The Aquatic Plant Community of Thompson Lake, Pepin County, Wisconsin

2006


Wisconsin Department of Natural Resources
Eau Claire, WI

April 2007

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Executive Summary

Thompson Lake is a hypereutrophic lake with very poor water clarity and water quality. Filamentous algae was very abundant, especially in the 1.5-5ft depth zone.

Aquatic plant community colonized 94% of the lake, to a maximum depth of 6 feet. The 0-1.5 ft. depth zone supported the most abundant aquatic plant growth. The community is a community of species tolerant of poor clarity and species known to increase to nuisance levels with nutrient enrichment.

The aquatic plant community in Thompson Lake is characterized by low quality, very good species diversity, a high tolerance to disturbance and a condition farther from an undisturbed condition than the average lake in the state and region.

Twenty-eight (28) aquatic plant species were recorded in Thompson Lake. *Ceratophyllum demersum* (coontail) was the dominant species within the plant community, occurring at nearly all of the sample sites and exhibiting a dense growth form. *Lemna minor* (small duckweed) was the sub-dominant species, occurring at more than three-quarters of the sites and at above average densities. *L. minor* and the other two duckweed species make up more than one-third of the total plant community. The exotic Eurasian watermilfoil is abundant in Thompson Lake, especially in the 1.5-5ft depth zone. The other two exotics, reed-canary grass and curly-leaf pondweed are commonly occurring in the lake.

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 cover that is found around Thompson Lake. Wooded cover, shrubs and native herbaceous growth protected nearly all of the shoreline. Maintaining natural shoreline cover is critical to maintaining water quality and wildlife habitat.
2) Lakes residents use best management practices on shoreland property to prevent nutrient enrichment and stormwater run-off to the lake.
3) Lake residents begin monitoring the water quality through the Self-Help Volunteer Lake Monitoring Program. Monitor water quality to expand knowledge of water quality in Thompson Lake.
4) Maintain exotic species educational signs at the boat landing to prevent the spread of exotic species from Thompson Lake.
5) Cooperate with programs in the watershed to reduce nutrients to the lake. The aquatic plant community in Thompson Lake is one of turbidity tolerant species and species that are favored by high nutrient conditions. Since Thompson Lake is transitional in its phosphorus:nitrogen ratio, either nutrient can increase algae growth.

The Aquatic Plant Community in Thompson Lake, Pepin County 2006

I. INTRODUCTION

A study of the aquatic macrophytes (plants) in Thompson 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 Thompson 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: Thompson Lake is a 42-acre backwater of the Chippewa River with a maximum depth of 23 feet.

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 16 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, 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 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 each side of the transect intercept with the shore and 30 feet deep was evaluated. The percentage of each shore cover type (Table 5) 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 "mean 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 was summed to obtain a dominance value for each species (Appendix III). Species 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 Thompson Lake (Table 5) 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 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. 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, clarity and alkalinity) 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. Phosphorus concentration, chlorophyll a concentration 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.

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.

July 2001 phosphorus concentration in Thompson Lake was 158ug/l

The concentration of phosphorus in Thompson Lake is indicative of a hypereutrophic lake (Table 1).

Table 1. Trophic Status

	Quality Index	Phosphorus ug/l	Chlorophyll a 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**
Thompson Lake – 2001	**Very Poor**	**158 ug/l**	**148 ug/l**	**1.6 ft.**

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

Although the majority of Wisconsin Lakes are phosphorus limited, about 10% are nitrogen limited, meaning that increases in nitrogen can increase algae growth. The

Nitrogen:Phosphorus ratio in Thompson Lake in July 2001 was 11:1. Lakes with N:P ratios between 10:1 and 15:1 are considered transitional, meaning at times inputs of nitrogen can increase algae growth and at times inputs of phosphorus can increase algae growth (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.

July 2001 chlorophyll a concentration in Thompson Lake was 148 ug/l.

This concentration of chlorophyll indicates that Thompson Lake is hyperuetrophic (Table 1).

Filamentous algae occurred at 62% of the sample sites in Thompson Lake; the 1.5-5ft depth zone had the greatest occurrence of filamentous algae (93%) (Figure 1).

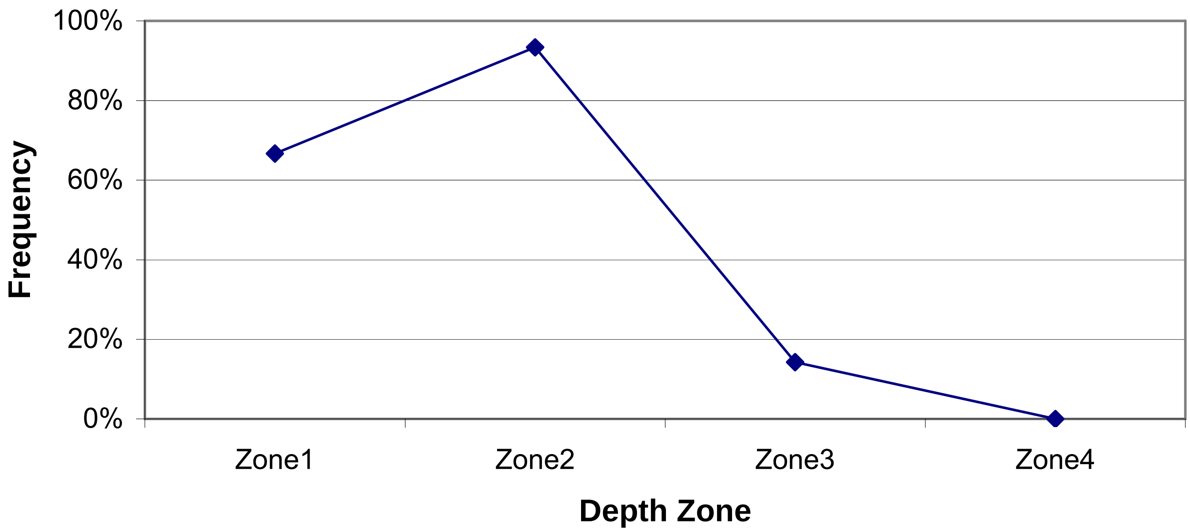

Figure 1. Occurrence of filamentous algae in Thompson Lake, by depth, July 2006.

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 is measured with a Secchi disc that shows the combined effect of turbidity and color.

July 2001 Secchi disc water clarity in Thompson Lake was 1.6 ft.

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

The combination of phosphorus concentration, chlorophyll concentration and water clarity indicates that Thompson Lake is a hypereutrophic lake with very poor water quality (Table 1). This trophic state would favor dense plant growth and very frequent algae blooms.

Alkalinity

July 2001 alkalinity of Rock Lake was 89mg/l CaCO3.

Lakes with an alkalinity between 61-120mg/l CaCO3 are considered moderately hard. Hard water lakes tend to support more aquatic plant growth than soft water lakes (Shaw et. al. 1993).

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).

Thompson Lake has a shallow basin with a gradually-sloped littoral zone over most of the lake. The only deep portions are along the road bed and under the bridge. Gradual slopes provide a more stable substrate for rooting and a broad band of water shallow enough for plant growth.

SEDIMENT COMPOSITION – Sand sediment and sand mixed with silt were the dominant sediments overall in Thompson Lake. Pure sand was common in the 0-5ft depth zone and dominated the deepest depth zones (5-20ft); sand mixed with silt was dominant in the shallowest zone (0-1.5ft depth zone) (Table 2). Organic muck dominated the 1.5-5ft depth zone. Silt alone was 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	10-20' Depth	Percent of all Sample Sites
Hard Sediment	Sand	20%	20%	43%	67%	28%
	Rock	7%				2%
Mixed Sediment	Sand/Silt	40%	20%		33%	25%
Soft Sediment	Silt	13%	20%	28%		18%
	Muck	13%	27%			15%
	Silt/Muck	7%	13%	28%		12%

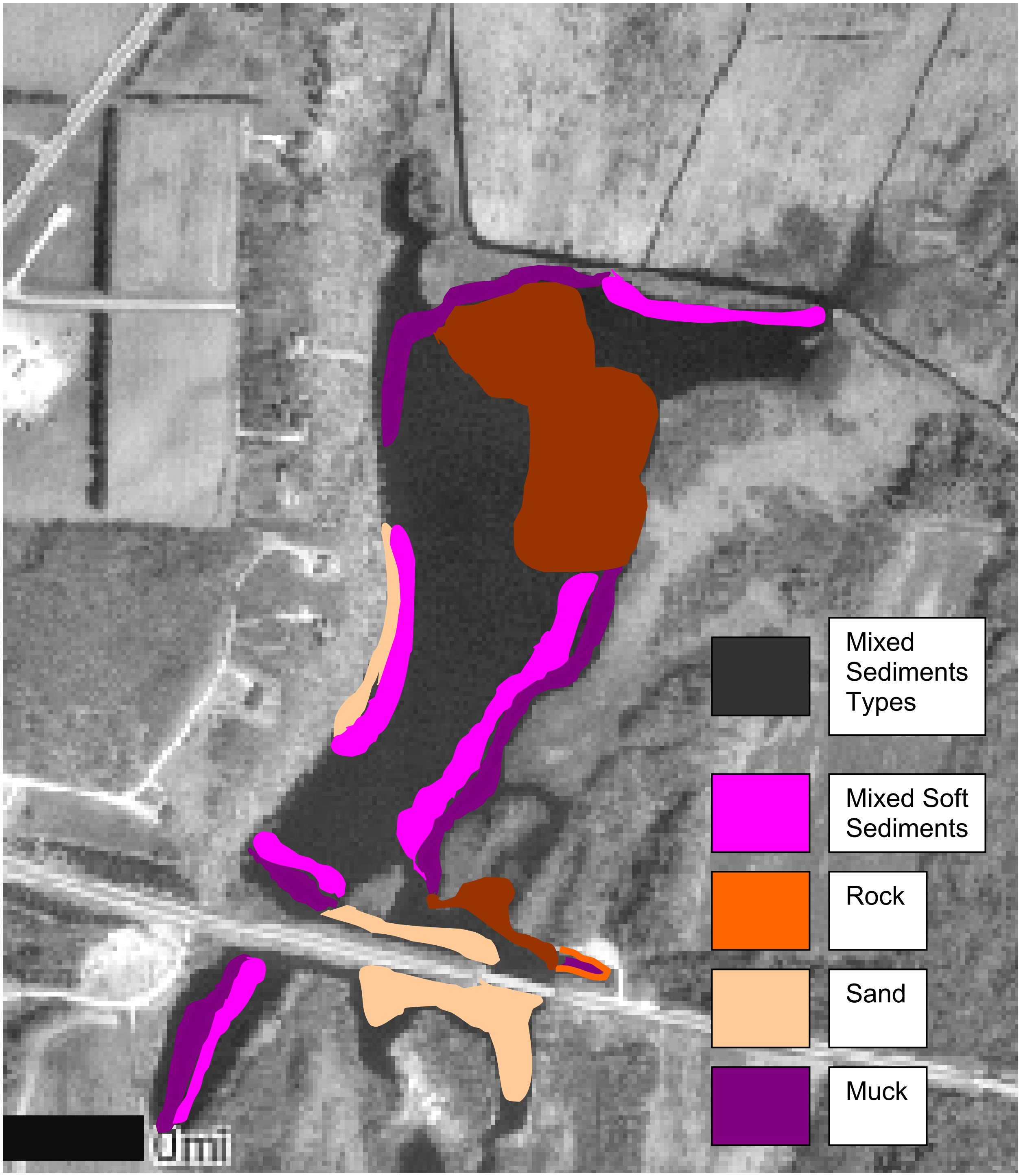

Figure 2. Sediment type distribution in Thompson Lake, 2006.

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 occurred in Thompson Lake but was not commonly occurring lakewide, however, it was common in the 1.5-10ft depth zone; silt was common mixed with sand (especially in the 0-5ft depth zone); silt was common mixed with muck in the 5-10ft depth zone (Table 2). Sand was the dominant sediment in Thompson Lake and can be limiting to plant growth due to its high density and lower nutrient availability but sand was more prevalent in the deeper water. However, all sediment types supported abundant vegetation in Thompson Lake.

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. Impacts occur in both rural and residential settings. 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 nutrients to the lake. Nitrogen and phosphorus input was 10-100 times greater at developed lawn than wooded areas (Hunt et. al. 2006).

Herbaceous growth was the most frequently encountered shoreline cover and had the highest mean coverage at the shoreline. Shrub cover and wooded cover were also abundant (Table 3). Some type of natural shoreline occurred at all of sites and covered approximately 88% of the shore.

Disturbed shoreline (roads and mowed lawn) was found at 20% of the sites and covered 12% of the shore (Table 3).

Table 3. Shoreline Land Use, 2006

Cover Type		Frequency of Occurrences at Transects	Mean % Coverage
Natural Shoreline	Native Herbaceous	87%	41%
	Shrub	80%	29%
	Wooded	40%	18%
Total Natural			88%
Disturbed Shoreline	Mowed Lawn	13%	5%
	Gravel Road	7%	5%
	Pavement	7%	2%
Total Disturbed			12%

<u>MACROPHYTE DATA</u>

SPECIES PRESENT

Of the 28 aquatic plant species found in Thompson Lake, 14 were emergent species, 4 were floating-leaf species and 10 were submergent species (Table 4). Three-quarters of the submergent species are known to be tolerant of poor water clarity. Two-thirds of the submergent species and half of the floating-leaf species are known to increase to nuisance levels with nutrient enrichment (Nichols and Vennie 1991).

No threatened or endangered species were found in the survey.
Three non-native species was found: *Myriophyllum spicatum* (Eurasian watermilfoil), *Phalaris arundinacea* (reed canary grass), *Potamogeton crispus* (curly-leaf pondweed).

Table 4. Thompson Lake Aquatic Plant Species, 2006

Scientific Name	Common Name	I. D. Code
Emergent Species		
1) *Asclepias incarnata* L.	swamp milkweed	ascin
2) *Calamagrostis canadensis* (Michx.) P.Beauv.	bluejoint grass	calca
3) *Carex aquatilis* Wahlenb.	lake sedge	caraq
4) *Carex comosa* Boott.	bristly sedge	carco
5) *Cicuta bulbifera* L.	bulb-bearing water hemlock	cicbu
6) *Eleocharis ovata* (Roth) Roemer & Schultes.	blunt spikerush	eleob
7) *Eleocharis smallii* Britt.	creeping spikerush	elesm
8) *Impatiens capensis* Meerb.	spotted jewelweed	impca
9) *Phalaris arundinacea* L.	reed canary grass	phaar
10) *Polygonum amphibium* L.	smartweed	polam
11) *Rumex orbiculatus* A. Gray	great water dock	rumor
12) *Sagittaria* spp.	arrowhead	sagsp
13) *Sparganium eurycarpum* Engelm.	giant bur-reed	spaeu
14) *Verbena urticifolia* L.	white vervain	verur
Floating-leaf Species		
15) *Lemna minor* L.	small duckweed	lemmi
16) *Nymphaea odorata* Aiton.	white water lily	nymod
17) *Spirodela polyrhiza* (L.) Schleiden.	great duckweed	spipo
18) *Wolffia columbiana* Karst.	water-meal	wolco
Submergent Species		
19) *Ceratophyllum demersum* L.	coontail	cerde
20) *Eleocharis acicularis* (L.) Roemer & Schultes.	needle spikerush	eleac
21) *Elodea canadensis* Michx.	common waterweed	eloca
22) *Myriophyllum spicatum* L.	Eurasain watermilfoil	myrsp
23) *Najas flexilis* (Willd.) Rostkov & Schmidt.	slender naiad	najfl
24) *Potamogeton crispus* L.	curly-leaf pondweed	potcr
25) *Potamogeton natans* L.	floating-leaf pondweed	potna
26) *Potamogeton nodosus* Poiret.	long-leaf pondweed	potno
27) *Potamogeton pusillus* L.	small pondweed	potpu
28) *Ranunculus longirostris* Godron.	white watercrowfoot	ranlo

FREQUENCY OF OCCURRENCE

Ceratophyllum demersum (coontail) was the most frequently occurring species in Thompson Lake in 2006 (95% of sample sites) (Figure 3). *Elodea canadensis, Lemna minor, Myriophyllum spicatum, Nymphaea odorata, Phalaris arundinacea, Potamogeton crispus, Spirodela polyrhiza* and *Wolffia columbiana* were also commonly occurring, (30%, 78%, 50%, 68%, 20%, 28%, 68%, 75%) (Figure 3).

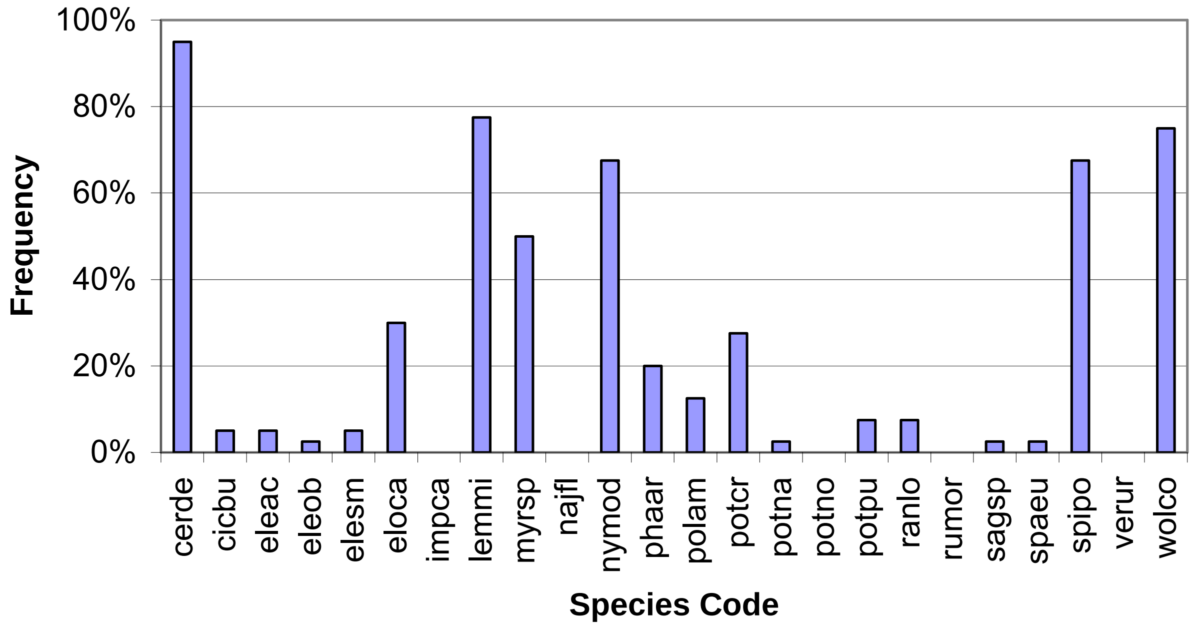

Figure 3. Frequency of aquatic plant species in Thompson Lake, 2006.

DENSITY

Ceratophyllum demersum (coontail) was the species with the highest mean density also (3.18 on a density scale of 0-4) in Thompson Lake (Figure 4).

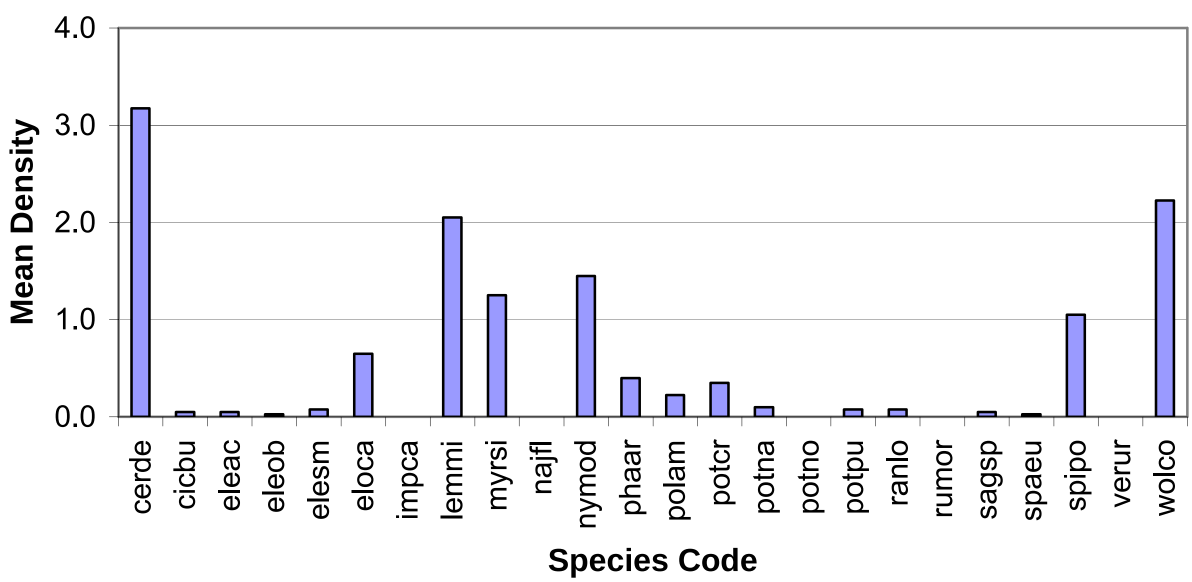

Figure 4. Densities of aquatic plant species in Thompson Lake, 2006.

"Mean density where present" indicates that a species exhibited a dense or aggregated growth form in a waterbody (Figure 5). *Potamogeton natans* (floating-leaf pondweed) had the highest "mean densities where present", indicating it exhibited an aggregated growth form, though it occurred in limited locations. *Carex aquatilis, Ceratophyllum demersum, Lemna minor* and *Wolffia columbiana* exhibited growth forms of above average density (Figure 5) in Thompson Lake. Only *C. demersum, L. minor* and *W. columbiana* were also commonly occurring.

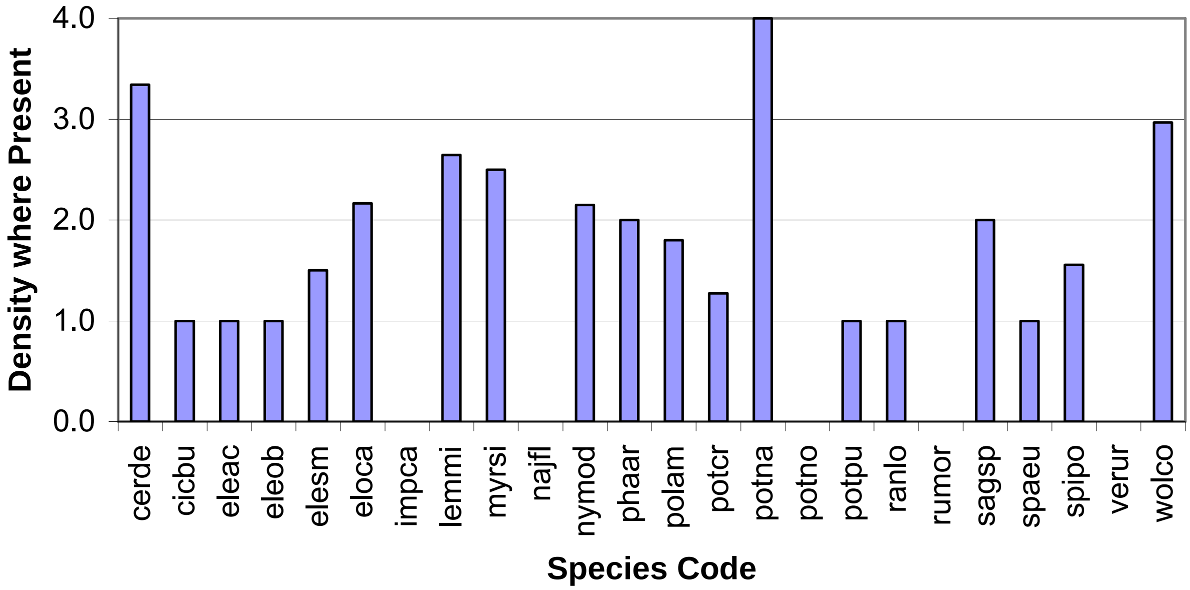

Figure 5. "Density where present" of aquatic plant species in Thompson Lake, 2006.

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, *Ceratophyllum demersum* (coontail) was the dominant aquatic plant species in Thompson Lake (Figure 6). *Lemna minor* (small duckweed) was sub-dominant. The combined dominance of the free-floating duckweed species, *Lemna minor, Spirodela polyrhiza* and *Wolffia columbiana*, makes up a large portion of the plant community, about one-third (Figure 6).

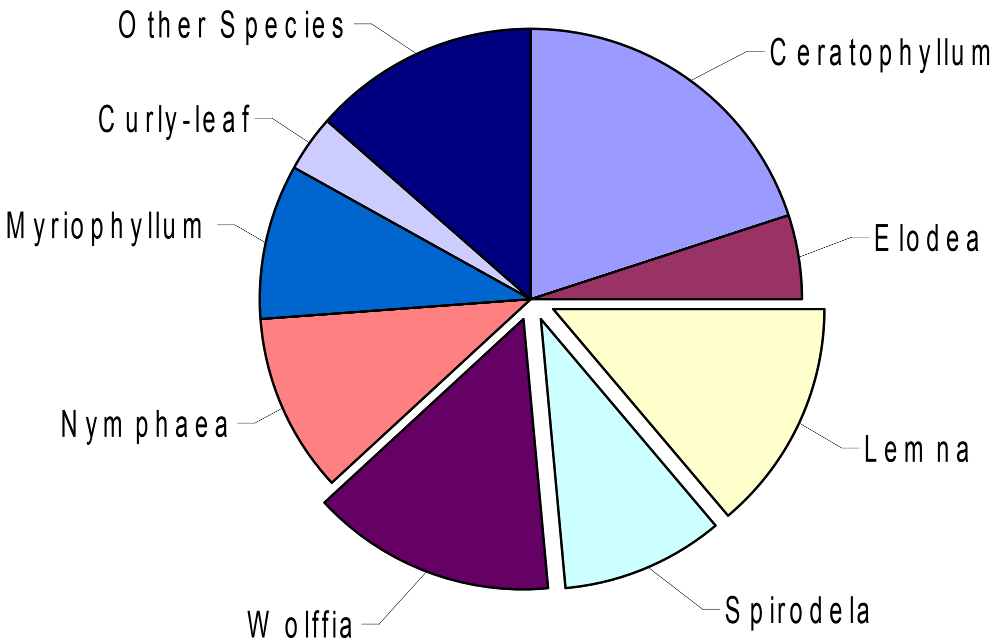

Figure 6. Dominance within the plant community, of the most prevalent aquatic plant species in Thompson Lake, 2006.

Ceratophyllum demersum, the dominant species, dominated all depth zones and occurred at its highest frequency and density the 1.5-5ft depth zone (Appendices I, II) (Figure 7, 8). *Lemna minor*, the sub-dominant species, was as frequent in the 0-1.5ft depth zone (Figure 7, 8). *Myriophyllum spicatum,* Eurasian watermilfoil an exotic invasive species, was common in the 0-10ft depth zone and occurred at its highest frequency and density in the 1.5-5ft depth zone. *Potamogeton crispus,* curly-leaf pondweed another exotic species, is common, especially in the 0-5ft depth zone.

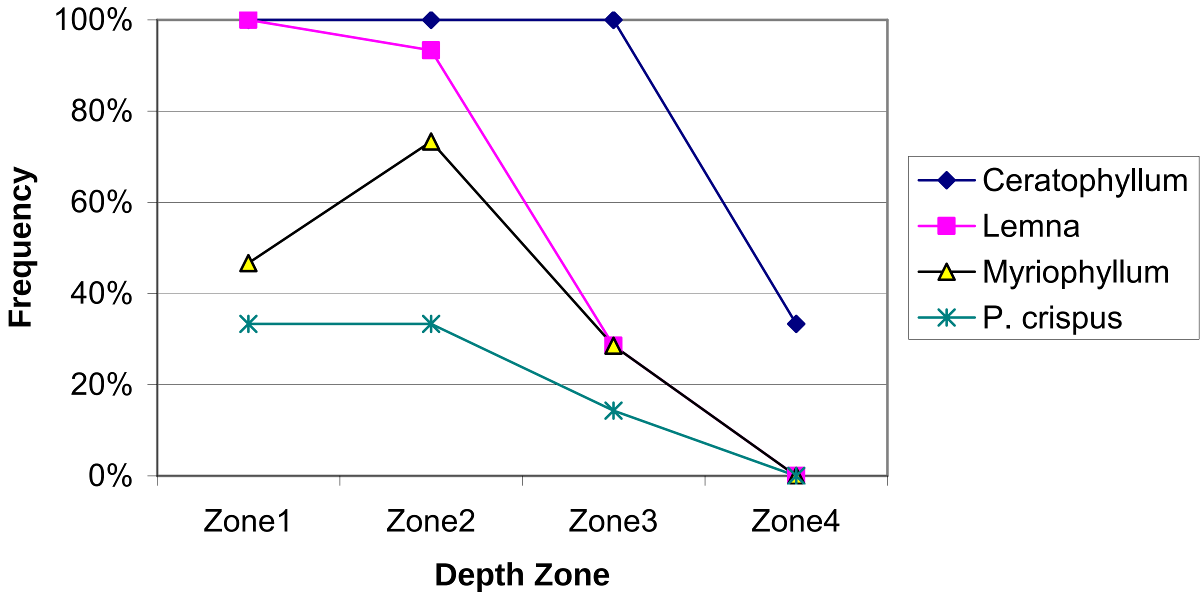

Figure 7. Frequency of most prevalent species in Thompson Lake, by depth, 2006.

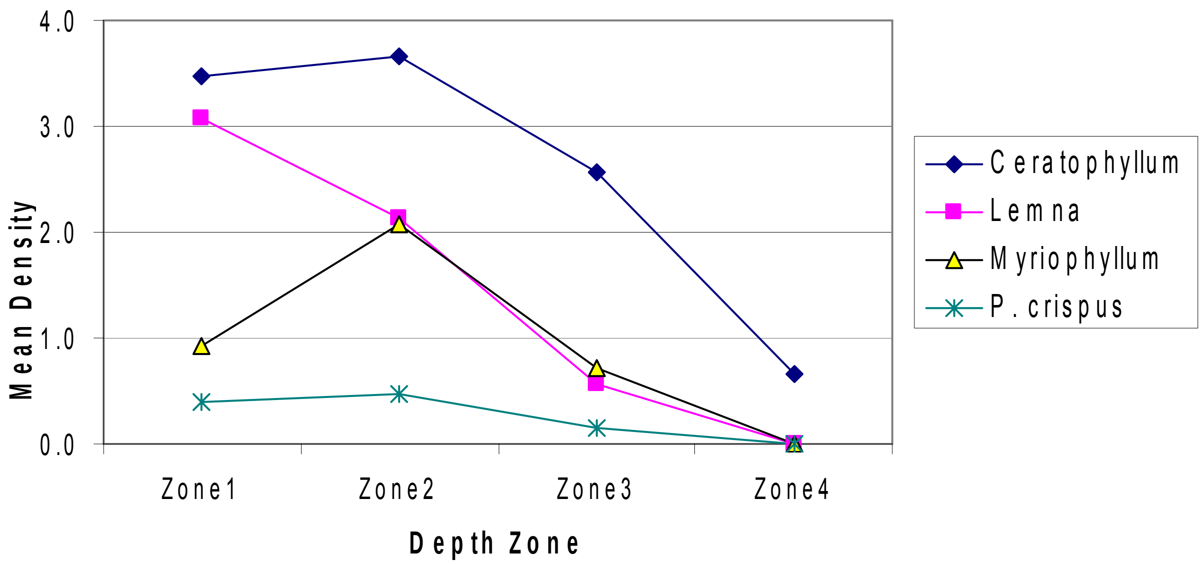

Figure 8. Density of the most prevalent plant species, by depth zone.

DISTRIBUTION

Aquatic plants occurred throughout Thompson Lake to a maximum rooting depth of 6 feet; *Potamogeton crispus* (curly-leaf pondweed) was found at the maximum rooting depth. *Ceratophyllum demersum* (coontail) was found deeper but is not truly rooted.

Vegetation colonized 95% of the littoral zone, 94% of the lake surface (40 acres). In 2006, approximately 40 acres (94% of the lake surface, 95% of the littoral zone) was vegetated with submergent vegetation. Rooted, floating-leaf species colonized approximately 25 acres (30% of the lake surface; 60% of the littoral zone). Emergent vegetation colonized about 2 acre (5% of the lake surface, 42% of the littoral zone) (Figure 9). On the day of the survey, free-floating species colonized 95% of the littoral zone, but these mats can move across a water body with shifts in wind and can expand or contract with changes in growing conditions. Mapping these as a permanent cover is not appropriate.

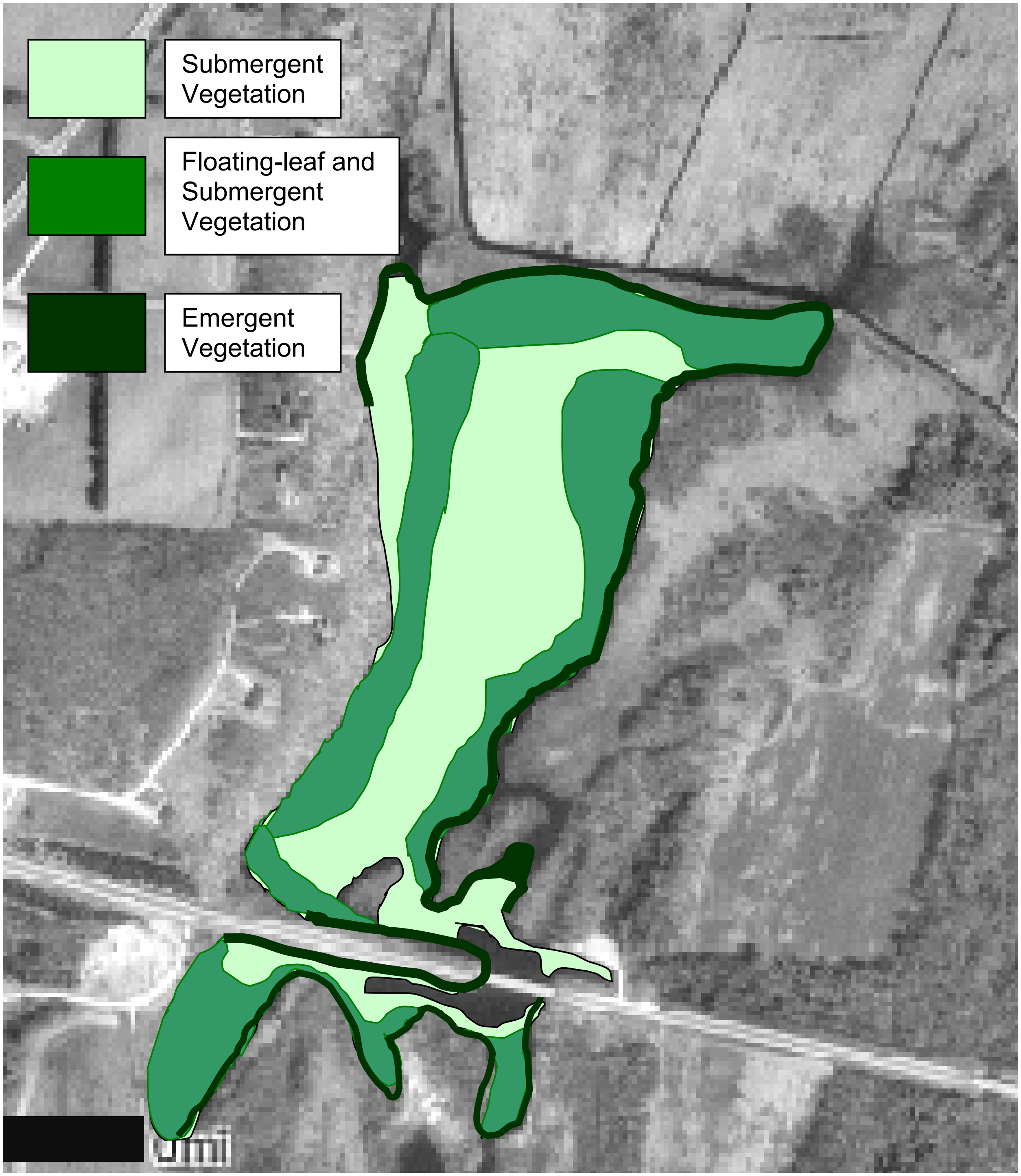

Figure 9. Distribution of aquatic plants in Thompson Lake, Pepin County, 2006.

The dominant and common species in Thompson Lake were found distributed throughout the littoral zone, except *Phalaris arundinacea* (reed canary grass) was not found on the east side of the lake and *Potamogeton crispus* (curly-leaf pondweed) was not found on the west shore and was more common in the south basin (Figure 10).

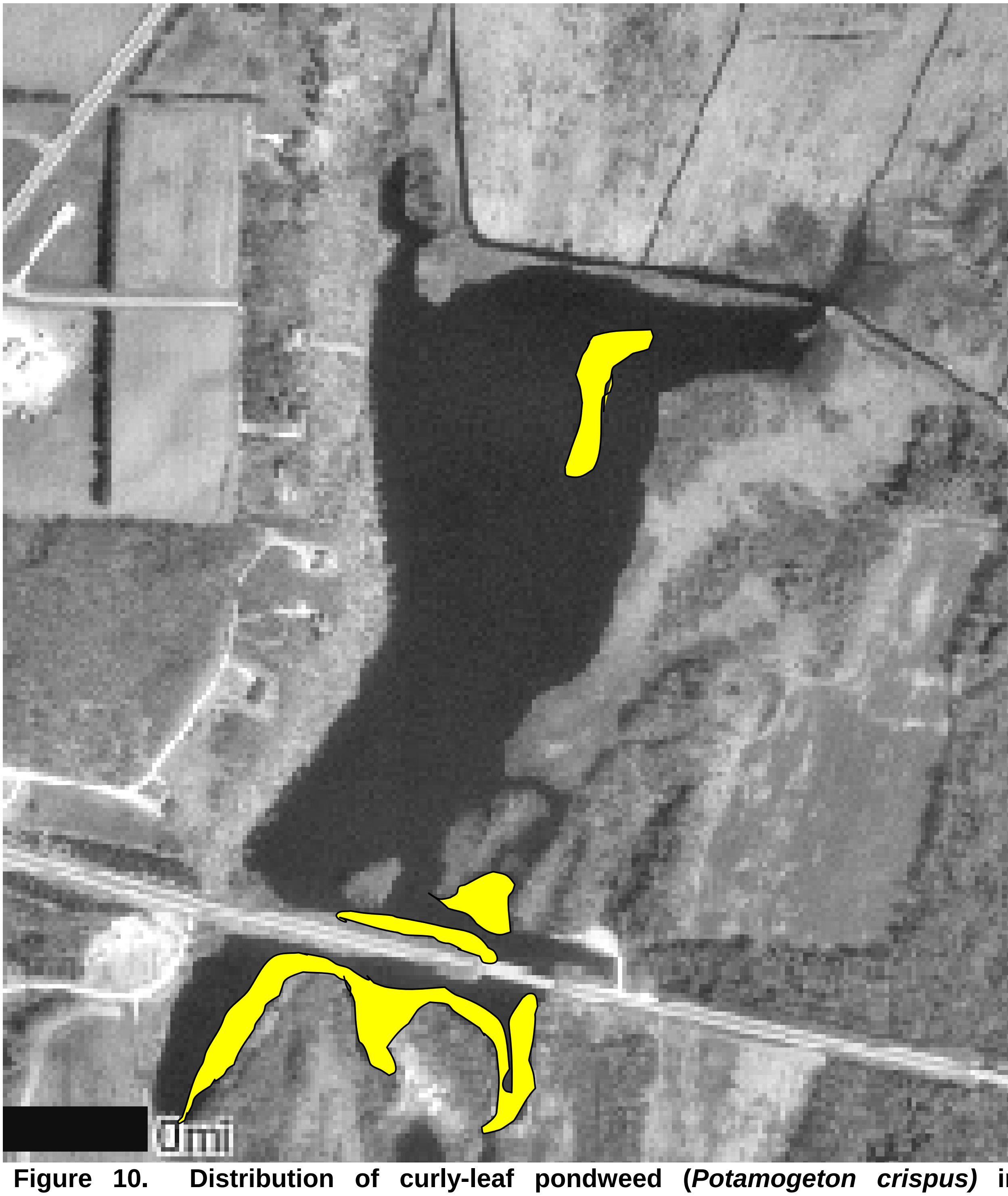

Figure 10. Distribution of curly-leaf pondweed (*Potamogeton crispus)* in Thompson Lake, July 2006.

Myriophyllum spicatum (Eurasian watermilfoil) was abundant in Thompson Lake (Figure 11).

Figure 11. Distribution of Eurasian watermilfoil (*Myriophyllum spicatum)* in Thompson Lake, July 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 July 2001 Secchi disc water clarity (1.6ft), the predicted maximum rooting depth in Thompson Lake would be 4.7 feet.

The maximum rooting depth of 6 feet is greater than the predicted maximum rooting depth based on water clarity. This may be due better clarity early in the year when plant growth is first starting to extend towards the surface.

The highest total occurrence and total density of plants was in the 0-1.5ft depth zone and declined rapidly with increasing depth (Figure 12).

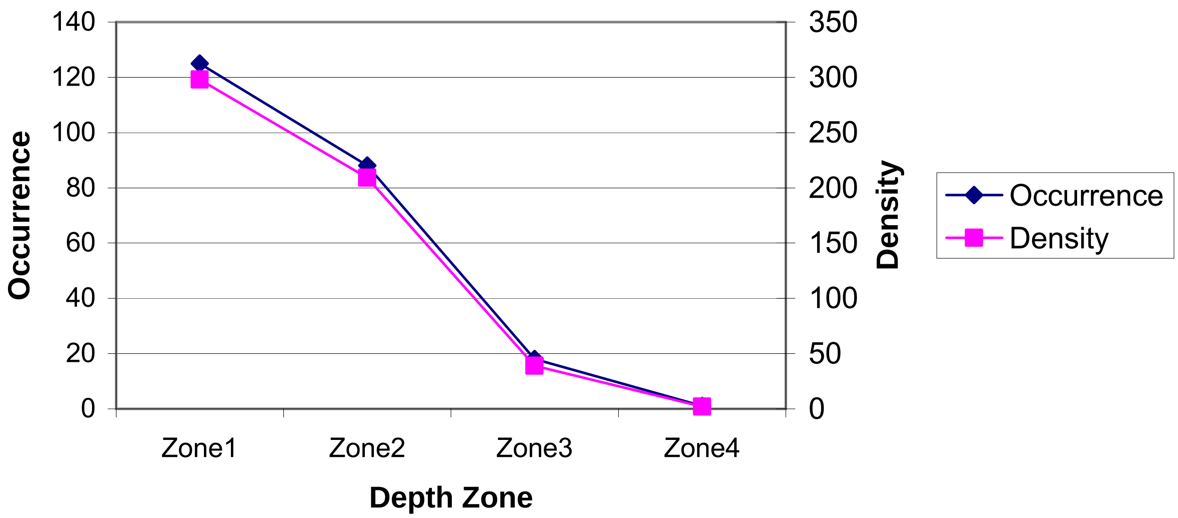

Figure 12. Total occurrence and total density of aquatic plants by depth zone in Thompson Lake, 2006.

The greatest species richness (mean number of species per site) was also recorded in the 0-1.5ft depth zone, declining rapidly with increasing depth (Figure 13). Overall Species Richness in Thompson Lake was 5.8. The highest percent colonization of the littoral zone was in the 0-10ft depth zone (Figure 13).

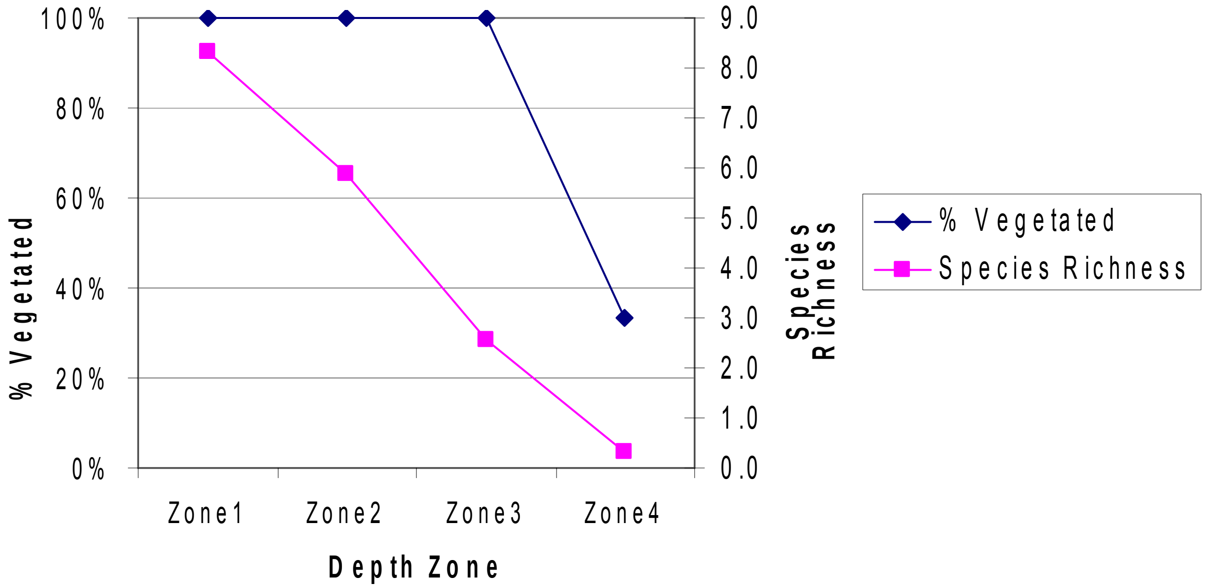

Figure 13. Species Richness (mean number of species per sample site) by depth zone in Thompson Lake, 2006.

THE COMMUNITY

Simpson's Diversity Index was 0.90, 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 Thompson Lake (Table 5) is 38, indicating a low quality plant community. This value places Thompson Lake in the lowest quartile of lakes in Wisconsin and the North Central Hardwood Region of the state as far as the quality of the aquatic plant community.

Table 5. Aquatic Macrophyte Community Index: Thompson Lake 2006

Category		Value
Maximum Rooting Depth	1.8 meters	2
% Littoral Zone Vegetated	95%	10
% Submergent Species	22% Rel. Freq.	1
# of Species	28	10
% Exotic species	17%	4
Simpson's Diversity	0.897	8
% Sensitive Species	1.3% Relative Freq.	3
Totals		38

The highest value for this index is 70.

Many factors are limiting the quality of the aquatic plant community in Thompson Lake: the shallow maximum rooting depth, the imbalance of free-floating species to rooted species, the high frequency of exotic species in the lake (Eurasian watermilfoil, curly-leaf pondweed and reed canary grass) and the lack of sensitive species.

The Average Coefficient of Conservatism for Thompson Lake was in the lowest quartile for lakes in Wisconsin and the North Central Hardwood Region (Table 6). This suggests that the aquatic plant community in Thompson Lake within the group of lakes most tolerant of disturbance. This is likely due to past disturbances.

Table 6. Floristic Quality and Coefficient of Conservatism of Thompson Lake, Compared to Wisconsin Lakes and Northern Wisconsin Lakes.

	† Average Coefficient of Conservatism	‡ Floristic Quality Index (FQI)	FQI (weighted by relative frequency)	FQI (weighted by dominance)
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		
Thompson Lake 2006	4.44	23.52	18.52	18.12

***** **-** 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 plant community in Thompson Lake is above average for lakes in the North Central Hardwood Lakes Region and Wisconsin (Table 6). This suggests that the plant community in Thompson Lake is closer to an undisturbed condition than the average lake in the state or region.

This value was based only on the presence or absence of sensitive and tolerant species in Thompson Lake, their frequency or dominance in the plant community was not taken into the consideration. The Floristic Quality Index was recalculated, weighting each species coefficient with its dominance and frequency in the plant community. The resulting values were different. Based on relative frequency and dominance of species in the community, the Floristic Quality Index places Thompson Lake below average. This suggests that Thompson Lake is farther from an undisturbed condition than the average lake in the state and 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 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 Thompson Lake is likely due to the introduction of exotic, invasive aquatic plant species and run-off from the road.

IV. DISCUSSION

Thompson Lake is a 42-acre lake with a maximum depth of 23 feet. Based on 2001 water quality data, Thompson Lake is a hypereutrophic lake with very poor water clarity and very poor water quality. Filamentous algae was very abundant, 62% of sample sites, 93% of the sites in the 1.5-5ft depth zone. The nitrogen:phosphorus ratio in Thompson Lake was 11:1, indicating that the lake is transitional in its nitrogen and phosphorus limitation. This means that at times, an increase in either nutrient can feed increased algal blooms.

The adequate nutrients (trophic state), moderately hard water, dominance of fertile silt sediments and silt mixtures, gradually-sloped littoral zone and the shallow depths in most of Thompson Lake would favor plant growth. The very poor water clarity in Thompson Lake may limit plant growth.

Aquatic plants colonized 95% of the littoral zone (94% of the lake surface), to a maximum depth of 6 feet. The greatest amount of plant growth occurred in the shallowest depth zone, 0-1.5ft. The highest total occurrence of plants, highest total density of plants and the greatest species richness occurred in the shallowest depth zone.

Twenty-eight (28) aquatic plant species were recorded in Thompson Lake. Three-quarters of the submergent species are known to be tolerant of poor water clarity. Two-thirds of the submergent species and half of the floating-leaf species are known to increase to nuisance levels with nutrient enrichment. *Ceratophyllum demersum* (coontail) was the dominant plant species in Thompson Lake, dominating all depth zones, occurring at nearly all of the sample sites and exhibiting a dense growth form. *Lemna minor* (small duckweed) was the sub-dominant plant species in Thompson Lake, occurring at more than three-quarters of the sites, exhibiting a growth form of above average density in Thompson Lake. *L. minor,* along with the other duckweed species (*Spirodela polyrhiza* and *Wolffia columbiana)* made up one-third of the plant community, based on dominance values and occurred over nearly the entire lake surface.

Three exotic species occur in Thompson Lake: *Myriophyllum spicatum* Euraisan watermilfoil) is abundant in the lake (especially in the 1.5-5ft depth zone); *Phalaris arundinacea* (reed canary grass) and *Potamogeton crispus* (curly-leaf pondweed) are both common.

The Aquatic Macrophyte Community Index (AMCI) for Thompson Lake was 38, indicating that Thompson Lake's aquatic plant community is of low quality compared to other Wisconsin lakes and lakes in the North Central Region. The Simpson's Diversity Index (0.90) for Thompson Lake indicates that the aquatic plant community had very good diversity of species. Species Richness was 5.8 species per sample site.

The Average Coefficient of Conservatism and the Floristic Quality Index suggests that Thompson Lake is tolerant of disturbance. It is within the group of lakes in the state and the North Central Hardwoods Region of Wisconsin most tolerant of disturbance and farther from an undisturbed condition than average. The introduction of exotic species and run-off from the road are likely the major disturbance factors in Thompson Lake.

Thompson Lake is protected by natural shoreline cover (wooded, shrub, native herbaceous growth) at 88% of the shore; all natural cover types were abundant. Mowed areas and road surface were the major disturbance-type shore covers and covered 12% of the shore. Preserving this natural shoreline is critical to maintaining water quality and wildlife habitat.

Although the disturbed shore covers 12% of the shore on Thompson Lake, even this amount may be having impacts to the lake. To quantify these impacts, transects at shoreline with 100% natural cover were separated from transects that had any amount of disturbed cover. These two sets of transects were analyzed as separate communities (Appendices V-VI) and a few measures of the aquatic plant community were different (Table 7).

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 Thompson Lake, the natural shoreline community Average Coefficient and Floristic Quality Index were higher than the disturbed shore community, suggesting more disturbances had impacted the disturbed shore community (Table 7). Natural shoreline aquatic plant communities were farther from an undisturbed condition than the average lake, but disturbed shoreline communities were in the bottom 25%, those farthest from an undisturbed condition.

Another clue to disturbance as a cause in the difference between the natural and disturbed shore communities is the decreased frequency of sensitive species at disturbed shoreline sites. The combined relative frequency of sensitive aquatic plant species (small pondweed and water crowfoot) did not occur at disturbed shoreline sites (Table 7).

The quality of the aquatic plant community was higher at the natural shoreline community, as measured by the AMCI (Table 7, 8).

Diversity in the aquatic plant community has been impacted by disturbance. Number of species, the Simpson's Diversity Index, Species Richness overall and Species Richness in the shallowest zones (zone in which shoreline disturbance would have the most impact) were all slightly higher at the natural shoreline community (Table 7). Natural shoreline aquatic plant communities had a very good diversity, while disturbed shoreline communities had a fair diversity. Greater diversity in the plant community supports greater diversity in the fish and wildlife community and provides a more stable community.

Disturbance may be impacting the quality of the habitat. Emergent and floating-leaf vegetation are particularly important components of quality habitat for wildlife and fish.

The cover of both of these structural types was higher at natural shoreline sites (Table 7).

Table 7. Comparison of the Thompson Lake Aquatic Plant Community at Natural and Disturbed Shorelines

	Natural	**Disturbed**
Average Coefficient of Conservatism	4.29	3.73
Floristic Quality Index	20.10	12.36
AMCI (quality of plant community) (Table 8)	38	30
Relative Frequency of Sensitive Species	3%	0
Simpson's Diversity Index	0.901	0.866
Number of species	22	11
Species Richness		
Overall	5.91	5.37
0-1.5ft depth zone	8.75	6.67
1.5-5ft depth zone	5.92	5.67
Cover of emergent vegetation	31%	25%
Cover of floating-leaf vegetation	69%	62%

Table 8. Comparison of AMCI at Natural vs. Disturbed Shoreline.

Category	Natural Shore Community	Disturbed Shore Community
Maximum Rooting Depth	2	2
% Littoral Zone Vegetated	10	10
% Submergent Species	1	1
# of Species	9	5
% Exotic species	4	5
Simpson's Diversity	9	6
% Sensitive Species	3	1
Totals	38	30

The highest value for this index is 70.

V. CONCLUSIONS

Thompson Lake is a hypereutrophic lake with very poor water clarity and water quality. Filamentous algae was very abundant, especially in the 1.5-5ft depth zone.

Aquatic plant community colonized 94% of the lake, to a maximum depth of 6 feet. The 0-1.5 ft. depth zone supported the most abundant aquatic plant growth. The community is a community of species tolerant of turbid water and known to increase to nuisance levels with nutrient enrichment.

Twenty-eight (28) aquatic plant species were recorded in Thompson Lake. *Ceratophyllum demersum* (coontail) was the dominant species within the plant community, occurring at nearly all of the sample sites and exhibiting a dense growth form. *Lemna minor* (small duckweed) was the sub-dominant species, occurring at more than three-quarters of the sites and at above average densities. *L. minor* and the other two duckweed species make up more than one-third of the total plant community and cover nearly the entire lake surface. The exotic Eurasian watermilfoil is abundant in Thompson Lake, especially in the 1.5-5ft depth zone. The other two exotics, reed-canary grass and curly-leaf pondweed are commonly occurring in the lake.

The aquatic plant community in Thompson Lake is characterized by low quality, very good species diversity, a high tolerance to disturbance and a condition farther from an undisturbed condition than the average lake in the state and region.

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants 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.

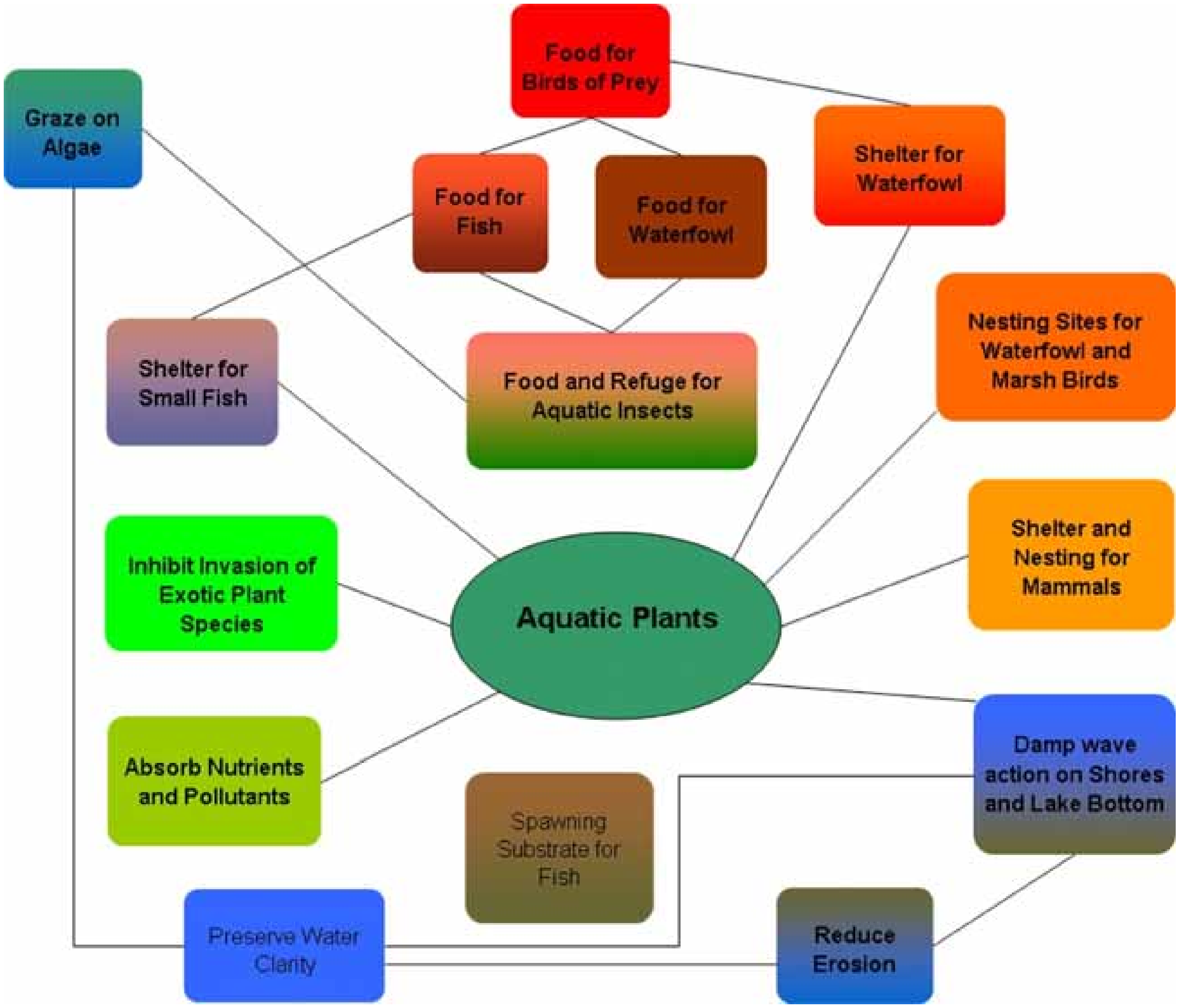

Figure 14. Benefits of aquatic plants in the lake ecosystem.

Aquatic plant communities improve water quality in many ways. Aquatic plants 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 9). Game fish populations have been found to decline when submerged aquatic vegetation is less than 10% and greater than 60% (Valley et. al. 2004). Plant cover within the littoral zone of Thompson Lake is 95% and over the entire lake is 94%. This is higher than ideal to support a balanced game fishery.

Table 9. Wildlife and Fish Uses of Aquatic Plants in Thompson Lake

Aquatic Plants	Fish	Water Fowl	Song / Shore Birds	Upland Game Birds	Muskrat	Beaver	Deer
<u>Submergent Plants</u>							
Ceratophyllum demersum	F,I*, C, S	F(Seeds*), I, C			F		
Eleocharis acicularis	S	F			F		
Elodea canadensis	C, F, I	F(Foliage) I					
Myriophyllum spicatum	F, C						
Najas flexilis	F, C	F*(Seeds, Foliage)	F(Seeds)				
Potamogeton crispus	F, C, S	F(Seeds, Tubers)					
Potamogeton natans	F, I, S*,C	F*(Seeds, Tubers)			F*	F	F
Potamogeton nodosus	F, I, S*,C	F*(Seeds)			F*	F	F
Potamogeton pusillus	F, I, S*,C	F*(All)			F*	F	F
Ranunculus longirostris	F	F(Seeds, Foliage)		F			
<u>Floating-leaf Plants</u>							
Lemna minor	F	F*, I	F	F	F	F	
Nymphaea odorata	F,I, S, C	F(Seeds)	F		F	F	F
Spirodela polyrhiza	F	F		F			
Wolffia columbiana		F			F		

Aquatic Plants	Fish	Water Fowl	Song / Shore Birds	Upland Game Birds	Muskrat	Beaver	Deer
<u>Emergent Plants</u>							
Asclepias incarnata				Nest Fibers	Roots		
Calamagrostis spp.					F*		F*
Carex aquatilis	S*	F*(Seeds), C		F*(Seeds)	F	F	F
Carex comosa	S*	F*(Seeds), C	F*(Seeds)	F*(Seeds)	F	F	F
Eleocharis smallii	I	F, C					
Eleocharis sp.	F, S, C	F(Tubers, Seeds), C	F(Seeds)	F (Seeds)	F	F	F
Polygonum amphibium	F, C	F*(Seeds)	F	F	F		F
Rumex spp.		F (Seeds)	F	F			F*
Sagittaria sp.		F*, C	F(Seeds), C	F, C	F	F	
Sparganium eurycarpum	I	F(Seeds), C	F, C		F		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 cover that is found around Thompson Lake. Wooded cover, shrubs and native herbaceous growth protected nearly all of the shoreline. Maintaining natural shoreline cover is critical to maintaining water quality and wildlife habitat. Several analyses suggest that even the small amount of disturbed shoreline may be impacting the aquatic plant community and habitat in the areas of the disturbance.
2) Lakes residents use best management practices on shoreland property to prevent nutrient enrichment and stormwater run-off to the lake.
3) Lake residents begin monitoring the water quality through the Self-Help Volunteer Lake Monitoring Program. Monitor water quality to expand knowledge of water quality in Thompson Lake.
4) Maintain exotic species educational signs at the boat landing to prevent the spread of exotic species from Thompson Lake.
5) Cooperate with programs in the watershed to reduce nutrients to the lake. The aquatic plant community in Thompson Lake is one of turbidity tolerant species and species that are favored by high nutrient conditions. Since Thompson Lake is transitional in its phosphorus:nitrogen ration, either nutrient can increase algae growth.

LITERATURE CITED

Barko, J. and R. Smart. 1986. Sediment-related mechanisms of growth limitation in submersed macrophytes. Ecology 61:1328-1340.

Dennison, W., R. Orth, K. Moore, J. Stevenson, V. Carter, S.Kollar, P. Bergstrom, and R. Batuik. 1993. Assessing water quality with submersed vegetation. BioScience 43(2):86-94.

Duarte, Carlos M. and Jacob Kalff. 1986. Littoral slope as a predictor of the maximum biomass of submerged macrophyte communities. Limnol. Oceanogr. 31(5):1072-1080.

Dunst, R.C. 1982. Sediment problems and lake restoration in Wisconsin. Environmental International 7:87-92.

Engel, Sandy. 1990. Ecosystem Response to Growth and Control of Submerged Macrophytes: A Literature Review. Technical Bulletin #170. Wisconsin Department of Natural Resources. Madison, WI.

Engel, Sandy. 1985. Aquatic Community Interactions of Submerged Macrophytes. Wisconsin Department of Natural Resources. Technical Bulletin No. 156. Madison, WI

Fassett, Norman C. 1957. A Manual of Aquatic Plants. University of Wisconsin Press. Madison, WI.

Gleason, H. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada (Second Edition). New York Botanical Gardens, NY.

Graczyk, David, R. Hunt, S. Greb, C. Buchwald and J. Krohelski. 2003. Hydrology, Nutrient Concentrations and Nutrient Yields in Nearshore Areas of Four Lakes in Northern Wisconsin, 1999-2001. USGS Water Resources Investigations Report 03-4144.

Hunt, Randall, S. Greb and D. Gracyzk. 2006. Evaluating the Effects of Nearshore Development on Wisconsin Lakes. USGS Fact Sheet 2006-3033.

Jessen, Robert and Richard Lound. 1962. An evaluation of a survey technique for submerged aquatic plants. Minnesota Department of Conservation. Game Investigational Report No. 6.

Lillie, R. and J. Mason. 1983. Limnological Characteristics of Wisconsin Lakes. Wisconsin Department of Natural Resources Tech. Bull. #138. Madison, WI.

Nichols, Stanley, S. Weber, B. Shaw. 2000. A proposed aquatic plant community biotic index for Wisconsin lakes. Environmental Management 26:491-502.

Nichols, Stanley. 1998. Floristic quality assessment of Wisconsin lake plant communities with example applications. Journal of Lake and Reservoir Management 15(2):133-141.

Nichols, Stanley A. and James G. Vennie. 1991. Attributes of Wisconsin Lake Plants. Wisconsin Geological and Natural History Survey. Information Circular 73.

Shaw, B, C. Mechenich and L. Klessig. 1993. Understanding Lake Data. University of Wisconsin – Extension. Madison, WI

Valley, Ray, T. Cross and P. Radomski. 2004. The Role of Submersed Aquatic Vegetation as Habitat for Fish in Minnesota Lakes, Including the Implications of Non-Native Plant Invasions and Their Management. Minnesota Department of Natural Resources Special Publication 160.

Appendix IV. Location of aquatic plant study transects in Thompson Lake.