SOUTH FLORIDA RESEARCH CENTER

Report T-665
A Survey and Inventory of the Plant Communities in the Raccoon Point Area, Big Cypress National Preserve

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INTRODUCTION

The Raccoon Point area is one of five 50 km^2 study areas in the Big Cypress National Preserve. The study areas are used to establish a baseline inventory of the plant communities of the Preserve. The Raccoon Point area is a mosaic of upland south Florida slash pine forests and lower elevation pondcypress forests (McPherson 1973). The pine forests in this study area are unique in the Preserve because no evidence of logging is present (Patterson and Robertson 1981). The older pine trees support a significant population of Red-cockaded woodpeckers, Picoides borealis, a species on the U.S. Fish and Wildlife Service "endangered" list (Patterson and Robertson 1981).

Information on the current conditions of the plant communities in this area is necessary for prudent resource management of habitat for endangered species, as well as to preserve native systems. Many groups now utilize the area, each with activities that affect ecological patterns. Seasonal hunting and associated burning practices may have altered the timing and frequency of fire (Duever et al. 1979, Taylor 1980) in the pine and cypress forests. Also, development of oil production is ongoing at the time of this writing. Hopefully, preliminary information on plant species composition in relation to elevational, edaphic and hydrologic patterns will be utilized in reclaiming disturbed sites when oil extraction activities are completed.

Three objectives were sought in this inventory: 1) Map the current spatial distribution of the plant communities, 2) Quantitatively inventory the spatially dominant plant communities, 3) Establish preliminary correlations between species composition and environmental parameters of elevation, soils and hydrologic pattern.

METHODS

Vegetation Map

The vegetation map was made by first delineating the plant communities on 9 in. x 9 in. color contact prints (1:7800 taken in 1978). Readily discernible features on the photographs were also outlined on USGS 7.5 minute orthophoto topographic maps. The features from the orthophoto maps were transferred to a skeleton map using a Map-O-Graph opaque projector. The features on the skeleton map were used as control points to transfer the delineations from the color photographs to the skeleton map using the same projector. The rough draft was field-checked on the ground and by helicopter during December 1980. The map was then drafted, painted and printed. The map was made at a scale of 1:10,000 but was reduced during printing, due to limitations on the press size, so that the scale of the enclosed map is approximately 1:16,000.

Vegetation Inventory

Quantitative vegetation inventories were done in three vegetation types: pine-Sabal-Serenoa forest, cypress dome and cypress prairie. These three types represent the spatially dominant associations in the area. The plots were chosen at sites thought to be representative of each plant community. The locations of the vegetation plots are shown on the vegetation map (enclosed in back of report), and all are within Section 34 of Township 51 south, Range 34 east. The corner of each plot was marked with a concrete post and an aluminum marker, so that the plot can be relocated in the field. Table 1 lists the Universal Transverse Mercator coordinates of each plot and designation made on each of the aluminum markers.

The vegetation was divided into three categories for quantitative analysis: trees, shrubs, and understory. Trees were defined as any woody stem greater than 5 cm (2 inches) in diameter at breast height (1.37 m or 4.5 ft). Shrubs included any plant with a woody stem less than 5 cm dbh and greater than 1 m tall. The understory category encompassed any herbaceous plant, any woody plant less than 1 m tall and any epiphyte with a basal elevation of less than 1 m above ground level.

Trees

The diameters (dbh) of tree-size stems which were rooted within a 15 x 40 m rectangular plot (Figure 1) were measured to the nearest 0.13 cm (0.05 in). Tree plots were oriented along cardinal bearings, either north to south or east to west, and placed in homogeneous vegetation types. Basal areas were calculated and used as an expression of dominance of each species. Relative dominance, based on the total area of the plot, was determined for each species. The number of tree stems was tallied within the tree plot to yield stem densities per 600 m^2 for each species. Relative density for each species was calculated based on the total stem density in the plot. Occurrence of each species within each of twenty-four 5 x 5 m subplots (Figure 1) was recorded and frequency of occurrence determined for each species. Relative frequency was calculated based on the summation of the frequencies of all species. Relative dominance, relative density, and relative frequency were summed for each tree species to yield an importance value index. Tree heights were measured. Canopy cover was estimated using the line intercept method.

Shrubs

Shrub dominance was expressed as the percent cover of each species. Percent cover was determined along four 40 m line segments by the line intercept method. The intersection of the live leaf cover of each species with the line was measured to the nearest centimeter using a retractable metric tape. Percent cover was calculated by the sum of intersection distances along all four line segments (A, B, C, D, in Figure 1) divided by the total length (160 m). All Sabal palmetto and Serenoa repens that were not trees (no measurable dbh) and not seedlings were

Table 1. Locations and designations of vegetation inventory plots. Coordinates are Universal Transverse Mercator (UTM, Zone 17).

Vegetation Type Sampled	UTM Coordinates (Center of Plot)	Designation on Vegetation Map	Designation on Cement Corner Posts
Pine Forest	$28_{74}850$ $5_{08}060$	1	1.1
Pine Forest	$28_{74}450$ $5_{07}780$	2	1.2
Cypress Prairie	$28_{74}820$ $5_{07}780$	3	1.3
Cypress Dome	$28_{74}820$ $5_{07}850$	4	1.4

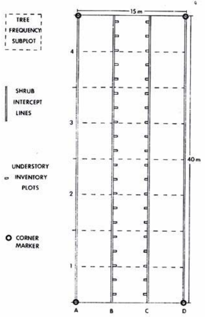

Figure 1. Schematic diagram of vegetation inventory plots.

measured by this method. Woody vines were usually inventoried in the shrub class. All intersections were recorded regardless of where the shrub was rooted, inside or outside the tree plot.

Shrub occurrence was noted in each of sixteen 10 m line segments (A1-A4, B1-B4, C1-C4, D1-D4; in Figure 1) and used to calculate frequency and relative frequency of each species. Relative dominance and relative frequency were summed to yield a shrub importance value.

Understory

Understory species were listed within forty 20 x 50 cm (0.1 m^2 plots placed at two meter intervals along the two center lines of the vegetation plot (Lines B, C in Figure 1)). The plots were placed in the center one-third of the tree plot and always placed on the same side of the two-meter interval mark. Cover classes were determined following Daubenmire's (1959) methods. Numerical values were assigned to each cover class as follows: (1) 0-5%, (2) 5-25%, (3) 25-50%, (4) 50-75%, (5) 75-95%, and (6) 95-100% for ease of recording in the field. The average percent cover of a species was obtained by summing the range midpoints of all recorded cover classes then dividing by the total number of plots (40). For example, Cladium was encountered six times in 40 plots and cover class values of 1, 2, 3, 4, 5, 6 were recorded. The midpoints of the cover classes (2.5, 15, 37.5, 62.5, 85, 97.5) were summed to yield 300 and then divided by 40 to give an average percent cover of 7.5%. Relative dominance (based on relative cover) was determined by calculating the percent of the total understory cover attributed to each species.

Frequency of occurrence was calculated from the number of times a species was found in the 40 plots. Relative frequency was calculated and added to relative dominance to yield an importance value for each understory species.

Species Identification

Identification references include Long and Lakela 1971, Lakela and Long 1976, Hitchcock 1950, and Ricketts 1967. Species not previously found in plots were collected and compared with species on file at the Herbarium at Everglades National Park, South Florida Research Center as well as being cross-checked with a species list for the Preserve (Black and Black 1980). Nomenclature generally follows Black and Black (1980).

Species Composition and Environmental Variables

In order to correlate species composition with environmental variables, two line transects were established to sample many different communities over a short distance (see vegetation map for locations). Transect I was approximately 435 m long and traversed plant communities of pine forest, hardwood scrub, cypress dome, and cypress prairie. Transect 2 measured 365 m in length and passed through cypress dome, cypress prairie, tropical hardwood hammock, and pine-hardwood associations. Benchmarks were established as measurement points at 23 m (75 ft) intervals along each transect. The benchmarks were set by driving .95 cm (3/8 in) diameter steel rod into the bedrock.

Soil surface elevations, soil depth and type were measured at each benchmark. The elevation of the top of each benchmark was surveyed from nearby known elevations. The soil surface elevation was obtained by subtracting the above-ground height of the steel rod from the elevation at the top of the rod. Soil depths were determined by inserting a soil probe at three points around the benchmark. A ringing sound indicated that bedrock was reached, then the depth was measured. The three measurements were averaged to yield a mean soil depth. A cut-away soil tube was used to assess each soil type. Major classes of soils were sands, marls, muck and litter.

A list was made of all vascular plant species within a 100 m^2 circular plot which was centered on certain benchmarks. Benchmarks which fell in ecotonal areas were the benchmarks excluded from this inventory.

Similarities among the benchmark stands were calculated using the index of Sorenson (1948). The index compares only the presence or absence of a species between stands and does not incorporate a species abundance within a stand. The stands were then ordinated using the polar ordination technique of Bray and Curtis (1957). Lists from 15 of the 20 benchmarks on transect one were used in the analysis, as were 10 of the 17 benchmarks on transect two.

Water levels were monitored at stations in the Pine-Sabal-Serenoa forest and the center of a cypress dome. Bimonthly water levels were obtained from a shallow ground water well in the pine forest located in the southwest quarter of Section 34, T. 51, S., R. 34 E. Surface water levels were measured during the same day at an iron rod in a cypress dome located near the center of Section 4, T. 52 S., R. 34 E. Water levels were measured between October 1980 and May 1981--not a complete annual hydrologic cycle, but encompassing the usual annual high and low water levels.

The water levels at the sample sites were correlated with the water levels taken the same day that the sample wells were monitored, at Bridge 105 along U.S. 41 (Tamiami Trail). The principal axis of each of the bivariate scattergrams were used as predictive equations for determining corresponding water level conditions between the sample sites and Bridge 105. Bridge 105 was used because of a 26 year period of record. The Pearson product-moment correlation coefficients (Sokal and Rohlf 1969) were 0.96 and 0.92 for the pine and cypress sites, respectively. The equations were used to determine the level at Bridge 105 equivalent to the water level at the test well, when the water level was equal to the ground surface elevation (i.e., when water levels went below ground). The value at Bridge 105 was then utilized to predict the number of days of annual inundation at the test wells. The hydroperiod (or number of days of inundation) was then calculated for every water year from 1952 to 1978 for the two sample wells.

RESULTS AND DISCUSSION

Pine Forests

The pine forests are one of the spatially codominant plant associations in the Raccoon Point Study Area. Pine forests are depicted on the vegetation map (enclosed in back cover) by green, with two subcategories identified. The more common Pine-Sabal-Serenoa forests are shown in plain green and pine-hardwood stands are represented by green with horizontal lines. Indefinite borders were found between the pine types, so no line was drawn to separate the two on the map.

Pine-Sabal-Serenoa Forests

The pine-Sabal-Serenoa forests are characterized by a sparse overstory of south Florida slash pine, Pinus elliottii var. densa. All measurements indicate an open, low-density overstory, which seems to be typical of present-day south Florida pine forests. Tree densities in the inventory plots were 9 and 6 trees/600 m^2 (150 and 100 stems/ha) in plots 1 and 2, respectively (Table 2). Summations of the density values may be on the low end of the range for Big Cypress pinelands, as Rochefort (pers. com.) measured trees in fourteen plots and found densities of 13-40 trees/600 m^2 in the same area. Although variable, the data indicate low densities of pine trees. Total basal areas (based on dbh) of the pines were 7400 cm^2 in plot 1, and 3200 cm^2 in plot 2 (Table 2). The largest tree in either plot was 40 cm (dbh), close to the maximum reported values of 40 cm (Duever et al. 1976) and 48 cm (Patterson and Robertson 1981) for south Florida slash pine. Canopy cover was low, with measured values of 23% and 40%, for plots 1 and 2. Tree heights ranged from 16 to 24 m in plot 1, and 12 to 23 m in plot 2. The measured heights are close to the maximum height of 30 m reported by Long and Lakela (1971), and Duever et al. (1975).

Sabal palmetto was the only other tree species in the pine plots and was only found in plot 1 (Table 2). Total basal area of Sabal was low (1100 cm^2/600 m^2) resulting in a tree importance value of 68, compared to 232 for pine. The Sabal trees only attained subcanopy heights, with a measured range of 4 to 5.5 meters.

Sabal and Serenoa repens formed important components in the shrub strata of both plots. Cover values of 19% and 8% were measured for Sabal in plots 1 and 2 (Table 3). The high cover value of Sabal in plot 1 accounted for its high importance value in that plot. Serenoa had cover values of 2% and 19% for the plots 1 and 2, respectively. The high importance value of Serenoa in plot 2 was also due to its high cover value. Myrica cerifera was the only hardwood shrub found in either pine plot, and was a minor feature in these pinelands.

The understory (excluding the palms) in the pinelands is typically gramineous, with Schizachyrium rhizomatum, Rhynchospora divergens, Muhlenbergia filipes, and Cassytha filiformis occurring as the most important understory species in both pine quantitative plots (Tables 4, 5). The combined importance values of these four species accounted for 54% of the total importance value for both plots. The

Table 2. Statistics for trees in vegetation inventory plots.

Plot	Species	Total Basal Area ($cm^2/600\ m^2$)	Density ($\#/600\ m^2$)	Frequency	Relative Dominance	Relative Density	Relative Frequency	Importance Value
Pine 1	Pinus elliottii var. densa	7,407	9	42	87	69	76	232
Pine 1	Sabal palmetto	1,120	4	13	13	31	24	68
Pine 2	Pinus elliottii var. densa	3,197	6	25	100	100	100	300
Cypress dome	Taxodium ascendens	40,648	111	96	98	90	92	280
Cypress dome	Annona glabra	9,985	13	8	2	10	8	20
Cypress prairie	Taxodium ascendens	2,966	58	96	100	100	100	300

Table 3. Statistics for shrub species in vegetation inventory plots.

Plot	Species	% Cover	Frequency	Relative Cover	Relative Frequency	Importance Value
Pine 1	Sabal palmetto	18.7	100	89	76	165
	Serenoa repens	2.0	19	11	15	26
	Rhus copallina	0.2	6	0	5	5
	Myrica cerifera	0.3	6	0	5	5
Pine 2	Serenoa repens	19.4	94	70	56	126
	Sabal palmetto	8.2	69	30	41	71
	Myrica cerifera	0.1	6	0	4	4
Cypress dome	Taxodium ascendens	1.2	38	100	100	200
Cypress prairie	Taxodium ascendens	7.6	56	95	69	164
	Stillingia aquatica	0.4	25	5	31	36

Table 4. Cover, frequency and importance values for understory species in pine plot 1.

Species	Average % Cover	Frequency	Relative Cover	Relative Frequency	Importance Value
Schizachyrium rhizomatum	25.50	77.5	39	13	52
Muhlenbergia filipes	10.00	45.0	15	8	23
Rhynchospora divergens	8.25	22.5	12	4	16
Cassytha filiformis	2.38	45.0	4	8	12
Flaveria linearis	3.25	32.5	5	6	11
Pluchea rosea	2.13	35.0	3	6	9
Jacquemontia curtissii	1.94	27.5	3	5	8
Melanthra angustifolia	0.56	27.5	1	5	6
Andropogon virginicus	1.00	15.0	2	3	5
Eupatorium mikanioides	1.13	20.0	2	3	5
Myrica cerifera	1.13	20.0	2	3	5
Panicum virgatum	1.38	17.5	2	3	5
Cladium jamaicense	1.25	15.0	2	3	5
Ruellia caroliniensis	0.50	20.0	1	3	4
Ludwigia microcarpa	0.75	12.5	1	2	3
Cirsium horridulum	0.31	17.5	1	3	3
Rudbeckia hirta	1.31	5.0	2	1	3
Sabal palmetto	0.50	7.5	1	1	2
Waltheria indica	0.25	10.0	1	2	2
Eryngium baldwinii	0.50	7.5	1	1	2
Cassia sp.	0.25	10.0	1	2	2
Stenandrium dulce	0.44	5.0	1	1	2
Mikania scandens	0.50	7.5	1	1	2
Stillingia aquatica	0.81	7.5	1	1	2
Phyla nodiflora	0.31	12.5	1	2	2
Pinguicula pumila	0.06	2.5	1	1	1
Setaria geniculata	0.06	2.5	1	1	1
Dichromena colorata	0.19	7.5	1	1	1
Centella asiatica	0.06	21.5	1	1	1
Physalis viscosa	0.19	7.5	1	1	1
Ipomea sagittata	0.13	5.0	1	1	1
Hypericum brachyphyllum	0.06	2.5	1	1	1
Lobelia glandulosa	0.19	7.5	1	1	1
Evolvulus sericeus	0.13	5.0	1	1	1
Serenoa repens	0.13	2.5	1	1	1
Solidago stricta	0.19	7.5	1	1	1
Pinus elliottii var. densa	0.19	7.5	1	1	1
Hyptis alata	0.06	2.5	1	1	1

Table 5. Cover, frequency and importance values for understory species in pine plot 2.

Species	Average % Cover	Frequency	Relative Cover	Relative Frequency	Importance Value
Rhynchospora divergens	32.44	75.0	37	14	51
Schizachyrium rhizomatum	21.56	72.5	24	13	37
Cassytha filiformis	9.00	62.5	10	12	22
Panicum virgatum	4.94	52.5	6	10	16
Andropogon virginicus	4.69	27.5	5	5	10
Panicum sp.	3.63	35.0	4	6	10
Pluchea rosea	2.25	37.5	3	7	10
Muhlenbergia filipes	2.19	15.0	2	3	5
Cladium jamaicense	1.69	17.5	2	3	5
Cirsium horridulum	0.44	17.5	1	3	4
Stenandrium dulce	0.50	20.0	1	4	5
Heliotropium polyphyllum	0.31	12.5	1	2	2
Pinquicula pumila	0.19	7.5	1	1	1
Phyla nodiflora	0.19	7.5	1	1	1
Hyptis alata	0.63	10.0	1	2	3
Myrica cerifera	0.50	7.5	1	1	2
Pinus elliottii var. *densa*	0.19	7.5	1	1	1
Eryngium baldwinii	0.25	10.0	1	2	2
Serenoa repens	0.75	5.0	1	1	2
Eupatorium mikanioides	0.81	7.5	1	1	2
Hypericum brachyphyllum	0.13	5.0	1	1	1
Solidago stricta	0.13	5.0	1	1	1
Aletris lutea	0.06	2.5	1	1	1
Hypericum cistifolium	0.13	5.0	1	1	1
Baccharis glomeruliflora	0.06	2.5	1	1	1
Physalis viscosa	0.06	2.5	1	1	1
Ruellia caroliniana	0.06	2.5	1	1	1
Ipomea sagittata	0.06	2.5	1	1	1
Sabal palmetto	0.06	2.5	1	1	1
Ludwigia microcarpa	0.06	2.5	1	1	1
Waltheria indica	0.06	2.5	1	1	1

remainder of the importance values was distributed among 34 species in plot 1 (total = 38 species) and 27 species in plot 2 (total = 31 species). One index of similarity (Sorenson 1948) showed 75% of the total number of species were common to both plots. Another index, which incorporates an importance value weighting factor indicated that 87% of the total importance value of both plots is accounted for by the species in common. This cursory similarity analysis indicates that the inventory adequately sampled the important understory species in the pine-Sabal-Serenoa forest, at least to the extent that the plots are representative samples of this type.

The pine-Sabal-Serenoa sites formed a distinct group in the ordination analysis (Figure 2). The distinction is a result of consistent dissimilarity in species composition to the other vegetation types. Indeed, only Myrsine floridana, Myrica cerifera, and Sabal palmetto were common to the pine and hardwood areas. These pine areas were also dissimilar to the cypress prairie. Cladium jamaicense and Myrica cerifera were the only species found in both the pine sites and cypress prairie, even though both have a majority of herbaceous species. The pine sites also formed a concise grouping in the ordination depiction, a result of consistently common species found around the pine benchmarks.

The soil surface elevations in the pine-Sabal-Serenoa sites were the highest elevations along transect one except for the elevations in the oak hammock (Figure 3). No pine-palm sites were sampled on transect two (Figure 4). The mean elevation in the pine areas was 68 cm above the low point on the transect (the center of a cypress dome) and 15 cm less than the mean elevation in a nearby oak hammock (Figure 5). The elevations within the pine sites varied 18 cm roughly 9 cm above and below the mean.

Soil depths in the pine-Sabal-Serenoa sites averaged 20 cm (Figure 6). The depths were fairly constant, with measured values between 10 and 35 cm, a range of 25 cm. The soils consisted of a fine to coarse sand. No litter or organic matter components were noticed.

Predicted hydroperiods in the pine well indicate only brief periods of inundation. No surface water was determined to have occurred during 17 of the 26 years of record. The longest duration calculated was in 1961, when 45 days of inundation occurred. Predicted inundation occurred 1.6% of the time during the period of record. A mean hydroperiod of 6 days/year was calculated, similar to that reported by Duever et al. (1978). Evaluation of the distribution of hydroperiods, however (Figure 7), indicates the mean may not be an accurate indicator of the hydrologic pattern if the mean is construed to indicate consistent (year-to-year) periods of brief (week-long) inundation. We believe that ground inundation is rarely seen in the pinelands, but that it can occur during high rainfall events, when water levels are already high.

Pine Hardwoods

Areas with a pine overstory and a dense subcanopy of hardwood species were designated as a separate category. The abundance of pine trees appears similar to the other pine forests (but no measurements were made). Hardwood species such

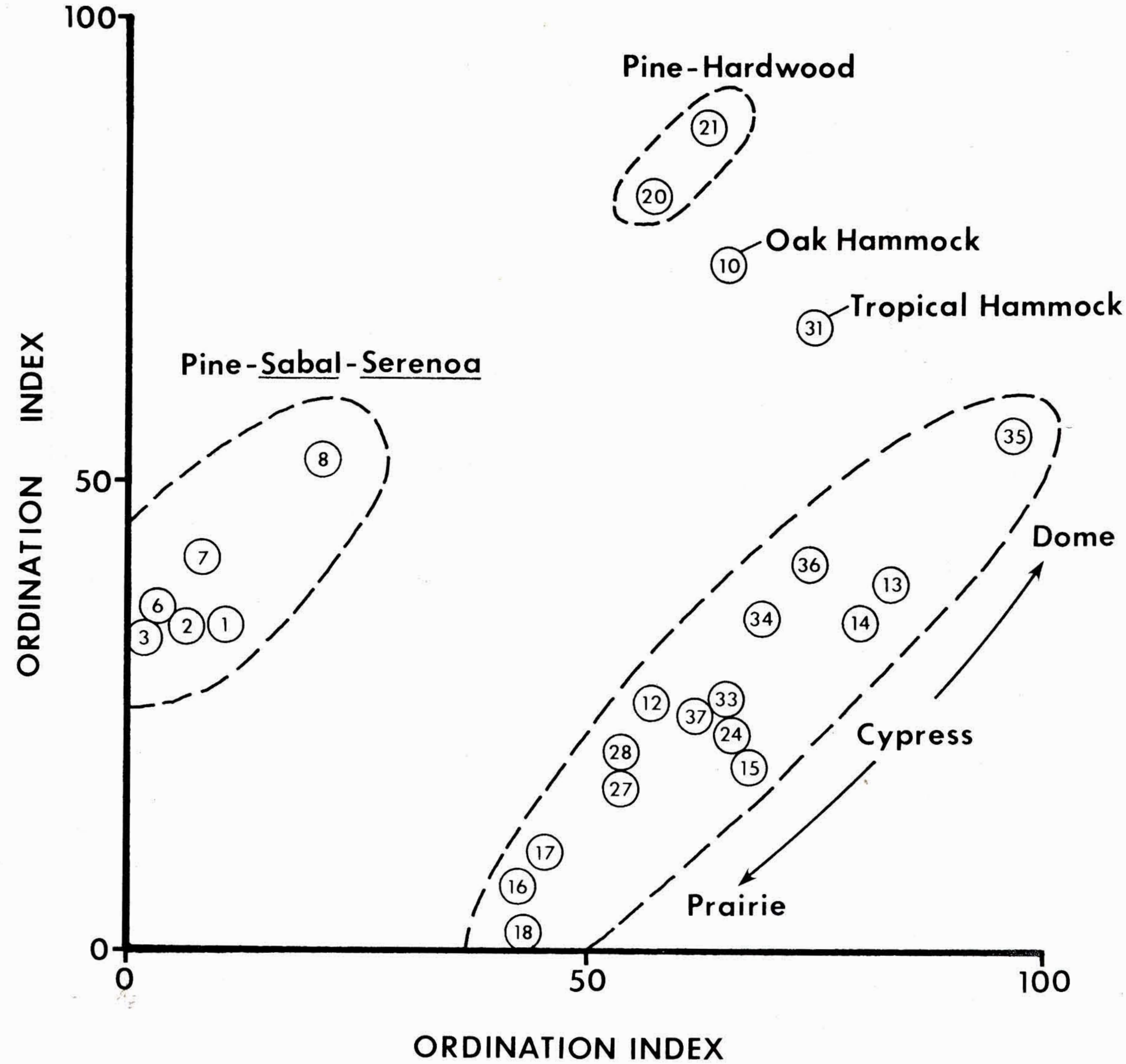

Figure 2. Ordination of benchmark stands along transects 1 and 2. Numbers in circles are benchmark numbers. Ordination technique of Bray and Curtis (1957).

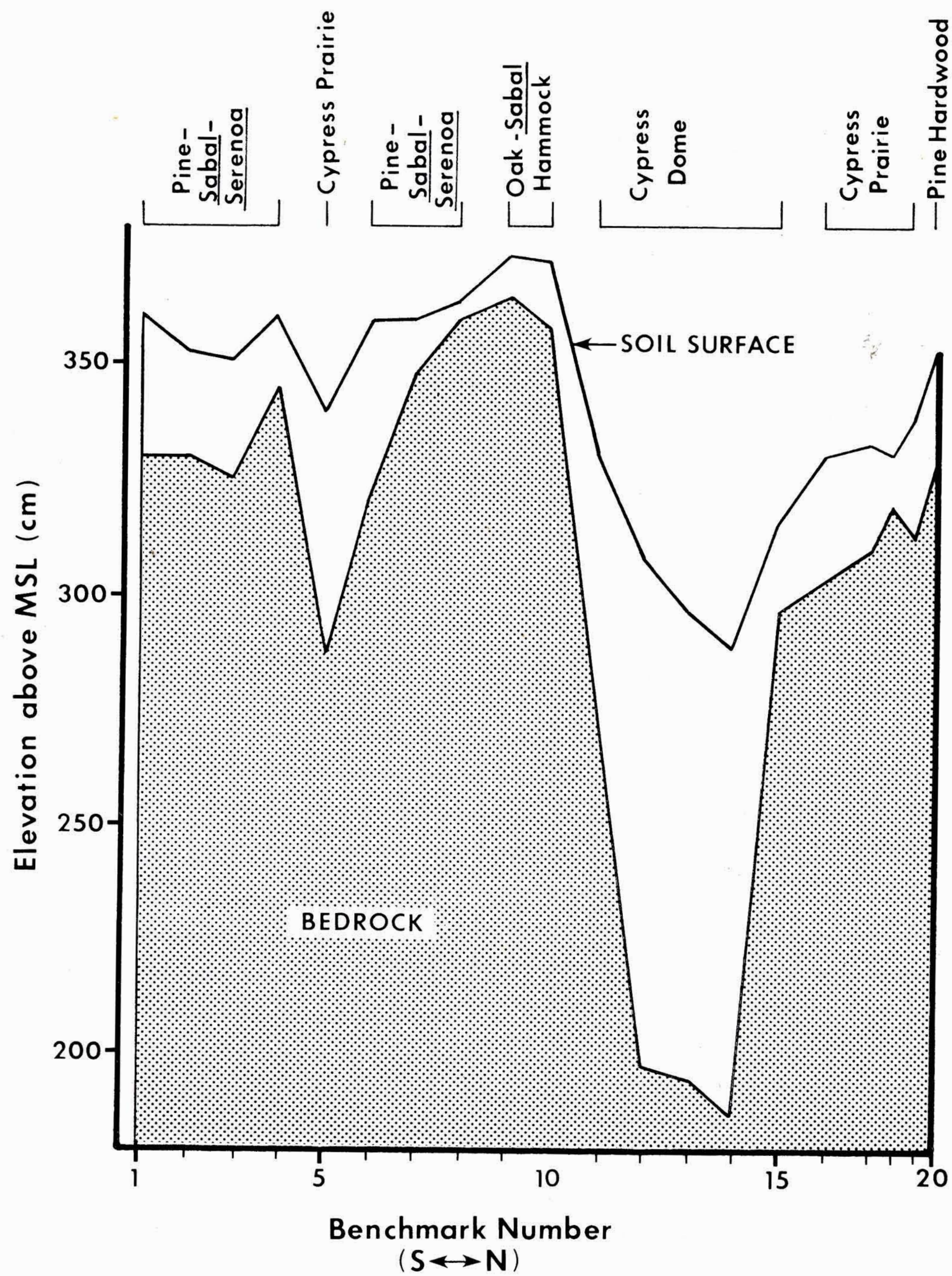

Figure 3. Profile of soil surface and bedrock elevations at benchmarks along transect 1, showing associated plant community.

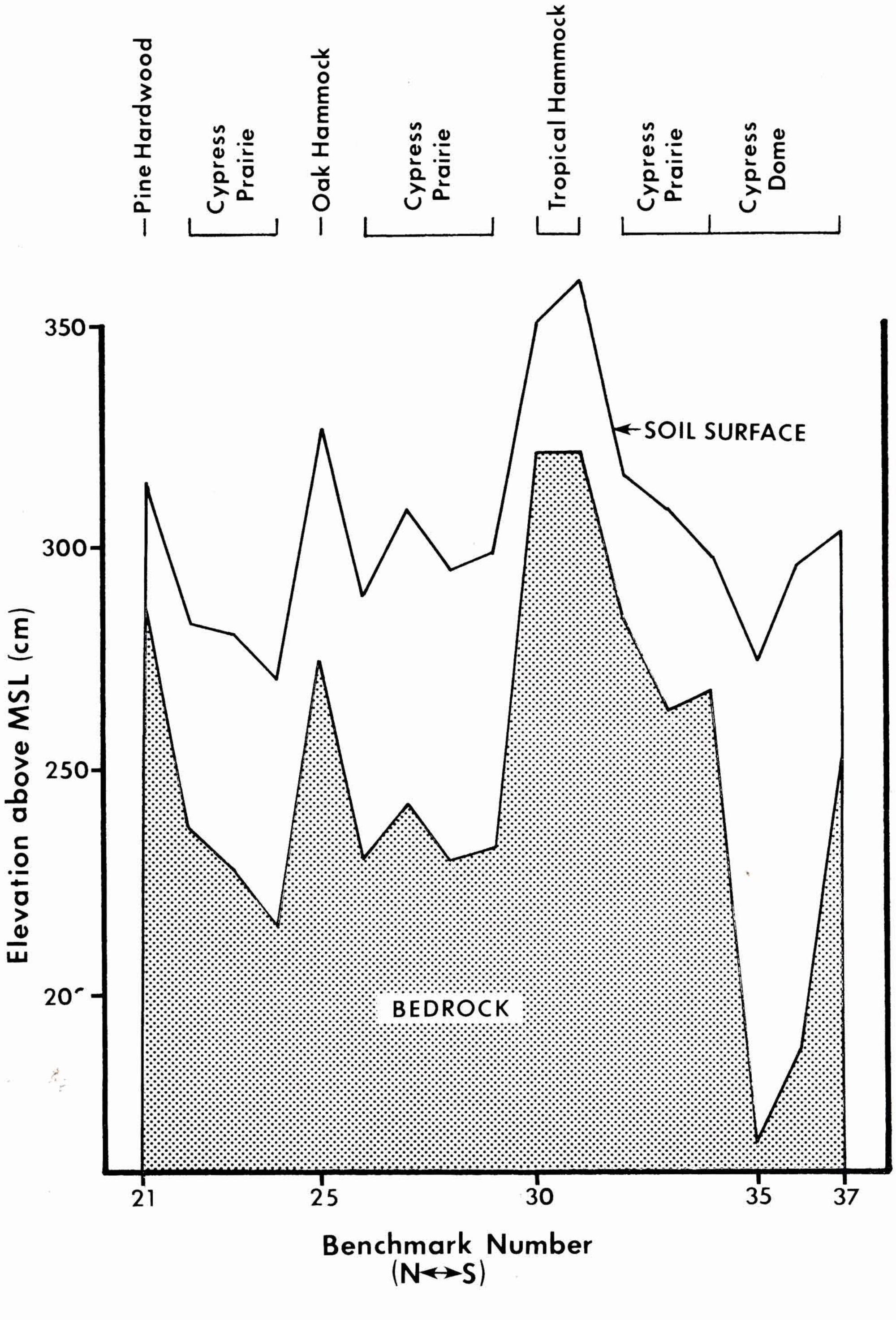

Figure 4. Profile of soil surface and bedrock elevations at benchmarks along transect 2, showing associated plant community.

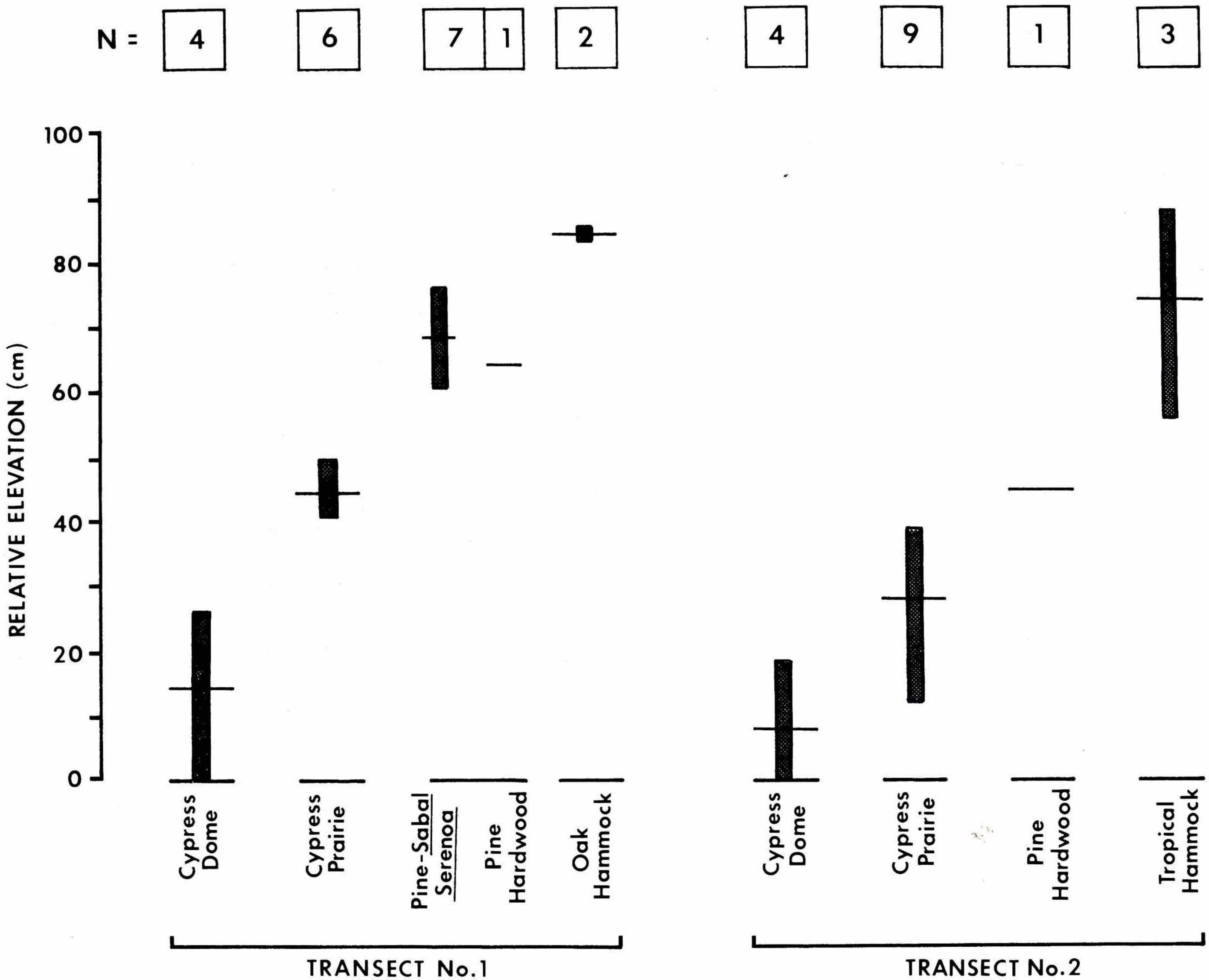

Figure 5. Relative soil surface elevations for plant communities along transects 1 and 2. Values are means, bars enclose range in values. Relative elevation of zero assigned to lowest point surveyed on each transect. N = number of samples.

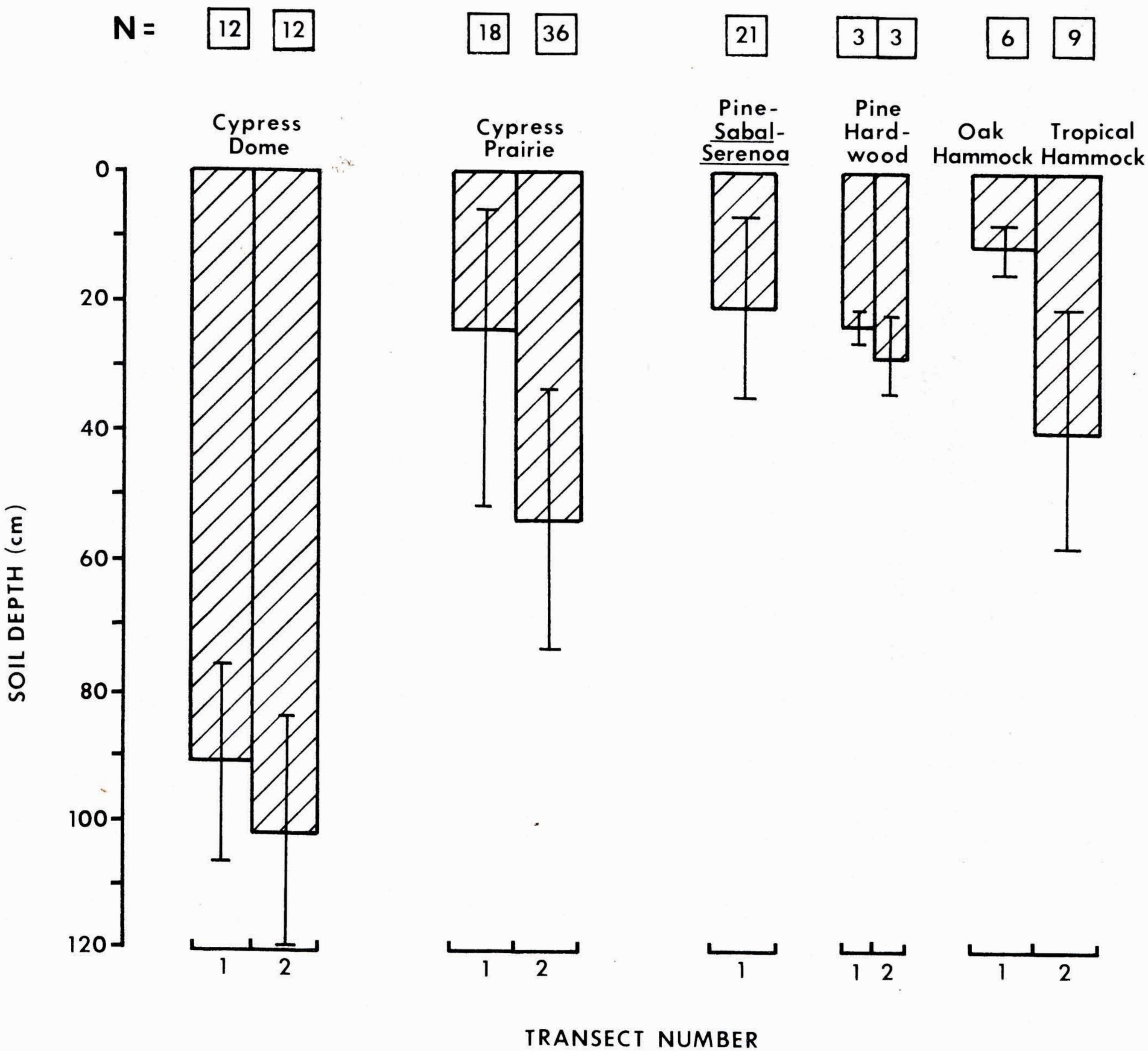

Figure 6. Soil depths beneath plant communities along transects 1 and 2. Bars represent means, brackets enclose range of values. N = number of samples.

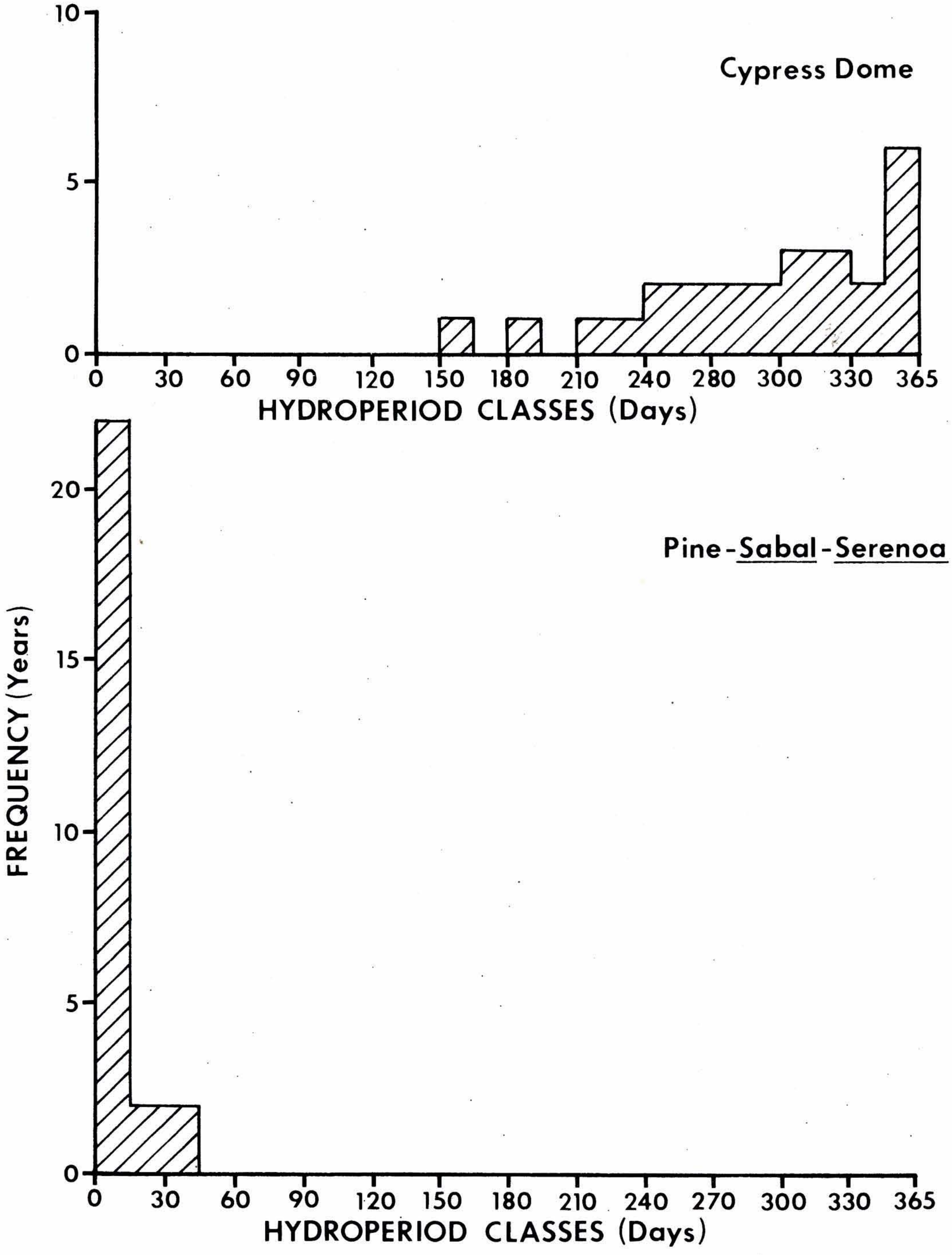

Figure 7. Hydroperiod distribution for pine-Sabal-Serenoa site and cypress dome site.

as Bumelia salicifolia, Chrysobalanus icaco, Ilex cassine, Myrica cerifera, Myrsine floridana, Persea borbonia, were trees and shrubs found in pine hardwood stands sampled along the transects (Table 6). The understory composition was also different from pine-Sabal-Serenoa stands, with abundant hardwood seedlings, shrubs and ferns in contrast to the palms and grasses. Because of the hardwoods present, the species composition in the pine-hardwood stands was more similar to hammock areas than to pine-Sabal-Serenoa forests, as is shown in the ordination analysis of the stands along the transects (Figure 2).

The soil surface elevations in the pine-hardwood stands did not appear to differ significantly from elevations in pine-Sabal-Serenoa forests. Based on few data points, the elevations seem to fall within the range of values for nearby pine forests (Figure 5). The elevations in the pine-hardwood stands were lower than the soil surfaces in hardwood hammocks.

Soil depths were similar in the two pine types, but the soils differed in composition (Figure 6). Soil depths varied between 10 and 35 cm in both types. The mean depth was 22 cm in the pine-Sabal sites and 25 cm in the pine hardwood sites (mean from both transects). The soil in the pine-hardwood sites was composed of a leaf-litter layer (approximately 5-10 cm deep) over fine to coarse sand. The litter layer was comprised of hardwood leaves and pine needles and appears to have accumulated since the hardwood establishment. The sub-litter sand is similar to the sands found in the pine-palm forest.

From these few indications, the environmental parameters do not appear to be different in the two pine forest types. Site elevation and edaphic conditions (and probably hydrologic patterns) are similar in the two types. Hardwood establishment and persistence is probably due to a low incidence of fire. The process of hardwood establishment in the absence of fire in south Florida slash pine forests has been well documented (Robertson 1953, Alexander 1967).

Observed ignition patterns may help explain the differences in fire frequencies between the two pine types. Hunters set many of the fires intentionally. Consequently, the fire pattern correlates well with the hunting season. The peak number of fires and acreage burned occurs between November and early March (Duever et al. 1979, Taylor 1980). Usually, during these months the cypress wetlands are wet enough to exclude fire. Only the large pine islands (pine-Sabal-Serenoa forests) are ignited and burn. The fires are contained within the large islands and do not expand into the surrounding wet areas. Since hunters utilize these areas year after year, the same areas burn probably as frequently as sufficient fuel loading exists.

The lower incidence of fire in the pine hardwood stands seems to be a result of their size and isolation. Many of the hardwood stands are small and therefore not directly ignited by hunters. The surrounding wetlands insulate these areas from fires set on the larger islands.

Table 6. Species found around benchmarks* along transects. Plant community groupings are from ordination analysis.

Species	Pine-Sabal Serenoa	Pine-Hardwoods	Mixed Hardwood	Cypress Prairie	Cypress Dome
Aletris lutea	x				
Andropogon virginicus	x				
Annona glabra				x	x
Ardisia escallonioides			x		
Aristida purpurascens	x			x	
Aster dumosus	x				
Aster tenuifolius				x	
Baccharis glomeruliflora			x	x	
Bacopa caroliniana				x	x
Berchemia scandens			x		
Blechnum serrulatum	x	x	x		
Boehmeria cylindrica			x	x	x
Bumelia salicifolia		x	x		
Bumelia reclinata			x	x	
Bursera simaruba			x		
Cassytha filiformis	x				
Cephalanthus occidentalis			x		x
Chiococca alba			x		
Chrysobalanus icaco		x	x		x
Cirsium horridulum	x				
Cladium jamaicense	x			x	x
Crotalaria sp.	x				
Cynanchum blodgetti			x		
Cynoctonum mitreola	x				
Dichanthelium dichotomum	x				
Dichromena colorata	x				
Drosera capillaris	x				
Eleocharis cellulosa				x	
Elytraria caroliniensis	x				
Encyclia tampensis			x	x	x
Eragrostis elliottii	x				
Eragrostis sp.				x	
Erianthus giganteus	x			x	
Eriocaulon compressum				x	x
Eupatorium coelestinum	x				
Eupatorium leptophyllum			x	x	x
Eupatorium mikanioides	x				

Species	Pine-Sabal Serenoa	Pine-Hardwoods	Mixed Hardwood	Cypress Prairie	Cypress Dome
Flaveria linearis	x				
Fraxinus caroliniana					x
Fuirena breviseta				x	
Fuirena scirpoidea				x	
Hedyotis procumbens	x				
Hypericum sp.	x				
Hyptis alata	x				
Ilex cassine		x	x		
Jacquemontia curtissii		x			
Juncus sp.			x	x	
Ludwigia repens				x	x
Ludwigia sp.	x				
Mikania scandens	x				x
Muhlenbergia filipes	x				
Myrica cerifera	x	x	x	x	x
Myrcianthes fragrans			x		
Myriophyllum brasiliensis					
Myrsine floridana	x	x	x		
Nephrolepis exaltata			x	x	x
Nymphoides aquatica					
Oxypolis filiformis				x	
Panicum hemitomon				x	x
Panicum sp.				x	
Panicum virgatum	x				
Parthenocissus quinquefolia		x	x		
Paspalum monostachyum	x			x	
Persea borbonia		x	x		
Petalostemmon carneum	x				
Phyllanthus caroliniensis	x				
Pinguicula lutea	x				
Pinus elliottii var. densa	x	x		x	
Piriqueta caroliniana	x			x	
Pluchea rosea	x			x	x
Polygala grandiflora					
Polypodium aureum			x		
Polypodium polypodiodes					x
Pontederia lanceolata					x
Proserpinaca palustris				x	x
Psilotum nudum		x			
Quercus virginiana	x		x		

Species	Pine-Sabal Serenoa	Pine-Hardwoods	Mixed Hardwood	Cypress Prairie	Cypress Dome
Randia aculeata			x		
Rhynchospora divergens	x				
Rhynchospora inundata					
Rhynchospora microcarpa	x			x	
Rhynchospora tracyii				x	
Rudbeckia hirta	x				
Ruellia caroliniensis	x				
Sabal palmetto	x		x		
Sagittaria graminea				x	x
Schizachyrium rhizomatum	x			x	
Serenoa repens	x	x			
Setaria gracilis	x			x	
Sisyrinchium atlanticum	x				
Smilax bona-nox	x		x		
Smilax laurifolia		x			
Solidago stricta	x				
Stillingia aquatica				x	x
Taxodium ascendens	x			x	x
Thalia geniculata					x
Thelypteris kunthii		x	x	x	x
Tillandsia balbisiana		x	x	x	x
Tillandsia circinata				x	x
Tillandsia fasiculata	x	x	x	x	x
Tillandsia recurvata			x	x	x
Tillandsia setacea			x	x	x
Tillandsia usneoides			x	x	x
Tillandsia utriculata					
Toxicodendron radicans	x	x	x		x
Utricularia foliosa					x
Vittaria lineata			x		
Vitis rotundifolia	x	x	x		
Xyris elliotii	x			x	
Zeuxine strateumatica	x				

Benchmark Numbers

*Benchmarks used in analysis	1	20	10	13	12
	2	21	31	14	15
	3			34	16
	6			35	17
	7			36	18
	8				24
					27
					28
					33
					37

Fire can enter these pine-hardwood stands during drought years, and the results seem to be catastrophic. With the large fuel loading, the fire becomes severe enough to kill not only the hardwoods but also the overstory pines. Only a few fire adapted species, such as Sabal palmetto, Serenoa repens and certain top-killed hardwoods resprout. Early successional species such as Pteridium aquilinum also invade the site. Examples of areas dominated by the aforementioned species with remnant pine snags are present in the study area. They are designated on the map as hardwood scrub because no live pine trees are present; hardwood and palms dominate the site and the vegetation forms a dense, scrubby thicket.

Succession in Pine Forests

The pine forests appear to occupy sites within a characteristic set of environmental parameters. The range of pine ground surface elevations only slightly overlaps elevations of the hardwood forests on higher ground and cypress forests on lower ground. Since the relative elevation of a site is closely linked to a hydrologic regime, distinctions in hydroperiod also exist among plant communities. No overlap was noticed in the hydroperiod distributions of the pine forests and the cypress dome (Figure 7). Although not documented here, hydrologic differences seem to occur between the pine and cypress prairie types, as well as the pine and hardwood areas. Some authors (Craighead 1974, Duever et al. 1979) contend that tropical hammocks may be found on distinct bedrock formations, different from the substrate of the surrounding pineland.

The observed environmental differences between sites occupied by major community types seem immutable in the short-term (< 100 years) and not capable of being overcome by short-term autogenic processes. Site elevation is determined by bedrock topography with relatively minor modifications through sand and marl depositions. Solution of the limestone substrate can lower ground surface elevations, but occurs very slowly. Organic matter accretion can shorten hydroperiods and modify edaphic conditions, but also occurs slowly and is subject to reversals by normal decomposition and fire. Major hydrologic changes are thought possible due to canal construction and drainage of neighboring areas. Hydrologic alterations of this magnitude have occurred in the nearby Golden Gates area (Tabb et al. 1976) where former cypress sites now support well-developed pine forests. However, we think that changes of this magnitude have not yet occurred in this study area of the Preserve, even though there may be evidence to the contrary. For example, we (the authors) and other workers (T. Alexander and W. B. Robertson, Jr., pers. comm.) have observed pine seedlings in cypress prairie areas. This phenomena may indicate a shortening of the hydroperiod, which has allowed establishment of this "upland" species in a "wetland" site. Other explanations are plausible such as an overlap in establishment requirements between the two species or a series of relatively dry years that have allowed pine establishment. We do not have any evidence to determine the causal factors of this invasion, but still believe that major hydrologic modifications have not yet occurred in this study area.

The following discussion of succession in pine forests is restricted to changes in species composition at a given pine site over a relatively short period of time (100 years).

Allogenic perturbations (or lack of) are major determinants of species change in southern pine forests. Disturbances which affect succession include lumbering, frosts, hurricanes, lightning and fire. Patterson and Robertson (1981) updated the work of Duever et al. (1979) and determined that the pinelands of the Raccoon Point area were not logged, based on the absence of logging roads and visible stumps, as well as the occurrence of stands of old-growth, large diameter pine trees. Frosts, lightning and hurricanes all occur infrequently and may not have drastic effects on species composition. The single most important factor in pineland succession of this area is fire.

We have attempted in Figure 8 to establish a preliminary model of succession in Big Cypress pine forest based on data gathered and observations made during the course of this study as well as extensive literature on the role of fire in southeastern pine forests. A recent review by Wade et al. (1980) brings together much of the information pertinent to the ecology of fire in south Florida. Ongoing fire ecology studies in the Big Cypress National Preserve will contribute to clarifying impacts of various fire regimes (time of year of fire, type of fire, and frequency of fire) on local pinelands.

Boxes in Figure 8 represent identifiable plant associations which exist in the Preserve; most of these are found in the Raccoon Point area. Arrows in Figure 8 represent driving processes and/or required conditions for successional change.

Pine-Sabal-Serenoa forest is the typical pine type in the Raccoon Point area, as well as most of the Preserve. Its component species are adapted to a regime of frequent fire (3-7 year interval); grasses and palms readily resprout following fires and the young pines can withstand light fires once they have attained a height of 2-3 m. The overstory pines are rarely affected by rapidly moving ground fires in regions of sparse fuel loading. After more than seven years of fire exclusion, accumulation of pine litter and hardwood encroachment creates a fuel load which can burn with severe impact to the pine stand.

Very frequent fires (less than 3 year intervals) may damage the cambial layers of the overstory pines, subjecting the pines to gradual attrition. Once a fire scar is made, consecutive fires consume more and more of the cambium and heartwood until the tree falls. Frequent fires may also kill seedlings, eliminating recruitment to the sampling stages when the species is more capable of surviving fires. Removal of the overstory pines and lack of pine regeneration leaves the site dominated by the more fire tolerant Sabal, Serenoa and grasses. Recurrent, frequent fires maintain this species composition. On the other hand, given nearby pine seed sources and restoration of a fire regime favoring pine, the site would presumably revert to a pine-Sabal-Serenoa stand.

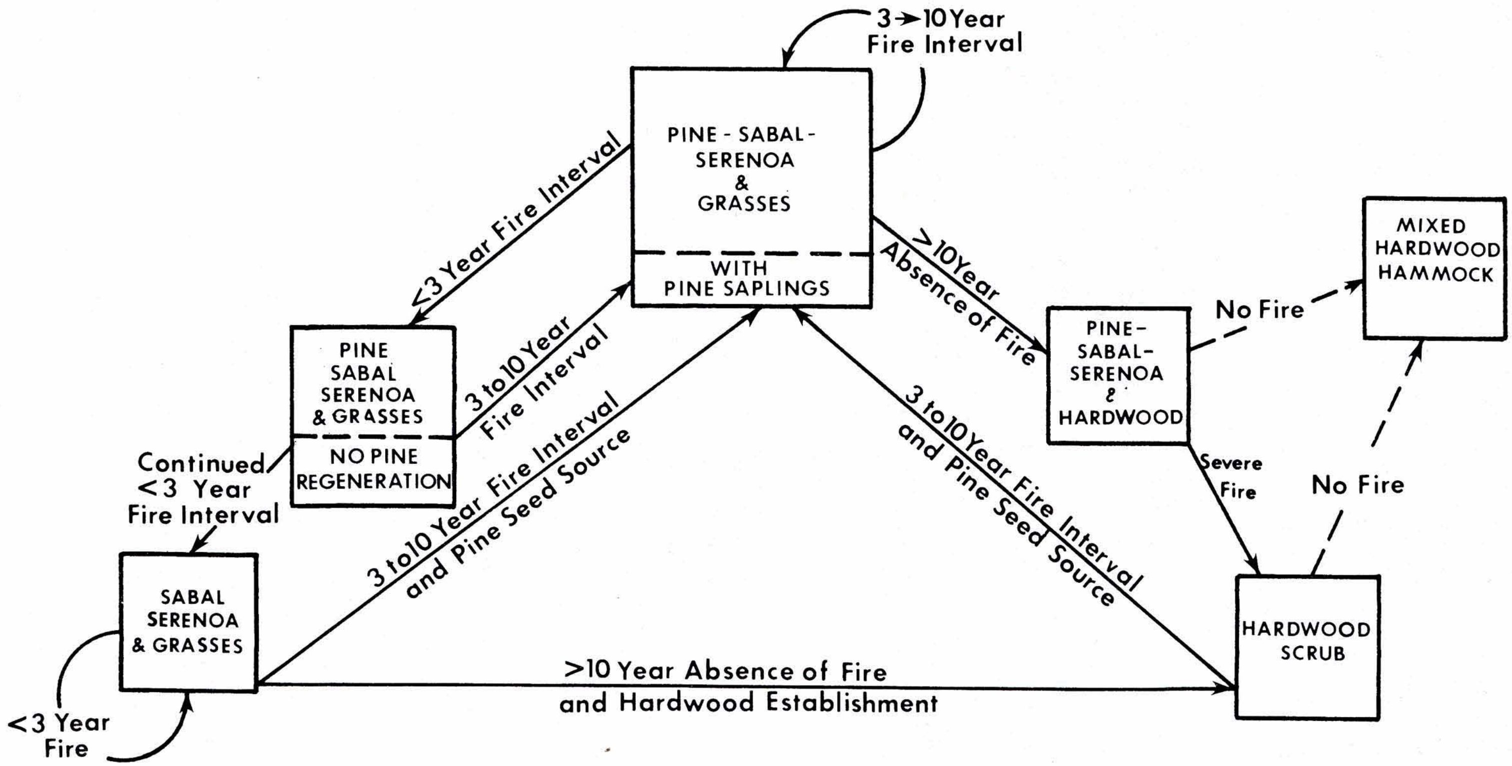

Figure 8. Proposed succession scheme for pinelands of the Raccoon Point area involving various fire regimes.

In the absence of fire (approximately 10-20 years) hardwoods invade pine sites, regardless of the previous species composition (i.e., hardwoods can invade either a pine-Sabal-Serenoa stand or a Sabal-Serenoa stand). With pine present, this leads to a pine-hardwood stage. The hardwood scrub, a result of hardwood invasion at Sabal-Serenoa sites, is comprised of such species as Myrica cerifera, Persea borbonia, Chrysobalanus icaco and Ilex cassine, usually with Sabal and Serenoa persisting. Severe fire in the pine hardwood results in a scrub stage, with tolerant hardwoods and palms surviving. This scrub stage seems to be maintained in a low-stature profile by frequent fire. Given an adequate pine seed source and fire regime (a catastrophic fire), the succession may proceed back toward the pine-palm forest.

With continued absence of fire, hardwood scrub and perhaps pine-hardwood may develop into hardwood hammock (probably oak-Sabal). Successional conversion or near-conversion of pine forest to mature hardwood hammock, as described by Alexander (1967) for the Miami coastal ridge, has not yet been observed by us in the Big Cypress National Preserve and seems unlikely with the current fire regime (there is no scarcity of ignitions during dry conditions). Overstory pines will probably persist without fire in a pine-hardwood stand for 100 years, continually shedding needles and creating a highly-ignitable fuel source. Furthermore, existing hardwood hammocks in the Raccoon Point area seem to consistently occupy higher sites than pine, and their soils may be related to a different parent material from soils of pine sites.

Cypress Forests

Two types of cypress forests were identified in this study area: cypress dome and cypress prairie. Both associations are dominated by pondcypress, Taxodium ascendens. The two types differ in structural aspects and subcanopy species composition. On the vegetation map, both are yellow; prairie areas are plain, whereas domes are stippled.

Cypress domes

Cypress domes are characterized by a dome-like hemispherical profile, with shorter trees on the periphery and the taller trees in the center. Measured heights in the inventory plot (#4 on map) ranged from 4 meters for trees at the edge of the dome to 20 meters for the tallest trees in the center, within the range reported by Wade et al. (1980), for south Florida domes. Measured canopy cover was 86%, slightly higher than the 70-80% of Duever et al. (1978). The high canopy cover is due to the high tree density. The total number of stems in the plot was 124--111 pondcypress trees and 13 pondapple, (Annona) trees (Table 1). These figures extrapolate to a tree density of 1850 trees/ha, slightly higher than the 1600 trees/ha reported by Duever, et al. (1978) for pondcypress areas of a cypress strand. The total tree basal area (based on dbh) for the plot was approximately 5 m^2/600 m^2, nearly as high as comparable figures for a cypress-mixed swamp forest (Gunderson et al. 1982), and is, to our knowledge, the highest reported value for any forest in south Florida. The only species with individuals in the "shrub" size class was pondcypress (Table 3), indicating possibly active regeneration.

Because of a high overstory cover, understory species are sparse. Two submerged aquatic plants of the genera Bacopa and Proserpinaca were the most important understory species (Table 7). Emergent aquatic species such as Panicum, Diodia, Rhynchospora, and Eriocaulon were present but not very abundant. The ferns Thelypteris and Nephrolepis were found growing on buttresses of Taxodium.

Species composition in the domes sampled along the transects was most dissimilar of any stands to the pine forests (Figure 2). Two Tillandsia species were the only common plants between these two associations. Hardwoods present in both domes and hardwood associations accounted for some similarity between these types. No clear distinction was shown in the ordination analysis (Figure 2) between the cypress dome and cypress prairie types, since the periphery of domes is similar to cypress prairie areas. A gradient of elevational and edaphic conditions, exists from the cypress prairie through to the center of the dome. The ordinated stands seem to follow the gradient, indicating a continuum between the types in terms of species composition, rather than a distinct separation of species groups.

The central interior portions of the cypress domes were at the lowest soil surface elevations and the lowest bedrock depressions along the transects (Figures 3 and 4). Because soil elevations increased towards the periphery of the domes, the average elevation (based on all measurements within the dome) was 15 cm above the lowest point on transect 1, and 10 cm on transect 2. The ranges in soil surface elevations within domes were 20 and 25 cm for transects 1 and 2, respectively (Figure 5). These ranges represent micro-gradients within the domes and overlap with the range of cypress prairie elevations (Transect 2 of Figure 5) indicating continuation of this gradient into the cypress prairie areas.

Soil depths in the central portions of the dome averaged 90 and 105 cm on transects 1 and 2, respectively (Figure 7). The range of measurements was from 75 to 120 cm for both transects. Soils in the domes consisted of a basal layer of sand overlain by a peat layer, with a surface layer of litter of fallen cypress needles.

Hydroperiod analysis in the central region of a cypress dome indicates prolonged wet conditions. Calculated mean hydroperiods (based on 26 years of record) was 299 days/year, with a high value of 365 days and a low value of 153 days. Inundation occurred 82% of the time during period of record. The mean value was within the range of 250-300 days/yr reported by Duever et al. (1978) for pond-cypress forests. The mean value does not provide a good hydrologic description since the distribution of hydroperiods is skewed toward the wet end of the spectrum. The hydroperiods do not form a normal distribution about the mean and year-to-year variability was high (Figure 7). Hydroperiods of 11-12 months occurred most frequently (14 of 26 years).

Cypress Prairie

The cypress prairie areas are typical for the region, with an overstory of stunted, low-density pondcypress. Measured tree density was 58/600 m^2 (967 trees/ha),

Table 7. Cover, frequency and importance values for understory species in cypress dome plot.

Species	Average % Cover	Frequency	Relative Cover	Relative Frequency	Importance Value
Bacopa caroliniana	6.63	37.5	50	41	91
Proserpinaca palustris	0.56	10.0	7	11	19
Panicum hemitomon	0.50	7.5	7	8	15
Eupatorium leptophyllum	0.50	7.5	7	8	15
Diodia virginiana	0.13	5.0	4	6	10
Rhynchospora mundata	0.13	5.0	4	6	10
Eriocaulon compressum	0.06	2.5	3	3	6
Nephrolepis exaltata	0.06	2.5	3	3	6
Thelyptris kunthii	0.06	2.5	3	3	6
Mikania scandens	0.06	2.5	3	3	6
Lobelia glandulosa	0.06	2.5	3	3	6

roughly half of the density in nearby cypress dome (Table 2) and 75% of the reported value of 1360 trees/ha (Wade et al. 1980). The total basal area in the cypress prairie inventory plot (Table 8) was 2966 cm^2/600 m^2, only 7% of the total in the cypress dome plot.

The size of the trees was also much smaller in the cypress prairie than in the dome, averaging 8 cm/tree, whereas the trees in the dome averaged 25 cm/tree (dbh). The trees in the cypress prairie were short in stature, ranging from 2 to 7 meters. With low, small trees characterizing the site, an open canopy cover (14%) was also measured. This forest was slightly more open than the 35 to 45% cover values measured by Flohrschutz (1978) in a dwarf cypress forest.

The understory is made up of a mixture of grasses, sedges and herbs which form a prairie-like physiognomy. For this reason, cypress prairie is used to describe these associations, rather than the previous terms of dwarfed (Davis 1943, Craighead 1971) stunted or hatrack cypress. The most important understory species, among the 18 encountered, were Rhynchospora microcarpa, Schizachyrium rhizomatum, and Muhlenbergia filipes (Table 8).

Succession in Cypress Forests

With the current hydrologic regime, there appears to be no short-term (order of 100 years) possibility of conversion of cypress domes to cypress prairies or vice versa. Domes occur over deep bedrock depressions where very long hydroperiods occur and much organic matter has accumulated. Cypress prairies have shallow marl soil and moderate hydroperiods. Fire and gradual oxidation will prevent sufficient further accumulation of organic matter in a cypress dome to significantly shorten hydroperiods. Therefore, succession occurs within these types, during recovery from fire and hurricanes, but neither such severe disturbances or lack of them will convert one type to the other.

Infrequent fire in cypress prairie associations seems to have little effect. Wade et al. (1980) cite a fire frequency of once every decade or two in cypress prairie areas. They relate the low fire incidence to slow production of fuel. We guess that sufficient fuel would be produced more rapidly than a ten year period, and now fire frequency seems to be determined by man-caused ignitions and time of year. With increased hunter activities and late winter ignitions, fire incidence may have increased in the cypress prairie in recent years, yet no serious effects of have been noticed. Increased ignitions could lead to attrition of cypress trees and these areas should be monitored for a decrease in tree density due to more frequent fires.

Cypress domes and strands can be modified by fire depending upon the time of year and severity of the fire. During late spring when water levels are low, severe peat-removing fires can enter the domes and strands. Stands of willow, popash, or sawgrass, can become established on severely disturbed sites, usually forming distinct, monospecific stands. For more information on succession in cypress domes following fire, the reader is referred to Cypert (1961), Ewel and Mitsch (1978); Gunderson (1977), Wade et al. (1980), and Gunderson and Loope (1982b).

Table 8. Cover, frequency and importance values for understory species in cypress prairie plot.

Species	Average % Cover	Frequency	Relative Cover	Relative Frequency	Importance Value
Rhynchospora microcarpa	7.75	75.0	28	27	55
Schizachyrium rhizomatum	7.50	57.5	28	21	49
Muhlenbergia filipes	5.00	40.0	18	14	32
Rhynchospora tracyii	1.81	22.5	7	8	15
Setaria geniculata	1.63	17.5	6	6	12
Rhynchospora inundata	1.38	7.5	5	3	8
Caldium jamaicense	0.56	12.5	2	4	6
Rhynchospora divergens	0.50	7.5	2	3	5
Ludwigia microcarpa	0.19	7.5	1	3	4
Sagittaria graminea	0.13	5.0	1	2	2
Taxodium ascendens	0.13	5.0	1	2	2
Pluchea rosea	0.13	5.0	1	2	2
Stillingia aquatica	0.13	5.0	1	2	2
Eupatorium leptophyllum	0.06	2.5	1	2	2
Bacopa caroliniana	0.06	2.5	1	2	2
Panicum sp.	0.06	2.5	1	2	2
Pinus elliottii	0.06	2.5	1	2	2
Eleocharis caribea	0.06	2.5	1	2	2

Willow Heads, Popash-Pondapple Sloughs

Willow heads are dense thickets of Salix caroliniana. Willow is usually the only tree present. The understory is composed of such aquatic herbs as Bacopa, Proserpinaca and Ludwigia. These stands are usually found in the center of a burned-out dome (see vegetation map). Very few willow heads were encountered in the Raccoon Point area. The willow areas are represented on the vegetation map by plain light green; popash-pondapple areas are the same color, but stippled.

Sawgrass and Mixed Marshes

Sawgrass marshes are dominated by dense, tall (up to 2 meters) sawgrass (Cladium jamaicense). A few species are found associated with Cladium, but no inventory was done in either marsh type to determine precise composition. Sawgrass areas are represented by plain blue on the map; stippled blue areas indicate mixed marshes. Mixed marshes are characterized by emergent aquatic plants such as Pontedaria lanceolata, Sagattaria latifolia, and Typha domingensis.

Hardwood Forests

Hardwood forests cover a relatively small percentage of the Raccoon Point area (see vegetation map). All hardwood areas are colored brown on the vegetation map and three types are identified: oak-Sabal hammocks are colored plain brown; tropical hardwood hammocks are depicted as stippled brown, and hardwood scrub areas have horizontal stripes over the brown color.

Oak-Sabal hammocks are characterized by an overstory of live oak, Quercus virginiana. Other tree species found in an oak hammock sampled on transect #1 were Sabal palmetto, Myrsine floridana, and Persea borbonia (Table 6). The understory is chiefly comprised of ferns of the genera Blechnum, Thelypteris and Nephrolepis, as well as various vines.

The species composition was quite similar between the oak-Sabal area and tropical hammock in the ordination analysis (Figure 2). Both hammock areas were similar to the pine-hardwood areas. Live oak was present in both hammocks, as were the same species of bromeliads, ferns and epiphytes. These common species accounted for the high degree of similarity. The presence of tropical tree species in the stand along transect #2 was the reason for its classification as a tropical hammock. The tropical species found were Bursera simaruba, Bumelia salicifolia, Eugenia axillaris, Myrcianthes fragrans and Simarouba glauca. The tropical hammocks in this study area had fewer tropical species than hammocks in other areas, such as the Pinecrest area (Gunderson and Loope 1982a).

The hardwood areas were found on the highest soil surface elevations (Figure 5). The soil surface highs were associated with "peaks" in the bedrock (Figures 3 and 4). Both the oak-Sabal and tropical hammocks were in the same range of elevations and are apparently inundated very rarely.

Based on a few preliminary measurements, the soil depths differ between the two types. Average soil depth in the oak-Sabal area on transect 1 was only 12 cm; the average depth in the tropical hammock was 40 cm. The soil types appeared similar, both having a litter layer over a black muck mixed with sand. If this difference in soil depths is consistent, then perhaps tropical hammocks occupy lower bedrock sites than the oak-Sabal hammocks.

Hardwood scrub areas are thought to be early successional stage hammock types. This category is somewhat of a "catch-all" in that the scrub areas may have different histories. Their common feature is that the vegetation is composed of hardwood species and has a scrubby appearance. The scrub term is used to describe thickets of short stature (less than 5 meters tall); thickets that are very difficult to walk through without use of a machete. Certain hardwood scrub areas can be easily recognized as disturbed oak-Sabal hammocks by their species composition. Others, with saplings of Bursera, Bumelia and Quercus seem to be disturbed tropical hammocks. Hardwood scrub may occupy sites where pine forests were engulfed by hardwoods then most of the vegetation was consumed by a severe fire.

Exotic Vegetation

Very few stands of exotic vegetation were found in the Raccoon Point area. Only two stands were identified on the vegetation map, but more may be present. These stands were made up of perhaps 10-20 individuals of Melaleuca quinquenervia. The tallest trees in the stands were approximately 10 m. Many saplings were found, indicating active regeneration. The stands were found in the ecotonal areas between pine and cypress prairie. The stands on the vegetation map are shown because they could be identified on the aerial photographs. A few additional small-sized trees and stands may occur within the area, but only these two small stands were encountered during ground-truthing activities.

SUMMARY AND CONCLUSIONS

1. A vegetation map is presented to document current patterns of plant communities in the study area.

2. Data from quantitative inventories of relocatable plots in pine-Sabal-Serenoa stand, cypress prairie and cypress dome are presented.

3. Ordination analysis of stands showed distinctions in species composition among communities designated as pine-Sabal-Serenoa, pine-hardwood, oak-Sabal hammock, tropical hammock, cypress prairie and cypress dome.

4. Range of relative soil surface elevations was less than one meter. Lowest sites supported cypress domes, and successively higher sites had cypress prairie, pine forests, oak and tropical hammocks.

5. Soil depths averaged 1 meter in cypress domes, other communities had soil depths less than 40 cm.

6. Hydroperiod analysis indicates rare periods of short (less than 30 day) inundation in pine forests and frequent inundation, usually in the eight to twelve month hydroperiod range, in cypress dome.

7. A model of successional relationships in pine forests involving varying fire regimes, is proposed.

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