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WETLAND MACROPHYTE PRODUCTION AND HYDRODYNAMICS IN HOPKINS PRAIRIE, OCALA NATIONAL FOREST, FLORIDA

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WETLAND MACROPHYTE PRODUCTION AND HYDRODYNAMICS IN HOPKINS PRAIRIE, OCALA NATIONAL FOREST, FLORIDA

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EXECUTIVE SUMMARY

Hopkins Prairie is located in the Ocala National Forest approximately 5 miles SSW of the town of Salt Springs, Marion County, in north central Florida. This wetland is considered a wet prairie (Snedaker and Lugo 1972), classified by the U.S. Fish and Wildlife Service as a persistent emergent wetland with organic soil (Cowardin et al 1979). The water regime is characterized by cyclic periods of flooded and drained conditions. The St. John's River Water Management District (SJRWMD) has identified Hopkins Prairie as the site for a long term research project to examine the effects of hydrology on wetland ecological functions. The present study examines the effects of hydrology and season on plant biomass production and species composition. The purposes of this phase of the research were (1) to estimate net above ground primary production of aquatic plants; (2) to evaluate the effects of variation in water levels on aquatic plant production; and (3) to test an alternative technique for examining below ground plant biomass dynamics. Monthly measurements were made of water level, above and below ground biomass, and plant species composition at a 10 m X 18 m study plot in Hopkins Prairie. Data were collected from March 1989 through February 1990.

Water levels at Hopkins prairie showed seasonal variation with lowest levels recorded during the period May through June (mean 0.8 cm) and highest levels during September through November (mean 33.4 cm). Highest plant biomass was recorded during the early summer growing season (June and July) when water levels were low. Two net primary productivity peaks, one in early summer and one in late fall, were recorded. These peaks corresponded to periods of water level changes. The summer productivity peak occurred during a period of decreasing water level and was accompanied by an increase in above ground dead biomass. Above ground live biomass during this period peaked after a 'lag' period (one month after lowest recorded water levels). These biomass changes were accompanied by a shift in species dominance from water tolerant species (Nymphaea odorata and Eriocaulon compressum) to less water tolerant species (Rhynchospora inundata) favoring drained conditions. The fall

productivity peak was also accompanied by a shift in species dominance. Water levels increased during this period and were accompanied by a shift to species favoring flooded conditions. Again, the above ground live component peaked after a lag period, one month after highest recorded water levels.

These data suggest that biomass changes resulted from the combined effects of water depth, season and species dominance changes. In early summer, upon draw down from flooded conditions to drained conditions, the more aquatic species died back (increase in the above ground dead component) and were replaced following an adjustment period by species favoring drained conditions (increase in the above ground live after a lag period). With re-flooding in late fall, water tolerant species returned.

Using sequential biomass sampling (monthly standing crop measurements), annual net primary productivity for Hopkins Prairie ranged from 29.2 g m^{-2} yr^{-1} to 135.1 g m^{-2} yr^{-1}. These values compare slightly lower than for similar studies on other wetlands in the southeastern United States (Boyd and Vickers 1971, Shew et al 1981, Twilley et al 1985 and Kaswadji et al 1990). This difference may be due to the oligotrophic (nutrient-poor) nature of Hopkins Prairie. Oligotrophic systems generally exhibit low primary productivity because of low concentrations of dissolved nutrients (Wetzel 1983).

An alternative method for measuring below ground biomass was investigated. Root-free soil cores constructed of porous material and containing various growth media were inserted into the soil. Monthly removal and measurement of root ingrowth into these cores revealed widely varying results. Results from sand and vermiculite filled nylon cores were closest to actual below ground biomass measurements collected in the field (the cores showed lower values); however, these data suggest that this method may not provide a consistent alternative to field sampling at Hopkins Prairie.

Water level measurements collected since the end of this study (March through August 1990) have been consistently lower than for the same period in 1989. During the period May through August 1990 drained conditions have persisted; where as, during this period in 1989, flooded conditions predominated. These data suggest that water levels may not fluctuate on a repeatable annual cycle. Further study is warranted to investigate the effects of hydrology on plant community dynamics at Hopkins Prairie over the long term.

WETLAND MACROPHYTE PRODUCTION AND HYDRODYNAMICS IN HOPKINS PRAIRIE, OCALA NATIONAL FOREST, FLORIDA

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INTRODUCTION

Recent concern about wetlands has focussed on the role of wetlands in water storage and groundwater recharge (LaBaugh 1986 and Mitsch and Gosselink 1986), pollutant removal (Kadlec 1987, Nichols 1983 and van der Valk et al 1978) and wildlife habitat (Weller 1978). These attributes of wetland ecosystems depend on the relationship between hydrology and ecological processes (LaBaugh 1986). The St. Johns River Water Management District has undertaken a research project to investigate ecological functions of wetlands in relation to hydrology (SJRWMD 1985). Hopkins Prairie (a wet prairie), located in the Ocala National Forest, Florida, has been chosen as a long-term ecological research site for this purpose. The present study examines the effects of hydrology and season on plant biomass production and species composition. The purposes of this phase of the research were (1) to estimate net above ground primary production of aquatic plants; (2) to evaluate the effects of variation in water levels on aquatic plant production; and (3) to test an alternative technique for examining below ground plant biomass dynamics.

Wetlands generally exhibit high productivity, combining energy sources of both terrestrial and aquatic environments (Odum 1983). Primary productivity can be represented by the following equation:

NET PRODUCTION + RESPIRATION = GROSS PRODUCTION

Hutchinson, in Lindeman (1942) defines productivity as the total rate of energy flow into a trophic level. Odum (1971) defines primary productivity of an ecosystem as the rate of photo- and chemosynthesis by which radiant energy is converted to organic substances by primary producers (mainly green plants). Using the concept of energy production, which may be measured as biomass, nutrients, carbon etc., Colinvaux (1986) defines gross primary production as the amount of plant biomass produced plus the energy which was used to produce it (respiration). Net primary production can then be defined as the biomass produced in excess of

respiration during production. By collecting sequential (monthly) measurements of standing crop, net primary production can be calculated as biomass changes per unit area per unit time (grams dry weight per m^2 per day). However, gross primary production measurements can not be calculated because data on respiration are not available. Sequential biomass sampling also does not account for loss through decomposition.

Past macrophyte productivity studies have focused on above ground productivity while ignoring below ground production (Mason and Bryant 1975 and Peverly 1985). Growth and senescence of rooted plants occurs above ground (shoots, stems and leaves) and below ground (roots, rhizomes etc.). Studies which attempt to quantify biomass of rooted plants should include both above and below ground measurements. Methods for the measurement of above ground biomass are well refined. Replicate samples harvested from a grid with sequential sampling of standing crop can provide information on above ground net primary productivity, when decomposition between sampling intervals is assumed to be minimal. Shew et al (1981) outlines five commonly used methods for estimating net primary productivity using sequential standing crop measurements. However, numerous technical limitations such as sample timing, decomposition and sampling variability make it difficult to obtain accurate below ground biomass estimates (Barbour et al. 1987) and results of studies have varied widely (Mitsch and Gosselink 1986).

An alternative technique for estimating root biomass production was also investigated. Joslin and Henderson (1984) used an "ingrowth core" method for a totally independent measure of root production. The method involved insertion of root-free soil cores, enclosed in mesh containers, into identically sized holes in the existing soil. Cores were excavated at varying intervals and ingrowth of roots measured. Root masses measured were used as an estimate of root production for a given time interval.

METHODS

Study Site Description

Hopkins Prairie is located in the Ocala National Forest approximately 5 miles SSW of the town of Salt Springs, Marion County, in north central Florida (Figure 1).

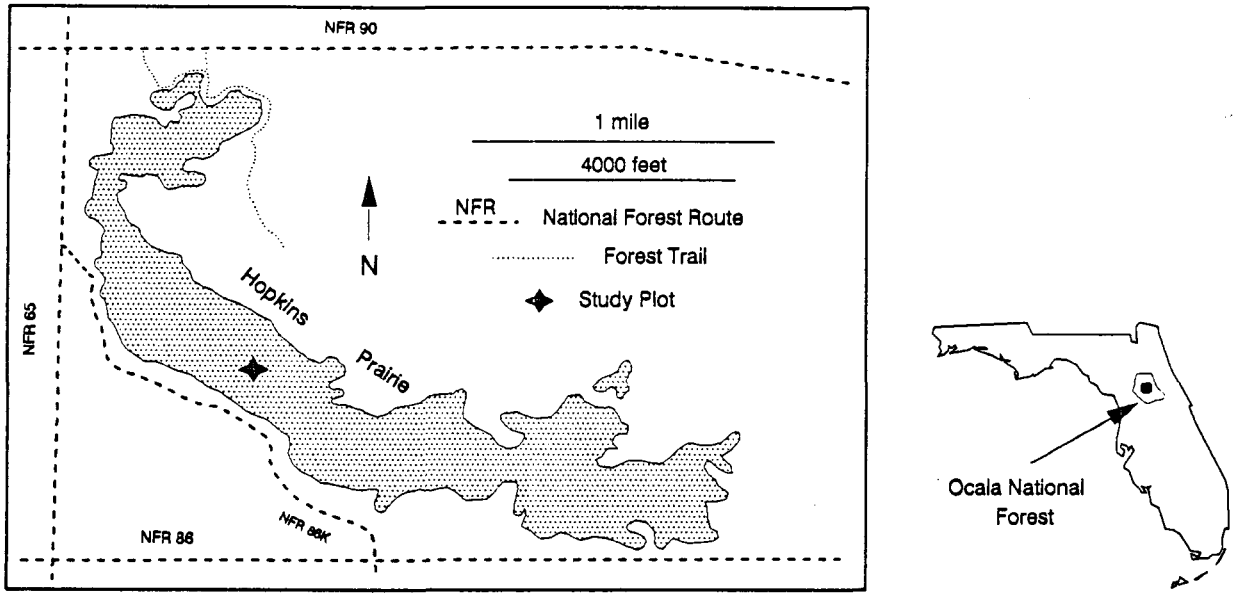

Figure 1. Study site of wetland hydrodynamics and macrophyte production study at Hopkins Prairie, Ocala National Forest, Florida. March 1989 - February 1990.

Above and below ground plant biomass

Three study plots were established (one for above and below ground biomass sampling and two for the root production core study) in a wet prairie plant community typical of much of the prairie. Six biomass samples were collected monthly from a study plot 10 m X 18 m. The plot was divided into six subplots 3 m X 10 m. Each subplot was further divided into 30 sampling sites 1 m^2. Monthly sampling of macrophyte biomass consisted of six replications, one from each subplot. The root production core study was conducted in two 16 m X 16 m sites, one north and one south of, and directly adjacent to, the biomass study plot.

Biomass was measured monthly in one randomly chosen site in each of the subplots (due to the method of biomass removal for laboratory processing as described below, no site was sampled more than once). A 25 cm X 25 cm metal sample frame was placed 10 cm deep into the soil at each sample site. A hand pump was used to remove the water from inside the sampling frame after recording water depth. Percent cover was recorded for each species in the frame. The top 10 cm of soil with attached above ground biomass was removed. This sample

represented the above ground to -10 cm biomass. The sample was sieved through a U.S. Standard #14 sieve. The sieved material was quartered and one of the quarter samples was processed for biomass calculations. All plant biomass was removed from the quarter samples using forceps. The plant samples were dried at 40° C for 72 hours and dry weights recorded.

After the above ground to - 10 cm sample was removed, a soil corer was used to remove a 12 cm diameter core sample 20 cm deep. This sample was divided to represent below ground biomass at 10-20 cm and 20-30 cm depths. Samples were sieved and all root materials oven-dried as described above. Water depth was measured in centimeters from the top of the water table to the soil surface. Under drained conditions, the water table was allowed to equilibrate inside the hole excavated by the below ground biomass sampling.

One of the greatest limitations of any measurement of root systems is the difficulty in separating roots from soil (Glinski and Lipiec 1990). Methods for determining root biomass have been developed for plants growing in mineral soils in which root materials are easily distinguished from the soils (Barraclough 1989, Ward et al 1978 and Whigham et al 1989). Van der Maarel and Totlyanoda (1989) used a red dye to color live and dead root tissue, providing a means to easily separate root biomass. Shipley (1989) measured root growth by uprooting and washing the roots of plants grown in potting soil in a green house. However, the roots may be difficult to separate from the organic soil component under field conditions. The method of sieving and hand picking below ground biomass samples can be used under these conditions (Montague and Day 1980 and Symbula and Day 1988).

Primary productivity

Net primary productivity was calculated by combining above ground live and above ground dead biomass. Values are expressed as changes in dry weight per m^2 per day, calculated exclusive of biomass loss to decomposition; therefore, reported values may be underestimates of actual productivity. During 1989, above ground biomass was combined with the below ground 0-10 cm biomass; therefore, total biomass measurements represent all above and below ground plant biomass to a depth of -10 m. In order to estimate net primary productivity of the above ground component during this period, an estimate of the above ground biomass was necessary. Beginning in March 1990, total biomass measurements were separated into above ground live and

dead, and below ground 0-10 components by harvesting and separating the above ground components in the field before the below ground 0-10 cm sample was removed. Allocation of above and below ground biomass during the period March through June 1990 was used to estimate above ground biomass during the study period. Monthly total biomass (above ground to -10 cm depth) (Appendix 1), species composition (Appendix 2) and water levels (Appendix 3) during the March through June periods for 1989 and 1990 were similar. This assumes that site conditions, species composition and total biomass were similar for each year; it was assumed that biomass allocation would also be similar. Caution is recommended when interpreting the 1989 primary productivity measurements since they are not based on biomass allocation during 1989.

Root production core study

The "ingrowth core" method as described by Joslin and Henderson (1984) was used to complement field data on below ground plant biomass production. In the root production subplot to the south of the biomass study plot, 16 cores of growth media were plugged into the existing peat soil. Each core sample was contained in a cylindrical sleeve or "sock", 50 cm X 5 cm, made of standard fiberglass window screening. Socks were filled with one of the following media: construction sand, commercial peat, perlite, or vermiculite. Socks were filled to within 5 cm of top and stapled closed, four replicates of each media were used. Pore space, bulk density, compaction, consistency, texture and structure may affect root growth (Glinski and Lipiec 1990). The above four media types were used in order to test a range of soil physical properties. Four rows of four holes each were created, one meter apart, by pushing a length of two inch diameter PVC pipe into the peat substrate. Soil socks were frozen to facilitate insertion and placed in an alternating pattern as follows:

(P= peat, V= vermiculite, S= sand, L= perlite)

P -- V -- S -- L
L -- P -- V -- S
S -- L -- P -- V
V -- S -- L -- P

In the root production subplot to the north of the biomass study plot, an identical arrangement of 16 cores of the four media was established. However, nylon "socks" were used instead of fiberglass socks. In order to maintain a 5 cm diameter, each nylon sock was placed inside a 50 cm length of 2 inch diameter PVC pipe, filled with test material and tied shut. After

core holes were punched into the soil with PVC, as above, pipes containing nylon socks were inserted to a depth of 45-50 cm. Using smaller diameter pipe as a piston, socks were held in place and the PVC "sleeve" was removed. One row, containing one each of the four media samples, was harvested every 30 days from both test plots. Socks were removed with a posthole digger to include surrounding soil. External plant roots and soil material were sheared away from test socks with scissors. Sample socks were processed in the laboratory by cutting open and placing the contents in a water filled picking tray. New roots were removed from test media with forceps and magnifying lens.

RESULTS

Above and below ground plant biomass

Total biomass (above plus below ground of all species combined) was highest in December (Figure 2). However, this high biomass measurement was due to the inclusion of a single large Nymphaea odorata rhizome in the below ground sample of subplot #4. Data were trimmed by excluding the December sampling of subplot #4 (Figure 3). Considering the trimmed data, total biomass was greatest in June and July and lowest in January/February (January and February are combined because January was not sampled) and March. Average total biomass values for these periods were 880.00 g m^{-2} and 363.42 g m^{-2}, respectively. Above and below ground biomass of the species present at the study site are listed in Appendix 5. Above and below ground biomass averaged 37% and 63%, respectively (Appendix 6).

Above ground biomass ranged from 70.08 g m^{-2} in March to 441.98 g m^{-2} in June (Figure 4). Below ground biomass (trimmed means) ranged from a low of 187.81 g m^{-2} in March to 566.44 g/m^2 in July.

Lowest water levels occurred in May and June, averaging 0.8 cm in depth. Highest water levels were recorded during September, October and November, averaging 33.4 cm. Rhynchospora inundata was present in the study site from June through January/February, with peak cover values in August (Figure 5) and peak biomass in September. Nymphaea odorata occurred throughout the study period, with highest percent cover in November and biomass in July. Eriocaulon compressum and Eleocharis elongata cover estimates were also greatest in November with peak biomass in January/February and November, respectively.

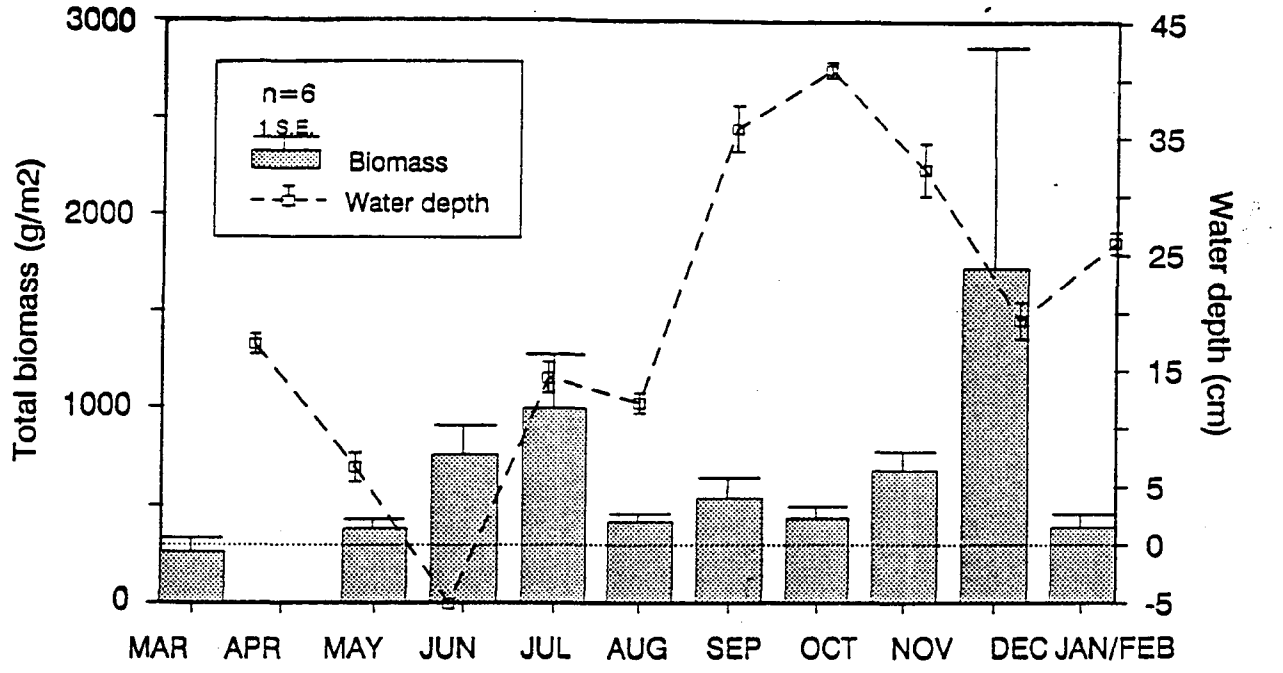

Figure 2. Mean total plant biomass (above plus below ground), and mean water depth at Hopkins Prairie study site, Florida. March 1989 - February 1990.

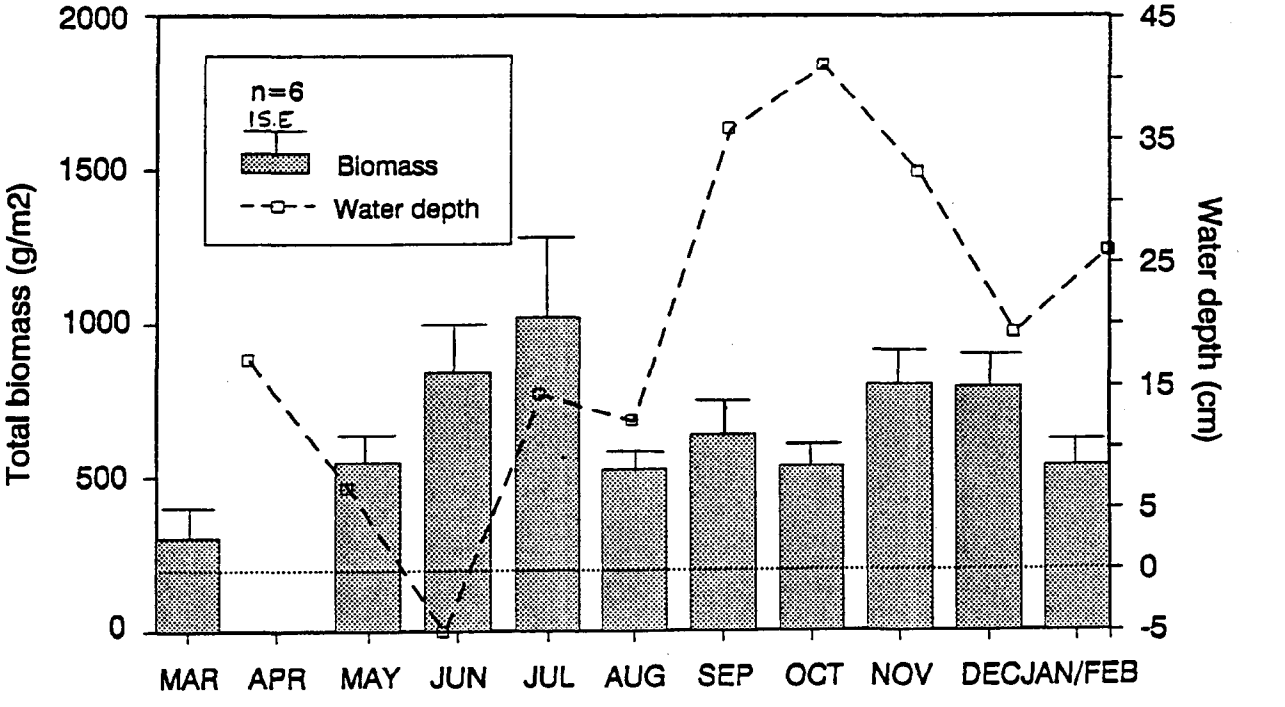

Figure 3. Trimmed mean (omission of one sample date containing extreme outlier) total plant biomass (above plus below ground), and mean water depth at Hopkins Prairie study site, Florida. March 1989 - February 1990.

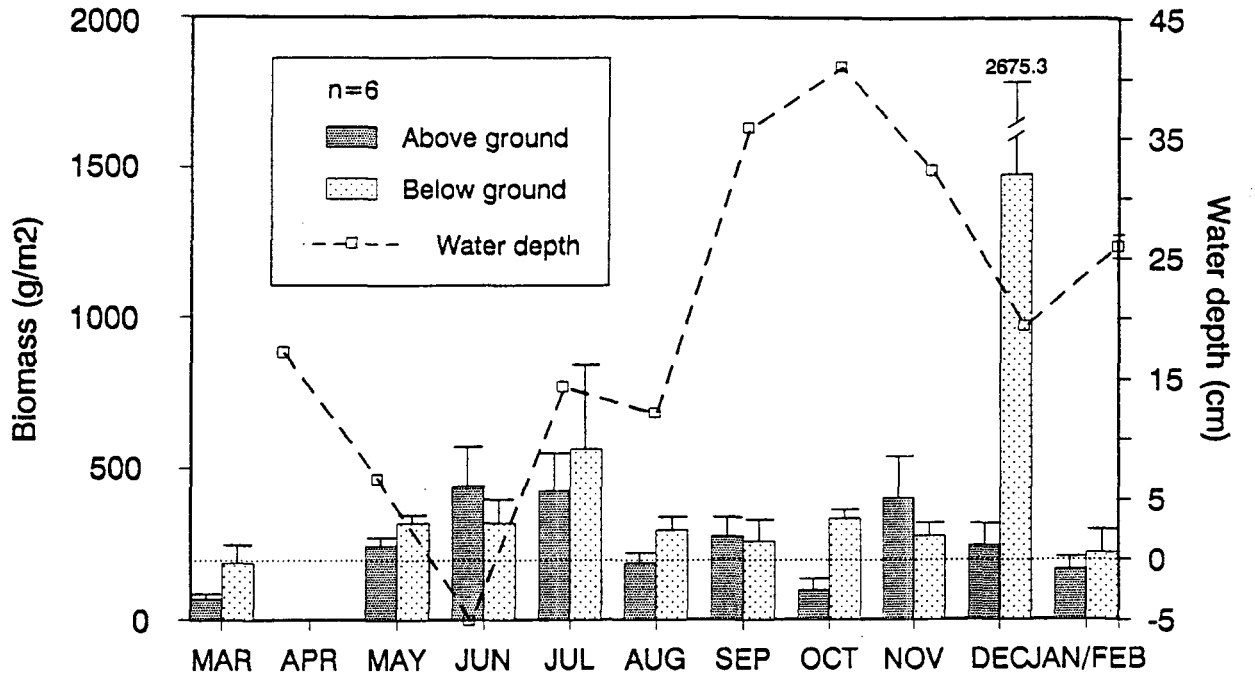

Figure 4. Mean above and below ground plant biomass, and mean water depth at Hopkins Prairie study site, Florida. March 1989 - February 1990.

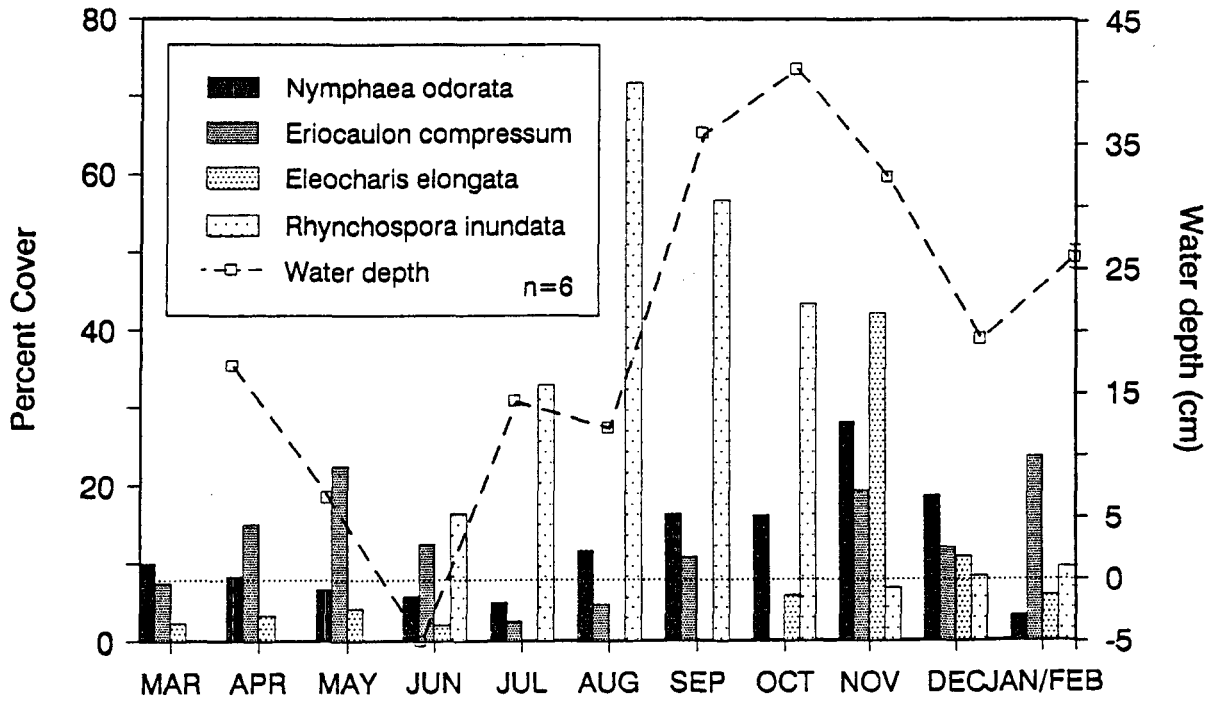

Figure 5. Mean perent cover of plant species, and mean water depth at Hopkins Prairie study site, Florida. March 1989 - February 1990.

Primary productivity

Above ground and below ground (0-10 cm) biomass averaged 2.4% and 97.6%, respectively, of the total biomass during 1990 (March through June). These allocation values were applied to the 1989 biomass measurements (March 1989 through February 1990). Net above ground primary productivity during 1989 showed two peak periods, one during June and July averaging 0.37 g m^{-2} day^{-1} and another during November averaging 0.26 g m^{-2} day^{-1} (Figure 6). Using Peak Standing crop (Shew et al 1981) these correspond to annual net primary productivities of 135.1 g m^{-2} yr^{-1} and 94.9 g m^{-2} yr^{-1}, respectively. These high productivity periods were separated by low productivity periods. Average low produtivity of 0.15 g m^{-2} day^{-1} (54.8 g m^{-2} yr^{-1}) and 0.08 g m^{-2} day^{-1} (29.2 g m^{-2} yr^{-1}) occurred during the periods August through October and January through March, respectively. Above ground live biomass production was greatest in July and November with average values of 0.12 and 0.09 g m^{-2} day^{-1}, respectively.

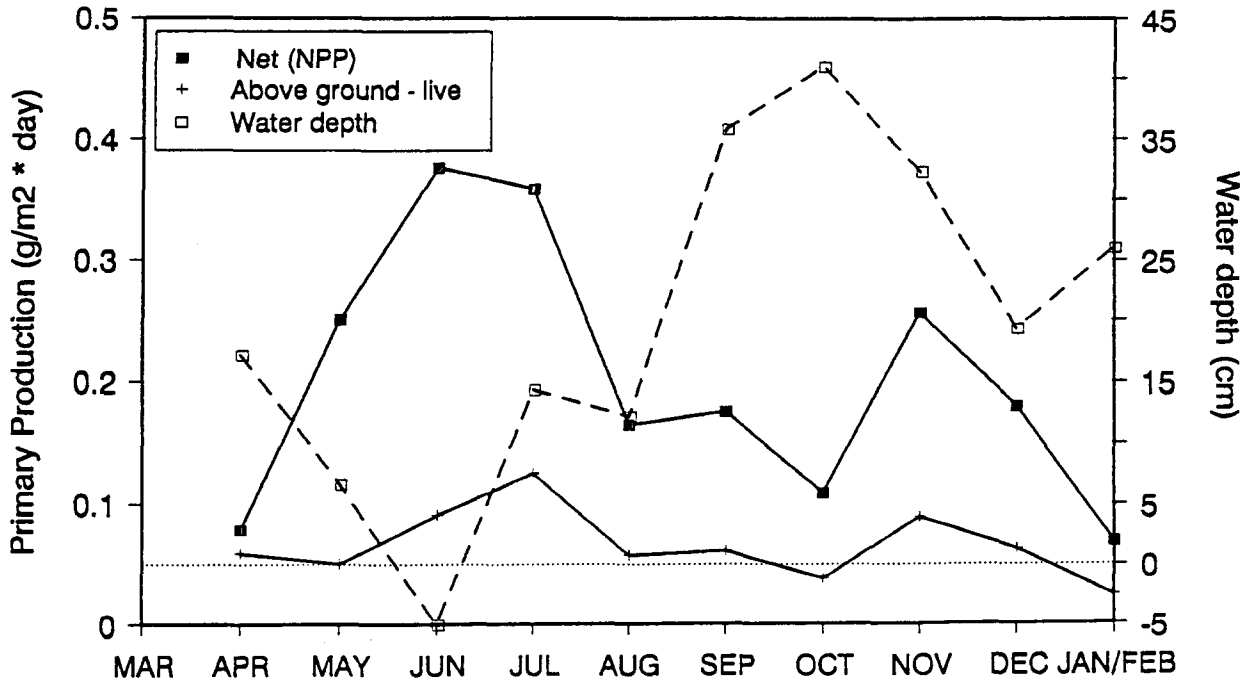

Figure 6. Approximation of mean above ground net primary productivity, and mean water depth at Hopkins Prairie study site, Florida. March 1989 - February 1990.

Root production core study

All socks showed root ingrowth during the first 30 days (Table 1). Overall, nylon socks gained root ingrowth quicker and had greater biomass production than fiberglass socks. Sand, peat, and vermiculite media supported the greatest ingrowth at both sites (Figure 7). Growth into sand filled nylon socks and vermiculite filled nylon socks showed a similar trend to average below ground biomass from the biomass study site from September through December 1989 (Figure 8).

Table 1. Root growth into sock cores of below ground plant biomass study at Hopkins Prairie, Florida. July - December 1989.

Sock type/# days	Sand	Peat	Perlite	Vermiculite	
NYLON SOCKS					
30	0.007	0.076	0.003	0.130	Total grams
	3.57	66.23	1.53	66.23	g/m^2
60	0.587	0.516	0.009	1.056	
	299.02	262.85	4.58	537.93	
90	0.197	0.304	0.052	0.177	
	100.35	154.86	26.49	90.16	
120	0.617	0.048	0.026	0.397	
	314.30	24.45	13.24	202.23	
FIBERGLASS SOCKS					
30	0.012	0.017	0.073	0.006	Total grams
	6.11	8.66	37.19	3.06	g/m^2
60	0.087	0.363	0.018	0.301	
	44.32	184.91	9.17	153.33	
90	0.206	0.624	0.004	0.349	
	104.94	6.00	2.04	177.78	
120	0.022	0.125	0.003	0.001	
	11.21	63.68	1.53	0.51	

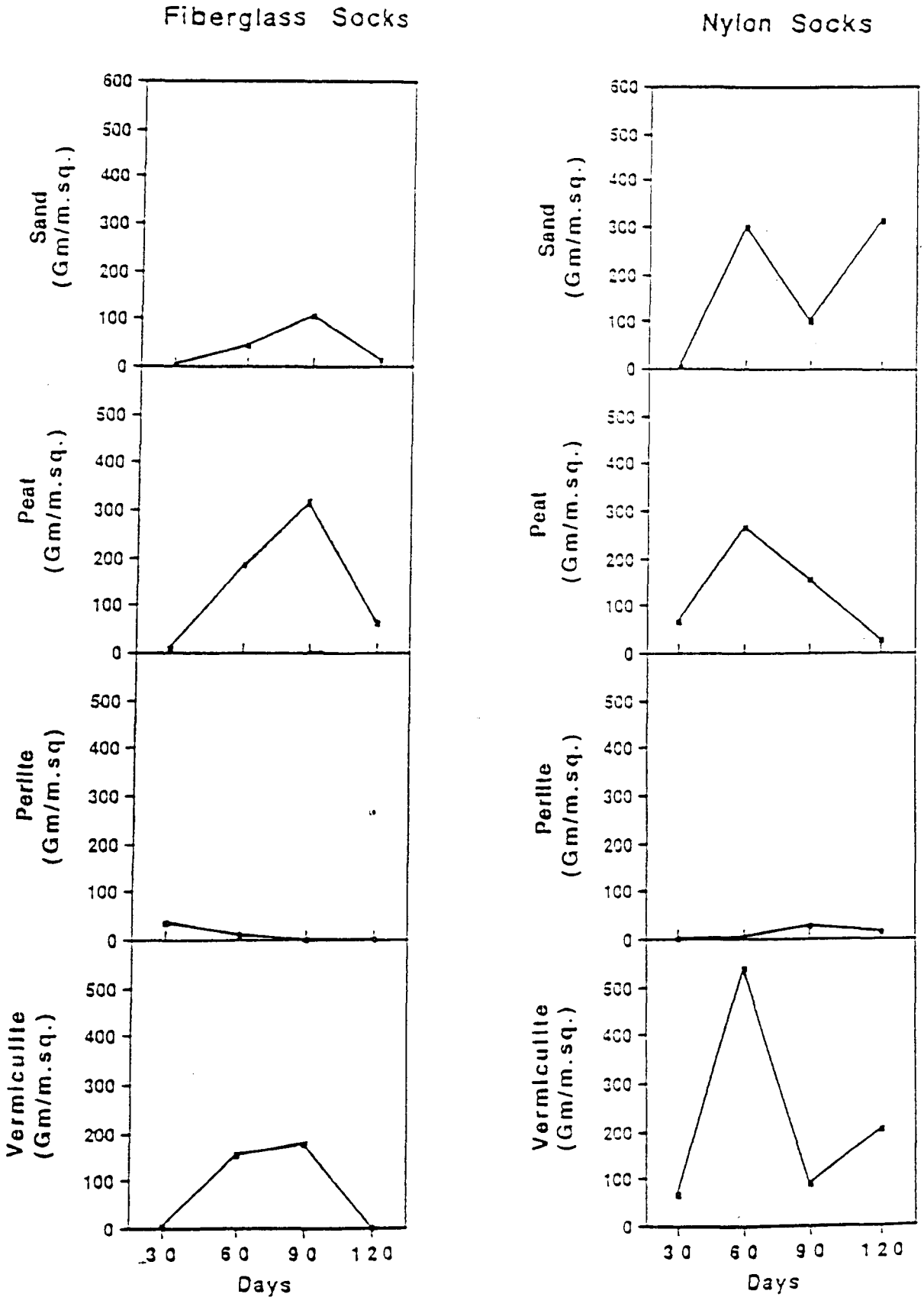

Figure 7. comparison of media and sock material in root biomass core study at Hopkins Prairie, Florida. July - December 1989.

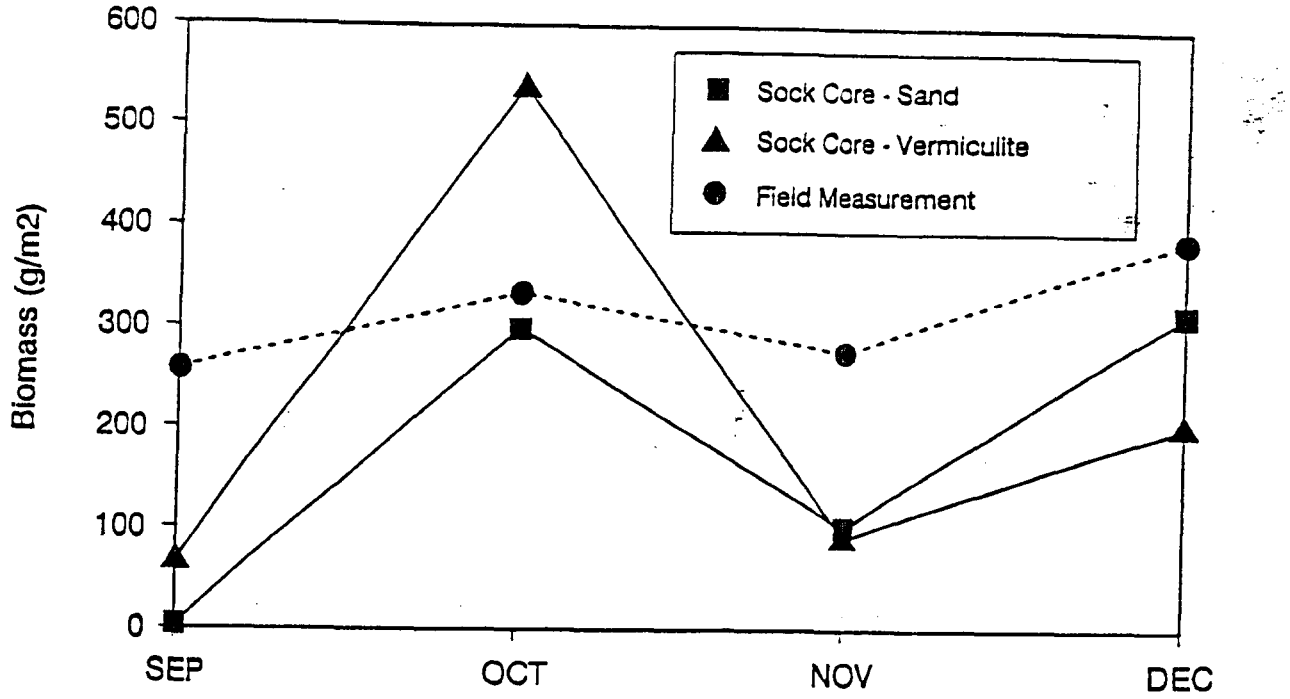

Figure 8. comparison of root biomass in sock cores (sand and vermiculite media) and field biomass measurements at Hopkins Prairie, Florida, 1989.

DISCUSSION

Above and below ground plant biomass

The growing season in Florida can be characterized by highest productivity generally occurring during the spring and summer months. Rainfall in Florida shows a similar seasonality with a summer wet season and a winter dry season. Results from the present study suggest a seasonality in water depth at Hopkins Prairie during 1989 with highest water levels in September through November after the summer wet season (late summer to fall), and lows during May and June after the winter dry season (early summer). Total biomass of macrophytes showed an inverse trend to that of water depth (Figure 2), a relationship seems to be suggested by the lower biomass values during high water levels and higher biomass during low water. Regression analysis suggests a poor correlation between water depth and total biomass ($r^2 = 0.07$) (Appendix

7) However, a stronger correlation exists between water depth and total biomass of the proceeding month ($r^2 = 0.26$). A response 'lag time' by the plants to changes in water depth may be operating, suggested by the stronger one month delay correlation.

Wetland plant species can be divided into two groups: those adapted to saturated soils and those adapted to inundated soils with standing water (Guntenspergen et al 1989). Rhynchospora inundata is a wetland species found on peaty or mucky soils often abundant in dried-up ponds in the east and southeast (Godfrey and Wooten 1979). Percent cover of Rhynchospora inundata increased in the study plot after the period of low water levels in May and June, and declined rapidly from August to November during the period of greatest increase in water depth. In contrast, percent cover of Nymphaea odorata, which favors inundated soils, also responded to favorable conditions, increasing with rising water levels and decreasing with lower levels. These trends were also present in both species in above ground to -10 cm biomass. Below ground biomass trends were less evident, possibly due to the continual saturation of the soils independent of water depth (with the exception of June in which water depth averaged -5.0 cm). Eriocaulon compressum and Eleocharis elongata grow in saturated or inundated soils (Godfrey and Wooten 1979). Trends in percent cover and above ground to -10 cm biomass of these two species were similar to Nymphaea odorata. Highest cover values for Rhynchospora inundata occurred two months following lowest water depth, highest cover values of the other three species (all water tolerant) occurred one month following peak high water levels.

Primary productivity

The present study calculates net primary productivity exclusive of biomass loss to decomposition; therefore, reported values may be underestimates of actual productivity. Measurements of biomass allocation from March through June 1990 were used to project net primary productivity during 1989. The consistency of above and below ground biomass allocation during 1990 and the similarity in water depth between years provides a basis for this projection. However, when interpreting these data, it should be noted that the productivity measurements are not based on biomass allocation in 1989.

The data suggest that the variability in net primary productivity at Hopkins Prairie may have resulted from a combined effect of season and water depth. During the growing season of

spring and summer the net primary productivity increased, as might be expected. However, a large portion of the increase was in the above ground dead component. This period was also accompanied by a decrease in water depth. The change in season may have produced the increased productivity while the lowered water level may have caused the species dominance shift, resulting in a die off of the core aquatic species (increase in above ground dead biomass) followed by replacement with species favoring the new conditions, after a lag period (the above ground live peaked in July, one month after the lowest water levels were recorded in June). Percent cover data (Figure 5) revealed a species dominance shift at this time in which Rhynchospora inundata became established in the above ground component and Nymphaea odorata declined.

The peak in net primary productivity which occurred in the fall (November) was lower and of shorter duration than in the summer. This was also the time of highest water levels. Again, species dominance as revealed in percent cover shows a shift during this period, where Rhynchospora inundata decreased and Nymphaea odorata, Eriocaulon compressum, and Eleocharis elongata increased. The allocation of biomass in the above ground live and dead components were similar to that during the growing season. Above ground live biomass production peaked in November after a lag period following maximum water levels from October.

Methods used in the present study are similar to that as described by Smalley (1959) (In, Shew et al 1981) in which positive changes in above ground live plus dead biomass were measured. Annual productivity is generally based on peak standing crop (highest sequential measurement recorded) or measurements collected during the growing season (Shew et al 1981 and Kaswadji et al 1990). Annual net primary productivity of this study compares lower than similar studies of aquatic macrophytes of the southeastern United States. Annual net primary productivity at Hopkins Prairie was measured to be 135.1 g m^{-2} yr^{-1}. Twilley et al (1985) measured Nuphar luteum (similar life form to Nymphaea odorata) net primary productivity to be 215 g m^{-2} yr^{-1}. Net primary productivity of Eleocharis quadrangulata in a fresh water pond ecosystem was measured at 725 g m^{-2} yr^{-1} (Polisini and Boyd 1972). Shew et al (1981) and Kaswadji et al (1990) measured net primary productivity of Spartina alterniflora in a coastal salt marsh at 224.6 g m^{-2} yr^{-1} and 1231 g m^{-2} yr^{-1}, respectively. The reasons for the lower values

measured in the present study are not obvious. Hopkins Prairie is an oligotrophic wetland (D.A. Graetz pers. comm.). Oligotrophic systems are characterized by low productivity and low dissolved nutrient concentrations (Wetzel 1983). The nutrient-poor water at Hopkins Prairie may not provide sufficient nutrition for high macrophyte production.

Root production core study

Results from this portion of the study were highly variable. Other studies have recorded fluctuations greater than 50% (Persson 1978, Grier et al. 1981, Mclaugherty et al. 1982 and Joslin and Henderson 1984). Socks of nylon hose filled with peat, sand or vermiculite should form the basis for further research. While trends in these treatments appear similar to field measured biomass, particular attention needs to be focused on reasons for the discrepancies in values recorded.

Conclusions

Above and below ground biomass showed trends similar to total biomass; however, variation in the below ground component was less pronounced. The static below ground environment may produce slower and less pronounced changes than the above ground environment which is exposed to more dramatic weather and water level changes. Lorenz (1977) found that a change in species composition in a mixed prairie of the northern great plains resulted in a change in root biomass. Species present at the Hopkins Prairie study site did not change over the study period; however, a seasonal shift in relative species abundance (measured by percent cover and biomass) was observed. These data suggest that macrophyte production and species dominance at Hopkins Prairie are affected by season and water depth. Net primary production was greatest during early summer. Elevated water levels in the fall produced an increase in the aquatic and water tolerant emergent species, while inhibiting production of the less water tolerant species. The seasonal decrease in water depth resulted in reverse trends for these species.

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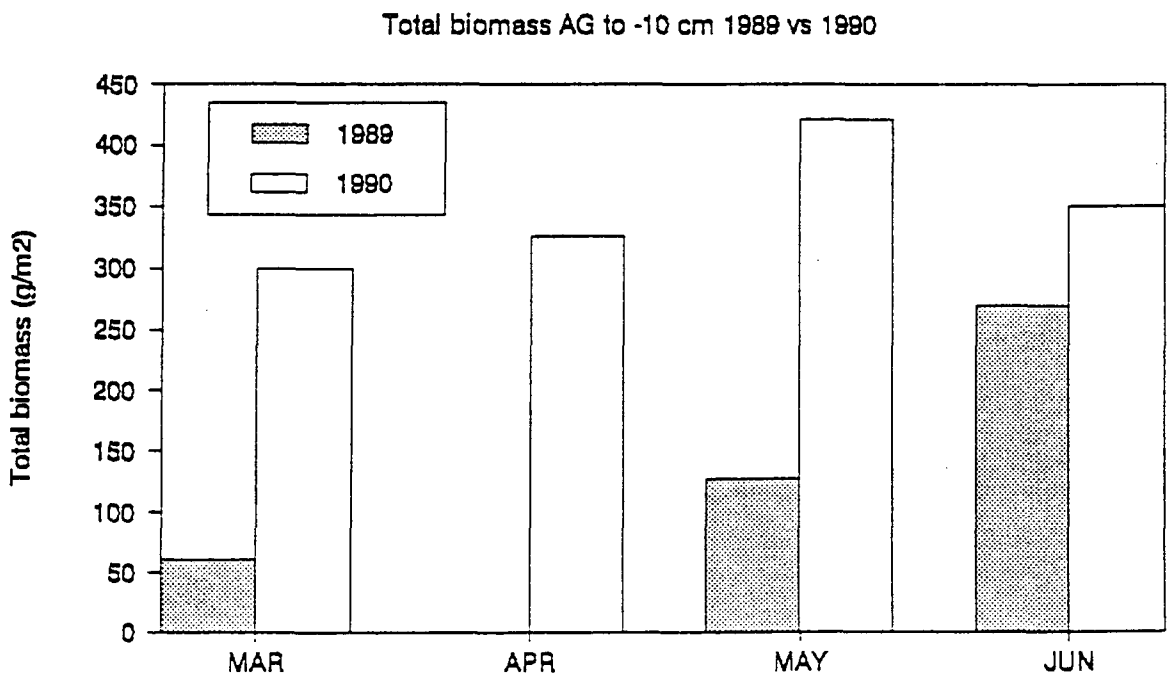
Appendix 1. Comparison of 1989 and 1990 above ground to -10 cm total biomass at Hopkins Prairie study site, Florida (1-6 = subplot #).

		AG to -10 cm total DWT (g/m2)							
Year	Month	1	2	3	4	5	6	Mean	S.D.
1989	MAR	97.66	38.06	35.14	NA	59.76	139.02	61.61	44.13
	APR	NA	NA	NA	NA	NA	NA	NA	NA
	MAY	184.38	306.78	271.10	NA	NA	NA	127.05	62.95
	JUN	105.79	457.47	805.58	NA	NA	251.18	270.01	303.54
1990	MAR	335.13	279.71	229.95	NA	302.72	351.84	299.87	48.08
	APR	210.46	230.00	303.47	610.31	299.97	304.35	326.43	144.95
	MAY	750.28	198.67	317.94	**	**	**	422.30	290.23
	JUN	472.73	327.65	374.10	**	**	233.50	352.00	99.50

** samples not yet processed

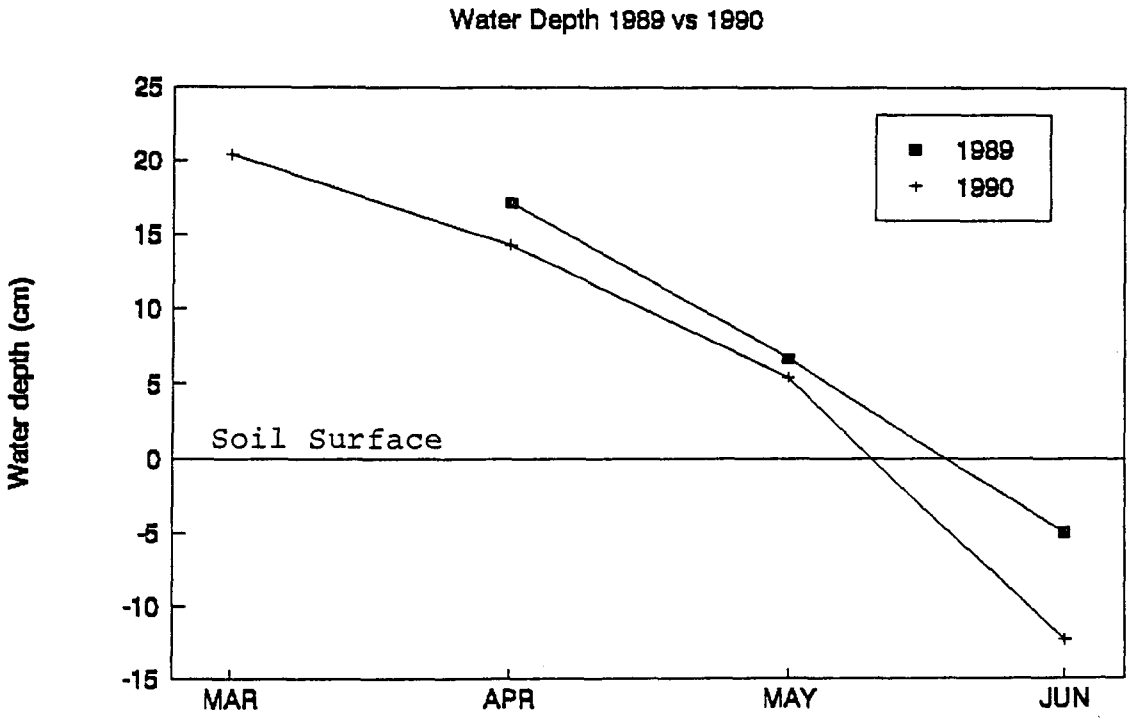


Appendix 2. Comparison of 1989 and 1990 species occurrance (presence-absence) at Hopkins Prairie study site, Florida.

Species	MAR '89	MAR '90	APR '89	APR '90	MAY '89	MAY '90	JUN '89	JUN '90
Nymphaea odorata	X	X	X	X	X	X	X	X
Eriocaulon compressum	X	X	X	X	X	X	X	X
Eleocharis elongata	X	X	X	X	X	X	X	X
Rhynchospora inundata		X		X		X	X	X
Amphicarpum muhlenbergianum						X		X

Appendix 3. Comparison of 1989 and 1990 water depth at Hopkins Prairie macrophyte study site, Florida, (1-6 = subplot #).

Year	Month	WATER DEPTH(cm) 1	2	3	4	5	6	Mean	S.D.
1989	MAR	no data recorded						----	NA
	APR	15.00	19.00	14.00	18.00	19.00	18.00	17.17	2.14
	MAY	7.00	5.00	11.00	2.00	8.00	7.00	6.67	3.01
	JUN	single measurement recorded						-5.00	NA
1990	MAR	26.5	27.0	26.0	NA	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



Appendix 4. Allocation of aboveground live and dead and belowground 0-10 cm biomass components during 1990 and extrapolated allocation during 1989 at Hopkins Prairie study site, Florida, (1-6 = subplot #).

		Percent of total biomass (%)							
1990	Component	1	2	3	4	5	6	Mean	S.D.
MAR	AG-live	0.31	NA	NA	NA	0.98	1.09	0.80	0.43
	AG-dead	0.52	NA	NA	NA	1.42	0.30	0.75	0.59
	BG 0-10	99.17	NA	NA	NA	97.60	98.60	98.46	0.80
APR	AG-live	2.43	0.67	0.82	NA	0.19	NA	1.03	0.97
	AG-dead	0.53	0.20	0.13	NA	0.55	NA	0.35	0.22
	BG 0-10	97.04	99.13	99.05	NA	99.26	NA	98.62	1.06
MAY	AG-live	0.93	0.21	0.56	NA	NA	NA	0.57	0.36
	AG-dead	1.10	4.34	1.30	NA	NA	NA	2.25	1.81
	BG 0-10	97.97	95.45	98.14	NA	NA	NA	97.19	1.50
JUN	AG-live	1.00	0.45	0.87	NA	NA	1.22	0.89	0.32
	AG-dead	1.73	1.73	1.94	NA	NA	5.70	2.78	1.96
	BG 0-10	97.27	97.81	97.19	NA	NA	93.08	96.34	2.19
MEAN:									
MAR-	AG-live							0.82	0.52
JUN	AG-dead							1.53	1.15
	BG 0-10							97.65	1.39

NOTE: Mar+Apr NA=AG live & dead combined/May+Jun NA= not processed

	g/m2 (based on 1990)			
1989	AG live	AG dead	BG 0-10cm	Total
MAR	0.56	0.52	69.00	70.08
APR	1.62	0.56	155.59	157.77
MAY	1.39	5.51	238.55	245.45
JUN	3.91	12.27	425.79	441.98
JUL	3.50	6.54	417.40	427.44
AUG	1.49	2.79	178.07	182.36
SEP	2.26	4.23	269.98	276.48
OCT	0.80	1.49	95.28	97.57
NOV	3.30	6.18	394.35	403.84
DEC	2.01	3.75	239.42	245.18
JAN/FEB	1.35	2.53	161.38	165.26

Appendix 5. Above ground (to -10 cm), below ground (20-30 cm depth) and total biomass of plant species during 1989 at Hopkins Prairie study site, Florida.

Date 1989/90	Rhynchospora inundata AG	Rhynchospora inundata BG	Rhynchospora inundata Total	Nymphaea odorata AG	Nymphaea odorata BG	Nymphaea odorata Total	Eriocaulon compressum AG	Eriocaulon compressum BG	Eriocaulon compressum Total
	Biomass (g/m2)								
March	0.00	0.00	0.00	26.92	37.69	64.60	1.97	0.00	1.97
April	not sampled								
May	24.00	0.00	24.00	79.38	0.00	79.38	14.20	0.00	14.20
June	33.73	99.71	133.45	213.13	51.85	264.98	12.78	0.00	12.78
July	25.20	89.95	115.15	340.04	289.63	629.67	0.13	0.00	0.13
August	26.55	80.94	107.49	97.83	59.09	156.92	2.85	0.00	2.85
September	56.81	59.99	116.80	90.44	11.54	101.98	15.69	0.00	15.69
October	19.01	83.60	102.61	45.84	35.95	81.79	4.21	0.00	4.21
November	17.74	112.35	130.09	298.77	17.32	316.10	13.45	0.00	13.45
December	23.37	79.78	103.15	147.03	1142.55	1289.59	7.52	0.00	7.52
Jan/Feb	14.20	27.41	41.61	84.74	91.15	175.89	12.32	0.00	12.32

Date 1989/90	Eleocharis sp. AG	Eleocharis sp. BG	Eleocharis sp. Total	*Other AG	*Other BG	*Other Total
March	0.56	0.00	0.56	40.63	233.00	273.63
April						
May	4.59	0.00	4.59	123.27	319.81	443.08
June	5.18	0.00	5.18	177.15	167.90	345.06
July	1.44	0.00	1.44	60.63	191.52	252.16
August	3.38	0.00	3.38	55.75	160.44	216.19
September	10.96	0.00	10.96	102.58	187.28	289.85
October	11.86	0.00	11.86	16.65	214.41	231.05
November	13.67	0.00	13.67	60.20	146.32	206.52
December	1.27	0.00	1.27	65.98	256.37	322.35
Jan/Feb	3.60	0.00	3.60	50.40	102.25	152.65

*Other = biomass portion unidentifiable to species.

Appendix 6. Aboveground (to -10 cm) and belowground (20-30 cm depth) biomass and percent of total biomass of vegetation at at Hopkins Prairie study site, Florida.

Date 1989/90	Above ground g/m2	%	Below ground g/m2	%	Total g/m2
March	70.08	20.6	270.69	79.4	340.77
April	not sampled				
May	245.45	43.4	319.81	56.6	565.26
June	441.98	58.0	319.47	42.0	761.45
July	427.44	42.8	571.11	57.2	998.55
August	186.36	38.3	300.48	61.7	486.83
September	276.48	51.6	258.82	48.4	535.30
October	97.57	22.6	333.95	77.4	431.52
November	403.84	59.4	275.99	40.6	679.83
December	245.18	14.2	1478.70	85.8	1723.88
Jan/Feb	165.26	42.8	220.81	57.2	386.06
MEAN	255.96	37.0	434.98	63.0	690.95

Appendix 7. Regression analysis of trimmed mean total biomass (above plus below ground) vs. mean water depth 1) month to month and 2) one month lag (biomass). Hopkins Prairie, Florida, 1989.

1989	Total biomass g/m2 Mean	Corrected Mean	Water depth cm	Regression Output:	*Month to Month	**One Month Lag
MAR	258.220	258.220	NA			
APR	NA	NA	17.2	Constant	649.66	729.50
MAY	377.271	377.271	6.7	Std Err of Y Est	214.80	194.20
JUN	761.489	761.489	-5.0	R Squared	0.0715	0.2566
JUL	998.475	998.475	14.3	No. of Observation	9.00	8.00
AUG	414.302	414.302	12.1	Degrees of Freedom	7.00	6.00
SEP	535.090	535.090	35.8			
OCT	431.672	431.672	41.0	X Coefficient(s)	-3.74	-6.70
NOV	679.841	679.841	32.3	Std Err of Coef.	5.10	4.66
DEC	1723.855	579.385	19.3			
JAN/FEB	386.125	386.125	26.0			

* May biomass v. May water depth etc.
**June biomass v. May water depth etc.