Interpretation - Shark Valley

SOUTH FLORIDA RESEARCH CENTER

Report SFRC-83/05
The Vegetation of Long Pine Key, Everglades National Park

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ABSTRACT

This report summarizes current knowledge of the vegetation of Long Pine Key, an extensive limestone region in the southern Everglades that constitutes the principal upland of Everglades National Park.

Historical review revealed that Long Pine Key was disovered about 1840, but its location and dimensions were not firmly established until Krome's survey of 1902-03. Since the area became accessible by road, farming (c. 1916-1976, initially in prairies, later also in uplands), lumbering of pine (c. 1936-1947), and prescribed burning of pine forests by the National Park Service (1958-present) have been the principal human activities that affected vegetation.

Initial botanical exploration of Long Pine Key (mainly by Small beginning in 1909) showed that the upland flora was predominantly West Indian and contained a number of endemic taxa. Ecological studies have centered on the role of fire in successional relations between pine forests and tropical hardwood forests, the occurrence of rare and endemic plants in the area, and the invasion of abandoned farmlands by aggressive exotics, especially Schinus terebinthifolius.

A vegetation map (scale 1:7800) was prepared from recent aerial photographs to delineate the distribution of 12 plant cover types in an area of 7 x 15 km including most of Long Pine Key. Principal types of native vegetation were pine forests, tropical hardwood forests (hammocks) and Muhlenbergia prairies.

Sampling along a 2 km transect provided data for quantitative description of the three principal plant communities in relation to site elevation, soil depth, and height of the water table. In all, 218 plant species were recorded of which 167 occurred in pine forest, 114 in prairies, and 51 in hammocks.

A definitive listing of the names of 120 Long Pine Key hammocks, originally named and numbered by tree snail collectors, was prepared to clarify previously confused nomenclature.

Study of aerial photography for the period 1940-1980 showed that 90 percent of the Long Pine Key hammocks suffered detectable fire damage during this period, chiefly in 1945 through 1960, and that the course of recovery after fire varied widely between sites. Despite the effects of frequent fire, hammocks tended to retain their original size and shape over the period.

The shrub understory of Long Pine Key pine forests was found to include a total of 61 taxa 75 percent of which were of West Indian origin. As many as 29 species occurred on plots .025 ha in extent and any of 19 species was locally dominant in the shrub understory. Between-site variation in shrub-stratum composition and diversity appeared to be related to long-term differences in fire effects and possibly to relict occurrence of several coastal plants in western areas of Long Pine Key.

Data for rockland pine forests throughout southern Florida showed a total shrub understory flora of about 95 taxa. The most diverse shrub stratum, about 60 taxa, occurred in the Lower Florida Keys and Long Pine Key areas decreasing to 40 in northern parts of the Biscayne Pineland of southeastern Florida and to fewer than 30 in pine forests of Big Cypress National Preserve. Diversity was diminished primarily by the loss of West Indian species as one proceeded north in the mainland pine forests. A few shrubs characteristic of pine flatwoods of the southeastern United States occurred at the more northerly sites where limestone was overlain by acid sand. The shrub stratum of pine forests in the northern Bahamas appeared from floristic literature to be similar to that of southern Florida but considerably more diverse.

INTRODUCTION

Long Pine Key is the collective name applied to the rocky islands, surrounded by marsh, which extend west and southwest from Taylor Slough for about 25 km into the southern interior of Everglades National Park and form the southern boundary of the Everglades basin. Long Pine Key has a maximum elevation of about 5 m msl and its total extent of approximately 8000 ha constitutes the principal upland area of Everglades National Park. The rock islands are exposures of a mid-Pleistocene oolitic limestone, the Miami Oolite, and represent an extension of the Atlantic coastal ridge into the interior of southern Florida (Hoffmeister 1974). The limestone formation was extensively modified by solution and erosion during low sea stands of the later Pleistocene and is cavernous at depth with the exposed portions extremely rough and pitted. Pioneer botanist, J. K. Small, gave perhaps the most graphic brief description of the substrate in stating (Small 1909:53), ". . . the surface consists mostly of holes." Fire-maintained forests of south Florida slash pine (Pinus elliottii var. densa) cover most of Long Pine Key, enclosing many small (seldom as large as 10 ha) stands of broad-leaved forest, termed hammocks. Tropical taxa predominate in the upland flora somewhat justifying Small's (1916a: 39) characterization of the area as, ". . . a portion of the West Indies isolated on the Florida peninsula." Much more extensive pine-forested limestone uplands (approximately 400 km^2) of similar character (but generally more elevated and less broken by erosion) formerly extended northeastward from Taylor Slough as far as the Miami River. However, except for a few small tracts preserved as Dade County Parks, urban and agricultural development has virtually eliminated native plant cover over this entire area. The pine rocklands of the Lower Florida Keys, also reduced by development with few areas assured of protection, differ considerably in aspect and floristics. Long Pine Key has, thus, become the principal remnant of a vegetation complex unique in the United States and the only area in which a number of tropical and endemic taxa are likely to survive in our flora.

This publication is divided into two major chapters. In the first chapter, we review the history of exploration and previous botanical work, present a detailed map of plant communities in a major part of the area, and discuss various aspects of the Long Pine Key flora and vegetation. In particular, the distribution of tropical hardwood hammocks and their fire history was an important aspect of this study. Quantitative plant analysis was undertaken along an elevation transect through pine forest, hammock, and glades. The elevation survey gives information about the relationship between plant communities and the environment. The second chapter treats the understory shrub flora of Long Pine Key in relationship to other south Florida pinelands. We hope to establish a base from which future botanical and ecological studies of the area may proceed without the need of extensive historical investigation, and also, perhaps, to suggest lines which such studies might profitably pursue.

CHAPTER 1

HISTORY

At least as early as the latter part of the 18th century it had been reported that pine-forested rocklands of a peculiar and forbidding character existed in far southern Florida. Thus, B. Romans (1962: 11) wrote of the soils in Florida pine forests:

> "In east Florida, in the southern parts, this kind of land is often very rocky, but especially from the latitude 25:50 southward to the point where it is a solid rock of a kind of limestone covered with innumerable small, loose and sharp stones, everywhere."

Again (op. cit.: 192), describing the lands south of his Rattones River (cf., Boca Raton):

> ". . . the remainder of the land is a heap of stones and rocks, very sharp, and little water to be found, there being only a few ponds, and these dry in a dry season. The only growth here is shrubby pine."

As far as it goes, Romans' description applies reasonably well to Long Pine Key, but it undoubtedly was drawn from areas immediately south of Miami, where pine rockland fronted on Biscayne Bay behind a narrow screen of mangroves and hammock and near anchorages commonly used by sailing ships. Romans' map of Florida and other maps as late as the early years of the Seminole Wars (Williams 1837, Mackay and Blake 1839) suggest that the westward extension of the coastal rock ridge into the interior remained unknown.

In the late 1830's, small military groups, moving Indian-fashion in dugout canoes, began to range widely in the southern Everglades and Big Cypress in search of the last Seminole camps (Griswold 1945). One result of this activity was the historical discovery of Long Pine Key. A careful search of military archives would be needed to identify the discovery positively, but one of the early visits (if not, in fact, the first) was that recorded in the diary of Army Surgeon J. R. Motte (Motte 1963). From a camp on Biscayne Bay near the present location of Cutler, Motte's party moved inland via a transverse glade and, thence, southwest to the end of the pinelands where "across a mile-wide prairie" they spied an Indian camp and fought a brief, inconclusive skirmish. The date was April 24, 1838, and a sketch map of the itinerary (op. cit.:221) locates the farthest point of advance on the eastern end of "Long Key." Motte's account of the march through the rocklands (op. cit.:232) was rendered in rather purple prose, but anyone who has worked in the area would not find it altogether unfamiliar.

> ". . . we pursued our way through a pine-barren, the ground being formed of coral rocks jutting out in sharp points like oysterbeds, which caused us great suffering by cutting through our boots and lacerating our feet at every step. . . We suffered also very much for want of water, not a drop even of that which was stagnant was to be met with in this parched-up region. . . . It

was certainly the most dreary and pandemonium-like region I ever visited; nothing but barren wastes where no grateful verdure quickened, and no generous plant took root--where the only herbage to be found was stinted, and the shrubbery was bare, where the hot steaming atmosphere constantly quivered over the parched and cracked land--without shade--without water--it was intolerable--excruciating. . . . But there was neither brook, nor bird, nor any living thing except snakes to be met with. About one o'clock P.M., we emerged from this rocky pine-barren . . . "

The account is especially notable for its plain portrayal of the fact that very severe spring drought occurred in the area on occasion long before there had been any human manipulation of water. We shall endeavor to show that the rockland vegetation (which may have burned shortly before, although Motte does not say so) is not as devoid of interest as he found it.

The sketch showing "Long Key," said to have been "reproduced from the Mackay and Blake map 1840" (op. cit.:221), depicts it as a narrow, crescentic reef about 40 km long and trending northeast-southwest more or less parallel to the coast. This representation is repeated on eight other military and U.S. Coast survey maps of the 1840's and 1850's that we examined. Several of these, such as the well-known Ives Map (Ives 1856), also show three military posts (Fort Henry, Camp Hunter, and Fort Wescott) in the general area of Long Pine Key. Perhaps these date from the March 1842 foray (Fort Dallas (i.e. Miami) to Long Pine Key to Shark River) of the command of a Lieutenant J. B. Marchand (Tebeau 1968). In any event, the later military expeditions do not seem to have added appreciably to geographical knowledge of Long Pine Key.

C. W. Tebeau (op. cit.:76) relates that a Federal surveyor named Jack Jackson "ran the township lines in the Paradise Key (Royal Palm) area in 1847," but there seems to be no other information on this event. G. W. Cornwell and K. Atkins (1975:34) quote Tebeau without citing him in this connection, and they are surely in error in stating "his (i.e. Jackson's) old surveyor's trail made overland travel to Paradise Key possible, if slow, and an increasing number of scientists visited the area." Perhaps the mistake resulted from the fact that W. J. Krome, more than 50 years later, gave the name Camp Jackson to one of his advance survey points. In any case, no observers who left a record, scientific or otherwise, are known to have visited Paradise Key, Long Pine Key, or anywhere else in that area until after 1880. The maps and reports of the Seminole War era seem to have been archived and, generally, forgotten. Many hunters and backwoodsmen in southern Florida doubtlessly knew of Long Pine Key and traversed (or avoided) it, but the area was unknown to the world at large. Near the end of the 19th century, H. L. Willoughby (1898:124) could write with tolerable accuracy:

"From the most easterly point reached on this day, I sighted the edge of Long Key and got a bearing on it. The existence of this large island at the southern end of the Everglades has been guessed at by white men, who have seen it from the edge of the pine timber bordering the Atlantic coast; but there is no accurate knowledge of its dimensions, and many have tried vainly to reach it."

All uncertainty about the location and size of Long Pine Key should have ended in 1902-1903 when Krome surveyed the area from Florida City to Cape Sable in the interest of a possible extension of the Florida East Coast Railroad. Notably, in the one published item that came out of this remarkable episode, Krome himself (1904:453) counted as a major result of the survey the thorough mapping of "Long Key, a pine island of some 18000 acres, lying in the Everglades, the very existence of which was previously doubted . . " Krome (1903) prepared a detailed draft map of the uplands extending from the approximate site of present-day Homestead to the southwestern extremity of Long Pine Key and the rough trails to his camps at the eastern edge of Taylor Slough became the major overland access routes into the wilderness south of Perrine and Cutler for early settlers and itinerant biologists (Small 1916a). The trail to Camp Jackson, located near the present eastern boundary of Everglades National Park about one-half mile north of State Road 27, was particularly important in the biological exploration of the Royal Palm Hammock-Long Pine Key area. C. T. Simpson and companions (Simpson 1920: 130-132) followed the Camp Jackson trail on what was probably the first significant scientific visit to Royal Palm Hammock in December 1903, as did Small in most of his early botanical work in the area (Small 1916b: 168-169). Many of the early naturalists knew Krome and evidently had access to his maps, for the depiction of "Long Key" on the maps published by W. E. Safford (1919: facing 434) and Simpson (1920: end papers) is obvously indebted to Krome's survey. Eventually, the Florida East Coast Railroad elected to route its Key West extension via the Florida Keys rather than Cape Sable; Krome's survey records were "lost or stolen" (Tebeau 1968:77) and his observations went unpublished except for a brief article in an engineering journal (Krome 1904), and Long Pine Key again lapsed, briefly, into obscurity.

The definitive end to its isolation occurred in 1915 when the so-called Ingraham Highway was extended southwestward from Homestead through Royal Palm Hammock (Small 1916b, Simpson 1923; facing 269 and 332). Shortly afterwards, at least by the early 1920's, but probably before that, a spur road was built from the Ingraham Highway to the southern edge of Long Pine Key and, thence, due west for about seven miles. Winter vegetable farming in the area began as soon as roads were available. Cornwell and Atkins (1975:36) state that the first farming was "in late 1916 or early 1917," and Howell (1921:259) referred to farming "on the Everglade prairie west of the hammock" in the winter of 1917-18. Early farming was largely limited to the higher and less flood-prone prairies near the Long Pine Key Road, particularly the so-called finger glades. Within our mapped area, the total extent of land affected by farming in the pre-park era was about 250 ha. Much of the farming apparently was somewhat ephemeral and the area actually cultivated seems to have varied widely from year to year depending primarily on water levels. However, some areas of deeper soil, such as the lower ends of the finger glades, may have been farmed virtually every winter for almost 60 years.

Easy access and, presently, a serviceable hotel in Royal Palm State Park led to a rapid increase in biological investigation of the area. Small (1916b) notes that the trip to Royal Palm Hammock, formerly about a four-day expedition from Homestead culminating in a three-mile slog across Taylor Slough from Camp Jackson, could now be made by automobile in an afternoon. Small continued to visit almost annually, though his attention was more directed to new areas opened by extension of the Ingraham Highway toward Cape Sable, and several ornithologists (Howell 1921, Holt and Sutton 1926) and other specialists worked in the area. However, additions to geographical knowledge of Long Pine Key in the 1920's and 1930's came mainly from explorations by the collectors of tree snails (Liguus fasciatus).

Liguus collecting ("ligging," Clench 1931) combined the appeal of natural history, esthetics, and exploration and attracted many conchologists and amateur enthusiasts. R. H. Humes' (1965) admittedly incomplete list of the known collectors included about 200 names. In monographing the genus, Simpson (1929) wrote that the destruction of hammocks had "almost exterminated" Liguus, but the snail populations proved to be more resilient than Simpson had thought. The history of Florida tree snails is replete with announcements of the extirpation and rediscovery of local populations, as well as of the discovery and exploration of wholly new areas of occurrence, such as Long Pine Key. The extreme variability of Liguus (with, ultimately, more than 50 named color forms, plus hybrids) held out hope that any of the scores of hammocks hidden in the pine forests of Long Pine Key might yield an undescribed population. Accurate maps of hammock locations and a system for identifying individual hammocks, thus, became highly desirable. Serious Liguus collecting in the Long Pine Key area began shortly after 1900 and several of the early collectors there, such as Simpson and C. Mosier (Humes 1965), apparently knew of and used Krome's manuscript map of Long Pine Key. However, Krome's map was never published, and by the 1920's the map had evidently been forgotten or was unavailable. Thus, collectors of that era laboriously built up their own maps by locating hammocks from the Long Pine Key Road and the numerous narrow prairies (finger glades) that penetrated the southern edge of the rocklands. Library files at the South Florida Research Center include copies of several of these maps. Date and author often are not clear, some of the maps are rather fanciful as regards hammock locations, and some evidently were prepared for sale to other collectors. The closest approach to a standard map of Long Pine Key Liguus localities is that prepared by W. E. Schevill and W. J. Clench, based in part upon air photos taken for that purpose (Clench 1931:13), and eventually published by Pilsbry (1946:65). In addition to the variant maps, various schemes existed for identifying Long Pine Key hammocks by numbers and/or names. Clench began the method of numbering hammocks as a means of identifying locations where he had collected Liguus (pers. comm.). In addition to the numbering system, Clench assigned names to some of the hammocks in honor of fellow shell collectors, scientists, and naturalists (pers. comm.). As more hammocks were discovered the numbering and naming system was continued by other Liguus collectors; C. N. Grimshawe, R. Deckert, C. C. Von Paulsen, and Humes. In more recent years, efforts were made (particularly by Clench, F. C. Craighead, Sr., Humes, A. Jones, and E. C. Winte) to standardize the hammock nomenclature. The designations we use in this paper are those presented by Jones, Winte, and Bass (1981).

In general, the first-cut lumbering of pine in the Dade County rocklands proceeded southward from the Miami area with the advance of the Florida East Coast Railroad. The pine forests of Long Pine Key were the last to be cut, and lumbering probably began there in 1936. A U. S. Forest Service survey in the winter of 1935-36 (Eldredge 1938) showed no sawmills operating on Long Pine Key at that time, although a mill located about one mile east of the present eastern boundary of Everglades National Park may conceivably have received logs cut on Long Pine

Key. D. B. Beard (1938: 10) wrote, "There is not very much of the original stand of large pines left on Long Pine Key because lumbering operations on state property have been in progress for a year or two now." However, the 1940 series of aerial photographs (Soil Conservation Service) suggests that the lumbering moved at a slower pace than Beard indicated, because at that time only the areas east of the present Long Pine Key Campground had been cut. Sawmills were located on the north side of the Long Pine Key Road at Osteen Hammock Glade and at Twin Hammock Glade near the present site of the South Florida Research Center, and some activity continued at the latter mill until 1947, immediately before the establishment of Everglades National Park. Trails used in bringing logs to the two mills were extended into most parts of the pineland on the large eastern island of Long Pine Key and many of these were later used as fire-break roads enclosing the prescribed burning blocks developed by Everglades National Park. Photographs of Long Pine Key taken in the early 1950's (Robertson 1953) indicate that the pine forest was clear-cut, the usual lumbering practice in southern Florida, leaving only cull trees of the original stand. Parts of the area may have been cut-over a second time removing pines that were originally considered unmerchantable. Thus, Cornwell and Atkins (1975:37) refer to lumbering during World War II which "cut out everything that would make a two-by-four." It has commonly been said (Robertson 1955:81, et al.) that all the pine forest on Long Pine Key was lumbered, except the small area at the east end of the Long Pine Key road (now heavily invaded by hardwoods, see D. L. Taylor and A. Herndon 1981, Fig. 1 and 2) which was within Royal Palm State Park. However, field work for this report indicated that lumbering did not reach several remote areas of the main part of Long Pine Key (north edges of prescribed burning blocks C and D) nor any of the outlying pine islands west of the west end of the Long Pine Key Road. We could find no cut stumps nor evidence of former logging trails in these areas. We estimate the total uncut area at approximately 1667 ha. In some of the stands concerned, such as west of Deer Hammock, the mature pines were probably too small to be worth cutting. Other areas, such as east of Sisal Pond, now have even-aged, younger stands which may represent relatively recent pine invasion of adjoining rocky glades, perhaps related to a decrease in average water levels. However, the uncut area includes fairly extensive stands of mature appearance with pines of 25-35 cm dbh which the timber cutters must have considered were too difficult to reach.

Until the early 1950's, farming in the Long Pine Key area was limited to prairies and (contra Cornwell and Atkins 1975: frontis.) did not involve rocklands to any extent. Principally because of the long-established winter agriculture, a large area, the so-called Hole-in-the-Donut, was left outside of Everglades National Park as originally established. Beginning in about 1954, application of newly-developed technology for rockland farming led to a rapid, massive extension of the agricultural area into virtually all of the available uplands of Long Pine Key. Thus, between 1954 and 1969 about 2000 ha of rockland were farmed. Preparation of the rockland sites for agriculture involved removal of the natural vegetation (mostly thin-soil prairie and cut-over pineland, but including several small hammocks) and pulverizing the limestone substrate to a depth of several feet. As C. E. Hilsenbeck (1976) and R. E. Meador, II, (1977) have discussed, these alterations profoundly affected plant growth potential of the sites, once they were no longer under agriculture. After an extended controversy, the Hole-in-the-Donut was purchased by the United States and added to Everglades National Park. The last farming in the area occurred in the spring of 1975. Management of the former agricultural lands has continued to be a significant resources problem for Everglades National Park.

The latest historical event which has exerted a large-scale effect upon the vegetation of Long Pine Key was the initiation in April 1958 of a prescribed burning program by Everglades National Park. This activity, undertaken as a result of the work of W. B. Robertson, Jr., (1953) and others, has led to repeated, deliberate burning of ten largely pine-forested blocks comprising the major part of Long Pine Key. The rationale, history, and (in part) gross effects of the prescribed burning were reviewed recently by Taylor and Herndon (1981) and need not be considered further here. However, it should be noted that the prescribed burning program has applied principally to the parts of Long Pine Key that were enclosed by logging trails and more recent roads. Only accidental or incendiary man-caused fires and lightning fires have affected the outlying westerly pine islands.

The name Long Pine Key seems to have replaced the earlier Long Key during the 1920's, although both terms continued in use for some time. The earliest reference to "Long Pine Key" that we found was by A. H. Howell (1921: 252 et seq.). Simpson called the area Long Key in 1920 and Long Pine Key in 1923 and later (Simpson 1920, 1923, 1929). The change may have been dictated by the existence of a number of other places in Florida called Long Key, such as the island of that name in the central Florida Keys. However, the gain in precision was marginal, because Long Pine Key has rather frequently been confused with Big Pine Key in the lower Florida Keys.

PREVIOUS WORK

Knowledge of the flora of the southern Florida rocklands, only fragmentary prior to 1900, developed rapidly thereafter, as overland access to areas south of Miami became easier. Although others contributed (see Harper 1927, Robertson 1955), botanical exploration of the region was primarily accomplished by Small who first collected there in 1901 and continued almost annual visits until the early 1930's. The results of his work in southern Dade County are embodied in his *Flora of Miami* (1913) and *Manual of the Southeastern Flora* (1933 and earlier eds.), volumes dealing particularly with the ferns, shrubs, and trees, and numerous descriptions of plants new to science or to the United States flora. Small briefly visited rockland areas west of Taylor Slough in May 1904 (Small 1904b), and, after being turned back by high water on an attempted trip to Long Pine Key in October 1906 (Small 1907), he returned there on a two-week collecting trip in January 1909 (Small 1909). The account of the trip suggests that the collecting party ranged widely reaching "the southwestern extremity of Long Key" (op. cit.:50) and crossing the main rockland area at several points. However, the coverage of Long Pine Key appears, quite understandably, to have been far from complete. Several plants conspicuous locally (e.g. *Hypelate trifoliata*) are not included in *Flora of Miami* and Small did not refer to such features as the Mahogany Hammocks, the royal palms (*Roystonea regia*) of Small Hammock and Little Royal Palm Hammock, nor the so-called rock reefs (linear elevations of limestone 2 to 5 m wide standing about 1 m above the surrounding marsh) which extend for miles around the western parts of Long Pine Key. Also, he later discussed (Small 1917) a trip to the present Osteen

Hammock, largest on Long Pine Key, as if it was his first visit to the area. Small later made a number of brief visits to Long Pine Key, but, as far as can be determined from his published reports, the 1909 venture was his only extended collecting trip to the area. Various later workers, particularly University of Miami botanists, W. M. Buswell, T. A. Alexander, and R. O. Woodbury, collected in the area, and in 1950-52, Robertson amassed a considerable collection primarily from Long Pine Key. From about 1954 until the early 1970's, Craighead, Sr., collected plants very extensively in Everglades National Park, including Long Pine Key. Craighead's work resulted in a floristic list for the three southernmost Florida counties (Craighead and Lakela 1965) and contributed importantly to Flora of Southern Florida (Long and Lakela 1976), currently the standard manual for the region. In recent years, G. N. Avery and L. L. Loope did considerable collecting in the course of preparing their preliminary list of vascular plants of Everglades National Park (Avery and Loope 1980). We follow their nomenclature in this report.

Not surprisingly, because he saw the entire area when it was virtually undisturbed by man, Small was also the first to enunciate many of the basic relationships in the plant ecology and plant geography of the southern Florida rocklands. For the most part, these observations appeared as passing remarks in the informal narratives of his collecting trips published in the Journal of the New York Botanical Garden. He recognized that the principal plant formations were pineland, hammocks, and Everglades prairies; that the upland flora was basically West Indian with the tropical element increasing rapidly as one proceeded south from Miami (Small 1904a); that the tropical plants new to the United States flora were found mostly in hammocks, while the new endemic species grew mostly in pinelands (Small 1904a); and, that the occurrence of pine forest and hammocks were largely governed by recurring fire which was destructive to hammocks, but relatively innocuous in pinelands (Small 1911). Among early authors, E. A. Bessey (1911) and Simpson (1920) also addressed the fire-mediated relationship between pinelands and hammocks, still a central question in rockland plant ecology, and Small returned to the subject frequently in his later, more formal, ecological papers (Small 1920, 1929, 1930). Observing the enormous destruction of the increasingly frequent man-caused fires, particularly after large-scale drainage had lowered water levels, Small concluded that the entire upland area must have been covered by tropical broad-leaved forest before early Indians introduced fire into the area. Echoing these views, Beard (1938) wrote ". . . the Everglades Keys were once all hammock growth with intervening sawgrass glade lands," and F. E. Egler (1952:226) commented, "In short, the vegetation of south Florida during late Pleistocene pre-Indian times may have been a dense evergreen broad-leaved tropical jungle. . ."

Robertson (1953, 1955) followed up on two traditions in the study of rockland vegetation. In the wake of the work of J. W. Harshberger (1914), R. M. Harper (1927), and J. H. Davis, Jr., (1943), he presented a more detailed view of the qualitative, descriptive ecology of southern Florida rocklands than had been available before, and he also considered the matter of fire and its effects upon rockland plant communities. In the latter context, he noted that the concentration of endemic plant species in fire-maintained communities argued for a long history of recurrent fire, that lightning fires appeared to be sufficiently frequent to provide an adequate ignition source, and that, in the absence of fire, invasion of pinelands by hammock hardwoods proceeded rapidly enough to alter the vegetation of sites within periods of 10 to 15 years. Based on these points, Robertson argued that the then-current National Park Service management policy of excluding or extinguishing all fires would lead quickly to the replacement of pinelands by young forests of hammock hardwoods with relict pines. The result, after extended debate, was the initiation in April 1958 of a program of prescribed burning of Long Pine Key pinelands, the first such program to be undertaken by the National Park Service. The prescribed burning has continued with frequent up-dating of procedures, as stated most recently in the present Everglades National Park Fire Management Plan (1979).

The past decade, especially since the establishment of the South Florida Research Center, has seen a large increase in research pertinent to rockland plant ecology with a move in the direction of more detailed, quantitative studies. Craighead (1971, 1974) addressed the familiar question of the dynamics of hammock-pineland relationships. Loope et al. (1979), and I. C. Olmsted, Loope, and Hilsenbeck (1980) presented floristic analyses of southern Florida pineland and hammock vegetation, both studies including stands on Long Pine Key. R. H. Hofstetter (1973) and Hofstetter and F. Parsons (1975) commented extensively on rockland vegetation in their review of fire effects in southern Florida pineland and marsh communities. Taylor (1981) summarized Everglades National Park fire history, and Taylor and Herndon (1981) analyzed the effects of long-term prescribed burning on the pineland shrub understory, utilizing study plots that Robertson, C. W. Senne, L. Chamberlaine, and others had established in the 1950's and 1960's. Hilsenbeck (1976) reported on the revegetation of former Long Pine Key agricultural lands with particular reference to invasion of these areas by Brazilian pepper (*Schinus terebinthifolius*) and Loope and V. L. Dunevitz (1981) studied the effects of *Schinus* invasion upon rockland pine forests. Additional work is in progress in several of the above areas.

METHODS

Vegetation Map

Aerial photography, flown in February 1980 at a scale of 1:7800, was used as the basis for determining the distribution of plant communities. A geographically controlled base map, drawn from U. S. Geological Survey orthophotomaps, was prepared at 1:15,000 by USGS, and the communities identified from the aerial photography were transferred to the base map using a MAP-O-GRAPH projector. Field checking was done on foot and from a helicopter between February and April 1981.

Numbers and Names of Hammocks

The *Liguus* collectors were the first naturalists to visit most of the hammocks. They started numbering the different hammocks as well as naming them. Over the years, some of the names and numbers have been changed and/or mixed up. To determine the exact identity (location, name, and number) of each hammock we referred to the original sources. The locations of the numbered hammocks on our map are based on the maps of W. S. Schevill, Grimshawe, M. Ross, Jr., and

Craighead, Sr., in library files of the South Florida Research Center. The hammock names that we used are based on those of Clench (pers. comm.) and Craighead (1974:56-57). We have provided a list of all the hammocks, using the numbers as they appear on the map and indicating the names that go with each number (Appendix I).

Elevation Survey, Soils, and Hydrologic Parameters

A transect along which elevation was determined at intervals of 30 m was surveyed for a length of 2 km from Osteen Hammock to Redd Hammock (Fig. 1), traversing pineland, hammocks, and glades. A Dumpy level was used as the surveying instrument. The elevations were sighted to benchmarks on culverts along State Road 27 (map).

Between 1979 and 1981, at irregular time intervals, groundwater level was measured with a meterstick in two wells, near Osteen Hammock and near Redd Hammock. These wells are located close to roads for easy access in case of fire in one of the hammocks. Soil depths were measured along the transect at 30 m intervals.

Quantitative Vegetation Analysis along Elevation Transect

Along the elevation transect, vegetation plots were placed every 60 m. Ten subplots, 1 m^2 in size, were sampled at each of 36 locations. Species' cover was visually estimated in each square meter, and frequency of all species determined. In circular plots of 100 m^2, all the pines were counted, dbh taken, and height measured with a clinometer. Within the same circular area all species were identified. The plot numbers are indicated on the elevation transect (Fig. 1).

Plants were classified as woody, forb, and graminoid. Woody vines and suffrutescent plants such as *Vitis rotundifolia*, *Passiflora suberosa*, and *Morinda royoc* were considered forbs. Polar ordination (Bray and Curtis 1957) was employed to group the vegetation along the transect.

Hammock Fire History

Fire history of hammocks was determined as accurately as possible from stereoscopic viewing of aerial photography. The air-photo series reviewed were black and white photography for 1940 (1:40,000), 1952 (1:20,000), 1960 (scale not known), 1964 (1:30,000), and color photography (1:7800) for 1980. In some years, especially 1960 and 1964, some hammocks were covered by clouds or otherwise obscured in the photography so that coverage was not complete. It should be noted that this method allows detection only of effects of major fires which kill a substantial portion of the canopy. Ground fires which did not kill much of the canopy cannot be detected. Similar methods were used by Loope and N. H. Urban (1980). The fire impact code used was as follows: M = Hammock has mature appearance on aerial photograph; PM = Hammock has mature appearance on aerial photograph, except for small shrubby portions; IM = Hammock appears to be in condition approaching maturity on aerial photograph; R = Hammock exhibits signs of progressive recovery from burn in previous intervals; D = Destroyed; B = Evidence of burn during interval. The difference between IM and R is age of recovery, with R being in an earlier state. Change of size or shape of the hammocks was also considered in the analysis.

Distribution of Shrub Stratum Plants in Long Pine Key Pinelands

Information on the shrub flora of Long Pine Key was drawn from published lists (Robertson 1953, 1955; Loope et al. 1979; Taylor and Herndon 1981), from the vegetation transect mentioned above and other field work undertaken specifically for this study, and, particularly, from plant lists for 73 one-tenth acre (c. 0.04 ha) plots established in 1958-1965 to study the effects of prescribed burning on pineland vegetation. These permanently marked plots (for locations see Taylor and Herndon 1981, Fig. 3) measuring 33x132 feet (c. 10x40 m, not "12x48 m", Taylor and Herndon 1981:5) were placed at intervals of about one-half mile along the interior fire roads of the main part of Long Pine Key. For convenience we have used the shrub lists compiled by Robertson when the study plots were originally established. Taylor and Herndon (1981) found that prescribed fires and other environmental events since 1958 have had relatively little effect upon the composition and diversity of the pineland shrub understory of Long Pine Key.

In general, we have followed the categories established in an earlier report on the flora of southeastern Florida pine rocklands (Loope et al. 1979) in defining shrub-layer plants as the native woody plants and palms occurring beneath an overstory of pines and reaching, at least on occasion, an erect stem height of .5 m or more on such sites. We have tried also to consider only areas of ecologically functional pineland, thus omitting stands consisting of relict pines in continuous-canopy young hardwood forest. Understory vegetation at such sites may often include species not found in more exposed areas of pine forest. Under our general definition we exclude: about 10 non-native shrubs and small trees of fairly frequent occurrence, of which only Schinus is abundant and widely distributed in pinelands; some 15 woody vines and sprawling shrubs (e.g. Chiococca sp., Morinda royoc, Smilax sp.); about 6 low-growing woody plants (e.g. Crossopetalum ilicifolium, Licania michauxii); and approximately 20 suffrutescent species (e.g. Eupatorium odoratum, Ludwigia sp.). Lantana camara, Leucaena leucocephala, and Waltheria americana, minor components of the pine forest shrub understory in a few areas, are also excluded here as being of ruderal habit often indicative of site disturbance. We depart from the treatment of Loope et al. (1979, Table 1) in considering that Eupatorium villosum is a shrub by the above criteria and that Lantana depressa and the regional pineland species of Hypericum are not.

RESULTS

Vegetation Map

The actual area of Long Pine Key extends beyond the western border of the map to the vicinity of the Mahogany Hammocks (10 km). The present map covers an area of 15 x 7 km. The pineland is more or less bounded on three sides by paved roads; State Road 27 on the north side, the Long Pine Key Road on the south side, and a connecting road on the east side. A system of logging roads was built in the 1930's and 1940's and many of these have been maintained by the National Park Service as fire roads. Other fire roads were added by the park in the late 1940's and early 1950's, particularly on the west side of Long Pine Key. Roads that are presently in use are shown on the map. Some of the old logging roads were not maintained and are now grown over. The pineland proper is surrounded by prairie on most sides and to the south by the "Hole-in-the-Donut," an area of abandoned farmland.

The Long Pine Key campground is located on the eastern half of the map and is used extensively during the dry season.

Pinelands

The major pineland areas of the map consist of open stands of slash pine (Pinus elliottii, var. densa). Most of the pine stands are more or less even-aged, having become established since the logging operations were ended in the late 1940's.

The understory is typically very rich in hardwoods, most of which are tropical. Typical temperate woody species are Rhus copallina, Myrica cerifera, Ilex cassine, Persea borbonia, and the palm Serenoa repens. Some tropical hardwoods are Dodonea viscosa, Guettarda elliptica, Psidium longipes, Bumelia salicifolia, and Myrsine floridana. The shrubs are mostly 1-3 m tall under the current prescribed fire regime. In the prescribed burn areas, the pineland has an "open" look to it: the pines are 12-18 m tall and are fairly widely spaced, with a low shrub understory.

The ground layer consists of many herbaceous and suffrutescent perennials which grow in minute amounts of soil and are perpetuated by fire. It has special interest because it contains a number of endemic taxa including Dyschoriste oblongifolia var. angusta, Phyllanthus pentaphyllus var. floridanus, Tragia saxicola, Chamaesyce porteriana var. porteriana, and Poinsettia pinetorum (Loope and Avery 1979; Loope et al. 1979). Several of the prominent herbs in this layer are graminoids, among them Schizachyrium rhizomatum and Andropogon cabanisii. Grasses usually grow in areas with a little more soil accumulation than the almost bare rocks forbs grow on.

The pineland of the Miami Rock Ridge is floristically the most diverse plant community of Everglades National Park. The microtopography of the limestone with solution holes and pinnacles under the prevailing climate provide more niches and a habitat for about 200 species. Proximity of tropical hardwood hammocks and the transverse glades help increase this number by several more species at ecotones. Affinities of the pineland species were described by Loope et al. (1979).

The diversity index for different areas within the pineland shows that the western half of the pineland is more diverse than the eastern half (Taylor and Herndon 1981). This aspect will be discussed separately under "Distribution of Shrub Stratum Plants in Long Pine Key Pinelands".

The western edge of the mapped pineland area is at a slightly lower elevation than most of the pineland and has a slightly different pattern of understory. While the species are still similar, larger areas with only graminoid cover occur here. The understory shrubs are not scattered evenly everywhere, but tend to grow in clumps on local elevations of limestone.

The ecotones between pineland and transverse glades are not always sharp. In several areas scattered pines extend into the prairie. Sometimes large areas of prairie are enclosed by pineland that is thinly stocked with pine towards the prairie side. Lowering of the water table during the past half century has probably made the ecotone between the two communities wider in some places.

Pineland with Tall Hardwood Understory

Prescribed burns and lightning fires do not always burn areas completely. Small corridors of pineland between two hammocks (as between Osteen and Walton, map) or between a road and a hammock (as Palma Vista 1 and the Long Pine Key Road, or Dark Hammock and an adjacent logging (fire) road) may escape fires and the hardwood understory grows up to hammock height. Instead of 1-3 m, the understory is 6-12 m tall, a deep layer of pine duff covers the ground, and forbs and endemic shrubs are absent (Loope and Dunevitz 1981). In such areas, pine reproduction is inhibited, the relict pines become senescent, and, in time the areas could become hammocks if fire is kept out. However, such places are few on Long Pine Key.

Tropical Hardwood Hammocks

The mapped area shows 120 numbered or named hammocks and many others that were never named. These hammocks are mixed stands of predominantly tropical hardwoods that form a closed canopy at from 5-12 m, with some trees extending to 18 m. The shrub understory is made up of small trees and bushes reaching to 5 m. The groundcover is very sparse with several graminoid species and some herbs. Hammocks and the pineland shrub understory have a number of tree species in common.

Dominant tropical hardwoods are _Lysiloma latisiliquum_, _Bumelia salicifolia_, _Nectandra coriacea_, _Exothea paniculata_, _Coccoloba diversifolia_, _Prunus myrtifolia_, and _Simarouba glauca_. Olmsted, Loope, and Hilsenbeck (1981) found several hammocks to be in different successional stages since disturbance by fire and hurricane. They found a total of 42-55 species/300 m^2, of which 18-22 were tree species.

Hammocks have a more or less continuous layer of organic soil (mostly duff) that averages 12-15 cm deep. The closed canopy vegetation and the moist soil layer create a more humid microclimate in the hammocks than in the adjacent pinelands. Because of this, the hammock interiors usually do not burn, except under extremely dry conditions, but fires burning around the hammocks prune edge plants along the interface with adjoining pineland or prairie.

Hardwood Scrub Without Pine Overstory

At the edges of the pineland, in areas where glades are adjacent to pines, a sparse to dense hardwood scrub forms which differs somewhat from the hardwood scrub under pine. The substrate in these areas is often more perforated with solution holes than in the pineland proper. Together with the moisture difference this substrate change encourages hardwood scrub of certain species rather than pines.

Metopium toxiferum, Conocarpus erectus, Myrica cerifera, Ilex cassine, and Persea borbonia are the most common species in this vegetation. The scrub does not usually grow taller than 6 m, but is mostly shorter.

Another type of hardwood scrub occurs in early succession after fire in tropical hardwood hammocks. In addition to the species mentioned before, we find Trema micranthum, Quercus virginiana, and Bumelia salicifolia. This successional growth can consist of trees and shrubs up to 6 m tall or may be of much lower scrubby stature. In most cases, a portion or all of the hammock floor is covered with the weedy bracken fern, Pteridium aquilinum. This species has allelopathic characteristics (Gliessman 1976) and can occupy a site for a number of years and exclude other species from establishing.

Hardwoods, Successional in Disturbed Areas

In some of the southern portions of the finger glades, just north of the Hole-in-the-Donut, the marl prairie was cultivated for many years and then abandoned in 1947 with the estabalishment of Everglades National Park. The hardwood vegetation that has become established in these areas is composed of some typical bayhead species such as Persea borbonia, Myrica cerifera, Magnolia virginiana, Ilex cassine, and the exotics Schinus terebinthifolius and Psidium guajava. Since these areas are lower in elevation than the pineland, other hardwoods rarely invade. This hardwood association has a very short average hydroperiod of up to one month.

Some successional hardwood associations in the Hole-in-the-Donut are similar to these former glades.

Muhlenbergia Prairies

Composition and species abundances vary from site to site. This extensive prairie type occupies extensive tracts south, west, and north of Long Pine Key and the finger glades within the pineland.

Muhlenbergia filipes is the dominant grass, with Cladium jamaicense (sawgrass) as a constant associate. About 20 other grass or sedge species occur in this community, as well as 60-80 forb species. Even though the species of forbs are more numerous than the graminoids, the grasses and sedges are by far the dominant plants in cover and biomass. The marl substrate is generally thin between 5 and 20 cm, though there are some solution holes with deeper soils. As compared to the Muhlenbergia prairie described and analyzed in Taylor Slough (Olmsted, Loope, and Rintz 1980), the prairie of the Long Pine Key area is more variable in composition and cover. The finger glades are floristically more diverse than the Taylor Slough prairie. There are many solution holes which contain pure sawgrass vegetation.

In places with slightly lower elevation, sawgrass is dominant because the hydroperiod is longer. The average hydroperiod for Muhlenbergia prairie is 2-4 months in northern Taylor Slough, but is less in the finger glades. Analysis of the Muhlenbergia prairie in the finger glades will be discussed in a later section. Some small vegetation stands of pure tall sawgrass around willowheads and stands of Phragmites australis in depressions in the Muhlenbergia prairie have not been separated as different communities because of their infrequent occurrence.

Prairie with Scattered Scrub (Hardwoods)

The prairie portion of this community is the same as described under Muhlenbergia prairie, but in a few areas where marl is either discontinuous or pinnacle rock crops out and the surface is slightly elevated, some hardwoods have invaded the prairie. These are usually short specimens of Persea, Metopium, Myrica, Conocarpus, and Ilex. Some of these places may only have become invaded since the lowering of the water table during this century. There are no data indicating such lowering, but it is assumed that the drainage of south Florida has had an effect on the pineland as well.

Prairie Species on Former Agricultural Land

Some of the finger glades that were only slightly disturbed by farming (i.e. had surface rows and furrows plowed, but were not rock-plowed) still show those rows today. The prairie vegetation is still mostly intact in such areas.

Cypress Prairie

The cypress prairie adjoins Muhlenbergia prairie on the west side of the mapped area. It is essentially a transition between a Muhlenbergia prairie and a sparse sawgrass marsh with stunted cypress trees (Taxodium ascendens). Sawgrass is more often dominant in this community, mostly because the average hydroperiod is longer (up to 6-7 months). The density of cypress densities varies considerably and is lower than that found for the same community in the Big Cypress National Preserve (Gunderson and Loope 1981). The marl soil is slightly deeper than in the Muhlenbergia prairie. Cypress is at its southern limit in this area, and its stunted growth can be attributed to the less than optimal edaphic conditions for this species.

Cypress Forest

Whether there are two distinct species of cypress in South Florida is not clear, but the morphologically different forms known as bald cypress and pond cypress both occur in the mapped area. Taxodium distichum ("bald cypress") grows very tall (20-35 m) in the Fahkahatchee Strand and similar swamps. T. ascendens or T. distichum var. nutans ("pond cypress") is smaller and often stunted. Abundant throughout the Big Cypress Swamp, it has a limited distribution in Everglades National Park. "Cypress forest," as designated on the accompanying vegetation map, includes diverse cypress vegetation which can be grouped as domes and heads. A dome is typically circular and has a tree height distribution that appears dome-like, with the shortest trees on the margins and the highest toward the center. Domes occupy bedrock depressions. The elevation of the soil surface is normally lower in the center of domes. The substrate is peat or muck and sometimes peaty marls (Hilsenbeck et al. 1979).

Another type of cypress community will be tentatively referred to here as "cypress head." This term is admittedly less than ideal since Davis (1943) used the term in a completely different sense--to refer to a dome connecting to a strand. Nevertheless, we use the term to describe cypress communities which are circular in shape, but with a higher soil surface at the center than at the margins. Hydroperiods may be very short in these heads--perhaps no more than 1-2 months.

Willowheads

Willowheads are very scarce in the mapped area. They may be round or elongate in shape, have peat of 1-2 m depth, often have a deep water hole or pond in the center, and are nearly pure stands of willow. Thalia geniculata (alligator flag) and Phragmites australis are constant associates of the willow which also supports several vines such as Sarcostemma clausum, Mikania scandens, and Ipomoea sagittata. Because of the long hydroperiod (4-8 months), more aquatic plants grow in willowheads than, for instance, in bayheads.

Fire is often responsible for willowhead changes. Willows invade deep burned sites. They are intolerant of shade and, therefore, mostly successional or maintained by fire (Robertson 1955, Craighead 1971, Alexander and Crook 1973).

Open Water

These bodies of water are "borrow pits," created during road construction, when the limestone was used as fill.

Hole-in-the-Donut

The Hole-in-the-Donut is an area of land which is currently in different stages of succession following agricultural use. Originally pineland, prairie, marsh, and hammock, these areas were farmed between the 1930's and 1970's and then abandoned. The present weedy plant cover consists mostly of the exotics Schinus terebinthifolius and Psidium guajava, and an association of woody vegetation, often with Baccharis sp. dominant.

Numbers and names of Hammocks

In Appendix I, we give the numbers and names of 120 hammocks found on Long Pine Key. However, many of the hammocks, especially the smaller ones, have never been numbered or named, and 11 of the hammocks listed in Appendix I are outside the boundaries of the vegetation map. Those hammocks not found on the map are indicated by an asterisk.

The locations of hammocks 1-58 and 59-115 on the vegetation map are based on maps by Schevill and Clench (Pilsbry 1946:65) and Craighead (1974:60), respectively. Hammocks 116-120 were named and numbered by Bass. A few discrepancies in the hammock location and nomenclature were found between the two source maps. The most important differences involved the location of hammock number 34 (Turkey) and the name of hammock number 28. We have followed Clench (pers. comm.) and have given the hammock names and numbers used by Craighead in parenthesis (Appendix 1).

Elevation Survey, Soils, and Hydrologic Parameters

The transect surveyed from the pineland just east of Osteen Hammock (#23, map) to Redd Hammock (#38a), traverses several finger glades (Fig. 1). The average elevation of the pineland along the transect is about 2 msl (mean sea level), but the portion that includes Osteen Hammock and the surrounding pineland increases to 4 m, this is probably the highest measured elevation in Everglades National Park. The survey shows that hammocks can either be slightly lower, slightly higher, or at the same elevation as the surrounding pineland. These findings should clarify questions that have existed regarding elevation differences between hammock and pineland sites (Craighead 1971). The finger glades are always lower than the adjoining pineland and, under prevailing hydrologic conditions, are the only areas that have a short hydroperiod during the rainy season (about 1 month). As indicated in Figure 1, the pineland has a very discontinuous shallow soil cover, while the organic soil in the hammocks has an average depth of 12-15 cm. The marl soil in the finger glades has an average depth of 6 cm. Water level measured in wells at the east and west end of the transect in 1979 and 1981 (Table 1) should give a good indication of general groundwater levels in the pinelands. The Osteen well (Table 1) showed a groundwater level 100-200 cm below the surface during the dry season. These low groundwater levels also suggest that the woody species are adapted to xeric conditions. Even during the summer of 1979, this well fluctuated between 100 and 132 cm below the surface. At Redd Hammock, which is considerably less elevated than Osteen, groundwater varied from 30 to 60 cm below the rock surface during the same period. Hurricane Dennis produced 17 inches of rain in two days in August 1981 added to already high summer water levels. This rainfall event brought groundwater in the Osteen well up to 60 cm below the surface (highest level measured between 1979 and 1981), and groundwater in the Redd Hammock well was up to the surface during this time. The same heavy rain flooded extensive low-lying pinelands farther west on Long Pine Key as deeply as 15 cm for periods of up to 6 weeks. Some of the area flooded had been burned by a prescribed fire about 2 weeks prior to flooding and the fire-adapted woody understory species had begun to resprout. Flooding delayed recovery of the shrub understory in such areas by up to 6 months. The inhibition of sprouting by high water levels suggested that the woody understory species are adapted to more xeric conditions and may not have been as plentiful in low pinelands prior to drainage as they are at present.

Quantitative Vegetation Analysis along Elevation Transect

For the characterization of vegetation in pineland, hammock, and transverse glade, a total of 36 plots was analyzed along the transect. The majority of these samples were located in the pineland at different elevations. These samples show characteristics of the eastern portion of the pineland.

A total of 208 species was encountered in the samples, of which 167 could be accounted for in the pineland samples, 114 in the glades, and 51 in the hammocks (Table 2(a)). The greatest number of species in the hammock were woody (30). Though the pineland also has a large number of woody species (49), the forbs outnumbered all plant forms with a total of 90. Forbs amounted to 20 species in the hammock and 68 in the prairie-glade. Of the total number of species in the glade the forbs ranked first with 68 and there were 20 woody species. In this analysis, the pineland also had two more graminoid species (total 28) than the glade, while only one grass species occurred in the hammock.

A large number of species occurred in more than one habitat; pineland and glade shared 93 species (Table 2a). The similarity between hammock and pineland, based on 29 species in common, is very slight, and between hammock and glade, with 9 species in common, even less. The dissimilarity between hammock and glade is easily understood. The woody species in common are occasional occurrences in both habitats. Since the greatest number of shared species between pineland and glade are in the forbs, this is also the plant form where the greatest similarity between the two resides. This number is particularly high for the pineland, because the prairie-glade forb flora is present in the low elevation pineland. The pineland has in structure alone more niches than either hammock or glade. The diverse groundcover that thrives in the open pineland and in the open glade does not exist in the shaded hammocks.

Table 2(b) shows average cover percentages for woody species, forbs, and graminoids. Because of the method chosen to analyze only shrubs and not the tall canopy trees in the hammocks, the major cover percentage in the canopy is not included in the hammock cover. One can probably assume a canopy cover of 80-100 percent. Following that suggestion, the total cover in the hammock would be canopy cover plus the woody vegetation cover in Table 2(b). The hammock vegetation is mostly woody.

The total plant cover (32%) in the pineland is also made up mostly of woody vegetation, but with a substantial portion in forbs and graminoids. Graminoid cover increases towards the lower elevation in the pineland. As might be expected, the vegetation cover in the glades is the lowest with an average 15 percent, of which 75 percent cover is graminoid and the remainder about equally divided between woody species and forbs. The woody portion in the glades vegetation can probably be attributed to the proximity of the pineland and may have increased due to the lowering of the water table during this century. Overall, the cover percentages in pineland and glade are low. The fairly poor nutrient levels, the lack of soil, the porosity of the limestone, and the seasonality of rainfall probably account for the lack of denser cover or more biomass in this plant association.

The current more or less even-aged pine distribution in Long Pine Key is essentially the result of logging that occurred in the 1930's and 1940's. Site quality (elevation, substrate, water, and nutrient availability) and logging history have created a pine cover of variable stature. Table 2(c) shows the average number of pines/100 m^2, average dbh and height as well as basal area for 19 pineland plots. The most stable parameter of those measured was dbh (14-15 cm), while height varied from 11 to 15 m, the lower heights being at the lower elevations. The number of pines varied from 2.5 to 6.6/100 m^2, the higher numbers occurring at the higher elevations. These basal area and density data are similar to those of Vernick and Taylor (1981) for other areas of Long Pine Key.

Table 3 shows the cover percentages and frequencies of individual species in each vegetation type. Species were selected for either commonness or importance. Species that occurred only in one vegetation type and also had less than .1 percent cover were omitted from Table 3, but are listed in Appendix II. Since the number of samples per vegetation type vary considerably, the values of cover and frequency are not comparable among vegetation types, but still give an impression of distribution (6 glade, 5 hammock, and 21 pineland plots). Apart from showing the species shared by two vegetation types, this table also indicates species that only occur in one community and are important there.

The most common trees or shrubs in the pineland plots are (in decreasing order) Guettarda scabra, Randia aculeata, Dodonoea viscosa, Myrsine floridana, Ardisia escallonioides, Sabal palmetto, Bumelia salicifolia, and Serenoa repens. Among the forbs, the fern Anemia adiantifolia was the most common in the pineland, followed by Phyllanthus pentaphyllus, Morinda royoc, and Dyschoriste oblongifolia. Of 53 forb species mentioned in Table 4, 38 (71%) occurred in pineland and prairie. Many of these latter species grow in low elevation pinelands that are edaphically similar to prairie. Many of the graminoid species were also shared between pineland and prairie. Muhlenbergia filipes and Rhynchospora sp., Dichanthelium dichotomon, Aristida purpurascens, and Cladium jamaicense are typical prairie species, while Andropogon cabanisii, Schizachyrium sanguinea, and Sorghastrum secundum are typical pineland species.

The species listed in Appendix II are those encountered in the 10-m^2 plots (for cover and frequency) as well as those present in the 100 m^2 circular plots.

Another important factor revealed in Table 4 is the small cover percentage of the forbs and graminoids, but the high frequency and number of these plants in the pinelands and glades. Though biomass and cover are very small, these plants account for the high diversity of these associations.

In trying to group the sample plots along the transect, we started with a simple polar ordination (Bray and Curtis 1957) based on Sorensen's similarity index (1948). This index indicates the similarity between sample plots based on species presence only. The plot numbers as they occur along the elevation transect and their ordination equivalent are indicated in Figures 2 and 3. In Figure 2, the sample plots are grouped according to the ordination. The distribution of plots is clustered according to hammock, pineland, and glade as might be expected, except for one group. Numbers 9, 10, 11, and 16 are pineland plots with a larger proportion of glades species than other pineland plots. The y-axis may indicate a gradient from wet (0) to dry (100). See also Table 5 for explanation.

Ordination of pineland plots alone produces the configuration in Figure 3. There seems to be a gradient along which the plots are distributed. The first four plots (1, 2, 3, 4) are on the highest elevation on the east side of Osteen hammock, suggesting a similarity in species within this group. The other two plots closest to a hammock (19, 20) and on fairly high ground follow closely the first group of plots along the gradient. The larger number of plots seems to be distributed according to elevation (and/or hydrology), as well as, similarity to neighboring plots. Plots 8, 9, 10, and 15 are those with largest glade-species complement, highest diversity, and lowest elevation. Based on species similarity, then, the pineland plots are distributed according to elevation (and/or hydrology) which is a determinant for species occurrence.

Table 4 lists the major tree and graminoid species in the pineland plots that may be indicative of certain environmental parameters. The occurrence of trees like Conocarpus, Persea, and Byrsonima in some plots and their absence in others suggest elevation and hydrology as a factor for this distribution. They do not occur in plots 1-4, but are more abundant in lower elevation plots. Lysiloma only occurs in one plot very close to Redd Hammock (#69). Guettarda scabra, Dodonaea viscosa, Metopium toxiferum, and Bumelia salicifolia are more or less evenly distributed in high and low pineland, while Randia aculeata and Myrica cerifera are more abundant in lower pineland. Plots 1-4 (the highest elevation) show Andropogon cabanisii, a pineland grass, but no Muhlenbergia filipes, a prairie grass. However, the prairie grass is abundant in low elevation pineland plots 5, 8, 9, 10, and 11, while Andropogon cabanisii is less common in these latter samples.

Hammock Fire History

Table 5 lists the hammocks named on the map with an indication of the fire damage that affected each hammock over the time period 1940-1980. Where no fire impact code is given for a hammock in the year of a particular air-photo series, either there was no aerial photography for that portion of pineland, or the proper status of the hammock could not be recognized on the photography due to cloud cover. Exact interpretation of the fire-damage status of a hammock from aerial photography was often difficult. Hammocks that had recently burned (B) were readily distinguishable in most cases, but study of park fire records and the entire series of available photographs was sometimes needed to distinguish immature (IM), recovering (R), and mature (M) stages. In the case of the 1980 aerial photography, we were able to verify interpretations of the photographs by a ground check of the condition of hammocks.

The size and shape of most hammocks seem to have stayed remarkably constant over the period studied. Most shifts were minor, either due to incomplete burning or lack of burning over an interval. In several places indicated on the map, stands of tall hardwoods have developed either between two narrowly separated hammocks or in unburned areas.

From the list of fire impacts (Table 5) note that some hammocks (about 10) did not burn during the time interval considered. However, the majority of hammocks (about 90%) burned repeatedly, particularly between 1945 and 1960. Maxwell Hammock (#86) burned in 1940 and has been recovering over the last 40 years and is still immature. More often, we find that hammocks burned in the 1940's were mature in 1980. Some examples of such recovery are Osteen (#23), Gun (#24), Turkey (#34), Clapp (#37), and Decamp (#47). As previously discussed (Olmsted, Loope, and Hilsenbeck, 1981), the time required for recovery after fire and the composition of the recovering stand tend to vary for each hammock.

Distribution of Shrub-stratum Plants in Long Pine Key Pinelands

The pine forests of Long Pine Key are characterized by the presence of a diverse understory of shrubby hardwoods and palms beneath the pines. For example, 45 species occurred in the pineland shrub stratum along the 2 km transect on eastern

Long Pine Key discussed above (see Appendix II). Overall, we have recorded 61 species that meet the stated criteria for shrubs (Table 6), and, although the list is based on extensive surveys, it is likely that a few additional shrubs will be found to occur rarely in the Long Pine Key pinelands. Species that are primarily West Indian in distribution comprise 75 percent (46 of 61) of the known shrub flora. Most of the species of more temperate distribution (10 of 15) occur typically at wetter pineland sites, such as in deep sinkholes or in the ecotonal belts between pine forest and Muhlenbergia prairie. This distribution is in line with Small's (1907) early observation that the upland flora of southern Florida was much more tropical in composition than the wetland flora.

The 73 plots established for study of the effects of fire on the Long Pine Key shrub stratum (see METHODS) provide the best available measure of the evenness of distribution of the shrub species. Fifty-seven of the 61 species known to occur in the Long Pine Key pinelands at large have been found on these one-tenth acre (0.04 ha) plots. The missing species are either extremely rare in the pineland understory (Crossopetalum rhacoma, Diospyros virginiana, Simaruba glauca; each recorded only one or two times), or (Alvaradoa amorphoides) are more common but very locally distributed on Long Pine Key.

Constancy of occurrence for each species found on the 73 study plots is shown in Table 6. In all, 21 species occurred on more than half the plots, 7 species on 26 to 50 percent of the plots, and 29 species (51% of the total) on less than one quarter of the plots. The 28 most constant shrubs included 21 West Indian and 7 more temperate species: the 29 least constant included 22 West Indian and 7 more temperate species. Of the least constant group, only a few species (notably Bourreria cassinifolia, Colubrina cubensis, and Hypelate trifoliata) are also rare in the flora of Long Pine Key at large. The remainder either have patchy, local distributions in the pineland shrub stratum, or they are typically plants of tropical hammock or wet-site thicket vegetation that occur only sparingly in pineland.

Number of shrub species per 0.1 acre plot was continuously distributed from 14 through 29 with a mean diversity of 22.1 species. Twenty-two plots (30%) had 14 through 19 species of shrubs, 32 plots (44%) had 20 through 24 species, and 19 plots (26%) had 25 through 29 species. The principal trends evident in the plot diversity data were tendencies toward decreasing diversity from upland to less elevated sites, and, within the upland sites, toward increasing diversity westward in the portion of Long Pine Key sampled by the plots. Most of the plots that had fewer than 20 shrub species were located in the transition belts between pineland and Muhlenbergia prairies. At the upper end of the diversity scale, 12 of 27 plots in A and B, the westernmost prescribed burning blocks (see Taylor and Herndon 1981, Figure 3), supported 25 or more species of shrubs as opposed to 7 of 46 plots in the more easterly prescribed burning blocks.

The somewhat greater diversity of the shrub stratum in western parts of Long Pine Key is associated with fairly obvious, but unexplained, differences in the limestone substrate. Over the eastern two-thirds of the major upland area of Long Pine Key, the surface of the Miami Oolite is extremely irregular with angular "dog-tooth" ridges and projections enclosing shallow solution cavities. By contrast, sizable areas in blocks A and B are characterized by monolithic exposures with relatively smooth surfaces and numerous large, well-like solution holes up to 3 m deep. In these characteristics the surface limestone is more similar to that of the Lower Florida Keys than it is to exposures in other pine rocklands of the southeastern mainland. Presumably, such present differences may indicate local variations in depositional environment or subsequent solution, but no relevant studies of the Miami Oolite seem to be available. The nature of the limestone affects shrub understory composition and diversity in two ways: the deep, more or less permanently wet solution holes support a more general distribution of such wet-site species as Salix caroliniana and Annona glabra than is found elsewhere on Long Pine Key; and, several of the less common pineland shrubs are largely limited on Long Pine Key to the areas of smoother, more massive surface limestone. These species include Alvaradoa amorphoides, Bumelia celastrina*, Colubrina arborea*, Colubrina cubensis, Hypelate trifoliata*, Jacquinia keyensis*, and Mastichodendron foetidissumum. We can see no adequate ecological explanation for the restriction of these West Indian species to a particular facies of limestone on Long Pine Key, but it is notable that several (starred above) occur elsewhere in southern Florida primarily in coastal or beach ridge hammocks. This suggests that their occurrence on Long Pine Key may be relict, perhaps dating from a higher, presumably post-glacial, sea stand when Long Pine Key uplands may have been in closer contact with coastal plant communities. The abundance of Conocarpus erectus throughout the pineland-Muhlenbergia prairie ecotonal belts surrounding Long Pine Key may also be relevant in this regard.

Counts of the number of hardwood stems more than 3 feet high are available for 104 areas of 0.025 acres (0.01 ha) within the 73 plots. These data show that any of 19 species may be the most abundant hardwoods in local areas of the Long Pine Key pineland shrub stratum. The 11 most frequent numerical dominants and the number of areas in which each was the most abundant hardwood species were: Guettarda scabra, 30; Myrsine floridana, 15; Ardisia escallonioides, 9; Conocarpus erectus, 8; Bumelia reclinata, 6; Dodonaea viscosa, 5; Guapira discolor, 5; Byrsonima lucida, 4; Ilex cassine, 4; Chrysobalanus icaco, 3; and Myrica cerifera, 3. The commonness of Myrica was also evident in the analysis of pineland between Osteen and Redd Hammock (Table 3). Most sites where Conocarpus, Bumelia, Ilex, Chrysobalanus, or Myrica was the most numerous hardwood were located in low pineland transitional to Muhlenbergia prairie (see also Table 4). On higher pineland sites, Guettarda scabra was ubiquitous in occurrence over the eastern sections of Long Pine Key, where it was the most common hardwood on 38 percent of the areas sampled (27 of 71, see Table 3). Farther west in prescribed burning blocks A and B, the species is generally absent or rare and it was the most numerous hardwood on only 9 percent of the sample areas (3 of 33). Less marked local variation in the abundance of particular species is widespread on Long Pine Key, usually without obvious explanation. It seems likely that some of these patterns of occurrence may reflect local variation in fire effects summed over periods of decades. Taylor and Herndon (1981) detected numerous, but mostly minor, changes in relative abundance of shrub understory species over a 22-year period and interpreted these as fire-related. Thus, although most plants in the Long Pine Key shrub understory seem to be old individuals that have survived many fires, slight differences in fire tolerance among species may result in long-term fluctuations in understory composition.

SUMMARY

1. We describe the history of discovery, exploration, and use of Long Pine Key in Everglades National Park.

2. A vegetation map of Long Pine Key is provided. The variations of pineland, tropical hardwood hammock and Muhlenbergia prairie in composition, structure, and environmental parameters are discussed in detail.

3. A 2 km elevation transect from Osteen Hammock to Redd Hammock shows the distribution of plant communities and soil depths along its length.

4. We trace the names and numbers of 120 tropical hardwood hammocks, appearing on the map, to original sources.

5. We give the results of quantitative analyses of 36 vegetation plots (10 x 1 m^2) along the elevation transect. Species plant cover is estimated and frequency calculated.

6. A total of 208 species occurred along the transect, with 168 in the pineland, 114 in the prairie glades, and 51 species in the hammocks.

7. We discuss the peculiarities of the understory shrub distribution and relate their occurrence to substrate differences.

8. The fire history of the tropical hardwood hammocks between 1940 and 1980 is traced from aerial photography and helicopter surveys.

CHAPTER 2

PINELAND SHRUB UNDERSTORY: COMPARISON OF LONG PINE KEY WITH OTHER SOUTHERN FLORIDA PINE FORESTS

As noted above, the pine forest of Long Pine Key is characterized by the presence of a remarkably species-rich understory of shrubby hardwoods and palms. Here we compare the pineland shrub stratum of Long Pine Key with that found in other regional pine forests extending from the Lower Florida Keys to Big Cypress National Preserve.

METHODS

Our comments on variation in shrub species diversity between stands of pine forest in the southern Florida region build upon the recent study of rockland pine forest floristics by Loope et al. (1979). These authors compared the flora of seven sites on Long Pine Key, five sites in southeastern mainland pine areas outside Everglades National Park, and one site on Big Pine Key based on the plants encountered within a 40 x 40 m "macroplot" and 20 quadrats each 1 m^2 at each site. We undertake to present complete lists of species occurring in the shrub stratum in five geographic areas of southern Florida pineland: 1) Lower Florida Keys, including extensive pine stands on Big Pine, Little Pine, No Name, Cudjoe, and Sugarloaf Keys, and smaller areas on several additional keys; 2) Long Pine Key; 3) Southern Biscayne pineland, remnant stands of pine in the rockland area east of Taylor Slough from its southern extremity north approximately to Silver Palm Drive (SW 232nd Street); 4) Northern Biscayne pineland, similar pine remnants north of the preceding and extending to the southern edge of the built-up area of greater Miami; and, 5) Big Cypress National Preserve, principally pinelands in the southern and central parts of this National Park Service area located west of the Everglades in Monroe and Collier counties. The division between areas 3 and 4 above is necessarily somewhat arbitrary as the original "Biscayne Pineland" (Small 1913a) was continuous across this region. We have elected to make the division at the point where deposits of siliceous sand become conspicuous on the pineland forest floor. Typically, as one proceeds northward in the Biscayne Pineland, scrub oaks (*Quercus minima*, *Q. pumila*, *Q. virginiana* var. *geminata*) first appear in the pine forest understory at such sites. Thus, the "Navy Wells" and "Camp Owaissa Bauer" stations of Loope et al. (1979) are placed in the southern section and their "Thompson Park", "USDA", and "Tamiami Pines" stations in the northern section.

In compiling lists of shrub species for the various areas (Table 6), we have drawn upon all available sources of floristic data. Our listing for the Lower Florida Keys pinelands depended critically upon the field notes and comments of G. N. Avery and included information from lists presented by J. D. Dickson, III, et al. (1953), Robertson (1953, 1955), and Loope et al. (1979). Listings for the two sections of the Biscayne pineland were derived from Robertson (1953, lists 1 and 2 of Table 10), Loope et al. (1979), the notes and comments of Avery and A. Herndon, and specific surveys undertaken by Robertson. The list of pineland shrubs of Big Cypress National Preserve was based on a preliminary checklist of vascular plants of the area (Black and Black 1980), data provided by L. Gunderson and R. Rochefort, and field surveys by Robertson.

The thoroughness of coverage of the available pine stands varied considerably between the four principal geographical areas. For Long Pine Key and the Lower Florida Keys, the lists of shrubs (Table 6) are based upon surveys that included most parts of these pinelands and may be considered largely complete. Coverage of the poorly accessible and greatly fragmented pine areas of Big Cypress National Preserve (Patterson and Robertson 1981, Fig. 6) was extensive, but less thorough. In contrast to these areas in which the overall extent of pine forest is relatively little changed from that present originally, the Biscayne pineland exists only as small, isolated stands, more than 95 percent of its original area having been destroyed by land development (Loope et al. 1979). Moreover, the diversity of understory vegetation in many of the existing stands has been greatly reduced as a result of invasion by the exotic tree Schinus terebinthifolius (Loope and Dunevitz 1981). Information on the composition of the shrub stratum of the Biscayne pineland was necessarily taken from a few remnant stands, particularly in Dade County parks, that seemed to approximate natural conditions. Present lists for the Biscayne pineland (Table 6), thus, probably omit an unknown number of less common shrubs that occurred originally. However, we feel that the likely number of omissions is too small to affect our general comments on the variation in diversity of the pineland shrub stratum within south Florida.

RESULTS

Our final sanitized list of plants occurring in the shrub stratum of southern Florida pine forests (Table 6) totalled 95 taxa. Their distribution across the region is discussed below.

Regional Distribution and Diversity of Shrub-stratum Plants

Twelve species occur in the shrub stratum of pine forests throughout southern Florida: Baccharis halimifolia, Bumelia salicifolia, Chrysobalanus icaco, Ficus aurea, F. citrifolia, Myrica cerifera, Myrsine floridana, Persea borbonia, Randia aculeata, Rhus copallina, Sabal palmetto, and Serenoa repens. These generally distributed pineland shrubs include both West Indian and temperate species. Most are relatively conspicuous in pinelands throughout southern Florida, but several (Bumelia salicifolia, Ficus citrifolia and Randia aculeata in northern Biscayne and/or Big Cypress) are rare or local in some areas.

Two other patterns of wide distribution are represented by the shrubs found throughout mainland areas, but not in pinelands of the Florida Keys, and those found in all areas except Big Cypress. Widespread taxa missing from the shrub layer of Florida Keys pine forests are: Bumelia reclinata, Callicarpa americana, Dodonaea viscosa, Ilex cassine, Quercus virginiana, and Salix caroliniana. Most range extensively north of our area and only Dodonaea is known to occur in the Lower Florida Keys (Small 1913b, 1933; Dickson et al. 1953; Avery pers. comm.), where it is an uncommon small tree in hardwood hammocks (= D. microcarya Small). Widespread taxa missing from the shrub layer of pinelands only in Big Cypress are: Bourreria cassinifolia, Byrsonima lucida, Cassia chapmanii, Coccothrinax argentata, Croton linearis, Guettarda scabra, Lantana involucrata, Metopium toxiferum, Psidium longipes, and Trema micranthum. All are tropical forms, and, except for the widely dispersed but very rare Bourreria cassinifolia, all are relatively prominent in the pineland shrub stratum on the Lower Florida Keys and Long Pine Key and tend to decrease rapidly northward in the Biscayne pineland. Only Metopium and Trema are reported from Big Cypress (Black and Black 1980) and neither has been noted there in pineland.

The shrub stratum of southern Florida pine forests is composed predominantly (67 of 95 taxa, 71%) of taxa derived from the flora of the Bahamas and Cuba, and, within southern Florida, most of these forms reach or approach their northern range limits. Elements of a second zonal flora, that of the pine flatwoods of the southeastern United States coastal plain, enter the shrub stratum of regional pinelands in northern Biscayne and Big Cypress at sites where the limestone substrate is mantled by deposits of acid sand. However, the characteristic shrubby plants of the pine flatwoods are represented only sparingly within our area (7 taxa, about 8 percent of the regional shrub-layer flora). Thus, species diversity of the pineland shrub stratum tends to decrease sharply from south to north within southern Florida (Table 7), primarily because the West Indian forms that reach range limits far outnumber the few flatwoods species added to the shrub stratum.

Diversity of the pineland shrub stratum also appears to be directly related to site-to-site differences in the linear extent of peripheral and internal interface between pine forest and other plant communities. Throughout southern Florida, the pineland shrub stratum typically is more diverse at sites where pine forest encloses or adjoins hardwood hammocks. Bursera, Exothea, and Lysiloma exemplify hardwoods whose occurrence as pineland shrubs is largely limited to such contact belts which rarely exceed 100 m in width. Sites where pine forest is in contact with lowland vegetation usually exhibit reduced shrub-stratum diversity, but may include species that are not found locally at more elevated pineland sites. Examples are seen in the frequent occurrence of Taxodium in the understory of smaller pine islands in Big Cypress and the extensive dominance of buttonwood (Conocarpus erectus) in the shrub layer of low pinelands on Long Pine Key (Robertson 1955:110-112). Limestone sinkholes of varying width and up to c. 4 m deep occur throughout the pinelands underlain by Miami oolite and are particularly frequent in the Lower Florida Keys and Long Pine Key. Many of the sinkholes intersect the ground water table and may hold water through much of the usual dry season. Swamp hardwoods (Chrysobalanus, Ilex cassine, Magnolia, Persea) are often found at such sites and the occurrence in pineland of Annona, Cephalanthus, Salix, and Sambucus is almost entirely limited to the deeper sinkholes (Robertson 1955:114,119).

More local characteristics of the shrub understory in particular areas of pineland are noted below.

Lower Florida Keys

The Florida Keys pineland differs from all other regional pine forests, perhaps from all other pine forests, in having a more-or-less continuous small-tree stratum (at roughly 3 to 8 m) of fan palms (Coccothrinax, Thrinax) at many sites. The shrub stratum beneath the pine-palm overstory is notable for the number of unique taxa (Table 7). More than one-third of the species are represented in southern Florida pine forests only at sites in the Lower Florida Keys. These include six West Indian species not known from the southern Florida mainland (Caesalpinia pauciflora, Catesbaea parviflora, Pisonia rotundata, Reynosia septentrionalis, Strumpfia maritima, and Thrinax morrissii), of which Pisonia and Thrinax are common and generally distributed in the Lower Keys pine forests; and 14 species which on the mainland are limited primarily to coastal plant communities. Occurrence of plants of the latter group in the pineland shrub stratum seems attributable to the very extensive linear edge between pine forest and shoreside vegetation types that exists in the Lower Keys. At many sites, the Lower Keys pinelands have abrupt junctions with areas of mangrove, coastal hammock, and beach hammock, and most of the plants concerned enter the pineland shrub stratum only in relatively narrow belts along these interfaces. However, such species as Coccoloba uvifera, Eugenia myrtoides, Piscidia piscipula, and Pithecellobium guadalupense are more widely distributed as pineland shrubs.

As might be expected, the shrub stratum of Lower Keys pine forests is most similar floristically to that of Long Pine Key (Table 7), the most southerly mainland pine area. Notably, however, a number of West Indian species found in the Long Pine Key pinelands are apparently missing from pine forests of the Lower Keys. Examples are: Alvaradoa amorphoides, Colubrina cubensis, Dodonaea viscosa, Eupatorium villosum, Ilex krugiana, and Tetrazygia bicolor. Some of these absences may result from the vagaries of overseas establishment and subsequent spread within southern Florida. However, some probably are due to the more xeric environment of the Lower Keys pinelands, rather than to failure to reach this area. Some plants that are abundant and generally distributed in the Long Pine Key pine forests are markedly restricted to moister sites in pine forests of the Lower Keys. Two good examples are saw palmetto (Serenoa) and bracken (Pteridium aquilinum var. caudatum), both ubiquitous in mainland pine areas, but confined to shallow saucer-like solution depressions in the Lower Keys pinelands and virtually absent from the general level of the forest floor. Shrubs showing a similar distribution include Chrysophyllum oliviforme, Eugenia axillaris, Ficus citrifolia, Guettarda elliptica, Guettarda scabra, and Myrsine floridana. In all cases the contrast is between general distribution in Long Pine Key pine forests and variously limited distributions related to moister sites in the Lower Keys. Other species common in the shrub understory of mainland pine forests (Ardisia escallonioides, Guapira discolor, and Lantana involucrata) tend to occur in the Lower Keys mostly within hammocks or at hammock edges. Such occurrence patterns suggest that the more xeric conditions in the Lower Keys pineland affect both the local and regional distribution of species in the pine woods understory.

Marked differences exist in the composition and density of shrub understory vegetation from site-to-site in the Lower Keys pineland. In many parts of Big Pine Key the shrub stand is low and sparse, and the forest floor is scantily covered with grasses or consists of smooth bare limestone under the pine and thatch palm-silver palm layers. In such areas the shrub understory vegetation is composed of prostrate plants of Ernodea littoralis, Morinda royoc, and Smilax havanensis; low mounded bushes of Byrsonima lucidum and Psidium longipes; and widely scattered erect shrubs, chiefly Croton linearis, Metopium toxiferum, Pisonia rotundata, and Pithecellobium guadalupense. Throughout the Big Pine Key forest local aggregations of shrubs form small incipient hammock clumps, apparently at sites enjoying greater fire protection than the general expanse of forest. These occur on the small rocky knolls found at the bases of some of the larger pines and around many of the sink holes. In contrast, the main pine area of Cudjoe Key has an almost continuous hardwood understory 6 m or more high in places. Here also the forest floor is covered with a deep mat of pine straw and dead grasses. The pineland shrub stratum of Little Pine and No Name keys is similar, but somewhat less dense.

These differences seem to be the result of the relative frequency of recent fires, largely man-caused. Big Pine Key pinelands are extensive, continuous, and readily accessible. They burn frequently, and signs of recent fire are evident throughout. Pine stands on other islands of the Lower Keys are smaller and more isolated (Little Pine Key is accessible only by boat), often consisting of relatively narrow ridges surrounded by mangroves and open salt flats. Signs of former fires are present in all areas, but many stands have not burned for many years and the more advanced development of the hardwood understory reflects this fire-free interval.

The solution holes mentioned above determine the occurrence of a number of taxa in the Lower Keys pine forests. Two general types occur - shallow saucer-like depressions in sizes to 20 m in diameter, and deep "wells" occasionally as much as 3 m in diameter, but usually much less. The former are seasonally flooded, and their lower parts may stay wet throughout the year. Most of the "wells" hold permanent water, although the level fluctuates greatly. The plants potentially occurring in any sink apparently depend upon moisture relations as governed by the depth of the depression, its areal extent, and the nature of the walls (relative steepness of the slope to the center in the case of the saucer depressions; presence or absence of crevices or niches in the perpendicular sides of the wells). The plants, of those possible, which actually occur doubtless illustrate the chances of establishment and survival, especially in the case of the wells, which often provide room for no more than a single shrub or fern clump.

Though there is much variety in the sink-hole vegetation, especially on Big Pine Key, several general types may be noted. Large saucer depressions are commonly occupied by sawgrass (Cladium) and ringed by buttonwood (Conocarpus) trees, and a mixed growth of scrubby hardwoods. Occasionally such aquatics as Typha and Sagittaria occur in the center. Shallower saucers may have dense beds of saw palmetto or a ring of saw palmetto around a central area of sawgrass. The slopes of many of the small saucers and the entire central area of some of the shallower ones commonly support growths of bracken. Higher slopes of the saucers usually have shrubby hardwoods ranging from a few individuals to a dense continuous fringe of sub-hammock growth. Several of the pineland shrub understory plants limited to such sites have been mentioned.

The deeper wells provide environmental niches for several species otherwise absent from the Lower Keys. Among these are Annona glabra, Chrysobalanus icaco, Persea borbonia, and leather fern (Acrostichum). Commonly each small well contains plants of only one of these species, several plants or a single large individual, or combinations such as one pond apple tree and a clump of leather fern. A few of the larger wells have more varied vegetation.

Long Pine Key

The diverse shrub layer of Long Pine Key pine forests (Table 7) results primarily from the area's intermediate location in relation to the principal regional climatic gradients. Thus, seven shrub-layer taxa of West Indian derivation occur only in Long Pine Key and the Lower Florida Keys and eight only in Long Pine Key and the Southern Biscayne pinelands (Table 6). It seems reasonable to suppose that the former group of plants tends to be limited northward by sensitivity to increasingly frequent frost and the latter group tends to be limited southwestward along the gradient of decreasing rainfall by sensitivity to the much more xeric environment of Lower Florida Keys pine forests. Of the five pineland shrubs that (within southern Florida) are unique to Long Pine Key, two (*Cephalanthus* and *Magnolia*) are widespread wet-site species of little biogeographical significance, and three are West Indian forms for which Long Pine Key evidently provides the only suitable pineland growth sites available in southern Florida.

Extensive edge with other plant communities and the extremely broken and eroded limestone substrate also contribute to the diversity of the shrub-layer in the Long Pine Key pinelands. The pine forest encloses scores of hardwood hammocks and is enclosed by *Muhlenbergia* prairies from which linear extensions, the so-called "finger glades," penetrate the main body of pineland (see vegetation map). As noted, many plants of the pineland shrub-layer are particularly associated with these ecotones. Besides an array of wetter sites in the deeper sink holes, the jagged, irregular limestone forest floor of much of Long Pine Key provides innumerable, semi-protected micro-sites favoring establishment and survival of shrub-stratum plants.

Southern Biscayne

From scanty descriptions in the literature (Harshberger 1914, Harper 1927) and present remnant stands, it is evident that the shrub understory quickly becomes much less diverse as one proceeds north across this area. The understory of stands at the extreme southern end of the Biscayne pineland (such as Pine Island and Parachute Key just east of Taylor Slough in Everglades National Park) closely resembles that of Long Pine Key in appearance and diversity. Only a dozen or so species of shrubs are missing. Most of these are rare and local on Long Pine Key and may well have been present originally in pine forests at the lower end of the Southern Biscayne area. Eight miles to the northeast in the vicinity of Homestead the aspect of the shrub understory in remnant patches of pine forest is dominated by low palms, most of the West Indian hardwoods have disappeared, and most of those that persist are rare. Areas of greater shrub-layer diversity tend to be closely restricted to the pinelands bordering hammocks (as at Camp Owaisa Bauer, Loope et al. 1979), and in this region, as Small (1904a:51) reported from his first foray into the area, ". . . the pinelands are vast and the hammocks are few and small." Increased diversity through local re-appearance of some West Indian hardwoods in the pine forest understory may also have occurred originally in the narrow transitional belts around deep sink holes ("banana holes", Harshberger 1914) and along the transverse glades and the bordering *Muhlenbergia* prairies to the east. However, such sites have been largely obliterated by development.

Northern Biscayne

In this area, the limestone becomes increasingly mantled by sand northward, several shrubs characteristic of southeastern United States pine flatwoods appear in the understory and attenuation of the West Indian element in the pineland shrub stratum continues. Species of West Indian derivation comprise about half the overall shrub-stratum list, but most are scarce and local and low palms and scrub oaks dominate the aspect of the pine forest understory at most sites.

Big Cypress

The pineland shrub understory of Big Cypress is the least diverse in our area and approaches a balance in number of species between those characteristic of southern sandy pine flatwoods (6) and tropical West Indian forms (9). The former tend to be more widely distributed and the flatwoods element also includes several conspicuous suffrutescent plants, such as Rubus trivialis and Satureja rigida. Conversely, the West Indian shrubs tend to be limited to cold-protected sites, such as pine islands surrounded by sloughs. Hundreds of such sites exist in Big Cypress and it is likely that additional West Indian plants will be added to the shrub-stratum list which already includes several taxa (Ardisia and Eugenia axillaris) that aren't recorded for the northern part of the Biscayne pineland.

Density Characteristics of the Pineland Shrub Stratum

Although considerable change in the density and aspect of the shrub understory appears to accompany the above trends of change in diversity, few comparative data are available. For Long Pine Key, Taylor and Herndon (1981) summarized counts of stems of the taller hardwoods on a number of study plots (bottom, Table 8), but no comparable data base exists for other southern Florida pinelands. Loope et al. (1979) recorded plot counts in areas representing all the regional pinelands except those of Big Cypress, and information on the density of shrub species, extracted from their data, is given in Table 8. The scanty quantitative record seems to support general impressions that overall density of the shrub stratum and the relative predominance of hardwoods in mainland pine forests tend to decrease sharply northward from Long Pine Key and nearby areas of Southern Biscayne, while relative predominance of palms increases. In northern parts of the original Biscayne pineland (e.g., Harshberger 1914, Plate IV) and in Big Cypress (Patterson et al. 1980, cover, Patterson and Robertson 1981, Fig. 26), palms comprised most of the shrub stratum with hardwoods prominent only locally. The low density of the shrub stratum on Big Pine Key (Table 8) reflects the monolithic, plate-like character of the limestone surface at the site studied. At Lower Florida Keys sites with more broken substrate, density of the pineland shrub stratum approximates that found at upland sites on Long Pine Key.

In contrast to the species characteristics of sandy pine flatwoods, a large proportion of the West Indian and swamp-forest hardwoods, (more than half the species listed in Table 6) are potentially capable of reaching at least small-tree stature on southern Florida pineland sites. For example, Taylor and Herndon (1981, Table 2) listed 24 species that had attained heights greater than 10 feet (c. 3 m) on

Long Pine Key study plots, even under conditions of frequently recurring fire. Pineland fires reduce the height of the shrub understory without having much effect on understory density, because most of the hardwoods resprout readily from underground parts protected in niches of the limestone. On Long Pine Key, recovery of hardwoods after fire is direct and rapid, and a fire-free interval as short as 10 to 15 years is sufficient at some sites for establishment of the a more-or-less continuous small-tree understory. Management to prevent excessive accumulation of fuel and to preserve populations of rare and endemic herbaceous plants in pinelands (Loope et al. 1979) must take account of the fact that many species of pineland "shrubs" in southern Florida are not genetically of shrub form or stature and will quickly become trees in the absence of fire.

DISCUSSION

Shrub-stratum diversity in southern Florida pine forests is greatest, around 60 species, in the Lower Florida Keys, Long Pine Key, and (probably) the southern part of the Biscayne pineland and decreases northward to fewer than 30 species in the pinelands of Big Cypress. Diversity is diminished primarily by the loss of West Indian hardwoods from the understory as one proceeds north in the Biscayne pineland. Attenuation of the West Indian element doubtless is related in part to increasing frequency of damaging freezes in the open pinelands, but the great decrease in the amount of interface between pine forest and tropical hardwood forest in the Biscayne pineland as compared with Long Pine Key may be an equally important influence. A few shrubs characteristic of the pine flatwoods of the southeastern United States enter the southern Florida pineland flora in Big Cypress and northern parts of the Biscayne pineland where sand deposits mantle the limestone. The fact that similar species of the same ericaceous genera (Lyonia, Vaccinium, and Befaria) are found in sandy pinelands of western Cuba (Leon and Alain 1974) suggests that their occurrence in southern Florida is limited by substrate, rather than by climate.

Ecologically similar forests of long-needle pines, which could be regarded as a single vegetation type, are the predominant upland vegetation over extensive areas of the Atlantic-Gulf-Caribbean coastal plain from the southeastern United States to Nicaragua and in parts of the West Indies (Robertson 1955, Luckhoff 1964). Within this geographical array, the "pineyard" of the northern Bahamas is by far the closest ecological counterpart of southern Florida pinelands. In both areas, pine forest occurs on a substrate of eroded limestone and has a species-rich understory of shrubby hardwoods and palms. The Bahaman pine forests - principally on the islands of Grand Bahama, Great Abaco, New Providence, and Andros - are roughly twice as extensive as the original pine areas of southern Florida considered here and the woody flora of the Bahamas is considerably richer in species than that of southern Florida. To judge from brief habitat notes in the species accounts of floras of the Bahamas (Britton and Millspaugh 1920, Correll and Correll 1982), overall diversity of the shrub stratum in Bahaman pine forests appears to be somewhat greater than that recorded for all southern Florida pine areas combined (Table 6). N. L. Britton and C. F. Millspaugh noted 47 hardwoods as occurring in "pine-lands" or "pine-barrens" and Correll and Correll made similar mention of approximately 90 taxa in introductory comments (1982:23) or in text. The combined lists include about 95 taxa of hardwoods, palms, and agaves, and presumably the plants listed were considered to be those more or less characteristic of the pineland understory. A list compiled according to the criteria used here for southern Florida, that is including species of infrequent or local occurrence in pineland, probably would show that at least 110 to 130 species enter the shrub stratum of Bahaman pine forests. Of the species listed, less than one-third (28 of c. 95) also occur in the shrub understory of southern Florida pinelands. As in southern Florida, most of the hardwood shrubs in Bahaman pine forests are also found (often as trees) in the "coppices", hardwood forests ecologically equivalent to southern Florida hammocks. The aspect of the understory in Bahaman pinelands differs principally in that palms tend to be much less prominent than in southern Florida. Serenoa is not known from the Bahamas. Thrinax, Coccothrinax, and Sabal occur at least locally in the pineland shrub stratum, but palms do not commonly form either a distinct small-tree understory as in the Lower Florida Keys, or relatively continuous stands of palmetto-sized plants.

Finally, one may note that the occurrence of pine forest on limestone in southern Florida and the northern Bahamas is unusual and apparently unexplained. Over its wide range, the tropical-subtropical, long-needle pine forest reportedly is found on sand, clay, gravel, shale, sandstone, granite, and other substrates, but not (or seldom) elsewhere on limestone. Almost throughout, local hardwood forest types occupy the limestone areas and pine forests commonly have abrupt interfaces with hardwood forest where limestone occurs, as in western Cuba (Henderson 1916, Seifriz 1943, Luckhoff 1964) and Belize (Russell 1964 and references cited there). The anomalous predominance of pine on limestone in southern Florida and the northern Bahamas invites the attention of ecologists.

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LITERATURE CITED

Alexander, T. R., and A. G. Crook. 1973. Recent and long-term vegetation changes and patterns in south Florida. Final Rept., Part 1. Mimeo. Rept. (EVER-N-51). USDI, National Park Service, 215 p. N.T.I.S. No. PB 231939.

Alexander, T. R., and A. G. Crook. 1975. Recent and long-term vegetation changes and patterns in south Florida.. Final Rept., Part 2. Mimeo. Rept. USDI, National Park Service, 856 p. N.T.I.S. No. PB 264462.

Avery, G. N., and L. L. Loope. 1980. Plants of Everglades National Park: A preliminary checklist of vascular plants. National Park Service, South Florida Research Center Report T-574, Homestead, FL. 41 p.

Beard, D. B. 1938. Everglades National Park project. National Park Service. Report on file at Everglades National Park, Homestead, FL. 106 p.

Bessey, E. A. 1911. The hammocks and Everglades of southern Florida. Plant World 14:268-276.

Black, D. W., and S. Black. 1980. Plants of Big Cypress National Preserve: A preliminary checklist of vascular plants. National Park Service, South Florida Research Center Report T-587, Homestead, FL. 28 p.

Bray, J. R., and J. T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. Ecol. Monographs 27:325-349.

Britton, N. L., and C. F. Millspaugh. 1920. The Bahamas flora. New York, published by the authors. 695 p.

Clench, W. J. 1931. "Ligging" in the Everglades of Florida. The Nautilus 45(1):10-15.

Cornwell, G. W., and K. Atkins. 1975. The Impact of Evicting Farmers from Everglades National Park's Hole-in-the-Donut. Ecoimpact, Inc., Gainesville, FL. 184 p.

Correll, D. S., and H. B. Correll. 1982. Flora of the Bahama Archipelago. J. Cramer, Vaduz. 1692 p.

Craighead, F. C., Sr. 1971. The trees of south Florida. Univ. of Miami Press, Coral Gables, FL. 212 p.

Craighead, F. C., Sr. 1974. Hammocks of south Florida. pp 53-60 In P. J. Gleason, (ed.), Environments of South Florida: Present and Past. Miami Geol. Soc. Mem. 2.

Craighead, F. C., Sr., and O. Lakela. 1965. Annotated checklist of the vascular plants of Collier, Dade, and Monroe Counties, Florida. Univ. of South Florida Botanical Laboratories, No. 15.

Davis, J. H. Jr. 1943. The natural features of southern Florida, especially the vegetation and the Everglades. Florida Geol. Survey Bull. 25:1-311.

Dickson, J. D., III, R. O. Woodbury, and T. R. Alexander. 1953. Check list of flora of Big Pine Key, Florida, and surrounding keys. Quart. Journ. Fla. Acad. Sci. 16:181-197.

Egler, F. E. 1952. Southeast saline Everglades vegetation, Florida and its management. Vegetatio: 213-265.

Eldredge, I. F. 1938. Forest resources of central and south Florida. U.S. Forest Service, Southeast. For. Exp. Stn. Release No. 38. 30 p.

Everglades National Park. 1979. Fire management plan, Everglades Natinal Park, 1979-80.

Gliessman, S. R. 1976. Allelopathy in a broad spectrum of environments as illustrated by bracken. Botanical Journal of the Linnean Society, 73:95-104.

Griswold, O. 1949. William Selby Harvey: Indian Fighter. Tequesta 9:73-80.

Gunderson, L., and L. L. Loope. 1982. A survey and inventory of the plant communities in the Pinecrest area, Big Cypress National Preserve. National Park Service, South Florida Research Center Report T-655, Homestead, FL. 43 p.

Harper, R. M. 1927. Natural resources of southern Florida. Fla. Geol. Surv. 18th Ann. Rept., Talahassee, FL. p. 25-206.

Harshberger, J. W. 1914. The vegetation of south Florida, south of 27°30' north, exclusive of the Florida Keys. Trans. Wagner Free Inst. Sci., Philadelphia, PA. 7:49-189.

Henderson, J. B. 1916. The cruise of the Tomas Barrera. G. P. Putnam's Sons, New York.

Hilsenbeck, C. E. 1976. An investigation of old field succession in Everglades National Park, First Interim Report, Everglades National Park, Homestead, FL. 63 p.

Hilsenbeck, C. E., R. H. Hofstetter, and T. R. Alexander. 1979. Description of the major plant communities in the East Eveglades. Dept. of Biology, Univ. of Miami. 34 p.

Hoffmeister, J. E. 1974. Land from the sea; the geologic story of south Florida. Univ. of Miami Press, Coral Gables, FL.

Hofstetter, R. H. 1973. Effects of fire in the ecosystem. Univ. of Miami Press, Goral Gables, FL. 156 p.

Hofstetter, R. H., and F. Parsons. 1975. Effects of fire in the ecosystem: an ecological study of the effects of fire on the wet prairie, sawgrass glades, and pineland communities of south Florida. Final Rept., Part 2. Mimeo. Rept. U.S.D.I., National Park Service, EVER-N-48. NTIS No. PB 264463.

Hofstetter, R. H., and C. E. Hilsenbeck. 1980. Vegetational studies of the East Everglades. Final report to Metropolitan Dade County, Miami, FL.

Holt, E. G. and G. M. Sutton. 1926. Notes on birds observed in southern Florida. Ann. Carnegie Museum. 16:409-439.

Howell, A. H. 1921. A list of the birds of Royal Palm Hammock, Florida. Auk 38:250-263.

Humes, R. H. 1965. A short history of Liguus collecting with a list of collectors, 1744 to 1958. Tequesta 25:67-82.

Ives, J. 1856. Military map of the peninsula of Florida south of Tampa Bay. U.S. 62nd Cong. 1st Session, Senate doc. #89.

Jones, A. L., E. C. Winte, and O. L. Bass, Jr. 1981. The status of Florida tree snails (Liguus fasciatus), introduced to Everglades National Park. National Park Service, South Florida Research Center Report T-622, Homestead, FL. 31 p.

Krome, W. J. 1903. Field map showing Long Key and the lower Biscayne pineland with proposed location line, Cutler Extension, F.E.C. Ry. Scale:1"=5000'. Copy dated November 3, 1903.

Krome, W. J. 1904. Railway location in the Florida Everglades. Engineering Record 49(14-15): 428-429, 452-453.

Lakela, O. and R. W. Long. 1976. Ferns of Florida. Banyan Books, Miami, FL. 178 p.

Leon, H., and H. Alain. 1974. Flora de Cuba. Vol. 2. Otto Koeltz Science Publ., Koenigstein.

Long, R. W., and O. Lakela. 1976. A flora of tropical Florida (second edition). Banyon Books, Miami, FL.

Loope, L. L., D. W. Black, S. Black, and G. N. Avery. 1979. Distribution and abundance of flora in limestone rockland pine forests of southeastern Florida. National Park Service, South Florida Research Center Report T-547, Homestead, FL. 37 p.

Loope, L. L., and V. L. Dunevitz. 1981. Impact of fire exclusion and invasion of Schinus terebinthifolius on limestone rockland pine forests of southeastern Florida. National Park Service, South Florida Research Center Report T-645, Homestead, FL.

Loope, L. L. and N. H. Urban. 1980. A survey of fire history and impact in tropical hardwood hammocks in the East Everglades and adjacent portions of Everglades National Park. National Park Service, South Florida Research Center report T-592, Homestead, FL. 48 p.

Luckhoff, H. A. 1964. The natural distribution, growth, and botanical variation of Pinus caribaea and its cultivation in South Africa. Annale Univ. van Stellenbosch 39, No. 1, 160 p.

Mackay, J., and J. E. Blake. 1839. Map of the seat of war in Florida. Headquarters, Army of the South, Tampa Bay, FL.

Meador, R. E., II. 1977. The role of mycorrhizae in influencing succession on abandoned Everglades farmland. Unpublished Master's thesis, University of Florida, Gainesville. 100 p.

Motte, J. R. 1953. Journey into wilderness, an army surgeon's account of life in camp and field during the Creek and Seminole Wars, 1836-1838. Univ. of Florida Press, Gainesville, FL.

Olmsted, I. C., L. L. Loope, and C. E. Hilsenbeck. 1981. Tropical hardwood hammocks of the interior of Everglades National Park and Big Cypress National Preserve. National Park Service, South Florida Research Center Report T-604, Homestead, FL. 58 p.

Olmsted, I. C., L. L. Loope, and R. E. Rintz. 1980. A survey and baseline analysis of aspects of the vegetation of Taylor Slough, Everglades National Park. National Park Service, South Florida Research Center Report T-586, Homestead, FL. 72 p.

Patterson, G. A., and W. B. Robertson, Jr. 1981. Distribution and habitat of the red-cockaded woodpecker in Big Cypress National Preserve. National Park Service, South Florida Research Center Report T-613, Homestead, FL. 137 p.

Patterson, G. A., W. B. Robertson, Jr., and D. E. Minsky. 1980. Slash pine-cypress mosaic (breeding-bird census). Am. Birds 34:61-62 and cover photograph.

Pilsbry, H. A. 1946. Land Mollusca of North America (north of Mexico). Academy of Natural Sciences of Philadelphia. Monogr. No. 3. II(1):65.

Robertson, W. B., Jr. 1953. A survey of the effects of fire in Everglades National Park. Mimeo. rept. National Park Service. 169 p.

Robertson, W. B., Jr. 1955. An analysis of the breeding-bird populations of tropical Florida in relation to the vegetation. Ph.D. Thesis. Univ. of Illinois. 599 p.

Romans, B. 1962. A concise natural history of East and West Florida. (Reproduction of 1775 edition). University of Florida Press, Gainesville, FL.

Russell, S. M. 1964. A distributional study of the birds of British Honduras. Ornithological Monographs No. 1, American Ornithologists' Union. 195 p.

Safford, W. E. 1919. Natural history of Paradise Key and the nearby Everglades of Florida. p. 377-434 In Smithsonian Institution, Annual Report for 1917.

Seifriz, W. 1943. The plant life of Cuba. Ecological Monographs 13:375-426.

Simpson, C. T. 1920. In Lower Florida Wilds. Putnman's Sons, New York, NY. 404 p.

Simpson, C. T. 1923. Out of Doors in Florida. E. B. Douglas, Miami, FL. 408 p.

Simpson. 1929. The Florida tree snails of the genus Liguus. Proc. U. S. Natl. Mus. 73:1-44.

Small, J. K. 1904a. Report on exploration in tropical Florida. Jour. New York Bot. Garden 5:49-55.

Small, J. K. 1904b. Report upon further exploration of southern Florida. Jour. New York Bot. Garden 5:157-164.

Small, J. K. 1907. Exploration of southern Florida. Jour. New York Bot. Garden 8:23-28.

Small, J. K. 1909. Exploration in the Everglades. Jour. New York Bot. Garden 10:48-55.

Small, J. K. 1911. Exploration in southern Florida. Jour. New York Bot. Garden 12:147-157.

Small, J. K. 1913a. Flora of Miami. New York, published by the author. 206 p.

Small, J. K. 1913b. Flora of the Florida Keys. New York, published by the author. 162 p.

Small, J. K. 1916a. Exploration in southern Florida in 1915. Jour. New York Bot. Garden 17:37-45.

Small, J. K. 1916b. Royal Palm Hammock. Jour. New York Bot. Garden 17:165-172.

Small, J. K. 1917. Botanical exploration in southern Florida. Jour. New York Bot. Garden 18:98-111.

Small, J. K. 1920. The land of ferns. Jour. Elisha Mitchell Sci. Soc. 11:92-104.

Small, J. K. 1929. The Everglades. Scientific Monthly 28:80-87.

Small, J. K. 1930. Vegetation and erosion on the Everglades Keys. Scientific Monthly 30:33-49.

Small, J. K. 1933. Manual of the southeastern flora. New York, published by the author. 1554 p.

Sorensen, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. Det. Kong. Danske Vidensk. Biol. Skr. (Copenhagen). 5(4):1-34.

Taylor, D. L. 1981. Fire history and fire records for Everglades National Park, 1948-1979. National Park Service, South Florida Research Center Report T-619, Homestead, FL. 121 p.

Taylor, D. L., and A. Herndon. 1981. Impact of 22 years of fire on understory hardwood shrubs in slash pine communities within Everglades National Park. National Park Service, South Florida Research Center Report T-640, Homestead, FL. 30 p.

Tebeau, C. W. 1968. Man in the Everglades; 2,000 years of human history in the Everglades National Park. Univ. of Miami Press, Coral Gables, FL.

Vernick, K., and D. L. Taylor. 1981. Cutover subtropical slash pine forest. Am. Birds 35:69-70.

Williams, J. L. 1837. Map of Florida. New York.

Willoughby, H. L. 1898. Across the Everglades: A Canoe Journey of Exploration. J. B. Lippencott Co., Philadelphia, PA. 192 p.

Table 1. Ground water levels (cm)* in pineland wells.

Date	Osteen Hammock	Redd Hammock
1979		
5/9	67	33
5/29	121	59
6/18	99	36
6/26	127	60
7/17	132	58
8/29	118	56
9/18	100	40
9/26	115	48
9/27		41
10/18		30
10/28		57
10/30	123	60
1981		
2/18	183	
2/23	105	
2/27	117	
3/22	158	
3/24	158	
4/13	188	
August, during Tropical Storm Dennis, after 17 inches rain	60	2
9/20	100	48

* Water levels were measured from the top of the well (rock surface) to the water surface.

Table 2. Summary of Vegetation Analysis

a. Number of woody, forb, and graminoid species per vegetation type

	Total	Woody*	Forbs	Graminoids
Transect	208			
Hammock	51	30	20	1
Pineland	167	49	90	28
Glades	114	20	68	26

. . . .

Hammock-pineland	29 common species
Pineland-glade	93 common species
Hammock-glade	9 common species

b. Cover percentages for woody, forb, and graminoid species per vegetation type

	Woody %	Graminoids %	Forbs %	Total %
Hammock	15**	-	1	16
Pineland	21	5	6	32
Glades	2	11	2	15

c. Characteristics of pine distribution

Mean density	mean dbh	mean height	mean basal area
250-660/ha	14-15 cm	12-15 m	44-116 m^2/ha

* Includes woody vines.

** The cover was estimated for shrub vegetation only and does not include canopy cover. Explanation in text.

Table 3. Mean cover percentage (per m^2) and frequency of woody, forb, and graminoid species in each vegetation type.

Species	Pineland (21 plots)		Hammock (5 plots)		Glade (6 plots)	
	Cover	Frequency	Cover	Frequency	Cover	Frequency
Woody						
Ardisia escallonioides	.7	27	1.6	60	-	-
Bumelia reclinata	.1	8.5	-	-	.6	11.7
B. salicifolia	.8	23.3	.1	18	-	-
Bursera simaruba	-	-	.1	8	-	-
Byrsonima lucida	.8	9.5	-	-	.4	3.2
Chrysobalanus icaco	.3	9.5	-	-	.3	3.2
Coccoloba diversifolia	-	-	2.5	4.4	-	-
Conocarpus erectus	.3	7.6	-	-	-	-
Dodonoea viscosa	2.0	38.1	-	-	-	-
Eugenia axillaris	.1	.4	1.1	56	-	-
Guettarda elliptica	1.1	18.1	-	-	-	
G. scabra	4.8	61.9	.1	4	-	-
Ilex cassine	.2	5.2	-	-	T	3.3
Lysiloma latisiliquum	.1	1.4	T	2	-	-
Metopium toxiferum	.9	15.7	.4	32	-	-
Myrica cerifera	.1	8.6	-	-	T	-
Myrsine floridana	.7	27.6	.6	34	-	-
Persea borbonia	.2	5.2	-	-	.1	1.6
Pinus elliottii	.6	26.2	-	-	T	10
Psychotria nervosa	.1	.4	2.6	92	-	-
Quercus virginiana	.1	1.9	T	6	-	-
Randia aculeata	.8	43.3	-	-	.1	4.8
Rhus copallina	.9	18.1	-	-	-	-
Serenoa repens	2.2	21.4	-	-	-	-
Tetrazygia biflora	.5	8.6	.1	6	-	-
Toxicodendron radicans	-	-	.1	6	-	-
Trema micranthum	.1	.9	-	-	-	-
Sabal palmetto	1.3	23.8	T	2	-	-
Forbs						
Acalypha chamaedrifolia	T	1.9	-	-	-	-
Adiantum tenerum	-	-	.7	12	-	-
Agalinis purpurea	.1	10.0	-	-	T	3.3
Aletris bracteata	.1	2.9	-	-	T	3.2
Anemia adiantifolia	.5	55.2	.1	4	-	-
Angadenia sagraei	.11	27.6	-	-	T	4.8
Aster adnatus	.1	4.8	-	-	T	21.0
A. dumosus	.1	10.4	-	-	T	8.3
A. tenuifolius	-	-	-	-	T	1.6

Table 3 continued.

Species	Pineland (21 plots) Cover	Pineland (21 plots) Frequency	Hammock (5 plots) Cover	Hammock (5 plots) Frequency	Glade (6 plots) Cover	Glade (6 plots) Frequency
Borreria terminalis	.1	28.1	-	-	-	-
Cassytha filiformis	.1	19.0	-	-	T	6.6
Centella asiatica	.2	3.0	-	-	.1	57.0
Chamaesyce pinetorum	.1	17.1	-	-	T	11.6
C. porteriana var. porter	.1	29	-	-	T	18.0
Chiococca parvifolia	.6	59.5	-	-	-	-
Cirsium horridulum	T	5	-	-	T	3.0
Coreopsis leavenworthii	T	3.8	-	-	T	1.7
Cynanchum blodgettii	T	1.0	-	-	T	1.5
Cynoctenum mitreola	T	5.2	-	-	T	25.0
Dyschoriste oblongifolia	.1	38.1	-	-	T	53.3
Eupatorium leptophyllum	.1	7.6	-	-	.1	15.0
E. mikanioides	T	.5	-	-	T	6.6
E. villosum	.2	4.8	-	-	-	-
Evolvulus sireceus	T	7.1	-	-	T	40.0
Galactia spp.	T	0.9	T	2.0	-	-
Heliotropium polyphyllum	.1	11.9	-	-	.1	43.0
Hyptis alata var. stenophylla	.1	20.5	-	-	.1	35.0
Ipomoea sagittata	T	.9	-	-	.1	25.0
Linum medium	-	-	-	-	.1	65.0
Lobelia glandulosa	T	1.9	-	-	T	3.3
Melanthera angustifolia	-	-	-	-	.2	53.3
Mikania scandens	.1	18.6	-	-	.1	26.6
Morinda royoc	.7	41.4	.1	8	-	-
Passiflora suberosa	.1	24.3	.1	4	.1	-
Phyla nodiflora	.1	0.9	-	-	.1	20
Phyllanthus caroliniensis	T	0.5	-	-	T	4.9
P. pentaphyllus	.1	47.6	-	-	T	16.6
Physalis viscosa	.1	10.5	-	-	.1	5
Piriqueta caroliniana	T	7.6	-	-	T	10
Pluchea rosea	.1	7.6	-	-	.1	28.3
Polygala boykinii	T	.5	-	-	T	1.7
P. grandiflora	T	2.9	-	-	T	10
Pteridium aquilinum var. caudatum	.6	18.1	-	-	-	-
Pteris longifolia var. bahamensis	.4	26.7	-	-	-	
Ruellia caroliniensis	.1	17.6	-	-	.1	21.6
Samolus ebracteatus	.1	13.3	-	-	T	15
Sida elliotii	.1	2.9	-	-	.1	13.3
Smilax auriculata	.2	16.7	.1	14	-	-
Solidago stricta	T	13.3	-	-	T	18
Stylanthes calcicola	T	2.8	-	-	.1	26

Table 3 continued.

Species	Pineland (21 plots) Cover	Frequency	Hammock (5 plots) Cover	Frequency	Glade (6 plots) Cover	Frequency
Thelypteris kunthii	T	1	.1	2	-	-
Vernonia blodgettii	T	4.3	-	-	T	26.6
Vitis rotundifolia	.1	15.2	T	6	T	1.7
Zamia pumila	.1	9.5	.1	4	-	-
Graminoids						
Andropogon cabanisii	2.5	62	-	-	-	-
Andropogon glomeratus	.1	8	-	-	.2	23
A. virginicus	T	.9	-	-	T	4.8
Aristida purpurascens	.1	12	-	-	.2	70
Cladium jamaicense	.3	20	-	-	3.0	95
Dicanthelium dichotomum	T	4.3	-	-	.3	61.6
Dichromena floridensis	.2	20.5	-	-	.4	53
Muhlenbergia filipes	.4	40	-	-	10.0	95
Rhynchospora divergens	T	1.9	-	-	.2	66.6
R. microcarpa	T	5	-	-	.1	31.6
Schizachyrium rhizomatum	.3	21.4	-	-	.2	48.3
S. semiberbe	.3	14.3	-	-	T	1.7
Setaria geniculata	-	-	-	-	.1	28.3
Sorghastrum secundum	.2	2.9	-	-	-	-

T = trace.

Table 4. Frequency and percent cover of certain tree and grass species (10 m^2 plots) indicating distribution in high and low elevation pineland sites (explanation in text).

	3* (1)**	5 (2)	1 (3)	7 (4)	69 (20)	65 (18)	61 (16)	63 (17)	67 (19)	19 (5)	23 (6)	27 (8)	25 (7)	29 (9)	37 (10)	39 (11)	41 (12)	45 (13)	49 (15)	47 (14)	53
<u>Lysiloma</u> <u>latisiliquum</u>					30																
					5																
<u>Guettarda</u> <u>scabra</u>	60	60	100	100	90	90	100	100	100	10	10	10	100			90	100	90		100	
	15	32	69	119	69	43	87	101	35	2	2	T	109			62	145	46		106	
<u>Guettarda</u> <u>elliptica</u>						20	40		70	60	90		20			60		20		20	
						3	6		13	12	127		2			67		5		2	
<u>Dodonea</u> <u>viscosa</u>	100	70	80	40		10	30	20	10	40	100		90	10		10	100	8		10	
	34	43	32	22		3	6	5	2	25	99		23	T		4	85	45		3	
<u>Metopium</u> <u>toxiferum</u>		10		30		90	50	20	10			10		40		20		20	30	40	60
		T		2		53	5	T	2			10		28		6		2	10	7	74
<u>Bumelia</u> <u>salicifolia</u>	50	30	10		40	10		50	20		50		10			100		20		60	
	21	5	T		27	1		13	2		15		2			60		9		7	
<u>Randia</u> <u>aculeata</u>	20			20			10		20	100	50	60	20	60	50	90	60		50	30	60
	T			5			T		T	61	3	22	4	12	9	17	8		11	11	5
<u>Ardisia</u> <u>escallonioides</u>		70				70	10	70		40	20	10	40	30	20	20	40		70	60	
		19				16	3	17		10	5	1	5	22	8	2	4		37	6	
<u>Ilex</u> <u>cassine</u>						40			10					30							
						18			1					14							
<u>Rhus</u> <u>copallina</u>		20	50				10	40					80					100		80	
		2	18				T	9					36					94		35	

Table 4 continued.

	3* (1)**	5 (2)	1 (3)	7 (4)	69 (20)	65 (18)	61 (16)	63 (17)	67 (19)	19 (5)	23 (6)	27 (8)	25 (7)	29 (9)	37 (10)	39 (11)	41 (12)	45 (13)	49 (15)	47 (14)	53
Persea borbonia													20 1						60 34		30 10
Myrica cerifera				10 6						20 1		20 T	10 T	10 T		10 T	10 T				20 T
Chrysobalanus icaco						10 T	30 6							20 9	10 1						40 4
Conocarpus erectus														40 32	30 9	40 20			30 12		60 13
Bumelia reclinata						10 1				40 3				20 1	10 T	10 T	20 3				40 2
Byrsonima lucida							10 10			10 3	50 87	10 1			40 7	50 50	20 2				10 6
Andropogon cabanisii	50 13	20 4	40 27	10 T	100 39	100 37	100 37	90 85	100 86	60 10	100 25	70 21	100 79			100 14	90 29	70 15		100 15	
Muhlenbergia filipes										100 65	70 3	100 111	100 47	100 33	100 58	100 6	50 6	10 T	70 29	30 T	10 T
Schizachyrizum rhizomatum	20 2			50 9						70 12	60 8	80 14		30 5	100 14		30 1				10 T

* Actual plot numbers of Figure 1.
** Numbers in parenthesis are numbers on ordination Figure 3.
Top number = frequency.
Bottom number = cover percent.

Table 5. Fire impact status and inferred fire history of hammocks, by year, as determined from aerial photography and helicopter flights in 1981.

#	Name	1940	1952	1960	1964	1980/81
1	Twin Glades	B	M	D for agriculture		
2	Barnes	B	M	D for agriculture		
3	Torre	M	M	M	M	M
4	Gould	M	M	M	-	M
5	Dall	B	R	IM	IM	M
6	Emery	B	B	-	-	PM
7	Lermond	B	R	-	-	R
8	Bequaert	B	R	R	-	M
9	Simmons	IM	M	M		M
10	Gifford	M	B*	R	-	M
11	Henderson	M	B	R	-	M
12	No name		M		-	M
13	No name		B		-	M
14	No name	B	B/R		-	M
15	No name	-	B	-	-	M
16	No name	B	B/R	-	-	IM
17	No name	B	R	-	-	M
18	No name	M	B^{N}	R	-	
19	Rafinesque	-	R	B	-	M
20	Baker	B	IM	-	-	M
21	Mosier	M	M	M	M	M
22	Rattlesnake	M	B^{W}	R	-	M
23	Osteen	B^{N} R	B	R	R	M
24	Gun	R	B^{NE}	R	-	M
25	Bartsch	M		-	-	M
26	Palma Vista #2	M	M	M	-	M
27	Palma Vista #1	M	M	M	-	M
28	Smith (Small)	M	M	M	-	M
29	McGinty	R	M	M	-	M
30	Walton	R	B	M	-	M
31	Deckert	R	B	R	-	PM
32	Tomlin	R	R	M	M	M
33	Chase	B	R	IM	B^{NE}	IM
34	Turkey	B	R	R	R/IM	M
34A	Mystery (Turkey)	B	R	M	-	M
35	Allen	B	R		R	PM
36	Marshall	B	B		-	M
37	Clapp	B	B^{NW}	R	-	M
38	Pilsbry	B			-	M
38A	Redd	M	M	M	M	M
40	Goodrich	M	B**	R	-	M
41	Johnson	R	B^{SW}	R	-	M
42	Fairchild	B	B**	R	-	PM
43	Archer	R	M	M	-	M

Table 5 continued.

#	Name	1940	1952	1960	1964	1980/81
44	Lea	B	R	R	-	IM
45	Conrad	-	-	-	-	IM
46	Call	B***	R	R	IM	M
47	DeCamp	B	R	R	R	M
48	Currier	B	B^{W}	R	R	M
49	Rehder	B	B	B	-	R
50	Bootlegger	M	M	B^{N}	-	IM
51	Dark	M	M	M	partial recent burn	
52	Simpson	B	B	B	R	R
53	Gill	B	B	B	R	M
54	Cadwaleder	B	B	-	R	M
55	Barbour	R	B^{E}	-	-	M
56	Say	B	R	M	M	M
57	Wright	M	M	M	M	M
58	Winkley	B^{N}	R	M	M	M
59	Clench	M	B	R	R	M
60	Frampton	B	R	R	R	M
61	No name	R	B	-	-	M
62	No name	B	R	-	-	M
63	Pfleuger	R	IM	-	-	M
64	Warren	B	R	-	-	
65	Lime	-	M	-	-	M
66	Squires	-	M	-	-	R
67	West End	R	-	M	-	
68	Schevill	M	B,R	-	-	
69	McDonald	R	M	M	-	M
70	Poppenhager	B	B	B	B	M
71	Lott	B****	R	IM	B^{S}	M
72	Dr. deBoe	B	R	R	R	
73	Top	B	B	R	R,B^{S}	M
76	Junk	IM	M	M	M	M
77	Jackson	B	R	R	-	PM
79	Pineridge	B	B	B	-	M
80	Clavata	B	R,B^{W}	R	-	IM
81	Rhodes	-	-	-	-	D
85	Fields	R	IM	M	R	IM
86	Maxwell	B	R	R	R	IM
87	Mathew	-	-	-	-	M
88	No name	R	B	-	R	M
89	Dead	B	R	-	IM	M
90	Barret	B	R	R	R	M
91	Deer	B^{W}	R	M	M	IM
92	VonPaulsen	M	B^{E}	R	M	M
93	Grimshawe	M	M	M	M	M
94	Winkleman	B	B	R	R	M
95	Coe	M	B,R	R	M	M
96	Powell	M,B^{SE}	-	R		
97	Remington	B^{S+E}	-	M		
98	Tryon	B	-	-		
99	Humes	B	B**	R	-	M

Table 5 continued.

#	Name	1940	1952	1960	1964	1980/81
100	Beard	B	B	-	R^{1969}	M
101	Pennecamp	B	R,B^{NW}	-	R	M
102	Jones	M	B	R	M	M
104	Craighead	M	B	R	M	M
105	Wild lime	M	B^{W}	R	M	M
106	Ebbitts	B	R	R	R	M
107	Robertson (A - F)	B	-	-	R	M
108	White rock	B	B	B	B	IM
109	Lysiloma	B,R	R	M	-	IM
110	F. N. Young	B	R	-	R	M
111	Simpson	B,R	B	-	R	M
112	Abbott	M	B	-	R	M
113	Buttonwood					M
114	No name					M
115	No name					M
116	Avery					M
117	Douglas (Marjorie Stoneman)					M
118	Simmons (Glenn and Maxie)					
119	Young, Fran					M
120	Brookfield					M

Legend:

Fire Impact Status

M = Hammock has mature appearance on aerial photograph

PM = Hammock has mature appearance on aerial photograph, except for small shrubby portions.

IM = Hammock appears to be in condition approaching maturity on aerial photograph.

R = Hammock exhibits signs of progressive recovery from burn in previous interval(s)

D = Destroyed

B = Evidence of burn during interval (N, S, W = north side, south side, etc.) (Mar = margins)

* scattered tall trees
** center
*** part
**** understory

Table 6. Distribution of 95 taxa of shrub-layer plants in pine forest areas of southern Florida.

Shrub Species	LFK	LPK	So. Biscyane	No. Biscayne	BICY
Acacia farnesiana	x			x	
Acacia pinetorum	x	x (4)[2]	x		
Alvaradoa amorphoides		x	x		
Amorpha crenulata				x	
Annona glabra	x	x (7)	x	x	
Ardisia escallonioides	x	x (93)	x		x
Asimina reticulata					x
Baccharis angustifolia	x				
Baccharis glomeruliflora		x (14)	x	x	
Baccharis halimifolia	x	x (14)	x	x	x
Befaria racemosa					x
Bourreria cassinifolia	x	x (1)	x	x	
Bumelia celastrina	x	x			
Bumelia reclinata		x (64)	x	x	x
Bumelia salicifolia	x	x (96)	x	x	x
Bursera simaruba	x	x (8)	x		
Byrsonima lucida	x	x (86)	x	x	
Caesalpinia pauciflora	x				
Callicarpa americana		x (4)	x	x	x
Cassia chapmanii	x	x (34)	x	x	
Catesbaea parviflora	x				
Cephalanthus occidentalis		x (1)	x		
Chrysobalanus icaco	x	x (71)	x	x	x
Chrysophyllum oliviforme	x	x (44)			
Citharexylum fruticosum		x (10)	x		
Coccoloba diversifolia	x	x (10)			
Coccoloba uvifera	x				
Coccothrinax argentata	x	x (18)	x	x	
Colubrina arborescens		x			
Colubrina cubensis		x			
Conocarpus erectus	x	x (22)	x		
Crossopetalum rhacoma	x	x	x		
Croton linearis	x	x (42)	x	x	
Diospyros virginiana		x			x
Dodonaea viscosa		x (64)	x	x	x
Drypetes diversifolia	x				
Erithalis fruticosa	x				
Eugenia axillaris	x	x (53)	x		x
Eugenia myrtoides	x				
Eupatorium villosum		x (26)	x		
Exothea paniculata		x (10)	x		
Ficus aurea	x	x (5)	x	x	x
Ficus citrifolia	x	x (62)	x	x	x

Table 6 continued.

Shrub Species	LFK	LPK	So. Biscyane	No. Biscayne	BICY
Forestiera segregata		x (16)	x		
Guapira discolor	x	x (71)	x		
Guettarda elliptica	x	x (77)	x		
Guettarda scabra	x	x (52)	x	x	
[1]Hippomane mancinella	x				
Hypelate trifoliata	x	x			
Ilex cassine		x (82)	x	x	x
Ilex glabra					x
Ilex krugiana		x (27)	x		
Jacquinia keyensis	x	x			
Laguncularia racemosa	x				
Lantana involucrata	x	x (21)	x	x	
Lyonia fruticosa				x	x
Lysiloma latisiliquum		x (8)	x		
Magnolia virginiana		x			
Manilkara bahamensis	x				
Mastichodendron foetidissimum		x (3)			
Metopium toxiferum	x	x (97)	x	x	
Myrcianthes fragrans		x (4)	x		
Myrica cerifera	x	x (93)	x	x	x
Myrsine floridana	x	x (99)	x	x	x
Persea borbonia	x	x (74)	x	x	x
Piscidia piscipula	x				
Pisonia rotundata	x				
Pithecellobium guadalupense	x				
Psidium longipes	x	x (67)	x	x	
Psychotria nervosa	x	x (4)	x		
Quercus minima				x	
Quercus pumila				x	
Quercus virginiana		x (23)	x	x	x
Quercus va. var. geminata				x	x
Randia aculeata	x	x (96)	x	x	x
Reynosia septentrionalis	x				
Rhizophora mangle	x				
Rhus copallina	x	x (44)	x	x	x
Sabal palmetto	x	x (100)	x	x	x
Salix caroliniana		x	x	x	x
Sambucus simpsonii				x	
Serenoa repens		x (92)			
Solanum donianum	x	x			
Solanum erianthum	x				
Sophora tomentosa	x				
Strumpfia maritima	x				
Suriana maritima	x				
Taxodium ascendens					x
Tetrazygia bicolor		x (90)	x	x	
Thrinax morrissii	x				

Table 6 continued.

Shrub Species	LFK	LPK	So. Biscyane	No. Biscayne	BICY
Trema lamarckianum				x	
Trema micranthum	x	x (5)	x	x	
Vaccinium myrsinites				x	x
Ximenia americana				x	

LFK = Lower Florida Keys.
LPK = Long Pine Key.

1 Neither Small (1933:829) nor Long and Lakela (1976:574) mentions occurrence of this species on the Florida mainland, but it is frequent in a relatively small area of southwestern Long Pine Key (Robertson 1953, Figure 23; South Florida Research Center Herbarium Nos. 49 and 2199). Our listing for the Lower Florida Keys is based on Small (loc. cit.). We have not seen the species there in pineland situations.

2 ( ) percentage of constancy of woody species encountered in 73 plots (see pineland shrub methods, Chapter 1).

Table 7. Summary: shrub stratum diversity and similarity in southern Florida pine forests.

Area	No. Taxa	No. Unique Taxa	No. of Taxa in Common 1	2	3	4	5
1. Lower Florida Keys	59	20	-	38	32	24	14
2. Long Pine Key	61	5	38	-	49	31	21
3. Southern Biscayne	49	0	32	49	-	31	20
4. Northern Biscayne	41	6	24	31	31	-	21
5. Big Cypress	28	4	14	21	20	21	-

Table 8. Density of shrub-stratum plants in southern Florida pine forests.

Area	No. Plants/100 m^2	Percent Hardwoods	Percent Palms
Big Pine Key[1]	400	85	15
Long Pine Key[1]	919 (360-1470)	96 (89-100)	4 (0-11)
Southern Biscayne[1] (Navy Wells)	1290	97	3
Southern Biscayne[1] (Camp Owaissa Bauer)	615	83	17
Northern Biscayne[1] (Thompson Park)	695	85	15
Northern Biscayne[1] (USDA)	605	70	30
Northern Biscayne[1] (Tamiami Pines)	265	81	19
Long Pine Key[2]	149 (57-313)	-	-

[1] Calculated from Loope et al. (1979, Table 1). Numbers represent number of identifiable individuals of all sizes. Extrapolated from counts on a series of 20 plots each/m^2 in each area. Long Pine Key data are the mean and range for seven such series of plots.

[2] From Taylor and Herndon (1981, Tables 1 and 2). Numbers represent hardwood stems 3 feet(0.9 m) or more high. Reduced from data given as no. stems/hectare.

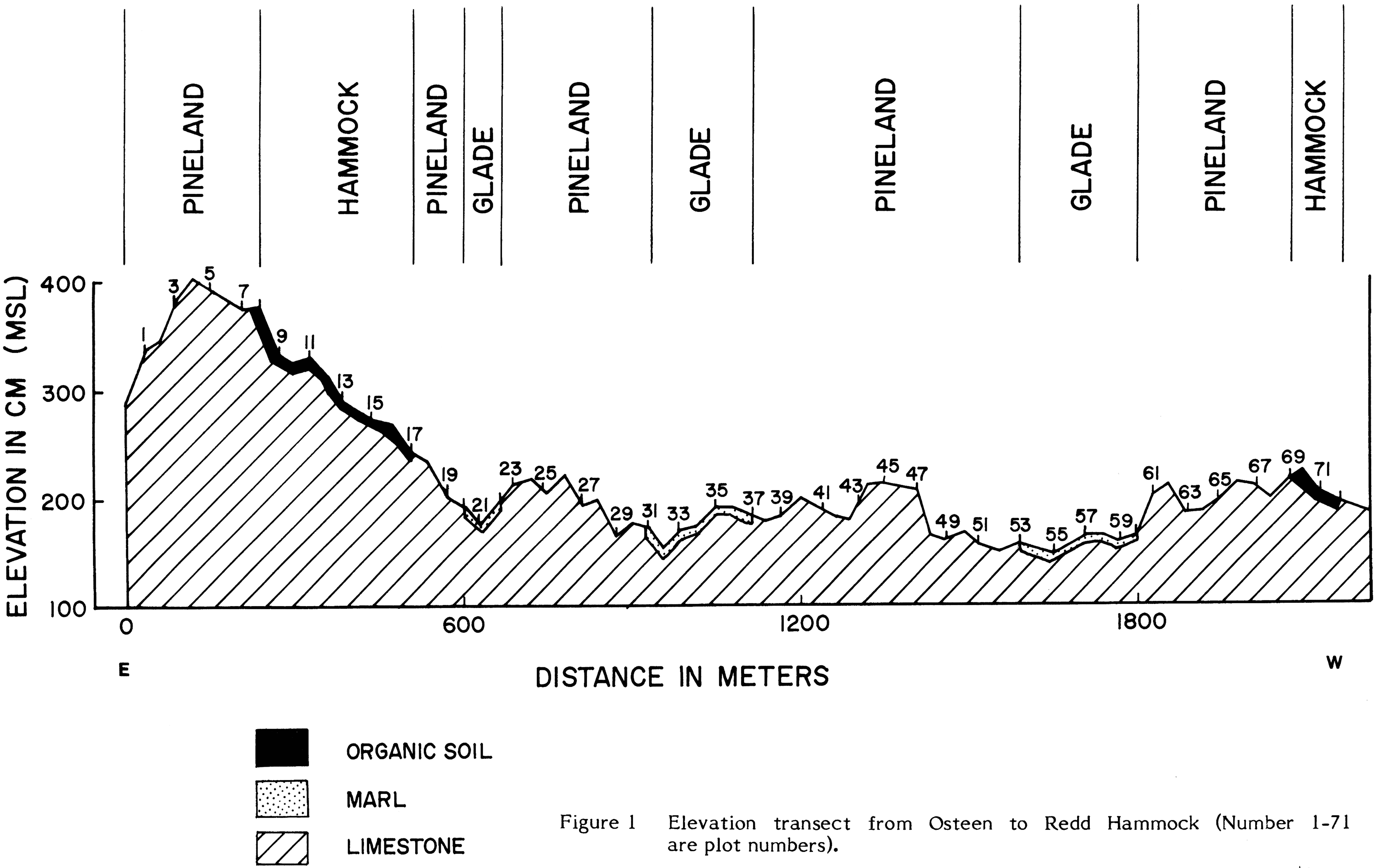


Figure 1 Elevation transect from Osteen to Redd Hammock (Number 1-71 are plot numbers).

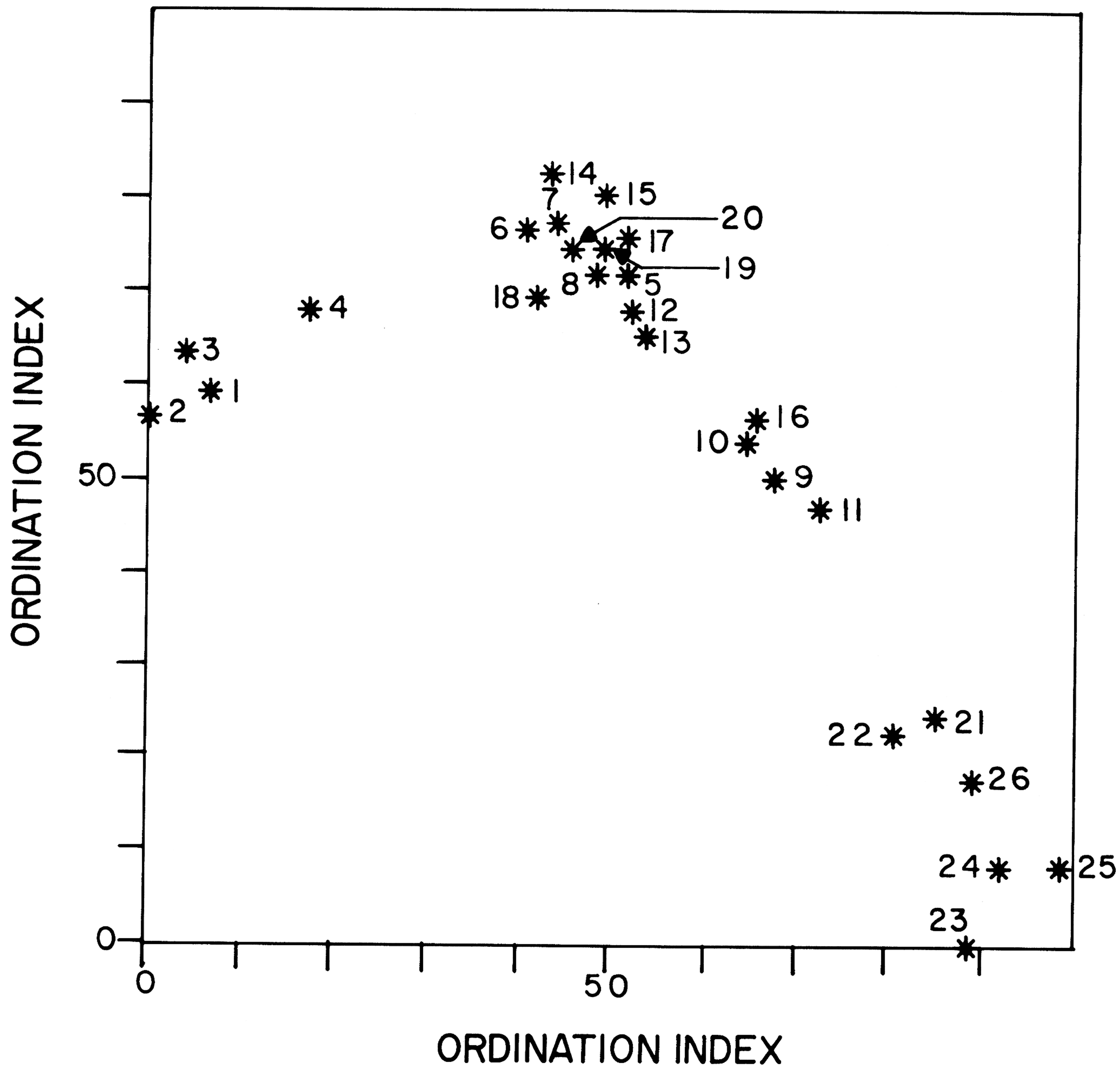


Figure 2 Ordination of 3 vegetation types:

1, 2, 3, 4 - Hammock plots.
5-20 - Pineland plots.
21-26 - Prairie plots.

Equivalence of Figure 2 numbers to actual plot numbers on elevation transect (Fig. 1), first number is from ordination figure:

1 - 9	15 - 47
2 - 13	16 - 49
3 - 15	17 - 61
4 - 71	18 - 65
5 - 3	19 - 67
6 - 5	20 - 69
7 - 7	21 - 21
8 - 25	22 - 33
9 - 27	23 - 55
10 - 29	24 - 57
11 - 37	25 - 59
12 - 39	26 - 51
13 - 41	
14 - 45	

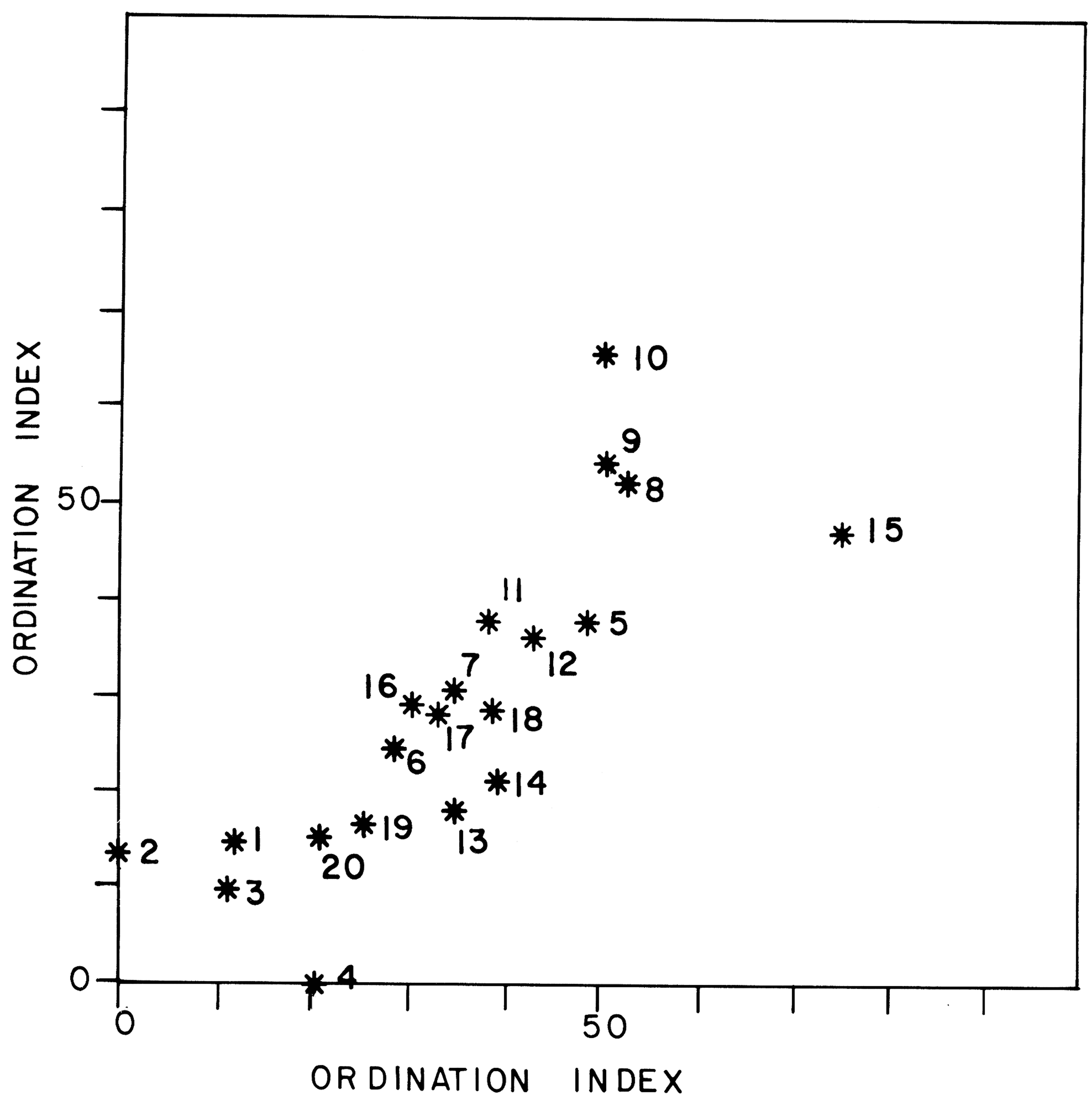


Figure 3 Ordination of pineland stands

Equivalence of Figure 3 numbers to actual plot numbers of Figure 1:

1 - 3	11 - 39
2 - 5	12 - 41
3 - 1	13 - 45
4 - 7	14 - 47
5 - 19	15 - 49
6 - 23	16 - 61
7 - 25	17 - 63
8 - 27	18 - 65
9 - 29	19 - 67
10 - 37	20 - 69

Appendix I. Numbers and names of Long Pine Key hammocks. Asterisk indicates named and numbered hammocks not found on vegetation map. Names and/or numbers in parentheses indicate synonymous hammocks.

1	Twin Glade
2	Barnes
3	Torre
4	Gould
5	Dall
6	Emery
7	Lermond
8	Bequaert
9	Simmons
10	Gifford
11	Henderson
12	No name
13	No name
14	No name
15	No name
16	No name
17	No name
18	No name*
19	Rafinesque
20	Baker
21	Mosier
22	Rattlesnake
23	Osteen
24	Gun
25	Bartsch
26	Palma Vista #2
27	Palma Vista #1
28	Smith (Small)
29	McGinty
30	Walton
31	Deckert
32	Tomlin
33	Chace
34	Turkey (72-deBoe, 74-Gold, 75-Lowe)
34A	Mystery (34-Turkey)
35	Allen
36	Marshall
37	Clapp
38	Pilsbry
38A	Redd
39	Winslow*
40	Goodrich
41	Johnson
42	Fairchild
43	Archer
44	Lea
45	Conrad
46	Call
47	DeCamp
48	Currier
49	Rehder
50	Bootlegger
51	Dark
52	Simpson
53	Gill
54	Cadwalader
55	Barbour
56	Say
57	Wright
58	Winkley
59	Clench
60	Frampton
61	No name
62	No name
63	Pfleuger
64	Warren
65	Lime
66	Squires
67	West End*
68	Schevill*
69	McDonald
70	Poppenhager
71	Lott
72	Dr. deBoe (34-Turkey)
73	Top
74	Gold (34-Turkey)
75	Lowe (34-Turkey)
76	Junk
77	Jackson
78	Sisal*
79	Pineridge
80	Clavata
81	Rhodes
82	No name*
83	No name*
84	Weber
85	Fields
86	Maxwell
87	Matthew
88	No name
89	Dead
90	Barret
91	Deer
92	VonPaulsen
93	Grimshawe

Appendix I continued. Numbers and names of Long Pine Key hammocks.

94	Winkleman
95	Coe
96	Powell*
97	Remington*
98	Tryon*
99	Humes
100	Beard
101	Pennecamp
102	Jones
103	Winte*
104	Craighead
105	Wild lime
106	Ebbitts
107	Robertson
108	White rock
109	Lysiloma
110	Young
111	Simpson
112	Abbott
113	Buttonwood
114	No name
115	No name
116	Avery
117	Douglas (Marjorie Stoneman)
118	Simmons(Glen and Maxie)
119	Young (Fran)
120	Brookfield

Appendix II. Species List

	Hammock	Pineland	Glade
Acacia pinetorum		x	x
Acalypha chamaedrifolia		x	
Adiantum tenerum	x		
Agalinis purpurea		x	x
Aletris bracteata		x	x
Andropogon cabanisii		x	
Andropogon glomeratus		x	x
Andropogon virginicus		x	x
Anemia adiantifolia	x	x	
Anemia wrightii		x	
Angadenia sagraei		x	x
Annona glabra			x
Ardisia escallonioides	x	x	x
Aristida purpurascens		x	x
Asclepias lanceolata		x	
Asclepias longifolia			x
Aster adnatus		x	x
Aster dumosus		x	x
Aster tenuifolius			x
Ateramnus lucida	x		
Baccharis glomeruliflora		x	x
Baccharis halimifolia		x	x
Borreria terminalis		x	
Bourreria cassinifolia		x	
Buchnera floridana		x	x
Bumelia reclinata var. *reclinata*		x	x
Bumelia salicifolia	x	x	
Bursera simaruba	x		
Byrsonima lucida		x	x
Calyptranthes pallens	x		
Callicarpa americana		x	
Cassia chapmanii		x	
Cassia deeringiana		x	
Cassytha filiformis		x	x
Catopsis berteroniana		x	
Centella asiatica		x	x
Centrosema virginianum		x	
Cephalanthus occidentalis			x
Chamaesyce adenoptera		x	
Chamaesyce pinetorum		x	x
Chamaesyce porteriana		x	x
Chiococca alba	x		
Chiococca parvifolia		x	x
Chrysobalanus icaco		x	x
Chrysophyllum oliviforme	x	x	
Cirsium horridulum		x	x

Appendix II. Species List continued.

	Hammock	Pineland	Glade
Citharexylum fruticosum	x	x	
Cladium jamaicense		x	x
Coccoloba diversifolia	x	x	
Coccothrinax argentata		x	
Coelorachis rugosa			x
Conocarpus erecta		x	x
Coreopsis leavenworthii		x	x
Crossopetalum ilicifolium		x	
Crotalaria pumila		x	
Croton linearis		x	
Cynanchum blodgettii		x	x
Cynoctenum mitreola		x	x
Desmodium lineare		x	
Dichanthelium dichotomum		x	x
Dichanthelium spp.		x	x
Dichromena colorata		x	
Dichromena floridensis		x	x
Digitaria pauciflora		x	x
Diodia virginiana		x	
Dodonaea viscosa		x	
Dyschoriste oblongifolia		x	x
Echites umbellata		x	
Elytraria caroliniensis			x
Encyclia tampensis		x	x
Eragrostis elliottii		x	x
Eriochloa michauxii		x	
Erythrina herbacea	x		
Eugenia axillaris	x	x	
Eupatorium coelestinum		x	x
Eupatorium leptophyllum		x	x
Eupatorium mikanioides		x	x
Eupatorium villosum		x	
Eustachys glauca		x	x
Eustachys petraea		x	x
Evolvulus sericeus		x	x
Exothea paniculata	x		
Ficus aurea	x		
Ficus citrifolia		x	x
Forestiera segregata var. pinetorum		x	
Fuirena breviseta			x
Galactia spiciformis	x		
Galactia spp.	x	x	
Galium hispidulum		x	
Guapira discolor var. longifolia		x	x
Guettarda elliptica		x	
Guettarada scabra	x	x	
Hedyotis nigricans var. filifolia		x	

Appendix II. Species List continued.

	Hammock	Pineland	Glade
Heliotropium polyphyllum		x	x
Heterotheca graminifolia var. tracyi		x	
Hymenocallis palmeri			x
Hypericum brachyphyllum			x
Hypericum hypericoides		x	x
Hyptis alata var. stenophylla		x	x
Ilex cassine		x	x
Ilex krugiana		x	
Ipomoea microdactyla		x	
Ipomoea sagittata		x	x
Ipomoea tenuissima		x	
Iva microcephala		x	x
Jacquemontia curtissii		x	
Justicia ovata			x
Lantana depressa		x	
Lantana involucrata		x	
Lasiascis divaricata	x		
Leipharmos parasitica	x		
Linum medium			x
Lobelia glandulosa		x	x
Ludwigia microcarpa		x	
Ludwigia repens		x	x
Lysiloma latisiliquum	x	x	
Mastichodendron foetidissimum	x		
Mecardonia acuminata		x	
Melanthera angustifolia			x
Melanthera parvifolia		x	
Metopium toxiferum	x	x	x
Mikania scandens		x	x
Morinda royoc	x	x	x
Muhlenbergia filipes		x	x
Myrcianthes fragrans	x		
Myrica cerifera		x	x
Myrsine floridana	x	x	x
Nectandra coriacea	x		
Oxypolis filiformis		x	x
Panicum hemitomon			x
Panicum rigidulum		x	x
Panicum tenerum		x	x
Panicum virgatum var. cubensis		x	x
Parthenocissus quinquefolia	x		
Paspalum caespitosum		x	
Paspalum monostachyum			x
Paspalum setaceum		x	
Passiflora suberosa	x	x	x
Persea borbonia		x	x

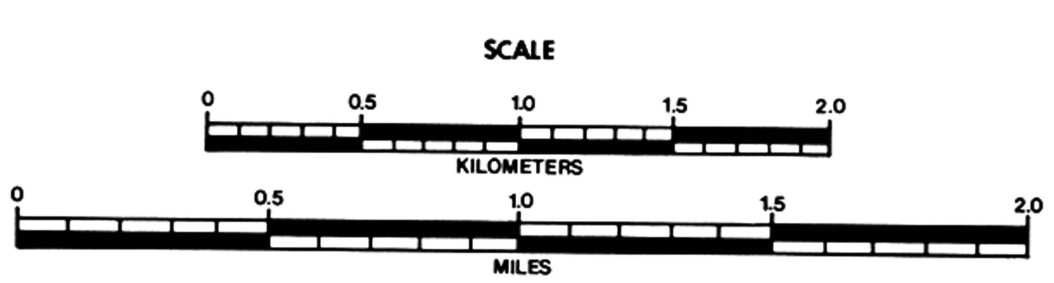
Appendix II. Species List continued.

	Hammock	Pineland	Glade
Phyla nodiflora		x	x
P. stoechadifolia		x	x
Phyllanthus caroliniensis		x	x
Phyllanthus pentaphyllus var. floridanus		x	x
Physalis viscosa		x	x
Pinus elliottii var. densa		x	x
Pisonia aculeata	x		
Piriqueta caroliniana var. glabra		x	x
Piriqueta caroliniana var. tomentosa		x	x
Pluchea rosea		x	x
Poinsettia pinetorum		x	
Polygala balduinii			x
Polygala boykinii var. sparsifolia		x	x
Polygala grandiflora		x	x
Polypodium phyllitidis	x		
Polypodium polypodioides	x		
Proserpinaca palustris			x
Prunus myrtifolia	x	x	
Psidium longipes		x	
Psychotria nervosa	x	x	
P. sulzneri	x		
Pteridium aquilinum var. caudatum		x	
Pteris longifolia var. bahamensis	x	x	
Quercus virginiana	x	x	
Randia aculeata		x	x
Phus copallina		x	
Rhynchosia minima		x	
Rhynchospora divergens		x	x
R. microcarpa		x	x
Ruellia caroliniensis spp. ciliosa		x	x
Sabal palmetto	x	x	
Sabatia grandiflora			x
Sachsia polycephala		x	
Samolus ebracteatus		x	x
Schinus terebinthifolius		x	
Schizachyrium gracile		x	
Schizachyrizum rhizomatum		x	x
Schizachyrium sanguineum		x	x
Schoepfia chrysophylloides	x		
Scleria ciliata			x
Serenoa repens	x	x	x
Setaria geniculata		x	x
Setaria spp.			x
Sida elliottii		x	x
Simarouba glauca	x	x	
Smilax auriculata	x	x	

Appendix II. Species List continued.

	Hammock	Pineland	Glade
Solanum donianum		x	x
Solidago chapmanii		x	x
Solidago stricta		x	x
Sorghastrum secundum		x	
Stillingia sylvatica ssp. tenuis		x	x
Stenandrium dulce			x
Stylosanthes calcicola		x	x
Tephrosia florida		x	
Tetrazygia bicolor	x	x	x
Teucrium canadense			x
Thelypteris kunthii	x	x	x
Tillandsia balbisiana	x		
Tillandsia circinnata		x	
Tillandsia fasciculata	x		
Tillandsia valenzuelana	x	x	
Toxicodendron radicans	x	x	
Tragia saxicola		x	
Trema micranthum		x	
Trichomanes kraussi	x		
Tripsacum floridanum		x	
Vernonia blodgettii		x	x
Vitis rotundifolia	x	x	x
Waltheria indica		x	x
Zamia pumila	x	x	

VEGETATION MAP OF LONG PINE KEY
EVERGLADES NATIONAL PARK



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1983

U.S. NATIONAL PARK SERVICE
EVERGLADES NATIONAL PARK
SOUTH FLORIDA RESEARCH CENTER

PINELAND. Open stands of slash pine (Pinus elliottii var. densa), ranging to 20 m, with an understory typically very rich in species including many of the tropical hardwoods found in hammocks as well as Serenoa repens, Myrica cerifera, Ilex cassine, Persea borbonia, Dodonea viscosa, and other tree and shrub species. Many forbs and suffrutescent shrubs are present, of which 20 are endemic. The substrate is jagged limestone with numerous solution holes and little soil development. The elevations are higher than adjacent prairies and are often as high as those of hammocks. Inundation is rare. The pineland is maintained by fire.

PINELAND WITH TALL HARDWOOD UNDERSTORY. Pinelands that have escaped recent fires, allowing the hardwoods in the understory to reach heights of 8-10 m. The species composition is similar to the pinelands, but pines no longer reproduce and forbs and endemic shrubs are disappearing because of a deep layer of pine duff and increasing shade.

TROPICAL HARDWOOD HAMMOCKS. Mixed stands with relatively closed canopy consisting predominantly of tropical hardwoods including Quercus virginiana, Lysiloma latisiliquum, Bursera simaruba, Myrsine floridana, Ardisia escallonioides, and Eugenia axillaris, which are found in the adjacent pineland, and Nectandra coriacea, Coccoloba diversifolia, Simarouba glauca, and Mastichodendron foetidissimum, found rarely outside hammocks. Tree heights range from 6-17 m. Groundcover is sparse and epiphytes are common. The limestone is covered by a thin layer (5-15 cm) of organic matter, and solution holes are abundant. Elevations are as high as those of the pinelands and ground surface is rarely, if ever, under water.

HARDWOOD SCRUB. Short hardwoods (to 6 m). In some ecotonal areas along the transverse glades, where moisture and substrate conditions are different from those of either pineland or glade, Metopium toxiferum, Conocarpus erectus, Myrica cerifera, Ilex cassine and Persea borbonia occur. Hardwood scrub also occurs in early successional growth after fire inside tropical hardwood hammocks, particularly in those surrounded by prairie. In addition to the species just named, we encounter Trema micranthum, Quercus virginiana and Bumelia salicifolia. Pteridium aquilinum is a constant associate.

FARMED PRAIRIE WITH HARDWOODS. Former marl prairies which were farmed and later abandoned. Now forested, these areas are dominated by Ilex cassine, Persea borbonia, Myrica cerifera, and the exotics Schinus terebinthifolius and Psidium guajava.

MUHLENBERGIA PRAIRIES. Fairly dry prairies in which the dominant species is Muhlenbergia filipes with varying percentages of Cladium jamaicense as well as a large assortment of other grasses, sedges and herbs. The substrate is marl.

PRAIRIE WITH SCATTERED HARDWOOD SCRUB. Dominated by graminoid species, with scattered hardwoods such as Ilex cassine, Metopium toxiferum, Persea borbonia, and Myrica cerifera.

FARMED PRAIRIE WITH PRAIRIE SPECIES. Prairie that was farmed for a short time and supports prairie vegetation again. Furrows are still visible. Serenoa repens is common in some areas.

CYPRESS PRAIRIE. Prairie, characterized by various densities of cypress trees (Taxodium distichum), often stunted, and dominated more often by Cladium jamaicense than by Muhlenbergia filipes. The soil is marl and a little deeper than in other prairies.

CYPRESS FOREST. Both cypress domes and heads, with overstories of Taxodium distichum. Domes are in a depression with a long hydroperiod and are nearly devoid of understory shrubs. Cypress heads are on slightly elevated ground with a shorter hydroperiod, an understory of Chrysobalanus icaco, Persea borbonia, Myrica cerifera and Magnolia virginiana, and support frequent fires. Both have an organic substrate. Epiphytes are plentiful.

WILLOW HEADS. Stands of Salix caroliniana often mixed with Thalia geniculata and Phragmites australis, growing in depressions of glades and prairies. Large willow heads are often surrounded by tall (2-3 m) sawgrass (Cladium jamaicense), Pontederia cordata var. lancifolia and Phragmites, and enclose ponds, 1-1.5 m deep.

OPEN WATER. Often "borrow pits" associated with road construction.

HOLE-IN-THE-DONUT. Former pineland, hammocks and prairies that were farmed and abandoned by 1975. Now in various successional stages, commonly dominated by weedy forbs and shrubs and the exotic tree Shinus terebinthifolius.

45 HAMMOCK NUMBERS. (see list in text for corresponding names)

17 SECTION NUMBERS.

BROAD TRANSITION BETWEEN PINELAND AND PRAIRIE.

PAVED ROADS.

UNPAVED ROADS.

TRAILS.

BUILDINGS.

METHODS

Plant communities were delineated on 9 in. x 9 in. color aerial photographs (1:7800). The details were transferred to a skeleton map (1:18,000), which was generated from USGS 7.5 minute orthophoto quadrangle sheets, using a Map-O-Graph opaque projector. Plant communities largely correspond to those used by Davis (1943) and Craighead (1971). Ground-truthing was done during February and March 1981. We thank Mr. Antonio Jurado of the Water Resources Division, U.S. Geological Survey, for aid and consultation.