Annual Report on Research Project

CYPRESS WETLANDS FOR WATER MANAGEMENT, RECYCLING AND CONSERVATION

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*A companion project, South Florida Environmental Study, funded by the U.S. Department of the Interior and the Florida Division of State Planning extends these results to regional applications. Its final technical report will be ready in December and will be submitted as an appendix to this report.

PHASE 12. CORKSCREW SWAMP, A VIRGIN STRAND (SUBCONTRACT TO NATIONAL AUDUBON SOCIETY, INC.)

WATER BUDGETS AND COMPARATIVE STUDY OF VIRGIN CORKSCREW SWAMP.

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Site Description

The National Audubon Society's Corkscrew Swamp Sanctuary is a 4400 ha preserve located in southwest Florida approximately 50 km northeast of Naples. The sanctuary is in northern Collier County and southern Lee County. It occupies approximately 20 percent of Corkscrew Swamp, which originates near Immokalee and extends southwest for approximately 30 km. The swamp likes in a pine flatwoods region and is dominated by open marshes, cypress strands, and pine islands. The sanctuary includes large areas of marsh and cypress, and smaller areas of pine flatwoods. The sanctuary is known for having the largest stand of virgin bald cypress left in the United States.

Although the pine flatwoods and some of the cypress have been logged, cattle graze in portions of the marsh, and a few small areas have been developed for management of the sanctuary, much of the 4400 ha is still relatively undisturbed and inaccessible.

Preliminary Activities

Research in this area began in December 1973. Initial efforts were directed toward familiarization with the known aspects of the ecology of Corkscrew Swamp Sanctuary, the Big Cypress area, and south Florida. This involved contacting many agencies and individuals working in the area, reviewing the literature, and thoroughly surveying the sanctuary from both land and air. This permitted establishment of research priorities, which in turn determined the selection of sampling sites, equipment, and facilities. Although this aspect of the study is never-ending, in March 1974, the focus of our efforts shifted to providing year-round access to the selected sampling sites.

Intensive Study Areas

The study areas selected for intensive study were four transects. Their locations are shown in Figure 1; their choice was based on varying combinations of the following factors:

1. All were placed perpendicular to the main southwesterly water flow through Corkscrew Swamp Sanctuary;

2. They passed through or near a variety of habitats;

3. Some access to or along them already existed; and,

4. They would not interfere with other activities at the sanctuary.

The habitats crossed by the transects are listed in Table 1.

Grapefruit Island transect (approximately 1500 m) crosses the sanctuary just inside its northeast boundary. It originates and ends on islands dominated by pines and sabal palms, and follows an old road

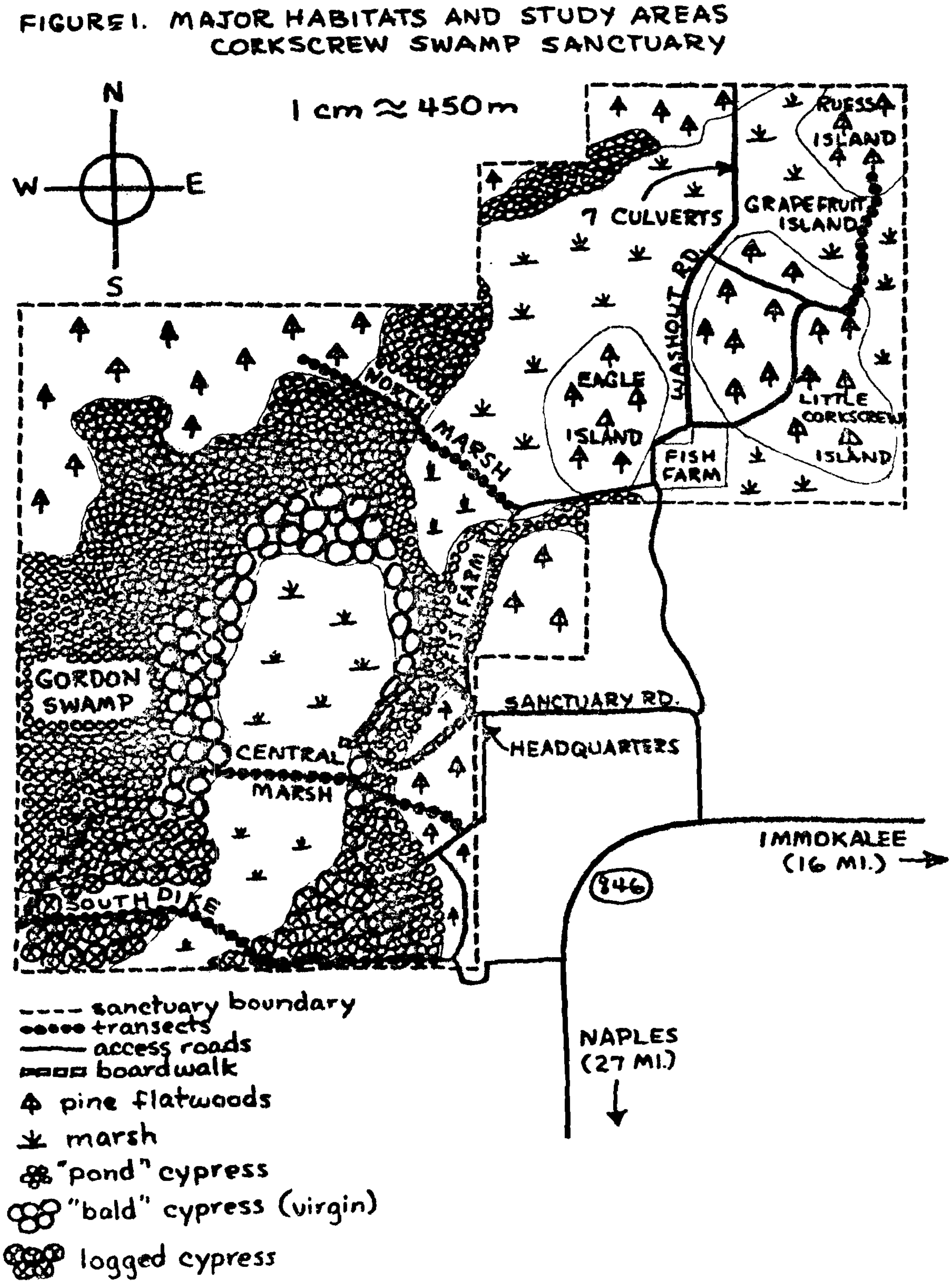

FIGURE 1
MAJOR HABITATS AND STUDY AREAS, CORKSCREW SWAMP SANCTUARY

TABLE 1
MAJOR HABITATS AND WELL SITES
ALONG THE CORKSCREW SWAMP SANCTUARY TRANSECTS

GRAPEFRUIT ISLAND

Pine-Palm Flatwoods*
Wet Prairie (mixed vegetation)
Palm-Oak Hammock
Wet Prairie (mixed vegetation)
Pine-Palm Flatwoods

NORTH MARSH

Willow Marsh
Wet Prairie (maidencane)
Wet Prairie (spartina)
Wet Prairie (buttonbush)
Freshwater Marsh (arrowhead)
Pond Cypress Swamp
Burned Pond Cypress Swamp
Pine Flatwoods*

CENTRAL MARSH

Pine Flatwoods*
Wet Prairie (wax mrytle)
Wet Prairie (mixed vegetation)
Maple Hammock
Pond Cypress Swamp
Bald Cypress Swamp
Willow Marsh
Sawgrass Marsh
Bald Cypress Swamp

SOUTH DIKE

Logged Bald Cypress Swamp**
Sawgrass Marsh**
Logged Bald Cypress Swamp**
Pond Cypress Swamp*

*Water level recorder
**Wells were located on both sides of the dike

through the intervening marsh dominated by spartina, maidencane, pickerel weed, and arrowhead (Figure 2). The transect passes near several sub-tropical hammocks and a permanent pond.

North Marsh transect (approximately 1900 m) crosses Corkscrew Swamp in the north-central part of the sanctuary. It begins at Fish Farm Road, passes west across a large pickerel weed-spartina-maidencane marsh, follows an old swamp buggy trail through a narrow cypress strand, and ends in the pine flatwoods (Figure 3). Water flows through marsh habitats, while just south of the North Marsh transect it enters the virgin cypress. Besides the undisturbed cypress habitat, this transect passes through a cypress forest that was severely burned approximately 15 years ago.

The Central Marsh transect (approximately 2100 m) originates just south of the sanctuary headquarters and extends across the swamp. The transect follows an old firebreak from the pine flatwoods through the wet prairie. The firebreak ends at the edge of the cypress, but the transect continues through the virgin cypress and across the sawgrass marsh, ending in the virgin cypress on the western side of the swamp (Figure 4).

The South Dike transect (approximately 6000 m) lies along the southern boundary of the sanctuary, and follows two old logging tramways which were connected by a dike to slow the flow of water leaving the sanctuary. This transect is similar to the Central Marsh, except that the cypress was logged 20-30 years ago and has been replaced by second-growth forest. Willow dominates the cut-over cypress habitat along the eastern side of the transect (which appears to have burned sometime in the past), while maple, willow, and some cypress dominate the western side (which does not show signs of fire).

Several other transects have been set up for less intensive work. One goes through Gordon Swamp along the western edge of the sanctuary where major flows of water leave, and another follows Washout Road where the major flow into the sanctuary is constricted to only a few points. As time permits additional sites will be selected for short term studies.

Climatology

There are relatively steep gradients of temperature and precipitation as one moves inland from the moderating influences of the Gulf of Mexico. This necessitated an understanding of these factors at Corkscrew Swamp Sanctuary. Studies of weather patterns are centered in the headquarters area which is equipped with the following instruments:

Hygrothermograph - provides a continuous record of temperature and relative humidity.

Rain gauge - measures total daily rainfall.

Recording Rain Gauge - provides continuous record of rainfall.

Evaporation Pan - measures total daily evaporation from an open water surface.

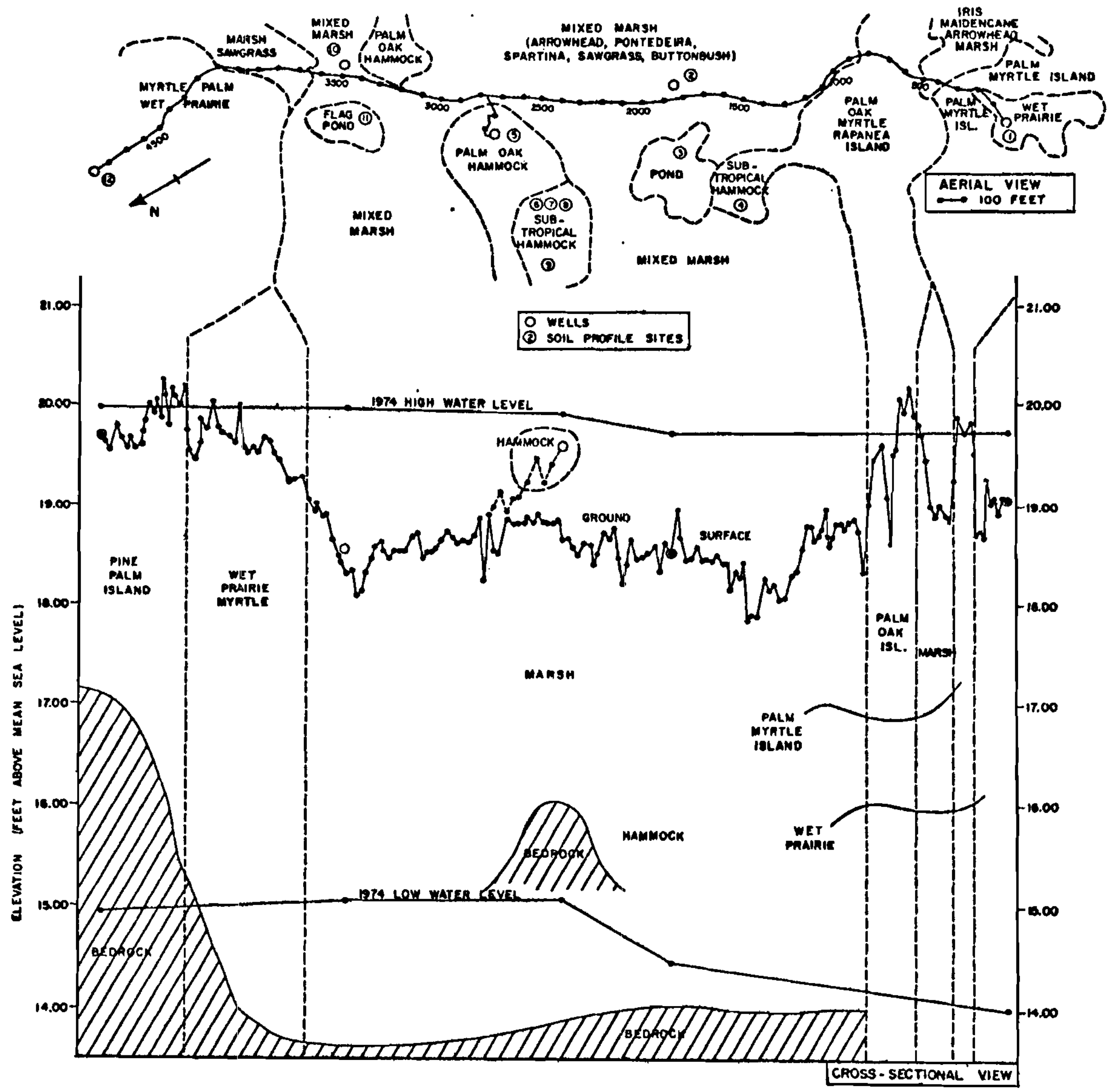

FIGURE 2

GRAPEFRUIT ISLAND TRANSECT, CORKSCREW SWAMP SANCTUARY

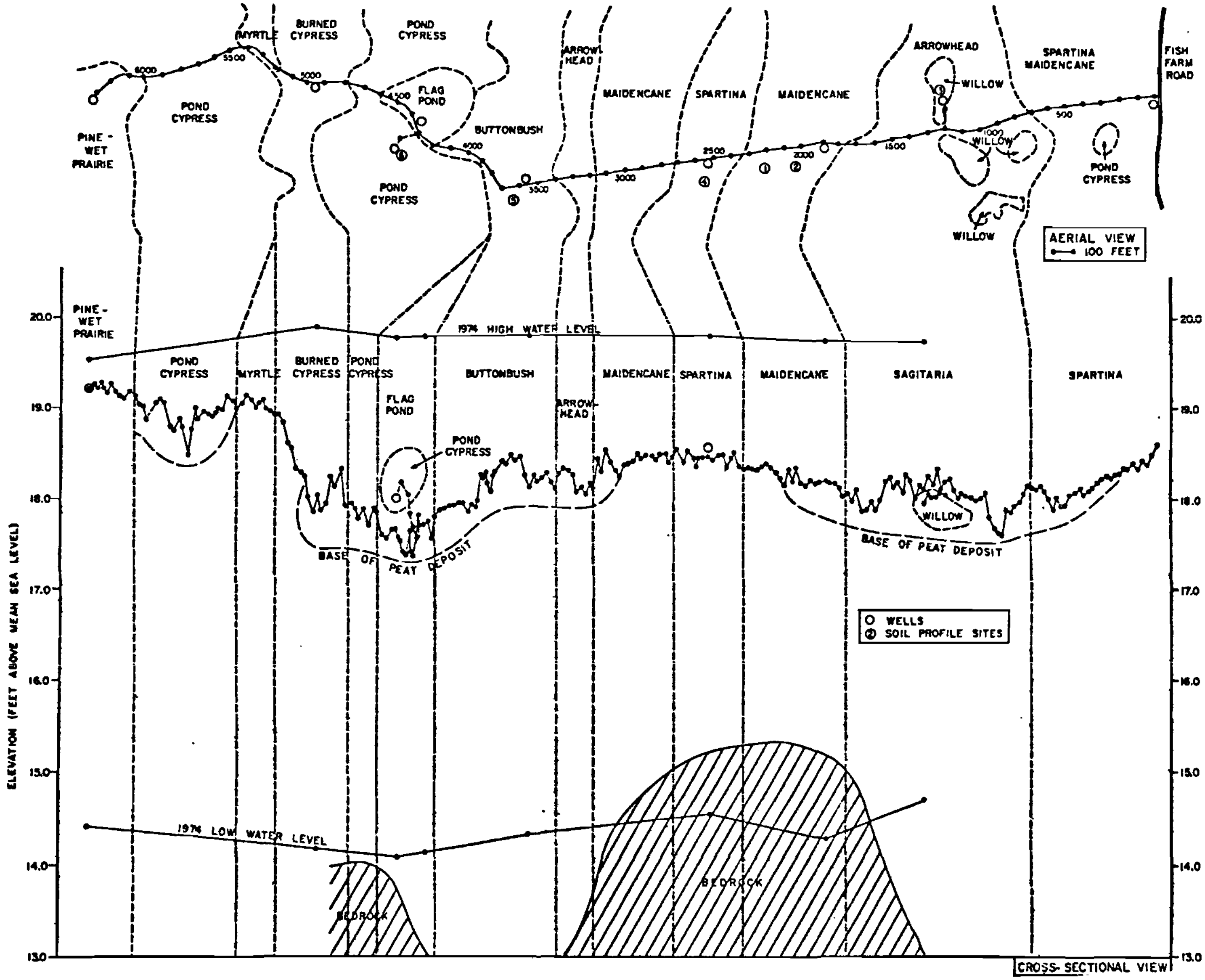

FIGURE 3

NORTH MARSH TRANSECT, CORKSCREW SWAMP SANCTUARY

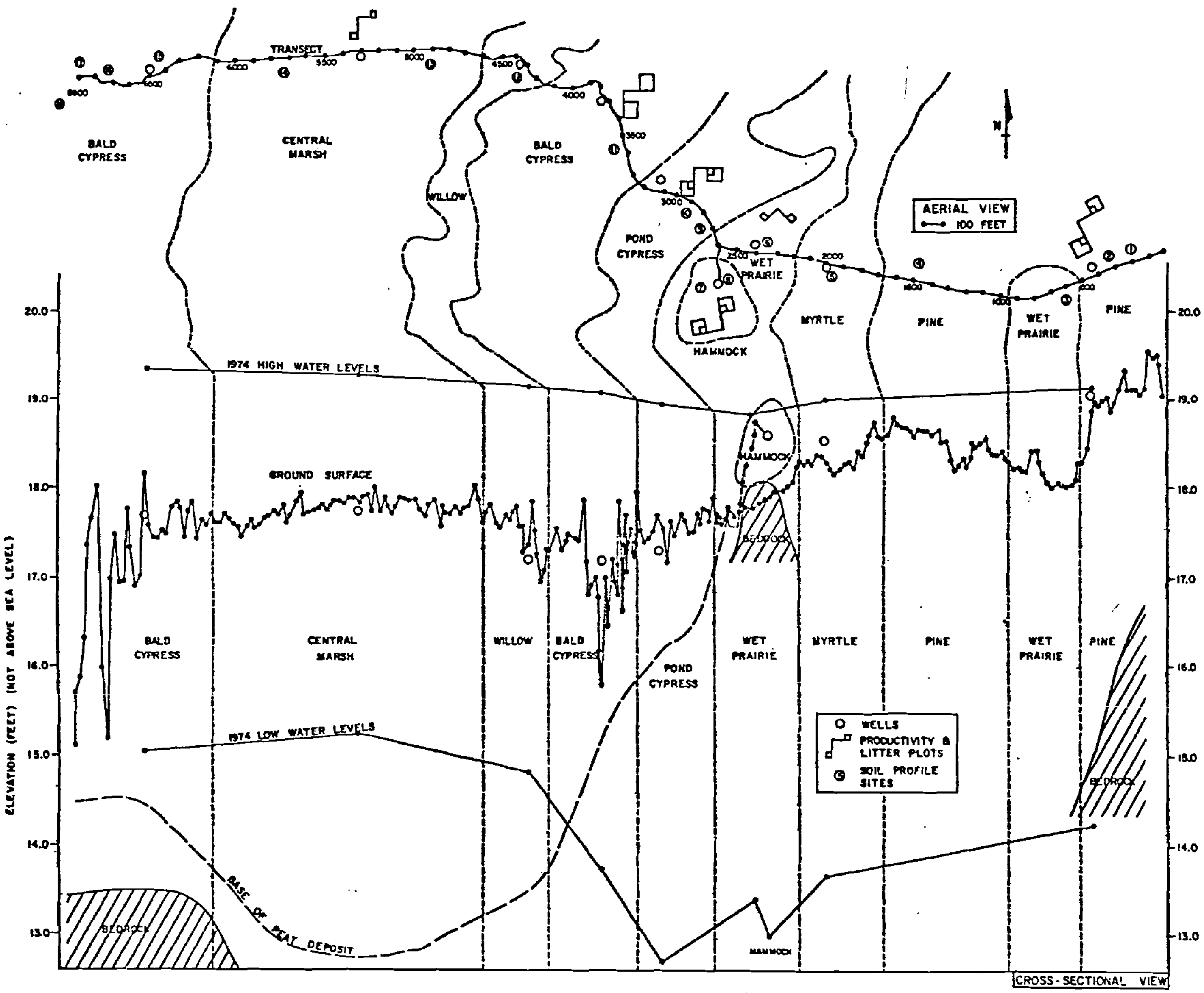

FIGURE 4

CENTRAL MARSH TRANSECT - CORKSCREW SWAMP SANCTUARY

Anemometer (near ground) - measures miles of wind over the evaporation pan.

Maximum and Minimum Thermometers - measures maximum and minimum daily temperatures.

Sling Psychrometer - measures relative humidity to provide a check on hygrothermograph.

In addition, recording rain gauges have been located on the Grapefruit Island, North Marsh, and South Dike transects, which provide a measure of precipitation in the northeast, northwest, and southwest portions of the sanctuary, respectively.

The headquarters weather station has been operational since mid-June, and the outlying rain gauges were installed around the first of July.

Data on solar radiation will be provided by Dr. Carlos Blazquez at the University of Florida Agricultural Experiment Station in Immokalee. He will also use our data in his studies of the relationship between micro-climate and plant diseases in southwest Florida.

We have gathered data from nearby long-established weather stations and will analyze it to supplement our short term data from the sanctuary. Weather measurements collected to date at the headquarters station are included in the Appendix.

Hydrology

Water is the major environmental influence determining the biological systems present in south Florida, and also strongly influences the physical and chemical cycles within these systems. While much information already exists on general flow patterns and water levels in south Florida, few studies have tried to relate these to natural environments, particularly in the Big Cypress area. Even less is known about water quality.

Therefore, we felt our first priority should be to obtain information on hydroperiods, depths of water above and below the land surface in different seasons, flows, and water quality in the major habitats found on the sanctuary. To provide such information we installed thirty water level stations along the prime transects during March and April 1974 (Table 1 and Figures 2-4). These wells were made of galvanized steel pipe driven into the ground and then flushed out. Twenty-five of these were 3.2 cm pipe and five were 10.2 cm pipe. Approximate depths of the wells varied from 1.5 to 5.8 m. They were set so as always to be below the water table, but still be as shallow and as close to the ground surface as possible. Some had to be set at depths greater than 3 m in order to provide a suitable well bed for pumping water quality samples. Water levels are monitored weekly at the 3.2 cm stations with a float and bobber arrangement, while water level recorders chart levels in the 10.2 cm stations. All thirty stations have been monitored weekly since April. The water level recorders were installed in early July.

To provide data for estimating flows into and out of the sanctuary, a number of staff gauges were installed in addition to the above water level monitoring program. Ground surface elevations at points of major inflow or outflow, such as road washouts and culverts or low-lying swamps or marshes, have been or will be determined. A pygmy current meter is used to relate the above water levels and ground profiles to flows and to determine a water budget for the sanctuary. Figure 5 indicates the positions where water flows are monitored in relation to the major flow pattern. Measurements at each of these positions were taken in September and October 1974 and will be continued throughout the year to obtain data for a wide variety of water level stages.

Data from two staff gauges in the virgin cypress near the headquarters area that have been monitored since the early 1960's will be used to extend the information from this study. One of these is located on a lettuce lake which is in one of the lowest areas in the sanctuary, and has only dried up during two of the last 14 years (Figure 6). Normal annual variation in surface water levels at this site is approximately one meter.

The 1974 dry season was unusually severe. Little rain fell from January to mid-May when the rainy season began to increase ground water levels. In late June a tropical depression dumped 27 cm of rain on southwest Florida and drastically increased water levels. Water levels became stable in July and remained so until mid-September when rains virtually ceased. Water levels then began a gradual decline which has continued through October.

In mid-April, water levels varied from approximately 25 to 125 cm below ground. By the time the rains came in mid-May, they had dropped to approximately 60 to 170 cm below ground (Figures 2-4). At this time, only a few man-made ponds and canals contained any water. Ground water levels began to increase in mid-May along the Grapefruit Island transect, but did not rise until early June in the southwestern part of the sanctuary. Water levels reached the ground surface over most of the sanctuary during the late June tropical depression. However, despite the 27 cm of rain that fell during the last week of June, water levels did not break the ground surface until a week later in Gordon Swamp. When rainy season water levels were stable from mid-July until mid-September, they varied from slightly below ground in some pine flatwoods to approximately 60 cm above ground in a North Marsh flag pond (Figures 2-4).

As expected, the upland habitats were consistently drier throughout the year than were marsh and cypress habitats (Figure 7). The marsh and cypress areas had a similar range of water levels during the dry season, but only the deeper marsh and shallower cypress habitats overlapped during the wet season. During the wet season, the willow sites had water depths similar to the deeper cypress and the flag pond occupied an area deeper than any other habitat (Figure 8). Water levels between April and September 1974 in the upland, marsh, and cypress habitats are shown in Figures 9, 10, and 11, respectively. In general, the variation between the individual sites within each group is small, compared to the seasonal variation of the group. Once exception is the division of the marsh sites into two components during the dry season, which appeared to

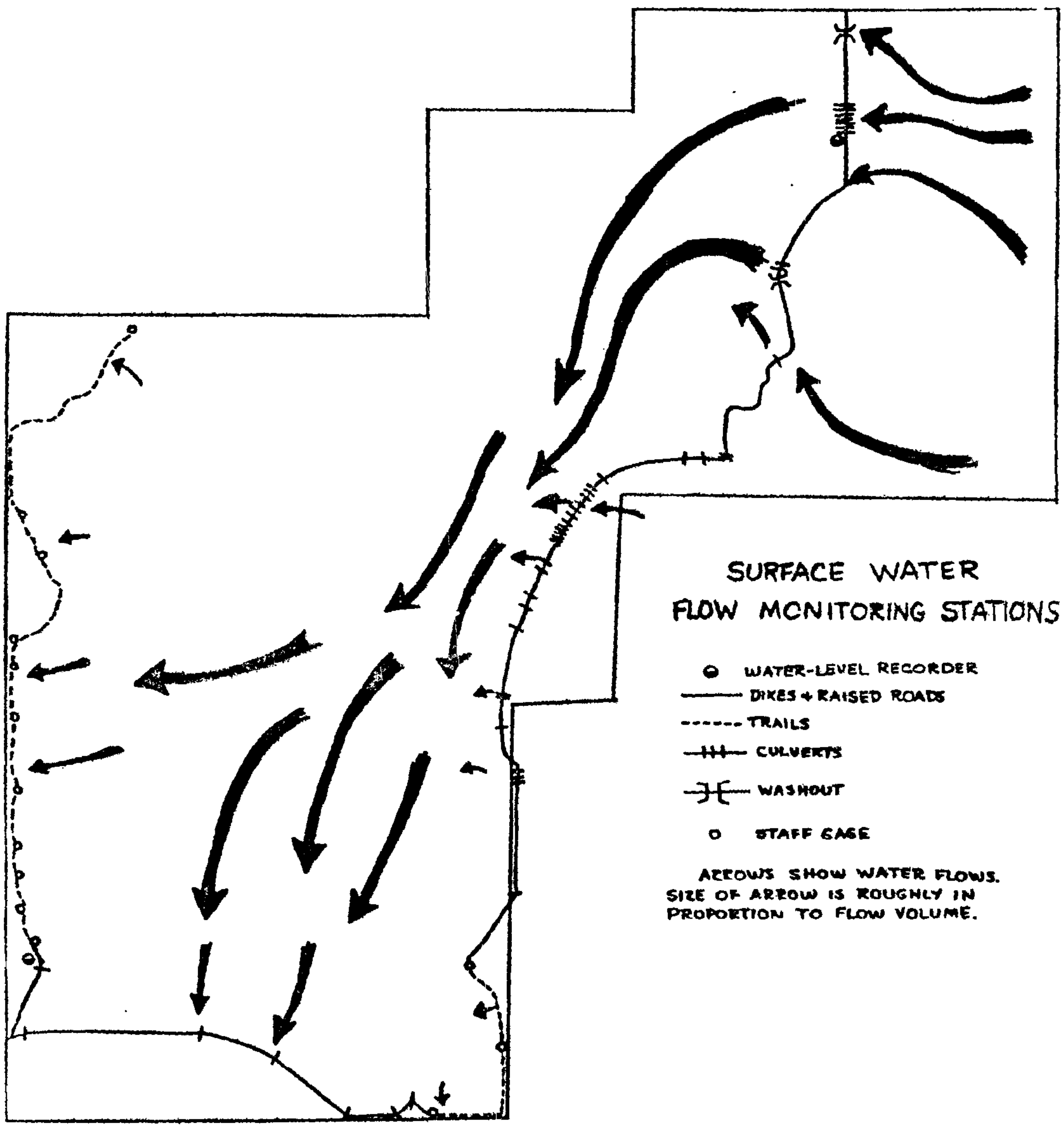

FIGURE 5
SURFACE WATER FLOW MONITORING STATIONS AT CORKSCREW SWAMP

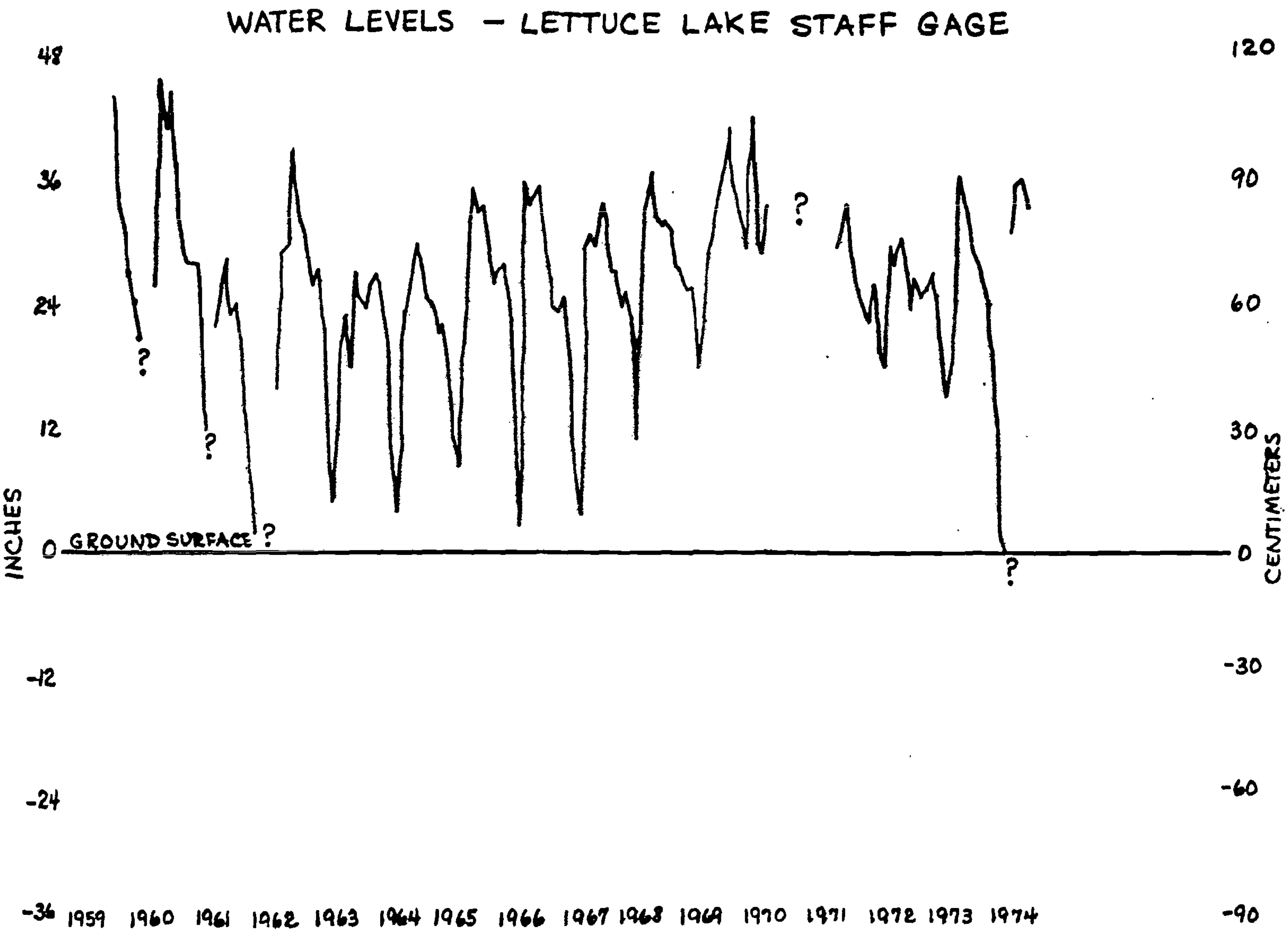

FIGURE 6
CHANGES IN THE WATER LEVEL AT LETTUCE LAKE

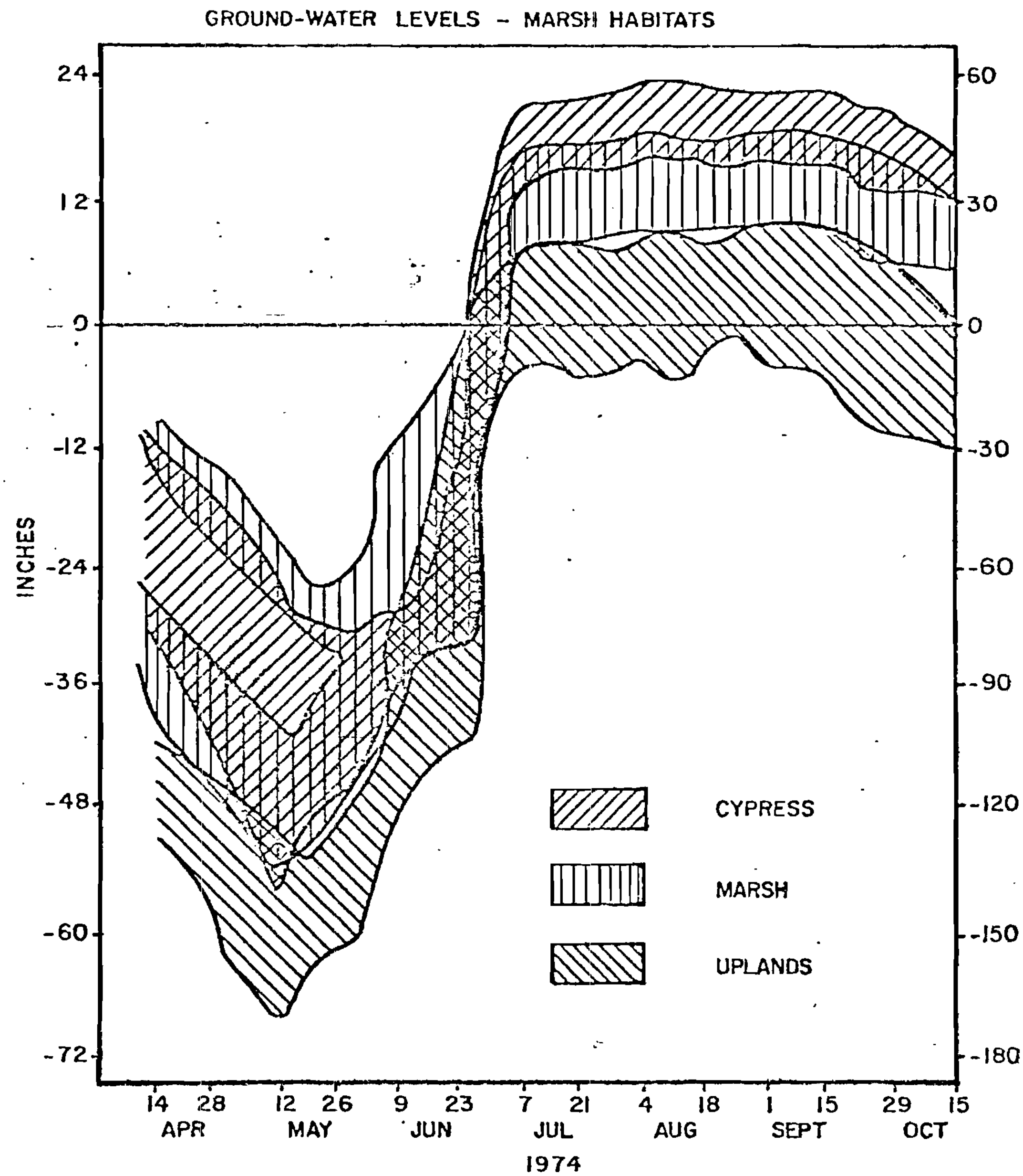

FIGURE 7
GROUND AND SURFACE WATER LEVELS

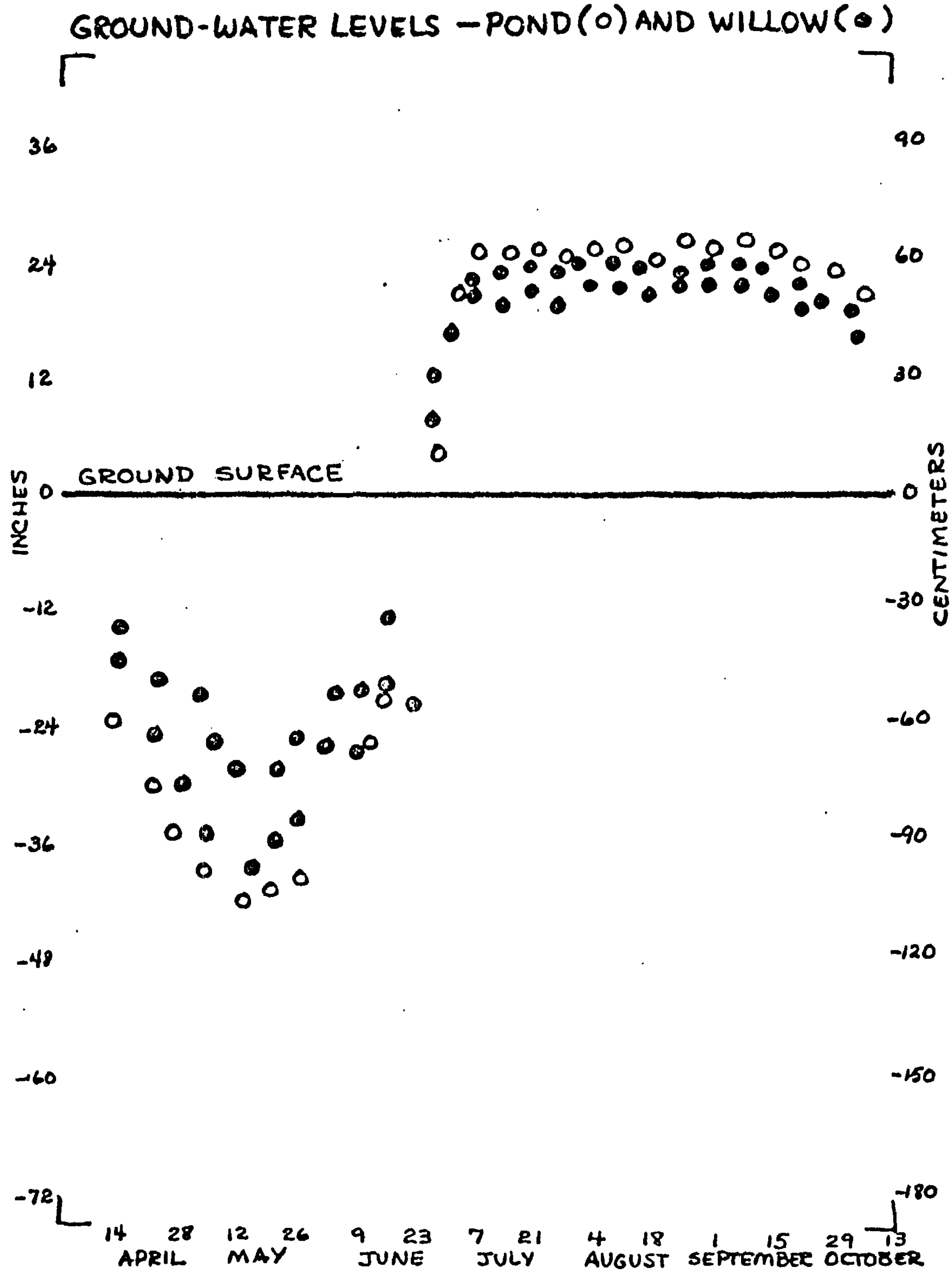

FIGURE 8

CHANGES IN GROUND WATER LEVELS AT THE POND AND WILLOW SITES

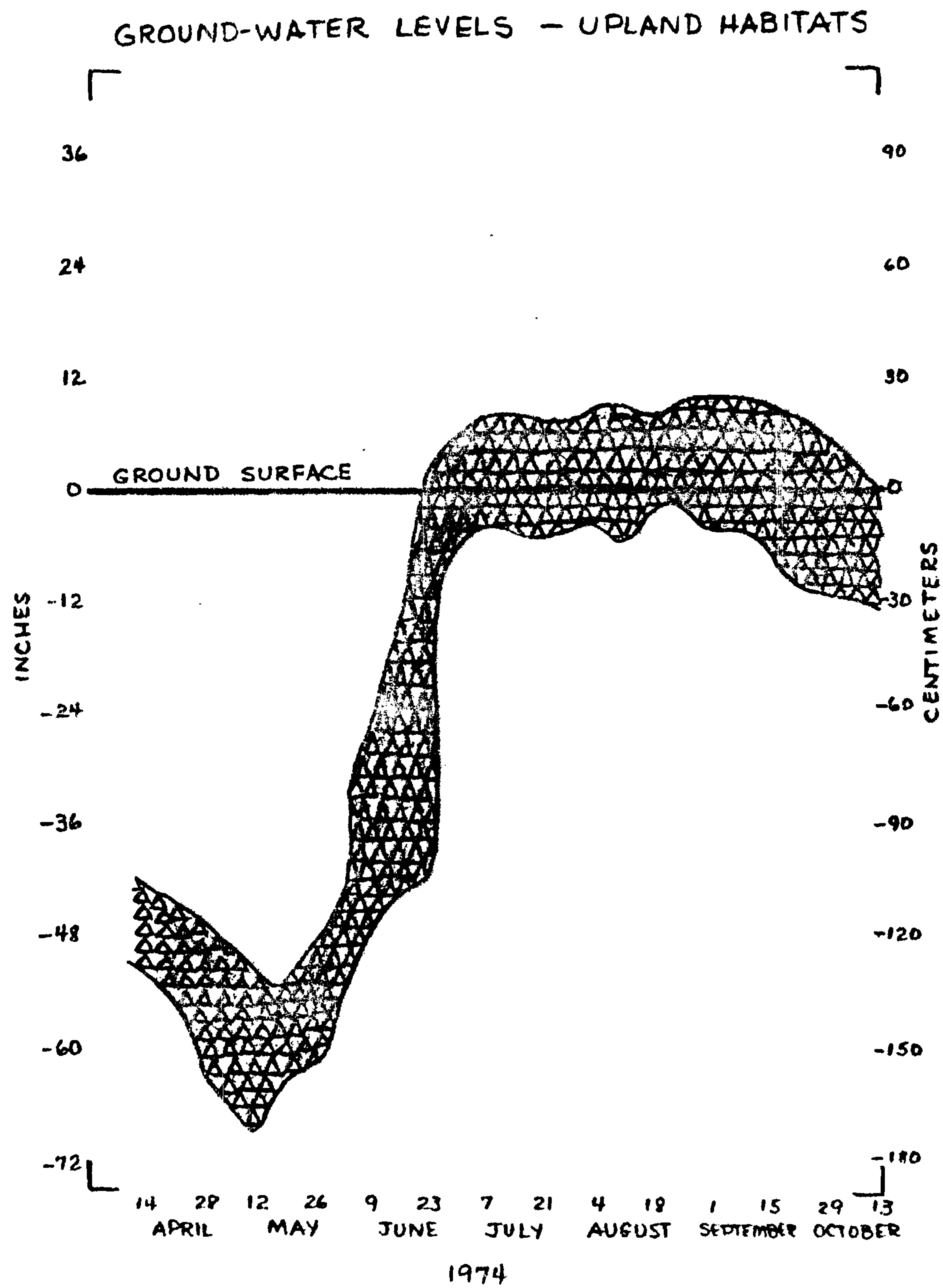

FIGURE 9
CHANGES IN GROUND WATER LEVELS AT THE UPLAND HABITATS

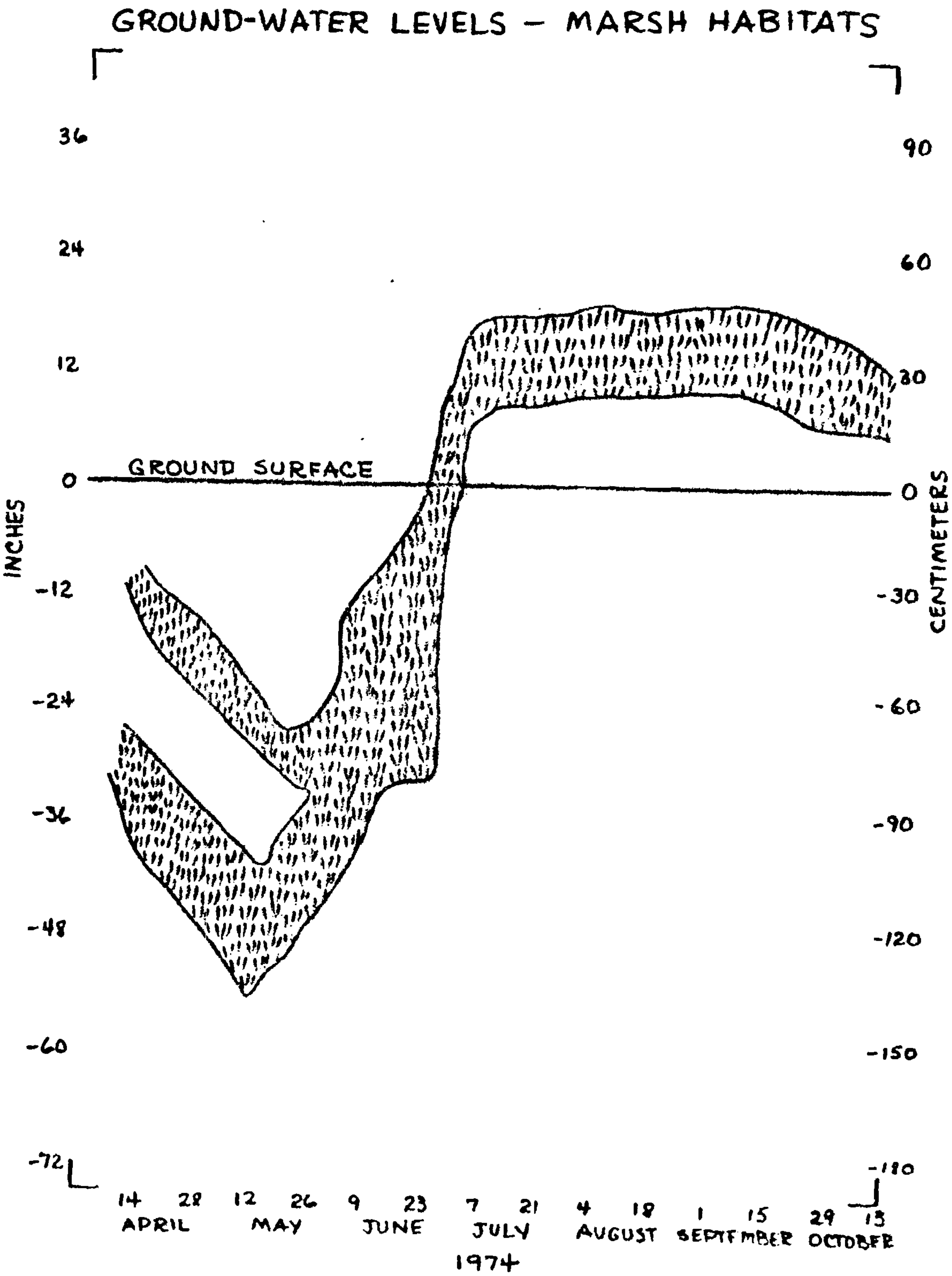

FIGURE 10
CHANGES IN GROUND WATER LEVELS IN THE MARSH HABITATS

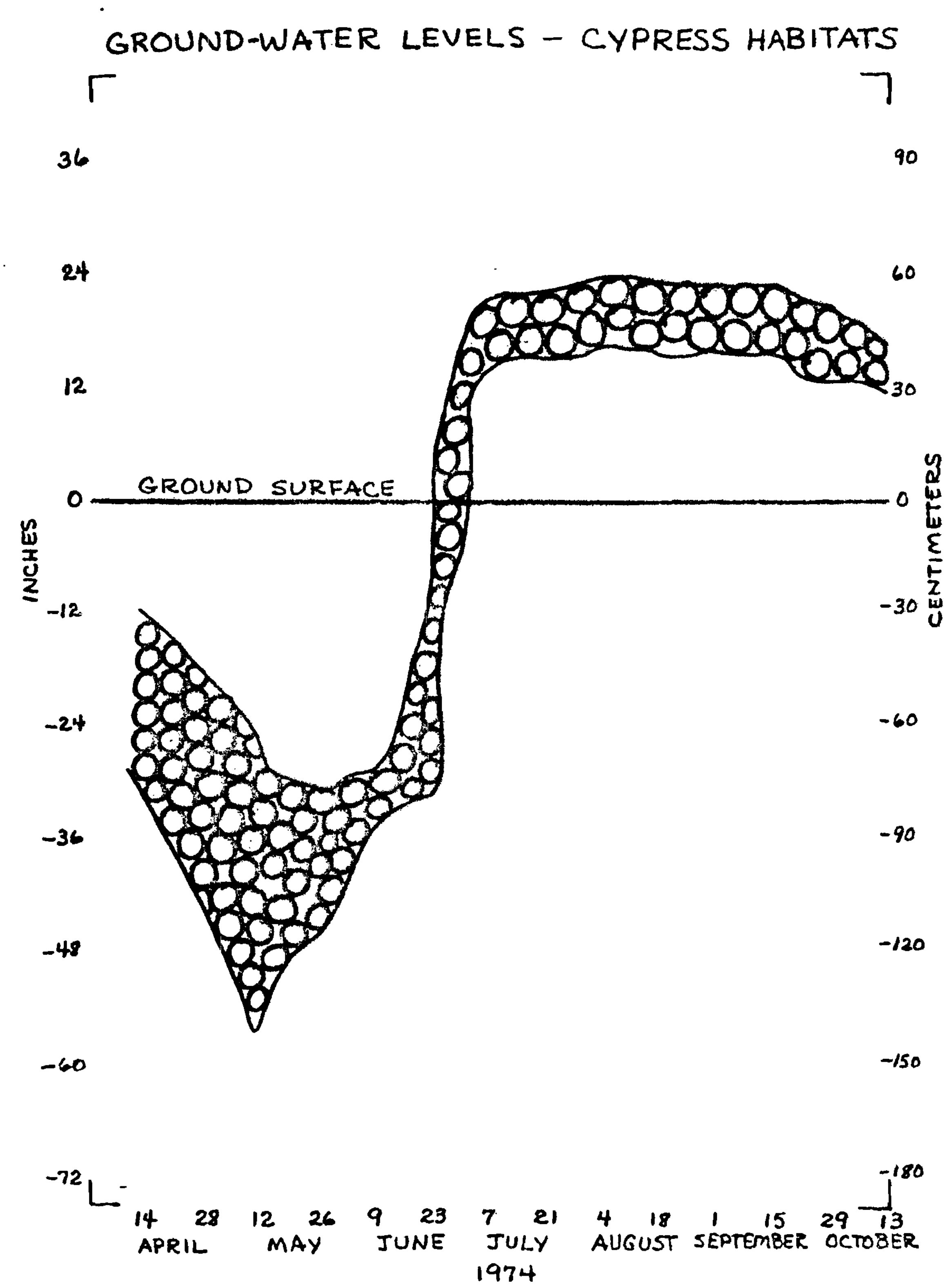

FIGURE 11
CHANGES IN GROUND WATER LEVELS AT THE CYPRESS HABITATS

TABLE 2
PRELIMINARY CHEMICAL ANALYSES
FOR FIVE WELLS AND TWO PONDS
CORKSCREW SWAMP SANCTUARY, APRIL 1974

VARIABLE ANALYZED	WELLS	PONDS*
pH	6.7 - 7.1	6.9 - 9.9
Conductivity (mhos)	760 - 1380	630 - 660
Turbidity (JTUs)	6 - 80	26 - 48
Total Kjeldahl nitrogen (mg-N/l)	0.9 - 5.7	2.5 - 5.7
NH_3 (mg-N/l)	0	0.28 - 1.96
NO_3 (mg-N/l)	0.01 - 0.28	0.01
Ortho-P (mg-P/l)	0.025 - 0.145	0.130
Total P (mg-P/l)	0.06 - 0.24	0.40 - 0.44

*Ponds were greatly reduced from their normal levels and contained dense concentrations of living organisms as well as the remains of many that had died.

TABLE 3
SURFACE WATER QUALITY DURING OCTOBER 1974

	DISSOLVED OXYGEN	ALKALINITY	HARDNESS	pH	NUMBER SAMPLES
UPLAND					
Pine	5.6 - 7.6	35	70	6.7	2
Hammock	2.2	105	120	6.5	1
MARSH					
Marl Prairie	7.0	205	240	8.5	1
Wet Prairie	5.2 - 7.2	85 - 120	85-120	6.9 - 8.0	2
Spartina	7.0	135	155	7.0	1
Mixed Marsh	5.2	120	135	7.0	1
Sawgrass Marsh					
Above Dike	2.2	120	120	6.5	1
Morning	0.0	105	105	6.1	1
Afternoon	2.2				1
Below Dike	0.0	255	240	7.2	1
CYPRESS					
Cypress (peat soil)	1.4 - 4.0	105 - 155	105 - 155	6.5 - 7.6	6
Cypress (sand soil)	5.2 - 716	105 - 135	120 - 135	7.5 - 7.8	3
Scrub Cypress (Marl)	10.8 - 14.6	135	135 - 155	8.7 - 9.2	2
Cutover Cypress					
Above Dike					
Morning	0.0 - 0.4	105	105	6.5	2
Afternoon	1.6 - 2.6				2
Below Dike	0.2 - 1.6	135 - 205	120 -205	6.5 - 6.7	2
Burned Cypress	4.4	120	105	6.7	1
Willow	3.0	135	135	7.3	1
PONDS					
Cypress (open water)					
Top	1.6	105	120	6.6	1
Bottom	0.8	105	120	6.6	1
Marsh (Emergent vegetation)	3.4	120	135	6.7	1
CANALS	4.8 - 7.6	105 - 135	105 - 155	6.7 - 7.6	3

TABLE 4
WATER QUALITY FROM WELL SAMPLES IN OCTOBER 1974

	ALKALINITY	HARDNESS	pH	NUMBER SAMPLES
UPLAND				
Hammock	445	375	7.0	1
MARSH				
Wet Prairie	600	220	6.9	1
Spartina	480	445	7.0	1
Mixed Marsh	735	495	7.2	1
Sawgrass Marsh			6.8	1
Above Dike	290	240	6.7	1
Below Dike		255	7.2	1
CYPRESS				
Pond Cypress	495 - 530	360 - 515	6.7 - 7.0	2
Bald Cypress	565	460	6.8	1
Cutover Cypress				
Above Dike	255 - 515	190	6.7	2
Below Dike	375	255	7.5 - 8.5	2
Burned Cypress	720	615	6.7	1
Willow	515	530	6.6	1
POND				
Marsh	480	495	7.0	1

be correlated with differences in the soils. The wetter sites were situated on deep peat deposits, while the drier sites had sandy soils containing little organic matter. Water level fluctuations from the peak of the dry season to the peak of the wet season varied approximately 120-180 cm depending on the habitat, although it must be remembered that this was an exceptionally dry year.

A number of preliminary water quality analyses have been made on surface and ground waters in the sanctuary. One set of seven samples was collected by Mr. William J. Mitsch from five wells and two surface water sites in April 1974 when most of the surface waters were confined to isolated ponds and canals. These samples were analyzed by Dr. Brezonik's lab at the University of Florida and give us an idea of concentrations of several important nutrients in the sanctuary (Table 2).

The other set of samples, from a variety of locations around the sanctuary, was taken during October 1974 when water levels were just beginning to drop from their high wet season levels (Tables 3-4). This has given us an idea of variability of water quality on the sanctuary which will permit the selection of representative sampling sites for more detailed monthly analysis of the nutrients listed in Table 2. Additional parameters may be monitored on a quarterly basis, but this has not yet been worked out.

In general, the results of the October sample analyses indicate large differences in water quality between surface samples and ground water samples from the wells. Alkalinity varied from 35 to 255 ppm for surface values as compared to 255 to 735 ppm for well samples; surface water hardness varied from 70-240 ppm as compared to 190-615 ppm for well samples; and pH varied from 6.1 to 9.2 as compared to 6.6 to 8.5. The higher alkalinity and hardness values in the ground water resulted from their association with the underlying mineral soils, and less dilution from rainfall. The pH values were more variable on the surface waters, primarily as a result of biological activity.

Dissolved oxygen concentrations in surface waters varied primarily in relation to the type of substrate in a habitat. Habitats with peat soils generally maintained low concentrations of less than 5 ppm, with values approaching 0 ppm in the early morning hours. Sandy soils supported environments with dissolved oxygen concentrations of approximately 5 to 8 ppm, while marl environments had oxygen levels in excess of 7 ppm, some reaching over 14 ppm in late afternoon. Obviously this pattern of oxygen concentrations is related to biological activity or decomposition in the low oxygen peat environments and high photosynthetic rates in the marl environments.

Alkalinity values normally ranged from about 100 to 160 ppm in surface waters. A lower value of 35 ppm in the pine was probably due to rainfall being the direct source of this water. Higher values of 200-250 ppm were found in the marl habitats or in water derived from ground water sources (such as that flowing under the south dike).

Hardness showed a similar pattern of values to alkalinity for similar reasons.

Surface waters in marl environments maintained high pHs, with a range of 8.5 to 9.2. Other habitats generally were within a range of 6.5 to 8.0.

Soils

Dr. Charles L. Coultas from Florida A & M University in Tallahassee conducted a preliminary survey of the soils on the Grapefruit Island, North Marsh, and Central Marsh transects in late May 1974. His comments on the soil profiles along these transects are included in the Appendix and shown in the cross-sectional views of the transects in Figures 2-4. Also included in this Appendix are comments on soils in two nearby domes visited by Dr. Coultas. Table 5 shows the results of more detailed analyses done on samples from several cypress and marsh sites in the sanctuary.

This survey and comments from Mr. Alvin Hester, our well driller, indicate that sand is the dominant soil material down to 2 m throughout the sanctuary. Shell beds occur sporadically and limestone bedrock was encountered in a few locations. The limestone was normally associated with hammocks or pine-palm woodlands, although some areas of marsh are shallowly underlain by limestone. Organic matter generally contributed little to the soil profile, except in depressions, flag ponds, willow-heads, and cypress, particularly the large virgin cypress. The depressions normally had less than 30 cm of peat, but in the large virgin cypress and sawgrass-dominated Central Marsh it reached a depth of at least 2 m. Typically peat was shallowest at the edge of a depression and deepest at its center.

Figure 12 shows the profile of a test well drilled at the fish farm and gives an idea of the deeper strata underlying the sanctuary.

Mr. Peter Stone from the Central and Southern Flood Control District sampled the peat deposits in the virgin cypress and expressed an interest in working out the historical sequence of vegetation types there on the basis of the remains in the peat.

More work on soil profiles will be done in order to analyze in greater detail soil patterns in relation to habitat types. Samples collected during this program will be used for nutrient analyses.

Vegetation

We plan to describe the major vegetative communities on the basis of dominant species composition, biomass, chemical composition, and productivity. The dominant species composition and biomass information will be obtained from sites along the transects near the wells once during the winter dry season and again during the summer wet season. It is feasible to obtain data on root biomass during the dry season. Chemical analyses will be conducted on vegetation obtained during the biomass sampling program.

TABLE 5
CHARACTERISTICS OF SEVERAL SOIL SAMPLES
FROM CORKSCREW SWAMP SANCTUARY

SITE	DEPTH	% SULPHUR	% ORGANIC MATTER	pH**
Central Marsh:				
Cypress	10-20"	0.70	89.2	6.0
	24-40"	0.21	5.5	6.2
Sawgrass	0-24"	0.48	88.2	6.5
	24-48"	1.46	84.4	6.3
North Marsh:				
Cypress	6-18"	0.03	2.3	7.0
	24-34"	0.04	0.8	7.3
Maidencane	0-6"	0.2	8.5	7.3
	6-12"	0.3	0.9	8.0
	12-18"	0.2	0.5	8.1

*Ignition at 400-450°C.
**pH - 1:1 Soil: Hzo

A preliminary list of the plants found in the vicinity of the wells along the prime transects is included in the Appendix. At the time the list was made, October 1974, the dry season had begun and the water table was receding. Many sites which had been submerged were newly emerged and the plant communities at these sites were in a state of transition.

Productivity estimates will be based on bimonthly samples of herbaceous vegetation and twice-a-year measurements of growth of shrubs and trees in six habitats along the Central Marsh transect: pine, wet prairie, hammock, pond cypress, bald cypress, and sawgrass marsh. In each habitat a 100 m transect has been set up, along one side of which five m^2 herbaceous plant samples are taken bimonthly. The results from the first set of these samples are shown in Table 6. Shrub and tree growth will be monitored in plots along the other side of the transect. This phase of the study is presently scheduled for December.

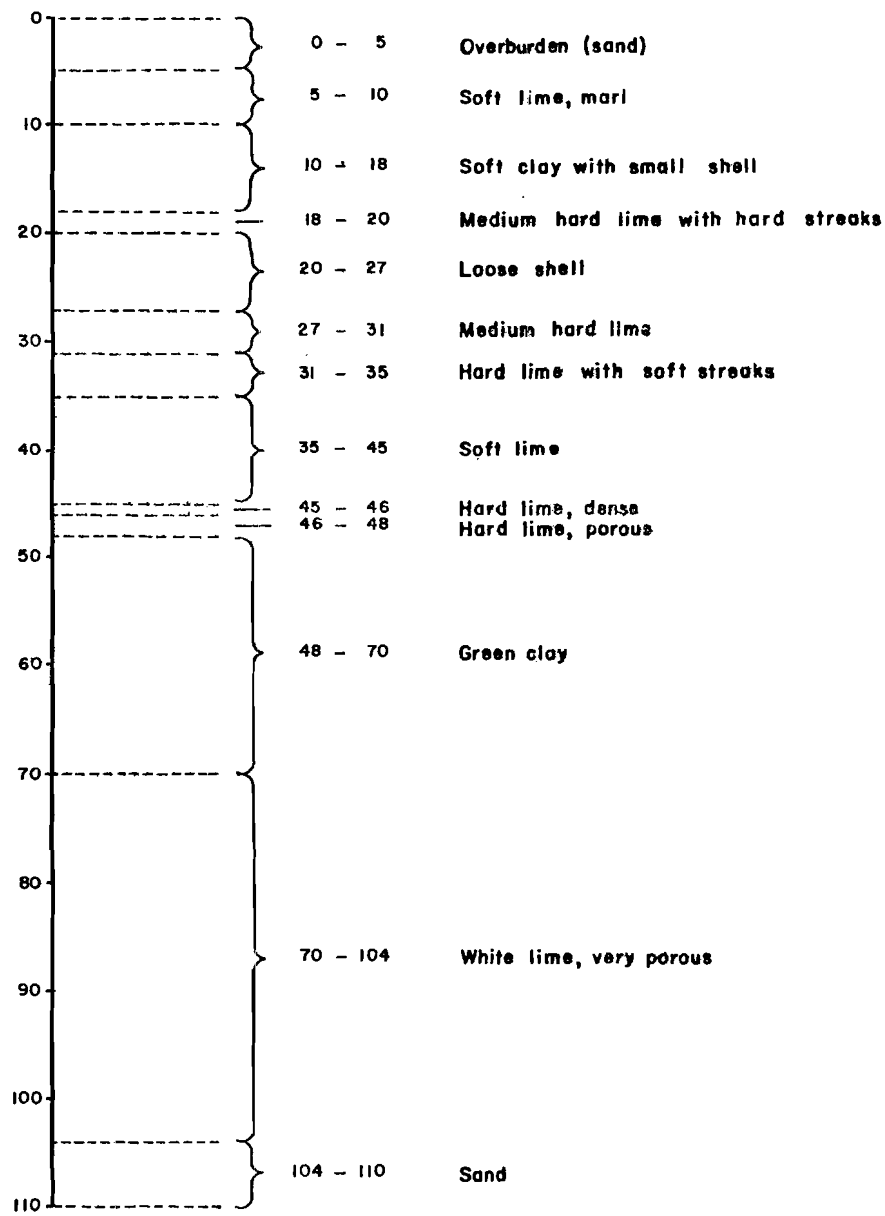

FIGURE 12

SOIL PROFILE FROM A TEST WELL DRILLED AT THE FISH FARM, CORKSCREW SWAMP SANCTUARY

TABLE 6
STANDING CROP OF UNDERSTORY VEGETATION
(dry wt. g/m^2) IN THE PRODUCTIVITY PLOTS

DATE	SAWGRASS MARSH	BALD CYPRESS	POND CYPRESS	HAMMOCK	WET PRAIRIE	PINE
9/1/74	763±156	182±124	71±30	23±9	150±19	134±27

Values are means ± S.E. for five 1m^2 plots in each habitat.

In addition to determining the hydrological and soil characteristics associated with the major vegetative communities, we are also measuring topographic relief to the nearest 0.3 cm at 7.6 m intervals along the transects. This has been completed for the Central Marsh, North Marsh, and Grapefruit Island transects, and the results are shown in Figures 2-4. This will also be done for other selected sites where a number of habitats exist in close proximity to one another.

We are also trying to obtain copies of aerial photos of the sanctuary from the mid-1940's and at five to ten year intervals to the present. From these we may be able to estimate rates of vegetation change and relate them to major events during the period, such as logging of the Big Cypress, opening of the Golden Gate Canal just to the south of the sanctuary, and construction of the South Dike (an attempt to offset the effects of the Golden Gate Canal).

Another aspect of our studies is the use of tree-ring analyses to explain the sequence of plant community development. This may also provide insight into long term hydrological patterns on the basis of the relative width of the tree rings in successive years. We are using a 40 cm increment borer to take cores, which are then mounted, sanded, and lightly stained for analysis under a microscope. In April 1974, we began coring cypress on the Central Marsh transect to determine their age distribution and to see if there was a correlation between diameter and age. Every 30 m along the transect we used the quadrant method to select the trees for coring. We then marked the trees, measured their DBH, and by June had completed coring all of the trees less than 80 cm DBH. In May 1974 a fire land was constructed along the western boundary of the sanctuary. To gain information about cypress ring formation and tree-to-tree variability, we cut a slab about breast height from the closest downed tree at 60 m intervals along the fire lane. Preparation of these slabs and some recently obtained from the domes near Gainesville is now in progress. Future tree-coring plans include: 1) large virgin slash pine; 2) dwarf cypress; 3) the larger cypress along the Central Marsh transect (when a longer increment borer is obtained); and 4) cypress and pine in mixed forests. We are cooperating with Dr. Frank C. Craighead, Sr. on the study of the pine-cypress sites, as well as on other aspects of our work.

Although no specific studies are planned, we also hope to evaluate the effects of fire logging, cattle grazing, impoundment, and drainage on sanctuary habitats.

Litter

We are monitoring seasonal variation in standing crop of litter at the six productivity sites along the Central Marsh transect. The litter at each site is sampled bemonthly from five 1-m^2 plots along the 100 m productivity transects. Sampling began in early September (Table 7).

Six 1-m^2 litterfall boxes were placed in the tree plots along each of the four productivity transects having more than just understory vegetation. The boxes were activated in late September, and the results from the first two biweekly samples are shown in Table 8.

We are measuring decomposition rates of litter at the six productivity sites with 40 x 45 cm bags made of fiberglass window screening. In October, litter was collected at each site, placed in the bags, dried, weighed, and returned to the site from which it originated. Four bags from each site will be collected quarterly for a year. This set of litter bag data will provide information on decomposition rates of litter available during the wet season. A second set of litter bags will be filled in April with litter available during the dry season to determine if there is any significant difference in the decomposability of litter on the ground at different times of the year.

To measure the effect of water depth on litter decomposition rates, we placed litter bags containing cypress litter at four positions in a lettuce lake along the Central Marsh transect; permanently dry, lake bottom, and two intermediate depths. Four bags will be collected quarterly from each position for a year.

Chemical analyses will be conducted on litter obtained from the litter-fall boxes, and decomposition bags.

Animals

We are cooperating with Mrs. Joan A. Browder in the collection of fish samples from a pond and marsh system near the Grapefruit Island transect. Sampling began in May 1974. Weekly samples are taken in a permanent pond and at marsh stations 600 and 1200 ~~meters~~ from the pond.

Models

The models being developed to describe the environmental interactions at Corkscrew Swamp Sanctuary are shown in Figures 13 and 14. These have been redrawn in energy flow language by William J. Mitsch in Figures 15 and 16. The major components of the system in Figures 13 and 15 include upland sites at the higher elevations, Cypress at the lower elevations and marsh lands at intermediate elevations. Outside sources to all three components include sunlight, rainfall, and deposition of airborne nutrients. Surface water and inflows and their associated nutrients enter the sanctuary primarily through the marshes. Marshes also receive inputs from upland habitats, while cypress receives terrestrial inputs only from the marshes. Factors that modify the undisturbed condition of the

TABLE 7
STANDING CROP OF LITTER (dry wt. g/m^2)
IN THE PRODUCTIVITY PLOTS

DATE	SAWGRASS MARSH	BALD CYPRESS	POND CYPRESS	HAMMOCK	WET PRAIRIE	PINE
9/1/74	864±160	1548±805	1470±304	937±125	1226±797	455±87

Values are means ±S.E. for five 1 m^2 plots in each habitat

TABLE 8
DRY WEIGHT (g) OF LITTER COLLECTED IN LITTERFALL BOXES (m^2)

DATE	DAYS	BALD CYPRESS	POND CYPRESS	HAMMOCK	PINE
10/5/74	13	26.8±4.4	50.1±4.9	82.2±13.5	6.4±1.8
10/18/74	13	15.1±3.2	27.0±2.8	65.7±6.2	2.7±1.0

There were six boxes in each habitat. Collections began 9/22/74. Values are means ±S.E.

major habitats are logging, fire, cattle, impoundment, and drainage. There are also losses from the system to ground water on beyond the boundaries of the sanctuary.

In addition to the general model for the sanctuary, several submodels are under development (Figures 14 and 16) to describe the functions of the major environments considered in the general model. Five components are included in the submodels with primary emphasis on surface water, vegetation, and litter. The animal component will receive the least emphasis because of the complex problems involved in dealing with it, considering the time available, and its relatively minor role in hydrological and nutrient cycles.

Again, sunlight, rainfall, nutrients, and surface waters (where appropriate) are the major inputs affecting the surface water and to a lesser extent the vegetation components of the systems. Surface waters in turn modify the vegetation, animal, and litter components. Vegetation has important inputs to animal and litter components, while deriving nutrients and water from the surface water and soil components. Animals are supported by the vegetation, surface water, and litter components as a function of their position in the trophic structure of the system. They represent a relatively minor source for the litter component. Litter has significant inputs to the animal and soil components, while deriving inputs from surface waters, plants, and animals. Sources for the soil component are primarily from subsurface materials, and to a lesser extent from the litter, and input from the soils are to the plant and surface water components.

Each of the major system components and pathways are scheduled to be determined. It will be possible to measure source directly such as rainfall, sunlight, and biomass, while others are measured indirectly or by difference such as the movement of litter to animals or soils, or the movement of vegetation to animals or litter, or the input of subsurface materials to soils.

Another factor to be considered in the submodels is the change in a system that is responding to perturbations by fire, logging, etc. These perturbations would significantly modify the status of one or more components, which would then be expected to respond to the modification by successional processes that would return the system to its original status.

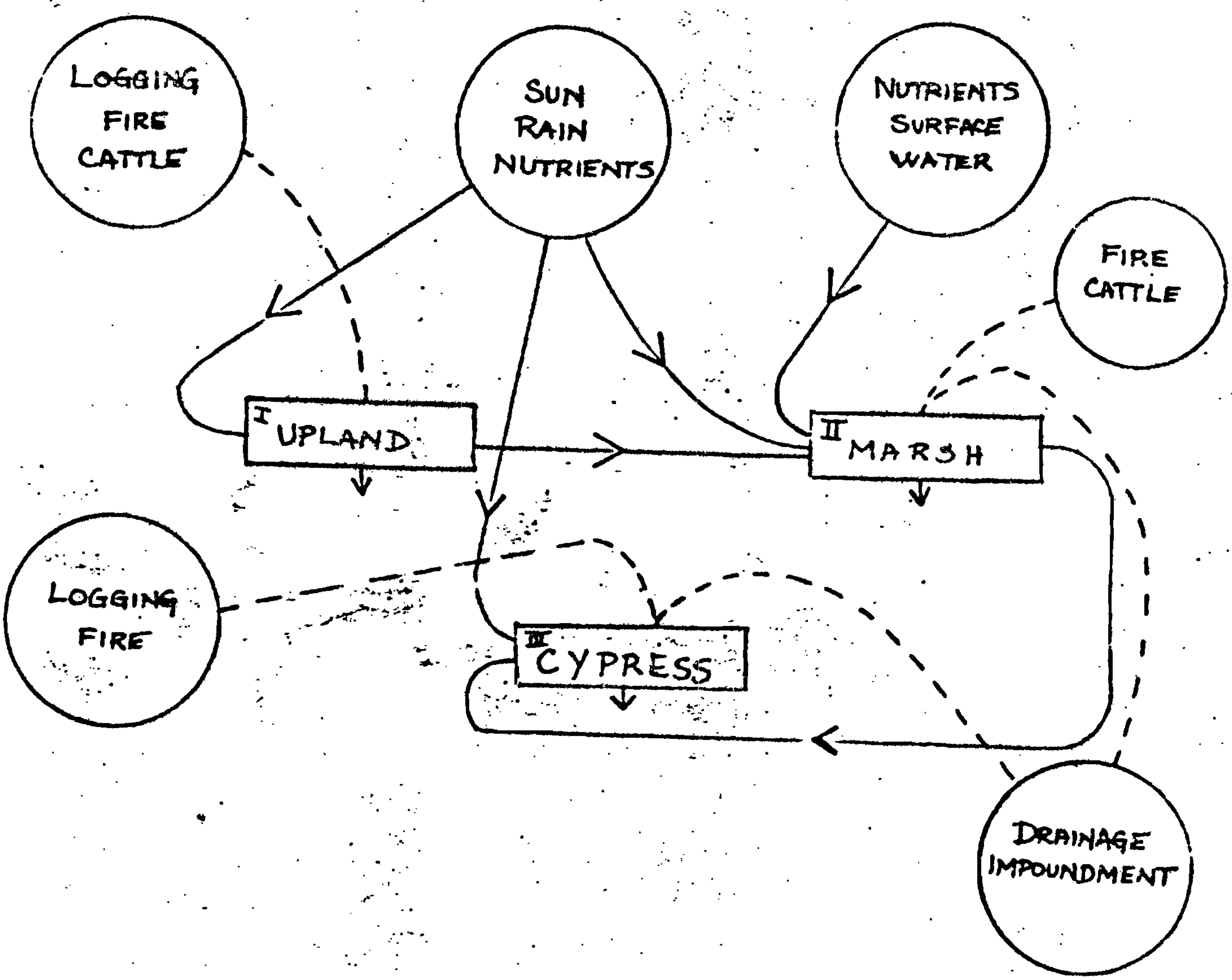

FIGURE 13

MODEL FOR CORKSCREW SWAMP SANCTUARY.

MODEL OF CORKSCREW SWAMP SANCTUARY

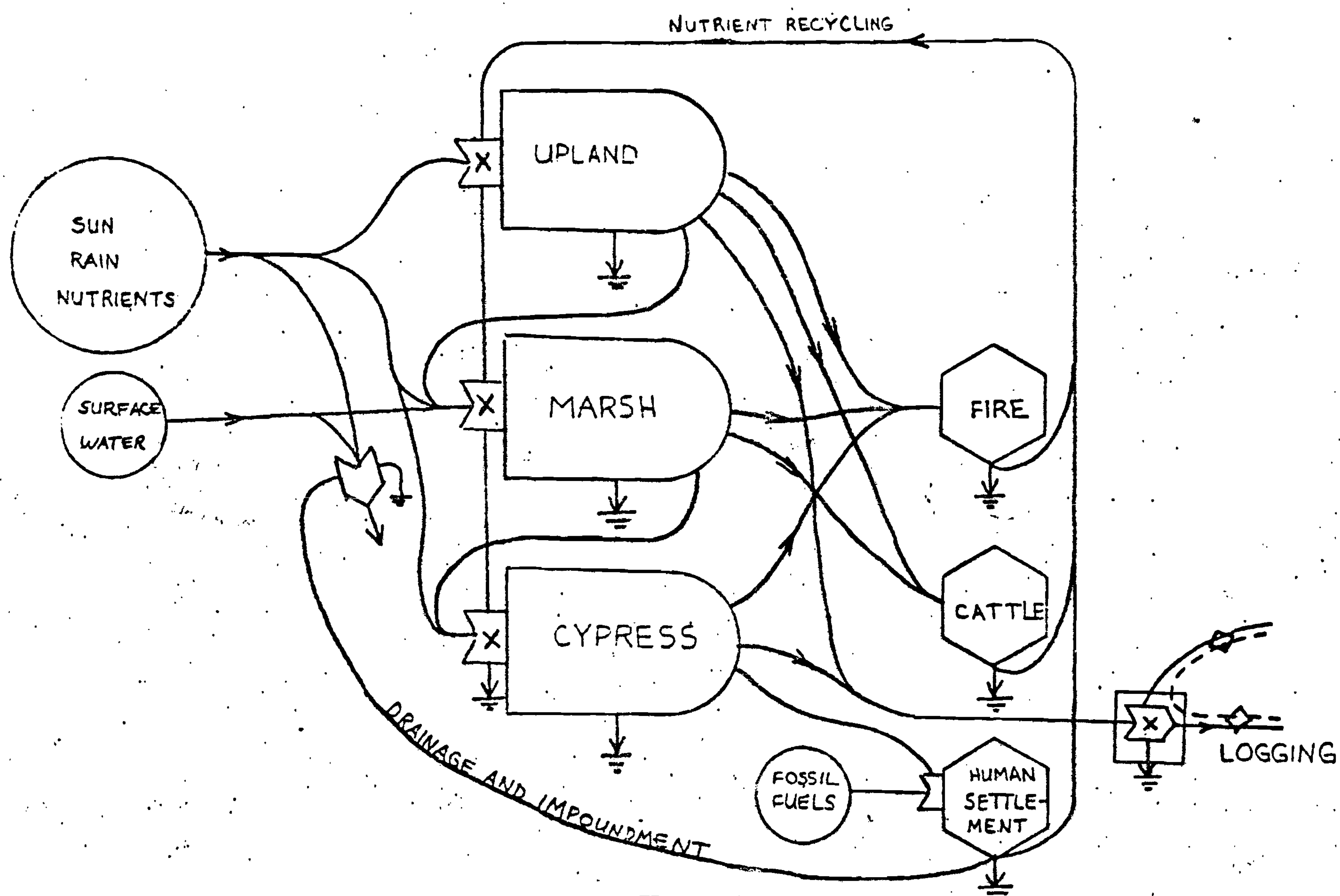

FIGURE 14

SUBMODEL FOR MAJOR HABITAT TYPES AT CORKSCREW SWAMP SANCTUARY.

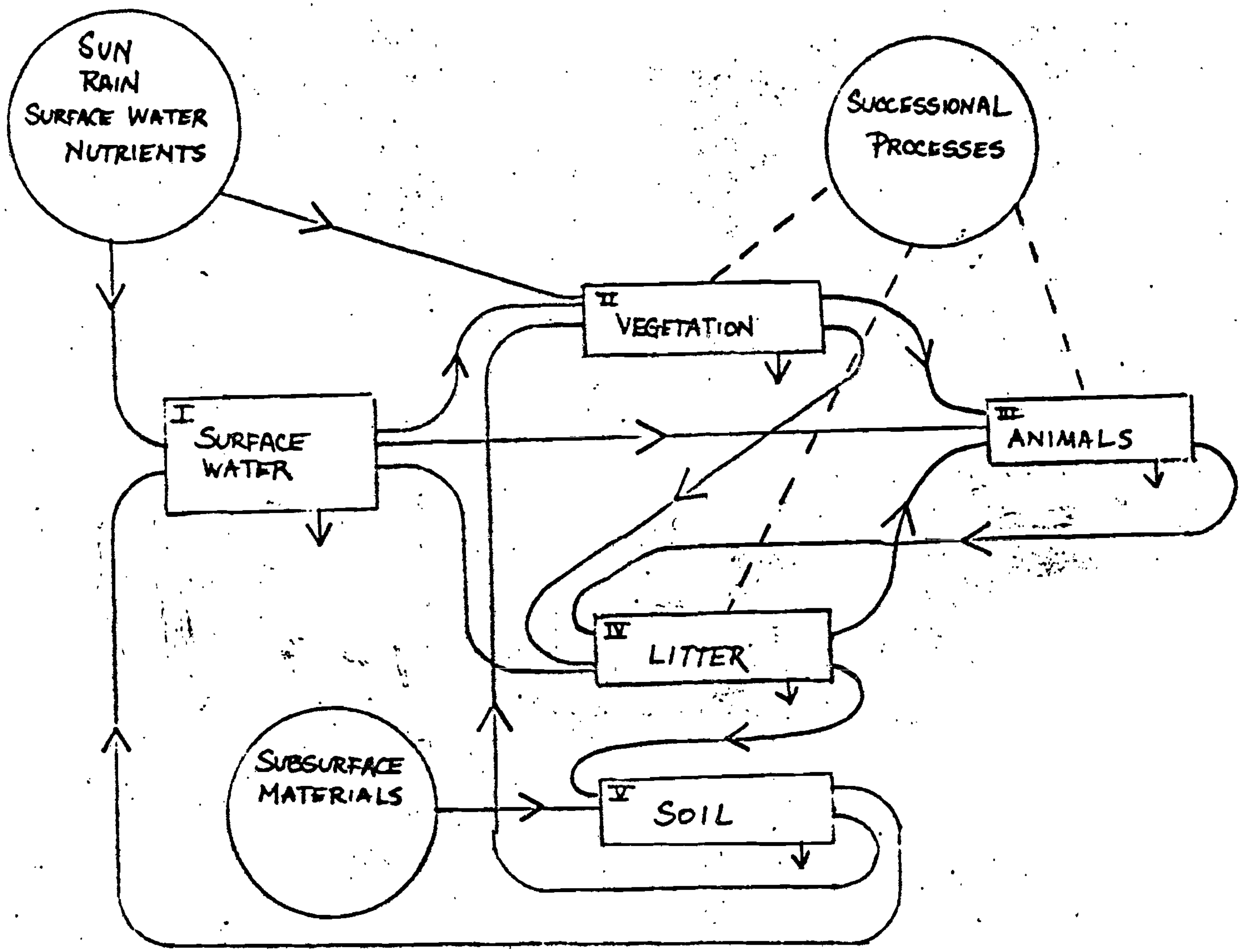

FIGURE 15

ENERGY FLOW MODEL OF THE ECOSYSTEM AT CORKSCREW SWAMP SANCTUARY AS DIAGRAMMED IN FIGURE 13.

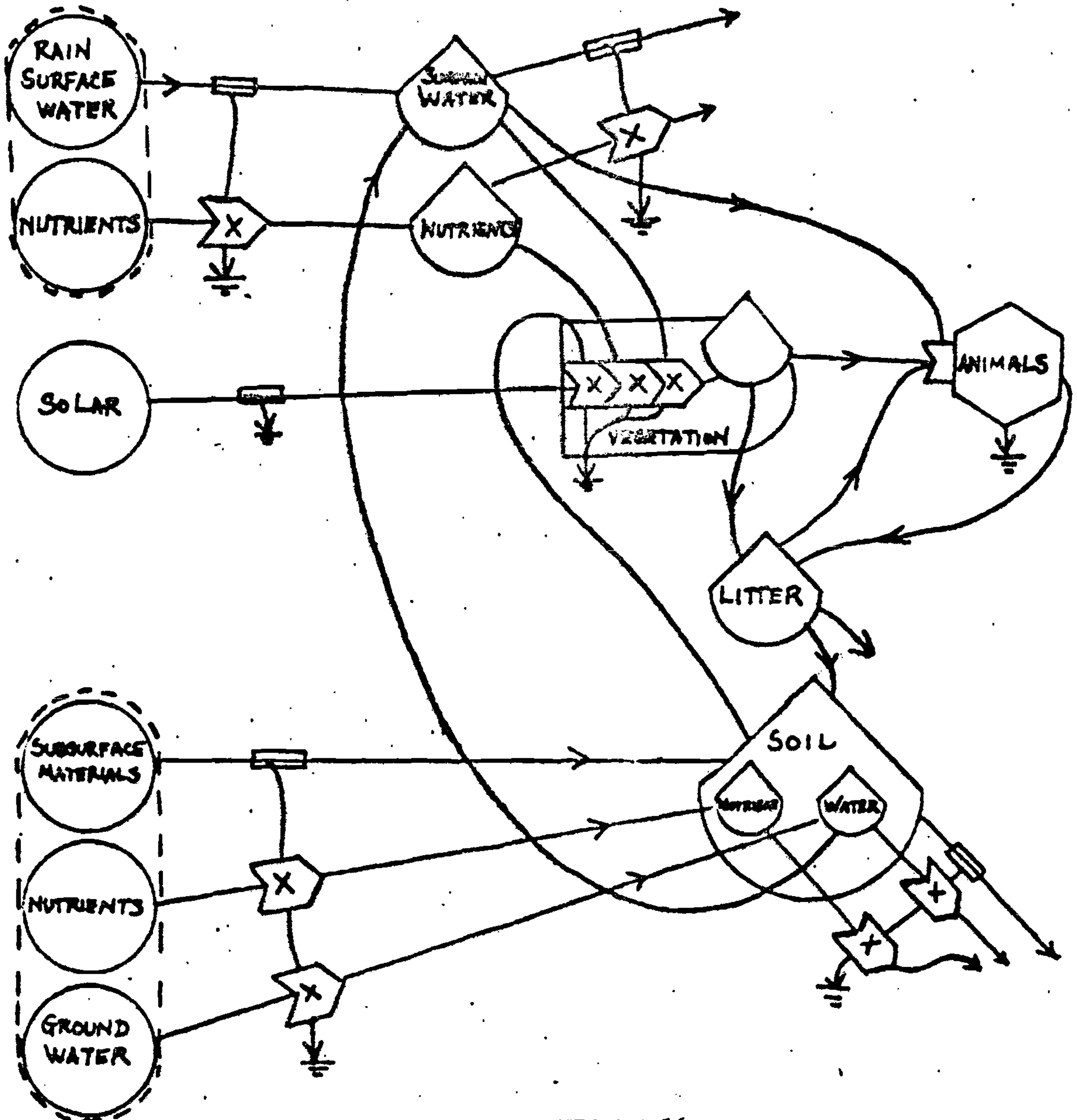

FIGURE 16

ENERGY FLOW MODEL OF CORKSCREW SWAMP MODEL IN FIGURE 13.

APPENDIX Table 1

Species were classified as Abundant (A), Common (C), Occasional (O), or Rare (R). Abundant species were those that completely dominated the community such as a large dense stand of Spartina grass or pine trees. Common species were those which were not so numerous as abundant one, but were fairly evenly distributed thorughout the community. Occasional species were widely scattered while rare species may have been represented by only one individual in the area surveyed.

PRELIMINARY LIST OF PLANT SPECIES FOUND IN THE VICINITY OF THE WELLS ALONG PRIME TRANSECTS

GRAPEFRUIT ISLAND TRANSECT:

Pine-Palm Flatwoods - Little Corkscrew Island	
Ludwigia palustris	A
Panicum geminatum (plus other panicums)	A
Panicum hemitomon (maidencane)	C
Bacopa caroliniana (lemon Bacopa)	C
Diodia sp. (button weed)	C
Pontederia cordata (pickerel weed)	O
Aster adnatus	O
Sabal palmetto (cabbage palm)	R
Myrica cerifera (wax myrtle)	R

Wet Prairie (Mixed Vegetation) - Mud Lake Marsh	
Spartina bakeri (sand cordgrass)	A
Pontederia cordata (pickerel weed)	A
Sagittaria lancifolia (tall arrowhead)	A
Ludwigia palustris	C
Bacopa caroliniana (lemon Bacopa)	C
Panicum hemitomon (plus other panicums) (maidencane)	C
Sagittaria graminea (grass-leaved Sagittaria)	C
Myrica cerifera (wax myrtle)	C
Polygonum punctatum (water smartweed)	C
Nymphoides aquatica (floating heart)	O
Cephalanthus occidentalis (buttonbush)	O

Palm-Oak Hammock - Grapefruit Island	
Sabal palmetto	A
Quercus Nigra (water oak)	C
Persea palustris (swamp bay)	C
Rapanea guianensis (myrsine)	C
Nephrolepis exaltata (wild boston fern)	C
Blechnum serrulatum (swamp fern)	C
Phlebodium aureum (serpent fern)	C
Acer Rubrum (red maple)	O
Myrica cerifera	O
Rhus Radicans (poison ivy)	C
Zanthoxylum fagara (wild lime)	O

Wet Prairie (Mixed Vegetation) - Ruess Marsh

Ludwigia palustris	A
Bacopa caroliniana	A
Utricularia foliosa (greater bladderwort)	A
Utricularia purpurea (purple bladderwort)	C
Utricularia inflata (floating bladderwort)	C
Spartina bakeri	C
Panicum hemitomon	C
Sagittaria graminea	O
Pontederia cordata	O
Cephalanthus occidentalis	O

Pine-Palm Flatwoods - Ruess Marsh

Myrica cerifera	A
Pinus elliottii (slash pine)	C
Sabal palmetto	C
Andropogon capillipes (chalky bluestem)	C
Aristida sp. (threeawn grass)	C
Serenoa Repens (saw palmetto)	O
Quercus Nigra (water oak)	O
Ximenia Americana (tallowwood)	O
Ilex cassine (dahoon holly)	R
Acer Rubrum	R

NORTH MARSH TRANSECT

Willow Marsh

Salix caroliniana (coastal plain willow)	A
Panicum hemitomon	C
Sagittaria lancifolia	C
Cephalanthus occidentalis	O

Wet Prairie (Maidencane)

Panicum hemitomon	A
Sagittaria lancifolia	C
Bacopa caroliniana	C
Utricularia foliosa	C
Ludwigia palustris	C
Pontederia cordata	O
Crinum Americana (swamp lily)	O
Ipomoea sagittata (arrow-leaved morning glory)	O
Mikania batifolia (climbing hemp weed)	O

Wet Prairie (Spartina)

Spartina bakeri	A
Sagittaria lancifolia	C
Crinum Americana	C
Mikania batifolia	C
Ipomoea sagittata	C
Bacopa caroliniana	C
Panicum hemitomon	C
Ludwigia palustris	C

<u>Wet Prairie (Button Bush)</u>

Cephalonthus occidentalis	C
Sagittaria lancifolia	A
Mikania batifolia	C
Panicum hemitomon	C
Polygonum punctatum	C
Taxodium distichum (bald cypress)	O
Pontederia cordata	O
Salix caroliniana	O
Panicum geminatum	O

<u>Fresh Water Marsh (Arrowhead)</u>

Sagittaria lancifolia (arrowhead)	A
Pontederia cordata	A
Thalia geniculata	C
Cephalanthus Occidentalis	C
Utricularia foliosa	C
Taxodium distichum	O
Mikania batifolia	C
Polygonum punctatum	O

<u>Pond Cypress Swamp</u>

Taxodium distichum	A
Pontederia cordata	A
Sagittaria lancifolia	C
Cephalanthus occidentalis	O
Blechnum serrulatum	C
Nymphoides aquatica	C
Peltandra virginica (arrow-arum)	O
Bacopa caroliniana	C
Panicum hemitomon	C
Diodia sp. (button weed)	C
Nymphaea Mexicana (yellow water lily)	C
Tillandsia sp.	C
Nephrolepis exaltata	C
Vallisneria americana (water celery)	C
Boehmeria drummondiana (bog hemp)	C
Annona glabra (pond apple)	O

<u>Burned Pond Cypress Swamp</u>

Taxodium distichem	A
Thalia geniculata	A
Nephrolepis exaltata	C
Pontederia cordata	C
Sagitaria lancifolia	C
Boehmeria drummondiana	C
Annona glabra	O
Salix caroliniana	O
Fraxinus caroliniana	O
Myrica cerifera	O
Panicum hemitomon	C
Makania batifolia	C
Ficus aurea (strangler fig)	O
Baccharis halimifolia (saltbush)	
Blechnum serrulatum (swamp fern)	C
Polygonum punctatum	C

<u>Burned Pond Cypress Swamp (Continued)</u>	
Ludwigia palustris	C
Bacopa caroliniana	C
Persea palustris	C
Azolla sp. + lemna sp. (duckweed)	C
Nymphoides aquatica	C
<u>Pine Flatwoods</u>	
Pinus elliottii	C
Sabal palmetto	C
Myrica cerifera	C
Mikania batifolia	C
Hydrocotyl umbellata	C
Diodia sp.	C
Andropogon sp.	C
Aster adnatus	O
Iris savannarum	C

CENTRAL MARSH TRANSECT:

<u>Pine Flatwoods</u>	
Pinus elliottii	A
Serenoa Repens	A
Sabal palmetto	O
Myrica cerifera	C
Elephantopus tomentosus	C
Hyptis alata	C
Lyonia lucida	C
Ilex glabra	C
Bigelowia Nudata	C
Liatrus tenuifolia	C
Lilium catesbaei	O
Drosera brevifolia	C
Piloblephus Rigidus	C
Pterocaulon undulatum	O
Pteridium caudatum	O
Solidago fistulosa	O
Andropogon capillipes	C
Aristida sp.	C
Xyris sp.	C
Dichromena colorata	C
Smilax sp.	O
<u>Wet Prairie (wax myrtle)</u>	
Myrica cerifera	A
Serenoa Repens	O
Pinus elliottii	O
Andropogon capillipes	C
Hyptis alata	O
Persea borbonia	R
Blechnum serrulatum	R
Aristida sp.	C
Cladium jamaicensis	O

Wet Prairie (Mixed Vegetation)

Spartina bakeri	A
Panicum beminatum	A
Hyptis alata	C
Myrica cerifera	C
Utricularia sp.	C
Ludwigia palustris	C
Panicum hemitomon	C
Mikania batifolia	
Taxodium distichum	O
Acer Rubrum	O

Maple Hammock

Rapanea gqlanensis	A
Acer Rubrum	A
Persea palustris	C
Sabal palmetto	O
Blechnum serrulatum	A
Smilax sp.	C
Tillandsia sp.	C
Myrica cerifera	O
Rhus Radicans	C
Vitis Rotundifolia	O
Woodwardia virginica	C
Amelopsis arborea	R

Pond Cypress Swamp

Taxodium distichum	A
Pontederia cordata	C
Thalia geniculata	C
Boehmeria drummondiana	C
Osmunda Regalis	C
Panicum hemitomon	C
Tillandsia sp.	C
Epidendron sp.	C
Salix caroliniana	O
Annona glabra	O
Ficus aurea	O
Perseas palustris	O
Acer Rubrum	O
Nephrolepis exaltata	A
Blechnum serrulatum	A
Myrica cerifera	O
Sagittaria lancifolia	O
Smilax sp.	O
Rhus Radicans	O
Rapanea guianensis	O
Nymphoides aquatica	O
Sabal palmetto	R
Pinus elliottii	R
Cladium jamaicensis	O

Bald Cypress Swamp	
Taxodium distichum	A
Acer Rubrum	C
Persea palustris	C
Annona glabra	C
Fraxinum caroliniana	C
Nephrolepis exaltata	A
Blechnum serrulatum	A
Thalia geniculata	C
Pontederia cordata	O
Sagittaria lancifolia	O
Boehmeria drummondiana	C
Mikania batifolia	O
Rhus Radicans	O
Crinum americanum	O
Polygonum punctutatum	C
Smilax sp.	O
Ficus aurea	O
Hydrocotyl umbellata	C
Campyloneuron phyllitidis	C
Tillandsia sp.	C
Epidendron sp.	C
Azolla sp. and Lemna sp.	C
Pistia stratiotes	O
Cephalanthus occidentalis	O
Acrostichum excelsum	O

Sawgrass Marsh	
Sagittaria lancifolia	A
Cladium jamaicensis	A
Pontederia cordata	C
Panicum hemitomon	C
Salix caroliniana	O
Utricularia sp.	O

APPENDIX TABLE 2

Soil Profiles in Transects

Central March Transect Soil Problems

1.	0 - 4"	dark gray sand
	4 - 18"	gray sand
		stained layer
		light gray sand
	30"	limestone
2.	Similar to profile #1 except stained layer better developed.	
	45"	limestone
3.	Immokalee series - weak organic hardpan	
4.	Immokalee series - organic hardpan at 40"	
5.	Immokalee series - organic hardpan at 36"	
6.	light yellowish brown mottled sand very dark gray sandy loam at 36" shell at 48"	
7.	dark gray sand limestone at 12"	
8.	same as profile #7	
9.	10 - 0"	organic
	0 - 20"	very dark gray loamy sand
		dark gray sand
	48"	shell
10.	14 - 0"	organic
	0 - 40"	very dark gray loamy sand
		dark gray sand (pH 7.4)
11.	18 - 0"	organic
	0 - 35"	very dark gray sandy loam
	35 - 45"	gray sandy clay loam with shell
12.	42 - 0"	peat and muck (organic)
		very dark gray sandy loam
13.	60 - 0"	organic (pH: 6.2 at 12" and 36")
		shell
14.	Similar to profile #14	

15. 36 - 0" organic
very dark loamy sand
50" limestone and marl

16. similar to profile #15 except organic is woody

17. similar to profile #16

18. similar to profile #15 except no limestone

Grapefruit Island Transect Soil Profiles

1. dark gray brown sand
yellowish brown mottled sand
pale yellowish brown sand
42 - 60" olive sand and sandy clay loam
Charlotte series mapped Keri

2. pale yellowish brown fine sand
- 34" light gray sand
34 - 48" dark gray brown sand
shell
55" hard limestone

3. brown sand } buried soil
dark gray sand }
green clay
36" shell

4. very dark gray sand
24" loamy sand mixed with shell and limestone

5. 0 - 6" very dark gray loam
gray loamy sand to sandy loam
pale yellowish sand
40" limestone

6. 0 - 10" very dark gray loam
limestone

7. similar to profile #6

8. similar to profile #6

9. gray sand
brown sand

10. 0 - 30" pale yellowish brown sand
30 - 36" gray, olive gray sandy clay loam
sand
40" shell

11. very dark sand
gray sand
54" Limestone and marl

12. gray brown sand
24" light brown sand
24 - 30" gray sandy clay - mottled
30" limestone

North Marsh Transect Soil Profiles

1.		dark gray sand
		brown sand
		olive clay
	30 - 36"	limestone
2.	similar to profile #1	
3.	10 - 0"	organic
	0 - 20"	dark gray loamy sand
		light gray sand
	60"	sandy clay
4.	0 - 6"	organic and light grayish brown sand mixed
		light grayish brown sand
		gray mottled yellowish brown sandy loam with shell
	32"	limestone
5.	8 - 0"	organic
	0 - 24"	mixed light gray and very dark gray loamy sand
		gray mottled sand
		bluish gray sand
	60"	shell
6.	0 - 16"	very dark gray and gray sand
	16 - 30"	gray sand
	30 - 44"	gray sandy loam
	44"	limestone

Dome Number One

1.	Outside of dome in surrounding pine flatwoods	
	0 - 4"	dark gray sand
	4 - 16"	gray sand
	16 - 26"	weak stained layer
	26 - 46"	gray mottled sandy clay loam
	46 - 55"	greenish gray sand
	55"	limestone
2.	Cypress	
	0 - 2"	dark gray sand
	2 - 30"	gray sand mottled (pH 6.2)
	30 - 36"	dark gray brown sand
	36 - 54"	greenish gray sandy clay loam (pH 7.0)
		yellowish brown sand (pH 7.0)
		limestone and shell
3.	Edge of marsh in center of dome	
	0 - 12"	black sandy much (pH 6.0)
	12 - 36"	black loamy sand
	36 - 48"	gray brown loamy sand
	48"	shell
4.	Middle of dome central marsh	
	0 - 36"	black sandy much
	36 - 48"	gray brown loamy sand
	48 - 60"	sandy clay
	60 - 72"	shell
	72"	shell mixed with limestone

Dome Number Two

1. Outside of dome in pine flatwoods
   Immokalee series

2. Outside of dome in wet prairie
   Similar to profile #1, except a weaker stained layer

3. In cypress

0 - 4"	dark gray sand
	white sand
60"	yellowish brown sand

4. Edge of dome central marsh

0 - 20"	very dark gray mucky sand
	light gray sand
60"	grayish brown sand