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STABILIZATION OF BEACHES AND DUNES BY VEGETATION IN FLORIDA

by
JOHN H. DAVIS, JR.

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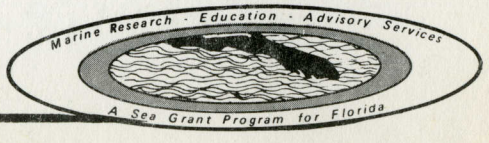

As a companion to this report, Florida Sea Grant Report No. 6 provides a guide to the use of seawalls and revetments in shore stabilization. These reports offer complementary approaches to a significant coastal problem.

STABILIZATION OF BEACHES AND DUNES BY VEGETATION IN FLORIDA

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Report Number 7

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STABILIZATION OF BEACHES AND DUNES BY VEGETATION IN FLORIDA

John H. Davis, Jr.

INTRODUCTION

Extremely valuable natural assets of the State of Florida are its coastal areas, especially its beaches and dunes that have become over the years the prime areas for recreation, homes, and associated commerce. Cities have grown on or near these beaches to serve residents and visitors alike. The attractiveness of these strand areas has made them the most valuable real estate in Florida.

At the time of early settlement and until recent years the beaches and dunes had retained most of their natural configuration, and erosion and other deterioration were due mostly to storms. Recently, however, significant stretches of beaches and some dune fields have become severely altered in many areas due to structures and activities that have increased erosion of sand and other materials, and in some cases altered offshore currents. Considerable concern has been expressed over how to retain these valuable assets, not only by decreasing the changes but also by making some restoration of the areas most depleted.

The shores have been partly built up and even extended seaward by the natural growth of plants that formed certain distinct kinds of vegetation that stopped and held materials brought in by waves, tides, and winds. Dense plant growth held these materials in place in the form of dunes. The purpose of this report is to provide coastal strand property owners and managers with guidelines for the use of vegetation in the protection and restoration of Florida beaches and dunes. This vegetation is described in Part I of this publication, and some methods of using plants to repeat the natural process of dune formation are considered in Part II.

Earlier Descriptions of Dune Vegetation and Coastal Processes

Strand vegetation and its role in making the upper beaches and dunes have been considered in many scientific and popular publications that describe areas in the United States and other parts of the world. This useful information cannot be applied in its entirety to Florida because of differences in environment. Whereas some publications have indeed shown how structures and plantings can be used to restore and improve strand areas, we need specific details about how this can be done in Florida, particularly the specific plants that can best be used.

One of the most comprehensive descriptions of dune plant life of Florida

is *Florida Dune and Scrub* by Herman Kurz. Details of nine sites along both coasts are given, and some illustrations of particular plants and dune field profiles are reproduced with modification in this publication. Kurz does not, however, consider the methods of stabilizing and restoring dune areas by using slat and brush fences and by appropriate plantings.

Ian L. McHarg's *Design with Nature* has good descriptions of coastal dune plant succession, with diagrams of this succession and photos of particular dune plants. McHarg considers coastal processes of erosion and transport, particularly the losses of shoreline along the New Jersey coast.

The author's publication *The Ecology of the Vegetation and Topography of the Sand Keys of Florida* describes islands west of Key West that have strand areas and the most tropical plants of Florida's shores. Some of these plants occur northward along the Atlantic coast mainly in the Scrub zone.

In *Man's Impact on Environment,* edited by Thomas R. Detwyler, this author considers "Influences of Man upon Coast Lines" through many centuries and in many countries.

The most detailed studies of shoreline conditions are the Regional Inventory Reports of the *National Shoreline Study* by the U. S. Army Corps of Engineers. These reports consider such remedial action as fill and beach nourishment, use of groins, rubble mounds and strips, jetties, breakwaters, and revetments. The reports give much information about Florida shorelines, including details about certain changes caused by erosion or deposition. However, the reports do not consider the remedial use of plants and the importance of particular kinds of vegetation for holding dunes.

In 1957 the author published *Dune Formation and Stabilization by Vegetation and Plantings,* listing most of the strand plants of the Atlantic, Gulf, and Pacific coasts and of the shores of the Great Lakes. Descriptions are given of dune building by use of fences and other windbreaks and soil holding structures, of planting methods, and of some costs.

The 1974 Tri-State Conference Report *Methods for Beach and Sand Dune Protection* is a good summary of erosion control and methods for beach and dune stabilization in Georgia, South Carolina, and North Carolina.

Some publications have dealt with plants useful as ornamentals and of their tolerance of wind, salt spray, and other coastal conditions. A recent bulletin by Karl E. Graetz, *Seacoast Plants of the Carolinas: For Conservation and Beautification,* lists many such ornamentals useful also in Florida.

The use of a specific plant to help stabilize spoil islands is detailed in *Propagation of* Spartina alterniflora *for Substrata Stabilization and Salt Marsh Development,* from the Coastal Engineering Research Center in Virginia. Spoil from dredging and other operations can be stabilized below the usual high tide level by this marsh plant, and the upland part can be stabilized by plants of the strand dune areas.

Finally, the Coastal and Oceanographic Engineering Laboratory, University of Florida, maintains an Archives in which numerous publications about Florida coasts are housed. A bibliography of reports and publications is available.

PART I

ZONES AND COMPOSITION OF THE STRAND VEGETATION AND ITS ROLE IN BUILDING AND HOLDING DUNES

Primarily, deposits of sand, shells, and other materials build up along seashores that have wave, wind, and tide energy. These develop into beaches and dunes through the continuing deposition processes plus the growth of plants and some other forms of life that occupy such deposits. Strand areas parallel to the coasts that thus develop generally have plants suited to the severe conditions that include alternate wetting and drying, salt spray, and soil salinity.

Plants catch and hold in place sands and other soil materials by the manner of growth of their above ground and underground parts. Usually the plants performing this role of dune building along the strand areas are of three different growth forms: (1) grasses, sedges, and other herbs; (2) woody and fibrous shrubs; and (3) woody and fibrous trees. These three growth forms show characteristic groupings in most strand areas.

Vegetation is the most effective barrier of the land against the sea in establishing and maintaining coastal positions. Over millions of years it has advanced the land toward the sea slowly but surely or has held the position of the land. In the eternal conflict between land and sea, the plants and the vegetation they form are the shock troops of the battle.

Character and Position of the Zones

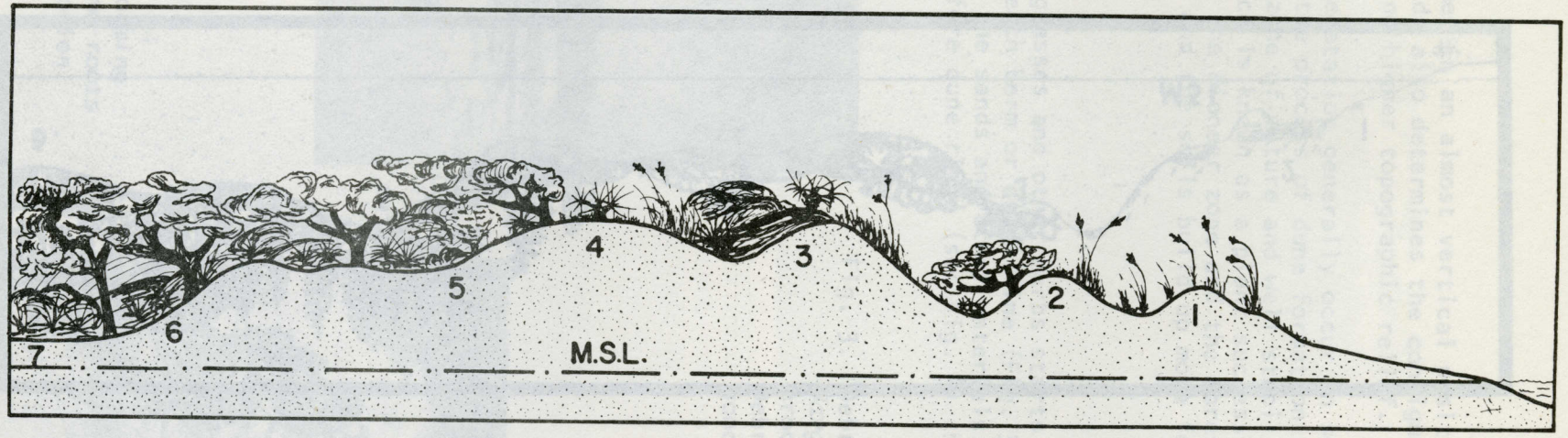
Because of the characteristic growth forms of the plants composing the vegetation and their roles in dune establishment, the three zones of vegetation usually present are here described as: (1) the Pioneer zone of grasses and other herbs; (2) the Scrub zone of shrubs and scrub form tree species; and (3) the Forest zone of tree size tree species, with which shrubs are often associated. See Figures 1 and 2.

These three zones do not always occur regularly along the coasts nor do they have equal width or density of plant cover. The position, configuration, and width of each are determined by various factors. These include the character of the seashore, i.e., the rapidity and continuity of the accretion processes that cause sand, shell, and other materials to accumulate on the upper beaches. The zones are widest where accretion has occurred steadily over long periods of time, and least wide where erosion processes have eaten back into the beach and dune areas.

Also affecting the character of the zones are the extent and violence of erosion processes, especially storms and to some extent onshore and alongshore currents.

The position of each zone is related mainly to the topography of the upper beach and dune field and to the rate of accumulation of sand and other materials. The angle of repose of some of these materials determines the steepness of slope on many dunes, as well as the effectiveness of the plants

Fig. 1. Profile of common dune field, showing common zones of vegetation.



6-7. Forest zone with hardwood trees and undergrowth.

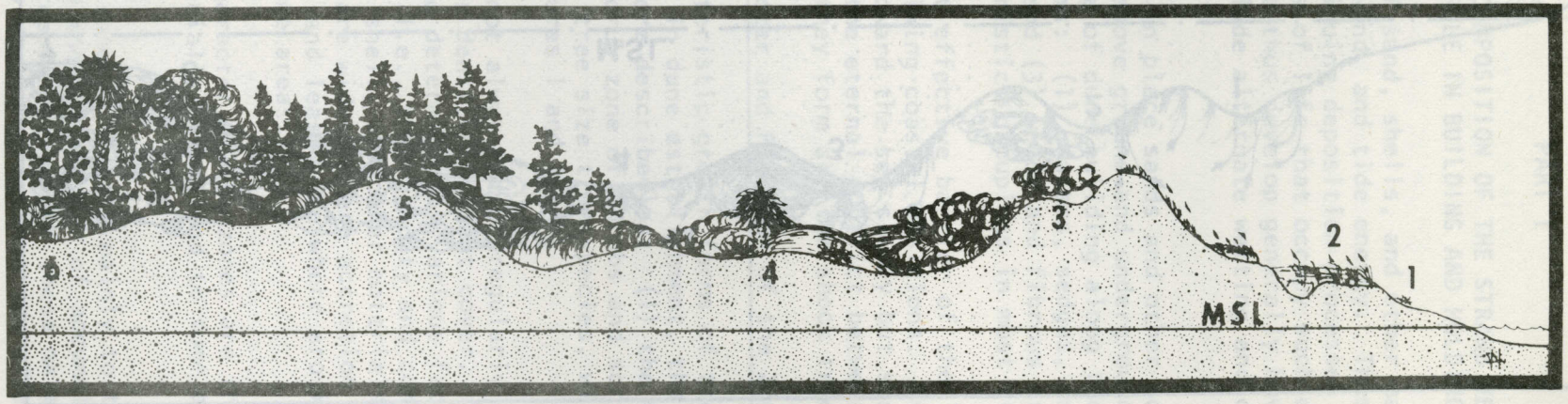
4-5. Scrub zone, here shown with oaks and saw palmetto most frequent.

3. Pioneer third high dune ridge with both bushes and grasses.

2. Pioneer second dune ridge with oaks and saw palmetto on interior side.

1. Pioneer fore dune with sea oats forming it.

Fig. 2. Profile of wide dune field showing mature forest zone with both sand pines and hardwood trees.



6. Mature forest zone, often with cabbage palms, pines, and hardwood trees.

5. Forest zone, often with sand pines and understory shrubs.

3-4. Scrub vegetation, often with oaks and other tree species having wind-blown form.

2. Pioneer sea oaks on front fore dune that they helped to form.

1. First Pioneer plants along drift line of upper beach.

in holding soils, sometimes in an almost vertical position. The age duration of the dune fields also determines the configuration with older dune fields usually showing higher topographic relief.

The three zones of vegetation generally occur in sequence from the Pioneer zone that starts the process of dune formation inland through the Scrub zone to the Forest zone of mature and well stabilized dune ridges or mounds. Such a sequence is known as a plant succession because the Scrub zone often replaces the Pioneer zone and the Forest zone replaces the Scrub zone as time passes and the soils build up more fertility and better water holding capacity.

The Pioneer Zone

The Pioneer zone of grasses and other herbs starts the dune-building process along the upper beach berm or drift line (Fig. 3), where debris adds organic materials to the sands and other materials. The drift line thus vegetated becomes a fore dune ridge (see Fig. 4) that is usually

Fig. 3. Debris, mostly alga, *Sargassum*, in front of eroded beach berm. Debris can help start good plant growth.

Fig. 4. Beach berry forming fore dune, some roots exposed by erosion.

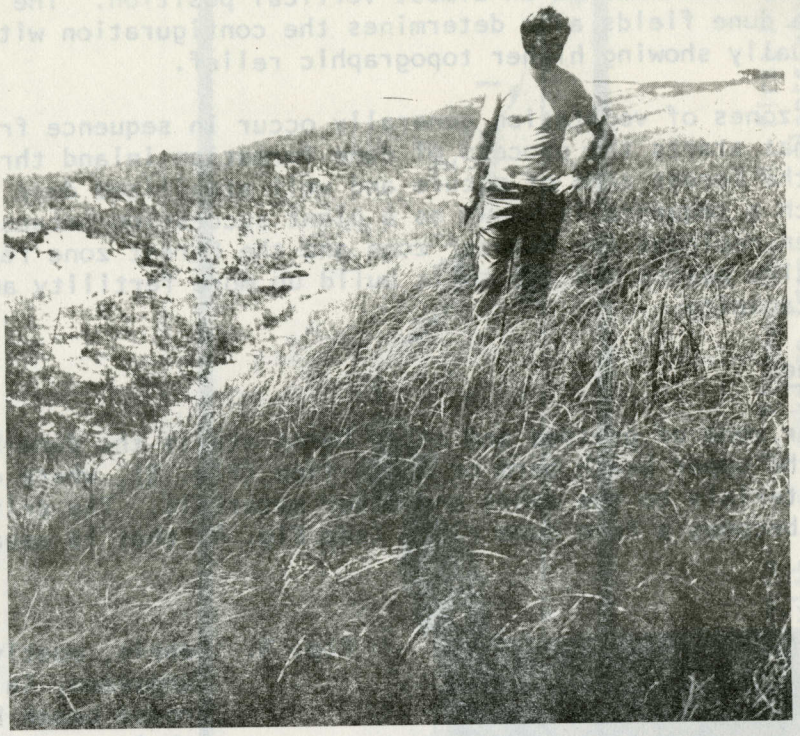


Fig. 5. High dunes of the Pioneer zone, Northwest region. Small cordgrass is dense on the face of the high second dune ridge.

unbroken in length where human action has not disturbed it. Plant density varies greatly in the Pioneer zone. Width of the zone also varies; it is usually widest where the energy factors of wind, waves, and tide do not carry materials inland high enough to support the Scrub zone plants (Fig. 5). It is often narrow where degrading processes have reduced the supply of sand and other materials of the upper beaches and where erosion has cut away former dune lines near the beach on which the Pioneer plants grew (Fig. 6). Such erosion has removed part or all of the Pioneer zone along some stretches of the Florida coasts, especially the Atlantic.

The Scrub Zone

The Scrub zone is most often present because it usually remains even after storms and other erosion have removed part or all of the Pioneer zone. The position of the front of the Scrub zone is usually inland a few dune ridges from the beaches but can be on the upper beach where erosion has removed the Pioneer zone. Plants of the Scrub zone often appear in parts of the Pioneer zone and help establish the Scrub zone progressively closer to the beach (see Fig. 7). In some places Scrub vegetation extends far inland where a series of dunes has built up but has not yet developed sufficiently rich soils to support a forest. Along some coasts old Scrub zones far inland indicate the approximate former shoreline.

Fig. 6. Sea oats and other Pioneer zone plants hold the eroding face of a beach berm.

Fig. 7. Common Scrub vegetation Spanish bayonets and grasses, in dune area.

The Forest Zone

The Forest zone does not develop on young dune sites nor usually on narrow dune fields, therefore it is absent along some coasts. Where present, the zone's width depends on the topography and soil conditions toward the interior.

Character and Position of the Vegetation

Certain general characteristics of the vegetation within the three zones can be noted. The zones vary in density of plant cover within short distances. Usually the upper beach and fore dunes are more densely covered on their interior faces.

In both the Pioneer and Scrub zones the roots, rhizomes, and other underground parts of the plants and the prostrate surface stems, as of saw palmettos (Figs. 8 and 9), are very frequent, useful dune builders and holders. Some Pioneer zone grasses have two or more levels of horizontal rhizomes; these levels indicate the former levels of the surface, which is built higher partly by the rhizome sand holding capacity (Fig. 10).

Fig. 8. Long surface stems of the saw palmetto hold moving sand.

Fig. 9. Extensive saw palmetto root system, here exposed by erosion.

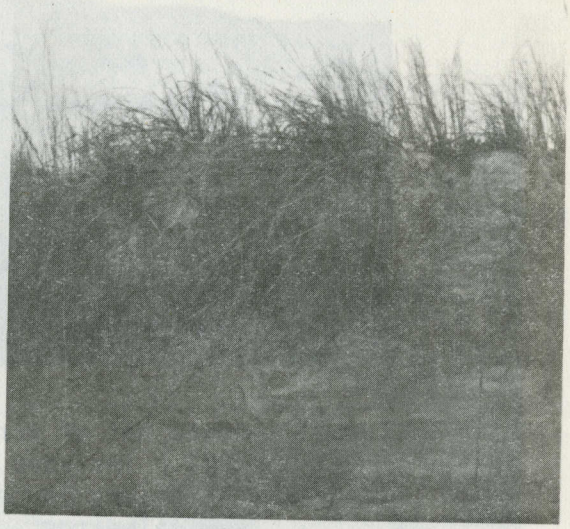


Fig. 10. Root system of small cordgrass holds the top of an eroded fore dune.

The growth form of many of the Scrub zone plants and some in the Forest zone is determined by winds, salt spray, and other harsh conditions along the coasts.

Density of Scrub plants on well fixed dunes is often so great that they form a continuous mat canopy (Fig. 11) that is difficult to walk through. Such density effectively holds the dunes in place even against high winds and water. Once this dense cover is disturbed, as by paths and partial clearing, high winds often cause the exposed sands to shift (Fig. 12), and numerous blow-outs may result.

Density in the Forest zone is usually greatest in the low swales where water may stand at times. The sand pine type of forest present, particularly along the middle Atlantic coast, has an open canopy of sand pines below which grow many of the shrubs and low trees of the Scrub zone, for example scrub oaks and the rosemary bush.

All human actions that decrease the density of plant cover, especially of the grasses and other herbs of the Pioneer zone, are harmful to the stability of the dune fields. Even foot paths and people walking up and down dune faces increase the sand and soil movements that once started are difficult to stop. The worst activity is human disturbance of the plants on sea-facing fore dunes. Also, clearing in the Scrub zone has started many moving dunes, blow-outs, and other destruction of dune topography. All construction should minimize disturbance of vegetation. (Setback lines for

Fig. 11. Dense mat of Scrub zone vegetation holds dunes well. Included in this area of the Northwest region are low stature scrub oaks and some saw palmettos.

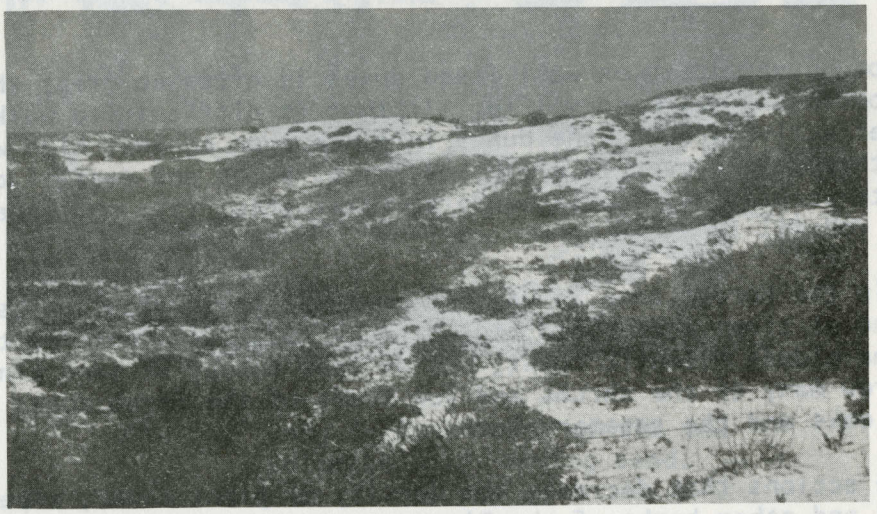


Fig. 12. Scrub zone vegetation on these interior dunes was dense but is now eroding due to foot traffic.

construction are discussed below.)

Offshore modifications may also intensify beach and dune erosion as shown in Figures 13 and 14.

Fig. 13. Beach material loss is due mainly to sea wall and groin structures. No dunes are present to restore with grass plantings, and sand beach renourishment would probably be impermanent.

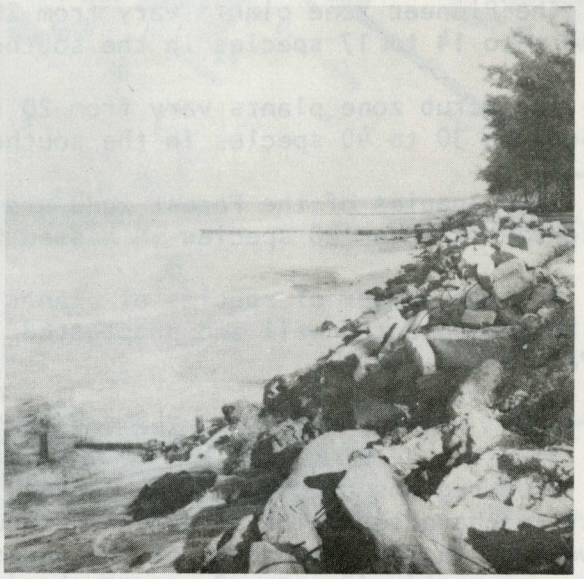


Fig. 14. Revetment on scarp of fore dune. No beach is visible at full tide.

Plants of the Three Zones of Vegetation

The kinds of plants commonly occurring in the three zones of vegetation vary both regionally and locally. The main regional differences occur with latitude, due mainly to changes in climate from temperate to tropical conditions. Another factor is the change from almost pure silica sands in the northwest areas along the Gulf of Mexico to sands with many shells and other calcareous materials along the southwest coast region.

Differences in local composition are often due to the configuration of the dunes and the width of the dune fields. More different species occur if the dune profiles are high ridges with low swales between them that furnish a varied habitat for the plants. Also, wider dune fields provide more space for more species.

Finally, introduced and naturalized species of plants, such as the coconut palm, Australian pines, Spanish bayonet, Brazilian pepper and other

trees, shrubs, and some grasses and herbs, add to the variety of plants. Many were introduced as ornamental plants; many can be used in plantings for dune stabilization.

In preparation for this report, all regions of the coast were visited and almost all species present were noted. The findings are as follows:

The Pioneer zone plants vary from 20 to 23 species in the northern regions to 14 to 17 species in the southern regions.

The Scrub zone plants vary from 20 to 25 species in the northern regions to 30 to 40 species in the southern regions.

Tree species of the Forest zone are more numerous in the northern regions, with over 20 species in Nassau County.

A great number of species of plants increases the plant materials that can be transplanted well and propagated in nurseries. These are discussed in Part II.

The Coastal Regions

Four regions of high energy coasts in Florida are recognized as distinct in characteristics of beaches and dunes and some offshore conditions, as well as in the components of the vegetation over the strand areas. They are:

1. Northeast: Extending from the northeast border of Florida along the St. Mary's River south to the tip of Cape Canaveral;

2. Southeast: Extending from Cape Canaveral along the Atlantic coast and west along the Florida Keys to Key West. The Florida Keys have some rocky shores and could be considered distinct;

3. Southwest: Extending from the small area of Cape Sable, and from Cape Romano of Collier County north along the Gulf coast through Pinellas County to near Anclote Key; and

4. Northwest: Extending from the eastern end of Franklin County south of Tallahassee west along the Gulf coast to the Alabama-Florida border.

Along the Northeast region the shore materials are mostly sands but not so fine or white as those in the Northwest region. The wind, wave, and tide actions are often intense due to strong northeast winds. Figure 15 illustrates how winds have blown out gaps in the Scrub zone and even in the Forest zone and moved sand inland to form high, bare dunes. Some areas in this region lack a wide Pioneer zone because severe erosion has cut back the Pioneer dunes into the Scrub zone. Beaches with sea walls established to protect them, as in southern Duval County, are for long reaches now almost destroyed (see Fig. 13), and no low dune ridges exist on which Pioneer plants can start growing to aid in reforming the dune field. Commonly seen are scarp walls with few or no plants on them, dropping steeply from the Scrub

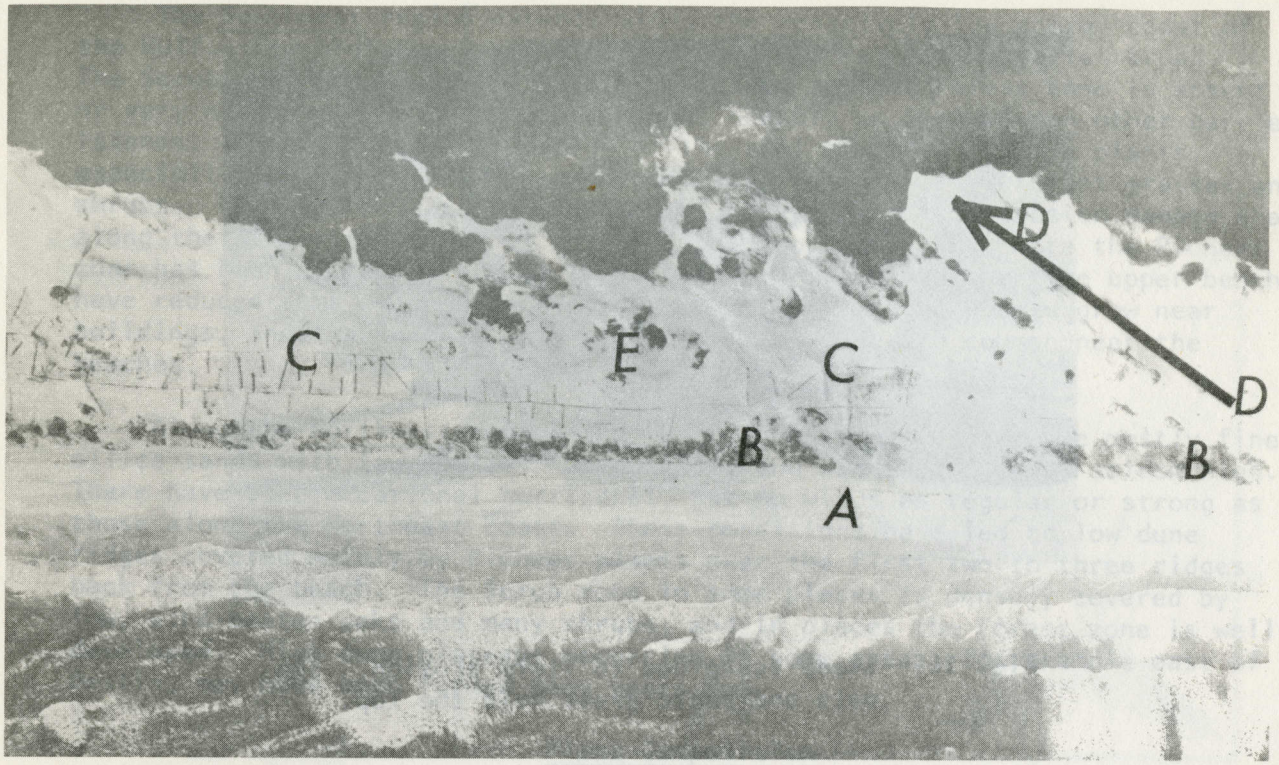


Fig. 15. Coastal area of Amelia Island, Nassau County, Florida.

A. Broad beach.
B. Pioneer vegetation on developing fore dune ridge.
C. Slat fences installed to aid in sand accumulation. (Also see Figs. 39, 46, and 47.)
D. Long blow-out area where Scrub vegetation has eroded. Arrow indicates wind direction from the northeast.
E. Remnant dunes left after erosion by NE winds.

vegetation zone (Fig. 16). This region needs much effort to rebuild the Pioneer and Scrub zones by reforming dunes and making plantings.

South from Cape Canaveral along most of the Southeast region, abundant shell materials occur with the silica sands. The wave, tide, and wind actions have been intense along many parts, resulting in steeply eroded fore dune scarps. Storms commonly occur. Dunes in the Scrub and Forest zones are usually high, and some are densely covered by vegetation. The further south, the more tropical plant species occur in this vegetation. Sea grapes, *Coccoloba uvifera* (Fig. 17), are large shrub plants consistently present, and coconut palms, *Cocos nucifera*, and Australian pines, *Casuarina equisetifolia*, are abundant near the beaches and over the dunes (Fig. 18). Establishment of numerous homes and other structures along the coast of this region has left only a few short strands of natural vegetation. However, many of these structures have landscaped grounds with fine ornamental plants, in some cases helpful in holding the dunes.

Fig. 16. Steep scarp due to storm erosion. Sea oats and panic grass hold the top.

Fig. 17. Sea grape, a large shrub with semi-orbicular leaves.

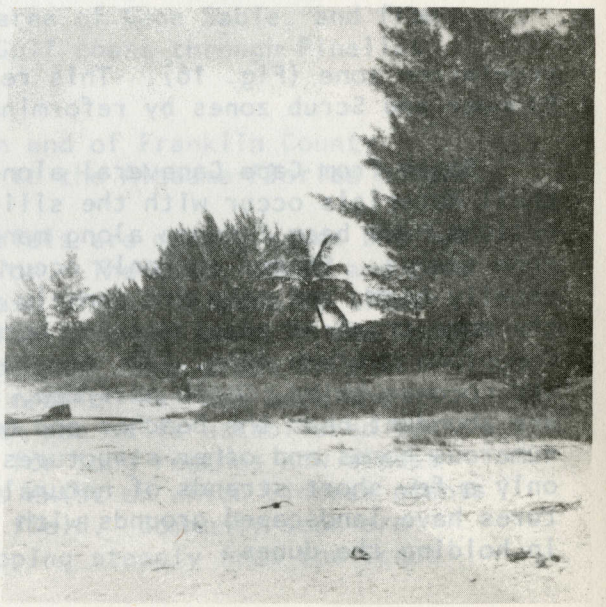


Fig. 18. Coconut palms and Australian pines with sea grapes underneath, often on southern region fore dune ridges.

The Southwest region extends along the relatively low energy coast of the Gulf. Few high dunes are present. The Pioneer zone is often broad. The Scrub zone has numerous tropical species, and the Forest zone is absent or very narrow. Shell materials abound, notably on Sanibel and other barrier islands. The calcareous condition of the soil promotes certain plants, especially an abundance of cabbage palms and some alkali-tolerant grasses and shrubs. Wind and wave action and storms have caused less erosion damage than along the Atlantic coast, but some steep scarp faces show where the Pioneer zone has been eroded by storms. Sea walls and revetments on the upper beaches have reduced some beaches to remnants. Many ornamental plants grow near buildings, and the coconut palm and Australian pine are common near the beaches.

Along the Northwest region the beach and dune materials are mostly fine silica sands with few shells. Wave, tide, and wind actions are seldom high. There have been occasional hurricanes, but no winds as regular or strong as those along the Northeast coast. These conditions have led to low dune ridges covered mainly by Pioneer plants over the first two to three ridges back from the beach. The Scrub zone in some places is densely covered by low, wind-beaten oaks and many shrubs, and in places the Forest zone is well-developed. High dune plateaus occurring in some areas, for example east of Destin, may have been formed many years ago.

Plant Composition

Northeast and Northwest Regions, Pioneer Zone

About 20 species occur on the upper beach and fore dunes at most places where the Pioneer zone is two to three ridges wide. The sea rockets, *Cakile* spp.; pennyworts, *Hydrocotyle* spp.; and sea oats, *Uniola paniculata* (Figs. 19-20), are often present on the drift line of the upper beaches. In places the small cordgrass, *Spartina patens* (see Figs. 5 and 10), is abundant. The introduced St. Augustine and Bermuda grasses and panic grass, *Panicum amarum* (Fig. 21), are locally common; all three could be useful in plantings on bare dunes.

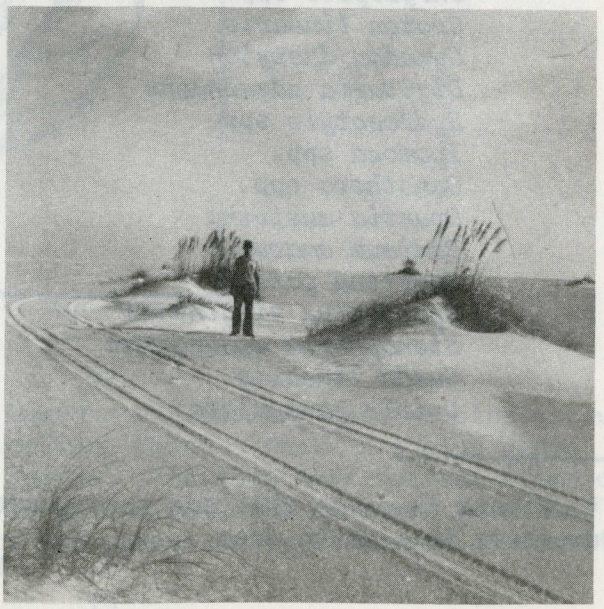


Fig. 19. Natural restoration of sea oats on filled area. (Car tracks across dune field could lead to future erosion.)

Fig. 20. Details of sea oat seed head.

Northeast and Northwest Pioneer Plants*

Scientific name	Common name
Andropogon spp.	coastal beardgrasses
Atriplex spp.	beach orachs
Cakile spp.	sea rockets
Cenchrus spp.	sand-spurs
Chrysopsis spp.	golden asters
Croton linearis	small croton
Cynodon dactylon	Bermuda grass
Digitaria adscendens	finger grass
Hydrocotyle spp.	pennyworts
Ipomoea spp.	running or beach morning glories
Oenothera spp.	evening primroses
Opuntia austrina	prickly pear cactus
Panicum amarum	panic grass
Spartina patens	small cordgrass
Sporobolus virginicus	rush grass
Stenophorum secundatum	St. Augustine grass
Sueda linearis	sea-blite
Uniola paniculata	sea oats

* Plants named in this and subsequent lists are those occurring most frequently in a given area.

Fig. 21. Panic dune grass shown in seed, which is not common.

Fig. 22. Yaupon holly, common shrub in northern regions.

Northwest Region, Scrub Zone

The scrub form of live oaks, *Quercus virginiana*, and two other scrub oaks are common as a dense growth on many dunes. There are also dense growths of saw palmettos, *Serenoa repens*. The long near-surface stems of this low palm very effectively build up and hold the dunes of this zone (see Fig. 8). Commonly occurring plants are yaupon holly, *Ilex vomitoria* (Fig. 22);

the stagger or hobble bushes, *Lyonia* spp.; rosemary, *Ceratiola ericoides* (Fig. 23); a woody goldenrod, *Chrysoma pauciflosculosa;* gopher apple, *Geobalanus oblongifolius;* some endemic basil mints, *Clinopodium* spp.; wild olive, *Osmanthus americanus;*and wax myrtle, *Myrica cerifera* (Fig. 24). Some of these occur rarely or not at all in the other Florida coastal regions.

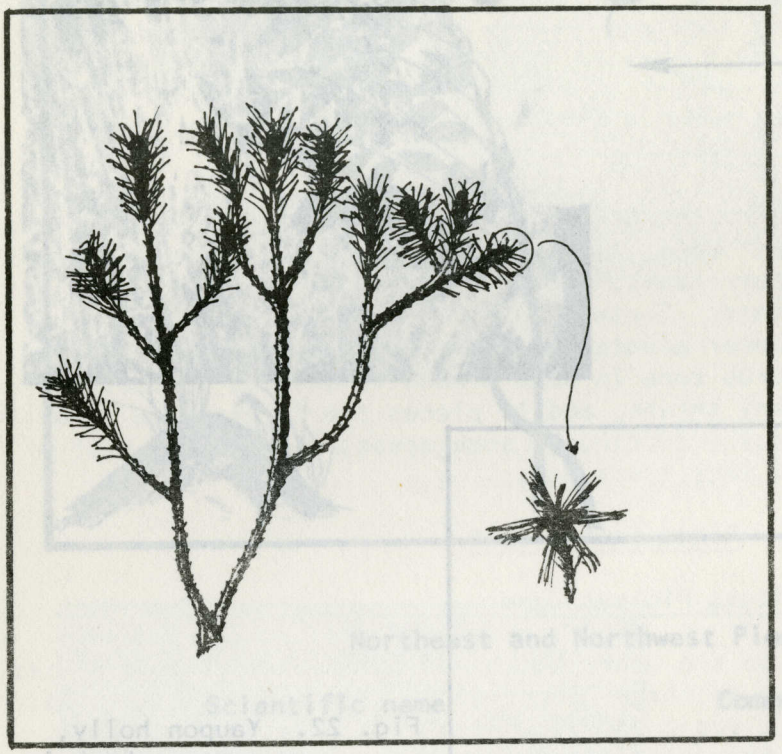


Fig. 23. Rosemary, common shrub in northern regions.

Fig. 24. Wax myrtle, common shrub in northern regions.

Northwest Scrub Plants

Scientific name	Common name
Baccharis spp.	groundsel bushes
Bumelia spp.	buckthorns
Ceratiola ericoides	rosemary
Chrysoma pauciflosculosa	woody goldenrod
Chrysopsis spp.	golden asters
Clinopodium spp.	woody mints, basils
Geobalanus oblongifolius	gopher apple
Hypericum spp.	bushy St. Johns worts
Ilex vomitoria	yaupon holly
Iva imbricata	marsh elder
Lyonia spp.	stagger or hobble bushes
Magnolia grandiflora	magnolia
Myrica cerifera	wax myrtle
Opuntia austrina	prickly pear cactus
Osmanthus americanus	wild olive
Persea littoralis	shore bay
Pinus spp.	pines
Pteridium aquilinum	bracken fern
Quercus chapmanii	Chapman's scrub oak
Quercus myrtifolia	myrtle-leaved oak
Quercus virginiana	live oak
Sabal palmetto	cabbage palm
Serenoa repens	saw palmetto
Sesuvium portulacastrum	sea purslane
Smilax spp.	greenbriar vines
Vitis spp.	wild grapes
Yucca spp.	Spanish bayonets

Some plants of the Scrub zone occur in the Pioneer zone especially where this Pioneer zone has been well developed. Helping to cause the change to Scrub vegetation, they include the Spanish bayonets, *Yucca* spp. (Figs. 7 and 25), marsh elder, *Iva imbricata* (Fig. 26), sea purslane, *Sesuvium portulacastrum*, and saw palmetto.

Northeast Region, Scrub Zone

Many plants common in the Northwest region are also common here, especially the live oak, saw palmetto, and cabbage palm. But also occurring here are some plants usually more abundant in the Southeast region, because the temperature drops less here than along the northwest coast. The Forest zone is better developed than in any other region with some trees occurring in the Scrub zone. Live oaks with distinct wind-blown form are prevalent; some large oaks grow on the border between the Scrub and Forest zones, as well as in the Scrub zone.

The composition of plants of the Scrub zone changes southward more than that of the Pioneer zone because the sea grape and other cold-sensitive

shrubs become more common and abundant. Live oaks and wax myrtles occur less frequently. An intensive development of homes and other structures from Ormond Beach through New Smyrna Beach has caused most of the vegetation to be removed or altered, but the coast along the projection toward Cape Canaveral shows little disturbance due to the Kennedy Space Center's retaining natural conditions of vegetation near the beach.

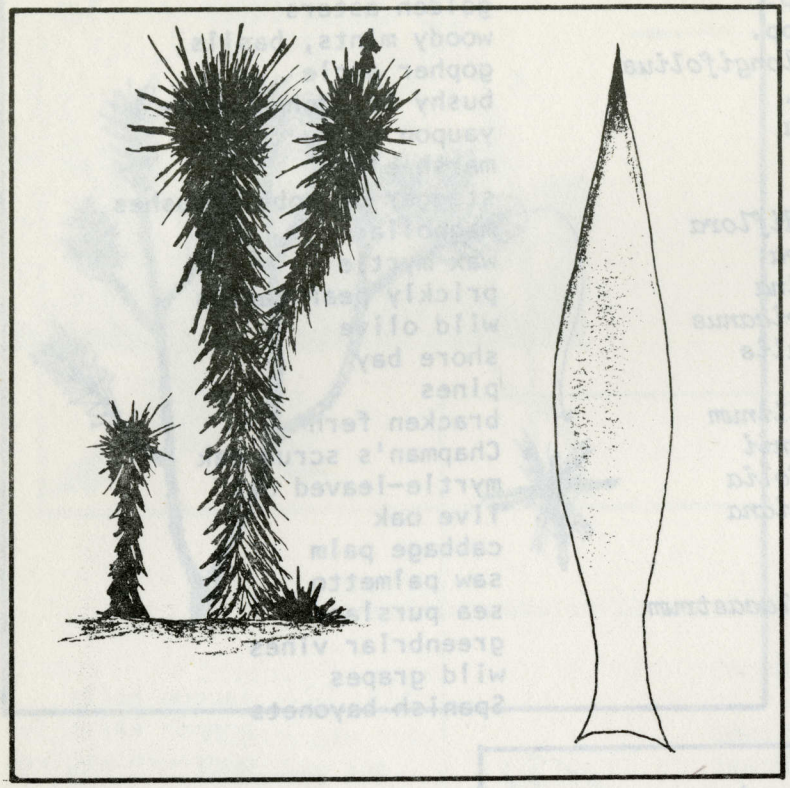


Fig. 25. Spanish bayonet, often planted and naturalized on fore dunes and in Scrub.

Fig. 26. Marsh elder helps form fore dune by holding sand.

Northeast Scrub Plants

Scientific name	Common name
Baccharis spp.	groundsel bushes
Bumelia spp.	buckthorns
Casuarina spp.	Australian pines
Coccoloba uvifera	sea grape
Geobalanus oblongifolius	gopher apple
Ilex spp.	hollies
Iva frutescens	marsh elder
Magnolia grandiflora	magnolia
Myrica cerifera	wax myrtle
Opuntia spp.	cactus
Osmanthus americanus	wild olive
Persea spp.	bay trees
Quercus virginiana	live oak
Sabal palmetto	cabbage palm
Scaevola plumieri	beach berry
Schinus terebinthifolius	Brazilian pepper
Serenoa repens	saw palmetto
Smilax spp.	greenbriar vines
Yucca spp.	Spanish bayonets

Southeast Region, Pioneer and Scrub Zones

The Pioneer zone has some of the same grasses as the other regions, but sea oats are not so common or dense. Running or beach morning glories, especially the goat's foot or railroad vine, *Ipomoea pes-caprae* (Figs. 27 and 28), are increasingly abundant. Some spurges, *Euphorbia* spp., which are very abundant on the Florida Keys, also occur here. The beach berry, *Scaevola plumieri* (Figs. 4 and 29), becomes very common in places. This zone is seldom wide and may lack some common plants at a given place because of restricted area.

The Scrub zone dominates the region with the greatest abundance of native and ornamental plants introduced, such as the coconut palms. These appear often in the Pioneer zone and are planted more than naturalized. The Scrub zone variety includes some very tropical species that are not common

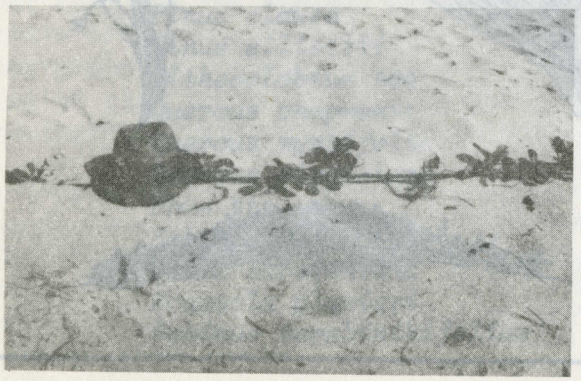


Fig. 27. Railroad vine morning glory holds upper beach sand.

far north of the Florida Keys islands. A few of these are the bay cedar, *Suriana maritima*, and the sea lavender, *Tournefortia gnaphalodes*. Two species of the thatch palms, *Thrinax*, occur on a few of the Florida Keys. The coastal ernode, *Ernodea littoralis*, and dune berry, *Erithalis fruticosa*, are common here but uncommon or lacking in the other regions.

Fig. 28. Detail of railroad vine morning glory.

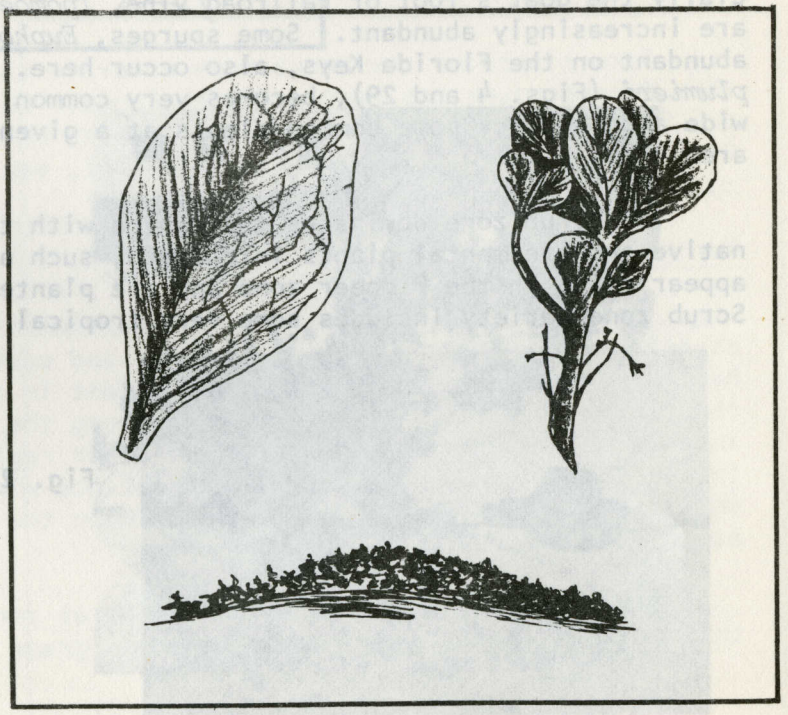


Fig. 29. The beach berry helps dune formation in the southern regions.

The sea grape (see Figs. 17 and 18) is probably the most common shrub and small tree and is used extensively as an ornamental. Australian pines are abundant, having become well naturalized.

Southeast Scrub Plants

Scientific name	Common name
Agave spp.	century plants
Avicennia germinans	black mangrove
Baccharis spp.	groundsel bushes
Batis maritima	saltwort
Borrichia aborescens	sea ox-eye
Capparis spp.	caper trees
Carica papaya	papaya
Casuarina spp.	Australian pines
Coccoloba laurifolia	pigeon plum
Coccoloba uvifera	sea grape
Cocos nucifera	coconut palm
Conocarpus erectus	buttonwood
Dalbergia ecastaphyllum	sea dalbergia
Erithalis fruticosa	dune berry
Ernodea littoralis	dune ernodea
Erythrina herbacea	red cardinal or coral bean
Eugenia spp.	stopper woods
Forestiera segregata	Florida privet
Geobalanus oblongifolius	gopher apple
Hibiscus tiliaceus	mahoe or sea hibiscus
Ilex vomitoria	yaupon holly
Iva imbricata	marsh elder
Jacquinia keyensis	joewood
Juniperus silicicola	red cedar
Laguncularia racemosa	white mangrove
Lonicera spp.	honeysuckles
Melaleuca leucodendron	cajaput, punk tree
Metopium toxiferum	poison wood
Nerium oleander	oleander
Opuntia spp.	prickly pear cactuses
Osmanthus americanus	wild olive
Pinus clausa	sand pine
Pinus elliottii	slash pine
Pithecolobium spp.	black beads
Quercus chapmanii	Chapman's oak
Quercus myrtifolia	myrtle-leaved oak
Quercus virginiana	live oak
Rhus spp.	sumacs
Sabal palmetto	cabbage palm
Salix caroliniana	willow
Scaevola plumieri	beach berry
Schinus terebinthifolius	Brazilian pepper

Continued

Scientific name	Common name
Serenoa repens	saw palmetto
Severinia buxifolia	thorn hedge
Smilax spp.	greenbriars
Suriana maritima	bay cedar
Thrinax microcarpa	thatch palm
Thrinax perviflora	thatch palm
Tournefortia gnaphalodes	sea lavender
Vitis spp.	grape vines
Yucca spp.	Spanish bayonets
Zamia integrifolia	koontee cycads

The list also shows that the shrubs and trees of the Southeast region are more diverse than in the other regions because they include both tropical-affinity plants and temperate-affinity plants. The list includes the small to medium sized trees present because along much of this coast no good distinction exists between the Forest zone and the Scrub zone. Where the dune field is wide, the sand pine (Fig. 30) commonly forms a forest; under the pines grow many Scrub zone shrubs and dwarfed trees (Fig. 31).

Fig. 30. Sand pine, two-needled with small, tight cones.

Some of the dune strand areas are flanked by mangrove swamps on the bay or lagoon side. The moving dune materials often cover some edges of these swamps, thus incorporating the black mangroves, white mangroves, and

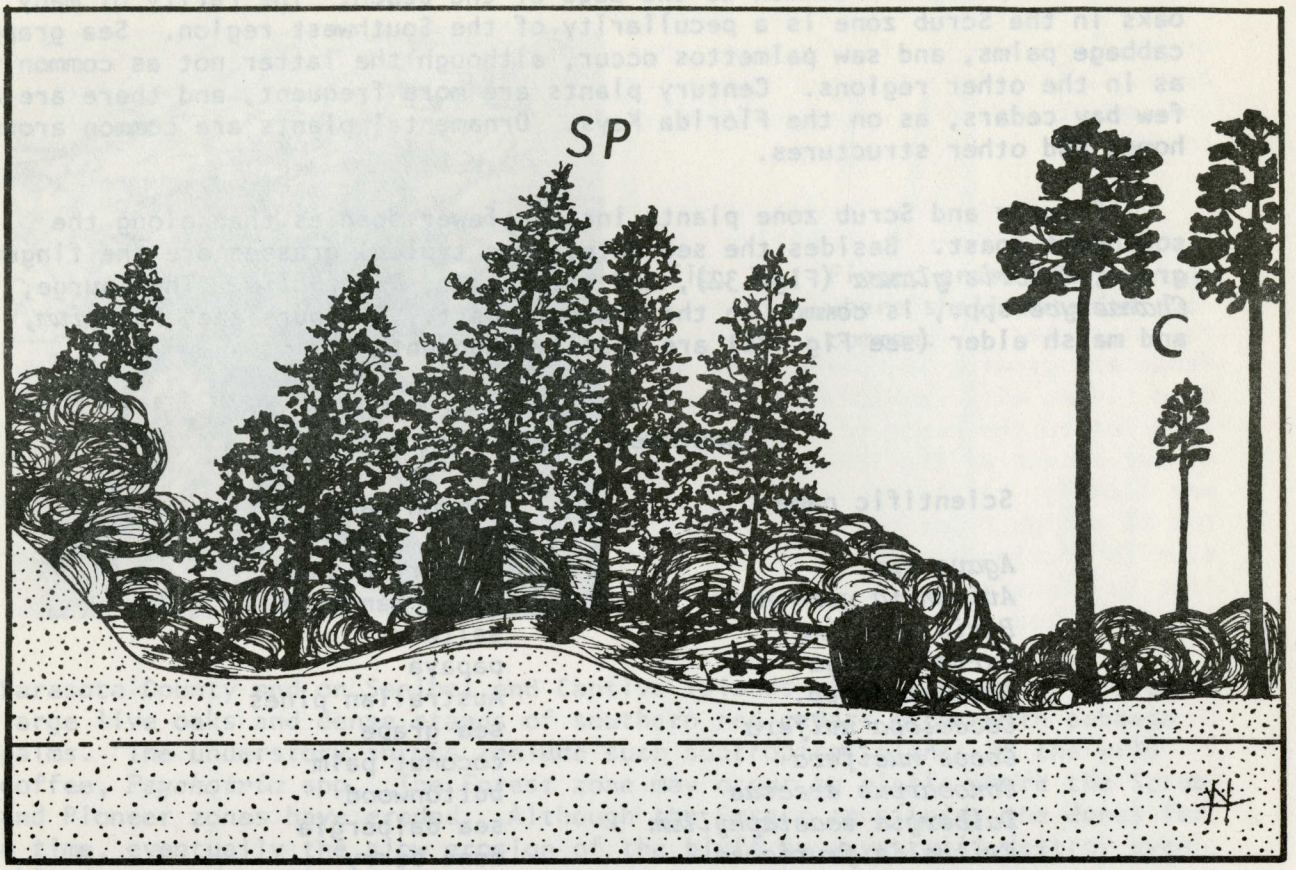


Fig. 31. Sand pine forest interior on old dunes near pine flatwoods. SP - sand pines; C - interior pine flatwoods.

buttonwoods into the dune Scrub and Forest zones. This condition is also common in the Southwest region.

Southwest Region

The main part of the Southwest region is from Marco Island and Cape Romano north along the coast to areas north of Pinellas County. This shore has light to moderate energy of waves, wind, and tide, and high dunes are not common. The beaches and dunes are abundant in places, and shell materials are common, for example on Sanibel Island. The calcium soil condition has promoted growth of such plants as cabbage palms and finger grasses. The region also includes the Cape Sable area beach strand and dunes at the southernmost tip of the peninsula.

Low fore dunes and lack of high dunes make the Pioneer zone wide, and no Scrub vegetation occurs for some distances along parts of this coast. Due to an abundance of bays and lagoons bordered by mangroves and the movement of dune materials into these, the buttonwood, black mangrove, and white mangrove are part of the Scrub zone in places. Many coconut palms occur,

especially on Cape Sable and planted as far north as Pasco County, and Australian pines are common to the edge of the beach. The rarity of many oaks in the Scrub zone is a peculiarity of the Southwest region. Sea grapes, cabbage palms, and saw palmettos occur, although the latter not as commonly as in the other regions. Century plants are more frequent, and there are a few bay cedars, as on the Florida Keys. Ornamental plants are common around homes and other structures.

Pioneer and Scrub zone plants include fewer species than along the southeast coast. Besides the sea oats, some typical grasses are the finger grass, *Chloris glauca* (Fig. 32), and salt grass, *Distichlis*. The spurge, *Chamaesyce* spp., is common in the southern part. The purslane, *Sesuvium*, and marsh elder (see Fig. 26) are locally abundant.

Southwest Scrub Plants

Scientific name	Common name
Agave spp.	century plants
Avicennia germinans	black mangrove
Batis maritima	saltwort
Carica papaya	papaya
Casuarina spp.	Australian pines
Coccoloba uvifera	sea grape
Cocos nucifera	coconut palm
Conocarpus erectus	buttonwood
Dalbergia ecastaphyllum	sea dalbergia
Erithalis fruticosa	dune berry
Ernodea littoralis	dune ernodea
Hibiscus tiliaceus	mahoe or sea hibiscus
Iva imbricata	marsh elder
Laguncularia racemosa	white mangrove
Melaleuca leucodendron	cajaput, punk tree
Nerium oleander	oleander
Opuntia spp.	prickly pear cactuses
Pinus clausa	sand pine
Rhus spp.	sumacs
Sabal palmetto	cabbage palm
Scaevola plumieri	beach berry
Schinus terebinthifolius	Brazilian pepper
Serenoa repens	saw palmetto
Severinia buxifolia	thorny hedge
Smilax spp.	greenbriar vines
Suriana maritima	bay cedar
Vitis spp.	grape vines
Yucca spp.	Spanish bayonets

Dune forests are few because old dune fields are not well developed. However, Forest zones are found on some islands of the Southwest region, especially on uplands of shell deposits on Casey and Manasota Islands of

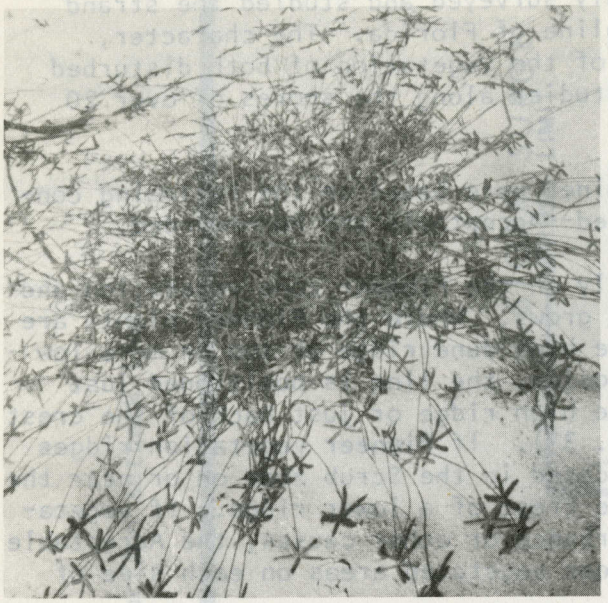


Fig. 32. Finger grass often occurs where shell material is common.

Sarasota County and on Sanibel and Captiva Islands of Lee County. In places large live oaks and dense stands of southern red cedars occur with cabbage palms. The understory shrubs include such subtropical plants as the wild coffee, *Psychotria* spp. The Forest zone may occur on bluffs where the Scrub and Pioneer zones have eroded. Although the Forest zone holds the dunes for a time, eventually the slow erosion of the bluff by waves will destroy even this forest vegetation.

The Forest zone has not been detailed in the regional descriptions above, but some species can be noted. The sand pine is a common tree forming forests along parts of the Atlantic coast. In some areas the longleaf and loblolly pines and live oak, magnolia, hickory, red bay, hackberry, and other hardwood trees form the Forest zone, especially in northern strands. The two common exotic trees, coconut palm and Australian pine, are common where planted or naturalized near the beaches as well as in the Scrub and Forest zones. The cabbage palm is the most common tree in all regions along the coasts.

The great abundance of forms and species of plants in all four regions offers many plant materials that can be used to restore old dunes and create new dunes. But few have been experimentally transplanted or grown in nurseries. More information about them is given in Part II.

How Vegetation Indicates the Setback Line

A significant example of the use of knowledge about how vegetation stabilizes the coastal strand is the establishment of coastal construction setback lines. A brief description of administrative procedures, regulations, and criteria is provided in a Marine Advisory Bulletin by James A. Purpura and William M. Sensabaugh (1974).

The State of Florida has thoroughly surveyed and studied the strand areas along almost all the outer shoreline of Florida. The character, density, position, and other features of the vegetation of both disturbed and undisturbed areas were carefully studied along the shores of over 20 counties.

The setback line positions determined were based on the following considerations for two lines being proposed--Acceptable and Recommended.

The Acceptable line is based mainly on the Pioneer zone vegetation and the character of the dunes on which it grows. Where the Pioneer plants are dense and growing well and there is one high dune ridge or two or more low dune ridges with few to no signs of erosion, the line is positioned just interior to the crest of either the one high ridge or just back of the crest of the second of the lower ridges (Fig. 33). If Pioneer vegetation ridges are lacking, the Acceptable line is located in the Scrub zone on or near the top of a high ridge or just back of the crest of a lower ridge. If vegetation is lacking because of human disturbance or other causes, the Acceptable line is located by interpolation between vegetated areas on each side of the disturbed area.

The Recommended line is located where vegetation is dense enough and has been established long enough to indicate good stability of the dune field. It is located where the storm surge would probably not reach for many years if at all. Usually this position is in the Scrub zone but may be farther inland in the Forest zone. This interior position is thus located where the zone of Scrub vegetation is disturbed and migration of sands and other soils is taking place.

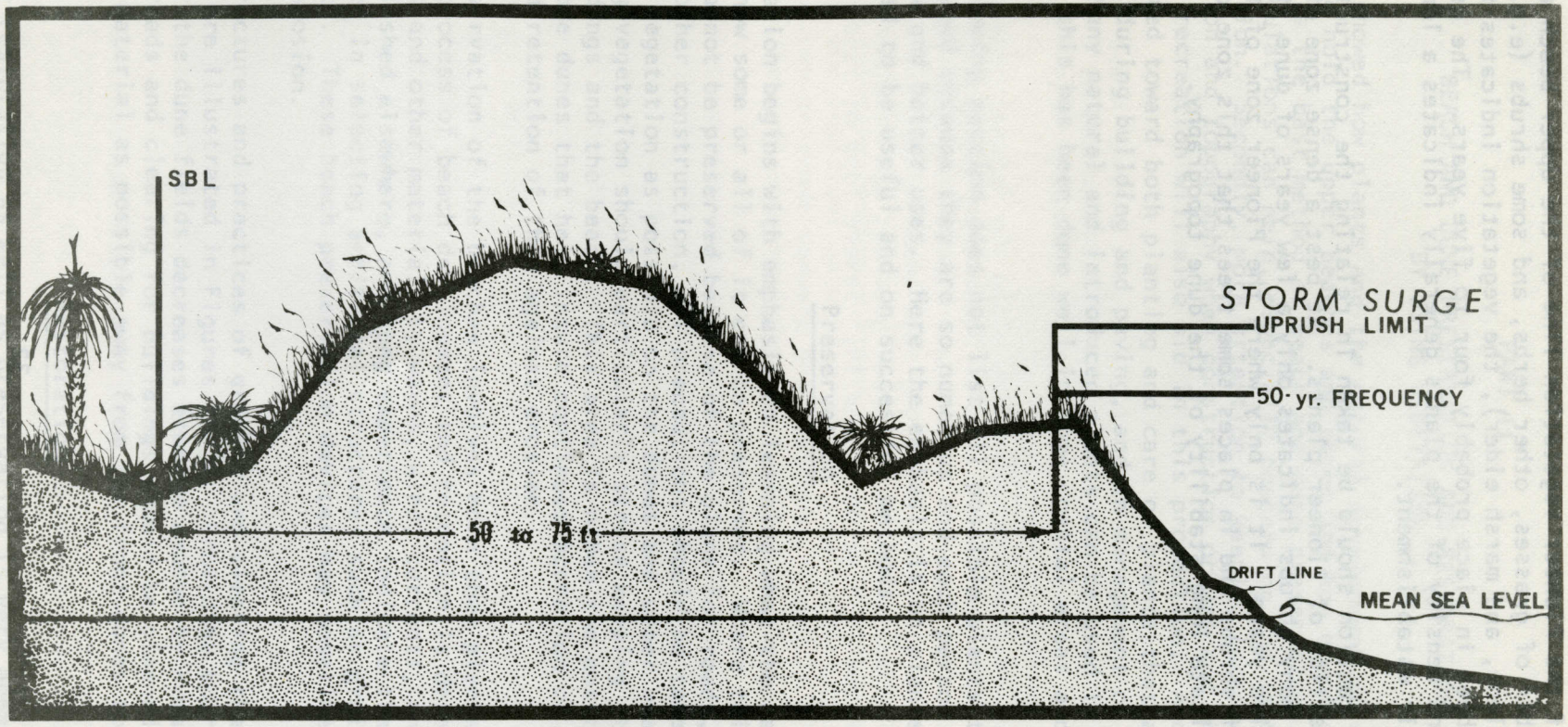
For many reasons the setback line should be related to the kind of vegetation because the plant cover indicates stability or lack of stability of the dunes. Favorable conditions of vegetation assure much protection against storm and other erosion factors.

Cautions Concerning the Age of Stability of the Vegetation Line

The presence of Pioneer plants, such as sea oats, sea rockets, railroad vine, other grasses and herbs, and some shrubs such as marsh elders, at or near the position of the reach of normal high tides cannot accurately indicate how long the sand and other depositions have been present and stabilized. This so-called "green line" or vegetation line may be the result of plant growth for only a few years or even months and does not indicate longevity of the plants in the area. This is because some plants grow rapidly on sands and other materials accumulated at these positions.

Generally only one or just a few plant species form the outer vegetation zone near the bare beaches if the vegetation line is young. Thus if only sea oats occur, the chances are that the area they cover is about two to three years old, in terms of presence of the plants, as this grass can attain full size and be densely arranged within this time. The sea rocket is an annual plant and grows to full size in a few months. Therefore, the rate of growth of the plants should be considered in estimating how long the deposits have been stabilized.

Fig. 33. Beach profile indicating Acceptable position of construction setback line.



SBL - The setback line suggested should be in the swale behind the high second dune ridge, which would not be topped by storm surge.

The fore dune profile shows the calculated height of storm surge in a northeastern coastal area.

The front Pioneer dune would be topped and destroyed probably within a 50-year period..

Usually if the Pioneer vegetation line of the upper beach and fore dune has a number of grasses, other herbs, and some shrubs (e.g., Spanish bayonets, purslane, and marsh elder), the vegetation indicates that the deposits have been in place probably four to five years. The greater number of kinds and density of the plants generally indicates a longer period of time of their establishment.

Therefore caution should be taken in relating the construction setback line to the position of Pioneer plants. At best a dense zone of Pioneer plants without many shrubs indicates only a few years of dune stability, about two to five years. It is only where the Pioneer zone of the fore dune has a number of shrubs and in places some trees that this zone can be considered to indicate long stability of the dune topography.

PART II

BEACH AND DUNE PRESERVATION AND RESTORATION BY USING VEGETATION

Part I showed how plants and the natural development of vegetation help form and hold the upper beaches and dunes and how keeping this vegetation intact is the best method of beach and dune preservation. Better laws and other regulations can help, especially concerning the setback lines for any construction. Secondly, more attention to keeping intact the natural dune vegetation and topography when construction occurs and when the areas are used for recreation will also aid in this protection. And more effort can be directed toward both planting and care of plants that are put into strand areas during building and paving, and in management of the areas developed. Many natural and introduced plants can be used in ornamental landscaping; this has been done well in some coastal areas and should be increased.

The following section does not list all possible plants that can be used and managed because they are so numerous and each person trying them will find new and better uses. Here the emphasis is on plants that have already proved to be useful and on successful methods.

Preservation

Preservation begins with emphasis on learning what the natural vegetation is and how some or all of it can be preserved. Where this vegetation absolutely cannot be preserved because of the plans for roads, parks, parking places, and other construction, all precautions should be taken to retain as much natural vegetation as possible on the dunes and upper beaches. Plans for retaining vegetation should particularly stress keeping it intact in the area between buildings and the beach. This area is often the position of Pioneer plants and fore dunes that help insure continued accretion of sand and other materials and retention of them against erosion.

The preservation of the beaches involves more than plants and vegetation. Much of the process of beach development and retention is dependent on movement of sands and other materials by waves, wind, currents, and tides. Many studies, published elsewhere, and long experience indicate that much more care is needed in selecting artificial structures such as groins, sea walls, and revetments. These beach preservation devices may sometimes actually cause beach erosion.

Some structures and practices of grading and clearing that can help in preservation are illustrated in Figures 34-36. Providing board and other walkways over the dune fields decreases erosion caused by human action. Grading for roads and clearing for buildings should be planned to move as little earth material as possible away from the front dunes toward the rear.

Restoration

Need for restoration as well as preservation is very apparent because

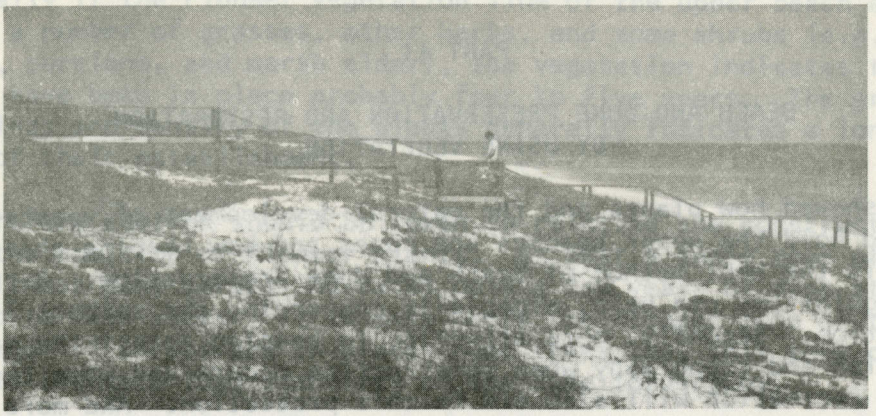


Fig. 34. Good example of board walk between house and beach to prevent erosion caused by people walking over the dunes.

in Florida there are now about 105 miles along the Atlantic coast and 145 miles along the Gulf coast where loss of beach area has occurred due to critical erosion and other causes. Significant losses have been due to the poor placement of groins at inlets and along some beach areas, sea walls too close to the reach of normal tides on the upper beaches, and revetments and other structures, as shown in Figures 13 and 14. Severe loss of land to the sea is shown in Figure 37.

Fig. 35. Well constructed board walk across a dune field that has been improved with plantings.

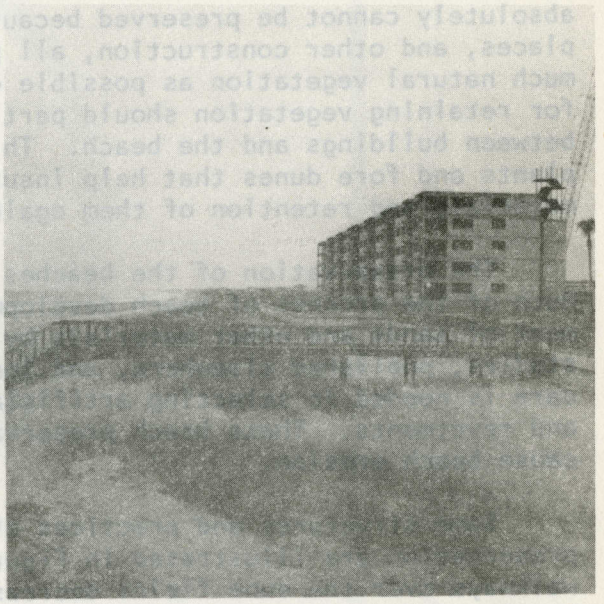


Fig. 36. New construction well positioned behind the second dune ridge with a retaining wall and board walk to the beach.

Fig. 37. Beach loss so severe that trees collapse and houses are undercut.

Some beach area loss is due to the failure of replenishment from the dune fields back onto the beaches. Steep scarp walls are cut into the dunes by storm surges, and insidious natural wind and wave actions cause these scarps to slump down or erode seaward onto beaches. There is little or no replenishment of the sand and other materials onto many of the upper beaches.

State and other agencies and local governments and even private efforts will probably continue the use of mechanical methods and structures to protect and renourish beaches, and some efforts will be more effective than in the past. However, adding beach materials to depleted areas is seldom permanently effective unless fill materials pumped or graded onto beaches are stabilized by plantings or natural plant growth.

In Florida few public or private attempts have been made to create fills by fencing or to make extensive and long term plantings. The most consistent attempts to restore dune topography and extend it back onto beach areas have been on Amelia Island, Nassau County, on property developed by the Amelia Island Plantation Company. The area was recently much damaged by northeast storm action that cut wide, deep gaps into the dune field that originally had high dunes well covered by both Scrub and Forest zone plants (Fig. 15). Sand fences and some filling by moving upper beach sand with machinery have been used effectively. A number of plantings of different grass varieties have been successful. Persons who plan to make plantings would do well to visit such sites. Much of the discussion below is based on the Amelia Island experience.

Fills and Methods

Fills made directly onto the lower and upper beach areas are becoming a more common practice. Some methods are dredge-pumping and by earth moving machinery. Where fill materials are placed above the usual storm surge and

high tide, the plantings can and often should be made on the new material to stabilize it.

Dune Area Fills

Concern here is mainly with (1) fills made in dune areas back from the beach by means of sand fences of wood slats or brush, and (2) fills made by earth moving machinery. With both methods the fills are only preliminary to permanent establishment of restored and new areas of upper beaches and dunes. It is first necessary to study the areas carefully to determine if the position selected for such fills will nurture continued replenishment of materials and plant growth. For optimal restoration the old configuration of the dunes before erosion should be known and duplicated. However, along some coasts the location of such former positions is difficult or impossible to estimate because no record of them was made, especially in areas of rapid alteration by construction activities. In such places fill positions can be partly determined by studies of dune lines adjoining both sides of the depleted areas.

An instance of partly successful fill planning with vegetation restoration is found along the coasts of the Outer Banks north of Cape Hatteras, North Carolina (see Davis, 1957). Here ridges of material were graded for miles. At the position of the fore dunes adjacent to the beach, plantings were made on both faces of the ridges by using grasses native to the region. Some of these have held for many years once the plants were well established as a dense vegetation cover.

Fills can also be made by the use of wind retarding structures that are slat or brush fences. The prevailing winds and some high waves move the materials against such structures, with deposition in front of and behind them. Rate of accumulation depends much on the fence position and on the amount of material carried by wind and waves. Figures 38-40 illustrate sand deposition around both slat and brush fences.

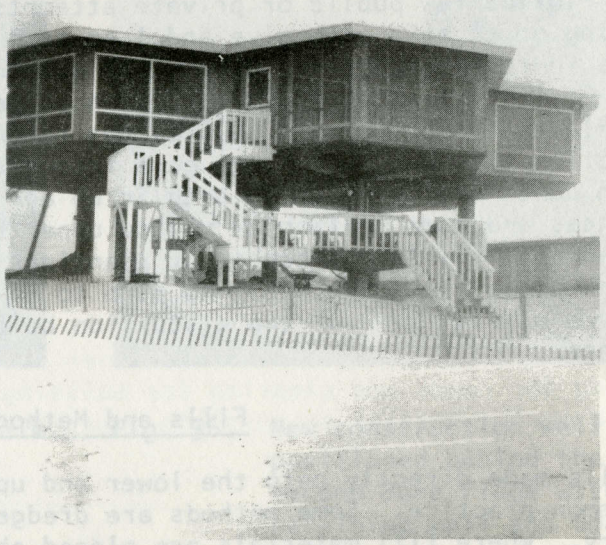


Fig. 38. Use of slat fences to build dune in front of house that is appropriately constructed on stilts.

Fig. 39. Two rows of slat fences, the outer straight and the inner undulating, help sand accumulate rapidly.

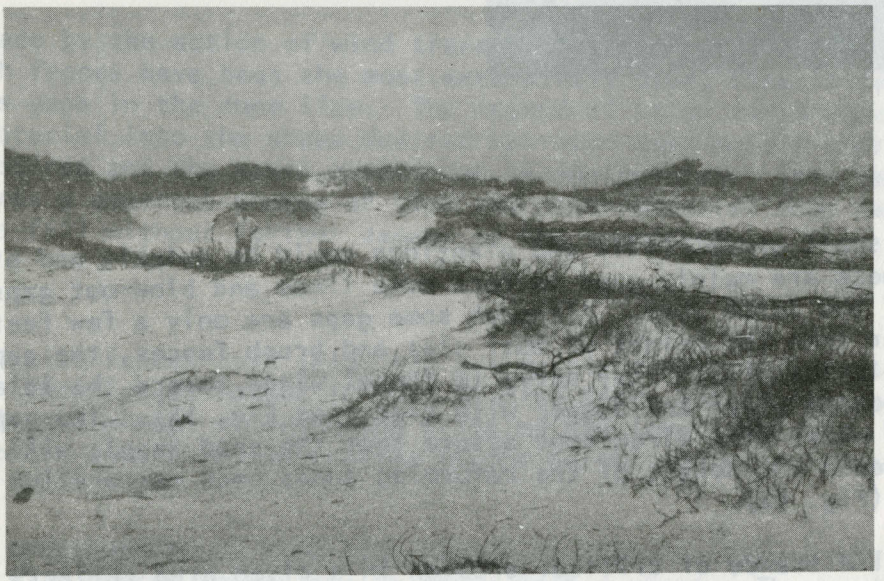


Fig. 40. Three rows of brush fences help close gap in eroding dune field.

Beach Area Fills

Now that some shorelines are being changed due to renourishment by pumping and other fill methods (Fig. 41), it is important to study the effect of widening beaches. Also, fill is now commonly placed on both sides of inlets flanked by groins and jetties. Some of this new land, such as that found in the Jupiter Island Beach Nourishment Project and the area between the Ft. George Inlet and the mouth of the St. Johns River in Duval County, is extensive. Some places are suitable for making dune ridges and plantings of appropriate vegetation on a large scale.

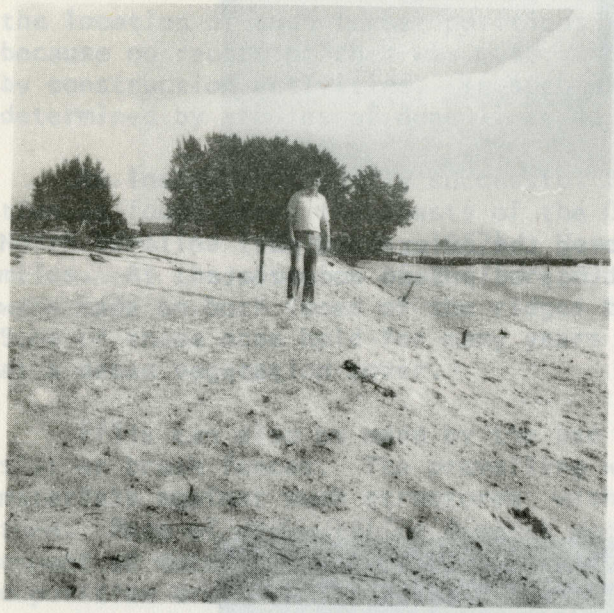


Fig. 41. Man-made fill, not stabilized, will erode without vegetation.

Repairs

In many small areas, fills and plantings could be quickly and efficiently employed. These are mainly gaps in fore dune lines and blow-out gaps in the back dunes of the Scrub zone. Although some gaps are only a few feet across and not deeper than the height of most slat and brush fences, the gaps are bad topographic features. They serve to funnel winds toward the inland areas and tend to become wider and deeper with time (see Fig. 15). The gaps usually occur where wind directions assure that the sand supply will continue to increase the height of the reforming dunes once restoration methods are employed (Fig. 42).

The total distance of critical erosion in a given area reflects a compilation of short gaps plus some long reaches of beach erosion. Where long reaches of depleted beaches are not involved, the reforming of dunes can be done by private enterprise of the land owners or project developers. Small-scale efforts would probably be successful and could draw on the results of larger-scale projects such as nurseries for raising appropriate dune-holding plants.

Fig. 42. A sand fence used to fill a gap in the fore dune line is now almost completely covered by sand. Sea oats are well-established after two years.

Where long stretches of critical erosion occur, sometimes caused by sea wall and revetment construction, large-scale cooperative efforts are needed in forming and stabilizing dune topography. Many counties badly need to practice forming and stabilizing methods over many areas. Extensive loss of beach material has occurred in southern Duval County, also in Brevard, Bay, and Okaloosa Counties. The method of fills and plantings cannot be used to restore beaches so narrowed that they are covered by full tides.

Fills made by the action of wind transporting the materials against wood slat or brush fences have been the most extensively used, especially for small areas such as gaps in the dune line. The method of using earth movers and piling the material into the shape desired has been used mostly where long ridges are desired and the earth movers can be manipulated. This earth moving method requires a generous source of sand and other material that can be borrowed for the fill without further damage to the topography.

Slat Fences

The wood slat fences used (Fig. 43) are mainly commercially available snow fences. Their usual height is four to five feet, but in some places this height is not enough to bring the fills up the level desired. Where necessary, fences should be constructed to the height and other dimensions desired.

General construction of wood slat fences is shown in Figure 43, with one by four inch slat boards spaced two to three inches apart. The wood material can be whatever is available and need not be long-lasting, because once sand accumulates around the fence, the slats and posts can rot with no harm done. Different dimensions of slats and openings should be tried for optimal effectiveness. Wider openings allow more sand to accumulate behind the fence,

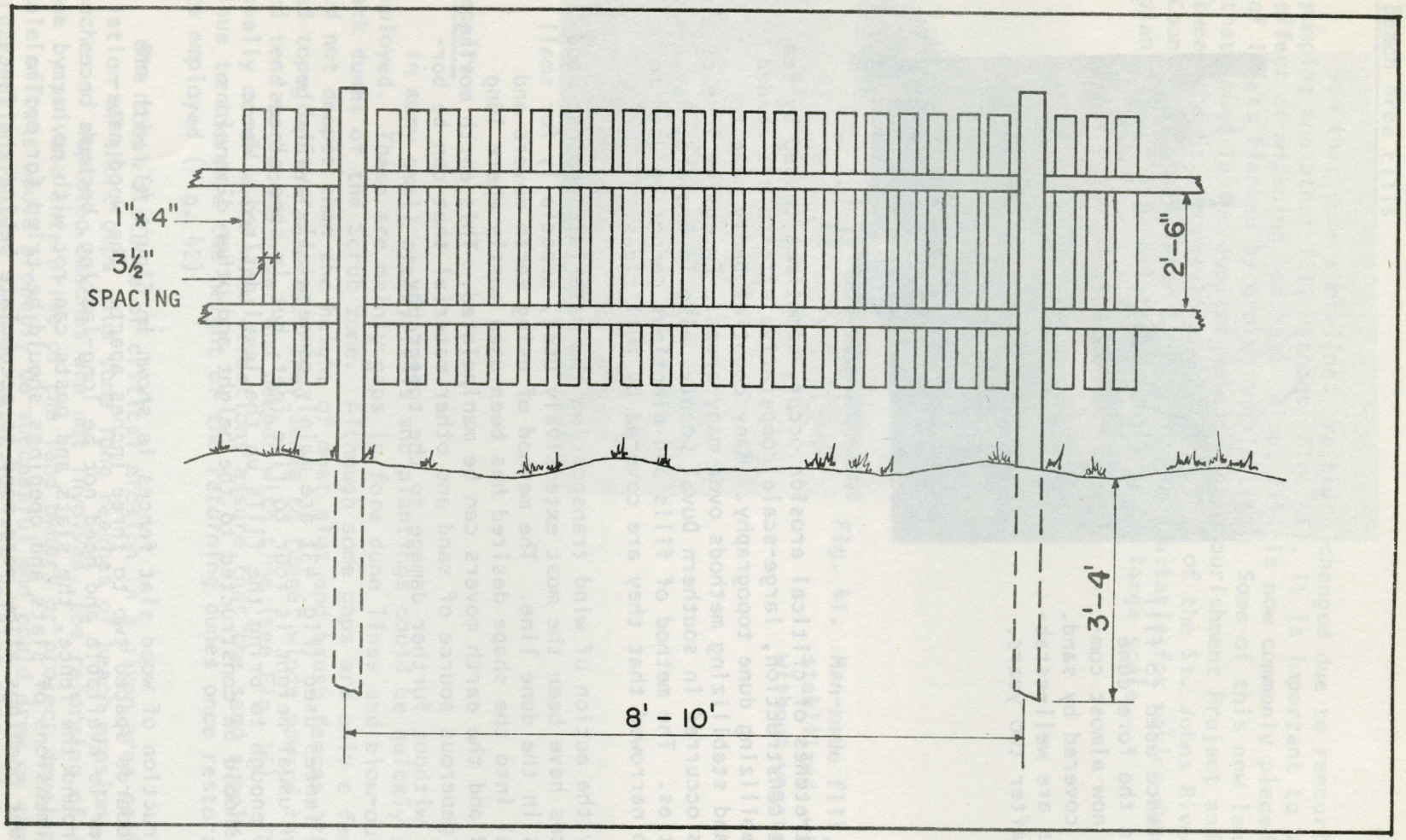


Fig. 43. Wood slat type of sand fence, often sold as snow fence. Equal width of slats and openings between slats is the usual spacing, although effectiveness can be varied by making the openings wider or narrower. Fence height depends on the height of fill desired, with four to five feet being usual.

whereas narrower openings allow more rapid sand build-up.

Where the fence footing cannot be well stabilized against wind and sand action, longer anchor posts are needed. The posts should be strong enough to withstand winds and the weight of the accumulating sand, although the post material need not be long-lasting. The distance between posts can be over 10 feet if the posts are strong, but too great a distance would allow too much flexibility in the fence, hence less sand build-up.

Brush Fences

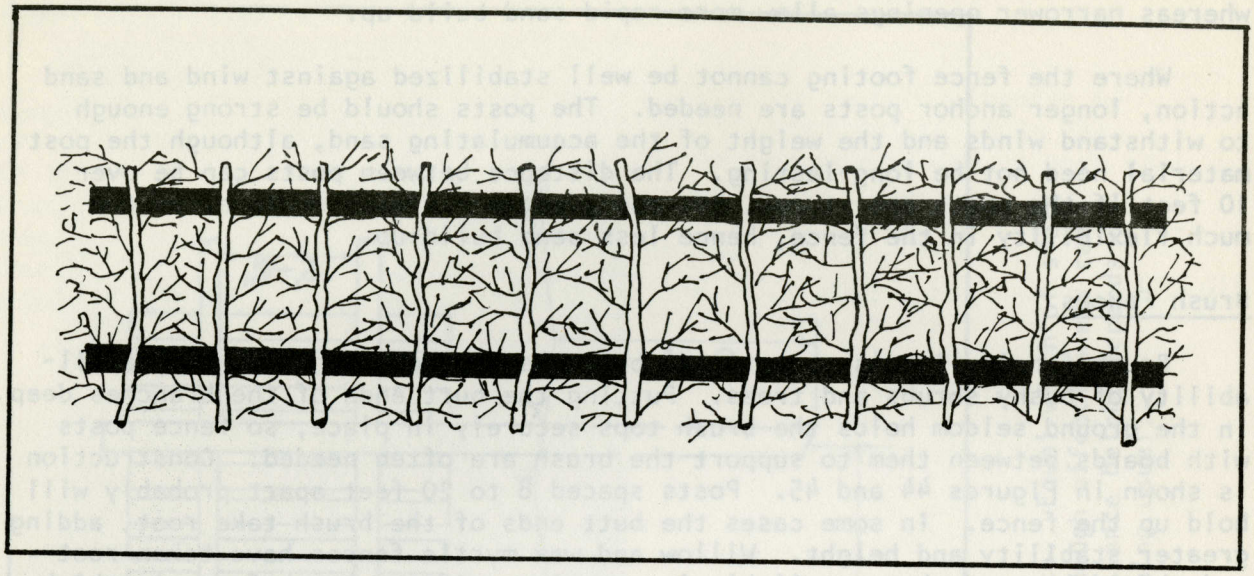
Brush fencing is also practiced, but this depends upon the ready availability of bushy shrubs and trees. Putting the butt ends of the branches deep in the ground seldom holds the brush tops securely in place, so fence posts with boards between them to support the brush are often needed. Construction is shown in Figures 44 and 45. Posts spaced 8 to 20 feet apart probably will hold up the fence. In some cases the butt ends of the brush take root, adding greater stability and height. Willow and wax myrtle fences have taken root and should be used where available in quantity. If the brush fence is thick, it will accumulate sand better than slat fences and allow a more rounded, natural-contour accumulation of sand. This type of fence can more easily be made to the height desired. Also, where bushes for making brush fences are abundant and labor not too expensive, they cost less than commercial slat fences.

Arrangement of Fences

The arrangement of the fences is very important. To establish a long fore dune near the upper beach, fences should be placed parallel to the primary dunes present in the vicinity and somewhat parallel to the drift line berm of the upper beach. The position should be far enough back of the upper beach that winds can move an adequate supply of sand inland and against the baffles of the fence. If Pioneer plants are growing in rows near the upper beach, the fence should be placed to prevent burial of the plants by sand deposited against the fence. This careful positioning was used for long fences of the Amelia Island project (Fig. 46, also Figs. 39 and 40).

Interior from the long fence and relatively parallel to the beach, especially where the dunes have been eroded, it is often advisable to arrange fences to build fills and help reform dune topography. Such fences should in most cases be placed so that they are across the direction of the prevailing onshore and storm winds; often this direction is not at a right angle to the beach. In Florida this is particularly true of the northern parts of the Atlantic coast where northeast high winds frequently occur. Here the fences are best placed in a northwest-southeast alignment (Fig. 47).

However, in many areas offshore and onshore winds shift in direction, and fences should be placed so that they obstruct winds from all directions. The arrangement found to be best for this purpose is a diamond shape, the size of which should vary with the specific conditions. The object is to trap sand all the way across the diamond enclosure; thus size will depend on the force of the winds and how well the sands and other materials are baffled and deposited around and behind the fences.



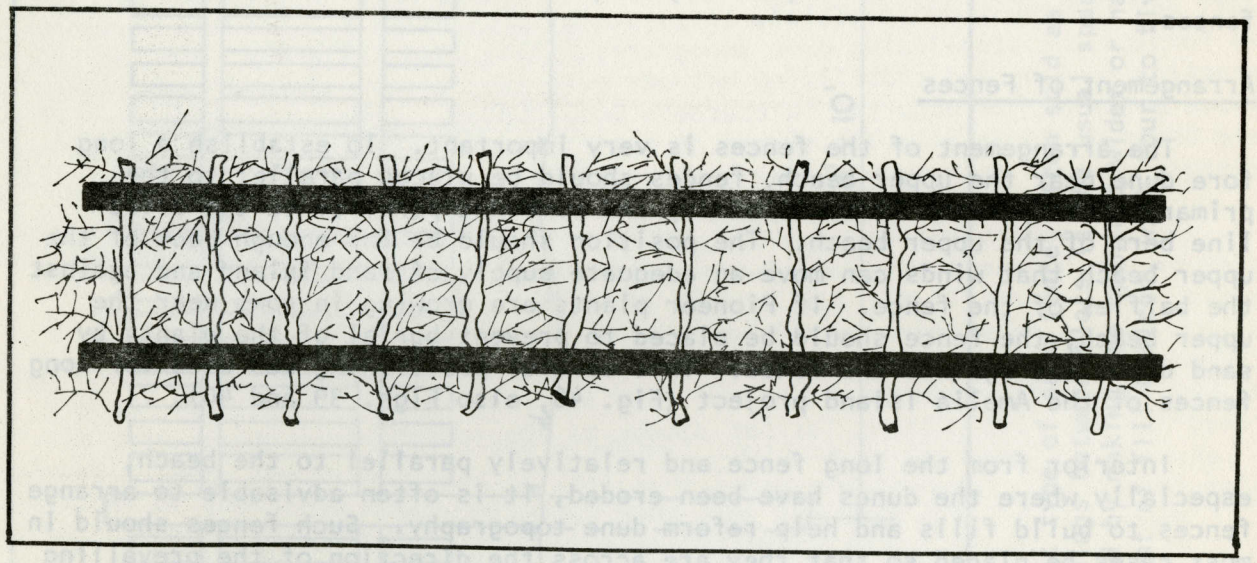


Fig. 44. Brush fence construction.

Top--Place brush on two rows of boards.
Bottom--Place two more rows of boards on top of the brush.
Tie or nail together the two sets of boards.

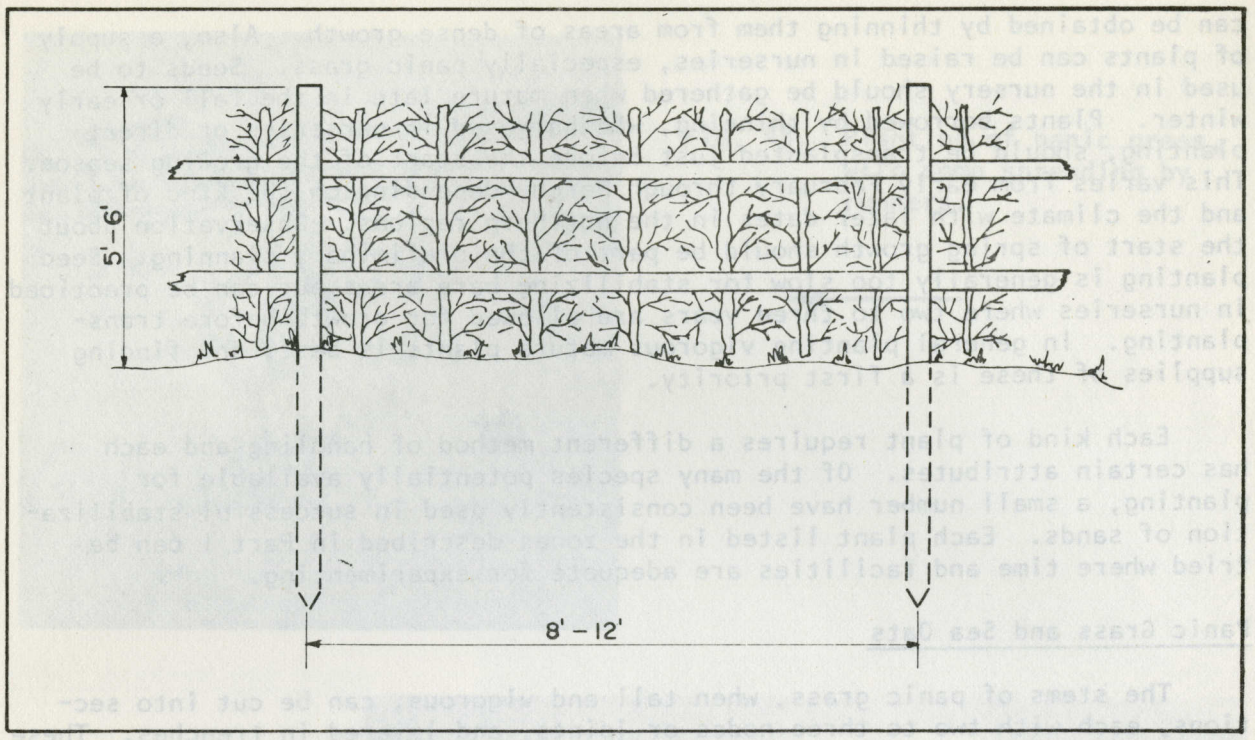


Fig. 45. Finished brush fence with long anchor posts.

Slat or brush fences can be used on fills along the upper beach in conjunction with plantings or without plantings if grasses are abundant near the fills and can grow onto them. Figure 46 illustrates this on Amelia Island. The fences should not be so high that sand would accumulate around them more rapidly than the growth rate of the plants. Sand fences can also be located on artificial fills to add to the amount of accumulating materials; this should be done more in gap and blow-out areas of dune fields.

Plantings

Plantings have been made successfully on fills made by sand fences and by earth movers and usually in areas of low dunes of the Pioneer zone. Many were done over bare sand areas where no natural grasses occurred, but some of the best plantings have been placed between widely scattered remnants of the original growth.

A general design for planting depends much on where the fill material or bare sand areas are located. If a supply of sand will probably be moved in by wind as the plants grow, the plantings should be closely spaced to catch the sand. Where little movement of sand is indicated, wider spacing of plants should be planned as the growth will gradually fill in the area.

It is important to estimate the amount of plant material needed for the job based on number per acre and to be sure that the necessary plants

can be obtained by thinning them from areas of dense growth. Also, a supply of plants can be raised in nurseries, especially panic grass. Seeds to be used in the nursery should be gathered when mature late in the fall or early winter. Plants borrowed by thinning, whether used in nurseries or direct planting, should be transplanted just before the start of the growing season. This varies from early February through March, depending on the kind of plant and the climate with later dates in the northern regions. Observation about the start of spring growth should be part of the preliminary planning. Seed planting is generally too slow for stabilizing bare areas but can be practiced in nurseries where two to three years are allowed for growth before transplanting. In general planting vigorous mature plants is best, and finding supplies of these is a first priority.

Each kind of plant requires a different method of handling and each has certain attributes. Of the many species potentially available for planting, a small number have been consistently used in successful stabilization of sands. Each plant listed in the zones described in Part I can be tried where time and facilities are adequate for experimenting.

Panic Grass and Sea Oats

The stems of panic grass, when tall and vigorous, can be cut into sections, each with two to three nodes or joints, and layered in trenches. These will take root and grow rapidly, especially in nurseries where fertilizer and

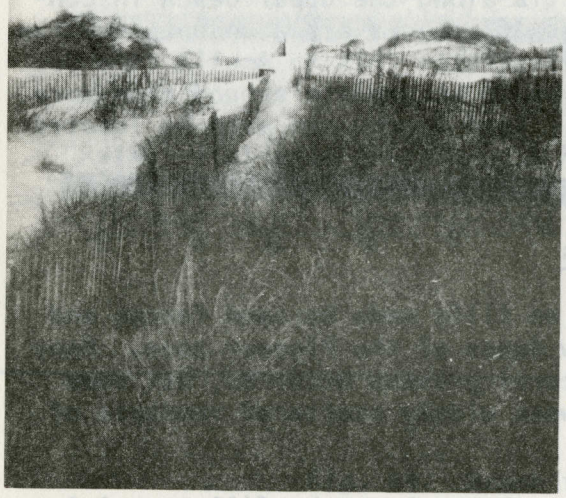


Fig. 46. Arrangement of sand fences to protect and encourage panic grass growth.

Fig. 47. Sand fences positioned across direction of prevailing wind, also some plantings in this eroded dune field.

Fig. 48. Planting of panic grass, with some spreading by runners.

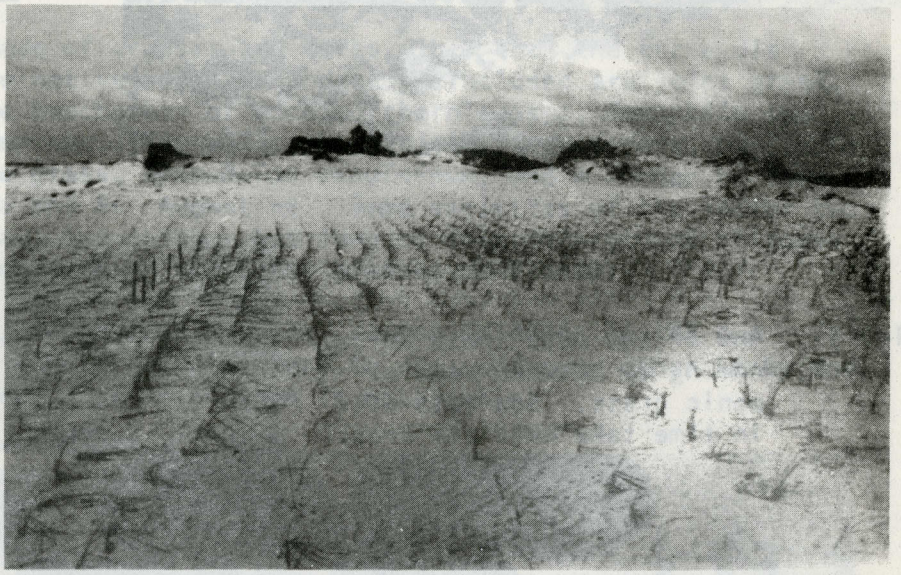


Fig. 49. Planting of panic grass by layering in rows on flat area of shifting sand.

water can be supplied. When transplanted they can again be layered in trenches (Figs. 46, 48-50).

The sea oats have grown best where sprigged into holes. If long rhizomes join the culm tops, the rhizomes can be cut to make more plant tops. Usually the leaves of the tops should be cut back some to reduce transpiration loss of water. Young seedlings can be used if large enough to have good root systems six to nine inches deep (Figs. 19-20 and 42).

Often where plantings of panic grass were made with sea oats nearby, the sea oats invaded the planted areas and thrived because the young seedlings were protected by the panic grass (Fig. 51). In time the sea oats, which are

more desirable because of their better rhizomes and root systems, tend to replace panic grass.

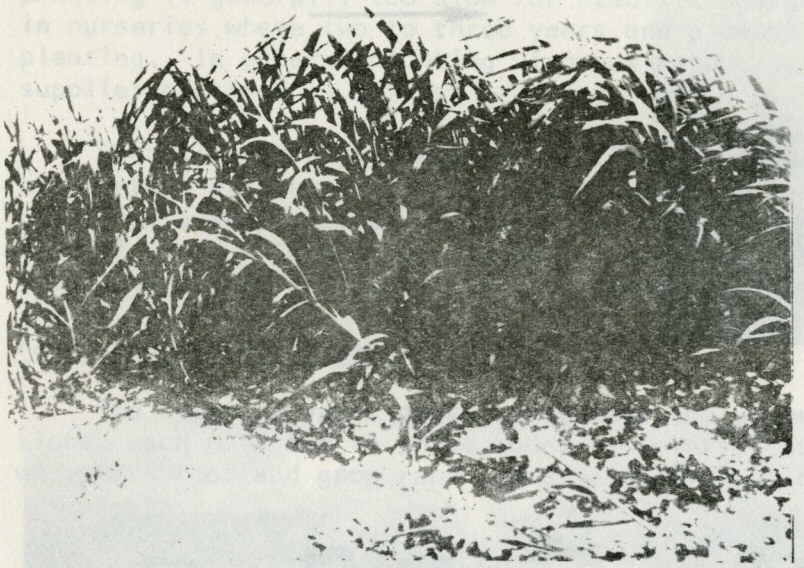


Fig. 50. Dense panic grass, layered in rows two to three years previously.

Fig. 51. Row of sea oats (note arrow) coming up between rows of panic grass. Sea oats will in time take over the area.

Cordgrass

The small cordgrass is often obtainable in low swale areas and can be transplanted to holes spaced as desired. When vigorous, these plants often spread rapidly and densely to form a single species plant cover (Figs. 5, 10, and 52).

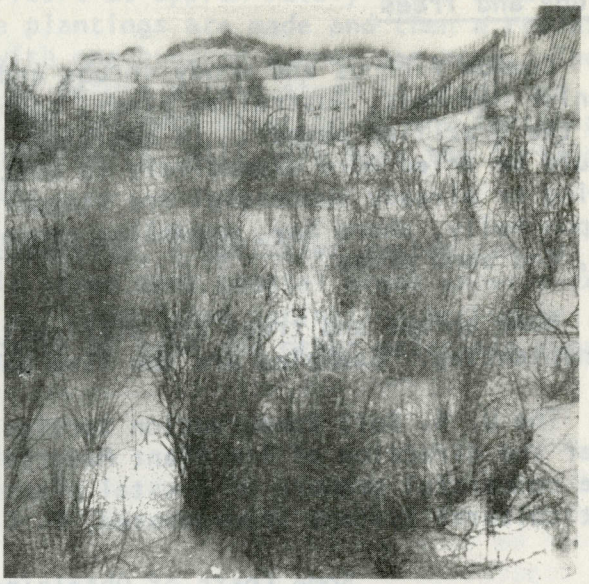


Fig. 52. Two year old growth of small cordgrass, sprigged in.

Other Grasses and Herbs

Use can also be made of grasses and herbs other than the three discussed above. Some are native, some introduced. Included are joint grass, *Paspalum vaginatum*, the beachgrass of more northern coasts, *Ammophila* spp., the sand-spurs, *Cenchrus* spp. (Fig. 53), the African finger grass, *Digitaria macroglossa*, a dropseed grass, *Sporobolus virginicus*, and a number of lawn grasses such as Bermuda and St. Augustine. Some varieties of the latter two can withstand salt spray, but neither has long or deep underground rhizomes to hold the sands, as do some of the other grasses mentioned.

The low sunflower, *Helianthus debilis*, common on dunes in the two southern regions, is a good ornamental herb to use, and many other herbs and shrubs can be tried where a stock of them is obtainable.

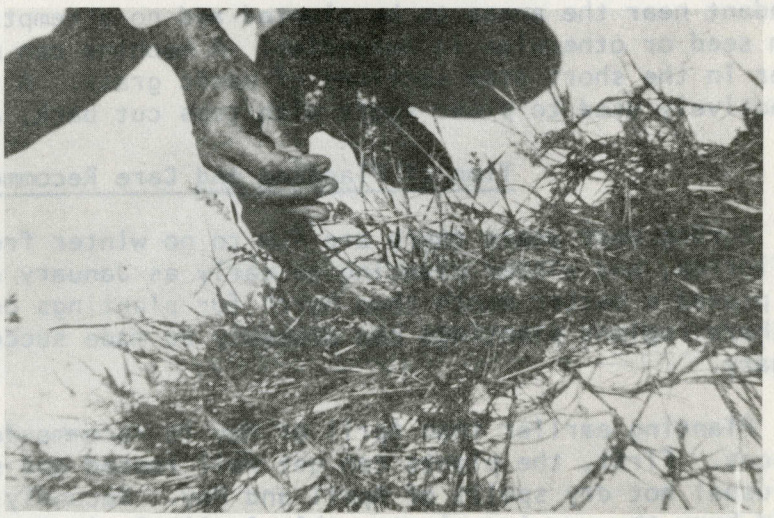


Fig. 53. Sand-spur, often found on Pioneer dunes but not easily handled or transplanted.

Shrubs and Trees

Common fibrous and woody shrubs and trees used successfully are: Spanish bayonets, Australian pines, cabbage palms, coconut palms, sea grapes, and the Brazilian pepper. In addition, the marsh elders and wax myrtle should be tried more extensively in northern areas. Other plants worth trying or already successful are stagger or hobble bushes, wild olives, yaupon holly, shore bay, magnolia, groundsel bushes, century plants, oleander, and sand pines.

Some shrubs and trees are difficult to handle and do not well survive transplanting. Examples are the live oak and saw palmetto.

The U. S. Soil Conservation Service conducts some plant experimentation under the direction of its Plant Materials Center, Brooksville, Florida. Some commercial growers of coastal plants can also be contacted, such as Horticultural Systems Incorporated, P. O. Box 3, Bradenton, Florida 33506.

Some Costs of Obtaining Plants and Planting

Much of the cost of obtaining and planting appropriate plants depends on such factors as the availability in quantity of the plants desired, the labor and other costs of handling them directly into dune areas and in nurseries, and the care of the plantings made. Costs of obtaining and handling the common species such as sea oats, small cordgrass, and panic grass can best be estimated by contacting persons experienced in their collection and handling. Total cost for the nursery and the plantings on dune areas of the Amelia Island Plantation project has been about fifty-seven thousand dollars for the three year project that has included about five to six acres of a nursery and over forty acres of the dune area planted. This expense might be unrealistic in areas where rapid and successful results are urgently needed.

Labor costs will be the main item in areas where native grasses are abundant near the areas to be planted and no attempts are made to grow plants from seed or otherwise in nurseries. A machine can make shallow trenches to layer in the short stem sections of panic grass. A spade or shovel can be effectively used to plant roots with tops cut back, as with sea oats.

Time of Planting and Care Recommended

During most years there are few to no winter freezes along the coasts of Florida, and winter planting as early as January can be done. February has proved a better month than March for plantings on Amelia Island. In southern regions plantings can probably be made successfully in December and January.

Planting earlier than April or May is recommended in all areas for two reasons. First, the plants can get well rooted and start top growth before the usual hot dry spells of April and May. Secondly, sand blown by high winds could bury the growing plants; this is likely in April and May.

Some fertilizing of plantings can be done by using 8-8-8 or 16-8-8 pellets or granular commercial fertilizers at approximately three hundred pounds per acre a few weeks after the plantings are made and then a repeat fertilization after about six weeks with one hundred pounds per acre. The time for fertilizing should not be just before a rain storm is predicted in order to avoid loss of effect through too much dilution of the fertilizer. Light watering, if it can be done economically, will help make the fertilizer more available to the plant roots.

Where water is available and inexpensive, a sprinkler system can be used to aid rapid growth, particularly since many coastal areas experience dry periods during April and May. A well-regulated sprinkling method is best; overwatering can cause some erosion of sand and other materials away from the plants.

SUMMARY AND SUGGESTIONS

It is not the purpose of this publication to review all the methods of coastal protection and restoration but to emphasize one that has been neglected. This is, as considered briefly here, the method of using the agency of plant life in terms of the natural vegetation and plantings. Many other methods, such as artificial nourishment of beaches, are generally used and partially effective. The methods suggested here should be more widely recognized and used by individuals and government agencies at all levels. More permanent retention of the coasts by keeping the vegetation in place is the first priority for every part of the shoreline, and the second priority is restoration by fills and plantings. Both of these can be better done than previously. The need is recognized, the methods need emphasis.

Part I shows the role of vegetation as the natural agency to contain and direct some of the forces of nature and use them to build and hold the beaches and dunes. The present emphasis and some laws related to regulation of construction and other use of strand areas should include more definite rules about retaining and improving this natural vegetation. It should be consistently the purpose of state and other regulations to keep the vegetation of the dunes and upper beaches primarily intact. This requires priorities not yet adequately recognized or enforced. One such priority is that the condition of the vegetation be considered in establishing a setback line for construction and similar uses of coastal areas.

Part II offers suggestions for use of sand fences and other methods of making fills and for use of plantings onto bare areas to restore vegetation. Private enterprise and county and state agencies might obtain better results by funding such projects than some of the more expensive renourishment methods. Of course, both plants as well as mechanical means of restoration can and should be used at the same places.

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