Executive Summary

Lake Emily is a mesotrophic lake with good water quality and clarity. Nutrients and algae have increased and water clarity has decreased during 2000-2005. Filamentous algae is common, especially in the 0-1.5ft depth zone.

The aquatic plant community is characterized by high quality, good species diversity, a below average amount of disturbance and an above average tolerance to disturbance. The aquatic plant community colonized 92% of the littoral zone to a maximum depth of 15.5 feet.

Chara spp. is the dominant species within the plant community, dominating all depth zones. *Vallisneria americana* was sub-dominant. All dominant, abundant and common species were distributed throughout the lake.

A healthy aquatic plant community is important because it can improve water quality, provide valuable habitat resources for fish and wildlife, resist the introduction of non-native species and check excessive growth of tolerant species that could crowd out the more sensitive species, thus reducing diversity.

Management Recommendations

1) Lake Association to become involved in the Volunteer Lake Monitoring Program.
2) Lake Association to develop a Lake Management Plan to assist in its management of Eurasian watermilfoil
3) Lake Association to become involved in the Clean Boats, Clean Waters Volunteer Watercraft Inspection Program.
4) DNR to maintain exotic species alert signs at the boat landings.
5) Lake residents to provide milfoil weevil winter habitat by protecting and restoring natural shoreline.
6) Lake Association to regularly update milfoil weevil surveys.
7) Lake residents to protect and restore natural shoreline
    a) Chemical treatments for Eurasian watermilfoil are not recommended as a long-term control method in Lake Emily due to the undesirable side effects of chemical treatments.
8) Lake Association to start a “Eurasian watermilfoil watch committee” that will locate beds of the exotic species and organize hand-pulling of the plants.
9) Lake residents to protect emergent plant beds for habitat and to prevent erosion.
10) Lake association and agencies cooperate with programs in the watershed to reduce nutrient input to the lake and preserve water clarity.
11) DNR to designate Sensitive Areas in Lake Emily.

The Aquatic Plant Community in Lake Emily, Portage County 2005

I. INTRODUCTION

A study of the aquatic macrophytes (plants) in Lake Emily was conducted during July 2005 by Water Resources staff of the West Central Region - Department of Natural Resources (DNR). This was the first quantitative vegetation study of Lake Emily by the DNR.

A study of the diversity, density, and distribution of aquatic plants is an essential component of understanding a lake ecosystem due to the important ecological role of aquatic vegetation in the lake 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 - the beginning of the food chain. Aquatic plants and algae provide food and oxygen for fish, wildlife, and the invertebrates that in turn provide food for other organisms. Plants provide habitat, 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 aquatic plant inventories and offer insight into any changes occurring in the lake.

Background and History: Lake Emily is a 105-acre seepage lake in eastern Portage County, Wisconsin. Lake Emily has a maximum depth of 36 feet and an average depth is 16 feet. The lake is fed by run-off, groundwater and an intermittent flow from Mud Lake on the northeast end of Lake Emily.

The lake has large areas of residential development around the shore, a county park on the east end of the lake and high level of recreational boat use.

The presence of Eurasian watermilfoil in Lake Emily was confirmed by Dr. Freckmann in 1998.

During a watermilfoil and milfoil weevil assessment of Portage County Lakes conducted by Amy Thorstenson of Golden Sands R C & D in 2003 and 2004, Eurasian watermilfoil was mapped and milfoil weevils were found. Weevils were found in four Eurasian watermilfoil beds (Table 1).

Table 1. Weevil Occurrence and Damage on Lake Emily Eurasian Milfoil Beds.

Weevil Bed	Stems with Weevil Damage	Weevils per Stem
A	19%	0.19
B	87%	0.33
C	31%	0.19
D	44%	0.94
Total	43%	0.60

Thorstenson 2004

The Eurasian water milfoil occurred in four dense beds and scattered in the littoral zone along portions of the shore (Figure 1). Eurasian watermilfoil in dense beds colonized 1.4 acres of Lake Emily and as scattered colonies in 1.1 acres of Lake Emily (Thorstenson 2004).

Figure 1. Occurrence of Eurasian watermilfoil in Lake Emily, 2004.

The Lake Association sponsored a selective chemical treatment for Eurasian watermilfoil in early-summer 2005. They also organized a milfoil pulling session with volunteer scuba divers.

Because of the late warming during the spring of 2005, the chemical treatment had to be delayed until June 1, 2005 to allow the water temperatures to warm enough for chemical treatment. At this later date, fish had already started spawning. A no-chemical treatment buffer of 50-feet was placed around all spawning beds to prevent disturbance to spawning. On June 3 a fish kill of about 45-50 fish was observed. The initial reaction was that the kill was due to the chemical treatment. However, after analysis by DNR Fish Health Specialists, the cause of death was determined to be columnaris disease (Meronek 2005).

Figure 2. Occurrence of Eurasian watermilfoil in Lake Emily, July 2005, post-treatment.

II.METHODS

Field Methods

The study design was based on the rake-sampling method developed by Jessen and Lound (1962), using stratified random placement of the transect lines. The shoreline was divided into 23 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), 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 <u>abundantly</u> present on all rake samples at that sample 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 percent cover of land use within this 100' x 30' rectangle was visually estimated.

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 density). 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 of each species were summed to obtain a dominance value for each species (Appendix III). Species diversity was measured by Simpson's Diversity Index (Appendix I).

The Aquatic Macrophyte Community Index (AMCI) developed by Nichols, et. al (2000) was applied to Lake Emily. Measures for each of seven categories that characterize a plant community are converted to values between 0 and 10 and summed.

The Average Coefficient of Conservatism and Floristic Quality Index were calculated, as outlined by Nichols (1998), to measure 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 as measures a community's tolerance to disturbance. The Floristic Quality Index 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 aquatic plant community. Water quality (nutrients, algae and clarity) influence the plant community as the plant community can in turn modify these parameters. Lake morphology, sediment composition and shoreline land use also impact the macrophyte community.

WATER QUALITY - The trophic state of a lake is a classification 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 populations of fish.

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 nutrient enrichment in a lake. Increases in phosphorus in a lake can feed algae blooms and plant growth.

2000-2005 summer mean phosphorus concentration in Lake Emily was 17.1 ug/l

This concentration of phosphorus in Lake Emily is 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
Eutrophic	Fair	30-50	10-15	5-6
	Poor	50-150	15-30	3-4
Lake Emily 2005 Mean	Fair	19	6.17	10.6

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

Phosphorus concentrations in Lake Emily varied during the years that water quality data was collected. Phosphorus concentrations have increased slightly (with a conspicuous decline in 2002), but have remained in the mesotrophic range (Figure 3).

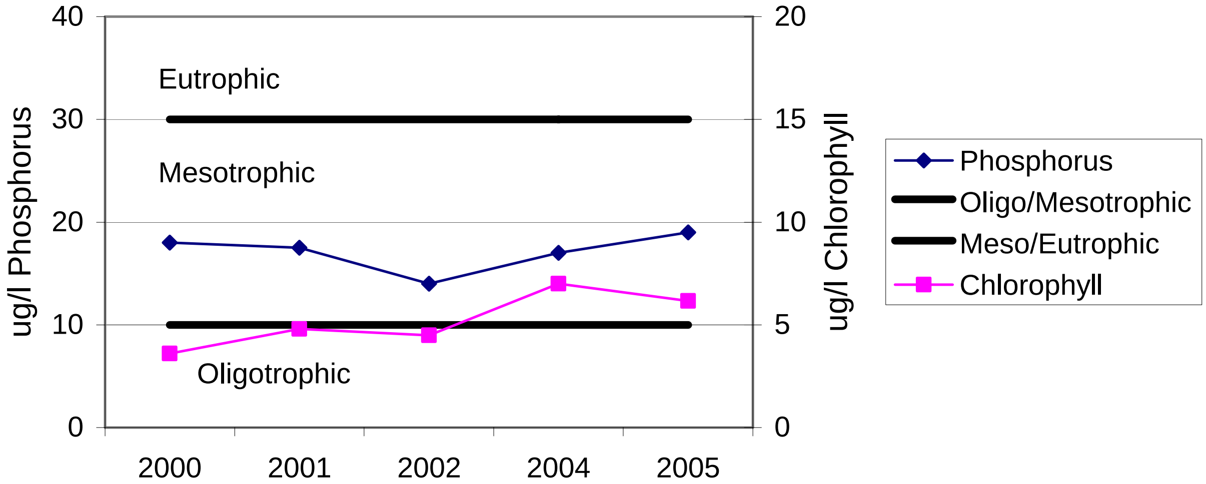


Figure 3. Variation in mean summer phosphorus and chlorophyll concentrations in Lake Emily, 200-2005.

Algae

Chlorophyll concentrations provide measures of the amount of algae in lake water. Algae are natural and essential in lakes, but high algae populations can increase turbidity and reduce the light available for plant growth.

2000-2005 summer mean chlorophyll concentration in Lake Emily was 5.21 ug/l.

The chlorophyll concentration in Lake Emily indicates that it was a borderline oligotrophic/mesotrophic lake (Table 2).

During 2000-2005, the chlorophyll (algae) concentration has increased much more than the nutrient concentration. The concentration of chlorophyll increased from an oligotrophic lake in 2000-2002 to a mesotrophic lake in 2004-2005 (Figure 3). Other factors besides nutrient availability can impact algae growth, such as variations in summer temperatures and rain events.

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

Mean summer Secchi disc clarity in Lake Emily, 1994-2005, was 10.2 ft.

Water clarity indicates (Table 3) that Lake Emily was an oligotrophic lake with good water clarity.

The water clarity in Lake Emily varied during 1994-2005, with the best clarity recorded in 1994 and the lowest clarity in 2001 (Figure 4). From 1994 to 2005, there has been a trend toward decreasing water clarity. Variations in clarity can be the result of variations in algae growth in different years, increased nutrients and turbidity after storm events.

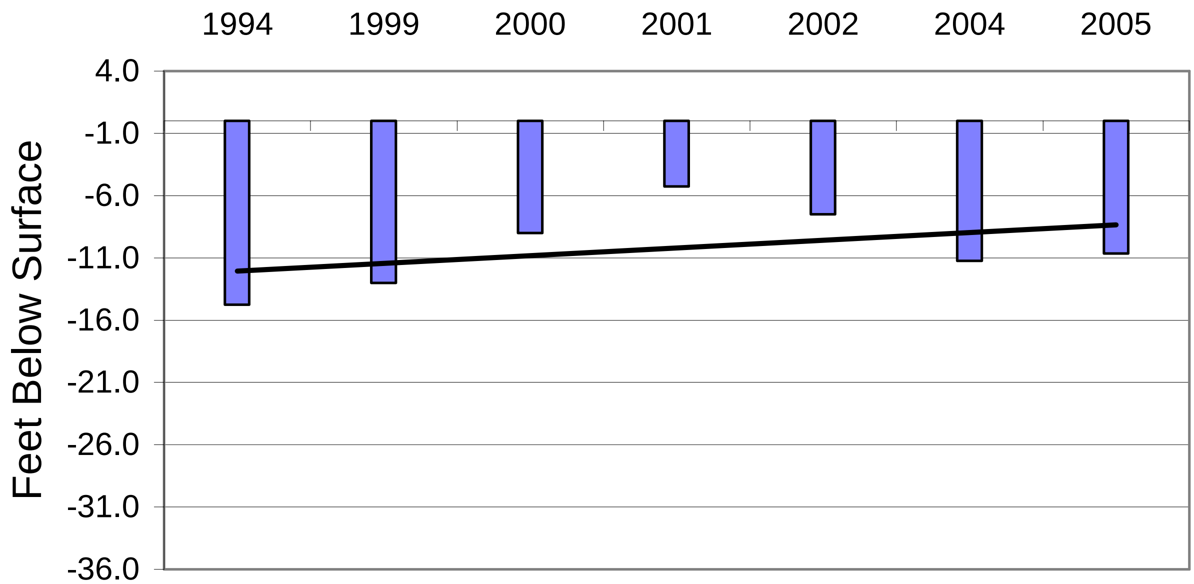


Figure 4. Variation in mean summer water clarity in Lake Emily, 1994-2005.

Filamentous algae occurred at 22% of the sample sites. Filamentous algae occurred at:

- 39% of the sites in the 0-1.5ft depth zone
- 8% of the sites in the 1.5-5ft depth zone
- 21% of the sites in the 5-10ft depth zone
- 17% of the sites in the 10-20ft depth zone

The combination of phosphorus concentration, chlorophyll concentration and water clarity data indicates that Lake Emily 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 a 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).

Lake Emily has an elongated, irregular shaped basin with a gradually sloped littoral zone over most of the lake. There are narrows that divide the lake into three basins. A small basin occurs on the west end of the lake; a larger oval basin is on the east end of the lake, surrounded mostly by County Park; the largest irregular-shaped basin in the middle has the deepest depths (Appendix IV).

SEDIMENT COMPOSITION – The dominant sediment in Lake Emily was a marl/silt mixture, dominant throughout the lake and in all depth zones (Table 3). Sand and marl mixtures were common in the 0.1.5ft depth zone, found only in the west half of the lake (Table 3).

Table 3. Sediment Composition in Lake Emily, 2005

Sediment Type		0-1.5' Depth	1.5-5' Depth	5-10' Depth	10-20' Depth	Percent of all Sample Sites
Soft Sediments	Silt/Marl	29%	53%	78%	68%	57%
	Marl	10%	10%	13%		8%
	Silt	5%			16%	5%
	Peat/Marl			4%	16%	5%
	Peat		5%			1%
	Muck		5%			1%
Mixed Sediments	Sand/Marl	24%	10%			8%
	Sand/Silt		5%	4%		2%
	Sand/Muck	5%				1%
	Sand/Silt/Rock	5%				1%
	Sand/Silt/Marl		5%			1%
Hard Sediments	Sand	10%	5%			4%
	Sand/Gravel	14%				4%

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. Intermediate density sediments such as silt are most favorable to aquatic plant growth because of their nutrient availability (Barko and Smart 1986).

Silt/marl was the dominant sediment found in Lake Emily and supported vegetation at 100% of the silt/marl sites (Table 4). However, all sediment types supported adequate vegetation. The only sediment types that did not support 100% vegetation were sand and sand/gravel sediments (Table 4). These are high-density, hard sediments are less favorable for plant growth.

Table 4. Influence of Sediment in Lake Emily, 2005

Sediment Type		**Percent of all Sample Sites**	**Percent Vegetated**
Soft Sediments	Silt/Marl	57%	100%
	Marl	8%	100%
	Silt	5%	100%
	Peat/Marl	5%	100%
	Peat	1%	100%
	Muck	1%	100%
Mixed Sediments	Sand/Marl	8%	100%
	Sand/Silt	2%	100%
	Sand/Muck	1%	100%
	Sand/Silt/Rock	1%	100%
	Sand/Silt/Marl	1%	100%
Hard Sediments	Sand	4%	67%
	Sand/Gravel	57%	67%

SHORELINE LAND USE – Land use can strongly impact the aquatic plant community and therefore the entire aquatic community. Land use can directly impact the plant community by increased erosion and sedimentation and increased run-off of nutrients, fertilizers and toxics applied to the land. These impacts occur in both rural and residential settings.

Native herbaceous cover was the most frequently encountered shoreline cover at the transects and had the highest mean coverage. It covered approximately one-third of the shoreline. Wooded cover, shrubs and rock, were also commonly encountered

(Table 5). Wooded shoreline protected more than one-quarter of the shore.

Disturbed shoreline was also common: cultivated lawn, bare sand and hard structures (Table 5). Cultivated lawn covered 19% of the shoreline.

Table 5. Shoreline Land Use - Lake Emily, 2005

Cover Type		**Frequency of Occurrences at Transects**	**Mean % Coverage**
Natural Shoreline	Native Herbaceous	91%	32%
	Wooded	82%	28%
	Shrub	48%	7%
	Rock	4%	1%
Total Natural Coverage			**68%**
Disturbed Shoreline	Cultivated Lawn	48%	19%
	Bare Sand	43%	5%
	Hard Structures	35%	5%
	Dirt Road	9%	3%
Total Disturbed Cover			**32%**

Some type of natural shoreline (wooded, shrub, native herbaceous) was found at 96% of the sites and had a mean coverage of 68% (Table 5).

Some type of disturbed shoreline (cultivated lawn, bare sand, hard structures and dirt road) was found at 61% of the sites and had a mean coverage of 32% (Table 5).

MACROPHYTE DATA

SPECIES PRESENT

Of the 24 species found in Lake Emily, 2 were emergent species, 4 were floating-leaf species and 18 were submergent species (Table 6).

No threatened or endangered species were found.

Two exotic species were found:

Myriophyllum spicatum	Eurasian watermilfoil
Potamogeton crispus	curly-leaf pondweed

Table 6. Lake Emily Aquatic Plant Species, 2005

Scientific Name	Common Name	I. D. Code
Emergent Species		
1) *Scirpus validus* Vahl.	softstem bulrush	sciva
2) *Typha latifolia* L.	common cattail	typla
Floating-leaf Species		
3) *Lemna minor* L.	small duckweed	lemmi
4) *Lemna trisulca* L.	forked duckweed	lemtr
5) *Nuphar variegata* Durand.	bull-head pond lily	nupva
6) *Nymphaea odorata* Aiton.	white water lily	nymod
Submergent Species		
7) *Ceratophyllum demersum* L.	coontail	cerde
8) *Chara* sp.	muskgrass	chasp
9) *Elodea canadensis* Michx.	common waterweed	eloca
10) *Myriophyllum sibiricum* Komarov.	common watermilfoil	myrsi
11) *Myriophyllum spicatum* L.	Eurasian watermilfoil	myrsp
12) *Najas flexilis* (Willd.) Rostkov and Schmidt.	slender naiad	najfl
13) *Najas guadalupensis* (Spreng.) magnus.	common water-nymph	najgu
14) *Nitella* sp.	nitella	nitsp
15) *Potamogeton amplifolius* Tuckerman.	large-leaf pondweed	potam
16) *Potamogeton crispus* L.	curly-leaf pondweed	potcr
17) *Potamogeton gramineus* L.	variable-leaf pondweed	potgr
18) *Potamogeton illinoensis* Morong.	Illinois pondweed	potil
19) *Potamogeton natans* L.	floating-leaf pondweed	potna
20) *Potamogeton pectinatus* L.	sago pondweed	potpe
21) *Potamogeton pusillus* L.	small pondweed	potpu
22) *Potamogeton zosteriformis* Fern.	flatstem pondweed	potzo
23) *Sagittaria* spp.	arrowhead	sagsp
24) *Vallisneria americana* L.	water celery	valam

FREQUENCY OF OCCURRENCE

Chara sp. was the most frequently occurring species in Lake Emily in 2005, (88% of sample sites) (Figure 5). *Najas flexilis, Nymphaea odorata, Potamogeton illinoensis, P. pectinatus, P. pusillus, P. zosteriformis* and *Vallisneria americana* were also commonly occurring species, (39%, 21%, 44%, 23%, 25%, 22% and 53%).

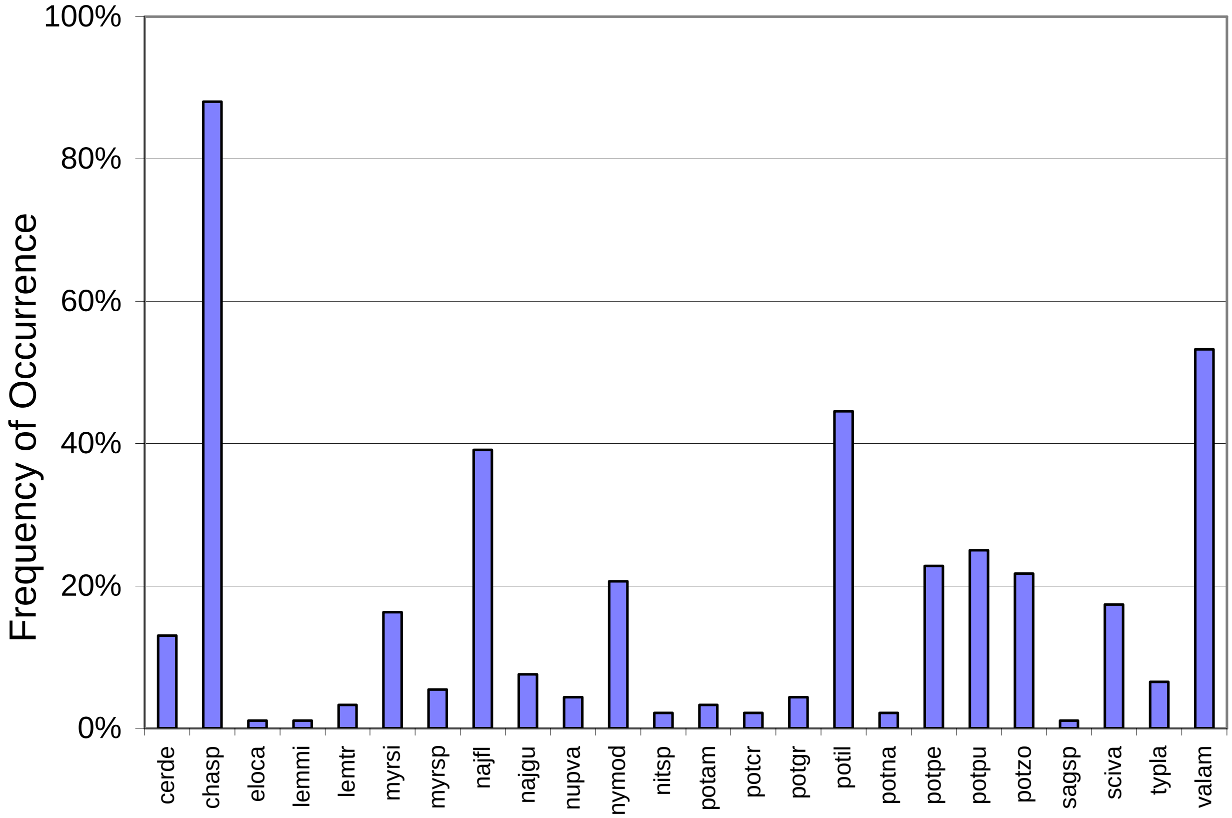


Figure 5. Frequency of occurrence of aquatic plant species in Lake Emily, 2005

DENSITY

Chara sp. was also the species with the highest mean density in Lake Emily (2.92 on a density scale of 1-4) (Figure 6).

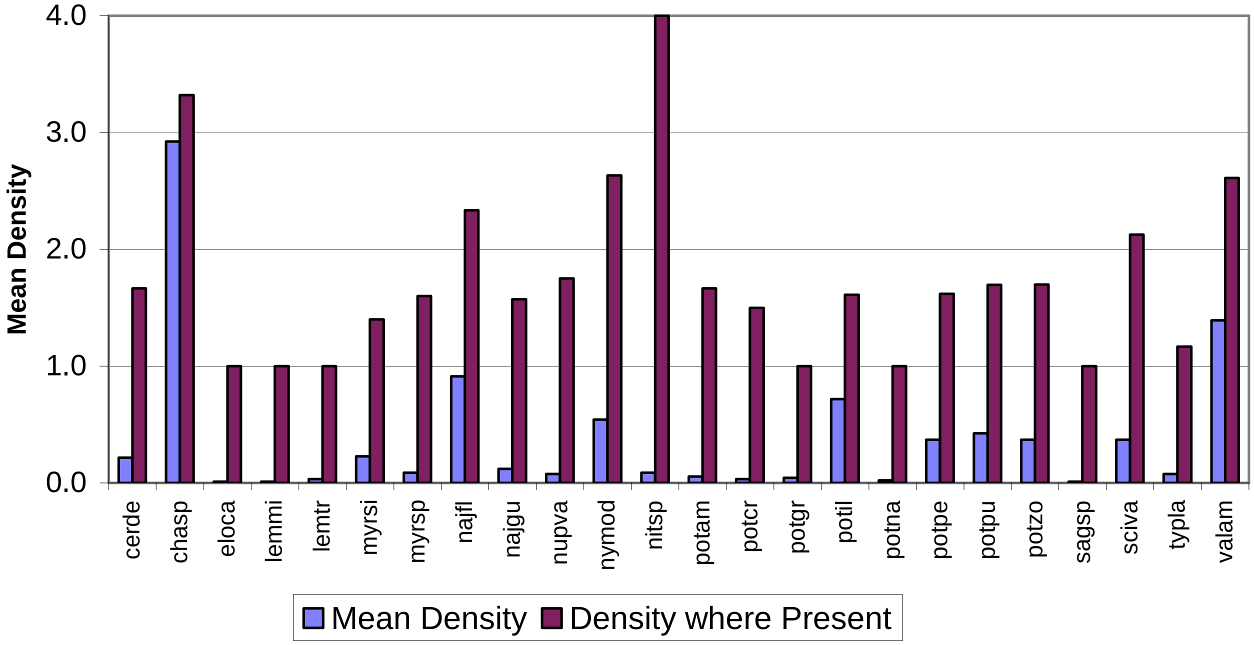


Figure 6. Densities of aquatic plant species in Lake Emily, 2005

Nitella spp. had a "mean density where present" of 4.0. Its "mean density where present" indicates that, where *Nitella* occurred, it exhibited an aggregated growth form or a growth form of above average density in Lake Emily (Figure 6). But *Nitella* occurred only in a limited area in the east end of the lake in deep water. *Chara* sp., *Nymphaea odorata* and *Vallisneria americana* also had "densities where present" of 2.5 or more, indicating that they also exhibited a dense growth form in Lake Emily.

DOMINANCE

Combining the relative frequency and relative density of a species into a Dominance Value illustrates how dominant that species is within the aquatic plant community (Appendix III). Based on the Dominance Value, *Chara* sp. was the dominant aquatic plant species in Lake Emily (Figure 7). *Vallisneria americana* was sub-dominant.

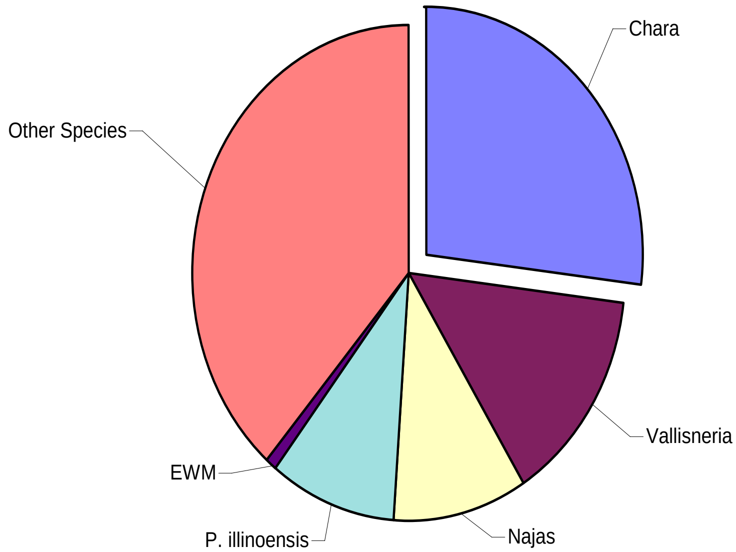


Figure 7. Dominance within the macrophyte community, of the most prevalent macrophyte species in Lake Emily, 2005.

Eurasian watermilfoil (EWM) was a minor part of the aquatic plant community in summer 2005.

DISTRIBUTION

The dominant species, *Chara* sp., was dominant in all depth zones (Figure 8, 9) and occurred at its highest frequency in the 5-10ft depth zone and at its highest density in the 1.5-5ft depth zone (Figure 8, 9).

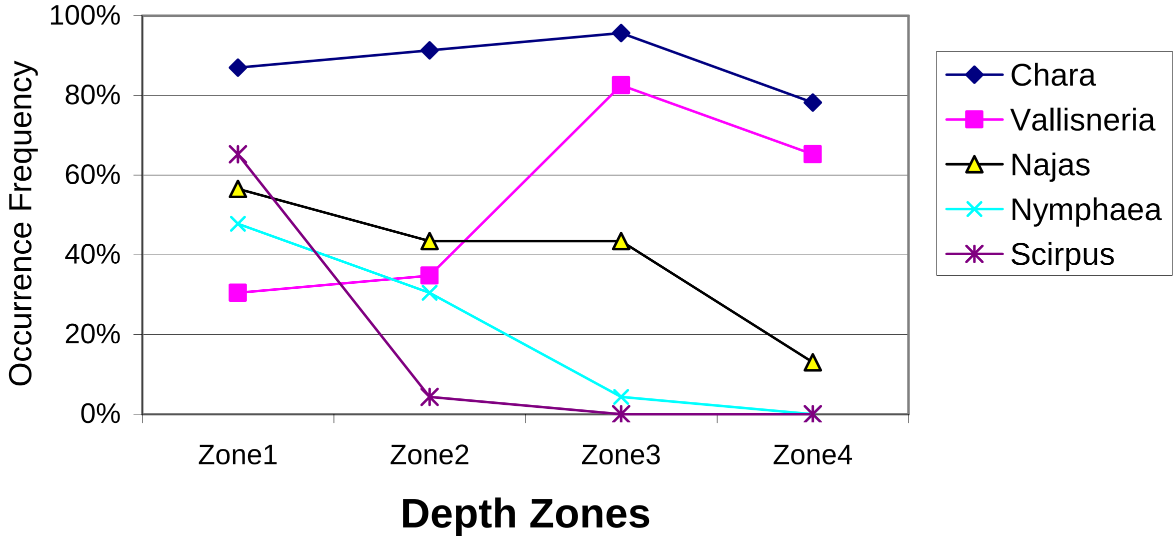


Figure 8. Frequency of occurrence of prevalent macrophyte species in Lake Emily, by depth zone, 2005.

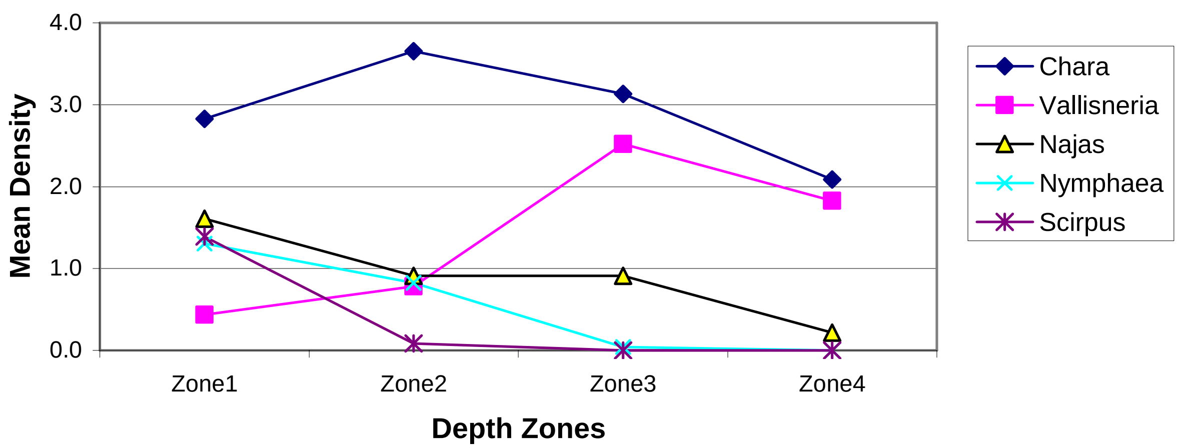


Figure 9. Density of prevalent macrophyte species in Lake Emily by depth zone, 2005.

The sub-dominant species, *Vallisneria americana,* occurred at its highest frequency and density in the 5-10ft depth zone (Figure 8, 9).

Aquatic plants occurred throughout Lake Emily, at 98% of the sampling sites, to a maximum depth of 15.5 feet. *Myriophyllum sibiricum, Potamogeton illinoensis, P. zosteriformis* and *Vallisneria americana* occurred at the maximum rooting depth. 92%

of the sample sites were vegetated with rooted plants. The species that occurred at more than 22% of the sites were found throughout the lake.

Secchi disc readings can be used to calculate a predicted maximum rooting depth for aquatic plants in a lake (Dunst 1982).
Based on the 2005 mean summer Secchi disc clarity, the predicted maximum rooting depth in Lake Emily would be 15.7 feet.
The actual maximum rooting depth of 15.5 feet is in agreement with the predicted maximum rooting depths based on water clarity (Figure 10).

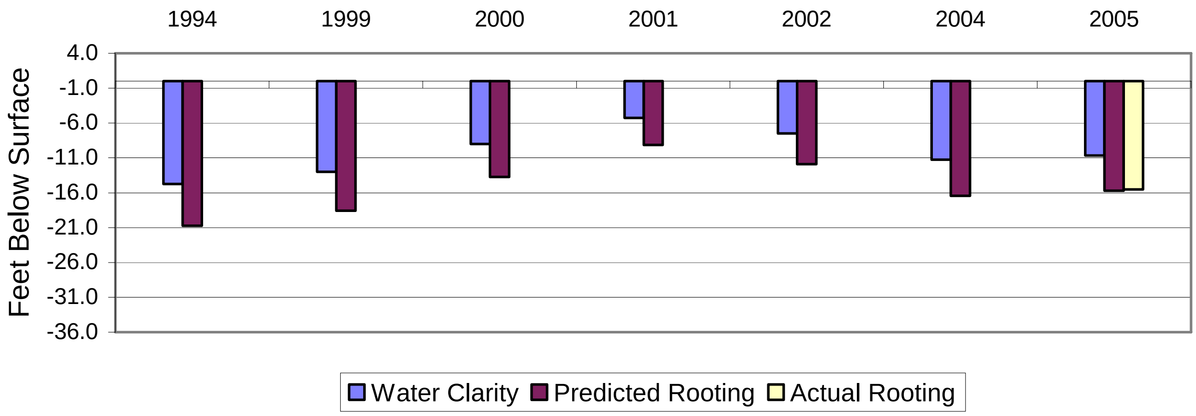


Figure 10. Predicted maximum rooting depth in Lake Emily, based on water clarity, 1994-2005.

The 0-1.5ft depth zone supported the highest total occurrence of plants and the 5-10ft depth zone supported the highest total density of plants (Figure 11).

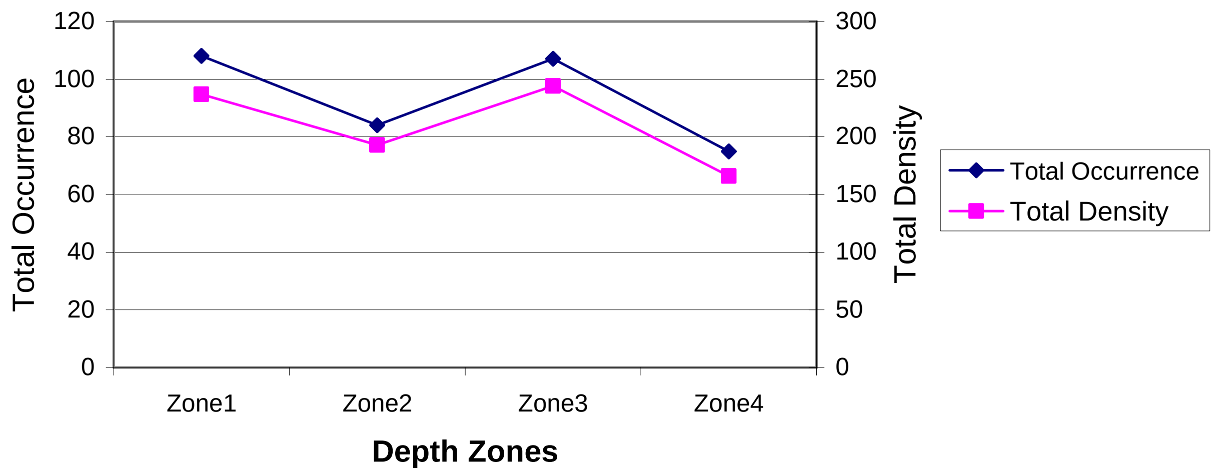


Figure 11. Total occurrence and total density of plants in Lake Emily, by depth zone, 2005.

The highest percentage of vegetated sites was in the 5-20ft depth zone and the greatest species richness (mean number of species per site) was recorded in the 0-1.5 ft depth zone (Figure 12).

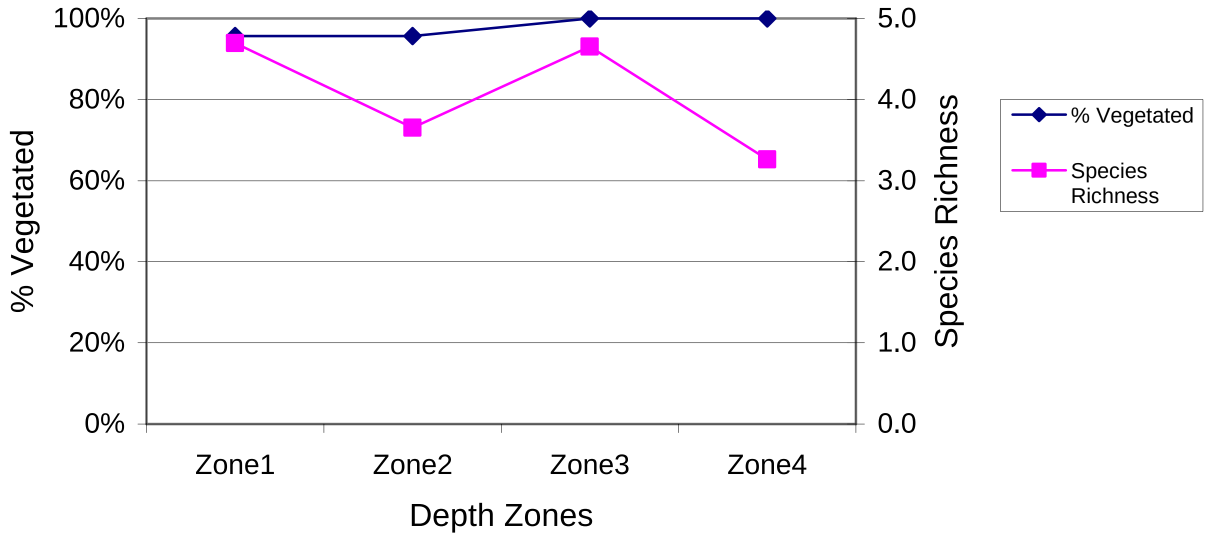


Figure 12. Percentage of vegetated site and species richness in Lake Emily, by depth zone, 2005.

Overall species richness (mean number of species found at sampling sites) was 4.07.

THE COMMUNITY

Simpson's Diversity Index was 0.897, indicating good species diversity, above average for lakes in the North Central Hardwood Region of Wisconsin. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable).

The Aquatic Macrophyte Community Index (AMCI) for Lake Emily (Table 7) is 60. This is in the upper quartile of lakes in the state and in the North Central Region of Wisconsin. The highest value for this index is 70 (Nichols, et. al 2000).

Table 7. Aquatic Macrophyte Community Index, Lake Emily, 2005

Category	Parameter	Value
Maximum Rooting Depth	4.7 meters	9
% Littoral Zone Vegetated	97.8%	10
Simpson's Diversity	0.897	8
# of Species	24	9
% Exotic species	2% Relative Freq.	6
% Submergent Species	84% Relative Freq.	10
% Sensitive Species	18% Relative Freq.	8
Totals		60

The presence of two exotic species is a limiting factor in the quality of the Lake Emily aquatic plant community.

The Average Coefficient of Conservatism for Lake Emily was below average for all Wisconsin lakes and lakes in the North Central Hardwood Region of the state (Table 8). This suggests that the aquatic plant community in Lake Emily is more tolerant of disturbance than the average lake in Wisconsin or the North Central Hardwoods Region. This is likely due to selection by past disturbance.

The Floristic Quality Index of the plant community in Lake Emily was above average for all Wisconsin lakes and in the upper quartile of North Central Hardwood Region lakes (Table 8). This indicates that the plant community in Lake Emily is closer to an undisturbed condition than the average lake in the state and among the group of lakes in the region closest to an undisturbed condition.

Table 8. Floristic Quality and Coefficient of Conservatism of Lake Emily, Compared to Wisconsin Lakes and North Central Wisconsin Lakes.

	Average Coefficient of Conservatism †	Floristic Quality ‡
Wisconsin Lakes	5.5, 6.0, 6.9 *	16.9, 22.2, 27.5
NCH Region	5.2, 5.6, 5.8 *	17.0, 20.9, 24.4
Lake Emily 2005	5.48	25.10

***** - 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).

Disturbances can be of many types:

1) Physical 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 competition from the introduction of a non-native or invasive plant species, grazing from an increased population of aquatic herbivores and destruction of plant beds by a fish or wildlife population.

V. DISCUSSION

Based on water clarity, chlorophyll and phosphorus data, Lake Emily is a mesotrophic lake with good water quality and water clarity. This trophic state should support moderate plant growth and occasional algae blooms. Nutrients in Lake Emily increased slightly from 2000-2005 and algae have increased even more. Subsequently, the water clarity has decreased since 1994.

Filamentous algae occurred at 22% of sites; most frequent in the 0-1.5ft depth zone (39%).

Aquatic plants occurred at 98% of the sites (92% with rooted vegetation), to a maximum depth of 15.5 feet. This maximum rooting depth is in agreement with the predicted maximum rooting depth based on water clarity. The dominance of intermediate-density silt/marl sediments, good water clarity, adequate nutrients (mesotrophic trophic state) and the gradually sloped littoral zone in Lake Emily favor would plant growth.

Twenty-four species of aquatic plants were recorded in Lake Emily in 2005. *Chara* spp. was the dominant plant species in Lake Emily, dominating all depth zones, occurring at more than three-quarters of the sample sites. *Chara* spp was especially frequent and dense in the 1.5-10ft depth zone and exhibited an aggregated growth form in Lake Emily.

Vallisneria americana was sub-dominant and also exhibited a growth form of above average density in Lake Emily.

Two other species exhibited growth forms of above average density in Lake Emily; one occurred in a limited area and one (*Nitella)* occurred at 20% of the sites. All the dominant, abundant and common aquatic plant species were distributed throughout the lake.

Eurasian watermilfoil, an exotic species, was found in Lake Emily in 1998. Its coverage was mapped in 2004; treated early in 2005; declined to a very minor part of the aquatic plant community by the time of the survey. Eurasian watermilfoil (*Myriophyllum spicatum)* was not common and was growing at low densities only at depths greater than 5 feet. However, the lake association must remain vigilant, locating and removing this invasive species when scattered colonies are found. Small areas should be physically pulled and larger areas could receive a selective, early-season chemical treatment.

The presence of native milfoil weevils (Thorstenson 2004) could provide the best long-term control. This control would be the most economical, the easiest and the most environmentally friendly method. It is imperative to preserve natural shoreline around the lake for this method to work long-term. The weevils require thick duff of natural vegetation for hibernation. If natural shoreline is replaced with lawn, rip-rap, sand or pavement, the weevils can not survive the winter. Since the weevils are weak flyers, this shoreline needs to be scattered around the entire lake.

The Aquatic Macrophyte Community Index (AMCI) for Lake Emily was 60, indicating that the quality of the plant community in Lake Emily is high, within the 25% of lakes in the state and the North Central Hardwood Region with the highest quality plant community. Simpson's Diversity Index (0.90) indicates that the plant community has a good diversity of aquatic plant species. Species richness was 4.07 species per sample site, meaning, on average, more than 4 species were found at each sample site.

The Average Coefficient of Conservatism and the Floristic Quality Index suggests that Lake Emily has an above average tolerance to disturbance and closer to an undisturbed condition than the average lake in the state.

Lake Emily has some protection by natural shoreline cover (wooded, shrub, rock, native herbaceous growth) that protected 68% of the shoreline. Herbaceous growth had the highest frequency and cover at the shoreline. However, disturbed shoreline covered 32% of the shore. One type of disturbed cover, cultivated lawn, occurred at 48% of the sample sites and covered 19% of the shoreline. Areas with cultivated lawn could impact the lake by increased run-off of lawn fertilizers, pesticides and pet wastes into the lake. The shorter blade length and root depth of cultivated lawn does not effectively slow run-off or absorb excess nutrients and water. Bare sand and hard structures increase run-off rate and do not absorb nutrients.

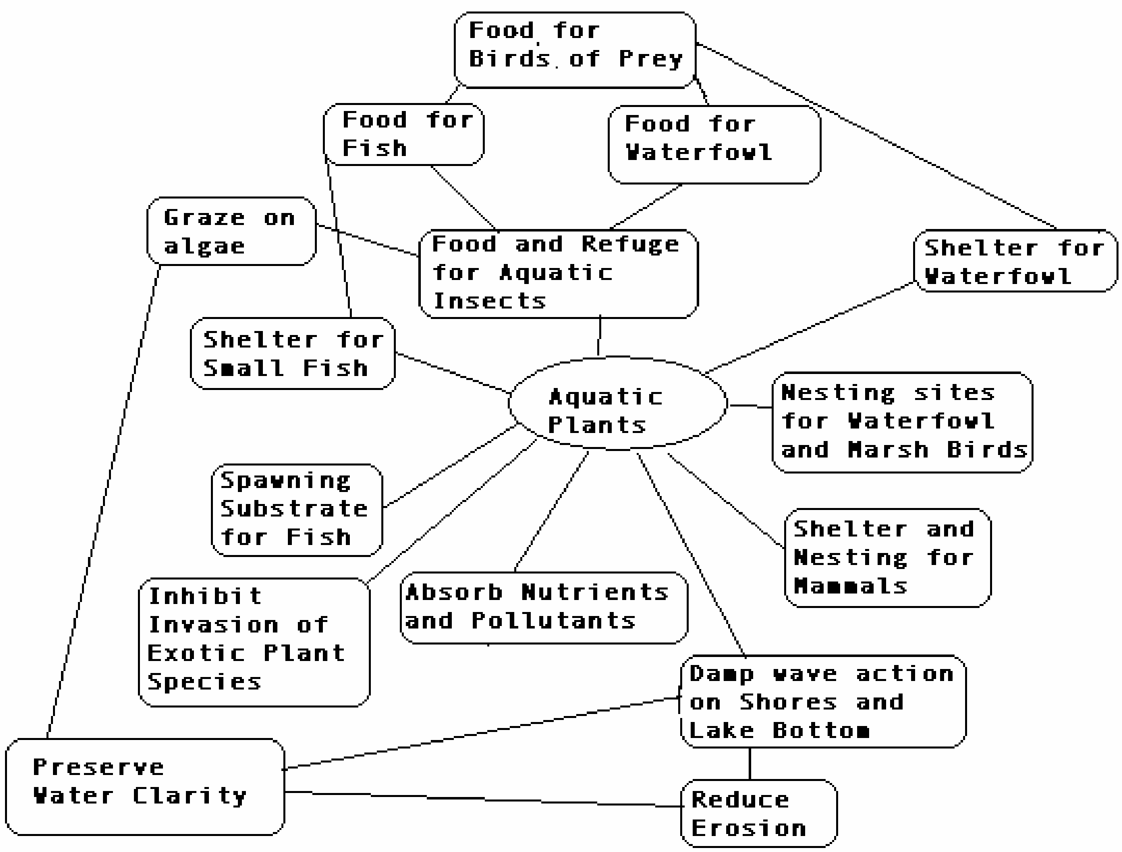
VI. CONCLUSIONS

Lake Emily is a mesotrophic lake with good water quality and clarity. Nutrients and algae have increased and water clarity has decreased during 2000-2005. Filamentous algae is common, especially in the 0-1.5ft depth zone.

The aquatic plant community is characterized by high quality, good species diversity, a below average amount of disturbance and an above average tolerance to disturbance. The aquatic plant community colonized 92% of the littoral zone to a maximum depth of 15.5 feet.

Chara spp. is the dominant species within the plant community, dominating all depth zones. *Chara* exhibited a dense growth form, its density highest in the 1.5-10ft depth zone. *Vallisneria americana* was sub-dominant and also exhibited a dense growth form, especially in the 5-10ft depth zone. All dominant, abundant and common species were distributed throughout the lake.

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) Aquatic plant 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).
1) Aquatic plant communities provide important fishery and wildlife resources. Plants and 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 Lake Emily is 92% and is greater than the ideal 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).

Management Recommendations

1) Lake Association to become involved in the Self-Help Volunteer Lake Monitoring Program.]
2) Lake Association to develop a Lake Management Plan to assist in its management of Eurasian watermilfoil
3) Lake Association to become involved in the Clean Boats, Clean Waters Volunteer Watercraft Inspection Program to prevent the spread of exotic species by educating boaters.
4) DNR to maintain exotic species alert signs at the boat landings. Lake residents must contact DNR when signs are missing from the boat ramps.
5) Lake residents to provide milfoil weevil winter habitat by protecting and restoring natural shoreline. Native milfoil weevils are the most economical, least expensive and most environmentally friendly long-term control method for Eurasian watermilfoil.
6) Lake Association to regularly update milfoil weevil surveys to determine status of the weevils.
7) Lake residents to protect and restore natural shoreline. Disturbed shoreline covers nearly one-third of the shore; mowed lawn alone covers 19% of the shore. Unmowed native vegetation reduces shoreline erosion and run-off into the lake and filters the run-off that does enter the lake. Shoreline restoration could be a as simple as leaving a band of natural vegetation around the shore by discontinuing mowing or as ambitious as planting native grasses, flowers, shrubs and trees on

the shore and native wetland vegetation in the shallow water zone off shore.

8) Chemical treatments for Eurasian watermilfoil are not recommended as a long-term control method in Lake Emily due to the undesirable side effects of chemical treatments.
    b) The decaying plant material dies in place, enriching the sediments that would encourage more plant growth.
    c) The decay releases nutrients that feed algae growth that reduce water clarity.
    d) The chemical used to treat Eurasian watermilfoil is toxic to insects and could reduce the population of milfoil weevils in the lake which would be counter-productive to long-term control.
    e) Since the frequency and density of EWM is low, treating scattered beds is less effective.
9) Lake Association to start a “Eurasian watermilfoil watch committee” that will locate beds of the exotic species and organize hand-pulling of the plants. This can be done without a permit under NR109.
10) Lake residents to protect emergent plant beds for habitat and to stabilize the shore and prevent erosion.
11) Lake association and agencies cooperate with programs in the watershed to reduce nutrient input to the lake and preserve water clarity.
12) DNR to designate Sensitive Areas in Lake Emily to preserve the most important habitat in the lake and preserve areas that contribute toward the protection of water quality.