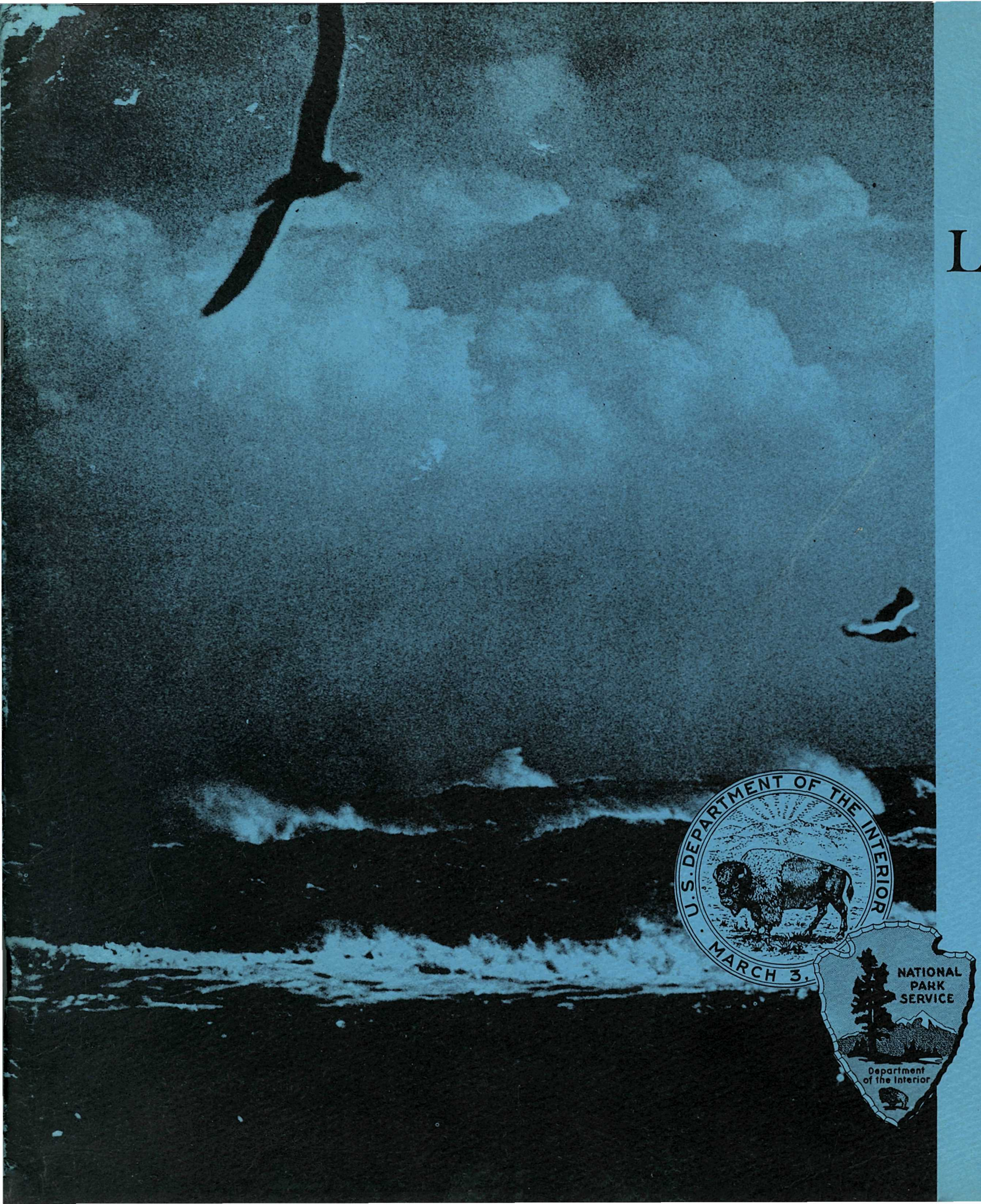

A Strategy for Management of

MARINE & LAKE SYSTEMS

within the National Park System

U.S. DEPARTMENT OF INTERIOR

NATIONAL PARK SERVICE

OFFICE OF NATURAL SCIENCE

WASHINGTON, D.C.

DUNE STABILIZATION STUDY

NATURAL SCIENCE REPORT NO. 6

1973

- UNIQUE COASTAL ENVIRONMENTS
- STRIKING VISUAL CONTRASTS
- IRREPLACEABLE NATIONAL FEATURES
- HISTORIC SITES

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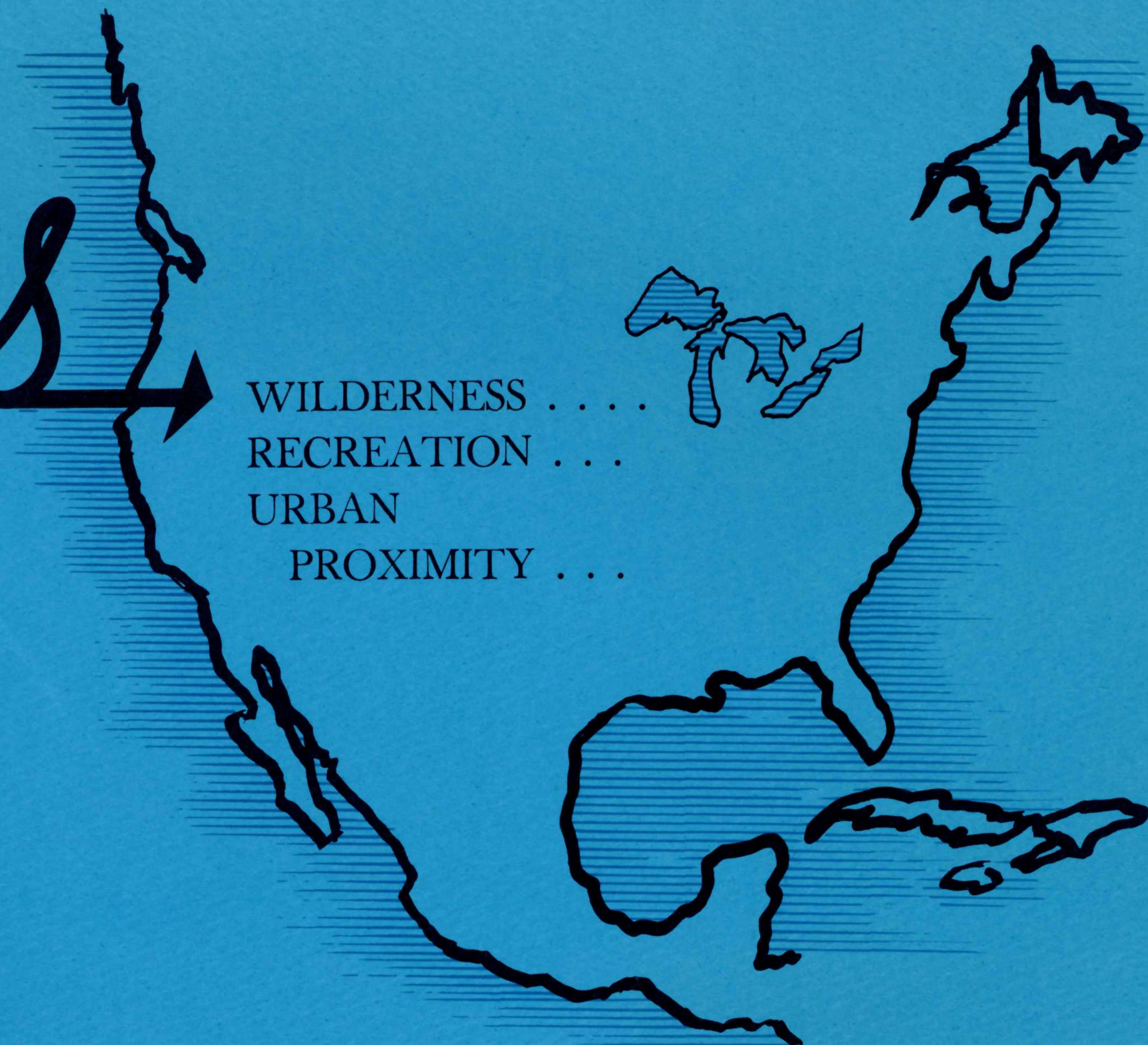

ISLE ROYALE

CAPE HATTERAS

ST. JOHN

GATEWAY

A Strategy for Management of

MARINE & LAKE SYSTEMS

within the

National Park System

Boundaries between land and sea are among the most dynamic environments administered by the National Park Service. In the "natural state" the marine and lake systems accommodate a wide range of wave and storm surge conditions. A proper management strategy must include protection of this natural state, even within areas designated for recreation pursuits. Seashore and lakeshore areas have high potential for recreational use, and if concern for the natural state is part of the management strategy, confrontation with nature may be avoided.

AUTHORS

Robert Dolan • Bruce Hayden • John Fisher
Department of Environmental Sciences, University of Virginia
and
Paul Godfrey, Department of Botany, University of Massachusetts

ILLUSTRATIONS
J. G. Carswell

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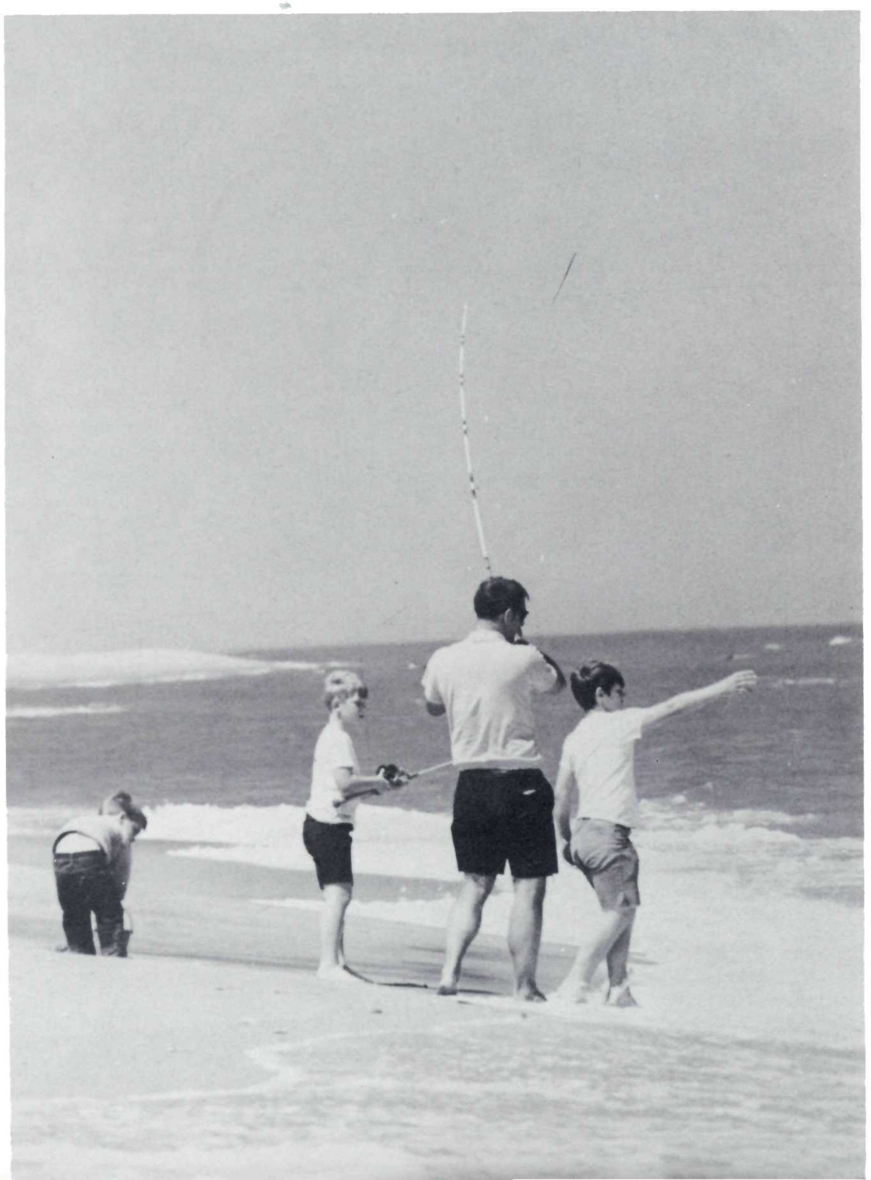
MANAGEMENT OBJECTIVES:

in 1916. . .

" to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of same in such a manner and by such a means as will leave them unimpaired for future generations."



. . . . for coastlines today.

Since the inception of the National Park Service in 1916, the concept of preservation has been fundamental in both planning and management. The marine parks, including the extensive shorelines of the national seashore and lakeshore areas, present special management problems in which the National Park Service must balance preservation with increasing demands for public recreation. Experience in these new areas has necessitated the reevaluation of the preservation concept within the context of environments undergoing constant change. Management policy and decisions for these areas require answers to three basic questions:

(1) What is the nature of the shoreline?

(2) How does it behave?

(3) Where are the areas of maximum physical and biological variability?

1 NATURE OF THE SHORELINE SYSTEM

Mobile material constantly in motion

Immobile material slowly changing

Resilient organic material self-generating

2 BEHAVIOR OF THE SYSTEM . . . RESPONSE TO ENERGY

The forces of Nature . . .

Storm
Tide
Wind
Surge

constantly reshaping the form .

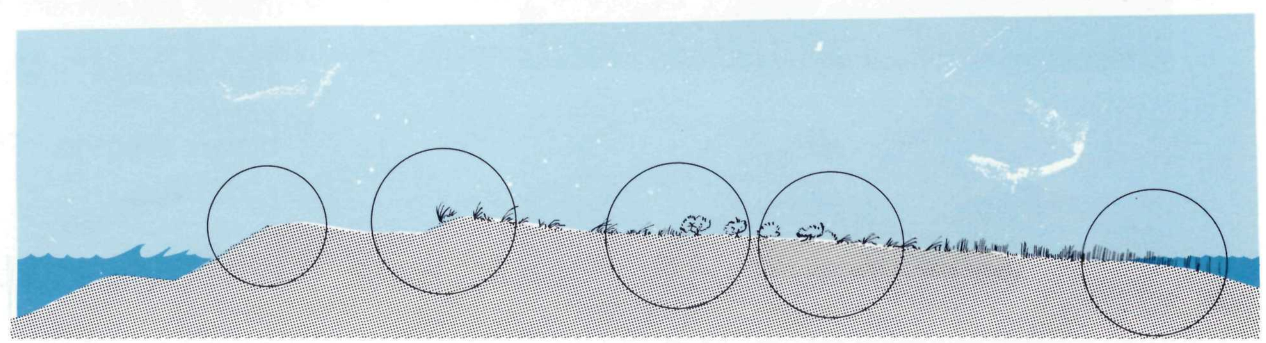
The natural rebuilding . . .

Vegetation
Soil

restoring the system to equilibrium.

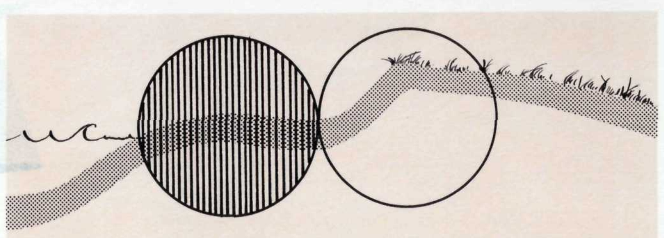
3 AREAS OF VARIABILITY

The nature of the shoreline material and its behavior under natural stress combine to define areas of greatest variability. An understanding of the shoreline response to stress is the key to management which PRESERVES as well as provides for public use.



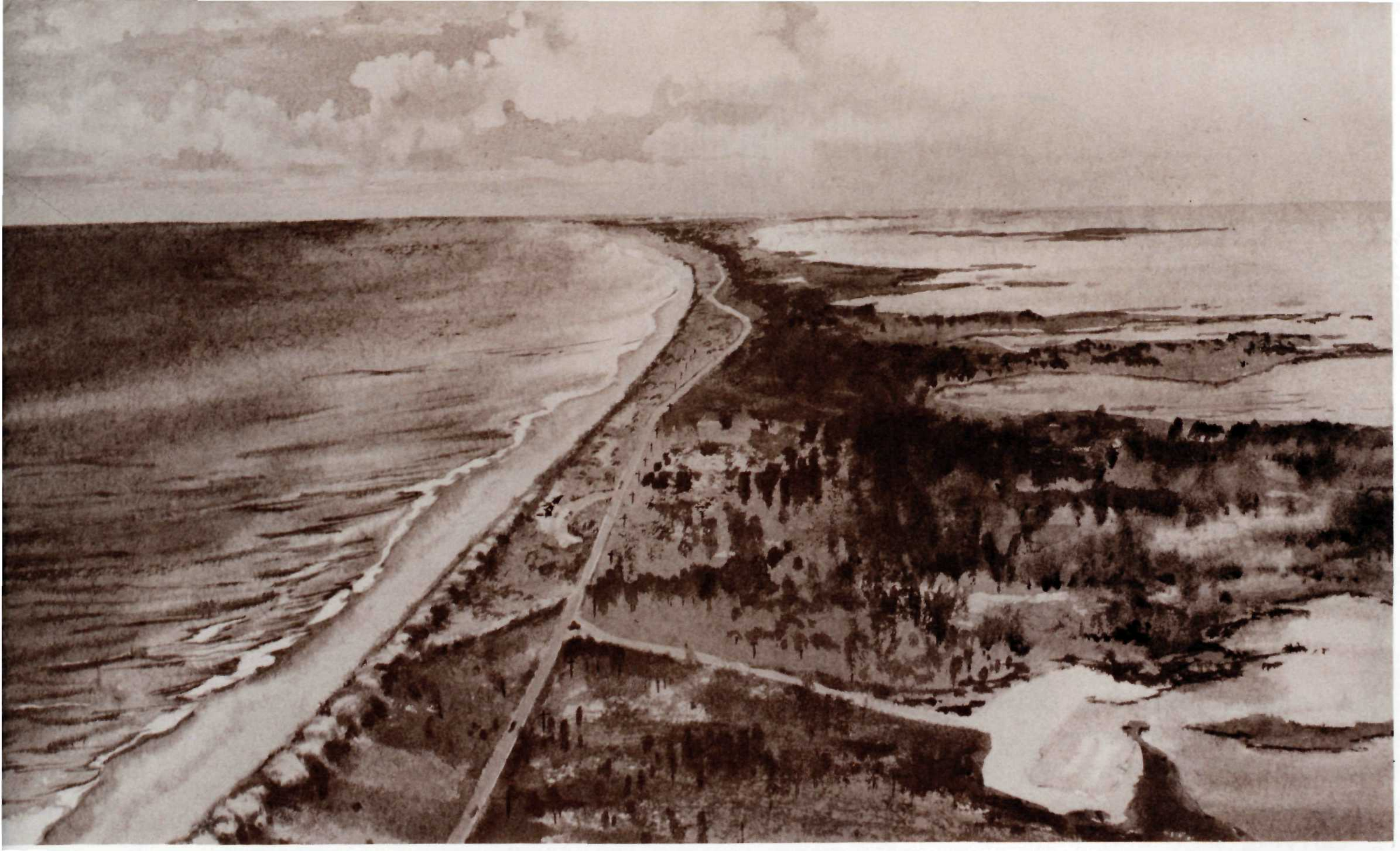
A NATURAL SYSTEM

The health of any shoreline environment depends upon its "freedom" to balance the powerful forces of storm waves and winds with various changes in its physical state. Management must recognize this dynamic nature. The results of man's past efforts to stabilize the primary interfaces of beaches and coasts have been mostly negative, commonly resulting in more serious management problems than existed with the natural state.

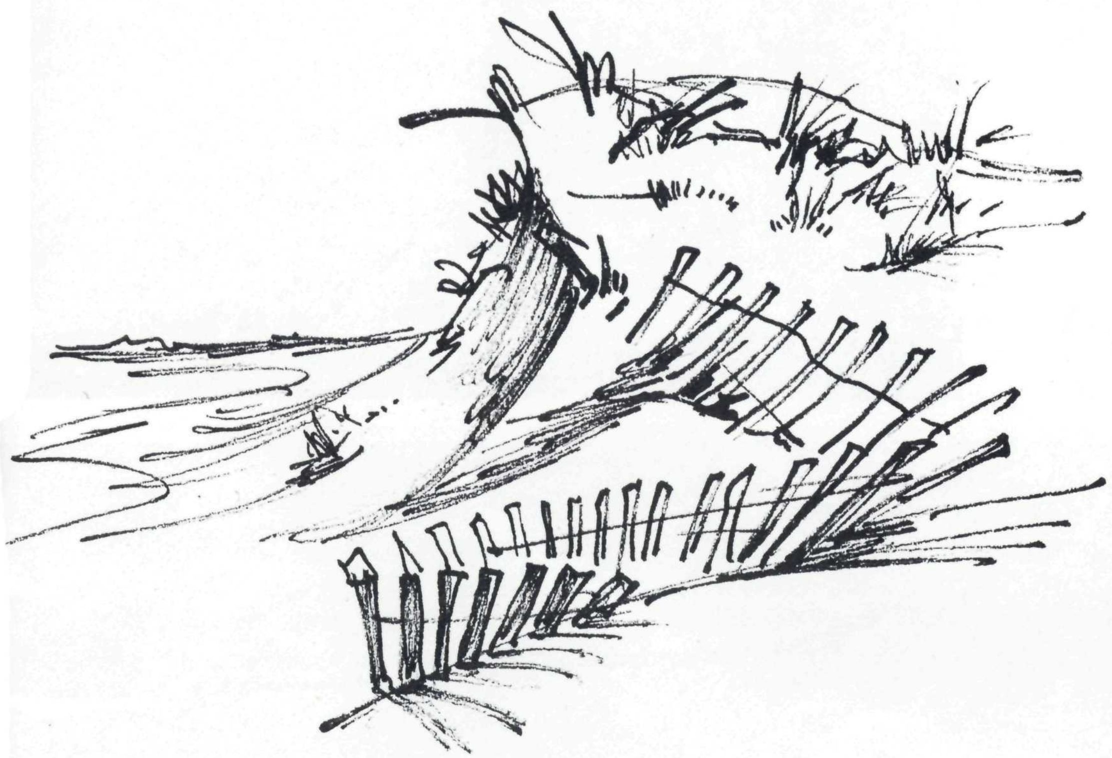


The physical interface between land and sea is a boundary in constant motion. On sand beaches, each wave alters the interface as materials are transported offshore, onshore, and in the direction of the prevailing longshore currents. In this way, beaches constantly adjust to accommodate different wave and tide conditions. When the waves are high, the active zone of the beach expands both landward and seaward. Conversely, the active beach contracts when waves are low. During hurricanes and other severe storms, the beach must make major adjustment to dissipate the increased wave energy. If the waves and surge are very high, the runup may extend into zones normally associated with wind-blown deposits. This penetration of water and sediment is called overwash.

NATURE . . . BEHAVIOR . . . VARIABILITY . . .

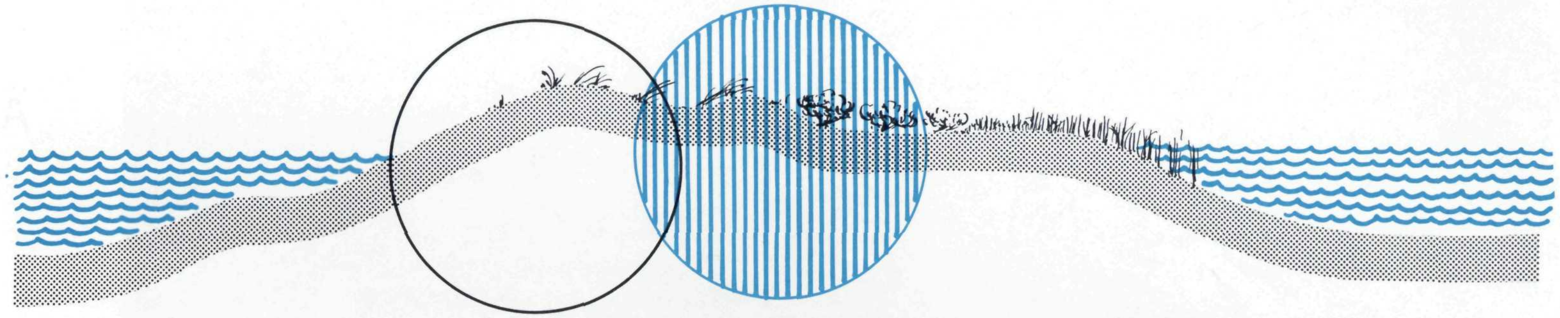


AN ALTERED SYSTEM



Along the barrier islands of North Carolina, man has responded to natural erosion and overwash by encouraging dune formation as a protective wall against the sea. Sand fences were erected, and the dunes were subsequently stabilized by planting and fertilizing beach grass. The barrier dunes originally provided protection against all but the most extreme events; however, the new beach system, altered in form, changed the precarious balance between erosion and deposition. Coarse sands are confined to the narrowed beach face; and storm waves, now focused in this zone, result in increased erosion and transport by along-the-shore currents. The wide flat beaches of the balanced natural system are replaced by progressively eroding narrowed beaches of the altered systems.

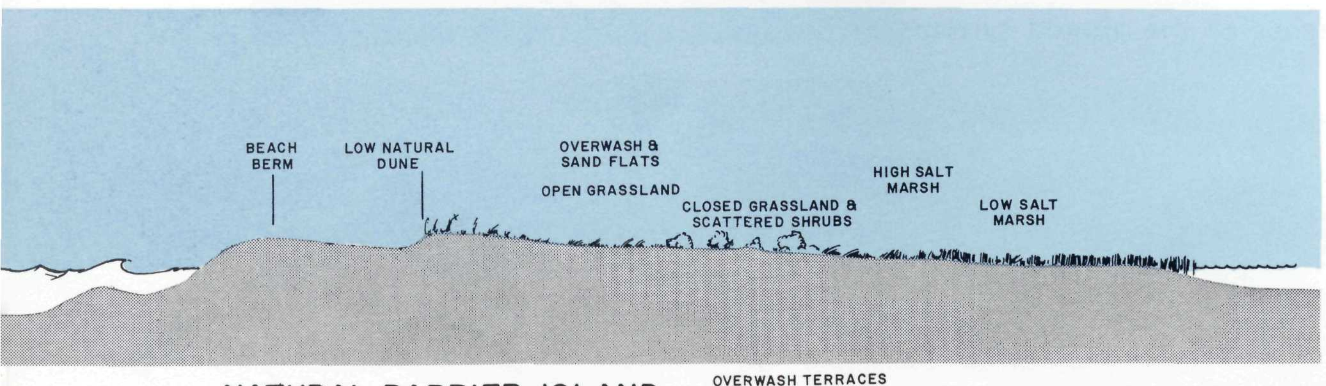
NATURAL



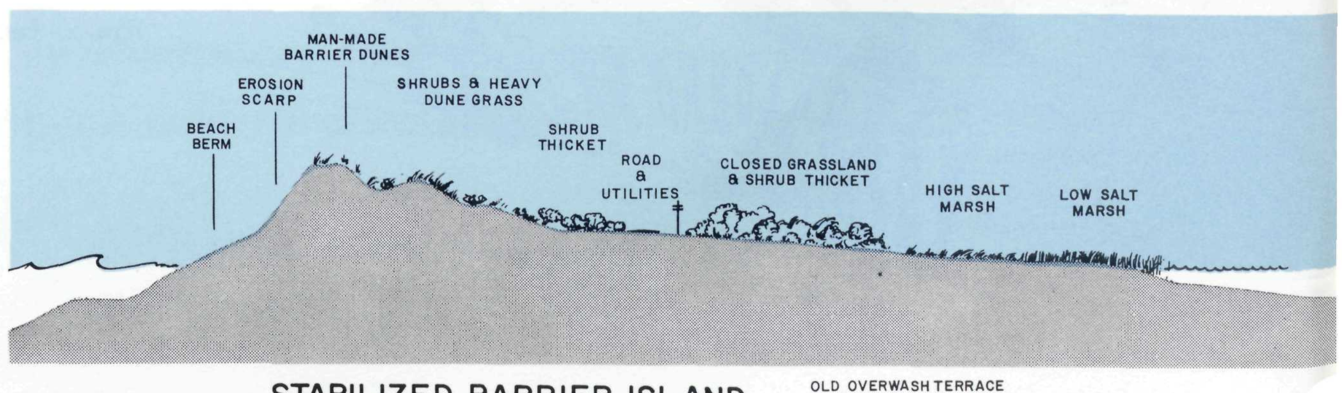
OVERWASH AND SAND FLATS

Immediately inland from the beach, there is a second zone threatened by man's modifications. In this region, only the extreme waves and storm surge penetrate, carrying sand and shell inland as overwash. This material forms a fresh interface between the beach and the vegetated stable sands. Overwash occurs frequently in natural systems, creating wide irregular biophysical interfaces. Stabilized dunes lead to narrow linear interfaces along the dune crests.

ALTERED



NATURAL BARRIER ISLAND



STABILIZED BARRIER ISLAND

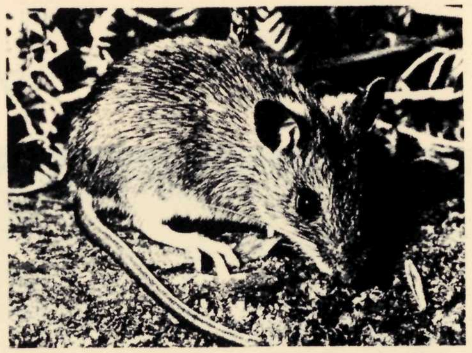
PHYSICAL INTERFACE/ECOTONE

The physical interfaces generated by waves, tides, winds, overwash, and other processes are coincident with ecotones, which are biologic boundaries between ecosystems.

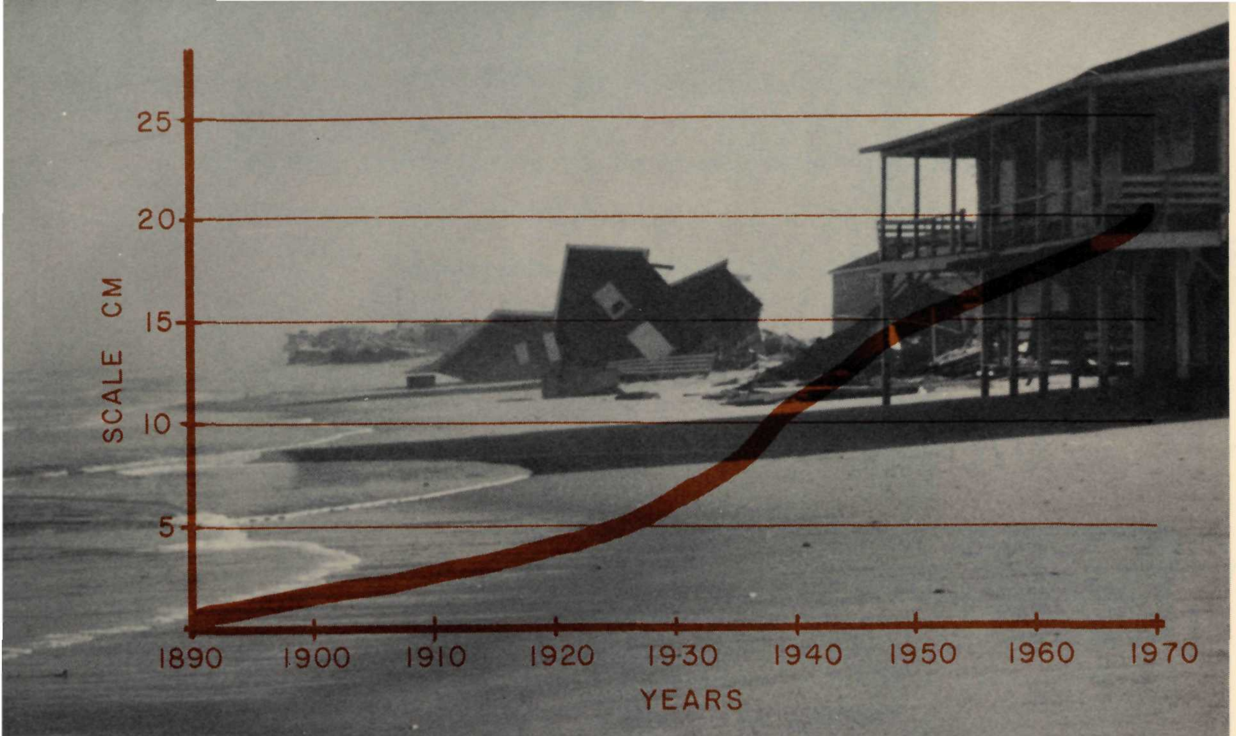
BEACH ECOTONE

Relatively few inhabitants visible without the aid of a microscope maintain permanent residence in the beach ecotone. Mole crabs and coquina clams are among the few organisms that can withstand the high stress and constant motion of the beach sands. Feeders and nesters are temporary residents of the beach. Countless shore birds come to feed while several marine organisms nest on the beaches. Among the most important are the sea turtles and the grunion. Irregularity of the shoreline, coupled with tidal fluctuations, maximize the total length and width of this ecotone and hence its productivity.

OVERWASH ECOTONE



The overwash ecotone, only sparsely vegetated with beach grasses, serves as the nesting grounds of numerous shore birds. It represents one of the few natural grasslands in the eastern United States. When protected from the periodic replenishment of beach sand and oceanic overwash, as in the case of the altered North Carolina barrier dune system, the ecological response is a progressive succession from grasses to shrub to forest. The irregular overwash pattern on a natural barrier island creates an ecotone perimeter length far in excess of its shoreline length. This same perimeter region in the altered system is usually a narrow strip along the backside of the barrier dune.



SEA LEVEL RISE: ATLANTIC COAST

The behavior of physical INTERFACES and their associated ECOTONES is a manifestation of the interacting processes of the marine environment. These processes often have ADVERSE effects on the shoreline systems from the standpoint of man's use . . .

ADVERSE TO MAN

The continual rise in sea level has resulted in shoreline recession throughout the world.

In some areas, storm waves and surge accelerate erosion and deposition. Nevertheless, BENEFICIAL results are also derived from these processes.

BENEFICIAL TO NATURE

Sea level rise and storm surge combine to transport material for construction of primary interfaces and nourishment of secondary interfaces. This BALANCE is characteristic of the natural behavior of unmodified shoreline systems. The maintenance of this balance is essential to the health and preservation of the marine parks, and it defines their optimum carrying capacity.

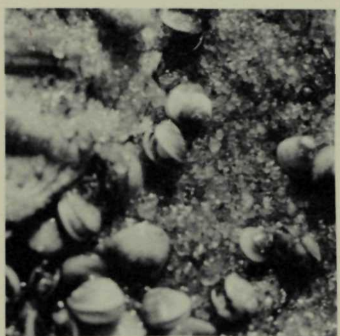
These ideas provide a foundation for:

CONCEPTS BASIC TO A MANAGEMENT STRATEGY

1. Biophysical interfaces are not fixed. Changing positions of the shoreline reflect both long-term sea level rise and short-term wave and tidal effects.
2. Movement of the physical interfaces by erosion and deposition is the natural and healthy state.
3. Change is fundamental to the ecological health of the marine and lakeshore systems.
4. Behavior of the "primary interfaces" determines the balance and health of the entire coastal system.
5. Interfaces and ecotones are interdependent, and therefore, must be considered as one continuous biophysical system.
6. Management of the marine and lakeshore areas administered by the National Park Service should be based upon the character of the primary and secondary interfaces.

FOUR TYPES OF PARKS

The natural behavior and special features of the marine and lake systems provide the basis for their division into four distinct classes:

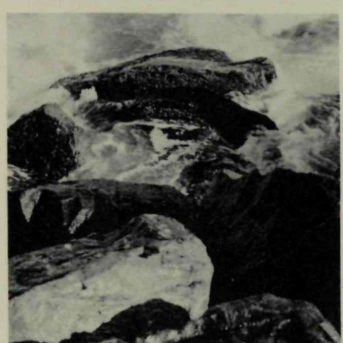


1. MOBILE MATERIALS

The primary interface is the beach. Waves and surge continually transform the shape of the easily-moved sand deposits.

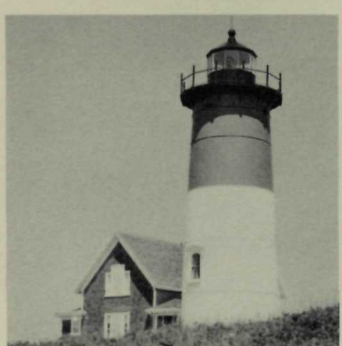
2. RESILIENT ORGANICS

Self-generating coral reefs or mangrove forests provide the first line of resistance to the forces of the marine environment.



3. IMMOBILE MATERIALS

Massive rocks and towering cliffs offer great resistance to the forces of the sea. Change is slow; the secondary interfaces are complex.



4. HUMAN ARTIFACTS

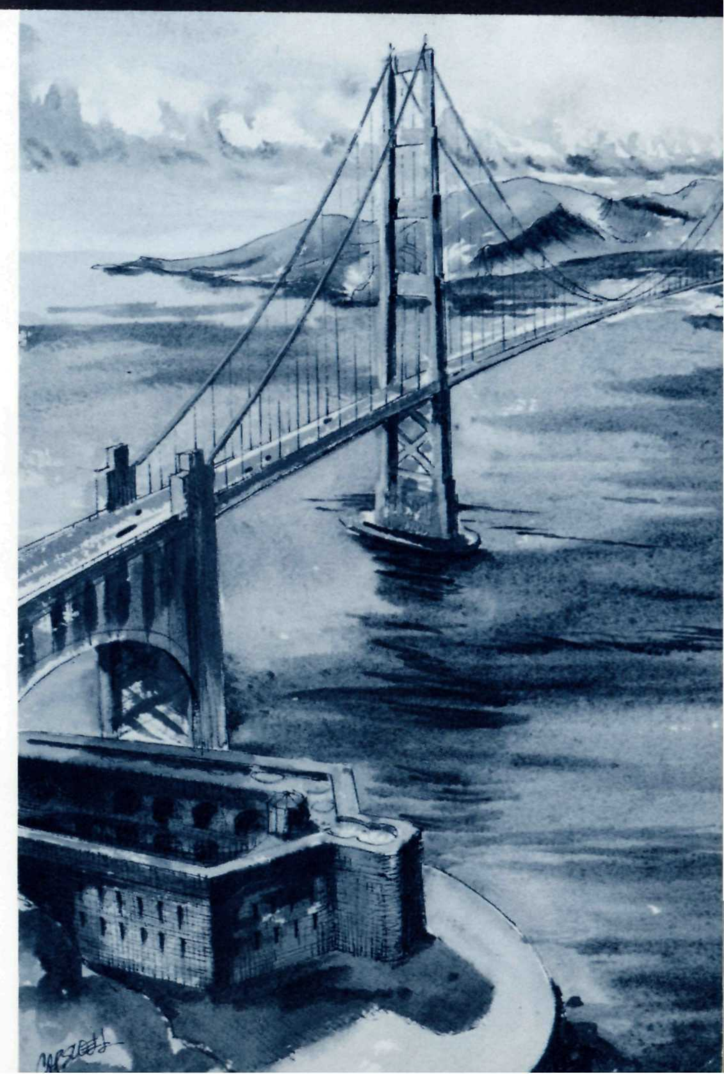
These parks have special historical importance or are located near great urban centers.

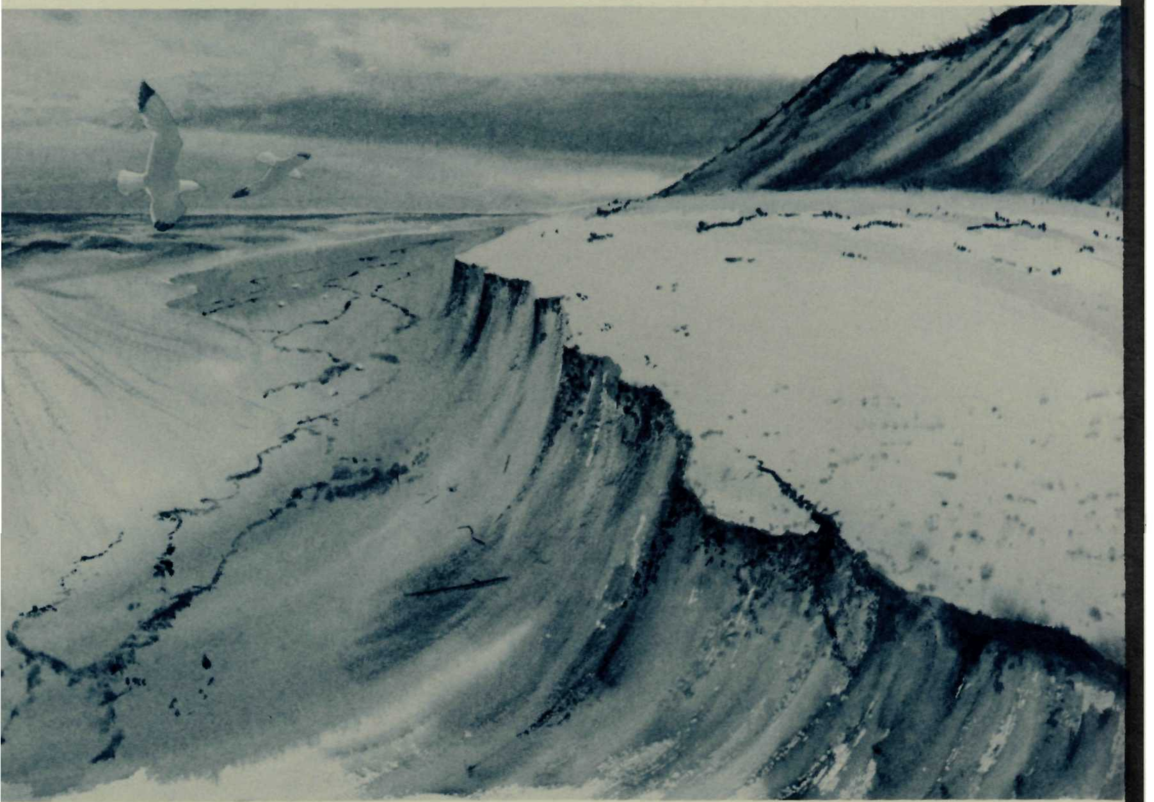
◀ IMMOBILE MATERIALS

ACADIA
CHANNEL ISLANDS
ISLE ROYALE
OLYMPIC
REDWOOD
APOSTLE ISLANDS
•
•
•

HUMAN ARTIFACTS

FORT JEFFERSON
DESOTO
GATEWAY
GOLDEN GATE
SAN JUAN
•
•
•





▲ MOBILE MATERIALS

VOYAGEURS
ASSATEAGUE
CAPE COD
CAPE HATTERAS
FIRE ISLAND
CUMBERLAND ISLAND
GULF ISLANDS
INDIANA DUNES
PADRE ISLAND
POINT REYES
SLEEPING BEAR DUNES
⋮

▼ RESILIENT ORGANICS

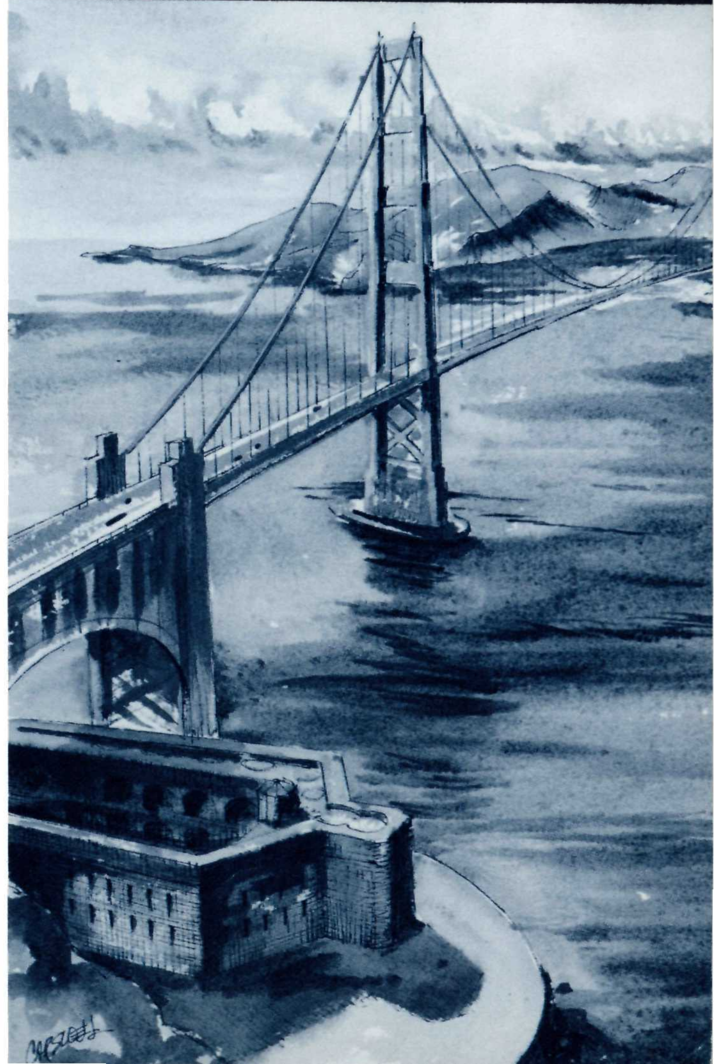
BISCAYNE BAY
EVERGLADES
VIRGIN ISLANDS
BUCK ISLAND
⋮

◀ IMMOBILE MATERIALS

ACADIA
CHANNEL ISLANDS
ISLE ROYALE
OLYMPIC
REDWOOD
APOSTLE ISLANDS
⋮

HUMAN ARTIFACTS

FORT JEFFERSON
DESOTO
GATEWAY
GOLDEN GATE
SAN JUAN
⋮



COASTS of MOBILE MATERIALS

Cape Cod, Cape Hatteras, Sleeping Bear Dunes . . . all of these parks have as their primary interfaces a highly mobile sand beach dominated by two fundamental processes:

(1) Transport of sands across the coastal interface.

(2) Plant growth stabilization of sands transported inland.

To illustrate the natural balance between these two processes and to identify the management implications, attention is focused on the barrier island shorelines of Cape Lookout, Cape Hatteras, and Assateague Islands.

THE SAND BEACHES AND BARRIER ISLANDS

The barrier islands are composed of three physical units reflective of the causal processes:

PHYSICAL UNITS		CAUSAL PROCESSES
BEACH ZONE	A	WAVES
DUNE ZONE	B	WINDS
OVERWASH TERRACES	C	OCEANIC SURGES

WAVES & BEACHES . . . . A CONSTANT STATE OF CHANGE

Beaches assume a variety of forms in response to changing wave and surge conditions. Sands are added to and eroded away from the beach. It is this fluid and material motion within and across the beach interface which sustains the physical and ecological health of the barrier islands. Therefore, the beach interface is the primary or controlling interface.

In the beach zone, the balance between sand transport and plant stabilization is heavily weighted toward the transport of sands. Periodic phases of erosion and deposition are superimposed on the longer term trend of a rising sea level, which submerges the beach and forces the barrier islands ever closer to the mainland.

A NATURAL BEACH HAS NO PERMANENT DIMENSION AND IS THEREFORE UNSUITABLE FOR ANY FIXED STRUCTURE.

Historically, man has taken numerous measures to stabilize the beach interface by constructing:

(1) Groins
(2) Sea Walls
(3) Dunes

The focus of wave and surge energy is altered with each of these, thereby providing protection for specific sites; however, this protection is usually at the expense of the land areas down the shoreline. With the prevailing trend of rising sea level and the occurrence of severe storms, these measures are only temporary. The building of barrier dunes or hurricane dikes is of special significance. The result is the division of the islands into two distinct subsystems. On the seaward side of the dune, wave energies are concentrated and erosion is accelerated. On the landward side, wave and surge energies are eliminated and the natural behavior of secondary interfaces is severely altered.

WINDS & DUNES

THE EPHEMERAL FEATURES OF THE SAND BEACHES AND BARRIER ISLANDS

TRANSPORT OF SANDS IN THE DUNE REGION:

Smaller beach sand grains are lifted by winds and transported across the island. On first contact with grasses, the winds are slowed, dropping the sand to form dunes. In the natural system barrier dunes are:

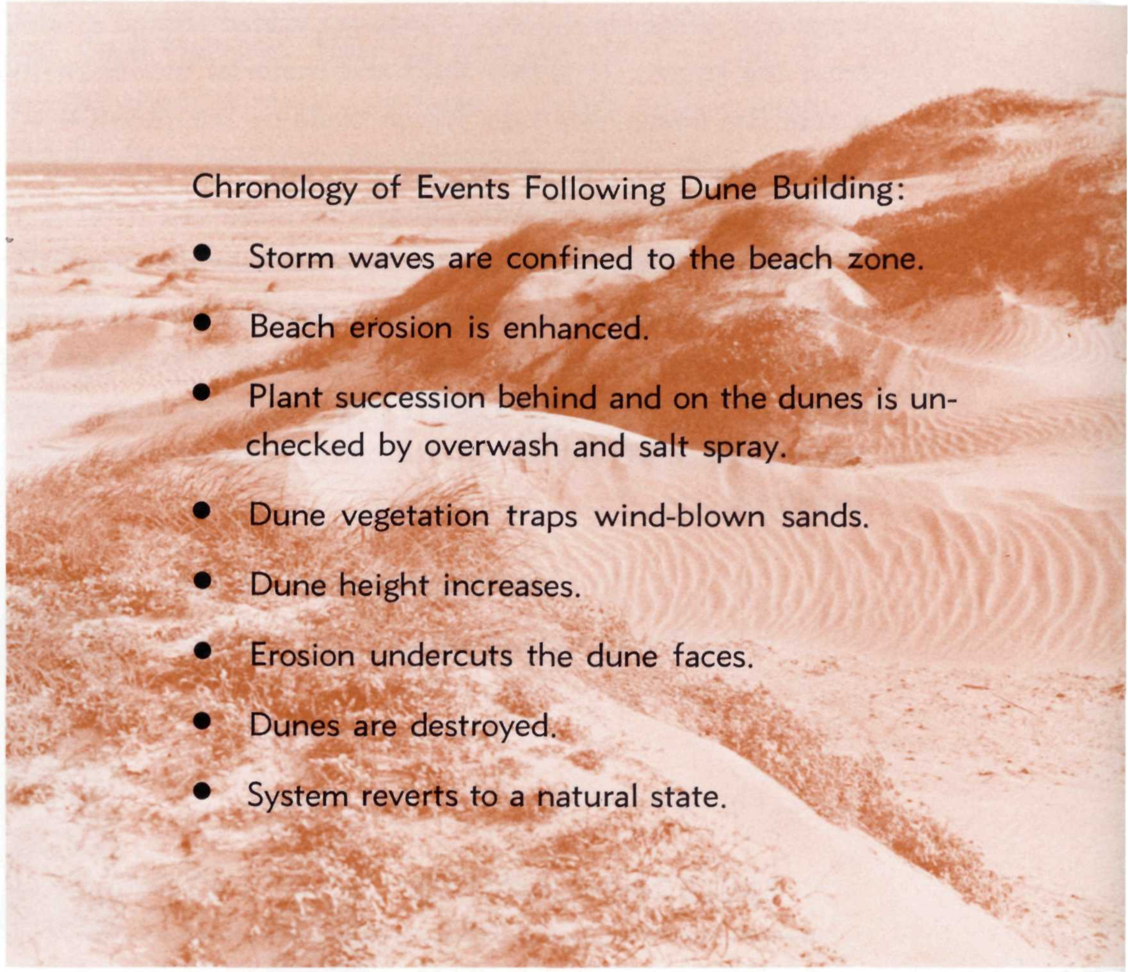
(1) GENERALLY LOW IN FORM.

(2) INDIVIDUAL SAND MASSES RATHER THAN LONG DUNE CHAINS.

(3) FREQUENTLY ERODED, BREACHED, AND REBUILT.

For many years, barrier dunes have been interpreted as natural barriers to overwash and erosion. Extensive programs of dune encouragement were thus initiated. Sand fences were built and sands trapped, dunes formed, which were then stabilized by grass plantings.

In some areas dune growth is naturally enhanced by rapid vegetative growth, as along parts of Fire Island and Padre Island; however, in the lakeshore areas, surges of lake water across the beach rarely result in vegetative control. Thus, succession proceeds to forest communities and large-scale sand trapping. Stabilized dune systems naturally result and are essentially permanent features of the landscape.



Eroding Dunes

FEBRUARY 1972
AND
FEBRUARY 1973

Photo Robie Rey Virginia Pitot

SURGE & OVERWASH TERRACES

HURRICANES AND WINTER STORMS GENERATE HIGH WAVES AND SURGES WHICH MAY CROSS THE ISLANDS. THIS OVERWASH PROCESS TRANSPORTS GREAT MASSES OF SAND INLAND.

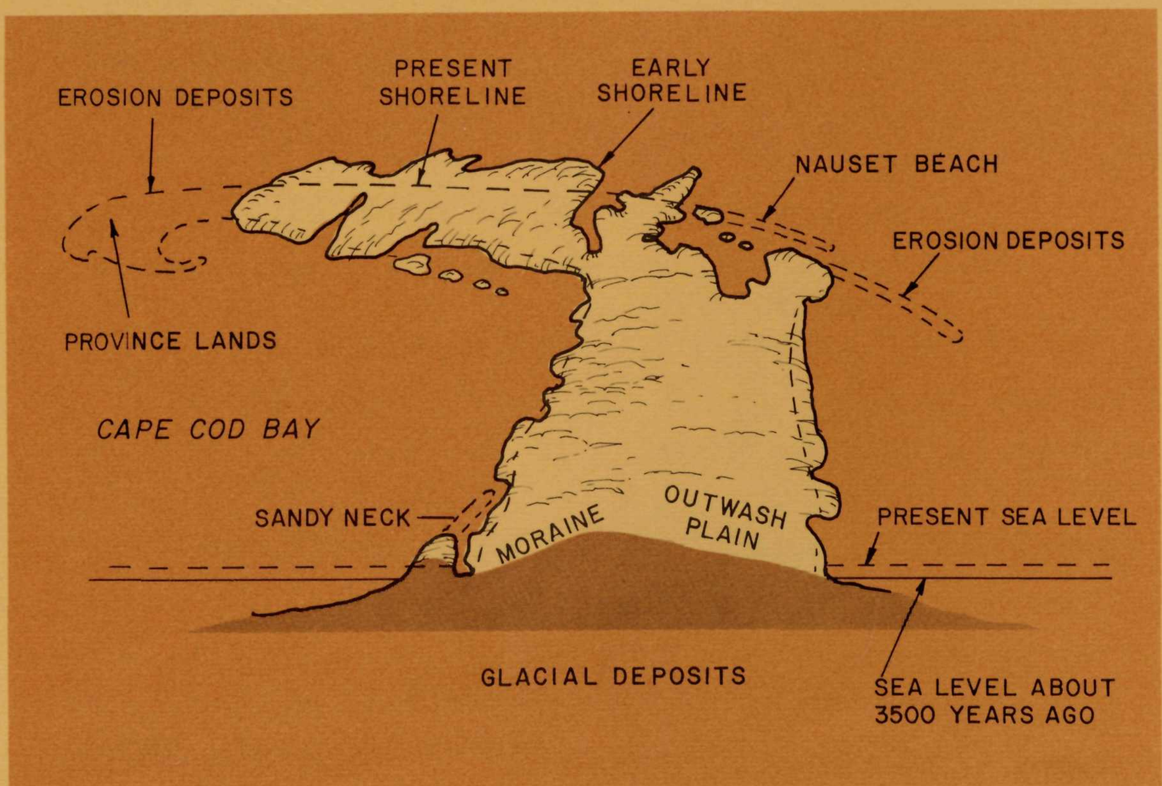
Periodic overwashes of sand are essential to the maintenance of the barrier island form and structure. Overwashes create sand terraces —the oldest on the sound side and the youngest behind the beach side dunes. The character of these terraces is a function of their age and the ecological succession of their plant communities.

Overwash terraces are differentiated by the ecologic process of succession.

MOST RECENT TERRACE	**A**	**OPEN GRASSLAND**
OLDER TERRACE	**B**	**HIGH SALT MARSH SHRUB SAVANNA AND**
OLDEST TERRACE	**C**	**LOW SALT MARSH**

CAPE COD . . .

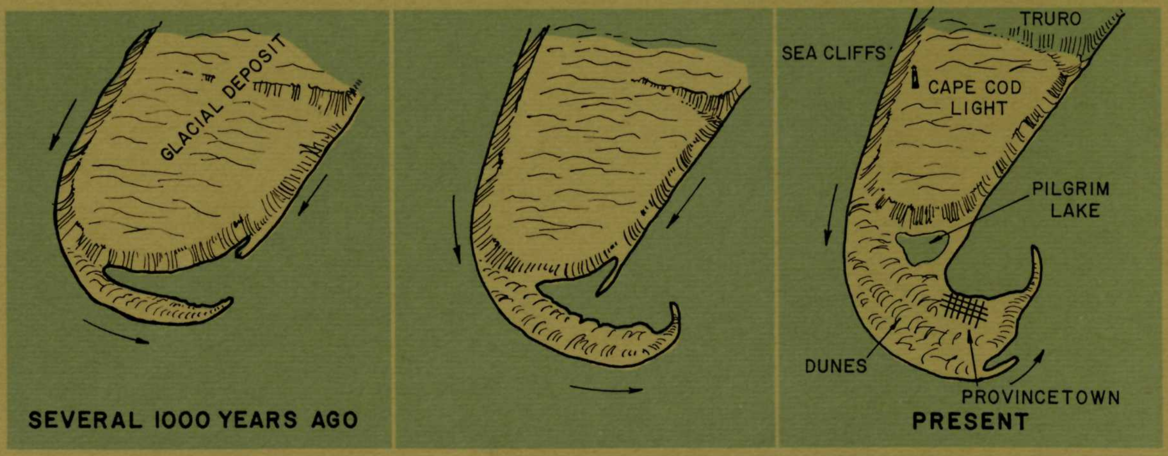
a history of natural and man-made changes



Early Cape Cod and effects of rising sea level and erosion.
(Adapted from A. N. Strahler)

The Cape Cod landscape developed about 10,000 years ago from glacial deposits. However, as recently as 3500 years ago, the Cape had a very different appearance. At that time it extended much farther east into the Atlantic Ocean and not as far north. As the sea continued to rise following the Wisconsin glacial period, the glacial gravels and sands were eroded, creating dramatic sea cliffs along the Outer Cape and providing material for beaches and dunes. Sediments carried to the north by waves and currents created the great curving dune system of the Province Lands. Material carried to the south produced the long, narrow spits of Coast Guard Beach, Nauset Beach, and Monomoy Island. As the beaches grew, winds transported sand into the dune arcs, some of which reached heights of more than 50 feet. The lengthening spits created sheltered bays which soon developed into salt marshes. The north and northwestward advancing dunes of the Province Lands became stabilized by sequential stages of vegetation. Three hundred years ago most of Cape Cod was covered by forests.

In the early 1600's the pilgrims described Cape Cod's Province Lands dunes as being covered with thickets and open woodlands on rich soils. There was no mention of the bare, migrating dunes that now exist, and remnants of former forests are exposed as the dunes move. Eighteenth and nineteenth century settlers first cleared the forests and began grazing livestock on the dunes, in spite of laws against such activities. The legislative history of the region dealt first with protecting the forests, then with restricting livestock on the deforested dunes, and finally with repairing the damage. By 1830, Provincetown residents were concerned lest their town and harbor be buried by the migrating dunes. Dune stabilization has been practiced near Provincetown, but elsewhere dunes continue to move into woodlands, and sometimes threaten roads. While some dune movement is expected, particularly in the active beach zone, in this case the migrating dunes are in an unnatural state, resulting from three centuries of human disturbance. Elsewhere, rising sea level causes highlands to erode, and barrier spits continue to retreat over older marsh surfaces. The history of man's use of the land on Cape Cod is a similar story to early settlement along the entire Atlantic Coast; however, the potential stress of massive visitations for recreational purposes may lead to more complex management problems than restoration of native vegetation and stabilization of migrating dunes.



Schematic stages in the development of the Province Lands.
Erosion of the glacial deposits creates sea cliffs and provides material for the growth of the Province Lands dune system.
(Adapted from A. N. Strahler)

ECOLOGICAL IMPLICATIONS

Sequence of Plant Succession:

- **Bare Overwashed Sands**
- **Sparse Grasses**
- **Closed Grass Canopy**
- **Shrub Savanna**
- **Closed Shrub Canopy**
- **Forest**

Barrier island vegetation varies according to geographic location. On Padre Island, the climax vegetation (the fairly stable end product of plant succession) is a closed canopy grassland. Along the mid-Atlantic barriers, pine forest is the natural climax, and on the New England Coast it is the hardwood forest.

The frequency of overwashes on the barrier islands precludes succession to a forest community in all but the most protected sites. Thus, the communities of the barrier islands are disclimaxes, or plant communities which depend upon continuing disturbance. On overwashes of varying ages, different disclimaxes dominate. The grasslands of the natural barrier island system perpetuated by overwashes are the only natural grasslands in the eastern United States—a unique natural phenomenon.

Man's alteration of barrier islands has a profound effect on ecological communities. By inhibiting overwashes, natural disturbances are eliminated and the succession process continues. Programs of controlled burning are needed to eliminate the resultant shrublands in favor of grasslands. In this case, fire is used in place of the natural overwash disclimax; this practice must be added to the cost of dune building programs.

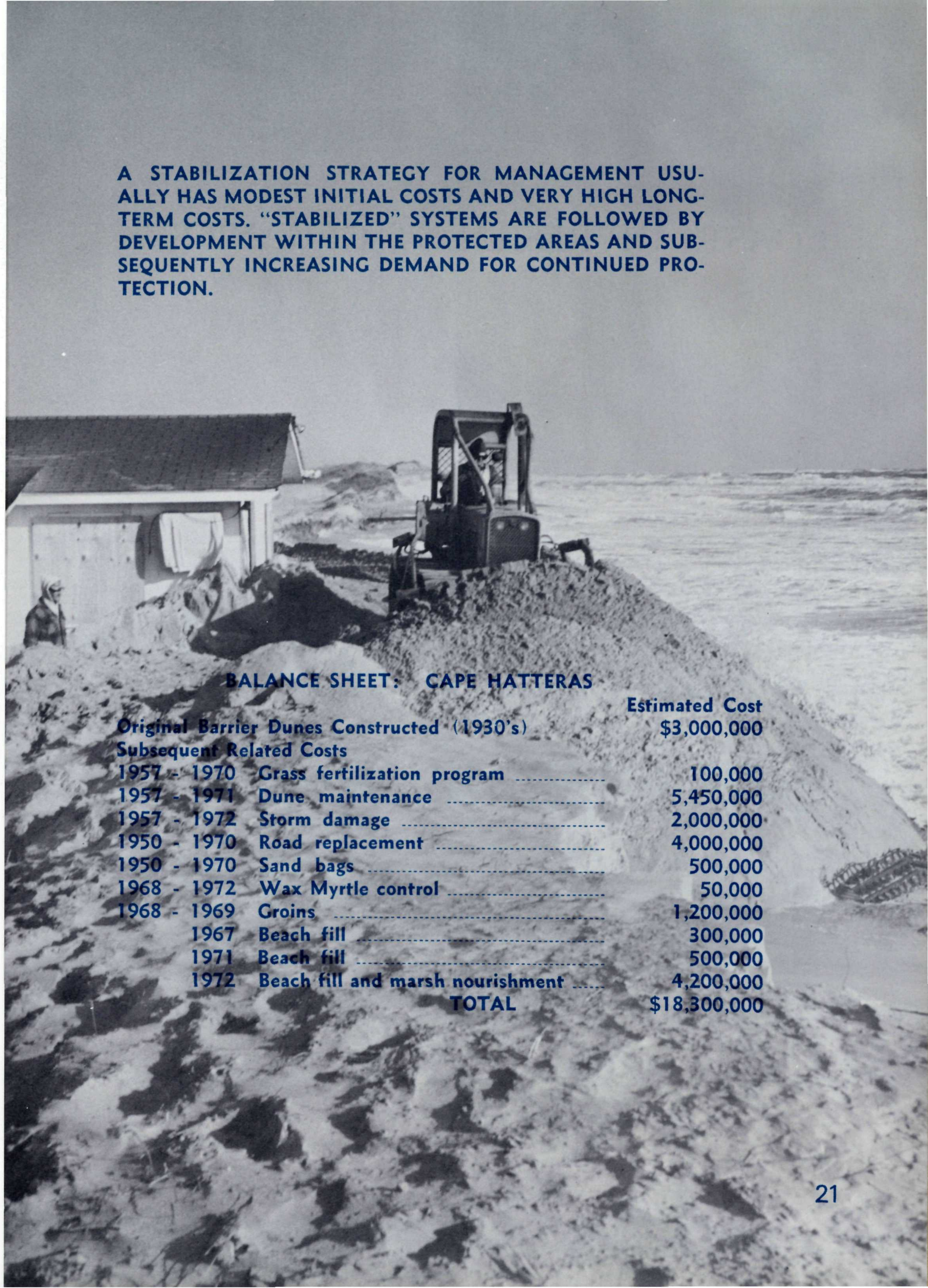
Within the sand beaches of the lakeshores, overwashing freshwater does not result in disclimax communities, and succession proceeds to forests.

SAND BEACHES AND
THE BARRIER ISLANDS,

CHANGE AND MANAGEMENT

The barrier islands are systems of continual and inseparable physical and biological change. Stability is the antithesis of their behavior. Management strategy based on the concept of permanent stability and fixed developments is destined for eventual failure. The degree of **management freedom is low** on coasts of mobile material.

The physical and biological interfaces are under constant stress and exhibit frequent changes. They are biologically diverse and productive, but subject to periodic disruption. The disclimaxes are unique natural environments. Their existence is dependent on continued stress from the physical interfaces.



A STABILIZATION STRATEGY FOR MANAGEMENT USUALLY HAS MODEST INITIAL COSTS AND VERY HIGH LONG-TERM COSTS. "STABILIZED" SYSTEMS ARE FOLLOWED BY DEVELOPMENT WITHIN THE PROTECTED AREAS AND SUBSEQUENTLY INCREASING DEMAND FOR CONTINUED PROTECTION.

BALANCE SHEET: CAPE HATTERAS

		Estimated Cost
Original Barrier Dunes Constructed (1930's)		$3,000,000
Subsequent Related Costs		
1957 - 1970	Grass fertilization program	100,000
1957 - 1971	Dune maintenance	5,450,000
1957 - 1972	Storm damage	2,000,000
1950 - 1970	Road replacement	4,000,000
1950 - 1970	Sand bags	500,000
1968 - 1972	Wax Myrtle control	50,000
1968 - 1969	Groins	1,200,000
1967	Beach fill	300,000
1971	Beach fill	500,000
1972	Beach fill and marsh nourishment	4,200,000
	TOTAL	$18,300,000

A REVIEW OF
SCIENTIFIC PRINCIPLES . . .
MANAGEMENT

IMPLICATIONS

The physical and biological interfaces of the barrier islands are subject to rapid and continuous change. °°°Facilities located within the area of the physical interfaces and ecotones should be short-lived temporary developments.

Physical interfaces and ecotones are relatively sparsely populated by permanent natural residents, but they are intensely used periodically. °°°Minimum visitor impact, as in day use, is most appropriate for these zones.

Dune stabilization retards island growth and within the context of a rising sea level, minimizes island width. °°°The narrower the islands, the greater the stress on facilities and the greater the need for corrective management decisions.

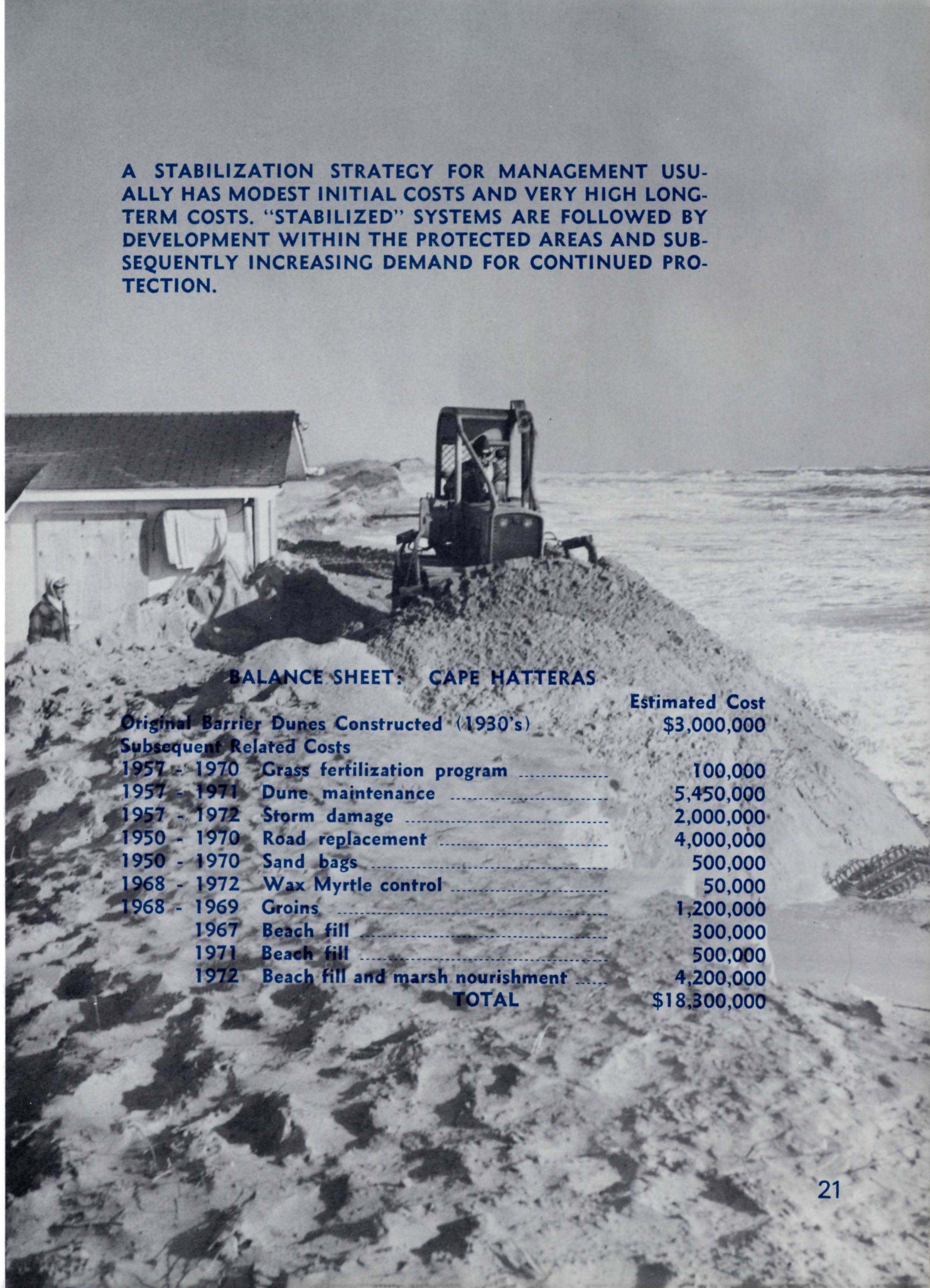
Stability of the barrier islands and sand beaches leads to less biologic productivity and diversity. °°°Management strategy based on the concept of stability and the encouragement of stability has real costs in terms of biological resources and related recreation.

The higher the dunes, the less frequent the overwash, and plant succession proceeds uninhibited. °°°Dune enhancement eliminates overwash and reduces salt spray, leading to the initiation of control programs for shrubs.

Regardless of the value of a completely natural environment with limited development, most of the park and seashore missions include protection and preservation of historic sites and recreational developments of regional and national significance. The importance of these features demands wider management latitude than adjacent areas.

After decades of experience and research on stabilized and unstabilized systems, no lasting solutions to protection are available. Temporary measures, such as beach nourishment, barrier dune enhancement, sea walls, and groins must be selected with great care.

Lighthouse at Cape Hatteras



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COASTS OF RESILIENT ORGANICS

LIVING PRIMARY INTERFACES

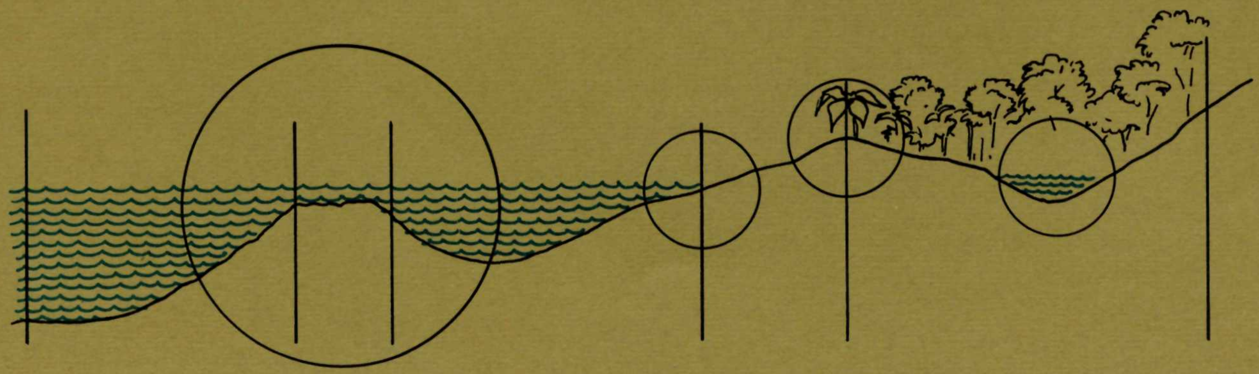
Among the most spectacular and unique of all park areas are those where living organisms create the primary interface between land and sea. The great extent of the Everglades and the narrow fringes of coral in tropical parks are both primary interfaces and highly productive ecotones.

These living interfaces grow and adjust to the long-term changes in sea level. In a healthy system this adjustment is constant; however, if sea level were to rise more rapidly or if growth were slowed, these systems would be threatened with extinction.

THE DELICATE BALANCE BETWEEN THE LIFE AND DEATH OF THE PRIMARY CONTROLLING INTERFACES REQUIRES NEW APPROACHES TO RECREATION USE.

CORAL INTERFACES
are . . .

- Buffers to coastal wave energies.
- Fish ecotones frequented by permanent residents and transient feeders and nesters.
- Highly complex in shape and thus biologically diverse and productive.
- Responsive to the sedimentary materials washed off the land.
- Imperiled by wastes dumped into the sea.
- Demanding of clear water easily penetrated by light.
- Subject to predation by human collectors.



PROTECTORS OF SECONDARY INTERFACES AND ECOTONES

The energies of approaching waves and storm surges are dampened by the coral reef, thus protecting the sand beaches of the land or island. This shadowing of wave and surge energies permits the thin veneer of sand to remain in place. Conversely, impairment of the health of the reef exposes the beach to higher waves and the potential for serious erosion. The reef and the coral beach are a coupled system.

Natural – Prior to 1700's

Mass Erosion – 1800's

Beach Erosion – 1973

A. Sugar cane terraces
B. Sediment collection area
C. Sediment release
D. Sediment plume
E. Turbid waters, siltation, and reef dieback

A. Reforestation
B. Construction/man caused sediment release
C. Shoreline erosion

St. John Island, V.I.

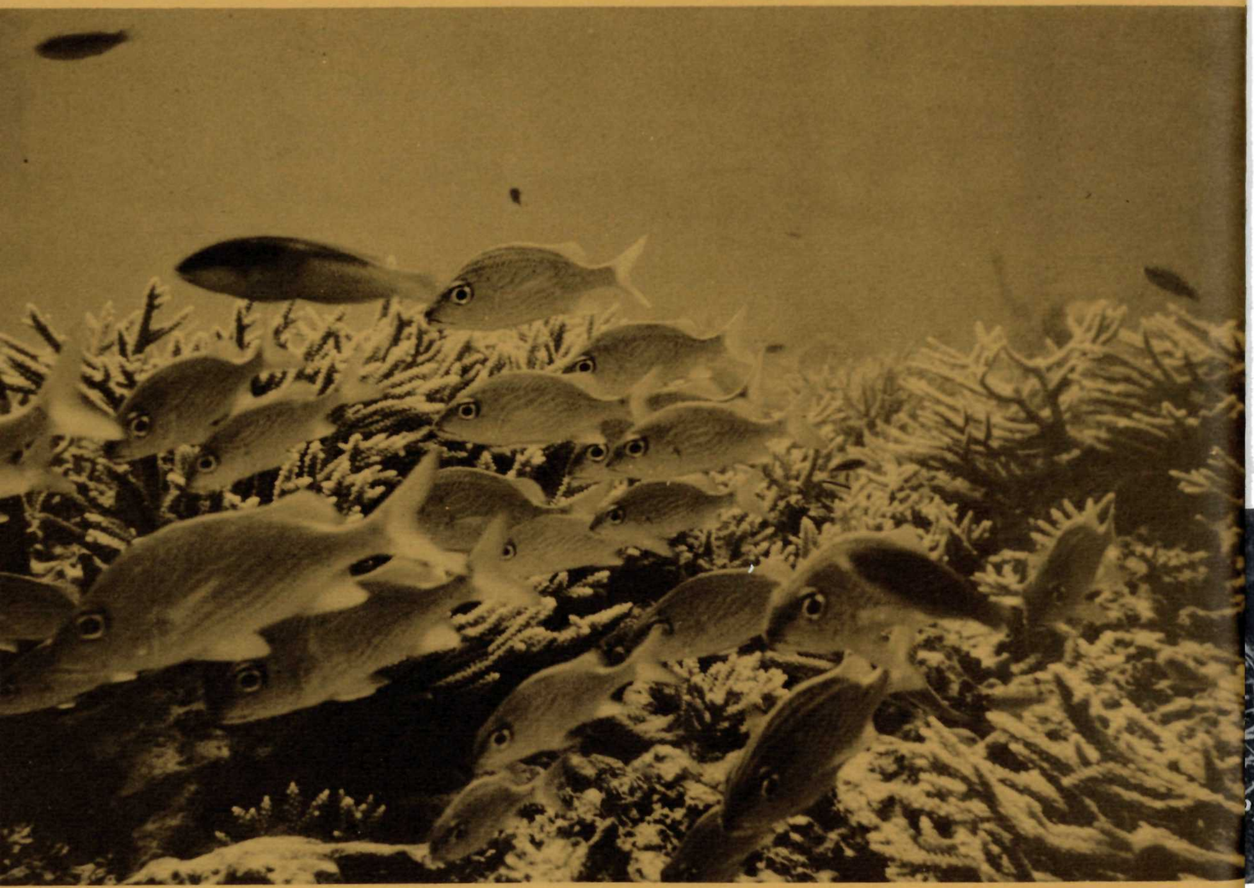
A LESSON IN LAND USE . . . .

THE VIRGIN ISLANDS

St. John was in a NATURAL STATE before Europeans arrived. This included a stable forest cover, broad coral sand beaches, rock cliffs, and healthy fringing reefs. But when the steep hillslopes were stripped of their native vegetation and replaced with sugar cane, tobacco, and other crops, soil erosion was accelerated, and resulted in increased siltation in bays and across the coral reefs. With the continuous rise in sea level demanding rapid healthy growth of the coral, the siltation of the 1700's endangered the very existence of the Virgin Island reefs. In fact, some of the reefs with marginal health today are located directly offshore from the island's largest watersheds where soil erosion and siltation were concentrated. Reduced vigor of the reefs results in deeper water above their surfaces and in time, allows larger waves to move onshore, accelerating beach erosion.

. . . THE LESSON

The balance between health and irreversible damage to the reefs of the Virgin Islands is extremely delicate. EVERY PRECAUTION SHOULD BE TAKEN TO REDUCE SOIL EROSION, RAPID RUNOFF, SILTATION, AND OTHER FORMS OF POLLUTION. Changes in the positions of the coral sand beaches should be considered normal rather than 'destructive.' Permanent developments should be minimized. Erosion control structures that alter wave action or the inshore currents within the coral bays are certain to lead to future environmental problems.



A LIVING RIVER

INTERFACING THE SEA

The Everglades is best described as a massive shallow river teeming with life and fringed at the sea with mangrove. The health of this complex system is balanced by the rising sea level and the release of fresh water from northern Florida. Alteration of either of these floods of water causes adjustments focused at the primary interface. The changing penetrations of the sea with each tide and storm surge and of the freshwater rivers with the rainy season create numerous brackish interfaces of complex form and shape that are mirrored by equally complex, diverse, and productive ecotones. Management strategy in this unique system is geared to the particular region and its water budget.

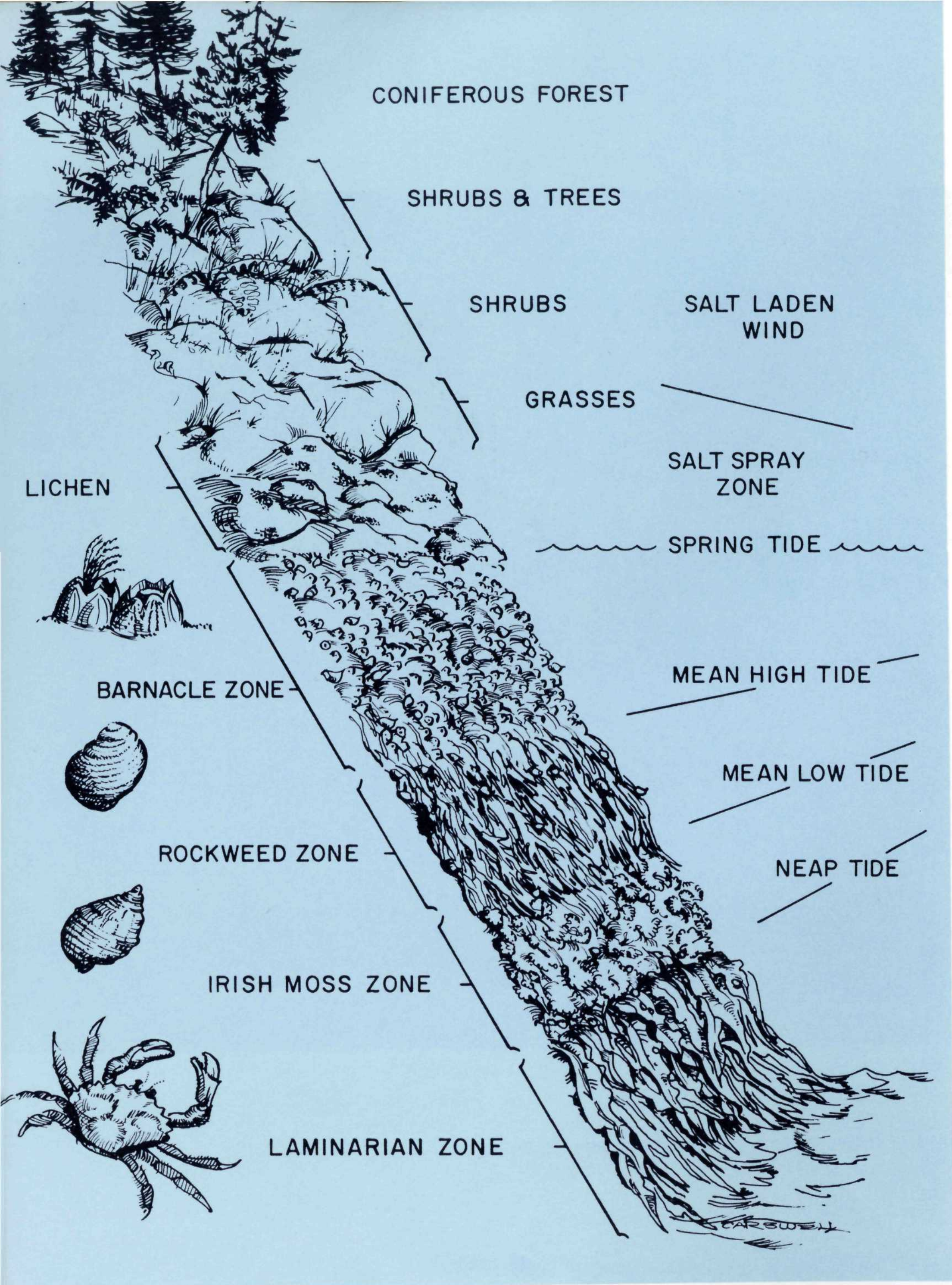
LIFE SYSTEMS MANAGEMENT

In those systems where the primary controlling interface is of biological origin, management strategy must be based on preventive measures. Experience with coral systems in the Pacific suggests that these systems are delicate and complex. Even biological control of the reef-devouring spiny starfish has had unexpected consequences.

- Coral requires clear waters to maintain a vigorous growth rate; turbid waters and siltation must be prevented.
- Coral is temperature sensitive; changes in bay temperatures must be prevented.
- Coral must be protected from man's toxic wastes.
- Coral is sensitive to "tourist pressure," and the recreation carrying capacity must be conservatively estimated.
- Coral reefs create embayments with poor flushing characteristics. Chemicals, wastes, and sediments discharged into these bays have long residence times.

COASTS OF IMMOBILE MATERIALS

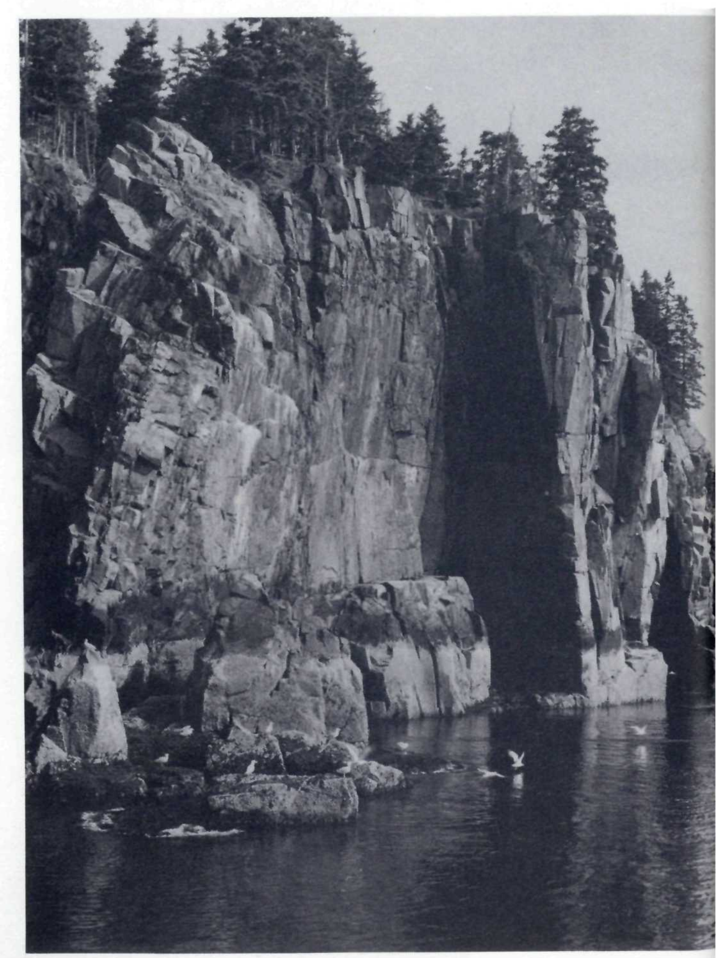
While coasts of mobile and organic materials are shaped by ongoing processes and thus have characteristic marine or lake forms, the coasts of immobile materials derive their form from the happenstance of coastal geology. The forces of waves, tides, and surges erode the softer rocks, leaving behind a highly irregular shore composed of the hardest rocks. These relatively stable rocks permit biological growth of amazing diversity forming coasts of stable physical interfaces and very dynamic ecotones.



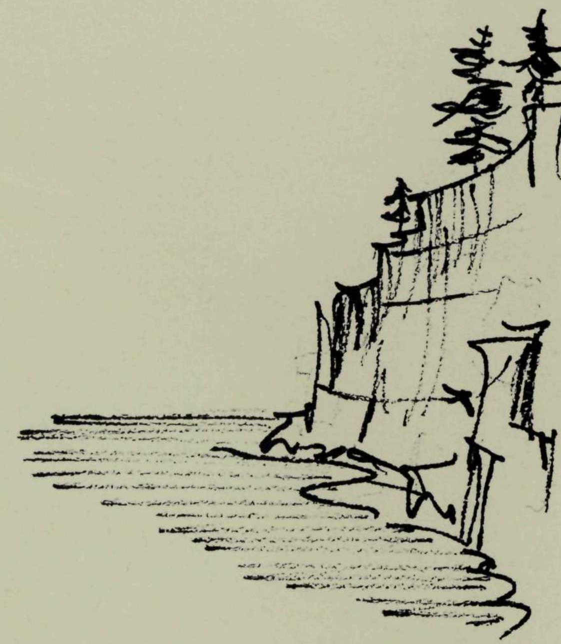
ACADIA

The physical interfaces and associated ecotones of rock coast parks are highly condensed. The broad flat zone characteristic of sand is replaced by a series of narrow vertical zones. Distances between interfaces are measured in feet rather than 100's of feet, and the processes which generate and sustain these zones occur on the time scale of hours rather than seasons or years. These systems are responsive to the regular tidal changes, and they are less influenced by the extreme events of storms and surge. The stable materials of the coasts provide an anchorage for hundreds of marine and terrestrial organisms. The highly irregular seascape of rock provides a great surface area for life forms. Communities are diverse, highly productive, and are dependent upon periodic tidal submersion for their nutrients and foods.

The highly condensed nature of these dynamic environments provides a unique opportunity for viewing the close interrelationships between the sea and life forms. Like the grasslands of the barrier islands, these communities are only able to maintain existence through the periodic variabilities of the sea. They are unique disclimax communities which can be preserved only by insuring the continuance of natural processes and the integrity of the coastal material.

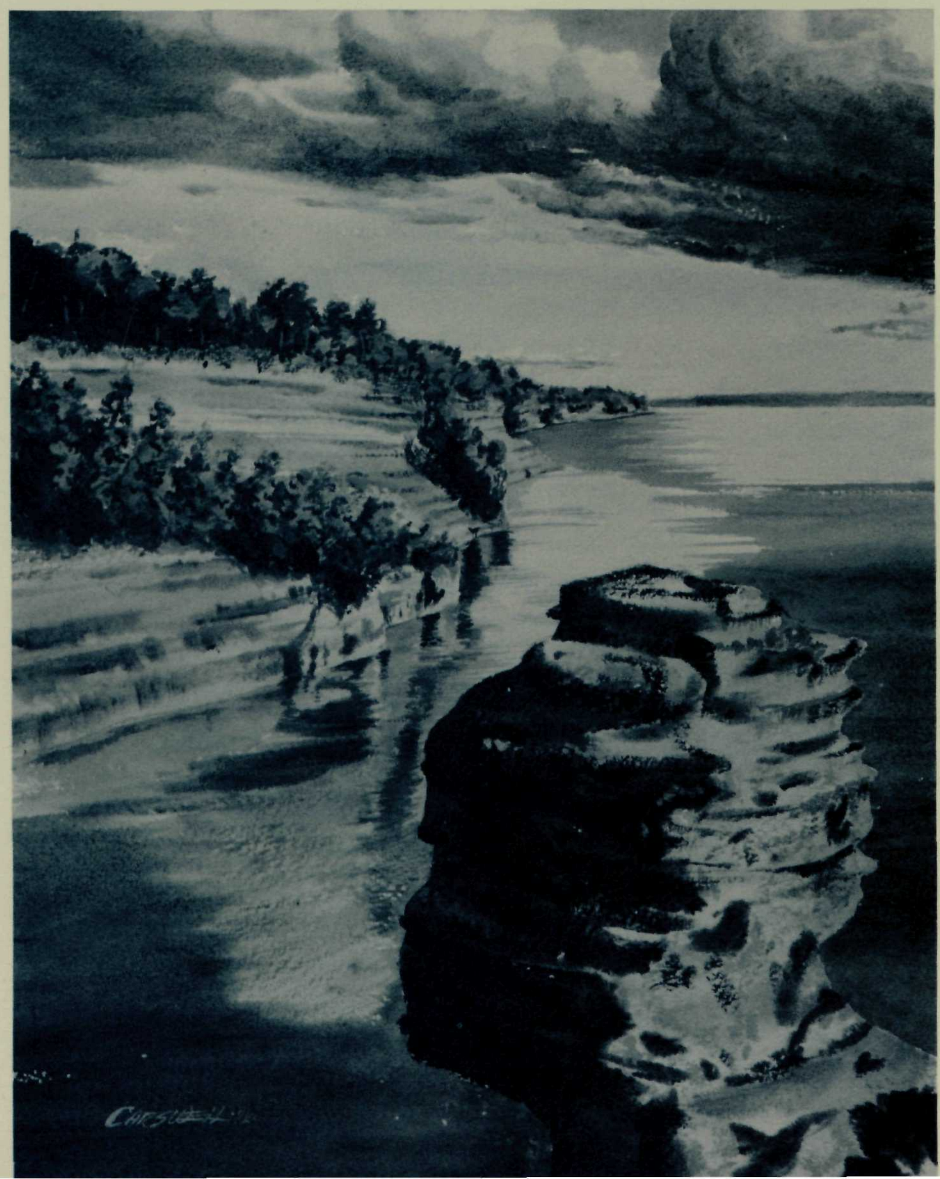


MANAGEMENT OF THE ROCK COAST PARKS



Although the bold landscapes of these park shores appear immune to the pressures of man, careful inspection reveals a fragile ecology, easily destroyed by careless use. The characteristically immobile primary interface, endlessly withstanding waves and storms, can only protect the tidal ecotones if the surrounding upland watersheds are preserved from thoughtless development.

The concentration of life forms and communities exposed to the sea are well adapted to and derive their health from the inherent variability of sea level. This adjustment to tidal stages is dependent upon a constant supply of high-quality water. Deviations from this quality constitute the major threat to these natural systems. Oil spills, sewage release, and excessive sedimentation from the land must be prevented. Sound land and water use practices for adjacent areas must be encouraged.

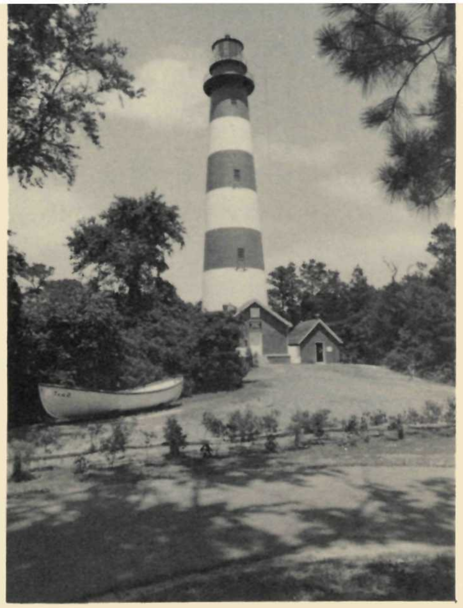


- Watershed development must be controlled.
- Water quality, both offshore and upland, must be maintained.
- Visitor use must recognize reasonable carrying capacities. The pressure of man on this secondary interface—the watershed—may seriously threaten and perhaps destroy the natural beauty of these shores.

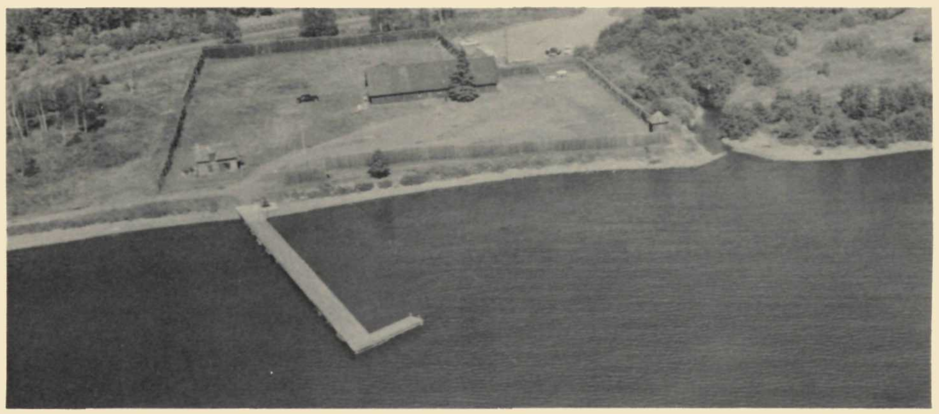
COASTS OF HUMAN ARTIFACT . . .

Participation and Recreation

The National Park Service has a long tradition of preservation of historic sites and monuments, many of which are located in the coastal zone. Recently, a new dimension has been added—the creation of large recreation parks in the proximity of urban centers. Although commonly located in dynamic physical interfaces, each of these areas is characterized by a focus on the artifact of man. Unlike the many natural coastal areas, the primary mission is one of accommodation. However, their location still requires a management strategy consistent with the nature of the physical system.



HISTORICAL PRESERVATIONS



HUMAN ARTIFACT MANAGEMENT

Adjacent to many of our major coastal urban centers are natural landscapes which have escaped development. This urban proximity increases their recreation potential. The National Park Service is committed to the recreational development of these vital urban resources.

THIS FARSIGHTED MISSION REQUIRES A CAREFUL STRATEGY FOR THESE DELICATE RESOURCES. Much of the natural area of what is to be the Gateway National Recreation Area is wetland. The construction of golf courses, tennis courts, and scenic walkways will require knowledge in areas such as tidal drainage patterns, nearshore currents, and the movement of sediments.

The National Park Service is committed to the preservation of the historic sites and monuments which dot the coastal zone. The historical value of these artifacts commonly demands a strategy of stability in environments inherently unstable. Confrontation of man and nature usually is expensive and demands the best management possible. This management requires study of the natural environment to determine those aspects subject to control. While the installation of groins and sea walls may be inappropriate in a natural area, they may be the only alternative in the immediate vicinity of a threatened historic feature.

For several decades the Cape Hatteras Lighthouse has been threatened by progressive shoreline erosion, a total of 500 feet since 1900. Sand bag sea walls, groin fields, and beach nourishment programs have been used and will be needed in the future. With sea level rising, the eventual loss of the lighthouse is foreseen unless a major commitment is made. The alternative is to move the lighthouse. This may appear prohibitively costly, but holding the shorelines stable near Cape Point may be even more expensive.

HUMAN ARTIFACT MANAGEMENT

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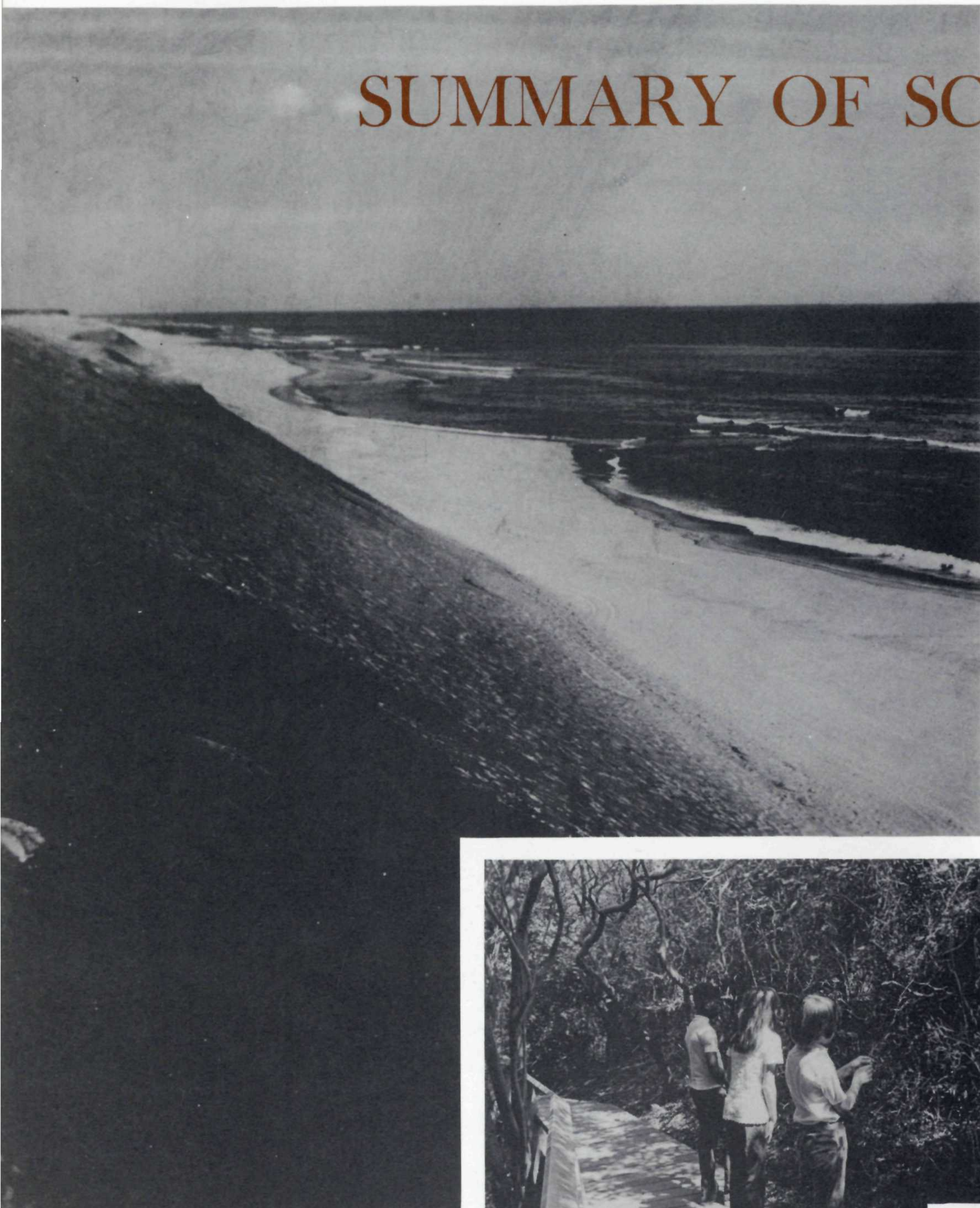
SUMMARY OF SCIENTIFIC PRINCIPLES . . . .



CHANGE . . .

Marine and lakeshore areas are constantly changing. Features of the natural landscape are not fixed in place but rather undergo shifts in position . . . .
MANAGEMENT STRATEGIES BASED ON THE CONCEPT OF STABLE FEATURES ARE IN CONFLICT WITH NATURE.
Change occurs on several time scales, two of which are most important to management: 1) short-term oscillations measured in years, and 2) long-term trends measured in tens of years . . . .
IN AREAS STRESSING NATURAL LANDSCAPES, MANAGEMENT STRATEGY MUST BE TOLERANT OF BOTH SHORT AND LONG TERM CHANGE, FOR CHANGE MAXIMIZES ENVIRONMENTAL HEALTH. LOCATIONS OF NATURAL HISTORIC SIGNIFICANCE MAY REQUIRE STABILIZATION OF SHORT-TERM CHANGES; HOWEVER, LONG-TERM TRENDS WILL REQUIRE CONTINUING CORRECTIVE MEASURES AT CONSIDERABLE COST.

NATURAL BOUNDARIES . . .

Physical interfaces and ecotones are boundaries between physical and ecological processes acting on both sides of the boundaries. **A SOUND MANAGEMENT STRATEGY SHOULD INCLUDE ACQUISITION AND CONTROL OF LANDS AND WATERS ADJACENT TO THE COASTAL INTERFACES. WHERE ACQUISITION IS NOT FEASIBLE EFFORTS SHOULD BE DIRECTED TOWARD ENCOURAGEMENT OF WISE LAND AND WATER USE POLICIES.**
Physical interfaces and ecotones are the most dynamic and vulnerable features of the shoreline environment.

. . . . LAND ACQUISITION OF INTERFACE AND ECOTONES SHOULD TAKE PRECEDENT OVER MORE STABLE AREAS WHEN FUNDS ARE LIMITED.

INTERRELATED BOUNDARIES . . .

The physical interfaces of the coastal system are interconnected by the processes that generate the interfaces and are controlled by the primary interface which intercepts most of the marine energies . . .

MANAGEMENT DECISIONS AFFECTING ONE INTERFACE ALSO AFFECT ADJACENT INTERFACES. MANAGEMENT COSTS OF INTERFACE MODIFICATION EXTEND BEYOND THE MODIFIED AREA.

Physical interfaces and ecotones vary in vulnerability to natural disruptions. Successional stages closest to the climax community are those least frequently disrupted by physical processes . . .

MANAGEMENT DECISIONS AFFECTING PRIMARY INTERFACES ARE AT BEST SHORT-TERM OR TEMPORARY WHILE THOSE AFFECTING MORE MATURE COMMUNITIES HAVE A LONG LIFE EXPECTANCY.

STABILITY . . .

Physical interfaces and ecotones in natural healthy systems are irregular in outline. This irregularity is conducive to highly productive, diverse, and complex ecologic systems. Stabilization tends to linearize these boundaries and thus reduce their ecologic productivity, diversity, and complexity . . . .

A MANAGEMENT STRATEGY BASED ON ENHANCING STABILITY OF PHYSICAL INTERFACES HAS REAL COSTS TO THE ECOLOGY OF PARK AREAS.

Stabilization of coastal interfaces eliminates successional stages as permanent features of the coastal landscape. These communities are rarely found in noncoastal areas, and thus their elimination is the loss of a unique environment . . .

STABILIZATION MANAGEMENT WITH RESERVATION OF DISCLIMAX COMMUNITIES REQUIRES DRASTIC SUBSTITUTE CONTROLS SUCH AS FIRE.

BEHAVIOR . . .

The behavior of physical interfaces is a function of the form of the interface and the nature of its material . . . . .

RESTORATION PROJECTS SHOULD RELY ON NATIVE MATERIALS, AND THE FORMS ENHANCED SHOULD BE CONSISTENT WITH NATURALLY OCCURRING FORMS.

Stable primary interfaces are usually mirrored by very dynamic ecotones and are highly susceptible to alterations in material composition . . .

AND MANAGEMENT IMPLICATIONS

MANAGEMENT INVOLVING CHEMICAL AND THERMAL EFFLUENTS MUST CAREFULLY CONSIDER THE LOCATIONS OF THESE DYNAMIC ZONES.

UNIFIED STRUCTURE . . .

Marine and lakeshore areas are highly structured systems which reflect the inherent variability of both space and time . . .

MASTER PLANS FOR THE NEW MARINE PARK AREAS AND REVISED PLANS FOR OLDER AREAS SHOULD INCLUDE ANALYSES OF PHYSICAL INTERFACES AND ECOTONES, AND DECISIONS SHOULD BE BASED ON THESE BOUNDARIES AND THE SURFACES BETWEEN.

ECONOMIC IMPLICATIONS

In attempts to stabilize and protect beach front property in the United States, tens of millions of dollars in both private and public funds have been invested over the past several decades. During this period we have modified some marine systems, and we have influenced a wide range of inshore processes; however, we have not been very effective along the high energy coasts. In general, most of our successes have been on the prograding coasts in regions of low energy, where the changes are slow and where we can cope with the forces of nature.

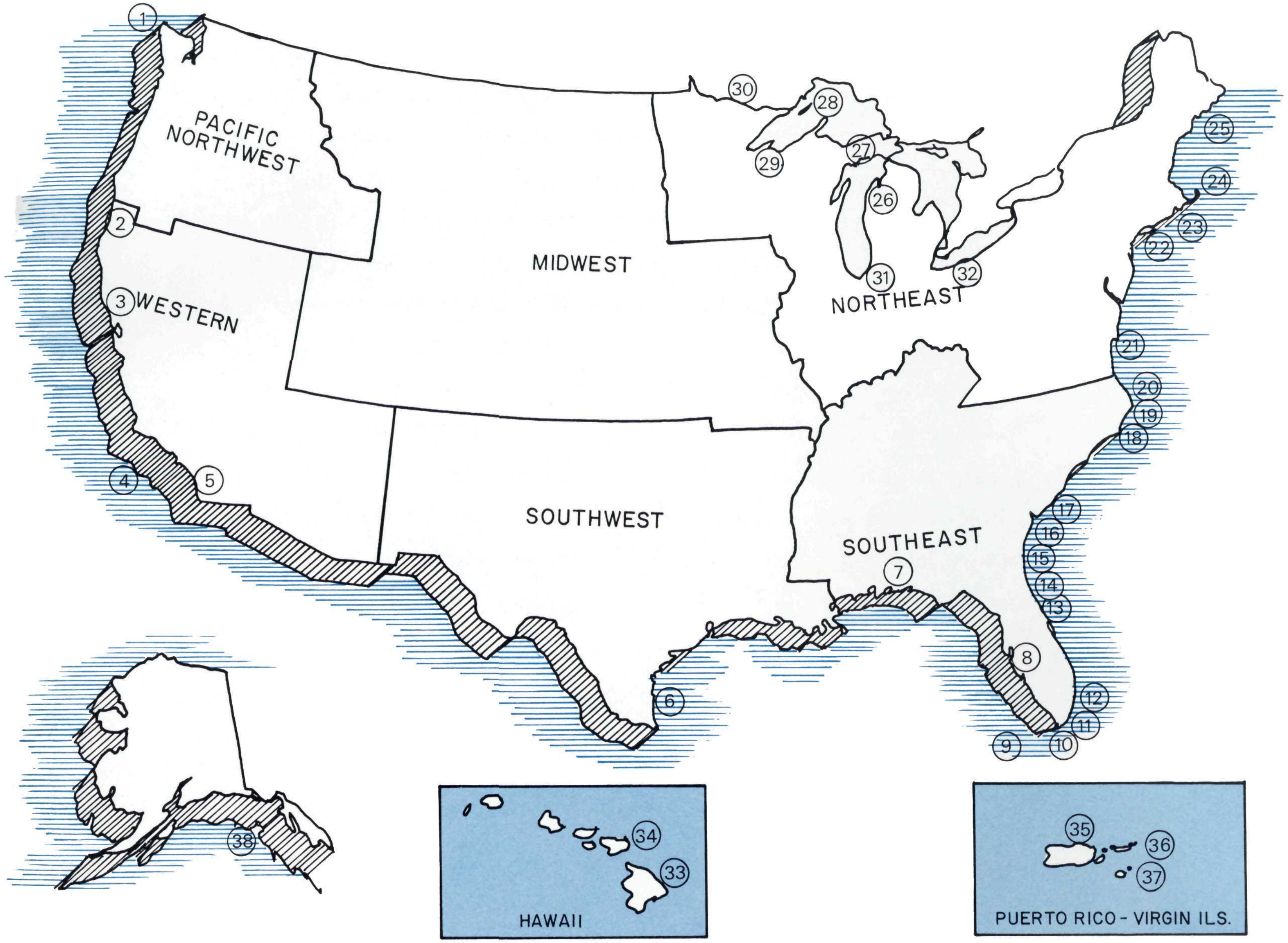
The Army Corps of Engineers recently completed the "National Shoreline Study" which concluded that approximately 2700 miles of shoreline in the United States were undergoing "critical erosion." It was also estimated that remedial measures to halt erosion for these 2700 miles would cost $1,800,000,000, plus an annual maintenance cost of $73,000,000. This is an average investment of $700,000 per mile, with an annual maintenance of $30,000 per mile.

The economic implications of shoreline stabilization become apparent when we consider the cost of protecting a single national seashore area. For example, an initial investment of more than $50,000,000 would be required for the stabilization of some 75 miles of shoreline along the Outer Banks in North Carolina. This would be followed with an annual beach stabilization budget of $2,500,000. It should be stressed that these are conservative figures for the Outer Banks. The Wilmington, North Carolina, District Office of the Corps of Engineers has estimated that the initial cost for stabilization of the Outer Banks might run as high as $20,000 per fifty foot beach front lot, or more than $2,000,000 per mile. One can see from these figures that staggering totals develop for only one of the National Park Service marine and lake systems.

Investments of this magnitude obviously limit beach erosion control projects to coastal areas or historic sites where man's confrontation with the natural systems has implications of national significance. In some cases it is necessary to adopt a "man over nature" strategy to protect a specific site of importance to the mission or integrity of the park; however, the same engineering concepts need not be applied to the entire park coastline.

There is no reason to assume that the strategies for management we have inherited are the best or the only ones for dealing with shoreline problems. These systems change rapidly. Most of our past decisions for park development were based upon the implicit assumptions that we can extend our stable "continental" world down to the edge of the sea. We now know this is impossible, both in terms of environmental degradation and simple economics.

ADMINISTRATIVE IMPLICATIONS



1. OLYMPIC
2. REDWOOD
3. POINT REYES / GOLDEN GATE
4. CHANNEL ISLANDS
5. CABRILLO
6. PADRE ISLAND
7. GULF ISLANDS
8. DESOTO
9. FORT JEFFERSON
10. EVERGLADES
11. BISCAYNE
12. MAR-A-LAGO
13. FORT MATANZAS
14. CASTILLO DE SAN MARCOS
15. CUMBERLAND ISLAND / FORT FREDERICA
16. FORT PULASKI
17. FORT SUMTER
18. CAPE LOOKOUT
19. CAPE HATTERAS
20. FORT RALEIGH
21. ASSATEAGUE ISLAND
22. GATEWAY
23. FIRE ISLAND
24. CAPE COD
25. ACADIA
26. SLEEPING BEAR
27. PICTURED ROCKS
28. ISLE ROYALE
29. APOSTLE ISLANDS
30. VOYAGEURS
31. INDIANA DUNES
32. PERRY'S VICTORY AND INTERNATIONAL PEACE MEMORIAL
33. HAWAII VOLCANOES
34. HALEAKALA
35. SAN JUAN
36. VIRGIN ISLANDS
37. BUCK ISLAND REEF
38. GLACIER BAY

Throughout the marine and lakeshore park systems, a basic underlying similarity of environmental attributes and management problems exists. Management of these dynamic areas demands:

(1) Development of scientific-engineering expertise at the regional and individual park levels.

(2) Coordination of marine and lakeshore research, planning, and management at the national level.

CONCLUSIONS

The land-sea interface is one of the most dynamic natural environments. Powerful forces of wind and waves continue to re-shape the land as they have for millions of years.

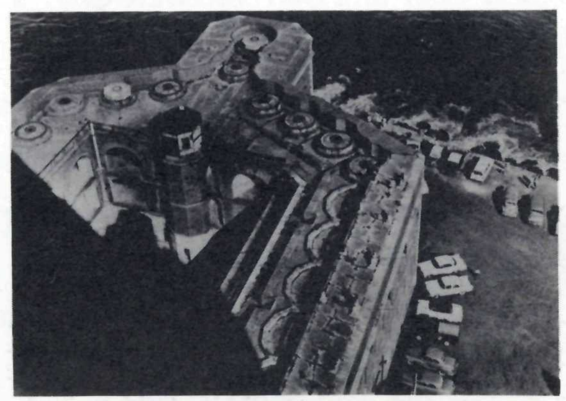
In most areas the land and the sea have reached a balance. The land erodes in one place and builds in another; woodlands and coastal grasslands are buried and new ones develop; sand dunes migrate while others are temporarily stabilized. In the past, man has been part of this balance, adjusting his activities to the patterns of the sea and the weather. Unfortunately, during the twentieth century we have become a conqueror rather than a participant in the natural system, regarding the sea as an enemy rather than an ally. The conflict between natural patterns of change and man's desire to stabilize environments within the coastal zone is a national issue.

By the year 2000 the demands for outdoor recreation will have increased more than two and one half times. To accommodate ever increasing numbers of visitors, new parks will be established, requiring new management concepts; older established locations will require reexaminations of current management strategies. In some cases the long-term trend of sea level rise may necessitate re-location of facilities and historic sites — administrative policies in these dynamic areas may demand a "nomadic" strategy rather than the current "sedentary" approach. As with the coastal landforms and ecological systems, National Park Service management must be adaptable to differences in the attributes and in the behavior of the environment rather than constantly confronting and opposing these systems.

Preservation of the natural attributes of the marine and lake systems and recreational utilization are compatible if the natural dy-namics of the park areas are understood. The major issue presented in this document is that the beaches, dunes, cliffs, terraces, grass-lands, woodlands, salt marshes, and estuaries are all interrelated in an environment controlled by the sea or lakes, and that we cannot alter one element within these systems without affecting the others. It is essential to change the concept of stability from static to dynamic. Unless we are knowledgeable and cautious in our management, we may very well contribute toward the destruction of the very features we are attempting to preserve.





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