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# HYDROLOGY, PLANT COMMUNITY STRUCTURE AND NUTRIENT DYNAMICS OF HOPKINS PRAIRIE, OCALA NATIONAL FOREST, FLORIDA
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# HYDROLOGY, PLANT COMMUNITY STRUCTURE AND NUTRIENT DYNAMICS OF HOPKINS PRAIRIE OCALA NATIONAL FOREST, FLORIDA

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## EXECUTIVE SUMMARY

This study examines the effects of water level fluctuations on above and below ground plant community structure and soil and plant tissue nutrient dynamics at Hopkins Prairie, a wet prairie in the Ocala National Forest, Florida. Hopkins Prairie is situated within the St. Johns River basin near the western shore of Lake George, one of the St. Johns River chain of lakes. It is classified as an emergent marsh on organic soils (Cowardin 1979).

Water level on Hopkins Prairie is characterized by recurring periods of flooded conditions (surface water present) and drawdown conditions (water table below soil surface) of varying frequency and duration. Water level at the study site has fluctuated between flooded and drawdown conditions on a 2 to 3 year cycle over the past 11 years. During this study the site shifted from flooded to drawdown conditions.

When standing water was present, the above ground plant community was dominated by the aquatic species, *Nymphaea odorata*, *Eleocharis elongata*, and *Eriocaulon compressum*. Two emergent species, *Rhynchospora inundata* and *Amphicarpum muhlenbergianum*, appeared in the last month of flooding. One month after drawdown, *Nymphaea* dropped out of dominance and the site became dominated by *Eriocaulon*, *Rhynchospora*, and *Amphicarpum*. After 16 months of drawdown conditions, the aquatic community had been replaced by a sedge/grass community dominated by *Rhynchospora* and *Amphicarpum*.

Below ground dynamics at Hopkins Prairie played a primary role in maintenance of the plant community and persistence of species under fluctuating environmental conditions. *Nymphaea* and *Eleocharis* which dropped out of aboveground dominance persisted below ground as live rhizomes throughout the drawdown period. Similarly, *Rhynchospora* which favored drawdown conditions was present below ground during the flooded period. The high moisture content of the soil during the drawdown period allowed rhizomes of the aquatic species to survive in the absence of standing water. Presumably, reflooding will occur and conditions will again be favorable for reestablishment of the aquatic community.

Repeated cycles of flooding and drawdown are a "normal" component of many ecosystems (Gopal 1986). The resulting vegetational changes have been termed circular succession, cyclic replacement or oscillatory fluctuations (Rabotnov 1974, Smith 1974) and describe well established sets of species repeatedly replacing each other as environmental conditions change. This type of "cyclic or transient climax" fluctuates in time but is stable overall (Ricklefs 1979). Hopkins Prairie has experienced repeated 2 to 3 year cycles of flooded and drawdown conditions. The shift from the aquatic plant community to the sedge/grass community is presumably cyclic. Reflooding should cycle conditions back to favor the persistent aquatic species. Repeated fluctuations in water level on the prairie result in a dynamic but stable plant community.

The extremely high C/N/P (carbon/nitrogen/phosphorus) ratios in Hopkins Prairie soil suggest that P may be limiting in the soil, particularly during non-flooded periods. The fluctuating hydrology controls nutrient availability by changing the aeration status (and redox) of the soil. Flooding promotes anaerobic conditions while drawdown results in aerobic conditions. The temporal and spacial distribution of anaerobic and aerobic conditions influences nutrient transformations. Available ammonium ($NH_4^+$) and soluble reactive P (SRP) were greatest under flooded conditions. Following drawdown nitrification increased nitrate ($NO_3^-$). This shifted N dominance from $NH_4^+$ to $NO_3^-$. Phosphorus availability decreased due to increased microbial uptake under aerobic conditions. Microbial activity controlled P availability in the peat soil with low mineral content.

Decomposition releases P, however, biological immobilization quickly binds the low levels released from the high C/N/P ratio soil. Slower decomposition during flooding would reduce microbial immobilization resulting in more plant available P. The C/N of the soil and the high N/P availability ratio suggest that N is not limiting.

Nitrogen and P concentration was slightly greater in above ground tissues than below ground throughout the period. However, below ground total biomass averaged 35 times greater than above ground. The large below ground biomass compared to above ground resulted in a much greater storage of N and P in below ground tissues. This may be important in providing nutrients for regeneration of each suite of species under the cyclic hydrology. For example, *Nymphaea* remaining in live rhizomes during the drawdown period will have sufficient N and P reserves (in addition to an increase in soil nutrients) to regenerate upon reflooding.

The location of the prairie in the landscape results in cyclic hydrology with fluctuating periods of flooded and drawdown conditions. The plant community is well adapted to these fluctuations and responds by cyclic changes in species dominance with each hydrologic shift. When drawdown occurs, a productive emergent community becomes established. With reflooding, an aquatic community becomes reestablished. Decomposition during drawdown periods breaks down organic matter which accumulated during the previous flooded cycle.

This cycle provides constant build up and turnover of vegetation and cyclic decomposition (nutrient release) and accretion of soil organic matter.

The moist below ground environment during drawdown periods allows persistence of aquatic species as live rhizomes and seeds. The high moisture content of the soil protects the peat and below ground propagules from fire damage and reduces soil subsidence. Periodic fires which preclude invasion by woody species are more probable during this time when water levels are low and above ground biomass is high. Fire would act primarily on the above ground biomass releasing nutrients during a time when they are at their lowest availability. Upon reflooding, the emergent species retreat to below ground and the aquatic community regenerates from the dormant below ground propagules. Reflooding would provide a flush of nutrients from rapid decomposition during the drawdown period facilitating regeneration of the aquatic species. Decomposition would be slowed and turnover of the emergent community would add peat to the soil.

The combined effects of hydrology and fire maintain the prairie plant communities and promote peat accumulation. Hydrology induces cyclic vegetation turnover with fire interacting on the above ground community during low water periods. Together, these physical factors promote pulses of primary production and nutrient availability which contribute to the overall stability of the prairie.

# ACKNOWLEDGEMENTS

This research was supported in significant part by a research grant from the St. Johns River Water Management District (SJRWMD) to the Center for Wetlands, University of Florida (Contract #49104510301-12) and in part by the Center for Wetlands.

# INTRODUCTION

Hydrology is the primary environmental factor controlling structure of wetland plant communities (Carter et al. 1978, Gosselink and Turner 1978, LaBaugh 1986). Depth, duration, frequency and timing of inundation or drawdown are variable, from wetlands that are continuously flooded to those experiencing infrequent flooding or continuously non-flooded conditions with saturated soils. Flooded and non-flooded conditions and changes between these hydrologic conditions have profound effects on wetland plant community structure and nutrient dynamics. Improving our understanding of the ecology of wetlands may provide information to aid wise management and stewardship of these beneficial ecosystems. A knowledge of the role of water level fluctuations on wetland community dynamics is essential, particularly in wetlands which experience wide variations in water level as occurs at Hopkins Prairie.

Presence or absence of surface water in wetlands varies with climatic conditions, landscape topography and hydrogeology. Flooding reduces soil oxygen concentration and alters nutrient availability resulting in dramatically different germination and growing conditions (Patrick and Mikkelsen 1971, Ponnamperuma 1984). Flooding depth, duration, frequency and timing influence environmental conditions and plant species distributions by selecting for or against certain species (Gill 1970, DeLaune and Pezeshki 1991). Fluctuating water levels with changes between flooded and drawdown conditions produce an "environmental sieve" which controls the establishment or extirpation of species as a function of physical factors (van der Valk 1981). Hydrologic control of plant species distribution results from the combined effects of variable environmental conditions and life history traits of adults and propagules (Shay and Shay 1986).

Permanently flooded non-forested wetlands are typically dominated by submersed, floating and floating-leaved species (Botts and Cowell 1988, Gopal 1986, van der Valk 1981). Permanently drained conditions with moist or saturated soils favor predominance by emergent species. Many wetlands experience cyclic changes between inundation and drawdown. Cyclic shifts in hydrology can lead to a stable plant community with oscillating shifts in species dominance in time and space (Bolen et al. 1989, Duever 1982, Gopal 1986, Gerritsen and Greening 1989, Greening and Gerritsen 1987, LaClaire and Franz 1991). Repeated disturbance, such as alternating hydrology, may promote cyclic replacement of dominant species coincident with changes in environmental conditions (Knapp 1974, Odum 1983, Ricklefs 1979, Rabotnov 1974, Smith 1974).

Wetlands generally exhibit high productivity (Odum 1983), serving as sinks, sources or transformers of nutrients (Best 1987, Mitsch and Gosselink 1986). Wetland vegetation utilizes nutrients during growth periods, while seasonal release of nutrients may result from dieback and mineralization of plant material during the non-growing season (Boyd 1969, 1970, Kadlec 1989, Reddy et al. 1989). Nutrient assimilation capacity by plants is a function of growth rate, standing crop, tissue nutrient concentration and physicochemical (soil and water) characteristics (Reddy and DeBusk 1987). The capacity for long term storage of nutrients by vegetation varies with species, age and habitat (Boyd and Goodyear 1971, Reddy and DeBusk 1987). Long term storage may exist in woody and below ground biomass and accumulated soil organic matter (Day 1984, Dierberg and Brezonik 1983, Brinson et al. 1981).

Hydrology is the primary factor controlling nutrient availability and dynamics in wetland ecosystems (DeLaune and Pezeshki 1991, R. Kadlec 1989, Patrick and Mikkelsen 1971). Flooding reduces oxygen ($O_2$) available to the soil which may result in anaerobic conditions. Temporal and spacial distribution of anaerobic and aerobic conditions influences nutrient dynamics within the soil, overlying water column (when present) and rhizosphere of hydrophytic vegetation (J. Kadlec 1989, Ponnamperuma 1984). In general, ammonium ($NH_4^+$) and soluble reactive phosphorus (SRP) are more available under flooded conditions (DeLaune and Pezeshki 1991, Kadlec 1989).

Nitrification increases nitrate ($NO_3^-$) under non-flooded conditions and adsorption processes and biological immobilization decrease SRP availability. Adjacent aerobic and anaerobic conditions in the rhizosphere or alternate flooding and draining may lead to loss of nitrogen (N) through nitrification-denitrification and alternate availability (flooded) and immobilization (non-flooded) of phosphorus (P) (Patrick and Mikkelsen 1971). Fluctuating hydrology may lead to more extensive decomposition and increased nutrient cycling compared to either continuously flooded or non-flooded conditions (Brinson et al. 1981, Reddy and Patrick 1983).

Objectives of this study were to examine the effects of naturally fluctuating water levels in a wet prairie on (1) structure and composition of the plant community and (2) the relationship between plant tissue N and P content and available N and P in the soil. This study was part of a more comprehensive research project to investigate the effects of fluctuating water levels on wetland functions and ecological processes. The study was funded in significant part by the St. Johns River Water Management District (SJRWMD) headquartered in Palatka, Florida. This research was conducted simultaneously with investigations of surface water quality, soil biogeochemistry and fish and macroinvertebrate population dynamics. Information is to be used by regulatory agencies as a baseline study of a hydrologically unaltered wetland. Development of management goals for similar wetlands which have been altered may be facilitated by reference to the ecology of Hopkins Prairie in an unaltered state.

## SITE DESCRIPTION

Hopkins Prairie is located in the Ocala National Forest approximately 8 km southwest of the town of Salt Springs, Marion County, Florida (Figure 1). Hopkins Prairie is approximately 5 km in length encompassing about 285 ha. This wetland is a wet prairie, classified as an emergent wetland with organic soils (Cowardin et al. 1979).

Hopkins Prairie is situated within the St. Johns River basin near the western shore of Lake George, one of the St. Johns River chain of lakes. It is one of many prairies within the St. Johns River Valley located in basins where sediment and vegetation accumulated during high sea level.

Topographically, Hopkins Prairie is in the transition area between Lake George to the east and the Marion uplands to the west. The hydrology of Hopkins Prairie is influenced by sea levels on a geologic time scale. Local hydrology both temporally and spatially is influenced by regional rainfall and groundwater flow patterns. Inflows to the prairie are through precipitation and groundwater only. Rainfall in the surrounding uplands readily percolates through the porous sandy soils then flows down gradient toward the basin where the prairie is located. Evapotranspiration by prairie vegetation is the primary hydrologic outflow affecting water

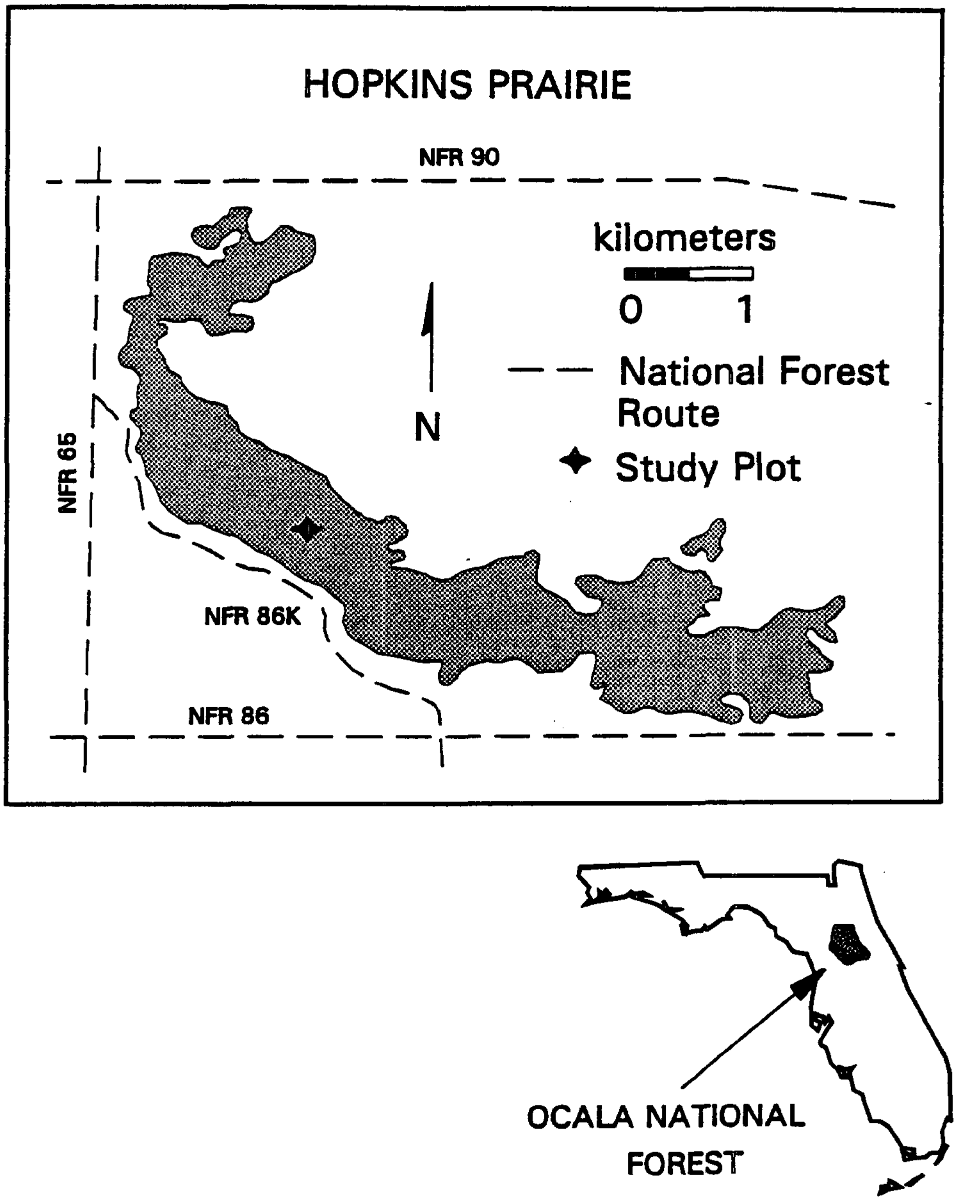


Figure 1. Study site of plant community and nutrient dynamics study on Hopkins Prairie, Marion County, Florida.

levels, particularly during the growing season. During dry periods, water level on the prairie is regulated by piezometric head relative to the surrounding area. Ground water outflow from the prairie toward the St. Johns River may occur during extreme drought conditions. Water level on Hopkins Prairie is characterized by recurring periods of flooded conditions (surface water present) and non-flooded conditions (water table below soil surface) of varying frequency (recurrence interval) and duration.

The following description of plant communities is representative of the vegetation in 1986 when the vegetation map was developed. It should be noted that while the community types are well established, the relative extent of these communities may vary depending on local environmental conditions which are controlled primarily by hydrology and fire. Hopkins Prairie is comprised of many wetland plant community types. Open water and deep marshes with floating-leaved aquatic species such as white waterlily (*Nymphaea odorata*) and spatterdock (*Nuphar luteum*) occurred in the lower wetter portions of the prairie. Intermixed with these areas were another type of deep marsh with aquatic species and open water bordered by maidencane (*Panicum hemitomon*) which extended northward onto the mid-section of the prairie. An extensive sawgrass marsh (*Cladium jamaicense*) occupied a slightly higher soil elevation area in the north central portion of the prairie. Within this marsh were shrub swamp islands with buttonbush (*Cephalanthus occidentalis*) and bayheads with sweetbay (*Magnolia virginiana*) overstory and wax myrtle (*Myrica cerifera*) and buttonbush understory. The middle section of the prairie between the deep marshes to the south and the sawgrass marsh to the north was occupied by a marsh dominated by inundated beak rush (*Rhynchospora inundata*) with localized areas of shrub swamp interspersed. The northern portion of the prairie was comprised of a shallow marsh dominated by *Panicum hemitomon*.

The study plot was located in the inundated beak rush deep marsh of the middle section of the prairie. This area is transitional in soil elevation between the lower wetter southern part of the prairie and the higher northern part. As a result of this transitional situation, water levels at the study plot were variable with fluctuations relative to the soil surface producing shifts between flooded and non-flooded conditions.

The St. Johns River basin is underlain with fresh water shell marl, sponge-spicule clay, peat and muck materials (Snedaker and Lugo 1972). As described in the geomorphology section above, the stratigraphy of the basin resulted from rising and lowering sea levels with sedimentation and accumulated vegetation in solution areas in the floodplain. Fossiliferous marl and peats were lain down during the last sea level rise when the sea was approximately 8 m higher than it is today (Faulkner 1970). The shell marls underlying the peats are estimated to be 16,500 to 17,000 years old. The overlying peat and muck soils are approximately 4,000 to 6,000 years old (Snedaker and Lugo 1972).

Peat depths on Hopkins Prairie increase from the perimeter inward and are 4 to 6 m in the deeper areas (Dr. G.B. Hall, St. Johns River Water Management District, pers. comm.). The highly organic peat soils have a high water holding capacity resulting in moist to saturated conditions under both flooded and drawdown conditions. The nutrient status of soils is also influenced by hydrologic conditions and anaerobiosis of the soil profile. Hopkins Prairie is an oligotrophic system with low soil porewater nutrient concentrations (Graetz 1991). Phosphorus is particularly low and may be limiting in the prairie.

Fire is an important part of wet prairie ecosystems in the Ocala National Forest (Snedaker and Lugo 1972). The developmental history of Hopkins Prairie from a portion of an open water estuary to its present structure has been shaped by the combined effects of hydrology and fire. During dry periods with water levels low, the vegetation serves as fuel for periodic fires which repeatedly set back succession and exclude invasion by woody species. Only species able to survive the wet and dry periods and adapted to periodic fires survive for long periods on the prairie. This combination of physical factors acts to suppress hydrarch succession preventing its progression toward the hydrarch climax of a forested system.

The U.S. Forest Service (Lake George Ranger District) has conducted five prescribed burns on part or all of the prairie and the understory vegetation of the surrounding forested buffer since 1976 (there are no records of prescribed burns prior to 1976). In 1976 and 1979 parts of the perimeter vegetation of the prairie were burned, in 1986 and 1989 the entire prairie was burned and in 1991 portions of the prairie were burned. The perimeter burns in 1976 and 1979 were spring burns conducted in March and February, respectively. The 1986 and 1989 burns were winter burns conducted in January and December, respectively.

## MATERIALS AND METHODS

A 10 m X 18 m study plot was established within a plant community typical of the lower elevation areas in Hopkins Prairie. The plot was divided into six subplots 10 m X 3 m. Each subplot was further divided into 30, 1 $m^2$ sampling sites. Monthly measurements were collected in replicates of six by sampling one randomly chosen 1 $m^2$ site within each subplot. Monthly measurements included water level, plant species percent cover, above ground plant biomass and below ground plant biomass. Above and below ground biomass was separated by species. Live and dead above ground biomass was also categorized. Appendix A presents an expanded outline of the protocol.

Water levels relative to the soil surface were recorded at each sample site by measuring the water depth (flooded conditions) or the depth to the water table (non-flooded conditions). Hydrologic data for the past 11 years were provided by the St. Johns River Water Management District. Stage data from 1981 to 1991 was used to examine hydrologic variability for comparison with conditions during the study period.

A 25 cm X 25 cm sample frame was placed 10 cm deep into the soil in the center of the randomly chosen 1 $m^2$ sample site. A hand pump was used to remove any standing water within the sample frame. Percent cover of each species was estimated visually. Above ground biomass was collected by cutting shoots at the soil surface. Soil was excavated to 10 cm to determine below ground biomass from 0-10 cm. A 10.2 cm diameter (4 in) PVC core was pushed 20 cm into the soil at the center of the hole created by the 0-10 cm sample. This sample was cut in half and processed to determine below ground biomass at 10-20 and 20-30 cm soil depths. Below ground biomass samples were sieved through a U.S. standard no. 14 sieve then placed in a pan of water, forceps were used to remove below ground plant materials. Unidentified biomass was placed in a general category. Above ground, below ground and algae biomass was oven dried at 60° C to constant weight for dry weight measurements.

Net above ground primary productivity was calculated as the difference in standing crop between each sampling event. A litter sac study was done to account for biomass loss to decomposition during the period. Two litter sacs were placed on the soil surface at each sample site, one containing live plant material and the other containing dead plant material. The sacs were collected at the following monthly sampling event, dried at 60° C and the plant material weighed. Weight loss during the period was attributed to decomposition.

Several measures of species diversity are used in ecological research, the most widely used statistic is the Shannon-Wiener Diversity Index, H′ (Colinvaux 1986) as follows:

$$H' = -\sum (p_i \log_2 p_i)$$

where, $p_i$ = proportion of species i in total sample. Plant species richness (R) is a direct count of the number of species recorded in a sampling event. The Shannon-Wiener index combines relative abundance and species richness to indicate the 'evenness' of the distribution of species.

Soil samples were collected within each 1 $m^2$ sampling site. Above ground litter was cleared from an area adjacent to the biomass sample to expose the soil surface. A 30 cm soil core was collected using a 6.4 cm diameter (2.5 in) acrylic core. The sample was extruded with a rubber stopper and push rod for sectioning into 0-10, 10-20 and 20-30 cm samples. Plant "available" N and P was estimated from a sequential extraction of deionized water (approximate ratio of 40:1, ml extractant to dry weight soil), representing readily available N and P, followed by a potassium chloride (KCl) extraction (approximate 70:1 extractant to soil), representing cation ($NH_4^+$) and anion ($PO_4^{2-}$) exchangeable N and P. Water extractable ammonium N ($NH_4$-N), nitrate+nitrite N ($NO_3$+$NO_2$-N) and soluble reactive P (SRP) and KCl extractable $NH_4^+$ and SRP were determined on a Technicon Autoanalyzer II using standard methods (APHA 1989, ASA 1982, and EPA 1979). Soil moisture content was determined by measuring weight loss of oven dried samples at 70° C. Nitrogen and P content is reported in mg N or P per kg DWT of soil. General soil characterization was conducted in September 1990. Parameters included pH, bulk density, a P-fractionation scheme and oxalate extractable iron (Fe) and aluminum (Al). The P-fractionation consisted of sequential extraction with KCl, sodium hydroxide (NaOH), and hydrochloric acid (HCl) solutions. Treatment with KCl, NaOH, and HCl extracts exchangeable, Fe and Al bound, and calcium (Ca) bound P, respectively. Digestion of the NaOH extraction measures labile organic and humic and fulvic acid associated P in addition to Fe and Al bound P. The oxalate extraction estimates the amount of phase I adsorbed (easily desorbed) Fe and Al oxides. Total carbon (C), N and P for soil characterization were obtained from concurrent research on soil biogeochemistry conducted by the University of Florida Soil and Water Science Department (Graetz 1991).

Plant tissues were analyzed for total kjeldahl nitrogen (TKN) and total phosphorus (TP). All plant species were combined in each tissue category, ie., above ground live, above ground dead and below ground biomass at three soil depths. Determination of TKN and TP was done on a Technicon Autoanalyzer II. Nitrogen and P content are reported in g of N or P per kg DWT of plant tissue. Linear regression analysis was used to test for correlations between soil available N or P ($mg/m^2$) and plant biomass N or P ($mg/m^2$).

Student-Newman Keuls (SNK) multiple comparison procedure was used to test for differences between monthly mean values of water level, plant biomass and soil nutrient content. Statistical analyses were performed using SAS/PC (SAS 1988).

## RESULTS

### Water Level and Soil Moisture

Mean annual water level alternated between flooded and non-flooded conditions over the last 11 years (Figure 2). Standing water was absent 1981-82, present 1983-84, absent 1985-86, present 1987-89 and absent 1990-91. Water level during the study period (March 1990 to December 1991) shifted

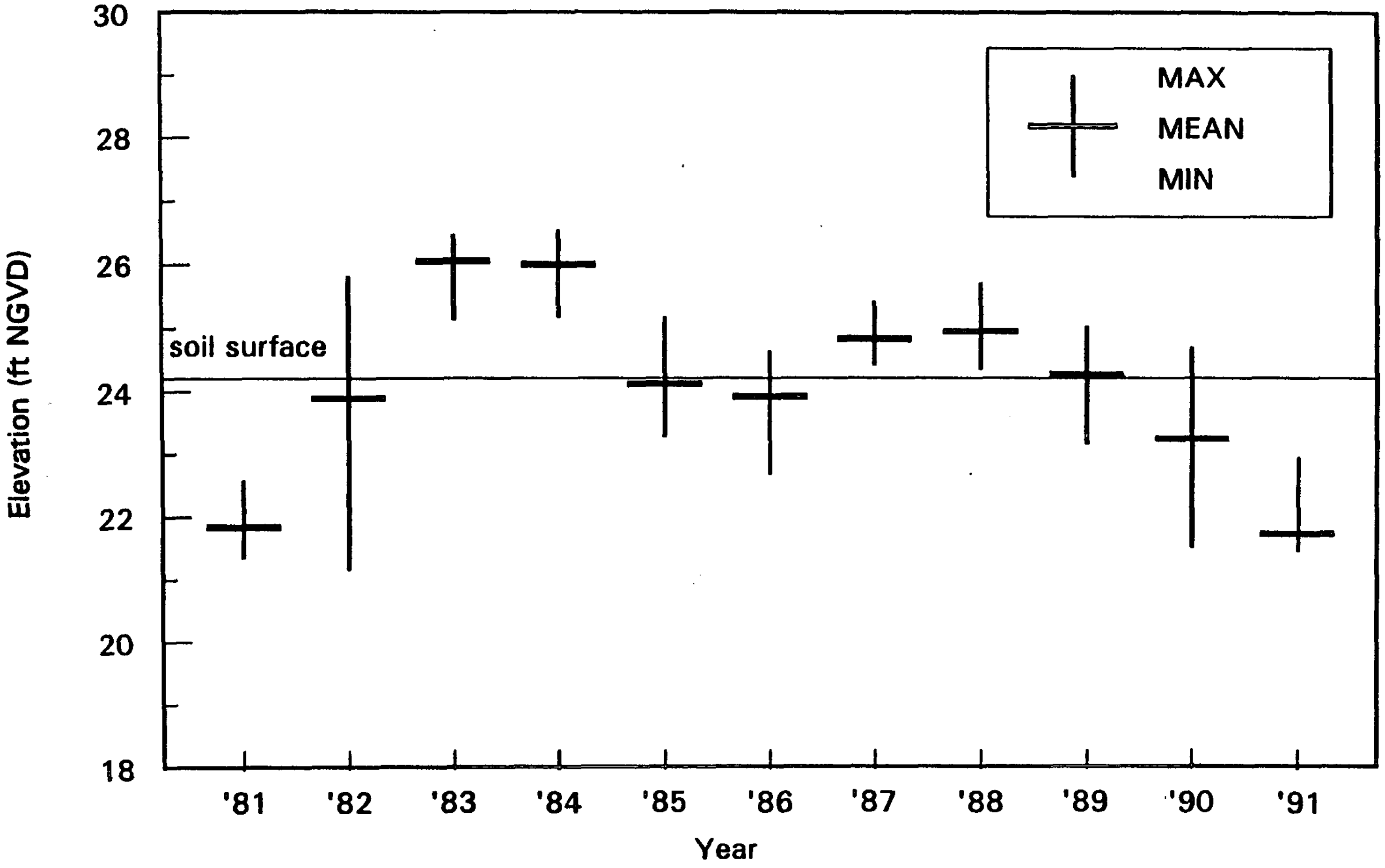


Figure 2. Mean, maximum and minimum annual stage at Hopkins Prairie from 1981 to 1991 (data from St. Johns River Water Management District).

from flooded to drawdown conditions in June 1990 (Figure 3, Appendix B). The study was conducted during 3 months of flooding followed by 19 months of non-flooded conditions. Water level decreased from a maximum of 20 cm above the soil surface in March 1990 to a minimum of 47 cm below the soil surface in February 1991. From March through December 1991 water level fluctuated between 13 and 40 cm below ground.

Soil moisture content during the flooded period was only available for May when it ranged from 88% at a soil depth of 20-30 cm to 91% at 0-10 cm (Table 1). Average soil moisture during the non-flooded period ranged from 88% at 0-10 cm to 89% at 10-20 and 20-30 cm. Soil moisture is expressed on a mass weight basis from 0 to 100%. Peat depth at the study site was approximately 6 m.

## Plant Species Percent Cover

White waterlily (*Nymphaea odorata*), Spikerush (*Eleocharis elongata*), Soft-headed pipewort (*Eriocaulon compressum*), Inundated beak rush (*Rhynchospora inundata*) and Blue maidencane (*Amphicarpum muhlenbergianum*) were present in at least one month during both the flooded and drawdown periods (Figure 4, Appendix C). *Nymphaea, Eleocharis* and *Eriocaulon* occurred in all flooded months. *Rhynchospora* and *Amphicarpum* were present in the last month of flooded conditions. Under non-flooded conditions, *Nymphaea* was present in 4 of the 19 monthly samples. *Eleocharis, Eriocaulon* and *Rhynchospora*

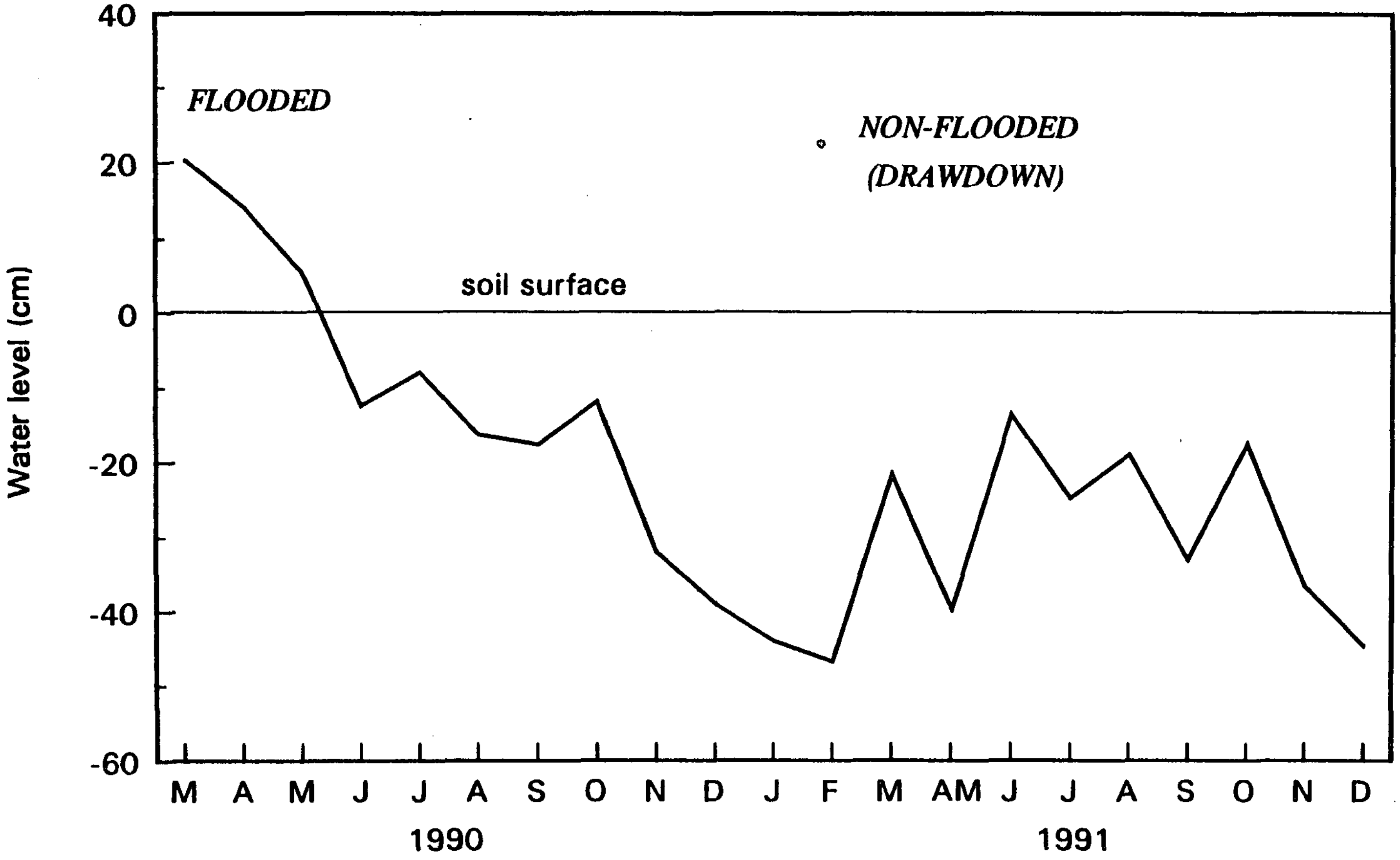


Figure 3. Mean monthly water level (n=6) at Hopkins Prairie from March 1990 to December 1991.

Table 1. Mean (standard deviation) percent moisture content of soil at Hopkins Prairie under flooded and non-flooded conditions. Values expressed on mass weight basis 0 to 100% moisture. (Non-flooded data from S. Yan and D.A. Graetz, University of Florida).

| Soil Depth (cm) | Flooded (5/90) | Non-flooded (6/90-12/90) |
|---|---|---|
| 0-10 | 91(1.4) | 88(1.3) |
| 10-20 | 89(1.1) | 89(0.4) |
| 20-30 | 88(1.2) | 89(1.4) |

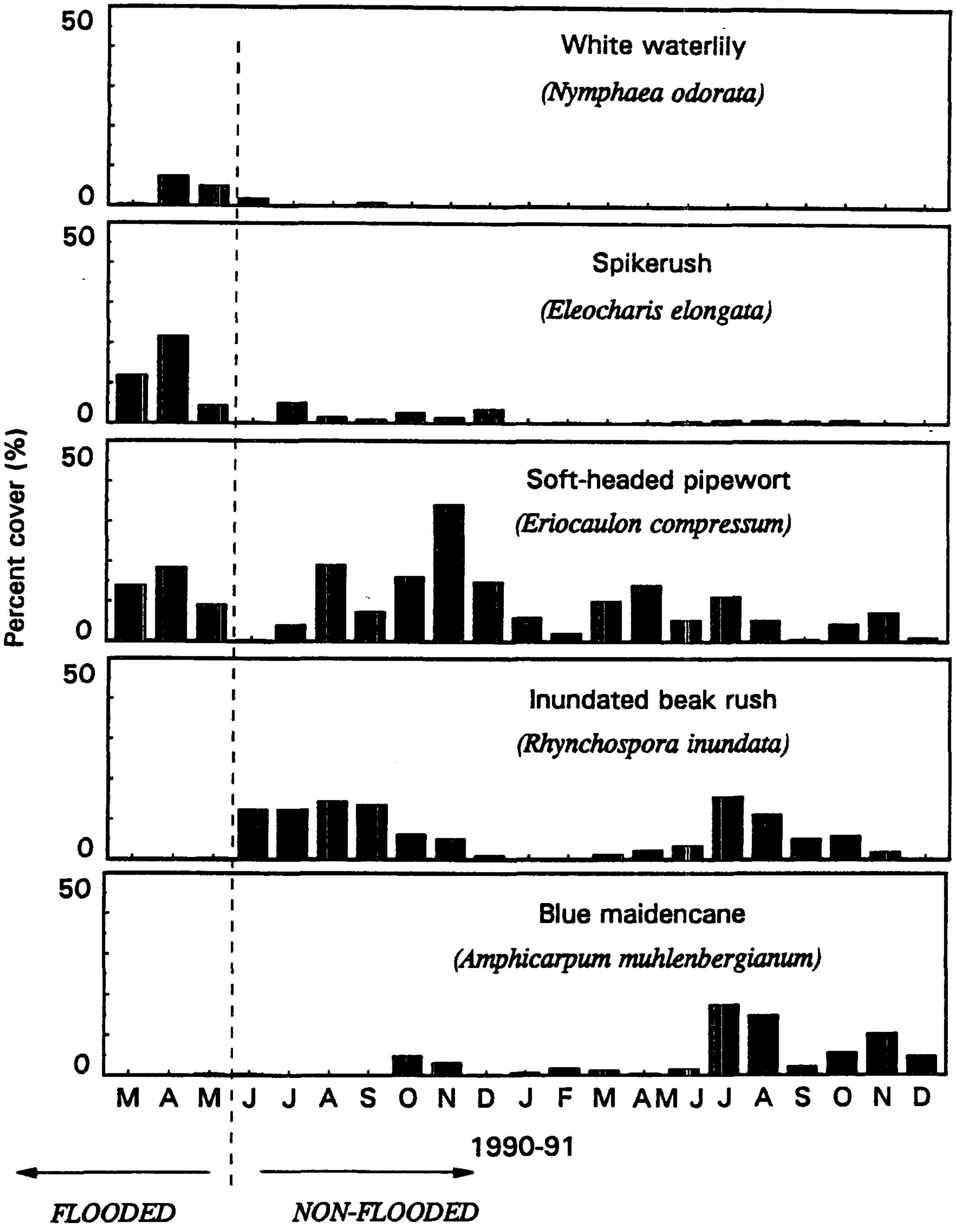


Figure 4. Mean percent cover (n=6) of species present under both flooded and non-flooded conditions.

occurred throughout the drawdown period, *Amphicarpum* in all but 3 months.

Highest percent cover of *Nymphaea* and *Eleocharis* occurred in May. *Nymphaea* averaged 4% cover while flood water was present and less than 1% during the drawdown period. *Eleocharis* averaged 13% cover when flooded compared to 1% following drawdown. Percent cover of *Eriocaulon* averaged 14% under flooded conditions and 9% under drawdown. Highest *Rhynchospora* and *Amphicarpum* cover was during the drawdown period when *Rhynchospora* averaged 6% and *Amphicarpum* 4%. Percent cover of both species was less than 1% when flooded.

### Above Ground Relative Dominance

Total above ground live biomass during the flooded period was 58% *Eriocaulon* and 30% *Eleocharis* in March, 68% *Eriocaulon* and 28% *Nymphaea* in April and 44% *Nymphaea* and 27% *Eriocaulon* in May (Figure 5, Appendix D). In June, *Rhynchospora* made up 61% of the total and *Nymphaea* 32%. From August 1990 through June 1991, *Eriocaulon* had the greatest relative above ground biomass (except September) averaging 68% of the total. In July 1991, *Rhynchospora* and *Amphicarpum* totalled 59% of all biomass, in August 89% and in September 78%. *Amphicarpum* and *Eriocaulon* made up 90% of total biomass in November and 96% in December.

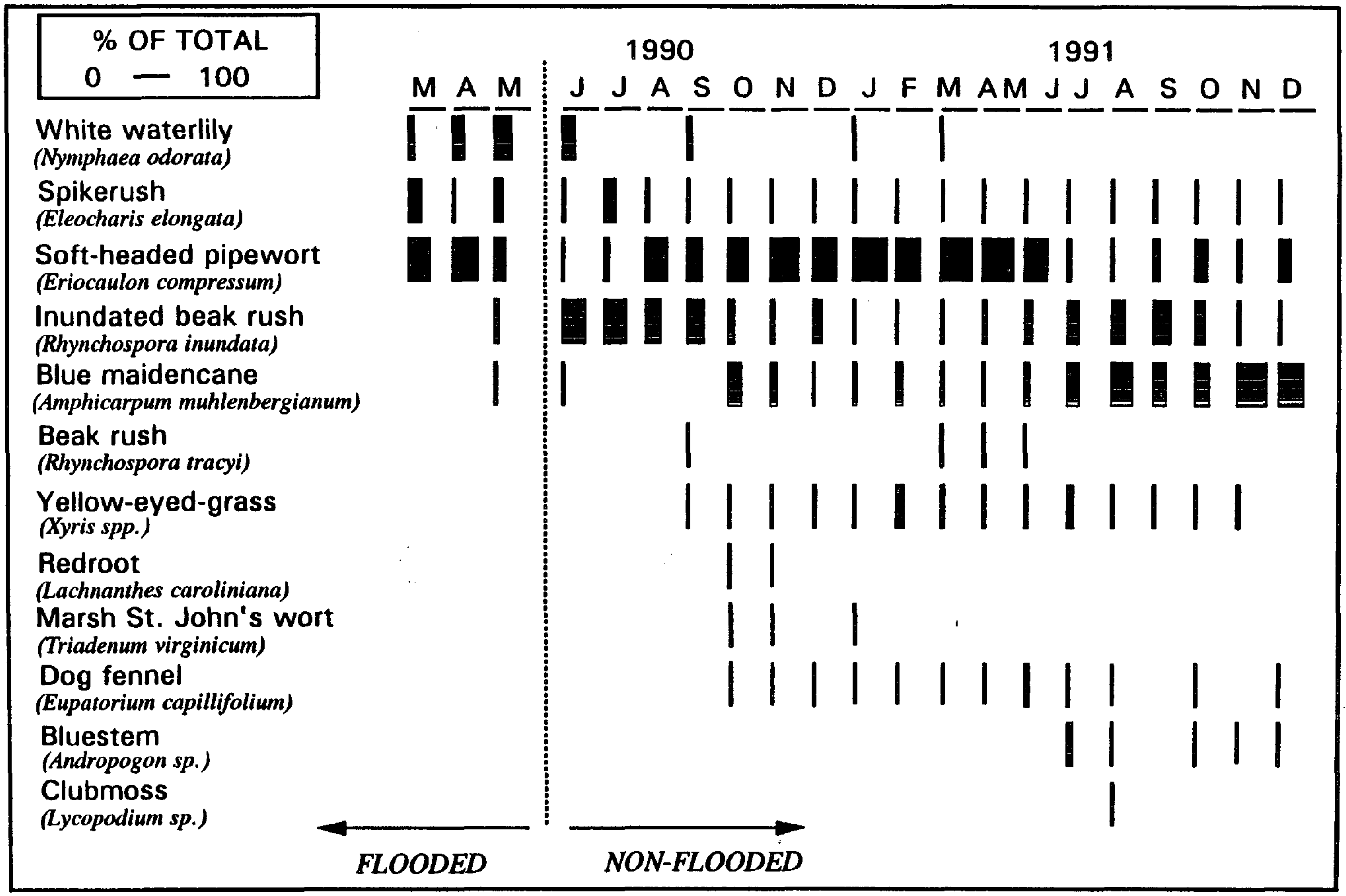


Figure 5. Mean relative dominance (n=6) as above ground live biomass.

## Species Richness and Diversity

Species richness was 3 in March and April 1990 (Table 2). Two more species were encountered in May. Six species were present in September 1990 and 8 in October. Twelve species (11 Angiosperms and 1 Pteridiophyte) were sampled during the study with a maximum species richness of 8 during any one sampling event. Initial appearance of additional species occurred in May, September and October 1990, June and July 1991.

Species diversity ranged from 1.07 to 1.86 during the flooded period and 0.55 to 2.36 when non-flooded. Maximum and minimum diversity occurred during the non-flooded period.

## Above and Below Ground Biomass

Maximum above ground live biomass of *Nymphaea* (7.40 g/m$^2$) and *Eleocharis* (3.17 g/m$^2$) occurred in May 1990 (Figure 6 and 7, Appendix E). Maximum biomass of *Rhynchospora* (17.69 g/m$^2$) and *Amphicarpum* (37.57 g/m$^2$) was in July and November 1991, respectively. *Nymphaea* above ground biomass was significantly greater during the last month of flooding compared to all months during the non-flooded period except June 1990 ($p$=0.02); however, May (flooded) was also significantly lower (Appendix F). *Rhynchospora* above ground biomass was significantly greater in July 1991 than March and April 1990, and January through March and December 1991 ($p$=0.04).

Table 2. Plant species richness (R) and Shannon-Wiener diversity index (H′) of plant community at Hopkins Prairie.

| Date | Richness (R) | Diversity (H′) |
|---|---|---|
| MAR 1990 | 3 | 1.35 |
| APR | 3 | 1.07 |
| MAY | 5 | 1.86 |
| JUN | 5 | 1.34 |
| JUL | 3 | 1.30 |
| AUG | 3 | 1.22 |
| SEP | 6 | 1.71 |
| OCT | 8 | 1.60 |
| NOV | 8 | 1.16 |
| DEC | 7 | 1.60 |
| JAN 1991 | 8 | 0.55 |
| FEB | 6 | 1.43 |
| MAR | 8 | 0.88 |
| MAY | 7 | 0.97 |
| JUN | 7 | 1.77 |
| JUL | 7 | 2.36 |
| AUG | 8 | 1.55 |
| SEP | 5 | 1.79 |
| OCT | 7 | 1.99 |
| NOV | 6 | 1.04 |
| DEC | 6 | 1.19 |

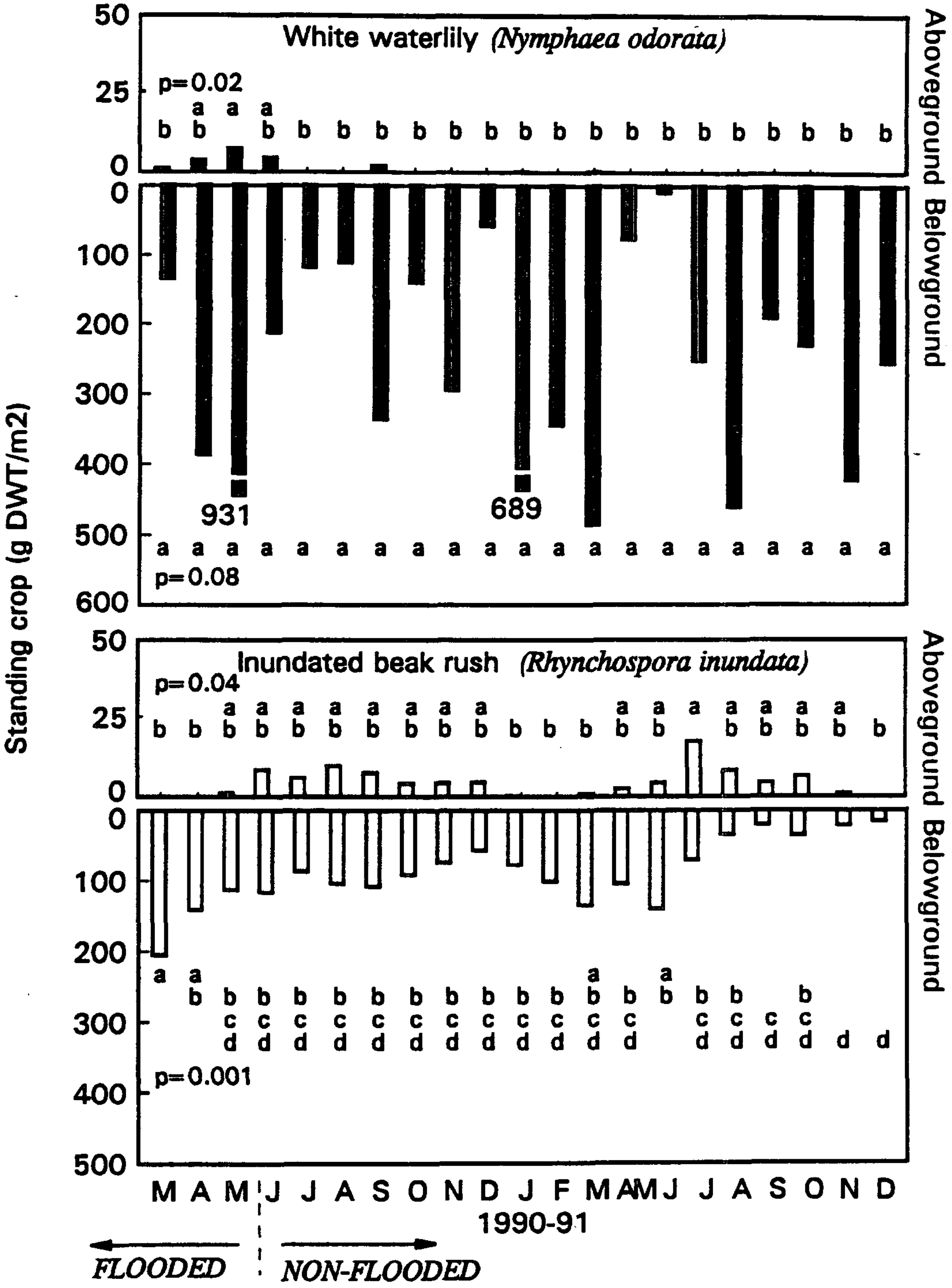


Figure 6. Mean above and below ground biomass (n=6) of species shifting above ground relative dominance (note difference in y-scale of paired graphs). Means with same letter are not significantly different.

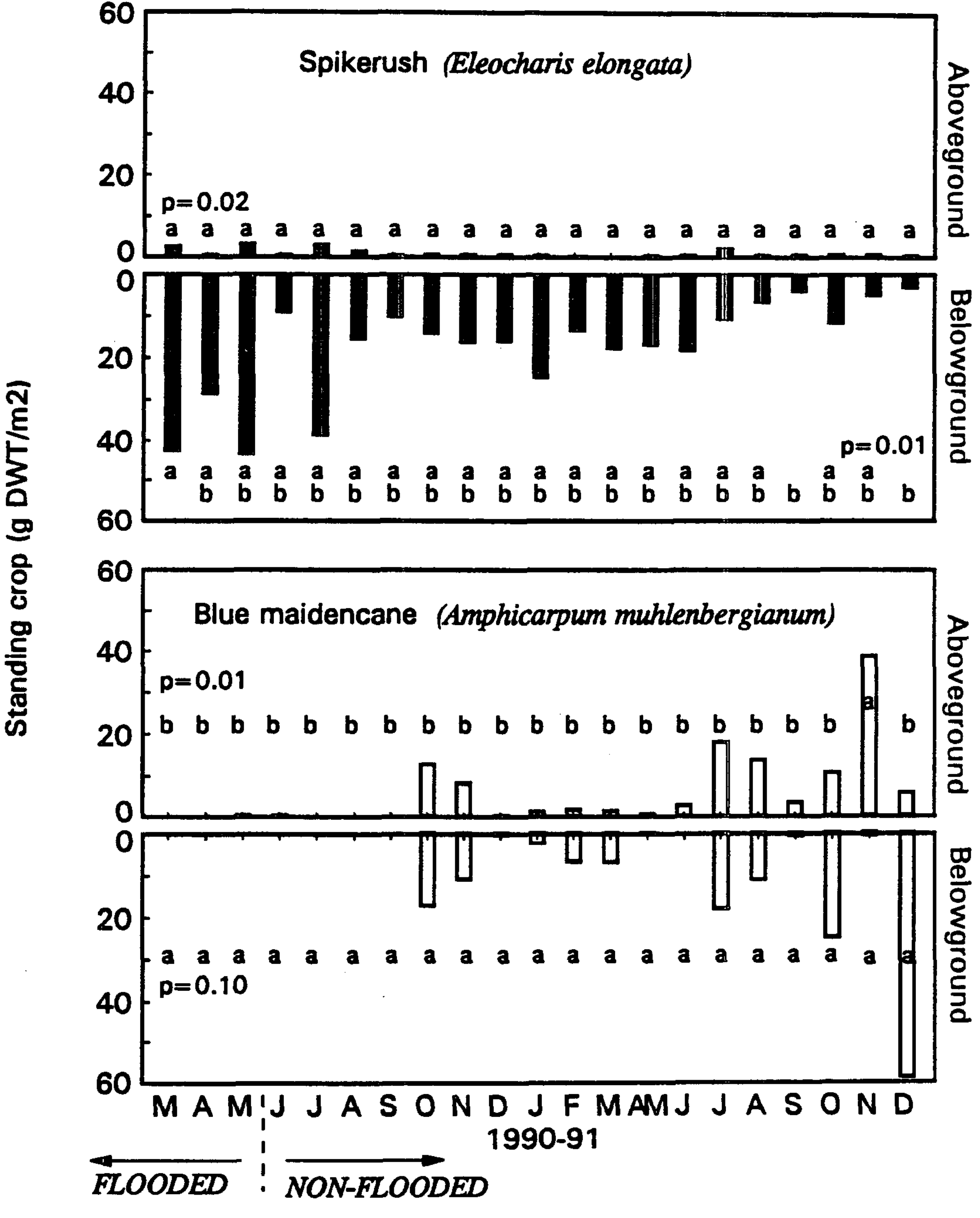


Figure 7. Mean above and below ground biomass (n=6) of species shifting above ground relative dominance. Means with same letter are not significantly different.

*Eleocharis* (*p*=0.02) and *Amphicarpum* (*p*=0.01) showed no significant differences between flooded and non-flooded conditions except during November 1991 when *Amphicarpum* biomass was greatest.

*Nymphaea*, *Eleocharis* and *Rhynchospora* were present in below ground samples during all months of the study. *Nymphaea* below ground biomass averaged 484.09 g/m$^2$ during the three months of flooded conditions compared to 262.60 g/m$^2$ through the drawdown period. *Eleocharis* averaged 38.20 and 14.05 g/m$^2$ during flooded and non-flooded conditions, respectively. Average flooded period *Rhynchospora* below ground biomass was 152.44 g/m$^2$ compared to 77.37 g/m$^2$ during the drawdown period. *Amphicarpum* was present in below ground samples from October 1990 through December 1991 averaging 5.62 g/m$^2$. No significant differences were found in *Nymphaea* (*p*=0.08) or *Amphicarpum* (*p*=0.10) below ground biomass. *Eleocharis* (*p*=0.01) and *Rhynchospora* (*p*=0.001) was significantly greater at the start of the study (flooded) compared to the end (non-flooded).

## Net Above Ground Primary Productivity

Net above ground primary productivity was variable throughout the study period (Figure 8). Values alternated between positive production and no net production with 8 of 21 months showing no net production. Decomposition of above ground live biomass ranged from approximately 20% to 30%

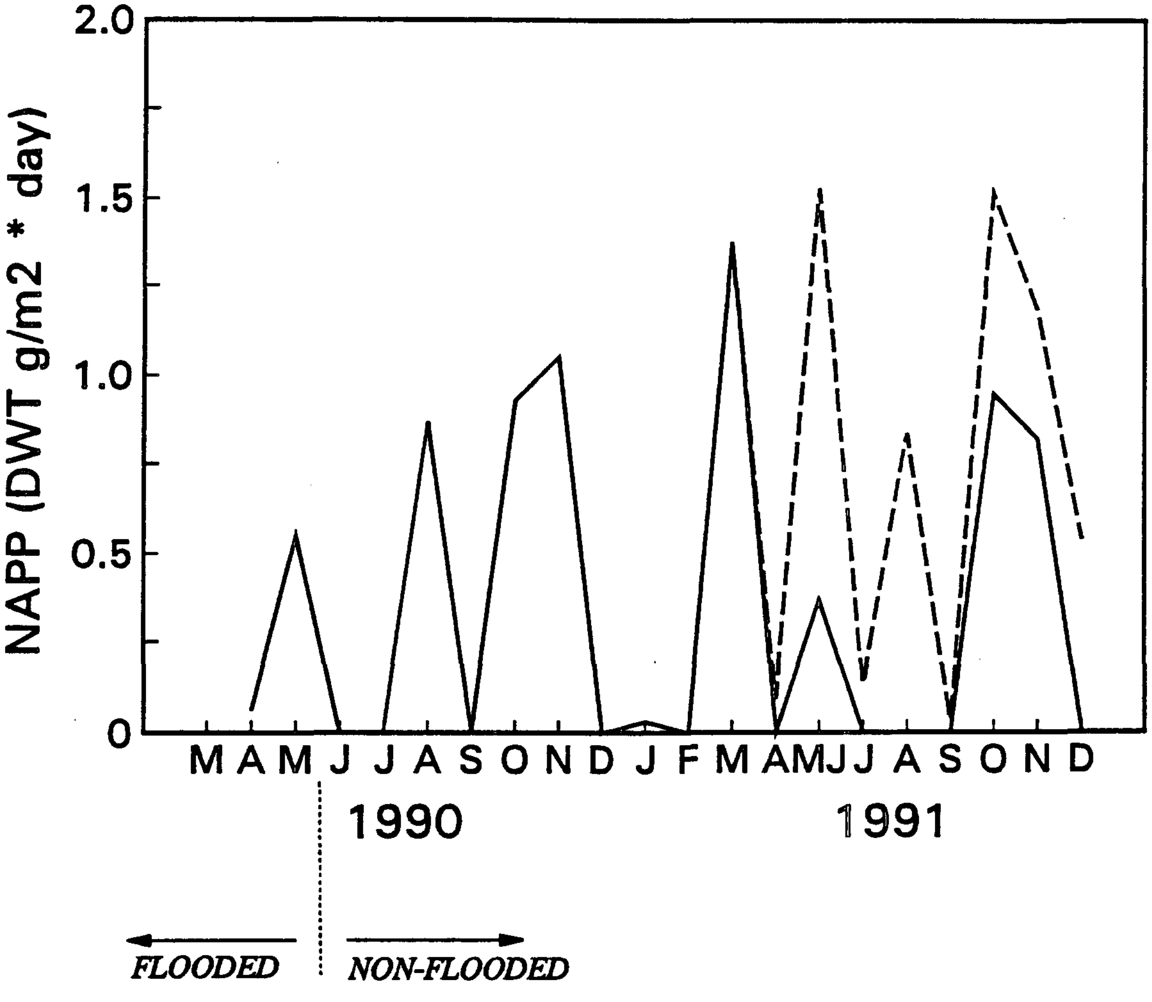


Figure 8. Mean above ground primary productivity (dashed line includes decomposition).

between sampling dates. Above ground dead decomposition ranged from approximately 1 to 13%.

## Soil Characterization

The peat at Hopkins Prairie was approximately 47-54 % C, 2-3 % N and 0.01-0.02 % P in the top 60 cm (Table 3). Ratios of C, N and P in the top 10 cm of soil were 14 (C/N), 1983 (C/P) and 146 (N/P). Soil pH ranged from 4.6-5.2 and bulk density 0.13-0.14 g/cm$^3$.

## Soil Available Nitrogen and Phosphorus

Total water extractable $NH_4^+$ averaged 113 mg/kg from May through August reaching its maximum of 152 mg/kg in September then decreasing to 46 mg/kg by December (Figure 9, Appendix G). Water extractable $NO_3^-$ increased during the study period from 0.6 mg/kg in May to 22 mg/kg in June and continued to increase to a maximum of 190 mg/kg in December. Maximum $NO_3^-$ was in the top 10 cm in December. Maximum water extractable SRP was 23 mg/kg in May. From June through December SRP ranged from 2 to 4 mg/kg. Exchangeable $NH_4^+$ as KCl extractable averaged 130 mg/kg from May to September, then decreased to 30 mg/kg in December (Figure 10, Appendix H). Potassium chloride extractable SRP was 13 mg/kg in May and ranged from 1.1 to 2.3 mg/kg June through September. In October, KCl extractable SRP decreased, averaging 0.4 mg/kg from October to December.

Table 3. Characterization of soil at Hopkins Prairie study site (data in top table from D.A. Graetz, University of Florida).

| Depth cm | pH | C % | TN % | TP % | C/N | C/P | N/P |
|---|---|---|---|---|---|---|---|
| 0-10 | 4.6 | 47.5 | 3.49 | 0.024 | 14 | 1983 | 146 |
| 10-20 | 5.0 | 49.7 | 3.14 | 0.013 | 16 | 3737 | 236 |
| 20-60 | 5.2 | 53.5 | 2.38 | 0.006 | 22 | 9727 | 433 |

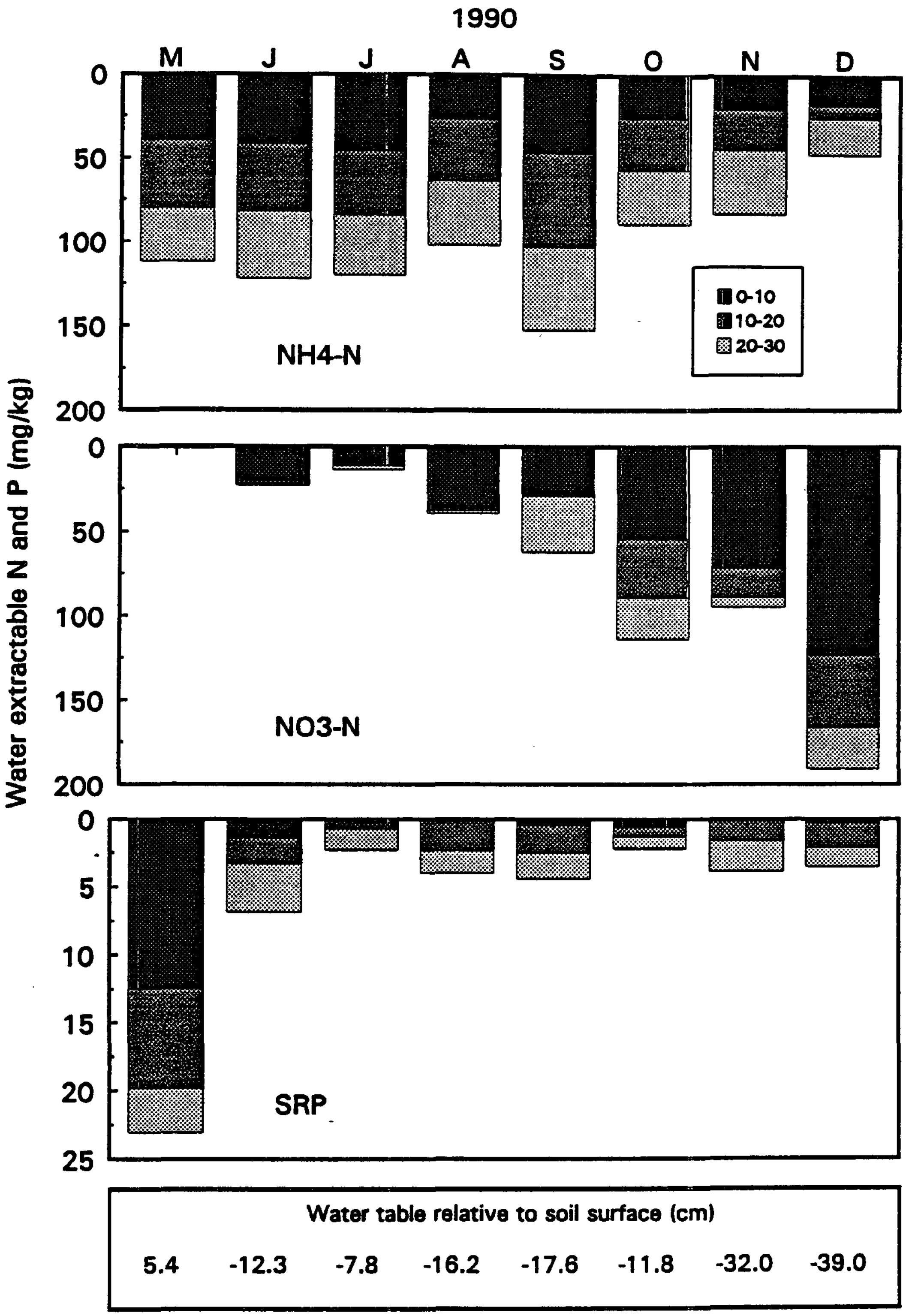


Figure 9. Mean (n=6) water extractable ammonium nitrogen (NH4-N), nitrate nitrogen (NO3-N) and soluble reactive phosphorus (SRP).

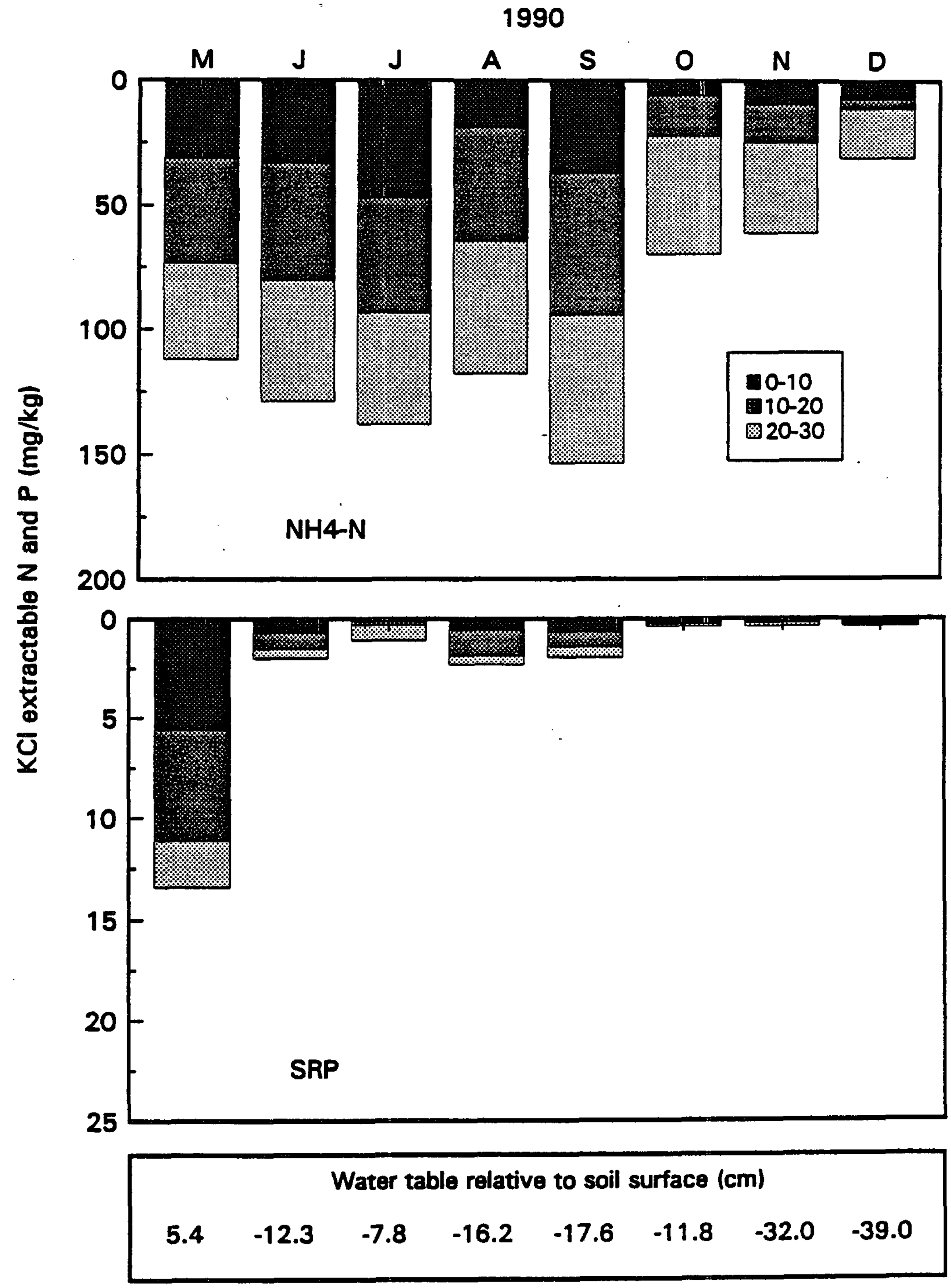


Figure 10. Mean (n=6) potassium chloride (KCl) extractable ammonium nitrogen (NH4-N) and soluble reactive phosphorus (SRP).

Available $NH_4^+$ as water extractable plus KCl extractable in the top 10 cm of soil was 71.10 mg/kg when flooded and 25.92 mg/kg at the end of the non-flooded sampling period (Figure 11). Ammonium values from October through December were significantly lower than the maximum in July ($p$=0.003). Available $NO_3^-$ was lowest when flooded increasing significantly from 0.26 to 123.90 mg/kg through the study ($p$=0.001). Total available N as $NH_4^+$ plus $NO_3^-$ in the top 10 cm ranged from 71 to 149 mg/kg (Figure 12). Nitrogen was significantly lower during May compared to the end of the study period ($p$=0.06). Ammonium availability was greater than $NO_3^-$ from May through September; $NO_3^-$ was greater from October through December. Total available SRP was 18.2 mg/kg in May then showed a significant drop to 2.2 mg/kg in June ($p$=0.001) and remained less than 1.2 mg/kg through the remainder of the study.

## Plant Tissue Nitrogen and Phosphorus

Tissue N content averaged 20.4 mg/g in above ground live biomass and 13.2 mg/g in below ground (0-10 cm) biomass (Figure 13, Appendix I). Above and below ground tissue P averaged 0.5 and 0.2 mg/g, respectively (Figure 14). Maximum N and P content in above ground tissues was in September. Tissue N and P in below ground biomass was greatest in the top 10 cm in all months. No significant differences were found in tissue content between flooded and non-flooded conditions ($p$>0.13).

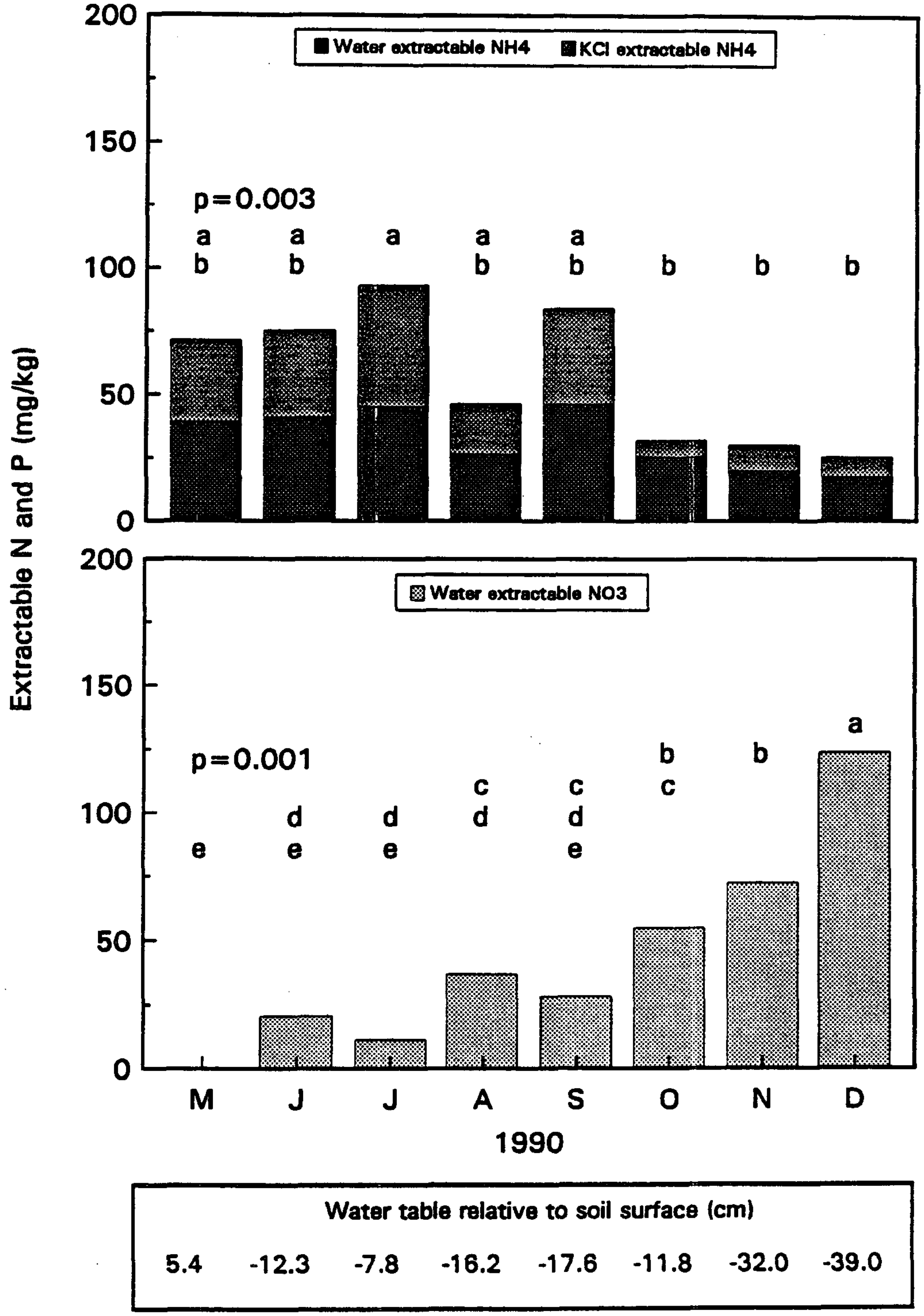
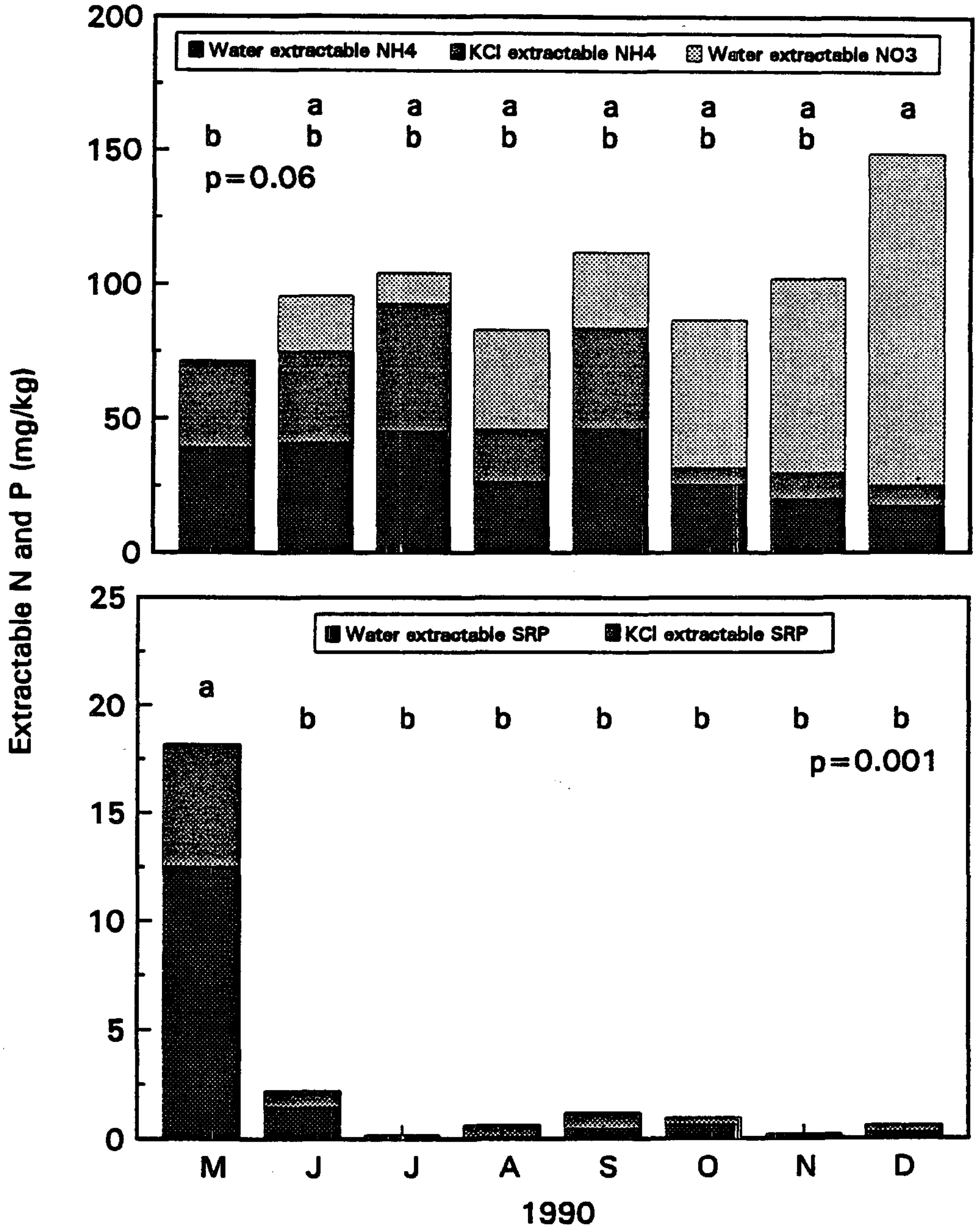
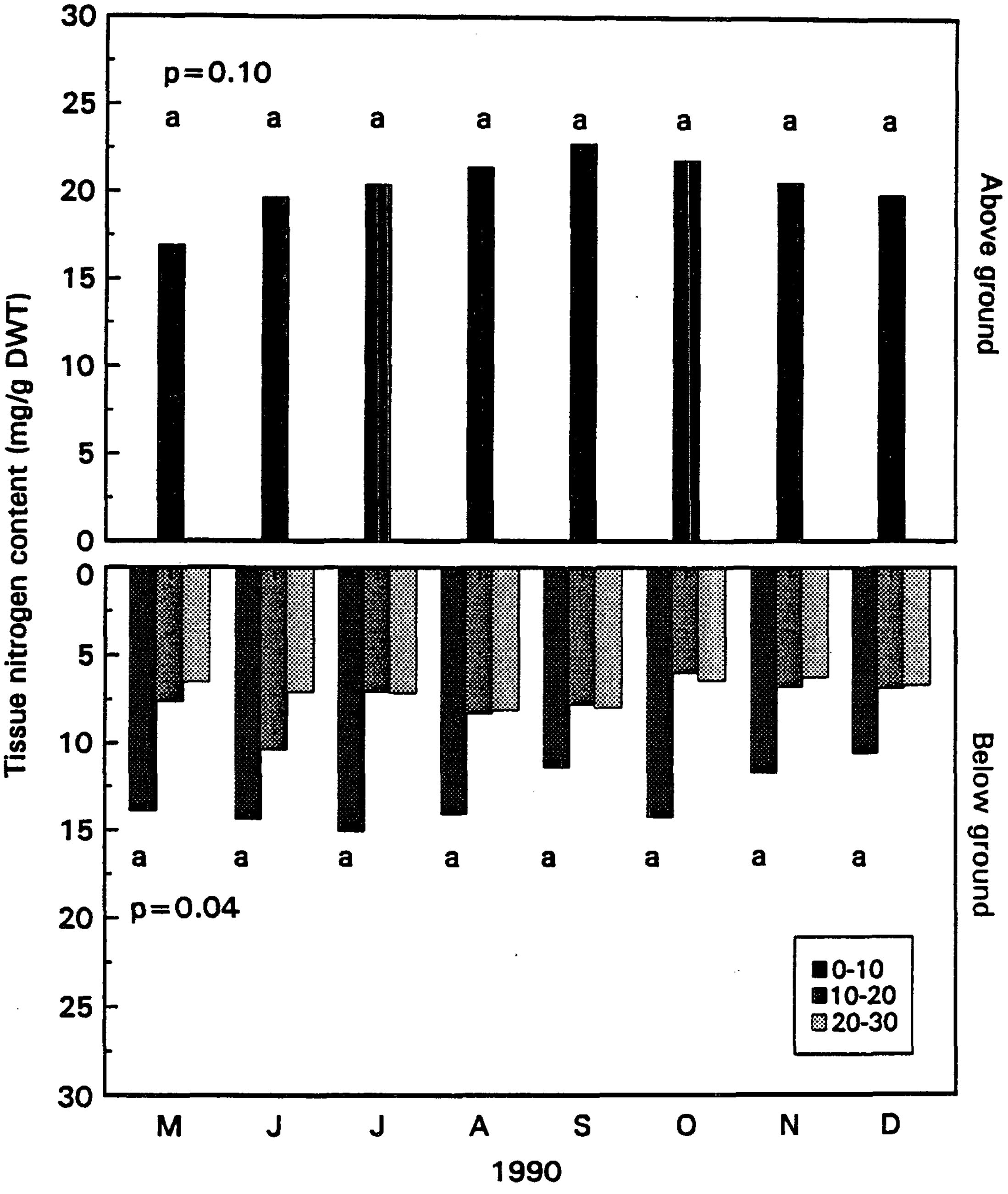


Figure 11. Mean (n=6) available nitrogen as water extractable plus potassium chloride (KCl) extractable ammonium nitrogen (NH4-N) and water extractable nitrate nitrogen (NO3-N). Means with same letter are not significantly different.



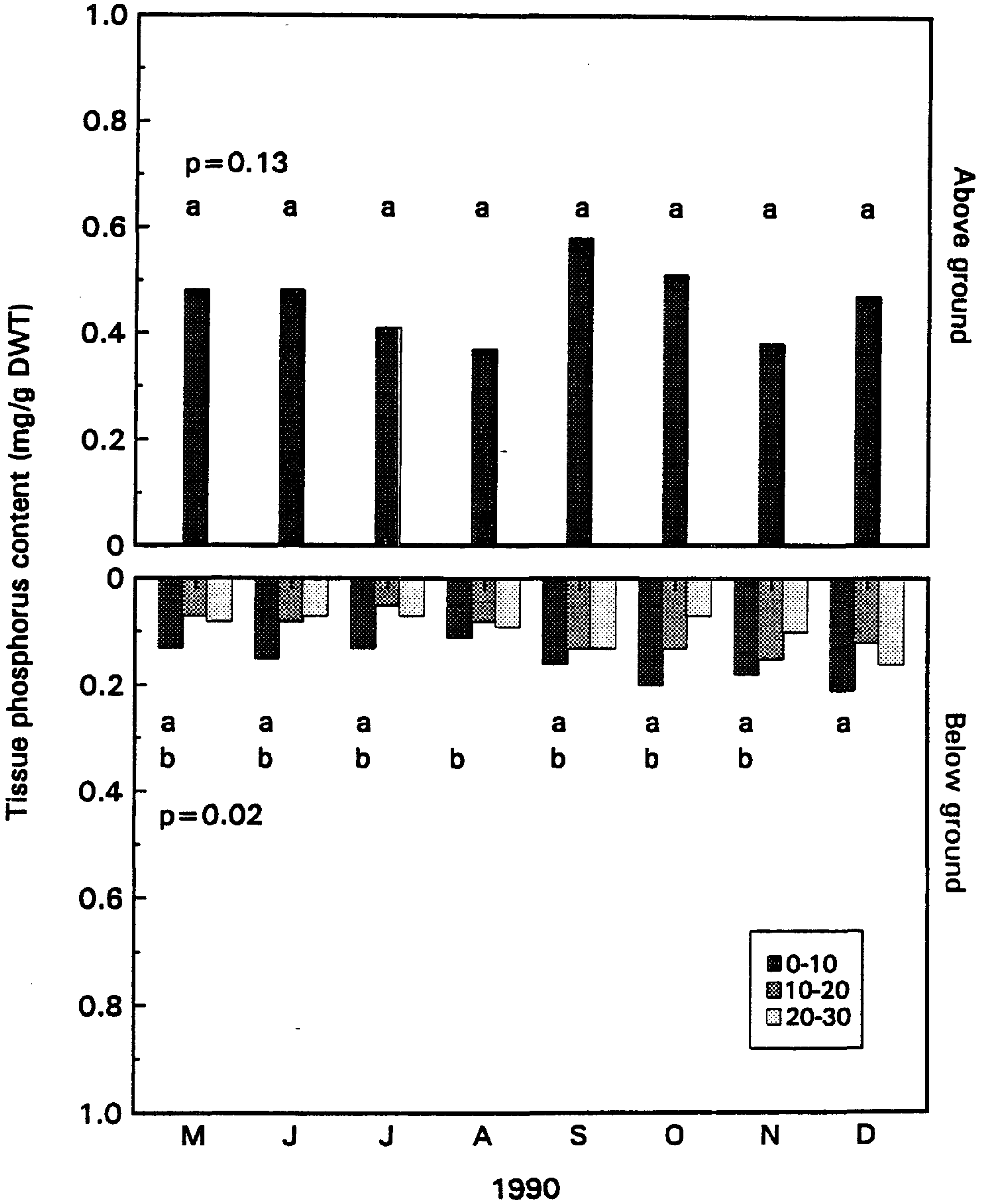
| Water table relative to soil surface (cm) | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5.4 | -12.3 | -7.8 | -16.2 | -17.6 | -11.8 | -32.0 | -39.0 |

Figure 12. Mean (n=6) available nitrogen and phosphorus as water extractable ammonium nitrogen (NH4-N), nitrate nitrogen (NO3-N) and soluble reactive phosphorus (SRP) plus potassium chloride (KCl) extractable NH4-N and SRP in the top 10 cm of soil. Means with same letter are not significantly different.



| Water table relative to soil surface (cm) | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5.4 | -12.3 | -7.8 | -16.2 | -17.6 | -11.8 | -32.0 | -39.0 |

Figure 13. Mean (n=6) above and below ground plant tissue nitrogen content. Means with same letter are not significantly different.



| Water table relative to soil surface (cm) | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5.4 | -12.3 | -7.8 | -16.2 | -17.6 | -11.8 | -32.0 | -39.0 |

Figure 14. Mean (n=6) above and below ground plant tissue phosphorus content. Means with same letter are not significantly different.

Above ground biomass increased and below ground biomass decreased through the study period (Figure 15). Below ground total biomass averaged 35 times greater than above ground biomass. The total amount of N and P in plant biomass (as tissue concentration multiplied by plant biomass) was greatest below ground in all months, averaging 22 times more N and 18 more P than in above ground biomass (Figures 16 and 17). Biomass N and P was highest in below ground 0-10 cm biomass.

Linear regression analyses of available N or P (mg/m$^2$) with total biomass (above and below ground) N or P (mg/m$^2$) revealed several significant correlations (Appendix J). Plant biomass N was negatively correlated ($r^2$=0.57) with available $NH_4^+$+$NO_3^-$ ($p$=0.05). Biomass P was positively correlated ($r^2$=0.72) with available P ($p$=0.05). Biomass N and P were highest when available N was low and available P was high. These correlations were calculated from monthly means (n=6). Correlations using all observations (n=48) revealed no significant linear regressions, caution is therefore recommended in interpreting the plots.

Ratio of N:P available in the soil increased from 4:1 in May to 44:1 in June then ranged from 92:1 to 633:1 through the non-flooded period (Table 4). Plant tissue N:P in above ground live tissues ranged from 35:1 to 58:1 through the entire study period and below ground from 11:1 to 15:1.

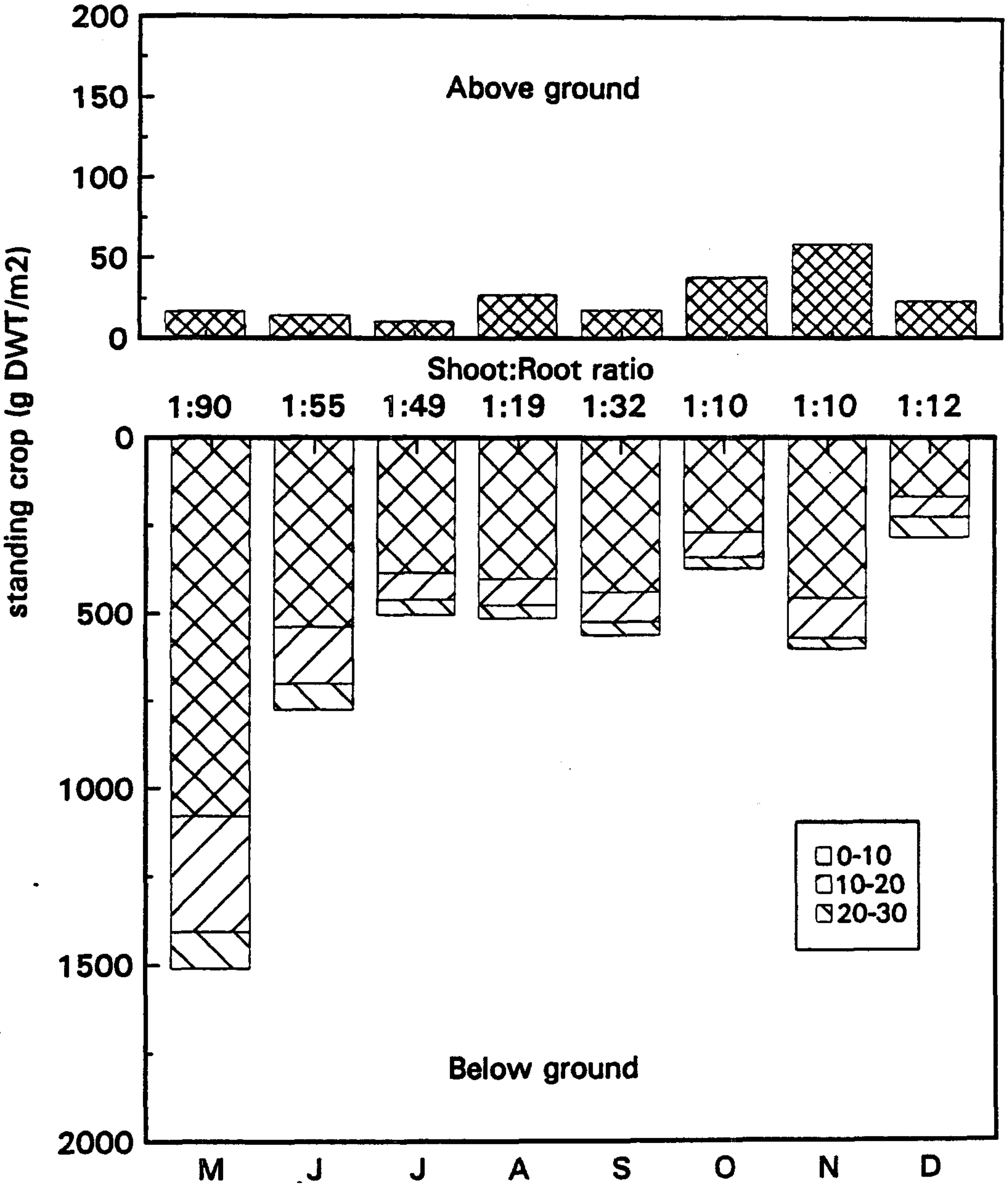
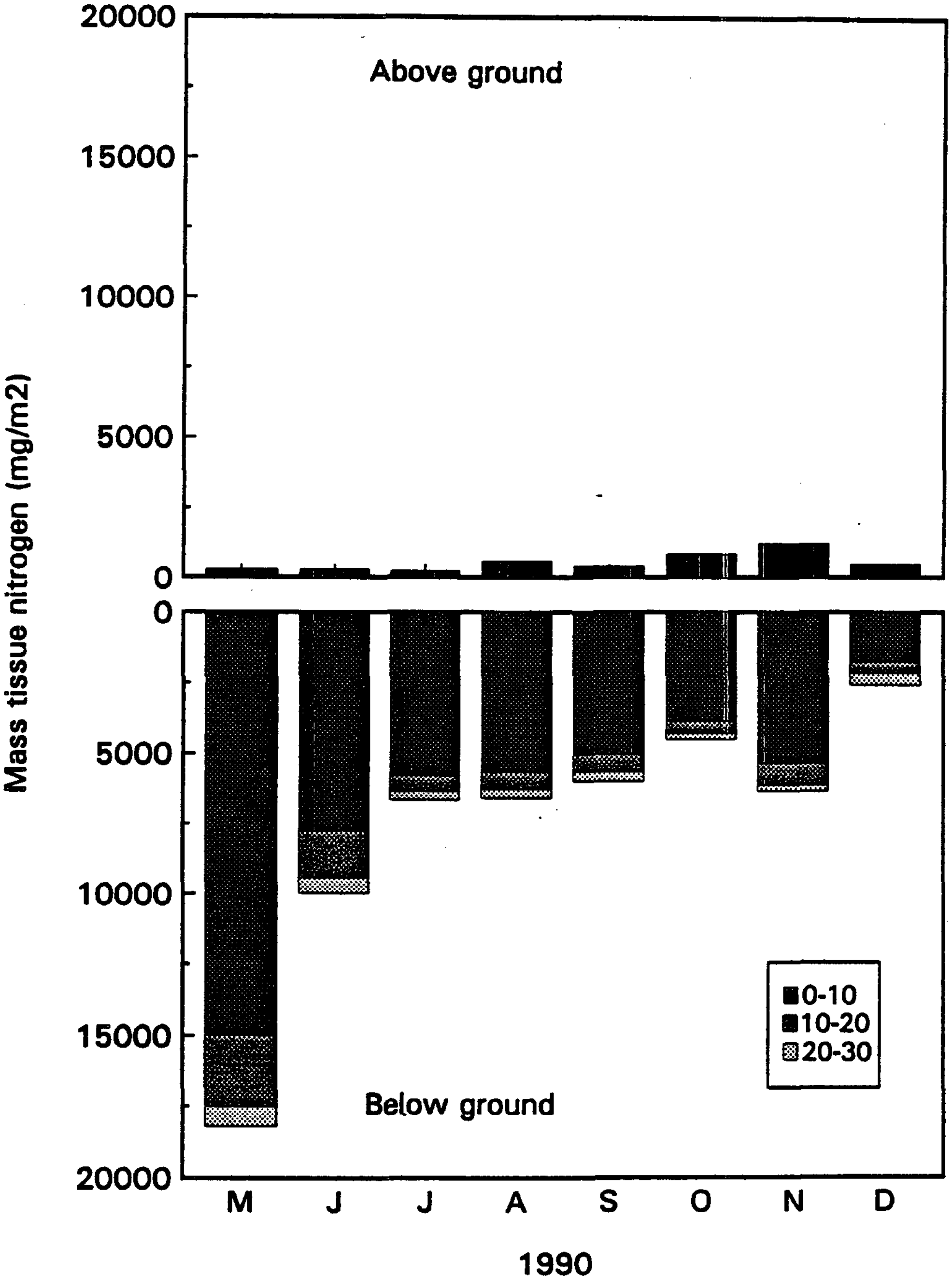


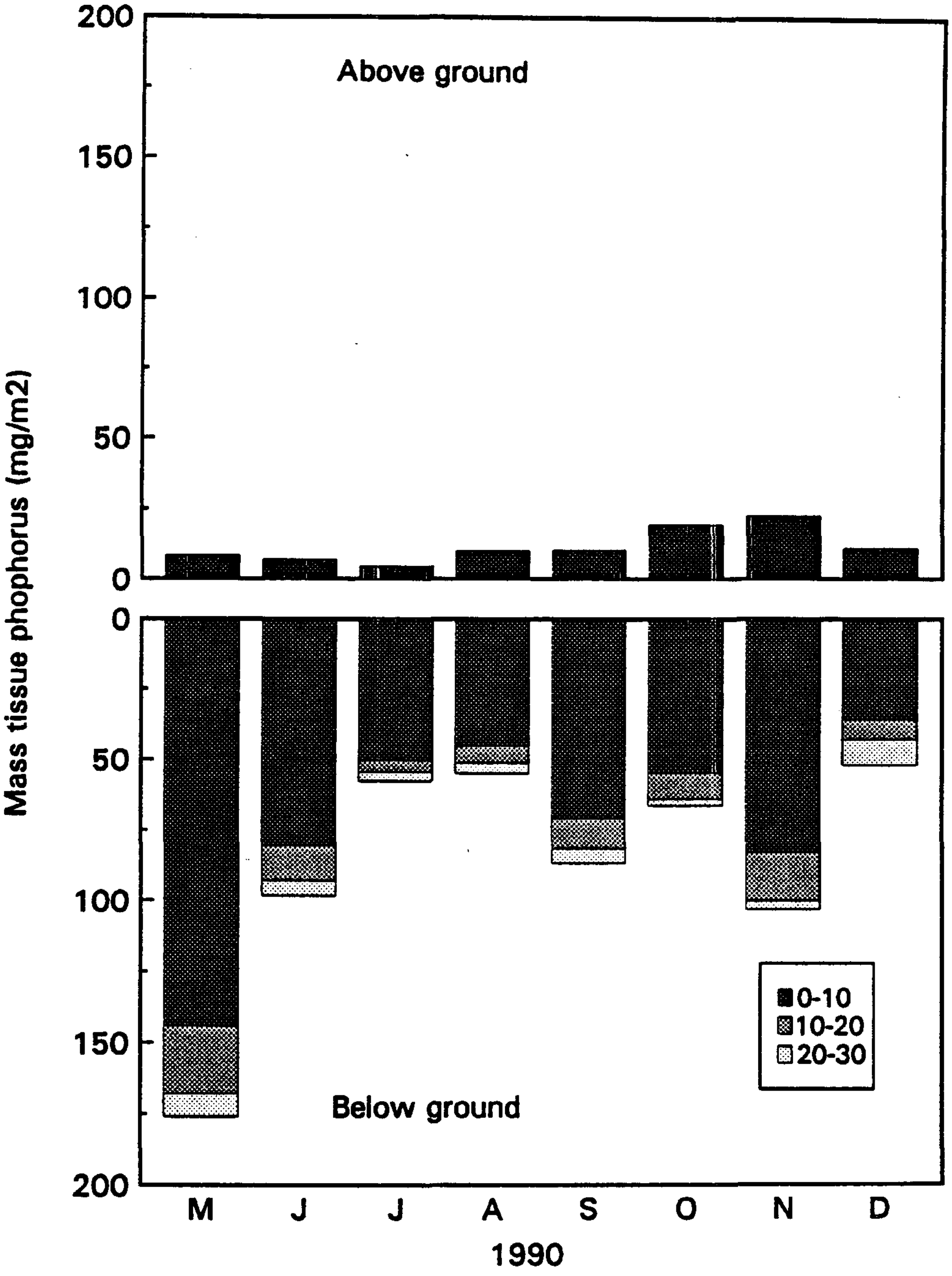
Figure 15. Mean (n=6) above and below ground plant biomass and shoot:root ratios (Note difference in y-scales).



Water table relative to soil surface (cm)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5.4 | -12.3 | -7.8 | -16.2 | -17.6 | -11.8 | -32.0 | -39.0 |

Figure 16. Mean (n=6) above and below ground mass tissue nitrogen (tissue content times biomass).



Water table relative to soil surface (cm)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5.4 | -12.3 | -7.8 | -16.2 | -17.6 | -11.8 | -32.0 | -39.0 |

Figure 17. Mean (n=6) above and below ground mass tissue phosphorus (tissue content times biomass).

Table 4. Nitrogen:phosphorus ratios in soil and plant tissues at Hopkins Prairie.

| Ratio | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|
| Available N:P | 4 | 44 | 633 | 142 | 97 | 92 | 538 | 258 |
| Tissue N:P | | | | | | | | |
| Above ground live | 35 | 41 | 49 | 58 | 39 | 43 | 54 | 42 |
| Below ground 0-10 cm | 14 | 14 | 15 | 14 | 11 | 14 | 12 | 11 |
| Mass N:P (Whole plant) | 98 | 94 | 107 | 103 | 64 | 58 | 58 | 44 |

# DISCUSSION

## Hydrology

Hopkins Prairie is situated in a closed basin. Hydrology on the prairie is controlled by climate and hydrogeology. Ground water seepage from the surrounding uplands and direct precipitation are the primary inflows. Water level at the study site has fluctuated between flooded and drawdown conditions on a 2 to 3 year cycle over the past 11 years. During this study the site shifted from flooded to drained conditions. Sampling was conducted during the last 3 months of an approximately 3 year flooded cycle followed by 19 months of drawdown conditions. Soil moisture content remained high following drawdown due to the high water holding capacity of the peat soil.

## Plant Community Dynamics

Above ground. Five species (*Nymphaea odorata, Eleocharis elongata, Eriocaulon compressum, Rhynchospora inundata* and *Amphicarpum muhlenbergianum*) occurred under both flooded and non-flooded conditions. Under flooded conditions the site was dominated by the aquatic species *Nymphaea*, *Eleocharis* and *Eriocaulon*. Two emergent species, *Rhynchospora* and *Amphicarpum* appeared in the last month of flooding. Immediately following drawdown relative dominance shifted to *Rhynchospora* and *Nymphaea*. After only one month of non-flooded conditions, *Nymphaea* dropped out of dominance and the site became dominated by *Eriocaulon*, *Rhynchospora* and *Amphicarpum*. *Nymphaea* is a floating-leaved aquatic species which requires standing water. *Eleocharis* is a sedge adapted to growing in standing water or on exposed soil but seemed to favor flooded conditions. *Eriocaulon* showed the greatest ecological amplitude growing well under both flooded and non-flooded conditions. *Rhynchospora* (a sedge) and *Amphicarpum* (a grass) grew best under non-flooded conditions. Drawdown occurred during the spring growing season. *Rhynchospora* which flowers in the spring and summer, showed peak growth immediately after drawdown in 1990 and again in the spring and summer of 1991. *Amphicarpum* flowers in the fall and became well established during the first fall of non-flooded conditions. After 16 months of non-flooded conditions, the aquatic community had been replaced by a sedge/grass community dominated by *Rhynchospora* and *Amphicarpum*.

Secondary succession is a progression toward higher species richness and diversity (Odum 1963). Species richness increased through the drawdown period as secondary succession was initiated on the newly exposed soil. Seeds in a persistent seed bank (mainly *Rhynchospora*) and seeds possibly transported to the site from outside sources germinated under favorable drawdown conditions. van der Valk (1981) describes a "sieve" of environmental factors which change with shifts in hydrology affecting establishment and extirpation of wetland species. Species richness increased; however, maximum and minimum Shannon-Wiener diversity occurred during the non-flooded period. Fluctuations in the species diversity index was likely due to dominance by a few species during most months. January 1991 had the highest species richness value but the lowest diversity when 92% of the biomass was *Eriocaulon*. In contrast, July 1991 had the highest diversity with each of seven species accounting for no more than 30% of the total. Species richness is a good measure for comparing ecosystems while species diversity gives information on dominance (Colinvaux 1986).

Net above ground primary productivity was variable without obvious trends. Hopkins Prairie primary productivity was low compared to other freshwater wetlands (Clough and Best 1991). The oligotrophic nature of the prairie and the potentially limiting effects of low available phosphorus may contribute to the low productivity observed during the study. The variability of productivity measurements may be due to the clumped distribution of species present at the study site. Replicate samples of six may not have been large enough to adequately represent standing crop each month. Although production measurements were variable, the shift in relative species abundances was clearly observable.

Other studies have described similar shifts in above ground species dominance following changes between inundation and drawdown (Bolen et al. 1989, Duever 1982, Gopal 1986, LaClaire and Franz 1990). Oscillatory hydrology in wet prairies in the Okefenokee Swamp of Georgia resulted in two distinct suites of plant species (Greening and Gerritsen 1987, Gerritsen and Greening 1989). Aquatic species such as *Nymphaea odorata* and *Nuphar luteum* dominated under flooded conditions and emergent species, primarily *Rhynchospora inundata*, dominated during drawdown periods. The cyclic shift from flooded to non-flooded conditions at Hopkins Prairie resulted in a similar replacement. Presumably, reflooding will occur and conditions will again be favorable for reestablishment of the aquatic community. The filamentous algae community may also become reestablished. A sample of the dry mat of algae on the soil surface during the non-flooded period was collected and submerged as a qualitative laboratory experiment. Viable spores in the mat regenerated suggesting that the filamentous algae community may reoccupy the water column upon reflooding.

Below ground. Below ground dynamics at Hopkins Prairie revealed a primary role in maintenance of the plant community and persistence of species under fluctuating environmental conditions. *Nymphaea* and *Eleocharis* which dropped out of above ground dominance persisted below ground as live rhizomes throughout the drawdown period. Similarly, *Rhynchospora* which favored non-flooded conditions was present below ground during the flooded period. The exception to this was *Amphicarpum* which did not become well established below ground until after drawdown when it germinated from seeds. *Rhynchospora* (numerous in the seed bank) germinated from seeds initially then through vegetative expansion from rhizomes after the growing season. The high moisture content (88-89%)of the soil during the non-flooded period allowed rhizomes of the aquatic species to survive in the absence of standing water. Grime (1979) describes a plant community type adapted to periodic disturbance in which the disturbance does not completely destroy existing plants. Vegetative structures and propagules (rhizomes, bulbs, tubers etc.) persist below ground, species regenerate through vegetative expansion or germination of seeds in a persistent seed bank. Vegetative expansion allows regeneration from a parent plant producing genetically "successful" individuals with low risk of mortality due to connection to the parent plant. However, reaction to severe disturbance may be catastrophic since all individuals are similar and in close proximity. Regeneration from a seed bank allows establishment of numerous independent individuals dispersed from the parent plant. Persistent seed banks are common in habitats with intermittent disturbance such as fire or flooding (Grime 1979, Gopal 1986). Seeds remain dormant in the soil until environmental conditions become favorable for germination. Possessing both strategies may widen the range of conditions in which a species can persist and is particularly advantageous under fluctuating environmental conditions.

Life history characteristics of species present under flooded and non-flooded conditions at Hopkins Prairie shows some similarities in regeneration strategies (Table 5). Reed (1988) assigns a wetland indicator category to wetland plant species based on their association with wetland habitats. Obligate wetland species (OBL) have greater than 99% probability of occurring under natural conditions in wetlands; facultative wetland (FACW) 67-99%; facultative (FAC) 34-66%; facultative upland (FACU) 1-33%; and obligate upland (UPL) less than 1%. All of the listed species with the exception of *Amphicarpum* are obligate wetland plants. There is a trend of decreasing flood tolerance from *Nymphaea* which requires standing water to germinate and grow to *Amphicarpum* requiring drawdown conditions. *Eleocharis*, *Eriocaulon* and *Rhynchospora* show greater adaptability to fluctuating hydrology. All 5 species are perennials with vegetative expansion and seed reproduction strategies. Perenniating below ground rhizomes and a persistent seed bank allow rapid response to changes in water level. *Nymphaea* and *Eleocharis* surviving the drawdown but moist soil conditions can become reestablished above ground upon reflooding. Less flood tolerant species such as *Rhynchospora* and *Amphicarpum* would decrease following reflooding until the next non-flooded cycle.

Restocking the seed bank is important to allow this cycle to continue. Flooding induced *Rhynchospora inundata* to flower and seed in the Okefenokee Swamp (Gerritsen and Greening

Table 5. Selected life history characteristics of five plant species occurring at Hopkins Prairie. Obligate wetland species (OBL) have greater than 99% probability of occurring under natural conditions in wetlands and facultative wetland species (FACW) have between 67-99% probability (Reed 1988).

| Species | Wetland Index | Habit | Duration | Reproduction | Germination | Growing Season |
|---|---|---|---|---|---|---|
| *Nymphaea odorata* | OBL | Floating-leaved | Perennial | Vegetative<br>Seed | Flooded | Spring-Fall |
| *Eleocharis elongata* | OBL | Submersed<br>Emersed<br>Moist soil | Perennial | Vegetative<br>Seed | Flooded<br>Drawdown | Spring-Summer |
| *Eriocaulon compressum* | OBL | Submersed<br>Emersed<br>Moist soil | Perennial | Vegetative<br>Seed | Flooded<br>Drawdown | Spring-Summer |
| *Rhynchospora inundata* | OBL | Emersed<br>Moist soil | Perennial | Vegetative<br>Seed | Flooded<br>Drawdown | Spring-Summer |
| *Amphicarpum muhlenbergianum* | FACW | Moist soil | Perennial | Vegetative<br>Seed | Drawdown | Fall |

1989). This strategy insures restocking of the seed bank. Proximity to external seed sources plays a role in species richness and diversity during succession. All species which invaded the site during the non-flooded period are found elsewhere on the prairie in areas with favorable growing conditions.

## van der Valk Model Applied to Predictions

van der Valk (1981) developed a qualitative model of plant succession in wetlands experiencing shifts between flooded and non-flooded conditions. By examining three life history traits, life span, propagule longevity and propagule establishment requirements, each species can be given a life history type. Twelve life history types were identified with predicted presence or absence under fluctuating hydrology. Determining the life history type of species present as adults or in the seed bank under one hydrologic state allows predictions of presence (as adults or in the seed bank) or extirpation under the alternate hydrologic state. The model was applied to the five dominant species present under both flooded and non-flooded conditions in Hopkins Prairie, and a prediction of species composition under reflooding was postulated.

Each species was classified according to life history type (Table 6) as defined by Gerritsen and Greening (1989), Godfrey and Wooten (1979) and van der Valk (1981). *Nymphaea*

Table 6. Life history type of 5 dominant species at Hopkins Prairie based on van der Valk (1981) model of succession in wetlands. (V = vegetatively reproducing perennial; S = long-lived; Type I = drawdown, Type II = inundation).

| Species | Life Span | Propagule Longevity | Propagule Establishment Requirements | Life History Type |
|---|---|---|---|---|
| *Nymphaea odorata* | V | S | Type II | VSII |
| *Eleocharis elongata* | V | S | Type I/II | VSI/II |
| *Eriocaulon compressum* | V | S | Type I/II | VSI/II |
| *Rhynchospora inundata* | V | S | Type I | VSI |
| *Amphicarpum muhlenbergianum* | V | S | Type I | VSI |

(Type VSII) is a vegetatively reproducing perennial (V) with long-lived seeds and vegetative propagules (S) requiring inundation for germination/regeneration (Type II). *Eleocharis* and *Eriocaulon* are types VSII or VSI germinating under both drawdown and inundated conditions. *Rhynchospora* and *Amphicarpum* are VSI species germinating under drawdown conditions only.

van der Valk's (1981) schematic representation of life history types under fluctuating water levels predicts that VSII species (the aquatic species at Hopkins Prairie) are present above ground as adults under flooded conditions; where as, VSI species (the emergent species) are present as adults under drawdown conditions (Figure 18). Solid lines indicate changes within the hydrologic state, dashed lines changes between states. During unfavorable conditions both types retreat to the seed bank or vegetative propagules but never become extinct. Type VSII species retreat under drawdown conditions and VSI under flooded. When conditions become favorable, each type regenerates above ground. Species changes during this study agree with predictions based on this model. Under flooded conditions *Nymphaea, Eleocharis* and *Eriocaulon* (VSII species) were present as adults and propagules. Following drawdown, *Rhynchospora* and *Amphicarpum* came into the site as adults from the seed bank and vegetative propagules present during the flooded period. Type VSII are expected to retreat to propagules during drawdown; *Nymphaea*

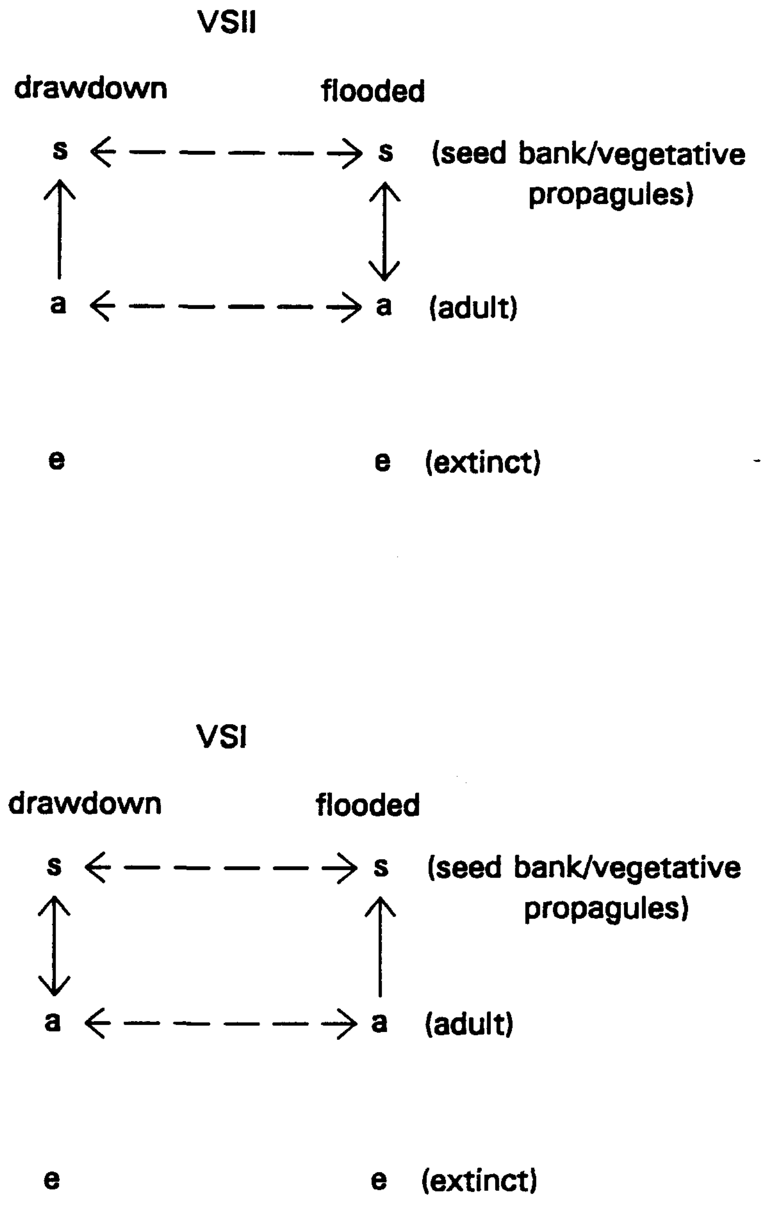


Figure 18. Predicted presence/ absence of wetland plant life history types under fluctuating hydrology (van der Valk 1981). VSI=vegetatively reproducing perennial (V), long-lived seeds (S), germinating during drawdown (I); VSII=germinating when flooded (II).

did disappear for the most part as adults above ground. However, *Eleocharis* and *Eriocaulon* as VSI or VSII species remained as adults under both flooding and drawdown. With reflooding, the predicted change would be reestablishment of VSII species regenerating from persistent propagules and a reduction of VSI species resulting in the postulated cyclic replacement of dominant species.

## Cyclic Succession or Oscillatory Fluctuations

Repeated cycles of flooding and drawdown are a "normal" component of many ecosystems (Gopal 1986). The resulting vegetational changes have been termed "cyclic succession" or "cyclic replacement" in which a disturbance shifts the plant community to an upgrade or downgrade stage of succession (Smith 1974). Succession proceeds from that point until the disturbance recurs. These plant community changes may be "oscillatory fluctuations" which are not successional (Rabotnov 1974). Succession may occur at the same time; however, oscillatory fluctuations occur when well established sets of species repeatedly replace each other as environmental conditions change. A "cyclic or transient climax" may result which is dynamic but stable overall (Ricklefs 1979). Hopkins Prairie has experienced repeated 2 to 3 year cycles of flooded and non-flooded conditions (Figure 2). The shift from the aquatic plant community to the sedge/grass community is presumably cyclic. Succession was clearly operating on the exposed soil following drawdown at the same that species dominance shifted. Reflooding would cycle conditions back to favor the persistent aquatic species. Stresses induced by flooding in addition to competition with established aquatic species may limit invasion by successional species. Both cyclic succession and oscillatory fluctuations seem to be operating at Hopkins Prairie resulting in a dynamic but stable plant community. During the non-flooded cycle, secondary succession and regeneration proceed while flooding favors regeneration of persistent species. Shifts in species dominance above ground are reversible cycling back and forth between flooded and non-flooded conditions. The persistent below ground plant community provides stability under the fluctuating environmental conditions.

## Soil Characterization

The C/N/P (Carbon/nitrogen/phosphorus) ratio of soil organic matter controls decomposer activity in soils (Paul and Clark 1989). Many systems are P limited due to high relative C and N contents. Redfield (1958) suggests that C/N/P ratios of organisms parallels that in the environment. He suggested an optimum ratio of 105:15:1 for non limiting growth in phytoplankton. Ratios above this optimum results in net immobilization and below in net release. Therefore, C/N ratios above 7 and C/P ratios above 105 would result in immobilization and possible limits of N or P. The N/P optimum ratio of 15 would also lead to immobilization/release of P. Hopkins Prairie C/N ratio was slightly higher than the Redfield ratio suggesting that sufficient substrate (C) and N are available for microbial activity with net release occurring during decomposition. The extremely high C/P and N/P ratios however, suggest that P may be limiting in the soil, particularly during the non-flooded period when P was less available.

## Soil Available Nitrogen and Phosphorus

Nitrogen was present only as $NH_4^+$ in May when flood water was present. The absence of $NO_3^-$ indicates that nitrification processes were insignificant under anaerobic flooded conditions. Increased aeration of the soil following drawdown increased nitrification resulting in higher $NO_3^-$ concentration. The increase in $NO_3^-$ did not reduce $NH_4^+$ levels during the beginning of the non-flooded period as mineralization release of $NH_4^+$ and diffusion toward zones of nitrification replaced oxidized $NH_4^+$. The water table drop in October which increased aerobic conditions in the soil profile resulted in higher nitrification as seen by the dramatic increase in $NO_3^-$ and reduction in $NH_4^+$ (mainly KCl extractable). Concurrent research on biogeochemistry adjacent to the study site indicated that nitrification-denitrification processes were active under non-flooded conditions resulting in N loss from the system (Graetz 1991). Available $NH_4^+$+$NO_3^-$ increased slightly through the study with a shift in the dominant species from $NH_4^+$ when flooded to $NO_3^-$ through the non-flooded period. Since many plants are able to utilize both $NH_4^+$ and $NO_3^-$, the shift in relative concentrations would not limit N availability. However, N limitation could occur if plants preferentially uptake $NH_4^+$. The C/N ratio of the soil and the high N/P availability ratio suggest that N is not limiting.

Available P was greatest under flooded conditions and decreased when the water table fell below the soil surface. Slower decomposition under anaerobic conditions (flooded) decreased microbial immobilization of limited P resulting in higher availability due to the low mineral content of the soil. Release of soluble phosphates under anaerobic conditions was not likely important in the peat soil. Increased decomposition with drawdown releases P. However, in a P limited system, biological immobilization would quickly bind the relatively small amount of P mineralized from the high C/P ratio materials. The high N/P ratio of available forms which increased following drawdown, also suggests that demand would exceed supply of P, particularly under non-flooded conditions when mineralization is slowed. Following drawdown, P was reduced and may have become limiting. Nitrogen was high during flooding and seemed not to be limiting during drawdown when $NO_3^-$ became the dominant species.

A filamentous algae community is present in the water column under flooded conditions. Blue-green algae if present could provide additional N input through biological $N_2$ fixation. Interestingly, the algae forms a dry crust on the soil surface following drawdown. Viable spores persist in the crust during non-flooded periods allowing regeneration upon reflooding. Over time sufficient N supplies would build up in the prairie while the limited P input may lead to the high C/P and N/P ratios seen in the soil and plants.

## Plant Tissue Nitrogen and Phosphorus

Nitrogen and P concentrations were slightly greater in above ground tissues than below ground throughout the study. Above ground biomass increased and below ground decreased. The replacement of plant species following drawdown occurred during the spring growing season favoring above ground production. Reduced below ground biomass likely resulted from lower *Nymphaea odorata* growth (an aquatic species with large below ground rhizomes). The large below ground biomass compared to above ground resulted in a much greater storage of N and P in below ground tissues. This may be important in providing nutrients for regeneration of each suite of species under cyclic hydrology. For example, *Nymphaea* remaining in live rhizomes during the non-flooded period contained N and P reserves which could facilitate regenerate upon reflooding. Increased decomposition during drawdown would be expected to produce a flush of inorganic nutrients in the soil upon reflooding further aiding regeneration.

Increased nutrient availability in soil may increase plant uptake and storage (Gerritsen and Greening 1989, Shaver and Melillo 1984, Tilman 1988). Higher biomass, shoot:root ratios and seedling growth may also result from higher nutrient availability (Reddy and Portier 1987)

Phosphorus in plant biomass was highest at the start of the study period when flooding resulted in maximum P concentration in the soil. Since microbial activity was likely controlling P, reduced decomposition under flooded conditions resulted in higher P availability. Availability of P decreased rapidly following drawdown, biomass P also decreased. This suggests that P was limited during the non-flooded period. Upon reflooding, increased availability of P would likely increase plant uptake and storage. Biomass N was highest when $NH_4^+$+$NO_3^-$ were lowest. The increase in N availability did not result in higher biomass N suggesting that N was not limiting.

## CONCLUSIONS

Water level at Hopkins Prairie fluctuates between flooding and drawdown on a 2 to 3 year cycle. During this study water level shifted from flooded to non-flooded conditions. When standing water was present, the above ground plant community was dominated by *Nymphaea odorata*, *Eleocharis elongata* and *Eriocaulon compressum*. One month after drawdown, dominance shifted to *Eriocaulon*, *Rhynchospora inundata* and

*Amphicarpum muhlenbergianum.* After 16 months of drawdown conditions the aquatic plant community had been replaced by a sedge/grass community dominated by *Rhynchospora* and *Amphicarpum.* Establishment of *Rhynchospora* following drawdown was from seeds in a persistent seed bank and vegetative expansion of rhizomes, *Amphicarpum* germinated from seeds. Live rhizomes of *Nymphaea* and *Eleocharis* persisted below ground throughout the non-flooded period. Presumably, reflooding will occur and conditions will shift back to favor the aquatic species. Perenniating below ground rhizomes will allow regeneration of *Nymphaea* and *Eleocharis* when flooding returns. Predictions of changes upon reflooding were supported by van der Valk's (1981) model of succession in wetlands. Gopal (1986) suggests that repeated cycles of flooding and drawdown are a "normal" component of many ecosystems. Cyclic replacement of two distinct suites of species is common in systems with repeated shifts in hydrology. Rhizomes and a persistent seed bank provide a reservoir for regeneration of each set of species resulting in a dynamic above ground plant community but a more stable below ground community. Hydrology induces reversible shifts in species dominance which are repeated with each recurring cycle in hydrology.

The shift from flooded to non-flooded conditions resulted in lower $NH_4^+$ and higher $NO_3^-$ in the soil due to increased nitrification under aerobic conditions. Nitrogen seemed not to be limited under flooded or non-flooded conditions though the dominant N form shifted to $NO_3^-$ following drawdown. Phosphorus availability was reduced following drawdown primarily due to increased microbial uptake under aerobic conditions. Phosphorus seemed to be limiting during the non-flooded period as available P was depleted.

Storage of N and P in perreniating below ground plant biomass provides a reservoir of nutrients. Persistent rhizomes of aquatic species dormant below ground during the non-flooded period can utilize this reservoir to regenerate when reflooding occurs. Reflooding would reduce nitrification increasing $NH_4^+$. Available P would increase as anaerobic conditions reduced decomposition, decreasing P immobilization. This flush of nutrients with reflooding would also aid regeneration of aquatic species.

## APPENDIX A
## FIELD AND LABORATORY SAMPLING PROTOCOL

### Sampling Design

A 10 m by 18 m study plot was established within a plant community typical of the lower elevation areas in Hopkins Prairie. The plot was divided into six subplots 10 m by 3 m. Each subplot was further divided into 30 sampling sites 1 $m^2$. Sampling was conducted monthly. Measurements were collected in replicates of six by sampling one randomly chosen 1 $m^2$ site within each subplot. Water level measurements were recorded. Above ground biomass and below ground biomass samples to -10 cm (0-10 cm) depth were collected within a 25 cm by 25 cm sampling frame. Below ground biomass samples to -30 cm (10-20 and 20-30 cm) were collected using a 10.16 cm diameter PVC core. Soil samples to -30 cm (0-10, 10-20 and 20-30) were collected using a 6.35 cm acrylic core. Nitrogen (N) and Phosphorus (P) analyses were conducted using standard methods (APHA 1989, ASA 1982 and EPA 1979). Biomass (separated by species) and soil were separated into the following categories:

| Biomass | Soil |
|---|---|
| Above ground-live | |
| Above ground-dead | |
| Below ground 0-10 cm | 0-10 cm |
| Below ground 10-20 cm | 10-20 cm |
| Below ground 20-30 cm | 20-30 cm |

### Water Level Measurements

#### Flooded Conditions

a. Record distance from soil surface to water surface (cm) at each subplot sample site.

### Drained conditions

a. Record distance from soil surface to water table (cm) within hole created by soil core (see below) at each subplot sample site. Allow at least 15 minutes equilibration time following soil core removal).

## Above and Below ground Biomass

### Field Methods

### Above ground and below ground 0 - 10 cm biomass

a. At each sample site, place 25 cm by 25 cm metal sample frame (Center for Wetlands -CFW- macroinvertebrate sampler) 10 cm deep into soil in center of 1 $m^2$. Bars on outside of sample frame denote 10 cm.
b. If standing water is present, record water depth as described above then remove water from inside sampling frame with hand pump.
c. Record percent cover as described below.
d. With a machete, cut vertically into soil (at least 10 cm deep) along inside four sides of sample frame.
e. If no standing water is present, sample frame can be removed at this point.
f. Excavate by hand all above and below ground material within the sample frame to a depth of 10 cm, avoid disturbing soil surface.
g. Place sample on flat surface for removal of above ground plant biomass.
h. Use scissors to collect live and dead shoot materials.
i. Remove any soil material from shoot samples to avoid contamination with soil N and P.
j. Place samples in labeled #1 brown paper bags separated by species and live and dead tissues.
k. Collect dried periphyton layer (drained conditions) in labeled #1 paper bag.
l. Place remainder of sample in labeled plastic bag for transport to Lab. After processing this sample will represent below ground 0 - 10 cm biomass.

### Below ground 10 - 20 and 20 - 30 cm biomass

a. Insert labeled 10.16 cm diameter PVC core into soil to a depth of 20 cm within the hole created by the 0-10 cm sample. The bevelled edge facilitates insertion and provides a means of identification of sample top and bottom.
b. Place core in plastic bag for transport to Lab. This sample is split during processing and will represent below ground 10 - 20 and 20 - 30 cm biomass.
c. Insert flag into soil at sample site to prevent resampling at later date.

## Laboratory Methods

### Above ground biomass

a. Oven dry bagged samples (live and dead shoots and periphyton) at 60° C for 72 hrs.
b. Remove samples from oven, allow to cool 2-3 min then record dry weight to nearest 0.001 g (dry weights will be used for biomass calculations).
c. Save samples for N and P analysis (see below).

### Below ground biomass

a. Sieve 0-10 cm sample through U.S. Standard no. 14 sieve collecting all roots greater than 0.5 cm diameter.
b. Place collected roots in labeled paper bags separated by species.
c. Homogenize sieved sample by mixing and breaking apart clumps of biomass.
d. Quarter homogenized sample using CFW macroinvertebrate sample splitter.
e. Divide one quarter in half by weight.
f. Retain one half (one eighth of total sample) for root biomass measurement, store remainder of sample in refrigerator.
g. Place one eighth sample in tray of water for picking.
h. Use forceps to remove all roots until a mixture of fine roots and organic soil remains (Be consistent with effort spent on each sample).
i. Place roots in labeled paper bags separated by species and including a general category for unidentifiable roots.
j. Oven dry and weigh all bagged samples as described above (a - c)

## Percent Cover

### Field Methods

a. Visually estimate percent cover of each species (live shoots) within the sample frame.
b. Categories include 0, <1, 1, 3, 5 and intervals of 5 to 100%.

## Plant Tissue Nitrogen and Phosphorus

### Laboratory methods

a. Grind all plant tissue samples (above and below ground) in Whiley mill combining all species in each category, ie., above ground live, above ground dead, etc.
b. Place 0.100 g of ground plant material into labeled digestion tubes.
c. Add 0.5 g Sel-dahl digestion powder (copper sulfate, potassium sulfate mixture) and 5 ml concentrated sulfuric acid ($H_2SO_4$).
d. Place tubes on block digester with glass funnels on each tube.
e. Digest samples at 380° C for 5 - 7 hrs.
f. Allow samples to cool before removing from block.
g. Add deionized water to tubes to 50 ml total volume.
h. Vortex completely and pour aliquot into labeled 20 ml scintillation vial, retain excess samples to be handled according to hazardous waste procedures (corrosive containing Cu and Se).
i. Determine total kjeldahl nitrogen (TKN) and total phosphorus (TP) content on Technicon Autoanalyzer II using methods EPA 351.2 (EPA 1979) and APHA 4500-P-F (APHA 1989), respectively.
j. Report N and P content per dry weight of plant biomass (mg/Kg)

# Soil Nitrogen and Phosphorus

## Sequential extraction with water and potassium chloride.

### Field methods

a. Expose soil surface by removing above ground material (live and dead shoots and periphyton) from approximately 10 $cm^2$ area directly adjacent to sampling frame.
b. Insert 6.35 cm diameter (2.5 in) acrylic core 30 - 35 cm deep into soil using a wooden 2 by 4 as a hammer. If soil compaction occurs, remove core from ground and repeat in other location.
c. While core is in ground, place no. 13.5 rubber stopper into top to provide suction with core removal.
d. To assist retention of soil in core, tilt core to approximately 45° angle and remove from ground.
e. Place no. 12 stopper inside core at bottom to serve as plunger for sample extrusion.
f. Place push rod (1.5 in PVC) with attached meter stick on no. 12 stopper and push soil upward inside core until original soil surface is even with top of soil core.
g. Note measurement on meter stick then extrude 10 cm of soil into labeled zip lock plastic bag.
h. This sample represents 0 - 10 cm.
i. Repeat step g above to collect 10 - 20 and 20 - 30 cm samples.
j. Remove air from bags, seal and place on ice for transport to Lab (minimize time from sample collection to placing on ice, do not set in direct sunlight for extended period).

### Laboratory methods

a. Perform sequential extraction within 7 days of sample collection (preferably the following day).
b. Record total wet weight of sample to nearest 0.1 g (adjusted for weight of plastic bag) for bulk density calculations.
c. Homogenize sample by thoroughly mixing in bag.
d. Place 3.00 g of fresh sample in labeled 40 ml centrifuge tube.
e. Place additional portion of fresh sample in aluminum tray for moisture content determination by recording initial wet weight and oven dried weight after drying 72 hrs at 70°.

f. Retain oven dried sample in labelled brown bag for future reference.
g. Add 12.0 ml of deionized water (water extractant) to centrifuge tube.
h. Shake on mechanical shaker for 1 hr.
i. Centrifuge at 6000 rpm for 18 min.
j. Filter through 0.47 um membrane filter paper (Gelman #60173) into labeled 20 ml scintillation vial. Retain culture tube with soil sample for sequential KCl extraction.
k. Acidify with 1 drop of purified concentrated $H_2SO_4$.
l. Store in refrigerator for analysis.
m. Add 20.0 ml of 1.0 N KCl extract solution.
n. Repeat steps h-l.
o. Determine ammonium nitrogen ($NH_4$-N), nitrate plus nitrite nitrogen ($NO_3$-N) and soluble reactive phosphorus (SRP) content in samples on Technicon Autoanalyzer II using methods EPA 351.2 (undigested) ($NH_4$-N), APHA 4500-$NO_3^-$-F ($NO_3$-N) and APHA 4500-P-F (SRP).
p. Report N and P content per unit volume of soil (bulk density basis).

## Water Column Nitrogen and Phosphorus

### Field Methods

a. Collect one 125 ml sample from within each subplot in an area of undisturbed soil surface and water column.
b. Place thumb over opening to sample bottle and insert to approximately mid-water column.
c. Remove thumb, allow sample bottle to fill.
d. Cap bottle and place on ice for transport to Lab. (minimize time from sample collection to placing on ice, do not set in direct sunlight for extended period).

### Laboratory Methods

a. Filter portion of original sample into labelled 20 scintillation vial through 0.45 um membrane filter paper (Gelman #60173) for analysis of inorganic forms of N and P.
b. Acidify with 1 drop of purified concentrated $H_2SO_4$, store in refrigerator for analysis.

c. Analyze for $NH_4$-N, $NO_3$-N and SRP as described in Soil N and P laboratory methods-o, above.
d. Digest 10 ml portion of original sample as described below for analysis of organic forms of N and P.
e. Pipet 10 ml of sample into labelled digestion test tube.
f. Add 5 ml of total Kjeldahl digestion reagent (EPA method 351.2) and 2-3 boiling chips.
g. Place tubes on block digester, set temperature at 150° C for 2-3 hrs (until volume is reduced to 5 ml or less).
h. Place glass funnels of tubes and digest 2-3 hrs at 375° C.
i. Allow samples to cool before removing from block.
j. Add deionized water to tubes to 25 ml total volume.
k. Vortex completely and place in labeled scintillation vial, retain excess samples to be handled according to hazardous waste procedures (corrosive containing Hg).
l. Determine N and P content of samples as described in Plant tissue nitrogen and phosphorus laboratory methods-i, above.
m. Report N and P content per volume of water (mg/L)

# APPENDIX B
# MONTHLY WATER LEVEL

| | | Subplot # | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Month | 1 | 2 | 3 | 4 | 5 | 6 | Mean | S.D. |
| | | - - - - - Water depth (cm) - - - - - | | | | | | | |
| 1990 | MAR | 26.5 | 27.0 | 26.0 | | 9.5 | 13.0 | 20.40 | 8.45 |
| | APR | 17.0 | 15.5 | 14.0 | 9.8 | 14.8 | 14.8 | 14.32 | 2.43 |
| | MAY | 5.0 | 7.0 | 4.5 | 9.6 | 6.5 | 0.0 | 5.43 | 3.21 |
| | JUN | -9.0 | -10.0 | -11.5 | -13.5 | -15.5 | -14.0 | -12.25 | 2.50 |
| | JUL | -5.5 | -9.0 | -8.0 | -7.0 | -9.0 | -8.5 | -7.83 | 1.37 |
| | AUG | -22.0 | -13.5 | -16.0 | -14.0 | -16.5 | -15.0 | -16.17 | 3.08 |
| | SEP | -14.5 | -15.5 | -18.8 | -17.5 | -18.5 | -20.5 | -17.55 | 2.22 |
| | OCT | -10.0 | -12.0 | -10.0 | -11.0 | -12.5 | -15.0 | -11.75 | 1.89 |
| | NOV | -31.0 | -34.0 | -30.0 | -31.0 | -30.0 | -36.0 | -32.00 | 2.45 |
| | DEC | -35.5 | -39.0 | -35.5 | -40.0 | -40.0 | -44.0 | -39.00 | 3.21 |
| 1991 | JAN | -43.0 | -41.0 | -44.0 | -41.0 | -48.0 | -47.0 | -44.00 | 2.97 |
| | FEB | -47.0 | -47.5 | -47.0 | -46.0 | -43.0 | -50.0 | -46.75 | 2.27 |
| | MAR | 19.6 | -20.0 | -20.5 | -21.1 | -27.3 | -20.9 | -15.03 | 17.18 |
| | A/M | -38.5 | -41.0 | -39.0 | -39.0 | -39.0 | -41.0 | -39.58 | 1.11 |
| | JUN | -13.5 | -11.0 | -14.5 | -15.5 | -13.0 | | -13.50 | 1.70 |
| | JUL | -21.5 | -23.5 | -23.5 | -27.0 | -24.0 | -29.0 | -24.75 | 2.73 |
| | AUG | -17.0 | -18.0 | -17.5 | -17.0 | -21.0 | -22.5 | -18.83 | 2.34 |
| | SEP | -32.0 | -31.0 | -30.0 | -37.0 | -34.0 | -34.0 | -33.00 | 2.53 |
| | OCT | -14.0 | -18.0 | -17.0 | -17.5 | -18.0 | -20.0 | -17.42 | 1.96 |
| | NOV | -33.0 | -32.0 | -37.0 | -35.0 | -37.0 | -46.5 | -36.75 | 5.19 |
| | DEC | -42.0 | -42.8 | -44.7 | -45.1 | -43.5 | -50.5 | -44.77 | 3.04 |

# APPENDIX C
# PLANT SPECIES PERCENT COVER

| Species | Year | Mo. | Subplot no.<br>1 | 2 | 3 | 4 | 5 | 6 | Mean | S.D. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | - - - - Percent cover (%) - - - - - - | | | | | | | |
| Nymphaea odorata | 1990 | M | 0 | 0 | 2 | | 0 | 0 | 0.40 | 0.89 |
| | | A | 0 | 0 | 5 | 15 | 5 | 20 | 7.50 | 8.22 |
| | | M | 15 | 0 | 0 | 0 | 0 | 15 | 5.00 | 7.75 |
| | | J | 2 | 0 | 10 | 0 | 0 | 0 | 2.00 | 4.00 |
| | | J- | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | A | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | S | 0 | 0 | 5 | 0 | 0 | 0 | 0.83 | 2.04 |
| | | O | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | N | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | 1991 | J | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 | 0.04 |
| | | F | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | M | 1 | 0 | 0 | 0 | 0 | 0 | 0.17 | 0.41 |
| | | A/M | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | J | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | J | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | A | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | S | 1 | 0 | 0 | 0 | 0 | 0 | 0.17 | 0.41 |
| | | O | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | N | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| Eleocharis elongata | 1990 | M | 10 | 15 | 25 | | 0 | 10 | 12.00 | 9.08 |
| | | A | 15 | 20 | 0 | 20 | 35 | 40 | 21.67 | 14.38 |
| | | M | 5 | 5 | 5 | 2 | 5 | 5 | 4.50 | 1.22 |
| | | J | 0 | 1 | 1 | 0 | 0 | 0 | 0.33 | 0.52 |
| | | J | 5 | 5 | 5 | 1 | 15 | 0 | 5.17 | 5.31 |
| | | A | 0 | 3 | 0 | 5 | 0 | 1 | 1.50 | 2.07 |
| | | S | 0 | 3 | 3 | 0 | 0 | 0 | 1.00 | 1.55 |
| | | O | 2 | 10 | 0 | 2 | 2 | 0 | 2.67 | 3.72 |
| | | N | 0 | 0 | 2 | 2 | 5 | 0 | 1.50 | 1.97 |
| | | D | 2 | 2 | 5 | 10 | 2 | 1 | 3.67 | 3.39 |
| | 1991 | J | 1 | 0 | 0 | 0 | 0 | 0 | 0.20 | 0.39 |
| | | F | 0 | 1 | 0 | 0 | 1 | 0 | 0.35 | 0.50 |
| | | M | 0 | 0 | 0 | 0 | 0 | 0 | 0.03 | 0.05 |
| | | A/M | 0 | 1 | 0 | 0 | 1 | 0 | 0.35 | 0.50 |
| | | J | 1 | 1 | 1 | 0 | 1 | 0 | 0.67 | 0.52 |
| | | J | 1 | 0 | 5 | 0 | 0 | 0 | 1.00 | 2.00 |
| | | A | 5 | 1 | 0 | 0 | 0 | 0 | 1.00 | 2.00 |
| | | S | 0 | 0 | 3 | 0 | 1 | 1 | 0.83 | 1.17 |
| | | O | 1 | 3 | 0 | 1 | 0 | 1 | 1.00 | 1.10 |
| | | N | 1 | 1 | 0 | 0 | 0 | 0 | 0.35 | 0.50 |
| | | D | 0 | 0 | 0 | 0 | 1 | 0 | 0.17 | 0.41 |
| Eriocaulon compressum | 1990 | M | 0 | 0 | 0 | | 50 | 20 | 14.00 | 21.91 |
| | | A | 40 | 10 | 25 | 30 | 5 | 1 | 18.50 | 15.48 |
| | | M | 15 | 0 | 0 | 15 | 5 | 20 | 9.17 | 8.61 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | J | 0 | 1 | 0 | 0 | 0 | 1 | 0.33 | 0.52 |
| | | J | 10 | 5 | 0 | 10 | 0 | 0 | 4.17 | 4.92 |
| | | A | 1 | 40 | 20 | 30 | 20 | 4 | 19.17 | 14.92 |
| | | S | 20 | 5 | 0 | 20 | 0 | 0 | 7.50 | 9.87 |
| | | O | 2 | 30 | 0 | 10 | 25 | 30 | 16.17 | 13.86 |
| | | N | 80 | 40 | 50 | 1 | 15 | 20 | 34.33 | 28.47 |
| | | D | 2 | 20 | 2 | 1 | 40 | 25 | 15.00 | 16.02 |
| | 1991 | J | 0 | 3 | 1 | 3 | 15 | 15 | 6.17 | 6.94 |
| | | F | 3 | 3 | 3 | 0 | 1 | 3 | 2.17 | 1.33 |
| | | M | 0 | 5 | 25 | 1 | 5 | 25 | 10.17 | 11.67 |
| | | A/M | 0 | 20 | 0 | 0 | 25 | 40 | 14.18 | 16.84 |
| | | J | 5 | 1 | 15 | 1 | 10 | 1 | 5.50 | 5.86 |
| | | J | 10 | 1 | 2 | 0 | 50 | 5 | 11.33 | 19.28 |
| | | A | 0 | 0 | 3 | 0 | 30 | 0 | 5.50 | 12.06 |
| | | S | 3 | 0 | 0 | 0 | 0 | 1 | 0.68 | 1.20 |
| | | O | 20 | 1 | 0 | 3 | 0 | 3 | 4.50 | 7.71 |
| | | N | 3 | 0 | 0 | 0 | 1 | 40 | 7.33 | 16.05 |
| | | D | 0 | 1 | 0 | 1 | 1 | 3 | 1.00 | 1.10 |
| Rhynchospora inundata | 1990 | M | 0 | 0 | 0 | | 0 | 0 | 0.00 | 0.00 |
| | | A | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | M | 0 | 0 | 0 | 0 | 0 | 2 | 0.33 | 0.82 |
| | | J | 0 | 15 | 5 | 20 | 30 | 5 | 12.50 | 11.29 |
| | | J | 5 | 15 | 15 | 10 | 10 | 20 | 12.50 | 5.24 |
| | | A | 25 | 25 | 2 | 5 | 10 | 20 | 14.50 | 10.17 |
| | | S | 10 | 25 | 15 | 20 | 7 | 5 | 13.67 | 7.79 |
| | | O | 3 | 2 | 20 | 5 | 5 | 3 | 6.33 | 6.80 |
| | | N | 0 | 5 | 10 | 5 | 1 | 10 | 5.17 | 4.26 |
| | | D | 1 | 1 | 1 | 1 | 1 | 1 | 1.00 | 0.00 |
| | 1991 | J | 1 | 0 | 0 | 0 | 0 | 0 | 0.22 | 0.39 |
| | | F | 0 | 1 | 0 | 0 | 0 | 0 | 0.20 | 0.39 |
| | | M | 3 | 0 | 3 | 0 | 1 | 1 | 1.35 | 1.35 |
| | | A/M | 3 | 5 | 5 | 0 | 1 | 0 | 2.33 | 2.34 |
| | | J | 3 | 5 | 10 | 0 | 2 | 1 | 3.50 | 3.62 |
| | | J | 40 | 2 | 50 | 1 | 1 | 0 | 15.68 | 22.94 |
| | | A | 50 | 1 | 5 | 1 | 10 | 0 | 11.18 | 19.37 |
| | | S | 15 | 10 | 0 | 0 | 1 | 5 | 5.17 | 6.18 |
| | | O | 20 | 5 | 5 | 0 | 5 | 0 | 5.83 | 7.36 |
| | | N | 0 | 10 | 0 | 1 | 1 | 0 | 2.00 | 3.95 |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0.03 | 0.05 |
| Amphicarpum muhlenbergianum | 1990 | M | 0 | 0 | 0 | | 0 | 0 | 0.00 | 0.00 |
| | | A | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | M | 0 | 0 | 0 | 0 | 0 | 1 | 0.17 | 0.41 |
| | | J | 0 | 0 | 0 | 0 | 1 | 0 | 0.17 | 0.41 |
| | | J | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | A | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | S | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 |
| | | O | 0 | 0 | 0 | 0 | 0 | 30 | 5.00 | 12.25 |
| | | N | 0 | 0 | 0 | 0 | 0 | 20 | 3.33 | 8.16 |
| | | D | 0 | 2 | 0 | 0 | 0 | 0 | 0.33 | 0.82 |
| | 1991 | J | 0 | 0 | 0 | 0 | 5 | 0 | 0.83 | 2.04 |
| | | F | 0 | 0 | 1 | 0 | 0 | 10 | 1.83 | 4.02 |
| | | M | 0 | 0 | 0 | 0 | 5 | 3 | 1.33 | 2.16 |
| | | A/M | 0 | 1 | 0 | 0 | 1 | 1 | 0.50 | 0.55 |
| | | J | 0 | 0 | 0 | 0 | 0 | 10 | 1.67 | 4.08 |
| | | J | 0 | 0 | 0 | 5 | 40 | 60 | 17.50 | 26.03 |
| | | A | 0 | 10 | 15 | 10 | 50 | 5 | 15.00 | 17.89 |
| | | S | 0 | 0 | 3 | 5 | 1 | 5 | 2.33 | 2.34 |
| | | O | 0 | 10 | 5 | 10 | 5 | 5 | 5.83 | 3.76 |
| | | N | 5 | 3 | 25 | 10 | 5 | 15 | 10.50 | 8.34 |
| | | D | 0 | 3 | 15 | 3 | 5 | 3 | 4.83 | 5.23 |

# APPENDIX D
# ABOVE GROUND BIOMASS AND RELATIVE DOMINANCE

| | Biomass g DWT/m2 | | | | | | | | Relative Dominance |
|---|---|---|---|---|---|---|---|---|---|
| Date | 1 | 2 | 3 | 4 | 5 | 6 | Mean | S.D. | (% total) |
| Nymphaea odorata | | | | | | | | | |
| Mar-90 | 0.00 | 0.00 | 5.20 | | 0.00 | 0.00 | 1.04 | 2.33 | 12.08 |
| Apr-90 | 0.00 | 0.00 | 0.91 | 6.34 | 0.00 | 14.46 | 3.62 | 5.86 | 28.33 |
| May-90 | 20.61 | 0.05 | 0.00 | 0.00 | 0.00 | 23.76 | 7.40 | 11.49 | 44.41 |
| Jun-90 | 16.64 | 0.00 | 10.10 | 0.00 | 0.00 | 0.00 | 4.46 | 7.21 | 31.76 |
| Jul-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-90 | 0.00 | 0.00 | 10.99 | 0.00 | 0.00 | 0.00 | 1.83 | 4.49 | 10.45 |
| Oct-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nov-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jan-91 | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.20 | 0.32 |
| Feb-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mar-91 | 0.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.26 | 0.32 |
| Apr-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jun-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jul-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nov-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Eleocharis elongata | | | | | | | | | |
| Mar-90 | 4.13 | 0.00 | 6.40 | | 0.00 | 2.43 | 2.59 | 2.75 | 30.11 |
| Apr-90 | 0.90 | 1.04 | 0.98 | 0.00 | 0.00 | 0.00 | 0.49 | 0.53 | 3.80 |
| May-90 | 0.67 | 1.58 | 7.07 | 0.00 | 1.10 | 8.56 | 3.17 | 3.67 | 18.99 |
| Jun-90 | 0.00 | 1.89 | 0.91 | 0.00 | 0.00 | 0.00 | 0.47 | 0.79 | 3.33 |
| Jul-90 | 4.51 | 2.88 | 3.01 | 0.46 | 7.14 | 0.00 | 3.00 | 2.64 | 29.16 |
| Aug-90 | 0.22 | 3.62 | 0.00 | 3.60 | 0.83 | 0.64 | 1.49 | 1.67 | 5.55 |
| Sep-90 | 0.00 | 1.84 | 1.22 | 0.00 | 0.00 | 0.00 | 0.51 | 0.81 | 2.90 |
| Oct-90 | 1.10 | 1.25 | 0.00 | 1.07 | 0.40 | 0.00 | 0.64 | 0.57 | 1.69 |
| Nov-90 | 0.00 | 1.49 | 0.83 | 0.80 | 0.31 | 0.00 | 0.57 | 0.58 | 0.98 |
| Dec-90 | 0.34 | 0.53 | 0.24 | 1.34 | 0.69 | 0.10 | 0.54 | 0.45 | 2.56 |
| Jan-91 | 0.58 | 1.02 | 0.98 | 0.00 | 0.00 | 0.00 | 0.43 | 0.50 | 1.68 |
| Feb-91 | 0.00 | 0.26 | 0.00 | 0.06 | 0.38 | 0.00 | 0.12 | 0.16 | 1.22 |
| Mar-91 | 0.00 | 0.30 | 0.00 | 0.00 | 0.00 | 0.02 | 0.05 | 0.12 | 0.16 |
| Apr-91 | 0.00 | 1.54 | 0.24 | 0.00 | 0.48 | 0.34 | 0.43 | 0.57 | 1.16 |
| Jun-91 | 0.69 | 0.69 | 1.31 | 0.00 | 0.08 | 0.30 | 0.51 | 0.49 | 1.95 |
| Jul-91 | 1.42 | 0.00 | 11.70 | 0.00 | 0.00 | 0.00 | 2.19 | 4.69 | 3.66 |
| Aug-91 | 1.50 | 1.15 | 0.00 | 0.00 | 0.00 | 0.22 | 0.48 | 0.67 | 1.98 |
| Sep-91 | 0.00 | 0.00 | 1.47 | 0.00 | 1.78 | 0.61 | 0.64 | 0.80 | 6.48 |
| Oct-91 | 0.64 | 3.60 | 0.00 | 0.40 | 0.00 | 0.00 | 0.77 | 1.41 | 2.72 |
| Nov-91 | 1.44 | 1.92 | 0.48 | 0.00 | 0.08 | 0.00 | 0.65 | 0.83 | 1.41 |
| Dec-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.64 | 0.00 | 0.11 | 0.26 | 1.32 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Eriocaulon compressum | | | | | | | | | |
| Mar-90 | 0.00 | 0.00 | 0.00 | | 11.92 | 12.96 | 4.98 | 6.82 | 57.81 |
| Apr-90 | 20.77 | 5.09 | 8.02 | 15.39 | 2.27 | 0.48 | 8.67 | 7.91 | 67.87 |
| May-90 | 6.72 | 0.00 | 0.00 | 5.74 | 3.78 | 11.09 | 4.55 | 4.26 | 27.32 |
| Jun-90 | 0.00 | 0.56 | 0.00 | 0.00 | 0.00 | 1.17 | 0.29 | 0.49 | 2.05 |
| Jul-90 | 1.31 | 1.46 | 0.00 | 3.84 | 0.00 | 0.00 | 1.10 | 1.50 | 10.70 |
| Aug-90 | 0.98 | 34.88 | 14.40 | 24.61 | 17.25 | 0.53 | 15.44 | 13.40 | 57.66 |
| Sep-90 | 20.85 | 7.46 | 0.00 | 13.38 | 0.00 | 0.00 | 6.95 | 8.71 | 39.62 |
| Oct-90 | 0.14 | 33.17 | 0.00 | 15.89 | 23.28 | 44.66 | 19.52 | 17.90 | 51.87 |
| Nov-90 | 130.96 | 29.17 | 70.62 | 0.00 | 5.38 | 29.92 | 44.34 | 49.23 | 75.87 |
| Dec-90 | 0.26 | 29.71 | 0.91 | 0.00 | 21.94 | 33.58 | 14.40 | 15.80 | 68.49 |
| Jan-91 | 0.00 | 36.53 | 2.96 | 3.54 | 31.49 | 66.64 | 23.53 | 26.33 | 92.05 |
| Feb-91 | 6.21 | 4.78 | 5.66 | 0.00 | 0.08 | 19.98 | 6.12 | 7.32 | 63.80 |
| Mar-91 | 0.00 | 46.13 | 52.06 | 0.18 | 22.32 | 53.01 | 28.95 | 24.97 | 85.91 |
| Apr-91 | 0.62 | 63.70 | 0.18 | 0.00 | 85.87 | 37.82 | 31.37 | 37.31 | 84.07 |
| Jun-91 | 15.49 | 0.00 | 52.10 | 0.88 | 27.89 | 0.00 | 16.06 | 20.91 | 61.22 |
| Jul-91 | 12.86 | 1.65 | 8.37 | 0.00 | 7.01 | 5.44 | 5.89 | 4.67 | 9.85 |
| Aug-91 | 0.00 | 0.00 | 1.76 | 0.00 | 2.21 | 0.00 | 0.66 | 1.03 | 2.73 |
| Sep-91 | 5.23 | 2.88 | 0.27 | 0.00 | 0.00 | 0.00 | 1.40 | 2.19 | 14.09 |
| Oct-91 | 52.32 | 0.59 | 0.00 | 2.34 | 0.00 | 0.00 | 9.21 | 21.14 | 32.37 |
| Nov-91 | 1.92 | 0.00 | 0.00 | 0.00 | 0.64 | 22.40 | 4.16 | 8.97 | 8.98 |
| Dec-91 | 0.00 | 8.64 | 0.00 | 0.48 | 1.28 | 3.84 | 2.37 | 3.39 | 29.37 |
| Rhynchospora inundata | | | | | | | | | |
| Mar-90 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| May-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.81 | 1.30 | 3.19 | 7.81 |
| Jun-90 | 2.27 | 3.50 | 2.05 | 7.81 | 25.66 | 10.21 | 8.58 | 8.98 | 61.17 |
| Jul-90 | 2.34 | 9.17 | 7.78 | 5.33 | 5.74 | 6.77 | 6.19 | 2.35 | 60.14 |
| Aug-90 | 8.22 | 23.12 | 1.20 | 9.68 | 10.08 | 6.80 | 9.85 | 7.25 | 36.79 |
| Sep-90 | 6.94 | 17.87 | 11.42 | 7.23 | 2.03 | 0.86 | 7.73 | 6.28 | 44.08 |
| Oct-90 | 1.50 | 9.18 | 6.45 | 1.87 | 5.14 | 1.49 | 4.27 | 3.19 | 11.35 |
| Nov-90 | 4.96 | 6.96 | 7.47 | 0.24 | 2.51 | 4.21 | 4.39 | 2.73 | 7.51 |
| Dec-90 | 2.30 | 4.48 | 10.00 | 4.48 | 1.68 | 4.43 | 4.56 | 2.93 | 21.70 |
| Jan-91 | 0.82 | 0.43 | 0.00 | 0.21 | 0.00 | 0.00 | 0.24 | 0.33 | 0.95 |
| Feb-91 | 0.00 | 0.38 | 0.02 | 0.00 | 0.10 | 0.00 | 0.08 | 0.15 | 0.86 |
| Mar-91 | 3.60 | 0.30 | 0.96 | 0.00 | 1.02 | 0.40 | 1.05 | 1.31 | 3.11 |
| Apr-91 | 2.82 | 7.78 | 2.50 | 0.00 | 2.46 | 0.00 | 2.59 | 2.84 | 6.95 |
| Jun-91 | 6.26 | 3.22 | 16.11 | 0.00 | 0.00 | 0.66 | 4.37 | 6.24 | 16.67 |
| Jul-91 | 28.82 | 3.15 | 71.97 | 1.12 | 1.10 | 0.00 | 17.69 | 28.79 | 29.59 |
| Aug-91 | 33.66 | 0.54 | 4.93 | 0.05 | 10.96 | 0.03 | 8.36 | 13.10 | 34.50 |
| Sep-91 | 13.92 | 9.49 | 0.00 | 0.00 | 0.00 | 3.57 | 4.50 | 5.92 | 45.35 |
| Oct-91 | 21.98 | 7.09 | 4.80 | 0.00 | 5.36 | 0.00 | 6.54 | 8.11 | 22.99 |
| Nov-91 | 0.00 | 9.12 | 0.96 | 0.00 | 0.74 | 0.00 | 1.80 | 3.61 | 3.89 |
| Dec-91 | 0.00 | 0.00 | 0.00 | 0.32 | 0.16 | 0.00 | 0.08 | 0.13 | 0.99 |
| Amphicarpum muhlenbergianum | | | | | | | | | |
| Mar-90 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| May-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.47 | 0.25 | 0.60 | 1.47 |
| Jun-90 | 0.00 | 0.00 | 0.00 | 0.00 | 1.42 | 0.00 | 0.24 | 0.58 | 1.69 |
| Jul-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 75.09 | 12.51 | 30.65 | 33.25 |
| Nov-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 47.98 | 8.00 | 19.59 | 13.68 |
| Dec-90 | 0.00 | 0.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.26 | 0.51 |
| Jan-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.80 | 1.13 | 2.78 | 4.43 |
| Feb-91 | 0.00 | 0.00 | 0.37 | 0.00 | 0.00 | 8.46 | 1.47 | 3.43 | 15.35 |
| Mar-91 | 0.00 | 0.00 | 0.00 | 0.00 | 6.51 | 0.77 | 1.21 | 2.61 | 3.60 |
| Apr-91 | 0.00 | 0.70 | 0.00 | 0.00 | 1.20 | 1.60 | 0.58 | 0.70 | 1.57 |
| Jun-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.99 | 2.50 | 6.12 | 9.53 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Jul-91 | 0.00 | 0.00 | 0.00 | 4.53 | 32.56 | 70.06 | 17.86 | 28.55 | 29.86 |
| Aug-91 | 0.00 | 8.11 | 12.86 | 2.70 | 54.08 | 3.49 | 13.54 | 20.37 | 55.86 |
| Sep-91 | 0.00 | 0.00 | 2.32 | 9.98 | 2.35 | 4.74 | 3.23 | 3.75 | 32.60 |
| Oct-91 | 0.00 | 16.10 | 8.37 | 17.60 | 2.38 | 18.00 | 10.41 | 7.98 | 36.59 |
| Nov-91 | 5.12 | 3.20 | 43.84 | 32.00 | 13.28 | 128.00 | 37.57 | 47.06 | 81.11 |
| Dec-91 | 0.00 | 7.52 | 10.40 | 5.60 | 1.92 | 6.72 | 5.36 | 3.81 | 66.34 |

Rhynchospora tracyi

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mar-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| May-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jun-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jul-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-90 | 0.00 | 0.00 | 0.00 | 2.70 | 0.00 | 0.00 | 0.45 | 1.10 | 2.57 |
| Oct-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nov-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jan-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Feb-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mar-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.34 | 0.56 | 1.37 | 1.65 |
| Apr-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.52 | 1.25 | 3.07 | 3.36 |
| Jun-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.85 | 0.00 | 0.14 | 0.35 | 0.54 |
| Jul-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nov-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Xyris spp.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mar-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| May-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jun-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jul-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 | 0.07 | 0.16 | 0.38 |
| Oct-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.61 | 0.00 | 0.10 | 0.25 | 0.27 |
| Nov-90 | 4.27 | 0.30 | 0.00 | 0.00 | 0.00 | 2.03 | 1.10 | 1.74 | 1.88 |
| Dec-90 | 0.00 | 3.73 | 0.00 | 0.00 | 0.67 | 1.47 | 0.98 | 1.47 | 4.65 |
| Jan-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.62 | 0.10 | 0.25 | 0.41 |
| Feb-91 | 0.00 | 0.00 | 0.00 | 2.67 | 0.00 | 8.02 | 1.78 | 3.24 | 18.57 |
| Mar-91 | 0.00 | 0.08 | 0.00 | 0.00 | 10.32 | 0.05 | 1.74 | 4.20 | 5.17 |
| Apr-91 | 0.00 | 2.24 | 1.07 | 0.00 | 2.62 | 0.19 | 1.02 | 1.17 | 2.74 |
| Jun-91 | 2.19 | 0.46 | 2.06 | 0.00 | 1.06 | 0.00 | 0.96 | 0.98 | 3.67 |
| Jul-91 | 2.98 | 1.50 | 42.91 | 0.85 | 3.28 | 0.00 | 8.59 | 16.86 | 14.36 |
| Aug-91 | 0.00 | 0.00 | 0.32 | 0.00 | 2.82 | 0.40 | 0.59 | 1.11 | 2.43 |
| Sep-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.88 | 0.00 | 0.15 | 0.36 | 1.48 |
| Oct-91 | 3.36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.56 | 1.37 | 1.97 |
| Nov-91 | 0.00 | 1.60 | 0.80 | 0.00 | 10.24 | 0.00 | 2.11 | 4.04 | 4.55 |
| Dec-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Lachnanthes caroliniana

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mar-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| May-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jun-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jul-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.31 | 0.55 | 1.35 | 1.47 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Nov-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.03 | 0.07 | 0.05 |
| Dec-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jan-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Feb-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mar-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jun-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jul-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nov-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Triadenum virginicum | | | | | | | | | |
| Mar-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| May-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jun-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jul-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.01 | 0.01 |
| Nov-90 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 |
| Dec-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| Jan-91 | 0.05 | 0.08 | 0.00 | 0.02 | 0.00 | 0.05 | 0.03 | 0.03 | 0.13 |
| Feb-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mar-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jun-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jul-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nov-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Eupatorium capillifolium | | | | | | | | | |
| Mar-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| May-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jun-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jul-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.03 | 0.08 | 0.09 |
| Nov-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.01 | 0.03 | 0.02 |
| Dec-90 | 0.00 | 0.00 | 0.00 | 0.00 | 2.22 | 0.40 | 0.44 | 0.89 | 2.08 |
| Jan-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.01 | 0.02 | 0.03 |
| Feb-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.02 | 0.05 | 0.19 |
| Mar-91 | 0.00 | 0.03 | 0.00 | 0.00 | 0.13 | 0.00 | 0.03 | 0.05 | 0.08 |
| Apr-91 | 0.00 | 0.34 | 0.00 | 0.00 | 0.00 | 0.03 | 0.06 | 0.14 | 0.16 |
| Jun-91 | 0.00 | 0.00 | 9.84 | 0.00 | 0.24 | 0.03 | 1.69 | 4.00 | 6.42 |
| Jul-91 | 0.00 | 0.00 | 0.00 | 0.00 | 1.71 | 0.22 | 0.32 | 0.69 | 0.54 |
| Aug-91 | 0.00 | 0.00 | 0.14 | 0.00 | 0.42 | 0.00 | 0.09 | 0.17 | 0.38 |
| Sep-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-91 | 0.02 | 4.16 | 0.00 | 0.00 | 0.02 | 0.02 | 0.70 | 1.69 | 2.47 |
| Nov-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec-91 | 0.00 | 0.16 | 0.00 | 0.00 | 0.16 | 0.00 | 0.05 | 0.08 | 0.66 |
| Andropogon sp. | | | | | | | | | |
| Mar-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Apr-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| May-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jun-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jul-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nov-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jan-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Feb-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mar-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jun-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jul-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 43.60 | 7.27 | 17.80 | 12.15 |
| Aug-91 | 0.00 | 0.00 | 0.00 | 0.00 | 1.81 | 0.00 | 0.30 | 0.74 | 1.24 |
| Sep-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-91 | 0.00 | 0.00 | 1.38 | 0.16 | 0.00 | 0.00 | 0.26 | 0.55 | 0.90 |
| Nov-91 | 0.00 | 0.00 | 0.16 | 0.00 | 0.00 | 0.00 | 0.03 | 0.07 | 0.06 |
| Dec-91 | 0.00 | 0.16 | 0.00 | 0.00 | 0.48 | 0.00 | 0.11 | 0.19 | 1.32 |

Lycopodium sp.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mar-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| May-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jun-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jul-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sep-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nov-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec-90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jan-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Feb-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mar-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Apr-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jun-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jul-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug-91 | 0.00 | 0.00 | 0.00 | 0.00 | 1.28 | 0.00 | 0.21 | 0.52 | 0.88 |
| Sep-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oct-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nov-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec-91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Total aboveground live biomass

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mar-90 | 4.13 | 0.00 | 11.60 | 0.00 | 11.92 | 15.39 | 8.61 | 6.66 | 100.00 |
| Apr-90 | 21.66 | 6.13 | 9.90 | 21.73 | 2.27 | 14.94 | 12.77 | 8.08 | 100.00 |
| May-90 | 28.00 | 1.63 | 7.07 | 5.74 | 4.88 | 52.69 | 16.67 | 20.01 | 100.00 |
| Jun-90 | 18.91 | 5.95 | 13.06 | 7.81 | 27.09 | 11.38 | 14.03 | 7.83 | 100.00 |
| Jul-90 | 8.16 | 13.50 | 10.78 | 9.63 | 12.88 | 6.77 | 10.29 | 2.63 | 100.00 |
| Aug-90 | 9.42 | 61.62 | 15.60 | 37.89 | 28.16 | 7.97 | 26.78 | 20.59 | 100.00 |
| Sep-90 | 27.79 | 27.17 | 23.63 | 23.31 | 2.03 | 1.26 | 17.53 | 12.44 | 100.00 |
| Oct-90 | 2.75 | 43.60 | 6.45 | 18.83 | 29.42 | 124.77 | 37.64 | 45.25 | 100.00 |
| Nov-90 | 140.19 | 37.92 | 78.93 | 1.07 | 8.20 | 84.37 | 58.45 | 52.94 | 100.00 |
| Dec-90 | 2.90 | 39.09 | 11.15 | 5.83 | 27.20 | 39.99 | 21.03 | 16.62 | 100.00 |
| Jan-91 | 1.44 | 38.56 | 3.94 | 3.76 | 31.49 | 74.16 | 25.56 | 28.60 | 100.00 |
| Feb-91 | 6.21 | 5.42 | 6.05 | 2.74 | 0.56 | 36.58 | 9.59 | 13.40 | 100.00 |
| Mar-91 | 4.24 | 46.85 | 53.02 | 0.18 | 40.30 | 57.58 | 33.70 | 25.11 | 100.00 |
| Apr-91 | 3.44 | 76.29 | 3.98 | 0.00 | 92.64 | 47.50 | 37.31 | 40.83 | 100.00 |
| Jun-91 | 24.62 | 4.37 | 81.42 | 0.88 | 30.11 | 15.98 | 26.23 | 29.29 | 100.00 |
| Jul-91 | 46.08 | 6.30 | 134.94 | 6.50 | 45.66 | 119.33 | 59.80 | 55.28 | 100.00 |
| Aug-91 | 35.17 | 9.81 | 20.02 | 2.75 | 73.57 | 4.14 | 24.24 | 27.00 | 100.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sep-91 | 19.15 | 12.37 | 4.06 | 9.98 | 5.01 | 8.91 | 9.91 | 5.49 | 100.00 |
| Oct-91 | 78.32 | 31.54 | 14.55 | 20.50 | 7.76 | 18.02 | 28.45 | 25.65 | 100.00 |
| Nov-91 | 8.48 | 15.84 | 46.24 | 32.00 | 24.98 | 150.40 | 46.32 | 52.64 | 100.00 |
| Dec-91 | 0.00 | 16.48 | 10.40 | 6.40 | 4.64 | 10.56 | 8.08 | 5.69 | 100.00 |

# APPENDIX E
# ABOVE AND BELOW GROUND BIOMASS OF FOUR SPECIES

|  |  | Biomass g DWT/m2 |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
| Species | 1 | 2 | 3 | 4 | 5 | 6 | Mean | S.D. |
| Nymphaea odorata - Aboveground live |  |  |  |  |  |  |  |  |
| MAR'90 | 0.00 | 0.00 | 5.20 |  | 0.00 | 0.00 | 1.04 | 2.33 |
| APR | 0.00 | 0.00 | 0.91 | 6.34 | 0.00 | 14.46 | 3.62 | 5.86 |
| MAY | 20.61 | 0.05 | 0.00 | 0.00 | 0.00 | 23.76 | 7.40 | 11.49 |
| JUN | 16.64 | 0.00 | 10.10 | 0.00 | 0.00 | 0.00 | 4.46 | 7.21 |
| JUL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| AUG | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SEP | 0.00 | 0.00 | 10.99 | 0.00 | 0.00 | 0.00 | 1.83 | 4.49 |
| OCT | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NOV | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DEC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| JAN'91 | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.20 |
| FEB | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| MAR | 0.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.26 |
| A/M | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| JUN | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| JUL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| AUG | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SEP | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OCT | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| NOV | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DEC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Belowground total |  |  |  |  |  |  |  |  |
| MAR'90 | 413.77 | 110.58 | 176.58 | 1.36 | 12.58 | 91.51 | 134.40 | 151.51 |
| APR | 172.34 | 175.04 | 20.72 | 1550.46 | 224.78 | 178.10 | 386.91 | 574.24 |
| MAY | 3222.76 | 51.20 | 113.19 | 632.01 | 65.50 | 1501.12 | 930.96 | 1253.68 |
| JUN | 1199.27 | 0.86 | 39.43 | 24.21 | 10.85 | 2.10 | 212.79 | 483.50 |
| JUL | 15.05 | 44.16 | 353.91 | 68.33 | 6.78 | 220.21 | 118.07 | 139.27 |
| AUG | 35.77 | 3.58 | 58.59 | 37.25 | 461.23 | 73.77 | 111.70 | 172.88 |
| SEP | 4.69 | 168.13 | 529.58 | 0.00 | 780.16 | 540.59 | 337.19 | 324.79 |
| OCT | 0.00 | 276.83 | 80.83 | 484.96 | 0.00 | 0.00 | 140.44 | 200.01 |
| NOV | 3.21 | 1625.87 | 135.73 | 0.00 | 0.00 | 8.32 | 295.52 | 653.91 |
| DEC | 0.00 | 0.00 | 135.36 | 106.08 | 0.00 | 108.79 | 58.37 | 64.76 |
| JAN'91 | 407.71 | 1284.92 | 829.59 | 886.53 | 726.82 | 0.00 | 689.26 | 440.27 |
| FEB | 0.00 | 0.00 | 1093.95 | 772.74 | 0.00 | 206.05 | 345.46 | 473.34 |
| MAR | 908.61 | 0.00 | 0.00 | 107.15 | 1490.42 | 415.62 | 486.97 | 601.38 |
| A/M | 84.74 | 0.00 | 0.00 | 142.34 | 0.00 | 234.64 | 76.95 | 96.92 |
| JUN | 0.00 | 0.00 | 61.62 | 0.00 | 0.00 | 0.00 | 10.27 | 25.15 |
| JUL | 253.92 | 892.29 | 0.00 | 375.25 | 0.00 | 0.00 | 253.58 | 350.90 |
| AUG | 527.36 | 580.74 | 0.00 | 1245.87 | 418.37 | 0.00 | 462.06 | 460.79 |
| SEP | 226.27 | 0.00 | 353.07 | 0.00 | 0.00 | 0.00 | 191.99 | 154.87 |
| OCT | 0.00 | 405.73 | 813.68 | 172.40 | 0.00 | 0.00 | 231.97 | 326.67 |
| NOV | 0.00 | 616.56 | 0.00 | 0.00 | 907.22 | 1088.80 | 435.43 | 500.22 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DEC | 35.92 | 619.88 | 279.78 | 207.20 | 157.47 | 312.96 | 268.87 | 197.86 |

Eleocharis elongata - Aboveground live

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MAR'90 | 4.13 | 0.00 | 6.40 | | 0.00 | 2.43 | 2.59 | 2.75 |
| APR | 0.90 | 1.04 | 0.98 | 0.00 | 0.00 | 0.00 | 0.49 | 0.53 |
| MAY | 0.67 | 1.58 | 7.07 | 0.00 | 1.10 | 8.56 | 3.17 | 3.67 |
| JUN | 0.00 | 1.89 | 0.91 | 0.00 | 0.00 | 0.00 | 0.47 | 0.79 |
| JUL | 4.51 | 2.88 | 3.01 | 0.46 | 7.14 | 0.00 | 3.00 | 2.64 |
| AUG | 0.22 | 3.62 | 0.00 | 3.60 | 0.83 | 0.64 | 1.49 | 1.67 |
| SEP | 0.00 | 1.84 | 1.22 | 0.00 | 0.00 | 0.00 | 0.51 | 0.81 |
| OCT | 1.10 | 1.25 | 0.00 | 1.07 | 0.40 | 0.00 | 0.64 | 0.57 |
| NOV | 0.00 | 1.49 | 0.83 | 0.80 | 0.31 | 0.00 | 0.57 | 0.58 |
| DEC | 0.34 | 0.53 | 0.24 | 1.34 | 0.69 | 0.10 | 0.54 | 0.45 |
| JAN'91 | 0.58 | 1.02 | 0.98 | 0.00 | 0.00 | 0.00 | 0.43 | 0.50 |
| FEB | 0.00 | 0.26 | 0.00 | 0.06 | 0.38 | 0.00 | 0.12 | 0.16 |
| MAR | 0.00 | 0.30 | 0.00 | 0.00 | 0.00 | 0.02 | 0.05 | 0.12 |
| A/M | 0.00 | 1.54 | 0.24 | 0.00 | 0.48 | 0.34 | 0.43 | 0.57 |
| JUN | 0.69 | 0.69 | 1.31 | 0.00 | 0.08 | 0.30 | 0.51 | 0.49 |
| JUL | 1.42 | 0.00 | 11.70 | 0.00 | 0.00 | 0.00 | 2.19 | 4.69 |
| AUG | 1.50 | 1.15 | 0.00 | 0.00 | 0.00 | 0.22 | 0.48 | 0.67 |
| SEP | 0.00 | 0.00 | 1.47 | 0.00 | 1.78 | 0.61 | 0.64 | 0.80 |
| OCT | 0.64 | 3.60 | 0.00 | 0.40 | 0.00 | 0.00 | 0.77 | 1.41 |
| NOV | 1.44 | 1.92 | 0.48 | 0.00 | 0.08 | 0.00 | 0.65 | 0.83 |
| DEC | 0.00 | 0.00 | 0.00 | 0.00 | 0.64 | 0.00 | 0.11 | 0.26 |

Belowground total

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MAR'90 | 72.08 | 40.44 | 109.72 | 25.89 | 0.00 | 7.33 | 42.58 | 41.75 |
| APR | 1.65 | 47.17 | 7.71 | 5.87 | 106.99 | 2.67 | 28.68 | 42.05 |
| MAY | 34.05 | 15.59 | 72.14 | 12.81 | 116.37 | 9.47 | 43.40 | 42.66 |
| JUN | 11.52 | 21.25 | 3.82 | 4.86 | 7.90 | 5.25 | 9.10 | 6.56 |
| JUL | 61.13 | 15.68 | 49.88 | 26.14 | 64.16 | 15.77 | 38.79 | 22.32 |
| AUG | 4.41 | 20.29 | 8.00 | 20.45 | 5.33 | 34.45 | 15.49 | 11.74 |
| SEP | 11.39 | 14.65 | 20.40 | 3.83 | 0.37 | 10.72 | 10.23 | 7.25 |
| OCT | 46.37 | 8.54 | 10.65 | 11.52 | 2.71 | 4.61 | 14.07 | 16.19 |
| NOV | 6.91 | 8.81 | 13.63 | 5.32 | 57.92 | 5.37 | 16.33 | 20.61 |
| DEC | 13.51 | 4.85 | 20.75 | 20.74 | 30.47 | 6.45 | 16.13 | 9.76 |
| JAN'91 | 15.66 | 48.71 | 44.13 | 36.10 | 1.79 | 2.93 | 24.89 | 20.81 |
| FEB | 5.87 | 11.72 | 7.46 | 8.32 | 41.94 | 4.98 | 13.38 | 14.19 |
| MAR | 0.25 | 39.99 | 34.81 | 3.30 | 7.06 | 21.51 | 17.82 | 16.91 |
| A/M | 0.62 | 44.57 | 13.84 | 10.77 | 16.13 | 15.52 | 16.91 | 14.70 |
| JUN | 26.86 | 26.22 | 23.49 | 10.17 | 12.80 | 8.87 | 18.42 | 8.34 |
| JUL | 8.75 | 1.41 | 32.26 | 5.15 | 4.61 | 12.18 | 10.73 | 11.18 |
| AUG | 17.26 | 6.59 | 0.14 | 2.58 | 8.29 | 5.66 | 6.75 | 5.92 |
| SEP | 0.94 | 4.13 | 6.85 | 0.02 | 0.16 | 0.37 | 3.98 | 2.80 |
| OCT | 11.42 | 15.07 | 20.96 | 3.12 | 8.43 | 11.31 | 11.72 | 6.03 |
| NOV | 6.16 | 4.71 | 4.42 | 2.92 | 4.70 | 7.10 | 5.00 | 1.46 |
| DEC | 1.04 | 3.05 | 1.21 | 3.98 | 3.63 | 5.70 | 3.10 | 1.77 |

Rhynchospora inundata - Aboveground live

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MAR'90 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| APR | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| MAY | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.81 | 1.30 | 3.19 |
| JUN | 2.27 | 3.50 | 2.05 | 7.81 | 25.66 | 10.21 | 8.58 | 8.98 |
| JUL | 2.34 | 9.17 | 7.78 | 5.33 | 5.74 | 6.77 | 6.19 | 2.35 |
| AUG | 8.22 | 23.12 | 1.20 | 9.68 | 10.08 | 6.80 | 9.85 | 7.25 |
| SEP | 6.94 | 17.87 | 11.42 | 7.23 | 2.03 | 0.86 | 7.73 | 6.28 |
| OCT | 1.50 | 9.18 | 6.45 | 1.87 | 5.14 | 1.49 | 4.27 | 3.19 |
| NOV | 4.96 | 6.96 | 7.47 | 0.24 | 2.51 | 4.21 | 4.39 | 2.73 |
| DEC | 2.30 | 4.48 | 10.00 | 4.48 | 1.68 | 4.43 | 4.56 | 2.93 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| JAN'91 | 0.82 | 0.43 | 0.00 | 0.21 | 0.00 | 0.00 | 0.24 | 0.33 |
| FEB | 0.00 | 0.38 | 0.02 | 0.00 | 0.10 | 0.00 | 0.08 | 0.15 |
| MAR | 3.60 | 0.30 | 0.96 | 0.00 | 1.02 | 0.40 | 1.05 | 1.31 |
| A/M | 2.82 | 7.78 | 2.50 | 0.00 | 2.46 | 0.00 | 2.59 | 2.84 |
| JUN | 6.26 | 3.22 | 16.11 | 0.00 | 0.00 | 0.66 | 4.37 | 6.24 |
| JUL | 28.82 | 3.15 | 71.97 | 1.12 | 1.10 | 0.00 | 17.69 | 28.79 |
| AUG | 33.66 | 0.54 | 4.93 | 0.05 | 10.96 | 0.03 | 8.36 | 13.10 |
| SEP | 13.92 | 9.49 | 0.00 | 0.00 | 0.00 | 3.57 | 4.50 | 5.92 |
| OCT | 21.98 | 7.09 | 4.80 | 0.00 | 5.36 | 0.00 | 6.54 | 8.11 |
| NOV | 0.00 | 9.12 | 0.96 | 0.00 | 0.74 | 0.00 | 1.80 | 3.61 |
| DEC | 0.00 | 0.00 | 0.00 | 0.32 | 0.16 | 0.00 | 0.08 | 0.13 |

Belowground total

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MAR'90 | 55.30 | 265.28 | 136.62 | 166.68 | 470.53 | 132.68 | 204.52 | 146.92 |
| APR | 133.01 | 156.90 | 68.76 | 254.84 | 120.78 | 108.33 | 140.44 | 63.20 |
| MAY | 27.90 | 50.72 | 43.78 | 108.38 | 217.16 | 226.22 | 112.36 | 88.99 |
| JUN | 133.63 | 81.28 | 106.30 | 121.22 | 156.34 | 97.00 | 115.96 | 26.93 |
| JUL | 51.76 | 60.51 | 107.52 | 118.47 | 90.49 | 86.96 | 85.95 | 25.92 |
| AUG | 107.59 | 57.29 | 50.05 | 150.86 | 233.69 | 23.93 | 103.90 | 78.14 |
| SEP | 70.16 | 119.27 | 22.35 | 51.48 | 188.32 | 196.06 | 107.94 | 72.52 |
| OCT | 127.66 | 108.47 | 68.89 | 31.69 | 51.92 | 158.69 | 91.22 | 48.51 |
| NOV | 24.10 | 41.38 | 94.91 | 72.95 | 25.95 | 183.25 | 73.76 | 60.39 |
| DEC | 48.22 | 22.22 | 27.45 | 63.45 | 78.40 | 103.10 | 57.14 | 30.93 |
| JAN'91 | 58.50 | 70.15 | 53.54 | 54.84 | 157.29 | 71.59 | 77.65 | 39.76 |
| FEB | 64.67 | 88.88 | 101.51 | 72.80 | 46.17 | 231.08 | 100.85 | 66.62 |
| MAR | 136.89 | 168.87 | 75.86 | 134.76 | 200.35 | 92.24 | 134.83 | 46.36 |
| A/M | 117.57 | 80.39 | 115.44 | 108.44 | 88.40 | 115.73 | 104.33 | 15.96 |
| JUN | 159.79 | 135.07 | 130.35 | 124.52 | 114.34 | 176.57 | 140.27 | 23.43 |
| JUL | 55.23 | 6.22 | 154.83 | 34.05 | 98.35 | 75.41 | 70.68 | 52.16 |
| AUG | 67.87 | 18.06 | 9.63 | 15.58 | 67.38 | 28.51 | 34.51 | 26.37 |
| SEP | 27.28 | 18.74 | 14.24 | 0.00 | 1.82 | 0.98 | 20.53 | 11.31 |
| OCT | 89.07 | 36.56 | 55.73 | 8.86 | 11.90 | 9.70 | 35.30 | 32.29 |
| NOV | 9.95 | 58.20 | 10.15 | 15.54 | 6.53 | 30.10 | 21.75 | 19.71 |
| DEC | 27.30 | 19.33 | 0.30 | 15.76 | 19.10 | 15.07 | 16.14 | 8.90 |

Amphicarpum muhlenbergianum - Aboveground live

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MAR'90 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| APR | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| MAY | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.47 | 0.25 | 0.60 |
| JUN | 0.00 | 0.00 | 0.00 | 0.00 | 1.42 | 0.00 | 0.24 | 0.58 |
| JUL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| AUG | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SEP | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OCT | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 75.09 | 12.51 | 30.65 |
| NOV | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 47.98 | 8.00 | 19.59 |
| DEC | 0.00 | 0.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.26 |
| JAN'91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.80 | 1.13 | 2.78 |
| FEB | 0.00 | 0.00 | 0.37 | 0.00 | 0.00 | 8.46 | 1.47 | 3.43 |
| MAR | 0.00 | 0.00 | 0.00 | 0.00 | 6.51 | 0.77 | 1.21 | 2.61 |
| A/M | 0.00 | 0.70 | 0.00 | 0.00 | 1.20 | 1.60 | 0.58 | 0.70 |
| JUN | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.99 | 2.50 | 6.12 |
| JUL | 0.00 | 0.00 | 0.00 | 4.53 | 32.56 | 70.06 | 17.86 | 28.55 |
| AUG | 0.00 | 8.11 | 12.86 | 2.70 | 54.08 | 3.49 | 13.54 | 20.37 |
| SEP | 0.00 | 0.00 | 2.32 | 9.98 | 2.35 | 4.74 | 3.23 | 3.75 |
| OCT | 0.00 | 16.10 | 8.37 | 17.60 | 2.38 | 18.00 | 10.41 | 7.98 |
| NOV | 5.12 | 3.20 | 43.84 | 32.00 | 13.28 | 128.00 | 37.57 | 47.06 |
| DEC | 0.00 | 7.52 | 10.40 | 5.60 | 1.92 | 6.72 | 5.36 | 3.81 |

Belowground total

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MAR'90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| APR | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| MAY | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| JUN | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| JUL | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| AUG | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SEP | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| OCT | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 104.61 | 17.43 | 42.71 |
| NOV | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 66.66 | 11.11 | 27.21 |
| DEC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.99 | 0.50 | 1.22 |
| JAN'91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.75 | 2.46 | 6.02 |
| FEB | 1.39 | 0.00 | 0.13 | 0.00 | 0.00 | 40.03 | 6.93 | 16.23 |
| MAR | 0.00 | 10.02 | 0.00 | 0.00 | 18.46 | 13.63 | 7.02 | 8.14 |
| A/M | 0.00 | 0.05 | 0.00 | 0.00 | 0.37 | 0.30 | 0.12 | 0.17 |
| JUN | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| JUL | 0.00 | 0.00 | 0.00 | 3.98 | 29.06 | 76.78 | 18.30 | 30.81 |
| AUG | 0.00 | 5.57 | 0.00 | 0.00 | 62.50 | 0.00 | 11.34 | 25.16 |
| SEP | 0.00 | 0.00 | 2.18 | 0.03 | 0.00 | 0.00 | 0.73 | 0.89 |
| OCT | 1.02 | 32.38 | 39.90 | 20.48 | 15.49 | 41.49 | 25.13 | 15.71 |
| NOV | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DEC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

# APPENDIX F
# RESULTS OF STATISTICAL ANALYSES

```
                         AG LIVE BIO-NYM ODO 1990-91
                        16:08 Wednesday, July 8, 1992
                        Analysis of Variance Procedure
                           Class Level Information

Class    Levels    Values
MONTH        21    A/M91 APR90 AUG90 AUG91 DEC90 DEC91 FEB91 JAN91 JUL90
                   JUL91 JUN90 JUN91 MAR90 MAR91 MAY90 NOV90 NOV91 OCT90
                   OCT91 SEP90 SEP91
                   Number of observations in data set = 126
NOTE: Due to missing values, only 125 observations can be used in this
      analysis.
                        Analysis of Variance Procedure

Dependent Variable: SUBPLOT
                                  Sum of          Mean
Source                  DF       Squares        Square   F Value     Pr > F
Model                   20   455.0769800    22.7538490      1.95     0.0161
Error                  104  1214.5775000    11.6786298
Corrected Total        124  1669.6544800

                  R-Square          C.V.      Root MSE          SUBPLOT Mean
                  0.272558      387.6362      3.417401            0.88160000

Dependent Variable: SUBPLOT
Source                  DF      Anova SS   Mean Square   F Value     Pr > F
MONTH                   20   455.0769800    22.7538490      1.95     0.0161

                      Analysis of Variance Procedure
                 Student-Newman-Keuls test for variable: SUBPLOT
          NOTE: This test controls the type I experimentwise error rate under
                the complete null hypothesis but not under partial null
                hypotheses.

                    Alpha= 0.05  df= 104  MSE= 11.67863
                     WARNING: Cell sizes are not equal.
                   Harmonic Mean of cell sizes= 5.943396

      Number of Means          2          3          4          5          6
      Critical Range   3.9311884  4.7136691   5.176272  5.5036051  5.7559095
      Number of Means          7          8          9         10         11
      Critical Range   5.9607741  6.1326704  6.2805123  6.4101753  6.5252387
      Number of Means         12         13         14         15         16
      Critical Range   6.6287363  6.7227002  6.8086764  6.8878687  6.9612351
      Number of Means         17         18         19         20         21
      Critical Range   7.0295513  7.0936352  7.1536012  7.2101447  7.2636318
```

```
                    AG LIVE BIO-NYM ODO 1990-91
Means with the same letter are not significantly different.

                SNK Grouping              Mean      N  MONTH

                         A               7.403      6  MAY90
                         A
                B        A               4.457      6  JUN90
                B        A
                B        A               3.618      6  APR90
                B
                B                        1.832      6  SEP90
                B
                B                        1.040      5  MAR90
                B
                B                        0.107      6  MAR91
                B
                B                        0.083      6  JAN91
                B
                B                        0.000      6  A/M91
                B
                B                        0.000      6  JUL90
                B
                B                        0.000      6  JUL91
                B
                B                        0.000      6  AUG90
                B
                B                        0.000      6  JUN91
                B
                B                        0.000      6  DEC90
                B
                B                        0.000      6  DEC91
                B
                B                        0.000      6  FEB91
                B
                B                        0.000      6  NOV90
                B
                B                        0.000      6  NOV91
                B
                B                        0.000      6  OCT90
                B
                B                        0.000      6  OCT91
                B
                B                        0.000      6  AUG91
                B
                B                        0.000      6  SEP91
```

```
                              BG BIO-NYM ODO 1990-91
                          16:08 Wednesday, July 8, 1992
                         Analysis of Variance Procedure
                            Class Level Information
Class     Levels    Values
MONTH         21    A/M91 APR90 AUG90 AUG91 DEC90 DEC91 FEB91 JAN91 JUL90
                    JUL91 JUN90 JUN91 MAR90 MAR91 MAY90 NOV90 NOV91 OCT90
                    OCT91 SEP90 SEP91
                    Number of observations in data set = 125
NOTE: Due to missing values, only 124 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                     Sum of             Mean
Source                      DF      Squares           Square   F Value     Pr > F
Model                       20  6015142.806       300757.140      1.55     0.0810
Error                      103 20003353.008       194207.311
Corrected Total            123 26018495.815
                      R-Square         C.V.         Root MSE           SUBPLOT Mean
                      0.231187     156.3514         440.6896             281.858468

Dependent Variable: SUBPLOT
Source                      DF      Anova SS     Mean Square   F Value     Pr > F
MONTH                       20   6015142.806      300757.140      1.55     0.0810

               Student-Newman-Keuls test for variable: SUBPLOT

         NOTE: This test controls the type I experimentwise error rate under
               the complete null hypothesis but not under partial null
               hypotheses.
                     Alpha= 0.05  df= 103  MSE= 194207.3
                      WARNING: Cell sizes are not equal.
                     Harmonic Mean of cell sizes= 5.88785
      Number of Means          2         3         4         5         6
      Critical Range   509.38866 610.79559 670.75097 713.17719 745.88029
      Number of Means          7         8         9        10        11
      Critical Range   772.43413 794.71552 813.87938 830.68635 845.60223
      Number of Means         12        13        14        15        16
      Critical Range   859.01886 871.19968 882.34512 892.61123 902.12216
      Number of Means         17        18        19        20        21
      Critical Range   910.97848 919.28503 927.05929 934.38983 941.32413
```

```
Means with the same letter are not significantly different.

        SNK Grouping              Mean      N  MONTH

                   A             931.0      6  MAY90
                   A
                   A             689.3      6  JAN91
                   A
                   A             487.0      6  MAR91
                   A
                   A             462.1      6  AUG91
                   A
                   A             435.4      6  NOV91
                   A
                   A             345.5      6  FEB91
                   A
                   A             337.2      6  SEP90
                   A
                   A             295.5      6  NOV90
                   A
                   A             268.9      6  DEC91
                   A
                   A             253.6      6  JUL91
                   A
                   A             232.0      6  OCT91
                   A
                   A             212.8      6  JUN90
                   A
                   A             161.0      5  MAR90
                   A
                   A             154.2      5  APR90
                   A
                   A             140.4      6  OCT90
                   A
                   A             118.1      6  JUL90
                   A
                   A             111.7      6  AUG90
                   A
                   A              96.6      6  SEP91
                   A
                   A              77.0      6  A/M91
                   A
                   A              58.4      6  DEC90
                   A
                   A              10.3      6  JUN91
```

```
                        AG LIVE BIO-RHY INU 1990-91
                       16:08 Wednesday, July 8, 1992
                      Analysis of Variance Procedure
                         Class Level Information

Class     Levels     Values
MONTH         21     A/M91 APR90 AUG90 AUG91 DEC90 DEC91 FEB91 JAN91 JUL90
                     JUL91 JUN90 JUN91 MAR90 MAR91 MAY90 NOV90 NOV91 OCT90
                     OCT91 SEP90 SEP91
                     Number of observations in data set = 126
NOTE: Due to missing values, only 125 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                     Sum of          Mean
Source                  DF          Squares        Square   F Value     Pr > F
Model                   20      2274.614415    113.730721      1.72     0.0418
Error                  104      6888.589950     66.236442
Corrected Total        124      9163.204365
                  R-Square             C.V.      Root MSE            SUBPLOT Mean
                  0.248234         180.0156      8.138577              4.52104000

Dependent Variable: SUBPLOT
Source                  DF         Anova SS   Mean Square   F Value     Pr > F
MONTH                   20      2274.614415    113.730721      1.72     0.0418


                      Analysis of Variance Procedure

               Student-Newman-Keuls test for variable: SUBPLOT

         NOTE: This test controls the type I experimentwise error rate under
               the complete null hypothesis but not under partial null
               hypotheses.
                     Alpha= 0.05  df= 104  MSE= 66.23644
                      WARNING: Cell sizes are not equal.
                    Harmonic Mean of cell sizes= 5.943396

      Number of Means         2         3         4         5         6
      Critical Range  9.3621674 11.225654 12.327347 13.106895 13.707761
      Number of Means         7         8         9        10        11
      Critical Range  14.195648 14.605021 14.957108 15.265902 15.539926
      Number of Means        12        13        14        15        16
      Critical Range  15.786407 16.010183 16.214936 16.403534 16.578256
      Number of Means        17        18        19        20        21
      Critical Range  16.740952 16.893569 17.036378 17.171037 17.298417
```

```
                   AG LIVE BIO-RHY INU 1990-91

Means with the same letter are not significantly different.

    SNK Grouping              Mean      N  MONTH

                 A          17.693      6  JUL91
                 A
         B       A           9.850      6  AUG90
         B       A
         B       A           8.583      6  JUN90
         B       A
         B       A           8.362      6  AUG91
         B       A
         B       A           7.725      6  SEP90
         B       A
         B       A           6.538      6  OCT91
         B       A
         B       A           6.188      6  JUL90
         B       A
         B       A           4.562      6  DEC90
         B       A
         B       A           4.497      6  SEP91
         B       A
         B       A           4.392      6  NOV90
         B       A
         B       A           4.375      6  JUN91
         B       A
         B       A           4.272      6  OCT90
         B       A
         B       A           2.593      6  A/M91
         B       A
         B       A           1.803      6  NOV91
         B       A
         B       A           1.302      6  MAY90
         B
         B                   1.047      6  MAR91
         B
         B                   0.243      6  JAN91
         B
         B                   0.083      6  FEB91
         B
         B                   0.080      6  DEC91
         B
         B                   0.000      6  APR90
         B
         B                   0.000      5  MAR90
```

```
                         Analysis of Variance Procedure
                            Class Level Information
Class     Levels    Values
MONTH         21    A/M91 APR90 AUG90 AUG91 DEC90 DEC91 FEB91 JAN91 JUL90
                    JUL91 JUN90 JUN91 MAR90 MAR91 MAY90 NOV90 NOV91 OCT90
                    OCT91 SEP90 SEP91
                    Number of observations in data set = 126
NOTE: Due to missing values, only 125 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                     Sum of            Mean
Source                  DF          Squares          Square   F Value     Pr > F
Model                   20      274181.5210      13709.0761      4.26     0.0001
Error                  104      334501.6707       3216.3622
Corrected Total        124      608683.1917
                  R-Square             C.V.        Root MSE          SUBPLOT Mean
                  0.450450         65.20322        56.71298            86.9788000

Dependent Variable: SUBPLOT
Source                  DF         Anova SS     Mean Square   F Value     Pr > F
MONTH                   20      274181.5210      13709.0761      4.26     0.0001

                         Analysis of Variance Procedure

              Student-Newman-Keuls test for variable: SUBPLOT

          NOTE: This test controls the type I experimentwise error rate under
                the complete null hypothesis but not under partial null
                hypotheses.

                      Alpha= 0.05  df= 104  MSE= 3216.362
                       WARNING: Cell sizes are not equal.
                     Harmonic Mean of cell sizes= 5.943396

      Number of Means          2          3          4          5          6
      Critical Range   65.239464   78.22501  85.902067  91.334277  95.521358
      Number of Means          7          8          9         10         11
      Critical Range   98.921159  101.77384  104.22733  106.37913  108.28865
      Number of Means         12         13         14         15         16
      Critical Range   110.00623  111.56559   112.9924  114.30662  115.52416
      Number of Means         17         18         19         20         21
      Critical Range   116.65789  117.72139  118.71655  119.65491  120.54254
```

```
                    BG BIO-RHY INU 1990-91

Means with the same letter are not significantly different.

        SNK Grouping              Mean      N  MONTH

                   A            212.08      5  MAR90
                   A
           B       A            140.44      6  APR90
           B       A
           B       A            140.11      6  JUN91
           B       A
           B       A   C        134.83      6  MAR91
           B           C
           B       D   C        115.96      6  JUN90
           B       D   C
           B       D   C        112.36      6  MAY90
           B       D   C
           B       D   C        107.94      6  SEP90
           B       D   C
           B       D   C        104.33      6  A/M91
           B       D   C
           B       D   C        103.90      6  AUG90
           B       D   C
           B       D   C        100.85      6  FEB91
           B       D   C
           B       D   C         91.22      6  OCT90
           B       D   C
           B       D   C         85.95      6  JUL90
           B       D   C
           B       D   C         77.65      6  JAN91
           B       D   C
           B       D   C         73.76      6  NOV90
           B       D   C
           B       D   C         70.68      6  JUL91
           B       D   C
           B       D   C         57.14      6  DEC90
           B       D   C
           B       D   C         35.30      6  OCT91
           B       D   C
           B       D   C         34.50      6  AUG91
                   D   C
                   D   C         21.75      6  NOV91
                   D
                   D             16.14      6  DEC91
                   D
                   D             10.51      6  SEP91
```

```
                         AG LIVE BIO-ELE ELO 1990
                      16:08 Wednesday, July 8, 1992
                      Analysis of Variance Procedure
                         Class Level Information

Class     Levels    Values
MONTH         21    A/M91 APR90 AUG90 AUG91 DEC90 DEC91 FEB91 JAN91 JUL90
                    JUL91 JUN90 JUN91 MAR90 MAR91 MAY90 NOV90 NOV91 OCT90
                    OCT91 SEP90 SEP91
                    Number of observations in data set = 126
NOTE: Due to missing values, only 125 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                     Sum of           Mean
Source                     DF       Squares         Square   F Value     Pr > F
Model                      20   105.4967312      5.2748366      1.88     0.0218
Error                     104   292.4020800      2.8115585
Corrected Total           124   397.8988112
                     R-Square          C.V.       Root MSE          SUBPLOT Mean
                     0.265135      180.0037       1.676770            0.93152000

Dependent Variable: SUBPLOT
Source                     DF      Anova SS    Mean Square   F Value     Pr > F
MONTH                      20   105.4967312      5.2748366      1.88     0.0218

                      Analysis of Variance Procedure

               Student-Newman-Keuls test for variable: SUBPLOT

          NOTE: This test controls the type I experimentwise error rate under
                the complete null hypothesis but not under partial null
                hypotheses.
                      Alpha= 0.05  df= 104  MSE= 2.811558
                       WARNING: Cell sizes are not equal.
                      Harmonic Mean of cell sizes= 5.943396

      Number of Means          2         3         4         5         6
      Critical Range   1.9288634 2.3127927 2.5397718   2.70038 2.8241748
      Number of Means          7         8         9        10        11
      Critical Range   2.9246929  3.009035 3.0815746 3.1451946 3.2016512
      Number of Means         12        13        14        15        16
      Critical Range    3.252433  3.298537 3.3407217  3.379578 3.4155757
      Number of Means         17        18        19        20        21
      Critical Range   3.4490955 3.4805387 3.5099614 3.5377048 3.5639486
```

```
                    AG LIVE BIO-ELE ELO 1990

Means with the same letter are not significantly different.

          SNK Grouping                Mean        N   MONTH

                     A               3.163        6   MAY90
                     A
                     A               3.000        6   JUL90
                     A
                     A               2.592        5   MAR90
                     A
                     A               2.187        6   JUL91
                     A
                     A               1.485        6   AUG90
                     A
                     A               0.773        6   OCT91
                     A
                     A               0.653        6   NOV91
                     A
                     A               0.643        6   SEP91
                     A
                     A               0.637        6   OCT90
                     A
                     A               0.572        6   NOV90
                     A
                     A               0.540        6   DEC90
                     A
                     A               0.512        6   JUN91
                     A
                     A               0.510        6   SEP90
                     A
                     A               0.487        6   APR90
                     A
                     A               0.478        6   AUG91
                     A
                     A               0.467        6   JUN90
                     A
                     A               0.433        6   A/M91
                     A
                     A               0.430        6   JAN91
                     A
                     A               0.117        6   FEB91
                     A
                     A               0.107        6   DEC91
                     A
                     A               0.053        6   MAR91
```

```
                      Analysis of Variance Procedure
                         Class Level Information

Class     Levels    Values
MONTH         21    A/M91 APR90 AUG90 AUG91 DEC90 DEC91 FEB91 JAN91 JUL90
                    JUL91 JUN90 JUN91 MAR90 MAR91 MAY90 NOV90 NOV91 OCT90
                    OCT91 SEP90 SEP91
                    Number of observations in data set = 126
NOTE: Due to missing values, only 125 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                    Sum of           Mean
Source                   DF        Squares         Square   F Value     Pr > F
Model                    20    17595.25313      879.76266      2.23     0.0047
Error                   104    40964.66489      393.89101
Corrected Total         124    58559.91802
                   R-Square           C.V.       Root MSE          SUBPLOT Mean
                   0.300466       114.5613       19.84669            17.3240800

Dependent Variable: SUBPLOT
Source                   DF       Anova SS    Mean Square   F Value     Pr > F
MONTH                    20    17595.25313      879.76266      2.23     0.0047

               Student-Newman-Keuls test for variable: SUBPLOT

         NOTE: This test controls the type I experimentwise error rate under
               the complete null hypothesis but not under partial null
               hypotheses.
                      Alpha= 0.05  df= 104  MSE= 393.891
                      WARNING: Cell sizes are not equal.
                     Harmonic Mean of cell sizes= 5.943396

      Number of Means          2         3         4         5         6
      Critical Range   22.830527 27.374814 30.061398 31.962398 33.427665
      Number of Means          7         8         9        10        11
      Critical Range   34.617424 35.615719 36.474316 37.227339 37.895574
      Number of Means         12        13        14        15        16
      Critical Range   38.496641 39.042339 39.541649 40.001562  40.42764
      Number of Means         17        18        19        20        21
      Critical Range   40.824389 41.196559 41.544813 41.873192  42.18382
```

```
                    BG BIO-ELE ELO 1990

Means with the same letter are not significantly different.

        SNK Grouping              Mean       N   MONTH

                   A             45.91       5   MAR90
                   A
           B       A             43.41       6   MAY90
           B       A
           B       A             38.79       6   JUL90
           B       A
           B       A             28.68       6   APR90
           B       A
           B       A             24.89       6   JAN91
           B       A
           B       A             18.07       6   JUN91
           B       A
           B       A             17.82       6   MAR91
           B       A
           B       A             16.91       6   A/M91
           B       A
           B       A             16.33       6   NOV90
           B       A
           B       A             16.13       6   DEC90
           B       A
           B       A             15.49       6   AUG90
           B       A
           B       A             14.07       6   OCT90
           B       A
           B       A             13.38       6   FEB91
           B       A
           B       A             11.72       6   OCT91
           B       A
           B       A             10.73       6   JUL91
           B       A
           B       A             10.23       6   SEP90
           B       A
           B       A              9.10       6   JUN90
           B       A
           B       A              6.75       6   AUG91
           B       A
           B       A              5.00       6   NOV91
           B
           B                      3.10       6   DEC91
           B
           B                      2.08       6   SEP91
```

```
                        AG LIVE BIO-AMP MUH 1990-91
                       16:08 Wednesday, July 8, 1992
                      Analysis of Variance Procedure
                         Class Level Information

Class     Levels    Values
MONTH         21    A/M91 APR90 AUG90 AUG91 DEC90 DEC91 FEB91 JAN91 JUL90
                    JUL91 JUN90 JUN91 MAR90 MAR91 MAY90 NOV90 NOV91 OCT90
                    OCT91 SEP90 SEP91
                    Number of observations in data set = 126
NOTE: Due to missing values, only 125 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                     Sum of          Mean
Source                  DF          Squares        Square   F Value     Pr > F
Model                   20      9888.869339    494.443467      2.09     0.0088
Error                  104     24626.666650    236.794872
Corrected Total        124     34515.535989
                  R-Square             C.V.      Root MSE          SUBPLOT Mean
                  0.286505         276.4350      15.38814            5.56664000

Dependent Variable: SUBPLOT
Source                  DF          Anova SS  Mean Square   F Value     Pr > F
MONTH                   20       9888.869339   494.443467      2.09     0.0088

               Student-Newman-Keuls test for variable: SUBPLOT

          NOTE: This test controls the type I experimentwise error rate under
                the complete null hypothesis but not under partial null
                hypotheses.

                     Alpha= 0.05  df= 104  MSE= 236.7949
                      WARNING: Cell sizes are not equal.
                    Harmonic Mean of cell sizes= 5.943396

      Number of Means         2         3         4         5         6
      Critical Range  17.701662 21.225078 23.308122 24.782064 25.918159
      Number of Means         7         8         9        10        11
      Critical Range   26.84064 27.614668 28.280382 28.864239 29.382355
      Number of Means        12        13        14        15        16
      Critical Range  29.848392   30.2715  30.65864 31.015234 31.345594
      Number of Means        17        18        19        20        21
      Critical Range  31.653213 31.941775 32.211795 32.466403 32.707249
```

```
                 AG LIVE BIO-AMP MUH 1990-91

   Means with the same letter are not significantly different.

          SNK Grouping                  Mean      N  MONTH

                     A                37.573      6  NOV91

                     B                17.858      6  JUL91
                     B
                     B                13.540      6  AUG91
                     B
                     B                12.515      6  OCT90
                     B
                     B                10.408      6  OCT91
                     B
                     B                 7.997      6  NOV90
                     B
                     B                 5.360      6  DEC91
                     B
                     B                 3.232      6  SEP91
                     B
                     B                 2.498      6  JUN91
                     B
                     B                 1.472      6  FEB91
                     B
                     B                 1.213      6  MAR91
                     B
                     B                 1.133      6  JAN91
                     B
                     B                 0.583      6  A/M91
                     B
                     B                 0.245      6  MAY90
                     B
                     B                 0.237      6  JUN90
                     B
                     B                 0.107      6  DEC90
                     B
                     B                 0.000      6  JUL90
                     B
                     B                 0.000      6  APR90
                     B
                     B                 0.000      6  AUG90
                     B
                     B                 0.000      6  SEP90
                     B
                     B                 0.000      5  MAR90
```

```
                          BG BIO-AMP MUH 1990-91                          95
                       18:24 Wednesday, July 8, 1992
                      Analysis of Variance Procedure
                          Class Level Information

Class     Levels    Values
MONTH         21    A/M91 APR90 AUG90 AUG91 DEC90 DEC91 FEB91 JAN91 JUL90
                    JUL91 JUN90 JUN91 MAR90 MAR91 MAY90 NOV90 NOV91 OCT90
                    OCT91 SEP90 SEP91
                    Number of observations in data set = 126
NOTE: Due to missing values, only 125 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                  Sum of          Mean
Source                  DF       Squares        Square   F Value     Pr > F
Model                   20   6835.872550    341.793628      1.49     0.0994
Error                  104  23807.847450    228.921610
Corrected Total        124  30643.720000
                  R-Square          C.V.      Root MSE          SUBPLOT Mean
                  0.223076      312.9945      15.13016            4.83400000

Dependent Variable: SUBPLOT
Source                  DF      Anova SS   Mean Square   F Value     Pr > F
MONTH                   20   6835.872550    341.793628      1.49     0.0994

                      Analysis of Variance Procedure

             Student-Newman-Keuls test for variable: SUBPLOT

         NOTE: This test controls the type I experimentwise error rate under
               the complete null hypothesis but not under partial null
               hypotheses.

                     Alpha= 0.05  df= 104  MSE= 228.9216
                      WARNING: Cell sizes are not equal.
                    Harmonic Mean of cell sizes= 5.943396

      Number of Means          2         3         4         5         6
      Critical Range   17.404891 20.869236 22.917357 24.366588 25.483637
      Number of Means          7         8         9        10        11
      Critical Range   26.390652 27.151703 27.806256 28.380324 28.889755
      Number of Means         12        13        14        15        16
      Critical Range   29.347979 29.763993 30.144643 30.495258 30.820079
      Number of Means         17        18        19        20        21
      Critical Range   31.122541 31.406266 31.671758 31.922098 32.158906
```

```
Means with the same letter are not significantly different.

        SNK Grouping              Mean      N  MONTH

                   A            25.127      6  OCT91
                   A
                   A            18.303      6  JUL91
                   A
                   A            17.435      6  OCT90
                   A
                   A            11.345      6  AUG91
                   A
                   A            11.110      6  NOV90
                   A
                   A             7.018      6  MAR91
                   A
                   A             6.925      6  FEB91
                   A
                   A             2.458      6  JAN91
                   A
                   A             0.498      6  DEC90
                   A
                   A             0.368      6  SEP91
                   A
                   A             0.120      6  A/M91
                   A
                   A             0.000      6  JUN90
                   A
                   A             0.000      6  JUL90
                   A
                   A             0.000      6  DEC91
                   A
                   A             0.000      6  MAY90
                   A
                   A             0.000      6  JUN91
                   A
                   A             0.000      6  NOV91
                   A
                   A             0.000      6  APR90
                   A
                   A             0.000      6  AUG90
                   A
                   A             0.000      6  SEP90
                   A
                   A             0.000      5  MAR90
```

```
                       AVAILABLE NH4-N 1990
                   18:38 Wednesday, July 8, 1992
                  Analysis of Variance Procedure
                      Class Level Information

             Class    Levels    Values
             MONTH         8    AUG DEC JUL JUN MAY NOV OCT SEP
                  Number of observations in data set = 48
NOTE: Due to missing values, only 46 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                 Sum of            Mean
Source                  DF      Squares          Square    F Value      Pr > F
Model                    7  27508.17928      3929.73990       3.84      0.0030
Error                   38  38850.39171      1022.37873
Corrected Total         45  66358.57099
                  R-Square         C.V.        Root MSE         SUBPLOT Mean
                  0.414538     54.61228        31.97466           58.5484783

Dependent Variable: SUBPLOT
Source                  DF     Anova SS     Mean Square    F Value      Pr > F
MONTH                    7  27508.17928      3929.73990       3.84      0.0030

             Student-Newman-Keuls test for variable: SUBPLOT

         NOTE: This test controls the type I experimentwise error rate under
               the complete null hypothesis but not under partial null
               hypotheses.

                    Alpha= 0.05  df= 38  MSE= 1022.379
                    WARNING: Cell sizes are not equal.
                  Harmonic Mean of cell sizes= 5.714286

           Number of Means          2         3         4         5
           Critical Range   38.295505 46.134319 50.818471 54.160511
           Number of Means          6         7         8
           Critical Range   56.748782 58.858667 60.637028
```

```
                    AVAILABLE NH4-N 1990

Means with the same letter are not significantly different.

        SNK Grouping                Mean       N  MONTH

                   A               92.81       6  JUL
                   A
           B       A               83.74       6  SEP
           B       A
           B       A               74.99       6  JUN
           B       A
           B       A               71.10       6  MAY
           B       A
           B       A               45.99       6  AUG
           B
           B                       34.48       5  OCT
           B
           B                       29.91       6  NOV
           B
           B                       25.92       5  DEC
```

```
                      AVAILABLE NO3-N 1990
                 18:38 Wednesday, July 8, 1992
                 Analysis of Variance Procedure
                    Class Level Information

             Class    Levels    Values
             MONTH         8    AUG DEC JUL JUN MAY NOV OCT SEP
                 Number of observations in data set = 48
NOTE: Due to missing values, only 46 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                  Sum of          Mean
Source                  DF       Squares        Square    F Value     Pr > F
Model                    7   66577.34466    9511.04924      22.03     0.0001
Error                   38   16408.19848     431.79470
Corrected Total         45   82985.54314
                  R-Square          C.V.      Root MSE          SUBPLOT Mean
                  0.802276      47.83031      20.77967            43.4445652

Dependent Variable: SUBPLOT
Source                  DF      Anova SS   Mean Square    F Value     Pr > F
MONTH                    7   66577.34466    9511.04924      22.03     0.0001


                 Analysis of Variance Procedure

         Student-Newman-Keuls test for variable: SUBPLOT

          NOTE: This test controls the type I experimentwise error rate under
                the complete null hypothesis but not under partial null
                hypotheses.

                  Alpha= 0.05  df= 38  MSE= 431.7947
                  WARNING: Cell sizes are not equal.
                 Harmonic Mean of cell sizes= 5.714286

           Number of Means          2         3         4         5
           Critical Range   24.887458 29.981742 33.025876 35.197799
           Number of Means          6         7         8
           Critical Range   36.879862 38.251034 39.406754
```

```
                    AVAILABLE NO3-N 1990
Means with the same letter are not significantly different.

        SNK Grouping              Mean      N  MONTH

                   A            123.90      6  DEC

                   B             72.06      6  NOV
                   B
           C       B             54.70      5  OCT
           C
           C       D             36.65      6  AUG
           C       D
           C       D   E         27.99      5  SEP
                   D   E
                   D   E         20.30      6  JUN
                   D   E
                   D   E         11.01      6  JUL
                       E
                       E          0.26      6  MAY
```

```
                           AVAILABLE NH4+NO3-N 1990
                        18:38 Wednesday, July 8, 1992
                        Analysis of Variance Procedure
                           Class Level Information

              Class    Levels    Values
              MONTH         8    AUG DEC JUL JUN MAY NOV OCT SEP
                   Number of observations in data set = 48
NOTE: Due to missing values, only 44 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                    Sum of           Mean
Source                   DF        Squares         Square   F Value     Pr > F
Model                     7    19778.47526     2825.49647      2.17     0.0602
Error                    36    46793.04298     1299.80675
Corrected Total          43    66571.51824
                   R-Square           C.V.       Root MSE          SUBPLOT Mean
                   0.297101       35.95355       36.05283            100.276136

Dependent Variable: SUBPLOT
Source                   DF       Anova SS    Mean Square   F Value     Pr > F
MONTH                     7    19778.47526     2825.49647      2.17     0.0602

                        Analysis of Variance Procedure

               Student-Newman-Keuls test for variable: SUBPLOT

         NOTE: This test controls the type I experimentwise error rate under
               the complete null hypothesis but not under partial null
               hypotheses.

                      Alpha= 0.05  df= 36  MSE= 1299.807
                      WARNING: Cell sizes are not equal.
                    Harmonic Mean of cell sizes= 5.393258

           Number of Means         2         3         4         5
           Critical Range  44.527399 53.664218  59.12908 63.029518
           Number of Means         6         7         8
           Critical Range  66.052698 68.520029  70.59516
```

```
                AVAILABLE NH4+NO3-N 1990

Means with the same letter are not significantly different.

        SNK Grouping              Mean      N  MONTH

                   A            148.51      5  DEC
                   A
          B        A            113.14      5  SEP
          B        A
          B        A            103.82      6  JUL
          B        A
          B        A            101.96      6  NOV
          B        A
          B        A             95.29      6  JUN
          B        A
          B        A             93.38      4  OCT
          B        A
          B        A             82.63      6  AUG
          B
          B                      71.35      6  MAY
```

```
                              AVAILABLE SRP 1990
                         18:38 Wednesday, July 8, 1992
                        Analysis of Variance Procedure
                           Class Level Information

              Class    Levels    Values
              MONTH         8    AUG DEC JUL JUN MAY NOV OCT SEP
                   Number of observations in data set = 48
NOTE: Due to missing values, only 44 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                    Sum of           Mean
Source                   DF        Squares         Square   F Value     Pr > F
Model                     7    1553.969056     221.995579     27.76     0.0001
Error                    36     287.884442       7.996790
Corrected Total          43    1841.853498
                   R-Square           C.V.       Root MSE         SUBPLOT Mean
                   0.843699       86.73811       2.827860           3.26022727

Dependent Variable: SUBPLOT
Source                   DF       Anova SS    Mean Square   F Value     Pr > F
MONTH                     7    1553.969056     221.995579     27.76     0.0001

         NOTE: This test controls the type I experimentwise error rate under
               the complete null hypothesis but not under partial null
               hypotheses.

                      Alpha= 0.05  df= 36  MSE= 7.99679
                      WARNING: Cell sizes are not equal.
                    Harmonic Mean of cell sizes= 5.333333

           Number of Means         2         3         4         5
           Critical Range  3.5121417 4.2328171 4.6638634 4.9715142
           Number of Means         6         7         8
           Critical Range  5.2099705 5.4045836 5.5682616
```

```
                    AVAILABLE SRP 1990

Means with the same letter are not significantly different.

        SNK Grouping              Mean      N  MONTH

                   A            18.147      6  MAY

                   B             2.162      6  JUN
                   B
                   B             1.148      6  SEP
                   B
                   B             0.938      6  OCT
                   B
                   B             0.585      6  AUG
                   B
                   B             0.577      6  DEC
                   B
                   B             0.283      4  NOV
                   B
                   B             0.245      4  JUL
```

```
                         AG LIVE TISSUE N 1990
                    Analysis of Variance Procedure
                       Class Level Information

              Class    Levels    Values
              MONTH         8    AUG DEC JUL JUN MAY NOV OCT SEP
                 Number of observations in data set = 48
NOTE: Due to missing values, only 42 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                  Sum of           Mean
Source                  DF       Squares         Square   F Value     Pr > F
Model                    6    93.58413333    15.59735556      1.97     0.0967
Error                   35   277.09411667     7.91697476
Corrected Total         41   370.67825000
                  R-Square          C.V.       Root MSE           SUBPLOT Mean
                  0.252467      14.02298       2.813712             20.0650000

Dependent Variable: SUBPLOT
Source                  DF      Anova SS    Mean Square   F Value     Pr > F
MONTH                    6   93.58413333    15.59735556      1.97     0.0967

               Student-Newman-Keuls test for variable: SUBPLOT

          NOTE: This test controls the type I experimentwise error rate under
                the complete null hypothesis but not under partial null
                hypotheses.
                       Alpha= 0.05  df= 35  MSE= 7.916975
 Number of Means        2         3         4         5         6         7
 Critical Range 3.2979739 3.9756043 4.3811047 4.6705887 4.8950485 5.0782193
```

```
                      AG LIVE TISSUE N 1990

     Means with the same letter are not significantly different.

           SNK Grouping              Mean      N  MONTH

                      A            21.843      6  OCT
                      A
                      A            21.355      6  AUG
                      A
                      A            20.573      6  NOV
                      A
                      A            20.338      6  JUL
                      A
                      A            19.867      6  DEC
                      A
                      A            19.605      6  JUN
                      A
                      A            16.873      6  MAY
```

```
                              BG TISSUE N 1990
                        Analysis of Variance Procedure
                           Class Level Information

                 Class     Levels    Values

                 MONTH          8    AUG DEC JUL JUN MAY NOV OCT SEP


                    Number of observations in data set = 48

Dependent Variable: SUBPLOT
                                       Sum of           Mean
Source                      DF        Squares         Square   F Value       Pr > F
Model                        7    117.1846479     16.7406640      2.32       0.0435
Error                       40    288.1295833      7.2032396
Corrected Total             47    405.3142313
                      R-Square           C.V.       Root MSE             SUBPLOT Mean
                      0.289120       20.37394       2.683885               13.1731250

Dependent Variable: SUBPLOT
Source                      DF        Anova SS    Mean Square   F Value       Pr > F
MONTH                        7    117.1846479     16.7406640      2.32       0.0435

                 Student-Newman-Keuls test for variable: SUBPLOT

            NOTE: This test controls the type I experimentwise error rate under
                  the complete null hypothesis but not under partial null
                  hypotheses.

                      Alpha= 0.05  df= 40  MSE= 7.20324

          Number of Means          2         3         4         5
          Critical Range   3.1318433 3.7714964 4.1533949 4.4258151
          Number of Means          6         7         8
          Critical Range   4.6365999 4.8084091 4.9532357
```

```
                     BG TISSUE N 1990

     Means with the same letter are not significantly different.

                 Analysis of Variance Procedure

          SNK Grouping             Mean      N  MONTH

                     A           15.072      6  JUL
                     A
                     A           14.362      6  JUN
                     A
                     A           14.273      6  OCT
                     A
                     A           14.087      6  AUG
                     A
                     A           13.888      6  MAY
                     A
                     A           11.720      6  NOV
                     A
                     A           11.397      6  SEP
                     A
                     A           10.587      6  DEC
```

```
                       AG LIVE TISSUE P 1990
                   Analysis of Variance Procedure
                      Class Level Information

             Class     Levels    Values
             MONTH          8    AUG DEC JUL JUN MAY NOV OCT SEP

               Number of observations in data set = 48
NOTE: Due to missing values, only 42 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                     Sum of          Mean
Source                  DF          Squares        Square   F Value     Pr > F
Model                    6       0.11214762    0.01869127      1.77     0.1340
Error                   35       0.36950000    0.01055714
Corrected Total         41       0.48164762
                  R-Square             C.V.      Root MSE           SUBPLOT Mean
                  0.232842         23.10179      0.102748             0.44476190

Dependent Variable: SUBPLOT
Source                  DF         Anova SS   Mean Square   F Value     Pr > F
MONTH                    6       0.11214762    0.01869127      1.77     0.1340

              Student-Newman-Keuls test for variable: SUBPLOT

         NOTE: This test controls the type I experimentwise error rate under
               the complete null hypothesis but not under partial null
               hypotheses.
                      Alpha= 0.05  df= 35  MSE= 0.010557
 Number of Means          2         3         4         5         6         7
 Critical Range   0.1204317 0.1451766 0.1599842 0.1705553 0.1787519 0.1854407
```

```
                  AG LIVE TISSUE P 1990

Means with the same letter are not significantly different.

              Analysis of Variance Procedure

      SNK Grouping              Mean      N  MONTH

                 A            0.5117      6  OCT
                 A
                 A            0.4833      6  MAY
                 A
                 A            0.4800      6  JUN
                 A
                 A            0.4733      6  DEC
                 A
                 A            0.4150      6  JUL
                 A
                 A            0.3800      6  NOV
                 A
                 A            0.3700      6  AUG
```

```
                    BG TISSUE P 1990
             Analysis of Variance Procedure
                 Class Level Information

       Class    Levels    Values

       MONTH         8    AUG DEC JUL JUN MAY NOV OCT SEP

          Number of observations in data set = 48

NOTE: Due to missing values, only 47 observations can be used in this
      analysis.

Dependent Variable: SUBPLOT
                                  Sum of          Mean
Source                 DF        Squares        Square   F Value     Pr > F
Model                   7     0.05165014    0.00737859      2.87     0.0163
Error                  39     0.10039667    0.00257427
Corrected Total        46     0.15204681
                 R-Square           C.V.      Root MSE          SUBPLOT Mean
                 0.339699       31.50136      0.050737            0.16106383
Dependent Variable: SUBPLOT
Source                 DF       Anova SS   Mean Square   F Value     Pr > F
MONTH                   7     0.05165014    0.00737859      2.87     0.0163

            Student-Newman-Keuls test for variable: SUBPLOT

         NOTE: This test controls the type I experimentwise error rate under
               the complete null hypothesis but not under partial null
               hypotheses.

                    Alpha= 0.05  df= 39  MSE= 0.002574
                    WARNING: Cell sizes are not equal.
                  Harmonic Mean of cell sizes= 5.853659

           Number of Means         2         3         4         5
           Critical Range   0.059989 0.0722545 0.0795805 0.0848069

           Number of Means         6         7         8
           Critical Range  0.0888527 0.0921506 0.0949303
```

```
                      BG TISSUE P 1990

               Analysis of Variance Procedure

Means with the same letter are not significantly different.

        SNK Grouping                  Mean         N  MONTH

                   A                0.2117         6  DEC
                   A
           B       A                0.2017         6  OCT
           B       A
           B       A                0.1833         6  NOV
           B       A
           B       A                0.1600         6  SEP
           B       A
           B       A                0.1483         6  JUN
           B       A
           B       A                0.1333         6  MAY
           B       A
           B       A                0.1300         6  JUL
           B
           B                        0.1120         5  AUG
```

# APPENDIX G
# WATER EXTRACTABLE NH4-N, NO3-N AND SRP

| Site | Depth cm | % dry | Sample WWT g | Sample DWT g | H2O extr. ml | AA concentration NH4 mg/L | AA concentration NO3 mg/L | AA concentration SRP mg/L | Water extractable N/P NH4 mg/kg | Water extractable N/P NO3 mg/kg | Water extractable N/P SRP mg/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MAY 1990 | | | | | | | | | | | |
| Mean | 0-10 | 0.17 | 3.00 | 0.50 | 12.00 | 1.70 | 0.01 | 0.52 | 39.57 | 0.26 | 12.53 |
| | 10-20 | 0.18 | 3.00 | 0.54 | 12.00 | 1.82 | 0.01 | 0.33 | 40.73 | 0.19 | 7.37 |
| | 20-30 | 0.19 | 3.00 | 0.58 | 12.00 | 1.49 | 0.01 | 0.15 | 31.28 | 0.19 | 3.15 |
| S.D. | 0-10 | 0.02 | 0.00 | 0.05 | 0.00 | 0.65 | 0.00 | 0.14 | 11.01 | 0.12 | 3.44 |
| | 10-20 | 0.01 | 0.00 | 0.03 | 0.00 | 0.21 | 0.00 | 0.12 | 6.03 | 0.07 | 3.05 |
| | 20-30 | 0.01 | 0.00 | 0.04 | 0.00 | 0.08 | 0.01 | 0.08 | 3.12 | 0.12 | 1.97 |
| JUN | | | | | | | | | | | |
| Mean | 0-10 | 0.16 | 3.00 | 0.48 | 12.00 | 1.68 | 0.83 | 0.06 | 41.47 | 20.30 | 1.46 |
| | 10-20 | 0.16 | 3.00 | 0.49 | 12.00 | 1.65 | 0.07 | 0.08 | 40.61 | 1.57 | 1.91 |
| | 20-30 | 0.16 | 3.00 | 0.48 | 12.00 | 1.59 | 0.02 | 0.14 | 39.52 | 0.52 | 3.47 |
| S.D. | 0-10 | 0.01 | 0.00 | 0.03 | 0.00 | 0.31 | 0.62 | 0.04 | 5.92 | 14.95 | 0.95 |
| | 10-20 | 0.01 | 0.00 | 0.03 | 0.00 | 0.20 | 0.07 | 0.05 | 5.79 | 1.64 | 1.17 |
| | 20-30 | 0.01 | 0.00 | 0.02 | 0.00 | 0.17 | 0.01 | 0.01 | 4.75 | 0.16 | 0.23 |
| JUL | | | | | | | | | | | |
| Mean | 0-10 | 0.15 | 3.00 | 0.44 | 12.00 | 1.67 | 0.40 | 0.00 | 45.45 | 11.01 | 0.00 |
| | 10-20 | 0.15 | 3.00 | 0.44 | 12.00 | 1.41 | 0.02 | 0.03 | 38.35 | 0.62 | 0.80 |
| | 20-30 | 0.15 | 3.00 | 0.44 | 12.00 | 1.29 | 0.06 | 0.05 | 35.52 | 1.66 | 1.47 |
| S.D. | 0-10 | 0.01 | 0.00 | 0.02 | 0.00 | 0.39 | 0.41 | 0.00 | 10.10 | 11.49 | 0.00 |
| | 10-20 | 0.01 | 0.00 | 0.02 | 0.00 | 0.13 | 0.00 | 0.02 | 3.53 | 0.10 | 0.62 |
| | 20-30 | 0.01 | 0.00 | 0.03 | 0.00 | 0.06 | 0.09 | 0.01 | 3.51 | 2.78 | 0.22 |
| AUG | | | | | | | | | | | |
| Mean | 0-10 | 0.13 | 3.00 | 0.40 | 12.00 | 0.90 | 1.22 | 0.00 | 26.69 | 36.64 | 0.01 |
| | 10-20 | 0.14 | 3.00 | 0.41 | 12.00 | 1.22 | 0.04 | 0.08 | 36.50 | 1.33 | 2.39 |
| | 20-30 | 0.14 | 3.00 | 0.41 | 12.00 | 1.26 | 0.04 | 0.05 | 38.13 | 1.12 | 1.60 |
| S.D. | 0-10 | 0.01 | 0.00 | 0.03 | 0.00 | 0.38 | 0.30 | 0.00 | 11.36 | 10.12 | 0.02 |
| | 10-20 | 0.01 | 0.00 | 0.03 | 0.00 | 0.35 | 0.01 | 0.02 | 12.30 | 0.29 | 0.52 |
| | 20-30 | 0.02 | 0.00 | 0.06 | 0.00 | 0.24 | 0.01 | 0.01 | 10.01 | 0.12 | 0.59 |
| SEP | | | | | | | | | | | |
| Mean | 0-10 | 0.13 | 3.00 | 0.40 | 12.00 | 1.59 | 0.77 | 0.02 | 46.56 | 27.99 | 0.48 |
| | 10-20 | 0.13 | 3.00 | 0.39 | 12.00 | 1.83 | 0.05 | 0.07 | 56.47 | 1.45 | 2.08 |
| | 20-30 | 0.12 | 3.00 | 0.37 | 12.00 | 1.53 | 0.02 | 0.06 | 49.15 | 0.87 | 1.86 |
| S.D. | 0-10 | 0.01 | 0.00 | 0.03 | 0.00 | 1.23 | 0.66 | 0.02 | 34.18 | 21.21 | 0.67 |
| | 10-20 | 0.01 | 0.00 | 0.02 | 0.00 | 0.63 | 0.02 | 0.03 | 19.68 | 0.72 | 0.95 |
| | 20-30 | 0.01 | 0.00 | 0.04 | 0.00 | 0.54 | 0.02 | 0.04 | 16.99 | 0.65 | 1.12 |
| OCT | | | | | | | | | | | |
| Mean | 0-10 | 0.14 | 3.00 | 0.41 | 12.00 | 0.87 | 1.54 | 0.02 | 25.64 | 54.70 | 0.65 |
| | 10-20 | 0.13 | 3.00 | 0.39 | 12.00 | 1.03 | 0.94 | 0.02 | 31.18 | 34.63 | 0.73 |
| | 20-30 | 0.13 | 3.00 | 0.39 | 12.00 | 1.09 | 0.75 | 0.03 | 31.89 | 24.32 | 0.81 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S.D. | 0-10 | 0.00 | 0.00 | 0.01 | 0.00 | 0.49 | 1.28 | 0.02 | 14.71 | 38.05 | 0.65 |
| | 10-20 | 0.01 | 0.00 | 0.02 | 0.00 | 0.84 | 0.68 | 0.02 | 25.19 | 21.72 | 0.68 |
| | 20-30 | 0.02 | 0.00 | 0.05 | 0.00 | 0.97 | 0.84 | 0.03 | 27.40 | 27.54 | 1.05 |
| NOV | | | | | | | | | | | |
| Mean | 0-10 | 0.14 | 3.00 | 0.43 | 12.00 | 0.72 | 2.59 | 0.00 | 20.29 | 72.06 | 0.04 |
| | 10-20 | 0.13 | 3.00 | 0.40 | 12.00 | 0.80 | 0.47 | 0.06 | 23.96 | 16.93 | 1.64 |
| | 20-30 | 0.14 | 3.00 | 0.42 | 12.00 | 1.33 | 0.15 | 0.07 | 37.93 | 5.51 | 2.18 |
| S.D. | 0-10 | 0.01 | 0.00 | 0.03 | 0.00 | 0.18 | 1.03 | 0.00 | 5.36 | 28.73 | 0.06 |
| | 10-20 | 0.01 | 0.00 | 0.02 | 0.00 | 0.49 | 0.32 | 0.03 | 15.06 | 9.85 | 0.92 |
| | 20-30 | 0.03 | 0.00 | 0.08 | 0.00 | 0.40 | 0.24 | 0.03 | 8.63 | 7.32 | 1.10 |
| DEC | | | | | | | | | | | |
| Mean | 0-10 | 0.15 | 3.00 | 0.45 | 12.00 | 0.57 | 4.67 | 0.01 | 17.81 | 123.90 | 0.31 |
| | 10-20 | 0.14 | 3.00 | 0.41 | 12.00 | 0.18 | 1.46 | 0.06 | 7.62 | 42.82 | 1.88 |
| | 20-30 | 0.14 | 3.00 | 0.41 | 12.00 | 0.75 | 0.77 | 0.04 | 20.95 | 23.67 | 1.35 |
| S.D. | 0-10 | 0.01 | 0.00 | 0.03 | 0.00 | 0.36 | 1.15 | 0.02 | 9.12 | 27.02 | 0.43 |
| | 10-20 | 0.01 | 0.00 | 0.03 | 0.00 | 0.17 | 0.38 | 0.02 | 4.38 | 12.29 | 0.62 |
| | 20-30 | 0.02 | 0.00 | 0.06 | 0.00 | 0.61 | 0.58 | 0.03 | 15.48 | 17.21 | 1.03 |

# APPENDIX H
# POTASSIUM CHLORIDE EXTRACTABLE NH4-N AND SRP

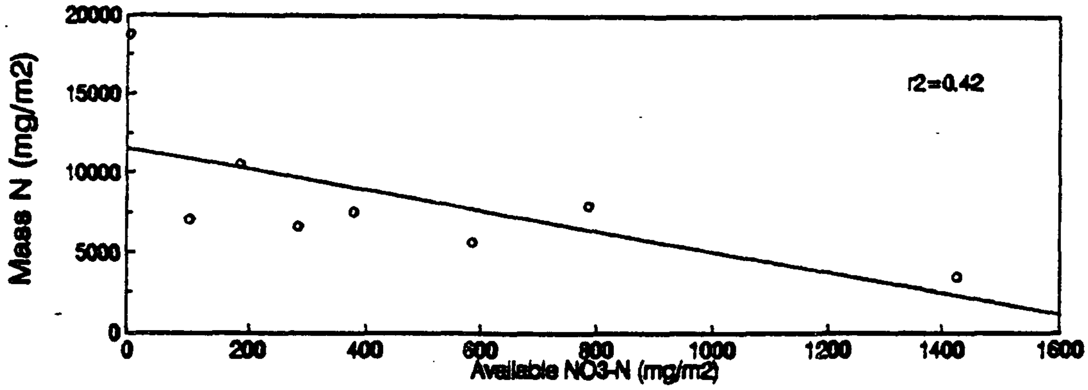
| | | | Sample | Sample | KCl | AA results | | KCl extractable | |
|---|---|---|---|---|---|---|---|---|---|
| | Depth | % | WWT | DWT | extr. | NH4 | SRP | NH4 | SRP |
| Site | cm | dry | g | g | ml | mg/L | mg/L | mg/L | mg/kg |
| MAY | | | | | | | | | |
| Mean | 0-10 | 0.17 | 3.00 | 0.50 | 20.00 | 0.81 | 0.14 | 31.53 | 5.62 |
| | 10-20 | 0.18 | 3.00 | 0.54 | 20.00 | 1.13 | 0.15 | 41.89 | 5.52 |
| | 20-30 | 0.19 | 3.00 | 0.58 | 20.00 | 1.11 | 0.06 | 38.44 | 2.22 |
| S.D. | 0-10 | 0.02 | 0.00 | 0.05 | 0.00 | 0.20 | 0.11 | 5.23 | 11.01 |
| | 10-20 | 0.01 | 0.00 | 0.03 | 0.00 | 0.13 | 0.10 | 4.96 | 6.03 |
| | 20-30 | 0.01 | 0.00 | 0.04 | 0.00 | 0.19 | 0.06 | 4.49 | 3.12 |
| JUN | | | | | | | | | |
| Mean | 0-10 | 0.16 | 3.00 | 0.48 | 20.06 | 0.81 | 0.02 | 33.52 | 0.71 |
| | 10-20 | 0.16 | 3.00 | 0.49 | 20.06 | 1.15 | 0.02 | 47.19 | 0.82 |
| | 20-30 | 0.16 | 3.00 | 0.48 | 20.07 | 1.15 | 0.01 | 48.02 | 0.42 |
| S.D. | 0-10 | 0.01 | 0.00 | 0.03 | 0.10 | 0.16 | 0.02 | 5.03 | 0.75 |
| | 10-20 | 0.01 | 0.00 | 0.03 | 0.10 | 0.20 | 0.03 | 8.71 | 1.01 |
| | 20-30 | 0.01 | 0.00 | 0.02 | 0.18 | 0.26 | 0.01 | 11.31 | 0.24 |
| JUL | | | | | | | | | |
| Mean | 0-10 | 0.15 | 3.00 | 0.44 | 20.13 | 1.04 | 0.00 | 47.36 | 0.16 |
| | 10-20 | 0.15 | 3.00 | 0.44 | 20.00 | 1.02 | 0.00 | 46.14 | 0.15 |
| | 20-30 | 0.15 | 3.00 | 0.44 | 20.02 | 0.97 | 0.02 | 44.24 | 0.75 |
| S.D. | 0-10 | 0.01 | 0.00 | 0.02 | 0.12 | 0.52 | 0.01 | 22.98 | 0.28 |
| | 10-20 | 0.01 | 0.00 | 0.02 | 0.00 | 0.14 | 0.00 | 6.09 | 0.17 |
| | 20-30 | 0.01 | 0.00 | 0.03 | 0.05 | 0.13 | 0.03 | 4.95 | 1.48 |
| AUG | | | | | | | | | |
| Mean | 0-10 | 0.13 | 3.00 | 0.40 | 20.03 | 0.39 | 0.01 | 19.30 | 0.58 |
| | 10-20 | 0.14 | 3.00 | 0.41 | 20.00 | 0.91 | 0.03 | 45.45 | 1.30 |
| | 20-30 | 0.14 | 3.00 | 0.41 | 20.10 | 1.05 | 0.01 | 52.73 | 0.41 |
| S.D. | 0-10 | 0.01 | 0.00 | 0.03 | 0.06 | 0.23 | 0.00 | 11.34 | 0.25 |
| | 10-20 | 0.01 | 0.00 | 0.03 | 0.00 | 0.25 | 0.02 | 14.24 | 1.24 |
| | 20-30 | 0.02 | 0.00 | 0.06 | 0.15 | 0.15 | 0.01 | 9.82 | 0.36 |
| SEP | | | | | | | | | |
| Mean | 0-10 | 0.13 | 3.00 | 0.40 | 20.29 | 0.77 | 0.01 | 37.18 | 0.67 |
| | 10-20 | 0.13 | 3.00 | 0.39 | 20.09 | 1.10 | 0.02 | 57.32 | 0.76 |
| | 20-30 | 0.12 | 3.00 | 0.37 | 20.06 | 1.10 | 0.01 | 59.04 | 0.47 |
| S.D. | 0-10 | 0.01 | 0.00 | 0.03 | 0.33 | 0.92 | 0.01 | 42.46 | 0.31 |
| | 10-20 | 0.01 | 0.00 | 0.02 | 0.14 | 0.34 | 0.01 | 20.34 | 0.33 |
| | 20-30 | 0.01 | 0.00 | 0.04 | 0.14 | 0.31 | 0.01 | 16.85 | 0.33 |

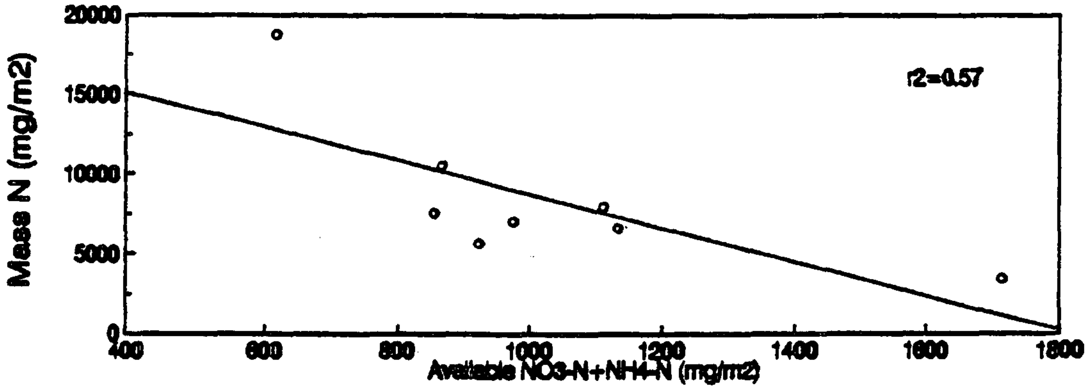
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| OCT | | | | | | | | | |
| Mean | 0-10 | 0.14 | 3.00 | 0.41 | 20.00 | 0.10 | 0.01 | 4.99 | 0.28 |
| | 10-20 | 0.13 | 3.00 | 0.39 | 20.00 | 0.34 | 0.00 | 16.48 | 0.02 |
| | 20-30 | 0.13 | 3.00 | 0.39 | 20.00 | 0.96 | 0.00 | 47.08 | 0.04 |
| S.D. | 0-10 | 0.00 | 0.00 | 0.01 | 0.00 | 0.06 | 0.00 | 2.82 | 0.12 |
| | 10-20 | 0.01 | 0.00 | 0.02 | 0.00 | 0.37 | 0.00 | 17.33 | 0.03 |
| | 20-30 | 0.02 | 0.00 | 0.05 | 0.00 | 0.55 | 0.00 | 21.61 | 0.11 |
| NOV | | | | | | | | | |
| Mean | 0-10 | 0.14 | 3.00 | 0.43 | 20.00 | 0.21 | 0.00 | 9.61 | 0.15 |
| | 10-20 | 0.13 | 3.00 | 0.40 | 20.00 | 0.31 | 0.00 | 15.33 | 0.09 |
| | 20-30 | 0.14 | 3.00 | 0.42 | 20.00 | 0.78 | 0.00 | 36.11 | 0.12 |
| S.D. | 0-10 | 0.01 | 0.00 | 0.03 | 0.00 | 0.06 | 0.00 | 2.26 | 0.17 |
| | 10-20 | 0.01 | 0.00 | 0.02 | 0.00 | 0.31 | 0.00 | 15.76 | 0.23 |
| | 20-30 | 0.03 | 0.00 | 0.08 | 0.00 | 0.37 | 0.00 | 13.92 | 0.21 |
| DEC | | | | | | | | | |
| Mean | 0-10 | 0.15 | 3.00 | 0.45 | 20.00 | 0.17 | 0.01 | 7.40 | 0.27 |
| | 10-20 | 0.14 | 3.00 | 0.41 | 20.00 | 0.07 | 0.00 | 3.23 | 0.06 |
| | 20-30 | 0.14 | 3.00 | 0.41 | 20.00 | 0.44 | 0.00 | 19.31 | 0.02 |
| S.D. | 0-10 | 0.01 | 0.00 | 0.03 | 0.00 | 0.07 | 0.01 | 2.72 | 0.25 |
| | 10-20 | 0.01 | 0.00 | 0.03 | 0.00 | 0.06 | 0.00 | 2.68 | 0.12 |
| | 20-30 | 0.02 | 0.00 | 0.06 | 0.00 | 0.62 | 0.00 | 24.82 | 0.05 |

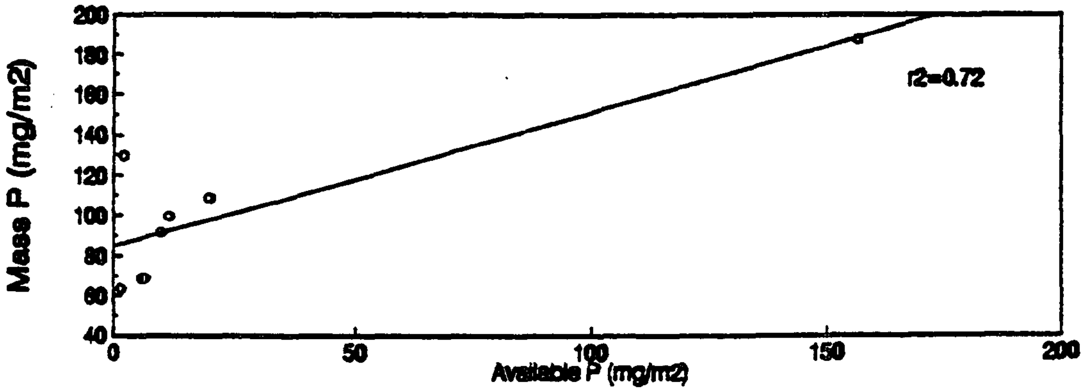
## APPENDIX I
## PLANT TISSUE CONCENTRATION AND BIOMASS N AND P

| Plant Part | Parameter | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|
| AG Live | N mg/g | 16.9 | 19.6 | 20.3 | 21.4 | 22.8 | 21.8 | 20.6 | 19.9 |
| | Bio g/m2 | 16.7 | 14.0 | 10.3 | 26.8 | 17.5 | 37.6 | 58.4 | 22.8 |
| | Tot N mg/m2 | 281.3 | 275.1 | 209.2 | 571.9 | 399.1 | 822.1 | 1202.4 | 453.2 |
| AG Dead | N mg/g | 15.4 | 15.5 | 14.2 | 17.0 | 17.0 | 16.0 | 15.7 | 14.2 |
| | Bio g/m2 | 20.3 | 18.6 | 14.7 | 24.2 | 13.8 | 21.5 | 24.9 | 30.6 |
| | Tot N mg/m2 | 312.3 | 289.1 | 208.0 | 412.4 | 235.2 | 344.5 | 391.8 | 432.8 |
| BG 0-10 | N mg/g | 13.9 | 14.4 | 15.1 | 14.1 | 11.4 | 14.3 | 11.7 | 10.6 |
| | Bio g/m2 | 1080.8 | 542.0 | 386.1 | 403.9 | 443.0 | 271.8 | 459.3 | 170.9 |
| | Tot N mg/m2 | 15010.9 | 7783.9 | 5818.2 | 5689.3 | 5047.9 | 3880.1 | 5382.6 | 1808.9 |
| BG 10-20 | N mg/g | 7.6 | 10.4 | 7.1 | 8.3 | 7.7 | 6.0 | 6.8 | 6.8 |
| | Bio g/m2 | 328.0 | 160.8 | 76.5 | 74.6 | 83.9 | 71.0 | 115.6 | 57.5 |
| | Tot N mg/m2 | 2502.1 | 1666.3 | 539.8 | 616.7 | 649.7 | 423.6 | 784.7 | 393.5 |
| BG 20-30 | N mg/g | 6.5 | 7.1 | 7.1 | 8.1 | 8.0 | 6.4 | 6.2 | 6.7 |
| | Bio g/m2 | 101.4 | 72.0 | 40.1 | 34.4 | 36.1 | 28.6 | 27.2 | 55.6 |
| | Tot N mg/m2 | 657.7 | 507.8 | 285.2 | 278.0 | 286.8 | 182.9 | 169.2 | 371.2 |
| BG AVG | N mg/g | 9.3 | 10.6 | 9.8 | 10.1 | 9.0 | 8.9 | 8.2 | 8.0 |
| TOTAL | Bio g/m2 | 1510.2 | 774.8 | 502.6 | 512.9 | 562.9 | 371.4 | 602.0 | 284.0 |
| TOTAL | Tot N mg/m2 | 18170.8 | 9958.1 | 6643.3 | 6584.0 | 5984.4 | 4486.6 | 6336.5 | 2573.7 |
| AG Live | P mg/g | 0.5 | 0.5 | 0.4 | 0.4 | 0.6 | 0.5 | 0.4 | 0.5 |
| | Bio g/m2 | 16.7 | 14.0 | 10.3 | 26.8 | 17.5 | 37.6 | 58.4 | 22.8 |
| | Tot P mg/m2 | 8.1 | 6.7 | 4.3 | 9.9 | 10.1 | 19.2 | 22.2 | 10.7 |
| AG Dead | P mg/g | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 |
| | Bio g/m2 | 20.3 | 18.6 | 14.7 | 24.2 | 13.8 | 21.5 | 24.9 | 30.6 |
| | Tot P mg/m2 | 4.2 | 3.9 | 2.7 | 4.9 | 3.3 | 7.0 | 5.1 | 6.7 |
| BG 0-10 | P mg/g | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 |
| | Bio g/m2 | 1080.8 | 542.0 | 386.1 | 403.9 | 443.0 | 271.8 | 459.3 | 170.9 |
| | Tot P mg/m2 | 144.4 | 80.8 | 50.3 | 45.3 | 71.1 | 55.0 | 83.3 | 36.1 |
| BG 10-20 | P mg/g | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| | Bio g/m2 | 328.0 | 160.8 | 76.5 | 74.6 | 83.9 | 71.0 | 115.6 | 57.5 |
| | Tot P mg/m2 | 23.7 | 12.3 | 4.2 | 6.1 | 10.7 | 9.1 | 17.1 | 7.0 |
| BG 20-30 | P mg/g | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 |
| | Bio g/m2 | 101.4 | 72.0 | 40.1 | 34.4 | 36.1 | 28.6 | 27.2 | 55.6 |
| | Tot P mg/m2 | 7.6 | 4.9 | 2.9 | 3.2 | 4.7 | 2.0 | 2.7 | 8.8 |
| BG AVG | P mg/g | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 |
| TOTAL | Bio g/m2 | 1510.2 | 774.8 | 502.6 | 512.9 | 562.9 | 371.4 | 602.0 | 284.0 |
| TOTAL | Tot P mg/m2 | 175.8 | 98.0 | 57.4 | 54.6 | 86.5 | 66.0 | 103.1 | 51.9 |

# APPENDIX J
# SOIL AVAILABLE N AND P VS PLANT BIOMASS N AND P







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