BARRIER ISLANDS and BEACHES

Technical Proceedings of the 1976
BARRIER ISLANDS WORKSHOP
Annapolis, Maryland
May 17-18, 1976

Workshop Sponsor:
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Office of Coastal Zone Management, National Oceanic and Atmospheric Administration

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The Technical Sessions
were sponsored by The Office of Coastal Zone Management,
National Oceanic and Atmospheric Administration

The Conservation Foundation
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In order to keep down the price of this book,
The Conservation Foundation is publishing these reports
in the form in which they were received from the 1976 Barrier Islands Workshop.

Publication of the proceedings was sponsored by
The Griffis Foundation, Inc., New York

Copies of the Proceedings may be ordered from
the Publications Department of The Conservation Foundation,
1717 Massachusetts Avenue, N.W., Washington, D.C. 20036

Library of Congress No. 76-46759
ISBN 0-89164-035-5

For general information on barrier islands contact:
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Foreword

As states move into the final phases of preparing comprehensive coastal management programs in cooperation with the Federal Government, choices must be made about the best methods of dealing with future uses of barrier islands and beaches. States are now evaluating environmentally or economically critical places and other areas of particular concern and planning for their wise management.

We know that barrier islands and beaches are especially fragile but dynamic systems. We also know that they play a major role in protection of inland areas and resources by serving as a buffer between fast land and sea. As we attempt to learn more about this active, interrelated system, development pressures are growing.

One of the most significant players in the drama of the land/sea interface is the Federal Government, yet its role in determining the future existence and character of these islands has not been fully appreciated. We are now becoming aware of the impact that incremental decisions of dispersed government agencies can have on the basic ecological function of barrier islands and beaches.

This volume is intended to stimulate thought regarding the development of more coherent Federal and state policies with regard to the management of valuable barrier islands and beaches. It is my hope that the attention now being turned to these issues will lead to wiser and more coherent planning and management strategies for these vital coastal resources.

Robert W. Knecht
Assistant Administrator
for Coastal Zone Management

Preface

A chain of sandy barrier islands and barrier beaches starts in New Hampshire and, with few breaks, continues south to Florida and west along the Gulf of Mexico shoreline to the Mexico border. While the Pacific shore has few sandy islands, it has numerous barrier beaches. The barrier islands and beaches are enormously rich in natural resources and extremely vulnerable to development impacts.

The natural properties of barrier islands and beaches provide a strikingly unique combination of values. A typical barrier island, with its ocean beach, dense jungle-like interior, and broad expanse of marsh, has scenic qualities unparalleled in the coastal zone. Barrier islands offer a rich diversity of recreational opportunities concentrated within small areas. They provide habitat and food for hundreds of species of coastal birds, fish, shellfish, reptiles and mammals. They enclose and protect priceless estuarine resources from the battering of storms and oceanic currents.

There is a unity about the barrier-island chain that is easily broken. The values of the islands are tightly intertwined and there is a natural dynamic flow among them. The sand, the water, the animals, even the plants (through seed transport), move from island to island and form a common pool for resource replenishment. One island damaged by thoughtless development can break the flow and weaken the whole chain. No barrier island exists apart.

Tragically, the barrier islands are increasingly the focus of intense real-estate speculation and development activity setting up a strong conflict. Natural values and public access are rapidly lost in the face of the seashore building boom. More than half of the major barrier islands and beaches are already fully committed to private housing and commercial enterprises.

Barrier islands are temporary structures that constantly move and change shape. They cannot be held in place easily. Despite the spending of millions of dollars in public funds, most seawalls, groins and beach-restoration projects have been unsuccessful. The powerful oceanic and meteorologic forces at work cannot be overcome. The great storms that sweep over these islands cannot be deflected.

The perpetuation of barrier islands along high-energy coasts depends upon a sensitive sand-dune system. Dunes are the island's frontal defense against the forces of wind and waves because they store sand to replace that lost to big storms. Typical development practice ignores or gives token attention to maintaining the integrity of the dune system. Houses are still being built on, or immediately behind, the dunes without considering their mobility or overwash during severe storms.

Barrier islands usually are fringed with extensive salt marshes on their landward side. The marshes provide essential habitat for many forms of life and supply basic nutrient to coastal ecosystems. They also stabilize the shore, absorb flood waters, and remove contaminants from the water. They are vital habitat areas which require special protection. The freshwater system too is often a critical factor in the survival of barrier-island animals, and a variety of marshy sloughs provide for this need.

With sand dunes or ridges bordering the ocean side and salt marshes or mangroves encompassing much of the estuarine side, barrier islands may be so narrow that these two types of vital habitat areas may embrace most of their total area. The limited strip of buildable land in the middle may be further reduced by interior waterways and wetlands. The preservation requirements are such that little, if any, suitable upland may be available for housing or other development on the narrower barrier islands. While narrow or unforested islands are not capable of sustaining any real-estate development, the interior forest areas of some larger barrier islands may be ecologically suitable for controlled development.

Because of the numerous practical difficulties, barrier-island development usually requires public subsidy. Bridges, roads, sewers, beach protection, pest control, health, fire protection and flood insurance often are directly or indirectly supported by public funds. The federal government is, perhaps inadvertently, now supporting or encouraging the development of these vulnerable islands through public works programs, federal flood insurance and housing mortgage guarantees, among other programs.

There is no clear national policy for the protection of these islands. There are innumerable examples of tax money used to fund facilities and "assistance" programs that lead to the degradation of barrier island resources.

Major purposes of the Barrier Island Workshop were to explore the national interest in Barrier Islands and to examine the status of federal policy for their conservation.

The consensus of the workshop was that most Federal programs affecting barrier islands, including subsidy and permit programs, do not yet recognize that these coastal islands call for different treatment than inland real estate. Federal agencies in general appear not to recognize that barrier islands:

1. Contain extraordinary high natural values: for outdoor recreation, for fish and wildlife habitat, and as places of rare beauty;

2. Provide high-value functions for human society in their natural condition--such as protector of the biologically productive estuaries behind them; and

3. As mobile land forms, can be extraordinarily hazardous to build on because of their vulnerability to hurricanes and other storm and tidal action.

The workshop further agreed that a cooperative effort was needed to improve Federal policies and to foster conservation efforts; to explore options for ensuring that Federal agencies of many kinds deal more appropriately with barrier-islands issues and to ensure the assistance of state and local governments in dealing with them in ways that respond to today's understanding of their high public values and high-hazard characteristics. First priority was to be placed upon getting barrier islands and beaches recognized, and designated, as a special class of resource with a presumption of public harm in tampering with their natural systems. Twenty-five groups subsequently formed a working coalition under the title of "The Barrier Island Workshop" to begin immediate action to conserve the barrier islands and beaches.

Reported herein are the technical papers presented during the scientific sessions on the first day of the 1976 Barrier Islands Workshops, held on May 18th and 19th at Annapolis, Maryland. Together they present a broad overview of the status of scientific knowledge of the value and vulnerabilities of the national inventory of barrier islands and beaches.

John Clark
Editor

September 1976

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Contribution No. 1

BARRIER ISLANDS AS SIGNIFICANT ECOSYSTEMS

Edward T. LaRoe *

I would like to sketch in general terms the common characteristics of barrier islands: those features which distinguish them as significant ecosystems, and which, not coincidentally, pose the difficult problems which the managers and users of barrier islands must face. Many of the panelists to follow will address individually these same features in greater detail.

Barrier islands are elongate, thin structures, parallel to the shoreline, formed of unconsolidated sediments (usually sand). These islands may range up to tens of kilometers long, and are usually less than a few km wide. They are separated from the mainland by estuaries and wetlands, which may range in size from narrow lagoons to the extensive sounds over 50 km (27 miles) wide found in North Carolina. They are generally located in areas with low sloping coastal plains and moderate tidal range.

In the United States, barrier islands range from New England, down the Atlantic coast, around the Gulf of Mexico, to Texas. As an example of their distribution: barrier islands form almost half of the Gulf of Mexico shoreline. Typical barrier islands include both relatively undeveloped ones, such as Sapelo and the Core Banks, Chincoteague and Cape Hatteras which are primarily used for recreational purposes, and severely perturbed areas such as Marco Island, Atlantic City, Galveston, and Florida's big mistake, Miami Beach. While true barrier islands do not exist on the Pacific Coast; a similar feature occurs there -- the barrier beach.

Barrier islands are dominated by energy stresses. Exceptional wave force, wind and tidal energies, and ocean flooding are the predominant factors which shape and regulate the barrier island ecosystem. As a result of these forces, barrier islands are extremely dynamic systems, constantly subject to change. Seasonal and other regular cyclic fluctuations in wave patterns and intensity combine with irregular ocean storms and hurricanes to form and reform island profiles. The beaches and dunes migrate in response to these fluctuations. Storm overwash periodically carries sands onto the island, leaving substantial deposits of new sediments. The result is that morphologically, the islands are in a continual state of flux. While we generally recognize the great impact that hurricanes have on barrier islands, I should emphasize that because of wave periodicity and duration, seasonal winter storms can play an equally important role in shaping the islands.

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It might be tempting to conclude, given the dynamic nature of barrier islands, that these forces lead to great island instability. While this may be correct in terms of man's needs for development, ecologically the contrary is true. It is the dynamic nature of the barrier island system that makes it stable. The island beaches offer little resistance to storm waves, and effectively absorb and dissipate the tremendous forces which confront them.

In the natural system, storm waves frequently breach the island dunes and flood the island. As waves wash over the dunes during storms, they carry sand and shells onto the island and distribute them across the grasslands, marshes, and even into the estuary behind. Storm overwash, therefore, actually contributes new sediments to the islands. In this fashion, overwash serves to maintain the island by supplying sand from the beach and offshore areas for new dune growth, adding to the island's elevation, and extending the island laterally into the estuary.

Soils characteristic of barrier islands are generally immature. Sandy soils predominate, and are perpetuated by the frequent overwash. Ocean flooding tends to carry finer sediments into lagoons. Sandy soils provide rapid absorption of water, except in deflation plains where the sand may be wind-scoured to the water table. They are also prone to problems of ground-water contamination, either by excessive drawdown leading to salt-water intrusion, or by septic waste disposal.

The barrier island fauna and flora not only reflect, but also depend upon the overwash and immature sandy soils. Progressing inland from the ocean, the first island plants are hardy grasses such as sea oats (Uniola paniculata) and salt meadow cordgrass (Spartina patens). Both grasses are well adapted to flooding and overwash, and will quickly grow even if completely buried by sand.

Regular overwash serves to maintain these productive, early successional forms. On smaller or frequently flooded barrier islands, these grasses may be the dominant vegetation across the island. However, protection from overwash allows the development of later successional stages which may displace, at least partly, the hardy and productive grasslands, so that on larger, more protected islands shrubs and forested woodlands can develop.

Barrier island ecosystems are generally biologically depauperate, with fairly simple food webs; this results in part from the periodic stress, as well as the reduced complexity associated with all insular systems. Characteristic of island ecosystems generally, special populations or subspecies, particularly of mammals (such as deer), are frequently found on barrier islands. Larger predators are generally absent. In response to the dynamic beach conditions, the beach fauna is largely composed of annuals. The short life-span and rapid turnover lead to swift recolonization of the beach sands following perturbation.

When we discuss barrier islands, we tend to focus on the extensive beach and dune systems and their interaction with the ocean. In doing so, we frequently overlook the great importance of barrier islands in creating and maintaining the extensive network of highly productive estuaries and wetlands along our coast. As a physical barrier, the islands protect both the estuaries and the mainland from the high energy forces. The semi-enclosed lagoons they form permit mixing of ocean and fresh waters and allow the development of estuarine conditions. The physical protection provided allows the development of lower-energy tidal wetlands and extensive marshes. These estuaries and wetlands are among the most important benefits of barrier islands.

The final feature of barrier islands is their strong appeal to man, and vulnerability to his influence. Man is attracted to barrier islands for a variety of reasons -- for recreation and aesthetic pursuit, for agricultural and forestry uses, and for real estate development. From the first efforts at colonizing the United States, to the most recent large scale developments, he has attempted to settle the barrier islands. And as with so many of his efforts, while he attempts to use and modify the barrier islands for his own benefit, he winds up, at great public cost, destroying the resource.

The very feature which maintains the islands -- their dynamic nature which allows them to yield and reform under the wave stress -- is hostile to man's objectives. Flooding and overwash, which sustain the islands, are inimical to man's presence and his structures. Development must be accompanied by static conditions. Through bulkheads, seawalls, groins, and dune stabilization efforts, man has tried to impose an artifical stability on the islands. And while he has accomplished little of long-term nature, man's efforts to stabilize the islands have, in fact, caused the loss of their natural defensive capability, causing severe perturbations in island ecology and geomorphology. Erosion has increased and beaches have narrowed. Where conditions have been temporarily stabilized, ecological succession has accelerated, leading to biota less tolerant of -- and less capable of recolonizing after -- storm flooding and overwash.

Characteristic of the natural system, the inlets between barrier islands migrate freely; the channel depth is seldom constant. Occasionally old inlets shoal over and close up, while new ones are formed where islands are breached. For his navigational use, man attempts, also, to stabilize these inlets. The groins and jetties, which are the primary tool for inlet stabilization, have led to substantial downcurrent erosion problems when sediment transport is interrupted. The channels themselves must be maintained by continuous dredging, which has ecologic and economic impacts of its own. In some areas where additional navigational access has been desired, new channels have been cut through barrier islands, leading to widescale changes in sediment flow along the beach.

Reports on the effects of livestock grazing on barrier islands are mixed. However, feral animals, especially hogs, have substantially altered the ecosystem on some islands.

These alterations have not generally been foreseen or desired. Man's stresses have had greater impact on the ecology and geomorphology of barrier islands than have those of nature. In many ways it is a shame that we couldn't have profited from the lesson of Sir Walter Raleigh 400 years ago, and abandoned all efforts to develop on barrier islands.

Before closing I would like to make one comment on whatever effort emerges from this workshop. I would urge that you not limit your effort to barrier islands, but add barrier beaches to your considerations. The barrier beaches of the West Coast -- the Silver Strand which encloses San Diego Bay, Long Beach which forms Willapa Bay, and the host of lesser barrier beaches such as those on Netarts and Sand Lake -- generally share the same characteristics as barrier islands. They are ecologically similar, provide the same natural benefits, possess the same hazards, and are generally under the same development pressures. I hope that they are not neglected.

In conclusion, let me indicate that barrier islands and beaches are significant ecosystems sharing common features. The great interrelation of ecology and geomorphology which characterizes barrier islands is probably unique among ecosystems. Further, the benefits provided by barrier islands, especially the related estuarine systems which they create, are also significant. And finally, the hazards to, and the stresses resulting from development on barrier islands are significant. Together these are the problems which coastal managers must address before the resource can be successfully managed, and the benefits which barrier islands provide retained.

Contribution No. 2

COMPARATIVE ECOLOGY OF EAST COAST BARRIER ISLANDS: HYDROLOGY, SOIL, VEGETATION

By

Paul J. Godfrey*

The chain of barrier beaches that stretches along the Atlantic coast from Maine to the Mexican border is one of the longest and most unique in the world. Despite the wide range of ecological conditions to be found over such an extensive latitude range, there are basic features which tie the barriers together, as well as differences that must be underscored if proper management of these beaches is to be attained. This brief overview of barrier beach ecology stems from my own research and that of my students on the response of vegetation to barrier island migration, particularly along the North Carolina coast, and more recently in Massachusetts. The National Park Service has sponsored most of this work. A review of relevant literature and discussions with colleagues provided further information.

GENERAL ECOLOGICAL CONSIDERATIONS

The unifying feature of these barrier beaches is that their vegetation, soils and hydrology must always be adapted to, or otherwise respond to, the physical forces which drive the retreat of shoreline -- rising sea level, storms, wave-driven currents and wind. We are learning that most natural ecosystems of barrier islands are capable of surviving sea level rise, storm flooding and sand migration. Those islands which are migrating the most rapidly are dominated by vegetation types which are well-adapted to such migration. These communities are unique in that they can respond to powerful forces without being destroyed by these forces. The barrier island ecosystems may not remain in the same place over time, but they have persisted and will continue to persist, through time. It is by understanding how these natural communities are adapted to barrier island migration that we will be able to manage these lands more effectively.

BARRIER ISLAND MIGRATION

The evidence -- marsh peat on beaches, stumps in tidal marshes and buried marshes -- shows clearly that most Atlantic barriers are retreating. The rise of sea level since the Pleistocene has been the underlying force behind this regression. Yet, while the mainland may

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be drowned, barrier islands and their vegetation can move and survive. The basic mechanisms by which the barriers retreat are overwash, inlet dynamics and dune migration. During overwash, storms drive ocean water over the beach, through or over dunes, and then across the island. This water may carry sand directly off the beach, or in many cases from frontal dunes. The sand is then deposited in the form of fans or terraces on the vegetation behind the beach.

Inlets, on the other hand, move sand through a barrier island system; when an island is broken by an inlet, the sand carried into the inlet by littoral currents is deposited as shoals. In time, these shoals build up until they are nearly exposed at high tide. Eventually, most of the inlets that form along a rapidly retreating beach system close, and the shoals and overwash deposits become new substrate for vegetation. In most cases, vegetation is necessary to start a dune and to hold the dunes in place. Even when dunes are stabilized for some time, natural forces or human disturbance may break the dune and start the sand moving again. Wherever barrier beaches exist, dunes will form, and they are as integral a part of the whole system as are overwash and inlets.

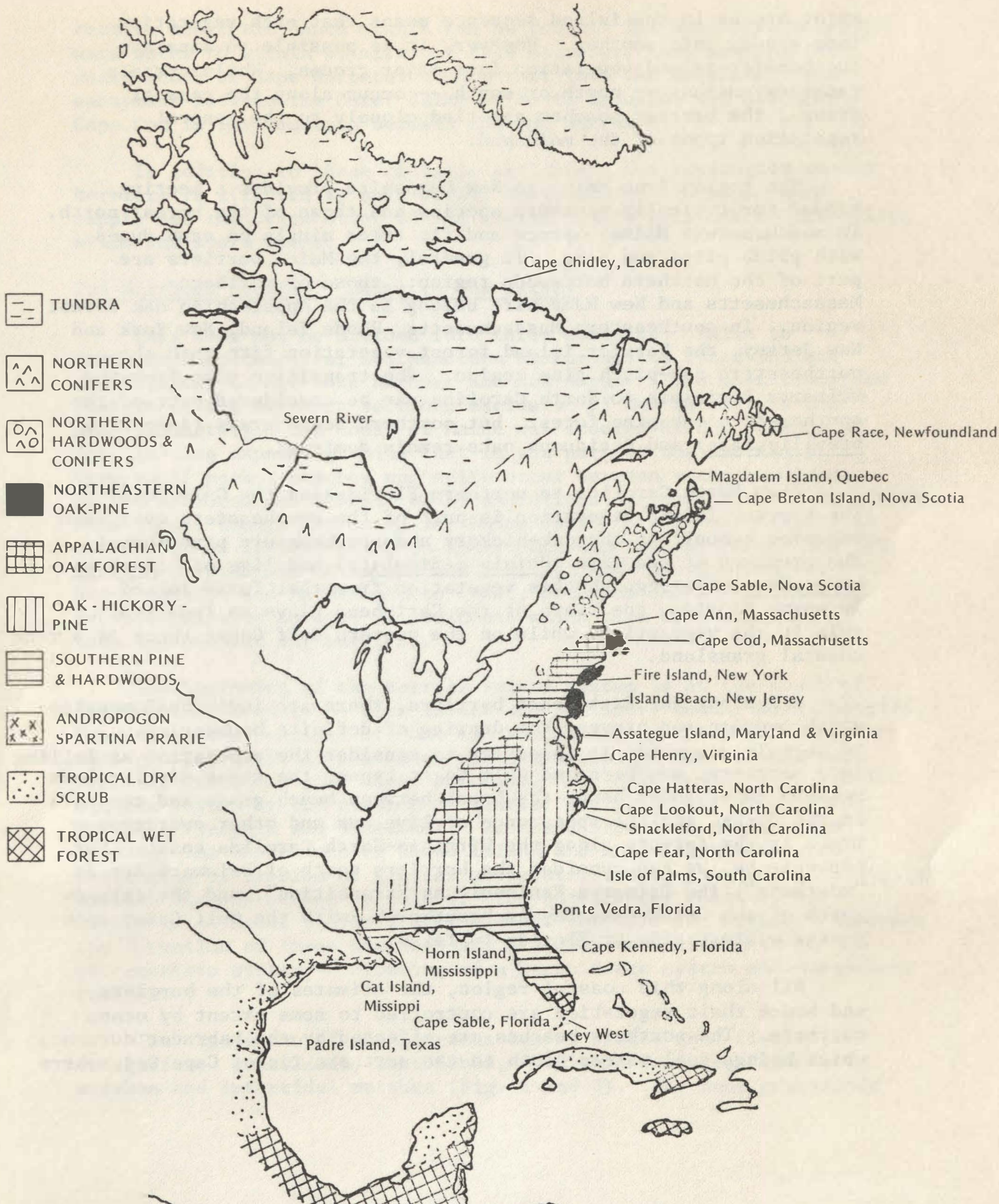
It is important to note that all three processes of retreat do not share equal importance along the East Coast. In some areas, as will be seen below, dune building and migration are the most significant processes. In others, overwash and inlets are more important than dune formation. And, as might be expected, there are many places where all three are important, their relative significance varying within just one barrier chain depending on orientation, sand supply, and storm exposure. An essential part of barrier island research is to learn what these small-scale differences are, and how they could affect management.

Corresponding to variations in physical processes are the different ecological responses to these processes. It is therefore necessary to determine how plants respond to the physical forces all along the East Coast, since plants interact with the physical forces that form the barriers to play a major role in determining the physiography of the islands.

ECOLOGICAL ZONES

Barrier spits and islands of the East Coast cross the major vegetation zones of eastern North America from Maine to Texas (Fig. 1). Throughout this extensive region there are gradual changes from one vegetation type to another, resulting in physiographic variations all along the chain. The fact that there are no

Figure 1 Vegetation of the east coast of North America.



major breaks in the island sequence means that each vegetation type grades into another. However, it is possible to separate the barrier island vegetation into major groups. While certain range extensions -- north or south -- occur along the coastal fringe, the barrier beaches are tied closely to the general vegetation types of the mainland.

The region from Maine to New Hampshire provides a meeting ground for typically southern species and those of the boreal north. In southeastern Maine, spruce and fir trees mingle on sand dunes with pitch pines and oaks. In general, the Maine barriers are part of the northern hardwoods region; those of northern Massachusetts and New Hampshire belong in the Appalachian oak forest region. In southeastern Massachusetts, Rhode Island, New York and New Jersey, the barrier island forest vegetation fits into the northeastern oak-pitch pine region. The transition zone from the Delmarva Peninsula to North Carolina can be considered part of the southeastern oak-pine forest, but northern beach grass (*Ammophila breviligulata*) and deciduous oaks remain dominant.

From North Carolina to northern Florida and the Gulf Coast, the barrier island vegetation is part of the southeastern evergreen oak-pine subunit of the oak-hickory and southeastern pine forest. The presence of sea oats (*Uniola paniculata*) and live oak (*Quercus virginiana*) distinguish this vegetation from that found inland. In south Florida, the flora of the Caribbean plays an important role in the vegetation, while on the western Gulf Coast there is a rich coastal grassland.

All along the East Coast barriers, there are individual species which overlap and prevent the drawing of definite boundaries. In certain respects, it is easier to consider the vegetation as falling into northern, southern and Gulf Coast types, the major distinctions between these zones being the break between beach grass and sea oats in the dunes, and the appearance of live oak and other evergreen trees in the forests along the Virginia-North Carolina coast. For convenience, we can consider the barriers north of Delaware Bay as "northern", the Delmarva Peninsula as "transition", and the islands south of the Chesapeake Bay as "southern", with the Gulf Coast zone on the western side of Florida to Texas.

All along this coastal region, the climates of the barriers and hence their vegetation are controlled to some extent by ocean currents. The northern beaches are affected by the Labrador current, which brings cool waters south to the northern tip of Cape Cod, where certain subarctic beach plants can be found. The Gulf Stream brings warm water to within 40 miles of Cape Hatteras, thus keeping the coast south of Cape Hatteras much warmer than the mainland. The embayment between the Outer Banks of North Carolina and southern Cape Cod is intermediate between the two extremes.

In addition to these climatic variables, the vegetation on the barriers is affected by salt spray, frequency of overwash, sand supply and the orientation of the barrier beach relative to prevailing winds and storm waves.

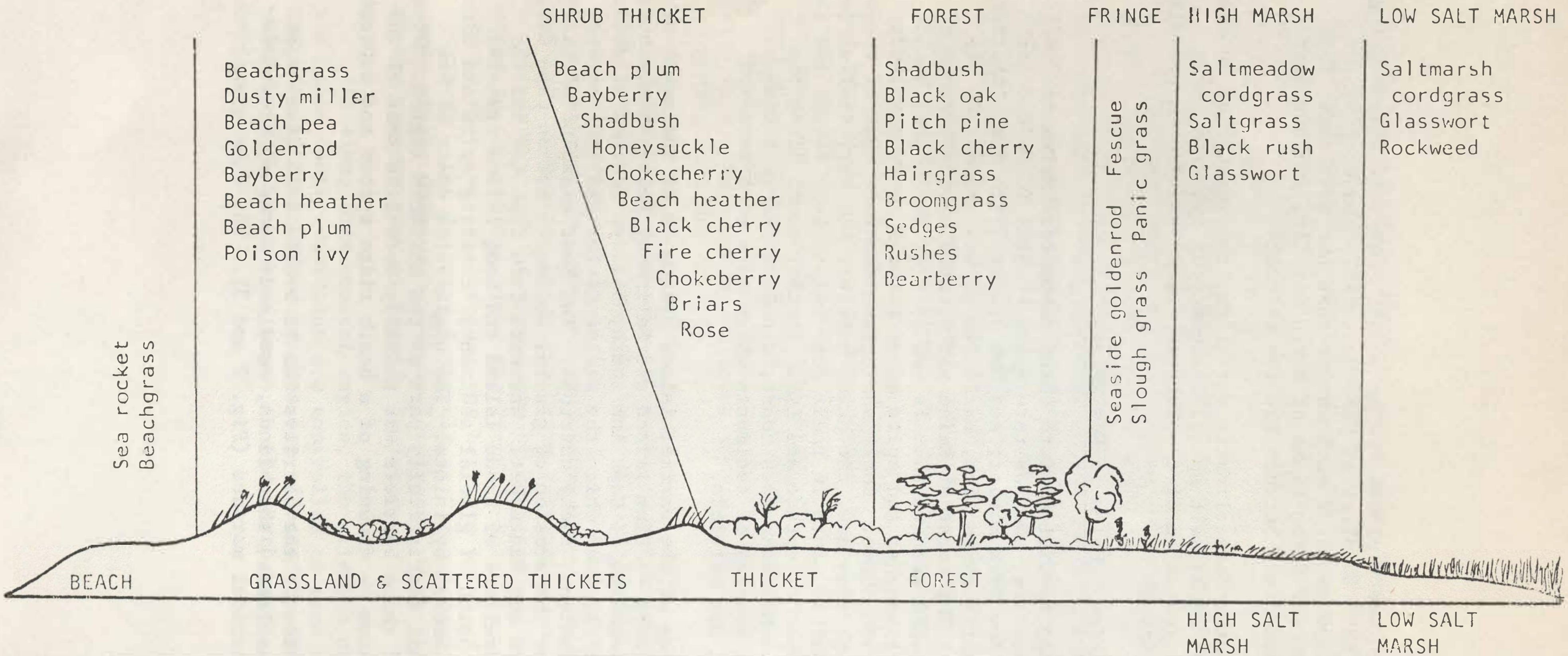
The Northern Section: Maine to New Jersey

This zone may be divided into three subunits: Maine to northern Massachusetts; southeastern Massachusetts (Cape Cod and the islands) to New York Harbor; and New Jersey. The most important feature of the northern section, exclusive of New Jersey, is its glacial history. The coast of Maine was scoured by the passage of ice, leaving exposed granite that is now part of the shoreline. Here small pocket beaches and spits occur between rocky headlands on the southeastern shore. Rocky shorelines dominate east of Penobscot Bay. Small though they are, the Maine barriers are very similar to their cousins further south in their dune vegetation, except for the occasional presence of spruce and fir. Further south along the New Hampshire and Massachusetts coast, drumlins and morraines provided massive sources of sediments which have been reworked into the present day barriers.

The beginning of the barrier island system is at the mouth of the Merrimac Estuary -- Plum Island and Salisbury Beach, Massachusetts. From the rocky headland of Cape Ann south, barrier beaches alternate with glacial cliffs, from which the sediments for the beaches were derived, and occasional rocky outcrops. The best examples of barrier beaches formed by the erosion of glacial sediments are on Cape Cod, Martha's Vineyard and Nantucket. Westward from Cape Cod and the islands, the shorelines of Rhode Island and Long Island are also the result of erosion of glacial sediments, creating spits and elongated barrier beaches broken by inlets. The unglaciated coast of New Jersey is at least floristically part of the northern region. However, the formation of these barriers was probably more like that of the southeastern system -- drowning of a beach ridge system and subsequent recession.

The vegetation of the barriers can be broken into five major categories: grasslands, shrublands, woodlands/forests, freshwater marshes and intertidal marshes (Fig. 2 and 3). The dune grasslands

Figure 2 General transect across Plum Island, Massachusetts.



Beachgrass - Ammophila breviligulata
Dusty miller - Artemesia stelleriana
Beach pea - Lathyrus japonicus
Beach heather - Hudsonia
Bayberry - Myrica pensylvanica
Poison ivy - Rhus radicans
Chokecherry - Prunus virginiana
Black cherry - Prunus serotina
Broomsedge - Andropogon scoparius
Pitch pine - Pinus rigida
Lichen - Cladonia
Honeysuckle - Lonicera Morrowi

Goldenrod - Solidago sempervirens
Beach plum - Prunus maritima
Hairgrass - Deschampsia flexuosa
Briars - Smilax
Rose - Rosa rugosa & R. virginiana
Shadbush - Amelanchier
Chokeberry - Aronia melanocarpa
Fire cherry - Prunus pensylvanica
Salt marsh cordgrass - Spartina alterniflora
Salt meadow cordgrass - Spartina patens
Panic grass - Panicum virgatum
Slough grass - Spartina pectinata
Fescue - Festuca rubra

Northeast:

Ammophila → Arctostaphylos   Pinus rigida   Fagus
Cakile   Lathyrus → Quercus ilicifolia → Quercus velutina →
Solidago → Amelanchier → Quercus alba →
Xanthium   Vaccinium corymbosum → Vacc. vacillans   Acer rubrum
Hudsonia → Prunus serotina → Sassafras
Lechea → Comptonia   Epigaea repens   Mitchella
Myrica pensylvanica → Gaultheria →
Prunus maritima → Juniperus   Chimaphila
Rhus toxicodendron →
Parthenocissus →

Fire Island:
Ilex opaca
Amelanchier
Sassafras

Southeast:

Uniola → Ilex vomitoria →   Quercus virginiana
Cakile →   Andropogon → Callicarpa   Q. phellos
Euphorbia   Solidago   Parthenocissus   Juniperus →   Carpinus caroliniana
Sesuvium   Croton   ~~Iva imbricata~~ →   Ilex opaca
Physalis   Strophlostyles   Myrica cerifera →   Morus rubra
S. patens   Oenothera   Smilax →   Cornus florida

Persea borbonia
Quercus nigra
Pinus taeda
Xanthoxylem

Figure 3 Generalized zonation of maritime vegetation (and possible successionary trends with a widening beach).

are dominated throughout by beach grass (Ammophila breviligulata), best developed in the more northerly section. The beach grass does best where new sand is moving into the community, spreading rapidly in the direction of the sand source and developing a vegetative cover. The result is rather continuous dunes close to the beach. Other species include seaside goldenrod (Solidago sempervirens), dusty miller (Artemesia stelleriana), poison ivy (Rhus radicans) and beach pea (Lathyrus japonicus). The more stable dunes frequently support a heath-like community of low shrubs: bearberry (Arctostaphylos uva-uris), beach heather (Hudsonia), crowberry (Corema) and pinweed (Lechea). This heath vegetation is one of the more characteristic features of the northern beaches.

The woodland vegetation is deciduous, except for the pines and junipers. In addition, this northern vegetation contains many members of the rose family -- beach plum, cherries, shadbush, and wild roses. The dominant hardwoods are oaks -- black (Quercus velutina) and white (Q. alba). Pitch pine (Pinus rigida) is found throughout. On some old and long stabilized dunes of Cape Cod, a mixed deciduous forest (thought to be climax vegetation) of beech (Fagus grandifolia), red maple (Acer rubrum), shadbush (Amelanchier), sassafrass (Sassafras albidum), black oak and white oak survives. On the south shore of Cape Cod, a typical southern species, American holly (Ilex Opaca), makes its appearance; it becomes more important on Fire Island and Sandy Hook, New Jersey. Excellent stands of this southern forest tree are protected within the National Parks on these barriers.

Fresh wetlands on the barriers are generally found between dunes or where blow-outs have reached the water table. In these communities, cattails (Typha) and reeds (Phragmites) dominate the marshes; azaleas (Rhododendron), blueberries (Vaccinium), alders (alnus), arrowwood (Viburnum), the shrub swamps; red maple (Acer rubrum) and tupelo (Nyssa sylvatica), the tree swamps. Tupelo, another southern species, goes as far north as the coast of southern Maine.

The salt marshes are typical of most of the East Coast, except that the high marsh of salt meadow cordgrass (Spartina patens), and salt grass (Distichlis spicata) is more extensive in the north; pannes or depressions in the high marsh are much more prevalent; and macroscopic brown algae -- rockweed (Fucus) and knotted wrack (Ascophyllum) are mixed with the Spartina alterniflora plants. The low marsh flooded by daily tides is dominated by S. alterniflora as in the south.

The general physiography of these beaches is one of well developed dune lines rather close to the beach. There is little in the way of barrier flats, although Fire Island has some regions which look more like southern beaches in this respect.

The Transition (or Central) Section: Delmarva Peninsula

On the Delaware coast a major change occurs in the vegetation and the physiography of the islands. Here the barriers are typically southern in their appearance: are relatively wide, with low dunes and extensive barrier flats. (This description does not apply to the few southern beaches with extensive dunes, to be mentioned later.) The dune grasslands are still dominated by beach grass, but it does not have the vigor that it shows further north. Of considerable importance is the appearance of the southern form of salt meadow cordgrass (Spartina patens var. monogyna) in the dunes and barrier flats of this area. The tall, upright form of S. patens does occur up to the New York shore, and even on Cape Cod, but it does not have the dominance it begins to achieve on the Delmarva coast. In the north, S. patens is mainly a plant of the high salt marsh, but in the south it occurs in the high marsh, on the barrier flats and on the dunes, and in all of these locations it plays an important role in overwash recovery.

The evergreen nature of the southern forests becomes increasingly evident as one goes south in Delmarva. The evergreen red bay (Persea borbonia) mixes with holly to create an evergreen hardwood forest. Red cedar (Juniperus virginiana) and Loblolly pine (Pinus taeda), evergreen conifers, are also significant members of the forest. Deciduous oaks, red maple and tupelo are other common trees. Loblolly pine forms extensive forests of considerable interest on Parramore, Assateague and Smith Islands. Such woodlands are also to be found scattered on certain wide or stabilized islands. For the most part, the Delmarva barriers are more like their counterparts to the south in showing the regular effects of overwash, and in being dominated by grasslands.

Fresh water wetlands of cattails and sedges occur on the larger islands. Regular overwash precludes the formation of fresh water wetlands in most places; those that do exist appear to have formed in interdunal low regions during the development of the dune fields.

Salt marshes here are extensive and well developed. The low marsh of Spartina alterniflora takes on more significance here than in the north, and there are many fewer pannes in the high marsh. The appearance of black needle rush (Juncus roemerianus) in the high marsh links this region with the south. As in the north, Spartina patens and Distichlis spicata are also common in the high marsh.

The Southern Section: North Carolina to Florida.

The great range of environmental conditions along the southeastern United States permits the division of this section into smaller subunits: the Outer Banks; Beaufort Inlet to Cape Romain; the Georgia embayment; and Florida. Of these regions, the Outer Banks are the most exposed to oceanic storms, and thus show the greatest rate of retreat. These islands are wide, low and flat with only certain areas having well developed dunes where orientation and sand supply permit. West of Beaufort Inlet, the barriers are close to the mainland and generally more protected. As a result they have well developed dune lines and forests. These barriers are oriented across prevailing winds and thus have a favorable dune building environment. Some islands are more related to the mainland, both geologically and floristically.

The Georgia embayment is the most protected section of the coast except for the occasional direct hit by a hurricane. Wave energies on the average are low. This shoreline consists of "sea islands", once part of the mainland and made up of Pleistocene deposits with a Holocene beach. As a result, these barrier islands have well developed soils and are relatively high and well forested. (The Outer Banks and barriers further north are entirely of Holocene age.) Along many of these southern barriers well developed dunes exist, while on others, dunes may be lacking entirely and the forest hit directly by storm waves. Overwashes occur along this section infrequently and in only the lowest areas. The coast of Florida is much like an extension of the sea island system, but more typical barrier beaches have formed between Jacksonville and Cape Kennedy. From there south, the barrier beaches have been developed as resorts and their natural character is difficult to determine. South of Miami, mangrove swamps and limestone outcrops mix with carbonate sand beaches.

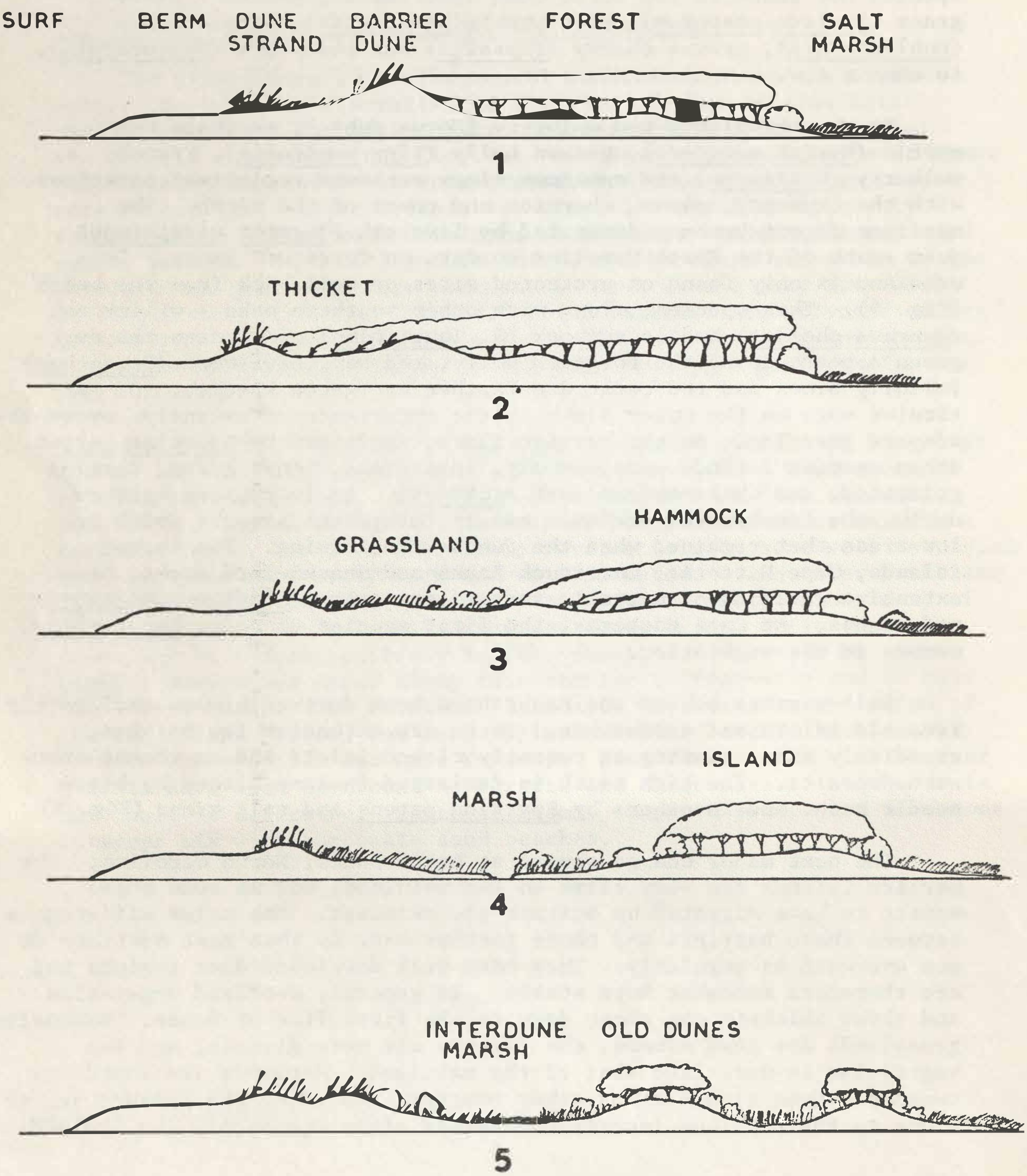
The major vegetation changes begin on the northern Outer Banks where sea oats take over dominance of the dune grassland (Fig. 3). Sea oats is the typical dune species of the southern United States coast, although beach grass has been planted well down onto the Banks. Other grasses also gain more importance; in some areas, Spartina patens shares dominance with sea oats. Numerous other species not found in the north come into the vegetation - panic grass (Panicum amarulum), love grass (Eragrostis), purple muhly (Muhlenbergia), ground cherry (Physalis) and pennywort (Hydrocotyie), to name a few.

In the shrublands red mulberry (Morus rubra), southern wax myrtle (Myrica cerifera), yaupon holly (Ilex vomitoria), French mulberry (Calicarpa) and numerous vines exchange ecological positions with the bayberry, plums, cherries and roses of the north. The maritime forest becomes dominated by live oak (Quercus virginiana) just south of the North Carolina border, on Currituck Banks. This woodland is only found on protected sites or well back from the beach (Fig. 4). This species, along with other southern oaks - willow oak (Quercus phellos) and laurel oak (Q. laurifolia), increases the evergreen appearance of the forest. Holly, red bay, devilwood (Osmanthus), loblolly pines and red cedar are further evergreen species. Of particular note on the Outer Banks is the occurrence of extensive overwash-adapted grasslands on the barrier flats, dominated by Spartina patens. Other species include purple muhly, love grass, panic grass, seaside goldenrod, and chairmaker's rush (Scirpus). As in regions further north, the fresh water wetlands are in interdunal sloughs which are low areas that remained when the dunes were forming. The larger islands, Cape Hatteras, Currituck Banks and Shackleford Banks, have extensive wetlands of cattail, sedges, saw grass (Cladium jamaicense) and rushes. At Cape Hatteras, the first species of palm, Sabal minor, occurs in the vegetation.

Salt marshes behind the Banks have been derived almost exclusively from old inlets and overwashes. There are extensive low marshes, especially near existing or recently closed inlets and on recent overwash deposits. The high marsh is dominated in some places by black needle rush, and in others by Spartina patens and salt grass (Fig. 5).

The next major change occurs at Bogue Banks, North Carolina. The barrier islands are very close to the mainland, and in some cases appear to have migrated up against the mainland. The major differences between these barriers and those further east is that most sections do not overwash as regularly. They have well developed dune systems and are therefore somewhat more stable. In general, woodland vegetation and shrub thickets can occur down to the first line of dunes. Extensive grasslands are less common, the forests are more diverse, and the vegetation is more like that of the mainland. Wetlands are found between the dune ridges as on other barriers and since the islands are so close to the mainland intertidal marshes often occupy all the lowlands

Figure 4 Typical forest profiles on barrier islands. (SOURCE: Godfrey and Godfrey.)



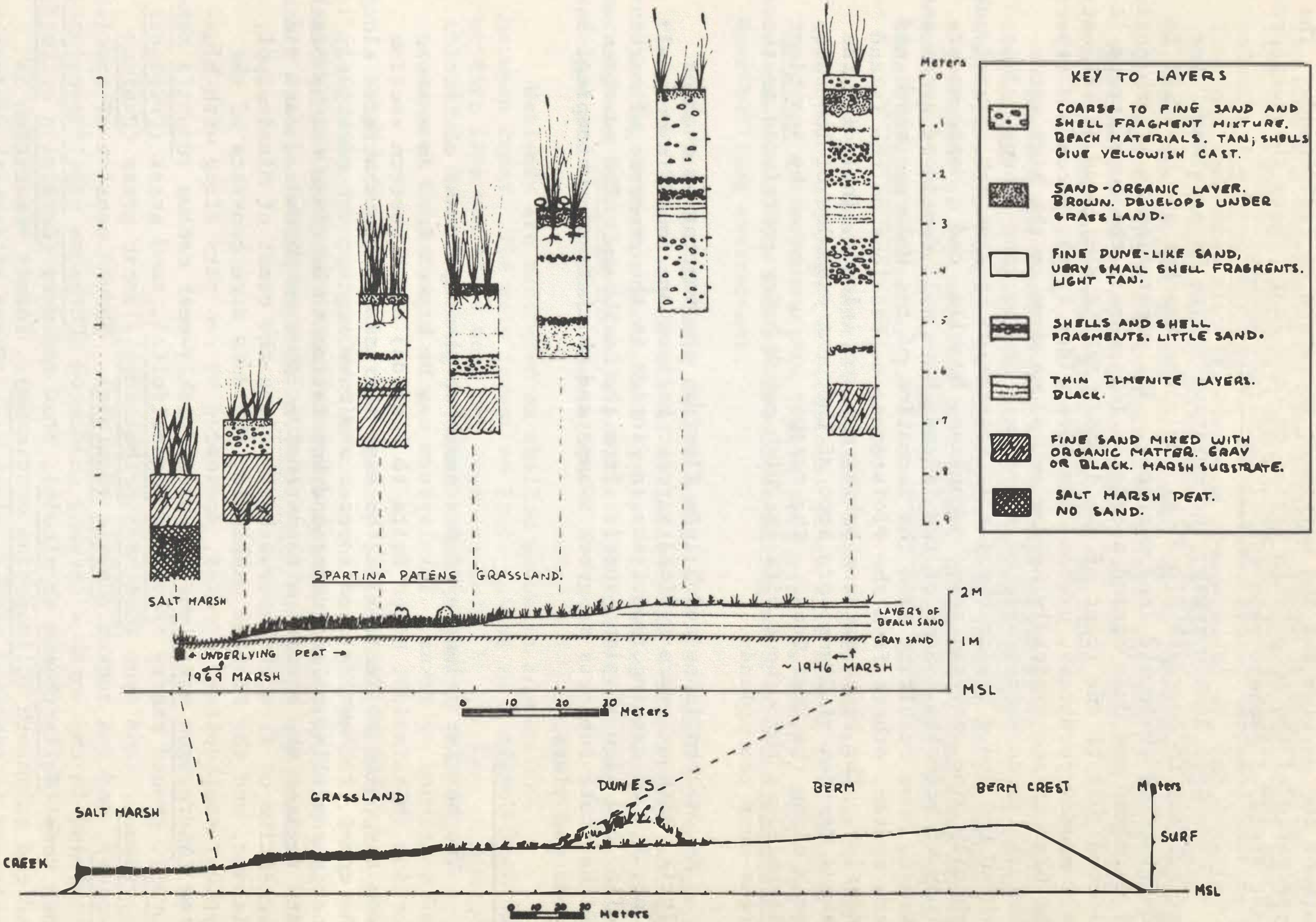


Figure 5 Transect profile across Core Banks at Codds Creek indicating low and high marsh vegetation.

between the barrier and the mainland; there are no real sounds. The appearance of the Deep South begins on Cape Fear, where the northernmost stand of cabbage palm (Sabal palmetto) occurs.

From Cape Romain south, the relatively high "sea islands" are not subject to overwash flooding. Holocene beaches are "welded" to the front of these old land surfaces. The vegetation is a combination of mainland and dune strand species. In general, the dune strand is limited just to the front of the islands and is dominated by sea oats, salt meadow cordgrass, croton, seashore elder (Iva), yucca and others. The beaches are typically narrow and slope down to the high water mark, as is characteristic of shorelines of low wave energy. Just behind the dunes begins the forest vegetation of live oak, laurel oak, loblolly pine, cabbage palm, magnolias, bumelia, and a dense understory of palmetto. Some of the islands have well developed ponds and swamps, some resulting from the formation of the Holocene beach and dune system, others from the Pleistocene depressions on the island interior. The broad marshes behind the sea islands, including the famous Marshes of Glynn, are some of the best examples of low salt marsh along the East Coast. The marshes are dominated by Spartina alterniflora throughout with the high marsh being restricted to those areas near the uplands.

As one continues south into Florida, the vegetation changes little, although more typical barrier beaches are found in central Florida. Of growing importance in Florida is the presence of carbonate soils, and also of plant species from the Caribbean. The southern end of the state supports mangrove swamps and thickets of subtropical hardwoods and vines.

The Gulf Coast:

The barrier island system resumes on the west coast of Florida and continues to Texas. This system can be broken into an eastern section (Mississippi River Delta to Florida) and a western section from the Delta to Texas. In the east the islands are scattered along the coast, reflecting sand sources and wave regime; the relatively low energy coastline allows dunes and vegetation to be close to the beach. Many regions are barren, with extensive low sand dunes and sand flats suggestive of frequent overwashes. Along the coast of Mississippi, Alabama, and the Florida panhandle, the dune zone consists of the typical southeastern species, dominated by sea oats along with bluestem (Andropogon maritimus), croton, pickly-pear cactus (Opuntia pescorvi), ground cherry (Physalis angustifolia), sand grass (Triplasis americana), sand spur (Cenchrus tribuloides), panic grass (Panicum repens), and sea rocket (Cakile edentula). Shrubs consist of species not found in the north - shrubby goldenrod (Chrysoma pauciflosculosa), rock rose (Helianthemum arenicola), sand rosemary (Ceratolia ericoides) and red calaminth (Clinopodium coccimeum). Forest vegetation is scattered in isolated groves: slash pine (Pinus elliottii) dominates the woodland vegetation on many islands, where it occurs with sand live oak (Quercus geminata), myrtle oak (Q. myrtifolia), and sawtooth palmetto (Serenoa serrulata). In isolated spots, hardwood forests of live oak, hercules club (Xanthoxylum clava-hercules), and bumelia (Bumelia), are mixed with palms and yaupon holly. Extensive salt marshes, the largest on the East Coast, exist throughout the Mississippi Delta region. They are dominated by several species of cordgrass (Spartina), with S. alterniflora being the most important. Numerous other grasses and rushes grow with the Spartinas.

West of the Mississippi, the barrier chain is well developed from Port Arthur to Brownsville, Texas, with Padre Island illustrating characteristic features of the coast. This barrier is dominated by a grassland of sea oats and salt meadow cordgrass, along with croton, sand spur, beach evening primrose (Oenothera humifusa), and railroad vine (Ipomoea stolonifera).

The low energy shoreline allows dune vegetation to grow on the open beach, although the occasional storm will remove this growth. The dunes are relatively well developed with few breaks, since the orientation of the island across prevailing winds creates a favorable dune-building environment.

The interior of Padre Island consists of low dunes and extensive flats; the latter may be either deflation plains or overwash terraces depending on recent geological events. Blue-stem (Andropogon scoparius), cordgrass (Spartina patens), prairie with numerous forbs, grasses and sedges are the dominate vegetation.

Wetlands are scattered as shallow ponds in depressions or between dunes. The only forest on Padre Island is a small stand of five live oak trees near the southern half; it has been suggested that human use and grazing pressure caused a general decline of the natural forest vegetation.

High salinity levels that develop behind Padre Island in Laguna Madre have precluded the successful establishment of salt marsh, so the western shore of Padre Island is a sandy beach with low dunes. Halophytes such as Salicornia and Batis are common.

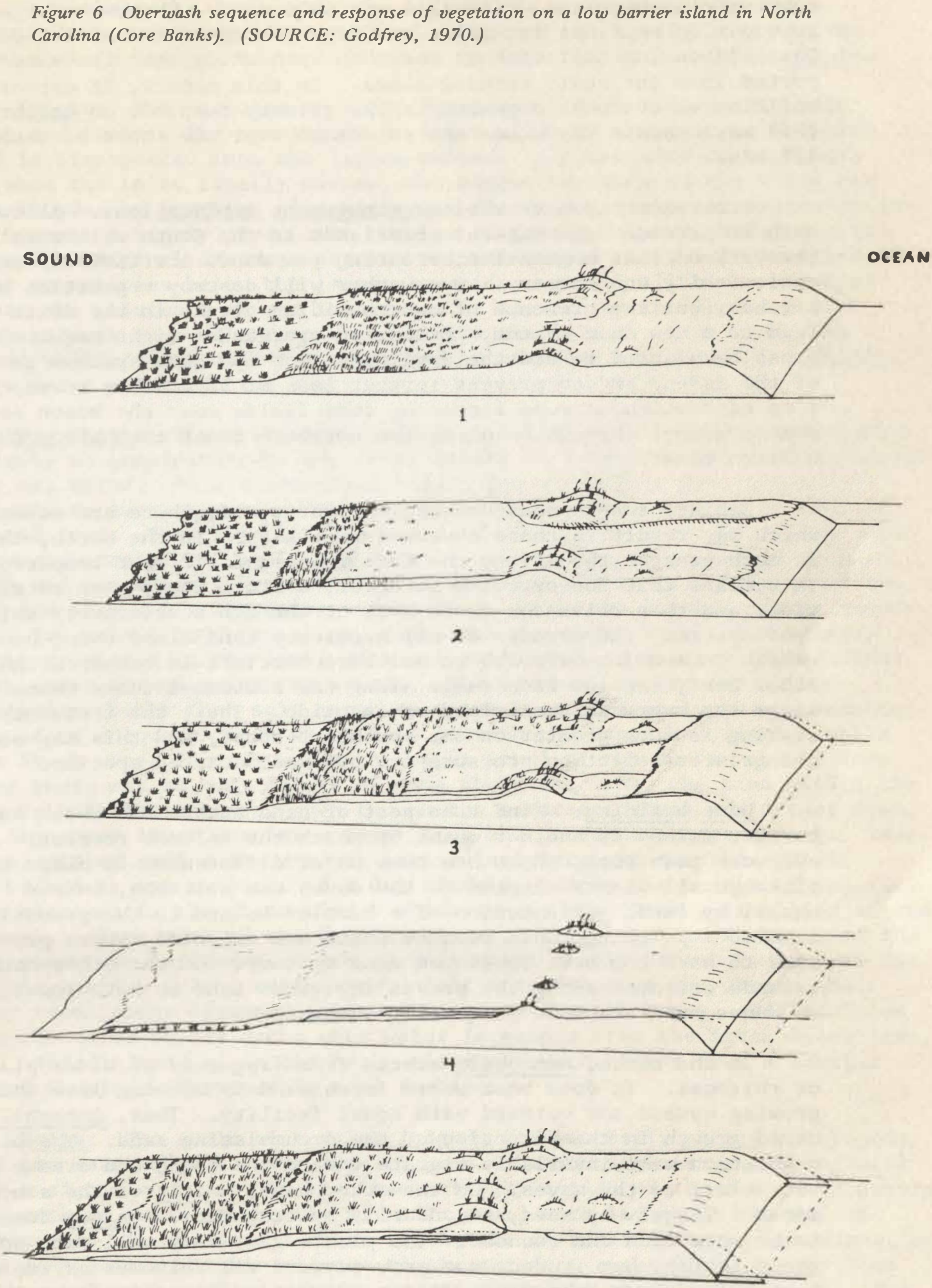
Response of vegetation to physical processes:

Overwash: During the past eight years my students and I looked into the response of vegetation to oceanic overwash on the Outer Banks. This has recently spurred interest by other workers, and we are now getting a good picture of the abilities of certain communities to recover from overwash burial. However, we have recently seen that there are important differences between the responses of northern and southern plants.

In the Southeast, particularly the Outer Banks, the grassland that is buried by overwash deposits - sometimes up to 0.5 m or more - shows a remarkable ability to push up through the sediment layers and recolonize the surface (Fig. 6). The most important species in this process is Spartina patens var. monogyna, or what we have casually called the "southern form." S. patens grows rapidly and within one year can revegetate an overwash deposit as long as vegetation was previously present. Recent studies by Dr. Richard Travis on Cape Hatteras have shown that as many as 20 species of plants are in some way adapted to, or tolerant of, overwash. Even where overwash occurs into relatively stabilized shrub vegetation, there are species that can respond and soon revegetate the overwash deposit, and begin forming new dunes. The presence of rapid response to overwash seems to be associated with the ecological range of overwash adapted species such as Spartina patens. It is possible that the extensive barrier flats of the Southeast may result from the fact that this grassland vegetation can recolonize an overwash area quickly and thus prevent excessive loss of sand by deflation and transport into the dunes. In addition, the high proportion of shells in the sand results in a "pavement" following deflation; this helps prevent further sand loss. When overwash goes into the lagoon behind the barrier, it is quickly colonized by salt marsh cordgrass and other marsh species.

In the north, however, we have seen a rather different response to overwash. There are no plants that show the same overwash adaptations as in the south. It may be that natural selection for this adaptation has not been a factor in the evolution of the northern flora. Yet overwashes do occasionally occur, especially during major storms, and on those beaches that are being built by littoral transport. (We also recently obtained samples of salt marsh peat from 3 m below the base of a dune line on Nauset Beach (Cape Cod); this stratigraphic record provides strong evidence that the northern beaches are retreating much like the southern ones.) When an overwash occurs, all plants so buried die, including the Spartina patens. The redevelopment of vegetation takes a rather different path than in the South. The northern oceans are laden with macroscopic algae, eelgrass and other marine detritus. In addition, the proximity of dunes to the beach means that dunes are often eroded away and the beach grass plants they contained are carried about by the waves. Following an overwash, wind-rows of organic drift are left behind on the new surface. The wind soon covers this drift with sand. Mixed with the algae, eelgrass, and other materials are the fragments of plants washed out of dunes elsewhere. As soon as the growing season begins, these fragments start growth and soon a line of beach grass plants, dusty miller, goldenrod and beach pea appears where formerly there was only drift. Since most dune species can survive fragmentation, they are well adapted to this type of transport. Eventually, a new dune

Figure 6 Overwash sequence and response of vegetation on a low barrier island in North Carolina (Core Banks). (SOURCE: Godfrey, 1970.)



zone exists where the drift line was laid down. Thus, the vegetative recovery is somewhat irregular and does not cover the entire deposit. This allows for deflation to occur in such a way that the sand is transported into the newly forming dunes. In this manner, it appears that dune building on overwash deposits is the primary response on northern beaches; this may explain why dunes are so common over the whole of these barrier islands.

Such patterns have obvious management implications. Allowing overwash to procede onto natural grasslands in the South will result in rapid recovery of that vegetation; creating new dunes artificially may be ecologically unnecessary. Overwashes will destroy vegetation of northern beaches, but the presence of dune building plants in the drift will soon lead to a new dune system. Extensive overwashes might require that beach grass be planted to aid the development of new dune systems in the interior of the island and to prevent further loss of vegetative cover. The formation of continuous dune lines and dune fields near the beach seems to be a more normal phenomenon along the northern coast than along the southeastern coast.

Besides the response of vegetation itself, there are other circumstances which may result in these observed responses. In the North, the tide range is much greater than along the Carolina coast (12 feet compared to 3 feet). This means that for overwash to occur, a storm would have to arrive at high tide, and then drive the waves over or through a relatively well developed dune system. The chances of all necessary conditions being present to result in a major overwash on northern barriers is rather slight. On the other hand, the low tide range along the southeast coast means that a major storm can overwash the island at any tide. Thus, the frequency of overwashing is much greater on the southeast coast, and this may account for the greater selection pressure for overwash adapted species.

Dune building: Wind transport of sand across the beach and into the barrier island is another means by which the islands retreat. As with the overwash transport, there are some major differences in plant response, although all plants adapted to the dunes can tolerate, indeed "prefer," burial by sand. Orientation of a barrier island to the prevailing winds is also important; those beaches which are oriented across prevailing winds tend to have the best developed dune systems. On the other hand, the islands oriented along the prevailing winds tend to have lower, more scattered dunes, and are more frequently overwashed.

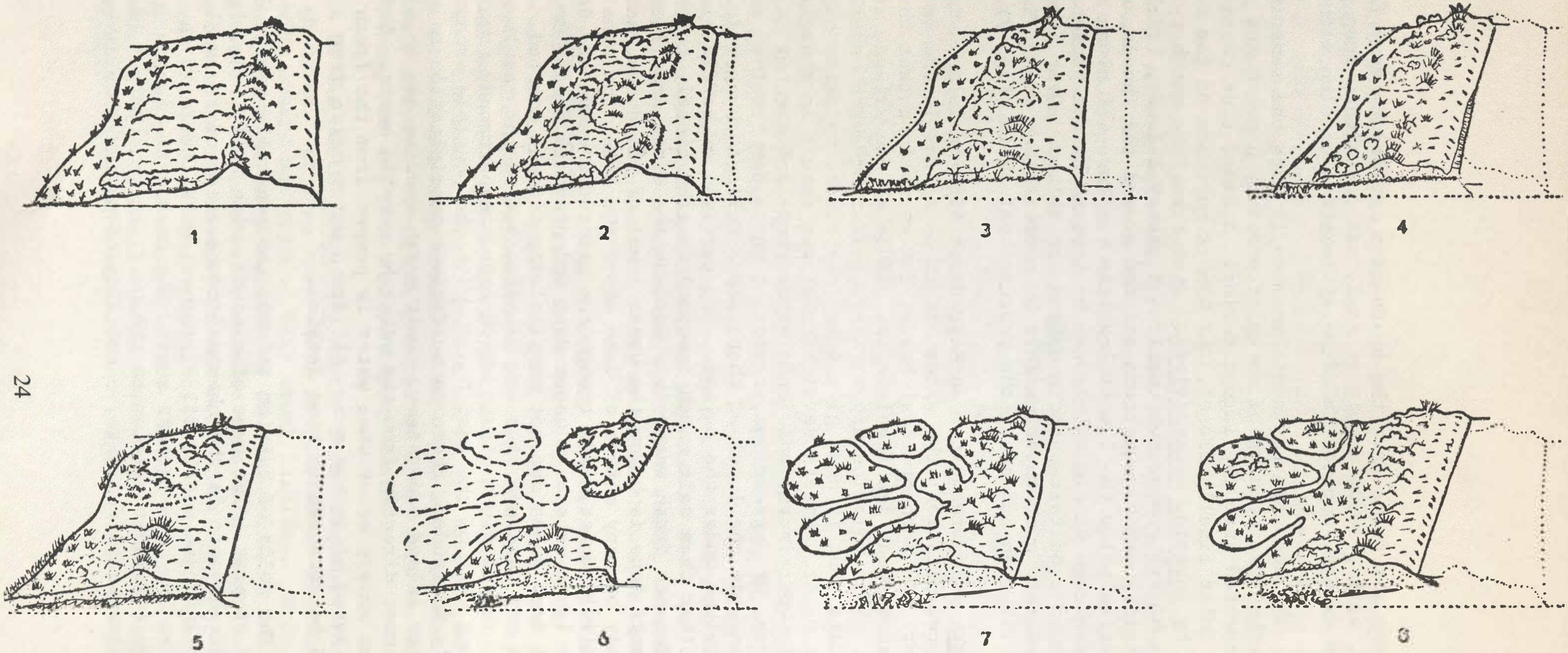
In the north, *Ammophila* starts from fragments of older plants, seeds, or rhizomes. It does best where fresh sand is blowing into the stands, growing upward and outward with equal facility. Thus, *Ammophila* dunes show rapid growth in the direction of the accumulating sand. The beach grass vegetation will invariably migrate toward the beach and create a dune line very close to the waves. On the other hand, *Uniola* of the southeast coast spreads largely by seed, secondarily by fragments. *Uniola* dunes also tend to be more open and rounded. The plants grow very well with upward sand accumulation, but it does not grow outward via rhizomes as rapidly as *Ammophila.* Thus, the dunes do not migrate so dramatically toward the beach;

and storms keep the dunes near the beach from developing very far. Nevertheless, with a ready supply of sand, and relatively long periods between storm damage, substantial dune systems can develop with Uniola.

Inlets: The response to inlet dynamics is much the same in both North and South. The opening of an inlet provides a new means by which sand is transported into the lagoon behind. A flood tide delta forms, and when the inlet finally closes, the higher portions of the delta are soon invaded by *Spartina alterniflora*. Over time, the marsh system builds and becomes a highly productive complex of grassy islands, tidal creeks where the original drainage pattern existed around the shoals, and underwater communities below the lowest low tide region. All along the East Coast, the existence of old inlets can be spotted by the presence of marsh islands in a deltaic pattern behind the island. Over time, the island will migrate over these marshes by overwash and wind. Eventually, a new inlet will open and start the process over again (Fig. 7).

Hydrology: The freshwater on East Coast barrier islands is dependent entirely on precipitation; the water exists as a lens in the sand "floating" over sea water. On a theoretical basis, for every foot that the water table rises above mean sea level in the middle of the island, it extends down 40 feet. This relationship varies considerably with underlying sediments and strata, but it does give some idea of the relationship between fresh and sea water. Excessive withdrawal can result in reduction of the lens and salt water intrusion. Open water ponds and marshes in the interdunal low areas, or depressions, represent the upper level of the lens. Slight decreases in the level of these ponds reflect changes in the total fresh water volume under the island. The survival of barrier island vegetation (other than salt marsh species) is tied closely to the maintenance of an adequate fresh water lens beneath the dunes and flats. While this fresh water lens is below the upper level of the dunes, and in some cases there may be many meters of dune above the lens, the sand within the dune is relatively moist, even though the saturated sands are deeper down. The dry upper layer acts as a vapor trap and prevents deeper drying. Thus, the plants of sand dunes are not particularly drought adapted. Their succulence is not evidence of a dry climate, but is the result of chloride accumulations in the plant tissue which causes hypertrophy (swelling of the tissue). Along most of the East Coast, with the possible exception of the most southerly latitudes, there is sufficient precipitation to support the typical barrier island ecosystems. Salt marsh species can obtain their water requirement directly from sea water by osmotic means. Difficulties with the water supply occur when water is pumped from the fresh water lens, used, and disposed of in the sea. All fresh water taken from a barrier island should be returned in some fashion.

Soils: The soils of barrier islands are generally poorly developed; most are sand or peat. The type of sand on which soil is developing will play a significant part in the chemical composition of the soil. In general, the northern sands are nearly all siliceous, with little in the way of carbonates. As one goes further south, the carbonate fraction increases, and thus adds more available calcium to the nutrient reservoir. In the Deep South, carbonate sands dominate, especially along the Florida coast. The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typical soil profile that develops on sand is the result of years of vegetative cover; it is best described as podzolic. As the vegetative cover increases, more organic material is added to the surface, from which organic acids are leached downward. This results in an ashy-white leached layer directly below the organic, or A, horizon. The leached materials are carried down into the sand where they accumulate in an orange or tan colored "zone of accumulation." The sandiness of the soil precludes any run-off and thus all the precipitation falling on the system drains down.

Old podzolic layers can frequently be found where migrating dunes have buried former woodlands, and then moved on. These exposed layers can be used to determine the location of former forests, long destroyed. The development of a podzolic profile depends on the relative stability of the surface, and many dunes have moved around enough, or the islands have washed over so frequently that the soil has not had time to develop.

On low barrier islands, overwash sediments can be incorporated into the soil horizon rather quickly where grasslands develop. The productivity from the grasses adds organic matter to the sand, and in a relatively short while a fairly substantial organic-sandy soil will form. These layers are often buried by later overwashes, and provide excellent markers for determining the previous surfaces of barrier islands, as we saw on Core Banks in North Carolina. In fact, a good test for determining whether a barrier is retreating by overwash is to look for soil horizons below the surface.

In terms of nutrients, silicious sands are notably poor, while carbonate sands are somewhat better. Barrier island soils are derived entirely from material carried onto the barrier by water and precipitation, and not from weathering of rock. The tremendous input of organic detritus to sand beaches is rapidly broken down by micro-organisms which are specific for agar and chitin in addition to the cellulose of higher plants. The seemingly empty sand beach is an important site for the recycling of nutrients, and without this recycling, beaches would soon be buried with drift. The major input of nutrients to the terrestrial vegetation is from salt spray and precipitation. Without this input, coastal vegetation would take much longer to develop. Henry Art showed that the forest on Fire Island developed in 300 years on siliceous sands, while similar forests along the Great Lakes would take thousands of years to reach the same stage. In addition to the salt input, many dune plants have the capacity to fix nitrogen from the air, as do many inland species. Beach grass, bayberry, and beach pea all have nitrogen fixing bacteria associated with them, and are important sources of nitrates for other plants.

The other major soil types are organic: peat and sandy peat. These soils form in fresh water wetlands or intertidal salt marshes. The salt marsh soils are the most common; the peat may form on silts, sands, gravels or even rock. Regardless of the underlying substrate, organic matter accumulates as the marsh grows upward in response to sea level rise. In the early stages, the peat will be mixed with the underlying sediments. As the marsh grows, pure organic matter eventually makes up the soil, and the peat is long lasting since decay rates are very slow in the anaerobic intertidal substrate. The peat formed by Spartina alterniflora may be recognized by fragments of the leaves that are present. When a high marsh begins forming on what was once low marsh, the peat that is laid down is much finer in texture than the low marsh. There is also more decay and therefore a more consolidated organic soil. This difference in peat types is very useful in determing the history of a salt marsh system, and for that matter a barrier island. Such material is further evidence that the barrier island is migrating, especially if found underneath existing dunes and beaches (Fig. 8).

Fresh water peats on these islands are similar in nature to salt water ones in that they form under anaerobic conditions, and thus they preserve the material from which they are derived. These peats will contain seeds, pollen, and plant fragments which have settled to the bottom of an acid bog or pond with limited drainage and been incorporated into the peat; they are good markers of the history of the wetland.

Salt spray: Another physical factor that markedly affects the distribution of plants on barrier islands is salt spray. Only the most tolerant plants can survive in the heavy spray zones of the beach and foredunes. The beach grasses, sea oats and other species found in the dunes are resistant to salt entry. As one goes further back from the beach, plants with less resistance are found, usually in the protection of dunes or other vegetation. Most forest species are not very tolerant of salt spray and thus have their best development behind barrier dunes, or in a forest community which has a dense, aerodynamic leading edge (Fig. 4). The active agent of salt spray is the chloride ion which enters the windward portions of a plant through cracks and lesions in the epidermis. The windswept form of coastal trees is the result of salt spray pruning. The presence of a dune system with salt resistant plants is essential if other, not adapted species, are to survive in the barrier island vegetation. Work by Oosting and Billings, and Stephen Boyce, clearly demonstrated the nature of salt spray zonation and plant damage.

Human impact on barrier island vegetation :

This topic can be the basis for a whole conference section in its own right, and certainly a full paper. We can only mention certain highlights here, and refer to some of our papers on the subject. European Man has influenced the vegetation of barrier islands since the first coastal settlements in the 17th Century. The early effects were in the form of grazing, clearing, and fire. In the North, there was extensive clearing on some barrier beaches for wood, and to increase grazing lands. Considerable dune migration began as the vegetative cover was damaged. In the South, similar activities took place in localized areas. Most of the barrier islands had herds of grazing animals for many years; there is no doubt that overgrazing seriously affected some of them. Today, grazing of livestock has stopped on most islands.

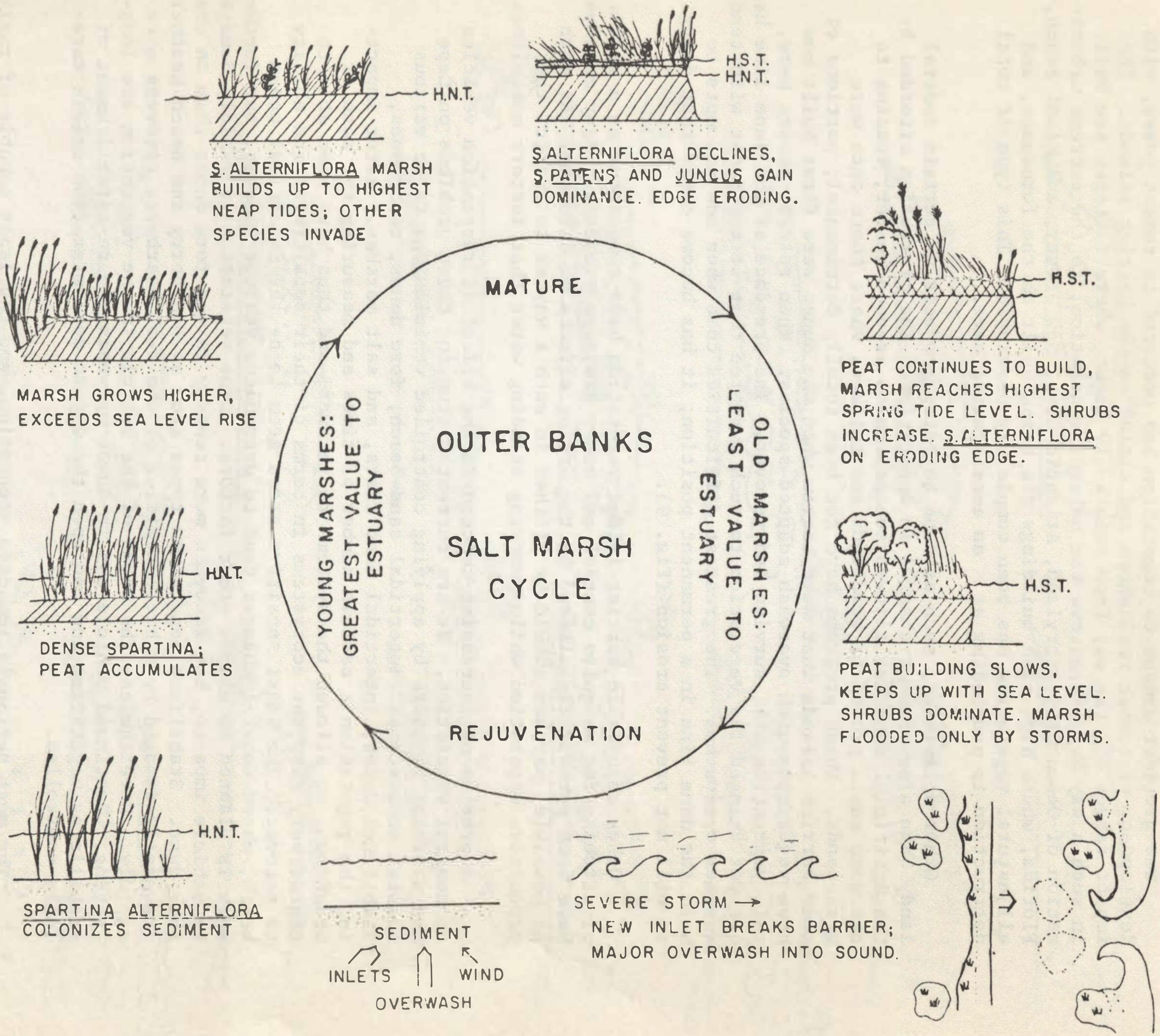


Figure 8 Some estuarine consequences of barrier island stabilization. (SOURCE: Godfrey and Godfrey, 1975.)

The greatest damage to vegetation has occurred in recent years, with development of summer residences and cities on the barrier islands. The impact ranges all the way from relatively light, where cottages are built in such a way as to preserve the natural vegetation, to the extreme urbanization of Ocean City, Maryland, Atlantic City, New Jersey, and Miami Beach, Florida, where high rise buildings are being built on the foredunes, and all natural vegetation has been completely destroyed. This type of total destruction is proceeding at an accelerating pace.

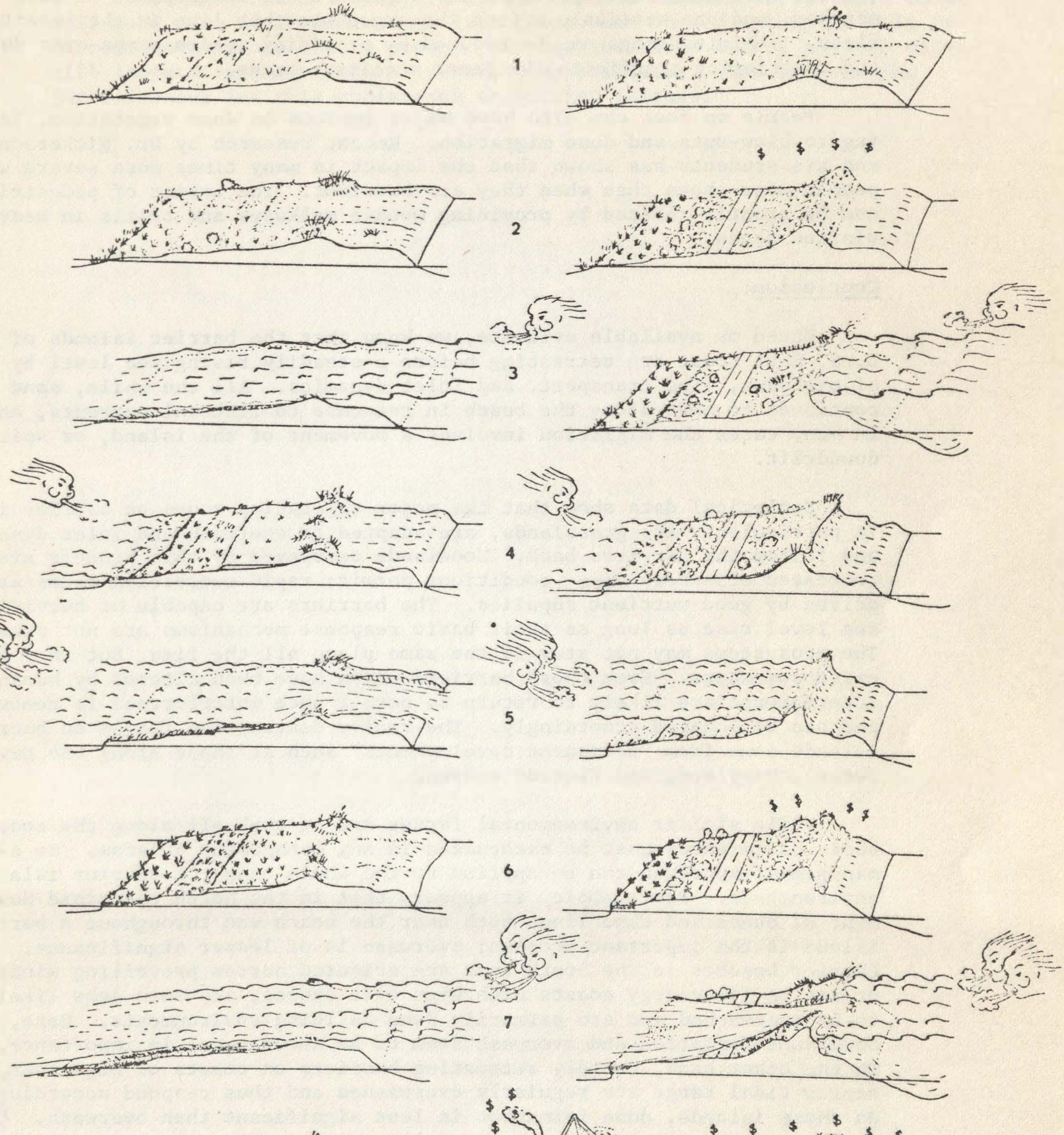
Other activities, such as dune building projects on certain federal land, have also created changes in vegetation. The protection afforded by the artificial dune has allowed succession to proceed faster, leading to the more rapid growth of woodlands and thickets where there once were grasslands. These programs have not been totally detrimental; portions of some barrier islands that were barren when the dunes were first built now have vegetation with overwash adapted species. When retreat occurs here, this vegetation will survive and recover. The presence of the dune line has not yet changed the vegetation to such a degree that it could not withstand further overwashes. The greatest difficulties come when one attempts to hold the dune line in a permanent position; it has become clear that doing so will not prevent erosion (Fig. 9).

Other changes in barrier island vegetation have come about as a result of ditching for mosquito control and other drainage projects. Many marshes have been permanently altered by the drying effects of ditching. As much as possible, marshes should be ditched in such a way as to protect the productive vegetation while removing standing water that fosters mosquitoes.

A problem of increasing concern is the effect of recreation vehicles on coastal vegetation. We are currently studying these problems on Cape Cod National Seashore by applying controlled vehicle impacts to various coastal ecosystems: intertidal sand beach, fore dunes, rear dunes, stabilized dunes, intertidal sand flats, and salt marshes. After impacting the vegetation a certain number of times and measuring the rate of breakdown, we allowed the systems to recover, and thus have been able to tentatively rate the ecosystems in terms of their sensitivity and ability to recover. The least sensitive areas seem to be the intertidal ocean beach, where natural changes tend to overshadow vehicle impacts, but further work is planned to assess other factors. Dune vegetation is rapidly damaged by vehicle impacts, but recovers more rapidly in the fore dunes than on the rear dune. Stabilized vegetation types such as bearberry and beach heather are easily damaged by vehicle traffic; of the two, bearberry recovers more rapidly. Nevertheless the marks of the vehicle in the vegetation are long-lasting. Continued vehicle use in dunes prevents the re-establishment of stabilizing vegetation and can open the way to dune migration unless carefully controlled.

The most seriously impacted vegetation, and the least capable of rapid recovery, are the low salt marshes of *Spartina alterniflora.* Vehicles tear up the salt marsh peat and create depressions which accumulate salt water. The salinity can become so high through evaporation as to preclude cordgrass survival. The whole salt marsh environment is changed by vehicle traffic. The high marsh recovers better, provided the substrate is mostly sand; if peat is the base, tire tracks will be visible for a long time. Continued

Figure 9 General effects of wave action on natural and stabilized barrier islands. (SOURCE: Godfrey and Godfrey, 1972.)



traffic over sand flats prevents the expansion and development of salt marshes, and can seriously affect the organisms that live in the intertidal flats. Vehicle damage can be reduced by providing wooden ramps over dunes, and restricting traffic to the least sensitive areas.

People on foot can also have major impacts on dune vegetation, leading to blow-outs and dune migration. Recent research by Dr. Nickerson and his students has shown that the impact is many times more severe when people wear shoes than when they are barefoot. The impact of pedestrians can be greatly reduced by providing wooden walkways and trails in heavily visited areas.

Conclusion:

Based on available evidence, we know that the barrier islands of the U. S. East Coast are retreating before a steadily rising sea level by means of overwash, wind transport, and inlet dynamics. All the while, sand continues to move along the beach in response to littoral currents, and in many cases the migration involves a movement of the island, or spit downdrift.

Ecological data show that the major vegetation zones on barrier islands, in particularly the grasslands, are adapted to overwash and inlet dynamics and follow the barriers back. Woodlands destroyed by this process are soon recreated elsewhere when conditions permit; rapid succession rates are driven by good nutrient supplies. The barriers are capable of surviving sea level rise as long as their basic response mechanisms are not derailed. The ecosystems may not stay in the same place all the time, but they will exist somewhere. Even those barriers which have been altered by human interference are likely to return to normal once interference is removed, and can be managed accordingly. The really destructive forces on barrier islands come from "permanent developments" such as those along the New Jersey, Maryland, and Florida coasts.

While similar environmental forces are at work all along the coast, basic differences must be recognized in any management program. No single management approach can be applied to the whole range of barrier island environments. For example, it appears that in the North the rapid development of dunes and dune lines both near the beach and throughout a barrier island is the important process; overwash is of lesser significance. Barrier beaches in the South that are oriented across prevailing winds, or are on low energy coasts with high tide ranges, are much less likely to be overwashed and are primarily dune building environments. Here, both dune formation and overwash seem to be about equal in importance. On the other hand, rapidly retreating barriers on coasts of high energy and narrow tidal range are regularly overwashed and thus respond accordingly. On these islands, dune formation is less significant than overwash. Certain regions of the coast, such as the Delmarva peninsula, show intermediate conditions.

The origin of the barriers must also be considered in their management. The Georgia sea islands are quite different from the migrating Outer Banks, and both contrast with the barrier spits of Cape Cod and Maine.

Like other natural ecosystems, the barrier islands of the East Coast will take care of themselves if left alone; man should interfere only to correct past errors and to protect the barriers from future actions which will jeopardize their natural recovery capabilities. And here is the justification for this conference on barrier islands.

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Contribution No. 3

THE WILDLIFE RESOURCES OF BARRIER ISLANDS

By

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The wildlife resources of the U. S. barrier islands exhibit a number of unusual characteristics that in sum support the contention that these islands represent both unique ecosystems and a set of interrelated natural resources. The variations and similarities in the structure and function of the wildlife resources are due to several phenomena, the scope and complexity of which can only be identified and superficially dealt with in this review. Readers are encouraged to consult additional treatments, particularly "Island Biogeography" by MacArthur and Wilson (1967) and the studies that they have stimulated, and the recent synthesis by Richardson and Worthington (1975).

Barrier islands comprise a significant portion of the interface between the terrestrial ecosystems of the United States and the marine ecosystems of the Atlantic and Gulf of Mexico coasts. Many oceanic species retain compulsory ties with terrestrial ecosystems. Prominent examples are the sea turtles (Caretta, Chelonic, and others) that must leave their usual marine surroundings to find suitable egg laying sites on the upper portions of barrier beaches. Other terrestrial species retain a brief but necessary link with the marine environment; the ghost crab (Ocypode) must return to the sea in order to insure successful reproduction. For still others, reliance on the "other" system is not obligatory but supportive. Island raccoons (Procyon) frequently hunt squareback and fidler crabs (Sesarma and Uca) in the salt marshes during the winter months when the island's seed, berry, and nut production is at an annual low. This supplementary food source no doubt helps assure that additional individuals survive the winter; however, access to the salt marsh is usually not a requirement for the survival of an island's total raccoon population.

Natural communities are influenced by the interplay of physical and biotic forces; unlike many mainland systems, the structure of barrier island communities becomes increasingly dominated by physical forces as one moves towards the ocean. Prominent among

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these forces are the effects of the pounding of waves, the often extreme variations in salinity and temperature, the flow of currents, erosion, accretion, island washover, wind, salt spray and air-borne nutrients, and tidal flux (including periodic submergence and dessication). Each of these, singly or in consort, imposes limitations on island communities. The ocean beach is a particularly harsh environment. Few plants other than diatoms manage to survive in this area. Most of the animal residents are burrowers; some, such as the ghost shrimp (Callianassa) or the ciliate protozoans, live continuously below the sand surface, while others, like the sand dollar (Dendraster) or the sand hoppers (Amphipoda), temporarily burrow to avoid unfavorable conditions. Other beach users are transients, visiting during periods of tidal inundation (e.g., blue crabs [Callinectes] or rays [Dasyatidae]), or recession (e.g., shorebirds of various Families, or tiger beatles [Cicindelidae]).

The continual reworking of barrier island shorelines in front of island interiors of varying degrees of stability create among the islands a series of communities whose characteristics range from the pioneer to the mature. Each island has its own combination and extent of these communities, and each of these communities contain species that are, to a greater or lesser degree, restricted to these habitats.

Probably the most important influence on the uniqueness of an island's wildlife resources is insularity, that is, the isolation of each island and the biological implications of that isolation. Barrier islands are separated from the mainland and other islands by open water of variable distance, by water of varying degrees of salinity, by currents, and often by other factors such as tidal oscillation, expansive salt marshes, creeks and soft mud banks, and prevailing offshore winds. These create a barrier to the dispersal of plants and animals to the islands. To many species, these barriers are formidable obstacles that often prevent island colonization. Salamanders and skinks (Caudata, Mephitis, Spilogale) are often poorly represented in island faunas. For other species, aquatic barriers are of little consequence; raccoons and rattlesnakes (Crotalus) are excellent swimmers, and are able to colonize distant islands. The specific nature of the barrier to colonization is often not well understood. Two examples from Georgia illustrate this: the tufted titmouse (Parus bicolor) is common all over the state, but is not found on Georgia's barrier islands (Robert et al. 1956); likewise, the blue jay (Cyanocitta cristata) is a common mainland bird, but it has a sporadic island distribution, common on some but absent from others (Johnson et al., 1974).

When a species does succeed in reaching an island, some of its mainland constraints are left behind. On Cumberland Island (Ga.), the cotton mouse (Peromyscus gossypinus) has, in absence of competition from other species of rats and mice, exploited virtually every habitat on the island: beach, dunes, forest, fields, pond margins, houses, and the edge of the salt marsh. Disease transmittal may also be reduced. Rabies is common in south Georgia's raccoon population, with 116 cases reported in 1974 out of a nation-wide total of 176 (Center for Disease Control: Rabies Surveillance Annual Summary 1974, Issued March 1976), but no cases have ever been reported from Georgia's barrier islands.

Insularity implies limited size; in the contiguous United States, islands range in size from the 1,723-square-mile Long Island in New York to the island that is a mere speck remaining above water at low tide (Table 1). On any one island, only a finite number of individuals can exist at a given time. This restriction, combined with the reduction in the number of recruits immigrating from the mainland, severely reduces the size of the available gene pool. Such conditions favor genetic drift and the evolution of forms that are phenotypically distinct from their mainland ancestors. Island inhabitants are often recognized as distinct taxa. The diversification of mammals has been relatively well documented in the U. S.; there are six insular species and 45 insular subspecies of recent mammals whose distributions are either entirely or in large part restricted to the islands of the contiguous states (Table 2).

The same insularity contributes not only to the evolution of species but to their extinction as well. Of the six insular species of mammals mentioned above, three are now extinct: the Sea Mink (*Mustela macrodon*) in about 1860, the Gull Island Vole (*Microtus nesophilus*) around 1900, and the Cumberland Island Pocket Gopher (*Geomys cumberlandius*) in 1970. While the activities of man have undoubtedly played some role in the extinction of these species, the primary causes are more likely related to the problems associated with a small population size and limited genetic heterozygosity.

The geologic history of an island and the amount of time that the island is available for colonization affects its species diversity. The older an island, the greater the probability that mainland species would have reached it, and that endemic forms would have evolved on it. Most U. S. barrier islands are either Pleistocene or Holocene in age, or a combination of both. A number of islands were at one time connected to the mainland. Cumberland Island (Ga.) is primarily a Pleistocene island (formed ca. 25,000 to 50,000 years ago; Henry *et al*., 1975). Adjacent to it is Little Cumberland Island; its sediments are Holocene (formed ca. 3,500 to 6,000 years ago). The numbers of three classes of vertebrates on these two islands and the adjacent main-

Table 1 Islands of the contiguous United States and the tropics (includes islands of ten acres and larger; excludes the three New York City islands). Source: Bureau of Outdoor Recreation (1970).

Size Class	Number of Islands	Percent of Total
10 - 99 acres	14,211	68.8 %
100 - 499 acres	3,922	19.0 %
500 - 999 acres	1,641	8.0 %
1000 acres or more	863	4.2 %
Total	20,637	100.0 %

Table 2 Species and subspecies of mammals from the contiguous United States whose distribution is either entirely or in large measure restricted to islands. (Data derived from Hall and Kelson, 1959).

Common Name of Species	Number of Insular Species or Subspecies	
Santa Catalina Shrew*	1	
Trowbridge's Shrew		1
Short-tailed Shrew		2
Broad-footed Mole		2
Eastern Mole		1
Eastern Cottontail		1
Gray Squirrel		1
Texas Pocket Gopher		1
Cumberland Is. Pocket Gopher	1	
Ord's Kangaroo Rat		2
Rice Rat		1
Western Harvest Mouse		2
Deer Mouse		9
Oldfield Mouse		1
White-footed Mouse		2
Cotton Mouse		2
Cotton Rat		2
Eastern Woodrat		1
Meadow Vole		1
Beach Vole*	1	
Gull Is. Vole	1	
Island Grey Fox	1	6
Raccoon		1
Sea Mink	1	
Western Spotted Skunk		1
White-Tailed Deer		5
Totals	6	45

* Some recent taxonomists dispute the validity of this as a distinct species.

land are (data from Hillestad et al., 1975):

Little Cumberland	Cumberland	Mainland	
8	18	35	Amphibians
23	34	67	Reptiles
10	17	36	Mammals

Cumberland also had, until 1970, an endemic species of pocket gopher (G. cumberlandius) and shares with Little Cumberland an endemic subspecies of cotton mouse (P. g. anastasae).

Elevation also contributes to species diversity on islands, primarily through the creation of different habitats: dune ridges, inter-dune savannahs, fresh and brackish water sloughs and so on. Climate, too, is a factor. Both regional variations and micro-climate differences (e.g., different exposures to salt spray and storm winds) support variations in island wildlife resources.

The most important aspect of insularity is the restriction in habitat diversity. Generally, larger islands support more species of plants and animals than do smaller islands (MacArthur and Wilson 1967). Limited habitat diversity will restrict the number of available niches, and this in turn will limit species diversity. Many islands are unable to support resident populations of medium-sized carnivores such as bobcat (Lynx rufus) or fox (Vulpes or Urocyon sp.). Large carnivores such as the mountain lion (Felis concolor) and bear (Ursus sp.) are usually only transients on some islands. Obviously, elimination of these species on the mainland implies the eventual elimination of them from the islands.

In situations of limited habitat diversity, species whose niches overlap will be subjected to greater competitive pressure. Competitive exclusion is a distinct possibility. Data from some Florida and Georgia islands (Pournelle and Barrington, 1953, and original) suggest that populations of the cotton rat (Sigmodon hispidus) are negatively correlated with populations of the cotton mouse. Where there are high populations of cotton rats, there are low populations of cotton mice, and vise versa. Man's activities, particularly those of agriculture, residential development, hunting, and deliberate persecution have reduced or eliminated many native species. One example among many possible choices may suffice: under natural conditions, the fecundity of the loggerhead sea turtle (Caretta caretta) is sufficient to maintain a viable population; that is done in the face of periodic fluctuations in predator populations (especially raccoons and ghost crabs), variations in climatic conditions (especially rainfall), and the occasional destruction of traditional nesting beaches by storms or erosion. Man's intervention has tipped the loggerhead's delicate balance with survival to the point where the species is threatened with extinction. Man's interference has been both direct (e.g., egg poaching, dune destruction, introduction of lights that disorient both adults and hatchlings, shrimp fishing that drowns turtles in nets) and indirect e.g., through the introduction of pigs that devour entire nests or even eviscerate the adult in an attempt to get to the eggs before other pigs do).

The various limitations impinging on island wildlife resources often result in situations not found on the mainland. Barn owls (Tyto alba) normally eat a variety of small mammals and birds. The 2,077 animal remains examined from 10 mainland localities in Georgia, Alabama and South Carolina by French and Wharton (1975) included no marsh rabbits (Sylvilagus palustris) and no moles (Scalopus aquaticus). On Sapelo Island (Ga.), the mole is a minor part of the barn owl's diet; on adjacient Blackbeard Island, the mole is a major part of the diet, and the marsh rabbit a minor part. The cause of this unique situation has not been determined.

Island ecosystems have often evolved subtle relationship, many of which are poorly understood. These relationships can have effects on the structure and function of island communities. Man's even seemingly innocuous manipulations can disturb these ties. Traditional wildlife management theory has suggested that whitetailed deer (Odocoileus virginianus) populations should be maintained at fairly constant levels at or near the carrying capacity of the habitat. However, the maintenance of deer populations at uniform levels on barrier islands may not be an appropriate management technique in all cases. A hypothetical example given by Richardson and Worthington (1975) describes a situation in which the uniform population of deer leads to the elimination of one plant species and the change in the distribution pattern of another species from dispersed to clumped. Richardson and Worthington (1975) recommend that "there must always be at least some examples of totally unmanaged coastal island systems which can be used for testing and comparing the effects of man-induced disturbances."

Islands and their wildlife resources have and will continue to play a major role in the development of our understanding of ecosystem structure and function and evolutionary processes. The theory of organic evolution of plants and animals was first formulated in the mid-19th century by two scientists independently observing island biotas: Charles Darwin in the Galapagos and Alfred Russel Wallace in the Malay Archipelago. The result of their observations, Darwin's "On the origin of species by means of natural selection, or the preservation of favored races in the struggle for life" (1859) was the most important book of the century; it spurred a revolution in both science and social philosophy.

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Contribution No. 4

THE NATIONAL INTEREST IN BARRIER ISLANDS AND BEACHES: NATURAL RESOURCE VALUES

By

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Over the past 25 years, the demand on barrier island resources has increased more rapidly than public institutions have been able to respond. This lag has exposed an urgent need to recognize the national interest in barrier islands and beaches and in their conservation.

The increasing leisure, prosperity, and mobility of the 1950's accelerated the demand for seacoast places and facilities. The momentum of this trend extended into the 1960's accompanied by demands for higher quality and diversity of experience and reactions against crowds, litter, and visual assault.

In the middle to late 1960's, a new mood emerged among young Americans -- a desire for greater harmony with nature and for more contemplative pursuits. Overlapping this trend was a new awareness that the seacoast was limited and should be a public resource rather than just a private playground and that the public was being denied access by private property barrier and by discriminatory practices.

THE PUBLIC DEMAND

The use of coastal resources is accelerating in nearly every category -- boating, fishing, hunting, swimming, diving, and particularly hiking, camping, nature study, and bicycling, which are growing rapidly in popularity. In recent years, public recreation areas have experienced a 10- to 12-percent annual increase in use[1]. By 1980, all outdoor recreation participation is predicted to increase almost 50 percent from the 1965 level[2]. Demand is rising particularly for simple or "passive" activities[3,4,5] -- those that do not require special skills and stamina or special facilities -- picnicking, pleasure driving, sightseeing, walking, and nature enjoyment.

Of the great variety of outdoor recreation environments, the ocean beachfront has an exceptionally strong appeal [6,7]. In 1960, an estimated 44 percent of all recreationists favored water-based recreation over any other type of recreation activity: between 1960 and 1970, the per-capita participation in swimming, boating, and saltwater fishing rose about 50 percent [8,2,9,6].

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Picnicking attracts more Americans than any other outdoor recreation activity. Over half of the United States population picnics every year. Picnic activity appears closely tied with use of the private auto [2,10] and many picnickers are attracted to the barrier islands and beaches.

Swimming is the third most popular form of outdoor recreation in the nation, with only picnicking and driving for pleasure having more participants [2]. In 1965, 104 million people, 54 percent of the U.S. population, enjoyed the sport -- and by the year 2000, some estimators predict as many as 300 million swimmers [2] -- a rate of increase that would make swimming the most popular outdoor recreation of the future. Sources report that 22 percent of all reported swimming days for 1965 were spent in the ocean,[2] or alternately, that 18 million people swam in the ocean in 1965 [11]. In 1965, expenditures by swimmers amounted to $2.9 billion. By the year 1980 this is expected to reach about $5.4 billion [2].

Most people listed as swimmers (104 million in 1965 [2]), probably engaged more in a variety of other beach sports or passive pursuits. A recent survey of a Rhode Island beach showed that diverse passive activities were more popular than such active sports as swimming [12]. In 1965, there was an estimated one million surfers in the United States. Surfing requires specialized shore and water conditions that exist only at ocean beaches [11].

Sport fishing appeals to people of all ages, both sexes, and various levels of income, education, and occupation [13,14]. There were more than 9.4 million saltwater anglers in the United States in 1970 who fished from surf and shoreline, piers, private boats, party boats, and rental craft. The total number of fish caught by saltwater anglers increased from 633 million in 1960 to 817 million in 1970 and the total weight was 1,577,000 pounds in 1970 [8].

The direct economic value of sportfishing is great, exceeding the value of commercial fishing in many areas [15]. More than $1.2 billion was spent by anglers on saltwater fishing pursuits in 1970, and the average expenditures per fisherman for the year amounted to nearly $130 [9]. The largest expenditures were for boats, automobiles, transportation, food and bait [9].

In many coastal areas, boating -- canoeing, rowing, sailing, motorboating, and waterskiing -- depend upon mainland barrier island-based resources. The reported number of boaters in 1975 was 56 million[2]. By one enthusiastic projection there will be 163 million boaters in the year 2000, supported by a $3 billion boating industry[2]; (however, population growth has since slowed considerably). The increase in boating activity has led to a shortage of shoreline facilities.

Waterfowl shooting is the major form of coastal hunting. In 1970, nearly three million waterfowl hunters spent some $250 million for hunting in the United States, an increase of 50 percent over 1955 [16].

While summer is a peak period for most coastal recreation activity, sixty percent of waterfowl hunting occurs in the fall,[16] principally for migratory ducks and geese [17].

Bicycling, hiking, and horseback riding are becoming increasingly more popular [18,19,2]. Nationwide, a minimum of 239,000 miles of developed trails exist, of which an unknown number are in coastal areas. About 12,000 miles of trail are designated for bike use, with the remainder for hiking and riding [2].

So strong is the lure of the coast that millions of families have built second homes or purchased land along the seacoast in order to make optimum use of scenic and recreational resources. Many working families near job markets have built primary homes on the coast, as have multitudes of retirees. This has created enormous pressure on barrier island and barrier beach land. It has given impetus to large scale condominium projects and caused heavy demand for bridges and causeways to open up new lands. This intense private use of land is threatening to close out the public and is endangering the resources of barrier islands and beaches.

MEETING THE DEMAND

The institutional response to the problem of conservation allocation and development management is severely hampered by problems of mixed and uncoordinated responsibility at local, state and Federal government levels. Often, no one seems to be in charge. There is a strong need for conservation and management guidelines that can protect the public interest and reduce the deterioration of barrier island resources [20].

Public Ownership

The United States has 36,000 miles of "nondetailed" shoreline (excluding Alaska) of which only 3,400 miles (9 percent) is set aside for public use (an additional 5,800 miles, or 16 percent, is used for privately controlled recreation). Barrier islands have thousands of miles of beachfront, however very little of this is in public ownership. The Federal government administers more than 150 parks and protected areas located in coastal areas under the National Park Service (more than 50)[22] and the Bureau of Sport Fisheries and Wildlife (more than 100)[23].

The lack of recreational opportunities for urban populations is a major problem [24,2,25]. While major shoreline recreational areas have been established in response to this lack -- for example, New York City's Gateway National Recreation Area [26,27] -- the situation is bleak. Because two-thirds of the U.S. population lives within a day's drive of the coast, and all cities greater than 2.5 million lie on the nation's shoreline,[21] recreation demand on coastal resources is great. Low per-capita recreation areas (.1 acre per person) include most of the Middle and North Atlantic States and Texas [21].

Clearly, more coastal public area is needed,[24] yet the expansion of coastal park recreation areas is inhibited by the accelerating demand for coastal land and the rising cost of acquisition [28,29].

About 300 miles of public seashore park has been added to the national inventory in recent years, including such barrier islands as Cumberland, Assateague, and Fire Island. Still, the strongest demand -- seashore outlets within 50 miles of urban centers -- has gone largely unmet. Equally, it appears that the nation has yet to take vigorous action to uphold the public rights of access to coastal recreation resources. The National Park Service has identified 195 acres in the forty-eight contiguous states that are deemed particularly suitable for public seashore recreation [30,31,32].

Access Problems

Physical access to beaches is in many cases restricted by private ownership of shoreland [11] or by discriminatory community restrictions. The problem of inaccessibility presently limits barrier island and beach recreation opportunities. Only about five percent of the shoreline suitable for recreation is available for public use [33]. Private property barriers are largely responsible [33]. Owners of residences and industries deny public use to a high proportion of suitable beaches by fencing off or enclosing the land adjacent to the beaches.

Many Americans are unable to use the beaches because of municipal ordinances that subtly restrict shoreline access, including rules that, for example, prohibit changing clothes in a car, walking on boardwalks without shoes, and parking without special stickers. Often, such exclusionary policies have been held unconstitutional by the courts. While the literature notes that there are social inequities in recreation opportunity, [34,2] it shows very little detailed study of actual inadequacies or the nature of specific problems.

Of 21,720 miles of "potential recreational" shoreline ("detailed" with a minimum 5-mile view) there are 4,350 miles of beach [24]. On a nationwide basis, there is one acre of swimming beach for every 1,450 Americans [2]. The areas of most serious shortage include the Northwest, where there is only one acre of swimming beach for each 3,200 people, and the South, which has only one acre for every 3,080 people [2].

The states have often led the way in initiating important marine recreation legislation. The Texas Open Beaches Act [35,36] has focused congressional attention on public access to the shoreline as a national problem. The often proposed National Open Beaches Act would establish a national policy to insure that the public's right to beach access exists independently of ownership of land.

Environmental Problems

By degrading water quality, many activities affect the use of resources fostered by barrier islands and beaches. Human waste introduced by municipal sewage outfalls, septic tanks, and boat facilities can produce high coliform bacterial counts, forcing the closure of beaches to swimming (variously, when total coliform counts exceed 200-1,000 organisms per 100 ml)[37,38].

Toxins such as heavy metals and pesticides introduced in agricultural land runoff and industrial wastes can drastically reduce fish and invertebrate species[39]. Outboard engine exhaust adds pollutants to the water and may produce aesthetically objectionable oil slicks. Power plants can damage fish and shellfish populations by using estuarine waters as a coolant, creating thermal pollution [39,40,41,42]. Improper design of marinas can reduce environmental quality by creating improper flushing conditions (leading to reduced oxygen content) and by concentrating sewage and outboard engine pollution [43,44,45]. Extensive sewage discharges also decrease fish stocks and downgrade aesthetic values by reducing the oxygen content which can, in turn, produce fish kills [46]. Shellfish beds can also be contaminated and forced to close in the presence of excessive sewage (normally when coliform counts exceed 70 per 100 ml).

Beach contamination by pollutants and debris carried by coastal currents is often a serious problem. Pollution from oil spills was brought to public attention by the Santa Barbara and Torrey Canyon oil spills of 1968 [47,48]. Problems of floating debris are particularly severe near such coastal urban centers as New York [49].

Dredging operations are known to reduce water quality by increasing turbidity and reintroducing into the water column pollutants that have accumulated in bottom sediments. High turbidities from such operations have caused the destruction of coral reefs [50]. Dredging operations can also destroy grass and shellfish beds by their physical removal or their burial [51].

A large problem facing the expansion of marine sport fishing is the degradation and elimination of coastal fish habitats that are cradled by barrier islands and beaches -- shallow estuaries, marshes, shellfish beds and other areas [52]. Two-thirds of the top-value Atlantic and Gulf coast species of fish are directly dependent in some stage of life on conditions of the estuaries [53]. Diminishing viable habitats in the face of increasing fishing demand will lead to a lower supply of coastal fish stocks.

Coastal wetlands, including salt marshes and mangrove swamps, are among the most vital units of coastal ecosystems. Besides their aesthetic appeal, these areas possess a tremendous habitat value for fish and wildlife, food for estuarine organisms of importance to both commercial and sporting interests, and flood protection for the higher shorelands [53,54]. The two principal dangers confronting these areas are obliteration by landfall or dessication by drainage [39,53]. Filling changes the character of the substrate and its elevation, effectively eliminating conditions necessary for mangrove and marsh development [54]. Even a narrow strip of fill for a highway can alter circulation patterns enough to impair the health of a wetlands area [39,53]. The drainage of marshes and swamps to eliminate mosquito breeding pools can have similar adverse effects [54].

The problem extends beyond wetlands conservation. Often management does not seem to recognize the unity and fragility of the whole shoreland fringe of barrier islands between the shore and uplands; including floodplains, dune fronts, and sand washover areas in addition to wetlands. These areas have high ecological open space, shore protection, and general psychic values. They form a ribbon of vulnerable shoreline area, which has often become the doormat of the beach, and which appears to have received inadequate attention by planners, policy-makers, and managers. The attempts to identify and preserve this fringe are inadequate.

Population declines of several shorebird species due to hunting and habitat disruption [55,17] have led to their being placed on the U.S. Department of the Interior's list of endangered species [56].

Other Conflicts

Hunting has unique problems. Unlike fishing or boating, hunting is not compatible with urban development because open space and high-quality habitats are preempted by city sprawl and activity. Comprehensive programs for general ecosystem protection (marsh preservation, pollution abatement) would benefit hunting resources [39].

Because of the relatively small number of participants and the extensive requirements for habitat protection, hunting often conflicts strongly with other shoreline uses. The perpetuation of hunting appears to present a difficult challenge to balanced coastal zone management. Standard high-capacity, facilities-oriented recreation development often results in the virtual elimination of hunting opportunity.

Beach driving, when extended to dunes or vegetated coastal areas, causes extreme environmental damage, but the impact on the beach itself is minimal[57]. Beach buggies are used most often as either basic transportation for surf fishers or for thrill riding. The latter, particularly, conflicts with most other beach pursuits. In spite of a presidential order in 1972 establishing policies and procedures to insure resource protection and personal safety with such "all-terrain vehicles," present rules are said to be neither strict enough nor adequately enforced[57].

Surveys indicate trends toward the more primitive type of camping and to advanced reservation and season-long rentals at commercial campgrounds[58]. Trails are a necessity for island activities, particularly bicycling, walking, horseback riding, and pleasure driving. Many serve more than one of these activities. Because of their nature orientation, walking trails frequently are located in some of the most fragile of recreation environments[2]. Several sources recommend the use of marked trails and time and space zoning of activity to provide access with minimal disturbance of the natural habitat[59,60].

THE FEDERAL ROLE

Confusion and conflict of interest between Federal agencies appears to be a major problem. Over 90 Federal agencies are directly involved in some aspect of legislated programs in outdoor recreation,[2] many of which affect barrier islands and beaches. There is obviously an immediate need for improving the application of existing laws rather then initiating new ones. But there are some remaining Federal legislative needs. For example, the proposed National Open Beaches Act [61] which could help solve the problems of access to barrier island beaches -- particularly for urban dwellers. Real and rapid improvement in administration, planning, development, and management can only be guaranteed by a major new Federal thrust in policy resolution and agency coordination, such as could be accomplished by a White House executive order or Congressional legislative action.

There appears to be one hope for solution in recent Federal authority. The Coastal Zone Management Act of 1972 provides for a Federally assisted program of state and local planning and management. Among the principal elements of the Act to which participating states must respond are "areas for protection" and "areas of particular concern" components. The Office of Coastal Environment (of the National Oceanic and Atmospheric Administration) has the authority to establish general guidelines for state management under the Act and the states have the right to require Federal conformance to their management programs. This innovative partnership would seem to provide a needed mechanism for a coordinated Federal-state program for barrier island protection that has been so obviously missing.

TOWARD A BETTER UNDERSTANDING OF RELATIONSHIPS

Only a program coordinated at the Federal level seems to offer hope for effectively accomplishing the needed conservation. It would be nearly impossible for local and state governments acting individually to protect barrier island and barrier beach resources because there appear to be such complex natural interdependencies among them. We know that long chains of islands are interconnected in many ways, yet there is a great amount of research in natural sciences, management, economics, and public rights that is needed to delineate the national interest and define the Federal role. In the summary to follow I have singled out the priority research jobs in the natural sciences.

Below are examples of some of the major types of natural interdependencies that should be included in a comprehensive research program on barrier islands and beaches:

1. The millions of migratory waterfowl and shorebirds that move along our seacoasts depend to an unknown degree on barrier island-beach-estuarine resources. Because of their migratory nature and their high importance, they are under Federal management, yet the program does not include any general protection for habitats. Therefore, the extent of the dependence of waterfowl, and birds of all kinds, upon Atlantic barrier island and beach chains should be known accurately.

2. Scores of important coastal fish species migrate seasonally along the Atlantic and Gulf coasts and yet there is no management program that recognizes this fact. These species depend upon beachfront and estuarine resources whose condition in turn depends upon the condition of the barrier islands and beaches. This dependency should be known precisely.

3. Many important invertebrate species migrate in similar fashion and are critically dependent upon the beaches and estuaries. Shrimps, whose migrations are well known, are a leading example. However we are just beginning to appreciate the migrations of other crustaceans; for example, blue crabs appear to migrate hundreds of miles from central Florida north to the Appalachicola area. Our knowledge of these dependencies should be greatly improved.

4. The inter-island relationships among mammals and other wildlife species is poorly known and should be extensively analyzed.

5. While the geological properties of beaches have been studied in extraordinary detail (mainly by the U.S. Army Corps of Engineers) no general analysis and summary of knowledge of

inter-island sand transfers has been accomplished. This should be initiated at the earliest possible time.

6. The importance of the transfer of seed stock of important plants from island to island has never been studied and remains a high priority subject,

7. Many of the official endangered species in the Federal protection program are among the migrants or residents of barrier islands and beaches. A complete summary should be prepared.

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Contribution No. 5

BARRIER ISLANDS AS NATURAL STORM DEPENDENT SYSTEMS

By

Stanley R. Riggs*

THE STORM DILEMMA

The Coastal zone is probably the most dynamic natural system on the surface of the Earth. The barrier islands and beaches of the coastal zone are both a total consequence of their geologic past, and a product of the dynamic geologic processes operating daily and continuosly. These continuously operating processes of the waves, tides and currents, along with the frequent high energy storms, are constantly affecting and modifying this buffer zone between the ocean and the land. It is ironic that most people would not consider high energy storms as a major natural resource of the barrier islands and barrier beaches, but rather consider them solely as hazards. Coastal storms however, supply the basic energy which drive the physical processes operating upon and within the many different environmental and geomorphic components of the coastal system; these components are a total product of the high energy storms and the resulting floods. Storms represent the major driving mechanism by which the barrier systems were formed in the geologic past, have evolved through geologic time, and are presently being maintained and modified in response to continuously changing geologic conditions. Thus, high energy storms represent a very basic and important part of the natural barrier island and barrier beach systems.

Now, there is another major variable which more and more is dictating the future responses of the coastal zone -- man. The construction of extensive walls of condominiums, summer homes, resorts, and highways along the beach areas produce 'permanent' economic barriers within a highly dynamic, changeable natural system. Thus, we take a not-so-fragile natural system which is a product of and that gives with and modifies itself to the ever changing high energy storms and the resulting coastal processes, and produce a 'quasi-permanent' system that is no longer allowed to change. We thereby create a very 'fragile' system that becomes increasingly more stressed. This stressed system will exist only until it is subjected to major periods of high energy.

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At this time major change will occur and the 'fragile' system will ultimately be restored to a natural equilibrium balance, but now at man's expense.

In the context of man's economic development of the barrier island and barrier beach system, the hazards resulting from the flooding and the high energy levels of the storm can hardly be defined as a resource. Herein lies the basic dilemma; the same storms which are the essential mechanism by which the coastal system maintains itself also force the designation of the coastal system as a high hazard area which is associated with high loss of life and property.

'Protection of our seacoasts' has been a priority project throughout the twentieth century. This attitude evolved with the development of our life style which includes second homes and leisure living along with major industries in tourism, recreation, and water-based sports. The attitude of man combating nature in order to control all potentially destructive natural coastal processes has led to massive efforts of technological development and implementation of coastal protection measures along much of the U. S. shorelines. Largely because of this philosophy, we have approached the economic development of this coastal 'battleground' with almost open defiance and challenge. The resulting all-pervasive 'man against the sea' philosophy has not only been totally unsuccessful, but all too often has culminated in increased adverse coastal responses. The present attitude towards the use and 'protection' of the coastal area does modify the coastal environment; the form and magnitude of the modification varies with the activity and the environmental sensitivity. These modifications stress the natural system generally disrupting whatever equilibrium does exist. The result is an unbalanced system in which the basic problem is accentuated and the consequences are compounded.

Barrier island systems can be thought of in much the same manner as river systems. The main beach is a product of the day to day energy flux and is capable of absorbing this energy level in the same way that the main channel of a river is formed by and responds to the energy level of the average daily water flow. During periods of high water discharge, the river needs a secondary channel - the floodplain. The river floodplain is now recognized as a high hazard zone that can be used, but under the basic conditions of the natural processes of the river system; to do otherwise leads to guaranteed disasters - it always has and it always will! In the same context, most barriers will be overtopped or breached during high energy conditions; in fact the barrier is generally the product of such high energy processes in the same way that the river floodplain is. Consequently, large portions of most barrier islands are equally high hazard zones that can be used, but under the basic conditions of the natural processes of the barrier system. To do otherwise also leads to guaranteed disasters - it always has and always will!

Thus, it seems clear that in resolving the basic dilemma we can no longer afford to attack nature as a 'bad guy' that needs taming, controlling, and molding into our ideas of the 'way it should be'. We have lost in most of our efforts with this classic approach in attempting to derive total economic development potential out of the coastal zone. The basic environmental losses, as well as the long range economic costs and losses to man are incredible. Barrier islands and barrier beaches must be approached with "the proposition that nature is process, that it is interacting, that it responds to laws, representing values and opportunities for human use with certain limitations and even prohibitions to certain of these...we must realize man's design with nature," (McHarg, 1969).

THE COASTAL SYSTEM

Barrier islands and barrier beaches constitute a major part of the extensive coastal system which extends from Texas to Florida in the Gulf of Mexico and northward along the Atlantic coast from Florida to Maine. The barrier chain encloses numerous smaller estuarine sounds, bays, and lagoons. These estaurine systems are bounded to the landward by the very low and swampy lowlands of the Gulf and Atlantic Coastal Plains from which they receive the fresh water discharge through the major river systems. The estuarine system is bounded on the seaward side by the barrier islands with a network of passes or inlets which connect the estuarine system with the ocean waters. Seaward of the barrier islands is a broad, shallow continental shelf. The shallow waters of the coastal system respond quickly to the many frequent fluxes in the basic energy regime of the atmosphere producing complex wave, current, and storm tide systems which are superimposed upon the normal astronomical tidal system and modified by the geometry of the various water bodies and the continental shelf. This system of mainland, rivers, estuaries, barrier islands, inlets, and nearshore shelf along with the respective energy regimes and the resulting processes represent a total coastal unit.

The coastal unit also extends along the coast with a strong interdependence from one barrier island to the next. The extensive coastal system of barrier islands and associated environments interacts throughout its entire length from Texas to Maine, as a chain which is both a product of and response to similar energy regimes and resulting processes. This unit is an integral system of environments and processes in which each part interacts with all other parts; a given process in one part of the system will produce responses in each other portion of the coastal unit.

The complex interacting coastal network is a total product of the energies, resulting processes, and the specific geographic conditions and therefore must be approached as a total system. Piecemeal development only leads to a disequilibrium situation which will have its consequences upon the adjacent portions within the system; the greater the modifications, the greater will be the resulting consequences elsewhere. Thus, all of the adjacent environments and the basic processes of each portion of the system must be included in developing any management or land use plan.

BARRIER ISLAND PROCESSES

Sea Level Rise

A continuing worldwide rise in sea level since the last Pleistocene glacial advance, has produced an unstable coastal system (O'Connor and Riggs, 1974). The resulting transgression of the sea has caused a rapidly changing coastal system which has moved upward and landward across the continental shelf during the past 17,000 years, and is still encroaching upon our present low coastal plain province (Riggs and O'Connor, 1975): 1) flooding of the mainland drainage tributaries and erosion of the adjacent shorelines producing an extensive estuarine system which is migrating and expanding landward; and 2) migration of the barrier islands by the processes of sediment overwash, inlet migration, beach ridge accretion, and wind-dune dynamics. The evidence for the continuing rapid retreat of the coastal zone includes: 1) the high rates of shoreline recession along both the barrier and the estuarine shorelines, 2) extensive occurrences of marsh peat and stumps in the barrier surf zone, 3) relict estuarine sediments on the near shore shelf and below the barrier island sands, and 4) displacement of upland forest vegetation landward by salt marsh encroachment and the inclusion of stumps and logs in the basal marsh peats. Carbon 14 age dating of these relict deposits have documented the fairly rapid, systematic, and continuing migration of the total coastal system upward and landward in response to the general rise in sea level.

Tectonic And Geographic Variables

The actual character of any barrier in any given location will depend upon certain local variables such as:

1. The tectonic setting which determines the relief, rock substrate, slope of the land, and the amount of sediment available.

2. The geographic latitude which determines the climatic conditions, the vegetative parameters, and the oceanic setting such as current conditions, tidal ranges, storm patterns, etc.

These are the parameters which determine the physical setting and the basic processes; the specific barrier island will be shaped in response to the energies and conditions of any particular setting. If the tectonic setting of the land is appropriate and if there is enough sediment available, a barrier island system will form along the high energy water-land-air interface in direct response to the energy regime operating within that specific system. The resulting barriers are completely mobile forms which will change and evolve with changing energy or changing geological setting. Thus, the barrier system represents a large scale flexible and complex energy filter system. This filter system responds to and comes to equilibrium with the high energy coastal storms - the driving mechanism for the various barrier island and barrier beach processes.

Beach Dynamics

The beach zone is much more than just the area between mean low and high tide; it includes the entire forebeach slope of the nearshore beach to the dunes. When composed of unconsolidated sand, this broad zone is totally flexible and molds itself to the energy regime of the ocean that is operating upon it at any given time; this energy is both complex and extremely variable. The beach responds to any energy change to produce a three dimensional profile that is in equilibrium with that specific energy regime. Thus, any sand beach has a specific set of responses to any set of processes and begins to change as soon as a disequilibrium appears. The sand is shifted back and forth expanding and contracting the beach zone in direct response to disequilibrium established by a change in specific energy conditions. During high energy periods, which may be a single storm or a seasonal pattern, increased wave heights require a broad offshore sand apron and offshore bar system to break the wave energy prior to reaching the swash zone. Consequently, great quantities of sand are pulled off the backbeach and stored offshore; this produces a narrow and steep backbeach commonly called a winter beach. As the energy abates, the lower wave heights do not require the extensive offshore sand apron and bar system. The sand which is temporarily stored offshore as an energy absorber, slowly migrates back up the beach face as one or more ridge and runnel structures and are ultimately welded to the backbeach face. The runnel is rapidly lost producing a broad shallow beach, commonly called the summer beach.

During periods of extremely high energy levels on a beach, the dunes themselves become the storm berm and washover becomes an active process. The water breaking over the top of the storm berm carries a significant amount of sediment over the back side of the storm berm or dune field to produce a broad structural overwash apron. Overwash is an important structural part of the storm beach and, on many barriers, is the basic mechanism for the construction, maintenance, and migration of the backside of the island. This overwash process has been described in considerable detail by Godfrey (in this publication) and by Dolan (1972 and 1973), Dolan, *et al.* (1973), and Godfrey and Godfrey (1973). Overwash is normally associated with a migrating or retreating barrier island in which the sediment supply is not adequate to maintain a stable shoreline or produce an accretionary situation. A rapidly rising sea level may also be the determining factor as to the importance of overwash in any given system. A barrier island which has an abundant sediment supply can actually grow upward and accrete seaward through time. Under these conditions, overwash plays the role of maintaining a structural berm during major storms in which the sediment fills the swales, decreasing the relief between the ridges and adding structural support.

A beach system is a three dimensional unit. Therefore, beach equilibrium profiles include the areal shoreline geometry as well as the vertical profiles already discussed. The shoreline geometry does not have the same rapid time response that the vertical profiles have. Rather changes in an areal profile represent responses to longer term seasonal wind and littoral drift patterns, sediment supply or lack thereof, and most important, to the dynamics of associated inlets.

Sand beaches are seldom straight, but consist of sinuous curves and bulges called sand waves. The wave length varies from 100 meters up to 1000 meters with amplitudes of 10 to 25 meters. Dolan (1971) found that sand waves have a definite rhythmic pattern and rate of migration along the shore in response to the littoral drift and storms. The focus of any shoreline erosion is a direct function of the position and phase of the sand wave fields. In addition to these intermediate sand waves, there are larger cuspate structures associated with most sand beaches which are usually related to inlets and inlet processes.

Inlet Dynamics

Inlets, or outlets, develop or change in direct response to the basic hydraulic system and storm pressures within the coastal system. They serve an essential role for four sets of hydraulic processes operating within the coastal zone: a) as an outlet for the fresh water discharge off the land, b) as an outlet for storm tides developed within the estuaries, c) as a buffer for storm tides generated on the ocean side, and d) as a channel for the water exchange in response to astronomical tides. The general inlet responses can be summarized as follows:

1. Inlets are self adjusting in that they open up by flushing or close down by shoaling (if there is sufficient sediment available) to fit the hydaulic pressures at any given time.

2. Inlets in the vicinity of rivers and that carry a large fresh water discharge are generally larger and more stable inlets with respect to both migration and opening-closing.

3. Inlets that are predominantly tidal tend to be more ephemeral

units. This is due to a) the lack of a constant hydraulic pressure as produced by the river discharge, and b) during normal conditions tidal fluxing does not always supply an adequate hydraulic pressure to maintain an inlet (particularly if there is an abundant sediment supply) and the inlet will either migrate and/or shoal over.

4. Inlets are natural safety valves. During conditions of high hydraulic pressure (floods and/or storm tides) a new inlet will open where needed to relieve the pressure. When this abnormal pressure is released, the inlet may close up naturally. Without this ability, the barrier islands act as dams increasing flood levels and resultant damages.

5. Inlets will commonly recur within the same general area as needed through geologic time.

Inlets, and their associated ebb and flood tide deltas or sediment fans, are major sediment storage bins for the coastal system. These deltas supply the sediment necessary to maintain an equilibrium system among all of the interacting energy regimes which come to focus at the inlet. The "loss" of sand into inlets is at most a temporary thing, and even then only where there are "new" inlets, which do not yet have tidal deltas, does this become a major process. Any sediment that is trapped in the inlet itself is ultimately moved either in or out into the tidal delta storage bins. Since the ebb currents are generally the dominant inlet force (Hayes, et al, 1973), most sand moving into an inlet will ultimately be deposited in the offshore ebb delta. The shape of the ebb delta and the sediment movement within the delta is then strongly controlled by the interaction of the ebb and flood currents with the offshore wave system and the longshore currents. The sand stored in the ebb delta is now available for littoral transport onto the downdrift beach system. Also, high energy storms and floods flush out the inlet and move the sand laterally to be used to absorb the storm energy in the adjacent forebeach areas.

The flood tide deltas play a major role in building a structural base upon which the barrier island will migrate in response to rising sea level. The sand shoals, which build up to high tide level, become the substrate for aquatic vegetation. Upon closure or migration of the inlet, the vegetated shoals continue to trap fine sands and organic matter, evolving into an explanding intertidal salt marsh along the backside of the barrier island. Barrier island migration takes place with continued shoreline recession along the front side, while the flood delta shoals and salt marshes supply a structural nucleus for the progressive island buildup through storm washover and wind blown sands.

Thus, inlet systems play important roles in sediment storage for use as an energy sponge during storms and as a structural base for barrier island migration. Consequently, inlet systems represent an integral part of the overall sediment budget of the coastal system and contribute to the overall natural ability of the system to roll with the energy punches with minimal adverse effects. Modification and/or stabilization of an inlet will limit or eliminate this ability, increasing the potential for accelerated shoreline erosion resulting from major storms.

THE DRIVING MECHANISM - HIGH ENERGY STORMS

Types of Storms

Basically, there are two types of storms which are of major significance to our Atlantic and Gulf coastal systems: the tropical cyclone or hurricane and the extratropical storms. Each of these two storm types have different characteristics, magnitudes, and frequencies, and consequently quite different resulting impacts upon the coastal system.

Tropical cyclones or hurricanes are storms of tropical origin with a cyclonic wind circulation (counter-clockwise in the northern hemisphere) of 74 mph or higher. Between 1879 and 1955, there were at least 270 tropical storms which reached hurricane intensity in the Caribbean and Atlantic areas (Cape Hatteras National Seashore). According to ESSA data (Coastal Plains Comm., 1970) "in an average year there will be fewer than 10 tropical cyclonic storms and about 6 develop into hurricanes" and will effect the coast from Texas to New England. "In the U.S. the average yearly death toll is between 50 and 100 people. The property damage in an average year will exceed $100 million in value." Hurricane Camille in 1969, caused 256 deaths and almost $1-1/2 billion in property damage. In the 1960-69 decade, hurricane damage in the U.S. totalled nearly $5 billion.

Extratropical storms are nearly circular areas of low pressure forming outside the tropics along a polar or stationary front which have steep temperature gradients between contrasting air masses. Bosserman and Dolan (1968) recognized a total of 857 extratropical storms which occurred along the N. C. Outer Banks between 1942 and 1967; this amounts to an average of 34 per year as compared to a hurricane frequency for the same area of 1 per every two years. They found that the most severe storms had wind speeds that average 38 mph, lasted an average of 2.5 days and occurred in the month of March. Jordan (1973) found that over a 70 year period there were an average of 9.4 extratropical storms per year in the northeast Gulf area while there were only 1.7 per year in the southeastern Gulf. On the basis of the much greater frequency of the extratropical storms in the central and north Atlantic areas and the longer storm duration, these storms are probably of increasing importance northward with respect to the total hazard and net geological responses of the barrier islands to the energy flux.

Storm Impact

The ultimate impact of any given storm upon any given coastal system is dependent upon a complex set of interacting variables. Many of these variables are at best, only poorly understood. For this paper we will consider seven of the more important variables.

1. Storm surge. This is a direct function of: (a) The wind strength dependent upon the depression of the storm's central pressure below a representative peripheral pressure. (b) Radius of maximum winds - the average distance from the storm center to the circle of maximum wind velocity and reflects the size and lateral extent of the storm. This is a function of the depression of the storm's central pressure. (c) Speed of forward motion increases storm surge with increasing storm speed. Thus fast moving hurricanes, particularly if they are large, pose a greater storm surge hazard than the slower moving hurricanes (Jelesnianski, 1972). (d) The shoaling factor - the water depth profile of the inner continental shelf; the shallower the coastal water becomes, the higher the storm surge (Ho, 1974). Ho found that the maximum shoal factor for the Atlantic coast occurs in central Georgia. Storm surge is itself quite variable as is indicated in the following calculated values:

Magnitude of storm	10 yr.	25 yr.	100 yr.	500 yr.
North Carolina (Knowles et al. 1973)		7.1-9.7 ft.	8-12.5 ft.	
South Carolina (Meyers, 1975)	6-7 ft.		12-14.5 ft.	up to 19.1 ft.
Georgia (Ho, 1974)	6.7-7.7 ft.		12.4-16.1 ft.	up to 21.5 ft.

Hurricane Camille (1969) which had a central pressure of 908 mb, generated a peak storm surge of 24.4 ft. above msl near Pass Christian, Miss. (Ho, 1974) and exceeded 20 ft. above msl over more than 20 miles of beach front (Meyers, 1975).

2. Direction of forward motion. The direction determines whether the storm will be landfalling, moving alongshore, or exiting from any given coastal area. Exiting storms

are often weak and have little affect upon the storm surge and consequently little hazard to most barrier islands. The greatest hazard then would be the fresh water flooding resulting from high inland rainfalls. However, in a coastal area which has a major estuarine system behind the barriers such as occur in North Carolina, an exiting storm can produce high estuarine storm surges and thus represent as high a hazard as a landfalling storm.

3. Pattern and magnitude of astronomical tides. The potential hazard of any hurricane is directly dependent upon the tidal position at the time the storm surge arrives. This is of less importance in an extratropical storm since their duration generally extends through at least one complete tidal cycle.

4. Backbarrier water bodies. The total impact of a storm upon a barrier system partly depends upon the size and extent of the estuarine water body behind the barrier. The presence of a major shallow estuarine waterbody guarantees major storm surges and flooding of the barrier and adjacent coastal areas from both sides. With increasing development along the estuaries, we are learning that the resulting storm impacts upon the barriers are often as great from the estuary side as they are from the ocean side. The storm impact also depends upon the size of the fresh water drainage system and its discharge into the coastal system.

   a. The impact is dependent upon the river discharge at the time of landfall of the storm - if the discharge is low, then the storm impact is decreased, if high then the storm impact is increased.

   b. The long term increase in fresh water discharge to the coastal system from upstream urbanization, channelization, and agricultural land drainage result in increased coastal water levels with time, thus an increasing potential flood hazard with time. Meade and Emery (1971) have demonstrated that 7 to 21% of the total variation in average annual sea level along the Atlantic and Gulf coasts is due to variations in annual river inflow.

   c. High discharge as a result of heavy interior rains following the storm produce a high pressure flood hazard from the estuarine side of the barrier island with extreme impacts upon the inlets. Since water levels often remain high for several weeks, additional storms may be superimposed upon the already high estuarine pressure and cause severe flooding from the backside, inlet flushing and migration, and the development of new inlets.

5. Increased development of the barrier islands. Mather et al., (1967) concluded that the significant increase in frequency of damaging storms along the east coast of the U.S. during the last decade (1957-1967) of their 40 year study was due largely to the generally unrestricted development of the outer coastal margin. Thus, continued unrestricted development of the remaining undeveloped barrier islands will assure a continuing significant increase in the frequency of damaging storms as well as the resulting damage.

6. Storm frequency. On the basis of historical records, the storm frequency varies between coastal areas. The long term impact or the 'rate of geologic change' will depend upon storm frequencies as well as the general movement patterns and intensities.

7. Storm duration. The greater the duration of the storm, the greater is the probability of increased impact. This is particularly true of the extratropical storms which are generally of lower intensity. However, the potential impact is as great as that of a hurricane largely because of the much greater storm duration.

Storm Hazards and Consequences

The hazards to barrier islands resulting from the storms as outlined above can be summarized as follows:

1. High winds produce high ocean and estuarine storm surges which upon occasion cause water levels to completely exceed all but the highest of elevations on the barrier islands.

2. High wave heights on top of the storm surge often cause the energy to be dissipated above and inland of the normal storm beaches and often sets up major high velocity water currents across unvegetated portions of the barrier.

3. Heavy rains after landfall produce flood conditions and an exceptionally high fresh water back pressure upon the barrier system.

The consequences of the major storm hazards to the barrier island as listed in the preceding paragraph are all natural processes which have been important in the geologic origin and still are basic to the maintenance of the barrier islands as we know them today. As geologic conditions continue to change, these processes will continue to be important in maintaining an equilibrium system in the future.

Such natural processes only become hazards when man enters the scene. Whereupon such natural processes as shoreline recession, which results from rising sea levels and the consequent migration of the coastal system landward, immediately becomes a severe economic hazard. Thus, the indirect consequences are those natural processes which are only hazards because they represent a change to the natural system which indirectly affects the economic structure. Whereas the direct consequences represent actual damage to man-made structures which don't belong in a high energy changing natural system. The impacts are obvious and can be summarized as follows:

1. Indirect consequences to man.

   a. Shoreline erosion - both ocean and estuarine.

   b. Inlet instability - flushing, closing, migration, and the opening of new inlets.

   c. Modification of fresh water system - contamination of fresh water table and fresh water ponds and the resulting effects upon water supplies and septic tank systems.

   d. Pressure upon the vegetation zones - only salt tolerant species survive.

   e. Barrier island modification - regression or migration of the barrier landward through overwash fans, longshore shoal and spit development, and flood tidal delta development; or aggradation due to beach ridge accumulation.

2. Direct consequences to man.

   This includes effects of flooding, high energy wave and current impact, and undercutting of man's structures including buildings, roads, bridges, etc.

SUMMARY

Barrier islands and barrier beaches are a product of and respond totally to the geologic processes operating in response to high energy storms within the coastal zone. To live and work within the framework of this balanced natural system, three most important geologic concepts must be kept foremost in the minds of all. First, the entire region must be considered as one interacting system which must include the adjacent barrier islands, neighboring inlets, the nearshore shelf, and the marshes, estuaries, and rivers behind the barrier. An apparent small change in any part of this overall system could have considerable effects on some other portion. Second, the cumulative effects of all actions and modifications by all users and user groups must be constantly considered. Even though the actions of one project in itself may be insignificant with respect to the overall system, by the time you accumulate ten or twenty such projects the results could be dramatic. Third, the time element is also critical in that the day to day processes operate under low energy situations and consequently require long time increments for the results to become apparent. On the other hand, most geologic work, including responses to major modifications to the system by man, happen during the less frequent high energy storm situations. Responses to disequilibrium situations during these periods are usually geologically complete and disastrous to man.

A general and continuing rise in world sea level dictates the basic long term response of the coastal systems. High energy storms, superimposed upon this transgressing sea, supply the driving mechanisms and the processes to which the coastal system must be able to respond.

The sands of the barrier islands are constantly being shifted by the changing energy regimes to more efficiently dissipate the energy flow. The health of a barrier is a function of this sediment economy which is maintained by numerous sand storage bins such as the ebb and flood tide deltas, the forebeach, the backbeach, and the dune fields. The sand budget at any given moment in time is a direct function of the energy regime operating at that moment. As the energy regime is changed, the sand budget also changes, redistributing the sands in a beautiful and fairly efficient economic adjustment of the filter system to absorb and dissipate the energies most efficiently. An infinite number of variables exist within the high energy storms affecting a coastal system, thus the barrier system energy filter must be completely flexible. If a barrier is to continue to function as an energy filter and respond with maximum efficiency to the pressures which initially produced the barrier, then it is essential that 1) there is an adequate sand supply within the various storage bins, 2) the sand must be available for immediate redistribution whenever and wherever needed, and 3) the entire barrier must be able to respond to any given energy pressure.

Man's efforts to stabilize and develop the beach are unfortunately and foolishly concentrated in the upper portion of the beach system. This upper backbeach area is an extremely important sediment response element to the fluctuating energy levels of the natural beach system, and is that part which is actually occupied and essential to the periods of extreme energy. The inevitable consequences of the continued modification of this zone is to narrow and steepen the beach zone with respect to the development or stabilized shoreline, thus increasing the energy expenditure per unit area of the beach. The results are a predictable increase in rates of shoreline erosion and recession during storms; this is the natural response of the beach in re-establishing a profile of equilibrium -- this time at man's expense.

The outlet-inlet environments, which constitute an integral and essential part of most barrier systems, are nothing more than self-adjusting safety valves. These valves respond rapidly to any change in the location, intensity, or direction of energy flow within the system -- they open, close, and migrate in direct response to the immediate pressure upon the barrier at any given moment of time. Modification and/or closure of any outlet-inlet system will produce resultant consequences elsewhere within the system at some future time during high energy periods.

It is ironic that the portion of barrier islands which appears to be the most stable, the heavily vegetated maritime forests, is also a delicately balanced system adapted to salt stress, limited soil moisture, low soil nutrient content, and high energy storms. According to Bellis and Proffitt (Per. Comm.) survival of the forest ecosystem is dependent upon rapid and continuous recycling of minerals gleaned from the salt spray by the vegetation along with constant mineral exchange between living and dead, between different species, and between different individuals. In short, there must exist a certain minimal vegetation density below which the survival functions of the forest cannot operate. If the forest is thinned below this density, the forest system spontaneously degenerates releasing the protected sands stored in the dunes to the full force of the storms and the drying sun. Development is currently attracted to the maritime forest because of its apparent stability yet most development activities tend to interfere with the system balance and contribute to eventual loss of the stabilizing vegetative cover. In the long term, intensive development of the maritime forest will destroy the very stability which was originally sought.

Thus, it is apparent that the natural high energy processes which have produced and continue to modify the coastal system produce a situation which is not compatible with our present attitudes towards barrier island utilization. Our present highways, bridges, inlet stabilization, building codes, condominiums, etc. are not in harmony with functions of the barrier as a natural large scale high energy flexible filter system. We cannot continue to approach the barriers as a piece of real estate that can be 'stabilized' for the purpose of maximum economic development. Future development and use must recognize the natural functions of these high energy filter systems and expect and allow the processes to continue to operate. These are the requirements that are dictated by the natural processes, and are essential if the coastal system is going to be preserved in both a healthy and stable non-stressed condition. They must be heeded if development is to proceed in a fashion which guarantees the greatest safety for life and property. However, to implement this approach many traditional patterns of thinking must change. This includes conventional attitudes towards geologic change such as shoreline fluctuations and inlet migration; land ownership and ownership rights; land use zoning to include large areas of environmental concern, and extensive hazard zones; and more stringent construction codes within the remaining portions of the barrier islands including building design, size and the type of construction of homes, motels, condominiums, and roads.

Geologic status of the storm dependent barrier islands:

1. Barrier islands are an integral part of a much larger coastal system of which all parts are intimately interrelated and interdependent in much the same way that the heart is to the human body. Any change or modification of some portion of the system will have some effects and responses on some other portion of the system.

2. Barrier islands are a total product of their past geologic history and all parts of the present topography, soils, water drainage, vegetative ecotomes, etc., are a total consequence of this history.

3. Barrier islands are dynamic geologic units in which the geologic processes which produced the islands are still actively operating to maintain and/or modify the island in response to major changes of the controlling variables.

4. Barrier islands, in their natural state, are in equilibrium with the multitude of energy regimes acting upon the system; any change in the energy regime causes geologic responses which operate to produce a new equilibrium situation for that energy regime.

5. Since the complex set of energy variables are in constant, and not always understandable flux, the barrier islands also are in a continuous state of flux in response to these changes. The barriers which are a product of these various energy regimes, will respond to disequilibirum situations and do whatever is necessary to bring the system back into an equilibrium state.

6. Barrier islands need 'elbow room' to respond to these natural processes; any restrictions, limitations, or modifications that are put in their way or forced upon them will either a) be eliminated by the periodic high energy regimes operating upon the system or b) modify the system to the point where the cumulative responses may bring about dramatic and undesirable long range effects including compounding the original problem.

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Contribution No. 6

BARRIER BEACHFRONTS

By

Robert Dolan*

Erosion is a serious national problem for barrier beachfronts as well as mainland beaches. About half of our U.S. shoreline is eroding and several coastal areas require continuous beach-restoration programs. Nevertheless, the shore zone remains one of the most desirable settings for recreational, residential, and commercial development, and competition for the remaining undeveloped land has increased in recent years. This trend has greatly accelerated the demand for barrier island and barrier beach properties. Planners and decision-makers responsible for the management of shoreline resources must have a basic understanding of the nature of the inshore zone and ready access to reliable information. This need is emphatically stated by planner William R. Vines:

> "In no other resource-management field is there more misconception, mysticism and generally confused thinking than in beach erosion control. The problem is often approached on an emotional rather than a scientific basis. Amateurish schemes for erosion control abound. The reason for the uncertainties about how to deal with erosion is that erosion control is far from an exact science. The professionals in the field are quick to announce that, although there is a large pool of scientific information on beach erosion, techniques for restoring and protecting eroding beaches must be substantially improved."

Beaches are constantly changing natural systems. Even a stable beach is one which undergoes constant change with periods of erosion balanced by periods of deposition. "Stable" does not mean permanent, nor does it imply that the beach is fixed, but rather that the natural processes are balanced over a long period of time.

This balance is delicate and can easily be upset. Beach stability is determined by: (1) the amount and type of materials making up the beach; (2) the intensity of the natural forces responsible for change; and (3) the stability of sea level (Figure 1; Pilkey, et al., 1975).

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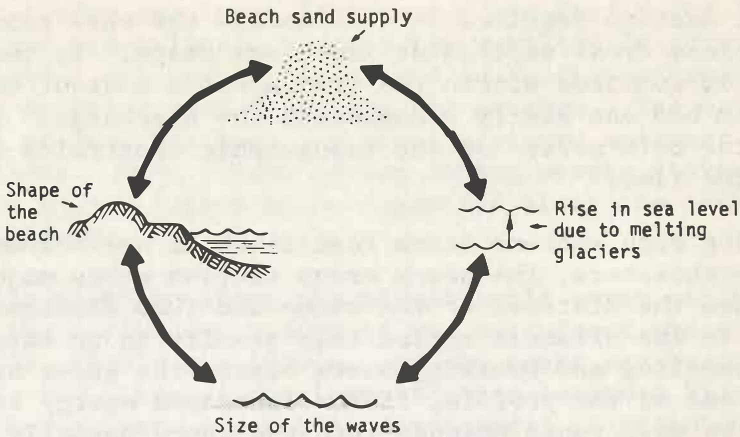

Figure 1 Several natural factors interact to compose the dynamic equilibrium of a sand beach. A change in any one factor affects the others.

Beaches recede when the capacity of the wave forces to transport sand exceeds the amount of sediment supplied to the system. The greater the deficiency of sand, or the greater the capacity of the wave forces, the more rapid the rate of sediment transport and, at times, erosion. A variation in any of three factors, energy, sediment, or sea level, can alter the balance of erosion and deposition. Beach erosion is a natural process and becomes a serious problem only when man's structures are placed in the path of shoreline recession.

The "natural condition" for beaches and barrier islands is simply a wide range of sand-deposit responses to various wave conditions. Like river systems in which streams adjust in cross section to accommodate the water flow, beaches adjust in cross section to accommodate wave runup. During winter storms, when the wave runup of the surf zone can be high, the active beach expands, landward and seaward; during the summer, when the runup is generally low, the active beach zone contracts.

Most of the time this process of beach-profile expansion and contraction is of minor significance, geologically or economically, because it is confined to the central part of the active zone where little change in the sand deposit is involved. Under these conditions, the cross section required to accommodate the wave runup is similar to the stream cross section at low-river stage. In the river system, the flow is confined within the stream banks most of the time, so the stream bed can easily accommodate the discharge. In the beach system, the berm serves as the topographic constraint for wave runup most of the time.

During such extreme storm conditions as hurricanes or severe winter northeasters, the beach cross section makes major adjustments to lengthen the distance of the runup and thus dissipate the increased energy. In the offshore region this results in an extension of the zone of shoaling and breaking waves beyond the outer bar. At the landward end of the profile, if the increased energy level is high enough, the wave runup extends into the zones normally associated with the sand dunes and adjacent sand flats.

The unaltered beach or barrier island can withstand periodic extreme storms because no permanent obstructions are in the path of the waves and surge and the broad beaches sustain the initial stress of an extreme storm. When no resistance is provided by impenetrable landforms or man-made structures, water flows harmlessly between the dunes and across the islands dissipating wave energy (Figure 2). The combination of high tides and high waves can erode the beach face and frontal dunes, carrying sand and shell inland across the island and into the marshes.

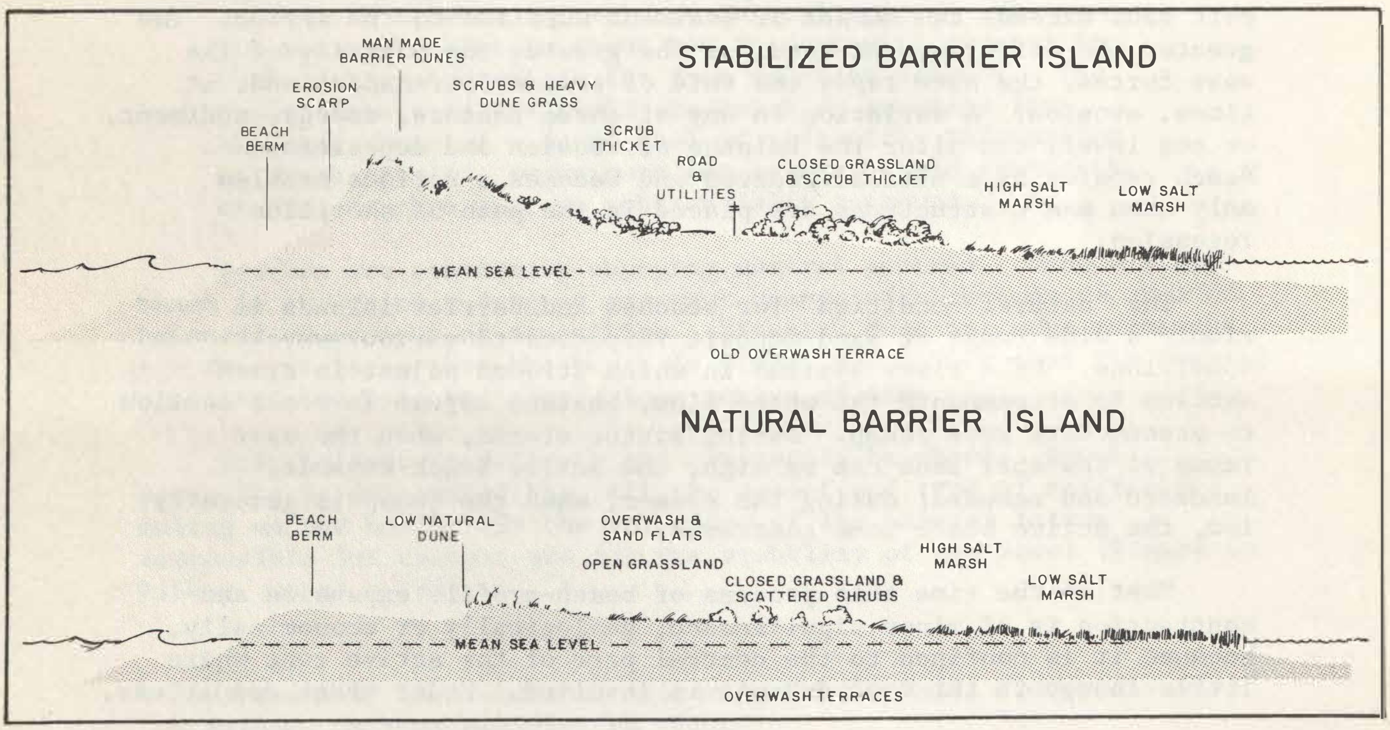

Figure 2 Natural barrier islands are resilient and well adapted to withstand storm impacts.

A steadily rising sea level (about one foot during the last century) along the mid-Atlantic beaches has resulted in increased wave energy reaching the frontal dunes and in further overwash and build-up in the interior sand flats and the marshes. The net effect of this natural process has been a gradual westward movement of the beaches and islands. Even inlets opened during severe storms have resulted in sand moving inland to be deposited along the inner margins of the barrier islands.

Most erosion problems along the mid-Atlantic coast can be traced back to the early development of the beachfront property during the 1920's, 1930's and 1940's. As the coast and beaches were stabilized, the "line of development" soon became a "line of defense." Further private and public development contributed directly to increased pressure to protect this line.

Along the coast of North Carolina, the initial concept of management was to create a continuous line of high barrier dunes approximately 500 feet inland from the active shoreline. The WPA/CCC labor force of the 1930's was used to construct sand fences out of millions of locally cut scrubs and trees. These fences disrupted the winds blowing across the beaches and adjacent sand flats, causing fine sands to drop near the fences. As the sand accumulated forming dunes, more fences were constructed at higher and higher levels, trapping large masses of windblown sand. Soon roads and utility lines appeared, followed by subdivisions. Unfortunately, sea level has continued to rise since the 1930's and the shoreline has receded hundreds of feet. The dunes are now disappearing rapidly under the direct attack of waves so other methods including fixed structures and beach nourishments are being explored.

The ideal solution to the beach-erosion problem would be (1) to plan all developments well inland from the highwater line and (2) to design all structures so that periodic severe-storm surges can occur without major damage. The life expectancy of any development should be planned according to its location; buildings placed near the upper limit of the storm-surge zone should not be designed to last for decades. However, since these ideal conditions seldom exist and, as we have indicated conditions along the shoreline change, what alternatives are available?

Shoreline-protection schemes fall into four categories. Protection designed (1) to stabilize sand, including dune and dike construction, and to use plants to trap sands moved by winds; (2) to construct breakwaters, seawalls, bulkheads, sandbags, or revetments; (3) to inhibit currents that transport sand with jetties and groins; and (4) to actually replace lost sand through beach nourishment.

Sand Stabilization. Wind flow across the beach can be modified to accumulate sand at predetermined locations; however, such works cannot prevent shoreline recession. At best, sand dunes can only stall the inland penetrations of storm surge.

Seawalls and Breakwaters. Seawalls and breakwaters are massive, expensive structures to be used only after all other means of protection are impractical. These structures are designed to absorb and to reflect wave energy and in the case of the seawall, to elevate the problem area above the high-water line. Breakwaters, seawalls, bulkheads, and revetments do not prevent the loss of sand in front of the structures; they commonly accelerate the loss of sand because the wall deflects the wave forces downward into the beach deposit.

Groins. Groins are damlike structures built perpendicular to the beach to trap sand transported along the shore by littoral drift processes. These structures should only be used where there is littoral-drift sediment of at least sandsize (.20 mm and larger) and where the shore downbeach is expendable. Because of their limitations, groins are often more expensive and less effective than a well-planned beach-nourishment program.

Beach Nourishment. For more than a century man has built jetties, groins, seawalls, and other structures in his futile effort to trap sand and to protect beaches. These structures, designed to alter the energy flow and to interfere with the natural equilibrium of the beach, only cause further problems. It is now clear that the best method of beach restoration does not alter the natural processes. Rebuilding beaches artificially (beach nourishment) by replacing sand lost to the system permits the natural process to continue unhampered. This artificial beach nourishment provides: (1) a beach suitable for recreational purposes; (2) an effective check on erosion in the problem area; (3) a supply of sand to adjacent beaches; and (4) an economical answer to beach erosion if large quantities of sand are available. Since no permanent structures are required, no major management commitment is necessary; if beach nourishment does not produce the desired result, the project may be discontinued.

The major limitation of artificial nourishment is that large quantities of sand of compatible type and size must be available near the problem beach. Nourishment sand can be dredged from sounds or bays immediately inland from the beach or transported from other inland sources. With the present concern about estuarine ecology estuarine sources are generally no longer available; and sound materials are usually not compatible with beach sand. Consequently sand for large beach-restoration projects of the future will probably come from offshore or from coastal inlets.

Any form of beach restoration is expensive. Groins may cost $500,000 each and seawalls, $200 to $500 a foot. The cost of sand used for beach nourishment can range from about $1.50 to $2.00 a cubic yard for sand pumped by a dredge over a short distance to as much as $5.00 a cubic yard if the sand is truck-hauled (1975 prices).

In attempts to stabilize beaches and to protect coastal property, tens of millions of dollars of private and public funds have been spent over the past two decades. Available methods of stabilizing beaches are limited and the best method (beach nourishment) leads directly to serious economic and sometimes environmental problems. The U.S. Arny Corps of Engineers recently completed a study (1973) in which the initial cost of restoring the average 50-foot beach-front lot along the North Carolina coast was estimated at around $20,000, with an additional $1,000 to $2,000 a year to maintain stability. Investments of this magnitude obviously limit beach-erosion-control projects to coastal areas where man's confrontation with the sea has implications of national significance. The best land utilization couples man's works with nature; it does not confront nature.

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Contribution No. 7

ENVIRONMENTAL CONSIDERATIONS AND THE MANAGEMENT OF BARRIER ISLANDS: ST. GEORGE ISLAND AND THE APALACHICOLA BAY SYSTEM

By

Robert J. Livingston*

As a major growth state with extensive wetlands resources, Florida is presently the battle-ground for a variety of environmental disputes. This is especially significant since 75 percent of the population is located in coastal regions of the state. In addition to various federal laws pertaining to the environment, several state laws are concerned with the management and conservation of natural aquatic systems. The Florida Land and Water Management Act of 1972 provides criteria for the designation of areas of critical concern (due to their environmental, historical, or archeological importance). Such areas are then placed under designated land and water management policies for planned growth and development. In addition, the Developments of Regional Impact (D.R.I.) evaluation process requires a developer to answer specific questions concerning the overall impact of a project on the region's environment, natural resources, economy, etc. The Comprehensive Planning Act of 1972 provides for goals, objectives, and planning policies with state sponsored coordination of planning efforts among local, state and federal agencies. The Land Conservation Act of 1972 directs purchase by the state of environmentally endangered land. Priorities for such land purchases are set by interagency planning committees with final approval by the governor and cabinet. These and other state laws provide a matrix for a number of approaches to the problem of how to protect Florida's wetlands from destructive forms of land development.

Unfortunately, the history of many of Florida's barrier islands is a sad one if viewed from an environmental standpoint. One after another, many of these islands have been developed with little regard for their unique ecological features. Usually such development has been the result of complex (interacting) factors which include the appeal and monetary value of barrier islands in general, and an almost complete lack of knowledge concerning the ecological role of barrier islands in coastal systems. This paper will involve a review of some of these principles with specific reference to the problems encountered in the development of an important barrier island estuary, the Apalachicola Bay System.

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THE APALACHICOLA BAY SYSTEM

The Apalachicola Estuary (Fig. 1) is a shallow, highly productive barrier island estuary which is physically dominated by the Apalachicola River (mean discharge of 24,000 cubic feet/second); this is the largest river in Florida with a drainage area of over 19,500 square miles. In addition to maintaining relatively low salinities over extended periods, the river provides nutrients for a relatively high level of phytoplankton productivity (Livingston et al., 1974a). Literally tons of detritus in the form of leaf matter, tree branches, etc., are swept into the bay each year from flooding upland areas thus providing a substrate for various detritivores (Livingston, 1974). It is thus not surprising that the Apalachicola Bay System provides over 80 percent of the state's oysters, and serves as one of the most productive areas of blue crab propogation along the Gulf coast of Florida (Livingston et al., 1976; Oesterling and Evink. 1977). In addition, this bay system is a major nursery for penaeid shrimp and a broad range of invertebrates and finfishes which supply extensive commercial and sports fisheries (Livingston et al., 1976). Thus far, because of a relatively low number of people in the drainage area, and little upland development, the Apalachicola Bay System remains relatively free of pollution. The shallow lagoon-barrier island complex is thus an integral part of a vast wetlands area. This thin line of land, together with input from the Apalachicola River, ultimately contributes to an extraordinary and productive estuarine system.

THE BARRIER ISLAND COMPLEX: ST. GEORGE ISLAND

There are three barrier islands which border St. Vincent Sound, Apalachicola Bay, and St. George Sound: St. Vincent Island, Dog Island, and St. George Island. St. Vincent Island, as a protected national wildlife refuge, is not presently under development. Dog Island is a smaller island to the east; with limited access to the mainland and a consequent low growth potential, it is not considered as a problem. However, St. George Island, which borders a considerable portion of Apalachicola Bay, has been connected to the mainland by a bridge and presently offers the most important prospect for residential and commerical development in Franklin County (Colberg et al., 1968). Because of its strategic position and its potential for development, St. George Island is considered to be a sensitive and important part of the bay system, and can be viewed as an excellent example of the integral part played by barrier islands in the complex ecological and economic relationships of a given aquatic system.

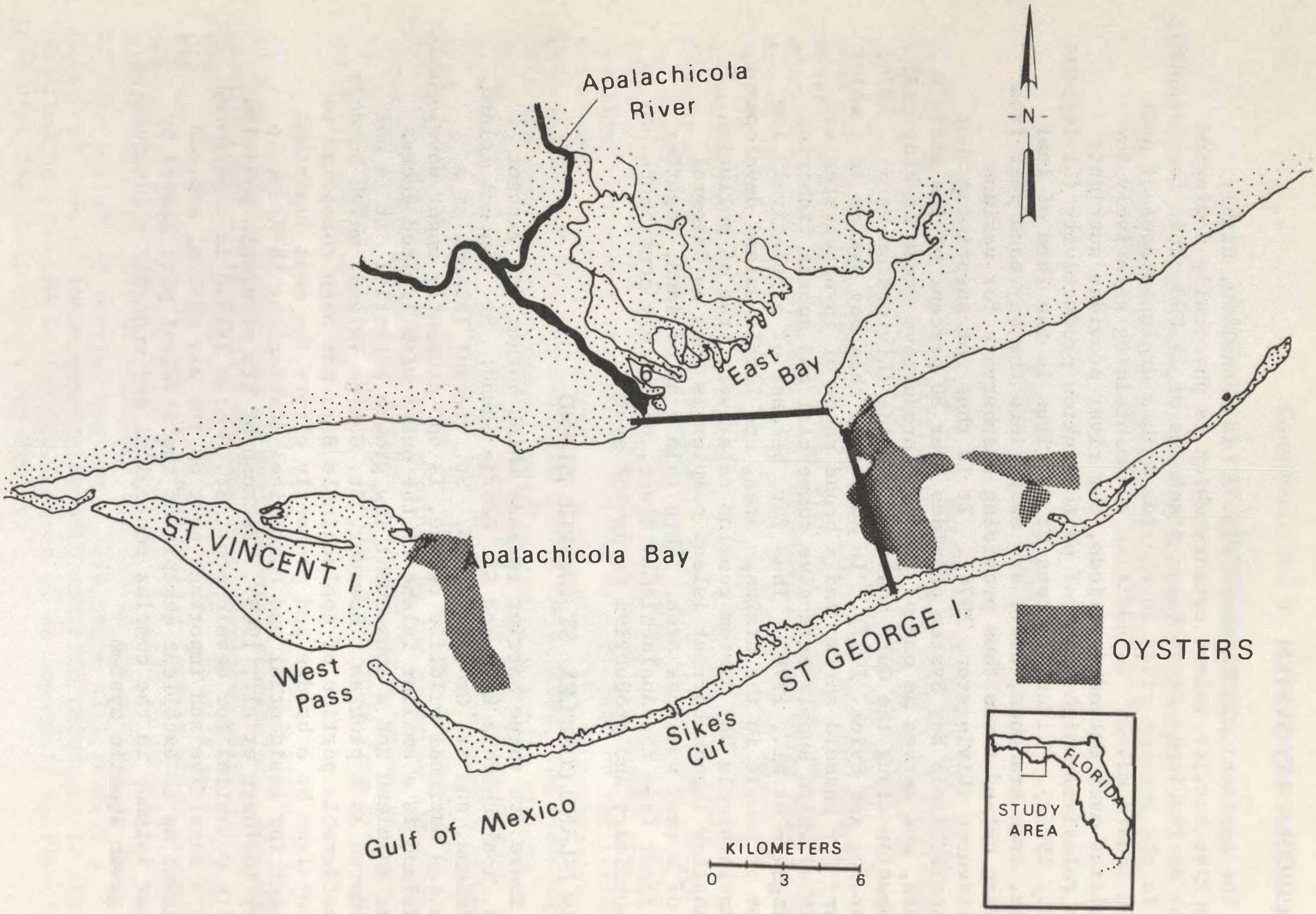

Figure 1 The Apalachicola Bay System showing the placement of the barrier islands, bridges, and some of the oyster bars of commercial value.

Of recent origin from a geological standpoint, the present island form is quite narrow, averaging less than one-third mile in width. The island is about 30 miles long and consists of approximately 7,340 acres of developable land and 1,200 acres of marshes. On the Gulf side, there is a narrow band of beaches and low-lying sand dunes that grade into mixed woodland grass, palmetto, and bayside marshes. This is somewhat typical of various barrier islands (Fig. 2). The island is entirely surrounded by salt water. Any fresh water input comes entirely from rainfall. The medium to fine grain sand provides relatively poor aquifer conditions. Due to the combination of the sandy soil, the occurrence of silty clay some 25' to 30' below the surface, and the relationship of the fresh and salt water, there is a shallow lens of fresh water beneath the island (delimited by the silty clay layer). This lens is thus (horizontally) in contact with the surrounding salt water of the bay and the Gulf, and is dependent on rainfall, transpiration, evaporation, and ultimately submarine discharge into the marine and estuarine environment. The physiography of the island is constantly changing due to wind, waves, and storm action. Such a barrier island is thus an integral geological feature of the marine system and is actually a vital determinant of the physico-chemical features (salinity, currents, productivity, etc.) of the contiguous lagoonal (bay) component.

Often, the unique biological characteristics of a barrier island are overlooked in an assessment of its intrinsic value. A complete review of the biota of St. George Island is presented by Livingston et al. (1974b). The terrestrial vegetation is an essential element of the island system (Clewell, 1974). The dunes, for instance, are protected from wind erosion by various forms of vegetation (sea oats, railroad vines, evening primrose, sand coco-grass, etc.) whose rhizomes and roots bind the sand. Such vegetation can be destroyed by hurricanes and human activities (foot-paths, dune buggies, etc.). Undercutting of the patches of saw palmetto and myrtle oak also contributes to the destabilization of the produnes. Blow-outs of the produnes can have severe secondary effects on the stabilized dunes behind. Damage can also be done to buildings which are constructed in this area. As one moves across the island, various unique assemblages of trees and shrubs can be encountered: this would include aesthetically appealing groves of sand-live oak and rosemary bushes, the slash pine-scrub complexes just behind the dunal system (slash pine, saw palmetto, myrtle oak, etc.), the pine flatwoods (slash pine, gallberry, and fetterbush), and the forms of slough vegetation (laurel oak, live oak, wax myrtle, buttonwood, sawgrass, etc.) which inhabit drainage areas characterized by standing water. These systems gradually merge with the salt marshes on the lee side of the island, with dominant species here including various forms of cord grass, needle-rush, marsh elder,

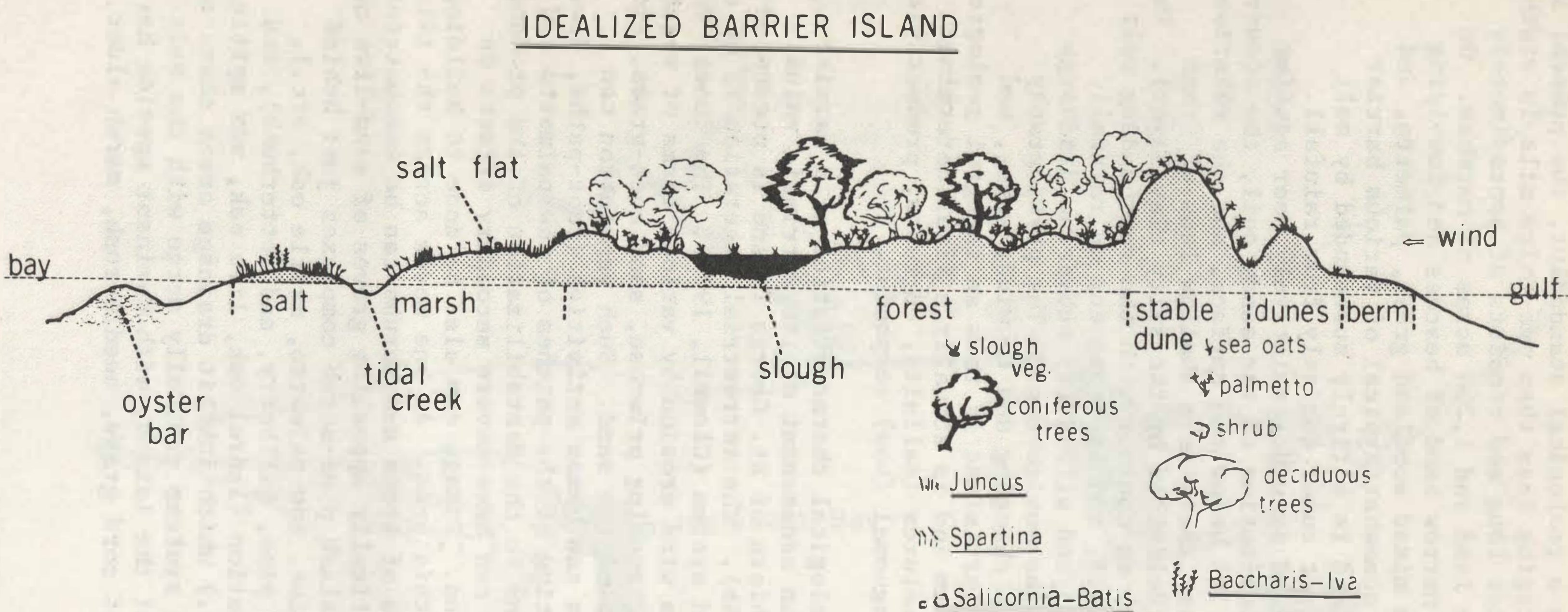

Figure 2 Diagrammatic cross-section of an idealized barrier island with some application to St. George Island (Apalachicola Bay, Florida).

and false willow. Clewell (1974) attributes plant zonation of such marshes to salinity gradients due to differential evaporation. Generally such marshes are associated with the shallow, low-energy (wave, tide, etc.) areas on the back side of the island. Clewell (1974) points out that extensive landscaping of islands is difficult because of the sand-oriented environment (unstable, low in nutrients, etc.) which is subject to salt spray and wind effects. Thus, the vegetation of St. George Island, as in many such areas along the Gulf Coast, is a product of the sea and is in large part subject to stress from a variety of sources associated with the position of the island in the aquatic system.

The terrestrial (vertebrate) fauna (excluding birds) is often relatively depauperate on islands such as St. George. For instance, Means (1974) lists only 6 amphibian species, 21 reptile species, and 4 forms of mammals. These species are associated in site-specific assemblages in the major habitat types: terrestrial (scrub zone, pine flatwoods, etc.), freshwater (sloughs, swales, ephemeral wet sites, etc.), and salt marshes. The freshwater fish fauna is depauperate and is dominated by topminnows which are usually well adapted for the stress of low dissolved oxygen and extreme (periodic) fluctuations in the physico-chemical environment. Most of the terrestrial vertebrates are effective colonizers according to Means (1974), and are tolerant of a variety of habitat types. They are ultimately dependent on the maintenance of enough native terrestrial vegetation to maintain a given population. There is, because of the small size of the island, an increased susceptibility of such species assemblages to man-induced disturbances in the natural systems of island vegetation; this emphasizes the extreme fragility of island biota. Although there is a differential response to habitat destruction, problems remain acute if any semblance of a natural biota is to be maintained.

According to Stevenson (1974), the importance of a barrier island such as St. George to various bird species should not be underestimated. Although islands generally have fewer species than mainland areas, with sedentary types such as woodpeckers, chickadees, and titmice not usually found, various trans-Gulf migratory species on spring flights will often utilize such first landfall as a safe harbor during adverse climatic conditions (e.g., 84 species were observed on St. George Island during a cold front in April, 1969). As with other island species, various groups are associated with different habitats. Some species, such as the snowy plover are restricted to sand beaches along the Gulf, and, according to Stevenson (1974), have sharply declined as so many such beaches have been taken over by human activities. Once again, dune vegetation becomes necessary for the maintenance of such animals. Other species are associated with pine woods (nuthatch, pine warbler), hardwoods (woodpeckers, blue jays), ponds and sloughs (green heron, least bittern, mottled duck), and salt marshes (clapper rail, seaside sparrow, long billed marsh wren, sharp-tailed sparrow). Various assemblages of migratory species tend to concentrate on particular portions of the island where a specific set of environmental parameters prevail. This is true in areas where live oaks and cedars border salt marshes, or near freshwater ponds and sloughs surrounded by various forms of vegetation. Stephenson (1974) identified these areas on St. George Island, and recommended that they be preserved and/or upgraded to maximize their utilization by avian species. He lists 251 species which are found in such areas, thus emphasizing the importance of barrier islands to a wide variety of birds.

Barrier islands are characterized by two distinct marine environments: the high (wave) energy offshore systems and the low energy brackish water (lagoonal) areas. Each is characterized by an entirely different aquatic fauna with offshore assemblages usually including various oceanic and migratory species. The inshore lagoons are ultimately created and maintained by the placement of the barrier island. Salinity, current systems, and the high productivity of the lagoonal areas is directly dependent on the barrier islands. The periodic low salinity which creates an environment favorable to oyster production (for which Apalachicola Bay has become famous), is a result of the barrier to the saline water of the open Gulf of Mexico. As an example of the importance of this to the bay system, the Sike's Cut Pass (Fig. 1) created several years ago to facilitate boat traffic, is now a source of the intrusion of highly saline Gulf water into Apalachicola Bay. The break in the island allowed such water to enter the bay and it remains throughout the year, thus establishing an entirely different fauna than the rest of the bay (Livingston, 1976). Various stenohaline oyster predators, normally kept out of oyster beds by low salinity, were no longer under such restrictions and are now considered to be the main reason for the severe debilitation of the once productive oyster bars which inhabited areas just east of St. Vincent Island (Fig. 1).

Of course, the highly productive lagoons of the barrier islands are often characterized by a wide variety of euryhaline fish and invertebrate species which form the basis for various sports and commercial species. This includes the penaeid shrimps, blue crabs, seatrout (sand and spotted),southern flounder, southern kingfish, mullet, spot, red drum, and many others. In addition to a high phytoplankton productivity due to Apalachicola River flow (Livingston et al., 1974), there are large concentrations of detritus from the river, contiguous marshes, and shallow-water benthic macrophytes which ultimately determine, and to a large extent control, the major food webs of the bay system. The position of the barrier island system (and particularly St. George Island) makes such land a critical factor in the productivity of the Apalachicola Bay area. Without the island, serving both as a physical barrier to the Gulf as well as a source of nutrients and detritus, it would be an entirely different system. Thus, anything that alters the island such as physical changes, pollution, altered patterns of runoff, etc. could have severe repercussions with regard to the natural (useful) productivity of the bay.

POLITICAL AND SOCIO-ECONOMIC ASPECTS OF BARRIER ISLAND DEVELOPMENT: THE "GREENING" OF ST. GEORGE ISLAND

Prior to the late 1960's, there was no concerted effort to develop St. George Island, and it remained in a relatively pristine state despite the fact that its potential economic significance to Franklin County had already been recognized (Colberg et al., 1968). This all changed with the recent construction of a toll bridge to the island, a move that was generally approved of by Franklin County officials. Franklin County is an economically depressed area with a considerable proportion of the 7,000 residents being either directly or indirectly dependent on the Apalachicola Bay system for a living. Despite a relatively low standard of living, there is far more involved than money here as the oystermen and fishermen have been associated with the bay for generations, and view it more in the sense of an emotional and historic association rather than simply a way to make a living. The local elected officials reflect this attitude (indeed, the county-commission is dominated by sports and commercial fishing interests), and so, to a surprising degree, have attempted to provide for a sound environmental approach to the problem of upland development. Their interest has not been misspent in view of the historic depletion of various once-productive estuaries and bays around Florida which have recently been severely altered by human activities. In short, in what may be described as a generally rural area in north Florida with a low rate of population growth, Franklin County stands out as genuinely concerned with environmental matters. Perhaps this is because the entire way of life of the residents is at stake.

With the construction of the bridge, it was not long before serious interest was engendered regarding full-scale development of St. George Island. McCulloch Properties, Inc. a land-development firm based in Arizona, took an option to buy a considerable portion of the island with the aim of the construction of an island community of 30,000 to 40,000 people. An extensive study was launched to determine the feasibility of such a venture. After all the information was in, McCulloch decided not to exercise its option. This decision was reportedly based on economic problems and the necessity for severe environmental restrictions which would be necessary for the continued productivity of the Apalachicola Bay system. Subsequently, the ownership of the island was consolidated by a group of people under the name of Leisure Properties, Ltd.; this was run jointly by a lawyer from Tallahassee and a land development specialist. Out of the ashes of the McCulloch dream was born a new plan which, although seemingly less ambitious from the start, was to gradually develop into a major concern for the people of Franklin County.

The same problems which had forced the McCulloch people to retire from the field were operational with Leisure Properties, Ltd. The island had limited freshwater resources. There were no sewage or solid waste disposal systems available. The island was extremely narrow with relatively little room for the disposal and processing of the usual wastes which accompany human activities. The bay was generally clean and, as Class II waters, was under close surveillance by a number of state agencies. A decision was made to reduce the scope of the project, and a gradual approach to development was taken although such plans were hampered by a lack of capital. The outlook for Leisure Properties was enhanced by an agreement with the Florida cabinet whereby the State of Florida would purchase a portion of the Leisure Properties holdings on the eastern portion of the island; this property would then be incorporated into the already existing state park at the easternmost tip of the island (Fig. 3). For its part, Leisure Properties, Ltd. promised to provide adequate fresh water and sewage facilities for the island. The stage was now set for the next major attempt to develop the island.

Meanwhile, the Franklin County Commission gradually became aware of the threat that the island now represented to the commercial fisheries of Apalachicola Bay. Although the construction of the bridge was now considered by many people to be a mistake, it was recognized that nothing would alter the fact that St. George Island was a very valuable piece of real estate. At the request of the Board of Commissioners of Franklin County, a group of scientists was formed in an attempt to work out a rational approach to the development of the island. This group, although working actively with Leisure Properties, Ltd., was actually responsible to the County-Commission. Leisure Properties, in turn, provided the county with money for the collection of appropriate scientific information. This formed the basis of a full report to the County-Commission (Livingston et al., 1974). This was a scientific effort to determine the sensitive portions of the island, and to make recommendations regarding restrictions that would be necessary to insure that development would not have an adverse effect on the island or the bay system.

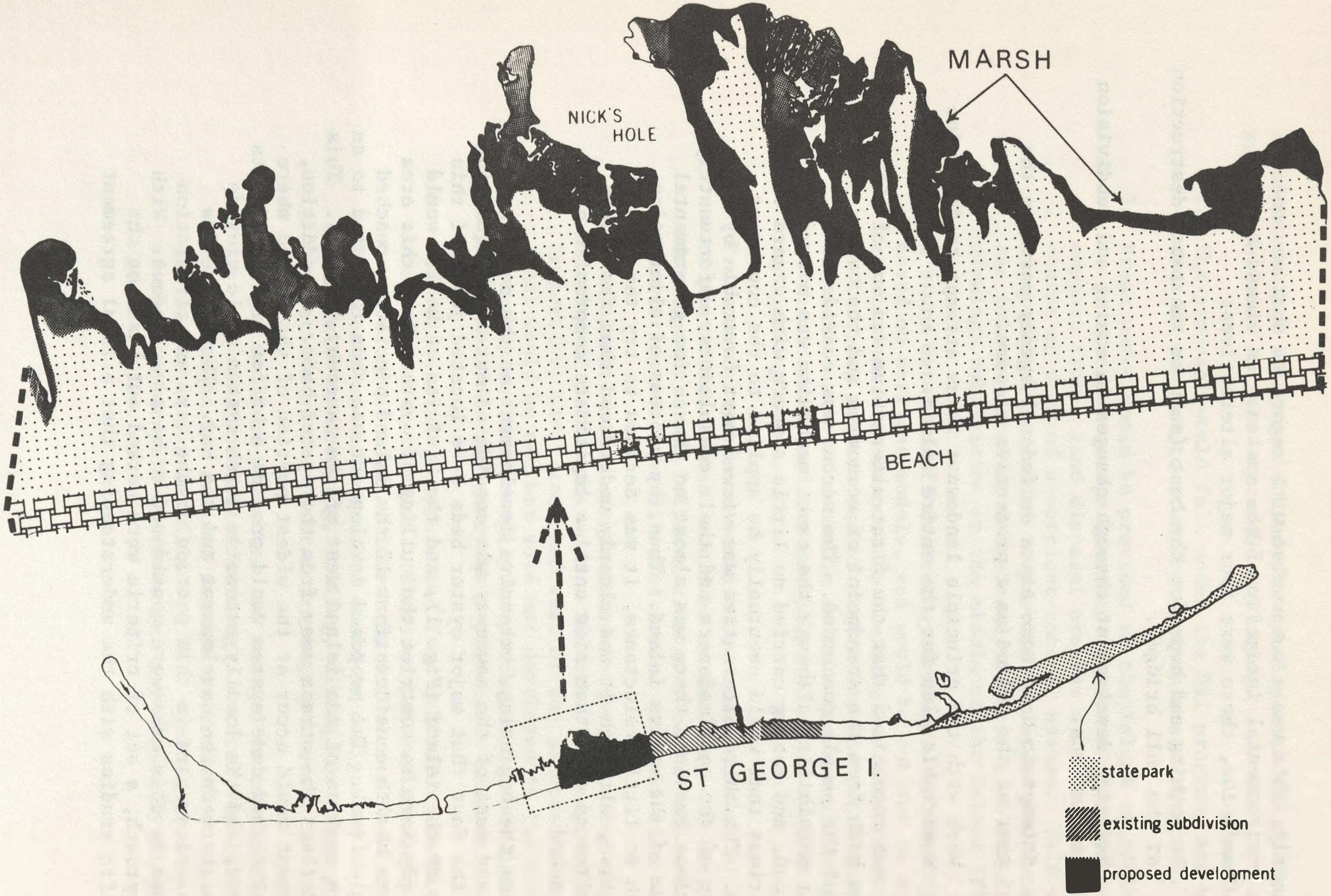

Figure 3 St. George Island (Apalachicola Bay, 1974) showing land ownership patterns. Platted (existing) development occurs at the center of the island. The state park occupies the eastern portion of the island. The remaining land, with the exception of sections west of Sike's cut, belongs to Leisure Properties, Ltd. The proposed development shows the 800 acre site chosen for the controlled project as specified in the D.R.I. As shown, this area is characterized by an extensive salt marsh on the Lee side of the island.

Clearly, this was a compromise with regard to what was needed for the environmental integrity of the system. As viewed by the County-Commission, there were four major alternatives:

1. Do nothing and hope for the best (such as the total destruction of the toll bridge).

2. Restrict development through changes in zoning and subdivision regulations.

3. Attempt to have some state or federal agency purchase the rest of the island as a protective measure.

4. Work with the principle landowner in an attempt to determine a workable plan for the entire island.

It was recognized that the first alternative was out of the question both from the standpoint of economics and the basic nature of the people concerned. The second was considered a distinct possibility although the exact mechanism was not well understood, and zoning carried no little concern with regard to restrictions that would eventually be applied to the county as a whole. The third alternative was viewed most favorable by a majority of the commissioners and their consultants; unfortunately, for various reasons, there was almost no chance for governmental purchase of the entire island. Thus, by process of elimination and with no little reluctance, it was decided to try the fourth alternative, although it was clearly understood that there were no commitments on either side until a legitimate compromise had been reached.

From the beginning, extensive development on the portion of the island east of the causeway was considered out of the question due to the fact that major oyster beds were located just off this portion of the island (Fig. 1), and the Division of Health would ultimately have to restrict the culling of oysters from this area for human health considerations if the island population reached a certain level. The proposed development was thus relocated to an 800 acre section of the island west of the causeway (Fig. 3). This would deflect the stress away from the oyster beds. In addition, development would occur at the widest portion of the island where the well-formed dune system would provide a buffer for the effects of storms, and the locally extensive marsh system would provide a filter between the development and the bay. There were few massive oyster bars in this portion of the bay, and circulation and depth in this area were considered to be advantageous. With this approach, a set of criteria were worked out based on the scientific studies with the understanding that a legal agreement could be reached which would bind the developer to the desired goals. Included in this were the following.

1. The proposal would fall under the DRI program, and would thus be subject to study by various state agencies.

2. Fresh water would be provided to the island in addition to an advanced sewage treatment system with supplemental support from a land disposal program utilizing a golf course as part of a nutrient control system. This would eventually be expanded to provide for other portions of the island including the already platted (and rapidly growing) subdivision in the middle of the island (Fig. 3).

3. A storm water runoff control system would be developed based on nutrient models, and would be subject to stringent regulations with respect to cleaning and construction activities, private use of pesticides and fertilizers, the maintenance of domestic animals (none would be allowed on the island), and the use of paved areas such as roads and parking areas.

4. Pest control programs would be restricted, with minimal use of pesticides. There would be no marinas, and residential development would follow a cluster format. All recreational activities would be directed toward the Gulf side of the island.

5. Development would be restricted to the 800 acres at a density of 3.75 units/acre. The other holdings of Leisure Properties, Ltd. (east and west of the proposed development area) would be neither sold nor developed in the hopes that they would eventually be purchased by some private, state, or federal agency as a protective measure.

6. Dune areas would be protected from vehicular traffic and construction activities. Elevated boardwalks would be constructed at regular intervals for access to beaches. Both beach and salt marshes would be designated as preservation areas with no dredging, filling, diking, or other physical alterations of the natural drainage patterns.

7. Sloughs would be protected and managed in conjunction with a program for controlled burning. Natural vegetation would be encouraged for maximal success in transplanting and minimal needs for fertilizer. This would include a series of slough-boardwalk networks and strategically placed nature trails.

8. Native vegetation would be maintained in large enough areas so that effective population sizes of indigenous faunal types could be maintained. The cluster-housing concept would aid in this aim by concentrating people in living areas surrounded by natural vegetation.

9. Solid waste would be collected and disposed of in approved mainland areas.

10. All developmental activities would be analyzed for ground water contamination (pesticides, metals, etc.), nutrient loading to the bay, salinity alterations, the ability of the system to handle adequate short-term (torential) rainfall, and the long-term effects of various human activities on the bay.

11. All development would occur in distinct increments of time. Such a staged program would be accompanied by an aquatic sampling program (nutrients, pesticides, trace metals). An adverse impact on the environment would delay the development until the problem was solved; Leisure Properties, Ltd. would provide the money for such a program which would be administered by the Board of County Commissioners of Franklin County. Research data would be continuously available to county and state regulatory agencies.

In this way, it was considered that the development would be staged with appropriate mechanisms to stop any activities which would prove to be detrimental to the natural systems; particular attention was paid to the island as a natural system which would be protected through imaginative forms of development. Thus, according to this approach, although a no-development policy was preferred, controlled development in one portion of the island was considered superior to uncontrolled development of the entire island.

Although this plan was considered to be environmentally sound and relatively restrictive in its requirements, certain difficulties arose. During the D.R.I. process, the proposed development was reviewed by various state agencies. The Northwest Florida Planning & Advisory Council (NWFPAC) recommended approval of the project only if a list of 24 modifications were included. Among these was the demand for the installation of the advanced waste treatment facility prior to the occupancy of the first residence and that no contruction could occur below the four foot contour line.

Meanwhile, Leisure Properties, Ltd. established an office in Apalachicola and proceeded to carry out a relatively intensive public relations program on behalf of the project. In addition, principals of the company reneged on promises concerning the moratorium on development outside the 800 acre area designated by the D.R.I. This did not have a positive effect on the Franklin County Commission. In addition, a variety of other problems arose. It was argued that the association for the island (set up by the developer) was arranged in such a way that environmentally protective measures would not exist as long as 51 percent or more of the land was owned by the developer. Indeed, some lawyers were openly skeptical whether the developer could be legally held to any of the environmental commitments. Thus, in addition to a question concerning the control of the Association, there was a growing need to determine if the environmental criteria could be carried out in a legal sense.

It was suddenly clear to the Franklin County Commission, which was empowered by law to make the final decision concerning the acceptance or rejection of the D.R.I., that adequate legal assurance would be necessary before such approval could be given. In addition to the legal doubts, some members of the commission questioned the proposed population density on the island. Eventually this could have become a problem with respect to the integrity of the Bay. There was a gradual shift of the Franklin County Commission to resort to the restrictive use of zoning and sub-division regulations. With the help of planners and a local committee, a county-wide plan was developed. This included the implementation of sub-division regulations for St. George Island. Eventually, this alternative was adopted, although it remains unclear to the author how this change in priorities actually came to pass. All this finally led to the demands by the Franklin County Commission that the developer abide by the recommendations made by the NWFPAC. Since there was no immediate capital to construct the advanced water treatment plant (the developer had proposed a phased scheme of implementation commensurate with the population), Leisure Properties Ltd. withdrew its application and this phase of its operations came to a close. In retrospect, the potential legal problems, the fear of too many people eventually inhabiting the island, and the growing acceptance that zoning and sub-division regulations could control destructive development, ultimately led to the demise of the D.R.I.

Since this time, the county has restrictively zoned the island with the help of state planners. Uncontrolled development has continued along the entire length of the island. Septic tanks are still being brought to the island without restriction. Leisure Properties, Ltd. has commenced to cut up their holdings and sell off the land in lots to private individuals and groups. The eastern end of the island, together with the platted central section has continued to be sold for private development except for portions falling within the state park. Leisure Properties Ltd. applied for zoning changes embracing considerable acreage for the development of several major commercial centers on the western end of the island. This has finally come to a clear test of the zoning concept as a viable way to deal with the development of St. George Island. The zoning requests led to a series of confrontations between Leisure Properties, Ltd. and the Franklin County Commission. After being turned down in several bids for less restrictive zoning, Leisure Properties Ltd. sued three of the commissioners. This suit was in progress as this article went to press. Meanwhile, various forms of environmental degradation continues. Some groups on the island favor incorporation, which would withdraw it from the mandates of the Franklin County Commission. The only generalization to be made is that the central environmental issues remain unresolved, and the situation remains in a state of flux. Clearly, the state planners and environmental groups who were responsible for the shift in the direction of development will have difficult problems to face in the future.

Summary and Conclusions

A barrier island such as St. George is an important component of a marine (coastal) ecosystem. The physico-chemical and biological composition of the lagoonal areas depends to a large degree on the placement and ultimate use of the barrier complex. Such islands are often environmentally fragile, with little support for the processing of runoff and wastes which are associated with concentrations of people. Thus, they do not lend themselves well to large-scale development, and often are rapidly transformed in the process to a different form of system. The terrestrial biota is easily affected even though this particular system is often overlooked by the developers and land planners. Various principles should be followed in such development; this includes adequate protection of the dunes and beaches, natural vegetation complexes, drainage patterns, and the salt marshes.

From an environmental standpoint, the construction of a bridge to a barrier island is the beginning of the end of the natural island system. In addition to the inflation of land values (so that it becomes difficult to purchase such land for environmental protection), this allows access to the island by large numbers of potential permanent residents and transitory (recreation-seeking) people. Without adequate controls imposed by local boards and commissions, there is a relatively rapid colonization with all the accompanying problems such as habitat destruction and pollution.

The St. George Island experience has been both illuminating and frightening. Despite the basically honorable intentions of most principals, no real program of planned development has resulted. Each approach to planning has met with resistance from some faction. So far, the well-intentioned efforts of environmental groups have not resulted in a workable alternative. In this sense, unless something is done to resolve the issue, the efforts to stop development could result in the gradual destruction of the island's natural assets. With the demise of the last attempt at comprehensive (island-wide) planning, the responsibility has fallen on the planners who proposed zoning as a viable approach. Clearly, if the environmental laws of Florida are to be applied successfully, there will have to be a greater development of state advisory services at a local level. Ultimately, those who oppose development for its own sake should recognize that the resulting chaos can be every bit as destructive as irresponsible development.

We are left with an unresolved question which is ultimately concerned with the conflict between the public's right to a clean environment and the various rights of private (individual) ownership. Although Florida has developed an intricate and effective system to carry out its advanced environmental laws, little attention has been paid to the advisement and guidance of local officials who are ultimately responsible for the application of the law in the form of an overall planned approach to development. One answer to such problems with respect to our remaining barrier islands could lie in a two-pronged approach; on the one hand, public money should not be expended to enhance the economic worth of the island (through the construction of bridges, for example), and advanced, comprehensive planning should be carried out by multi-disciplinary teams of professionals (legal experts, federal and state agency personnel, scientists, public health officials, land planners, economists) and representatives of the various local and regional interests (elected officials, industrial leaders, environmentalists, etc.). Only in this way can some uniform approach be made concerning the development of environmentally sensitive systems such as barrier islands.

Meanwhile, the St. George Island experiment goes on.

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Contribution No. 8

BARRIER ISLAND PRESERVATION: THE VIRGINIA COAST RESERVE PROGRAM

By

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The marshes and islands of the Virginia Coast Reserve are a precious resource. They are the least disturbed remnant of the thin green line of wetlands which once cloaked the Eastern Seaboard. They include beaches, maritime forests and thickets, sand dunes, grasslands, and salt marsh communities and provide a variety of habitats to adapted associations of terrestrial fauna, upland birds, waterfowl and plant species. Simultaneously they serve as a buffer separating the fragile fertile marshes and agricultural land of the Eastern Shore of Virginia from the Atlantic Ocean, support a large sector of the Shore's economy and provide an accessible aesthetic resource. Poorly planned development and wetlands alteration have accounted for the desecration of much of this resource along most of the Eastern United States' coastline. The Virginia Barrier Islands represented the last intact set of islands which faced this plight. Their relative isolation had protected them for years.

STUDY AREA DESCRIPTION

The Virginia Coast Reserve consists of approximately 33,371 acres of barrier islands and marshes owned by The Nature Conservancy on the Eastern Shore of Virginia. It contains thirteen islands (See map on following page). The barrier islands of the reserve are Metomkin, Cedar, Parramore, Hog, Cobb, Ship Shoal, Myrtle, and Smith. The reserve's Revel and Rogue Islands are upland islands which do not front on the Atlantic Ocean. Sandy, Godwin, and Mink Islands are salt marsh components of the system. The Conservancy owns these islands with the exception of major portions of Cedar Island and small parts of Hog and Smith Islands. All of the Virginia Coast Reserve may be reached from the adjacent peninsula by boat but there are no roads connecting the islands with the mainland. This system stretches along the southern seaward edge of the Delmarva Peninsula, a coastal plain outcrop, for about fifty-one miles. The islands represent the most unaltered barrier island-lagoon complex along the east coast of North America. Latitude-longitude coordinates for the Virginia Coast Reserve are 37° 05', 37° 34'N and 75° 56', 75° 37'W.

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VIRGINIA COAST RESERVE STUDY
The Nature Conservancy

The low lying islands' eastern border is the Atlantic Ocean. At intervals along the coast, inlets connect the sea with the extensive lagoon system westward of the reserve. These lagoons typically have salinities of 25 to 34 parts per thousand. The tidal range along the ocean front of the islands normally averages 4.2 feet but may reach nine feet or more during excessive storm surges. The expansive marshes behind the barrier islands are much incised and well flushed by tidal action. Brackish and fresh water occurs in the interior of the larger islands at the head of their upland drainages or as small ponds.

Biological communities of the reserve are controlled by the islands' dynamic geology. The sandy soil of the islands is in a constant state of flux, subjected to the influences of wind, tidal currents, temporary stabilization by vegetation and high energy input along the coastal front. The system has a wide diversity of aquatic and terrestrial biota.

Human influence on the system has been persistent but for the most part, it has not altered the Reserve's integrity. The present Virginia Coast Reserve has been traditionally used for pastureland, pirateering, waterfowl and shorebird market hunting, resort development, and homesites. These human impacts have had little long term effect on the structure and function of the island's natural systems. Their resiliency, isolation, and inaccessibility protect them from most direct human influences.

The Eastern Shore of Virginia is a peninsula bordered on the east by the Atlantic Ocean and on the west by the Chesapeake Bay. It is the mainland adjacent to the Virginia Coast Reserve's islands. The landmass is divided into two counties; Northampton, the southern county, and Accomack, the northern county. The region is the southernmost extension of the Delmarva Peninsula, a physiographic unit encompassing Delaware and parts of Maryland and Virginia's total shoreline and 47% of her salt marshes.

The peninsula supports a rural population dependent primarily on agriculture and fisheries for subsistence. Land use categories of the peninsula include 29.1% agricultural land, 29% woodland, 32.2% tidal marsh, 1.5% coastal beach, and 8.2% miscellaneous. The Shore has been historically isolated. Until 1964, the peninsula was only accessible from the rest of the state by a ferry which crossed the Chesapeake Bay. U.S. Route 13 entered the region from the north through Maryland. Now, the Chesapeake Bay Bridge-Tunnel connects the southern tip of the Eastern Shore to the mainland via a 17 mile span crossing the mouth of the Chesapeake Bay. The area has traditionally been an isolated cul-de-sac. This fact, more than any other, was responsible for the maintenance of a rural life style and the preservation of the Virginia Barrier Islands until the time they were acquired by The Nature Conservancy, and their preservation was insured.

In 1967 the sanctity of the Virginia Barrier Islands was threatened when developers considered building a bridge connecting Smith Island, in the south of the island chain, with the mainland. The ill-suited development, typical bane of other coastal systems, had come at last. Convention centers, airports, and second-home subdivisions were planned. The Nature Conservancy purchased the island from developers with funds provided by The Mary Flagler Cary Charitable Trust to insure the preservation of the island. This acquisition triggered the ensuing chain of purchases which ultimately led to the formation of today's Virginia Coast Reserve, a chain of thirteen islands preserving this coastal resource.

STUDY OBJECTIVES

The objective of The Nature Conservancy's involvement with the Virginia Barrier Islands is to insure the perpetual preservation of this unique barrier island-lagoon ecosystem.

The Conservancy's concern for the barrier islands has been exemplified through the Virginia Coast Reserve Study. The objective of this investigation was to establish a base line of information that would yield an understanding of the operationally significant factors governing the stewardship of the island system. The study was divided into four separate sections. Objectives were set for each portion of the research.

1. Objectives of the Legislative Compendium, Title Search and Acquisition Priorities Section

   a. Provide The Nature Conservancy with a clear image of its ownership and inholdings within the reserve system.

   b. Compile the legislation which pertains to the ownership of the islands, marshland and adjacent riparian and subaquatic rights to determine how it affects land stewardship.

   c. Establish a strategy for the further acquisition of key lands within this island-lagoon system that are worthy of preservation from an ecological or strategical perspective.

2. Objectives of the Ecosystem Description Section

   a. Identify the limiting ecological factors which must be known in order to administer the Reserve, preserving its unique qualities.

   b. Define the ecological components of the system to begin the establishment of a monitoring program which will expose the scientific community to the potential for innovative research possibilities within the Virginia Coast Reserve.

3. Objectives of the Social and Economic Analysis Section

   a. Establish economic baseline information about the two counties within the Eastern Shore of Virginia.

   b. Assess effects of the preservation of the Virginia Coast Reserve Study on the local communities of Accomack and Northampton Counties.

   c. Assess the impacts of potential regional growth, land-use, and recreational needs on the Virginia Coast Reserve.

   d. Assess the indirect socio-economic benefits of the Virginia Coast Reserve associated with preservation of the system.

   e. Determine popular opinion regarding the preservation of the Virginia Coast Reserve.

4. Objectives of the Stewardship portion of the Virginia Coast Reserve Study

   a. Develop a list of the stewardship needs and procedures which offer maximum protection for the system.

   b. Determine agencies capable of accomplishing these goals and where ultimate stewardship responsibility should lie.

   c. Establish a preliminary management scheme accommodating preservation, research, education, and if appropriate, recreation.

   d. Determine the cost associated with this management scheme.

To achieve these objectives, the Virginia Coast Reserve Study coalesced the efforts of more than thirty professional administrative and research personnel. The experience and input of Eastern Shore residents also contributed to collecting this data.

LEGISLATIVE COMPENDIUM, TITLE SEARCH AND ACQUISITION

At the time of the acquisition of the Virginia Barrier Islands, the Conservancy became part of a parcel of difficulties including counter-claims for ownership of the system, diverging interpretations in the chain of title to certain tracts, varying interpretations of existing island- and wetlands-related legislation, and threats to the effectiveness of our preservation scheme from "inholdings" within the island system and lands owned adjacent to the reserve. We employed the full-time assistance of an environmental lawyer to catalogue, interpret and resolve these difficulties.

A complete title search was also conducted to determine the present ownership pattern of the barrier islands. This ownership information provided a basis from which to assess the security of the Conservancy's present position as the controlling landowner within the island system, and of the intentions of insuring preservation of the complex. A review of the situation fostered the preparation of an acquisition strategy designed to fill the gaps in the present pattern of ownership.

At the same time, the complex environmental legislation pertinent to the administration of this marine wetlands area at federal, state and local levels was collected. The laws which may be used to insure the integrity of the reserve were compended. This allows their quick and efficient utilization in the administration of the reserve.

ECOSYSTEM DESCRIPTION

Information already existing pertinent to the natural history of the reserve has been collected. Additional basic field work was also completed to compliment this data.

The documentation of existing material included compilation of publications, maps, aerial photographs and other supportive material. The supply of existing comprehensive ecological data was scarce. Some information was available in the fields of geology, ornithology, and rudimentary plant community associations. A substantial body of material existed regarding the fisheries resources of the waters surrounding the island chain.

Supplementary ecological work was undertaken with the intention of complimenting existing data so that predictions and stewardship decisions based on a fundamental understanding of the ecology of the Virginia Coast Reserve system could be made.

SOCIAL AND ECONOMIC ANALYSIS

The barrier islands represent a valuable resource to the Eastern Shore of Virginia. They offer a livelihood to some by protecting marshland which provides a haven for marketable fish and shellfish. They offer attributes to residents of the "seaside" of the peninsula by buffering the shoreline from storm surges and winds. More intangible benefits are realized by a wider spectrum of the population. The islands are an integral part of the rural lifestyle, the preferred quality of life, of the Eastern Shore resident.

These aspects, the benefits of the Virginia Barrier Islands to the local economy, lifestyle, and the residents' perception of the Eastern Shore, are analyzed in this section of the study. By the purchase of the barrier islands, the Conservancy has become the largest property owner in both Accomack and Northampton Counties. Addressing both the economic and social arguments for and against preservation of this huge system required the full-time assistance of a professional economist and the assistance of several contractual personnel from Salisbury State College, a local institution.

The economic analysis centered on the benefits and costs of barrier island preservation. This approach incorporated their tangible benefits and costs to the local communities and tangible and intangible benefits on a regional basis. Additionally, a detailed analysis of Virginia's Eastern Shore economy, in terms of the utilization of the local resource base, was conducted. The intent of this investigation was to assess the effect of barrier island preservation from the economic perspective of the Eastern Shore's citizenry.

The "quality of life" of the Eastern Shore is a well-debated issue in local circles. The average citizens' perception of their lifestyle and general well-being are clues to the satisfaction or dissatisfaction with the style of life that The Nature Conservancy's natural area acquisition philosophy tends to preserve. The Conservancy was interested in determining whether its activities in the Virginia Barrier Islands were in accordance with or in opposition to the majority of sentiment of local residents. To assess these feelings, a broadly-based opinion poll of a representative sample of Eastern Shore citizens was conducted. Its aim was to gather data directly applicable to determining the "quality of life" dilemma here; were local residents happy with life as it is and the barrier islands as they are? The direct answers to these and associated questions have fostered conclusions about the Eastern Shore residents' perception of The Nature Conservancy's operations in this area and their wishes for the future of the Eastern Shore.

STEWARDSHIP

Effective administration of the reserve by any agency depends on the recognition of stewardship realities. In this section of the Virginia Coast Reserve Study, these were assessed and a scheme to deal with them is proposed.

Initially, a list of needs and procedures prerequisite to preserving the Virginia Barrier Islands was developed. The remainder of this section of the study dealt with how best to insure their fulfillment.

One of the greatest unknowns for the Virginia Barrier Islands preservation strategy was the ultimate managing agency for the system. It has traditionally been the Conservancy's policy to transfer some of its finest preserves to federal or state agencies interested in their management. Recently, a decision to internalize the the management of selected preserves was made in accordance with The Nature Conservancy's model preserve "1980 Program". These conflicting policies had to be resolved in the best interest of the Virginia Barrier Islands.

The stewardship capabilities and policies of The Nature Conservancy and selected federal, state, and county agencies were examined. The interest each group had in the islands was assessed. Each agency's program was inspected to see whether it fit into the Conservancy's plan for the preservation of the Reserve. Finally, a review of their legislative, financial and enforcement abilities rounded out the picture.

The success or failure of The Nature Conservancy's own participation in this Virginia Coast Reserve management blend will be based on an operating budget. Present operating funds have been fully utilized in the preparation of this document. To continue operation requires the coordination of our management priorities and approximating an associated operating budget.

The stewardship option available to the Virginia Coast Reserve under the Conservancy's supervision is incorporated in this report. The scheme accommodates preservation, research and educational uses in differing proportions. This proposed stewardship plan addresses the number and functions of proposed Conservancy staff personnel to fulfill this preservation scheme, equipment requirements, office space and housing needs, future acquisition, and required research costs. The plan's implementation depends upon the identification of funding sources to power these programs.

The Conservancy has a tremendous opportunity and, indeed, a responsibility to see that we do not now turn our attention from the barrier islands, but indeed that we intensify our efforts in such a way that what has been accomplished so far has a multiplying effect in helping us to achieve additional conservation objectives both in the barrier islands and elsewhere. We have determined that the Conservancy must retain ownership and management responsibilities in spite of the difficult task this will set for us and the ease with which we might transfer these lands to another agency for management. We always retain the future option of transferring out to some other agency if we determine that this would be in the best interest of the perpetuation of those qualities which make the islands such an exciting and important natural area. However, we have not found any agency which would be perfectly suitable or reliable or even more effective than the Conservancy is apt to be. Combining these conclusions with the important opportunities represented by the private sector management for the continuation of private sector action by which these resources were preserved, and without which they would otherwise have certainly been lost to the forces of development, we are determined to shoulder this responsibility.

One of the crucial reasons for the Conservancy's retaining ownership at this time is that the preservation of barrier islands is not yet assured. They are threatened by the proposed expansion of the inter-coastal waterway system which would almost certainly bring increased development and increased pressure in its wake. In spite of the financial uncertainties that may plague private sector actions of this kind, the Conservancy is at least as able to resist pressures for development on and around the islands which might be detrimental to their continuation as an integral natural system as any of the potential alternative managers. However, it is the Conservancy's increasing conviction that in the face of relentless pervasive pressures for land alteration in this country, it is going to be necessary to pursue preservation objectives in a much more comprehensive manner than we have in the past. Because of the size, scope and conspicuously outstanding quality of the barrier islands, they represent perhaps the best opportunity in the country today to act as a laboratory for experimenting with just such comprehensive preservation planning as it pertains to the islands themselves, the regions in which they are located and to barrier islands generally as a particular ecological system more or less universally affected by the same laws, practices and pressures.

This scheme would involve The Nature Conservancy as the immediate land steward responsible for the islands' supervision. Duties of the Virginia Coast Reserve office would switch from temporary, primarily academic orientation, to those associated with permanent land preservation. Information from similar federal and private sanctuaries indicate that this would include increasing personnel, housing, office space and equipment.

Added to this basic stewardship program which surveys, manages and protects the Reserve, the program will expand to accomplish even greater objectives.

Added Layers of Protection: The preserve may be protected with several layers of overlapping, government sponsored protection. These are primarily status designations which may be obtained while the islands remain in Conservancy ownership. They include protection at various levels:

Federal: U.S. Department of the Interior, National Park Service National Natural Landmark, National Environmental Education Landmark.

U.S. Department of the Interior, Fish and Wildlife Service Wetlands lease or easement agreement.

U.S. Department of Commerce, National Oceanographic and Atmospheric Association, Marine or estuarine sanctuary.

State: State Water Control Board, critical groundwater area.

Division of Planning and Community Affairs, state critical area, protected by the Coastal Zone Management Act.

Division of Game and Inland Fisheries, wetlands lease or easement agreement.

Local: County use plans -- designation as critical environmental areas.

(Additional protected designations are outlined in Volume II of The Virginia Coast Reserve Study in the Legislative Compendium Section).

Scientific Developments and Educational Opportunities: The immense value of the Virginia Coast Reserve as a living natural laboratory has barely been realized. The research sponsored by the Virginia Coast Reserve Study has awakened the scientific community to study possibilities available nowhere else on the Atlantic Coastal Plain. Our work has shown that perhaps the most stirring opportunities provided by the islands are in the fields of future island preservation, island biogeography and ecosystem management and restoration. As testimony to their value, universities, researchers and businessmen have encouraged the Conservancy to retain ownership of the islands and proceed in developing a Virginia Barrier Islands Research Consortium. This facility would provide a nucleus for development of undergraduate, graduate and post-graduate studies in environmental processes of the coastal zone which would be applicable to broader scale land use decisions throughout this region.

Island Use Program: The value of the islands as a recreational asset will incorporate planned compatible use program for island enthusiasts. Various methods of allocating this sparse resource are proposed including maintenance of existing, non-destructive, traditional use; cooperative regional planning and organized recreational areas supervised by local recreation commissions; and, organized wilderness outings for groups such as the Wilderness Society, Sierra Club and Audubon Society.

Land Acquisition and Regional Development: The ongoing identification and acquisition of Eastern Shore natural areas would further stimulate the Conservancy's already enormous regional ecological protection. The impact of the proposed Conservancy's office and island-related preservation activities will develop a following further promoting the preservation of vital island and wetland areas by regional decision-makers.

Each of these tasks described above deserves a fuller explanation and consideration of the resources and programs that will have to be developed in order to make them possible. The fundamental resource for all these is the barrier islands themselves in their pristine natural condition. Through our systematic work, foresight and setting of rational priorities both by the Conservancy and its cooperators, these islands have been set aside as the most impressive privately managed natural area preserve in the nation.

Contribution No. 9

CRITICAL AREA DESIGNATION: THE COASTAL ZONE SOUP BOWL

By

Garrett Power*

At the outset of the New Deal, Alfred E. Smith observed that government was becoming submerged in a bowl of alphabet soup. My assignment for this afternoon is to describe for you a contemporary cup of this briney broth -- the Coastal Zone Soup Bowl.

BACKGROUND

The Coastal Zone Management Act (CZMA)[1] was enacted by Congress in 1972. It charges the participating states with the obligation of designating "geographical areas of particular concern"[2] (GAPC) and "areas for preservation and restoration" (APR).[3] My job is to discuss the utility of characterizing barrier islands (BI) as either GAPCs or APRs under the CZMA.

A short legislative history may serve as the Rosetta stone making possible the decipherment of these hieroglyphics.[4] President Nixon's 1971 Environmental Message[5] proposed national land use policy "areas of critical environmental concern" including the coastal zone and estuaries among them.[6] National Land Use Policy legislation floundered and was never passed, but the more limited Coastal Zone Management Act (CZMA) has been enacted.[7] The CZMA borrowed from the Administration's legislation the notion of "critical areas" but relabeled them geographical "areas of particular concern" (GAPCs) and viewed them as a subset of important areas within the coastal zone.[8] Administrative regulations provide the following illustrative GAPCs:

(1) Areas of unique, scarce, fragile, or vulnerable natural habitat, physical feature, historical significance, cultural value, and scenic importance;

(2) Areas of high natural productivity or essential habitat for living resources, including fish, wildlife, and the various trophic levels in the food web critical to their well-being;

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(3) Areas of substantial recreational value and/or opportunity;

(4) Areas where developments and facilities are dependent upon the utilization of, or access to, coastal waters;

(5) Areas of unique geologic or topographic significance to industrial or commercial development;

(6) Areas of urban concentration where shoreline utilization and water uses are highly competitive;

(7) Areas of significant hazard if developed, due to storms, slides, floods, erosion, settlement, etc.; and

(8) Areas needed to protect, maintain or replenish coastal lands or resources, such areas including coastal flood plains, aquifer recharge areas, sand dunes, coral and other reefs, beaches, offshore sand deposits, and mangrove stands.[9]

In simpler terms the sample GAPCs seem to divide into two categories: either areas which it is important to preserve because of ecologic or other special values, or areas which need special regulatory attention because they are "prime ripe" for development. And this division explains the significance of "areas for preservation and restoration"; APRs are the subset of GAPCs which are to be kept pristine.

SIGNIFICANCE OF DESIGNATION

It seems clear that barrier islands may be fit into the GAPC category as envisioned by the CZMA either because of their special environmental values or because they may be under intense developmental pressure. The administrative regulations supporting Section 305(b)(3) of the Act give discretion to the states in determining whether to so include barrier islands (in whole or part). The Atlantic and Gulf states have for the most part not yet completed development of Coastal Zone Management programs which contain the inventory and designation of GAPC, but a telephone survey done May 6-7, 1976 indicates that none of the states plan to designate barrier islands as such, as GAPCs (see Appendix 1). On the other hand, in the states which have worked out the rudiments of their Coastal Zone Management plans, portions of their barrier beach are almost invariably to be included (the frontal dune in North Carolina, Sapelo Island in Georgia, the Florida Keys, etc.).

More significant is the consequence of the designation of the barrier island as a GAPC. The availability of federal funding for state programs is conditioned on development of an acceptable management program. Portions of the barrier islands which are designated GAPCs because of their environmental values will also be APRs and the state will have a duty in its management plan to take steps to preserve or restore; portions of the barrier islands which are designated as GAPCs because of development pressures impose or obligate on the state to develop techniques for resolving use conflicts. Hence, the availability of federal funds is at least nominally dependent on fulfillment of these duties.

CONCLUSIONS AND RECOMMENDATIONS

The question then arises as to how organizations which are dedicated to conserving the barrier island chain should respond to this legislation. Two recommendations seem appropriate. First, the designation of GAPCs under the CZMA should not be taken too seriously. The alphabet noodles of the coastal zone soup are limp and lukewarm. Efforts to abolish governmental subsidies to island development are much more important. Second, little would be accomplished by having the states designate all of their respective barrier beaches as GAPCs. Such status does not necessarily preclude development; moreover, in light of the recreation potential of these islands, conservation groups are unlikely to have the political muscle to throttle development throughout the whole island chain. Hence, it would seem desirable to concentrate on designation of circumscribed APRs (areas for preservation and restoration) and to keep a watchful eye on their conservation.

APPENDIX I

Survey done by telephone (May 6-7, 1976) -- called the states Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, Louisiana and Texas and asked the following three questions:

1. Does your coastal zone management program designate areas of particular concern? If yes, please give examples.

2. Are some or all barrier islands so designated?

3. What special preservation and restoration programs do you have for barrier islands?

Delaware

Delaware hasn't yet worked up its areas of particular concern, but is in the process. However, a good deal of the Delaware coastline is already protected under state law. Though there are no special preservation and restoration programs for barrier islands as a whole, the barrier wetlands and dunes are protected as part of the general protection plan offered by the Beach Preservation Act (1972) and the

Wetlands Act (1973). There are restrictions on building on beaches; there are set back requirements for structures built on the beaches.

Maryland

In Maryland there is no special coastal zone legislation at this time. Department of State Planning is supposed to designate areas of critical state concern. Their way of defining critical areas is broad enough so that it will undoubtedly work in the determination of areas of particular concern for the purposes of the Coastal Zone Management Act. As far as barrier islands are concerned, Assateague Island is presently a National Seashore and Wildlife Preserve. Ocean City is protected by a beach erosion control act -- anything east of the dune line is under state control.

Virginia

The State of Virginia is in the process of making designations of areas of particular concern. The barrier islands of Virginia will probably be included in this designation as they are presently protected by a private, non-profit organization called the Nature Conservancy. The state actually has no legal say in the management of the barrier islands because of the Nature Conservancy's ownership. The Nature Conservancy is doing or not doing the sorts of things that are agreeable to the Virginia Coastal Zone Management Office, so that office is working as closely as it can with the Conservancy. There are also a few more privately owned areas as well as areas of federal ownership such as Assateague and Wallops Island.

North Carolina

North Carolina is in its second year of working out areas of environmental concern. When asked if barrier islands would likely be included among the critical concern designations, the answer was "probably not" -- their main concern with reference to barrier islands is the frontal dune and there are already dune protection ordinances in local areas. There is also state enabling legislation which is designed to protect barrier island dunes as well as non-barrier island dunes. There is also a beach stabilization program in effect, conducted by the Corps of Engineers. The state offers matching funds to local areas that will do groin work. It is actually a federal-state-local program, with the federal government paying for about 80 percent of the project and the state and local governments paying 10 percent each.

South Carolina

Areas of particular concern have not yet been designated in South Carolina. Many areas, however, are owned by the state and those are, in effect, being protected. Once the areas of particular concern are designated, barrier islands will undoubtedly be included. The exceptions would be already developed areas such as Hilton Head. In South Carolina at this time there is really only one special preservation or restoration program, the Heritage Trust Program, which is under federal auspices. Several thousand acres of primarily marshland have been donated generally by private groups, to be administered as wildlife trusts.

Most of the barrier islands are owned by the state and are under the control of the Wildlife Agency, the same agency that administers the Heritage Trust program. Essentially, these islands are being kept for biological preservation. The state recently bought, with the federal government, a barrier island called Capers Island, and this purchase indicated it will be preserved.

Georgia

The State of Georgia hasn't yet adopted or even proposed a coastal zone program. The Department of Natural Resource has identified on a technical basis certain resource areas of particular concern for consideration by the Coastal Zone Management group. Their technical recommendation for barrier islands is that they be looked at as a total system instead of on a more selective basis. Because the coastal zone program in Georgia is in its infancy, limited technical work has been done on the barrier islands and discussion as to what should be considered an area of particular concern is just beginning.

There is really only one tangible management element in place regarding barrier islands -- Sapelo Island. The south end of that island and the Daplin watershed adjacent to the island were purchased by the state using federal funds. It has been approved by the Department of Commerce as an estuarine sanctuary representing the south Atlantic area. This is not an official area of particular concern, although it's difficult to imagine it not being considered so when these areas are finally designated.

There are preservation and restoration programs for barrier islands which, as in most of the other states mentioned, are outside the context of the Coastal Zone Management Program. There is federal and state funding for a Beach Erosion Control program on Tybee Island which is conducted by the Corps of Engineers. There are also various wildlife refuges, national seashore and state park areas. In general, state and federal islands are protected for wildlife and recreation. Several private owners protect them as well.

Florida

Florida's areas of particular concern remain to be designated. The coastal zone has been mapped from a bio-physical standpoint, and there are a number of areas which are already under the protection of the state -- aquatic preserves, coastal mangroves, tidal marshes, class 1 (drinking) water and class 2 (shellfish) water. These will undoubtedly be considered areas of particular concern when they are finally worked up. Parts of the barrier islands are presently being protected through set back lines and tidal marsh protection. These are part of a total protection plan and not just designed for barrier islands.

There are already areas of critical state concern in Florida. For example, all of the Florida Keys are so designated and will probably be incorporated into the geographic areas of particular concern. Even though there is no special barrier island designation now, when the regional plan is developed, specifics dealing with barrier islands will probably be included.

Louisiana

The state of Louisiana is now in the process of determining areas of particular concern. Currently-pending legislation directs that a list of areas of particular concern be developed using information supplied by the State Planning Office. If that legislation passes, at least some barrier islands are likely to be included on the list, as they have been suggested by the Planning Office.

At this point there are no special preservation or restoration programs for barrier islands in Louisiana. The use of a barrier island called Grand Terre as an erosion control demonstration has been suggested to the Corps of Engineers. A sanctuary proposal which would include the barrier islands has also been recommended.

Texas

Texas has had areas of particular concern since 1900. For the purposes of the Coastal Zone Management Program, however, there aren't yet official APCs. The state's management agencies are still nominating areas of prime concern to them. Many barrier islands are already designated as APCs in the context of previous state regulations. Since 1959 some portions of many barrier islands have been protected by the State of Texas through various beach legislation which requires that recreation be one of the major concerns on the Gulf. The state owns many miles of barrier islands and has set many of these areas aside for recreation, historic parks and the like.

It seems apparent that whatever portions of barrier islands are currently protected by the state will surely be considered areas of particular concern for the purposes of the Coastal Zone Management Program.

This last statement would seem to apply equally well to all of the states interviewed. Although none seemed to be in the final stages of designating areas of particular concern, they all appeared quite sure that at least portions of the barrier islands would be covered when the official list was prepared, especially if they were already designated as areas of critical state concern, which in many instances is the case. Until then, for most of the states, there are not many special preservation and restoration programs designed for barrier islands alone. There are, however, programs which were developed for the coastal region, which incidentally cover certain portions of the barrier islands such as the dunes and wetlands.

The following individuals were contacted in my survey: Delaware, Mr. Don Sherman; Maryland, Ms. Margaret Johnston; Virginia, Mr. Keith Buttleman; North Carolina, Mr. Stuart George; South Carolina, Mr. Bill Moser; Georgia, Ms. Lillian Dean; Florida, Ms. Mary Lou Sturza; Louisiana, Mr. Paul Templet; and Texas, Mr. Jep Hill.

REFERENCES

1. 86 Stat. 1280, 16 U.S.C. §1451-1464 (1972).

2. Id. at §305(b)(3), see 15 C.F.R. §920.13.

3. Id. at §306(c)(9), see 15 C.F.R. §923.16.

4. See 2, Zite, A Legislative-Political History of the Coastal Zone Management Act of 1972, 1C.Z.M.J. 235 (1974).

5. Council on Environmental Quality, Second Annual Report (1971).

6. S. 992, 1st Sess., 92nd Congress [§102(a)].

7. Supra, note 1.

8. §305(b)(3).

9. 15 C.F.R. §920.13.

Contribution No. 10

THE FLORIDA CRITICAL AREA PROGRAM: IDEAS FOR BARRIER ISLAND PROTECTION

By

Eastern W. Tin*

My presentation will focus on the Florida Critical Area Program in hopes that our implementation experience might offer some useful ideas for a national barrier island program. The highlights include:

1. A brief overview of our critical area program;

2. A discussion of our most recent designation involving the Florida Keys; and finally

3. A summary of some lessons we have learned.

OVERVIEW

As many of you already know, the Florida Critical Area program is patterned substantially after the American Law Institute Model Land Development Code. Minor revisions required to mesh the ALI approach into Florida Law are incorporated into Chapter 380, Florida Statutes, more commonly known as the "Florida Environmental Land and Water Management Act of 1972."

Under the law, the Governor and Cabinet, acting on recommendations from the Division of State Planning, may designate, by administrative rule, discrete geographic areas as Areas of Critical State Concern. Essentially, the purpose of such designations is twofold: first, to focus public attention on resources or public investments of greater-than-local significance; and second, to assure that the state or regional interests in such resources or investments are protected through the implementation of appropriate local land development regulations.

Underlying this approach is a philosophy that in dealing with certain issues of greater than local concern, the state should exercise a strong leadership role to promote an intergovernmental partnership aimed at balancing state, regional and local interests.

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Procedures to implement our critical area program are actually quite simple. First, critical areas selected for recommended designation are subjected to a rigorous analysis by the Bureau in consultation with appropriate governmental agencies, private organizations, and citizens. Upon completion of this phase, the Bureau's findings and recommendations are incorporated into a Critical Area Report encompassing:

(a) the boundaries of the proposed area;

(b) the reasons why the proposed area is of critical concern to the state or region;

(c) the dangers that would result from uncontrolled or inadequate development of the area;

(d) the advantages that would be achieved from the development of the area in a coordinated manner; and

(e) specific principles for guiding development within the area.

Second, the report is transmitted to the Governor and Cabinet which, under the State Administrative Procedures Act, must issue notice and hold a public hearing on the proposed designation. Following its public hearing, the Governor and Cabinet adopt its designation rule incorporating both the critical area boundaries and specific principles for guiding development.

Finally, following designation, local governments are afforded a six-month period to adopt land development regulations for the area which in turn are approved by the Division of State Planning if they comply with state-established development principles. If, however, local governments fail to respond within this six-month period, then the critical area regulations are prepared and adopted by the state. In either case, regardless of the adoption procedure, critical area regulations are administered and enforced locally, subject to review and in some cases appeal at the state level (Fig. 1).

THE FLORIDA KEYS

To date over 1.2 million acres within the State of Florida have been placed under critical area designation. These include: the Big Cypress Swamp, the Green Swamp and the Florida Keys. Of the three areas, the Florida Keys clearly stands apart. Aside from getting the state out of the swamp business, the Florida Keys designation served as a vehicle to examine problems associated with the urbanization of a unique chain of islands stretching some 130 miles from the

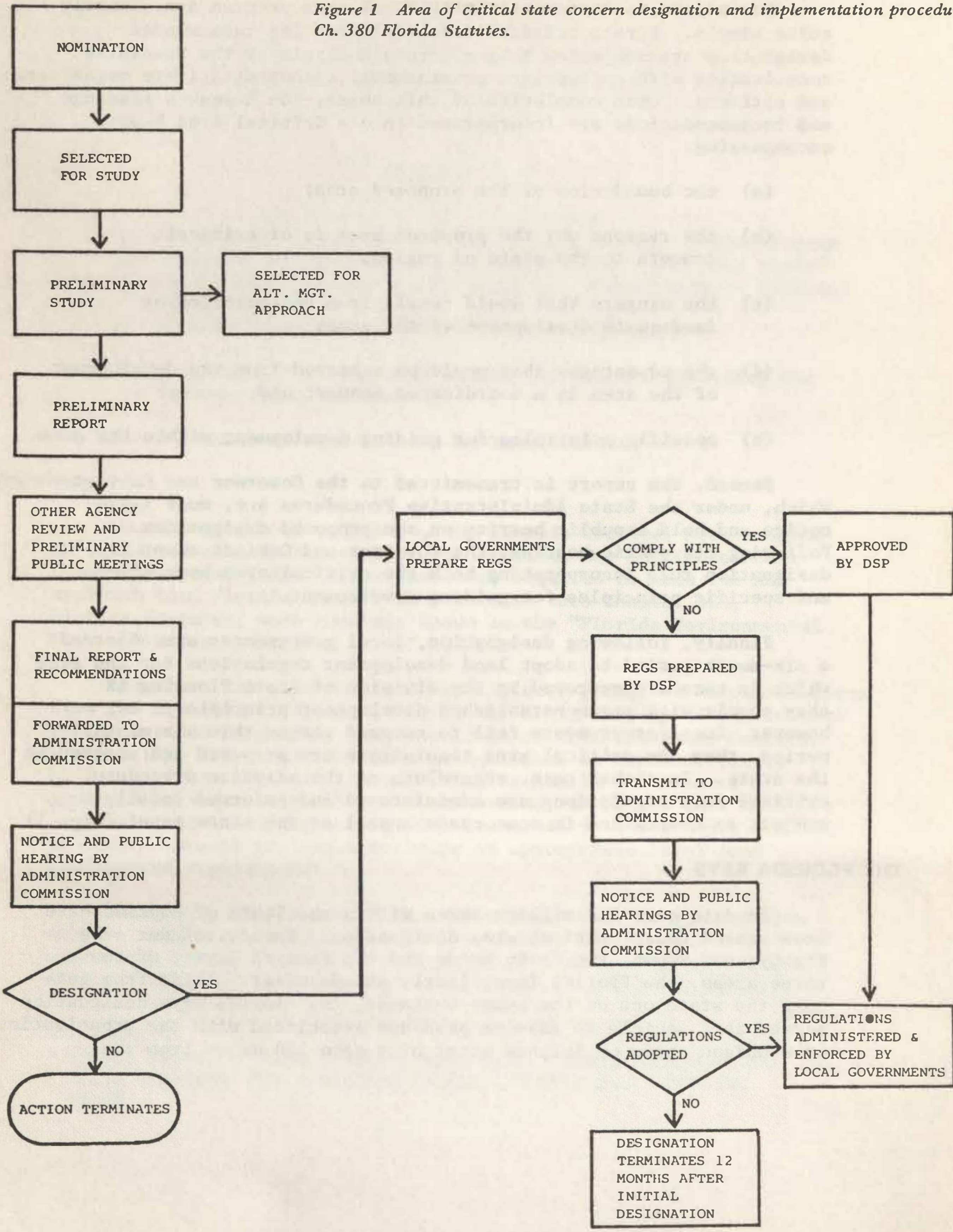

Figure 1 Area of critical state concern designation and implementation procedure - Ch. 380 Florida Statutes.

Florida mainland down to Key West. In our designation report we stressed not only the environment and scenic attractiveness of the area, but also the manner in which environmental, urban structure and economic systems interelated to both limit as well as benefit the system as a whole. In this regard, we emphasized on the one hand that the Key's resource-based tourist economy was dependent upon an attractive, pollution-free environment; while on the other hand, urban service shortages and resulting pollution caused by expanding population threatened to undermine the area's original attractiveness and hence its overall economic stability. In sum, we attempted to draw, as Governor Askew so aptly described, a balance between the Key's short-term economic needs and its long-term environmental necessities. The results of this effort by the Division of State Planning are now history. After a lengthy controversy and sometimes colorful public debate, the Keys were designated on April 15, 1975. Over a year later, on April 19, 1976, local regulations were adopted resulting in establishment of:

1. A special airport zoning district to protect a substantial federal investment in the Key West Naval Air Station;

2. A community impact assessment procedure requiring a comprehensive assessment of development proposals along with a system to assure the phasing of development approvals consistent with urban service delivery capabilities;

3. Site alteration regulations to protect tropical vegetation unique to the Keys;

4. A shoreline protection ordinance to protect the natural values and functions of mangrove areas; and

5. Approval criteria to protect the integrity of the Key West Historic Preservation District.

In addition to strengthening local regulatory capabilities, the Keys designation led to the establishment of a comprehensive assistance program aimed at orchestrating state and federal technical and financial assistance to solve many problems of a non-regulatory nature. As a product of this effort, initiated by the Division of State Planning, over $3.4 million have been funneled to assist governmental agencies in the Florida Keys. Included in this amount were:

1. $2.8 million from the Economic Development Administration to help alleviate critical water shortage problems;

2. $21 thousand from the Department of Commerce to hire a badly needed coastal zone planner;

3. $10 thousand from the Department of Housing and Urban Development to prepare and update zoning base maps;

4. $285 thousand from the Environmental Protection Agency to establish a solid and liquid waste program.

Finally, to assure the sustained implementation of various administrative and regulatory improvement programs, the Division has established an ongoing state-federal tracking system to monitor and expedite the approval of federal grant requests for local governments in the Keys.

PROBLEMS AND LESSONS

Moving on to the last part of this presentation, I'd like to briefly touch on a few implementation problems we've encountered because I think they will offer some food for thought in the development of ideas on a national barrier island program.

As I mentioned previously, one of the major features of Florida's Critical Area Program is that it relies on local regulatory mechanisms to protect the state's interests. In this regard, one of our major problem areas has been the difficulty of providing local governments an incentive to protect the state's interests when they already have enough difficulties protecting their own. This has been further complicated by the tendency for some local officials to perceive a state critical area designation as a form of paternalistic criticism of local incompetence. Although I understand that it is fashionable for each level of government to blame the other for its problems, this attitude has led to an unfortunate waste of time and energy. Rather than wasting time on fixing fault or blame, we have learned to concentrate on a means to focus the combined resources of federal, state and local governments on solving environmental and urban service delivery problems. I am confident that our comprehensive assistance program for the Florida Keys is not only a major step in the right direction but also one that will lead us away from the unproductive conflicts which have plagued us in the past. While this assistance program is obviously not a panacea for solving all problems in the Keys, the main point is that it reflects a new relationship accentuating the positive role state and federal levels of government can play in focusing their technical and financial resources to assist local governments.

In conclusion, I recommend that you give strong consideration to the combined regulatory and assistance program we have developed in the Florida Keys. In the long run I think you will find that the approach will not only result in the protection of a valuable resource, but also provide a basis to realize the full potential of a working intergovernmental partnership.

Contribution No. 11

BARRIER ISLANDS, BARRIER BEACHES, AND THE NATIONAL FLOOD INSURANCE PROGRAM: SOME PROBLEMS AND A RATIONALE FOR SPECIAL ATTENTION

By

H. Crane Miller*

I have been asked to help define the extent of the coastal flood hazard areas, associated risk zones, and the operation of the National Flood Insurance Program in coastal areas. From New Hampshire to Florida, and virtually the entire length of the coast of the Gulf of Mexico, our coast is a succession of barrier islands, beaches, sand dunes, bluffs, and other unconsolidated landforms. As reported in the National Shoreline Study of the Corps of Engineers, some of the highest natural erosion rates are found along the East Coast and the Gulf Coast of the United States. The hurricane experience of those two coasts is common knowledge.

Less well known are the dynamic characteristics of those coastal reaches, and the important and efficient role that they play as natural buffers and dissipators of storm energy. Descriptions in preceding papers, of the dynamic characteristics of barrier islands and barrier beaches have laid the groundwork for the principal theme that I would like to address. Namely, the natural and developmental characteristics of coastal flood hazard areas are distinctly different from riverine areas and require attention specifically designed for the dynamics of the coastal zone. The National Flood Insurance Program is an important force through which special attention can be directed to particularly hazardous areas of our coasts. It is also a program subject to a number of external forces over which it has no control or jurisdiction. In developing a rationale for special attention to coastal flood plains, I would like to look briefly at some national demographic trends, the legislative goals of the National Flood Insurance Program, and then turn to the four basic areas of: insurance, financing, technical information, and coastal flood plain management; to probe into some unsettled problem areas concerning our coasts and the flood insurance program.

I strongly favor the National Flood Insurance Program as one of the most important management programs administered by the federal government in the coastal zone. But I also think that its provisions should be strengthened to achieve some important national goals; my criticism of the program is offered not as solace to those who want to weaken the program, but as the beginning of a public debate to improve its provisions, giving special attention to the unique problems of coastal flood plains. Moreover,

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if environmental groups are to lend political support to the program, we should understand that we have some common problems with which we must deal before our support, and the program, can be effective in the coastal zone.

GROWTH TRENDS

A number of growth trends converge to cause serious environmental and economic impacts in the coastal zone of the United States. Among the trends in land use are high concentrations of population in coastal areas -- well over half of the country's population lives within counties, villages, towns, and cities within 50 miles of our coasts. Population growth on the nation's coasts is accompanied by increased demand for residential, commercial, industrial, and recreational use of the limited strand of lands bordering the coasts. Economic values of such lands go persistently upward in light of increased demand for a limited resource.

The Department of Housing and Urban Development estimates that 90% of all natural disasters in the United States are flood-related and cause an estimated $1.5 billion in damages annually. The United States has invested billions of dollars in both riverine and coastal flood management structures, only to find increased federal disaster costs annually; mean average losses due to floods have increased yearly since 1936 when the National Flood Control Act was enacted, and the trend persists upward. Studies indicate that 75% of all flood-related damages are the consequence of improper building location, design and construction. Much of the coastal development destroys beaches, dunes, marshes, barrier islands, and other natural features which are efficient buffers and dissipators of storm wave energy. Equally important, such development is at high risk to properties and property owners located in coastal high hazard areas.

LEGISLATIVE GOALS

With federal disaster costs mounting annually, Congress modified its approach to attempt to shift the cost burden of flood disasters to those at risk in the flood plains -- the property owners who locate in flood hazard areas. Both the National Flood Insurance Program and the Federal Disaster Assistance Program share increased reliance on insurance to compensate victims of disasters. Both require flood plain management measures to prevent or reduce future disasters. By the flood insurance program the federal government seeks to reduce flood disaster losses through flood plain management measures which encourage or require property owners to locate outside flood hazard areas, or, to elevate or floodproof their homes and businesses to reduce potential flood damage. It also seeks to protect investments backed by the federal government in known flood hazard areas. Ultimately the National Flood Insurance Program is to substitute for and eventually replace federal disaster relief for structures and their contents which are insurable. In its early stage the administrators of the program state that they seek to accomplish wise management of flood plains rather than to obtain adequate premiums for the insurance coverage provided.

While the "mandatory" features of the National Flood Insurance Program have been in force for a relatively short time, quite a bit of experience has been developed in certain areas of the country through which one can evaluate the effectiveness of the program. Rhode Island is one of those areas. The flood insurance program has been well received in Rhode Island; 21 of the 26 communities lying along the coast have become eligible for the full-scale, regular flood insurance program, probably a higher percentage of coastal communities than any other state in the Union. Largely based on studies in Rhode Island, but also the result of contacts with several other coastal areas of the country, I would like to offer some thoughts on both the strengths and weakness of the program in the four principle areas of: insurance, financing, technical information, and coastal flood plain management.

INSURANCE

The strengths of the insurance program lie in its potential for shifting some of the insurable costs of flood disasters to the people and properties at risk, those located in the nation's flood plains. If the program works ultimately as conceived, flood disaster costs for structures and their contents will be borne by flood insurance, shifting this major disaster relief expenditure away from federal appropriations to the insurance industry and the people at risk. The shift is to be accomplished gradually, beginning with the heavily subsidized program that is now in force. As more and more communities enter the regular program, as more properties are subject to actuarial rates, and as the base of property owners covered by flood insurance expands, theoretically the federal government should be able to decrease its subsidy until the cost of flood insurance is borne entirely by the people at risk and the insurance industry.

There are a number of concerns as the flood insurance concept is applied in coastal areas. These concerns affect whether the insurance will have its full potential effect, particularly as a market incentive to reduce flood damages.

The first area of concern is the method for determining actuarial rates in coastal high hazard areas and other coastal flood hazard areas. Currently actuarial rates for coastal high hazard areas are determined by arbitrarily adding 50% to the rate for a coastal flood hazard area that does not have the added hazards of wind-driven waves. I recall a conversation with an official of the Federal Insurance Administration who stated that upon review of percent-damage curves used by the Corps of Engineers, the FIA determined that nationally the average damages to structures experienced from flooding were on the order of 30% of the property's value, rather than the 80% damage rate being used by the corps, and that to be conservative the FIA was using a 40% damage curve in deriving its actuarial rates. These percentages are national figures, and based on both riverine and coastal flooding, as I understand it.

My first question is whether it is appropriate to determine actuarial rates by averaging the experience of both riverine and coastal flooding together. From a mathematical perspective, and perhaps even administratively, it makes obvious sense. But it seems to me that in this particular program actuarial rates have a function that extends beyond the mere determination of premium rates that assure that participating companies can cover insured losses and earn a fair profit. A principal thrust of this program is to reduce flood damages and to provide incentives for people to live and work outside of flood hazard areas. Right now the insurance rates do not act as disincentives in coastal high hazard areas, and I ask, "Should there not be a careful review of the methods for determining actuarial rates in coastal high areas, and the purposes to which they are applied?"

Areas that should be explored include:

1. Storm damage experience and percent-damage rates in coastal high hazard areas. I suspect that they are significantly higher than the averages derived from all riverine and other coastal flood damage experience.

2. The automatic surcharge of 50% for properties located in identified coastal high hazard areas. Does the flood damage experience in such areas warrant an increase or decrease in the rate? Should not the surcharge for identified high hazard areas be more flexible to adjust to the risks involved and flood plain management objectives for the specific area?

3. The use of actuarial rates as a disincentive to property sales and development in coastal high hazard areas. Currently, if a property owner located landward of mean high tide, elevates the lowest floor of his house to or above the 100-year flood level, and

has the under side free of obstructions or builds breakaway walls, the cost of flood insurance is quite low. If elevated two or three feet above the 100-year flood level, the rates become so low that the maximum coverage available under the program could be obtained for less than $25.00 per year were it not for the $25.00 minimum premium imposed.

Where existing one-to-four family structures have a lower floor level below the 100-year flood level, there is a so-called "stop-rate" of $0.50 per $100 coverage applicable, even in coastal high hazard areas. A limit on the cost of flood insurance was required by the Congress, on the supposition that prior to the flood insurance program there was insufficient knowledge and technical information about flood conditions, and property owners should not be charged full actuarial rates in such cases. Particularly as applied to coastal high hazard areas, I think that this supposition should be challenged and reviewed by the Congress, perhaps as an adjunct to the question whether any subsidized flood insurance should be available in such areas.

Another flood insurance-related area that I feel should be explored is the possibility of denying flood insurance and federal disaster assistance to those located in coastal high hazard areas, and perhaps other coastal flood hazard areas where there is a history of recurring damages. Currently, if a community is eligible, and minimum flood plain management requirements of the program are satisfied, flood insurance cannot be denied to property owners in coastal high hazard areas. One potential legislative change might authorize the administrator of FIA, by regulation, to deny flood insurance coverage to properties located in coastal high hazard areas under certain circumstances. A history of high property damages during storms, demonstrated ineffectiveness of local or state regulations, repeated losses related to coastal storms followed by persistent repairing and rebuilding in the same high hazard area, might be examples of circumstances under which flood insurance and federal disaster relief might be denied, and the parties at risk assume the entire risk of loss. Surely, if the program were entirely in the private insurance sector, insurance would be denied, or the premium rates would be prohibitively high. A similar rationale might be applied to the federal legislation.

Finally, the effects of federal subsidy should be weighed and continually reviewed. The need for the federal subsidy while the program is being established is clear, especially in light of the reluctance of most communities to enter the program on a voluntary basis, and while federal disaster relief assistance was available. My particular concern about the subsidy is that it provides no incentive to the insurance industry itself to act as a force to influence communities and property owners to reduce flood damages or to urge location of insurable structures outside flood hazard areas. If so, we are missing the benefits of an important market force that might be brought to bear if the subsidy did not exist or was substantially lower.

FINANCING

In November 1975, the Urban Land Insitute published a paper of mine on coastal flood plain management and the National Flood Insurance Program, based on a study of three Rhode Island coastal communities. Probably the most controversial part of that paper related to financing. On reading the paper, the tendency is to get distracted by the fact that, prior to the availability of flood insurance, lending institutions in Rhode Island had voluntarily created mortgage exclusion areas because of the damages incurred in the 1938 and 1954 hurricanes, but opened those areas to first mortgages once flood insurance was available to secure the loans. I have been able to find only one other area of the country, in New Jersey, where financial institutions acted the way they did in Rhode Island.

There is a larger issue than merely how Rhode Island's financial institutions have responded to local conditions and the availability of flood insurance. Currently nothing in the law prohibits or impedes financing of properties in coastal high hazard areas if the community is participating in the program, and the development complies with the minimum flood plain management requirements of the program. There are virtually no linkages between sound flood plain management and the availability of financing, and so long as that occurs probably the most important potential force for reducing flood damages and encouraging people not to locate in high hazard areas is not brought to bear. The problem area that I am identifying requires legislative action, and is outside the authority of the FIA, except in the unlikely event that the FIA could persuade other federal agencies to strengthen their regulations.

Another important phenomenon related to financing and coastal areas is that high percentages of coastal property owners are from out-of-state, and obtain financing for coastal properties from their local out-of-state lending institution, both by first mortgages and frequently by second mortgages on the primary home. Except as the lender might inquire and require flood insurance as a condition for the loan, there is no legal requirement to purchase flood insurance under those circumstances. Again, my concern is not the security of the loan -- the lending institution is well secured. Rather, I suspect that a significant volume of coastal development and sales financing derives from this source, and that an important influence on coastal development is simply not reached by the National Flood Insurance Act.

Indeed, the closer one looks at the intricacies of financing, the more one has to question the direct and indirect impacts of federal financial assistance upon property development in the coastal zone. Federal activities related to financing include those agencies that regulate, supervise, approve, insure, or guarantee lending institutions, and those that give direct financial assistance for acquisition or construction, such as the Small Business Administration and the Veterans Administration. Some agencies, such as the Environmental Protection Agency, influence where and what development will take place, through the placement of sewage treatment and other public utilities. Federal permitting and technical assistance programs also have a profound impact on coastal development, such as the Corps of Engineers' dredge and fill permits, and the Coast Guard's bridge permits. Each such agency has its own primary tasks which often run counter to the flood plain management responsibilities of the FIA. My impression has been that many federal agencies have been reluctant to cooperate with the FIA, a fact which may place an almost insuperable burden upon FIA to administer its program effectively, especially in the flood plain management area. I would urge that careful and comprehensive studies of the influence of other federal programs on coastal development, and their impacts on the National Flood Insurance Program, be undertaken and reported to the Congress.

For reasons that I shall develop more fully in my discussion of coastal flood plain management, without stronger constraints on coastal flood plain development exercised through financing controls, the coastal flood plain management aspects of the National Flood Insurance Program may be overwhelmed and rendered ineffective.

TECHNICAL INFORMATION

One of the great strengths of the National Flood Insurance Program is its design and funding for technical information. Few programs recognize as well as this one does the importance of technical information, which is needed for the insurance and the flood plain management aspects. About 90% of the FIA's annual appropriation is devoted to its mapping and flood insurance rate studies. Unfortunately, if the appropriations granted by Congress in the future continue at the rates of the near past, the mapping and flood insurance rate studies will take at least ten years to be completed nationwide, perhaps longer.

The importance of technical information to the effectiveness of the program cannot be stressed too much. The ability to move communities into the regular program, to charge actuarial rates for flood insurance, to institute sound flood plain management measures in participating communities, and the ability of the nonstrucutral flood plain management measures to withstand judicial challenge, all rest on the quality of the technical information available. The quality of technical information on coastal flooding has been criticized in almost every coastal area of the country as far as I have been able to determine.

The recent National Academy of Sciences report, "Methodology for Estimating the Characteristics of Coastal Surges from Hurricanes," strongly suggests that the methodologies used by the Corps, the U.S. Geological Survey, and the National Ocean Survey for estimating coastal surges are deficient, particularly as to landward extent and impact. The Academy recommended that steps be taken to improve the quality of methods for estimating coastal surges and the onshore effects and range of such surges. The Academy did recommend the use of NOAA's SPLASH model and the method of joint probabilities for estimating the temporal and spatial characteristics of hurricane-induced surges, but stated that substantial improvement in the accuracy currently attainable by these methods requires an expanded oceanographic and meteorological data base.

In terms of the technical information needed in the National Flood Insurance Program, the accuracy of the various methods used is of critical importance. One of the end results of the flood insurance rate studies is a set of maps, both for actuarial purposes and for local flood plain management purposes, and these lines must be able to stand up to challenge administratively through FIA procedures, or judicially. So saying, one of the most disturbing parts of the National Academy's report is the statement:

> "Even when the meteorology of a particular hurricane is well defined, the predicted maximum surge height at a community on the open coast using the SPLASH models seems to lie rather consistently within a range of (plus or minus) 2 feet of observed maximum surge height at the point."

On all but the steepest coastal slopes, vertical heights in a range of four feet (i.e., two feet above or below that modeled) imply substantial horizontal distances on land, and maps that cannot withstand challenge. FIA regulations calling for vertical accuracies of plus or minus six inches can be achieved in most riverine situations, but appear to be beyond the state of the art in estimating coastal surges. Careful review of NOAA's SPLASH program is being made, as well as the accuracy of the historic data approach used by the Corps, and the methods used by the

U.S. Geological Survey. Proprietary techniques of firms such as Tetra Tech, Inc. of California are also being reviewed and tested in coastal areas. FIA clearly recognizes the importance of the issues, has given their resolution top priority, and has imposed a moratorium on coastal flood plain mapping while the issues are being resolved.

Another area of technical concern relates to the improvement of modeling and prediction of hurricane surge heights within estuaries, bays, lagoons, and other semi-enclosed tidal waters, and their extent and impact on adjacent low-lying lands. According to the National Academy, "little is understood about how the presence of bays and estuaries affects the surge at points along the coast away from the entrance to the bays and estuaries." The issues raised by the Academy's comment appear to apply to areas such as the Great South Bay of Long Island, Delaware Bay, Chesapeake Bay, and similar systems. I am not aware of any major effort being made in this area, in either the public or private sector.

COASTAL FLOOD PLAIN MANAGEMENT

The tools of flood plain management are either structural or nonstructural. Structural methods are those that try to keep water away from the people -- bulkheads, dikes, dams, etc. Nonstructural methods are those that try to keep people away from the water -- acquisition for open space, zoning, subdivision controls, clearance and relocation, wetlands regulations, construction setbacks, and a host of others.

Minimum flood plain management requirements are absolutely essential to the National Flood Insurance Program. Without them the government would be in the position of encouraging people to move into flood hazard areas and providing them with low-cost, heavily subsidized flood insurance to reimburse them when their homes and businesses are damaged by flooding. The program would achieve just the opposite of its stated goals without flood plain management requirements. If anything, those requirements should be strengthened to improve the program.

Nevertheless, I think that we must assess the adequacy of FIA's minimum flood plain management requirements in light of coastal hurricane experience, and attempt to determine whether the insurance, financing, and technical information aspects of the program support or limit the effectiveness of the management provisions and together achieve the legislative goals of reduction or prevention of flood damages.

As you know, the FIA does not have authority to intervene directly in state or local regulatory efforts, but in return for the availability of subsidized flood insurance, FIA imposes minimum flood plain management requirements. At the outset of the program the requirements are that a community must have in force a building permit program and provisions for building permit application review. Anchoring of structures, use of flood resistant materials and equipment, and use of construction methods to minimize flood damage are required. Provision must also be made to regulate subdivisions and new developments. As more technical information is provided by FIA to the participating communities, the communities must require that new or substantially improved residential structures be elevated to or above the 100-year flood level, and in coastal high hazard areas structures must be located landward of mean high tide, elevated above the 100-year flood level and anchored to pilings, and provide space below the lowest floor free of obstruction or constructed with "breakaway walls."

Note that the FIA does not prohibit development in flood hazard areas, but rather requires that if development takes place, certain structural features must be incorporated. I can readily understand why the Congress does not want to enter the political morass of determining where development should take place. At the same time, we should ask whether the minimum requirements of the program tend to become maximum, and inhibit fuller coastal flood plain and coastal zone management. Some states, such as Rhode Island, are prohibiting construction on barrier beaches and barrier dunes. Do the minimum requirements of the flood insurance program assist such state regulations, or do they tend to weaken the state efforts?

Some of the concerns related to flood plain management grow out of counter forces inherent in the availability of flood insurance and financing for coastal real property sales and development. Using the State of Rhode Island as an example, the R.I. Coastal Resources Management Council follows a general policy to prohibit construction on or alteration of sand dunes except where associated with an approved restoration or stabilization project. Despite the administrative efforts of FIA to support state and local flood plain management restrictions on development in coastal high hazard areas, the availability of low-cost, subsidized flood insurance, and the availability of mortgages and other financing secured by flood insurance as a minimum supports already high demand for oceanfront properties, sustaining and perhaps increasing property values in the hazardous areas. The problem is inherent in the legislation as it is presently written, and in my opinion is not within the current authority of the FIA to alter.

Until the legislation is amended to use the market forces present in both the insurance and financing aspects of the program, I feel that the flood plain management objectives of the act cannot be fully realized, nor can the program be fully supportive of more stringent state and local regulatory efforts where those regulatory efforts are being challenged administratively and in the courts.

Changes to strengthen the flood plain management portion of the program need not be major. For example:

1. Authority to prohibit the sale of flood insurance in coastal high hazard areas under circumstances of recurring damages is one possibility. Another possibility in this regard might be through exercise of state insurance authority, prohibiting the sale of flood insurance in certain designated areas.

2. Activation of existing authority under the act to assist communities in acquiring flood prone areas would add a potent management tool, particularly where state or local exercise of the police power has been challenged and the regulation has been declared unconstitutional.

3. As noted earlier, regulation of federally assisted financing is inadequately related to coastal flood plain management goals. Change might be accomplished through existing legislation, or most certainly could be accomplished through amendment of the National Flood Insurance Act. A question pertinent to the issue is: "Should the availability of financing in coastal high hazard areas, or other coastal flood hazard areas, be more closely related to coastal flood plain management restrictions of state and local governments?

4. Authority currently exists in the National Flood Insurance Act to strengthen the flood plain management requirements. One technique that might yield considerable dividends would be to require coastal communities to have coastal construction setback provisions in their local ordinances, with the setback determined by such factors including the rate of erosion in the area and the useful life expectancy of the structures being constructed.

One major change in the legislation that might be considered is the denial of <u>both</u> flood insurance <u>and</u> federal disaster assistance for structures and their contents located in coastal high hazard areas or in formally designated areas of critical or particular concern.

SUMMARY

The basic premise of this paper is that the natural and developmental characteristics of coastal flood hazard areas are distinctly different from riverine areas and require attention specifically designed for the dynamics of the coastal zone. The National Flood Insurance Program is an important force in the coastal zone, particularly with respect to barrier islands and barrier beaches; it is also subject to a number of external forces over which it has no control or jurisdiction. Discussion of some problems of the program is divided into four areas: insurance, financing, technical information, and coastal flood plain management.

Insurance

Flood insurance concerns in coastal areas relate principally to its potential effect as a market force to reduce or prevent flood damages. Currently insurance rates do not act as disincentives in coastal high hazard areas. Actuarial rates average the experience of both riverine and coastal flooding together, and are not specifically adapted to coastal experience. A careful review of the methods for determining actuarial rates and the purposes to which they are applied appears called for, including: storm damage experience and percent-damage rates in coastal high hazard areas; whether coastal flood damage experiences warrant an automatic surcharge of 50% for properties located in coastal high hazard areas; use of actuarial rates as a disincentive to property sales and development in coastal high hazard areas; possible removal of the $0.50/$100 coverage "stop-rate" on one-to-four family structures located in coastal high hazard areas; possible denial of flood insurance to those located in coastal high hazard areas, in areas of high recurring damages, or in formally identified areas of critical or particular concern; and, means to induce the flood insurance industry to influence communities and property owners to reduce flood damages and to urge location of insurable structures outside flood hazard areas.

Financing

Financing is a potential force for reducing flood damages and encouraging people not to locate in high hazard areas. However, currently there are virtually no linkages between sound flood plain management and the availability of financing. Financing of properties located in coastal high hazard areas and secured by flood insurance acts as a strong market force against community and state efforts to regulate development of barrier islands, barrier beaches, and other coastal flood hazard areas.

A largely unknown quantity is the direct and indirect impact of federal financial assistance and federal permits upon property

development on barrier islands and barrier beaches. Careful and comprehensive studies of the influence of federal programs on coastal development, and their impacts on the National Flood Insurance Program, should be undertaken and their results reported both to the Executive and to the Congress.

Technical Information

Technical information for mapping, flood insurance rates, flood plain management, etc., is critical to the effectiveness of the National Flood Insurance Program. Yet the techniques used by NOAA, the Corps of Engineers, and the U.S. Geological Survey to estimate coastal surges have been criticized by a panel of the National Academy of Sciences as deficient, particularly as to landward extent and impact. NOAA's preferred SPLASH program for predicting coastal surges has, on average, a plus or minus two feet vertical height range above or below observed maximum surge height in communities lying on the open coast. FIA's regulations calling for vertical accuracies of plus or minus six inches appear to be beyond the current state of the art for estimating coastal surges. Another area of technical concern relates to improvement of modeling and prediction of hurricane surge heights within estuaries, bays, lagoons, and other semi-enclosed tidal waters.

Coastal Flood Plain Management

Concerns related to coastal flood plain management grow out of counter forces inherent in the availability of flood insurance and financing for coastal sales and development. The limited minimum coastal flood plain management requirements of the National Flood Insurance Program tend to become maximum requirements, and inhibit fuller coastal flood plain management. Until the market forces of insurance and financing are brought more effectively to bear, I do not feel that the flood plain management aspects of the act can be fully realized; nor can the program fully support more stringent state and local regulatory efforts. Nevertheless, the flood plain management aspects can be strengthened somewhat by: authority to prohibit the sale of flood insurance in coastal high hazard areas and designated areas of particular concern such as barrier islands and barrier beaches; funding of existing authority under the act to assist communities in acquiring flood prone areas; regulation of federally assisted financing to make it more compatible with state and local coastal flood plain management goals; use of a broader range of nonstructural flood plain management techniques in conjunction with the National Flood Insurance Program, including coastal construction setbacks; and denial of both flood insurance and federal disaster assistance for structures located in coastal high hazard areas, or areas of critical or particular concern.

Contribution No. 12

AESTHETIC AND RECREATIONAL FACTORS IN BARRIER ISLAND PLANNING

by

John Felleman*

> "Here is the battleground between the ocean and the land. Here is the surf, which varies from gentle and playful to awesomely violent. Here the tides move forward and back, stranding the shells of clams and sand dollars and horseshoe crabs. Here is a rich assembly of easily visible life, the fascinating and beautiful creatures, from the darkness-loving ghost crab to the voracious herring gull, that has learned to survive on the battlefield."
>
> (Jonathan Norton Leonard, "Atlantic Beaches")

This quote deals with an experience of the shore. If you reflect on your own experience, you can call to mind lucid images of the shore, both first hand and vicarious as interpreted by artists, poets, and naturalists. The latter were trying to capture a total essence of the dynamic power, magnitude, beauty and complexity of the ocean's edge. An elusive goal.

I will concentrate on two areas of major interest. First, I hypothesize that aesthetic and recreation concerns are two inseparable, desirable and necessary facets of human experience. Second, I would like to briefly highlight those current aspects of aesthetic and recreation research which are significant to barrier island analysis and management.

An initial linkage between aesthetics and recreation can be made directly from working concepts of each:

> "Recreation refers primarily to creative leisure-time activities...'since the chief value of recreation is that it balances the human organism physically and psychologically,...(it) must be based on self choice, initiative, and spontaneity.'"
>
> (Wagar, 1964)

In contrast, there are no widely accepted definitions of aesthetics (U.S. EPA, 1973). If we ignore philosophical discussions of art, and deal only with natural settings,

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"The importance of aesthetic quality has revolved around the idea that people receive psychological benefit from viewing, inhabiting, or otherwise experiencing attractive areas."
(Haskett, 1975)

Beauty, a central factor in aesthetics, has been defined as the,

"...aggregate of qualities in a thing which gives pleasure to the senses or pleasurably exalts the mind or spirit."
(Webster's New Collegiate Dictionary, 1960)

In natural settings, both psychological "balance" and physical exercise can be obtained by pleasurably interacting with a stimulating environment.

AESTHETIC RESEARCH

The majority of aesthetic research is primarily concerned with scenery evaluation. Because of the dearth of clear definitions and widely accepted standards of quality, there is much popular confusion related to issues of scenery evaluation. Researchers have found it useful to develop models of the scenery perception process, an example of which is illustrated in Figure 1 (Felleman, 1976). Such models permit efforts to

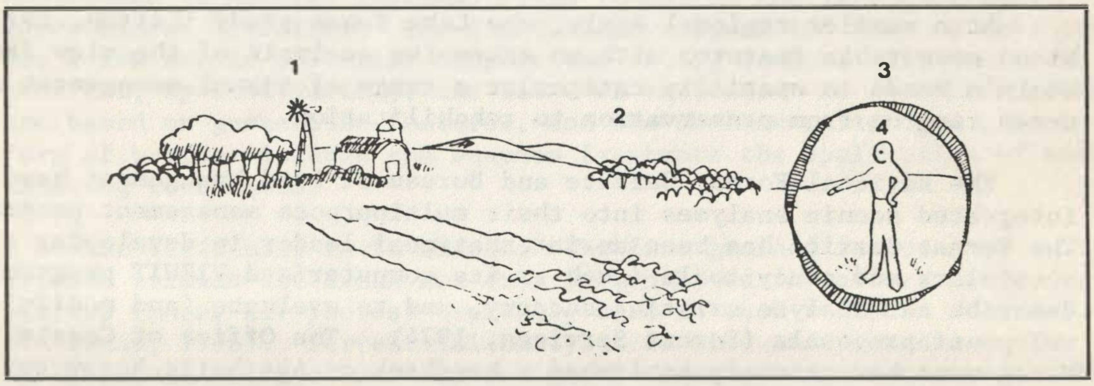

Figure 1 Scenic perception process: 1. Landscape - a composition of natural and manmade forms; 2. Visibility - the physical view zone, and distance relationships between viewer and landscape; 3. Viewer Environment - the local surroundings, viewer mobility, and sequence of views; 4. Interpretation - the viewer's psychological analysis of a view's content and meaning.

be focused on clarifying specific components, such as description of natural forms or dynamic relationships between components. An example of the latter would be the effect of local noise on a viewer's judgment of a scene. As components and interrelationships are clarified, diagnostic and predictive processes should emerge.

Beginning with the 1962 ORRRC (U.S. Outdoor Recreation Resources Review Commission) report, Water for Recreation Values and Opportunities, and accelerating with passage of the National Environmental Policy Act and its charge to federal agencies to,

> "...identify and develop methods and procedures... which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making,"

considerable attention has been given in the public and private sectors to describing, measuring, and predicting the "quality" which user groups associate with their surroundings. These studies have been oriented to aiding decision makers in the management of large land areas, and the siting and designing of recreation and development projects.

Within the past five years visual analyses have become a standard element of regional resource planning. The pioneering North Atlantic Regional Water Resources Study (May, 1972) by the Corps of Engineers utilized regional physiographic characteristics and the scale and pattern of urbanization to differentiate discrete visual units throughout the North Atlantic Watershed. These descriptions were subsequently arrayed by naturalness, relief, variety, and water edge to rank visual quality (Research Planning and Design Associates, 1967).

At a smaller regional scale, the Lake Tahoe study (Litton, 1971) combined measurable features with an extensive analysis of the view from the basin's roads to spatially categorize a range of visual management concerns ranging from preservation to rehabilitation.

The National Forest Service and Bureau of Land Management have fully integrated scenic analyses into their multipurpose management programs. The Forest Service has been an international leader in developing a vocabulary and study tools (such as its computerized VIEWIT program) to describe and analyze existing scenery, and to evaluate (and modify) development proposals (Forest Services, 1974). The Office of Coastal Zone Management has recently published a handbook on Aesthetic Resources of the Coastal Zone (Mann, 1975). These techniques and procedures are adaptable to both agency personnel, and citizens who can participate through a variety of formats. For example, the Martha's Vineyard study (Vineyard Open Land Foundation, 1973) utilized "mental maps" drawn by residents and visitors to clarify perceptions of coastal and inland features. Extensive use has been made of user-preference studies incorporating field visits, photographs, and color slides (Zube, 1974; Viohl, 1975).

Some general conclusions regarding this research are:

1. The aesthetic experience is a complex phenomenon involving the stimuli to the observer (physical setting), the transmission

of these stimuli to the observer, and psychological perception and processing by the observer (Craik, 1970).

2. A good deal of aesthetic research has dealt solely with the visual component of aesthetics (Mann, 1975). This is due in part to the visual usually being our dominant sense, and in part to its being the easiest to document, and model (Litton et al, 1974, p. 13).

3. It is now possible to fairly accurately predict a passive viewer's response to a static moderate to large scale landscape based on the composition of the scene. The middle ground is established as the key visual line between foreground details and background form (Forest Service, Vol. I, p. 16, 1972). In particular, water edge, topographic relief, physical enclosure, degree of naturalness and other measurable dimensions are strongly correlated to viewer response (Zube, 1974; Shafer, 1969).

4. Quantification of scenic quality for use in environmental decision making would be possible only if all interested user groups share the same attitudes and values, and the decision process includes extensive participant interaction (Landscapes Limited, 1974).

I have been able to locate no extensive application of these approaches to barrier islands. This is due to the lack of recent governmental attention. The N.A.R. study classified them as exhibiting a low scenic potential because the rating factors used--internal contrast, spatial variety, and sense of enclosure--as in other systems, are based on geomorphic features, and the shallow relief and linear form of barrier islands and beaches frustrate the application of such existing techniques.

The difficulty is threefold: The fine grained features of barrier islands are often not clearly exhibited in the secondary data sources (maps, air photos) typically used in such regional studies (Felleman, 1976). Terrestrial analysis is slow and expensive. The usual substitution of scenery for aesthetics does not account for the strong multisensory inputs available on barrier islands. In addition, barrier islands are experienced by active pedestrian recreationists, not auto or tour based viewers as in many parks and forests. Leonard (1972, p. 107) expresses the experience as follows:

"Now the beach was all my own, utterly virgin, not a print on it except the delicate embroidery made by the feet of little shore birds. Nothing looked different from the day before, but in my solitude, the beach felt different. The air smelled pure. The shore on which the waves were breaking seemed as deserted as in the far-off time before even the first Indians settled along the Atlantic coast. I looked around for signs of man; there were none. No planes marred the sky, no boats the ocean. The emptiness of the beach made me feel all the more intimately tied to it. Everything I observed seemed focused with an extra intensity, as if I were looking through a microscope and a telescope at the same time."

Rather than to passively observe, as we might at Old Faithful, Niagara Falls, or on the Maine or Oregon coasts, a barrier island compels us to interact with the fine grained environment. The noises, smells, winds, and spray create a total experience in which all the senses are orchestrated. The lack of a distinct middle ground in the visual continuum exaggerates the immediate local surroundings (hot sands and cold foam on our bare feet) while the ocean-sky horizon creates a humble feeling of finiteness.

The challenge is to develop efficient local-scale methods for utilizing available visual analysis techniques, and to supplement these analyses with other sensory data.

RECREATION

The previous discussion has dealt mainly with aesthetic concerns of a hypothetical single person in a totally natural setting. Such a model is, of course, not representative of our present and future experiences on barrier islands. Two modifications are necessary to fully comprehend the recreational problem. First, the vast majority of outdoor recreation is done in groups. Thus, people are not only interacting with the environment but with each other. Second, the human presence necessarily modifies the experience of one's physical environment.

Barrier islands can potentially host a variety of recreational activities. In light of the policy of the Coastal Zone Management Act of 1972 to:

". . . preserve, protect, develop and where possible, to restore or enhance the resources . . .",

we can group these activities by their level of development intensity. Intensive activities generated by or near residential and resort areas involve long term structures which must be carefully located and designed, such as tennis courts and clubhouses. Extensive activities, on the other hand, are uniquely suited to barrier islands. Camping, swimming and outdoor education require relatively few structures with the latter utilizing many elements of the dynamic resource base (Conservation Foundation, 1975). The National Seashores afford many opportunities for such appropriate low-intensity uses.

Finally, the recreational opportunity for which barrier islands have no peer is the oceanfront "wilderness" experience. The environmental and psychological need for preserving remote natural settings was recognized early in this century with the creation of the National Parks. The Wilderness Act of 1964 has clarified both the experiential concept and the leadership role of the Federal Government in providing such opportunities to our citizens:

> "A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untravelled by man; where man himself is a visitor who does not remain . . . which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable, (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation . . ."
> (Wilderness Act of 1964)

There are substantial problems involved in managing recreation in sensitive, dynamic environments. These interrelated issues can be categorized as subsets of "carrying capacity" - "the ability of something to absorb outside influence and still retain its essence" (Penfold, 1972). The issue subsets include:

- Physical Carrying Capacity - for example, effects of trail erosion;
- Ecological Carrying Capacity - the condition of food chains, habitats, and species behavior;
- Psychological Carrying Capacity - the effect of visitors on the capacity of the wilderness to yield satisfying experience to others.

Much research has been undertaken in each of these areas. Briefly summarizing, physical carrying capacity, although quite complex, can be systematically studied and lends itself to quantification and management practices (Nerikar, et al, 1976; Ketchledge and Leonard, 1970). Ecological carrying capacity analyses are in relatively primitive states due to the difficulties in establishing base level information and constructing dynamic models. This situation may be further complicated in barrier islands where the natural terrain is in a constant state of flux.

Environmentally based development plans represent major advances but are open to criticism on the basis of their static nature (Ris, 1974). Psychological carrying capacities involve all the senses as well as the cultural and educational background of the users. Significant progress is being made in establishing visual, noise, and user-density criteria for various quality levels of wilderness experience (Wagar, 1974; Stankey and Lime, 1973).

If carrying capacity, in all its dimensions, is to become an operational approach to management, processes will be needed to control the amount (and possibly type) of users. The erosion of quality in our National Parks is directly a function of overuse. Approaches currently being tested include: first come-first served, permits, lotteries, and "risk zoning" (Echelberger, et al, 1974; Greist, 1975).

CONCLUSIONS

Aesthetic and recreational considerations can play a central role in the wise management of our nation's barrier islands. Existing methods of analysis must be adapted to the unique features of these fragile systems. Experience in resource management has demonstrated the need for a comprehensive approach. This will entail both the integration of various analytical inputs as well as the administrative mechanisms necessary to manage the entire set of islands as a whole.

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