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THE MAJOR PLANT COMMUNITIES OF LAKE OKEECHOBEE, FLORIDA, AND THEIR ASSOCIATED INUNDATION CHARACTERISTICS AS DETERMINED BY GRADIENT ANALYSIS

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The Major Plant Communities of Lake Okeechobee, Florida, and Their Associated Inundation Characteristics as Determined by Gradient Analysis

by

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and

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Resource Planning Department
South Florida Water Management District
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ABSTRACT

Frequency data collected from two surveyed transect lines within the Lake Okeechobee littoral zone were used to determine the elevation ranges and preferred periods of inundation of six major plant communities. Species composition was documented within each community by use of species presence data.

The study provides baseline data for assessing the impact that changes in hydroperiod, resulting from future water management techniques, may have upon littoral zone vegetation.

INTRODUCTION

This project was one of a series of biological and chemical investigations being conducted within the littoral zone of Lake Okeechobee by the South Florida Water Management District. It was designed to:

1. Determine the significance of hydroperiod to the distribution of several major plant communities within the littoral zone.
2. Document the distribution and species composition of these communities.
3. Develop a predictive tool for use in evaluating the impact that changes in hydroperiod may have upon emergent marsh vegetation.

PREVIOUS INVESTIGATIONS

Sincock (1957), using line transects and a point sampling technique, investigated vegetation-water level fluctuation relationships on the northwest shore of the Lake prior to the construction of the levees that now form the northwest perimeter of the Lake. Ager and Kerce (1970) repeated Sincock's work along one of his original transect lines and reported that water level stabilization had brought about a greater definition of general vegetation types, with a tendency to reduce annual plants and increase perennials.

Pesnell and Brown (1976) mapped and described 15 vegetation communities within the littoral zone of Lake Okeechobee. These maps are attached to the back cover of this report.

DESCRIPTION OF THE STUDY AREA

Lake Okeechobee is located in the south central portion of the Florida peninsula and occupies parts of Palm Beach, Glades, Martin, Okeechobee and Hendry Counties. The Lake is approximately 35 miles across from north to south and 30 miles across from east to west. The Lake has a surface area of about 750 square miles and a drainage basin of 4500 square miles.

The Lake is almost totally surrounded by flood control levees. A littoral zone of emergent vegetation is located lakeward of the levees and occupies 95,482 acres. Most of the littoral zone is located in the western and northern portions of the Lake. These marshes occupy a band 1/2 to 9 miles wide that extends from Clewiston on the southwest to the Kissimmee River on the north shore. The littoral zone includes land elevations from 10' msl to 15' msl with occasional higher elevations. Land slope varies from about one foot in 1.5 miles to one foot in 0.6 miles. The greatest slope occurs within the northwest portion of the Lake basin.

Soils of the littoral zone are sandy and shallow with scattered deposits of muck and fibrous peat and are underlain by Fort Thompson limestone that outcrops in many places.

There are four major islands in Lake Okeechobee. Kreamer, Ritta and Torry Islands are located near Belle Glade at the extreme south end of the Lake. These islands are composed of organic soils and have been subjected to extensive agricultural use. Observation Island, located on the west side of the Lake, contains coarse, sandy soils. This island has not been farmed for about 30 years.

HISTORICAL ASPECTS

The vegetation that now exists as the littoral zone of Lake Okeechobee has developed as a response to post drainage lake stages. The vegetation of the Lake at the turn of this century was considerably different. Except for that of the major islands, most of the vegetation was located outside of the existing levee system as a consequence of predrainage hydrological conditions.

The first reliable documentation of the vegetation of Lake Okeechobee was made by Harshberger (1914), who published a vegetation map of south Florida. He described the south shore of the Lake, from the vicinity of Moore Haven to the approximate location of Canal Point, as being bordered by dense custard apple swamp. This swamp was reported to be 3 miles wide in some places. To the south, custard apple was replaced by willow that extended to the sawgrass of the Everglades. Sawgrass arms of the Everglades extended up both sides of the Lake as to almost surround it. Wills (1968), saw the area in the early 20th century and confirmed much of that description. He estimated that 32,000 acres of custard apple once occupied the south shore of the Lake. Dense groves of cypress grew behind sand ridges along the northeast and east sides of the Lake.

The vegetation of Torry Island was described by Harshberger (1914) as "covered with hammocks, acres in extent, surrounded by dense growths of custard apple trees with curiously buttressed or branched trunks. Access to the island is made difficult by extensive liquid mud-flats which surround it and in which grow the maidencane (Panicum hemitomon, Schult.), bulrush (Scirpus validus Vahl.), water hyacinth (Piaropus crassipes [Mart.]

Britton), and water lettuce (Pistia stratiotes L.)" Wills (1968) mentioned that cypress, rubber trees and pop-ash grew on Torry and Kreamer Islands.

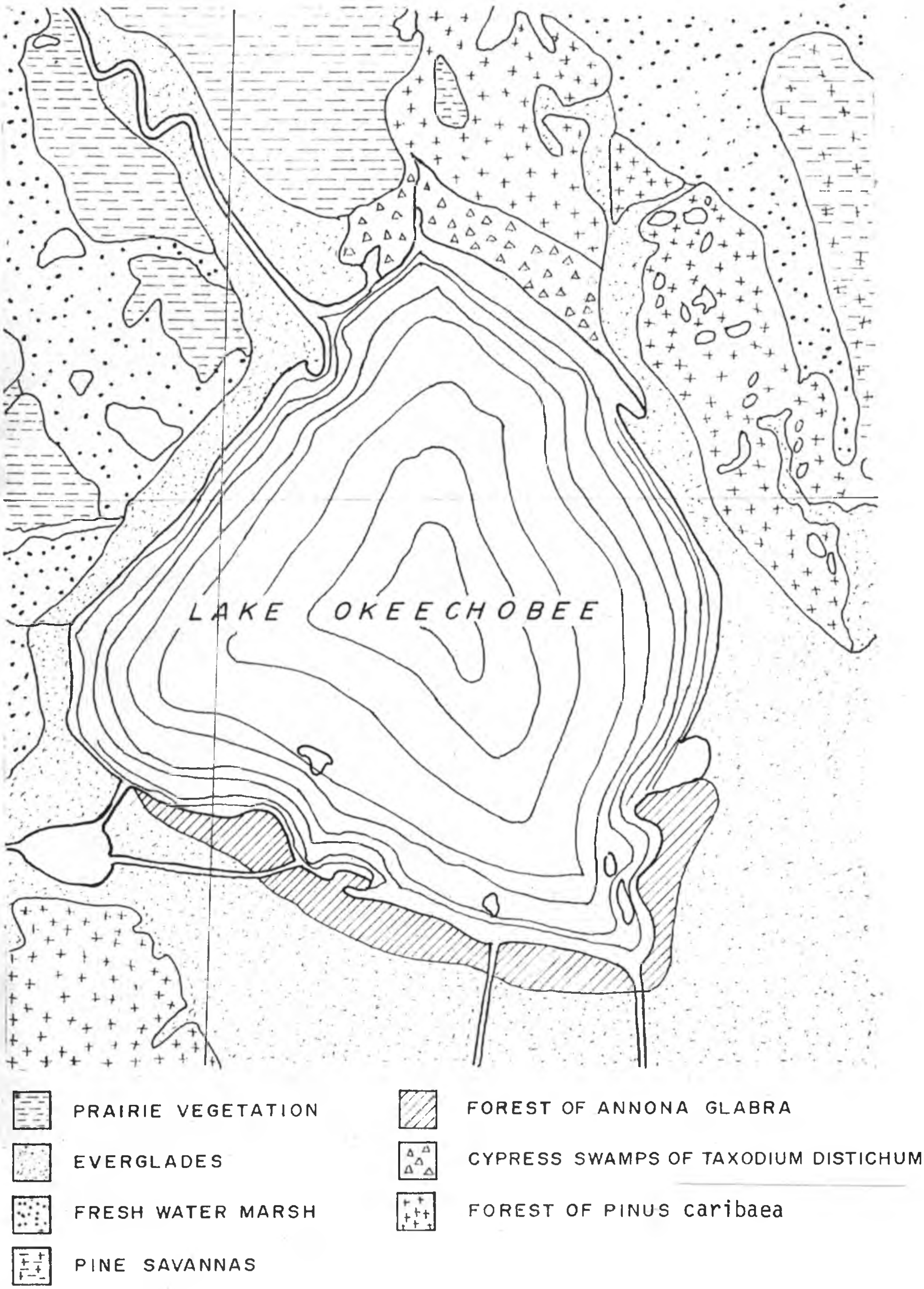
Horton (1911) described the timber of Observation Island as cypress, ash, willow and custard apple, and the soils as being sandy and "second rate". He also mentioned that sawgrass, willow, custard apple and ash grew along the Lake shoreline near Clewiston. Helprin (1887) mentioned landing on the west shore of Observation Island. There is currently three miles of emergent vegetation extending west from the island to the Lake levee.

The vegetation map by Harshberger (1914)(Figure 1) implies that the western portion of the Lake now occupied by extensive littoral zone, was open water in the early 1900's.

A landmark that denotes the historical Lake shoreline is Observation Cypress, a tree that once marked the entrance of the Three Mile canal that ran out of Lake Okeechobee. The town of Moore Haven, where the tree can still be seen, has developed on this site. The open water of the Lake has receded about nine miles, eight miles of which is now emergent marsh.

Reliable stage records are available for Lake Okeechobee as far back as 1912. Since that time stages have fluctuated from a high of over 20' msl (1912) to a low of 10.14' msl (1956). Interpretation of the few recorded lake stages prior to 1912 is confusing. Such accounts make reference to mean sea level datum, mean low Punta Rassa datum, Okeechobee datum, or no datum at all.

Johnson (1974) stated that the lake, in its natural condition overflowed its banks at about 21.5' Okeechobee datum or about 20' msl. Matson and Sandford (1913) stated that the overflow level was about 22' msl. They



LAKE OKEECHOBEE VEGETATION
AS DEPICTED BY HARSHBERGER (1914)

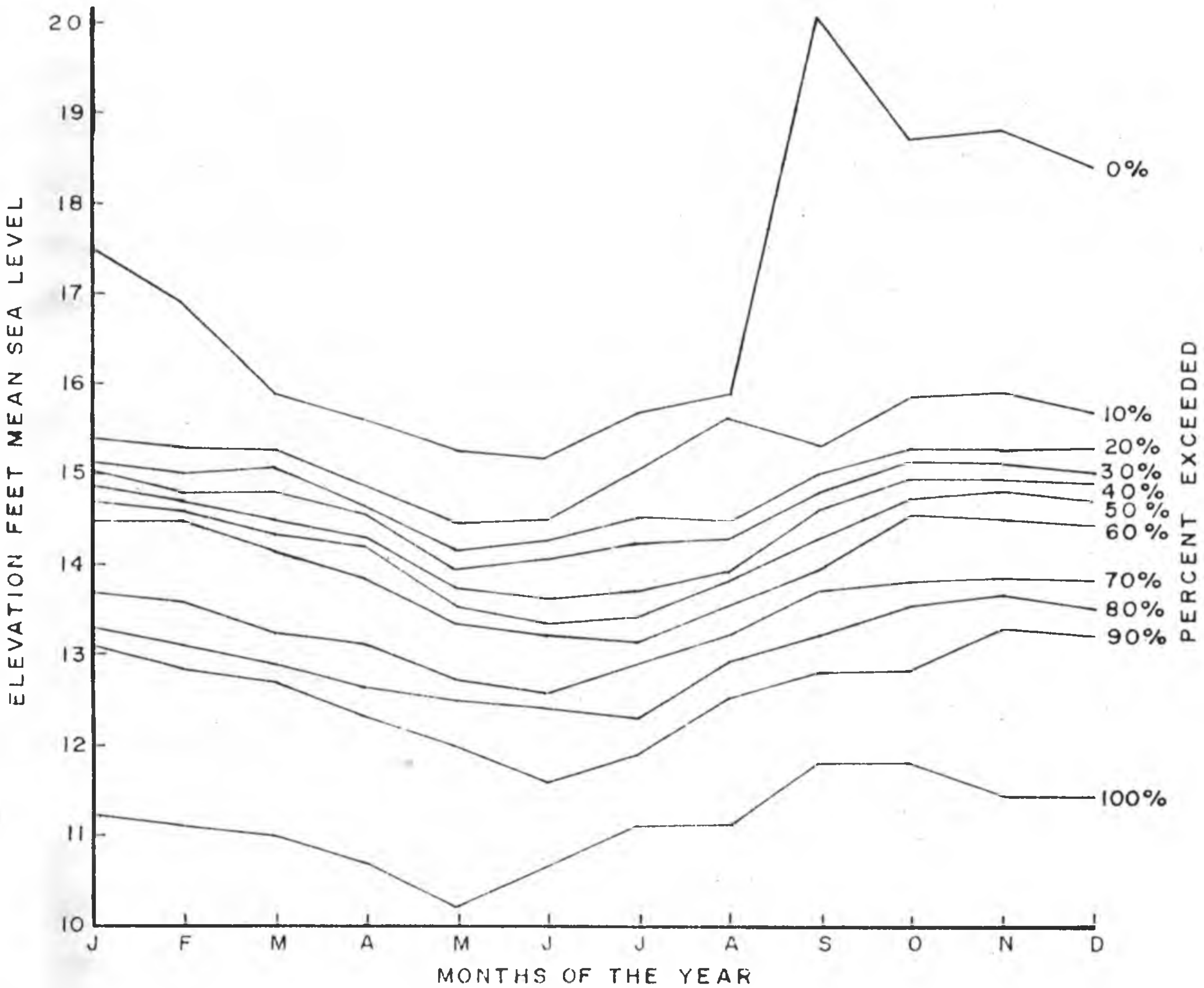
FIGURE 1

also reported high water in 1878 as 23.4 feet and in 1886 as being 22.4 feet. However, no datum for these elevations is specified. When these figures are corrected for both Okeechobee datum and mean low Punta Rassa datum, they still indicate lake levels between 18' and 21' msl. It seems a reasonable assumption that lake stages commonly fluctuated around 20' msl at the turn of this century.

Lake Okeechobee had no channelized outlets prior to the Three Mile Canal (1881-1887). Klein and Hampton (1972) discussed the pre-drainage history of south Florida and noted that the North New River Canal, the Palm Beach Canal, the Hillsboro Canal, and the Miami Canal were fully operational by 1921. These canals were equipped with hurricane gates which were closed at high lake stages to prevent flooding of land adjacent to the canals. Construction of the St. Lucie Canal was begun in 1916 and it was operational in 1924.

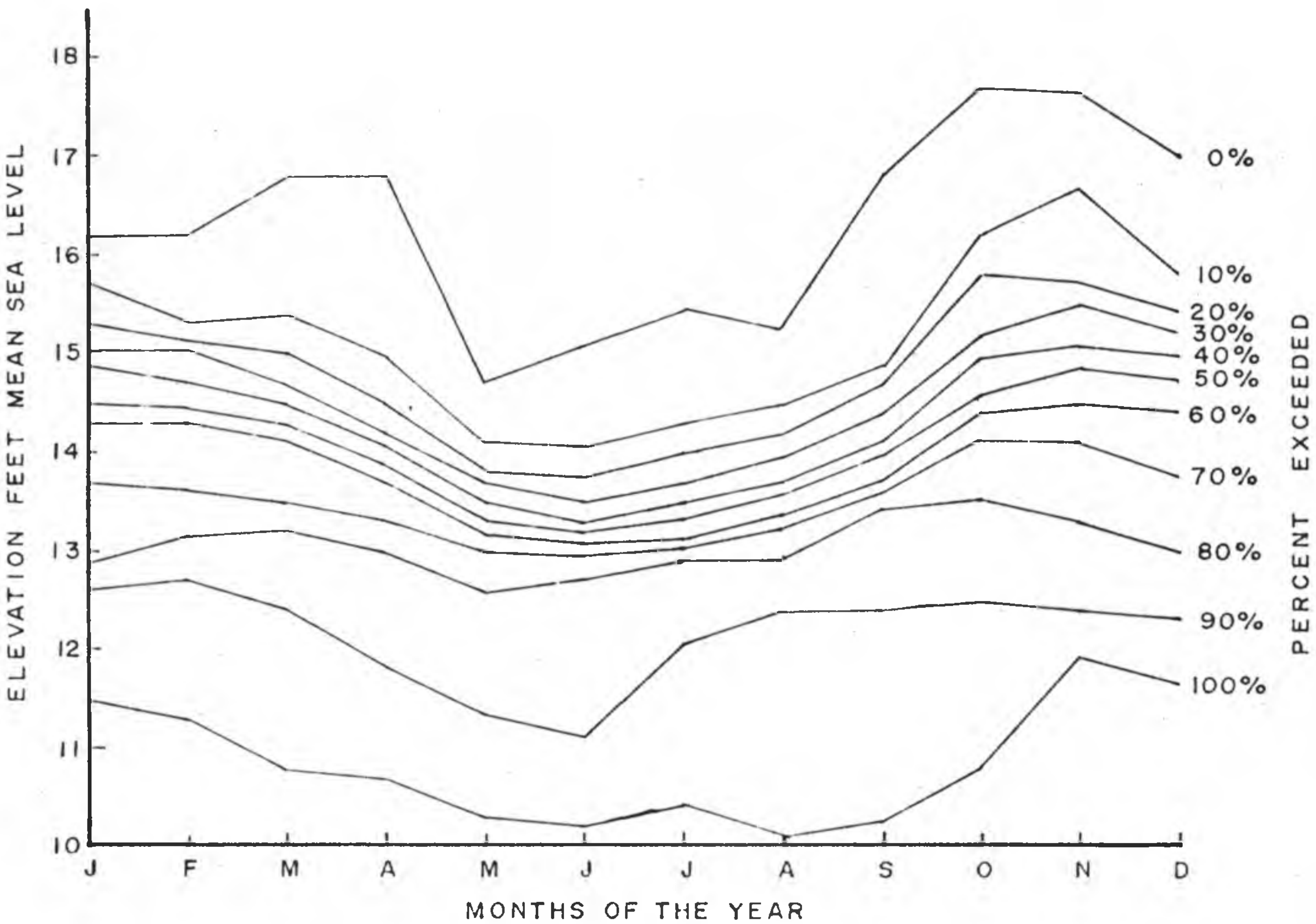
It is difficult to separate the influence of the initial drainage works from that of climatic conditions on Lake Okeechobee stages. However, by 1919, lake stages were significantly lower from those of 1912 and 1913 and have not since regained historic high levels.

Figures 2 and 3 show the percent of daily lake stages that equaled or exceeded given land elevations for the time periods 1931-1950, and 1951-1970, respectively. These figures reveal that, on a frequency basis, lake stages have remained fairly consistent for at least 40 years. These stage fluctuations represent the hydroperiod under which the present littoral zone vegetation has developed.



Iso-frequency lines for Lake Okeechobee stages, 1931-1950. Lines express the percentage of daily lake stages (right margin) that equalled or exceeded given ground elevations (left margin) during each month of the year.

FIGURE 2



Iso-frequency lines for Lake Okeechobee stages, 1951-1970. Lines express the percentage of daily lake stages (right margin) that equalled or exceeded given ground elevations (left margin) during each month of the year.

FIGURE 3

METHODS

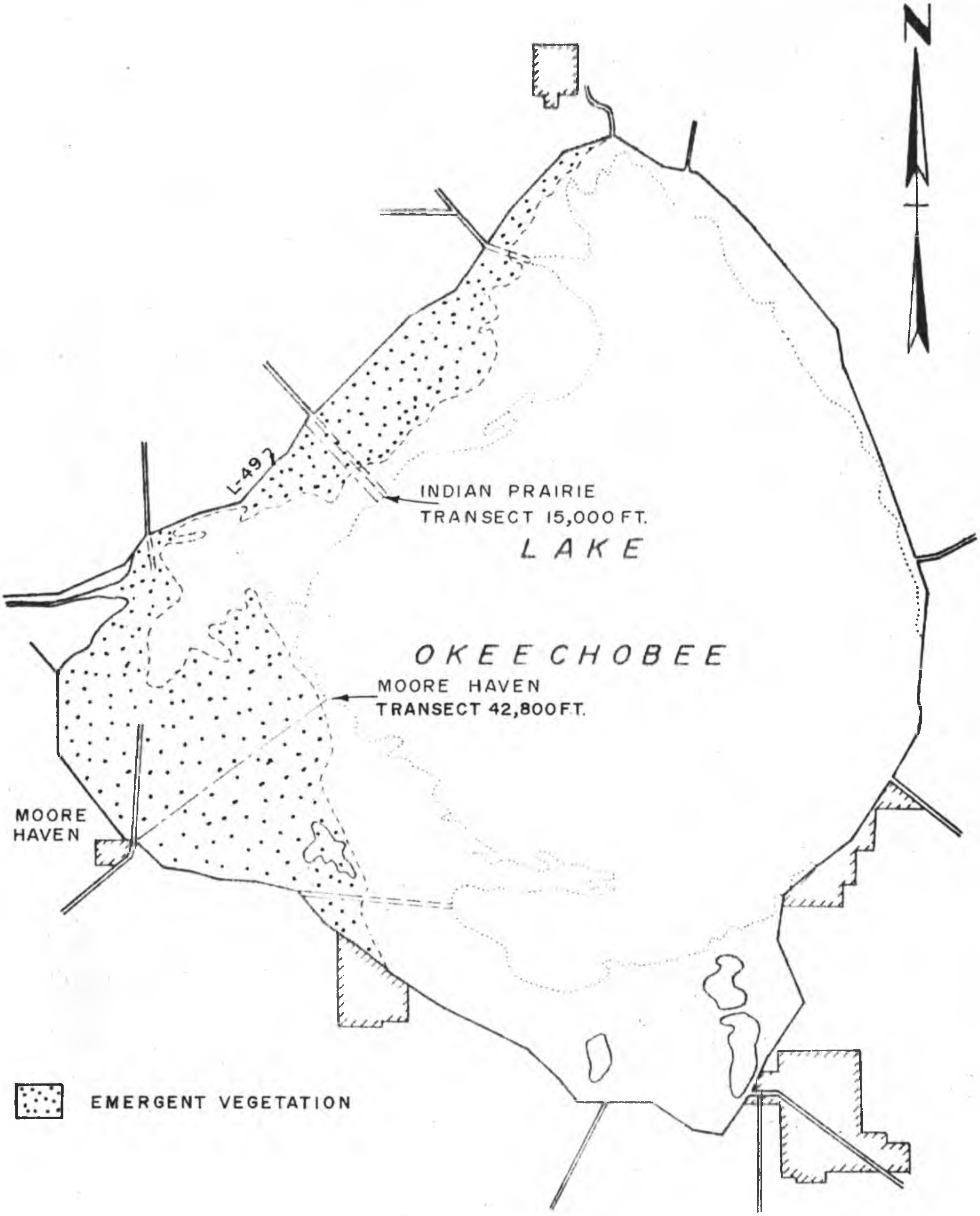
Community Designation

The designation of plant communities was based upon the use of indicator species. The indicator species were those species that, by abundance or morphological distinction, provide the characteristic appearance of the community. The indicator species, as used herein, is comparable to the "preferential species" as discussed by Braun-Blanquett (1972).

Transects

Data gathered along two transects were used to determine relationships between species and land elevations (Figure 4). The transects were situated so that they ran perpendicular to the general trend of land contours and crossed the greatest number of vegetation communities. The Indian Prairie transect was located approximately 3/4 mile southwest of and parallel to Indian Prairie Canal (C-41) in the northwest portion of the Lake. This transect extended for 15,000 feet from the base of L-49 to the lakeward edge of the emergent marsh. Land elevations in feet mean sea level (to within 1/10 foot) were determined every 25 feet throughout the length of the transect (Appendix A).

The Moore Haven transect was located in the southwest portion of the Lake. This transect extended for 42,800 feet from near the junction of the rim canal and the Old Moore Haven Canal to the lakeward edge of the emergent marsh. Land elevations (to within 1/10 foot) were determined at 100 foot intervals throughout the length of this transect. Land elevations at 25 foot intervals were estimated by interpolation (Appendix B).



LAKE OKEECHOBEE TRANSECT LOCATIONS

FIGURE 4

Documentation Procedures

Stations were established at 25 foot intervals along the transects. The land elevations at each station were considered to be representative of an area 10 feet wide and 25 feet long that was offset 10 feet to one side of the transect.

Vegetation at each station was documented by recording every species that was present within the rectangle. Several grass species could not be identified due to the absence of floristic structures. These plants were designated as "unknown grasses".

The Indian Prairie transect was documented between July 25 and August 11, 1972. The Moore Haven transect was documented between December 5, 1972 and April 25, 1973.

Vegetation - Land Elevation Relationships

The "frequency" (Cain and Castro, 1971) with which an indicator species occurred at a given land elevation was determined by dividing the number of times the species occurred at an elevation by the total number of times that elevation occurred on the transect. The frequency data for each species was smoothed by a five unit moving average (Yomane, 1964). The smoothed frequency data was then plotted against elevations. The elevations most frequently utilized by the species were identified by peaks of the frequency curve. The frequency curves for some species had more than one peak. In such cases, the stations along the transect within the range of land elevations under each peak were examined to determine the general range of land elevations characterized by each species.

A second curve was plotted representing the range of land elevations for which each species was an indicator. An optimum range for each species was delineated by the elevations at which the frequency curve of a species intersected the curve of the species above and below it. This intersection represents the elevation that both species utilize with equal efficiency. On either side, one species becomes more efficient than the other.

Composite frequency curves were prepared by combining the frequency data from both transects. The composite curves were calculated as if the data were from a continuous transect to show the overall vertical distribution and optimum range for each species.

Soil Analysis

Where more than one indicator species occupied the same general elevation range at different locations along the transect, soils were examined at each location. Soil samples were collected at stations at the land elevations that were most frequently utilized by the indicator species in question. Fifty samples were collected to represent the soils at the locations of three indicator species.

The averages of each of the chemical parameters for each indicator species were compared by a two-tailed t-test for samples with unequal variance (Snedecor and Cochran, 1968). The test statistic was compared to the critical value for 4% and 10% levels of significance.

Soil depth measurements were made at 100 foot intervals for the first 36,000 feet of the Moore Haven transect. Measurements were made with a metal probe that was pushed through the soil until rock was encountered. The subsurface rock elevation and soil depths are presented in Appendix B.

Species Composition

Species other than the indicator species that were present within a community were termed "associated species". The percent occurrence of an associated species of a station in conjunction with an indicator species within the optimum range of that indicator species was termed the "degree of presence" (Braun-Blanquet, 1972).

Degree of presence classes were used to describe the species composition of each community and to compare communities on the two transects.

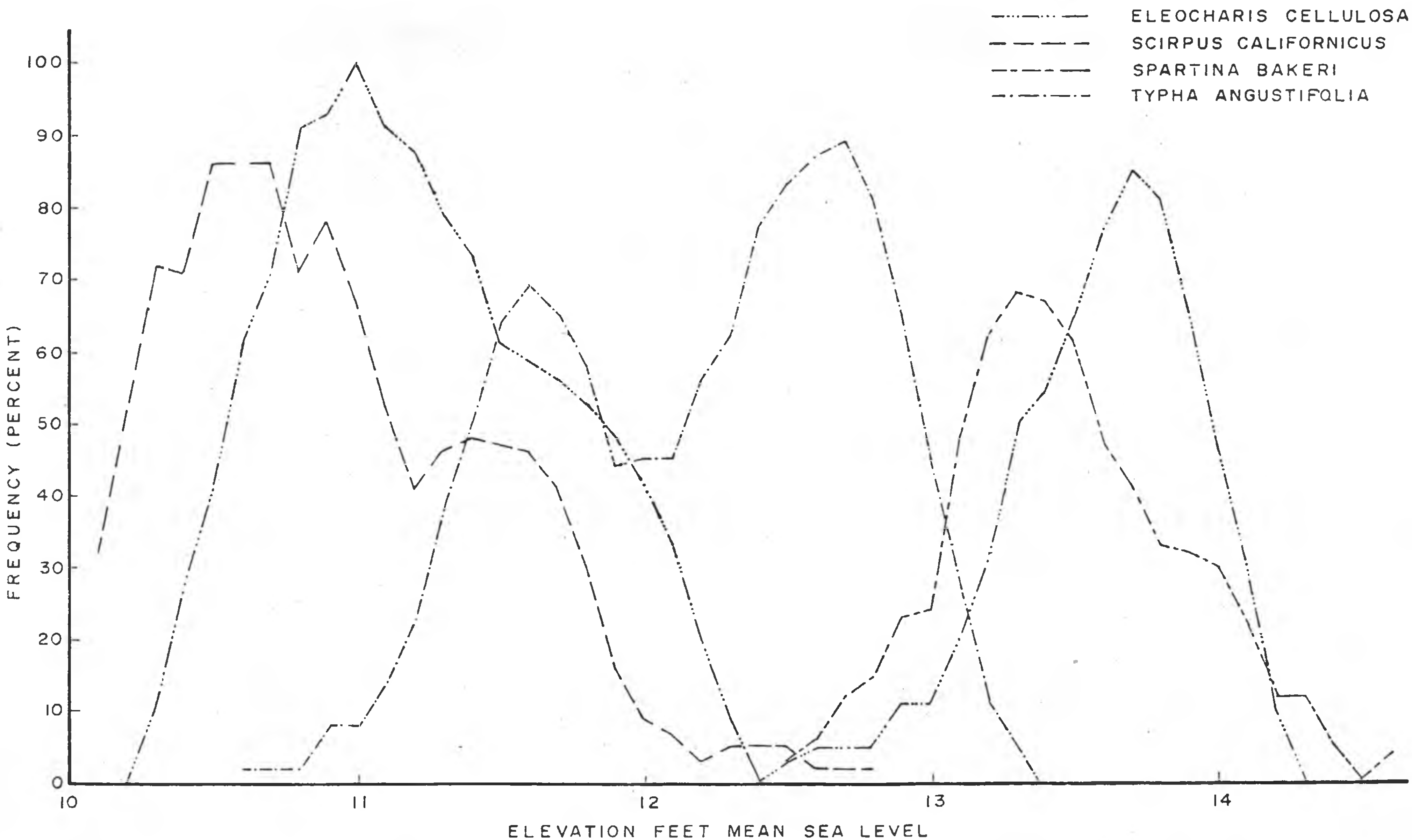
Class A	1% - 20%	(rare)
Class B	21% - 40%	(seldom present)
Class C	41% - 60%	(often present)
Class D	61% - 80%	(mostly present)
Class E	81% - 100%	(constantly present)

RESULTS

Six major plant communities were present along the transect. The indicator species of these communities were Scirpus californicus (C.A. Mayer) Britton., Eleocharis cellulosa Torr., Typha angustifolia L., Spartina bakeri Merr., Salix caroliniana Michx., and Rhynchospora tracyi Britton. Salix caroliniana and Rhynchospora tracyi were unique to the Moore Haven transect as indicator species. The other indicator species occurred on both transects.

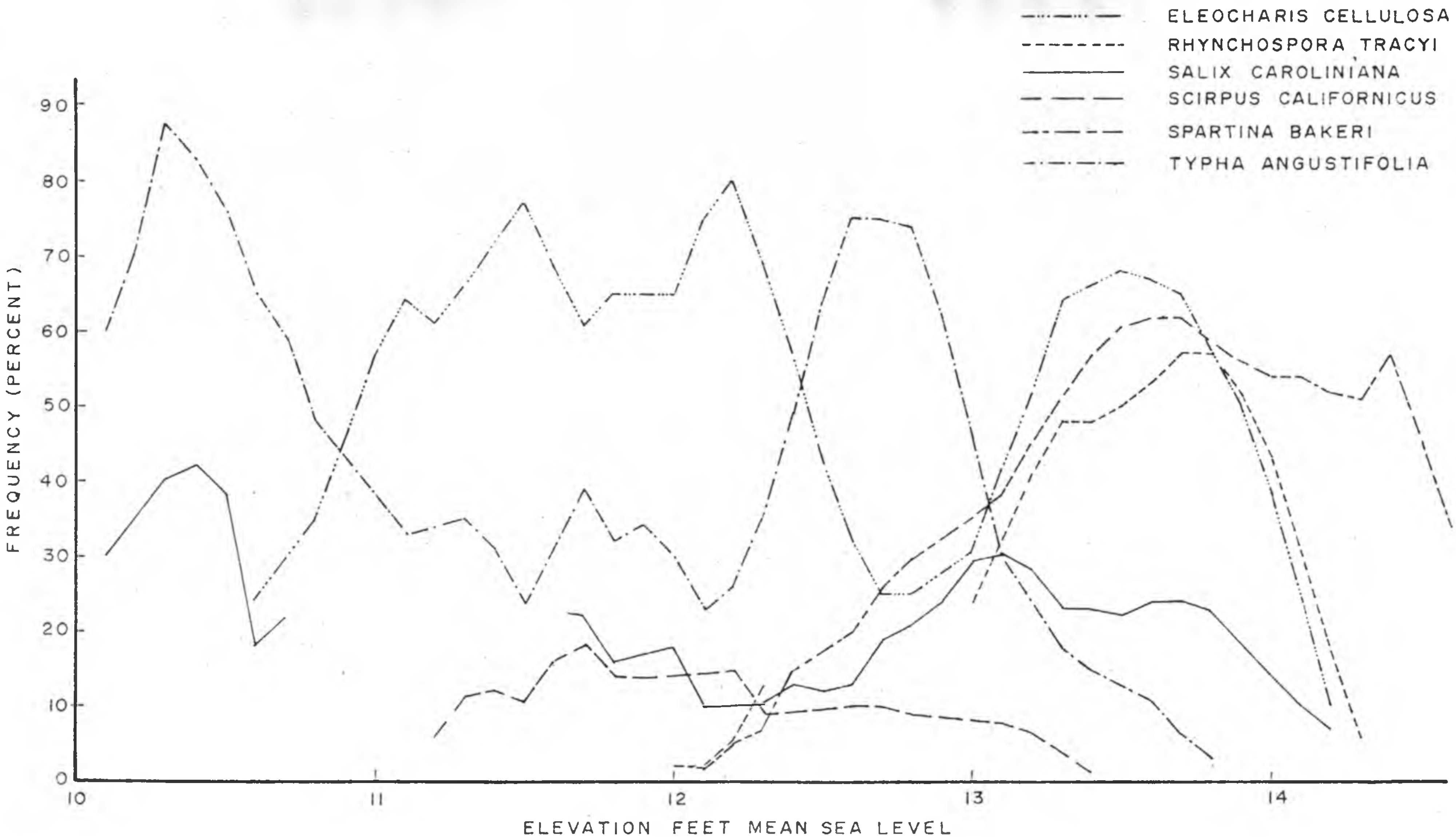
The frequency curves showing the overall vertical distribution of the indicator species are illustrated for the Indian Prairie transect (Figure 5); the Moore Haven transect (Figure 6) and the composite of both transects (Figure 7). The overall vertical distribution for each indicator species on each transect and the composite of both transects are as follows:

Indian Prairie Transect	Total Range
Scirpus californicus	10.0 - 12.8
Eleocharis cellulosa	10.2 - 14.3
Typha angustifolia	10.6 - 13.3
Spartina bakeri	12.5 - 15.0



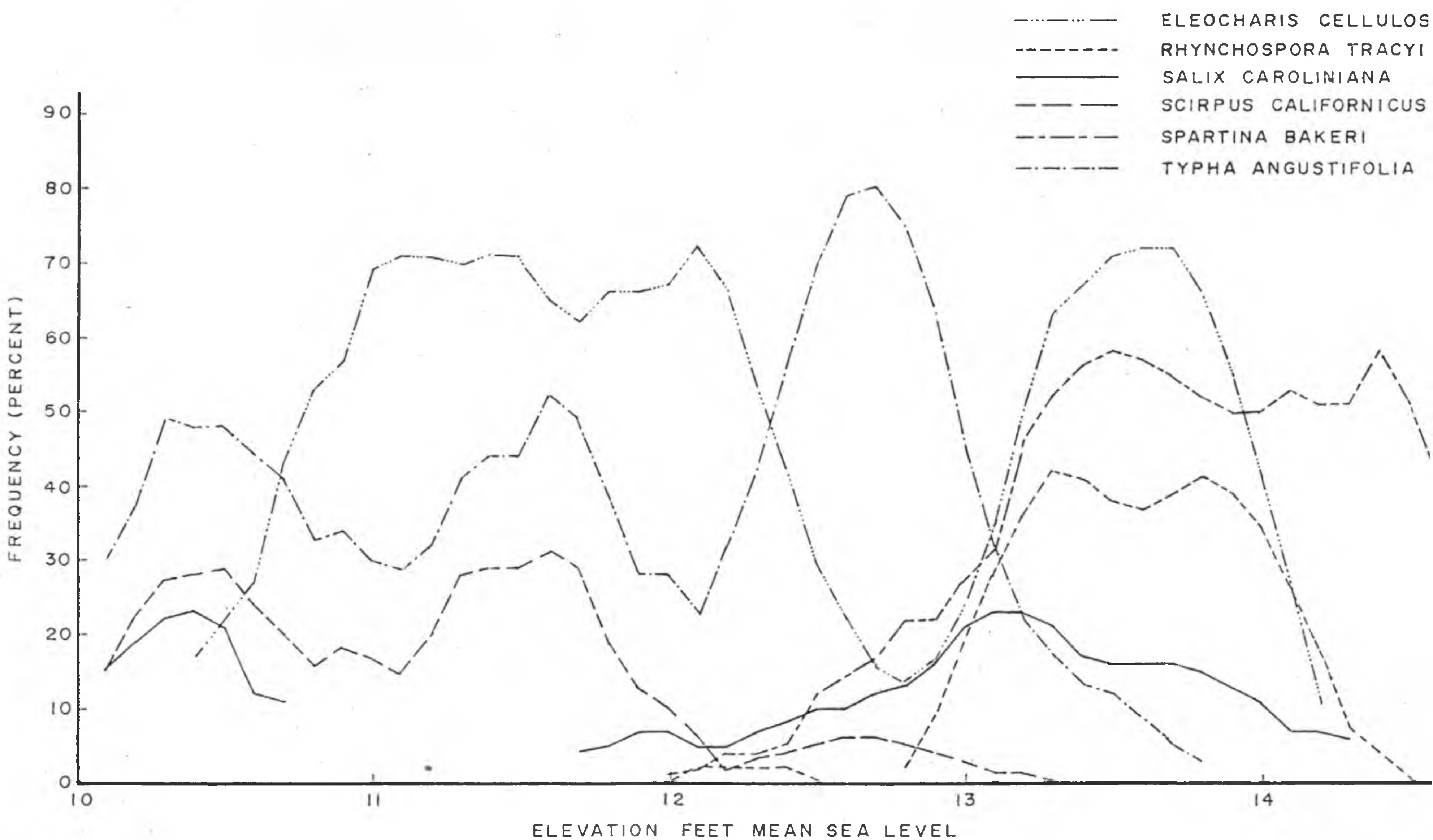
Overall vertical distribution of the indicator species of the plant communities on the Indian Prairie transect by "frequency of occurrence."

FIGURE 5



Overall vertical distribution of the indicator species of the plant communities on the Moore Haven transect by "frequency of occurrence."

FIGURE 6



Overall vertical distribution of the indicator species of the plant communities on the composite transect by "frequency of occurrence".

FIGURE 7

Moore Haven Transect	Total Range
Scirpus californicus	11.2 - 13.4
Eleocharis cellulosa	10.6 - 14.2
Typha angustifolia	10.1 - 13.8
Spartina bakeri	12.0 - 14.6
Rhynchospora tracyi	12.1 - 12.3
	13.0 - 14.6
Salix caroliniana	10.1 - 10.7
	11.7 - 14.2

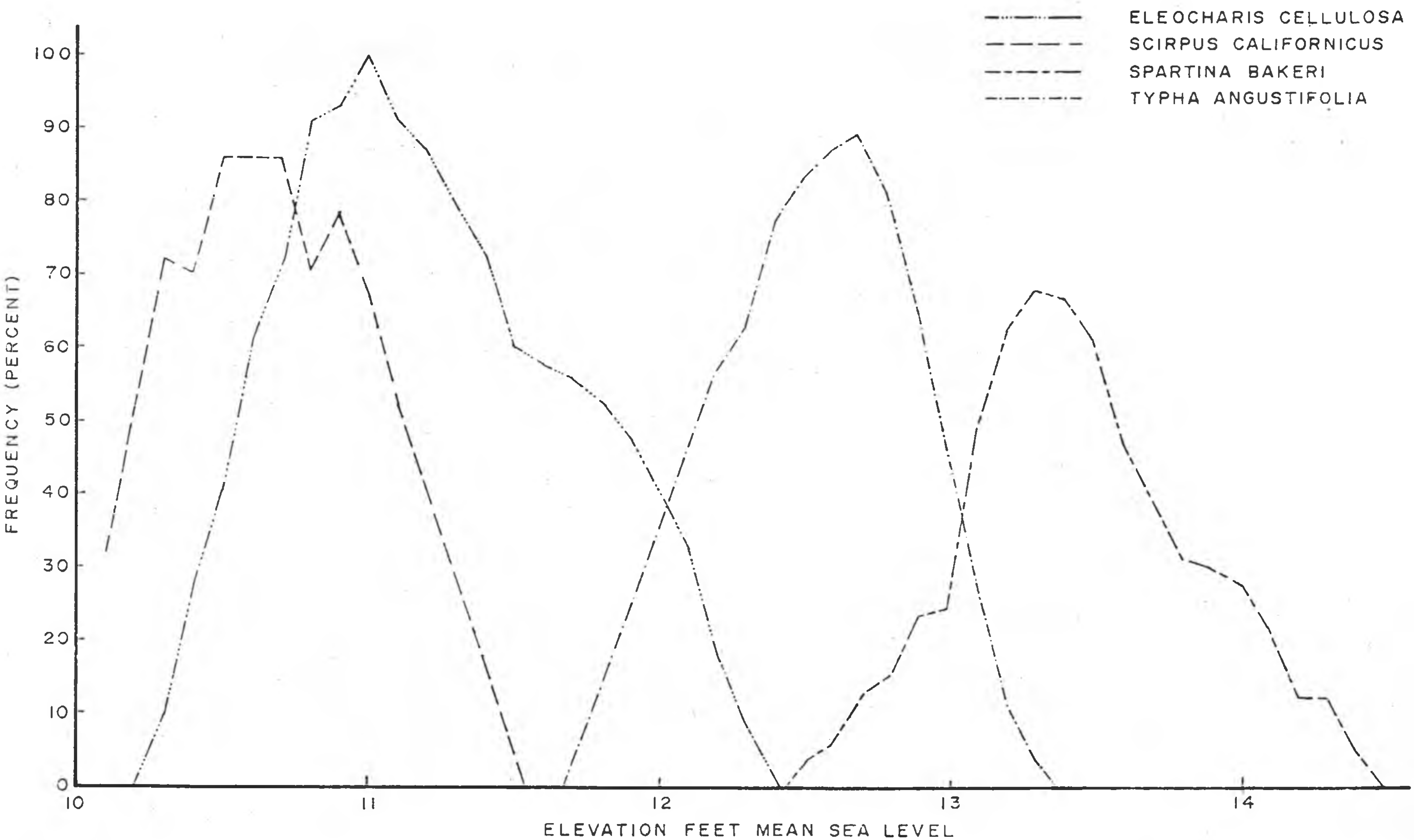
Composite Transect	
Scirpus californicus	10.1 - 13.3
Eleocharis cellulosa	10.4 - 14.2
Typha angustifolia	10.1 - 13.8
Spartina bakeri	12.0 - 15.0
Rhynchospora tracyi	12.0 - 12.5
	12.8 - 14.6
Salix caroliniana	10.1 - 10.7
	11.7 - 14.3

The frequency curves showing the elevation range in which each species is an indicator are illustrated for the Indian Prairie transect (Figure 8), the Moore Haven transect (Figure 9), and for the composite of both transects (Figure 10).

The optimum elevation range of the indicator species on each transect and the composite of both transects is as follows:

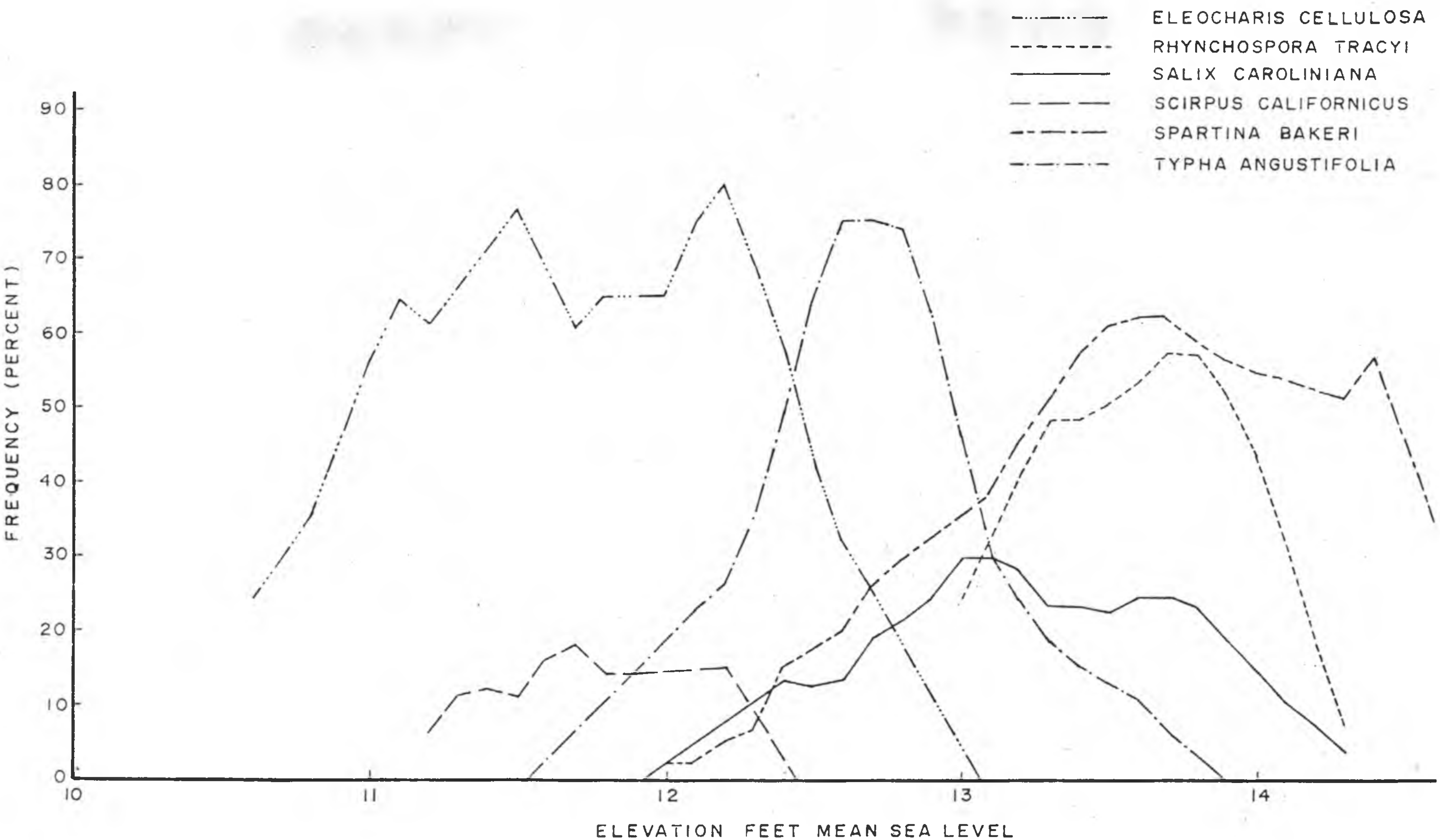
Indian Prairie Transect	Optimum Range (feet msl)
Scirpus californicus	10.1 - 10.7
Eleocharis cellulosa	10.7 - 12.0
Typha angustifolia	12.0 - 13.0
Spartina bakeri	13.0 - 14.5

Moore Haven Transect	
Scirpus californicus	11.1 - 12.3
Eleocharis cellulosa	10.6 - 12.4
Typha angustifolia	12.4 - 13.1
Spartina bakeri	13.1 - 14.6
Salix caroliniana	13.2 - 14.3
Rhynchospora tracyi	13.1 - 14.6



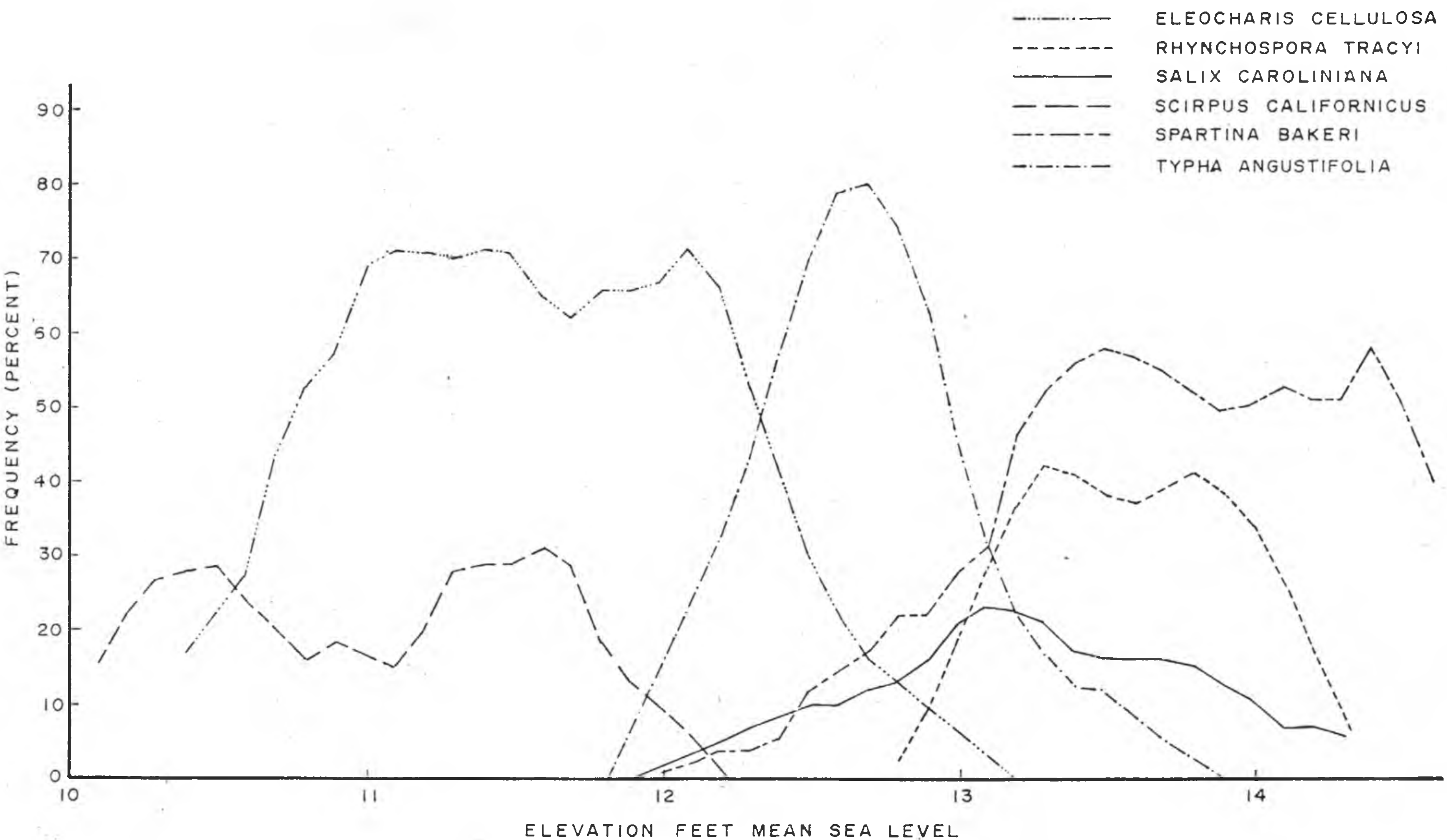
The optimum range of the plant communities of the Indian Prairie transect by the "frequency of occurrence" of the indicator species.

FIGURE 8



The optimum range of the plant communities of the Moore Haven transect by the "frequency of occurrence" of the indicator species.

FIGURE 9



The optimum range of the plant communities of the composite transect by the "frequency of occurrence" of the indicator species.

FIGURE 10

Composite Transect	Optimum Range (feet msl)
Spartina bakeri	13.1 - 15.0
Rhynchospora tracyi	13.1 - 14.6
Salix caroliniana	13.2 - 14.3
Typha angustifolia	12.4 - 13.1
Eleocharis cellulosa	10.6 - 12.4
Scirpus californicus	10.1 - 10.6

Soils

Three indicator species, Spartina bakeri, Salix caroliniana, and Rhynchospora tracyi occupied the same general optimum elevation range at different locations along the Moore Haven transect. The results (mean, range and standard deviation) of soil sample analysis from stations at elevations most frequently utilized by each species within this range are presented in Appendix C. The parameters for which the sample means differ significantly between species are shown in Table 1.

Visual examination of soils from each of the three communities revealed distinct differences in soil organic content. Soils from the Salix caroliniana community consist mostly of organic material in the form of muck or fibrous peat. Soils from the Spartina bakeri community contained a lesser amount of organic material which was in a particulate form mixed with sand. Soils from the Rhynchospora tracyi community had few traces of organic materials. These soils were primarily sand with some fine clay.

Analysis of soil samples from each of the three species communities showed differences in major soil constituents. Soils of the S. caroliniana community were higher than those of S. bakeri and R. tracyi communities in specific conductivity, and contained higher concentrations of phosphorus and major ions. The average specific conductivity of S. caroliniana soils

TABLE 1. Soil Parameters with Significantly Different Sample Means.

Parameter		Sample Mean	
		S. caroliniana	*R. tracyi*
Aluminum	**	1.376 ppm	0.724 ppm
Ammonia	**	0.195 ppm	0.033 ppm
Iron	**	3.595 ppm	1.753 ppm
Calcium	**	20.309 ppm	9.373 ppm
Magnesium	**	2.254 ppm	0.348 ppm
Phosphorus	**	0.130 ppm	0.015 ppm
Potassium	**	0.424 ppm	0.101 ppm
Sodium	**	3.382 ppm	0.851 ppm
Sulfate	**	5.336 ppm	1.775 ppm
Specific Conductivity	**	509 micromhos	202.23 micromhos
pH	**	6.4	7.2
		S. caroliniana	*S. bakeri*
Potassium	**	0.424 ppm	0.198 ppm
Phosphorus	**	0.130 ppm	0.042 ppm
Sodium	**	3.382 ppm	1.103 ppm
Magnesium	**	2.254 ppm	0.942 ppm
Specific Conductivity	**	509 micromhos	241.4 micromhos
Aluminum	*	1.376 ppm	1.475 ppm
Sulfate	*	5.366 ppm	2.552 ppm
		R. tracyi	*S. bakeri*
pH	**	7.2	6.6
Magnesium	*	0.348 ppm	0.942 ppm
Potassium	*	0.101 ppm	0.198 ppm

* significant at the .10 level

** significant at the .04 level

was twice that of *S. bakeri* and *R. tracyi* soils. *S. bakeri* soils differed from those of *R. tracyi* in pH and in magnesium and potassium concentrations.

Soil depths along the Moore Haven transect ranged from 0 to 8.8 feet (Appendix B). Although the land surface relief was slight along this transect, soil depth probes a few inches apart often revealed soil depths differing by several feet. The topography of the underlying limestone was extremely irregular.

Associated Species

The degree of presence of associated species within each community is presented for the Indian Prairie transect in Appendix D and the Moore Haven transect in Appendix E.

Qualitative differences in associated species between transects within the *Scirpus californicus* community consisted of 14 species, excluding the unknown grasses. Eleven (79%) of the species were encountered with a degree of presence of 20% or less. Nine were common to this community on both transects and two species fell within the same frequency class on both transects (Class A, 1-20%).

Qualitative differences between the two transects within the *Eleocharis cellulosa* community consisted of 11 species. Ten (91%) of these species were encountered with a degree of presence of 20% or less. Fourteen species were common to this community on both transects. Six of these species were grouped into the same frequency classes on both transects, five within Class A (1-20%) and one within Class C (41-60%).

Qualitative differences in associated species between transects within the *Typha angustifolia* community consisted of 32 species. Twenty nine (91%)

of these species were encountered with a degree of presence of 20% or less. Thirteen species were common to this community on both transects. Six of these species occurred within the same frequency classes on both transects five within Class A (1-20%) and one in Class D (61-80%).

Forty-five associated species differed between transects within the Spartina bakeri community. Eighty two percent (37) of these were encountered with a degree of presence of 20% or less. Sixteen associated species were common to this community on both transects. Five of these species occurred within the same frequency classes on both transects, all within Class A (1-20%).

The two transects were documented over a period of 276 days. The time factor involved in the documentation procedures undoubtedly had some influence on the data. The effects involving the indicator species were probably insignificant. Species presence data is relatively insensitive to density changes that may have occurred. Barring fire or extreme lake stages, the influence of a single season upon the indicator species distribution is very small and probably would not have been detected by the methods of this study. Also, most of the documentation occurred when the season and water levels were not conducive to propagation of the indicator species.

The degree of presence data were most likely to be influenced by the time differences in documenting the transects. This would be particularly true in the case of annuals that appear only during certain times of the year and/or specific water level conditions. Generally, such species are not major components of the plant communities and seasonal and/or water level influences can be detected in the data. However, the data must be considered in light of this potential for error.

DISCUSSION

Gradient Analysis

The distribution of the indicator species along the elevation gradient of the two transects is characterized by overlapping, generally bell-shaped frequency curves. A series of overlapping curves generally occur along many environmental gradients (Gouch, Chase, and Whittaker, 1974; Whittaker, 1969) and imply a continuous intergrading of species along the elevation gradient as opposed to sharply delineated zones.

This integration appears on a statistical basis. Vegetation along the transect is often sharply divided into clearly defined units without evidence of a typical transition zone. The overlap of two species frequency curves, therefore, represents a transition elevation range, but not necessarily a physical integration of the two species.

Scirpus californicus

The vertical distribution of *S. californicus* on the two transects is considerably different. However, as a community indicator, bulrush is limited to a narrow band that forms the lakeward edge of the emergent marsh. The elevation range of bulrush is different on the two transects because it is prevented from growing below elevation 11.2' msl at the lakeward edge of the Moore Haven transect by outcrops of rock.

Bulrushes may be dependent upon a high energy environment to sustain the community in face of competition from other species. Individual plants can withstand intense wave action. In areas not subject to frequent wave action, *S. californicus* is usually absent and *Eleocharis cellulosa* forms the lakeward edge of the emergent marsh.

This dependence upon a high energy environment may be responsible for the affinity of the community for the lakeward edge of the littoral zone and the disparity in elevation ranges of the community on both transects. Observations indicate that the 10.1' - 10.7' msl range of S. californicus on the Indian Prairie transect is most typical of the vertical distribution of the species throughout the littoral zone.

New S. californicus plants appear primarily during April, May and June. Although reproduction thus far has been observed to be vegetative, it is likely that reproduction from seed does occur. Seed production is prolific from February through June of each year.

Vegetative reproduction occurs in saturated soils and in water as deep as 2.5 feet at the lakeward edge of the littoral zone. Elsewhere within the littoral zone, reproduction occurs in saturated soils.

Eleocharis cellulosa

The frequency curves showing the overall vertical distribution of E. cellulosa on both transects show two relatively high peaks of frequency, one within the general range of 10.5' to 12' msl and one within the 13' to 14' msl range. On both transects the peak within the lowest elevation range represents the range in which the species is a community indicator. Within the 13' to 14' range, E. cellulosa is a common component of the Spartina bakeri community on the Indian Prairie transect. On the Moore Haven transect, E. cellulosa is a common component of both the S. bakeri and Rhynchospora tracyi communities.

E. cellulosa appears to require drying during portions of March, April or May, and then reflooding to reproduce from seed. New plants appear in formerly dry areas with the advent of the rainy season. Ponded rainwater promotes seed germination at land elevations far higher than the lake stage during this time of year.

Vegetative reproduction generally begins in June in water depths that range from 3 inches to about 2 feet and continues through July in that portion of the range where water depths do not exceed 2 feet. Vegetative reproduction appears to be primarily responsible for new plant production within the optimum range of this species. The production of basal shoots from established plants occurs as early as April when plants are standing in water that is less than 12 inches deep.

Typha angustifolia

The optimum range of *T. angustifolia* on the two transects is represented by peaks of frequency within the general range of 12' to 13' msl. Both transects show peaks of frequency between 11' and 12' msl. Cattail within this range consist of scattered, well defined, and often extensive clumps, usually found within the *E. cellulosa* community. Cattail growing between 11' and 12' msl on both transects appear to be the result of lake stages maintained since 1962.

The frequency peak of *T. angustifolia* below 11 ft msl on the Moore Haven transect represents floating cattail mats. These mats take root in the flocculent organic substrate during low water and usually float free as lake stages rise. This floating phenomenon is undoubtedly the property that allows these plants to survive at such low land elevations. Old cattail stubble has been observed elsewhere in the littoral zone at land elevations below 11' msl in firm substrate. This stubble is from plants that apparently became established at low lake stages and subsequently died.

New Typha angustifolia plants were observed from March through June on saturated soils. Some of the new plants were the result of vegetative reproduction from rootstock of parent plants. Other cattail were isolated and apparently developed from seed. Observations of cattail reproduction during this study are consistent with those of other investigators. Mathiak (1971) reported that Typha sp. developed from seed on liquid mudflats during artificial drawdowns. Kadlec (1962) reported that Typha latifolia required wet soils for establishment. Harris and Marshall (1963) mention cattail development occurring in areas of incomplete soil drainage.

Spartina bakeri

The upper optimum limit of Spartina bakeri (14.6' msl) on the Moore Haven transect is the highest elevation that occurs on that transect. On the Indian Prairie transect, the highest elevation at which this species occurs is 15.0' msl. The upper optimum elevation is 14.5' msl. S. bakeri is limited on the Indian Prairie transect by burning and cattle grazing that has turned much of that transect between 13.5' and 15.0' msl into a disturbed pasture. The upper limit of S. bakeri growth, based on observation elsewhere in the littoral zone, is approximately 15.5' msl. This elevation is not represented on either transect.

Spartina bakeri seedlings were observed in May and June and occurred at land elevations which were dry by mid-March. Seedlings and vegetative reproduction have been observed only during years when lake stages were 2.0 to 2.5 feet below the elevations at which new plants occurred.

Salix caroliniana

Frequency curves that show the overall vertical distribution of Salix caroliniana on the Moore Haven transect (Figure 5) indicate two discontinuous peaks of frequency. The peak representing elevations 10.1' to 10.7' msl is the result of willows growing on floating Typha angustifolia mats. The willows in the floating mats have died since 1973. The frequency curve representing land elevations from 11.7' to 14.3' is the result of S. caroliniana occurring only in locations that contain muck and fibrous peat soils. On the Moore Haven transect these soils are confined to two prominent ridges between transect stations 08500 and 20000 and 38000 to 41000 (Appendix B).

The establishment of new Salix caroliniana plants from seed has seldom been observed within the littoral zone. The willows that grew in the floating cattail mats apparently originated from seed. These willows were growing independently and had no root connection to other plants. Seed production by this species is prolific and occurs during January and February. The seeds have been disbursed by the end of March. Vegetative reproduction of S. caroliniana is frequently observed within the optimum range of this species. The new vegetative growth reached heights of eight feet and had a diameter of up to 1.5 inches within 12 months. Vegetative reproduction of S. caroliniana within its optimum range occurs in dry and saturated soils from March through June. This observation is consistent with observations of Dineen (1974) who reported new growth of willows on drowned tree islands in Everglades Conservation Area 2A after two years of reduced water levels.

Rhynchospora tracyi

The frequency curves showing the overall vertical distribution of Rhynchospora tracyi on the Moore Haven transect (Figure 5) shows two discontinuous peaks of frequency. The small peak at elevation 12.1' - 12.3' msl is the result of small, scattered patches of this species growing within the Eleocharis cellulosa community. The second peak (13.1' - 14.3' msl) represents the optimum range of R. tracyi. Within its optimum range, R. tracyi is limited to sandy soils.

The production of new R. tracyi plants from seed was observed in June in soils that had been dry since March, and in saturated soils. Vegetative growth of new stems from the base of established plants was observed in dry soils and in three to six inches of water. Vegetative reproduction may continue throughout the summer in areas where water remains shallow.

Species - Water Fluctuation Analysis

Most of the indicator species are found over a wide range of land elevations and tolerate a wide range of water level fluctuations. Distinct relationships to land elevations occur primarily as a function of distinct physiognomic units. The species relationship to land elevation exists as a community function. This relationship is not direct, but is coincidental to the water level fluctuations under which the community exists.

The seasonal water level requirements for reproduction of a given indicator species coincide with those of one or more of the other indicator species. The physiological requirements for growth and survival of the various indicator species in relation to hydroperiod apparently overlap somewhat as evidenced by the considerable overlap of the vertical distribution of most of the indicator species. The influence of seasonal water levels, therefore, appears cumulative over a period of years.

Although undoubtedly complex, the relationship between the plant community and hydroperiod can be generalized into two influences. 1) The hydroperiod must meet the reproductive requirements of the community's indicator species with sufficient frequency to establish and maintain that species. 2) The seasonal water level fluctuations must provide the conditions under which the indicator species is vigorous enough to exhibit the morphological characteristics required to characterize a distinct community type in the face of competition from other species.

New plant production by the indicator species characteristically depends upon water levels during March, April, May and June. Although some of the indicator species (R. tracyi, E. cellulosa) reproduce throughout the summer months, conditions that promote this growth are usually predicated by low water that usually occurs between the middle of May and the middle of June.

Water level fluctuations to which each indicator species has been exposed for the 1951-1970 time period can be expressed as the percent of time that lake stages equalled or exceeded the upper and lower limits of its optimum range for each month of the year. This percentage is essentially the percent inundation and is presented for each indicator species on each transect and the composite of both transects in Tables 2, 3 and 4. The percent inundation that is critical to the indicator species is that from March through June.

TABLE 2. Indian Prairie Transect. Percentage of Lake Stage Events that Equaled or Exceeded Upper and Lower Optimum Elevations (1951-1970).

Indicator Species	Elevation	ft. msl	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spartina bakeri	Lower	13.0	80	84	87	81	70	68	76	79	86	85	84	80
	Upper	14.5	50	47	42	19	0.5	2	10	12	26	54	60	55
Typha angustifolia	Lower	12.0	95	95	93	89	95	87	91	95	95	97	98	94
	Upper	13.0	80	84	87	81	70	68	76	79	86	85	84	80
Eleocharis cellulosa	Lower	10.7	100	100	100	100	96	93	95	95	97	100	100	100
	Upper	12.0	95	95	95	89	85	87	91	95	95	97	98	94
Scirpus californicus	Lower	10.1	100	100	100	100	100	100	100	100	100	100	100	100
	Upper	10.7	100	100	100	100	96	93	95	95	97	100	100	100

TABLE 3. Moore Haven Transect. Percentage of Lake Stage Events that Equaled or Exceeded Upper and Lower Optimum Elevations (1951-1970).

Indicator Species	Elevation ft. msl		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spartina bakeri	Lower	13.1	80	81	85	77	65	59	65	78	85	85	83	79
	Upper	14.6	50	42	39	17	1<	2	10	8	22	49	57	53
Rhynchospora tracyi	Lower	13.1	80	81	85	77	65	59	65	78	85	85	83	79
	Upper	14.6	50	42	39	17	1<	2	10	8	22	49	57	63
Salix caroliniana	Lower	13.2	80	78	80	74	60	49	58	73	84	85	82	79
	Upper	14.3	60	59	52	27	4	3	10	16	34	64	68	65
Typha angustifolia	Lower	12.4	95	95	90	87	81	83	90	95	90	91	90	90
	Upper	13.1	80	81	85	77	65	59	65	78	85	85	83	79
Eleocharis cellulosa	Lower	10.1	100	100	100	100	97	95	98	95	98	100	100	100
	Upper	12.4	95	95	90	87	81	83	90	95	90	91	90	90
Scirpus californicus	Lower	11.2	100	100	100	95	93	90	95	95	95	99	100	100
	Upper	11.8	95	95	95	90	89	89	93	95	95	97	100	99

TABLE 4. Composite Transect
Percentage of Lake Stage Events that Equaled or Exceeded Upper and Lower Optimum Elevations (1951-1970)

Indicator Species	Elevation ft msl		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spartina bakeri	Lower	13.1	80	81	85	77	65	59	65	78	85	85	83	79
	Upper	15.0	33	34	20	9	0	1	8	1	8	36	45	37
Rhynchospora tracyi	Lower	13.1	80	81	85	77	65	59	65	78	85	85	83	77
	Upper	14.6	50	42	39	17	1<	2	10	8	22	49	57	53
Salix caroliniana	Lower	13.2	80	78	80	74	60	49	58	73	84	85	82	79
	Upper	14.3	60	59	52	27	4	3	10	16	34	64	68	65
Typha angustifolia	Lower	12.4	95	95	90	87	81	83	90	90	90	91	90	90
	Upper	13.1	80	81	85	77	65	59	65	78	85	85	83	79
Eleocharis cellulosa	Lower	10.6	100	100	100	100	97	95	98	95	98	100	100	100
	Upper	12.4	95	95	90	87	81	83	90	90	90	91	90	90
Scirpus californicus	Lower	10.1	100	100	100	100	100	100	100	100	100	100	100	100
	Upper	10.6	100	100	100	100	97	95	98	95	98	100	100	100

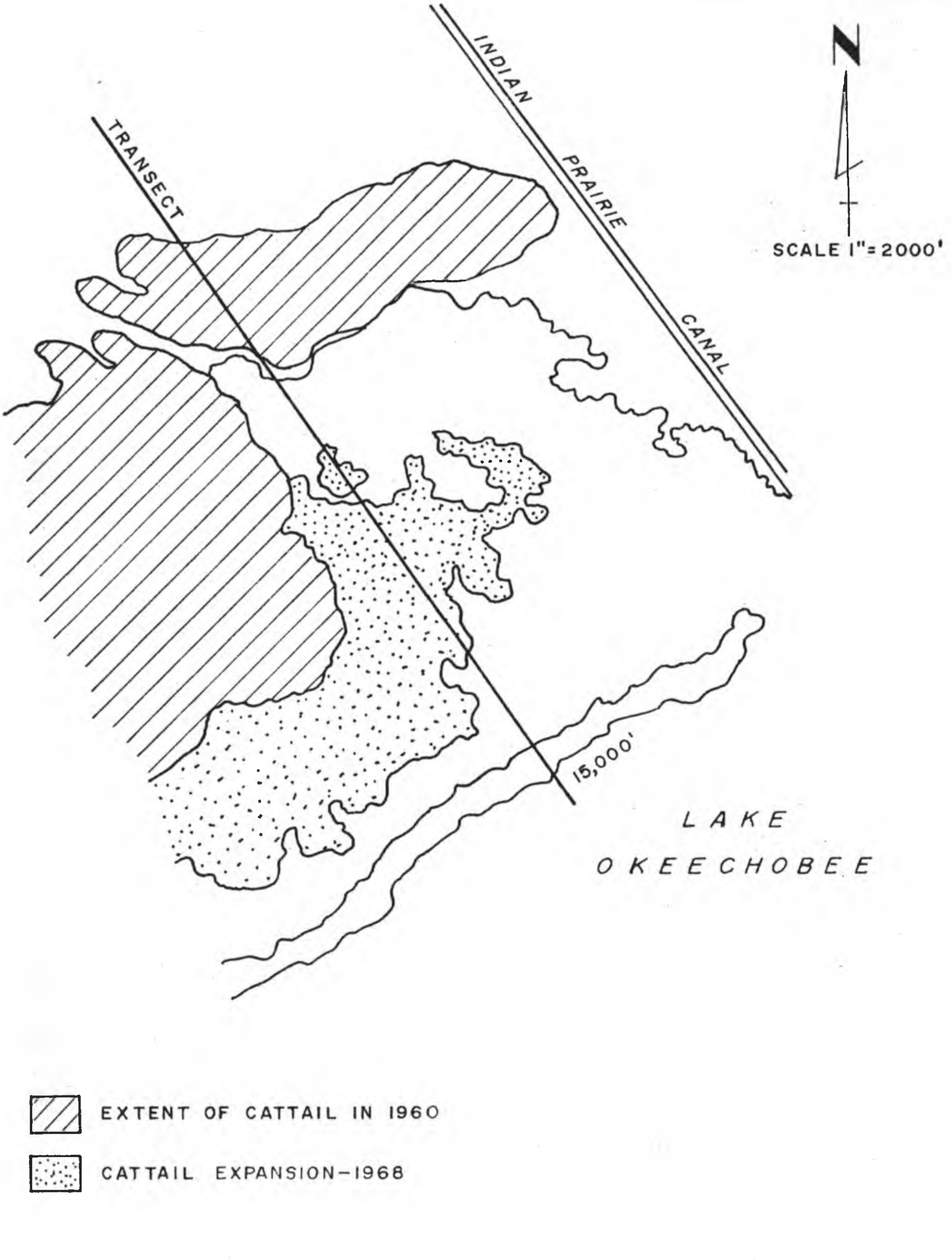
The response of vegetation to cumulative water level fluctuations during the primary months of new plant production can be demonstrated using the vertical distribution of *Typha angustifolia* on the Indian Prairie transect.

Aerial photography of the Indian Prairie transect area from 1960 and 1968 showed that *Typha angustifolia* became established within the 11.0' to 12.0' msl elevation range, between 1960 and 1968 (Figure 11). The cattail within this range exists as well-defined patches within the optimum elevations range of *Eleocharis cellulosa*. Low lake stages of 1962 (Appendix 1) offered the first opportunity after 1960 for *T. angustifolia* to become established within the 11.0' to 12.0' elevation range.

The percent inundation of the lower optimum elevation of *T. angustifolia* on the Indian Prairie transect (12.0' msl) for the months of March, April, May and June during the 1951-1970 time period was 93%, 89%, 85% and 87%, respectively. The land elevations at which these percentages were duplicated during the 1962-1970 time period (Figure 12) ranged from 11.0' to 11.8' msl.

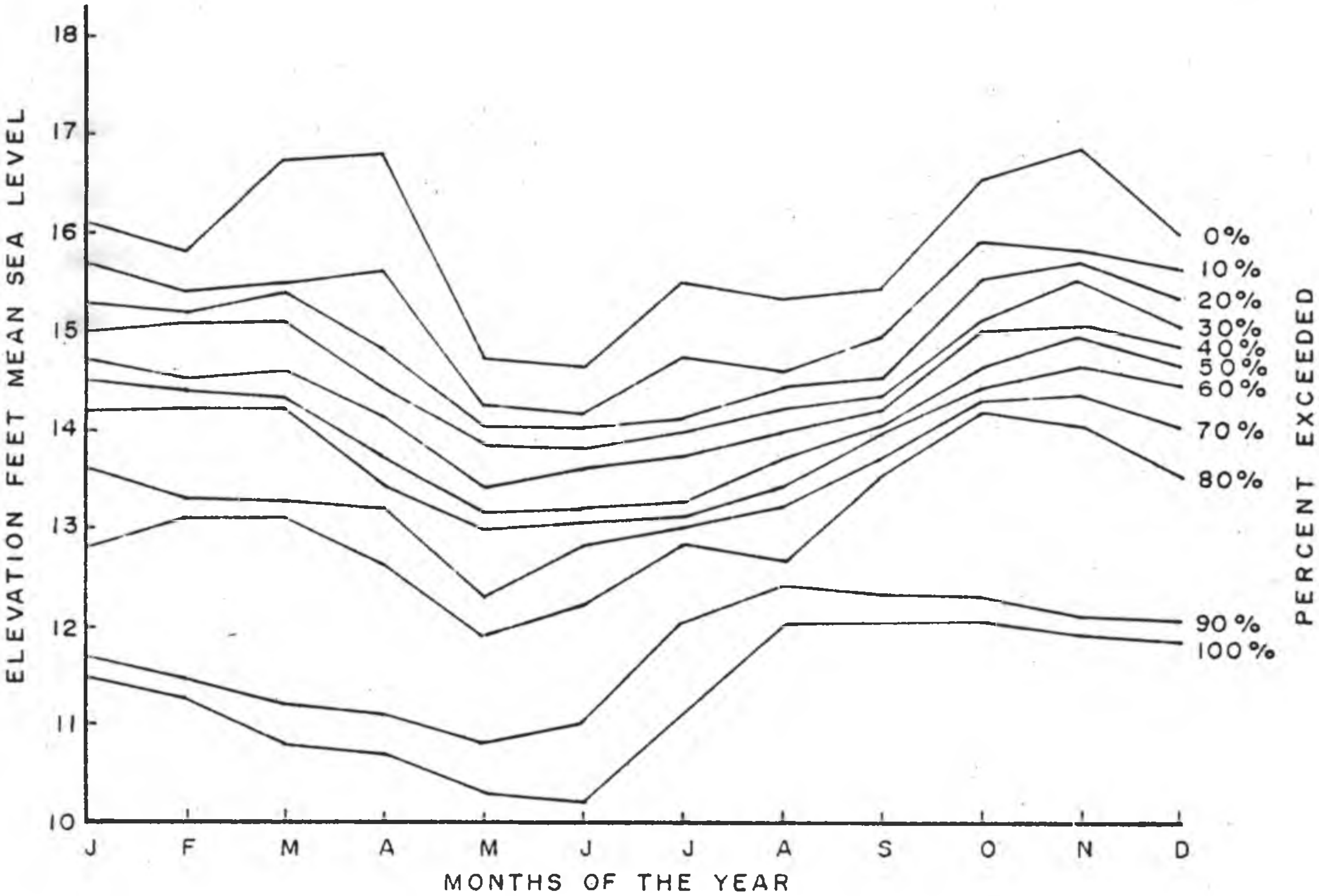
Cattail also occurs within the 11' to 12' msl range on the Moore Haven transect, as it should if water levels determined growth at that elevation range. The percent inundation of the lower optimum limit of *T. angustifolia* on this transect (12.4' msl) for the months of March, April, May and June during the 1951-70 time period was 90%, 87%, 81% and 83%, respectively. The land elevations at which these percentages were duplicated during the 1951-70 time period ranged from 11.0' to 12.0' msl.

The percent inundation can account for the occurrence of *T. angustifolia* between the elevations 11.0' and 12.0' msl, at least through 1970



INDIAN PRAIRIE TRANSECT AREA

FIGURE 11



Iso-frequency lines for Lake Okeechobee stages, 1962-1970. Lines express the percentage of daily lake stages (right margin) that equalled or exceeded given ground elevations (left margin) during each month of the year.

FIGURE 12

the last year that data are available). T. angustifolia remains within this elevation range.

Soils and Vegetation Distribution

The littoral zone soils are predominantly sandy and shallow, but there is sufficient variation in soils to influence the distribution of vegetation. Soil influences are secondary and tend to modify the effects of hydroperiod. The influence of hydroperiod upon the vertical distribution of willow, beak-rush, and Spartina communities is conspicuous as the frequency curves of all 3 intersect that of Typha angustifolia within 0.1 foot of land elevation. The horizontal distribution of these species appears related to soil constituents.

The physiological requirements from soils for these species is unknown and the mechanism for these soil-species relationships is not clear. There was no consistent relationship between species and soil depth. In some instances both willow and Spartina occurred as distinct community types, associated with depressions in underlying limestone. In such cases, the association appears to be indirect. Soils in the depressions tended to be higher in organic content than that of the surrounding area. There was no consistent relationship between soil depth and soil constituents.

Davis (1943) mentioned that willow was associated with organic soils, but did not point out specific relationships between soils and R. tracyi and S. bakeri. One unusual aspect of soil-species relationships within the littoral zone is the limitation of R. tracyi to sandy soils. R. tracyi occurs in organic soils of Everglade Conservation Areas 1 and 3A.

The major sawgrass communities within the littoral zone were not intersected by the transects. Intensive soundings of these communities indicate that they are found within the same elevation range as willow, beak-rush and *Spartina* communities. The sawgrass communities are confined primarily to organic soils or sandy soils with a high organic content. In some areas sawgrass is adjacent to, and intergrades, with, willow communities, indicating that sawgrass and willow may have similar soil preferences.

The influence of soils upon vegetation distribution is of importance primarily above land elevation 13.0' msl. Most of the communities found below this elevation are not soil specific. However, emergent plants are seldom found in flocculent organic substrate while floating leaved plants usually predominate in such areas.

Species Composition

The degree of presence of associated species within a particular community is the probability of finding a given associated species at the same station as a given indicator species in a random sample of stations within the optimum range of that indicator species. Degree of presence is not an estimate of density or abundance except in a general sense and is used herein to describe the species composition of each major community and the probability with which each associated species occurred. The majority of species that were found within a community on one transect and not on the other, fell within the 1-20% (rare) degree of presence category. The majority of species that fell within the same degree of presence category within a community on both transects also occurred within the 1-20% (rare) category. A species found within a community on one transect with a relatively high degree of presence, may likely be found within that same community on the other transect, although the degree of presence may be considerably different. When considered collectively, the species with the greatest probability of being encountered were generally found on both transects.

The Scirpus californicus community on the Moore Haven transect is located within the 11.2' - 12.3' msl elevation range, which is considerably higher than S. californicus community on the Indian Prairie transect. The species composition of the Moore Haven S. californicus community generally reflects higher land elevations than that of the Indian Prairie transect. This is evident by the high degree of prescence of Typha angustifolia in this community.

The Eleocharis cellulosa, Typha angustifolia and Spartina bakeri communities each inhabit similar elevation ranges on both transects. Inconsistencies in species composition between transects within these communities are, therefore, probably not related to differences in land elevations.

Most of the species found within each of these communities that were present on one transect and not on the other were annual plants that reflected seasonal and/or water level differences at the time that the transects were documented. Annual species were predominately within the 1-20% degree of presence class, and accounted for much of the variation, especially within the Spartina bakeri and Typha angustifolia communities.

However, there was a great deal of variation among the more persistent species, some of which were found with a relatively high degree of frequency on one transect or the other. Variation in the degree of presence of such species indicates that the species composition is not very consistent, quantitatively or qualitatively, from one place to another within a community.

Some of the variation may be explained by variation in soils, especially in communities where the indicator species is not soil specific. Panicum hemitomon, for example, is seldom found within the E. cellulosa community except in soils of high organic content, where it is often abundant.

Another likely explanation is the non-random distribution of species due to clustering of individuals (Kershaw, 1973). The causative agents for clustering may be complex and are not often apparent. However, such patterns are often visually distinct among Pontederia lanceolata, Sagittaria lancifolia, Furiena scirpoidea, Polygonum punctatum, Panicum repens, Panicum paludivagum and Phragmites communis in both E. cellulosa and T. angustifolia communities.

Applications to Water Management

Analysis of preferred hydroperiods of the various plant communities by the techniques presented in this paper has potential as a predictive tool in evaluating environmental consequences of water management decisions. Models that compute lake stage levels in response to changes in regulation schedules and water use demands can provide projected lake stage statistics. A change in the water regime should induce corresponding alterations in vegetations. These statistics, in conjunction with a knowledge of soil type and Lake topography, could then be used to predict alterations in vegetation.

CONCLUSIONS

1. The littoral zone of Lake Okeechobee is a product of post-drainage lake stages.
2. The distribution of the indicator species of the 6 communities investigated is related primarily to land elevation, with soil type exerting an influence in some cases.
3. Species-land elevation relationships are not direct, but coincidental to hydroperiod.
4. The hydroperiod under which each community has developed is characterized by the percent inundation of the upper and lower elevation limits of the community during March, April, May and June for the 1951-1970 time period.
5. The species composition of a given community is variable from one location to another within the littoral zone.
6. The identification of the hydroperiod under which the communities have developed has potential as a predictive tool in evaluating future water management decisions.

REFERENCES

AGER, Lothian A. and King E. Kerce. 1970. Vegetational Changes Associated with Water Level Stabilization in Lake Okeechobee, Florida. 24th Ann. Conf. of the SE Assoc. of Game and Fish Commissioners. pp 338-351.

BRAUN-BLANQUET, J. 1972. Plant Sociology. Hafner Publishing Co., New York. 439 pp.

CAIN, Stanley A. and G. M. Oliveira Castro. 1971. Manual of Vegetation Analysis. Hafner Publishing Co., New York. 439 pp.

DAVIS, John H. 1943. The Natural Features of Southern Florida. Fla. Geol. Sur. Biol. Bull. No. 25, 311 pp.

DINEEN, J. Walter. 1974. Examination of Water Management Alternatives in Conservation Area 2A. In Depth Report. Vol. 2, No. 3. Central and Southern Florida Flood Control District.

FERNALD, M.L. 1970. Gray's Manual of Botany. Van Nostrand Reinhold Co., New York.

GOUCH, Hugh G., Gene B. Chase, and Robert H. Whittaker. 1974. Ordination of Vegetation Samples by Gaussian Species Distribution. Ecology Vol. 55, No. 6. pp 1382-1390.

HANNA, Alfred Jackson and Kathryn Abbey Hanna. 1948. Lake Okeechobee. Bobbs-Merrill Company. Indianapolis-New York.

HARRIS, Stanley IV and William H. Marshall. 1963. Ecology of Water Level Manipulations on a Northern Marsh. Ecology, Vol. 44, No. 2.

HARSHBERGER, J. W. 1914. The Vegetation of South Florida, South of 27°30' North, Exclusive of the Florida Keys. Transactions, Wagner Free Institute of Science, Philadelphia.

HELPRIN, Angelo. 1887. Explorations on the West Coast of Florida and in the Okeechobee Wilderness. Wagner Free Institute of Sciences of Philadelphia.

HITCHCOCK, A. S. 1971. Manual of the Grasses of the United States, Vol. 1 and Vol. II, 2nd Ed. Dover Publications, Inc. New York.

HORTON, J. P. 1911. Field Notes of the Survey of Observation Island, Lake Okeechobee.

JOHNSON, Lamar. 1974. Beyond the Fourth Generation. University Presses of Florida. Gainesville, Florida.

KADLEC, John A. 1962. Effects of Drawdown on a Waterfowl Impoundment. Ecology Vol. 43, No. 2

KERSHAW, Kenneth A. 1963. Pattern in Vegetation and its Causelity. Ecology Vol. 44, No. 2. pp 377-388.

LEACH, S. D., Howard Klein, and E. R. Hampton. 1972. Hydrologic Effects of Water Control and Management of Southeastern Florida. Dept. of Nat Res Report of Investigations #60. Bureau of Geology.

LONG, R. W. and O. Lakela. 1971. A Flora of Tropical Florida. Univ. of Miami Press, Coral Gables.

LOVELESS, Charles M. 1959. A Study of the Vegetation of the Florida Everglades. Ecology, Vol. 40, No. 1, 9 pp.

MATHIAK, Harold A. 1971. Observations on the Status of Cattails at Horicon Marsh, Wisconsin. Research Report #66. Dept of Nat Res, Madison, Wisconsin.

MATSON, G. C. and Samuel Sandford. 1913. Geology and Groundwaters of Florida vs Geological Survey Water Supply Paper 319. pp 1-445.

PESNELL, G. L. and R. T. Brown, III. 1976. The Vegetation of Lake Okeechobee, Florida, Map, 3 pp. Central & Southern Florida Flood Control District, West Palm Beach, Fla.

SINCOCK, John L. 1957. A Study of the Vegetation on the Northwest Shore of Lake Okeechobee. Florida Game and Fresh Water Fish Comm.

SMALL, J. K. 1933. Manual of the Southeastern Flora. Univ. of North Carolina Press. Chapel Hill.

SNEDECOR, G. W. and W. G. Cochran. 1968. Statistical Methods. Iowa State Univ. Press, Ames. pp 114-116.

WHITTAKER, Robert H. 1970. Communities and Ecosystems. Macmillan and Co. Collier Macmillan Limited, London. 162 pp.

WILL, Lawrence E. 1964. A Cracker History of Okeechobee. Great Outdoors Association, St. Petersburg, Florida 317 pp.

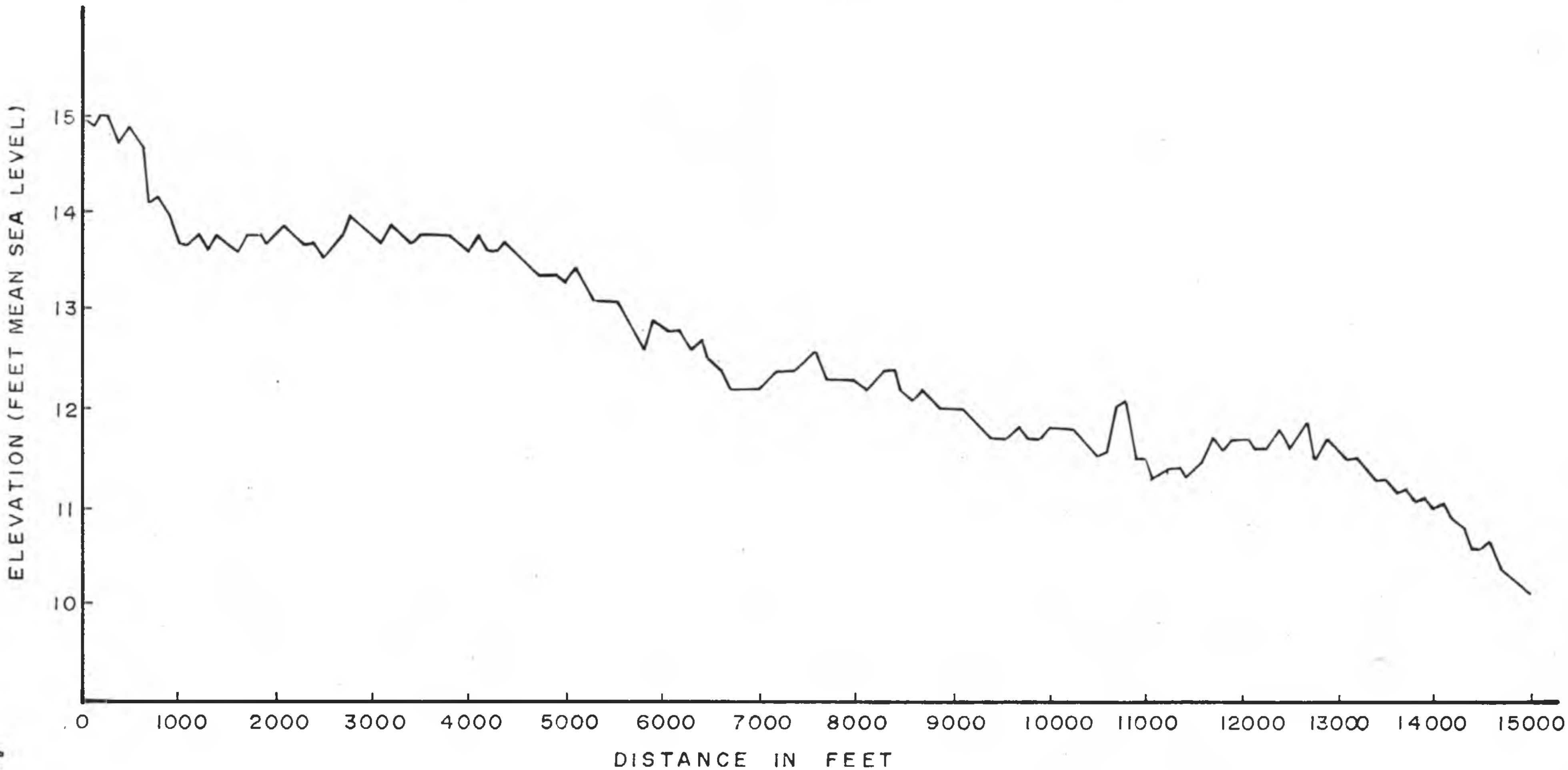
---- 1965. Okeechobee Boats and Skippers. Great Outdoors Publishing Co., St. Petersberg, Florida 165 pp.

---- 1968. Swamp to Sugar Bowl, Pioneer Days in Belle Glade. Great Outdoors Publishing Co., St. Petersburg, Florida 235 pp.

YAMANE, Taro. 1964. Statistics, An Introductory Analysis. Harper and Row, Pub., Inc. New York. pp 337-339.

APPENDIX A

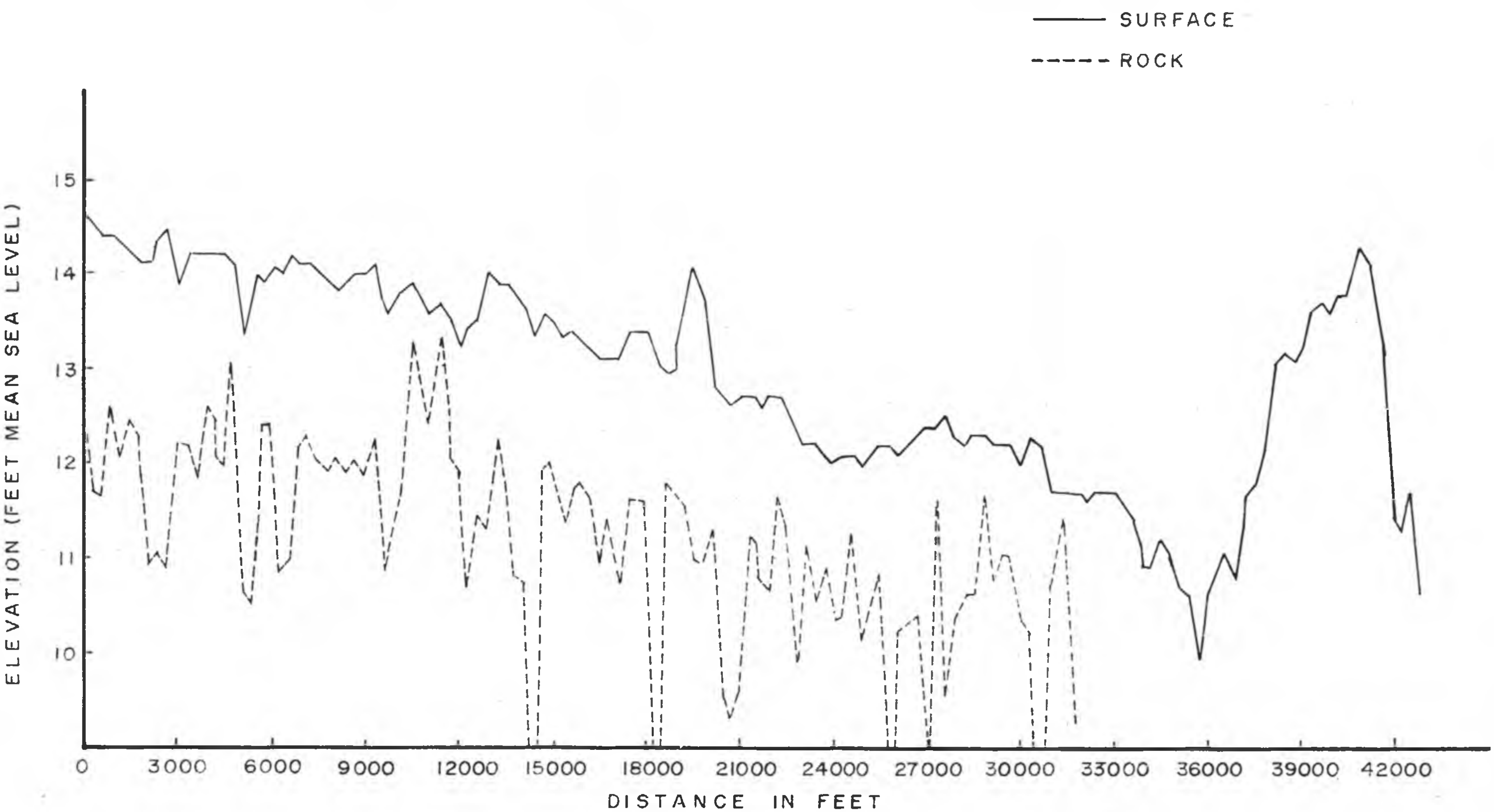
Appendix A



INDIAN PRAIRIE TRANSECT ELEVATION PROFILE

APPENDIX B

Appendix B



MOORE HAVEN TRANSECT ELEVATION PROFILE

APPENDIX C

Salix caroliniana

Parameter	Mean	Range	Standard Deviation
pH	6.4	5.9 - 7.0	0.313
		micromhos/cm^2	
Specific Conductivity	509	361 - 629	68.036
		ppm	
Al	1.376	0.691 - 2.919	.579
Fe	3.595	1.709 - 5.729	1.053
NH_3-N	0.195	0.086 - 0.322	0.064
Mn	0.017	0.008 - 0.044	0.009
K	0.424	0.208 - 0.583	0.121
P	0.130	0.056 - 0.425	0.093
Cl	0.018	2.979 -12.119	0.009
Ca	20.309	8.234 -28.141	5.953
Zn	0.011	0.002 - 0.039	0.009
Cu	0.003	0.002 - 0.005	0.002
Mg	2.254	1.235 - 3.211	0.586
Na	3.382	1.494 - 4.885	1.126
SO_4	5.336	2.459 -13.762	2.562
B	0.032	0.019 - 0.420	0.007

Rhynchospora tracyi

Parameter	Mean	Range	Standard Deviation
pH	7.20	6.3 - 8.0	0.57
		micromhos/cm^2	
Specific Conductivity	202.23	97 - 396	69.64
		ppm	
Al	0.724	6.271 - 1.231	0.284
Fe	1.753	0.735 - 3.922	1.023
NH_3-N	0.033	0.013 - 0.059	0.014
Mn	0.013	0.005 - 0.024	0.005
K	0.101	0.066 - 0.159	0.026
P	0.015	0.006 - 0.023	0.005
Cl	0.022	0.681 - 2.835	0.007
Ca	9.373	2.419 -18.177	5.679
Zn	0.004	0.002 - 0.007	0.001
Cu	0.001	0.0005- 0.003	0.001
Mg	0.348	0.161 - 0.923	0.224
Na	0.851	0.271 - 1.961	0.467
SO_4	1.775	1.401 - 2.999	0.443
B	0.007	0.003 - 0.012	0.003

Spartina bakeri

Parameter	Mean	Range	Standard Deviation
pH	6.64	5.8 - 7.8	.67
		micromhos/cm^2	
Specific Conductivity	241.4	114 - 629	104.6
		ppm	
Al	1.465	0.307 - 8.448	1.761
Fe	3.431	0.594 -21.386	4.439
NH_3-N	0.139	0.027 - 1.189	0.244
Mn	0.022	0.004 - 0.199	0.041
K	0.198	0.057 - 1.049	0.201
P	0.042	0.005 - 0.144	0.038
Cl	0.023	0.599 -10.246	0.029
Ca	15.361	0.535 -115.638	23.402
Zn	0.007	0.001 - 0.059	0.012
Cu	0.003	0.001 - 0.011	0.003
Mg	0.942	0.233 - 5.613	1.131
Na	1.103	0.401 - 3.204	0.720
SO_4	2.552	0.682 -21.791	4.361
B	0.013	0.002 - 0.088	0.018

APPENDIX D

INDIAN PRAIRIE TRANSECT

Scirpus californicus Community

10.1' - 10.7' msl

Associated species by degree of presence classes

Class A (1-20%)	%
Chara spp.	7
Eleocharis flavescens	7
Typha angustifolia	7
Eichhornia crassipes	20
Furiena scirpoides	20
Pistia stratiotes	20

Class B (21 - 40%)	%
grass, unknown	27
Utricularia spp.	27
Eleocharis cellulosa	33
Potamogeton illinoensis	33

Class C (41 - 60%)	%
Sagittaria lancifolia	53

Class D (61 - 80%)	%
Pontederia lanceolata	67

Class E (81 - 100%)	%
Vallisneria americana	93

INDIAN PRAIRIE TRANSECT

Eleocharis cellulosa Community

10.7' - 12.0' msl

Associated species by degree of presence classes

Class A (1 - 20%)	%
Nelumbo lutea	1
Polygonum spp.	1
Scirpus americanus	1
sedge, unknown	1
Panicum hemitomon	2
Alternanthera spp.	3
Hydrilla verticillata	7
Eichhornia crassipes	8
Najas quadalupensis	13
Eleocharis flavescens	15
Nmyphaea odorata	16
Furiena scirpoidea	19
Vallisneria americana	20

Class B (21 - 40%)	%
Chara spp.	22
Typha angustifolia	37
Pontederia lanceolata	40

Class C (41 - 60%)	%
Sagittaria lancifolia	48
Scirpus californicus	48
Potamogeton illinoensis	60

Class E (81 - 100%)	%
Utricularia spp.	81
grass, unknown	88

INDIAN PRAIRIE TRANSECT

Typha angustifolia Community

12.0' - 13.0' msl

Associated species by degree of presence classes

Class A (1 - 20%)	%
Scirpus californicus	1
Eleocharis cellulosa	2
sedge, unknown	2
Cephalanthus occidentalis	3
Eleocharis equisetoides	3
Salix caroliniana	3
Spartina bakeri	4
Nelumbo lutea	7
Vigna luteola	14
Salvinia rotundifolia	20

Class B (21 - 40%)	%
Alternanthera spp.	22
Utricularia spp.	26
Nymphaea odorata	33

Class C (41 - 60%)	%
Sagittaria lancifolia	50

Class D (61 - 80%)	%
grass, unknown	68
Pontederia lanceolata	71
Polygonum spp.	75

INDIAN PRAIRIE TRANSECT

Spartina bakeri Community

13.0' - 14.5' msl

Associated species by degree of presence classes

Class A (1 - 20%)	%
Lythrum sp.	1
Mikania scandens	1
Sagittaria lancifolia	1
Alternanthera spp.	4
Potamogeton illinoensis	4
Chara spp.	6
Utricularia spp.	6
Cephalanthus occidentalis	10
Lippia nodiflora	13
Scirpus americanus	15
Hibiscus gradiflorus	16
Baccharis sp.	19

Class B (21 - 40%)	%
Ludwigia sp.	25
Centella repanda	32
Eupatorium coelestinum	32
Pluchea sp.	38

Class C (41 - 60%)	%
Hydrocotyle spp.	42
Sesuvium portulacastrum	48
Bacopa monnieri	59

Class D (61 - 80%)	%
Eleocharis cellulosa	61
Polygonum spp.	61
sedge, unknown	66
Nymphaea odorata	68
Pontederia lanceolata	80

APPENDIX E

MOORE HAVEN TRANSECT

Eleocharis cellulosa Community

10.6' - 12.4' msl

Associated species by degree of presence classes

Class A (1 - 20%)	%
Chara spp.	1
Najas quadalupensis	2
Panicum repens	2
Polygonum spp.	2
Rhynchospora tracyi	2
Salvinia rotundifolia	2
Scirpus californicus	2
Spartina bakeri	3
Vallisneria americana	3
Scirpus americanus	6
Potamogeton illinoensis	8
Typha angustifolia	11
Pontederia lanceolata	14
Pancium hemitomon	17

Class B (21 - 40%)	%
Panicum paludivagum	27
Nymphaea odorata	32
Furiena scirpoidea	36

Class C (41 - 60%)	%
Sagittaria lancifolia	44

Class D (61 - 80%)	%
Utricularia spp.	61

MOORE HAVEN TRANSECT

Scirpus californicus Community

11.2' - 12.3' msl

Associated species by degree of presence classes

Class A (1 - 20%)	%
Echinochloa walteri	4
Eichhornia crassipes	4
Hibiscus gradiflorus	4
Sarcostema clausa	4
Mikania scandens	9
Najas quadalupensis	9
Polygonum spp.	9
Potamogeton illinoensis	9
Furiena scirpoidea	13
Nymphaea odorata	13
Vallisneria americana	13
Panicum paludivagum	17

Class B (21 - 40%)	%
Scirpus americanus	22
Sagittaria lancifolia	26
Panicum hemitomon	30
Pontederia lanceolata	30
Salvinia rotundifolia	39

Class C (41 - 60%)	%
Eleocharis cellulosa	48
Typha angustifolia	52
Utricularia spp.	52

MOORE HAVEN TRANSECT

Typha angustifolia Community

12.4' - 13.1' msl

Associated species by degree of presence classes

Class A (1 - 20%)	%
Cladium jamaicensis	1
Cyperus haspan	1
Echinochloa crusgalli	1
Eichhornia crassipes	1
Eleocharis caribaea	1
Eleocharis equisetoides	1
Eleocharis flavescens	1
Eupatorium coelestinum	1
Hibiscus grandiflorus	1
Lippia nodiflora	1
Peltandra sp.	1
Psilocarya nitens	1
Sagittaria sp.	1
Salvinia rotundifolia	1
Scirpus americanus	1
Centella repanda	2
Eleocharis baldwinii	3
Ludwigia bonariensis	3
Sacciolepis striata	3
Cephalanthus occidentalis	4
grass, unknown	4
Panicum repens	4
Echinochloa walteri	5
Leersia hexandra	5
Teucrium canadense	5
Kosteletzkya virginica	6
Scirpus californicus	7
Utricularia spp.	7
Hydrocotyle spp.	8
Panicum hemitomon	8
Mikania scandens	11
Phragmites communis	11
Salix caroliniana	11
Nymphaea odorata	14
Paspalum sp.	14
Eleocharis cellulosa	15
Alternanthera spp.	17

Class B (21 - 40%)	%
Spartina bakeri	29
Sarcostema clausa	39

Moore Haven Transect
Typha angustifolia Community Continued:

Class C (41 - 60%)	%
Pontederia lanceolata	43
Panicum paludivagum	45
Panicum sp.	60
Class D (61 - 80%)	
Polygonum spp.	69
Class E (81 - 100%)	
Sagittaria lancifolia	91

MOORE HAVEN TRANSECT

Spartina bakeri Community

13.1' - 14.6' msl

Associated species by degree of presence classes

Class A (1 - 20%)	%
Bidens sp.	1
Echinochloa crusgalli	1
Hydrocotyle spp.	1
Panicum lancearium	1
Panicum repens	1
Sacciolepis striata	1
Teucrium canadense	1
Vigna luteola	1
Boltonia sp.	2
grass, unknown	2
thistle, unknown	2
Eupatorium coelestinum	3
Furiena scirpoidea	3
Heliotropium polyphyllum	3
Kosteletzkya virginica	3
Phragmites communis	3
Pontederia lanceolata	4
Psilocarya nitens	4
Scirpus americanus	4
Seuvium portulacastrum	4
Echinochloa walteri	5
Hibiscus grandiflorus	5
Lythrum sp.	5
Baccharis sp.	6
Buchnera floridana	6
Ludwigia sp.	6
Paspalum sp.	6
Polygonum spp.	6
Salix caroliniana	6
Setaria geniculata	6
Bacopa caroliniana	7
Lachnanthes caroliniana	7
Rhynchospora inundata	7
Xyris spp.	7
Mikania scandens	8
Rhynchospora sp.	8
Typha angustifolia	8
Panicum paludivagum	9
Rhynchospora divergens	9
Sarcostema clausa	12

Moore Haven Transect
Spartina bakeri Community   Continued:

Class A (1 - 20%)	%
Cladium jamaicensis	13
Melaleuca leucodendren	13
Myrica cerifera	13
Andropogon virginicus	16
Rhynchospora globularis	20
Class B (21 - 40%)	
Sagittaria lancifolia	24
Cephalanthus occidentalis	27
Panicum sp.	29
Eragrostis elliottii	31
Class C (41 - 60%)	
Rhynchospora tracyi	48
Centella repanda	49
Pluchea sp.	49
Eleocharis cellulosa	57
Panicum tenerum	57

MOORE HAVEN TRANSECT

Salix caroliniana Community

13/2' - 14.5' msl

Associated species by degree of presence classes

Class A (1 - 20%)	%
Bacopa caroliniana	1
Convolvulus sp.	1
Cyperus haspan	1
Echinochloa crusgalli	1
Ludwigia sp.	1
Panicum tenerum	1
Scirpus californicus	1
sedge, unknown	1
Setaria geniculata	1
Utricularia spp.	1
Eleocharis equisetoides	2
Leersia hexandra	2
Panicum hemitomon	2
Peltandra sp.	2
Pontederia lanceolata	2
Baccharis sp.	3
Bacopa monnieri	3
Colocasia sp.	3
Sesuvium portulacastrum	3
Vigna luteola	3
Pluchea sp.	4
Ludwigia bonariensis	5
Panicum sp.	5
Centella repanda	6
Typha angustifolia	7
Sacciolepis striata	12
Cladium jamaicensis	13
Eupatorium coelestinum	13
Ipomea alba	13
thistle, unknown	19

Class B (21 - 40%)	
Hydrocotyle spp.	21
Kosteletzkya virginica	21
Spartina bakeri	21
Teucrium canadense	21
Sagittaria lancifolia	28
Phragmites communis	32
Polygonum spp.	38

Moore Haven Transect
Salix caroliniana Community   Continued:

Class C (41 - 60%)	%
Cephalanthus occidentalis	48
Mikania scandens	58
Class D (61 - 80%)	
Hibiscus grandiflorus	64
Class E (81 - 100%)	
Sarcostema clausa	97

MOORE HAVEN TRANSECT

Rhynchospora tracyi Community

13.1' - 14.3' msl

Associated species by degree of presence classes

Class A (1 - 20%)	%
Bacopa monnieri	1
Eupatorium coelestinum	1
Lachnanthes caroliniana	1
Ludwigia sp.	1
Panicum repens	1
Polygonum spp.	1
Pontederia lanceolata	1
sedge, unknown	1
Boltonia sp.	2
Melaleuca leucodendron	2
Mikania scandens	2
Andropogon virginicus	3
Bacopa caroliniana	3
Echinochloa walteri	3
Myrica cerifera	3
Psilocarya nitens	3
Rhynchospora sp.	3
Sarcostema clausa	3
Xyris spp.	3
Paspalum sp.	4
Rhynchospora sp.	4
Scirpus americanus	4
Cladium jamaicensis	6
Heliotropium polyphyllum	6
Sagittaria lancifolia	6
Baccharis sp.	7
Sesuvium portulacastrum	8
Cephalanthus occidentalis	9
Furiena scirpoidea	9
Lythrum sp.	10
Panicum paludivagum	10
Rhynchospora globularis	13

Class B (21 - 40%)	%
Eragrostis elliottii	29
Panicum sp.	38
Centella repanda	39

Moore Haven Transect
Rhynchospora tracyi Community Continued:

Class C (41 - 60%)	%
Pluchea sp.	57
Panicum tenerum	60
Class D (61 - 80%)	
Spartina bakeri	64
Class E (81 - 100%)	
Eleocharis cellulosa	82

APPENDIX F

List of Species Observed in the Lake Okeechobee Littoral Zone

Characeae	*Chara spp.**
Pteridaceae	*Acrostichum danaeifolium* Langsd & Fisch
Salviniaceae	*Salvinia rotundifolia** Willd.
Taxodiaceae	*Taxodium distichum* (L.) Richard
Typhaceae	*Typha angustifolia** L.
Potamogetonaceae	*Potamogeton illinoensis** Morong
Najadaceae	*Najas quadalupensis** (Sprenge.) Mangus
Alismataceae	*Sagittaria lancifolia** L. *Sagittaria sp.**
Hydrocharitaceae	*Hydrilla verticillata** Royle *Vallisneria americana** Michx.
Poaceae	*Andropogon glomeratus* (Walt.) B.S.P. *Andropogon virginicus** L. *Cynodon dactylon* (L.) Pers. *Echinochloa crusgalli** (L.) Beauv. *Echinochloa walteri** (Puish) Heller *Eleusine indica* (L.) Gaertn. *Eragrostis elliottii** S. Wats *Erianthus giganteus* (Walt.) Muhl. *Eriochloa michauxii* (Poii) Hitchc. *Leersia hexandra** Siv. *Panicum agrostoides* Spreng. *Panicum dichotomiflorum* Michx. *Panicum hemitomon** Schult. *Panicum lancearium** Trin. *Panicum paludivagum** H & C. *Panicum repens** L. *Panicum tenerum** Beyr. *Panicum sp.** *Paspalum distichum* L. *Paspalum notatum* Flugge *Paspalum sp.** *Pennisetum purpureum* Schumach. *Phragmites communis** Trin.

Poaceae continued:	Sacciolepis striata* (L.) Nash
	Setaria geniculata* (Lam.) Beauv.
	Setaria magna Griseb.
	Spartina bakerii* Merr.
	Sporobolus indicus (L.) R.Br.
Cyperaceae	Cladium jamaicensis* Crantz
	Cyperus haspan* L.
	Dichronmena latifolia* Baddu.
	Eleocharis baldwinii* (Tori) Chapm.
	Eleocharis caribaea* (Rottb.) Blake
	Eleocharis cellulosa* Tori.
	Eleocharis equisetoides* (Ell.) Torr.
	Eleocharis flavescens* (Poir.) Urban
	Fimbrystylis spadicea (L.) Vahl.
	Furiena scirpoidea* Michx.
	Psilocarya nitens* (Vahl.) Wood
	Rhynchospora divergens* M.A. Curtis
	Rhynchospora globularis* (Chapm.) Small
	Rhynchospora intermixta C. Write
	Rhynchospora inundata* (Oakes) Fern.
	Rhynchospora schoenoides (Ell.) Wood
	Rhynchospora tracyi* Britton
	Rhynchospora sp.*
	Scirpus americanus* Pers.
	Scirpus californicus* (C.A. Meyer) Britton
	Scirpus cubensis Poepp. & Kunth
	Scirpus validus Vahl.
	Scleria reticularis Michx.
	Colocasia sp.
Arecaceae	Roystonea regia (H.B.K.) O.F. Cook
	Sabal palmetto (Walt.) Todd
	Serenoa repens (Bartr.) Small
Araceae	Colocasia sp.* (L.) Schott
	Peltandra sp.* Ref.
	Pistia stratiotes* L.
Lemnaceae	Lemma sp.
Xyridaceae	Xyris spp.*
Pontederiaceae	Eichhornia crassipes* (Mart.) Solms
	Pontederia lanceolata* Nutt.

Juncaeae	Juncus scirpoides* Lam.
Haemodoraceae	Lachnanthes caroliniana* (Lam.) Dandy
Cannaceae	Canna flaccida Salisb.
Marantaceae	Thalia geniculata L.
Casuarinaceae	Casuarina equisetifolia Forst.
Salicaceae	Salix caroliniana* (Lam.) Dandy
Myricaceae	Myrica cerifera* L.
Ulmaceae	Celtis laevigata Willd.
Polygonaceae	Polygonum punctatum Ell. Polygonum spp.*
Amaranthaceae	Alternanthera spp.*
Aizoaceae	Sesuvium portulacastrum* L.
Portulacaceae	Portulaca spp.*
Nymphaeaceae	Brasenia schreberi Gmel. Nelumbo lutea* (Willd.) Pers. Nuphar advena Aiton Nymphaea mexicana Zucc. Nymphaea odorata* Ait.
Annonaceae	Annona glabra L.
Fabaceae	Sesbania* Vigna luteola* (Jacqium) Bentham
Euphorbiaceae	Poinsetta sp. Ricinus communis L.
Aquifoliaceae	Ilex cassine L.
Aceraceae	Acer rubrum L.
Malvaceae	Hibiscus grandiflorus* Michx. Kosteletzkya virginica* (L.) A. Gray
Caricaceae	Carica papaya L.

Lythraceae	_Lythrum sp._*
Myrtaceae	_Melaleuca leucodendren_* L.
Onagraceae	_Jussia leptocarpa_ Nutt. _Ludwigia bonariensis_* (Micheli) Hara _Ludwigia spp._*
Apiaceae	_Centella asiatica_*(Pers.) Small _Hydrocotyle_ sp.*
Oleaceae	_Fraxinus caroliniana_ Mill.
Asclepiadaceae	_Sarcostema clausa_* (Jacq) R. & S.
Convolvulaceae	_Convolvulus sp._* _Ipomoea alba_* L.
Boraginaceae	_Heliotropium polyphyllum_* Lehm.
Verbenaceae	_Lantana sp._ _Lippia nodiflora_* (L.) Michaus.
Lamiaceae	_Teucrium canadense_* L.
Scrophulariaceae	_Bacopa caroliniana_* (Walt.) Robins _Bacopa monnieri_* (L.) Pennell _Buchnera floridana_* Gandoger
Lentibulariaceae	_Utricularia spp._*
Rubiaceae	_Cephalanthus occidentalis_* L.
Asteraceae	_Baccharis halimifolia_ L. _Bidens sp._* _Boltenia sp._* _Eupatorium capillifolium_ (Lam.) Small _Eupatorium coelestinum_* L. _Iva microcephala_ Nutt. _Mikania scandens_* (L.) Willd. _Pluchea sp._* _Solidago spp._

*Species found on transect