Preface

The South Carolina Beachfront Management Act

In the Beginning

The Coastal Zone Management Act of 1977 was enacted to protect our coastal resources from unwise development. This legislation served the beaches well during its first decade, but as South Carolina became a more popular tourist destination, it became apparent that the portion of the Act that dealt with beaches was inadequate. As development crept seaward, seawalls and rock revetments proliferated, damaging the public's beach. In many areas there was no beach left at high tide. In some areas, there was no beach at low tide, either. In 1988 and again in 1990, South Carolina's legislators took action and amended and strengthened the Coastal Zone Management Act. The resulting Beachfront Management Act protects South Carolina's sandy shores by increasing the state's jurisdiction and encouraging development to move landward.

South Carolina's Beachfront Jurisdiction

To find the boundaries of this jurisdiction, staff from the Office of Ocean and Coastal Resource Management must first locate the baseline, which is the crest of the primary oceanfront sand dune. Where there are no dunes, the agency uses scientific methods to determine where the natural dune would lie if natural or man-made occurrences had not interfered with nature's dune building process. The setback line is the most landward boundary and is measured from the baseline. To find the depth of the setback line, the beach's average annual erosion rate for the past forty years is calculated and multiplied by forty. For example, if the erosion rate is one foot per year, the results will be a setback line that stretches forty feet from the baseline. Folly Beach in Charleston County is the only exception to this rule. The Charleston Harbor jetties, a federal project built in the late 1800's, are a major source of erosion on Folly Beach. To compensate property owners for their loss, the General Assembly set Folly Beach's baseline along the beach's erosion control structures. There is no setback on Folly Beach, thus the state's jurisdiction is seaward of the baseline only. To see where the baseline and setback lines fall on a particular property, contact OCRM. If any portion of your proposed project falls seaward of the setback line, talk with someone in the OCRM permitting section before beginning construction. Failure to do so may result in a fine and/or the removal of the structure at the property owner's expense.

Building in the Setback

Several activities are allowed in the setback, including the construction of new homes, the repair or replacement of a home, routine maintenance of an erosion control device and the replacement of a destroyed swimming pool. A permit is not needed, but property owners are required to contact OCRM, in writing, before work begins. The agency has a notification form for this purpose. Using the form, OCRM will determine if the proposed project is in compliance with the Beachfront Management Act. New habitable structures, for example, must be built as far landward as possible and are limited to a maximum of 5,000 square feet. New swimming polls may be constructed if located behind a functioning erosion control device. No construction may alter the beach's primary sand dune or active beach zone.

Building Seaward of the Baseline

In some instances, a special permit may be obtained to build structures seaward of the baseline. To qualify, the structure (usually a home) must be built as far landward as possible and have no impact on the primary sand dune or active beach area. If the beach erodes and the permitted structure becomes situated on the active beach, the property owner must agree to remove the structure if so ordered by OCRM.

Erosion Control Structures

Erosion control structures represent the greatest threat to the preservation of the beach. On an eroding beach, seawalls and rock revetments may actually accelerate erosion, effectively killing the beach. South Carolina takes a hard position where these structures are concerned. No new erosion control structures are allowed seaward of the setback line. Functional erosion control structures may not be enlarged, strengthened or rebuilt, but may be maintained in their present condition. If destroyed, the structure must be removed at the owner's expense. With the removal of erosion control structures, sand dunes will once again become the best protection against high tides and minor storms. Property owners, local governments and the public need to do what they can to protect sand dunes. The office of Ocean and Coastal Resource Management's "How to Build a Dune" is a guide for creating and preserving sand dunes. Contact OCRM for a free copy.

Introduction

South Carolina is made up of three distinct geographic regions-the mountainous Blue Ridge, overlying a small northwest portion of the state; the Piedmont foothills, reaching east from the mountains' edge to the Fall Line (so named because as streams tumble off the more resistant rocks at the edge of the Piedmont into the softer sediments of the Coastal Plain, also known as the Low Country, sloping gently eastward from the Fall Line down to the coast. The land meets the ocean in South Carolina as sandy beach, marsh and estuarine waters.

South Carolina's coastline can be divided into three distinct geographical segments:

1) a crescent-shaped beach stretching from the North Carolina border to Winyah Bay

2) the Santee River Delta extending approximately 18 miles along the shore between Winyah Bay and Bulls Bay, and

3) the southern section extending from Bulls Bay to the Georgia border - an area fronted by a series of barrier islands separated from the mainland by a wide zone of salt marsh. Within these three areas are found four major landforms which can be distinguished by their geological history and the wave and tidal-current energy present in the areas.

One of these landforms, the *arcuate* (pronounced ar-kyoo-wit) *strand*, mentioned above as a crescent-shaped beach, is a stretch of stable, nearly continuous beach area some 60 miles long. The few tidal inlets which disrupt the continuity of this area increase in size and frequency along the southern portion of the strand where salt marshes begin to appear.

South of the arcuate strande, between Winyah Bay and Bulls Bay, lies a second type of landform, the *cuspate delta* (commonly known to coastal residents as the Santee River Delta). Here, points of land called headlands or capes jut out into the ocean, and elongated *spits*

(narrow peninsulas of sand) form off the headlands.

The major portion of the central and southern length of the coast is bordered by barrier islands - both *beach ridge* barrier islands and *transgressive* barrier islands, which are the third and fourth main types of landforms found along our coast. Located behind the islands and separating them from the mainland are the highly productive salt marshes.

Alongside the intricate maze of estuaries and creeks flourish thousands of acres of marsh, constituting some of the richest, most productive areas in earth - areas vital to the existence of the majority of marine life found in both offshore and inshore water s of our coast. Inland from the barrier islands, beaches and estuaries, a visitor to South Carolina's coastal zone will find many other natural resources of great significance, areas such as floodplains, swamps, pocosins, Carolina Bays and savannahs. These areas perform a number of important functions not the least of which is the provision of habitat for an abundance of wildlife including sensitive species such as the American alligator, bobcat, red fox, river otter, mink, black bear and Southern Bald Eagle.

Certain activities of man have caused or contributed to the disappearance of a number of species, such as the Carolina Paroquet, Ivory-billed Woodpecker, Passenger Pigeon, Red Wolf, Elk and American Bison, from our coastal zone and state. (The Carolina Paroquet and Passenger Pigeon no longer exist anywhere on earth.) In spite of these losses, however, our coastal resources as a whole have remained healthy and abundant. Several factors have contributed to this good fortune. Primary among them has been South Carolina's small population relative to the North Atlantic and Gulf coastal states and the fact that the economy of our coast, until recent times, was based almost solely on agricultural and forestry-related ventures. More specifically, the fact that much of South Carolina's coastal zone remains unspoiled may be attributed in large part to the plantation system and to the aftermath of civil war. The plantation system served to keep large tracts of land under single ownership and in non-commercial use until about the time of the War Between the States. During Reconstruction, many plantations were sold to hunt clubs or to large corporations whose owners allowed the fields and rice impoundments to return to their natural state.

It is not enough that our coastal resources of today be healthy and abundant; they must also be understood and protected by well-informed, concerned citizens. Through proper protection they will sustain their unique richness and esthetic appeal while supporting a growing human population.

Barrier Islands

Barrier Islands, so named because they form a barrier or protection for the mainland against the ocean, "are formed by various geologic processes – in most cases, through the transportation and deposition of sand by wind, tide, wave action and ocean flooding." Because they lie parallel to the shoreline and bear the brunt of the ocean waves, storms and flooding, barrier islands are highly unstable areas (in terms of human development) – "being shaped and reshaped, eroding (wearing away) and accreting (building up) in a dynamic, never-ending evolution." Although inland portions of some barrier islands may remain stable for hundreds of years, the outward shape of all barrier islands is constantly changing. While rates of erosion and accretion and the direction of sand movement are often unpredictable, it is generally believed

that most barrier islands tend to migrate, over periods of years and hundreds of years, toward the mainland shore.

It is interesting to note that the natural stresses of wind, tides, waves and flooding are the very things which allow barrier islands to survive.

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 contribute 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.

Generally speaking South Carolina barrier islands are thin and elongate in shape, fringed with salt marsh on the landward side and having a beach and sand dune system on the side bordering the ocean. The larger islands, known as beach ridge islands, are composed of a beach, vegetated sand dunes and shrubs leading into dense maritime forest. Hilton Head and Kiawah are examples of this type of island which usually contains interior waterways and wetlands.

The other type of barrier island, referred to by coastal geologists as the transgressive barrier island, is extremely unstable, being very narrow and lacking the dunes and heavy vegetation that would prevent ocean waves from washing over it. It is believed that transgressive barrier islands may be the erosional end-product of beach-ridge barrier islands; as a result of the removal of beach ridge dunes, either by man or through natural processes, these islands tend to erode on the ocean side faster than they can build, or accrete, on the landward side. In fact, transgressive barrier islands sometimes erode so fast that marsh that was once present behind the islands becomes buried in the sand and can be found layered beneath the front beach after a storm.

An interesting example of trangressive barrier island movement can be seen on Morris Island, located at the mouth of the Charleston Harbor. Historical charts show that beach ridges (dunes) existed there in 1779. Today, lacking the beach ridges which provide storm protection, and without the constant renourishment from the offshore shoals that were present before the dredging of Charleston Harbor, Morris Island has become transgressive. Statistics show that it is eroding at an average of 30 feet/year. In fact, in some places it has a yearly erosion rate of up to 50 feet.

Striking evidence of erosion on Morris Island can be observed in the outcropping of marsh peat along its beaches as well as the precarious position of its lighthouse. In 1850 the shoreline was approximately 300 feet seaward of the present lighthouse, and by 1935, due to the continuous erosion, the lighthouse was at the edge of the shore. As of 1981 the shoreline retreat has passed the lighthouse and is about 1600 feet inland from where that structure stands partially submerged in the ocean. Even more awesome than this is the fact that this lighthouse was built to replace its predecessor which, located further out, had succumbed to the sea. In fact, there have been three lighthouses on the Morris Island point. The remains of the original

lighthouse, standing firmly on Morris Island only 170 years ago, now lie nearly two miles off the coast.

Barrier island's are one of South Carolina's most valuable resources and offer unique opportunities for both recreation and scientific study.

Larger barrier islands contains shrubs and forested woodlands, whereas smaller frequently flooded islands are devoid of trees and are dominated by hardy grasses such as sea oats (Uniola paniculata) and salt meadow cordgrass (Spartina patens). Barrier islands usually lack a complete representation of the fauna found on the mainland. This situation is the result of the distances between the islands and the mainland along with the inability of some species to cross salt water barriers. Characteristic of some barrier islands are special populations or subspecies of animals, especially mammals, which through their isolated situation develop characteristics which distinguish them from their relatives on the mainland.

*One of the most important benefits provided by barrier islands is their creation of the proper conditions necessary for the development and continuing existence of salt water wetlands and estuaries. By breaking the force of the ocean waves and creating behind them ****(((See text under picture - page 8)))****

Island Migration

Island migration is a term frequently heard in discussions of barrier island erosion. Migration does not refer simply to the processes of erosion and accretion but also to the displacement and re-formation of an island in the direction of the mainland. This fascinating process, associated with a rise in sea level, is nature's means of keeping barrier islands from being submerged by the sea.

Today the sea level worldwide appears to be rising about one foot/century, although in some areas it is rising more rapidly than this. In fact, coastal geologists have noted that the rate of rise seems to have increased over the last 50 years. The reasons for this are unclear, perhaps there is more rapid melting of glaciers due to a heating of the earth's atmosphere (known as the greenhouse effect), or perhaps it is because of a displacement of water from the ocean as the mid-Atlantic ridge rises. (The mid-Atlantic ridge is a chain of mountains lying beneath the waters of the Atlantic Ocean.) Recent figures for Charleston show a rise of one foot two inches since 1920.

Ten thousand years ago the ocean's shoreline was roughly out fifty miles from that of today on what is not the continental shelf. During this time tremendous glaciers were releasing vast amounts of water as they melted, thus causing the sea level to rise. The land behind sand dunes became submerged, and the dunes, which remained above sea level, became the barrier islands. The newly formed barrier islands, through the process explained below, began migrating until they reached the position which they occupy today. The islands are still migrating an average of five feet/year. (Any beach front property owner will tell you the significance of this).

Migrations or retreat, as it is sometimes called, of a barrier island occurs in this manner. As the rise in sea level continues, ocean waves break higher up on shore. During storm surges waves often cap the dunes, causing a breach or break in their lines, and beach sand buoyed by the water is carried over the dunes and deposited behind them. As this action is repeated, the

layers of newly-deposited sand make the island slightly higher or, in other words, increase its elevation. The beach front, which is providing sand for deposit on the backside of the dunes, is, of course, being eroded away. Gradually, sand from the beaches is both blown by the wind and washed by tidal action over the marshes behind the island. As the beach front erodes away and is washed behind the dunes, and as marshes immediately behind that island are gradually covered by sand, island vegetation (including dune plants, shrubs and maritime forest vegetation) "retreats" backward in the direction of the mainland, and a new beach and sand dune area evolves on top of the former sand dunes and shrub zone. Thus, it can be seen that the entire island re-evolves parallel to its former position. The marshes immediately behind the old island are replaced by new marsh areas which slowly creep up on the mainland as the sea level continues to rise.

Tidal Inlets and Spits

Tidal inlets – short, narrow waterways between barrier islands – serve as passages through which water is exchanged between the estuaries and the ocean. Because inlets are constantly shifting back and forth, the land on either side of an inlet is extremely unstable – accreting for a while, then rapidly eroding. The phenomenon of inlet migration can influence adjacent barrier islands for a distance of one half mile or more, making any kind of development within that area a most foolhardy venture.

As water rushes out of an inlet on the ebb (outgoing) tide, the swift current which is created transports and deposits sand offshore, forming and maintaining offshore sandbars. These offshore bars, in turn, influence the beaches by breaking the force and determining the direction of incoming waves. The direction in which the waves approach the beach determines the direction of the longshore current and thus the direction of littoral drift or transport (movement of sand up or down the beach through means of waves and currents). All of these phenomena (tidal inlets, currents, offshore sandbars, wave direction and littoral drift) work together in a complex and interrelated manner to determine the erosion/accretion patterns of barrier islands. Because there are so many variables involved, it is impossible to predict erosion patterns with any real degree of certainty.

Inlet formation can occur on barrier islands where areas of weakness are found – areas such as the neck of a spit of a low inland area unprotected by dunes or vegetation. These new inlets, formed during or immediately following a hurricane or severe storm, break through the weak areas from the landward side of the island to the ocean. It is usually the rush of waters that have accumulated on the land following heavy rains and winds that create the force and water mass necessary to break open a new tidal inlet.

In places where the littoral drift is strong in one direction, we often find the formation of spits. A spit is a narrow peninsula of constantly shifting sand that extends from the end of a barrier island. Spits are formed by sand that arrives by littoral drift at the far end of a barrier island and survives being pulled into the inlet by tidal action. Spits have a tendency to accrete, or grow in length, as inlets move downdrift.

Spits are similar in makeup to transgressive barrier islands – neither has vegetational or dune growth; both are equally susceptible to frequent overwash. Spits, however, are even more subject to fluctuation and change than are trangressive barriers. They are connected to their

parent island only by a thin strand or neck which has a tendency to break or breach during storms. Breaching of the sand tie results in a new inlet and a separation of the spit from the parent island.

Beaches and Dunes

Beaches and dunes are formed by the water and wind transport of sand. Sand that is deposited on a beach might have been carried there from adjacent shorelines by the current, or it might have been brought shoreward by wave action from offshore bars, depending upon local conditions. Beaches, dunes and offshore sandbars are constantly exchanging sand, responding to the forces of the waves and the direction of the wind and nearshore currents.

Beaches protect the highland by absorbing the tremendous force of waves and tidal currents, and dunes serve as reservoirs of sand, helping to replenish the beaches by replacing sand which is washed away from them by waves, tidal currents and periodic storms. The offshore sandbars play a very significant role by providing sand for the building-up of existing dunes as well as for the forming of new ones.

Sand dunes are formed in this manner. As sand from offshore sandbars is washed ashore, it is picked up and carried by the wind. Flotsam and jetsam (grasses, sticks and other obstructions which wash up on the beach) block the wind and cause it to drop its load of sand. As sand is deposited on the downwind side of the debris, it forms the beginnings of a sand dune.

Seeds are also carried onto the beach by the action of the tide and sometimes come to rest in the vegetational debris and accumulating sand. Those such as sea oats, salt meadow cordgrass and marsh elder – the primary dune colonizers – are well suited to dune growth, as they germinate only if covered with sand. The sand itself is low in nutrients and water-holding capacity; however, the vegetational debris contains the moisture and nutrients necessary for new plant growth. Thus, only the seeds that come to rest on the debris will germinate and grow. This new growth, which consists primarily of sea oats and salt meadow cordgrass, grows and develops roots which extend to a depth of several feet into the sand. A six-inch sea oat has roots that extend five feet below the surface. Thus, sea grasses stabilize the dune and keep it from blowing away, while at the same time trapping more sand as the wind blows, thus building up and strengthening the dune.

Primary dunes, the first row of dunes nearest the ocean, accrete (build up) during periods of calm weather. During storms they are washed back in to the ocean, and their sands become redistributed along the beach. Secondary dunes, characterized by the growth of heavier shrubs and located behind the primary dunes, do not as readily wash away.

The slope of the beach or the beach profile changes in response to wave action. During normal wave action the beach will build through the constant deposition of sand, and its overall profile will steepen. When a storm strikes, the beach and dunes are eroded by the short, steep storm waves, and the redistributed sand results in a gradual beach slope. With a return to normal wave action, the cycle begins anew.

Estuaries

Estuaries are places where fresh water from inland lakes, rivers and streams joins with

inflowing salt water from the ocean – places known to the layman as bays, lagoons and tidal rivers. Estuaries contain salt, brackish and freshwater marshes and mud and sand flats. They are dynamic ecosystems (natural environmental units in which living and nonliving parts interact to produce a stable system), constantly changing in response to tidal action, varying amounts of fresh water inflow, seasonal weather conditions and the biological demands of the organisms living within them.

Unlike communities with stable environmental conditions where competition for food, etc. is a predominant factor in determining populations, estuaries are communities whose populations are predominantly determined by physical environmental factors. Because of the constant changes occurring within estuaries – due to tidal action, fresh water inflow, temperature variations, etc. – animals living in them are constantly under stress. While organisms from both fresh and salt water environments are found there during a portion of their life histories, only a limited number of species are adapted for permanent residence in estuarine environments. Although these organisms are adapted for survival in stressful conditions, additional stresses posed on them by man are often more than they can tolerate. It is in this sense that the estuarine ecosystem is delicately balanced and extremely vulnerable to the additional stresses imposed on it by man.

The rivers and creeks of an estuary serve as arteries, transporting throughout the estuarine system the nutrient-enriched materials washed from uplands in addition to detritus (nutrients formed from decaying plant and animal life) and rich oceanic nutrients brought in with the tides. Because of this unique accumulation of nutrients, estuaries are extremely productive areas, having tremendous food reserves and supporting vast numbers of organisms.

Estuaries play a vital role as breeding and/or nursery grounds for commercially important species such as shrimp, crab, oysters, clams and numerous kinds of fish. In fact, it has been estimated that two-thirds of the species of fish harvested in offshore Atlantic and Gulf coast waters are estuarine dependent.

Marshes

South Carolina contains some 504,445 acres of coastal marshes – more than any other Atlantic coast state. Of this amount, 334,501 acres are classified as salt marsh.

A component of the estuarine system, salt marshes are one of the most productive natural resource areas in the world. Smooth cordgrass, the most abundant salt marsh plant in South Carolina, has been estimated to produce as much or even more organic material than the most productive wheat field. While the living salt marsh its utilized for food by a very limited number of animals, the dead marsh plants become a source of nourishment for many species. When broken down by wind and wave action and decomposed by bacteria into a form known as detritus, the salt marsh grasses along with phytoplankton (microscopic plants that drift and float in the oceans and estuaries) become the foundation of and the all essential link in the food chain for nearly all marine life.

In very simplified terms, the food chain of the salt marsh/estuarine ecosystem works in this manner. Detritus (the mixture of decomposed marsh grass and animal matter in combination with bacteria and fungi) provides nourishment for the zooplankton (microscopic animals that drift and float in the oceans and estuaries; includes larval stages of shellfish) as well as for

shellfish (clams, mussels, oysters, crabs, shrimp), worms, snails and certain types of fish. These creatures serve in turn as food for many kinds of fish as well as certain birds and mammals. Even this oversimplified explanation of the food chain can serve to illustrate that all creatures living in the salt marsh/estuarine ecosystem depend either directly or indirectly on the marsh grasses for their food supply.

In addition to providing food, the marshes serve as a shelter and nursery grounds for many marine species. Without the shelter provided by the exposed root and stem systems of the marsh, the larval stages of creatures such as shrimp, oysters and crabs would not be able to survive long enough to reach adulthood. Certain mammals such as raccoons, otters and mink also find food and shelter in the salt marsh, and birds such as the marsh wren and clapper rail use these areas for nesting purposes. Other creatures found within the salt marsh/estuarine ecosystem are the diamondback terrapin, loggerhead sea turtle and the bottlenose dolphin, commonly referred to as the porpoise by South Carolina citizens.

In addition to the functions discussed above, salt marshes also serve several other vital purposes along the coast. While barrier islands protect the marshes from ocean waves, the marshes in turn act as buffers for the mainland by slowing and absorbing storm surges as well as the daily inrush of tides, thus preventing erosion of the coastline. In addition, salt marshes serve as filters where pollutants such as excess nutrients and pesticides, entering them from various sources, are broken down from dangerous compositions into forms that are less harmful to the environment. The detrimental effects of non-biodegradable substances can also be minimized through sedimentation and burial within the marsh floor. There is a limit, however, to the marshes' capacity to serve as waste treatment plants. Excessive amounts of pollutants will overburden their cleansing capabilities.

As one travels away from the ocean through the salt marshes and up South Carolina's coastal rivers, he will soon come upon the brackish water marshes. These areas, occurring in the less salty reaches of the rivers and estuaries, represent a transition zone between salt and tidal marshes and contain plant species characteristic of both. South Carolina contains over 30,000 acres of brackish water marsh. Characteristic of these areas are such plants as black needlerush, giant cordgrass, salt marsh bulrush, marsh elder, sea myrtle, salt meadow cordgrass, sea ox-eye as well as other species typical of fresh water marshes.

Tidal fresh water marshes are found farther up the tidal rivers beyond the reach of salt water (The rivers at this point are fresh or very low in salinity; however, the effects of the tides are still felt there through the rise of the fresh water as it is pushed up the rivers by incoming (flood) tides and the subsequent lowering of the waters as the tide along the coast ebbs or flows out to sea.) The diversity of plants in these marshes is greater than in either salt or brackish water marshes. Plants which are typical of these areas are cattails, sedges, wild rice, smartweeds, giant cutgrass, pickerel-weed, water parsnip, sawgrass and alligator-weed, just to name a few.

Both brackish and fresh water marshes play an important role in catching, storing and releasing nutrients into the overall estuarine system of which they are a part. They also serve as shelter as well as nesting, feeding and nursery grounds for numerous animal species.

Unique to South Carolina and several other South Atlantic coastal states are rive field impoundments dating back to the 1800's when the tidal culture of rice was perfected. During this time thousands of acres of land along the coastal rivers, beyond the salt water reach of high

tide, were enclosed or impounded. The impoundments, which consisted of a system of banks, ditches, floodgates and trunks, were designed to utilize the natural rise and fall of the tidewater rivers and creeks as a means of drainage and irrigation for the fields of rice.

The majority of coastal impoundments that exist today represent former rice fields which are being managed to attract waterfowl. Through techniques such as the raising and lowering of water levels, burning of the impounded marsh plants or a combination of these practices, waterfowl impoundments can be made to produce vegetation which is attractive to the wintering duck population. Other uses made of impoundments include cattle pastrage, water storage, wildlife sanctuaries and mariculture.

Mud and Sand Flats

Two very important components of South Carolina's estuarine ecosystem are the mud and sand flats – stretches of soft, dark silt (mud) and similar areas composed of sand. These areas are constantly being covered and then exposed by the continuous rise and fall of the tides; thus, they are referred to as the intertidal flats.

Although they may appear barren at times, mud and sand flats support a wide variety of life. Certain animals, the permanent inhabitants, spend their entire adult lives there; others, known as temporary inhabitants, move on and off the flats in search of food during high and low tides.

If one were to observe a mud or sand flat during a twelve hour period (one tidal cycle or the time it takes for the tide to flow into the estuaries, rivers and creeks and then return to the ocean), he would see a fascinating flow of events. Beginning his watch at low tide, he would observe fiddler crabs and snails feeding on the rich detritus sediment. Shortly after these creatures make their appearance, the arrival of many different kinds of shore birds would be seen. These animals arrive to prey on the crabs, worms, clams and snails. (Most shore birds are totally dependent upon the intertidal flats as feeding grounds. In fact, the intertidal flat is of far greater significance to shore birds than are the salt marshes, seagrass beds or any other of the estuarine communities.) In addition to shore birds, a patient observer would also see predators such as otters and raccoons, especially if part of his vigil were to take place on a moonlit night, for these mammals are chiefly nocturnal. As the tide comes in and slowly covers the flats, the birds and mammals leave, and predators such as blue crabs, stingrays and various other types of fish take their place.

Other important members of the mud and sand flat community are the diatoms and blue-green algae. These microscopic plants, found in the surface sediments, are a source of food for snails, clams and polychaete worms. Perhaps the most important members of this interesting natural community are the bacteria which perform a vital service. When dead plant (chiefly marsh grasses) and animal matter settles on the flats, these bacteria decompose or change it into detritus which is used for food by both plants (the microscopic photoplankton as well as the marsh plants) and certain animals. Without the bacteria, this dead matter could not be recycled by living organisms, and the cycle of life in the estuarine ecosystem would come to a halt.

Oyster Reefs

In many sections of coastal rivers and creeks are found clusters of oysters called reefs, bars or oyster beds. Oyster reefs are formed over a period of time as oyster larvae, carried by tidal currents, find and attach themselves to solid material or other suitable substrate. After attaching themselves to a substrate, the animals become sessile or immobile and mature into adults. Other oyster larvae continue to attach to the substrate as well as to the sessile adults, and a cluster of oysters on a reef evolves and increases in height, width and length.

Other organisms such as algae, sponges, bryozoans, barnacles, mussels and worms live on the reef surfaces, and still other animals find shelter in crevices formed by the reef growth. In time an entire balanced community of plants and animals evolves.

Flood Plains

The term flood plain refers to the nearly level land along the course of a river or stream which is subject to overflow flooding. The extent of a flood plain fluctuates with the size of overbank flows, thus its exact boundaries cannot be fixed. Consequently, flood plains are delineated in terms of some specified flood size (e.g. the 50-year flood plain – the area that would be flooded by the largest stream flow that will, on the average, occur once within a 50-year period).

While "flood plain" is most often thought of in terms of inland areas where rivers and streams overflow their banks after large amounts of rainfall, coastal riverine and beach front areas are also considered to be within the flood plain. However, residents of South Carolina's coastal areas do not experience the same type of flooding as do those persons living farther away from the coast. Heavy rainfall is not usually a threat along the marsh-fringed areas of our coastal rivers or on the beaches. In beach areas, rainwater runoff simply flows down the beach into the ocean. In coastal riverine areas, the excess rainfall is received by the adjacent marshes and released into the creeks and rivers. The problems of flooding do arise, however, along coastal rivers and streams when heavy rains occur in combination with extremely high tides. Beach front areas can also experience flooding during these times, and most especially during hurricanes.

Flood plains serve the purpose of collecting and absorbing excess rain water and thus protecting surrounding uplands from flooding. A portion of the excess water which is absorbed by the flood plains and bottomland forests is later released into aquifers, underground layers of porous, water-containing rock.

Many serious drainage and flooding problems have arisen where flood plain (bottomland) forests have been cut and the cleared land has been developed for housing, commercial or other uses. When heavy rains occur, the land, covered with houses, buildings, streets and parking lots, cannot absorb the rainwater as it falls or the subsequent overflow from swollen creeks and rivers. Thus, these developments can be damaged by standing water which has no place to go and which will remain until such time as it can slowly drain away.

Swamps

Swamps are an integral part of South Carolina low country ecology. They are low-lying areas which are submerged by fresh water or have a water table which is at or near the ground's surface throughout the year, except during periods of drought. Even during severe

droughts, however, portions of swamps will remain covered with water. South Carolina low country swamps are characterized by water-tolerant plants and trees including pawpaw, spicebush, blue-stem palmetto, various woody vines, bald cypress, tupelo gum, sweetgum, sycamore, oaks, elms, ashes, hickories, red maple, red mulberries and American holly.

Our coastal zone has two types of swamps – the *river* or *alluvial* swamp and the *inland* or *non-alluvial* swamp. A river swamp lies between a river and adjacent uplands and exists because of the periodic flooding of the river. Inland swamps. On the other hand, are fed by springs and slow-moving streams.

Swamps are extremely important resources for a number of reasons, one of them being the role they play in controlling floods. When a river, swollen from heavy rains overflows its banks, its waters fan out over the adjacent bottomland swamp. The swamp serves as a holding basin for the water and helps protect surrounding upland as well as down-stream areas from flooding. Some of the excess water is then gradually absorbed by the forest and eventually released into aquifers (underground layers or porous, water-containing rock).

In addition to their role as flood controllers, swamps can help control water pollution through their natural ability to purify sewage and rainwater runoff. Perhaps their most important contribution is the habitat they provide for animal life, including certain endangered species. Forbidding as they may seem to those familiar with them only through the literature and screen, swamps provide interesting and pleasant recreation grounds via canoe or boardwalk, and are fascinating areas for scientific study.

Inland, black-water swamps are dominated by bald cypress, tupelo and black gum. The "black-water," characteristic of this type of swamp, rather than being unsanitary as is thought by many people, is actually clear and potable in those swamps which have not been altered by man. Although actually clear, the water appears black due to the tannic acid in the bark and leaf litter on the swamp floor.

The South Carolina lowcountry is fortunate to contain what is believed to be the world's only remaining tract of virgin tupelo-cypress swamp. Know as the Francis Beidler Forest, it is a part of the black-water swamp known as Four Holes. The Francis Beidler Forest is a Nation Audubon Society sanctuary featuring an interpretive visitor's center and 6,500 feet of boardwalk through the forest.

Savannahs

Savannahs are seasonally flooded grasslands located in poorly drained depressions within pine flatwoods. The savannah-type ecosystem owes its existence to fire, and if not burned yearly, or at least once every two years, these grasslands give way to other types of vegetation.

Savannah soil is nutrient-poor and highly acidic, and plants found in this special environment – grasses, sedges, orchids, and insect-eating plants such as the sundews, pitcher plants and the Venus fly-trap – are those which are tolerant of the harsh soil conditions.

When savannah begetation is protected from fire, the soil is able to accumulate nutrients from decomposing plants. The enriched soil then becomes able to support other types of vegetation which, once established, become the dominant growth. When this happens, the savannah's specialized flora can no longer exist, and communities such as evergreen shrub bogs come into being.

Pocosins and Carolina Bays

Pocosins are a type of fresh water wetland scattered throughout the coastal plain of the southeaster United States. They are low, flat, swampy areas found in savannah type environments that consist of water-logged, peaty soil with a ground cover of sphagnum moss. Their characteristic vegetation, which is adapted to long periods of waterlogging followed by drought, consists of dense broad-leaved shrubs, small evergreens and thorny vines, forming nearly impenetrable thickets.

The fluctuating water table of pocosins is the all-important factor in helping them maintain their unique ecosystem. Marsh plants, which grow in these areas when the ground is wet, die during periods of drought. Conversely, the bacteria and fungi, which flourish in the surface soil layer during dry periods, are destroyed during periods of wetness. Destruction of these bacteria results in an absence of decay and the forming of pear through the natural preservation of fallen leaves and other debris.

The full significance of the pocosin ecosystem is not yet fully known. Some of the functions of pocosins, however, are clear. Like swamps, they provide areas where excess storm water can settle and be slowly filtered down through the earth into aquifers, an important source of water supply for towns and cities. Because pocosins contain preserved material their contents can sometimes reveal – much like the tar pits in other parts of the country – information about plants and animals existing in prehistoric eras. These findings can often be useful in understanding recent climatic and geological changes.

Vegetation common to pocosins and able to withstand its periods of waterlogging and drought includes fetterbush, ti-ti, honeycup, gallberry, chokeberry, blueberry, and Virginia willow. Endangered and threatened plants which have been found to live there include the Venus fly-trap, green-fringed orchid and spring-flowered goldrenrod.

Similar in some ways to pocosins, Carolina Bays are elliptically-shaped depressions all of which are aligned in the same northwest-southeast firection. Found only in the coastal plains of the Carolinas and northern Georgia, these curious natural areas have caused much speculation as to their geological origin. One theory holds that they may be a result of ancient meteorite showers; another has it that they were spawning beds for schooling fish during times when much of our present-day coastal plain was covered by the ocean. A third theory is that Carolina Bays were formed by a sinking action of surface areas resulting from movement of underground water. Their true origin, however, still remains a mystery.

There are hundreds of these bays in South Carolina, ranging in size from a few hundred feet to several miles in length. While biologically similar to pocosins, Carolina Bays differ from those natural communities mainly in water depth, being generally deeper. They can be identified readily from surrounding areas by their vegetation which may include stands of cypress, bay or black gum. Unlike pocosins which are usually composed of one biological community, Carolina Bays can contain several different communities within a few yards of each other, for example – marsh, swamp, savannah and sand hills. The bays serve as habitat for a wide variety of wildlife and act as groundwater or aquifer recharge basins, much as do pocosins.

Hurricanes

A hurricane is a tropical cyclone with a wind speed of at least 74 mph. The tropical cyclones that affect South Carolina breed in the Atlantic, the Caribbean, and the Gulf of Mexico, and do so most frequently in the months of August, September, and October.

When water temperatures are above 80 degrees, wind speeds are low, and the trade winds begin circling around a low pressure area, a hurricane is in the making. If conditions are right, a hurricane will eventually reach fifty to one thousand miles in diameter, its strength corresponding to its size and speed.

Hurricanes enter the eastern and southern coasts of the United States on an average of four times a year. It is far less frequent that these storms make landfall along the South Carolina coast; since 1893 only 17 of the sixty-one hurricanes that have passed through the state have made landfall on its coast. Most storm centers reach South Carolina from the southwest after having made landfall along the shores of the Gulf of Mexico and traveled across Florida and Georgia. Hurricanes begin to lose their force as soon as the make landfall.

It would be a mistake, however, to belittle the effects of hurricanes that fail to make landfall in South Carolina. A 1916 storm which came overland brought about sixteen inches of rain to portions of South Carolina, causing major flooding. Tornados, too, accompany the hurricane circulation and move with the general flow of air around the parent storm. These small but destructive offshoots can cause considerable damage, as did the tornado which formed off Hurricane Donna in 1961, leaving a highly destructive wake in South Carolina despite the fact that the parent hurricane remained well offshore.

Hurricanes or tropical storms which approach the South Carolina coast directly from the Atlantic pose the most immediate and dramatic threat. A recent example of a direct hit was Hurricane Hugo. Hugo was the costliest storm to strike the United States this century with damage in excess of six billion dollars. Water levels exceeded 20 feet above main sea level in northern Charleston County. Losses of life were minimal due to early evacuations, but there were 13 deaths directly attributed to Hugo and 15 deaths indirectly caused by the hurricane.

Gracie, a hurricane that hit South Carolina in September, 1959, had sustained winds of 100 mph, brought six to eight inches of rain, and raised the Charleston water level six feet above normal. Following Hurricane Hazel on October 15, 1954, a storm surge at Myrtle Beach carried water to 17.8 feet above the mean low water level.

The most damaging and memorable hurricanes to hit South Carolina's coast occurred in 1752, 1885, 1893, 1911, 1940, 1959, & 1989. These storms cost many lives and billions of dollars in property damage. The time interval between these hurricanes has been an average of 21 years.

Accompanied by extremely high winds, heavy rains, erosive surf and storm tides, hurricanes are the most damaging and common natural disaster occurring in South Carolina. The most widespread destruction is often caused by the storm tides which, in combination with heavy winds and rain, produce tidal flooding and highly erosive storm surge conditions.

A storm surge is a great dome of water, sometimes fifty miles wide, that sweeps along the coastline near where the eye (center) of the hurricane makes landfall. Like a giant bulldozer, it sweeps everything in its path. The stronger the hurricane, the higher the storm surge. This most dangerous part of the hurricane claims nine of every ten victims.

The offshore islands have always been easy targets for hurricane damage due to their low terrain and convergence with the sea. In 1893 a hurricane with wind force of 96 mph for a five minute period and 120 for one minute was accompanied by a tremendous wave that totally submerged a number of islands in the southern portion of the state, causing structures to appear to be standing out at sea.

One of South Carolina's most memorable hurricanes struck Charleston in 1752. In it, a shipping vessel was driven with anchor ahead from White Point through Vanderhorst Creek (the location of today's Water Street). In passing, it carries away the southwest corner of the new Baptist Church and grounded on the west side of Meeting Street. Her draft of water was from nine to ten feet.

Since the beginning of record-keeping on hurricanes which have made landfall in South Caroline, the state has not been hit with hurricane winds greater than 135 mph, though elsewhere winds have been known to reach 200 mph. Storm surges of nineteen feet above normal are the maximum ever recorded for the state. When these surges occur at high tide – an occurrence induced whenever a hurricane moves up from the south causing water to remain high even after the time of normal high tide – the storm surge height is added to high water height and wind crest height. Such an event occurred in 1954 with the arrival of Hurricane Hazel, which brought seventeen foot waves to Myrtle Beach. It happened again when Hurricane Hugo (1989) hit Charleston during high tide, causing a 19 foot wall of water to wash over McClellanville. Hurricane Gracie, which landfell in South Carolina on September 29, 1959, did relatively minor damage because it struck from the east at low tide. Camille, which struck Mississippi from the south in 1969, caused a twenty-four foot storm surge on top of a six foot high tide. At 1700 pounds per cubic yard and a speed of 50 mph, Camille's storm surge struck shore like a battering ram weighing 20,000,000 tons. Because of the variability of hurricane surge heights, the National Weather Service in Charleston recommends that structures built on beaches and low-lying areas be constructed at twenty feet above mean sea level.

Though powerfully destructive, hurricanes serve a useful purpose. On a global scale, they help to distribute rainfall and to maintain the world's heat balance. Formed as the yare in the extremes of equatorial heat, hurricanes encircle and transport heat and moisture northward until the surrounding cold disperses their heat, causing them to lose their force. Their overall effect is to moderate temperature extremes through the equatorial, temperate and polar zones.