THE AQUATIC PLANT COMMUNITY OF JORDAN LAKE, ADAMS COUNTY, WI

2006

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I. INTRODUCTION

An aquatic macrophyte (plant) field study on Jordan Lake was conducted during between 2004 and 2006 by a staff member of the Wisconsin Department of Natural Resources, a staff member from the Adams County Land and Water Conservatism Department and a private consultant hired by the Jordan Lake District.

Information about the diversity, density and distribution of aquatic plants is an essential component in understanding the lake ecosystem due to the integral ecological role of aquatic vegetation in the lake and the ability of vegetation to impact water quality (Dennison et al, 1993). This study will provide information useful for effective management of Jordan Lake, including fish habitat improvement, protection of sensitive areas, aquatic plant management, and water resource regulation. This baseline data will provide information that can be used for comparison to future information and offer insight into changes in the lake.

Ecological Role: Lake plant life is the beginning of the lake's food chain, the foundation for all other lake life. Aquatic plants and algae provide food and oxygen for fish and wildlife, as well as cover and food for the invertebrates that many aquatic organisms depend on. Plants provide habitat and protective cover for aquatic animals. They also improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake, and impact recreation.

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

Background and History: Jordan Lake is located in the Town of Jackson, Adams County, Wisconsin. The impoundment is over 213 surface acres in size. Maximum depth is over 80'. During the summer of 2006, when the last part of the aquatic plant survey was gathered, the lake was at slightly lower level than usual due to drought and very hot weather. There are public boat ramps located on the west and north sides of the lake.

Jordan Lake is easily accessible off of County Road G. Residential development around the lake is found along most of the lakeshore. The surface watershed is 17.4% residential, 21.3% non-irrigated agriculture, 8.8% irrigated agriculture; 2.7% open grasslands; 23.7% woodlands, and 26.6% water. The ground watershed contains 24.65% non-irrigated agriculture, 21.11% irrigated agriculture, 1.33% open grasslands, 26.2% woodlands, 16.6% residential, and 9.02% water. There are reports of banded killifish, an endangered species, in Jordan Lake. Native American burial mounds (Jordan Lake Group) are located on the north side of the lake. There are large wetland areas located east of the lake and on the northwest side of the lake.

The most recent fish shocking survey was conducted on Jordan Lake in October 2006. A good panfish population was found, including bluegills, crappie and perch. Less common were largemouth bass and northern pike.

Soils directly around Jordan Lake tend to be sands or loamy sands of various slopes. Such soils tend to be excessively-drained, with infiltration of water being rapid to very rapid, and permeability also high. Such soils also usually have a low water-holding and low organic matter content, thus making them difficult to establish vegetation on. These soils tend to be easily eroded by both water and wind.

Historically, management of aquatic plant growth has been by chemical treatments starting in 1981. Several different chemicals have been used, with up to half the lake being treated chemically at one time and multiple treatments within a year also occurring. Early treatments were broad-spectrum treatments that targeted all plant species and may have opened areas for invasion and colonization of the two exotic species now in the lake. Later treatments, from approximately 1980 onwards, were more selective, targeting Eurasian Watermilfoil. Chemical applications are listed below:

Year	Diquat (gal)	AV70 (gal)	Aquacide (lbs)	2,4-D (lbs)	Navigate (lbs)	DMA 4_IVM (gal)	Aqua-Kleen (lbs)
1981	1.5	4					
1982	5						
1990			15				
1997				20			
1998			100	60			
1999			115				
2000			100		25		
2001			175				
2002					2005		
2003					1050	210	
2004					245.88		3763
2005					2745		
2006					385		
	6.5	4	505	80	6455.88	210	3763
	gal	gal	lbs	lbs	lbs	gal	lbs

In 2002, the residents of the area formed the Jordan Lake District for carrying out programs to improve the lake. The Lake District completed a lake management plan in 2006 that is awaiting approval by the WDNR.

II. <u>METHODS</u>

Field Methods

The study was based on the rake-sampling method developed by Jessen and Lound (1962), using stratified random transects. The shoreline was divided into 12 equal sections, with one transect placed randomly within each segment, perpendicular to the shoreline.

One sampling site was randomly chosen in each depth zone (0-1.5 feet; 1.5-5 feet; 5-10 feet; 10-20 feet) along each transect. Using long-handled, steel thatching rakes, four rake samples were taken at each site. Samples were taken from each quarter around the boat. Aquatic species present on each rake were recorded and given a density rating of 0-5.

A rating of 1 indicates the species was present on 1 rake sample.

A rating of 2 indicates the species was present on 2 rake samples.

A rating of 3 indicates the species was present on 3 rake samples.

A rating of 4 indicates the species was present on 4 rake samples.

A rating of 5 indicates that the species was <u>abundantly</u> present on all rake samples.

A visual inspection and periodic samples were taken between transects to record the presence of any species that didn't occur at the raking sites. Gleason and Cronquist (1991) nomenclature was used in recording plants found.

Shoreline type was also recorded at each transect. Visual inspection was made of 50 feet to the right and left of the boat along the shoreline, 35 feet back from the shore (so total view was 100' x 35'). Percent of land use within this rectangle was visually estimated and recorded.

Data Analysis:

The percent frequency (number of sampling sites at which it occurred/total number of sampling sites) of each species was calculated. Relative frequency (number of species occurrences/total of all species occurrences) was also determined. The mean density (sum of species' density rating/number of sampling sites) was calculated for each species. Relative density (sum of species' density/total plant density) was also determined. "Mean density where present" (sum of species' density rating/number of sampling sites at which species occurred) was calculated. Relative frequency and relative density results were summed to obtain a dominance value. Species diversity was measured by Simpson's Diversity Index.

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

An Aquatic Macrophyte Index was determined using the method developed by Nichols et al (2000). This measurement looks at the following seven parameters and assigns each of them a number on a scale of 1-10: maximum depth of plant growth; percentage of littoral zone vegetated; Simpson's diversity index; relative frequency of submersed species; relative frequency of sensitive species; taxa number; and relative frequency of exotic species. The average total for the North Central Hardwoods lakes and impoundments is between 48 and 57.

III. RESULTS

Physical Data

The aquatic plant community can be impacted by several physical parameters. Water quality, including nutrients, algae and clarity, influence the plant community; the plant community in turn can modify these criteria. Lake morphology, sediment composition and shoreline use also affect the plant community.

The trophic state of a lake is a classification of water quality (see Table 1). Phosphorus concentration, chlorophyll a concentration and water clarity data are collected and combined to determine a trophic state. **Eutrophic lakes** are very productive, with high nutrient levels and large biomass presence. **Oligotrophic lakes** are those low in nutrients with limited plant growth and small fisheries. **Mesotrophic lakes** are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes;

those with a good and more varied fishery than either the eutrophic or oligotrophic lakes.

The limiting nutrient in most Wisconsin lakes, including Jordan Lake, is phosphorus. Measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. **The 2004-2006 summer average phosphorus concentration in Jordan Lake was 28.86 ug/l.** This is above the average for natural lakes (20 ug/l). This concentration suggests that Jordan Lake is likely to have some nuisance algal blooms. . Such total phosphorus readings place Jordan Lake in the "good" water quality category for lakes and in the "mesotrophic" level for phosphorus (Table 1). It is worth noting that Total Phosphorus readings for the lower depths of Jordan Lake are approximately three times that of the surface level readings, suggesting that the lake bottom may be serving as a phosphorus sink.

Chlorophyll a concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth. **The 2004-2006 summer average chlorophyll a concentration in Jordan Lake was 2.54 ug/l.** This low chlorophyll a level places Jordan Lake at the "oligotrophic" level for chlorophyll a results (Table 1).

Water clarity is a critical factor for plants. If plants receive less than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a

Secchi disk. **Average summer Secchi disk clarity in Jordan Lake in 2004-2006 was 10.7'.** This is very good clarity, putting Jordan Lake into the "oligotrophic" category for water clarity (Table 1).

It is normal for all of these values to fluctuate during a growing season. They can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events. Phosphorus tends to rise in early summer, than decline as late summer and fall progress. Chlorophyll a tends to rise in level as the water warms, then decline as autumn cools the water. Water clarity also tends to decrease as summer progresses, probably due to algae growth, then increase as fall approaches.

Table 1: Trophic States

Trophic State	Quality Index	Phosphorus	Chlorophyll a	Sechhi Disk
		(ug/l)	(ug/l)	(ft)
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	**1 to 5**	**8 to 19**
Mesotrophic	Good	**10 to 30**	5 to 10	6 to 8
	Fair	30 to 50	10 to 15	5 to 6
Eutrophic	Poor	50 to 150	15 to 30	3 to 4
Jordan Lake		**28.66**	**2.54**	**10.7'**

According to these results, Jordan Lake scores as **"mesotrophic"** in its phosphorus readings, but **"oligotrophic"** in its chlorophyll a and Secchi disk readings. With such phosphorus readings, considerable plant growth and very occasional algal blooms would be expected.

Jordan Lake readings for hardness score its water as “hard”. Its pH between 2004 and 2004 ranged between 6.11 and 8.65. Such hard water lakes tend to produce more fish and aquatic plants than soft water lakes.

Lake morphology is an important factor in distribution of lake plants. Duarte & Kalff (1986) determined that the slope of a littoral zone could explain 72% of the observed variability in the growth of submerged plants. Gentle slopes support higher plant growth than steep slopes (Engel 1985).

Jordan Lake is an oval natural lake with several areas of sharply-dropping slopes. With very good water clarity, the near-shore depths and even some depths further out from shore in Jordan Lake would support plant growth, since the sun can reach much of the sediment to stimulate plant growth.

Sediment composition can also affect plant growth, especially those rooted. The richness or sterility and texture of the sediment will determine the type and abundance of macrophyte species that can survive in a particular site.

Table 2: Sediment Composition—Jordan Lake

		Zone 1	Zone 2	Zone 3	Zone 4	Overall
Hard	Sand	60.87%	52.18%	100.00%	100.00%	78.26%
Sediments	Sand/Gravel	4.35%				1.09%
Mixed	Sand/Peat	4.35%	4.35%			2.17%
Sediments	Sand/Silt	4.35%				1.09%
Soft	Peat		34.78%			8.70%
Sediments	Peat/Silt	8.69%				2.17%
	Silt	13.04%	8.69%			5.43%
	Silt/Marl	4.35%				1.09%

Over 78% of the sediment in Jordan Lake is hard with little natural fertility and minimal available water holding capacity. Although sand sediment may limit growth, all sandy sites in Jordan Lake were vegetated in the shallower depths. In fact, 97.8% of the sample sites were vegetated in Jordan Lake, no matter what the sediment. Sediment composition does not appear to be a limiting factor in aquatic plant growth in Jordan Lake.

Shoreline land use often strongly impacts the aquatic plant community and thus the entire aquatic community. Impacts can be caused by increased erosion and sedimentation and higher run-off of nutrients, fertilizers and toxins applied to the land. Such impacts occur in both rural and residential settings.

Some type of natural vegetation covered 28.27% of the lake shoreline. Some 71.73% of Jordan Lake's shoreline was covered with disturbance. Traditional cultivated lawn was the shoreline type with highest coverage (42.17%). Other disturbed sites, such as those with rock/riprap, and hard structures (piers, etc), were also frequent, covering over 17.82% of the shoreline. Bare unprotected soil or eroded soil had 11.74% coverage of the shore.

Table 3: Shoreland Land Use—Jordan Lake

		Frequency	Coverage
Vegetated	Herbaceous	78.26%	20.22%
Shoreline	Shrub	13.04%	1.96%
	Wooded	21.74%	6.09%
Disturbed	Bare Sand/Eroded	69.40%	11.74%
Shoreline	Cultivated Lawn	73.91%	42.17%
	Hard Structure	86.96%	15.00%
	Rock Riprap	17.39%	2.82%

Macrophyte Data

SPECIES PRESENT

Of the 35 species found in Jordan Lake, 32 were native and 3 were exotic invasives. In the native plant category, 10 were emergent, 3 were floating-leaf rooted plants, 1 was a free-floating plant, and 18 were submergent types (see Table 4). Three exotic invasives, *Myriophyllum spicatum* (Eurasian Watermilfoil), *Phalaris arundinacea* (Reed Canarygrass) and *Potamogeton crispus* (Curly-Leaf Pondweed) were found.

Table 4—Plants Found in Jordan Lake, 2006

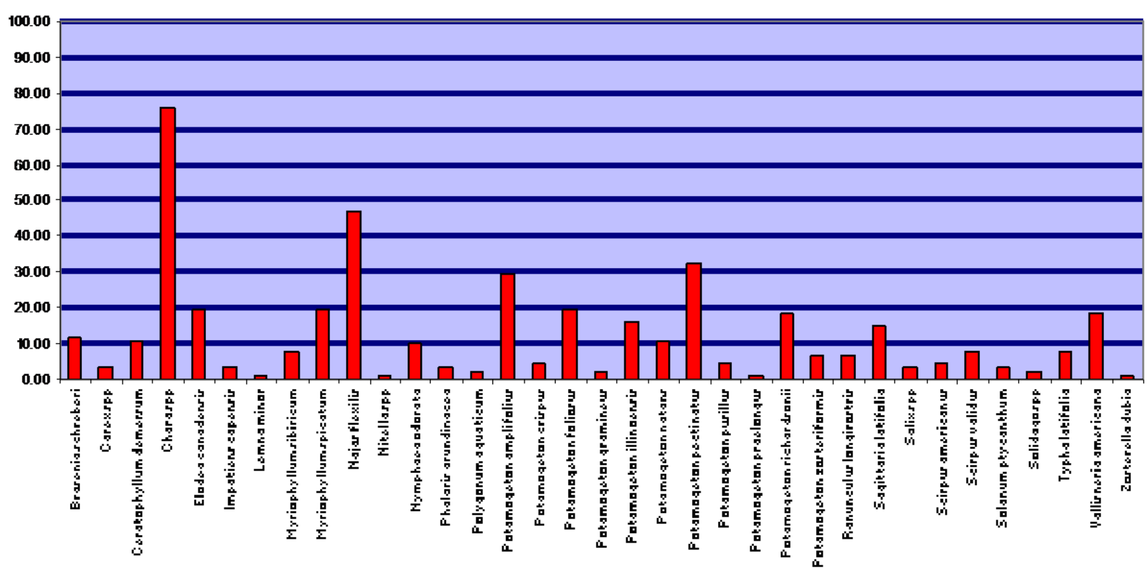
Scientific Name	Common Name	Type
Brasenia schreberi	Watershield	Floating-Leaf
Carex spp	Sedges	Emergent
Ceratophyllum demersum	Coontail	Submergent
Chara spp	Muskgrass	Submergent
Elodea canadensis	Waterweed	Submergent
Impatiens capensis	Jewelweed	Emergent
Lemna minor	Small Duckweed	Free-Floating
Myriophyllum sibiricum	Northern Milfoil	Submergent
Myriophyllum spicatum	Eurasian Watermilfoil	Submergent
Najas flexilis	Bushy Pondweed	Submergent
Nitella spp	Brittlewort	Submergent
Nymphaea odorata	White Water Lily	Floating-Leaf
Phalaris arundinacea	Reed Canarygrass	Emergent
Polygonum aquaticum	Water Smartweed	Floating-Leaf
Potamogeton amplifolius	Large-Leaf Pondweed	Submergent
Potamogeton crispus	Curly-Lead Pondweed	Submergent
Potamogeton foliosus	Leafy Pondweed	Submergent
Potamogeton gramineus	Variable-Leaf Pondweed	Submergent
Potamogeton illinoensis	Illinois Pondweed	Submergent
Potamogeton natans	Floating-Leaf Pondweed	Submergent
Potamogeton pectinatus	Sago Pondweed	Submergent
Potamogeton pusillus	Small Pondweed	Submergent
Potamogeton praelongus	White-Stem Pondweed	Submergent
Potamogeton richardsonii	Clasping-Leaf Pondweed	Submergent
Potamogeton zosteriformis	Flat-Stem Pondweed	Submergent

Ranunculus longirostris	Longbeak Buttercup	Emergent
Sagittaria latifolia	Arrowhead	Emergent
Salix spp	Willow	Emergent
Scirpus americanus	Chairmaker's Bulrush	Emergent
Scirpus validus	Soft-Stem Bulrush	Emergent
Solanum ptycanthum	Nightshade	Emergent
Solidago spp	Goldenrod	Emergent
Typha latifolia	Wide-Leaf Cattail	Emergent
Vallisneria americana	Water Celery	Submergent
Zosterella dubia	Water Stargrass	Submergent

FREQUENCY OF OCCURRENCE

Chara spp was the most frequently-occurring "plant" in Jordan Lake in 2006 overall (76.09% occurrence frequency. No other species reached a frequency of 50% or greater, although *Najas flexilis* was close with 46.74% occurrence frequency.

Chart 1: Occurrence Frequency



Chara spp was the most frequently-occurring plant in each of the four depth zones, occurring between 52.38% (Depth Zone 4) and 95.65% (Depth Zone 2).

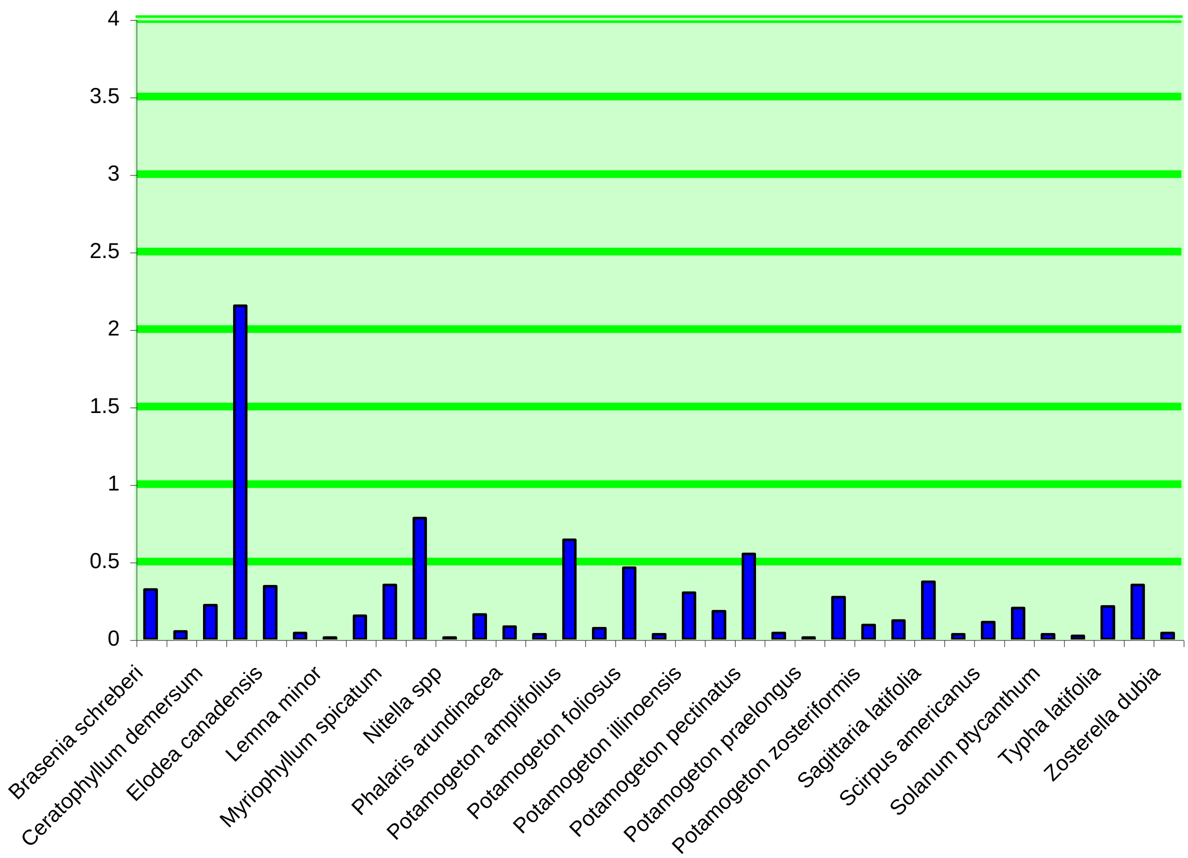
In the shallowest depth zone, both *Potamogeton pectinatus* and *Sagittaria latifolia* occurred with more than 50% frequency. In Zone 3 and 4, *Najas flexilis* occurred at more than 50% frequency.

DENSITY OF OCCURRENCE

Chara spp was the densest plant in Jordan Lake, with a mean density of 2.15 overall (on a scale of 0-4). It was the only species with a mean density over 2.0, meaning only that plant grew at more than average density in the lake overall. *Chara* spp was also the densest species in each of the individual depth zones, growing at more than average density in Zones 2, 3 and 4. No other species came close to *Chara* spp in mean density.

Density figures are higher when the data is evaluated on the basis of "mean density where present." More plants are found at higher than average densities at the sites where they are present, in addition to *Chara* spp: *Brasenia schreberi; Phalaris arundinacea; Potamogeton amplifolius; Potamogeton foliosus; Sagittaria latifolia; Scirpus americanus; Scirpus validus; Typha latifolia;* and *Zosterella dubia.* However, only *Chara, Potamogeton amplifolius* and *Potamogeton foliosus* were commonly-occurring. The others were densely aggregated in only a few limited locations. Although there are few unvegetated sites on Jordan Lake, several of the sites that do have aquatic vegetation have dense beds of several kinds of aquatic plants

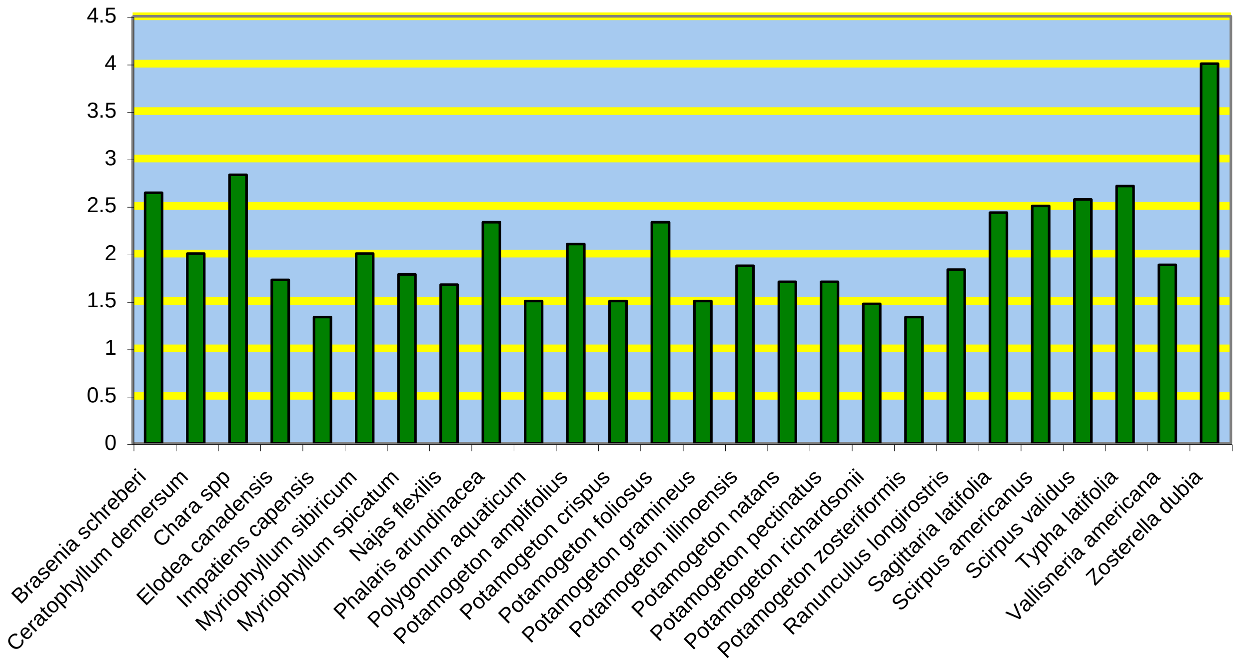
Chart 2: Mean Density



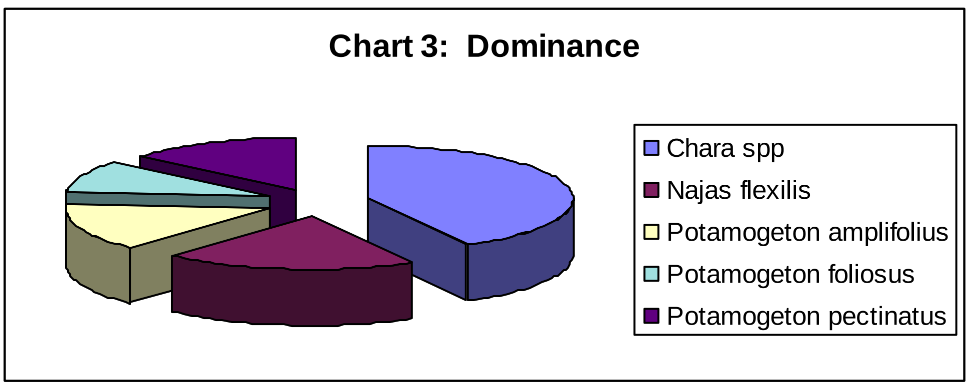
DOMINANCE

Relative frequency and relative density are combined into a dominance value that demonstrates how dominant a species is within its aquatic plant community. Based on dominance values, *Chara* spp was the dominant aquatic plant species in Jordan Lake. Next closest in dominance value, at less than one-half of that of *Chara* spp, was *Najas flexilis.* *Myriophyllum spicatum*, *Potamogeton crispus* and *Phalaris arundinacea*, the two exotics found in Jordan Lake, were not present in high frequency, high density or high dominance. It is possible that *Potamogeton crispus* was under-represented in

Chart 2A: Density Where Present



these calculations, since this survey was performed in August, somewhat later than its peak season.



Chara spp was dominant in all four depth zones individually.

DISTRIBUTION

Aquatic plants occurred at 97.8% of the sample sites in Jordan Lake to a maximum rooting depth of 19'. Free-floating plants were found only in the shallowest zone (see plant maps in appendices).

Secchi disc readings are used to predict maximum rooting depth for plants in a lake (Dunst, 1982). Based on the summer 2004-2006 Secchi disc readings, the predicted maximum rooting depth in Jordan Lake would be **15.78 feet.** During the 2006 aquatic plant survey, rooted plants were found at a depth of **19**, i.e., rooted plants were a deeper depths than that to be expected by Dunst calculations, probably due to the better water clarity in the spring when plants are first beginning growth.

The 0-1.5' depth zone (Zone 1) produced the highest total occurrence of plant growth, as well as the highest total density. There was a sharp drop in occurrence and density in Zone 2 (1.5'-5'), then another drop to Zone 3 (5'-10'). Zone 4 had the least total occurrence of aquatic plants and the least total density of plants.

The greatest number of species per site (species richness) was found in Zone 1 with 6.83 species richness. A sharp drop was found in Zone 2 and Zone 3, with species richness of 4.17 and 3.39 respectively. Another drop to Zone 4 occurred, with a species richness of 2.87. Overall species richness was 4.41.

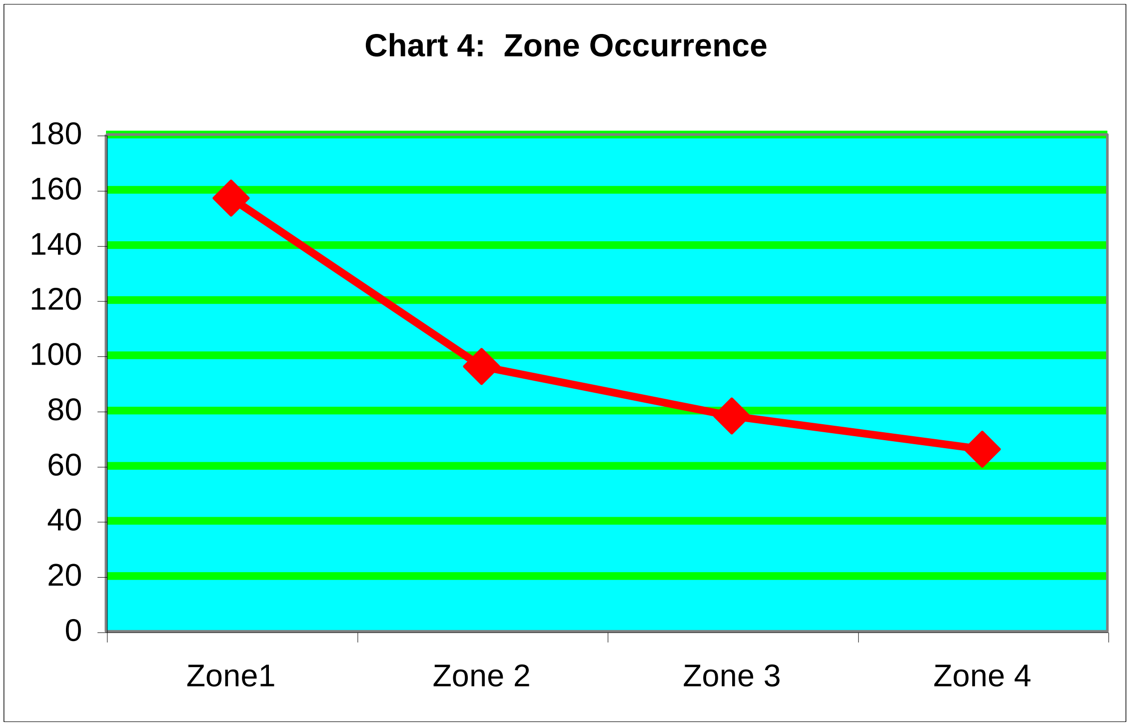


Chart 4: Zone Occurrence
180
160
140
120
100
80
60
40
20
0
Zone1
Zone 2
Zone 3
Zone 4

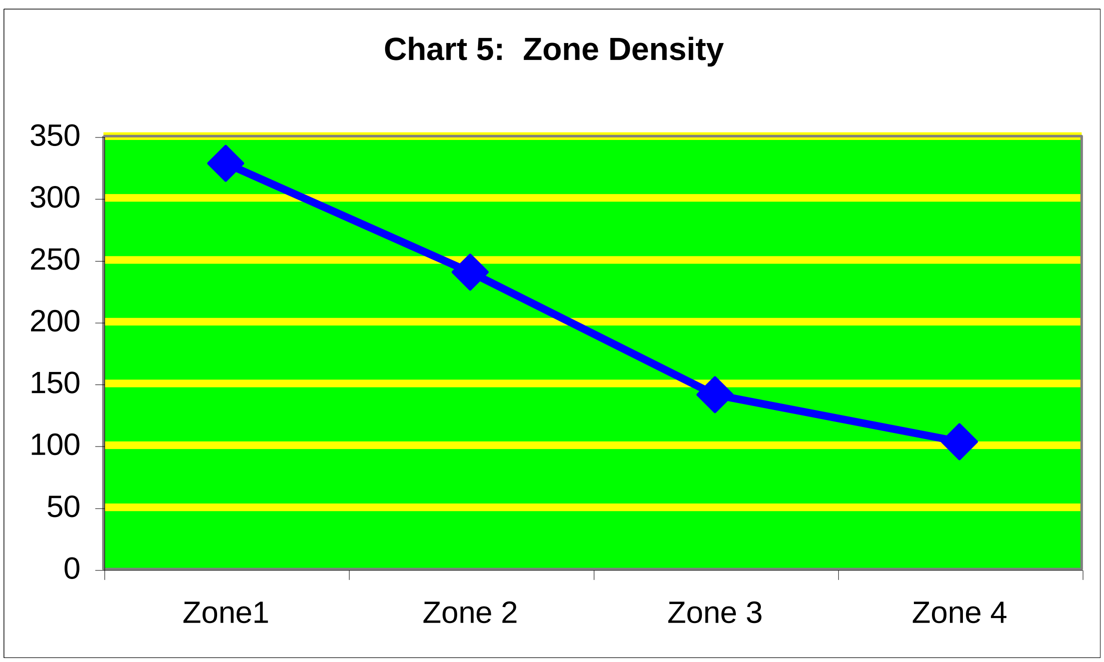


Chart 5: Zone Density
350
300
250
200
150
100
50
0
Zone1
Zone 2
Zone 3
Zone 4

THE COMMUNITY

The Simpson's Diversity Index for Jordan Lake was .93, suggesting excellent species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). This places it in the highest quartile for Simpson's Diversity Index readings for both North Central Hardwood Forest and for all Wisconsin Lakes. The Aquatic Macrophyte Community Index for Jordan Lake is 63 (maximum score is 70). This is in highest quartile for North Central Wisconsin Hardwood Lakes and all Wisconsin lakes.

Table 5: Aquatic Macrophyte Community Index

Aquatic Macrophyte Community Index for Jordan Lake 2006		
Category	Jordan Lake results	Value
Maximum rooting depth	19'	10
% littoral area vegetated	97.8%	10
%submersed plants	86%	9
% sensitive plants	25%	9
# taxa found	35 (3 exotic)	10
exotic species frequency	7%	5
Simpon's Diversity	.93	10
total		**63**

The presence of several invasive, exotic species could be a significant factor in the future if they are not held in check. Currently, none of the exotic species appear to be taking over the aquatic plant community, perhaps due to the high density and occurrence of native plants. *Myriophyllum spicatum* should be monitored, since it is the exotic species with the highest presence and since its tenacity and ability to spread to large areas fairly quickly could make it a danger to the diversity of Jordan Lake's currently excellent aquatic plant community.

An Average Coefficient of Conservatism and a Floristic Quality Index calculation were performed on the field results. The Average Coefficient of Conservatism measures the community's sensitivity to disturbance, while the Floristic Quality Index measures the community's closeness to an undisturbed condition. Indirectly, they measure past and/or current disturbance to the particular community.

Previously, a value was assigned to all plants known in Wisconsin to categorize their probability of occurring in an undisturbed habitat. This value is called the plant's Coefficient of Conservatism. A score of 0 indicates a native or alien opportunistic invasive plant. Plants with a value of 1 to 3 are widespread native plants. Values of 4 to 6 describe native plants found most commonly in early successional ecosystem. Plants scoring 6 to 8 are native plants found in stable climax conditions. Finally, plants with a value of 9 or 10 are native plants found in areas of high quality and are often endangered or threatened. In other words, the lower the numerical value a plant has, the more likely it is to be found in disturbed areas.

The Average Coefficient of Conservatism for Jordan Lake was 4.52. This puts it in the lowest quartile for Wisconsin Lakes (6.0) and for lakes in the North Central Hardwood Region (5.6). The aquatic plant community in Jordan Lake is in the category of those most tolerant of disturbance, probably due to selection by a series of past disturbances, including the current heavy recreational use and high level of shoreline development.

The Floristic Quality Index of the aquatic plant community in Jordan Lake of 25.14 is in the highest quartile for Wisconsin Lakes (22.2) and the North Central Hardwood Region (20.9). This indicates that the plant community in Jordan Lake is within the group of lakes closer to an undisturbed condition in Wisconsin overall and in the North Central Hardwood Region than many lakes. The Jordan Lake aquatic plant community is close to an undisturbed condition.

"Disturbance" is a term that covers many disruptions to a natural community. It includes physical disturbances to plant beds such as boat traffic, plant harvesting, chemical treatments, dock and other structure placements, shoreline development, erosion and fluctuating water levels. Indirect disturbances like sedimentation, erosion, increased algal growth, and other water quality impacts will also negatively affect an aquatic plant community. Biological disturbances such as the introduction of non-native and/or invasive species (such as the Eurasian Watermilfoil, Reed Canarygrass and Curly-Leaf Pondweed found here), destruction of plant beds by fish or wildlife can also negatively impact an aquatic plant community.

Because there were no transect sites that had shorelines that were not disturbed, no comparison between the effect of natural vs. disturbed shores on the aquatic plant community seemed appropriate.

IV. DISCUSSION

Based on water clarity, chlorophyll and phosphorus data, Jordan Lake is a mesotrophic/oligotrophic lake with very good water clarity and good water quality. This trophic state should support substantial plant growth and occasional algal blooms.

Sufficient nutrients (trophic state), hard water, and very good clarity in Jordan Lake favor plant growth. Despite the sometime limiting effect of sand sediments on aquatic plant growth, over 97%% of the lake is vegetated, suggesting that even the sand sediments in Jordan Lake hold sufficient nutrients to maintain aquatic plant growth. The shallowest depth zone supported the greatest amount of plant growth to a maximum depth of 19'.

All recorded aquatic plant treatments in Jordan Lake have been chemical. There is no record of mechanical harvesting to try to reduce plant growth. A regular schedule and pattern of machine harvesting could help in removing vegetation from the lake and may significantly help with nutrient. The harvesting should also be designed to set back the growth of Eurasian Watermilfoil and Curly-Leaf Pondweed, not spread them further.

Chara spp was the most frequently-occurring "plant" in Jordan Lake in 2006 overall (76.09% occurrence frequency. No other species reached a frequency of 50% or greater, although *Najas flexilis* was close with 46.74% occurrence frequency. *Chara* spp was the densest plant in Jordan Lake, with a mean density of 2.15 overall. It was the only species with a mean density over 2.0, meaning only that plant grew at more than average density in the lake overall. *Chara* spp was also the densest species in each of the individual depth zones, growing at more than average density in Zones 2, 3 and 4. No other species came close to *Chara* spp in mean density.

The Simpson's Diversity Index for Jordan Lake was 0.93, suggesting excellent species diversity. The Aquatic Macrophyte Community Index (AMCI) Jordan Lake is 63, placing it in the highest quartile for Wisconsin Lakes and for North Central Wisconsin Hardwood Lakes. The Average Coefficient of Conservatism score puts Jordan Lake in the category of those very tolerant of disturbance. The Floristic Quality Index of the aquatic plant community in Jordan Lake of 25.14 is above average for Wisconsin Lakes and lakes in the North Central Hardwood Region. This indicates that the plant community in Jordan Lake is among the group of lakes closer to an undisturbed condition than the average state or regional lake.

Disturbed shores—including cultivated lawns, hard structures, rock riprap and eroded soil--were the dominant shore cover in Jordan Lake (71.73%). Of natural shorelines, herbaceous vegetation had the most coverage (20.22%). Some type of disturbed shoreline was found at 100% of the sample sites. Disturbed shorelines offer little protection for water quality or habitat for wildlife and have significant potential to negatively impact Jordan Lake's water quality by increased runoff (including lawn fertilizers, pet waste, pesticides) and shore erosion. The disturbed shores cannot filter the increased runoff as natural vegetation can.

The areas of wooded and wetland shores on the lake should be preserved as they are important to maintain habitat and to serve as a water quality buffer for the lake. Studies have suggested that runoff from establish wooded land is substantially less than that of developed areas.

The earliest aquatic plant survey of any kind of Jordan Lake was in 1954. It recorded *Ceratophyllum demersum, Chara* spp., *Juncus, Myriophyllum, Potamogeton richardsonii, Scirpus, Sagittaria,* and *Utricularia* as abundant. *Nymphae, Potamogetons* and *Typha latifolia* were noted as present. Most of these plant types are still present in Jordan Lake's aquatic plant community.

V. CONCLUSIONS

Jordan Lake is a mesotrophic/oligotrophic natural lake with good water quality and very good water clarity. The quality of the aquatic plant community in Jordan Lake is high for Wisconsin lakes and for lakes in the North Central Hardwood region, as measured by AMCI, with excellent diversity of species and a condition close to undisturbed Floristic Quality Index. However, Average Coefficient of Conservatism suggest the aquatic plant community has high tolerance to disturbance, likely due to past disturbances. Filamentous algae are not abundant. Structurally, the aquatic plant community is diverse and contains emergent plants, free-floating plants, floating-leaf rooted plants and submergent plants.

Chara spp is dominant, occurring at ¾ of the sites and exhibiting a dense growth form. It dominates in all four depth zones. It was the only species with a mean density over 2.0, meaning only that plant grew at more than average density in the lake overall. No other species came close to *Chara* spp. *Najas flexilis* was subdominant, occurring at ½ of the sites, but in low density. Eurasian Watermilfoil is neither common nor dense (see plant distribution maps in appendices).

A healthy and diverse aquatic plant community plays a vital role within the lake ecosystem. Plants help improve water quality by trapping nutrients, debris and pollutants in the water body; by absorbing and/or breaking down some pollutants; by reducing shore erosion by decreasing wave action and stabilizing shorelines and lake bottoms; and by tying-up nutrients that would otherwise be available for algae blooms. Aquatic plants provide valuable habitat resources for fish and wildlife, often being the base level for the multi-level food chain in the lake ecosystem, and also produce oxygen needed by animals.

Further, a healthy and diverse aquatic plant community can better resist the invasion of species (native and non-native) that might otherwise “take over” and create a lower quality aquatic plant community. A well-established and diverse plant community of natives can help check the growth of more tolerant (and less desirable) plants that would otherwise crowd out some of the more sensitive species, thus reducing diversity.

Vegetated lake bottoms support larger and more diverse invertebrate populations that in turn support larger and more diverse fish and wildlife populations (Engel, 1985). Also, a mixed stand of aquatic macrophytes (plants) supports 3 to 8 times more invertebrates and fish than do monocultural stands (Engel, 1990). A diverse plant community creates more microhabitats for the preferences of more species.

MANAGEMENT RECOMMENDATIONS

(1) Because the plant cover in the littoral zone of Jordan Lake is over the ideal (25%-85%) coverage for balanced fishery, consideration should be given to reducing plant growth in at least some areas by cutting fishery

lanes A map of areas to have plants removed should be developed, then removal should occur by hand in shallow areas (no wider than 30’ per landowner) to be sure that entire plants are removed and to minimize the amount of disturbance to the settlement.

(2) Mechanical harvesting could be considered in deeper water. Removal of the harvested plants could significantly reduce the level of nutrients in the lake.

(3) Natural shoreline restoration in many areas is needed. Disturbed shorelines cover too much of the current shoreline (nearly 72%). A buffer area of native plants should be restored in these areas, especially on those sites that now have traditional lawns mowed to the water’s edge. Stormwater management of these impervious surfaces is essential to maintain the high quality of the lake water. Natural shoreline is also needed around the lake for any significant survival of milfoil weevils that could help control Eurasian Watermilfoil.

(4) No lawn chemicals, especially lawn chemicals with phosphorus, should be used on properties around the lake. If they must be used, they should be used no closer than 50’ to the shore.

(5) An aquatic plant management plan should be developed with a regular activity schedule. Such plans will be required by the Wisconsin DNR for aquatic plant permits and grants and will also assist in improving the quality of the native aquatic plant community in Jordan Lake.

(6) The plan should consider including target harvesting for Eurasian Watermilfoil (EWM) to prevent further spread.

(7) The Jordan Lake District may want to apply for grants from the Wisconsin Department of Natural Resources to help defray the cost of aquatic plant management.

(8) Exotic species signs at the boat landing should be maintained.

(9) No broad-scale chemical treatments of aquatic plant growth are recommended due to the undesirable side-effects of such treatments, including increased nutrients from decaying plant material and decreased dissolved oxygen and opening up more areas to the invasion of EWM. Chemical treatments should be used selectively for EWM or CLP only.

(10) Fallen trees should be left at the shoreline for fish & wildlife habitat.

(11) Although Adams County Land & Water Conservatism Department currently takes regular surface water samples, the program only goes through 2006. Jordan Lake residents should continue with the Wisconsin Self-Help Monitoring Program to permit on-going monitoring of the lake trends for basically no cost.

(12) Jordan Lake residents should identify, cooperate with and participate in watershed programs that will reduce nutrient and sediment inputs.

(13) Once critical habitat areas are formally determined, the lake management plan should include recommendations for preserving these areas, including making them no-wake zones.

(14) The areas where there is undisturbed natural vegetation on shore and wetlands should be maintained and left undisturbed.

(15) The Jordan Lake District should make sure that its lake management plan takes into account all inputs from both the surface and ground watersheds and addresses the concerns of this lake community.

(16) The aquatic plant survey should be updated every 3 to 5 years to assist in determining the health of the lake.

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