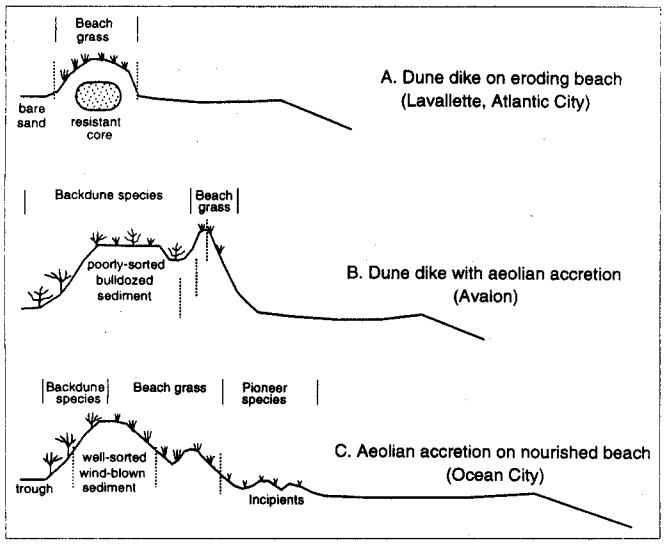

Figure 5. Characteristics of representative dunes found in developed New Jersey municipalities. The dune depicted in Profile C is considered the optimum for natural values in addition to protection, but it requires beach nourishment to ensure long-term viability.

rules that predated the 1994 CAFRA amendments and begin to apply them to all developments along the shore. That is when measurable progress in controlling impacts to beaches and dunes began. The dune rule is written for shore protection, not habitat, aesthetic or heritage value. The regulation prohibits direct disturbance to dunes that would reduce their dimensions, but sand can be added to dunes by bulldozing, and vegetation may be planted. Elevating existing buildings or constructing a second story does not require a permit if the footprint of the building is not increased. Walkways across the dune are permitted, and structures are permitted seaward of the dune if they are used for shore protection, for seasonal or recreational uses and are movable, or for permanent water-dependent recreational use and are elevated on pilings (NJDEP 1998). As a result of these amendments, more areas of dunes are protected, with less coverage of the surface of dunes, more setbacks from the primary crest, and in some cases, reduced density of development (fewer homes) on the dune.

FEMA Community Rating System Program

The dune programs in New Jersey enable NFIP policy holders to qualify for reduced flood insurance premiums through the FEMA Community Rating System Program implemented in 1990 and codified in the National Flood Insurance Reform Act of 1994. Premium reductions range from 5% for a "Class 9" community to 50% for a "Class 1" community. Most municipalities in New Jersey that participate are rated as Class 8, with a 10% reduction, with a few Class 7 municipalities, with a 15% reduction. It is difficult to have ratings better than that, unless a municipality maintains large areas of open space, which is not likely on the New Jersey coast.

Attaching an economic cost to environmental protection is a major problem in environmental management. The reduction in insurance premiums and replacement costs for sediment used to create dunes places a direct economic value on these landforms in their role as a protection structure. The compensation is not a direct support of nature, but natural values are accommodated as a byproduct (Nordstrom et al. in press).

PRESENT CONDITIONS AND TRENDS

The New Jersey shore is characterized by great variety of managed coastal landscapes. Some municipalities, such as Longport and Wildwood (Figure 1), manage beaches as flat, featureless recreation platforms, whereas other municipalities have vigorous dune-building programs. The least valuable dunes are the bulldozed ridges constructed to provide short-term protection where beaches are too narrow to allow dunes to form by aeolian accretion. The dunes at Lavallette (Figure 2) and Atlantic City (Figure 3) represent commitment to dune building where beach widths are insufficient for dunes to evolve into naturally functioning (or even naturally appearing) landforms. Dunes in these areas are usually a single narrow ridge (Figure 5a). Wave attack of the toe of this kind of dune is frequent, and any incipient dunes that form on the beach do not survive long enough to create an irregular dune toe. Foredunes of this size and location may only be viable as protection structures if they are built with a resistant core (Figure 5a). Their small size and proximity to the sea provide little shelter from salt spray and blowing sand. Plants characteristic of stable backdunes cannot thrive, and vegetation is characterized by species commonly found on the active beach and seaward portions of natural dunes. Ammophila breviligulata usually dominates because it is planted, but seaside goldenrod (Solidago sempervirons) often colonizes the dune, providing some vegetative diversity. The image that these dunes convey is not a natural one (as much because of their linear, truncated look as the lack of diverse or

Figure 6. Dune at Avalon, New Jersey, showing species diversity within compressed environmental gradient at a location that is closer to the water than is commonly found within a natural dune system.

dense vegetation), but these dunes are a step toward achieving greater tolerance for natural landforms.

Avalon, Ocean City and Barnegat Light (Figure 1) have some of the largest and best vegetated dunes in developed areas in New Jersey. These dunes represent achievable restoration outcomes over a period of less than 10 years that falls well within the time frame of local planners. The dunes in Avalon (Figures 5b, 6) reveal how landforms built and used as protection structures can evolve into a condition that appears natural, at least in terms of surface vegetation. A State/municipal nourishment project in 1987 provided 991, 800 m^3 of sediment (Valverde et al. 1999) to create a protective beach and dune along the eroding northern shore of the borough. The dune was essentially a flat-topped sand dike built to an elevation of 3.7 m above mean low water and composed of sediment dredged from a nearby inlet and shaped by earth-moving equipment.

The initial shape of the structure and its sediment characteristics, consisting of a large amount of coarse shell and gravel, revealed its non-aeolian origin. Subsequent placement of sand fences on the seaward side (to build the dune up to 6.7 m above mean low water to protect against flooding from a Category 3 hurricane) resulted in greater topographic diversity. The nourished and artificially shaped foredune is higher and wider than a natural dune would be this close to the backbeach. The cross shore zonation of vegetation is similar to that of a natural dune, but the environmental gradient across which the vegetation types are distributed is much narrower, and backdune species are within only a few meters of the backbeach. Woody shrubs, such as bayberry (Myrica pennsylvanica), break up the surface of the flat, graded dune, increasing its aesthetic value (Nordstrom et al. in press). These dunes do not convey a truly natural image because of their engineered shape and altered spatial context, but they reveal resource potential in their species diversity and aesthetic value.

The dunes in Ocean City (Figures 4, 5c) reveal what can be accomplished where beaches are widened by nourishment and the seaward portion of the dune is allowed to evolve naturally. The nourishment project that led to dune building was a federal project conducted in two phases (1992 and 1995) using 6.6 million m^3 of fill to create a beach berm 30 m wide and 2.4 m above NGVD (USACOE 1989; Valverde et al. 1999). Foredune construction began early in 1993, when the municipality used sand fences and dune grass plantings to allow a dune to build by aeolian accretion. The municipality obtained easements from the shorefront property owners to build dunes with the proviso that they would reach an elevation no higher than 0.9 m above the existing bulkheads. Initially, this dune looked like the small dunes built in Lavallette (Figure 2), but the nourished beach provided a better source of wind-blown sediment and protected the foredune from wave damage during small storms, resulting in rapid growth. The municipality progressively placed rows of sand fences on the seaward side of the dune to encourage horizontal rather than upward growth. The landward side of the dune was fixed in position using a sand fence.

The dynamic incipient dunes that formed at bird nesting sites at Ocean City (Figure 4) are visible examples of the cycles of growth and destruction that characterize natural coastal environments, and they help re-establish a proper image of the coastal landscape. Only the seaward portion of the dune is dynamic, and the landward crest retains its integrity as a protection structure. The crest and narrow backdune evolved into a stable vegetated environment. The design includes the unvegetated trough that has become a characteristic feature landward of foredunes where developed residential land is close to the beach and where past resident actions have attempted to keep dunes from migrating onto properties.

Troughs are most conspicuous seaward of shore-parallel bulkheads and boardwalks that perpetuate the feeling that wild nature and human habitation are separable and incompatible. Troughs also provide shore-parallel access from residential properties to designated dune crossovers that are maintained at ends of shore-perpendicular streets. Some troughs were created after landward properties were inundated by blowing sand, but troughs are often incorporated directly into the design of new dunes. Troughs are not considered appropriate where there is a tradition of allowing dunes to migrate onto properties, as at Long Beach Island (Figure 1).

SIGNIFICANCE OF BEACH NOURISHMENT TO RESTORATION PROJECTS

Beach width is a primary control on the type and location of dunes, whether natural or artificially created. Most locations in New Jersey that have not been nourished recently are similar to Lavallette and Atlantic City in having narrow beaches, with narrow dune ridges fronting dense development, but there are all types, sizes, shapes and functions of dunes, even within the

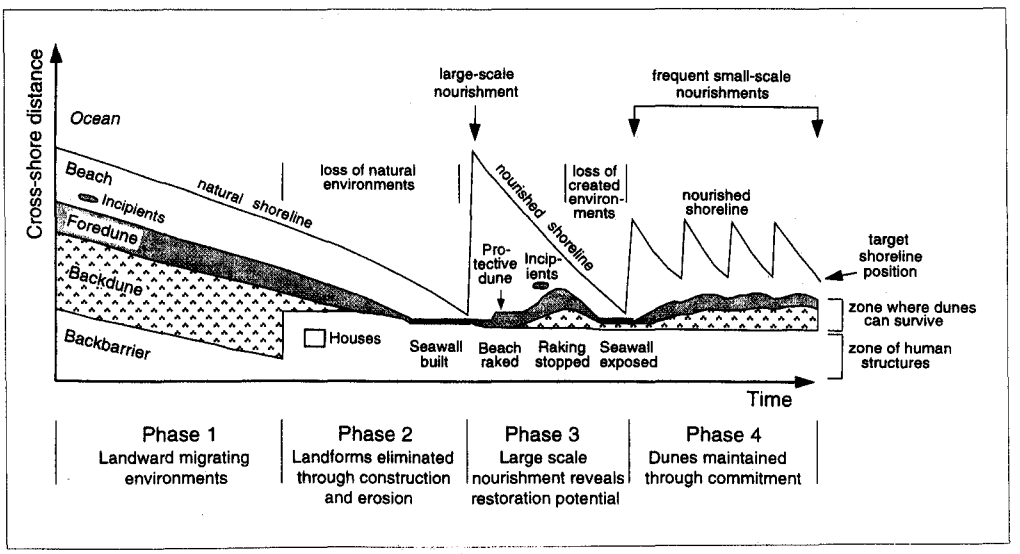

Figure 7. Time line of changes in width of shoreline environments along a single cross-shore transect on a barrier island.

same municipality. Northern Lavallette has large, wide dunes with sand volumes exceeding the FEMA 50.2 m^2 standard and diverse vegetation, and Atlantic City has wide beaches and dunes in the south. In Ocean City and Avalon, the dunes are narrow at erosional hot spots where beaches are narrow, and at Avalon, it has been necessary to embed geotextiles within the dune as backup protection. Long Beach Island (Figure 1) has environments that vary from a natural dune field with multiple ridges in the north to dune scarps at the limit of houses in the south.

The primary objective of beach nourishment has been storm protection, and real estate values have justified the huge costs of the projects. Beach nourishment need not be viewed as a protection measure that favors the relatively few people who own residential or commercial property near the beach. Justification for nourishment as creation and restoration of recreational beach provides a utilitarian value to which now can be added both the utilitarian (nature appreciation) and intrinsic values of wildlife habitat. Under the Public Trust Doctrine, everyone has a right to use the beach, regardless of residency, so maximization of these values extends the benefits to all of the public. Creation of recreational beaches and restoration of habitat can be used in addition to shore protection to make a compelling case for nourishment, but true restoration may not occur in the absence of a detailed restoration plan that includes control of subsequent human activities.

Figure 7 identifies the significance of beach nourishment by placing its effects within a time line of changes in relative dimensions and locations of shoreline environments. The figure does not depict actual events at a specific site but an idealized composite of changes observed on the New Jersey shore, with our vision of what is possible to achieve in the future. Phase 1 depicts natural conditions of a migrating barrier island, where dimensions of the natural beach and dune are unhindered by humans. Phase 2 represents the elimination of landward portions of the dune to accommodate development, followed by attempts to protect property investments. The end of Phase 2 depicts the loss of beach and dune habitat that is one consequence of using static protection structures without beach fill (Hall and Pilkey 1991). Phase 3 represents the replacement of the lost beach through nourishment. The initial large-scale project creates the potential for full restoration, but the effect differs according to subsequent management actions. The new sand may be treated solely as as a recreation platform and graded, preventing growth of natural dunes. Sand fences may be placed on the backbeach to provide flood protection or prevent sand drift, creating the linear sand dike often associated with a developed coast. Suspension of raking leads to a wider dune with greater topographical and biological diversity, but loss of created environments can occur if administrative delays prevent nourishment from occurring in a timely fashion (end of Phase 3).

Fencing and vegetation plantings can be used to build dunes in a sand deficient environment, but inevitably, beach nourishment may be required to maintain a healthy, well vegetated dune (Mendelssohn et al. 1991). Phase 4 depicts the need for nourishment to retain dune integrity, given erosion and competition for recreation space. Restrictions to beach space have been used as a reason for resisting construction of dunes in the past and even for eliminating dunes when not prevented by regulations. This problem will not occur as long as beach width is maintained by nourishment. A significant aspect of the management approach in Phase 4 is that the restored dune landscape (not just the recreation beach or the development) is considered a resource and is protected by nourishment. Preservation of existing landforms and habitats argues for small, frequent nourishment operations, supporting previous studies that suggest operations at similar scales (Dette et al. 1994; van Noortwijk and Peerbolte 2000). Design studies for projects in New Jersey include nourishment at the relatively high frequency of 3 years (USACOE 1989, 1996), which should be adequate. Restored dunes in developed areas would probably not be as wide as landforms in the undeveloped enclaves identified on Figure 1, but judicious placements of sand fences and vegetation plantings could re-create the types of habitats lost, if not the area and spatial relationships.

The NJDEP now allows municipalities complete flexibility for planting details (within a range of species that does not include exotics). More diverse landscaping, with a more varied vegetative community, could be required as part of future dune enhancement projects. Evolution of dune vegetation at Avalon indicates that greater species richness occurs through time on restored dunes, even when they are not artificially planted (Nordstrom et al. in press), but plantings would place a restored site on a natural trajectory sooner and may obtain public support more readily. A rule amendment could require vegetative diversity in the dune plans that are approved. The goal of the requirement would be habitat restoration and enhancement rather than solely protection.

OVERCOMING IMPEDIMENTS TO DUNE RESTORATION

There is still a sizeable and often highly vocal component of the population that opposes dune construction. Much of the resistance may come from non-resident property owners (Vandemark 2000), but even some municipal managers still oppose dune construction. Education of residents and landowners is considered crucial to acceptance of dunes, even where dunes already exist (in part because the turnover in resident population is rapid). Ongoing efforts in Avalon include information displays in the library, presentations at meetings of the Chamber of Commerce, Realtors Association, and Land and Homeowners Association, write-ups in the borough newsletter and regular mailings of flood hazard information to property owners (Nordstrom et al. in press).

Acceptance of dunes in New Jersey has evolved slowly and has relied on aggressive actions of a few key people and programs. Conversations with managers in municipalities where dunes have been created since 1984 indicate that they recognize dunes as an effective and inexpensive means of reducing storm damage. Informal surveys of homeowners in Lavallette reveal that they may not like the direct blockage of ocean views, but they think that the dunes are an aesthetic improvement because they restore a degree of natural beauty and remind them of other places they have visited where dunes are more prevalent (e.g. Cape Hatteras, Cape Cod). Preference for natural landscapes can change as experiences are improved and people are enlightened as a result of incremental improvements in nature quality (Arler 2000). The federal (FEMA) and state (NJDEP) empha-

sis on dune creation and enhancement as shore protection and a reimbursable hazard mitigation option helped obtain municipal support. Economic incentives may be the key to re-establishing the natural resource base, but improvements to the environment provide further incentives for restoration.

The growth of dunes in Ocean City is accompanied by an ongoing dispute between disgruntled shorefront residents and municipal managers. The municipality was successfully sued in 1999 by one property owner when the dune elevation increased to a height that was considered unacceptable. The court ruling, upheld in the State Supreme Court, required the city to pay $37, 000 for loss of view and access to the beach. The underlying causes of the Ocean City problems are that: 1) the dunes were built on privately owned land, not municipal property, as is the case in most municipalities; 2) the city agreed to a dune height limit as a condition for acquiring the easements (perhaps not imagining the dunes would grow so high); and 3) the city did not appropriately compensate owners, paying a $1.00 fee for easements. The municipality is now examining ways to reduce dune height to restore views, which would involve changes in state CAFRA guidelines. A precedent for reversing state guidelines to allow grading to restore views was established in Oregon (Cortright 1987; Marra 1993). The situation in Ocean City differs in that the dunes are more critical for shore protection because of higher surge heights. Grading in Oregon was considered acceptable because the issue was one of management, not conservation. Grading is less acceptable where it interferes with the goal of restoration, where a naturally functioning dune is the target. Finding solutions that accommodate increases in the dimensions of the dune are preferable to those that restrict these dimensions.

Not surprisingly, municipalities that have resisted dune projects have buildings constructed at low elevations or boardwalks placed directly on the beach, such as at Lavallette (Figure 2). This problem may be less critical in the future in New Jersey because most multiple unit structures with more than one story are being built with dwelling units placed side by side rather than one on each floor. This type of construction provides a view from the upper floor when the view from the bottom is obscured by a dune. The interior layouts have changed accordingly, with bedrooms downstairs and living room, dining room, family room, den, and kitchen upstairs. This method of building includes homes that are rebuilt, and structures may be rebuilt to this design without requiring a CAFRA permit.

The great intensity of development of the New Jersey shore and the resulting increase in the benefit-cost ratio for protection projects is one of the reasons why beach nourishment is a practical solution. However, nourishment and dune construction add levels of protection (and natural beauty) that may, in turn, increase demand for new development. This problem has already occurred at Cape May, where a large subdivision (the Poverty Beach Development) was able to be built in a FEMA V-zone (area subject to damaging wave action during a 100 year event) only because of the large-scale federal beach nourishment project. The developer was denied a CAFRA permit but appealed to the Office of Administrative Law, and the NJDEP decision was overturned because the attorney successfully argued that the nourishment project had reduced the vulnerability of the site.

Beach fills have also increased pressure to build seaward. NJDEP has had applications for permits to build new structures and legalize existing structures including tiki bars, decks, and cabanas (changing rooms with electricity and some with water service) at Sea Bright, Monmouth Beach, and Long Branch following completion of federal nourishment projects there. The 1992 beach nourishment in Ocean City has led to refurbishing of the commercial boardwalk zone there. Increase in levels of investment can be considered an advantage of nourishment (Wright and Butler 1984), but this gain should not come at the expense of gains in nature value.

CONCLUDING DISCUSSION

The large volumes of sand scheduled to be pumped onto the New Jersey beaches represent an invaluable resource, but the full potential of this sediment will not be realized without a multi-objective management approach that addresses habitat improvement and nature based tourism in addition to the traditional goals of protection from erosion and flooding and provision of recreation space. Best management practices and standards (e.g., guidelines for raking, alternative sand fence configurations, new ways of using vegetation) are required to enhance habitat, diversify vegetative communities and restore the natural values and beneficial functions of dunes.

A better job of outreach and education is also required to provide stakeholders an understanding of dunes in their many roles and why larger dunes with greater diversity of vegetation and topography are important. The benefits provided by dunes extend beyond the front row of homes, and there is a need to educate and mobilize residents who live landward of the first row of buildings and tourists to push for dune creation and enhancement as a benefit to the community and the tourism experience. A historical perspective will show that many of the problems that have resulted from development of the oceanfront are directly related to the destruction and elimination of dunes and provide stakeholders with a glimpse of the coastal environmental heritage that has been lost but is once again obtainable. Retreat from the coast may not be a viable option, but it is still possible to recover many of the characteristics and values that have been lost.

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