The Aquatic Plant Community in Mayflower Lake, Marathon County 2002

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Executive Summary

Mayflower Lake is a mesotrophic lake with good water quality and fair water clarity. Filamentous algae is common, especially at depths greater than 5 feet and in the west end of the lake. Nutrients and algae increased slightly from 1997 to 2002 and water clarity decreased during the same time period. Since the watershed is small compared to lake size, it is most likely that the nutrient source is internal loading or run-off from the lakeshore properties.

The macrophyte community colonized one-third of the littoral zone to a maximum depth of 13 feet. Nearly all aquatic plant growth is found in the west end of Mayflower Lake and the 0-1.5 ft. depth zone supported the most abundant aquatic plant growth.

Adequate nutrients and a gradually-sloped littoral zone in the shallow end of the lake favor plant growth. The dominance of high-density sediments can limit aquatic plant growth.

The quality of the aquatic plant community is above average for Wisconsin lakes and is characterized by very good species diversity and an average tolerance to disturbance.

Myriophyllum sibiricum is the dominant species within the plant community, especially in the 5-10ft depth zone. *Chara* sp, and *Nymphaea odorata* were sub-dominant species, especially in the 0-5ft depth zone.

As a shallow lake, Mayflower Lake is a unique resource that can not be forced to act like a deep-water lake. Shallow lakes exist in either in a clear-water state with abundant aquatic plant growth or in a murky, algae-dominated state with sparse aquatic plant growth. Once the balance is tipped from a clear water state to a turbid water state, it is very hard to bring a shallow lake back to a clear water state.

Taking steps to protect the aquatic plant community in Mayflower Lake will help increase and preserve water

clarity.

Management Recommendations

1) Continued water quality monitoring by the DNR.
2) DNR should designate sensitive areas within Mayflower Lake.
3) All lake users must protect the submerged plant communities. Chemical treatments for plant growth are not recommended in Mayflower Lake due to the lack of nuisance plant growth and the undesirable side-effects of chemical treatments.
4) Lakeshore property owners should preserve natural buffer zones of native vegetation along the shore.
5) Lakeshore property owners should also expand the buffer of natural vegetation around the shore of Mayflower Lake.

I. INTRODUCTION

A study of the aquatic macrophytes (plants) in Mayflower Lake was conducted during August 2002 by Water Resources staff of the West Central Region - Department of Natural Resources (DNR). This was the first quantitative vegetation study of Mayflower Lake by the DNR. A preliminary qualitative assessment was conducted in July 1997 and a pre-treatment assessment was conducted in 1977.

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 in the lake ecosystem 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 and impact recreation.

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 macrophyte inventories and offer insight into any changes occurring in the lake.

Background and History: Mayflower Lake is a 98-acre, hardwater, seepage lake in eastern Marathon County, Wisconsin. With a maximum depth of 16 feet and an average depth is 7 feet, Mayflower Lake would be classified as a shallow water resource.

The watershed that drains into Mayflower Lake is approximately 600 acres. This is a drainage area/lake ratio of approximately 6:1. Lakes with drainage area/lake size ratios greater than 10:1 tend to have water quality problems (Field 1994).

Winter fishkills have occurred on Mayflower Lake due to low dissolved oxygen. Winter fishkills were recorded in 1972, 1974 and 1975.

Residents have written to the Department as early as 1948, asking for advice on aquatic plant control, even proposing to dynamite portions of the lake. Chemical control for aquatic plants were conducted in Mayflower Lake (Table 1).

Table 1. Herbicides Applied to Mayflower Lake

	Cutrine+ (gal.)	**Aquathol**	**Diquat (gal.)**	**2, 4-D (gal.)**	**Rodeo (qt.)**	**Species***
1971		750 lbs	4.5		1	cerde; myrsp; nupva; nymod; potam
1988	2		2		2	chasp; myrsi; nymod; nupva; potam; potpu; potri;
1991	9.5	5.75 gal	7.25	1.5	1.5	cerde; chasp; elesp; myrsi; nupva; nymod; potam; potpu; potri; typla;
1992	6	6 gal 40 lbs	6			cerde; chasp; elesp; myrsi; nupva; nymod; potam; potpu; potri; typla;
Total	17.5	790 lbs 11.75 gal	19.75	1.5	4.5	

*cerde=*Ceratophyllum demersum*; coontail
chasp=*Chara*; muskgrass
elesp=*Eleocharis*; spike rush
myrsp=*Myriophyllum spicatum*; Eurasian watermilfoil
nupva=*Nuphar variegata*; yellow pond lily
nymod=*Nymphaea odorata*; white water lily
potam= *Potamogeton amplifolius*; large-leaf pondweed
potri=*Potamogeton richarsonii*; clasping-leaf pondweed
potpu=*Potamogeton pusillus*; small pondweed
typla=*Typha latifolia*; cattail

Treatment areas have, in different years, been conducted in the middle of the lake, along sections of the north shore and encompassing nearly the entire south shore. More than 2000’ of continuous shoreline had been treated during a single treatment.

Wildlife biologists have objected to the past treatments; they were concerned about the removal of lily pads that provide fish habitat. They also objected that the reduction of cattails, spike rush and other emergents would reduce wildlife habitat and food production and therefore adversely impacting furbearers, waterfowl, amphibians, turtles, upland birds and marsh birds.

Rusty crayfish, a non-native invertebrate, was observed in Mayflower Lake during the aquatic plant survey.

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 14 equal segments and a transect, perpendicular to the shoreline, was randomly placed within each segment (Appendix IV), using a random numbers table.

One sampling site was randomly located in each depth zone (0-1.5ft, 1.5-5ft, 5-10ft 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 diameter 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 2 indicates that a species was present on two rake samples
a rating of 3 indicates that it was present on three rake samples
a rating of 4 indicates that it was present on all four rake samples
a rating of 5 indicates that a species was abundantly present on all rake samples at that sampling site.

Visual inspection and periodic samples were taken between transect lines 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).

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 deep was evaluated. The percentage of each cover type within this 100' x 30' rectangle was visually estimated and verified by a second researcher.

Data Analysis

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

The Aquatic Macrophyte Community Index (AMCI) developed by Weber et. al. (1995) was applied to Mayflower Lake (Table 4). Values between 0 and 10 are given for each of six categories that characterize a plant community.

The Average Coefficient of Conservatism and Floristic Quality (FQI) was calculated, as outlined by Nichols (1998), to determine disturbance in the plant community. A coefficient of conservatism is an assigned value, 0-10, the probability that a species will occur in an undisturbed habitat. The Average Coefficient of Conservatism is the mean of the Coefficients for all species found in the lake. The FQI is calculated from the Coefficient of Conservatism (Nichols 1998) and is a measure of a plant community's closeness to an undisturbed condition.

III. RESULTS

PHYSICAL DATA

Many physical parameters impact the macrophyte community. Water quality (nutrients, algae and clarity) influence the macrophyte community as the macrophyte community can in turn modify these parameters. Lake morphology, sediment composition and shoreline use also effect the macrophyte community.

WATER QUALITY - The trophic state of a lake is an indication of its water quality. Phosphorus concentration, chlorophyll concentration, and water clarity data are collected and combined to determine the trophic state.
Eutrophic lakes are high in nutrients and therefore 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.

Nutrients

Phosphorus is a limiting nutrient in many Wisconsin lakes and is measured as an indication of the nutrients in a lake. Increases in phosphorus in a lake can feed algae blooms and, occasionally, excess plant growth.
August 2000 phosphorus in Mayflower Lake was 16ug/l
This level of phosphorus in Mayflower Lake was indicative of a mesotrophic lake (Table 2).

Table 2. Trophic Status

	Quality Index	Phosphorus ug/l	Chlorophyll ug/l	Secchi Disc ft.
Oligotrophic	Excellent	<1	<1	> 19
	Very Good	1-10	**1-5**	8-19
Mesotrophic	Good	**10-30**	5-10	6-8
	Fair	30-50	10-15	**5-6**
Eutrophic	Poor	50-150	15-30	3-4
Hypereutrophic	Very Poor	>150	>30	>3
Mayflower Lake	Good	16	3.2	5.5

After Lillie & Mason (1983) & Shaw et. al. (1993)

Algae

Measuring chlorophyll in lake water measures algae concentrations. Algae are natural and essential in lakes, but high algae populations can increase turbidity and reduce the light available for plant growth.
August, 2000 chlorophyll a in Mayflower Lake was 3.2 ug/l.
The chlorophyll concentration in Mayflower Lake indicates that it was an oligotrophic lake (Table 2).

Water Clarity

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 is measured with a Secchi disc that shows the combined effect of turbidity and color. **Secchi disc clarity in August 2000 was 5.5 ft.**
Secchi disc readings can be used to calculate a predicted maximum rooting depth for plants in a lake (Dunst 1982).
Based on the 2000 Secchi disc clarity, the predicted maximum rooting depth in Mayflower Lake would be 9.5 ft.
Water clarity indicates (Table 2) that Mayflower Lake was a mesotrophic lake with fair water clarity.

The combination of phosphorus concentration, chlorophyll concentration and water clarity indicates that Mayflower Lake is a mesotrophic lake with good water quality. This trophic state would favor moderate levels of plant growth and occasional algae blooms.

LAKE MORPHOMETRY - The morphometry of a lake is an important factor in determining 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).

Mayflower Lake has a narrow basin that is shallow and gradually sloped in the west half (Appendix IV). The littoral zone in the east end has a slightly steeper slope. Areas of the lake with shallow depths and gradual slopes would favor plant growth.

SEDIMENT COMPOSITION – The dominant sediment in Mayflower Lake was a mixture of sand and gravel, especially in the shallow zone along the east end and along the south shore (Table 3). Sand alone was common in the 1.5-5ft depth zone.

Silt was commonly occurring, especially in the 5-17ft depth zones and in the west end of the lake. Peat was commonly found mixed with silt in the 10-17ft depth zone, occurring in the middle portion of the lake (Table 3).

Table 3. Sediment Composition

Sediment Type		0-1.5' Depth	1.5-5' Depth	5-10' Depth	10-20' Depth	Percent of all Sample Sites
Hard Sediments	Sand/Gravel	38%	31%	27%	30%	32%
	Sand	8%	23%	9%	10%	12%
	Sand/Rock	8%	15%	9%		8%
	Rock/Gravel	15%				4%
Mixed Sediments	Sand/Silt	15%				4%
Soft Sediments	Silt	15%	31%	36%	40%	30%
	Silt/Peat			18%	20%	8%

SHORELINE LAND USE – Land use practices can strongly impact the aquatic plant community and, therefore, the entire aquatic community. These practices can directly impact the plant community through increased sedimentation from erosion, increased nutrient input from fertilizer run-off and soil erosion and increased toxics from farmland and urban run-off.

Wooded cover was the most frequently encountered shoreline cover at the transects and had the highest mean coverage. Native herbaceous growth occurred at more than one-third the sample sites and wetland was also common (Table 4).

Disturbed shoreline was also common. Cultivated lawn and hard structures occurred at more than one-third of the sites and eroded areas were commonly encountered. Cultivated lawn covered nearly one-third of the shoreline (Table 4).

Table 4. Shoreline Land Use

Cover Type		Frequency of Occurrences at Transects	Mean % Coverage
Natural Shoreline	Wooded	50%	39%
	Native Herbaceous	36%	4%
	Wetland	21%	18%
	Shrub	14%	2%
Disturbed Shoreline	Cultivated Lawn	36%	30%
	Hard Structures	36%	2%
	Eroded Soil	21%	1%
	Pavement	7%	3%

Some coverage of natural shoreline (wooded, shrub, native herbaceous, wetland) was found at 78% of the sites, with a mean coverage over the entire shore of approximately 63%. Disturbed shoreline (cultivated lawn, hard structures, eroded soil and pavement) was found at 64% of the sites and had a mean coverage of 37%.

MACROPHYTE DATA

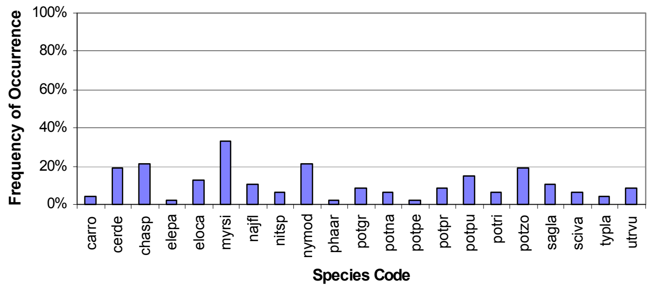
SPECIES PRESENT

Of the 21 species found in Mayflower Lake, 6 were emergent species, 1 was a floating-leaf species and 14 were submergent species (Table 5). No non-native species, threatened or endangered species were found.

Table 5. Mayflower Lake Aquatic Plant Species

Scientific Name	Common Name	I. D. Code
Emergent Species		
1) *Carex rostrata* Stokes.	sedge	carro
2) *Eleocharis* sp.	spike rush	elesp
3) *Phalaris arundinacea* L.	reed canary grass	phaar
4) *Sagittaria latifolia* Willd.	common arrowhead	sagla
5) *Scirpus validus* Vahl.	softstem bulrush	sciva
6) *Typha latifolia* L.	common cattail	typla
Floating-leaf Species		
7) *Nymphaea odorata* Aiton.	white water lily	nymod
Submergent Species		
8) *Ceratophyllum demersum* L.	coontail	cerde
9) *Chara* sp.	muskgrass	chasp
10) *Elodea canadensis* Michx.	common waterweed	eloca
11) *Myriophyllum sibiricum* Komarov.	common water milfoil	myrsi
12) *Najas flexilis* (Willd.) Rostkov and Schmidt.	slender naiad	najfl
13) *Nitella* sp.	nitella	nitsp
14) *Potamogeton gramineus* L.	variable-leaf pondweed	potgr
15) *Potamogeton natans* L.	floating-leaf pondweed	potna
16) *Potamogeton pectinatus* L.	sago pondweed	potpe
17) *Potamogeton praelongus* Wulfen.	whitestem pondweed	potpr
18) *Potamogeton pusillus* L.	small pondweed	potpu
19) *Potamogeton richardsonii* (Ar. Bennett) Rydb.	clasping-leaf pondweed	potri
20) *Potamogeton zosteriformis* Fern.	flatstem pondweed	potzo
21) *Utricularia vulgaris* L.	common bladderwort	utrvu

FREQUENCY OF OCCURRENCE



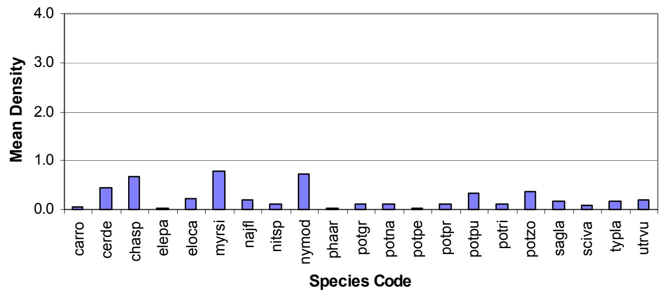
Myriophyllum sibiricum was the most frequently occurring species in Mayflower Lake in 2002, (33% of sample sites) (Figure 1). *Chara* sp. and *Nymphaea odorata* were also a commonly occurring species, (20%, 20%).

Figure 1. Macrophyte frequencies in Mayflower Lake

Flamentous algae occurred at 21% of the sample sites, mainly in the west end of the lake. Filamentous algae occurred at:

7% of the sites in the 0-1.5ft depth zone
15% of the sites in the 1.5-5ft depth zone
36% of the sites in the 5-10ft depth zone
30% of the sites in the 10-17ft depth zone

DENSITY

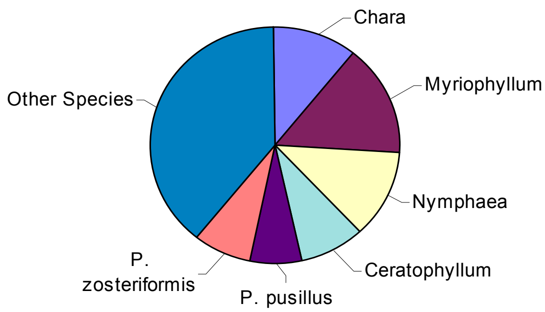


Myriophyllum sibiricum and *Nymphaea odorata* had the highest mean densities (0.77 and 0.73 on a density scale of 1-4) in Mayflower Lake (Figure 2).

Figure 2. Densities of macrophytes in Mayflower Lake, 2002

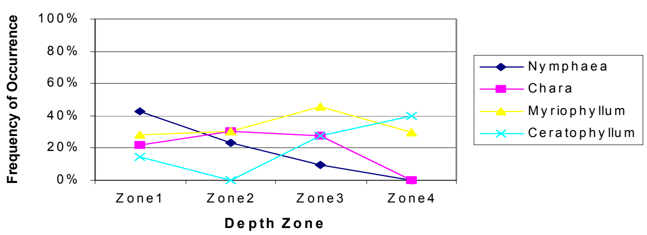
Typha latifolia had a "mean density where present" of (4.0). Its "mean density where present" indicates that, where *T. latifolia* occurred, it exhibited a dense growth form in Mayflower Lake, even though it occurred at a limited number of sites (Appendix II). *Chara* sp. and *Nymphaea odorta* were two other species in Mayflower Lake that had "densities where present" of 2.5 or more, indicating that they exhibited a growth form of above average density (Appendix II).

DOMINANCE



Combining relative frequency and relative density into a Dominance Value illustrates how dominant a species is within the macrophyte community (Appendix III). Based on the Dominance Value, *Myriophyllum sibiricum* was the dominant aquatic plant species in Mayflower Lake (Figure 3). *Nymphaea odorata* and *Chara* sp. were sub-dominant.

Figure 3. Dominance within the macrophyte community, of the most prevalent aquatic macrophytes in Mayflower Lake, 2002.



Nymphaea odorata, a sub-dominant species, dominated the 0-1.5ft depth zone (Appendices I, II) and was found at its highest frequency and density in this depth zone (Figure 4, 5). *N. odorata* declined with increasing depth.

Figure 4. Frequency of occurrence of prevalent macrophytes in Mayflower Lake, by depth zone.

Chara sp., another sub-dominant species, dominated the 1.5-5ft depth zone (Appendices I, II) and was found at its highest frequency and density in this depth zone (Figure 4, 5).

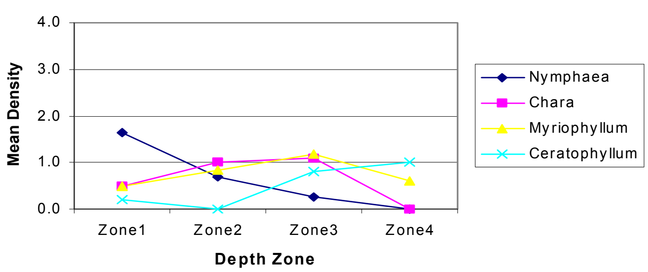


Figure 5. Density of prevalent macrophytes by depth zone.

Myriophyllum sibiricum, the dominant species, dominated the 5-10ft depth zone (Appendices I, II) and occurred at its highest frequency and density in this depth zone (Figure 4, 5).

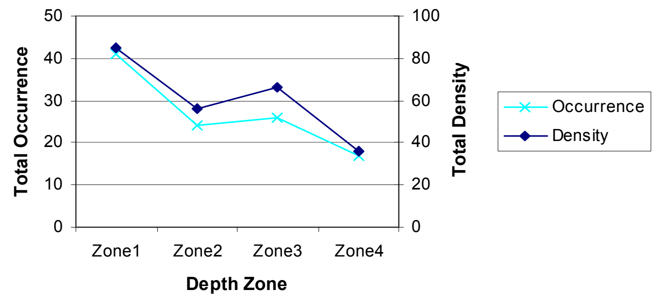
Another prevalent species, *Ceratophyllum demersum*, dominated the 10-17ft depth zone and occurred at its highest frequency and density in this depth zone (Figure 4, 5).

DISTRIBUTION

Aquatic macrophytes occurred mainly in the west end of Mayflower Lake. The dominant and prevalent species were found only in the western two-thirds of Mayflower Lake.

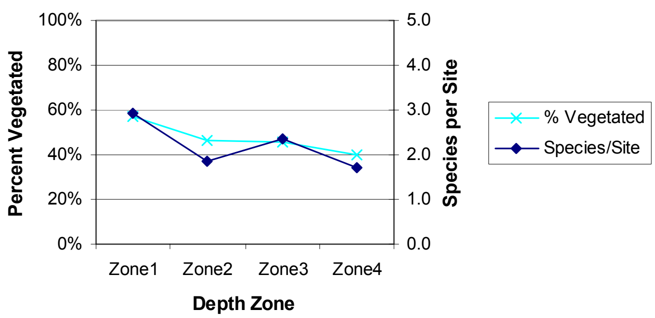
Over the whole lake, 33% of the sampling sites were vegetated, with rooted macrophytes. Macrophytes were found up to a maximum depth of 13 feet, with *Ceratophyllum demersum, Myriophyllum sibiricum* and *Potamogeton zosteriformis* at the maximum rooting depth. This rooting depth is deeper than the predicted maximum rooting depth of 9.5, based on water clarity.

The 0-1.5ft depth zone supported the greatest amount of plant growth. The highest total occurrence and total



density of plant growth was recorded in the 0-1.5ft depth zone (Figure 6).

Figure 6. Total occurrence and density of plants by depth zone.



The highest percentage of vegetated sites and the greatest mean number of species per site were also found in the 0-1.5 ft. depth zone (Figure 7).

Figure 7. Percentage of vegetated site and mean number of species per site in Mayflower Lake, by depth zone.

The mean number of species found at each sampling sites was 2.25

25 sites had 0 species
3 sites had 1 species
3 sites had 2 species
3 sites had 3 species
4 sites had 4 species
1 sites had 5 species
3 sites had 6 species
1 sites had 7 species
2 sites had 8 species
3 sites had 9 species

INFLUENCE OF SEDIMENT - Some plants depend on the sediment in which they are rooted for their nutrients. The richness or sterility and texture of the sediment will determine the type and abundance of macrophyte species that can survive in a location.

Sand/gravel mixtures were the predominant sediment found in Mayflower Lake and may limit plant growth due their high-density (Barko and Smart 1986). Only 9% of the sites with sand/gravel sediment were vegetated (Table 6). Other high-density sediments (sand/rock and rock/gravel) did not support any vegetation in Mayflower Lake. Sand supported vegetation at 50% of the sites

Silt sediments, which were common at the sample sites in Mayflower Lake, are intermediate density sediments. The availability of mineral nutrients for growth is highest in sediments of intermediate density (Barko and Smart 1986). Silt sediments supported abundant vegetation; 78% of these sites were vegetated.

Silt mixed with peat supported vegetation at 75% of the sites at which it occurred; silt mixed with sand supported vegetation at all of the sites at which it occurred. These favorable sediments had a lower occurrence in Mayflower Lake (Table 6).

Table 6. Sediment Influence

Sediment Type		**Percent of all Sample Sites**	**Percent Vegetated**
Hard Sediments	Sand/Gravel	32%	9%
	Sand	12%	50%
	Sand/Rock	8%	0%
	Rock/Gravel	4%	0%
Mixed Sediments	Sand/Silt	4%	100%
Soft Sediments	Silt	30%	78%
	Silt/Peat	8%	75%

THE COMMUNITY

Simpson's Diversity Index was 0.93, indicating very good species diversity. A rating of 1.0 would mean that each plant in the lake would be a different species (the most diversity achievable).

The Aquatic Macrophyte Community Index (AMCI) for Mayflower Lake (Table 7) is 44. This is above average quality (40) for lakes in Wisconsin. The highest value for this index is 60.

Table 7. Aquatic Macrophyte Community Index

Category		Value
Maximum Rooting Depth	3.9 meters	6
% Littoral Zone Vegetated	48%	10
Simpson's Diversity	0.93	10
# of Species	21 (no exotics)	8
% Submergent Species	67% Rel. Freq.	8
% Sensitive Species	6% Relative Freq.	2
Totals		44

The Average Coefficient of Conservatism for Mayflower Lake was in the lowest quartile for all Wisconsin lakes analyzed and below the mean for lakes in the North Central Hardwood Region (Table 8). This suggests that the aquatic plant community in Mayflower Lake are among the group of lakes most tolerant of disturbance in Wisconsin and more disturbance tolerant than the average lake in the North Central Hardwoods Region.

Table 8. Floristic Quality and Coefficient of Conservatism of Mayflower Lake, Compared to Wisconsin Lakes and Northern Wisconsin Lakes.

	(C) Average Coefficient of Conservatism †	Floristic Quality (FQI) ‡
Wisconsin Lakes *	5.5, 6.0, 6.9	16.9, 22.2, 27.5
NCHR *	5.2, 5.6, 5.8	17.0, 20.9, 24.4
Mayflower Lake 2002	5.29	24.22

* – Values indicate the highest value of the lowest quartile, the mean and the lowest value of the upper quartile.

† – Average Coefficient of Conservatism for all Wisconsin lakes ranged from a low of 2.0 (the most disturbance tolerant) to a high of 9.5 (least disturbance tolerant).

‡ – lowest Floristic Quality was 3.0 (farthest from an undisturbed condition) and the high was 44.6 (closest to an undisturbed condition).

The Floristic Quality of the plant community in Mayflower Lake was above average for Wisconsin lakes and North Central Hardwood Lakes (Table 8). This suggests that the plant community in Mayflower Lake is closer to an undisturbed condition than the average lake in Wisconsin or North Central Hardwood Region.

Disturbances can be of many types:

1) Direct disturbances to the plant beds result from activities such as boat traffic, plant harvesting, chemical treatments, the placement of docks and other structures and fluctuating water levels.
2) Indirect disturbances are the result of factors that impact water clarity and thus stress species that are more sensitive: resuspension of sediments, sedimentation from erosion and increased algae growth due to nutrient inputs.
3) Biological disturbances include the introduction of a non-native or invasive plant species, grazing from an increased population of aquatic herbivores and destruction of plant beds by the fish population.

V. DISCUSSION

Based on water clarity, chlorophyll and phosphorus data, Mayflower Lake is a mesotrophic lake with fair water clarity and good water quality. The watershed to lake ratio is small, therefore the watershed would not likely be a large source of nutrient input. Filamentous algae commonly occurred, especially in the west end of the lake and at depths greater than 5 feet.

Adequate nutrients and the shallow depth and gradually sloped littoral zone in the west portion of Mayflower Lake favor macrophyte growth. The dominance of high-density sand and sand/gravel sediments in Mayflower Lake may limit plant growth. Favorable silt sediments are more common in the deeper water, below the photic zone.

Some attempts to chemically treat plant growth with broad-spectrum have been conducted in Mayflower Lake in the past (1971-1992). These treatments impacted large areas of the lake, as much as 2000 feet of continuous littoral zone in some years.
The treatments were approved in spite of objections of wildlife biologists concerning the loss of habitat. Two species that occurred in the treatment areas are no longer found in Mayflower Lake: *Nuphar variegata, Potamogeton amplifolius*. If the treatments eliminated these two species, that is unfortunate, since these species are considered premier habitat components.

There are other disadvantages of chemical treatments besides the loss of habitat provided by the aquatic plants. Chemically treating the plants releases nutrients into the lake water for algae growth. Treatments create open, disturbed areas that are prime areas for colonization of more invasive plant species.

Future chemical treatments are not advisable. Mayflower Lake does not have an over-abundance of aquatic plant growth and the species that occur in Mayflower Lake are not species that typically cause nuisance growth.

Most of the rooted aquatic plant growth occurred in the west half of Mayflower Lake. Aquatic plants occurred at 33% of the sites, to a maximum depth of 13 feet. This maximum rooting depth is greater than the predicted maximum rooting depth of 9.5 ft. This is likely due to better water clarity early in the season when plant growth is beginning.

The highest total occurrence of plants, highest total density of plants, the greatest percentage of vegetated sites and the largest mean number of species per sample site occurred in the shallowest depth zone (0-1.5ft).

Myriophyllum sibiricum was the dominant macrophyte species in Mayflower Lake, especially in the 5-10ft depth zone, occurring at one-third of the sample sites. *Chara* sp. and *Nymphaea odorata* were sub-dominant macrophyte species in Mayflower Lake and exhibited a growth form of above average density. *Typha latifolia* also exhibited a dense growth form in Mayflower Lake. *Chara* sp. dominated the 1.5-5ft depth zone; *N. odorata* dominated the 0-1.5ft depth zone and occurred only in the far west end of the lake on silt sediments.

Myriophyllum spicatum, Eurasian watermilfoil, was listed during a pre-treatment assessment. It is doubtful that this species occurred in Mayflower Lake at that time. It was likely confused with the native milfoil, *Myriophyllum sibiricum,* which occurs in Mayflower Lake.

The Aquatic Macrophyte Community Index (AMCI) for Mayflower Lake was 44, indicating that the quality of the macrophyte community in Mayflower Lake is above average (40) for Wisconsin lakes. Simpson's Diversity Index (0.93) indicates that the macrophyte community had a very good diversity of species. The mean number of species per sample site was 2.25.

The Average Coefficient of Conservatism and the Floristic Quality Index suggests that Mayflower Lake has been impacted by an average amount of disturbance as compared to lakes in Wisconsin and in the North Central Hardwoods Region of Wisconsin.

Mayflower Lake is protected by a high coverage of natural shoreline (wooded, shrub, native herbaceous growth and wetland). However, disturbed shoreline covered 37% of the shore. Two types of disturbed cover, cultivated lawn and hard structures occurred at 36% of the sample sites and cultivated lawn covered 30% of the shoreline. Areas with cultivated lawn could result in increased run-off of lawn fertilizers, pesticides and pet wastes into the lake. Preserving and expanding the buffer of natural vegetation along the shore will help prevent shoreline erosion and reduce additional nutrient/chemical run-off that can add to algae growth and sedimentation of the lake bottom.

VI. CONCLUSIONS

Mayflower Lake is a mesotrophic lake with good water quality and fair water clarity. Filamentous algae is common, especially at depths greater than 5 feet and in the west end of the lake. Water quality sampling in 1997 and 2002 suggests that nutrients and algae increased slightly from 1997 to 2002 and water clarity decreased during the same time period. The small watershed to lake ratio suggests that the watershed is not likely the source of added nutrients, but more likely, the nutrient source is internal loading or run-off from the lakeshore properties.

The quality of the aquatic plant community is above average for Wisconsin lakes and is characterized by very good species diversity and an average tolerance to disturbance. Nearly all aquatic plant growth is found in the west end of Mayflower Lake.

The macrophyte community colonized one-third of the littoral zone to a maximum depth of 13 feet. The 0-1.5 ft. depth zone supported the most abundant aquatic plant growth. Adequate nutrients and a gradually-sloped littoral zone in the shallow end of the lake favor plant growth. The dominance of high-density sediments can limit aquatic plant growth.

Myriophyllum sibiricum is the dominant species within the plant community, especially in the 5-10ft depth zone. *Chara* sp, and *Nymphaea odorata* were sub-dominant species, especially in the 0-5ft depth zone.

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play in 1) improving water quality 2) providing valuable habitat resources for fish and wildlife 3) resisting invasions of non-native species and 4) checking excessive growth of tolerant species that could crowd out the more sensitive species, thus reducing diversity.

1) Macrophyte communities improve water quality in many ways:
   - they trap nutrients, debris, and pollutants entering a water body;
   - they absorb and break down some pollutants;
   - they reduce erosion by damping wave action and stabilizing shorelines and lake bottoms;
   - they remove nutrients that would otherwise be available for algae blooms (Engel 1985).

2) Aquatic plant communities provide 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, cover and nesting/spawning sites by a variety of wildlife and fish (Table 9). Plant cover within the littoral zone of Mayflower Lake is 33% and is adequate (25-85%) to support a balanced fishery.

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

As a shallow lake, Mayflower Lake is a unique resource that can not be forced to act like a deep-water lake. Shallow lakes exist as two, alternate types:

1) clear water with abundant aquatic plant growth

or

2) murky, algae-dominated with sparse aquatic plant growth

Once the balance is tipped from a clear water state to a turbid water state, it is very hard to bring a shallow lake back to a clear water state. Shallow lakes are much more susceptible to certain disturbances than deep water lakes. Wind has a much greater impact on shallow lakes. A 10-25 mph wind can resupsend the sediments in a shallow lake. A 25hp motor can disturb sediments 10 ft. below the surface (Asplund and Cook 1997). Both wind and propeller resuspension of sediments reduce water clarity and allow nutrients in the sediments to circulate in the water, feeding algae growth, further reducing clarity. In addition, boat propellers can also chop up plants, destroying the plant beds that are needed to keep the sediments stabilized.

It is important to take measures to improve and protect water quality and the plant communities that play a key role in protecting water quality:

Management Recommendations

6) Continued water quality monitoring by the DNR. Changes in water quality parameters from 1997 to 2002 may have

been due to natural variations or could be a trend of declining water quality.

7) DNR should designate sensitive areas within Mayflower Lake. These are areas that are most important for habitat and maintaining water quality.
8) All lake users must protect the submerged plant communities. Chemical treatments for plant growth are not recommended in Mayflower Lake due to the lack of nuisance plant growth and the undesirable side-effects of chemical treatments. The decaying plant material releases nutrients that feed algae growth that further reduce water clarity. Broad-spectrum treatments open areas that would be vulnerable to invasion by exotic species. Past treatments may have already eliminated two species that are valuable habitat components.
9) Lakeshore property owners must preserve natural buffer zones of native vegetation along the shore. Unmowed native vegetation reduces shoreline erosion and run-off into the lake and filters the run-off that does enter the lake.
10) Expand the buffer of natural vegetation around the shore of Mayflower Lake. More than one-third of the lakeshore is impacted by disturbed shoreline. Most of this disturbance is from cultivated lawn. Leave a band of natural vegetation around the shore by discontinuing mowing and cutting at the shoreline.

Taking steps to protect the aquatic plant community in Mayflower Lake will assist efforts to increase and preserve water clarity and fish and wildlife resources.