The Aquatic Plant Community

of

Half Moon Lake

Eau Claire County, Wisconsin

submitted by

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The Aquatic Plant Community of Half Moon Lake

I. INTRODUCTION

A study of the aquatic plants (macrophytes) in Half Moon Lake was conducted during June 1995 by Water Resources staff of the Western District - Department of Natural Resources (DNR). This was the first quantitative vegetation study done by the DNR on Half Moon Lake. A limited qualitative survey was conducted in June 1989 by Water Resource staff.

A study of the diversity, density, and distribution of aquatic plants is an essential component of understanding a lake due to the important ecological role of aquatic vegetation and the ability of the vegetation to characterize the water quality (Dennison et al. 1993).

Ecological Role: All other life in the lake depends on the plant life (including algae) - the beginning of the food chain. Aquatic plants provide food and shelter for fish, wildlife, and the invertebrates that in turn provide food for other organisms. Plants improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake, impact recreation, and serve as indicators of water quality.

Characterize Water Quality: Aquatic plants serve as indicators of water quality because of their sensitivity to water quality parameters, such as water clarity and nutrient levels (Dennison et. al. 1993).

The present study will provide information that is important for effective management of the lake including fish habitat improvement, protection of sensitive wildlife areas, aquatic plant management, and water resource regulations. The baseline data that it provides will be compared to future plant inventories and offer insight into any changes occurring in the lake.

Half Moon Lake is a 132-acre oxbow cutoff from the Chippewa River in Eau Claire County, Wisconsin. Half Moon Lake was cut off from the Chippewa River prior to 1800. The lake is now dependent upon seepage, stormwater runoff and pumping from wells to maintain its level. The maximum depth of Half Moon Lake is 9 feet (Figure 1).

The lake is the focal point of the largest city park and wildlife area within the city of Eau Claire, Wisconsin. Half Moon Lake is a popular recreation lake because of its setting in an urban area with few natural lakes (Brakke 1995). Generations of residents have used the lake for fishing, swimming and boating (Barr 1992).

The watershed for Half Moon Lake is 577 acres; 45% of the land is in residential use, 41% of the land is in park and other open space and 14% of the lane is in commercial/industrial use (Barr 1992).

In the 1970's the city of Eau Claire initiated a program of acquiring properties along Half Moon Lake to provide public access to the majority of the lakeshore and control runoff into the lake. To date, 15 properties have been acquired. Only three privately owned properties remain along the lakeshore resulting in 95% of the shoreline being controlled and managed by the city (City of Eau Claire 1995).

Half Moon Lake has had water quality problems for a number of years. Algal blooms and dense aquatic plant growth have had a detrimental impact on the recreational use (Brakke 1995). Plant growth became extensive, limiting recreational use of the lake and compromising the fish population (Borman 1990).

Swimming is no longer a recreational use of Half Moon Lake. The city of Eau Claire monitored beach use and found a 89% decrease in swimming use from 1972 to 1986. In 1987 and 1988, the beach was closed and has never been reopened (Figure 2).

Beach closed Staff photo by John Lindrud

Lifeguard Brenda Stahl surveys the closed beach on Half Moon Lake. The swimming area was closed Thursday afternoon under orders from the Eau Claire Parks and Recreation Department and the City-County Health Department. The beach will remain closed until the city completes an aquatic weed-cutting program, scheduled for next week on Half Moon Lake, and until the City-County Health Department completes sampling for bacteria next week, according to Jim Ryder, department health director. Heavy mats of weeds in the swimming area present a safety problem, Ryder said. Both South and DeLong pools will be open from 1 to 5 p.m. today and Sunday, according to the Parks and Recreation Department.

Figure 2. News item in the June 21, 1986 issue of the Eau Claire Leader-Telegram pertaining to beach closing.

Fish surveys found that the fish population was stunted (Barr 1992). Dense plant growth limits predator success, allowing the fish population to grow beyond its food source.

In 1857, during the heyday of the logging era, a canal was built between the lake and the Chippewa River so that the lake could be used for log storage. Logs were stored in the lake for area sawmills; bark and other lumber industry wastes were dumped in the lake until the 1920's.

Phosphorus being recycled from the sediments has a strong impact on the water quality (Barr 1992). Half Moon Lake's use for log storage during the mid-1800's may be the reason for the high organic content of the sediment (tree bark and sawdust) that contribute to the lake nutrients (Barr 1992). The phosphorus is released when sediments are resuspended or chemically released during anoxic conditions. The early growth and senescence of *Potamogeton crispus* also releases nutrients into the water were obtained from the sediments.

Storm sewer effluent has been a major contributor to nutrients in the lake. There are thirteen storm sewers that flow into Half Moon Lake. These sewers contribute 93% of the phosphorus in the lake each year (Baker 1989).

Chemical treatments had been used for many years as a plant management tool (Table 1). The first documented copper sulfate treatment was in 1926.

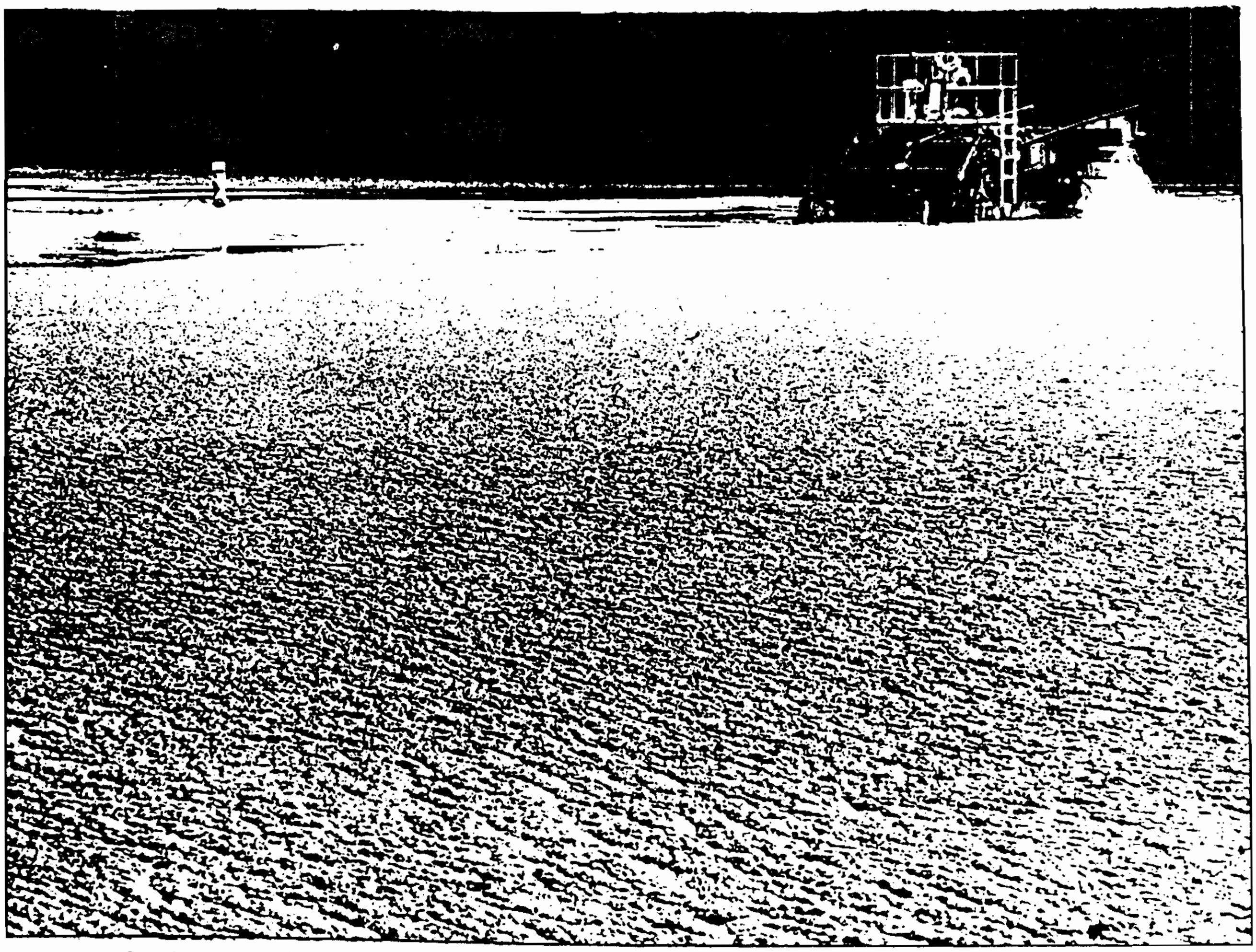
Table 1. Chemical Treatments in Half Moon Lake.

	Copper sulfate	Endothall compounds	2,4-D compounds	Sodium arsenite	Calcium carbonate	Calcium & Aluminum sulfate
1949						
1951						
1953				4032	619	
1955				pounds	pounds	
1957				added	added	
1959			925			
1961			pounds			
1963			added			
1965						
1967	51.5					
1969	tons	336				
1971	added	pounds				8200
1973		and				pounds
1975		100				added
1977		gallons				
1979		added				
1981						
1983						
1985						
1987						
1989						

Chemicals have been added for other reasons besides aquatic plant management. Although plants were not the target, these chemicals probably impacted the plant community. Chlorination of the water around the beach to counteract high bacterial levels started in 1962. From 1969 until 1986, 7135 pounds and 2269 gallons of chlorinated compounds were added to Half Moon Lake.

The decision was made to discontinue chemical treatments in favor of harvesting. There are a number of advantages to harvesting. 1) There is more control over the location of plant removal to best improve the aesthetics, boating and fish habitat. 2) Harvesting removes the plant material and its nutrient content. Chemical treatments leave the plant material to add more nutrients and deplete oxygen levels upon decay. 3) There are no water use restrictions after harvesting.

Aquatic plant harvesting started in 1979 (Figure 3).



Acres of lake weeds

Staff photo by Steve Kinderman

A weed cutter chops a swath through a thick mat of aquatic weeds Monday in Half Moon Lake. The city hired Mid-west Aqu-Care of Edina, Minn., to mechanically remove much of the thick weed growth on the lake. The harvested weeds are composted by the city. After the weed cutting, the city's Parks and Recreation Department will chemically treat the lake, under supervision from the Department of Natural Resources, to control algae. Half Moon Beach has been temporarily closed because of the weed growth. Both South and DeLong pools will be open from 1 to 5 p.m. Saturday and Sunday this weekend for interested swimmers.

Figure 3. News item in the June 24, 1986 issue of the Eau Claire Leader-Telegram pertaining to aquatic plant harvesting.

A harvesting plan was prepared in 1989 by DNR staff to improve fish habitat and provide better recreational access. Boating lanes (30 feet wide) are to be cut along each shore (about 25-75 feet from the shore). Numerous cross lanes are to be cut (Table 2).

Table 2. Aquatic Plant Material Removed by Harvesting

Year	Cubic Yards of Plants Removed	Highest Concentration of Harvest
1982	1175	
1983	1255	
1984	435	
1985	550	
1986	1000	
1991	1067	South of causeway
1992	1340	North of causeway & south of outfall area
1993	1270	North of causeway & west of beach
1994	100	
1995	1638	

Harvesting has improved the fishery, resulting in a healthier fish population. The 1995 fish survey found the average size of bluegills has increased 1.5 inches since 1990. Bluegill growth rate has also increased (Holzer 1995).

In 1974, the city and lakeshore landowners formed the Inland Lake Protection and Rehabilitation District and conducted a number of rehabilitation projects: dredging the beach and southwest end (1977), diverting a major storm sewer from the lake (1980), diverting water from the Chippewa River into Half Moon Lake to compensate for the water lost from the storm sewer and to provide low-nutrient water (1980) and installing aeration systems in three areas to reduce winterkills from insufficient oxygen (1973, 1992).

II. METHODS

Field Methods

The study design was based primarily on the rake-sampling method developed by Jessen and Lound (1962), using stratified random placement of the transect lines.

The shoreline was divided into 27 equal segments and within each segment, the transect was randomly placed, using a random numbers table.

One sampling site was randomly located in each depth zone (0-1.5ft., 1.5-5ft., 5-10 ft., and 10-20ft.) along each transect. Using a long-handled steel thatching rake, four rake samples were taken at each sampling site. The four samples were taken from each quarter of a 6-foot square quadrat. The aquatic plant species that were present on each rake sample were recorded. Each species was given a density rating (0-5) based on the number of rake samples on which it was present at each sampling site. (A rating of 1 indicates that a species was present on one rake sample...a rating of 4 indicates that it was present on all four rake samples and a rating of 5 indicates that it was abundantly present on all rake samples at that sampling site.) The sediment type at each sampling site was also recorded.

The type of shoreline cover was recorded at each transect. A section of shoreline, 50 feet on either side of the transect intercept with the shore and 30 feet back from the shore, was evaluated. The percentage of each cover type within this 100' x 30' rectangle was estimated.

Visual inspection and periodic samples were taken between transect lines in order to record the presence of any species that did not occur at the sampling sites. Specimens of all plant species present were collected and saved in a cooler for later preparation of voucher specimens. Nomenclature was according to Gleason and Cronquist (1991).

Data Analysis

The percent frequency of occurrence of each species was calculated (number of sampling sites at which it occurred / total number of sampling sites) (Appendix I). Relative frequency was calculated based on the number of occurrences of a species relative to all species occurrences (Appendix I). The mean density was calculated for each species (sum of a species' density ratings / number of sampling sites) (Appendix II). Relative density was calculated based on its average density relative to all plant densities. A "mean density where present" was calculated for each species (sum of a species' density ratings / number of sampling sites at which it occurred) (Appendix II). The relative frequency and relative density were summed to obtain an importance value (Appendix III). Simpson's Diversity Index was calculated (Appendix I).

III. RESULTS

PHYSICAL DATA

WATER CLARITY - The trophic state of a lake is an indicator of water quality. Phosphorus concentrations, chlorophyll concentrations, and water clarity data are collected and combined to determine the trophic state. Eutrophic lakes are high in nutrients and support a large biomass. Oligotrophic lakes are low in nutrients and support limited plant growth and smaller fish populations. Mesotrophic lakes have intermediate levels of nutrients and biomass.

Phosphorus is a limiting nutrient in many Wisconsin lakes. Increases in phosphorus in a lake can feed algal blooms and excess plant growth. Phosphorus data has been collected for various studies over the years by different agencies, but has remained within the eutrophic range (Figure 4).

Figure 4. Phosphorus and Chlorophyll levels in Half Moon Lake.

Measuring the levels of chlorophyll in the water gives an indication of algal levels. Algae is natural and essential in lakes, but high algal levels can cause problems, contributing to the turbidity of many lakes, and reducing the light available for plant growth.

1993 Mean summer chlorophyll in Half Moon Lake was 37.2 ug/1.
Chlorophyll was collected only once (1993) but chlorophyll levels in this range are considered eutrophic (Figure 4).

Water clarity is a critical factor for plants. When plants receive less than 1 - 2% of the surface illumination, they can not survive. Water clarity is reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color the water. Water clarity can be measured with a Secchi disc that shows the combined effect of turbidity and color. Secchi disc readings indicate that the water clarity in Half Moon lake ranges from poor to very poor (Figure 5).

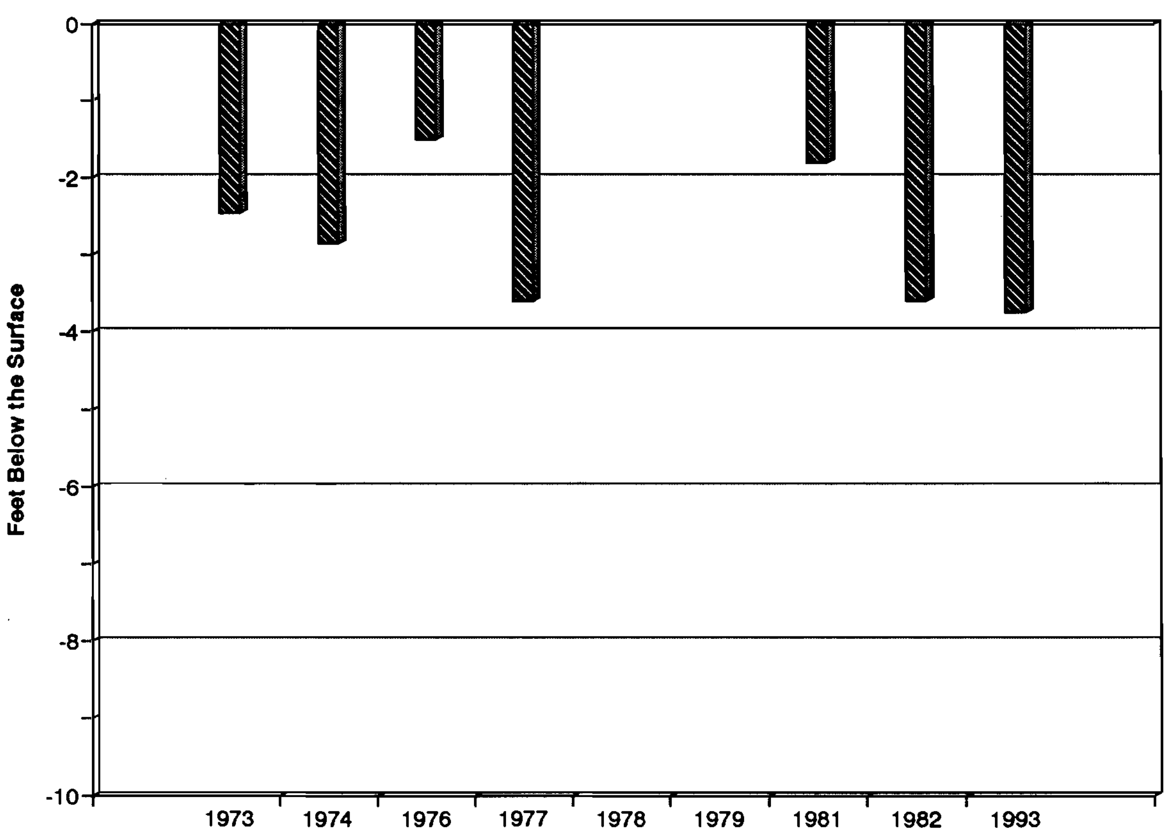


Figure 5. Water Clarity in Half Moon Lake.

The pH of a lake indicates the acidity or alkalinity of the water. (pH 7 indicates neutral water; pH < 7 indicates acidic water; pH > 7 indicates alkaline water) The pH in Half Moon Lake has varied between 7.2 and 9.8 (Figure 6). This would favor plants adapted to neutral and slightly alkaline conditions and discourage the growth of plants adapted to acidic water.

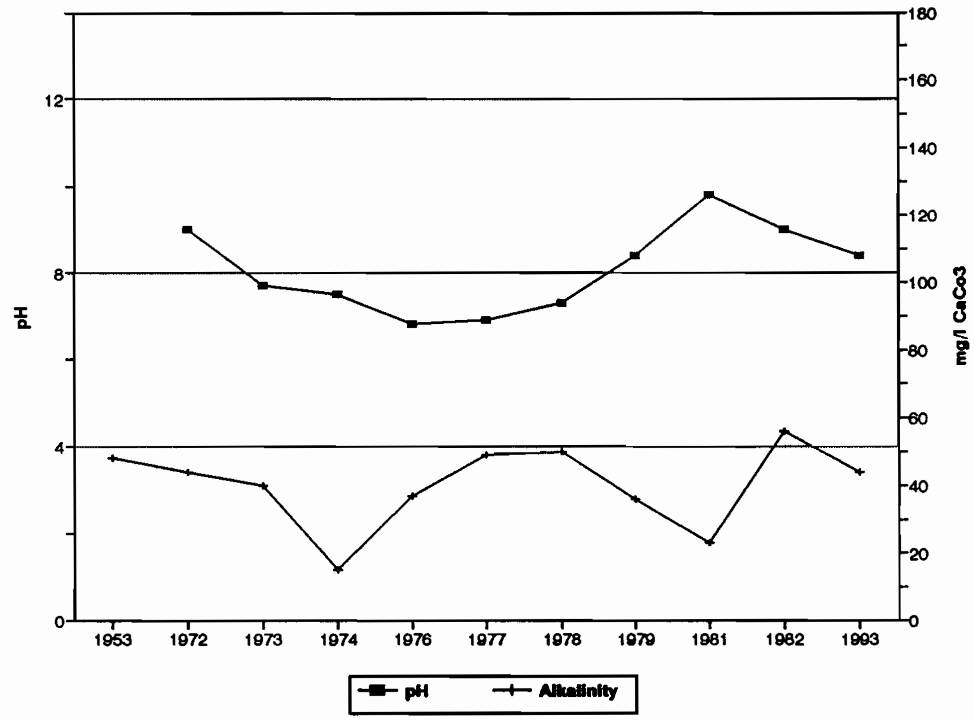


Figure 6. **Alkalinity and pH of Half Moon Lake.**

Alkalinity levels in Half Moon Lake have varied between 15mg/l CaCO3 and 58mg/l CaCO3 (Figure 6). Water with a hardness level less than 60mg CaCO3/l is considered soft. Soft water lakes tend to have less plant growth.

LAKE MORPHOMETRY - The morphometry of a lake is an often overlooked factor in analyzing the distribution of aquatic plants. Duarte and Kalff (1986) found that the slope of the littoral zone could explain 72% of the observed variability in the growth of submerged plants. Gentle slopes support more plant growth than steep slopes (Engel 1985). Half Moon Lake is a narrow, long oxbow lake with a gradually sloped littoral zone. It is a shallow lake with and average depth of 5 1/2 feet. Its morphometry favors abundant plant growth.

SHORELINE LAND USE - There has been an increased awareness recently, that land use practices strongly impact the aquatic plant community. Practices on shore can directly effect the plant community through increased sedimentation from erosion, increased nutrient levels from fertilizer run-off and soil erosion and increased toxics from farmland and urban run-off.

Wooded cover and herbaceous growth was found at all of the shoreline transects. Wooded coverage had the greatest mean coverage at the transect sites and herbaceous growth had a moderate mean coverage. Shrub growth had a high occurrence and moderate coverage (Table 3).

Table 3. Shoreline Land Use

Cover Type	Frequency of Occurrences at Transects	Mean % Coverage
Wooded	100%	45%
Herbaceous	100%	17.9%
Shrub	93%	14.6%
Cultivated Lawn	18%	9.3%
Hard Surface	41%	7.4%
Bare Soil	37%	5.4%

SEDIMENT INFLUENCE

Silt was the most prevalent sediment at the sample sites, found more commonly at depth zones greater than 1.5 feet (Table 4). Sand sediments were also common, more prevalent in the shallow zone.

Table 4. Sediment types and occurrence

	Occurrence in 0-1.5' Depth Zone	Occurrence in 1.5-5' Depth Zone	Occurrence in 5-10' Depth Zone	Percent Frequency at All Depths
Silt	5	19	20	57%
Silt/rock	1	1		2%
Sand	14	2		21%
Sand/rock	5	1		8%
Muck	1	3	3	9%
Rock	1	1		2%

Muck sediments were found primarily at the south end of the east bend. Rock sediments were found near the shore along the north end of the west bend and along the outside shore of the east bend.

MACROPHYTE DATA

SPECIES PRESENT

A total of 32 species was found in Half Moon Lake. Of the 32 species, 18 were emergent species, 4 were floating-leaf species, and 10 were submergent species (Table 5). No endangered or threatened species were found. One non-native species, *Potamogeton crispus*, was found.

Table 5. Half Moon Lake Aquatic Plant Species

Scientific Name	Common Name	I. D. Code
Emergent Species		
1) *Acorus calamus* L.	sweet flag	acoca
2) *Asclepias incarnata* L.	swamp milkweed	ascin
3) *Carex comosa* F. Boott.	bristly sedge	carco
4) *Carex rostrata* Stokes.	sedge	carro
5) *Carex crinita* Lam.	sedge	carcr
6) *Carex* sp.	sedge	carsp
7) *Eleocharis acicularis* (L.) Roemer & Schultes.	needle spikerush	eleac
8) *Eleocharis palustris* L.	creeping spikerush	elepa
9) *Iris versicolor* L.	northern blue flag	irive
10) *Juncus effusus* L.	soft rush	junef
11) *Leersia oryzoides* .	rice cut-grass	leeor
12) *Phalaris arundinacea* L.	reed canary grass	phaar
13) *Polygonum sagittatum* L.	arrow-leaf tearthumb	polsa
14) *Sagittaria latifolia* Willd.	common arrowhead	sagla
15) *Sagittaria rigida* Pursh.	stiff arrowhead	sagri
16) *Scirpus cyperinus* (L.) Kunth	wool grass	scicy
17) *Scirpus validus* Vahl.	softstem bulrush	sciva
18) *Typha latifolia* L.	broad-leaf cattail	typla
Floating-leaf Species		
19) *Lemna minor* L.	small duckweed	lemmi
20) *Nuphar variegata* Durand.	bull-head pond lily	nupva
21) *Spirodela polyrhiza* (L.) Schleiden.	great duckweed	spipo
22) *Wolffia columbiana* Karst.	common watermeal	wolco
Submergent Species		
23) *Ceratophyllum demersum* L.	coontail	cerde
24) *Elodea canadensis* Michx.	common waterweed	eloca
25) *Najas flexilis* (Willd.) Rostkov. & Schmidt.	slender naiad	najfl
26) *Nitella* sp.	nitella	nitsp
27) *Potamogeton crispus* L.	curly-leaf pondweed	potcr
28) *Potamogeton foliosus* Raf.	leafy pondweed	potfo
29) *Potamogeton natans* L.	floating-leaf pondweed	potna
30) *Potamogeton nodosus* Poiret.	long-leaf pondweed	potno
31) *Potamogeton pusillus* L.	small pondweed	potpu
32) *Vallisneria americana* L.	water celery	valam

FREQUENCY OF OCCURRENCE

Of the 33 species found in Half Moon Lake, 25 occurred at sampling sites. The species with the highest frequency of occurrence was *Potamogeton crispus* (82%) (Figure 7). Other frequently occurring species were *Elodea canadensis* (75%), *Ceratophyllum demersum* (53%), *Lemna minor* (27%), *Najas flexilis* (26%), *Potamogeton pusillus* (26%) and *Spirodela polyrhiza* (27%).

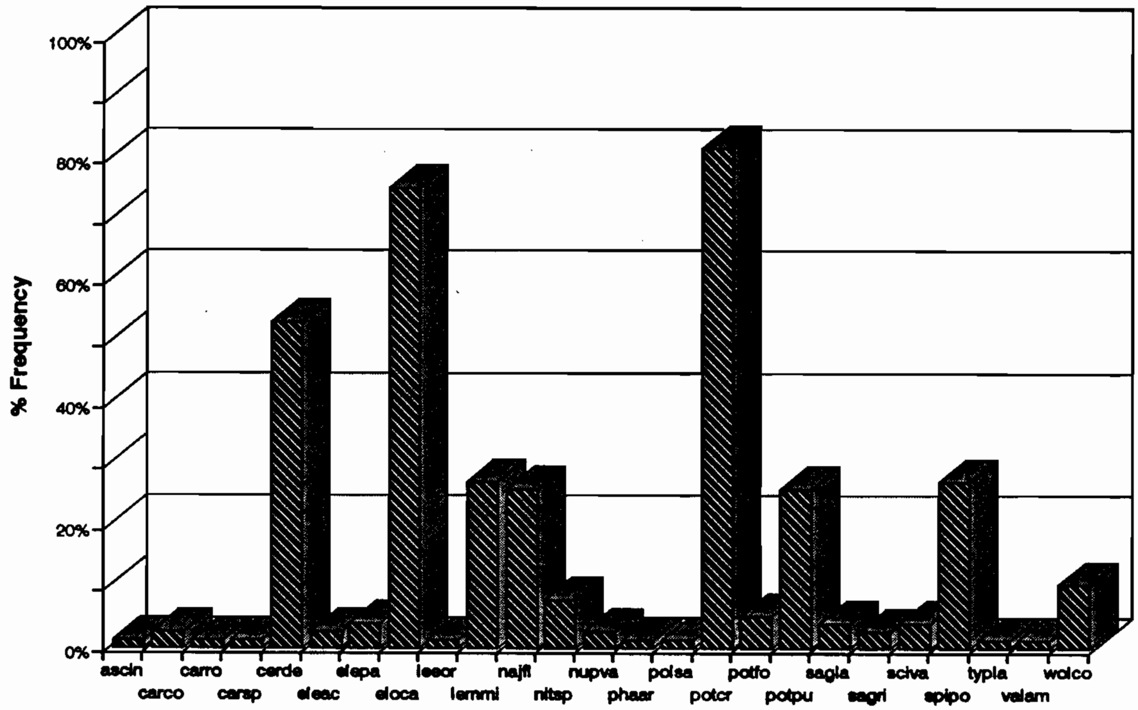


Figure 7. Macrophyte Frequencies in Half Moon Lake

Filamentous algae was found at 83.1% of the sampling sites.

DENSITY

In addition to having the highest frequency of occurrence, *Potamogeton crispus* also had the highest mean density (2.7 on a density scale of 1-4). *Ceratophyllum demersum* and *Elodea canadensis* were found at the next highest mean densities (1.2 and 2.0) (Figure 8).

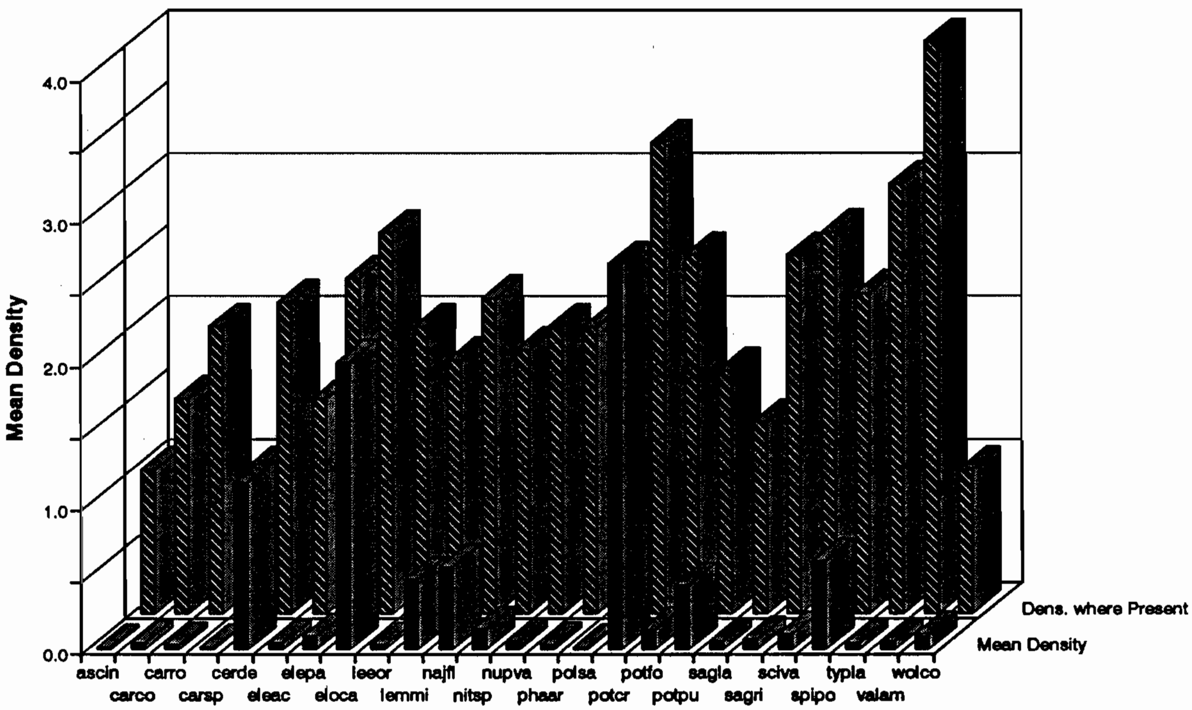


Figure 8. Mean Densities and Densities Where Present of Macrophytes in Half Moon Lake.

Potamogeton crispus, *Vallisneria americana* and *Typha latifolia* had the highest densities where present (3.3, 4.0 and 3.0 respectively). High densities at sites at which they were present indicate that these species had dense growth forms in Half Moon Lake (Figure 8).

DOMINANCE

Combining relative frequency and relative density into an importance value (Appendix III.) had very little impact on the standing of the most prevalent and most dense species when compared to their standing according to frequency or density alone. This points out that the most frequently encountered species were also encountered at the highest densities. Based on the importance value, *Potamogeton crispus, Elodea canadensis* and *Ceratophyllum demersum* were the dominant species in the lake (Figure 9).

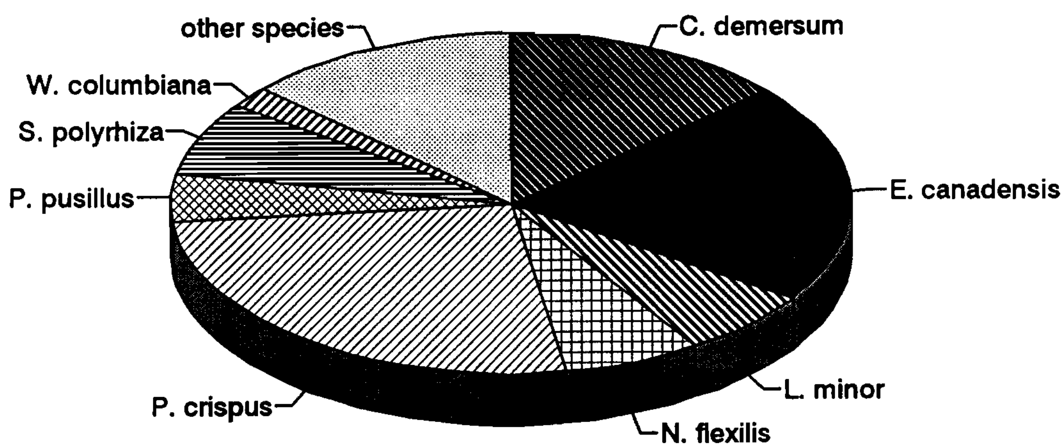


Figure 9. Dominance of the Most Prevalent Macrophytes within the Macrophyte Community, Based on Importance Value.

The qualitative survey conducted in 1989 found that *Potamogeton crispus* was the dominant species, colonizing the entire lake. *Ceratophyllum demersum* and *Elodea canadensis* were sub-dominant species and found growing at over-abundant levels in some areas.

DISTRIBUTION

Aquatic plants were found growing at all of the sampling sites. Rooted vegetation was found at 96.1% of the vegetated sampling sites.

The mean number of species found at each sampling site was 3.7.
In the 0-1.5' depth zone, the mean number of species per sample site was 5.1.
In the 1.5-5' depth zone, the mean number of species per site was 3.2.
In the 5-10' depth zone, the mean number of species per site was 2.6.

7 sites had 1 species
17 sites had 2 species
19 sites had 3 species
13 sites had 4 species
7 sites had 5 species
8 sites had 6 species
2 sites had 7 species
2 site had 9 species
1 site had 10 species
1 site had 11 species

Besides having the highest mean number of species per site, the 0-1.5 ft. depth zone has the highest total occurrence and total density of macrophytes (Figure 10).

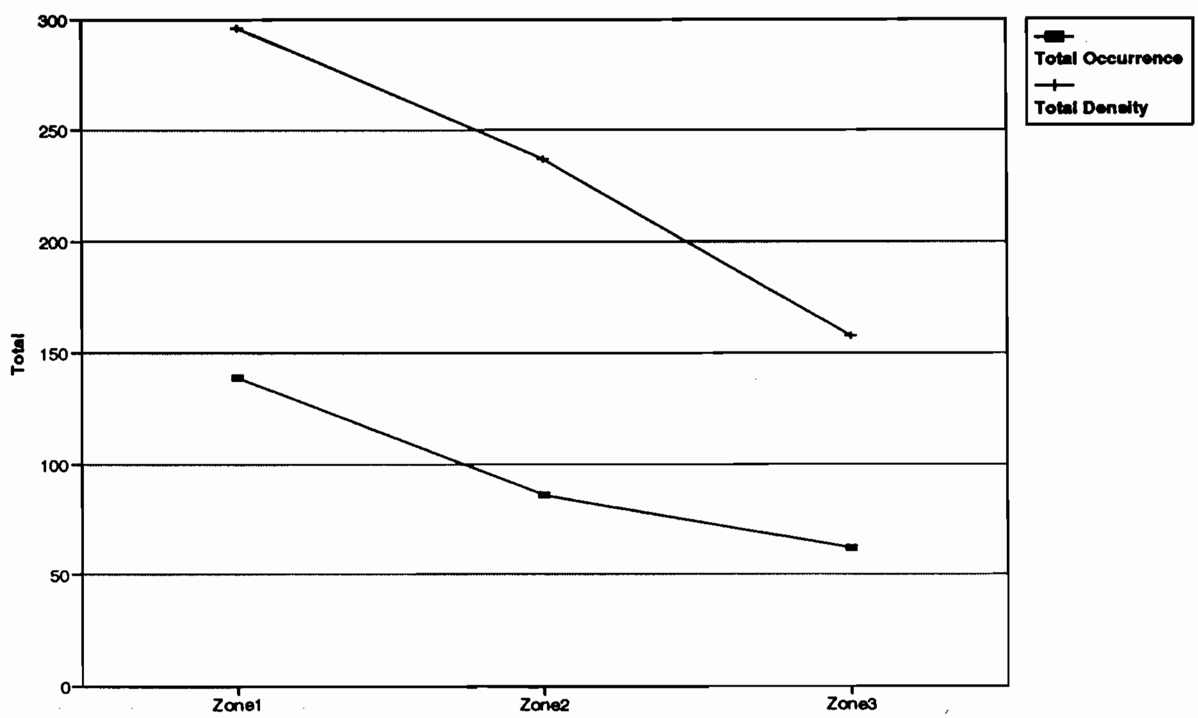


Figure 10. Total Occurrence and Density of Macrophytes by Depth Zone.

The frequency and density of individual species varied with depth zone. *Elodea canadensis*, *Lemna minor*, *Potamogeton crispus* and *Spirodela polyrhiza* were the most frequent (Figure 11) and dense species in the 0-1.5ft. depth zone.

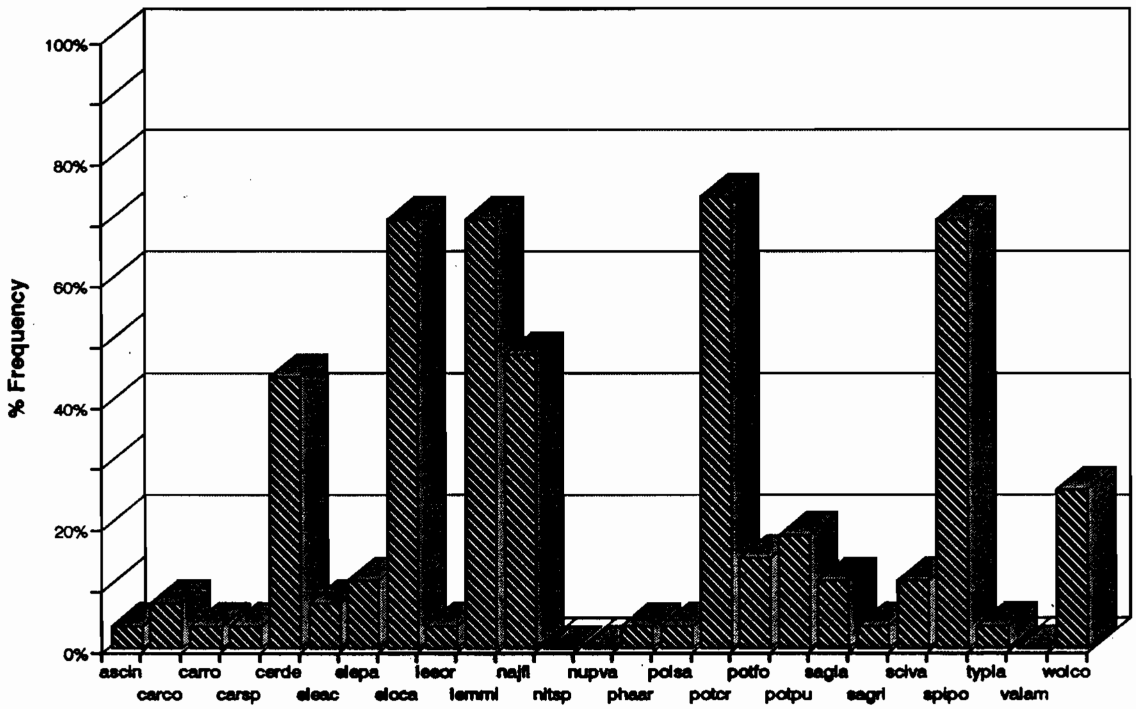


Figure 11. Macrophyte Frequencies in the 0-1.5 Foot Depth Zone.

Ceratophyllum demersum, *Elodea canadensis* and *Potamogeton crispus* were the most frequent and dense species in the 1.5-5 ft. depth zone (Figure 12).

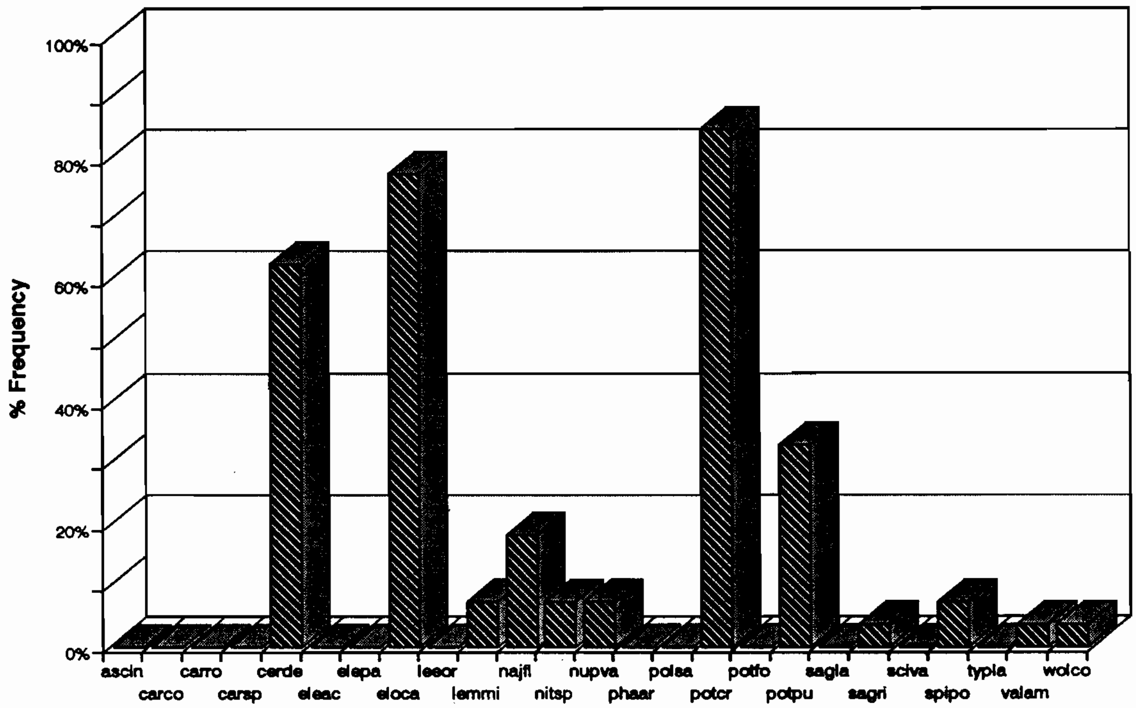


Figure 12. Macrophyte Frequencies in the 1.5-5 Foot Depth Zone.

In addition, *Ceratophyllum demersum* had its highest frequency and density in the 1.5-5 ft. depth zone (Figure 13). Its frequency and density declined in the shallower and deeper depth zones.

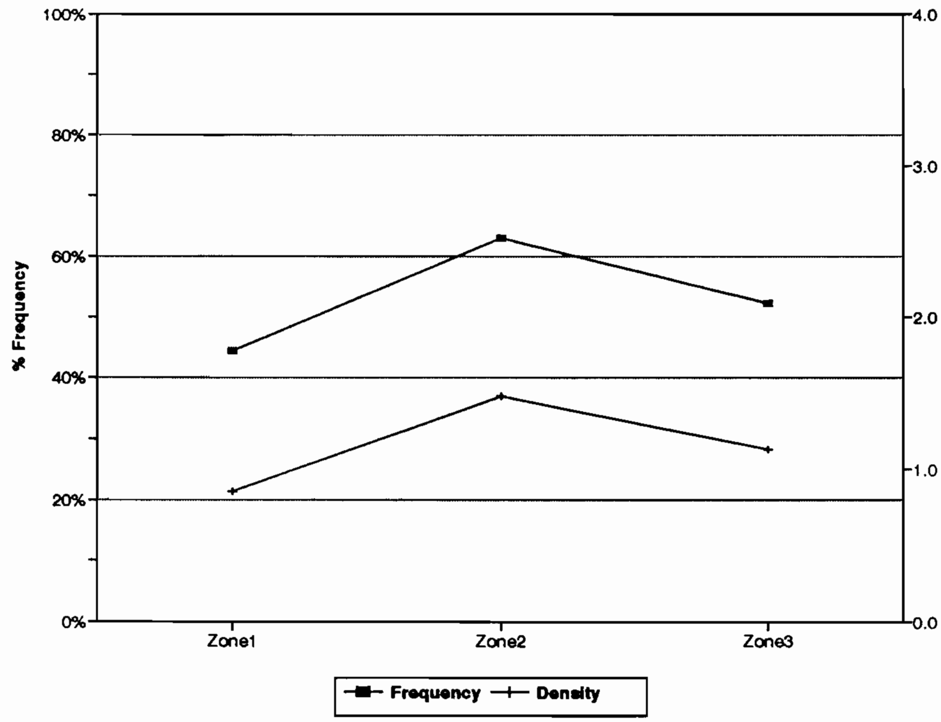


Figure 13. Frequency and Density of *Ceratophyllum demersum* by depth zone.

Elodea canadensis had its highest density in the 1.5-5 ft. depth zone and its highest frequency in the 5-10 ft. depth zone (Figure 14). However, its frequency was nearly as high in all depth zones.

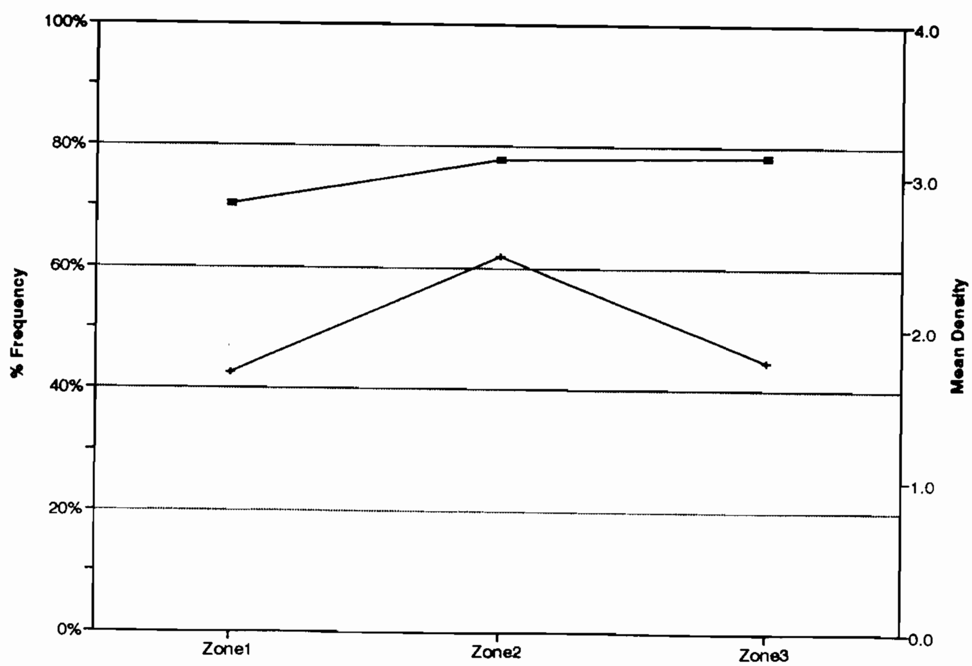


Figure 14. Frequency and density of *Elodea canadensis* by depth zone.

Potamogeton crispus was the most frequent species in the 5-10 ft. depth zone (Figure 15). *P. crispus* had its highest frequency and density in this depth zone, yet its frequency and density was nearly as high in the 1.5-5 ft. depth zone also (Figure 16).

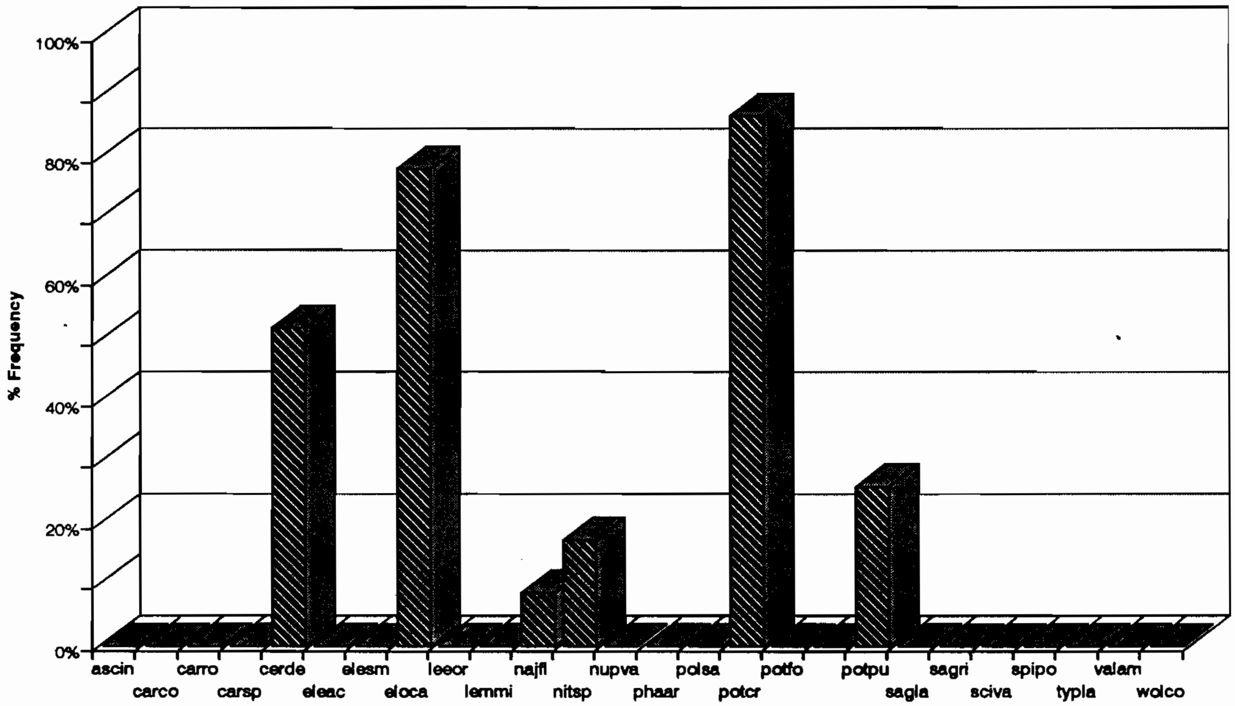


Figure 15. Macrophyte Frequencies in the 5-10 Foot Depth Zone.

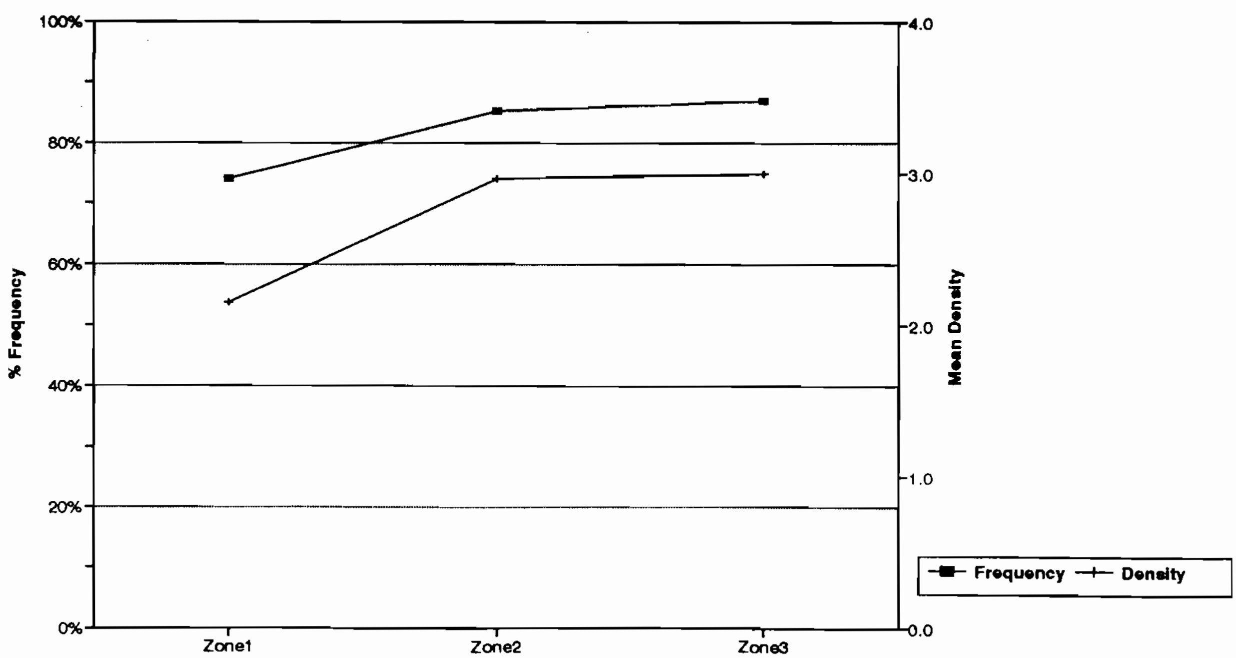


Figure 16. Frequency and Density of *Potamogeton crispus* by Depth Zone.

The most common species in Half Moon Lake were found throughout the lake. *Wolffia columbiana* was found only in the west half of the lake.

Elodea canadensis, *Potamogeton crispus* and *P. pusillus* were found at the greatest depth (9 feet).

SEDIMENT INFLUENCE - Some plants depend on the substrate in which they are rooted for nutrients. The richness or sterility of the sediment can influence which plants can survive and how abundantly they grow.

Silt was the most prevalent sediment in the lake. It was found throughout the lake, most often at deeper sites. Since the percentage of vegetated sites was high overall, all sediment types had high levels of vegetation (Table 6).

Table 6. Occurrence of Vegetation at Sediment Types

	Frequency at Sample Sites	Percent Vegetated
Silt	57%	98%
Silt/rock	2%	100%
Sand	21%	94%
Sand/rock	8%	100%
Muck	9%	86%
Rock	2%	100%

THE COMMUNITY

Simpson's Diversity Index was 0.87, indicating a moderately high level of diversity. A rating of 1.0 would mean that each species in the lake would be a different species (the most diversity achievable). However, much of this diversity was in the emergent community. The emergent communities in the bays at the south ends of the horseshoe bends added to the diversity of the lake.

The recently developed Aquatic Macrophyte Community Index (AMCI) (Weber et. al. 1995) was applied to Half Moon Lake. Values between 0 and 10 are given for six categories that characterize the aquatic community (Table 7). The highest value for this index is 60. AMCI for Half Moon Lake is 40. This is average for lakes in Wisconsin.

Table 7. Aquatic Macrophyte Community Index

Category		Value
Maximum Rooting Depth	2.7 meters	4
% Littoral Zone Vegetated	100%	10
Simpson's Diversity	0.87	9
# of Species	25 (1 non-native)	9
% Submersed Species	73% Rel. Freq.	8
% Sensitive Species	1% Relative Freq.	0
Totals		40

V. DISCUSSION

Based on the water clarity, chlorophyll levels and phosphorus levels, Half Moon Lake is a eutrophic lake. This trophic state favors abundant plant growth with periods of high turbidity likely. Its gradually sloped littoral zone and shallow depth would also favor plant growth. Its soft water could limit the biomass of macrophytes.

Silt sediments were the most prevalent sediments. Silt sediment favors plant growth because of its intermediate density (Barko and Smart 1986). Sand sediments are also prevalent and limiting to plant growth due to their high density.

Much of the shoreline of Half Moon Lake was protected by native plant growth: tree, shrub and herbaceous growth. Preserving this buffer of natural vegetation is important to prevent decreased water quality. Since the city of Eau Claire has acquired most of the shoreline as a park, this will help protect this buffer. However, some of the park area along the shore consists of cultivated lawn for picnic and play areas and roads made of hard surface or bare soil. It is important to manage these areas with the water quality in mind.

Abundant plant growth was found throughout the littoral zone, up to the maximum rooting depth of 9 feet. All of the sites were vegetated and 96% of the sites had rooted vegetation.

Thirty-two species were found in Half Moon Lake; *Potamogeton crispus* was the dominant species based on its high frequency of occurrence and high density. It was dominant in all depth zones. *Ceratophyllum demersum* and *Elodea canadensis* were sub-dominant species. Filamentous algae was also abundant at the sample sites.

P. crispus may be suppressing the growth of other species. It has an advantage over other species due to its early growth, shading out species that are just starting their growth. Its early decay releases nutrients that can feed algal blooms that increase turbidity and further shade macrophytes. Harvesting may be helpful to increase the diversity of species. The 1989 survey found *P. crispus* to be dominant at that time also. But *Elodea canadensis* and *Ceratophyllum demersum* (species tolerant of low light levels) were the only other species evident in the main body of the lake in 1989.

Simpson's Diversity Index indicates that the macrophyte community has a moderately-high diversity. But, emergent species contribute much of this diversity. More than half of the species in Half Moon Lake were emergent species. In addition, the 0-1.5ft. depth zone had the highest mean number of species per site and the highest total occurrence and total density of macrophytes. This is due to the emergent species. Braun's Bay, a backwater on the southwest end of the lake, contributes significantly to the diversity.

Several species in Half Moon Lake (*Ceratophyllum demersum, Eleocharis acicularis, Elodea canadensis, Lemna minor, Najas flexilis, Potamogeton crispus, Spirodela polyrhiza* and *Vallisneria americana*) have been known to grow to over-abundance when there is an excess of nutrients in the lake (Nichols and Vennie 1991). Since six of these species were the most prevalent species in the lake and are abundant (freq. > 20%), the water quality may be determining the character of the macrophyte community in the lake.

Years of chemical treatments may have also determined the character of the macrophyte community. Copper compounds were used to control algae. *Chara* sp. and *Nitella* sp. are also susceptible to copper. *Chara* was not found and *Nitella* was found at a frequency less than 10%. Endothall was used to control *Potamogeton crispus*, but it will also control other, more valuable species of *Potamogeton, Ceratophyllum demersum, Myriophyllum* and *Vallisneria*. 2,4-D was also used for the control of *P. crispus*, but it limits *Brasenia, Myriophyllum, Nymphaea* and *Utricularia*. Of the species susceptible to Endothall and 2,4-D, only *Ceratophyllum demersum, Vallisneria americana* (at only 1% of the sample sites) and only three species of *Potamogeton* were found in the lake.

Harvesting aquatic plants instead of chemical treatments has the advantage of removing plants from the lake so that their decay does not feed algal blooms. It also eliminates the risks associated with chemical carry-over and residues. Early season harvesting of *P. crispus* also better prevents the formation and release of winter buds (turions) from which new growth starts than chemical applications after the turions have formed. Overtime, this can significantly reduce the dominance of *P. crispus*.

VI. CONCLUSIONS

Half Moon Lake is a eutrophic lake with very poor water clarity.

Due in part to the emergent community, it has a moderately-diverse macrophyte community characterized by abundant growth. The common species in the lake (freq. > 20%) are composed almost entirely of species that are known to grow to over-abundant levels in high nutrient systems.

Potamogeton crispus was the dominant species, possibly suppressing the growth of other species. *Ceratophyllum demersum* and *Elodea canadensis* were sub-dominant and are tolerant of low light levels and high turbidity. High levels of filamentous algae were found in the lake.

A healthy aquatic plant community plays a vital role within the lake community. Plants provide improved water quality and valuable resources for fish and wildlife (Table 8). Lakes with a healthy and diverse community of native macrophytes, are more resistant to invasions of non-native species and excessive growth of more tolerant species.

Healthy macrophyte communities improve water quality in many ways: they trap nutrients, debris, and pollutants entering a water body; they may absorb and break down the pollutants; they reduce erosion by stabilizing banks and shorelines, stabilizing bottoms, and reducing wave action; they remove nutrients that would otherwise be available for algae blooms (Engel 1985). By intercepting the sunlight and shading, plants can have a cooling effect on the water (Engel 1985).

A balanced, healthy aquatic plant community provides important fishery and wildlife resources. Plants (including algae) start the food chain that supports many levels of wildlife, and at the same time produce oxygen needed by animals. Plants are used as food and cover by a variety of wildlife and as food, cover, and spawning sites by fish. Plants can become a major food source for certain fish during the summer (Engel 1985).

Compared to non-vegetated lake bottoms, macrophyte beds supported larger, more diverse invertebrate populations (Engel 1985). These larger and more diverse invertebrate populations will in turn support larger and more diverse fish populations. Mixed stands of macrophytes support 3-8 times as many invertebrates and fish as monocultural stands. Diversity creates more microhabitats for the preferences of more species (Engel 1990). Additionally, macrophyte beds of moderate density support adequate numbers of small fish without restricting the movement of predatory fish (Engel 1990).

Harvesting appears to be increasing the diversity of the macrophyte community and reducing the dominance of *Potamogeton crispus*. The fish community also appears to have improved since the harvesting. Harvesting does not add chemicals to the water, can be more specifically designed to improve fish habitat and can remove plants from the lake that would otherwise decay and release nutrients.

Careful management of the park area in order to preserve the natural buffer of native vegetation around the lake will be beneficial to the water quality and wildlife habitat.

It is important to protect the water quality in Half Moon Lake. It has been an important asset to the community (Eau Claire 1995). Reducing the amount of nutrients entering the lake is necessary to protect the aquatic macrophyte community and water quality. A diverse macrophyte community will be better able to support a diverse fish and wildlife community.

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