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Vegetation of the Southern Coastal Region of Everglades National Park between Flamingo and Joe Bay

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VEGETATION OF THE SOUTHERN COASTAL REGION OF EVERGLADES NATIONAL PARK BETWEEN FLAMINGO AND JOE BAY

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INTRODUCTION

Mangrove forests of southern Florida cover about 140,000 ha, of which two thirds are in Everglades National Park. The very gentle elevational gradient at the southern tip of the Florida peninsula provides a wide area (1-8 km) of habitat for the salt-tolerant trees. It is the interplay of freshwater discharge and saltwater intrusion, driven by persistent winds, that influences the salinity of the eastern portion of the mangrove zone. Irregular wind-driven tides are effective along a very narrow band of the shore of Florida Bay, while the coastal area bordering the Gulf of Mexico experiences diurnal tides (D. White, pers. comm.).

The taxa classed as mangroves in southern Florida are Rhizophora mangle (red mangrove), Avicennia germinans (black mangrove), and Laguncularia racemosa (white mangrove). A fourth species, Conocarpus erectus (buttonwood), though not a true mangrove, is often classed as such. Buttonwood does not show any obvious tendency to vivipary or root modification as do true mangroves (Tomlinson, 1980).

Although much excellent ecological work has been carried out in the mangrove zone of Florida during the past half century (e.g., Davis 1940, 1943; Egler 1948; Robertson 1955; Craighead and Gilbert 1962; Craighead 1964; W. Odum 1971; Lugo and Snedaker 1974; and Pool, Snedaker and Lugo 1977), remarkably little progress has been made in interpreting details of the long-term dynamics of this system. Changes in mangrove vegetation due to hurricane destruction and silt deposition, freezing temperatures, rising or falling sea levels, input of freshwater due to natural fluctuations of precipitation and runoff have been occurring for thousands of years and will continue. Changes may also be occurring due to human alterations of freshwater regimes.

The relative inaccessibility and inhospitability of the mangrove environment, and the brevity of ecological studies due to human lifetimes in relation to processes involved, are some of the reasons for the paucity of detailed knowledge of specific changes. This mapping project was initiated as a first step toward acquiring sufficient baseline information to allow workers the potential for interpreting change in the mangrove zone.

The segment of coastal area between Flamingo and Joe Bay was chosen because of its accessibility, and because of the considerable variety of vegetation types which occurs within an elevational gradient of less than 60 cm. In addition to mangrove and buttonwood stands, the mapped area includes tropical hardwood hammocks and "Salicornia and Batis flats."

It should be noted that the mangrove zone from Cape Sable to Everglades City, along the Gulf of Mexico on the west side of Everglades National Park, is quite different from the area mapped in physiognomy, distribution of vegetation types, topography, geomorphology, and tidal influence.

DISTURBANCE AND THE DYNAMICS OF THE COASTAL VEGETATION

Occurrences of natural disturbances like hurricanes, fires, and freezing temperatures and how they affect the coastal vegetation will be discussed in the following chapter. Sea level changes and human influences will be mentioned as well.

Hurricanes

The prevalence of hurricanes is recognizable almost everywhere in the mapped area. A recent analysis of the probability of hurricanes striking within 80-km segments of coastline showed that a hurricane (with winds in excess of 119 km/hr) may be expected to strike the southern coast of Everglades National Park once in eight years. A "great hurricane" (with winds in excess of 201 km/hr) may be expected to strike this coastal section once in 25 years (Gentry, 1974).

The most intense hurricane of this century that hit the study area occurred in 1935 with winds of 320 km/hr and a storm surge of 5.5 m. No vegetation documentation for the mangove zone before or after that storm exists. However, there are still standing, but mostly prostrate, dead trunks of black mangrove and buttonwood visible as in the mapped unit "115" on either side of Coot Bay Hammock. Standing dead boles of black mangroves are reminders of the sizes these trees might reach if protected long enough from a hurricane.

Another very destructive hurricane, Donna, in 1960, with winds of 220-290 km/hr was accompanied by a storm surge of 4 m at Flamingo. Craighead and Gilbert (1962) described the damage Donna produced, and the same authors made available a set of photographs of different locations in the study area taken immediately after the storm in October and November of 1960. The reconnaissance done by Craighead and Gilbert after Donna indicates that most of the low-lying mangrove zone of the area which we have mapped showed 90% mortality, while those trees on slightly higher ground, like buttonwoods and tropical hardwoods in coastal hammocks, only suffered 25-50% mortality. The reasons for the differential mortality are uncertain. Craighead (1971) attributed most of the mortality to deposition by the storm surge of a marl silt layer up to 12 cm in thickness. This layer, deposited as far inland as 5 km, was believed to have interfered with mangrove root aeration. Toxic substances in the soil were believed to have contributed to the mortality as well (Craighead and Gilbert, 1962).

Hurricane Betsy of 1965 was the most recent major storm to hit the area. Much of the reproduction that had become established since Hurricane Donna in 1960 was damaged or destroyed. The winds were estimated at 190 km/hr with a storm surge of 2 m (Alexander, 1967). Effects of the 1965 hurricane were greatest in the region immediately to the northeast of the mapped area.

Fire

Although fire is a major ecological force throughout most of the Everglades region, it is less important in the mangrove zone, where it is largely confined to salt marsh areas north and west of the study area. Mangrove vegetation will rarely burn, except in the unusual circumstance of ignition after severe freeze damage (Wade, Ewel and Hofstetter, 1980) or hurricane damage (Craighead and Gilbert, 1962). Some evidence exists that logging of mahogany and man-caused fires damaged hammock vegetation in the past (Craighead, 1971). Small (1916) mentions great quantities of smoke from fires in the hammock regions of Madeira Bay and the Cape Sable area in 1915. Tebeau (1968) reports fires from the charcoal era and the whiskey still time. Lightning without fire kills mangroves in small circular patterns all over the mangrove zone (Craighead, 1973).

Freezing Temperatures

Occasional hard freezes that occur periodically have killed off large areas of mangrove, especially white mangroves and red mangrove scrub. Buttonwoods are very susceptible to freezing temperatures, and it is possible that some of the buttonwood reproduction that may have gotten established after the 1960 and 1965 hurricanes was killed by the January 1977 freeze (Robertson, pers. comm.). The 1977 freeze has left its mark, still visible today, over many hectares north of Madeira, Little Madeira and Joe Bays.

Sea Level Changes

According to Fairbridge (1974), sea level rose concurrently with glacial retreat until about 6000 years ago and has since been oscillating. His scenario includes a rise in sea level of up to 3-4 m above the present one during the period of 6000 - 4700 B.P., with continuing lesser sea level fluctuations to the present. Details of the rise 6000 years ago remain to be verified; however, some vegetation changes support recent fluctuations in sea level (Craighead 1964; Gleason et al. 1974; Fairbridge 1974; and Alexander 1974). The interbedding of marl and peat, which frequently occurs in the stratigraphic record, suggests the continual shifting of base level. An alternate view is provided by Scholl, Craighead and Stuiver (1969) who present data in support of a continually rising sea level over the past 6000 years. Interpretation of the sea level curve allows small fluctuations.

Human Influence

Tebeau (1968) reported on the early settlements in the area between Flamingo and Joe Bay. Homesteading occurred on current hammock sites at Davis Creek, Mud Creek, East Creek, Madeira Point and elsewhere. The inhabitants grew tomatoes and produced charcoal from buttonwood. The charcoal was put on shallow draft boats and brought to Flamingo for shipment to Key West. Charcoaling must have had a substantial impact on the buttonwood population. Exotic trees were introduced. At several places along Little Madeira Bay, on hammock sites, are date palms. The exotic *Schinus terebinthifolius*, dispersed by birds, has established in all the hammocks along Little Madeira Bay and numerous other places along the south coast.

METHODS

The maps were prepared from color aerial photography (1:7800) that was flown in December 1978. A base map was produced at a scale of 1:24,000 from existing USGS orthophotomaps for the mapped area. The study area was divided into an east and west map. The different vegetation units were outlined on mylar over the aerial photography and then transferred to the base map. A photographic printing process was used for reproduction of the maps.

We decided to use the capability of a parallax bar to indicate the different mangrove types by height. It was possible to identify scrub as <2 m, another group between 2-5 m and the next one in access of 5 m. Further differentiation was not possible.

Stands with only one mangrove species dominant were more easily identifiable than those stands with a mixture of species. The vegetation units were verified on the ground, on foot as well as from the air, by helicopter, and by boat. It should be realized that the large, sometimes impenetrable and inhospitable mangrove system presents some problems in ground-truthing. Mixed mangrove units cause the most difficult problems in identification. Out of 24 possible permutations of mixtures, twenty were actually recognized. Some misinterpretations and omissions have been found since printing of the maps. A sheet of corrections is appended.

Olmsted and Loope (1981) analyzed the vegetation along a transect through Coot Bay Hammock. Some of the results are included here.

DESCRIPTION OF FLORISTIC COMPOSITION AND STRUCTURE OF MAPPED UNITS

Red Mangrove (Rhizophora mangle)

350 - Rhizophora scrub, < 2 m tall and 351 - Rhizophora, 2-5 m tall

Rhizophora scrub and the next taller category "351" are probably the most abundant red mangrove vegetation types in the mapped area. Since red mangroves occur from Florida Bay up into Taylor Slough, they grow in a range of salinities and in freshwater as well. It is this scrub zone north and northeast of Little Madeira Bay and Joe Bay that was affected most severely by the freeze of January 1977. Although the damage is still very apparent in 1981, some patchy recovery has been observed. The red mangrove cover of this vegetation type is 20-25%.

352 - Rhizophora, > 5 m

Stands of larger (> 5 m) red mangroves are very few and exist only near Little Madeira and Joe Bays. These areas are flooded most of the year. Rhizophora of this size is more common in mixed mangrove stands.

354 - Rhizophora, fringing

Fringing red mangroves are most extensive along Terrapin Bay and along the shores of lakes. It is usually inundated. Red mangroves on the west coast of south Florida grow under different substrate and tidal conditions, and have apparently not been hit by hurricanes as often as those on the south coast. Some areas have red mangroves that are more than 20 m tall. In the mapped area, however, the tallest red mangrove probably does not exceed 10 m.

Black Mangrove (Avicennia germinans)

360 - Avicennia scrub, < 2 m

The black mangrove scrub is almost as dense as that of white mangroves. Unlike the red mangrove scrub, this type is inundated only periodically during the rainy season. The habitat tends to be hypersaline at times. There is some halopytic herbaceous vegetation in the groundcover where sufficient light penetrates the canopy. The canopy of Avicennia scrub is very uniform in certain areas where reproduction has occurred since the last hurricane, in striking contrast to buttonwood, which has very uneven reproduction in the current vegetation make-up.

362 - Avicennia, 2-5 m

Pure black mangrove stands of this tall size occur mostly between Garfield Bight and Little Madeira Bay. The highest class of black mangrove has its greatest extent in mixed stands with other mangroves.

364 - Avicennia, >5 m

There are some older black mangrove stands where the tree heights are greater than 5 m. In black mangrove stands in the vicinity of Coot Bay (Olmsted and Loope, 1981), some of the trees are 10 m tall. There is practically nothing else growing in these older stands, except an occasional Rhizophora. The ground is covered with the pneumatophores of the black mangroves. Large black mangroves are widely spaced. They are inactive in winter and active in summer and produce widely-spaced tiers of vigorous branches which alternate with lengths of stems with a few weak branches and short internodes (Tomlinson, 1980). The black mangrove can become a rather tall tree with a large diameter, given a long enough time between hurricanes. Today, the largest dead trunks still visible anywhere in the mapped mangrove zone belong to black mangroves killed in 1935.

366 - Avicennia, fringing

The fringing black mangroves, though a narrow band, extend over many kilometers from Snake Bight to Santini Bight. They occur just forward of shore lines and are just below mean sea level. Red mangrove borders shorelines that are either elevated 30-60 cm above mean sea level or grow in a similar situation as the fringing black mangrove.

White Mangrove (Laguncularia racemosa)

370 - Laguncularia scrub, <2 m and 352 - Laguncularia, 2-5 m

Laguncularia racemosa probably occupies disturbed sites faster and in greater abundance than any other mangrove. White mangrove scrub (370), as well as the 2-5 m height class (372), is very dense. In a stand southeast of Coot Bay, there were more than 800 stems/100 m^2. These two vegetation types are most abundant east and south of Coot Bay, southwest of West Lake and west of Garfield Bight, as well as northeast of Little Madeira Bay.

374 - Laguncularia, >5 m tall

A more mature white mangrove vegetation type is rare in the study area and occurs only in small areas within the other Laguncularia vegetation types. In a white mangrove stand near Coot Bay (Olmsted and Loope, 1981), most of the stems measured were between 6 and 9 m tall and 10-15 cm in diameter. These mangroves have apparently been established from seed since the last hurricanes in 1960 and 1965.

376 - Laguncularia, fringing

The white mangrove fringe has a very minimal extent and only occurs at Henry and Monroe Lakes. It does not occur bordering Florida Bay.

Buttonwood (Conocarpus erectus)

380 - Conocarpus scrub, 2 m tall

Buttonwood scrub is currently present in only a few localities. It consists of young buttonwood plants along with an understory of Batis, Salicornia or Distichlis, and Borrichia frutescens. This scrub is different from black or white mangrove scrub, in that it is not very dense, and the saplings are widely spaced.

382 - Conocarpus, 2-5 m and 384 - Conocarpus, >5 m

The more mature buttonwood forest occurs in large stands south of Route 27 and just west of Garfield Bight and north of Snake Bight. Buttonwood is by far the dominant tree species. The understory is sparse to dense in cover. Table 1 lists species for a mature buttonwood forest.

Piscidia piscipula and Colubrina arborescens occur where buttonwood strands intergrade with buttonwood hammocks. One buttonwood strand along a vegetation transect near Coot Bay (Olmsted and Loope, 1981) had only 34 stems/300 m^2, of which 13 were white mangroves. The tallest plant was 6 m and the largest diameter was 22 cm.

However, there is a narrow band of buttonwood/manchineel (Hippomane mancinella) forest between the buttonwoods and a madeira hammock along this transect in which the buttonwoods were up to 10 m tall and up to 45 cm in diameter. This buttonwood/manchineel forest is not mentioned as a separate vegetation type, but is included in the buttonwood type "384". Wherever buttonwood strands (384) and hammock vegetation occur is a potential site for clumped manchineel. Since the manchineel is dense in this community, there is very little groundcover of halophytes.

Mixed Mangrove

390 - 396

The largest area of the west map has stands of different mixtures of mangroves and buttonwoods. These stands have mostly become established since the last hurricane. Since these areas are difficult to walk through, structure and understory were not examined thoroughly.

It should be noted that the mangrove mixtures are not evenly scattered like a mixed hardwood forest, but are mostly mixtures of small stands of each mangrove species.

Halophytic Herbaceous Vegetation

110 - Batis-Salicornia-Sesuvium - dominated flats, low cover of vegetation

112 - Batis-Salicornia-Sesuvium - dominated flats, high cover of vegetation

The halophytic herbaceous and shrub vegetation in the mangrove zone is made up of five major species: Batis maritima, Philoxeris vermicularis, Sueda linearis,

Table 1. Species list for a mature Buttonwood Forest (384) near Rowdy Bend Road.

Trees

- *Bumelia celastrina*
- *Capparis flexuosa*
- *Carica papaya*
- *Eugenia foetida*
- *Forestiera segregata* var. *segregata*
- *Zanthoxylum fagara*

Shrubs

- *Borrichia frutescens*
- *Lycium carolinianum*
- *Randia aculeata*
- *Solanum donianum*

Vines

- *Caesalpinia bonduc*
- *Cissus sicyoides*
- *Ipomea alba*
- *Sarcostemma clausum*

Forbs

- *Alternanthera ramosissima*
- *Batis maritima*
- *Chamaesyce blodgettii*
- *Philoxerus vermicularis*
- *Rivina humilis*
- *Salicornia virginica*
- *Sueda linearis*

Cacti

- *Cereus pentagonus*

Salicornia virginiana and Sesuvium portulacastrum. These species cover extensive open flats as well as form the groundcover in open black and white mangrove and buttonwood forest. Usually the halophytic vegetation flats occupy sites that are slightly higher in elevation than an adjacent black or white mangrove zone (Olmsted and Loope, 1981). The substrate for these two vegetation units is marl. The high cover vegetation type (112) is very dense and covers virtually 100% of the ground, whereas "110" occurs in variable cover percentages. The low cover type often has bare spots as well as small islands of the grasses Monanthochloe or Distichlis interspersed within it.

The halophytic designation "112" occurs in species compositions of 1-5 species of halophytes. Batis maritima often forms pure stands. Distichlis and Sporobolus are sometimes mixed with the halophytic shrubs and forbs.

Salicornia is the most abundant species in the halophytic herbaceous vegetation along a vegetational transect near Coot Bay (Olmsted and Loope, 1981). Ground cover, made up of the halophytic vegetation type 110/112, has the following values in the various vegetation types along the transect through Coot Bay Hammock (Olmsted and Loope, 1981).

White Mangrove (372)	1.5%
Salicornia/Batis flat (115)	77.0%
Buttonwood (384)	61.0%
Buttonwood/Manchineel (384)	28.0%
Madeira Hammock (449)	-
Black Mangrove (374)	-

When the study area receives normal rainfall during the wet season this vegetation type often has standing water toward the end of the season. Although the water table is raised by heavy summer precipitation, the water is saline due to irregular tidal influence. Salinities in the surface soil (to 20 cm depth) vary from 7-15 ^{o}/oo during October when the surface water measured 10 ^{o}/oo. These were spot measurements in the coastal prairie near Coot Bay hammock. The flats can become hypersaline during the dry season (up to 40 ^{o}/oo).

115 - Batis-Salicornia-Sesuvium - dominated flats, low cover of vegetation with dead mangroves and buttonwoods

This designation is very similar to 110 and 112, except it includes many old dead buttonwood trunks and black mangrove trunks.

230 - Distichlis-Sporobolus-flats

This vegetation unit is very similar to the Distichlis-Sporobolus patches that occur in units "110" and "112", except they cover much larger areas.

Graminoid Vegetation

210 - Eleocharis Marsh

The Eleocharis marsh is a freshwater vegetation type that can tolerate salinity of up to 15°/oo (Tabb et al. 1967). Eleocharis cellulosa forms almost pure stands. Eleocharis (spikerush) is distributed at different densities, but mostly has a cover of 5-40%. It is often associated with red mangrove scrub. Periphyton is abundant in this community. This type is widespread to the northeast of the study area, east of Taylor Slough, and north of Little Madeira Bay and Joe Bay.

270 - Cladium Marsh

The Cladium (sawgrass) marsh is usually on the freshwater side of the Eleocharis community. The sawgrass marsh is dense and often has a cover of 100%. Sometimes, sawgrass and spikerush occur together in sparse cover. Some sawgrass islands are surrounded by open water and scrub Rhizophora. Acrostichum danaeifolium (leather fern) occasionally grows in clumps in the sawgrass marsh. Where Cladium grows the salinity probably does not reach above 10°/oo. It is not as salt-tolerant as spikerush. Craighead (1973) suggested that the occurrence of plants with such low salt tolerance in the saline zone may be dictated by the low surface soil salinity in places where saltwater intrusion is leached out by rains in a few days.

Tropical Hardwood Forest

The tropical hardwood forests are located on the highest ridges (nearly 1 m above msl) in the mangrove zone. The ridges are assumed to be old shorelines or areas of sedimentation during storms with deep deposits of marl and/or sand. The term "hammock" is used locally in southern Florida to refer to tropical hardwood forest. We distinguish three types of hammocks on these maps: buttonwood, madeira and fan palm hammocks. The classification is based on species composition, abundance and substrate. This scheme was adopted without quantitative sampling. The dominant species are common to all three hammock types, but have different observed abundances.

440 - Fan Palm Hammock

This hammock type derives its name from Thrinax radiata, a "fan palm." The fan palm is usually the tallest species in the hammock and quite conspicuous from the air or sea. Fan Palm hammocks are located immediately adjacent to Florida Bay. The soil substrate is calcareous sand. These hammocks are best developed on the leeward (inland) side. The canopy does not reach more than 8 m and is shorter on the windward side. Table 2 shows a characteristic species composition of a fan palm hammock.

Although the composition is somewhat similar to that of madeira hammocks, there are some marked distinctions. Drypetes diversifolia occurs here, and several species that may be sparsely represented, if at all, in madeira hammocks are abundant in fan palm hammocks, like Erithalis fruticosa, Casasia clusiifolia and Thrinax radiata. Since much of the field checking has been done from a helicopter, the occurrence of Thrinax radiata has been taken as an indicator of fan palm

Table 2. Species composition of Fan Palm Hammock (440), Little Madeira Bay.

Trees

Avicennia germinans
Bumelia celastrina
Canella winterana
Casasia clusiifolia
Casuarina equisetifolia
Coccoloba diversifolia
Conocarpus erectus
Cordia sebestena
Drypetes diversifolia
Erithalis fruticosa
Eugenia axillaris
Eugenia foetida
Guapira discolor
Jacquinia keyensis
Metopium toxiferum
Piscidia piscipula
Pithecellobium guadalupense
Randia aculeata
Rhizophora mangle
Suriana maritima
Swietenia mahagoni
Zanthoxylum fagara

Shrubs

Borrichia arborescens
Borrichia frutescens
Chiococca alba
Lantana involucrata
Solanum donianum

Vines

Chiococca parvifolia
Echites umbellata
Galactia sp.
Morinda royoc
Tournefortia volubilis

Forbs

Agave dicipiens
Hymenocallis latifolia
Paspalum caespitosum

Palms

Thrinax radiata

hammocks. However, Thrinax radiata does occur in madeira hammocks as well. Some of the "440" designations along Little Madeira Bay and Alligator Bay may be madeira hammocks and should be "449".

It should be noted that Coccoloba diversifolia occurs in both fan palm and madeira hammocks. The height of the tallest trees is about 1-2 m taller in the madeira hammocks than in the fan palm hammocks. The madeira hammocks that are furthest inland (Coot Bay) have the highest canopy (10 m).

449 - Madeira Hammock

This is probably the most extensive hammock type in the mangrove zone. The term "madeira hammock" has been historically used for these forests, apparently because of the past abundance of large mahogany trees (Swietenia mahagoni). (Madeira stems from "madera," wood in Spanish). Descriptions of dead mahogany stumps from the coastal area and reported salvage lumbering after the 1935 hurricane (Glen Simmons and Dr. Taylor Alexander, pers. comm.) suggest larger mahoganies than those currently existing. Although mahogany hammocks further inland have huge mahoganies dominating the forest (Olmsted, Loope and Hilsenbeck, 1981), very few large mahoganies remain in the coastal madeira hammocks, probably because of past fire, logging, and hurricanes.

Table 3 lists the species found in a "madeira" hammock north of Alligator Bay and west of Davis Creek.

These are additional species of Coot Bay Hammock, another "madeira hammock:"

Capparis flexuosa
Canella winterana
Bursera simaruba
Mastichodendron foetidissimum
Sabal palmetto.

The madeira hammocks have the largest number of species of the three types and number of hammocks we investigated, and are distinguished from the buttonwood hammocks by the near absence of buttonwood and the greater species diversity. However, upon checking more coastal hammocks we would probably find similar species abundances in madeira and fan palm hammocks. Madeira hammocks are not flooded except during major storms. The madeira hammocks are underlain by marl and have a 10-15 cm organic layer (leaf mold) which intergrades with the marl layer. The largest living mahoganies encountered during groundtruthing were at Alligator Bay and measured 37-42 cm in diameter and just under 8 m in height. Piscidia piscipula is an important species in this hammock type. The species include a high number of vines.

450 - Buttonwood Hammock

Buttonwoods (Conocarpus erectus) generally occupy higher ground than the three mangrove species. Buttonwood hammocks occur on slightly higher sites than the buttonwood vegetation described under 380-384. Buttonwood stands (384) and hammocks (450) intergrade and are not as discrete as their separate classification indicates. Separate delineation is often difficult, and where much intergradation

Table 3. Species list for a "Madeira" Hammock (449) north of Alligator Bay.

Trees

Bumelia celastrina
Coccoloba diversifolia
Coccoloba uvifera
Conocarpus erectus
Cordia sebestena
Erithalis fruticosa
Eugenia axillaris
Eugenia foetida
Forestiera segregata
Guapira discolor
Manilkara bahamense
Metopium toxiferum
Piscidia piscipula
Pisonia aculeata
Pithecellobium guadalupense
Swietenia mahagoni
Zanthoxylum fagara

Shrubs

Chiococca alba
Randia aculeata
Solanum donianum

Vines

Caesalpinia bonduc
Chiococca parvifolia
Cissus sicyoides
Dalbergia brownei
Echites umbellata
Erythrina herbacea
Galactia spiciformis
Heliotropium angiospermum

Vines (cont)

Hippocratea volubilis
Ipomea sp.
Morinda royoc
Passiflora pallens
Passiflora suberosa
Sarcostemma clausum
Tournefortia volubilis

Forbs and Grasses

Capsicum annuum var. glabriusculum
Eupatorium odoratum
Setaria chapmannii

Epiphytes

Encyclia tampensis
Tillandsia circinnata
Tillandsia flexuosa

Palms

Thrinax radiata

Cacti

Opuntia stricta

occurs, (as in the area north of Snake Bight), striping of the two unit designations has been used on the maps. Buttonwoods are the dominant species in buttonwood hammocks with Zanthoxylum fagara, Eugenia foetida and Colubrina arborescens following in abundance. Jamaica dogwood (Piscidia piscipula) often occurs in clumps in this vegetation type. The understory is made up of sparse to medium cover of Borrichia frutescens, Solanum donianum, Lycium carolinianum and Randia aculeata.

689 - Hammocks on artificially built embankments

These hammocks are similar in composition to that of madeira hammocks. There are only very few along Bear Lake Canal.

Miscellaneous Types

010 - Barren Flats exposed at low tide

These flats do not support any vegetation and are mostly hypersaline. They occur in small areas close to the halophytic herbaceous vegetation or to a larger extent on points close to the shore and separated from it by a fringe of mangroves.

102 - Marl Beach with little or no vegetation

The marl beach is a rare unit and carries practically no vegetation. The only plants growing on it are Sesuvium portulacastrum and Portulaca oleracea.

140 - Ipomoea - Baccharis scrubland

Ipomoea alba, Baccharis halimifolia, and Baccharis glomeruliflora dominate this vegetation type which has the appearance of a degraded coastal hammock. There are a few scattered individuals of Eugenia foetida as well as Piscidia piscipula and Colubrina arborescens. We initially suspected that a rise in the water table due to sea level rise might have been the cause of hammock collapse, but probing of the water table here and in intact nearby hammocks failed to confirm this hypothesis. Fire is another possible cause for hammock deterioration.

679 - Areas dominated by the exotic Colubrina asiatica

A secondary objective for the map was the determination of the occurrence of Colubrina asiatica in the mangrove zone. Colubrina asiatica is an invader which was first noticed in the park in 1954 (Russell and Loope, 1981). This species probably arrived from the Caribbean, but is a native of the Pacific region.

Colubrina asiatica forms pure stands locally in the study area, especially within buttonwood vegetation (384 and 450). Although it has the habit of a vine and frequently sprawls over the canopy of other vegetation, it is capable of attaining the form of a sprawling tree and forming pure stands. It appears locally to engulf stands of buttonwood and has been regarded as a possible severe threat to native vegetation. However, Russell and Loope (1981) find that as yet pure stands of Colubrina cover less than 50 hectares in Everglades National Park.

DISCUSSION

Much of the early mangrove literature for southern Florida has emphasized the land building role of mangroves. Davis (1940) presented a diagram showing that Rhizophora colonizes the "marine aquatic community," is replaced by Avicennia which is in turn replaced by Conocarpus and eventually by a tropical forest climax association. Egler (1952) and Robertson (1955) were among the first to disagree with this description of mangrove succession. Robertson agreed that Rhizophora is a pioneer species on low sites, and that they tend to be invaded gradually by Avicennia and Laguncularia. However, sea level fluctuations dwarf any effects of land buildup by peat formation. We agree with Robertson (1955) that succession beyond the mangrove stage depends on the deposition of sediments during storms. Thom (1967) emphasized the importance of geomorphic processes to micro-distribution of mangrove species in coastal Mexico.

Lugo (1980) reviewed the literature on mangrove succession, and concluded that mangrove ecosystems are true "steady-state" ecosystems in the sense that they are self-maintaining in spite of cyclic perturbations, as long as environmental tolerances of salinity and moisture fall within their optimal tolerance range. We are comfortable with this view, although we find it convenient to speak of the process of mangrove ecosystem recovery from hurricanes as succession.

The hurricane of 1960 killed most of the mangrove vegetation within the mapped area. However, reestablishment of mangrove vegetation was rapid in many areas (Craighead and Gilbert, 1962). Red, black and white mangrove, as well as buttonwood, normally have ripe propagules during the hurricane season (Loope, 1980), and the current vegetation pattern suggests that all except buttonwood were able to establish immediately following the 1960 hurricane. Soil moisture and salinity, as well as propagule availability, probably determined which species established in a given locality.

Though we do not know the alteration of species composition between most stands killed by the hurricane, and new stands becoming established, the maps tell us much about certain other stands. Buttonwood and hammock vegetation, located on higher ground, largely escaped severe destruction by the last hurricanes. Even though mechanical damage from the hurricane was considerable for these "upland" types, numerous trees survived. In many cases, buttonwoods which were uprooted later produced new shoots along the fallen trunks. In fact, vegetative reproduction seems to have been the prime mode of reproduction for buttonwood. Buttonwood seedlings and saplings are very rare.

The presence of scattered tall, old mangroves towering above a dense canopy of young white mangroves in the area north of Snake Bight and Garfield Bight shows clearly that white mangrove has colonized the area since the 1960 hurricane. Wadsworth (1959) also mentions the great reproductive capacity of white mangrove and its ability to colonize bare sites.

The current vegetation mosaic frequently has a band of halophytic herbaceous vegetation located between mangrove and buttonwood or buttonwood-hammock vegetation. These saline flats have increased substantially in the area since the early 1930's (Craighead and Gilbert, 1962; Glen Simmons, pers. comm.). Large areas (mapped as "115") of saline flats occur with skeletons of dead trees, usually

Conocarpus. Little or no reproduction is evident in what was formerly a forest. Reasons for the lack of mangrove or buttonwood reproduction here are not clear, but presumably changes in substrate, salinity and/or water table are involved.

ACKNOWLEDGEMENTS

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ERRATA

1. "452" in Coot Bay Hammock should read "449".

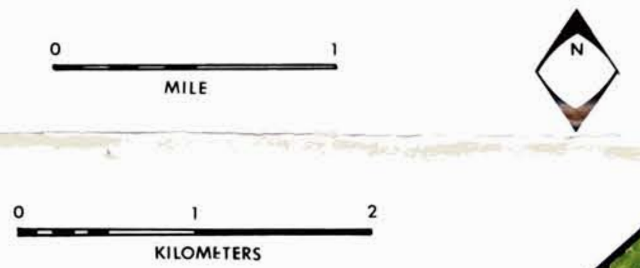
2. On the southern shore of Deer Key (the most eastern key on east map) there should be a strip of hammock vegetation (449 or 440) from west to east.

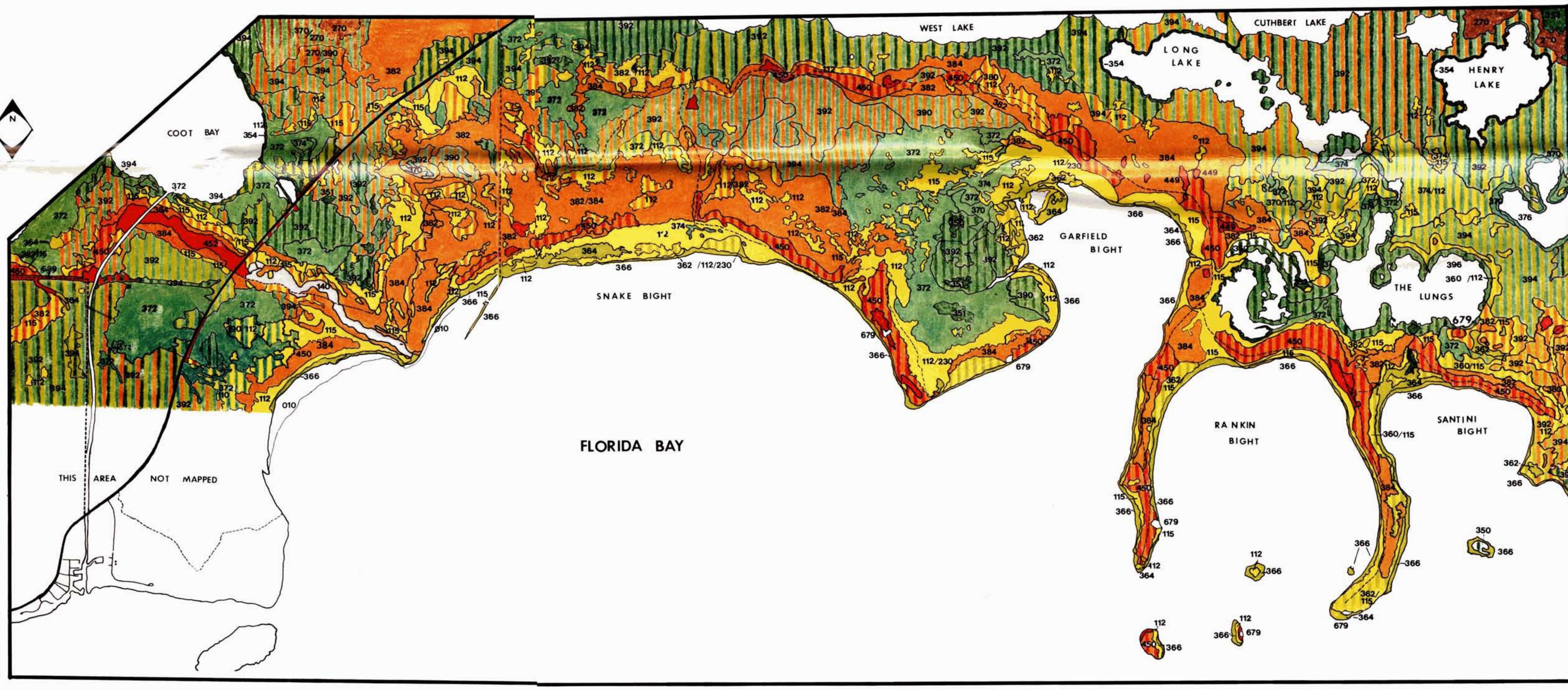
3. On the north shore of Monroe Lake there is a white spot with "449" pointing to it. It should be red indicating hammock.

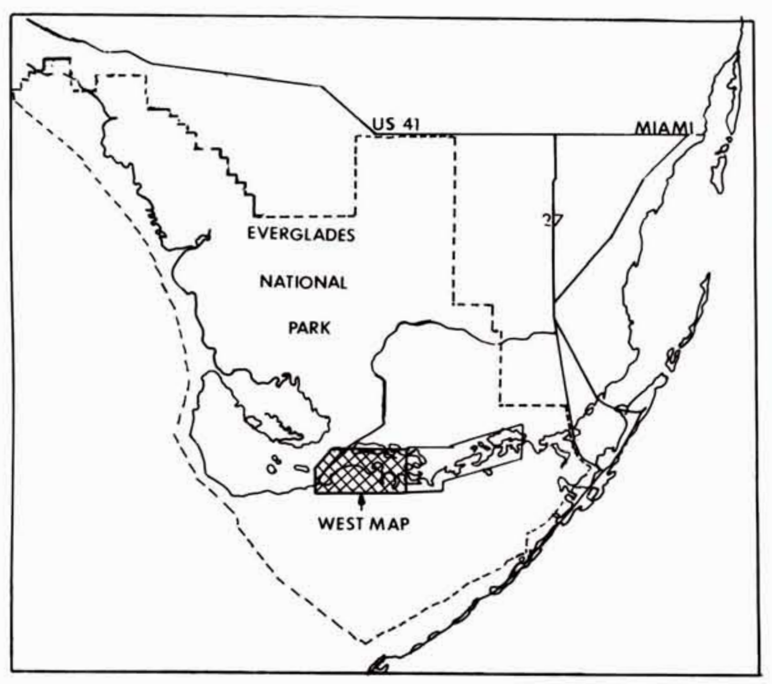
4. On the northeastern shore of Madeira Bay, the "380" should be changed to "362", which is the surrounding vegetation.

5. The fringing mangrove at Madeira Point and north along the west shore should be indicated as red and black mangrove, not just red (350 and 360).

VEGETATION MAP OF THE COASTAL REGION BETWEEN FLAMINGO AND JOE BAY OF EVERGLADES NATIONAL PARK (WEST MAP)







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SOUTH FLORIDA RESEARCH CENTER

EVERGLADES NATIONAL PARK

U.S. NATIONAL PARK SERVICE

1980

RED MANGROVE (Rhizophora mangle)

350 - Rhizophora scrub, <2m tall
351 - Rhizophora, 2-5m tall
352 - Rhizophora, >5m tall
354 - Rhizophora, fringing

BLACK MANGROVE (Avicennia germinans)

360 - Avicennia scrub, <2m tall
362 - Avicennia, 2-5m tall
364 - Avicennia, >5m tall
366 - Avicennia, fringing

WHITE MANGROVE (Laguncularia racemosa)

370 - Laguncularia scrub, < 2m tall
372 - Laguncularia, 2-5m tall
374 - Laguncularia, >5m tall
376 - Laguncularia, fringing

BUTTONWOOD (Conocarpus erectus)

380 - Concocarpus scrub, <2m tall
382 - Conocarpus, 2-5m tall
384 - Conocarpus, >5m tall

MIXED MANGROVE STANDS (Combinations of Rhizophora, Avicennia, Laguncularia and/or Conocarpus, as indicated by color)

390 - Mixed mangrove scrub, < 2m tall
392 - Mixed mangrove, 2-5m tall
394 - Mixed mangrove, >5m tall
396 - Mixed mangrove, fringing

HALOPHYTIC HERBACEOUS VEGETATION

110 - Batis - Salicornia - Sesuvium dominated flats, low cover of vegetation
112 - Batis - Salicornia - Sesuvium dominated flats, high cover of vegetation
115 - Batis - Salicornia - Sesuvium flats with dead mangrove trees, generally Conocarpus
230 - Distichlis - Sporobolus flats

GRAMINOID VEGETATION

210 - Eleocharis marsh
270 - Cladium marsh

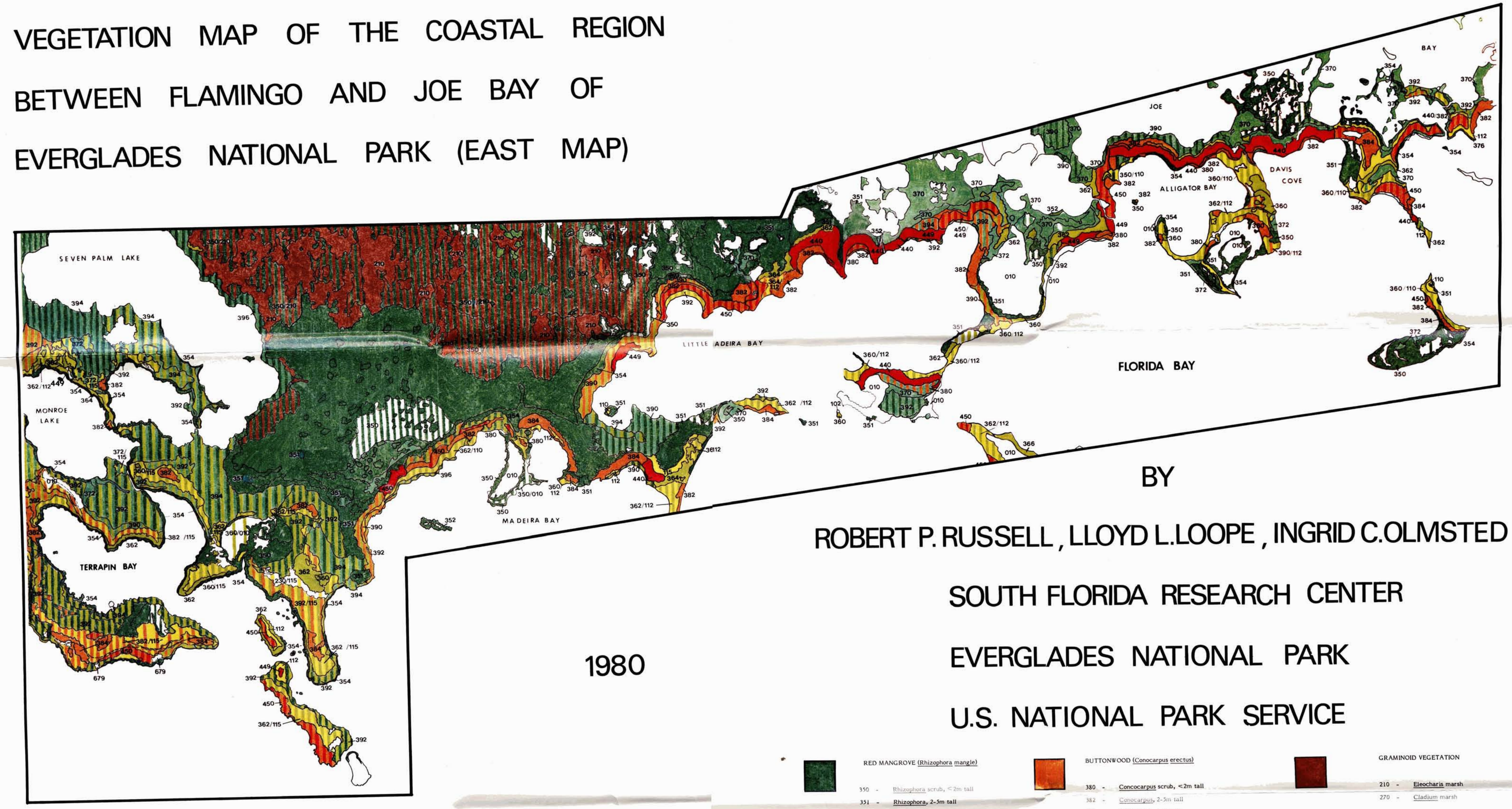
TROPICAL HARDWOOD FOREST

440 - Fan Palm hammocks (Thrinax, Casasia, Erithalis important)
449 - Madeira hammocks (Swietenia, Piscidia, Colubrina arborescens important)
450 - Buttonwood hammocks (very similar to type 384, but with tropical hardwoods such as Zanthoxylum and Eugenia foetida present, due to slightly higher elevation)
689 - Hammocks on artificially built up embankments

MISCELLANEOUS TYPES

010 - Barren flats exposed at low tide
102 - Marl beach with little or no vegetation
140 - Ipomoea - Baccharis scrubland (See discussion in text of "collapsed hammock".)
679 - Areas dominated by the exotic Colubrina asiatica

VEGETATION MAP OF THE COASTAL REGION BETWEEN FLAMINGO AND JOE BAY OF EVERGLADES NATIONAL PARK (EAST MAP)



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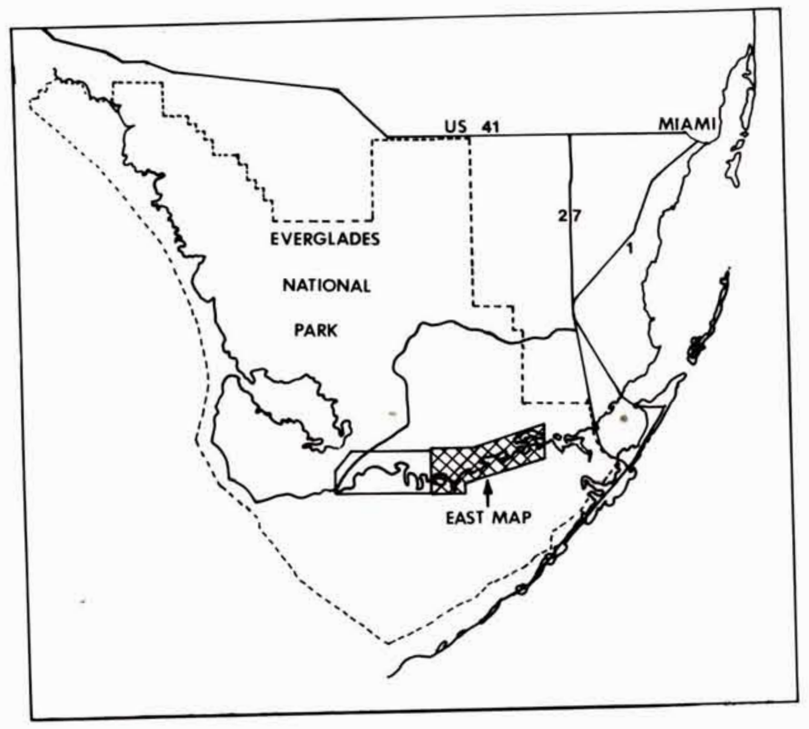
EVERGLADES NATIONAL PARK

U.S. NATIONAL PARK SERVICE

1980

0 — 1 MILES

0 — 1 — 2 KILOMETERS



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- 362 - Avicennia, 2-5m tall
- 364 - Avicennia, >5m tall
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- 370 - Laguncularia scrub, < 2m tall
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- 374 - Laguncularia, >5m tall
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Table 1. Diurnal catches of spotted seatrout and all larvae at Little Shark River, May 1983. Mean values are averages of 6 replicate tows with 333 micron mesh bongo net.

	Day		Night	
	Flood	Ebb	Flood	Ebb
Seatrout				
Mean catch / 100 m3	0	0	3.0	0
1 s.d.			0.7	
All larvae				
Mean catch / 100 m3	10.7	36.5	209.5	28.1
1 s.d.	2.3	10.2	101.3	7.1

Table 2. Results of Kruskal-Wallis tests of spotted seatrout larval catches (No./100m^3) by season at monitoring stations in Everglades National Park, 1983. Underlined seasons are not statistically different at a=.05 level.

	Seasons Compared	Significance
Little Shark River	$1<4<2<3$	$p < .001$
Cape Sable	$2<3$	$p < .02$
Marker 5		
Middle Ground	$2<3$	$p < .07$
Conchie Channel	$2<3$	$p < .70$

Table 3. Percent successful stations for spotted seatrout larvae by season in ENP, 1982-83.

	No. stations sampled	No. stations successful for spotted seatrout larvae	% successful for spotted seatrout larvae
1982			
Jan - Mar	2	1	50
Apr-Jun	2	1	50
Jul-Sep	5	0	0
Oct-Dec	21	3	14.3
1983			
Jan-Mar	10	3	30.0
Apr-Jun	13	8	61.5
Jul-Sep	11	9	81.8
Oct-Dec	3	2	66.7

Table 4. Mean size of spotted seatrout larvae (< 8.0 mm S.L.) caught in 333 micron and 475 micron mesh nets in Everglades National Park, 1982-1983. Mean values include 95% confidence intervals.

	Mean	Range	N	Months Caught
1982-83				
All stations				
Parkwide	3.2±0.1	1.3-8.0	1540	2-12
W. Florida Bay	2.7±0.1	1.4-6.1	1006	2-9,11-12
Whitewater Bay	4.5±0.1	2.0-8.0	442	3-10
E. Florida Bay	2.7±0.2	1.3-5.6	92	4,5,8,9,11
475 micron stations				
Parkwide	2.6±0.1	1.3-6.1	442	2-9,11
W. Florida Bay	2.6±0.1	1.4-6.1	348	2,4-8
Whitewater Bay	3.8±2.5	3.6-4.0	2	3-9
E. Florida Bay	2.7±0.2	1.3-5.6	92	4,5,8,9,11
333 micron stations				
Parkwide	3.4±0.1	1.4-8.0	1098	3-12
W. Florida Bay	2.7±0.1	1.4-5.3	658	3,5-9,11-12
Whitewater Bay	4.5±0.1	2.0-8.0	440	3-10
1983				
All stations				
Parkwide	3.2±0.1	1.3-8.0	1529	2-11
W. Florida Bay	2.7±0.1	1.4-6.1	1001	2-9,11
Whitewater Bay	4.5 0.1	2.0-8.0	440	3-10
E. Florida Bay	2.7±0.2	1.3-5.6	88	4,5,8
475 micron stations				
Parkwide	2.6±0.1	1.3-6.1	436	2,4-8
W. Florida Bay	2.6±0.1	1.4-6.1	348	2,4-8
Marker 5	2.6±0.2	1.4-6.1	319	2,4-8
Conchie Channel	3.1±0.7	1.9-4.9	29	4,6-8
E. Florida Bay	2.7±0.2	1.3-5.6	88	4,5,8
Jewfish Creek	2.6±0.3	1.6-5.4	86	4,5
333 micron stations				
Parkwide	3.4±0.1	1.4-8.0	1093	3-11
W. Florida Bay	2.7±0.1	1.4-5.3	653	3,5-9,11
Cape Sable	2.7±0.1	1.4-5.3	652	3,5-9
Whitewater Bay	4.5±0.1	2.0-8.0	440	3-10
Little Shark River	4.6±0.1	2.0-8.0	408	3-10
Cormorant Pass				
Clearwater Pass	5.5±0.1	3.3-7.9	32	4,6,8,9
Joe River				

Table 5. Mean size of spotted seatrout larvae (< 8.0 mm S.L.) caught by month at stations in Everglades National Park, 1983. Mean values have 95% confidence intervals.

	*333 micron			*475 micron	
	All Stations	Cape Sable	Little Shark River	All Stations	Marker 5
Feb.	....	....	....	2.0	....
March	2.6±0.1	2.5±0.2	5.2±18.4	....	....
April	4.8±0.2	....	4.9±0.5	2.8±0.4	3.5±3.4
May	3.8±0.1	3.4±0.4	4.2±0.3	2.7±0.2	3.6±1.4
June	4.6±0.2	3.3±0.2	5.6±0.2	2.8±0.2	2.8±0.1
July	4.0±0.3	2.3±0.8	4.5±0.7	2.5±0.1	2.4±0.1
Aug.	2.6±0.1	2.2±0.1	3.4±0.2	4.6±1.1	4.7±1.0
Sept.	3.2±0.1	2.7±0.1	3.8±0.1	....	....
Oct.	5.8±0.4	....	5.8±0.8	....	....
Nov.	3.1	....	....	....	....

* Mesh Size

Table 6. Number of spotted seatrout preflexion larvae (< 2.4 mm S.L.) caught in Everglades National Park, 1982-1983, all gears combined.

	Number	Percent
Station		
Shell Creek	1	0.2
Jewfish Creek	38	6.7
Man O War Channel	2	0.3
Marker 5	168	29.7
Cape Sable	328	58.0
Conchee Channel	9	1.6
Bradley-Murray Key	5	0.9
Little Shark River	15	2.6
Area		
W. Florida Bay	512	90.4
E. Florida Bay	39	6.9
Whitewater Bay	0	....
Shark River	15	2.7
Month		
Feb.	1	0.2
March	29	5.1
April	11	1.9
May	37	6.5
June	35	6.2
July	161	28.4
Aug.	158	27.9
Sept.	128	22.6
Nov.	1	0.2
Dec.	5	0.9
Totals:	N = 566	