

THE VEGETATION OF CAPE LOOKOUT
NATIONAL SEASHORE

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by

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I. INTRODUCTION

The barrier islands of Cape Lookout National Seashore have been the subject of several ecological and geological investigations during the last few years.¹ It has been possible to trace historical changes in the development of these islands, and as a result of recent studies, many of the processes involved in barrier island development have been elucidated. We have undertaken the present study to provide baseline information on the vegetation of Cape Lookout National Seashore (C.L.N.S.).

In any barrier system, the vegetation plays an important role in retarding erosion. The extensive root systems of maritime grasses, in particular, act to stabilize windblown sand and waterborne sediments. In the protected lagoons behind the islands, the high productivity of salt marsh and subtidal vegetation supports a food chain that includes many species of commercially valuable invertebrates, fish, and birds.

A comprehensive set of vegetation maps has been produced to be used for resource planning and for documenting the ecological changes that occur on these rapidly migrating islands (see frontispiece). Changes in the position and cover area of each plant community can be used to examine such processes as the stabilization of accreting spits, revegetation of overwash deposits, gradual burial and redevelopment of the maritime forest on Shackleford Island, and general successional changes in the vegetation.

In classifying the major vegetation types, we have tried to use categories that are useful to resource planners and are also consistent with previous ecological descriptions of the area. The vegetation maps and this accompanying report can be used by naturalists, planners, rangers, and interested laymen to identify and gain a basic understanding of the vegetation of any part of the National Seashore. An in-depth treatment of the barrier island ecology of this area may be found in the N.P.S. Scientific Monographs No. 6 (Au, 1974) and No. 9 (Godfrey and Godfrey, 1976).

1. Au (1974), Dolan (1972), Godfrey and Godfrey (1976), and Hosier (1973).

II. METHODS

A. IMAGERY

The vegetation maps were made using aerial infrared photography lent to us by the Chesapeake Bay Ecological Program, NASA, Wallops Island, Virginia. The photographs were taken at an altitude of 10,000 feet at various times of year (NASA flights W316, 12/3/74; W345, 9/5/75; W376, 7/20/76). It was necessary to use several sets of imagery because the details of marsh and subtidal vegetation were more visible in the summer photographs, while the grassland vegetation was easiest to interpret from the winter photographs. The 1976 imagery was used to map the shoreline, which changes dramatically from year to year in areas such as New Drum Inlet.

B. MAPPING PROCEDURE

Recent U.S.G.S. topographic maps of the Seashore were enlarged to a scale of 1":12,000' to be used as base maps. Initially, 35 mm slides were projected onto the base maps so that the vegetation could be traced to scale. The slides were projected on a moveable screen that could be adjusted to the appropriate scale and orientation using field landmarks as control points.

The plant communities were identified based on subtle variations in color and texture and taking into account the investigators' familiarity with barrier island vegetation. The area of each vegetation type was drawn on acetate sheets and labeled according to a lettering scheme that defines each plant community. The smallest area delimited was about 50 m².

Preliminary maps were checked in the field during the first two weeks of June 1977. Subsequent maps were checked at NASA, Wallops Island, by viewing enlarged 9" x 9" imagery on an Itek Film Viewer (Model AM-6). A trained draftsman traced the final copies on reproducible mylar from which paper copies were made.

C. ECOLOGICAL CLASSIFICATION OF C.L.N.S.

The classification system is based on the dominant species of each major plant community. The estimated cover of the dominant species was used to identify plant communities in the field and was closely correlated with previous sampling data from studies by

Au (1974), Godfrey and Godfrey (1976), Hosier (1973), and Silander (1976). The detail in our system of classification was limited to some extent by the quality of the color and resolution of the NASA imagery. The following is a breakdown of the ecological categories that we were able to distinguish using the available imagery at a scale of 1":12,000'. Detailed descriptions of these categories, based on the work of Au (1974) and Godfrey and Godfrey (1977), are given in the fourth section of this report.

- (1) beach and berm -- barren sand (S)
- (2) tidal flats (TF)
- (3) grasslands -- dune grassland (DG)
 - open grassland (OG)
 - closed grassland and mesic meadow (CG)
 - shrub savanna (SS)
- (4) woodlands -- shrub thicket (ST)
 - maritime forest (F)
- (5) marshlands -- fresh or brackish marsh (FM)
 - needlerush marsh (FMn)
 - cattail marsh (FMc)
 - sawgrass marsh (FMs)
 - dune slack (FMd)
 - high salt marsh (HM)
 - needlerush salt marsh (HMn)
 - salt meadow cordgrass marsh (HMc)
 - pannes (HMP)
 - supratidal salt marsh (HMs)
 - low salt marsh (LM)
- (6) subtidal marine vegetation (MV)
- (7) water (W)
- (8) developed land (D)

Species names follow those in The Manual of the Flora of the Carolinas (Radford, Ahles, and Bell, 1964). Specimens of certain key species and unidentified plants were identified by Harry Ahles, University of Massachusetts, Amherst.

III. PHYSIOGRAPHY OF CAPE LOOKOUT NATIONAL SEASHORE

Cape Lookout National Seashore is made up of two island groups that differ in their topography and vegetation (see Fig. A). Most of the Seashore consists of Core Banks, a 44-mile (71-km)-long barrier system that is oriented in a southwest to northeast direction. Cape Lookout juts out from its southern end, and abandoned Portsmouth Village is located at its northern end. New Drum Inlet makes a break in the barrier, separating northern Core Banks and Portsmouth Island from southern Core Banks.

Shackleford Banks is the other barrier system within the Seashore. Extending westward from Cape Lookout, Shackleford Banks (8 mi, 13 km long) is smaller and ecologically more diverse than Core Banks. What follows is a brief description of these two barrier systems.

A. CORE BANKS

Core Banks is a long, narrow expanse of low dunes, maritime grasslands, and extensive salt marshes. Shrub thickets border the grassland in many places, and small areas of higher ground, such as Guthries Hammock, are occupied by a low maritime forest. The islands are generally about 1 to 2 meters in elevation and 1 to 2 kilometers in width. For the most part, they are open and treeless. Windblown salt spray is carried across the entire barrier.

The wide berm and low, scattered dunes of Core Banks are characteristic of overwash-influenced barrier systems that have not been altered by man-made structures. When storms occur, the dunes here offer little resistance to flooding. Once the waves have overtopped the berm, their energy is dissipated and their sediment load is deposited as overwash fans and terraces (see Fig. B). Along narrow sections of the islands, overwash deposition may extend across the salt marsh and into Core Sound, creating new intertidal areas that may be colonized by salt marsh cordgrass. The sand deposited on the grasslands behind the dunes is colonized by species such as salt meadow cordgrass (*Spartina patens*), which can grow through as much as 1 meter of sand. On a geologic time scale, a barrier island can be said to be "rolling over on itself" as overwash events carry sand from the ocean side of the island to the sound side. This process, in combination with shoreline erosion and rising sea level (about 25 cm/100 yrs.; Hicks, 1972), has led to the gradual retreat of Core Banks.

Another process that has shaped these islands is the opening and closing of inlets. Dramatic changes in the positions of inlets may take place in the period of a few years or even months. Many of the creeks in the marshes along Core Banks have probably been inlets in the past. Near Portsmouth Island, Swash Inlet and Whalebone Inlet have closed recently, as has Old Drum Inlet, which closed in January 1971. New Drum Inlet was opened about 2.8 miles (4.5 km) farther south by the Army Corps of Engineers in December 1971.

An inlet remains open as long as the rate of erosion due to tidal flow is greater than the rate of deposition of sediments carried by littoral transport. On Core Banks, inlets tend to migrate southward, in the direction of net littoral drift. Some of the sand carried by littoral drift enters the inlet and is deposited as a flood tide delta. When an inlet closes, the shoals of the flood tide delta become prime areas for the development of new salt marshes. Behind the new berm, small dunes develop around hardy plants like sea oats (Uniola paniculata) and Spartina patens. Eventually, overwash deposition may build terraces on the site of the former inlet until it resembles the adjacent barrier island.

While the physiography of Core Banks is more or less uniform along its length, the areas of Portsmouth Village and Cape Lookout are unique. Instead of exhibiting the typical zonation of a wide berm, low dunes, grasslands and shrub thickets, and salt marsh, the northern end of Portsmouth Island is characterized by vast tidal sand flats (averaging 1 km in width) located between the berm and the dunes of a series of marsh-fringed islands. The last and largest of these islands is the site of Portsmouth Village, which was inhabited in the early and mid-1800s.

At triangular Cape Lookout, continuous dunes similar to those on Shackleford Banks can be found on the southwest side. Several small freshwater marshes are present in depressions between the dunes; shrub thickets have further stabilized the flats of the Cape's interior. The dunes here are high enough to prevent overwash from occurring.

A long spit extends from the western tip of Cape Lookout, where a jetty built in the early 1900s has encouraged accretion in this direction. Another alteration of the Cape's shoreline has been the recent erosion of the shore at Barden Inlet. A channel maintained by the Army Corps of Engineers is scouring away the beach in front of Cape Lookout lighthouse. In recent years approximately 6 meters (20 ft) of land have been lost annually (Godfrey and Godfrey, 1976).

B. SHACKLEFORD BANKS

The physiography of Shackleford Banks is more varied than that of Core Banks. The dunes at the western end of the island are 10 to 13 meters (34 to 44 ft) above sea level and contain the highest

elevations on Shackleford. The presence of high dunes on the western section may be due to the island's east-west orientation. Because the island faces the prevailing southwest winds rather than being parallel to them, sand is continually blown from the accreting beach into the dunes, where it is trapped and stabilized by the dune grass Uniola. Uniola grows through new layers of wind-deposited sand, and in this way the dunes increase in height.

In the lee of this wall of rolling dune ridges there is an impressive maritime forest, as well as several fresh and brackish marshes. Although Shackleford's dunes seem to be fairly stationary at present, the weathered, dead trees that can be found in the dune hollows indicate that the dunes have migrated northward, burying the forest edge. On the side of the island that faces Back Sound, the beach is narrow and, in some places, the scarped bank is eroding away. Unlike most of the Outer Banks, the inner shore here is not fringed with salt marsh.

The western end of Shackleford is an accreting sandspit. Young dunes with Spartina patens and Fimbristylis castanea are forming along the edge of the curving berm, while areas of salt marsh are developing on the sound side of the spit. Au (1974) noted that 60 hectare (150 acres) of land were added between 1956 and 1966.

The eastern two-thirds of Shackleford Banks consists of low dunes, grassland, and salt marsh, and in contrast to the western third, it is influenced by overwash. This end of the island was attached to Core Banks in the mid-1800s, when it was wooded and was the site of the small settlement of Diamond City. The forest was heavily harvested by the island's inhabitants and was finally destroyed by a severe hurricane in 1899, after which Diamond City was abandoned. Now this part of the island is characterized by dunes less than 3 meters (10 ft) in height, open grassland (on overwash terraces), mesic meadows, and salt marsh. Shrub thickets occur in a few areas.

In addition to being exposed to the effects of wind, salt spray, flooding, and sand movement, the vegetation of Shackleford Banks is also influenced by the presence of feral animals. The horses, cattle, sheep, and goats have made numerous trails across the island, causing erosion in a few areas. There is a distinct browse line where the animals have grazed the understory of the forest, and grazing on the low salt marsh generally prevents the cordgrass from growing more than a few centimeters in height (see Godfrey and Godfrey, 1976).

A complete treatment of the vegetation and ecological processes of Shackleford Banks is given by Shu-fun Au in the N.P.S. Scientific Monograph No. 6 (1974).

IV. DESCRIPTIONS OF THE MAJOR VEGETATION TYPES

The vegetation of barrier islands shows a definite zonation pattern that to a large extent can be attributed to salinity. Few species of plants can tolerate the toxic effects of salt spray and saltwater flooding. Of the plants found on the Outer Banks, woody species are the least tolerant of salinity. Thus, one finds various plant communities in specific zones: A few are adapted to the zone of heaviest salt spray, others occur in the lee of protective dunes or at a certain distance from the ocean, and a few are tolerant of tidal flooding. Elevation and depth of the water table, which are often a function of overwash deposition, are other important factors that determine the distribution of plant communities.

The zones of vegetation that can be seen across a typical barrier island transect are shown in Figure C. We will describe the major vegetation types as they tend to occur along such a transect, beginning with the exposed ocean-facing side of the island and proceeding to the protected side. The common and scientific names of each species are listed in the Appendix.

A. BEACH AND BERM

1. Barren Sand

mapping symbol: S

The outer sandy beach is essentially devoid of vegetation. It is within the reach of high tides, whose wave energy and salinity cannot be tolerated by any plants but a few species of unicellular algae. Above the level of maximum high tide is the berm, which is flooded only by storm tides.

The few plants that are able to colonize the berm usually arrive as seeds or plant fragments in the driftline. These plants are "pioneer" species, the first to invade an unvegetated area. They are widely spaced, often grouped around piles of debris, and are generally temporary, depending on the frequency of storms. The most common species in this zone are Cakile edentula (sea rocket), Amaranthus pumulis (sea-beach amaranth), Salsola kali (Russian thistle), Euphorbia polygonifolia (seaside spurge), Polygonum glaucum (sea-beach knotweed), and Uniola paniculata (sea oats). Uniola is a perennial grass that begins to build small dunes by the lateral growth of its roots and rhizomes. Unless they are located near an area of accretion where they could eventually become isolated from the full energy of storm tides, these young dunes will eventually be washed away.

The berm along C.L.N.S. ranges from 100 to 200 meters in width and is about 2.5 meters above mean sea level at its highest point. (This is also the maximum height of most of the dunes along Core Banks.) Some of the plants found on the inner berm include Spartina patens (salt meadow cordgrass), Hydrocotyle bonariensis (seaside pennywort), Croton punctatus (silverleaf croton), Oenothera humifusa (evening primrose), Cenchrus tribuloides (sandspur), Physalis maritima (ground cherry), Conyza canadensis (horseweed), and Atriplex arenaria (sea-beach orach), as well as those found on the outer berm. Obviously, all of these plants are among the most salt-tolerant species of the flora of this area.

The mapping symbol "S" has also been used for inland areas of barren sand, such as large blowouts in the dunes, where very few plants occur. The inner beach of Shackleford and Core Banks is narrow or absent (where salt marsh occurs). In a few places there are dunes associated with it.

2. Tidal Flat

mapping symbol: TF

Tidal flats are intertidal areas that, with the exception of a few species of algae, are essentially unvegetated. They occur where the wave energy is low and are most common on the protected side of accreting spits. The substrate is made up of silt and fine-grained sand. Just as the beach and berm are colonized by species of dune plants, tidal flats tend to be colonized by salt marsh species. If storm damage and the scouring effects of tidal currents are not too severe, the flats will be colonized by lush stands of Spartina alterniflora (salt marsh cordgrass). Small dunes sometimes develop on tidal flats that are just behind the berm and are exposed to windblown sand.

B. GRASSLAND

1. Dune Grassland

mapping symbol: DG

The vegetation of the supratidal area of a barrier island is generally dominated by grasses. Three types of grasslands have been recognized in this study: dune grassland, open grassland, and closed grassland. The dune grassland forms an almost continuous band along the margin of the inner berm. The most important dune grass, both in terms of abundance and its role in the formation of dunes, is Uniola paniculata (sea oats). Uniola is the primary species on low, scattered dunes in overwash-influenced areas and also on the high, densely vegetated dunes of Cape Lookout and the western end of Shackleford Banks. Another common dune grass is Spartina patens.

(salt meadow cordgrass), which is not as vigorous in dune building, but forms low dunes and is often found in the hollows and flats between the dunes. Spartina patens and Fimbristylis castanea, which occur together in the high salt marsh, occasionally form small dunes on the sand flats of accreting spits.

There are quite a few species, mostly annuals, that occur in the Uniola and Spartina dominated dune grassland. Cakile edentula (sea rocket) and Iva imbricata (seashore elder) are found on the most exposed dunes, while the following species are generally restricted to the more protected areas: Solidago sempervirens (seaside goldenrod), Salsola kali (saltwort), Cirsium horridulum (thistle), Andropogon littoralis (dune bluestem), A. scoparius (little bluestem), Erigeron pusillus (flea-bane), Heterotheca subaxillaris (camphor weed), Uniola laxa (spike grass), Croton punctatus (silverleaf croton), Conyza canadensis (horseweed), Cenchrus tribuloides (sandspur), Euphorbia polygonifolia (seaside spurge), and Hydrocotyle bonariensis (seaside pennywort). The low dunes dominated by Spartina patens are characterized by Triplasis purpurea (sand grass), Erigeron, Hydrocotyle, Eragrostis pilosa (love-grass), Physalis maritima (ground cherry), Croton, and Oenothera humifusa (seabeach evening primrose). The number of species in the dune grassland increases as one proceeds inland. Some of the vines of the rear dunes include Parthenocissus quinifolia (Virginia creeper), Rhus radicans (poison ivy), Smilax bona-nox (China brier), Strophostyles helvola (wild bean), Ampelopsis arborea (pepper vine), and Vitis rotundifolia (muscadine grape).

The dune slacks that occur in the hollows of continuous dune fields (such as at the western end of Shackleford Banks) will be described as a type of brackish marsh.

2. Open Grassland

mapping symbol: OG

Open grasslands refer to the sparsely vegetated barrier flats that are dominated by Spartina patens. Vegetation cover is about 20% to 50%; the sandy ground surface is always visible through the stems of the grasses and forbs. This vegetation type could also be called an open dune grassland, since low, widely scattered dunes are often associated with it.

Open grasslands are characteristic of recently formed overwash fans and terraces. They generally begin behind the berm and between the dunes, where periodic flooding is likely to occur, and extend back across the island to the edge of an overwash deposit, often grading into a closed grassland.

As we have mentioned earlier, Spartina patens is extremely salt tolerant and responds to burial by quickly growing up through the sand,

accounting for its dominance in the open grassland community. Other common species of the open grassland include Hydrocotyle bonariensis and Solidago sempervirens, and well as Euphorbia polygonifolia, Cakile edentula, Cirsium horridulum, Oenothera humifusa, and Gaillardia pulchella (blanket flower). Hydrocotyle is one of the few herbaceous perennials here that is not a grass. Like the grasses, it has an extensive system of rhizomes just below the soil surface, allowing it to colonize open areas by means of lateral growth and to overwinter below ground.

Open grassland may be referred to as an "overwash subclimax," meaning that this community will persist as long as overwash occurs periodically. In the absence of overwash flooding and deposition, vegetation cover increases and additional species colonize the open grassland as it is gradually transformed into a closed grassland.

3. Closed Grassland and Mesic Meadow

mapping symbol: CG

Closed grasslands, which have at least 50% cover, are usually found at slightly lower elevations on the older overwash terraces along the center of a barrier island. These areas are further from the ocean and closer to the water table than open grasslands. The dominant species are Spartina patens, Andropogon virginicus (broom sedge), Fimbristylis castanea, Muhlenbergia capillaris (hairgrass), and Hydrocotyle bonariensis. Many other species are present, including Solidago sempervirens, Eragrostis pilosa, Cynodon dactylon (Bermuda grass), Cenchrus tribuloides, Chloris pectraea (finger grass), Festuca rubra (red fescue grass), Gaillardia pulchella, Pluchea spp., Plantago virginica (plantain), Sabatia stellaris (sea pink), Cynanchum palustre (climbing milkweed), Ipomea sagittata (morning glory), Spiranthes vernalis (nodding-ladies-tresses), and Opuntia humifusa (prickly pear cactus). Mosses such as Trichostomium and Barbula are common on the more protected flats and on stabilized dunes.

Closed grasslands are not distinguished from mesic meadows in our vegetation maps, although the two are quite different floristically. There are many additional species of forbs, sedges, and rushes in a mesic meadow, the most diagnostic being Dichromena colorata (whitetop sedge). These meadows could almost be considered a type of freshwater marsh, since standing water may be present following periods of heavy rainfall. The species found here include those mentioned above as well as Gaura angustifolia, Lactuca canadensis (wild lettuce), Solidago spp., Lythrum lineare (loosetrife), Centella asiatica, Lippia nodiflora (frogbit, capeweed), Erigeron quercifolius, Eleocharis spp. (spike rush), Sisyrinchium rosulatum (blue-eyed grass), Borrichia frutescens (sea ox-eye), Scirpus americanus (three-square rush), the grasses Paspalum and Panicum, and several species of the

rush Juncus. Of the scattered shrubs that occur in these areas, Baccharis halimifolia (silverling) is the most common.

4. Shrub Savanna

mapping symbol: SS

Shrub savannas develop on closed grasslands that are flooded infrequently. They occur most commonly in the zone between closed grassland and shrub thicket or high marsh. The vegetation of shrub savannas consists of closed grassland species with scattered shrubs. Baccharis halimifolia, Myrica cerifera (wax myrtle), and Iva frutescens are the first shrubs to invade closed grasslands. The hardy tree Juniperus virginiana (red cedar) is another early arrival. If flooding is sufficiently infrequent, the shrubs will coalesce to form a shrub thicket, which will shade out most of the grasses and forbs.

Areas of shrub savanna and low shrub thicket also occur on high salt marsh. Iva frutescens and Baccharis halimifolia are the major shrubs. In most cases this type of shrub savanna has been mapped as the supratidal high marsh; it is discussed in a later section.

C. WOODLAND

1. Shrub Thicket

The woody vegetation on barrier islands is limited to those areas that are high enough to avoid being flooded but are also protected from salt spray, either by large dunes or by occurring at a considerable distance from the beach. Therefore, shrub thickets are usually found on well-protected flats and stabilized dunes.

Shu-fun Au (1974) distinguished between wet thickets and dry thickets on Shackleford Banks. These types generally correspond to those found on the flats and those found on stabilized dunes as they occur throughout the Seashore. Wet thickets are characterized by Myrica cerifera, Baccharis halimifolia, Iva frutescens, and Ilex glabra (gallberry). Juniperus virginiana, Callicarpa americana (beauty berry, French mulberry), Morus rubra (red mulberry), and Cornus stricta (dogwood) may be present, as well as vines such as Smilax bona-nox, Smilax laurifolia (bamboo vine), Parthenocissus quinquefolia (Virginia creeper), Vitis rotundifolia (muscadine grape), and Berchemia scandens (rattan vine). Marsh species, especially rushes, make up the understory. Most of the shrub thickets along Core Banks are "wet" thickets; they occur along the edges of the high marsh and are dominated by Myrica and Baccharis.

The key species of dry thickets are Ilex vomitoria (yaupon), Quercus virginiana (live oak), Zanthoxylum clava-herculis (Hercules'

club), Diospyros virginiana (persimmon), and Juniperus virginiana. The tangle of vines such as Smilax spp., Rhus radicans (poison ivy), Vitis aestivalis (summer grape), V. rotundifolia, Parthenocissus, and Ampelopsis arborea (pepper vine) make these thickets completely impenetrable.

2. Maritime Forest

mapping symbol: F

The maritime forests of Core and Shackleford Banks are small in area, but they are very rich floristically and are ecologically unique. Few areas of C.L.N.S. are suitable for the development of a mature forest, which is the vegetation type most susceptible to salt spray. Figure D illustrates the various types of woodland within the Seashore.

The effects of sea level rise, severe hurricanes, migrating sand dunes, and harvesting of wood have destroyed many of the forests of these islands. Shu-fun Au (1974) estimated that most of the trees on Shackleford Banks are less than 70 years old. The trees of this forest range from 5 to 10 meters in height, with the highest tree crowning at the level of the highest dunes. In more exposed locations, such as at Guthries Hammock, the trees are stunted and flag-formed due to salt spray "pruning."

The many species of trees, shrubs, vines, and herbs that are found in the maritime forest are too numerous to be listed here. The most important trees are Quercus virginiana, Juniperus virginiana, and Ilex opaca (American holly). Other common species include Pinus taeda (loblolly pine), Xanthoxylum clava-herculis, Quercus phellos (willow oak), Q. laurifolia (laurel oak), Persea borbonia (red bay), Magnolia virginiana (sweet bay), Osmanthus americanus (wild olive), Cornus florida (flowering dogwood), and Carpinus caroliniana (hornbeam). Epiphytes such as Tillandsia usneoides (Spanish moss), Phorandendron flavescens (mistletoe), and Polypodium polypodioides (resurrection fern) are common in the forest's interior. Several species of lichens are present, one of the most conspicuous being Lopadium leucoxanthum (wedding ring lichen), which forms a red crust on the bark of Ilex opaca and Ilex vomitoria.

In small open areas and at the edge of the forest a dense growth of shrubs and vines is usually present; the species are the same as those of the shrub thicket with the addition of less hardy species such as Gelsemium sempervirens (yellow jessamine). In the forest's interior the typical understory shrubs are Callicarpa americana, Ilex vomitoria, Myrica cerifera, Rhus copallina (winged or dwarf sumac), and Morus rubra. The understory shrubs are widely spaced or absent where there is heavy grazing by livestock (see Fig. 16).

The herbaceous species of the forest floor are generally sparse, especially where livestock are numerous. Common species include Uniola laxa (spike grass), Stipa avenacea (black oat-grass), Panicum spp., Mitchella repens (partridge berry), Bidens bipinnata (beggars' ticks), Elephantopus nudatus (elephant's foot), Lepidium virginicum (poor man's peppergrass), and Cnidioscolus stimulosus (bull or spurge nettle). Many species that occur at inland locations are found in the maritime forest as well since salt spray rarely penetrates the forest's interior.

D. MARSHLAND

1. Fresh or Brackish Marsh

mapping symbol: FM (dune slack: FMd; needlerush marsh: FMn; cattail marsh: FMc; sawgrass marsh: FMs)

Fresh and brackish marshes are found in areas where the islands' topography intersects the water table. These marshes are most common where high dunes prevent storm tides from sweeping across the island. Dune slacks are those marshes that occur within the dune zone where wind erosion carries away sand until the water table is reached. The flat-bottomed marsh that forms in such blowouts is dominated by rushes, sedges, and grasses. It includes closed grassland species as well as freshwater marsh species. Standing water is present only after periods of heavy rainfall. The fluctuating water level and exposure to salt spray limit the number of species that occur in this type of marsh. Fimbristylus castanea, Spartina patens, Andropogon virginicus, Setaria geniculata (foxtail grass), and Panicum spp. are the major grasses. Juncus spp. sometimes occur in pure stands, and Scirpus americanus and Hydrocotyle bonariensis are common. The wetter areas are characterized by Dichromena colorata, Lippia nodiflora (capeweed), Bacopa monnieri (water hyssop), Samolus parviflorus (water pimpernel), and Mikania scandens (climbing hempweed). Other species include Polygonum glaucum (smartweed), Commelina erecta (dayflower), Diodia virginiana (button-weed), Oenothera fruticosa (sundrops), and Cynanchum palustre.

Deeper marshes that are surrounded by shrub thicket or maritime forest, often occupying old interdune swales, have a much richer flora. These marshes are usually dominated by Juncus spp. (needlerush marsh), Typha latifolia (cattail marsh), Cladium jamicense (sawgrass marsh), or a combination of these species. With the exception of Spartina patens, most of the dune slack species are present as well as Sagittaria latifolia (arrowhead), Kosteletzkya virginica (marsh mallow), Boehmeria cylindrica (bog hemp, false nettle), Hydrocotyle umbellata (water pennywort), Ipomea sagittata (morning glory), Cyperus spp. (cyperus), Centella asiatica (pennywort), Chara spp. (stonewort), Ludwigia (false loosestrife), Paspalum floridanum, Eleocharis albidia (spike rush), Samolus parviflorus (water pimpernel), and many other species.

In many areas there is a gradual transition between fresh, brackish, and salt marshes. Juncus roemerianus can be a dominant species in all of these areas; the species associated with it will vary depending on the salinity of the habitat and the depth of standing water.

2. Salt Marsh

a. Low salt marsh

mapping symbol: LM

Salt marshes characteristically develop on the intertidal mudflats behind barrier islands. As we have already mentioned, new marshes form on old flood-tide deltas and on other intertidal shoals, such as recently deposited overwash sediments. Although the tide range along the Outer Banks is relatively small (less than 1 m), the intertidal marshes that fringe these islands are extensive and are generally 50 to 100 meters in width.

Salt marsh vegetation has been divided into two zones, low marsh and high marsh. Low marsh is flooded at mean high tide and is dominated by Spartina alterniflora (salt marsh cordgrass); high marsh is flooded only by storm and spring tides and is dominated by Spartina patens and Juncus roemerianus. Low salt marsh borders almost all of the marsh islands and creeks, but is often too narrow (less than 5 m in width) to be represented on the vegetation maps. In addition to S. alterniflora, Salicornia bigelovii (dwarf glasswort) and Salicornia virginica (perennial glasswort) occur in the low marsh. Limonium carolinianum (sea lavender) and Distichlis spicata (salt grass) may also be present.

Spartina alterniflora and Salicornia spp. are the first "terrestrial" species to invade newly exposed flats. Salt marshes are now recognized as being highly productive in terms of plant biomass. Spartina alterniflora is probably the most productive salt marsh species, having an annual above-ground standing crop of about 2,000 gm/m². Much of this organic matter is converted to detritus and exported to marine food chains. The growth of Spartina alterniflora is greatest on newly colonized areas and wherever it is most exposed to tidal flooding.

b. High salt marsh

mapping symbol: HM (needlerush high marsh: HMn; salt meadow cordgrass marsh: Hmc; pannes: Hmp; supratidal high marsh: HMs)

Needlerush high marsh is the most common type of high marsh in the Seashore. The brackish or saline wetlands that occur on old overwash terraces adjacent to closed grasslands and shrub thickets are the prime habitat for Juncus roemerianus. Dense stands of this ubiquitous rush may be 1 to 2 meters in height. In the more saline areas Spartina patens is a codominant. Other species include Fimbristylis castanea, Atriplex arenaria, and scattered shrubs such as Iva frutescens and Borrchia frutescens.

Salt meadow cordgrass marsh is dominated by Spartina patens and may include all of the species of the needlerush high marsh. S. patens and Fimbristylis castanea are often codominants. This type of high salt marsh generally replaces low marsh vegetation as siltation and accumulation of organic matter raise the level of the marsh. While S. patens high marsh is widespread in northern salt marshes, along the Outer Banks it usually occupies a narrow band between low salt marsh and Juncus-dominated high salt marsh. Spartina patens marsh seems to be most common near inlets, which guarantee high salinity and regular tidal flooding, and appears to be unable to compete with Juncus where tidal flooding has become irregular.

Salt marsh pannes are poorly drained depressions where evaporation of tide pools produces a highly saline habitat. Located in the high marsh or between high and low marsh, these areas support little vegetation. Salicornia spp. and short Spartina alterniflora are usually the only plants to colonize pannes.

Supratidal high marsh is the zone of low shrubs that can often be found along the landward border of the high marsh and on the slightly elevated driftlines on many of the marsh islands. In the aerial photographs these driftline "levees" are conspicuous on the northeast shores of the marshland behind northern Core Banks. The supratidal zone is flooded only rarely. Iva frutescens and Borrchia frutescens are the two major species; Baccharis halimifolia and Myrica cerifera are present occasionally.

Most of the areas designated as high marsh in the vegetation maps are probably the needlerush type of high marsh, but it was difficult to distinguish this type from salt meadow cordgrass high marsh using the available infrared imagery. Therefore, the detailed categories of high marsh vegetation are not always indicated on the maps. A few areas classified as high marsh are actually dominated by the low marsh species Spartina alterniflora, which is rather short and sparse in the high marsh habitat.

E. SUBTIDAL MARINE VEGETATION

In the protected shallow waters behind Core and Shackleford Banks there are extensive stands of Zostera marina (eelgrass), Ruppia maritima (widgeon grass), and various algae. These plants colonize areas that are always submerged. Like salt marsh vegetation, they act to stabilize the sediments and are very productive, contributing a great deal of organic matter to coastal food chains. Subtidal vegetation also provides a unique habitat for many species of invertebrates and fish, particularly for larval and immature animals.

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APPENDIX

LIST OF COMMON SPECIES REFERRED TO IN TEXT BY SCIENTIFIC AND COMMON NAMES

- Amaranthus pumulis: sea-beach amaranth
Ampelopsis arborea: pepper vine
Andropogon littoralis: dune bluestem
Andropogon scoparius: little bluestem
Andropogon virginicus: broom sedge
Atriplex arenaria: sea-beach orach
Baccharis halimifolia: silverling
Bacopa monnieri: water hyssop
Berchemia scandens: rattan vine
Bidens bipinnata: beggars' ticks
Boehmeria cylindrica: bog hemp, false nettle
Borrchia frutescens: sea ox-eye
Cakile edentula: sea rocket
Callicarpa americana: beauty berry, French mulberry
Carpinus caroliniana: hornbeam
Cenchrus tribuloides: sandspur
Centella asiatica: pennywort
Chara spp.: stonewort
Chloris pectraea: finger grass
Cirsium horridulum: thistle
Cladium jamaicense: sawgrass marsh
Cnidoscolus stimulosus: bull or spurge nettle
Commelina erecta: dayflower
Conyza canadensis: horseweed
Cornus florida: flowering dogweed
Cornus stricta: dogwood
Croton punctatus: silverleaf croton
Cynanchum palustre: climbing milkweed

Cynodon dactylon: Bermuda grass
Cyperus spp.: cyperus
Dichromena colorata: whitetop sedge
Diodia virginiana: buttonweed
Diospyros virginiana: persimmon
Distichlis spicata: salt grass
Elocharis albidia: spike rush
Elephantopus nudatus: elephant's foot
Eragrostis pilosa: love grass
Erigeron pusillis: fleabane
Erigeron quercifolius: fleabane
Euphorbia polygonifolia: seaside spurge
Festuca rubra: red fescue grass
Fimbristylis castanea
Gaillardia pulchella: blanket flower
Gaura angustifolia
Gelsemium sempervirens: yellow jessamine
Heterotheca subaxillaris: camphor weed
Hydrocotyle bonariensis: seaside pennywort
Hydrocotyle umbellata: water pennywort
Ilex glabra: gallberry, inkberry
Ilex opaca: American holly
Ilex vomitoria: yaupon
Ipomea sagittata: morning glory
Iva frutescens: shrubby marsh elder
Iva imbricata: seashore elder
Juncus roemerianus: needlerush
Juniperus virginiana: red cedar
Kosteletzkya virginica: marsh or seashore mallow
Lactuca canadensis: wild lettuce
Lepidium virginicum: poor man's peppergrass
Limonium carolinum: sea lavender
Lippia nodiflora: frogbit, capeweed
Lopadium leucoxanthum: wedding ring lichen

- Ludwigia spp.: false loosestrife
Lythrum lineare: linear-leaved loosestrife
Magnolia virginiana: sweet bay
Mikania scandens: climbing hempweed
Mitchella repens: partridge berry
Morus rubra: red mulberry
Muhlenbergia capillaris: hairgrass
Myrica cerifera: wax myrtle
Oenothera fruticosa: sundrops
Oenothera humifusa: evening primrose
Opuntia humifusa: prickly pear cactus
Osmanthus americanus: wild olive
Panicum spp.: panic grass
Parthenocissus quinquefolia: virginia creeper
Paspalum floridanum: paspalum
Persea borbonia: red bay
Pinus taeda: loblolly pine
Phoradendron flavescens: mistletoe
Physalis maritima: ground cherry
Plantago virginica: plantain
Pluchea sp.: marsh fleabane
Polygonum glaucum: smartweed, sea-beach knotweed
Polypodium polypodioides: resurrection fern
Quercus laurifolia: laurel oak
Quercus phellos: willow oak
Quercus virginiana: live oak
Rhus copallina: winged or dwarf sumac
Rhus radicans: poison ivy
Ruppia maritima: widgeon grass
Sabatia stellaris: sea pink
Sagittaria latifolia: arrowhead
Salicornia bigelovii: dwarf glasswort, dwarf saltwort
Salicornia virginica: perennial glasswort, perennial saltwort
Salsola kali: Russian thistle

- Samolus parviflorus: water pimpernel
Scirpus americanus: three-square rush, chairmaker's rush
Setaria geniculata: foxtail grass
Sisyrinchium rosulatum: blue-eye grass
Smilax bona-nox: China brier
Smilax laurifolia: bamboo vine
Solidago sempervirens: seaside goldenrod
Spartina alterniflora: salt marsh cordgrass
Spartina patens: salt meadow cordgrass
Spiranthes vernalis: nodding-ladies'-tresses
Stipa avenacea: black oat-grass, needlegrass
Strophostyles helvola: wild bean
Tillandsia usneoides: Spanish moss
Triplasis purpurea: sand grass
Typha angustifolia: narrow-leaf cattail
Typha latifolia: common cattail
Uniola laxa: spike grass
Uniola paniculata: sea oats
Vitus aestivalis: summer grape
Vitus rotundifolia: muscadine grape
Xanthoxylum clava-herculis: Hercules's club
Zostera marina: eelgrass

FIGURES

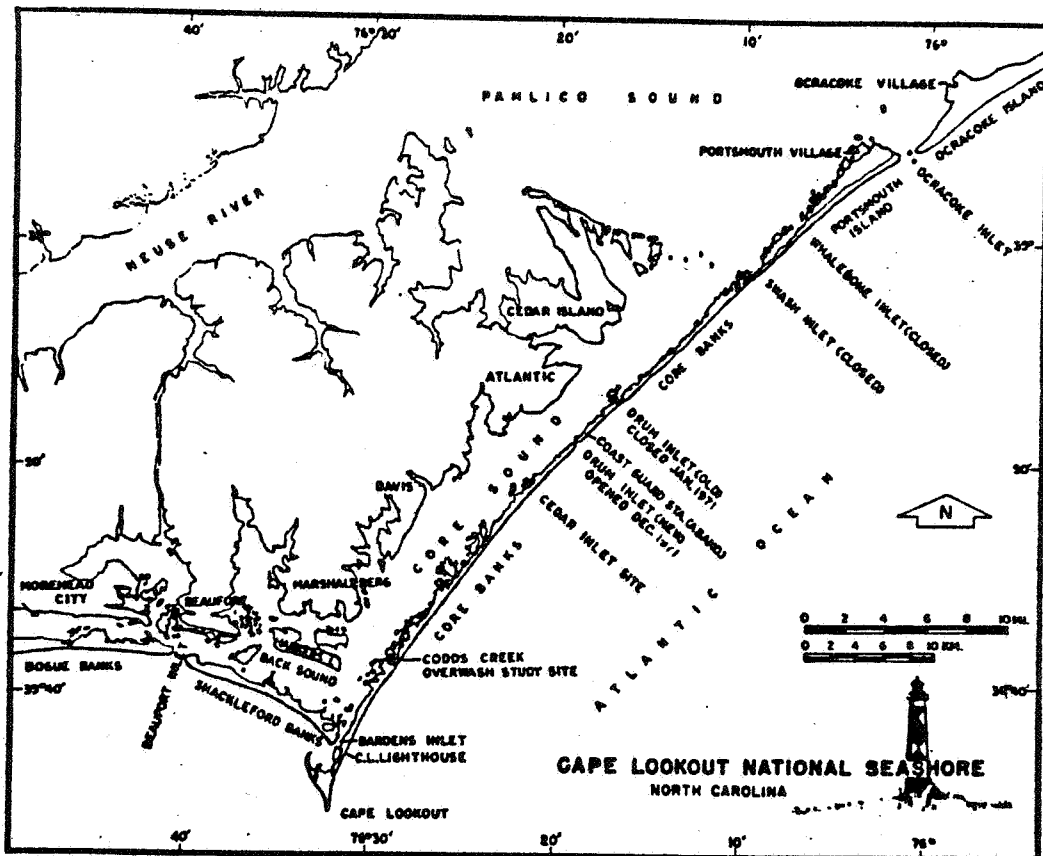


Fig. A. Map of Cape Lookout National Seashore, showing major study areas described in text (from Godfrey and Godfrey, 1976).

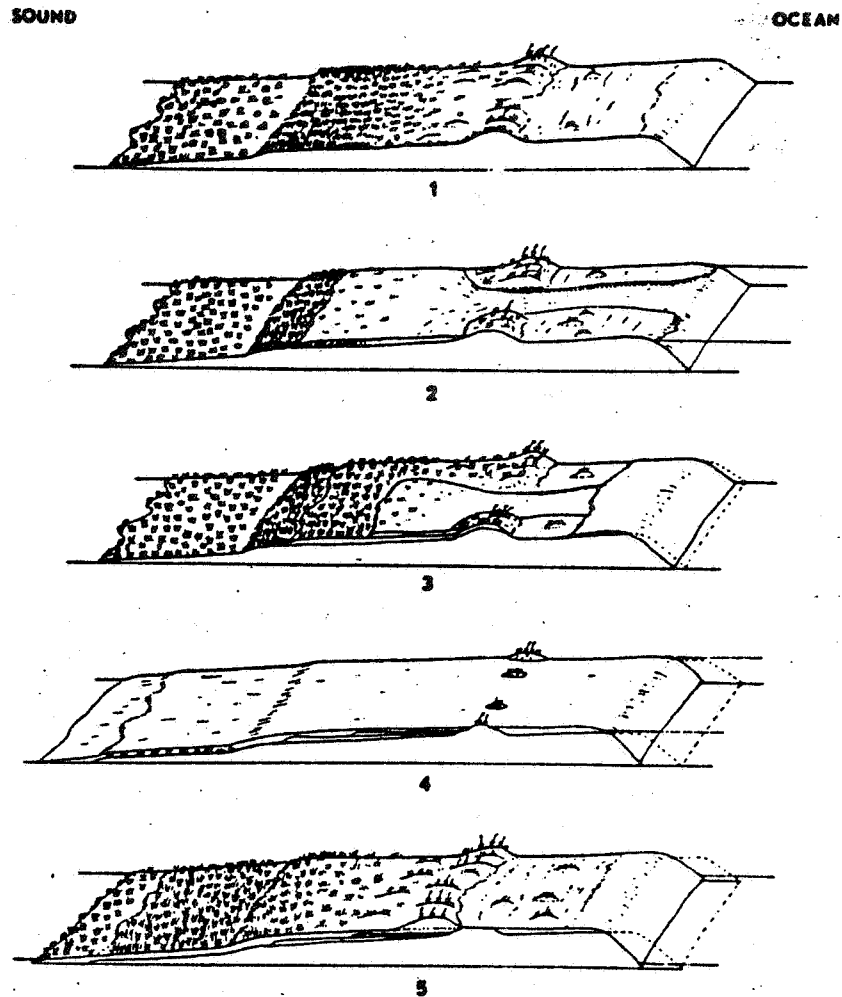


Fig. B. Diagrammatic interpretation of the overwash process and recovery of a low barrier island such as Core Banks (from Godfrey, 1970). (1) Cross-section of a low barrier island at any starting time. (2) A severe storm will push high tides over the beach berm; as the water flows back across the island, it carries sand into the grasslands. (3) A second, less severe storm carries a smaller quantity of sand onto the earlier deposit. Abnormally high tides have pushed a little sand over the edge of the berm. Grass has pushed up through the earlier layer. The front of the island has retreated slightly. Following the storm, the berm will build seaward. (4) A severe storm inundates the island and adds a great deal of sand to the earlier layers. Old dunes have been knocked down and the sand spread out. The beach front has retreated substantially. In some places, the berm front may be lowered as sand is removed. (5) After a few years of relative storm quiet, the island surface has completely recovered, although the vegetation zones have been displaced slightly. Low salt marsh has grown up on the new base in the sound, the former low marsh has become high marsh, and the sand flat has extended into the old high marsh border.

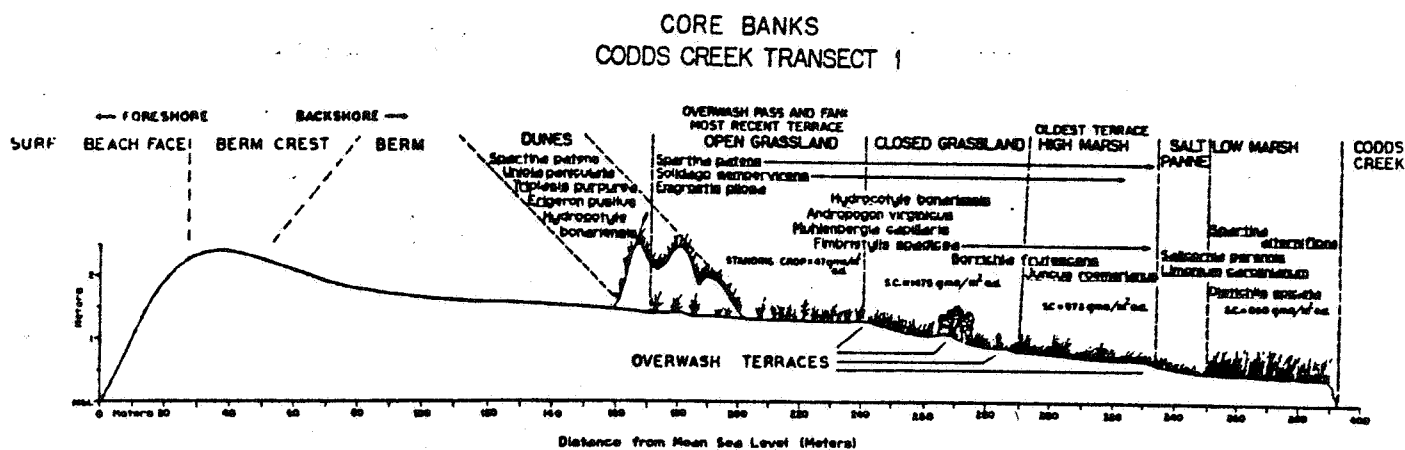


Fig. C. Diagrammatic cross-section of ecosystem zonation at Codd's Creek along Transect 1 in relation to elevation and distance from the beach. The vegetation is closely related to ages of overwash terraces and frequency of overwash. Species listed in each zone represent the most important members of that community (cover of 5% or more) and their relative positions along the transect, as determined in a 1-m-wide belt across the island.

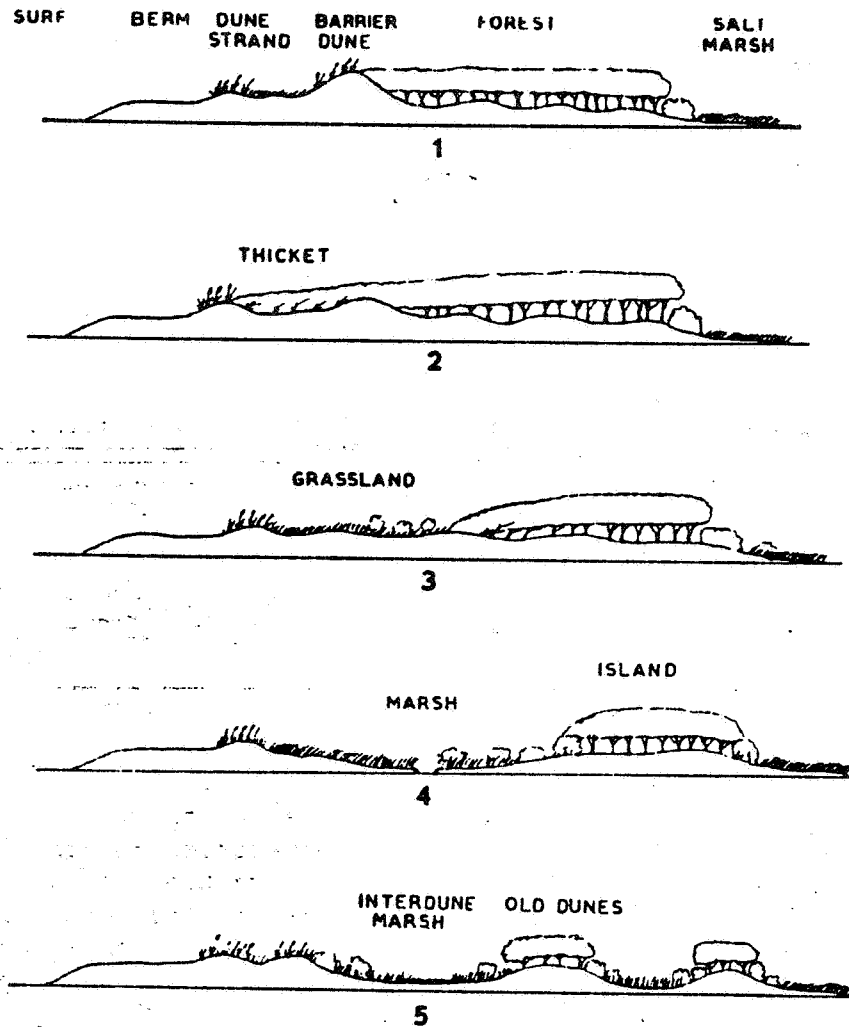


Fig. D. Diagrammatic cross-sections of barrier island woodland types in the vicinity of Cape Lookout National Seashore. (1) Forest growing behind a high barrier dune, which may have migrated over some of the trees. (2) Forest with thicket extending out to first dune line. (3) Forest with a sloping front and a thicket type of leading edge, separated from the dunes by grassland. (4) Forest on old dunes on the high part of a marsh island, separated from the main island by salt marshes. (5) Forest on old dune ridges, with interdune freshwater marshes and ponds (from Godfrey and Godfrey, 1976).

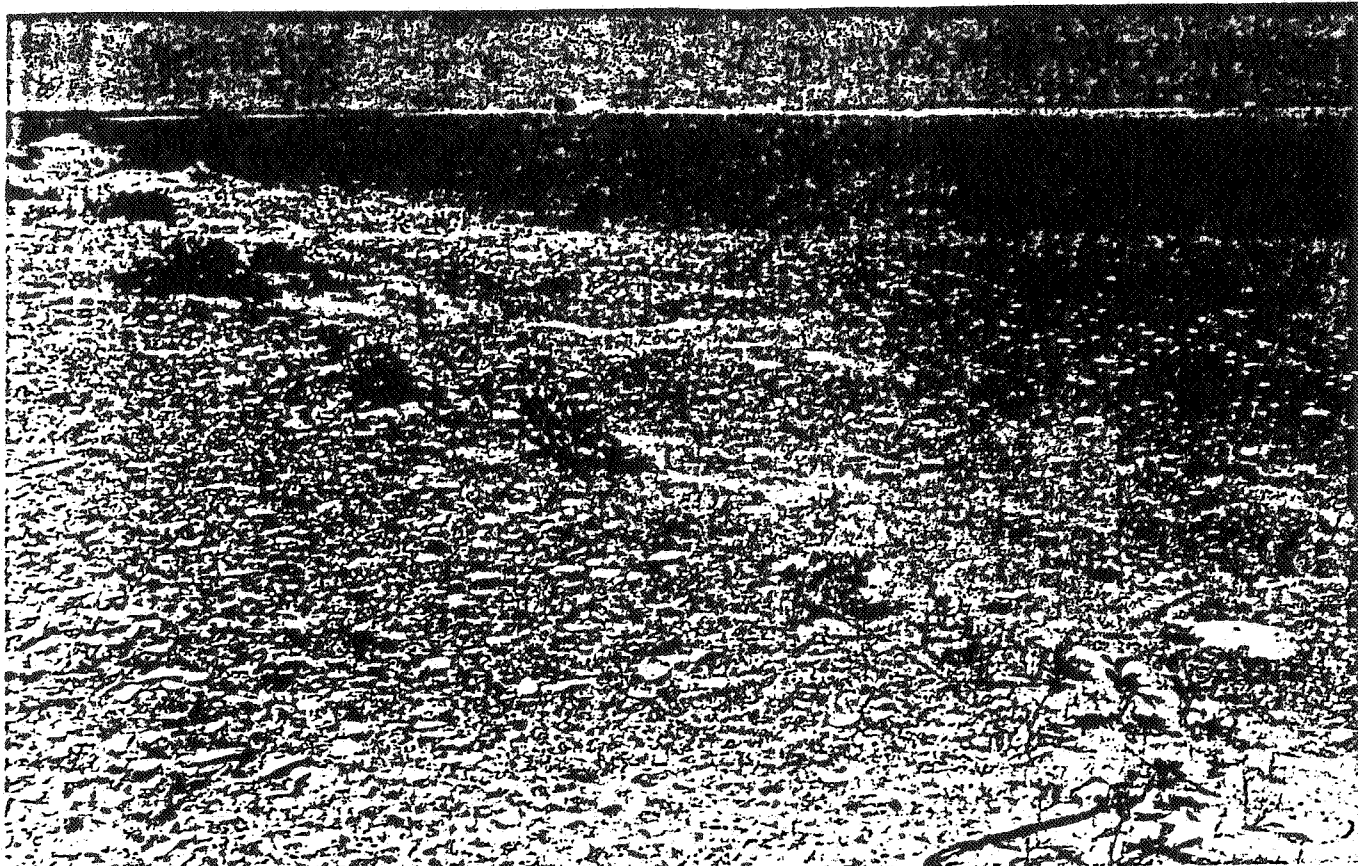
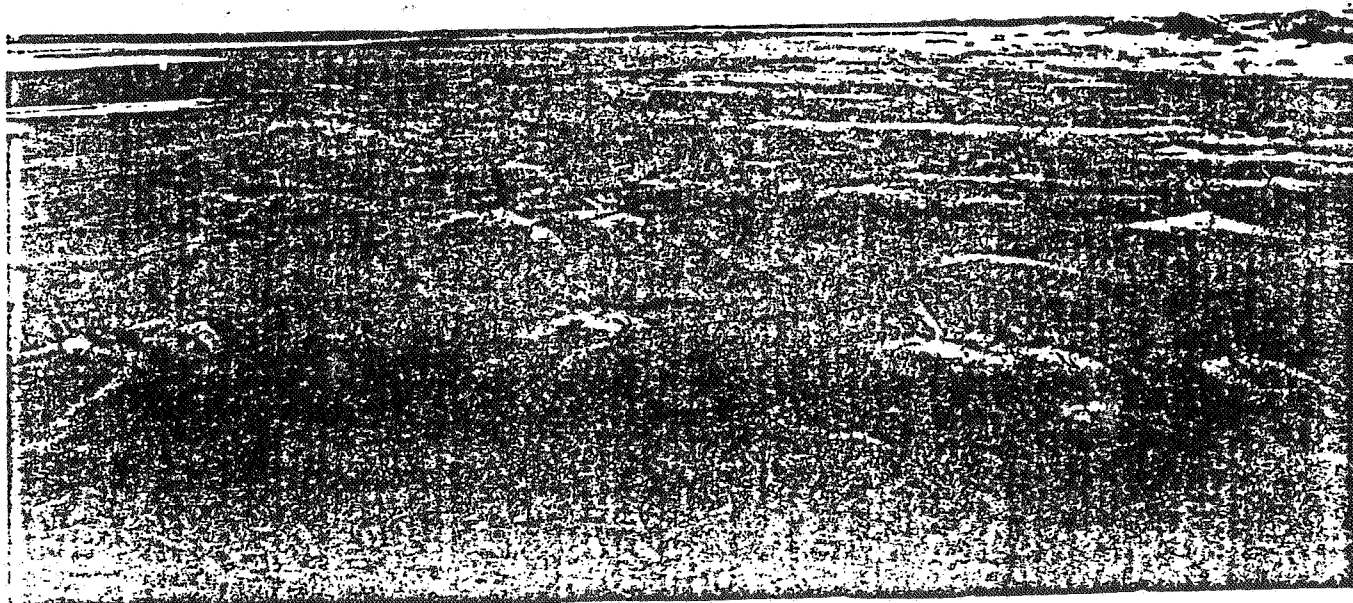


Fig. 1. Beach and berm. Very few plants occur on sandy beaches. Cakile edentula (sea rocket) is shown here with small Uniola paniculata (sea oats) dunes in the background.

7

Fig. 2. Tidal flats near Portsmouth Island.





Figs. 3 and 4. Dune grassland (above) and closer view of Uniola paniculata (below).



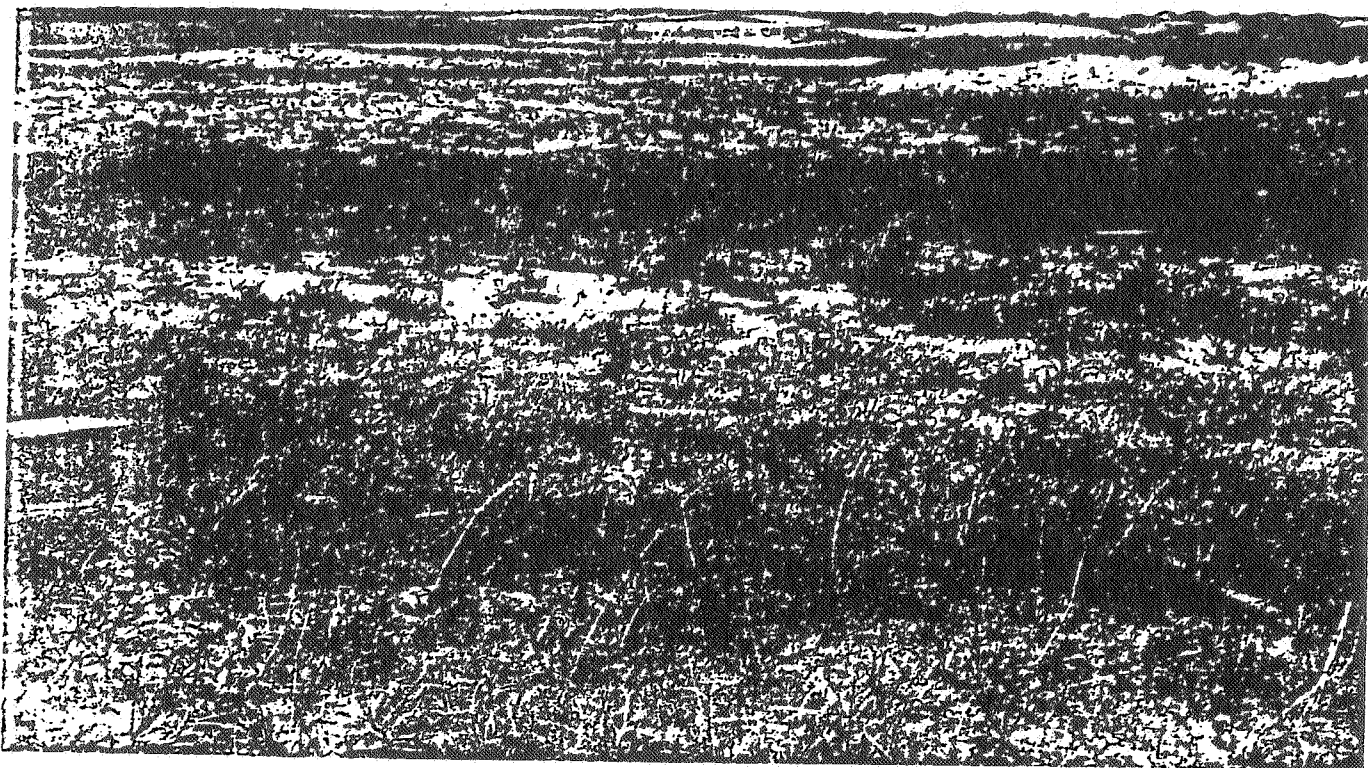
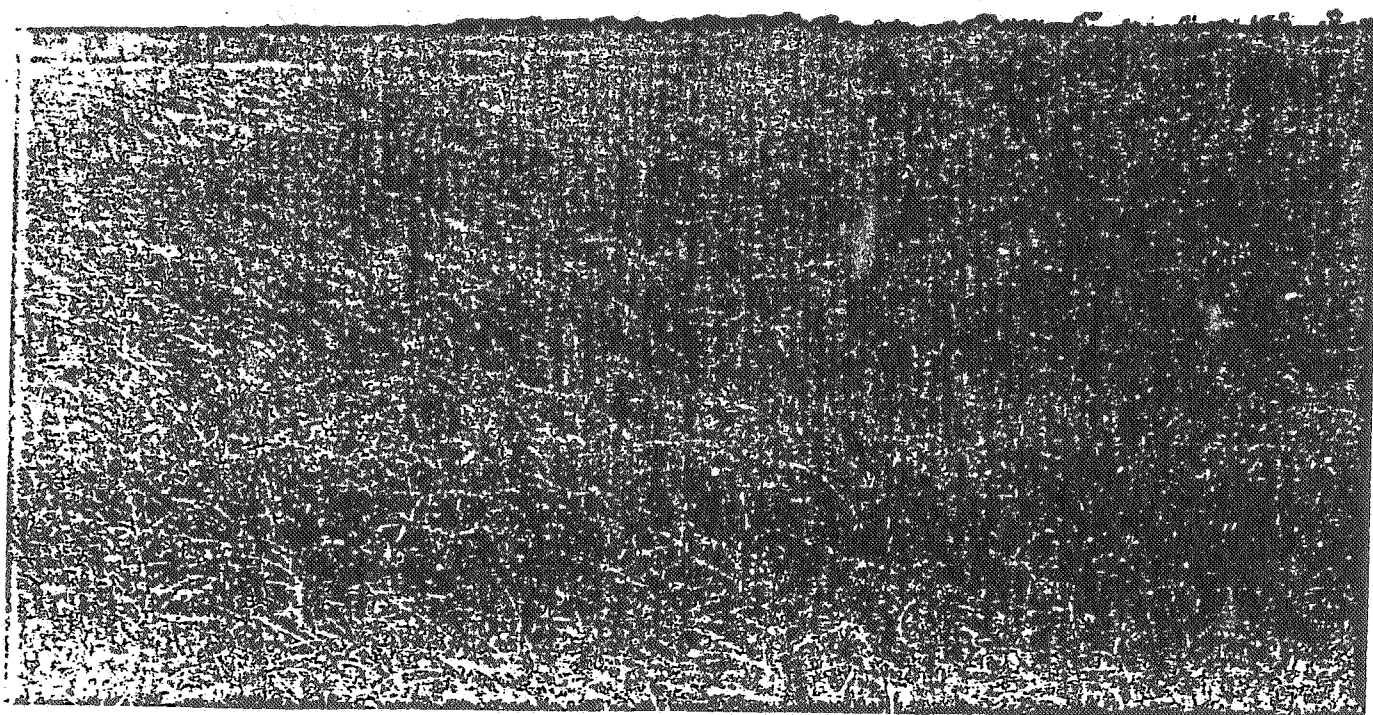


Fig. 5. Open grassland on recent overwash deposits at Core Banks. Vegetative cover is generally less than 50%.

Fig. 6. Closed grassland is made up of several grass species. Scattered stands of Juncus roemerianus (needlerush) and shrubs are shown in the background.



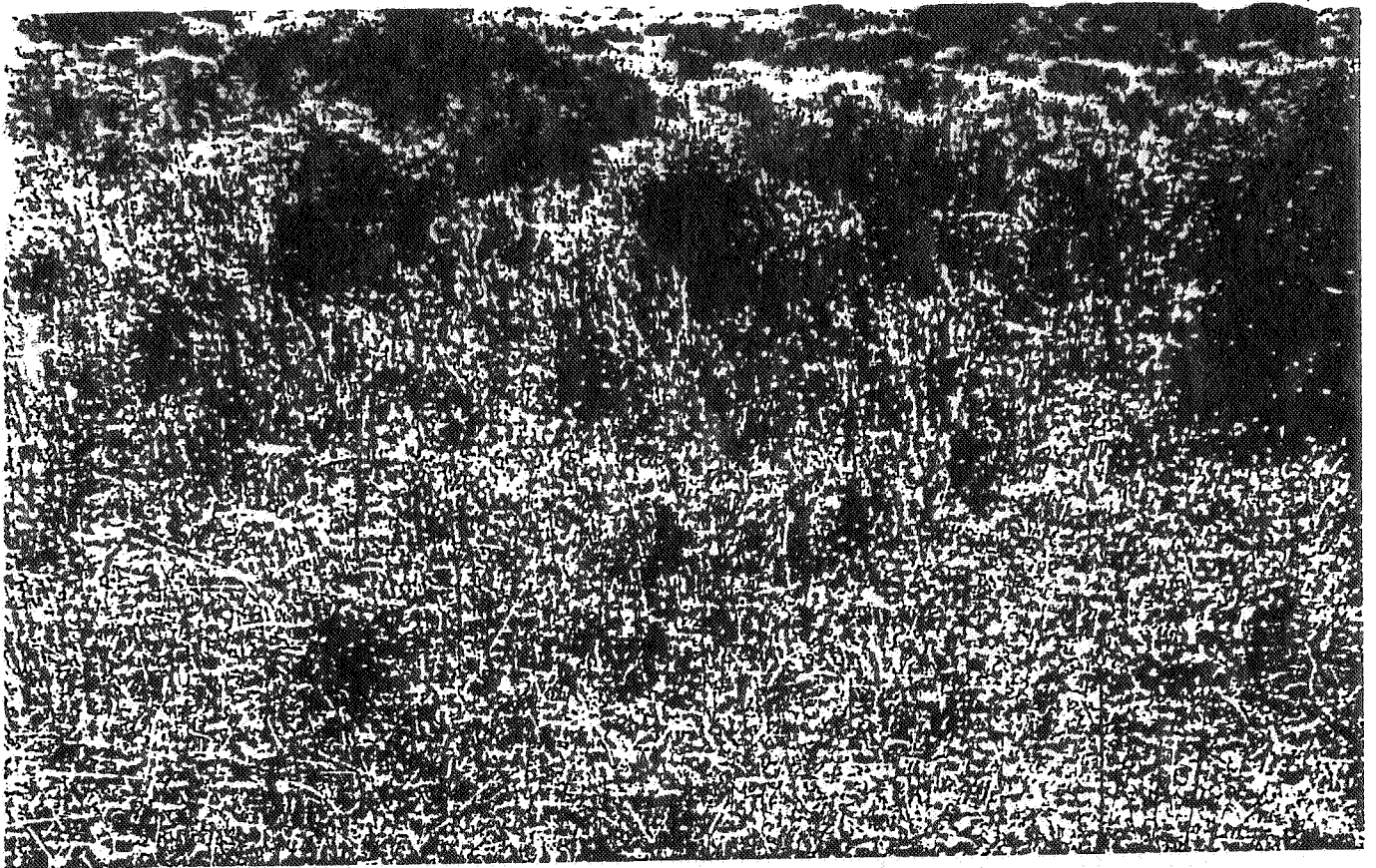
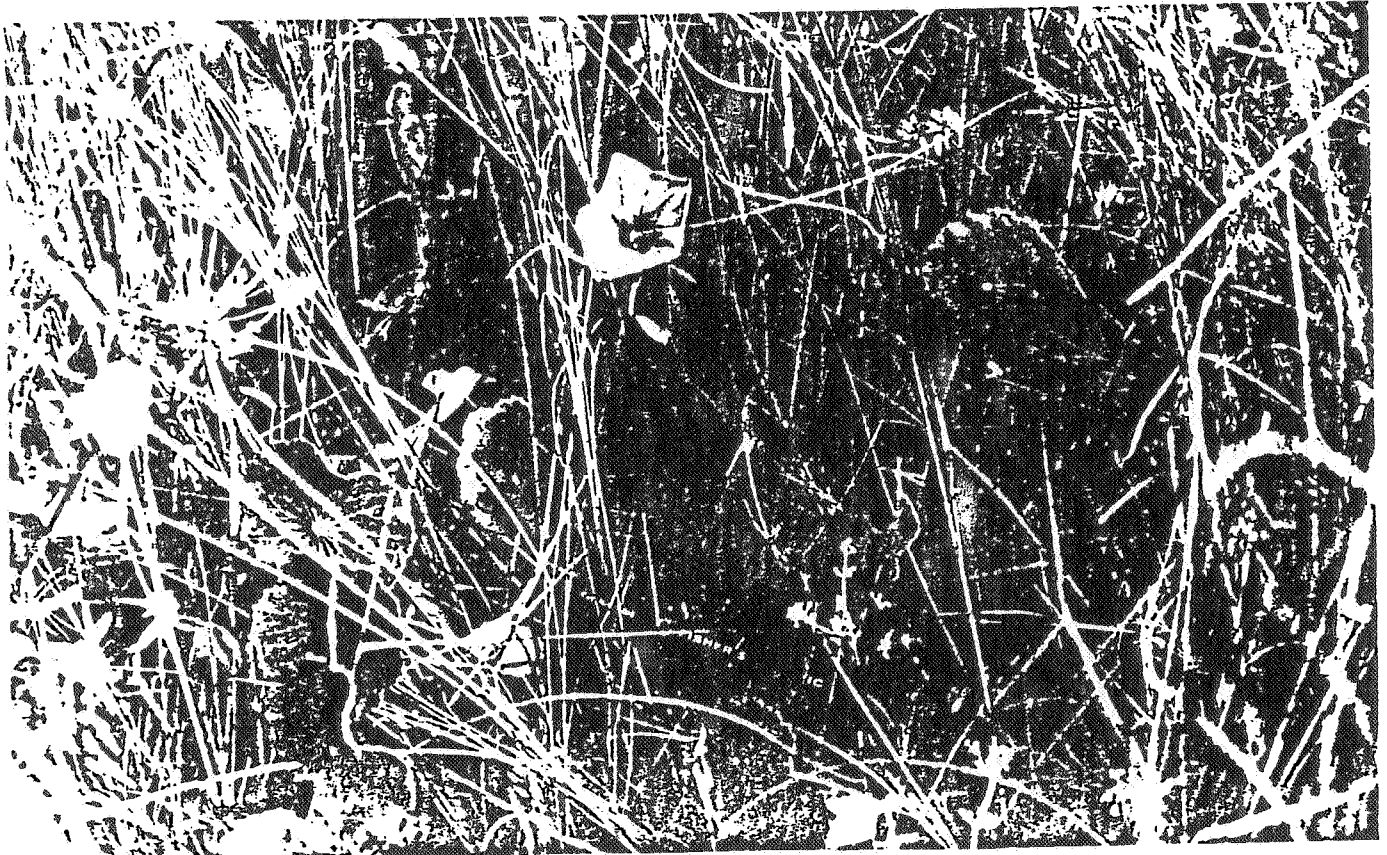


Fig. 7. Mesic meadow and scattered shrubs. Dichromena colorata (white-top sedge) is shown in the foreground. Mesic meadows have been mapped as closed grasslands.

Fig. 8. Detail of mesic meadow showing grasses, the round-leaved Hydrocotyle bonariensis (seaside pennywort), seed heads of Dichromena (top right), and flower of Ipomea sagittata (morning glory).



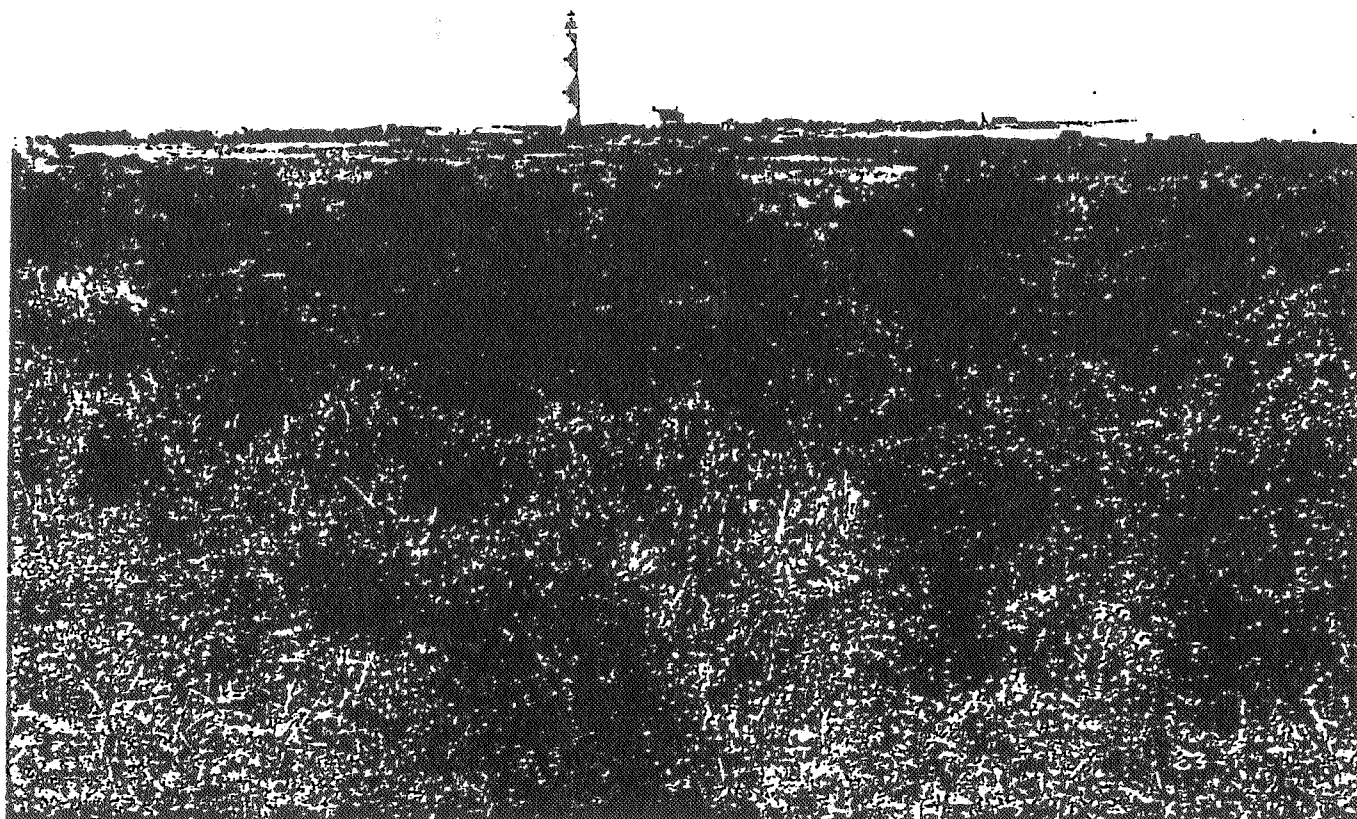
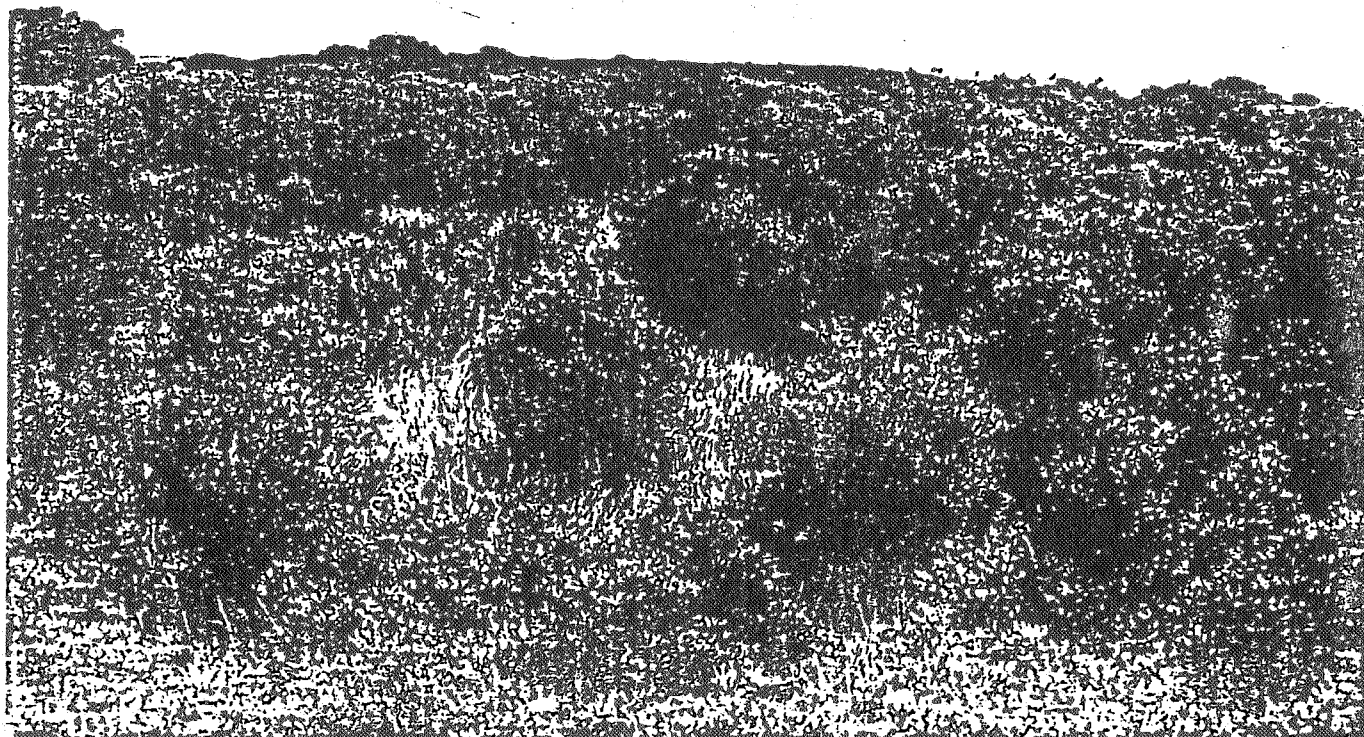


Fig. 10. Shrub thicket near the same location as above. Iva frutescens and Myrica cerifera (wax myrtle) are the dominant species.



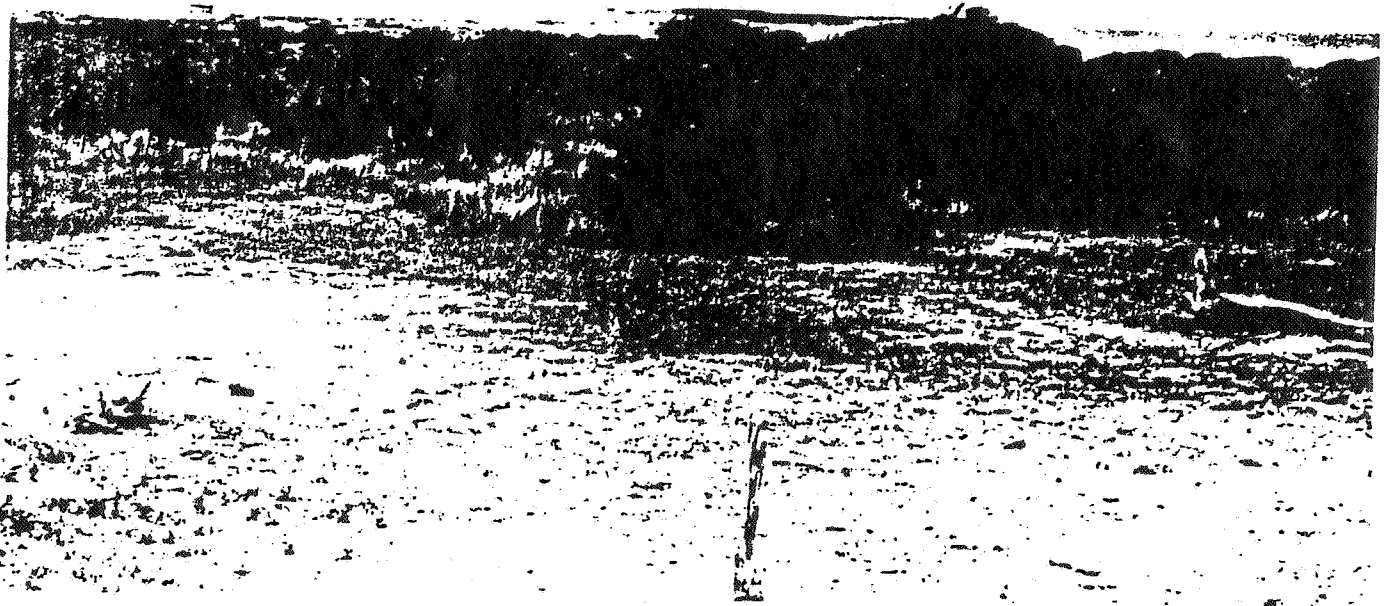


Fig. 11. Shrub thicket on Shackleford Banks. (Note overgrazed vegetation in the foreground.)

Fig. 12. Detail of wet shrub thicket showing Juncus roemerianus in the foreground, Baccharis halimifolia (silverling) in center, and Myrica cerifera at the right.



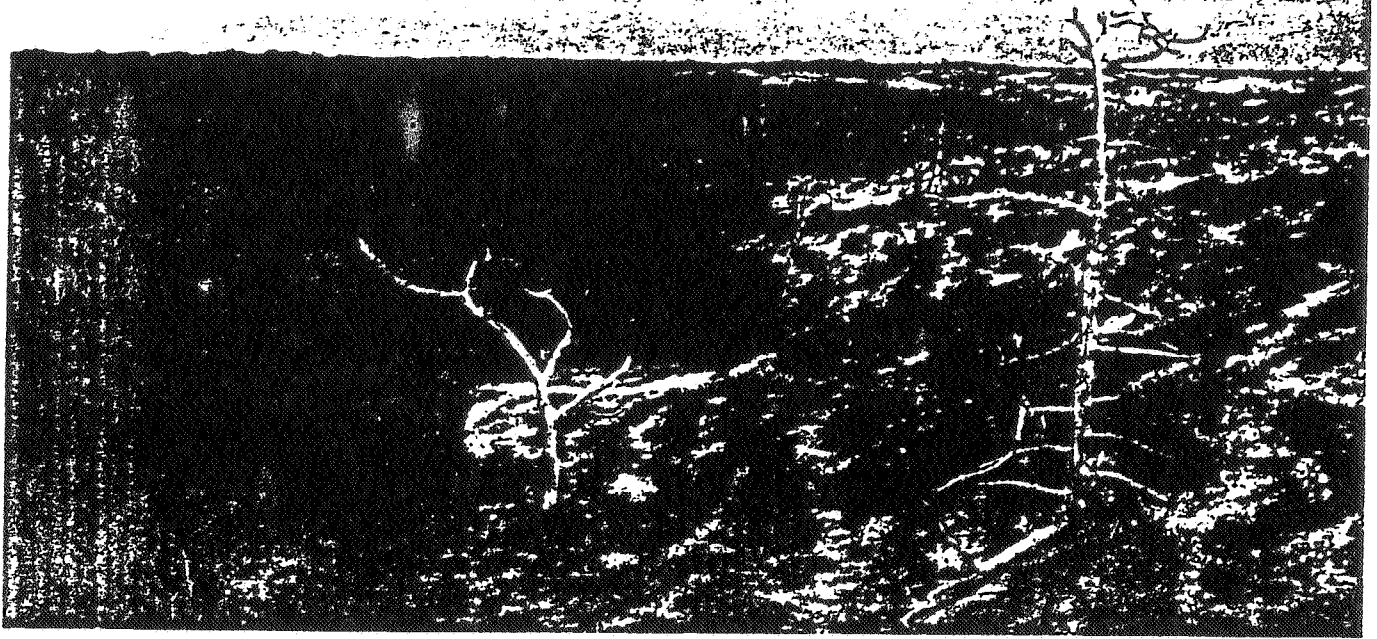


Fig. 13. Maritime forest on Shackleford Banks. The trees are the same height as the migrating dunes, which are slowly burying the forest.

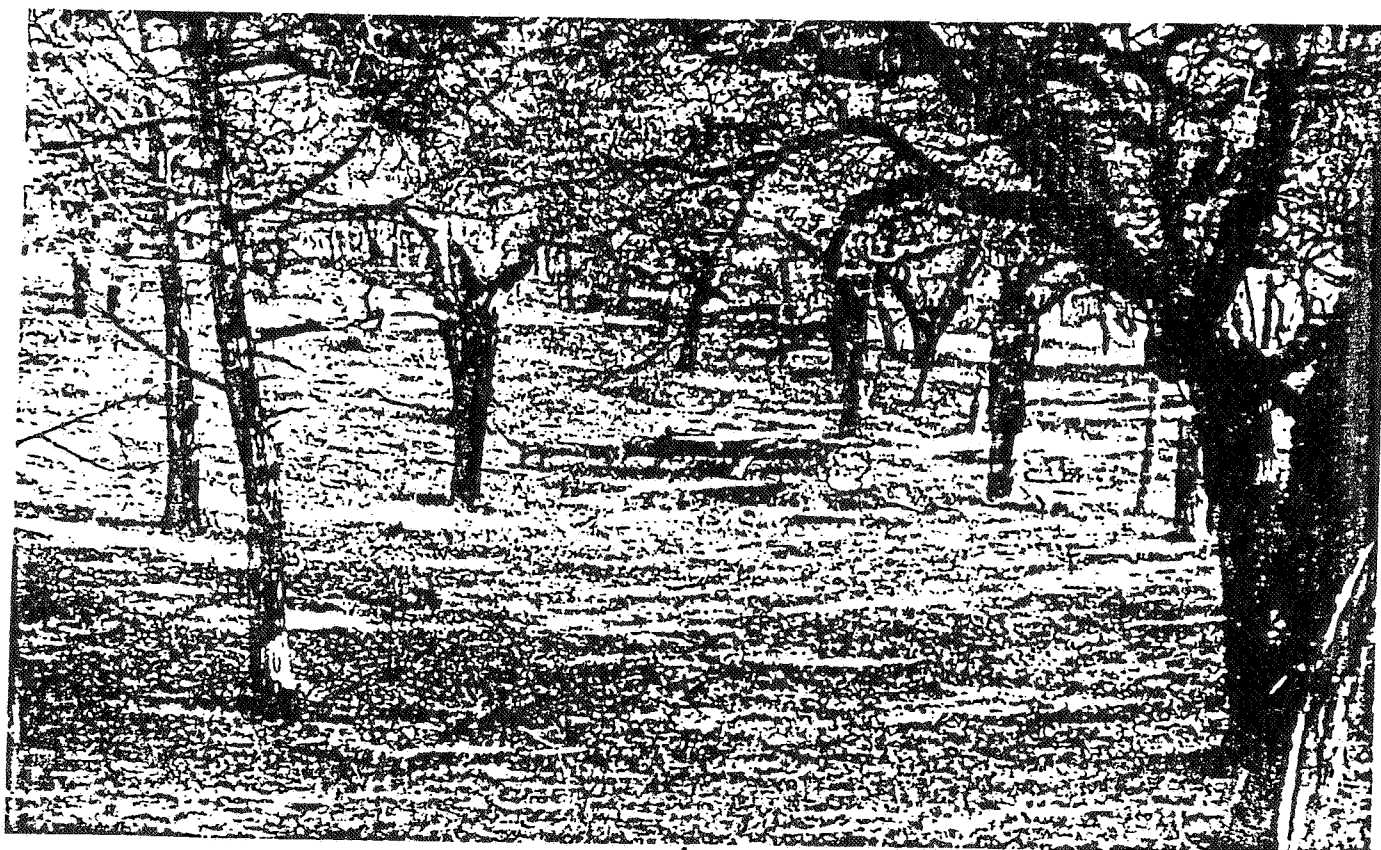
Fig. 14. An old Quercus virginiana (live oak) tree. The tree has not attained a very great height because of the toxic effects of salt spray.





Fig. 15. The interior of a maritime forest, showing Tillandsia usneoides (Spanish moss).

Fig. 16. The parklike appearance of part of the forest on Shackleford Banks, where livestock are abundant and ground cover is very sparse.



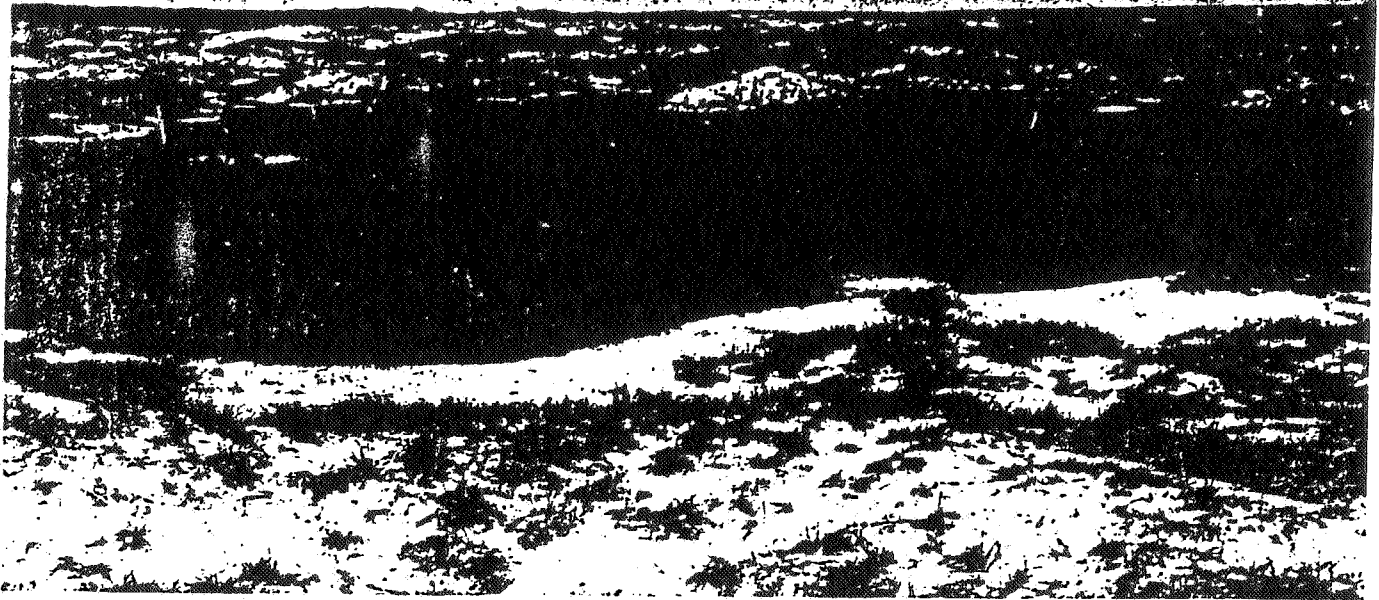


Fig. 17. A dune slack type of marsh. The dead tree stumps indicate that the dunes have migrated over the maritime forest.

Fig. 18. Dune slacks that have been heavily grazed.





Fig. 19. A needlerush marsh showing Juncus roemerianus with Kosteletzkya virginica (seashore mallow) in the foreground.

Fig. 20. A cattail marsh at Mullet Pond on Shackleford Banks. Typha angustifolia (narrow-leaf cattail) is the dominant species.

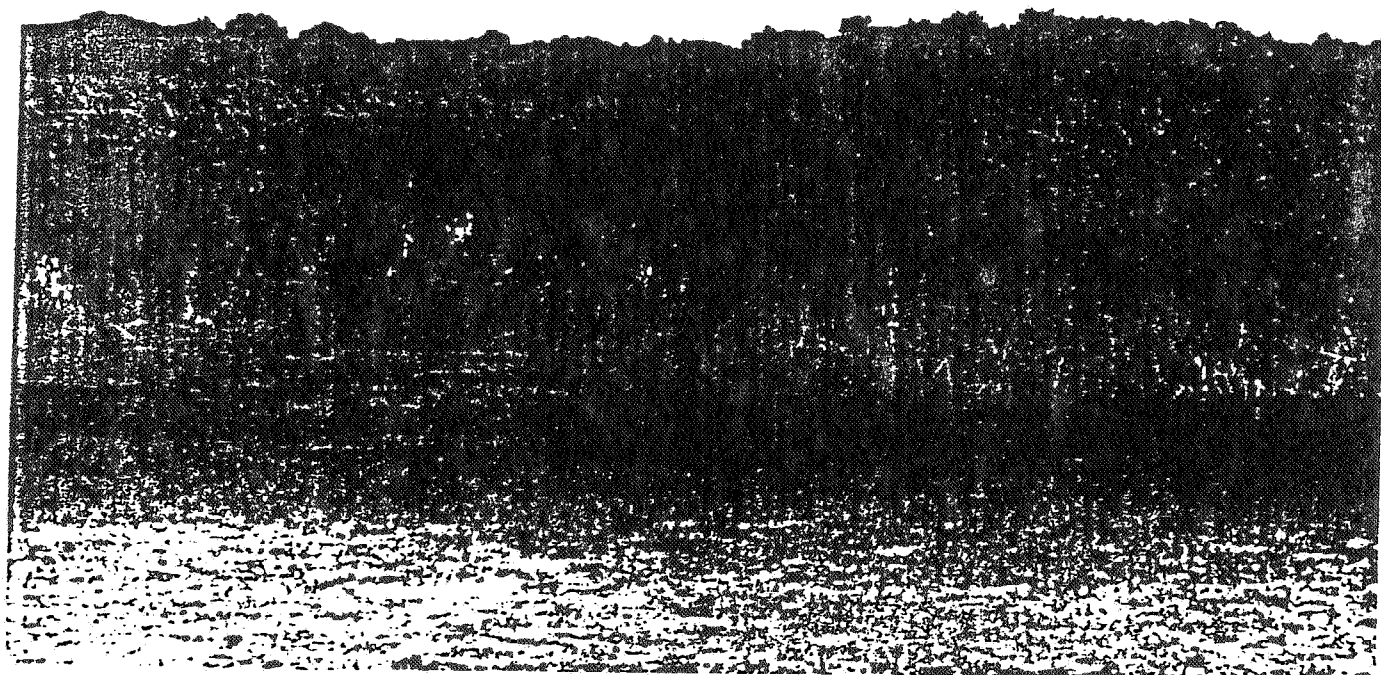




Fig. 21. Cladium jamaicense (sawgrass marsh) occurs in fresh or brackish situations.

Fig. 22. Low salt marsh is dominated by Spartina alterniflora (salt marsh cordgrass) and is flooded daily.

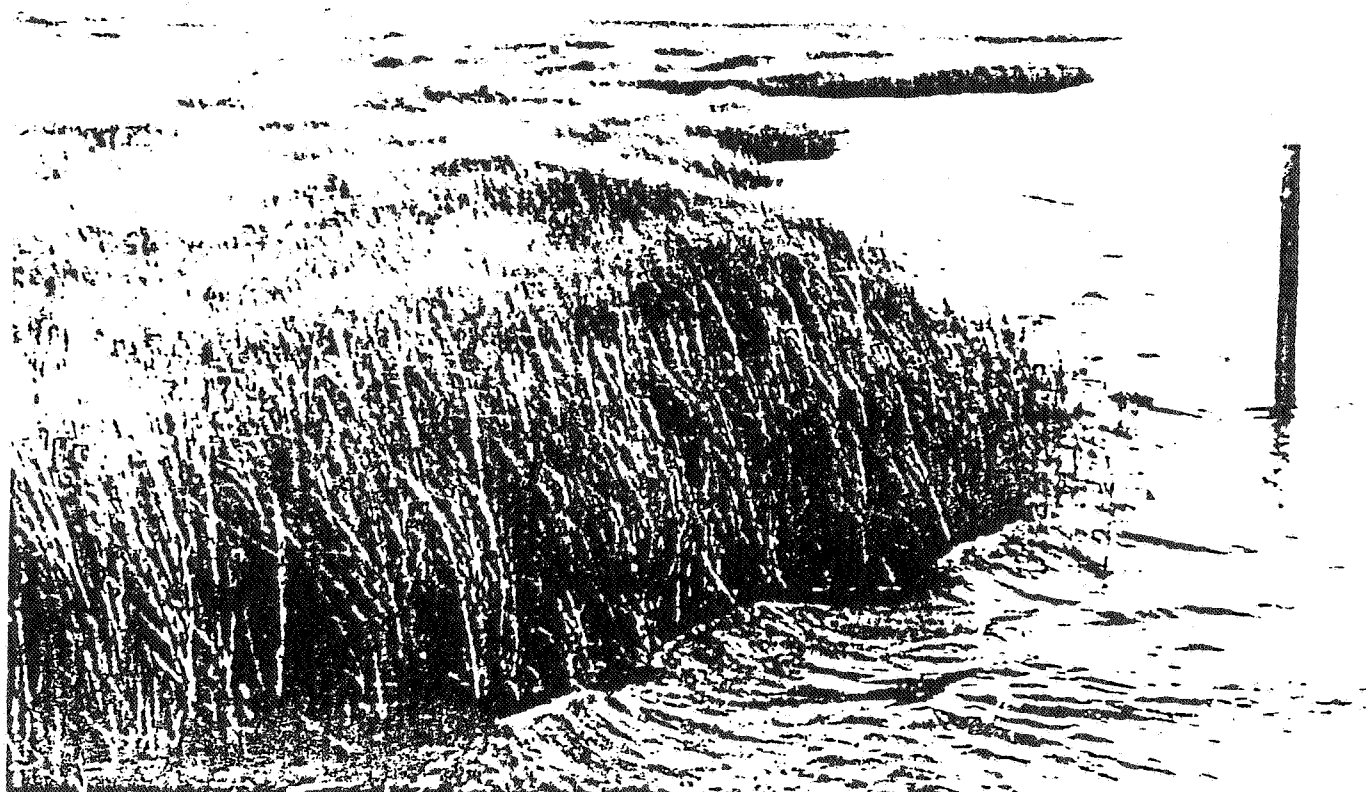
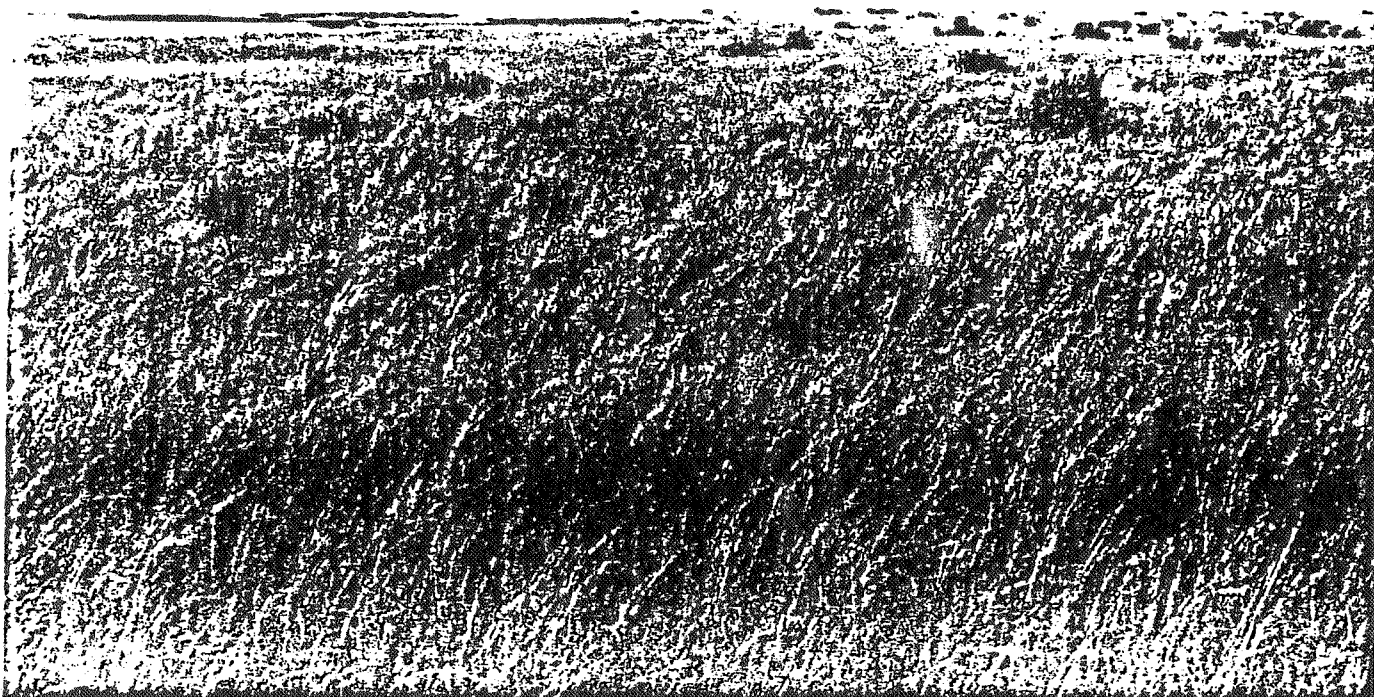




Fig. 23. A high salt marsh dominated by Juncus roemerianus (needlerush).

Fig. 24. A Spartina patens (salt meadow cordgrass) type of high salt marsh.



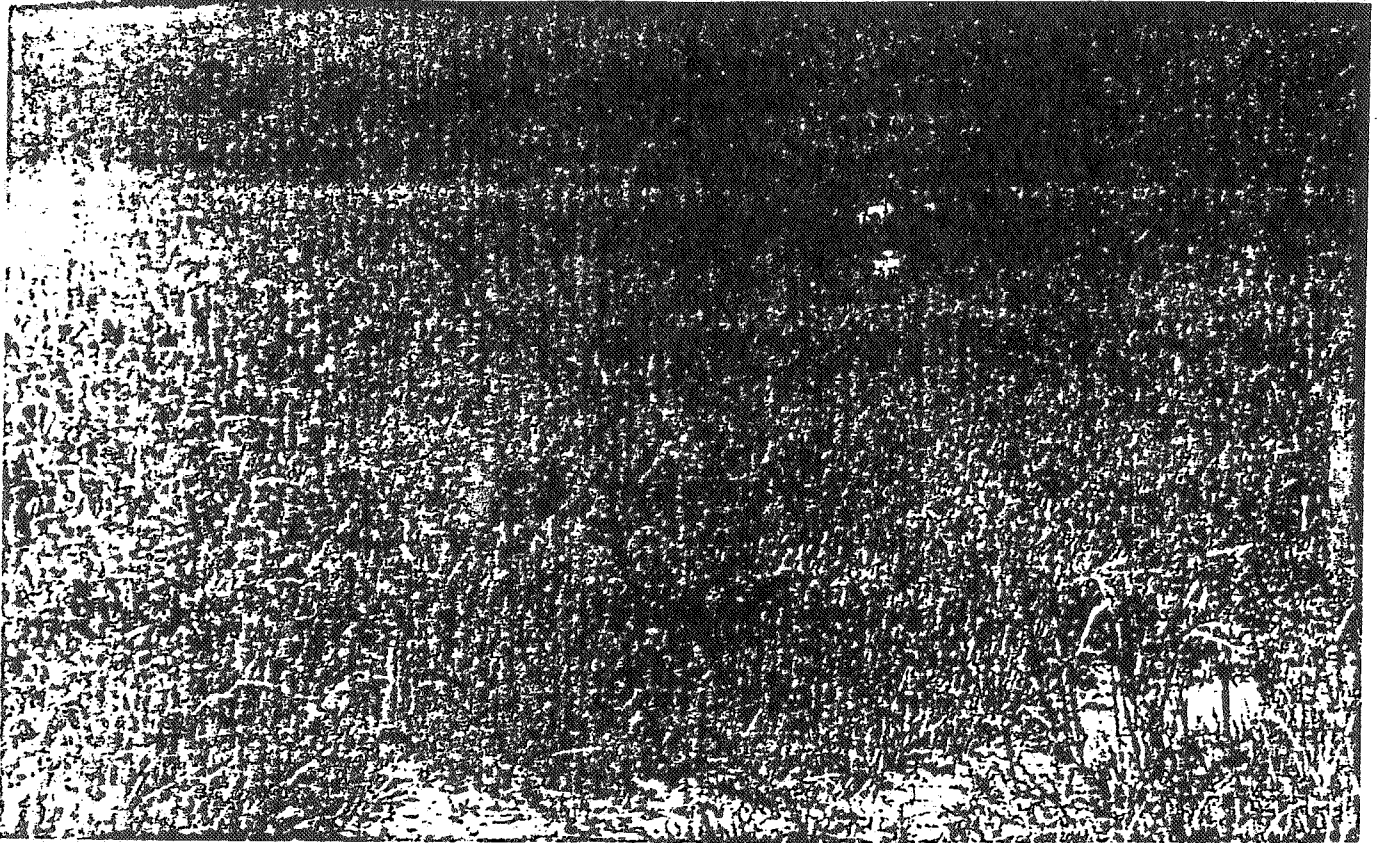


Fig. 25. A salt marsh panne that has been colonized by Salicornia spp. (glassworts).

Fig. 26. A supratidal high marsh showing Iva frutescens and Borrchia frutescens (sea ox-eye) at the edge of a needlerush salt marsh.

