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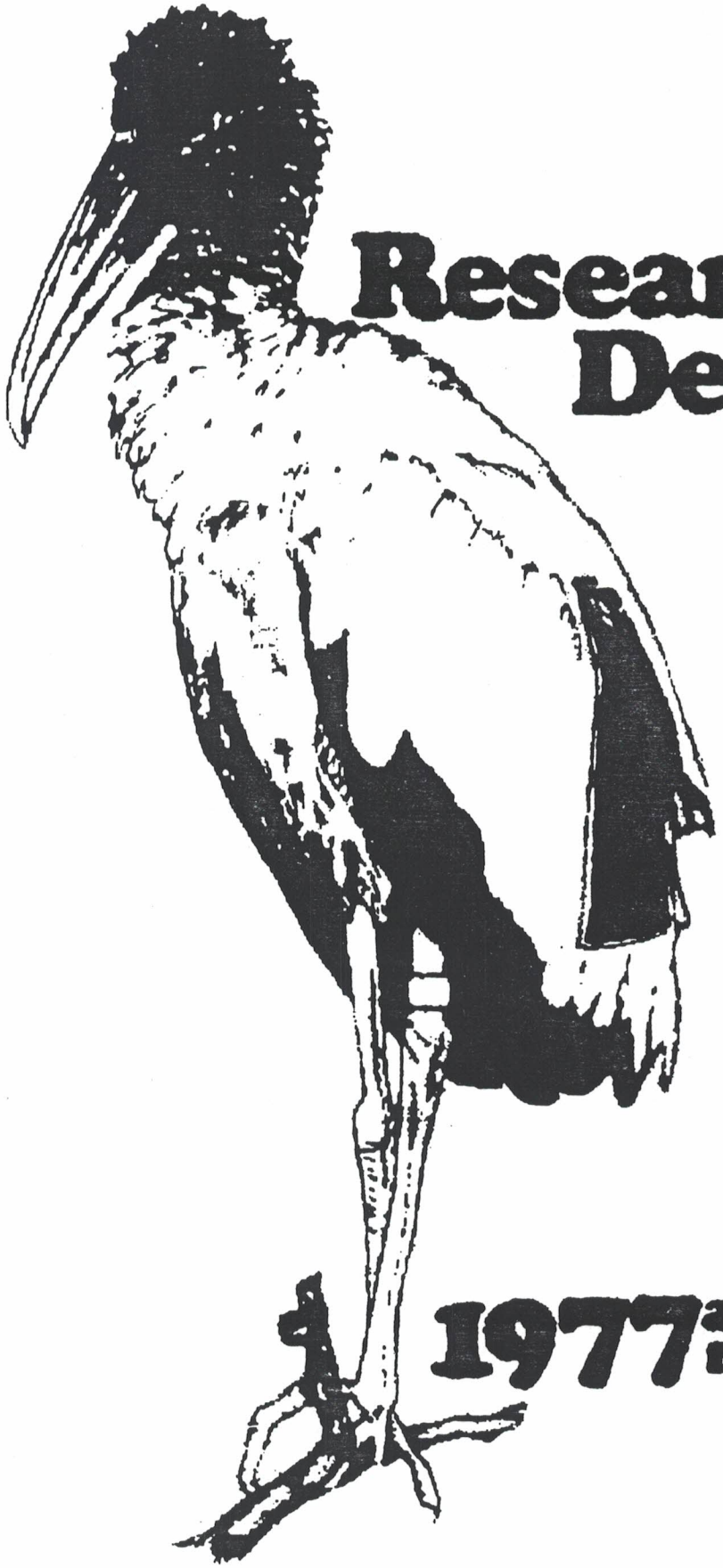

Research Dept.

1977 annual report

1977 ANNUAL REPORT

NATIONAL AUDUBON SOCIETY
RESEARCH DEPARTMENT

JANUARY THROUGH DECEMBER, 1977

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Introduction

The National Audubon research program has gained respect within the scientific community for it's tradition of conducting intensive, long-term studies of endangered and threatened species and the ecosystems that support these species. This long-term approach to research was apparent with the Society's first studies of Roseate Spoonbills and Ivory-billed Woodpeckers initiated during the late 1930s, and has been continued to the present research program. Several decades of experience with these kinds of studies have shown this approach to provide the best insight into the complex dynamics of populations and ecosystems. Audubon's long-term studies take on special value in this age when complex ecological data are necessary for proper management and conservation of species and ecosystems, while economic considerations and the ever-increasing number of biologists have forced many institutions and governmental agencies towards short-term and highly specialized studies. Thus the information gained during Audubon research provides authority to the Society in it's traditional role as a leader in wildlife conservation, and has in-house management application on Audubon sanctuaries.

Species studies have been the backbone of the Audubon research effort, and form a major part of the present program. Species presently being studied are the Reddish Egret, Wood Stork, colonial herons in Florida, and the Whooping Crane. The research program has broadened during the 1970s to include studies of wetland ecosystems, necessary for habitat management and protection, and the creation of a colonial bird data system to handle the complex organization and utilization of waterbird survey and distribution reports.

This volume is the first annual report of the National Audubon Society Research Department. It includes summaries of the major projects by each of the Research Department's biologists during calender year 1977. These summaries describe the kinds of research being conducted, the objectives of each project, and the progress made during 1977 towards reaching these objectives. Since this is the first annual report produced, considerable variation has been allowed between individual reports in format, information included and length. We will select a more standardized format for future annual reports, in large part based on response from the National Audubon directors and staff to the various styles in this 1977 volume.

Alexander Sprunt, IV
Research Director
April 1978

SPECIES STUDIES

ANNUAL REPORT - 1977

David R. Blankinship
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JOB DESCRIPTION

My primary assignment is to conduct research on the behavior and ecological requirements of whooping cranes in their wintering area along the Central Texas Coast. This involves the collection of field data pertaining to the cranes' distribution, spatial requirements, territorial and other social behavior, food habits and food availability as well as monitoring possible threats to the cranes and their habitat and evaluating responses of the cranes to management programs.

As a result of the above research activities and because of the Society's long involvement with whooping cranes and sanctuaries along the Texas Coast and also my experience in dove research prior to joining the staff, I have become involved in several additional activities and programs.

Current field research activities have decreased somewhat as more opportunities open to apply the knowledge gained from research of previous years.

WHOOPING CRANE PROGRAM

The 1976-77 winter was a banner year for whooping cranes with a record 69 birds counted on the Texas Coast including 12 chicks, also a new high. An uncertain record number of 70 or 71 whoopers, including 9 chicks, arrived on the wintering grounds in the fall of 1977.

Eight of the 9 chicks had been both banded and individually color marked with plastic leg bands before they were able to fly. This activity by the Canadian Wildlife Service marks the first time wild whooping cranes have been banded. For the first time we can identify individual whoopers and age classes of the birds. Close observation of these marked birds over the next several years will provide many long sought answers to questions about whooping cranes. We should gain insight into annual survival rates, age at pairing, age at first breeding, longevity of adults, and distribution of subadult birds both on the wintering ground and

during migration, to name a few.

Field Research

Habitat conditions continued favorable for wintering cranes and were very similar to conditions existing in previous years when intensive sampling of potential food organisms and physical parameters was carried out. It was decided to reduce such sampling until climatic conditions change.

Whooping crane field research activities were directed primarily toward gathering additional data on food habits and territorial behavior. Observations of crane feeding behavior and social interactions were made from boats and from platform markers along the Gulf Intracoastal Waterway. Observations of areas of crane use and behavior of the birds were coordinated with aerial mapping of crane distribution carried out by personnel of the Aransas National Wildlife Refuge during regular census flights. As in previous years, the primary food items taken by the cranes were blue crabs, fiddler crabs, and razor clams supplemented with eels, crayfish, snails, and limited vegetable material. Water levels were very important in determining availability of food organisms with blue crabs being most important during periods of high water and clams and fiddler crabs being increasingly important as water levels dropped.

Considerable clumping of cranes was noted both on the Aransas NWR and Matagorda Island. One group of 10 birds including a pair with a chick and at least one other adult pair spent much of the late winter and spring of 1977 in one tidal pond on Matagorda Island. Very little antagonistic behavior was observed. The pond was found to have an unusually high population of razor clams.

A grouping of 8 to 10 birds was noted in the Dunham Bay area of the Aransas NWR during both 1976-77 and 1977-78 winters. Little interaction was recorded in 1976-77 but more definite pairing and increased aggressive displays were evident in the group during 1977-78.

Other pairs and family groups defended their territories as usual but with individual pairs showing considerable variation in their reaction to other specific pairs, single birds or trios. A better understanding of the whooping crane's social behavior will hopefully be achieved through observation of the maturing colormarked individuals.

I anticipate completion of a paper on the territorial behavior of whooping cranes by early 1979.

Coccidia Study

Droppings of whooping cranes were collected on the wintering area for examination for coccidia infections. This proved to be very difficult as the droppings had to be collected while quite fresh and the birds spend much of their time in water or in low but dense vegetation. Six of 19 samples were found to be infected with coccidia, 4 with Eimeria gruis and 2 with E. reichenowi. Three out of three sandhill crane droppings from the same general area contained spores of both coccidia species. These potential pathogens should be considered in planning any program which tends to concentrate whooping cranes or whoopers and sandhills.

Results of this study are presented in a paper being published in the Journal of Wildlife Diseases. Cooperators in this study were Dr. Donald Forrester of the University of Florida and Dr. James Carpenter of the Patuxent Wildlife Research Center.

Whooping Crane Recovery Team

In late 1975, I was appointed to the U. S. Fish and Wildlife Service Whooping Crane Recovery Team. This six member group has the responsibility of preparing a Recovery Plan which will serve as a guideline for future state and federal activities concerning whooping cranes. The team also reviews project proposals concerning whooping cranes and provides recommendations on such matters as critical habitat for the species. This activity has required considerable time and effort but has provided the Society with a real opportunity to apply knowledge obtained from research projects and to have a strong voice in whooping crane programs.

The Recovery Team met twice in 1977, once in Sinton, Texas, and in Winnipeg, Canada. The Draft Recovery Plan has been circulated for technical review and is now being revised. I am pleased to report that many of the recommendations the team has made in the plan have already been implemented by the Fish and Wildlife Service. Dr. Harold Irby of the Texas Parks and Wildlife Department and myself drew up the proposed boundaries for critical habitat on the Texas Coast.

Whooping Crane Sighting Reporting Network

Efforts of the Whooping Crane Recovery Team to determine critical habitat in the cranes migration route were frustrated by a lack of current sightings and the lack of a well defined pattern of sightings, particularly in the area from northern Nebraska to the Canadian border. We received indications that many whooper sightings by the general public and by some conservation agency personnel as well were going unreported or were being reported too late for confirmation.

In an action to correct this the Fish and Wildlife Service established a reporting network for Federal and many state conservation agencies. In an effort to enlist the aid of birders, sportsmen and others interested in wildlife, the National Audubon Society Whooping Crane Network, inactive for several years, was reactivated. Regional Representatives were utilized to arrange publicity to local chapters, bird groups, newspapers, television stations, etc.

A brochure was prepared and widely distributed by the Society which aids in whooper identification, explains the reporting network and tells where to report sightings. Sighting data collected through both the federal and Audubon networks is sent to a central reporting station in the U. S. Fish and Wildlife Service office at Pierre, South Dakota.

This program was tried during the spring migration of 1977 and was fully operational for the fall 1977 southward migration. Results were very encouraging with 63 confirmed or very probable sightings reported during the fall period. Less than 20 per year were being reported before the networks were activated. Data from the reporting networks are also being used in planning programs to scare whoopers away from areas where avian disease outbreaks are discovered and in planning hunting seasons to reduce risks to migrating whoopers.

Aransas NWR Pipeline

Mitchell Energy Offshore Corporation proposed in 1976 to lay a gas pipeline across one of the most valuable whooping crane feeding areas on the Aransas National Wildlife Refuge. Careful consideration was given to alternate routes and all were determined to be much more environmentally damaging than the short route across the whooper habitat. An environmental assessment of the project was prepared by the petroleum company and the proposal was approved by the Fish and Wildlife Service. The line was installed during the summer of 1977.

Close coordination was maintained between company personnel, refuge personnel and myself during assessment preparation, site selection, design of installation methods and actual laying of the line.

Hunting Blind Notices

Numerous waterfowl hunting blinds are located in areas used by wintering whooping cranes in St. Charles Bay and near Isla San Jose (St. Joseph Island) and Matagorda Island. Aransas NWR personnel and myself place notices in each blind warning hunters to be on the alert for whooping cranes.

ACTIVITIES WITH OTHER SPECIES

Brown Pelicans

The population of endangered eastern brown pelicans in Texas has been reduced to less than 20 breeding pairs. 1977 was a record year, however, with a new high of 17 nests producing 34 young. In the years from 1960 through 1976 a total of 40 young had been produced. Practically all nesting takes place on islands operated as santuaries by the Society or an affiliated chapter.

Activities with Texas brown pelicans in 1977 included a program of banding and colormarking all young produced for movement and population studies, periodic census of wintering, summering and breeding pelicans, and providing patrols to prevent human caused disturbance to nesting birds. I have assisted the Eastern Brown Pelican Recovery Team with selection of areas for proposed critical habitat designation. Many of these activities were done in cooperation with National Audubon Society biologist Richard T. Paul.

Colonial Waterbird Survey

The Texas Colonial Waterbird Survey is an annual census of nesting colonial waterbirds. It is a cooperative effort of several organizations and agencies including National Audubon, Texas Parks and Wildlife, U. S. Fish and Wildlife Service, Welder Wildlife Foundation, Texas General Land Office, Texas A & M University, Texas A & I University and others. I am currently representing the Society on the survey's Executive Committee. Rich Paul and I both had an active part in censusing waterbird colonies on the Texas Coast in 1977. Results of the survey are supplied to the Colonial Bird Registry at Cornell.

Reddish Egrets

Occasional assistance was rendered Rich Paul in his research activities with reddish egrets on the Texas Coast and on the coast of Northeastern Mexico.

White-crowned Pigeon

The white-crowned pigeon is the major game bird of the Bahamas. The Society has been involved with research on the species both in the Bahamas and the Florida Keys. Activities have included surveys of population numbers, nesting colony locations, banding studies and collection of hunting harvest data. My 1977 field activities were limited to collection of hunting season data such as number of birds bagged, crippling losses, and age ratios of birds bagged.

A paper giving results of earlier research activities was presented at the International White-crowned Pigeon Conference in Nassau in March. Other papers were presented by Rich Paul and Sandy Sprunt.

SANCTUARY ACTIVITIES

Warden Duties

I serve as warden for the second chain of islands and Matagorda Island Sanctuaries. Duties include periodic patrols to prevent disturbance of rookeries, maintenance of sanctuary signs and monitoring of bird population levels. These duties will be expanded to include Deadman Island and Long Reef Sanctuaries now that Rich Paul has completed most of his research activities on these islands.

Sabal Palm Grove

I have assisted in planning and implementation of management programs for the Palm Grove Sanctuary near Brownsville, Texas. Activities have been mostly directed toward replanting of cleared areas of the sanctuary with native vegetation.

OTHER ACTIVITIES

Review of Corps of Engineers Permit Applications

An average of 20 U.S. Army Corps of Engineers 404 permit applications are received each week for review. These are applications for permits for dredging, draining, construction, drilling or other activities along the entire Texas Coast. Comments and recommendations are made to the Corps when a project should be denied a permit or modified to avoid excessive environmental damage.

I often am requested to supply information or advice to agencies, particularly the U. S. Fish and Wildlife Service to aid them in preparing their comments on Corps applications.

Public Programs

In 1977, programs on whooping crane research, colonial nesting birds and other Society research projects were presented to Audubon chapters in Dallas, Orange, and Edinburg, Texas. Programs were also presented in local schools and Cub Scout pack meetings.

PLANS FOR 1978

It is anticipated that most of the activities described above will be continued in 1978. Much emphasis will be placed on observations of marked whooping cranes. This will be the first opportunity for recording survival rates and social interactions of known subadult whooping cranes.

WOOD STORK FEEDING PROJECT

A progress report covering the period
July 1, 1976 - November 30, 1977

James L. Hansen, Research Biologist
National Audubon Society
Corkscrew Swamp Sanctuary

In recent years the largest wood stork nesting colony in the United States has been at the National Audubon Society's Corkscrew Swamp Sanctuary in southwestern Florida. The number of nesting pairs there has declined from 6000 in the early 1960's to an estimated 2800 in the mid 1970's. A shortage of food for wood storks, especially at certain critical times of the year, seems to be one of the main problems contributing to this decline. Because of the possibility of more drainage and development of feeding areas, the food shortage could become more severe in the future. For these reasons the National Audubon Society initiated this project to investigate the feasibility of raising fish to supplement the natural food supply of wood storks.

The study is being conducted in 11 ponds which have been constructed on the sanctuary. Eight of the ponds are about 3.1 acres in size, and three are about 2.4 acres. The ponds are designed to hold up to three feet of water when full, and a ditch about two feet deeper provides an area in which to concentrate fish for the storks. Individual ponds can be filled or drained by pumping to make fish available to birds at certain times.

The most important aspect of the project is that we are learning how to raise fish and make them available to wood storks so that such information will be available if it should become necessary to add more ponds in the future. In some years it may be possible to save at least a portion of the stork production by making the limited supply of fish available at the proper time.

METHODS AND MATERIALS

New Developments and Equipment

The perimeter canal at the fish farm has been used very little since the ponds were constructed, and it was known to have fish in it. I decided to construct a pond of manageable size in the canal to see if these fish could be made available to storks. In November of 1976 sanctuary personnel put an earthen plug across

the perimeter canal north of pond A-1 (Fig. 1), blocking off an area of about 0.4 acre, and I seeded Bahia seed on the plug to stabilize it. The canal is deep enough that pumping will not be necessary to keep water in it. The only pumping needed will be to drain it to make the fish available to birds. For a pump-out pump to drain the pond, sanctuary personnel modified an old Crane-Deming pump by adding a suction hose and an 8 hp. Briggs and Stratton engine.

The new well for the C ponds was checked by pumping from it with a portable pump. It seemed to be a good well, so the transformer and pump were moved, and underground electric lines were run to the new well.

Stocking and "Treatments"

Emphasis is being placed on the use of native species of fish in the ponds, particularly those that seem to do well with little or no help. After birds fed in the ponds in 1976, the post-feeding fish samples taken were used as a basis for determining stocking rates.

Four ponds, A-4, B-2, B-3, and B-4, were each stocked in June and July of 1976 with 200 warmouth and 312 dollar sunfish, all large enough to reproduce. Water levels in ponds A-4 and B-2 were maintained at about 26" by pumping, and fish in A-4 were fed catfish chow and a mixture of cottonseed meal, wheat shorts, and blood meal (100:100:16). Water levels in B-3 and B-4 were permitted to drop to about 12" to see if fish can be raised more economically by pumping less. Pond C-3 was stocked with 56 yellow bullheads of breeding size from June 16 to August 9, 1976. Pond A-3 was stocked with 8000 golden shiners on November 27, 1976, and these fish were fed the same cottonseed meal, wheat shorts, blood meal mixture.

Feeding experiments started in 1975 and continued until the spring of 1977 included bluegills in A-1 being fed catfish chow and golden shiners in B-1 fed cottonseed meal, wheat shorts, and blood meal.

New experiments were begun in 1977 to see if fertilization would be an effective way to increase fish production. Ponds A-4,

B-1, and B-4 each received 1700 pounds of 8-8-2 fertilizer from June through November. The fertilizer was added 200 or 300 pounds at a time at three week intervals. Pond A-4 was stocked with 203 warmouth and 226 dollar sunfish of breeding size between June 15 and July 9. Sampling indicated that fish stocking was not necessary in the other ponds in 1977.

Vegetation

A reference plant collection was begun in January of 1977 to be used during vegetation sampling in the ponds and also for future use. Specimens were identified to genus and species, pressed, and stored in the herbarium. Several specimens that were only tentatively identified were verified or corrected with the help of Dr. Taylor Alexander of the University of Miami. Additional specimens will be collected and mounted as time permits.

Point frequency surveys were conducted along five line transects in each of the 11 fish ponds from January 31 to February 15, 1977. By determining the percentage of each pond covered by particular species of plants and the extent of open water, it may be possible to relate fish production to vegetation. In each pond, five points were randomly stratified and staked along the north and south shores. A 100-m fiberglass tape was stretched between stakes on opposite shores. At each meter mark the first species encountered above (and) below the tape was recorded, along with the distance from the point-plant intercept to the pond bottom, and the water depth at that point. Distances were measured with a folding metric rule. Observations in the center ditches were made from a canoe. Percent frequency was calculated for each species in each pond.

During March of 1977, plant biomass sampling was done in ponds A-1, A-4, and C-3 along the five line transects used in the point frequency surveys. The 1/5 m^2 biomass plots were located one meter east of randomly selected points along the line transects. The plots were rectangular, 30 X 66.7 cm, and were marked by a sheet metal box or a reinforcing rod frame open on one end, depending on the type of plant community. All plants in the quadrate were clipped at the soil surface, sorted to species, and

placed in individual plastic bags. In the lab each species was oven dried at 100°C in a nylon mesh bag for 24 hours and weighed to the nearest tenth of a gram. Biomass data from these ponds will be used to check on the correlation with point frequency data and to evaluate the effects of fertilization.

Water Chemistry

Water samples from the ponds were tested at various times to obtain indicators of relative productivity and also to monitor the possibility of oxygen depletion in fertilized ponds. A Hach test kit was used to test for dissolved oxygen, carbon dioxide, pH, total alkalinity, hardness, and sodium chloride. Conductivity of water samples was tested with a Beckman Model RS5-3 Salinometer.

Fish Sampling

The block net--rotenone technique that was used in 1976 was used again in 1977 to obtain data on the standing crop of fish in 10 of the 11 ponds and in the new perimeter canal pond. One refinement in the technique this year was designed to minimize the guesswork about the percentage of fish present that are not retrieved after rotenoning.

Sampling was done in April, May, and early June, when the water levels were down so that there was water only in the center ditch of the pond to be sampled. Ten percent of the center ditch was blocked off with a fine mesh seine the afternoon before the rotenoning was to be done, and three funnel traps of $\frac{1}{4}$-inch mesh hardware cloth were placed in the sample area and left overnight. The next morning, fish were removed from the traps, marked by removing a portion of the caudal fin with large nail clippers, and then released. All fish in the sample area were then killed with a rotenone concentration of about 2 ppm. Fish were picked up the day of rotenoning and the following day. Second day pickup totals were adjusted for weight loss by weighing and measuring a representative sample. Totals were then adjusted according to the recovery rate of the marked fish.

Wood Stork Feeding and Nesting

During the time that ponds were drawn down for storks to feed, a record was kept of all wading birds seen in the ponds. Counts were usually made once or twice every day.

Wood stork nesting at Corkscrew was monitored as in previous years, with counts being made both from an airplane and from the ground.

RESULTS

New Developments and Equipment

The new earthen plug for the perimeter canal pond was covered with grass and other vegetation within a few months and it held up very well, even during the rainy season. We were able to sample fish in the pond with a block net and rotenone, but it was more difficult with the wider and deeper canal. Fish data will be presented in a later section. The pump that was assembled to drain the pond did not work well, primarily because the motor was too small, but it may be modified so that it will work next year. This pond was not drained for stork feeding in 1977 because of pump problems and because there were very few storks in the area to feed.

The new well for the C ponds seems to supply an adequate amount of water for its intended purpose. One problem that has been noted it that when this pump is run for 24 hours, the water level in the perimeter canal will drop about 2 inches. The water level might fall slightly when other wells are pumped, but this is the worst, apparently because there is less well casing for it. The water must be coming from a shallower source.

Vegetation

To date about 40 species of plants have been identified in the ponds, and most of these have been added to the herbarium. Many of the species were not on a plant list that was compiled for Corkscrew Swamp Sanctuary a few years ago.

Major results of the point frequency surveys are given in Table 1. This table does not include species that comprised less than two percent of the points in a pond. The most common species was Eleocharis interstincta (a spikerush), and other important

species were Bacopa monnieri (water hyssop), Chara sp. (muskgrass), and Pontederia cordata (pickerelweed). Ponds C-3 and B-1 had the largest percentage of open water points, while in A-1 less than one percent of the points were in open water. In pond B-2, torpedograss (Panicum repens) was found at about 29 percent of the points. Further analysis of the point frequency data, including water depths and point-plant intercepts, will be presented in a later report. Analysis of the biomass data is not yet completed and will also be included in a later report.

Water Chemistry

Results of some of the water testing (Table 2) suggest that the water in the ponds is quite similar and that no particular problems for fish survival were apparent. It has been claimed that, other things being equal, the higher the level of electrolytes in a body of water, the greater its biological productivity. Ponds A-1, A-3, and B-3 had the highest conductivity. Some studies have found a direct relationship between total alkalinity and the standing crop of fish in some lakes. Total alkalinity was highest in pond A-1 and lowest in pond B-4. The sodium chloride levels of 75 to 112 ppm are similar to those found in other surface waters on the sanctuary. Water samples from the wells at the fish farm were also about 100 ppm sodium chloride. Well water will be tested occasionally to see that salt content does not increase.

Dissolved oxygen levels at several stations in the ponds in February generally peaked at from 6.0 to 13.0 ppm in the late afternoon, and dropped to 3.0 to 8.0 ppm in the early morning, just before sunrise. Some exceptions were noted in ponds C-1 and C-2, where DO levels in dense cattails peaked at 6.0 and 2.5 ppm, respectively, and dropped to 0.6 and 1.0 ppm. Higher DO levels were found in the summer, with peaks of 18.5 to 19.5 ppm found in ponds A-4, B-4, and C-3. It appeared, as might be expected, that diurnal fluctuations in DO levels were greater for fertilized than for unfertilized ponds, but more samples need to be taken under various conditions.

Water chemistry work will be continued, particularly to monitor the effects of fertilization.

Fish Sampling

The use of fin-clipped fish to estimate recovery rate after rotenoning seemed to work very well. If less than 25 marked fish of a species were available in a sample, that sample was not used to calculate a recovery rate. Recovery rates for warmouth (n=11) averaged 74.3 percent (range 43.7 - 87.8), for dollar sunfish (n=10) the average was 77.7 percent (range 61.9 - 95.1), for Gambusia (n=8) the average was 63.8 percent (range 43.0 - 80.0), and for flagfish (n=3) the average was 70.1 percent (range 59.4 - 83.1). The one sailfin molly sample had a recovery rate of 59.9 percent. These recovery rates were used to adjust the estimates for the standing crop of fish in the ponds.

Estimates of standing crops (Table 3) for the 10 fish ponds sampled ranged from 58 pounds/acre in C-2 to 188 pounds/acre in A-1, and the perimeter canal pond estimate was 456 pounds/acre. Other ponds that had low estimates were C-3 and A-4. Duplicate samples taken in ponds A-1, A-2, and C-2 were used in making the calculations.

The standing crops and species composition of each of the ponds are expressed graphically in Fig. 2, 3, and 4. Warmouth made up the highest percentage by weight in every pond except two. In A-2 bluegills were number one, and Gambusia ranked first in pond C-3.

Even though ponds A-1 and A-2 had good fish production, nearly all of the bluegills and redear sunfish in these ponds were too large for storks to eat. There was also little evidence of reproduction by these species. Yellow bullheads made up only about 10 percent of the standing crop in pond C-3, but at least they had reproduced successfully. Pond B-1 was a golden shiner pond in which the fish had been fed, but shiners were not collected in the rotenone sample. Data from the two shallow ponds, B-3 and B-4, were encouraging. The standing crop for B-3 was somewhat low, but the 96 lb./acre for B-4 suggests that a lot of pumping may not be necessary. Production for A-4 was low even though the fish were fed. It appeared during the year that few warmouth and dollar sunfish were eating the feed.

The high estimate for the standing crop in the perimeter canal pond was somewhat surprising, and more samples should be taken in the canal next year. The main differences between this pond and the others is that it is deeper, and the entire pond is deep, instead of only 10 to 15 percent of it.

Wading Bird Use of the Ponds

There was little use made of the ponds by wading birds in 1977. Since the wood storks were not nesting, no particular effort was made to drain the ponds to feed birds. Water levels were permitted to drop in April and May, and some birds did feed in the ponds, especially B-2 and A-4, from April 30 to May 9. The main species using the ponds were little blue heron, great egret, and white ibis. Only three wood storks were seen in the ponds, in B-2 on May 6.

Wood Stork Nesting, 1976 - 77

Wood storks began nesting activities at Corkscrew on December 5, 1976, when a few moved into the baldcypress trees in the lettuce lake colony along the boardwalk. All of the usual stork nesting colonies were occupied by December 16. On an aerial count made December 28, Jerry Cutlip and Jim Hansen estimated that 650 stork nests were being incubated.

A rainy period began December 23, and over the next 12 days five rains totalling about 2½ inches resulted in the desertion of all of the wood stork nests. Nearly all of the nests were deserted by January 8, before the eggs hatched. Two nests at the lettuce lake colony were incubated long enough for the eggs to hatch on January 15, but even these nests were abandoned by January 19. Nearly four inches of rain January 14 - 16 raised the water levels to such an extent that it was very unlikely that the storks would be able to return and nest successfully.

Some wood storks returned in mid-April. There were from 35 to 70 storks in trees in the lettuce lake colony at various times during the period April 14 - 21, 1977, but they did not begin to nest. At about the same time, wood storks did begin nesting in the area where the great egrets usually nest, about a half mile north of the horseshoe-shaped area of large baldcypress. In a

flight on April 21, John Ogden estimated that about 300 wood stork nests were being incubated, and some were still being incubated when a ground check was made on May 3, 1977. All of the nests were deserted by May 17. No wood storks were produced at Corkscrew this season.

DISCUSSION

Many fish culture studies have been done in the United States and in other countries, and there is a lot of information available on the subject. However, other studies have not been conducted in sandy-bottomed ponds, with dense vegetation, in southern Florida to raise fish for wading birds. So while we can use some of the information from other studies, we must find many of our own answers because of the unique situation.

One recommended species, the golden shiner, has simply not survived in the ponds, even when fed. The cause of mortality could be low oxygen, high water temperatures, or possibly a disease or parasite. Bluegills survived in the ponds, but they grew too large and did not reproduce well. Yellow bullheads did at least reproduce and will be tried another year.

More emphasis was placed on warmouth and dollar sunfish during the past year, and these species still seem to do well. It was found that artificial feeding was not very useful in increasing production of these species, because very few fish fed. Results of the fertilization experiments now being conducted should prove interesting. Following the fish sampling done in April and May of 1978, enough information should be available to make some good recommendations on management of the ponds. If fertilization is to be part of the management plan, application rates and timing would still need to be worked out, but this could perhaps be done without having someone working full time on the project. Depending on the results of next year's fish sampling, it should be possible to conclude most of the field work on the project by June of 1978.

During the coming year, vegetation sampling, water sampling, and fish sampling will be continued to monitor the results of

fertilization, to check on changes in vegetation, and to estimate fish production. This winter, underwater mowing will be done in the center ditches of several ponds to kill the cattails.

At the present time I would not recommend the construction of more ponds in the perimeter canal. There is a large standing crop of fish in the canal, but it remains to be seen whether the present pond can be drawn down and held down long enough for storks to eat the fish. I hope to try that next spring.

One objective of this project is to try to aid wood stork production by making fish available at the proper time. It seems apparent from the last three years that whether or not the ponds can help depends on conditions in a particular year. Last year there was so much rain during the nesting season that there was no way for the ponds to help enough. Feeding conditions in 1974-75 were so good that the storks needed no help. In 1975-76, feeding conditions were marginal, and I feel that the fish ponds did contribute somewhat to wood stork production.

Table 1, part 1. Percent frequency for the more common plant species in 11 fish ponds.

	Pond					
	A-1	A-2	A-3	A-4	B-1	B-2
Open Water	0.6	1.5	5.0	8.3	13.8	6.0
Eleocharis interstincta	60.4	28.0	22.0	12.5	15.3	23.6
Bacopa monnieri	5.2		8.3	12.3	15.9	4.7
Chara sp.	12.0	38.6	43.3	29.1	23.2	10.7
Pontederia cordata	12.9	16.9	8.0		4.6	8.8
Ludwigia repens			5.3	14.1	7.3	6.3
Eleocharis cellulosa	2	2.7		7.4		
Najas guadalupensis	2.5				2.1	
Graminae				5.8		
Paspalum sp.						
Panicum sp.						
Typha angustifolia		3.6				
Eleocharis caribaea					9.5	
Bacopa caroliniana						2.5
Eleocharis baldwinii				3.1		
Bacopa cyclophylla						
Panicum repens						28.9
Potamogeton illinoensis						
Utricularia foliosa		2.1				
Sagittaria graminea						
Hydrocotyle umbellatum						
Other	6.4	6.6	8.1	7.4	8.3	8.5

Table 1, part 2. Percent frequency for the more common plant species in 11 fish ponds.

	Pond				
	B-3	B-4	C-1	C-2	C-3
Open water	5.8	12.1	1.3	5.1	15.6
Eleocharis interstincta	48.9	28.2	23.4	17.3	7.4
Bacopa monnieri	8.7	4.3	10.6	13.8	8.2
Chara sp.	9.7	17.0			25.8
Pontederia cordata		3.3	13.2	11.8	9.4
Ludwigia repens			4.7		4.5
Eleocharis cellulosa		5.9		12.6	8.2
Najas guadalupensis	4.5			3.5	2.0
Graminae			6.0	5.9	3.7
Paspalum sp.	2.9	4.3	3.8		3.7
Panicum sp.		6.9	3.8	2.8	
Typha angustifolia			12.3	9.1	
Eleocharis caribaea	4.2	6.2			
Bacopa caroliniana	5.8		3.4		
Eleocharis baldwinii			2.1		
Bacopa cyclophylla			2.6	3.1	
Panicum repens					
Potamogeton illinoensis			3.4		
Utricularia foliosa					
Sagittaria graminea		2.0			
Hydrocotyle umbellatum				2.0	
Other	9.5	9.8	9.4	13.0	11.5

Table 2. Chemical analysis of water in 12 ponds, January and February, 1977.

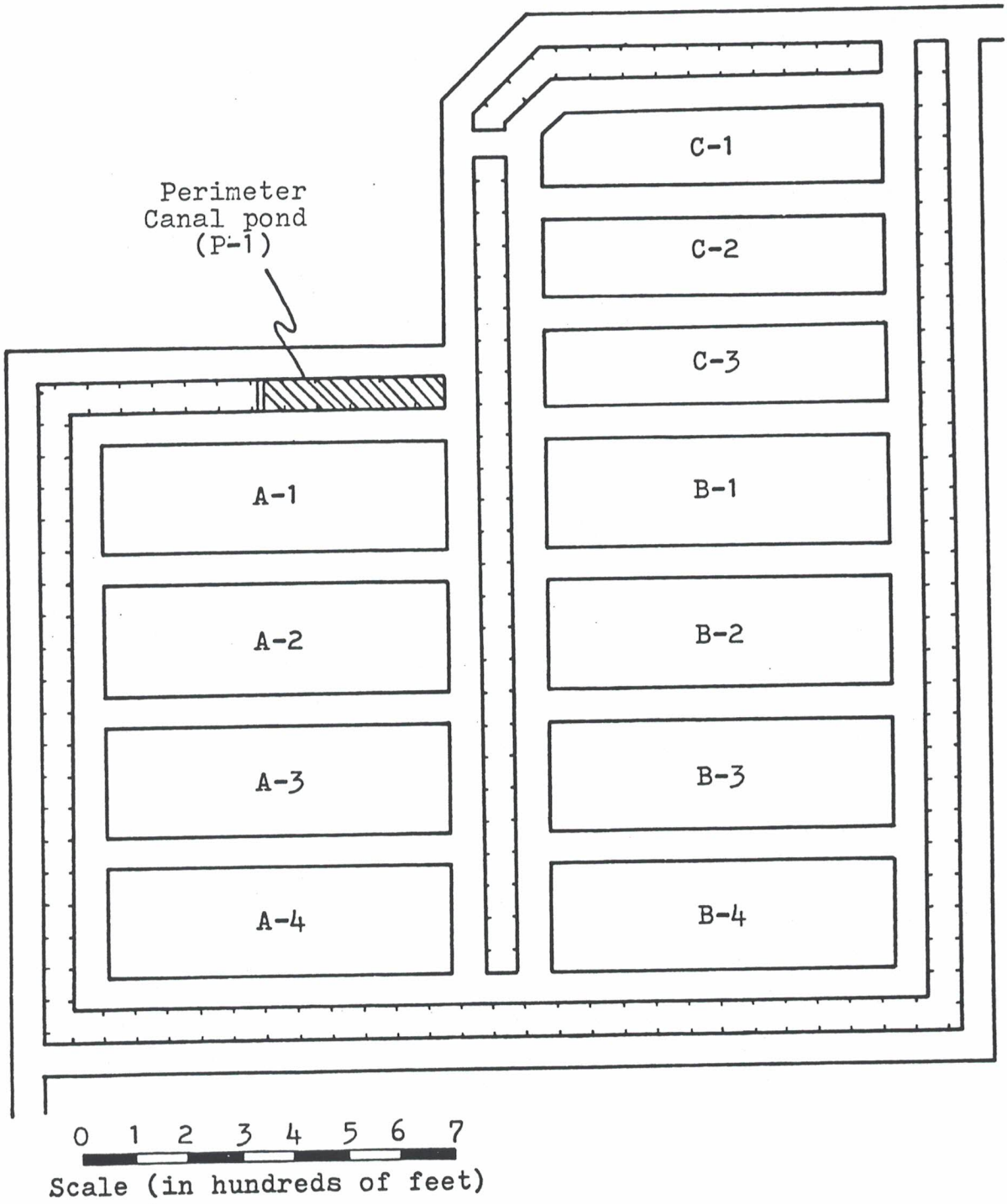
Pond	Conductivity (umhos/cm3)	pH	Total Alkalinity (mg/l)	Hardness (mg/l)	Carbon Dioxide (mg/l)	Sodium Chloride (ppm)
A-1	520	8.5	260	290	40	75
A-2	380	9.0	190	190	20	75
A-3	530	9.0	200	200	30	112
A-4	480	9.0	190	170	20	100
B-1	390	9.0	190	200	10	75
B-2	420	9.0	190	200	20	75
B-3	550	8.5	220	240	25	75
B-4	440	9.0	150	190	15	75
C-1	380	8.0	200	190	25	87
C-2	470	8.5	200	200	20	100
C-3	370	9.0	170	170	20	75
Perim. Canal	470	9.0	220	220	25	75

Table 3. Estimated standing crop of fish in 11 ponds, 1977.

Pond	Size of pond acres	Size of pond hectares	Date Sampled	Grams of fish in 10%	Production lb./acre	Production Kg./ha.
A-1	3.1	1.26	Apr. 28 May 25	26,463	188	211
A-2	3.1	1.26	May 4 & 6	13,771	98	110
A-4	3.1	1.26	Apr. 26	8370	60	67
B-1	3.1	1.26	Apr. 19	13,154	94	105
B-2	3.1	1.26	Apr. 14	12,535	89	100
B-3	3.1	1.26	Apr. 12	9492	68	76
B-4	3.1	1.26	Apr. 8	13,530	96	108
C-1	2.4	.97	May 10	5880	59	66
C-2	2.4	.97	May 12 & 18	5760	58	65
C-3	2.4	.97	Apr. 21	8676	80	90
P-1	0.4	.16	June 1	9920 *	456	511

* 12 percent of the perimeter canal pond was sampled.

Fig. 1. **FISH PONDS AT CORKSCREW SWAMP SANCTUARY,** showing location of new perimeter canal pond.



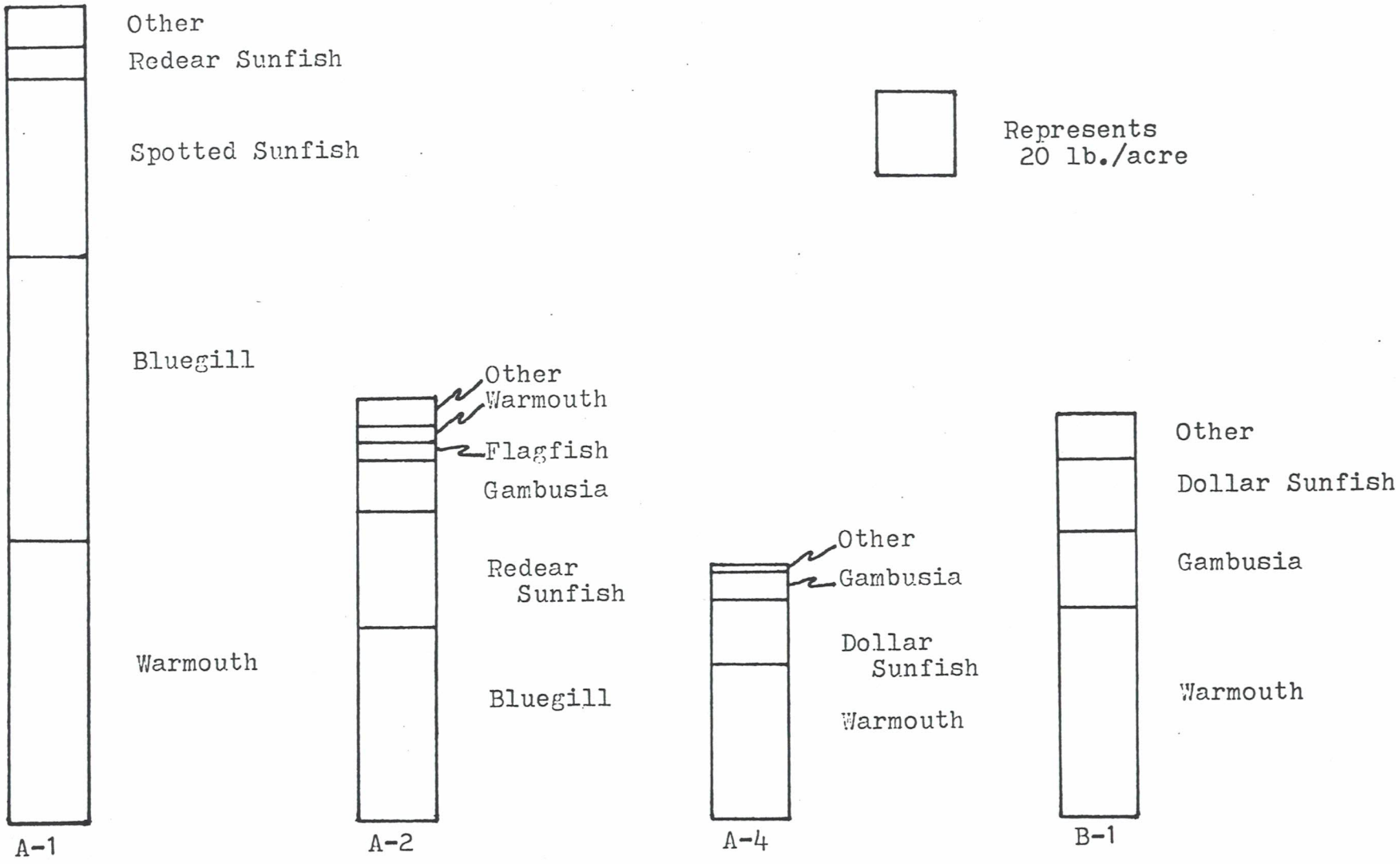


Fig. 2. Standing crop and species composition in ponds A-1, A-2, A-4, and B-1, 1977.

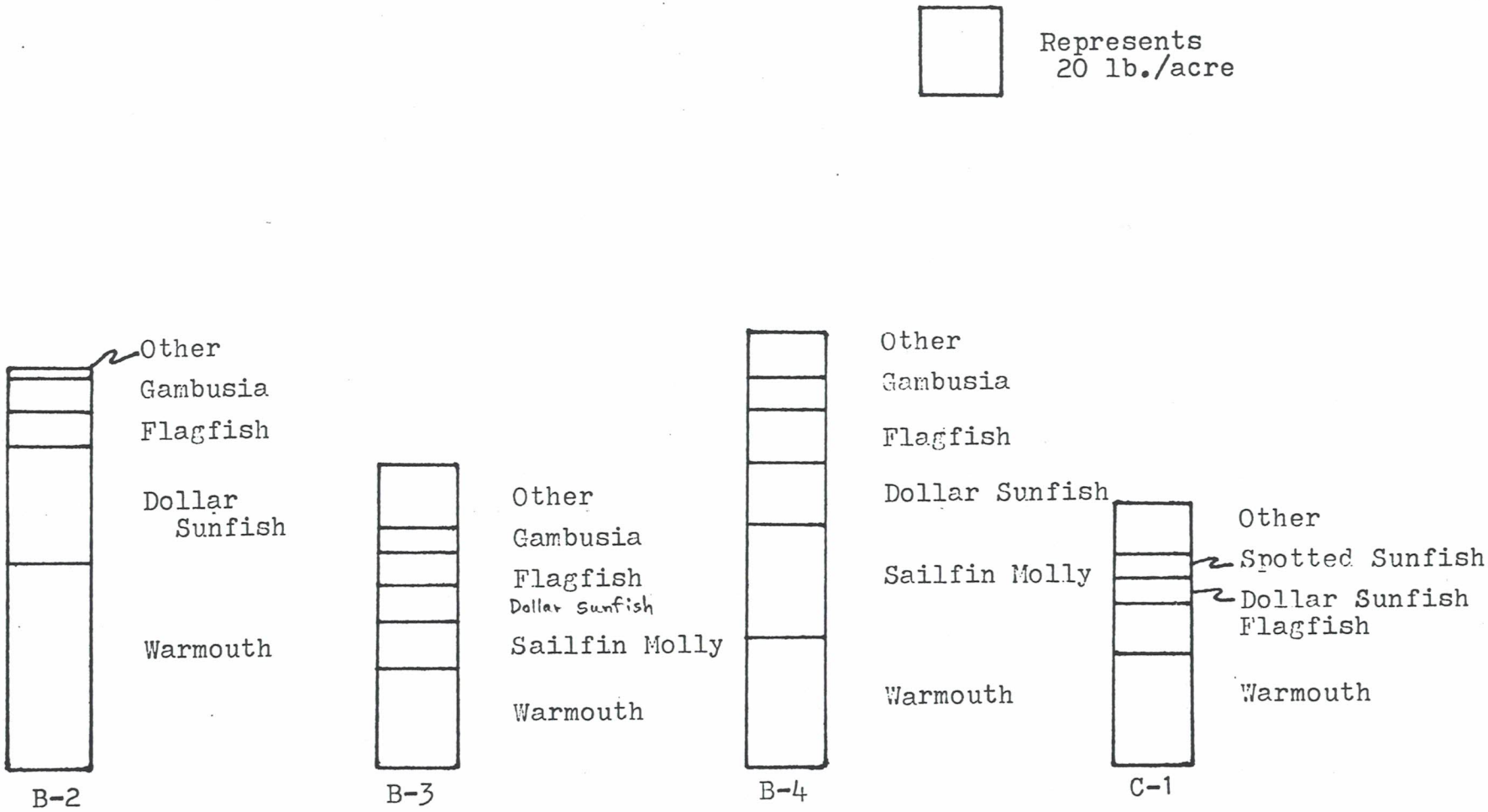


Fig. 3. Standing crop and species composition in ponds B-2, B-3, B-4, and C-1, 1977.

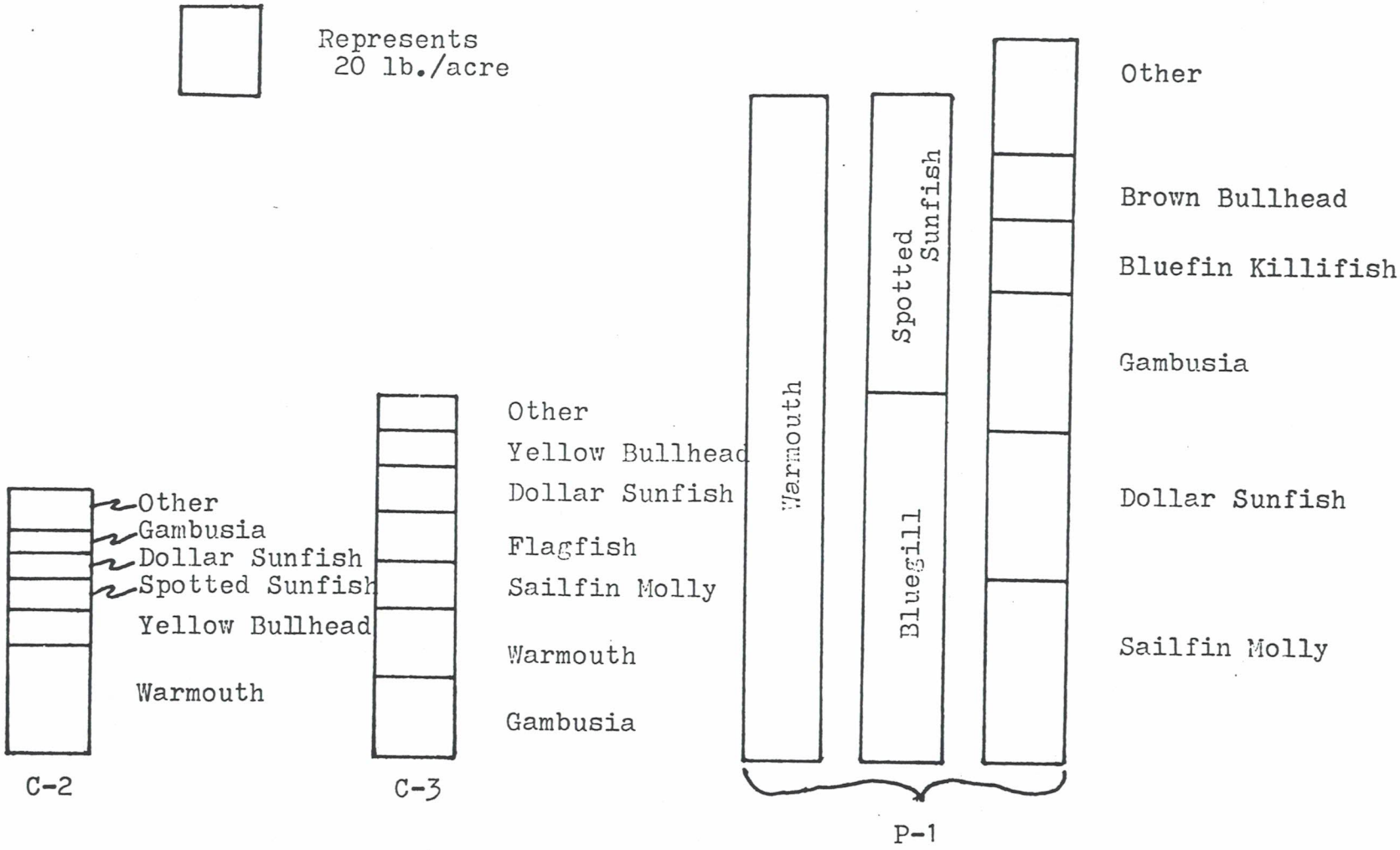


Fig. 4. Standing crop and species composition in ponds C-2, C-3, and P-1, 1977.

1977 Progress Report

John C. Ogden

Dynamics of regional colonial wading bird populations

Introduction

Numbers of colonial wading birds (herons, egrets, ibis, storks, etc.) nesting in colonies throughout the United States have varied considerably during recent decades, in response to a wide range of population regulating factors (for ex. Allen 1936, 1958, Ryder 1967, Siegfried 1971). Plume hunting, habitat alteration, direct disturbance to colony sites and pesticides have been reported as major adverse factors on wader populations, while creation of sanctuaries, protection of coastal wetlands, creation of dredge islands, decline in pesticides and the termination of plume hunting are factors responsible for wader increases (Allen 1958, Anderson 1978, Ohlendorf et al, 1978, Parnell & Soots 1978). Various combinations of these positive and negative regulating factors have operated at local and regional levels to produce constrasting and often difficult to explain population trends by waders. An especially interesting constrast in trends has occurred since the 1950s as numbers of waders nesting along the mid and north Atlantic coast have increased dramatically, while waders nesting in the interior wetlands of Florida have declined (Ogden 1978).

In addition to man-caused factors listed above, annual climitological variation has considerable influence on nesting waders (Lowe-McConnell 1967). In Florida we have noted correlation between the number of waders in colonies, location of colonies, geographical shifts within regional populations, and the timing of nesting with annual and seasonal variation in rainfall and temperature.

The combination of man-caused and climitological factors determines the number, species and reproductive success of waders that nest in individual

colonies and within regional populations. The direction and magnitude of long range population trends, however, is much more likely determined by human than by natural factors because the former may have more lasting influence on the kinds of places utilized by nesting waders and on the number of young produced. How these factors actually operate to regulate numbers, distribution and nesting success of waders remains poorly known, as no attempt has been made to correlate long-term history of regional populations with climitological and man-caused regulating factors. Thus several important changes in status within regional populations remain unexplained. For example, the apparent dramatic decline in numbers of waders nesting in the southern everglades between 1933 and 1940 (from 500,000-600,000 birds to 120,000 birds) has long been thought to represent an absolute decline in numbers (Robertson & Kushlan 1974). A recent analysis of historical data by the National Audubon Research Department (Ogden 1978) includes the suggestion that the decline may have been due in part to a shift in nesting locations by large numbers of White Ibis, for reasons not presently understood. More recently, NAS aerial surveys of wader colonies in south Florida since 1974 have shown a seasonal shift in nesting, where species that historically nested during spring in the freshwater marshes now nest during some years in both spring and summer, as late as October. The ultimate reasons for both geographical and seasonal shifts in nesting in southern Florida are almost certainly man-caused, although annual variation in the number of birds participating in the shifts may be regulated by climitological factors.

Most previous field work with colonial wading birds has been designed to census or study individual colonies or local populations, and has not produced the kinds of data needed to understand regional dynamics

(for ex. Shanholtzer et al, 1970). A few regional censuses already conducted, for example on the Texas and Louisiana coasts by National Audubon and the Texas Fish-eating Bird Survey, were primarily set up to locate colonies and estimate number of birds in each, but not to assess regional dynamics. During 1975 and 1976 the Patuxent Research Center of the Fish and Wildlife Service organized a more thorough census of wader colonies along the entire Atlantic coast, which produced the kinds of data necessary for understanding regional dynamics (Custer & Osborn, 1977). All field work on the Atlantic coast survey terminated after two years, however, and those data are of too brief a period for significant interpretation.

Project description

It has become increasingly apparent that because of seasonal and geographical shifts in wader nesting locations, that determination of population trends, and factors regulating these trends, cannot be adequately measured by studies of local colonies. Thus we have set our project over a large enough geographical region so that we can show correlations between wader population trends and the various human-caused and natural regulating factors. Because several species of waders appear to be declining in Florida, we have established the Florida peninsula, east of the Ochlockonee River, as our study area.

Specifically, the questions we seek to answer are as follows:

1) What are the numbers of birds and distribution of nesting sites for each species of colonial wading bird in peninsular Florida?
2) Comparing our census data with historical data, can population trends be determined, on either a species or regional basis?
3) On a species basis, what are the characteristics of sites presently

used for nesting by waders in peninsular Florida?

4) What is the annual variation in numbers and geographical distribution of nesting waders, related to climitological and human-caused regulating factors?

5) What are the seasonal and geographical variations in colony productivity related to colony characteristics, colony location, human influence and climitological factors?

Our plan has been to initiate this project with a three year aerial census of peninsular Florida, primarily designed to achieve objectives 1, 3 and part of 4 listed above. The census is set up as a cooperative venture, with Steve Nesbitt of the Florida Game and Fresh Water Fish Commission flying northern Florida, Herb W. Kale of the Florida Audubon Society flying east Florida, while I census the south and west peninsula. Aerial censuses are conducted twice annually, in April and again in June or July. In south Florida where nesting occurs during much of the year, once monthly censuses are flown between January and October. The procedure during each aerial census has been to view each known colony to determine characteristics and species involved. New colonies are located by systematic searches of likely habitat, and by locating waders in flight lines and following them to colonies. A standardized data sheet used for each colony check is attached.

During the final (third) year of the aerial census, ground studies will be initiated to achieve objectives 4 and 5. The ground studies will be continued two years beyond termination of aerial censuses. Ground studies will be conducted in a representative sample of the total peninsula colonies, with the number and location of colonies to be studied not yet determined. Following three years of ground studies, a thorough evaluation of the project

will determine the need for additional data.

At the termination of this project, we will know the number and distribution of each species of colonial wader nesting in peninsular Florida, and the major factors that regulate productivity for each, including the kinds of sites required for nesting. These data should show why certain species are declining (if they are), or indicate specific avenues of research that will provide this information. We will prepare reports on the numbers and distribution of waders nesting in peninsular Florida, the characteristics of colony sites, and the influence of human and climitological factors on regional wader populations.

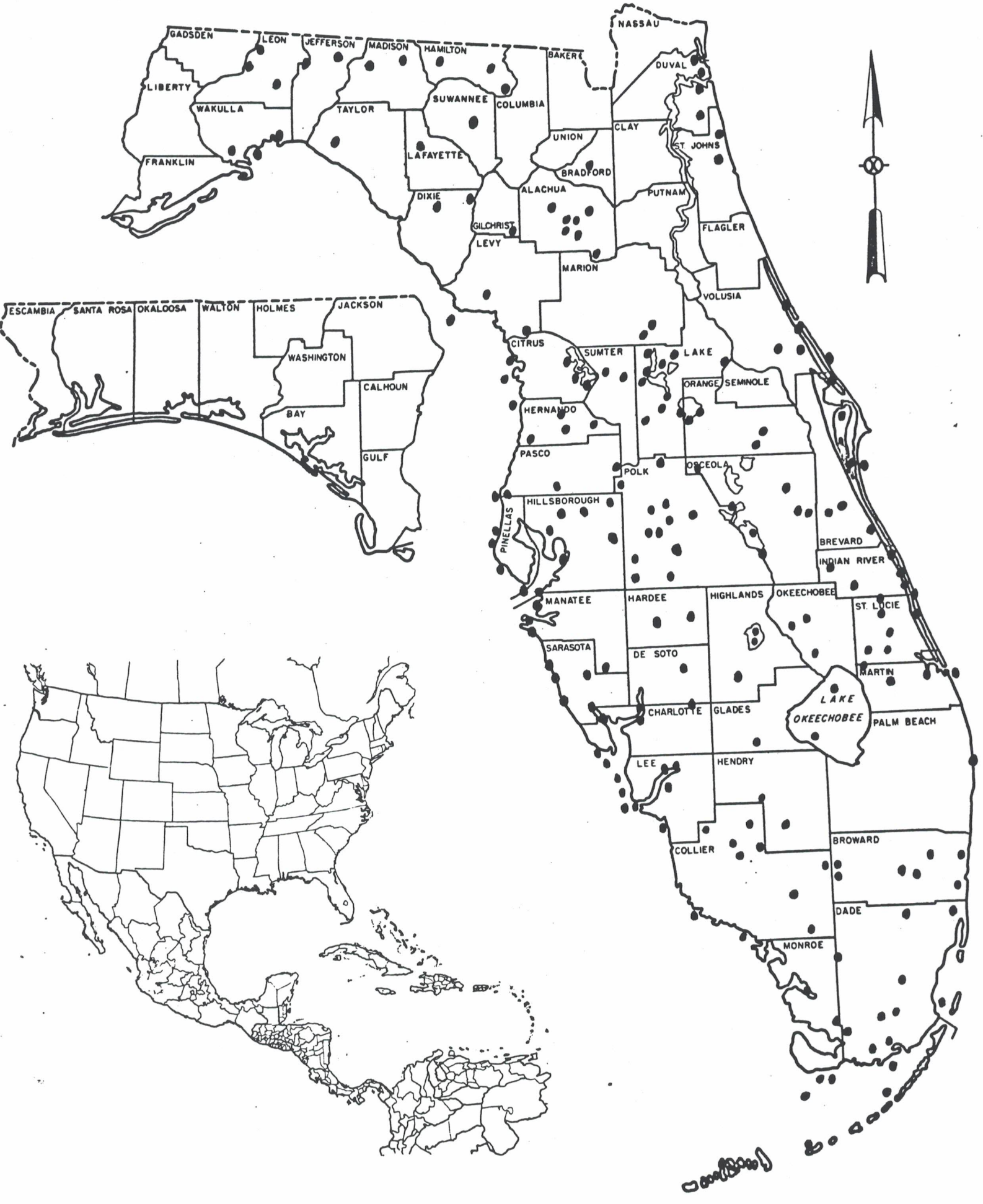
1977 results

Aerial censuses during 1977 were flown on April 26, 27 and July 14 by Nesbitt, on April 27, 28, May 3, June 9, 10 and 20 by Kale, and January 4, February 3, March 3, April 6, 20, 21, June 6, July 13, 15, 22, and October 17 by myself. We accumulated data on 223 wading bird colonies through the October census. Locations of these colonies are shown on Figure 1.

Beginning in the summer of 1976, we have issued bi-annual reports to land management, conservation and governmental agencies in south Florida that describe location and contents of colonies in the southern peninsula. If properly utilized, these reports provide advanced information needed for protection of south Florida colonies during future land management or development ventures. Copies of the two 1977 reports are attached.

Some preliminary analyses of peninsular Florida colonies is presented here, to illustrate the kinds of data being collected for objective 3. Our data will eventually be organized and interpreted with respect to relationships between colony location and species composition, habitat, geographical

Figure 1. Location of 223 wading colonies located in peninsular Florida during 1976 and 1977 censuses. Some dots represent more than single colonies.


GADSDEN
LEON
JEFFERSON
MADISON
HAMILTON
BAKER
NASSAU
DUVAL
LIBERTY
WAKULLA
TAYLOR
SUWANNEE
COLUMBIA
CLAY
UNION
ST. JOHNS
FRANKLIN
LAFAYETTE
BRADFORD
ALACHUA
PUTNAM
DIXIE
GILCHRIST
FLAGLER
LEVY
MARION
VOLUSIA
ESCAMBIA
SANTA ROSA
OKALOOSA
WALTON
HOLMES
JACKSON
WASHINGTON
CITRUS
SUMTER
LAKE
ORANGE
SEMINOLE
CALHOUN
BAY
HERNANDO
PASCO
POLK
OSCEOLA
GULF
HILLSBOROUGH
PINELLAS
BREVARD
INDIAN RIVER
MANATEE
HARDEE
HIGHLANDS
OKEECHOBEE
ST. LUCIE
SARASOTA
DE SOTO
MARTIN
LAKE
OKEECHOBEE
CHARLOTTE
GLADES
PALM BEACH
LEE
HENDRY
COLLIER
BROWARD
DADE
MONROE

location or relationship to human activity centers.

The preliminary analyses shows that all 223 colonies are associated with water, with 59 percent being located in vegetation over standing water, and 41 percent on islands in lakes, rivers, or along coastlines. 76 percent of the colonies are located at natural sites where water and vegetation appear to be unaltered by human activities. Colonies in altered sites were 30 (14%) located in water impoundments and 23 (10%) on dredge islands. Dominant vegetation in colonies, from highest frequency to lowest, included willow thickets (32%), mangrove (30%), cypress (19%), mixed swamp hardwoods (14%), a mixture of other woody plant classifications (4%), and herbaceous vegetation (1%). Nesting colonial waders in Florida are surprisingly tolerant of close human activity, so long as direct disturbance to colonies does not occur. 41 percent of the surveyed colonies are less than one-half mile from regular human activity, such as highways, marinas or towns.

During 1977 we looked at nesting success and food habits of waders in select colonies in the Everglades region of Florida as a preliminary investigation of techniques and results needed to accomplish objective 5 listed above. Furthermore, the Everglades colonies were selected for preliminary study as part of our attempt to understand the dynamics of the seasonal shifts in nesting recently documented in south Florida.

Tables 1 and 2 show our preliminary food habits data for two common waders, Snowy Egrets and Louisiana Herons, in the Everglades region. The interesting comparison between these two waders is the strong similarity in both frequency of each species of fish in the diet of the two waders, and similarity in size of fish taken by the two.

Table 1. Prey items from food samples of Snowy Egrets and Louisiana Herons showing significance of differences in percentage of each prey species in total diet.

Prey Item	Snowy Egrets #	(% of total)	Louisiana Herons #	(% of total)	t_s	
Gambusia affinis	362	(24)	130	(25)	-0.781	ns
Poecilia latipinna	266	(17)	104	(20)	-1.46	ns
Jordanella floridae	124	(8)	56	(11)	-1.89	ns
Heterandria formosa	109	(7)	12	(2)	4.568	***
Lepomis sp.	52	(3)	18	(4)	-0.118	ns
Fundulus chrysotus	96	(6)	42	(8)	-1.46	ns
Cyprinodon variegatus	1	(0.07)	71	(14)	-13.907	***
Fundulus confluentus	85	(6)	50	(10)	-3.12	**
Lucania goodei	35	(2)	8	(2)	1.03	ns
Lepomis punctatus	5	(0.33)	1	(0.19)	0.544	ns
Lepomis gulosus	1	(0.07)	0	(0)	-----	--
Fundulus grandis	5	(0.33)	0	(0)	-----	--
Adinia xenica	2	(0.13)	1	(0.19)	-0.296	ns
Lepomis macrochirus	0	(0)	1	(0.19)	-----	--
Fundulus sp.	0	(0)	1	(0.19)	-----	--
Notropis maculatis	0	(0)	1	(0.19)	-----	--
Palaemonetes paludosus	389	(25)	12	(2)	14.68	***
Dragonflies, etc.	3	(0.20)	6	(1)	-2.309	*
	1535		514			

ns = not significant, *** $P \leq 0.001$, ** $P \leq 0.01$, * $P \leq 0.05$

Table 2. Lengths (in mm) of prey items taken by Snowy Egrets and Louisiana Herons showing significance of differences in length means between the two waders for each prey species.

Prey item	Snowy Egrets n	$\bar{x}$ ± s.d.	Louisiana Herons n	$\bar{x}$ ± s.d.	Test statistic	
Gambusia affinis	359	20.97 6.00	130	21.53 4.22	-1.153	ns
Poecilia latipinna	266	29.19 5.81	104	28.63 6.59	0.63	ns
Jordanella floridae	120	26.38 4.73	56	24.41 4.84	6.49	*
Heterandria formosa	109	13.43 3.82	12	13.75 2.80	0.08	ns
Cyprinodon variegatus	1	21.00 ----	71	19.89 6.26	----	--
Fundulus chrysotus	96	33.12 6.70	42	31.10 8.31	2.31	ns
Palaemonetes paludosus	211	8.97 1.86	12	9.42 1.78	0.66	ns
Lepomis sp.	52	34.96 9.10	18	30.39 6.75	3.80	ns
Lucania goodei	35	19.80 5.22	8	20.50 5.68	0.11	ns
Lepomis punctatus	5	44.60 4.28	1	44.00 ----	----	--
Lepomis gulosus	1	69.00 ----	0	---- ----	----	--
Fundulus grandis	5	42.40 8.56	0	---- ----	----	--
Adinia xenica	2	22.50 2.12	1	25.00 ----	----	--
Lepomis macrochirus	0	---- ----	1	34.00 ----	----	--
Fundulus sp.	0	---- ----	1	43.00 ----	----	--
Notropis maculatus	0	---- ----	1	52.00 ----	----	--
Fundulus confluentus	85	38.29 6.52	50	35.38 11.85	1.615	ns

t_s for F. affinis and F. confluentus; Fs for all others.

ns = not significant, * $P \leq 0.05$

1978 plans

During 1978, we have the following goals.

1) Complete the third and final year of our aerial census of peninsular Florida.

2) Initiate ground studies of select colonies to determine nesting success related to colony type, location, and human and climitological factors (objective 5). Barbara Warren, biological technician who joined our staff in 1977, has greatly increased the capability of our staff to collect these kinds of data, and she will be heavily involved in this project during 1978. It is important that a representative sample of the different types of colonies be selected for ground study, thus we will work with Don McCrimmon when developing a procedure for selection of study colonies.

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FLORIDA WADING BIRD COLONY

AERIAL SURVEY FORM

1. County: 2. Date: 3. Observer:

4. Colony name (if known, or assign one):

5. Location: T_____ R_____ Sect_____ 1/4 Sect (if possible)_____
(Give complete description in relationship to local landmarks, and distance-direction to nearest town):

6. Size of colony (estimated acres or dimensions):_____

7. Dominant vegetation supporting nests:_____

Surrounding vegetation:_____

8. Estimate of vegetation height:_____

9. Colony is island in: _____lake, _____river creek, _____coastal

10. Colony is: _____natural, _____spoil island, _____water impoundment

Colony is: _____within 1/2 mile of building or heavy human activities

_____more than 1/2 mile, etc.

11. Nests are: _____over water

_____over high ground that probably is never or rarely flooded

_____at a seasonally flooded site, now ____ wet or ____ dry

_____don't know

Colony name: _____

12. Species (waders only: list in apparent order of abundance, using adults in flight lines to help determine relative abundance).

	Species	Approx. # pairs*	Nest-build*	Eggs**	Downy young**	Large young**
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						

* Aerial estimates on numbers will have to be very rough at most sites. Make your best estimate, and we'll try to check many sites later on.

**Check more than one when necessary.

13. Comments (anything additional that may be useful: notes on ground access, previous history, anything unusual, other species nesting at site, etc.):

14. Please show with arrows the major directions of flight lines out from colony. Use larger arrows for heavier flight lines, where birds are going in several directions.

NORTH

WEST COLONY EAST

SOUTH

COLONIAL WADING BIRD NESTING SITES, REPORT # 2
SPRING, 1977

National Audubon and Florida Audubon continue to conduct aerial surveys of colonial wading bird nesting colonies in south Florida. We make these data available in the hope that they will be useful to land management and conservation organizations, and for regional planning.

Included in Report #2 are the colonies we located during aerial surveys between March and May 1977. The region reported here is north from the Tamiami Trail to the Cypress Creek-Allapattah Flats region of southwestern St. Lucie County, the lower Kissimmee drainage, and coastal Charlotte County. Important contributions to the survey were made by Larry Riopelle of National Audubon, Tim Regan and Steve Schwikert of the Florida Game and Fresh Water Fish Commission, and Ted Below of Naples, Florida. Colonies in the Everglades National Park and vicinity were surveyed by Jim Kushlan, and are reported separately.

The enclosed map shows locations for 34 colonies that were surveyed during spring, 1977. Perhaps typical of the spring nesting season in south Florida, most colonies are located on coastal islands. Since freshwater wetlands are largely dry during spring, most inland colonies are located either on islands in lakes (18-20), or in water impoundments (21-23, 25-30). Numbers on the map correspond to descriptions of the colonies listed below. All bird numbers are estimates of nesting pairs. Estimates of pairs in some densly vegetated colonies were not possible from an airplane, especially for the smaller, dark herons. These 34 colonies contained a minimum of 12,000 pairs of White Ibis (WI), 7500 pairs of Cattle Egrets (CE, also present 4 colonies where numbers not determined), 6800 pairs of Snowy Egrets (SE, also present 8 colonies where numbers not determined), 3400 pairs of Great Egrets (GE), 2700 pairs of Louisiana Herons (LH, also present 7 colonies where numbers not determined), 450 paris Wood Storks (WS), 360 pairs Great Blue Herons (GBH), 250 pairs Little Blue Herons (LBH, also present 1 other colony where numbers not determined), 250 pairs Black-crowned Night Herons (BCNH - only counted one colony), and 100 pairs of Glossy Ibis (GI).

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SPRING 1977 COLONIES

The following estimates are the highest recorded during one or more surveys between March and May 1977. These data are preliminary, and should not be used without approval of National or Florida Audubon. We would very much appreciate learning of any colonies not included in this report.

(1) North Port Charlotte, Sarasota Co., 150 GE, 50 SE, plus GBH, CE and LH.

(2) Lower Myakka River, Charlotte Co., 15 GBH and 10 GE.

(3) Shell Creek, Charlotte Co., 45 GE, plus SE and several hundred CE in early nesting on 20 April.

(4) Lower Peace River, Charlotte Co., 17 GBH.

(5) Placida, Charlotte Co., 50 GE, 15 GBH, plus SE and LH.

(6) East of Boca Grande, Charlotte Co., 15 GBH, 5 GE.

(7) Broken Island, Lee Co., 300 SE, 50 WI, 25 GBH, 25 GE.

(8) Useppa Bird Island, Lee Co., mostly pelicans, but includes 15 GBH, 5 GE, and some LH.

(9) Hemp Key, Lee Co., 100 GE, plus LH.

(10) Cork Key, Lee Co., 20 GBH.

(11) Lower Pine Island Sound, Lee Co., 35 GE and 5 GBH.

(12) Matacha Pass Bird Island, Lee Co., 25 GE.

(13) Ft. Myers Power Plant, Lee Co., 200 CE, 25 GBH, 25 GE, plus SE and LH.

(14) Midway Island, Lee Co., 200 GE, 25 GBH, plus SE and LH.

(15) Estero Bay, Lee Co., 50 GE, plus SE and LH.

(16) Marco A-B-C colony. Collier Co., 300 SR, 250 LH and 60 GE.

(17) Corkscrew Sanctuary, Collier Co., contained 300 WS, 200 GE, 200 CE, 50 GBH, plus SE on 21 April; the storks later deserted.

(18) Istokpoga marsh island, Highlands Co., 1000 WI, 1000 CE, 500 SE, 50 LBH and 5 GBH.

(19) Bumblebee Island, Highlands Co., 200 GE.

(20) Kings Bar, Okeechobee Co., 5000 CE-SE, 1000 WI, 250 GE, 50 LBH.

(21) Bootheel Creek, Highlands Co., 750 CE, 50 GE, 50 WI, plus LBH.

(22) Cypress Creek, St. Lucie Co., 150 WS, 250 CE, 250 SE, 50 GE and 50 LBH (called Allapattah Flats in Report #1).

(23) Foxbrown Road, St. Lucie Co., 1000 Se, 1000 CE, 150 GE, 100 LH and 100 LBH.

(24) Lettuce Creek Bayhead, Martin Co., 100 GE.

(25) Andytown East, Broward Co., 10,000 WI, 1900 SE, 1200 LH, 1000 GE, 250 BCNH and 100 GI.

(26) Andytown West, Broward Co., 200 LH and 25 GE.

(27) Andytown East Melaleuca, Broward Co., 40 GBH.

(28) L-67, Dade Co., 1450 SE, 850 LH and 450 GE.

(29) L-67 Melaleuca, Dade Co., 30 GBH.

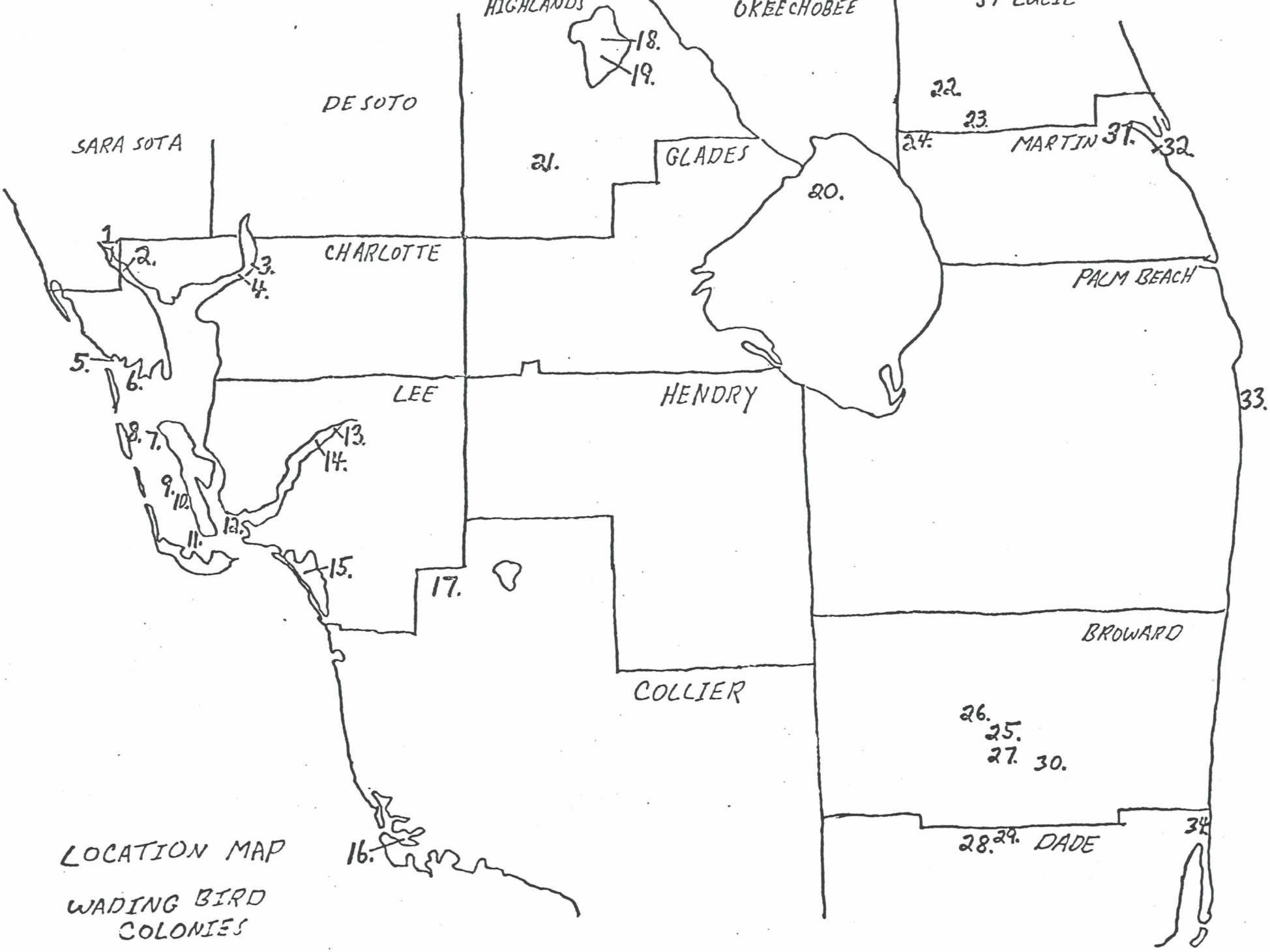
(30) Holiday Park Melaleuca, Broward Co., 20 GBH.

(31) Palm City, Martin Co., 500 CE-SE, 100 LH and 50 GE.

(32) Sewall, Martin Co., 150 SE-CE, 75 GE and 25 GBH.

(33) Fisherman's Island, Palm Beach Co., 1000 CE-SE, 50 GE and 15 GBH.

(34) Greynold's Park, Dade Co., not surveyed, but known to be active, primarily CE.



LOCATION MAP

WADING BIRD COLONIES

SPRING 1977

NOT FOR PUBLICATION

Colonial Wading Bird nesting sites, Report #3
Summer 1977

This report is the third in a series of twice-yearly reports on the location of colonial wading bird nesting colonies in south Florida. We make these data available with the hope that they will be used for land management, regional planning and conservation purposes.

Included in Report #3 are the colonies we censused during aerial surveys between June and October 1977. The region of survey is north from the Tamiami Trail to the Cypress Creek-Allapattah Flats region of southwestern St. Lucie County, the lower Kissimmee drainage, and Charlotte County. Although some coastal colonies were included during the summer surveys, most were not surveyed. Locations and species in the coastal colonies omitted from report #3 are included in the previous report for the spring 1977 surveys. A few well known inland colonies are also omitted from this report (King's Bar, Lake Istokpoga, etc.) since our major effect during the summer surveys was to search for new colonies rather than re-examine known sites. Previous information on the omitted inland sites is included in reports # 1 and 2.

Important contributions to the summer 1977 surveys in south Florida were made by Larry Riopelle and Barbara Warren of National Audubon, Tim Regan and Steve Schwikert of the Florida Game and Fresh Water Fish Commission, Ted Below of Naples, Florida, and James King of Miami.

The attached map show locations for 28 colonies censused during summer 1977. The major theme of this summer was reduced nesting compared to 1976, due to generally low water conditions throughout the everglades-cypress regions. Certain 1976 summer colonies that failed to form during 1977, or which were much reduced (Alligator Alley North, Alligator Alley South, Roberts Lake Strand, Okaloacoochee North, Boggy Slough, Ortona and L-28 Interceptor) remained dry during most of the summer. Keeping in mind the inaccuracy of aerial censuses, the number of waders that initiated nesting in inland colonies during summer 1977 was much less than in 1976. The 28 colonies in 1977 contained a minimum of 20,000 pairs of Cattle Egrets (CE), 700 pairs of White Ibis (WI), 660 pairs of Little Blue Herons (LBH), 175 pairs of Great Egrets (GE), 150 pairs of Snowy Wgrets (SE), and lesser numbers of other species.

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Summer 1977 colonies (birds reported in pairs)

1. L-67, Dade Co. (T52S, R37E, Sect. 23). 1500 SE, 900 LA, 500 GE, (most with large young) on 6 June; about empty with only 10-15 unidentified egret nests and some Anhinga on 22 July.

2. Greynolds Park, Dade Co. (T52S, R42E, Sect. 9). 16 June ground survey by J. King - 435 CE, 7 LA, 8 LBH, 6 GrH, 2 GE, 1 SE, 4 YCNH, 1 BCNH, 85 WI plus 20 Anhinga and 17 cormorants.

3. Arsenicker Key, Dade Co. (T58S, R40E). 1000+ CE, LBH, LH, WI,)some fledged ibis) on 22 July.

4. 3B, Dade Co. (T52S, R39E, about Sect. 7). New Colony, 100± CE, GE, GBH, Anhinga on 17 October, at tail-end of nesting.

5. Alligator Alley South, Broward Co. (T50S, R35E, w. of L-28). Empty on 6 June and 22 July; small numbers of GE, CE, Anhinga, and night herons at tail-end of nesting on 17 October.

6. Alligator Alley North, Broward Co. Empty on 6 June, 22 July, and 17 October. New drainage ditches since 1976.

7. Andytown West, Broward Co. Apparently deserted on 6 June.

8. Andytown East, Broward Co. (T50S, R38E, Sect. 12-13). 500-1000 CE, 10,000 WI (several 1000 feathered young), 1900 SE, 1200 LH, 1000 GE, 250 BCNH, 100 GI, (SE, GE, LAH with large feather young) on 6 June; on 22 July, native waders finished and gone and 3000 CE nesting.

9. Executive Airport, Broward Co. (T49S, R42E, Sect. 17). 50 CE on 22 July.

10. Power Plant, Broward Co. (T50S, R42E, Sect. 19+). 40-50 LBH with large young on 22 July.

11. Conservation Area 2B, Broward Co. Empty on 22 July.

12. Camp Keais, Collier Co. (T48S, R29E, Sect. 6). New location, 2500 CE, 50-75 LBH on 22 July.

13. Big Cypress Preserve, Collier Co. (NW of jetport to Alligator Alley) 6 small colonies in willows in center of small marsh ponds, includes previous Quakanssee site - combined colonies contained minimum 325 LBH, 100 CE, 1 GE (most LBH with large feathered young) on 22 July.

14. Sunniland, Collier Co. (T48S, R29E, Sect. 33). Empty on 6 June; 500 CE, 50+ LBH, and a few GE on 22 July.

15. Robert's Lake Strand, Collier Co. (T53S, R33E, Sect. 24). Empty on 6 June; 2 GE and 1 GBH on 22 July.

16. Corkscrew, Collier Co. (T47S, R27E, Sect. 3). 6 June: second nesting attempt by WS failed; on 13 July at Corkscrew Sawgrass Pond, 1000 CE in a new location.

17. Marco A-B-C, Collier Co (T52S, R26E, Sect. 9-10). 500 CE, 50 GE, 50 LBH, LH on 20 July.

18. Okaloacoochee South, Collier Co. (T48S, R30E, Sect. 24). Empty on 6 June; on 22 July, much smaller than last year with 1000-1500 CE, LBH.

19. Okloacoochee North, Hendry Co. (T45S, R30E, Sect. 36, R31E, Sect. 31). Empty on 6 June and on 22 July.

20. Boggy Slough, Hendry Co. Empty on 6 June and on 22 July.

21. Fisherman's Island, Palm Beach Co. (T43S, R43E, Sect. 34). On 6 June: 500 CE, 500 WI, 150 SE, 25 GE, LH, LBH.

22. Fox Brown, Martin Co. (T38S, R38E, Sect. 27, 28 & 34). 5000 CE, 500 LH, 150 LBH, 100 GE on 6 June, all with young except CE with eggs.

23. Lettuce Creek Bayhead, Martin Co. (T38S, R37E, Sect. 15, 16). Empty in June.

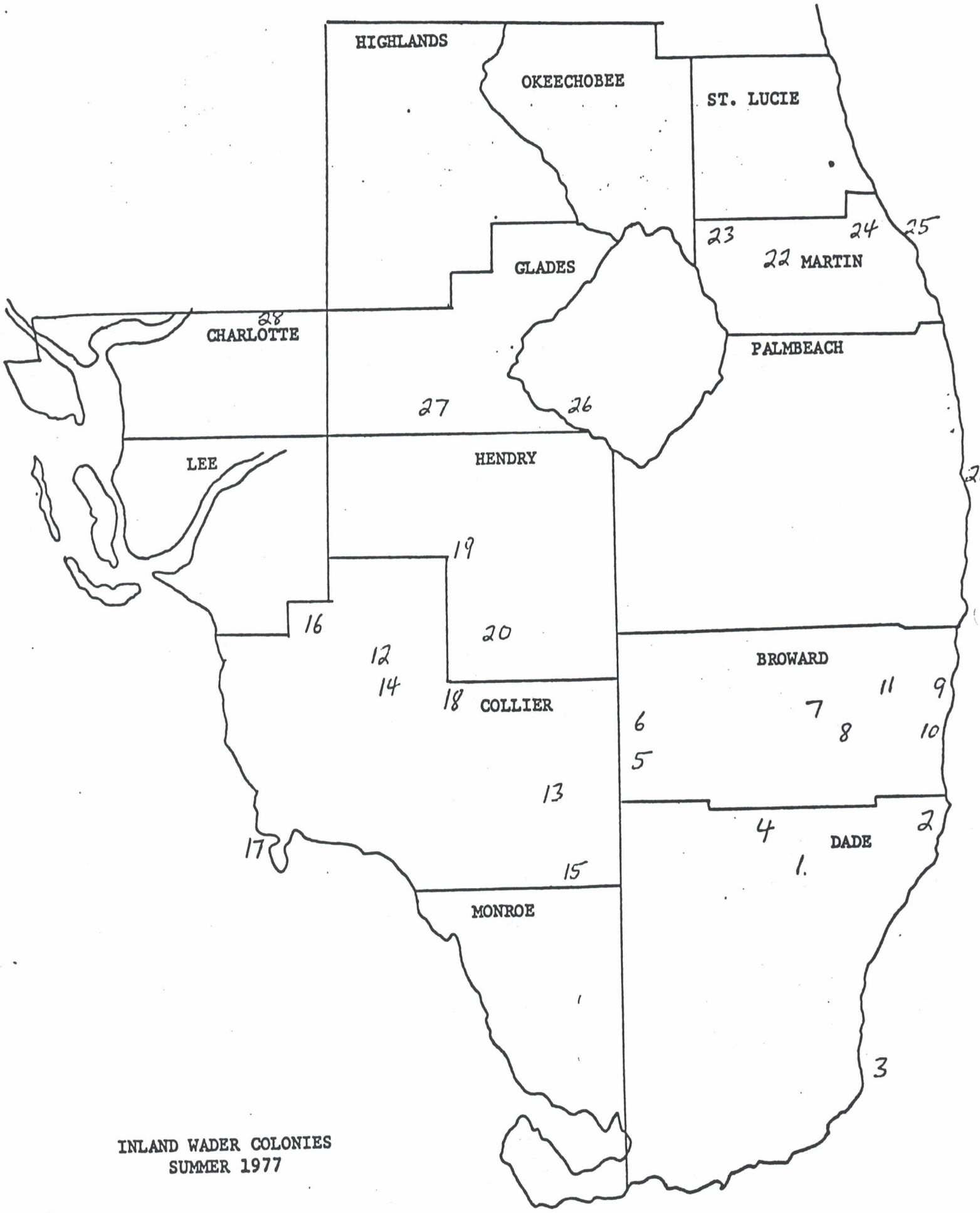
24. Palm City, Martin Co. (T38S, R41E, Sect. 17). On 6 June: 1000 CE, 500 WI, 500 LH, 50 GE, 25 LBH, most with young except CE.

25. Sewall North, Martin Co. (T38S, R42E, Sect. 7). 75 GE on 6 June (plus 100 Brown pelicans).

26. Northeast of Moore Haven, Glades Co. (T41S, R33E, Sect.). New colony 2500-3000 CE, 100± GE, SE, 100+ LH, LBH, WI on 13 July.

27. Ortona, Glades Co. Empty on 13 July.

28. Fairbee Pond, Charlotte Co. Not active in July 1977 (or in April 1977).



INLAND WADER COLONIES
SUMMER 1977

NOT FOR PUBLICATION

STATUS AND BIOLOGY OF THE WOOD STORK IN THE UNITED STATES

John C. Ogden
Annual Report for 1977

Introduction

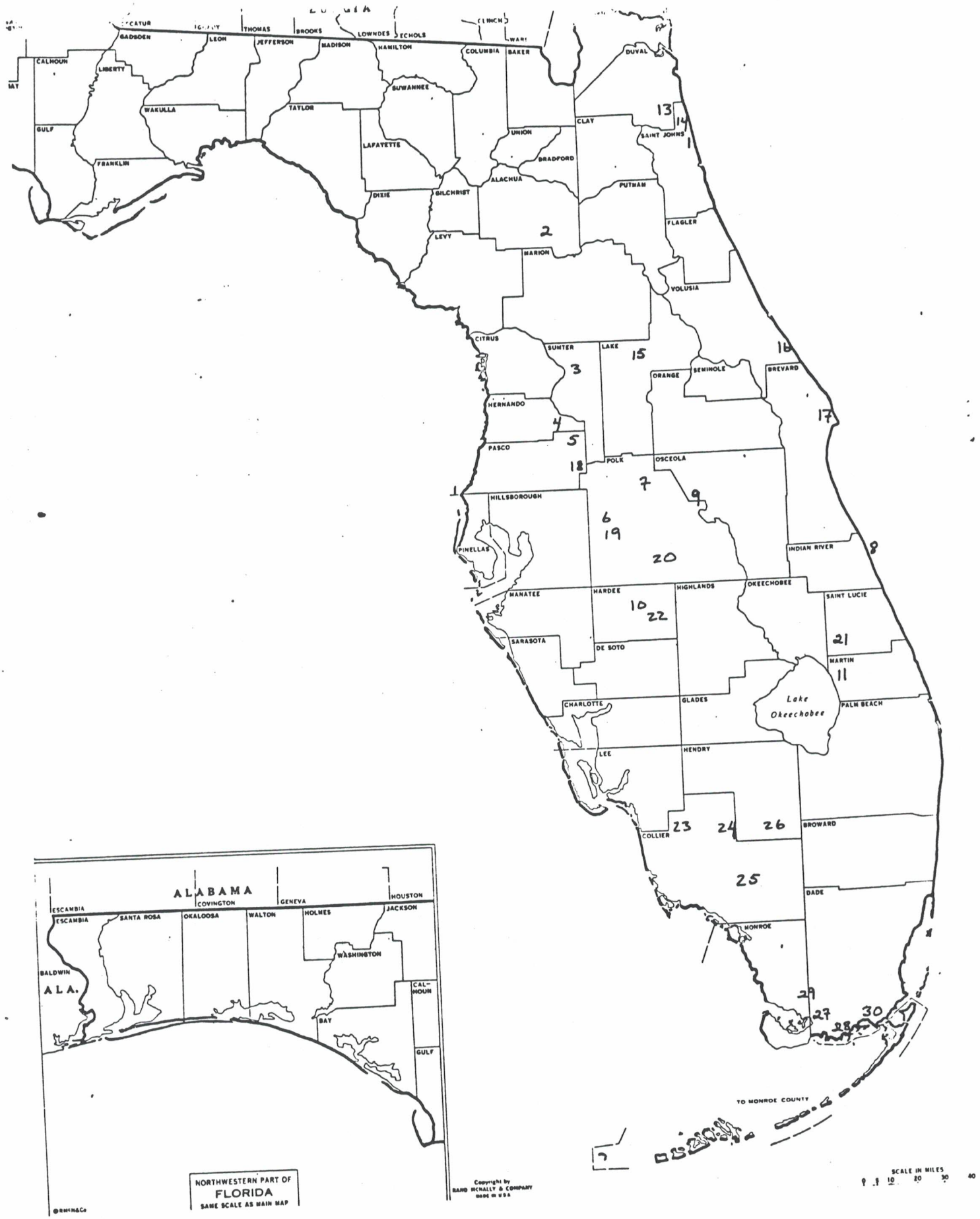
The Wood Stork (Mycteria americana) is one of the larger and more spectacular of colonial wading birds that nests in the United States. It may also be the most threatened wader. All presently known stork nesting colonies are located in Florida and southeastern Georgia, although small stork rookeries formerly were reported in South Carolina, Alabama, Mississippi, Louisiana and Texas. Storks were not hunted by plume-hunters during the 19th and early 20th century, and large colonies existed as recently as the 1930s. They have suffered greatly since the 1940s, however, because of accelerated manipulation of freshwater wetland ecosystems. I estimate approximately 75,000 adult storks were in Florida during the early 1930s, while a series of state-wide surveys during the late 1950s located only 20,000 to 25,000 adults (Ogden, 1978). Concern for the fate of this species in the United States was first expressed during the late 1950s (Allen 1958, Sprunt and Kahl 1960).

Our present study revealed that storks have continued to decline, to an estimated 12,000 adults in 1975-1976. Locations of active colonies and numbers of pairs in each during the late 1950s and mid-1970s censuses are shown in Figure 1 and Table 1. Most of the decline between these two series of censuses has been due to nesting failures caused by lowered water tables, which adversely affected both food supply and nesting sites. Clearly the stork is in need of serious study if we are to hope that viable colonies will persist in the United States.

Table 1. Active Wood Stork colonies for 1959, 1960, 1975 and 1976.

Colony #	Colony	1959 # Pairs	1960 # Pairs	Colony #	Colony	1975 # Pairs	1976 # Pairs
1	Guano	50	50	2	River Styx	100	70
2	River Styx	450	150	4	Croom	85	0
3	Panasofkee	125	120	8	Pelican Island	275	160
4	Croom	325	300	12	Craven Hammock	0	16
5	Lacoochee	0	40	13	Dee Dot	85	125
6	Panther Point	40	120	14	Cabbage Swamp	?	45
7	Teneroc	120	10	15	Lake Yale	150	110
8	Pelican Island	2	0	16	Turnbull	100	50
9	Reedy Creek	215	200	17	Moore Creek	150	225
10	Charlie Creek	175	35	18	Blue Lake	(active)	150
11	Barky Barber	?	200	19	Mulberry	(active)	450
				20	Payne Creek	0	4
				21	Cypress Creek	75	40
				22	El Clair	0	250
Total North-Central Florida		1502	1225			1020(1620)	1695
23	Corkscrew	4000	4700	23	Corkscrew	3000	2100
24	Sadie Cypress	5	1400	24	Sadie Cypress	0	40
26	Rocky Lake	0	235				
28	Deep Lake	150	0				
Total Big Cypress		4155	6335			3000	2140
27	East River	1000	1500	27	East River	110	75
28	Cuthbert	1000	1000	29	Lane River	1100	1200
				30	Madeira	90	0
Total Everglades-mangrove		2000	2500			1300	1275
Total Florida Pairs		7657+	10,060			5320(5920)	5110

Figure 1. Active Wood Stork colonies, 1959-60 and 1975-76.



Project description

The Wood Stork project is designed to determine the number of birds remaining in the United States, location and size of each nesting colony, productivity at different colonies, food habits, daily and seasonal movements of storks in different colonies and regions of the state, habitat requirements for nesting and feeding sites, and as much as possible of population dynamics (annual recruitment, age of first breeding, mortality rates). Emphasis will be on determining factors that regulate stork numbers in the United States, and on aspects of stork biology not reported in Kahl's earlier studies (Kahl 1962, 1964). Ultimately, this project should result in the following:

1. A detailed publication describing historical and present status, distribution, nesting biology, food habits and factors regulating Wood Stork numbers in the southeastern United States.
2. A report, intended for use by regional governmental and conservation agencies, describing the location and characteristics of Wood Stork nesting and major feeding sites within Florida, with recommendations for protection and management of these sites for continued utilization by storks.
3. A report to National Audubon on the status and problems of the United States population of storks, and my recommendations on how the stork populations can be stabilized. Particular attention in this report will be given to the possibility of developing a management program for storks in Florida, which might include an experimental attempt to create new rookery sites in regions of the state where storks may be losing natural rookery sites.

Generally the plan of action for both past and future work with this project has been, and is expected to be, as follows:

(1) 1973-74: A fairly intense study of food habits of storks in Everglades National Park, including samples of fish at feeding sites, and collection of food from nestlings. Results of this project were published (Ogden, et al 1976). Begin studies of nesting biology in E.N.P. rookeries.

(2) 1974-75: Intense nesting biology study in E.N.P. rookeries, to measure chick growth rates, nesting success and colony dynamics. Rear several young storks in captivity to experimentally measure growth rates. Color-mark young with patagial streamers. Conduct first statewide aerial surveys in attempt to locate all active stork rookeries.

(3) 1975-76: Repeat statewide aerial surveys of active stork rookeries. Spend a few weeks in large, successful stork rookery in Campeche, Mexico, to gain comparative data on nesting biology.

(4) 1976-77: Repeat statewide aerial surveys, with emphasis on identifying important feeding sites utilized by storks from each rookery. Begin intense studies of stork nesting biology and food habits in select rookeries in central and north Florida, making special attempt to relate different rates of nesting success between colonies in same year to ecological factors. Color-mark young storks in central and north Florida for growth and development and dispersal data.

(5) 1977-78: Repeat statewide aerial survey of stork colonies. Continue nesting biology studies at select central and north Florida rookeries, with monitoring in south Florida to watch for color-marked

birds.

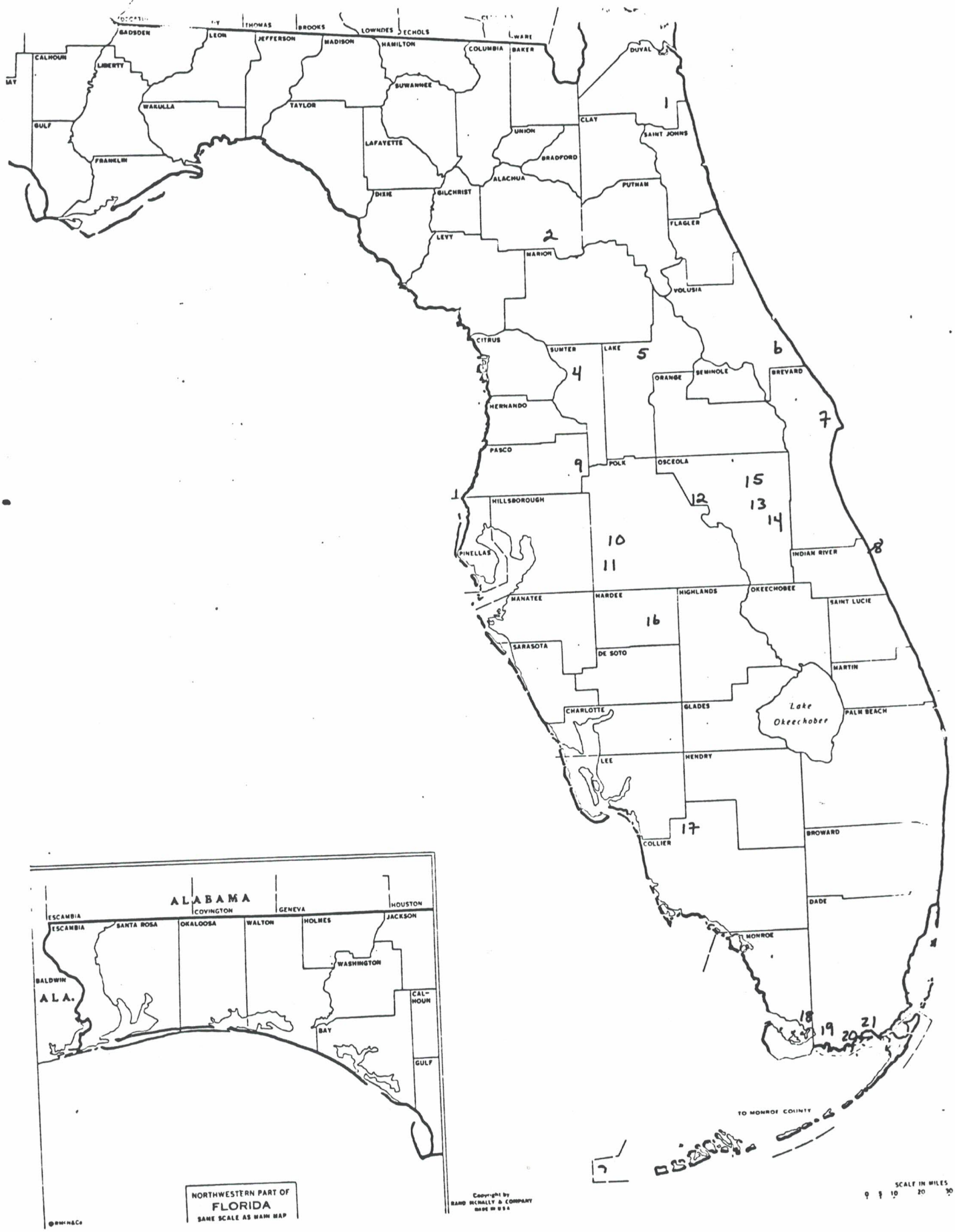
(6) 1978-79: Final year of field work, again with major emphasis in central-north Florida colonies. Begin writing various reports, and continue monitoring the state stork population. Establish stork management programs where appropriate.

1977 results

Locations of Wood Stork colonies active during 1977 are shown in Figure 2, with estimates of pairs and nesting success at each site reported in Table 2. This year produced the first hard evidence that storks may regionally shift nesting sites, when nesting conditions in a part of Florida are decidedly adverse early in a nesting season. Southern Florida experienced a record cold and rainy winter of 1976-77, and relatively few storks attempted to nest at the traditional Big Cypress and Everglades rookeries. Approximately 2000 pairs of storks were missing from south Florida colonies, while central-north Florida colonies during the following spring showed an increase of 1500 pairs (compare with counts in Table 1). Most of the increase was due to additional birds in established colonies, although three small stork colonies in Osceola County were previously unknown. A newly located large colony near Tallahassee (Chaires) has been suspected to exist in previous years, although it's size in 1977 must have been considerably larger than earlier.

We collected food samples from nestling storks at three central Florida colonies (Moore Creek, Pelican Island, Brewster) to compare with earlier food data from the Everglades, and to look at the relationship between amount and size of food brought to nestlings and the number of young fledged in different colonies. Food data from the three colonies is summarized in

Figure 2. Active Wood Stork colonies, 1977.



NORTHWESTERN PART OF FLORIDA
SAME SCALE AS MAIN MAP

Table 2. Active Wood Stork colonies for 1977.

Colony #	Colony	# Pairs	Success
1	Dee Dot	150	?
2	East River Styx	150	Successful
3	Chaires	350	Successful
4	Panasofkee	40	?
5	Lake Yale	225	Successful
6	Turnbull	350	Failed
7	Moore Creek	350	Successful
8	Pelican Island	235	Successful
9	Blue Lake	175	Successful
10	New Mulberry	150	Successful
11	Brewster	250	Successful
12	Reedy Creek	250	Successful
13	Crabgrass	30	?
14	Jane Green Creek	20	Failed
15	Lake Conlin	50	Successful
16	El Clair	428	Successful
Total North-Central Florida		3200	
17	Corkscrew	800 & 250	Failed
Total Big Cypress		1050	
18	Lane River	550	Failed
19	East River	50	Failed
20	Cuthbert	75	Failed
21	Madeira	50	Failed
Total Everglades-mangrove		725	
Total Florida Pairs		4975	

Table 3. As expected, most of the food items were freshwater fish, with several relatively larger species such as sunfish (Lepomis sp.) most important.

To look at the relationships between food and nesting success, we calculated the "mean meal" for each of the three colonies. Mean meals were determined by taking regurgitations from 75 stork chicks at Moore Creek, 35 at Pelican Island and 8 at Brewster, and figuring the average weight and number of food items per regurgitation in each colony. At the same colonies we calculated the average number of young fledged per successful nest by counting the number of large, feathered chicks in 100 or more nests. Data on "mean meals" and chicks per successful nest are presented in Table 4.

Although the sample size is small, especially at Brewster, these data support my previous impression that where adult storks deliver relatively large sized fish to chicks, the average number of young fledged per nest is higher than at colonies where adults deliver small fish. In the latter, adults returning to the colony tend to bring in relatively large numbers of small fish, and presumably take longer to capture fish and expend more energy in the process than adults that capture a few large fish. We need to collect more of these kinds of data, and determine if nestlings being fed piles of small fish are fed fewer times a day than nestlings that are fed large fish. If this relationship holds true, then factors that regulate reproduction, growth rates and distribution of freshwater fishes in Florida may ultimately determine Wood Stork production rates.

We begun observations during 1977, at the Moore Creek colony, of daily activity patterns at stork nests that contained chicks. These data will be useful in answering questions about the number of feedings per day related to nestling growth rates and the quality and quantity of food delivered to

Table 3. Wood Stork food from three central Florida colonies, 1977.

Food	Merritt Island		Pelican Island		Brewster	
	No. (%)	Weight (%)	No. (%)	Weight (%)	No. (%)	Weight (%)
1. Lepisosteus platyrhincus (Florida Gar)	3 (0.26)	2280.0 (3.1)	6 (1.5)	236.2 (10.6)	-	-
2. Harenqula sp. (Sardine sp.)	8 (0.70)	8.40 (+)	-	-	-	-
3. Esox americanus (Redfin Pickerel)	1 (0.09)	61.40 (0.8)	-	-	-	-
4. Notemigonus crysoleucus (Golden Shiner)	17 (1.00)	216.5 (2.9)	-	-	-	-
5. Notropis chalybaeus (Iron-colored Shiner)	1 (0.09)	0.5 (+)	1 (0.25)	0.2 (+)	1 (0.45)	0.6 (+)
6. Erimyzom succetta (Lake chubsucker)	6 (0.53)	290.10 (4.0)	-	-	-	-
7. Ictaluras nebulosus (Brown Bullhead)	3 (0.26)	142.7 (1.9)	3 (0.75)	46.1 (2.0)	-	-
8. I. natalis (Yellow Bullhead)	38 (3.00)	493.2 (6.8)	-	-	2 (0.89)	111.7 (19.2)
9. Ictaluras sp. -	-	-	-	-	1 (0.45)	6.4 (+)
10. Noturus gyrinus (Tadpole Madtom)	1 (0.09)	1.2 (+)	-	-	-	-
11. Lucania goodei (Bluefin Killifish)	11 (0.96)	4.30 (+)	1 (0.25)	0.3 (+)	-	-
12. Fundulas seminolus (Seminole Killifish)	2 (0.18)	23.7 (+)	-	-	2 (0.89)	2.6 (+)
13. F. majalis (Striped Killifish)	1 (0.09)	0.7 (+)	-	-	-	-
14. F. confluentus (Marsh Killifish)	96 (8.4)	182.7 (2.5)	-	-	-	-
15. F. Chrysotus (Golden Topminnow)	5 (0.44)	6.80 (+)	3 (0.75)	5.52 (+)	-	-
16. F. species -	2 (0.18)	1.40 (+)	-	-	-	-

Table 3. Wood Stork food from three central Florida colonies, 1977 (continued).

Food	Merritt Island		Pelican Island		Brewster	
	No. (%)	Weight (%)	No. (%)	Weight (%)	No. (%)	Weight (%)
17. Cyprinodon variegatus (Sheepshead Minnow)	1 (0.09)	3.8 (+)	-	-	-	-
18. Jordanella floridae (Flagfish)	80+5 (7.4)	65.0 (0.9)	109+2 (27.8)	85.6 (3.8)	13 (5.8)	18.33 (3.1)
19. Gambusia affinis (Common Mosquitofish)	367+2 (32.3)	199.1 (2.7)	35+12 (11.8)	8.9 (0.3)	152+35 (83.4)	52.5 (9.0)
20. Heterandria formosa (Least Killifish)	5 (0.44)	0.55 (+)	-	-	1 (0.45)	0.14 (+)
21. Poecilia latipinna (Sailfin Molly)	118+3 (10.6)	156.0 (2.1)	1 (0.25)	0.3 (+)	-	-
22. Labidesthes sicculus (Brook Silversides)	1 (0.09)	0.4 (+)	1 (0.25)	0.2 (+)	-	-
23. Morone saxatalis (Striped Bass)	4 (0.35)	365.6 (5.0)	-	-	-	-
24. Elassoma evergladii (Everglades Pygmy Sunfish)	-	-	-	-	2 (0.89)	0.2 (+)
25. Micropterus salmoides (Largemouth Bass)	6 (0.53)	23.26 (+)	7 (1.5)	209.1 (9.4)	-	-
26. Lepomis gulosus (Warmouth)	99 (8.6)	2455.2 (34.0)	22 (5.5)	453.3 (20.5)	4 (1.7)	134.2 (23.2)
27. L. punctatus (Spotted Sunfish)	64 (5.6)	658.1 (9.1)	25 (6.2)	250.7 (11.3)	2 (0.89)	18.0 (3.1)
28. L. microlophus (Red-eared Sunfish)	34 (2.9)	371.3 (5.1)	13 (3.2)	221.0 (10.0)	-	-
29. L. marginatus (Dollar Sunfish)	13 (1.1)	41.1 (0.5)	24 (6.0)	59.4 (2.6)	2 (0.89)	1.6 (+)
30. L. macrochirus (Bluegill)	32 (2.8)	571.4 (7.9)	11 (2.7)	228.0 (10.3)	3 (1.3)	197.0 (34.2)
31. Lepomis sp. -	20 (1.7)	60.5 (0.8)	23 (5.7)	168.0 (7.6)	3 (1.3)	30.8 (5.2)
32. Enneacanthus gloriosus (Blue-spotted Sunfish)	1 (0.09)	3.6 (+)	-	-	-	-

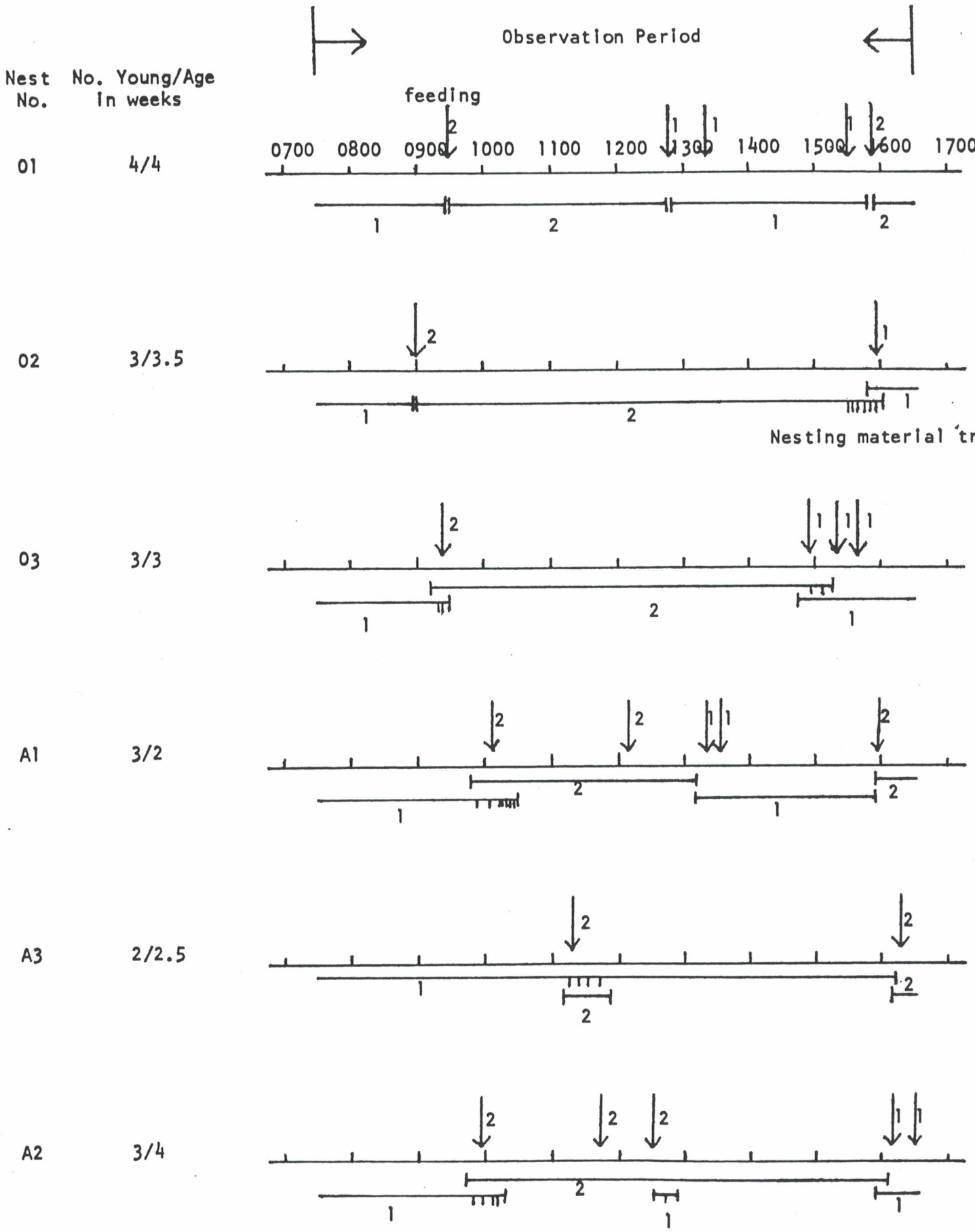
Table 3. Wood Stork food from three central Florida colonies, 1977 (continued).

Food	Merritt Island		Pelican Island		Brewster	
	No. (%)	Weight (%)	No. (%)	Weight (%)	No. (%)	Weight (%)
33. Etheostoma fusiforme (Swamp Darter)	1 (0.09)	0.8 (+)	-	-	-	-
34. Lelostomus xanthurus (Spot)	1 (0.09)	12.4 (+)	-	-	-	-
35. Cichlasoma bimaculatum (Two-spotted Cichlid)	-	-	7 (1.5)	117.3 (5.3)	-	-
36. Unid. fish -	51 (4.4)	131.3 (1.8)	14 (3.5)	14.9 (0.6)	-	-
37. Rana sp. (Tadpoles)	16 (1.4)	46.6 (0.6)	38+2 (10.0)	29.5 (1.3)	-	-
38. Misc. crustacea -	19+2 (1.8)	24.0 (+)	5 (1.2)	7.28 (+)	-	-
39. Misc. Insects -	1 (0.09)	0.1 (+)	-	-	1 (0.4)	2.4 (+)
Totals	1141	7217.9 g.	398	2206 g.	224	576 g.

Table 4. "Mean meals" and numbers of large young per successful nest at three central Florida Wood Stork colonies, 1977.

	Moore Creek	Pelican Island	Brewster
Food items per meal	15.5	11.3	28.0
Grams per meal	98.2 g.	63.0 g.	72.0 g.
Young per nest prior to fledging	2.3	2.0	1.75

Figure 3. Observations of six Wood Stork nests on 3 May 1977. Horizontal lines below time lines show adult at nest. Vertical arrows indicate feeding times. Short vertical lines below horizontal line indicate nest material forays by adult at nest.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Nest No.
No. Young/Age in weeks
feeding
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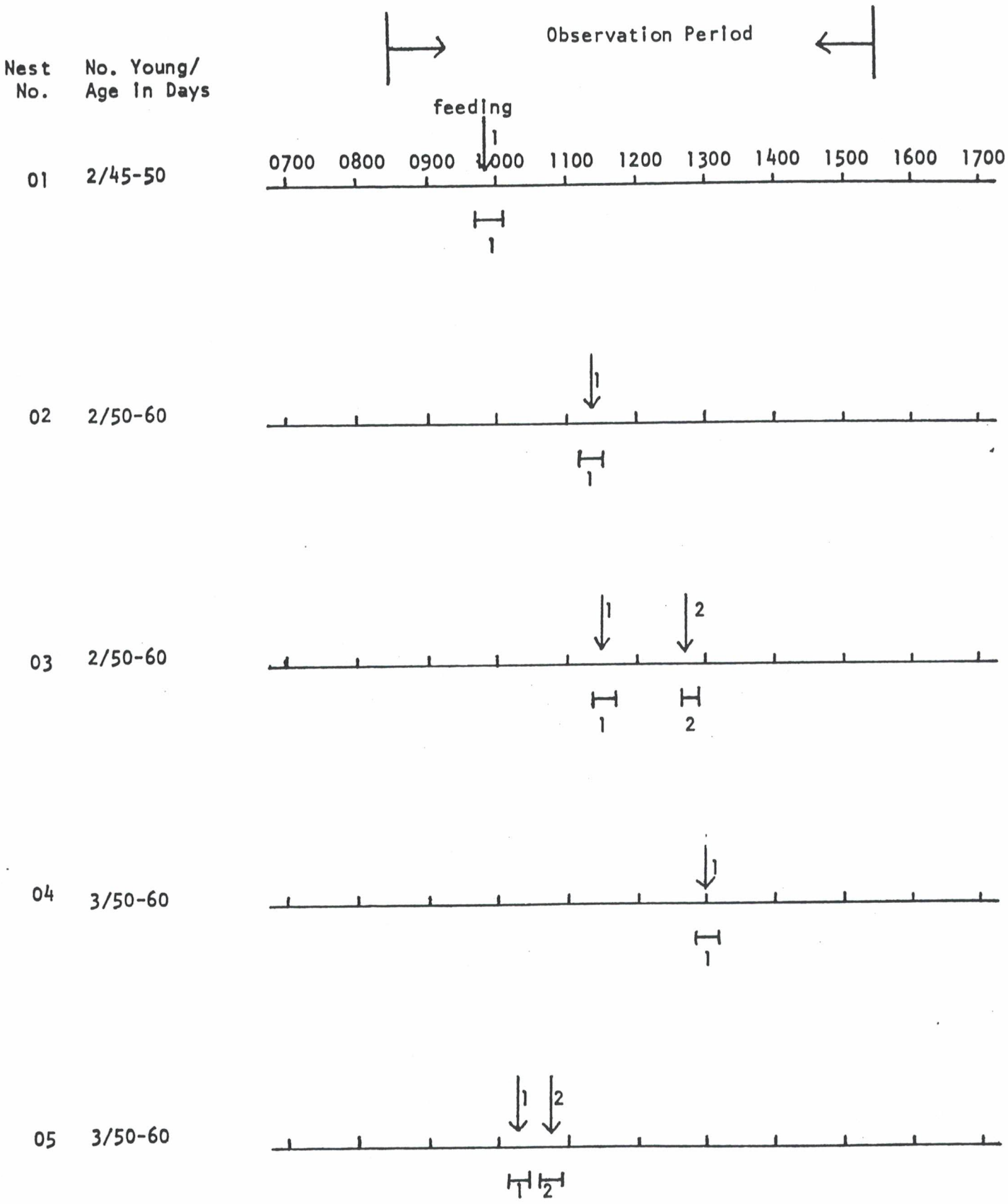
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
01
4/4
02
3/3.5
Nesting material 'tr
03
3/3
A1
3/2
A3
2/2.5
A2
3/4

Figure 4. Observations of five Wood Stork nests on 8 June 1977. Horizontal lines below time lines show adult at nest. Vertical arrows indicate feeding times.

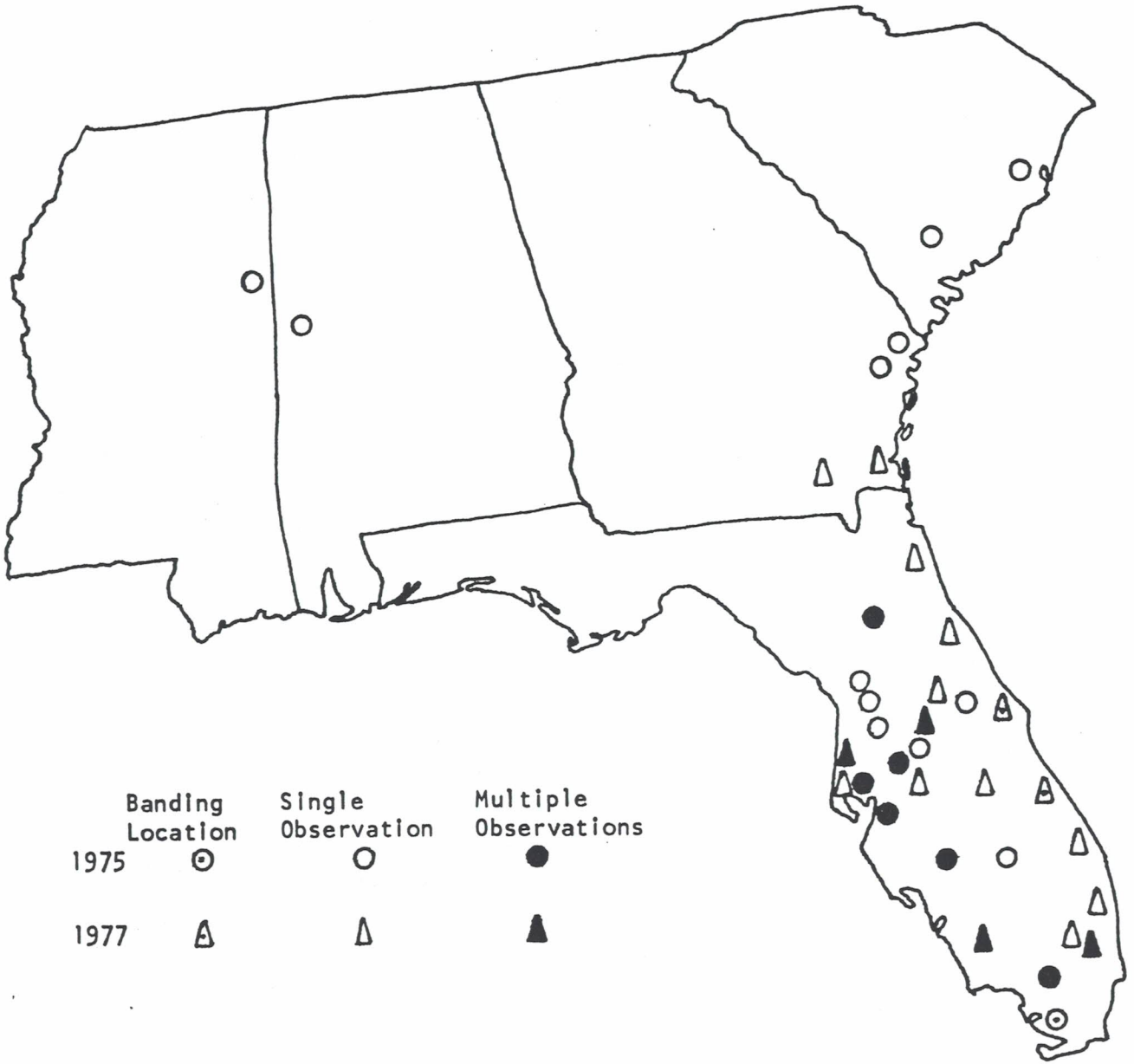

Observation Period
Nest No.
No. Young/ Age in Days
feeding
0700 0800 0900 1000 1100 1200 1300 1400 1500 1600 1700
01 2/45-50
02 2/50-60
03 2/50-60
04 3/50-60
05 3/50-60

nests. Eventually I hope to develop a technique for rather quickly judging the well-being of a colony of nestlings by measuring the rate or daily distribution of feedings at several nests. This technique will not require climbing to nests, so could be useful at colonies like Corkscrew where nests are high, and some advanced warning of food-shortage stress in the colony will allow for accurate manipulation of the artificial stork-feeding ponds. Our 1977 data on nest activity patterns are shown in Figures 3 and 4. In Figure 3, the chicks were relatively small and adult storks were in attendance throughout the day. In Figure 4, the large nestlings were only visited by adults to be fed. The reduced number of feedings during the 8 June observations probably is a factor of the age of the chicks and/or the distance that adults were travelling to feeding grounds, and was not an indication of food shortage.

We banded and color-marked 100 nestlings at Pelican Island, and 200 at Moore Creek during May 1977. In this project, we were assisted by the U.S. Fish and Wildlife Service, the Florida Game and Fresh Water Fish Commission, and Scott Clark, a graduate student at Florida Tech. University in Orlando. The marking program is producing information on seasonal movements of storks from these central Florida colonies, to contrast with similar data gained from marked storks from an Everglades colony in 1975. Reports of marked birds seen during the first summer and fall following marking, both during 1975 and 1977, are plotted in Figure 5. Peninsular Florida was generally dry during the summer of 1977, and low water produced good feeding conditions for newly fledged storks. This situation is the probable explanation for the less-rangy dispersal of young storks in 1977 compared to 1975.

An important second reason for initiating the color-marking project at Moore Creek and Pelican Island is that these two colonies are among the most

Figure 5. Sighting locations of Wood Storks banded in 1975 and 1977.



successful and regularly-active in Florida. A marking program of juvenile storks (known-aged birds) at these sites should provide the best opportunity to determine the age at which storks begin to nest, and characteristics of sub-adult plumages. These data are presently unknown (Parmer 1962).

1978 plans

1978 will basically be a repeat of 1977, with emphasis on field work at central Florida colonies. Particular attention will be given towards building a large pool of data on the relationship between "mean meal", daily feeding patterns at nests, and characteristics of food delivered to nestlings. We will again band and color-mark chicks at Moore Creek and Pelican Island, and vigorously search for birds marked in 1977. State-wide aerial censuses will be repeated, including some ground visits to colonies not previously visited.

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Additional 1977 activities

John C. Ogden

1. Assisted in organization of the annual meeting of the Colonial Waterbird Group at Northern Illinois University in DeKalb, October 1977, and presented a paper at that meeting: "An evaluation of interspecific information exchange by waders on feeding flights from colonies." I was elected president of the C.W.G. for 1978-79. The C.W.G. was formed during the National Audubon sponsered wading bird conference at Charleston, South Carolina during October 1976, and is designed to improve communication between people involved in the study and conservation of colonial waterbirds and provide coordination of regional studies and surveys of colonial waterbirds.
2. Served as a member of the U.S. Department of the Interior's recovery team for the American Crocodile. A copy of a narrative section that I prepared for the crocodile recovery plan is attached. The narrative section is intended to briefly describe the status and biology of the endangered species, and reasons for it's decline. A paper reporting the results of my earlier field studies with the American Crocodile, "Status and nesting biology of the American Crocodile, Crocodylus acutus, in Florida", was accepted early in 1977 for publication during 1978 in the Journal of Herpetology.
3. Along with Mike Duever, I conducted an extensive survey of the Usumacinta Delta of southeastern Mexico, during September, and assisted in the preparation of a proposal from National Audubon to the World Wildlife Fund for an intensive ecosystem analysis of that region of Mexico. The Usumacinta Delta is a major North American habitat for wading birds, as

well as supporting crocodiles, jaguars and other threatened species. We consider that this region should be considered as a potential Biosphere Reserve.

4. Served as co-editor, with Sandy Sprunt and Suzanne Winckler, of National Audubon Research Report #7, the proceedings of the North American Wading Bird Conference. Title of the report is "Wading birds".
5. Served as Vice-president of the Florida Ornithological Society.
6. Presented talks on the National Audubon research program to Audubon chapters in St. Petersburg and Marathon, Florida, and Nashville, Tennessee.
7. Worked with Bill Robertson, of Everglades National Park, on a cooperative National Park Service - National Audubon study of Roseate Spoonbill population dynamics. Most of the work thus far has been in Florida Bay, with some aerial surveys as far north as Tampa Bay. The project began during late summer.

Narrative Account

Introduction

The American Crocodile (Crocodylus acutus) is a tropical, estuarine species, that reaches its northern range limit in southern Florida. Elsewhere, this species occurs in Cuba, Jamaica, Hispaniola, Puerto Rico and both coasts of Mexico from Sinaloa and Tamulipas south through Central America to Ecuador and Columbia. The American Crocodile is listed as "endangered" throughout its total range by the International Union for Conservation of Nature and Natural Resources (Honegger 1975). In Florida, the crocodile has only infrequently been the subject of surveys or studies, thus its status and distribution has generally been poorly known. Surveys, and some assessment of nesting success, primarily by National Park Service personnel since the early 1950s (unpublished NPS records, Moore 1953, Ogden 1978) revealed continued declines by the Florida population, to the point where only a few hundred are thought to remain. The American Crocodile was placed on the U.S. Department of the Interior's list of Endangered and Threatened Wildlife on 25 September 1975 (Fed. Reg. 40:44149), and critical habitat was designated 24 September 1976 (Fed. Reg. 41:41914-15).

General Life History

The American Crocodile in south Florida is generally associated with mangrove-lined creeks and bays, isolated from frequent human intrusion. Crocodiles often are detected in small ponds or creeks with two to five feet of water, which are protected from winds or strong currents, and which are adjacent to larger bodies of water. Crocodiles readily move into abandoned or little-used canals or flooded quarries in mangroves or coastal hardwoods where similar conditions exist. This species appears to be shy, and may not often

be seen even where a few live in close proximity to human dwellings. Crocodiles are generally inactive during the day, and rest on secluded creek or canal banks, in dens or hidden in thickets at the edge of water. They become active at night, moving into creeks, canals or open bays, primarily to feed. Mullet and blue crabs are suspected to be important food items for adult crocodiles (Ogden, pers. comm.)

Crocodiles construct low nest mounds in sand, marl or peat soils, at the heads of small beaches, along high creek banks or on abandoned canal levees through mangrove swamps. A female will return to re-use the same mound for several years, unless human disturbance causes relocation. Eggs are laid in the nest mounds during late April or early May, and hatch during late July or early August. Average clutch size in Florida Bay during the early 1970s was 44 eggs. Adult females are not known to guard nests, but females do open nests to release young, and may carry hatching eggs or young from the mound to the nearby water (Ogden and Singletary 1973). Ogden (1978) reports that adults and newly hatched young apparently move away from the more exposed nesting sites in Florida Bay within a few days after the hatch, possibly going to places that are better for salinity, food and cover. Little is known of American Crocodile behavior patterns or daily and seasonal activity patterns and movements of each age-class, although Garrick and Lang (1977) have recently reported that American Crocodile courtship is complex and occurs over a 6 week period during February and March.

Crocodiles are approximately 22 cm. long at hatching, while the smallest breeding females seen in Florida Bay during the early 1970s were about 2.5 m. long and of unknown age. The largest crocodiles reported from Florida have been about 4.6 m. in length.

Historical Florida Range and Numbers

The first certain record of an American Crocodile in Florida was in 1869, based on a specimen from the Miami River (Barbour 1923). Succeeding visits to southeastern Florida by naturalists and biologists revealed that crocodiles occurred on the Atlantic coast at Lake Worth, Palm Beach County, in proper habitat along the entire length of Biscayne Bay, Dade County, and south into Florida Bay and the Florida Keys to the Matecumbe Keys (Smith 1896, Hornaday 1904, Dimock 1918). The occurance of crocodiles in the lower Florida Keys, including Key West (Neill 1971), was poorly documented, and it remains uncertain if the two populations were once contiguous. Crocodiles have been occasionally reported, both historically and recently, along the southwest and western coast of Florida (LeBuff, 1957), including an unverified 1953 report of a crocodile hatch in the Ten Thousand Islands region (Campbell, pers. comm.). Within this historical range, verified crocodile nesting was observed along the shoreline and on islands of eastern and central Florida Bay (Dimock & Dimock 1908), along the shoreline of Biscayne Bay (Smith, 1896), and at Lake Worth (G. Voss, pers. comm.)

The numbers of crocodiles in south Florida during the late Nineteenth Century is unknown, although it seems likely that it was not a common animal. Crocodiles were regularly seen along the mainland shore between northern Biscayne Bay and central Florida Bay, and were most numerous in a region 10 miles long and 3 miles wide lying west from Card Sound into northeastern Florida Bay (Dimock, 1918). A close reading of the accounts of the exploration of this region suggests that no more than 5 to 10 crocodiles were seen in a day in prime habitat. Based on this information, Ogden (1978) estimated that the number of crocodiles in southern Florida near the end of the Nineteenth Century probably was no greater than 5 times the present number, or roughly

1000 to 2000 animals. Crocodiles may have been more numerous prior to the late Nineteenth Century, as there is evidence that crocodiles were already fairly extensively hunted by the 1890s (Dimock and Dimock 1908, Hornaday 1904).

Several American Crocodiles from Florida are known to be in captivity. A list of these animals and their locations is being prepared.

Recent Florida Range and Numbers

The range of crocodiles in Florida during the early 1970s is based on Ogden (1978) and more recent observations by members of the recovery team (see map). Crocodiles are regularly seen in Everglades National Park along the mainland shoreline of Florida Bay from Terrapin Bay east to Long Sound and on some adjacent islands in the northeastern Bay, and less frequently west to the Cape Sable peninsula. Crocodiles are also on the upper Florida Keys from lower Plantation Key north to the upper end of Key Largo, and along Cross Key to the mainland shoreline of Barnes Sound, Card Sound and southern Biscayne Bay north to Black Point. A disjunct group of crocodiles is in the lower Florida Keys, primarily within the boundaries of the Key Deer and Great White Heron National Wildlife Refuges, on Big Pine, Little Pine, Howe, Johnston and upper Sugarloaf Keys (J. Watson, pers. comm.). Within this range, nesting is known from the mainland shore of Florida Bay, on one island in north-central Florida Bay, in mangrove swamps on the Barnes Sound side of upper Key Largo, and on Little Pine Key. Nesting may also occur on the mainland inland from Mangrove Point, where a newly hatched young was found during September 1976. Comparison of this nesting range with the historical records shows that crocodiles have ceased to nest at Lake Worth in Palm Beach County, along the full length of Biscayne Bay, Dade County, and in most of Florida

Bay, Monroe County. Ogden (1978) estimated the number of crocodiles in this region during the 1970s at 100 to 400 animals, including no more than 20 breeding females.

Reasons for Decline

The decline in the south Florida population of the American Crocodile has been due to two levels of human activities, (1) habitat alteration and (2) direct human disturbance to crocodiles and their nests. Considering the scarcity of supporting data, the relative importance, both historically and presently, of the two factors is difficult to assess.

Mangrove estuaries have been considerably reduced outside of Everglades National Park, thus crocodiles have been displaced by urbanization at Lake Worth, central and northern Biscayne Bay and along most of the upper Florida Keys. Conversely, crocodiles remain in the few regions where habitats are relatively unaltered, Florida Bay, Upper Key Largo, spots along the mainland shore between southern Biscayne Bay and Barnes Sound, and in the National Wildlife Refuges in the lower Florida Keys. No management action that will benefit crocodiles can be taken where habitats are already lost, thus our serious attention should be directed towards protection of remaining crocodile habitat, and control of human activities therein.

We have learned of direct, human-caused mortality involving 14 crocodiles between 1971 and 1977, 6 by shooting, 7 as highway road kills, and 1 from an unknown cause. Six of these animals died on northern Key Largo, and 5 were reported from the Lake Surprise-Blackwater Sound region of central Key Largo. At least 6 were adults. This rate of human-caused mortality to adult crocodiles on Key Largo may exceed the recruitment of young adults into that segment of the Florida population. Vandalism to active nests does not appear

to occur frequently, although the combined affects of vandalism and direct killing likely is adversely affecting crocodile numbers, especially in the Key Largo region. Between 1971 and 1976, we know of 3 crocodile nests that were opened and the eggs removed by unknown people, 2 in Florida Bay and one on Key Largo.

Indirect disturbance to crocodiles by people is less measureable, but may be as important a factor in the human regulation of crocodile numbers as is killing andnest molestation. Remaining crocodile nesting sites share a high degree of remoteness, suggesting that crocodiles are less tolerant of human activities than are alligators. Crocodiles may have abandoned some otherwise suitable habitats because of the presence of apparent innocuous human activites such as fishing and boating. Observations made in Florida Bay during the early 1970s (Ogden pers. comm.) suggests that adult female crocodiles may become disturbed by repeated close human presence during the weeks that nests are being built or reworked, and may relocate nests. On northern Key Largo, nests near the Old Card Sound Road in 1971 and at Basin Hills in 1976, were abandoned following increased human activity at these two sites. The need for adult crocodiles to open nests to release newly hatched young means that the females must make repeated trips to nests during late summer, again creating a situation where human presence near nests can adversely affect crocodile reproductive success. Additionally, disturbance during courtship may be disruptive, as has been suggested for the Nile Crocodile (Cott, 1968). Crocodile nesting sites on creeks along the north shore of Florida Bay have been seasonally closed to human activities by the National Park Service since the early 1970s, an action that appears to have resulted in increased nesting activity at these sites (Ogden, pers. comm.).

The impact that recent levels of raccoon predation on crocodile nests have had on the decline remains unknown. Between 1970 and 1974, 6 of 40 nesting attempts in Florida Bay and the upper Keys were destroyed by raccoons. Although not obviously high, this 15 percent rate of nest predation could be a factor in the failure of Florida Bay crocodiles to recover since that region has been protected by the National Park Service. Radio-tracking of juvenile crocodiles in 1973 (Lang, pers. comm.) revealed that newly hatched animals are eaten by raccoons, although the extent of this predation remains unknown.

The effects that commercial fishing has on crocodiles are unknown, although mullet fishermen working at night in Florida Bay use gill nets in the same "lakes" and bays where crocodiles are active. Crocodiles have occasionally been caught in the gill nets and, at least in the past, sometimes killed.

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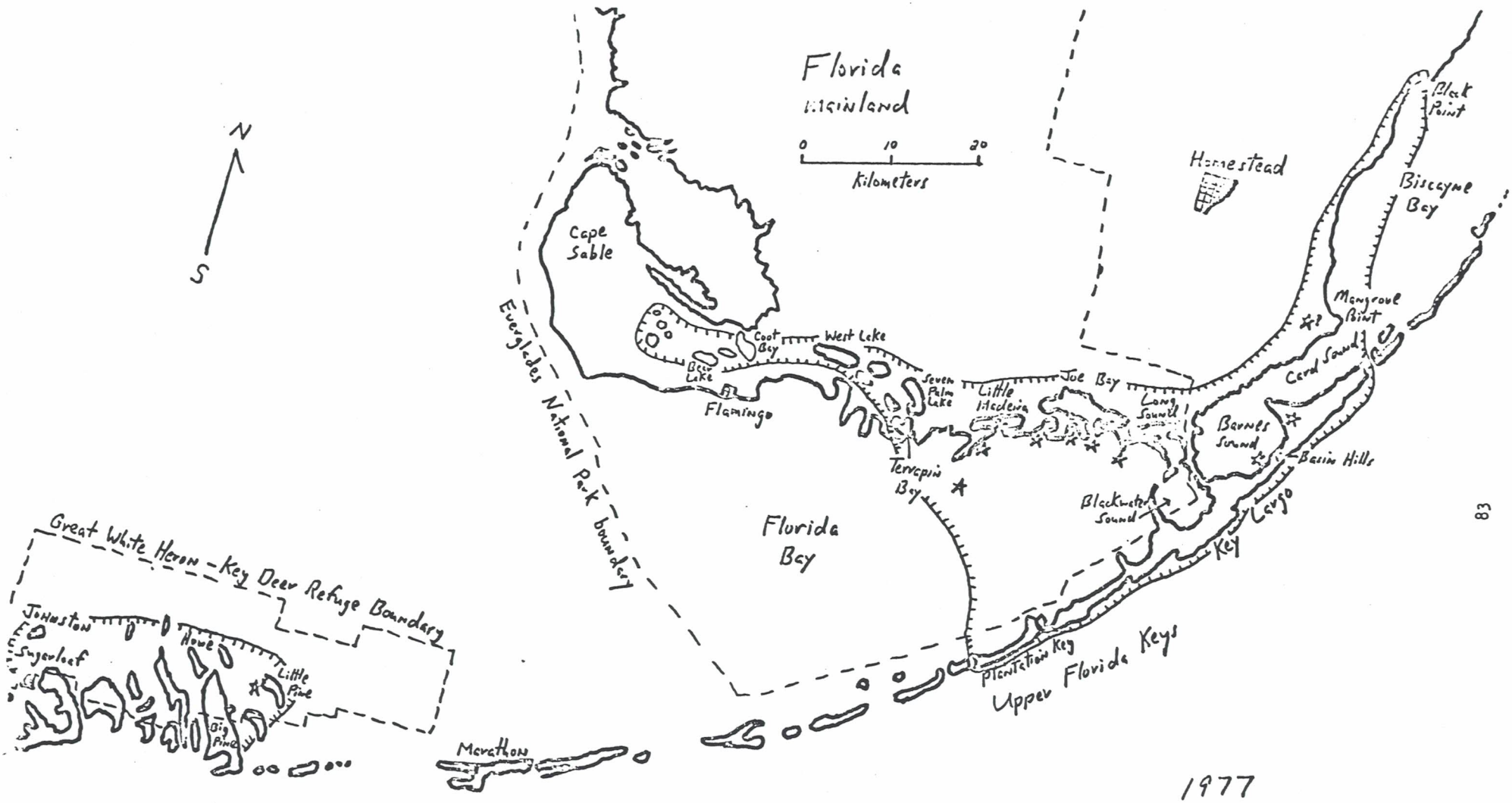
Second Revised Draft
October 1977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Mangrove Point
Card Sound
Barnes Sound
Basin Hills
Blackwater Sound
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Nesting :
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ECOLOGY OF THE REDDISH EGRET

Richard T. Paul
Annual Report for 1977

Introduction

This report reviews the justification for a study of the ecology of Reddish Egrets begun in 1975, summarizes the work completed in 1977 and outlines the schedule and scope of anticipated future research.

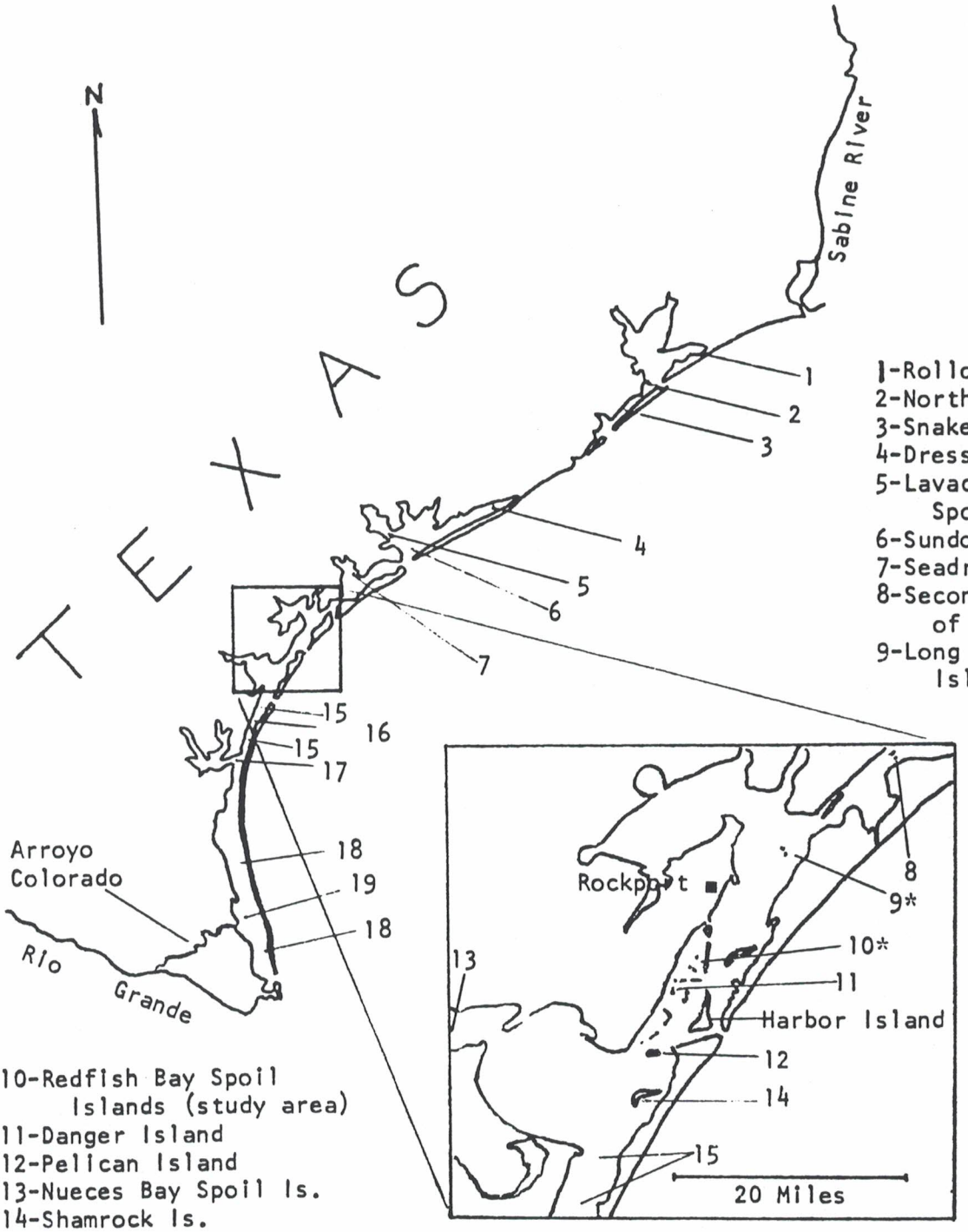
When the decision was made in early 1974 to conduct such a study, available data showed a serious decline in the Texas breeding population since the 1930s (Table 1). The causes of the decline were unknown. Moreover, the decline had occurred despite protection of most of the known nesting sites by Audubon wardens. This study was initiated to determine the status of the population, particularly in Texas, and to study aspects of Reddish Egret ecology that might affect reproductive success or survival. Parallel studies in Florida and the Bahamas were planned for comparative purposes.

This was the third and final season of intensive research in Texas. I was in the field in Texas from mid-February until early August studying nesting activities, and again in November to investigate the ecology of wintering egrets. Most of my work was carried out at colonies in Aransas and Redfish Bays (Figure 1), and at nearby feeding flats.

Results

1. Population Size

Because of the highly coastal nature of Reddish Egrets and the narrow coastal habitat in Texas, it is fairly simple to locate and census colonies (Figure 1). In 1975 and 1976 I estimated about 1600 breeding pairs (Table 1).



1-Rollover Pass
2-North Deer Is.
3-Snake Is.
4-Dressing Point
5-Lavaca Bay
Spoil Islands
6-Sundown Island
7-Seadrift Spoil Is.
8-Second Chain
of Islands
9-Long Reef-Deadman
Islands (study area)

10-Redfish Bay Spoil
Islands (study area)
11-Danger Island
12-Pelican Island
13-Nueces Bay Spoil Is.
14-Shamrock Is.
15-Upper Laguna Madre
spoil islands
16-South Bird Island
17-Baffin Bay Spoil Islands
18-Lower Laguna Madre
spoil islands
19-Green Island

Figure 1. Nesting sites of Reddish Egrets in Texas, 1975-1977. (Primary study areas marked with *)

TABLE 1. Reddish Egret populations in Texas, 1936-1977.

Year	Breeding Pairs
1936	2626
1937	2606
1939	3206
1950	2015
1959	1623
1965	552
1972	1280
1975	1605
1976	1617
1977	1523

Both surveys were conducted in May and June, when the largest number of pairs are normally nesting. However, in both years I relied on the observations of others at two key colonies, Green and North Deer Islands. In 1977 I visited both these colonies and as many others as possible, and estimated 1523 pairs.

The 1977 estimate should not be interpreted to indicate a decrease in breeding birds since 1976. Though the survey was again carried out in late May and June, this turned out to be later in the nesting cycle. Not only were there fewer adults to be found in the colony, but pairs failing late in the cycle were not counted at all. Therefore I consider the 1977 estimate to be very conservative, and that 1600 pairs is a good estimate of the Texas breeding population in 1975-77.

Three annual surveys are insufficient to show a trend in themselves. But periodic surveys clearly show a strong recovery of the population since 1965 (Table 1). Periodic surveys of coastal heronries will remain an efficient way to monitor the population in Texas.

Elsewhere in the United States Reddish Egrets nest only in Louisiana and Florida. The Louisiana has increased to an estimated 150 pairs in 1976 (Portnoy 1978, in press). The Florida population is still poorly known but is believed to number 300 birds (Robertson and Kushlan, 1974), and to be increasing (Paul et. al., 1975).

Adult Mortality

One of the original objectiveswas to measure the annual adult mortality rate by analyzing band recoveries. This now appears to be impractical. In 3 years I have banded 715 nestlings in Texas. With only 5 recoveries to date, it is clear that I will not obtain a large enough sample to derive

mortality rates.

As of January 1976 the Bird Banding Laboratory files contained data on 43 recoveries. Thirty were suitable for analysis and suggested an annual adult mortality rate of 35%. In view of the small sample and existing data on other herons, I consider the estimate to be unrealistically high.

The value of future banding efforts lies in information about seasonal movements, not mortality rates (see below).

Nesting Success

In 1977 I monitored nesting success at several islands in Redfish Bay. Table 2 summarizes for the period March through June (additional data remain to be analyzed). Due to very mild spring weather, survival of eggs through incubation was exceptional. Ninety-five per cent of the nesting pairs succeeded in hatching at least one young. Over 85% of all eggs hatched; about half the apparent egg loss in fact involves young which hatched but died and disappeared between successive nest inspections.

Survival of young was excellent at first but decreased in late May. Analysis is incomplete but field observations suggested that high water levels impeded feeding efforts for a week, and numbers of young may have starved. Approximately 1.3 young per nest fledged, a figure slightly below the 1975-76 estimates (1.6 young/nest).

For the third year there were no indications of abnormally low nesting success along the central coast of Texas. Observations elsewhere were sporadic but sufficient to indicate "normal" nesting success.

Age at First Breeding

Deferred maturation is a characteristic of many species, and is important in consideration of a species' reproductive potential. Two published accounts

TABLE 2. Early nesting success at Big Bayou Spoil Island, Redfish Bay, Texas, 1977 (March-early June only).

Number of nests	144
Clutch size (mean ± s. e.)[1]	3.19 ± .05
(range)	2-6
Percentage of eggs hatching	85 %[2]
Nesting success in incubation (= per cent nests hatching young)	95 %
Average brood size (1 or more eggs hatching, n=128)	2.87 ± .07
Estimated no. young fledged per pair	1.3

[1]Two nests with 1 egg excluded.

[2]Minimum figure; some young may have hatched, died and disappeared between nest inspections.

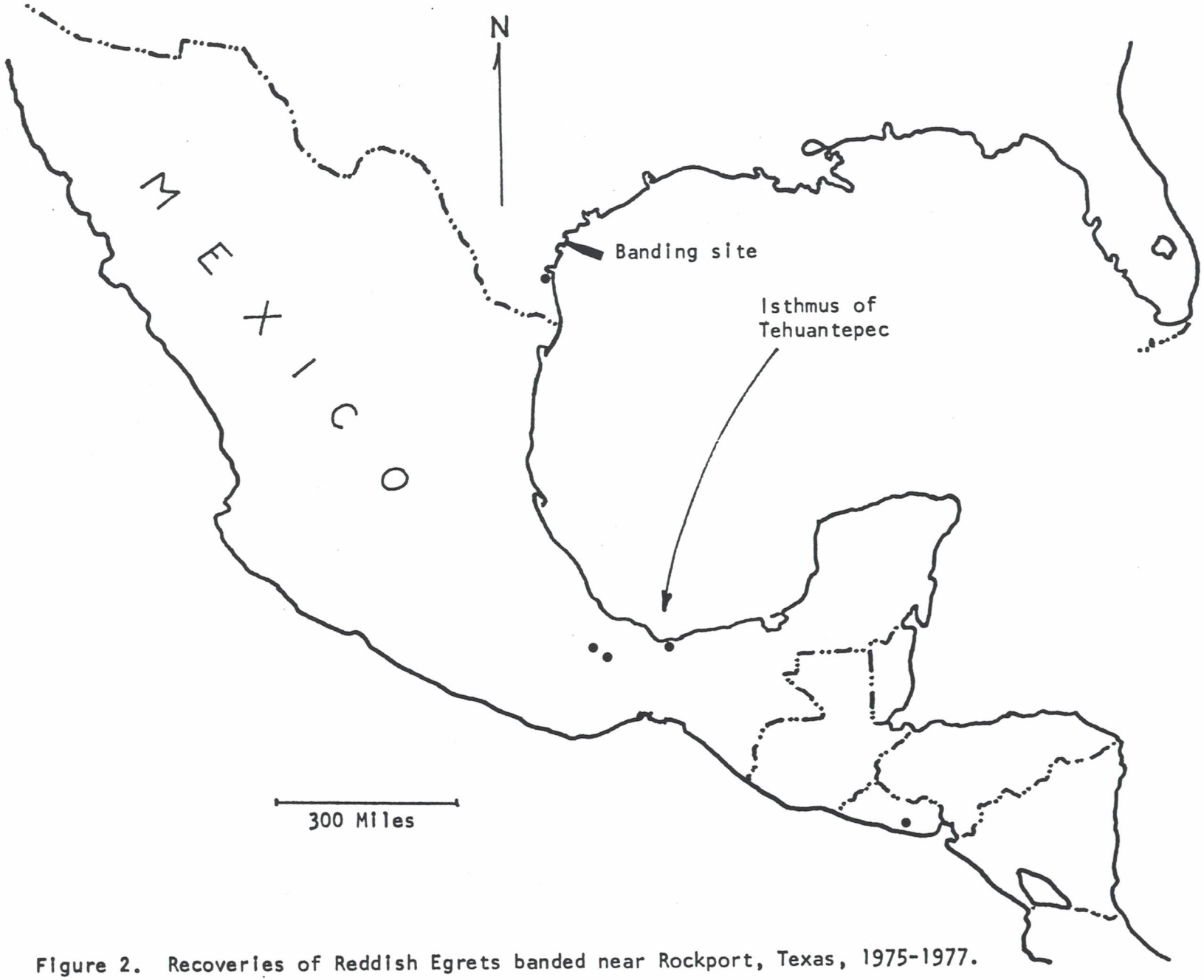


Figure 2. Recoveries of Reddish Egrets banded near Rockport, Texas, 1975-1977.

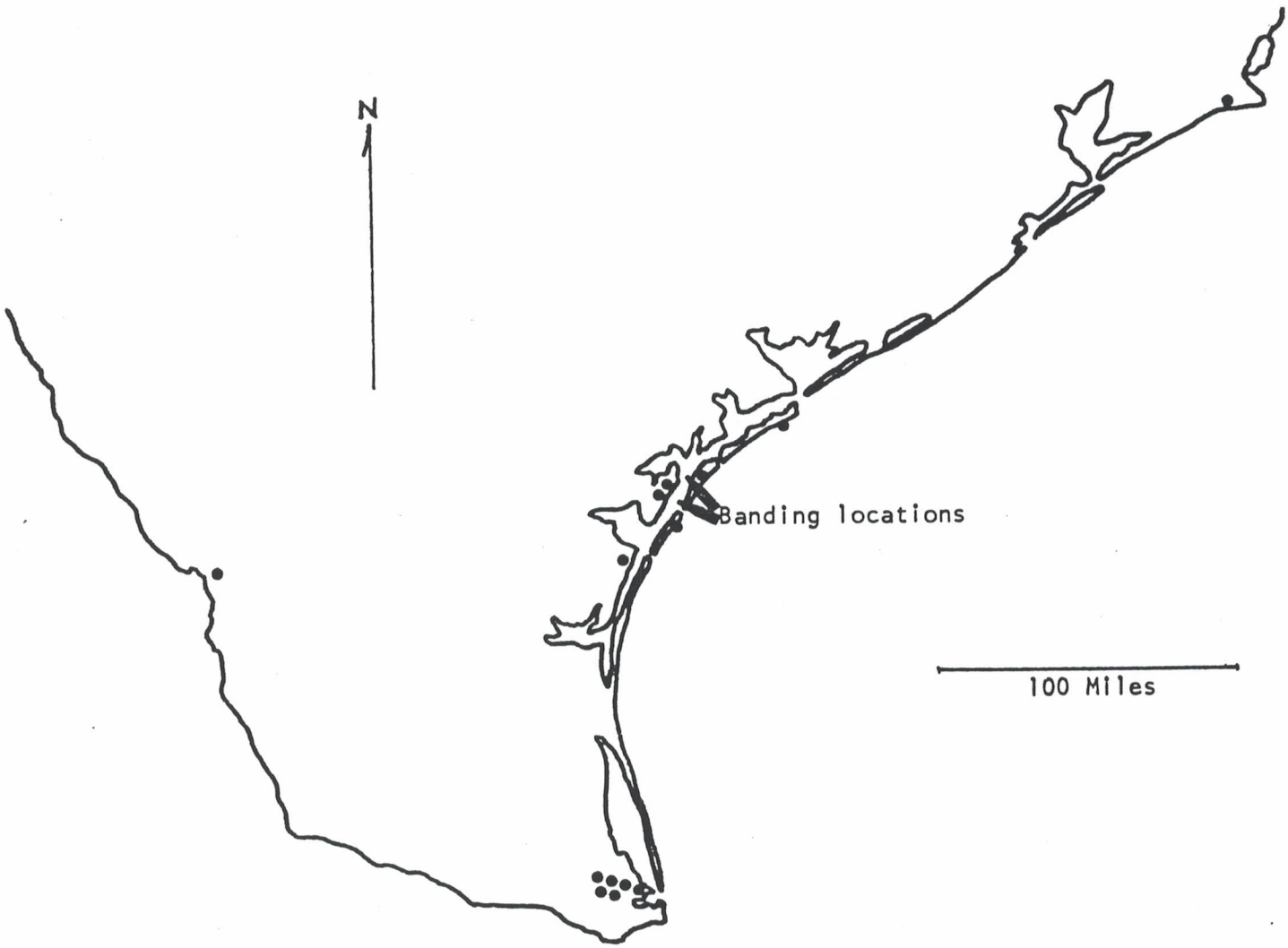


Figure 3. Sightings of color-banded young of the year, 1975-1977.

suggest that Reddish Egrets assume their adult plumage at the end of the second year of life. I color-banded nestlings in Texas to determine the age at which egrets first breed. Marked, year-old egrets appeared infrequently in colonies in 1976 and 1977. They were easily distinguishable from adults by plumage and soft-part (bill, lores, legs) characteristics, and did not breed. In 1977 4 marked 2-year-old egrets did nest at Long Reef Island. All were paired with unmarked egrets. The sexes of the 4 known-age birds were unknown. One pair raised at least one young, while the other three nests all failed after the young had hatched. No other marked 2-year-olds were found breeding in a statewide survey of colonies.

Movements/Migration

A second objective of banding was to document movements of egrets, through sightings of color-marked birds and through recoveries of dead birds. Though part of the Texas population remains in the state in winter, a substantial number of egrets move south in winter. So far I have received information on five band recoveries, all in the October-January period immediately after banding. Three are from southern Mexico, and one - astoundingly - is from El Salvador (Figure 2). Continued banding may help clarify the magnitude of this movement, and may indicate the route taken by birds crossing to the Pacific shore. The best guess is that they cross at the Isthmus of Tehuantepec.

Sightings of color-banded young of the year are summarized in Figure 3. Just 14 birds were seen, all in the period July-November. Generalizations are impossible, but two reports are quite interesting: one immature was present at Laredo for 3 weeks in July and August 1976, 150 miles inland. A flock of 94 egrets, apparently mostly immatures, contained 5 color-banded

immatures near Port Isabel on September 26, 1976.

Post-breeding flocks in Reddish Egrets are poorly known. I have now seen a number of flocks in late summer and in November, numbering 35-750 birds. Some flocks clearly form to exploit temporary aggregations of fish, while others possibly persist for a minimum of 2-3 days. Allen (1954-55) Unland (pers. comm.) and Fluman (pers. comm.) have noted flocking tendencies at Green Island and nearby feeding areas near the end of nesting. They felt that flocks formed immediately prior to migration south.

The occurrence of large flocks is exceedingly interesting and worth far more attention than I will be able to devote to it during the remainder of my study.

Food

The diet of Reddish Egrets was assessed by collecting items regurgitated by nestlings at colonies in Aransas and Redfish Bays (Figure 1). Organisms were identified, weighed and measured. As in 1975 and 1976, sheepshead minnows, mullet and pinfish were the most important prey species, accounting for 88% of all items in the sample (Table 3). These same species comprised 86% of the sample by weight.

Reddish Egrets characteristically feed in shallow estuarine waters subject to rapid fluctuations in salinity and temperature. Sheepshead minnows are especially abundant in such conditions. Mullet and killifish are also common there. Pinfish are typically found in shallow "grass flats" and are abundant in Redfish Bay and the wetlands of Harbor Island (Figure 1).

At my Redfish Bay study area the proportion of mullet, pinfish and other grass flats species increased during the summer. This was correlated with falling water levels, which caused some of the shallow flats normally

TABLE 3. Food items of Reddish Egrets in Texas, 1977.

Species	Percentage of		
	Individuals	Weight	Samples
Sheepshead minnow	71	35	70
Striped mullet	9	29	33
White mullet	5	17	33
Pinfish	3	5	11
Tidewater silverside	3	3	11
Longnose killifish	3	3	30
Gulf killifish	2	3	22
Black drum	0.4	2	7
Shrimp	0.4	0.4	7
Blue crab	0.2	0.6	4
Spot	0.2	0.6	4
Needlefish	0.2	0.1	4
Diamond killifish	0.2	<0.1	4
Assorted fragments (incl. mullet, silversides, killifish, unidentified)	3	1	
n	541	805 g.	27

used to dry out and some grass flats to become available.

Food samples are currently being collected in south Florida to assess diet (December 1977). These have not yet been analyzed; however a few samples collected in late 1975 and 1976 suggest that sheepshead minnows, sailfin mollies and gold-spotted killifish are the three most important diet items by far (90% of the sample). Again, these are species adapted for life in the shallows where they are subject to rapid changes in salinity, temperature and water level.

Feeding Efficiency

Studies of feeding activity included measuring of feeding efficiency. The data are in the initial stages of analysis; only a few comments are possible now. Adults appear to forage more efficiently than immatures (Table 4). This is known for several bird species requiring agility in prey capture (Brown Pelicans, Little Blue Herons, Sandwich and Royal Terns) and was expected. Differences between color phases are not yet clear, nor are the effects of other variables such as time of year, water depth, water temperature, salinity, etc.

Some measure of the size of prey is crucial to estimating feeding efficiency. Yet in the field it is exceedingly difficult to collect such data. One of the most important efforts of the next year will be to evaluate the fragmentary data on prey size collected so far and design a reliable method of estimation.

Color Phases

Reddish Egrets are known to be dimorphic but the phenomenon has not been studied in this species. For three years I have collected data on the color phases of nesting egrets and their offspring. These data await analysis

TABLE 4. Feeding efficiency of Reddish Egrets in Texas, 1977[1].

	Adults[2]	Immatures[3]
Capture success	42 %	29 %
# strikes/minute	2.8	3.3
# captures/minute	1.2	1.0
# minutes	584	169

[1]Data combined over all habitats for March, May, June, July, November.

[2]All birds 23 months and older.

[3]All birds 2-7 months.

but field observations confirm that the dark genotype is dominant to white, that white pairs breed true (homozygous recessive) and that occasional hetrozygous (dark) pairs produce white young.

In combination with observations of feeding birds these data may help to explain the increasing proportion of white-phase egrets in some portions of Texas.

There is little recent data on the proportion of white-phase birds in U.S. populations. Bolen and Cottam (1975) reported that 5.1% of a flock of 206 birds were white-phase. However, this flock was seen long after the breeding season had ended and its place in the Texas population is difficult to assess. In 1977 I collected data on the proportion of white-phase birds in breeding colonies (Table 5; for locations of colonies see Figure 1). The white-phase is generally more common from Redfish Bay south, and is more common than generally supposed. Oberholser (1974), relying largely on data collected in the 1920s and 30s, estimated that 1-4% of the Texas population were white-phase.

Parasites

As in 1975 and 1976, larval ticks Ornithodoros capensis were found on some nestlings. No infestations were noted, and no standard data were collected. Fecal samples and blood smears were preserved and sent to Dr. Donald Forrester of the University of Florida. The fecals (n=12) were all negative when checked for coccidia; the blood smears have not yet been analyzed. Nematodes found in regurgitated food have been preserved and will be sent to Dr. Forrester for examination.

TABLE 5. Proportion of white phase Reddish Egrets estimated in breeding colonies in Texas, 1977.

Colony	% White Phase	N[1]
North Deer Island[2]	1	15
Dressing Point[3]	3	40
Sundown Island	6	32
Long Reef-Deadman Islands	4	160
Redfish Bay Spoil Islands	18	300
Pelican Island	4-7	27
Upper Laguna Madre		
Spoil Islands north of South Bird Is.	11	9
South Bird Island	15	53
Spoil Islands south of South Bird Is.	0	32
Baffin Bay Spoil Islands	3	71
Green Island (adults)[4]	5	395
(fledged young)	11	336

[1]N=adults seen in or flying to and from colony, except where noted.

[2]Texas A & I Spoil Island Study found 1 white egret nesting in 1977. My best estimate of nesting population was 45-52 pairs; despite repeated surveys in area I never saw a white phase bird. Estimate is therefore based on 1/90.

[3]1975 data courtesy of Kirke A. King (count of large young).

[4]Bias likely-suspect some white adults were missed.

Anticipated Activities, 1978-1979

Studies of Reddish Egrets will continue through 1979. During this period most of my field work will be in Florida. I have the following objectives:

(1) Determine the size and distribution of the breeding population.

(2) Measure nesting success.

(3) Determine timing of breeding season.

(4) Determine the proportion of white phase birds in the population.

(5) Attempt to follow movements through banding and color-marking of nestlings.

(6) Assess diet through analysis of regurgitations.

Some field work will also be conducted on Inagua in the southern Bahamas, where there is a nearly ideal set-up for study of a population that is 80-90% white phase.

I hope to visit Texas colonies twice in 1978, once to study ecological aspects of colony formation and courtship behavior, and once to band nestlings and search colonies for color-banded breeding adults.

I expect to begin analysis of portions of the data collected so far and to prepare materials for publication. One important area will be feeding ecology, as noted earlier. It is there that Reddish Egrets differ most from other herons, and there that they are most intriguing.

Literature cited

Allen, R.P. 1954-55. The Reddish Egret: bird of colors and contrasts. Audubon Magazine, 56:252-255; 57:24-27.

Paul, R.T., A.J. Meyerriecks and F.M. Dunstan. 1975. Return of Reddish Egrets as breeding birds in Tampa Bay, Florida. Fla. Field-Nat., 3:9-10.

Portnoy, J.W. 1978. Field methods and results of a North Gulf Coast wader inventory. Research Report No. 7 National Audubon Society. (in press).

Robertson, W.B., Jr., and J.A.Kushlan. 1974. The southern Florida avifauna. pp 414-452, In Miami Geol. Soc. Mem. 2, Environments of south Florida: present and past.

Additional Activities, 1977

1. Papers published

   Ticks as a factor in the 1975 nesting failure of Texas Brown Pelicans. Wilson Bull., 89:157-158.

2. Attended annual meeting of Colonial Waterbird Group in DeKalb, Illinois,

   21-23 October.

3. Paper presented

   History and current status of Reddish Egrets in the United States. To be published in conference proceedings, Colonial Waterbird Group. (abstract attached)

4. Popular article published

   Pelican comeback. Texas Parks and Wildlife, 35(3):12-15.

5. Monitoring of Texas Brown Pelican population

   In Texas Brown Pelicans were very nearly extirpated during the late 1960s. The population may have fallen to as few as 4 pairs, which in 2 years failed to breed at all. In 1977 17 pairs nested at 2 colonies in the state. Nine pairs nested at Long Reef Island, where I served as warden on weekends. Nesting success was excellent: 34 young were produced, including 22 at Long Reef. All were banded and color-banded by a team directed by David R. Blankinship and myself.

6. White-crowned Pigeon studies in Florida and the Bahamas

   I returned to Andros Island, Bahamas for the fifth year to monitor the opening of the White-crowned Pigeon hunting season (October 1-3). The following data were collected: age ratio in harvest, number of hunters,

hunters' daily bags, crippling rate, total kill for the first 3 days of the season. Dave Blankinship collected similar information on South Andros. A report to the Bahamian Ministry of Agriculture and Fisheries is in preparation.

History and Current Status of Reddish Egrets in the United States

Richard T. Paul

National Audubon Society
Research Department

Reddish Egrets were among the species decimated by plume hunters in the last century. The available historical data show prompt recovery of the Texas breeding population (or lack of pressure by plume hunters in the first place) through the 1930's, then a decline which reached serious proportions in the 1960s. In Florida and Louisiana, egrets were very slow to increase; with breeding not rediscovered until 1938 and 1958, respectively. Currently estimated populations are 1600 pairs in Texas, 150 in Florida and 150 in Louisiana. In all three states numbers appear to be stable or increasing. Probable causes for the current increases are discussed.

(Abstract)

COLONIAL BIRD REGISTER

Colonial Bird Register Annual Report on Activities for Calendar Year 1977.

I. Introduction

During 1977, the Colonial Bird Register substantially expanded all phases of its operation. The Register progressed from announcing its existence and calling for data, to achieving an operational data retrieval system.

II. Cooperators with the Colonial Bird Register

In response to numerous mailings in 1975 and 1976, over 600 individuals, institutions or agencies indicated a desire to cooperate with the Colonial Bird Register. Of these, 276 persons actually contributed information to our data base. Much of the information which we now hold has been contributed by investigators associated with the Seabird and Wading Bird Colony Surveys of the United States Fish and Wildlife Service as well as other Federal programs.

To date, 3,165 colony survey forms have been received. Almost 2,900 of these forms have been computerized. The contributors of information may be summarized as follows:

Source	Number of Forms
Contributors allied primarily with the CBR	1,021
Corps of Engineers Dredge Spoil Island Survey	218
Louisiana Cooperative Wildlife Research Unit	211
Maine Cooperative Wildlife Research Unit	328
Massachusetts Cooperative Wildlife Research Unit	651
Patuxent Wildlife Research Center	587
Texas Fish-Eating Bird Survey	149

A state-by-state breakdown of computerized information is presented in Figure 1. A list of species for which computerized retrieval is possible is presented in Table 1.

III. Computerization of information

Two temporary full-time data entry technicians worked from mid-November 1976 through June 30, 1977 editing and keying data. A Cornell undergraduate work-study student also worked temporarily from January to April 1977, during periods of intensive data editing and entry. Since July 1, a single permanent research assistant, Ms. Nancy McGinnis, has continued data entry and editing. On October 1, 1977 the ISIS information storage and retrieval system of the Colonial Bird Register became operational.

CBR computerized records can be retrieved on a number of variables, either singly or in various combinations: Month, Year, Observer, Colony Name, Latitude

and Longitude, County, State/Province/Territory, Species, Survey. The current retrieval output format is illustrated in Figure 2. To facilitate interpretation of data, Ms. McGinnis and Dr. Donald McCrimmon, Director of the Register, prepared a CBR Retrieval Manual for Data Users - 1977.

The Wang 2200S computer terminal, jointly purchased by the National Audubon Society and the Cornell Laboratory of Ornithology, has been an effective instrument for handling data. Wang Laboratories provided systems analysts who constructed initial data entry and data editing programs. Dr. McCrimmon later attended an advanced programming course at the Wang Laboratories in Tewksbury, Massachusetts. The skills gained in this course helped him to restructure and make more efficient the CBR data entry and editing programs.

The United States government has shown considerable interest in establishing and/or supporting data bases of information on colonially nesting birds. In March 1977, a representative of the Non-game Migratory Bird Habitat Research Laboratory of the Patuxent Wildlife Research Center came to the Laboratory of Ornithology and reviewed the Colonial Bird Register, ascertaining the feasibility of a working relationship between the Register and the U.S. Fish and Wildlife Service. During this visit, the representative commented that the operations of the Register were several years advanced beyond the colony data handling capabilities of the Fish and Wildlife Service. Furthermore, upon the recent recommendation of Dr. Stanley H. Anderson, Chief of the Migratory Non-game Bird Section of the Patuxent Wildlife Research Center, a proposal for partial support from the Fish and Wildlife Service for CBR operations is being prepared. We intend to submit this report to the Director of the Fish and Wildlife Service during mid-winter 1978.

IV. The travel activities of the Director of the Register

During calendar 1977, Dr. McCrimmon attended numerous conferences on behalf of the Register and the National Audubon Society.

Purpose of trip	Location	Dates
Pacific Seabird Group annual meeting	Monterey, CA	Jan. 6-9
U.S. Fish and Wildlife Service Habitat Classification Conference	Phoenix, AZ	Jan. 24-28
*Address on CBR to Linnaean Society	New York City	Feb. 8
U.S. Fish and Wildlife Service Eastern Colony Survey Personnel meeting	Boston, MA	Feb. 23-25
*North American Wildlife Conference	Atlanta, GA	Mar. 5-7
National Audubon Society Research Dept. meeting	Tavernier, FL	Mar. 19-24
*BTO/BOU Conference on Changing Seabird Populations of the North Atlantic	Aberdeen, Scotland	Mar. 25-31

Planning Session for 1978 Colonial Waterbird Group meeting	New York City	April 13
Consultation with NY State Department of Environmental Conservation on the Hart Bill	New Paltz, NY	July 21-22
*Endangered Bird Species Management Conference	Madison, WI	Aug. 17-21
AOU meetings	Berkeley, CA	Aug. 22-25
AOU/NSF Workshop on Special Data Banks	Berkeley, CA	Aug. 26
National Audubon Society Research Staff meeting	Tavernier, FL	Aug. 27-31
Conference with Dr. Stanley H. Anderson on CBR/FWS data bank interfacing	Laurel, MD	Sept. 13-14
National Audubon Society Administrative Personnel meeting	Greenwich, CT	Sept. 25-30
Colonial Waterbird Group annual meeting	DeKalb, IL	Oct. 22-23
*Texas Fish-Eating Bird Survey annual meeting	Dallas, TX	Oct. 28-29

*paper read or presentation made

V. Other activities of the Director of the Register

During 1977 Dr. McCrimmon served on the steering committee for the Colonial Waterbird Group. In October of 1977 he was elected to the office of Treasurer, a position he will hold until January of 1980. Further, Dr. McCrimmon serves as Chairperson for the Workshop on Censuses and Surveys of the Colonial Waterbird Group.

At the Laboratory of Ornithology, Dr. McCrimmon sits on the Executive Staff and attends all meetings of the Administrative Board. In addition to his duties for the Colonial Bird Register, Dr. McCrimmon spends an average of an additional 20-30 hours per month administrating the North American Nest Record Card Program. He also has been appointed to the ad hoc Graduate Faculty in the Department of Natural Resources at Cornell. In this capacity he serves as Minor Professor for two graduate students, consulting with them regularly.

Papers published in 1977:

McCrimmon, Donald A. Jr. 1977. The Colonial Bird Register and Allied Federal Inventories: Resources for the Study of Avian Hazards to Aircraft. in Proceedings of Bird Hazards to Aircraft Training Seminar and Workshop (Sidney A. Gauthreaux, Jr., editor) Department of Zoology, Clemson University, Clemson, South Carolina.

Papers submitted in 1977 and accepted for publication:

McCrimmon, D.A. Jr. 1977. The Management and Exchange of Information on Colonially Nesting Birds. in Wading Birds: Research Report no.7 of the National Audubon Society (A. Sprunt, IV, J.C. Ogden, and S. Winckler, editors) National Audubon Society, New York (in press)

_____ 1977. A Review of Some Methods and Considerations for the

Assessment of Breeding Populations of Colonial Waterbirds. in Proceedings of the 1976 Conference of the Texas Fish-Eating Bird Survey (J. Smith, editor) Texas Parks and Wildlife Department, Austin, Texas (in press)

_____ 1978. Nest-site Characteristics among Five Species of Herons on the North Carolina Coast. Auk 95 (in press).

_____ and J. Bart. 1978. An Analysis of Reproductive Patterns in Three North American Raptors using Nest Record Card Data: An Example of Long-Term Population Monitoring. in Proceedings of the Conference on Endangered Bird Species Management (S. Temple, editor) University of Wisconsin Press, Madison, Wisconsin. (in press)

VI. The Outlook for 1978

The 1978, the emphasis of the Register will shift from implementation of the data retrieval system to announcing to potential users, the availability of the Register's information. For this purpose a special brochure and announcement campaign are planned. At the same time, the Register will collect data from east coast colonies, surveyed in 1977 by the Fish and Wildlife Service. We anticipate acquisition of substantial quantities of additional information from the United States Corps of Army Engineers.

The Fish and Wildlife Service in cooperation with the National Oceanic and Atmospheric Administration have conducted extensive surveys of colonies in Alaska. At the present time, although some annual reports have been prepared by Federal biologists, the data has not been organized to facilitate retrieval by personnel other than those of the U.S. Department of the Interior. The Register must access this Alaskan information and make it available to our users.

An extensive campaign, emphasizing to Colonial Bird Register cooperators the need for continuing their survey efforts in 1978 and beyond, is planned. Newsletters and other special mailings will be used to stimulate additional input of information.

In 1977, the American Ornithologists Union, with the support of the National Science Foundation, reported on the role of the amateur in contemporary ornithology. The Colonial Bird Register and the North American Nest Record Card Program were cited as outstanding examples of important programs enlisting the aid of amateurs for the collection of ornithological data. In February, the National Audubon Society and the Laboratory of Ornithology are co-sponsoring a Conference to further explore methods of enhancing involvement of North American amateur ornithologists. The Register will be represented at that Conference and has been intimately involved in its planning.

The Director of the Register already spends considerable time administrating and working with the data of the North American Nest Record Card Program. The Nest Record Card Program has contracted with the World Wildlife Foundation to analyze productivity data for all species of North American Raptors. The person who originally acquired this contract left the employ of Cornell before the contract was fulfilled. In his absence, the responsibility for continuing and concluding the analysis has fallen on Dr. McCrimmon.

Dr. McCrimmon has accepted an invitation to address the Centennial of the Linnaean Society in conjunction with the annual meeting of the Colonial Waterbird Group. The subject of his paper will be the ecology of colonial nesting and will be a full-scale review of the available literature.

Figure 1. State-by-state geographic representation of the number of colony visits computerized in the CBR data base at the end of calendar 1977. Each visit to a colony receives an individual record number when incorporated into CBR data files.


5
9
8
38
9
46
240
5
1
6
68
4
8
67
165
169
138
47
40
4
21
5
1
38
9
123
11
45
39
9
7
2
4
6
175
240
21
18
12
25
13
108
21
28
67
190
154
307
BAHAMAS 1
HAWAII 1

Figure 2. An example of the output format of computerized CBR data. Digitized data can be easily interpreted by the user by referring to a specially prepared manual included with the output of each retrieval.

ISIS STORAGE AND RETRIEVAL SYSTEM 330/77

SEARCH NO. 00004

COLONIAL BIRD REGISTER, 159 SAPSUCKER WOODS ROAD, ITHACA, NY 14853
A PROJECT OF THE NATIONAL AUDUBON SOCIETY AND THE CORNELL LAB OF ORNITHOLOGY.

RECORD NO.02522 MO 04 DAY 04 YR 72 START END ZONE EST VISIT 1
COLONY BARLEY BARBER LAD 27LAM 02LOD 080LOM 35 M-1 OBSERVER A SPRUNT
NEAREST TOWN PORT MAYACA COUNTY MARTIN S/P/T FL CO USA
ELEVATION COLONY SIZE ISLAND SIZE SUB COLONY
GEN AREA 3 GEN HABITAT 5 COLONY HISTORY SURVEY MAP REF
IMMED TECH DIST 4 POT TECH DIST 0 PRECIPITATION
IMMED HAB DIST 4 POT HAB DIST 0 WIND SPEED
IMMED REC DIST 4 POT REC DIST 0 SEA
IMMED VEH DIST 4 POT VEH DIST 0 TIDE
IMMED SCI DIST 4 POT SCI DIST 0 PHOTOG?

CENSUS TECH 1 OTHER TECHS? RECORD#S
RANGES GIVEN? N OTHER RECORD#-S FOR >10 SPECIES

SPECIES	CEN TEC	TOT POP	ACT NESTS	YOUNG OUT	NEST STAGE	NEST SITE	NO BAND
0502010100	01		00000250		05	02	0000

****

RECORD NO.02521 MO 04 DAY 04 YR 72 START END ZONE EST VISIT
COLONY KINGS BAR LAD 27LAM 06LOD 080LOM 50 M-1 OBSERVER A SPRUNT
NEAREST TOWN OKEECHOBEE COUNTY OKEECHOBEE S/P/T FL CO USA
ELEVATION COLONY SIZE ISLAND SIZE SUB COLONY
GEN AREA GEN HABITAT COLONY HISTORY 1 SURVEY MAP REF
IMMED TECH DIST 4 POT TECH DIST 0 PRECIPITATION
IMMED HAB DIST 4 POT HAB DIST 0 WIND SPEED
IMMED REC DIST 4 POT REC DIST 0 SEA
IMMED VEH DIST 4 POT VEH DIST 0 TIDE
IMMED SCI DIST 4 POT SCI DIST 0 PHOTOG?

CENSUS TECH 10 OTHER TECHS? N RECORD#S
RANGES GIVEN? N OTHER RECORD#-S FOR >10 SPECIES

SPECIES	CEN TEC	TOT POP	ACT NESTS	YOUNG OUT	NEST STAGE	NEST SITE	NO BAND
0405010100	10		00000100		07	02	0000
0501010100	10		00001000		07	02	0000
0501030100	10		00000200		07	02	0000
0501040100	10		00000100		07	02	0000
0501060100	10		00002500		07	02	0000
0501070100	10	00000200			07	02	0000
0501080100	10	00000100			07	02	0000
0503010100	10	00000050			07	02	0000
0503020100	10	00005500			07	02	0000

****

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Table 1. Identification codes, names and numbers of computerized records for species of birds reported to the Colonial Bird Register. Non-colonially nesting species have been included when they have been reported by an observer as nesting in association with a colony.

SPECIES ID	NAME	NO. OF COMPUTERIZED RECORDS
0000000000	Unidentified nests	5
0201010300	Eared Grebe (Podiceps nigricollis)	4
0201020100	Western Grebe (Aechmophorus occidentalis)	1
0303020200	Leach's Petrel (Oceanodroma leucorhoa)	6
040201000001	Pelican species	3
0402010100	White Pelican (Pelecanus erythrorhynchos)	23
0402010200	Brown Pelican (Pelecanus occidentalis)	55
0403010400	Red-footed Booby (Sula sula)	1
040401000001	Cormorant species	40
0404010100	Great Cormorant (Phalacrocorax carbo)	40
0404010200	Double-crested Cormorant (Phalacrocorax auritus)	163
0404010300	Olivaceous Cormorant (Phalacrocorax olivaceus)	16
0405010100	Anhinga (Anhinga anhinga)	72
0406010100	Magnificent Frigatebird (Fregata magnificens)	7
050100000001	Heron species	27
050100000002	Egret species	4
0501010100	Great Blue Heron (Ardea herodias)	600
0501010700	Great White Heron (Ardea occidentalis)	39
0501020100	Green Heron (Butorides virescens)	55
0501030100	Little Blue Heron (Florida caerulea)	237
0501040100	Cattle Egret (Bubulcus ibis)	244
0501050100	Reddish Egret (Dichromanassa rufescens)	62
0501060100	Great Egret (Casmerodius albus)	417
0501070100	Snowy Egret (Egretta thula)	332
0501080100	Louisiana Heron (Hydranassa tricolor)	296
0501090100	Black-crowned Night Heron (Nycticorax nycticorax)	286
0501100100	Yellow-crowned Night Heron (Nyctanassa violacea)	48
0501110100	Least Bittern (Ixobrychus exilis)	8
0502010100	Wood Stork (Mycteria americana)	45
050301000001	Plegadis species	17
0503010100	Glossy Ibis (Plegadis falcinellus)	84
0503010200	White-faced Ibis (Plegadis chihi)	34
0503020100	White Ibis (Eudocimus albus)	123
0503020200	Scarlet Ibis (Eudocimus ruber)	1
0503040100	Roseate Spoonbill (Ajaia ajaja)	53

0504010100	Flamingo (Phoenicopterus ruber)	1
0601030100	Canada Goose (Branta canadensis)	6
0601090100	Mallard (Anas platyrhynchos)	2
0601090300	Black Duck (Anas rubripes)	2
0601090500	Mottled Duck (Anas fulvigula)	2
0601090600	Gadwall (Anas strepera)	1
0601091200	Blue-winged Teal (Anas discors)	1
0601091300	Cinnamon Teal (Anas cyanoptera)	1
0601170100	Common Eider (Somateria mollissima)	148
0601190100	Ruddy Duck (Oxyura jamaicensis)	2
0702100100	Red-tailed Hawk (Buteo jamaicensis)	1
0703010100	Osprey (Pandion haliaetus)	23
0903010100	King Rail (Rallus elegans)	1
0903010200	Clapper Rail (Rallus longirostris)	2
0903070100	Common Gallinule (Gallinula chloropus)	1
0903080200	American Coot (Fulica americana)	1
1002010200	American Oystercatcher (Haematopus palliatus)	21
1003020300	Piping Plover (Charadrius melodus)	8
1003020400	Snowy Plover (Charadrius alexandrinus)	4
1003020600	Wilson's Plover (Charadrius wilsonia)	3
1003020700	Killdeer (Charadrius vociferus)	1
1004010100	Ruddy Turnstone (Arenaria interpres)	3
1004080100	Spotted Sandpiper (Actitis macularia)	1
1004110100	Willet (Catoptrophorus semipalmatus)	9
1005010100	American Avocet (Recurvirostridae americana)	1
1005020100	Black-necked Stilt (Himantopus mexicanus)	2
100800000001	Gull species	28
100800000002	Tern species	5
1008010400	Great Black-backed Gull (Larus marinus)	231
1008010800	Herring Gull (Larus argentatus)	459
1008011000	California Gull (Larus californicus)	10
1008011100	Ring-billed Gull (Larus delawarensis)	48
1008011500	Laughing Gull (Larus atricilla)	263
1008011600	Franklin's Gull (Larus pipixcan)	7
1008060100	Gull-billed Tern (Gelochelidon nilotica)	147
1008070200	Forster's Tern (Sterna forsteri)	129

continued...

1008070300	Common Tern (Sterna hirundo)	401
1008070400	Arctic Tern (Sterna paradisaea)	7
1008070500	Roseate Tern (Sterna dougallii)	51
1008070700	Sooty Tern (Sterna fuscata)	5
1008070800	Bridled Tern (Sterna anaethetus)	1
1008070900	Least Tern (Sterna albifrons)	479
1008070902	Least Tern (S.a.browni)	2
1008070903	Least Tern (S.a.athalassos)	54
1008080100	Royal Tern (Thalasseus maximus)	93
1008080300	Sandwich Tern (Thalasseus sandvicensis)	62
1008090100	Caspian Tern (Hydroprogne caspia)	25
1008100100	Black Tern (Chilidonias niger)	21
1009010100	Black Skimmer (Rynchopidae nigra)	354
1010020100	Razorbill Auk (Alca torda)	1
1010050100	Black Guillemot (Cepphus grylle)	61
1010130100	Common Puffin (Fratercula arctica)	1
2004080100	Cliff Swallow (Petrochelidon pyrrhonota)	3
2004090100	Purple Martin (Progne subis)	1
2005070500	Fish Crow (Corvus ossifragus)	1
2026040100	Red-winged Blackbird (Agelaius phoeniceus)	2
2026070100	Great-tailed Grackle (Cassidix mexicanus)	1
2028030100	Rose-breasted Grosbeak (Pheucticus ludovicianus)	1

ECOLOGICAL SYSTEMS ANALYSIS

1977 ANNUAL REPORT

Ecosystem Research Unit

National Audubon Society

Michael J. Duever, Director

John E. Carlson

Lawrence A. Riopelle

Linda C. Duever

National Audubon Society

Lance H. Gunderson

University of Florida Center for Wetlands

TABLE OF CONTENTS

RESEARCH PROJECTS

ECOSYSTEM ANALYSES AT CORKSCREW SWAMP

Funded by the Rockefeller Foundation through a subcontract from the University of Florida Center for Wetlands.

NAS staff: Mike Duever (Principal Investigator), Ed Carlson, Larry Riopelle, Linda Duever. CFW staff: Lance Gunderson.

This is an ecosystem overview study designed to 1) provide the Center for Wetlands with data on the natural functioning of an undisturbed mature cypress strand to supplement data on the potential value of swamps as natural sewage treatment systems; and 2) supply necessary scientific data for ecologically sound management planning at Corkscrew Swamp Sanctuary.

The study was begun in 1973 and is now in the final data analysis, write-up, and tying-up-loose-ends phase. We are meeting regularly with the sanctuary staff and expect to have a management recommendations report completed in 1978.

Virtually all fieldwork for this project was finished by January, 1977. In order to obtain data for three full annual cycles, we continued to monitor the wells (at monthly intervals) through May, and the main weather station through August. By June we had dismantled all other field equipment except that which will be used for long-term National Audubon Society research programs or sanctuary management monitoring purposes.

We took advantage of special opportunities for conducting short-term research on freeze effects, cypress leaf-out sequences, and Sabal palmetto ecology. Results of these studies are included in our 1977 annual report to the Rockefeller Foundation.

Laboratory analyses of vegetation, soil, and water chemistry and soil

physical characteristics were completed by summer, 1977. Analysis of data on chemistry and vegetation biomass and productivity is scheduled for completion in spring, 1978.

Hydroperiod Analyses

In our 1975 report we discussed hydroperiod-plant community relationships based on 1974-1975 water level data from 30 wells in six major habitats at Corkscrew Swamp Sanctuary. We now have two more years' data from these sites, and we have correlated water level data from these three annual cycles with 14 years of data from a staff gage located in one of the sanctuary's deeper sloughs. When water levels are above-ground, measurements at the staff gage correlate well with those at the other sites and we feel we can accurately extrapolate surface water levels and hydroperiods from the staff gage records. However, substrate characteristics create localized variations in the groundwater table and prevent extension of below-ground water level information to distant sites.

We used the staff gage - well site correlations to calculate the 14-year hydroperiod record for each well site. Since the wells were situated along surveyed transects through a cross-section of habitats with elevation and vegetation type data recorded at 7.6 m intervals, we were able to calculate average hydroperiods for each habitat. This gave us a 14-year hydroperiod record for 43 sites representing all major Corkscrew habitats. Mean hydroperiods ranged from 10 to 346 days (Fig. 1) and standard errors were consistently between 7 and 22 days.

These data generally support the conclusions on habitat-hydroperiod relationships presented in our 1975 and 1976 reports although they modify our understanding of transition zones between certain plant communities. Data from additional pine and hammock sites indicate that the two habitats

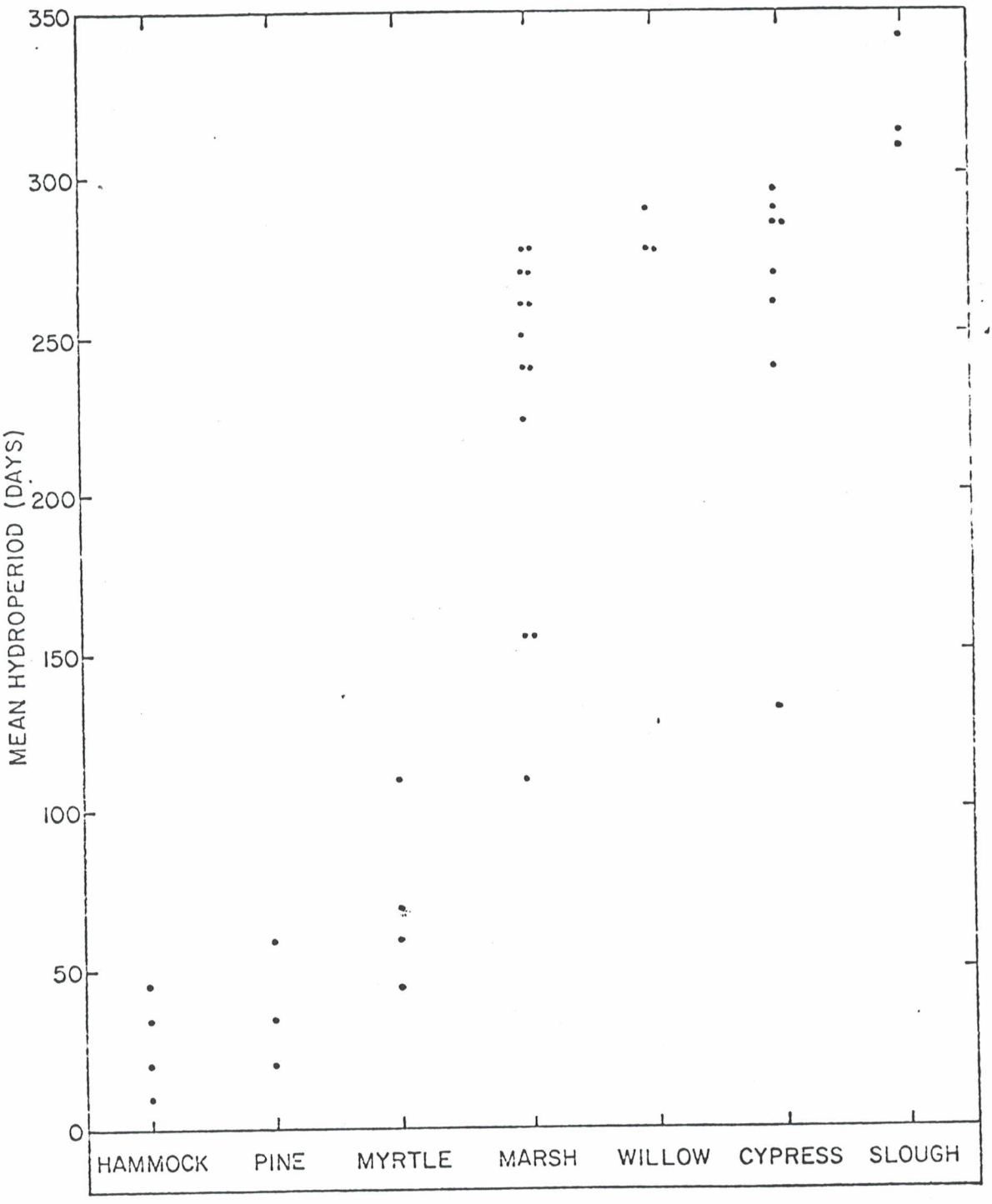


Fig. 1. Mean hydroperiods for 43 sites at Corkscrew Swamp Sanctuary over a 14-year period.

are not significantly different in hydroperiod. Apparently atypical hydroperiods can be explained in terms of special site characteristics.

Marsh hydroperiods normally fell in the range of 224 to 278 days per year, but three sites had shorter hydroperiods (111-155 days). These sites are somewhat different in species composition than the wetter marshes and are probably more appropriately termed "wet prairie" than "marsh". They are essentially myrtle prairies where fire has limited shrub invasion. The two marsh sites with unusually long hydroperiods (286-296 days) are affected by impoundment by and seepage from a dike.

The four sites with the largest and fastest-growing cypress (Taxodium distichum) had hydroperiods of between 286 and 296 days. Tree-ring analyses indicate that longer hydroperiods (306-325 days) at four cypress sites along the dike are slowing tree growth. Cypress growth rates were also relatively slow on the four sites with the shortest hydroperiods (133-270 days). Poor growth was particularly obvious on the 133 day hydroperiod site, where there was a vigorous shrub stratum of wax myrtle (Myrica cerifera), a species characteristic of sites with hydroperiods between 45 and 155 days. The cypress sites with hydroperiods of 260 and 270 days were severely burned in 1962 and, although the species is still present, the sites can no longer be considered healthy cypress communities. All four of the sites with low hydroperiods and slow cypress growth rates are located in the periphery of the main strand or in a smaller nearby strand, and all but one of them are underlain (at depths of less than 1.5 m) by a stratum of almost pure shell. Although these shell beds serve as groundwater conduits, they also tend to depress the water table in the vicinity.

At our study sites willows grow where hydroperiods are between 278 and 291 days, but we have observed them growing well elsewhere on canal banks or in similar situations where their bases are in much shorter hydroperiod sites,

but their root systems have access to water most of the year.

Sloughs, Corkscrew's deepest habitats, had average hydroperiods of 310 to 346 days. No natural habitat was continuously inundated; within the 18 years of record through 1977 there were three times when no natural surface water was present at Corkscrew Swamp.

Actual habitat hydroperiods are not evenly distributed over the theoretically possible range of hydroperiods. Our nine upland sites had hydroperiods of between 10 and 70 days, and five other sites had hydroperiods of under 156 days. The twenty wetland habitats had hydroperiods of between 224 and 296 days, and the sloughs had hydroperiods of up to 346 days. Thus there were very few sites with hydroperiods between 70 and 224 days, and none with hydroperiods between 155 and 224 days.

From the 14 years of staff gage data we calculated the average hydroperiod for each 2.54 cm interval from the ground surface to the highest recorded water level. When these hydroperiods were plotted against the corresponding water levels (Fig. 2) it became obvious that intermediate water depths were by far the most significant in terms of length of hydroperiod. Variations in high or low water levels had relatively little effect on hydroperiod, but the 12 cm difference between water depths of 69 and 81 cm caused a 113 day increase in hydroperiod.

This "vacant" hydroperiod range corresponds to the transition between upland and wetland habitats. Although the narrow bands of land at this hydroperiod are undoubtedly vegetated, no plant community seems to find optimum conditions here. This is at least partially because sites at this hydroperiod are actually scarce due to topographic characteristics and seasonal weather patterns.

Wetland habitats had hydroperiods of over 223 days. Peat accumulation was insignificant at sites with hydroperiods of less than 241 days, but peat

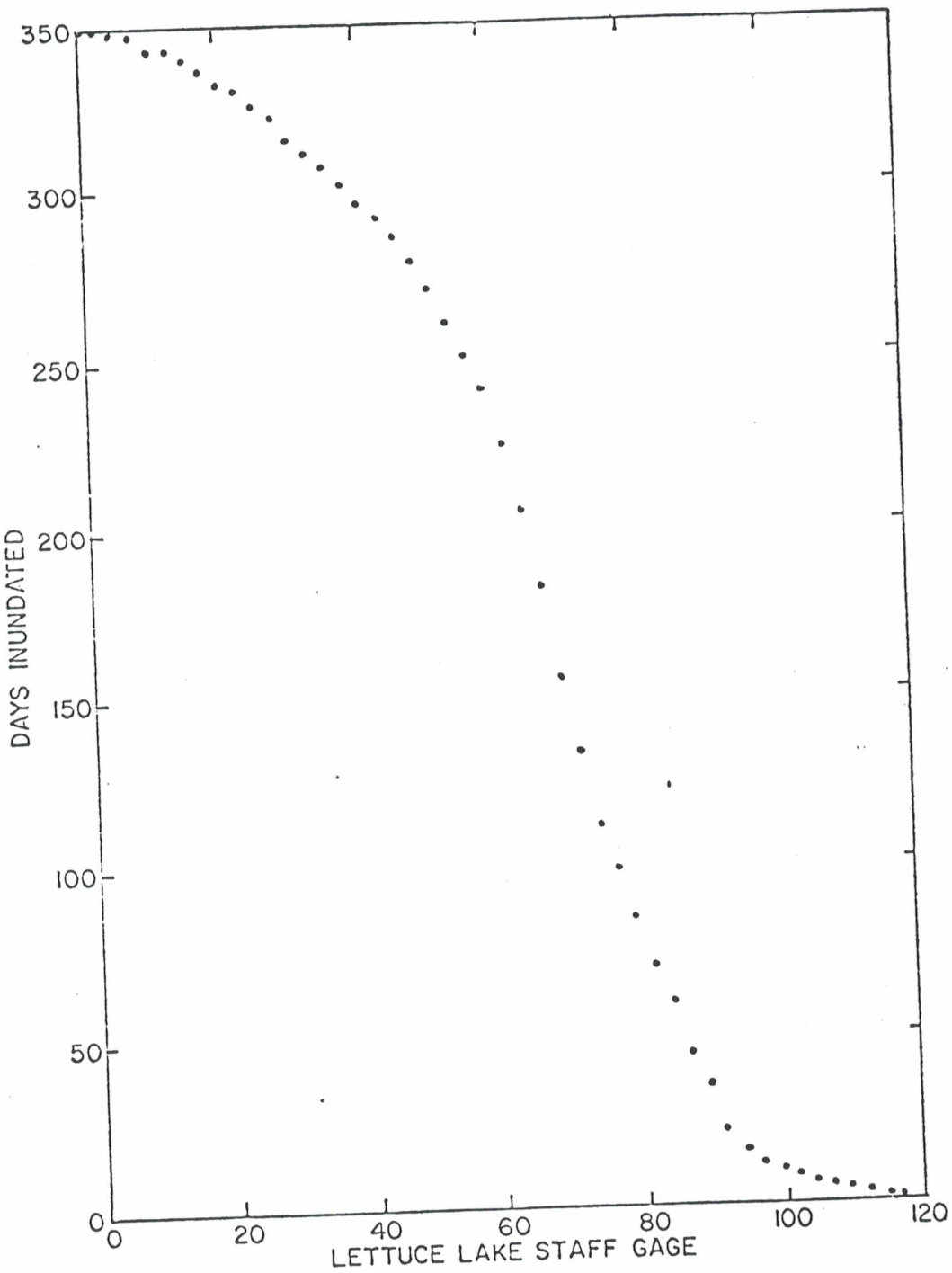


Fig. 2. Mean number of days per year that water levels were above given points on the Corkscrew Swamp Sanctuary staff gage.

deposits were characteristic of habitats inundated for longer periods. Extensive shallow wetlands are formed by peat filling in deeper depressions and building them up to an elevation where additional organic matter oxidizes instead of accumulating. As peat deposits fill the lower parts of ponds and sloughs, they force water up onto higher ground and increase hydroperiods in surrounding areas.. Because of these processes, large areas of wetlands are maintained at hydroperiods near the peat accumulation-oxidation balance point.

South Florida's sharply defined wet and dry seasons accentuate the distinction between upland and wetland hydroperiods. Figure 3 illustrates the seasonal rainfall pattern. The rapid transition between summer and winter water levels (and vice versa) prevents intermediate water levels from prevailing for very long. In such extreme flat terrain this means that most of the time either practically every place is under water or only the deeper marshes, swamps, and sloughs are wet.

Although hydroperiod appears to be the primary determinant of wetland community distribution, water levels are also an important influence. Abnormally high or low water can threaten cypress survival, but in natural cypress strands water levels are most significant in terms of understory composition and animal populations.

Table 1 gives average first-of-the-month water levels at the boundaries between marsh and "pond" cypress and between "bald" cypress and slough (Lettuce Lake) at Corkscrew Swamp. The values are extrapolated from 16 years of water level records from two staff gages along the sanctuary boardwalk. Extreme values associated with unusual drought or rainfall were excluded from the averages and "normal" ranges.

The range of water level variation was greatest (58-66 cm) during the dry season - wet season transition period, due to year-to-year variability in drought severity and timing of rainy season onset. Water levels were most

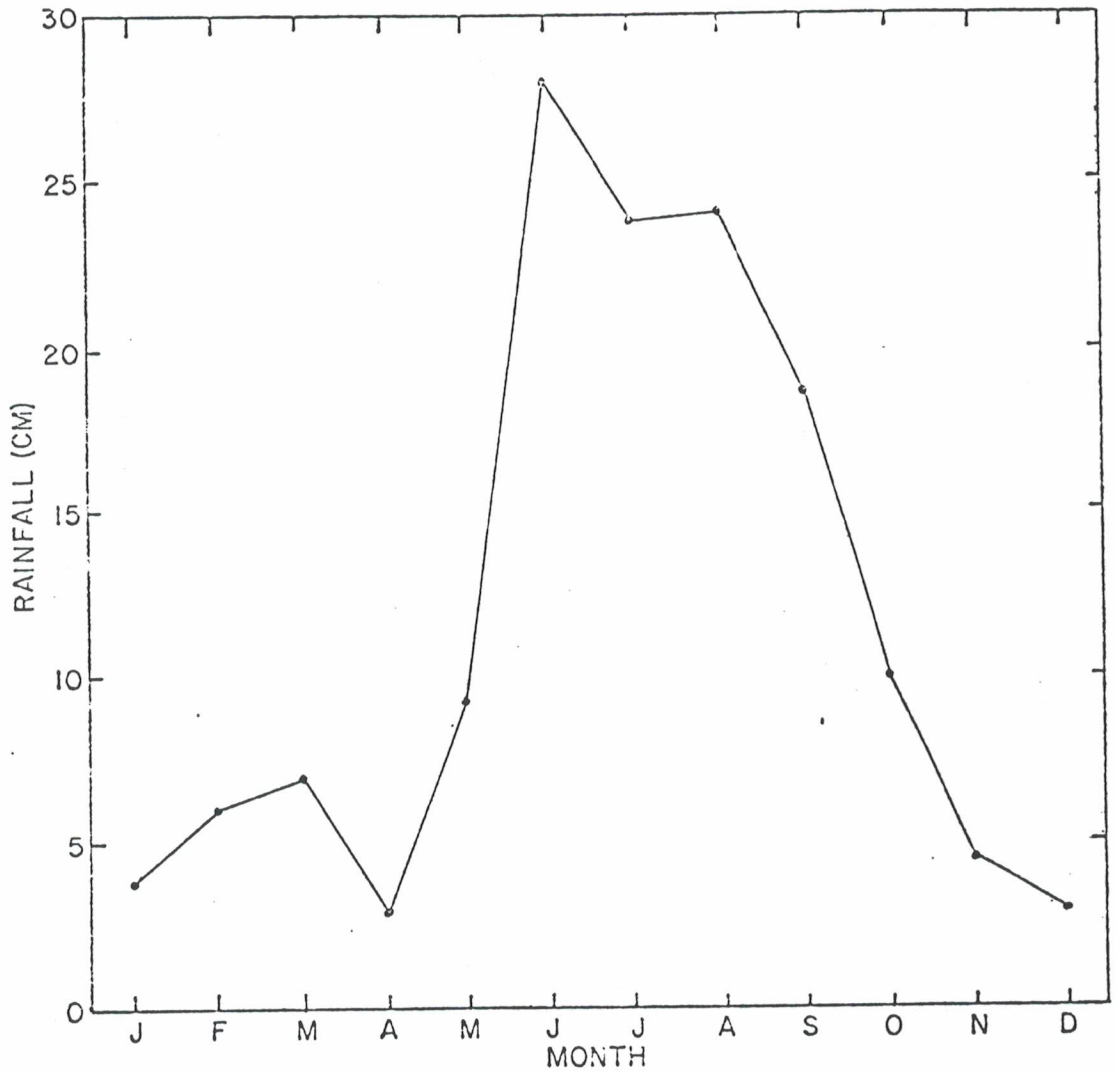


Fig. 3. Average monthly rainfall at Corkscrew.

Table 1. "Normal" Corkscrew Surface Water Depths (cm).

	"Pond" Cypress - Marsh Edge			"Bald" Cypress - Lettuce Lake Edge		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Jan	10	17	20	33	39	43
Feb	-3	13	20	20	36	43
Mar	-5	10	20	18	33	43
Apr	-18	1	15	5	24	38
May	<-58	-23	0	<-36	0	23
Jun	<-58	-28	5	<-36	-5	28
Jul	-25	9	41	-3	32	64
Aug	5	23	43	28	46	66
Sep	20	29	43	43	52	66
Oct	8	32	43	30	55	66
Nov	10	25	33	33	48	56
Dec	10	22	28	33	44	51
Hydroperiod (days inundated)	155	240	290	270	290	320

consistent for December and January, cold months with low and constant evapotranspiration rates. These winter months are also the driest, so rainfall variations are on a relatively small scale.

The average water depths were typically skewed towards the maximum "normal" values, although less so during the wet season. This suggests that there have been more "wet" than "dry" years during the period from 1959 to 1975.

Our 1975 report discussed the effects of canals, dikes, and pumps on water levels at the staff gages. Deletion of data for periods when such influences were operating did not significantly affect the mean water depth values for the months from November through April. However, the May and June average depths are approximately 3 cm higher than would have been the case if years when pumps were run during the dry season were excluded, and dike effects raised average depths 2-6 cm above what they would be under "natural" conditions. In view of normal year-to-year variability, these deviations are probably significant only in terms of lengthening hydroperiods.

It is important to recognize that the relationships between water depths and hydroperiods observed at Corkscrew Swamp are a function of that particular strand's topography. The Corkscrew cypress forest has a ground elevation range of 23 cm from the strand interior to the periphery. Since hydroperiod is a more important factor than water depth, we expect that other cypress forests would have similar hydroperiods (Table 1), although they might have quite different topographic gradients and hence different water depths. Seasonal water level fluctuations would probably be minimal in swamps situated in large shallow depressions, or on coastal plains or deltas, and greatest in river valleys, especially those with rivers fed by large watersheds.

As we discussed in our 1975 report, rainfall and water levels at Corkscrew Swamp Sanctuary correlate well. Since rainfall measurements were not taken at Corkscrew prior to 1959, we compared Corkscrew and Fort Myers

precipitation records to see if Fort Myers rainfall data, which has been recorded since 1892, could be used to calculate earlier Corkscrew water levels. We correlated the two sets of rainfall data by comparing: 1) each month ($r = 0.81$); 2) each January-May period ($r = 0.97$); 3) each June-September period; and 4) each June-May period ($r = 0.98$). Thus it appears that we will be able to reconstruct hydrologic data for Corkscrew Swamp from 1892 to the present with reasonable accuracy. In addition to giving us valuable information on year-to-year variability, a record of this length should permit us to relate variations in cypress growth rates (as determined through tree-ring analysis) to climatic events.

A preliminary examination of Fort Myers precipitation data revealed no major changes in rainfall patterns during the period of record. We calculated the mean annual Fort Myers rainfall and its variability for each 10-year period from 1901 to 1970 and for the shorter periods from 1892 to 1900 and f from 1971 to 1975 (Table 2). Since this analysis revealed no major changes in precipitation patterns during the period of record, we feel that the water level data gathered since 1959 is probably representative of hydrologic conditions at Corkscrew over the entire 1892-1975 period.

Our 1976 report described hydrologic patterns, substrate characteristics, and forest structure along a transect actoss the Corkscrew cypress strand and hypothesized that minimum dry season water levels, peat depth, and fire frequency and severity are the key factors responsible for the observed community structure. Figure 5 shows the relationship between tree size and peat depth along the eastern part of the Central Marsh Transect. A similar analysis of the western arm of the horseshoe-shaped strand yielded virtually identical results, although variability was greater because of a smaller sample size.

There are certain consistent deviations from the otherwise excellent

(inches of rainfall)

Table 2. Precipitation patterns at Fort Myers, Florida*

	Number of years	$\bar{X}$	S.E.	Min	Max
1892-1900	9	55.77	2.94	41.17	69.65
1901-1910	10	50.50	1.85	38.99	56.84
1911-1920	10	51.33	3.00	40.06	74.69
1921-1930	10	55.13	3.79	32.85	77.35
1931-1940	10	51.66	2.77	42.00	67.13
1941-1950	10	53.00	4.37	34.17	80.17
1951-1960	10	55.33	2.86	39.85	66.68
1961-1970	10	53.49	3.81	32.83	71.94
1971-1975	5	50.50	2.16	44.33	56.71

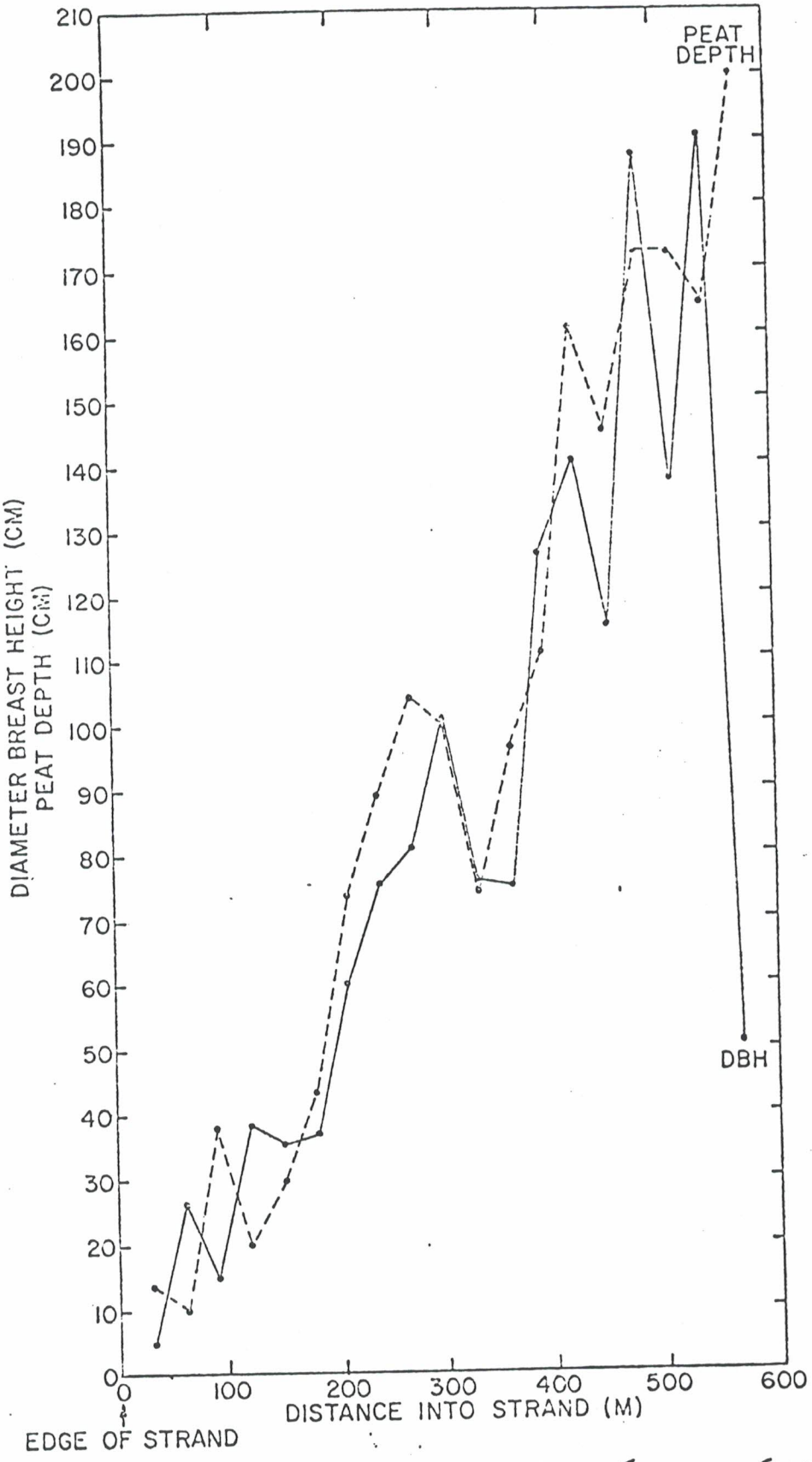


Fig. 5. Cypress DBH and peat depth, Central Marsh Transect, East Strand.

correlation of tree age and diameter (DBH): the intermediate-size trees towards the outside edge of the strand are smaller than would be expected for their ages and the trees growing along both the inner (Central Marsh) and outer borders of the strand are large for their ages. This suggests that other factors also significantly affect cypress growth rates. In an attempt to identify these other influences, we have examined tree-ring growth patterns of cypress from a wide variety of sites.

Growth rate can change as a tree ages, even if environmental conditions remain constant. Therefore, we felt it was important to define the normal growth patterns associated with each stage in the life of a cypress tree before we tried to relate growth changes to external factors. Computer plots of tree-ring widths versus age of several hundred cypress trees indicate that poor growing conditions cause similarly slow growth in trees of all ages, but young trees apparently have a greater capacity to respond to optimum conditions (Fig. 6). Young trees regularly put on ring width increments of up to 5-6 mm in a good growth year, whereas older trees rarely produce more than 1-1.5 mm in even the best growth years. Figure 7 illustrates the ages at which Corkscrew trees underwent the transition between the youthful high growth potential phase and the mature stable growth phase.

It has been suggested that the huge trees in the interior of the Corkscrew strand are the result of the optimum cypress site conditions. In order to better evaluate this hypothesis we plotted the maximum early growth rates and maximum stable growth rates of trees along the Central Marsh Transect (East Strand). Maximum stable growth rates were uniform across the strand (Fig. 8). Maximum early growth rates, however, generally increased from the strand edge towards the center, confirming the better quality of the interior sites. Growth rate analysis of the western arm of the strand revealed the same patterns. Higher growth rates were observed at three points

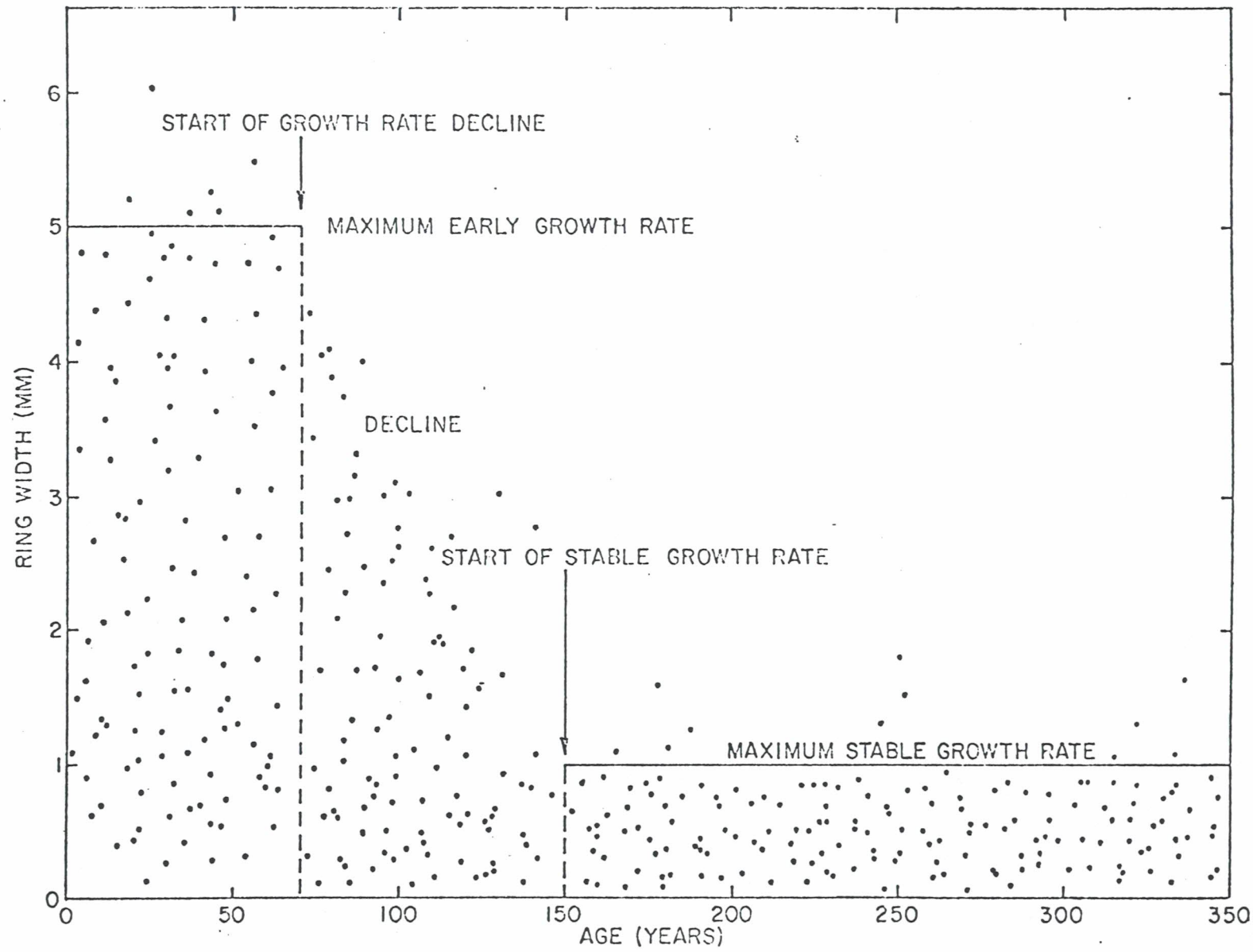


Fig. 6. Cypress growth rate patterns (schematic representation).

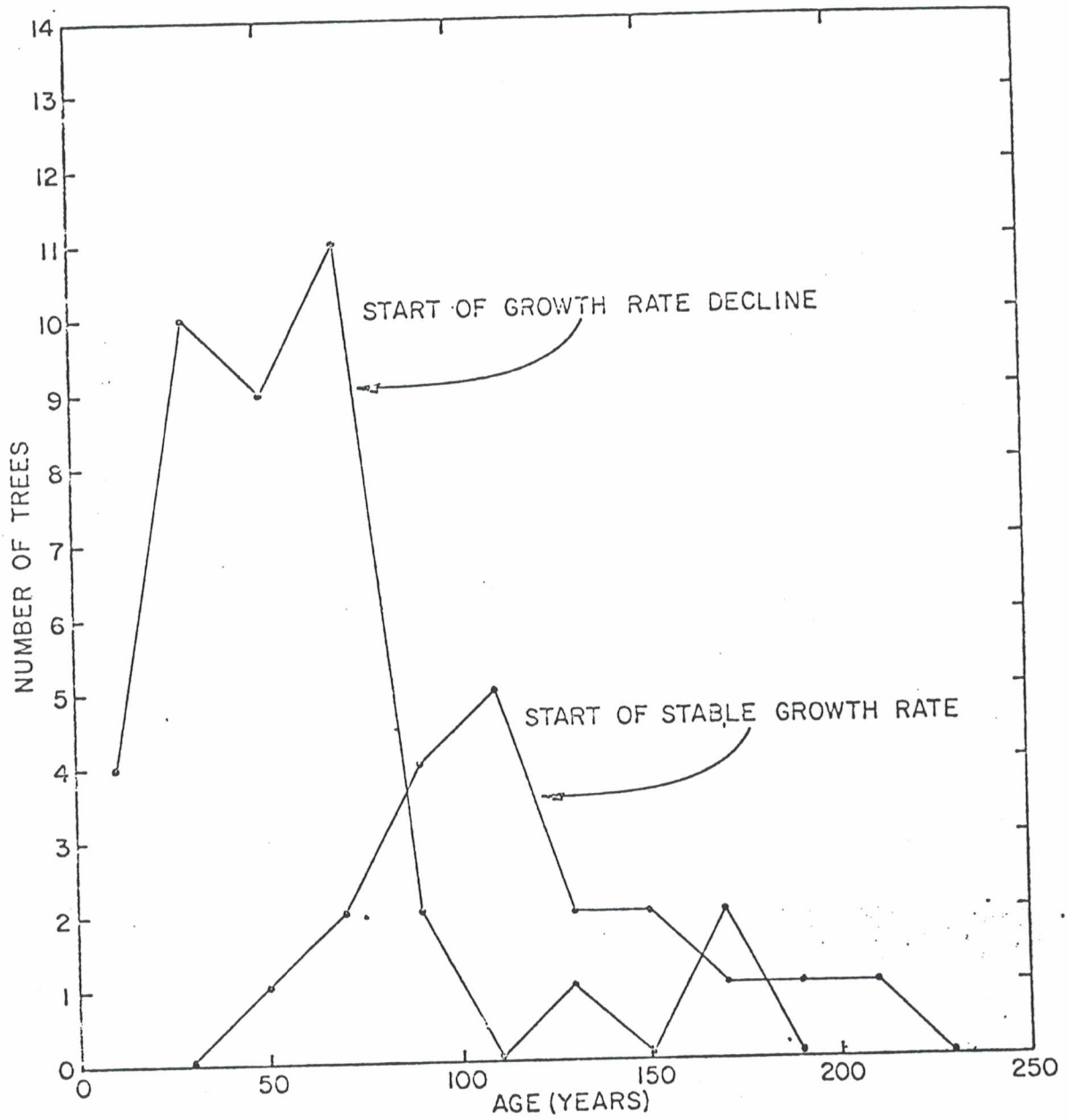


Fig. 7. Onset of cypress growth periods.

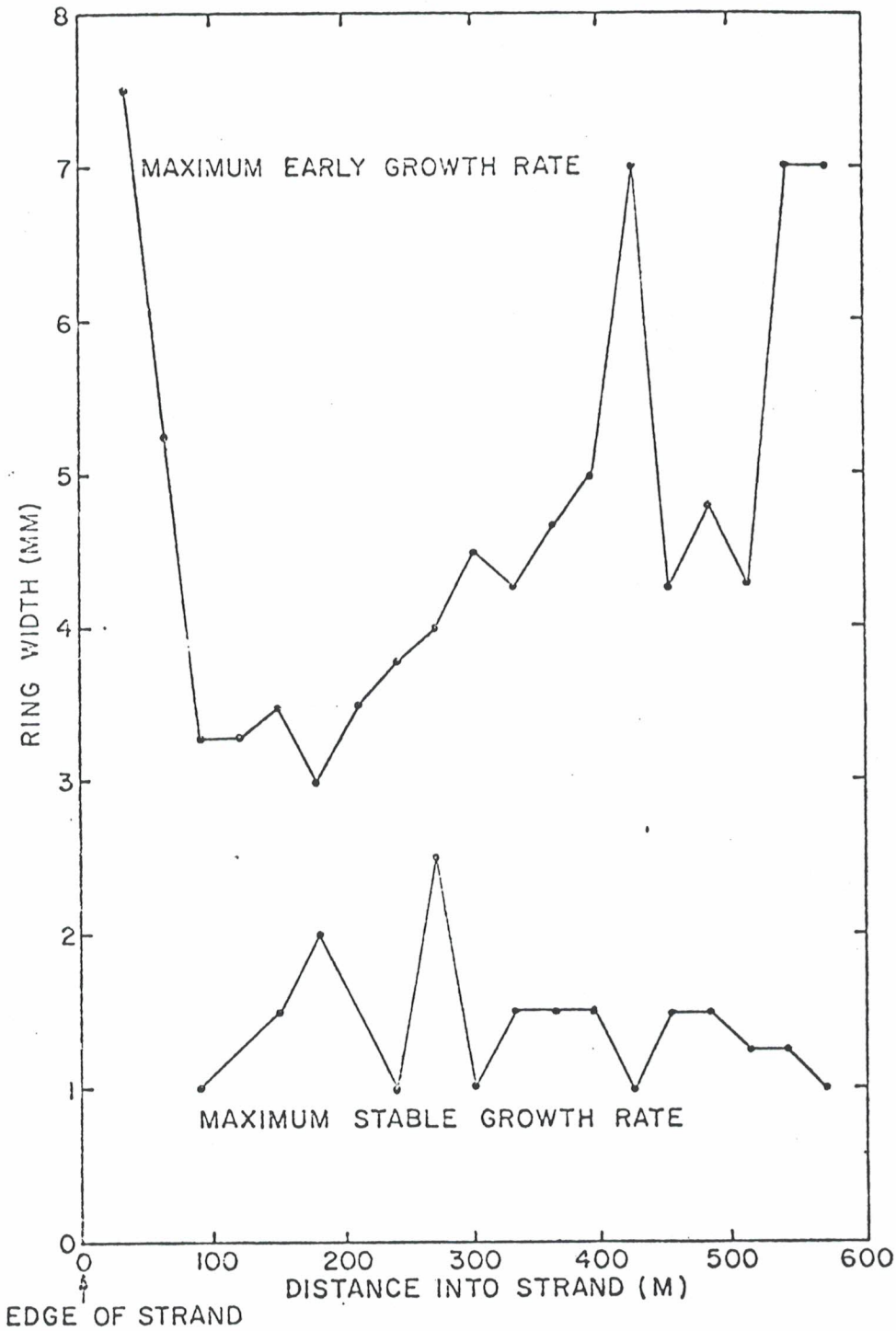


Fig. 8. Cypress growth rate patterns, Central Marsh Transect, East Stran

along the Central Marsh Transect and all of them were places where the trees had greater than usual access to sunlight: at both the inner and outer edges of the strand and in a canopy opening beside a lettuce lake.

Figure 9 illustrates the relationship between age and DBH of cypress from a variety of sites. With a few easily explained exceptions, age and DBH correlate well. However, trees growing in marls or in shallow soils with rock near the surface (usually sites with short hydroperiods) are generally small for their ages. This is most dramatic in the bonsai-like dwarf or scrub cypress with very enlarged buttressed bases and small boles and crowns. Understandably, stump sprouts regenerating from the root system of large cut trees grow faster than seedlings. Not only do they have the advantage of the same deep peat soil which produced the original big tree, but they have full access to sunlight. The relatively rapid growth of trees along strand edges and in canopy openings is also simple to explain in terms of light availability to trees on deep peat soil.

In order to assess the generality of conclusions based on data from the Corkscrew Swamp strand, we analyzed cypress age, growth rates, and DBH in relation to ground surface elevation and peat depth along a transect through Gordon Swamp, a strand of smaller cypress in the southwest part of the sanctuary. We found that this strand occupies a shallow depression and the trees grow on peat soils up to 0.5 m deep (Fig. 10). However, the size (DBH) of the trees was quite variable, perhaps partially due to small sample size, and we did not detect the largest-in-the-center pattern observed elsewhere. Tree-ring analysis indicates that this is because the youngest trees are in the interior in the Gordon Swamp strand (Fig. 11). Nevertheless, the trees in the center still exhibit the fastest maximum early growth rates.

Similar structure has been observed in burned cypress domes (Craighead, pers. comm.) and we feel that Gordon Swamp is a strand which has been burned

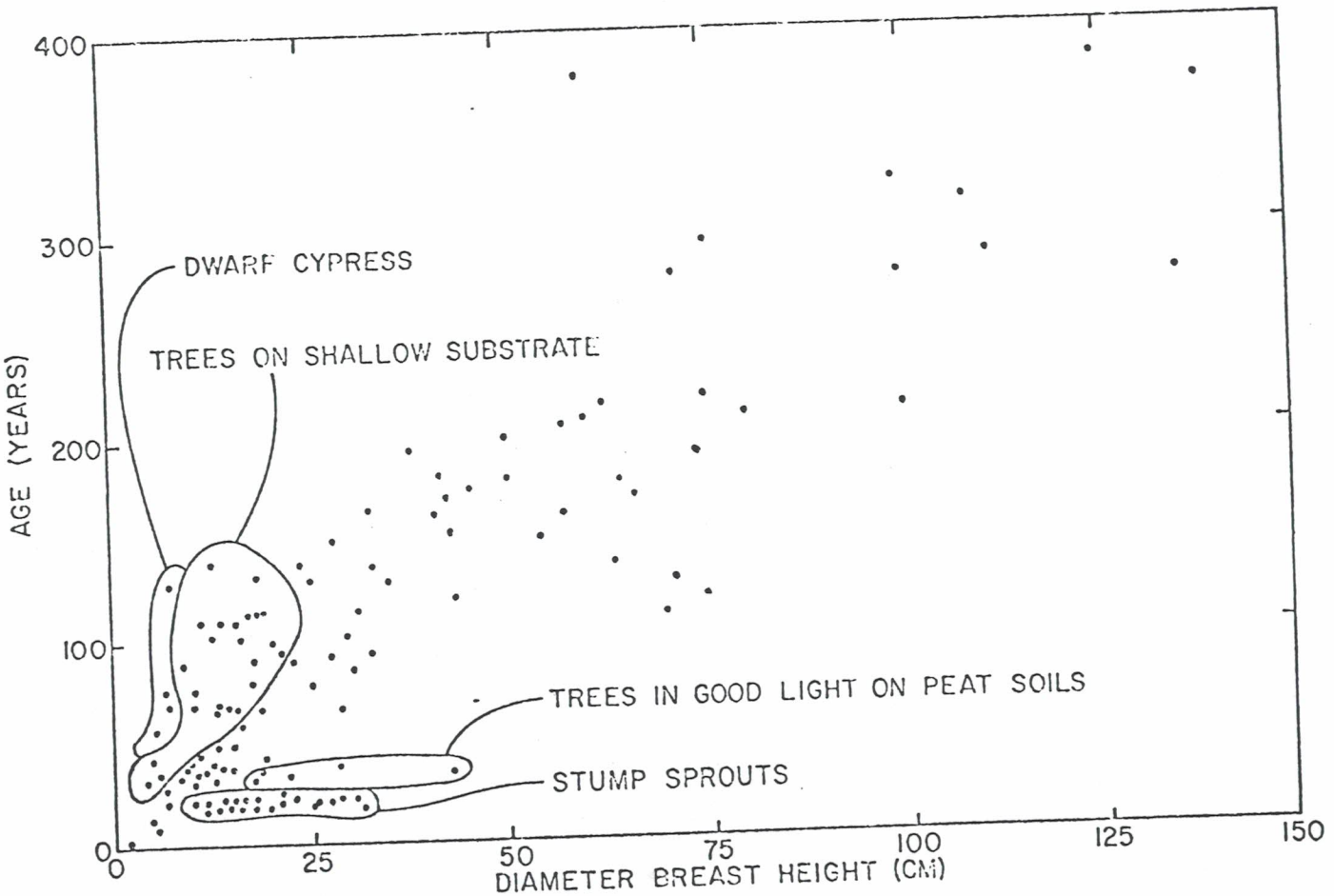


Fig. 9. Correlation between cypress age and DBH.

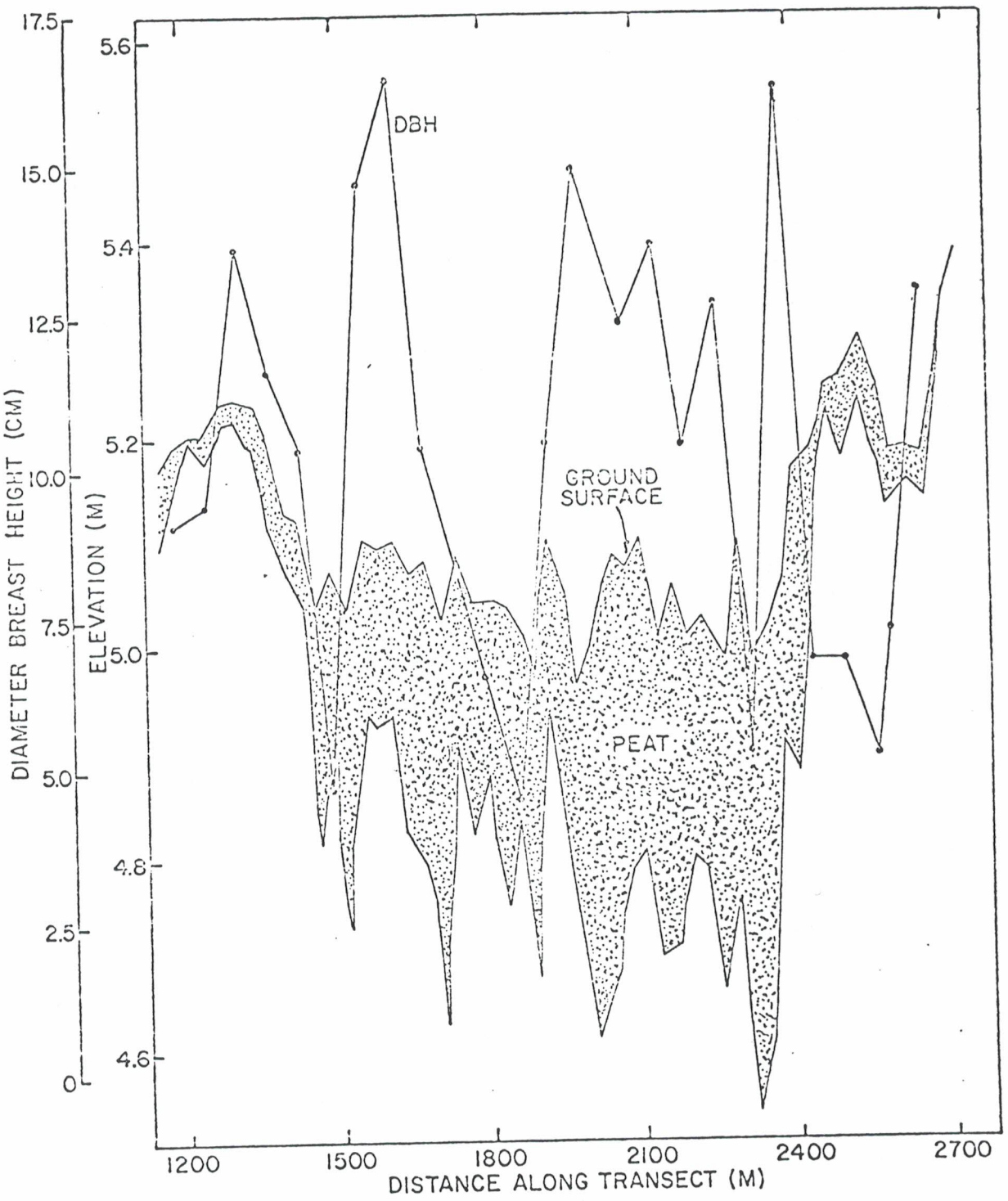


Fig. 10. Cypress DBH and peat depth in Gordon Swamp.

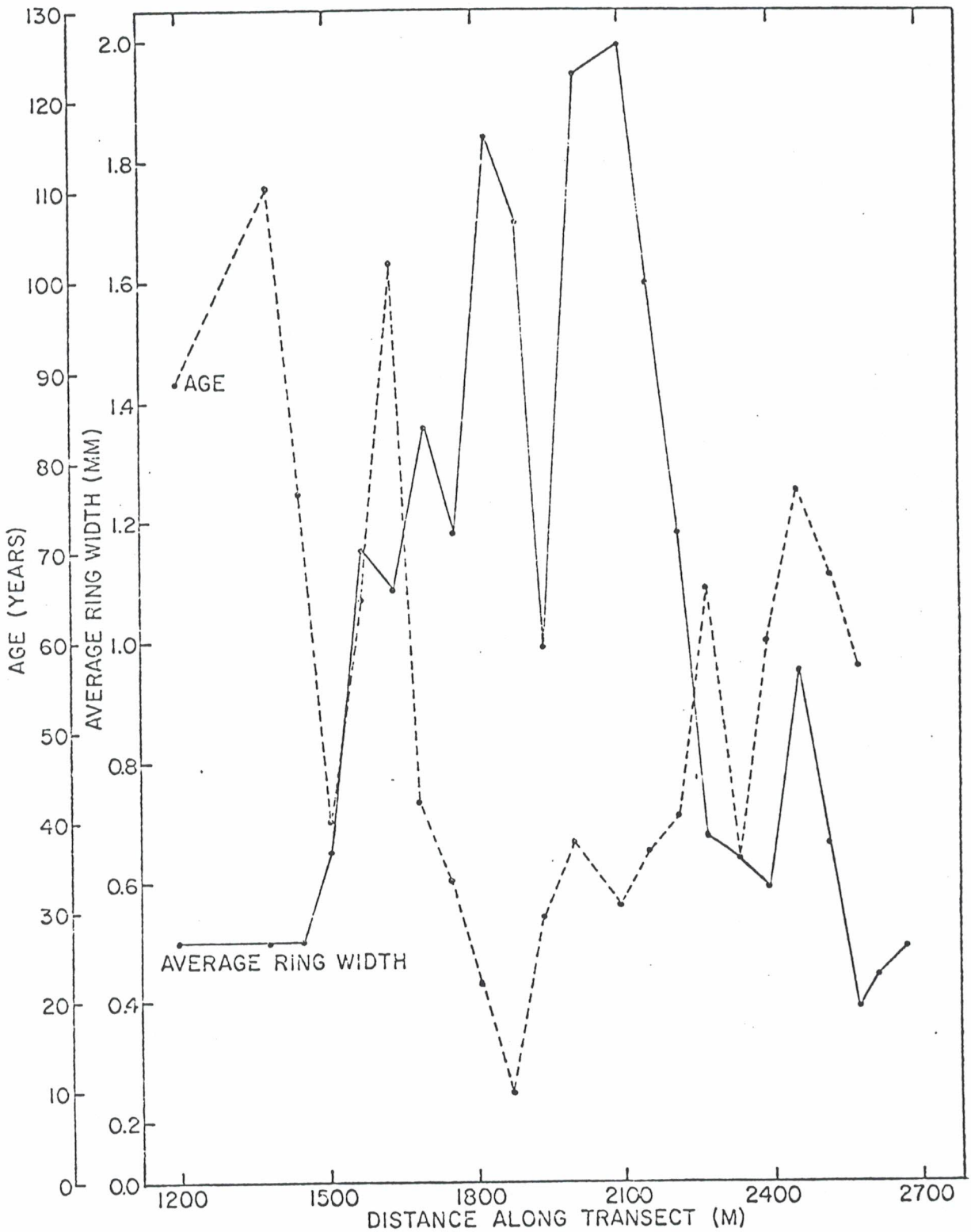


Fig. 11. Cypress age and growth in Gordon Swamp.

out and is regenerating. Apparently, during a severe drought when the water table was below the shallow peat deposits, fire entered Gordon Swamp. Since the trees at the edges were rooted in mineral soil, they were singed, but survived. In the strand interior, however, a slower-moving peat fire consumed soil and roots, killing the cypress. In time, cypress trees became reestablished in the center of the strand, and, since they were on a higher quality site, rapidly grew to sizes comparable to those of the older peripheral trees.

Since the fire histories of cypress swamps are quite varied, these processes can be expected to result in considerable site-to-site differences in forest size and age structure. Even so, in both strands and domes, the fastest maximum early growth rates should be found where peats are deepest.

In order to confirm that cypress trees at Corkscrew do indeed lay down annual growth rings, we counted tree-rings from cores of known age trees. One set of these cores came from stump sprouts of trees logged in the early 1950's in the vicinity of the South Dike, which impounded water flowing out of Corkscrew Swamp from 1967 to 1975. In the course of analyzing these samples, we noticed a dramatic difference in pre- and post-impoundment growth rates both above and below the dike (Fig. 12).

In addition to the expected general decline in growth rates with age, there were several abrupt growth changes which correlate closely with hydrologic conditions. Immediately after construction of the dike in 1967 there was a striking decrease in cypress growth rates. In 1968, when dike maintenance problems returned water levels and hydroperiods to pre-dike levels, growth improved, but was still not quite up to earlier rates. After dike repairs in 1969, the trees grew even more slowly.

Sanctuary hydrologic records reveal that abnormally high water levels and long hydroperiods prevailed above the dike from 1967 through 1973 (except for 1968). Dike seepage caused unusually long hydroperiods but not particularly

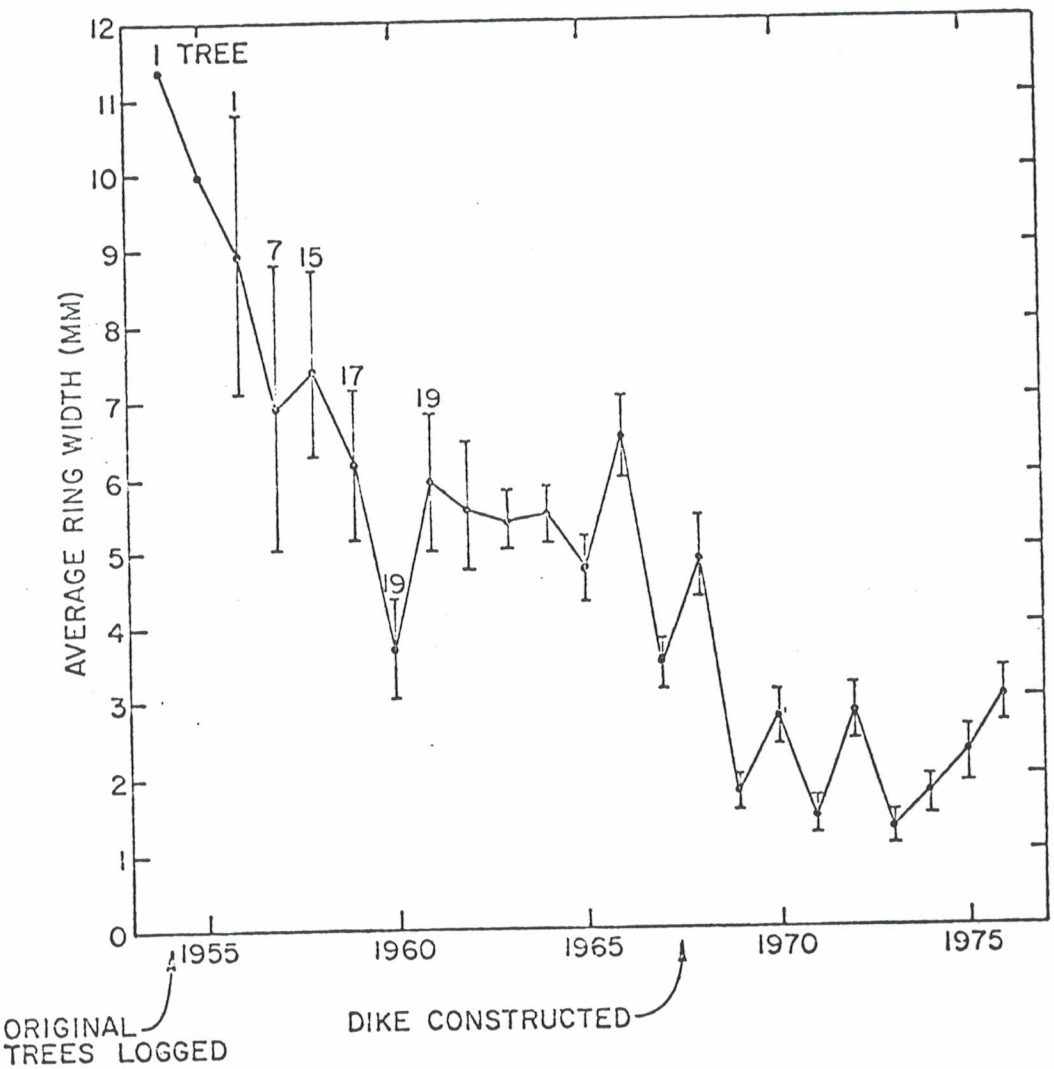


Fig. 12. Cypress stump sprout growth along the South Dike (trees both above and below dike).

high water levels below the dike. Since equally poor cypress growth was observed both above and below, it appears that hydroperiod was the responsible factor. Further evidence of this is that in 1960, the only year out of 7 years of record when natural hydrologic conditions resulted in year-round surface water, cypress growth was also extremely poor. Thus, it seems that even one year of continuous inundation can be enough to drastically slow cypress growth.

Although the trees immediately resumed rapid growth following a single year's flooding in 1960, recovery after lengthier inundation apparently takes much longer. The 1974 and 1975 droughts and opening of the dike culverts in 1976 permitted water levels to recede below ground each spring, but cypress growth rates remained below normal.

Cypress Leaf-Out Sequences

During aerial surveys conducted in the course of our research at Corkscrew Swamp Sanctuary, we noticed that all parts of a cypress strand do not put out spring foliage at the same time. At Corkscrew the trees leaf out in a three-stage sequence: first the intermediate trees, then the large ones towards the interior of the strand, and last the small trees along the strand's outer edges. At Sixmile Cypress, a strand east of Fort Myers, leaf-out begins at the center of the strand and progresses towards the edge in two phases.

Since timing of leaf-out affects both the functional growing season for cypress and light availability to understory vegetation, it has implications to strand productivity. Therefore, we decided to attempt to document and interpret this phenomenon.

Darcy Knoble, a seasonal naturalist at the sanctuary, volunteered to monitor leaf-out along three transects extending across the Corkscrew strand from the outer edge of the cypress forest to the interior Central Marsh. Two

of these transects followed the boardwalk which loops through the strand near sanctuary headquarters. The Central Marsh Transect, where we have done intensive studies of soils, hydrology, and vegetation, served as a third transect until surveys there had to be discontinued because understory foliage blocked the observer's view of the cypress canopy. The raised boardwalk permitted a better view of the trees along the other two transects. The Central Marsh Transect survey was conducted on March 7, 1977. The other two transects were surveyed every 4-10 days from February 26 to March 26.

We used a densiometer to measure percent canopy cover along the Central Marsh Transect and every 15 m along the boardwalk transects. Peat depths were probed at the same intervals. Along the Central Marsh Transect elevations were surveyed every 7.6 m. Water depth was measured every 15 m along the boardwalk and ground surface elevations were calculated from water levels.

The north boardwalk transect most clearly illustrates the three-stage leaf-out pattern (Fig. 13). On February 26 some foliage was appearing on trees beyond 75 m into the strand, and canopy cover was greatest from about 90 to 135 m from the strand edge. This pattern continued through March 12. Leaf-out was well advanced by March 22. Canopy cover measurements along the south boardwalk transect reflected a sporadic leaf-out pattern throughout the study period. The March 7 Central Marsh Transect survey showed a distinct canopy cover maximum between 90 and 150 m into the strand.

Peat depth, tree diameter (DBH), and tree age increase from the strand's outer edge towards the interior, and ground elevation and tree density decrease.

Peat depth, which ranged from zero at the edge to 2 m in the center, was about 30 cm in the early leaf-out area. The trees averaged approximately 100 years old and 25-30 cm in diameter and were slightly shorter than the mature 30-35 m cypress in the strand interior. Cypress density was between 1000 and 2000 stems per hectare.

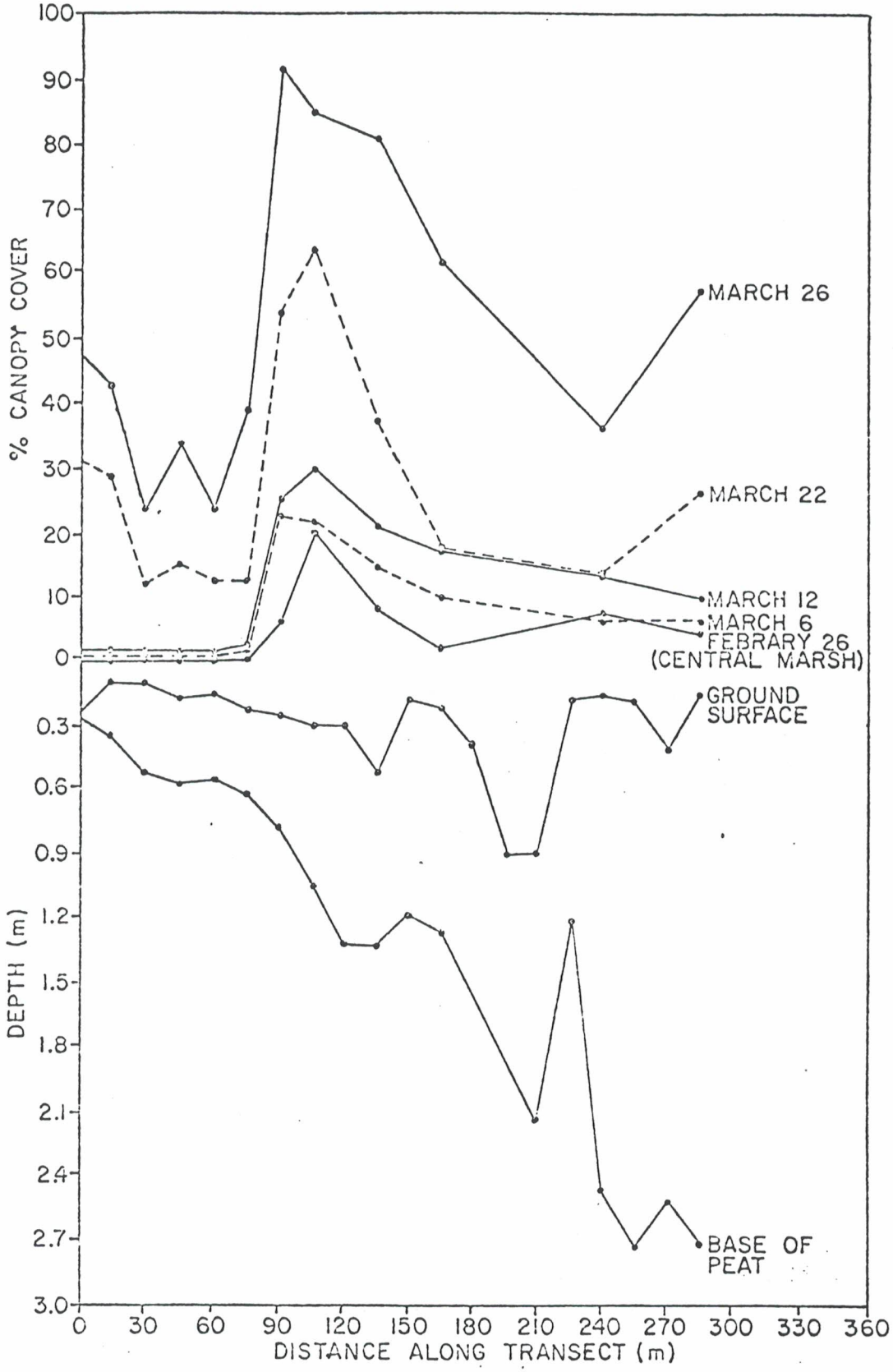


Fig. 13. Canopy cover, and peat depth, North Boardwalk Transect.

The two-stage leaf-out pattern at Sixmile could easily be attributed to a number of factors, since peats are deepest, water levels highest, and trees oldest in strand interiors. The center trees also have "bald" cypress characteristics whereas the exterior trees are "pond" cypress. Corkscrew's three-stage sequence is not so easy to explain. However, Corkscrew is a larger and probably, in successional terms, older strand, which suggests that the three-stage pattern might be related to long-term strand processes.

There are four possible explanations for this sequence. The simple explanation that the trees growing under optimum conditions leaf out first is unsatisfactory. Tree-ring studies along the Central Marsh Transect reveal that the fastest cypress growth rates occur on deep peat sites in the strand interior. Another possible interpretation involves hydrologic patterns caused by the shell stratum shallowly underlying the band of trees which puts on foliage first. However, the boundaries of the shell beds do not correspond closely with those of the early leaf-out area. Furthermore, since there was surface water at the time of our survey, water flows associated with the porous shell layer were probably not a factor. In fact, the leaf-out sequence does not appear to be related to water availability at all; we observed the same leaf-out pattern under drought conditions in 1975 and 1976. Taxonomic differences might be the basis for a third hypothesis, but this would suggest either three separate forms of cypress or hybridization (hybrid vigor). Although there is disagreement as to whether "pond" and "bald" cypress are one or two species, no third form has been proposed. Hybridization could not account for Sixmile's two-stage leaf-out sequence. Perhaps our best hypothesis is that the first trees to leaf out are the immature trees growing on the most nearly optimum sites. The several-hundred-year-old trees in the center may be senescent and unable to respond vigorously to the excellent growing conditions of the strand interior. And, the trees in the strand

periphery, although still in the rapid growth phase seen in cypress under about 90 years old, are limited by a marginal site.

Future Research

In addition to assisting with design of monitoring programs needed to keep track of sanctuary hydrologic conditions and evaluate the effects of various management procedures, we plan the following future research activities at Corkscrew:

1) Continuation of overstory productivity studies to assess long-term patterns of tree and shrub growth and mortality.

2) Continuation of cypress regeneration studies.

3) A comparison of the effects of control-burning at different times of year. Natural fires in South Florida are set by lightning during the summer rainy season and we feel that the usual practices of winter control-burning may be changing plant communities. We plan to conduct this study in conjuction with the sanctuary's fire management program.

4) An evapotranspiration study intended to provide data on comparative water losses in different habitats. This information is vitally needed for water management planning in South Florida, but the techniques we are devlopping will have application anywhere that water use by different plant communities is of interest. The habitat variety and site security at Corkscrew make it an ideal place to do the research.

RESOURCE INVENTORY AND ANALYSIS: BIG CYPRESS NATIONAL PRESERVE

Funded by the National Park Service through a contract to and subcontract from the University of Florida Center for Wetlands.

NAS staff: Mike Duever (Co-Principal Investigator), Ed Carlson, Linda Duever, CFW staff: Dan Spangler (Principal Investigator), Lance Gunderson, Jack Meeder.

This project, which began in July, 1977, is a one-year baseline planning study intended to assemble available information on the Big Cypress National Preserve and develop recommendations for management and research. Management themes to be considered include geology; soils; hydrology; vegetation; fire; exotic species; rare and endangered plants and animals; hunting; grazing; farming; logging; oil, gas, and minerals; and land use (including structures, roads, human use patterns, and Indians). In addition to assembling, summarizing, and assessing published data, we are interviewing appropriate individuals and agency representatives with expertise on the Big Cypress region and conducting a limited field reconnaissance program to test the adequacy a and accuracy of the previously compiled information and to provide data on areas or topics about which little is presently known. The assembled information will form the input to an objective evaluation methodology which will identify appropriate management alternatives and necessary future research.

During the last two months of field work we will conduct detailed examinations of sites affected by major theme activities (fire, exotics, grazing, oil extraction).

By the end of the seventh month we will have assembled information on man's activities and impacts on localized BCNP environments. During the eighth and ninth months we will combine this data with information derived from detailed examination of aerial photos, spot checks from the air and on the ground, and interviews with individuals familiar with the region in order to fill information gaps and discern environmental and human use patterns throughout the BCNP area.

Recommendations for future management and research will be developed during the 10th and 11th months by integration of all available data through an appropriately modified version of the methodology described previously.

This step will undoubtedly reveal small pieces of missing information that we can find with relatively little additional work. It will also identify larger unknowns that need to be examined in future studies.

The final month will be used to complete analyses, theme reports and management recommendations and produce the final report.

ECOSYSTEM ANALYSIS OF OKEFENOKEE SWAMP: TREE-RING AND HYDROPERIOD STUDIES

Funded by the National Science Foundation through a subcontract from the University of Georgia Institute of Ecology.

NAS staff: Mike Duever (Principle Investigator), Larry Riopelle, Linda Duever.

This new series of studies, begun in April, 1977, is designed to gather data on successional processes and microhydrology-vegetation relationships to test the generality of swamp ecology and management theories developed through our previous research. It is part of a larger program intended to advance ecosystem modeling theory and improve computer techniques for analyzing complex natural systems.

Tree-Ring Analysis Potential

Cypert's unpublished list of Okefenokee plants describes 35 woody plants as common in swamp and swamp edge habitats. We have not yet attempted to work with the five vines or six small shrubs, and have not encountered the red chokeberry (Pyrus arbutifolia), but we have examined tree-rings of all the other woody speices. We did not differentiate the hollies Ilex myrtifolia and Ilex cassine or the blueberries Vaccinium arkansanum and Vaccinium ashei. We did sample three shrubs Cypert did not regard as common in the swamp: willow (Salix sp.), alder (Alnus serrulatea), and azalea (Rhododendron sp.).

We cut about six slabs (generally less than 15 cm in diameter) of each species, polished them with 400 grit sandpaper, then studied the rings

through a binocular microscope. As we aged each slab, we noted the clarity of the growth rings and classified the ring quality as poor (33), usable (67), or good (100). We averaged the ring quality "grades" for all slabs of a species to get the ring quality index numbers in Table 1.

After we had become familiar with the ring patterns on the slabs, we collected cores from larger trees and polished and evaluated them. Since older trees are more difficult to age and cores are less informative than slabs, we used a four-point scale for rating the cores: very poor (25), poor (50), usable (75), good (100).

We found that pine, cypress, titi, buttonbush, red bay, willow, ash, and alder have easily distinguished useful-looking growth rings. Gordonia, myrtle, sweet bay, maple, Leucothoe, azalea, Lyonia ligustrina, and the four Ilex species have useful but subtle rings. The Nyssa species, Itea, and blueberry have poor quality rings of questionable utility, although our attempted ring counts for these species did give us age estimates which seem reasonable in view of site histories and forest age structures. Although blackgum is in this doubtful category, we are still trying to improve our techniques for aging it because data on such a large and widely abundant tree would be extremely valuable.

Since some trees are known to lay down growth rings at other-than-yearly intervals, before attempting to age trees it is necessary to confirm that the species in question does indeed produce annual rings. With this in mind, we have gone through the refuge files and made notes of all environmental events we would expect to have had a marked effect on tree growth. Below are comparisons of ring count tree ages and known site histories at a variety of documented sites.

TABLE 1

Ring quality indexes, ages, and diameters of Okefenokee trees and shrubs.

Species	Ring Quality Index* Slabs	Cores	Age of ** Oldest Tree	DBH of *** Largest Tree (cm)	Sample Size
slash pine (Pinus elliottii)	98	100	70	53	9
cypress (Taxodium distichum)	97	90	381	74	65
titi (Cyrilla racemiflora)	90	93	65	25	17
buttonbush (Cephalanthus occidentalis)	97	80	22	18	14
red bay (Persea borbonia)	94	77	78	43	13
big gallberry (Ilex coriacea)	95	-	14	11	7
gallberry (Ilex glabra)	86	-	10	5	7
holly (Ilex sp.)	98	61	96	39	19
Lyonia ligustrina	89	69	24	7	7
Gordonia lasianthus	81	66	90	55	15
wax myrtle (Myrica cerifera)	82	63	28	26	8
sweet bay (Magnolia virginiana)	83	54	114	60	21
red maple (Acer rubrum)	82	53	108	42	8
Leucothoe racemosa	50	72	15	7	15
Lyonia lucida	56	56	27	10	14
Clethra alnifolia	100	58	29	6	9

TABLE 1 (cont.)

blueberry (*Vaccinium* sp.)	25	39	25	9	13
blackgum (*Nyssa sylvatica*)				57	11
Ogeechee gum (*Nyssa ogeche*)			22	29	6
Itea virginica			13	6	6
willow (*Salix* sp.)	100	-	8	22	6
water ash (*Fraxinus caroliniana*)	100	-	13		2
azalea (*Rhododendron* sp.)	69	-	32		2
alder (*Alnus serrulata*)	100	-	5	7	4

*See text for definition.

**Oldest tree with reliable ring quality counted to date.

***Diameter breast height of largest tree sampled - ring counts not necessarily complete.

Above the Sill

The berm above the Suwannee River Sill was constructed 17-19 years ago and the tree ages there seem to confirm that a major event affected the forest approximately 20 years ago. Two sweet bays aged at 97 and 111 years were undoubtedly there before the berm was constructed. In our work at Corkscrew Swamp we have found it possible to age cypress only within about five percent of actual age, so the ring count age of 20 we found for a cypress on this site is not really a variance with the site's history. All the other trees sampled were younger than the berm itself: Lyonia lucida - 19; blackgum, maple, and holly - 18; red bay - 15; Clethra - 14; myrtle and Itea - 13; Lyonia ligustrina - 12; another sweet bay - 11; and buttonbush - 8.

Along the upper edge of the berm we found three more older trees: a sweet bay (114), a maple (108), and a holly (70). These may have come in after the severe fires of 117 and 67 years ago. On this site we also found several younger trees: a Lyonia lucida (27) and two azaleas (24 and 32). These could have been growing there before the berm was built and survived having dirt piled over their root systems.

The oldest trees we sampled in the swamp above the Sill were six cypress ages 132 to 381. In the 29 to 31 year range were a blackgum and two cypress, and in the 19 to 23 year range (which could represent regrowth after the 1954-55 drought and fire) were three Ogeechee gum, two buttonbush, a titi, one sweet bay, and one cypress. Six of the trees sampled (three cypress, one blackgum, and two Ogeechee gum) apparently began growth 13-17 years ago, during or immediately after construction of the Sill. The three cypress were from a large stand of even-sized and vigorous-looking young trees.

Below the Sill

On the Sill we found three maples ages 14 to 16 and three willows ages

5 to 8. This indicates a minimum age of 16 years for a site we know to have been constructed 17-19 years ago.

A 28 year old myrtle sampled at the edge of the Sill was probably there prior to construction.

In the swamp below the Sill, the oldest trees were six cypress ages 138 to 314. The other species on this site were all in the range of 16 to 20 years old, which suggests that they have come in in response to Sill influences. These trees included three sweet bay, two buttonbush, two holly, one red bay, and one blueberry.

Suwannee River

We took a number of samples along the Suwannee River, but the sites and the ages of the trees were both so scattered that we do not feel we can draw any meaningful conclusions about the age structure of the forest at this point.

Minnie's Lake

We have not yet been able to obtain precise logging records for the Minnie's Lake area, but we do know that timber operations were in progress from 51 to 68 years ago. Two sprouts from a cut cypress stump in the logged area above Minnie's Lake were aged at 56 and 58 years. A nearby hollow cypress was over 217 years old.

In an apparently unlogged area along Minnie's Lake we cored two cypress which were 153 and 276 years old. Two Gordonia, two holly, one sweet bay, and one red bay were between 56 and 96 years old. There is no clear correlation between tree ages and known environmental events at this site, so the entrance of hardwoods is probably just a manifestation of a gradual successional process.

Blackgum Swamp (Cornbox area)

Refuge records are unclear as to whether logging of this area took place in the late 1890s (77-82 years ago) after construction of the Suwannee Canal (83-87 years ago) or during the major Okefenokee logging operations 51-68 years ago.

The oldest trees we found were cypress growing on or along the Suwannee Canal berm. One of these was 150 years old and the rest were between 204 and 264. Most of the other trees in the area were in the 29 to 81 year age range. Our oldest specimens of pine, red bay, holly, and sweet bay apparently began growth during the 1890s logging period. Ten of the trees we sampled fell into this 69 to 81 year old category. Seven of our specimens came in 50-61 years ago, during the major logging operations. Among these was the site's oldest Gordonia. The eighteen 29 to 43 year old trees could represent regeneration after the 1932 fire. The oldest titi was in this group. We sampled 15 shrubs of four species and found that they ranged in age from 5 to 26 years. These included five Clethra, four Lyonia lucida, three blueberry, and a myrtle.

Suwannee Canal (near Camp Cornelia)

We found one 344 year old cypress on the Suwannee Canal berm. Otherwise, the oldest trees on the berm were a 67 year old cypress, a 59 year old titi, a 54 year old pine, and a 41 year old red bay. This age structure suggests the either logging during the intensive timber operations 51-68 years ago or the 1910 fire eliminated whatever forest had developed on the berm since its construction in the early 1890s.

Twenty-eight of our specimens had become established since the 1954-55 fire: six Leucothoe, five cypress, three Itea, two titi, two gallberry, two maple, two Lyonia lucida, one Clethra, one blueberry, one buttonbush, one red bay, one Gordonia, and one myrtle.

Except for one 237-plus year old cypress, all the trees we sampled in the swamp behind the berm were between 17 and 52 years old. These trees (six pine, two Gordonia, and a Clethra) apparently came in after the 1932 fire.

Pinewoods (around Camp Cornelia Boat Landing)

This site is a pine plantation. We have not yet ascertained the exact year it was planted, but it was probably after the severe fire that burned this area in 1954-55. We found one 28 year old myrtle the fire might have missed, but all the other shrubs (myrtle, holly, sweet bay, Lyonia ligustrina, and big gallberry) were between 10 and 17 years old.

Thus, tree-ring ages of Okefenokee woody plants are within the ranges expected in view of documented environmental events. Apparent effects of logging operations, Sill construction, and the 1932 and 1954-55 fires can be seen in forest age structures. The Sill and Cornbox sites also appear to have been affected by an undetermined environmental perturbation (perhaps the hurricane of 1944, 1949, or 1950 or the floods of 1945) which took place about 30 years ago.

To ascertain how far back in time we could get growth information from living trees, we aged the largest easily accessible trees of each species. The oldest one was a 381 year old cypress. This was not the largest cypress we encountered, but it was the largest we could sample with the 16-inch tree corer we had with us at the time. Other trees had higher ring counts, but they were specimens with many questionable rings. We found 65 to 114 year old individuals of seven of the thirteen swamp species with promising ring quality (Table 1). The other six useful species are all shrubs with stems generally under 30 years old.

Battery Succession

Since one of our primary objectives was to evaluate techniques for aging

"batteries" (floating islands of peat) and "tree houses" (isolated stands of swamp forest), we selected three small examples in Chesser Prairie just west of the junction of the Grand Prairie and Cooter Lake boat trails for preliminary analysis. Peat depths (rod penetration measurements) in the area vary from 2.5 to 3 m. The numerous wood fragments in the peat suggest that the site was once forested.

The youngest battery (#2) was a 3-4 m wide band along the boat trail. It supported primarily herbaceous vegetation, grasses, and sedges. There was one large buttonbush (1.5 m) and several buttonbush shoots (1 m), a few scattered young cypress (1 m) and a titi (.5 m). The four buttonbush sampled were three to ten years old, the two cypress were nine and eleven, and the titi was seven. This battery developed at least eleven years ago, probably in response to activity along the boat trail.

The other two batteries were larger (about 15 m in diameter) and older and had a greater variety of vegetation. There were a few fire-scarred, stressed cypress less than 27 cm DBH and less than 10 m high. These trees had narrow, poor quality growth rings which indicated that they were between 200 and 450 years old. The other woody plants were less than 24 years old and apparently came in after the 1954-55 fires which severely burned Chesser Prairie. The shrubs formed a canopy 3-5 m high, beneath which there was little understory and only a sprinkling of cypress knees.

Two older cypress and a Leucothoe on battery #1 were growing on peat mounds approximately .3 m above the general terrain, which suggests that this amount of peat has been lost from the surrounding area sometime in the past few hundred years. On this battery were also two cypress ages 23 and 24, three titi ages 20-23, and a 22 year old buttonbush. The three largest sweet bays were between 15 and 19, the oldest holly was 15, the oldest Leucothoe 13, and the oldest blueberry 10. Lyonia lucida and gallberry less than .5 m tall

were present, but not sampled.

There appeared to be four age classes of cypress on battery #3. One large tree was approximately 451 years old. There were four trees ages 21 to 22, three ages 16 to 18, and one age nine. We could see no clear relationship between diameter and age. The first shrub to have become established on this site was buttonbush; the oldest of three sampled was age 22. The oldest of three titi was 21, the oldest of two sweet bay 17, the oldest of three Leucothoe eleven, and the oldest of two holly nine. Three Lyonia lucida were between five and six years old.

The rapid appearance of young cypress, buttonbush, and titi after the 1954-55 fire suggests that these originated as root sprouts from burned trees. Regeneration of the other species could have been accelerated by the presence of the large cypress to serve as perches for seed-carrying birds. The dense thicket of root sprouts would also have provided shelter to attract animal seed dispersal agents. Thus succession has probably progressed more rapidly on these sites than it normally would on a newly arisen battery.

Hydroperiod Analysis

We found that hydroperiod was the fundamental factor determining distribution of major plant communities at Corkscrew Swamp Sancutary. Duration of inundation appears to exert direct control by eliminating those species intolerant of extended flooding and indirect control by influencing frequency of severe fires. Within major habitat types, degree of structural development and/or species composition is affected by other modifying factors, such as depth of organic soil, type of mineral substrate, proximity to seed sources, nutrient availability, and history of disturbance.

The significance of fire to the distribution of Okefenokee plant communities has been well documented. However, the relationship of hydroperiod to

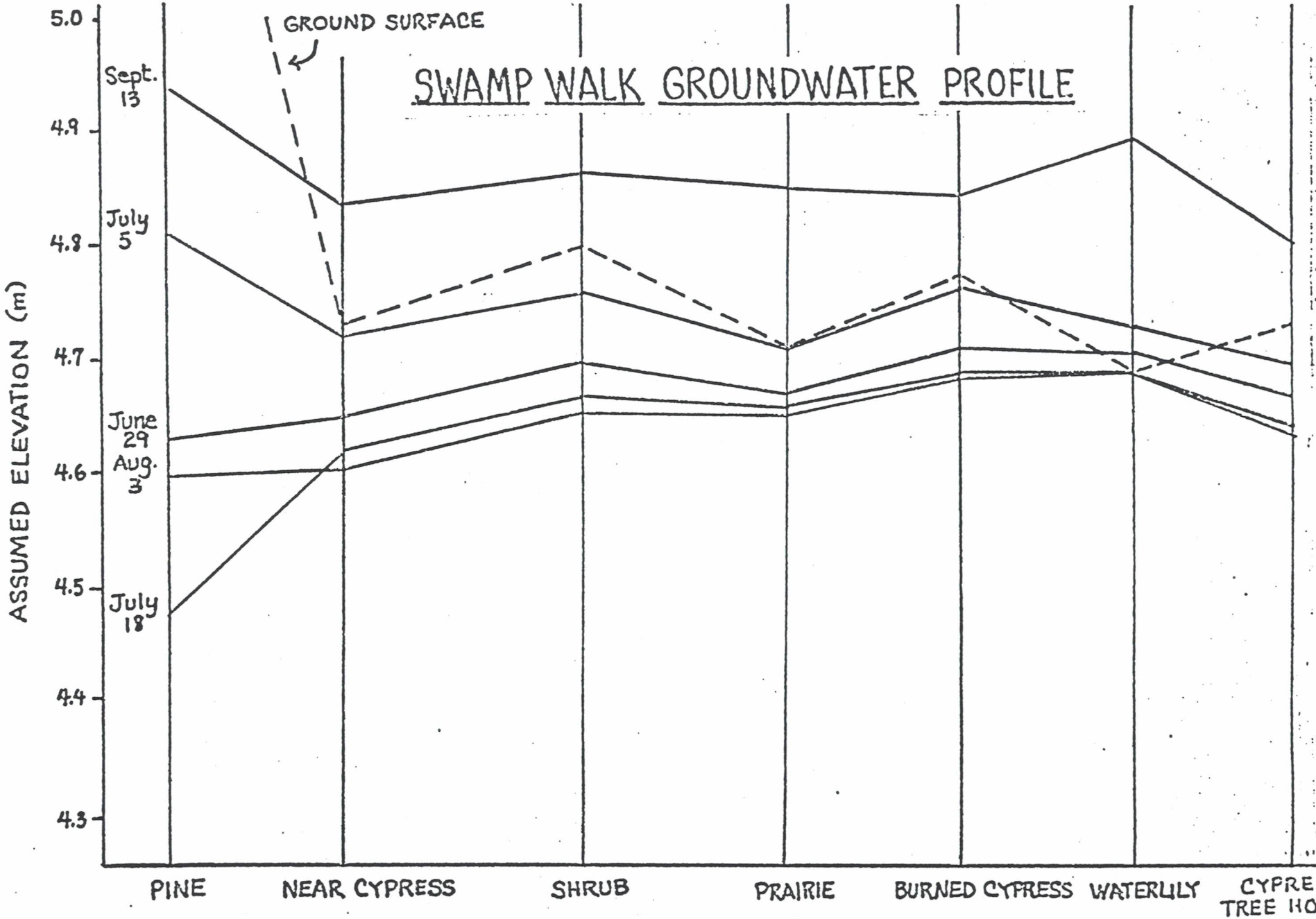
major Okefenokee community types is unknown. Possibly there are more subtle hydroperiod contrasts differentiating habitats in the Okefenokee because water levels fluctutate less there than at Corkscrew. However, preliminary data from the wells along the Swamp Walk Transect at Camp Cornelia suggest that the basic pattern of hydroperiod - habitat relationships prevailing in the Okefenokee is similar to that found at Corkscrew Swamp.

A thorough understanding of hydroperiod - vegetation relationships is essential to proper management of the Okefenokee. The long-controversial Suwannee River Sill, a low earthen dam which backs water up into the swamp is undoubtedly affecting hydroperiods and its long-term effects on successional processes is unknown. Ages of trees below the Sill indicate a change in forest composition after installation of the dam and some trees as far as ten miles upstream show evidence of dramatic growth rate changes at the time of Sill construction. Fire frequency is almost certainly also affected.

In June we installed seven groundwater monitoring wells in a variety of habitats along the Swamp Walk boardwalk at Camp Cornelia. The wells are 3.3 cm galvanized steel pipes driven to depths of less than 5m and set firmly in the subpeat soils. Five of the wells were fitted with sand points and two were left open-ended. All were pumped out to remove debris and assure good water exchange with the groundwater table. The wells are monitored at least once a month and checked weekly when possible.

We have surveyed ground elevations at 10 m intervals along the transect and tied them into well elevations to produce groundwater profiles (Figure 1).

We did rod penetration peat depth measurements at 10 m intervals along the first 400 m of the boardwalk and at 20 m intervals along the last 600 m. There was no clear correlation between peat depth and habitat type, but the distribution of woody material (which probably includes both living roots and above and below ground portions of dead trees) was closely associated with


SWAMP WALK GROUNDWATER PROFILE
GROUND SURFACE
ASSUMED ELEVATION (m)
5.0
4.9
4.8
4.7
4.6
4.5
4.4
4.3
Sept. 13
July 5
June 29
Aug. 3
July 18
PINE
NEAR CYPRESS
SHRUB
PRAIRIE
BURNED CYPRESS
WATERLILY
CYPRE
TREE HO

the cypress. This suggests that the present shrub, prairie, and waterlily sites have not supported cypress in the past several thousand years.

We characterized the habitats along the boardwalk transect according to dominant canopy species and/or gross structural form of the community. Averaging the elevations measured in each habitat segment of the transect, we found only a 12 cm difference between the average elevations of the different swamp habitats (Table 2). The pine uplands and adjacent transitional shrub habitats were considerably higher. When we ordered the habitats according to elevation, we found pine occupying the highest sites, waterlily dominating the lowest spots, and cypress growing on slightly higher sites than waterlily. Marsh habitats were distributed at both higher and lower elevations than cypress. We have not yet done a sufficiently detailed vegetation analysis to determine whether these marsh types are similar or are actually subtly different prairie communities. The shrub dominated habitats found at a variety of elevations may also actually represent several different communities, but are probably successional stages between marsh and forest.

Our water level measurements seem to follow patterns observed at Corkscrew Swamp. The lowest habitat, the waterlily prairie, was dry for only two months, but the other habitats were without surface water for considerably longer. The groundwater profile was fairly level within the swamp, but at times declined beneath the uplands, suggesting flows from the swamp to the uplands under drought conditions. The higher upland water table after heavy rains indicates flows into the swamp. Since it is generally believed that groundwater flows relatively unimportant to Okefenokee, this data suggesting that there may be some groundwater exchange with the uplands is particularly noteworthy. Such flows are quite significant in Corkscrew water budgets and should be carefully examined in the Okefenokee.

By correlating water level information from the habitats along the

TABLE 2

Average elevations of habitat segments of Swamp Walk transect.

Habitat	Assumed Elevation (cm) $\bar{X}$	S.E.
pine/shrub	230	4
shrub	190	3
pine/shrub/Gordonia	178	3
shrub/Gordonia	176	1
shrub/small cypress	176	6
prairie	175	3
prairie	174	2
burned cypress/shrub/young cypress/Gordonia	174	1
mixed shrub and prairie	174	2
shrub/Gordonia	174	2
big cypress/shrub	170	1
big cypress	169	2
prairie	167	2
waterlily	166	1

Swamp Walk transect with data from the Camp Cornelia staff gage, we should be able to determine hydroperiods of the various vegetation communities. Integrating this information with knowledge of successional processes and tree growth data derived from our other studies will permit us to predict the likely long-term effects of the Suwannee River Sill and suggest appropriate water management strategies for the Okefenokee.

Future Research

We plan to continue our 1977 investigations and examine other aspects of Okefenokee successional processes. Our tree-ring study program will be expanded to tree houses and forests throughout the swamp to evaluate the generality of the data obtained at our intensive study sites. Tree-ring analyses will also be used to define optimum site conditions for each major woody species and to date significant past changes in growth rate patterns. Since colonization capacity is an important aspect of succession, we intend to examine seed dispersal patterns and evaluate the stump regrowth potential of important species. We plan to gather three additional years of hydroperiod data to provide a better estimate of year-to-year variability and add new study sites in distant parts of the swamp to improve our understanding of geographical variations.

WASTEWATER FROM SANITARY LANDFILL IN THE BIG CYPRESS SWAMP

Funded through University of Florida Center for Wetlands.

NAS staff: Ed Carlson, Mike Duever. CFW staff: Eric Flershutz (Principal Investigator), Sandra Brown.

This study, begun in December, 1976, documents the impact of runoff from the Naples landfill on a dwarf cypress community.

All field work on the project is complete and the final report will be submitted in March, 1978.

Dwarf or scrub cypress is the most widespread cypress forest type in southwest Florida. These communities are dominated by small, widely scattered trees. Understory vegetation is sparse and there is a marl or rock substrate with little organic soil.

A recently constructed landfill operation in Collier County uses a dwarf cypress forest to absorb excess water. The water is used to leach domestic and commercial garbage in the pit, and is then pumped to a holding basin. This water is recycled to the landfill as needed for leaching, and when quantities exceed the capacity of the holding basin, the excess enters the adjacent dwarf cypress forest.

The existence of the landfill operation and its use of the adjacent dwarf cypress forest to absorb periodic releases of nutrient-enriched waters provides an opportunity for evaluation of the nutrient-filtering capacity of this widespread South Florida plant community. The forest's normally low nutrient condition indicates its potential for absorbing larger quantities of nutrients than more productive sites. Examination of this nutrient absorption potential could enhance understanding of the comparative nutrient-filtering abilities of more vs. less productive cypress.

We are measuring nutrient status (surface and groundwater, soil, and vegetation) and response of the plant community (vegetation structure, gross and net productivity, development of organic soil).

Some hydrological measurements are necessary to determine the influence of enriched waters on the dwarf cypress in terms of both nutrients and increased depth and period of inundation. Groundwater quality is now monitored by the United States Geological Survey. Under a contract with Collier County, coliforms are monitored by agencies from Collier County and Naples, and records of water entering the dwarf cypress from the holding basin are maintained by county personnel.

Intensive study plots are located on enriched and natural dwarf cypress areas on the landfill site. Within these plots we are monitoring: 1) seasonal species composition and structure of the plant community; 2) quarterly gross production (using gas metabolism techniques); 3) net production (using annual changes in biomass of overstory vegetation and seasonal harvest plots of the understory components); 4) litterfall; and 5) decomposition rates. These studies will permit definition of enrichment effects: Is the community type being modified? Is production going into structure or just more rapid cycling? Are soil conditions being improved?

TREE-RING STUDIES

Although NAS funds the basic organization and continuation of this program, most of thework has been paid for by the Rockefeller Foundation and the National Science Foundation. Additional support has (or may) come from Morton Salt Company and Johnson Engineering, Inc.

NAS staff: Mike Duever, Larry Riopelle, Linda Duever.

This is an ongoing series of studies which began with our cypress tree-ring analyses at Corkscrew in 1974. Objectives are 1) to assess the usefulness of tree-ring analysis in investigating environmental cycles, successional patterns, and long-term effects of human activities; and 2) to refine techniques for use of tree-ring analysis as an environmental information gathering tool.

If we are to manage ecosystems so as to maintain them in a natural state, we must be able to differentiate normal processes from aberrations due to man-caused disturbance. Distinguishing the two is often much more difficult than it seems, particularly in situations where natural variability and/or short-term cycles mask real differences. In such cases, and those in which changes took place before data collection began, natural fluctuations and

human impacts frequently cannot be separated if long-term records are unavailable.

A number of research techniques have proven useful for reconstructing environmental history on the scale of five-hundreds or thousands of years. Among these are fossil studies, radiocarbon dating, and palynological and petrological analyses of peat deposits. These methods, however, are useful only at sites with appropriate geological formations. Personal observations, photographs, and historical records can provide valuable information on what has taken place in some areas over the past century, but these data are rarely complete enough to be scientifically useful.

We feel that tree-ring analysis has great potential as a means of tracing the environmental changes of the past several hundred years. It can yield particularly valuable data because it measures an actual biological response, rather than simply another environmental parameter. Tree-ring analysis has the further advantage of detecting negative effects at the less-than-lethal stage, when they can often be reversed through proper management adjustments.

At Corkscrew (See Ecosystem Analyses at Corkscrew Swamp), we successfully correlated cypress growth ring increments with tree age, soil type, and light availability, and detected changes in ring width patterns due to fire and hydrologic modifications. As we study more species from more sites, we expect to find tree-ring patterns reflecting the influence of other ecological factors.

We have collected cores and slabs from trees at a number of other South Florida sites and are comparing growth patterns with those from Corkscrew. These sites include dwarf cypress communities (among them the forest receiving effluent from the Naples landfill), the severely drained GAC development area, and Everglades National Park.

We have also been asked to examine tree-rings from Sixmile Cypress near Fort Myers, Florida, to monitor the effects of a water management program

intended to restore pre-drainage hydrologic conditions.

Our tree-ring work at Okefenokee (See Ecosystem Analysis of Okefenokee Swamp: Tree-Ring and Hydroperiod Studies) is primarily disigned to 1) develop methods of using tree-ring analysis to assess successional patterns and rates; 2) trace both the geographical extent and the intensity of changes in tree growth due to impoundment by the Sill, a low dam which restricts the flow of water leaving the swamp; and 3) identify environmental factors controlling growth rates of the various tree species.

On Great Inagua, site of the Bahamas National Trust Flamingo Sanctuary we are doing a preliminary evaluation of tree-ring patterns to assess the feasibility of correlating tree growth and rainfall to reconstruct long-term weather records. Morton Salt Company is supporting our work because of the implications rainfall and evaporation trends have to salt production, but the information is also relevant to flamingo nesting success, mangrove survival, and many other ecological processes. Although many of the trees we have sampled produce confusing ring patterns in the constantly warm tropical climate, several species lay down distinct enough rings to be promising.

We now have over 100 species in our tree slab reference collection. Most of these are from wetland habitats, and the majority are from the southeastern U.S. The collection does, however, include a number of little-studied tropical species from Florida, the Bahamas, Mexico, Trinidad, and Jamaica. We have also examined slabs from Four Holes Swamp and have specimens in our reference collection from northern Wisconsin habitats comparable to those of the Hunt Hill and Dory's Bog sanctuaries. We have become aware of a number of wetland sites with well-documented environmental histories along the Mississippi River and we plan a June, 1978 field trip to that area to collect samples for tree-ring analysis.

One drawback to tree-ring work is that to be accurate it must be done by

skilled personnel. Unless the growth ring patterns are studied under a microscope by an observer familiar with wood anatomy and the peculiarities of the species involved, gross errors in ring counts are quite likely. And, meaningful differences in ring width patterns are difficult to detect without computer analysis utilizing specieal programs developed for the purpose.

Tree-ring analysis has been used for monitoring timber production for many years, and has recently been used to follow climatic patterns in the western United States, but we were among the first to apply these techniques to evaluation of successional patterns and environmental disturbances. Consequently, we have begun receiving numerous requests for information and have found ourselves spending more and more time teaching others how to do this sort of work. We are therefore preparing a booklet on potential uses of tree-ring analysis in environmental research and methods of collecting, preparing, and reading tree slabs and cores. This booklet, now in first draft form, will be published as a Center for Wetlands bulletin.

GEOGRAPHIC VALIDATION STUDIES

NAS funded.

NAS staff: Mike Duever, Larry Riopelle, Linda Duever, Ed Carlson.

These spot-check surveys of ecological parameters are intended to fill in gaps between our contract research projects and test the generality of theories developed through intensive studies at our major research sites. Since the need for testing concept validity at a variety of sites always exists, we expect studies of this sort to be a continuing part of our program.

Our geographic validation studies currently emphasize transects across wetland areas to generate data for comparison to that from Corkscrew and Okefenokee where we have found complex but predictable relationships between hydrologic characteristics, soil types, and plant communities.

For each study, we select a site where there are a variety of wetland and upland habitats in close proximity and lay out a transect crossing as many of these as practical. We then survey ground elevations, measure water levels, probe or core soils, and make notes on vegetation type and structure at regular intervals. If possible, we choose sites near water level recorders with available long-term records which can be used in conjunction with ground elevation data to calculate water levels and hydroperiods along the entire transect. On forested sites of particular interest, we often take a series of cores for tree-ring analysis.

We conducted our first major series of validation studies at Everglades National Park in November, 1977. We chose this area because, although the habitats are the same as those at Corkscrew, they are in radically different proportions. Our general impressions of soil, water, and plant relationships supported the ideas developed at Corkscrew, but tree-ring sample processing is not complete and we have yet to subject the data to rigorous analysis.

We plan to conduct a second series of validation studies along the Mississippi River in June, 1978. These surveys should indicate to what extent data from the non-river-associated wetlands we have been studying can be extrapolated to floodplain swamps.

MISCELLANEOUS ACTIVITIES

The rapidly increasing number of excavations in southwest Florida is of concern to conservationists who fear that such development methods may be aggravating already severe water shortages. Therefore, in May, 1977 the Collier County Board of Commissioners authorized a study committee to investigate the situation and make recommendations. Since our data on hydrologic patterns associated with topographic depressions at Corkscrew Swamp was the only relevant information available, we were asked to participate and Mike Duever was

appointed a member of the EXCAVATION ORDINANCE REVIEW COMMITTEE of the Collier County Water Management Advisory Board. We recommended and assisted in the design of a monitoring program to measure depth of the groundwater table along transects extending away from several excavations. This study is now underway and is expected to yield definitive data on net gains or losses of water due to pond construction. The next step, to be undertaken by the regional water management district (the Big Cypress Basin), will be to assess effects on water quality. Our measurements from natural habitats at Corkscrew will make excellent baseline data for comparison. After excavation impacts on water quantity and quality are determined, we will evaluate implications to wildlife, health and safety factors, and aesthetic considerations.

SIX-MILE CYPRESS is a Lee County nature preserve just east of Fort Myers, Florida. Its purchase was authorized last year in a conservation triumph: high school students campaigning to save the cypress strand proposed a referendum and persuaded the voters to approve a tax increase to pay for the land. However, the swamp has been affected by nearby canals and careful management of a series of dikes and weirs will be necessary to restore natural hydrologic conditions. Johnson Engineering, Inc., the company charged with this responsibility, asked us to recommend a month by month schedule of water levels for Six-Mile. We gave them average monthly water levels from Corkscrew and suggested that they base their initial program on those, monitor the results, and make adjustments as necessary. (Since hydroperiod is more important to cypress than water level per se, precise Corkscrew water levels are unlikely to be ideal for a strand with different topographic characteristics). We expect to be involved to some extent in future monitoring and interpretation of hydroperiods and cypress growth rates.

Last winter brought record low temperatures to South Florida. Many large and obviously quite old trees and shrubs were killed and it was immediately evident that the severe weather had had significant impact on plant communities. We therefore conducted a survey to document EFFECTS OF THE FREEZE on southwest Florida vegetation. This study is discussed in our 1977 report on Ecosystem Analyses at Corkscrew Swamp, Appendix 1. Unfortunately, there was no way to be certain that comparable data was gathered on other ecological parameters or in other parts of the region. To avoid such missed opportunities in the future, we are coordinating organization of a system whereby personnel from a variety of South Florida agencies and organizations will be prepared to monitor and analyze the effects of extraordinary events of major ecological significance (acronym: EXTREMES): FREEZES, HURRICANES, SEVERE DROUGHTS, etc.

At the 1977 meeting of the PALEOECOLOGY SECTION OF THE ECOLOGICAL SOCIETY OF AMERICA, Mike Duever was elected Vice-Chairman. Responsibilities of the office include organizing a field trip and chairing the paleoecology session at next year's ESA meeting.

Sandy Sprunt, Mike Duever, and Ariel Lugo (mangrove expert from the University of Florida Center for Wetlands) did a series of field studies to evaluate the impact of Morton Salt Company operations on the BAHAMAS NATIONAL TRUST FLAMINGO SANCTUARY on Great Inagua. We measured soil and surface water salinities, inspected mangroves, and examined hydrologic patterns, and concluded that mangrove dieback in the Upper Lakes area was the result of natural more-or-less cyclical processes rather than due to Morton activities. However, we determined that the flamingo nesting area was below sea level and would therefore not flush properly if Morton constructed a proposed dike-canal system on Trust lands.

Mike Duever has served as a member of two University of Florida GRADUATE STUDENT COMMITTEES this year. He supervised the thesis research done by botany student Lance H. Gunderson (thesis: "Regeneration of cypress, Taxodium distichum and Taxodium ascendens, in logged and burned cypress strands at Corkscrew Swamp Sanctuary, Florida") and environmental engineering student Eric Florshutz (thesis: "Sanitary Landfill in the Big Cypress Swamp").

Last May, Mike led a Corkscrew field trip for a graduate MARSH ECOLOGY CLASS from the University of Florida.

It is well known that when a plant community is destroyed, animal species dependent upon that habitat are also lost. However, we have been unable to find a reference summarizing just WHAT ANIMALS USE WHICH HABITATS in South Florida. Since such data would be invaluable in management planning for Corkscrew, the Big Cypress, and numerous other areas, we are compiling an index indicating significance of each of the region's habitats to each vertebrate species (except fish). We have completed a preliminary draft and sent it to vertebrate ecology authorities for review.

Research and Sanctuary Department representatives met last March and discussed RESEARCH ON SANCTUARIES. The consensus was that the ecosystem study at Corkscrew Swamp Sanctuary (See "Ecosystem Analyses at Corkscrew Swamp" under Research Projects) had worked out well for both departments and we should undertake more such projects in the future, with an ecosystem analysis of Four Holes Swamp being the first priority when finances permit. We developed a set of guidelines for research on sanctuaries which were approved by both departments.

We drew up a tentative outline for baseline studies at SILVER BLUFF PLANTATION and met with officials of the nearby Savannah River Ecology Laboratory

to discuss the possibility of a cooperative research program.

COWPENS KEY is much more productive bird habitat than apparently similar nearby islands, but we do not know why. We have been discussing this with mangrove ecologists and marine biologists and are exploring possible sources of research funds. An extra water level recorder was moved from Corkscrew to Cowpens to begin gathering hydrologic data.

RESEARCH PROPOSALS

ECOSYSTEM ANALYSES AT CORKSCREW SWAMP

Principal Investigator: Michael J. Duever, National Audubon Society.

See Research Projects for program description.

Submitted to the Rockefeller Foundation on January 1, 1977 through the University of Florida Center for Wetlands to be funded as part of joint National Science Foundation - Rockefeller Foundation grant entitled "Cypress Wetlands for Water Management, Recycling, and Conservation."

Budget: $11,028

Time Period: May 1, 1977 - April 30, 1979.

Status: Funded and underway.

ECOSYSTEM ANALYSIS OF OKEFENOKEE SWAMP: TREE-RING AND HYDROPERIOD STUDIES

Principal Investigator: Michael J. Duever, National Audubon Society.

See Research Projects section for program description.

Submitted to the University of Georgia on March 5, 1977 to be funded as a subcontract to National Science Foundation grant entitled "Integrated Studies of the Okefenokee Swamp Ecosystem."

Budget: $11,422

Timer Period: March 15, 1977 - May 14, 1978.

Status: Funded and underway.

A proposal to renew this subcontract was submitted to the University of Georgia on October 22, 1977.

Budget: $57,968

Time Period: July 1, 1978 - June 30, 1981.

Status: Under review.

RESOURCE INVENTORY AND ANALYSIS: BIG CYPRESS NATIONAL PRESERVE

Co-Principal Investigator: Michael J. Duever, National Audubon Society.

Principal Investigator: Daniel P. Spangler, Dept. of Geology, University of Florida.

See Research Projects section for program description.

Submitted to U.S. National Park Service on April 1, 1977 through Center for Wetlands, University of Florida.

Budget: $103,533 ($53,115 subcontracted to NAS)

Time Period: July 5, 1977 - May 31, 1978.

Status: Funded and underway.

The National Park Service plans to soon request research proposals for ecological studies in the Everglades and Big Cypress, and we expect to submit another proposal(s) at that time. Research topics scheduled for funding in 1978-1979 include exotic plants, fire ecology, hydrology, and off-road vehicle impacts.

FAHKAHATCHEE STRAND/GAC DEVELOPMENT AREA WATER RESOURCES PROJECT (Star 77-011)

Principal Investigator: Daniel P. Spangler, Dept. of Geology, University of Florida.

Field Director: Michael J. Duever, National Audubon Society.

The GAC area (Golden Gate) covers over 200 square miles of cypress swamp and pine flatwoods just south of Corkscrew Swamp Sanctuary in southwest Florida. In the 1960s the land was subdivided and a road system and an extensive canal

network were built with the intention of draining a 390 square mile area for residential development. Little of the land proved suitable for building, however, and drainage of the area has created severe ecological problems. The dry season water table is now several feet below normal and frequent severe fires are changing plant communities. The excessive amount of freshwater carried off by the canals is damaging the estuaries and limiting aquifer recharge to the point that nearby urban areas are experiencing serious water shortages. Local experts generally agree that something must be done and the county government has formed a committee to study the problem.

We propose to gather environmental data we feel is essential to sound redevelopment. Our program includes 1) examination of soils and shallow geology affecting groundwater flows, 2) evapotranspiration measurements, and 3) evaluation of the effects of canals on surface and groundwater levels, both within the GAC area and in the adjacent Fahkahatchee Strand, a state preserve.

Submitted to Florida Board of Regents by the University of Florida Center for Wetlands.

Budget: $49,953 ($33,130 subcontracted to NAS)

Time Period: October 1, 1977 - September 301, 1978.

Status: Not funded.

As opportunity arises, we plan to rewrite portions of this proposal and submit to other agencies.*

INTERIM GUIDELINES FOR HIGHWAY CONSTRUCTION THROUGH WETLANDS

Co-Principal Investigator: Ariel Lugo, Dept. of Botany, University of Florida.

Co-Principal Investigator: Michael J. Duever, National Audubon Society.

Co-Principal Investigator: Flora C. Wang, Center for Wetlands, University of Florida.

*Revised proposal submitted March 15, 1978 under review.

This project will produce a manual outlining environmental considerations pertinent to highway construction in wetland areas.

Submitted to U.S. Dept. of Transportation on August 16, 1977 by Center for Wetlands.

Budget: $76,349 ($4,544 subcontracted to NAS)

Time Period: One year.

Status: Under review.

ECOSYSTEM ANALYSIS OF THE USUMACINTA DELTA

Principal Investigator: Michael J. Duever, National Audubon Society.

Co-Principal Investigator: Alexander Sprunt, IV, National Audubon Society.

The Usumacinta Delta is an extensive marsh-mangrove wetland in southern Mexico. Little disturbed except by limited logging, grazing, and agriculture, it is still a healthy wilderness ecosystem with tremendous wading bird rookeries and populations of several endangered species. The estuaries, which are fed by Middle America's largest river, support a major shrimp fishery. However, a huge oil field has been found beneath the region and the eoclogical information necessary for developing this resource without damaging the system's productivity is not available.

We propose to do an ecosystem analysis of the Usumacinta Delta with emphasis on: 1) evaluating relevant existing information and identifying significant gaps in this knowledge; 2) conducting a field research program to gather data to fill these gaps; and 3) using this information to assess the implications of various "alternative futures" possible for the Usumacinta region.

We plan to examine geology, climate, hydrology, aquatic productivity, plant communities, animal communities, and human activities, then analyze the interactions of these ecosystem components and produce management recommendations.

Submitted to International Union for the Conservation of Nature and Natural Resources January, 1978.

Budget: $708,044

Time Period: July 1, 1978 - June 30, 1981.

Status: Under review.

We have made preliminary contacts about the following research projects, but have not yet reached the stage of preparing formal proposals.

Salt Pond Ecology on Great Inagua, Bahamas

Morton Salt Company is interested in having us study ecology of the evaporation ponds at their salt production facility on Great Inagua because ponds with darker waters dry up and produce salt most rapidly and they know little about the microorganisms responsible for the reddish color of the most profitable ponds. Such a study would have dual value since flamingos from the nearby Bahamas National Trust Flamingo Sanctuary feed on minute organisms in the salt ponds.

Tree-Rings, Climate, and Salt Production

Morton Salt is also concerned about long-term rainfall and evaporation trends on Great Inagua and at other solar salt operation sites. We are doing a preliminary evaluation of the feasibility of using tree-rings to trace climatic patterns on Great Inagua. If initial results look sufficiently promising we may submit a proposal for funding of further studies.

Water Management and Cypress Growth at Six-Mile Cypress

We have been advising Johnson Engineering, Inc. on proper water mangement for Six-Mile Cypress, a cypress strand near Fort Myers, Florida being purchased by Lee County as a nature preserve, and they are interested in having us monitor the effects of this program by examining cypress tree-ring patterns.

PUBLICATIONS

Carlson, J.E. and M.J. Duever. Seasonal fish population fluctuations in a south Florida swamp. Proc. 31st Ann. Conf. S.E. Assoc. Game and Fish Comm. In Press

Coultas, C.L. and M.J. Duever. Soils in cypress swamps. In H.T. Odum and K.C. Ewel (eds.) Cypress swamps (tentative title). Univ. Florida Press, Gainesville. In press.

Duever, L.C. Understanding the Corkscrew (tentative title). Audubon. In press.

Duever. M.J., J.E. Carlson, L.A. Riopelle, and L.C. Duever. Ecosystem analyses at Corkscrew Swamp. In H.T. Odum, K.C. Ewel, and M.K. Johnston (eds.) Cypress Wetlands for Water Management, Recycling, and Conservation. Center for Wetlands, Univ. of Florida, Gainesville. In press.

Duever, M.J., L.A. Riopelle, and L.C. Duever. 1977. Ecosystem analysis of Okefenokee Swamp: tree-ring and hydroperiod studies. Annual Report. National Audubon Society, Ecosystem Research Unit, Naples, Florida. 14p.

Gunderson, L.H. Regeneration of cypress, Taxodium distichum and Taxodium ascendens, in logged and burned cypress strands at Corkscrew Swamp Sanctuary, Florida. 1977. M.S. thesis. Univ. Florida, Gainesville. 88p.

PRESENTATIONS

Mike Duever:

Ecosystem analyses at Corkscrew Swamp and tree-ring and hydroperiod studies at Okefenokee. Presentation to National Science Foundation committee reviewing Integrated Studies of the Okefenokee Swamp Ecosystem grant. Institute of Ecology, University of Georgia, Athens, Georgia. May 5, 1977.

Marsh ecology at Corkscrew Swamp Sanctuary. Lecture to graduate marsh

ecology course, University of Florida, Gainesville, Florida. May 6, 1977.

Seasonal snake activity patterns on the Savannah River Plant. Scientific paper presented at annual meeting of American Society of Ichthyologists and Herpetologists, Gainesville, Florida. June 23, 1977.

Factors controlling structure and productivity of a South Florida cypress swamp. Scientific paper presented at annual meeting of Ecological Society of America, East Lansing, Michigan. August 23, 1977.

Factors controlling structure and productivity of a South Florida cypress swamp. Seminar, Center for Wetlands, University of Florida, Gainesville, Florida. October 12, 1977.

Seasonal fish population fluctuations in a South Florida swamp. Scientific paper presented at Southeastern Limnology Conference, Augusta, Georgia. October 15, 1977.

Ed Carlson:

Seasonal fish population fluctuations in a South Florida Swamp. Scientific paper presented at Southeastern Association of Game and Fish Commissioners, San Antonio, Texas. October 15, 1977.

Mike Duever, Ed Carlson, and other members of study team:

Progress report: Resource Inventory and Analysis of Big Cypress National Preserve. Presentation to research staff, Everglades National Park, Florida. November 10, 1977.