The Aquatic Plant Community

of

Emerson Lake,

Clark County, Wisconsin

2006

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Submitted by:

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Executive Summary

Emerson Lake is a hypereutrophic shallow water resource with very poor water clarity and quality. Filamentous algae was very abundant in the Emerson Lake, especially in the shallowest zone.

The aquatic plant community colonized half of the sample sites but only 6% of the total lake area, to a maximum rooting depth of 3.5 feet. The 0-1.5 ft. depth zone supported the most abundant aquatic plant growth, but all species occurred at low mean densities.

Fifteen (15) aquatic plant species were recorded in Emerson Lake. *Lemna minor* (small duckweed) was the dominant species within the plant community, occurring at half of the sample sites. *Phalaris arundinacea* (reed canary grass) was sub-dominant, occurring at nearly one-third of the sites and exhibiting a dense form of growth in Emerson Lake. No other species was commonly occurring in Emerson Lake.

The aquatic plant community in Emerson Lake is characterized by low quality, very poor species diversity, a high tolerance to disturbance and within the quartile of lakes in the state and region farthest from an undisturbed condition.

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

Management Recommendations

1) Lake property owners preserve the natural shoreline buffer that is found at 82% of the shoreline of Emerson Lake. The disturbed shore appears to be impacting the in-lake plant community at those sites. The Average Coefficient of Conservatism and Floristic Quality Index quantified more impact by disturbance. This disturbance appears to be lowering the quality of the aquatic plant community (AMCI), decreasing the amount of habitat, decreasing the cover of important emergent and rooted floating-leaf vegetation structure and lowering the diversity oft the plant community.
2) Shoreline property owners use best management practices on property to prevent nutrient enrichment and stormwater run-off to the lake that may be resulting in the abundant filamentous algae growth.
3) Lake residents cooperate with programs to reduce nutrient run-off from the watershed, another potential source of nutrient enrichment to Emerson Lake.
4) Lake residents begin monitoring the water quality through the Citizen Lake Monitoring Program to expand knowledge of water quality in Emerson Lake.
5) Maintain exotic species educational signs at the boat landing to prevent the spread of exotic species into Emerson Lake.

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The Aquatic Plant Community in Emerson Lake, Clark County 2006

I. INTRODUCTION

A study of the aquatic macrophytes (plants) in Emerson Lake was conducted during July 2006 by Water Resources staff of the West Central Region - Department of Natural Resources (DNR). This was the first quantitative vegetation study of Emerson Lake by the DNR.

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

Background and History: Emerson Lake is a 33-acre drainage lake in southwest Clark County, Wisconsin. Emerson Lake has a maximum depth of 8 feet and a mean depth of 4 feet. The lake is an impoundment on the East Fork of Halls Creek.

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 13 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 and 5-10ft) along each transect. Using a long-handled, steel, thatching rake, four rake samples were taken at each sampling site, 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 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 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 each side of the transect intercept with the shore and 30 feet deep was evaluated. The percentage of each shore cover type (Table 4) 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 density). A "density where present" was calculated for each species (sum of a species' density ratings/number of sampling sites at which that species occurred) (Appendix II). The relative frequency and relative density of each species are summed to obtain a dominance value for each species (Appendix III). Diversity was measured by calculating Simpson's Diversity Index $1-(\sum(\text{Relative Frequency}^2))$ (Appendix I).

The Aquatic Macrophyte Community Index (AMCI) developed for Wisconsin Lakes by Nichols (2000) was applied to Emerson Lake (Table 6) to quantify the quality of the plant community. Values between 0 and 10 are given for each of seven categories that characterize a plant community and summed.

The Average Coefficient of Conservatism and Floristic Quality Index were 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 Floristic Quality Index is calculated from the Average 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 use also impact the aquatic plant community.

WATER QUALITY - The trophic state of a lake is an indication of its water quality. Nutrient, algae 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 populations of fish.

Mesotrophic lakes have intermediate levels of nutrients and biomass.

The only water quality data found for Emerson Lake was from 1979, old data.

Nutrients

Phosphorus is a limiting nutrient in the majority of 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 1979 Phosphorus in Emerson Lake was 600ug/l.

This concentration of phosphorus is indicative of a hypereutrophic lake (Table 1).

Table 1. Trophic Status

	Quality Index	Phosphorus ug/l	Chlorophyll a ug/l	Secchi disc ft. Satellite Estimate
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**
Emerson Lake – 1979	**Very Poor**	**600 ug/l**	**4 ug/l**	**0.3 ft.**

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

Algae

Chlorophyll a concentrations measure 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.

August 1979 Chlorophyll a for Emerson Lake was 4ug/l.

This concentration of chlorophyll is indicative of an oligotrophic lake (Table 1).

Filamentous algae was found at 50% of the sample sites at the time of the survey, more abundant in the shallow zone (Figure 1).

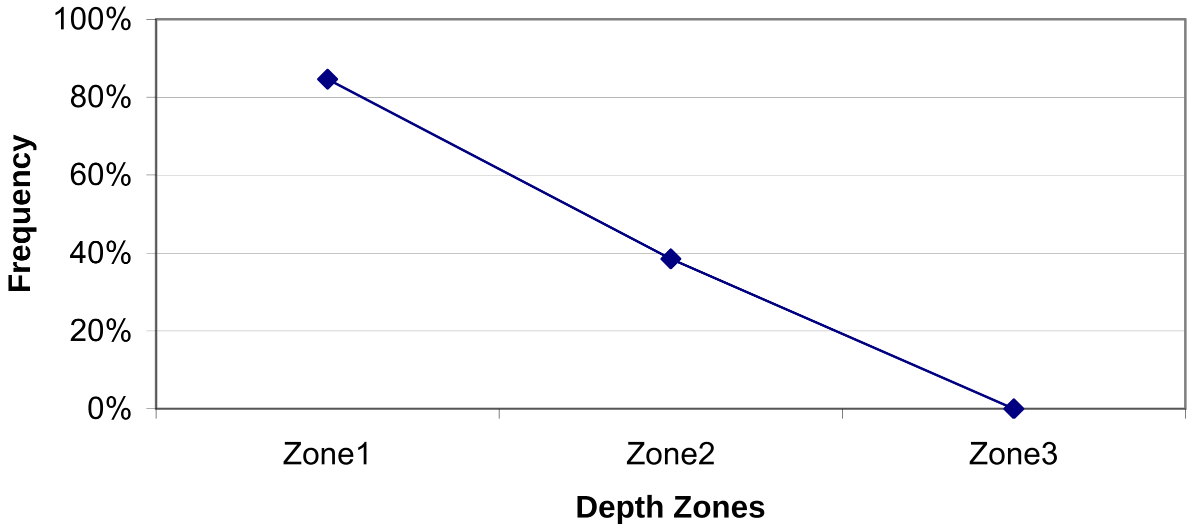

Figure 1. Occurrence of filamentous algae in Emerson Lake, 2006.

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 can be measured with a Secchi disc which shows the combined impacts.

August 1979 Secchi Disc water clarity in Emerson Lake was 0.3 ft.

Water clarity indicates (Table 1) that Emerson Lake was a hypereutrophic lake with very poor water clarity.

The phosphorus, chlorophyll and water clarity data suggests that Emerson Lake is a hypereutrophic lake with very poor water quality (Table 1). This trophic state would favor abundant plant growth and frequent 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).

Emerson Lake has an oval basin, shallow depth and a gradually-sloped littoral zone over most of the lake (Appendix IV). Gradual slopes provide a more stable substrate for rooting and a broad band of water shallow enough for plant growth. This means Emerson Lake has the potential to support aquatic plant growth over most of the lake.

SEDIMENT COMPOSITION – Sand, silt and mixtures of sand and silt were the most common sediments in Emerson Lake, dominating the 5-20ft depth zones (Table 2). Sand was most common in the 0-1.5ft depth zone; silt and silt mixtures were most common in the 1.5-5ft depth zone (Figure 2).

Table 2. Sediment Composition, 2006

Sediment Type		**0-1.5' Depth**	**1.5-5' Depth**	**5-10' Depth**	**Percent of all Sample Sites**
Hard Sediment	Sand	31%	23%	33%	28%
Mixed Sediment	Sand/Silt	23%	31%	33%	28%
	Sand/Muck	8%			3%
soft Sediment	Silt	23%	23%	33%	25%
	Muck	15%	15%		12%
	Silt/Muck		8%		3%


Silt
Sand
Organic Muck
Mixed Soft Sediments
Mixed Sediment Types

Figure 2.

Distribution of sediment types in Emerson Lake, 2006.

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 plant species that can survive in a location.

Silt sediments are intermediate density sediments and considered most favorable for plant growth because of their intermediate density. The availability of mineral nutrients for growth is highest in sediments of intermediate density (Barko and Smart 1986). Silt was the common in the lake, at all depth zones and supported plant growth at half the sites it occurred. Sand was common also, in all depth zones, in Emerson Lake and can be limiting to plant growth due to its high density. Sand and sand/silt mixtures supported vegetation at less than half the sites it occurred. Organic muck and mixtures of muck with other sediments supported the most vegetation.

Table 3. Sediment Influence on Vegetation

Sediment Type		Percent of all Sample Sites	Percent Vegetated
Hard Sediment	Sand	28%	44%
Mixed Sediment	Sand/Silt	28%	44%
	Sand/Muck	3%	100%
soft Sediment	Silt	25%	50%
	Muck	12%	75%
	Silt/Muck	3%	100%

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.

Herbaceous growth was the most frequently encountered shoreline cover at the transects and had the highest mean coverage. The occurrence of wooded and shrub cover was also high (Table 4). Some type of natural shoreline occurred at 85% of the sites and covered approximately 82% of the shore. Disturbed shoreline occurred at 23% of the sites and covered 17% of the shore (Table 4).

Table 4. Shoreline Land Use, 2006

Cover Type		Frequency of Occurrences at Transects	Mean % Coverage
Natural Shoreline	Native Herbaceous	69%	34%
	Wooded	54%	30%
	Shrub	54%	16%
	Bare Sand	8%	2%
Total Natural			82%
Disturbed Shoreline	Mowed Lawn	23%	15%
	Hard Structure	15%	2%
Total Disturbed			17%

MACROPHYTE DATA
SPECIES PRESENT

Fifteen (15) aquatic plant species were found in Emerson Lake, 9 were emergent species, 2 were floating-leaf species and 4 were submergent species (Table 5).
No threatened or endangered were found in the survey.
One non-native species was found: *Phalaris arundinacea,* reed canary grass.

Table 5. Emerson Lake Aquatic Plant Species, 2006

Scientific Name	Common Name	I. D. Code
Emergent Species		
1) *Alnus viridis* (Villars) Lam.	green alder	alnvi
2) *Bidens* L	bur marigold	bidsp
3) *Carex crinita* Lam.	sedge	carcr
4) *Oncolea sensibilis* L.	sensitive fern	onose
5) *Phalaris arundinacea* L.	reed canary grass	phaar
6) *Scirpus validus* Vahl.	softstem bulrush	sciva
7) *Solanum dulcamara* L.	nightshade	soldu
8) *Symplocarpus foetidus* (L.) Nutt.	skunk cabbage	symfo
9) *Typha latifolia* L.	common cattail	typla
Floating-leaf Species		
10) *Lemna minor* L.	small duckweed	lemmi
11) *Nelumbo lutea* (Willd.) Pers.	American lotus	nellu
Submergent Species		
12) *Chara* sp.	muskgrass	chasp
13) *Eleocharis acicularis* (L.) Roemer & Schultes.	needle spikerush	eleac
14) *Elodea canadensis* Michx.	common waterweed	eloca
15) *Najas flexilis* (Willd.) Rostkov & Schmidt.	slender naiad	najfl

FREQUENCY OF OCCURRENCE

Lemna minor (small duckweed) was the most frequently occurring species in Emerson Lake in 2006, (50% of sample sites) (Figure 3). *Phalaris arundinacea* (reed canary grass) was a commonly occurring species, (31%) (Figure 3).

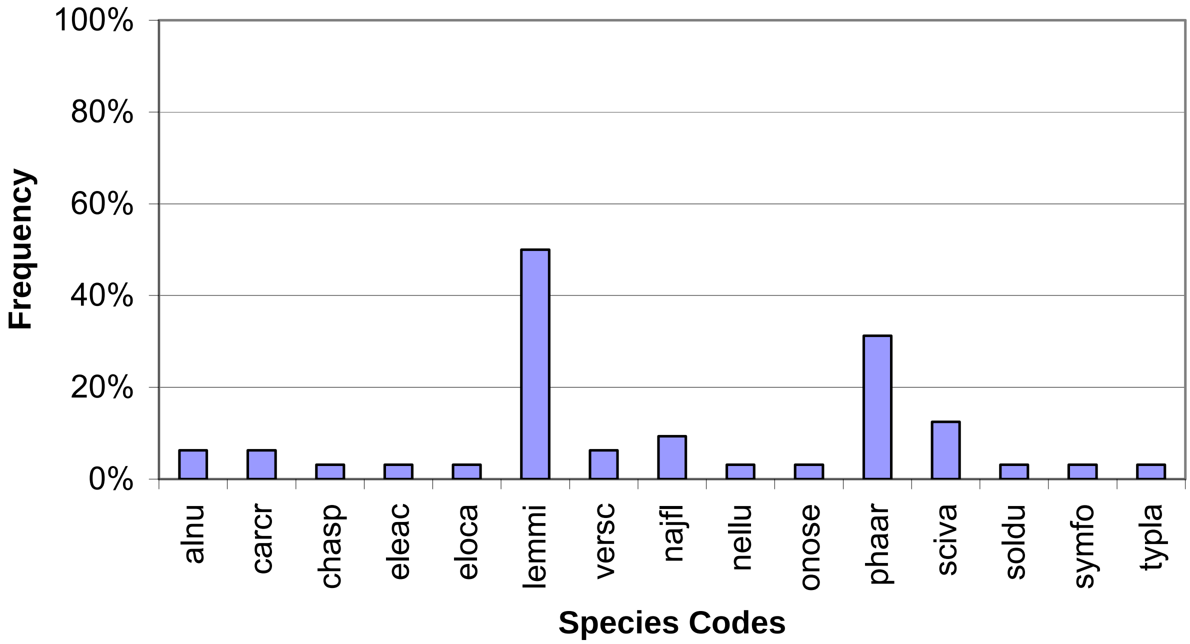

Figure 3. Frequency of aquatic plant species in Emerson Lake, 2006.

DENSITY

Lemna minor (small duckweed) was the species with the highest mean density (0.94 on a density scale of 0-4) in Emerson Lake (Figure 4). All aquatic plant species were found at low mean densities in Emerson Lake.

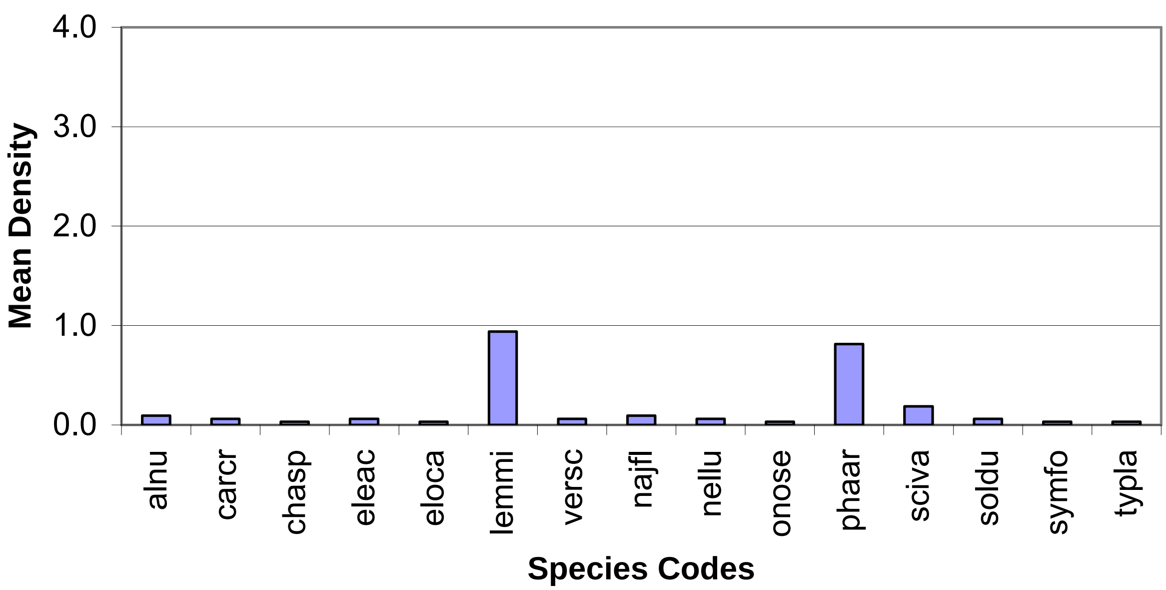

Figure 4. Mean densities of aquatic plant species in Emerson Lake, 2006.

Only *Phalaris arundinacea* (reed canary grass) had a "density where present" greater than 2.5 (2.60 on a density scale of 0-4) (Figure 5), indicating that *P. arundinacea* exhibited a growth form of above average density in Emerson Lake.

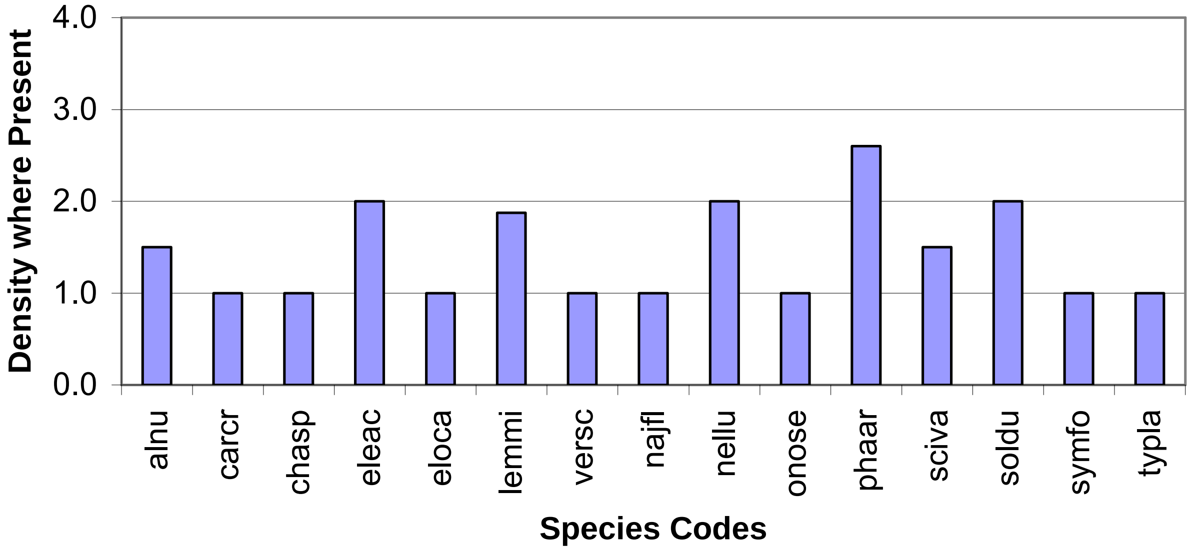

Figure 5. "Density where present", density of growth form in Emerson Lake, 2006.

DOMINANCE

Combining the relative frequency and relative density of a species into a Dominance Value illustrates how dominant a species is within the plant community (Appendix III). Based on the Dominance Value, *Lemna minor* (small duckweed) was the dominant aquatic plant species in Emerson Lake (Figure 6). *Phalaris arundinacea* (reed canary grass) was sub-dominant. These two species alone made up two-thirds of the aquatic plant community.

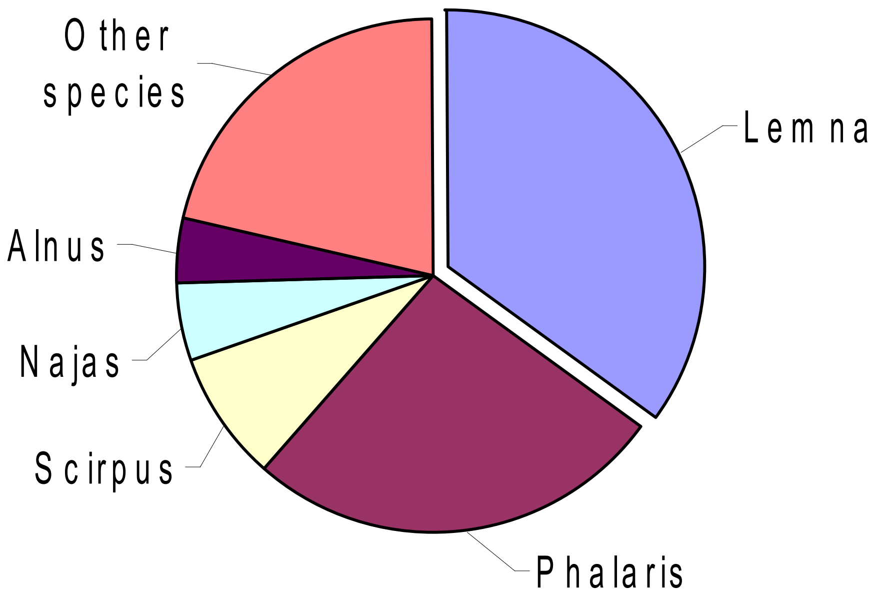

Figure 6. Dominance within the plant community, of the most prevalent aquatic plant species in Emerson Lake, 2006.

DISTRIBUTION

Aquatic plants occurred scattered throughout the littoral zone of Emerson Lake to a maximum rooting depth of 3.5 feet. *Nelumbo lutea* (American lotus) was found at the maximum rooting depth.

Vegetation colonized 53% of the littoral zone, 6% of the lake surface (2 acres). In 2006, approximately 1 acre (3% of the lake surface, 16% of the littoral zone) was vegetated with rooted submergent vegetation. Rooted floating-leaf vegetation colonized about 0.5 acres (2% of the lake surface, 3% of the littoral zone) and emergent vegetation colonized about 0.5 acre (2% of the lake surface, 40% of the littoral zone) (Figure 7). Free-floating duckweed species move around with the wind and the size of the mats will expand and shrink with growing conditions, so mapping it as a permanent cover is not appropriate. In July 2006, free-floating vegetation colonized 50% of the littoral zone.

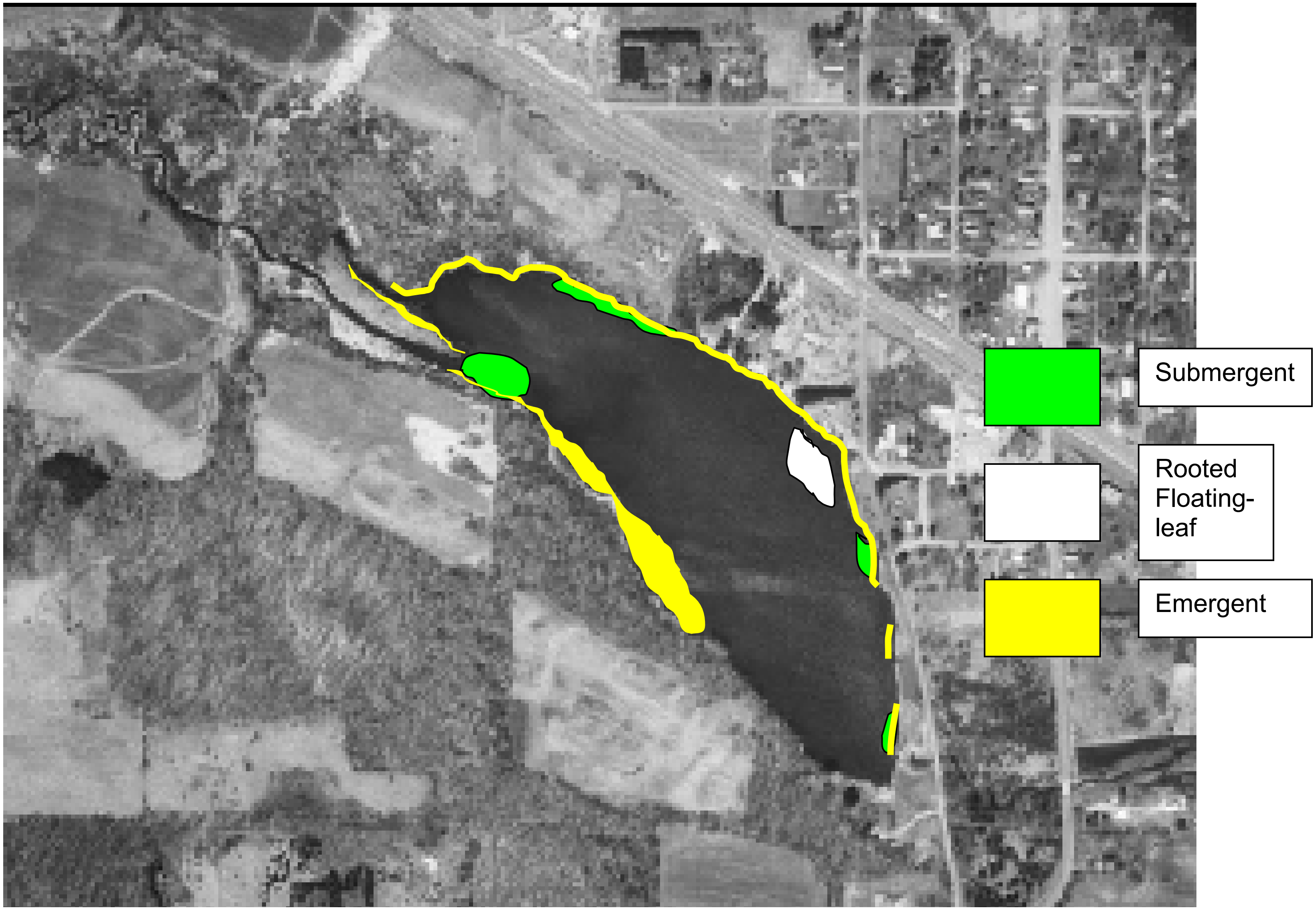

Figure 7. Distribution of aquatic plants in Emerson Lake, Clark County, 2006.

Water clarity data can be used to calculate a predicted maximum rooting depth for plants in a lake (Dunst 1982).

Predicted Rooting Depth (ft.) = (Secchi Disc (ft.) * 1.22) + 2.73

Based on the 1979 Secchi disc water clarity (0.30ft), the predicted maximum rooting depth in Emerson Lake would be 3.0 ft.

The maximum rooting depth of 3.5 feet is close to the predicted maximum rooting depth based on water clarity.

The highest total occurrence and total density of plants was in the 0-1.5ft depth zone and declined rapidly with increasing depth (Figure 8),

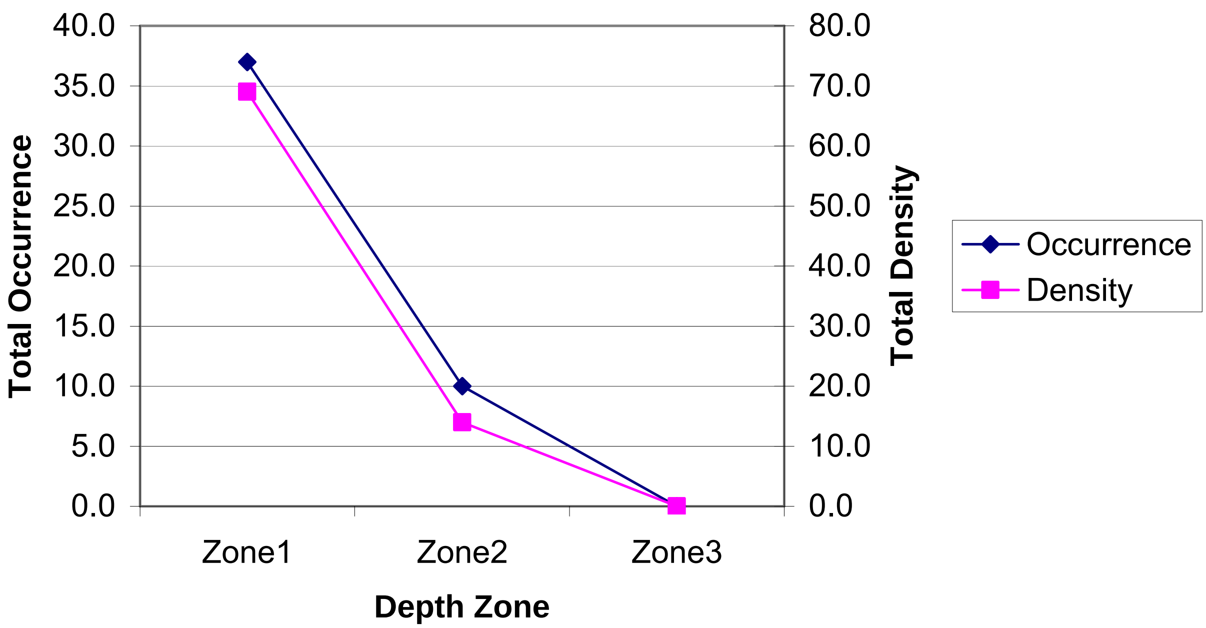

Figure 8. Total occurrence and total density of aquatic plants by depth zone in Emerson Lake, 2006.

The highest percent of vegetated sites and the greatest species richness (mean number of species per site) were also recorded in the 0-1.5ft depth zone, both declining with increasing depth (Figure 9). Overall Species Richness in Emerson Lake was 1.47.

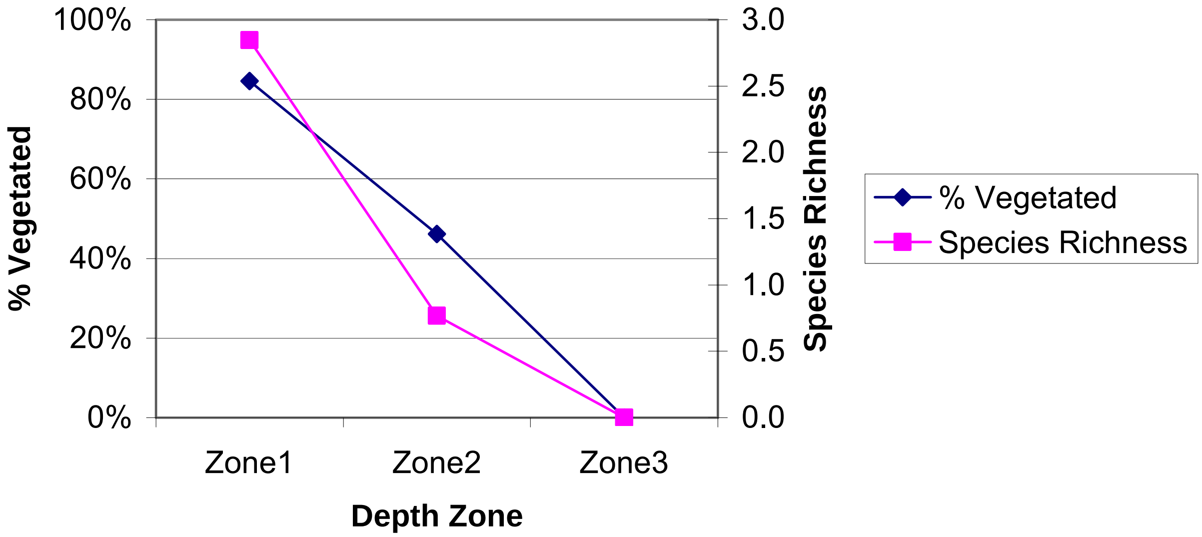

Figure 9. Percent of vegetated sites and Species Richness (mean number of species per sample site) by depth zone in Emerson Lake, 2006.

THE COMMUNITY

Simpson's Diversity Index was 0.82, indicating very poor 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 Emerson Lake (Table 6) is 32, indicating a low quality plant community. This value places Emerson Lake in the lowest quartile of lakes in Wisconsin and the North Central Hardwood Region for quality of the aquatic plant community. The shallow rooting depth, low frequency of submerged species and high frequency of non-native reed-canary grass are limiting the quality of the plant community in Emerson Lake.

Table 6. Aquatic Macrophyte Community Index: Emerson Lake 2006

Category		Value
Maximum Rooting Depth	1.07 meters	1
% Littoral Zone Vegetated	53%	10
% Submergent Species	12% Rel. Freq.	1
# of Species	15	7
% Exotic species	21%	3
Simpson's Diversity	0.82	5
% Sensitive Species	8.5% Relative Freq.	5
Totals		32

The highest value for this index is 70.

The Average Coefficient of Conservatism for Emerson Lake was in the lowest quartile of lakes in Wisconsin and the North Central Hardwood Region (Table 7). This suggests that the aquatic plant community in Emerson Lake is within the group of lakes most tolerant of disturbance, likely due to past disturbance.

Table 7. Floristic Quality and Average Coefficient of Conservatism of Emerson Lake, Compared to Wisconsin Lakes and Northern Wisconsin Lakes, 2006.

	Average Coefficient of Conservatism †	Floristic Quality ‡	Based on Relative Frequency	Based on Dominance Value
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		
Emerson Lake 2006	4.79	18.54	14.83	13.90

***** - 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 Index of the aquatic plant community in Emerson Lake is below average for lakes in the North Central Hardwood Region and Wisconsin (Table 7). This suggests that the plant community in Emerson Lake is farther from an undisturbed condition than average lake.

These values were calculated only on the presence or absence of sensitive and tolerant species in the lake. The abundance or rarity of these species was not taken into consideration. The Floristic Quality Index was recalculated, weighting each species Coefficient with its relative frequency and dominance value. The resulting values had a different meaning. Floristic Quality Indices based on relative frequency and dominance of the species indicate that Emerson lake is in the lowest quartile of lakes in the state and region, the group of lakes farthest from an undisturbed condition.
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 from wave action and boat traffic, 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.

Disturbance in Emerson Lake is likely due to inputs of nutrients and pesticides/herbicides from the watershed.

IV. DISCUSSION

Emerson Lake is a 33-acre shallow water resource with a maximum depth of 8 feet. Based on 1979 water quality data, Emerson Lake is a hypereutrophic lake with very poor water clarity and very poor water quality. Filamentous algae occurred at 50% of sample sites, most abundant in the 0-1.5ft depth zone and common in the 1.5-5ft depth zone.

The adequate nutrients (trophic state), shallow depth and gradually-sloped littoral zone in Emerson Lake would favor plant growth. The poor water clarity and dominance of high-density sand sediment in Emerson Lake may limit plant growth.

Aquatic plants colonized 53% of the littoral zone (6% of the lake surface), to a maximum depth of 3.5 feet. The greatest amount of plant growth occurred in the shallowest depth zones, 0-1.5ft. The highest total occurrence of plants, highest total density of plants, highest percent of vegetated sites and the greatest species richness occurred in the 0-1.5ft depth zone.

Fifteen (15) aquatic plant species were recorded in Emerson Lake. *Lemna minor* (small duckweed) was the dominant plant species in Emerson Lake, occurring at half of the sample sites. *Phalaris arundinacea* (reed canary grass) was sub-dominant in Emerson Lake, occurring at nearly one-third of the sites and exhibiting a growth form of above average density. The remainder of the aquatic plant species occurred at low frequencies and mean densities in Emerson Lake.

The Aquatic Macrophyte Community Index (AMCI) for Emerson Lake was 32, indicating that Emerson Lake's aquatic plant community is of low quality compared to other Wisconsin lakes and lakes in the North Central Hardwood Region. The Simpson's Diversity Index (0.82) for Emerson Lake indicates that the aquatic plant community had very poor diversity of species. Species Richness was 1.47 species per sample site.

The Average Coefficient of Conservatism suggests that Emerson Lake has a high tolerance of disturbance. It is within the group of lakes in Wisconsin and the North Central Hardwoods Region most tolerant of disturbance. The Floristic Quality Index shows Emerson Lake to be within the group of lakes in the state and region farthest from an undisturbed condition.

Emerson Lake is protected by natural shoreline cover (wooded, shrub, native herbaceous growth) at 82% of the shore. Preserving this natural shoreline is critical to maintaining water quality and wildlife habitat. Disturbed shoreline however, was common and occurred at 17% of the shore; mowed areas were most common. Conversion of the natural shoreline to lawn, rip-rap or hard structures results in significant loss of shoreline habitat for wildlife. The loss of natural shoreline also destroys the buffer that infiltrates stormwater run-off to the lake. Run-off volume from developed lawn is approximately 10 times greater than run-off from natural wooded cover and more run-off events occurred at sites with lawn (Graczyk et. al. 2003). This increased run-off carries more fertilizers, pesticides and other toxics to the lake.

Nitrogen and phosphorus input was 10-100 times greater at developed lawn than wooded areas (Hunt et. al. 2006).

Even this small amount of disturbance appears to have impacted the plant community in those disturbed areas. To quantify the impact of disturbed shore on the aquatic plant community in Emerson Lake, transects at shoreline with 100% natural cover were separated from transects that had any amount of disturbed cover and analyzed as separate communities (Appendices V-VI), a few measures of the aquatic plant community were different (Table 8).

The Average Coefficient of Conservatism and Floristic Quality Index measure a plant community's tolerance to disturbance and closeness to an undisturbed condition, therefore measuring the impact of disturbance on the community. In Emerson Lake, these indices were higher at the natural shoreline community than the disturbed shore community, suggesting disturbance on shore has impacted the aquatic plant shore community (Table 8). The natural shore community is farther from an undisturbed condition than the average lake, but the disturbed shore community was in the 25% of lakes farthest from an undisturbed condition.

Disturbed shore may be impacting the quality of the nearby aquatic plant community. The quality (AMCI Index) (Table 8, 9) is higher at the natural shore community.

The natural shoreline community in Angelo Pond supported more cover of vegetation and a greater maximum rooting depth (Table 8). This results in more total area of habitat at natural shore sites. This greater cover of vegetation also includes greater cover of emergent and floating-leaf vegetation, two especially important habitat structural types (Table 8).

Diversity in the aquatic plant community has been impacted slightly by disturbance. The number of species and Species Richness (mean number of species per site) were both higher at the natural shoreline community (Table 8). Greater diversity in the plant community supports greater diversity in the fish and wildlife community and provides a more stable community.

Table 8. Comparison of the Emerson Lake Aquatic Plant Community at Natural and Disturbed Shorelines

	Natural	Disturbed
Average Coefficient of Conservatism	5.08	3.71
Floristic Quality Index	18.30	9.83
AMCI Index (quality)	35	27
Maximum rooting depth	3.5 feet	1.5 feet
% of Littoral Zone Vegetated	61%	33%
% Cover of Emergent Vegetation	44%	33%
% Cover of Rooted Floating-leaf Veg.	4%	0%
Number of species	13	7
Species Richness	1.61	1.11

Table 9. AMCI Index: Natural Shore vs. Disturbed Shore Communities.

Category	Natural Shoreline Transects	Disturbed Shoreline Transects
Maximum Rooting Depth	1	1
% Littoral Zone Vegetated	10	5
% Submergent Species	1	1
# of Species	5	3
% Exotic species	10	10
Simpson's Diversity	4	5
% Sensitive Species	4	1
Totals	35	27

The highest value for this index is 70.

V. CONCLUSIONS

Emerson Lake is a hypereutrophic shallow water resource with very poor water clarity and very poor water quality based on 1979 water quality data. Filamentous algae occurred at more than half of the sites, very abundant in the shallowest zone.

The aquatic plant community colonized half of the sample sites, but only 6% of the total lake area, to a maximum rooting depth of 3.5 feet. The 0-1.5 ft. depth zone supported the most abundant aquatic plant growth.

Fifteen (15) aquatic plant species were recorded in Emerson Lake. *Lemna minor* (small duckweed) was the dominant species within the plant community, occurring at half of the sample sites. *Phalaris arundinacea* (reed canary grass) was sub-dominant, occurring at nearly one-third of the sites and exhibiting a dense form of growth in Emerson Lake. All species occurred at low mean densities in the Emerson Lake.

The aquatic plant community in Emerson Lake is characterized by low quality, very poor species diversity, a high tolerance to disturbance and within the quartile of lakes in the state and region farthest from an undisturbed condition.

A healthy aquatic plant community plays a vital role within the lake community (Figure 10). 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 out compete sensitive species, thus reducing diversity.

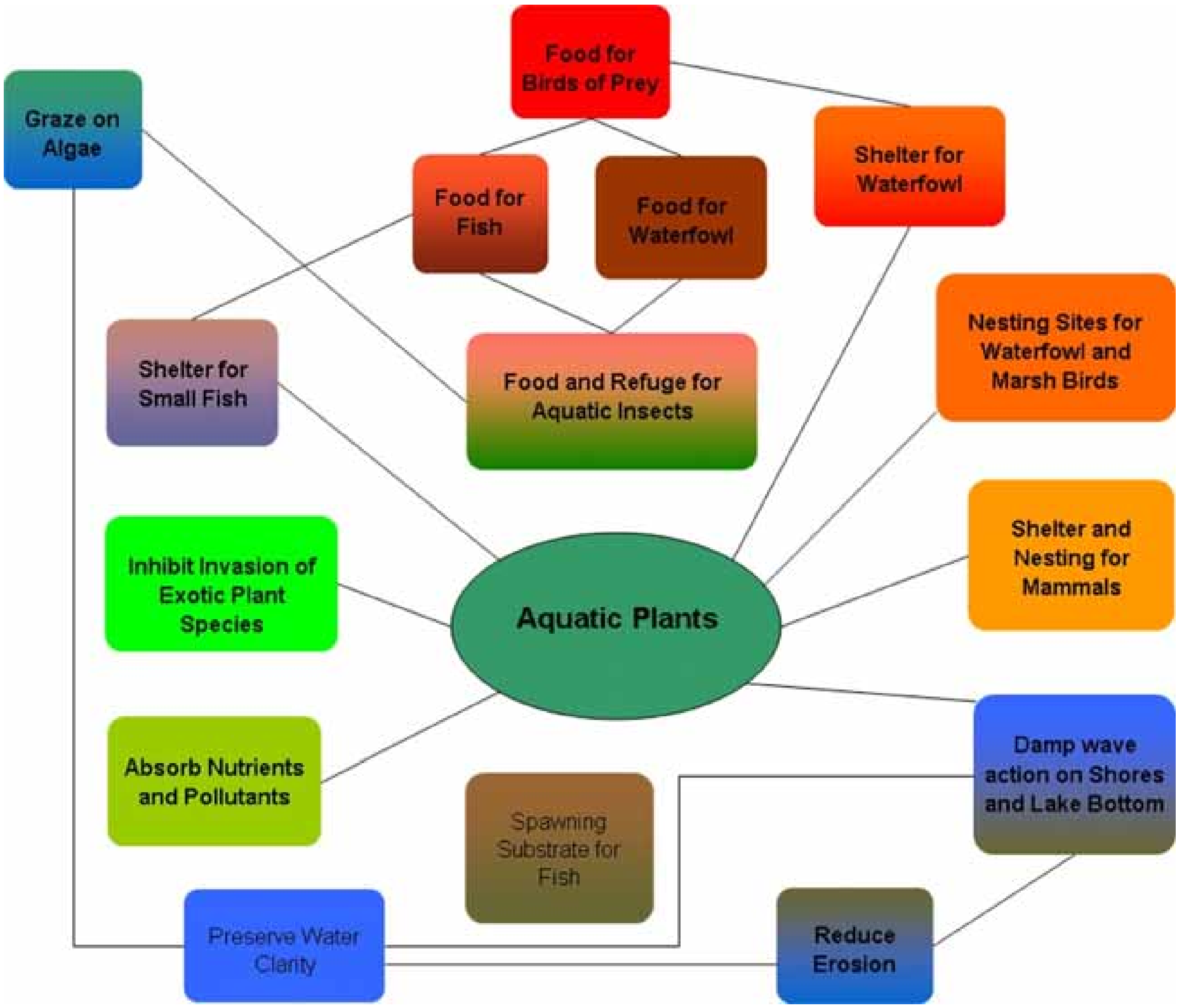

Figure 10. Benefits of Aquatic Plants in the Lake Ecosystem.

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

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 10). Plant cover within the littoral zone of Emerson Lake is 53% and over the entire lake is 6%. The cover more sparse than desirable to support a balanced fishery. Game fish populations have been found to decline when submerged aquatic vegetation cover is less than 10% and greater than 60% (Valley et. al. 2004).

Table10. Wildlife and Fish Uses of Aquatic Plants in Emerson Lake

Aquatic Plants	Fish	Water Fowl	Song and Shore Birds	Upland Game Birds	Muskrat	Beaver	Deer
Submergent Plants							
Chara sp.	F*, S	F*, I*					
Eleocharis acicularis	S	F			F		
Elodea canadensis	C, F, I	F(Foliage) I					
Najas flexilis	F, C	F*(Seeds, Foliage)	F(Seeds)				
Floating-leaf Plants							
Lemna minor	F	F*, I	F	F	F	F	
Nelumbo lutea	F, C	F			F	F	
Emergent Plants							
Alnus viridis						F	
Bidens spp.		F (Seeds),	F	F	F		
Calamagrostis spp.					F*		F*
Carex spp.	S*	F*(Seeds), C		F*(Seeds)	F	F	F
Scirpus validus	F, C, I	F (Seeds)*, C	F(Seeds, Tubers), C	F (Seeds)	F	F	F
Solanum dulcamara			F (seeds)				
Typha latifolia	I, C, S	F(Entire), C	F(Seeds), C, Nest	Nest	F* (Entire), C*, Lodge	F	

F=Food, I= Shelters Invertebrates, a valuable food source C=Cover, S=Spawning
***=Valuable Resource in this category**

*Current knowledge as to plant use. Other plants may have uses that have not been determined.
After Fassett, N. C. 1957. A Manual of Aquatic Plants. University of Wisconsin Press. Madison, WI
Nichols, S. A. 1991. Attributes of Wisconsin Lake Plants. Wisconsin Geological and Natural History Survey. Info. Circ. #73

Compared to non-vegetated lake bottoms, plant 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 plants 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. Plant beds of moderate density support adequate numbers of small fish without restricting the movement of predatory fish (Engel 1990).

Management Recommendations

1) Lake property owners preserve the natural shoreline buffer that is found around Emerson Lake. Wooded cover, shrubs and native herbaceous growth protected 82% of the shoreline. Maintaining natural shoreline cover is critical to maintaining water quality and wildlife habitat. Even the amount of disturbed shore (17%) on Emerson Lake appears to be impacting the aquatic plant community at those sites.
    a. The evidence that disturbance has impacted the aquatic plant community is that the Average Coefficient of Conservatism and Floristic Quality Index is lower at the disturbed shore transects indicating they are more tolerant of disturbance and farther from an undisturbed condition, likely due to disturbance.
    b. Disturbance appears to be impacting the quality of the aquatic plant community. The quality of the aquatic plant community is lower at disturbed shores (AMCI).
    c. Disturbance appears to be impacting the habitat. A lower percent colonization by vegetation and lower maximum rooting depth at the disturbed shore community results in less habitat. The disturbed shore aquatic plant community supports less cover of emergent and rooted floating-leaf vegetation which is a very important component of quality habitat for fish spawning and wildlife cover, nesting and feeding. The lower number of species and lower species richness indicate a less diverse plant community at disturbed shore sites which will support a less diverse wildlife and plant community.
2) Lakeshore property owners use best management practices on shoreland property to prevent nutrient enrichment and stormwater run-off to the lake. Abundant filamentous algae suggests nutrient enrichment to the lake.
    a. Eliminate fertilization near shoreline
    b. Use no-phosphorus fertilizer on remainder of the property
    c. Minimize use of toxic chemicals and no disposal of chemicals in the lake
    d. Use and maintain erosion barriers during any construction
    e. Inspect and maintain septic systems
    f. Reduce size of areas with hard surface
    g. Design landscaping so that stormwater run-off runs away from the lake, onto porous land cover and/or into rain barrels or rain gardens
3) Lake residents cooperate with programs to reduce nutrient run-off from the watershed, another potential source of nutrient enrichment to Emerson Lake.
4) Lake residents begin monitoring the water quality through the Citizen Lake

Monitoring Program to expand knowledge of water quality in Emerson Lake.

5) Maintain exotic species educational signs at the boat landing to prevent the spread of exotic species into Emerson Lake.

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Appendix IV. Location of Aquatic Plant Study Transects, 2006.