UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

A Survey

of

The Effects of Fire in Everglades National Park

by

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TABLE OF CONTENTS

APPENDIX

LIST OF TABLES

DATA ON PHOTOGRAPHS

Fig. #1 (frontispiece) May 7, 1952 - T. 59 S., R. 35 E., Sec. 22 - Small glades bayhead. The plants of this stand are Paurotis, poisonwood (Metopium), myrsine (Rapanea), wax myrtle (Cerothamnus) and redbay (Tamala).

Fig. #2 - April 15, 1952 - T. 58 S., R. 37 E., Sec. 9 - Shot NE from tree marked (X19).

Fig. #3 - April 15, 1952 - Same area as #2 - Looking E. to edge of Palma Vista #1 hammock.

Fig. #4 - April 15, 1952 - T. 58 S., R. 37 E., Sec. 8 - Shot of Pine Area #2, Long Pine Key, looking NW from marked tree (#20) on Dark Hammock Road.

Fig. #5 - April 8, 1952 - T. 58 S., R. 36 E., Sec. 25 - Pine Area #1, Long Pine Key, looking W. from marked tree (#11) on Sawmill Road. Taller understory shrubs are dahoon holly (Ilex Cassine). Other shrubs are wax myrtle, redbay, bustic (Dipholis), satinleaf (Chrysophyllum), Tetrazygia, cabbage (Sabal), and rough velvetseed (Guettarda scabra).

Fig. #6 - April 8, 1952 - Same area as #5 - Looking SW from marked tree (#12). Understory of fire-pruned buttonwood (Conocarpus) in pineland.

Fig. #7 - April 8, 1952 - T. 58 S., R. 36 E., Sec. 24 - Pine Area #1, Long Pine Key, looking SW from 12' NW of marked tree (7C). Low pinewoods with pure saw palmetto (Serenoa) understory.

Fig. #8 - April 8, 1952 - Same area as #7 - Looking NE from 25' W. of marked tree (7C). Open saw palmetto flat in pinewoods.

Fig. #9 - May 5, 1952 - T. 58 S., R. 36 E., Sec. 15 - Clump of willows in deep pothole in pine woods. West edge of Crabwood Hammock.

Fig. #10 - April 30, 1952 - T. 58 S., R. 37 E., Sec. 4 or 5 - View of the interior of Dark Hammock, Long Pine Key.

Fig. #11 - April 15, 1952 - T. 58 S., R. 36 E., Sec. 13 or 25 - View of the west edge of Sawmill Road Hammock. Looking NE from 12' W. of marked tree (#15).

Fig. #12 - May 6, 1952 - T. 59 S., R. 35 E., Sec. 16 - Trunk of a large mahogany (Swietenia) in Big Mahogany Hammock.

Fig. #13 - May 7, 1952 - T. 58 S., R. 36 E., Sec. 11 - Looking across sawgrass marl glades at a bayhead north of Concrete Bridge.

Fig. #14 - May 6, 1952 - Same as #12 about 1/2 mile E. of Big Mahogany Hammock - View of one end of a small hammock (?) or bayhead (?) in glades. This is one of the rare stands in which hammock species seem clearly to be replacing bayhead species on a deep peat deposit. Individuals of bayhead species are more abundant than hammock species at this site, but the specific representation is about equal. Woody plants present are live oak, cabbage, gumbo-limbo (Elaphrium), poisonwood, bustic, cocoplum (Chrysobalanus), wax myrtle, redbay, sweet bay (Magnolia), strangler fig (Ficus aurea), marlberry (Icacorea), lancewood (Nectandra) and myrsine.

Fig. #14A - May 7, 1952 - T. 59 S., R. 36 E., Sec. 16 or 17 - View of bayhead trees on rows in Jennings plantation area looking S from Ingraham Highway.

Fig. #15 - April 15, 1952 - T. 58 S., R. 36 E., Sec. 25 - Looking NNE up Twin Hammock Glade from Long Pine Key Road. Saw palmetto invading glades.

Fig. #16 - May 14, 1952 - T. 58 S., R. 37 E., Sec. 21 - Ragweed growth on marl glades farmed for winter tomatoes - Barne's farm. South of Long Pine Key.

Fig. #17 - May 7, 1952 - T. 58 S., R. 37 E., Sec. 32 - View of west side of bay-cypress head north of Cocoplum Bend, looking NNE from INgraham Highway across scrub cypress area.

Fig. #18 - May 13, 1952 - T. 57 S., R. 38 E., Sec. 29. Overstory pines killed by fire 123-6 (March 1951).

Fig. #19 - April 15, 1952 - Same area as #2. Basal fire scar on pine just NE of turn of Long Pine Key Road.

Fig. #20 - April 29, 1952 - T. 58 S., R. 37 E., Sec. 16 - Fire-pruned wild tamarind (Lysiloma) in pineland.

Fig. #21 - April 9, 1952 - Same area as #20 - Base of fire-pruned poisonwood in pineland.

Fig. #22 - May 5, 1952 - T. 58 S., R. 36 E., Sec. 23 - Fire marked mastic (Sideroxylon) in pineland.

Fig. #23 - May 5, 1952 - Same area as #9 - Trees, white ironwood (Hypelate) and wild tamarind, in pineland.

Fig. #24 - April 8, 1952 - Same area as #20 - Gopher apple (Geobalanus) in bloom on new burn.

Fig. #25 - April 29, 1952 - T. 58 S., R. 36 E., Sec. 23 or 28 - View of broom grass (Andropogon) growth on a one-year old burn. Looking SSE from 30' S of marked tree (#29) on east side of firebreak for fire 123-12 (June 1951).

Fig. #26 - May 14, 1952 - Same area as #9 - Another view of broom grass growth on this burn. Looking WSW toward the east edge of Crabwood Hammock.

Fig. #27 - May 6, 1952 - T. 59 S., R. 35 E., Sec. 3 or 4 - Looking SW from 100 yards N of red marker on glades buggy trail NW from end of Canal Road. Dense fire-induced growth of palmetto.

Fig. #28 - May 26, 1952 - T. 58 S., R. 36 E., Sec. 30 - Severe edge damage (fire 123-14, May 1950) to southeast corner of Little Royal Palm Hammock, Long Pine Key.

Fig. #29 - April 9, 1952 - Same area as #20 - Small hammock area that turned a pineland ground fire.

Fig. #30 - Same as Fig. #11.

Fig. #31 - April 30, 1952 - Same area as #10 - View of the east end of Dark Hammock, Long Pine Key, looking N. from 35' N. of marked tree (#25).

Fig. #32 - April 30, 1952 - T. 58 S., R. 37 E., Sec. 15 - View of burned-out interior of Paradise Key, looking E. from marked tree (#31) on old road to south end of Paradise Key.

Fig. #33 - April 30, 1952 - Same area as #10 - Basal fire scar on a large mastic inside Dark Hammock.

Fig. #34 - April 30, 1952 - Same area as #32 - View of fireweed growth of sumac (Rhus leucantha), Paradise Key, looking NE from 35' N. of marked tree (#32).

Fig. #35 - April 30, 1952 - Same area as #10 - Live oak invasion of pineland near Dark Hammock, looking WSW from 10' N. of marked tree (#26).

Fig. #36 - Same as Fig. #3.

Fig. #37 - April 15, 1952 - Same area as #2 - Encroachment of hammock vegetation into fire-protected pineland, looking E from 20' ENE of marked tree (#17).

Fig. #38 - April 30, 1952 - Same area as #4 - Hammock nucleus around a large sink hole.

Fig. #39 - May 5, 1952 - T. 58 S., R. 36 E., Sec. 23 - View looking W. across Hidden Glade, Long Pine Key, at south end of Turkey Hammock.

Fig. #40 - April 29, 1952 - Same area as #4 - Small hammock of wild tamarind in pineland, Long Pine Key. Looking WNW from Dark Hammock Road 4' NE of marked tree (22).

Fig. #41 - May 7, 1952 - T. 59 S., R. 36 E., Sec. 13 or 14 - Interior of burned-out bay-cypress head.

Fig. #42 - Same as Fig. #14.

Fig. #43 - May 7, 1952 - Same area as #41 - View of burned-out bay-cypress head looking S. from Ingraham Highway.

Fig. #44 - May 26, 1952 - T. 58 S., R. 36 E., Sec. 29 - View of ruins of burned-out bayhead two years after fire 123-14 (May 1950).

Fig. #45 - May 14, 1952 - Same area as #41 - Close-up view of the edge of a burned-out bay-cypress head. The interior now occupied by a growth of willow.

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SUMMARY

The present report provides the results of recent field investigations of the effects of wildfire upon the vegetation of Everglades National Park. This project was carried on in the winter and spring of 1951-52 at which time the author held a temporary position as Fire Control Aid in Everglades National Park. Earlier field investigations in south Florida by the author supplied much of the original data presented here, and provided a background of knowledge of the area without which the present work would have been impossible.

The information presented is divided into four sections as follows: Fire history of the Everglades National Park area; Description of the burnable vegetation types; Effects of fire on the burnable vegetation types; and, Conclusions and recommendations. The following paragraphs summarize these sections.

I. Fire History - An attempt is made to reconstruct the history of fire occurrence throughout the geological existence of south Florida in its present relationship to sea level. Evidence is presented which strongly suggests that natural fire has been a constant factor affecting the local distribution of vegetation types through the ages, and that the arrangement of plant cover types has probably always been similar to that seen today. Fire frequency is believed to have increased as aboriginal peoples occupied the area. With white settlement came another marked increase in fire frequency and also an increase in the severity of fire damage as drainage lowered water levels in the Everglades. Records indicate severe and widespread fire in south Florida for more than 1/3 of the years between 1900 and 1952. A half-century fire chronology compiled from the scientific literature, from newspaper accounts and from interviews with local residents is given. A summary of rainfall records since 1900 is presented. Examination of these data indicates that the Lake Okeechobee-Everglades system is no longer an effective drainage unit, and that water levels and fire danger in Everglades National Park now depend entirely on rainfall south of the Tamiami Trail. This section is concluded with an account of fire occurrence since the establishment of Everglades National Park including a map of fire occurrence by years, and a graph of fire occurrence by months in the two chief fire types.

II. Description of Vegetation Types - This section presents accounts of the following burnable vegetations: Rockland pine forests; tropical hammock forests; bayhead forests; and Everglades marshes. For each the description includes as detailed a survey as is possible from data at hand of: The plant species and general aspect of the vegetation type; the major variations noted from stand to stand through south Florida; the factors which appear to govern local occurrence of the vegetation type; and, the major gaps existing in our present ecological understanding of the vegetation type. It is emphasized that present knowledge of the vegetation of Everglades National Park is incomplete and that these gaps hinder understanding of the effects of fire upon the plant cover.

III. Fire Effects - For each of the above cover types a discussion is given of fire effects upon the soil and upon the plant cover. Recovery of the plant cover after fire is discussed, and the influence of fire upon the successional relations of the plant communities is analyzed.

Pineland fires remove the ground cover vegetation and prune back the shrubs of the hardwood understory leaving bare limestone. The fires are ground fires which do not ordinarily kill the overstory pines. Recovery after fire is marked by an outburst of bloom of the small pine woods herbaceous plants, and by stands of tall broom grass on one-year old burns. A single fire kills few hardwood shrubs. The roots of these shrubs are deeply driven into the limestone, and are protected by it. They soon send up crown-sprouts and most individuals show a typical many-stemmed growth-form brought about by frequent fire-pruning. There is some evidence that hardwoods tend to be eliminated from the pineland by frequently recurring fires, and to be replaced by an understory of low palms, especially saw palmetto.

Two kinds of fire effects are noted in the case of hardwood hammocks: 1.) pruning back of the hammock edges; and, 2.) complete hammock destruction occurring when fires ignite the organic soil deposit of the hammock. In the latter case the trees of the forest canopy are commonly killed by fires burning around their roots, or later windthrown due to loss of supporting soil. Recovery is long-delayed in the case of complete burn-outs, and some of the more sensitive epiphytic orchids and ferns may be lost entirely. In early stages of recovery, hammock interiors become clogged with a rank growth of fire weed shrubs and vines.

Fire prevents succession of hardwoods into pine forest by fire-pruning hardwood shrubs and cutting back hammock edges. In the Long Pine Key area of Everglades National Park this succession is rapid in the absence of fire. Here a fire-free period of 15 to 25 years is considered sufficient to establish a continuous young hardwood forest on most pineland sites.

Fire effects upon the bayheads of the Everglades are similar to those on upland hammocks, but more severe. These tree islands occupy deep deposits of combustible peat and their occurrence requires the elevation above the surrounding marsh which the peat mass provides. Fires remove the peat entirely commonly leaving burn-out ponds, and a long period of plant succession must occur before bayhead forest can again occupy the site. Where these peat burn-outs result in establishment of ponds, they have the beneficial effect of furnishing a dry-season refuge for many glades water animals.

In sawgrass glades fire damage is severe only in the muckland area little of which now remains south of the Tamiami Trail. It is probable that over a period of years sawgrass fires have decreased the water storage capacity of the Everglades by destruction of the peat and marl seal over the highly permeable underlying limestone. Over most of the marl soil glades of the park no definite fire effect can be indicated. Much more information on the ecology of the many species of sedges and grasses which comprise the Everglades vegetation is needed before fire effects on stand composition can be satisfactorily studied.

With drainage much of the Everglades area has become suitable for invasion by woody plants, especially willow and the woody species of the bayheads. Fire acts to restrict this forest extension into the marsh. In spite of the severe fires of the last twenty years plant succession has entirely changed the aspect of considerable areas, from open herbaceous marsh to scrubby thickets.

IV. <u>Conclusions</u> - Fire is a natural environmental factor in Everglades National Park. Elimination of fire would result in eventual disappearance of the fire-maintained cover types, the pine forest and Everglades marsh prairies.

The severe and frequent fires occurring under present altered conditons are rapidly eliminating the hardwood forest types, and seem capable, also, of causing degenerative changes in the fire types. It thus seems imperative that an attempt be made to control all fires in the area with special efforts to protect the tropical hammock and bayhead vegetation.

Restoration of former water levels on the glades would change the necessities of fire control, and should bring about a situation in which only areas of special use or interest need be guarded from fire.

Careful long-term attention should be given to the study of fire effects on vegetation of Everglades National Park with particular concentration upon the problem of fire effects upon the stand density and composition of the sub-climax fire types. A program of investigation designed to meet this need is outlined.

The fire problem promises to remain one of key importance in Everglades National Park. Enlightened administrative procedures will require a background of full information on all aspects of fire effects in the area.

Tree island with a clump of tree saw-palmetto (Paurotis wrightii) in sawgrass glades

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Resume of Research Time

The field investigations upon which this report is based were carried on over the period November 26, 1951 - June 18, 1952. During this time the author was employed as a GS-3 Seasonal Fire Control Aid in Everglades National Park. Field work was thus subject to some interruptions, particularly in times of fire emergency, by calls to perform the more usual duties of a Fire Control Aid. A few days earlier in the period, and morning hours during the months of April, May, and June, 1952 were devoted to field work directed toward the completion of a study of the abundance and ecological distribution of breeding-bird populations of the region, begun in the summer of 1950. Such a division of research time was agreed upon in discussions in June 1951 when the fire effects study was first planned. A total of 123 days or parts thereof were devoted to field study of fire effects. This total includes many lieu days spent in the field.

Previous to the above period of employment the author had spent nine months (June - August 1950, February - July 1951) in ecological field work in southern Florida, as a National Park Service Collaborator. During the fire emergency of the spring and early summer of 1951 several periods totalling about one month were spent as an emergency fire fighter, permitting first hand observation of glades and pineland fires and their effects. Field notes and experience gained from earlier work were constantly drawn upon in the preparation of this report. Without this background, particularly in knowledge of the regional flora, progress in the study of fire effects would have been much more difficult.

The initial work of preparing the report, including investigation of available literature and interviewing local residents as to past fire history of the area, occupied five weeks in July and August 1952, spent in South Florida. Several months of additional time in the fall and winter of 1952-53 spent at the University of Illinois were devoted to completing the report.

STUDY METHODS

Shortly after the beginning of the present study it was decided that the time available could best be spent in obtaining an extensive qualitative survey of fire effects rather than in making intensive quantitative studies of plots in particular burned areas. Several reasons contributed to this decision.

1. Difficulty of determining the fire history of any particular site.

2. Lack of adequate ecological information on the vegetation which makes up the most important fire-types.

The above difficulties which now hinder study of fire effects in Everglades National Park will be discussed later in this report. They make the obtaining of reliable data on the quantitative effects of fire on stand density and composition well-nigh impossible at this time. I am fully conscious that quantitative data are needed to complete the picture presented here; and aware that important fire effects may be concealed from this qualitative survey, however painstaking. A study program calculated to meet this need is presented at the end of the report.

The qualitative survey undertaken had as its object the collecting of information bearing on the following questions for each burnable vegetation type:

1. What effect does fire have on the soil?

2. What is the effect of burning on the vegetation, including plants killed and injury to those that survive the fire?

3. What are the major features in the recovery of the vegetation after fire?

4. What would be the probable course of development of the vegetation in the absence of fire?

With these points in mind all major burns of known age were examined and notes were obtained on fire effects and recovery after fire, as well as lists of the plant species of the areas. Areas free of fire for the five years covered by Everglades National Park records were studied noting the development of vegetation during the fire-free interval and evidence of earlier fire. A number of people with long field experience in the Everglades region were interviewed in order that their observations and beliefs concerning long-term fire effects in the region might be put on the record. Finally, some of the literature pertinent to the problem was examined and the bibliography accompanying this report compiled.

Introduction

Fire and water, two of the four "primary elements" of the ancients, are matters of the utmost present day importance in Everglades National Park. Interaction between fire and water played a major role in shaping the Everglades landscape. Disruption of their natural balance by ill-conceived land use practices of the past forty years has brought the entire region to the point where its survival in any condition resembling the original is seriously in question. The ecological problems which pose this question are essentially problems in the control of fire and water. It is not too strong a statement to say that all hope for the future of Everglades National Park rests in their proper management.

This report is a survey of the effects of fire in Everglades National Park. Or, more exactly, it is a survey of the effects, primarily upon vegetation, of a few recent fires, together with an attempt to synthesize from all available fragments of evidence a clearer concept of the total ecological role of fire in the area. The writer's aim has been twofold: to array information now at hand in a manner designed to lead to its practical application; and, to provide a foundation for future study. In a region such as this, where published information on plant ecology is extremely sketchy, and where reliable records of fire-history are virtually non-existent, conclusions formed from a six-months study of fire effects are necessarily tentative in large part. Some talent in the employment of the prayerful "educated guess" is required for one to be able to present a report at all. Throughout, however, I have felt the strong necessity of keeping information of various grades of reliability sternly categorized. It is hoped thus to avoid the downhill leap from insufficient data to unwarranted conclusions - so easy and frequent a hop in the Everglades, a country half-destroyed before it was even half understood.

To date in South Florida the approach to the problem of wildfire has been governed by attitudes more often emotional than realistic. The debate, both written and spoken, which has gone on at length under these conditions has been largely unencumbered by facts, and has been vastly more heated than enlightening. The crying present need is for more and far more realiable information as to just what fires do here in different vegetation types and under different conditions. It is intended that this report will provide a contribution in that direction.

I. FIRE HISTORY OF THE EVERGLADES NATIONAL PARK AREA

A. Introduction

South Florida is perhaps unique in that it has had more fires and kept less account of them than any other section of the country. This questionable distinction of the area placed many a roadblock in the path of the investigator who, arriving on the scene at this late date, attempts an inquiry into the effects of fire. One reason for this casual attitude has been the very frequency of fire. The belief is widespread that wildfire is an intimate and perhaps a necessary part of the natural order in south Florida rather than an exceptional or catastrophic event. Over and over one hears such statements as, "This country always has burned and always will. Anyway fires don't hurt anything here."

In truth there is much to justify this view. Within a few weeks after fire the glades are green with sawgrass shoots, and the pinelands full of flowering herbs and new grasses. Even the scars of burned-out hammocks are soon hidden by a rank growth of fireweed shrubs and vines. To a not overly careful observer it must seem inconceivable in many cases that the fire can have done any significant damage.

These local conditions - frequent and widespread fire, fire which often had little obvious effect, and a vast wilderness area where fires might burn undiscovered for days without threat to any works of man - have long retarded any serious consideration of fire effects. The succession of severe fire years within the last decade finally brought the problem to general attention. The realization has gorwn that, whatever its previous ecological role, wildfire has gained a new and menacing importance under the radically altered conditions of present day south Florida.

In consideration of fire effects it is important to reconstruct the history of fire occurrence in the area as fully as possible. This section of the report is an attempt at such a reconstruction considering the fire history of the region in four periods:

The pre-aboriginal period.

The period of aboriginal occupation of south Florida.

The period of intensive occupation by white man beginning around 1900.

The period 1948-52, for which detailed records of fire occurrence are available.

Obviously any comments on the first period are entirely conjectural, based on backward projection of certain present day characteristics of the area. Comments on the second period are also largely educated guesses, plus fragmentary early records. I believe that these mental exercises are justifiable, however, because of the theoretical importance of determining about how long fire has been a major ecological factor in south Florida. For the third period considerable information has been collected including weather data, accounts from the scientific literature, newspaper reports, and personal reminiscenses of residents with much field experience in the area.

This material, however, is extremely scattered and scanty when applied to the picture of fire occurrence throughout the area for this period.

B. Fire in the Pre-aboriginal Period

It is of some importance to an understanding of the area to attempt to determine whether or not wildfire was a major ecological factor in South Florida under original conditions prior to any human occupancy of the region. Although a definite answer is not within reach here, consideration of geological and paleobotanical evidence as well as characteristics of the present vegetation permit certain reasonable inferences to be drawn.

1. The Geological Background - Detailed studies of the geology of South Florida have been presented by Parker and Hoy (1943), Parker and Cooke (1944), and Cooke (1945). These accounts show that throughout the Pleistocene Ice Age the Florida peninsula was alternately flooded by shallow seas and exposed beyond its present shores, as sea level rose and fell in response to glacial controls. Sea levels were below present sea level during each of the five major ice advances of the Pleistocene. During each of the four warmer interglacial periods melting back of the continental glaciers increased the volume of water in the oceans and submerged much of the Florida peninsula. High stands of the sea are well marked by marine terraces and old shore lines in the southeastern coastal plain at elevations from 270 to 25 feet above present sea level. During the high stand of the sea of the interglacial period between the third and fourth Pleistocene glaciations the limestones, which occur at or near the surface in South Florida, were deposited. The corresponding low stands of the sea during the five glacial periods are more difficult to investigate, and little agreement exists as to their distance below present sea level. It is probable, however, that sea levels at these times were sufficiently low to empty Florida Bay and establish broad land connection between the Florida Keys and the mainland; and it is extremely unlikely that they were low enough to establish any sort of land connection between South Florida and Cuba or the Bahamas. The lower end of the peninsula south of Lake Okeechobee was inundated by the Pamlico Sea of the fourth interglacial period (Cooke, 1945: Fig. 47), and last elevated at the onset of the second Wisconsin glaciation (the last glacial advance), about 50,000 years ago according to the usual time scale given for the Pleistocene (Schuchert and Dunbar, 1941: 160). This sets an absolute time limit for formation of the present soil mantle and for invasion of the area by its present plant and animal life. The most recent geological event has been a rise in sea level in the post-glacial period with a consequent reduction of South Florida's land area, and re-isolation of the Florida Keys.

2. The Paleobotanical Background - Studies of fossil plants give us no reason to suspect that the group of plant species which occupied South Florida after its last Pleistocene submergence varied much in composition from that found today. Many of the tropical forms which characterize South Florida's present flora have a long fossil history in the southeastern United States. For example Berry's (1930: 41-47) lists show 31 genera of the Lower Eocene Wilcox Flora, largely from excavations in western Tennessee and Kentucky, which now occur in the United States only in South Florida. In all 32% of the genera of woody plants in the present South Florida flora are known from this fossil flora of 60 million years ago. Braun (1950: 451-455) gives a general summary of the fossil record of plants for late

Mesozoic and Tertiary time. The record indicates an early period of warmer climates during which tropical and sub-tropical plants occurred far north of their present limits. Beginning in Miocene time there was a gradual cooling of climates and a southward shift of vegetation zones. The fossil flora from the late Pliocene Citronelle formation of the Gulf Coast in west Florida closely resembles that found in the same area today (Berry, 1916). This indicates that by this time (about one million years ago) tropical forms in the flora of the southeastern United States must have been confined to peninsular Florida.

As has been mentioned, the Florida peninsular suffered extreme changes in area during the Pleistocene. In general, however, the periods of greatest land emergence from the sea were times of cooler climates and the periods of submergence times of warmer climates, so that it seems probable that the tropical flora was able to maintain a continuous foothold on the peninsula, moving north or south as compelled by changes in the climate and area of its range. The latest elevation of South Florida marks only one more stage in its migrations before changing climates and landforms. Through the ages there has doubtless been continual change in the specific composition of this isolated flora with loss of species by extinction and arrival of new species from the West Indies. It seems unlikely, however, that any significant change has occurred in the relatively short interval of post-glacial time.

3. The Present Vegetation - We may now ask a question more directly pertinent to the fire history of the area. If the plant species present have evidently undergone little recent change, what of the vegetation types they form?

The ecological picture of present-day South Florida shows a bewildering mosaic of vegetation types some of which seem to be successionally related. As will be discussed later, tropical hardwood forest rapidly occupies pine forest areas; and bay and, in some cases, mangrove swamp forests tend to invade sawgrass prairie areas. It seems obvious that the status quo could not be long maintained unless some ecological factor operated to periodically return large areas to a sub-climax condition. At the present time fire is such a factor. It thus becomes of interest to examine the available evidence to see what it may indicate concerning the occurrence of natural fires in times before any human occupancy of South Florida.

4. Lightning Fires - Up until two years ago or less the answer to the question "does natural fire occur in South Florida?" would have been "No." There was a strong belief that lightning fires did not occur, and in the absence of any direct evidence to the contrary this was generally accepted. One feature of the newspaper coverage of fire in South Florida has been the search for other explanations for fires occurring in remote sections of the glades, which has produced some notable flights of fancy. This assumption that natural lightning fires were too infrequent to be of consequence has hindered understanding of the role of fire in South Florida, as well as planning for fire control. For example, several authors (Small, 1924, 1930; Beard, 1938; Egler, 1952) have considered the present vegetation, accepted the belief that natural fire was rare or absent, and concluded, quite logically with the assumption that a continuous broad-leaved forest must

once have existed in south Florida. Egler's comment (op. cit.: 226) is typical. "In short, the vegetation of south Florida during late Pleistocene pre-Indian times may have been a dense evergreen broad-leaved tropical jungle....."

With the establishment (in 1951) of two fire lookout stations overlooking large sawgrass areas in Everglades National Park it soon became evident that natural fires caused by lightning do occur frequently. Several fires were seen to start from observed lightning strikes in sawgrass and in tree islands of the Everglades. In all, lightning was the reported cause of 12 fires in 1951 and of 11 in 1952 (up to July 1). Some of these fires were extinguished by rain which accompanied the electrical storm, but among them are also some of the major fires in the history of Everglades National Park. Too few data are at hand to permit much to be said about the seasonal occurrence of Everglades lightning fires. But the "dry storms" which set them appear at present to be a phenomenon of the very end of the dry season. Of 23 lightning fires reported to date three occurred in late May, 16 in June, and four in August.

With the establishment of the present importance of lightning-caused fires it becomes reasonable to assume that they have been a continuing factor throughout the geological existence of South Florida, and that the fire-maintained cover types have been a continuing feature of the South Florida vegetation.

(A word of caution may be needed here. With proof that lightning fires do occur comes the natural tendency to attribute all unexplained fires to lightning. Such overemphasis will serve the problem of understanding fire in the area as poorly as the earlier reluctance to consider the possibility of lightning fires.)

5. Endemic Plants - One of the characteristics which makes the flora of South Florida so interesting is the group of plant species which have originated in the region. Small's Manual of the Southeastern Flora (1933) shows 103 such species that have evolved in South Florida. These are distributed in 31 plant families and 66 genera and include plants from both tropical and south temperate zones. Almost all of them are herbaceous plants or low shrubs. Examination of the habitats of these species gives us important additional evidence of long ages of natural fire in South Florida. Table 1 shows the distribution of these species according to the vegetation types in which they occur. Notice that well over half are limited to pine forest areas, and in all 70% of the species occur in vegetation types that today are maintained by fire.

Differentiation of new species requires geographic isolation of populations under new ecological conditions to which they become adjusted through a long period of natural selection. The evolution of low-growing plants of the kind which make up this unique South Floridian group certainly required that their sub-climax habitats remain constant for a long period, and this in turn required recurring natural fire. (Or other natural disturbance, of course, but fire seems the only likely factor). For example, at the present time almost all of the endemic pinewoods species are shaded out by invading hardwoods in pine forest areas that are free of fire for as little as five years. It is quite clear that they could not have evolved

TABLE I: Ecological Distribution of Endemic Plant Species of South Florida

Vegetation Type	No. of Endemic Plant Species
Pineland	58
Hammock	22
Everglades Marshes	14
Other (Strand, Mangrove, Etc.)	9

if natural fire had been absent, or even of irregular and infrequent occurrence in the region. Their existence as distinct species is inescapable proof of ages of regularly recurring natural fire sufficient to maintain large areas of sub-climax vegetation. It can thus be said with some assurance that the aspect of the vegetation of South Florida probably never differed much from that pictured in the earliest historical accounts.

C. Indian Fires.

The arrival of aboriginal populations in South Florida has not been accurately dated. Discovery of human remains in deposits at Vero Beach, which are referred to the Pamlico Inter-glacial stage (Cooke, 1945: 305-7), may indicate that aborigines occupied the lower peninsula almost as soon as the receding waters of the last interglacial sea made the area available. It is probable, however, that with the establishment of aboriginal populations, the picture of fire occurrence in south Florida was considerably modified. The following passage from the Journal of a 16th century South Florida tourist, Alvar Nunez Cabeza de Vaca, is quoted by Small (1929:8)

"Those from further inland have another remedy.....which is to go about with a firebrand setting fire to the plains and timber so as to drive off the mosquitos, and also to get lizards and similar things which they eat to come out of the soil. In the same manner they kill deer encircling them with fires, and they do it also to deprive the animals of pasture, compelling them to go for food where the indians want."

Egler (1952: 226-7) devotes considerable attention to an analysis of the probable effect exerted on South Florida vegetation by aboriginal use of fire. He makes two main points:

1 - The sum effect of Indian fires was to modify the continuous "Pre-indian Swamp Forests" creating a mosaic of vegetation types similar to that seen today (i.e. pineland with scattered hardwood hammocks, sawgrass prairie with scattered tree islands).

2 - Indian fires were likely most frequent early in the dry season, occurring at a time when organic soils and hardwood hammock vegetation were still too wet to burn, and hence caused less destruction than fires later in the dry season.

In the previous section compelling evidence has been presented to show that natural fires must have been sufficiently frequent in south Florida from the earliest times to maintain large areas of sub-climax vegetation. I do not, therefore, see the need to invoke Indian fires as a major factor in the origin of these fire-maintained types. I agree, however, with Egler's assumptions that Indians were probably free and careless in using fire; that Indian fires were probably frequent; and that they probably tended to occur as early in the dry season as sawgrass would burn.

Concluding, there is reason to believe that fire incidence in south Florida increased sharply as early Indians became established with the addition of their fire-hunting and escaped fires to the recurring natural fires.

D. White Man Fires

One of the statements in Egler's (ibid.) analysis of the history of fire in south Florida with which I cannot agree is the following: "The chief difference between Indian fires and White Man fires: Indians burned with no conscience, as soon as things would burn. White Man with a conscience only delays burning...." Though perhaps true for many areas this view does not hold for the behavior of the white man in south Florida. In the Everglades area white man's incendiary activities have beggared those of his dusky brothers. I believe that the frequency of man-caused fires probably increased sharply as whites replaced aborigines in the area. White man in south Florida burned freely for every reason that the Indian did, and for some all his own. Even today with the present finally awakened fire-consciousness ones does not go long in south Florida before hearing of fires set to kill mosquitoes, kill rattlesnakes, clear out the brush, drive out game, create fresh pasture for cattle or deer, etc. Burning to locate gator holes in sawgrass areas was a common practice of commercial hide hunters. In a copy of an interview on file at Everglades National Park Headquarters, Mr. Loren Roberts describes the burning of the Ingraham Prairie behind Cape Sable by gator hunters about 1902. Add to these frankly indendiary fires those which spread more or less accidentally from farming and lumbering operations on the eastern rim of the glades, and an imposing picture of fire occurrence for the white man's half-century in south Florida is obtained.

Prior to the establishment of Everglades National Park little or no attempt was made to control fires on wild lands. Fire protection activities of local and state agencies were confined for the most part to guarding developed lands against wildfire. Their universal protective maneuver was (and is) backfiring, and it is at least to be suspected that in some instances the backfires themselves have spread widely to adjacent wild lands. In south Florida white man certainly did not, "With smug righteousness...forbid all fires" (loc. cit.)

As white occupation became established, the drainage of the glades began, and with lowering water levels the increasingly frequent fires did increasingly severe damage. Everglades water levels were lowered both by local direct drainage, and by the diking of Lake Okeechobee (complete in 1935) which cut off the slop-over that had formerly drained off to the south and may have provided an important source of water for the glades. The drainage of the Everglades has been discussed in detail by others (see Dovell, 1942:

132-161, also Turner, 1942; Bestor, 1942; and Herr, 1943), and will not be taken up here, except for the following summarizing statement:

> "The arterial canal system of the Everglades was begun about 1905. The beginning of the construction was along the coast working toward Lake Okeechobee. Connection with Lake Okeechobee was made between 1916 and 1920 for the various canals. I believe that you could say that drainage was partially effective after about 1918." (Johnson, in. litt.)

Since drainage began to be effective, a pattern of increasingly severe fire has developed. Under present conditions the lower glades may be completely dry for months in dry years, much extending the period of critical fire danger. Previously a sort of balance had existed, with the generally higher water levels acting to restrict both the extent and severity of fires. Dry years with severe fires and much destruction of organic soils and hammock vegetation undoubtedly occurred, but it can be safely assumed that these were rare. Fires under the altered conditions brought about by drainage have been notable in two respects:

1. Destruction of organic soils, which in turn has decreased the water-holding capacity of the glades due to the loss of the peat and marl seal over the highly permeable underlying limestone.

2. Widespread destruction of hardwood forest vegetation, both upland hammocks and tree islands.

A chronological summary of fire occurrence in south Florida for the period 1900-1948, and a table of rainfall records for the period 1900-1952 at 14 weather stations in the Lake Okeechobee-Everglades region are included in the Appendix. A brief discussion of the rainfall records follows.

Table 8 (see Appendix) shows the rainfall recorded at 14 weather stations in the Kissimmee River-Lake Okeechobee-Everglades drainage for all years in which reports are available over the period 1900-1952. It is compiled chiefly from data given in the Florida Division of Water Survey and Research publication Observed Rainfall in Florida (1948). The 14 stations surveyed are distributed over the drainage basin from Kissimmee south to Homestead and Everglades City. They were selected as the stations with the most complete records, giving most complete geographic coverage of the south Florida region. In several cases, as indicated in the table, gaps occurring in the records of the 14 original stations have been filled using data for the same year from another nearby station. The average rainfall for each station is shown as well as the minimum rainfall, maximum rainfall and the years of minimum and maximum rainfall for each station. In addition an annual average rainfall figure for the region has been calculated for each year in which reports are available from five or more of the stations.

In the table rainfall data are broken down into 12 month periods extending from May 1 to May 1. The annual figures are thus arranged in what may be called "biological years" rather than in calendar years, years extending approximately from the beginning of one rainy season to the beginning of the next. This appears to me to give a much clearer picture of the relation of rainfall to fire danger in South Florida than does the usual presentation. The severity of fire danger in any late winter - spring dry season is largely dependent on the rainfall of the immediately preceding summer - fall rainy season. In instances where extremely wet years have followed extremely dry years, as has often been the case in southern Florida, some confusion has arisen regarding the true date of the bad fire year in the period. In addition rainfall data presented in the usual manner often obscure the real severity of a drought period by lumping it with the succeeding rainy season, rather than the preceding one. A good illustration of both these effects is provided by rainfall data for the years 1930 through 1932. This span included two rainy seasons of well above normal rainfall (1930 & 1932), and one which was greatly deficient (1931). Various South Florida stations reported the following:

	1930	1931	1932
Canal Point	63.29	39.87	67.91
Belle Glade	63.07	42.57	65.09
Miami	73.51	60.87	79.90
Coconut Grove	69.96	50.61	64.75
Pennsuco	76.50	65.35	83.92

On the basis of these figures by calendar years 1931 is indicated as a dry year at some stations and normal or slightly above at others. It does not look like a year of extreme fire hazard from these data. Compare, then, the picture when rainfall is shown for the years May 1, 1930 to May 1, 1931 and May 1, 1931 to May 1, 1932.

	1930-31	1931-32
Canal Point	57.09	33.11
Belle Glade	58.22	37.70
Miami	77.07	48.42
Coconut Grove	75.34	38.62
Pennsuco	78.14	53.42

It is seen that there was a 12 month period of extreme drouth in this span of years (the second most severe on record for the region) not noticeable in the former figures because it occurred between two unusually wet periods. The effect of presenting rainfall data for South Florida by calendar years is to smooth and minimize the rainfall extremes, and to some degree the relation between fire hazard and rainfall. Notice also that the dry period extended into 1932, and it is probable that fire hazard was most severe in the spring of 1932 at the end of the prolonged drought. Examination of rainfall records presented by calendar years gives no hint of this. 1932 is shown as a year of above normal rainfall throughout the region, yet the spring of 1932 was marked by severe and general fire.

Close comparison of the rainfall records, and the narrative fire history will reveal some apparent inconsistencies most of which I am unable to resolve. So many of the fires in the area are man-caused, that an absolute relation between rainfall and fire occurrence need not be expected. Much of the area will burn at almost any time except during a rain or when covered by standing water (and to a limited extent even then). However, there is certainly a general positive relation between periods of low rainfall and increased frequency and severity of fire occurrence. For this reason one cannot help suspecting that in some cases sources quoted in the fire history may be in error. It seems odd for example that the 1927 - 28 period with the lowest recorded rainfall for the region should have passed without notice, while 1929 is cited as a bad fire year.

Taking into account the great variation in rainfall from year to year, and the amount of local variation in a given year for closely located stations (e.g. Miami and Coconut Grove recorded 72.23 and 50.98 respectively in 1933 - 34) it seems unsafe to attempt to generalize from the relatively short records at hand. A few points may, however, be noted. The included table lists the ten periods of lowest recorded rainfall and shows some of their characteristics.

Table 2. May 1 to May 1 Periods of Lowest Average Rainfall

Period	No. of Stations of Record	Recorded Rainfall	Comments
1927-28	10	40.85	Low throughout region.
1931-32	13	41.37	Near average at Dania, Ft. Lauderdale and Hypoluxo.
1938-39	12	42.41	Low throughout region.
1944-45	13	42.96	4" above average at Dania.
1921-22	7	43.25	Near average at Dania and Ft. Lauderdale.
1942-43	14	45.78	Low throughout region.
1943-44	13	46.54	Low throughout region.
1950-51	11	47.13	Above average at Tamiami Trail, 40 Mile Bend. Near average at Kissimmee.
1951-52	11	47.61	Above average at Kissimmee, Okeechobee, Moore Haven and Belle Glade.
1913-14	6	48.70	Near average at Homestead.

Rainfall records strongly indicate that water levels on the lower glades now depend entirely upon the local rainfall south of the Tamiami Trail. In the 1951-52 period above average rainfall at Kissimmee, Okeechobee, and around the south rim of Lake Okeechobee did not relieve drought conditions in the Everglades National Park area where fire hazard remained extreme through most of the winter and spring. Similarly, as may be seen from the above table, several periods of low rainfall and extensive fires, have occurred at times when east coast stations in Broward and Palm Beach counties reported average or above-average rainfall. It seems evident that the former Kissimmee River - Lake Okeechobee - Everglades system is no longer an effective drainage unit. Canal and road barriers and the diking of the lake have created several smaller drainages each largely dependent on its local rainfall. The importance of exact local data in rating rainfall effects upon fire hazard in Everglades National Park is thus emphasized.

A final point to be noted is the importance of rainfall distribution as well as total rainy season rainfall. Severe fires have occurred in years of above-average total May 1 to May 1 rainfall (as in 1949-50) when rainfall is highly concentrated in the summer and early fall with little thereafter. In 1949-50, although the total rainfall was slightly over average, very little fell after October 1 and the following April and May were marked by bad fires.

E. Fire Since The Establishment of Everglades National Park

The accompanying map (see Appendix) table, and graph summarize the recent fire history of the area within the fire boundary of Everglades National Park. During this five year period all fires (with the exception of a few either completely inaccessible or discovered after fire was out) were actively fought by Park Service personnel until controlled. In the face of this all-out effort the total acreage burned, 205,641 acres, is far from encouraging. Two facts must be kept in mind, however:

1. The period included 1951 and 1952 (to July 1), both of which were abnormally dry years, at least by all previous standards.

2. The group "started from scratch," both as regards ideas and equipment for direct suppression of pine rockland and sawgrass fires; and was forced to evolve suppression techniques, and invent (or at least inventively select) equipment, as it went along.

TABLE 3. Summary of fire occurrence in Everglades National Park 1948-52.

Year	Number of Reportable Fires	Acreage Burned	Fire Suppression Costs
1948	11	1,965	195.54
1949	32	18,431	1,566.12
1950	23	121,370	25,261.61
1951	27	57,771	21,230.93
1952 (to July 1)	15	6,104	2,276.38

Fires of this period extensively damaged hammocks of the western half of Long Pine Key. Over much of this area all hammocks are either badly gutted or severely burned around the edges. Many tree islands of the Everglades have suffered likewise, particularly as a result of the Ironpot Hammock and Shark Valley fires of June 1951. Considerable destruction of organic soil has occurred in tree islands of the Everglades, and some of the remaining mulch deposits of sawgrass areas have also burned out.

In summation, the results of five years of fire fighting, that has absorbed much of the productive energy of the Everglades National Park staff, inspire no feeling more robust than a very reserved optimism. Much has been learned, and a high degree of fire-fighting skill, both strategic and tactical, has been achieved. However, unless the problem of additional water supply can be solved, the best efforts of fire detection and suppression are likely to provide only local victories in a lost war. Obviously the maintenance of more water on the glades is the central problem in management of South Florida wild lands. It is probable that the glades cannot be long maintained in their present aspect, even in the absence of fire, unless this problem is satisfactorily solved. Clayton and Neller (1939: 156) have reported that annual loss of water by evaporation and transpiration from experimental plots of sawgrass averaged 12 inches more than the total annual rainfall over a series of years. This indicates that the glades will continue to dry up unless some way is found to hold water in storage areas or to carry excess water from Lake Okeechobee to the south, instead of out to sea via canals. So long as each year of below average rainfall in the immediate Everglades National Park area results in a five to seven month period of extreme fire danger over much of the area, we can expect continued large and destructive glades fires in the park.

DESCRIPTION OF THE BURNABLE VEGETATION TYPES

INTRODUCTION

This section lists the plant species and describes the aspect of the principal fire types of south Florida, which include all of the major regional vegetation types, except mangrove swamp forests. The mangrove forests are probably locally burnable under some conditions but they do not present a major fire control problem. Material for the following accounts is drawn mainly from personal field notes. Considerable discussion of these same vegetation types may be found in the scientific literature. These reports fall readily into two classes: Extensive qualitative surveys of the vegetation types of the entire region south of Lake Okeechobee, such as the papers of Harshberger (1912), Harper (1927), and Davis (1943); and, quantitative, (or at least intensive) studies of particular limited areas, as the work of Phillips (1940), and Egler (1952). All of these, and others which could be mentioned, contain much useful descriptive material, as well as some interesting comment on the factors controlling occurrence of the vegetation types, and the relations between vegetation types. References to the pertinent literature are included for each vegetation type discussed.

The accumulation of full ecological data on the vegetation types affected by fire forms an essential background to fire effects study. Such information should include: Quantitative data on variation in the specific composition of the vegetation from site to site through the region; identification of the factors that control the distrubution of the vegetation types, and the variation within each; and data-supported conclusions on the successional relations between the various vegetation types. Only fragments of this information are available in the present scientific literature. The survey papers present general discussions and composite lists of the plant species of the different vegetation types. I feel, however, that their comments on controlling factors and successional relationships are not convincingly supported in many cases. Other papers give largely adequate portrayals of small areas, but are inadequate for the understanding of the vegetation types concerned throughout their south Florida range. The papers cited and others represent valuable, indeed indispensable, preliminary work to which all later workers in the area must acknowledge indebtedness. Previous work has established the broad outlines of regional plant ecology, and serves as a point of departure for more intensive and detailed studies.

1. PINE FOREST AREAS

The pine forests of lower Florida are often considered to be southern outliers of the extensive longleaf pine forests of the southeastern United States. It seems to be less generally appreciated that they are more strongly related to pine forest areas of the Bahamas, Cuba, Hispaniola, and parts of Central America. Although there is considerable similarity of general forest aspect to longleaf pine forests, the different climactic conditions, the different substrate, and the differences in the species involved are bars to a close comparison with pine forests of the southeastern longleaf belt. On the other hand the south Florida pine forests show detailed resemblance to the Bahaman "Pineyards" and similarities to pine forests of Pinar del Rio, the Isle of Pines, and the Atlantic shope of Central America. The southeastern longleaf pine forests have received a great deal of ecological study, particularly study of fire effects, and one is tempted to search there for information helpful in understanding the South Florida pine areas. For the reasons cited above I believe that it is well to move with caution in attempting this transfer. For pine forest areas, as well as most other South Florida vegetation types, a good rule of thumb is — when in search of useful ecological information from comparable areas, look to the South.

Accounts of the vegetation of South Florida pine forests may be found in the following works: Harshberger (1912: 87-98), Simpson (1920: Chap. 7), Harper (1927: 90-92, 176-179), Davis (1943: 160-166), and in many of John K. Small's narrative accounts of botanical exploration in South Florida.

SUBSTRATE - The pine forests of South Florida are restricted to elevations of Miami Limestone. These occur in two widely separated areas:

1. The so-called Miami Rock Ridge, predominantly a pine forest area, which extends southwest from Miami to below Florida City, and thence west by slightly south (as Long Pine Key) into Everglades National Park almost to the Dade-Monroe County Line.

2. The Lower Florida Keys, where extensive pine forests are found on Big Pine, No Name, Little Pine and Cudjoe Keys, and additional small stands of pine on Sugarloaf, Howe, and Big Torch Keys.

The actual elevation of these "upland" limestone areas is slight, ranging, on the mainland, from near 25 feet above sea level at Miami to five feet, or perhaps less, in parts of Long Pine Key. Some sites on Big Pine Key may reach 15 feet above sea level, but most of the Lower Florida Keys pine area is considerably less elevated. Lower parts of the pine forest area, particularly that of Long Pine Key, are subject to some flooding during the summer rainy season. It appears that adequate elevation above the water table is the essential characteristic of pineland sites, rather than any relation to the specific geological formation. Exposures of Miami Limestone at lower elevations subject to longer periods of annual flooding are occupied by other vegetation types. At all but a few sites the boundary between pine forest and adjoining vegetation types, (such as sawgrass prairie) is clear-cut with only a narrow zone in which plants of the two vegetation types occur together.

The grotesquely eroded limestone substrate is a characteristic feature of the South Florida pine forests, and one which presents much difficulty to firefighting in the pinelands. A statement by Ginsburg (in. litt.) attached as an appendix to this report, discusses the erosion processes in detail. Limestone is exposed at the surface throughout the pinelands. The usual reaction of one seeing such an area for the first time is to wonder where the trees find soil to grow in. There is virtually no soil in the usual sense but in the Lone Pine Key area, and more commonly in the so-called "Redlands" section west and north of Homestead, potholes in the limestone often contain small quantities of a reddish clay which is apparently a product of limestone decomposition. Despite the formidable material and the expense of preparation, the rockland area is presently enjoying an agricultural boom. Large tracts of pineland have been cleared for mango, avocado, and lime groves, and for winter vegetable fields. At the present rate of development the South Florida pineland seems likely to disappear almost entirely except for the Long Pine Key section in Everglades National Park. In addition, the method of agricultural preparation (by bulldozing off vegetation, scarifying, and rock plowing) produces such extreme changes that pine is very slow to recolonize abandoned rockland fields.

VEGETATION - THE PINE OVERSTORY - South Florida pine forests are composed entirely of Caribbean pine (*Pinus caribaea*) in open stands with a variously developed shrub understory, and a ground cover of grasses and herbs. In mature stands the pines typically have long clear trunks and small, often much twisted, tops. The photographs below (Figs. 4, 2, & 3) show the appearance of the only near-mature stand of Caribbean pine remaining in South Florida. This is the small area of pineland of the original Royal Palm State Park now included in Everglades National Park. The largest trees here reach 16" DBH. With the exception of this small tract all of the rockland pine forest of South Florida has been cut over, much of it several times. Several small sawmills still operate in the Homestead area, but very little useable timber remains.

The following account of early lumbering operations in the region is largely from information provided by a former lumberman, Mr. F. L. Skill of Homestead. — Cutting began in the Redlands area about 1905. The chief sawmill was at Princeton a few miles northeast of Homestead. Mules and oxen were used to get out the logs, and large steam tractors to haul them to the mill. The so-called "Dade County pine" was the hardest pine timber known, and was also strongly termite-resistant. Logs "more than thirty inches in basal diameter" were not uncommon, and during World War I many thirty foot 12 x 12" timbers were supplied to the U. S. Navy. To Mr. Skill's knowledge no South Florida pine forests were ever turpentined. Lumbering began on Long Pine Key around 1935 and continued up to 1946 or 1947. Mr. Skill stated that the pines of Long Pine Key were smaller than those of the Redlands, the largest being about 24" in basal diameter. Beard (1938: 10) says "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." Two sawmills operated on Long Pine Key, one at Osteen Hammock Glade about one mile west of the east end of the Key, and a later one at Twin Hammock Glade, some four miles farther west. According to information supplied by Mr. C. C. von Paulsen of Homestead, cutting at the Twin Hammock Glade mill proceeded until 1947. Trails used in bringing logs to these mills run throughout much of the Long Pine Key pinelands. These have recently been used as access roads for firefighting, and occasionally as fire breaks. Apparently considerable cutting was done after 1940, as many of the present logging trails do not appear on aerial photographs of the 1940 series. Fig. 4 shows a pine stand typical of much of Long Pine Key, with a thin overstory of cull trees left at the last cutting, and a vigorous understory of young pine. Other areas of Long Pine Key now have even-aged second growth stands of somewhat larger pines, roughly 35 - 50 feet tall and 4 - 8" DBH (see Fig. 7). Mr. Skill states that clean cutting was the usual lumbering practice in south Florida, and that Long Pine Key was lumbered in this manner. He believed that parts of Long Pine Key were gone over again, at which time any remaining usable trees were cut. This would account for present variations in pine stands of the area.

VEGETATION - SHRUB UNDERSTORY - The rockland pine forests of South Florida are characterized by an extremely varied understory of low palms and hardwood shrubs. In some areas of Long Pine Key 40 or more species can be found growing within a radius of a few yards. More than 100 species occur in the understory of South Florida pine woods, and perhaps half of these are of fairly regular occurrence. Table 10 included in the Appendix shows the specific composition of the pine woods shrub understory vegetation at 18 South Florida sites and the constancy of occurrence of the various species.

As might be expected from the large number of species involved, a great deal of variation occurs in the composition of pine woods understory vegetation from stand to stand. Some of this variation may be well correlated with slight differences in the elevation, topography, and/or soil of the sites occupied. The following series of photographs show some of the major understory types found in the Long Pine Key area which I interpret as the result of such site differences.

Figures 5 shows a shrub small tree understory of mixed hammock hardwoods which is typical of the "upland" pinewoods sites. These are the most elevated sections of rockland with much-eroded limestone at the surface, and with many deep solution holes and occasional small areas of red clay (Redlands) soil.

The height and density of the understory developed at any such site depends largely on its recent fire history. Vegetation of this sort variously modified by fire occupies much of the Long Pine Key pineland.

Figure 6 shows a shrub understory characterized by fire-pruned buttonwood (<u>Conocarpus erecta</u>) occurring at transitional low pineland sites along the slope from pine forests to sawgrass glades. These sites have less exposed limestone, and the pot holes are filled with marl. The size of the area occupied by this buttonwood zone seems to depend on the steepness of the slope from pineland to glades. Along many of the transverse "finger" glades, which indent the south side of Long Pine Key, this slope is abrupt (for South Florida), and the buttonwood strip is narrow. Elsewhere on more gradual slopes, as at the site shown, extensive buttonwood areas occur in pinelands.

Proceeding along the "slope" from "elevated" pine rockland to sawgrass glades one encounters areas where most of the limestone is covered by a thin layer of marl, with little rock exposed. At such sites the understory is dominated by saw palmetto (<u>Serenoa repens</u>). No hardwoods occur, and the grasses and characteristic herbaceous plants of the higher pinelands are replaced by sawgrass, and other sedges, and many gladeland herbs. Figure 7 shows an area where palmettos, occur under pines. Higher rockland with a mixed hardwood understory appears in the background. On slightly lower sites the pines disappear and extensive palmetto flats are found (Figure 8).

The stages discussed are rather arbitrarily chosen. Their occurrence is apparently controlled by gradual changes in elevation and substrate developed along a gentle slope. As would be expected one finds complete intergrading, with few abrupt transitions between "stages."

Another definitely site-related variation in the pineland shrub understory is that brought about by deep solution holes of the high rockland areas. These holes come in all sizes up to 50 feet in diameter. In the Long Pine Key area six feet is about their maximum depth. The holes are usually well-filled in summer, and may hold water well into the dry season.

Hardwood species characteristic of wet sites (such as the bayheads of the glades) are often found growing from the bottoms of these potholes in the pinelands. Species commonly occurring are: Dahoon holly (Ilex cassine), pond apple (Annona), willow (Salix amphibia), sweetbay (Magnolia), and redbay (Tamala). Figure 9 shows a clump of willows growing from a bathtub-sized pineland solution hole on Long Pine Key. Such locations enjoy some fire protection, and the plants often survive to reach tree size.

Variations discussed above may be more or less definitely associated with obvious site differences. In addition there is much variation in the total density and specific composition of the hardwood shrub understory of "upland" pine forest which is evidently not related to site differences. Part of this undoubtedly results from the different fire effects histories of the various sites but the absence of exact information on the fire histories of local areas makes this relation difficult to demonstrate.

In order to get a clearer idea of the extent of the variation of the shrub understory in a extremely limited area counts of understory plants were made on a series of 12 closely adjacent 1/10-acre plots. The pineland area chosen for this quantitative study has a poorly developed shrub understory and is believed to represent the lower limit of variation in pinewoods understory vegetation. The plots studied show no obvious differences in soil or elevation and are so nearly contiguous that any differences in fire effects history seems most unlikely. The results of this study are presented in Table 11 (Appendix).

In this case the specific composition of the shrub understory is fairly uniform. One of two species, rough velvetseed (Guettarda scabra) or varnish leaf (Dodonaea jamaicensis), predominates in numbers on all plots. Seven species occurred on all plots studied, and these include the six most abundant species. Sixteen species occurred on two-thirds or more of the plots. In contrast, the plots studied show great variation in the density of the shrub understory. The plot with the most dense shrub layer supports over five times more woody plants than the plot with the least dense shrub growth.

For the Long Pine Key area as a whole, variation in the specific composition of the shrub understory is much more marked. As noted in Table 10 any of ten or more species may predominate in local areas. Also as shown in Table 11 either or both of the two species which were predominant on the present quantitative study plots may be absent elsewhere. It seems probable that some of the variation results from variations in the frequency and season of burning at different sites, but the influence of this possibly important fire effect cannot be determined from data now at hand.

VEGETATION - GRASS-HERBACEOUS LAYER. To complete the description of south Florida pine forest vegetation some account of the rich herbaceous flora is in order. This flora contains many striking species, and should eventually prove to be a considerable attraction even to casual visitors. In addition a sizeable proportion of the species are endemics, found only in south Florida, which adds to their botanical interest. Since virtually all pineland fires are ground fires, the development of this grass-herbaceous layer varies greatly from place to place according to how recently the area has burned. This relation will be discussed in the next section of the report. A list of the characteristic pineland ferns, grasses and herbaceous plants is included in the Appendix.

2. TROPICAL HAMMOCK FORESTS

Introduction

The hammock forests of Everglades National Park are one of the Park's most notable biological features. Along with the mangrove swamp forests they serve to give the region its tropical character. And, since they fulfill to some extent the popular idea of "Jungle", they are of great visitor interest. Information on their ecology is valuable both for proper interpretation and as a guide for management practices. However, despite the botanical interest of these forests their ecology is still but poorly known. Phillips (1940) study of Castellow Hammock is the only detailed ecological work yet published. This section of the present report provides a considerable amount of new data on the flora of hammock forests on a variety of sites, and quantitative data on the forest composition of some. In addition an attempt is made to point out some of the geographic and theoretical areas from which further information is to be desired.

In considering the hammock forests two basic ideas should be kept in mind. - 1. The tropical element of the flora represents that part of the Antillean, particularly the Cuban, flora that has been able to become established across a water barrier through the action of natural agencies of dispersal that are still operative. There is every reason to believe that the process continues and that the chances of dispersal and establishment will bring additional species of tropical plants to South Florida. There is at least some reason to suspect that some of the present species which are rare or, which show puzzling patterns of distribution in South Florida, may be the more recent arrivals. - 2. Within the range of the tropical vegetation in South Florida occur two climatic gradients which may influence the distribution of the tropical species and the aspect and composition of tropical hammock forest vegetation. These are the south to north gradient of increasing frequency of killing frosts, and the roughly east to west gradient of decreasing annual rainfall from an average of about 60" per year at Miami to 40-" per year at Key West.

The South Florida tropical hammock forests must be considered to be in a tentative state of development which reflects the geological youth of the region, the vagaries of dispersal across water barriers, and the approach to a critical climatic boundary.

ORIGIN OF THE TROPICAL FLORA

The point of origin of South Florida's tropical plants and the probable modes of transport are matters for interesting speculation though no "answers" are likely to be forthcoming. Of the two nearby Antillean areas Cuba seems a more likely source than the Bahamas both because it is geologically older and because ocean currents appear to favor Cuba to Florida transport over the other. Simpson (1932, pp. 53-54) indicates the source more precisely as the Sierra de las Organos region of northwestern Cuba, and calculates that fruits or seedlings carried into the Gulf Stream by rivers draining these mountains would be off the Florida Keys in two and one-half days. Considerably more rapid transport either by wind or water presumably could occur during hurricanes.

The possible natural vectors of plant propagules from the West Indies to Florida include ocean currents, migratory birds, and hurricane winds. There is considerable interest in attempting to evaluate the relative importance in the South Florida situation of these several transport facilities.

At the present time casual field observations suggest that hurricane winds and tides are the major factor in the natural establishment of West Indian plants in South Florida. Simpson (1932, p. 55) writes "I have seen again and again little bays and shallows of the sea in Cuba, Jamaica, Haiti, Central America and the Bahamas filled with logs, branches of trees, decaying wood and leaves, as well as millions of seeds ... here the cargo lay awaiting shipment ... Once about a month after a severe hurricane I visited the Lower Keys where the water overwhelmed a considerable part of the land and I found hundreds of acres on Big Pine and other keys simply buried in West Indian trash and seeds; <u>millions of the latter were sprouted and growing, the very same species that constituted the flora of these islands.</u>" Darlington (1938) has discussed the role of hurricanes in the origin of the fauna of the Greater Antilles. Although his paper deals mostly with transport of animals by hurricanes much of the discussion is also pertinent to the present problem. Careful field observations in the wake of future South Florida hurricanes may provide additional information on the hurricane as a vector of organisms, a bio-geographical factor of great importance throughout the Caribbean area.

The role of migrant birds in the spread of plants across water barriers in the Antillean region is uncertain. Howard (1950) considered birds as well as other agencies of inter-island transport in his study of the vegetation of the Bimini Islands, Bahamas. From results of feeding tray experiments conducted on Bimini in May (ibid, p. 239) he concluded that birds are probably effective vectors only of species with small fruits and seeds that are completely ingested and may remain viable after passing through the digestive tract. He found that the pericarp of larger fleshy fruits (such as those of pigeon plum, <u>Coccolobis</u> <u>laurifolia</u>) was usually pecked away and eaten, while the seed itself was seldom carried for any distance. Accordingly in his very interesting table (<u>op. cit.</u> pp. 342-349) Howard lists birds as a probable major factor in the inter-island dispersal of a number of species. Several questions may, however, be raised in regard to Howard's feeding station experiments. The species of birds which participated in the experiments are not named, nor is it definitely stated that they were migrants rather than resident Bahaman species. The exact dates in May on which the work was done are not given. Since specific differences in plant food preferences among birds almost undoubtedly exist, as well as specific differences in the method of dealing with the same plant food item, it would seem to be important to distinguish the bird species involved. The exact May dates are equally important, so far as South Florida is concerned, since the bulk of spring migrant passerines have passed through South Florida before the middle of May. The following comment of Simpson (1932, p. 52) is of interest in the consideration of seed transport to Florida by birds. "Nearly all the trees and shrubs of Cuba and the nearer tropics blossom in the spring or early summer and ripen their fruit in late summer or fall. This is especially true of those that bear drupes or berries.... They furnish excellent food for migrating birds, but unfortunately they are going south - the wrong way. When they come back on the homeward flight in the spring nearly all the fruits have fallen."

Proper evaluation of the possible role of birds in the dispersal of West Indian plants to South Florida will require much data on the coincidence of available seed sources with the spring migration dates and routes of particular bird species; on the food habits of the bird species involved; and, on the viability of seeds of various plants after passage through a bird's digestive tract. There seems no reason to doubt the importance of birds in South Florida in the local dispersal of many plants. In addition to seeds passed with feces, many field observations, involving a wide variety both of plants and birds, suggest that entire fruits of many plants are commonly carried distances up to several hundred yards by adult birds feeding nestlings. The rapid appearance of such plants as Trema floridana on any newly available bare area is likely due largely to seeds dropped by birds.

Howard's study of possible methods of plant distribution by feeding experiments with various fruits and seeds offered to birds and land crabs seems to offer many possibilities for significant work in a field where the rhetorical approach has been more common. Other lines of investigation in experimental plant geography, such as experimental study of toleration of exposure to salt water by fruits of various species immediately suggest themselves.

THE TERM "HAMMOCK"

Much effort has been spent in attempts to define, de-limit and derive the term "Hammock" in its use in reference to southeastern United States forest types. The term enjoys wide (and unfortunately rather flexible) lay usage locally and throughout Florida and tries at a scientific definition have not been signally successful. I am compelled to cite some of these for two reasons: 1. To give a brief historical review of the development of scientific notice of the difficulties involved in use of the term, and, 2. To illustrate some of the clustering ambiguities which almost defy a precise application of the term.

(Harper, 1905, p. 400-402) "... It may be broadly defined as a limited area with comparatively dry soil (at least never inundated and thus distinguished from a swamp), containing a large proportion of trees other than pines, and located in a region where "prairies", marshes or open pine forests predominate. Topographically a hammock may be either a slight elevation or a depression, or a slope, and its soil may be sandy, clayey or rocky. The soil is usually rather rich, and the trees growing in it are usually mostly evergreens - though there is probably no one tree which characterizes all hammocks - and they usually grow so close together as to shade the ground and allow the formation of humus, which is almost wanting in the adjacent areas ... A hammock as here defined is always characterized by its vegetation rather than by its topography, it can hardly have anything to do with 'hummock'."

(Harper, 1911a, p. 217 footnote) "Many residents of other states who have written about Florida have attempted to define "hammock" (a term which is used in Florida more than in all the rest of the world) but most of them have missed the mark by attempting to correlate it with soil. A hammock is nothing more or less than a certain type of vegetation: namely a comparatively dense growth of trees other than pines on comparatively dry soil ... in a region where open pine forests predominate. The ground in such places is usually covered with more or less humus derived from the trees but under the humus may be either sand, clay, marl or limestone."

(Small, 1916, p. 165) "A hammock - the word probably of indian origin - is a dense growth of mostly broad-leaved shrubs and trees, thus giving shade, in a pine forest or on a prairie. The use of the word is confined to Florida and adjacent states."

(Simpson, 1920, p. 190) "The word "hammock" is generally applied in Florida to the forests of broad-leaved trees as distinguished from pine woods."

(Small, 1930, p. 14, footnote 2) "... Sometimes hammock growth occupies a whole geologic formation, at other times it exists as islands, so to speak, in pinewoods or on prairies, or surrounded by other plant associations. They occur only in regions protected from fire, or in fire-ravaged regions they represent areas that fire has not yet run through. It cannot be correlated with altitude or with soil, for beneath the humus ... may be sand, clay, marl or rock."

(Byers, 1930, p. 227) "In Florida the term hammock is used to designate hardwood forests."

(Small, 1931, p. 1) "It (hammock) was formerly confused with the word hummock, a topographic term. Hammock is a phytogeographic term."

(Phillips, 1940, pp. 166-7) "Southwest of Miami on the limestone ridge there are numerous islands of vegetation known as tropical hammocks. These particular hammocks are composed of a dense growth of trees of tropical origin ... The term hammock is applied to several different types of plant associations. The term as here used corresponds to the definition given by Harper (1905) in a paper in which he discusses the derivation of the word and its various corruptions. In a later paper Harper uses the term hammock as synonomous with climax. The term hammock as used in northern Florida by Thone (1927) also refers to the climax type of vegetation and does not give the idea of an island of vegetation."

(Carr, 1940, p. 15) "In Florida the word hammock is applied to any hardwood forest. The prevalence of coniferous woods - pinelands and cypress swamps - lend significance to a term which distinguishes between these common types and the hardwoods ... (ibid., pp. 17-18) A mesophytic forest of hardwoods mostly West Indian in species, appears to be the climax association for the Florida Keys and the peninsula south of Palm Beach County on the east coast, Hendry County in the interior and Lee County on the west coast. Hammocks of this type occur in potholes or in old detritus-filled depressions in the limestone flatwoods; as insular elevations in the Everglades; along the banks of many creeks and rivers; and intermittently in the prairie land and buttonwood forests back of the mangrove swamps in the Cape Sable region and along the shores of Florida Bay."

(Laessle, 1942, p. 35, and footnote 14) "Hammocks are woods dominated by Broadleaved Evergreen trees.[14] They occur on a variety of soils, ranging from well-drained to nearly saturated, but never occupy areas that are seasonally or periodically flooded ... Although Watson (1926), Carr (1940) and others have defined hammocks as hardwood forests, I believe that a more restricted definition of the term is not only desirable but is closer to the accepted usage of the term in Florida. Areas of considerable size dominated by evergreen hardwood trees are so abundant and well-marked over most of the state that they constitute a characteristic feature of the landscape and require some distinguishing term. The term hammock as used in Florida nearly always connotes such evergreen hardwood associations, and should be restricted to this use as a definite ecological term."

(Davis, 1943, pp. 166-7) "The term hammock as used in Florida has come to mean groups of broad-leaved trees, either evergreen or deciduous, which are frequently associated with the cabbage palm or other palms. These groups of trees usually form a dense forest as compared to the surrounding forests, marshes or prairies. They also usually cover small areas and ... stand out on the horizon as islands of trees ... The outstanding feature of the southern Florida hammocks is the great diversity in the kinds of plants that form them."

(Douglas, 1947, p. 32) "The islands are like the sawgrass, the particular feature of the glades ... They look like hummocks and many books persist in calling them so. They are called also "heads", "strands" and "tree islands", but the right name is "hammock" from "hamaca", an Arawak word for jungle or masses of vegetation floating in a tropical river."

(Egler, 1952, p. 232, footnote) "Hammock, a vernacular south Florida term, derived from Hamaca an Arawak Indian word for jungle, or masses of vegetation floating in a tropical river (Douglas, 1947). A hammock (not to be confused with hummock) is a physiognomic vegetation type, an "island" of dense forest in a "sea" of open forest or grassland. Hammocks may be higher than, lower than, or on the same soil level as the surrounding vegetation. They may be developmentally younger than (i.e. a pioneer stage) or older than (i.e. nearer a "climax") than the surrounding vegetation. They are usually more fire resistant, and less often burned, than the surrounding vegetation."

Table 4 summarizes the hammock definitions. The difficulties involved in the use of the word stem from amalgamation of several concepts into one term. The term "hammock", as applied to vegetation incorporates two main ideas: the physiognomic idea of a limited or island stand of vegetation; and the structural idea of a definite type of vegetation (i.e. a floristically diverse, mature hardwood forest with a deep humus deposit occupying a non-swamp site). Perhaps the term was originally applied only to islands of the particular forest type. If so, usage has long since ceased to observe this restriction. The use of the term has varied from the extreme physiognomic sense, in which any island stand of forest, regardless of type, is called a "hammock"; to the extreme structural sense, in which any stand of presumed climax or near-climax vegetation, regardless of extent, is called a "hammock". Cases offering opportunity for confusion are far more numerous than are the stands qualifying as "hammock" by both counts, thus, the continuous tropical forests of the Upper Florida Keys are "hammocks" in local parlance and in structure, but they are not islands of vegetation. And, a stand of cypress in a flatwoods pond is a "hammock" in the strictly physiognomic sense of being an island of dense vegetation, but in no other.

TABLE 4. A SUMMARY OF THE DEFINITIONS OF "HAMMOCK"

Authority	Physiognomy	Topography	Soil Type	Soil Water Relations	Flora	Forest Type	Forest Aspect
Harper (1905, 1911a)	A limited area in a region where other vegetation predominates	No special topography, may be an elevation a depression or a slope	With humus deposit - No characteristic substrate	Comparatively dry soil	Trees other than pines	Mostly evergreen	Comparatively dense
Small (1916, 1930, 1931 et al)	May either occupy an entire geological formation or exist in islands	Cannot be correlated with altitude	A variety of soil types beneath the humus deposit			Mostly broad-leaved trees and shrubs - usually fire-protected	A dense growth
Simpson (1920)						Broadleaved trees	
Byers (1930)						Hardwood forests	
Phillips (1940)	(S. Florida) islands of vegetation				(S. Florida) of tropical origin		(S. Florida) a dense growth of trees
Carr (1940)	(S. Florida) Not necessarily islands of vegetation	(S. Florida) Depressions in limestone flatwoods - insular elevations in the Everglades			(S. Florida Mostly West Indian in species	Any hardwood forest - (S. Florida) a climax mesophytic forest of hardwoods	
Laessle (1942)			A variety of soils	Never seasonally or periodically flooded		Woods dominated by broad-leaved evergreen trees	
Davis (1943)	Usually cover small areas and stand out as islands				Frequently associated with palms (S.Fla.) great diversity in the kinds of plants	Groups of broadleaved trees either evergreen or deciduous	usually form a dense forest

Authority	Physiognomy	Topography	Soil Type	Soil Water Relations	Flora	Forest Type	Forest Aspect
Egler (1952)	Island of forest in a sea of open forest or grassland	Higher, lower or on same soil level as surrounding vegetation				Developmentally younger or older than the surrounding vegetation - usually less often burned	

The foregoing definitions were not summoned out of the literature for the purpose of providing the author with antagonists. There is really no question of right usage vs. wrong usage involved, except, perhaps, where authors have failed to clearly distinguish "hammock," in their own definition, from other forest types (such as "bayhead") to which they apply different terms. Egler's (1952) use of the term in its strictly physiognomic sense with reference to "cypress low hammocks" (p. 235) and "Avicennia hammocks" (p. 259) seemed completely foreign at first glance. I acknowledge, however, that this usage is perfectly at peace with his definition.

It is difficult to see how one should proceed in the fact of this semantic stalemate. A possible solution, of course, is to abandon ecological usage of the term. However, it is so firmly entrenched in the vernacular, that this extreme measure would be advisable only as a last resort, and if no restricted usage can be agreed upon. Certainly the problem merits the careful attention of all southeastern botanists.

For the purposes of this paper the term "hammock" is used in its structural or floristic sense. Since the flora of South Florida "hammocks" largely differs from that of "hammocks" elsewhere in the region where the term has currency they will here be referred to as "tropical hammocks," following Phillips (1940) and Carr (1940) in this usage. As here used, "tropical hammock forest" refers to both extended and island stands of the forest type composed of a variety of predominantly West Indian hardwoods which is the presumed climax vegetation on all sufficiently elevated sites in South Florida. This usage definitely excludes such vegetation as the bay and cypress islands of the Everglades which some authors (Ledin, 1950; Egler, 1952; et al.) have termed "hammocks." These are herein referred to as "bayheads" or "cypress heads." Usage of both terms is in accord with my understanding of their local employment in South Florida. I have not, however, conducted a plebiscite on the matter, and admit the possibility that the present interpretation may be a mistaken one.

√ ZONAL POSITION OF SOUTH FLORIDA HAMMOCK FORESTS

It has become customary to refer to the South Florida hammocks as "sub-tropical". Thus, Davis states (1943, p. 140) "There is little doubt that nearly tropical conditions exist in southern Florida, especially on the Florida Keys, because so many tropical plants are at home there, but the climate is, however, considered sub-tropical and the hammocks are therefore sub-tropical and not tropical." — I confess a failure to follow this reasoning completely. It is true that frost occurs throughout South Florida, perhaps more widely and more frequently than weather records may show. It is also true that occasional frosts are severe enough, at least on the mainland, to do extensive damage to native tropical vegetation. This factor, however, has not had sufficient influence to prevent the development of vegetation types which show detailed resemblance to several in the unabashedly "tropical" Antilles. Since the vegetation developed under the reigning climate is a community composed of tropical plant species, there seems no clear need for a prefix. The term "sub-tropical hammock" does not describe or explain anything and it contributes confusion by suggesting differences that do not exist. What "sub-tropical" species are involved? Most of the plants concerned occur throughout the West Indies, or even more widely in the Neotropics. It seems much more important to emphasize the striking similarities, rather than the minor differences.

The ecological understanding of the South Florida hammock forests is not likely to be served by forcing them into classifications of vegetation developed for the southeastern United States, as has sometimes been attempted (Davis, Fla. Acad. Sci., Nov. 1951, p. 5).* The union seems most unnatural. Lower Florida from about the line Tampa-Cape Canaveral south is a region where species of south temperate and tropical floras both approaching their climatic range extremities, meet and sometimes mingle to form transitional vegetation types. It may be said that the tropical species and vegetation types tend to predominate near the coasts with the south temperate assemblages extending far south on suitable sites in the interior. There is no sharp junction and no reason to expect one, but it is evident in traversing the region that a major zonal boundary is crossed. One passes from an area in which the dominant elements of the flora are almost wholly south temperate to one in which they are almost wholly tropical. South of the latitude of Miami the passage into the zone of a tropical flora is virtually complete. Here the proportion of south temperate species which enter into the self-maintaining hardwood forest community becomes insignificant.

It seems reasonable, therefore, to try to relate the South Florida hardwood forests to vegetation-type classifications developed for the New World Tropics and particularly for the West Indies. This point will bear much emphasis. It indicates the direction in which we need look in order to obtain ecological information of use in the interpretation and management of these tropical forests which are one of the high spots of interest in Everglades National Park.

One of the most useful classifications of neotropical vegetation types is that developed in the paper "Climax Vegetation in Tropical America" (Beard, 1944). This classification arranges vegetation types into a number of "formations" primarily distinguished by physiognomic aspect rather than floristics. These plant formations are grouped into "formation-series" formations which occur under similar habitat conditions. Moisture relations are considered to be the most significant environmental factor in determining the stage at maturity of vegetational development on most sites. In Beard's classification the tropical hammock forests of South Florida fall into the series termed "seasonal formations" (ibid., p. 137). The important feature of the habitat of these vegetation types is seasonal drought, a more or less regular annual period during which evaporation - transpiration exceeds precipitation. Beard cites the work of Charter (1941) in British Honduras which indicated that in tropical America the drought point is reached (on sites with normal drainage) with a monthly rainfall of less than four inches. Sites with excessive internal drainage, such as may be true of some in South Florida, may experience drought conditions at a somewhat higher monthly rainfall.

*In his discussion Davis indicates that he has considered and rejected the possibility that South Florida hammock forests may belong to the tropical formations of Beard. In his classification (p. 5, Table I) these forests are listed under the "Southeastern Broadleaved Hardwoods Forest Formation" as "Subtropical Hammock Forest Associations and Associes." Still more singular is the inclusion of mangrove vegetation in this formation.

Table 9 (included in the appendix) was prepared in order to better estimate South Florida rainfall on the basis outlined above. The table shows by years (1900-1947) all periods of two or more consecutive months in which less than four inches of rain per month was recorded at six South Florida stations. Also shown are the months of each drought period and the recorded rainfall for these months. From the data shown the average length in months of the annual drough period, and the average total (and monthly) drought period rainfall is calculated for each station. The table shows that a well-marked annual drought period occurs throughout South Florida. There is much variation and records from several stations are short. It is perhaps safe, however, to generalize to this extent. In the Miami-Homestead area the drought period generally extends from November or December to April or May. Proceeding south and west out the Florida Keys the drought period is lengthened, primarily through the occurrence of a secondary midsummer period, and approaches eight months duration at Key West.

Some authors have referred to the South Florida hammocks as "rain forests" (see Harshberger, 1912; p. 120, and Byers, 1930: p. 229). This view is completely in error, justified neither by the aspect of the forest nor the regional rainfall. Beard states (loc. cit.) "These (seasonal) formations are typically the expression of a seasonal -- as against a well-distributed rainfall ... The duration of seasonal drought determines the degree of divergence of physiognomy in the formation from rain forest."

Six formations distinguished by the relative severity of the seasonal drought comprise Beard's seasonal formation - series. It is emphasized that the transition is complete, and that the stages selected, ranging from near rain forest to desert, are rather arbitrary. The South Florida tropical hardwood forests evidently belong near the more mesophytic end of this series with the "Evergreen Seasonal Forests", "Semi-evergreen Seasonal Forests", and "Deciduous Seasonal Forests." Salient characteristics of these forest types are given below.

Evergreen Seasonal Forests (op. cit., p. 138).

Forests with three tree strata - a discontinuous upper layer reaching 100 +'; a middle layer forming a closed canopy at 45' - 90'; and a lower layer at 10' - 30'. Occasional large trees in a forest of smaller growth. Larger trees branch low and have spreading rounded tops. Lianas and epiphytes are common, and ground vegetation is abundant. -- Predominantly an evergreen forest but some species in the upper tree layer may be deciduous. Species of the lower strata are evergreen. Compound-leaved species predominate in the upper two strata. Most species in the lower strata have simple leaves. -- A rich flora with 80+ tree species per association.

Semi-evergreen Seasonal Forests (op. cit., p. 138-9)

Forests with two tree strata -- an upper story at 60' - 80' and a lower between 20' - 45'. Occasional large trees, but with most of the mature specimens about 18" in diameter. The trees fork low and tend to be umbrella-shaped. Lianas are very abundant, epiphytes are relatively rare, ground vegetation is scanty.

Fan palms may be common. Species in the lower story are mainly evergreen, most of those in the upper story are deciduous in varying degrees depending upon the severity of the dry season. Compound leaves predominate in the upper story, simple leaves in lower story. 50 to 80 tree species per association.

Deciduous Seasonal Forests (op. cit., p. 139-40)

Two layered forests with a closed canopy formed by the lower story at 10' - 30' and a scattered upper layer of trees reaching 60'. The trees branch low and are often crooked. Lianas and epiphytes are rare, ferns and mosses are virtually absent. Ground vegetation is sparse to absent. Two-thirds or more of individuals in the upper stratum are deciduous. Trees in the lower stratum are mostly evergreen. Compound and simple leaves are about equally distributed in the upper story, simple leaves predominate in the lower story, a relatively poor flora with 30 to 50 tree species per association.

It is scarcely to be expected that forests developed in a tropical fringe area such as South Florida would fit all details of this classification. In addition much of the data needed in order to test the closeness of the fit are still in the woods. It may be said, however, that such forests as those of Paradise Key and the Mahogany Hammocks appear to closely approach the Evergreen Seasonal Forest type; while hammocks of the middle and lower Florida Keys (such as that of Lignum-Vitae Key) tend equally toward the Deciduous Seasonal Forests.

DECIDUOUSNESS IN SOUTH FLORIDA HAMMOCK FORESTS

As shown, degree of deciduousness of the emergent tree stratum is a key point in the classification of the seasonal forest types. The scarcity of precise information on this point is typical of the general state of ecological knowledge concerning South Florida hammock forests. Harper (1927, 108-112) seems to be the only author who considered this aspect in any detail. In his lists of plants for hammock forests of several areas some evergreen and deciduous tree species are distinguished. Pioneer South Florida naturalist, Charles Torrey Simpson, was intrigued by this matter and makes several general observations about deciduousness in South Florida hammocks. He writes (1932, p. 174) "In that part of the state which may be truly called semi-tropical only a few trees such as the willows and the red mulberry among the hardier ones, and, the Gumbo-limbo and Metopium or poisonwood, partially or even almost wholly cast their leaves in winter." Simpson evidently concluded that deciduousness was inconsequential since he later states (ibid., p. 182) "Put the most accomplished northern botanist into one of our hammocks and I defy him to tell whether it is June or January, Spring or Autumn."

Notwithstanding the above statements many hardwood tree species are regularly deciduous in South Florida and others appear to drop their leaves irregularly depending on the severity of the dry season. Three general types of deciduousness may be distinguished.

1. One type is that shown by woody species of northern origin that are regularly deciduous in late autumn as in temperate regions. These species usually are bare for only a short period, beginning to leaf out again soon after leaves are dropped. Species in this group include:

Salix amphibia (willow)

Morus rubra (Red mulberry)

Celtis mississippiensis (southern hackberry)

Rhus leucantha (sumac)

2. A number of tropical species appear to be irregularly deciduous in south Florida, the degree of leaf fall varying with the intensity of the drought period. Cool weather may be another factor that affects deciduousness, since Simpson observed (*op. cit.*, p. 172) that gumbo-limbo and poisonwood didn't drop their leaves in the cool winter of 1930-31. -- This sort of deciduousness can be very misleading. There is no general leaf fall and the change in aspect of the forest from week to week may be scarcely noticeable. Nonetheless the crowns evidently thin gradually until at the end of a severe dry season, such as the winter of 1951-52, the hammock canopy may be virtually leafless, and the usually dark forest interiors are open and sunny. The following lists some of the notable members of this group. It should be noted that this list also includes most of the species which enter the upper canopy of the hammock forests.

Ficus aurea (strangler fig)

Dipholis salicifolia (bustic)

Sideroxylon foetidissimum (mastic)

Elaphrium simaruba (gumbo-limbo)

Metopium toxiferum (poisonwood)

Lysiloma bahamensis (wild tamarind)

Ichthyomethia piscipula (Jamaica dogwood)

Swietenia Mahagoni (mahogany)

Simaruba glauca (paradise tree)

3. Besides the above irregular deciduousness several tropical species regularly drop most or all of their leaves at the very end of the dry season, flower on bare branches and then put out new foliage. This is striking in the case

of Jamaica dogwood, soapberry (Sapindus), coral bean (Erythrina), mahogany, and gumbo-limbo, and also occurs in poisonwood, rough velvet seed (Guettarda scabra), blolly (Torrubia), Pisonia rotundata, and the armed hammock liana, Pisonia aculeata.

Additional information on the extent of deciduousness in south Florida hammock forests and its more precise correlation with climactic conditions would be of considerable interest.

DESCRIPTIONS OF SOUTH FLORIDA HAMMOCK FORESTS

The distribution of hammock forest vegetation in the region is governed by the occurrence of sufficiently elevated sites. These elevations may either be features of the original substrates (e.g. the Miami Rock Ridge), or vegetation-induced through peat deposits built up under swamp forest vegetation types (bay and perhaps mangrove forests). A third class of elevations occupied by hammock forests are the mounds resulting from the activities of early Indians. In areal extent the hammocks of natural elevations are much more prominent than those occupying deep peat deposits, although the latter are of great ecological interest. The necessary elevation for hammocks on deep peat is provided by soil that is subject to destruction by fire, as discussed later. This may account for the relative rarity of such hammock sites. Disregarding these, it may be said that the available elevations are located in four discrete regions: 1. The Miami Rock Ridge, 2. The south and southwest coasts; 3. The Upper Florida Keys; and 4. The Lower Florida Keys*. The hammock forests of sites within each of these regions show certain similarities, and differ somewhat as a group from those of each of the other regions, both in floristic composition and in general forest aspect. At present it cannot be definitely stated to what extent many of the supposed differences are due to inadequate knowledge of the regions (e.g. incomplete botanical exploration, comparison of forests not strictly comparable in age or disturbance history, etc.). Some of the differences, however, appear to truly represent the vegetational expression of differing characteristics of the particular regions (i.e. regional variation of climate, substrates, geographic location and geological history).

In the following account these hammocks of four regions are briefly discussed and the regional peculiarities noted. Table 5 shows the floristic relations between the regions as indicated by present knowledge of the distribution of the woody plant species of the tropical hammock forests. Table 13 (see Appendix) gives complete lists of the woody plants of 25 sites representing all four regions.

MIAMI ROCK RIDGE HAMMOCKS

These are hammocks occurring on the ridge of Miami Oolite which extends south and southwest from Miami into the Everglades. Within the

* A complete consideration of the south Florida hammock forest vegetation would have to include hammocks of the Pinecrest area of upper Monroe Co., and the more northerly hammock outliers along both coasts of the peninsula and both sides of the Everglades. None of these areas were covered in the present survey.

region individual stands often show much floristic variation. This appears to be associated with two factors: 1. Nearness to the coast and 2. Fire.

1. The rock ridge fronts on Biscayne Bay from the present site of Miami south to the vicinity of Cutler. This is the most elevated oolite area, probably the oldest part of the rock ridge, and the area most accessible to water-borne seeds. Much of it originally supported hammock forest, isolated patches of which remain. These coastal rock ridge hammocks because of their location and because they are evidently older and less disturbed by fire contain a number of woody plants not found elsewhere in the region. Some of these species occur generally in hammocks near the coasts and their presence merely indicates a coastal site. Examples of these are Sophora tomentosa, Jamaica dogwood (Ichthyomethia), bay cedar (Suriana), Geiger tree (Cordia), and seven year apple (Casasia). Other restricted species are not necessarily limited to coasts, and their presence in the coastal rock ridge hammocks may be a floristic indication of the greater maturity of these hammocks as compared to others on the rock ridge. Some of these species are bitterbush (Picramnia), Misanteca triandra and red stopper (Eugenia confusa).

2. With the possible exception of the coastal hammocks just mentioned all rock ridge hammocks show signs of fire damage. The effects now visible vary greatly from stand to stand and it is likely that no two have the same history of fire disturbance. Available fire history information for any particular area is vague at best, and it is not now possible to form a clear picture of fire effects on the composition of the rock ridge hammock forests. Provisionally I attribute the great floristic variation often seen in closely adjacent stands of hammock forest (especially in the Long Pine Key area) to variations in the effects of fire.

Eighteen woody plants are limited to the hammocks of the rock ridge of which ten (*) represent widespread south temperate species here reaching their southern range extremities. The species restricted to rock ridge hammocks are: Salix amphibia, *Morus rubra, *Celtis mississippiensis, *Magnolia virginiana, Laurocerasus myrtifolia, Alvaradoa amorphoides, *Rhus leucantha, Ilex Krugiana, *Ilex Cassine, *Ampelopsis arborea, Misanteca triandra, Tetrazygia bicolor, Anamomis Simpsonii, *Diospyros Mosieri, Bumelia reclinata, Forestiera pinetorum, *Callicarpa americana, and *Cephalanthus occidentalis.

The rock ridge hammocks are more uniform in aspect than in composition. In general they give the impression of moist forests with an abundance of mosses and hepatics (including epiphyllous species) and often with a dense growth of ferns on the forest floor. Wet sinks with the rock walls covered with ferns and mosses are frequent. Epiphytic ferns, orchids and bromeliads are abundant and lianas of several species are common. The stratification of the woody vegetation is difficult to judge because many stands are obviously disturbed and immature. If such a hammock as Paradise Key represents near-mature structure, it appears that three fairly well defined strata are present: A discontinuous upper layer of scattered large trees; the closed forest canopy; and a shrub-small tree layer. Figs. 10 and 11 show views of two Long Pine Key hammocks; an interior picture of Dark Hammock and a view of the edge of Sawmill Road Hammock from the adjacent pineland.

The Mahogany Hammocks lying southwest of the west end of Long Pine Key near the inner mangrove edge do not properly belong to any of the four main regions outlined. In structure, however, they resemble the rock ridge hammocks more than they do those of the other regions. They are also moist forests, with many lianas and epiphytes and several strata of woody vegetation. The ecologically interesting point about these hammocks is that they appear to occupy deep peat deposits built up over marl and not original rock elevations. This suggests that they may represent a more mature stage in the development of vegetation on sites once occupied by bayheads. No evidence of fire was found in the mahogany hammocks investigated. They are certainly burnable but the sites may lie beyond the usual limit of sawgrass fires burning down toward the mangrove edge. The southwestern most finger of the May 1950 Long Pine Key fire reached to within a little over a mile northeast of the northeasternmost mahogany hammock. Fire protection is provided by two characteristics of the surrounding marl glades. 1. Glades in this area are flooded for a longer period than most of the rest of the south glades. They may be completely dry late in the dry season, however, and one can often hike dry-shod to the nearer mahogany hammocks (as was true on several trips made in April 1952). 2. Sawgrass vegetation of glades surrounding these hammocks is very sparse and possibly would not carry fire readily.

List #11 (Table 13: appendix) shows the woody plants of the most accessible of the Mahogany Hammocks. The flora shows relations to that of the nearby Long Pine Key hammocks in the presence of such species as live oak, bustic and Hippocratea. The point of greatest interest of course, is the occurrence here of numerous large mahogany trees some of which exceed 4' DBH. Fig. 12 shows one of those. Only the two or three northeasternmost (and most accessible) hammocks have been explored botanically, and it is quite possible that knowledge of the flora of the Mahogany Hammocks is incomplete. There is, for that matter, some reason to doubt that the extent of the mahogany hammock area is entirely known.

Also located at (or within) the inner mangrove edge are tree islands characterized by the presence of the rare palm, Paurotis Wrightii. This belt is crossed by the Ingraham Highway to Flamingo and the half dozen or so stands most easily reached from the road have been much visited and quite a few of the palms were removed in pre-park days. The Paurotis belt extends for a considerable distance on both sides of the road. It is one of the least known areas of Everglades National Park which prompts one to speak cautiously in discussing it.

This vegetation type may be described as islands of hardwood forest located in a bush-savannah of red mangrove (Rhizophora). The ground cover vegetation in openings between the mangroves consists of scattered tufts of small sawgrass or thinly distributed Eleocharis cellulosa. The soil of surrounding areas is deep marl. The forest sites themselves are characterized by deep peat deposits, and hence are similar to the mahogany hammock and bayhead sites. Characteristics of the surrounding glades provide fire-protection in the manner just noted for the mahogany hammocks. This vegetation may be called either hammock or bayhead almost equally aptly. Egler (1952, pp. 258-259) points out the general structural similarity to bayheads of the more landward glades and gives a plant list for the one stand studied. To his list of species the following may be added: Trees - spicewood (Calyptranthes pallens), Marlberry (Icacorea paniculata), poisonwood (Metopium toxiferum) and gumbo-limbo (Elaphrium simaruba). Lianas-Hippocratea volubilis, hammock snowberry (Chiococca alba), and poison ivy (Toxicodendron). The few stands visited in the course of this study showed considerable variability in the relative importance of bayhead and hammock species. The observed floristic variability, considering the very few stands investigated, suggests the wisdom of awaiting more data before making any more definite pronouncement on the status of this vegetation. It is possible that the Paurotis tree islands represent a number of stages in the replacement of bayhead vegetation by tropical hammock forest. They certainly merit much more study.

SOUTH AND SOUTHWEST COAST HAMMOCKS

Hammocks here referred to occur on two substrate types: 1. Elevated areas of marine marl near the coast; and, 2. Shell beach ridges fronting on Florida Bay or the Gulf of Mexico. It is convenient to discuss these separately although there is evidence that mature hammock forests of the two sites may not differ greatly.

The marl hammock areas are largely confined to a discontinuous belt along the south coast extending from near Bear Lake east as far as Trout Cove. Other hammock stands such as those occurring along the north side of Cuthbert, Munroe and Seven Palm Lakes are perhaps also to be included here. The hammock areas are shown on U. S. Coast and Geodetic Survey Topo. Sheets T-5439, T-5440 and T-5441 prepared from the 1940 series of air photos. The total hammock area is quite extensive, and much of it has suffered from fire and hurricanes. Many large mahogany trees were reportedly cut in the hammock strip between Snake Bight and Crocodile Point, and elsewhere along the south coast, in the years prior to the establishment of Everglades National Park; but I was not able to locate much definite information on this unique chapter in the history of U.S. lumbering. Only small sections of this hammock area have received careful botanical exploration. The present account is based on the hammocks of the Bear Lake - Coot Bay - Snake Bight section (see list #9, Table 13), the only area in which this vegetation type was studied.

Hammock forests of this area resemble those of the Florida Keys more than they do rock ridge hammocks both in floristics and in aspect. The floral relation is shown positively by the prominence of such species as Jamaica dogwood, slender thatch palm (Thrinax parviflora), soapberry (Sapindus), several species of columnar cacti, mahogany, Eugenia buxifolia, wild cinnamon (Canella) and manchineel (Hippomane). They seem to lack such characteristic plants of the rock ridge hammocks as bustic (Dipholis), live oak, paradise tree (Simaruba) and Lysiloma. As now known the woody flora is much poorer in species than that of any of the other regions, but further exploration will doubtless add many species to the present list.

In appearance the marl coastal hammocks are dry forests. Epiphytes are not common in the hammocks, although adjacent buttonwood and mangrove forests have many bromeliads and had at one time an abundance of large spray orchids (Oncidium). Lianas are not well-developed, and no ferns occur on the forest floor. Some of the trees are regularly dry-season deciduous. No stands which appeared mature were seen but it seems likely that the mature forests of the region will be of simpler structure and less statified than the rock ridge hammocks.

The hammocks of shell beach ridges are found in this region and on the Florida Keys and Florida Bay Keys wherever sufficiently elevated beaches occur. The vegetation is quite similar at sites throughout this area. Plant lists for several beach ridge hammocks are given in Table 13 and these sites are briefly discussed. Davis (1942) has discussed a number of beach ridge hammocks in his study of the vegetation of the keys west of Key West.

Early hammock growth on beach ridges is usually a low thicket composed of a few pioneer species. Usually prominent at this stage are: sea grape (Coccolobis uvifera), blolly (Torrubia), bay cedar (Suriana), Pithecolobium guadelupense, Sophora tomentosa, buttonwood (Conocarpus), Spanish stopper (Eugenia buxifolia), Joewood (Jacquinia), sea lavender (Mallotonia), seven year apple (Casasia), Erithalis and Borrichia arborescens. From this community, which is quite distinct in composition, development evidently proceeds toward a mixed forest dominated by gumbo-limbo, Jamaica dogwood, mastic, strangler fig, poisonwood, pigeon plum (Coccolobis laurifolia) and inkwood (Exothea). The mature forest on beach ridge sites (as represented by the Cape Sable hammocks) will evidently be similar in aspect and composition to those developed on other substrates in the south coast region and the Florida Keys.

An interesting feature of the beach ridge vegetation is the frequent development of distinct vegetation belts, especially at places where the foreshore slopes steeply. The exact arrangement of these varies with the profile of the beach ridge. Commonly there is an outer hedge of bay cedar developed. In some cases as near Middle Cape Sable, a double hedge, (the outer a pure stand of bay cedar, the inner a pure stand of Pithecolobium) occurs in front of the hammock proper.

The tropical hammock forests of the Florida Keys do not enter Everglades National Park and remarks on them here will be accordingly brief.

UPPER FLORIDA KEYS HAMMOCKS

These hammocks occur on elevations of Key Largo coral Limestone which forms the keys from Soldier Key to the West Summerland Keys. This geological formation also forms the Hawk Channel front of some of the Lower Florida Keys, including at least Big Pine Key and the Newfound Harbor Keys and perhaps others southwest to Sugarloaf Key. On the main Key Largo Limestone keys hammock forest originally occupied virtually the entire upland area between mangrove belts on either shore. Much of the hammock area has been obliterated by clearing and the remainder disturbed to some extent by fire so that little original forest remains, except for that of such outlying islands as Lignumvitae Key and Pumpkin Key. Abandoned cleared areas are occupied by tangled thicket growth of such species as Lantana involucrata, Solanum verbascifolium, Trema and hog plum (Ximenia). Hammock forest appears to replace this thicket vegetation directly, if no further disturbance occurs.

The Upper Keys extend southwestward across a sizeable sector of the east-west gradient of decreasing rainfall. This is evident in comparing the aspect of the hammock forests of upper Key Largo and Lignumvitae Key.

The former more resemble those of the Miami Rock Ridge, while the Lignumvitae Key hammock is similar to hammocks of the south coast, except that it is apparently still dryer and lacks epiphytes almost completely. The decreasing rainfall may also affect the distribution of some species such as Lysiloma, which is not conspicuous in the hammocks south of upper Plantation Key, and thatch palms, which become increasingly prominent as one proceeds southwest along the keys.

The flora of the Upper Keys hammocks lacks all of the south temperate species which occur sparingly in the rock ridge hammocks. Two woody species nakedwood (Colubrina reclinata) and lignumvitae (Guaiacum) are limited to Upper Keys hammocks. A number of species are shared between Upper Keys hammocks (especially north Key Largo) and the coastal rock ridge hammocks. These include: bitterbush (Picramnia), red stopper (Eugenia confusa) and Calyptranthes zuzygium.

LOWER FLORIDA KEYS HAMMOCKS

As indicated in the preceding section the geological Lower Keys are not precisely equivalent to the geographical Lower Keys due to the southwestern extension of the Key Largo limestone. These are keys formed by Miami Oolite which extend from Little Pine Key to the Marquesas. Only a few of them have extensive uplands and most of the upland area is occupied by pine-palm forest. The pinelands burn frequently and the hammock-pineland relation appears to be similar to that existing on the Miami Rock Ridge. The Lower Keys hammock forests are probably the most xeric hammock type in South Florida.* These hammocks virtually lack epiphytes, lianas and forest ferns, many of the trees are deciduous, and forest statification is not highly developed.

The flora is interesting for several reasons. Six tropical species of woody plants occur in Florida only in the Lower Keys. These are: Pisonia rotundata, Caesalpinia pauciflora, Savia bahamensis, Gyminda latifolia, Cupania glabra and Clusia rosea. Several species of the rock ridge hammocks, absent from the Upper Keys, reappear in the Lower Keys. These include: wax myrtle, Byrsonima cuneata, redbay, cocoplum, myrsine, and Guettarda scabra. Finally some expected species, such as mastic and mahogany, appear to be absent.

*This excepts the hammocks associated with tree cacti (Cephalocereus) which are of limited extent in South Florida. Stands were originally present on Lower Matecumbe Key, Key West and Big Pine Key (Southeast Hammock). The first two of these have probably been destroyed. These hammocks perhaps represent an approach to the "Thorn Woodland" or "Cactus Scrub" formations of Beard (1944: 140).

TABLE 5. Distribution of woody plants of tropical hammock forests in the four hammock regions of south Florida.

	Ridge	Coasts	Up. Keys	Lower Keys
Total number of Species	110	71	94	94
Species Limited to the Region	19	2	3	6
Number of Species in Common and (in parenthesis) No. of Sp. Limited to two regions.				
Miami Rock Ridge		56(2)	76(8)	72(10)
South and Southwest Coasts	56(2)		65(1)	61(0)
Upper Florida Keys	76(8)	65(1)		74(3)
Lower Florida Keys	72(10)	61(0)	74(3)	

HOW MANY HAMMOCK "TYPES" IN SOUTH FLORIDA?

The foregoing section has shown that considerable variation, both in composition and structure, occurs in the tropical hammock forests in their south Florida range. The above question is thus obvious, but it is one that cannot be finally answered from information now at hand. Provisionally, it seems best to consider that there is a single tropical hammock forest type in south Florida which varies, probably in response to many factors, of which the principal ones appear to be increasing frequency of destructive frost northward, decreasing rainfall westward, and location of the site in relation to the coast. There has been considerable speculation attempting to explain the total floristic similarities and differences between various south Florida regions (see Simpson, 1920, Chapters I and VII) by juggling the sequence of late Pleistocene geological events. It seems preferable in an ecological consideration of this vegetation type to determine first just what the extent of variation is in stands of comparable maturity in the various regions.

Several things suggest the desirability of this suggested hypothesis as a working position that deserves careful testing in the field.

1. With few exceptions the species of large trees available in the flora as possible dominants of a self-maintaining hardwood forest are prominent throughout south Florida. This is true of poisonwood, gumbo-limbo, inkwood, strangler fig, shortleaf fig, pigeon plum, leadwood, Jamaica dogwood and satinleaf. The apparent exceptions such as the absence of live oak except on the Miami Rock Ridge*, of bustic from much of the Upper Keys and the south coast; of *Lysiloma* from the south coast and Lower Keys; of paradise tree from the south coast; and of mastic and mahogany from the Lower Keys, may have ecological rather than geological or phytogeographical explanations. It seems, therefore, that an eventual hammock forest permitted to mature should have much the same dominants throughout south Florida. Simpson (*loc. cit.*, Chaps. IX and X), for example, has described the elimination of live by succession in

* Occurs very rarely in Key Largo (Alexander, 1953).

TABLE 6. Species composition of the forest canopy at four South Florida tropical hammock forest sites.[1]

Species	Paradise Key	Long Pine Key Dark Hammock	Long Pine Key Saw-Mill Road Hammock	Lignum-vitae Key
Quercus virginiana (live oak)	45%	4%	19%	
Metopium toxiferum (poisonwood)	11%	6%	11%	26%
Elaphrium simaruba (gumbo-limbo)	9%	9%	9%	30%
Dipholis salicifolia (bustic)	8%	17%	4%	
Calyptranthes zuzygium (no common name)	7%			
Ficus aurea (strangler fig)	5%	3%	3%	#
Simaruba glauca (paradise tree)	5%	#	1%	
Laurocerasus myrtifolia (laurel cherry)	4%			
Exothea paniculata (inkwood)	3%	#	#	3%
Roystonea regia (royal palm)	1%			
Ficus brevifolia (shortleaf fig)	1%			#
Sideroxylon foetidissimum (mastic)	1%	1%	3%	11%
Lysiloma bahamensis (wild tamarind)	#	58%	43%	
Coccolobis laurifolia (pigeon plum)	#	2%	7%	12%
Ichthyomethia piscipula (Jamaica dogwood)				8%
Krugiodendron ferreum (leadwood)				6%
Torrubia longifolia (blolly)				2%
Gymnanthes lucida (crabwood)				1%
Sapota achras (sapodilla)				1%
Number of Species	12	8	9	10

1 Data from random counts of trees entering the forest canopy. Based on counts of 200 + trees in the least disturbed parts of the four sites.

Occurs in canopy stratum elsewhere in the hammock but not in area studied.

mature rock ridge hammocks, an occurrence which (if general) eliminates the major difference in the hammock dominants of this region. The great difference in the relative importance of the various canopy species from stand to stand (see Table 6) are provisionally regarded as due (in part at least) to the different stages of maturity and different disturbance histories of the stands studied.

2. It seems probable that most of the floristic differences eventually found between mature forest stands of the various tropical hammock regions will involve sub-dominant woody species, ferns and epiphytes. These species are more dependent on a narrow range of micro-climatic conditions than are the dominant trees that form the hammock canopy. The differences in aspect and structure of hammocks of the various regions have been noted. Some of these can certainly be translated into environmental differences that affect the sub-dominant plants and limit them to a particular segment of the climatic range represented within the tropical hammock forest vegetation type.

It appears to me that species distributions should first be carefully examined to see whether or not the various range limits can be explained in relation to present temperature and rainfall gradients in South Florida, or to other ecological factors. Only in instances where the present variations of environmental factors seem inadequate to explain the facts of distribution does it appear either wise or necessary to entertain more remote speculations.

BAYHEADS - SUBSTRATE

This vegetation type occupies deep deposits of organic soils. Bayhead soils of South Florida are classified as "Gandy Peat" by Henderson (1939) who also gives a description of the components and characteristics of the soil type.

BAYHEADS - VEGETATION

The principal study of South Florida bayheads is that of Egler (1952: 241-248), who discusses their floristic composition, structure, site relations, origin, and successional trends and the factors affecting them. His study was limited to the southeastern area between the Miami Rock Ridge and the coast. A briefer general account of the bayhead vegetation of the "slough and tree island area" of the main Everglades drainage is given by Davis (1943: 265-268). In view of this recent work only a brief description of this vegetation type will be given here.

The bayheads are hardwood forests composed of relatively few species, which occur as tree islands in the Everglades prairies. As Egler's table of frequency of occurrence of species (op. cit.: 242) shows the most constant of the woody plants are redbay (Tamala Borbonia), wax myrtle (Cerothamnus ceriferus), myrsine (Rapanea guayanensis), cocoplum (Chrysobalanus icaco), dahoon holly (Ilex Cassine), and sweet bay (Magnolia virginiana). These species make up the major part of the bayhead vegetation throughout the region. Locally, cypress (Taxodium) and pond apple (Annona) may occur in bayheads, and willow (Salix) and buttonbush (Cephalanthus) are frequently present, especially in the main glades. Toward the southern part of the region various tropical hardwoods and palms enter this vegetation type, but these are usually present only as scattered individuals. Many hammock tree species may be found, but among the more frequent are marlberry (Icacorea), strangler fig (Ficus aurea poisonwood (Metopium), white stopper (Eugenia axillaris), cabbage palm (Sabal), and Wright's palm (Paurotis).

In structure the bayheads are dense forests of low-growing trees. Typically they have a tight hedge border of cocoplum with more open forest inside. Shade is dense and herbaceous plants are few. The forest floor may lack vegetation, or support an understory of ferns, Blechnum serrulatum and Dryopteris normalis being two species frequently found. The forest is characteristically much overgrown by such lianas as Smilax laurifolia, Virginia creeper (Parthenocissus), and muscadine (Muscadinia). Relatively few epiphytes occur, these chiefly bromeliads. Fig. 13 shows the manner of occurrence of the bayheads as islands in sawgrass marshes. Fig. 14 gives a closer view of the edge of a bayhead showing the abrupt transition between forest and sawgrass, and the outer cocoplum hedge.

BAYHEADS -- ECOLOGICAL PROBLEMS

The bayhead vegetation is relatively simple in floristics and structure. Descriptively the vegetation type is well understood, yet it presents a trio of unsolved ecological problems, and a vexing question of terminology, which have plagued every student of South Florida vegetation. These may be indicated as follows: 1. What is the relation of the bayhead vegetation type to other regional hardwood forests; 2. What factors control the location of bayheads; 3. What is the true nature of certain disputed characteristics of bayhead sites; and, 4. What is the proper term to designate this forest type? The nature of these problems will be briefly sketched here. Their solution will demand much careful field study.

Relation of Bayheads to Other Hardwood Forest Types.

The floristic picture of the bayhead vegetation is as follows: In the South Florida area hundreds of separate stands of this forest type occur as islands in the glades. In composition the forest is remarkably uniform throughout the region. Nearly all stands are composed almost entirely of the five or six species listed earlier. These species appear to possess in common the ability to tolerate wetter sites than most of the hardwoods of the region. As a group they also appear to be intolerant of competition on hammock forest sites, and are found only sparingly in the hammock forests. Throughout the bayhead vegetation type occur scattered individuals, frequently seedlings, of hardwood species characteristic of hammock forests. These seldom constitute more than a very small percentage of the total vegetation in any stand, but most bayheads, at least in the southern part of the region, contain a few specimens. The species of hammock hardwoods which occur more frequently have been mentioned. A complete list of all species that have been observed would include a large proportion of the woody plants of the hammock forest vegetation type.

From information such as the above the inference that hammock forests will replace bayhead vegetation on undisturbed sites is easily drawn. Both Davis (op. cit.: 211-212) and Egler (op. cit.: 247-248) have reached this conclusion. The bayhead vegetation is viewed as a pioneer forest community on wet sites, which is replaced by a hammock forest of mixed hardwoods in the course of succession. I agree with this concept of the relation of the two hardwood vegetation types, but wish to point out that its present status is that of a reasonable working hypothesis, which awaits convincing demonstration. Two chief difficulties exist:

1. Intermediate stages showing bayhead species being replaced by hammock hardwoods have rarely been observed. If succession occurs as outlined above one would expect to find forests showing mixed dominance. It is probable, as Egler suggests, that fire prevents this development on most sites; that most bayheads burn out before the site can develop to the point where it is suitable for hammock forest species.

2. The exact nature of the changes in the characteristics of the site which permit replacement of bayhead vegetation by hammock forest are obscure.

The Mahogany Hammocks and Paurotis Hammocks of the extreme southern Everglades occupy sites which are similar to bayhead sites. These hammock forests, near the inner mangrove edge, are well-protected from fire by the nature of the surrounding glades. They are possibly hammock forests developed from bayheads during a long fire-free interval. Careful study of these sites, and comparison with bayhead sites is indicated as a likely starting point in investigation of the successional relations of the bayheads. Also further botanical exploration of the bayheads should reveal at least a few clear cases of succession of hammock forest species on bayhead sites, if this phenomenon really occurs.

Factors Determining Bayhead Location.

The ecologist in South Florida is soon faced with the problem of explaining why bayheads are located at the particular sites they now occupy. Two views are possible: 1 - that present bayhead locations represent survival sites of islands of a former continuous forest; or, 2 - that occurrence of bayheads is limited by special topographic characteristics of the sites they occupy.

The extreme interpretation of the first view would hold that bayheads are actual fragments of a former forest whose present locations are entirely the result of chance survival. A modified interpretation is that the bayhead tree islands are segments of former forest that have survived only at sites where special topographic characteristics provide fire protection. The evident floristic immaturity of the present bayhead vegetation seems to be strong evidence against the idea that they are in any manner actual fragments of an old forest, and no author has maintained this view. Egler (op. cit.: 234) has presented the hypothesis that a continuous swamp forest clothed the entire glades in preaboriginal time, and that fire acted to restrict the remnants (bayheads) to their present sites. He believes, however, that present bayheads have also been reduced by fire, probably many times, and that they have been able to become re-established only at sites which enjoy special fire protection.

The second possible interpretation is that only certain sites in the glades are suitable for invasion by bayhead vegetation. This contrasts with Egler's (ibid.) view that any glades site is open to invasion by bayhead species, but that fire prevents establishment of bayheads except at certain site

Just what the special characteristics of bayhead sites are remains obscure. In some areas bayheads are oriented with the direction of flow (or former flow) of Everglades surface waters, and many of them exhibit a teardrop shape with rounded upstream "head," and tapering downstream "tail." These characteristics have been interpreted as indicating a relation between drainage channels and the location of bayheads, but the nature of the relation is not clear. Davis (op. cit.: 258) discussing the "slough and tree island area" of the main Everglades drainage, states that bayheads develop on "ridges" between the slough runs. Egler (op. cit.:246) discussing the area southeast of Long Pine Key, believes that the initial bayhead establishment is in a drainage channel where the wetter site provides additional fire protection. In addition there are sizeable areas where bayheads show no regular orientation in relation to drainage pattern.

This question of the factors which determine the occurrence of bayheads is still entirely undecided. Of the suggested factors I believe that elevation is the most likely control, and suggest the hypothesis that duration and extent of annual flooding determines whether or not bayhead species can invade a glades site. The requisite elevation for the occurrence of bayhead species could occur either in the original topography or by buildup of peat deposits. Under the above hypothesis a lowering of glades water levels should result in an expansion of bayheads. I believe that this is now occurring throughout the lower glades.

Disputed Characteristics of Bayhead Sites.

The uncertainty about the factors controlling location of bayheads stems from the existence of seemingly contradictory information concerning their site characteristics. No agreement exists as to whether or not bayhead sites are more elevated than the adjacent glades. A wealth of random observational evidence suggests that they are considerably more elevated. However, Egler (op. cit.:244) found that the surface of the peat mass in two bayheads he studied was at the same level as the marl surface of the surrounding glades. Careful study of a series of levels along a transect from glades through the centers of bayheads, at a time when both glades and bayhead soils are dry, suggests itself as a means of approach to this puzzling problem. There is so much casual evidence that elevation does affect the occurrence of bayhead species that despite Egler's findings, further investigation seems required. Fig. 14a shows how bayhead species occupy relatively slight elevations in the sawgrass marsh. The picture, a view of the old Jennings Plantation, shows plants of redbay, sweetbay, myrsine, wax myrtle, and dahoon holly that have invaded elevated sites on rows in the onetime citrus grove. The soil is thin marl over oolite throughout.

There is also question as to whether the pH of the soil solution in the bayheads is acid or alkaline. Davis (1943:115) writes:

"The bay-head trees, Persea, Myrica, and Magnolia, and ferns, Osmunda and Blechnum, occur on very acid to circum-neutral soils ... It ranges from pH 3.55 to pH 6.80 for the surface soils. The bay forests grow on a great variety of soils but in general the humus and peat layers they form are strongly acid."

Ledin (1951:63) refers to "bay tree hammocks in the Everglades on very acid peat." However, Egler (1952:244-5) writes:

"Mr. Gallatin reports that of several hundred soil tests he has made on hammock peat, the pH ranges from 7.5 to 8.5, with an extreme of 7.0. From these data, it must be assumed that the soil solution is normally basic."

Egler (ibid.) however, continues:

"Without in any way refuting these data, it must be said that there are certain botanical conditions (including not only the kinds of plants present, but the size and shape of the peat lens below the hammock) that lead one to infer that the soil solution can under certain abnormal and temporary circumstances, become sufficiently acid to alter radically the characteristics of the hammock in ways that persist through succeeding alkaline times."

This hypothesized occasional acidity is the important element in Egler's explanation of the flatness of the bayheads. He writes (op. cit.:246-7):

"The hypothesis is presented that peat-deposition and marl-dissolution work simultaneously. Although tests earlier referred to indicate that the soil solution of the peat is normally alkaline, it was then suggested that this solution could be acid at isolated times under unusual circumstances. On such rare occasions, the basic marl could be dissolved... that some sort of balance exists between the two processes is indicated by the flatness of the hammocks, i.e., peat does not build up faster than the marl dissolves below."

Little more can be said of this problem except to note that the reported pH range, 3.55 to 8.5, is exceptional, if not unprecedented, for a presumed single soil type. The need for careful re-investigation is obvious.

BAYHEADS - TERMINOLOGY

I have here referred to the tree island hardwood forests dominated by Tamala, Magnolia, Dorothamnus, Ilex Cassine, and

Chrysobalanus as bayheads. Davis (1943) uses this term and also refers to "Bay Tree Forests" and "Bay Tree Islands." Other authors (Egler, 1952: Ledin, 1951: et al.) have referred to this vegetation type as "hammocks." Objections to this usage were given earlier. — This vegetation type differs from the hammock forests only in its floristics. Since hammock forests will (quite possibly) invade and eventually replace bayhead vegetation, these floristic differences may be expected to disappear in the course of succession. The need for two terms may thus be easily questioned on logical grounds. I believe, however, that the usefulness of the two terms is apparent in the field. The reason for this is that, due perhaps to fire, extremely few forests representing intermediate successional stages exist. The terms "bayhead" and "hammock" are thus almost mutually exclusive under present conditions, and the practical value of distinguishing the two floristically different forest types by common names is apparent.

I am not prepared to go to bat very vigorously for the term "bayhead." It enjoys local usage, and I have followed this. However, as noted for the term "hammock," it is variously used elsewhere in Florida and the southeastern states. In other areas the term is commonly applied to forests occurring in flatwoods ponds and to some riparian swamp forests. Laessle (1942, p. 41) terms bayheads the "Gordonia - Tamala pubescens - Magnolia virginiana Association" and states, "the term 'bayhead' designates an association dominated by broadleaved evergreen trees that grow in very acid, saturated soils which are subject to periodic flooding." Although I am not familiar with the North Florida "Bayheads," it appears from published descriptions that these "bayhead" sites may differ considerably from those of South Florida though some of the same tree species are prominent in both. Confusion is thus possible (perhaps, likely) but I have no alternative term to suggest.

SAWGRASS GLADES -- SUBSTRATE

The sawgrass areas of Everglades National Park occur on low-lying seasonally flooded freshwater marl and peat soils which form a blanket of varying thickness over the Miami Oolite. At the present time most of the deep sawgrass peat areas in the park are found in the Shark River "Valley," which forms the main southwestern drainage of the Everglades. Elsewhere marl predominates with only scattered areas of peat. Davis (1946, Figure 13, p. 122) has discussed and mapped the peat areas of the southern Everglades. His map shows little deep peat present in the Everglades National Park area.

At many places particularly near the edges of the glades and around Long Pine Key there are extensive glades rockland areas. Here much-eroded limestone "pinnacle rock" is exposed and the marl soil is limited to solution pockets in the oolite.

SAWGRASS GLADES - VEGATATION

The sawgrass glades vegetation occupies a larger area than all other vegetation types of Everglades National Park combined, but perhaps less, definite information is available concerning it than for any other vegetation type. The vegetation can be described in general terms as a winter dry marsh dominated by various grasses and sedges of which sawgrass (*Mariscus jamaicensis*) is the most prominent species. Several local variations in the vegetation may be distinguished such as the areas modified by farming operations, the "aquatic pockets" and gator holes, the savanna areas of red mangrove or cypress, and areas dominated by grasses and sedges other than sawgrass; but we cannot say with much assurance just what controls the occurrence of many of these variations. Data are not at hand to permit discussion of the distribution of glades plant species in relation to soil type, to the length of the period of annual flooding or to salinity, all of which are factors of possible importance. This ecological blindspot is most unfortunate because the sawgrass glades is undoubtedly the vegetation type most likely to undergo widespread changes under the impact of drainage and fire. Some of these changes that involve extensions of shrub vegetation into the marsh are already noticeable as mentioned in the previous section. It is possible that important and widespread changes in the dominance relations of the various herbaceous species of the Everglades formation may also be taking place. The importance of a program of careful ecological study of the Everglades marshes seems clear.

The following section will briefly describe some of the major variations that occur in the glades vegetation of the Everglades National Park Area.

Agricultural Areas — Egler (1952, pp. 249-251) has described the modifications of vegetation in the cultivated marl glades east of the park. A similar picture is apparent in the farm area south of Long Pine Key. The general succession on abandoned farm lands proceeds from weed fields of ragweed (*Ambrosia elatior*), sesbania (*Sesban emerus*) and giant panic-grass (*Panicum maximum*), to a low thicket community dominated by primrose willow (*Jussiaea scabra*), to woody growth of willow and *Baccharis* (*B. halimnifolia* and *B. glomeruliflora*). At present the oldest abandoned farm lands in the immediate park area are occupied by this willow-*Baccharis* growth. Scattered trees of bayhead plants are to be found throughout, which suggests that, given time, a vegetation type similar to bayhead vegetation will occupy what were open glades before cultivation. Fig. 15 shows dense summer growth of ragweed on marl glades after winter farming.

A number of plants have become established around the cultivated glades areas below Long Pine Key, many of them widespread weed species. Most of these will probably disappear when the land is finally abandoned, but some may be potential nuisances. A list of some of the species observed is given below:

Argemone mexicana (prickly poppy)
Cheirinia cheiranthoides (wormseed mustard)
Verbena bonariensis (vervain)
Vigna repens (a vining legume)
Medicago lupulina (black medic)
Spilanthes repens (a vining composite)
Solanum nigrum (common nightshade)
Melilotus alba (white sweet clover)
Sonchus asper (sow thistle)
Lactuca intybacea (wild lettuce)
Spermolepis divaricata (in carrot family)
Verbena scabra(vervain)

"Aquatic Pockets" and Gator Holes - Throughout the glades are found scattered depressions of various sizes wetter than the surrounding marsh plains and characterized by different vegetation. Egler (ibid., p. 249) has termed these "aquatic pockets." They are also commonly called "'gator holes" from their resemblance to the ponds often maintained by large alligators. These ponds have probably originated in several ways. Some are actually 'gator holes though their distribution is much more general over the glades than that of the alligator at present. Others may represent spots where deep peat accumulations have burned out. Whatever their origin the deeper ones are extremely important in the ecology of the animal life of the glades in dry years. Plant species of such areas include: cattails (Typha), cane (Phragmites), glades lily (Crinum americanum), pickerel weed (Pontedaria), fire flag (Thalia) and arrowleaf (Sagittaria)

Scrub Cypress Area - Southwest of Paradise Key is an area of considerable extent, crossed by the Ingraham Highway, in which small pond cypress (Taxodium ascendens) occur scattered through the glades. A similar separate area lies along the north side of the west end of Long Pine Key. This weird vegetation first came to attention when the construction of the Ingrahan Highway reached the lower cypress area. Since that time many authors have given brief descriptions (Small 1920, 1931a, 1933; Harper, 1927; Egler, 1952, et al.), but no adequate explanation of the vegetation type has been advanced. The general assumption has been that the cypress here occur at an unfavorable site and are dwarfed in consequence. Certainly the aspect of the area hasn't changed noticeably since Small's first pictures and descriptions, and growth of the cypress here is evidently very slow. At some places along its borders this cypress savanna vegetation has an abrupt junction with the surrounding open glades, which raises questions as to what the controlling site factors may be.

Following is a description of the area from field notes.— The substrate is thin marl over oolite with scattered areas of exposed rock. The ground surface is covered by the algal mat that occurs throughout the glades. The overstory is scrubby gnarled pond cypress nearly all under 20' in height with many trees showing severe fire damage. The grass-sedge-herb layer under cypress is identical with that of the surrounding glades with black rush (Schoenus nigricans) dominant on higher sites, and sawgrass (Mariscus) on wetter sites. Irregularly throughout the scrub cypress area are clumps and strands of taller cypress in denser aggregations. These stands seem to occupy places lying below the level of the general area. Also throughout the area are bayheads usually with fairly large cypress around the edges, and the usual mixture of broadleaved tree species in the interior. — This is yet another vegetation type of Everglades National Park deserving close ecological study. Fig. 16 shows the aspect of the scrub cypress area with a bayhead and open glades without cypress in the background.

Red Mangrove Bush Savanna — Where the sawgrass glades meet the coastal mangrove forests a belt up to several miles in width occurs, in which red mangrove (Rhizophora) bushes are scattered over the glades. There is considerable evidence that this mangrove vegetation is extending inland, and widely scattered plants are to be found well in advance of the main belt throughout the glades south of Long Pine Key. Several authors have studied this vegetation (Davis, 1940; Egler, 1952) but the ecological controls over relations between the two vegetation types cannot be regarded as well-understood. Factors involved are certainly complex and possibly include fire, storm effects in dispersing Rhizophora seedlings, and rising sea level and surface water salinities. The present survey did not involve this vegetation and it can only be indicated here.

General Glades Vegetation - Herbs — Over the glades areas of Everglades National Park many herbaceous species occur along with the dominant sedges and grasses. These are seldom important in total numbers over any extended area, but they characterize the glades vegetation. In general these species appear to be more common in thin marl and rocky areas, and more common in areas recently burned than in those that have gone a number of years without fire. The following lists some characteristic species:

Calopogon barbatus
Aletris bracteata
Acnida cuspidata
Tubiflora angustifolia
Oxypolis filiformis
Proserpinaca palustris
Sabatia Elliottii
Kosteletzkya virginica
Hydrocotyle verticillata
Phyla nodiflora
Samolus floribundus
Samodea ebracteata
Agalinis Harperi
Ipomoea sagittata
Hypericum galioides
Heliotropium Leavenworthii
Asclepias lanceolata
Polygonum sp.
Eupatorium capillifolium
Eupatorium mikanioides
Conoclinium coelestinum
Mikania batatifolia
Helenium vernale
Pluchea foetida

Teucrium Nashii
Justicia lanceolata
Lobelia glandulosa
Solidago petiolata
Pluchea purpurascens
Cirsium vittatum
Coreopsis Leavenworthii

General Glades Vegetation - Sedges and Grasses — The list below gives the species of glades sedges and grasses detected in the course of this survey. It is certainly incomplete.

Grasses

Andropogon glomeratus
(broom grass)
Setaria geniculata
(foxtail)
Echinochloa Crus-galli
(barnyard grass)
Chloris glauca
(branching foxtail)

Rushes

Juncus scirpoides

Sedges

Cyperus surinamensis)
Cyperus polystachyos) sweet
Cyperus ligularis) rushes
Cyperus odoratus)
Mariscus jamaicensis (sawgrass)
Schoenus nigricans (black rush)
Eleocharis cellulosa (spike rush)
Rynchospora globularis)
Rynchospora Tracyi) beak
Rynochospora corniculata) rushes
Dichromena colorata
(white top)

Sawgrass is certainly dominant over a much larger area than any of the associated species, but the glades vegetation is not a vegetationally featureless sawgrass plain throughout. Over some areas of the park it is more a mosaic of pure stands of several different species evidently associated with small differences in elevation. It is important that the ecological relations of these species to wetter or dryer sites be carefully worked out, because they may offer a ready index to the direction of development of the glades vegetation, and a means of estimating the effects of future water management measures. We can easily note the invasion of sawgrass areas by shrubs or palmetto and associate this with the drying of the glades, but we cannot at present say whether changes in the areas occupied by various sedges and grasses of the glades mean anything or not. Yet, trends in drying of the habitat as it affects vegetation must be apparent first as changes in the dominance relations of species within the marsh vegetation.

The following notes some of the major variations seen.
1. Around Long Pine Key the black rush (*Schoenus*) occupies large areas to the exclusion of sawgrass. This species may be associated with slightly dryer sites as it sometimes occurs as a narrow belt around bayheads, or on obviously elevated spots. In some glades locations immediately adjoining rockland areas the vegetation is a mixture of black rush and various grasses. Also in such areas the advance of saw palmetto into the glades is often apparent.

BAYHEAD VEGEGATION OF
REDBAY, DAHOON HOLLY,
BAYBERRY, AND SWEET BAY
WITH AN UNDERGROWTH OF FERNS

FRINGE OF WILLOW, COCOPLUM, BUTTONBUSH, AND BAYBERRY

STRAND
OF
TALL
SAWGRASS

OTHER SEDGES AND GRASSES

"NEEDLE GRASS" SLOUGH RUN
VEGETATION OF BEAK RUSHES
(RHYNCHOSPORA TRACYI)

* "GATOR HOLES" WITH ARROWLEAF, GLADES LILY (CRINUM), PICKEREL WEED, CATTAIL, ETC: AND OCCASIONAL WILLOW AND POND APPLE TREES.

Diagrammatic cross section of an Everglades slough run -- T. 57 S., R. 35 E., Dade County, Florida.

This zoned configuration is quite apparent in aerial photographs of this section. Much variation from the above may be found. For example the "ridges" between slough runs are sometimes occupied by sawgrass strands without woody vegetation or by dense willow thickets. From brief study the major ecological control determining this arrangement of vegetation appears to be length of the period of annual flooding as governed by relative elevations.

EFFECTS OF FIRE ON SOUTH FLORIDA VEGETATION TYPES

> "It is my contention that the herbaceous Everglades and the surrounding pinelands were born in fires; that they can survive only with fires; that they are dying today because of fires."
>
> (Egler, 1952, p. 227)

PINE FOREST AREAS - SUBSTRATE, SOIL, AND GROUND LITTER

Direct effects of pineland fires upon the erosion of the limestone substrate of the pinewoods are apparently very minor. This is discussed in the attached statement by Ginsburg (Appendix). The idea that fires cause slaking of the limestone evidently originated with Small (1930) and has been perpetuated by later authors (Garren: 1943).

As previously mentioned, little soil exists in South Florida pine forest areas. The effects, if any, of fires upon the patches of Redlands clay soils which occur in pinelands have not been reported upon, so far as I could discover. The chief observed effect of pineland fires upon the substrate is to destroy most of the organic material accumulated since the last fire; the ground cover mat of pinestraw, dried grasses, and leaves; virtually all small ground litter; and many down logs and stumps.

PINE FOREST AREAS - PINE OVERSTORY

Small (1911:151) states "The pitch of the Caribbean pine does not flow readily, consequently these trees are not, as a rule, much damaged by forest fires." Various studies of fire effects on slash (or Caribbean) pine forests within the Southeastern Longleaf Belt are summarized by Garren (1943: 631-633). In general, findings of this work indicate that Caribbean pine is less fire tolerant than longleaf pine, and that it usually occupies sites having a lower fire - frequency where the two species occur in the same region. Germination and seedling survival of Caribbean pine was little stimulated by fire in marked contrast to longleaf pine, and survival of light burning by seedlings was only 10% that of longleaf. After passing the seedling stage, however, Caribbean pine was found to be virtually as fire tolerant as longleaf.

The pineland fires of South Florida are almost entirely ground fires. Small crown fires occasionally occur in areas where pine reproduction is very dense, but they are too infrequent to be of much consequence. Damage to trees beyond the seedling stage is limited to fire-scarring of trunks, which may kill the trees. Fig. 18 shows a part of the burned area of fire 123-6 (March 1951) where many overstory pines in an even-aged (approximately 20-year old), second growth stand were killed by trunk-charring. Older trees may accumulate severe basal fire scars as a result of repeated fires. Fig. 19 shows a pine 15 inches in diameter breat high fire-marked to a height of over six feet.

Counts made on new burns in South Florida show that about 50% of pine seedlings under three feet in height and a few of the larger seedlings are killed by the usual ground fire.

PINE FOREST AREAS - SHRUB UNDERSTORY

The typical Long Pine Key pineland site has a diverse shrub understory of hardwoods many of which are the same species which occur as trees in the hammock forests. Pineland fires usually kill the above ground parts of these shrubs. Roots of the plants, often deeply lodged in the limestone, usually survive fires, and the plant soon sends up a number of root-sprouts. Fig. 20 shows a sizeable tree of wild tamarind (*Lysiloma bahamensis*) killed by fire (123-25: Dec. 1951) with the growth of root-sprouts evident four months later.

Fig. No. 20

These pineland hardwoods commonly have a fire-pruned growth form with several stems rising from the surface of the limestone. Fig. 21 shows a typically fire-pruned specimen of poisonwood (*Metopium toxiferum*) shortly after it had suffered still another setback by fire. From the size of the gnarled bases of some of these shrubs it seems clear that they may survive many pineland fires and reach considerable age. Most of the fire-dwarfed pineland hardwoods flower and fruit regularly. Widely scattered individual hardwoods escape fire-pruning, and survive to achieve tree size in pinelands, usually as much stunted and severely fire-scarred specimens. Hardwood species most frequently seen as sizeable isolated trees in pineland are: live oak, poisonwood, pigeon plum (*Coccolobis laurifolia*), wild tamarind, gumbo-limbo (Elaphrium simaruba), and mastic (*Sideroxylon foetidissimum*). Fig. 22 shows the fire-scarred base of an isolated 6" DBH mastic in pineland. Fig. 23 shows two such isolated hardwoods. The tree at the left is white ironwood (*Hypelate trifoliata*), a tropical species first located in Everglades National Park in the

Fig. No. 22

course of field work for this report. Tree on the right is a wild tamarind. Such trees are often rooted in spots which enjoy some fire protection, notably at the edges or on the walls of deep solution holes in the limestone substrate. It appears evident

that many of the pineland "shrubs" are hammock trees dwarfed by recurring fire-pruning.

Most of the smaller seedlings of the understory hardwoods are killed by fire, and a few shrubs over two feet in height are also killed. The following table shows the effects of a single pinewoods fire (123-25: Dec. 1951) on several shrub species. Percentages are based on a random count of 200 or more individual plants over two feet in height for each species made four months after the fire. It is believed that nearly all of the survivors would show evidence of resprouting by this time. A high percentage of resprouting after complete fire-pruning was also recorded on this

Species	Fire Effect: Killed	Fire-pruned Resprouting	Partially Fire-pruned	Uninjured
Torrubia longifolia (blolly)		97%		3%
Byrsonima cuneata (locust berry)	1%	91%	7%	1%
Metopium toxiferum (Poisonwood)	3%	81%	15%	2%
Dodonaea jamaicensis (varnish leaf)	2%	95%	2%	1%
Rapanea guayanensis (myrsine)		100%		
Icacorea paniculata (marlberry)	5%	91%	3%	1%
Dipholis salicifolia (bustic)	1%	94%	3%	2%
Guettarda elliptica (velvet seed)		97%	2%	1%
Guettarda scabra (rough velvet seed)	10%	88%	2%	

Table 7. Fire Effects on Shrub Understory Species in Pineland

burn for such less common shrub understory species as bay berry (Cerothamnus ceriferus), Croton linearis, sumac (Rhus leucantha), red bay (Tamala borbonia), Tetrazygia bicolor, white stopper (Eugenia axillaris), and Mosiera longipes. Palm species occurring in pinewoods are seldom killed by fires except in unusual circumstances, as where the stem lies alongside a down log that burns completely. Recovery of palm species, especially saw palmetto, is usually more rapid than resprouting of the hardwoods.

PINE FOREST AREAS - GRASS-HERB LAYER

Pineland fires kill annual herbs and grasses, and fire-prune perennial species in much the same manner as they affect the shrub hardwoods. Many of the perennials have large root masses deeply driven into fissures and solution pockets in the limestone. Notable in this respect are such species as bracken (Pteris caudata), partridge pea (Chamaecrista Deeringiana), and rabbit bells (Crotalaria pumila). The usual ground fire in pine woods completely removes the ground covering fern-grass-herb flora leaving bare limestone. These fires, however, seldom cover the entire surface over any extended area but leave unburned islets, where vegetation hasn't been touched. These protected spots result from the interplay of burning conditions, especially wind velocity and direction, and the local micro-topographic characteristics of the forest floor; and it seems unlikely that the same areas would go unburned in any two fires.

PINE FOREST AREAS - RECOVERY AFTER FIRE

The following account presents a brief view of the stages in the recovery of the vegetation on upland pine woods sites after the usual ground fire. As for all vegetation types this is a composite picture put together from qualitative examination of several burns of different known ages, and hence is open to much possibility of error and misinterpretation. Data on post-fire recovery, as well as on succession, is most convincing when acquired from quantitative study of single areas over a span of time.

Within a month after pineland fires, sprouts of fire-pruned hardwood shrubs and herbaceous perennials, and seedlings of herbaceous annuals and grasses begin to make a show of green on the fresh burn. The first notable event in the post-fire recovery of pineland vegetation is the outburst of bloom of herbaceous plants. This phenomenon is familiar to all who have done botanical collecting in South Florida, and I noted it on recent "pineyard" burns in the Bahamas in July 1952. New burns several months after fire are much better collecting collecting localities for the herbaceous elements of the pineland flora, than are pine areas which have gone several years without fire. This quick display of flowering is not limited to new burns, but may be seen on any recently disturbed site in pine woods, as, for example, along newly bulldozed trails. Most of the species included in the list of pineland herbaceous plants (see appendix) are seen at best advantage at this time. Also prominent are such low-growing woody plants as gopher apple _Geobalanus oblongifolius_, _Rhacoma ilicifolia_, _Rhabdadenia corallicola_, _Echites Echites_, _Lantana depressa_, and _Chiococca pinetorum_. Fig. 24 shows Geobalanus in flower four months after fire 123-25 (Dec. 1951). It appears that in the absence of fire, the accumulating mat of pine needles, dead grasses, and leaves, plus the shade exerted by understory hardwoods act quickly to decrease, and eventually to eliminate much of the pineland herbaceous flora. I interpret the quick showing after fire as due to removal of these inhibiting effects exerted by the more dominant elements of the vegetation, and the favoring effect of frequent rains after the close of the fire season.

Figs. 25 and 26 show views of the next major stage noted in the recovery of pineland vegetation after fire. This stage is

Figs. 25 and 26

characterized by a tall growth of broom grass (Andropogon glomeratus) which marks the pineland burn approximately one year after fire. This grass typically occurs in fairly dense stands reaching four or five feet in height, which give the area the appearance of pine forest growing in tall grass prairie. The quick growth of the grass may be due to mineral supplies which become immediately available in ash left by the fire. The stage is ephemeral, typically lasting only one year. Two years after fire Andropogon is represented by only scattered plants, and developing sprouts of fire-pruned hardwood shrubs once more dominate the aspect of the pine forest understory.

Figs. 25 and 26, illustrating sites with maximum development of the broom grass stage, were photographed about eleven months after fire 123-12 (June 1951). The old logging trail in the pictures was used as a firebreak on this fire. Fig. 25 also shows a contrasting two-year old burn (fire 123-12, April 1950) to the left side of the trail.

On some low pineland sites adjoining sawgrass glades, fire is followed by an exceptionally dense and vigorous growth of saw palmetto. Fig. 27, a picture taken two years after fire 123-14 (May 1950), shows such a site. Tops of fire-killed hardwoods (mostly bayberry) are visible in the background. The reason for this apparent fire-induced vigor in saw palmetto is obscure at present. It may be due to nutrients made available in ash, and/or to decreased competition brought about by the more severe setback received by the other low vegetation. I have not observed the phenomenon except in pineland adjoining glades; sites at which saw palmetto appears to be the most successful species of the pineland flora (as discussed page 23) and pictured Figs 8 & 15).

I wish to again emphasize that the foregoing is a synthetic and generalized presentation, dealing largely with the recovery of vegetation of "typical" upland pine sites of Long Pine Key after "typical" late dry season ground fires. Variations depending upon fire frequency, season of burning, and site differences are to be expected.

PINE FOREST AREAS - SUMMARY

As shown, fire effects in pineland are largely exerted upon the understory shrub and herb layers. These elements of the pineland flora seem to have become well-adapted in growth habit to withstand successfully the recurring ground fires. Few individuals, except annual plants, are killed; and I cannot demonstrate from present data that fire has any important effect either upon the total density or specific composition of the pineland understory except apparently to induce the short-lived broom grass stage. Obviously any fire-intolerant species must long ago have been eliminated.

The above is all that can be said now about fire effects in the Long Pine Key pineland, but I believe that there are indications that it is far from the complete story. Discussion of this is deferred to the next section.

TROPICAL HAMMOCK FORESTS - SUBSTRATE

All of the phases of this forest type are associated with deposits of organic soils resulting from the influence of the vegetation upon the site it occupies. It is the vegetation types situated upon combustible soils that have been most severely affected by fire in south Florida; the hardwood hammocks, the bayheads, and the sawgrass mucklands. Fire moves slowly through these organic soil deposits, sometimes travelling only a few feet in any one burning period, but it may destroy the soil completely, burning down to the underlying marl or limestone. This fact is all too evident in many places (see Fig. 41). Once well ignited, fires of this sort are virtually impossible to extinguish, except on a very small scale. They continue their horizontal progress till stopped by rain or exhaustion of the fuel supply; and the vertical progress until reaching a non-organic substrate, or soil so wet that the smouldering mass cannot dry out fuel ahead of it.

TROPICAL HAMMOCK FORESTS - VEGETATION

The effects of soil destruction, as described above, on the forest vegetation of the site are seen most clearly in the case of bayheads and will be detailed in the discussion of fire effects on that vegetation type. Similar results (jumbled piles of windthrown timber, etc.) could be expected in hammocks of the *Paurotis*, and *Mahogany Hammock* types, which also occupy deep deposits of organic soils. (As mentioned previously, I believe that these hammock types may represent later successional stages on bayhead sites in the southernmost Everglades.) Fortunately, the present *Paurotis* and *Mahogany Hammocks* occupy virtually fireproof locations near the inner mangrove edge; or, perhaps more correctly stated, they now survive only at such sites.

Discussion of fire effects in hammock forests will be limited to the upland hammocks of the Long Pine Key area. I have not seen *Paurotis* or Mahogany Hammocks that had been reached by fire. Present sites of these hammock types are relatively inaccesible to fire due to the long period of annual flooding, and sparse vegetation of the surrounding glades. It seems probable, however, that the isolated *Paurotis* clumps found in the glades (see frontispiece) up to ten miles north of the present main hammock area at the mangrove edge are relics of former *Paurotis* hammocks that have been obliterated by fire. Persistence of the palms is explainable by the greater ability of these monocots to withstand fire damage to their stems. The coastal hammock types on marl (Madiera Bay Hammock, etc.), and on shell beach ridges (Cape Sable Hammock, etc.) have burned in the past. There have been no recent fires (at least since 1945), and I have spent too little field time investigating these areas to feel secure in pronouncing on fire effects. These south coast hammocks are burnable, however, and should be so considered in fire control planning, although much of the area is so inaccessible that fire suppression would be difficult.

In the Long Pine Key area many pineland ground fires do not penetrate to the interior of hammock areas in their paths. The hammocks divide the fire, and only the periphery of the hardwood forest vegetation is affected. Such edge damage of varying severity can be seen on all Long Pine Key hammocks. Fig. 28 shows a view of severe edge damage to an upland hammock (Little Royal Palm Hammock, two years after fire 123-14; May 1950). Note the standing dead *Lysiloma* trees and the rank growth of fireweed shrubs (mostly *Trema floridana*) coming up underneath. The success of any hammock area in turning fire depends entirely on the burning conditions at the time the fire reaches the hammock edge. Principal governing factors are fuel supply (i.e. length of time since the last fire in the adjacent pinelands), wind direction and velocity, and time of day. A pineland fire in heavy fuel, running with a brisk wind, during the middle of the day will destroy or severely damage any hammock area in its path. Quite small hammocks, however, may turn pineland fires when conditions for burning are less favorable. Fig. 29 shows a hammock area ten yards in greatest diameter around a small solution hole, which turned a pineland fire (123-25: Dec. 1951) escaping with minor edge damage. The hammock is composed of live oak, poisonwood, gumbo-limbo, and bayberry. Relatively early in its development, therefore, the hammock's modifying influences on the site it occupies appear to provide it with some protection from the usual pineland ground fires. It forms a tight little mesophytic island in the more extreme climate of the pinelands; maintaining a shaded and wind-protected area of higher humidity and smaller temperature range, and presenting a front of poorer fuel to pineland fires.

Any fire which burns around a hammock acts to cut back hammock edges by fire-pruning outer seedlings which have invaded pineland in the period between fires. Phillips (1940, p. 169) mentions the tangled shrubby edges of rock ridge hammocks, and names some of shrub species commonly found. These dense shrubby hammock borders are at least partially attributable to the effects of repeated fires. To this edging effect of fire I also attribute the cliff-like hammock fronts with abrupt transition from pineland to hammock which are commonly seen. Fig. 30 illustrates this.

Fig. No. 30

This point is of some importance to the understanding of successional relations between pineland and hammock forest which will be discussed at the end of this section. Fig. 31 shows the contrasting appearance of the hammock-pineland edge at a site free of fire for seven years.

The most serious effects on hammocks result from fires that burn inside the hammock in the humus deposits. Any fire of this sort does long-lasting damage and the most severe of them may completely obliterate the hammock. Fig. 32 shows the aspect of the burn-out inside Paradise Key, seven years after the 1945 fire. Scattered canopy trees may survive these fires, but most of the trees are usually either killed by fire or so weakened from destruction of soil around

Fig. No. 31

Fig. No. 32

their roots that they are soon windthrown. As shown, standing dead trees, particularly live oaks, may remain for some time. The absence of standing dead live oaks in the north end of Paradise Key, which burned in 1929, has caused some puzzlement. However, pictures of the north end taken very shortly after the fire (Small 1929: Plates 2 and 12) show many dead oaks. These snags were cut down by CCC workers based at Royal Palm State Park in 1933 or 1934 (Winte, pers. comm.). Commonly a narrow zone of living trees marking the former hammock perimeter is left when hammocks burn out. Survival of these outer trees may be due to the fact that they occur at the edges of the hammock humus deposit and have a smaller depth of burnable soil around their roots. This same fire effect occurs strikingly in the cypress and bayheads of the Everglades (see Fig. 43). I have seen a few instances where fires have evidently burned inside hammocks without killing the hammock trees. Many of the present canopy trees in Dark Hammock, for example, are fire marked at the base. Fig. 33 shows fire scar of a 23" DBH mastic (Sideroxylon) inside Dark Hammock. This sort of fire effect may result when fires occur at a time when much of the humus is too wet to burn, and hence pass through relatively rapidly, burning only litter on the forest floor.

The occurrence of some species of the hammock forest flora appears to be dependent on the environment created by the hammock. These include many woody plants such as lancewood (Nectandra), laurel cherry (Laurocerasus) and paradise tree (Simaruba); and the entire hammock herbaceous flora, both epiphytes and humus plants. These species with smaller ranges of tolerance of varying environmental factors are the species most likely to be eliminated by fire and the ones whose reestablishment in the recovering hammock is likely to be longest delayed. The erratic occurrence of some of the presumed intolerant tree species in the Long Pine Key hammocks has been mentioned. Much more information on successional changes in the specific composition of hammock forests must precede any more definite pronouncement on the effects of fire upon the site to site distribution of the various woody species. Fire effects upon distribution of the hammock ferns, Bromeliaceae, Orchidaceae, and Piperaceae are more evident. Many Long Pine Key hammocks which appear at first glance to be in good shape with fairly large trees, an unbroken forest canopy, and deep humus are found largely to lack these plants. More detailed survey of several such sites revealed evidence of old severe burn-outs in the form of much charred fallen logs, etc: I have not attempted to estimate the ages of these burns. From the size of present canopy trees some of them, as in Palma Vista #2 Hammock, evidently occurred long ago. Indications are that reinvasion of burned-out hammocks by the characteristic hammock species of ferns, orchids, bromeliads, and peperomias must be very slow. Some species such as the tropical maidenhair fern (Adiantum melanoleucum) and Brassia caudata, an epiphytic orchid, appear to have been virtually exterminated in Long Pine Key hammocks, perhaps as a result of fire. Other epiphytic species are apparently more tolerant of hammock disturbance. These include strap ferns (Campyloneurum), resurrection fern (Polypodium), and the common spray orchid (Encyclia tampense). Plants of this group, especially the epiphytic forms, command a popular interest out of proportion to their relatively minor ecological influence in the community. Their longtime loss in burned hammocks is, therefore, an important fire effect.

TROPICAL HAMMOCK FORESTS - RECOVERY AFTER FIRE

Hammock forests of mixed tropical hardwoods are the apparent climax vegetation type in South Florida. As indicated earlier, successional changes among hardwood species evidently occur for some time after the original establishment of hammock at any site; and the specific composition of the eventual self-maintaining climax forest is more or less conjectural. This uncertainty complicates discussion of hammock recovery after fire, since complete reestablishment of mature hammock may involve much more than return of a continuous hardwood forest at the site. For the purposes of the present report this presents little problem, but in a more refined treatment it would have to be closely considered.

The age range of hammock burns of known age which are available for study is inadequate to enable one to construct a synthetic picture of the course of hammock recovery. The oldest burns in the Everglades National Park area which can be reliably dated are the Osteen Hammock and Paradise Key burns of 1945. As Fig. 32 shows, seven years recovery at Paradise Key has produced a dense shrub-small tree tangle on the burned area. From this, a guess of about 25 years required to establish a young hardwood forest with a continuous canopy may be hazarded. The time lapse from the first continuous forest cover to a completely recovered mature hammock would certainly be much longer.

Obviously recovery patterns will vary a great deal according to the severity of the burn-out. Logical explanation of the co-existence of hammock forest and pineland on topographically similar sites seems to require that there have been recurring fires, (or other disturbance) perhaps at very long intervals, which destroyed hammocks completely; and required succession through a pine forest stage in hammock recovery. I have seen a few seedling pines inside recently burned hammocks, but no extensive stands that would indicate the potential establishment of pine forest. This hypothetical case would appear to require complete removal of hammock humus, such as might be caused by several closely successive fires. Even after severe hammock burns, enough humus remains to support a quick growth of fire-weed species, which soon fills the hammock interior with a dense shrub tangle, leaving no bare areas available to invasion by pine. Throughout the Long Pine Key area sizeable pines enclosed by hammock forest may be found. Many of these are evidently trees overtaken by outward encroachment of hammock edges, but some may be relics from a pine stage which followed hammock burn-outs.

The shrubby tangles which fill the interiors of hammocks after fire are composed of three floral elements. 1. Hammock forest survivors, and seedlings and sprouts of hammock species. 2. Shade intolerant species characteristic of the pineland flora which invade the area opened by fire. 3. Opportunist fireweed species which make a quick growth on any disturbed area. Some species of the latter category also occur frequently in pineland, but those listed as fireweeds attain notable luxuriance on new hammock burns.

1. This category may contain any of the species which occurred in the hammock before fire, but the more tolerant species such as live oak, bustic (Dipholis), wild tamarind, poisonwood, gumbo-limbo, myrsine (Rapanea), and marlberry (Icacorea) are usually most frequent. In addition, species of vines such as poison ivy, Virginia creeper, muscadine, pepper vine (Ampelopsis), Hippocratea and Pisonia bind the shrub tangle making it virtually impenetrable. All of these vines occur in hammock forests; but some species, particularly the first four listed, make especially rank growth on new hammock burns and could perhaps be considered as fireweeds.

2. Pineland species

Anemia adiantifolia (a fern)
Pteris caudata (bracken)
Pycnidoria bahamensis (a fern)
Serenoa repens (saw palmetto)
Callicarpa americana (beauty berry)
Eupatorium villosum

3. Fireweed species

Pteris caudata
Trema floridana
Rhus leucantha (See Fig. 34 showing dense growth of sumac on hammock burn at Paradise Key.)
Carica Papaya (papaya)
Psidium guajava (guava)
Calonyction sp. (moon flower)
Solanum verbascifolium (potato tree)
Lantana involucrata
Morinda Roioc
Baccharis halimifolia

The fireweeds develop very rapidly on hammock burns. Within two years after fire they have commonly clogged the hammock interior with an imposing biomass of new growth. All of the fireweed species are weak-stemmed and shade-intolerant, and are eventually eliminated from the flora of the recovering hammock.

TROPICAL HAMMOCK FORESTS - FIRE EFFECT ON SUCCESSIONAL RELATION TO PINELANDS

In the account of the fire history of the region presented earlier in the report, it has been indicated that pine forest in South Florida is evidently a fire-maintained sub-climax vegetation type. If this view is correct, hammock forest would be expected to invade pineland sites in the absence of fire. This section advances evidence intended to show that such invasion does occur.

Most authors who have considered the hammock-pineland relation have reached conclusions similar to the above (Bessey, 1911: Harper, 1911 et al.). Harshberger (1912: 104-106) has raised a dissenting voice, stating that basic differences exist between pineland sites and hammock sites. This opinion is also held by some local naturalists with wide field acquaintance with the area. The abrupt transition between the two vegetation types seen at many places (See Fig. 30) has sometimes been cited as evidence in support of the hypothesis that intrinsic differences exist between hammock sites and pineland sites. I cannot agree with this contention, regarding these sharp vegetational boundaries as due to the action of fire in pruning peripheral hammock plants. Close study of many sites where such abrupt transitions occur has failed to disclose any basic edaphic or topographic differences. Existing differences seem to be entirely those which result from the modifying influence exerted by the hammock vegetation upon the site of its chance establishment and chance survival in pineland.

The chief defect in the view of Harshberger lies in the fact that it appears to deny the possibility of any successional relation between pineland and hammock forest vegetation. The following lines of evidence seem to provide convincing proof that this succession does occur.

1. In the absence of fire, hammock edges appear to advance into the adjacent pineland rather rapidly. Fig. 35 shows a dense understory of young live oak that has encroached outward from the

Fig. No. 35

edge of Dark Hammock (visible in background) during a seven year fire-free period. Figs. 36 and 37 provide additional views of hammock edges that have enclosed a number of pines.

2. Any site in pinelands at which frequency and/or intensity of fire is reduced tends to be occupied by incipient hammock growth. Large solution holes often provide enough fire-protected niches to maintain a hardwood hammock nucleus from which hardwoods may encroach into pineland during the intervals between fires. This is especially true of the large holes, to fifty feet or more in diameter, which are formed by the collapse of the ceilings of solution caverns. One of these is shown in Fig. 38. The foreground has been cleared to show the edge of the hole. Long Pine Key is penetrated by a number of fingers of sawgrass gladelands which extend into the pineland in a south to north direction roughly perpendicular to the axis of the pine-forested rock ridge. At present water levels, these glades areas are dry season burnable in most years, but they do offer some protection as fire breaks during a part of the year. It is notable that many of the present hammock forest sites of Long Pine Key are located with a glade area to windward. Fig. 39 shows one of these.

Fig. No. 38

Fig. No. 39

3. Groups of hardwoods which appear to represent incipient hammocks may occasionally be found in pineland at sites which are not at all protected from fire. Fig. 40 illustrates this. The site shown is far removed from any present hammock, and shows no sign of

Fig. No. 40

having been previously occupied by hammock forest. It seems to represent an early stage in the establishment of a new hammock under pines. No readily apparent site factors favor invasion of hammock species at this particular spot (e.g. no noticeable variation in topography or substrate from surrounding pine forest, no large hammock trees to provide a nearby source of seed). The location seems due to chance establishment of seedlings at the site, and a sufficient time lapse without fire (or interval of fire survival) for some of the plants to mature, followed by peripheral expansion from the hammock nucleus. The principal tree species is Lysiloma bahamensis with the larger specimens centrally located. Some of the trees are several-stemmed from the ground indicating that they have survived fire-pruning.

4. As presented in the account of fire effects in pineland, much of the shrub layer of the pine woods is composed of fire-dwarfed individuals of species which are trees in the hammock forests. This fact was recognized and discussed by Small (1930, pp. 46-47). It seems abundantly clear that with the elimination of fire these hardwoods would provide a seed source speeding the establishment of hammock forest at the site.

Considering the above, I believe that a period of 15 to 25 years freedom from fire is ample to permit the conversion of any upland site on Long Pine Key from open pine forest with an understory of palmetto and fire-dwarfed hardwoods to dense young hammock forest with relic pines, and no reproduction of pine.

I wish to restrict the above statement to the Long Pine Key pinelands, since several unique features of this area urge caution in attributing of similar hammock--pineland relations to other south Florida rockland areas. Indications are that the Long Pine Key area may have been less frequently burned than the pine forests from south of Florida City to Miami, (the Biscayne pineland of Small) for the following reasons:

1. Long Pine Key has the protection of a deep Everglades slough (Taylor River) to windward. Fires have crossed the slough in years of exceptional drouth, as in 1945, but in most years it provides an effective fire break to the east of Long Pine Key. A clear example of this may be found in the narrative account of fire 123-6, April 1952. This fire reached Taylor Slough and went out although burning conditions (wind, time of day) were much in its favor.

2. Some fire protection is provided by the transverse glades of Long Pine Key, as previously mentioned.

3. Since a great many fires in this area are man-caused, the fact that Long Pine Key was the last part of the Miami Rock Ridge to become accessible may indicate (considering the Taylor River barrier against fire from the east) a significantly lower frequency of man-caused fires.

The following differences in vegetation notable in the Biscayne pineland are perhaps the result of a greater fire frequency.

1. The area of established hammock forest is very much smaller in relation to the area of pineland than is true of Long Pine Key.

2. The shrub understory in the Biscayne pineland contains strikingly fewer individual hardwoods, and a much poorer representation of species. Over large areas in the Redlands district the forest understory is composed almost entirely of low palms (saw palmetto, cabbage palm, and silver palm). I interpret this as a fire-impoverished understory, and believe that frequent burning may eventually eliminate hardwoods from the shrub understory even though a single fire kills only a small percentage of them.

It seems likely, therefore, that in much of the Biscayne pineland succession of hammock forest on pineland sites may be long-delayed, primarily due to the remoteness of many areas from sources of seeds. A pineland tract in the Redlands unburned for 25 years shows but little evidence of hardwood invasion (see description page 110).

NOTE: I have spent relatively little field time in the pine areas outside Everglades National Park, and cannot, at present, exclude the possibility that there may be site differences sufficient to partially account for observed differences in the vegetation.

BAYHEAD - SUBSTRATE

As with the humus deposits of upland hammocks, the peat soil of the bayheads is burnable. These soil deposits are usually deeper than those of upland hardwood forests, and complete burnouts are perhaps more destructive in terms of time needed for recovery after fire. Some of the most striking fire effects to be found anywhere in the region have occurred in this vegetation type. Fig. 41 shows the interior of a bayhead in which the peat mass burned completely, exposing the underlying oolite. In other cases fire evidently burned down to the water table and went out. Leaving some of the peat unburned. In several incomplete burn-outs which were

Fig. No. 41

examined, three to four feet of soil had burned with the unburned areas occurring as elevated knolls inside the bayhead. Peatfires in bayheads move slowly, as described for upland hammocks, and these incomplete burns evidently result when rains put out creeping fires. The peat deposits often burn down to a level below that of the surrounding marl glades, and wet-season ponds may then occupy the one-time bayhead site. A number of burnouts of this sort were examined in the Ironpot Hammock burn (123-16, June-July 1951).

BAYHEADS - VEGETATION

Typically bayheads are ringed with a dense hedge of shrubby vegetation. The most frequent constituent of this bordering zone is cocoplum (Chrysobalanus). These plants, sometimes sizeable with trunks to 18" diameter, are often rooted in the outer edge of the peat mass and extend 10 or 12 feet into the glades over an area of nearly bare marl. This growth form presents a barrier effective against some glades fires. It tends to break the front of the fire which may then pass around the bayhead without getting inside to burn in the peat mass. Possibly this type of edge is an expression of repeated peripheral fire effects, but the case is not so clear as with the shrubby borders of upland hammocks. Fig. 42 illustrates the cocoplum hedge of a bayhead in the southern Everglades.

Fig. No. 42

Whether or not the whole depth of the peat mass is burned, fires which burn inside bayheads usually destroy the vegetation completely. A few trees at the edges survive, and these may occur as an outer ring marking the former bayhead perimeter (Fig. 43).

Fig. No. 43

The interior of the bayhead is ordinarily gutted, leaving fantastic tangles of fallen and leaning dead trees, that have toppled as supporting soil was burned away from their roots. Fig. 44 shows the wreck of a bayhead in a transverse glade of Long Pine Key two years after fire 123-14 (May 1950). The bayhead pictured occupied a more

Fig. No. 44

elevated site than usual for the vegetation type and contained several species of hammock hardwoods and a few pines. I have not seen cases in which fires burned inside bayheads destroying only surface litter, without killing trees. Presumably this could occur, especially in the case of early day season fires.

BAYHEADS - RECOVERY AFTER FIRE

Recovery of bayheads from severe fire damage requires deposition of a new peat mas which must build up to sufficient elevation for the bayhead tree species to reoccupy the site. This process is evidently very slow. As mentioned, at some places the peat is burned to below the general glades level so that semi-permanent ponds are established. On these sites succession through various hydrosere stages must occur in bayhead recovery. A site of this sort was examined just north of the boundary of the Ironpot Hammock fire. Here what appears to be a burn-out pond is occupied by sizeable pond apple (Annona) trees, and several species of emergent aquatic plants, including spatterdock (Nymphaea), arrowleaf (Sagittaria), and pickerel weed (Pontederia). No information is available on the age of this burn, but the fire must have occurred at least 20 years ago to judge from the size of the pond apple trees.

At sites where the peat burn-out is not so extreme, recovery after fire may be somewhat more rapid. Many burned-out bayheads in the area of the Ironpot Hammock fire, and also further south are now occupied by dense growths of young willow (Salix). Fig. 45 illustrates this.

Fig. No. 45

Several of these sites are known to have burned in 1945. No evidence is available on which to base an estimate of the time span required for displacement of the willow by the usual woody species of the bayheads. In the Ironpot Hammock area a year after fire a few rootsprouts of fire-pruned trees and seedlings of cocoplum, wax myrtle, and redbay (Tamala) were found in small spots around the rim of the bayhead where the peat had not burned. Survival of specimen trees in islands of unburned soil may speed the return of bayhead vegetation to the site by providing a local seed source. In general, however, fires in bayheads destroy the soil and with it the elevation necessary for the occurrence of the bayhead species. Reinvasion will occur only after plant succession and organic deposition have restored the elevation of the site.

Many shrubby and herbaceous fireweed plants quickly invade bayhead areas opened by fire. With the exception of willow these species ordinarily do not persist long. A list of some of the major constituents of this assemblage follows:

Ferns:

Osmunda regalis (Royal fern, also locally known as fire fern)
Blechnum serrulatum) (Also occur in some established
Dryopteris normalis) bayheads)
Pteris caudata (Bracken)

Shrubs:

Salix amphibia (willow)
Trema floridana
Jussiaea scabra (primrose willow)
Baccharis glomeruliflora
Baccharis halimnifolia

Herbs:

Solanum nigrum (common nightshade)
Sonchus asper (sow thistle)
Conoclinum coelestinum
Pluchea foetida
Pluchea purpurascens
Eupatorium capillifolium
Melanthera sp.
Mikania batatifolia

BAYHEADS - SUCCESSIONAL RELATIONS BETWEEN BAYHEADS AND SAWGRASS GLADES

Local residents most familiar with the Everglades area agree that within the period of their observations (roughly 25 years) there has been a marked expansion of woody vegetation at the expense of the sawgrass area. It is also agreed that, in spite of fires which have destroyed many tree islands, this invasion has been sufficient to change the whole aspect of large areas particularly in the region south of the Tamiami Trail. The species most involved in this thicket extension is willow (Egler, 1952: 240; Poppenhager, Redding, Winte, pers. comm.). Some of the present willow areas mark the sites of burned-out bayheads, but there seem to be many sites where willow scrub is independently invading sawgrass. It appears a reasonable hypothesis to attribute this development to the drying of the lower glades. It has, at least, occurred under conditions of lowered water levels, and cannot be interpreted as a fire effect because, as Egler points out (*ibid.*), fire acts to limit this thicket extension. Possibly willow in this case is a pioneer species heralding the eventual establishment of bayhead vegetation in present sawgrass areas. Isolated individuals of all the tree species of the bayheads may often be found in the surrounding sawgrass areas. Frequently these are fire-pruned just as are individuals of hammock hardwoods in pineland, and it seems clear that their occurrence would be more widespread in the absence of fire.

The relation between bayhead vegetation (including willow) and Everglades prairie vegetation appears to be more complex than that between upland hammocks and pineland. In the latter case the single factor, fire, controls succession with hammock forest rapidly invading pine woods that are protected from fire. Between bayhead and sawgrass areas the picture is complicated by the fact that strong site differences exist. Bayheads appear to occupy elevated sites (see discussion page 45) on peat, Everglades prairies, less elevated sites on marl or sawgrass peat. Under conditions of pre-drainage water levels succession of bayheads into sawgrass must have been dependent on the slow growth of the peat mass. This encroachment into the marsh would be affected by fire in a manner similar to fire effects on the edges of upland hammocks encroaching into pine woods. I have previously indicated that elevation (i.e. duration and extent of annual flooding) seems the important factor limiting bayhead occurrence. Bayhead species can invade sawgrass soils, provided the sites are dry enough (see Fig. 48). With drainage much of the sawgrass area has apparently become enough drier to be open to general invasion by woody species, which is now going on even in the face of severe fire. This hypothesis of the inter-type successional relations may be summarized as follows:

1. Pre-drainage conditions: A mosaic of bayhead and Everglades prarie vegetation types with their occurrence limited by topographic site differences - Slow succession of bayhead vegetation into the marsh as the accumulating peat deposit built up requisite elevation - Fire acting to control this succession through effects on periphery of the bayhead.

2. Present conditions: Lowered water levels eliminate the effect of topographic differences between the two vegetation types -- Widespread establishment of woody seedlings in marsh areas - Fire acting to preserve sawgrass marsh by pruning back woody seedlings, but ineffective to prevent large extensions of woody vegetation into sawgrass areas.

If the above is correct, the eventual result with continued low water levels and continued fire may be a savanna or thicket of fire-pruned shrubs over much of the glades. In addition Egler (1952, 252-256) has pointed out an additional threat to the open glades posed by the naturalized Australian pine (Casuarina). This species seems capable of establishing a pure stand forest in sawgrass glades at present general water levels. As yet Casuarina is not common in Everglades National Park, but it will almost surely present a problem in the future.

SAWGRASS GLADES - FIRE EFFECTS

As shown by graph #1 (page 33a) the sawgrass glades area is the most important fire type in Everglades National Park in terms of total acreage burned. The entire glades area has certainly burned many times, yet we have remarkably little information on the effects of fire on the vegetation.

In muckland areas the soil destroying effects of fire are notable. Undoubtedly some of the present rockland areas of the glades have resulted from complete removal of the soil by repeated muck fires.

Over the general marl soil area that makes up most of the glades of the park no such definite fire effect can be indicated. The glades burn and soon afterwards the same plants that were there before fire may again be found. There are, in other words, no readily apparent short-term effects of fire in the marl glades. It is difficult to believe that repeated fires over a longer period do not have effects on the density and specific composition of the glades vegetation, but there are no records of the fire history of particular areas adequate to enable us to discern this. In some marl glades areas fire is followed by a conspicuous show of flowering herbs similar to that described for newly burned pinelands. The roots of most of the sawgrass plants are usually not killed and their recovery is direct. As previously stated, fire kills or prunes back seedlings of woody plants that have become established in the marsh, between fires and thus acts to slow the invasion of shrub vegetation into those glades areas dry enough to support it.

The arrangement of vegetation in the Shark River Valley area of the main glades described earlier (see page 55) has important effects on the movement of fires that may be useful in fire suppression, here. Glades fires in this area usually "wander" a great deal following the heaviest fuels. They thus tend to fan out into multiple fingers along the tall sawgrass and willow strands, and ordinarily do not cross the centers of the slough runs. In some instances it should be more feasible to cut off fires by making breaks across the sawgrass strands (with fair assurance that the flanks will not be able to cross the confining slough runs), rather than to attempt attack on the whole perimeter.

The whole question of fire in the glades must be realistically considered. We need to acquire information on just what is happening to glades vegetation under present water conditions and just what part fire plays in these developments. <u>And</u>, once reliable information is at hand, we need to consider objectives and to direct fire suppression activities accordingly. It may, for example, be ecologically sound to protect ten bayheads at the expense of ten square miles of marl glades. The possibility of the use of controlled burning as a management practice to check invasion of willows or mangrove into the marsh should at least be examined. The job of maintaining the glades in their present aspect is not likely to be either short or simple.

IV. FIRE EFFECTS ON ANIMAL POPULATIONS

Fire effects other than the effects on vegetation were not specifically investigated. However, a few observations and ideas regarding fire effects on animal populations in South Florida may well be included here.

Direct mortality due to fire is probably a relatively insignificant factor in the population dynamics of animal species in the region. It is insignificant at least in comparison with indirect effects upon animal populations through the ecological changes caused by fire. Animals of many species are frequently killed, however, particularly by sawgrass fires.

In the following account an attempt is made to estimate fire effects on animals in lowland (sawgrass and bayheads) and upland (pineland and tropical hammocks) communities. No effort is made to discuss animals other than vertebrates. The possibility that fire is a major limiting factor affecting populations of some invertebrates, such as the large freshwater snail, Ampullaria (or Pomacia), should not be overlooked.

Lowland Communities - Direct Fire Effects. Probably all the species of amphibians and reptiles of the area are at least occasionally killed by sawgrass fires. I have seen small alligators, cottonmouth mocassins (Agkistrodon piscivorous), water snakes (Natrix), indigo snakes (Drymarchon), ground rattlesnakes (Sistrurus miliarius) and several species of frogs, lizards, and turtles killed by fire in sawgrass areas. Babbitt and Babbitt (1951) reported finding large numbers of some amphibians and reptiles killed by fire in a small glades area. Their casualty list included: tree frogs (Hyla), green snakes (Opheodrys), black snakes (Coluber), ribbon snakes (Thamnophis), glass lizards (Ophisaurus), anoles (Anolis) and box turtles (Terrapine).

Direct mortality of birds as a result of fire is probably limited to nestlings and occasional adults of weak-flying species such as the rails. Dry season bird populations of the glades are low except for areas in the immediate vicinity of ponds and sloughs, and direct fire effects are probably of little importance.

Judging from the number of dead or badly burned living individuals of such species as cotton rats (Sigmodon) and marsh rabbits (Sylvilagus aquaticus) which are seen, it seems possible that sawgrass fires may exert considerable influence on the rodent populations of the glades. As for larger mammals, occasional opossums and raccoons were seen that had apparently been overrun and killed by glades fires. Deer sometimes accumulate bad burns on the hocks and lower legs from running through burning peat beds (Poppenhager, pers. comm.). It is not likely, however, that this is the cause of much mortality, nor is it likely important even in the limited deep peat areas of Everglades National Park.

Lowland Communities - Indirect Fire Effects. The chief indirect fire effect of importance to the animal populations of the glades is the formation of burn-out ponds where deep peat deposits of bayheads burn down below the level of the surrounding marl glades. To some extent there burn-out ponds may substitute for onetime gator holes in the ecology of many glades animals. The dry season use of glades areas by animals depends very largely on the availability of permanent water, which provides a refuge for the smaller aquatic organisms and feeding sites for the larger birds and mammals. Due to the present poor dispersion of such ponds, large areas of the Everglades are a virtual dry-season desert. Thus the destruction of bayheads by fire may have valuable incidental effects to many animal populations. This is, however, a notably inefficient way of meeting the need for glades water holes.

Upland Communities - Direct Fire Effects. I have seen few vertebrates killed by pineland fires and suspect that direct mortality is much less than is the case with glades fires. Babbitt and Babbitt (op. cit.) report finding many diamondback rattlesnakes (Crotalus adamanteus) and box turtles killed by pineland fires. Other reptiles, ground-nesting birds such as the bobwhite and wild turkey, passerine birds which nest in shrubby growth in pineland, and small mammals doubtless suffer to some extent. It does not appear, however, that the total direct effect of pineland fires can be of much importance.

Upland Communities - Indirect Fire Effects. Fire acts to prune shrub growth in pineland and cut back the edges of hardwood hammocks. Speaking primarily of bird populations, fire thus tends to maintain or enlarge the habitat area available to pine woods species, such as the pine warbler and bluebird, and to restrict the habitat area of forest-edge species, such as the Carolina wren and cardinal. These forest-edge species alternately advance into and retreat from the pinelands as the shrub understory becomes sufficiently dense to suit their requirements and then is once more reduced by fire. Conversely, complete burn-out of hammocks and the resulting interior shrub tangle creates habitat for forest-edge species. This interplay or bird populations is very largely controlled by fire. I have no information on other animal groups, but it is reasonable to assume that many of them are somewhat similarly affected.

As noted, pineland fires destroy nearly all ground litter, down logs and stumps, etc., I suggest that this bare forest floor may account for the very low densities of the pine woods rodent populations reported by Opsahl (1951).

In all consideration of fire effect, it should be clearly realized that the immediate destruction of vegetation by fire, and the new plant successions set in motion on burned areas will have attendent and often long-endaring influences on the animal popula- tions of the areas involved.

CONCLUSIONS AND RECOMMENDATIONS

1. Fire Suppression Practices.

From the foregoing consideration of fire effects I can only repeat with emphasis the conclusion reached by the fire critique discussions of May 1950; under present conditions it is imperative that all fires in the area be actively suppressed. Water is the key to any change in this situation. If means of restoring water on the glades to something near pre-drainage levels can be found, I believe that fires can then be largely forgotten; except perhaps in extreme drought years, or as they may threaten areas of special use or special interest. There can be no reasonable doubt that fire is a natural ecological factor in the Everglades National Park area, and that complete elimination of fire would eventually result in disappearance of the fire-maintained sub-climax vegetation types (pine forest and sawgrass prairies) and major changes in the aspect of the region. However the low water conditions of the past thirty years have resulted in an increase in both the frequency and the intensity of fires. I believe that the present fire regimen is potentially capable of completely eliminating the hardwood forest vegetation types on South Florida, and of causing floristic impoverishment and other degenerative changes in the sub-climax types. There is no question that fire suppression must be continued at increasing efficiency to maintain the ecological status quo in South Florida.

As I have attempted to show, the most extreme fire damage occurs in hardwood forest vegetation types, both bayheads and hammock forests. In contrast to pineland and sawgrass, the recovery of hardwood forest areas from severe fire is always long-delayed. It therefore seems advisable that fire suppression operations take this into account and protect hammock areas whenever possible, even when it can only be done at the expense of larger acreages burned of pine or sawgrass. Having fought a few glades fires, I realize the difficulties involved in putting this advice into practice because of the rapid movement of going fires, and the mosaic occurrence of the vegetation types. It is, however, a point to be kept in mind.

I would also like to suggest that the possibility of providing advance fire break protection for some of the hardwood hammocks of Long Pine Key be thoroughly considered. Admittedly there are undesirable features to such a practice in a national park, but these should be weighed against the possibility of fire damage to the few hammocks which remain in a relatively undisturbed condition. At least, protection of these hammocks should become a top priority in the event of fire in the Long Pine Key pineland.

The following Long Pine Key hammocks should certainly be given preferential protection: Palma Vista #1, Palma Vista #2, Dark, Mosier (fire damaged, but contains a number of unusual plants), Saw Mill Road, Turkey (fire-damaged, but has a notable abundance of *Oncidium floridanum*, a rare terrestrial orchid), Crabwood and the glades edge hammock just south of it (Crabwood Hammock is burned-out, but the surviving fragments contain many rare plants), and Little Royal Palm. Special vigilance is also advised with regard to the large cypress-bay head just north of Cocoplum Bend (see Fig. 16) Dowhurst Hammock, and the Mahogany hammocks. It is probably impractical to attempt to maintain permanent fire breaks around these Everglades tree islands, but, again, their protection should be the first concern whenever fires threaten their general region. Particularly in the case of the rather remote Mahogany Hammocks, frequent patrols should keep track of water conditions on the surrounding glades, sothat special protective measures may be taken if the region becomes dangerously dry.

2. Fire Records.

More exact and more detailed records should be kept of fires in the Everglades National Park area. Initial records to be of ecological use should include: A complete account of burning conditions; location and size of the areas of different vegetation types burned; progress of the fire from discovery to final suppression; length of time since the last fire, if known; and a careful survey of damage over the fire area. Much of this information is recorded on the usual fire reports submitted to the regional office. The chief difference would be that the data be gathered with the degree of care suitable to the objective of providing definite information on fire effects. I am aware of the personnel problem which will arise, since collecting these data will require considerable time (particularly on class E fires) at a time when all hands are usually none too many for the actual work of suppression. It is suggested that the job of recording preliminary information on location, vegetation types, and progress of the fire be assigned to the fire scout; and that a detailed survey of the burn begin as soon as the fire has been put on a patrol basis.

I wish to further recommend that observation of particular burned areas be continued at intervals, with the recovery of the vegetation being noted in detail. These resurveys should be made at annual intervals until the recovery of the vegetation is substantially complete. They should take the form of: 1. General qualitative surveys of the entire burn; and, 2. Quantitative study of an adequate number of permanent study plots representative of all vegetation types burned, on which changes in the density and specific composition of the vegetation may be followed in detail.

3. <u>Test Burning Experiments</u>

To complete the program of investigation of fire effects in Everglades National Park the following experimental procedure is suggested to supplement study of natural and accidental fires. I recommend that permanent test-burning and control plots be established on which fire-frequency may be varied as an experimental factor. Such study-plots would need to be set up only in the two major fire types, pinelands and Everglades prairie; but they should encompass all major variations of these types. Following is the suggested detailed procedure for establishing one study plot series. Other series would be similar.

<u>Area</u>: Pine rockland with a mixed hardwood understory of fairly uniform density and composition.
--Establish eight one-quarter acre study plots and set permanent corner marks. (Actually the size of adequate plots would need to be determined by study of the vegetation after the manner suggested by Vestal (1949). One-quarter acre is believed to represent a probable maximum size needed.)
--Census and map vegetation on each plot.
--The plots would then be studied as follows:

1. A control plot; unburned.
2. Burn twice a year, winter and summer.
3. Burn annually in winter.
4. Burn annually in summer.
5. Burn at two year intervals in winter.
6. Burn at three year intervals in winter.
7. Burn at five year intervals in winter.
8. Burn at ten year intervals in winter.

--A quantitative re-check of vegetation on each plot would be made just before and shortly after burning. In addition an annual re-check of vegetation would be made on the control plot, and on experimental plots with less than annual fire frequencies.
--Modifications that will increase the value of the recoverable data will certainly suggest themselves as study progresses.
--Study plots should be guarded against unscheduled burns by firebreaks.

The above suggested program is doubtless contrary to some Park Service policies, at least in their narrow interpretation; but I believe that the importance of the problem amply justifies the departure. It will be noted also that the suggestions advanced in parts "2" and "3" of this section spell out a long-term project of fire effects study. I can see no other real solution. It is worth emphasizing that Everglades National Park is also a long-term project, and that the problem of fire promises to stay right with us.

4. <u>Study of Plant Species and Vegetation Types</u>

Earlier in this report I referred to the difficulties presented to fire effects study by incomplete knowledge of the plant species and the ecology of the regional vegetation types. It is difficult to distinguish and examine modifications due to fire, when we have so relatively little definite information on the specific composition, and the course of ecological development of the plant communities in the absence of fire. The study of fire effects will ultimately be best served, if investigation of the flora and the ecological relations of the vegetation types proceeds apace. Data from work suggested in the two preceding parts of this section will contribute also to this more theoretical aspect. In addition the following are suggested:

1. <u>Herbarium</u> - Collection and identification of plants of the Everglades National Park area should be actively pursued with the objective of establishing a complete working herbarium of the park flora. The nucleus of such a collection is now in existence (See Appendix). The herbarium of the Botany Department of the University of Miami contains an excellent representation of the regional flora. This is, and will remain, of much value to the study of the Everglades National Park flora; but an immediately available local collection is much to be desired.

2. Along with the collection of plants in the park area, information on the geographicaland ecological distribution of plant species within the park should be accumulated. -- The Park Biologist and the Park Naturalist have already amassed much information of this sort, particularly as regards the occurrence of woody plants. They have not felt able to devote the time to make it quantitative.

3. A program of ecological studies, particularly quantitative studies of stand composition and density of the various vegetation types; and studies of the factors controlling the occurrence of the vegetation types, should be developed.

4. The suggested studies can be expected to provide a detailed knowledge of the plant ecology of the area, and of the role of fire in this picture. Such information would have valuable applications to many problems besides fire effects study.

It would, for example, provide a fund of essential background material facilitating approach to many of the problems which will arise in connection with various animal populations. Almost every national park has had to deal with problems involving over-populations of animal species, predation, unexplained dwindling of the populations of some species, etc.: There is no reason to believe that Everglades National Park will be spared those. It requires no great foresight to anticipate a time when Everglades National Park may, for example, be faced with necessity to study "a deer problem" or "a raccoon problem" arising from over-populations of these species. There already exists the problem of explaining the disappearance or extreme rarity of such species as the mangrove fox squirrel and red-cockaded woodpecker. Knowledge of the vegetation types is readily translatable into the necessary knowledge of animal habitats in all these cases and many other conceivable ones. -- Much of the ecological information would also be of use in the work of the interpretive division which has a particularly important and difficult job in Everglades National Park.

Statements on the Everglades National Park "Broadside," received by all passing tourists, inform us that Everglades National Park is: 1. A unique area; and 2. An area whose features attractions are biological. Granting "2", may it then be suggested that, since the park succeeds or fails with the waxing or waning of its biological resources, we are well advised to learn all we can about them. And, conceding that the area is unique, where "Familiar things take unfamiliar shape," the place to get this information is South Florida.

LIMESTONE EROSION ON THE MIAMI ROCK RIDGE

By Doctor Robert N. Ginsburg

The surface exposures of Miami Oolite on the Rock Ridge extending southwestward from Miami are characteristically much affected by solution. Where the rock surface is only slightly above the water level during the summer or rainy season, the surface is highly irregular with sharp projections, pits, holes and channels, ranging in size from less than an inch to several feet. Where the rock surface is slightly higher, these irregularities are less pronounced and more or less circular pools or wells leading to subterranean passages are the rule. In both cases the subsurface rock below the water level is extensively honeycombed by passages and cavities of variable size.

Irregular surfaces and honeycombed interiors are characteristic for the Miami Oolite, whether covered by pineland, hammocks, or sawgrass prairies, though in the latter two cases it is less noticeable due to the masking effect of vegetative debris. Variations in the forms and extent of erosion in the rock covered by the different floral communities do exist, but for present purposes they are not considered important.

Three main processes are responsible for the solution of limestone in this area:

1. Solution by rainwater. Though the solubility of $CaCO_3$ in fresh water is relatively low, the heavy rainfall, approximately 60 inches, makes possible removal of considerable $CaCO_3$. (Taking the solubility of $CaCO_3$ as 0.10 gr/l. and the rainfall as 150 cm/yr. 1500 grm. or 535 cc. of $CaCO_3$ can be dissolved from a square meter of pure limestone.) Most of this chemical solution takes place below the water table where there is continued contact between water and limestone.

2. Humic acids. Acids produced in the decay of vegetative debris, as for example from hammock soils, also dissolve limestone.

3. Micro-organisms particularly blue-green algae are capable of dissolving limestones. Boring algae are probably abundant on the moist rock surfaces throughout the area; the characteristic blackened appearances of exposed rock surfaces is similar to that of the intertidal zone of the rocky shores along the Keys. In this latter case, algae and other micro-organisms are responsible.

Slaking of the surface limestone by fires, which are common in the pinelands, has been considered an important agent of limestone erosion (Small, 1930 : 41-42). Since a temperature of 550°C is required for decomposition of $CaCO_3$ it seems unlikely that the fires in the pinelands, where there is essentially no combustable soil, could produce any appreciable slaking. The heating of the surface may be of some importance in weakening the rock by unequal expansion or splitting by vaporization of water contained in the limestone.

Aqueous and organic solution are adequate to explain the observed features.

Chronology of Fire Occurrence in South Florida 1900-1948. The following account represents the results of efforts to produce a half-century fire history for South Florida, bringing together material from all available sources. This information leaves much to be desired. For example, it is only very rarely possible to say definitely that a particular spot burned in a particular year. I believe, however, that further ransacking of the literature and local memories is not likely to much improve the quality of the record. It at least makes possible identification of most of the "fire years."

1909 - January 1909, date of John K. Small's first extensive botanical exploring trip into the Long Pine Key area (Small, 1909: 52-53). "We explored both the pineland and such hammocks as had not been burned out by recent fires.... The larger hammocks contained a more varied flora.... But the fires had been so recent that not a plant could be found in condition to collect."

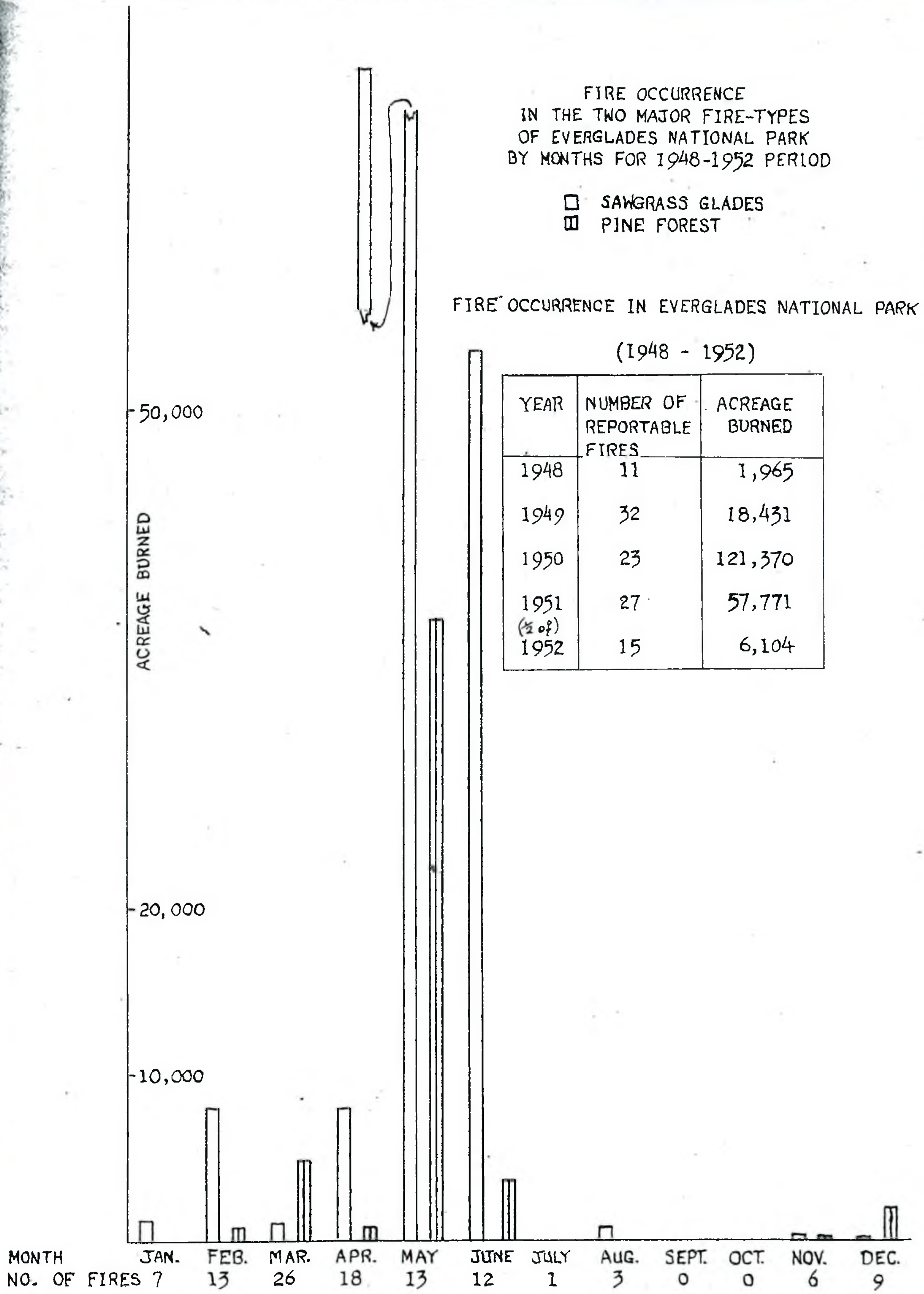
1911 - January-February 1911 (Small, 1911: 151, photograph, fig. 28). "This fire swept the keys below Homestead while we were collecting there.... The vegetation of the burned areas is restored after the rains begin again: And all the plants that grew there before seem to re-appear."

1916 - (Small, 1916b: pl. 182, facing p. 171) shows a picture of burned-over glades west of Paradise Key. Not dated.

April 15-17, 1916 (Small, 1916 c : 200) - "When during the afternoon of the previous day we were approaching Madeira Bay we had noticed that the hammock was on fire...we saw miles of hammock rolling clouds of black smoke skyward. This calamity was not confined to the neighborhood of Madeira Bay but in the Cape Sable region three or four vast forest fires were to be observed.... Forest fires are perhaps more frequent in southern Florida than usual this year as, beginning with the end of last year, there had been a prolonged drought."

- Rainfall December 1915 to May 1916. Homestead - 7.84" - Miami - 7.80".

1917 - April 30, 1917 (Small, 1918 : 283) - "Fires had recently swept over the prairie between Royal Palm Hammock (i.e. Paradise Key) and Long Key (i.e. Long Pine Key), and also through much of the pinelands and parts of the hammocks of Long Key.... The forest fires were evidently more severe than usual on account of the increased supply of tinder and fuel resulting from the freezing spell of weather of the earlier part of the year." - Referring to Big Pine Key in the Lower Florida Keys "... A great part of the pinelands were fire-swept."



FIRE OCCURRENCE IN EVERGLADES NATIONAL PARK

(1948 - 1952)

YEAR	NUMBER OF REPORTABLE FIRES	ACREAGE BURNED
1948	11	1,965
1949	32	18,431
1950	23	121,370
1951	27	57,771
(½ of) 1952	15	6,104

- Simpson (1932 : 155) gives the following illustrative particulars concerning the historic February 1917 freeze: A "backyard thermometer" at Key West recorded 27°F; 28°F was recorded at Long Key (Upper Florida Keys); crops were wiped out on Big Pine Key, February 4, 1917; $\frac{1}{4}$" of ice was frozen at Flamingo on the south coast; and, bananas were frozen to the ground at Cape Romano.

1919 - April-May 1919 (Small, 1921) - (p. 32) referring to the hammock strip along the east edge of Lake Okeechobee "... fire had been in it perhaps more than once." - (p. 35) refers to fires burning in pine woods on the west coast between Myakka and Sarasota - (p. 39)... "On this occasion nearly the whole Istokpoga Prarie was on fire, and far to the southeast was that continuing cloud of smoke from the delta of the Kissimmee River .... The hammock and humus there has been burning for years, the heaviest rains having failed to extinguish it." - (p. 58) refers to fires in the Fisheating Creek area northwest of Lake Okeechobee - (p. 63) "We passed through Royal Palm Hammock where it was gratifying to see the several acres of former forest, that was fireswept ad completely destroyed a few years ago, rapidly reforesting itself." — Note: I have not found any other information concerning this early fire in Paradise Key.

1920 - (Dovell, 1942: 152, fig. 8) A picture taken in 1920 with the following legend "A general view of an Everglades fire from a position along one of the main arterial canals."

- April 1920 (Small, 1922 : 140) "As we emerged onto the Okeechobee Prarie we found most of it afire.... The fire had not at this time reached the hammock along Lake Okeechobee, but it had on other occasions."

1921 - According to William McKinley Osceola, Seminole patriarch, the first big over-all fires in the lower glades occurred in 1921, which was a dry year with the effects of glades drainage just beginning to be felt. Many of the garden hammocks of the Seminoles were destroyed. (fide E. C. Winte)

- March-April 1921 (Small, 1923) - (p. 196) "...protracted drought, very severe in Florida" - (p. 223) referring to the Everglades City area "The long drought had turned a large part of the vegetation into tinder, and prairies, pinelands, hammocks, and cypress strands were food for terrific conflagrations." - (p. 231) Devil's Garden area southwest of Lake Okeechobee "Fires were raging in various parts of the Garden" - (p. 246-7) general south Florida area "The drought already referred tohad made much more tinder than usual, and fires were very numerous. Every day we passed through recently burned areas or through fires raging in prairies, in pinelands and in hammocks."

1922 - April-May 1922 (Small, 1929) - (p. 14) "... A seven-months drought has rendered vegetation backward" - (p. 52-3) "...ditches along the highway about Royal Palm Hammock were dry."

- Dovell, 1942 : 153) - Rainfall for the nine months period ending September 30, 1922 10" in excess of the annual average for the whole year - many lake shore towns around Lake Okeechobee flooded.

1923 - April-May 1923 (Small, 1928) - (p. 207) Indian Prairie area "Terrific fires had swept the praries and palms since our last crossing (in 1921)." - (p. 196, fig. 10) picture of cypress on east side of Lake Okeechobee with four feet of humus burned away from roots.

1924 - (Holt and Sutton, 1926 : 436) "In March the region /Cape Sable Prarie/ was very dry and fires were often seen."

1926 - (Dovell, 1942 : 154) "Dry weather through the winter witnessed an unprecedented series of grass and muck fires. The muck fires were put out by spring rains."

1929 - (E. C. Winte, personal communication) Fire burned the north end of Paradise Key, ad the east end of Long Pine Key. Edges of Osteen Hammock were singed.

1929 - 1931 - (Winte, personal communication) A "siege of fire" marked these years with especially heavy damage to hammocks in the Pinecrest area.

1931 - 1932 - (Dovell, 1942 : 159) "Unusually low water levels in Lake Okeechobee and the Everglades in 1931 and 1932 found many grass and muck fires throughout the glades. The big lake fell below 11 feet, and many fires which began in the summer and fall of 1931 continued to burn into June of the following year. The 1931 legislature had appropriated an emergency fund of $50,000, but many of the fires were out of control and it took the rains of the summer and fall of 1932 toextinguish them."

- (Winte, prsonal communication) 1931 was "a bad year" particularly in some areas of Long Pine Key. Hammock # 9 at Pinecrest burned out in 1931. Winte believed that most of the muck in sawgrass areas south of the Tamiami Trail had burned out prior to 1931.

- (J. J. Redding, personal communication) Redding first began frogging in the Shark River area by gator boat about 1931. At that time many of the hammocks in the lower glades had apparently never had fire in them.

1933 - (Small, 1933 : 267) "This part (southern end) of the Everglades ... is dotted with thousands of hammock islands. These islands represent the only spots in the Everglades that have not been seriously fireswept in historic and prehistoric times.... The fires as a result of lightning and aboriginal methods of civilization were evidently not so frequent as those resulting from careless use of fire and vandal incendiarisms following the white man's occupation, for many hundreds of these picturesque hammocks have been rapidly and completely wiped off the face of the Everglades within the past score years."

<u>1934</u> - <u>1935</u> - <u>1936</u> - (Winte, personal communication) All were wet years with no widespread fire.

"<u>Late 1930's</u>" - (C. C. von Paulsen, personal communication) These were "bad fire years" especially in the Flamingo area, the Madeira Bay hammock strip, and the Long Pine Key area around Osteen ad Palma Vista #2 hammocks. Damage to hammocks south of Pinecrest and 40-mile Bend (on Tamiami Trail) was particularly severe.

- (Beard, 1938) - (p. 51) "The Everglades Park area was badly burned during the winter of 1937-8, and there was no time during the drier part of the year that one could not see smoke somewhere on the horizon." - (p. 52) "This past winter was very dry. About one-half of the piney woods in the park area were burned, about 80% of the Everglades prairie, approximately 30% of the coastal prairie, probably 5% or less of the Ten Thousand Island coast, and about the same amount of the cypress."

- (Phillips, 1940 : 166) "There have always been fire sweeping the area (Miami Rock Ridge pineland), but none like the fires of the last few years and especially of 1939."

<u>1939</u> to <u>1942</u> - (Winte, personal communication) a succession of "bad fire years."

- (<u>Miami Herald</u>) - <u>April 3, 1939</u> - A 1200 acre fire on the outskirts of Hollywood. Rain checked many fires last week after an 18 months drought. - <u>May 5, 1939</u> - A muck fire twenty miles west of Miami between the Tamiami Trail and Route 27 - <u>December 14, 1939</u> - A 100 acre muck fire three miles west of Coral Gables.

<u>1940</u> - (Winte, personal communication) Severe fire in the Pinecrest area and in glades south of the Tamiami Trail.

- (Donald J. Poppenhager, personal communication) The Iron Pot Hammock country south of 40-mile Bend was badly burned out in 1940.

<u>1941</u> - (Stephens, 1943 : 31, Fig. 6) Photograph of a glades fire taken in the spring of 1941, four miles south of the Bolles Canal along Route 27.

- (<u>Miami Herald</u>) <u>February 6, 1942</u> - A glades fire burning on a five mile front nineteen miles west of Miami.

1943 - (Proc. Soil Sci. Soc. Fla. - VA : 113) March 17-18, 1943. "... practically the entire glades are on fire."

- (Bender, 1943 : 150) "In the last sixty days we have been faced with one of the most hazardous situations that has existed in a number of years. In addition to having a severe drought we have suffered the effects of a killing frost."

- (Proc. Soil Sci. Soc. Fla., VA : 177-187) March 18, 1943 - A number of glades fires were seen in the course of the society's inspection trip down Route 27 from Belle Glade to Miami.

Winter of 1943-1944 - (Winte, personal communication) Wet year with no widespread fire in the lower glades.

- (Miami Herald) February 2, 1944 - Fire four miles wide burning on a 25 mile front in Broward and Palm Beach counties. Fire extends from eight miles south of Okeelanta to 26 Mile Bend - February 10, 1944 - Several muck fires burning in Broward Co. - May 8, 1944 - Planes believed to be setting fires on practice bomb ranges along Tamiami Trail west of Miami - July 8, 1944 - Sawgrass and muck fire in Broward Co. 12.79" rainfall deficiency to date. November 25, 1944 - Miami smoked-in by smoke from muck fires.

1945 - (Winte, personal communication) An extremely dry winter. There were no hurricanes in 1944, and "not over 1"" of rain from October 1944 to July 1945. The glades were virtually a "dust bowl." There was no water to be found anywhere in the glades, Taylor Slough and the canals around Paradise Key were dry. The Tamiami Canal was almost dry.

- (Redding, personal communication) The Tamiami Canal was dry except for deep holes near the 'Blue Shanty'. Fires crossed the Tamiami Canal on Several occasions.

- (Winte, personal communication) According to the State Game Commissioner much of the area from Kissimmee south burned. - Paradise Key and 50% of Long Pine Key burned. Osteen, Fairchild, and Deckert Hammocks burned out completely, and fire burned into the northeast corner of Dark Hammock. Edges of these hammocks had burned before but they were still in "primitive condition." — The main Everglades burned from March to July. Two-thirds or more of the glades burned, both soil and vegetation. No cover was left for deer, a "hunter's heyday." — Some individual fires travelled over 25 miles and went out for lack of anything left to burn. The smoke began to clear before rains came. — Many big *Lysiloma* hammocks in the area from Pinecrest to Moss Camp west of the glades were reduced completely to bare rock jumbles. — Winte now believes that some of the 1945 fires were probably lightning-caused.

- (Miami Herald) February 2, 1945 - Ohlert, Dade County Fire Warden, warns of extreme fire hazard. No rain since October 1, 1944. -- April 5, 1945 - Smoke from fire north of the Tamiami Trail, 22 miles west of Miami stops traffic on the Tamiami Trail. - April 6, 1945 - Aerial reconnaisance with pictures of a large fire south of the Tamiami Trail. Four other fires seen north of the Trail. - April 6, 1945 - Fires have been burning inside Paradise Key for at least two weeks. No sign that anyone has tried to fight them. - April 7, 1945 - Large fires burning around Paradise Key, west and south of Princeton, and near Florida City. "Only an Act of God can halt the flames." - Sun rays focused by broken bottles believed to cause fires in remote glades. - April 8, 1945 - Light showers help fire fighters. Ohlert says "While Paradise Key looks bad now, within a year there will be noticeable physical damage (?)." - April 9, 1945 - Heavy rains on fires. Area south of the Tamiami Trail and west of Krome Avenue still smoldering. - April 10, 1945 - Coe states "Paths in Paradise Key broke the fire. Many acres of the most valuable of the park's forest trees are within the area protected by paths (?)." - April 11, 1945 - Glades fires threaten to rekindle. Estimated1/4 of the muck south of the Tamiami Trail and west of Krome Avenue has burned. - April 12, 1945 - Glades fires start again. Fires burning north and south of the Tamiami Trail, and others in Broward Co. Spotty fires burning from four to 15 miles south of Trail on an eight mile front west from Krome. - April 30, 1945 - 5000 acre fire in Broward County, Ft. Lauderdale smoked in. Dade County fires believed to be out. - May 1, 1945 - Broward Co. cities blacked out by smoke from glades fires. - May 3, 1945 - Fires believed to be dying down north of Trail. - May 5-6, 1945 - West winds bring a pall of muck smoke from Broward and Palm Beach County fires over Miami. - Feature article with photographs of frying an egg over burning muck. - June 1, 1945 - Fires still burning all along the east coast. Mostly "controlled." - June 2, 1945 - All Dade County fires reported to be under control. - June 3, 1945 - Aerial survey finds the glades "a sea of smoke." - June 4, 1945 - Six fires burning in Broward County, five in Dade County - June 5, 1945 - Disk harrows brought into use to build fire lines on glades fires. Smoke over Miami, air traffic at a standstill. - June 6, 1945 - Six inch rain on glades. Miami smoked in. Air stations shut down. - June 7, 1945 - All south Florida still under smoke pall, rain hasn't put out fires. Lee County cypress near Naples burning. - Bender, Chief Everglades Fire Control District, says that Dade County fires are under control. - June 8, 1945 - Miami comes out of the smog. Fires still burning in Lee, Collier, Hendry, and Broward counties. Norton (Weather Bureau) says that 1944 had 28 66" rainfall, and a 29.11" rainfall deficiency. Water table three feet below sea level in the Miami well field. - June 12, 1945 - Winds fan new Broward County Fire. Many other fires in North Dade and Broward counties. - June 13, 1945 - More smoke than ever over glades. Fire at Pennsuco threatens Dade-Broward muck levee. - June 15, 1945 - Pennsuco fire controlled. June 17, 1945 - New fires in North Dade-Broward. Bender "situation hopeless." June 21, 1945 - Fires controlled. Route 84 opened. Light rain.

– (Douglas, 1947 : 374–384) – Gives a lyric account of the 1945 fires.

1946 – (Miami Herald) April 13, 1946. Major muck fire burning west of 20-Mile Bend; first major fire of season. Ft. Lauderdale smoked in. Routes 27 and 84 closed by fire. April 19, 1946. South Broward muck fire out after one week.

1947 – (Winte, personal communication) Extremely high rainfall. The glades were "a vast lake" with up to five feet of water of open glades north of Tamiami Trail; 3½ feet of water in rocky glades near Grossman's Hammock. Open glades often had waves too rough for air boats, which had to run in the willow and sawgrass strands.

– (Miami Herald) – February 2, 1947 – No big glades fire for the second consecutive winter. – April 2, 1947 – Little danger seen of general fires. June 12, 1947 – 5½" rain in first ten days of June eliminate danger of fure.

1949 – (Miami Herald) – February 15, 1949 – Everglades National Park puts out fire at Grossman's Hammock. "Man's first victory over a sawgrass fire." – March 15, 1949 – Bender "driest in 14 years." Fires all over glades mostly north of Dade-Broward County line. – April 13-15, 1949 – Muck fires west of Ft. Lauderdale. – April 30, 1949 – Smoke from glades fires in Palm Beach Co. seen in Tampa.

1952 – (Miami Herald) – April 19, 1952 – Biggest glades fire in 15 years (!) burning in Palm Beach County near South Bay.

TABLE 8. RAINFALL AT 14 SOUTH FLORIDA STATIONS: 1900-1952.

STATIONS:

1 KISSIMMEE # 1 - Lat. 28°17' N., Long. 81°25' W.
2 OKEECHOBEE - Lat. 27°15' N., Long. 80°50' W.
#Okeechobee, Harding Bridge - Lat. 27°15' N., Long. 80°59' W.
##Okeechobee H.G.S. #6 - Lat. 27°12' N., Long. 80°47' W.
3 MOORE HAVEN #1 - Lat. 26°50' N., Long. 81°05' W.
4 CANAL POINT #1 - Lat. 26°53' N., Long. 80°38' W.
#Canal Point, West Palm Beach Canal Lock #1 - Lat. 26°52' N., Long. 80°38' W.
##Canal Point H.G.S. #5 - Lat. 26°52' N., Long. 80°38' W.
5 BELLE GLADE # 1 - Lat. 26°39' N., Long. 80°39' W.
6 HYPOLUXO - Lat. 26°32' N., Long. 80°03' W.
#Boynton Control #10 - Lat 26°32'N., Long. 80°03' W.
7 FORT LAUDERDALE - Lat. 26°10' N., Long. 80°10' W.
8 DANIA, 5 MILES WEST - Lat. 26°04' N., Long. 80°13' W.
#Davie, North New River Canal Lock #4 - Lat. 26°03' N., Long. 80°14' W.
##Davie, Stirling - Lat. 26°03' N., Long. 80°14' W.
9 MIAMI #1 - Lat. 25°48' N., Long. 80°12' W.
#Miami # 3 - Lat. 25°47' N., Long. 80°11' W.
10 COCONUT GROVE, CHAPMAN FIELD GARDEN - Lat. 25°39' N., Long. 80°18' W.
11 PENNSUCO # 2 - Lat. 25°54' N., Long. 80°22' W.
12 TAMIAMI TRAIL, 40 MILE BEND - Lat. 25°45' N., Long. 80°49' W.
13 EVERGLADES, COLLIER COUNTY - Lat. 25°51' N., Long. 81°23' W.
14 HOMESTEAD, EXPERIMENT STATION # 1 - Lat. 25°30' N., Long. 80°30' W.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average All Stations
May 1, 1899 May 1, 1900	65.49		-												
" " 1900 " " 1901	48.87					59.03									
" " 1901 " " 1902	50.51					76.82									
" " 1902 " " 1903	46.24					68.01									
" " 1903 " " 1904	57.70														
" " 1904 " " 1905	44.43					56.37									
" " 1905 " " 1906	69.38					61.33									
" " 1906 " " 1907	33.49					59.75			61.41						
" " 1907 " " 1908	50.48					44.43			38.78						
" " 1908 " " 1909	42.21					77.31			91.21						
" " 1909 " " 1910	45.23					67.66			66.20						
" " 1910 " " 1911	50.06								61.01						
" " 1911 " " 1912	49.90								56.80					72.78	
" " 1912 " " 1913	58.89					76.59			67.11						
" " 1913 " " 1914	39.35					42.92	52.74	#53.05	45.61					58.51	48.70
" " 1914 " " 1915	43.54					54.85	51.23	#55.73	47.31						50.53
" " 1915 " " 1916	45.33					60.33	76.07	#76.42	51.22					61.31	61.78
" " 1916 " " 1917	48.44					53.08	44.42	#55.77	44.21					66.15	52.01
" " 1917 " " 1918	49.20					61.22	55.95	#49.91	49.82					60.18	54.38

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average All Stations
May 1, 1918 May 1, 1919			36.37			54.02	66.36	#63.94	51.08					54.71	54.41
" " 1919 " " 1920			48.33			56.49	54.62	#55.72	48.18					55.80	53.19
" " 1920 " " 1921						60.12	54.50	#59.04	52.05					67.41	58.62
" " 1921 " " 1922		29.64		#33.05		39.94	60.47	#58.30	39.07					42.26	43.25
" " 1922 " " 1923	44.48		62.37	60.89		70.49	82.57	#91.14	66.39						68.33
" " 1923 " " 1924	64.43		59.63	55.58			55.66		47.02					69.35	58.61
" " 1924 " " 1925		50.08	58.84	62.85		71.52	83.01	#89.14	69.00	67.51					68.99
" " 1925 " " 1926			45.63	57.34	50.89	69.65	68.22	#55.67	70.91	77.25					61.95
" " 1926 " " 1927		42.84		45.79	60.43				61.10						
" " 1927 " " 1928			45.72	37.63	53.83	37.88	43.49	#43.45	29.77	34.12	45.60		37.00		40.85
" " 1928 " " 1929			48.94	60.21			62.59	62.92	62.02	50.78	55.40		55.28	66.69	58.31
" " 1929 " " 1930			55.87	69.43		69.50	88.49	#83.84	90.68	89.27	100.13		68.30		79.50
" " 1930 " " 1931	47.91	58.11	78.56	57.09	58.22	#63.05	75.51	#79.14	77.07	75.34	78.14		76.35		68.71
" " 1931 " " 1932	30.48	25.65	32.97	33.11	37.70	55.85	51.06	54.04	48.42	38.62	53.42		34.73	41.81	41.37
" " 1932 " " 1933	55.43	53.24	57.88	74.77	71.44	71.18	63.85	67.74	81.98	69.16	82.20		63.83	75.66	68.34
" " 1933 " " 1934	68.05	#52.17	37.98	61.93	64.22	74.90	79.16	78.46	72.23	50.98	60.10		46.14	66.92	62.56
" " 1934 " " 1935	50.89	52.45	45.76		57.33	48.11	62.92	61.00	60.18	50.04	68.29		56.75	62.81	56.38
" " 1935 " " 1936	46.96	48.35	45.84	44.35	51.77	#93.02	55.30	56.62	52.93	61.24	60.36		61.64	76.34	58.06

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average All Stations
May 1, 1936 May 1, 1937	44.47	54.94	59.09	62.42	70.31	54.44			79.18	79.30	65.80		63.13	79.93	64.82
" " 1937 " " 1938	45.55	43.84	48.57	47.71	46.18	#61.38			47.66	43.53			47.39	61.37	49.32
" " 1938 " " 1939	38.05	48.22	36.45	40.35	41.72	40.62	43.19	43.12	43.00	46.51			49.33	38.37	42.41
" " 1939 " " 1940	58.37	61.73	58.39	59.76	62.86	55.93	55.59		63.30	55.22	59.80		54.82	68.92	59.56
" " 1940 " " 1941	54.72	54.31	64.34	71.71	62.65	#69.33	73.58		81.29	67.52	58.11		66.20	85.70	67.45
" " 1941 " " 1942	60.46	49.22	59.25	59.98	59.31	77.30	57.44	#57.56	53.31	57.59	50.17	54.74		68.23	58.81
" " 1942 " " 1943	40.08	39.58	35.59	42.85	55.55	#46.32	41.76	56.23	46.41	42.93	52.84	52.65	37.55	50.64	45.78
" " 1943 " " 1944	42.51	43.20	41.05	47.25	44.95	42.35	46.61	46.93		49.97	51.07	56.39	36.03	56.71	46.54
" " 1944 " " 1945	39.29	##30.08	39.30	34.74	48.95	36.17		##66.97	#28.30	45.28	40.54	44.28	49.27	55.35	42.96
" " 1945 " " 1946	50.34	#53.52	44.26	57.22	55.28	56.75		59.08	#33.94	55.08	42.56	52.24	51.13	53.43	51.14
" " 1946 " " 1947	58.65	48.33	48.26	##62.57	78.13	65.43	54.99	69.06	#45.31	71.44	63.25	52.59	66.30	66.83	60.80
" " 1947 " " 1948	59.41	##54.97	67.89		83.57	102.54	105.62		#67.24	85.38		78.23	69.14	92.40	78.76
" " 1948 " " 1949	43.84	##31.87	44.14	##42.08	52.09	62.57	62.77	69.19	#55.55			57.67	53.91	72.28	54.00
" " 1949 " " 1950		##52.03	51.31	##46.76	54.29	55.69		72.33	#49.66	54.87		71.02		61.80	56.98
" " 1950 " " 1951	48.60	##35.43	41.83	##32.54	52.70		56.20		#49.61	44.65		58.29	47.80	50.73	47.13
" " 1951 " " 1952	57.84	##48.31	51.25		66.09	41.40		44.80	#39.20	44.00		37.70	41.99	51.08	47.61

Stations:	No. of Years Record:	Average May 1 to May 1 Rainfall	Minimum May 1 to May 1 Rainfall
1	·42	49.75	30.48
2	25	46.48	25.65
3	31	50.05	32.97
4	28	52.21	##32.54
5	25	57.62	37.70
6	45	60.53	36.17
7	32	62.06	41.76
8	31	62.46	43.12
9	45	56.53	28.30
10	26	57.98	34.12
11	18	60.43	40.54
12	11	55.98	37.70
13	23	53.65	34.73
14	32	62.89	41.81
Average All Stations		56.39	40.85

Year of Minimum Rainfall	Maximum May 1 to May 1 Rainfall	Year of Maximum Rainfall
1931-32	69.38	1905-06
1931-32	61.73	1939-40
1931-32	67.89	1947-48
1950-51	74.77	1932-33
1931-32	83.57	1947-48
1944-45	102.54	1947-48
1942-43	105.62	1947-48
1938-39	#91.14	1922-23
1944-45	91.21	1908-09
1927-28	89.27	1929-30
1944-45	100.13	1929-30
1951-52	78.23	1947-48
1931-32	76.35	1930-31
1931-32	92.40	1947-48
1927-28	79.50	1929-30

TABLE 9. DROUGHT PERIODS IN SOUTH FLORIDA 1900--1947. - A SUMMARY OF ALL PERIODS OF TWO OR MORE MONTHS DURATION IN WHICH LESS THAN INCHES OF RAIN PER MONTH WAS RECORDED.

Dry Season	Miami		Homestead		Tavernier	Long Key	Key West	
1900-01							2 July-Aug 7 Nov-May	6.25 7.74
1901-02							2 Oct-Nov 5 Jan-May	1.04 5.35
1902-03							6 Dec-May	12.06
1903-04							6 Nov-April	7.42
1904-05	6 Dec-May	10.63					2 June-July 3 Dec-Feb	3.10 1.33
1905-06	2 Jan-Feb	6.98					5 Apr-Aug 4 Jan-Apr	13.37 11.14
1906-07	6 Dec-May	6.50					2 July-Aug 6 Dec-May	4.92 4.58
1907-08	10 July-Apr	26.90					2 July-Aug 8 Oct-May	2.84 9.01
1908-09	2 Nov-Dec 2 Feb-Mar	2.51 0.83					6 Nov-April	6.64
1909-10	7 Nov-May	8.85					10 Nov-Aug	11.20
1910-11	5 Nov-Mar	3.92					9 Nov-July	15.32
1911-12	2 Feb-Mar	5.84	4 Dec-Mar	12.14			3 Feb-April	5.40

Dry Season	Miami			Homestead			Tavernier
1912-13	3	Aug-Oct	8.30	3	Dec-Feb	4.94	
1913-14	4	Dec-Mar	3.87	4	Dec-Mar	4.92	
	2	May-June	4.39				
1914-15	5	Jan-May	12.86				
1915-16	6	Nov-Apr	10.24	6	Nov-Apr	10.24	
1916-17	6	Nov-Apr	9.43	7	Nov-May	14.95	
1917-18	6	Oct-Mar	8.65	5	Nov-Mar	5.44	
1918-19	2	Jan-Feb	4.27	6	Nov-Apr	12.79	
1919-20	9	Aug-Apr	21.71	6	Oct-Mar	9.26	
1920-21	4	Nov-Feb	7.33	3	Dec-Feb	4.85	
1921-22	4	June-Sept	10.18	6	Nov-Apr	5.21	
	6	Nov-May	5.09				
1922-23	5	Dec-Apr	4.37				
1923-24	6	Nov-Apr	9.08	5	Nov-Mar	7.18	
1924-25	2	Nov-Dec	1.38				
	3	Feb-Apr	7.03				

Long Key			Key West		
			2	July-Aug	4.05
			9	Nov-July	15.11
			10	Nov-Aug	14.45
			3	Feb-Apr	6.36
			3	June-Aug	7.81
			8	Nov-June	11.13
9	Nov-July	10.18	10	Oct-July	17.01
8	Nov-June	14.73	7	Oct-Apr	10.71
3	Nov-Jan	2.80	4	June-Sept	7.53
			6	Nov-April	8.03
7	Oct-Apr	14.45	8	Dec-July	13.62
2	June-July	3.81	8	Oct-May	11.07
7	Oct-Apr	12.07			
6	Nov-Apr	7.63	6	Nov-April	7.22
6	Nov-Apr	9.56	6	Nov-April	8.26
8	Nov-June	7.33	3	June-Aug	9.90
			11	Oct-Aug	18.51
6	Nov-Apr	7.24	6	Nov-April	9.29

Dry Season	Miami		Homestead		Tavernier	
1925-26	2 Sept-Oct	3.85				
	3 Feb-Apr	2.86				
1926-27	8 Nov-June	12.38	2 Dec-Jan	1.40		
			3 Mar-May	4.28		
1927-28	6 Nov-Apr	4.73	6 Nov-Apr	7.22		
1928-29	5 Oct-Feb	6.26	6 Nov-Apr	12.62		
1929-30	3 Jan-Mar	10.34				
1930-31	2 Nov-Dec	4.56	2 Nov-Dec	2.33		
			3 May-July	8.43		
1931-32	2 June-July	2.70	6 Nov-Apr	8.58		
	6 Nov-Apr	11.00				
1932-33	4 Dec-Mar	5.36	4 Dec-Mar	5.45		
1933-34	3 Nov-Jan	4.45	6 Nov-Apr	10.69		
1934-35	6 Oct-Mar	7.22	6 Oct-Mar	5.00		
1935-36	5 Dec-Apr	12.62	2 Dec-Jan	3.18		
1936-37	2 Dec-Jan	3.38	5 Oct-Feb	11.13	6 Nov-Apr	11.95
	3 Apr-June	7.88				
1937-38	6 Nov-Apr	4.87	7 Nov-May	9.99	6 Nov-Apr	3.75

Long Key			Key West		
3	June-Aug	9.19	3	June-Aug	6.52
5	Dec-Apr	6.68	7	Oct-April	10.65
10	Nov-Aug	13.64	10	Nov-Aug	7.87
9	Nov-July	13.82	9	Nov-July	9.55
8	Nov-June	11.69	6	Nov-Apr	8.87
			2	Nov-Dec	6.05
2	Nov-Dec	2.94	2	Jan-Feb	7.87
			4	Apr-July	11.33
2	May-June	5.06	4	Jan-Apr	7.49
9	Nov-July	17.11			
3	Dec-Feb	1.17	7	Nov-May	8.33
3	Apr-June	4.91			
6	Nov-Apr	4.75	6	Nov-Apr	5.55
8	Nov-June	11.91	9	Oct-June	12.91
			2	Dec-Jan	3.04
			2	Apr-May	4.53
			7	Oct-Apr	12.32
			17	Nov 1937 to Mar 1939	28.94

Dry Season	Miami	Homestead	Tavernier	Long Key	Key West
1938-39	6 Nov-Apr. 7.89	6 Nov-Apr. 6.39	3 June-Aug. 8.10 8 Nov-June 17.60		
1939-40	6 Nov-Apr. 16.15	7 Nov-May 13.21	8 Nov-June 15.35		5 May-Sept. 14.74 8 Nov-June 14.24
1940-41	5 Oct-Feb. 15.58	4 Oct-Jan. 11.38	4 Oct-Jan. 10.37	Lignumvitae Key	2 Oct-Nov. 2.62 4 May-Aug. 7.64
1941-42	4 Dec-Mar. 8.49	4 Dec-Mar. 8.51	3.Jan-Mar. 5.96		4 Dec-Mar. 10.04
1942-43	2 July Aug. 4.60 7 Nov-May 17.97	7 Oct-Apr. 11.08	5 July-Nov. 11.00 8 Jan-Aug. 15.01	13 July-July 19.50	11 July-May 14.75
1943-44	*7 Oct-Apr. 13.90	6 Nov-Apr. 5.53	5 Dec-Apr. 4.15	6 Dec-May 7.14	2 July-Aug. 4.28 9 Dec-Aug. 16.15
1944-45	*11 Aug-June 18.40	8 Nov-June 11.81	9 Nov-July 9.09	8 Nov-June 3.99	8 Nov-June 7.99
1945-46	*6 Nov-Apr. 8.49	5 Dec-Apr. 7.14	7 Nov-May 13.16	7 Nov-May 12.28	7 Nov-May 11.45
1946-47	*2 July-Aug. 7.25 4 Dec-Mar. 7.24	5 Dec-Apr. 10.41	6 Dec-May 16.18		2 Aug-Sept. 6.38

Station Averages	Average Duration in Months of Annual Drought Period	Average Monthly Drought Period Rainfall	Average Total Drought Period Rainfall
Miami	5.6	1.88	10.51
Homestead	5.3	1.63	8.63
Tavernier	7.1	1.46	10.32
Long Key	7.5	1.44	10.71
Key West	7.7	1.61	12.43

1. Table 9 compiled from available rainfall records for the 1900-1947 period at the following stations:

Miami #1 - Dade County - Lat. $25^{\circ}48'$ N., Long. $80^{\circ}12'$ W.
*(Miami #3 - Dade County - Lat. $25^{\circ}47'$ N., Long. $80^{\circ}11'$ W., for July 1943 through July 1947)

Homestead, Experiment Station #1 - Dade County - Lat. $25^{\circ}30'$ N., Long. Long. $80^{\circ}30'$ W.

Tavernier - Monroe County - Lat. $25^{\circ}00'$ N., Long. $80^{\circ}33'$ W.

Long Key - Monroe County - Lat. $24^{\circ}49'$ N., Long. $80^{\circ}50'$ W.

Lignumvitae Key - Monroe County - Lat. $24^{\circ}49'$ N., Long. $80^{\circ}42'$ W.

Key West (Fort Taylor) - Monroe County - Lat. $24^{\circ}33'$ N., Long. $81^{\circ}48'$ W.

Description of Pineland Sites for which Lists of Shrub Understory Plants are Given

1. Northwestern part of the Redlands (east of Redland Road just north of Silver Palm Drive) - A 10-acre tract which last burned in the spring of 1926. This tract is low-lying in relation to the surrounding grove lands and water stands here in wet years. The original pine stand was cut before 1920 with a few large pines and seedlings left and the area was farmed for one year (1922) - Tomatoes were planted in potholes, but the area was never bulldozed. At present parts of the area have a dense understory of cabbage palms to 20' tall, but there are few hardwood shrubs, and virtually no pine reproduction. The ground is covered with an ankle-deep mat of pine needles; herbs and grasses sparse.

2. Pineland five miles southwest of Homestead in the area of the Loveland Road Fire (123-23) of December 1951.

3. Pineland Study Area #1 in Sawmill Road area of Long Pine Key in Everglades National Park.

4. Pineland Study Area #2 east end of Long Pine Key in Everglades National Park.

5. Shrubby pineland in the vinicity of Dark Hammock, Long Pine Key in Everglades National Park last burned in 1945.

6. Low pineland two miles northwest of Concrete Bridge in Everglades National Park. Badly burned in Long Pine Key fire of May 1950 (123 - 14).

7. Pineland two miles northeast of the end of Long Pine Key Road in Everglades National Park last burned in June 1951 (123-12).

8. Pineland along north edge of fire break for June 1951 Long Pine Key fire in Everglades National Park, probably unburned since 1945.

9. Pineland outside burn along firebreak for Rock Reef fire of June 1951 (123-17) north side of Long Pine Key in Everglades National Park.

10. Shrubby pineland one mile north of Long Pine Key Fire Tower in Everglades National Park.

11. Pineland near Turkey Hammock, Long Pine Key in Everglades National Park. Part of the area surveyed burned in May 1950 (123-12).

12. Pineland around Palma Vista Hammock east end of Long Pine Key in Everglades National Park.

13. Pineland near Little Royal Palm Hammock two miles west of the end of Long Pine Key Road in Everglades National Park badly burned-over in May 1950 (123-14).

14. Osteen Hammock Pineland, Long Pine Key in Everglades National Park. Burned in November 1948 (123-10).

15. Pine Island in the glades two miles south of Long Pine Key Fire Tower. Outside present Everglades National Park boundaries.

16. Densely shrubby low pineland along Saw Mill Road two and one-half miles north of Long Pine Key Road, Long Pine Key in Everglades National Park.

17. Pine-Palm forest three miles north of Overseas Highway (U. S. Route # 1) Big Pine Key, Monroe County.

18. Densely overgrown Pine-Palm Ridge north of Overseas Highway, Cudjoe Key, Monroe County.

Sites 17 and 18 are in the Lower Florida Keys. These pine forests differ considerably in the species composition of the shrub understory as shown by the table. They also differ greatly in aspect; many sites having a well-developed layer of tall (5-25') thatch palms (*Thrinax*) and silver palms (*Coccothrinax*) under the pines. Nothing similar is found on the mainland. Silver palms occur in the pine forest shrub layer on the mainland, but only rarely reach heights of over five feet there.

The species lists given in the table were chosen from a number of such plant survey lists at hand, and are believed to show the complete woody flora of the shrub understory at their respective sites.

TABLE 10. WOODY PLANTS OF SHRUB UNDERSTORY AT 18 REPRESENTATIVE SITES OF SOUTH FLORIDA PINE FORESTS.

1. Species marked (#) noted as locally predominant plants of shrub understory in various areas of pine forest.
2. Species starred (*) usually restricted to sink holes in their occurrence in pineland shrub understory.

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Constancy
#Sabal Palmetto (cabbage palm)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100%
#Serenoa repens (saw palmetto)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100%
#Cerothamnus ceriferus (wax myrtle, bayberry)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100%
Quercus pumila (scrub oak)	X																		6%
Quercus gemimata (scrub oak)	X																		6%
*Chrysobalanus icaco (cocoplum)	X	X	X	X	X		X	X	X	X	X	X		X	X	X	X		83%
Geobalanus oblongifolius (gopher apple)	X	X	X	X			X	X		X	X			X					50%
Tetrazygia bicolor (No common name)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			89%
#Metopium toxiferum (poisonwood)	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	94%
Byrsonima cuneata (locust berry)	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	94%
*Tamala Borbonia (redbay)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		94%
Croton linearis (No common name)	X	X	X	X	X		X	X		X	X	X	X	X	X		X		78%
*Annona glabra (pond apple)	X			X			X	X	X		X		X	X					44%

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Con-stancy
Randia aculeata (No common name)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100%
Morinda Roioc (No common name)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100%
Chiococca pinetorum (pinewoods snowberry)	X	X	X	X	X		X	X		X	X	X	X	X	X		X		78%
Rapanea guayanensis (myrsine)	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	94%
Zamia sp. (coontie)	X	X	X	X	X		X	X	X	X	X	X		X					67%
Baccharis glomeruliflora (No common name)	X		X		X			X				X							28%
Icacorea paniculata (marlberry)		X	X	X	X		X	X	X	X	X	X	X	X	X	X			78%
# Guettarda scabra (rough velvetseed)		X	X	X	X			X	X	X	X	X	X	X	X		X	X	78%
Guettarda elliptica (velvetseed)		X	X	X	X		X	X	X	X	X	X	X	X			X		72%
Dipholis salicifolia (bustic)		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	89%
Peiranisia bahamensis (wild cassia)		X	X	X			X	X	X		X		X	X		X	X	X	67%
Torrubia longifolia (blolly)		X	X	X	X		X	X	X	X	X	X		X	X			X	72%
# Coccothrinax argentea (silver palm)		X		X	X		X	X		X	X			X			X	X	56%
Rhus leucantha (sumac)		X	X	X	X		X	X	X	X	X	X	X	X					67%
Bumelia reclinata (pinewoods buckthorn)		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			83%
# Ilex Cassine (dahoon holly)		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			83%

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Con-stancy
<u>Smilax sp.</u> (greenbriars)		X	X	X	X		X		X	X	X	X	X	X	X		X	X	78%
<u>Lantana involucrata</u> (No common name)		X	X	X	X		X	X			X	X	X	X				X	56%
<u>Quercus virginiana</u> (live oak)		X	X	X	X		X	X		X	X	X	X	X					61%
<u>Ilex Krugiana</u> (Krug's holly)		X	X	X	X					X	X	X		X					44%
<u>Rhacoma ilicifolia</u> (No common name)		X	X	X	X		X	X				X	X				X	X	56%
<u>Trema floridana</u> (No common name)		X	X	X	X	X	X			X	X	X	X	X					61%
<u>Muscadinea Munsoniana</u> (Muscadine grape)		X			X	X						X		X	X				33%
<u>Eugenia axillaris</u> (white stopper)		X	X	X	X		X	X	X	X	X	X	X		X		X	X	78%
<u>Waltheria americana</u> (No common name)		X			X				X		X	X	X	X		X			44%
# <u>Conocarpus erecta</u> (buttonwood)		X	X		X		X	X		X	X		X	X	X	X	X	X	72%
<u>Rhabdadenia corallicola</u> (No common name)		X	X	X	X		X	X	X	X	X	X	X	X		X	X	X	83%
<u>Callicarpa americana</u> (beauty berry)		X		X	X							X		X					28%
<u>Echites Echites</u> (coathook vine)		X	X	X	X		X	X	X		X	X		X				X	61%
<u>Lantana depressa</u> (ground lantana)		X	X	X	X						X	X							33%
<u>Mosiera longipes</u> (pinewoods stopper)			X	X			X	X	X	X	X	X	X		X	X	X	X	72%
# <u>Dodonaea jamaicensis</u> (varnish leaf)			X	X	X			X	X	X	X	X	X	X					56%
<u>Forestiera pinetorum</u> (pinewoods privet)			X	X	X			X	X	X	X		X	X					50%

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Constancy
Ficus brevifolia (shortleaf fig)			X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	83%
Chrysophyllum olivaeforme (satinleaf)			X	X	X		X	X	X	X	X		X	X	X	X	X		72%
*Magnolia virginiana (sweet bay)			X		X		X	X			X			X		X			39%
*Salix amphibia (willow)			X		X		X	X	X	X	X		X	X		X			56%
*Solanum Blodgettii (No common name)			X		X					X		X		X	X			X	39%
# Lysiloma bahamensis (wild tamarind)			X	X	X		X	X	X	X	X	X		X		X			61%
Jacquinia keyensis (joewood)			X				X	X	X		X					X		X	39%
Colubrina Colubrina (No common name)			X	X	X			X	X	X	X			X					44%
Elaphrium simaruba (gumbo-limbo)			X	X	X			X		X	X	X				X	X	X	56%
Coccolobis laurifolia (pigeon plum)			X		X		X	X	X	X	X	X					X	X	56%
Vachellia sp. (wild acacia)			X		X			X	X		X			X			X	X	44%
Bumelia angustifolia (saffron plum)			X				X	X			X						X	X	33%
Eupatorium villosum (No common name)			X	X	X		X	X	X		X	X		X					50%
Ficus aurea (strangler fig)				X	X		X												17%
# Citharexylum fruticosum (fiddlewood)				X	X							X		X					22%
Exothea paniculata (inkwood)				X	X		X	X			X								28%

4

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Constancy
Toxicodendron radicans (poison ivy)					X							X	X		X				22%
Sideroxylon foetidissimum (mastic)					X		X	X			X								22%
Psychotria nervosa (wild coffee)					X					X	X	X		X					28%
Baccharis halimifolia (No common name)						X			X					X		X	X		28%
Hypelate trifoliata (white ironwood)							X	X		X									17%
Colubrina cubensis (No common name)							X	X	X		X								22%
Alvaradoa amorphoides (No common name)							X												6%
Anamomis Simpsonii (Simpson's stopper)								X											6%
Psidium Guajava (guava)												X							6%
*Diospyros virginiana (persimmon)												X							6%
Parthenocissus quinquefolia (Virginia creeper)												X	X	X					17%
*Cephalanthus occidentalis (buttonbush)														X					6%
Ernodea littoralis (No common name)																	X	X	11%
Pisonia rotundata (No common name)																	X	X	11%
Pithecolobium guadalupense (blackbead)																	X	X	11%
Coccolobis uvifera (sea grape)																	X	X	11%

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Constancy
Ichthyomethia piscipula (Jamaica dogwood)																	X	X	11%
Rhacoma Crossopetalum (No common name)																	X	X	11%
Catesbaea parvifolia (No common name)																	X	X	11%
# Thrinax microcarpa (silky thatch palm)																	X	X	11%
Urechites lutea (wild allamanda)																	X	X	11%
Caesalpinia pauciflora (No common name)																	X	X	11%
Solanum verbascifolium (potato tree)																		X	6%
Borrichia arborescens (sea oxeye)																		X	6%
Eugenia buxifolia (Spanish stopper)																		X	6%
Suriana maritima (bay cedar)																		X	6%
Mimusops emarginata (wild dilly)																		X	6%
Reynosia septentrionalis (darling plum)																		X	6%
Sophora tomentosa (necklace pod)																		X	6%
Erithalis fruticosa (black torch)																		X	6%
*Rhizophora Mangle (red mangrove)																		X	6%
*Laguncularia racemosa (white mangrove)																		X	6%

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Con-stancy
Borrichia frutescens (blueweed, sea oxeye)																		X	6%
Hippomane Mancinella (manchineel)																		X	6%
Drypetes diversifolia (white wood)																		X	6%
Total Number of Species	19	39	52	53	57	12	50	45	41	44	56	50	38	53	28	28	38	50	

*
*

The following table presents counts of shrubs over two feet high on a series of closely adjacent one-tenth acre circular plots on Pine Study Area #1 near the eastern end of Long Pine Key. Successive marked trees 55 yards apart, which were part of a grid established in mapping a pine woods breeding bird census area, were taken as the center paints of the shrub study plots. Since the radius of a one-tenth acre circle is slightly over twelve yards it is seen that a gap about 30 yards wide occurred between plots in each of the two rows studied. Data are given for six plots studied in Row "D", and for six studied in Row "B", which is 110 yards east of "D", and parallel to it. The most abundant shrub species in each plot is underlined in the table.

TABLE 11. Quantitative Study of Pine and Shrub Understory, Long Pine Key

Shrub Layer Species	Range Ttoal 1/10 Acre Abundance	Constancy
1. Dodonaea jamaicensis (varnish leaf)	252-26	100%
2. Serenos repens (saw palmetto)	80-14	100%
3. Guettarda scabra (rough velvetseed)	550-29	100%
4. Sabal palmetto (cabbage palm)	23- 7	100%
5. Torrubia longifolia (blolly)	36- 0	92%
6. Rhus leucantha (sumac)	14- 0	83%
7. Metopium toxiferum (poisonwood)	10- 2	100%
8. Icacorea paniculata (marlberry)	38- 0	92%
9. Dipholis salicifolia (bustic)	13- 2	100%
10. Guettarda elliptica (velvetseed)	63- 1	100%
11. Coccothrinax argentea (silver palm)	9- 0	67%
12. Ilex Krugiana (Krug's holly)	5- 0	75%
13. Pinus caribaea (slash pine)	9- 0	83%
14. Zamia floridana (coontie)	3- 0	50%
15. Trema floridana (no common name)	2- 0	25%
16. Rhabdadenia corallicola (no common name)	2- 0	25%
17. Lantana involucrata (no common name)	5- 0	67%
18. Morinda Roioc (no common name)	11- 0	92%

Shrub Layer Species	Range Total 1/10 Acre Abundance	Constancy
19. Smilax sp. (greenbriar)	7-0	50%
20. Croton linearis (no common name)	7-0	58%
21. Ficus brevifolia (shortleaf fig)	4-0	58%
22. Byrsonima cuneata (locust berry)	2-0	75%
23. Rapanea guayanensis (myrsine)	4-0	42%
24. Tetrazygia bicolor (no common name)	2-0	58%
25. Elaphrium simaruba (gumbo-limbo)	1-0	17%
26. Eupatorium villosum (no common name)	3-0	33%
27. Callicarpa americana (beauty berry)	1-0	8%
28. Cerothamnus ceriferus (wax myrtle, bayberry)	5-0	33%
29. Quercus virginiana (live oak)	1-0	17%
30. Chiococca pinetorum (pinewoods snowberry)	2-0	17%
31. Ilex Cassine (dahoon holly)	1-0	8%
32. Citharexylum fruticosum (fiddlewood)	2-0	25%
33. Eugenia axillaris (white stopper)	5-0	25%
34. Randia aculeata (no common name)	4-0	17%
35. Tamala Borbonia (redbay)	1-0	8%

Station	2D			3D			4D			5D		
Size-Classes (in feet)	2/4	4/7	7/10	2/4	4/7	7/10	2/4	4/7	7/10	2/4	4/7	7/10
Shrub Layer Species												
1.	39			26			152	5		170	16	
2.	37			44			52			73		
3.	29			80			134	5		185	10	
4.	21	2		8			9			10	2	
5.	15			7	1		1			2	5	
6.	10			8			6			10	2	
7.	7	1		7	2		1	3		6	3	
8.	5	1		8						4	1	
9.	6			8	2		1			9	3	
10.	5			22			7			10		
11.	4			6						2		
12.	4			2							1	
13.		3		2		2					1	3
14.	1						1			3		
15.	1										1	
16.	1											
17.	1						1				5	
18.				5			3			4	1	
19.				2						1	2	
20.				2						1		
21.				1						1		
22.										2		
23.										1	2	
24.										1	1	
25.												1
26.										1		
27.												
28.												
29.												
30.												
31.												
32.												
33.												
34.												
35.												
Total Plants in each size-class	186	7	0	238	5	2	369	13	0	496	56	0
Total Plants in 1/10 acre plot		193			245			382 382			556	
Total number Shrub Species in 1/10 acre plot		17			17			13			25	

Station	6D			7D			7B			6B		
Size-Classes (in feet)	2/4	4/7	7/10	2/4	4/7	7/10	2/4	4/7	7/10	2/4	4/7	7/10
Shrub Layer Species												
1.	103	7		100	5		36	4		170	3	
2.	49			48			14			70		
3.	212	14		143	5		184	3		178	2	
4.	6	1		15	3		18	2		17	2	
5.	2	1		8	2		2			4		
6.	11			5			8			3		
7.	8			1	6	1	4	3		2		
8.	5	1		2	2			1		8	1	
9.	10	3		10	2		6			2		
10.	10			2			6			14		
11.	1			2			2					
12.				3	1		3	1		4	1	
13.		1	2	1	1		1	4	4			
14.				1			1			1		
15.												
16.												
17.	1			1						2	1	
18.	8			3			4			10	1	
19.	2	1		6			5			7		
20.	2											
21.				1			1			1		
22.	1			2			1			1		
23.				1			4					
24.	1									2		
25.					1							
26.	1						3			1		
27.	1											
28.							1					
29.							1					
30.							1			2		
31.											1	
32.												
33.												
34.												
35.												
Total Plants in each size-class	434	29	2	355	28	1	306	18	4	499	12	0
Total Plants in 1/10 acre plot		465			384			328			511	
Total number Shrub Species in 1/10 acre plot		20			21			23			21	

Station	5B			4B			3B			2B		
Size-Classes (in feet)	2/4	4/7	7/10	2/4	4/7	7/10	2/4	4/7	7/10	2/4	4/7	7/10
Shrub Layer Species												
1.	216	14		238	14		115	4		94	3	
2.	34			71	1		80			43		
3.	468	14		476	74		85			44		
4.	9	2		5	2		20	1		11	2	
5.	20	16		12	5					3		
6.	13	1		2								
7.	2	7		3	7		1	3		4	4	1
8.	5	2		22	16		3			9		
9.	7			2	2		2			3		
10.	1			62	1		6			27		
11.							6			9		
12.	1			2	1					2		
13.	1			1		1	3	4	2		1	
14.												
15.				2								
16.	1						2					
17.							1			1		
18.	7			9			4			6		
19.												
20.				7			1					
21.	3	1		1								
22.	2			2			1					
23.							1			4		
24.	1				1		1			2		
25.												
26.												
27.												
28.	5						1			5		
29.							1					
30.												
31.												
32.	2						1			1		
33.	1			5						1		
34.	1			4								
35.					1							
Total Plants in each size-class	801	57	0	926	125	1	335	12	2	269	10	1
Total Plants in 1/10 acre plot		858			1052			349			280	
Total number Shrub Species in 1/10 acre plot		21			21			20			19	

TABLE 12. Characteristic Plants of the Grass-Herbaceous Layer in South Florida Pinelands.

x - Confined to Lower Florida Keys
* - South Florida Endemic
v - Mainly in sinks and low pineland

Ferns

Anemia adiantifolia
Pteris caudata
Pycnidoria pinetorum
vSphenomeris clavata

Grasses

*Tripsacum floridanum
Andropogon glomeratus
Sorghastrum secundum
Chaetochloa geniculata
Cenchrus echinatus
Panicum virgatum
Aristida stricta
Chloris glauca

Sedges

Fimbristylis castanea
Dichromena colorata

Herbs

Leucojaceae

Aletris bracteata

Orchidaceae

* Limodorum pinetorum
Bletia purpurea

Mimosaceae

Neptunia floridana

Cassiaceae

x*Chamaecrista keyensis
*Chamaecrista Deeringiana

Fabaceae

Crotalaria maritima
Crotalaria pumila
Dolicholus minimus

Herbs - Continued

Fabaceae - continued

Rhynchosia cinerea
Leucopterum parvifolium
Rhynchosia simplicifolia
*Galactia pinetorum
*Galactia parvifolia
Bradburya virginiana
*Stylosanthes calcicola

Linaceae

vCathartolium Curtissii
Polygalaceae
*Asemeia leoides
Polygala verticillata
*Pilostaxis arenicola
vPilostaxis Baldwinii

Euphorbiaceae

*Croton arenicola
*Ditaxis Blodgettii
*Tragia saxicola
vStillingia sp.
Bivonea stimulosa
x*Chamaesyce serpyllum
x*Chamaesyce keyensis
*Chamaesyce pinetorum
*Chamaesyce conferta
*Chamaesyce adenoptera

Turneraceae

*Piriqueta carliniana

Passifloraceae

Passiflora pallida

Cassythaceae

Cassytha filiformis

Herbs - continued

Lythraceae

vAmmannia Koehnei

Gunneraceae

vProserpinacea palustris

Gentianaceae

vSabbatia Elliottii

Asclepiadaceae

Asclepias Rolfsii
vAsclepias lanceolata
Asclepiadora viridis
Metastelma Blodgettii

Convolvulaceae

xEvolvulus glaber
xEvolvulus Wrightii
xEvolvulus macilentus
Ipomoea tenuissima
Exogonium microdactylum
*Jacquemontia Curtissii

Solanaceae

Physalis angustifolia

Heliotropiaceae

v*Heliotropium Leavenworthii

Verbenaceae

*Glandularia maritima
*Lantana depressa

Lamiaceae

Scutellaria Havanensis
vHyptis radiata

Herbs - Continued

Rhinanthaceae

Agalinis purpurea
vAgalinis fasciculata
Buchnera elongata

Acanthaceae

*Dyschoriste angusta
*Ruellia hybrida

Rubiaceae

Houstonia sp.
vDiodia tetragona
*Borreria terminalis

Carduaceae

*Vernonia Blodgettii
Veronia scaberrima
vEupatorium mikanioides
vConoclinium coelestinum
vMikania batatifolia
*Kuhnia Mosieri
Laciniaria gracilis
*Pityopsis Tracyi
Solidago Chapmanii
vSolidago petiolata
Aster adnatus
Erigeron quercifolius
vPluchea foetida
Pterocaulon undulatum
Melanthera parvifolia
Coreopsis Leavenworthii
Bidens pilosa
Flaveria linearis
*Cirsium vittatum

Primulaceae

vSamodia ebracteata

HAMMOCK SITES OF TABLE 13.

The sites for which woody plant lists are given in the table were chosen to represent the greatest geographic range and the greatest variety of site conditions within the region possible from data at hand. The sequence of arrangement is roughly from south to north; and from dryer andcoastal sites to moister and interior sites. The amount and intensity of field study varied considerably from area to area, and some of the lists are certainly incomplete.

Sites 1 through 4 are in the Lower Florida Keys.

#1 - Southeast Hammock, Big Pine Key, Monroe County

Low hammock thicket partially on a shell beach ridge, partially on Key Largo (corralline) Limestone. Notable for the development of tree cacti, especially Cephalocereus keyensis.

#2 - Big Pine Key, Monroe County.

Hammock and hammock thicket located between mangrove swamp and pine-palm woods at east side of Big Pine Key on Miami Oolite. Edges frequently burned. Includes some pine woods plants. Notable for the presence of the rare tree, Gyminda latifolia.

#3 - North end of Little Torch Key, Monroe County.

Scrubby hammock thicket on Miami Oolite. Notable as the only presently known U. S. locality for the tree, Clusia rosea.

#4 - Watson Hammock, Big Pine Key, Monroe County.

Mature hammock patches dominated by gumbo-limbo (Elaphrium), strangler fig (Ficus aurea), pigeon plum (Coccolobis laurifolia), Jamaica dogwood (Ichthyomethia), poisonwood (Metopium), and satinleaf (Chrysophyllum); and recently fire-swept scrubby fields. On Miami Oolite. Only known U. S. locality for the tree, Cupania glabra.

Site 5 is in the Upper Florida Keys.

#5 - Lignumvitae Key, Monroe County.

A high (to 16 + ') key of Key Largo limestone with undisturbed hammock forest. Intensively surveyed. The list includes plants from both upland and shore portions of the hammock. A large area of mature hammock notable for its variety of woody plants, and for such rare items as lignumvitae (Guaiacum), Schaefferia frutescens, and Drypetes lateriflora.

Sites 6, 7, and 8 are coastal hammocks on shell beach ridges.

#6 - North Nest Key, Florida Bay, In Everglades National Park.

Scrubby immature hammock on open shell beach exposed to much damage by wind and salt spray. Elevation of the beach ridge probably no more than 2--3' above the interior mangrove swamp and salt ponds of this Florida Bay key.

#7 - Long Key, Monroe County.

Hammock on shell beach facing the ocean. An older better-developed hammock than #6, on a considerably more elevated beach ridge and protected by a wide front beach.

#8 - Cape Sable, Monroe County, Everglades National Park.

Between East and Middle Cape Sable. An old mature hammock on stabilized low dunes of shell sand with 50 - 150 yards of beach grasses and open beach between hammock and shore. Much of the hammock now shows extensive fire and hurricane damage.

The hammocks of sites #6, 7, and 8 represent three stages in the development of hammock forest on south Florida shell beaches. This development seems dependent on the topographic development of the beach, as increasing elevation of the beach ridge and increase in width of the front beach give increased protection against winds and salt spray. The vegetational development proceeds from a scrubby and discontinuous thicket growth of the few species which can tolerate the extreme conditions; to a closed hammock forest which closely resembles those developed on other substrates of the region in its physiognomy and floristics.

Sites #9 and 10 are in the southwest coastal area.

#9 - Bear Lake Road, Monroe County, Everglades National Park.

Hammock forest on deep coastal marl. Young forest on canal banks and road shoulders, and adjacent naturally elevated hammock areas. Surrounded by mangrove swamps, the site is at least occasionally exposed to some flooding by brackish water. The hammock is notable for the abundance of manchineel (Hippomane), an Euphorbiaceous tree with toxic sap.

#10 - Turner River Mounds, Collier County, Everglades National Park (?)

Hammock forest developed on large aboriginal (Calusa?) shell mounds on the south side of Turner River near its mouth. The tropical species which comprise this hammock are here approaching their northern range extremities. The list, based on a single visit, is probably not complete.

Sites #11, 12, and 13 are tree island hammocks on the southwestern Everglades near the inland edge of the mangrove.

#11 - Big Mahogany Hammock, Dade County, Everglades National Park.

Hammock forest dominated by very large mahogany (Swietenia) to 50 + " DBH. This hammock is of much ecological interest since it has apparently developed on deep hammock peat built up over marl, and not on an elevation of limestone. The indication is that this may represent a later stage in the development to maturity of the bay tree islands and cypress-bay heads of the southern Everglades.

#12 - Oak-Mahogany Hammock, Dade County, Everglades National Park.

Hammock on an island elevation of Miami oolite about 1½ miles northeast of #11. Shows interesting mixed dominance of live oak and mahogany.

#13 - Dewhurst Hammock, Dade County, Everglades National Park.

Another glades hammock on a rock island outlier of Long Pine Key.

Sites #14 through 22 are restricted island areas of hammock forests on the main "ridge" of Miami oolite (Long Pine Key), partially or entirely surrounded by pine forest. They have suffered varying amounts of fire damage which is perhaps largely responsible for the floristic differences which are found. These hammocks were mapped and named by early tree snail (Liguus) collectors, and hammock names on the map of C. N. Grimshawe (1923) have been used insofar as the areas studied could be located on that map. Sites are numbered in sequence from west to east on Long Pine Key.

#14 - Small Hammock and Royal Palm Hammock (not to be confused with Paradise Key, site #23), Dade County, Everglades National Park.

Two closely adjacent hammocks, notable as the only Long Pine Key hammocks containing royal palms.

#15 and #16 could not be identified from the Grimshawe map. They are located about two miles ENE of the west end of Long Pine Key Road. Edges of both were singed by the June 1951 Long Pine Key fire. In addition #15 has been badly burned out inside by an earlier fire.

#17 - Turkey Hammock, Dade County, Everglades National Park.

#18 - Also could not be located from the map. It is $1\frac{1}{2}$ miles NW of the Long Pine Key Road along Saw Mill Road. Dominated by live oak.

#19 - Mosier Hammock, Dade County, Long Pine Key, Everglades National Park.

#20 - Osteen Hammock, Dade County, Long Pine Key, Everglades National Park.

A large hammock almost completely burned out inside with a few unburned patches around the edges.

#21 - Dark Hammock, Dade County, Everglades National Park.

Dominated by *Lysiloma bahamensis*.

#22 - Palma Vista #2 Hammock, Dade County, Everglades National Park.

#23 - Paradise Key, Dade County, Everglades National Park.

The largest and most highly developed of the rock ridge hammocks of the park due to the fact that it was protected by deep sloughs on all sides until drainage lowered water levels. Since this time fires in 1929 and 1945 have devastated much of the hammock.

Sites #24 and 25 are tree island hammocks in the main Everglades north of Long Pine Key. Elevation appears to govern the occurrence of hammock species in this area. Hammocks are found on Indian mounds, on elevated limestone islands, and probably also on sites developing from bayheads where up-building peat deposits produce the requisite elevation.

#24 - Hammock on a rock island between the headwaters of Broad River and Lostman's River and close to inland mangrove edge. Notable among the glades hammocks seen, in the variety of tropical species it contains.

#25 - Composite list from two adjacent hammocks on Indian mounds in the east part of the Iron Pot Hammock fire of June and July 1951. Both are dominated by hackberry (*Celtis*) and contain relatively few tropical species.

#26 - 'Coppice' Hardwoods, Marsh Harbour, Great Abaco, Bahamas.

List compiled during a visit to the northern Bahamas in July 1952 and presented to illustrate the great floristic similarity between hardwood forests there and the south Florida hammocks. Dense second or third growth thickets on limestone coastal hills.

TABLE 13. Woody Plants of 25 South Florida Hammock Forest Sites, with a List for a Bahaman 'Coppice" Forest (#26) shown for comparison. A total of 153 species.

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Con-stancy	26
Agave decipiens	x				x			x																		12%	
(1) Casuarina equisetifolia (Australian pine)	x					x	x																			12%	
Ficus brevifolia (shortleaf fig)	x		x	x	x										x	x	x						x			32%	
Coccolobis laurifolia (pigeon plum)	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x		88%	x
Coccolobis uvifera (sea grape)	x		x	x	x	x	x																			24%	x
Pisonia aculeata (pull-and-hold-back)	x				x			x	x	x			x	x					x	x	x	x	x			48%	x
Torrubia longifolia (blolly)	x	x			x	x	x							x	x	x										32%	x
Capparis flexuosa (bay-leaved caper-tree)	x			x	x		x		x																	20%	
Capparis cyanophallophora (caper-tree)	x				x																					8%	
Pithecolobium Unguis-cati (cat's claw)	x				x					x																12%	
Pithecolobium guadelupense (blackbead)	x	x	x	x	x	x	x	x	x																	36%	
Peiranisia bahamensis (No commom name)	x	x		x												x	x				x					24%	
Ichthyomethia piscipula (Jaimaica dogwood)	x	x	x	x	x	x		x	x	x																36%	x
Zanthoxylum fagara (wild-lime)	x				x			x	x				x									x	x	x		32%	
Amyris elemifera (torch wood)	x				x																					8%	
Suriana maritima (bay cedar	x				x	x	x	x																		20%	x

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Con-stancy	26
Elaphrium simaruba (gumbo-limbo)	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	96%	x
Metopium toxiferum (poisonwood)	x	x	x	x	x		x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	88%	x
Toxicodendron radicans (poison ivy)	x										x		x	x		x	x		x				x	x		36%	
Maytenus phyllanthoides (gutta percha mayten)	x				x																					8%	
Krugiodendron ferreum (lead wood)	x	x			x			x	x						x				x							28%	
(1) Carica Papaya (papaya)	x				x			x	x					x												20%	
Acanthocereus floridanus (dildoe cactus)	x				x			x	x																	16%	
Harrisia Simpsonii (prickley apples)	x								x																	8%	
Cephalocereus keyensis (No common name)	x																									4%	
Conocarpus erecta (buttonwood)	x		x	x	x	x	x	x	x		x						x									40%	x
Eugenia buxifolia (Spanish stopper)	x	x	x	x	x	x	x	x	x	x	x															44%	x
Icacorea paniculata (marlberry)	x	x		x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		84%	x
Bumelia angustifolia (saffron plum)	x	x		x	x	x		x																		24%	
Mimusops emarginata (wild dilly)	x	x					x																			12%	
Vallesia glabra (No common name)	x				x																					8%	
Urechites lutea (wild allamanda)	x	x																								8%	

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Con-stancy	26
Solanum bahamense (No common name)	x				x		x																			12%	
Solanum verbascifolium (potato tree)	x		x		x			x	x																x	24%	
Solanum Blodgettii (No common name)	x		x	x					x														x			20%	
Varronia globosa (No common name)	x				x				x																	12%	
Bourreria ovata (strongbark)	x	x	x						x																	16%	x
Mallotonia gnaphalodes (sea lavender)	x							x																		8%	
Lantana involucrata (lantana)	x	x	x		x		x	x		x						x	x		x	x	x		x			52%	x
Citharexylum fruticosum (fiddle wood)	x				x												x					x	x			20%	
Ximenia americana (hog plum)	x	x	x	x	x				x										x	x			x			36%	
Casasia clusiifolia (seven year apple)	x				x	x	x																			16%	
Randia aculeata (No common name)	x	x	x	x	x	x		x	x	x	x	x				x	x						x	x		60%	x
Guettarda elliptica (smooth velvetseed)	x	x			x				x														x			20%	
Morinda Roioc (No common name)	x	x	x	x	x	x		x								x	x		x	x	x		x			52%	x
Baccharis halimnifolia (groundsel tree)	x		x										x						x				x			20%	
Borrichia frutescens (blueweed, sea oxeye)	x				x		x		x																	16%	x
Borrichia arborescens (sea oxeye)	x				x	x	x	x																		20%	x
Thrinax microcarpa (silky thatch palm)		x	x	x																						12%	

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Con-stancy	26
Coccothrinax argentea (silver palm)		x		x										x												12%	
Serenoa repens (saw palmetto)		x									x	x					x						x			20%	
Pisonia rotundata (No common name)		x		x																						8%	
(2) Vachellia sp. (popinack)		x	x	x																						12%	
Byrsonima cuneata (locust berry)		x	x																							8%	x
Savia bahamensis (maidenbush)		x																								4%	x
Drypetes diversifolia (white wood)		x			x																					12%	x
Rhacoma Crossopetalum (Christmas berry)		x																								4%	
Gyminda latifolia (false boxwood)		x																								4%	
Exothea paniculata (ink wood)		x			x			x			x	x	x	x	x	x	x	x	x	x	x	x	x			64%	x
Reynosia septentrionalis (darling plum)		x		x	x																					12%	
Eugenia axillaris (white stopper)		x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		84%	x
Chrysophyllum olivaeforme (satinleaf)		x		x				x		x	x		x	x		x	x	x	x	x	x	x	x	x		64%	
Myriopus volubilis (no common name)		x							x																	8%	
Exostema caribaeum (prince wood)		x																								4%	
Guettarda scabra (rough velvetseed)		x											x	x	x	x	x	x	x	x	x	x	x			48%	x

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Con-stancy	26
Chicococca alba (hammock snowberry)		x		x	x		x	x	x	x				x	x	x	x	x	x	x	x		x			64%	x
Psychotria nervosa (wild coffee)		x		x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		76%	x
Cerothamnus ceriferus (bayberry, wax myrtle)			x	x							x		x	x	x	x	x				x		x	x	x	48	
Trema floridana (No common name)			x											x			x		x				x	x		24%	
(1) Albizzia lebbek (woman's tongue tree)		x																								4%	
Clusia rosea (monkey apple)		x																								4%	
Mosiera longipes (No common name)		x																								4%	
Rapanea guayanensis (myrsine)		x	x								x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	68%	x
Dipholis salicifolia (bustic)		x								x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	68%	x
Erithalis fruticosa (black torch)			x			x																				8%	
Chiococca pinetorum (pinewoods snowberry)			x																							4%	
Ernodea littoralis (No common name)			x																							4%	
Sabal Palmetto (cabbage palm)				x				x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	72%	
Ficus aurea (strangler fig)				x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	80%	
Vachellia Farnesiana (popinack)				x																						4%	
Simarouba glauca (paradise tree)				x									x	x		x	x	x	x	x	x	x	x	x		48%	
Hoppomane Mancinella (manchineel)				x					x																	8%	

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Constancy	26
Cupania glabra (No common name)				x																						4%	
(1) Psidium Guajava (guava)				x				x		x																12%	
Sebesten Sebestena (geiger tree)				x	x																					8%	
Hamelia patens (scarlet bush)				x	x								x	x									x			20%	
Baccharis glomeruliflora (salt bush)				x								x		x		x	x						x			24%	
Thrinax parviflora (slender thatch palm)					x		x	x																		12%	
Yucca aloifolia (Spanish bayonet)					x			x																		8%	
(3) Smilax sp. (grenbriars)					x		x									x		x	x		x		x	x		32%	x
(1) Agave sisalana (sisal)					x				x																	8%	
Annona glabra (pond apple)					x						x	x	x	x		x			x	x			x	x	x	44%	
Guilandina Crista (nicker bean)					x																		x			8%	x
Guaiacum sanctum (lignum vitae)					x																					4%	
Swietenia Mahagoni (mahogany)					x				x		x	x	x										x			24%	x
Drypetes lateriflora (Guiana plum)					x																					4%	
Gymnanthes lucida (crabwood)					x	x									x	x			x							20%	
Schaefferia frutescens (yellow wood)					x																					4%	
Sapindus Saponaria (soapberry)					x				x	x													x			16%	

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Constancy	26
Canella Winteriana (wild cinnamon)					x			x	x																	12%	
Nectandra coriacea (lancewood)					x				x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		64%	
Jacquinia keyensis (joewood)					x	x									x											12%	x
(1) Sapota achras (sapodilla)					x																					4%	x
Sideroxylon foetidissimum (mastic)					x			x	x	x				x	x	x		x	x	x	x	x	x			52%	x
Schoepfia chrysophylloides (greytwig)					x										x	x	x		x				x			24%	x
Sophora tomentosa (necklace pod)						x																				4%	x
Waltheria americana (No common name)						x	x																			8%	
(1) Cocos nucifera (coconut palm)							x	x																		8%	
Erythrina arborea (coral bean)								x	x	x	x			x		x	x		x		x	x	x			44%	
Parthenocissus quinquefolia (Virginia creeper)								x		x				x			x		x				x			24%	
Forestiera porulosa (Florida privet)								x	x	x																12%	x
Roystonea regia (royal palm)									x		x			x									x			16%	
Paurotis Wrightii (Wright's palm)									x		x		x													12%	
(1) Citrus sp. (sour orange)									x																	4%	
Colubrina Colubrina (wild coffee)									x								x									8%	
(4) Pinus caribaea (Caribbean pine)											x	x				x							x			16%	

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Constancy	26
Taxodium ascendens (pond cypress)											x		x										x			12%	
Quercus virginiana (live oak)											x	x	x	x	x	x	x	x	x	x	x	x	x	x		56%	
Magnolia virginiana (sweet bay)											x		x										x	x		16%	
Chrysobalanus icaco (cocoplum)											x	x	x	x	x	x	x	x				x	x	x		44%	
Ilex Cassine (dahoon holly)											x		x	x		x	x		x				x	x	x	36%	
Hippocratea volubilis (No common name)											x		x										x			12%	
Vitis sp. (wild grape)											x					x			x				x	x		20%	
Muscadinia Munsoniana (bullace grape)											x		x	x		x	x	x	x	x	x		x	x		44%	
Tamala Borbonia (redbay)											x	x	x	x			x						x	x	x	32%	
Calyptranthes pallens (spice wood)											x		x										x			12%	x
Rhizophora Mangle (red mangrove)											x															4%	
Diospyros Mosiera (persimmon)											x						x						x	x		16%	
Cephalanthus occidentalis (buttonbush)											x												x	x	x	16%	
Anamomis Simpsonii (naked wood)												x		x	x	x	x	x	x	x	x		x			40%	
Lysiloma bahamensis (wild tamarind)													x	x	x	x	x	x	x	x	x	x	x	x		48%	
Ampelopsis arborea (pepper vine)													x	x		x	x						x	x		24%	
Rhabdadenia biflora (rubber vine)													x													4%	

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Con-stancy	26
Baccharis angustifolia (salt bush)													x													4%	x
Celtis mississippiensis (southern hackberry)														x							x	x	x	x	x	24%	
Cissus sicyoides (possum grape)														x									x			8%	
Tetrazygia bicolor (No common name)														x		x	x	x	x	x	x	x	x			36%	x
Eupatorium villosum (dog fennel)														x		x	x				x					16%	
Salix amphibia (willow)															x	x	x									12%	
Hypelate trifoliata (white ironwood)															x	x	x									12%	
Zamia sp. (coontie)																x	x	x					x			16%	
Rhus leucantha (sumac)																x	x		x				x			16%	
Ilex Krugiana (krug's holly)																x	x			x			x			16%	x
Laurocerasus myrtifolia (laurel cherry)																	x	x	x	x	x	x	x			28%	
Colubrina cubensis (No common name)																	x									4%	
Bumelia reclinata (pinewoods buckthorn)																	x						x			8%	
Forestiera pinetorum (pinewoods privet)																	x									4%	
Psychotria Sulzneri (wild coffee)																			x		x	x	x	x	x	24%	
Morus rubra (red mulberry)																					x	x	x			12%	

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Con-stancy	26
Callicarpa americana (beauty berry)																					x	x	x			12%	
Calyptranthes zuzygium (myrtle-of-the-river)																							x			4%	x
Tournefortia hirsutissima (sea lavender)																							x			4%	
Sambucus Simpsonii (elder)																									x	4%	
Ficus jacquinifolia (No common name)																											x
Coccolobis sp. (No common name)																											x
(5) Leucaena glauca (lead tree)																											x
(5) Picramnia pentandra (bitter bush)																											x
Pera bumeliaefolia (No common name)																											x
Celastraceae (staff tree family)																											x
(5) Eugenia confusa (red stopper)																											x
Anamomis sp. (No common name)																											x
Bumelia loranthifolia (buckthorn)																											x
Duranta repens (golden dewdrop)																											x
Tabebuia bahamensis (No common name)																											x

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Con-stancy	26
(5) <u>Psychotria bahamensis</u> (wild coffee)																											x
(5) <u>Baccharis dioica</u> (salt bush)																											x
Unknown #1																											x
Unknown #2																											x
Unknown #3																											x
Number of Species	49	38	31	38	64	18	21	37	41	21	37	21	38	41	29	47	52	26	41	29	35	31	73	33	15		57

(1) - Naturalized or escaped exotics.

(2) - Probably includes both <u>Vachellia peninsularis</u> Small and <u>Vachellia insularis</u> Small.

(3) - Includes several species.

(4) - Pines enclosed by encroaching hammock edges.

(5) - Bahaman species which occur in Florida, but were not found on any of the hammock sites covered in the above table.

BOTANICAL NAMES

Following is a list of all the botanical names used in this report. Names shown in the left hand column are those under which the species in question are treated in Small's Manual of the Southeastern Flora (1933), the latest complete taxonomic coverage of south Florida plants. For the convenience of readers who are not taxonomic botanists and who may wish to refer to the Manual, Small's names are used in the text.

For various reasons the nomenclature of Small's Manual is not acceptable in many cases and is no longer in correct use for a number of south Florida plant species. In the course of field work specimens were collected of many of the plant species encountered. This material was sent to Dr. Richard A. Howard, a leading student of the Antillean flora, for study and determination. In cases where Howard's determinations differed from the nomenclature of Small's Manual, the current names are shown in the right hand column opposite the appropriate species in order to permit reference to other botanical literature. Names in the left hand column marked "X" are those of species for which Howard indicated that the nomenclature of Small's Manual is correct, after study of south Florida specimens. Unpaired, unmarked names represent species of which no specimens were collected and are the writer's identifications and Small's names. Names marked with an asterisk indicate that specimens of the species have been deposited in the Everglades National Park Herbarium.*

Ferns - (nomenclature of Small's Ferns of Florida (1931)

Osmunda regalis L.
*X-Anemia adiantifolia (L.) Sw.
Polypodium polypodioides (L.) A. Hitchc.
Pteris caudata L. -- Pteridium aquilinum (L.) Kuhn.
(Bracken) var. caudatum (L.) Sadebeck
Pycnodoria pinetorum Small
Adiantum melanoleucum Willd.
Blechnum serrulatum Rich.
Dryopteris normalis C. Chr.
Sphenomeris clavata (L.) Maxon

* Since this report was submitted, Little's Check List of Native and Naturalized Trees of the United States (1953) has appeared. In cases where names used by Little for south Florida trees differ from those of Small's Manual (other than in non-capitalization of specific names) Little's names are shown in brackets in the right hand column of this list.

Cycadaceae

Zamia integrifolia Ait.
(Coontie)

Pinaceae

Pinus caribaea Morelet -- /*P. elliottii* Englm. var. *densa* Little and Dorman/
(Caribbean pine,
Dade County Pine)

Juniperaceae

Taxodium ascendens Brongn. -- /*T. distichum* (L.) Rich. var. *nutans* (Ait.) Sweet/
(Pond cypress)

Typhaceae

Typha angustifolia L.
(Cattail)

Alismaceae

Sagittaria lancifolia L.
(Arrowleaf)

Poaceae

X-*Tripsacum floridanum* Porter
Andropogon glomeratus (Walt.) B.S.P.
(Broom grass)
X-*Sorghastrum secundum* (Ell.) Nash
*X-*Panicum maximum* Jacq.
X-*Panicum virgatum* L.
*X-*Echinochloa Crus-galli* (L.) Beauv.
*-*Chaetochloa geniculata* (Lam.) Millsp. & Chase -- *Setaria geniculata* (Lam.) Beauv.
Cenchrus echinatus L.
Aristida stricta Michx.
(Wire grass)
*X-*Chloris glauca* (Chapm.) Vasey
Phragmites phragmites (L.) Karst.

Cyperaceae

Cyperus odoratus L.
(**Cyperus odoratus* L. - in part
(**Cyperus polystachyos* Rottb. - in part
(**C. polystachyos* Rottb. var. *texensis* (Torr.) Fern.

Cyperaceae - continued

*X-Cyperus surinamensis Rottb.
*X-Cyperus ligularis L.
*X-C. Brunneus Sw.
*-Abildgaardia monostachya (L.) Vahl. -- Fimbristylis monostachya (L.) Hassk.
*X-Fimbristylis castanea (Michx.) Vahl.
X-Eleocharis cellulosa Torr.
*X-Dichromena colorata (L.) A. Hitchc.
*X-Rhynchospora Tracyi Britton
X-R. corniculata (Lam.) A. Gray
*-R. globularis (Chapm.) Small -- R. globularis (Chapm.) Small var. recognita Gale
*X-Mariscus jamaicensis (Crantz) Britton
(Sawgrass)
*X-Schoenus nigricans L.

Arecaceae

Roystonea regia (H.B.K.) O. F. Cook -- [R. elata (Bartr.) F. Harper]
(Royal palm)
Sabal Palmetto (Walt.) Lodd.
(Cabbage palm)
Thrinax parviflora Sw.
(Brittle thatch palm)
X-T. microcarpa Sarg.
(Silky thatch palm)
Coccothrinax argentea (Lodd.) Sarg. -- [C. argentata Jacq. Bailey]
(Silver palm)
Serenoa repens (Bartr.) Small
(Saw palmetto)
Paurotis Wrightii (Griseb.) Britton

Pontederiaceae

Pontederia cordata L.
(Pickerel weed)

Juncaceae

*X-Juncus scirpoides Lam.

Dracaenaceae

Yucca aloifolia L.
(Spanish bayonets)

Smilacaceae

X-*Smilax laurifolia* L.
X-*Smilax havanensis* Jacq.

Leucojaceae

*-*Aletris bracteata* Northrop
Agave decipiens Baker
A. sisalana Perrine
(Sisal)
Crinum americanum L.
Hymenocallis keyensis Small

Marantaceae

Thalia geniculata L.
(Fire flag)

Orchidaceae

Limodorum pinetorum Small
Encyclia tampensis (Lindl.) Small
Bletia purpurea (Lam.) DC.

Saururaceae

Saururus cernuus L.
(Lizard tail)

Casuarinaceae

Casuarina equisetifolia Forst. -- [*C. equisetifolia* L.]
(Australian pine)

Myricaceae

*-*Cerothamnus ceriferus* (L.) Small -- *Myrica cerifera* L.
(Wax myrtle, Bayberry)

Salicaceae

Salix amphibia Small -- [*S. caroliniana* Michx.]
(Willow)

Fagaceae

Quercus minima (Sarg.) Small
Q. virginiana Mill.
(Live oak)
Q. pumila Walt.

Artocarpaceae

*X-*Morus rubra* L.
(Red mulberry)
Ficus aurea Nutt.
(Strangler fig)
F. brevifolia Nutt. -- /*F. laevigata* Vahl./
(Shortleaf fig)

Ulmaceae

*X-*Trema floridana* Britton -- /*T. micrantha* (L.) Blume/
Celtis mississippiensis Bosc -- /*C. laevigata* Willd./
(Hackberry)

Polygonaceae

*-*Coccolobis laurifolia* Jacq. -- *Coccoloba diversifolia* Jacq.
(Pigeon plum)
C. uvifera (L.) Jacq. -- /*C. uvifera* (L.) L./
(Sea grape)

Amaranthaceae

Acnida cuspidata Bertero

Batidaceae

Batis maritima L.

Pisoniaceae

X-*Pisonia aculeata* L.
*X-*P. rotundata* Griseb.
*X-*Torrubia longifolia* (Heimerl.) Britton
(Blolly)

Annonaceae

X-Annona glabra L.
(Pond apple)

Magnoliaceae

Magnolia virginiana L.
(Sweet bay)

Nymphaeaceae

Nymphyaea macrophylla Small
(Spatterdock)

Papaveraceae

Argemone mexicana L.
(Prickly poppy)

Brassicaceae

*-Cheirania cheiranthoides (L.) Link -- Erysimum cheiranthoides L.

Capparidaceae

Capparis flexuosa L. -- /C. flexuosa (L.) L./
Capparis cynophallophora L.

Amygdalaceae

*X-Chrysobalanus Icaco L.
(Cocoplum)
*-Geobalanus oblongifolius (Michx.) Small -- Chrysobalanus oblongifolius Michx.
(Gopher apple)
Laurocerasus myrtifolia (L.) Britton -- /Prunus myrtifolia (L.) Urban/
(Laurel cherry)

Mimosaceae

*-Pithecolobium Unguis-Cati (L.) Benth. -- Pithecellobium unguis-cati (L.) Benth.
(Cat's claw)
P. guadalupense Chapm. -- /Pithecellobium guadalupense (Pers.) Chapm./
(Blackbead)
Albizzia lebbek (Willd.) Benth. -- /Albizia lebbek (L.) Benth./
(Woman's tongue tree)
*X-Lysiloma bahamensis Benth.
(Wild tamarind)
Vachellia peninsularis Small)
V. insularis Small)
V. Farnesiana (L.) Wight & Arn.) Probably all = Acacia Farnesiana (L.) Willd.
Leucaena glauca (L.) Benth.
X-Neptunia floridana Small

Cassiaceae

*-Peiranisia bahamensis (Mill.) Britton & Rose -- Cassia bahamensis Mill.
*-Chamaecrista keyensis Pennell -- Cassia keyensis (Pennell) Macbr.
*-C. Deeringiana Small & Pennell -- C. Deeringiana (Small & Pennell) Macbr.
*X-Caesalpinia pauciflora (Griseb.) C. Wright
Guilandina Crista (L.) Small
(Nicker bean)

Fabaceae

Sophora tomentosa L.
*X-Crotalaria pumila Ortega
*-C. maritima Chap. -- Crotalaria rotundifolia (Walt.) Poir.
*-C. linaria Small -- C. rotundifolia (Walt.) Poir.var. linaria (Small) Fern. & Schub.
*X-Melilotus alba Desr.
(White sweet clover)
Sesban emerus (Aubl.) Britton & Wilson -- Sesbania occidentalis Poir.
Ecastophyllum Ecastophyllum (L.) Britton
Amerimnon Brownei Jacq.
*-Ichthyomethia piscipula (L.) A. Hitchc. -- Piscidia communis (Blake) Johnston /P. piscipula (L.) Sarg./
(Jamaica dogwood)
*-Dolicholus minimus (L.) Medic. -- Rhynchosia minima DC.
*-Leucopterum parvifolium (DC.) Small -- R. parvifolia DC.
*X-Rhynchosia cinerea Nash
*X-R. simplicifolia (Walt.) Wood
Erythrina arborea (Chapm.) Small -- Erythrina herbacea L.
(Coral bean)
*X-Galactia parvifolia A. Rich.
G. pinetorum Small
*-Bradburya virginiana (L.) Kuntze -- Centrosema virginiana (L.) Benth. var. angustifolium (DC.) Griseb.
*X-Vigna repens (L.) Kuntze
*X-Stylosanthes calcicola Small

Linaceae

Cathartolinum Curtissii Small
C. arenicola Small

Zygophyllaceae

Guaiacum sanctum L.
(Lignum-vitae)

Malpighiaceae

*-Byrsonima cuneata (Turcz.) P. Wilson - Byrsonima lucida (Mill.) Rich.
(Locust berry)
-- [B. lucidum DC.]

Rutaceae

Zanthoxylum fagara (L.) Sarg.
(Wild lime)
X-Amyris elemifera L.
(Torchwood)

Surianaceae

*X-Suriana maritima L.
(Bay cedar)

Simaroubaceae

Simarouba glauca DC.
(Paradise tree)
Picramnia pentandra Sw.
(Bitterbush)
Alvaradoa amorphoides Liebm.

Burseraceae

*-Elaphrium simaruba (L.) Rose -- Bursera simaruba (L.) Sarg.
(Gumbo-limbo)

Meliaceae

*X-Swietenia Mahagoni Jacq.
(Madeira, Mahogany)

Polygalaceae

*-Asemeia leiodes (Blake) Small -- Polygala grandiflora Walt. var. leiodes Blake
X-Polygala verticillata L.

Polygalaceae - continued

*X-*P. ambigua* Nutt.
Pilostaxis arenicola Small
P. Baldwinii (Nutt.) Small

Euphorbiaceae

*X-*Savia bahamensis* Britton
Drypetes lateriflora (Sw.) Krug & Urban
(Guiana plum)
D. diversifolia Krug & Urban
(White wood)
*X-*Croton linearis* Jacq.
*X-*Ditaxis Blodgettii* (Torr.) Pax
Caperonia castaneaefolia (L.) St. Hil. -- *Caperonia castaneifolia* (L.) St. Hil.
*X-*Tragia saxicola* Small
*X-*Gymnanthes lucida* Sw.
(Crabwood)
X-*Hippomane Mancinella* L.
(Manchineel)
*-*Bivonea stimulosa* (Michx.) Raf. -- *Cnidoscolus stimulosus* (Michx.) Gray
(Tread softly, Turkey foot)
*X-*Chamaesyce Serpyllum* Small
C. keyensis Small
*X-*C. pinetorum* Small
C. conferta Small
X-*C. adenoptera* (Bertol.) Small

Spondiaceae

*X-*Metopium toxiferum* (L.) Krug & Urban
(Poisonwood)
Toxicodendron radicans (L.) Kuntze
(Poison ivy)
*X-*Rhus leucantha* Jacq. -- [*R. copallina* L. var. *leucantha* (Jacq.) DC.]
(Sumac)

Aquifoliaceae

*X-*Ilex Krugiana* Loes.
(Krug's holly)
*X-*I. Cassine* L.
(Dahoon holly)

Celastraceae

Maytenus phyllanthoides Benth.
X-*Rhacoma Crossopetalum* L. -- /*Crossopetalum rhacoma* Crantz/
*X-*R. ilicifolia* (Poir.) Trelease
X-*Gyminda latifolia* (Sw.) Urban
*X-*Schaefferia frutescens* Jacq.
(Yellow-wood)

Hippocrateaceae

*X-*Hippocratea volubilis* L.

Staphyleaceae

*-*Dodonaea jamaicensis* DC. -- *Dodonaea viscosa* L. var. *linearis* Sherff.
(Varnish leaf)

Sapindaceae

Sapindus Saponaria L.
(Soap berry)
*X-*Exothea paniculata* (Juss.) Radlk.
(Ink wood)
Hypelate trifoliata Sw.
(White ironwood)
Cupania glabra Sw.

Frangulaceae

*X-*Krugiodendron ferreum* (Vahl.) Urban
*X-*Reynosia septentrionalis* Urban
Colubrina reclinata (L'Her.) Brongn.
(Naked wood)
*-*C. colubrina* (Jacq.) Millsp. -- *Colubrina ferruginosa* Brongn.
-- /*C. arborescens* (Mill.) Sarg./
*X-*C. cubensis* (Jacq.) Brongn.

Vitaceae

Vitis coriacea Shuttlew.
V. Simpsonii Munson
Miscadinea Munsoniana (Simpson) Small
Cissus sicyoides L.
Ampelopsis arborea (L.) Rusby
(Pepper vine)
Parthenocissus quinquefolia (L.) Planch.
(Virginia creeper)

Malvaceae

*X-Kosteletzkya virginica (L.) A. Gray
*X-Thespesia populnea (L.) Soland.
(Seaside mahoe)

Buettneriaceae

Waltheria americana L.

Canellaceae

*X-Canella Winterana (L.) Gaertn.
(Wild cinnamon)

Clusiaceae

Clusia rosea L. -- /C. rosea Jacq./
(Monkey apple)

Hypericaceae

*-Hypericum galioides Lam. -- Hypericum gallioides Lam. var. reductum Sw.

Turneraceae

*X-Piriqueta caroliniana (Walt.) Urban

Papayaceae

Carica Papaya L.
(Papaya)

Passifloraceae

Passiflora pallida L.

Opuntiaceae

Acanthocereus floridanus Small
Harrissia Simpsonii Small
Cephalocereus keyensis Britton and Rose

Lauraceae

*-Tamala Borbonia (L.) Raf. -- Persea Borbonia (L.) Spreng.
(Redbay)
*X-Nectandra coriacea (Sw.) Griseb.
(Lancewood)
Misanteca triandra (Sw.) Mez -- [Licaria triandra (Sw.) Kosterm.]

Cassythaceae

Cassytha filiformis L.
(Woe vine)

Melastomaceae

*X-Tetrazygia bicolor (Mill.) Cogn.

Lythraceae

Ammannia Koehnei Britton -- Ammannia teres Raf.

Terminaliaceae

*X-Conocarpus erecta L. -- [C. erectus L.]
(Buttonwood)
Laguncularia racemosa Gaertn. f.
(White mangrove)

Myrtaceae

*X-Eugenia buxifolia (Sw.) Willd. -- [E. myrtoides Poir.]
(Spanish stopper)
*X-E. axillaris (Sw.) Willd.
(White stopper)
E. confusa DC.
(Red stopper)
Anamomis Simpsonii Small -- [Eugenia simpsonii (Small) Sarg.]
*-Mosiera longipes (Berg.) Small -- Eugenia longipes Berg.
Psidium Guajava Raddi. -- [P. guajava L.]
(Guava)
Calyptranthes pallens (Poir.) Griseb.
(Spicewood)
*X-Calyptranthes zuzygium (L.) Sw.

Rhizophoraceae

Rhizophora Mangle L.
(Red mangrove)

Epilobiaceae

Jussiaea scabra Willd.

Gunneraceae

Proserpinaca palustris L.

Ammiaceae

*-Hydrocotyle verticillata Thunb. -- Hydrocotyle verticillata Thunb. var. triradiata (A. Rich.) Fern.
*X-Spermolepis divaricata (Walt.) Raf.
*X-Oxypolis filiformis (Walt.) Britton

Primulaceae

X-Samolus floribundus H.B.K.
*-Samodia ebracteata (H.B.K.) Baudo. -- Samolus ebracteatus H.B.K.

Theophrastaceae

*X-Jacquinia keyensis Mez -- [Jaquinia keyensis Mez]
(Joewood)

Ardisiaceae

*X-Rapanea guayanensis Aubl. -- [R. guianensis Aubl.]
(Myrsine)
*-Icacorea paniculata (Nutt.) Sudw. -- Ardisia escallonioides Schlecht & Cham.
(Marlberry)
-- [A. escallonioides Schiede & Deppe]

Ebenaceae

X-Diospyros Mosieri Small -- [D. virginiana L. var. mosieri (Small) Sarg.]
(Persimmon)

Sapotaceae

*-Chrysophyllum olivaeforme L. -- Chrysophyllum oliviforme L.
(Satinleaf)
Sapota achras Mill. -- /Achras zapota L./
(Sapodilla)
*-Sideroxylon foetidissimum Jacq. -- Mastichodendron foetidissimum (Jacq.) Cron.
(Mastic)
*X-Dipholis salicifolia (L.) A. DC.
(Bustic)
Bumelia angustifolia Nutt. -- /B. celastrina H.B.K./
(Saffron plum)
B. reclinata Vent.
Mimusops emarginata (L.) Britton -- /Achras emarginata (L.) Little/
(Wild dilly)

Oleaceae

Forestiera porulosa (Michx.) Poir. -- /F. segregata (Jacq.) Krug & Urban/
(Florida privet)
F. pinetorum Small
(Pinewoods privet)

Gentianaceae

*X-Eustoma exaltatum (L.) Griseb.
*-Sabbatia Elliottii Stend. -- Sabatia Elliottii Stend.

Apocynaceae

*-Vallesia glabra Cav. -- Vallesia antillana Woodson
*X-Urechites lutea (L.) Britton
(Wild allamanda)
Rhabdadenia biflora (Jacq.) Muell. - Arg.
*-R. corallicola Small -- Angodenia Berterii (A. DC.) Miers
*-Echites Echites (L.) Britton -- Echites umbellata Jacq.
(Coathook vine)

Asclepiadaceae

*-Asclepias Rolfsii Britton - Asclepias tuberosa L. subsp. Rolfsii (Britton) Woods
*X-A. lanceolata Walt.

Asclepiadaceae - continued

X-Asclepiadora viridis (Walt.) A. Gray
*X-Metastelma Blodgettii A. Gray

Convolvulaceae

X-Evolvulus glaber Spreng.
*-E. Wrightii House -- Evolvulus Grisebachii Peter
E. macilentus Small -- E. Linifolius L.
*X-Ipomoea sagittata Cav.
X-Ipomoea tenuissima Choisy
IX-Exogonium microdactylum (Griseb.) House
Calonyction aculeatum (L.) House
(Moon vine)
*-Jacquemontia Curtissii Peter -- Jacquemontia jamaicensis (Jacq.) Hall

Solanaceae

*X-Physalis angustifolia Nutt.
*X-Solanum nigrum L.
*X-S. bahamense L.
S. verbascifolium L.
(Potato tree)
*X-S. Blodgettii Chapm.
Lycium carolinianum Walt.

Ehretiaceae

Sebesten Sebestena (L.) Britton -- [Cordia sebestena L.]
(Geiger tree)
*-Varronia globosa Jacq. -- Cordia globosa (Jacq.) H.B.K.
Bourreria ovata Miers
(Strong bark)

Heliotropiaceae

Mallotonia gnaphalodes (Jacq.) Britton
(Sea lavender)
*X-Tournefortia hirsutissima L.
*-Myriopus volubilis (L.) Small -- Tournefortia volubilis L.
*X-Heliotropium Leavenworthii Torr.

Verbenaceae

*X-Verbena scabra Vahl.
*X-V. bonariensis L.
*X-Phyla nodiflora (L.) Greene
*X-Lantana depressa Small
*X-Citharexylum fruticosum L.
(Fiddlewood)
*X-Callicarpa americana L.
(French mulberry)
Glandularia maritima Small
*X-L. involucrata L.

Avicenniaceae

Avicennia nitida Jacq.
(Black mangrove)

Lamiaceae

*X-Teucrium Nashii Kearney
*X-Scutellaria havanensis Jacq.
*X-Hyptis radiata Willd.

Rhinanthaceae

Agalinis purpurea (L.) Pennell -- Gerardia purpurea L.
A. fasciculata (Ell.) Raf. -- G. fasciculata Ell.
*-A. Harperi Pennell -- G. Harperi (Pennell) Pennell
*X-Buchnera elongata Sw.

Acanthaceae

*-Tubiflora angustifolia (Fernald) Small -- Elytraria angustifolia (Fern.) Leonard
X-Dyschoriste angusta (A. Gray) Small
Ruellia hybrida Pursh. -- Ruellia heteromorpha Fern.
*-Diapedium assurgens (L.) Kuntze -- Dicliptera assurgens Juss.
X-Justicia lanceolata (Chapm.) Small

Olacaceae

Schoepfia chrysophylloides (A. Rich.) Planch.
(Greytwig)
Ximenia americana L.
(Hog plum)

Rubiaceae

Exostema caribaeum (Jacq.) R. & S.
(Princewood)
*X-Casasia clusiifolia (Jacq.) Urban -- /Genipa clusiaefolia (Jacq.) Griseb./
(Seven year apple)
*X-Randia aculeata L.
X-Catesbaea parviflora Sw.
X-Hamelia patens Jacq.
(Scarlet bush)
*X-Cephalanthus occidentalis L.
(Buttonbush)
X-Guettarda elliptica Sw.
(Velvetseed)
*X-G. scabra Vent. -- /G. scabra (L.) Vent./
(Rough velvetseed)
*X-Erithalis fruticosa L.
(Black torch)
X-Chiococca alba (L.) A. Hitchc.
(Snowberry)
X-C. pinetorum Britton
(Pinewoods snowberry)
*X-Strumpfia maritima Jacq.
Psychotria Sulzneri Small
*-P. nervosa Sw. -- Psychotria undata Jacq.
(Wild coffee)
Morinda Roioc L. -- M. Royoc L.
*-Diodia tetragona Walt. -- Diodia virginiana L. var. latifolia T. & G.

*X-Borreria terminalis Small
X-Galium tinctorium L.

Caprifoliaceae

Sambucus Simpsonii Rehder
(Elder)

Cucurbitaceae

*X-Melothria crassifolia Small

Lobeliaceae

*X-Lobelia glandulosa Walt.

Ambrosiaceae

Ambrosia elatior L.

Carduaceae

*X-Vernonia scaberrima Nutt.
V. Blodgettii Small
*X-Eupatorium capillifolium (Lam.) Small
*X-E. mikanioides Chapm.
*X-E. villosum Sw.
*-Conoclinium coelestinum (L.) DC. -- Eupatorium coelestinum L.
*X-Mikania batatifolia DC.
Kuhnia Mosieri Small
*-Laciniaria gracilis (Pursh) Kuntze -- Liatris gracilis Pursh
Pityopsis Tracyi Small -- Chrysopsis Tracyi
*X-Solidago Chapmanii T. & G.
*X-S. petiolata Mill.
*X-S. Leavenworthii T. & G.
*X-Aster adnatus Nutt.
*X-Erigeron quercifolius Lam.
Baccharis dioica Vahl.
B. halimifolia L.
B. glomeruliflora Pers.
B. angustifolia Michx.
*-Pluchea foetida (L.) DC. -- Pluchea foetida (L.) BSP
*X-P. purpurascens (Sw.) DC.
Pterocaulon undulatum (Walt.) C. Mohr
*X-Melanthera parvifolia Small
*-Spilanthes americana (Mut.) Hieron -- Spilanthes americana (Mut.) Hieron var. repens (Walt.) Moore
X-Borrichia frutescens (L.) DC.
B. arborescens (L.) DC.
*-Coreopsis Lewtonii Small -- Coreopsis Leavenworthii T. & G. var. Lewtonii (Small) Sherff.
*-Bidens pilosa L. -- Bidens pilosa L. var. radiata Schz.
*X-Helenium vernale Walt.
*X-Flaveria linearis Lag.
X-Cirsium vittatum Small

Cichoriaceae

*-Brachyrhamphus intybaceus (Jacq.) DC. -- Lactuca intybacea Jacq.
*X-Sonchus asper (L.) Hill

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