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TECHNICAL REPORT A-78-2

LARGE-SCALE OPERATIONS MANAGEMENT TEST OF USE OF THE WHITE AMUR FOR CONTROL OF PROBLEM AQUATIC PLANTS

Report I

BASELINE STUDIES

Volume I

The Aquatic Macrophytes Of Lake Conway, Florida

by Larry E. Nall and Jeffrey D. Schardt

Florida Department of Natural Resources
Division of Resource Management
Bureau of Aquatic Plant Research and Control
Tallahassee, Fla. 32304

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Report I of a Series

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U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

LARGE-SCALE OPERATIONS MANAGEMENT TEST OF
USE OF THE WHITE AMUR FOR CONTROL OF
PROBLEM AQUATIC PLANTS

Report 1: Baseline Studies

Volume I: The Aquatic Macrophytes of Lake Conway, Florida

Volume II: The Fish, Mammals, and Waterfowl of Lake Conway, Florida

Volume III: The Plankton and Benthos of Lake Conway, Florida

Volume IV: The Nutrient Budget of Lake Conway, Florida

Volume V: The Herpetofauna of Lake Conway, Florida

Volume VI: The Water and Sediment Quality of Lake Conway, Florida

Volume VII: A Model for Evaluation of the Response of the Lake Conway, Florida, Ecosystem to Introduction of the White Amur

Volume VIII: Summary of Baseline Studies and Data

Report 2: First Year Poststocking Results

Report 3: Second Year Poststocking Results

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This report presents the results of studies intended to provide baseline information in preparation for measuring the effect of the white amur on the aquatic vegetation of Lake Conway, Florida. The sponsors hope to assess the environmental impact of the fish, evaluate its ability to control vegetation, develop ecological models to predict the effect of the fish on other systems, and devise a management plan for large-scale use. Included herein are (1) descriptions of the methods of and materials used in aquatic plant research in
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20. ABSTRACT (Continued).

Lake Conway, (2) results and observations made during and subsequent to the test period, and (3) a literature review. Appendix A presents the Stratified Random Sample Results; Appendix B, Numerical Summary of Transect Results; Appendix C, Graphs of Selected Transect Results; Appendix D, Monthly Standing Crop Changes; Appendix E, Numerical Summary of Permanent Plot Data; Appendix F, Graphs of Selected Permanent Plot Data; and Appendix G, The Approximate Distribution of the Dominant Plants in Lake Conway.

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PREFACE

The work described in this volume was performed under Contract No. DACW39-76-C-0084 between the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., and the Florida Department of Natural Resources. The work was sponsored by the U. S. Army Engineer District, Jacksonville, and by the Office, Chief of Engineers, U. S. Army.

This is the first of eight volumes that constitute the first of a series of reports documenting a large-scale operations management test of the use of the white amur for control of problem aquatic plants in Lake Conway, Fla. Report 1 presents the results of the baseline studies of Lake Conway; subsequent reports will present the annual poststocking results.

This volume was written by Mr. Larry E. Nall and Mr. Jeffrey D. Schardt of the Florida Department of Natural Resources. The authors wish to thank Mr. Robert L. Lazor for his administrative management of the project and his aid in plant identification, biologists Terry Goldsby, David Tarver, and especially Mike Mahler for their help with sampling during the initial months of the project, and particularly our field assistants, John Swed and Chip Swindell, and our secretary, Lis Frey.

The work was monitored at WES in the Mobility and Environmental Systems Laboratory (MESL), under the general supervision of Mr. W. G. Shockley, Chief of MESL, and Mr. B. O. Benn, Chief of the Environmental Systems Division, and under the direct supervision of Mr. J. L. Decell, Chief of the Aquatic Plant Research Branch (ARPB). The ARPB is now part of the recently organized Environmental Laboratory of which Dr. John Harrison is Chief.

Commander and Director of WES during the period of the contract was COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

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U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
acres	2.49	hectares
tons	907.1847	kilograms

LARGE-SCALE OPERATIONS MANAGEMENT TEST OF USE OF THE WHITE AMUR FOR CONTROL OF PROBLEM AQUATIC PLANTS

BASELINE STUDIES

The Aquatic Macrophytes of Lake Conway, Florida

PART I: INTRODUCTION

1. The U. S. Army Corps of Engineers is charged with the responsibility of maintaining the navigability of the nation's waterways as one of its primary tasks. Nuisance aquatic plants often so clog these waterways that navigation is greatly impeded. Chemical plant controls, which the Corps presently uses, are expensive and only temporary. The Corps' Waterways Experiment Station (WES) has begun a search for biological control agents for aquatic weeds. Biocontrol promises to be the best long-term and least expensive solution to the problem. The white amur (grass carp) has shown the greatest potential as a biocontrol agent for aquatic plants, especially hydrilla, the submerged plant which creates the greatest problem in the South.

2. To evaluate the effectiveness of the amur as a weed control agent, the Corps selected Lake Conway as a test site. The official title of the project is "Large-Scale Operations Management Test of Use of the White Amur for Control of Problem Aquatic Plants" (LSOMT). From the Lake Conway study, the Corps hopes to assess the environmental impact of the fish, evaluate its ability to control vegetation, develop ecological models to predict the effect of the fish on other systems, and devise a management plan for large-scale use.

3. Various Florida agencies have been contracted by the Corps of Engineers to conduct research on a particular phase of the project. The Game and Fish Commission is sampling the fish and waterfowl populations. Orange County Pollution Control is collecting water and sediment samples. The University of South Florida is monitoring the herpetofauna and the University of Florida is studying the plankton and periphyton. The

University of Florida is also developing the ecosystem model.

4. The Florida Department of Natural Resources is responsible for monitoring the aquatic macrophytes in the lake. Area coverage, biomass, species composition, phenology, stem density, and height profile were measured for one year before stocking. The results of these studies are reported herein and is classified as baseline data. These parameters will be monitored after stocking until the termination of the project. From these data we hope to determine the effect of the amur on the ecology of the aquatic plants. Of especial interest is the effect on hydrilla, which is the target plant of the study, and the associated response of other species after its removal. Specific goals and methodology were outlined in a preliminary report; however, some modifications in the project design have been made since that time.[1]

5. The white amur was stocked in Lake Conway on September 9, 1977. The stocking rates, which are different for each pool, are shown in Table 1. These figures were determined by the experimental stocking rate model, which considers vegetation biomass and other parameters in its computations. The stocking rate model predicts control after about four years (Figure 1). All fish used in Lake Conway are monosex to insure reproduction will not occur. The monosex technique is reviewed by Stanley.[2]

6. For greater detail about the project design, refer to References 3 and 4 and reports by individual contractors.

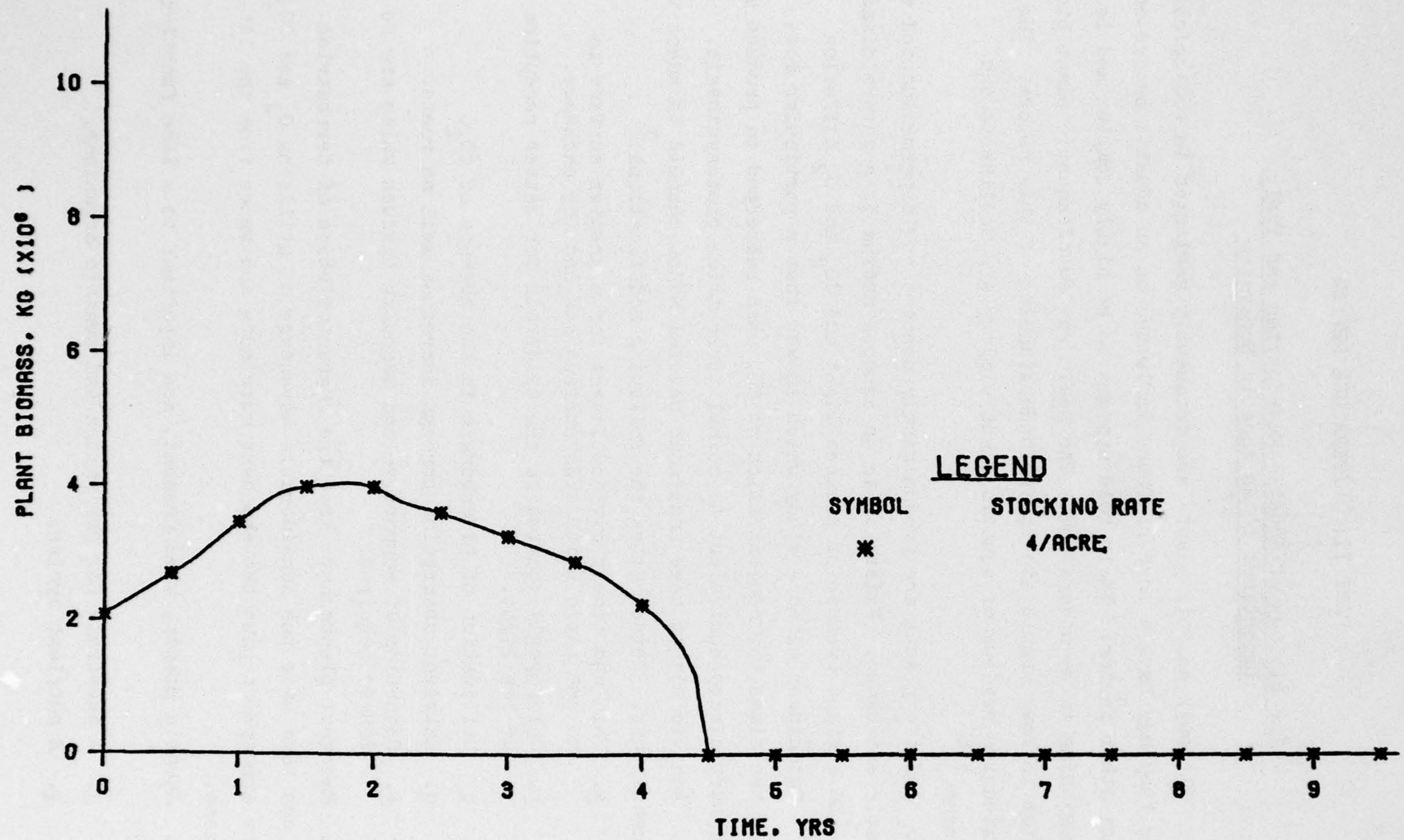

Figure 1. Stocking rate model prediction of vegetation control in Lake Conway, given as plant biomass vs time with stocking weight equaling 0.32 kg/fish

PART II: LITERATURE REVIEW

The Biology of Aquatic Macrophytes and Their Importance to an Aquatic Ecosystem

7. Although aquatic plants are frequently neglected in ecological studies they may have a more profound influence on an aquatic ecosystem than any other factor. Their role appears to be highly complex and is only beginning to be understood. The basic review of aquatic plant biology which follows should aid in the understanding of this report. The most extensive reviews of aquatic plant biology are Sculthrope and Hutchinson.[5,6]

8. Aquatic plants are predominantly monocot angiosperms adapted to an aquatic existence. Existence in an aqueous medium is a severe disadvantage to a plant because of reduced light and CO_2 and O_2 diffusion rates.[6] Hutchinson cites a study which showed that a particular moss required ten times the concentration of CO_2 when submerged to produce a photosynthetic rate equivalent to normal terrestrial photosynthesis.

9. Aquatic plants have undergone several major changes to adapt to these conditions. Wetzel cites the following modifications:[7]

- a. Thin and finely divided leaves for a greater surface to volume ratio which aids surface gas and ion exchange.
- b. Chlorophyll located in the epidermis for better reception of low light.
- c. Utilization of bicarbonate in the absence of CO_2.
- d. Nutrient absorption through leaves as well as roots.
- e. Reduction of supportive and vascular tissues which are no longer required.

10. Emergent plants have kept the characteristics of terrestrial plants and thus have the considerable advantage of utilizing O_2 and CO_2 from the atmosphere plus the abundant nutrients and water from the littoral zone.

11. Aquatic plants, when present, are important to a lake functioning as:

- a. A substrate for periphyton and benthic organisms.
- b. A nutrient cycler.

c. A food source.

d. Inhibator of phytoplankton and some zooplankton.

e. Cover for larger organisms.

f. An influence on the chemical composition of the water.

g. An influence on the hydrologic cycle.

h. Directly or indirectly responsible for most of a lake's production.

12. Perhaps the most important function of aquatic plants in a lake is to provide habitat for other organisms. Harrod and Hall hypothesized that the biomass of periphyton and the associated community are directly proportional to the surface area of the submerged plants. They felt that the surface area of plants is a valuable parameter and suggested a method for its measurement.[8]

13. Aquatic plants can be valuable for a fishery by providing nutrients and a substrate for periphyton which is necessary for macroinvertebrate production; although detritus materials are supposedly more productive as a substrate than any aquatic plant communities.[9,10] Martin and Shireman described a new device to sample macroinvertebrates on hydrilla and presented information on its fauna.[11] An increase in vegetation density can increase macroinvertebrate diversity and standing crop.[12] Although aquatic plants indirectly provide much fish food via macroinvertebrate production, they can also have considerable detrimental effect on fish production. Dense stands of aquatic plants provide excellent cover for forage fishes.[13,14] This cover can reduce predation by piscivorous fishes thus reducing production. The cover can also cause overpopulation and stunting of the forage species.[15,16,11] Numerous authors including Buck et al., Heman et al., and Hickman and Congdon cite an improvement in the fishery when aquatic plants are removed.[17,14,18] Phillipphy briefly reviewed the positive and negative effects of vegetation on fisheries.[19] Carter and Hestand found that a 30-40 percent cover of aquatic vegetation is necessary to stabilize a lake's water quality and phytoplankton population. They state that Florida fishery biologists recommend a 50 percent cover for maximum fishery production.[20] Carter and Hestand believe that a 40 percent cover would be

a good compromise between water condition, fisheries, and lake utilization.

14. Aquatic macrophytes, including the charophytes, are able to actively remove nutrients from the water column and the sediments.[6,21] There has been considerable debate over whether the roots or the leaves are the primary site of absorption. In fact, roots were once considered as organs of attachment only.[6,7] However, it has been shown that the roots are the primary site of absorption.[22,6,21,7] Also, bottom type (and its nutrient content) greatly influences plant distribution.[23] Even the rootless Ceratophyllum demersum and the sparsely rooted hydrilla showed significantly greater growth when planted in a rich mud versus a poor sand substrate. Hydrilla appeared highly dependent on its root system which is curious in view of that system's relatively small size.[23] Even the nonvascular charophytes can absorb nutrients from the sediments and translocate them upward.[6]

15. Since the leaves of aquatic plants are capable of absorbing nutrients from the water, it has long been assumed that the submerged plant community removed nutrients from a body of water, thus inhibiting other forms of plant growth. This might not be true! McRoy and Barsdate showed that Zoster marina absorbed radioactive phosphorus from the sediments and transported it throughout the plant where much was lost to the surrounding water.[24] Reimold showed a similar action in Spartina alterniflora.[25] Wetzel stated that aquatic macrophytes secrete dissolved organic carbon and N_2.[7] Wetzel discussed the factors influencing dissolved organic matter secretion and production in calcareous lakes.[26] Wetzel and Manny found that the organic carbon secreted from macrophytes varied from one to ten percent of the total carbon fixed.[26] They also discovered that the secreted compounds were simple sugars, primarily glucose, and that as eutrophication increases, so does the relative percentage of secretion. Wetzel and Manny also stated that secretion proceeds faster in the dark and Hough and Wetzel found that the secretion rate was up to twice as fast in darkness as in light.[28] They also found a seasonal variation which showed a four times increase during the fall senescence. Allen found that Najas flexilis secreted seven percent of the total

dissolved organic carbon fixed during a 3-3/4 hour period.[29] Allen felt that this nutrient secretion was responsible for much of the epiphytic production, which was 21.4 percent of the total production in his study lake. The presence of diatomaceous epiphytes actually induces an increase in the rate of secretion.[28] This could indicate a type of symbiosis between submerged plants and their epiphytes. McRoy and Barsdate hypothesized that the primary site of nutrient uptake and the amount of secretion is controlled by the relative concentration of the nutrients in the water and sediments.[24]

16. The presence of aquatic plants may physically and chemically alter a body of water. During photosynthesis, plants consume CO_2 and produce O_2, and thus, could oxygenate a lake. But, during respiration, the reverse is true and the plants can deplete a lake's oxygen. Buscemi described oxygen depletion produced by a heavy cover of Elodea canadensis.[30] The depletion was caused by inhibition of vertical circulation and by oxygen consumption by lower stems and leaves shaded by the surface cover. Westlake calculated that 1.78 kg/m^2 fresh weight of Potamogeton pectinatus can produce 0.72 g $O_2/m^2 \cdot hr^{-1}$ and could raise the dissolved oxygen content of a stream by 2.6 ppm per kilometre.[31] The consumption of CO_2 causes a shift in the inorganic carbon state. A raise of pH accompanies this shift and the relative supply of carbonates and bicarbonates increases. These compounds can be used as carbon sources but are less efficient than CO_2, thus, production is lower.[6] In one case, Potamogeton crispus metabolism caused a rise in pH to 10.2 which inhibited spawning in bass.[32] The measurement of the evolution and consumption of O_2 and CO_2 has been the basis for production studies of many lakes and species of plants. Most of the studies are probably invalid because the effect of the lacunal system was not considered.[33] The lacunal system in aquatic plants is a storage reservoir for excess CO_2 and O_2. The plants will consume the products stored in this system before drawing them from the water, thus the lacunal system dampens the effect the plant has on the lake.

17. The hydrologic cycle is also affected by aquatic plants. Typha latifolia was shown to triple water loss per unit inhabited area

during the day.[6] This is caused by transpiration and increased evaporation because of reduced water movement. The net loss of water, however, is actually lessened, because the plants impede air movement which would carry away the moisture-saturated air and increase evaporation. Transpiration does not occur at night.

18. Aquatic macrophytes may possibly be a phytoplankton inhibitor. Penfound and Hasler and Jones have observed inhibition of the phytoplankton by aquatic macrophytes but were unable to find the cause.[34,35] Possible reasons cited were as follows: competition for nutrients, shading, or an inhibiting antibiotic.

19. Although aquatic macrophytes are poorly productive when compared to terrestrial plants they are often directly or indirectly responsible for most of the production in a lake where they are abundant.[36] Rich et al. found that macrophytes produced 48.3 percent of the production (82.77 g $C/m^2 \cdot yr^{-1}$) of a Michigan marl lake.[37] Adams and McCracken measured a production rate of 3.35 g $C/m^2 \cdot day^{-1}$ for _Myriophyllum spicatum_.[38] As previously mentioned, aquatic plants are responsible for most of the nutrients used by epiphytes, which also constitute a considerable portion of the lake's production. Submerged macrophytes may outproduce phytoplankton three to four times per unit weight.

Biomass and Production Studies

20. Although aquatic macrophytes often represent a substantial portion of the production in many lakes and are a vital part of the ecosystem, many ecological studies totally ignore this phase of the system. In fact, only two major limnology texts, Wetzel and Hutchinson, adequately review the aquatic macrophytes.[7,6] At best, aquatic plant studies have been directed at species composition and percent cover along point transects. Present estimates of vegetation for plant control are made by estimating percent cover. This is quite inadequate since chemical and biological control agents will affect the biomass of plants rather than the percent cover which might be totally unrelated. The reason for this lack of knowledge is an absence of technology.[39]

"Standard Methods for the Examination of Water and Wastewater," which is the bible of water quality studies, devotes only a page to the subject and in essence states such studies should be done but offers little information on technique.[40] R. D. Wood authored a manual on "Hydrobotanical Methods" which gives step-by-step procedures for aquatic vegetation surveys and estimation of production using laboratory techniques; however, little guidance is given for the measuring of biomass, especially for lake systems.[41]

21. Westlake and Fosberg adequately reviewed the problems facing an investigator in this field.[42,39] Aquatic plant biomass is extremely variable through time and from point to point and plant distribution is often non-random. This creates difficulty in normal statistical methodology. Westlake recommends a stratified random type of sampling design. Sampling in large areas without vegetation produces a large amount of zeros in the data which further complicate analysis. Biomass analysis of only the area with plants was recommended. He also suggests restricting intensive sampling to homogenous quadrants representative of the lake. Recommended sampling techniques include using a diver with a standard square or various types of grabs (i.e. Eckman, Peterson, etc.). Lind and Cottam, Wood, and Wood and Hargraves also recommend the use of scuba divers to sample aquatic vegetation.[43,44,45] Fosberg states that diving with a square is inconvenient, slow, the visibility is poor (resulting in sampling error), and the square placement can modify the plant mass resulting in a non-representative sample.[39] We heartily concur with his opinion. Westlake and Harrod and Hall warn that grabs may yield erroneous samples.[42,8] In Florida, these grabs can not contain the quantity of vegetation they sample. Fosberg constructed a sampling device specifically for dense vegetation, but concedes that it only works on a soft bottom and that it consistently underestimates the standing crop.[39] Rich et al. used a free-falling steel tube with a toothed cutting edge but found it was not effective in elongated plants such as Potamogeton.[37] Manning and Sanders described their sampler, which is a free-falling 0.37-m^2 box with a sharp cutting edge.[46] This sampler also requires a diver to manipulate a cutter to sever the plants at the hydrosoil;

although this appears to be the best aquatic macrophyte sampler reported in the literature to date, the use of a diver makes it time consuming and inconvenient. Owens et al. correlated biomass with light extinction using a submarine photometer and thus developed a technique acceptable for rapid survey.[47] Westlake emphasizes that there have to be tradeoffs between time, manpower, funds, and the quality and quantitiy of data taken.[42]

22. Westlake also attempted to standardize terminology and techniques since the results of earlier studies were not comparable because of the variety of techniques used.[35] The following terms were defined:

- a. Crop--total weight taken over a period (usually excludes roots).
- b. Standing Crop--weight harvested from an area at a particular time.
- c. Yield--crop expressed as a rate per unit time.
- d. Biomass--weight per unit area (all parts included).
- e. Productivity--production per unit time.
- f. Gross Production--production with respiratory losses included.
- g. Net Production--production excluding respiratory losses.

23. The terms crop, standing crop, and yield are non-technical and imprecise since they are based on crop which varies with each investigator's need. The other definitions are fixed and precise.

24. Production may be estimated by measurement of change in biomass or by measuring changes in O_2 and CO_2 (which can often give misleading results) or by measuring uptake of radioactive ^{14}C which requires some rather specialized equipment and procedures.[36,41,48] Time units used in calculating productivity may be chosen to suit the particular situation and the results can be expressed as weight, organic matter or carbon per unit area per unit time.[35] Westlake states that the maximum seasonal biomass of aquatic macrophytes probably represents one year's production since, in his estimation, no more than 20 percent could remain from the previous year and these will probably die during the course of the year.[35]

25. Westlake also reports that the maximum known biomass of a

freshwater aquatic macrophyte was 680 g dry weight/m^2 of Ceratophyllum demersum.[36] Adams and McCracken found the maximum standing crop of Myriophyllum spicatum was 172 tons dry weight in a 139.6 ha Wisconsin lake (112 g/m^2). The maximum production found was 3.35 g C/day^1/m^2.[38] Adams and McCracken reviewed other works on Myriophyllum and concluded that their biomass and production values were much higher than any previously reported. Odum found 578 g dry weight/m^2 for Sagittaria lorata in Silver Springs, Florida.[49] Penfound reviewed production in aquatic plants and found that they exceeded the production of typical field crops such as hay, grasses and rice. He noted that the highest aquatic plant production occurred in the spring and fall and the lower in summer. He concluded that this was due to the low photosynthesis-to-respiration ratio which occurs at high temperatures.[34] Adams and McCracken, Odum, and Westlake state that peak biomass occurs at the time of fruiting or flowering.[38,49,36]

A Review of Hydrilla Verticillata Royle

26. A review of the information available about hydrilla is appropriate here since control of that plant is the ultimate goal of this research.

27. Hydrilla is a submerged, rooted vascular plant which belongs to the family Hydrocharitaceae. The plant is long and flexible with branching stems and is supported by its own buoyancy. The leaves are found in whorls of 4-8, typically five. The internodal distance is highly variable depending on water conditions and light. Only the female plant is known in the United States. Pendland studied the internal anatomy of hydrilla.[50] The plant forms dense growths in many lakes and typically forms a thick surface mat which restricts light penetration. Hydrilla may have 20 percent of its total biomass in the upper 10 cm of the water column.[51] The plant is often confused with two other members of the family, Elodea canadensis and Egeria densa. Serated leaf margins distinguish hydrilla from those plants.

28. Hydrilla was introduced into canals in south Florida in 1960, presumably by the aquarium industry. The plant is now found in Alabama,

Georgia, Louisiana, Texas, Iowa, and California. Hydrilla has the ability to rapidly infest and dominate an aquatic environment. Hydrilla went from a 1-ha infestation in 1971 to a 1200-ha coverage in four years in Rodman Reservoir.[52] In Orange Lake, hydrilla spread form 1 ha to over 4000 ha in three years; this represents a 90 percent cover for that lake.[53] Lakes George, Jackson, Okeechobee, Seminole, Tohopekaliga, and East Lake Tohopekaliga, which are some of Florida's most famous and most utilized lakes, all contain recent hydrilla populations which have the potential for major infestations.

29. Since the male plant is absent from the United States, all reproduction is asexual. Hydrilla reproduces itself from fragmented tissues, rhizomes, turions (axial formed buds), and tubers at a depth of 5 to 10 cm in the hydrosoil.[53] Tubers are the most important source of regrowth of hydrilla and are highly resistant to environmental and control factors. Tuber formation occurs from October through April in Florida; germination occurs throughout the year, though primarily in spring and summer.[54] Tuber size and number are positively correlated with water depth. Light is the only known stimulant needed for sprouting.[54] Haller and Sutton found 257 tubers per square metre in a study pond.[51] Tubers may lie dormant but viable for up to ten years.*

30. Haller and Sutton studied the competitive ability of hydrilla.[51] The plant is highly efficient in its utilization of light. Hydrilla can actively produce at ten to twelve microeinsteins m^{-2} sec^{-1} which is equivalent to about three percent of high incident light levels. This is significantly less than other Florida species which might compete with hydrilla. Many species are adapted to narrow light realms, restricting their distribution within a lake. Hydrilla has none of these restrictions; it can colonize the deep low light areas as well as shallow high light situations.[55] Chromatic adaptation and efficient conservation of respiratory energy are partially responsible for the ability to exist in low light.[56,55] Hydrilla also has a low percentage (13 percent) of roots relative to its biomass. A high proportion of non-photosynthetic

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* W. T. Haller, personal communication.

material deprives the rest of the plant of much of its energy.[51] The ability to photosynthesize in low light levels is a special advantage in the early morning. Hydrilla is able to use the free CO_2 that was evolved during the night's respiration before the other plants are active. Use of CO_2, versus use of HCO_3^-, is much more efficient. The thick canopy formed by hydrilla cuts light penetration by as much as 95 percent in the first 0.3 m, which eliminates other competing species and insures a monotypic stand of hydrilla.

31. The light-saturated photosynthetic rate for hydrilla was round to be 5.4 μ mole CO_2/mg^1 Chl/hr^1.[55] This rate is similar to those reported earlier by Van et al.[57] Studies on the biomass production by hydrilla are lacking. Haller and Sutton found 184 g/m^2 of dry weight in shallow ponds.[51] This is not particularly impressive compared to reports on other species cited previously. The dry weight of hydrilla varies from 5.8 to 13.5 percent of the wet weight according to Boyd and Blackburn or 10.3 percent according to Tan.[58,59] Little Lake Barton in Orlando contained an average of 2.919 kg/m^2 wet weight in October, 1976.* Peak biomass appears to occur in late summer at the time of flowering.

32. After peak biomass is attained, a rapid decline occurs.[53] This decline appears to be more drastic in hydrilla than other submerged plants, which seems curious for such an agressively competitive plant. This decline is of particular interest since it represents a possible weak point in the plant's life cycle. Berg studied this phenomenon and found the decline is caused by (1) an overabundance of toxin producing epiphytic bacteria promoted by dissolved organic matter secreted by the hydrilla mat, (2) epiphytic interference with CO_2 diffusion, (3) self shading, (4) seasonal reduction in solar radiation which causes respiration to increase and negative production to occur.[53] There is also a possibility that hydrilla undergoes an intrinsic seasonal decline regardless of external factors. Temperature is not suspected since the decline also occurs in south Florida where temperature drops are not severe.

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* John Osborne, personal communication.

33. Control of hydrilla is accomplished almost entirely with herbicides. Mechanical control is expensive and unable to keep up with rapid regrowth. Biocontrol agents are unknown, except for the white amur which is still experimental. Drawdown is an excellent control measure for hydrilla but the capability is often not present and the tubers are resistant and may presist for many years.[60] Control of hydrilla by controlling its nutrients has been proposed but as yet has not been developed.[61] Diquat with copper and Endothall compounds appear to give the longest control of hydrilla and favor regrowth of native plants but chemical control causes considerable imbalance in water quality and phytoplankton populations.[62,20]

Feeding Preferences of the White Amur

34. Table 2 shows the approximate order of feeding preference of the white amur on species common to Florida. The list was derived from the literature listed on the table. Occasionally subjective judgement was used to integrate the various studies. Edwards reported that grass carp grazed little on other species when a highly preferred species was present.[63] Edwards also stated that if Nitella hookeri, a highly preferred species, was present, no other species would be heavily grazed. However, it is unknown if the fish is selective when two or more highly favored species are present.

PART III: METHODS AND MATERIALS OF AQUATIC PLANT RESEARCH IN LAKE CONWAY

Aquatic Macrophytes

35. The term aquatic macrophyte is not clearly defined and usually varies from one study to another often according to the author's "likes" rather than a standard definition. This study will use Fassett's definition of aquatic macrophyte as a plant that may, under normal conditions, germinate and grow with at least its base in the water and is large enough to be seen with the naked eye.[72] This definition includes the macrophytic algal family Characeae; however, in our usage no other algaes are included. The large filamentous algaes are not accurately sampled with our device.

Identification

36. Plants collected during this study were identified using Fassett, Beal, Hotchkiss, Muenscher, and Radford et al.[72-76] For each species, photographs and voucher specimens are taken. If our identification is questionable for any plant, the specimens will be sent to various museums until they can be accurately identified.

Study Site

37. Lake Conway is a 737.1-ha lake (Figure 2) located in South Orlando, Florida.[77] The lake is divided into five interconnected pools consisting of Lake Gatlin, Little Lake Conway (east and west pools) and Lake Conway (north and south pools). Lake Conway is an urban lake representative of central Florida. The typical shoreline vegetation of cattail (Typha latifolia L.), maidencane (Panicum hemitomon Schult), and torpedograss (Panicum repens L.) has been removed around much of the lake. Illinois pondweed (Potamogeton illinoensia Morong.), nitella (Nitella megacarpa), American eelgrass (Vallisneria americana L.), and hydrilla (Hydrilla verticilla Royle) are the dominant submersed aquatic

Figure 2. Lake Conway, Florida

species. Pondweed is a problem in parts of the lake. Hydrilla has been a problem in the past, but it has not recovered from a chemical treatment in 1975.

Transects

38. Each month, 18 transects (Figure 3) are sampled at 100-m intervals with a prototype biomass sampling barge (Figure 4a). The barge is firmly anchored over the sample site and the sampling device (Figure 4b) is slowly lowered through the water column. As the cylindrical sampler is lowered, the rotating blades cut a core through the vegetation. Upon contact with the bottom, doors on the bottom are closed and the sampler is returned to the surface bearing a 0.257-m^2 sample of vegetation (Figure 4c). The sampler is powered totally by hydraulics. About 200 samples are obtained each month.

39. Each sample is separated to species. Reproductive structures, if any, are noted. Mud and periphyton are washed from each sample and excess water is removed by vigorous shaking. Fresh weight is then taken to the nearest gram. Each sample is then put through a five-minute spin cycle in a washing machine to insure that all excess water is removed; again each sample is weighed to the nearest gram. All samples are dried at 105° C for 24 hours in a circulating air-type oven and then weighed to the nearest thousandth of a gram immediately to avoid hygroscopic errors. All three methods of weighing are used so that the project results will be comparable with other experiments which use only one of these methods.

Random Sampling

40. Transect sampling, because of its fixed nature, cannot estimate the actual amount of vegetation in the lake. Random sampling can give an estimate of this value as well as an estimate of its accuracy. Fixed sampling is more appropriate for accurately measuring change at a particular point. Random sampling requires a large number of samples

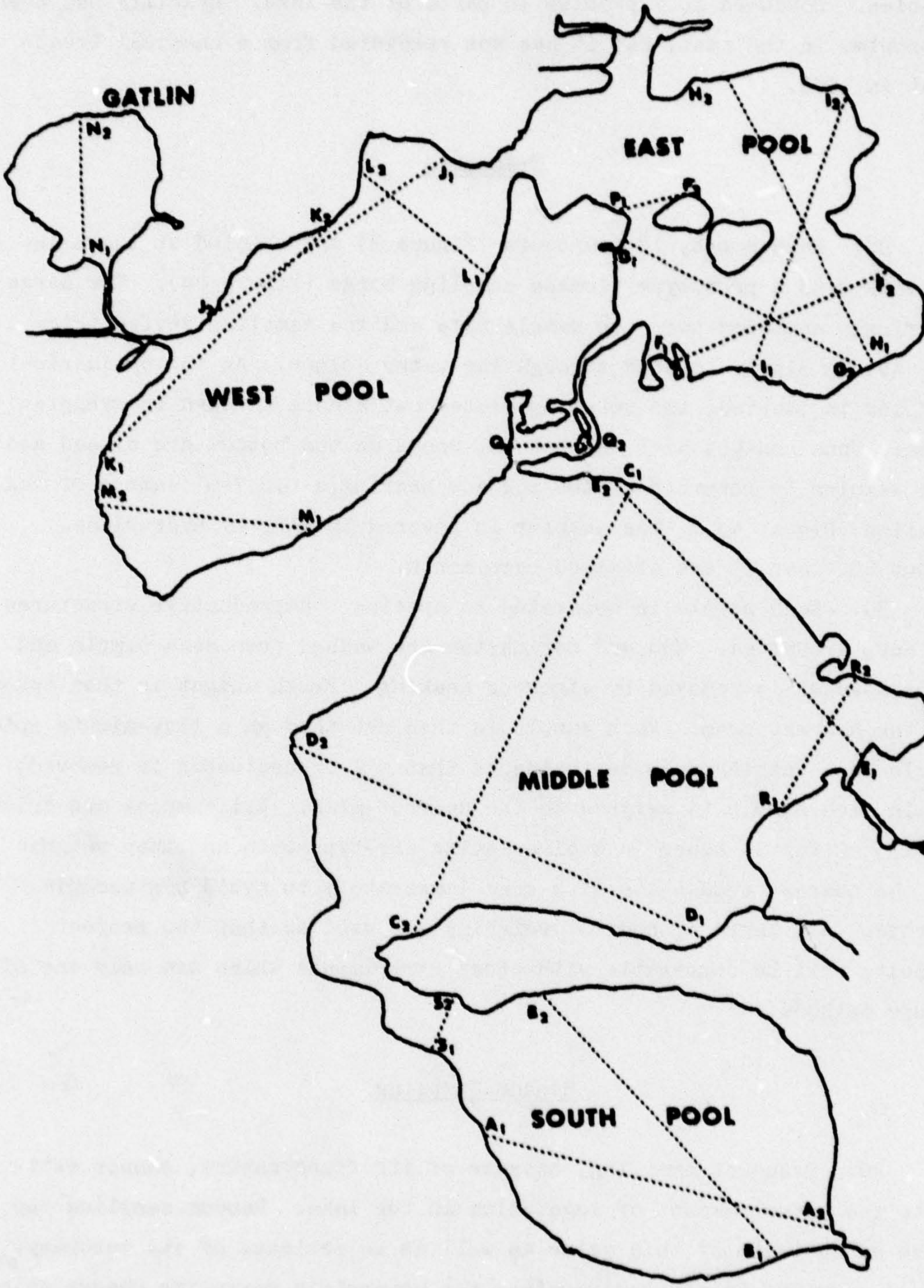
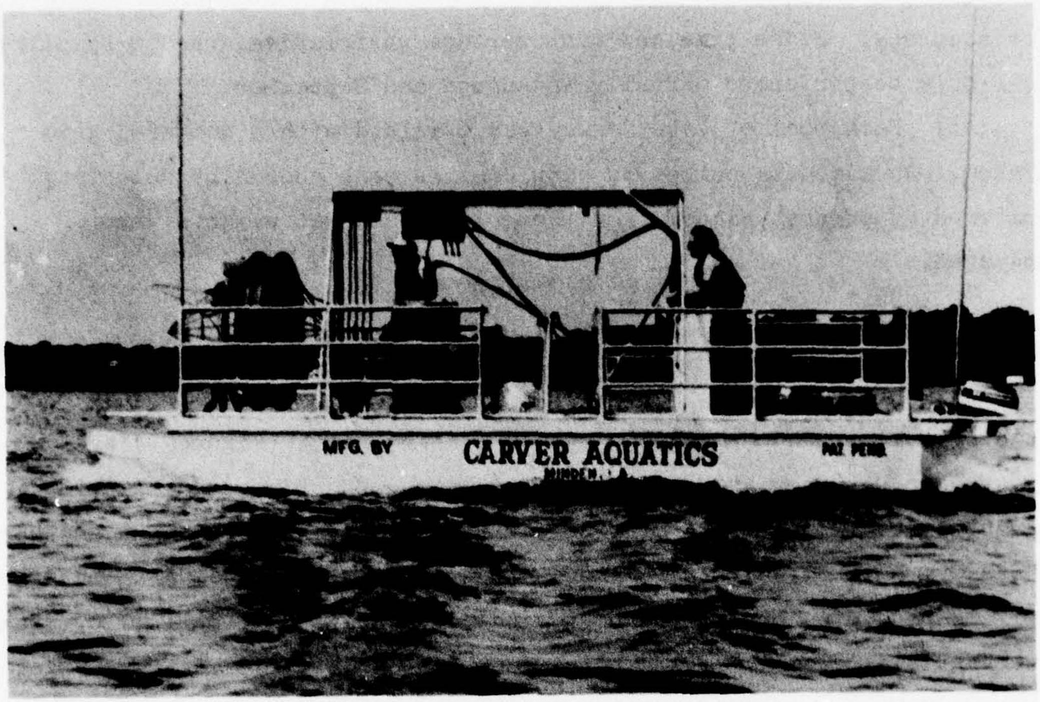
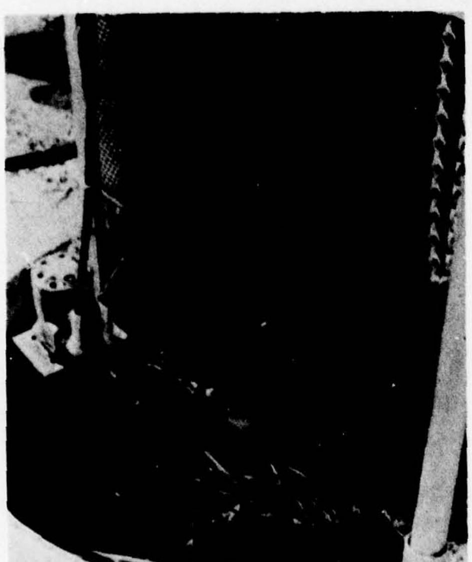
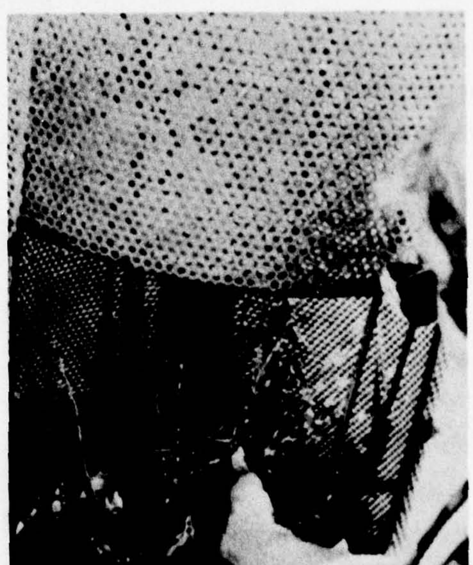


Figure 3. Transect locations



(a)





(b) (c)

Figure 4. Sampling device

for accuracy. Since time and manpower are restrictive, random sampling will only be performed annually in August and September.

41. Each pool of Lake Conway was overlaid with a numbered grid system. An adequate number of sample sites were chosen by selecting numbered squares at random from the grid. Only wet weights were measured.

Fixed Plots

42. Eighteen permanently marked 0.10-ha plots (Figure 5) are located in representative areas of the lake. Shortly after sampling began, plots 12 and 17 were treated with herbicide by residents and were therefore omitted. Figure 6 shows a representative plot. A scuba diver swims a random underwater pattern within the plot while making 30 visual observations. This yields species composition of the area. Two vegetation heights are measured at exactly the same points each month. Two random areas within the plot are selected and a 0.25-m^2 of vegetation is removed by the diver. From this square, the vegetation height is measured, the number of rooted stems is counted, and the internodal lengths and stem lengths of representative plants are recorded.

Exclosures

43. Several 5- × 5-m exclosures will be placed in heavily vegetated areas. These areas should visually show the effect of the amur around the structure, while offering an untouched control area inside. Each month one random 0.25-m^2 of vegetation will be taken and treated as are the plot quadrants above. Exclosures will also be monitored photographically.

Diversity

44. The number of species and their relative abundance (either number or weight) is important to consider. Many mathematical

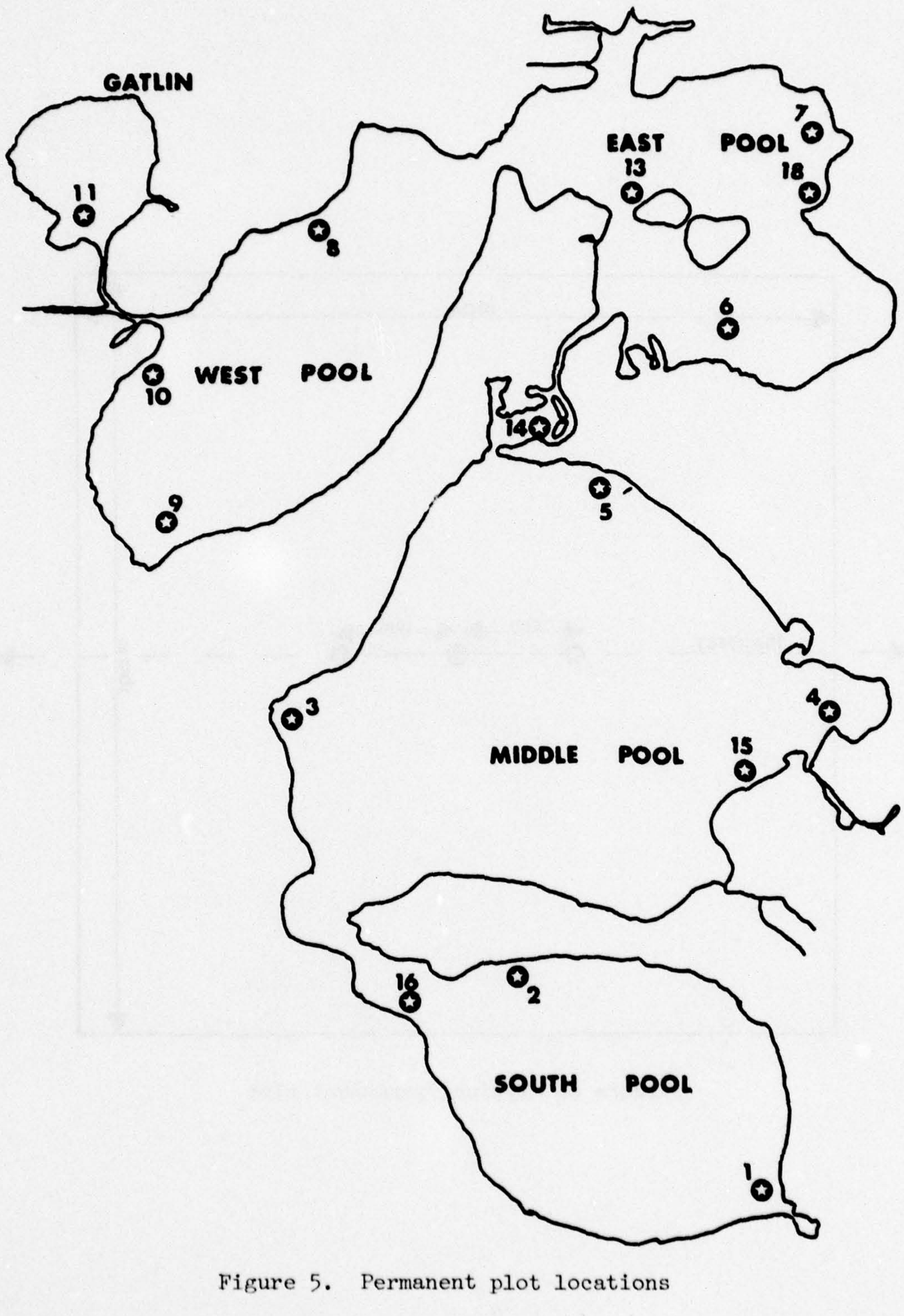


Figure 5. Permanent plot locations

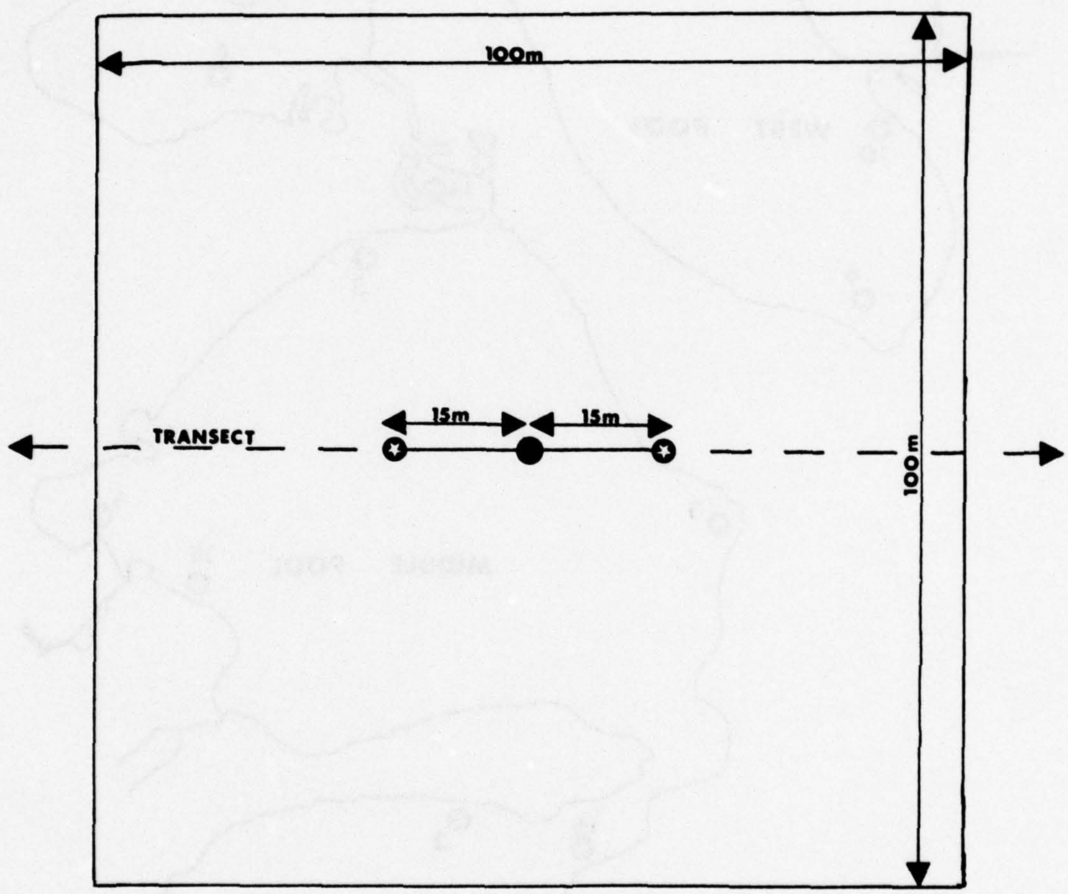


Figure 6. Typical permanent plot

distributions have been used to describe these species-abundance relationships with a single value. Poole reviews the use of various diversity indices.[78] The commonly used Shannon-Weaver species diversity index (H'), which is based on information theory, is modified for use here.

45. Shannon-Weaver diversity indices can be calculated in each pool of the lake for each month of the year, using the standing crop data collected from the transects and random sample. Diversity of the sample plots can be computed by using percent frequency of occurrence for the species rather than weight values. The assumptions of the Shannon-Weaver index are random sampling and presence of all species in the sample. Transect samples violate the random sampling assumption and none of the sampling methods reflect all of the species found in the lake. Thus, the results of these indices must be viewed cautiously. However, it should be realized that the purpose of presenting these values is to observe their change from year to year rather than report them as accurate diversity values.

46. Two variations of the Shannon-Weaver formula were used:

$$H'_{\%} = \frac{C}{N} (N \log_{10} N - \Sigma n_i \log_{10} n_i)$$

where:

$C = 3.321928$

$N = n_i$

n_i = percent occurrence observed for the i^{th} species

and

$$H'_{sc} = \frac{C}{N} (N \log_{10} N - \Sigma n_i \log_{10} n_i)$$

where:

$C = 3.321928$

$N = n_i$

n_i = standing crop observed for the i^{th} species

Vegetation Maps

47. Monthly vegetation maps will be prepared by patrolling the lake margin and noting plant distribution against an enlarged aerial photograph. Only marginal and visible submergent vegetation will be recorded. This should show gross changes in vegetation distribution, as well as provide ground truthing for aerial photography.

Fathometer Studies

48. During August 1977, measurements of the bottom contours were taken with a recording whiteline-type fathometer along closely spaced transects throughout the lake. This yielded the bottom morphology. The whiteline feature enables accurate separation of the vegetation from the bottom contour thus yielding the submerged vegetation map.

Definition of Terms

49. The following terms are used throughout the report:

Standing Crop--weight of vegetation above the hydrosoil per specified area per unit time.

Percent Frequency Occurrence--number of samples in which a species occurred divided by the total number of samples taken multiplied by 100.

Standing Crop (AP)--standing crop-area present, determined by totalling the weight collected for a species and dividing by the number of samples where that species occurred.

Standing Crop (TA)--standing crop-total area, determined by totalling the weight collected for a species and dividing by the total number of samples taken.

Actual Standing Crop Change--the difference between the standing crop (AP) values of sample period N minus sample period N + 1. May also be called "yield."

Relative Standing Crop Change--the actual standing crop change presented as a percentage of value for sample period N.

Daily Standing Crop Change--the actual standing crop change divided by the number of days in that sample period.

Density--number of plant stems per unit area.

Height Profile--average height above the bottom of the plants in an area.

Statistical Design

50. Ideally, before undertaking any research problem, the investigator should specify his goal, decide exactly what hypothesis he wishes to test and design his experiment to effectively test that hypothesis, which includes selecting the most prudent statistical analysis procedures to test the results. Too frequently the investigator chooses his analysis procedures after conducting the experiment, which may allow his personal bias to affect the outcome.

51. Although we are, unfortunately, also guilty of beginning our sampling program before giving much thought to statistical analysis, we have, at least, attempted to select the best applicable procedures available and decided what results will constitute success or failure of the experiment before we have begun to interpret the data.

52. The experimental design of the LSOMT dictates that the lake system parameters be monitored for one year before stocking. The year of the baseline data (Y_b) is to be compared to the subsequent test years (Y_2, Y_3, etc.) to determine the effect, if any (see Reference 4), the white amur has on the Lake Conway ecosystem.

53. The analysis of the transect data will be done point by point. That is, data collected during Y_b at a particular point along a transect will be compared with data collected at that point in subsequent years. The results of this analysis for 200 sample points will be voluminous and would not be possible without the WES computing facilities. The results will be presented as a percentage of points which have changed significantly. When interpreting these results, one should realize that at a 10 percent level of significance, for example, with 200 separate tests being run, about 20 of the findings will be significant by chance alone. Thus, if after 200 tests only 20 were found significantly different, the results should be interpreted as no change in the lake. The transect points may also be averaged. This will be extremely valuable

for descriptive purposes, but it is not amenable to statistical analysis.

54. The t-test or a one-way analysis of variance (ANOVA) would be effective in analyzing the difference between years at each point; however, the seasonal variability plus sampling variation would lessen the power of the test. A paired t-test eliminates the seasonal variation since it analyzes the difference between pairs of data (in this case comparable months in the baseline year and treatment years) rather than two separate groups of data.[79] The paired t analysis will be used for all before-and-after type testing with the exception of the plot fixed heights and possibly the random samples.

55. The assumptions of the paired t-test are: (1) random sampling, (2) some positive correlation between samples in Y_b and Y_2, etc., and (3) normality and homogeneity of variance. Sampling methods within the permanent plots are random (except the fixed heights). The sample taken at each point along the transect is also assumed to be randomly selected. Thus, assumption one is satisfied. It appears logical to assume that, in general, data taken at a point in Y_b should roughly correspond with data taken at the same point in subsequent years; however, this must remain unconfirmed until the correlation can be tested. If assumption two is not verified, a normal t-test or a one way ANOVA can be substituted. Assumption three also cannot be evaluated until subsequent years' data are analyzed. ANOVA and t-tests are tolerant of some deviation from normality or homogeneity of variance but if a large deviation should be discovered, the Wilcoxon Matched Pairs Sign Rank Test can be substituted.[80] The test is non-parametric and does not require that assumption three be true.

56. Power is the probability that a statistical test will detect a difference between the population if that difference exists. The significance level (α) is the probability of rejecting a hypothesis if it is true (Type I error). Power and significance are closely related. If one seeks to avoid rejection of a true hypothesis by choosing a small α , he loses power and thus is less likely to detect a difference that exists. The analyst must choose an acceptable compromise between the two. Table 3 shows the power of the paired t-test at various

significance (α) levels and correlation coefficients. We are unwilling to accept a significance (α) level greater than 0.10 for any of our statistical tests. Since the vegetation often fluctuates considerably, trying to accurately detect a small effect (σ.26) would be difficult. A medium effect size (σ.56) or possibly a large effect size (σ.96) would be feasible to detect. The final power of the tests will not be known until all the data is analyzed and the correlation coefficients between the various years are known. When the correlation coefficient is zero, the paired t-test and the t-test have equal power. The Wilcoxon test has approximately 95 percent of the power of the paired t-test when the assumptions of the t-test are met. The power is unknown when they are not met.

57. The fixed nature of the plot heights excludes statistical analysis. However, in this case any variation can be easily interpreted visually.

58. Random samples of each pool can be effectively analyzed by a simple one way ANOVA with a significance level of 0.10 or less. A Kruskal-Willis One Way ANOVA by Ranks non-parametric test may be used if normality and homogeneity of variance are violated. It has been suggested that all subsequent random samples be taken at the same point as in the initial sample. If this were done, the paired t-test could again be used and thus greatly increase the power of the test. This fixing of the sample points might violate the assumption of random sampling. Further investigation of this is needed.

59. Although the vegetation is increasing rapidly in much of the lake, there was not a serious vegetation problem in the lake during Y_b. If this level can be maintained or reduced significantly by the test agent, we will conclude that vegetation control has been effective.

60. Analysis of other factors of the experiment, apart from the test of the amur's effect, will also be necessary. It will be particularly valuable to be able to convert from one form of weight measurement to another. Since the relationship is linear, a linear regression[79] will yield an equation to represent the relationship between the various measurements for each species. A correlation coefficient will show

the accuracy of the regression equation.[79]

61. The analysis of monthly difference in the equations will detect possible seasonal variation in the wet to dry weight ratio. The relationship of two or more regressions may be tested by an analysis of covariance (ANCOVA), which is a specialized type of ANOVA.[79] The assumptions of normality and homogeneity of variance are met and any violation of random sampling in this case should be of little consequence. If no differences are found, the data may be combined and one equation derived for the entire year. If a difference is detected, it may be necessary to present equations for each month or season. This analysis will also be used to detect differences in the wet and dry relationships between different species.

62. The variability of each of the weight measures must be calculated. The least variable measure overall will be used in all analyses to increase the power of the test. The coefficient of variation can be calculated using the weights yielded by each method.[79] The coefficient of variation measures the standard deviation as a percentage of the mean, thus allowing comparison of the variation of sets of data with widely varying means.

63. An attempt will be made to establish a relationship between stem number, height and internodal length versus weight for each of the dominant plants. A multiple linear regression can find the relationship between the three most important variables.[80]

PART IV: RESULTS

Bottom Morphology

64. The bottom contour maps for the pools are shown in Figure 7. The areas between each metre interval are shown in Tables 4-8. The contour map was made when the lake level was 0.5 m below the overflow structure at Daetwyler Drive.

65. The deepest area in the system was 10 m and occurred in Middle Pool. Middle Pool, South Pool, and Lake Gatlin have a similar depth distribution; these pools have about half their bottom area below 4 m. West Pool is slightly deeper, with about half of its area below 4.5 m. East Pool is the shallowest pool in the system having half of its bottom area above 3 m. Six metres consistently seems to be the depth past which plants are not found. The area deeper than 6 m varies from 28 to 37 percent of the pools except for East Pool which has only 16.7 percent of its bottom below that level.

Flora of Lake Conway

66. Table 9 presents the species of aquatic plants encountered in Lake Conway to date. Fifty-seven species have been identified. Although we believe these identifications are correct, they will all be confirmed by authorities before termination of the project. Habitat and abundance notes are also included. The majority of these plants are emergent and bank species. Currently there is tremendous development of their shoreline habitat. If this trend continues, we assume the diversity of marginal plants will decrease considerably.

Weight Conversions

67. Since three different methods of measuring weight are used (see methods and materials), but only wet weight data is reported and analyzed, it is necessary to be able to convert these values to

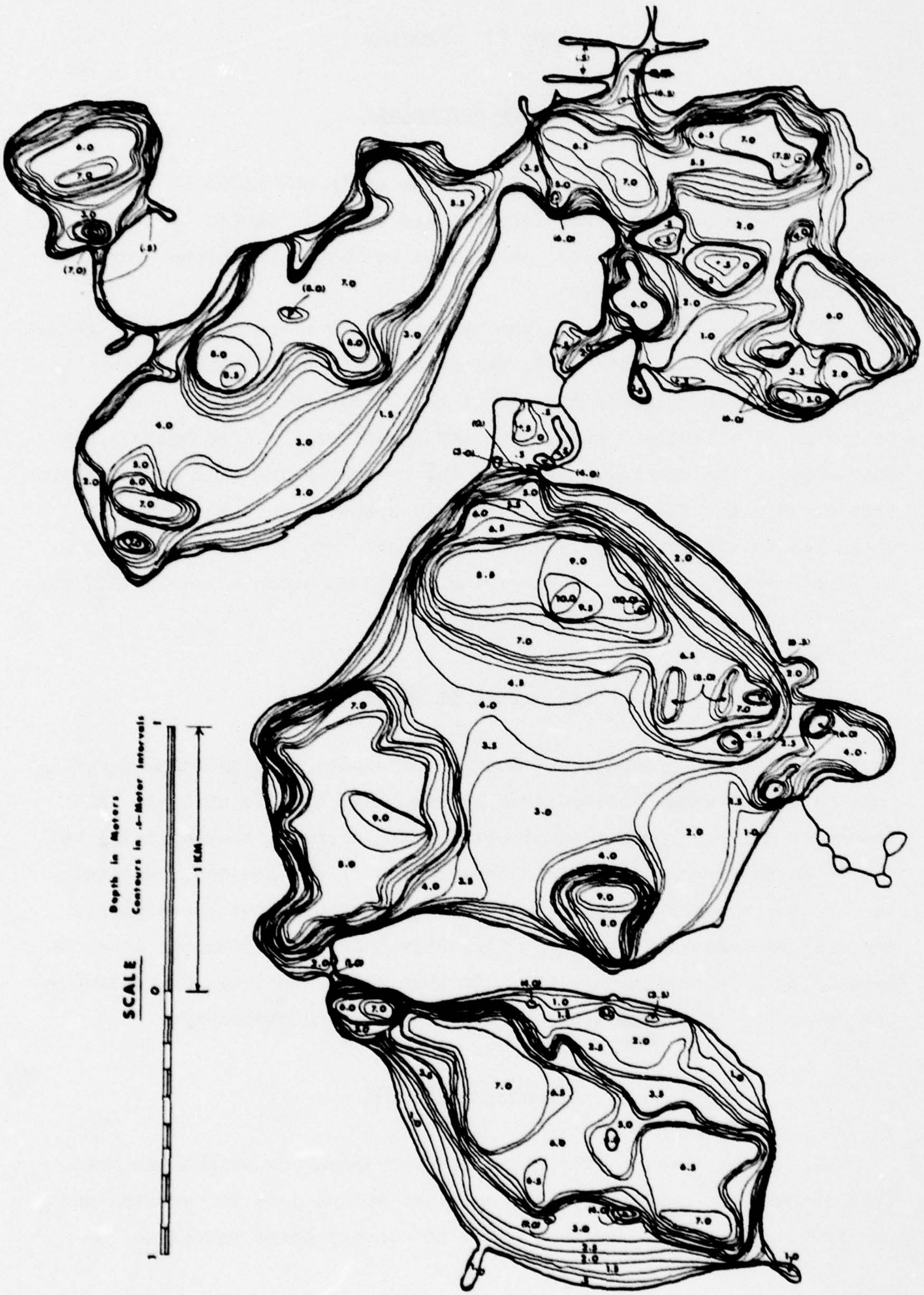


Figure 7. Bottom morphology of Lake Conway

whichever form is needed for comparison with other studies. The values presented in Table 10 are averages of the percentages of the relationships between the various measures. The coefficient of variation expresses the variability of this percentage value and the correlation coefficient from a linear regression expresses the accuracy of conversion between the types of measures. This analysis is only preliminary and was conducted on the first few months of data for which the various measures were available. Spun and dry weights were not measured during the first four months of sampling because of a lack of equipment. Once a full year's data is accumulated, a more sophisticated analysis will be conducted (see statistical methods section).

68. The dry/wet percentage is the relationship most frequently discussed. Ten percent is usually the value cited as the typical dry/wet percentage. This is exactly right for hydrilla and pondweed. Nitella and eelgrass have a percentage of about eight percent. The smallest correlation coefficient for any of the relationships was 0.83 for nitella's dry/wet ratio; this value is sufficiently high to indicate that the conversion between the measures is acceptable. Most of the other relationships have coefficients of 0.97 or better indicating a very high conversion accuracy.

69. A t-test was performed to discover if the dry/wet percentage was statistically different. The results showed that nitella contained less dry matter than either pondweed or eelgrass. Nitella was not different from hydrilla because of the large variation in hydrilla's dry/wet ratio.

Variation of the Weight Measures

70. To increase the power of the statistical methods, it is necessary to choose the weight measure with the least variability (Table 11). The coefficient of variation was used for comparison (refer to statistical methodology for further discussion). In each case, except for the dry weight of hydrilla, the wet weight had the least variation; the spun weight was slightly more variable and the

dry weight was the most variable. Thus, all weights used in this report refer to wet weight unless otherwise noted.

Standing Crop and Production Distribution, Diversity

Production

71. The results of the random samples of all the pools are presented for the major plants in Table 12 and in Appendix A these results are given in more detail and stratified by depth zones for each individual pool. These values should be considered the actual amount of vegetation in the lake at the time of sampling. The results of the transect samples are presented numerically in Appendix B and graphically (for species with sufficient data to illustrate trends) in Appendix C. These values are derived by averaging the data found at all transect points within each pool. The transect data should show variation in the standing crop relative to the actual population but should not be used to represent the actual amount of vegetation in the lake. Appendix D presents the actual and relative changes in standing crop between months based on the averaged transect standing crop (AP). The changes are also expressed as grams per square metre per day ($g/m^2 \cdot day^{-1}$) for production estimation. Table 13 offers easy comparison of the unvegetated area predicted by three methods. The largest discrepancy between the estimation of the transects and random sample was 15 percent which is actually very little considering the difference in methodology. Total area of each pool is also presented in Table 13.

72. Appendix G contains maps of the distribution of the major submersed plants in the lake. These maps were drawn using data from the random sample, transects, plots, and visual observations.

Hydrilla

73. Random sample. Hydrilla has significant populations in West, South, and East Pools with average standing crops of 296.9 g/m^2, 40.3 g/m^2, and 15.6 g/m^2 overall. The frequency of occurrence was 23.7 percent, 18.6 percent, and 8.5 percent respectively. The random sample did not detect hydrilla in Middle Pool, however, it is present in a few

isolated areas. Hydrilla was the dominant plant in West Pool only and is on the verge of becoming a severe problem. The coverage of hydrilla in deeper waters is much higher. Hydrilla occupies 75 percent of the 4.1- to 6-m depth interval in West Pool and 77.8 percent in South Pool. Hydrilla was the only plant found growing deeper than 6 m. Obviously, hydrilla is more competitive in the deeper waters where less light is present. Hydrilla was most uncommon in the 0- to 2-m area. Competition with other species is greatest in this region.

74. Transect samples. The percent frequency in South Pool varies seasonally from 10 to 38 percent, 6 to 21 percent in East Pool and 15 to 34 percent in West Pool. The seasonal pattern of frequency change is similar in each pool. The occurrence is highest in mid-winter but declines in late winter to its low in spring and then increases again. The high frequency in winter may be a response by hydrilla to the increased winter water clarity thus allowing the deeper areas to be colonized. The percentage of hydrilla in East and West Pools is unchanged after one year's sampling. The distribution has increased slightly in South Pool.

75. The standing crop (AP) values range from a minimum of 135 g/m^2 to a maximum of 846 g/m^2 in South Pool, 60 g/m^2 to 426 g/m^2 in East Pool, and 122 g/m^2 to 1552 g/m^2 in West Pool. All three pools show peak crop values in June or July. A considerable decline in weight occurs after the late summer peak in each pool as was noted by Berg.[53] West Pool shows the most dramatic growth curve exhibited by hydrilla. The area present (AP) crop values consider the area occupied only by the species being studied and is not affected by changes in frequency as is the total area (TA) crop estimate. Thus, all standing crop values which follow will be (AP) crops.

76. Production. The greatest actual growth (946 g/m^2 or 30.5 $g/m^2 \cdot day^{-1}$) occurred in West Pool in May. The greatest relative change (369 percent) happened in East Pool in February when an unusual mid-winter growth peak occurred. Negative net production generally occurred from about August through March or April. The largest relative and actual decreases were found in the fall decline. South and East Pools showed

slight annual overall increases (81 and 75 g/m^2 respectively). West Pool showed a tremendous overall increase of 676 g/m^2.

Potamogeton

77. Random sample. Pondweed is found commonly in all pools. It occurs in 25 percent of South Pool, 29 percent of Middle Pool, 22 percent of East Pool and 19 percent of West Pool. The average standing crops are 65 g/m^2 in South Pool, 59 g/m^2 in Middle Pool, 302 g/m^2 in East Pool, and 74 g/m^2 in West Pool. East Pool, because of its shallow depth, has the greatest crop of pondweed, which is dominant in that pool. Pondweed is most common in the 0- to 2-m depth zone and common, but less so, in the 2.1- to 4-m zone. It occupied 78.6 percent of the 0- to 2-m zone in South Pool, 40 percent in the Middle Pool, 62.5 percent in the East Pool, and 42.9 percent in the West Pool. The biomass within the shallow zone is also far greater than that of the other areas.

78. Transect samples. The percent frequency of pondweed varies from a low of 10 percent to a high of 27 percent in South Pool. It varies from 18 percent to 30 percent in Middle Pool, 30 percent to 42 percent in East Pool and from 13 percent to 33 percent in West Pool. South, Middle, and West Pools show a pattern in pondweed frequency with a mid-winter peak similar to that shown by hydrilla. The population distribution is remarkably stable in East Pool. There was also little or no change in the coverage in South and West Pool. Middle Pool showed a definite increase in the occurrence of pondweed.

79. The standing crop (AP) of pondweed varied from a low of 90 g/m^2 to a high of 637 g/m^2 in South Pool, from 152 g/m^2 to 405 g/m^2 in Middle Pool, from 145 g/m^2 to 886 g/m^2 in East Pool, and from 67 g/m^2 to 840 g/m^2 in West Pool. Trends in pondweed growth are inconsistent among the pools. South, East, and West Pools showed maximum growth in the spring to early summer. A lesser late fall or early winter growth peak is evident in all pools. South and West Pools show definite winter declines, but Middle and East Pools show mid-winter increases in standing crop.

80. Production. Pondweed showed erratic increases and decreases in its standing crop. The greatest actual increase (352 g/m^2 or

11.7 $g/m^2 \cdot day^{-1}$) came in June in West Pool. East Pool also had two very large increases of 334 g/m^2 or 10.8 $g/m^2 \cdot day^{-1}$ and 332 g/m^2 or 10.7 $g/m^2 \cdot day^{-1}$ for May and July. The largest actual declines were -689 g/m^2 or -22.2 $g/m^2 \cdot day^{-1}$ in West Pool in January and -511 g/m^2 or -16.5 $g/m^2 \cdot day^{-1}$ in March in East Pool. The greatest relative increases occurred in December in South Pool (190 percent) and Middle Pool (31 percent), in May in East Pool (153 percent) and in April in West Pool (30 percent). Middle and West Pools showed negative annual net changes in standing crop of -72 g/m^2 and 132 g/m^2 respectively. East Pool showed an increase of 188 g/m^2 over the year and South Pool showed a very large increase of 450 g/m^2.

Nitella

81. Random sample. Nitella is by far the most common macrophyte in South and Middle Pools covering 39 percent and 42 percent of those pools respectively. It is less common in East Pool (9 percent) and West Pool (7 percent). The average standing crops of 658 g/m^2 in Middle Pool and 461 g/m^2 in South Pool exceed the average crop values attained by any of the other species anywhere in the lake system. Nitella is most prevalent in the deeper areas of the lake, although it is also common in shallow areas. It occupies 90 percent of the 2.1- to 4-m zone and 33 percent of the 4.1- to 6-m zone in South Pool. It is found over 73.7 percent and 87.5 percent of the 2.1- to 4-m and 4.1- to 6-m zones, respectively, in Middle Pool.

82. Transect samples. The percent occurrence along transects varied from a low of 7 percent to a high of 31 percent in South Pool, 26 percent to 42 percent in Middle Pool, 12 percent to 36 percent in East Pool, and 2.5 percent to 20 percent in West Pool. The frequencies of nitella in Middle and West Pools are quite stable; South and East Pools show some fluctuation. Minor declines were noticed in Middle and East Pools; however, in Middle Pool nitella appears to be recovering. No consistent seasonal trends in distribution are evident among the pools. However, seasonal trends in the standing crop are very apparent. Large peaks in the crop curve occur between April and June and drop steeply after that period. The standing crop remains low through the

summer and then all pools show another large growth peak in the fall just before the winter decline in December. The standing crop values range from 1040 g/m^2 to 3069 g/m^2 in South Pool, 1723 g/m^2 to 3449 g/m^2 in Middle Pool, 1175 g/m^2 to 3282 g/m^2 in East Pool, and 765 g/m^2 to 2918 g/m^2 in West Pool.

83. <u>Production.</u> The highest actual increases measured were 1276 g/m^2 (42.5 $g/m^2 \cdot day^{-1}$) in West Pool and 1199 g/m^2 (40.0 $g/m^2 \cdot day^{-1}$) in South Pool. Both of these increases occurred in September. The greatest relative growth was 112 percent which occurred in South Pool in September. The highest production was usually in the early spring and again in the early fall. The greatest decline (-2625 g/m^2 or -84.7 $g/m^2 \cdot day^{-1}$) occurred in the West Pool in December. This was a 71 percent drop in the crop and was the largest relative decline recorded for nitella. The largest nitella decline, which occurred consistently throughout the lake, occurred in July. Penfound suspected that lower summer production, which is common in aquatic plants, is caused by a higher respiration rate which occurs at higher summer temperatures.[34] There is also a mid-summer drop in the average amount of solar radiation in Orlando (Figure 8). Middle and East Pools show substantial annual net losses of -669 g/m^2 and -1272 g/m^2 respectively. South and West Pools showed increases of 774 g/m^2 and 686 g/m^2 respectively.

<u>Vallisneria</u>

84. <u>Random sample.</u> American eelgrass is the only remaining macrophyte which is common in the lake system. Eelgrass was not detected by the random sample in Middle Pool although it occurs there. The plant is found in only about 2 percent of South Pool and also only comprises about 2 percent of the pool's total standing crop. Eelgrass is the least important of the major species in West Pool where it occurs in 5 percent of the area and contributes only about 8 percent (52 g/m^2) of the standing crop. In East Pool, eelgrass is second to pondweed with a 19 percent frequency and 154 g/m^2 which comprises about one-fourth of the total standing crop. Eelgrass is a shallow water plant. In East Pool the plant covers 43.7 percent of the 0- to 2-m zone and 26.7 percent of the 2.1- to 4-m zone.

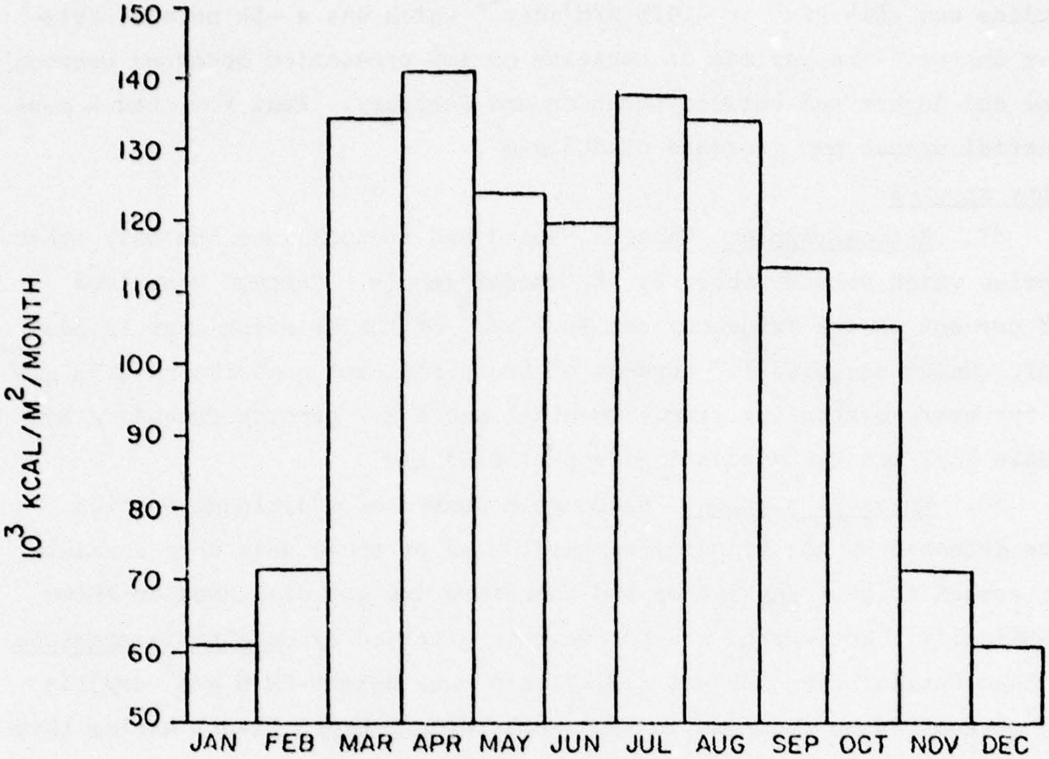


Figure 8. Monthly horizontal insolation for Orlando, Florida

85. Transect samples. The values obtained for eelgrass in Middle and West Pools were either so low or variable that graphs or discussion was not necessary since no trends were evident. In South Pool the percent occurrence and standing crop began at zero in the first sampling period and increased rapidly afterwards. The occurrence stabilized at about 6 percent, but the standing crop increased to a peak of 1378 g/m^2 in February. The standing crop decreased afterwards and stabilized between 200 and 250 g/m^2. In East Pool the percent occurrence is very stable at about 26 percent. The standing crop ranged from a low of 117 g/m^2 to a high of 1179 g/m^2 in November. The peak standing crops occurred in late spring and again in the early fall. Eelgrass exhibited the same mid-summer decline as nitella.

86. Production. The greatest actual monthly increase for eelgrass was 1062 g/m^2 or 35.4 $g/m^2 \cdot day^{-1}$ which occurred in East Pool. This was a 908 percent increase relative to the prior month. The greatest actual

decline was $-614\ g/m^2$ or $-19.8\ g/m^2 \cdot day^{-1}$ which was a -54 percent relative change. The periods of negative or low production occurred between June and August and between December and February. East Pool had a substantial annual net increase of $803\ g/m^2$.

Other species

87. Random sample. Cabomba, naiad and coontail are the only other species which were detected by the random sample. Cabomba comprised 1.7 percent of the frequency and $56.2\ g/m^2$ of the standing crop in East Pool. Naiad occupied 1.7 percent of South Pool and contributed $0.53\ g/m^2$ to the average standing crop. Coontail has a 3.4 percent frequency in Middle Pool and had a standing crop of $0.98\ g/m^2$.

88. Transect samples. Although a number of additional species were detected by the transect samples, none of these data were consistent enough to show any trends and therefore are not discussed or shown graphically. Noteworthy are the weights attained by *Saggitaria graminea* in Lake Gatlin. The largest ($13,172\ g/m^2$ wet weight-$2218\ g/m^2$ dry) is the largest value recorded in any sample of submerged plants during this study, nor are we aware of any value reported in the literature that exceeds it. This density is, however, attained only in a limited area.

Total vegetation

89. Random sample. Table 12 allows comparison of the total vegetation in each of the pools. West Pool had a 44 percent frequency of vegetation which was the least of the major pools. The percent frequency increases as one goes down the lake chain to South Pool which has the highest occurrence of vegetation (69 percent). The average standing crop is highest in Middle Pool with $717\ g/m^2$ and lowest in South Pool with $583\ g/m^2$, however, the average crops per square metre are not statistically different. Thus, the actual amount of plants produced by the four major pools is the same in spite of the tremendous differences in species composition.

90. Transect samples. The percent occurrence of vegetation as shown by the transects shows a gradual increase in area covered in all pools. The only consistent drop in the area covered occurred in the winter. The increasing trend began in the early spring in all pools.

Diversity

91. The Shannon-Weaver diversity indices for the transects (H'_{sc}) are presented in Table 14. South, East and West Pools have the essentially equal diversity. Middle Pool, which is almost totally dominated by nitella, had a much lower diversity. Lake Gatlin, which has little stable vegetation, had the lowest diversity which often was zero. The higher values noted in certain pools in October and November were caused by the occurrence of peripheral emergent plants in the samples. It was decided in December that the transect end-points should sample shallow submerged plants since the sample number for marginal plants was inadequate to accurately represent them.

92. Diversity is generally higher in the fall and winter: drops from late winter through the spring and then rises again. The seasonal trends are not consistant for all pools.

Permanent Plots

93. The permanent plots, whose locations are shown in Figure 5, were established to study the changes in the vegetation more intensely than was possible using the biomass samples. Each plot was located in a plant community of particular interest. Water quality data is available at 11 of the sites. Sites one and three contain primarily *Nitella*. Site ten contains primarily *Hydrilla*. Sites 13 and 15 are for the study of *Potamogeton*. Site 18 studies *Vallisneria* and site 4 is located within the only large *Ceratophyllum* population in the lake. Although site 14 is irregular and difficult to sample, it contains the greatest *Utricularia* populations available. Plot eight was largely unvegetated when selected and was intended to show encroachment of vegetation on a barren area. Plot eleven is also largely barren and is typical of Lake Gatlin. The remaining plots contain significant populations of two or more of the major species and are intended to show competition between them. Each major species will be discussed separately. The numerical results are presented in Appendix E. The trends are presented graphically in Appendix F.

Hydrilla

94. Hydrilla has been found at plots 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 13, 14, 15, 16, and 18. Although hydrilla has occurred at all but one of the study plots, it is only found commonly and consistently at plots 1, 2, 7, 8, 10, and 16. Hydrilla has occurred at over 50 percent frequency in each of these plots. Consistent measurable stem densities have occurred in plots 1, 2, 3, 7, 10, 13, and 16; however, hydrilla only forms a significant part of the total stem density in plots 7, 8, 10, 13, and 16.

95. Except for a one month drop to 97 percent, hydrilla has always dominated 100 percent of plot 10. Nitella and pondweed were also present at a low frequency but did not produce a detectable stem density. The fixed height measurements showed a height profile of 0.2 to 0.3 m during the winter. During early spring rapid growth in height of up to 0.5 m per month began. This height peaked in about July or August and then rapidly decreased. The maximum height reached at the sampling point was 2.3 m. The plotted curve of fixed heights looks very similar to the hydrilla standing crop curve shown for West Pool. Hydrilla maintained a stem density of about 1,000 stems/m^2 during the winter, but in early spring this increased rapidly to a high of 2798 during May. The density dropped rapidly thereafter. No apparent drop in the standing crop in the West Pool occurred simultaneously with the large drop in stem density. This may indicate that the larger plants have outcompeted the smaller plants for light or nutrients. The demise of these small plants caused no significant effect on the crop.

96. Plots seven and eight show the ability of hydrilla to encroach on largely unvegetated areas. When first sampled plot eight was 87 percent unvegetated. Almost immediately, hydrilla increased until it was present in 57 percent of the area in January, but for some unknown reason, it decreased to zero in May. Again it increased rapidly until it occurred in 93 percent of the plot in September. The stem density is still low with 70 stems/m^2 but is apparently increasing rapidly. Plot seven initially began with only 27 percent hydrilla, but the frequency has increased steadily until hydrilla is present in 93 percent of

the area. The height profile showed the typical winter drop, the spring increase and the fall decline. The stem density began to increase rapidly in the spring and has continued to the present with no decline.

97. Plot 13 was dominated by pondweed when first sampled. Pondweed's frequency decreased steadily during the winter. During the spring growth period, hydrilla, which had been present at a low level, was able to outcompete the pondweed and become the dominant plant in frequency and stem density.

98. Hydrilla, nitella, and pondweed are apparently competing for dominance in plot 16. Nitella presently exceeds hydrilla in frequency of occurrence and stem density. However, if hydrilla can maintain its much greater height advantage, it may be able to reduce the other plants' densities by shading them.

Potamogeton

99. Pondweed was present in all plots except plot 11 in Lake Gatlin and is significant in plots 2, 5, 6, 9, 13, 15, and 16. Even when pondweed is present at its greatest density, other plants are usually present. The maximum measured density was 554 stems/m^2 at plot 6 in September. This value is very low when compared to nitella and hydrilla. Nitella and eelgrass appear especially adapted to coexistence with pondweed; both species form dense carpets with a low height profile beneath the pondweed canopy. The maximum height measured for pondweed was 3.2 m at plot 2 during September. The heights are greatest in the fall months. In plots 6 and 15, where pondweed is dominant, the density varies little seasonally.

Nitella

100. Nitella occurred at all sample plots except for 8, 11, and 13 and was a significant portion of the population at points 1, 2, 3, 4, 5, 6, 9, 14, 15, and 16. When nitella was the dominant plant at a plot, other species are usually comparatively insignificant. Nitella attained its maximum density of 12,100 stems/m^2 at plot 1 in May and generally maintains densities of over 2,000 stems/m^2 year round when dominant. Height profiles often reach 1 m. With a density of many thousand stems/m^2 and a height of 1 m, no light is able to reach the hydrosoil

and thus germination of propagules of any other species is inhibited. Nitella does coexist well with other species when its height is shorter as in plots 5, 6, 15, and 16.

101. No consistent seasonal trend is apparent in the frequency of occurrence. Seasonal trends in stem density at plots 1, 3, 5, 6, and 9, where nitella is dominant, are evident. A large peak in stem density occurs during the fall and is followed by a sharp drop in the winter. A larger peak occurs in the spring followed by a less drastic mid-summer decline. A winter decline in height occurred in plots 1 and 6 but was not observed in the other plots. Large changes in the number of plants present appear to have little effect on the height profile. These changes in stem density correspond well with changes in standing crop noted in the transect samples.

102. When nitella is dominant, it and the other species present are usually quite stable; however, if the distribution is even among species, then there is considerable variation in frequency indicating interspecific competition for dominance. Nitella is declining in frequency and height at plot 2 and the density is highly variable. Pondweed and hydrilla have apparently taken advantage of this and increased in frequency. The growth in height of pondweed is evident in the graph. Neither species has built up a significant stem density. Nitella is also declining at height, density, and frequency at plot 5 and pondweed appears to be taking advantage of this. Nitella is, however, increasing rapidly in plot 6. It did not occur when first sampled but now it occurs at 100 percent frequency in the plot. It did not occur at the height measuring point until May but has maintained a short understory since then. Density is also increasing rapidly, but is still irregularly distributed. This increase has apparently resulted in the competitive exclusion of eelgrass which formerly occupied 100 percent of the plot but now is not present. Plot 9 has shown a slight drop in height but is also showing a consistent increase in stem density. There appears to be considerable competition between nitella and hydrilla in plot 16. Nitella exhibited a large drop in frequency in the winter and hydrilla increased rapidly; it appeared hydrilla would dominate the site.

However, in the spring, nitella showed a great increase in frequency and hydrilla has declined steadily since then. Hydrilla has shown a steady increase in height. If it can maintain this trend, it may begin to shade the nitella and eventually dominate the site.

Vallisneria

103. Eelgrass occurred in plots 6, 9, 13, 15, and 18 but was common only in plots 6 and 18. Initially eelgrass occupied 100 percent of plot 6 and formed a low (0.2-m height profile) carpet under the pondweed canopy. Nitella rapidly became common at the site and the eelgrass declined rapidly. Presently, eelgrass is completely absent and nitella occupies 100 percent of the plot, where it forms a low carpet beneath the pondweed. Vallisneria is the dominant plant at plot 18 and has all but excluded other species. The eelgrass at this shallow location has always reached the surface. The variation in the height profile is more reflective of the changes in water depth at the sample points rather than changes in growth of the plant. The water level in Lake Conway is dropping slowly. The rises in spring and late summer were reflected in a rise in water level caused by seasonal heavy rains. The stem density of eelgrass at plot 18 varied from 688 to 3546 stems/m^2. The estimates of densities were too variable to detect seasonal fluctuations if present.

Ceratophyllum

104. Coontail is the only remaining species which developed a sufficient population to justify discussion. Coontail is the dominant plant at plot 4. The frequency varied between 50 and 75 percent during most of the sampling year; however, during August and September, a noticeable increase occurred. A slight decrease in height profile occurred during the winter followed by a slow increase during the spring and summer. One of the height measuring points showed a rapid height increase to over one metre. The stem density showed a slow but steady increase throughout the year with a large growth peak to 616 stems/m^2 in August followed by a large decline.

105. Nitella is also present over much of the plot and is apparently increasing slowly. Nitella's stem density showed the two

characteristic growth peaks and has shown an overall increase during the year. Nitella may become competitive with coontail at this site.

Diversity

106. Shannon-Weaver diversity indices for the plots ($H'_{\%}$) are presented in Table 15. Plots 2, 6, 9, and 16 consistently show the highest diversity. These plots have high pondweed populations. As previously mentioned, pondweed seems to coexist readily with other species. No consistent trends were apparent among the plots.

PART V: DISCUSSION

107. The random sample (Table 12) of the lake shows the actual standing crop of vegetation per unit area is equal in the major pools; however, the area covered by the plants is greatest in the South Pool and decreases as one proceeds northward through the lake chain. Other investigators in the project have also noticed this same trend of increasingly eutrophic conditions when proceeding north through the chain. This reverse correlation between vegetation cover and eutrophic conditions is probably due to the lower light penetration in the more eutrophic waters.

108. Hydrilla, pondweed, nitella and eelgrass are the only abundant submerged plants in the lake. Three of these species are in the highly preferred category of white amur feeding preferences give in (Table 2) and should be controlled if the stocking rate is adequate. Nitella, which is the lake's most abundant plant, is the most highly preferred species. It has, however, been suggested that nitella may not be utilized by the amur because it appears to have a high water content (and thus a lower food content). This probably is not true since hydrilla and nitella were shown not to be different in water content. Eelgrass is the lake's only abundant plant that is in the "will not control effectively" category.

109. Lake Conway once had a severe hydrilla problem. Nitella was present in small quantities. In the fall of 1974, the lake was treated with "System L," a selective herbicide which does not affect algae, including nitella. Apparently, when all vascular competition was removed, nitella was able to densely colonize the lake. With a high profile and tremendous stem density in many areas, nitella has shaded the bottom and thus prevented other plants from reestablishing themselves. There has been concern that the amur will remove the nitella first and allow hydrilla to populate those areas. Wood states that the charophytes are opportunistic plants that may colonize an area which is disturbed, but that they are transitional and are gradually displaced by other species unless the conditions remain very stable.[81,82] Considering the

competitiveness of hydrilla and the increases in other species, it appears inevitable that nitella would be eventually replaced under natural conditions.

110. Hydrilla has shown tremendous increases in standing crop, height and stem density in many areas of the lake. The hydrilla height profile was nearing the surface in West Pool during its peak. The plant should form its typical surface mat in that pool next year, and should again eventually become the dominant plant in the lake system.

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Table 1

Stocking Rates and Weights of the White Amur in Lake Conway*

	Pools					
	South	Middle	East	West	Gatlin	Overall
$\bar{x}$ weight (kg)	0.25	0.25	0.25	0.61	0.61	0.61
# per acre	5.00	5.00	3.00	3.00	3.00	4.00

* From data provided by WES.

Table 2

Approximate Feeding Preferences of the White Amur*,**

I. Greatly prefers:

- Nitella and Chara spp.
- Hydrilla verticillata
- Najas spp.
- Potamogeton spp.
- Duckweeds (Lemna, Spirodella, Wolffia, Wolffiella, Azolla)
- Ceratophyllum demersum
- Eleocharis acicularis
- Elodea canadensis
- Pithophora sp.

II. Will control but does not prefer:

- Myriophyllum spp.
- Bacopa spp.
- Egeria densa
- Nymphaea spp.
- Polygonum spp.
- Spirogyra sp.
- Utricularia spp.
- Cabomba spp.
- Fuirena scirpoides
- Brasenia schreberi
- Hydrocotyle spp.

III. Will not control effectively:

- Vallisneria spp.
- Typha spp.
- Myriophyllum brasiliense
- Phragmites spp.
- Carex spp.
- Scirpus spp.
- Eichhornia crassipes
- Alternanthera philoxeroides
- Pistia stratiotes
- Nymphoides spp.
- Nuphar macrophyllum

* Only those species common to Florida are listed.

** List numbers of references used to compile this list are: 64, 65, 66, 67, 68, 63, 69, 70, and 71.

Table 3

Power Levels of the Paired T-Test at Various Alpha Levels and Correlation Coefficients for Three Effect Sizes*

	Effect Size (N = 12)		
r	Small	Medium	Large
	= 0.01 (2 tailed)		
0.25	0.02	0.10	0.30
0.50	0.03	0.17	0.50
0.75	0.05	0.38	0.72
0.90	0.12	0.72	0.72
	= 0.05 (2 tailed)		
0.25	0.09	0.27	0.52
0.50	0.11	0.38	0.74
0.75	0.15	0.65	0.90
0.90	0.30	0.90	0.90
	= 0.10 (2 tailed)		
0.25	0.12	0.40	0.70
0.50	0.18	0.52	0.83
0.75	0.25	0.77	0.96
0.90	0.45	0.96	0.96

* The values for effect size are: small (0.25); medium (0.55); large (0.85) (Cohen, Statistical Power Analysis for the Behavior Sciences).

Table 4

Depth Distribution

South Pool

Depth Interval (m)	Area ha	Area A.	Percent Total Area	Percent Below
Surface	142.61	352.39	100.00	100.00
0-1	6.86	16.95	4.81	95.19
1-2	20.76	51.30	14.56	80.63
2-3	20.96	51.79	14.70	65.94
3-4	19.71	48.71	13.82	52.11
4-5	10.68	26.39	7.49	44.63
5-6	14.23	35.16	9.98	34.65
6-7	34.31	84.78	24.06	10.59
7-8	0	0	0	10.59
8-9	15.1	37.31	10.59	0

Table 5

Depth Distribution

Middle Pool

Depth Interval (m)	Area ha	Area A.	Percent Total Area	Percent Below
Surface	301	741	100.00	100.00
0-1	11	27	3.65	96.35
1-2	21	52	6.98	89.37
2-3	33	81	10.96	78.41
3-4	74	183	24.58	53.83
4-5	31	77	10.3	43.53
5-6	20	49	6.64	36.89
6-7	30	74	9.97	26.92
7-8	25	62	8.31	18.61
8-9	44	109	14.62	3.99
9-10	12	30	3.99	0

Table 6

Depth Distribution

East Pool

Depth Interval (m)	Area ha	Area A.	Percent Total Area	Percent Below
Surface	128.39	317.25	100.00	100.00
0-1	18.71	46.23	14.57	85.43
1-2	12.54	30.99	9.77	75.66
2-3	31.22	77.14	24.32	51.34
3-4	16.43	40.60	12.80	38.54
4-5	11.14	27.53	8.68	29.86
5-6	16.86	41.66	13.13	16.73
6-7	20.57	50.83	16.02	.71
7-7.5	0.91	2.25	0.71	0

Table 7

Depth Distribution

West Pool

Depth Interval (m)	Area ha	Area A.	Percent Total Area	Percent Below
Surface	144.45	356.94	100.00	100.00
0-1	5.82	14.38	4.03	95.97
1-2	12.45	30.76	8.62	87.35
2-3	17.40	42.99	12.05	75.30
3-4	22.56	55.75	15.62	59.68
4-5	28.69	70.89	19.86	39.82
5-6	9.73	24.04	6.74	33.08
6-7	10.19	25.18	7.05	26.03
7-8	33.22	82.09	23.00	3.03
8-8.5	4.38	10.82	3.03	0

Table 8

Depth Distribution

Lake Gatlin

Depth Interval (m)	Area ha	Area A.	Percent Total Area	Percent Below
Surface	26.59	65.7	100.00	100.00
0-1	3.16	7.81	11.88	88.12
1-2	1.78	4.4	6.69	81.43
2-3	3.45	8.52	12.97	68.46
3-4	4.48	11.07	16.85	51.61
4-5	3.33	8.23	12.52	39.09
5-6	3.1	7.66	11.76	27.33
6-7	6.47	16.00	24.33	3.00

Table 9

Flora of Lake Conway

Scientific Name	Common Name	Habitat*	Occurrence**
Andropogon virginicus	Broom sedge	B	R
Bacopa caroliniana	Lemon bacopa	S-E	C
Bacopa monnieri	Water hyssop	S-E-F	C
Bidens bipinnata	Water beggar tick	E	R
Cabomba caroliniana	Fanwort	S	U
Ceratophyllum demersum	Coontail	S-F	U
Chara sp.	Muskgrass	S	U
Cladium jamaicensis	Sawgrass	E	R
Colacasia antiquorum	Elephant ears	B-E	C
Cyperus lecontei	Sedge	E-B	U
Cyperus odoratus	Sedge	E-B	C
Cyperus papyrus	Papyrus sedge	E-B	U
Cyperus pseudovegetus	Sedge	E-B	A
Cyperus rotundus	Sedge	E-B	C
Cyperus strigosus	Nutgrass	E-B	A
Eichornia crassipes	Waterhyacinth	F-E	C
Eleocharis acicularis	Slender spikerush	S-E	C
Eleocharis balwinii	Hairgrass	S-E	C
Eupatorium capillifolium	Dog fennel	E	C
Fimbristylis sp.	Sedge	E-B	R
Fuirena scirpoides	Lake rush	E	A
Fuirena squarrosa		E	C
Habenaria repens	Water orchid	E	R
Hydrilla verticillata	Hydrilla	S	A
Hydrocotyle umbellata	Pennywort	E-F	A
Hydrocotyle verticulatus	Pennywort	E-F	R
Hypericum petiolatum	St. John's wort	E	U
Juncus acuminatus	Rush	B	U
Juncus scirpoides	Rush	B	U
Ludwigia octavalis	Primrose willow	E-B	C
Ludwigia peruviana	Primrose willow	E-B	C
Mayaca fluviatalia	Bogmoss	S	U
Najas guadalupensis	Southern naiad	S	U
Nitella megacarpa	Stonewort	S	A
Nitella sp.	Stonewort	S	R
Nuphar macrophyllum	Spatterdock	F	C
Nymphaea odorata	Fragrant waterlily	F	C
Panicum hemitomon	Maidencane	E	A
Panicum purpurascens	Paragrass	E	C
Panicum repens	Torpedo grass	E-B	A
Pluchea purpurascens	Fleubane	E	C
Polygonum punctatum	Smartweed	B	U
Pontederia lanceolata	Pickerel weed	E	A
Potamogeton illinoensis	Illinois pondweed	S	A
Potamogeton puscillus	Slender pondweed	S	R
Rhyncospora cephalantha	Beakrush	B	U
Rhyncospora milaea	Beakrush	B	U
Salvinia rotundifolia	Salvinia	F	U
Sagittaria lancifolia	Arrowhead	E	C
Sagittaria graminea	Slender arrowhead	E-S	C
Typha latifolia	Cattail	E	A
Utricularia gibba	Bladderwort	F-S	U
Utricularia foliosa	Leafy bladderwort	S-E	R
Utricularia inflata	Big floating bladderwort	S-E	U
Utricularia purpurea	Purple bladderwort	S-E	R
Utricularia resupinata	Lavender bladderwort	S-E	R
Vallisneria americana	Eelgrass	S	A

* Habit Key: B- bank; E- emergent; F- floating; S- submerged.

** Occurrence Key: A- abundant; C- common; R- rare; U- uncommon.

Table 10

Wet, Spun, and Dry Weight Relationships

Plant Species	Weight Relationship* Dry/Wet	Dry/Spun	Spun/Wet
Hydrilla			
$\bar{x}$ percentage	10.06	15.71	65.94
Coef. Var.	90.06	88.92	24.17
Corr. Coef.	0.98	0.97	0.99
Potamogeton			
$\bar{x}$ percentage	10.16	16.47	62.31
Coef. Var.	40.16	38.49	18.49
Corr. Coef.	0.98	0.99	0.99
Nitella			
$\bar{x}$ percentage	8.09	12.54	67.06
Coef. Var.	40.67	44.50	13.33
Corr. Coef.	0.83	0.98	0.83
Vallisneria			
$\bar{x}$ percentage	8.79	12.09	74.89
Coef. Var.	39.25	41.44	21.78
Corr. Coef.	0.86	0.85	0.99

Critical Value df = 60, α = 0.05, Two-Tailed Test = 2.000

Plant Species	Pot	Nit	Hyd	Val
Pot	--	2.78498**	0.07050	0.38554
Nit			-1.44437	-4.28243**
Hyd				0.02240
Val				

* Values of t-tests of wet/dry weight percentages.
** Significantly different.

Table 11

Coefficients of Variation for Weighing Techniques

Plant Species	Weighing Technique Wet	Spun	Dry
Hydrilla	136.77	144.73	133.52
Potamogeton	142.88	145.31	163.68
Nitella	70.06	75.61	101.08
Vallisneria	130.77	133.82	152.71

Table 12

Lake Conway Random Sample Results

Pool	Total Vegetation	Hydrilla	Potamogeton	Nitella	Vallisneria
South Pool					
Percent occurrence	69	19	25	39	2
$\bar{x}$ crop (g/m^2)	583	40	65	461	12
± percent error	31	73	76	38	--
Middle Pool					
Percent occurrence	51	--	29	42	--
$\bar{x}$ crop (g/m^2)	717	--	59	658	--
± percent error	29	--	57	32	--
East Pool					
Percent occurrence	46	9	22	9	19
$\bar{x}$ crop (g/m^2)	619	16	302	92	154
± percent error	39	76	61	93	63
West Pool					
Percent occurrence	44	24	19	7	5
$\bar{x}$ crop (g/m^2)	617	297	74	190	52
± percent error	41	57	77	99	157

Table 13

Comparison of Sampling Methods

	Fathometer Study					Random Sampling	Transects
	Total Area		Unvegetated Area		Unvegetated Area	Unvegetated Area	Unvegetated Area
Pool	ha	A	ha	A	Percent	Percent	Percent
South	131.9	325.8	41.7	103.0	31.6	31	36
Middle	275.9	681.5	115.8	286.0	42.0	49	48
East	124.0	306.3	42.1	104.0	34.0	54	40
West	143.9	355.4	62.0	153.1	43.1	56	44
Gatlin	26.0	64.2	16.8	41.5	64.6	77	62

Table 14

Shannon-Weaver Diversity Indices of Transects

	Months											
Pool	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
South	2.03	0.81	1.95	1.28	1.10	1.50	1.40	1.18	1.15	1.56	1.68	1.53
Middle	0.58	0.72	0.67	0.82	0.76	0.72	0.45	0.46	0.38	0.35	0.53	0.77
East	1.15	1.74	1.45	1.42	1.70	1.27	0.93	1.39	1.43	1.78	1.55	1.74
West	1.23	1.90	1.35	1.49	1.46	1.19	1.63	1.58	1.59	1.40	1.52	1.37
Gatlin	0.35	0	0.29	0	0.43	0	0	0.99	0.91	0.68	0	0.47

Table 15

Shannon-Weaver Diversity Indices of Permanent Plots

Plot	Months											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.88	0.97	1.00	1.35	1.30	1.39	1.29	0.82	1.10	1.24	0.88	0.52
2	1.15	1.00	1.28	1.64	1.38	1.44	1.53	1.33	1.59	1.57	1.55	1.58
3	1.41	0.53	1.00	1.20	0.19	1.12	1.47	0.38	0.77	1.19	0.76	0.74
4	1.52	0.58	0.41	0.91	1.08	1.23	1.27	0.91	1.34	1.27	1.06	0.92
5	1.38	0.97	1.19	1.00	0.81	1.07	1.00	0.96	0.99	0.95	1.00	0.99
6	1.00	1.48	1.57	1.57	1.57	1.48	1.42	1.80	1.80	1.64	1.71	1.35
7	0	0	0	0.27	1.14	0.41	0.91	0.30	0	0.41	0.85	0.63
8	0	0	0	0.61	0.35	0.47	0.93	0	0	0	0	0.20
9	1.32	1.20	1.33	0.94	0.94	1.41	0.94	1.03	1.44	1.54	1.42	1.66
10	0.78	0.89	1.16	0.68	0.95	0.80	1.21	1.37	0.19	1.28	1.28	1.74
11	0.78	1.00	0	0.70	0.78	0.88	0	0.88	0	0.70	0.97	0.58
13	0.38	0	0	0.52	0.67	0.78	0.93	1.49	0.93	1.55	1.09	1.42
15	1.17	1.01	1.08	1.18	1.28	1.27	1.47	1.17	1.41	1.04	0.81	1.00
16	1.66	1.51	1.56	1.53	0.99	1.55	1.45	1.51	1.56	1.61	1.49	1.70
18	1.04	0.51	1.31	0.44	0.80	1.07	0.52	0	0.52	0.35	0.44	0.51

APPENDIX A: STRATIFIED RANDOM SAMPLE RESULTS

Table A1

South Pool

Plant Species	Overall	Depth Zone 0-2 m	2.1-4 m	4.1-6 m	6.1 m+
N	59	14	20	9	16
Hydrilla					
Percent frequency	18.6	0	10.0	77.8	12.5
x̄ S. C.	40.3		25.3	204.9	1.7
± percent error	72.8		131.6	82.9	121.6
Potamogeton					
Percent frequency	25.4	78.6	20.0	0	0
x̄ S. C.	64.6	228.9	30.2		
± percent error	75.9	86.6	108.6		
Nitella					
Percent frequency	39.0	14.3	90.0	33.3	0
x̄ S. C.	460.7	91.8	1210.0	187.2	
± percent error	37.8	119.7	31.0	132.5	
Vallisneria					
Percent frequency	1.7	7.1	0	0	0
x̄ S. C.	0.05	0.21			
± percent error	--	--			
Najas					
Percent frequency	1.7	7.1	0	0	0
x̄ S. C.	0.53	0.21			
± percent error	--	--			
Total vegetation					
Percent frequency	69.5	85.7	95.0	88.9	12.5
x̄ S. C.	583.3	321.6	1317.85	392.1	1.7
± percent error	30.8	66.9	27.2	93.15	121.6

Table A2

Middle Pool

Plant Species	Overall	Depth Zone 0-2 m	2.1-4 m	4.1-6 m	6.1 m+
N	59	10	19	8	22
Potamogeton					
Percent frequency	28.8	40.0	63.2	12.5	0
$\bar{x}$ S. C. (g/m^2)	59.0	140.1	97.8	23.3	
± percent error	57.0	126.4	52.7	186.0	
Nitella					
Percent frequency	42.4	40.0	73.7	87.5	0
$\bar{x}$ S. C. (g/m^2)	657.9	571.9	970.2	1832.9	
± percent error	32.1	79.2	38.2	44.5	
Ceratophyllum					
Percent frequency	3.4	10	5.3	0	0
$\bar{x}$ S. C. (g/m^2)	0.98	31.1	26.5		
± percent error	117.5	--	--		
Total vegetation					
Percent frequency	50.9	60.0	89.5	87.5	0
$\bar{x}$ S. C. (g/m^2)	716.9	709.0	1071.3	1856.1	
± percent error	29.5	62.7	33.8	42.7	

Table A3

East Pool

Plant Species	Overall	0-2 m	2.1-4 m	4.1-6 m	6.1 m+
		Depth Zone			
N	59	16	15	10	18
Hydrilla					
Percent frequency	8.5	0	20.0	10.0	0
$\bar{x}$ S. C. (g/m^2)	15.6		32.7	43.0	
$\pm$ percent error	76.0		103.7	--	
Potamogeton					
Percent frequency	22.0	62.5	20.0	0	0
$\bar{x}$ S. C. (g/m^2)	301.8	620.4	525.2		
$\pm$ percent error	60.6	73.2	103.2		
Nitella					
Percent frequency	8.5	6.3	20.0	10.0	0
$\bar{x}$ S. C. (g/m^2)	91.5	49.9	286.2	30.8	
$\pm$ percent errror	93.3	--	116.0	--	
Vallisneria					
Percent frequency	18.6	43.7	26.7	0	0
$\bar{x}$ S. C. (g/m^2)	153.8	235.6	353.5		
$\pm$ percent error	63.2	102.4	81.6		
Cabomba					
Percent frequency	1.7	6.3	0	0	0
$\bar{x}$ S. C. (g/m^2)	56.2	221.1			
$\pm$ percent error	--	--			
Total vegetation					
Percent frequency	45.8	81.3	80.0	20.0	0
$\bar{x}$ S. C. (g/m^2)	618.8	905.9	1418.6	73.8	
$\pm$ percent error	39.2	56.3	47.2	132.0	

Table A4

West Pool

Plant Species	Overall	0-2 m	2.1-4 m	4.1-6 m	6.1 m+
		Depth Zone			
N	59	15	14	8	22
Hydrilla					
Percent frequency	23.7	6.7	50.0	75.0	0
$\bar{x}$ S. C. (g/m^2)	296.9	130.3	493.6	1081.4	
$\pm$ percent error	56.8	175.3	91.0	78.3	
Potamogeton					
Percent frequency	18.6	42.9	28.6	12.5	0
$\bar{x}$ S. C. (g/m^2)	74.3	272.2	39.5	2.6	
$\pm$ percent error	77.0	90.1	92.1	--	
Nitella					
Percent frequency	6.8	0	28.6	0	0
$\bar{x}$ S. C. (g/m^2)	190.4		802.4		
$\pm$ percent error	99.2		98.8		
Vallisneria					
Percent frequency	5.1	7.1	14.3	0	0
$\bar{x}$ S. C. (g/m^2)	51.9	3.0	215.5		
$\pm$ percent error	156.8	176.1	167.1		
Total vegetation					
Percent frequency	44.1	57.1	78.6	87.5	0
$\bar{x}$ S. C. (g/m^2)	617.1	430.4	1550.6	1084.0	
$\pm$ percent error	41.3	75.1	52.3	77.9	

APPENDIX B: NUMERICAL SUMMARY OF TRANSECT RESULTS

Table B1

South Pool

Percent Unvegetated Area	Oct 52	Nov 63	Dec 60	Jan 58	Feb 38	Mar 60	Apr 61	May 55	Jun 52	Jul 34	Aug 36	Sep 36
Total vegetation												
Percent frequency	48	37	40	42	62	40	39	45	48	66	64	64
$\bar{x}$ standing crop (AP) (g/m^2)	971	1410	755	933	1261	867	1241	1351	1422	753	564	1180
$\bar{x}$ standing crop (TA) (g/m^2)	470	517	302	396	788	347	489	614	688	494	359	751
Hydrilla												
Percent frequency	29	10	20	27	31	20	15	15	16	38	36	36
$\bar{x}$ standing crop (AP) (g/m^2)	276	492	314	143	135	181	157	548	846	388	286	357
$\bar{x}$ standing crop (TA) (g/m^2)	80	49	63	39	42	36	24	83	136	146	104	130
Potamogeton												
Percent frequency	23	10	20	18	22	23	18	15	16	22	21	27
$\bar{x}$ standing crop (AP) (g/m^2)	262	94	273	90	220	262	517	269	304	245	377	637
$\bar{x}$ standing crop (TA) (g/m^2)	59	9	55	16	48	61	94	41	49	54	80	174
Nitella												
Percent frequency	16	20	7	27	31	10	21	21	16	22	15	18
$\bar{x}$ standing crop (AP) (g/m^2)	1518	2194	1641	1040	1959	2200	1528	2163	3069	1236	1073	2272
$\bar{x}$ standing crop (TA) (g/m^2)	245	439	109	284	612	220	324	459	495	270	163	413
Vallisneria												
Percent frequency	0	7	10	6	6	13	6	9	3	6	6	6
$\bar{x}$ standing crop (AP) (g/m^2)	0	297	751	916	1378	228	766	344	245	381	199	277
$\bar{x}$ standing crop (TA) (g/m^2)	0	20	75	56	86	30	46	31	8	24	12	17
P. repens												
Percent frequency	3.2	0	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	673.3	0	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (TA) ($gm/^2$)	21.7	0	0	0	0	0	0	0	0	0	0	0
Hyacinth												
Percent frequency	3.2	0	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	1297.2	0	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)	41.84	0	0	0	0	0	0	0	0	0	0	0
F. scirpoidis												
Percent frequency	3.2	0	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	708.3	0	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)	22.84	0	0	0	0	0	0	0	0	0	0	0
P. hemitonon												
Percent frequency	0	0	0	3.1	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	0	0	0	23	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)	0	0	0	0.71	0	0	0	0	0	0	0	0
Najas												
Percent frequency	0	0	0	0	0	0	3.1	0	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	0	0	0	0	0	0	31.13	0	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)	0	0	0	0	0	0	0.97	0	0	0	0	0

Table B2

Middle Pool

Percent Unvegetated Area	Oct 42	Nov 54	Dec 53	Jan 54	Feb 58	Mar 53	Apr 55	May 53	Jun 45	Jul 49	Aug 48	Sep 41
Total vegetation												
Percent frequency	58	46	47	46	42	47	45	47	55	51	52	59
$\bar{x}$ standing crop (AP) (g/m^2)	1954	1870	1522	1335	1911	1698	2930	1843	2235	1341	1323	1270
$\bar{x}$ standing crop (TA) (g/m^2)	1135	861	725	616	794	928	1312	864	1222	681	691	754
Hydrilla												
Percent frequency	2	2	5	5	2	2	0	2	0	2	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	82	3	105	3	Tr	Tr	0	Tr	0	Tr	0	0
$\bar{x}$ standing crop (TA) (g/m^2)	1	Tr	5	Tr	Tr	Tr	0	Tr	0	Tr	0	0
Potamogeton												
Percent frequency	19	24	23	28	24	23	18	28	20	25	30	30
$\bar{x}$ standing crop (AP) (g/m^2)	333	289	380	405	360	348	355	247	152	182	214	261
$\bar{x}$ standing crop (TA) (g/m^2)	64	69	86	112	87	78	64	70	31	45	64	77
Nitella												
Percent frequency	42	35	30	26	30	32	34	30	41	35	36	36
$\bar{x}$ standing crop (AP) (g/m^2)	2462	2163	2070	2890	2248	2509	3449	2658	2856	1796	1723	1793
$\bar{x}$ standing crop (TA) (g/m^2)	1033	755	627	494	681	809	1184	789	1160	636	617	644
Vallisneria												
Percent frequency	0	0	2	3	2	5	0	2	3	2	4	2
$\bar{x}$ standing crop (AP) (g/m^2)	0	0	416	146	687	450	0	83	241	Tr	83	774
$\bar{x}$ standing crop (TA) (g/m^2)	0	0	6	4	10	22	0	1	8	Tr	4	12
Ceratophyllum												
Percent frequency	2	2	2	2	2	3	3	3	2	3	0	8
$\bar{x}$ standing crop (AP) (g/m^2)	1454	1064	78	35	463	555	1074	113	770	Tr	0	273
$\bar{x}$ standing crop (TA) (g/m^2)	23	17	1	1	7	18	32	4	12	Tr	0	21
E. acicularis												
Percent frequency	1.6	0	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	185.3	0	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)	2.99	0	0	0	0	0	0	0	0	0	0	0
U. inflata												
Percent frequency	1.6	3.2	1.5	1.5	1.5	0	0	0	1.6	0	1.5	0
$\bar{x}$ standing crop (AP) (g/m^2)	404.8	754.2	12	346	621	0	0	0	682	0	163	0
$\bar{x}$ standing crop (TA) (g/m^2)	6.53	11.97	0.18	5.3	9.4	0	0	0	11	0	2.4	0
Mayaca												
Percent frequency	1.6	1.6	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	272.8	499.3	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)	4.4	7.9	0	0	0	0	0	0	0	0	0	0
Nymphaea												
Percent frequency					1.5	0	0	0	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)					44	0	0	0	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)					0.67	0	0	0	0	0	0	0
Najas												
Percent frequency								1.6	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)								19	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)								0.31	0	0	0	0
Bacopa												
Percent frequency								1.6	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)								48	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)								0.77	0	0	0	0

Table B3

East Pool

Percent Unvegetated Area	Oct 40	Nov 49	Dec 40	Jan 50	Feb 49	Mar 48	Apr 42	May 46	Jun 36	Jul 38	Aug 33	Sep 40
Total vegetation												
Percent frequency	60	51	60	50	51	52	58	54	64	62	67	60
$\bar{x}$ standing crop (AP) (g/m^2)	1708	2074	1315	1163	970	1120	1786	2367	1508	1398	1235	1367
$\bar{x}$ standing crop (TA) (g/m^2)	1011	1058	789	570	485	572	1036	1256	965	877	832	820
Hydrilla												
Percent frequency	13	19	16	18	18	13	6	10	12	12	21	10
$\bar{x}$ standing crop (AP) (g/m^2)	80	216	60	80	375	154	171	158	227	426	148	155
$\bar{x}$ standing crop (TA) (g/m^2)	10	41	10	14	69	20	10	16	27	51	31	16
Potamogeton												
Percent frequency	40	31	38	28	35	30	38	36	42	40	40	40
$\bar{x}$ standing crop (AP) (g/m^2)	620	358	408	403	656	145	218	552	554	886	538	808
$\bar{x}$ standing crop (TA) (g/m^2)	245	112	155	113	228	44	83	199	233	354	213	323
Nitella												
Percent frequency	29	25	28	28	12	28	36	24	26	16	21	20
$\bar{x}$ standing crop (AP) (g/m^2)	2447	2089	1665	1278	1267	1407	2336	3282	2286	1656	2255	1175
$\bar{x}$ standing crop (TA) (g/m^2)	714	522	466	358	155	398	841	788	594	265	470	235
Vallisneria												
Percent frequency	21	29	28	30	24	28	26	26	26	30	33	26
$\bar{x}$ standing crop (AP) (g/m^2)	117	1179	565	284	137	390	393	975	426	691	352	920
$\bar{x}$ standing crop (TA) (g/m^2)	24	344	158	85	33	110	102	253	111	207	117	239
Furina												
Percent frequency	0	2.1	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	0	1761.3	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)	0	36.69	0	0	0	0	0	0	0	0	0	0
P. hemitonon												
Percent frequency	2.1	2.1	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	887.4	102.8	0	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)	18.49	2.14	0	0	0	0	0	0	0	0	0	0
Najas												
Percent frequency	0	2.1	0	0	0	0	0	0	0	0	4.2	6.
$\bar{x}$ standing crop (AP) (g/m^2)	0	9	0	0	0	0	0	0	0	0	19.2	426
$\bar{x}$ standing crop (TA) (g/m^2)	0	0.19	0	0	0	0	0	0	0	0	0.8	8.
S. graminea												
Percent frequency											2.1	0
$\bar{x}$ standing crop (AP) (g/m^2)											5.8	0
$\bar{x}$ standing crop (TA) (g/m^2)											0.12	0

Table B4

West Pool

Percent Unvegetated Area	21 Oct 53	26 Nov 65	27 Dec 69	20 Jan 50	24 Feb 59	26 Mar 68	27 Apr 67	18 May 45	22 Jun 56	17 Jul 43	18 Aug 46	18 Sep 44
Total vegetation												
Percent frequency	47	35	31	50	61	32	33	55	44	57	55	56
$\bar{x}$ standing crop (AP) (g/m^2)	1253	897	996	638	608	652	815	1700	1558	1103	1007	1329
$\bar{x}$ standing crop (TA) (g/m^2)	595	314	332	319	252	206	265	935	701	634	554	731
Hydrilla												
Percent frequency	33	20	18	30	34	16	15	33	24	28	33	29
$\bar{x}$ standing crop (AP) (g/m^2)	172	161	122	470	344	734	552	1498	1337	1552	837	848
$\bar{x}$ standing crop (TA) (g/m^2)	56	32	22	141	118	116	83	487	326	427	272	248
Potamogeton												
Percent frequency	25	18	26	25	15	13	23	33	22	20	23	17
$\bar{x}$ standing crop (AP) (g/m^2)	277	520	840	151	133	67	274	295	647	418	275	145
$\bar{x}$ standing crop (TA) (g/m^2)	69	91	215	38	20	9	62	96	142	83	63	25
Nitella												
Percent frequency	20	2.5	8	13	12	11	8	18	10	13	13	15
$\bar{x}$ standing crop (AP) (g/m^2)	2232	3691	1066	1088	889	765	1544	1729	2284	807	1642	2918
$\bar{x}$ standing crop (TA) (g/m^2)	446	92	82	136	108	81	116	303	223	101	206	427
Vallisneria												
Percent frequency	13	12.5	8	0	10	3	5	8	2	8	8	10
$\bar{x}$ standing crop (AP) (g/m^2)	46	792	174	0	66	Tr	85	660	401	126	169	266
$\bar{x}$ standing crop (TA) (g/m^2)	6	99	13	0	6	Tr	4	49	10	9	13	26
Najas												
Percent frequency	0	0	0	5.12	2.4	0	0	5.1	0	2.5	0	2.5
$\bar{x}$ standing crop (AP) (g/m^2)	0	0	0	158	8	0	0	20	0	560	0	191
$\bar{x}$ standing crop (TA) (g/m^2)	0	0	0	4.3	0.195	0	0	0.51	0	14	0	4.78
P. repens												
Percent frequency	2.5											
$\bar{x}$ standing crop (AP) (g/m^2)	624.3											
$\bar{x}$ standing crop (TA) (g/m^2)	15.61											
P. hemitomon												
Percent frequency	2.5											
$\bar{x}$ standing crop (AP) (g/m^2)	110.9											
$\bar{x}$ standing crop (TA) (g/m^2)	2.77											

Table B5

Lake Gatlin

Percent Unvegetated Area	4 Oct 67	4 Nov 67	4 Dec 67	5 Jan 71	3 Feb 43	5 Mar 71	6 Apr 86	4 May 57	4 Jun 57	3 Jul 43	5 Aug 71	3 Sep 43
Total vegetation												
Percent frequency	33	33	33	29	57	29	14	43	43	57	29	57
$\bar{x}$ standing crop (AP) (g/m^2)	138	15	69	668	238	318	2009	2093	2203	1806	413	3586
$\bar{x}$ standing crop (TA) (g/m^2)	46	5	23	191	136	91	287	897	944	1032	118	2049
Hydrilla												
Percent frequency	0	17	0	14	29	0	0	14	0	14	0	14
$\bar{x}$ standing crop (AP) (g/m^2)	0	Tr	0	Tr	Tr	0	0	26	0	Tr	0	Tr
$\bar{x}$ standing crop (TA) (g/m^2)	0	Tr	0	Tr	Tr	0	0	4	0	Tr	0	Tr
Potamogeton												
Percent frequency	33	0	17	14	14	29	14	14	14	14	14	14
$\bar{x}$ standing crop (AP) (g/m^2)	129	0	2494	1335	870	319	2007	2364	899	1315	825	903
$\bar{x}$ standing crop (TA) (g/m^2)	43	0	416	191	124	91	287	338	128	187	118	129
Vallisneria												
Percent frequency	17	0	0	0	0	0	0	14	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	17	0	0	0	0	0	0	3882	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)	3	0	0	0	0	0	0	555	0	0	0	0
Nitella												
Percent frequency	0	0	0	0	0	0	0	0	14	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	0	0	0	0	0	0	0	0	434	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)	0	0	0	0	0	0	0	0	62	0	0	0
E. baldwinii												
Percent frequency	0	0.167	0.167	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (AP) (g/m^2)	0	27.2	136	0	0	0	0	0	0	0	0	0
$\bar{x}$ standing crop (TA) (g/m^2)	0	4.54	22.67	0	0	0	0	0	0	0	0	0
Najas												
Percent frequency	0	0	0	0	0.167	0	0	0	0	0	0	0.167
$\bar{x}$ standing crop (AP) (g/m^2)	0	0	0	0	86	0	0	0	0	0	0	269
$\bar{x}$ standing crop (TA) (g/m^2)	0	0	0	0	12.2	0	0	0	0	0	0	38.43
S. graminea												
Percent frequency									0.167	0.167	0	0.167
$\bar{x}$ standing crop (AP) (g/m^2)									5279	5915	0	13,172
$\bar{x}$ standing crop (TA) (g/m^2)									754.14	845	0	1881.71

APPENDIX C: GRAPHS OF SELECTED TRANSECT RESULTS

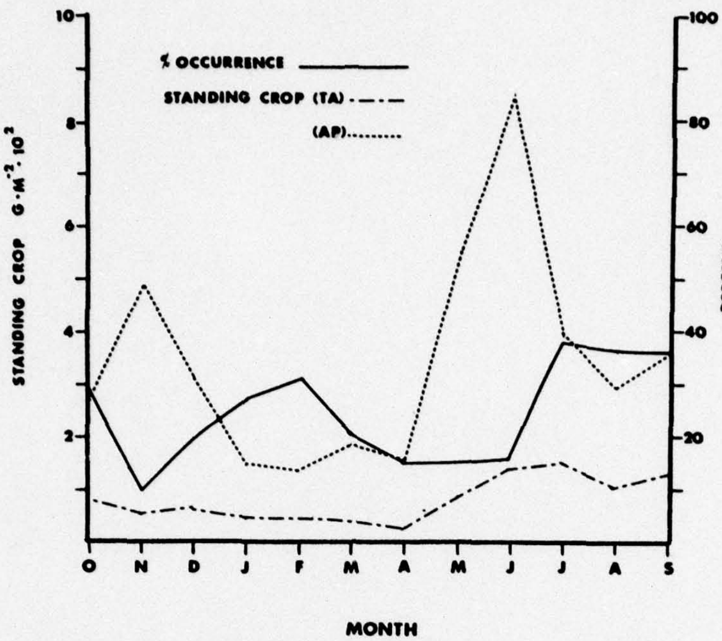

Figure C1. Transect results, South Pool-hydrilla

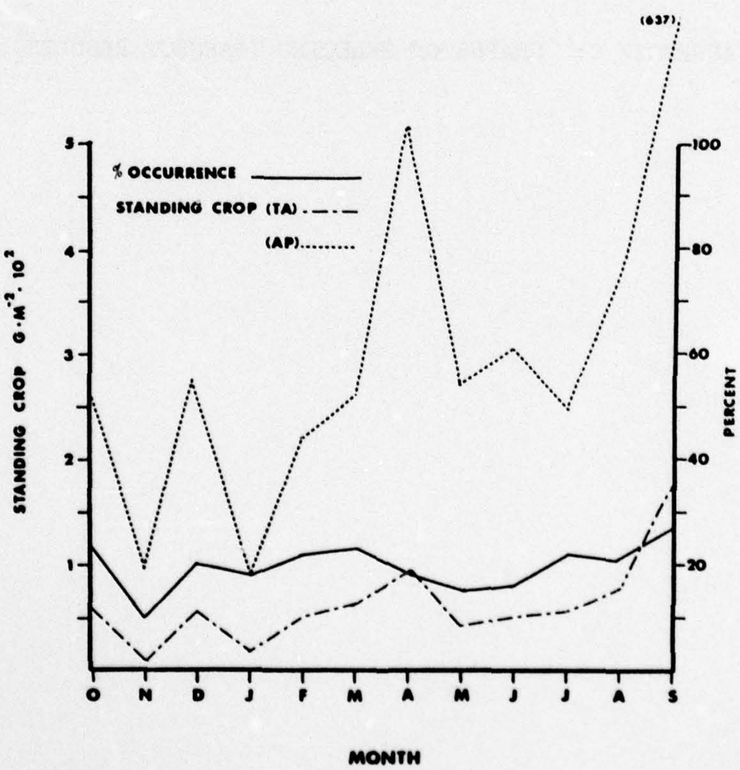

Figure C2. Transect results, South Pool-potamogeton

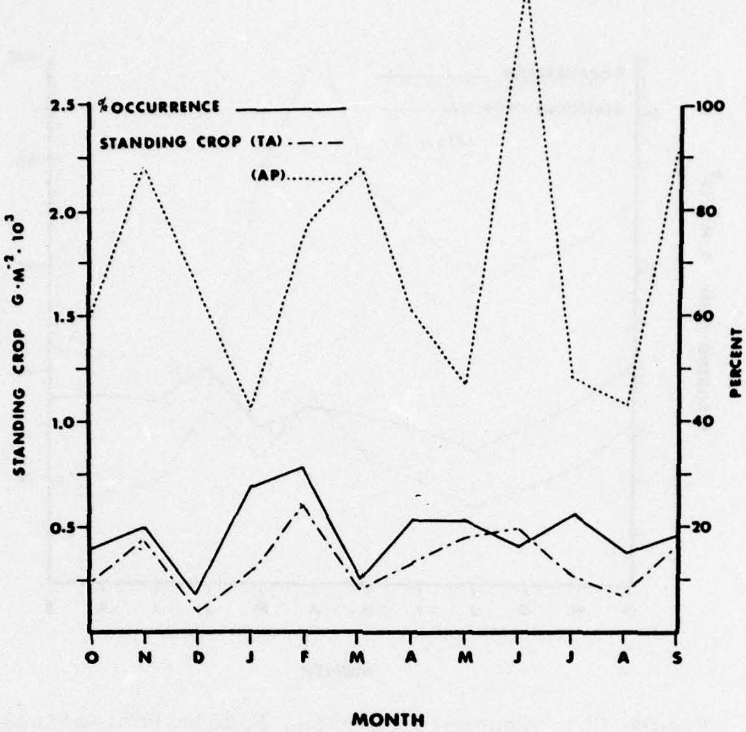

Figure C3. Transect results, South Pool-nitella

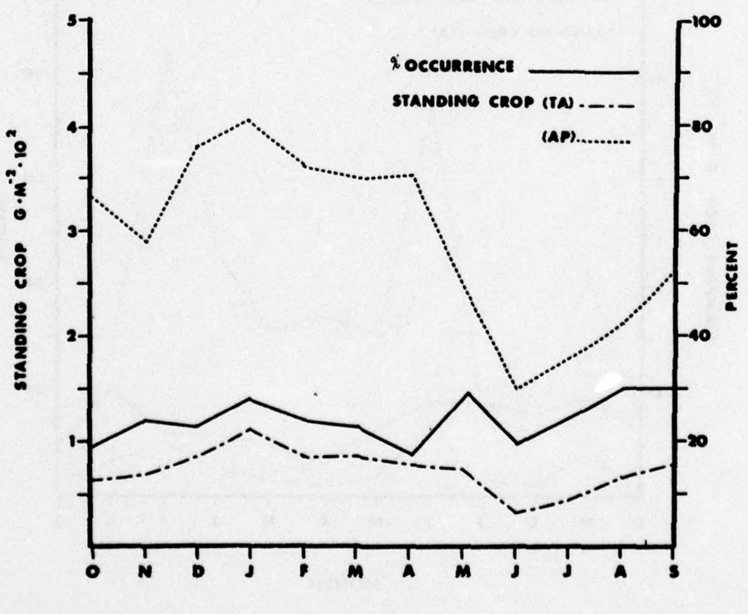

Figure C4. Transect results, Middle Pool-potamogeton

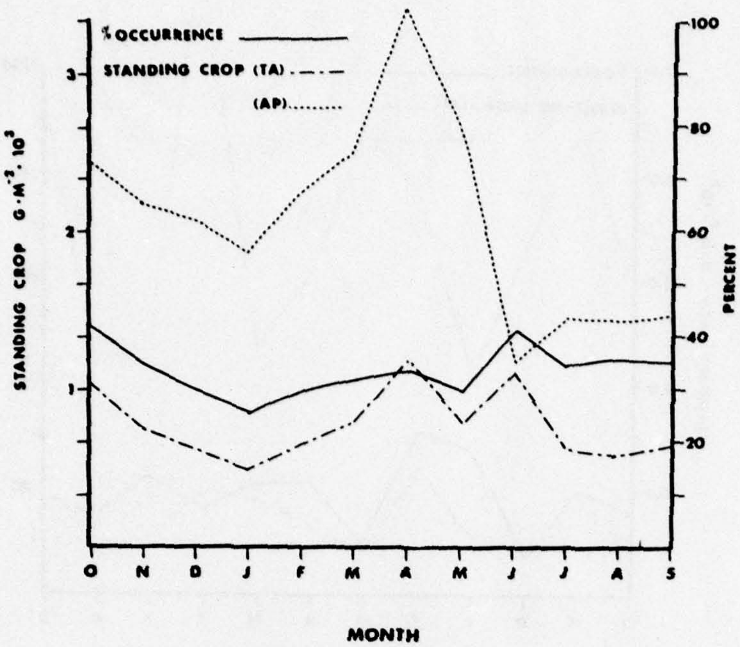

Figure C5. Transect results, Middle Pool-nitella

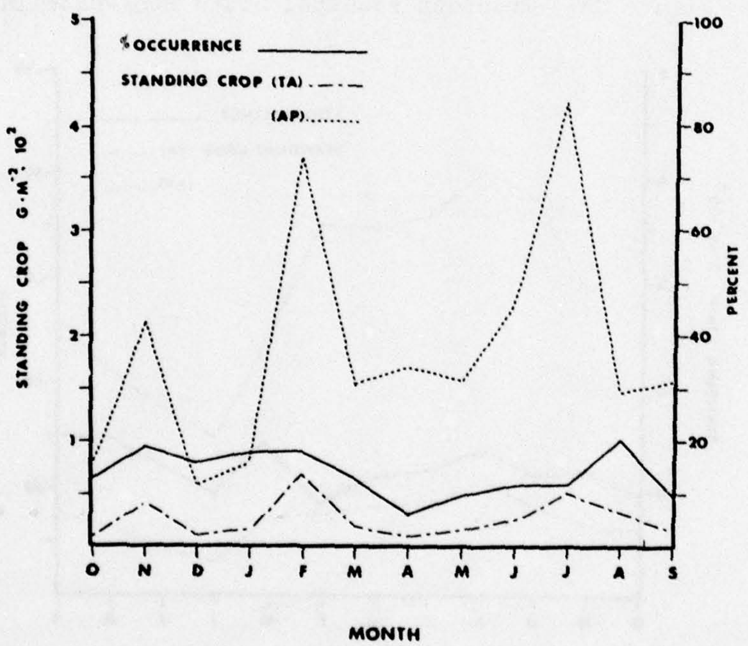

Figure C6. Transect results, East Pool-hydrilla

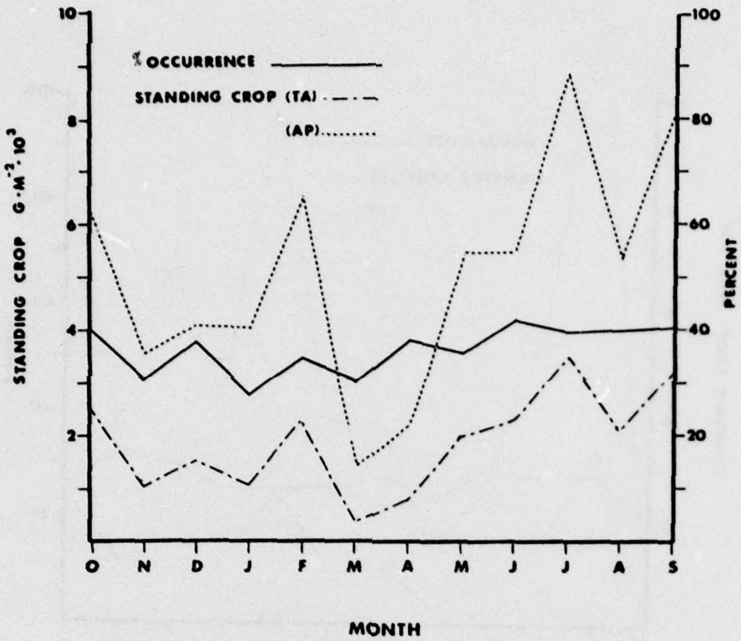

Figure C7. Transect results, East Pool-potamogeton

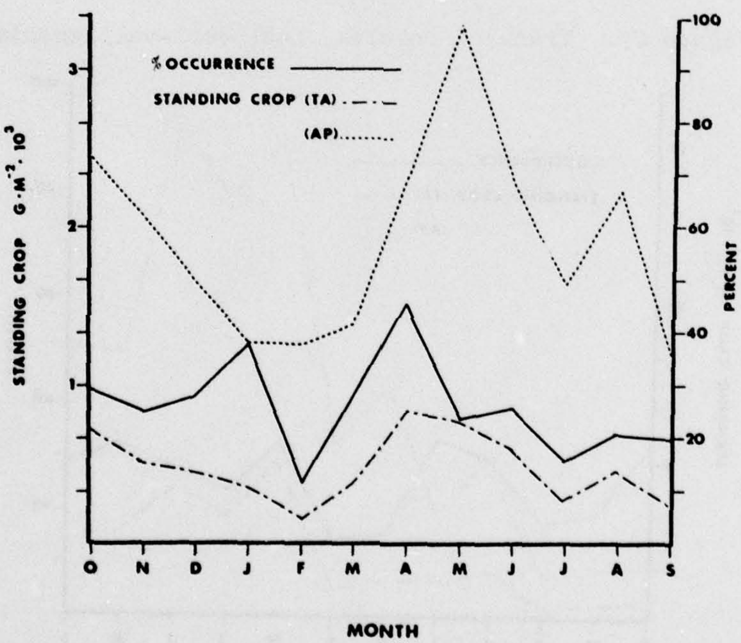

Figure C8. Transect results, East Pool-nitella

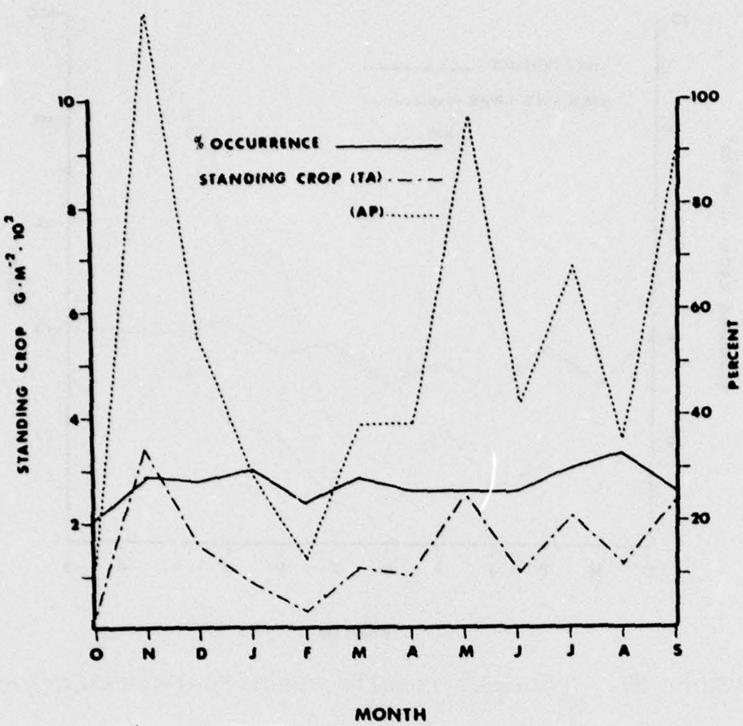

Figure C9. Transect results, East Pool-vallisneria

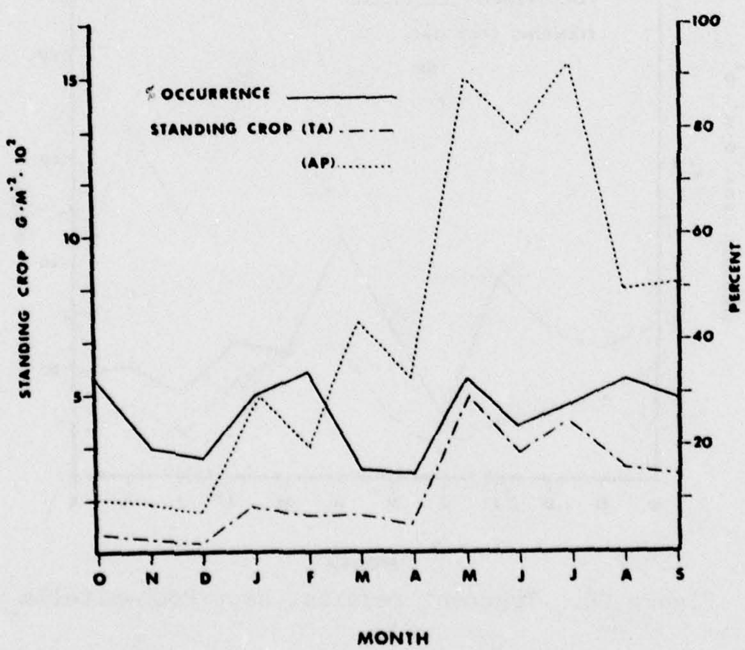

Figure C10. Transect results, West Pool-hydrilla

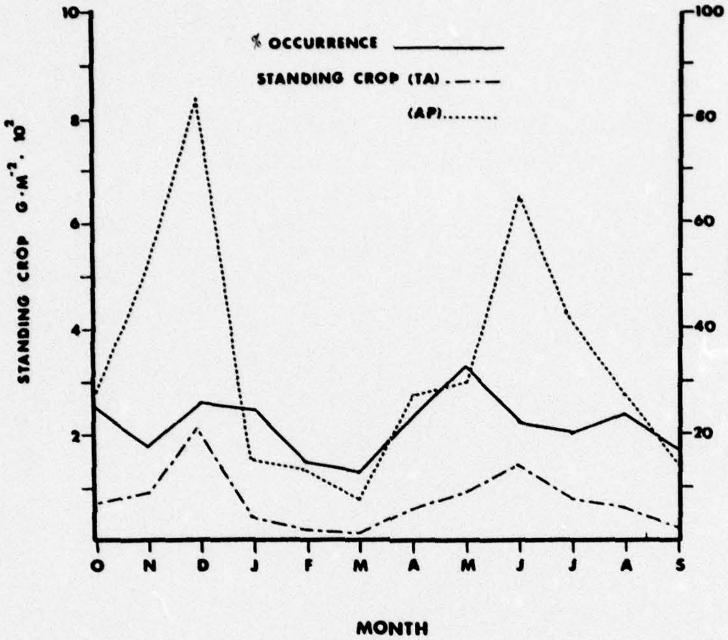

Figure C11. Transect results, West Pool-potamogeton

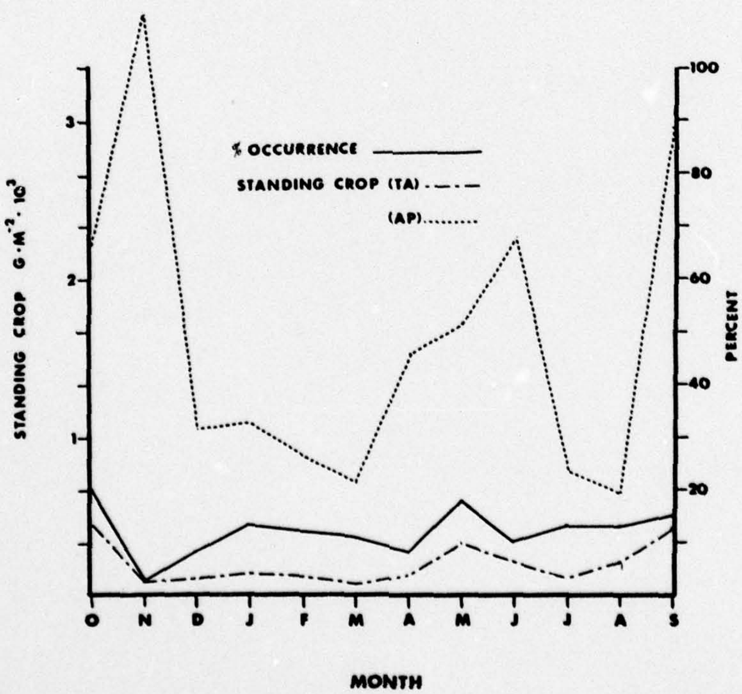

Figure C12. Transect results, West Pool-nitella

APPENDIX D: MONTHLY STANDING CROP CHANGES

Table D1

Monthly Standing Crop Change

Total Vegetation	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Net Change
South Pool												
actual change (g/m^2)	439	-655	178	328	-394	374	110	71	-669	-189	616	271
relative change (percent)	45	-46	24	35	-31	43	9	5	-47	-25	109	
$g/m^2 \cdot day^{-1}$	14.6	-22.2	5.7	11.7	-12.7	12.5	3.6	2.4	-21.6	-6.1	20.5	
Middle Pool												
actual change (g/m^2)	-274	-136	-109	178	134	384	-448	358	-541	10	63	-381
relative change (percent)	-24	-16	-15	29	17	41	-34	41	-44	1	9	
$g/m^2 \cdot day^{-1}$	-9.1	-4.4	-3.5	6.4	4.3	12.8	-14.5	11.9	-17.5	0.32	2.1	
East Pool												
actual change (g/m^2)	366	-759	-152	-193	150	666	581	-859	-110	-163	132	-341
relative change (percent)	21	-37	-12	-17	15	59	33	-36	-7	-12	11	
$g/m^2 \cdot day^{-1}$	12.2	-24.5	-4.9	-6.9	4.8	22.2	18.7	-28.6	-3.6	-5.3	4.4	
West Pool												
actual change (g/m^2)	-356	99	-358	-30	44	163	885	-142	-455	-96	322	76
relative change (percent)	-28	11	-36	-5	7	25	109	-8	-29	-9	33	
$g/m^2 \cdot day^{-1}$	-11.9	3.2	-11.6	-1.1	1.4	5.4	28.6	-4.7	-14.7	-3.1	10.7	

Table D2

Monthly Standing Crop Change

	Hydrilla											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Net Change
South Pool												
actual change (g/m^2)	216	-178	-171	-8	46	-24	391	298	-458	-102	71	81
relative change (percent)	78	-36	-54	-6	34	-13	249	54	-54	-26	25	
$g/m^2 \cdot day^{-1}$	7.2	-5.7	-5.5	-0.3	1.5	-0.8	12.6	9.9	-14.8	-3.3	2.4	
East Pool												
actual change (g/m^2)	136	-156	20	295	-221	17	-13	69	199	-278	7	75
relative change (percent)	170	-72	33	369	-59	11	-8	44	88	-65	5	
$g/m^2 \cdot day^{-1}$	4.5	-5.0	0.6	10.5	-7.1	0.6	-0.4	2.3	6.4	-9.0	0.2	
West Pool												
actual change (g/m^2)	-11	-39	348	-126	390	-182	946	-161	215	-715	11	676
relative change (percent)	-6	-24	285	-27	113	-25	171	-11	16	-46	1	
$g/m^2 \cdot day^{-1}$	-0.4	-1.3	11.2	-4.5	12.6	-6.1	30.5	-5.4	6.9	-23.1	0.4	

Table D3

Monthly Standing Crop Change

	Potamogeton											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Net Change
South Pool												
actual change (g/m^2)	-168	179	-183	130	42	255	-248	35	-59	132	260	450
relative change (percent)	-64	190	-33	144	19	97	-48	13	-19	54	69	
$g/m^2 \cdot day^{-1}$	-5.6	5.8	-5.9	4.6	1.4	8.5	-8.0	1.2	-1.9	4.3	8.7	
Middle Pool												
actual change (g/m^2)	-44	91	25	-45	-12	7	-108	-95	30	32	47	-72
relative change (percent)	-13	31	7	-11	-3	2	-30	-38	20	18	22	
$g/m^2 \cdot day^{-1}$	-1.5	2.9	0.8	-1.6	-0.4	0.2	-3.5	-3.2	1.0	1.0	1.6	
East Pool												
actual change (g/m^2)	-262	50	-5	253	-511	73	334	2	352	-348	270	188
relative change (percent)	-42	14	-1	63	-78	50	153	1	60	-39	50	
$g/m^2 \cdot day^{-1}$	-8.7	1.6	-0.2	9.0	-16.5	2.4	10.8	0.1	10.7	-11.2	9.0	
West Pool												
actual change (g/m^2)	243	320	-689	-18	-66	207	21	352	-229	-143	-130	-132
relative change (percent)	88	62	-82	-12	-50	309	8	119	-35	-34	-47	
$g/m^2 \cdot day^{-1}$	8.1	10.3	-22.2	-0.6	-2.1	6.9	0.7	11.7	-7.4	-4.6	-4.3	

Table D4

Monthly Standing Crop Change

	Nitella											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Net Change
South Pool												
actual change (g/m^2)	676	-533	-601	919	241	-672	635	906	-1833	-163	1199	774
relative change (percent)	45	-25	-37	88	12	-31	74	42	-60	-13	112	
$g/m^2 \cdot day^{-1}$	22.5	-17.2	-19.3	32.8	7.7	-22.4	20.5	30.2	-59.1	-5.3	40.0	
Middle Pool												
actual change (g/m^2)	-299	-93	-180	358	261	940	-791	198	-1060	-73	70	-669
relative change (percent)	-12	-4	-9	19	12	37	-23	7	-37	-4	4	
$g/m^2 \cdot day^{-1}$	-10.0	-3.0	-5.8	12.8	8.4	31.3	-25.5	6.6	-34.2	-2.4	2.3	
East Pool												
actual change (g/m^2)	-358	-424	-387	-11	140	929	946	-996	-630	599	-1080	-1272
relative change (percent)	-15	-20	-23	-1	11	66	40	-30	-28	36	-48	
$g/m^2 \cdot day^{-1}$	-11.9	-14.7	-12.5	-0.4	4.5	31.0	30.5	-33.2	-20.3	19.3	-36.0	
West Pool												
actual change (g/m^2)	1459	-2625	22	-199	-124	779	185	555	-1477	835	1276	686
relative change (percent)	65	-71	2	-18	-14	102	12	32	-65	103	78	
$g/m^2 \cdot day^{-1}$	48.6	-84.7	-0.7	-7.1	-4.0	26.0	5.9	18.3	-47.6	26.9	42.5	

AD-A057 345 FLORIDA DEPT OF NATURAL RESOURCES TALLAHASSEE BUREAU--ETC F/G 6/3
LARGE-SCALE OPERATIONS MANAGEMENT TEST OF USE OF THE WHITE AMUR--ETC(U)
JUN 78 L E NALL, J D SCHARDT DACW39-76-C-0084

UNCLASSIFIED WES-TR-A-78-2-VOL-1 NL

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Table D5

Monthly Standing Crop Change

Vallisneria												
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Net Change
East Pool												
actual change (g/m^2)	1062	-614	-281	-147	253	3	582	-549	265	-339	568	803
relative change (percent)	908	-52	-50	-52	185	1	148	-56	62	-49	161	
$g/m^2 \cdot day^{-1}$	35.4	-19.8	-9.1	-5.3	8.2	0.1	18.8	-18.3	8.6	-10.9	18.9	

APPENDIX E: NUMERICAL SUMMARY OF PERMANENT PLOT DATA

Table E1

Plot Frequencies

Plot Number Plant Type	Month Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Plot #1												
Hydrilla	17	37	27	37	40	33	33	10	53	57	17	13
Potamogeton	7	3	7	27	20	37	23	10	3	10	7	0
Nitella	100	100	100	100	100	100	100	100	80	90	100	97
Barren	0	0	0	0	0	0	0	0	0	0	0	0
Plot #2												
Hydrilla	23	17	10	50	30	33	37	17	47	53	43	47
Potamogeton	10	10	43	30	27	37	70	80	27	40	67	53
Nitella	77	90	73	60	83	87	67	37	73	57	70	53
Najas	0	0	0	3	0	0	0	0	3	0	0	0
Barren	23	10	3	20	7	13	0	3	3	7	0	3
Plot #3												
Hydrilla	17	0	23	10	3	27	13	3	10	17	3	0
Potamogeton	7	7	0	13	0	13	17	0	0	10	10	10
Nitella	87	97	90	90	100	100	93	97	93	100	100	100
Ceratophyllum	10	3	7	7	0	0	10	3	7	7	3	7
Vallisneria	3	0	0	0	0	0	0	0	0	0	0	
Utricularia inflata	0	0	3	0	0	0	3	0	0	0	0	
Barren	7	3	10	0	0	0	0	0	0	0	0	
Plot #4												
Hydrilla	37	0	0	0	3	7	7	0	13	7	3	0
Potamogeton	3	0	0	0	0	3	3	3	0	0	0	0
Nitella	33	3	7	27	33	23	13	33	70	47	47	43
Ceratophyllum	93	53	77	57	67	77	67	43	67	57	90	87
Nymphaea	0	3	0	0	0	0	0	3	0	0	0	0
Barren	0	43	20	23	17	10	20	27	7	20	3	3
Plot #5												
Hydrilla	20	0	7	0	0	3	0	0	0	0	3	0
Potamogeton	87	67	70	70	33	60	90	63	77	97	100	73
Nitella	87	100	93	77	100	100	93	100	100	57	100	73
Barren	0	0	0	0	0	0	0	0	0	0	0	0
Plot #6												
Potamogeton	100	100	100	100	100	100	100	100	100	100	100	100
Nitella	0	40	77	77	70	57	27	100	100	67	93	100
Vallisneria	100	100	100	100	80	40	77	100	97	83	77	0
Najas	0	0	0	0	3	0	0	17	17	3	7	20
Barren	0	0	0	0	0	0	0	0	0	0	0	
Plot #7												
Hydrilla	27	43	33	63	43	33	39	53	47	77	90	93
Potamogeton	0	0	0	0	10	3	7	3	0	7	13	3
Nitella	0	0	0	0	0	0	3	0	0	0	0	0
Vallisneria	0	0	0	3	7	0	0	0	0	0	7	10
Barren	73	57	67	37	40	67	67	47	53	20	10	7
Plot #8												
Hydrilla	13	7	20	57	43	27	13	0	7	33	60	93
Potamogeton	0	0	0	10	3	3	7	0	0	0	0	3
Barren	87	93	80	30	53	73	80	100	93	67	40	7
Plot #9												
Hydrilla	17	10	3	3	0	0	0	3	10	37	10	20
Potamogeton	60	50	83	33	57	50	33	47	47	47	67	60
Nitella	100	100	100	100	100	100	100	100	100	100	100	100
Vallisneria	0	0	10	0	0	30	3	0	10	3	7	17
Barren	0	0	0	0	0	0	0	0	0	0	0	0

(Continued)

Table E1 (Concluded)

Plot Number Plant Type	Month Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Plot #10												
Hydrilla	100	100	97	100	100	100	100	100	100	100	100	100
Potamogeton	30	10	23	3	17	3	30	20	0	17	37	50
Vallisneria	0	7	17	7	10	20	17	7	3	43	20	47
Najas	0	0	0	0	0	0	0	20	0	0	0	7
Nymphaea	0	3	0	3	0	0	0	0	0	0	0	0
Barren	0	0	3	0	0	0	0	0	0	0	0	0
Nitella	0	0	0	0	0	0	0	0	0	0	0	3
Plot #11												
Hydrilla	10	3	0	13	10	7	3	7	0	7	13	7
Najas	33	3	0	3	3	0	0	3	0	30	20	43
Nymphaea	0	0	0	10	7	3	0	0	0	0	0	0
Barren	63	93	100	73	80	90	97	90	100	67	70	53
Plot #13												
Hydrilla	0	0	0	7	7	0	13	33	50	37	73	60
Potamogeton	87	60	27	53	33	10	7	27	27	57	40	30
Vallisneria	7	0	0	0	0	3	0	13	0	37	3	3
Barren	13	40	73	43	60	87	80	27	23	10	13	23
Nymphaea												3
Najas												3
Plot #14												
Potamogeton	3	0	10	10	0	10	3	27	37	7	17	23
Nitella	10	17	33	50	30	33	50	20	40	30	47	37
Ceratophyllum	0	0	3	0	0	0	0	0	0	0	0	
Vallisneria	0	0	0	0	0	0	0	0	0	0	0	
U. Fibrosa (gibba)	0	0	7	7	3	0	0	0	0	0	0	23
Utricularia inflata	23	30	47	27	37	33	20	27	40	20	23	17
Cabomba	0	0	0	0	0	0	3	0	0	3	0	7
Nymphaea	13	3	3	7	3	10	6	20	23	30	7	7
Najas												3
Barren	67	50	33	33	40	33	0	23	33	37	47	57
Hydrilla												3
Mayaca												7
Plot #15												
Hydrilla	7	0	0	0	0	0	3	0	0	0	3	
Potamogeton	100	100	100	100	97	100	100	100	100	100	100	100
Nitella	63	43	37	73	93	100	80	43	83	50	13	100
Ceratophyllum	0	0	0	0	0	3	0	0	0	0	0	
Vallisneria	0	0	7	0	3	0	3	0	7	0	0	
Bacopa	0	3	0	7	7	7	13	10	10	3	7	
Barren	0	0	0	0	0	0	0	0	0	0	0	
Plot #16												
Hydrilla	67	67	73	37	100	60	93	40	100	57	17	60
Potamogeton	43	40	53	33	10	53	20	43	37	47	90	43
Nitella	63	90	80	60	20	87	93	80	87	93	100	100
Najas	3	0	0	0	0	0	3	0	3	3	7	10
Barren	0	7	0	7	0	0	0	0	3	0	0	0
Plot #18												
Hydrilla	20	0	13	0	3	7	0	0	3	0	0	0
Potamogeton	13	13	7	10	20	10	7	0	7	7	10	13
Nitella	0	0	23	0	0	7	3	0	0	0	0	
Vallisneria	100	100	100	100	100	100	100	100	100	100	100	100
Barren	0	0	0	0	0	0	0	0	0	0	0	

Table E2

Plot Densities

(#/m^2)

Plot Number Plant Type	Month Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Plot #1												
Hydrilla	37				384		14		10	56	0	
Potamogeton							4	72	0	0	0	
Nitella	863	10,184	3954	2190	3448	4767	5436	12,100	4919	4034	3483	5343
Plot #2												
Hydrilla							144	110	88	22	0	
Potamogeton					52	8			0	30	26	44
Nitella	649	2094	2006	66	5850	727	1011	1766	52	1764	370	0
Plot #3												
Hydrilla	54		374	16	106	40			0	0	0	
Potamogeton	2	8					8		0	0	0	
Nitella	1108	1268	3080	2448	2228	3518	1993	6432	6082	3602	8262	6969
Ceratophyllum					6				4			
Plot #4												
Hydrilla	9			6		6		196	10	0	0	
Potamogeton			2						0	0	0	
Nitella	7		190			14		56	8	784	260	314
Ceratophyllum	19	24	83	152	152	102	154	196	268	230	606	66
Plot #5												
Potamogeton	12	12	2			4	16		48	150	78	86
Nitella	375	9680	5920	5008	5032	12,532	6017	2772	2990	40	2016	1832
Plot #6												
Sagittaria												10
Potamogeton	64	260	80	264	288	252	238	166	296	366	414	554
Nitella	11	170	414	26	3764	1780	2008	298	2556	3955	174	1485
Vallisneria	68	304	32	178	250	278		336	146	110	216	52
Najas												534
Plot #7												
Hydrilla					34			10	19	50	54	100
Plot #8												
Hydrilla											32	70
Plot #9												
Hydrilla			10						0	0	0	4
Potamogeton	2		34			10		6	10	0	0	8
Nitella	624	5996	3528	3146	2465	4441	4820	4221	6914	6512	5802	5865
Ceratophyllum						2			0	0	0	
Plot #10												
Hydrilla	571	1590	708	1202	794	1326	1506	2798	1732	1988	1102	1396
Potamogeton		18		4				4	482	0	0	
Nitella				6					0	0	0	
Vallisneria		4	168			60	474	6	0	0	0	
Ceratophyllum							2		0	0	0	
Najas		50		4		6			0	0	0	
Plot #11												
Najas	1									0	0	
Hydrilla											8	
Plot #13												
Hydrilla								48	26	4	70	34
Potamogeton		6		16				12	4	14	10	
Plot #14												
Potamogeton	20	12							0	0	0	
Nitella	165	1194				3150			770	74	484	
Eleocharis	2906								0	0	0	
Nymphaea						6			44	0	0	
Plot #15												
Potamogeton	35	198	162	396	176	131	258	110	138	189	82	44
Nitella	527	2230	6	1812	4954	451	0	1252	3471	170	24	1822
Plot #16												
Hydrilla	18	18	3958	700	908	138	102		992	816	0	572
Potamogeton	12		36			16	58		8	0	6	
Nitella	1245	4610	392	1286	4888	5244	1100	4278	1550	3416	4027	2083
Vallisneria			160				146		0	0	0	
Najas					46				2	0	0	
Plot #18												
Hydrilla					4				0	0	0	
Potamogeton			12						0	6	0	24
Vallisneria	688	982	3546	832	1992	1050	2832	1336	2748	2824	614	2630

Table E3

Plot Fixed Heights

(m)

Plot Number / Plant Type	Point	Month: Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Plot #1													
Nitella	1	0.9	1.0	0.7	0.6	1.0	0.6	0.5	0.5	0.6	0.6	0.6	0.7
	2	0.8	1.1	0.9	0.5	0.5	0.6	0.6	0.5	0.5	0.4	0.4	0.5
Plot #2													
Nitella	1	0.4	0.7	0.5	0.6	0.5	0.5	0.4		0.4	0.2	0.2	0.2
	2	0.4	0.5	0.6	0.3	0.6	0.4	0.3	0.3	0.4	0.4	0.2	0.1
Potamogeton	1				1.0	1.0	1.0	1.0	0.5	1.5	2.0	2.4	3.0
	2	0.5							0.1				
Plot #3													
Nitella	1												0.5
	2	0.9	0.9	0.9	0.9	0.8	1.0	0.7	0.6	0.7	0.6	1.0	0.6
Ceratophyllum	1	0.3						0.1	0.2	0.1	0.2	0.1	0.3
	2	1.2											
Plot #4													
Hydrilla	1	0.5											
	2	0.3											
Nitella	1	0.6											1.0
	2												
Ceratophyllum	1	0.3	0.2	0.2	0.2	0.1	0.1	0.2	0.3	0.4	0.4	0.6	0.5
	2	0.4	0.2	0.4	0.2	0.1	0.2	0.2	0.3	0.4	0.3	0.5	1.2
Plot #5													
Hydrilla	1												
	2	0.3											
Potamogeton	1	0.7	0.4		0.3	0.3	0.3			0.1	0.4	0.3	0.4
	2	0.3								0	0.4	0.4	0.5
Nitella	1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1
	2	0.4	0.5	0.8	0.5	0.6	0.4	0.5	0.4	0.3	0.4	0.3	0.2
Plot #6													
Potamogeton	1	1.2	1.3	0.8	0.5	0.5	0.2	0.6	0.5	0.4	0.6	0.6	0.6
	2	1.3	1.2	1.0	0.5	0.6	0.2	0.4	0.5	0.5	0.9	1.0	1.0
Vallisneria	1	0.4	0.4	0.1		0.2			0.4	0	0	0	
	2	0.4	0.2	0.2		0.2	0.1	0.2	0.2	0.1	0	0	
Nitella	1						0.1		0.3	0.4	0.2	0.2	0.3
	2								0.2	0.1	0	0.1	0.2
Plot #7													
Hydrilla	1	0.4	0.5	0.3	0.5		0.1			0.8	0.5	0.1	0.1
	2									0.5			
Plot #8													
Hydrilla	1				0.2	0.2	0.2	0.1					0.1
	2				0.4								0.1
Plot #9													
Potamogeton	1												
	2	0.7	0.5	0.6	0.5	0.6	0.6	0.3	0.3		0.4	0.8	0.3

(Continued)

Table E3 (Concluded)

Plot Number Plant Type	Point	Month Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Plot #9 (Continued)													
Nitella	1	0.5	0.4	0.5	0.4	0.4	0.5	0.3	0.4	0.2	0.2	0.2	0.3
	2	0.4	0.5	0.4	0.4	0.5	0.6	0.4	0.4	0.2	0.2	0.3	0.3
Plot #10													
Hydrilla	1	1.5	0.3	0.2	0.2	0.3	0.3	0.3	0.8	1.0	1.2	1.0	0.6
	2	0.3	0.5	0.6	0.3	0.2	0.4	0.8	1.3	1.6	1.5	2.3	0.8
Vallisneria	1												0.5
	2								0.3				0.2
Plot #11													
Najas	1	0.1											
	2					0.1							
Plot #13													
Potamogeton	1	0.2	0.2										
	2	0.4	0.4	0.2	0.2	0.1	0.2	0.1	1.5	1.4	1.2	2.3	1.2
Plot #14													
Potamogeton	1							0.1					
	2												
Utricularia	1		0.3					0.1	0.4			0.1	
	2	0.1											
Nitella	1												
	2					0.1							
Nymphaea	1							0.1	0.1	0.2			
	2												
Plot #15													
Potamogeton	1	1.0	0.5	0.5	0.4	0.1	0.3	0.4	0.9	0.2	0.4	0.2	0.4
	2	0.7	0.5	0.9	0.7	1.0	0.6	0.5	0.5	0.4	0.4	0.4	0.4
Vallisneria	1	0.1											
	2									0.5			
Nitella	1					1.0							
	2	0.6		0.6	0.5	0.3	0.6	0.5		0.2	0.3		0.2
Plot #16													
Hydrilla	1												
	2				0.1	0.1	0.1	0.3	0.8	1.2	0	2.2	1.2
Potamogeton	1	0.5	0.5	0.5	0.4	0.3		0.6	0.5	0.4	0.6		0.4
	2												
Nitella	1	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
	2											0.9	1.2
Plot #18													
Vallisneria	1	0.7	0.4	0.6	0.2	0.2	0.3	0.5	0.1	0.1	0.3	0.2	0.3
	2	1.4	1.2	1.0	0.9	0.8	1.0	0.8	0.4	0.4	0.4	0.7	0.6
Potamogeton	1	0.5	0.5	0.6	0.2		0.2	0.4		0.2	0.3		0.2
	2												

APPENDIX F: GRAPHS OF SELECTED PERMANENT PLOT DATA

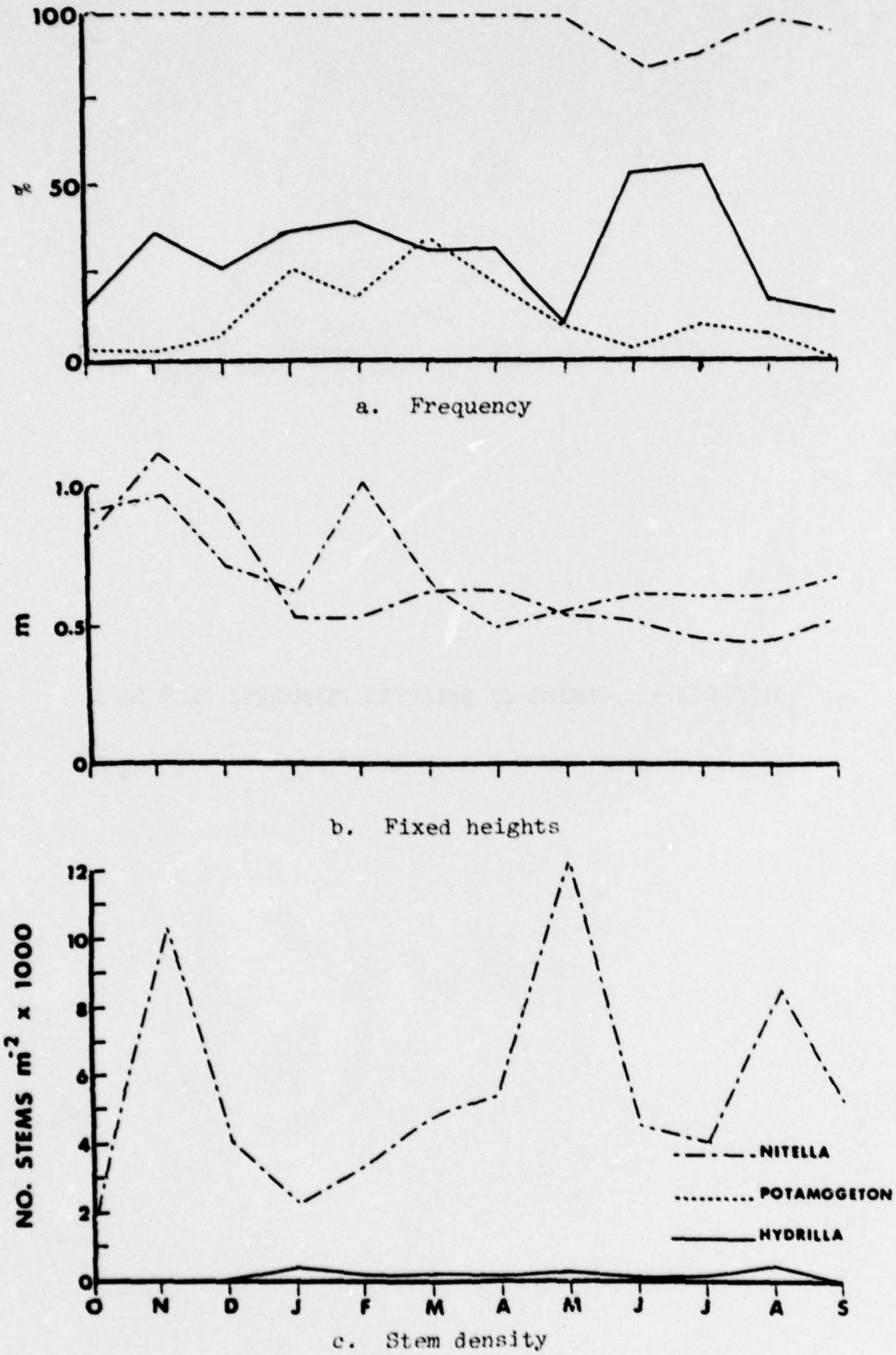


Figure F1. Selected permanent data, Plot One

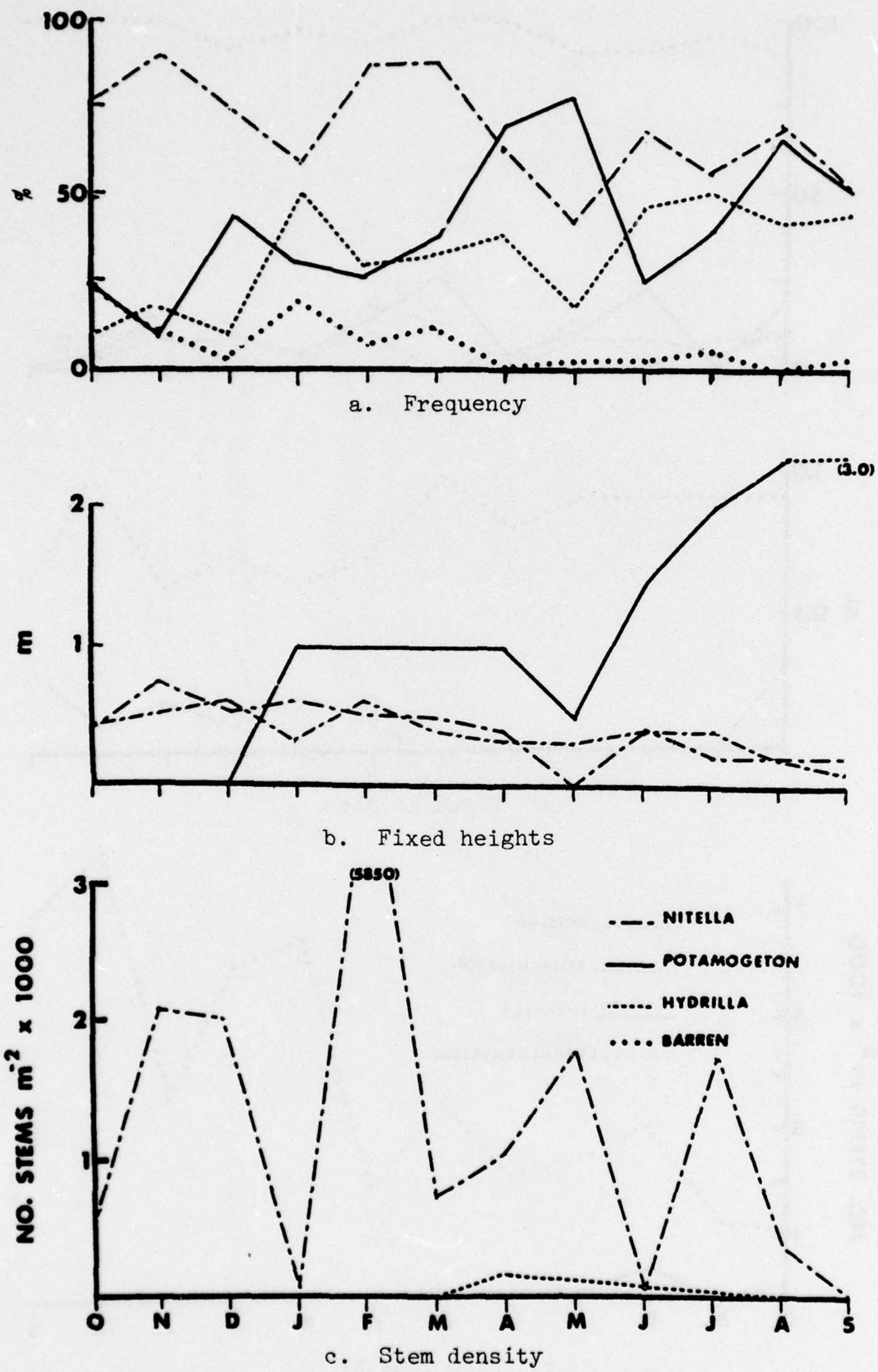


Figure F2. Selected permanent data, Plot Two

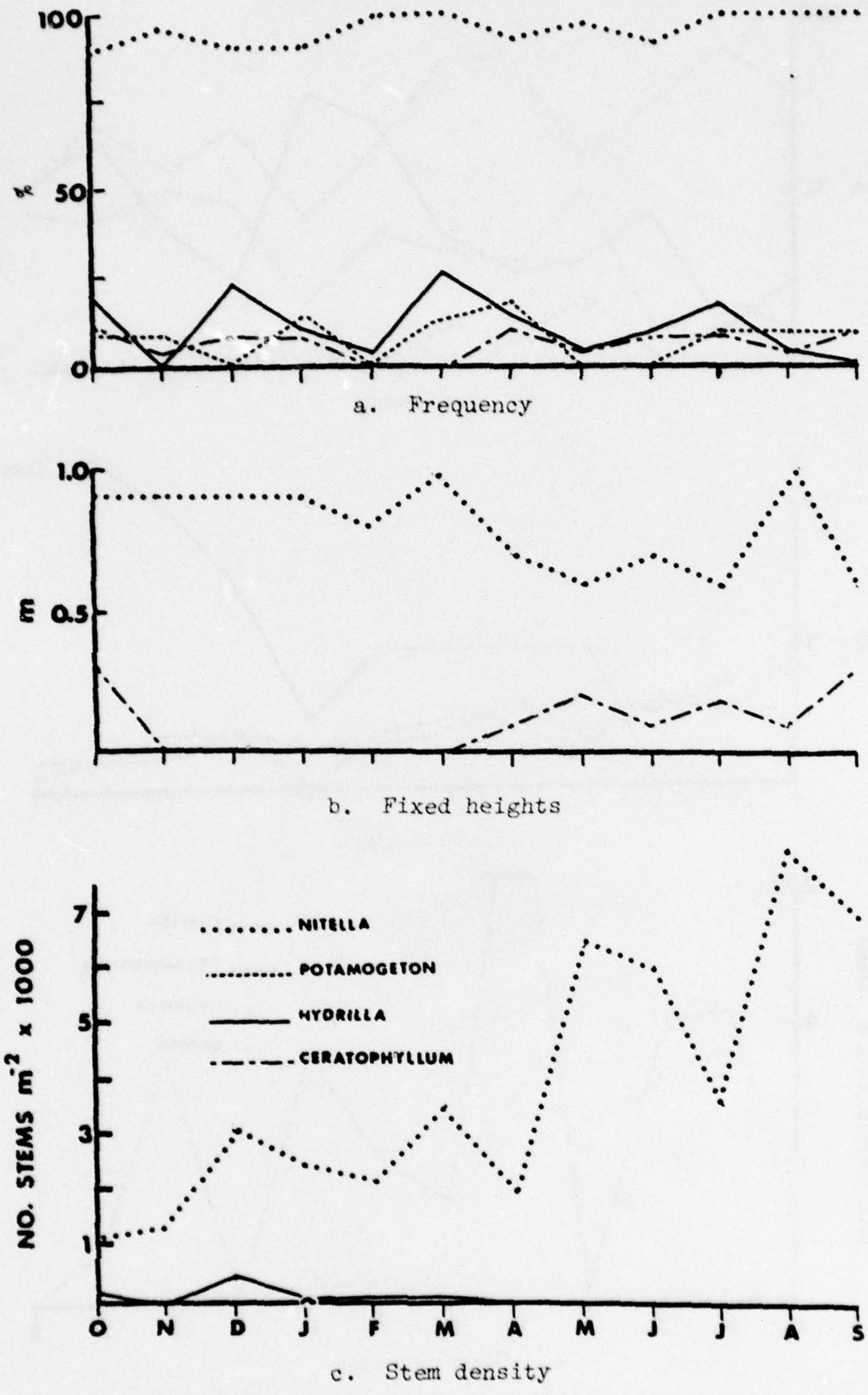


Figure F3. Selected permanent data, Plot Three

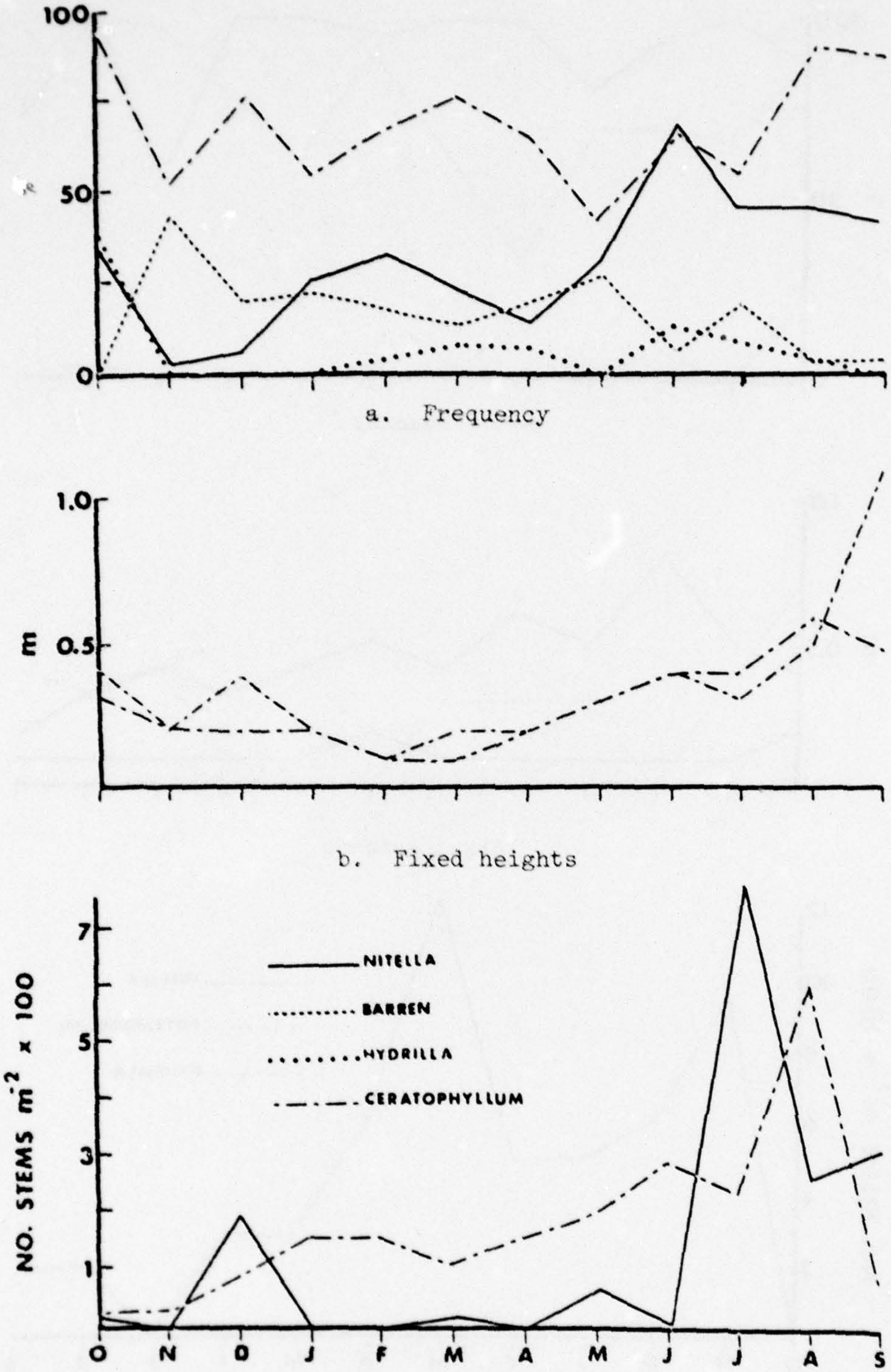


Figure F4. Selected permanent data, Plot Four

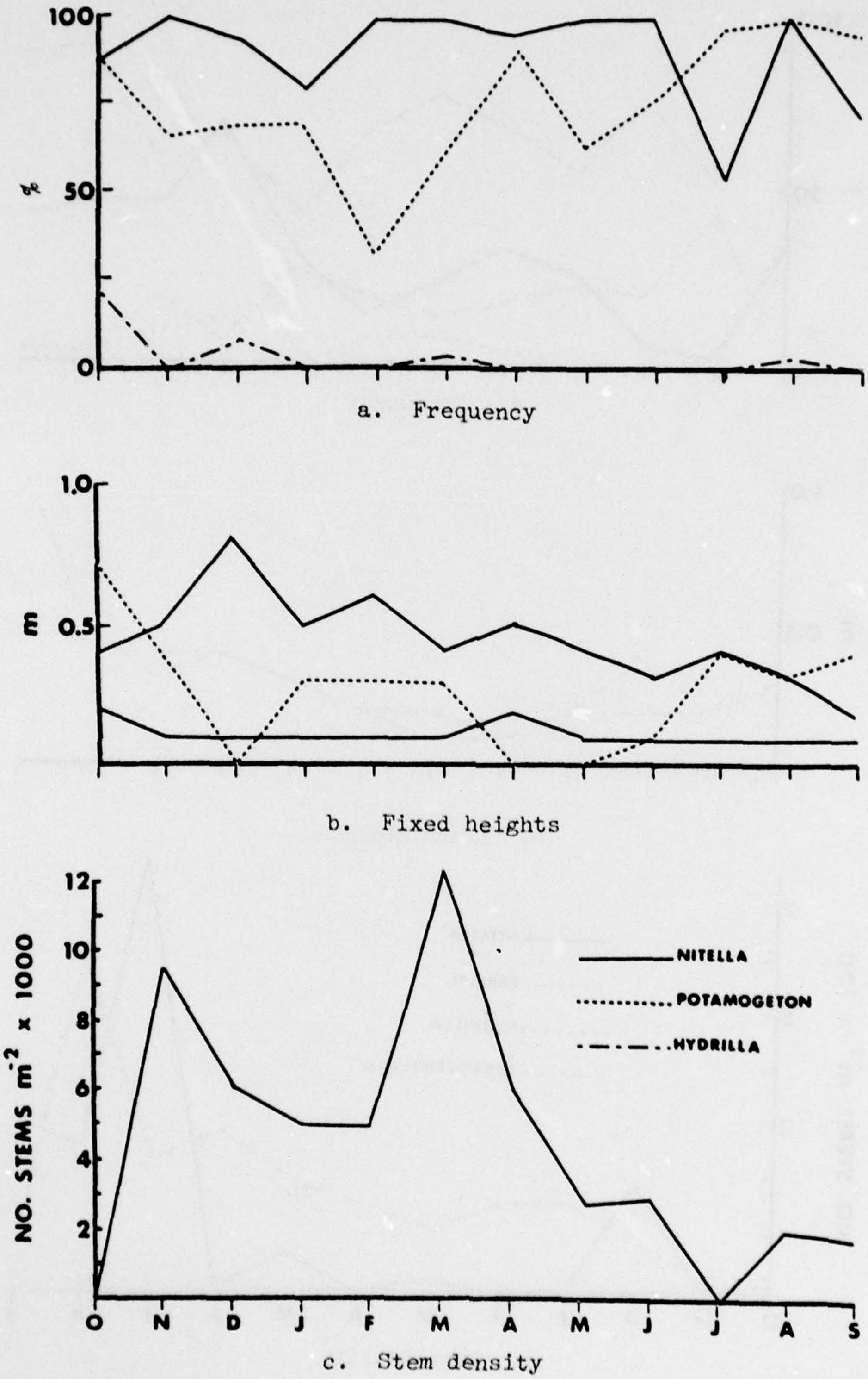


Figure F5. Selected permanent data, Plot Five

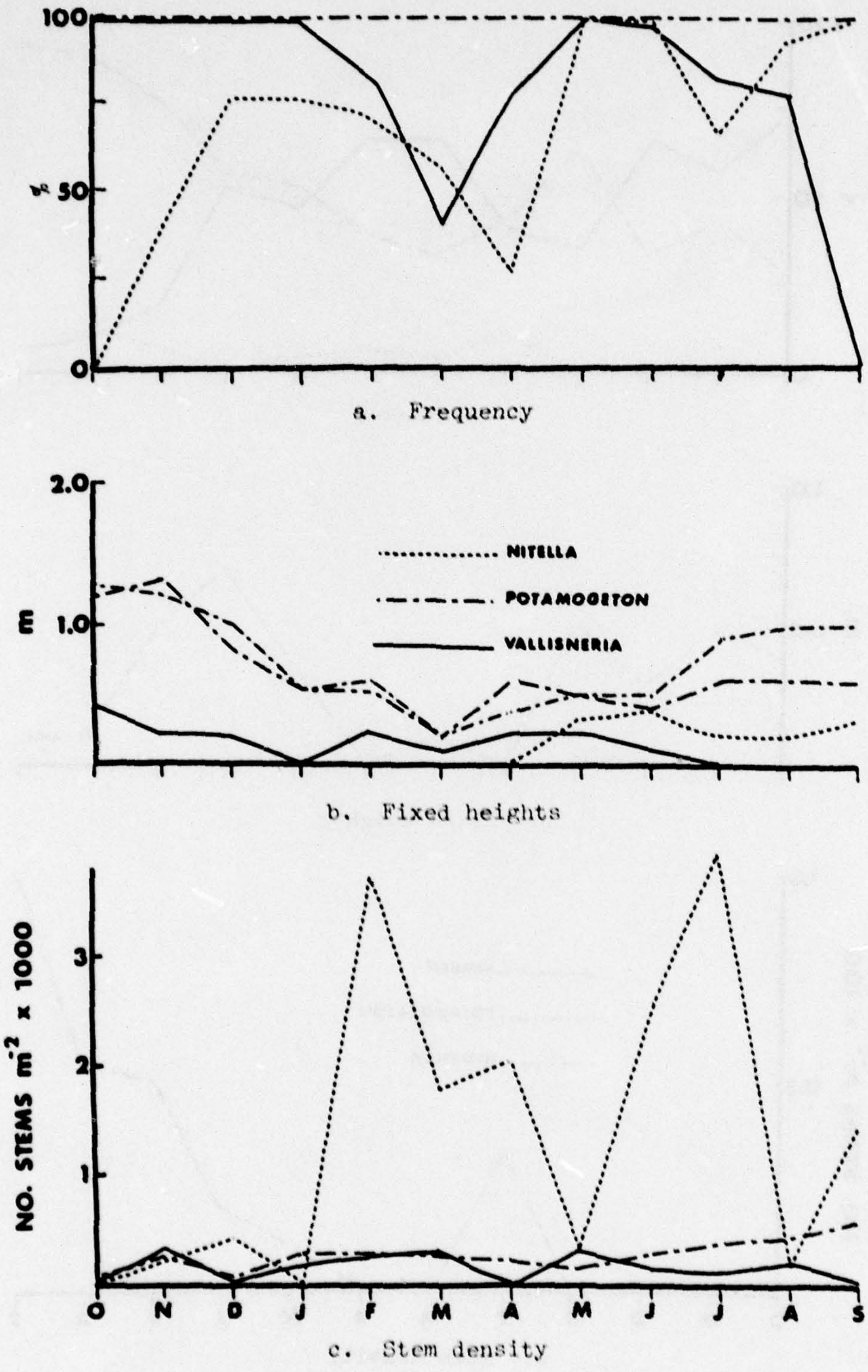


Figure F6. Selected permanent data, Plot Six

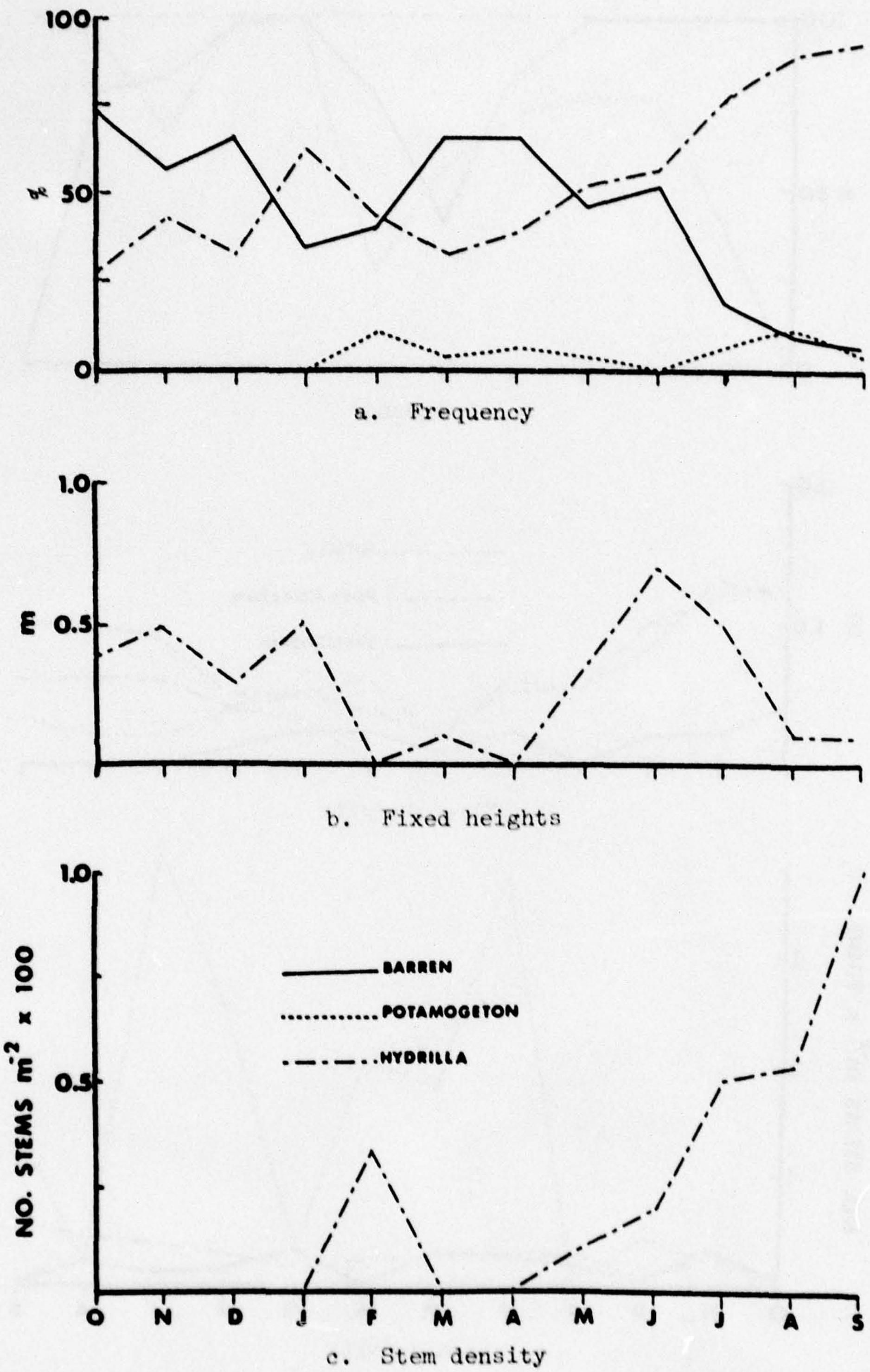


Figure F7. Selected permanent data, Plot Seven

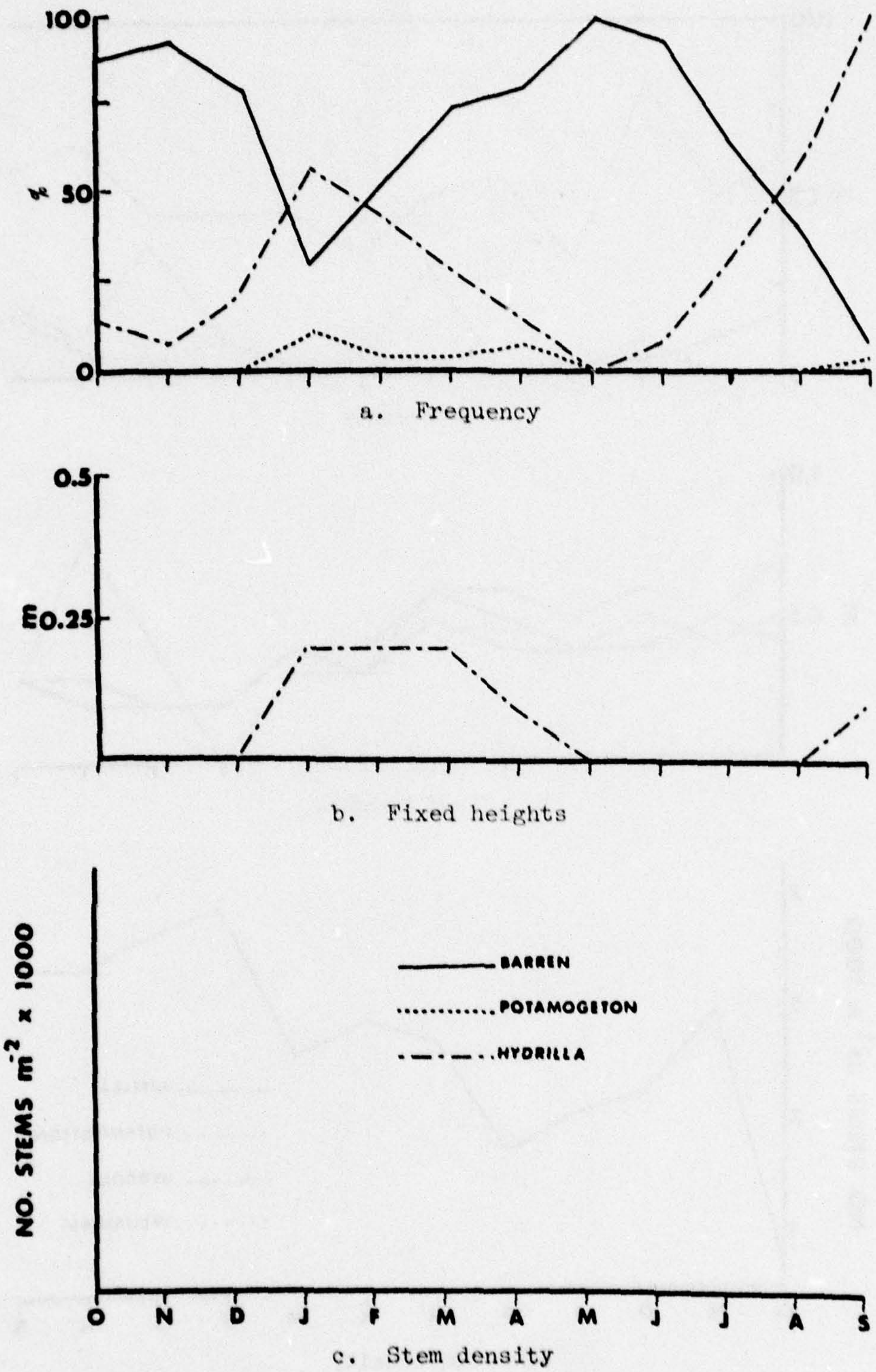
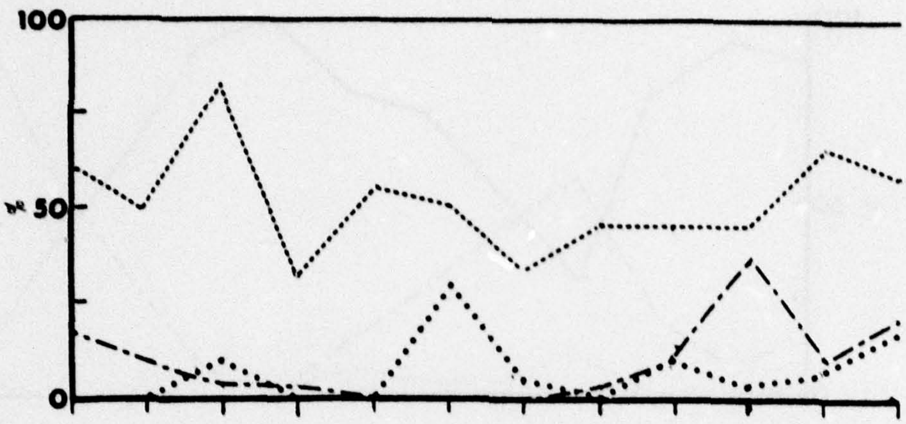
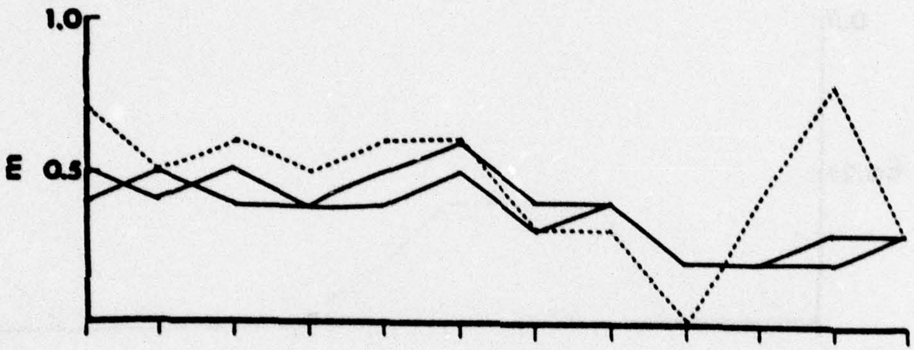


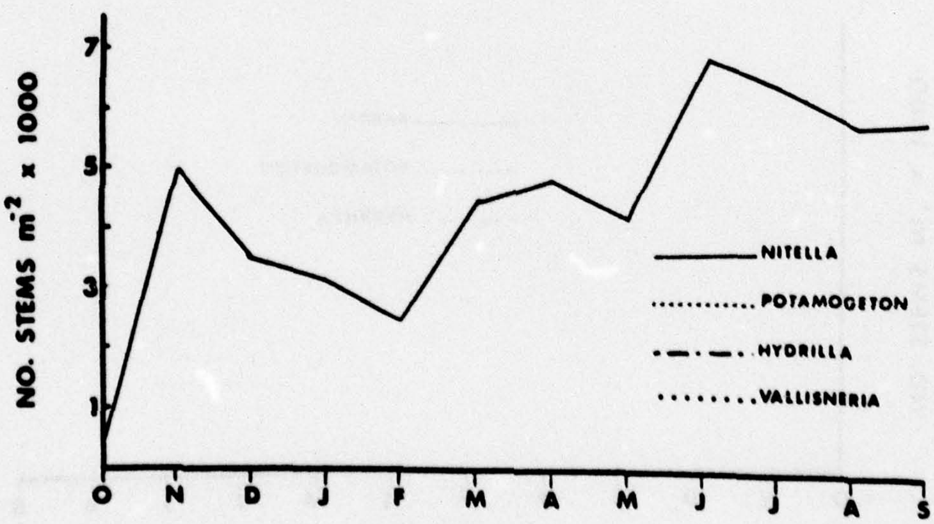
Figure F8. Selected permanent data, Plot Eight



a. Frequency



b. Fixed heights



c. Stem density

Figure F9. Selected permanent data, Plot Nine

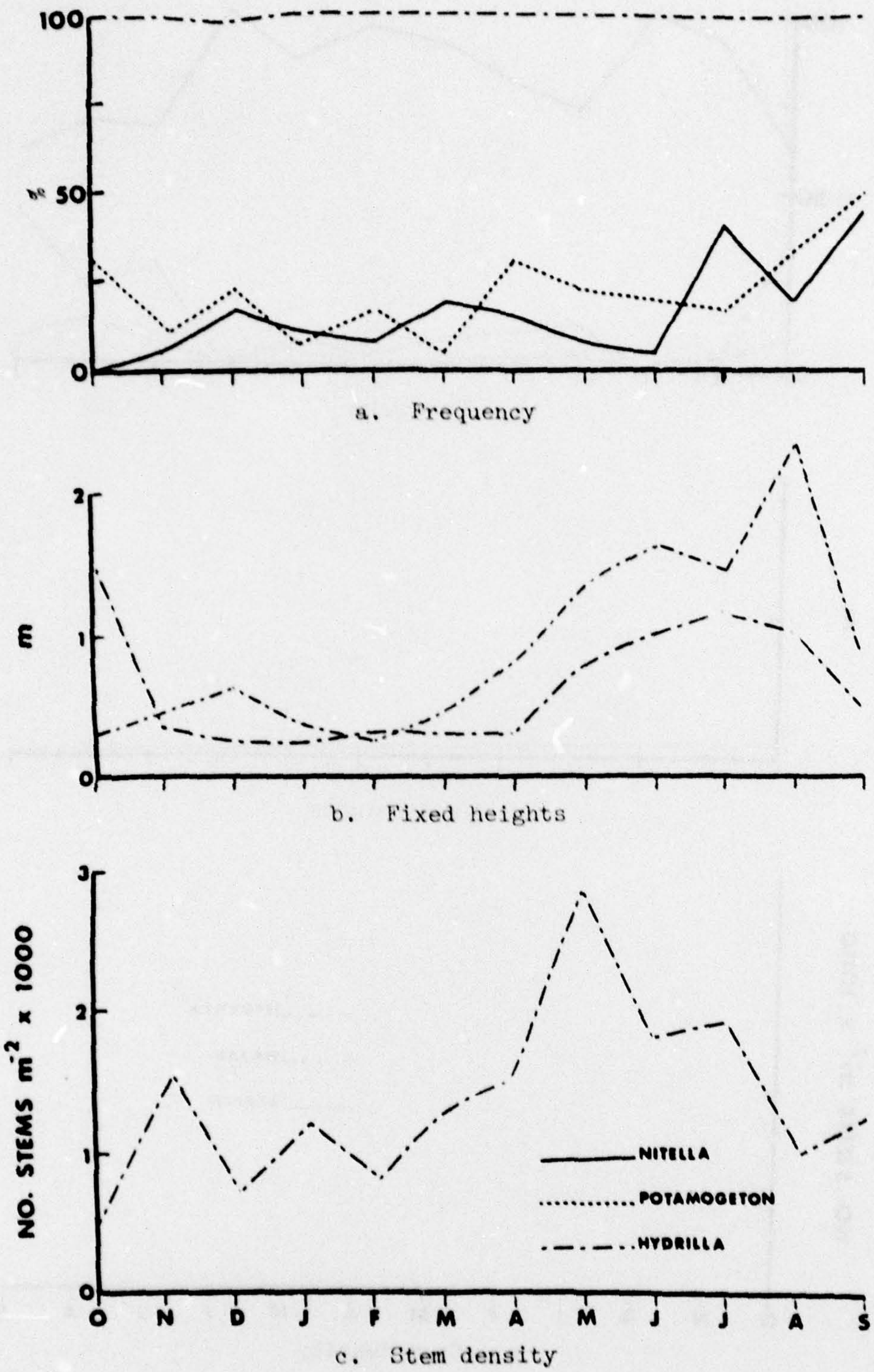


Figure F10. Selected permanent data, Plot Ten

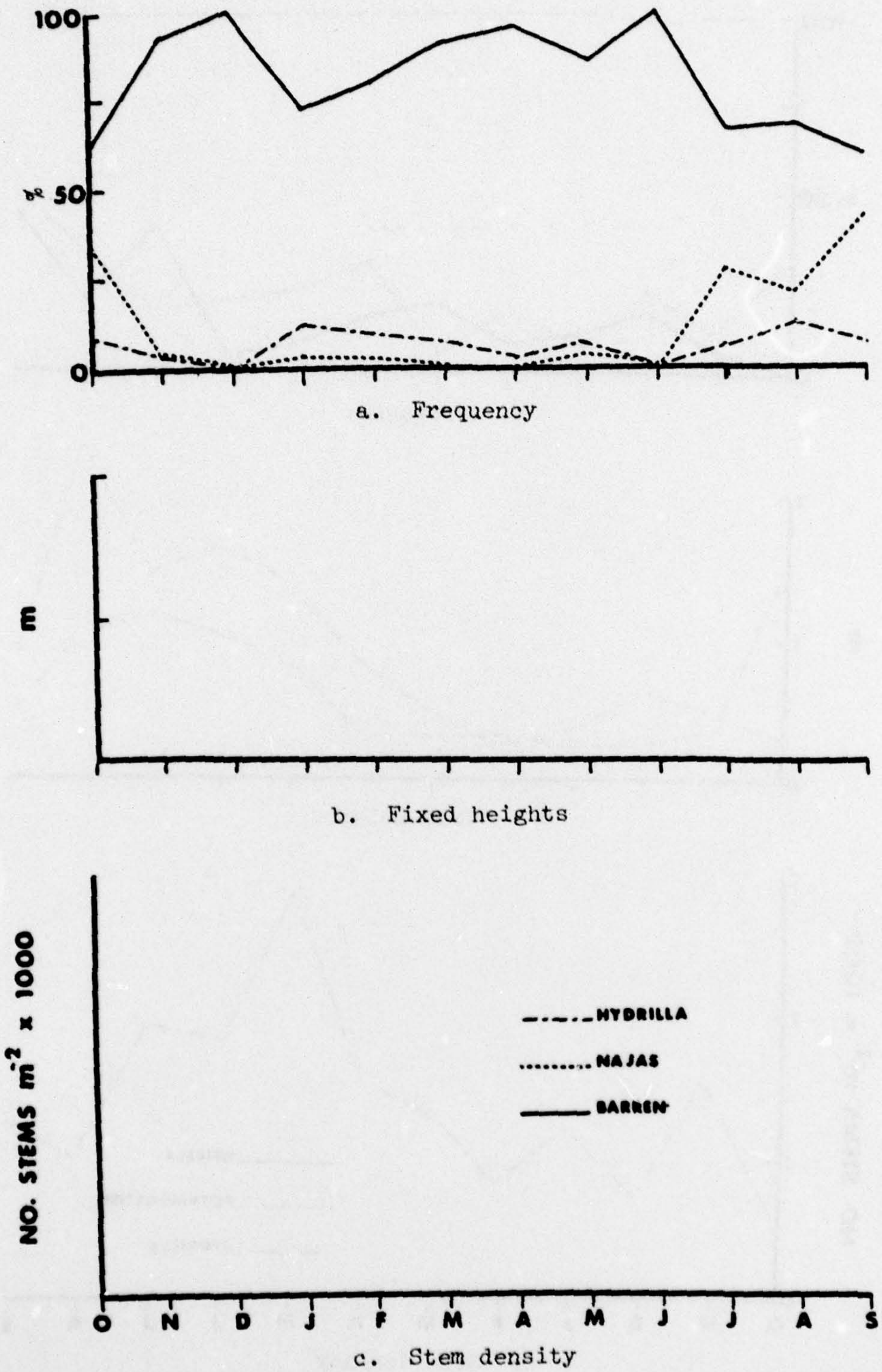


Figure F11. Selected permanent data, Plot Eleven

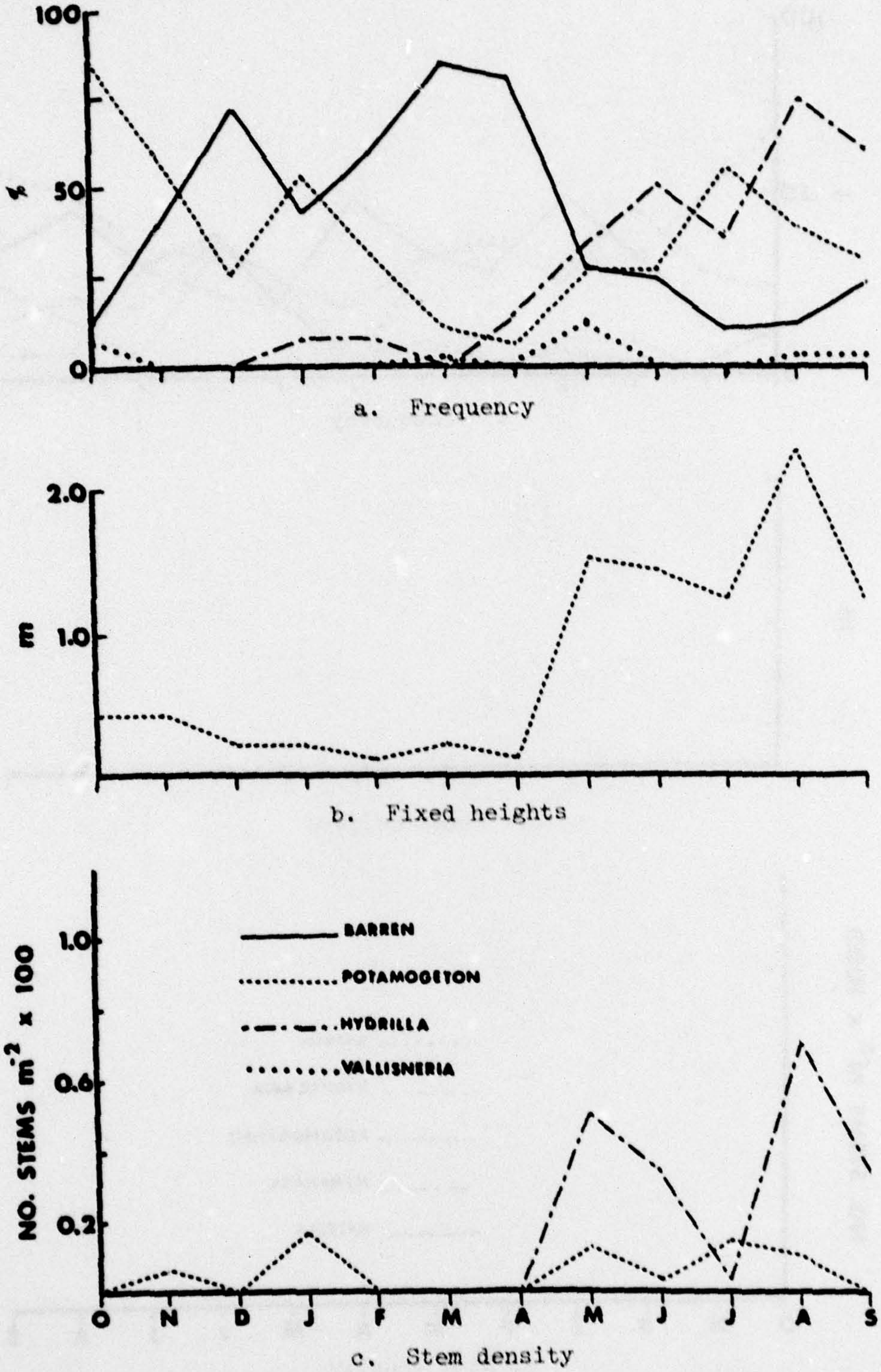
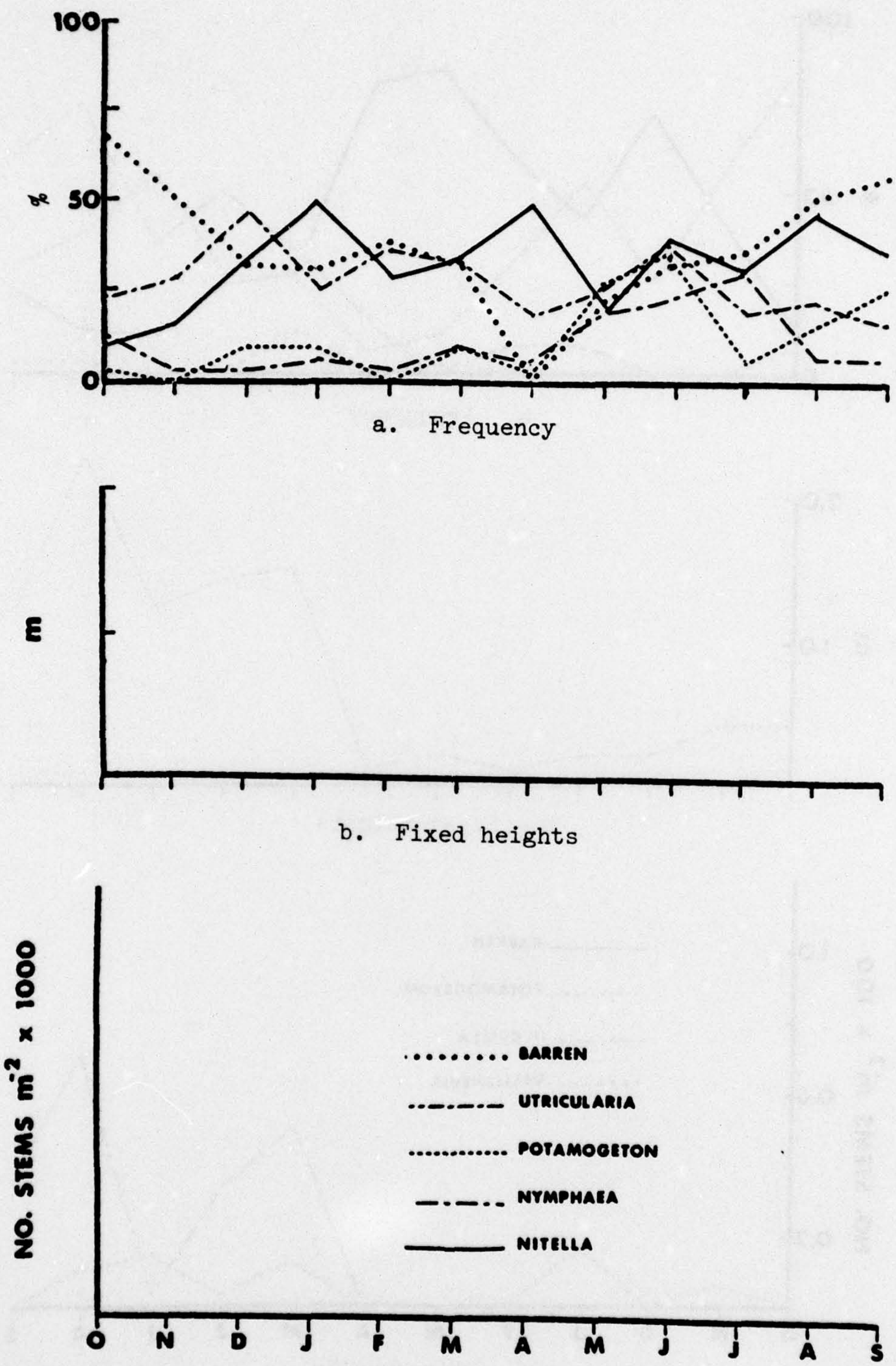
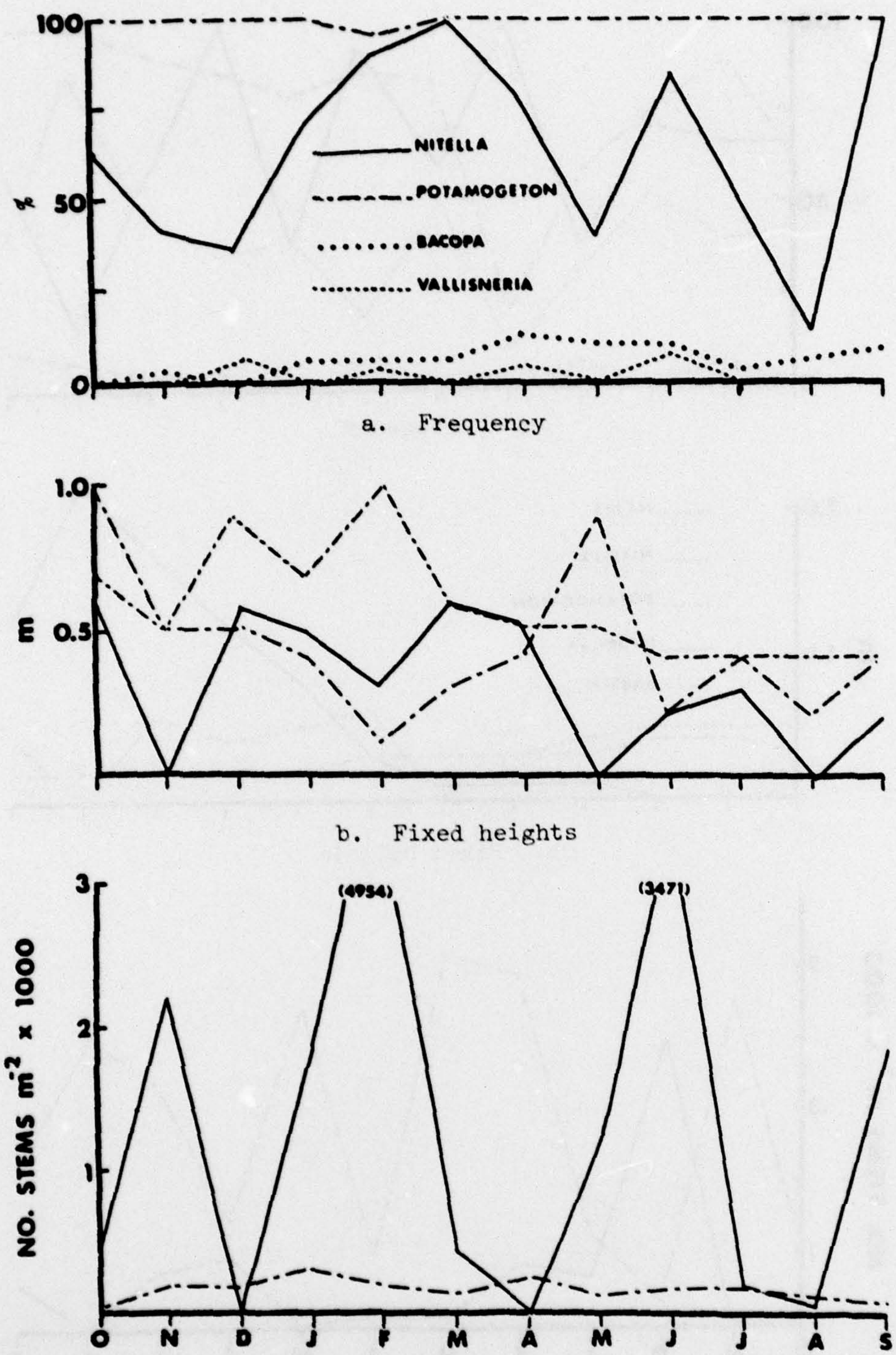


Figure F12. Selected permanent data, Plot Twelve



c. Stem density

Figure F13. Selected permanent data, Plot Fourteen



a. Frequency

b. Fixed heights

c. Stem density

Figure F14. Selected permanent data, Plot Fifteen

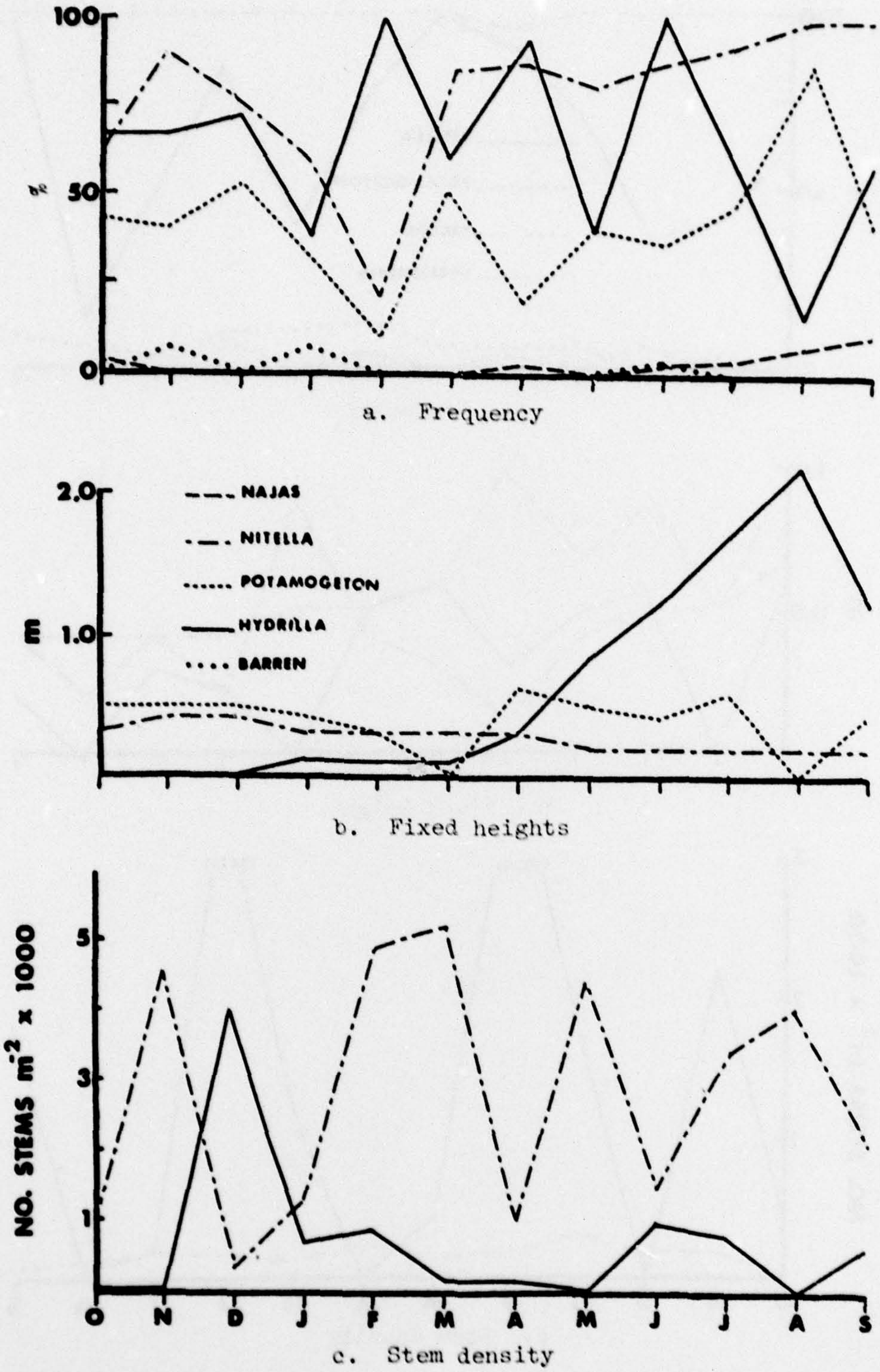


Figure F15. Selected permanent data, Plot Sixteen

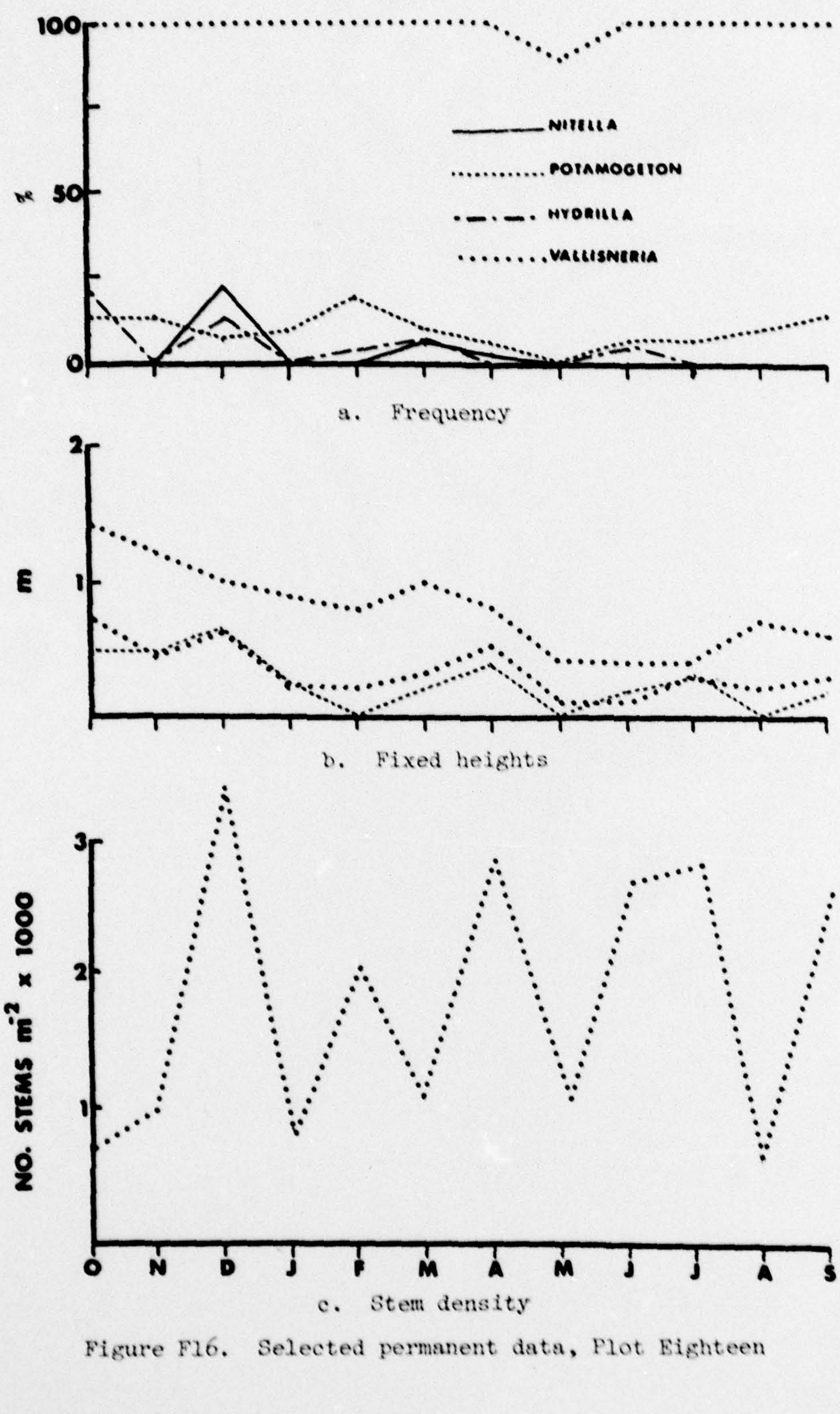


Figure F16. Selected permanent data, Plot Eighteen

APPENDIX G: THE APPROXIMATE DISTRIBUTION OF THE DOMINANT PLANTS IN LAKE CONWAY

Figure G1. Approximate distribution of hydrilla in Lake Conway

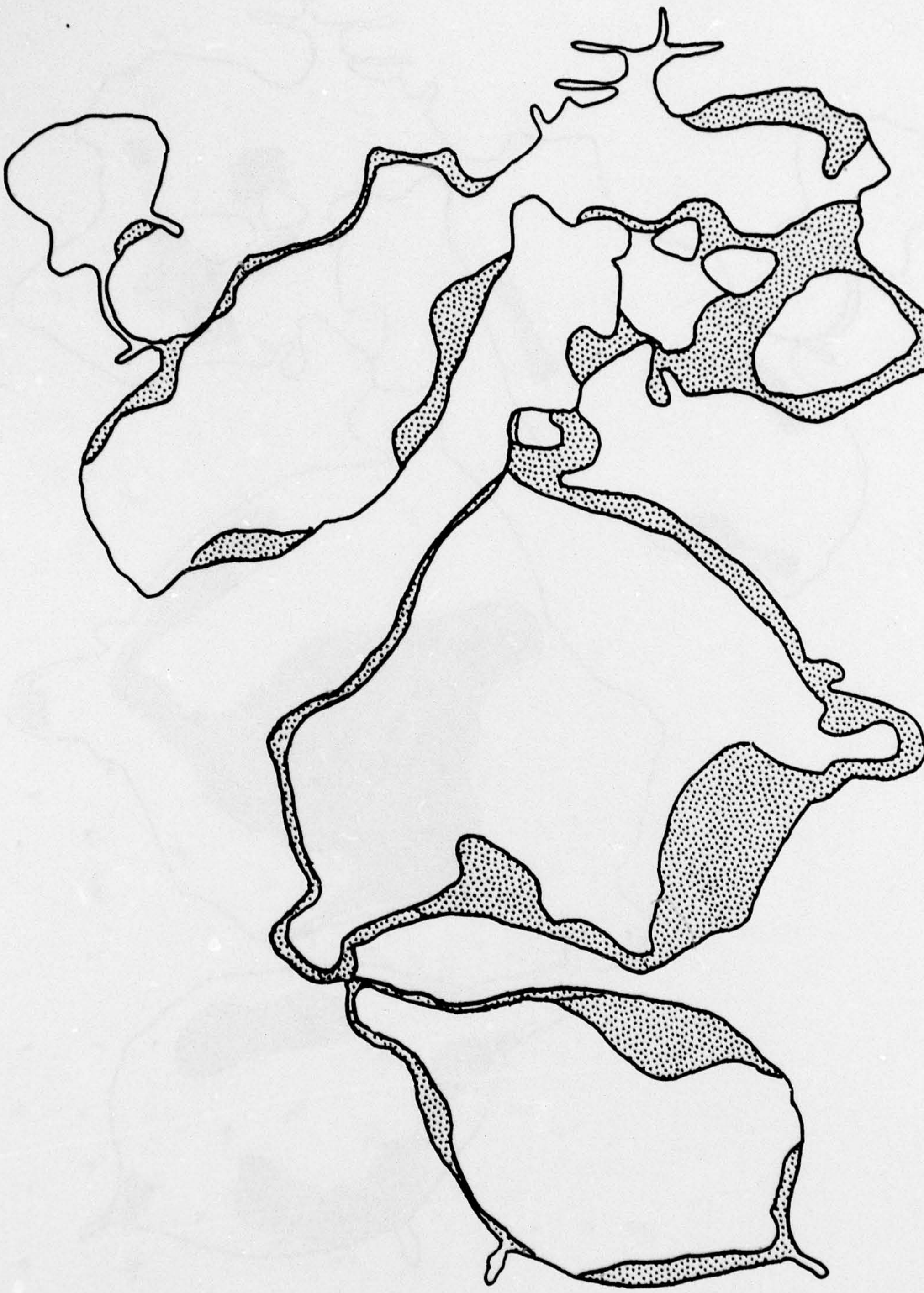


Figure G2. Approximate distribution of potamogeton in Lake Conway

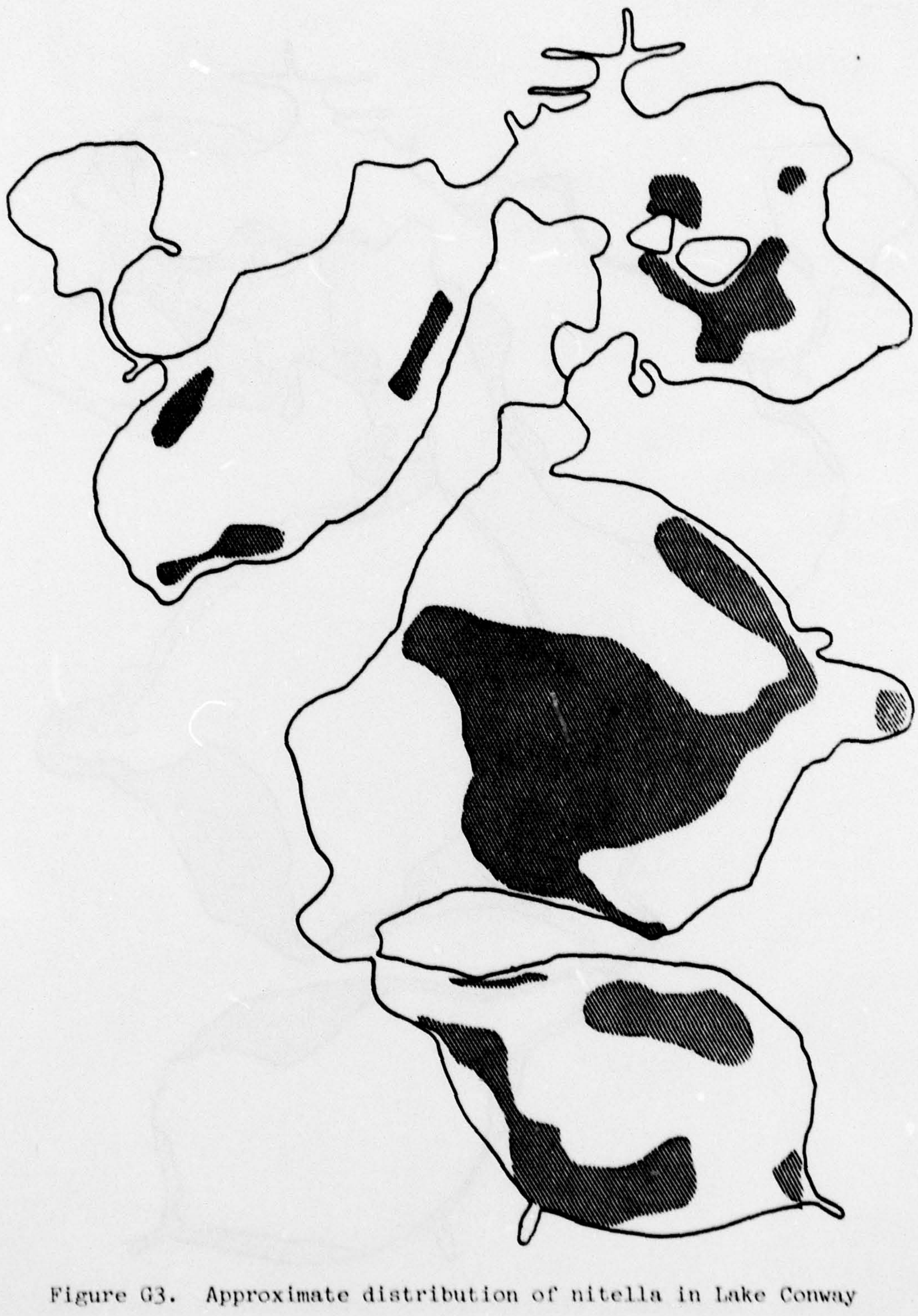


Figure G3. Approximate distribution of nitella in Lake Conway

Figure G4. Approximate distribution of vallisneria in Lake Conway

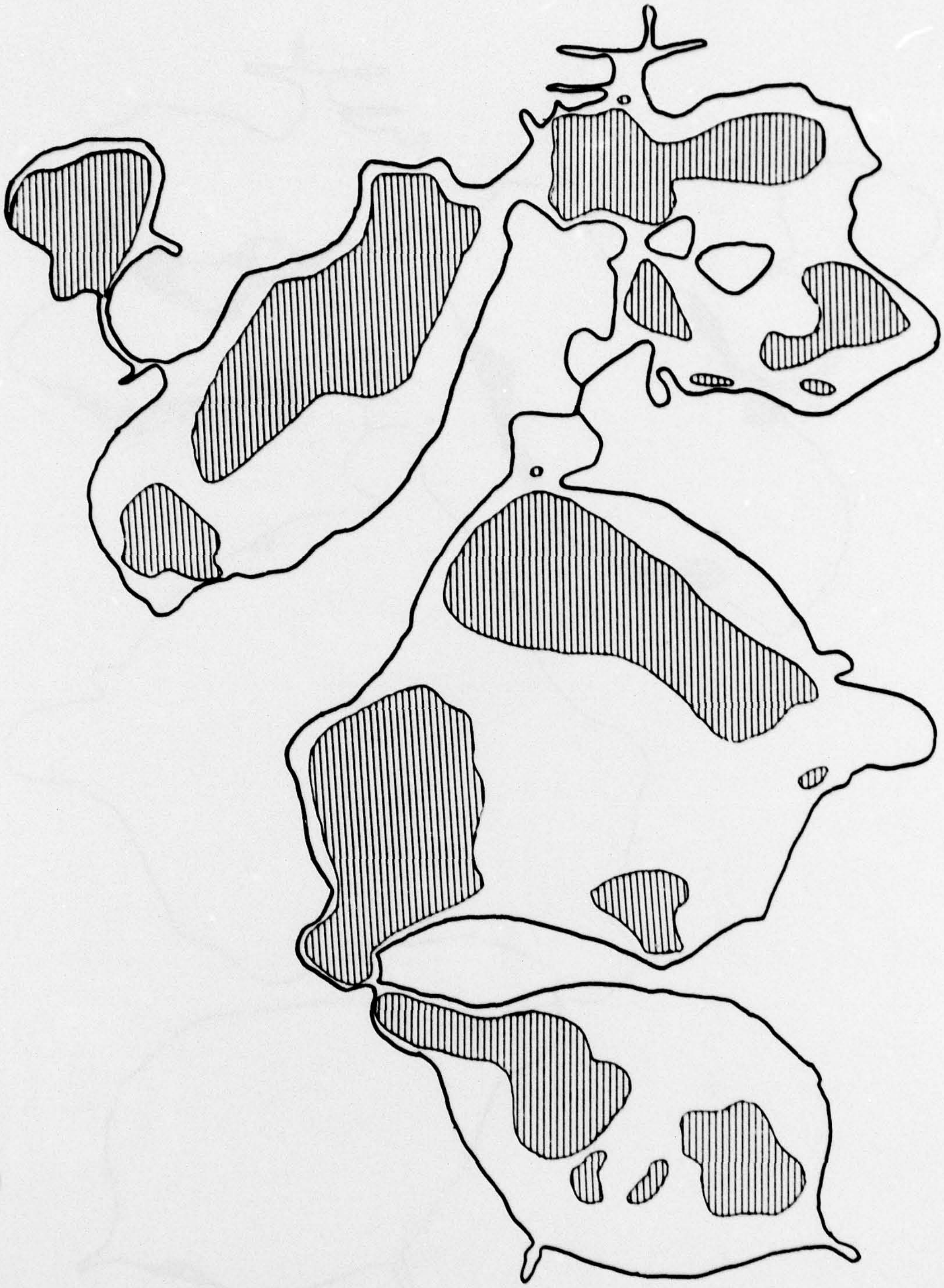


Figure G5. Approximate distribution of the unvegetated area of Lake Conway

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Nall, Larry E
Large-scale operations management test of use of the white amur for control of problem aquatic plants; Report 1: Baseline studies; Volume I: The aquatic macrophytes of Lake Conway, Florida / by Larry E. Nall and Jeffrey D. Schardt, Bureau of Aquatic Plant Research and Control, Division of Resource Management, Florida Department of Natural Resources, Tallahassee, Fla. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.
58, [64] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; A-78-2, Report 1, v.1)
Prepared for U. S. Army Engineer District, Jacksonville, Jacksonville, Fla, and Office, Chief of Engineers, U. S. Army, Washington, D. C., under Contract No. DACW39-76-C-0084.
References: p. 53-58.

1. Aquatic plant control. 2. Aquatic plants. 3. Ecological models. 4. Environmental effects. 5. Lake Conway. 6. White amur. I. Schardt, Jeffrey D., joint author. II. Florida.

(Continued on next card)

Nall, Larry E
Large-scale operations management test of use of the white amur for control of problem aquatic plants; Report 1: Baseline studies; Volume 1: The aquatic macrophytes ... 1978. (Card 2)

Bureau of Aquatic Plant Research and Control. III. United States. Army. Corps of Engineers. IV. United States. Army. Corps of Engineers. Jacksonville District. V. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; A-78-2, Report 1, v.1.
TA7.W34 no.A-78-2 Report 1 v.1