Executive Summary

Bob Lake is a eutrophic lake with fair-to-poor water quality and poor water clarity. Nutrients and algae have increased dramatically since 1977. Filamentous algae is common in the 0-1.5ft depth zone.

The aquatic plant community in Bob Lake is characterized by high quality, excellent species and a high sensitivity to disturbance. The plant community is close to an undisturbed condition.

The aquatic plant community colonized slightly more than half of the littoral zone to a maximum depth of 9 feet. The 0-1.5ft depth zone supported the most abundant aquatic plant growth. The most common species were found distributed throughout the lake.

Brasenia schreberi was the dominant species within the plant community, especially in the 1.5-5ft depth zone. *Nuphar variegata* was sub-dominant, most prevalent in the 0-1.5ft depth zone. *Potamogeton robbinsii* dominated the 5-10ft depth zone and was the species found at the greatest maximum rooting depth. The aquatic plant community is composed in large part of northern, soft-water bog species.

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

Management Recommendations

1) Lake residents investigate applying for a grant to determine the source of nutrients that has significantly enriched Bob Lake since 1977.
2) All lake residents practice best management on their lake properties:
    a) Keep septic systems cleaned and in proper condition
    b) Use no lawn fertilizers
    c) Clean up pet wastes
    d) Do not compost near the water or allow yard wastes and clippings to enter the lake
3) Residents become involved in the Self-Help Volunteer Lake Monitoring Program, monitoring water quality to track seasonal and year-to-year changes.
4) DNR should designate sensitive areas within Bob Lake. These are areas within a lake that are most important for habitat and maintaining water quality.
5) Lake residents protect and restore natural shoreline around Bob Lake. Comparison of the aquatic plant community at natural vs. disturbed shoreline indicate that disturbance on shore may already be impacting the aquatic plant community, its quality and its habitat value.
6) All lake users protect the aquatic plant community in Bob Lake. This community in Bob Lake is composed of sensitive, unique species that could easily be replaced with less valuable, more aggressive plant communities.

The Aquatic Plant Community in Bob Lake, Chippewa County 2004

I. INTRODUCTION

A study of the aquatic macrophytes (plants) in Bob Lake was conducted during August 2004 by Water Resources staff of the West Central Region - Department of Natural Resources (DNR). This was the first quantitative vegetation study of Bob Lake by the DNR.

A study of the diversity, density, and distribution of aquatic plants is an essential component of understanding a lake ecosystem due to the important ecological role of aquatic vegetation in the lake and the ability of the vegetation to characterize the water quality (Dennison et al. 1993).

Ecological Role: All other life in the lake depends on the plant life - the beginning of the food chain. Aquatic plants and algae provide food and oxygen for fish, wildlife, and the invertebrates that in turn provide food for other organisms. Plants provide habitat, improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake and impact recreation.

Characterize Water Quality: Aquatic plants serve as indicators of water quality because of their sensitivity to water quality parameters, such as water clarity and nutrient levels (Dennison et. al. 1993).

The present study will provide information that is important for effective management of the lake, including fish habitat improvement, protection of sensitive wildlife areas, aquatic plant management and water resource regulations. The baseline data that it provides will be compared to future aquatic plant inventories and offer insight into changes occurring in the lake.

Background and History: Bob Lake is a 97-acre drainage lake in central Chippewa County, Wisconsin. Bob Lake has a maximum depth of 68 feet and an average depth is 27 feet. Alder and tamarack bogs make up approximately half of the shoreline of Bob Lake, likely providing water sources and drainage. The North Fork of Bob Creek enters the lake on the west shore and exits the lake on the southeast shore.

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 15 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, one from each quarter of a 6-foot diameter quadrat. The aquatic plant species that were present on each rake sample were recorded. Each species was given a density rating (0-5), the number of rake samples on which it was present at each sampling site.

a rating of 1 indicates that a species was present on one rake sample at that site
a rating of 2 indicates that a species was present on two rake samples at that site
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 4 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 percent cover of each land use category within this 100' x 30' rectangle was visually estimated.

Data Analysis

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

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

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

III. RESULTS

PHYSICAL DATA

Many physical parameters impact the aquatic plant community. Water quality (nutrients, algae, water clarity and water hardness) 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 a classification of its water quality. Phosphorus concentration, chlorophyll concentration and water clarity data are collected and combined to determine the trophic state.

Eutrophic lakes are high in nutrients and therefore support a large biomass.

Oligotrophic lakes are low in nutrients and support limited plant growth and smaller populations of fish.

Mesotrophic lakes have intermediate levels of nutrients and biomass.

Nutrients

Phosphorus is a limiting nutrient in many Wisconsin lakes and is measured as an indication of nutrient enrichment in a lake. Increases in phosphorus in a lake can feed algae blooms and, occasionally, excess plant growth.

August 2004 phosphorus concentration in Bob Lake was 30 ug/l

This concentration of phosphorus in Bob Lake is indicative of a mesotrophic lake (Table 1).

Table 1. Trophic Status

	Quality Index	Phosphorus ug/l	Chlorophyll ug/l	Secchi Disc ft.
Oligotrophic	Excellent	<1	<1	> 19
	Very Good	1-10	1-5	8-19
Mesotrophic	Good	**10-30**	5-10	6-8
	Fair	**30-50**	10-15	5-6
Eutrophic	Poor	50-150	**15-30**	**3-4**
Bob Lake 2004	Fair/Poor	30	44.3	4.6

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

Algae

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

August 2004 chlorophyll concentration in Bob Lake was 44.3 ug/l.

The chlorophyll concentration in Bob Lake indicates that it was a hypereutrophic lake

(Table 1).
Filamentous algae occurred at 12% of all sample sites. Filamentous algae occurred at:

33% of the sites in the 0-1.5ft depth zone
13% of the sites in the 1.5-5ft depth zone
0% of the sites in the 5-10ft depth zone
0% of the sites in the 10-16ft depth zone

Both phosphorus and chlorophyll have increased dramatically since early testing was conducted on Bob Lake in 1977 (Figure 1). Bob Lake was an oligotrophic lake in 1977, but nutrients and algae have increased enough to place the lake in the eutrophic range.

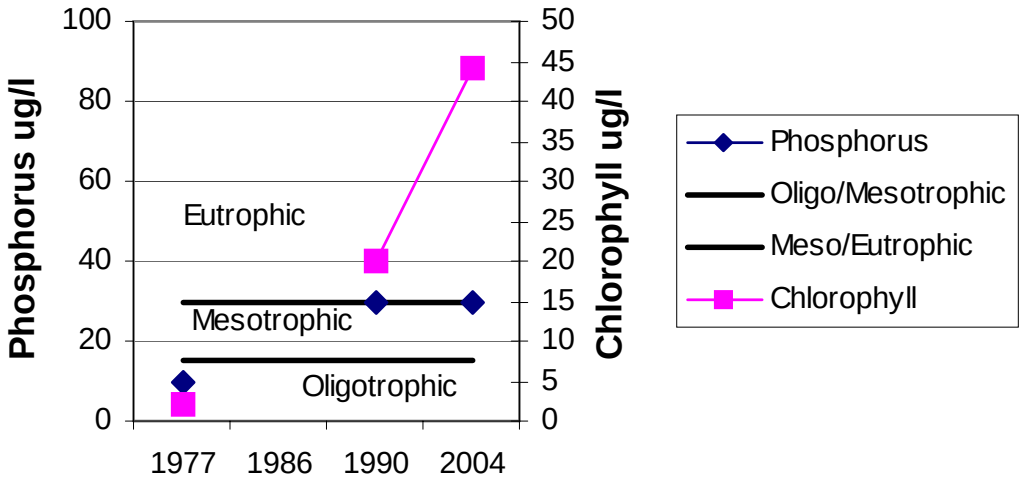

Figure 1. Increase in phosphorus and chlorophyll in Bob Lake, 1977-2004

Water Clarity

Water clarity is a critical factor for aquatic 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

August 2004 Secchi Disc clarity in Bob Lake was 4.6 ft.

Water clarity indicates (Table 1) that Bob Lake was a eutrophic lake with poor water clarity.

The combination of phosphorus concentration, chlorophyll concentration and water clarity indicates that Bob Lake is a eutrophic lake with fair-to-poor water quality. This trophic state would favor abundant plant growth and frequent summer algae blooms.

Hardness

The hardness or mineral content of lake water also influences aquatic plant growth. The hardness value in Bob Lake has varied between 22-25 mg/l CaCO3 during 1977-2004.

Lakes with hardness values less than 60mg/l CaCO3 are considered soft water lakes. Soft water lakes tend to have less plant growth than hard water lakes.

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).

Bob Lake has a deep oval basin with a gradually sloped littoral zone over most of the lake. Areas of the lake with gradual slopes would favor plant growth.

SEDIMENT COMPOSITION – The dominant sediment in Bob Lake was sand, especially in the 0-5ft depth zone (Table 2) (Figure 2). Another hard, high-density sediment, sand and gravel mixtures, was common in the shallow zone. Silt was common overall, but did not occur in the shallow depths and common only at depths greater than 5 feet.
Silt mixed with peat or sand was common only at depths greater than 5 or 10 feet.

Table 2. Sediment Composition: Bob Lake, 2004

Sediment Type		0-1.5' Depth	1.5-5' Depth	5-10' Depth	10-20' Depth	Percent of all Sample Sites
Hard Sediments	Sand	60%	53%	7%	13%	33%
	Sand/Gravel	33%	7%	7%		12%
	Rock		7%	20%		7%
	Sand/Rock		7%	13%		5%
	Gravel		7%			2%
Mixed Sediments	Sand/Silt	7%	13%		20%	8%
Soft Sediments	Silt			20%	60%	22%
	Silt/Peat		7%	27%		8%
	Peat			7%	7%	3%

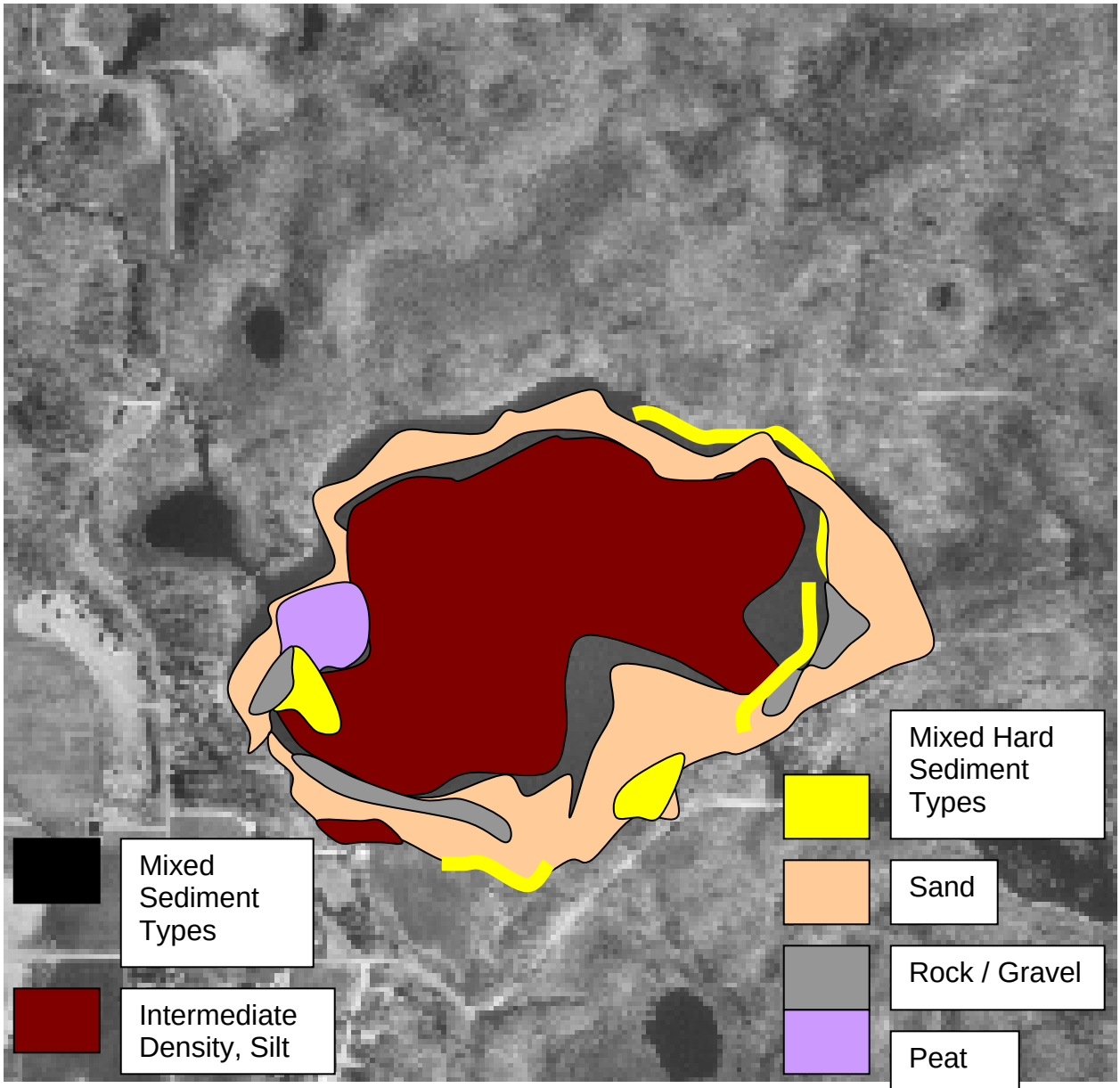

Figure 2. Distribution of sediment types in Bob Lake, 2004.

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.

Sand was the overall dominant sediment found in Bob Lake and sand-gravel mixture was common in the shallow zone. These are high-density sediments that may be limiting for plant growth (Barko and Smart 1986). However 85% of the sites with sand sediment were vegetated (Table 3). Other high-density sediments supported adequate vegetation in Bob Lake (Table 3).

Silt sediments, which were common at the sample sites in Bob Lake, are intermediate density sediments. The availability of mineral nutrients for growth is highest in sediments of intermediate density so these sediments are considered most favorable for plant growth (Barko and Smart 1986). However, silt sediments supported vegetation at only 15% of the sites at which it occurred (Table 3). This is likely due to the greater depth at which the silt sediments were more commonly found (Table 2).

Sand and sand/gravel dominated the shallower sites where light availability was greater and silt was more common at the deeper depths where light penetration may become a limiting factor to plant growth. It appears that light availability was a more important factor than sediment in determining plant distribution in Bob Lake.

Table 3. Influence of Sediment in Bob Lake, 2004

Sediment Type		Percent of all Sample Sites	Percent Vegetated
Hard Sediments	Sand	33%	85%
	Sand/Gravel	12%	86%
	Rock	7%	50%
	Sand/Rock	5%	33%
	Gravel	2%	100%
Mixed Sediments	Sand/Silt	8%	40%
Soft Sediments	Silt	22%	15%
	Silt/Peat	8%	20%
	Peat	3%	0%

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 through 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.

Wooded cover was the most frequently encountered shoreline cover at the transects and had the highest mean coverage. Other natural shoreline cover types had high occurrences (Table 4). Some of these natural covers were components of tamarack bog that comprises a large part of the shoreline of Bob Lake. Bog occurred at 60% of the transects and made up approximately 40% of the shoreline.

Cultivated lawn and hard structures were commonly occurring (Table 4).

Table 4. Shoreline Land Use - Bob Lake, 2004

Cover Type		**Frequency of Occurrences at Transects**	**Mean % Coverage**
Natural Shoreline	Wooded	93%	42%
	Native Herbaceous	80%	19%
	Shrub	73%	18%
	Rock	40%	5%
	Bare Sand	20%	2%
Total Natural			86%
Disturbed Shoreline	Cultivated Lawn	20%	9%
	Hard Structures	33%	3%
	Rip-rap	7%	1%
Total Disturbed			13%

Some type of natural shoreline (wooded, shrub, native herbaceous, rock, sand) was found at all of the sites, having a mean coverage of 86%.

Some type of disturbed shoreline (cultivated lawn, hard structures and rip-rap) was found at 40% of the sites and had a mean coverage of 13%.

MACROPHYTE DATA
SPECIES PRESENT

Of the 29 species found in Bob Lake, 13 were emergent species, 5 were floating-leaf species and 11 were submergent species (Table 5).
No exotic species were found
Two Species of Special Concern were found:
Ceratophyllum echinatum
Scirpus torreyi
Special Concern Species are species with which there is concern about their lack of abundance or distribution. The main purpose of this designation is to focus attention on these species before they become threatened or endangered.

Table 5. Bob Lake Aquatic Plant Species, 2004

Scientific Name	Common Name	I. D. Code
Emergent Species		
1) *Alnus incana* (L.) Moench.	tag alder	alnin
2) *Carex* spp.	sedge	carsp
3) *Chamaedaphne calyculata* (L.) Moench.	leatherleaf	chaca
4) *Dulichium arundinaceum* (L.) Britton	three-way sedge	dular
5) *Eleocharis smallii* Britt.	creeping spikerush	elesm
6) *Eriocaulon aquaticum* (Hill) Druce.	pipewort	eriaq
7) *Iris versicolor* L.	northern blue flag	irive
8) *Potentilla palustris* (L.) Scop.	marsh cinquefoil	potpa
9) *Sagittaria cristata* Engelm.	arrowhead	sagcr
10) *Scirpus torreyi* Olney.	Torrey's bulrush	scito
11) *Scirpus validus* Vahl.	softstem bulrush	sciva
12) *Thelypteris palustris* Schott.	marsh fern	thepa
13) *Typha latifolia* L.	common cattail	typla
Floating-leaf Species		
14) *Brasenia schreberi* J. F. Gmelin.	watershield	brasc
15) *Nuphar variegata* Durand.	bull-head pond lily	nupva
16) *Nymphaea odorata* Aiton.	white water lily	nymod
17) *Polygonum amphibium* L.	water smartweed	polam
18) *Sparganium fluctuans* (Morong) Robinson	floating-leaf burreed	spafl
Submergent Species		
19) *Ceratophyllum echinatum* A. Gray.	spiny hornwort	cerec
20) *Eleocharis acicularis* (L.) R & S.	needle spikerush	eleac
21) *Isoetes echinospora* Durieu.	spiny-spored quillwort	isoec
22) *Juncus pelocarpus* E. Meyer.	brown-fruited rush	junpe
23) *Najas flexilis* (Willd.) Rostkov & Schmidt.	slender naiad	najfl
24) *Najas gracillima* (A. Braun) Magnus	slender water-nymph	najgr
25) *Potamogeton amplifolius* Tuckerman.	large-leaf pondweed	potam
26) *Potamogeton gramineus* L.	variable-leaf pondweed	potgr
27) *Potamogeton oakesianus* Robbins.	Oakes' pondweed	potoa
28) *Potamogeton robbinsii* Oakes.	fern pondweed	potro
29) *Potamogeton spirillus* Tuckerman.	n. snail-seed pondweed	potsp

FREQUENCY OF OCCURRENCE

Nuphar variegata was the most frequently occurring species in Bob Lake in 2004, (37% of sample sites) (Figure 3). *Brasenia schreberi, Najas gracillima, Potamogeton gramineus* and *P. robbinsii* were also commonly occurring species, (30%, 27%, 22%, 23%).

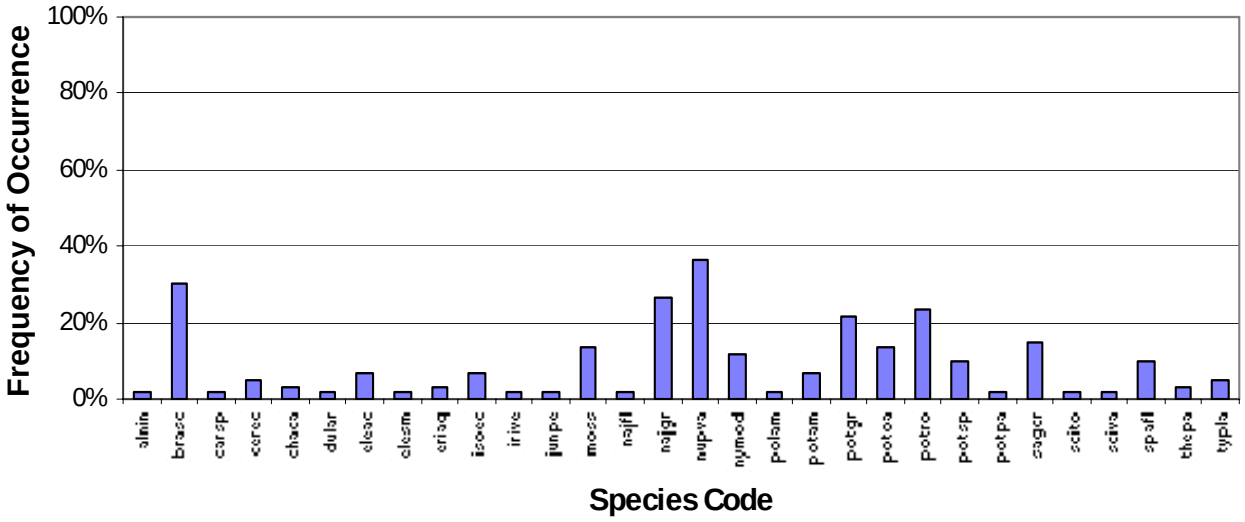

Figure 3. Frequencies of aquatic plant species in Bob Lake, 2004

DENSITY

Brasenia schreberi was the species with the highest mean density in Bob Lake (1.07 on a density scale of 0-4) (Figure 4).

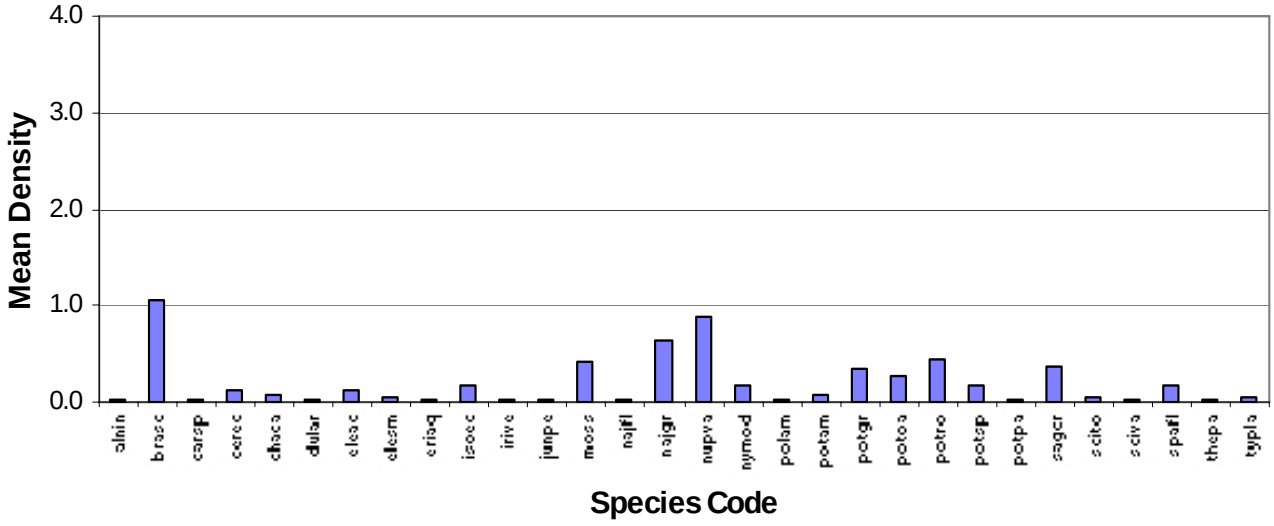

Figure 4. Mean densities of aquatic plant species in Bob Lake, 2004

Brasenia schreberi had a "mean density where present" of 3.56. Its "mean density where present" indicates that, where *B. schreberi* occurred, it exhibited an aggregated or a dense growth form in Bob Lake (Appendix II). *Ceratophyllum echinatum, Eleocharis smallii, Isoetes echinospora, Scirpus torreyii* and aquatic moss also had "densities where present" of 2.5 or more, indicating that they also exhibited an aggregated growth form or a growth form of above average density. However, even though these species exhibited a dense growth form where they occurred, they were not commonly distributed in Bob Lake (Appendix I, II).

DOMINANCE

Combining the relative frequency and relative density of a species into a Dominance Value illustrates how dominant that species is within the aquatic plant community (Appendix III). Based on the Dominance Value, *Brasenia schreberi* was the dominant aquatic plant species in Bob Lake (Figure 5). *Nuphar variegata* was sub-dominant.

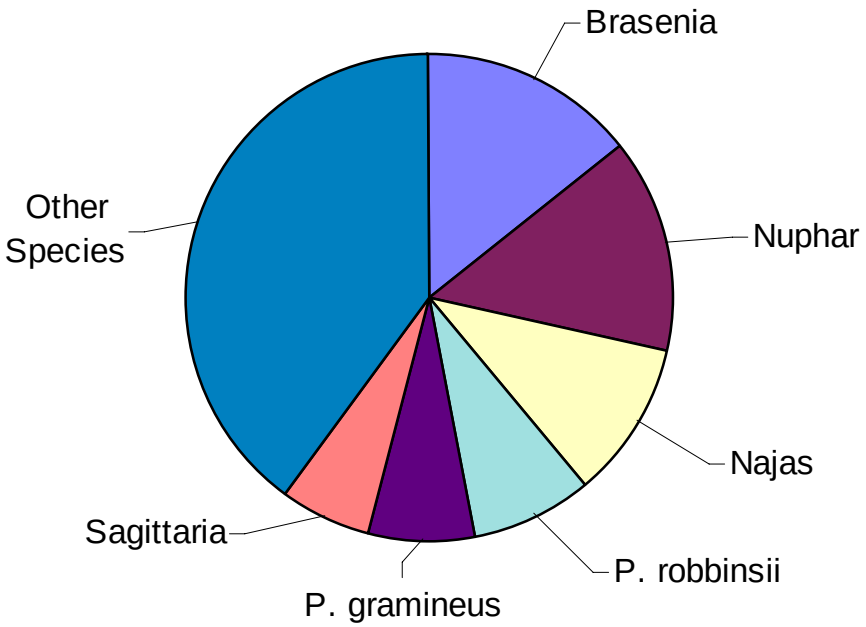

Figure 5. Dominance within the plant community, of the most prevalent aquatic plants in Bob Lake, 2004.

Nuphar variegata, the sub-dominant species overall, was the dominant species in the 0-1.5ft depth zone and occurred at its highest frequency and density in this depth zone, declining with increasing depth (Figure 6, 7). *Brasenia schreberi*, the dominant species overall, was the dominant species in the 1.5-5ft depth zone and occurred at its highest

frequency and density in this depth zone (Figure 6, 7). *Potamogeton robbinsii* was the dominant species in the 5-10ft zone, even though its frequency and density was highest in the 1.5-5ft depth zone.

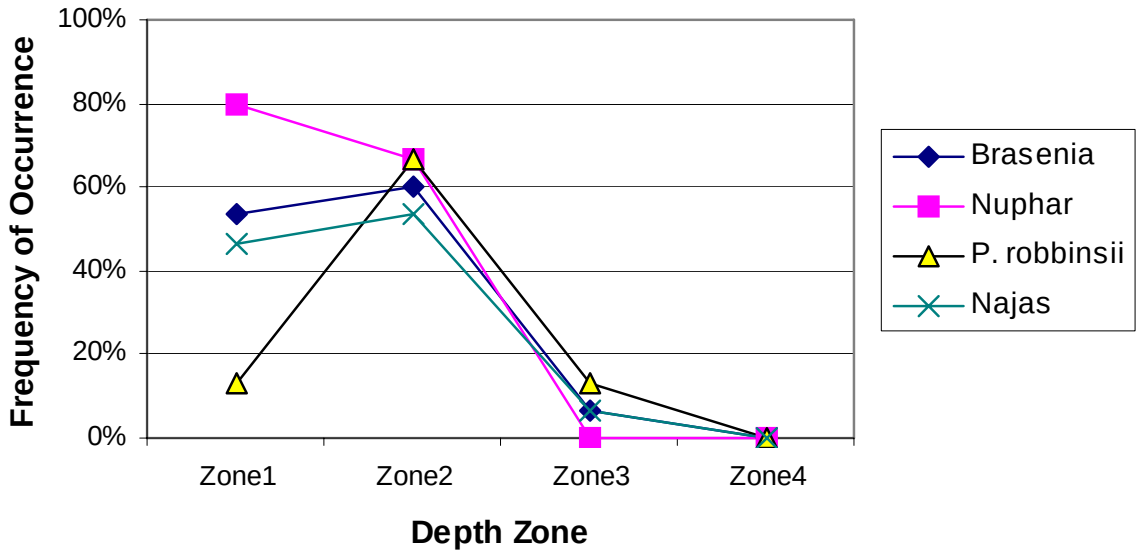

Figure 6. Frequency of occurrence of prevalent aquatic plant species in Bob Lake, by depth zone, 2004.

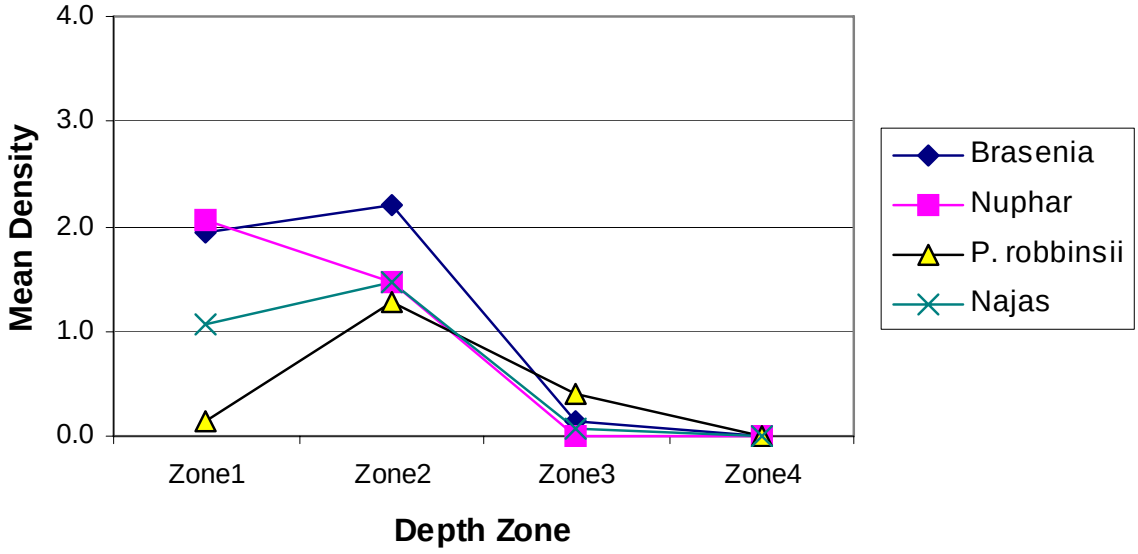

Figure 7. Density of prevalent species in Bob Lake by depth zone, 2004.

DISTRIBUTION

Aquatic plants occurred throughout Bob Lake, at 53% of the sampling sites (52% with rooted plants) to a maximum depth of 9 feet. This is approximately 20% of the total lake area (Figure 8). *Potamogeton robbinsii* occurred at the maximum rooting depth. The dominant and common plant species were found throughout the lake. The sensitive species found in bob Lake occurred throughout the littoral zone (Figure 9) and the two Special Concern Species occurred near some of the bog edges (Figure 9).

Secchi disc water clarity data are used to calculate a predicted maximum rooting depth for plants in a lake (Dunst 1982).

Based on the 2004 Secchi disc clarity, the predicted maximum rooting depth in Bob Lake would be 8.3 ft.

This maximum rooting depth is close to the predicted maximum rooting depth based on water clarity.

The 0-1.5ft depth zone supported the greatest amount of plant growth. The highest total occurrence and total density of plant growth was recorded in the 0-1.5ft depth zone and declined dramatically with increasing depth (Figure 10).

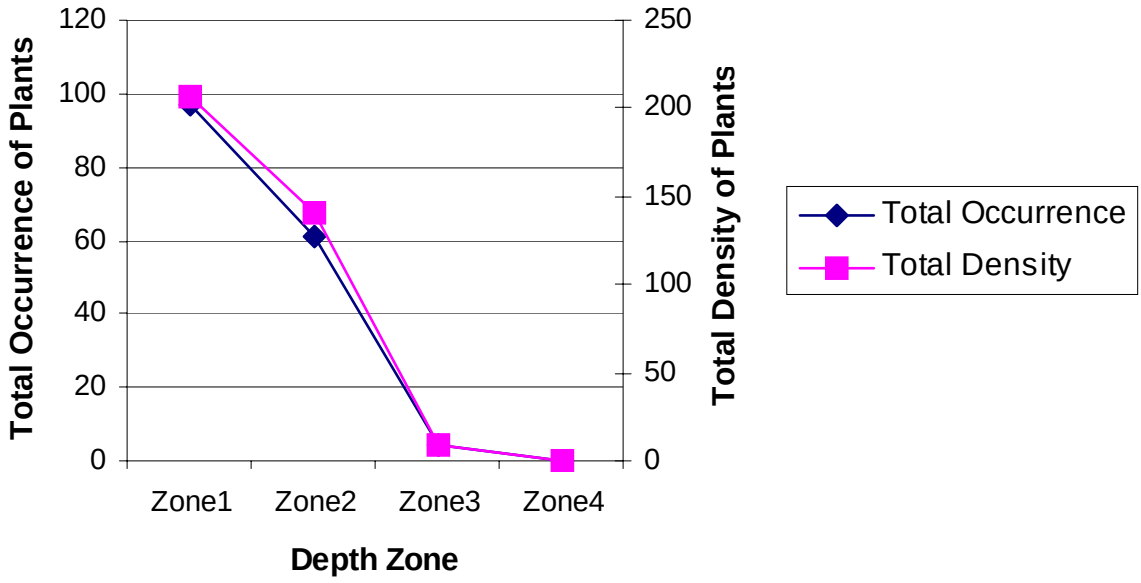

Figure 10. Total occurrence and density of plants in Bob Lake by depth zone.

The highest percentage of vegetated sites and the greatest species richness (mean number of species per site) were also found in the 0-1.5 ft. depth zone (Figure 11).

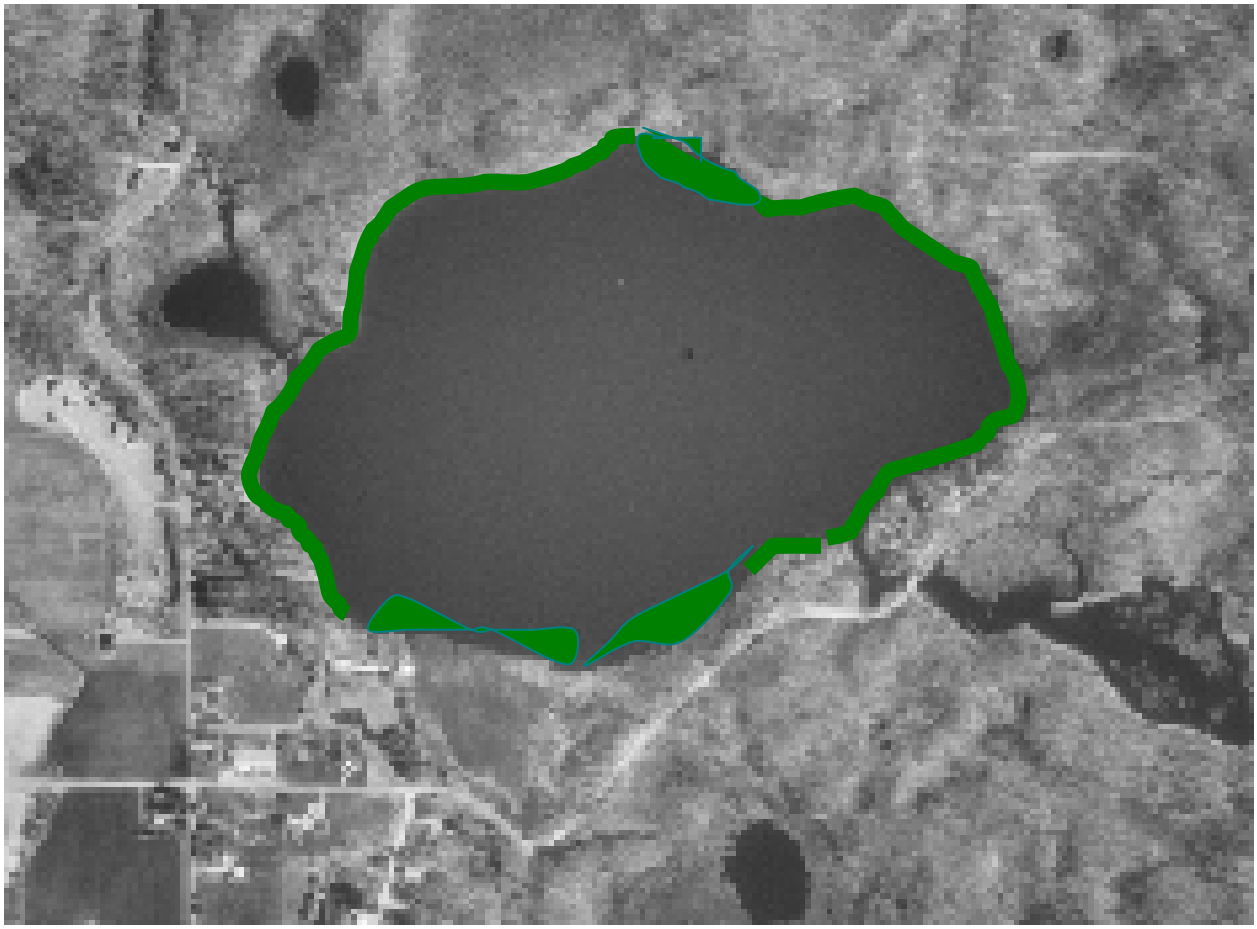

Figure 8. Distribution of aquatic vegetation in Bob Lake, August 2004.

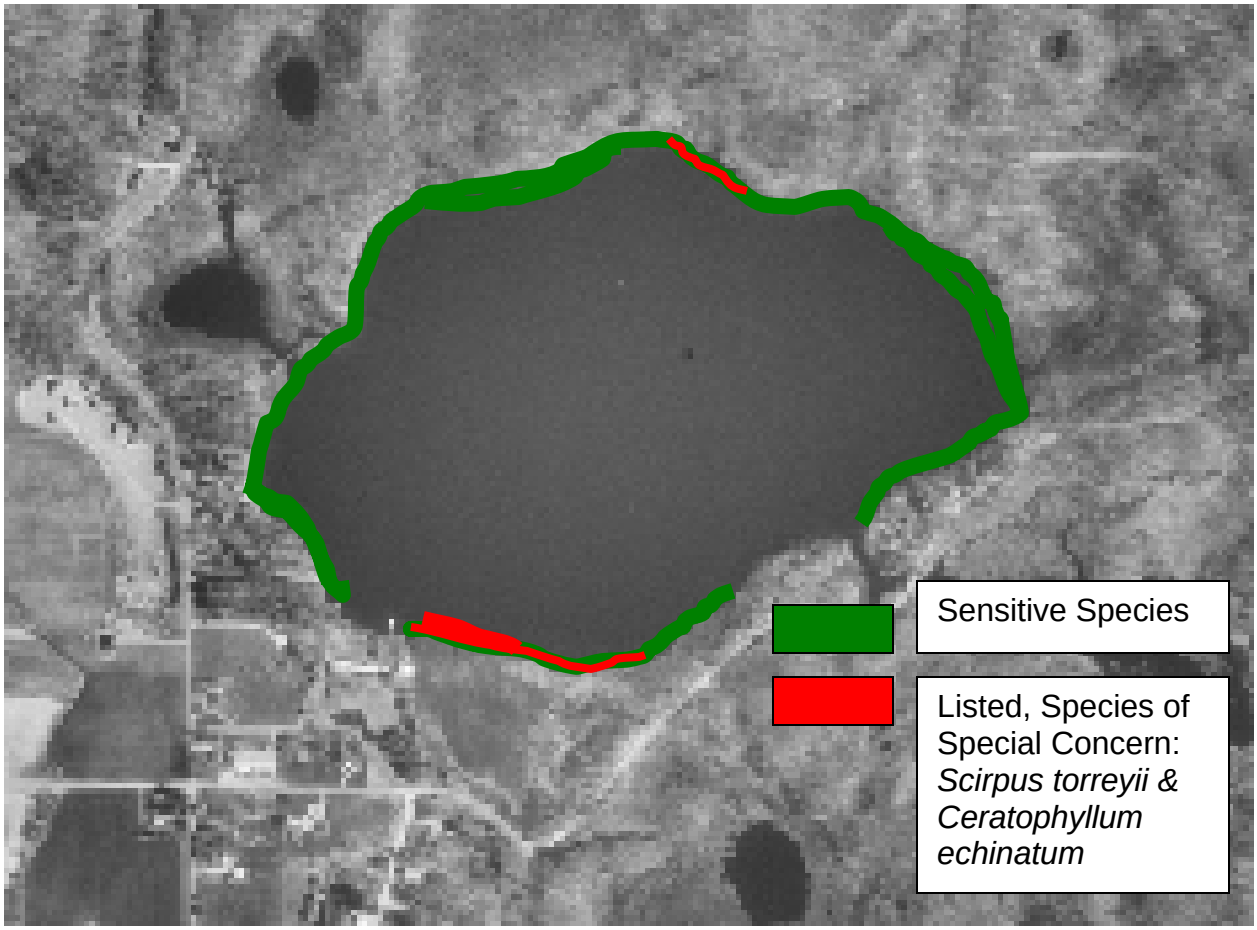

Figure 9. Distribution of sensitive species in Bob Lake, 2004.

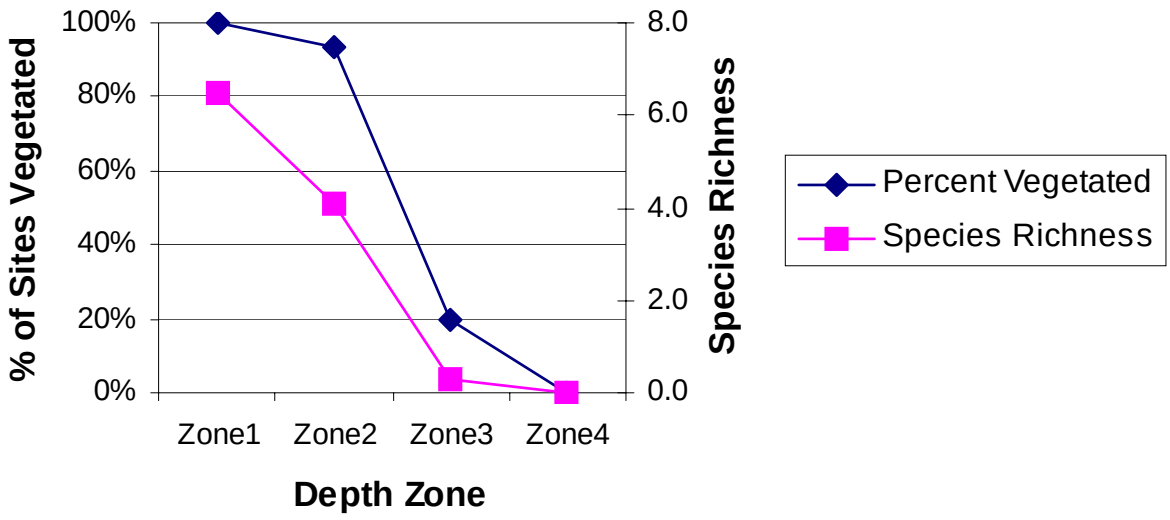

Figure 11. Percentage of vegetated site and species richness in Bob Lake, by depth zone, 2004.

The mean number of species found at each sampling sites was 2.7

THE COMMUNITY

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

The Aquatic Macrophyte Community Index (AMCI) for Bob Lake (Table 6) is 58. This is in the upper quartile of lakes in Wisconsin and the North Central Hardwoods Region of the state. The highest value for this index is 70. This value places Bob Lake in the top 25% of lakes in the state and region with the highest quality aquatic plant community.

Table 6. Aquatic Macrophyte Community Index

Category		Value
Maximum Rooting Depth	2.74 meters	4
% Littoral Zone Vegetated	53%	10
% Submergent Species	56% Rel. Freq.	4
# of Species	29	10
% Exotic Species	0	10
Simpson's Diversity Index	0.93	10
% Sensitive Species	35% Relative Freq.	10
Totals		58

The Average Coefficient of Conservatism for Bob Lake was in the highest quartile for all Wisconsin lakes and lakes in the North Central Hardwood Region (Table 7). This suggests that the aquatic plant community in Bob Lake is among the group of lakes in Wisconsin and the North Central Hardwoods Region most sensitive to disturbance.

Table 7. Floristic Quality and Coefficient of Conservatism of Bob 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
NCHR	5.2, 5.6, 5.8 *	17.0, 20.9, 24.4
Bob Lake 2004	7.04	37.23

* - 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 Bob Lake was also in the upper quartile of Wisconsin lakes and North Central Hardwood Region lakes (Table 7). This indicates that the plant community in Bob Lake is within the group of lakes in the state and region closest to an undisturbed condition.

Disturbances can be of many types:

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

IV. DISCUSSION

Based on water clarity, chlorophyll and phosphorus data, Bob Lake is a eutrophic lake with poor water clarity and fair-to-poor water quality. Since 1977, phosphorus and chlorophyll (algae) concentrations have increased dramatically from an oligotrophic state to a eutrophic state. The current trophic state would support abundant plant growth and frequent algae blooms. Filamentous algae occurred at 12% of the sites and was common (33% of sites) in the 0-1.5ft depth zone.

Abundant nutrients (trophic state) and the gradually sloped littoral zone in most of Bob Lake would favor plant growth. The soft water, poor water clarity and dominance of high-density sand and sand/gravel sediments in Bob Lake could limit plant growth. Favorable silt sediments were more abundant in the deeper water, where light penetration is less.

Aquatic plants occurred at 53% of the sites (52% with rooted vegetation), to a maximum depth of 9 feet. This maximum rooting depth is in agreement with the predicted maximum rooting depth, based on water clarity. The highest total occurrence of plants, highest total density of plants, the greatest percentage of vegetated sites and the greatest species richness occurred in the 0-1.5ft depth zone.

Twenty-nine (29) species of aquatic plants were recorded in Bob Lake in 2004. *Brasenia schreberi* was the dominant plant species in Bob Lake, especially in the 1.5-5ft depth zone, occurring at more than half of the sample sites and exhibiting a dense form of growth. Four other species exhibited an aggregated or dense growth form in Bob Lake, but there occurred only at a few locations. *Nuphar variegata* was sub-dominant, dominating the 0-1.5ft depth zone and occurring at the greatest number of sites. *Potamogeton robbinsii,* which occurred at the maximum rooting depth, was the dominant species in the 5-10ft depth zone. The dominant and common species were found throughout the lake. A group of the species in Bob Lake are sensitive soft water species found only in northern lakes, common to tamarack bogs. Bog fringed approximately 40% of the shoreline of Bob Lake.

The Aquatic Macrophyte Community Index (AMCI) for Bob Lake was 58, indicating that the quality of the plant community in Bob Lake is high, in the top quartile of lakes in Wisconsin and the region with the highest quality aquatic plant community. Simpson's Diversity Index (0.93) indicates that the plant community had an excellent diversity of species.

The Average Coefficient of Conservatism and the Floristic Quality Index indicates that Bob Lake is in the upper quartile of lakes (top 25%) in the state and region, in the group of lakes most sensitive to disturbance and closest to an undisturbed condition.

Bob Lake has some protection by natural shoreline cover (wooded, shrub, native herbaceous growth, natural rock), but disturbed shoreline covered 13% of the shore. Two types of disturbed cover, cultivated lawn and hard structures, were commonly occurring and covered 12% of the shoreline. Shorelines with cultivated lawn can impact

the plant community through increased run-off of lawn fertilizers, pesticides and pet wastes into the lake. Hard structures and mowed lawn also speed run-off to the lake without filtering these pollutants. Expanding and protecting the buffer of natural vegetation along the shore will help prevent shoreline erosion and reduce additional nutrient/chemical run-off that can add to algae growth and sedimentation of the lake bottom.

In order to determine impacts to the aquatic plant community from disturbance on shore, the plant community in Bob Lake was divided into two communities: the plant community offshore from shoreline with 100% natural cover and the plant community offshore from shoreline with any amount of disturbed cover (cultivated lawn and hard structures). Metrics that measure the communities were compared.

The quality of the aquatic plant community was higher at the natural shoreline community (Table 8) as measured by the Aquatic Macrophyte Community Index. The quality of the natural shoreline community was above average for the Northern Lakes and Forest Region and the disturbed shoreline community was below average for the region.

Table 8. AMCI Index at Natural vs. Disturbed Shorelines

Category	Natural	Disturbed
Maximum Rooting Depth	4	2
% Littoral Zone Vegetated	10	9
% Submergent Species	3	5
# of Species	10	8
% Exotic Species	10	10
Simpson's Diversity Index	10	9
% Sensitive Species	10	10
Totals	57	53

Besides the higher quality at natural shoreline sites, other differences between the developed shoreline and natural shoreline communities were:

1) The Average Coefficient of Conservatism and Floristic Quality Index were higher at natural shoreline sites, verifying that disturbance is impacting the community. The natural shoreline community is less tolerant of disturbance (Average Coefficient of Conservatism) and much closer to an undisturbed condition (Floristic Quality Index). The disturbed shoreline community is closer to an undisturbed condition than the average lake in the Northern Lakes and Forest Region, but the natural shoreline community is within the upper quartile, the

group of lakes in the region closest to an undisturbed condition (Table 9).

2) The natural shoreline community supported more sensitive species and the combined relative frequency of sensitive species was slightly higher at the natural shoreline (Table 9).
3) The natural shoreline community has greater diversity that provides a more diverse habitat for more diverse fish and wildlife populations. The number of species, the diversity index and Species Richness (the mean number of species found at a site) were all greater at the natural shoreline sites. Species Richness was especially higher in the shallowest depth zones (0-5ft) of the natural shoreline community where the impacts of developed shoreline would be greater (Table 9).
4) The natural shoreline community provided more habitat for fish and wildlife. The maximum rooting depth of aquatic vegetation was greater, providing a wider band of habitat. The percent of vegetated sites was greater at the natural shoreline community, providing more habitat within that band. All types of vegetative structure (emergent, submerged, floating-leaf and rosette/turf-forming) exhibited a higher occurrence at the natural shoreline community. Floating-leaf vegetation and emergent vegetation are critical habitat. Rosette/turf-forming species protect the lake bottom yet are low growing, not interfering with recreation and fish movement (Table 9).

Table 9. Comparison of the Plant Community at Natural and Disturbed Shoreline.

Metric		Natural Shoreline Community	Disturbed Shoreline Community
Average Coefficient of Conservatism	Sensitivity to disturbance	7.19	7.00
Floristic Quality Index	Closeness to undisturbed condition	36.67	28.00
Sensitive Species (Nichols 1998, 2000)	Number of sensitive species	13	8
	Combined relative frequency	46%	43%
Number of Species		28	17
Simpsons Diversity Index		0.931	0.914
Species Richness		3.0	2.25
	0-1.5ft Depth Zone	7.0	5.67
	1.5-5ft Depth Zone	4.67	3.17
	5-10ft Depth Zone	0.33	0.17
Maximum Rooting Depth		9 feet	6.5 feet
Cover of Vegetative Structure	Percent littoral zone vegetated	56%	50%
	Floating-leaf vegetation	50%	38%
	Emergent Vegetation	25%	8%
	Submerged Vegetation	56%	46%
	Rosette species	17%	12%
AMCI Index	Community Quality	57	53

V. CONCLUSIONS

Bob Lake is a eutrophic lake with fair-to-poor water quality and poor water clarity. Nutrients and algae have increased dramatically since 1977. Filamentous algae is common in the 0-1.5ft depth zone.

The aquatic plant community is characterized by high quality and excellent species diversity. Bob Lake is in the top quartile of lake in the state and region, the group of lakes most sensitive to disturbance and closest to an undisturbed condition.

The aquatic plant community colonized slightly more than half of the littoral zone to a maximum depth of 9 feet. The 0-1.5ft depth zone supported the most abundant aquatic plant growth.

Brasenia schreberi was the dominant species within the 29-species aquatic plant community, especially in the 1.5-5ft depth zone. *Nuphar variegata* was sub-dominant, most prevalent in the 0-1.5ft depth zone. *Potamogeton robbinsii* dominated the 5-10ft depth zone and was the species with the greatest maximum rooting depth. The most common species were found throughout the lake. A large part of the plant community was composed of northern, soft-water, sensitive species.

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

Aquatic plant communities improve water quality in many ways (Engel 1985):

- 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.

Aquatic plant communities provide important fishery and wildlife resources. Plants and algae start the food chain that supports many levels of wildlife, and at the same time produce oxygen needed by animals. Plants are used as food, cover and nesting/spawning sites by a variety of wildlife and fish (Table 10). Plant cover within the littoral zone of Bob Lake is 53% and 20% over the entire lake acreage. This is appropriate (25-85%) to support a balanced fishery.

Table 10. Fish and Wildlife Uses of Aquatic Plants in Bob Lake

Aquatic Plants	Fish	Water Fowl	Song and Shore Birds	Upland Game Birds	Muskrat	Beaver	Deer
Submergent Plants							
Eleocharis acicularis	S	F			F		
Najas flexilis	F, C	F*(Seeds, Foliage)	F(Seeds)				
Najas gracillima	F, C	F*	F(Seeds)				
Potamogeton amplifolius	F, I, S*,C	F*(Seeds)			F*	F	F
Potamogeton gramineus	F, I, S*,C	F*(Seeds, Tubers)			F*	F	F
Potamogeton oakesianus	F, C	F*(Seeds)			F*	F	F
Potamogeton robbinsii	F, I, S*,C	F*			F*	F	F
Potamogeton spirillus		F(Seeds)	F		F	F	F
Floating-leaf Plants							
Brasenia schreberi	S, I, C	F(Seeds)			F	F	F
Nuphar variegata	F,C, I, S	F, I	F		F*	F	F*
Nymphaea odorata	F,I, S, C	F(Seeds)	F		F	F	F
Sparganium fluctuans	C	F (Nutlets)		F		F*	
Emergent Plants							
Alnus incana				F, C		F	F
Carex spp.	S*	F*(Seeds), C	F*(Seeds)	F*(Seeds)	F	F	F
Chamaedaphne calyculata				F			F
Eleocharis smallii	I	F, C					
Eriocaulon aquaticum	F, S, C	F(leaves), C	F(Seeds)	F (Seeds)	F	F	F
Iris versicolor		F, C	F		F		
Sagittaria cristata		F(seeds, tubers), C			F (tubers)	F (tuber)	
Scirpus torreyi	F, S, C	F, C	F(Seeds, Tubers), C	F	F	F	F
Scirpus validus	F, C, I	F (Seeds)*, C	F(Seeds, Tubers), C	F (Seeds)	F	F	F
Typha latifolia	I, C, S	F(Entire), C	F(Seeds), C, Nest	Nest	F* (Entire), C*, Lodge	F	

F=Food, I= Shelters Invertbrates, a valuble 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.

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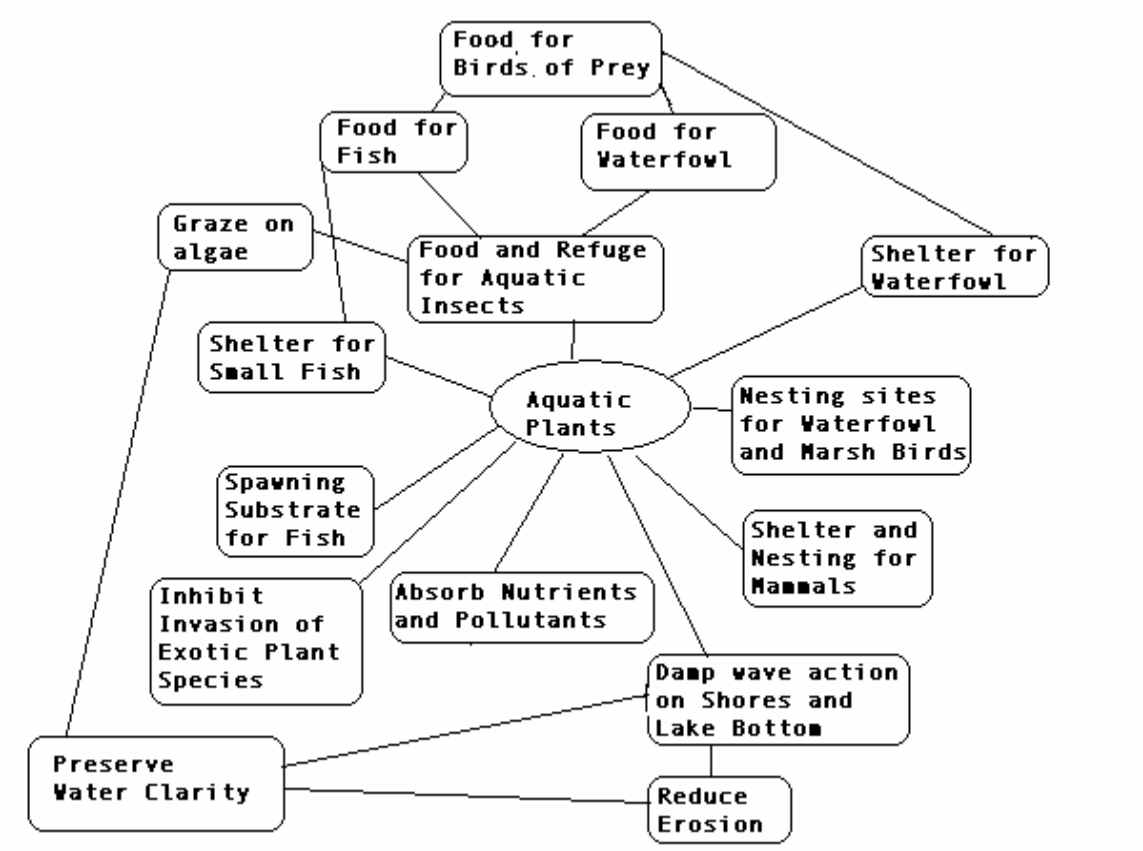
Compared to non-vegetated lake bottoms, plant beds support larger, more diverse

invertebrate populations that in turn will support larger and more diverse fish and wildlife populations (Engel 1985). Additionally, mixed stands of aquatic 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. Aquatic plant beds of moderate density support adequate numbers of small fish without restricting the movement of predatory fish (Engel 1990).



Management Recommendations

1) Lake residents investigate applying for a grant to determine the source of nutrients that has significantly enriched Bob Lake since 1977.
2) All lake residents practice best management on their lake properties to reduce further nutrient enrichment :
    a) Keep septic systems cleaned and in proper condition
    b) Use no lawn fertilizers
    c) Clean up pet wastes
    d) Do not compost near the water or allow yard wastes and clippings to enter the lake
3) Residents become involved in the Citizen Lake Monitoring Program, monitoring water quality to track seasonal and year-to-year changes.
4) DNR should designate sensitive areas within Bob Lake. These are areas within the lake that are most important for habitat and maintaining water quality.
5) Lake residents protect and restore natural shoreline around Bob Lake. Bob Lake

has some protection from natural shoreline buffers on portions of the lake, but disturbed shoreline (cultivated lawn and hard structures are common) covers 13% of the shore. Unmowed native vegetation reduces shoreline erosion and run-off into the lake and filters the run-off that does enter the lake. Developed, disturbed shoreline may already be impacting the aquatic plant community in Bob Lake.

a) Disturbed shoreline sites (mowed lawn and hard structures) support fewer sensitive species and as a community are farther from an undisturbed condition (FQI Index) than natural shoreline sites.
b) Disturbed shoreline sites support a less diverse plant community (lower species diversity, fewer species and lower species richness) that will support less diversity in the fish and wildlife community.
c) Disturbed shoreline sites provide less habitat. The maximum rooting depth is less, the percent of sites vegetated is less and the coverage of all vegetation structural types is less.
d) The aquatic plant community at the disturbed shoreline sites is of lower quality as measured by the AMCI Index.

6) All lake users protect the aquatic plant community in Bob Lake. The standing-water emergent community, floating-leaf community and submergent plant community are all unique plant communities. Each of these plant communities provide their own benefits for fish and wildlife habitat and water quality protection. These communities in Bob Lake are composed of sensitive, unique species that could easily be replaced with less valuable, more aggressive plant communities.

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