Special Publication SJ 91-SP3

FINAL REPORT

AVIFAUNAL AND SUBMERGED AQUATIC VEGETATION SURVEYS

SOUTH AND FOX LAKES, BREVARD COUNTY

Prepared for:

St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32078-1429

Prepared by:

Bart J. Baca and Ruth A. Dolan
Coastal Science Associates, Inc.
3288 South Third Street (A1A)
Jacksonville Beach, FL 32250

January 1991

CSA

EXECUTIVE SUMMARY

A study of the wetland-dependent birds and their vegetative food and habitat in South and Fox Lakes (Brevard County, Fla.) was performed March - November 1990. Field surveys of submerged aquatic vegetation (SAV) and emergent (cattail) vegetation were performed using specialized survey techniques to map the locations of species and communities. Field and literature surveys of area birds were also conducted. The objectives of the study were to (1) map the SAV of the lakes, (2) describe the area habitats used by wetland-dependent birds of the area, and (3) evaluate the lakes for use by wetland-dependent birds. The information from this study is intended for use in developing cost-effective and ecologically sound recommendations for restoration and management of the lakes.

The results of the vegetation study showed that six communities of SAV were dominant in different parts of South Lake: *Hydrilla verticillata, Najas guadalupensis, Vallisneria americana, V. americana/N. guadalupensis co-dominant, Potamogeton pectinatus/N. guadalupensis co-dominant,* and *V. americana/P. pectinatus co-dominant*. Much of the area near shore was dominated by cattail, *Typha latifolia*. Fox Lake was dominated by hydrilla. Hydrilla coverage has increased by 20 percent in South Lake compared to a similar study (Brevard County, 1983), and the plant now covers practically all of Fox Lake. Native species dominate in the northwestern half of South Lake.

The bird surveys showed that the lakes are moderately used by waterfowl, especially those feeding upon SAV, and by other wetland-dependent birds. Comparison of avifaunal data with previous summaries and counts shows that the lakes are still important habitat. Over 20 species of wetland-dependent birds may nest in the area. Waterfowl species that heavily use hydriilla have apparently increased in numbers. However, the continued increase in hydrilla and cattails may adversely affect the long-term use of these lakes by migratory waterfowl and similar birds.

Based on the present and previous studies, with the primary focus being bird habitat, it is recommended that the excessive growth of cattails and the spread of hydrilla be managed through the continued use of herbicides and consideration of the introduction of grass carp (for hydrilla control). Extensive restoration activities in either lake do not appear necessary for continued, moderate use by wetland-dependent birds.

TABLE OF CONTENTS

INTRODUCTION

History

South and Fox Lakes are natural bodies of water, connected by a man-made channel, which are part of the St. Johns River Basin (Fig. 1). A sewage treatment facility operated on South Lake from 1958 to 1973, releasing over 25,000 gallons per day of secondarily-treated, nutrient- and organic-rich effluent for much of this period (Brevard County, 1983). Nutrients from the treatment plant; a severe drought in the area in 1962; drawdown of Fox Lake in the late 1970s; and the introduction of hydrilla created conditions favorable for aquatic vegetation growth in the lakes. In the lakes today, this vegetation interferes with boating and recreation, and it may reduce the value of the lakes for fish and avifaunal use. Although a number of wetland-dependent birds use aquatic vegetation, dense aquatic vegetation growth can preclude use by certain waterfowl, diving birds, raptors, and other species.

A study performed by Brevard County in 1983 provided management alternatives to restore the South Lake system, but necessary resources were unavailable to implement restoration work. Primary restoration alternatives evaluated in the study included: (1) no action, (2) dredging, (3) lake drawdown, (4) raising water levels, (5) herbicide control, (6) biological control, (7) sediment covering, (8) mechanical harvesting, and a number of various combinations of these. Using an alternatives evaluation method, with emphasis on bass fishing and boating, the three top-ranking options all involved complete drawdown and stormwater management. Combining the evaluation results with public and private comments, the "ideal" option included (not in order of implementation): (1) minor dredging for lake access, (2) mechanical removal of 15 percent of the aquatic vegetation, (3) lake drawdown, (4) restocking with fish, and (5) stormwater ordinance, adoption and enforcement.

Aquatic Vegetation Concerns

Preliminary field work at South and Fox Lakes showed that four species of submerged aquatic vegetation (SAV) were dominant in the lakes, and several species were less common. Following is a discussion of these plants and their importance to avifauna.

Hydrilla verticillata (L.f.) Royle (Hydrilla)

Hydrilla is a non-native species introduced from the Old World which has become a serious pest in southern waters. The plant can grow in deep water to 8.5 meters (26 feet) (Godfrey and Wooten, 1979), extending upward from the bottom and branching outward until the entire surface of the water is covered. Toothed leaves occur in whorls along elongate stems with multiple branches, each containing active growing tips.

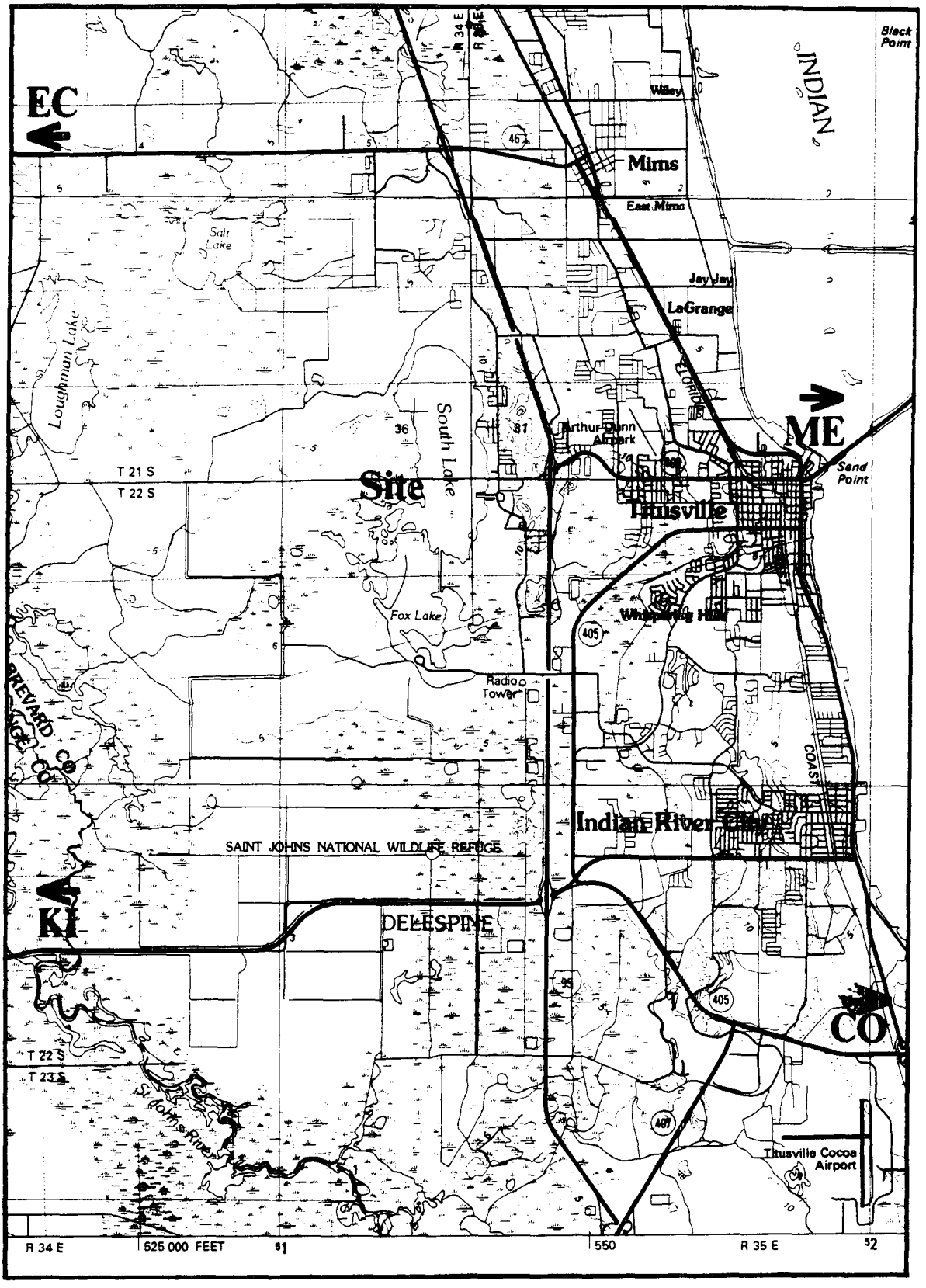

Figure 1. South and Fox Lakes, west of Titusville (scale 1 cm = 1 km). Arrows show the directions to comparative, Christmas bird count sites. Key to sites: ME = Merritt Island N.W.R.; CO = Cocoa; EC = Econlockhatchee; and KI = Kissimmee Valley. The letters are at the approximate outer ranges of the counts.

Hydrilla was introduced in Florida as an aquarium species in 1958 (Montalbano et al., 1979), and first appeared in the wild in 1960. It is now established in over a dozen other states and is third among aquatic macrophytes requiring the use of chemical control in Florida (Colle et al., 1987). The value of hydrilla to wildlife is much debated. The branches provide some habitat and nursery area for fish and invertebrates, and many waterfowl and similar birds feed on the plants themselves.

The major problem associated with growth and control of hydrilla is the strong competitive ability of the species. The plant forms a dense canopy and limits light penetration by 95 percent in the first 0.3 m of the water column, and over 87 percent of hydrilla biomass can be standing crop (Haller et al., 1975). The large canopy produced by hydrilla not only creates a great amount of photosynthetic material, but also restricts other aquatic plants by limiting light availability. The reproductive propagules and large number of axillary meristems formed by hydrilla also favor its competitive growth potential (Haller et al., 1975).

Because of the high propagation rate of hydrilla, there has been much discussion and debate concerning its control. Skiers, boaters and many sports fishermen would often like to see its complete elimination. Some fishermen who benefit from the increased fish production in hydrilla-abundant areas are interested in control only in access points and boat trails (Colle, 1982). However, there is conflicting evidence as to whether hydrilla is beneficial or detrimental to sportfish species. Moxley et al., (1982) reported a positive effect of hydrilla growth in two eutrophic lakes in Florida, with an increase in sportfish standing crop. In contrast, studies by Colle (1982) showed that hydrilla coverage of 50 percent and volume infestation of 20 percent will cause decreases in sportfish growth, resulting in large populations of subharvestable individuals. Most studies conclude that a certain amount of hydrilla is generally beneficial to a lake and that a reasonable coverage is between 20 and 50 percent.

With the decline of wetlands in Florida, hydrilla can become an important food source for overwintering waterfowl, which enables the deposition of fat reserves necessary for migration. Johnson et al. (1984) found 12 species of waterfowl using hydrilla while overwintering in Lake Okeechobee. Ring-necked ducks, American wigeon, scaup, fulvous whistling-ducks, blue-winged teal, and mottled ducks were the most abundant species. The authors determined that the community most preferred overall by waterfowl is hydrilla-dominated, followed by water celery (*Vallisneria americana*) and spike rush (*Eleocharis* spp.). In a similar study of two Florida lakes, Montalbano et al. (1979) found hydrilla to be the most common plant food found in the esophagi of ducks and coots, the duck species analyzed being blue-winged teal, American wigeon, ring-necked duck, mottled duck, green-winged teal, pintail and mallard.

Duck and coot herbivory may be helpful in maintaining hydrilla coverage at a reasonable level. Esler (1989) found that the use of hydrilla as food, mainly by coots, has a significant effect on its biomass. Using a statistical method that estimates food consumption of wintering waterfowl, Montalbano et al. (1979) found that an average population of ducks and coots at two study sites in Florida would consume approximately 39 percent of the maximum growth rate of 30.5 g/m^2/day reported for hydrilla.

Although herbivory from overwintering waterfowl may help control the plant in the winter season, hydrilla is known for its ability to rebound from yearly declines caused by herbivory and climate (Esler, 1989). Esler (1990) reported (for a Texas reservoir) that total bird use in experimental plots was substantially lower without hydrilla present. Furthermore, he found that birds which primarily used other habitat types did not exhibit population changes. However, he determined that if hydrilla were to dominate most open water areas, birds selecting these habitats may be inhibited.

The primary means of hydrilla control has been chemical and mechanical measures, but introduction of grass carp may be considered as a control. Using grass carp, complete eradication of hydrilla from an 80 percent coverage level occurred over a two year period in Lake Baldwin, Florida (Colle et al.,1989). Despite the controversy concerning the use of grass carp, 27 states currently allow this method for controlling aquatic macrophytes. Grass carp stocked at an amount of 12 fish/acre (25 fish/hectare) can eliminate vegetation from a lake's littoral zone (Colle et al., 1989). The major problem with grass carp is that they may not have a preference for hydrilla, and they are known to feed on native aquatic plants, which can be detrimental to a lake.

Najas guadalupensis (Spreng.) Magnus (Southern Naiad)

Southern naiad or common water nymph is a short-leaved, much-branched native plant with reddish stems and leaves. In the U.S., the plant occurs from California to Florida (Hotchkiss, 1967). Seeds and all vegetative parts are important waterfowl foods (Chabreck and Condrey, 1979), and the plants provide nursery area and habitat for fish and invertebrates.

Vallisneria americana Michx. (Water Celery)

Known also as tape grass or eel grass, *Vallisneria americana* is a native perennial which produces long, ribbonlike leaves. It spreads by underground stems and through copious seed production. The plant produces flowers at the ends of long stalks which lay on the surface until pollination, after which the stalks coil tightly and pull the fruit under water, whereupon the seeds mature (250-500 seeds per fruit) and are released (Godfrey and Wooten, 1979). The growth habit of water celery is very similar to its marine relative,

Thalassia testudinum, turtle grass (both in the family Hydrocharitaceae). Turtle grass is perennial; it spreads predominantly by rhizomes; and it is the dominant submerged vascular plant in the tropics. Turtle grass research generally indicates that the plant thrives in established beds, but that physical damage (eg., from boats) and overgrowth by epiphytes (resulting from nutrients or water quality changes), cause major declines in beds. The same may apply to water celery.

Water celery (roots and seeds) is an important waterfowl food throughout freshwater lakes and streams of the Atlantic coast. It also provides valuable habitat and nursery areas for fish and invertebrates.

Potamogeton pectinatus L. (Sago Pondweed)

Sago pondweed is a dense, bushy perennial growing from matted rhizomes. The long, thin leaves and growth habit result in confusing this species with widgeon grass, *Ruppia maritima* (Eleuterius, 1980). Since waterfowl management began (Martin and Uhler, 1939), sago pondweed has been cited as one of the most important waterfowl foods. It produces numerous seeds, and its starchy tubers (tender, underground growing tips) and abundant leaves are important waterfowl diets. As with other SAV, it provides habitat and nursery areas for fish and invertebrates.

Less Common Species

Coontail, *Ceratophyllum demersum* L., is a perennial of often deeper, clear waters. The leaves and stems provide food for waterfowl, and the plant is important in the food chain (Chabreck and Condrey, 1979). Bladderwort, *Utricularia foliosa* L., produces two distinct types of branches which extend outward (for up to a distance of 3 meters) from an older stem portion, the latter often disintegrating to allow the plant to become free-floating. The plant texture is slimy with mucous from glands and with bladders which trap crustaceans for digestion. Its use by waterfowl and fish is limited. Muskgrass, *Chara* sp., is a non-vascular alga with spiny, lime-encrusted leaves and bushy habit. Although it is eaten by some waterfowl, its value to wildlife is limited, its primary function being the formation of inland marls and other calcium deposits. Spiny naiad, *Najas marina* L., is a fragile, spiny-leaved plant. Its value to wildlife is also limited.

Emergent Vegetation

Cattail, *Typha latifolia* L. (and other cattail species), produces long, erect, strap-shaped leaves from fleshy rhizomes. It is often considered a weed, but it can be important in providing habitat for water-dependent fauna if it is not excessively dense. Giant bulrush, *Scirpus californicus* (C. Meyer) Steud., and pickerel weed, *Pontederia cordata* L.,

provide habitat for aquatic and water-dependent fauna, and the seeds are eaten by waterfowl. Spatterdock, *Nuphar luteum* (L.) Sibth. & Sm., and water lily, *Nymphaea odorata* Ait., also provide habitat for fauna and the seeds and tubers are valuable waterfowl foods.

Waterfowl Management Concerns

Migratory waterfowl are primarily ducks and geese. Ducks which use the area lakes and wetlands can be divided into two types - puddle ducks and diving ducks. Puddle ducks generally prefer shallow water and feed on seeds and parts of aquatic vegetation by dabbling along the surface, or "tipping up" so that their tails show above the water. Area puddle ducks include mallard, mottled duck, shoveler, blue-winged teal, green-winged teal, wood duck, pintail, and American wigeon. Diving ducks feed by diving for aquatic animals and vegetation. Common area species include ring-necked duck, greater scaup, lesser scaup, common goldeneye, bufflehead, ruddy duck, and mergansers. These ducks prefer open water in bays, lakes and rivers. Waterfowl allies include species which have similar appearances, feeding habits, and migrations. Common area species include loons, grebes, and American coot.

Waterfowl have been experiencing a drastic decline in numbers in recent years. The primary reason for decline is loss of habitat, both in breeding areas in Canada and northern U.S., as well as losses in wintering habitat in the U.S. and southward. It is obvious that management of remaining waters and wetlands, such as South and Fox Lakes, is one step necessary to stop this decline. South and Fox Lakes supported a number of waterfowl hunters between 1961 and 1963 (Brevard County, 1983), and waterfowl use of the lake is important at present.

Waterfowl management for overwintering species primarily involves management of water and vegetation. Water levels may be adjusted in the summer to encourage desirable vegetation growth (eg., widgeon grass) or to discourage undesirable vegetation. Water levels are kept highest during the winter months for use by wintering waterfowl. Vegetation can be managed by water level manipulation, planting of waterfowl food species, and biological, chemical or physical control of undesirable species.

Study Objectives

The St. Johns River Water Management District (District) is assisting Brevard County in the restoration of the two lakes through the production of a management plan. The present study was conducted to provide a current assessment of the avifaunal and submerged vegetation resources of the lakes. The objectives of the study were to (1) map the SAV of the lakes, (2) describe the area habitats used by wetland-dependent avifauna, (3) conduct wetland-dependent avifaunal surveys of the area, (4) evaluate the lakes for use by wetland-dependent avifauna, (5) prepare a report on these objectives, and (6) prepare SAV maps for use in the Geographic Information System (GIS). The information from this study will be used to develop cost-effective and ecologically sound recommendations for restoration and management of South and Fox Lakes.

METHODS

Vegetation Mapping

Submerged and emergent vegetation were mapped using aerial photography obtained from the District, ground surveys, and previous vegetation and bathymetry studies. Ground surveys were performed in Fox Lake by positioning a surveyor and survey instrument (total station) on the shore and locating the instrument in relation to state plane coordinates. A survey rod/prism holder and biologist were positioned in a boat. The boat was navigated along the edges of various vegetation zones and periodic position shots were taken by the surveyor with the prism held above the delimited edge. This survey method had an estimated accuracy of ± 1 foot. Survey shots and vegetation descriptions were coordinated through the use of hand-held radios. For this study, Fox Lake included the entire channel connection to South Lake.

South Lake could not be surveyed in this manner because of its size and variability of submerged plant communities. Instead, a survey team was positioned onshore using a Hydro-1(R) theodolite which takes constant measurements of angle/distance by laser. Following location of the instrument with state plane coordinates, a surveyor and biologist made transects across the lake by airboat or jonboat. The rod and prism were affixed to the boat (Fig. 2) to enable instantaneous recordings of location (initiated by hand-held radio). As the boat moved along the transect, the biologist estimated the percent coverage, by species, of SAV using a 0.5 square meter quadrat constructed of PVC (Fig. 3). The quadrat was held over the side of the boat and the beginning and ending of each vegetation community (the distance between two survey points) was recorded. Where the SAV could not be seen clearly from the surface (turbid or deeper areas), a grappling hook was used for sampling the bottom (Fig. 4). Survey points (accuracy ± 1 foot) were taken at the beginning and end (relative to the transect) of all major vegetation zones encountered.

Infrared aerial photography was used to locate and delineate the general locations of emergent wetland vegetative communities (predominantly cattails). A number of survey readings were also taken of the existing cattail border (much of the entire cattail edge in both lakes), and these are referenced to state plane coordinates for comparison with the aerial photography. The border of the emergent vegetation was digitized onto Autocad for the final map.

Vegetation coverage was estimated at Fox Lake by calculating the area within surveyed boundaries of each vegetation type using Autocad. Vegetation coverage for each species in South Lake was determined by taking the average of occurrences of each species between the survey points on the transects. The areal coverage of each species was then determined using points within the transects for each species, wherein the coverage

was 30 percent or greater for that species, which was shown on Autocad as separate, colored lines connecting survey points. The 30 percent cutoff was used because it was a break point between communities. For example, using a 20 percent cutoff resulted in nearly all transect points having a mix of all four species; conversely, a 40 percent cutoff resulted in a misleading amount of open water with pure stands of few species. The areas of the resulting seven communities (including cattail) were then determined by Autocad. The percent coverage of each species within the seven communities was determined by averaging all of the coverages for that species within the community.

The areas of SAV were shown as polygons in South and Fox Lakes. The Fox Lake polygon was produced from direct surveys of the vegetation boundaries. The South Lake maps were produced from the community coverages by connecting the survey points at the edge of each community to form individual polygons.

Herbarium mounts of all SAV species collected, including those with flowers and seeds, were prepared and submitted to the District.

To assess the potential for growth of brackish-water vegetation, salinity measurements were taken throughout South and Fox Lakes with a portable refractometer (Biomarine Aquafauna, temperature compensating).

Bird Habitat Assessment

Avifaunal surveys were conducted on the following dates:

March - for overwintering species, migrating species, early spring migrants, and residents;

May - for spring migrants, early nesting species, and residents;

June - for nesting species, juveniles, residents, and late or off-season migrants; and

November - for early winter migrants, overwintering species, and residents.

Bird surveys were conducted by foot, car, and/or boat using binoculars and spotting scope. Table 1 is a summary of the methods used in the surveys.

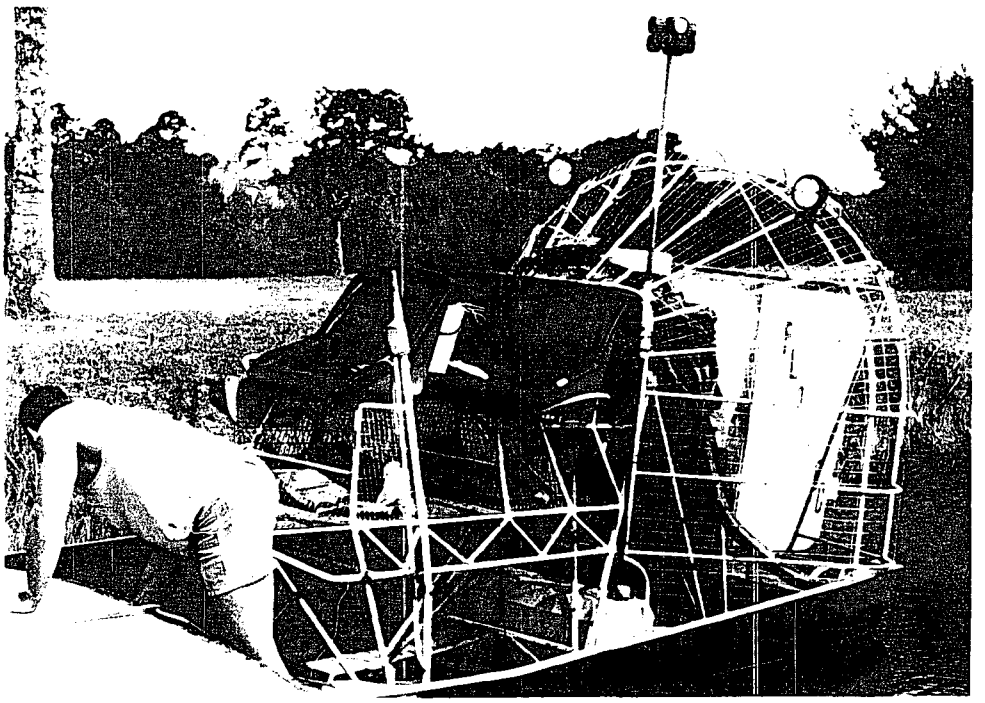

Figure 2. Airboat fitted with rod and prism for use in surveying transects across South Lake. A surveyor was stationed onshore with a laser theodolite which allows constant readings of the location of the prism.

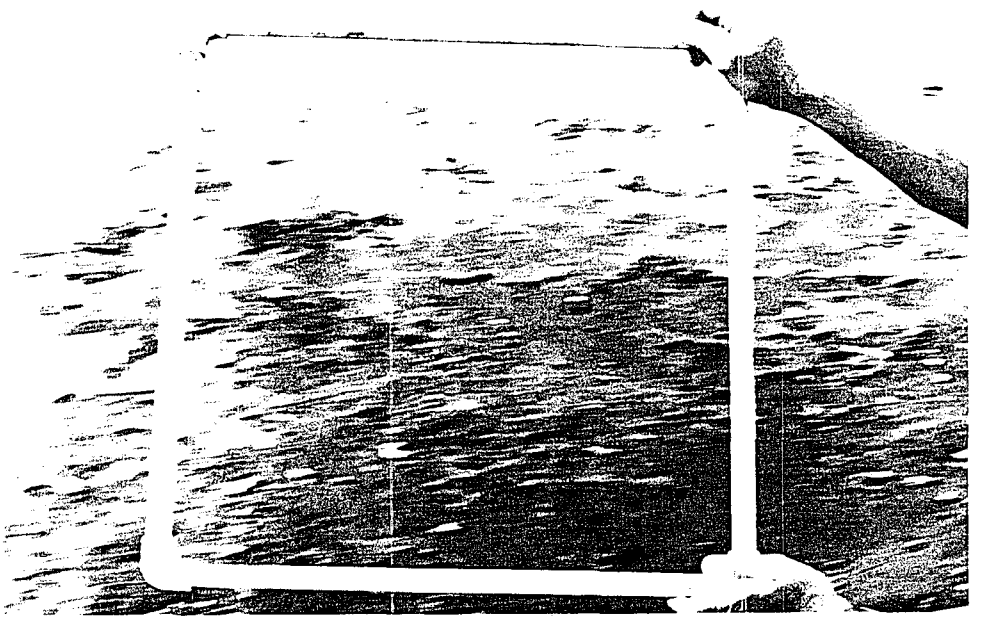

Figure 3. PVC frame, measuring 0.5 square meter, used to estimate percent coverages of submerged vegetation.

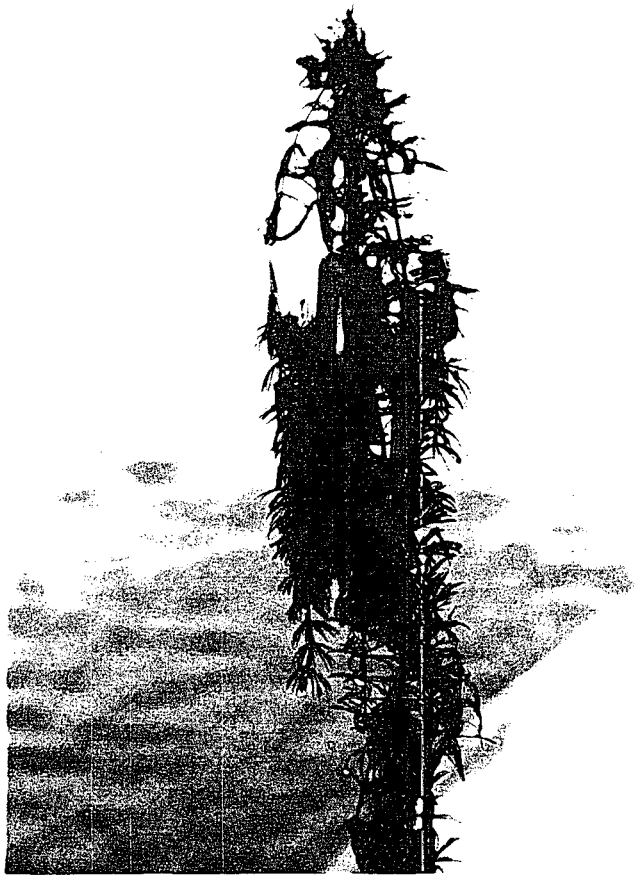

Figure 4. Grappling hook used to sample murky or deeper waters. As shown, *Ceratophyllum demersum* was usually the only plant obtained from open areas of deep water.

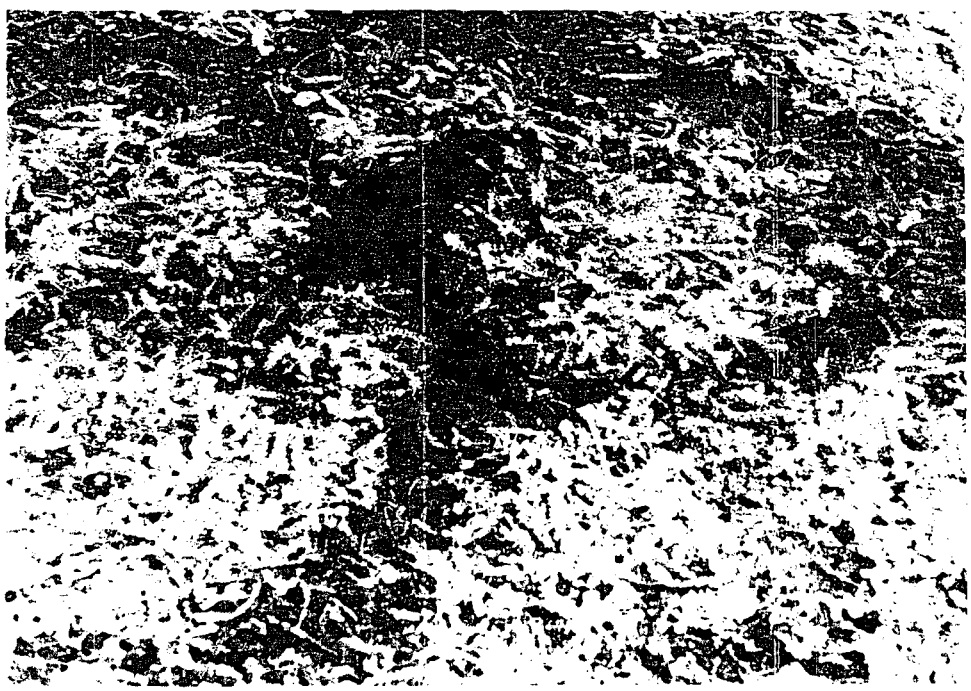

Figure 5. *Hydrilla verticillata* , which has grown from deeper water, extending upward and outward until the surface is covered. Boats break branches free, creating floating and wind-driven rafts of hydrilla.

Table 1. Summary of bird survey methods and scheduling used on South and Fox Lakes.

Date	Times	Area	Person Hours	Methods
March 7-8	10:00AM-6:00PM	E. shore of South Lake; s. shore Fox Lake	16	Car/foot
May 4	10:00AM-1:30PM; 4:30PM-6:30PM	S. shoreline of Fox Lake	5	Boat
May 7	10:00AM-11:00AM; 12:30PM-4:30PM	Connecting channel, w. shoreline, and east to west across South Lake	5	Boat
May 8	10:00AM-1:30PM	Connecting channel, w. shoreline, and east to west across South Lake	3.5	Boat
June 22	10:00AM-3:00PM	Entire shoreline of Fox Lake; channel, w. shoreline of South Lake	5	Boat
June 23	11:30AM-7:00PM	E. shore of South Lake; s. shore Fox Lake	7.5	Car/foot
November 11	9:00AM-12:30PM; 1:30PM-6:00PM	E. shore of South Lake; s. shore Fox Lake	15	Car/foot

The survey results were compared to avifaunal species lists from the area, including the following:

1) Brevard County Report (1983)
2) Area Christmas bird counts
3) Field guides containing precise distribution information.

The Brevard County Report contains a list of area birds, with suggested habit preferences and occurrence. Area Christmas bird counts included the stations of Merritt Island N.W.R., Cocoa, Econlockhatchee, and Kissimmee Valley (see map, Fig.1). Besides 1987-1989, the years 1939-1941 (averaged) were included to gain historical comparisons.

The information used for Christmas bird counts was obtained from *American Birds* (*Bird Lore* and *Audubon Magazine* for historic counts), and the areas are described as follows:

1) *Cocoa.* The area is southeast of South and Fox Lakes, with its center on Merritt Island, and extending across the Indian River, including the eastern quarter of Lake Poinsett.

2) *Econlockhatchee.* The area is located northwest of the lakes, including Oviedo; Chuluota, Lake Harney, Lake Jessup, and the St. Johns and Econlockhatchee Rivers.

3) *Kissimmee Valley.* This area is southwest of South and Fox lakes, and includes East Lake Tohopekalgia, Lake Tohopekal gia, St. Cloud, and Lake Russell.

4) *Merritt Island National Wildlife Refuge.* This area is concen trated on Merritt Island and on the Titusville shoreline, direct ly east of the lakes.

Field guides used to determine potential species present and to check bird identification included Peterson (1980) and Robbins et al. (1966).

RESULTS

Vegetation Mapping

The map of submerged and emergent (cattail) vegetation of South Lake is given in Figure 6. Six SAV communities were delineated. A vegetation map of Fox Lake is provided in Figure 7. The survey points represent the edges of SAV and emergent vegetation zones as per the plotted patterns. For both lakes, the cattail boundary was located in the field and was digitized from an aerial photograph (1984). The coverage of SAV is summarized in the following section.

Vegetation Composition

Submerged aquatic vegetation in Fox Lake and southern South Lake was dominated by hydrilla (Fig. 8). SAV at South Lake was dominated by six communities, in decreasing order of abundance (based on mean percent coverage over all South Lake):

1) *Vallisneria americana,*
2) *Najas guadalupensis,*
3) *Hydrilla verticillata,*
4) *Vallisneria americana/ N. guadalupensis* community,
5) *Potamogeton pectinatus/N. guadalupensis* community, and
6) *Vallisneria americana/P. pectinatus* community.

Less abundant were the individual species *Ceratophyllum demersum, Utricularia foliosa, Chara* sp., and *Najas marina. Ruppia maritima* was reported in the Brevard County (1983) study but probably was misidentified as *P. pectinatus*. The salinity was zero in the lake, which would also severely inhibit growth of *Ruppia*, a brackish-water species. A summary of the abundance and locations of each community is presented in Table 2. Following is a discussion of these results, by community.

Vallinsneria americana and Co-dominant Communities

Water celery is singularly-dominant in one small community type and is co-dominate with two other species in separate communities: *N. guadalupensis* and *P. pectinatus*. Water celery occurs in South Lake in three forms: (1) scattered, large, homogeneous beds, (2) small, circular beds, and (3) a large, central bed associated with other species. Large, homogeneous beds of water celery were uncommon. Small, circular beds (Fig. 9) were most common in the northern section of the lake. The main body of South Lake was dominated by an aquatic bed containing various mixes of the dominant species, and water celery was usually present. Water celery was actively growing in April and May, but leaves

were turning brown in many beds by the end of June. In Fox Lake, water celery was seen only in a few scattered spots along the main channel.

Water celery coverage in South Lake averaged 28 percent, which placed it in a similar coverage category as southern naiad. It was also found at greater than 29 percent coverage at more transect points than any other SAV species. Within the three communities (*V. americana, N. guadalupensis, P. pectinatus*), its coverage was 49 percent, 43 percent, and 60 percent, respectively (Table 2).

Najas guadalupensis Community

Although southern naiad does flower, only vegetative samples were collected. It occurs throughout South and Fox Lakes in three basic habitats: (1) dense, homogeneous beds in open, more turbid water along the shore (Fig. 10), (2) large beds in several sections of South Lake, and (3) interspersed with other species in the aquatic beds. Areas as shown in Figure 10 provide fish spawning habitat and waterfowl feeding habitat. The best growth of naiad was in the northern portion of South Lake which was lacking in hydrilla. Plants in the southern portion of the lake appeared dead in the spring and summer sampling. The dense mats became so coated with fungi, blue-green algae, and silt that some areas took on the appearance of unvegetated mud bottom. This "false bottom" at first was misleading until it was sampled with grappling hook and the moribund, naiad bed was discovered.

Southern naiad was very abundant throughout South Lake, with a mean coverage in the transects of 27 percent. The naiad community was the largest native SAV community in South Lake, covering 176 acres.

Hydrilla verticillata Community

This community is dominated by hydrilla, with coverage by other species at less than 20 percent each. Hydrilla began growing quickly in the spring. At the end of the summer growing season, the branches of hydrilla broke free or were broken free by boats, and these were spread by wind to other waters. Hydrilla was undergoing rapid growth in May at South and Fox Lakes, and by mid-June rafts of broken plants were floating throughout the lakes (Fig. 11). At the free-floating stage, and as it continues to grow, hydrilla prevents light penetration to SAV below (eg., *Vallisneria*) thereby stressing and killing these plants. *Najas guadalupensis* appeared particularly vulnerable to shading as mass mortality was observed in areas where *Najas* and hydrilla were co-dominant, but not where *Najas* was singularly dominant (common observation in southern South Lake).

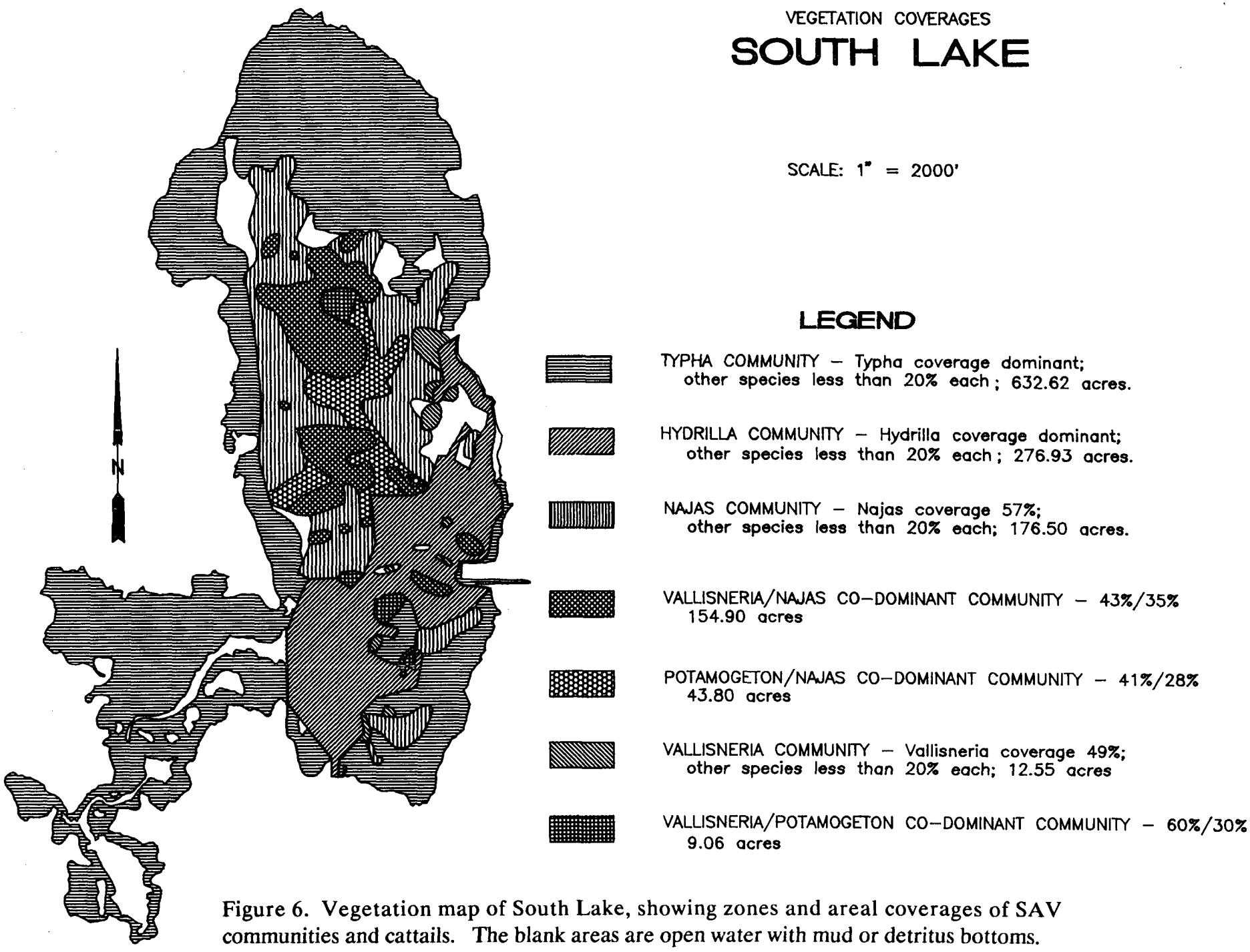

Figure 6. Vegetation map of South Lake, showing zones and areal coverages of SAV communities and cattails. The blank areas are open water with mud or detritus bottoms.

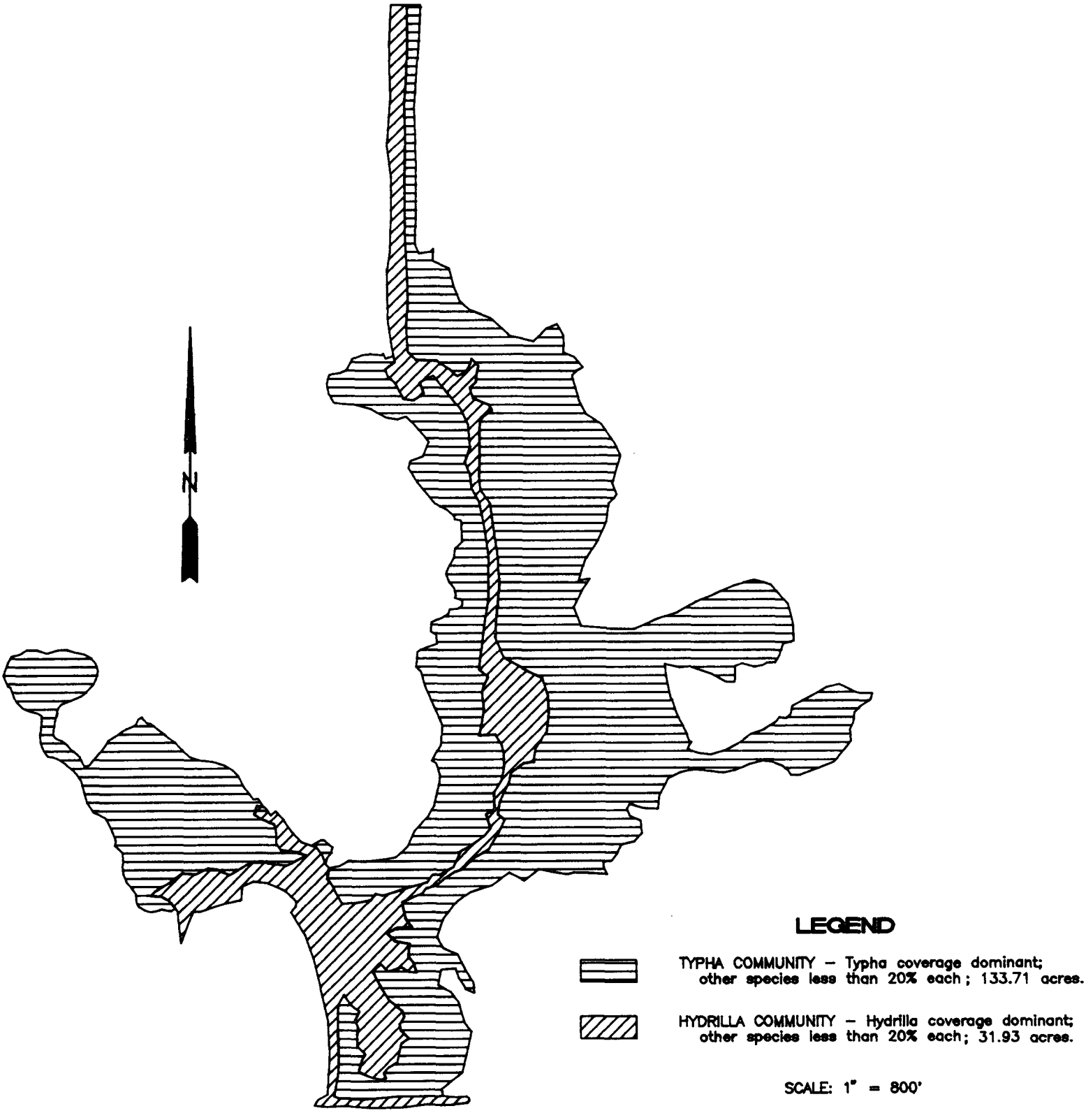

Figure 7. Vegetation map of Fox Lake, showing extensive areas of cattail and hydrilla. Other species coverages were too small to map; however, they were located in small patches along the channel connection to South Lake.

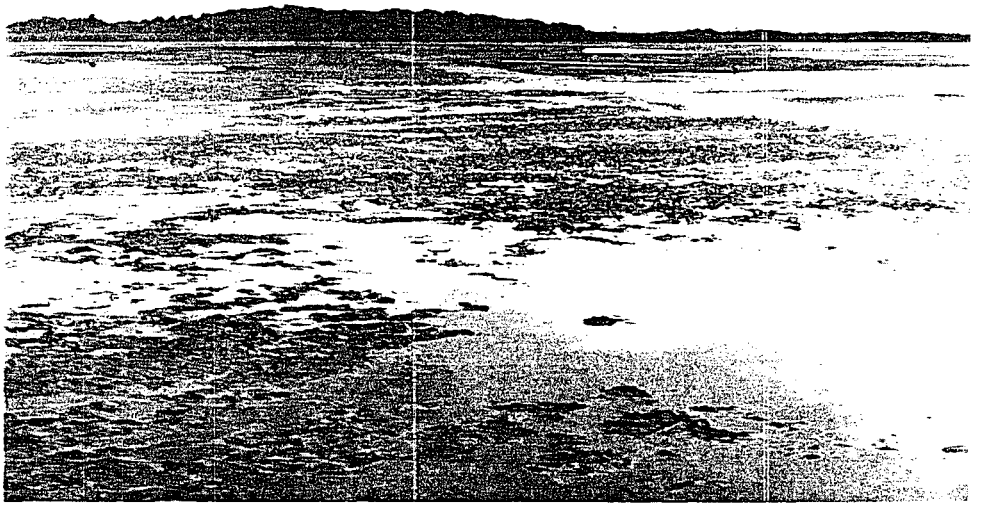

Figure 8. Dense SAV bed, predominantly hydrilla, which covered the southern half of South Lake (and most of Fox Lake) by late June.

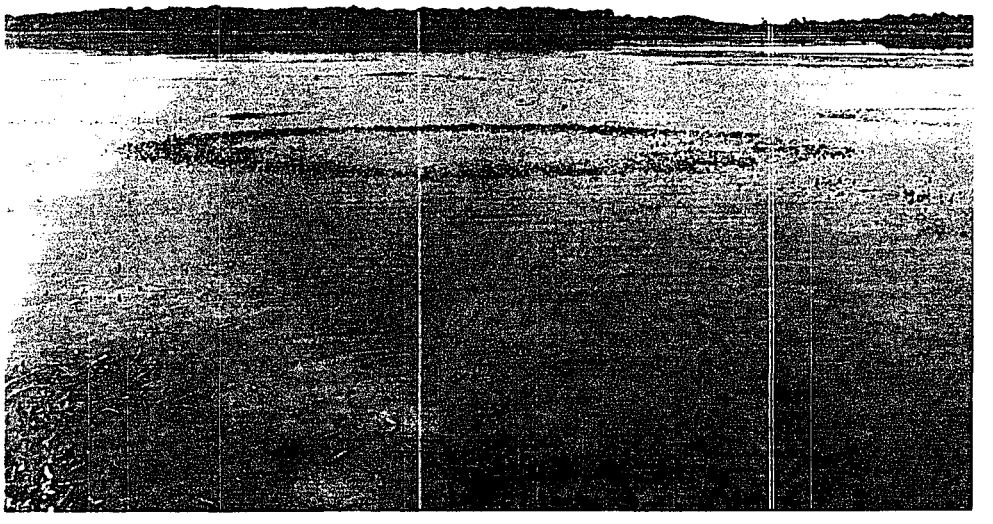

Figure 9. Circular beds of *Vallisneria americana* which frequently occur in pure stands in the northern section of South Lake.

Table 2. Summary of aquatic vegetation coverage in Fox and South Lakes. Fox Lake coverage was estimated by Autocad. Points with > 29 percent coverage were used to draw polygons and maps. N = the number of transect points. *Estimates of less significant communities too small to include on maps.

Fox Lake:

Species	Area of coverage (acres)	Mean % Coverage
Typha latifolia	134	76
Hydrilla verticillata	32	18
**Najas guadalupensis*	4	2
**Ceratophyllum demersum*	3	2
**Vallisneria americana*	<1	<1
**Potamogeton pectinatus*	<1	<1

South Lake:

Species/Communities	Area of Coverage (acres)	Mean % coverage (N = 456)	Mean% coverage in communities where species coverage is >29%
Typha latifolia	632	NA	100
Hydrilla verticillata	277	22	56
Najas guadalupensis	176	27	57
Vallisneria/Najas	155	NA	43/35
Potamogeton/Najas	44	NA	41/28
Vallisneria americana	13	28	49
Vallisneria/Potamogeton	9	NA	60/30
**Potamogeton pectinatus*	1	15	44
**Ceratophyllum demersum*	<1	<1	<1

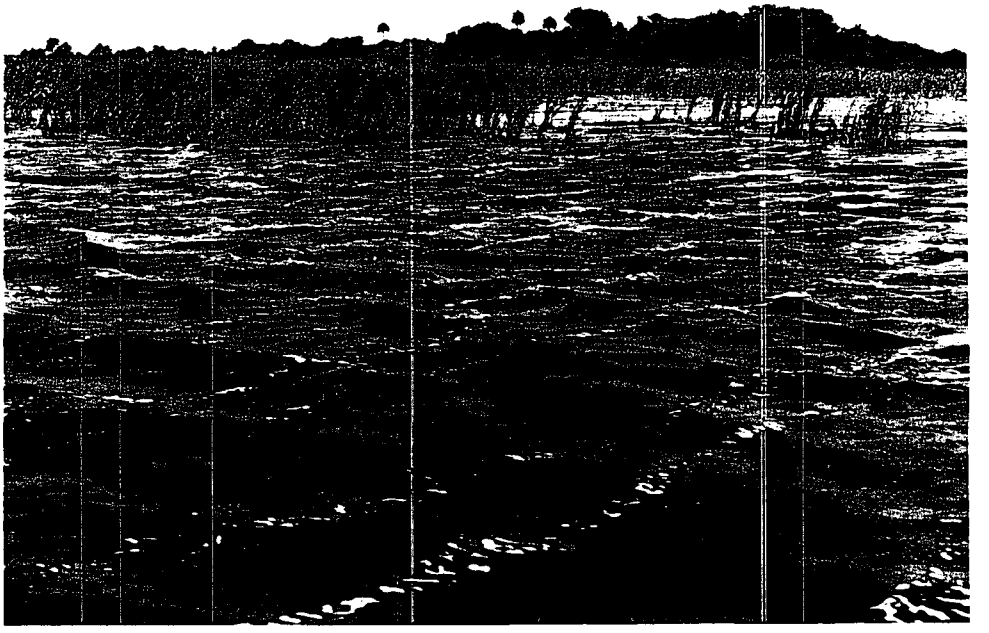

Figure 10. Open water along the cattail line of South Lake which is dominated by *Najas guadalupensis*, and which also provides fish spawning habitat and waterfowl feeding habitat.

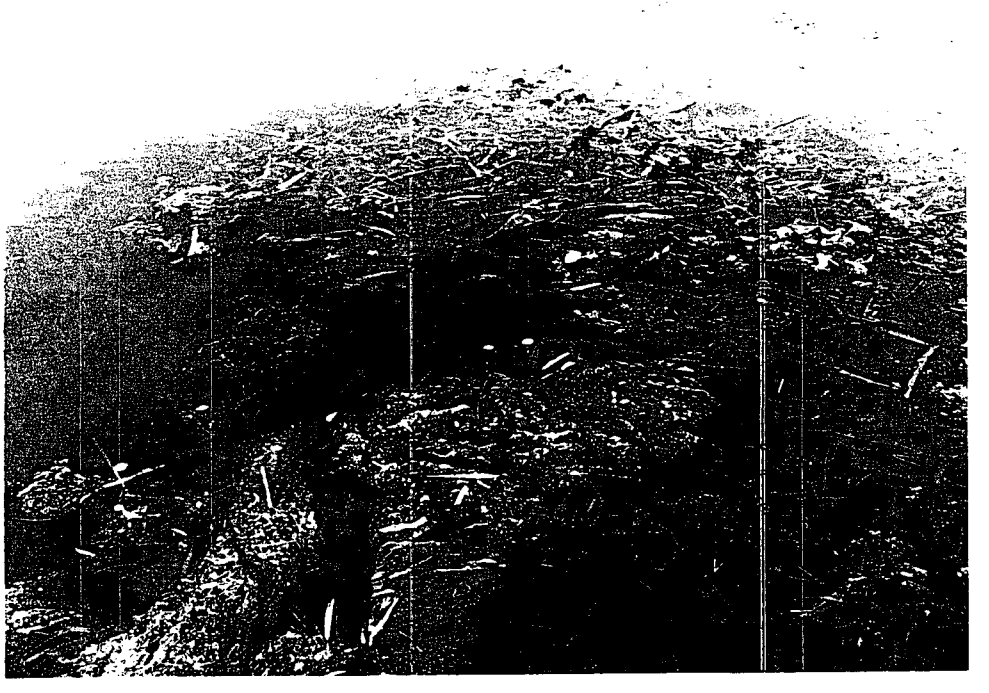

Figure 11. Aquatic vegetation, predominantly hydrilla and water celery, which was cut up by boat propellers and set adrift.

The mean coverage of hydrilla in South Lake based on the transects was 39 percent. Within the hydrilla-dominant community, which was the largest homogeneous SAV community, the estimate of coverage is 56 percent. The estimate of coverage in Fox Lake is 18 percent (individual units of other species were too small to place on the map). However, hydrilla covers approximately 90 percent of the "open" water areas in Fox Lake.

Potamogeton pectinatus/N. guadalupensis Community

The presence of flowers and seeds in the lakes during May and June facilitated positive identification of sago pondweed. The plant forms a few dense, homogeneous beds in the main body of South Lake, but it was most often associated with the other three species of dominant SAV. Although actively growing throughout the study area, it was absent in the shallow waters at the edge of the cattails; it was rarely found in deeper waters; and it was the least abundant of the four dominant species, with a mean coverage of 15 percent. The coverage of sago pondweed within its co-dominant community was 41 percent.

Less Common SAV

Potamogeton pectinatus was found, but not singularly dominant as a community, with mean coverage in South Lake of 15 percent. Coontail, *Ceratophyllum demersum*, was confined to the deeper waters and channel sections of both lakes. Areas which appear to be open water in aerial photography and cursory ground truthing often contain a dense growth of coontail. It was usually the only species sampled by grappling hook. Bladderwort, *Utricularia foliosa*, was only abundant in the cattails and along the shallow sections of shoreline in both lakes, where it provided an average of approximately 20 percent coverage (determined from cruising these areas by airboat). Muskgrass, *Chara* sp., was found in small, dense beds scattered throughout South Lake, predominantly in the northern section. Spiny naiad, *Najas marina*, was rare in South Lake and was not found in Fox Lake.

Emergent Vegetation

Cattail, *Typha latifolia*, is a dense component of both lakes, where it crowds out other emergent and SAV species and produces excess organic detritus. The detritus accumulates until sediments underneath become anaerobic. Some positive aspects of this detrital production is that (1) nutrients are locked in these sediments to slow the process of eutrophication, and (2) bottoms devoid of SAV as a result of shading are sometimes used by spawning fishes. Cattails have been sprayed with herbicides (Brevard County Herbicide Control, pers. comm.) and have evidently been experiencing a die-off over the last few years. Field evidence includes dead rhizomes and early yellowing of leaves. Aerial photography, when compared with survey data, indicates a retreat of the cattail line

shoreward. Cattail covered 58 percent of both lakes for a total of 766 acres (determined by Autocad).

The emergents next in abundance were giant bulrush, *Scirpus californicus*, and pickerel weed, *Pontederia cordata*. Bulrush formed a few isolated clumps in both lakes and pickerel weed was found along several shorelines.

Rooted, floating-leaved aquatics were predominantly spatterdock, *Nuphar luteum*, and water lily, *Nymphaea odorata*. These were scattered throughout, but were most abundant in terms of coverage in Fox Lake and the main channel.

Water hyacinth, *Eichhornia crassipes*, is a floating aquatic which is a serious pest in southern waters. It was uncommon at the lakes during the surveys, but evidently increases in abundance such that herbicide spraying there is necessary each summer (Brevard County Herbicide Control, pers. comm.).

Bird Habitat Assessment

Results of the bird surveys (Table 3) indicate that the area lakes and wetlands are used by many migratory and resident species. Overwintering species were numerous, and many wading species (eg., herons, egrets and allies) and diving species (eg., cormorants, terns, and similar species) are present year-round. However, only three wetland-dependent species were observed to nest in the immediate vicinity of the lakes, but many more are expected to nest there. The introduced muscovy duck was not listed, but one was observed in Fox Lake during the March survey and two there in November.

As a regional comparison, Christmas counts for wetland-dependent birds are shown in Table 4. The wetland-dependent bird counts are quite high. Although comparisons between bird counts are difficult because of variable numbers of counters and areas, general comparisons, and an indication of the species which might use South and Fox Lakes, are possible. The Christmas waterfowl are further separated, and listed in order of abundance, in Table 5. Lesser scaup (including greater scaup) was the dominant waterfowl, as it was in November in both lakes. South and Fox Lake counts differ from others in the area by having higher percentages of American coot, ring-necked duck, and common gallinule. Species common at Merritt island N.W.R., such as American wigeon and pintail, were not seen at the study lakes. As a temporal comparison, historical waterfowl counts from nearby Merritt Island N.W.R. (1938-1940) are given in Table 6. Relative percentages for each species were calculated to give a comparison between the current and historical data. Although comparisons between Christmas bird counts are difficult to make, they provide the only historical data. Historically, lesser scaup (including greater scaup) has dominated area counts, although the percentage of the total has dropped to less than half, with increases in wigeon, pintail, and American coot evident.

Table 3. Wetland-dependent birds observed in the lakes in the present study (signified by number counted); those expected to occur (E); those not expected to occur (X); and questionable or uncertain occurrences(?).

Species	March '90	May/June '90	Nesting '90	November '90
Common Loon	E	X	X	E
Pied-billed Grebe	5	4	4	8
Double-crested Cormorant	2	E	X	24
Anhinga	6	6	E	4
Mottled Duck	E	E	E	E
Gadwall	E	X	X	6
Mallard	E	?	X	E
Mottled Duck	E	E	E	E
Pintail	E	X	X	E
American Wigeon	E	X	X	E
Wood Duck	E	E	1	1
Northern Shoveler	E	X	X	2
Blue-winged Teal	6	E	X	16
Green-winged Teal	E	E	X	E
Ring-necked Duck	110	X	X	E
Lesser Scaup	45	X	X	48
Greater Scaup	E	X	X	E
Common Goldeneye	E	X	X	E
Bufflehead	E	X	X	E
Ruddy Duck	E	X	X	E
Hooded Merganser	E	E	E	E
American Coot	126	?	X	22
Common Gallinule (Com. Moorhen)	30	32	8	68
Purple Gallinule	E	E	E	E
White Pelican	E	?	?	E
Brown Pelican	E	E	X	E
Herring Gull	2	?	X	11
Ring-billed Gull	11	?	X	E
Laughing Gull	6	E	X	E
Gull-billed Tern	E	?	X	E
Caspian Tern	E	?	X	15
Least Tern	?	E	X	X
Common Tern	8	X	X	E
Great Blue Heron	6	6	X	5
Little Blue Heron	1	2	?	3
Louisiana Heron (Tri-colored)	4	3	?	4
Great Egret	4	9	?	13
Snowy Egret	E	E	X	4
Cattle Egret	7	14	?	E
Black-crowned Night Heron	E	E	?	E
Yellow-crowned Night Heron	E	E	?	E
Green Heron	4	5	?	1
Least Bittern	E	E	?	E
American Bittern	E	?	X	E
Wood Stork	2	2	?	E
Sandhill Crane	E	E	?	E
Limpkin	E	?	?	E
Glossy Ibis	1	1	?	2
White Ibis	1	E	?	E
Roseate Spoonbill	E	?	?	E
Virginia Rail	E	X	X	E
King Rail	E	E	E	E

Table 3. Continued.

Species	March '90	May/June '90	Nesting '90	November '90
Clapper Rail	E	E	?	E
Sora	E	E	?	E
Black Rail	?	?	?	?
Yellow Rail	?	?	?	?
Black-necked Stilt	E	E	?	E
American Avocet	E	?	X	E
Killdeer	2	5	E	E
American Woodcock	E	?	X	E
Common Snipe	E	X	X	E
Short-billed Dowitcher	E	X	X	E
Long-billed Dowitcher	E	X	X	E
Long-billed Curlew	E	X	X	E
Whimbrel	E	X	X	E
Willet	E	E	?	E
Greater Yellowlegs	E	X	X	E
Lesser Yellowlegs	E	X	X	E
Sanderling	E	X	X	E
Spotted Sandpiper	E	X	X	E
Least Sandpiper	E	X	X	E
Snail Kite	E	E	?	E
Swallow-tailed Kite	?	E	X	X
Northern Harrier (Marsh Hawk)	1	X	X	1
Red-tailed Hawk	1	2	?	E
Red-shouldered Hawk	E	E	?	E
Short-tailed Hawk	?	?	?	?
Bald Eagle	1	1	?	E
Osprey	8	4	2	3
Turkey Vulture	18	21	?	3
Black Vulture	2	E	?	8
Crested Caracara	E	E	?	E
Merlin	?	?	?	?
Peregrine Falcon	E	?	X	E
Short-eared Owl	?	?	?	?
Great Horned Owl	E	E	E	E
Barred Owl	E	E	E	E
Whip-poor-will	E	?	X	E
Chuck-will's Widow	E	E	?	E
Belted Kingfisher	1	1	?	3
Pileated Woodpecker	1	3	E	E
Downy Woodpecker	E	E	E	E
Rough-winged Swallow	2	E	?	20
Fish Crow	11	13	E	31
American Crow	2	E	E	E
Marsh Wren	?	?	?	?
Yellow-rumped Warbler	5	?	X	E
Common Yellowthroat	E	E	?	E
Red-winged Blackbird	7	18	E	E
Common Grackle	15	16	E	34
Boat-tailed Grackle	15	6	E	26
Cardinal	3	3	2	E
Swamp Sparrow	?	?	?	E
Song Sparrow	?	?	?	E

Table 4. Wetland-dependent birds from area Christmas Bird counts (1987-1989). Key: CO = Cocoa, EC = Econlockhatchee, KI = Kissimmee Valley, and ME = Merritt Island N.W.R.

Species	CO	EC	KI	ME
Common Loon	13	0	0	37
Pied-billed Grebe	88	132	57	534
Double-crested Cormorant	3416	105	225	1858
Anhinga	260	162	136	333
Black Duck	2	0	1	25
Gadwall	1	1	0	19
Mallard	6	2	1	19
Mottled Duck	113	67	43	168
Pintail	38	86	0	3398
America Wigeon	60	282	0	3959
Wood Duck	4	22	29	7
Northern Shoveler	162	12	14	211
Green-winged Teal	34	34	1	380
Blue-winged Teal	295	211	117	1268
Ring-necked Duck	66	159	832	1017
Lesser Scaup	36026	278	352	17090
Greater Scaup	3	0	0	18
Common Goldeneye	1	0	0	0
Bufflehead	14	0	0	181
Ruddy Duck	7	1345	282	8
Hooded Merganser	10	38	3	141
American Coot	1827	2200	774	7963
Common Gallinule (Common Moorhen)	323	183	197	1137
Purple Gallinule	0	1	1	0
White Pelican	381	236	265	482
Brown Pelican	1593	0	0	375
Herring Gull	465	5	2	1047
Ring-billed Gull	3721	7133	3778	2635
Laughing Gull	5694	3770	3	3917
Gull-billed Tern	1	0	0	0
Caspian Tern	31	35	16	60
Common Tern	1	0	0	1
Great Blue Heron	346	153	136	310
Little Blue Heron	352	306	87	203
Louisiana Heron (Tri-colored Heron)	358	145	96	391
Great Egret	277	210	153	384
Snowy Egret	235	148	93	312
Cattle Egret	766	2443	823	131
Black-crowned Night Heron	26	32	48	58
Yellow-crowned N. Heron	3	3	1	3
Green Heron	54	15	15	112
Least Bittern	1	1	2	2
American Bittern	1	1	4	1
Wood Stork	465	64	40	165
Sandhill Crane	134	110	278	0
Limpkin	4	11	12	0
Glossy Ibis	265	489	102	169
White Ibis	2614	5850	650	1774
Roseate Spoonbill	1	0	0	1
Virginia Rail	6	1	0	5
King Rail	23	6	1	10
Clapper Rail	11	0	0	5

Table 4. Continued.

Species	CO	EC	KI	ME
Sora	22	13	5	9
Black Rail	1	0	0	0
Black-necked Stilt	1	0	0	0
American Avocet	22	0	0	57
Killdeer	280	753	386	294
American Woodcock	1	1	0	0
Common Snipe	32	224	134	70
Short-billed Dowitcher	120	1	67	83
Long-billed Dowitcher	0	1	0	0
Long-billed Curlew	0	0	0	0
Whimbrel	1	0	0	0
Willet	33	0	0	102
Greater Yellowlegs	60	84	28	105
Lesser Yellowlegs	23	51	25	117
Sanderling	186	1	0	229
Spotted Sandpiper	7	0	0	3
Least Sandpiper	29	68	10	76
Snail Kite	0	0	3	0
Northern Harrier (Marsh Hawk)	17	33	15	38
Red-tailed Hawk	44	43	22	48
Red-shouldered Hawk	25	62	39	49
Bald Eagle	7	57	41	12
Osprey	139	30	26	174
Turkey Vulture	427	536	325	441
Black Vulture	95	79	159	111
Crested Caracara	2	0	1	0
Merlin	4	1	0	4
Peregrine Falcon	4	2	0	2
Short-eared Owl	1	0	0	1
Great Horned Owl	6	4	4	7
Barred Owl	1	7	3	2
Whip-poor-will	1	0	0	1
Chuck-will's Widow	0	0	0	1
Belted Kingfisher	144	50	33	257
Pileated Woodpecker	33	42	17	23
Downy Woodpecker	14	23	12	14
Rough-winged Swallow	0	0	0	5
Fish Crow	2358	12767	1273	3513
American Crow	363	20	53	1
Marsh Wren	9	4	0	9
Yellow-rumped Warbler	3317	1667	26	4439
Common Yellowthroat	126	60	766	186
Red-winged Blackbird	1536	3543	2357	1026
Common Grackle	1576	1690	1435	449
Boat-tailed Grackle	2244	1873	933	1319
Cardinal	72	147	61	122
Swamp Sparrow	14	26	11	42
Song Sparrow	3	2	0	15

Table 5. Waterfowl and allies from Christmas counts (1987-1989) in the areas near Fox and South Lakes, listed in decreasing order of abundance. Key: CO = Cocoa, EC = Econlockhatchee, KI = Kissimmee Valley, and ME = Merritt Island N.W.R.

Waterfowl:	CO	EC	KI	ME
Greater/Lesser Scaup	36029	278	352	17108
American Wigeon	60	282	0	3959
Pintail	38	86	0	3398
Ring-necked Duck	66	159	832	1017
Blue-winged Teal	295	211	117	1268
Ruddy Duck	7	1345	282	8
Green-winged Teal	34	34	1	380
Northern Shoveler	162	12	14	211
Mottled Duck	113	67	43	168
Bufflehead	14	0	0	181
Wood Duck	4	22	29	7
Mallard	6	2	1	19
Black Duck	2	0	1	25
Gadwall	1	1	0	19
Common Goldeneye	1	0	0	0
Hooded Merganser	10	38	3	141
Allies:				
American Coot	1827	2200	774	7963
Common Gallinule (Common Moorhen)	323	183	197	1137
Pied-billed Grebe	88	132	57	534
Common Loon	113	67	43	168
Purple Gallinule	0	1	1	0

Table 6. Waterfowl and allies from Christmas counts using the Merritt Island region and comparing recent, historical counts. Relative percentages of recent and historical data are given for comparison.

Waterfowl:	Mean Recent (1987-1989)	% Recent Waterfowl	Mean Historical (1938-1940)	% Historical Waterfowl
Greater/Lesser Scaup	17108	45.5	5667	92.2
American Wigeon	3959	10.6	0	0.0
Pintail	3398	9.1	21	0.3
Ring-necked Duck	1017	2.7	7	0.1
Blue-winged Teal	1268	3.4	351	5.7
Ruddy Duck	8	<0.1	1	<0.1
Green-winged Teal	380	1.0	6	0.1
Northern Shoveler	211	0.6	8	0.1
Mottled Duck	25	0.1	6	0.1
Bufflehead	181	0.5	1	<0.1
Wood Duck	7	<0.1	1	<0.1
Mallard	19	0.1	0	0.0
Black Duck	25	0.1	1	<0.1
Gadwall	19	0.1	3	<0.1
Hooded Merganser	141	0.4	6	0.1
Allies:				
American Coot	7963	21.3	6	0.1
Common Gallinule (Common Moorhen)	1137	3.0	2	<0.1
Pied-billed Grebe	534	1.4	58	0.9
Common Loon	37	0.1	3	<0.1
Purple Gallinule	0	0	0	0.0
Totals	37412		6148	

DISCUSSION AND CONCLUSIONS

Submerged Aquatic Vegetation

The SAV found in the lakes provides good waterfowl and wetland-dependent bird habitat. However, a potential problem is that hydrilla is outcompeting other species by rapid, spreading growth and through the formation of floating rafts which block out light penetration to other SAV. Since none of the other three species of SAV can match the productivity of hydrilla, hydrilla may soon dominate throughout the system. This situation occurred prior to the drawdown of Fox Lake (1978-1979), which substantially reduced hydrilla for a short time but allowed the invasion of cattails. Hydrilla is again the dominant submerged aquatic in Fox Lake, and its invasion is rapidly occurring in South Lake. As reviewed previously, hydrilla coverage of over 20 to 50 percent (as in both lakes) can negatively affect the productivity of the lake.

Water celery appears to be doing well in parts of South Lake as evidenced by overall occurrence and homogeneity of many beds. The morphology of the plant makes it more useful than other species as a forage and nursery habitat, since it does not fill the water column with dense growth. Southern naiad grows best (cleaner, faster growing leaves; much less epiphytes) and provides more important fish spawning and nursery habitat (based on observations of spawning beds) along shore. The plant is part of the SAV problem only by virtue of its being part of the large aquatic bed which occupies the central portion of South lake. Large beds of southern naiad evidently die early in the growing season. The formation of dense mats in turbid water appears to be a common growth habit of the plant (Chabreck and Condrey, 1979), and these mats, living and moribund, are particularly noticeable in South Lake. Importantly, transects in the southern part of the lake showed that hydrilla was dominant in areas where naiad was moribund. Sago pondweed is also important to South Lake, and floating seeds and branches were seen throughout.

The SAV surveys were performed in early summer, when densest vegetation growth had not yet occurred. This provided a truer representation of the distribution of the plants prior to spreading. Visits later in summer indicated that SAV, particularly hydrilla, had become much more dense.

Annual herbicide spraying for cattails and water hyacinth control evidently succeeds in many areas. It is not known what impact the spray or the resulting decaying organic matter have on the environment. More studies of the results of spraying (especially regarding cattails and organic matter deposition) should be performed.

The District also sprays each summer for hydrilla (District, pers. comm.). The spraying takes place from a boat in South Lake and only the dense beds in the southern half and the southeastern shore of the lake are sprayed. This spraying location is ideal as shown by the present study. Because the abundance of native, less invasive SAV is greater in the northern half and western shore, spraying herbicides in these areas should be avoided at present. Fox Lake is sprayed by airplane, since hydrilla dominates much of this area. The low toxicity of the herbicides (Diquat^R, Aquathol^R, and Rodeo^R) and accurate spraying should make the environmental impact of spraying negligible.

In the Brevard County study, the major species of SAV found on South Lake in October 1980 were widgeon grass (far dominant over other species), southern naiad, and water celery. Hydrilla was rare and restricted to the eastern shore and in the channel connection to Fox Lake. In January 1982, much of the lake was determined to be unvegetated by Brevard County, with SAV being dominated by (in approximate descending order of abundance) widgeon grass, southern naiad, and water celery. The present study indicates that widgeon grass was misidentified and was probably sago pondweed. This indicates that sago pondweed was much more common than at present; however, its bushy habit is obvious late in the season, and this habit may have made it appear more abundant. The major change (reduction) in SAV coverage in January 1982 was attributed to dewatering during a 1981 drought. This appears correct, although the "false bottom" of southern naiad seen in the present study may have appeared as unvegetated bottom to researchers in previous studies. A major change in this period as shown in the Brevard County maps is the lakeward growth of cattails (over 500 ft in some areas). Another major trend seen in comparing the Brevard County study with the present one is the tremendous recent increase in hydrilla. Hydrilla coverage increased from an estimated 1 to 22 percent in South Lake.

Avifaunal Habitat

Comparison of avifaunal data with previous summaries and counts shows the lakes are still important bird habitat. Over 20 species of wetland-dependent avifauna may nest in the area. The Brevard County results relative to wetland-dependent species are very similar. The waterfowl numbers from area Christmas bird counts (1987-1989) are important since they show migratory and resident species which should also use South and Fox Lakes. Many of the waterfowl and allies found in these counts do use the lakes, but not necessarily in the same order of abundance. The historical counts (1939-1941) must be used with caution in comparisons, but certain species common today were also common fifty years ago with notable exceptions. Based on historical counts, American wigeon, pintail, ring-necked duck, American coot, and common gallinule may have increased (although national levels are much reduced). One explanation for the increases is the management of the waterfowl which occurred over the past 50 years. It is also possible

that wigeon and pintail both have benefited from migrating and feeding together (facilitating protection and management), and from feeding with geese (e.g., in midwestern and southern croplands). Since the counts are pre-hydrilla, and since American coot, common gallinule, and pied-billed grebe prefer hydrilla, one may also assume their increase is somehow connected to the spread of hydrilla. The waterfowl which heavily use or feed on hydrilla (ring-necked duck, American wigeon, lesser scaup, and blue-winged teal; Johnson and Montalbano, 1984) also underwent large population increases (based on local bird counts) concurrent with the spread of hydrilla.

The lakes provide important habitat for wetland-dependent birds, as evidenced by large numbers of migratory waterfowl, occurrence by bald eagle, osprey, and peregrine falcon, and use by diving and wading birds. However, of species which use the lakes, the migratory waterfowl would be those most adversely affected by the loss of important SAV and degradation of the lakes. Wading and diving birds often seek out lakes with aquatic vegetation and water quality problems (eg., searching for fish kills and stressed fish). The birds which most utilize the lakes during the summer months - the gallinules, diving birds, wading birds, and raptors, and the birds which feed on hydrilla - would probably not be affected by continued hydrilla invasion.

Consequently, restoration activities for the lake relative to the present study may best be focused on migratory waterfowl. Migratory waterfowl need quality foods, and if the productivity of the lake does not supply these, then there are three options: (1) plant waterfowl feeds (wild rice, etc.), (2) manage the growth of, and invasion by, hydrilla, or (3) do nothing. The latter two options were thoroughly evaluated in the Brevard County study, but with primary emphasis on bass fishing and boating. From the viewpoint of migratory waterfowl, the lake still has a number of productive years left before important SAV disappears. Planting feeds will require ongoing, often intensive management, and constant battling with cattails. Upland shorelines would have to be scraped, tilled, and planted with desirable waterfowl foods. The creation of vegetated islands, where cattails might not appear for a period of time, is another partial solution. These types of actions are similar to the stationing of wood duck nesting boxes, except that they require more effort and are not as well-tested. The primary goal relative to wetland-dependent bird management may best be to control, rather than to eliminate, hydrilla (ie., keep it at or below an identified coverage).

Stopping the growth and invasion of hydrilla has been impossible in the U.S., and the plant has become irreversibly naturalized. A number of methods have been used with little long-term success. Annual aquatic vegetation maintenance by mechanical harvesting, and the use of low stocking densities of herbivorous fish, have shown problems (harvesting kills forage fish and carp remove all SAV). The do-nothing option may be favored in view of the efforts which have failed to stop hydrilla growth and lake deterioration. However,

the best advice has been noted by Colle et al. (1987) who stressed that management actions should be taken immediately if hydrilla growth is to be checked at all. This is the situation at South Lake, and at Fox Lake hydrilla has grown beyond the managing stage. For this reason, the recommendation is to act quickly to control hydrilla. Based on the research, the favored options for the lakes are treatment with herbicides (direct application to mapped areas of hydrilla concentration, using ecologically-compatible chemicals) and consideration of low-rate stocking of sterile grass carp. Restoration may be re-evaluated for Fox Lake, including another drawdown and additional work towards removal of cattails. The focus of the present study has been towards avifauna, but studies of the effects of hydrilla on fisheries, and the results of the present fish study being completed by the District, should also be taken into account in the final recommendations.

REFERENCES

Brevard County Water Resources Department. 1983. South Lake 314 Lake Restoration Project: Design and feasibility Study. Brevard County, 273 pp.

Chabreck, R.H. and R.E. Condrey. 1979. Common Vascular Plants of the Louisiana Marsh. L.S.U. Center for Wetland Resources. Sea Grant Pub. # LSU-T-79-003, 116 pp.

Colle, D.E. 1982. Hydrilla - Miracle or migraine for Florida's sportfish. Aquatics, 4(2): 6.

Colle, D.E., R.L. Cailteux and J.V. Shireman. 1989. Distribution of Florida largemouth bass in a lake after elimination of all submersed aquatic vegetation. N. American J. of Fisheries Management, 9:13-218.

Colle, D.E., J.V. Shireman, W.T. Taylor, J.C. Joyce and D.E. Canfield Jr. 1987. Influence of hydrilla on harvestable sportfish populating angler use, and angler expenditures at Orange Lake, Florida. N. American J. of Fisheries Management, 7: 410-417.

Eleuterius, L.N. 1981. Tidal Marsh Plants of Mississippi. Mississippi-Alabama Sea Grant Consortium, 131 pp.

Esler, Daniel. 1989. An assessment of American coot herbivory of hydrilla. Journal of Wildlife Management, 53(4): 1147-1149.

Godfrey, R.K. and J.W. Wooten. 1981. Aquatic and Wetland Plants of Southeastern United States. Vols. I and II. University of Georgia Press, Athens.

Haller, W.T. and D.L. Sutton. 1975. Community structure and competition between Hydrilla and Vallisneria. Hyacinth Control J., 13:48-50.

Hotchkiss, N. 1970. Common Marsh Plants of the United States and Canada. Dover Publications, Inc., N.Y., 244pp.

Johnson, F.A. and F. Montalbano, III. 1984. Selection of plant communities by wintering waterfowl on Lake Okeechobee, Florida. J. Wildl. Management 48:174-178.

Johnson, F.A. and F. Montalbano, III. 1987. Considering waterfowl habitat in hydrilla control policies. Wildlife Society Bulletin, 15:466-469.

Martin, A.C. and F.J. Uhler. 1939. Food of game ducks in the United States and Canada. U.S. Dept. Agri. Tech. Bull. 634, Wash., D.C.

Montalbano, F., III, S. Hardin, and W.M. Hetrick. 1979. Utilization of hydrilla by ducks and coots in central Florida. Proc. Ann. Conf. Southeast Assoc. Fish and Wildl. Agencies, 33:36-42.

Moxley, D.J. and F.H. Langford. 1982. Beneficial effects of hydrilla on two eutrophic lakes in central Florida. Proc. Ann. Conf. Southeast Assoc. Fish and Wildl. Agen cies, 36:80-286.

Peterson, R.T. 1980. A Field Guide to the Birds East of the Rockies. Houghton Mifflin Co., N.Y., 384pp.

Robbins, C.S., B. Brunn, and H.S. Zim. 1966. A Guide to Field Identification: Birds of North America. Western Pub. Co., Racine, Wisc., 340pp.