

# Changes in the Aquatic Plant Community of Perch Lake, St. Croix County, Wisconsin 1993-2004

## **I. INTRODUCTION**

Surveys of the aquatic plants (macrophytes) in Perch Lake were conducted during August, 1993 and 2004 by Water Resources staff from the Western Central Region – Wisconsin Department of Natural Resources (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 data that it provides will be compared to past and future aquatic plant inventories and offer insight into any changes occurring in the lake.

## **Background and History**

Perch Lake is a 43-acre seepage lake in western St. Croix County, Wisconsin. It has a maximum depth of 63 feet and a mean depth of 34 feet, with 70% of the lake over 20 feet deep. There is one public access boat landing and watercraft motors are restricted to electric trolling motors. The lake has been classified as an Outstanding Resource Water by the state and recreational use of the lake is primarily fishing with large mouth bass as the dominant game fish.

The Perch Lake watershed is 384 acres, which is nearly 9 times the size of the lake.

During 1997-2003, a new, 95-acre county park, Homestead Parklands, was developed on the north and northeast side of Perch Lake. The park encompasses approximately half of the shoreline of Perch Lake and has a picnic area, canoe rental/launch area, fishing area

and fishing pier on the north half of the east shore and a new swimming beach on the north shore of the lake.

Planning for the new park included plans to protect the water quality in Perch Lake. Hard surfaces were minimized and designed to drain away from the lake; infiltration areas were designed to slow stormwater run-off to the lake; eroding sites on the north shore were restored; native plant communities (woodlands, prairie and oak savanna) will be restored in the parkland to protect a portion of the watershed.

In 2003, the county applied for and received a permit to manually remove aquatic plants in the 212-ft x 100-ft swim area.

During the 2004 aquatic plant survey, Eurasian watermilfoil was found to have invaded Perch Lake since a 2002 invasive species assessment.

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## **II. METHODS**

### **Field Methods**

The same study design and transects were used for the 1993 and 2004 aquatic plant studies. The design was based on the rake-sampling method developed by Jessen and Lound (1962). Fourteen equal-distance transect lines were placed perpendicular to the shoreline with the first transect being randomly placed (Appendix VII).

One sampling site was randomly located at each depth zone (0-1.5ft., 1.5-5ft., 5-10 ft., and 10-20ft.) along each transect. Using a long-handled, steel, thatching rake, four rake samples were taken at each sampling site. The four samples were taken at each corner of a 6-foot square 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 at each sampling site on which it was present.

A rating of 1 for each species present on one rake sample at a site;

A rating of 2 for each species present on two rake samples at the site;

A rating of 3 for each species present on three rake samples;

A rating of 4 for each species present on four rake samples;

A rating of 5 indicates that a species was abundant on all rake samples at that sampling site.

The species recorded include aquatic vascular plants and macrophytic algae, such as muskgrass and nitella. The presence of filamentous algae was recorded. The actual depth and sediment type at each sampling site was recorded.

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 cover type within this 100 ft. X 30 ft. rectangle was recorded.

Visual inspection and periodic samples were taken between transect lines in order to record the presence of any species that did not occur at the sampling sites. Specimens of each species present were collected and saved in a cooler for later preparation of voucher specimens. Nomenclature was according to Gleason and Cronquist (1991).

### **Data Analysis**

The data was analyzed separately for each year and compared. The percent frequency of occurrence of each species was calculated (number of sampling sites at which it occurred/number of sampling sites) (Appendices I-II). Relative frequency was calculated (number of sample sites at which it occurred/the sum of all species occurrences) (Appendices I-II). The mean density was calculated for each species (sum of a species' density ratings/number of sampling sites) (Appendices III-IV). Relative density was calculated (the density rating of a species/the sum of all species densities) (Appendices III-IV). 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) (Appendices III-IV). The relative frequency and relative density of each species was summed to obtain a Dominance Values (Appendices V-VI).

Simpson's Diversity Index was calculated for each sampling year (Appendices I-II). Each sampling year was compared by a Coefficient of Community Similarity.

An Aquatic Macrophyte Community Index (AMCI), developed for Wisconsin lakes, was applied to Perch Lake. Data in seven categories that characterize the aquatic plant community is converted to values 0 - 10 and summed as outlined by Nichols (2000).

Coefficients of Conservatism and Floristic Quality Index were used to evaluate the closeness of the aquatic plant community to an undisturbed condition (Nichols 1998). 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 of conservatism for all species found in a lake and measures the sensitivity of the community to disturbance. Floristic Quality Index is calculated from the coefficients and measures the plant community's closeness to an undisturbed condition.

### **III. RESULTS**

#### **PHYSICAL DATA**

##### **Water Chemistry**

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

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

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

**Mesotrophic lakes** have intermediate levels of nutrients and biomass.

##### **Nutrients**

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

**2004 summer mean phosphorus concentration in Perch Lake was 10 ug/l**

This concentration of phosphorus in Perch Lake is indicative of an oligotrophic/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	<b>1-10</b>	<b>1-5</b>	<b>8-19</b>
Mesotrophic	Good	<b>10-30</b>	5-10	6-8
	Fair	30-50	10-15	5-6
Eutrophic	Poor	50-150	15-30	3-4
Perch Lake 2004	Very Good	10	2.4	16.6

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

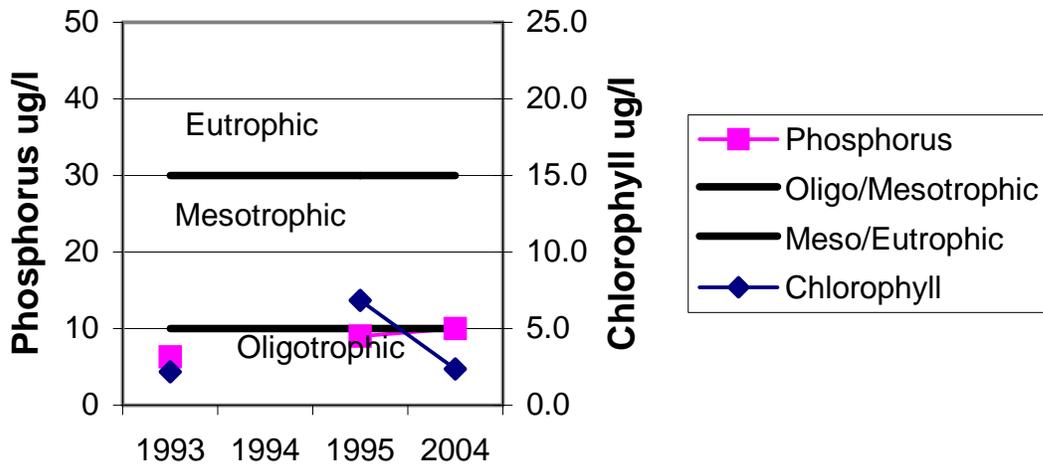
##### **Algae**

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.

**2004 summer mean chlorophyll concentration in Perch Lake was 2.4 ug/l.**

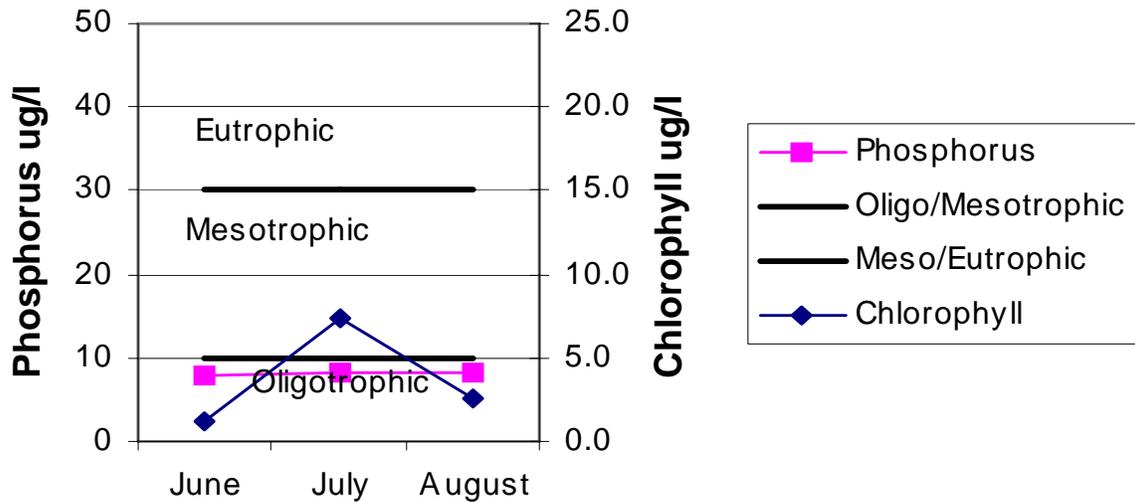
The chlorophyll concentration in Perch Lake indicates that it was an oligotrophic lake (Table 1).

Phosphorus concentrations in Perch Lake have increased since 1993 while chlorophyll concentrations have fluctuated (Figure 1). Other factors besides nutrients, such as weather conditions, can impact chlorophyll production.



**Figure 1. Change in mean summer phosphorus and chlorophyll concentrations in Perch Lake, 1993-2004.**

Phosphorus and chlorophyll also vary during the growing season. Phosphorus concentrations remain stable throughout the summer (Figure 2). Chlorophyll peaks in July when the water warms, favoring increased algae growth, and declines again in late summer as the water cools (Figure 2).



**Figure 2. Chlorophyll and phosphorus concentrations during the growing season in Perch Lake, 1995-2004.**

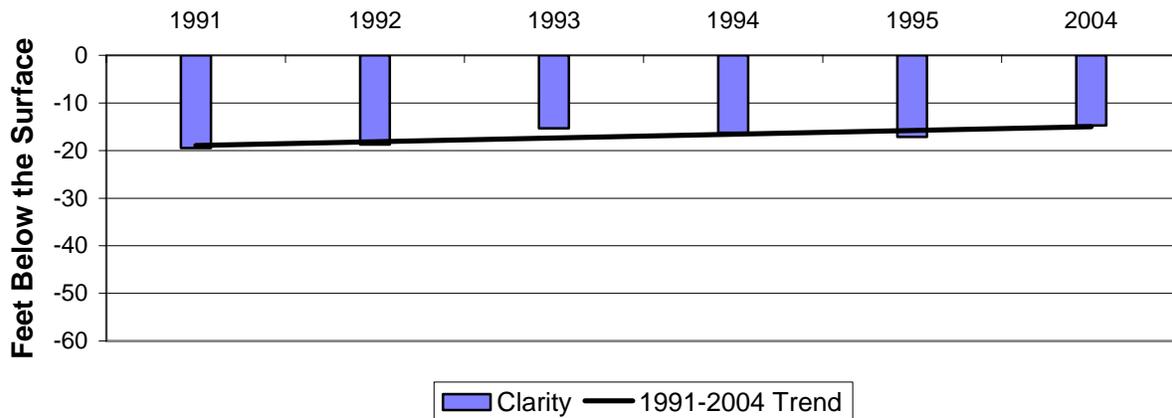
### Water Clarity

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

**2004 summer mean Secchi Disc clarity in Perch Lake was 16.6 ft.**

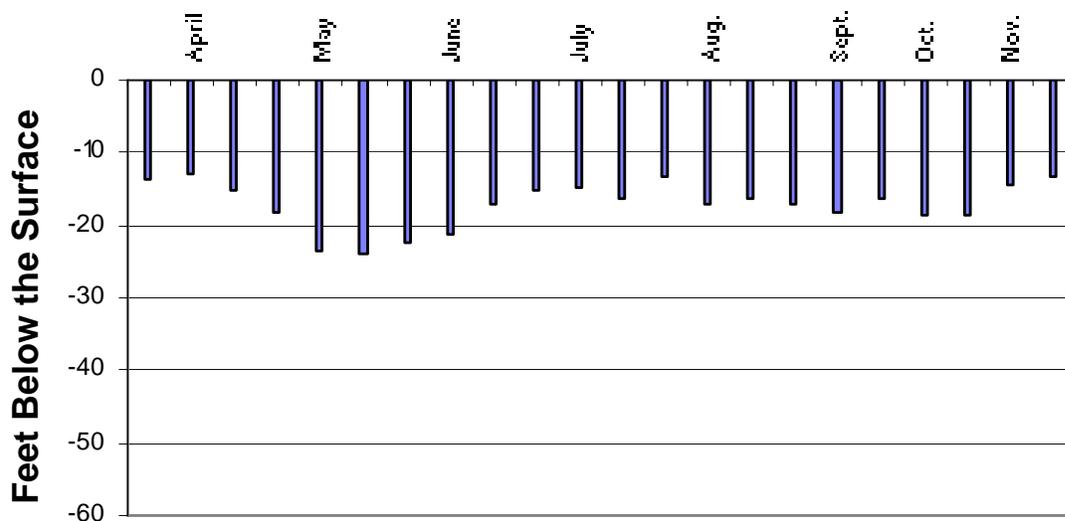
Water clarity indicates (Table 1) that Perch Lake was an oligotrophic lake with very good water clarity.

Pat Collins, a volunteer lake monitor in the Self-help Volunteer Lake Monitoring Program, collected water clarity data on Perch Lake 1991-1995. The water clarity in Perch Lake declined during 1991-2004 (Figure 3). Variations in clarity can be the result of variations in algae growth in different years and turbidity after storm events.



**Figure 3. Variation in mean summer water clarity in Perch Lake, 1991-2004.**

Water clarity varies during the growing season also (Figure 4). Clarity is low in very early spring during spring turnover. The clarity increases to its greatest during late spring and starts decreasing during the summer as the water warms and algae growth increases. Clarity increases slightly in autumn as the water cools until fall turnover when clarity decreases again.



**Figure 4. Variation in mean water clarity during the growing season in Perch Lake, 1991-2004.**

The combination of phosphorus concentration, chlorophyll concentration and water clarity indicates that Perch Lake is an oligotrophic lake with very good water quality.

This trophic state would limit plant growth and summer algae blooms, yet the good water clarity could favor plant growth.

**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).

Perch Lake has a deep oval basin with a gradually sloped littoral zone along the north end and in the southwest bay. The littoral zone is more steeply sloped along the remainder of the shoreline.

#### **Hardness**

The 2004 hardness value was 56 mg CaCO<sub>3</sub>/l. Lakes with a hardness value of 0-60mg CaCO<sub>3</sub>/l are considered soft water lakes. Soft water lakes tend to have less abundant plant growth than hard water lakes.

#### **SEDIMENT COMPOSITION**

The dominant sediment in Perch Lake was sand, especially at depths greater than 1.5 feet (Table 2). The occurrence of sand sediment increased with increasing depth.

Sand/gravel mixture was dominant in the 0-1.5' depth zone, found along the east and west shores. Sand/silt mixture was common, more abundant at the mid-depths of 1.5-10 feet.

**Table 2. Sediment Composition: Perch Lake, 2004**

<b>Sediment Type</b>		<b>0-1.5' Depth</b>	<b>1.5-5' Depth</b>	<b>5-10' Depth</b>	<b>10-20' Depth</b>	<b>Percent of all Sample Sites</b>
<b>Hard Sediments</b>	Sand	31%	50%	67%	82%	56%
	Boulder/Gravel/ Sand	8%			9%	4%
	Boulder		7%	8%		4%
	Sand/Gravel/ Asphalt	8%				2%
	Sand/Gravel	38%				10%
<b>Mixed Sediments</b>	Sand/Silt	15%	36%	25%	9%	22%
	Sand/Silt/Peat		7%			2%
<b>Soft Sediments</b>	Silt					

### **SEDIMENT INFLUENCE**

Many aquatic plants depend on the sediment in which they are rooted for required nutrients. The richness or sterility of the lake sediment and its density will determine which species of plants can survive in a location and how abundantly they will grow.

Sand, the overall dominant sediment in Perch Lake, and sand/gravel, the dominant sediment in the 0-1.5ft depth zone, can be limiting to plant growth due to their high density. The availability of mineral nutrients essential for plant growth is highest in sediments of intermediate density, such as silt (Barko & Smart 1986). All sediment types except boulder supported abundant plant growth in Perch Lake (Table 3). Sand sediment supported vegetation at 100% of the sites at which this sediment occurred (Table 3). It appears that sediment is not the primary determining factor for plant growth in Perch Lake.

**Table 3. Sediment Influence**

<b>Sediment Type</b>		<b>Percent of all Sample Sites</b>	<b>Percent Vegetated</b>
<b>Hard Sediments</b>	Sand	56%	100%
	Boulder/Gravel/Sand	4%	50%
	Boulder	4%	100%
	Sand/Gravel/Asphalt	2%	100%
	Sand/Gravel	10%	100%
<b>Mixed Sediments</b>	Sand/Silt	22%	100%
	Sand/Silt/Peat	2%	100%
<b>Soft Sediments</b>	Silt		

### **WATER LEVEL**

Fluctuating water levels place stress on aquatic plants. The shallow zone becomes exposed beach when the water level drops and this environment is too harsh for aquatic plants. The deep end of the littoral zone becomes shallower with a drop in water level, but the plants cannot usually spread quickly enough to take advantage of this area before the water level returns to a depth they can not tolerate (Nichols 1975). Perch Lake has experienced fluctuating water levels in recent years related to seasons of high rainfall followed by seasons of drought.

### **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 wooded cover had the highest mean coverage. Shrubs, rock and bare sand were also commonly encountered (Table 4).

Several types of disturbed shoreline were commonly encountered: cultivated lawn, pavement for roads, gravel at the road base and hard structures (Table 4).

**Table 4. Shoreline Land Use - Perch Lake, 2004**

Cover Type		Frequency of Occurrence at Transects	Mean % Coverage
Natural Shoreline	Native Herbaceous	86%	21%
	Wooded	64%	31%
	Bare Sand	57%	9%
	Shrub	28%	3%
	Rock	28%	2%
	<b>Total</b>		<b>66%</b>
Disturbed Shoreline	Cultivated Lawn	21%	12%
	Pavement	21%	9%
	Gravel	21%	6%
	Hard Structures	21%	4%
	Rip-rap	14%	2%
	<b>Total</b>		<b>33%</b>

Natural shoreline (wooded, shrub, native herbaceous, sand, rock) was found at 93% of the sites and had a mean coverage of 66%.

Disturbed shoreline (cultivated lawn, hard structures, road bed, hard structures, rip-rap) was found at 57% of the sites and had a mean coverage of 33%.

**MACROPHYTE DATA**  
**SPECIES PRESENT**

Of the 26 species of aquatic plant species found in Perch Lake, 6 were emergent species, 1 was a floating-leaf species and 19 were submergent species (Table 5).

No endangered or threatened species were found.

One exotic species was present in 2004:

*Myriophyllum spicatum* – Eurasian watermilfoil

**Table 5. Aquatic Plant Species in Perch Lake, 1993-2004**

<u>Scientific Name</u>	<u>Common Name</u>	<u>I. D. Code</u>
<u>Emergent Species</u>		
1) <i>Carex comosa</i> Boott.	bristly sedge	carco
2) <i>Cyperus strigosus</i>	false nut-sedge	cypst
3) <i>Iris versicolor</i> L.	northern blue flag	irive
4) <i>Juncus balticus</i> Willd. var. <i>littoralis</i> Engelm.	wire rush	junba
5) <i>Sagittaria</i> sp.	arrowhead	sagsp
6) <i>Typha angustifolia</i> L.	narrow-leaf cattail	typan
<u>Floating-leaf Species</u>		
7) <i>Brasenia schreberi</i> J. F. Gmelin.	watershield	brasc
<u>Submergent Species</u>		
8) <i>Ceratophyllum demersum</i> L.	coontail	cerde
9) <i>Chara</i> sp.	muskgrass	chasp
10) <i>Eleocharis acicularis</i> (L.) Roemer & Schultes.	needle spikerush	eleac
11) <i>Elodea canadensis</i> Michx.	common waterweed	eloca
12) <i>Myriophyllum sibiricum</i> Komarov.	northern watermilfoil	myrsi
13) <i>Myriophyllum spicatum</i> L.	Eurasian water milfoil	myrsp
14) <i>Najas flexilis</i> (Willd.) Rostkov & Schmidt.	slender naiad	najfl
15) <i>Nitella</i> sp.	stonewort	nitsp
16) <i>Potamogeton amplifolius</i> Tuckerman.	large-leaf pondweed	potam
17) <i>Potamogeton gramineus</i> L.	variable-leaf pondweed	potgr
18) <i>Potamogeton illinoensis</i> Morong.	Illinois pondweed	potil
19) <i>Potamogeton natans</i> L.	floating-leaf pondweed	potna
20) <i>Potamogeton pectinatus</i> L.	sago pondweed	potpe
21) <i>Potamogeton pusillus</i> L.	small pondweed	potpu
22) <i>Potamogeton robbinsii</i> Oakes.	fern pondweed	potro
23) <i>Potamogeton zosteriformis</i> Fern.	flat-stem pondweed	potzo
24) <i>Ranunculus longirostris</i> Godron.	white watercrowfoot	ranlo
25) <i>Vallisneria americana</i> L.	water celery	valam
26) <i>Zosterella dubia</i> (Jacq.) Small	water stargrass	zosdu

## FREQUENCY OF OCCURRENCE

*Potamogeton robbinsii* was the most frequently occurring species in Perch Lake in 2004 (67% of the sample sites) (Figure 5). *Najas flexilis* had been the most frequently occurring species in 1993.

Other species that were commonly occurring both years were *Chara* sp., *Myriophyllum sibiricum*, *Potamogeton amplifolius*, *Vallisneria americana* and *Zosterella dubia*. *Potamogeton pusillus* and *P. zosteriformis* were commonly occurring in 1993, but declined in 2004. *Elodea canadensis*, *Potamogeton illinoensis* and *P. robbinsii* were not commonly occurring in 1993, but increased in frequency to become a common species in 2004 (Figure 5).

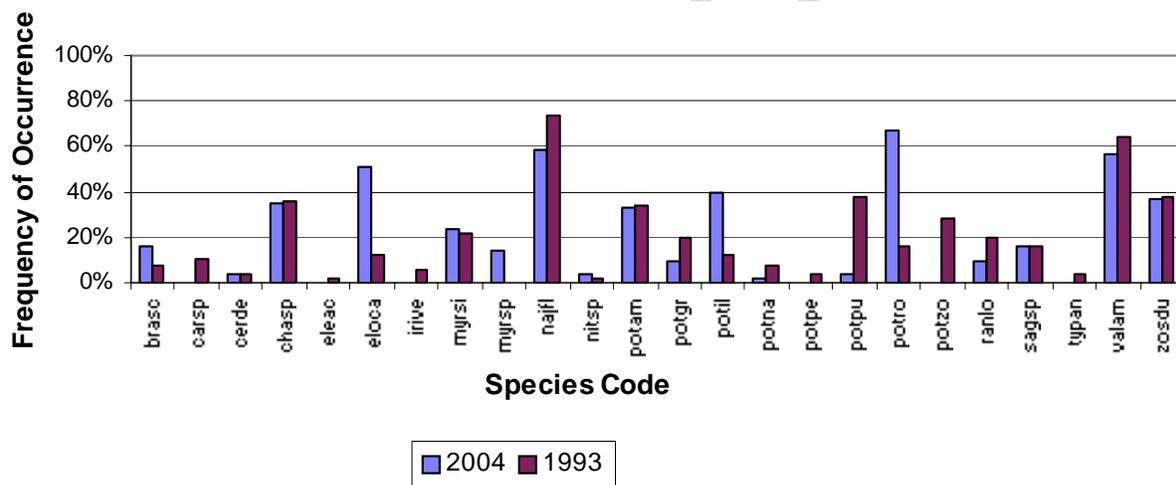


Figure 5. Frequency of aquatic plant species in Perch Lake, 1993-2004.

## DENSITY

*Potamogeton robbinsii* was also the species with the highest mean density in 2004 (2.04 on a scale of 0-5). This was a dramatic increase from a mean density of 0.34 for *P. robbinsii* in 1993. *Najas flexilis* had been the species in 1993 that had the highest mean density, but declined in density in 2004.

The “density where present” of *P. robbinsii* (3.06) indicates that this species exhibited an aggregated growth form or a growth form of colonizing at an above density in 2004. *P. robbinsii* had not exhibited an aggregated or dense growth form in 1993. Another species that exhibited an above average “density where present” was *Sagittaria* spp., however, *Sagittaria* was not commonly occurring in Perch Lake (Appendices III-IV).

## DOMINANCE

Combining the relative frequency and relative density of each species into Dominance Values, illustrates how dominant each species is within the plant community (Appendices V-VI).

In 2004, *Potamogeton robbinsii* was the dominant species with *Vallisneria americana* and *Najas flexilis* as the sub-dominant species. This is a change from 1993, when, *Najas flexilis* had been the dominant species, with *Vallisneria americana* as the sub-dominant species (Figure 6).

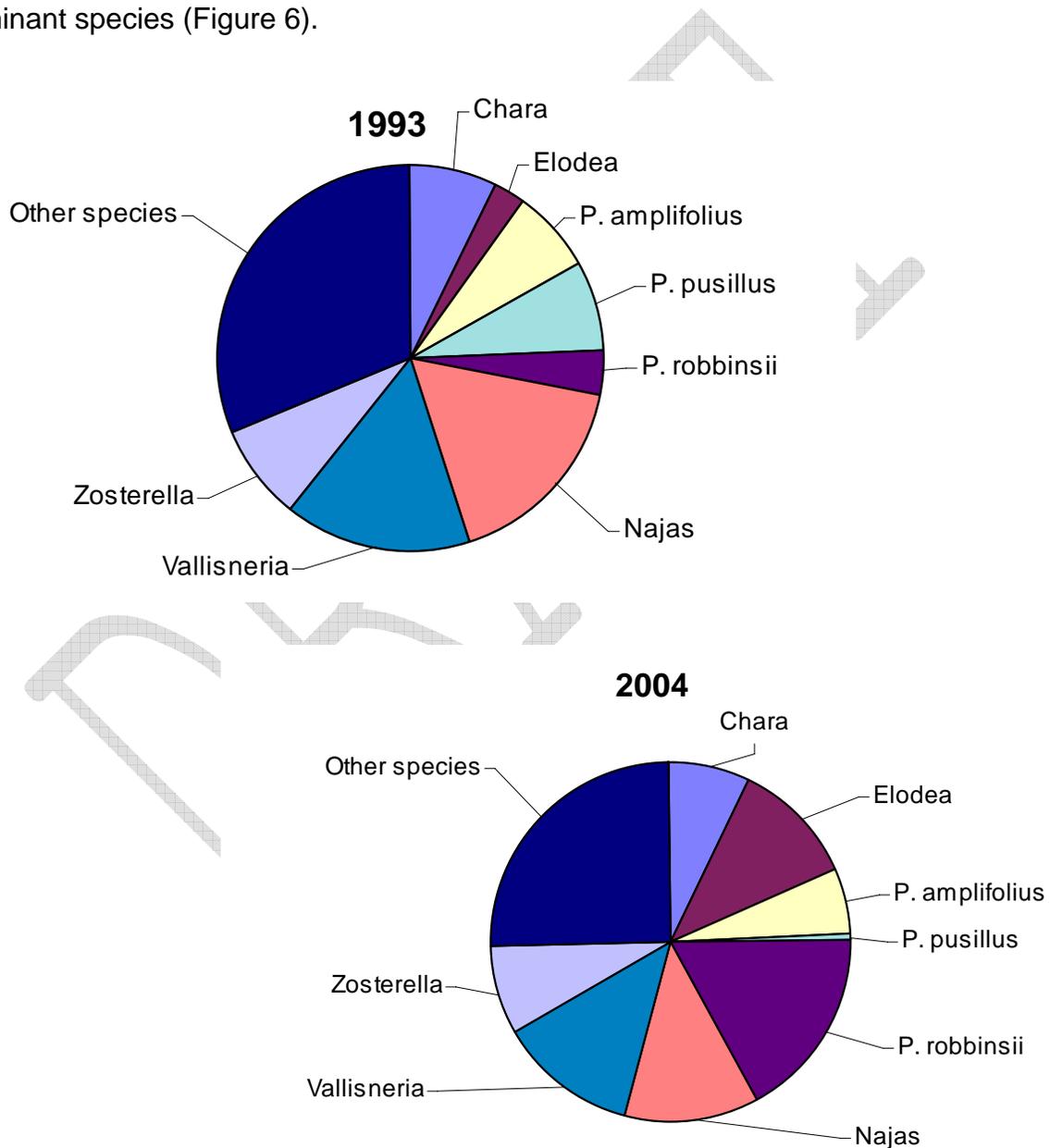


Figure 6. Dominance of the most prevalent aquatic plant species within the Perch Lake aquatic plant community, 1993-2004.

*Potamogeton robbinsii* became the dominant species because its dominance within the aquatic plant community increased, as did the dominance of *Elodea canadensis* (Figure 6). The Dominance Value of *Najas flexilis*, which had been dominant in 1993, decreased slightly, but did not decrease as much as the Dominance Value of *P. robbinsii* increased. Other species whose dominance decreased were *Potamogeton pusillus* and *Vallisneria americana* (Figure 6).

## DISTRIBUTION

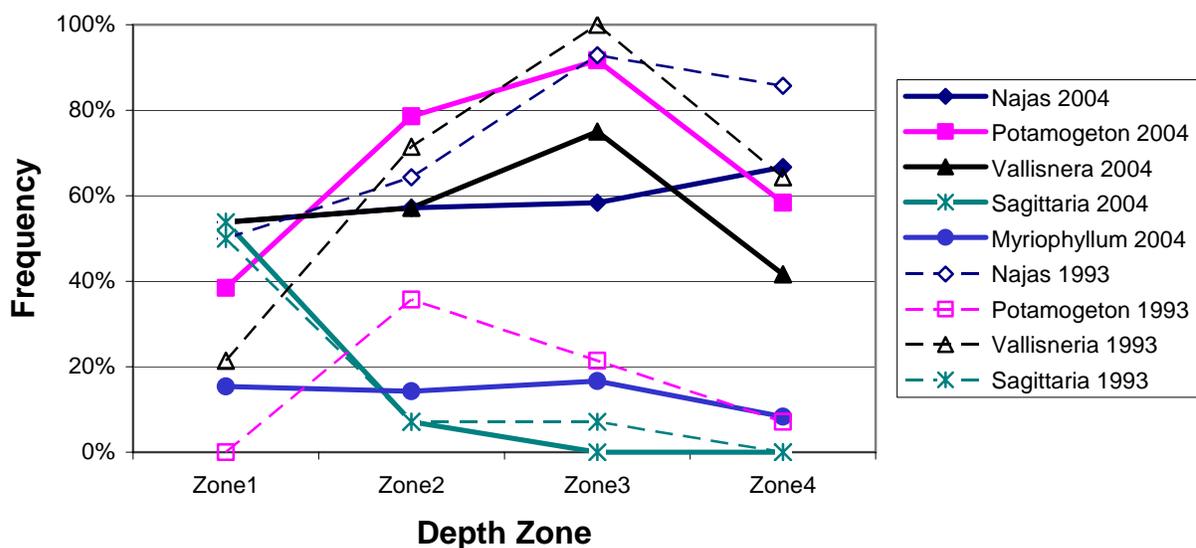
Aquatic plants occurred throughout the littoral zone of Perch Lake to maximum depth of 21 feet. Because much of the littoral zone in Perch Lake is steeply-sloped, plant growth was limited to a narrow band along the shoreline with the exception of the southwest bay, which had extensive plant beds. Overall, aquatic plants occurred at 93% of the sampling sites in 1993 and 98% of the sampling sites in 2004. The dominant, abundant and common species were distributed throughout the lake.

Secchi Disc water clarity data can be used to calculate and predicted maximum rooting depth (Dunst 1979).

**The predicted maximum rooting depth in Perch Lake, based on water clarity, is 20.7-21.4 feet.**

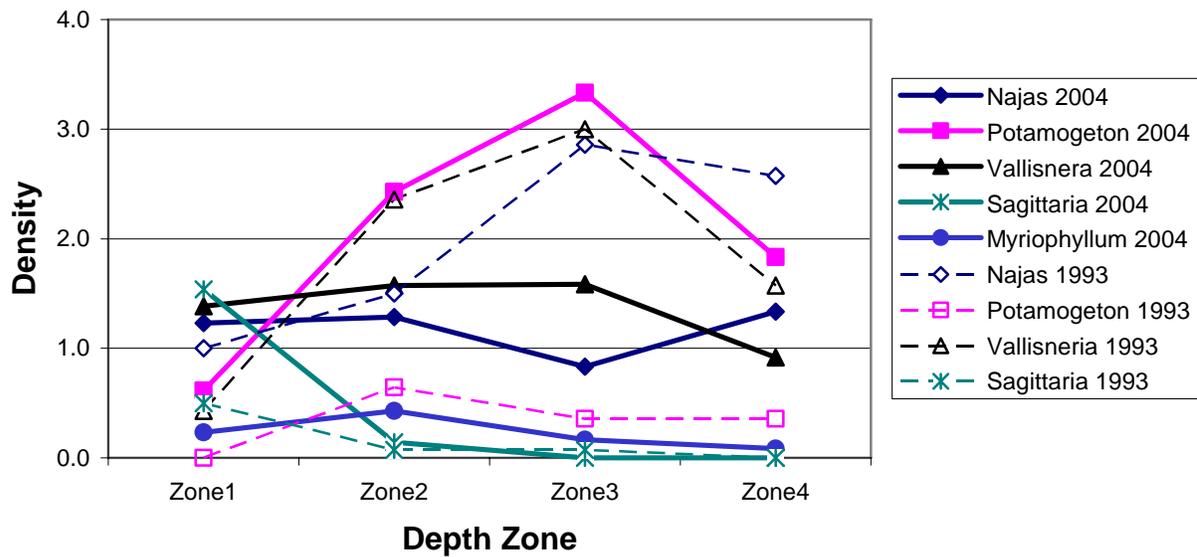
This is close to the actual maximum rooting depth of 21 feet recorded in Perch Lake.

*Sagittaria* spp. was the dominant species in the 0-1.5ft depth zone in 1993 and 2004. *Sagittaria* occurred at its highest frequency and density in this depth and declined with increasing depth. Its density increased between 1993 and 2004 (Figure 7, 8).



**Figure 7. Frequency of most prevalent aquatic plants by depth zone, 1993-2004.**





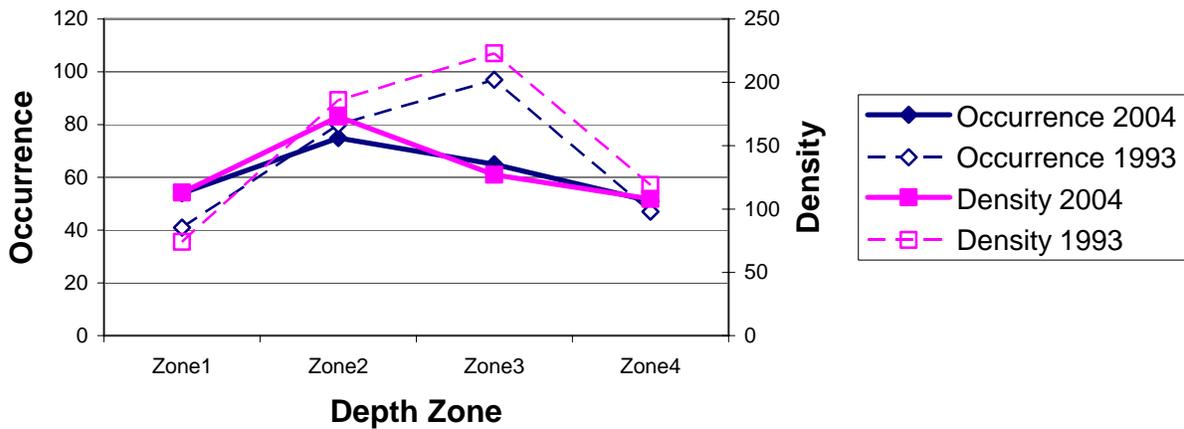
**Figure 8. Mean density of prevalent aquatic plants by depth zone, 1993-2004.**

*Vallisneria americana* was a sub-dominant species in both 1993 and 2004. *V. americana* was also the dominant species in the 1.5-10ft depth zone in 1993, occurring at its highest frequency and density in the 5-10ft depth zone. The frequency and density of *V. americana* decreased between 1993 and 2004 (Figure 7, 8).

*Potamogeton robbinsii*, the dominant species overall in 2004, dominated the 1.5-10ft depth zone in 2004 and had the highest mean density in the 10-20ft depth zone. *P. robbinsii* increased substantially between 1993 and 2004. *P. robbinsii* occurred at its highest frequency and density in the 5-10ft depth zone (Figure 7, 8).

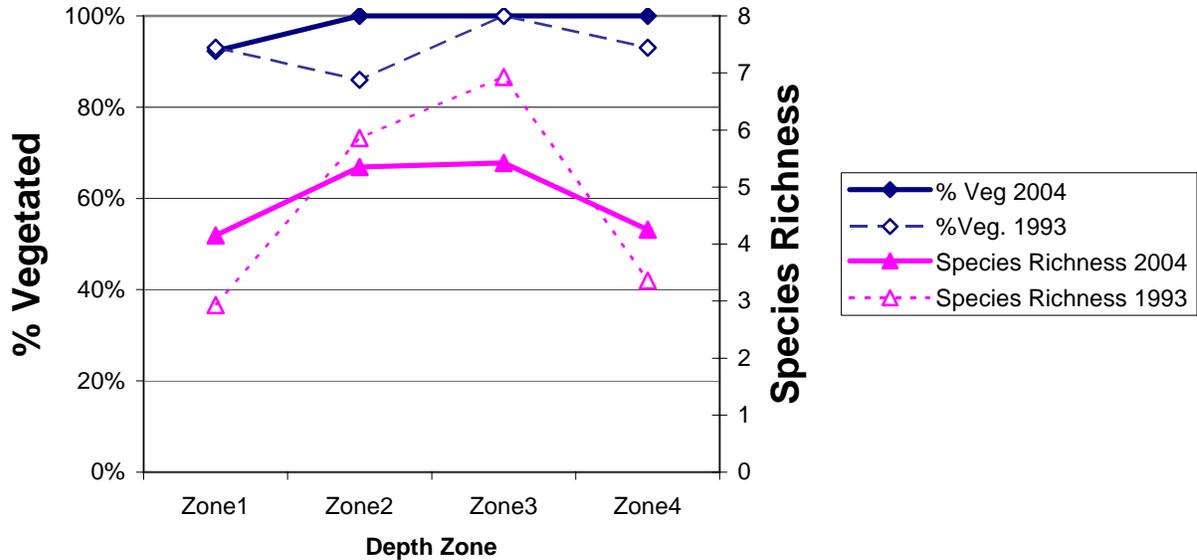
*Najas flexilis* had been the dominant species in 1993, but decreased in frequency and density in 2004, especially in the 5-10ft depth zone. *N. flexilis* was the sub-dominant species in 2004. *N. flexilis* had the highest frequency in the 10-20ft depth zone (Figure 7, 8).

Total occurrence of plants and total density of plant growth decreased between 1993 and 2004 (Figure 9). The highest total occurrence and total density of plant growth occurred in the 5-10ft depth zone in 1993, but shifted into the 1.5-5ft depth zone in 2004 (Figure 9).



**Figure 9. Total occurrence and total density of aquatic plant growth, by depth zone in Perch Lake, 1993-2004.**

The percent of the littoral zone vegetated increased between 1993 and 2004. The depth zone with the highest percent vegetation was the 5-10ft depth zone in 1993. The zone with the highest percent vegetation expanded to the 1.5-20ft depth zone in 2004.



**Figure 10. Percent of littoral zone vegetated and Species Richness in Perch Lake, by depth zone, 1993-2004.**

The greatest Species Richness (species per sample site) occurred in the 1.5-10ft depth zone in 1993 and in the 5-10ft depth zone in 2004 (Figure 10). Species Richness

increased slightly between 1993 and 2004.

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### **Change in Individual Species, 1993-2004**

Excerpted from the 1993 Perch Lake Aquatic Plant Report (Borman 1995):

*There were a number of aquatic plants identified in the 1993 survey as sensitive species (Davis and Brinson 1980). These species tend to disappear as alterations to the ecosystem increase. The sensitive species found in Perch Lake included one rosette species, needle spikerush, and five northern pondweeds: broad-leaf pondweed, variable-leaf pondweed, Illinois pondweed, floating-leaf pondweed and flat-stem pondweed. These plants are indicators of good water quality and low disturbance. If they become less frequent or disappear in future plant surveys, it can be an indication of water quality degradation.*

All of the six species mentioned by Borman (1995), except *Potamogeton illinoensis*, have either disappeared or decreased in the Perch Lake aquatic plant community.

Between 1993 and 2004, six species disappeared from the transects at Perch Lake: 3 emergent species, the turf-forming species noted by Borman (1995) that protects the lake bottom and 2 of the pondweed species noted by Borman (1995). Only one new species appeared, the exotic invasive species, Eurasian watermilfoil.

Seven species decreased in frequency, density and dominance: *Najas flexilis*, ***Potamogeton amplifolius***, ***P. gramineus***, ***P. natans***, *P. pusillus*, *Ranunculus longirostris*, *Vallisneria americana* (Appendix IX). *P. pusillus* decreased the most. The three bold-typed pondweeds were noted by Borman (1995).

Six species increased in frequency and density in Perch Lake between 1993 and 2004: *Brasenia schreberi*, *Ceratophyllum demersum*, *Elodea canadensis*, *Nitella*, *Potamogeton illinoensis*, *P. robbinsii* (Appendix IX). *P. robbinsii* increased the most, more than tripling in frequency, density and dominance. *Elodea canadensis* increased nearly as much, tripling in frequency and dominance. *P. illinoensis* doubled in frequency, density and dominance.

Five of the six species that increased, are known to increase to nuisance levels when nutrients increase in a lake ecosystem (Nichols and Vennie 1991).

### **Changes in Community, 1993-2004**

The Coefficient of Community Similarity measures the percent similarity between two communities. Coefficients less than 0.75 indicate that the communities are less than 75% similar and considered significantly different (Nichols pers. comm.)

**The Coefficient of Community Similarity of the 1993 and 2004 aquatic plant communities in Perch Lake was 0.705. This suggests that the 1993 and 2004 aquatic plant communities are only 70% similar and therefore significantly different (Appendix VIII).**

Several parameters that measure an aquatic plant community can be compared to show the type of changes that have occurred. Between 1993 and 2004, the number of species

occurring at the sample sites decreased 22% and emergent species disappeared from the sample sites. Other parameters that decreased were: the diversity index, the plant community's closeness to an undisturbed condition (Floristic Quality, discussed later) and the quality of the plant community (AMCI, discussed later) (Table 6).

Parameters that increased were: species richness (mean number of species per sample site), the percent of the littoral zone colonized by vegetation, cover of submergent vegetation, the community's sensitivity to disturbance (Average of Coefficient of conservatism, discussed later), coverage of floating-leaf vegetation and coverage of free-floating vegetation.

The greatest increase was in the coverage of floating-leaf vegetation, which more than doubled. The greatest decrease was the loss of emergent vegetation.

**Table 6. Changes in the Perch Lake Aquatic Plant Community, 1993-2004**

	1993	2004	Change 1993-2004	%Change 1993-2004
<b>Number of Species</b>	23	18	-5	-22%
<b>Maximum Rooting Depth</b>	21	21	0	0%
<b>% of Littoral Zone Vegetated</b>	93	98	5	5.4%
<b>%Sites/Emergents</b>	21		-21	-100%
<b>%Sites/Free-floating</b>	3.6	3.9	0.3	8%
<b>%Sites/Submergents</b>	89	98	9.0	10%
<b>%Sites/Floating-leaf</b>	7.0	16.0	9.0	129%
<b>Simpson's Diversity Index</b>	0.92	0.91	-0.01	-1%
<b>Average Coefficient of Conservatism</b>	5.62	5.76	0.14	2%
<b>Floristic Quality</b>	25.75	23.77	-1.98	-8%
<b>AMCI</b>	60	59	-1.0	-2%
<b>Species Richness</b>	4.76	4.80	0.04	0.8%

The Aquatic Macrophyte Community Index (AMCI) developed by Nichols, et al (2000) was applied to Perch Lake. The AMCI for Perch Lake decreased slightly from 60 in 1993 to 59 in 2004 (Table 7). The maximum for the value is 70.

The AMC Indices for Perch Lake were in the upper quartile of lakes in the state and region, indicating that Perch Lake is within the top 25% of the lakes in the state and region with the highest quality aquatic plant community.

**Table 7. Aquatic Macrophyte Community Index, Perch Lake, 1993-2004**

Category	1993		2004	
	Maximum Rooting Depth	6.4 meters	10	6.4 meters
% Littoral Zone Vegetated	93%	10	98%	10
Simpson's Diversity	92	9	91	9
# of Species	23	9	18	8
% Submergent Species	92% Rel. Freq.	8	93% Rel. Freq.	7
Exotic Species	0	10	3% Rel. Freq.	8
% Sensitive Species	3 % Rel. Freq.	4	14% Rel. Freq.	7
Totals		60		59

The Average Coefficient of Conservatism for Perch Lake was below the mean for all Wisconsin lakes analyzed and above the mean for lakes in the North Central Hardwood Region (Table 8) in both 1993 and 2004. This suggests that the aquatic plant community in Perch Lake is more tolerant of disturbance than the average lake in Wisconsin and less tolerant of disturbance than the average lake in the North Central Hardwoods Region.

**Table 8. Floristic Quality and Coefficient of Conservatism of Perch Lake, Compared to Wisconsin Lakes and Northern Wisconsin Lakes, 1993-2004.**

	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
Perch Lake 1993	5.62	25.75
Perch Lake 2004	5.76	23.73

\* - 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 Perch Lake was in the upper quartile of lakes in the North Central Hardwood Lakes Region and above the mean for Wisconsin lake in 1993 (Table 8). In 2004, the Floristic Quality decreased and was above the mean for lakes in the state and region. This suggests that the plant community in Perch Lake is closer to an undisturbed condition than the average lake in the state and region and moved farther from an undisturbed condition between 1993 and 2004.

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, 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.

Disturbances in Perch Lake likely include toxic run-off from roads, nutrient enrichment from watershed run-off that decreased water clarity, introduction of a non-native aquatic

plant species and past fluctuating water levels.

#### **IV. DISCUSSION**

Perch Lake has been designated as an Outstanding Resource Water in the state. It is an oligotrophic lake with very good water quality and clarity. Between 1993 and 2004, there has been an increase in nutrient concentration (phosphorus) and a decrease in water clarity. This change in nutrients and clarity is pushing Perch Lake from an oligotrophic status to a mesotrophic status. Crossing this threshold will result in increased aquatic plant growth and more frequent and severe algae blooms.

The very good water clarity and areas with a gradually sloped littoral zone would favor plant growth. The low nutrients, soft water, dominance of high-density sand and gravel sediments, fluctuating water levels and areas with steeply-sloped littoral zone could limit aquatic plant growth.

The aquatic plant community in Perch Lake is closer to an undisturbed condition than the average lake and characterized by excellent species diversity, an average sensitivity to disturbance and a high quality aquatic plant community. Aquatic plants colonize the entire littoral zone, 93-98%, up to the maximum rooting depth of 21 feet. The 1.5-5ft depth zone supported the greatest amount of aquatic plant growth in 2004.

There was a total of 26 species found during the plant survey. *Potamogeton robbinsii* was the dominant species in 2004, especially in the 1.5-10ft depth zone. *P. robbinsii* exhibited a growth form of above average density in Perch Lake. *Najas flexilis* and *Vallisneria americana* were sub-dominant in 2004. Another species that exhibited an aggregated or dense growth form was *Sagittaria* spp., which dominated the 0-1.5ft depth zone. This species increased in density from 1993 to 2004. The dominant abundant and common species were distributed throughout the lake.

Perch Lake has some protection from natural shoreline. Some type of natural shoreline covered 66% of the lake shore. Native herbaceous cover had the highest occurrence and wooded shoreline covered 31% of the shore.

However, disturbed shoreline covered 33% of the shore. Cultivated lawn, paved and gravel roads, hard structures were commonly encountered on the shore. Cultivated lawn alone covered 12% of the shore. There are several reasons for concerns about non-natural shorelines. Cultivated lawn increases the run-off of fertilizers and pesticides into the lake that could feed increased algae and plant growth and harm portions of the aquatic community. Road surfaces and hard structures also increase run-off, can contribute toxic substances and are detrimental to the aesthetics of the lake.

#### **Changes**

There has been a significant change in the aquatic plant community in Perch Lake between 1993 and 2004 as measured by Coefficients of Community Similarity. The 1993 and 2004 aquatic plant communities are only 70% similar.

The dominant species in Perch Lake changed from *Najas flexilis* with *Vallisneria americana* as sub-dominant in 1993 to *Potamogeton robbinsii* with *Najas flexilis* and *Vallisneria americana* as sub-dominant in 2004.

The depth zone that supported the greatest amount of aquatic plant growth shifted from the 5-10ft depth zone in 1993 to the 1.5-5ft depth zone in 2004.

Increases from 1993-2004:

- 1) The percent of vegetated sites
- 2) Species Richness (number of species per sample site). Richness decreased in the shallowest and deepest depth zone, but increased in the 5-10ft zone.
- 3) Coverage of free-floating, submergent and floating-leaf species
- 4) Sensitivity to disturbance
- 5) Frequency, density and dominance of six species increased in Perch Lake, five of which are known to increase to nuisance levels with an increase in nutrients.
- 6) Three of these species doubled or tripled in frequency and density, *Elodea canadensis*, *Potamogeton illinoensis* and *P. robbinsii*.
- 7) *Potamogeton robbinsii* increased dramatically in frequency of occurrence and coverage. Its growth form increased from a below average density in 1993 to above average density in 2004.

Decreases from 1993-2004:

- 1) Emergent species disappeared from the transects, possibly due to water level fluctuations.
- 2) Loss of three other species: a turf-forming spikerush that protects the lake bed and two pondweed species that are valuable habitat.
- 3) Total occurrence and total density of aquatic plants species
- 4) Number of aquatic plant species decreased 22%
- 5) Species Diversity Index
- 6) Slight decrease in quality of the aquatic plant community (AMCI)
- 7) Floristic Quality Index, indicating increased disturbance in the plant community. The disturbances may include:
  - a) nutrient enrichment that results in reduced water clarity
  - b) reduced water clarity
  - c) past water level fluctuations
  - d) introduction of a non-native aquatic plant species

The change of concern in Perch Lake is the introduction of Eurasian watermilfoil sometime after spring 2002. This exotic invasive species has spread to cover the south, east and north shores out to a depth of 12 feet. However, Eurasian watermilfoil has a low dominance in Perch Lake at this time. It is not commonly occurring and occurs at low densities, making up only 5% of the community at this time. The steeply-sloped littoral zone and large areas of deep water in Perch Lake will likely prevent Eurasian watermilfoil from "taking over the lake". It will at worst, form a narrow band around the entire shore, leaving large areas of deep water open for recreation.

## V. CONCLUSIONS

Perch Lake, a designated Outstanding Resource Water, is an oligotrophic lake with very good water quality and clarity. However, the water clarity has been decreasing and the nutrients have been increasing since 1993 and are pushing Perch Lake close to a mesotrophic status. Crossing this threshold will result in noticeably decreased water clarity, more frequent and severe algae blooms and possibly increased aquatic plant growth.

The aquatic plant community of 26 species colonizes the entire littoral zone (98%) to a maximum rooting depth of 21 feet. The greatest amount of plant growth occurred in the 1.5-5ft depth zone. *Potamogeton robbinsii* was the dominant species in 2004, especially in the 1.5-10ft depth zones and exhibited a growth form of above average density. *Najas flexilis* and *Vallisneria americana* were sub-dominant species in the community.

The high quality aquatic plant community in Perch Lake is characterized by excellent species diversity, an average sensitivity to disturbance and is closer to an undisturbed condition than the average lake in Wisconsin and the North central Hardwoods Region.

Eurasian watermilfoil was introduced into Perch Lake since early 2002. Currently, this exotic, invasive species is found scattered along most of the north, east and south shores, but is not common in the Perch Lake and exhibited a low density of growth, a minor species in the community.

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

1) improving water quality 2) providing valuable habitat resources for fish and wildlife 3) resisting invasions of non-native species and 4) checking excessive growth of tolerant species that could crowd out the more sensitive species, thus reducing diversity.

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

The excellent distribution of plants in Perch Lake enhances their functional value in protecting water quality.

2) Aquatic plant communities provide important fishery and wildlife resources. Plants and algae start the food chain that supports many levels of wildlife, and at the same time produce oxygen needed by animals. Plants are used as food, cover and nesting/spawning sites by a variety of wildlife and fish (Table 9). The dominant and sub-

dominant species in Perch Lake; fern-leaf pondweed, wild celery and slender naiad; are noteworthy as excellent fish and waterfowl plants.

- a) Wild celery is considered a premier waterfowl plant, particularly for diving ducks. It also provides food and cover for a variety of fish.
- b) Slender naiad is an annual plant which has prolific seed production. These seeds are ranked as an excellent food value for waterfowl. Slender naiad also provides high quality fish cover and supports a varied population of invertebrates for fish grazing.
- c) Fern pondweed is an important buffer against exotic species invasions and an important food and shelter for fish, especially northern pike

Plant cover within the littoral zone of Perch Lake is 98%, which is high for the ideal coverage (25-85%) to support a balanced fishery. However, the steep slope of the littoral zone in Perch Lake limits this coverage to a thin band in most areas.

Compared to non-vegetated lake bottoms, aquatic 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).

There has been a significant change in the aquatic plant community in Perch Lake from 1993-2004. The dominant species has changed from *Najas flexilis* in 1993 to *Potamogeton robbinsii* in 2004. This was due mainly to a dramatic increase in *P. robbinsii*.

Changes of concern in Perch Lake are:

- 1) the increase in nutrient concentration
- 2) the decrease in water clarity
- 3) decrease or loss of 5 of the 6 species identified as sensitive species in 1993 whose loss could indicate water quality degradation
- 4) loss of emergent vegetation at the transects
- 5) decrease in the number of species found at the transect
- 6) decrease in the Simpson's Diversity Index
- 7) increase of five species that are known to increase to nuisance potential with nutrient enrichment to the lake
- 8) introduction of Eurasian watermilfoil

### **Recommendations**

- 1) Township to maintain motor restriction on Perch Lake. Large gas motors would result in increased pollutants into the water, spreading of the Eurasian watermilfoil from fragmentation by propellers, shoreline erosion from wakes near shore, reduced water clarity from propeller suspension of lake bed sediments.
- 2) Survey Perch Lake for the presence of native milfoil weevils. Since native

northern watermilfoil has been a common member of the aquatic plant community during 1993-2004. The crash of the Eurasian watermilfoil population in Bass Lake, St. Croix County, has been attributed to the milfoil weevil (Konkel 2003). It is very likely that milfoil weevils occur in Perch Lake and could provide the best long-term control of Eurasian watermilfoil. This biological control method would be more ecologically sound, cheaper and easier. However, it is imperative to preserve natural shoreline all around the lake for the weevil's winter habitat.

- 3) Lakeshore residents develop a Eurasian watermilfoil control strategy as part of an aquatic plant management plan with the help of county park officials and DNR staff.
  - a. Chemical treatments in Perch Lake would result in a large nutrient flush to the system that would promote algae blooms and decrease water clarity.
  - b. Mechanical harvesting is not practical in Perch Lake due to the location of the Eurasian watermilfoil as a band near the shore where a harvester could not navigate.
  - c. Hand removal. This is feasible around the docks and along the shoreline of lakeshore property owners. Although it is a large task to control all the Eurasian watermilfoil, it is feasible where milfoil conflicts with recreation. A training session on Eurasian watermilfoil identification and removal methods could be presented by the DNR to lakeshore property owners.
  - d. Biological control. After surveying for milfoil weevils, investigate the feasibility of weevil control, naturally or by augmenting the population.
- 4) Lake shore residents protect and expand natural shoreline buffers that protect water quality and provide habitat. **This is especially important for Eurasian watermilfoil control by the milfoil weevil to provide winter habitat for the weevil.** In 2004, natural native shoreline covered 2/3 of the shore, but this means that disturbed shoreline covers 1/3 of the shore. Mowed lawn, paved and gravel road and hard structures were all common and do not provide the filtering capacity of natural shoreline vegetation. Increased run-off to the lake of fertilizers and pesticides from lawns can compromise habitat and water quality. Increased run-off of toxics and debris comes from roads and hard structures.
- 5) Residents and agencies initiate and cooperate with programs that protect land in the watershed. Since the watershed to lake surface area in Perch Lake is 9:1, this is approaching the range at which watershed impacts can overwhelm a lake's ability to dilute run-off. There has already been an increase of nutrients and decrease in water clarity since 1993. The plant community is also suggesting this decreased water clarity through;
  - a. the shifting of the depth zone with the greatest amount of plant growth into a shallower zone,
  - b. the loss or decrease of 5 species sensitive to decreased water quality.The increase in nutrients is suggested by
  - a. the increase in coverage of aquatic vegetation,
  - b. the increase in three classifications (free-floating, rooted floating-leaf and submergent)

- c. the increase of five species in Perch Lake that are known to increase in a lake with nutrient enrichment to the lake.
- 6) Lakeshore residents explore the possibility of restoring emergent beds with help of county and state grant programs. Many of the emergent beds have been lost since 1993. Emergent beds provide fish spawning areas, premier wildlife habitat, protect the shoreline from erosion, stabilize the nearshore lake sediments and provide natural beauty.
- 7) Careful planning and protection will be required to preserve the integrity of Perch Lake's aquatic plant community which plays a pivotal role in water quality and provides needed habitat for fish, waterfowl and wildlife. Perch Lake is located in a part of St. Croix County that is experiencing significant development pressure and its aquatic plant community includes species sensitive to environmental change.

DRAFT

## **EXECUTIVE SUMMARY**

Perch Lake, an Outstanding Resource Water, is an oligotrophic lake with very good water quality and clarity. The water clarity has been decreasing and the nutrients have been increasing since 1993 and are pushing Perch Lake close to a mesotrophic status.

The Perch Lake aquatic plant community colonizes the entire littoral zone to a maximum rooting depth of 21 feet. The greatest amount of plant growth occurred in the 1.5-5ft depth zone. *Potamogeton robbinsii* was the dominant species in 2004, especially in the 1.5-10ft depth zones and exhibited a growth form of above average density. *Najas flexilis* and *Vallisneria americana* were sub-dominant species in the community.

The high quality aquatic plant community in Perch Lake is characterized by excellent species diversity, an average sensitivity to disturbance and is closer to an undisturbed condition than the average lake in Wisconsin and the North central Hardwoods Region.

There has been a significant change in the aquatic plant community in Perch Lake from 1993-2004. The dominant species has changed from *Najas flexilis* in 1993 to *Potamogeton robbinsii* in 2004. Eurasian watermilfoil has been introduced into Perch Lake since early 2002. Emergent vegetation has been lost from the plant community. Three submergent species have been lost. Five sensitive species have either declined or disappeared. Increase in five species that are favored by nutrient enrichment

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.

## **Recommendations**

- 1) Township maintain motor restriction on Perch Lake
- 2) Survey Perch Lake for the presence of native milfoil weevils.
- 3) Lakeshore residents develop a Eurasian watermilfoil control strategy as part of an aquatic plant management plan with the help of county park officials and DNR staff.
- 4) Lake shore residents protect and expand natural shoreline buffers.
- 5) Residents and agencies initiate and cooperate with programs that protect land in the watershed.
- 6) Lakeshore residents explore the possibility of restoring emergent beds with help of county and state grant programs.
- 7) Maintain exotic species signs at the boat landing.