WATER RESOURCES research center

Publication No. 24

Establishment of Mean High Water Lines in Florida Lakes

By
John H. Davis, Jr.

FLORIDA WATER RESOURCES RESEARCH CENTER
University of Florida
Gainesville

UNIVERSITY OF FLORIDA

ESTABLISHMENT OF MEAN HIGH WATER

LINES IN FLORIDA LAKES

by

John H. Davis, Jr.

PUBLICATION NO. 24

of the

FLORIDA WATER RESOURCES RESEARCH CENTER

RESEARCH PROJECT TECHNICAL COMPLETION REPORT

OWRR Project Number A-015-FLA

Annual Allotment Agreement Numbers

14-31-0001-3209 (1971)
14-31-0001-3509 (1972)
14-31-0001-3809 (1973)

Report Submitted: November 1, 1973

The work upon which this report is based was supported in part by funds provided by the United States Department of the Interior, Office of Water Resources Research as Authorized under the Water Resources Research Act of 1964

TABLE OF CONTENTS

	Page
Abstract	1
Introduction	1
Methods of Detection	9
Methods Used on Cypress Lake	15
Plants of Littoral Zones	18
Plant Growth Forms and Habits	23
Uses of Photography	25
Final Establishment of High-Water Position	25
Lake Hatchineha Results	27
Other Difficulties Encountered	32
General Results From Use of These Botanical Methods	35
Lakes Inspected	35
Appendix	49
References	53

Abstract

This project was undertaken to provide a method of detecting former high-water levels by using plants presently growing in, and near, Florida's lakes. Species, position, growth form, and other characteristics were used to develop viable statistics. The project was not intended for final legal determinations of former mean high-water lines but for the determination, where applicable flora exists, of the physical location of the boundary between riparian land and state-owned lake bottoms to assist in the formulation of a state policy for the establishment of mean high-water monuments in Florida lake basins. Results show this botanical method can be used in some cases with a high degree of reliability to date shoreline water positions back to 1845, when Florida became a state.

The inspections of lake shores not only included the vegetation and particular plants, especially large old trees, but also some of the geology, soils, sediments, and the stage records of lake levels. Two reports were used extensively as references: "Florida Lakes," by Bishop (1967), and "Stage Characteristics of Florida Lakes," by Kenner (1961). The Cabinet Board of Trustees of the Internal Improvement Trust Fund and the State Bureau of Geology collaborated in this study.

Introduction

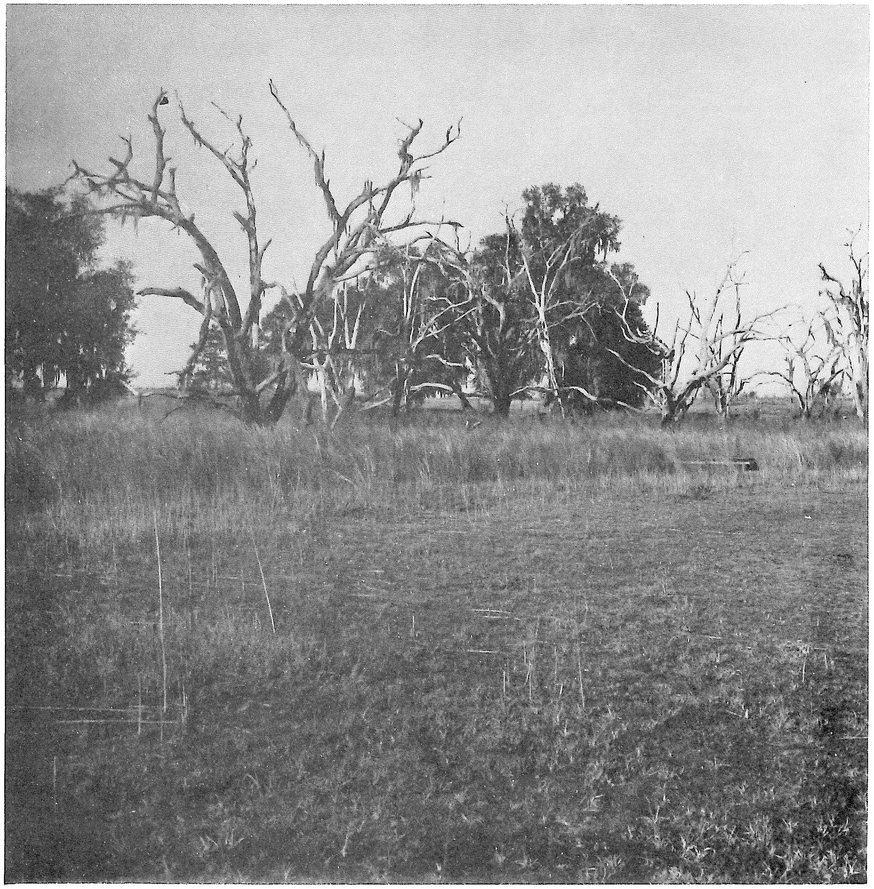
It has been observed and well established that many forms of plant life are distinctly related to the amount, position, and duration of water over the surface of soils, rocks, and substratum. Some of these plants have distinct preferences for water over and around themselves, or over their roots and lower parts. There are some that do not tolerate water over the soil except for short periods of time. The "water-requiring" and "water-tolerating" plants are distinct kinds and often have a particular form of growth, such as the buttressed bases of cypress and gum trees. These are examples of the aquatic and wetland plants that form distinct types of vegetation in Florida known as swamps, marshes, wet prairies, and bay heads. The plants that do not need or tolerate surface water, except for short periods of time, are generally known as upland plants.

The aquatic plants are those dependent upon water for buoyancy, and there are many kinds that vary in size and form from the microscopic plankton to the surface-floating plants such as the water hyacinth. Where they occur indicates that water has been consistently around or over them. They can be temporarily washed ashore and stranded by a lowering of the water levels, and their presence in windrows and drift-lines indicates where water levels have been.

The plants preferring and tolerating water around their bases, but for most of the time remaining emerged above the water level, are known as hydrophytes or wetland plants. Many of these are trees and bushes and a great variety of grasses, sedges, rushes, and other herbs. They predominate in the shoreline zones known as the littoral areas, where water often advances and recedes over the soil as the lakes change levels. Some of these plants, such as many cypress, gum, maple, ash, buttonwood, and other trees and bushes, live permanently with water around their bases. Some sedges, rushes, grasses, and other herbs also have their bottom parts usually submerged in water. These are the hydrophytes of the shorelines and shallow-water areas that best serve as indicator plants for water-level positions. Woody plants with distinct rings of growth are particularly good indicator plants because, when they are cut down and sectioned, their annual growth rings can be counted to determine how many years they have been growing in their present position.

The upland plants that seldom tolerate water around their bases for long periods of time are a great variety of trees and bushes, many grasses, and a variety of other herbs. Those that grow under the driest conditions are known as xerophytes, and their presence indicates that water has never covered the soil in which they grow for more than a few weeks or a few months. A few of the large trees, especially the live oak and the longleaf pine, are xerophytes, and are useful indicators (see Figure 1).

By comparing the positions of the upland plants with those of the wetland plants, or hydrophytes, one can determine with some reliability the present and former positions of water level. If the woody plants present can be cut, sectioned, and their growth rings counted, the time at which the water levels were favorable to the growth of the hydrophytes can be determined and the time of certain elevations of water on the shore thus indicated. The presence of non-woody plants without growth rings may also indicate where water now occurs or formerly occurred, but the presence of such plants cannot indicate the time period of water over the surface. However, some estimate of the length of time of water cover at the places where they grow can be derived from their size and



Dead and living live oaks on upland around a Florida lake that has in the recent past had high water levels. This high water killed the live oaks nearest the lake. The nearly bare area in the foreground is the usually sparse growth of herbs of the middle zone of the littoral. The upper zone is indicated by the taller, denser herbs Andropogons and dog fennel.

Typical border of dense maidencane in water to depths of 5-6 feet. This zone often borders Florida lake shores. With the lowering of lake levels they often persist, but are not as tall and erect.

FIGURE 1

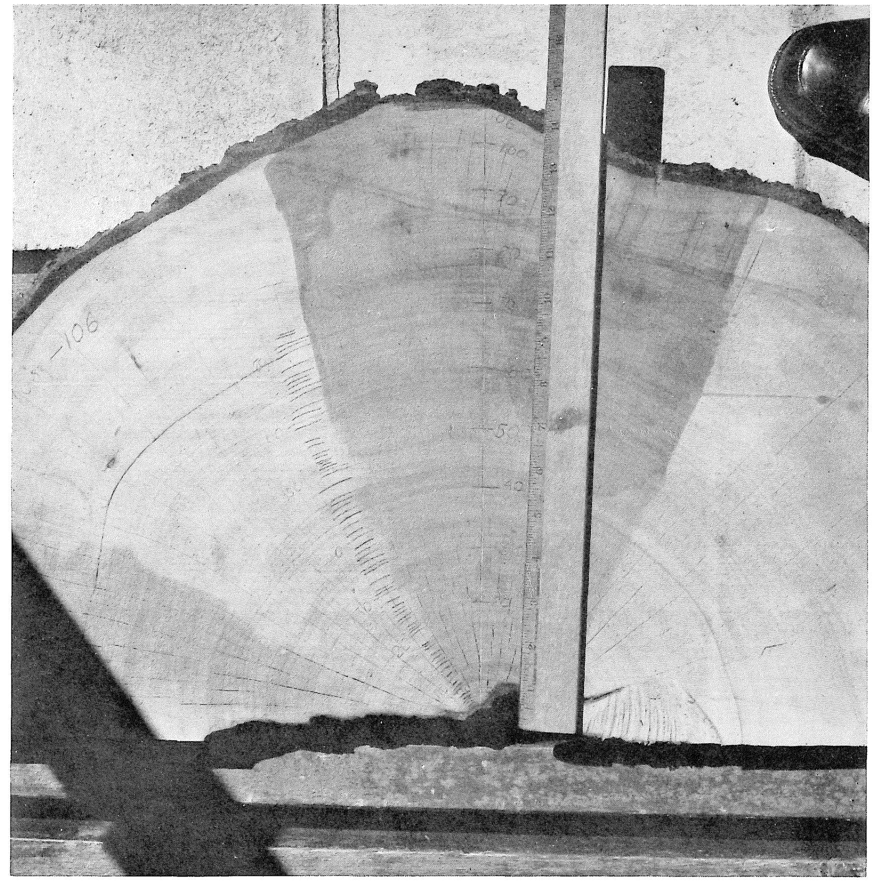
degree of robust growth, and also by the organic character of the sediments deposited and accumulated around them. This method was used especially by Bishop (1967) (see Figure 2).

In addition to the report by Bishop, there is a report of a study of eight Florida lakes by Knochenmus (1967) that very briefly considers the pattern of growth of slash pines as a means of helping to identify the position of high water. He may have confused slash and longleaf pines by considering all of the upland pines near lakes as slash pines, when many of them are longleaf pines. The longleaf pines do not withstand flooding for more than a few months whereas slash pines can withstand flooding for probably over half a year. Some of the lakes, he reported, such as Lake Kerr, have longleaf pines almost exclusively on the uplands bordering the lake. His report cannot be used as an example of how tree growth can be used to locate high water because it is not botanically accurate.

However, the stress that Knochenmus gave to the shoreline features of beach ridges, or berms, and beach scarps is very useful. As will be emphasized later, both of these deposition and erosion features are reliably indicative of high-water position. The high, broad berm ridges of some lakes, such as Cypress and Hatchineha, that have both cypresses and live oaks growing on them, have proved to be very accurate in the establishment of past and present lake levels. The beach scarps, such as those of Lake Jackson in Leon County, are also useful in identifying high-water position.

Because many lakes and ponds in Florida have wide fluctuations in water levels during a year, often due to the prevalent dry and rainy season and variations over a period of years, there are many wide-shore, or littoral, areas. In some places these littoral areas have distinct zones from low-water to high-water lines. These zones are (1) the upper, (2) the middle, and (3) the lower.

The upper zone, where water reaches the highest level, is the critical zone for the method of investigation used in this study. Here occur some of the plants that can withstand water for a short period of time. The presence of these plants indicates where high water occurred. A few such trees and bushes are sweet gum, magnolia, some oaks, such as laurel oak, some hickories, slash pine, saw palmetto <u>Serenoa repens</u>, and the sand cypress bushes <u>Hypericum</u>. Carpet grasses <u>Axonopus</u>, Bermuda grass, and crab grass are frequent. The dry upland plants, such as wire grass <u>Aristida stricta</u>, the live oak <u>Quercus virginiana</u>, and longleaf pine <u>Pinus palustris</u> occur at levels above this upper littoral zone. Their presence is indicative of elevations above mean



Shown above are button bushes, distinguished by fruits similar to round buttons, and two bald cypress trees. Both typically grow in water a few feet deep. Note bald cypress on right has lichen growth on its bark, the bottom of which growth indicates the highest water level.

The section of a bald cypress cut near its base shows how growth rings are counted. Area near ruler was stained to increase visibility of rings.

FIGURE 2

high water. It is important to locate this upper zone first in an examination of shorelines so that the approximate elevation of high-water levels can be measured.

However, it is often difficult to find the upper zone of water in the case of tree and bush swamps, such as in bay heads. Many of the woody plants, such as the bay, titi, red maple, water ash, and saw grass and other large-to-small herbs do not continually require water about their bases. They are facultative hydrophytes and, as such, may or may not indicate the exact location of former high-water levels.

The other two shoreline, or littoral, zones are not so important but should in many cases be identified. The middle zone is often wide and has more herbs than bushes and trees, and many of the herbs are seasonal, especially where water levels fluctuate widely. In fact, due to the recent lowering of the level of many lakes in Florida and along the rivers, such as the Kissimmee, this middle zone is often wide, and wet conditions of the past do not regularly occur. Where it is wide, the general name given it is wet prairie, or shore prairie. Due to the recent lowering of water levels, bald cypress trees are often found with distinct buttresses at their bases, and, in places, some gum trees also.

Over this often seasonally flooded middle zone grow a variety of sedges: *Cyperus*, *Eleocharis*, *Rhynchospora*; rushes: *Juncus*; grasses: *Spartina bakerii*; and many flowering herbs, such as *Centella*, *Ludwegia*, *Hydrochloa*, and *Rhexia*. Their variety is great, and the plants may need detailed identification.

The lower zone abuts the standing water or is, in many cases, covered by water, depending upon the season. It has the marsh and other constant hydrophytes such as cattail *Typha*, saw grass *Mariscus*, pickerelweed *Pontederia*, and maidencane *Panicum hemitomum*. Cypress, gum, willow, red maple, water ash, elderberry, and sometimes wax myrtle and buttonbush *Cephalanthus*, are common in this lower zone. The position of this lower zone is important in the botanical method presented here (see Figure 3).

The reach of high water, except during short periods of flood and casual water after hard rains, is indicated by whatever kind of upland vegetation grows in the area of the lake concerned. This vegetation and the upland plants composing it vary a great deal from region to region in Florida. In many of the sandhill areas, such as the central upland of Florida, many lake basins are surrounded by the longleaf pine, turkey oak, and wire-grass type of vegetation. There are often groves or lines of live oaks near the shore areas.

Markers on buttress of bald cypress:

Lowest -- present water level

Middle -- average water level

Upper -- highest water level

The water mark between the middle and the upper marker is probably the position of the mean high water line of this body of water.

The high water line (shown by arrow) on the broad buttressed base of this tupelo gum was determined from water marks and water level records.

FIGURE 3

Another kind of vegetation is the flatwoods of slash, longleaf, or pond pine, saw palmetto, wax myrtle, and low-stature hardwood trees, especially laurel and live oak. Pond cypress is common. The lakes of such areas generally have low-lying shores, and many upper shore areas are bordered by saw palmetto, wax myrtle, and other woody plants, but these are not good indicators of age. When the high water occurred cannot be determined unless live oaks and longleaf pines can be located and cut and sectioned to count the rings.

Other areas with lakes in Florida are bordered by forests of a number of hardwood trees, the vegetation often being known as hammock forest. The laurel oak, cabbage palm, hickory, sweet gum, magnolia, dogwood, plum, and many other woody plants present are indicative of some wet-soil conditions, but many do tolerate surface water for long periods, and the high-water level is difficult to detect unless live oaks and other xerophytic types of trees and bushes occur. Most of the hammock plants are known as mesophytes or facultative hydrophytes, and for this reason very few of them were used in this investigation and are not recommended as indicator plants for locating high-water levels.

In addition to these almost regularly distinct kinds of plants and vegetation, there are several assemblages of plants in wet habitats that do not fit into any of the regularly recognized types. One such type of vegetation is the bay tree forest. Bay trees are usually abundant. With them often grow ferns, some tall herbs, many scrubs, and some of the typical hydrophytes, and even aquatic plants in shallow water pools. Such bay tree forests, often called bay heads, are not regularly flooded but may have water in them for many years and then endure a long period of dry-to-nearly-dry conditions. The whole assemblage may be termed facultative to water, and for this reason bay tree forests are not recommended as good indicators of mean high-water levels.

Similarly there are small-to-large assemblages of pond cypresses creating cypress domes, cypress heads, and long cypress strands. The usually open strand of cypresses has water seasonally over the surface, and some have interior pools or streams of permanent water. The water levels often fluctuate greatly during seasons or over a period of years. It may be said that the outermost cypresses of such vegetation are at, or near, the location of the average high-water level over a period of years. However, the past history of such cypress vegetation shows that regularity of water position is not well indicated by the location of the cypresses. Often there is a ring of saw palmetto around such cypress strands, and these are often regularly at the position where surface water seldom, if ever, occurs. Thus palmetto hedges are good indicators of high-water level.

With the above in mind, one can employ the methods of using plants and vegetation around lakes where the indicator plants and certain topographic features occur with a variety of degrees of accuracy. This project considered 37 lake and river borders that represented most of the types of lakes and rivers in Florida. Methods of inspection and determination of the time at which a certain water level occurred were refined as the investigation progressed. By following the methods presented here, it is probable that the location of lake and river high-water levels can be determined with sufficient accuracy to use them for legal and other purposes.

In the following section, the use of trees as indicators will be discussed first. Later on, the use of other plants and vegetation will be covered.

Methods of Detection

Trees and Large Bushes

A number of hydrophytic trees and bushes growing in, or near, water, or formerly growing in these positions, now border, or are in, the water of lakes and rivers. Of these, the two which most obviously show growth-form reactions to their water habitat are the bald cypress *Taxodium distichum*, and the gums *Nyssa sylvatica* and *Nyssa aquatica*. These develop swollen buttressed bases in nearly all cases where they live or have lived with water around the bases of their trunks. In addition, the cypresses also may have blunt, upright projections from their horizontal roots, known as knees. Usually the trees were growing in water when the knees were formed. The pond cypress *Taxodium ascendens* is very similar to the bald cypress but seldom develops knees and distinct buttressed bases.

The bald cypress occur in the water and on the shore of many lakes and rivers in Florida; the gum trees with buttressed bases are also present in such places but are not so abundant. The object of this part of the research was to locate such trees that were large and old enough and without rotted centers or other deformities. Then the tree, or trees, in a position where the upper shoreline of the present or past occurred were cut down and a section made that was used to count the growth rings to determine the age of the tree. The age of the tree indicates the time at which water regularly covered its base. Trees thus dated now growing above the present shoreline indicate that the former shoreline was higher than at present.

Cypress and gum trees also indicate positions of high water by their growth-form and other features. The height of the buttresses on them indicates that water fluctuated over a range that is about two-thirds the height of the buttress. This two-thirds position of high water was estimated by measurements of many cypress and gum trees now growing where water level fluctuates (see Figure 4).

In some cases, as along the eastern shore of Cypress Lake (see Plate I), some erosion of the berm on which the cypresses grow has exposed their horizontal roots. Such roots definitely developed and grew under the soil surface, and the original soil surface was about 6 to 18 inches above the level of the horizontal roots.

The height of the knees of cypresses is not sufficiently regular in relation to the height of water for this criterion to be confidently used as an indicator of water levels.

Also many cypress have a grey moss (lichen), growing near the base of the trunk, and it was found by survey measurements that in some areas the base line of the lower part of this lichen growth was consistently at a certain level, and this level seems to be the position of ordinary high water at the time the lichen developed.

With these methods, cypress and gum trees in certain locations can be used to approximate with some degree of accuracy the present, or former, position of the mean high-water line. However, to more accurately estimate such a position, the study of growth rings of some upland xerophytic trees growing near cypress or gum trees is needed to detect the position where high water did not regularly occur. The tree most frequently used for this method was the live oak _Quercus virginiana_.

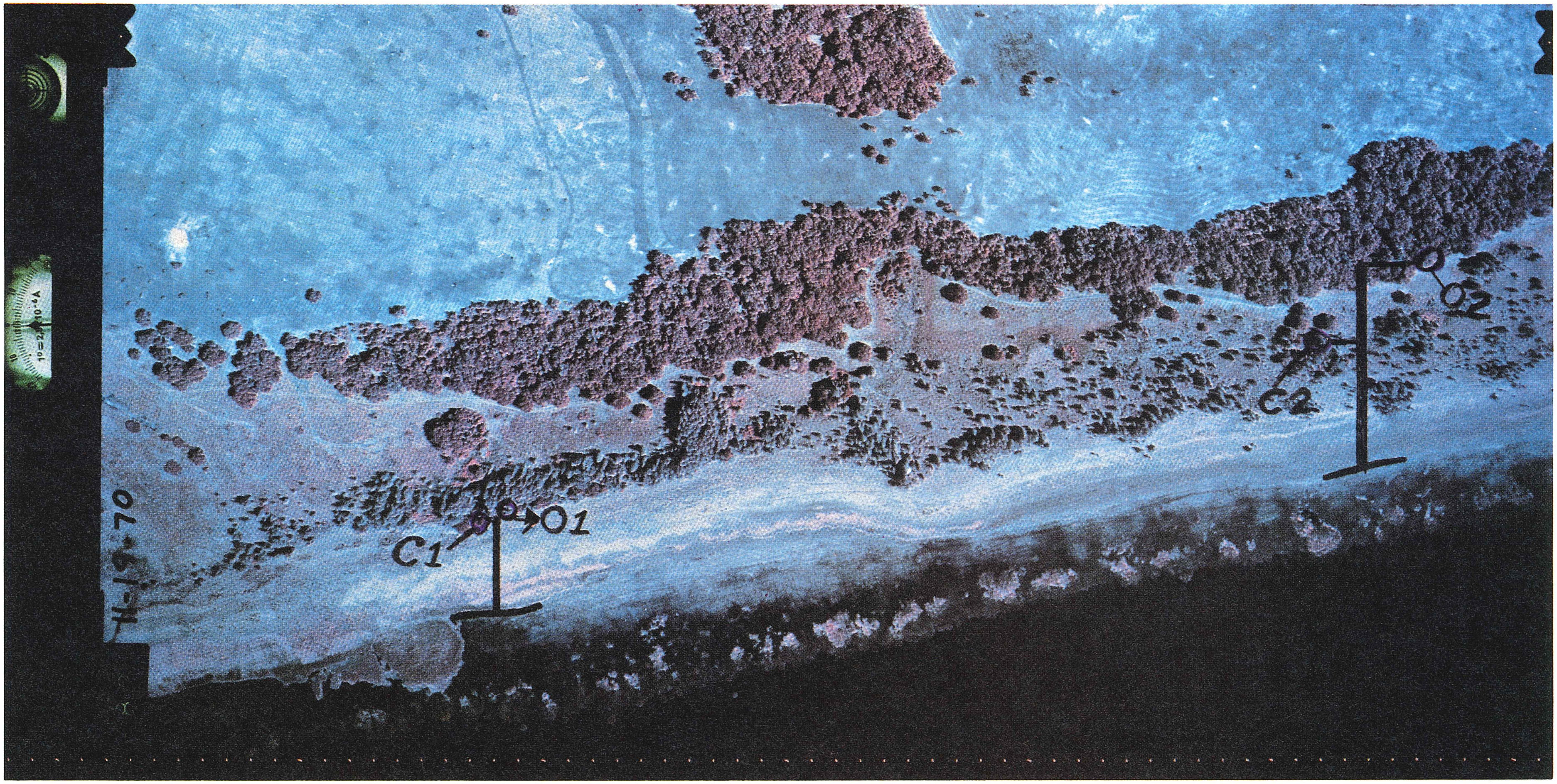
Some live oaks were located on the upper part of the slope of a shoreline (often a distinct berm ridge). Preference was given to such oaks that grew near large cypress or gum trees. Some such oak trees were cut down and sectioned and their growth rings counted. Their age indicated that surface water was not regularly present at their bases during the years of their growth, because if such water had stood around them for only a few months, they would have died. The main difficulty in using live oaks for dating purposes is that such old oaks often have rotten centers. Another difficulty is in getting permission from the landowner to cut them down. Also it is frequently difficult to obtain a reliable count of the growth rings because of indistinct rings.

In a few cases, a large limb of such a live oak was cut off and the growth rings counted, but it has not yet been determined how to relate the age of a lower limb to the age of the main trunk near its base. This may be done with more study.

Pictured above are the roots of a bald cypress growing on the eroded berm on the eastern shore of Cypress Lake. The horizontal roots were at one time below original soil level and surface water was about up to the pockets on the man's shirt.

The lowering by stages of this lake exposed these bald cypress buttresses. Water marks indicate two former higher levels. Grey lichens grow down the trunks to the former highest water level.

FIGURE 4



Commercial infrared aerial photograph of the east shore of Cypress Lake. Oaks and other hardwood trees have a red tinge. Cypress trees are grey. C1 and O1 indicate locations of bald cypress and live oak cut in lower berm. C2 and O2 mark the locations of bald cypress and live oak cut on higher berm. See also the profile of this shore (Figure 5).

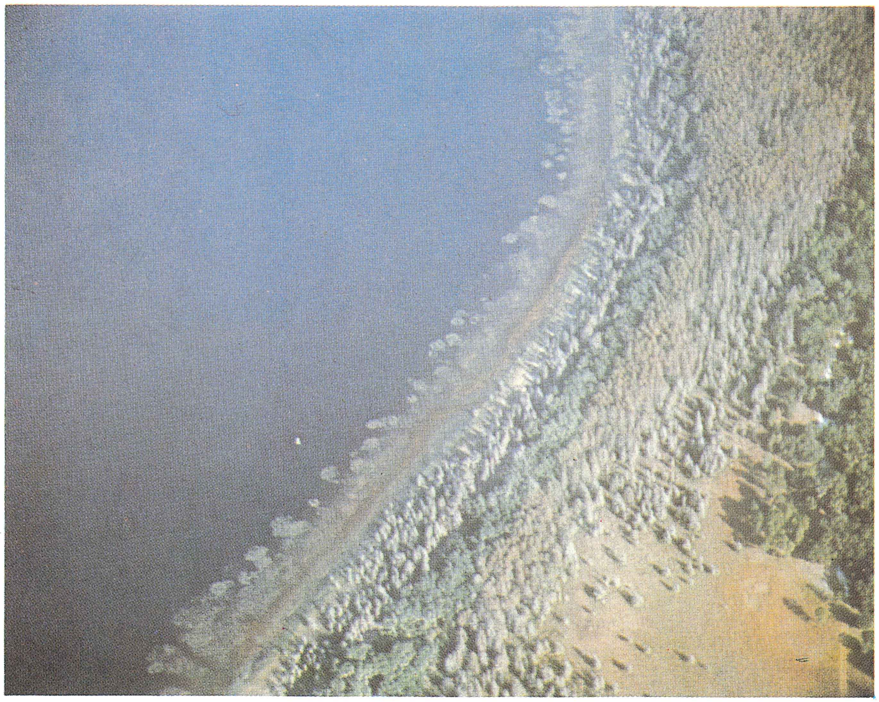
PLATE I

The best method of determining approximate high-water levels is by using live oaks which are growing near cypress or gum trees. After age and elevation are determined, the former or present upper-water level can be considered to be located between the base of the live oak and the base of the cypress or gum tree. This method was used especially well on the berm ridge and slopes of both Cypress Lake and Lake Hatchineha (Plates I, II). At Cypress Lake, the position of high water was also estimated by the level of former soil. It is about one foot above the presently exposed horizontal roots. And on a berm of Lake Hatchineha the position at the base of the lichen growth was also used to estimate the former high-water line.

Other trees and bushes were used along shores of lakes that did not have adequate cypress or gum tree growth. These indicated only approximately where high water had occurred. These plants were mainly the buttonbush Cephalanthus, willow Salix, red maple Acer rubrum, white bay Magnolia virginia, water ash Fraxinus, and swamp holly Ilex cassine. In many areas a number of such trees and bushes of medium to small size grew together in dense stands. Growth rings of a few were counted. However, since no old trees were located, they were not used to estimate shorelines of the past. In many instances the woody plants are growing where water does not regularly flood their bases, so it would be inaccurate to use them to indicate where water was, or had been, regularly present.

Around some lakes, particularly those with wide fluctuations of water levels, there are bushes and often some small trees growing in the upper littoral zone. One of the common bushes is sand cypress Hypericum. When present in a definite zone or ring around shorelines, they indicate the approximate position of mean high water. However, the accuracy of using them as indicators needs to be more extensively tested. Similarly, it may be possible to use the position of wax myrtle, saw palmetto, and other bushes to indicate high-water position, but none of these plants are old enough to have distinct growth rings sufficient to calculate their age and the time when high water occurred.

In showing how old trees can be used for locating the position and date of old high-water shorelines, the results of the investigation of Cypress Lake are appropriate. Here there were berm ridges that indicated shorelines of the past. The sediments forming the ridges were probably washed up to their high elevation by hurricane winds and waves. After they were formed the trees grew, some on the top of the ridges—mostly live oaks—and some on the often water-covered slopes—mostly cypresses.



Color aerial photograph of portion of the east shore of Lake Hatchineha depicting the shoreline vegetation:

Dark green -- canopy of live oaks on top of berm ridge.

Grey -- cypresses on the down-slope of the ridge toward the lake.

Brown -- broad littoral or shore zone with patches of bullrush and maidencane growing in the water.

PLATE II

Method Used on Cypress Lake

Cypress Lake in Osceola County is one of the Kissimmee River chain of lakes. It has along its eastern shore two berm ridges. These ridges and the plants on them were located by means of the color infra-red photograph (see depiction in Figure 5). During the inspection of this area for topographic and sediment information, live oak, cypress, and gum trees of old age were located. Some of these trees were on one of the berms and some were on the nearly level swale area between the two berm ridges. Measurements by surveyors showed that the higher, broad berm inland from the narrow, lower berm had an elevation between 57 and 61 ft. MSL. The narrow berm nearer the lake had elevations between 52 and 54 ft. MSL. The swale area between the ridges had elevations between 50 and 57 ft. MSL. There were some low level areas in the swale in which cypress and gum trees were growing. On the ridges were old cypresses and live oaks on the narrow berm near the shore, but only old live oaks, palmettos, cabbage palms and other hardwood trees were found on the higher inland berm. From the narrow berm to the present lake level of 48.21 ft. MSL (at the time of inspection) is a broad littoral zone vegetated primarily by grasses and other herbs with old cypress trees widely spaced on it. Many of these old trees now have horizontal roots exposed above the soil level. The soil was above these roots at one time and has been eroded away. The height of this former soil level was estimated at between 51 and 52 ft. MSL.

One live oak and one bald cypress growing on the narrow lower berm were cut and sectioned. They were both growing at about the same elevation. The age of the live oak was 67 years and the age of the cypress 104 years. This difference in age indicates that water was over the position of the ridge probably from about 1860 to about the time the live oak began growth, which was about 1905. The lake has probably had levels above 49 ft. MSL, but not for many months above 52 ft. MSL since 1900. Before that time the levels are indicated by the other trees cut and sectioned.

A black gum with a distinct buttressed base was cut and sectioned. In the swale area where it grew, the elevation is 55.5 ft. MSL. Also a cypress was cut and sectioned in this swale area. It, too, was growing at an elevation of 55.5 ft. MSL. The black gum was about 110 years old and the cypress was about 115 years old. Water covered this swale area from about 1900 to as far back as 1855 or earlier (see Figure 6).

One oak on the broad, high ridge, that appeared to be one of the oldest, was cut and sectioned. It was growing at 57.9 ft. MSL elevation. It was about 85 years old. This indicates

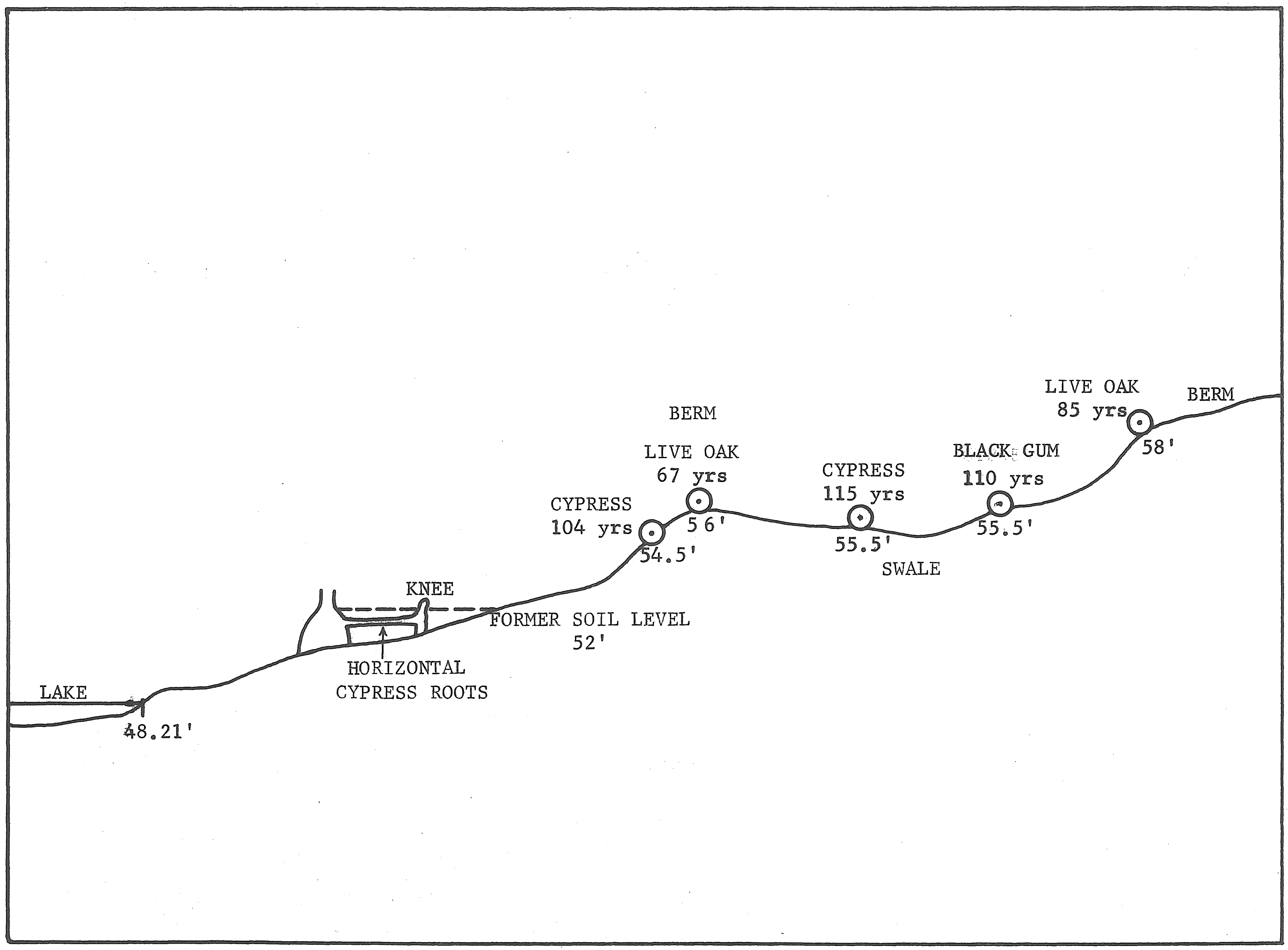
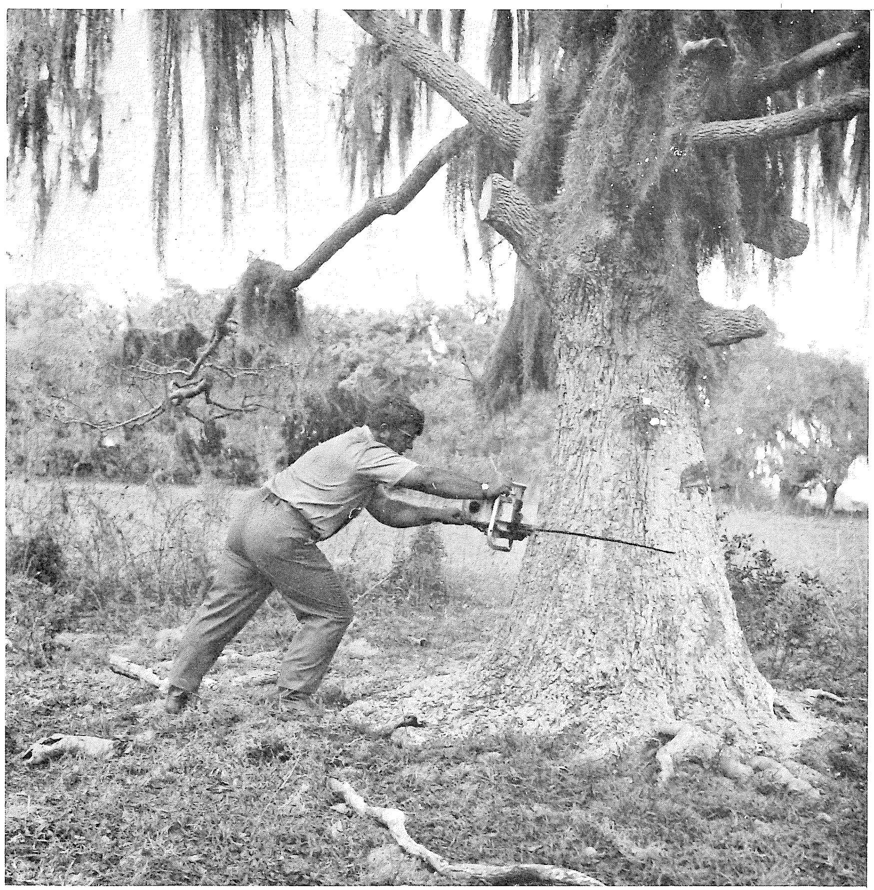


FIGURE 5. CYPRESS LAKE
(Five Trees Cut)



This photograph shows the cutting down of a black gum located in the swale between the two berms on the eastern shore of Cypress Lake. The buttressed base shows that surface water was present during early years of growth. The tree's calculated age of 110 years indicates a water level of 55.5 ft. MSL circa 1865.

Cypress buttresses along this lake are indicative of former higher water levels. Tall switch grasses inhabit the narrow littoral zone with longleaf pines defining the highest water position.

FIGURE 6

that water up to about 56 to 57 ft. MSL probably occurred to about 1885. The cypress and gum growing at 55.5 feet elevation had water around them probably 1 to 2 ft. deep at times, as indicated by their buttresses and the height of the knees of the cypress.

These two berms of different heights, the swale between them, and the age of the five trees cut and sectioned indicate that before 1885 this lake had water-level elevations to about 56 ft. MSL. The water lowered to approximately 52 ft. beginning about 1900. In recent years the lake has had levels around 50 ft. MSL and up to 57 ft. at highest flood periods for a short time. When the water lowered after 1900, the lower berm eroded in part and soil was washed away from the cypresses, exposing their horizontal roots. Before erosion of the soil, its level was about 51 ft. MSL. Some of the topography, location of trees, etc., are shown in Figure 5.

Plants of Littoral Zones

In addition to the trees useful in determining water levels, there are many herbs, some shrubs, and other hydrophytic plants that occur in the shoreline zones where water level fluctuates from season to season or year to year. This zone may be very wide in areas of flat topography, or very narrow and not significant around lakes or along rivers with steep banks. This zone of fluctuating water level in some ways is similar to ocean beach zones. If wide, where water levels fluctuate over a high vertical range, it may be divided into three sub-zones known as (1) upper, or epilittoral, (2) middle, or eulittoral, and (3) lower, or sublittoral. The upper littoral has both plants of the hydrophytic type and the upland xerophytic and mesophytic types. At the top of the zone, water seldom, if ever, occurs for more than very short periods. In the middle zone are mostly a great variety of herbs, many of which are hydrophytes that withstand some water cover. In the lower zone all the plants are hydrophytes and some are aquatic plants, such as water hyacinths which drift from the open water onto this zone. Some plants occur over these zones the year-round, but others are present only for the short growing season so that some areas are virtually bare for part of the year. A few of the typical indicator plants for each zone are discussed below.

The Upper Littoral Zone

Shrubs and a few trees help define the upper littoral zone, but the herbs are more numerous and some indicate where high water reaches. A common shrub is the sand cypress *Hypericum*, which has small leaves and yellow flowers. Often the saw palmetto *Serenoa repens* occurs as a hedge margin at the upper level of this zone. Slash and loblolly pines grow here. Where cypress or gum trees occur they are without buttressed bases since surface water does not remain around them for long periods of time.

Many grasses are common, a few of which are the broom sedges *Andropogon*, Bermuda grass *Cynodon*, carpet grass *Axonopus*, the running panic grass *Panicum repens*, and the crab grass *Digitaria serotina*. They survive some water cover for short periods of time, but ordinarily do not survive long-period coverage. There are a few sedges and rushes in this upper zone and some showy flowering herbs, but not nearly so many kinds as in the middle zone.

The upper levels of this zone, where *Hypericum* and dry-soil grasses, such as Bermuda and carpet grasses, occur abundantly, are at the probable position of high water for the length of time equivalent to the age of these plants. However, because the age of these plants cannot be accurately determined, the date of such high-water level is not well indicated.

The upper zone also has sand sediments with little or no organic matter compared to the middle and lower zones which have organic matter that darkens the sands. It is often the case that this upper zone is a berm ridge that was thrown up by wave action from past storms. Such berms themselves indicate high-water position at the time when they were formed. The low shrubs and herbs growing on berms can indicate high-water level, but only by using live oak and other dry-soil trees can an approximate date for the high-water position be estimated.

The Middle Littoral Zone

The middle littoral zone is usually the widest of shore zones where water advances and recedes almost every season or often during a period of years. The kinds and numbers of plants and the density of the vegetation depend on the amount and regularity of the presence of surface water and its depth. The zone can be almost bare of plants or very densely covered by them. Many of the plants are annuals because of the rapid changes in water conditions. Low-stature vegetation is the rule, with herbs more common than bushes or young trees. The term wetlands applies generally to this zone, especially if it is wide and extensive, which is the case around some lowland lakes. Large areas in Florida are without definite lake basins and have this wetland kind of semi-marsh vegetation over seasonally flooded areas. The general name for such low, herbaceous vegetation is wet prairie.

Some of the most common plants are low and spreading types such as the buttonweed *Diodia*, southern water grass *Hydrochloa caroliniensis*, *Centella repanda*, and false loosestrife Ludwigia. There are a number of species of sedges and rushes among which the common genera are Cyperus, Eleocharis, Rhynchospora, and Fimbristylis. These sedges have triangular stems. There are Juncus and other rushes and tall-to-short grasses, such as Spartina bakerii, the switch grass, and a number of Panicum and Paspalum grasses.

This zone is colorful in season with a variety of flowering plants of low stature, such as Rhexia, Sabbattia, Polyganum, low Sagittaria species Eriocaulon, Bacopa, and the colorful sedge Dichromena colorata with white leaves. The bullrush Scirpus californicus, the pickerelweed Pontederia, and the tall Sagittaria lancifolia are not regularly found in the lower littoral zone growing on organic muck soils. When present, they mark the lower limit of this zone.

Cypress and gum trees, and some willows, bay trees, and other hydrophytic trees and shrubs also occur in the middle littoral zone as well as in the lower littoral zone. They do not definitely delimit this zone as do the herbaceous plants noted. Here the trees can be used in obtaining dates of water cover, especially if they have buttressed bases.

The Lower Littoral Zone

In the lower littoral zone the water cover is a few inches to a few feet deep. The soil is usually highly organic. There are some aquatic plants, as well as tall and dense growths of herbs. Some shrub and tree hydrophytes are frequent. The water hyacinth Eichornia and other plants often wash into windrows and driftlines onto this zone. The tall pickerelweed Pontederia, tall Sagittaria lancifolia, known locally as flags, and the common maidencane grass Panicum hemitomon are a few of the indicator plants frequently present. Cattails Typha are common. The buttonbush Cephalanthus, white bay Magnolia virginiana, willows, and red maples, as well as cypress and gum trees, occur in areas where muck soils are common. The elderberry Sambucus is locally abundant.

The presence here of these and similar plants indicates that there is nearly constant water cover, even if the area is not now flooded. They definitely indicate that high water was not at its upper limits in this location over a long period of time since such plants would not grow under such conditions. This vegetation zone with its highly organic soils should always be studied carefully.

During recent years, in which time many Florida lake and river levels have been constantly lowered, wider shore littoral zones have been created. These wide lake borders have become pasture areas in some cases, or otherwise have been modified by man and animals. This makes it difficult to appraise the former shoreline position either by vegetation or by soils and sediments. The sediments have been altered by both exposure to drying and trampling by animals. Many weed species and some introduced pasture grasses, such as the torpedo grass Panicum repens, take over large areas.

The organic driftline, which Bishop (1967) stressed, is a good indicator of where high water occurs, or has occurred, in these broad littoral zones. The presence of a berm ridge is the best indicator of former high-water lines.

Bishop (1967) used plants as indicators. He noted that certain plants occurred along the profiles of shorelines. He also noted particularly that longleaf pines, live oaks, saw palmettos, and other dry-soil oaks, such as the turkey oak Quercus laevus, and cabbage palm Sabal palmetto, occur on dry, sandy soils above the usual reach of high water. However, the cabbage palm is so facultative to water that it is not a reliable indicator of soils which are not covered occasionally by water. Cabbage palms grow in soils from dry to very wet, and can withstand their bases being submerged by water for indefinite lengths of time.

Bishop (1967) noted that some of the plants located where water covers the soil are the white bay, red maple, slash pine, wax myrtle, and, in places, the red bay and the gums Nyssa, as well as cypresses. In his graphs of their distribution, he noted how some of these plants, such as the wax myrtle, grow over a wide range of water levels along the shore profiles. Such plants are facultative both to water cover and to dry conditions and cannot be reliably used as indicators of water cover or absence of water.

There are more littoral plants than those indicated above, and there is much variation in kinds and numbers from lake to lake. A graphic summary of some of the most common plants is given in Figure 7 to show where they occur along the littoral profile. In addition there is a more complete list of trees, shrubs, and herbs given in the Appendix.

An investigator will find many more plants than these that are locally abundant and significant, such as the coco plum Chrysobalanus icaco, common at low-water positions in subtropical areas of southern Florida. He should examine more than one part of a shore littoral to become familiar with plants that are consistently present in the three littoral zones.

The plants of the upper littoral will usually be the most significant. For this reason, care should be taken to locate trees and shrubs such as live oak, turkey oak, longleaf pine, dogwood, hawthorn, and the hairy hickory that

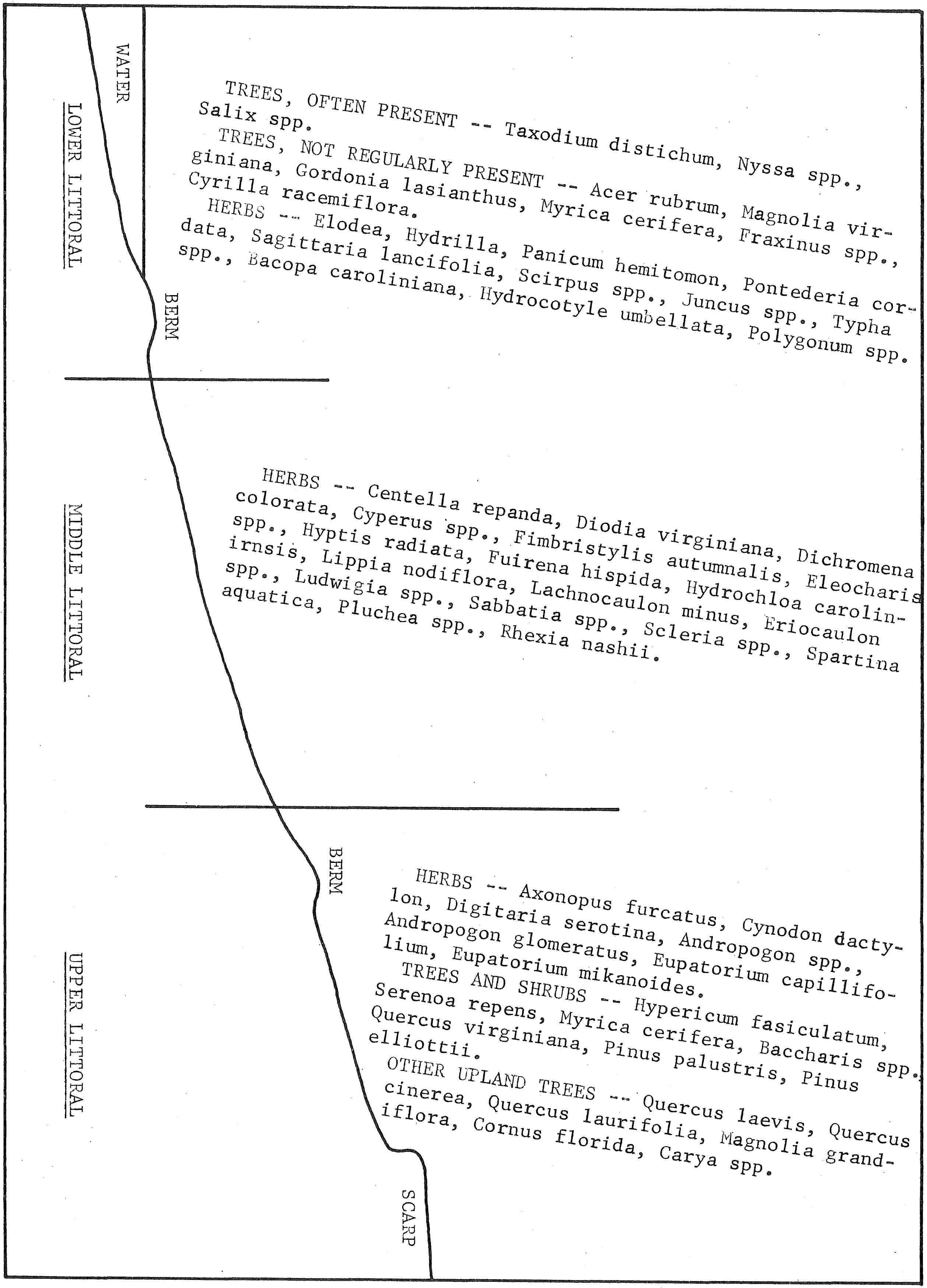


FIGURE 7. LITTORAL ZONES - FREQUENT PLANTS

indicate non-flooded soils, usually dry. Some of the herbs that also are good indicators of the high-water line are broomsedges Andropogon, Bermuda grass, crab grass, dogfennel, switch grass, and wire grass Aristida stricta. The sand cypress bushes Hypericum are often found along the shore near or at the high-water line.

By comparison, the lower littoral plants, in water most of the time, such as cattails, pickerelweeds, and the large flag Sagittaria lancifolia, definitely indicate low water or permanent water levels.

Plant Growth Forms and Habits

The botanical and ecological aspects of the growth forms of the plants, their seasonal aspects, and other features were studied in this project. The presence or absence of such features as the buttressed bases on the bald cypress and the black and tupelo gums, the adventitious roots above the soil level,the elongated internodes of grasses and other herbs, and other growth features of many plants were noted to see if they indicated the presence and depth of surface water at some time.

The buttressed bases of the cypress and gum trees are a direct response of the trees to water around their bases, usually for all of the growing season, April to November. The question not yet well answered is: At what position on the buttressed base is the location of the ordinary high-water line? This was investigated by relating the height of the buttressed bases andthe position on the buttresses where water now occurs, and has occurred over a number of years, in water areas that have stage records of water levels. From these data, as mentioned above, it seems very probable that the location of the mean high-water line is about two-thirds the distance from the bottom to the top of the buttresses. There are some water-line discolorations on many of these buttresses and also lichen growth. These also indicate that probably two-thirds the distance up on buttressed bases is the usual high-water postion.

There is, at times, a stooling out of lower limbs on many bushes and trees. This growth of numerous limbs is ordinarily a few inches above the usual high-water level. In some bushes, such as loosestrife Decodon, a development of spongy, air-filled tissue occurs at and before the water line.

The relations of growth form to water depth show in a number of herbaceous plants. In the grasses,the space between joints (internodes) is longer where these grasses grow in deep water which inundates their stems. Also many grasses develop a runner-vine-like habit in water. Numerous plants, such as the water penny Hydrocotyle, have longer stalks, or petioles, to their leaves when growing in water than when growing without enough water to float their leaves. And it is often the case that plants under water at their bases, such as the button Lachnonocaulon, have a rosette arrangement of leaves at their bases.

The flowering time indicates water conditions for some plants. A number of plants have no, or few, flowers during the time of surface water, and bloom profusely as water recedes from around them. The vine-type plants, such as Hydrocotyle, tend to spread upslope as the water rises.

These and many other features of the details of plant-growth habits can be used with continued observations to note how particular plants react to the presence or absence of surface water or to wet or dry soil and water conditions.

Upland Plants

Locations where surface-water coverage has not regularly occurred are indicated by a variety of upland plants that are not adapted to water. In many cases, they cannot withstand water over their roots for more than a few weeks or months. They are, as pointed out above, plants found in very dry soil and known as xerophytes. There are also those which tolerate moderate amounts of soil water that are known as mesophytes. Several of the trees common on such soils have been used, as discussed above, to indicate where water has not been regularly present. Of these, the live oak, longleaf pine, turkey oak, blue-jack oak, and many of the shrubs, such as dogwoods, plum bushes, hawthorns, and saw palmettos, are present on uplands and berm ridges near lakes. They are useful for locating where high water has not occurred. A number of grasses, such as wire grass Aristida stricta, and a number of other herbs, such as dogfennel Eupatorium capillifolium, are also indicators of dry-soil conditions.

It is not always the case that a lake or river border has upland topography near its shore, and in such situations the location of areas above ordinary high water cannot readily be determined by the presence of upland plants. In many cases, however, by a comparison of the position of upland plants with the position of hydrophytic plants, an approximate location of the mean high-water line can be identified. This is especially the case where a lake or river has a ridge berm or levee ridge. It thus becomes appropriate to try to locate such ridges first and then find the plants on them that indicate former water levels.

The upland mesophytic trees and other plants that grow on a variety of soils, from those flooded to those seldom, if ever, flooded, such as sweet gums, cabbage palms, laurel oaks, and myrtle bushes, are not reliable indicators of water level. Their presence does, however, indicate that most of the time water had not flooded the area around them. A big problem is the presence of slash and pond pines of flatland situations that grow readily in wetland areas and on the lake or river borders. Also, the pond cypresses grow where surface water may, or may not, be regularly present. Therefore, a determination of water levels based on these pine and cypress trees is not reliable to indicate levels for more than a few years. Also, as has been pointed out, the bay trees, especially those growing in bay heads, are often present in areas seldom flooded as well as in areas subject to regular flooding and, therefore, are not reliable indicator plants.

Uses of Photography

Photography proved useful in many ways. Aerial photographs were especially useful in locating the presence and position of berm ridges, types of plants, and the general-to-particular zones of vegetation. Also, ground photography was useful to show some of the growth-form features, such as the cypress and gum tree buttresses and exposed horizontal roots.

The black-and-white, scaled aerial photographs of the U.S. Department of Agriculture, Soil Conservation Service, in conjunction with the U.S.G.S. quadrangle maps, were particularly useful in locating many features of topography and vegetation. In addition to these, the use of commercial air photographs and aerial photographs taken by the investigators proved to be very informative. Color, infra-red, and black-and-white aerial photographs were used. Commercial infra-red photographs of Cypress Lake that showed not only the berms and their vegetation but also the individual trees proved very useful. Infra-red was used around other lakes including Santa Fe, Orange, the Rodman Pool, and Lake Yale, and proved helpful in pinpointing exact places and sometimes the exact trees to inspect. In some cases the ordinary color photographs and black-and-white photographs which were taken at low altitudes (400 to 1,000 ft.) aided in finding areas to inspect, and in some cases they dramatically showed differences in littoral shoreline zones of vegetation.

A number of photographs of the trees and other plants from the ground position proved useful, partly as a record. But in some cases, the photographs added to the visual observations. The photographs were also used in counting the annual growth rings of cut sections of trees.

Final Establishment of High-Water Position

The botanical method of using plants is only one means of identifying the position of probable mean high water. Former surveys, usually done as meander lines, recent surveys, water-stage records, evidence of sediments and profiles of shores, as done by Bishop (1967), are all useful methods. A legally established mean high-water line, often known as the boundary line, can be defined by a number of procedures. Where physical evidence can not be found and where gauging stations and former meander-line and other surveys are not reliable, location of the mean high-water line can be accomplished most expeditiously by the botanical method herein described.

Not many former meander lines or water-stage records date back to 1845 or even back a few decades. By using shore profiles and location of the position of certain differences in sediment deposits along these profiles, it is possible to locate the high-water position in some places; but so far no method has been devised to reliably date the sediments, and the time that they were formed has had to be assumed.

In contrast, the date of the high-water line can be determined within a narrow range of accuracy by the use of trees and other botanical methods in some cases. Therefore, the botanical method may prove more useful than other methods.

The results obtained at Cypress Lake were given above. Similar results were obtained at Lake Hatchineha. These are given below to illustrate the usefulness of the botanical method when old trees are present that can be cut and sectioned so that the annual growth rings can be counted.

In addition to the evidence from old trees and their age, there are a number of other botanical indicators of water-level position and time. A few of these will be noted in the descriptions of lakes examined.

One of these is the survey-level measurements to the bases of the old and young trees on a berm or other lake-border location. The relative positions of live oaks, longleaf pines, and other upland trees compared to the positions of cypress, black and tupelo gums, and other water habitat trees can be interpreted. If most of the old cypresses are located on, or near, the top of the shore slope and smaller (younger) ones are consistently located downslope, while on the same slope the older live oaks are upslope and younger live oaks downslope, there is an indication that water levels have receded. Even if the trees are not cut and ring counts not made of the sections, the historic sequence of lowering water levels is indicated. This method is well illustrated by the findings on the shores of East Lake Tohopekaliga, and to a lesser degree the shores of Lake Istokpoga.

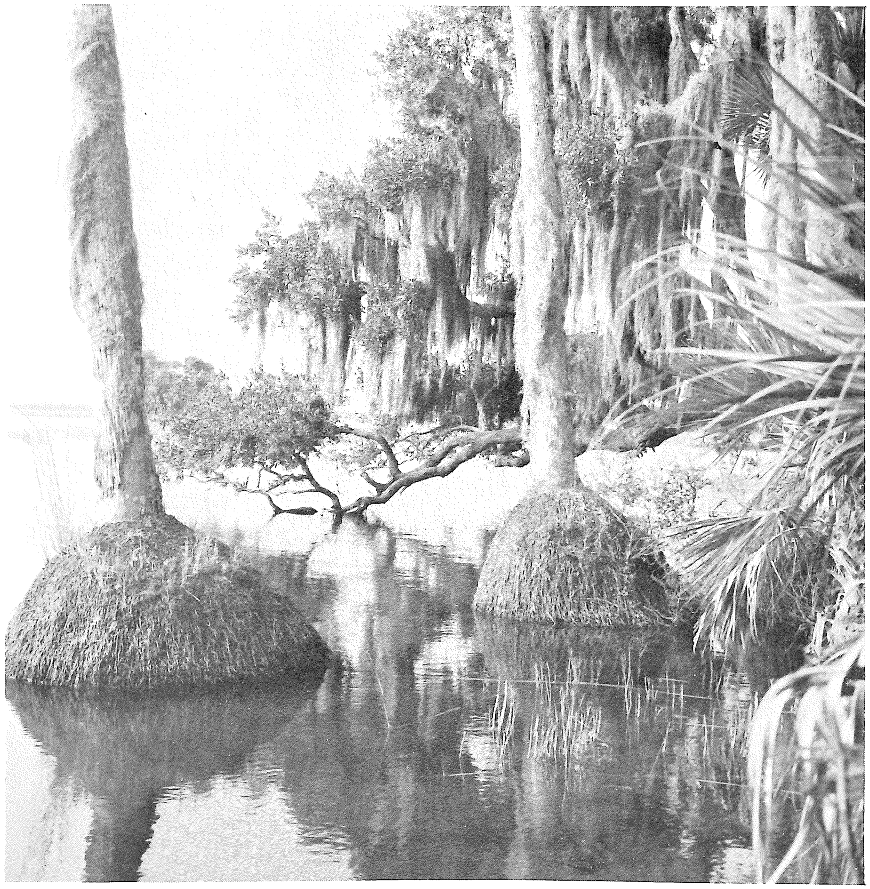
The presence of adventitious roots on the trunks of trees, as on cypress at Lake Jackson, Leon County, and on cabbage palms in Lake Yale, are indicative of water levels at about the position of these roots (see Figure 8). Such roots usually sprout out a few inches above the water and grow down into it. They, at times, continue to lengthen downward and outward as the water level falls. The height is not a very reliable indicator of water level, but their position can add to the information about former water levels. Red maples, water ashes, and other hydrophytic trees also develop such adventitious roots. These have been studied in some detail in the Rodman Pool of the Oklawaha River. Rapid lowering of the water level in the pool killed most such roots.

There is some evidence of former water levels in the deposits and kinds of plants in many marshes and some swamps. In general, the dense growths of saw grass, cattails, tall flags Sagittaria lancifolia, pickerelweeds Pontederia cordata, and other marsh plants occur mainly where water stands about 2-4 feet above the soil during wet seasons or over a period of years. Therefore, the presence of such marsh vegetation now growing where little or no surface water occurs indicates that, formerly, regular surface water from 2 to 3 feet was present. Many such marshes in coves of lakes have been drained in Florida by canals cut through them. The hydrophytic plants remaining indicate former higher water. There is also a possibility of obtaining the dates of the layers of organic (cumulose) materials (mucks and peats) that are formed by such vegetaion. If these deposits are deep and well layered, as in parts of the Everglades and the upper St. Johns River Valley, the layers can be dated by Carbon-14 determinations. Such determinations of age are not, however, very accurate for time periods of recent centuries, and this method may not be useful for dating lake shores for the 19th century.

The wave-built terraces (berms and other ridges) have been stressed as evidence of former water levels, especially by Bishop (1967). He and others have also studied the wave-cut scarps. Some of the deposition of sand and other materials, and some of the wave-cutting of such sediments, have caused at times some damage to trees, bushes, and other plants. Water injury is the term usually used for such effects. Such injuries indicate water position at some level near, or at, the plant, but not an exact still-water position.

Lake Hatchineha Results

The stage-duration curve of water levels of this lake by means of gauges, as noted by Bishop (1967), is for 22 years—1942-1964. The position of the high-water line was



Adventitious roots of cabbage palms stand more than two feet above present water level showing the position of former higher water levels. Long limb is from a live oak growing on top of the berm on the east shore of Lake Yale.

FIGURE 8

given as 54.3 ft. MSL. Bishop based this level mainly on the landward termination of stratified lake deposits. He showed water levels at, or above, 54.3 ft. only 9 percent of the time. The lowest had been 47.5 ft. in 1956, and the highest was 56.8 ft. in 1947.

It is doubtful that the upper termination of stratified lake deposits indicated the high-water position back to the middle and early 1800s. Therefore, an intensive inspection of the lake shore was undertaken.

Well-defined berm ridges were located on the eastern shore, and also on the southeastern shore, as shown in Figure 9. On these ridges and downslope from their tops were found cypress trees with buttresses and knees and live oak trees of large size and old age. The following is a summary of the findings.

The elevations of the soil levels at the bases of the live oaks on these ridges are, in most instances, above the position of the cypress trees. The cypresses near, and on top of, the ridge have few well-developed buttressed bases and few knees, showing that water was not regularly about their bases. Some water levels of the past probably must have been higher than recent levels to promote cypress growth at the high elevations on the ridges. The live oaks are nearly all on the top of the ridge, but a few are on the downslopes and grow among some of the old cypresses. The object was to determine which were the older and their age at certain elevations on the ridge. If the oaks were younger, they could have developed after the cypress growth and after the water had receded.

Survey measurements to the bases of a number of oaks selected at random on the ridge showed them to average about 54.7 ft. MSL elevation. Some old cypress trees are at 55.9 ft. MSL elevation, but most of them averaged below 53.5 ft. MSL.

The two cypress trees, cut and sectioned, were at elevations of 55.9 and 53.6 ft. MSL. Counts of their growth rings gave an age of 164 and 172 years, respectively. This indicates that they started growth about 1808 and 1800.

In contrast, the two live oaks, cut and sectioned, were at elevations of 57.08 and 56.2 ft. MSL. Their ages indicated by their growth rings were 105 and 98 years, respectively. This indicates that they started growth about 1867 and 1874.

The difference in the ages of the cypresses and live oaks is about 60 to 70 years, the period between about 1805 and 1865. This indicates that the top, and near top, of the

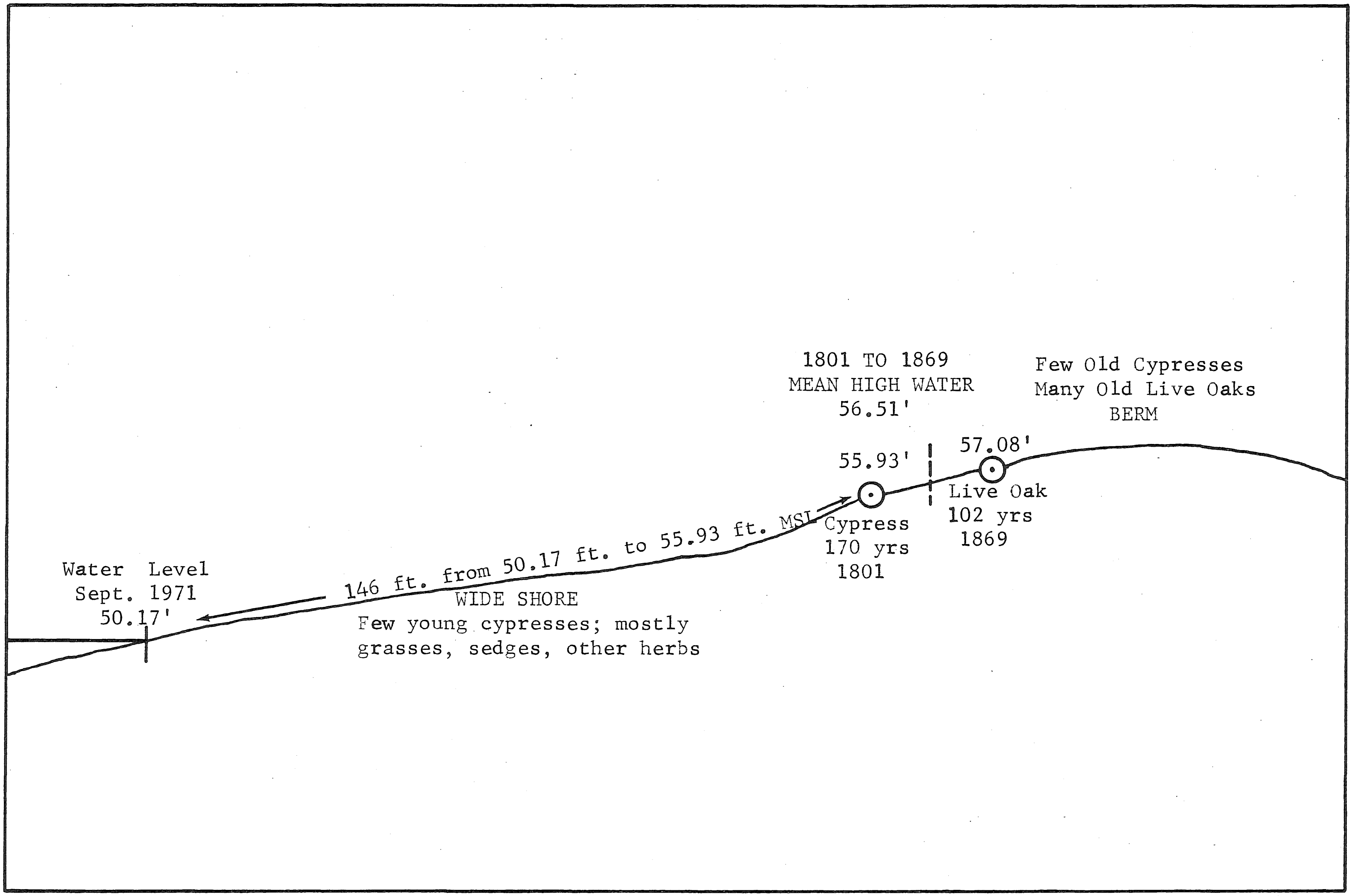


FIGURE 9. LAKE HATCHINEHA BERM
(Two Trees Cut)

ridge was not dry enough during those years to support the growth of live oaks, but near the top, and perhaps on it, the ridge was flooded often enough to promote the growth of cypress trees.

The upper part of the ridge may not have been there during some of the 60-70 year period, and the upper part could have been formed just a few years before the live oak trees began growth as a result of storm waves and winds. An examination of the sediments showed them to be layered by water stratification.

The position between the bases of the live oaks and the bases of the cypress trees is 56.7 ft. MSL. This elevation may be taken as the mean high-water position of the lake since about 1870. The high-water position in 1845 was probably about 57 ft. MSL, but how much higher is not well indicated. It is most likely that it was not regularly above the 57 ft. MSL elevation because the cypresses at that elevation do not have the buttressed characterisitcs of such trees growing in water around their bases.

Summary

With the methods and findings of Cypress Lake and Lake Hatchineha in mind, it is apparent that the time and position of certain water levels can be reliably approximated where the shore topography and the old trees are present. However, this method is limited to certain lakes and rivers that have the appropriate combinations.

Only six lakes of those inspected had the combination of old trees growing on berms and trees that were available for cutting and the counting of growth rings. These were Lake Yale, Lake Tohopekaliga, Cypress Lake, Lake Hatchineha, Lake Istokpoga, and Lake Jackson (Leon County). There were old cypress, gum, and live oak trees along the shores of some other lakes, such as Sante Fe, but the difficulty of getting permission to cut down the trees made it impossible to obtain the ages of these trees.

The lakes with steep shores, such as Lake Kerr in Marion County, are without wide littoral zones in most cases, and some do not have old cypress trees near the shore. In some cases, these lakes do, however, have old live oak trees and longleaf pine trees that indicate that former high water was not above the level of the bases of these trees.

With each passing year it is becoming more and more difficult to find old trees that can be cut and dated. This is due mainly to the rapid development of homes and other human facilities on lakes where many trees are destroyed and owners will not give permission to cut down any of the remaining ones.

Other Difficulties Encountered

Information concerning former shoreline elevations of sandhill lakes with steep shores proved the most difficult to obtain. Detailed inspections were made of Lake Kerr in Marion County, Lake Weir in Marion County, Lake Louisa in Lake County, Kingsley Lake in Clay County and Compass Lake in Jackson County, but, in each case, without locating the combinations of live oak, cypress, and gum trees appropriate for detecting the probable former water levels. There were places around these lakes that had large live oaks, longleaf pines, and other upland trees near the present shoreline, but, except for Compass Lake, there were no large cypress or gum trees growing near these live oaks. The position and age of the live oaks could indicate the elevations above which water had not regularly occurred or long remained. The ages of some of these trees were estimated, but none of the oaks was cut down and the growth rings counted because no permits could be obtained.

Another difficulty has been in the use of red maples, bay trees, water ash, laurel oaks, and other non-xerophytic trees to locate the high-water position and the age of the trees. In many places these trees grow over such a wide range of water levels that no definite position where water seldom occurs is indicated by them. Cabbage palms, having no growth rings and being facultative to both dry and wet conditions, cannot be used as reliable indicator plants.

The way standing water affects some of these trees is now being studied by the reaction of many of them to the raising and lowering of water levels in the basin (pool), known as Lake Oklawaha, made by the Rodman Dam on the Oklawaha River. Here water levels of 3-4 ft. above the bases of the trees have killed or badly stressed many of the red maples, water ashes, and some bald cypresses. All the oaks were killed, and, in most cases, elms and gums were also killed. It appears that few trees can withstand 2-3 years of inundation of water around their trunks, especially when impoundment has brought about a very rapid rise in the water level. The kill of bald cypress in Compass Lake, as well as in the Rodman Pool, indicates that cypresses are killed by impoundment. But, in natural slow rises of water level and some seasonal lowering of such levels, the cypresses survive even when water is over 7-10 feet deep around them part of the year. Dead Lake of the Chipola River provides another example of how cypresses are killed by impounded water.

As mentioned earlier, one vexing technical difficulty has been the obtaining of reliable evidence of age of the trees or other plants. Obtaining cross sections of tree trunks that were solid at levels of about 3.5 ft. above the ground was difficult since trees are often rotten at their centers. Also, the sections cut had false or indistinct growth rings. In bald cypress, the false growth rings are those that do not continue around the whole section. They are common on the buttress part of the trunk, and this is the position where most sections were cut. To correct for these, the false rings were subtracted from the rings counted to obtain the probable age. In live oaks, the difficulty is mainly the indistinct growth rings. This tree has less and less length of dormant season in Florida from north to south, and in the central and southern parts of the state the growth rings are often very indistinct.

Attempts were made to use an increment borer to get a plug from a tree and from it to count the growth rings. For this purpose a special coring instrument powered by a gasoline engine and having a coring bit of three-fourths of an inch in diameter was obtained. After many trials, the use of coring was abandoned (see Figure 10). Some of the reasons for this were the following:

1. It was usually impractical to line up the coring instrument so that a core could be obtained through the center of the tree. This was due to the fact that most centers were not in the geometric center, and one, two, or even five borings did not hit the center.

2. The cores through live oaks were often along the same radial direction as the radial medullary rays of the tree. These rays have no cross-growth rings that are circular. This resulted in a core that could not be read accurately. Also, the tissues involved were so difficult to stain or otherwise make more visible that any counts of growth rings were at best speculative.

3. Cores through cypress trunks near their bases (buttresses) proved readable, but a core does not show which rings are false rings and which are true annual rings. The true annual rings extend around the whole trunk and a core shows only a small three-fourths of an inch of this trunk so that distinctions of false rings compared to the true rings could not be made. And a great difficulty was experienced in getting a continuous core because the bit often overheated and burned out a section of the core.

Attempts were made to arrive at the age of the herbaceous and fibrous-stemmed plants that are present in upper parts of the shore zones. Roots, rhizomes, and stems were sectioned, and some showed growth rings indicating age. However, such rings were rare, and dates obtained from such examinations were considered inaccurate. In some cases, the size of the bushes, such as <u>Hypericum</u> and <u>Serenoa</u>, gave an idea of the age of the plants.

Technician using 3/4 inch power increment borer. The borer did not prove useful as seldom could the center of a tree be cored. Growth rings could not be accurately counted (especially those of live oaks) because cores are taken along the broad rays and the growth rings fail to show on ray tissue.

FIGURE 10

General Results From Use of These Botanical Methods

The locations of the lakes inspected during the project are pinpointed in Figure 11. Some reliable information was obtained from about 25 of these lakes. Of the other sites inspected, there are some shore and plant conditions that, with further inspection, would yield even more reliable information. A continuation of this botanical method is strongly recommended. It alone can show, in many instances, both the position and the time of former high-water lines, or present high-water lines. There is also a need for more correlation with land surveys run to the plants that give evidence. Such correlations should be made with records of water-level gauges where these cover long periods of time.

Probably more correlations can be made with the geologic evidences and soil sediments, as presented by Bishop (1967). His method for the use of wave-cut scarps on some shorelines was used in these investigations and was found reliable in cases where such scarps were distinct. However, in many cases the scarps are positions of wave action for only a few recent years, as in the case of Lake Jackson in Leon County.

For future determinations of former lake levels, the botanical method is reliable, especially for lakes in flatland areas that have distinct berm ridges. It is not as useful for lakes in the sandhill areas, especially if no low shores exist and if no berms are present. A number of the lakes not yet examined may have shorelines useful for this method.

Lakes Inspected

The following are short descriptions of 20 of the 37 lakes inspected in this investigation. These are given to show the results (both adequate and inadequate) and to illustrate most of the kinds of lakes studied.*

Cypress Lake and Lake Hatchineha were more fully described previously in order to illustrate how this botanical method can give reliable indications of former high-water lake levels. Fewer adequate results were obtained from most of the other lakes because of the character of some of the lake shores without berms and old trees, and the inability to obtain permits to cut some of the significant indicator trees that were located. Further investigation is needed.

---

*The geographical positions of these lakes and others can be found in Figure 11.

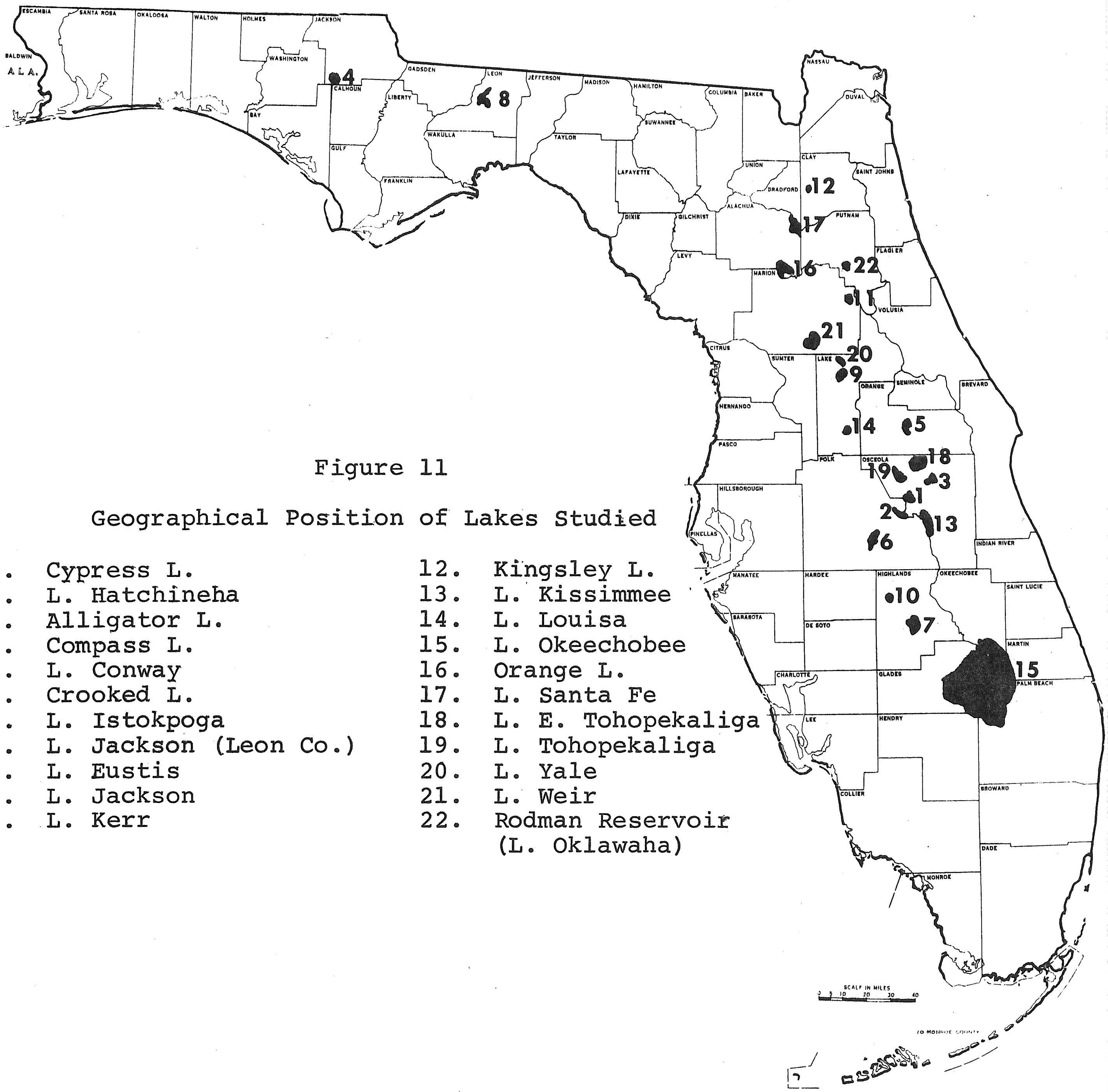


Figure 11

Geographical Position of Lakes Studied

1. Cypress L.
2. L. Hatchineha
3. Alligator L.
4. Compass L.
5. L. Conway
6. Crooked L.
7. L. Istokpoga
8. L. Jackson (Leon Co.)
9. L. Eustis
10. L. Jackson
11. L. Kerr
12. Kingsley L.
13. L. Kissimmee
14. L. Louisa
15. L. Okeechobee
16. Orange L.
17. L. Santa Fe
18. L. E. Tohopekaliga
19. L. Tohopekaliga
20. L. Yale
21. L. Weir
22. Rodman Reservoir (L. Oklawaha)

Alligator Lake (Osceola County)

Alligator Lake is 20 miles east of Ashton, Florida. It is one of the many lakes of the Kissimmee River flatlands region. It has low shores with only a few low berm ridges. On the west shore are some upland trees on a low berm ridge. Among these trees are a few old live oaks that indicate where continuous water cover has not occurred since they began growth. None of these oaks were cut to determine their ages, but by their sizes they can be judged to be 60-70 years old. They grow at an elevation of about 67 ft. MSL, and this lake probably did not rise above this level during most of this century. However, more study of these trees should be done in order to date the high-water level of the lake which recently has fluctuated between 60.6 and 66.4 ft. MSL.

Compass Lake (Jackson County)

Compass Lake was studied as an example of a northwest Florida sandhills region lake. It was also studied because its outlet stream was dammed in 1917 to power a mill. This dam raised the water level of the lake.

Around this lake's shoreline and in shallow water, especially in some embayments, are bald cypress trees of two distinct sizes and ages. There are old, mostly dead, large cypress trees in the deeper water. An examination of these trees revealed that all were rotted in their centers, the trunks being mere shells. Therefore, the ages of these old cypress trees could not be determined. However, their diameters, with many over 30 in. DBH,* indicate that a number were over 150 years old. Since residents of the area saw many of these trees die soon after 1917, this indicates that water was at their bases as far back as the early 1800s.

The other kind of cypress is the young-to-middle-aged vigorous tree with a distinct buttress in some cases. Trees of this type apparently developed after the water level was raised by the dam, or some of them were in shallow water when the water rose and were not drowned. Two of these cypresses were cut and sectioned, and their ages were 62 and 82 years, respectively. One of these began growth 27 years before the dam raised the water level; the other, 7 years before that time. Both indicate water cover at regular intervals at the location in which they grow.

On the steep slopes to the present lake level, no large and old live oaks or longleaf pines were located. The few smaller ones did not seem to be as old as 55 years (back to the time of the dam construction). Only wave-cut scarps

---

*Diameter breast high.

marked the level of recent water. Some of these were only a few inches above the level when the lake was inspected.

Lake Conway (Orange County)

Lake Conway is the basin now joined by canals into one body of water which was formerly two or three lakes, depending on water level. The digging of several drainage wells about 1953 also contributed to the lowering of the lake water level. Since that time, the lake's water level has been kept near 86.4 ft. MSL.

Parts of the present shoreline have young upland trees growing in soils which are below former water levels. At positions higher than these are some old large live oaks and other upland trees, which, if cut and sectioned, would indicate the time that the position they now occupy was not regularly flooded. However, none of these old higher-level trees was cut down because permission could not be obtained to do so. Much of the lake is surrounded by homes, roads, and parks, and it is doubtful that any trees can be obtained for sectioning.

Crooked Lake (Polk County)

Crooked Lake is bordered on the east side by the Central Florida Highlands, and its shore is steep. There are no old live oaks or longleaf pines near the shore at a position that would indicate where high-water levels stood during the past century. On the west shore of the lake the relief is low and a low berm ridge is in evidence. Between this ridge and the present lake level there is a broad littoral zone well covered by plants that indicate the middle and upper littoral zones. The position of the recent high-water levels shown by these plants is at about 121 ft. MSL.

The levels of this lake have been raised and lowered by a canal, and have varied from 118 to 122 ft. MSL with some stages up to 124 ft. MSL after 1945. The berm ridge is somewhat higher than 124 ft. Landward from this berm ridge are located a few black gum trees with distinct buttressed bases which indicate that they were surrounded by 2-3 feet of water for a number of years. One of these trees was cut and sectioned, which had 55 growth rings. This indicates that water was a few feet deep here back to 1918 or earlier. This means that water flooded up to 126.5 ft. MSL, and probably 2-3 ft. higher, during a few years after 1918, or for the number of years required to develop the buttressed bases on the black gum trees.

However, the gum trees are in a swale, and their growth period may not have been connected with the lake. If so, they do not indicate a former lake level.

A grove of live oaks, farther inland than the gum trees, on soils above 130 ft. MSL, indicates that the lake water probably did not exceed this elevation for the time of the age of these trees, which is estimated at about 75 years, or back to before 1900.

Lake Istokpoga (Highlands County)

Lake Istokpoga has a low-relief shoreline around its eastern and northern parts, and on its western side it abuts the Central Florida Highlands and has mostly steep shores. The lake is approximately 43 square miles in area, with a fetch long enough to develop wave action capable of creating berm ridges.

Since 1949 the level of the lake has been kept lower than formerly by a canal connecting it with the Kissimmee River. The levels have usually been held between 39 and 40 ft. MSL. Our investigation was aimed at finding the position of the higher lake levels.

A distinct berm ridge was located along the northeastern shore, and survey levels were run to the bases of a number of the cypress trees and to one live oak tree. The cypress trees did not have the characteristic buttressed bases that indicate water cover about them, but stage records show that water was up to 43 ft. MSL in 1945, and probably that high at prior times.

The elevations of the soil at the bases of the cypresses were between 42.4 and 43.1 ft. MSL. The growth-ring counts of two trees cut and sectioned indicated ages of 67 and 74 years. Some water was probably over parts of the ridge back to about 1900.

One live oak tree which was cut and sectioned was growing on soil at 44.5 ft. MSL elevation. It had a hollow center, but its age was calculated to be 55 years. The flood waters probably did not rise above 44 ft. MSL back to about 1915. There is the need to find other live oaks on this ridge and to obtain sections of them in order to better determine the time of high water.

Lake Jackson (Leon County)

Lake Jackson has a history of distinct changes in water level that has ranged from a high of 96 ft. MSL to a low of 85 ft. MSL over a period of about 100 years. Some of the various levels have been noted and recorded by surveys of former shorelines. The botanical evidences of some of the former levels were made to determine if the levels could be verified by plants, mainly old live oak trees and a few planted cypress trees. From about 1885 to about 1948, the lake level was usually below 88 ft. MSL. One old live oak tree that probably grew at the border of this low, level shore was found, cut, and sectioned. It had been dead since a rise in water level in 1945, and the growth-ring counts were not accurate due to the sap wood having been mostly rotted away. However, an estimate of its age is about 65 years. The level at its base is 88.5 ft. MSL. This indicates that water levels were probably not regularly over an elevation of 88.5 ft. MSL between 1880 and 1945.

After 1948 some cypress trees were planted at about the same elevation as the base of the old, dead live oak, and water surrounded them for a number of years. They developed adventitious roots on the main trunk at levels of about 5-6 ft. above the soil. Since they would not have developed more than a few inches above the top of the water, the water levels were up to about 93-94 ft. MSL for a number of years.

The shoreline after 1948 has been as high as 95 ft. MSL, and at times a few feet above that level, especially during 1966. This is generally shown by the position of wave-cut scarps present at a number of places around the lake. There is at one point a number of live oaks on, and near, such a wave-cut scarp. A few of these were killed by high water. The scarp is at an elevation of 96.5 ft. MSL.

Cypress Lake (Osceola County)

Cypress Lake and its shoreline yielded the best information concerning mean high-water lines of any lake studied. This, and the information obtained from survey levels and the ages of two bald cypresses, two live oaks, and one black gum that were cut and sectioned, gave a reliable estimate of former water levels. The description of this lake is presented above as an example of how the method of using indicator trees can be used.

In brief, the two berm ridges on the eastern shore of the lake are on two levels and were formed at different times. The lower, narrower ridge is about 52 to 54 ft. MSL, and the inner, broader ridge is about 57-60 ft. MSL. Between these ridges is a swale that has elevations between 50 and 57 ft. MSL. The ages of the trees cut and sectioned indicate that this lake had water levels to about 56 ft. MSL before 1885. The water became lower to about 52 ft. beginning about 1900. It was probably between 56 and 52 ft. elevation during the period of 1885 to 1900. After 1900 the levels receded to an average of about 49 ft. elevation. This recession caused some of the lower ridge at 52 ft. elevation to erode on the slope toward the lake. This is now indicated in some cypresses by exposed horizontal roots above the soil level. The former soil level was about 51 ft. MSL. Much of the original southern end of the low berm near the lake is now eroded away.

It is speculated, but not proved, that these two berms were probably made by storm waves of hurricanes, which may have occurred just before 1885 and just before 1900.

Lake Eustis (Lake County)

Lake Eustis has an area of about 11 square miles, and its water level has been controlled for some time by means of lift gates in Haines Creek, which connects it with Lake Griffin. Most of the shoreline consists of steep banks, and it has no berms with old trees. Much of the shore vegetation has been greatly changed by building and lawn development. There are, however, two low berm ridges along the west shore of the lake. Their elevation is about 67 ft. MSL. A few live oaks of moderate size grow on the highest parts of these berms, and bald cypress, black gum, water ash, and other hydrophytic trees grow on the lower parts and in the nearshore water. Some of these are at levels above 64 ft. MSL and indicate higher former lake levels.

No trees were cut and sectioned, but it is very probable that if some were cut they would show growth rings and the berm could be dated. The controlled level of the lake is between 61 and 64 ft. MSL. The former level could have been regularly above 63 ft. In 1936 it reached 64.84 ft.

Lake Jackson (Highlands County)

Since 1946, the level of Lake Jackson has been controlled by means of a canal. It has changed level very little in recent years: from 101.65 to 102.33 ft. MSL. It is reported that the lake was permanently lowered about 4 ft. It was inspected to see if there were any botanical evidences of the former higher levels.

Many houses and lawns occupy much of the shoreline, and very few, if any, of the original live oak or other trees remain. A few old live oaks now present are usually at positions well above 106-108 ft. MSL. No cypresses, bays, red maples, buttonwood bushes, or other hydrophytes are located near the lake. The lack of any such indicator vegetation makes it difficult, if not impossible, to assign any water-level position before drainage began. This lack of shoreline plants is typical of the sandhill region lakes, such as this one. Therefore, little effort should be expended on botanical inspections of such lakes.

Lake Kerr (Marion County)

Lake Kerr has steep sides and in places is more than 16 ft. deep. It covers about 7 square miles. Between 1936 and 1965, the water levels have fluctuated between 26.6 and 19.9 ft. MSL, with the highest level at 26.6 ft. MSL in 1948. The recent high-water condition is indicated by some longleaf pines now flooded at their bases by 1-2 ft. of water and dead as a consequence of the flooding. These pines developed where they were not regularly flooded, and their presence indicates that former lake levels were lower.

Some of the shore, especially at Lake Kerr Park, has old, large live oak trees and some old live oak stumps. Some of these are now growing within 1 ft. elevation of the present water level, which indicates that water has risen nearly to their bases after having been well below their bases when they were younger and more vigorous. Permission could not be obtained to cut and section any of these live oaks; therefore, the years when they started growth are not known. Their sizes indicate that lower lake levels occurred over 100 years ago.

No cypress trees were noted, and the few young hydrophytic trees, such as red maples, willows, and black gums, are not sufficiently old to indicate water levels back over 50 years.

Low beach ridges less than 1 ft. high were noted by Knochenmus (1967), but these were not evident during this inspection. They probably have been covered by recent high water.

Kingsley Lake (Clay County)

Kingsley Lake is nearly circular in shape and is 85 ft. deep in some places. The shoreline is mostly steep slopes with some wave-cut scarps which indicate recent high-water levels. There are some low parts of the shore, and a few low berm ridges occur along them. Along these low shores are willows, bay trees, red maples, and other hydrophytic plants which indicate that water was at their level for at least a few decades. There are only a few old live oak and longleaf pine trees near the shore that would indicate no water at their positions. None of these were cut and sectioned to count growth rings, but, if this were done, some age of the upland might be determined.

Because much of the shore is now occupied by Camp Blanding and many homes and their lawns, few, if any, of the original plants nearshore remain undisturbed.

The water level has fluctuated from 174.3 to 177.8 ft. MSL during the past two decades and the average present level is about 176 ft. MSL. It is not probable that the lake has had many higher water levels during the past century, although Bishop (1967) found evidence from shoreline deposits, gauges, and the vegetation that the water level was above 177 ft. MSL about 8 percent of the time during recent years.

Lake Kissimmee (East Shore, Osceola County; West Shore, Polk County)

Lake Kissimmee, a large lake of 54 square miles, has low shores with some berm ridges along its eastern side and mostly steep shores along its western side. A broad, old berm with a grove of old live oak trees was located on the eastern shore, and two of the trees were cut, sectioned, and their growth rings counted, revealing that they were 73 and 55 years old. The ridge elevation is about 57-60 ft. MSL, and it is probable that no flood water has been up to such levels during this century. A level of 56.6 ft. occurred in 1953, and the stage-duration curve of Bishop (1967) indicates that water levels above 53.5 ft. have recently occurred about 10 percent of the time. The lake level, by record and evidence of the shoreline plants, has gradually been lowered recently by about 3 ft. and now is regulated by Kissimmee River controls.

Lake Louisa (Lake County)

Lake Louisa is a typical lake of the sandhills region of central Florida, with mostly steep shores and a narrow shoreline awash with high water that fluctuates about 2-3 ft. Here there are some shorelines with cypresses that are well buttressed. The buttresses indicate that water levels probably fluctuate 2-3 ft., usually within the range of 93.5 to 95.5 ft. MSL. At about the high-water position, as shown by Bishop (1967) to be nearly 98 ft., occur some beach scarps recently wave cut. Live oaks, longleaf pines, and the switch grasses at the top of such scarps indicate the position usually above high water. The live oaks and longleaf pines were not cut and their growth rings not counted, but their sizes indicate that they are about 75 to 100 years old. It is probable that no high water above about 98 ft. MSL occurred during this century.

Lake Okeechobee (Parts of Shore in Glades, Okeechobee, St. Lucie, and Martin Counties)

Lake Okeechobee is the largest lake in Florida and since the early 1900s has been lowered from its original levels a number of times by numerous drainage canals. Stage records have been kept since 1912, and at very few times has it been as high as 18.7 ft. MSL. Changes of the shore by numerous road, town, and home developments have removed, or otherwise altered, the ridges that once enclosed much of this lake on the

Santa Fe Lake (Alachua, Bradford, and Putnam Counties

Santa Fe Lake is a cypress-bordered lake with the older of these trees having high and wide buttresses which indicate past fluctuations in water levels over many years. Behind the offshore zone of cypress trees, the shore slopes steeply a few feet high along much of the shore, and on this grow live oaks, other oaks, and a number of kinds of both upland and hydrophytic trees and bushes. No distinct berm ridge was located, but there are places where a beach scarp occurs. Many of the original shore features have been altered by the intensive development of residences and fish camps with boat channels. Very few of the old live oaks and other upland trees remain.

The cypresses with high buttresses now grow mainly in water of about 140 ft. MSL. The height of these buttresses indicates that water fluctuated over a range of 3 ft. or more during the time of their growth. Since most of the old cypresses are hollow, growth rings could not be accurately counted, but the sizes of the trees indicate that many are over 150 years old. Water levels up to about 143 ft. MSL probably occurred during these 150 years.

Some old live oaks located on the slopes at elevations from about 150 to 145 ft. MSL indicate that water probably did not rise above these levels for many decades, but permits could not be obtained to cut any of these trees to determine their ages.

According to the human record, a series of lake-level changes has occurred as far back as surveys of 1835, especially around the arm of the lake now known as Melrose Bay. Unverified observations indicate that this bay was formerly not connected with the main part of the lake. Other unverified records indicate that the gap between Santa Fe Lake and Little Santa Fe Lake became clogged, causing the water level to rise. The Sante Fe Canal was cut from this little part of Santa Fe to Lake Altha, and this may have lowered its water level.

The growth form of many of the old cypresses and the human record both indicate past levels possibly ranging from as low as 140 ft. MSL up to about 146 ft. MSL. It is doubtful that any level during the early decades of the 1800s can be reliably determined, except by old meander survey lines.

East Lake Tohopekaliga (Osceola County)

East Lake Tohopekaliga, now separated from Lake Tohopekaliga to the southwest of it, may have been formerly an extended arm of that lake. It seems that a distinct marsh area of saw grass joined the two parts. A canal dug through this marshy part lowered the present eastern part and made it distinct. Field notes of a 1944 survey state: "It (East Lake Tohopekaliga connects with the main body of Tohopekaliga on the southwest by a saw grass marsh, now drying." In a 1923 survey the notes state: "The lowering of the water level in these lakes has changed the location of the shoreline as it existed in 1845." Another survey in 1910 states that the elevation of the lake was 64.5 ft. MSL.

With this information about prior lake levels and conditions, the Board of Trustees of the Internal Improvement Trust Fund, State of Florida, did an in-house study of both the botanical and geological evidences of former lake levels. These were also studied in this investigation. The findings of both inspections are summarized here.

Much of the lake shore is surrounded by berm ridges with elevations between 63 and 66 ft. MSL. On the berms and the slopes down to present water level are cypress trees of different ages, and some old live oak trees occur on top of the ridge and younger ones down the slope. Three cypress trees at elevations 60.58, 63.16, and 63.20 ft. MSL were cut and their ages determined. They were 24, 61, and 82 years old, respectively. The younger one, about 3 feet lower than the two older ones, probably started growth after the water level was lowered by drainage canals. Other cypress trees noted occurred at levels of up to 64.95 ft. MSL on the berms. In some cases the older cypress trees (not cut) were larger, and probably older, than those cut. These, and those cut, indicate that some surface water stood above 64 ft. during the latter part of the 1800s.

The live oaks growing on the berm and a few black gum trees are also indicators of water levels, and, if cut and their ages determined, they could give position and dates when dryness prevailed at certain elevations. Five of the live oaks are over 4 ft. in diameter at breast height. They occur at elevations of from 62.2 to 64.2 ft. MSL. None was cut and sectioned. They may be as old, or older, than the cypresses sectioned and aged, but that is doubtful from experience of other live oaks cut. Their ages should be determined. Smaller live oaks occur downslope at elevations up to 61.9 ft. MSL. Some of these may have grown in their position after the lake level was lowered.

These botanical evidences indicate that probably the lake level before 1900, and possibly before 1885 (when some accounts indicate that the first drainage canal was dug), was in the range of over 65 ft. MSL, at least for part of the time. The presence of the large oaks indicates that lower levels were down to about 62 ft. MSL. The range of water level seems to have been from 62 to 65 ft.

The lowered level has produced a wide littoral zone, and studies of plants on this zone could provide data on the recent positions of water levels.

Lake Tohopekaliga (Osceola County)

Lake Tohopekaliga, a large lake of 29 square miles, has since 1942 had low water levels of between 54.5 and 58.6 ft. MSL, and some drawdowns of the past few years have lowered it to less than 53 ft. The berms, and the cypress trees on them, indicate that former water levels were often above 60 ft. MSL. Some of the recent lowering of water level is the result of the construction of a canal from Lake Tohopekaliga to Cypress Lake. Judging from the position of some of the live oaks, it seems that water levels below 60 ft. MSL on the berm date from before 1900.

The best berm for botanical research is located along the southeastern shore of the lake. Both cypress and live oak trees grow close together near, and at the top of, the berm. Two of the topmost cypresses were cut. Both had hollow centers, and their ages could not be well estimated; however, their sizes (about 2.5 ft. DBH) indicated that their ages are probably well over 100 years. Two live oak trees on the downslope, at elevations below the position of the cypress trees, were cut, but these also had hollow centers, and their ages could not be accurately estimated.

These two investigations of the position and age of the trees on the berm are not conclusive. More trees should be cut, and accurate surveys of elevations to the bases of the trees should be made. The past condition indicates that water was at, and in some places over, the top of the berm ridge during the 1800s when the cypresses began growth. After about 1900, the water level lowered and the live oaks grew on slopes and on the top of the berm ridge among the former cypress trees.

Upper-water levels stood as high as 58.3 ft. MSL until about 1956. Lake levels were lowered after 1970, in some cases to 49 ft. MSL. The lowering of levels after 1900 from about 60 ft. MSL has created a broad littoral zone occupied by many herbs and a few shrubs and young trees.

Lake Yale (Lake County)

Lake Yale has low, narrow berm ridges especially on its east side. These ridges act as dams between the lake's open water and the marshes and swamps back of them. Many live oaks, cabbage palms, a number of other hardwood trees and bushes, and a few pines grow on these ridges. There are no cypress trees (an unusual condition), and their absence made it impossible to date early water levels.

northern side. However, some parts of this ridge remain, probably about the same height as they were during the 1800s. Old trees can still be found on parts of these ridges.

Some parts of the northern ridges, where live oaks, cypresses, cabbage palms, laurel oaks, hackberries, and other large trees now grow, were inspected. In one area the elevation of the ridge is about 20 ft. MSL. It is known locally as Palm Ridge. There is another ridge on the eastern side of the lake (Martin County) where there is a continuous elevation of about 20 ft. MSL for a number of miles.

The live oak and cypress trees at the Palm Ridge site are not large enough to be older than about 75 years, and, if so, they would not date the ridge earlier than 1900. Along the ridge in Martin County there are numerous live oaks that are large, and some of these show that they probably grew here above the mean high-water line before 1900. No trees were cut nor sections made for growth-ring count. This should be done. It is probable that it could be shown that before 1900 this second ridge had water on it up to about 20 ft. MSL at times. In some places the ridge is wide and over 22 ft. MSL elevation. Storms probably built the ridges a number of times in the past, and lake water may have been held up to well above 22 ft. MSL during the 19th century and before. More botanical evidence should be obtained.

<u>Orange Lake (Alachua County)</u>

Orange Lake has a history of changes in water level due to sinkholes that have opened a number of times and lowered the lake level. The levels have varied from 40 to 61.2 ft. MSL. Recently it has been kept at a nearly constant level by a regulation of the outflow through Orange Creek. The wide fluctuation of past water levels has promoted the growth of many hydrophytic plants along the shore, some of which are abundant saw grasses, cattails, cypresses, cabbage palms, red maples, bay, and gum trees--all being able to withstand some flooding. On the upland areas nearshore are live oaks, magnolias, and other dry-situation trees, that indicate that no water has been at their elevation for a number of decades.

An upland position nearshore was inspected that had live oaks and other upland trees growing near some cypress trees and some black gums with buttressed bases. Since permission could not be obtained to cut and section any of these upland trees, their ages are not known. Some of the live oaks are large enough to be over 100 years old, and they occur at levels between 62 and 64 ft. MSL. From this scanty evidence, it appears that the shoreline seems to have been at about 62 ft. MSL during this century.

The cabbage palms grow both on the berm ridge and in the lake water. Those in the lake have adventitious root masses above the present water level about 3-4 ft. These roots developed at, or just above, water levels of the past. They indicate that levels were probably at about 63 ft. MSL when these roots were formed. The level of the lake in November 1972 was 69.35 ft. MSL. The time when these adventitious roots were formed could not be determined because cabbage palms do not have annual growth rings. However, the height of these trees indicates that they are very old.

The live oak trees on the berm also gave information about former lake levels, because their positions and ages indicate where high water has not regularly occurred. Soil elevations to the bases of five of these live oaks ranged from 60.82 to 61.78 ft. MSL. These elevations are lower than the level of water indicated by the position of the cabbage palm adventitious roots.

Two of the live oaks were cut and sectioned, and they were both approximately 75 years old. This indicates that water since about 1900 has not regularly been above 61 ft. MSL.

There is a possibility that some information about the age of the berm ridge could be obtained from the organic muck and peat deposits in the marshes behind the ridge. The organic sediments can be dated.

Lake Weir (Marion County)

Lake Weir has a shoreline of steep slopes around most of it, but also some low, level shores, as along Sunset Harbor. It has fluctuated in water levels from 69.6 to 53.5 ft. MSL during the past 25 years, and there are both berm ridges and beach scarps that indicate that high water has been above recent levels during the past.

A number of old live oaks located on the slopes and tops of some of the berms could be used to indicate the age of the berm at positions above high water, but permits to cut these trees could not be obtained. Also some hydrophytic trees growing in places that are at times flooded were located, but likewise permission to cut them was not obtained.

Appendix

TREES AND SHRUBS AS RELATED TO SURFACE AND SOIL WATER

Hydrophytes (grow in flooded areas)

Scientific name	Common name
Betula nigra	river birch
Carya aquatica	water hickory
Cephalanthus occidentalis	buttonbush
Cyrilla racemiflora	titi
Fraxinus caroliniana	pop ash
Ilex cassine	swamp holly
Nyssa aquatica	tupelo gum
Nyssa ogeche	ogechee gum
Salix longipes	willow
Taxodium distichum	bald cypress

Facultative Hydrophytes
(grow in water or without surface water)

Scientific name	Common name
Acer rubrum	red maple
Baccharis spp.	grounsel bush
Celtis laevigata	hackberry
Fraxinus americana	white ash
Gordonia lasianthus	loblolly bay
Hypericum spp.	sand cypress
Liquidambar styraciflua	sweet gum
Magnolia grandiflors	magnolia
Magnolia virginiana	white bay
Myrica cerifera	wax myrtle
Nyssa sylvatica	black gum
Persea borbonia	red bay
Pinus eliotti	slash pine
Pinus serotina	pond pine
Planera aquatica	water elm
Quercus laurifloia	laurel oak
Quercus nigra	water oak
Sabal palmetto	cabbage palm
Sambucus simpsoni	elderberry
Serenoa repens	saw palmetto
Taxodium ascendens	pond cypress
Tilia floridana	basswood
Ulmus floridana	elm

Upland dry soil woody plants, not tolerating flooding
(a few of many)

Scientific name	Common name
Aesculus pavia	buckeye
Carya tomentosa	hairy hickory
Cornus florida	dogwood
Craetagus spp.	hawthorn
Diospuros virginiana	persimmon
Fagus grandiflora	beech
Ficus aurea	strangler fig
Liriodendron tulipifera	yellow poplar
Pinus palustris	longleaf pine
Prunus serotina	black cherry
Quercus cinerea	bluejack oak
Quercus laevis	turkey oak
Quercus prinus	basket oak
Quercus virginiana	live oak
Rhus copallinum	sumac
Viburnum spp.	haws

COMMON HERBS AND SOME SHRUBS OF LAKE LITTORAL ZONES, LOWER, MIDDLE, UPPER

LOWER, and some plants of MIDDLE if water lowered

Scientific name	Common name
Bacopa caroliniana	water hyssop
Cephalanthus occidentalis	buttonbush
Crinum aquaticum	swamp lilly
Cyperus spp.	umbrella sedges
Echinochloa crassipes	millet
Eleocharis spp.	spike rushes
Elodea densa	anacharis
Eriocaulon decangulare	pipewort
Gyretheca tinctoria	pink root
Hydrilla verticillata	anacharis
Hydrochloa caroliniensis	water grass
Hydrocotyle umbellata	water pennywort
Juncus spp.	rushes
Juncus repens	creeping rush
Leersia hexandra	cypress grass
Ludwegia palustris	false loosestrife
Mariscus jamaicensis	sawgrass
Panicum hemitomon	maiden cane
Panicum geminatum	panic grass
Paspalum dissectum	marsh grass
Paspalum vaginatum	marsh grass
Polygonum spp.	knotgrasses
Pontederia cordata	pickeral weed
Rhynchospora spp.	beak rushes
Sagittaria lancifolia	large flag
Scleria spp.	nut rushes
Scirpus californica	bullrush
Typha latifolia	cattail
Utricularia spp.	bladderworts

MIDDLE, and some plants of UPPER if water raised

Scientific name	Common name
Althernanthera philoxeroides	alligator weed
Centella repanda	coin weed
Cynodon dactylon	Bermuda grass
Dichondria carolinensis	pennywort
Dichromena colorata	white top sedge
Diodia virginiana	buttonweed
Eupatorium mikanoides	fennel
Fimbristylis autumnalis	rush
Fuirena hispida	umbrella rush
Hydrochloa caroliniensis	marsh grass
Hypericum cystifolium	sand cypress
Ludwegia acuata	false loosestrife
Myrica cerifera	wax myrtle
Panicum repens	torpedo grass
Pluchea foetida	fleabane
Sabatia elliottii	marsh pink
Sagittaria graminea	arrow-leaf
Sambucus simpsonii	elderberry
Spartina bakeri	switch grass
Stillingia aquatica	Queen's root

UPPER, and some plants of MIDDLE if water raised

Scientific name	Common name
Andropogon glomeratus	bushy broomsedge
Andropogon virginicus	broomsedge
Axonopus furcatus	carpet grass
Cyperus LeContei	nut grass
Digitaria serotina	crab grass
Eupatorium capillifolium	dog fennel
Hypericum fasciculatum	sand cypress
Serenoa repens	saw palmetto

References

Bishop, E. W., 1967, Florida Lakes, Division of Water Resources, Florida Board of Conservation, Tallahassee.

Kenner, W. E., 1961, Stage Characteristics of Florida Lakes, Information Circular no. 31, Florida Geological Survey, Tallahassee.

Knochenmus, D. D., 1967, Shoreline Features as Indicators of High Lake Levels, U.S. Geological Survey Professional Paper 575-C, pages C236-C241.