The Aquatic Plant Community of Bear Lake, Portage County, Wisconsin

2006

Wisconsin Department of Natural Resources
Eau Claire, WI
2007

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Submitted by:

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Executive Summary

Bear Lake is a mesotrophic lake with very good water clarity and good water quality. Filamentous algae occurred in Bear Lake and was common in the 0-5ft depth zones.

Aquatic plant community colonized the entire littoral zone, approximately 60% of the total lake area, to a maximum depth of 13 feet. The 0-1.5 ft. depth zone supported the most abundant aquatic plant growth.

Brasenia schreberi (watershield) was the dominant species within the plant community, especially in the 0-5ft depth zones, occurring at more than half of the sample sites and exhibiting a dense growth form. *Ceratophyllum demersum* (coontail) and *Potamogeton pusillus* (small pondweed) were sub-dominant species, both occurring at approximately half of the sites and at above average densities. The dominant and common species occur throughout the lake.

The aquatic plant community in Bear Lake is characterized by high quality, very good species diversity, an average tolerance to disturbance and within the quartile of lakes in the region closest to 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) Preserve the natural shoreline cover that is found around nearly all of Bear Lake. Maintaining natural shoreline cover is critical to maintaining water quality and wildlife habitat. Indices suggest that even the small amount of disturbance at the shore appears to have impacted the aquatic plant community in that area and that the disturbance has impacted the water quality (filamentous algae), the quality of the plant community and the quality of the habitat.
2) Lakes shore property owners use best management practices on shoreland property to prevent nutrient enrichment and stormwater run-off to the lake.
2) Lake residents continue monitoring through the Citizen Lake Monitoring Program. Monitor water quality to expand knowledge of water quality in Bear Lake.
3) DNR to designate sensitive areas within Bear Lake. These are areas that are most important for habitat and maintaining water quality.
4) Maintain exotic species educational signs at the boat landing to prevent the spread of exotic species into Bear Lake. This is critical sense stem of EWM was found washed up on shore and suggests that a boater brought in a sprig and it could happen again.
5) Do not improve boat landing on Bear Lake. As a small lake it is not appropriate for large boats or high-speed boating.

The Aquatic Plant Community in Bear Lake, Portage County 2006

I. INTRODUCTION

A study of the aquatic macrophytes (plants) in Bear 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 Bear Lake by the DNR. Herbarium records from various qualitative surveys by University of Wisconsin-Stevens Point staff and students have been compiled into a plant list of floating-leaf and submergent vegetation.

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: Bear Lake is a 34-acre seepage lake in central Portage County, Wisconsin. Bear Lake has a maximum depth of 36 feet and a mean depth of 7 feet. Because Bear Lake is fed primarily by groundwater, fluctuations in the groundwater table have a significant impact on the lake level. There is an unimproved boat landing for the lake.

In 2006, at the time of the aquatic plant survey, the lake level was extremely low. The western quarter of the lake was not navigable by canoe; lily pads were growing in a terrestrial condition. The lake level has cycled recently. A 1960 aerial photo shows that water level in Bear Lake was as low in 1960 as currently, the lake level was up at the beginning of this century and currently the water level is very low again.

The watershed of Bear Lake is 219 acres; the watershed area to lake area ratio is a little more than 6:1.
The watershed study in 2002, found that forest cover was the dominant watershed cover in the Bear Lake watershed, protecting more than half of the watershed (Table 1). Approximately 80 % of the watershed is protected with natural vegetation.

Table 1. Bear Lake Watershed, 2005.

Cover Type	Acres	%
Forest	122	56
Crop	32	15
Pine Plantation	27	12
Shrub/Herbaceous	26	12
Residential	7	3
Roads	5	2
Total	219	

(2005 UW-SP Bear Lake Preliminary Results)

Dr. Freckmann and students at UW-Stevens Point have conducted several qualitative surveys over the years and have compiled a list of 20 species that have been found up to November 2003 (Table 2).

Table 2. Bear Lake Herbarium Records up to November 2003.

Scientific Name	Common Name
Floating-leaf Species	
1) *Brasenia schreberi* J. F. Gmelin.	watershield
2) *Lemna turionfera* (reference unknown)	perennial duckweed
3) *Nuphar variegata* Durand.	bull-head pond lily
4) *Nymphaea odorata* Aiton.	white water lily
5) *Polygonum amphibium* L.	smartweed
Submergent Species	
6) *Ceratophyllum demersum* L.	coontail
7) *Elodea canadensis* Michx.	common waterweed
8) *Megalodonta beckii* (Torr. ex Spring) Greene	water marigold
9) *Myriophyllum sibiricum* Komarov.	common water milfoil
10) *Najas flexilis* (Willd.) Rostkov and Schmidt	slender water-nymph
11) *Potamogeton amplifolius* Tuckerman.	large-leaf pondweed
12) *Potamogeton crispus* L.	curly-leaf pondweed
13) *Potamogeton gramineus* L.	variable-leaf pondweed
14) *Potamogeton illinoensis* Morong.	Illinois pondweed
15) *Potamogeton natans* L.	floating pondweed
16) *Potamogeton praelongus* Wulf.	white-stem pondweed
17) *Utricularia gibba* L.	small bladderwort
18) *Utricularia intermedia* Hayne	bladderwort
19) *Utricularia minor* L.	small bladderwort
20) *Utricularia vulgaris* L.	great bladderwort

During the growing season of 2003, staff from Golden Sands Resource Conservation & Development Council, Inc. conducted a survey of Eurasian watermilfoil (*Myriophyllum spicatum*) in Portage County lakes. A stem of *M. spicatum* was found washed up at the Bear Lake boat landing, collected and vouchered at UW-SP (Thorstenson 2003). However, no other rooted or floating Eurasian watermilfoil plants were found in Bear Lake.

Portage County recruited and trained a volunteer, Tom Zielinski, to monitor for *Myriophyllum spicatum* and other exotic invasive species. Tom reported no *Myriophyllum spicatum* or other exotics found in Bear Lake in 2005. The present study found no *Myriophyllum spicatum* in Bear Lake in 2006.

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 12 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 either side of the transect intercept with the shore and 30 feet deep was evaluated. The percentage of each shore cover type within this 100' x 30' rectangle was visually estimated and verified by a second researcher.

Data Analysis

The percent frequency of each species was calculated (number of sampling sites at which it occurred/total number of sampling sites) (Appendix I). Relative frequency was calculated (number of occurrences of a species/total occurrence of all species) (Appendix I). The mean density was calculated for each species (sum of a species density ratings/number of sampling sites) (Appendix II). Relative density was calculated (sum of a species density/total plant 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 Bear Lake (Table 7) 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, water level fluctuations 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.

2002-03 Mean summer phosphorus concentration in Bear Lake was 33ug/l

The concentration of phosphorus in Bear Lake was indicative of a mesotrophic lake (Table 3). Historic water quality data for mean summer phosphorus in Bear Lake was 32ug/l, very close to the most recent data collected.

Table 3. 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
Bear Lake – 2002/03	**Good**	**33 ug/l**		**9.5 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. No chlorophyll data has been found for Bear Lake.

Filamentous algae occurred at 12% of the sample sites in Bear Lake, but only the shallow depth zones supported filamentous algae, a 25% occurrence in the 0-1.5ft depth zone and a 25% occurrence in the 1.5-5ft depth zone.

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.

2002-03 Mean summer Secchi disc water clarity in Bear Lake was 9.5 ft.

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

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

LAKE MORPHOMETRY - The morphometry of a lake is an important factor in determining the distribution of aquatic plants. Duarte and Kalff (1986) found that the slope of the littoral zone could explain 72% of the observed variability in the growth of submerged plants. Gentle slopes support more plant growth than steep slopes (Engel 1985).

Bear Lake has a roughly rectangular basin that has a gradually-sloped littoral zone (Appendix IV). The gentle slopes provide a more stable substrate for aquatic plant growth and a broader band of shallow waters favorable for plant growth.

SEDIMENT COMPOSITION – Soft sediments dominate Bear Lake. The dominant sediment in Bear Lake was peat, especially in the deeper zones (Table 4, Figure 1). Silt sediments were dominant in the shallowest zone.

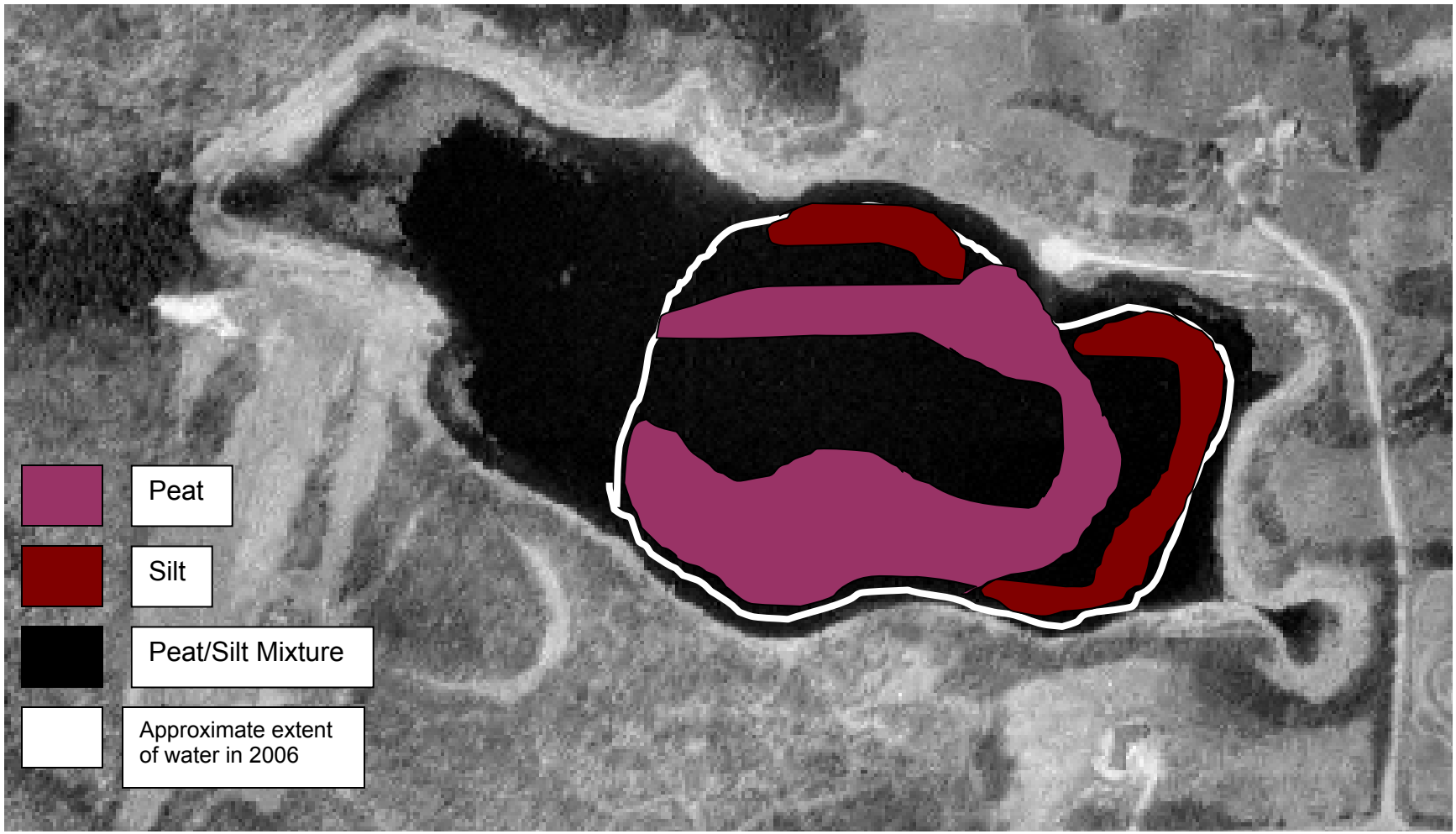


Figure 1. Sediment distribution in Bear Lake, 2006.

Table 4. Sediment Composition, 2006

Sediment Type		0-1.5' Depth	1.5-5' Depth	5-10' Depth	10-20' Depth	Percent of all Sample Sites
Soft Sediments	Peat	25%	50%	43%	75%	48%
	Silt	75%	25%		12%	29%
	Silt/Peat		25%	57%	12%	22%

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.

Peat sediment was the dominant sediment found in Bear Lake and may limit plant growth due its flocculent nature, resulting in an unstable rooting substrate. However, peat was more abundant in the deeper areas of the lake. 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 sediments and silt mixed with peat were common in Bear Lake, especially in the shallowest zones (0-5ft).

All sample sites supported vegetation in Bear 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. These impacts occur in both rural and residential settings.

Native herbaceous plant growth was the most frequently encountered shoreline cover at the transects and had the highest mean coverage. The occurrence and cover of shrub growth was also high and wooded cover was commonly occurring at the shoreline (Table 5).

Some type of natural shoreline was occurred at all sites and covered approximately 95% of the shore. Disturbed shoreline (pavement, eroded) was found at 25% of the sites, but only had a 5% cover at the shore.

Table 5. Shoreline Land Use, 2006

Cover Type		Frequency of Occurrences at Transects	Mean % Coverage
Natural Shoreline	Native Herbaceous	100%	57%
	Shrub	88%	24%
	Wooded	38%	14%
Total Natural		100%	95%
Disturbed Shoreline	Pavement	12%	4%
	Eroded	12%	1%
Total Disturbed		25%	5%

MACROPHYTE DATA

SPECIES PRESENT

Of the 20 aquatic plant species found in Bear Lake, 3 were emergent species, 3 were floating-leaf species and 14 were submergent species (Table 6).
No non-native species were found. No Threatened, Endangered or Species of Special Concern were found.

Table 6. Bear Lake Aquatic Plant Species, 2006

Scientific Name	Common Name	I. D. Code
Emergent Species		
1) *Carex* spp.	sedge	carsp
2) *Scirpus validus* Vahl.	softstem bulrush	sciva
3) *Typha latifolia* L.	common cattail	typla
Floating-leaf Species		
4) *Brasenia schreberi* J. F. Gmelin.	watershield	brasc
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) *Eleocharis acicularis* (L.) Roemer & Schultes.	needle spikerush	eleac
9) *Elodea canadensis* Michx.	common waterweed	eloca
10) *Megalodonta beckii* (Torr. ex Spring) Greene	water marigold	megbe
11) *Najas flexilis* (Willd.) Rostkov and Schmidt	slender water-nymph	najfl
12) *Potamogeton amplifolius* Tuckerman.	large-leaf pondweed	potam
13) *Potamogeton gramineus* L.	variable-leaf pondweed	potgr
14) *Potamogeton natans* L.	floating-leaf pondweed	potna
15) *Potamogeton pusillus* L.	small pondweed	potpu
16) *Potamogeton zosteriformis* Fern.	flatstem pondweed	potzo
17) *Scirpus subterminalis* Torr.	water bulrush	scisu
18) *Utricularia gibba* L.	small bladderwort	utrgi
19) *Utricularia intermedia* Hayne	bladderwort	utrin
20) Aquatic moss		moss

FREQUENCY OF OCCURRENCE

Brasenia schreberi (wtershield) was the most frequently occurring species in Bear Lake in 2006, (62% of sample sites) (Figure 2). *Ceratophyllum demersum, Nymphaea odorata, Potamogeton amplifolius, P. pusillus, Scirpus subterminalis* and *Utricularia intermedia* were also commonly occurring species, (53%, 25%, 47%, 56%, 31%, 31%) (Figure 2).

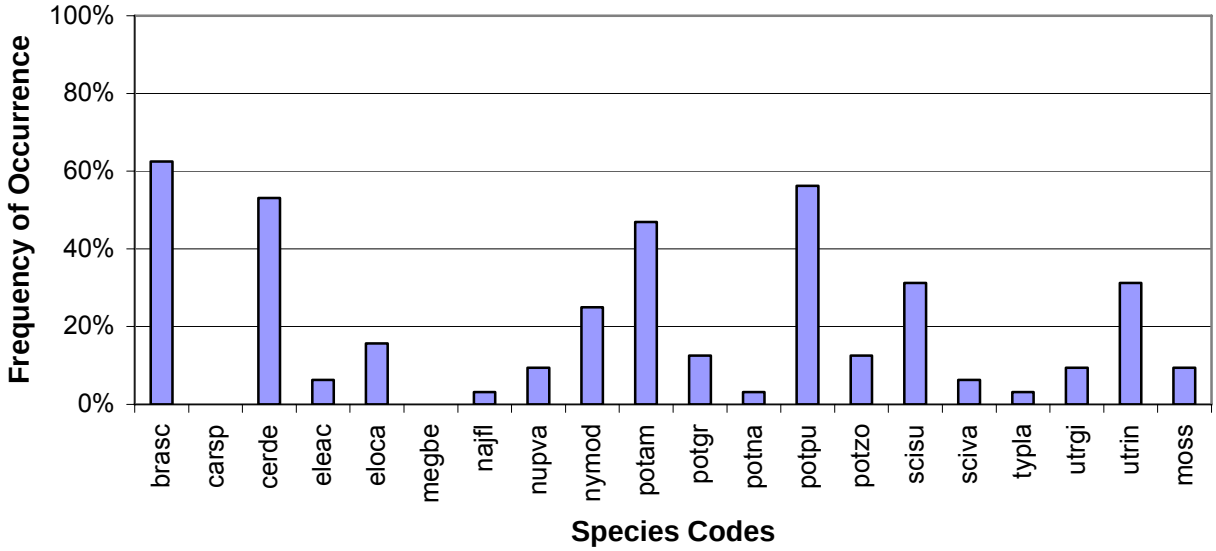


Figure 2. Frequency of aquatic plant species in Bear Lake, 2006.

DENSITY

Brasenia schreberi (watershield) was also the species with the highest mean density (2.03 on a density scale of 0-4) in Bear Lake (Figure 3).

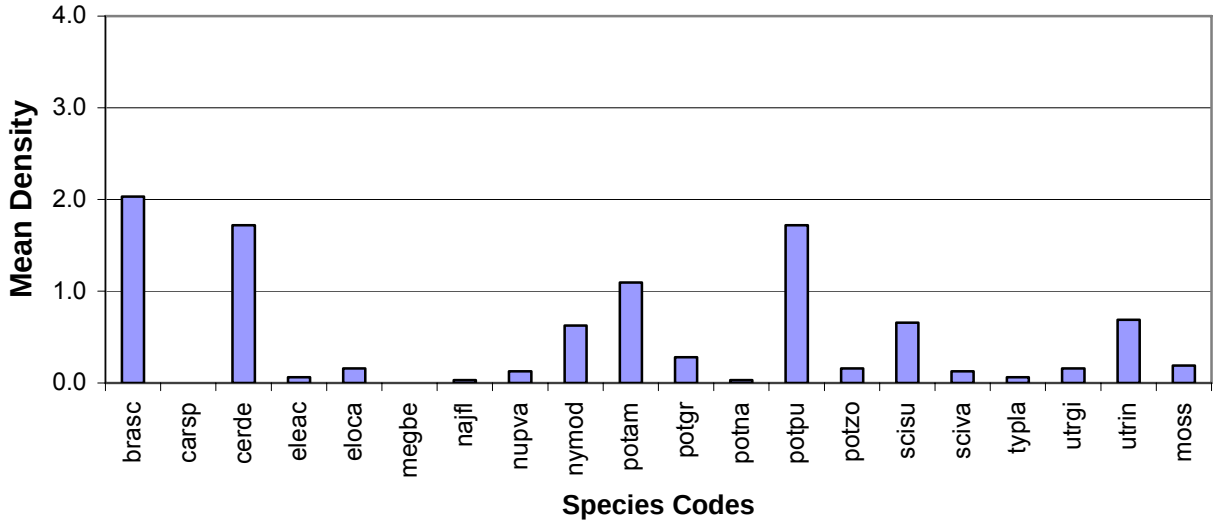


Figure 3. Densities of aquatic plant species in Bear Lake, 2006.

Brasenia schreberi (watershield) had a "mean density where present" of 3.25 (Figure 4). Its "mean density where present" indicates that where *B. schreberi* occurred, it exhibited a dense growth form in Bear Lake (Appendix II). *Ceratophyllum demersum* (coontail)

and *Potamogeton pusillus* (small pondweed) were other species in Bear Lake that had "mean densities where present" of 2.5 or more, indicating that they exhibited an aggregated growth form or a growth form of above average density (Figure 4).

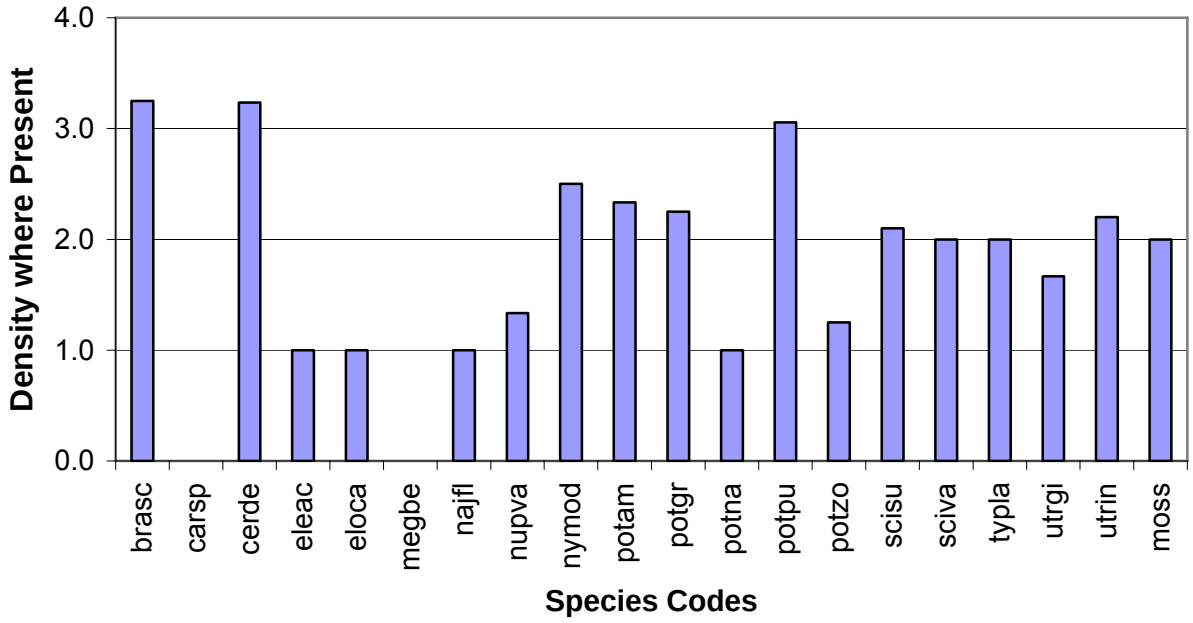


Figure 4. "Density where Present" of species in Bear Lake. 2006.

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, *Brasenia schreberi* (watershield) was the dominant aquatic plant species in Bear Lake (Figure 5). *Ceratophyllum demersum* (coontail) and *Potamogeton pusillus* (small pondweed) were sub-dominant.

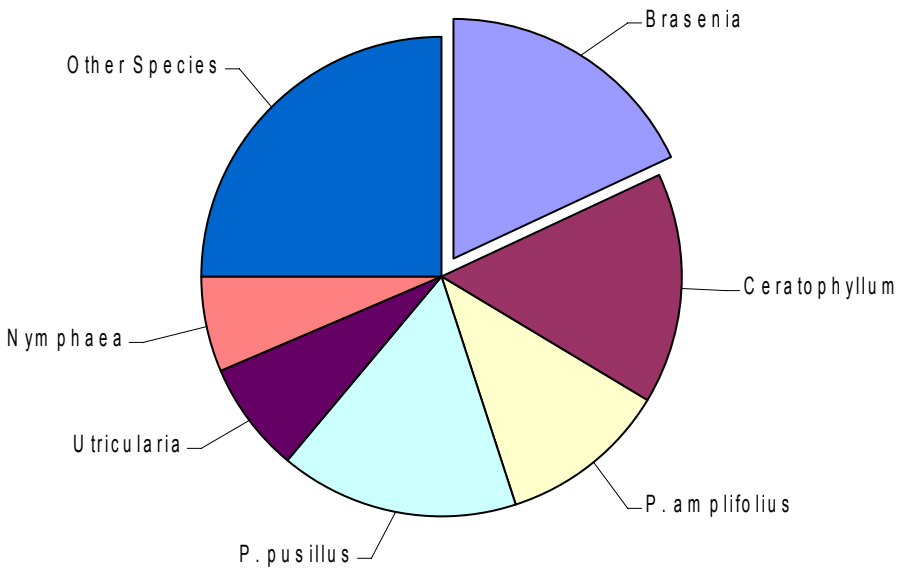


Figure 5. Dominance within the plant community, of the most prevalent aquatic plant species in Bear Lake, 2006.

Brasenia schreberi, the dominant species, dominated the 0-5ft depth zones and occurred at its highest frequency and density in those depth zones (Appendices I, II) (Figure 6, 7). *Ceratophyllum demersum, Potamogeton amplifolius* and *P. pusillus* dominated the 5-10ft depth zone, occurring at their highest frequency and density in this depth zone. *Potamogeton pusillus* dominated the 10-20ft depth zone (Appendices I, II) (Figure 6, 7).

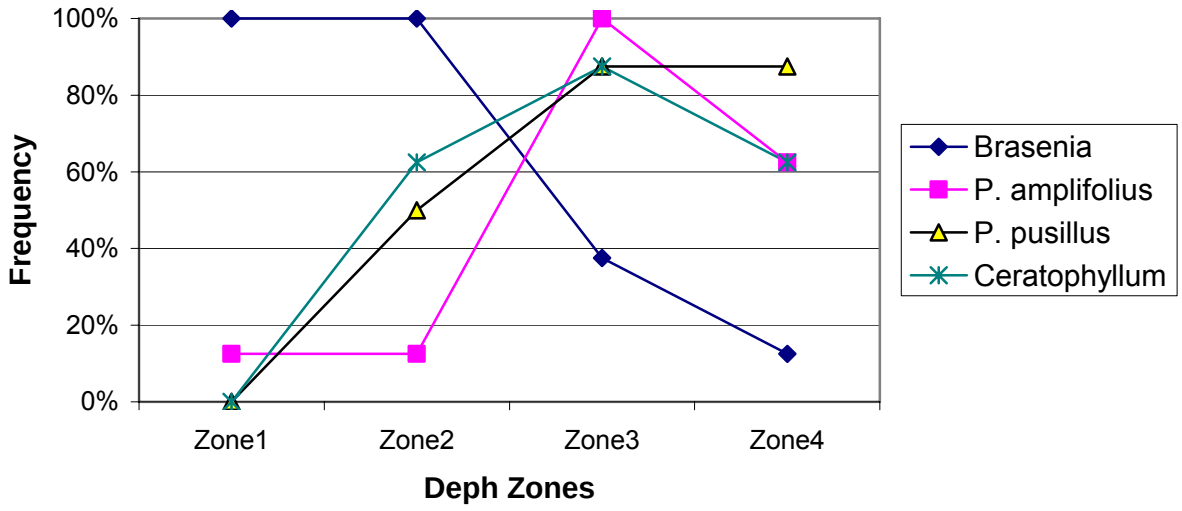


Figure 6. Frequency of most prevalent species in Bear Lake, by depth.

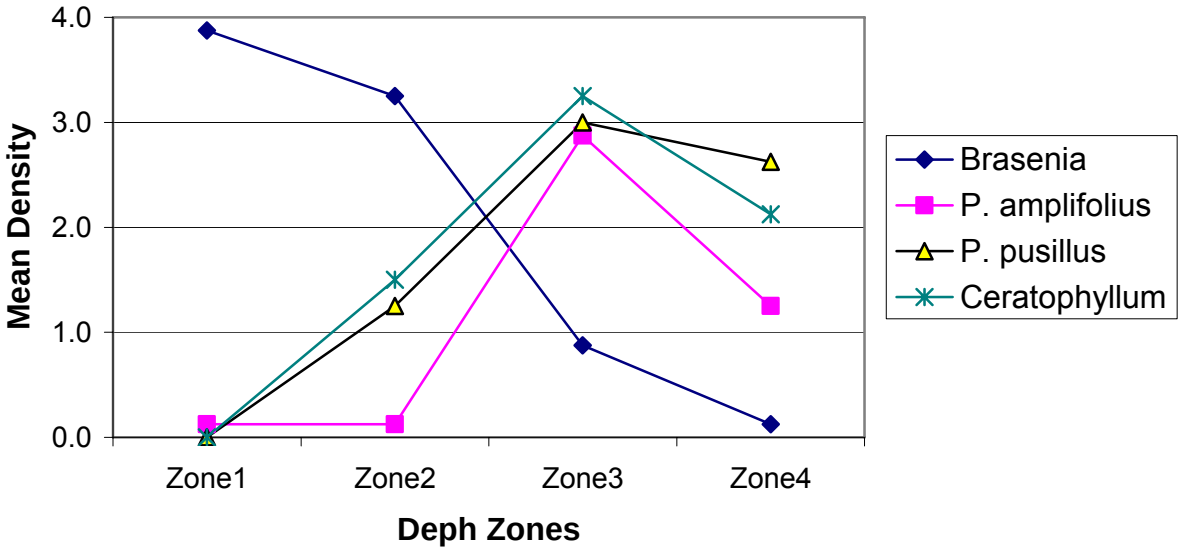


Figure 7. Density of the most prevalent plant species, by depth zone.

DISTRIBUTION

Aquatic plants occurred throughout Bear Lake to a maximum rooting depth of 13 feet. *Potamogeton amplifolius, P. pusillus* and *Ceratophyllum demersum* were found at the maximum rooting depth.

The entire littoral zone (all sampling sites) was vegetated. However, in 2006, much of the lake bed was exposed mudflats leaving the lake at only half its maximum size (~18 acres), therefore estimating cover of vegetation in a normal year is not possible. The majority of the emergent and floating-leaf beds were on exposed mud flats and would have a greater coverage in normal years. In 2006, approximately 11 acres (61% of the lake surface, 94% of the littoral zone) was vegetated with submergent vegetation. Floating-leaf vegetation colonized about 7 acres (39% of the lake surface, 63% of the littoral zone) and emergent vegetation colonized about 1 acre (6% of the lake surface, 9% of the littoral zone) (Figure 8).

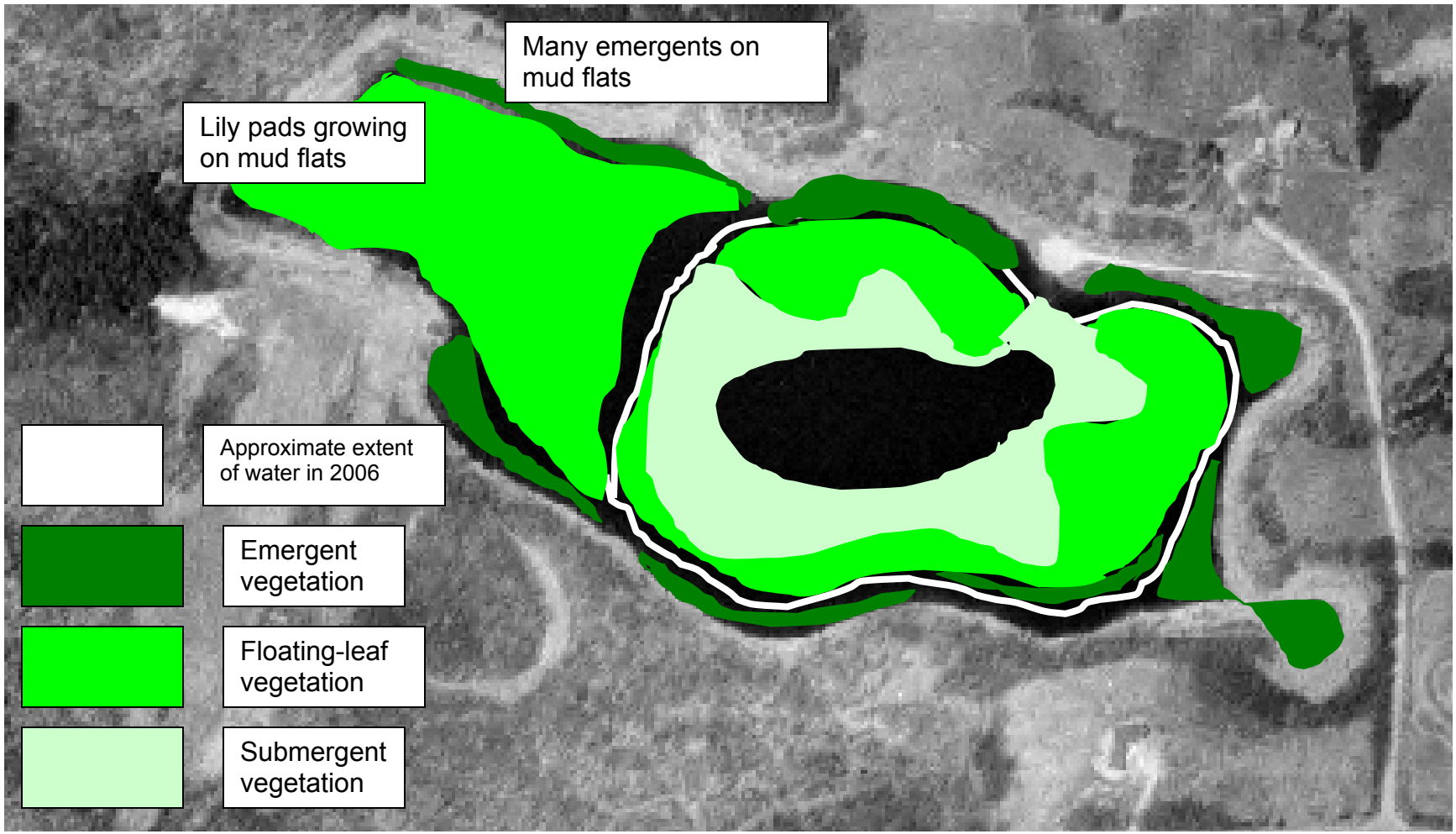


Figure 8. Distribution of aquatic plants in Bear Lake, Portage County, 2006.

The dominant and common species in Bear Lake were found distributed throughout the littoral zone.

Water clarity data can 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 2002-03 mean summer Secchi disc water clarity (9.5ft), the predicted maximum rooting depth in Bear Lake would be 14 ft.

The maximum rooting depth of 13 feet is very close to the predicted maximum rooting depth based on water clarity.

The highest total occurrence of plants, total density of plant growth and greatest species richness (mean number of species per site) were recorded in the 0-1.5ft depth zone, decreased somewhat in the 1.5-5ft depth zone, increased in the 5-10ft zone and declined at greater depths (Figure 9). Overall Species Richness in Bear Lake was 3.97.

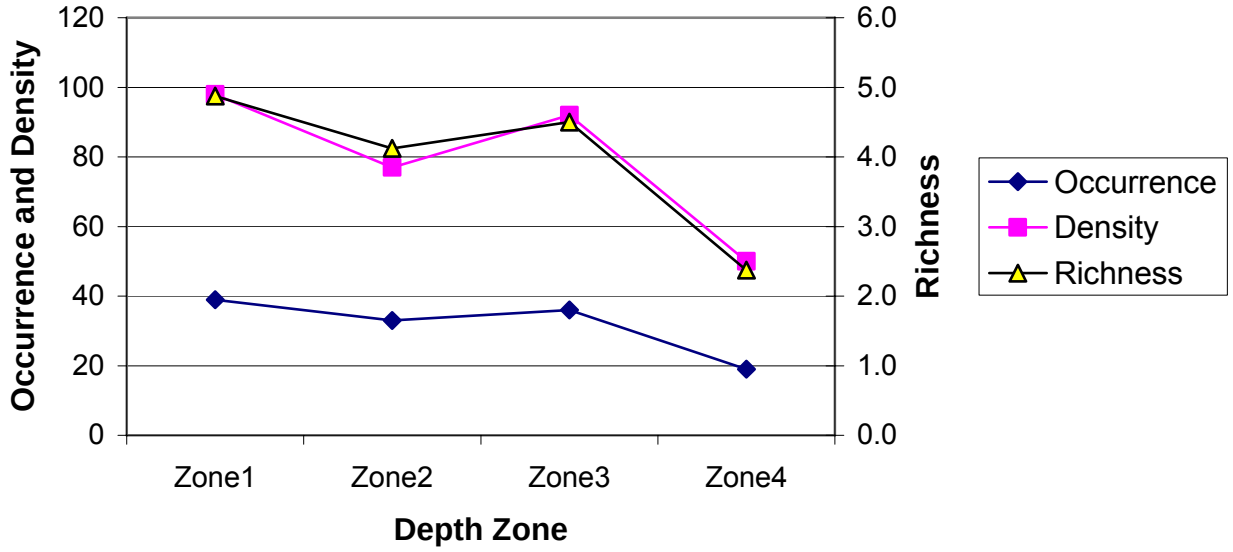


Figure 9. Total occurrence and total density of aquatic plants and species richness by depth zone in Bear Lake, 2006.

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 Bear Lake (Table 7) is 61, indicating a high quality plant community. This value places Bear Lake in the upper quartile of lakes in Wisconsin and the North Central Harwood Region of the state as far as quality of the aquatic plant community.

Table 7. Aquatic Macrophyte Community Index: Bear Lake, 2006

Category		Value
Maximum Rooting Depth	3.96 meters	7
% Littoral Zone Vegetated	100%	10
% Submergent Species	60% Rel. Freq.	6
# of Species	20	9
% Exotic species	0	10
Simpson's Diversity	0.90	9
% Sensitive Species	36% Relative Freq.	10
Totals		61

The highest value for this index is 70.

The Average Coefficient of Conservatism for Bear Lake was in the upper quartile for lakes in the North Central Hardwood Region and at the mean for all Wisconsin lakes (Table 8). This suggests that the aquatic plant community in Bear Lake is among the group of lakes in the North Central Hardwoods Region least tolerant of disturbance and with an average tolerance of disturbance compared to all lakes in Wisconsin.

Table 8. Floristic Quality and Coefficient of Conservatism of Bear Lake, Compared to Wisconsin Lakes and Northern 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
Bear Lake 2006	6.00	25.45

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

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

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

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

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.

The major disturbance in Bear Lake is likely the fluctuating water levels.

IV. DISCUSSION

Bear Lake is a 34-acre lake with a maximum depth of 36 feet. Based on 2002-03 water clarity and phosphorus data, Bear Lake is a mesotrophic lake with very good water clarity and good water quality. The lake level was extremely low in summer 2006, leaving the west half of the lake terrestrial. Filamentous algae occurred at 12% of sample sites, 25% of the sites in the 0-5ft depth zone.

The combination of 1) the small water shed of Bear Lake relative to the lake size and 2) natural vegetation cover protecting 80% of the watershed results in a condition that run-off from the watershed would not likely impact water quality significantly. The adequate nutrients (trophic state), very good water clarity, gradually-sloped littoral zone and the shallow depths in half of Bear Lake would favor plant growth. Fluctuating water levels in Bear Lake could limit plant growth.

Aquatic plants colonized 100% of the littoral zone (60% of the lake surface), to a maximum depth of 13 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 (0-1.5ft).

Twenty (20) aquatic plant species were recorded in Bear Lake. *Brasenia schreberi (*watershhield) was the dominant plant species in Bear Lake, especially in the 0-5ft depth zones, occurring at more than half of the sample sites and exhibiting a dense growth form. *Ceratophyllum demersum* (coontail) and *Potamogeton pusillus* (small pondweed) were sub-dominant plant species in Bear Lake. Both occurred at approximately one-half of the sites, exhibiting growth forms of above average density in Bear Lake. *P. pusillus* dominated the deepest zone, 10-20ft depth zone. The dominant and common species were found throughout the lake.

The Aquatic Macrophyte Community Index (AMCI) for Bear Lake was 61, indicating that Bear Lake's aquatic plant community is of high quality compared to other Wisconsin lakes and lakes in the North Central Region. The Simpson's Diversity Index (0.90) for Bear Lake indicates that the aquatic plant community had very good diversity of species. Species Richness was 3.97 species per sample site.

The Average Coefficient of Conservatism and the Floristic Quality Index suggests that Bear Lake has an average tolerance of disturbance. It is within the group of lakes in the North Central Hardwoods Region of Wisconsin and the state closest to an undisturbed condition.

Bear Lake is protected by natural shoreline cover (wooded, shrub, native herbaceous growth) at 95% of the shore; all natural cover types were commonly occurring. Nearly all of the shoreline is protected by natural cover. Preserving this natural shoreline is critical to maintaining water quality and wildlife habitat.

Although the disturbed shore is very limited on Bear Lake, even this limited 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 some disturbed cover and these two groups were analyzed as separate communities (Appendices V-VI), a few measures of the aquatic plant community were different (Table 9).

A clue that disturbance has had an impact that is resulting in differences between disturbed shoreline and natural shoreline communities is the decreased frequency of sensitive species at disturbed shoreline sites. The combined frequency of sensitive aquatic plant species (large-leaf pondweed, variable-leaf pondweed, flatstem pondweed, water bulrush and both bladderworts) was higher at natural shoreline sites than at disturbed shoreline sites (Table 9).

Disturbance may be impacting the quality of the plant community. The quality of the aquatic plant community was slightly higher at the natural shoreline community, as measured by the AMCI (Table 9).

The lower quality may be impacting the habitat potential at the disturbed areas. The cover of emergent vegetation, which is a very important component of quality habitat, was missing at the disturbed shores. Slightly more species were found at natural shoreline sites (Table 9). More species also create better habitat by providing more diversity for fish and wildlife resources.

Conversely, the frequency of filamentous algae, which can suggest nutrient enrichment, was greater at disturbed shoreline sites than natural (Table 9).

Table 9. Comparison of the Bear Lake Aquatic Plant Community at Natural and Disturbed Shorelines

	Natural	Disturbed
AMCI (quality of plant community) (Table 10)	59	57
%Sites/Emergent Vegetation	12%	0%
Number of species	16	14
Relative Frequency of Sensitive Species	38%	31%
Occurrence of filamentous algae	8%	25%

Table 10. Comparison of AMCI at Natural vs. Disturbed Shoreline.

Category	Natural Shore Community	Disturbed Shore Community
Maximum Rooting Depth	7	7
% Littoral Zone Vegetated	10	10
% Submergent Species	5	4
# of Species	8	7
% Exotic species	10	10
Simpson's Diversity	9	9
% Sensitive Species	10	10
Totals	59	57

The highest value for this index is 70.

V. CONCLUSIONS

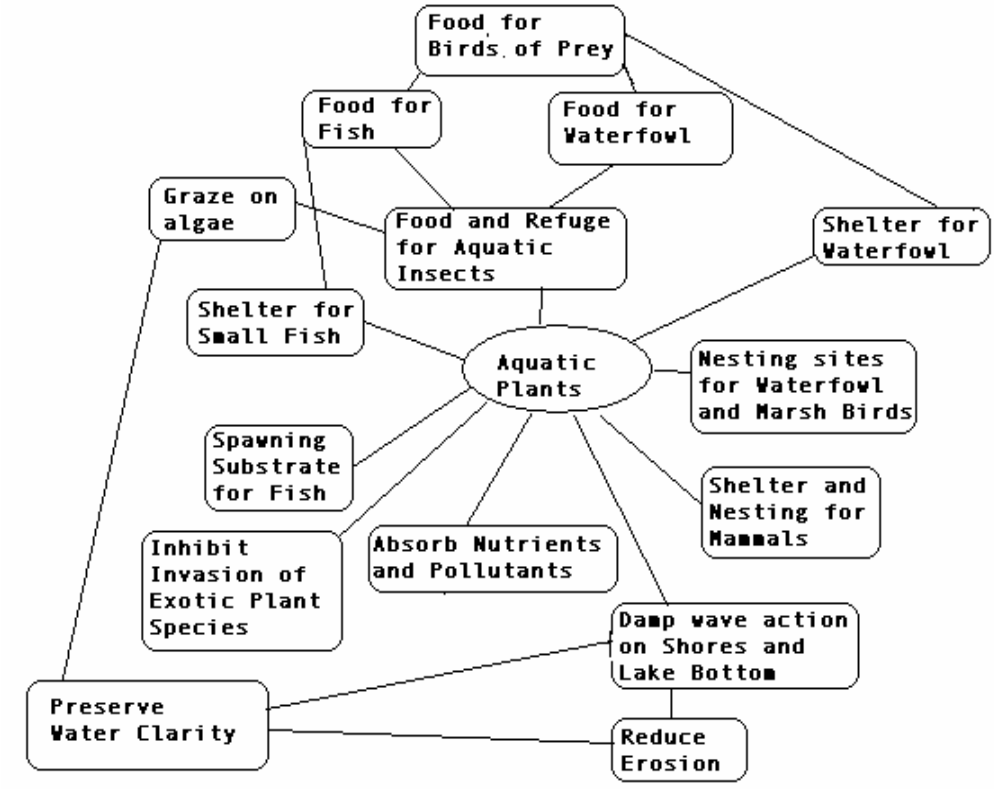
Bear Lake is a mesotrophic lake with very good water clarity and good water quality. Filamentous algae occurred in Bear Lake and was common in the 0-5ft depth zones.

Aquatic plant community colonized the entire littoral zone, approximately 60% of the total lake area, to a maximum depth of 13 feet. The 0-1.5 ft. depth zone supported the most abundant aquatic plant growth.

Twenty (20) aquatic plant species were recorded in Bear Lake. *Brasenia schreberi* (watershield) was the dominant species within the plant community, especially in the 0-5ft depth zones, occurring at more than half of the sample sites and exhibiting a dense growth form. *Ceratophyllum demersum* (coontail) and *Potamogeton pusillus* (small pondweed) were sub-dominant species, both occurring at approximately half of the sites and at above average densities. The dominant and common species occur throughout the lake. The dominant and common species occur throughout the lake.

The aquatic plant community in Bear Lake is characterized by high quality, very good species diversity, an average tolerance to disturbance and within the quartile of lakes in the region closest to 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
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.



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).

2) Aquatic plant communities provide important fishery and wildlife resources. Plants (including algae) start the food chain that supports many levels of wildlife, and at the same time produce oxygen needed by animals. Plants are used as food, cover and nesting/spawning sites by a variety of wildlife and fish (Table 12). Plant cover within the littoral zone of Bear Lake is 100% and over the entire lake is 60%. This is appropriate (25-85%) to support a balanced fishery.

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) Preserve the natural shoreline cover that is found around Bear 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. Even the small amount of disturbance at the shore appears to have impacted the aquatic plant community in that area.
    a. The combined frequency of sensitive species was lower at disturbed shore, confirming that disturbance has impacted the community.
    b. The disturbance has impacted the quality of the plant community. The quality (AMCI Index) is lower at disturbed shore sites.
    c. The disturbance may be impacting the quality of the habitat. There is lower diversity in the plant community (that results in less stability of the community and a habitat that could support less diverse fish and wildlife communities) and loss of important habitat structure (emergent vegetation) at disturbed shore communities.
    d. The occurrence of filamentous algae is higher at disturbed shore sites.
2) Lakes shore property owners use best management practices on shoreland property to prevent nutrient enrichment and stormwater run-off to the lake.
3) Lake residents continue exotic species monitoring and consider beginning monitoring the water quality through the Self-Help Volunteer Lake Monitoring Program. Monitor water quality to expand knowledge of water quality in Bear Lake.

4) DNR to designate sensitive areas within Bear Lake. These are areas that are most important for habitat and maintaining water quality.
5) Maintain exotic species educational signs at the boat landing to prevent the spread of exotic species into Bear Lake. Critical sense stem of EWM was found washed up on shore. Suggests that a boater brought in a sprig and it could happen again.
6) Do not improve boat landing on Bear Lake. As a small lake it is not appropriate for large boats or high-speed boating.