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COASTAL DUNE AND VEGETATION CHANGES ALONG THE MARTIN COUNTY, FLORIDA COASTLINE FROM 1974 THROUGH 1981

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Abstract. **A study was conducted during 1974, 1975, and 1976 and updated in 1980 and 1981, to determine coastal dune changes and plant succession at the Hobe Sound Wildlife Refuge in Martin County, Florida. Fifty-three sites were studied in detail along a 5.6 kilometer stretch of coastal dunes.**

Results indicate that beach morning glory, *Ipomoea pes-caprae* (L.) Sweet, bitter panicum, *Panicum Amarum* Ell., cucumberleaf sunflower, *Helianthus deblis* Nutt., sea oats, *Uniola paniculata* L., sea purslane, *Sesuvium portulacastrum* L., seashore elder, *Iva imbricata* Walt., and seashore paspalum, *Paspalum vaginatum* Swartz., are the most important plants to use in revegetating coastal dunes. They are also the first plants to become established on newly formed coastal dune soils.

Results also indicate that Australian pine, *Casuarina equisetifolia* L., generally occurs as a dominant plant on areas of dune erosion. Thick stands produce dense shade and sufficient plant litter to prevent growth of shrubs, grasses, herbs, and vines that help reduce erosion.

The Atlantic Ocean shoreline of Florida is 805 kilometers long with coastal dunes and beaches occurring along the 618 kilometers of shoreline. Dunes and beaches are valuable assets and are prime areas for recreation and development. In 1973, the U.S. Army Corps of Engineers (6) reported that 241 kilometers of the 618 kilometers of beach and dune have erosion problems. This problem is severe near almost all urban areas including Martin County. As documented by Davis (3), much of this erosion is caused or accelerated by inadequate vegetative cover on coastal dunes.

In 1974, the Department of Interior asked the United States Department of Agriculture, Soil Conservation Service (SCS) for assistance in controlling coastal dune erosion at the Hobe Sound Wildlife Refuge in Martin County, Florida. Erosion was damaging sea turtle nesting sites and destroying the fragile coastal dune ecosystem. Initial efforts to establish native coastal dune plants were largely unsuccessful due to severe erosion caused by wave action from northeast storms. A detailed study was then designed to find suitable plants and locations for revegetating dune areas. The initial study was started in 1974 and completed in 1976 and the results published by Craig (1) in 1977. In 1980 and 1981 the study was updated to see if the initial results were still valid.

Materials and Methods

A study was conducted during 1974, 1975, 1976, 1980, and 1981 on coarse textured, well drained, coastal dune soils located at Hobe Sound Wildlife Refuge in Martin County, Florida. The 1980 and 1981 study updated information previously published by Craig (1). Fifty-six permanent sites were originally located along a 5.6 kilometer stretch of coastal dunes. Three of these sites were omitted in the 1980 and 1981 study because they had been modified after 1976 by the construction of a rock sea wall. The sites were evenly spaced and had a history of both erosion and deposition. Permanent markers were established inland at each site as reference points for site location and measurement points.

Vegetative studies were made at each of the 53 locations during the winters of 1974, 1976, and 1980 and the summers of 1975, 1976, 1980, and 1981. Information was obtained along a transect from the first vegetation above the water inland to the permanent markers, which were generally located in the shrub and forest zones. The items recorded were dominant and minor vegetation and distance from the permanent marker to the first vegetation inland from the ocean. Unknown plants were identified by University of Florida Herbarium personnel.

The individual studies were then reviewed with special consideration given to plant succession in relation to dune types and dune changes over the 6-year study period.

Results and Discussion

Dune Profile Changes. Dune changes were determined by the distance measurements from the permanent marker to the first vegetation inland from the ocean. The 53 sites were divided into 3 groupings: (1) Erosion, (2) Variable and (3) Deposition. Erosion sites had lost soil and deposition sites had gained soil at each of the measurement and study periods. A few sites moved into another group from 1976 to 1981. However, the percentages of sites in each group remained relatively constant. Twelve percent, rather than 18 percent of the sites were classified in the erosion group, 48 percent, rather than 43 percent in the deposition group, and 40 percent rather than 39 percent in the variable group.

Erosion sites averaged losing 7 meters of land but some lost as much as 11 meters by the end of 7 years. Deposition sites gained an average of 7 meters of land and as much as 12 meters by the end of the 7 years. This shows that the width of coastal dunes at the Hobe Sound location, changed rapidly in a relatively short period of time.

Table 1. Percentage of dominant plants at start (1974) and end (1980) or study period by dune types.

Dominate plants	Total	Erosion	Variable	Deposition
Casuarina equisetifolia L.	54-63	57-86	60-67	48-52
Coccoloba uviferal (L.) L.	4-0	z	z	9-0
Distichlis spicata (L.) Green	0-2		–	0-4
Helianthus debilis Nutt.	0-4	z	–	0-9
Ipomoea pes-caprae (L.) Sweet	4-2	z	4-0	4-4
Iva imbricata Walt.	44-48	14-29	48-22	42-57
Panicum amarum Ell.	12-4	–	8-4	20-4
Paspalum vaginatum Swartz	15-13	–	16-20	20-9
Rhizophora mangle L.	10-6	29-14	4-8	–
Scaevola plumieri Vahl.	8-2	–	8-0	9-4
Schinus terebinthifolius Raddi	0-2		0-4	z
Serenoa repens (Bartr.) Small	2-2	–	0-4	4-0
Sesuvium portulacastrum L.	8-2	–	4-4	14-0
Spartina patens (Alt.) Muhl.	2-0	–	2-0	–
Uniola paniculata L.	15-23	–	8-24	29-29
Total	16	4	12	14

[z]Occurred during study period but not at start or completion of study.

Plant Succession. The relationship of vegetation to the relatively rapidly changing dunes is of importance. On erosion sites, the plants may help reduce the rate of erosion. On deposition sites, plants are needed to vegetate the newly formed land before violent northeast storms that occur during the winter months.

Information on dominant and minor plants was separated according to the grouping used in studying dune widths, i.e. erosion, deposition, and variable. This information is presented in Tables 1 and 2.

Dominant Plants. The dominant plant species had not changed since 1976 with the exception of seashore saltgrass, *Distichlis spicata* (L.) Greene, being dominant on one deposition site. Table 1 contains information on the percentage of dominant plants at the start and end of the study period by dune types. As in the original study, there was a distinct difference in the number and type of dominant plant species in reference to site conditions.

Only Australian pine, *Casuarina equisetifolia* L., seashore elder, *Iva imbricata* Walt., and red mangrove, *Rhizophora mangle* L., were persistent on the erosion sites. The erosion sites were commonly dominated by Australian pine. As previously reported by Craig (1), there are strong indications that it accelerates erosion of the dunes due to effects of dense shade and thick cover of plant litter that limits the growth of other plants. Red mangrove occurred as the eroding dune invaded the mangroves natural wetland habitat. Seashore elder were most dominant along the open areas not completely shaded by Australian pine.

The variable sites contained a wider variety of dune plants. Nine plant species remained dominant in comparison to 3 on the erosion sites. This plant succession can be explained by looking at the deposition sites.

The deposition sites were the most diverse in regard to dominant plants with 10 plant species at the end of 7 years. The changes from 1976 involved the addition of seashore saltgrass and the elimination of sea grape, *Coccoloba unifera L., red mangrove, Brazilian pepper, Schinus terebinthifolius* Raddi, sawpalmetto, *Seremoa repens* (Bartr.) Small, sea purslane, *Sesuvium protulacastrum* L., and Marsh hay cordgrass, *Spartina potens* (Alt.) Muhl. as dominant plants. All of the above plants occurred originally on only a few sites. Many of the more common dominant plants were shrubs and grasses which helped prevent erosion because of their growth habits. Australian pine was a common dominant plant but stands were more open and permitted establishment of other plant species.

The low growing, spreading shrub, seashore elder had increased in dominance from 50 to 57 percent on deposition sites. Its ability for adapting to each of the 3 dune conditions is noteworthy. It still occurred most often on frontal dune locations adjacent to the beaches.

The value of sea oats, *Uniola paniculata* L. for dune erosion control is well known and documented by Craig (2) and Gretz (4). It was not present on the erosion sites but did occur as a dominant plant on 24 percent of the variable sites and 29 percent of the deposition sites at the end of study period.

Other important dominant plants on deposition sites were cucumberleaf sunflower, *Helianthus debilis* Nutt., and seashore paspalum, *Paspalum vaginatum* Swartz.

Minor Plants. The minor plants had changed since 1976 with the addition of 10 plant species. Table 2 contains information on the percentage of minor plants at the start and end of the study period by dune types. As with the original study, there was a distinct difference in the number and type of dominant plant species depending on the dune type. Only 10 occurred and were persistent on the erosion sites, 31 on the variable sites and 41 on the deposition sites.

The wide variety of plants on the variable and deposition sites helped prevent, or at least slowed down, erosion of the dunes. Several of these plants can be considered to be especially important in dune erosion control.

Seashore paspalum, a low growing perennial grass, has been recommended by Craig (2) and Morton (5) for erosion control on coastal areas. Its occurrence on all 3 dune sites and especially the variable and deposition sites substantiates this recommendation.

Beach morning glory, *Ipomoea pes-caprae* (L.) Sweet, occurred on 54 percent of the sites, seashore elder on 43 percent of the sites, sea purslane on 43 percent, sea oats on 33 percent, and bitter panicum, Panicum Amarum Ell., on 24 percent of the sites at the end of 7 years. This occurrence and increase on the deposition sites point out their value for use in vegetating newly-formed dunes.

Summary

This study indicates, at this location, that beach morning glory, bitter panicum, cucumberleaf sunflower, sea

Table 2. Percentage of minor plants at start and end of study period by dune types.

Minor plants	Total	Erosion	Variable	Deposition
Alternanthera maritima (Mart.) Standley	0-8		0-8	0-10
Amaranthus retroflexus L.	z			z
Baccharis halimfolia L.	0-2			0-5
Cakile fusiformis Greene	6-4		4-0	10-10
Capparis cynophallophora L.	0-2		0-4	
Capparis flexuosa L.	0-2		0-4	
Cassia spp. L.	0-2			0-5
Casuarina equisetifolia L.	23-10	33-14	16-24	19-5
Catharanthus roseus G. Don	2-2			5-5
Cenchrus spp. L.	0-2			0-5
Chamaesyce ammannioides (H.B.K.)	z		z	
Chloris petraea Swartz			z	
Chrysobalanus icaco L.	0-2			0-5
Coccoloba uvifera L.	10-10	19-0	4-0	5-20
Cocos nucifera L.	z		z	
Croton punctatus Jacq.	0-2			0-5
Dactyloctenium aegyptium (L.) Beavu.	z		z	z
Dalbergia escalophyllum (L.) Britton	0-2		z	0-5
Daucus carota L.		z	z	z
Distichlis spicata (L.) Greene	4-0			10-0
Helianthemum corymbosum Michaux.		z	z	
Helianthus debilis Nutt.	2-6		8-12	0-5
Heliotropium angiospermum Murr.	2-0			5-0
Ipomea pes-caprae (L.) Sweet	35-42	17-0	32-20	43-50
Ipomea stolonifera (Cyr.) J. F. GMEL.	0-2			0-5
Iva imbricata Walt.	25-25	17-17	20-16	33-43
Oenothera humifusa Nutt.	0-26	0-20		0-28
Opuntia spp. Mill	0-2			0-5
Panicum amarum Ell.	8-15		12-12	5-24
Panicum amarulum Hitchc. and Chase	z		z	z
Parthenocissus quinquefolia (L.) Planch	0-2			0-5
Paspalum vaginatum Swartz	38-35	17-0	48-40	52-57
Physalis angustifolia Nutt.	0-4			0-27
Randia aculeata L. White	0-2		4-4	0-5
Remirea maritima Aubl.	0-2			0-5
Rhizophora mangle L.	23-10	50-17	28-16	10-0
Rhus toxicodendron L	2-4		0-4	0-5
Scaevola plumieri Vahl.	21-12		16-12	28-20
Schinus terebinthifolius Raddi	2-4		0-4	5-5
Serenoa repens (Bartr.) Small	6-4		4-0	10-10
Sesuvium portulacastrum L.	13-27	z	16-24	15-43
Solanum nigrum L.	z		z	
Spartina patens (Alt.) Muhl.	13-6	17-0	8-8	20-5
Sporobolus virginicus (L.) Kunth	0-28	0-36		0-38
Suriana maritima L.	4-2			10-5
Tournefortia gnaphalodes R. Br.	2-2			5-5
Tribulus cistoides L.	z		z	z
Uniola paniculata L.	25-23		24-20	33-33
Vitis spp. L.	z		z	
Yucca aloifoilia L.	2-2			5-5

[z]Occurred during study period but not at start or completion of study.

oats, sea purslane, seashore elder, and seashore paspalum are the most important plants in reducing the rate of erosion. Cucumberleaf sunflower, sea oats, and bitter panicum are currently under investigation by the SCS through its plant materials program. Collections have been made of superior plant materials and selections of the best of all of these will be made. Methods of planting and management are also being determined. Field plantings will soon be made to determine climatic adaption and the plants response to field conditions. These plantings are made with the cooperation of Florida's Soil and Water Conservation Districts.

All of the deposition and most of the variable sites could be revegetated with the above mentioned plants. Erosion sites contain a very restrictive number of plants and these are usually trees and shrubs with little value for erosion control. Revegetation of these sites will require special efforts such as sand-trapping devices, surface mulch and/or pedestrian access walkways to reduce concentrated foot traffic.

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BIOLOGICAL CONTROL OF FRANGIPANI RUST WITH *VERTICILLIUM LECANNI*

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Abstract. **Foliar sprays of *Verticillium lecanii* (Zimm.) Viegas conidia at 100, 1000, and 10,000/ml effectively controlled rust (*Coleosporium domingense* (Burk.) Arth.) and defoliation of frangipani (*Plumeria rubra* L.) in greenhouse and field trials. *V. lecanii* required no environmental changes to enhance parasitism.**

The fungus *Coleosprium domingense* is the cause of leaf rust of frangipani. It is probably the most serious disease of nursery and dooryard grown frangipani (1,10,11). The rust occurs on all known cultivars of frangipani throughout its tropical range (10). It causes severe leaf drop in the spring months and is controlled with foliar fungicides (4). In the spring of 1984 uredial pustules were observed to be covered with a white hyphial colony (5). The fungus was identified as *Verticillium leancii. Verticillium lecanii* is used commercially in Europe for biological control of many different species of insects (3), and is reported to provide effective control of bean rust *Uromyces appendiculatus* (1), carnation rust *Uromyces dianthi* (Pers.) Niessl., leaf rust of wheat *Puccinia recondita* f. sp. *tritici* Rob. ex Desm. (8,9), and stripe rust *Puccinia striiformis West (6).*

This paper describes the biological control effectiveness of V. lecanii on greenhouse and field grown frangipani infected with rust.

Materials and Methods

Two tests were carried out in Apr. 1984, one in the greenhouse on nursery stock and the second on field stock.

The greenhouse frangipani stock were inoculated with *C. domingense* uredia spores collected from mature infected leaves gathered from the field. The uredia spores were washed from the pustules on the leaf surface with distilled water into a 100-ml beaker. The resulting suspension of uredia spores was filtered through several layers of cheesecloth and adjusted to 5.0×10^4 uredia/ml. A DeVilbiss atomizer was used to spray the uredia spore suspension onto the leaves of the plants in the greenhouse. The field stock used in the experiment were naturally infected.

A single-conidium culture of *V. lecanii* originally isolated from a naturally parasitized rust pustule on a frangipani leaf was transferred periodically on potato dextrose agar (PDA) and maintained at 25°C (5). This isolate was employed throughout this study.

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Spore suspensions of *V. lecanii* were prepared by adding sterile distilled water to petri plate cultures and gently washing the spores into a small amount of sterile distilled water. Conidia were then washed twice by centrifugation and resuspended in sterile distilled water and adjusted to 100, 1000 and 10,000 conidia per ml with a hemacytometer.

All inoculations were accomplished by atomizing with a DeVilbiss atomizer, conidial suspensions of the fungus on to the upper and lower leaf surfaces. Immediately prior to inoculation, the greenhouse and field stock plants were watered and the foliage thoroughly wetted with a fine misting nozzle.

Conidial suspensions were sprayed on the plants with a DeVilbiss atomizer on 4, 11, 18, and 25 Apr. Relative humidity readings were made daily in the greenhouse by a Fischer sling psychrometer and in the field by a Campbell Scientific Model 201 Relative Humidity Sensor. Disease was rated by estimating the number of pustules on the fourth fully expanded leaf from the branch tip. The percent defoliation was measured by counting the leaves at the time of the first inoculation and the number of leaves at the termination of the test 4 weeks later.

Four replicates were used for each treatment in the greenhouse and the field test and each plot contained four plants.

Results

Rust caused significant defoliation of plants in both the greenhouse and field. Applications of *V. lecanii* conidia at all three concentrations significantly reduced rust on greenhouse and field plants (Table 1). The 1000 and 10,000 conidia/ml were significantly better than the 100 conidia/ml. The same relationships also existed for the control of leaf drop in both the greenhouse and field experiments (Table 1).

The leaf rust ratings following application of *V. lecanii* conidia at 1000 and 10,000 spores/ml was 0.2 greenhouse and 0.9 field, and 0.3 greenhouse and 0.7 field, respectively. The application of 100 conidia/ml resulted in ratings of 1.4 greenhouse and 2.3 field. The control that received no application other than water, developed a mean disease rating of 4.9 in the greenhouse and 5.0 field respectively. The conidia at 1000 and 10,000/ml reduced leaf drop to 0.0% in the greenhouse and field plants. At 100/ml there was 0.4% at 1.1% leaf drop in the greenhouse and field, respectively whereas the control suffered 50.2% leaf drop in greenhouse and 71.0% in the field. The disease ratings in the field tests tended to be somewhat higher than those in the greenhouse. This may have been related to the higher relative humidity in the field and a somewhat lower